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Noise Assessment

Kurnell Planning Proposal - 251, 260R, 27, and 280-282 Captain Cook Drive, Kurnell

Prepared for Besmaw Pty Ltd
December 2023

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Report Number

E230956 RP1

Client

Besmaw Pty Ltd

Date

1 December 2023

Version

Final

Approved by

Najah Ishac
Director
1 December 2023

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1 Introduction

1.1 Overview

This Noise Assessment report has been prepared by EMM Consulting Pty Limited (EMM) to accompany a proponent initiated Planning Proposal (Planning Proposal) in support of the proposed amendment to *State Environmental Planning Policy (Precincts—Central River City) 2021* (SEPP Precincts) and *Sutherland Shire Local Environmental Plan 2015* (SSLEP 2015).

The Planning Proposal aims to translate and amend current land uses zones under the applicable controls to be consistent with the standard instrument local environmental plan zones and enable additional uses to accommodate a diverse range of land uses at 251, 260R, 278, and 280-282 Captain Cook Drive, Kurnell (the site). The Planning Proposal will establish a new mixed-use community encompassing residential, employment, tourism, education, cultural facilities, ecological regenerative zones and public open space areas.

This report has been prepared to assess the noise impacts associated with and on the proposal (masterplan) and relies on previous studies including the Noise and Vibration Study dated 6 June 2018 (refer Appendix D).

The aim of the SEPP Precincts review process is to set the strategic land use framework for the Site, within the context of the broader Kurnell Peninsula and South District. The review process commenced in June 2017, and a scope of works for technical studies was issued by the DPE on 25 September 2017 to inform the master planning process. The scope of works identified a number of technical studies to be undertaken, including biodiversity, bushfire, flooding and water cycle management, indigenous heritage, non-indigenous heritage, land capability, hazards and air quality, noise and vibration, traffic and transport and economic feasibility.

A Project Control Group (PCG) has been established with the Department to facilitate a proponent-initiated SEPP amendment process, as it relates to the Site. The intent of the Planning Proposal is to translate the land use zones and permissible uses (including residential accommodation) presently applying to the Site, into Standard Instrument zones. This will enable the Site, which is presently identified as a “deferred matter” under Sutherland Local Environmental Plan 2015 (the LEP), to be zoned under that LEP and for SEPP Kurnell Peninsula 1989 as it relates to the Site to be repealed.

To inform the Planning Proposal, a range of technical studies have been prepared to provide evidence based planning in accordance with the 'scope of works' issued by the Department in September 2017 and the technical methodologies which were endorsed by the PCG on 25 July 2019 and to address agency feedback on the earlier technical studies.

In March 2023 the proponent submitted a Scoping Proposal to Sutherland Shire Council to commence the formal Planning Proposal process, in accordance with the LEP Making Guidelines. The Scoping Proposal provided a comprehensive ‘status update,’ outlining the concept master plan, the intended development outcome, the proposed planning controls and the environmental considerations which were to be further resolved.

As part of the Scoping Proposal process, Council referred the Scoping Proposal package to the DPE, State agencies, and several internal Council teams for review and comment. The advice received from these stakeholders has provided clear directives on the necessary updates and key focus areas within the technical documentation.

Separate to the Scoping Proposal package, extensive and ongoing engagement with relevant State Agencies has occurred since November 2022, with the objective of clarifying and resolving any of the outstanding considerations.

EMM is engaged to prepare acoustic input to address the noise matters and considers feedback received on the Besmaw Kurnell Scoping Proposal Report (May 2023) from a number of stakeholders including Sutherland Shire Council (6 June 2023), Sydney Airport Corporation Limited (SACL, 7 June 2023), DPE (10 August 2023), Airservices Australia (16 May 2023) and Department of Infrastructure, Transport, Regional Development, Communications and the Arts (20 June 2023).

On 17 October 2023 we met with Ted Plumber and Ellie Stamatelatos of SACL to discuss the key points in their submission and we confirmed that the site's masterplan had changed since their review and that the changes are positive with respect to their key points. The findings of this report have informed the master planning process for the Site.

This study has been completed with reference to the following polices, standards and guidelines:

- State Environmental Planning Policy (SEPP) Precincts;
- Greater Sydney Commission South District Plan 2018;
- NSW Department of Planning (DoP) 2008, Development Near Rail Corridors and Busy Roads – Interim Guideline;
- NSW EPA 2017, Noise Policy for Industry (NPfI);
- NSW EPA 2011, Road Noise Policy (RNP);
- Australian Standard AS 2021-2015 "Acoustics - Aircraft noise intrusion - Building siting and construction.";
- Department of Infrastructure, Transport, Regional Development, Communications and the Arts, National Airports Safeguarding Framework principles and guidelines (Guideline A - Measures for Managing Impacts of Aircraft Noise, November 2016);
- Australian/New Zealand Standard AS/NZS 2107-2016 "Acoustics - Recommended design sound levels and reverberation times for building interiors"; and
- Australian Standard AS 1055-2018 "Acoustics - Description and Measurement of Environmental Noise."

1.2 Kurnell Scoping Proposal feedback

The Besmaw Kurnell Scoping Proposal Report was issued in May 2023. Table 1.1 provides a list of feedback from various stakeholders on the Kurnell Planning Proposal with respect to noise and the section of this report where the items have been addressed.

Table 1.1 Kurnell Scoping Proposal feedback on noise and where addressed

Requirement	Comment or section of report where addressed
DPE (10 August 2023)	
5.3 Development Near Regulated Airports and Defence Airfields • Addressing the proposal's consistency with this Direction must include: ○ addressing the site's affection by Sydney Airport's Australian Noise Exposure Forecast (ANEF) contours and how proposed future development can adequately address noise impacts; and	Section 4.3.1 and Section 5.1. The ANEF metric and contours are provided and assessment under AS2021-2015 adopted. Note:

Table 1.1 Kurnell Scoping Proposal feedback on noise and where addressed

Requirement	Comment or section of report where addressed
○ *addressing the proposed maximum building heights and the impacts of Sydney Airport's Obstacle Limitation Surfaces and PAN-OPS.* Consistency with these requirements should be informed by pre-Gateway consultation with Sydney Airport Corporation (SAC). The proposal will need to adequately address any feedback from SAC.	obstacle limitation surface and PAN-OPS are not noise related issues. SAC feedback included as below.
Breen Site at 330 Captain Cook Drive, Kurnell • To the immediate west of the site is the Breen Resource Recovery Facility. o The facility is currently operating and accepts excavated materials and construction and demolition waste as part of the land restoration activities permitted under DA269/90 from Council. • A proposed SSD application for a new Resource Recovery Facility is currently under assessment by the Department's Industry Assessments team (SSD-10412). • The proposed SSD seeks to process up to 650,000 tpa of construction and demolition and commercial and industrial wastes and land restoration, landfilling and contouring. • The Department notes that there is no existing buffer between the Breen site and the site. It is also noted that the pending SDD application does not propose a buffer. • The proposal will need to address the compatibility of proposed land uses and densities with the existing and proposed future resource recovery facility on the Breen site. This response will need to be informed by pre-Gateway agency consultation with the NSW Environment Protection Authority.	Section 7.
Sydney Airport Corporation (7 June 2023)	
Proposed residents beneath flight path	Section 5.2.2 and Figure 5.3. The site's masterplan avoids residential land uses beneath the flight path based on this study's advice even though this would be 'conditionally acceptable' according to AS2021-2015.
Expectation of noise complaints from new residents	Section 5.5 and Section 5.6
Noise will increase over time	Section 4.2.2
Health impacts of noise, especially the elderly (eg aged care facility)	Section 5.6. Aged care facilities are not proposed, rather seniors living.
LTOP –flights to the south over Botany Bay and uninhabited areas of Kurnell Peninsula, especially in non-curfew periods (6am to 11pm) – airport achieves on average 52% of all movements to the south of the airport. Pressure would mount from complaints from new residents of the site to change LTOP's fundamental principle of maximising flights over non-residential areas.	Section 4.2.2 and Appendix D. The captured data across several years includes typical to saturated aircraft operations over the site. The metric ANEF includes frequency of events within its determination, and this informs the initial considerations with land use planning.
ANEF is not enough on its own and must include other metrics in noise assessment, eg N70 events and maximum noise levels. Aircraft noise does not stop at ANEF 20 and metrics other than ANEF must be used.	Section 4.2.4, Section 4.5 and Section 5.1. Agreed. N70, N60, LAmax are all provided herein and recommended for future occupants of the site.

Table 1.1 Kurnell Scoping Proposal feedback on noise and where addressed

Requirement	Comment or section of report where addressed
AS2021- 2000	AS2021 was revised and the current version is 2015.
Single event maximum noise level – eg A380 or B777 arrival on 34L of 71.5 to 75.5dBLAmax and relying only on ANEF to assess impacts is flawed.	Section 5.2 and Section 5.4. Such noise levels are within the adopted levels used in the example design.
SACL post 17 October 2023 meeting:	
Ted Plumber noted that SACL's remaining concerns with the proposal relate to the risk of constraining its operations under the Long Term Operating Plan for Sydney Airport (which sets the noise sharing framework).	Ted noted that SACL could look at amending the departure flight path over Kurnell, diverting it from the Besmaw site (noting Airservices is currently examining this).
Airservices (16 May 2023)	
Nothing specific and nothing relating to noise	n/a
Department of Infrastructure, Transport, Regional Development, Communications and the Arts (9 and 20 June 2023)	
New residents directly under flight path.	Section 5.2.2 and Figure 5.3. The site's masterplan avoids residential land uses beneath the flight path based on this study's advice even though this would be conditionally acceptable according to AS2021-2015.
Should this development proceed the Department would expect an increase of aircraft noise complaints.	Section 5.5 and Section 5.6

1.3 Glossary

Several technical terms are discussed in this report. These are explained in Table 1.2.

Table 1.2 Glossary of acoustic terms

Term	Descriptions
ANAc	Aircraft noise attenuation required of each building component
ANR	Aircraft noise reduction
BCA	Building Code of Australia
Curfew	Defined as the hours 11pm to 6am for Sydney Kingsford Smith Airport aircraft operations
dB	Unit of sound in decibels
dB(A)	A unit of sound measurement which has its frequency characteristics modified by a filter (A-weighted) so that it approximates the frequency response of the human ear.
DL	The distance in metres from the closer end of the runway to the intersection of the extended runway centre-line and a line drawn perpendicular to the extended runway centre-line and passing through the building site, known as the 'sideline projection' (refer to AS2021-2015 Figure 3.1).
DS	The perpendicular distance in metres from the building site to the extended runway centreline (refer to AS2021-2015 Figure 3.1).
DT	The distance in metres from the further end of the runway to the intersection of the runway centre-line and a line drawn perpendicular to the extended runway centre-line and passing through the building site, known as the 'sideline projection' (refer to AS2021-2015 Figure 3.1).
EPN (EPNL or EPNdB)	Effective Perceived Noise level is a modification of the Perceived Noise Level (PNL) to take into account tone components in aircraft broad band noise as well as the duration of the noise. It is measured in EPNdB, and defined as the PNL in PNdB plus a tone correction and a duration correction.
L_{Smax}	Maximum noise level with slow time response (measured in dB(A))
L_{eq}	The "equivalent continuous noise level" is the summation of noise events integrated over a selected period of time. This noise metric is the energy-averaged noise level over the measurement period and is commonly used to correlate noise exposure and human annoyance.
N70	The number of daily aircraft noise events that are above a maximum noise threshold of 70 dB(A) L_{Smax}. Similarly for N60 etc.
NEC	Noise Exposure Concept, is a single number index for predicting the cumulative exposure to aircraft noise during a specified time period (normally one future year) during consideration of options for development, based on a hypothetical set of conditions. This shows the average daily aircraft noise exposure for that period and is usually presented graphically in the form of noise contours.
NEF (or ANEF)	Noise Exposure Forecast is an index for predicting the cumulative exposure to aircraft noise during a particular future year, generally 10 to 20 years from the date of issue, based on a firm forecast of aircraft operations. This shows the average daily aircraft noise exposure for that period and is usually presented graphically in the form of noise contours.
NEI (or ANEI)	Noise Exposure Index, is an index for calculating the cumulative exposure to aircraft noise during a specified time period, based on historical data, where exact types and numbers of aircraft, which used the aerodrome, are known. This shows the average daily aircraft noise exposure for that period and is usually presented graphically in the form of noise contours.
NMT	Noise monitoring terminal
Rw	Weighted sound reduction index
Daytime	For aircraft noise modelling purposes, the day period is 7am to 7pm.

Table 1.2 Glossary of acoustic terms

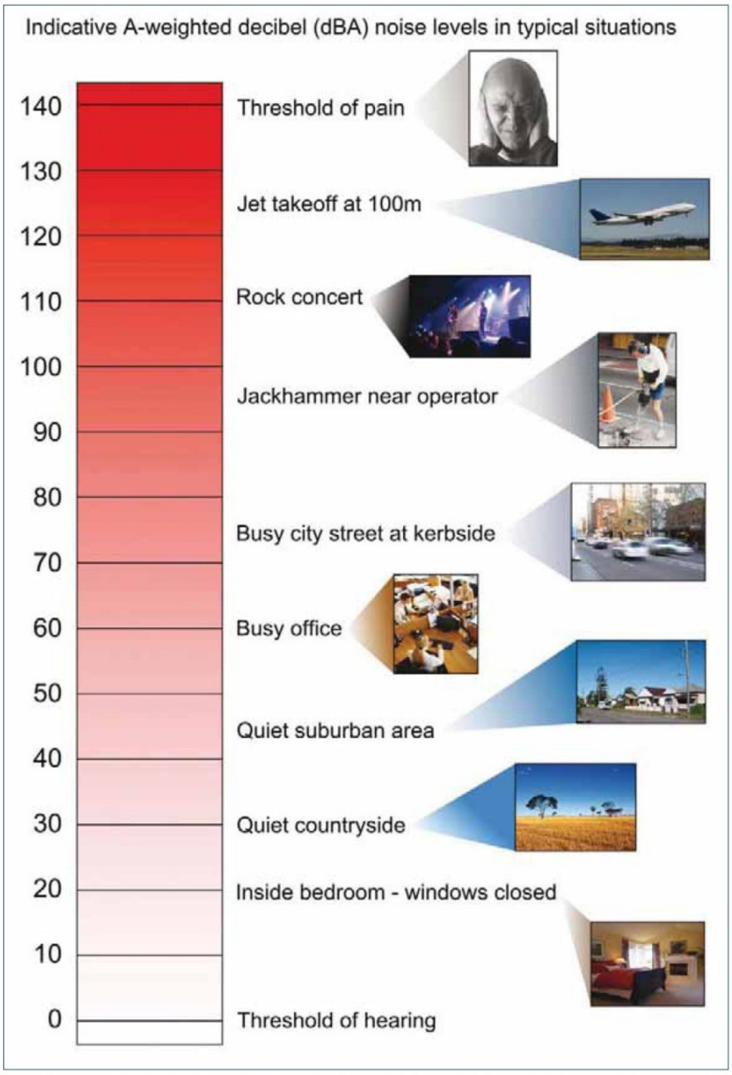
Term	Descriptions
Evening/Night	For aircraft noise modelling purposes, the evening/night period is 7pm to 7am.
Movement	One pass of an aircraft as it takes off or lands.

It is useful to have an appreciation of decibels, the unit of noise measurement. Table 1.3 gives an indication as to what an average person perceives about changes in noise level.

Table 1.3 Perceived change in noise

Change in sound level (dB)	Perceived change in noise
3	just perceptible
5	noticeable difference
10	twice (or half) as loud
15	large change
20	four times as loud (or quarter) as loud

Examples of common noise levels are provided in Figure 1.1.



Source: *RTA Environmental Noise Management Manual (RTA, 2001)*

Figure 1.1 Common noise levels

2 Site description

The land to which this planning proposal relates is 251, 260R, 278, and 280-282 Captain Cook Drive, Kurnell and is located within the Sutherland Shire Local Government Area (LGA).

The key features of the site are summarised in Table 2.1

Table 2.1 Land details

Feature	Lot 2 North	Lot 2 South	Lot 8	Lot 9
Street Address	251 Captain Cook Drive	280-282 Captain Cook Drive	278 Captain Cook Drive	260R Captain Cook Drive Kurnell
Legal Description	Lot 2 in DP1030269	Lot 2 in DP559922	Lot 8 in DP586986	Lot 9 DP 586986
Site Area	16ha	160ha	34.5ha	82m^2
	Total Area: Approximately 210.5 hectares			
Local Government Area	Sutherland Shire			

Lot 2 North is bound by Quibray Bay to the north and north-east, Towra Point Nature Reserve to the west and Captain Cook Drive to the south. It has been occupied in part by Kurnell Boarding Stables and Riding School since 1976.

Lot 2 South is bound by Captain Cook Drive to the north, industrial zoned land to the northeast (including the Sydney Water Desalination Plant), Kurnell Village and the Ampol Fuel Terminal, Kamay Botany Bay National Park to the east, Bate Bay to the south, Wanda Reserve to the west.

Lot 2 South comprises the following uses:

- Extractive operations that provide a significant portion of fine building sand to the Sydney construction market. In addition to the extraction, rehabilitation activities are undertaken including filling of the extraction area with Virgin Excavated Natural Material (VENM), management of the frontal dune system to Bate Bay, removal of noxious weeds, and planting of endemic species to protect the dunes.

- Safety and security fencing erected within the Site.

- A collection of dwellings to the north of Boat Harbour, known as the Boat Harbour cabins, used for permanent and vacation accommodation.

The property title of Lot 2 South extends down to mean high water mark in Bate Bay. Lots 8 and 9 make up the remainder of the site areas as described in Table 2.1.

The entire Site is privately owned, including the foreshore areas along Bate Bay and Boat Harbour. It is proposed to dedicate these foreshore areas to the relevant State and local government authorities to be integrated into the adjoining National Park and local open space networks.

The surrounding land uses and activities that may potentially impact the Site are:

- Sydney Kingsford Smith Airport over flight operations (flight paths traverse over parts of the Site);

- road traffic noise from Captain Cook Drive which is the main arterial approach to the Site from the west; and
- industrial noise from the Ampol Fuel Terminal, desalination plant and other industry to the east and west.

The Site layout and surrounding Site context is shown in Figure 2.1.

Figure 2.1 Site aerial and map (*Source: Group GSA*)

2.1 Land use proposal

The project's draft master plan includes a variety of land uses generally focused on residential accommodation, leisure and hospitality and commercial retail. Uses will include:

- Residential
- Residential Aged Care Facilities
- Independent Living Units
- Retail
- Hotel Accommodation
- Dharawal Cultural Destination
- Educational Establishment

The development is generally separated into four distinct precincts each containing a mixture and range of land uses, these are summarised as follows:

1. **Quibray Bay:** Located north of Captain Cook Drive, this precinct features indigenous seniors housing and residential units. The residential area in this precinct is positioned to the west of the primary flight path to Sydney Airport.

2. **Town Centre:** Situated south of Captain Cook Drive on the western half of the site, the Town Centre serves as the commercial and retail hub of the master plan. It is further divided into North and South sub precincts. Town Centre North hosts a variety of commercial amenities in close proximity to hotels, the arrival precinct, and high-density residential. Town Centre South primarily comprises residential neighbourhoods with a range of housing types. Like the Quibray Bay precinct, the residential area here is located to the west of the primary flight path to Sydney Airport.

3. **Bate Bay:** Positioned centrally on the site, the Bate Bay precinct is dispersed around local and district parks, incorporating various residential land uses. Again, the residential areas in this precinct are situated to the west of the predominant flight path to Sydney Airport.

4. **Boat Harbour:** Covering the eastern third of the site, Boat Harbour includes a mix of tourism, recreation, and residential uses. This precinct offers seniors housing, and a tourism community, particularly around Boat Harbour and the beachfront. Residential developments in this area are positioned to the east of the precinct to ensure they are not beneath the primary arrival flight path to Sydney Airport.

Residential receivers will make up the bulk of sensitive type noise receptors within the development and are spread throughout the development. The master plan will generally incorporate 50 m offsets from the boundary with a 100 m offset proposed for the southeast boundary adjoining the Boat Harbour Aquatic Reserve. Notably, single dwellings will not be included in the development and residential development of any type will avoid the areas beneath the flight path.

3 Existing acoustic environment

3.1 Unattended noise monitoring

To establish the existing ambient noise environment of the area, long-term, unattended noise monitoring was conducted at four locations within the Site (denoted as L1 to L4) and an additional location outside the Site boundary (denoted as L5). These locations are shown in Figure 3.1. Logger locations L1, L2 and L4 were selected primarily to capture road traffic noise levels from Captain Cook Drive, while logger locations L3 and L5 were selected to capture existing industrial noise surrounding the Site. Aircraft noise is also a contributor to the environment at the logger positions but was not the focus of the sampling on this occasion. Aircraft noise data is addressed separately, and data is sourced from a previous studies including that in Appendix C.

The monitoring was conducted using five Acoustic Research Laboratories NGARA noise loggers (serial number 878138 (L1), 878123 (L2), 878125 (L3), 878127 (L4) and 878124 (L5)). The procedures described in Australian Standard AS 1055-1997 *Acoustics - Description and Measurement of Environmental Noise* and the NPfI (EPA, 2017) were adhered to. The noise loggers were installed from Thursday 30 November to Thursday 21 December 2017 (total of 22 days). All monitoring locations were selected to avoid, as much as practicable, the Site's operational noise contributions.

The noise loggers were programmed to record statistical noise level indices continuously in 15-minute intervals, including the L_{Amax}, L_{A1}, L_{A10}, L_{A50}, L_{A90}, L_{A99}, L_{Amin} and L_{Aeq} parameters. Calibration of the equipment was checked prior to and following the monitoring. Drift in calibration did not exceed ±0.5 dB. All equipment carried appropriate and current NATA (or manufacturer) calibration certificates.

Monitoring data affected by adverse meteorological conditions such as high winds (greater than 5m/s at microphone height) or rain was excluded. Where applicable, other uncharacteristic noise events have also been excluded from the assessment in accordance with the methods provided in the NPfI. Weather data was sourced from Bureau of Meteorology automatic weather stations (AWS) at Sydney Airport (ID 066037) and Little Bay (ID 066051). The results of the long-term unattended noise monitoring are summarised in Table 3.1. Daily statistical data and charts are provided in Appendix A.

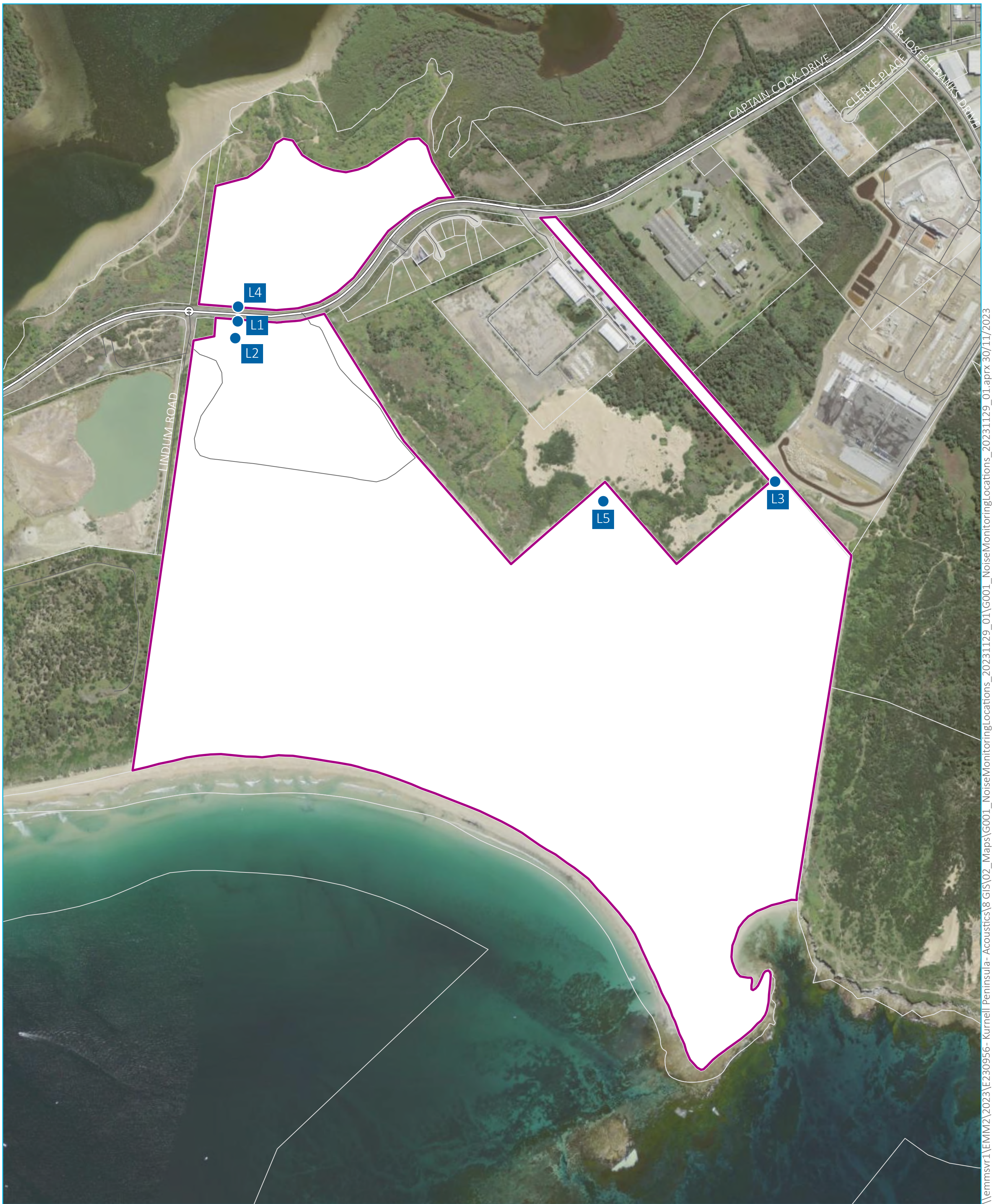
Table 3.1 Unattended long term noise monitoring result summary

Location	Measured background noise level, RBL, dB[1]			Measured L_{Aeq}, dB[2]	
	Day (7 am to 6 pm)	Evening (6 pm to 10 pm)	Night (10 pm to 7 am)	Day (7 am to 10 pm)	Night (10 pm to 7 am)
L1	50	44	34	68	63
L2	45	42	33	58	53
L3	43	36	32	59	55
L4	48	42	32	66	61
L5	44	40	33	63	56

Notes: 1. Rating background level (RBL) defined and analysed in accordance with NPfI.

2. $L_{Aeq,period}$ is the energy averaged noise level over the measurement period and representative of general ambient noise.

Noise levels at logger locations L1 and L4 were dominated by road traffic noise from Captain Cook Drive. The recorded day and night noise levels at these two locations are considered representative of road traffic.



Source: EMM (2023); DCSSS (2023); ESRI (2023); GA (2009); MetroMap (2023)

KEY

Site boundary

Noise monitoring location

Existing environment

Major road

Minor road

Cadastral boundary

Attended and unattended noise monitoring locations

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Figure 3.1

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3.2 Attended noise monitoring

EMM completed 15 minute attended noise measurements on 30 November 2017 at the five unattended monitoring locations (L1 to L5) as outlined in Figure 3.1, to identify noise sources contributing to the ambient noise environment. This data remains representative given relatively little development in the years since collecting that could materially influence the noise environment.

Operator attended measurements were conducted using a Brüel & Kjær Type 2250 integrating sound level meter (serial number 2759405) to both quantify and qualify the existing noise sources. Field calibration of the instrument was completed using a Brüel & Kjær type 4230 calibrator. Attended measurements were undertaken in accordance with AS 1055-1997 Description and Measurement of Environmental Noise, Parts 1, 2 and 3. Meteorological conditions throughout the survey period were relatively calm and clear with no winds above 5 m/s and no rain.

A summary of results of the attended noise monitoring is provided in Table 3.2.

Table 3.2 Summary of 15-minute attended noise measurements

Location	Date	Start time	Measured noise level dB			Comments
			L_{Aeq}	L_{A90}	L_{Amax}	
L1	30/11/17	11:56	65	52	81	Frequent bird noise, wind in trees and traffic on Captain Cook Drive. Occasional aircraft noise. Site noise inaudible.
L2	30/11/17	12:45	54	49	68	Frequent bird noise and traffic on Captain Cook Drive. Occasional aircraft noise and wind in trees. Site noise occasionally audible.
L3	30/11/17	13:17	60	46	76	Occasional aircraft noise and traffic on Beach Road. Site noise occasionally audible. Industrial noise to north very infrequent.
L4	30/11/17	13:52	65	51	87	Frequent bird noise and traffic on Captain Cook Drive. Occasional wind in trees and aircraft noise. Site noise infrequently audible.
L5	30/11/17	14:29	62	43	78	Insects consistent. Occasional aircraft noise and distant traffic. Site noise inaudible.

The ambient noise environment was found to be dominated by local and distant traffic with varying degrees of aircraft noise contributions, birds, insects and industrial noise also evident.

4 Regulatory context

4.1 Aircraft noise

4.1.1 Australian Standard AS 2021-2015

The fundamental tool used for building site acoustic planning purposes around aerodromes is Australian Standard *AS 2021 - 2015 Acoustics - Aircraft noise intrusion - Building siting and construction*. This is the fifth edition in this standard with the original published in 1977 and it replaces the prior edition which was published in 2000. The fundamental principles for land use planning did not change between the 2000 and 2015 versions. AS2021 states:

> "*The aircraft Noise Exposure Forecast (NEF) technique was first developed in the United States of America in the late 1960s. It was subsequently redefined in Australia in 1982. The NEF system is a scientifically based computational procedure for determining aircraft noise exposure levels around aerodromes. It can be used for assessing average community response to aircraft noise and for land use planning around aerodromes. In the Australian NEF system, noise exposure levels are calculated in Australian Noise Exposure Forecast (ANEF) units, which take into account the following features of aircraft noise:*
>
> *(a) The intensity, duration, tonal content and spectrum of audible frequencies of the noise of aircraft take offs, approaches to landing, and reverse thrust after landing (for practical reasons, noise generated on the aerodrome from aircraft taxiing and engine running during ground maintenance is not included).*
>
> *(b) The forecast frequency of aircraft types and movements on the various flight paths, including flight paths used for circuit training.*
>
> *(c) The average daily distribution of aircraft arrivals and departures in both daytime and night-time (daytime defined as 0700 hours to 1900 hours, and night-time defined as 1900 hours to 0700 hours).*
>
> *ANEF charts are provided for most aerodromes throughout Australia. The charts are simply plans of the aerodrome and the surrounding localities on which noise exposure contours of 20, 25, 30, 35 and 40 ANEF units have been drawn. These contours indicate land areas around an aerodrome which are exposed to aircraft noise of certain levels as defined by Clause 1.5.6; the higher the ANEF value the greater the noise exposure.*
>
> *In the areas outside 20 ANEF, noise from sources other than aircraft tends to predominate over aircraft noise, although individual reactions to aircraft noise may differ markedly. Within the area from 20 ANEF to 25 ANEF, aircraft noise exposure starts to emerge as an environmental problem, while above 25 ANEF the noise exposure becomes progressively more severe.*
>
> *The land use compatibility recommendations made in this Standard relate to the above ANEF contours.*"

Item (a) above is largely not relevant given the distance between the airport and the Site (ie at least 7km to the nearest runway end). Aircraft approaches to landing is relevant and is captured in this study.

Other useful context from AS2021 includes:

> "*Prior to 1982, Australian land use recommendations were essentially similar to the criteria used in the U.S. NEF system. However, with the availability of an Australian dose/response function derived from the NAL social survey, the U.S. criteria were revised to take into account the general reaction of Australian communities to aircraft noise.*
>
> *In essence, this revision was limited to a firmer definition of the criterion for residential land use compatibility. In the NEF system as originally adopted in Australia, the U.S. criterion of 30 NEF was adhered to, but, in accordance with a recommendation of the House of Representatives Select Committee on Aircraft Noise made in 1970, cautious restraint was urged to be applied by land zoning authorities when applying the system to Australian*

conditions. Where possible, the 25 NEF contour was used rather than the 30 NEF as a conservative safeguard until the system was validated in Australia.

The NAL Report provided substantial evidence to support the use of 25 ANEF as the appropriate criterion for residential land usage. The 25 ANEF as a residential land usage criterion was recommended in 1985 by the House of Representatives Select Committee on Aircraft Noise, and subsequently adopted as policy by the Commonwealth Government. The only qualification which arises from the findings of the NAL Report is that some people will find that the noise exposure at 25 ANEF is still unacceptable (refer to Figure A1 for the percentage of people affected in the 20 ANEF to 25 ANEF zone). Accordingly, the issuing authorities enter the 20 ANEF contour on all ANEF charts. It is to be stressed, however, that the actual location of the 20 ANEF contour is difficult to define accurately, because of variations in aircraft flight paths, pilot operating techniques, and the effect of meteorological conditions on noise propagation. For that reason, the 20 ANEF contour is shown as a broken line on ANEF charts."

i Site acceptability

The standard considers whether a building site is ‘acceptable’, ‘conditionally acceptable’ or ‘unacceptable’ on acoustic grounds. To do this, an Australian Noise Exposure Forecast (ANEF) noise contour map is needed, which shows the aerodrome’s noise footprint on the surrounding environment. The ANEF map is a function of noise levels from various aircraft that are forecast to use the airport and the number of aircraft movements. The ANEF values are used for land use planning around airports in Australia. Most councils around the airport adopt this approach, and in the absence of such guidance in local or state policies, advice in AS 2021 is the most authoritative available.

The Australian Standard recommends an initial screening approach to determine the acceptability of a site for nominated land uses. Table 4.1 provides a reproduction of Table 2.1 from AS 2021 and the associated notes that follow the table.

Table 4.1 Building site acceptability based on ANEF zones (AS 2021)

Building Type	ANEF Zone of site		
	Acceptable	**Conditionally Acceptable**	**Unacceptable**
House, home unit, flat, caravan park	Less than 20 ANEF	20 to 25 ANEF	Greater than 25 ANEF
Hotel, motel, hostel	Less than 25 ANEF	25 to 30 ANEF	Greater than 30 ANEF
School, university	Less than 20 ANEF	20 to 25 ANEF	Greater than 25 ANEF
Hospital, nursing home	Less than 20 ANEF	20 to 25 ANEF	Greater than 25 ANEF
Public building	Less than 20 ANEF	20 to 30 ANEF	Greater than 30 ANEF
Commercial building	Less than 25 ANEF	25 to 35 ANEF	Greater than 35 ANEF
Light industrial	Less than 30 ANEF	30 to 40 ANEF	Greater than 40 ANEF
Other industrial	Acceptable in all ANEF zones		

Notes: *1. The actual location of the 20 ANEF contour is difficult to define accurately, mainly because of variation in aircraft flight paths. Because of this, the procedure of Clause 2.3.2 may be followed for building sites outside but near to the 20 ANEF contour.*

2. Within 20 ANEF to 25 ANEF, some people may find that the land is not compatible with residential or educational uses. Land use authorities may consider that the incorporation of noise control features in the construction of residences or schools is appropriate (see also Figure A1 of Appendix A).

3. There will be cases where a building of a particular type will contain spaces used for activities which would generally be found in a different type of building (e.g. an office in an industrial building). In these cases Table 2.1 should be used to determine site acceptability, but internal design noise levels within the specific spaces should be determined by Table 3.3.

4. This Standard does not recommend development in unacceptable areas. However, where the relevant planning authority determines that any development may be necessary within existing built-up areas designated as unacceptable, it is recommended that such development should achieve the required ANR determined according to Clause 3.2. For residences, schools, etc., the effect of aircraft noise on outdoor areas associated with the buildings should be considered.

5. In no case should new development take place in green field sites deemed unacceptable because such development may impact airport operations.

AS 2021 defines the terms in Table 4.1 as follows:

Acceptable

> *If from Table 2.1, the building site is classified as 'acceptable', there is usually no need for the building construction to provide protection specifically against aircraft noise. However, it should not be inferred that aircraft noise will be unnoticeable in areas outside the ANEF 20 contour. (See Notes 1, 2 and 3 of Table 2.1).*

Conditionally acceptable

> *If from Table 2.1, the building site is classified as 'conditionally acceptable', the maximum aircraft noise levels for the relevant aircraft and the required noise reduction should be determined from the procedure of Clauses 3.1 and 3.2, and the aircraft noise attenuation to be expected from the proposed construction should be determined in accordance with Clause 3.3 (See Notes 1 and 3 of Table 2.1).*

If an area is found to be 'conditionally acceptable' this typically means that any proposed buildings could require an improved level of building fabric above standard or light weight materials to achieve internal noise goals set by AS 2021.

Unacceptable

> *If, from Table 2.1 the building site is classified as 'unacceptable', construction of the proposed building should not normally be considered. Where in the community interest redevelopment is to occur in such areas, e.g. a hotel in the immediate vicinity of an aerodrome, refer to the notes to Table 2.1.*

ii Requirements for construction

If buildings are constructed in 'conditionally acceptable' areas, AS 2021 sets out required internal noise levels, based on L_{Smax} values from the highest noise level of either departure or landing operations of aircraft. Importantly, the standard states at Section 3.1.4:

> The only exception is where there is evidence that the particular aircraft type and movement which produced that noise level do not constitute a typical operation.

A procedure is described in AS 2021 for determining the required performance of building elements to meet these levels, but this is not a requirement of the Standard and in this study is replaced with a more accurate method – measurements to determine external noise levels, and accurate frequency based calculations to determine resulting internal levels.

iii Maximum noise levels

If a building is within a 'conditionally acceptable' ANEF zone, it is necessary to quantify the typical L_{Smax} noise level from aircraft. The representativeness of noise data should reflect typical events at the aerodrome, which can be ambiguous in some cases, particularly when trying to estimate future operations and associated impacts. For Sydney Airport this is relatively straightforward because of its well established flight path movements, runways and aircraft types.

For aerodromes with a relatively high number of movements (defined as an airport), AS 2021 suggests that data tabulated in the standard be supplemented by site-specific field measurements. A significant quantity of onsite field measurements was obtained during a previous study for this Site to provide an accurate way of assessing impacts.

Where a site is 'conditionally acceptable', AS 2021 recommends that buildings be designed to achieve internal noise levels no greater than identified maximum values from aircraft.

Table 4.2 reproduces recommended internal maximum noise levels for various spaces as categorised in AS 2021. These are the L_{Smax} or maximum noise inside buildings. The spaces with the most onerous criteria are theatres, cinemas and recording studios, although these are often designed and constructed with highly noise attenuating building elements.

For residential buildings, it is necessary to consider aircraft noise levels of greater than 60 dB(A) L_{Smax} as an external level of 60 dB(A) is typically reduced to 50 dB(A) inside, even with a partially open window or door. This satisfies the strictest residential criterion which applies to sleeping areas and dedicated lounges.

Table 4.2 Indoor design sound levels

Building type and activity	Indoor L_{Smax} Design Sound Level, dB(A)
Houses, home units, flats, caravan parks	
Sleeping areas, dedicated lounges	50
Other habitable spaces	55
Bathroom, toilets, laundries	60
Hotels, motels, hostels	
Relaxing, sleeping	55
Social activities	70
Service activities	75
Schools, universities	
Libraries, study areas	50
Teaching areas, assembly areas	55
Workshops, gymnasia	75
Hospitals, nursing homes	
Wards, theatres, treatment and consulting rooms	50
Laboratories	65
Service Areas	75
Public buildings	
Churches, religious activities	50
Theatres, cinemas, recording studios	40
Court houses, libraries, galleries	50
Commercial buildings, offices and shops	
Private offices conference rooms	55
Drafting, open offices	65
Typing, data processing	70
Shops, supermarkets, showrooms	75
Industrial	
Inspection, analysis, precision work	75
Light machinery, assembly, bench work	80
Heavy machinery, warehouse, maintenance	85

AS 2021 defines the 'aircraft noise level' at Section 1.5.2 as:

> *The arithmetic average of the maximum sound levels occurring during a series of flyovers by a specific aircraft type and load conditions measured in A-weighted decibels (dB(A)) using the S time-weighting of a sound level meter.*

iv Additional information

AS 2021 states:

> *ANEF values average noise exposure over a year and do not take account of variations in noise exposure patterns to which the community reacts on an hourly, daily, weekly or seasonal basis. To address this issue, other parameters such as maximum noise levels and frequency of noise events may be included in noise assessment of airports to supplement ANEF levels.*

Additional noise metrics were also provided and included Number Above values (eg N60, N70 etc.) as well as movement data, flight path information and respite analysis to provide a comprehensive suite of information. This allows occupants to better understand the noise exposure on a site.

4.2 Sydney Airport Master Plan 2039

The Sydney Airport Master Plan presents the vision for Sydney Airport, forecasting growth in air travel for tourism and trade to and beyond 2039. The Sydney Airport Master Plan assumes that the night time curfew, aircraft movement cap, noise sharing arrangements, flight paths, runways and regional airline access arrangements will be maintained. These factors are important for informing land use planning generally around the airport.

4.2.1 Describing aircraft noise

A description of aircraft noise exposure is useful to potential occupants of a site. The Sydney Airport Master Plan 2039 provides the most current airport operations and related noise information. Relevant aircraft noise exposure information from this document is summarised below.

4.2.2 Flight paths

One factor in determining aircraft noise impacts under AS 2021 is site location relative to runways.

Chapter 15 'Aircraft Noise' of the Sydney Airport Master Plan includes actions and strategies for managing aircraft noise. It shows aircraft flight paths, noise measurement methods and provides information on ground-based noise. Sydney Airport acknowledges its noise impacts on the community, and it commits to working with the community, governments and the aviation industry to manage and mitigate these impacts. The Sydney Airport Master Plan states that aircraft in Australian skies are some of the most modern in the world and with quieter aircraft replacing older aircraft, the impacts will continue to reduce. This is confirmed by the published ANEF contours for 2039, which cover a smaller area than in previous ANEF contours (i.e.2033 and earlier). Refer to Appendix B for the ANEF 2039 and ANEF 2033 maps.

Sydney Airport's Long Term Operating Plan (LTOP) (refer to Appendix D) has 10 modes, with modes 7, 8 and 9 dominated by arrivals from the south and are the modes most relevant to the site. The LTOP puts in place noise sharing arrangements developed in consultation with the Sydney community.

4.2.3 Available noise maps

The Sydney Airport Master Plan includes typical maps for various airport operations. These are essential for planning land use developments under AS 2021 and are discussed later in this report as they relate to the Site. Fundamentally, the approach to land use planning is based on the ANEF maps. The Sydney Airport Master Plan at Chapter 16 states:

The ANEF contained within this chapter is a land use planning tool to manage noise sensitive land uses around the airport. It provides guidance for the NSW Government and local councils to make informed planning and development decisions.

4.2.4 Other noise descriptors

Another useful noise metric that is often used in airport noise impact assessments is Number Above (NA) indices. Whilst there are no formal standards or policies that adopt these indices for land use planning, they do provide another perspective on impacts. The Sydney Airport Master Plan, for example, cites that an internal noise level greater than 60 dB(A) is likely to interfere with conversation or with listening to radio or television (refer to Sydney Airport Master Plan 2039 Appendix B Glossary, for N70 contours). The corresponding outdoor noise level would be 70 dB(A), considering windows or doors are partially open. The Sydney Airport Master Plan therefore advocates the use of N70 as another way of informing the community about aircraft noise; however, this does not imply that N70 or other similar metrics should be used for land use planning.

Similarly, Airservices Australia in its publication "Sydney Airport N477 Australian Noise Exposure Index 1 January to 31 March 2012", states the following:

> *"'Number Above' (Nxx) noise maps are an approach which provides additional information on aircraft noise in a form that is more easily understood by the community. The contours provide a visual depiction that shows the number of noise events during a given period that are louder than a selected threshold level. The N70 Aircraft Noise Map for Sydney Airport shows for all areas around the airport how many aircraft noise events louder than 70 dB(A) there were, on a daily average, during the period from 1 January to 31 March* 2012 ANEI (N477).
>
> 70 dB(A) is generally considered to be the external sound level below which no difficulty with reliable communication from radio, television or conversational speech in a typical room with windows open is expected. (Reference - Department of Transport and Regional Services, 2000, Expanding Ways to Describe and Assess Aircraft Noise, pp23-35)."

This is because external noise is reduced by about 10 dB, even with light weight building construction and windows partially open.

It is noted that the 2015 update to AS 2021 did not incorporate the number above metrics into the assessment of land use planning and continues to rely on the planning criteria based on ANEF values. This implies that additional metrics were not supported by the standards committee on aircraft noise and land use planning. Similarly, the number above (eg N60, N70) criteria have not gained broad support in the acoustics community for land use planning purposes. However, they are considered to provide useful information, particularly for future occupants of sites exposed to aircraft noise.

4.3 Local planning directions

A list of Directions issued by the Minister for Planning to relevant planning authorities under section 9.1(2) of the Environmental Planning and Assessment Act 1979 includes Direction 5.3 as quoted below. These directions apply to planning proposals lodged with the Department of Planning and Environment on or after the date the particular direction was issued and commenced.

Relevant to this project and noise is sub-clause 5.3 (4) as shown below.

4.3.1 Direction 5.3 Development Near Regulated Airports and Defence Airfields (Issued to commence 1 March 2022 (replaces previous Direction 3.5))

(1) In the preparation of a planning proposal that sets controls for development of land near a regulated airport, the relevant planning authority must:

(a) consult with the lessee/operator of that airport;

(b) take into consideration the operational airspace and any advice from the lessee/operator of that airport;

(c) for land affected by the operational airspace, prepare appropriate development standards, such as height controls;

(d) not allow development types that are incompatible with the current and future operation of that airport.

(2) In the preparation of a planning proposal that sets controls for development of land near a core regulated airport, the relevant planning authority must:

(a) consult with the Department of the Commonwealth responsible for airports and the lessee/operator of that airport;

(b) for land affected by the prescribed airspace (as defined in clause 6(1) of the Airports (Protection of Airspace) Regulation 1996, prepare appropriate development standards, such as height controls.

(c) not allow development types that are incompatible with the current and future operation of that airport.

(d) obtain permission from that Department of the Commonwealth, or their delegate, where a planning proposal seeks to allow, as permissible with consent, development that would constitute a controlled activity as defined in section 182 of the Airports Act 1996. This permission must be obtained prior to undertaking community consultation in satisfaction of Schedule 1 to the EP&A Act.

(3) In the preparation of a planning proposal that sets controls for the development of land near a defence airfield, the relevant planning authority must:

(a) consult with the Department of Defence if:

i. the planning proposal seeks to exceed the height provisions contained in the Defence Regulations 2016 – Defence Aviation Areas for that airfield; or

ii. no height provisions exist in the Defence Regulations 2016 – Defence Aviation Areas for the airfield and the proposal is within 15km of the airfield.

(b) for land affected by the operational airspace, prepare appropriate development standards, such as height controls.

(c) not allow development types that are incompatible with the current and future operation of that airfield.

(4) A planning proposal must include a provision to ensure that development meets Australian Standard 2021 – 2015, Acoustic- Aircraft Noise Intrusion – Building siting and construction with respect to interior noise levels, if the proposal seeks to rezone land:

(a) for residential purposes or to increase residential densities in areas where the Australian Noise Exposure Forecast (ANEF) is between 20 and 25; or

(b) for hotels, motels, offices or public buildings where the ANEF is between 25 and 30; or

(c) for commercial or industrial purposes where the ANEF is above 30.

(5) A planning proposal must not contain provisions for residential development or to increase residential densities within the 20 Australian Noise Exposure Concept (ANEC)/ANEF contour for Western Sydney Airport.

In summary, consultation with SACL has occurred as discussed in Section 1.2 and responses provided. The masterplan also responds to SACL's comments as will all future detailed design of buildings to ensure development types are not incompatible with the current and future operations of the airport. The Planning Proposal includes provision for meeting AS2021-2015 internal aircraft noise levels as required by the Directions.

4.4 Sutherland Shire Council LEP

The Sutherland Shire Council Local Environmental Plan or LEP (revision 18 August 2023) states the following:

6.13 Development in areas subject to aircraft noise

(1) The objectives of this clause are as follows—

(a) to prevent certain noise sensitive developments from being located near the Sydney Airport and its flight paths,

(b) to assist in minimising the impact of aircraft noise from that airport and its flight paths by requiring appropriate noise attenuation measures in noise sensitive buildings,

(c) to ensure that land use and development in the vicinity of that airport do not hinder or have any other adverse impacts on the ongoing, safe and efficient operation of that airport.

(2) This clause applies to development that—

(a) is on land that—

(i) is near the Sydney Airport, and

(ii) is in an ANEF contour of 20 or greater, and

(b) the consent authority considers is likely to be adversely affected by aircraft noise.

(3) Despite any other provision of this Plan, development consent must not be granted to development for any of the following purposes—

(a) if the development will be on land that is in an ANEF contour of 25 or greater—boarding houses, centre-based child care facilities, dual occupancies, educational establishments, health consulting rooms, home businesses, home industries, medical centres, multi dwelling housing, respite day care centres, secondary dwellings, seniors housing, shop top housing and tourist and visitor accommodation,

(b) if the development will be on land that is in an ANEF contour of 30 or greater—community facilities, information and education facilities, places of public worship and recreation facilities (indoor),

(c) if the development will be on land that is in an ANEF contour of 35 or greater—businesses premises, food and drink premises, landscaping material supplies, neighbourhood shops, office premises, service stations, shops, timber yards, vehicle sales or hire premises and veterinary hospitals,

(d) if the development will be on land that is in an ANEF contour of 40 or greater—industrial retail outlets, industrial training facilities, light industries, self-storage units, vehicle body repair workshops, vehicle repair stations, warehouse or distribution centres and waste or resource management facilities.

(4) Despite subclause (3), development consent may be granted to development for any of the following purposes on land identified as "Kurnell Village" on the Activity Hazard Risk Map if the development is otherwise permitted by this Plan—

(a) centre-based child care facilities,

(b) dwelling houses,

(c) educational establishments,

(d) home businesses,

(e) home industries.

(5) Development consent must not be granted to development to which this clause applies unless the consent authority is satisfied that the development—

(a) will not result in an increase in the number of dwellings or people affected by aircraft noise, and

(b) will meet the indoor design sound levels shown in Table 3.3 (Indoor Design Sound Levels for Determination of Aircraft Noise Reduction) in AS 2021—2000 if—

(i) the development will be on land that is in an ANEF contour of 20 or greater and is for the purposes of boarding houses, centre-based child care facilities, community facilities, dual occupancies, dwelling houses, educational establishments, health consulting rooms, home businesses, home industries, information and education facilities, medical centres, multi dwelling housing, places of public worship, recreation facilities (indoor), respite day care centres, secondary dwellings, seniors housing or shop top housing, or

(ii) the development will be on land that is in an ANEF contour of 25 or greater and is for the purposes of businesses premises, food and drink premises, neighbourhood shops, office premises, service stations, shops, tourist and visitor accommodation, vehicle sales or hire premises or veterinary hospitals, or

(iii) the development will be on land that is in an ANEF contour of 30 or greater and is for the purposes of industrial retail outlets, industrial training facilities, light industries, self-storage units, vehicle body repair workshops, vehicle repair stations, warehouse or distribution centres or waste or resource management facilities.

(6) Nothing in this clause prevents development consent being granted for the repair, renovation, minor alteration, extension of or addition to an existing building if there will be no resulting reduction in the degree of insulation of the building interior.

(7) In this clause—

ANEF contour means a noise exposure contour shown as an ANEF contour on the Noise Exposure Forecast Contour Map for the Sydney Airport prepared by the Department of the Commonwealth responsible for airports.

AS 2021—2000 means AS 2021—2000, Acoustics—Aircraft noise intrusion—Building siting and construction.

We note that reference to AS 2021-2000 is outdated and that the current revision of this standard is AS2021-2015. This study adopts and recommends adherence with AS2021 and final building designs will ensure this standard is met. An example of this is provided in Section 5.4.

4.5 National Airports Safeguarding Framework

The National Airports Safeguarding Advisory Group (NASAG) developed the National Airports Safeguarding Framework in 2012. While the documented principles within this document are widely recognised and accepted, the Guideline A which includes number above (eg N60, N70) metrics have not been adopted as criteria by the acoustics community. A 2015 update to AS 2021, prepared after the release of these alternate criteria, continues to provide land use planning criteria based on ANEF values. EMM's experience with Department of Infrastructure and Regional Development (DIRD) representatives on similar projects provided confirmation that the principles are more relevant and that the guidelines are not.

The recommendations from NASAG suggest development in the subject site is possible with appropriate conditions, while areas below 20 ANEF are considered suitable for the full range of land uses.

NASAG comprises Commonwealth, State and Territory government planning and transport officials, the Australian government Department of Defence, the Civil Aviation Safety Authority (CASA), Airservices Australia and Australian Local Government Association (ALGA).

Guideline A '*Measures for managing impacts of aircraft noise'* was last updated in 2016 to reflect the revised AS2021 Standard in 2015. Consultation with the Department of Infrastructure and Regional Development (DIRD) representatives on similar projects confirmed that the principles are more relevant and that the guidelines are not used for land use planning purposes.

Commonwealth, State and Territory Ministers considered the framework in a meeting on 18 May 2012. A 'communiqué' of that meeting stated the following:

> Ministers agreed a National Airports Safeguarding Framework, a national land use planning regime to protect airports and communities from inappropriate off-airport development, noting reservations from New South Wales on the format of the guideline on measures for managing impacts of aircraft noise. The agreement represents a collective commitment from Governments to ensure that an appropriate balance is maintained between the social, economic and environmental needs of the community and the effective use of airport sites.

The principles of the guidelines are provided below:

- Principle 1. The safety, efficiency and operational integrity of airports should be protected by all governments, recognising their economic, defence and social significance.
- Principle 2. Airports, governments and local communities should share responsibility to ensure that airport planning is integrated with local and regional planning.
- Principle 3. Governments at all levels should align land use planning and building requirements in the vicinity of airports.
- Principle 4. Land use planning processes should balance and protect both airport/aviation operations and community safety and amenity expectations.
- Principle 5. Governments will protect operational airspace around airports in the interests of both aviation and community safety.

- Principle 6. Strategic and statutory planning frameworks should address aircraft noise by applying a comprehensive suite of noise measures.
- Principle 7. Airports should work with governments to provide comprehensive and understandable information to local communities on their operations concerning noise impacts and airspace requirements.

Where relevant to this study, the above principles are being followed, for example Principle 7 is addressed through the suite of information presented on aircraft noise and this will be available to future occupants of the site.

The relevant sections of the NASAG guideline are provided below (Guideline A: Measures for Managing Impacts of Aircraft Noise):

II. Rezoning of brownfield areas to permit noise sensitive uses

> 19. This section applies to urban land that is currently primarily designated for non-noise sensitive uses and is being considered for rezoning, for example, for residential infill or increasing residential densities, such as within a mixed use precinct near a transport corridor.
>
> 20. In some instances, areas identified for urban consolidation can also be subject to aircraft noise impacts. In these circumstances, there is a need to balance the need to provide housing, economic growth and strategic planning outcomes against the operational needs of the airports. This approach may identify some adversely impacted parties and it can also identify where benefits outweigh the overall disadvantages.
>
> 21. Whilst it would not be appropriate to allow for development that would impact on the operational safety of an airport, there may be circumstances where increasing settlement in existing areas exposed to a significant degree of aircraft noise, would be acceptable given other benefits the site has to offer.
>
> 22. Consideration should be given to measures to manage the implications. This could include conditions that require development to be undertaken in a manner that physically reduces noise impacts (e.g. through appropriate construction techniques) and requirements for disclosure processes that ensure future residents are made aware of these impacts prior to purchase.
>
> 23. In some circumstances, redevelopment of areas already exposed to aircraft noise can result in a better outcome through better design and construction responses.
>
> 24. In locations considered ‘marginal’ in terms of exposure to aircraft noise, a case-by-case assessment of development proposals could be used.
>
> 25. Other relevant aircraft noise information tools (see paragraphs 17 and 29) are available to assist in informing these rezoning considerations.

The above are addressed by the planning studies and masterplan this report is supporting. Paragraph 22 is particularly relevant to the subject study by requiring minimum construction techniques of buildings and disclosure processes for future residents.

Paragraph 17 of the guidelines referenced in paragraph 25 of the NASAG guideline is part of the list for ‘greenfield’ sites and therefore is not strictly applicable to the subject development. Nonetheless, this has been considered and the suggested N70 contours have been overlayed on the study area as shown in Figure 5.3.

The 2016 revision of the guidelines at paragraph 17 iii) indicates a softening in the approach compared to previous revisions with respect to N60 events at night where the text “may be appropriate” has replaced “would be appropriate” in reference to measures for aircraft noise amelioration and restriction on noise sensitive development as shown below. Paragraph 17 iii) states:

> 17. It is important that consideration be given to the application of the following approach to land use planning:
>
> iii. Zoning for noise–sensitive development should take into account likely night time movements and their impact on residents' sleeping patterns. For example, where there are more than 6 events predicted between the hours of 11pm to 6am which create a 60 dB(A) or greater noise impact, measures for aircraft noise amelioration and restriction on noise sensitive development may be appropriate.

NASAG's suggestion relating to AS 2021-2000 in paragraph 17 in the 2012 revision of the guidelines did not result in the recommended approach to land use planning being adopted in the revision of this standard which was final and released in March 2015. Hence the wording in paragraph 17 was changed in the 2016 revision. This suggests that the proposed metrics were not supported by the standards committee on aircraft noise and land use planning. The 2012 revision of the NASAG guidelines stated:

> 17. Governments agree to ask Standards Australia to undertake a review of AS2021-2000, with the review to also consider (but not limited to) the application of the following approach to land use planning:

4.6 Road traffic noise

4.6.1 Development near Rail Corridors and Busy Roads – Interim Guidelines

Guidance for the specification of internal noise levels of habitable rooms is prescribed in Department of Planning's (DoP) *Development near Rail Corridors and Busy Roads – Interim Guidelines* (2008) ('the guideline').

The guideline assists in the planning, design and assessment of development in or adjacent to, rail corridors and busy roads and supports the State Environmental Planning Policy (SEPP) (Transport and Infrastructure) 2021. The guidelines are mandatory for residential developments proposed adjacent to busy roads with an Annual Average Daily Traffic (AADT) of greater than 40,000 vehicles (consistent with the superseded SEPP of 2007). The current SEPP (Transport and Infrastructure) 2021 however applies for roads having an AADT of 20,000 vehicles or higher. Otherwise the noise targets shown below are consistent between the old and new SEPP.

The guideline outlines internal criterion levels for rail and road noise:

> *"If the development is for the purposes of residential accommodation, the consent authority must not grant consent to the development unless it is satisfied that appropriate measures will be taken to ensure that the following L_{Aeq} levels are not exceeded:*
>
> *(a) in any bedroom in the residential accommodation - 35 dB(A) at any time 10 pm–7 am; and*
>
> *(b) anywhere else in the residential accommodation (other than a garage, kitchen, bathroom or hallway) - 40 dB(A) at any time."*

Table 3.1 of the guideline clarifies that the noise criteria above are to be determined as a $L_{eq,15hr}$ for the daytime and $L_{eq,9hr}$ for the night time period.

The guideline allows noise levels of up to 10 dB above the noise limits when windows and/or doors are open for natural ventilation. This equates to a noise limit of 45 dB, $L_{eq,9hr}$ for bedrooms at night and 50 dB, $L_{eq,15hr}$ for other habitable space during the daytime.

4.6.2 Road noise policy

Potential noise impacts resulting from development generated road traffic on public roads is assessed against criteria defined in the NSW Road Noise Policy (RNP). The application of appropriate road traffic noise criteria for the master plan has followed the two-step process identifying the assessment and relative increase criteria as outlined in Section 3.4.1 of the RNP.

The RNP requires that the traffic generated by the development be addressed in accordance with the relative increase criteria provided in Table 6 of the RNP and reproduced in Table 4.3 below.

Table 4.3 RNP relative increase criterion

Road category	Type of project/development	Total traffic noise level increase – dB(A)	
		Day (7 am–10 pm)	**Night (10 pm–7 am)**
Freeway/arterial/sub-arterial roads and transitways	New road corridor/redevelopment of existing road/land use development with the potential to generate additional traffic on existing road	Existing traffic $L_{Aeq,\ (15\ hour)}$ + 12 dB (external)	Existing traffic $L_{Aeq,\ (9\ hour)}$ + 12 dB (external)

Following the relative increase assessment, the total traffic noise impact on residential receivers is assessed against the traffic generating development criterion provided in Table 3 of the RNP reproduced in Table 4.4 below.

Table 4.4 Road traffic noise assessment criteria for residential land uses

Road category	Type of project/development	Assessment criteria, dB	
		Day (7 am–10 pm)	**Night (10 pm–7 am)**
Freeway/arterial/ sub-arterial roads	3. Existing residences affected by additional traffic on existing freeway/arterial/sub-arterial roads generated by land use developments.	$L_{Aeq,15hour}$ 60 (external)	$L_{Aeq,9hour}$ 55 (external)
Local roads	6. Existing residences affected by additional traffic on existing local roads generated by land use developments.	$L_{Aeq,1hour}$ 55 (external)	$L_{Aeq,1hour}$ 50 (external)

Table 4.5 was reproduced from Table 4 of the RNP and provides relevant noise management levels for non-residential land uses that have been identified in the area.

Table 4.5 Road traffic noise assessment criteria for non-residential land uses

Existing sensitive land use	Assessment criteria, dB		Additional considerations
	Day (7 am–10 pm)	**Night (10 pm–7 am)**	
Open space (active use)	$L_{Aeq,15hour}$ 60 (external)	-	Active recreation is characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion. Passive recreation is characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion (eg playing chess, reading). In determining whether areas are used for active or passive recreation, the type of activity that occurs in that area and its sensitivity to noise intrusion
Open space (passive use)	$L_{Aeq,15hour}$ 55 (external)	-	

Table 4.5 Road traffic noise assessment criteria for non-residential land uses

Existing sensitive land use	Assessment criteria, dB		Additional considerations
	Day (7 am–10 pm)	Night (10 pm–7 am)	
			should be established. For areas where there may be a mix of passive and active recreation, e.g. school playgrounds, the more stringent criteria apply. Open space may also be used as a buffer zone for more sensitive land uses.

Additionally, the RNP states where existing road traffic noise criteria are already exceeded, any additional increase in total traffic noise level should be limited to 2 dB where all feasible and reasonable noise mitigation is considered.

4.7 Noise Policy for Industry (NPfI)

The NPfI provides noise assessment criteria to protect the community from excessive intrusive noise and preserve amenity for specific land uses. To ensure these objectives are met, the EPA provides two separate criteria: intrusiveness criteria and amenity criteria. The fundamental difference being intrusiveness criteria apply over 15 minutes in any period (day, evening or night), whereas the amenity criteria apply to the entire assessment period (day, evening or night).

4.7.1 Intrusiveness criteria

The intrusiveness criteria require that $L_{Aeq\ (15\ min)}$ noise levels from the proposed development do not exceed the RBL by more than 5 dB. Measured RBLs have been used to derive intrusiveness criteria at each noise monitoring location.

Table 4.6 presents the intrusive noise criteria determined for the Site based on the adopted RBLs.

Table 4.6 Intrusive noise criteria

Location	Measured background noise level, RBL, dB[1]			Intrusive noise criteria $L_{Aeq,15min}$, dB[2]		
	Day	Evening	Night	Day	Evening	Night
L1	50	44	34	55	49	39
L2	45	42	33	50	47	38
L3	43	36	32	48	41	37
L4	48	42	32	53	47	37
L5	44	40	33	49	45	38

Notes. 1.The daytime is 7.00 am to 6.00 pm; evening 6.00 pm to 10.00 pm; night-time 10.00 pm to 7.00 am. On Sundays and Public Holidays, the daytime is 8.00 am to 6.00 pm; evening 6.00 pm to 10.00 pm; night-time 10.00 pm to 8.00 am.

2. The RBL is an INP term and is used represent the background noise level.

3. L_{Aeq} is the energy averaged noise level over the measurement period and representative of general ambient noise.

4.7.2 Amenity criteria

The assessment of amenity is based on noise criteria specific to the land use. The amenity criteria are used to assess the cumulative impacts of industrial noise. Where the measured existing industrial noise approaches recommended amenity criteria, it needs to be demonstrated that noise levels from new industry will not contribute to existing industrial noise such that criteria are exceeded.

The corresponding recommended amenity criteria for the proposed development are given in Table 4.7.

Table 4.7 Amenity criteria

Receiver type	Indicative area	Period[1]	Recommended noise level dB, $L_{Aeq\ (period)}$
Residential	Rural	Day	50
		Evening	45
		Night	40
	Suburban	Day	55
		Evening	45
		Night	40
	Urban	Day	60
		Evening	50
		Night	45
Hotels, motels, caretakers' quarters, holiday accommodation, permanent resident caravan parks	See column 4	See column 4	5 dB(A) above the recommended amenity noise level for a residence for the relevant noise amenity area and time of day
School classroom – internal	All	Noisiest 1-hour period when in use	35 (see notes for table)
Hospital ward			
internal	All	Noisiest 1-hour	35
external	All	Noisiest 1-hour	40
Place of worship – internal	All	When in use	40
Area specifically reserved for passive recreation (e.g. national park)	All	When in use	50
Active recreation area (e.g. school playground, golf course)	All	When in use	55
Commercial premises	All	When in use	65
Industrial premises	All	When in use	70
Industrial interface (applicable only to residential noise amenity areas)	All	All	Add 5 dB(A) to recommended noise amenity area

Notes. 1. The daytime is 7.00 am to 6.00 pm; evening 6.00 pm to 10.00 pm; night-time 10.00 pm to 7.00 am. On Sundays and Public Holidays, the daytime is 8.00 am to 6.00 pm; evening 6.00 pm to 10.00 pm; night-time 10.00 pm to 8.00 am.

The recommended amenity noise levels represent the objective for total industrial noise at a receiver location, whereas the project amenity noise level represents the objective for noise from a single industrial development at a receiver location. To ensure that industrial noise levels (existing plus new) remain within the recommended amenity noise levels for an area, a project amenity noise level applies for each new source of industrial noise as follows:

- Project amenity noise level for industrial developments equals the recommended amenity noise level (Table 3.2) minus 5 dB(A).

The following exceptions to the above method to derive the project amenity noise level apply:

- in areas with high traffic noise levels;
- in proposed developments in major industrial clusters;
- where the resultant project amenity noise level is 10 dB or more lower than the existing industrial noise level. In this case the project amenity noise levels can be set at 10 dB below existing industrial noise levels if it can be demonstrated that existing industrial noise levels are unlikely to reduce over time; and
- where cumulative industrial noise is not a necessary consideration because no other industries are present in the area, or likely to be introduced into the area in the future. In such cases the relevant amenity noise level is assigned as the project amenity noise level for the development.

4.7.3 Project noise trigger level

The project noise trigger level (PNTL) is the lower of the calculated intrusive or amenity targets. The PNTL specific to future site land use and existing off site receptors would be developed as the scheme progresses and as relevant to the end land use. It is important to note that there is a lack of existing off-site industrial noise impacting the Site currently, based on observations at monitoring stations deployed for this study, and this is not expected to change in future, with the possible exception of the neighbouring property on the western site boundary (Breen). This is addressed in Section 7.1. The analysis of any future industrial noise is applicable for potential areas of the Site developed for business purposes (eg industrial and commercial) and how these may impact other noise sensitive land uses developed within the Site (eg residential uses). Commercial uses are provided as part of the master plan. However, the specific use of these is unknown at this stage and does not form part of this study, but will need to be assessed at the Development Application stages.

5 Aircraft noise assessment

5.1 Flight paths

The Site location with respect to Sydney Kingsford Smith Airport flight paths, 2039 ANEF and 2039 N70 contours is provided in Figure 5.1, Figure 5.2 and Figure 5.3, respectively and as published in the 2039 Sydney Airport Master Plan.

The main noise influences on the Site are aircraft approaches on runway end 34L, and to a lesser degree, departures on runway end 16R and arrivals on 34R (Figure 5.1). These are the two parallel north-south runways at Sydney Airport.

The most relevant departure runway end is 16R where take-offs occur towards but adjacent to the Site. This runway end is over 10.5 km from the northern (closest) site boundary. Take-off flight path for runway end 16L is to the west of the Site. The arrival path of runway end 34L passes directly over part of the Besmaw land and is approximately 7 km from the Site.

5.2 Aircraft movements and noise levels

EMM has previously completed an extensive aircraft noise survey of the Site, the results of which are appended to this report (Appendix C). An analysis was conducted of noise monitoring data collected at five fixed stations on site during a 13-month period to end September 2015. The quantity of data used in the assessment is unprecedented in our experience and is representative of movements for any given day at Sydney Kingsford Smith Airport for both arrival and departures on runways that potentially impact the Site. The survey results provide a comprehensive and an accurate reflection of existing and potential aircraft noise exposure.

Additional supplementary monitoring was also completed for the whole of September 2011 and September 2017, with the latter providing updated data since the 13-month study that ended in 2015.

The results for September 2017 are as follows:

- The most frequent daytime aircraft type according to ASA was the B738, or the Boeing 737-800.
- During the monitoring period, B737-800 aircraft accounted for 3,792 movements, with nine of these events (0.2%) occurring in the curfew period.
- In the monitoring period, 68 different aircraft types were identified over Kurnell, and the B737-800 comprised 31% of all movements.
- For the curfew period (11pm to 6am), the ASA data showed B463 or British Aerospace BAe-146-300 aircraft were the most frequent. In fact, this aircraft type was rarely observed outside the curfew period according to ASA's movement data.

The above findings are consistent with prior period studies (ie September 2011, September 2014 and September 2015).

5.2.1 Mean noise level for B747-400 aircraft

A comparison of AS 2021 data and the unattended measurements collected between August 2014 to September 2015 (13 months of continuous sampling) for the B747-400 aircraft is shown in Table 5.1. The agreement between the two methods (AS 2021 vs. measured) is good and generally no more than 3 dB apart. This is a reasonable level of agreement for field monitoring data, particularly given the unattended nature of measurements. In all instances, the measured data were higher or the same as the AS 2021 values for departure events. For arrivals, the converse is true with measured data being 1 to 3 dB lower than AS2021 calculated values.

Table 5.1 Measured vs. AS 2021 B747-400 aircraft noise level comparison, L_{Smax} dB(A)

Location	Flights	Measured (Unattended data 2014 - 2015)	Calculated (From AS2021-2015)
1	Arrivals	61	64
	Departures	75	75
2	Arrivals	70	73
	Departures	70	70
3	Arrivals	75	78
	Departures	68	63
4	Arrivals	68	70
	Departures	75	72
5	Arrivals	76	77
	Departures	66	60

5.2.2 Number above levels

As described earlier, Number Above values are another useful way to provide public with more information on aircraft noise.

i N70

The average daily number above 70 dB(A) L_{Smax} (ie N70) is relevant to the daytime period. Map 27 of the Sydney Airport Master Plan 2039 provides Sydney Kingsford Smith's current projection of N70 contours. For the Site this shows that some areas, which are beneath the flight path, are exposed to 100+ events of N70, other parts are exposed to as little as 10 to 20 N70 events, and the remaining areas are exposed to the range in-between these (ie 20 to 50 and 50 to 100 events). Refer to Figure 5.3.

Based on the assessment of the current masterplan, avoiding residential land uses beneath the flight path results in lower N70 exposure events for these land uses. Some residential areas will have less than 10 events of N70 (refer to Figure 5.3).

ii N60

The average daily number above 60 dB(A) L_{Smax} (ie N60) is relevant to the night time and curfew period. Map 28 of the Sydney Airport Master Plan 2039 provides Sydney Kingsford Smith's current projection of N60 contours. For the Site this shows that some areas, which are beneath the flight path, are exposed to 10 to 20 events of N60 during the airport's curfew hours, while other parts are exposed to 5 to 10 N60 events.

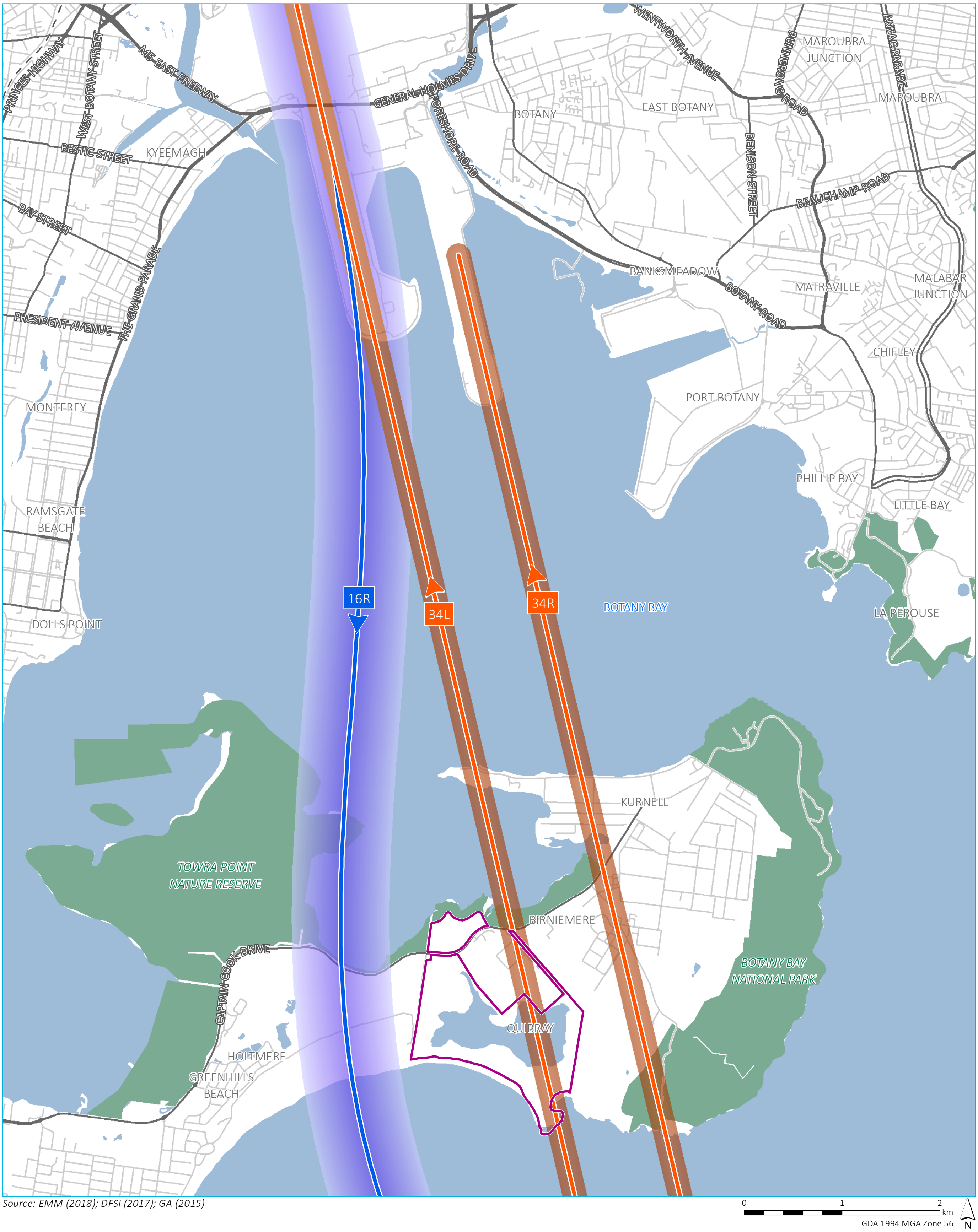
Importantly, these night events do not typically include large jet aircraft. The Sydney Airport Master Plan 2039 shows nil movements for the 'design' noisiest aircraft the B747-400 during the night period. For the curfew period, historic ASA data shows B463 or British Aerospace BAe-146-300 aircraft were the most frequent, and virtually exclusive to the curfew period. With the opening of the Western Sydney Airport 24-hour and 7-day a week in 2026, a logical expectation is that freight aircraft at night would reduce at Sydney Airport, and hence reduce impacts over the site.

As described later, the design aircraft noise level will be up to 80 dB(A), which corresponds to the very infrequent B747-400 arrival event (an aircraft that is likely to be completely phased out before residential occupants potentially exist at the site). The building fabric will as a minimum be such that an internal AS2021 goal of 50 dB(A) is maintained for bedrooms from such events (ie a 30 dB aircraft noise reduction or ANR as per AS2021). This building design will by default address any possible night time aircraft noise event to ensure the same level of noise reduction. Given night time events are not as noisy as the design level of 80 dB(A), night time internal noise amenity will be well protected beyond AS2021 requirements.

Unattended sampling between August 2014 to September 2015 shows curfew or night time mean aircraft noise levels of up to 67 dB(A) L_{Smax} (at location 3 located beneath the flight path). Achieving the same ANR of 30dB will mean internal night time noise levels will be 37dB(A) L_{Smax} or lower across less affected locations on the Site. For perspective, the World Health Organisation (WHO) quotes a level of 42dB(A) L_{max} for the onset of awakening reactions.

Over the period of monitoring (September 2011, 2014, 2015 and 2017) some consistent observations were found. Location 3 (beneath the arrival flight path 34L) had higher mean noise levels of all locations for all data sets presented (ie for all aircraft types, all noisiest aircraft movements (ie B747-400) and the most prominent aircraft (ie 737-800)). This is one trend that is apparent and consistent with expectations given its location relative to the flight paths. A similar observation is apparent for location 3 in respect of N70 daytime (ie highest of all locations), however is not extended to the N60 night values. The latter is not unexpected given what is known about the airport's modes of operations for restricted night flying above Kurnell generally. The relatively larger fluctuation in mean noise level is apparent for locations 3 and 4 as compared to other locations. The mean noise level changes at other locations were not as pronounced and generally within accepted field measurement tolerances of ±2 dB. Hence, a logical conclusion is that these locations had equally small changes in noise over time. There is a consistent outcome that shows the latest (2017) data generally presents less of an impact on the Site than prior years even though movement volumes were higher. The latter is possibly related to weather influences on the airport's modes of operation.

The representative typical external aircraft noise level determined through this study and in accordance with AS 2021 was between 70 dB(A) L_{Smax} and 80 dB(A) L_{Smax}, depending on the location. This was associated with the relatively infrequent and noisier B747-400 aircraft, with virtually all these levels occurring during the daytime.



Source: EMM (2018); DFSI (2017); GA (2015)

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KEY

- Site boundary
- Approximate flight path centreline - arrivals
- Approximate flight path centreline - departures

Approximate flight paths

- Arrival
- Departure
- Rail line
- Main road
- Local road
- Waterbody
- NPWS reserve

Site location and Sydney Kingsford Smith Airport flight paths

Amendment of SEPP (Kurnell Peninsula) 1989
Noise and vibration assessment
Figure 5.1

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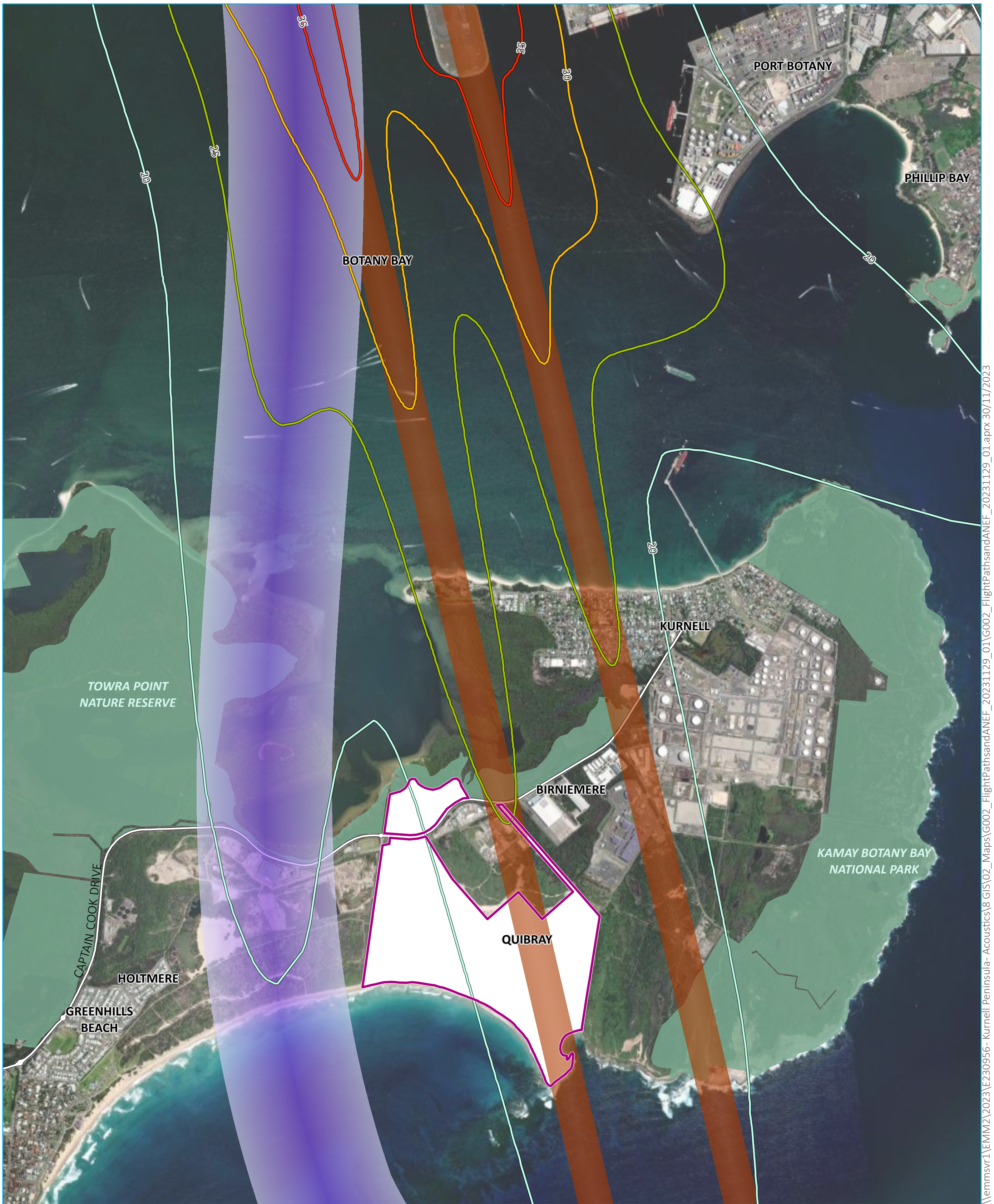


Source: EMM (2023); DCSSS (2023); ESRI (2023); GA (2009)

0 1 2 km
GDA 1994 MGA Zone 56
N

KEY

Site boundary

Existing environment

Major road

NPWS reserve

Approximate flight paths

Arrival

Departure

ANEF 2039 contours

20

25

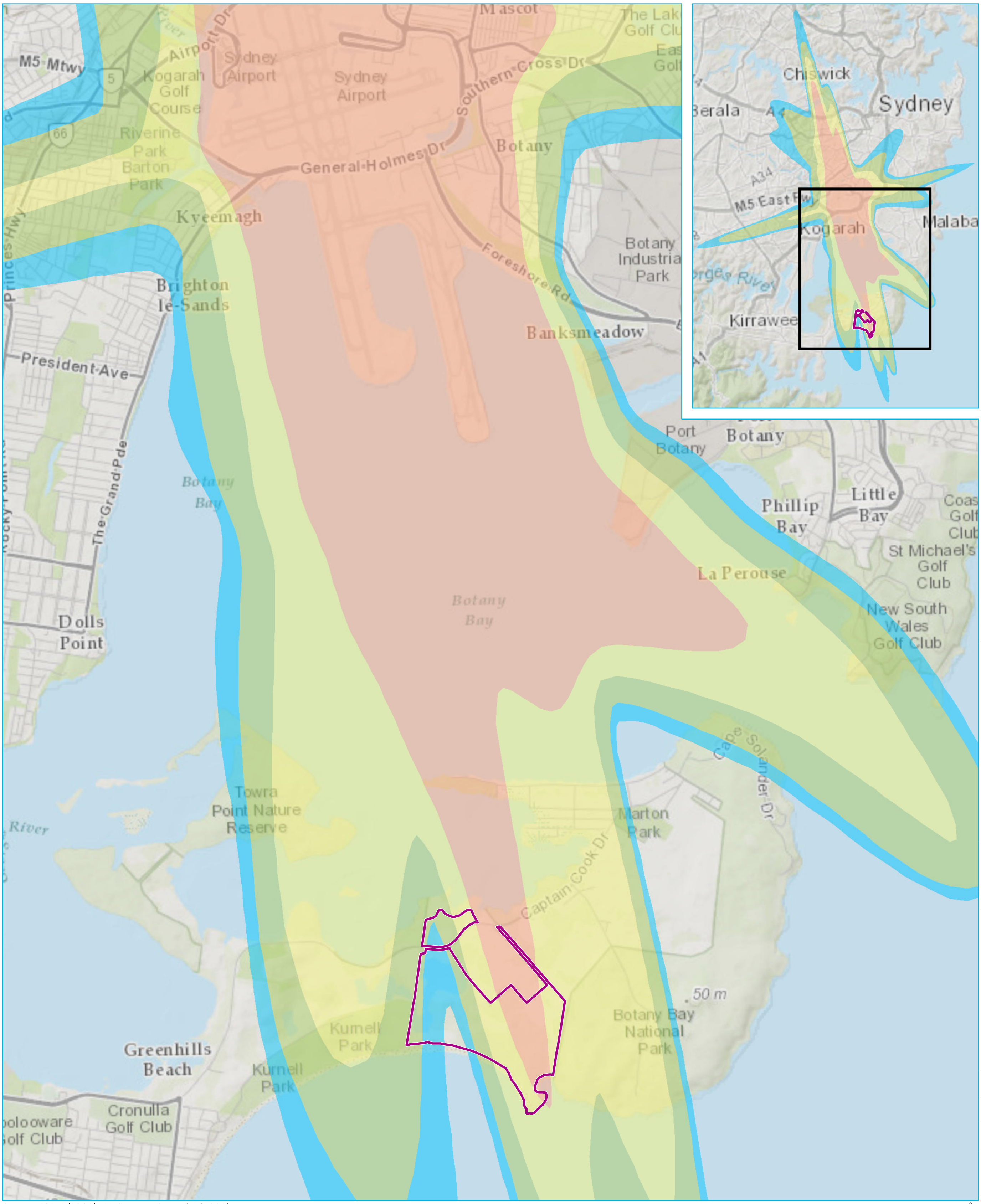
30

35

Site location and Sydney Kingsford Smith Airport 2039 ANEF contours

Kurnell Planning Proposal
Noise Assessment
Figure 5.2

EMM
creating opportunities



Source: EMM (2018); Air Services Australia (2018)

0 1 2 km
GDA 1994 MGA Zone 56
N

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KEY

Site boundary

ANEF 2039 N70 contours

10 to 20

20 to 50

50 - 100

100+

Site location and Sydney Kingsford Smith Airport 2039 N70 contours

Amendment of SEPP (Kurnell Peninsula) 1989
Noise and vibration assessment
Figure 5.3

EMM creating opportunities

5.3 Building siting and land use strategy

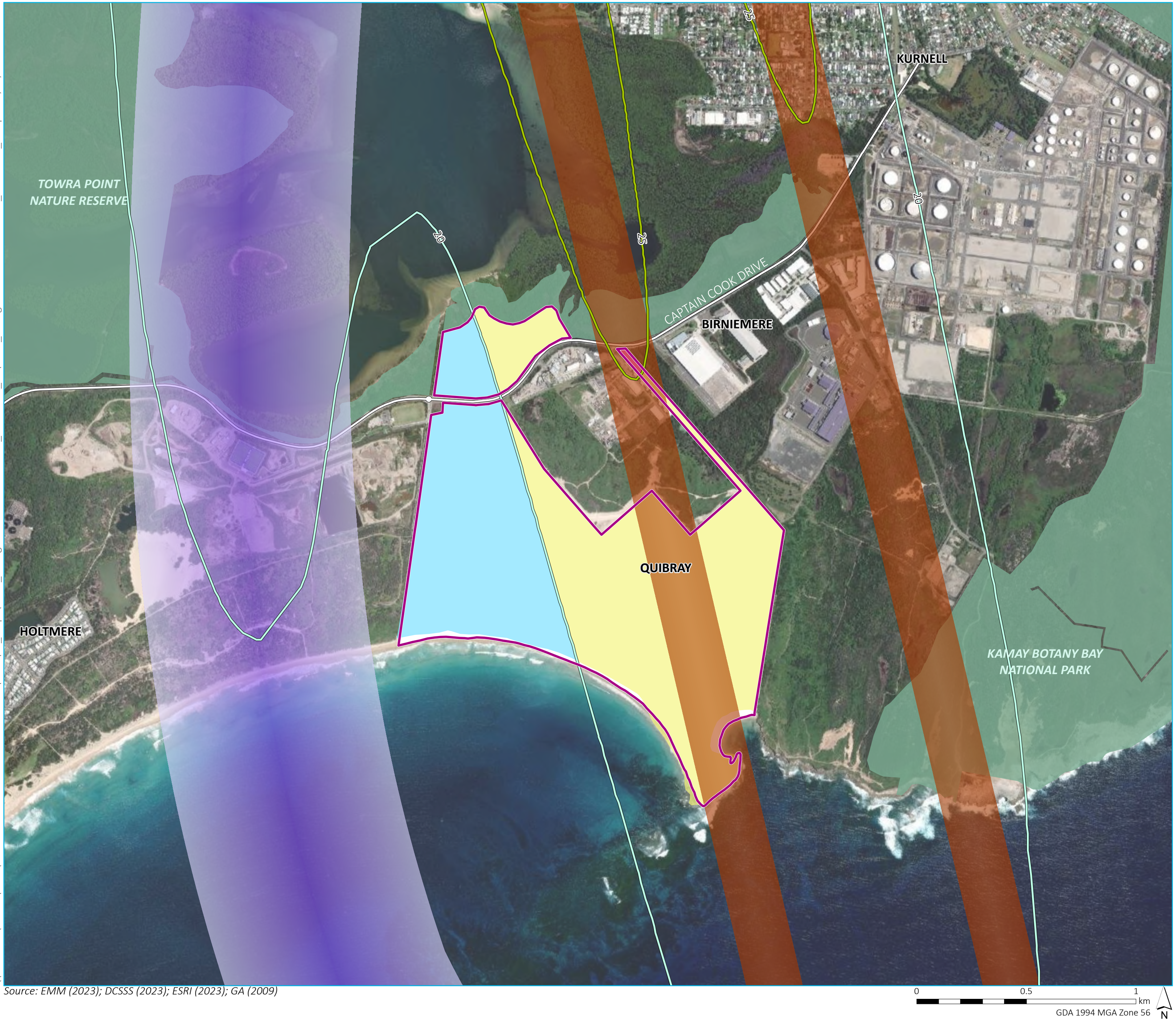
The acceptability of land use across the Site based on AS2021-2015 requirements and Sydney Airport ANEF 2039 contours is shown in Figure 5.4. The figure shows areas which are:

- acceptable for residential development (blue zone);
- conditionally acceptable for residential development, subject to site specific building design (yellow zone); and
- there are no developable areas of the Site that are unacceptable for any type of land use.

The study's master plan design has also endeavoured to position noise sensitive residential development outside of the fight path zone (refer to Figure 5.5). This is to provide a higher level of external noise amenity for land uses which are more sensitive to aircraft noise as interpreted by AS2021-2015, and to minimise the cost of building upgrades needed to satisfy internal noise level requirements for these areas exposed to higher aircraft noise levels.

All other development potential such as commercial, retail, hotels/motels, is either acceptable or conditionally acceptable across the Site. In accordance with AS2021, there is no restriction from a land use perspective for any development type.

Where sites are defined as conditionally acceptable for a particular land use, the building fabric must be designed so that internal AS2021-2015 maximum noise levels are satisfied. An example showing indicative construction based on a typical residential apartment floor plan is provided in Section 5.4 to show the extent of building construction upgrade needed to satisfy ASS2021-2015.



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Source: EMM (2023); DCSSS (2023); ESRI (2023); GA (2009)

Aircraft noise and permissible land uses

Kurnell Planning Proposal
Noise Assessment
Figure 5.4

EMM creating opportunities

5.4 Worked building construction example

An example apartment layout is provided and assessed to demonstrate a typical solution. The floor plan provided for this example is shown in Figure 5.5. The calculations herein are indicative and used to demonstrate that feasible solutions are available with typical building construction. Other alternate solutions may be available based on the specific building design and position within the Site. Therefore, detailed design must be completed for future development applications.

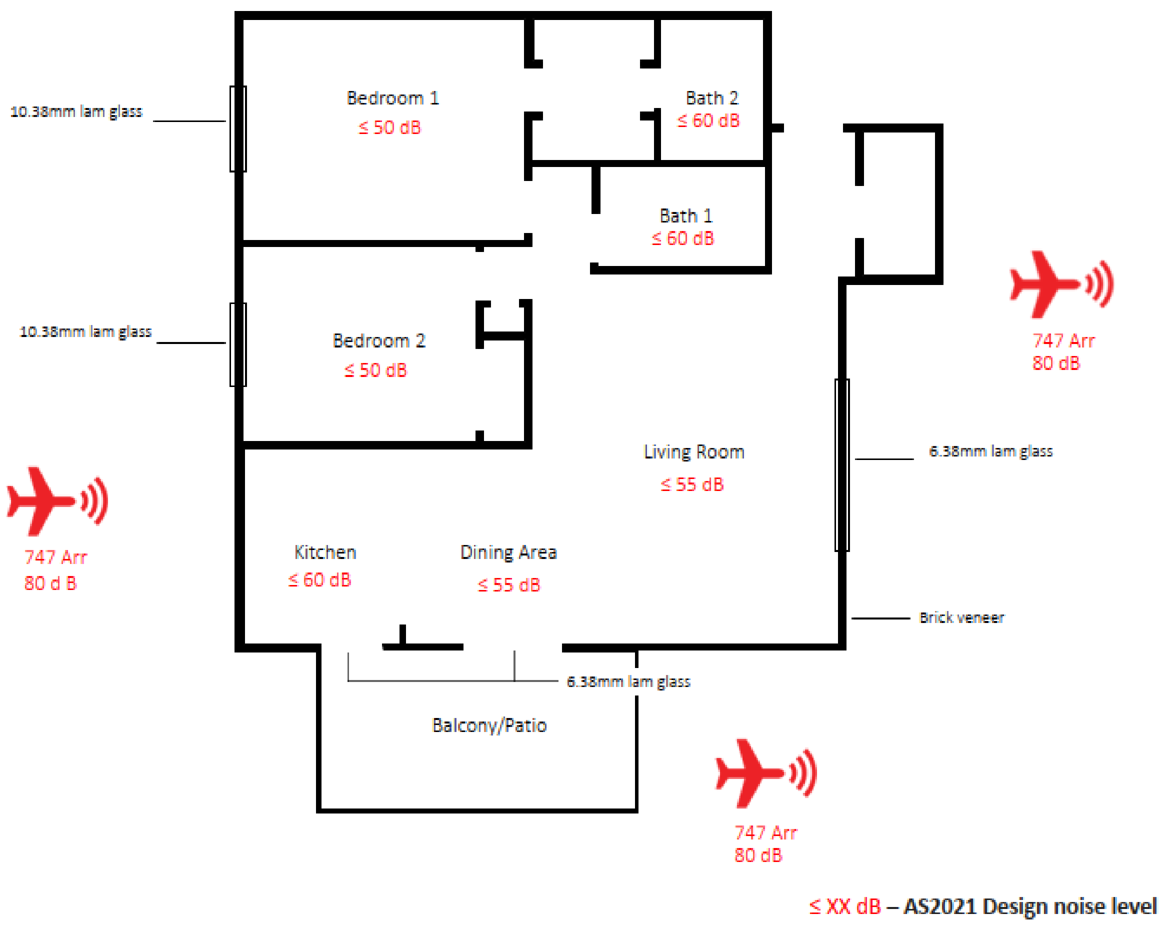


Figure 5.5 Indicative floor plan for apartment development

This example adopts a B747-400 event for the most affected area of the Site, coinciding with the 20 to 25 ANEF zone based on the ANEF 2039 contours. The typical representative maximum external noise level as per AS 2021 for the Site is 80 dB(A). This results in an ANR 30 or ANR 25 for sleeping or other habitable spaces to satisfy AS 2021 internal targets of 50 dB(A) and 55 dB(A), respectively.

The worked example assumes typical room dimensions for living and sleeping areas and also that the apartment is situated on the top floor, accounting for the aircraft noise transmission path through the roof/ceiling.

The resulting building upgrades for living and sleeping areas required to satisfy internal AS2021-2015 noise levels for this scenario are:

- Glazing (windows and doors) which achieve a minimum Rw 35 for bedrooms and Rw 30 for other habitable spaces. This can typically be achieved with 10.38 mm single laminated glazing and 6.38mm single laminated glazing respectively in a well sealed aluminium frame.
- facade system which satisfies a minimum Rw 45. This can typically be achieved with a brick veneer facade system with standard plasterboard internal lining and thermal cavity insulation;
- roof and ceiling system which satisfies a minimum Rw 43. This can typically be achieved with a pitched concrete or terracotta tile or metal sheet roof with sarking, 10mm plasterboard ceiling fixed to ceiling joists, R1.5 insulation batts in roof cavity; and
- entry door system which achieve Rw 30. This can typically be achieved with 45mm solid timber with full perimeter acoustic seals; and
- mechanical ventilation conforming to National Construction Code requirements, allowing windows to remain closed.

It should be noted that the example in Figure 5.5. applies to the worst affected area of the Site. A lower standard building fabric is plausible in other areas outside the 20 ANEF as per ANEF 2039 contours. However, adopting this example across the entire Site would provide added acoustic performance beyond AS 2021 for those areas that are exposed to lower aircraft noise levels. Furthermore, the assessment at development application stage of any future residence may find that the design aircraft used herein (ie B747) is no longer in use and hence building design could be based on a much quieter aircraft noise event.

5.5 Aircraft noise information for future occupants of the Site

To ensure potential future occupants of the Site are well informed of the site's noise exposure, using some form of notation on the title of every residential property would be a consideration, and furnishing with all the information in the Sydney Airport Master Plan 2039 (or its replacement) as well as information within this report. Key points of information should include flight path maps, respite maps, ANEF maps, N70 and N60 maps.

Furthermore, to safeguard Sydney Airport's future operations from future occupants on the Site, an approach similar to that adopted at the Carter Street precinct in Homebush NSW could be adopted. This would include building design requirements to ensure internal aircraft noise levels satisfied AS2021 as well as a 'non-complaint' clause within the appropriate planning instrument. In the Carter Street example, the Carter Street Precinct Development Control Plan (DCP) includes at Section 4.8:

> a. To ensure that development does not restrict the continued use of Sydney Olympic Park by the Sydney Olympic Park Authority in the exercise of its statutory functions in relation to events.

The recommended controls in the DCP to satisfy this objective are then provided in Section 4.8 as follows:

1. Relevant development approvals are to note that:

    - residents are not able to complain in any forum or seek to make any claim or institute action against the Sydney Olympic Park Authority in relation to major events in accordance with the Sydney Olympic Park Act 2001, and

    - proximity to Sydney Olympic Park results in impacts of noise and lighting, restrictions on vehicle or pedestrian access and security measures associated with certain events.

It is noted that Section 4.8 is mostly to prevent ongoing noise complaints and does not remove the requirement to provide an acceptable level of internal noise amenity when events occur.

The above is one example of how Sydney Airport's operations could be protected and achieves a sensible balance for coexistence of varying land uses at the Site.

5.6 Literature review

AS2021 provides a useful summary relevant to community reaction to aircraft noise. Many factors can affect community and individual responses to aircraft noise. These factors should be reflected in the information provided. There is clear evidence that people are more affected by aircraft noise following significant changes to the level or pattern of noise exposure. Changes could include an abrupt or large change in the amount, extent or timing of aircraft noise. Where significant change is expected, or has occurred, this should be clearly identified and information provided at greater levels of detail. For example, areas that did not previously have aircraft flying directly overhead should be provided with more detailed information.

To ensure the highest level of understanding about aircraft noise it is important to provide information about changes well before the change.

The above is relevant for existing residential areas newly impacted by aircraft noise. This could be due to a new flight path or significant changes to movement volumes on existing flight paths. This is the converse of what could potentially occur at the Besmaw site in that the aircraft noise is existing and any future occupant would be aware of the existing acoustic environment. Flight paths, aircraft types and movement volumes are not expected to significantly change based on data presented herein and those in the airport's Master Plan 2039. Future users of the Besmaw site will knowingly move into an area exposed to aircraft noise armed with a comprehensive suite of information from the airport's Master Plan and this report.

In respect of the latter situation, that is new people moving into an existing situation, literature indicates that there is no correlation between noise reaction and length of residence. Brown (2009b) talks about "self-selection" and that "...people with high noise sensitivity will have already self-selected themselves out of such highly exposed sites. The self-selection explanation for excess response suggests that such movement will result in sites where respondents have lower average noise sensitivity. After a change to lower noise levels, these less vulnerable (that is, less noise sensitive) respondents will report much lower annoyance scores than predicted by exposure-response curves, resulting in a change effect".

Furthermore, Brown (2009b) states:

> "However, a self-selection hypothesis requires that for a situation of unchanging high noise exposure, there should be a negative correlation between annoyance and length of residence. There is no evidence of this correlation. Weinstein (1982) indicated that the majority of noise studies have found no appreciable relationship between noise disturbance and length of residence, though the study of Griffiths and Langdon (1968) was an exception. Recent evidence of no self-selection effect can be found in Nijland et al. (2007). There is no convincing evidence supporting this explanation (Baughan and Huddart, 1993)".

In the context above, negative correlation is the statistical relationship between annoyance and length of residency. The above supports a view that potential occupants at the Besmaw site, being informed of the noise climate, are unlikely to react negatively to aircraft noise exposure.

6 Road traffic noise assessment

This section addresses potential road traffic noise impacts associated with the future developed Site. Road traffic noise impacts from Captain Cook Drive on future uses within the proposed development are discussed in Section 6.1. Additional road traffic noise impacts on existing properties along Captain Cook Drive due to development generated traffic is discussed in Section 6.2.

6.1 Road traffic noise intrusion into the Site

6.1.1 Method

Road traffic noise has been calculated using the *Calculation of Road Traffic Noise* (CoRTN) algorithm, developed by the UK Department of Transport. This method incorporates consideration of traffic flow volume, average speed, percentage of heavy vehicles, and road gradient to establish noise source strength, and includes attenuation via spherical spreading (or cylindrical in the case of a line source such as a road), soft ground, atmospheric absorption and screening from buildings or barriers.

SoundPlan noise modelling software was used to develop a noise prediction model based on the above method. Road traffic noise levels were predicted for 2017 and 2026 scenarios. Road traffic volumes and vehicle speeds provided in Table 6.1 have been adopted from SCT Consulting (SCT) (2023) *(Report Name]* prepared for Besmaw. Road traffic noise levels were predicted for day (7.00am to 10.00pm) and night (10.00pm to 7.00am) periods. It is noted that such traffic projections are for an upper limit gross floor area (GFA) for the project and hence is conservative.

The road traffic noise model was calibrated to the road traffic noise levels measured at L1, L2 and L4 (refer Figure 3.1) and therefore provides a calibrated representation of existing and, by extension, future road traffic noise levels across the development.

6.1.2 Traffic volumes

Existing and projected traffic volumes are provided in Table 6.1. The development is expected to generate up to 20,000 vehicles per day 10 years post opening of the first stages, with traffic flow relatively evenly split between eastbound and westbound along Captain Cook drive.

The vast majority of traffic into the Site is expected via the main development entrance off Captain Cook Drive, proposed approximately 150m east of Lindum Road. Traffic noise modelling has therefore been undertaken using the following assumptions:

- Proposed development generated traffic along Captain Cook Drive will enter the Site at the main entrance and will not continue through to the Kurnell peninsula;
- traffic volumes past the main entrance have been assumed as the future volumes along Captain Cook Drive in the absence of the proposed development (ie future peninsula traffic only).

With Site generated traffic, Captain Cook Drive is projected to have an AADT volume of approximately 32,455 vehicles in 2039 (ie 10 years post completion of what is known as Stage1A). Indoor noise criteria provided in the Transport and Infrastructure SEPP are therefore recommended for the project given volumes are above 20,000 AADT. Traffic volumes modelled in the traffic noise assessment is provided in Table 6.1.

Table 6.1 Modelled road traffic volumes and assumptions

Road	Period	Existing (2023) traffic volumes[2]		Opening Year (2029) traffic volumes[3]		10 years post opening (2039) traffic volumes[4]		Speed limit (km/h)
			%HV		%HV		%HV	
Captain Cook Drive (no development)	Day	10,260	3%	10,415	3%	10,670	3%	80
	Night	1,525	3%	1,550	3%	1,585	3%	80
Captain Cook Drive (with development)	Day	-	-	12,690	3%	28,215	3%	80
	Night	-	-	1,890	3%	4,235	3%	80

Notes. 1. For traffic noise, daytime is 7.00 am to 10.00 pm; night-time 10.00 pm to 7.00 am.

2. The "existing" i.e. 2023 was not surveyed. Analysis was undertaken of permanent count stations on the Kingsway which indicated a reduction in traffic from 2018 to 2023, hence a 0% growth rate (as a conservative assumption) has been applied to the 2018 surveyed volumes to estimate the 2023 current demand.

3. Adopts CAGR growth rates from the previous modelling for background traffic growth (a 6-year increase from existing to opening).

4. Adopts the same CAGR growth rates as above for background traffic growth. With project development, trips include 100% of the development – consistent with BAU for traffic modelling as expected by Transport for NSW. Though this may be a conservative estimate, as based on the Program only up to Stage 3B are delivered in full, with partial delivery of 4, and 5A and 5B has not commenced construction.

6.1.3 Noise modelling results

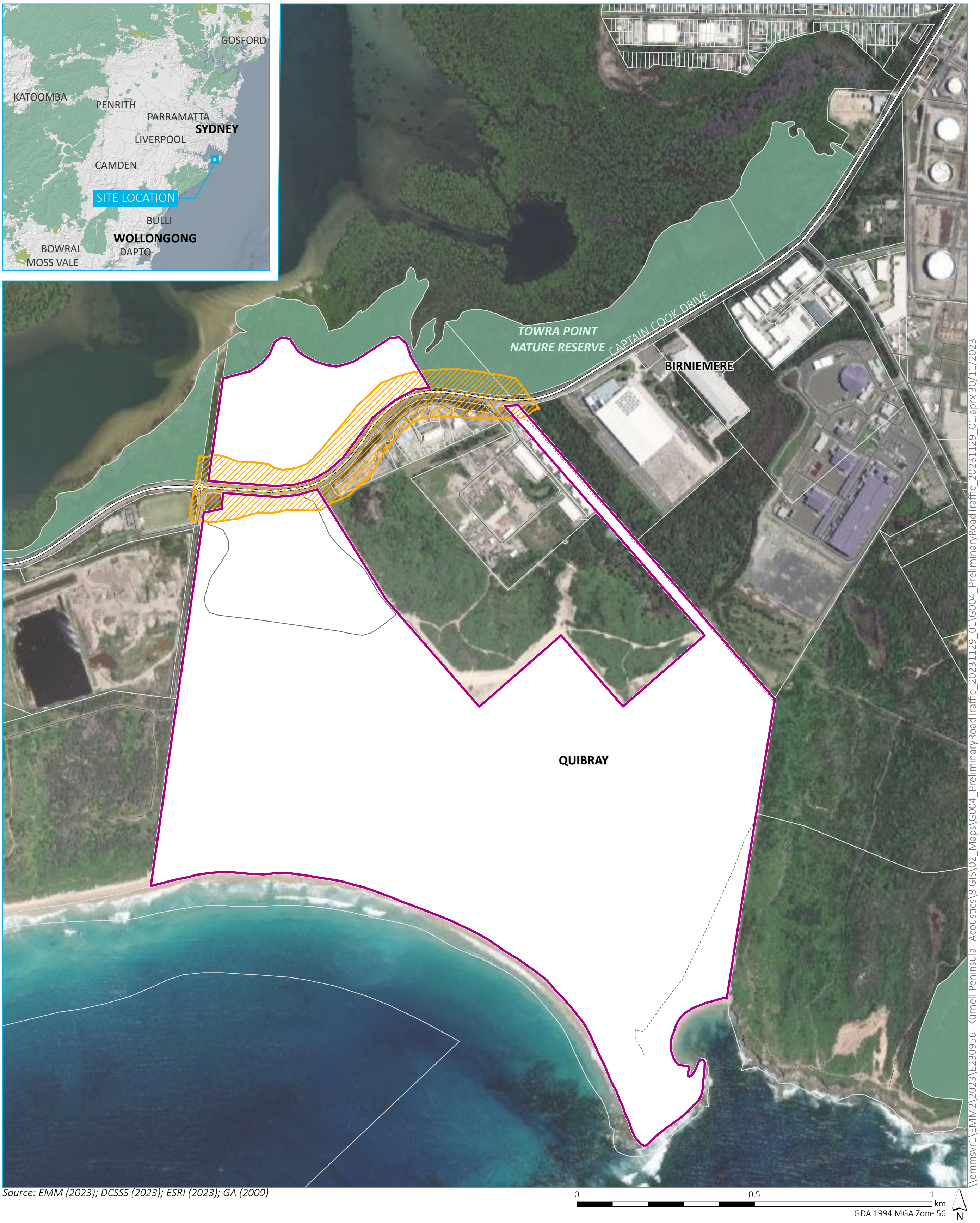
Road noise modelling has been conducted for the 2036 scenario for day and night periods in Figure 6.1. The shaded area represents a potential zone for the consideration of ameliorative measures for sensitive land uses (eg residential).

6.1.4 Recommendations

The following recommendations are provided based on the noise modelling results:

- consider less sensitive developments in the noise zone indicated on Figure 6.1, eg commercial; and/or
- incorporate land buffers or easements for part of this zone; and/or
- if residential land uses are desired in this zone, additional building treatments will be required (eg increased glazing). The first row of building/structures will act as a traffic noise barrier for development behind.

Notwithstanding, aircraft noise impacts will take precedence if AS2021 conditionally acceptable zones overlap traffic noise zones. Good practice would be to apply some level of building fabric upgrades to residences in this zone to address both aircraft and road traffic noise, because aircraft noise would still be present in these areas, but not at a level as high as other areas of the site. Hence, any building treatment incorporated for the purpose of mitigating aircraft noise will also adequately address road traffic noise intrusion and hence a road traffic noise buffer is not required in such circumstances.



Source: EMM (2023); DCSSS (2023); ESRI (2023); GA (2009)

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KEY

Site boundary

Preliminary noise impact zone

Existing environment

Major road

Minor road

Vehicular track

Cadastral boundary

NPWS reserve

INSET KEY

Major road

NPWS reserve

State forest

Preliminary road traffic noise impacts

Kurnell Planning Proposal
Noise Assessment
Figure 6.1

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6.2 Road traffic noise generated by the Site

This section addresses potential road traffic noise from the proposed development of the Site impacting other land uses.

The proposed development will generate additional traffic movements which will increase the level of traffic noise emanating from Captain Cook Drive. An increase in road traffic noise due to the development has been assessed against the requirements of the RNP as discussed in Section 4.6.2. It should be noted that the changes in road traffic volumes and possible related effects are likely to be gradual as the Site is developed over time.

The RNP addresses traffic noise generated by a development in two ways discussed as follows:

- cumulative traffic noise levels from existing traffic volumes and that generated by the development are compared against the relative increase and planning noise levels provided in Table 3 and Table 4 of the RNP (Table 4.4 and Table 4.5) of this report);
- where existing traffic noise levels exceed the relative increase criteria or planning noise levels of the RNP, any additional increase in total traffic noise level should be limited to 2 dB where all feasible and reasonable noise mitigation is considered.

Traffic generated by the Site will enter and exit the peninsula via Captain Cook Drive which runs past the following immediate land uses provided in Table 6.2.

Table 6.2 Existing land uses along Captain Cook Drive

Assessment location	Land use	Traffic generation planning levels, dB $L_{Aeq\ period}$[1]	
		Day – 7.00am to 10.00pm	Night – 10.00pm – 7.00am
Greenhills Beach residential development	Residential	60	55
Towra Point nature reserve	Passive recreation	55 – when in use	-
Greenhills skate park and football field	Active recreation	60 – when in use	-
Marang Parklands hockey fields	Active recreation	60 – when in use	-

Note: 1. NSW RNP Tables 3 and 4.

Noise modelling utilising existing traffic volumes indicates existing road traffic noise levels exceed the planning levels provided in Table 6.2 at all assessment locations. Refer to measured data at the closest monitoring locations to Captain Cook Drive (1 and 4) in Table 3.1 showing 68dB $L_{Aeq,15hr}$ and 66dB $L_{Aeq,15hr}$ respectively, and both above the RNP 60dB $L_{Aeq,15hr}$ planning target. Location 2 which is setback from Captain Cook Drive shows compliance with the RNP daytime and night time residential goals.

The development is expected to result in the generation of approximately 20,000 vehicle movements per day in addition to the existing or future (2039) volumes using Captain Cook Drive. However, as noted earlier, this increase in traffic is likely to be gradual as the Site is developed over time through nine development stages to 2045. Considering the initial stages of approval and the first 10 years post opening year as required by the RNP, the traffic generated by the master plan is predicted to increase traffic noise levels along Captain Cook Drive by approximately 2dB for each of the opening and 10-year post stages (total of 4dB increase). The predicted increase will occur gradually over years and therefore the intent of the RNP relative increase criterion provided in Table 4.3 adhered to, for a traffic generating development as dictated by Section 3.4 of the RNP.

The ultimate traffic volumes generated by the Site would be realised over the course of the development and not immediately upon inception of initial stages within the development. In this regard, increases in traffic volume and inherently road traffic noise would be gradual over a period of years. The impacts of road traffic noise generation should be considered with each individual development application as part of the Site. This is consistent with industry practice for such land use developments.

Mitigation measures which may be considered to reduce traffic noise from Captain Cook Drive include:

- road side noise barriers for existing or future residential locations;
- quieter pavement surfaces;
- traffic calming devices to reduce speed; and
- at-property acoustic treatments or localised noise barriers or mounds.

It is noted that the established land uses, such as the Greenhills Beach residential development, are likely to have included building treatment measures given the current noise profile of Captain Cool Drive being above RNP targets as described earlier. This is consistent with a road traffic noise condition included in the consent of Cable Street residences which references compliance with internal noise targets provided in the DoP *Development near Rail Corridors and Busy Roads – Interim Guidelines*. An example condition is provided in the below excerpt from DA13/0145 relating to 25 Cable Street, Greenhills Beach NSW.

> 16. Road Noise Design Criteria
>
> To minimise the impact of noise and vibration from the adjoining major road on the occupants of the development, the building shall be designed to meet the internal noise level criteria provided in:
>
> a) State Environmental Planning Policy (Infrastructure) 2007; and
>
> b) Development near Rail Corridors and Busy Roads - Interim Guideline‟ produced by the NSW Department of Planning.

The approach described above for Cable Street is considered suitable for any of the development’s residences potentially exposed to Captain Cook Drive traffic noise. Furthermore, the above condition confirms that existing residences of Greenhills are adequately protected from road traffic noise and hence further amelioration is unlikely required as a consequence of the Besmaw project.

7 Industrial noise assessment

The potential for industrial noise impact on the development has been addressed for the known neighbouring uses including the Breen Resources landfill and waste management facility to the west and the Sydney Desalination Plant approximately 390m from the eastern boundary.

7.1 Breen Resources

The Breen Resources site is located at 330 Captain Cook Drive, Kurnell and occupies the following lots:

- Lot 1122 & 1123 on DP794114; and
- Lot 5 & 6 on DP 1158627.

The current waste management facility generally operates toward the western portion of the Breen Resources site which by virtue minimises noise impacting the Site. Noise generated by the existing Breen Resources site operations has been observed to be below residential intrusiveness triggers provided in the NPfI. Hence, impacts are not expected and a detailed assessment of the current noise from the Breen Resources site is to be addressed at the development application stage of any residential development within the Site.

At the time of writing this report, a state significant development application for the Breen Resource Recovery facility was active on the NSW Department's online portal, with a status of "more information required" indicated (as of 31 October 2023). It is noted that should the Breen project be approved, it would include a new resource recovery facility along the shared site boundary with Besmaw. Furthermore, such a facility would need to cater for the permissible uses of the Besmaw site, which includes some level of residential development (irrespective of the current masterplan and process) and hence mitigate noise appropriately. It is noted that the Breen noise impact assessment exhibited on the department's portal does not make an allowance for permitted residential uses at Besmaw's site (as highlighted by Urbis' submission of objection dated 2 September 2021 and as available on the department's portal) and hence the department is expected to require the Breen proposal to mitigate its noise appropriately. Notwithstanding the outcome of the Breen proposal, industrial noise from the lawful operation of the Breen site will need to be considered during the development application stage of any residential development within the western areas of the Besmaw site.

7.2 Sydney Desalination plant

Noise from the Sydney Desalination Plant is addressed in the GHD-Fichtner (2006) *Preferred Project Report for Sydney's Desalination Project* prepared for Sydney Water. Section 7.3.13 of Appendix C addresses concerns relating to operational noise from the plant and states the following:

> 'Based on the output from the noise modelling and on the noise emissions criteria presented in Table 7.3, the 'worst case' predicted $L_{Aeq\ (15\ minute)}$ noise level contributions from the proposed desalination plant are expected to be less than 30 dBA at the nearest residences, significantly below the most stringent night-time criteria of 45 dBA and 41 dBA at BG1 and BG2, respectively.'

The nearest residences identified in the GHD-Fichtner (2006) are those along:

- BG1 - Horning Street, Kurnell approximately 800 m to the north of the desalination plant; and
- BG2 - Torres Street, Kurnell approximately 1.2 km to the northeast of the desalination plant.

Using the Horning Street receivers' proximity to the desalination plant as a basis, an estimation of noise impacting the Site can be established based on the following:

- operational noise levels were predicted to be less than 30 dBA at the Horning and Torres Street receivers. For the purposes of this study, 30 dBA has been assumed as the operational noise level at the nearest receivers at a range of 800 m;
- the desalination plant is located approximately 400 m to the northeast of the Besmaw boundary. This results in an operational noise level in the order of 36 dBA at the Site boundary; and
- the nearest sensitive structures as part of the Site are potentially 650 m from the desalination plant. This results in an operational noise level of 32 dBA at the nearest potential sensitive receiver on the Site.

Based on the above, operational noise levels from the desalination plant are below levels likely to be intrusive or to affect amenity as defined in the NSW EPA NPfI (Section 4.3). Noise impact from desalination plant on future development within the Site is therefore highly unlikely.

7.3 Remaining industry

Existing noise levels from remaining nearby industry in Kurnell was measured to be negligible and well below levels likely to be intrusive or to affect amenity as defined in the NSW EPA NPfI (Section 4.7). This is based on EMM's various studies over the years and is reflected in data from locations 3 and 5 as described in Table 3.2 earlier in this report.

Potential noise impacts from new developments within the Site which could introduce industrial noise sources (eg mechanical plant and equipment) will be assessed at the development application stage for such development. It is noted that the proposed development is generally limited to residential, commercial and eco-tourism uses and not uses of an industrial nature.

8 Conclusion

EMM has completed a study to address the matters raised by DPE, Sydney Airport Corporation and the federal department of transport , including the Scoping Proposal feedback and the Local Planning Directions. The study included analysing monitoring data for aircraft, road traffic and industrial noise. The primary consideration for development at the Site is aircraft noise exposure. The quantity of aircraft data used in the assessment is unprecedented in our experience and is representative of movements for any given day at Sydney Airport for both arrival and departures on runways that potentially impact the Besmaw land. The assessment is a comprehensive and an accurate reflection of existing and potential aircraft noise exposure.

It was also clear that mitigation measures needed for aircraft noise would also be adequate for ameliorating road traffic noise, as well as industrial noise, which was found to be relatively benign. Traffic noise impacts potentially affecting the development may be managed using acoustic treatment to the building fabric (ie improved glazing). Alternatively, a combination of offset buffer zones between Captain Cook Drive and future residences and building treatment.

The development is expected to generate additional road traffic along Captain Cook Drive and as such the potential for road traffic noise impacts on existing receivers adjoining Captain Cook Drive has been assessed. Road traffic noise predictions indicate that existing noise levels exceed the planning levels provided in the RNP Tables 3 and 4 for the assessment locations considered. The Site was conservatively assessed to generate approximately 20,000 additional vehicle movements per day 10 years after completion of the first stage. However, this will occur gradually over a period of years resulting in a 2dB traffic noise increase during initial and final stages of the development (4dB total) from Captain Cook Drive. This study provides management and mitigation measures to be considered in future as relevant.

With respect to aircraft noise, the study adopted the guidelines in Australian Standard (AS 2021 - 2015) as well as extensive on-site measurement of aircraft noise to assess the likely noise exposure of different areas across the Site. In accordance with AS2021, all areas of the site are either ‘acceptable’ or ‘conditionally acceptable’ for any type of land use. The Sydney Kingsford Smith Master Pan 2039 was considered. Contemporary noise metrics are also provided as well as movement information, respite data and flight path patterns to provide a comprehensive suite of information. This was aided by existing noise contour maps for Sydney Kingsford Smith Airport as published in the airport’s master plan. Together, all this information could ensure that potential future occupants of the Site are well informed about aircraft noise.

A worked example is given of how commonly available buildings can achieve acceptable indoor aircraft noise levels required by AS2021.

The study found the following:

- According to Sydney Airport Master Plan ANEF 2039 contours, the entire Site (excepting a small portion at the east Captain Cook Drive entry) is below (less than) 25 ANEF, while some parts are below 20 ANEF. Based on Table 2.1 of AS 2021, for the most sensitive land uses, the area below 25 ANEF is ‘conditionally acceptable’, while areas below 20 ANEF are acceptable. An initial AS 2021 test indicated that the full range of land uses is appropriate for the developable areas of the Site.

- The ANEF 2039 contours cover a smaller area than the ANEF 2033 and 2029 contours, indicating a calculated and expected improvement in aircraft noise performance over time according to SACL's 2039 Master Plan.

- In cases where the Site is ‘conditionally acceptable’, AS 2021 recommends that buildings include specific acoustic design to achieve appropriate internal noise levels, based on maximum noise levels during representative operations.

- As expected, the number above metric of interest (N70) thought to interfere with internal communications when windows are open is highest beneath the flight path 34L with about 100+ events on average per day (as per the Sydney Airport Master Plan 2039). The central and western areas of the Site average considerably fewer N70 values. This finding corresponds broadly with 25 ANEF and 20 ANEF areas of the Site. As previously discussed, whilst the N70 metric provides additional understanding into the potential impact of aircraft noise, AS 2021 continues to adopt the ANEF values for planning purposes. As such, the number above metric is informative only.

- The site's masterplan responds to submissions to avoid sensitive land uses beneath flight paths, ensuring no residential development in such areas.

- Another important element is respite. A key finding is that on average no or little changes are expected for arrival respite over Kurnell between current operations and those in the Master Plan 2039.

- The representative typical external aircraft noise level determined through this study and in accordance with AS 2021 was between 70 dB(A) L_{Smax} and 80 dB(A) L_{Smax}, depending on the location. This was associated with the relatively infrequent and noisier B747-400 aircraft, with virtually all these levels occurring during the daytime.

- For central and western areas of the Site, standard buildings with single glazing would meet the specified acoustic performance with windows closed.

- For eastern parts of the Site, relatively modest building improvements will be needed to achieve AS 2021 goals for bedrooms and dedicated lounges (ie 50 dB(A)). Given the requirement to close windows, mechanical ventilation would be needed for exposed rooms according to the BCA.

- For all parts of the Site, standard brick veneer walls and pitched roof with cavity insulation will meet AS 2021 goals.

The above findings are expected to improve in the future as newer and quieter aircraft come into service all over the world. This is consistent with the contraction of ANEF contours as compared to previous publications shown in the Sydney Airport Master Plan 2039. This is also a logical outcome when Sydney's second airport opens in the future. Furthermore, should the B747 aircraft (the basis of the building design herein) be phased out completely (as anticipated) the requirements on building construction will be materially reduced.

The conclusions of this study from the extensive monitoring carried out, are that on acoustic grounds the developable areas of the Site is acceptable or conditionally acceptable for the full range of land use building types included in the Site's master plan. The external acoustic amenity of the Site is conducive to active recreational uses (eg parks, sporting fields, golf course, and similar activities). The Site's master plan however locates the vast majority of relatively more sensitive land uses away from the main flight path over the Site, which is a logical approach. This together with providing potential future occupants with a wide range of noise information will mitigate the likelihood of adverse reaction and impacts.

Appendix A

Daily noise logger baseline results and charts

Table A.1 Summary of daily noise logging results – L1

Date	ABL Day	ABL Evening	ABL Night	$L_{Aeq, 15 Hour}$ Day	$L_{Aeq, 9 Hour}$ Night
Thursday, 30-11-17	0	45	37	0	63
Friday, 01-12-17	0	0	0	0	0
Saturday, 02-12-17	0	0	29	0	62
Sunday, 03-12-17	47	43	0	67	0
Monday, 04-12-17	0	45	0	0	0
Tuesday, 05-12-17	0	0	36	0	63
Wednesday, 06-12-17	49	44	32	68	64
Thursday, 07-12-17	52	0	0	0	0
Friday, 08-12-17	51	45	40	69	63
Saturday, 09-12-17	46	44	30	68	61
Sunday, 10-12-17	45	44	32	67	64
Monday, 11-12-17	53	41	33	68	63
Tuesday, 12-12-17	52	43	35	69	64
Wednesday, 13-12-17	0	0	37	0	64
Thursday, 14-12-17	0	0	0	0	0
Friday, 15-12-17	52	44	35	69	63
Saturday, 16-12-17	49	0	36	0	61
Sunday, 17-12-17	45	41	30	66	63
Monday, 18-12-17	52	42	34	68	63
Tuesday, 19-12-17	0	0	36	0	63
Wednesday, 20-12-17	0	41	32	0	63
Thursday, 21-12-17	0	0	0	0	0
Overall					
RBL	50	44	34	-	-
Average L_{Aeq}	-	-	-	68	63

Notes: 1. 0 indicates periods with too few valid samples due to weather or logger operation.

Table A.2 Summary of daily noise logging results – L2

Date	ABL Day	ABL Evening	ABL Night	$L_{Aeq, 15 Hour}$ Day	$L_{Aeq, 9 Hour}$ Night
Thursday, 30-11-17	0	42	33	0	52
Friday, 01-12-17	0	0	0	0	0
Saturday, 02-12-17	0	0	28	0	52
Sunday, 03-12-17	44	43	0	56	0
Monday, 04-12-17	0	45	0	0	0
Tuesday, 05-12-17	0	0	38	0	54
Wednesday, 06-12-17	45	43	31	58	55
Thursday, 07-12-17	47	0	0	0	0
Friday, 08-12-17	47	46	39	61	56
Saturday, 09-12-17	42	41	28	58	50
Sunday, 10-12-17	41	41	30	56	53
Monday, 11-12-17	49	40	31	57	53
Tuesday, 12-12-17	47	42	33	57	53
Wednesday, 13-12-17	0	0	35	0	53
Thursday, 14-12-17	0	0	0	0	0
Friday, 15-12-17	44	42	34	60	53
Saturday, 16-12-17	45	0	37	0	53
Sunday, 17-12-17	42	36	29	59	52
Monday, 18-12-17	48	41	34	57	52
Tuesday, 19-12-17	0	0	36	0	53
Wednesday, 20-12-17	0	40	33	0	54
Thursday, 21-12-17	0	0	0	0	0
Overall					
RBL	45	42	33	-	-
Average L_{Aeq}	-	-	-	58	53

Notes: 1. 0 indicates periods with too few valid samples due to weather or logger operation.

Table A.3 Summary of daily noise logging results – L3

Date	ABL Day	ABL Evening	ABL Night	$L_{Aeq, 15 Hour}$ Day	$L_{Aeq, 9 Hour}$ Night
Thursday, 30-11-17	0	37	34	0	56
Friday, 01-12-17	0	0	0	0	0
Saturday, 02-12-17	0	0	31	0	52
Sunday, 03-12-17	36	35	0	60	0
Monday, 04-12-17	0	54	0	0	0
Tuesday, 05-12-17	0	0	40	0	57
Wednesday, 06-12-17	40	39	32	58	55
Thursday, 07-12-17	43	0	0	0	0
Friday, 08-12-17	42	39	33	54	46
Saturday, 09-12-17	38	35	30	57	54
Sunday, 10-12-17	43	36	31	61	54
Monday, 11-12-17	46	34	31	61	60
Tuesday, 12-12-17	46	36	32	62	53
Wednesday, 13-12-17	0	0	35	0	55
Thursday, 14-12-17	0	0	0	0	0
Friday, 15-12-17	42	35	33	61	55
Saturday, 16-12-17	48	0	29	0	53
Sunday, 17-12-17	41	35	28	56	53
Monday, 18-12-17	45	36	32	60	50
Tuesday, 19-12-17	0	0	33	0	54
Wednesday, 20-12-17	0	34	31	0	50
Thursday, 21-12-17	0	0	0	0	0
Overall					
RBL	43	36	32	-	-
Average L_{Aeq}	-	-	-	59	55

Notes: 1. 0 indicates periods with too few valid samples due to weather or logger operation.

Table A.4 Summary of daily noise logging results – L4

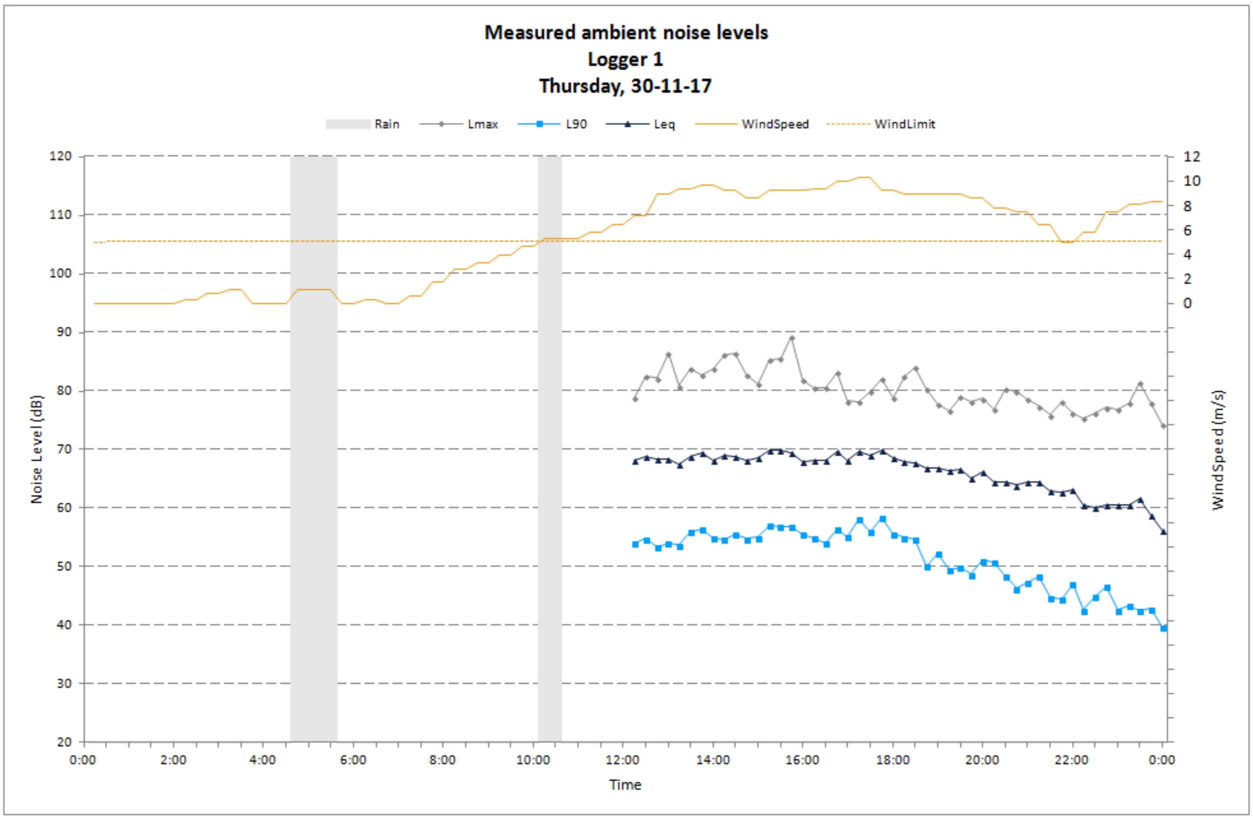
Date	ABL Day	ABL Evening	ABL Night	$L_{Aeq, 15 Hour}$ Day	$L_{Aeq, 9 Hour}$ Night
Thursday, 30-11-17	0	43	33	0	60
Friday, 01-12-17	0	0	0	0	0
Saturday, 02-12-17	0	0	27	0	60
Sunday, 03-12-17	46	45	0	65	0
Monday, 04-12-17	0	45	0	0	0
Tuesday, 05-12-17	0	0	38	0	62
Wednesday, 06-12-17	48	43	31	66	62
Thursday, 07-12-17	50	0	0	0	0
Friday, 08-12-17	47	46	39	67	61
Saturday, 09-12-17	47	42	28	66	59
Sunday, 10-12-17	44	42	30	64	61
Monday, 11-12-17	50	39	31	65	61
Tuesday, 12-12-17	50	42	32	66	62
Wednesday, 13-12-17	0	0	35	0	61
Thursday, 14-12-17	0	0	0	0	0
Friday, 15-12-17	53	42	33	67	61
Saturday, 16-12-17	47	0	35	0	59
Sunday, 17-12-17	45	38	29	64	61
Monday, 18-12-17	50	40	34	66	61
Tuesday, 19-12-17	0	0	34	0	61
Wednesday, 20-12-17	0	40	32	0	62
Thursday, 21-12-17	0	0	0	0	0
Overall					
RBL	48	42	32	-	-
Average L_{Aeq}	-	-	-	66	61

Notes: 1. 0 indicates periods with too few valid samples due to weather or logger operation.

Table A.5 Summary of daily noise logging results – L5

Date	ABL Day	ABL Evening	ABL Night	$L_{Aeq, 15 Hour}$ Day	$L_{Aeq, 9 Hour}$ Night
Thursday, 30-11-17	0	42	36	0	58
Friday, 01-12-17	0	0	0	0	0
Saturday, 02-12-17	0	0	30	0	54
Sunday, 03-12-17	39	39	0	63	0
Monday, 04-12-17	0	44	0	0	0
Tuesday, 05-12-17	0	0	37	0	50
Wednesday, 06-12-17	42	40	34	61	58
Thursday, 07-12-17	43	0	0	0	0
Friday, 08-12-17	45	40	33	55	48
Saturday, 09-12-17	36	37	29	60	56
Sunday, 10-12-17	45	42	32	64	57
Monday, 11-12-17	48	41	32	64	57
Tuesday, 12-12-17	46	41	34	64	56
Wednesday, 13-12-17	0	0	37	0	57
Thursday, 14-12-17	0	0	0	0	0
Friday, 15-12-17	44	38	34	57	57
Saturday, 16-12-17	50	0	33	0	50
Sunday, 17-12-17	40	34	30	60	59
Monday, 18-12-17	45	41	33	69	54
Tuesday, 19-12-17	0	0	35	0	59
Wednesday, 20-12-17	0	37	31	0	50
Thursday, 21-12-17	0	0	0	0	0
Overall					
RBL	44	40	33	-	-
Average L_{Aeq}	-	-	-	63	56

Notes: 1. 0 indicates periods with too few valid samples due to weather or logger operation.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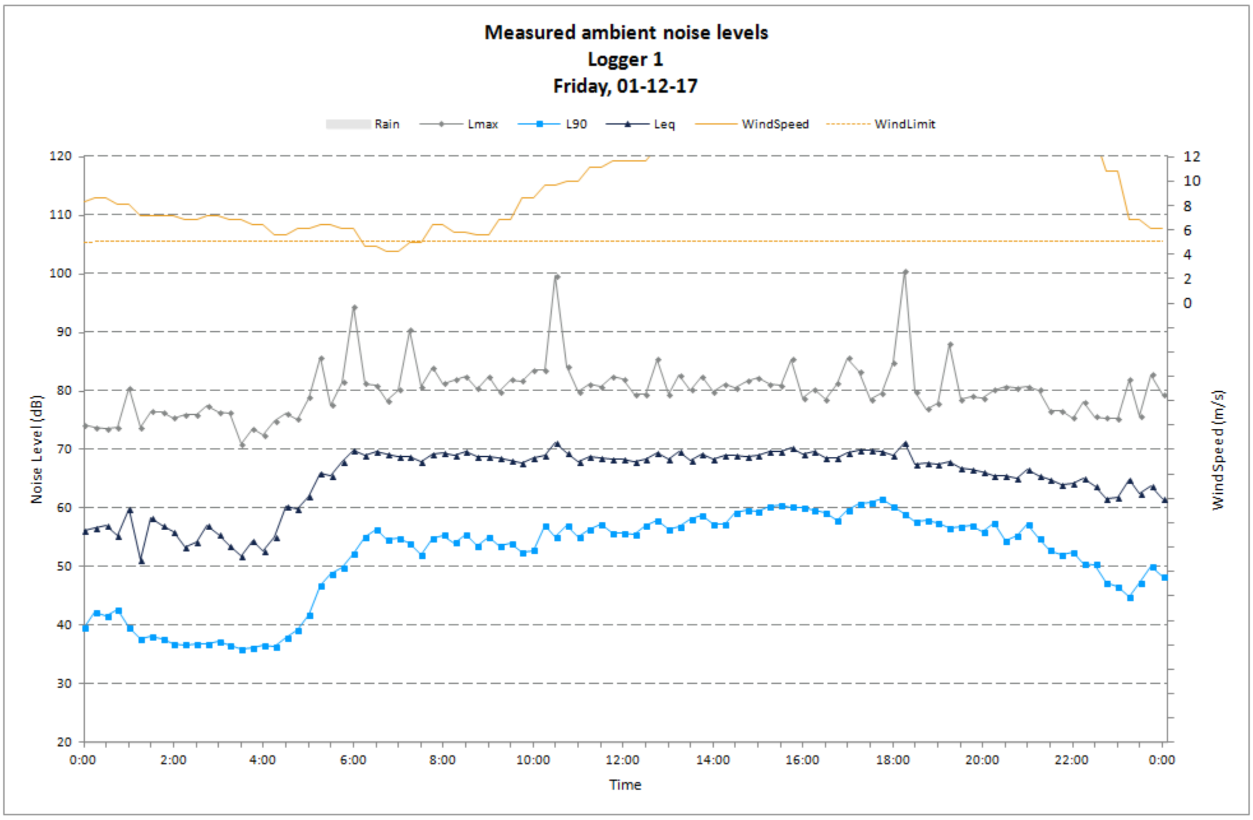
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time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Rain
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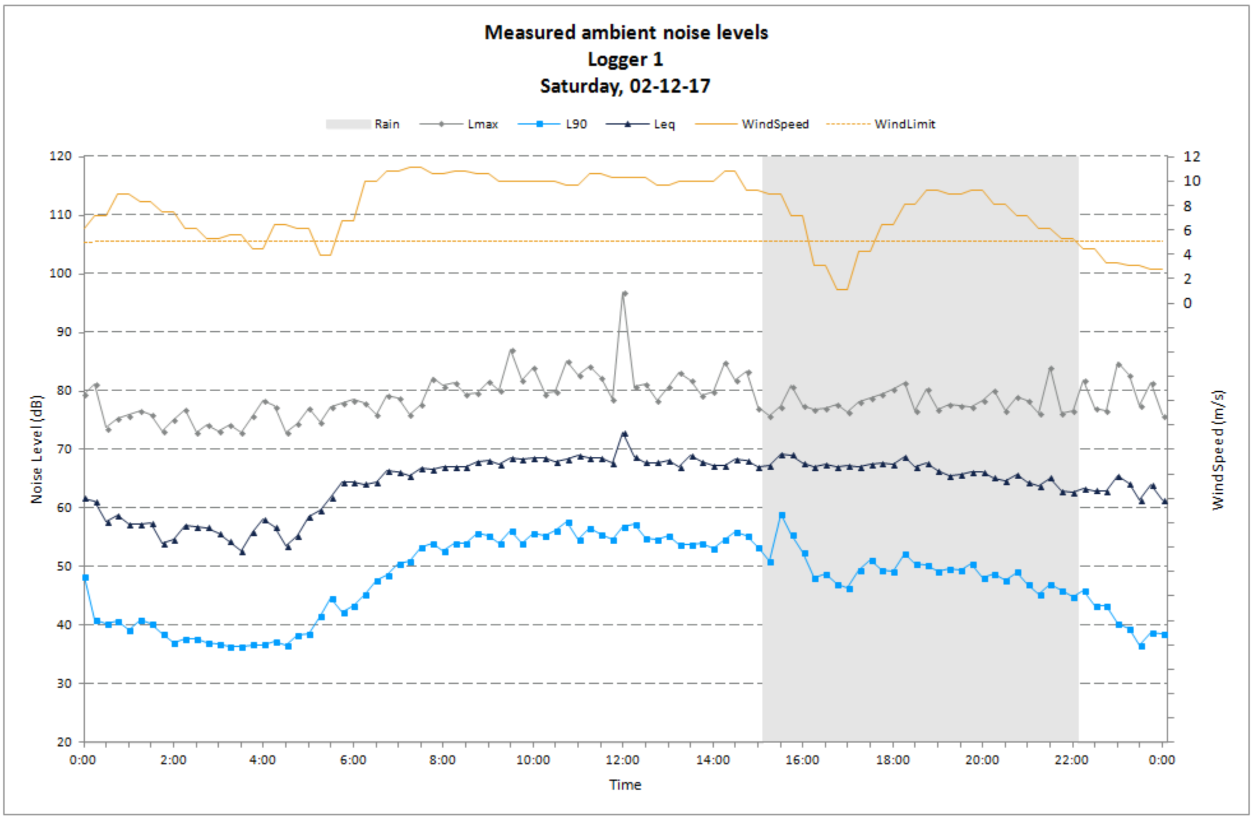
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time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Saturday, 02-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
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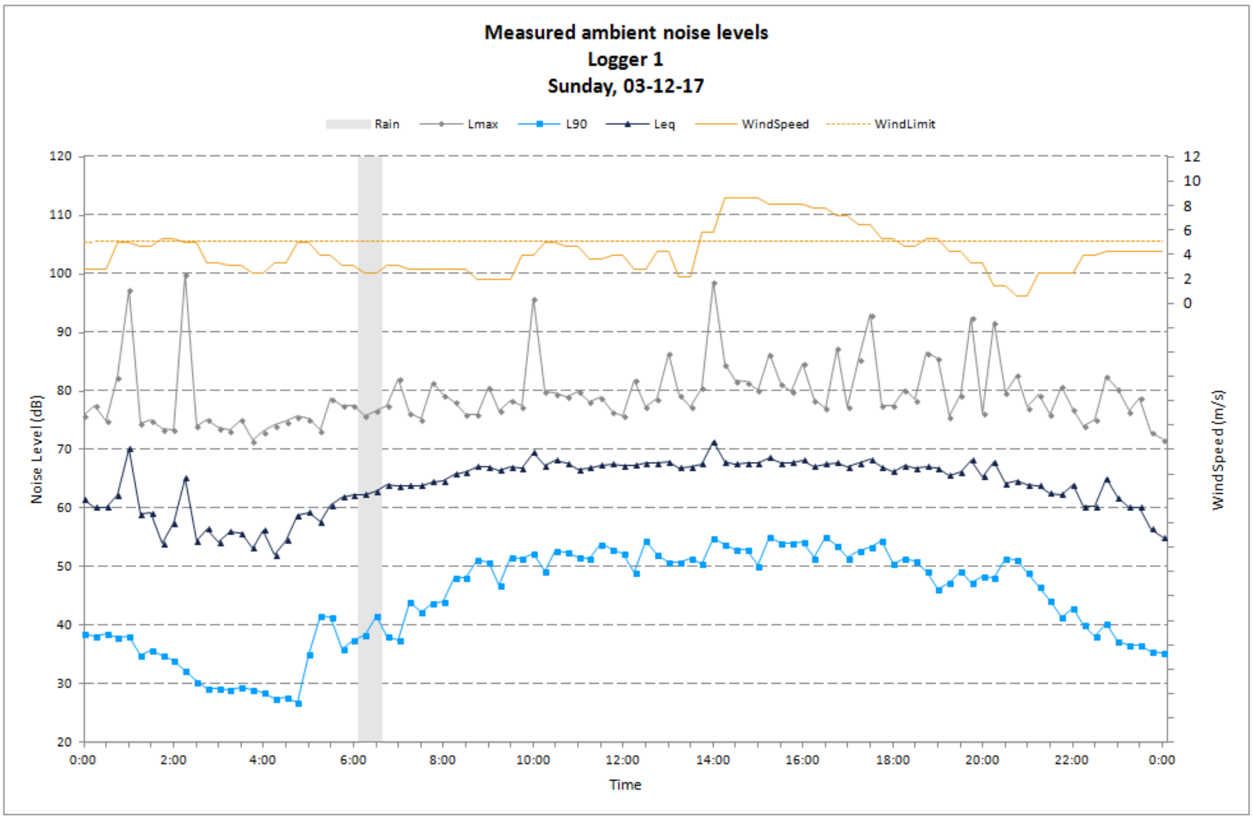
16:00
18:00
20:00
22:00
0:00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Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
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10:00
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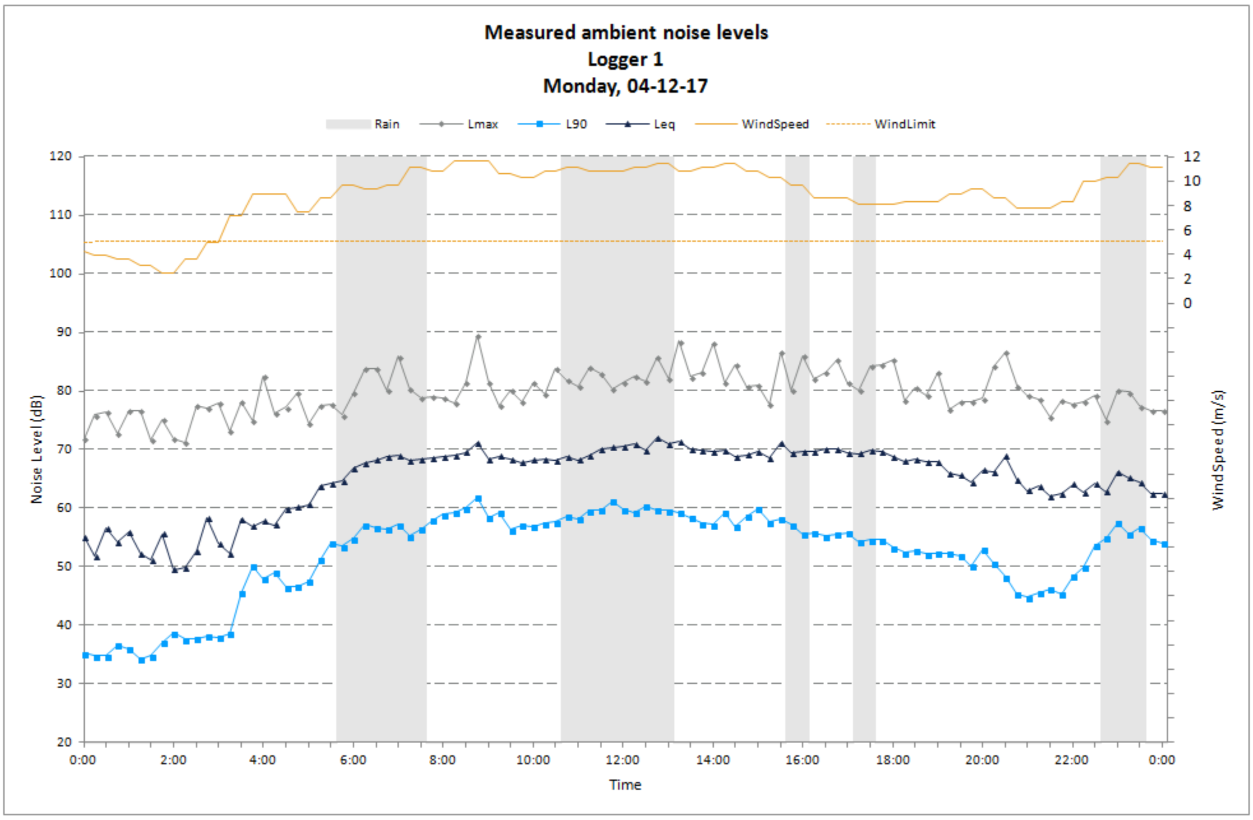
14:00
16:00
18:00
20:00
22:00
0:00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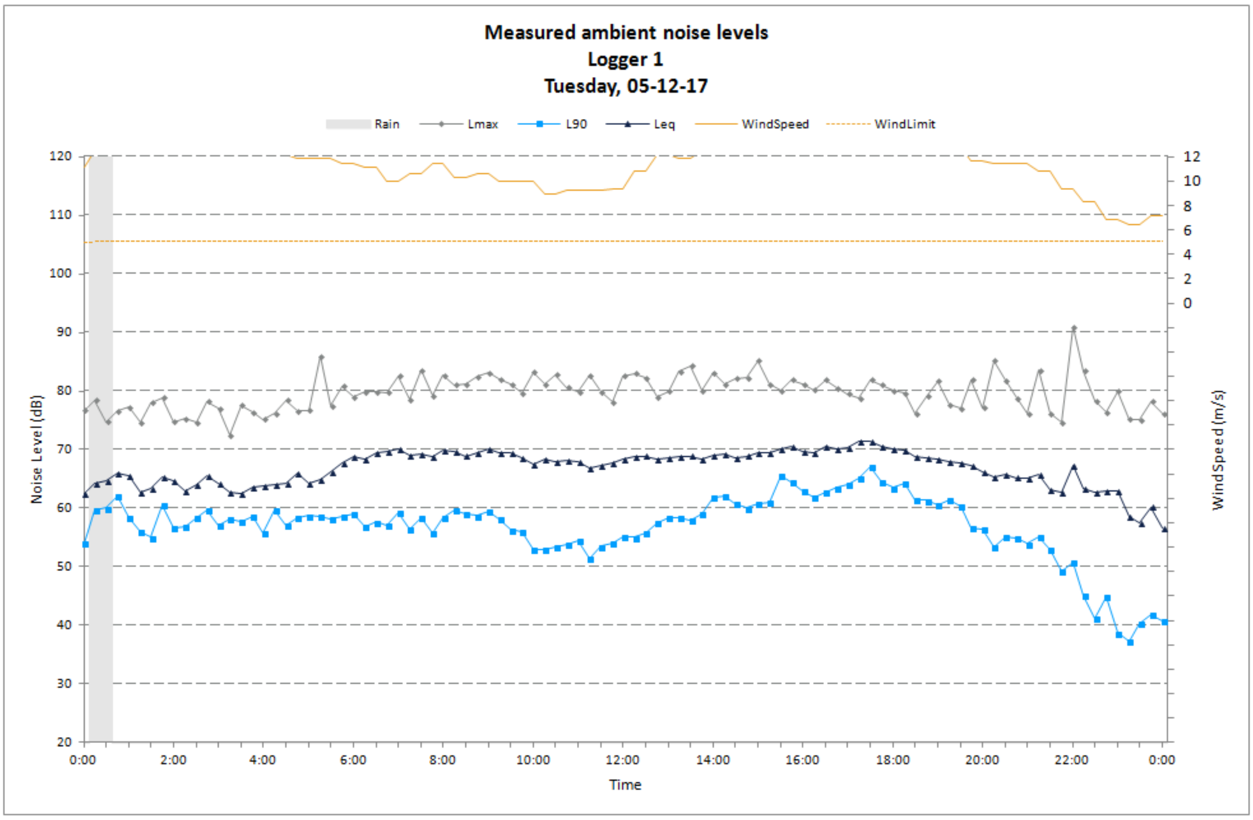
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time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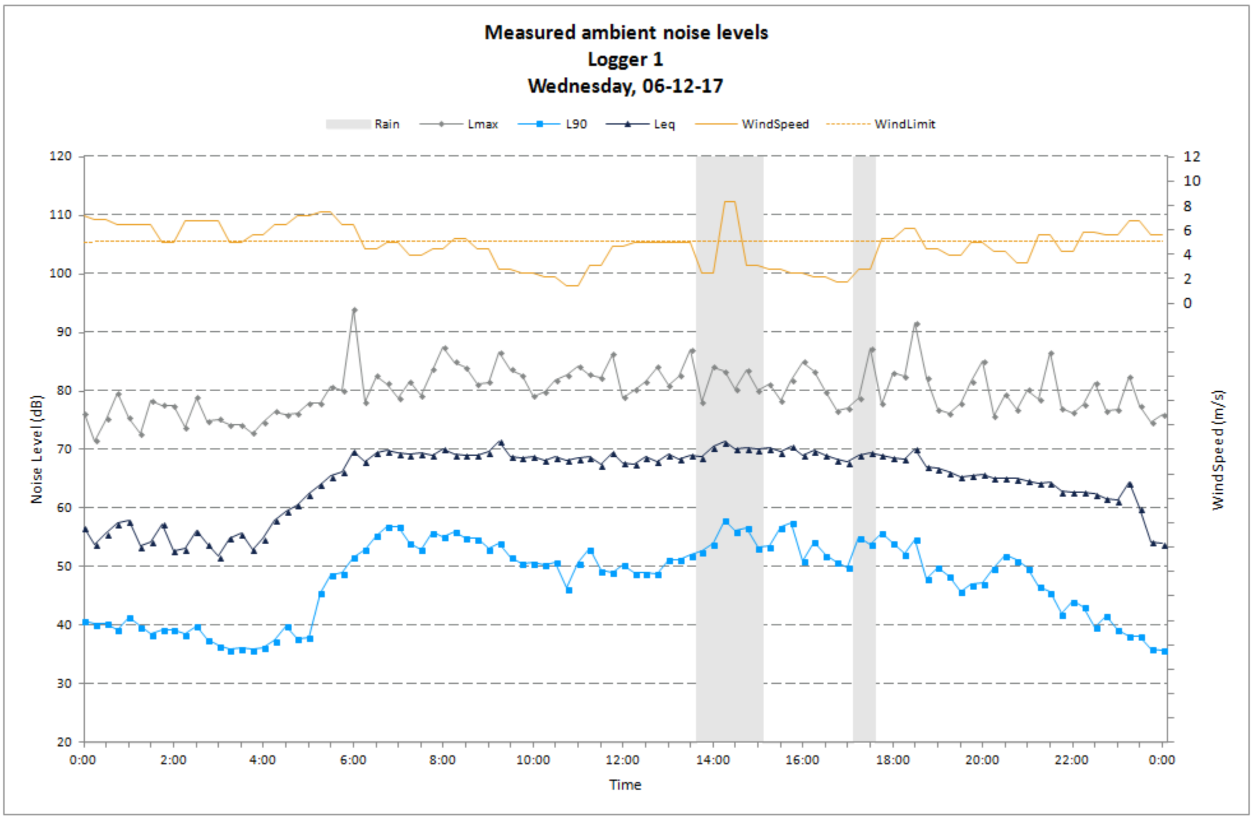
Tuesday, 05-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time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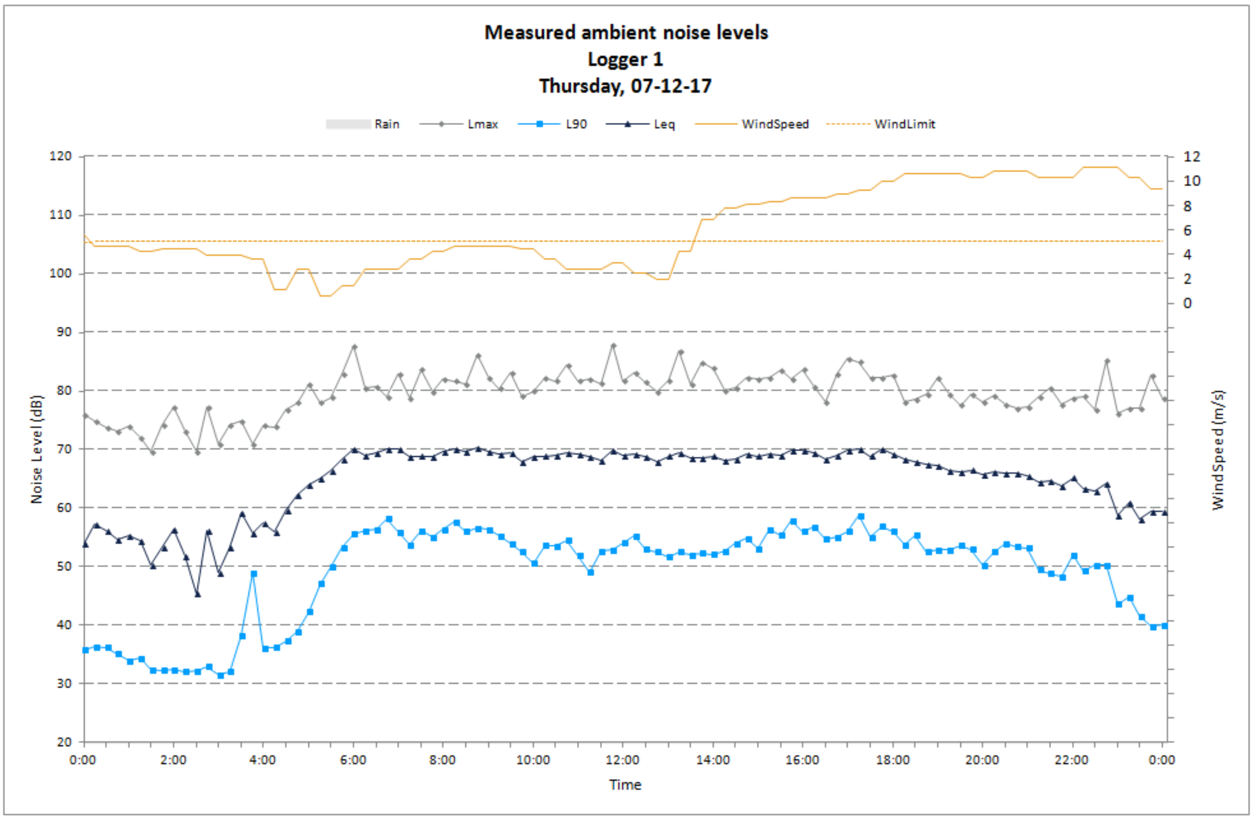
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time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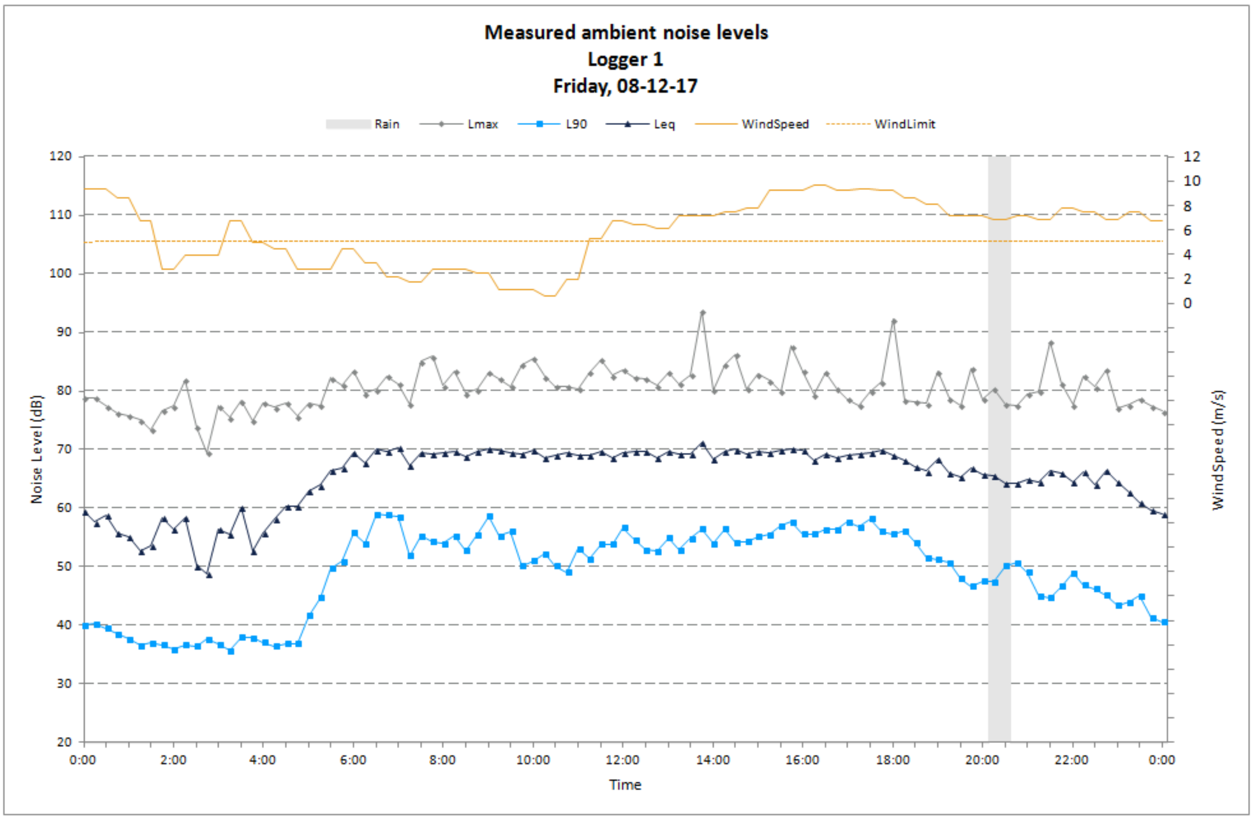
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time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Logger 1
Friday, 08-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
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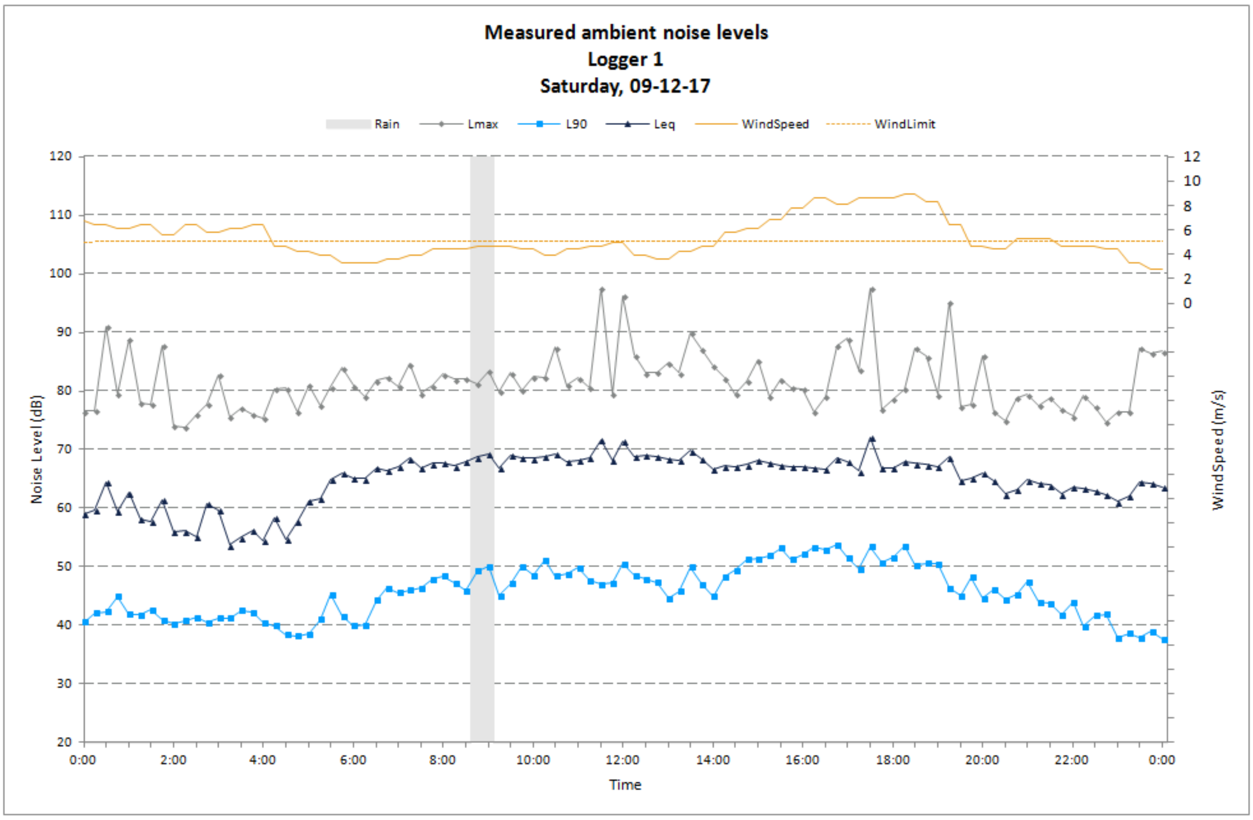
Measured ambient noise levels
Logger 1
Saturday, 09-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
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10:00
12:00
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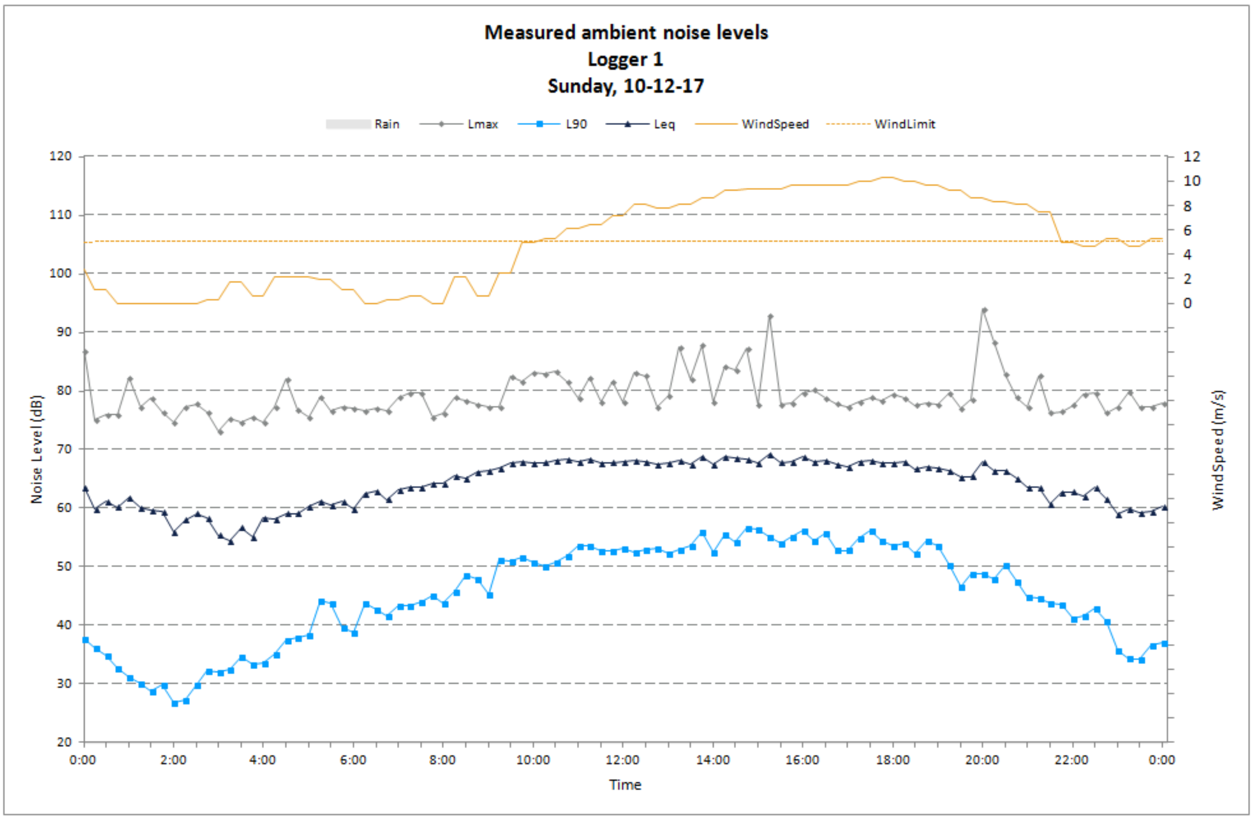
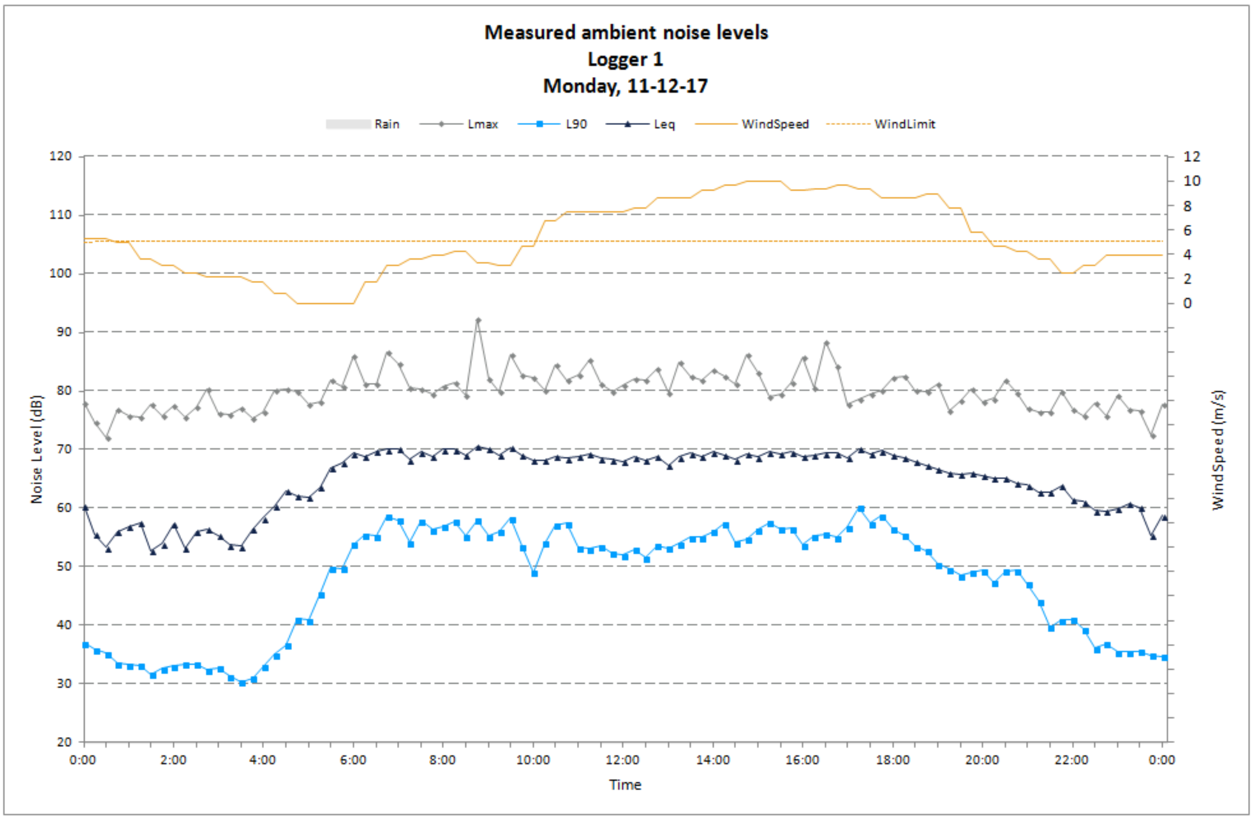
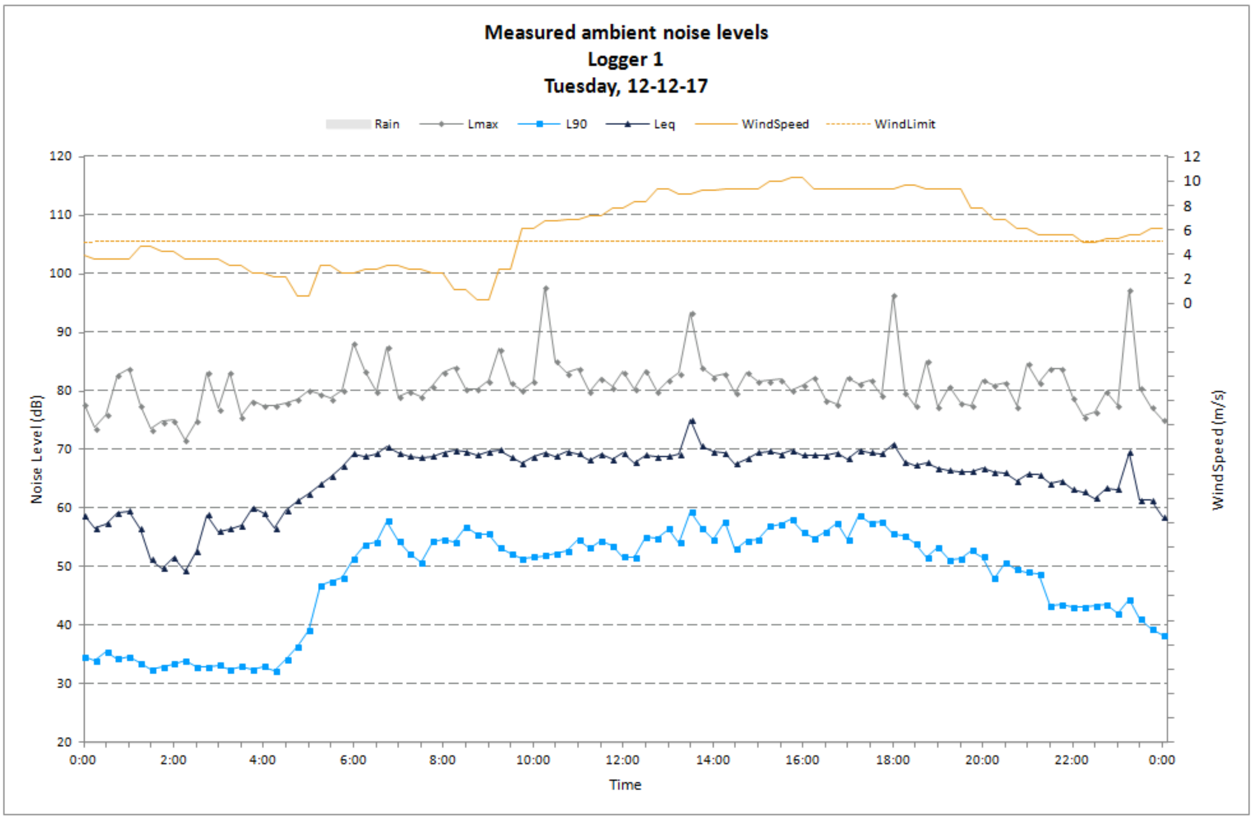
16:00
18:00
20:00
22:00
0:00

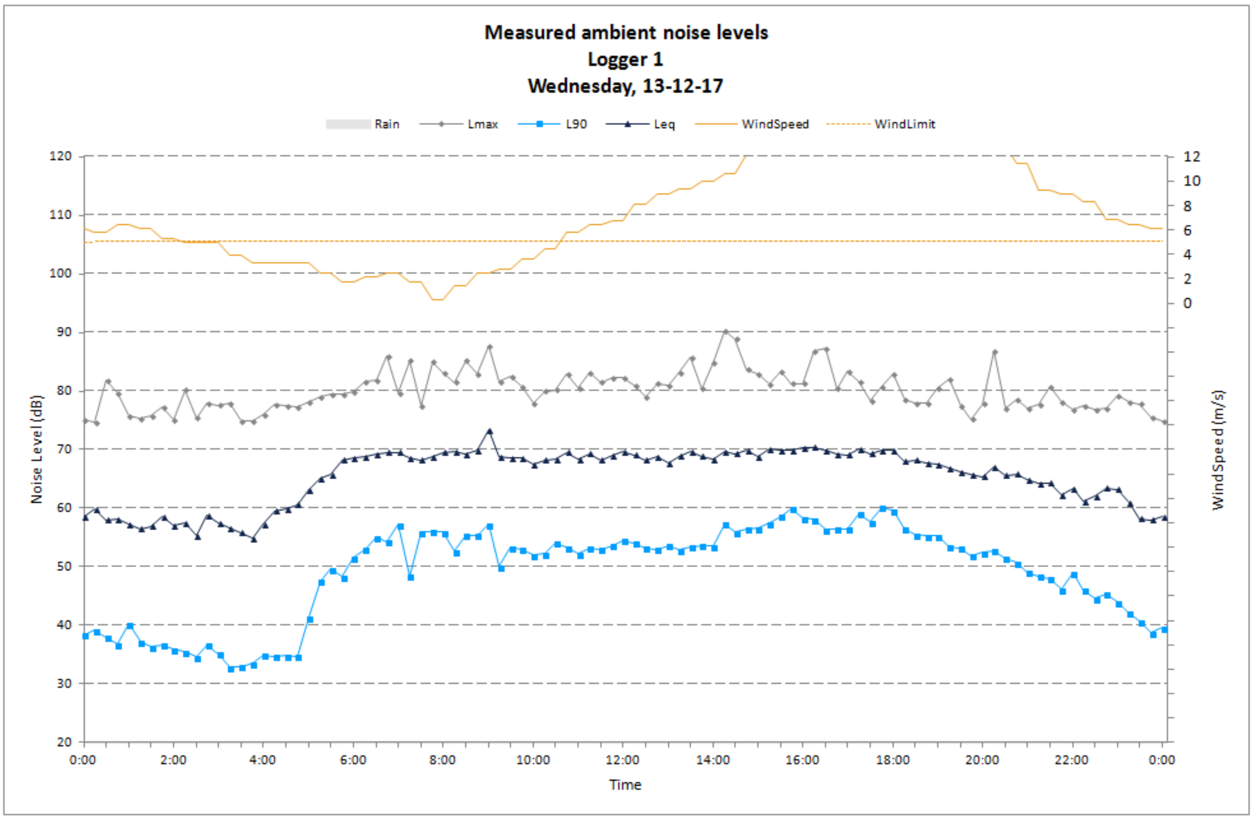


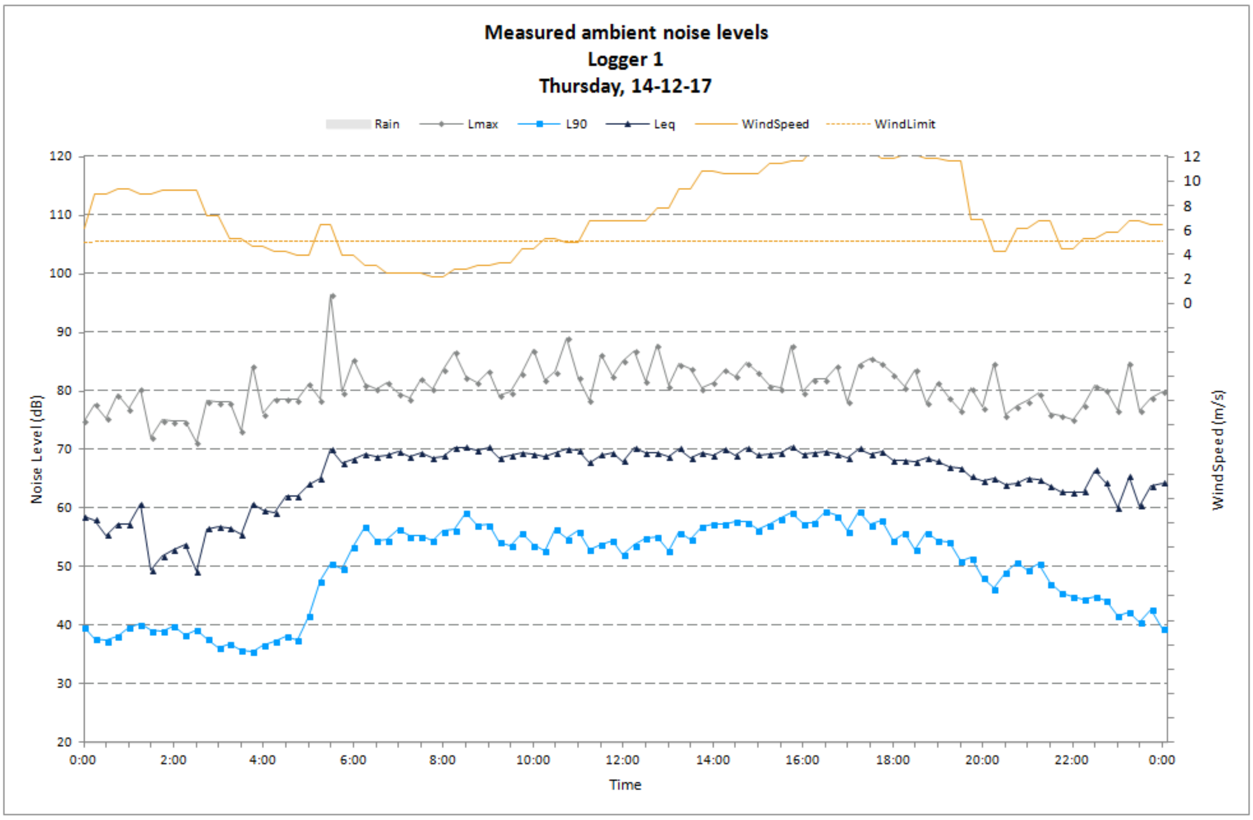
Measured ambient noise levels
Logger 1
Sunday, 10-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
WindSpeed (m/s)
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time

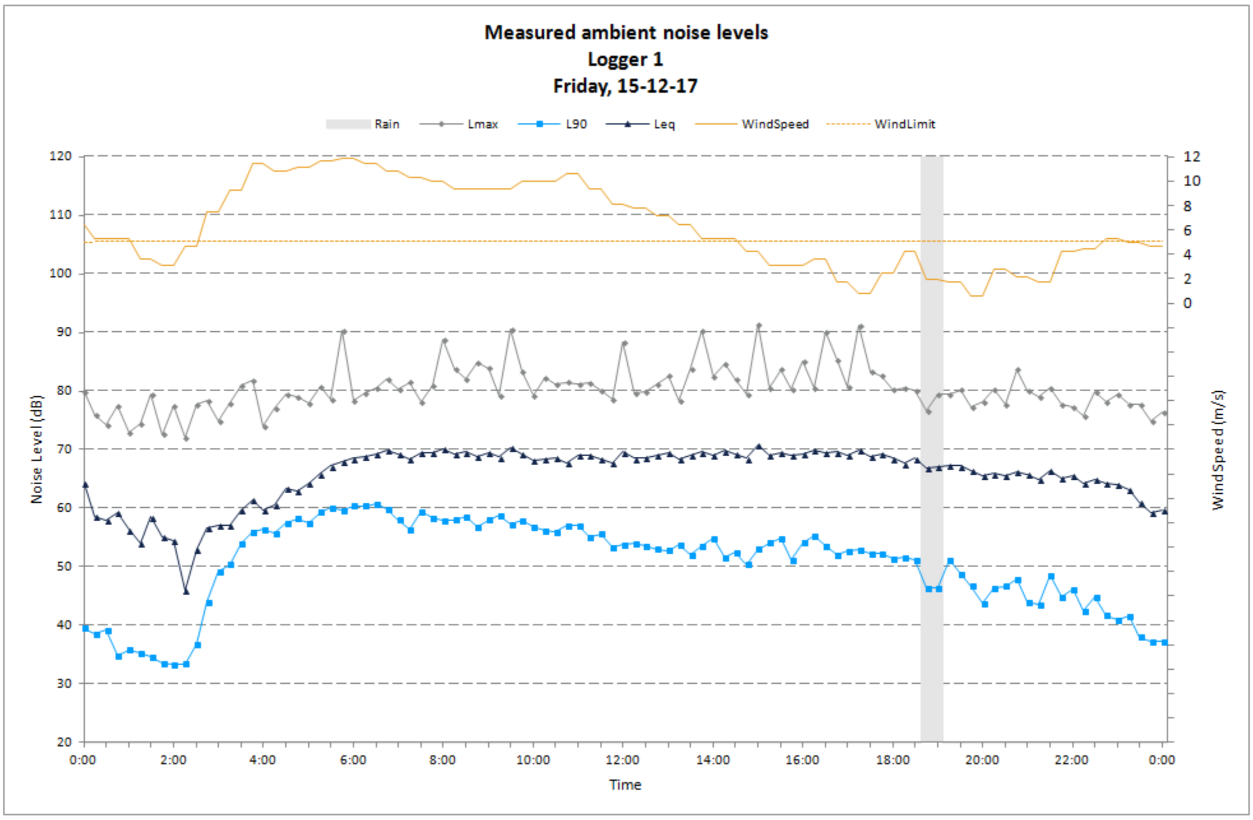


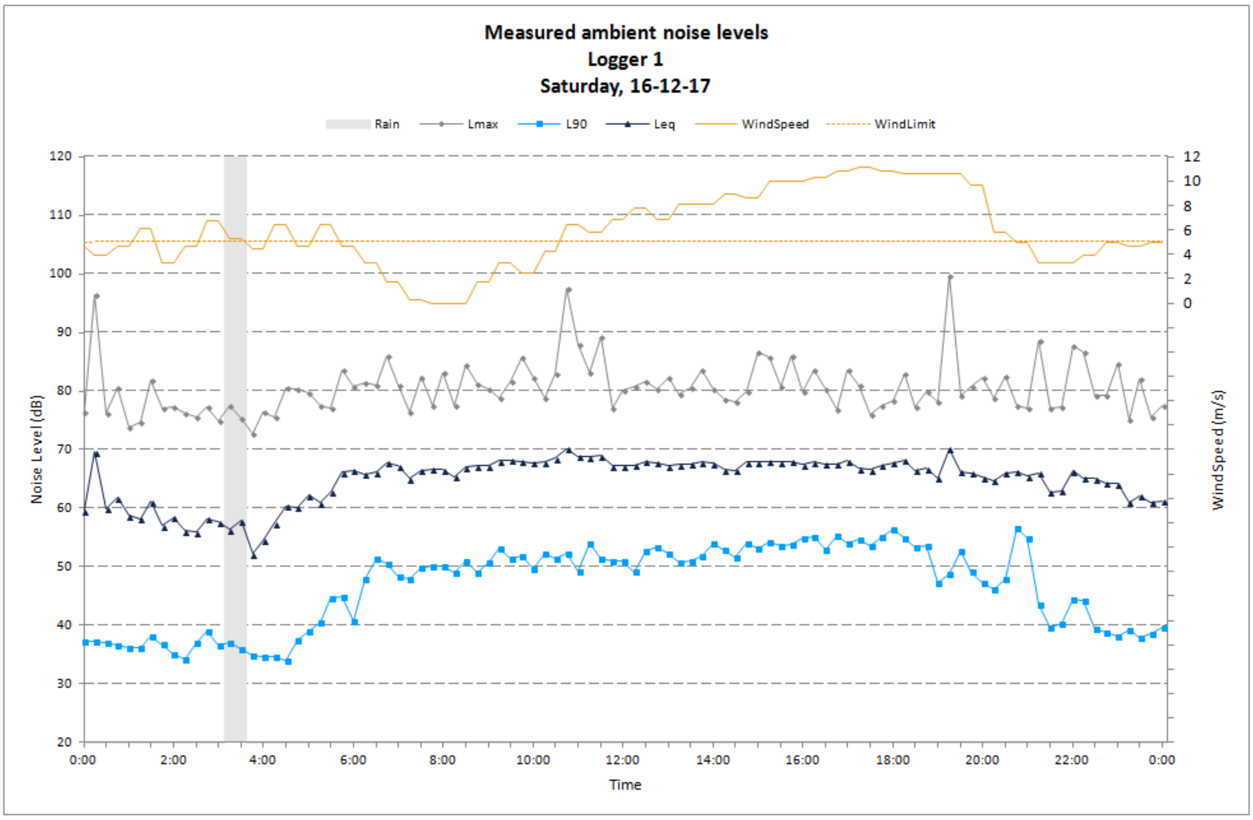
Measured ambient noise levels
Logger 1
Monday, 11-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
WindSpeed (m/s)
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time

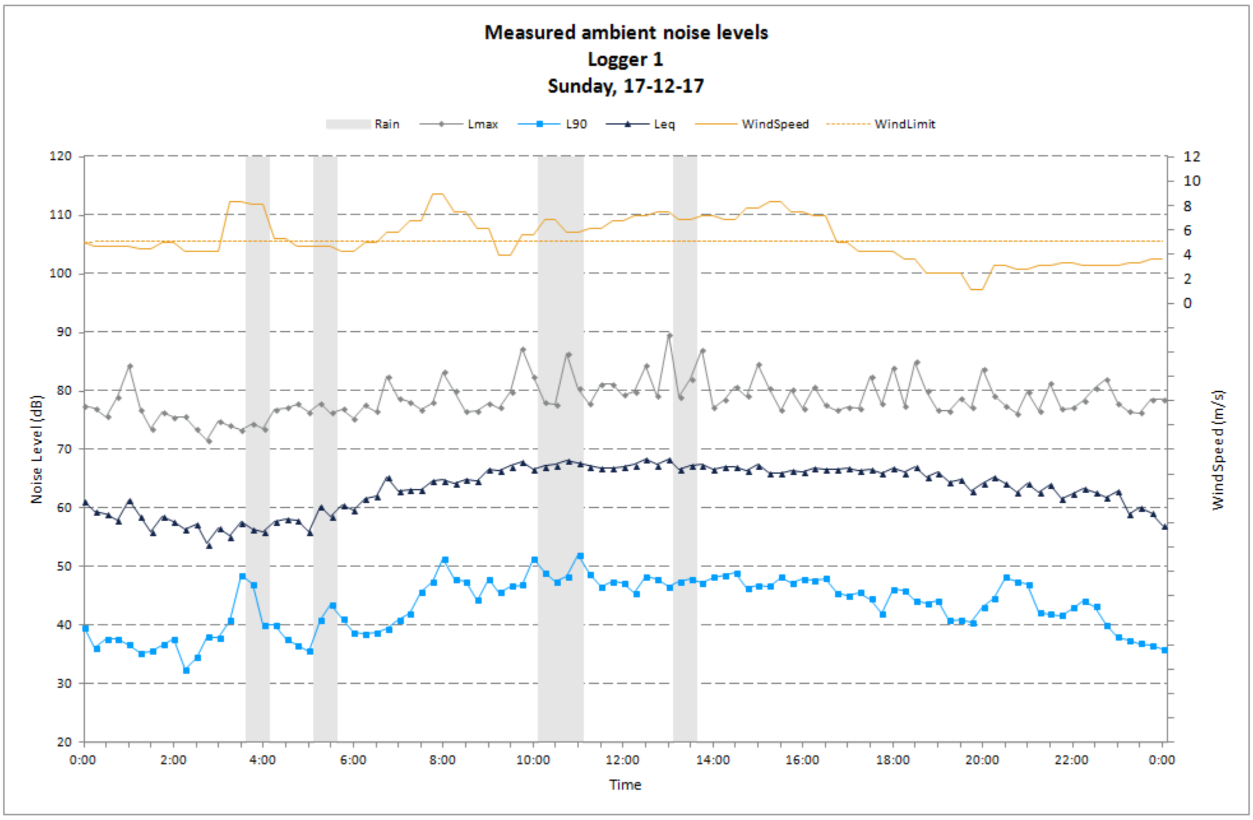

Measured ambient noise levels
Logger 1
Tuesday, 12-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time

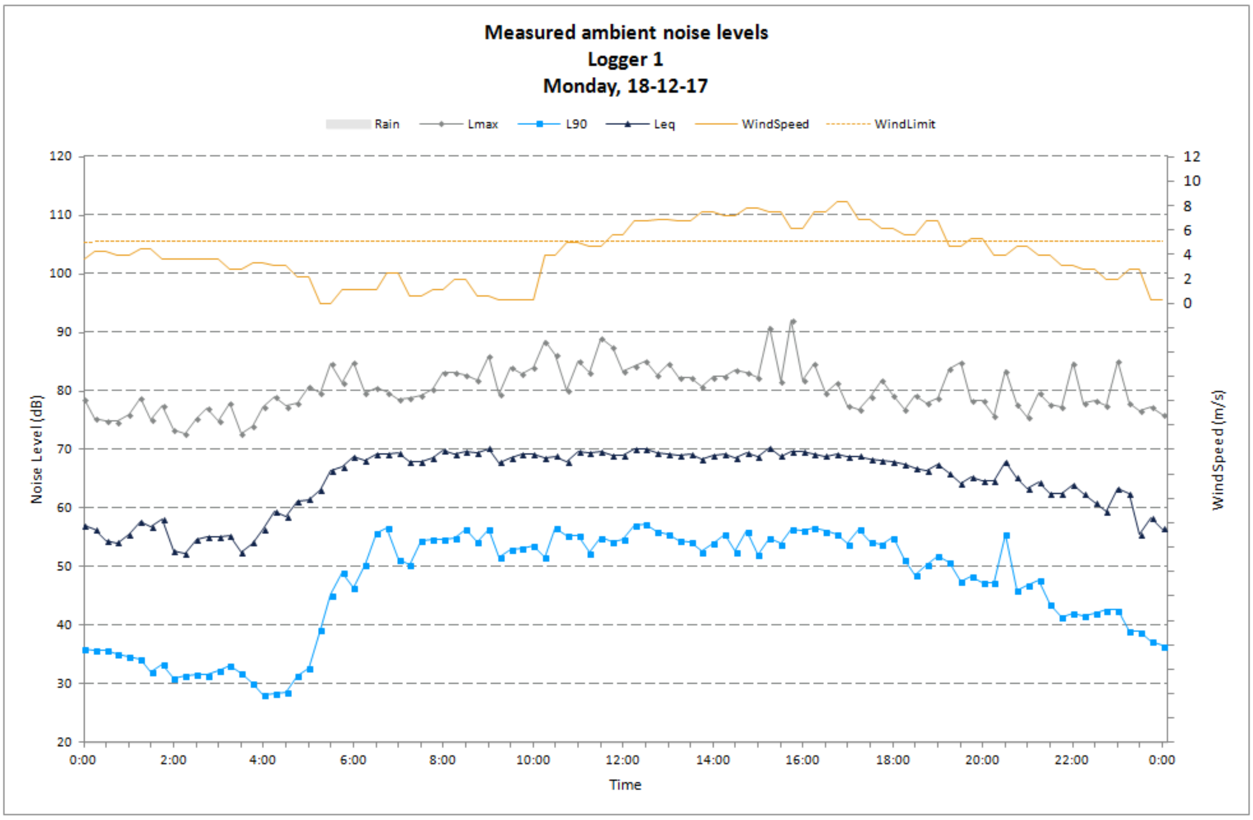

Measured ambient noise levels
Logger 1
Wednesday, 13-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time

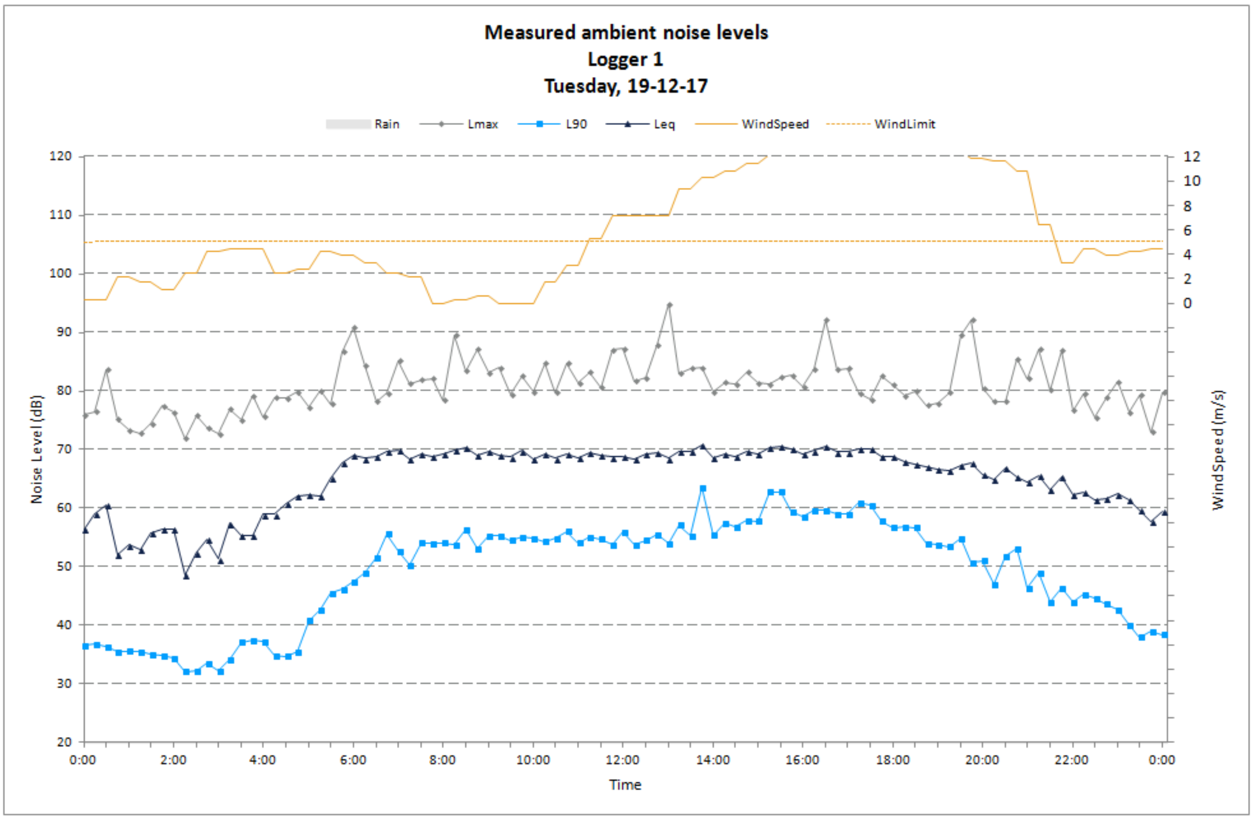

Measured ambient noise levels
Logger 1
Thursday, 14-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00


Measured ambient noise levels
Logger 1
Friday, 15-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00


Measured ambient noise levels
Logger 1
Saturday, 16-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 1
Sunday, 17-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 1
Monday, 18-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00


Measured ambient noise levels
Logger 1
Tuesday, 19-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
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8:00
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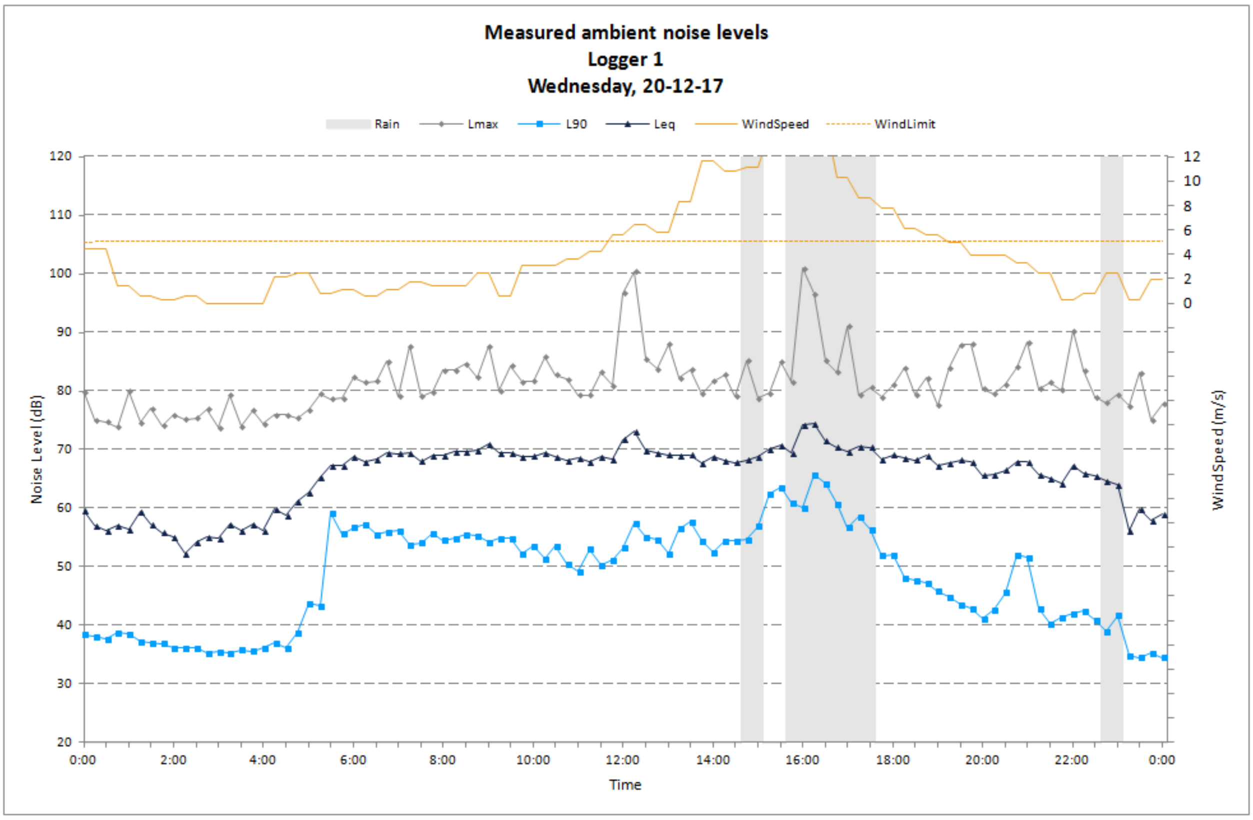
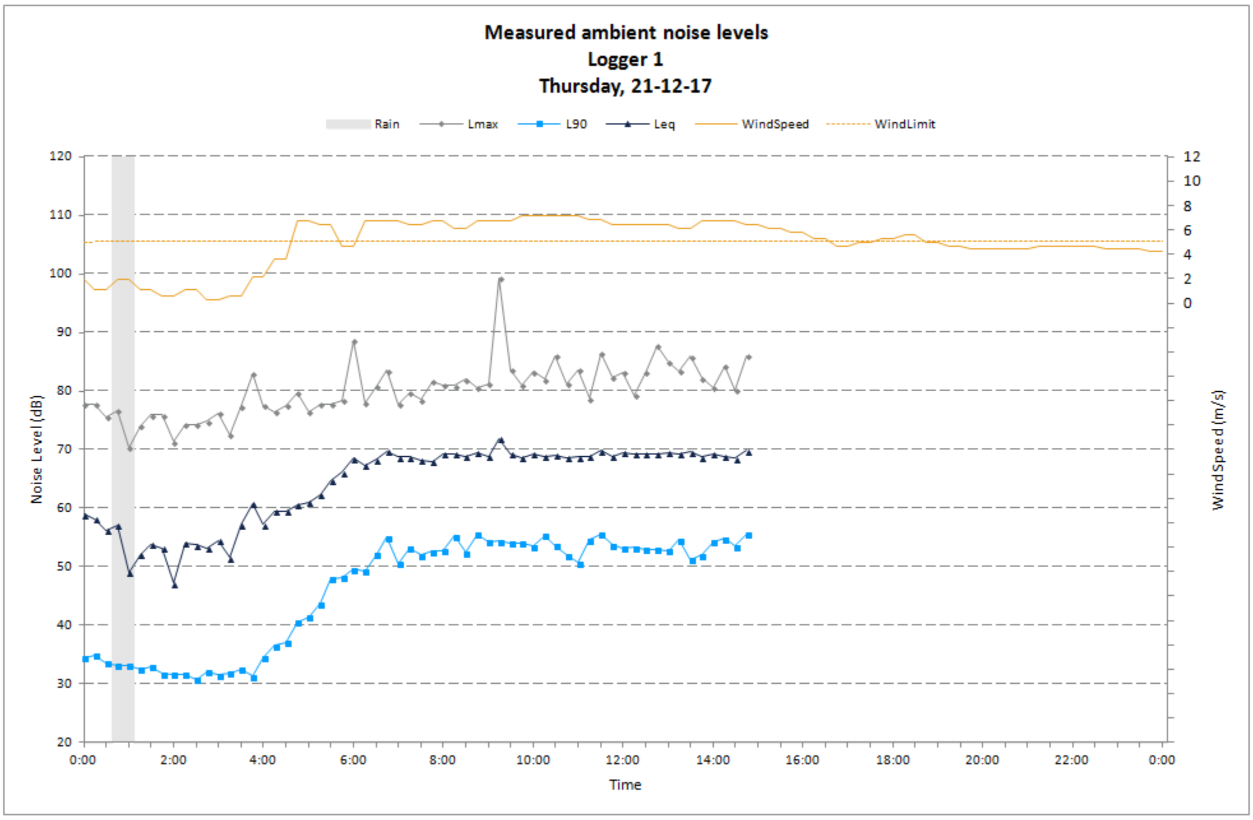
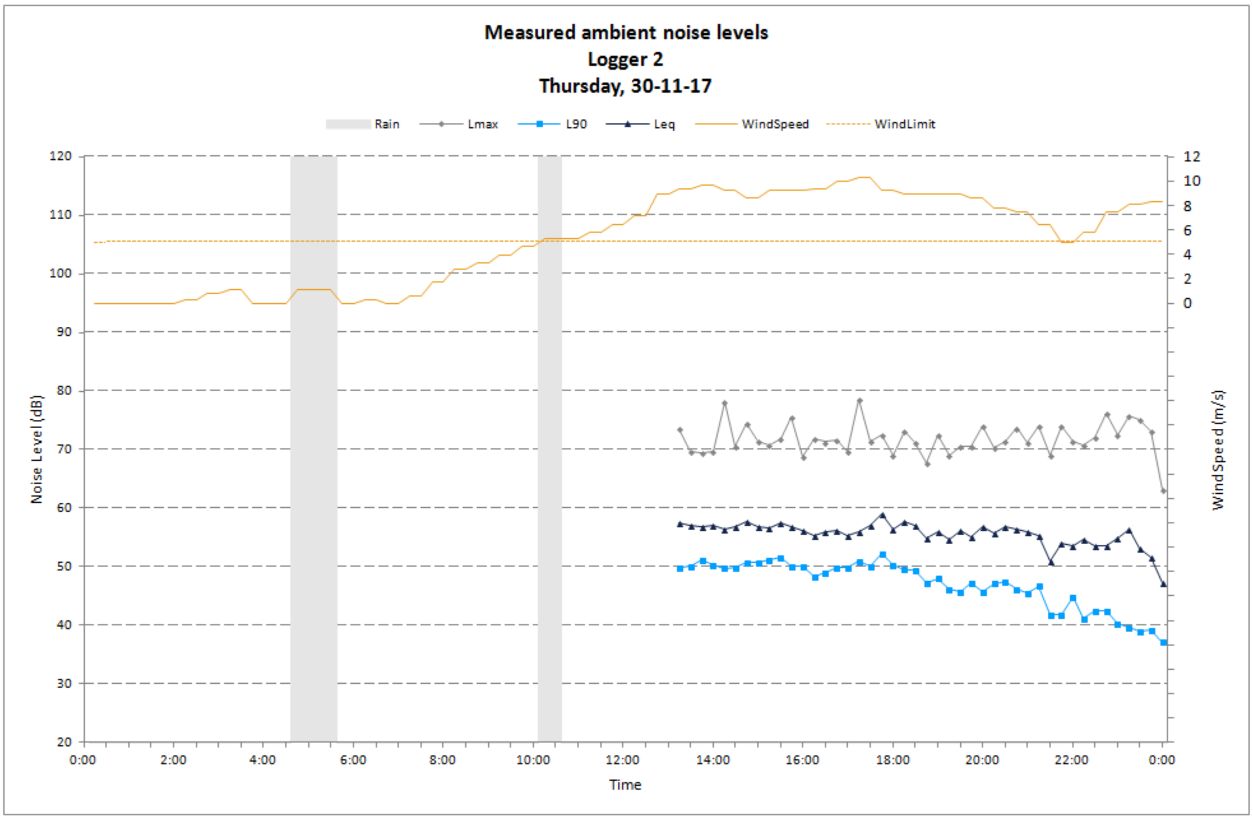
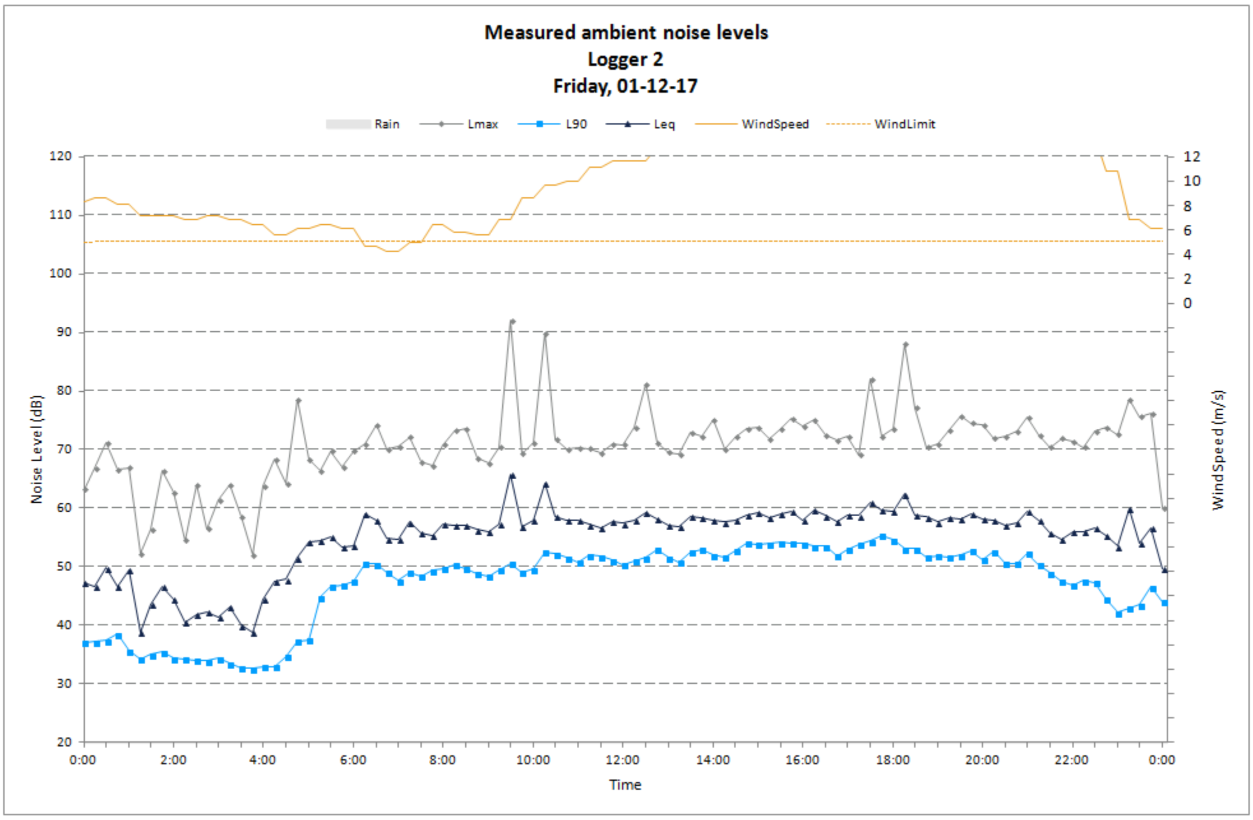
12:00
14:00
16:00
18:00
20:00
22:00
0:00


Measured ambient noise levels
Logger 1
Wednesday, 20-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time

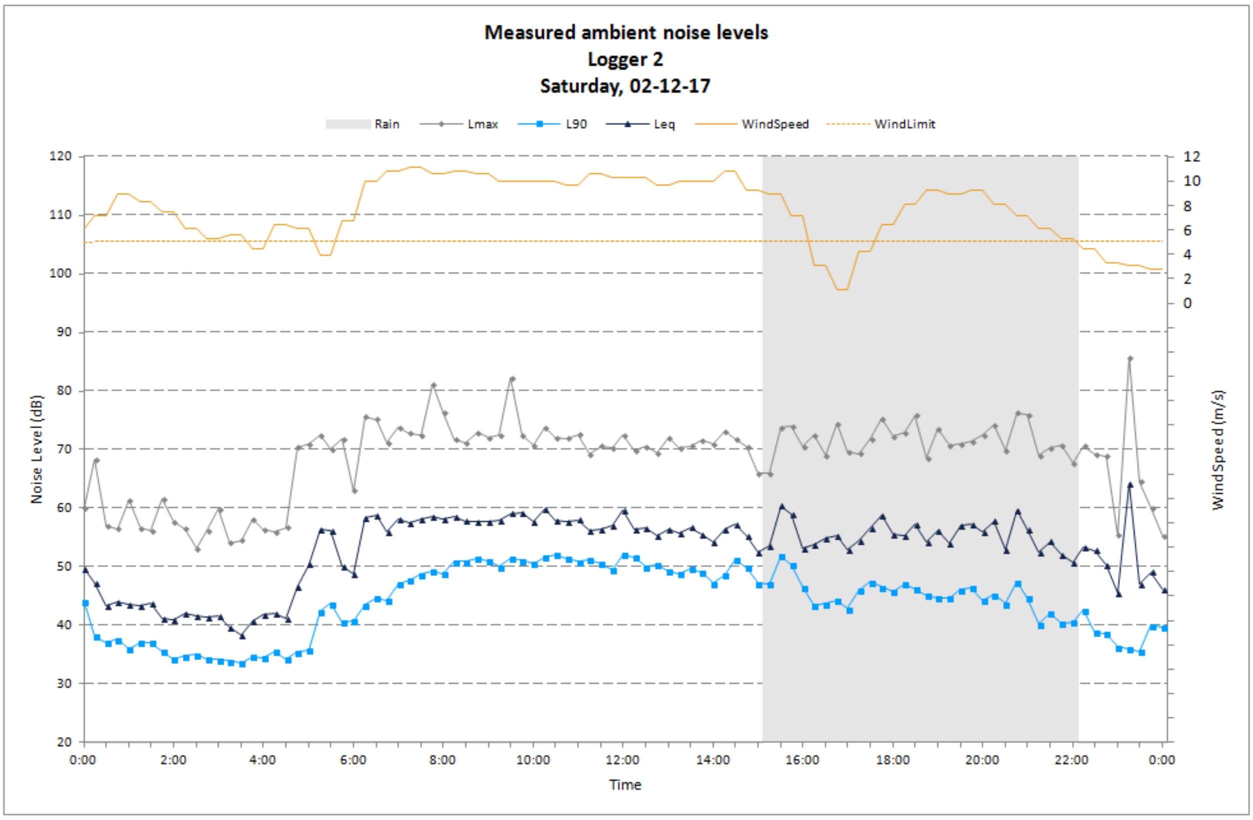

Measured ambient noise levels
Logger 1
Thursday, 21-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time

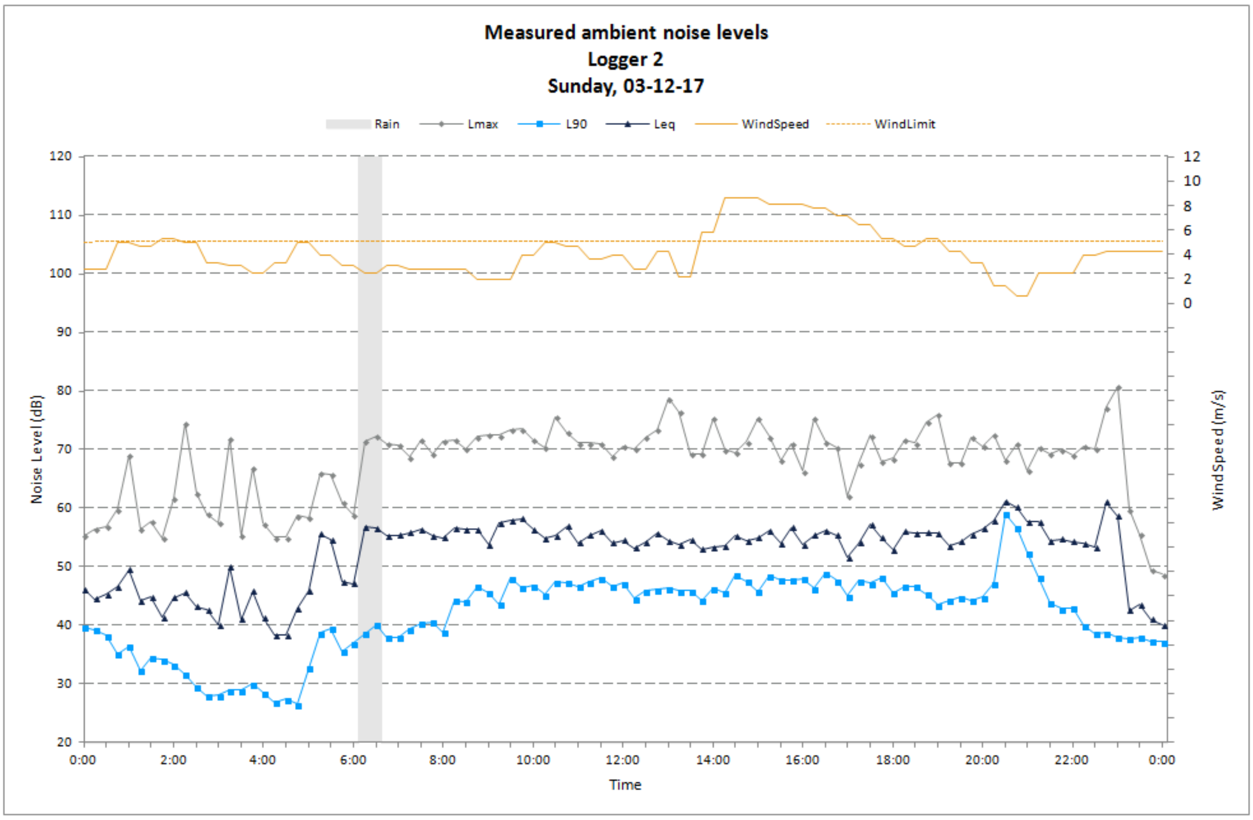


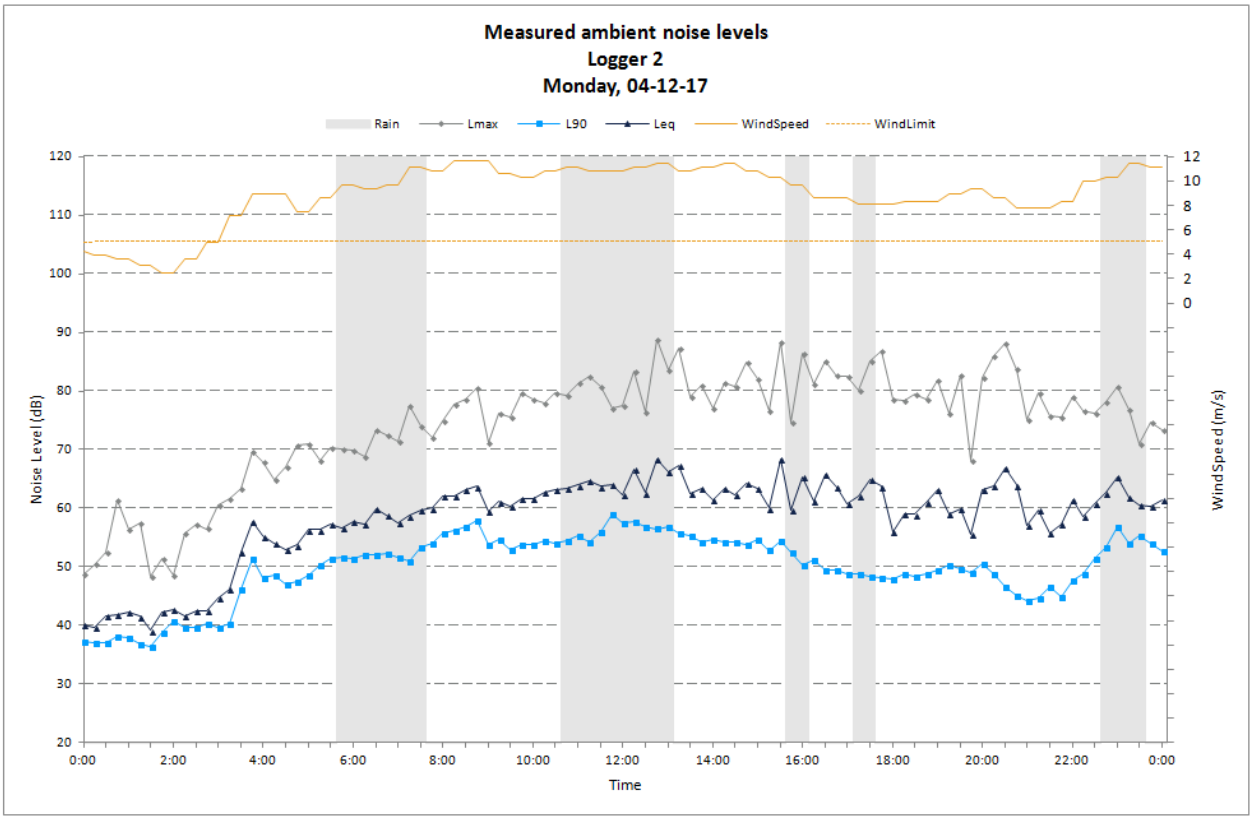
Measured ambient noise levels
Logger 2
Thursday, 30-11-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time

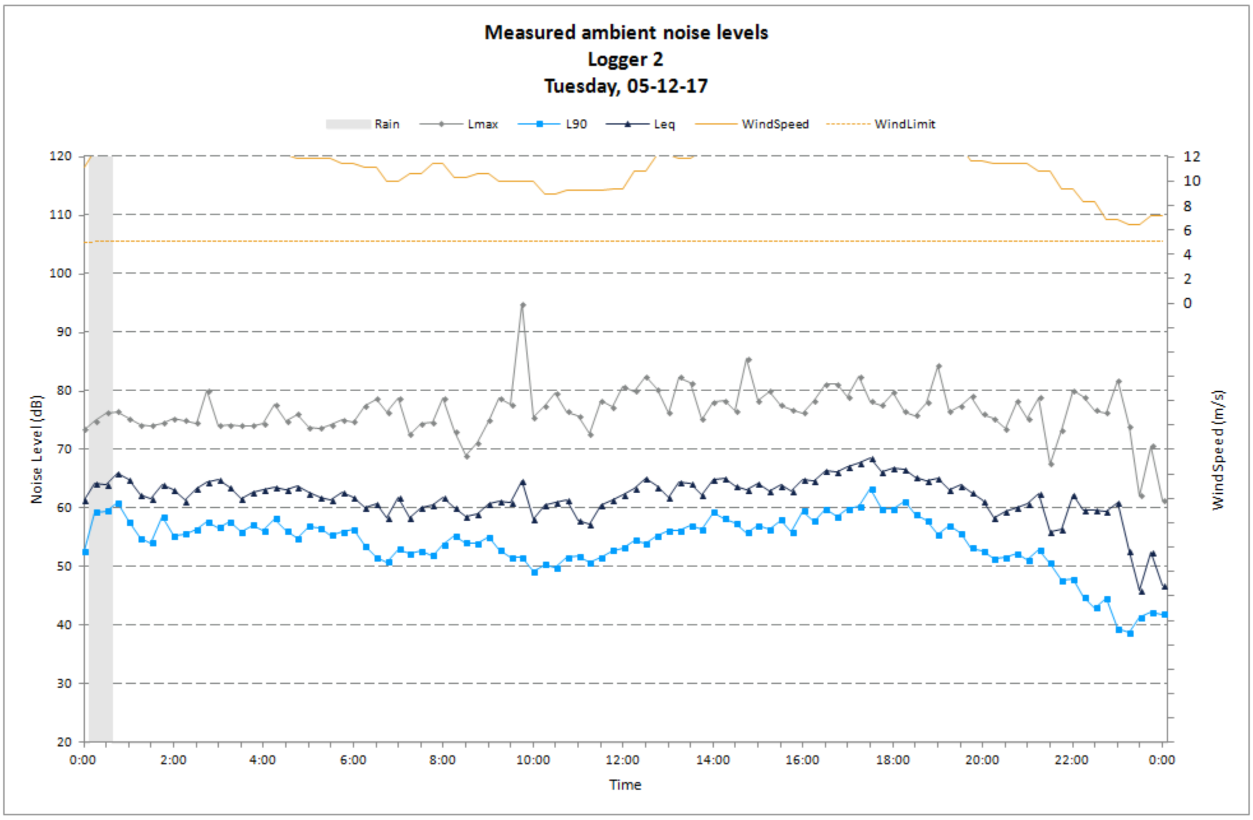


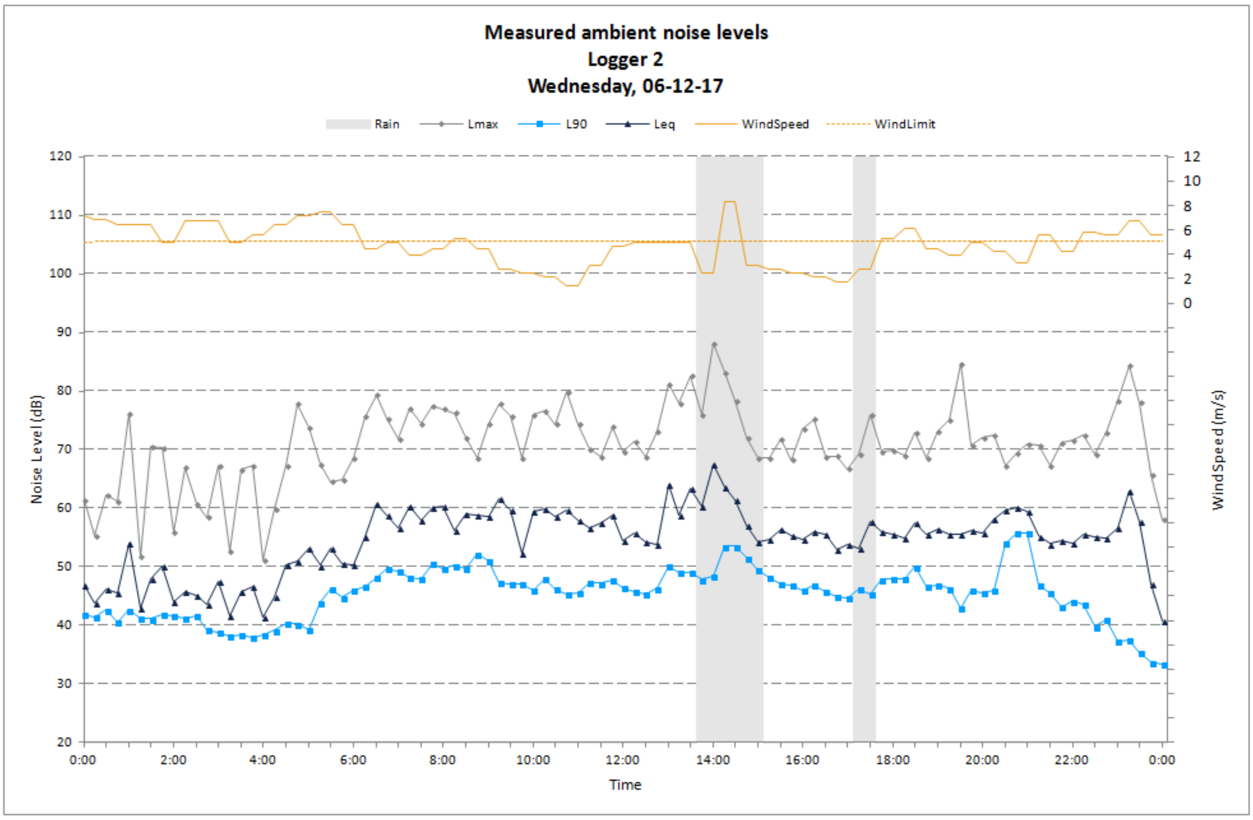
Measured ambient noise levels
Logger 2
Friday, 01-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 2
Saturday, 02-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time

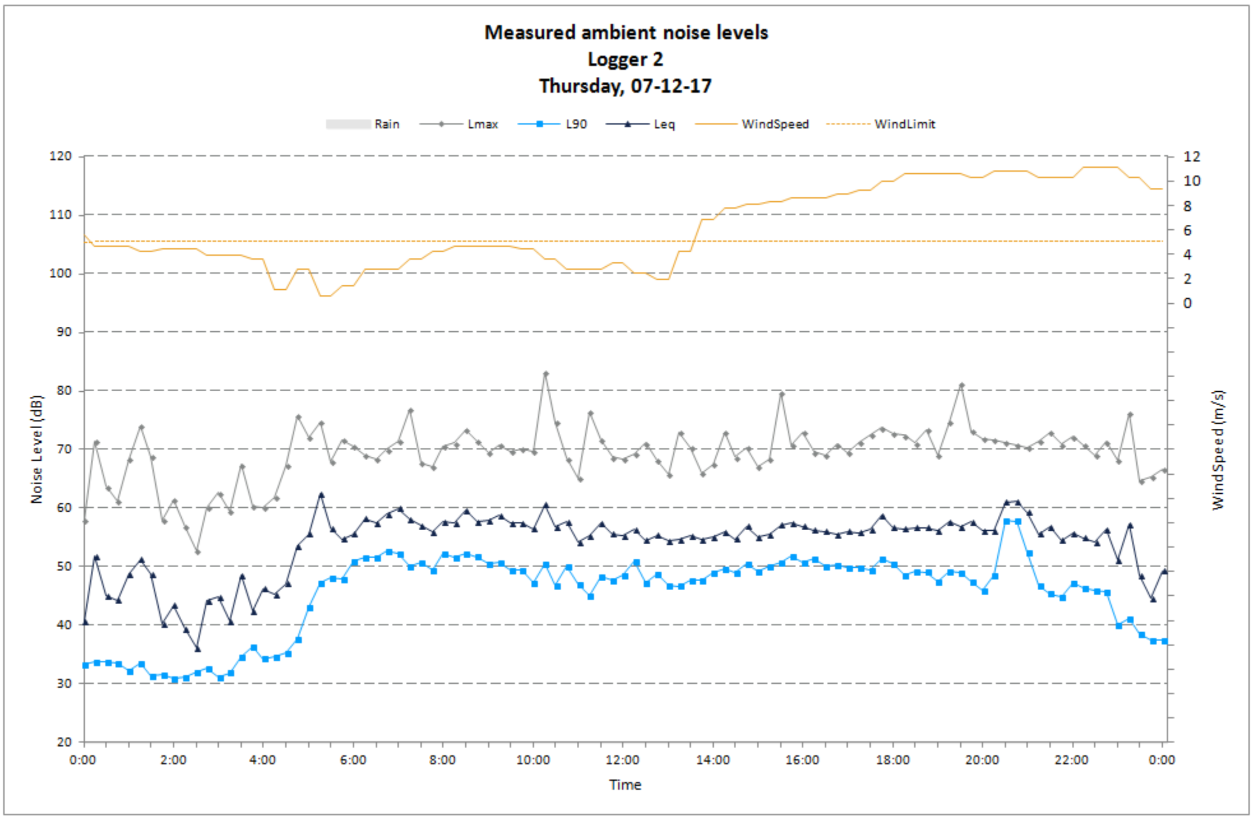

Measured ambient noise levels
Logger 2
Sunday, 03-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time


Measured ambient noise levels
Logger 2
Monday, 04-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00

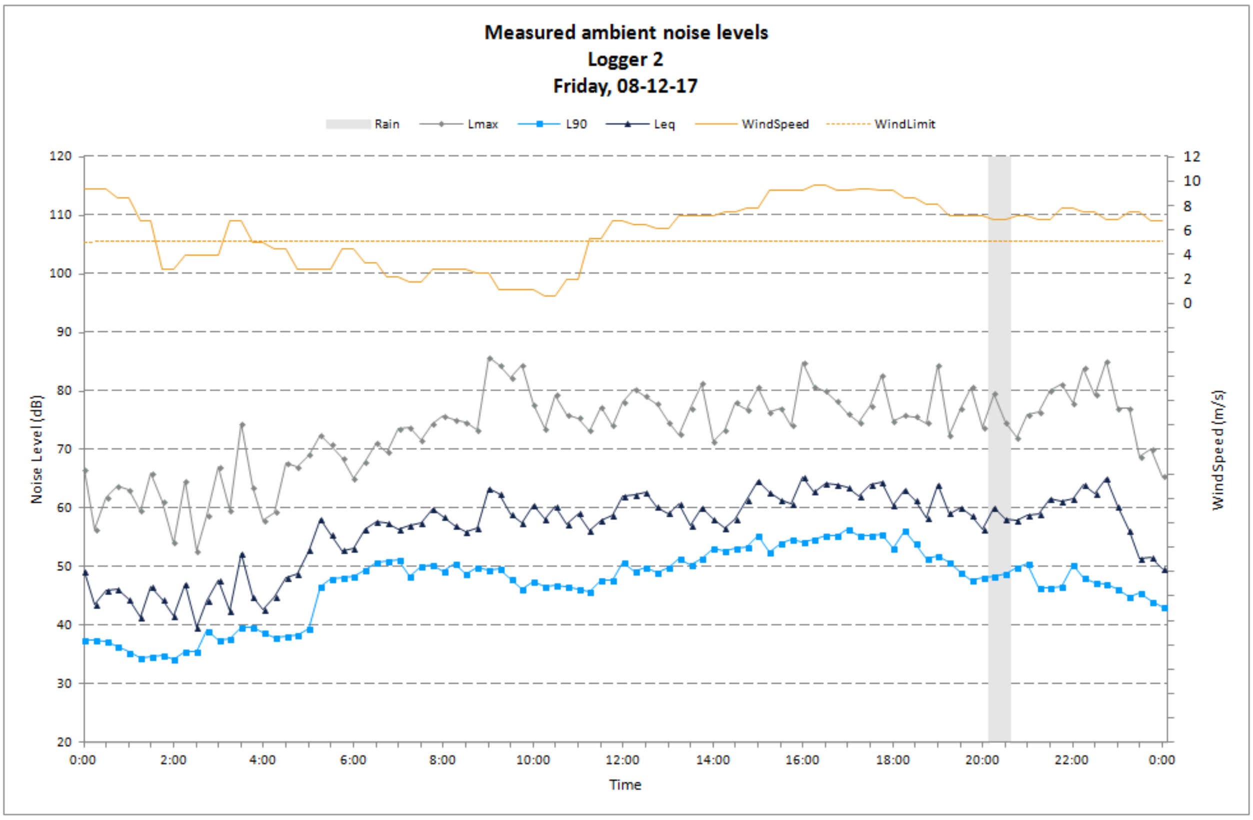

Measured ambient noise levels
Logger 2
Tuesday, 05-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00

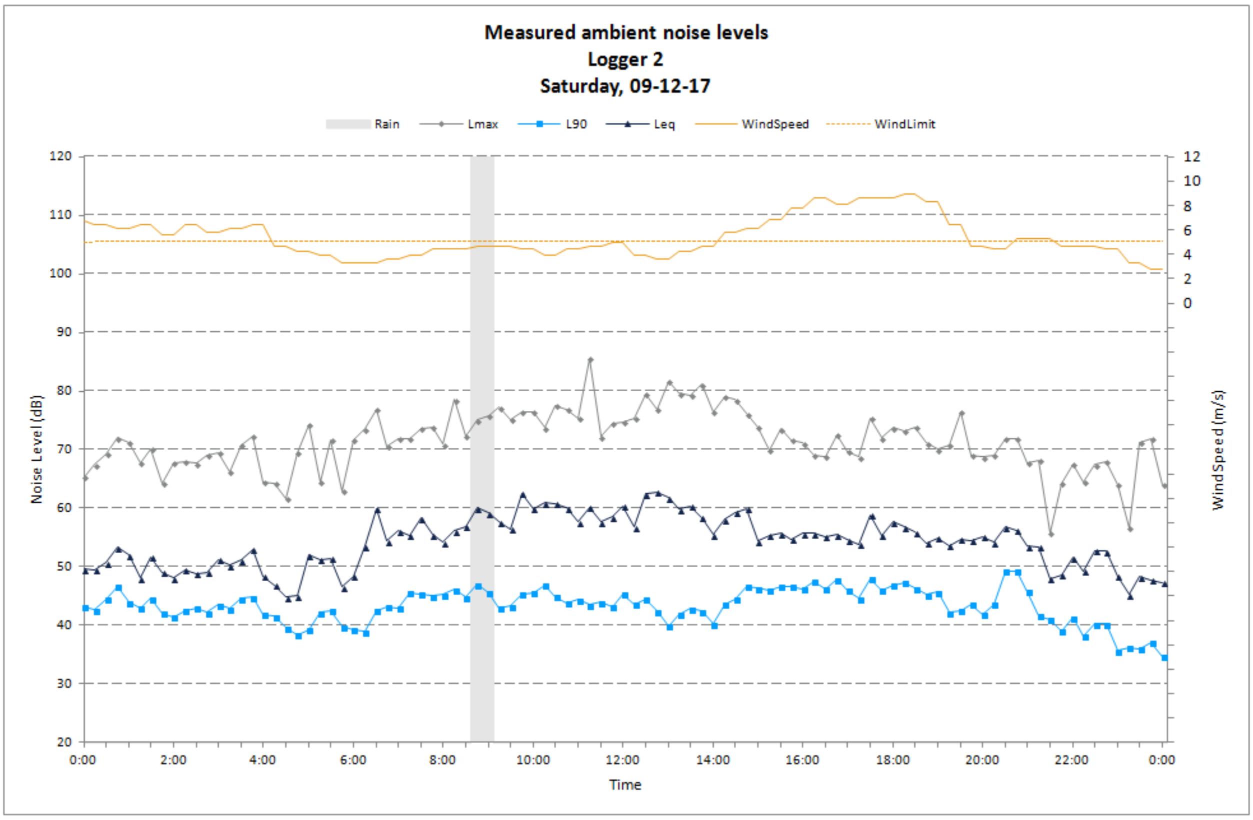


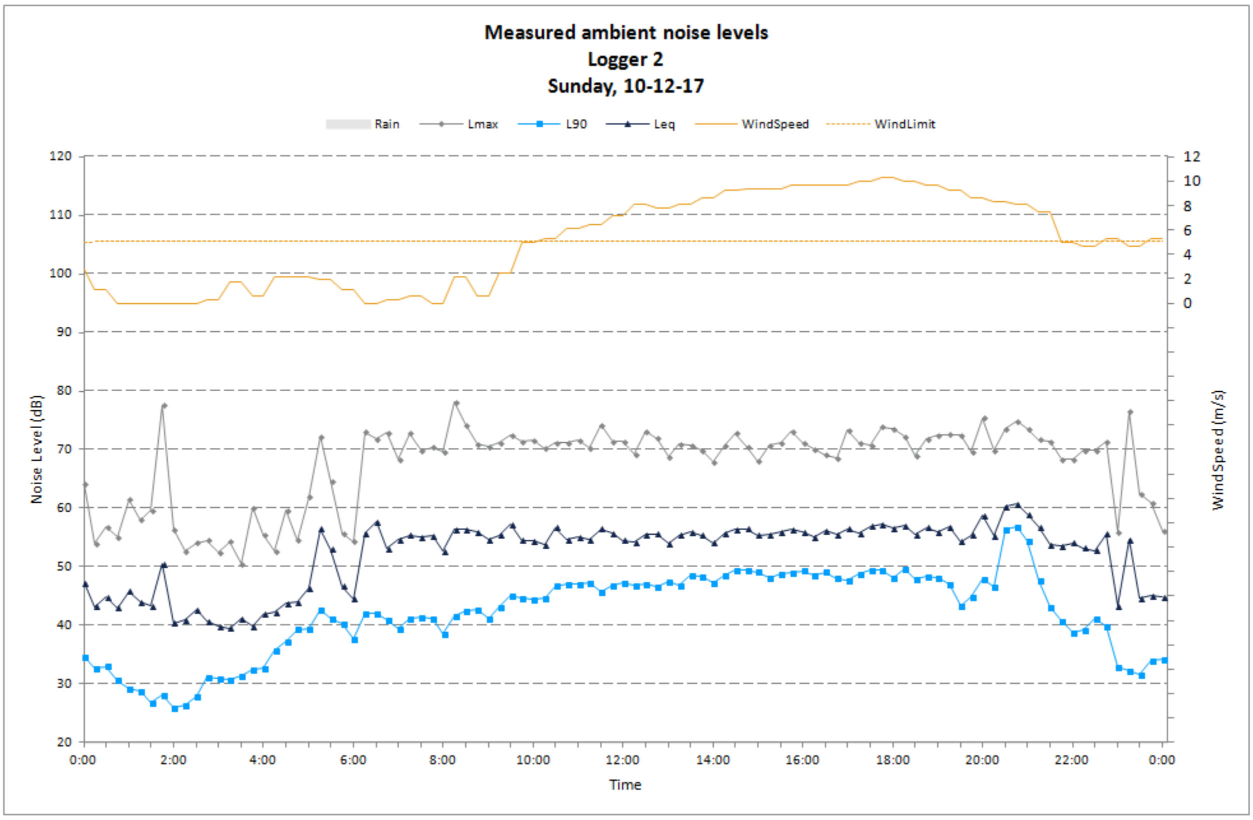
Measured ambient noise levels
Logger 2
Wednesday, 06-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time

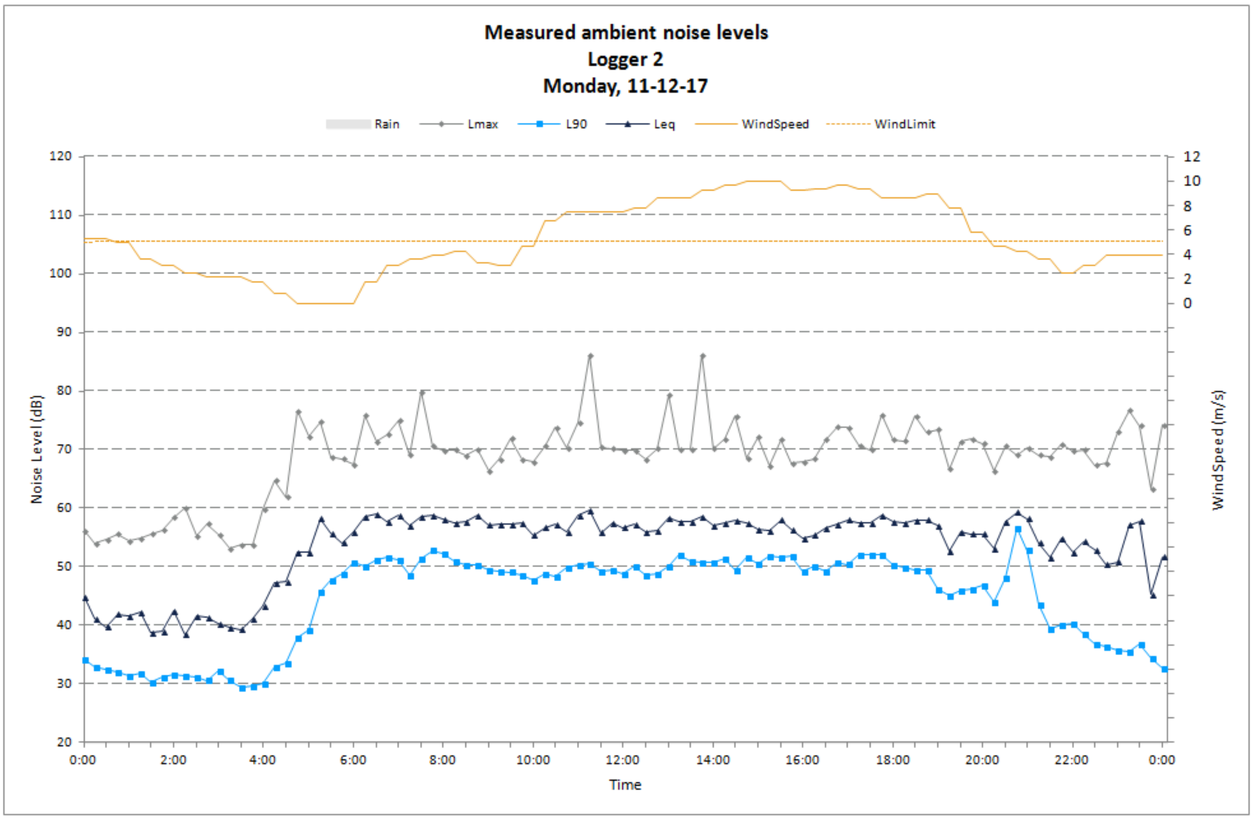


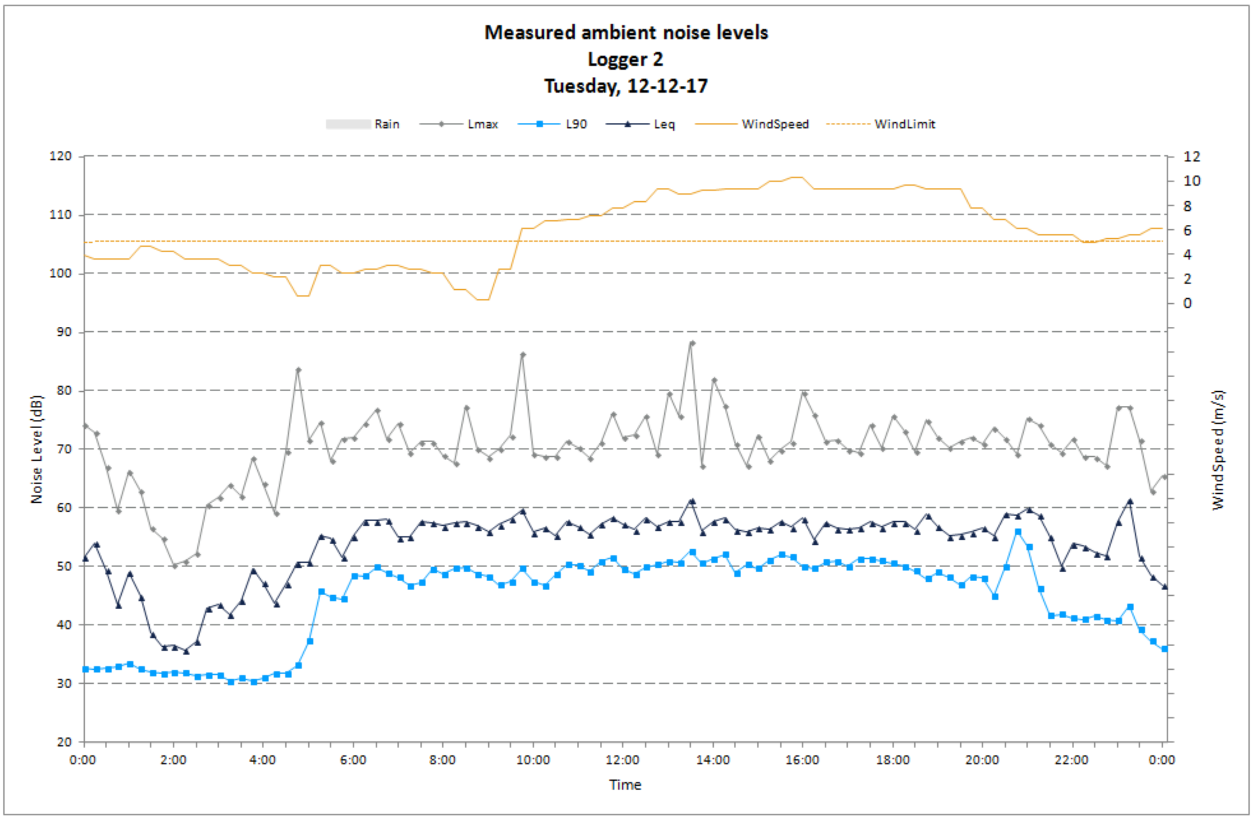
Measured ambient noise levels
Logger 2
Thursday, 07-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 2
Friday, 08-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00

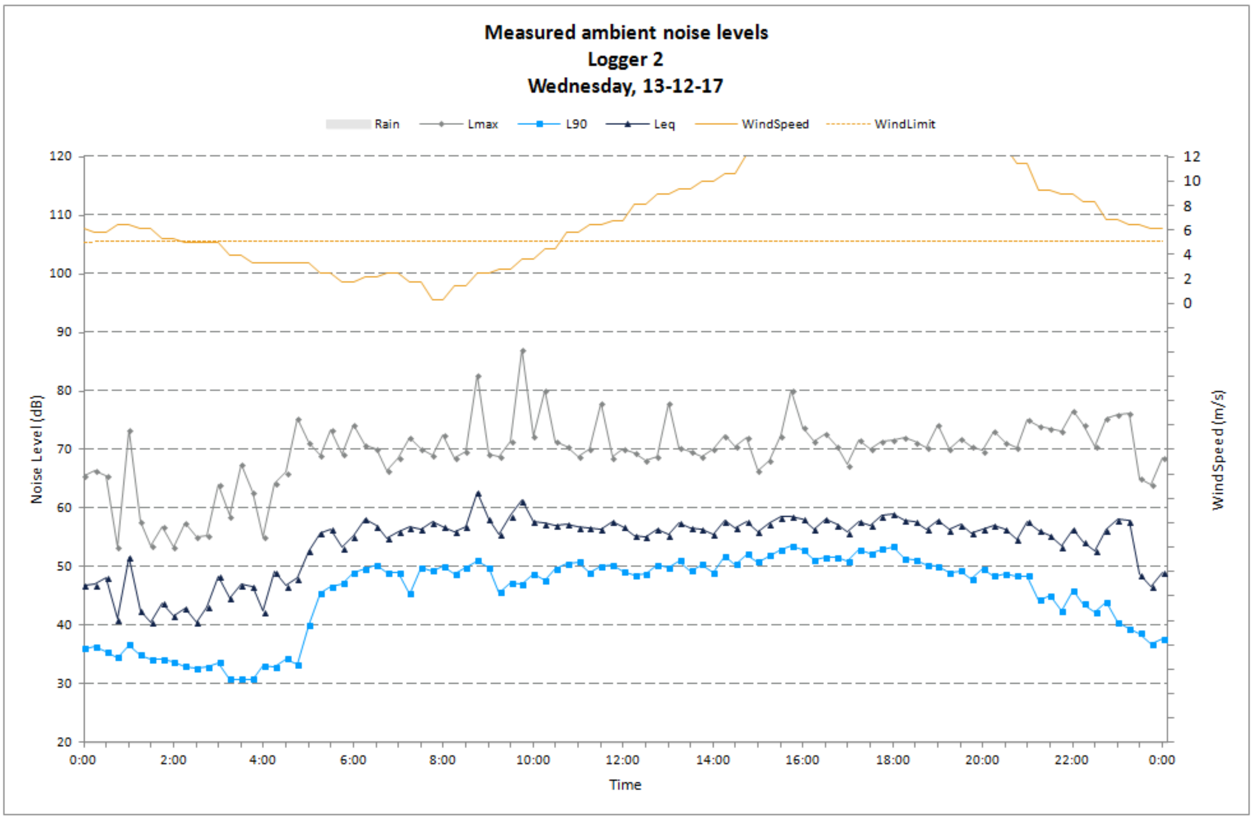

Measured ambient noise levels
Logger 2
Saturday, 09-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00


Measured ambient noise levels
Logger 2
Sunday, 10-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time

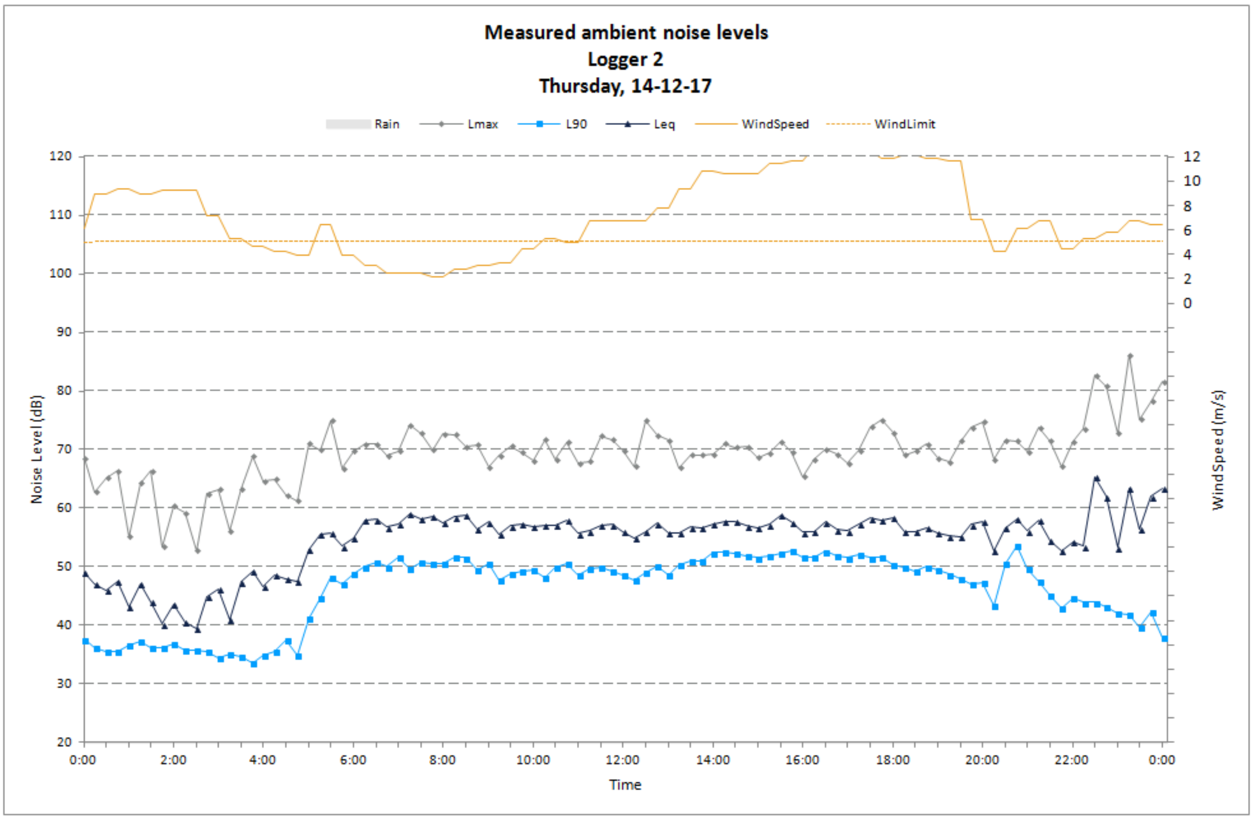

Measured ambient noise levels
Logger 2
Monday, 11-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time



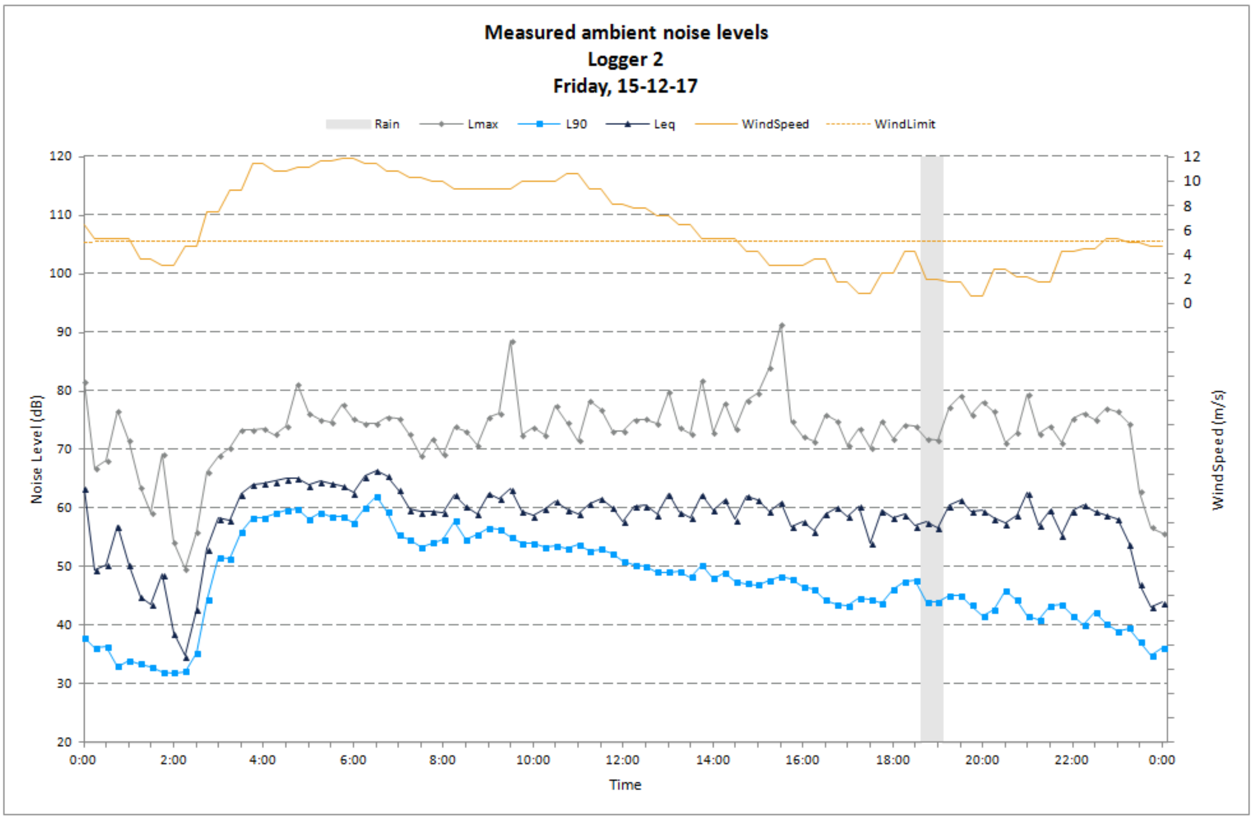
Measured ambient noise levels
Logger 2
Tuesday, 12-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time



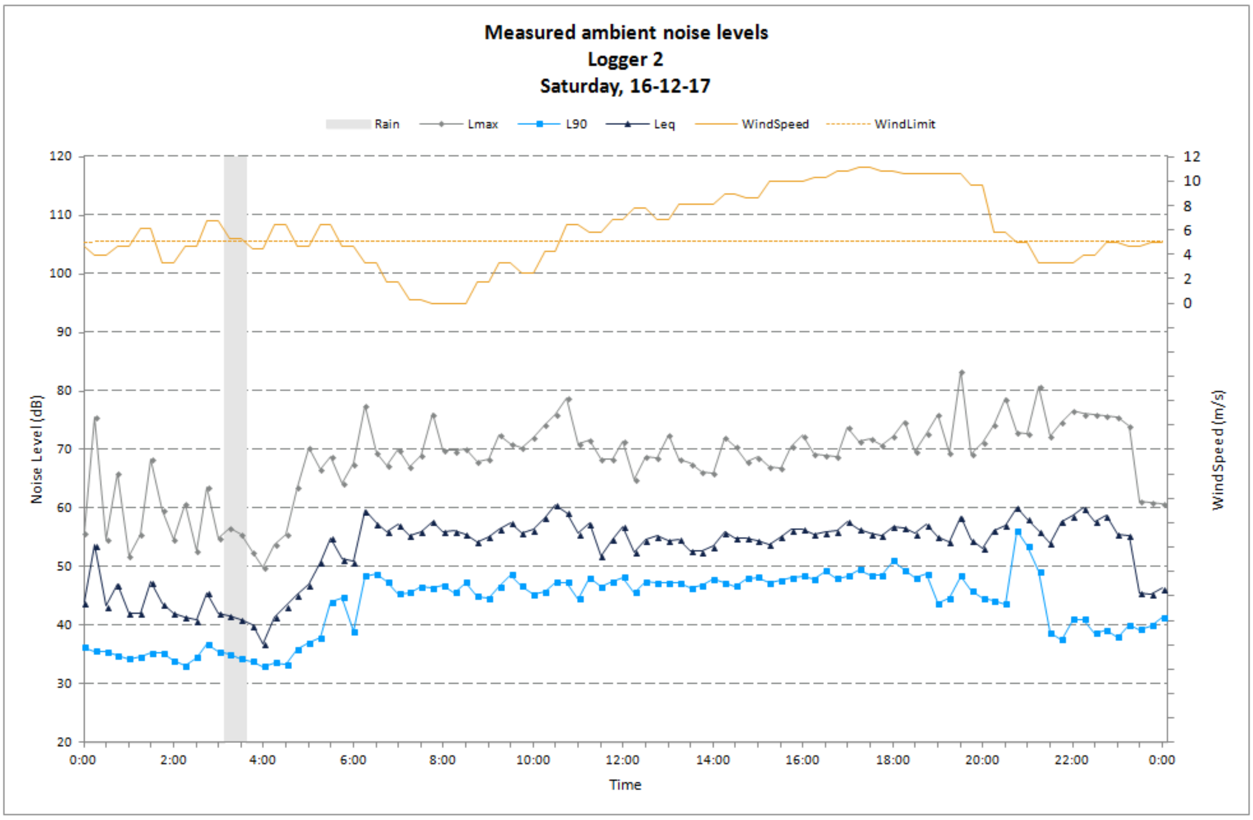
Measured ambient noise levels
Logger 2
Wednesday, 13-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time

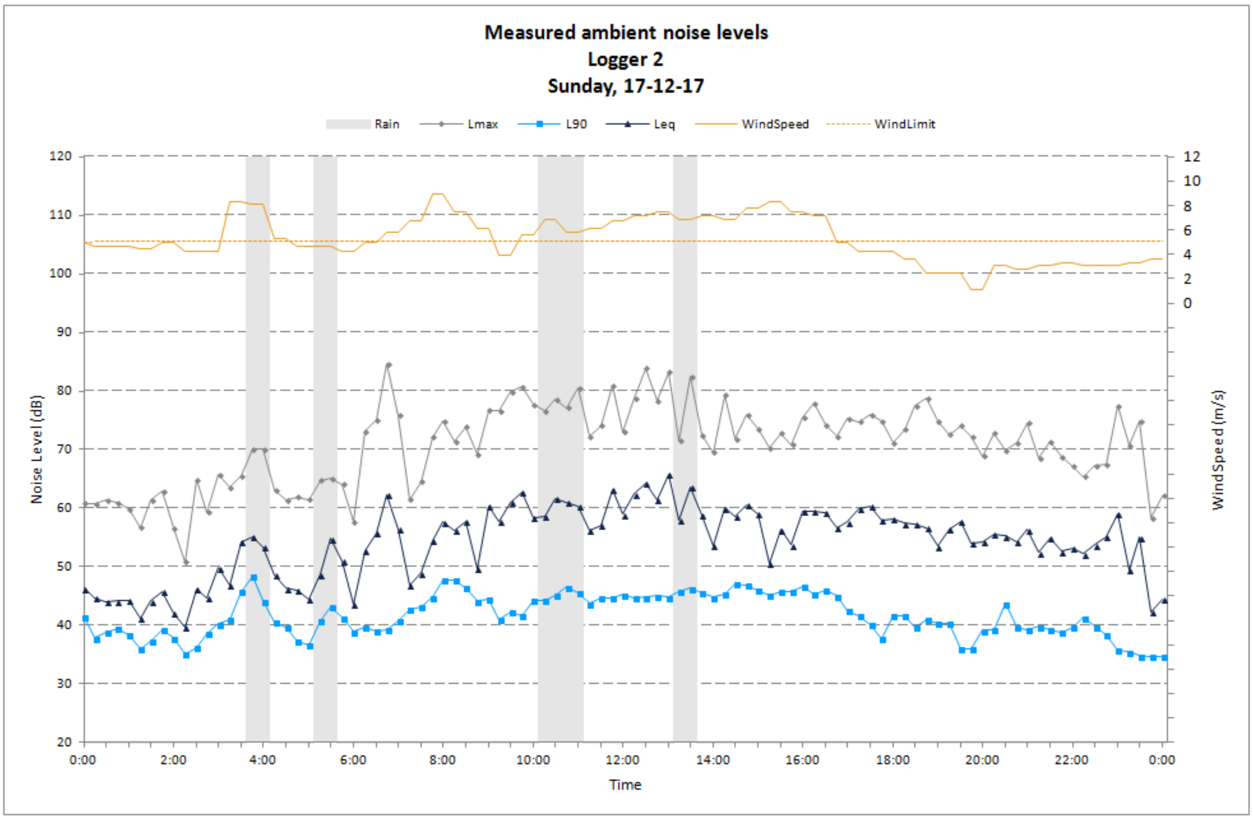


Measured ambient noise levels
Logger 2
Thursday, 14-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time



Measured ambient noise levels
Logger 2
Friday, 15-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 2
Saturday, 16-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00


Measured ambient noise levels
Logger 2
Sunday, 17-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
0:00
2:00
4:00
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8:00
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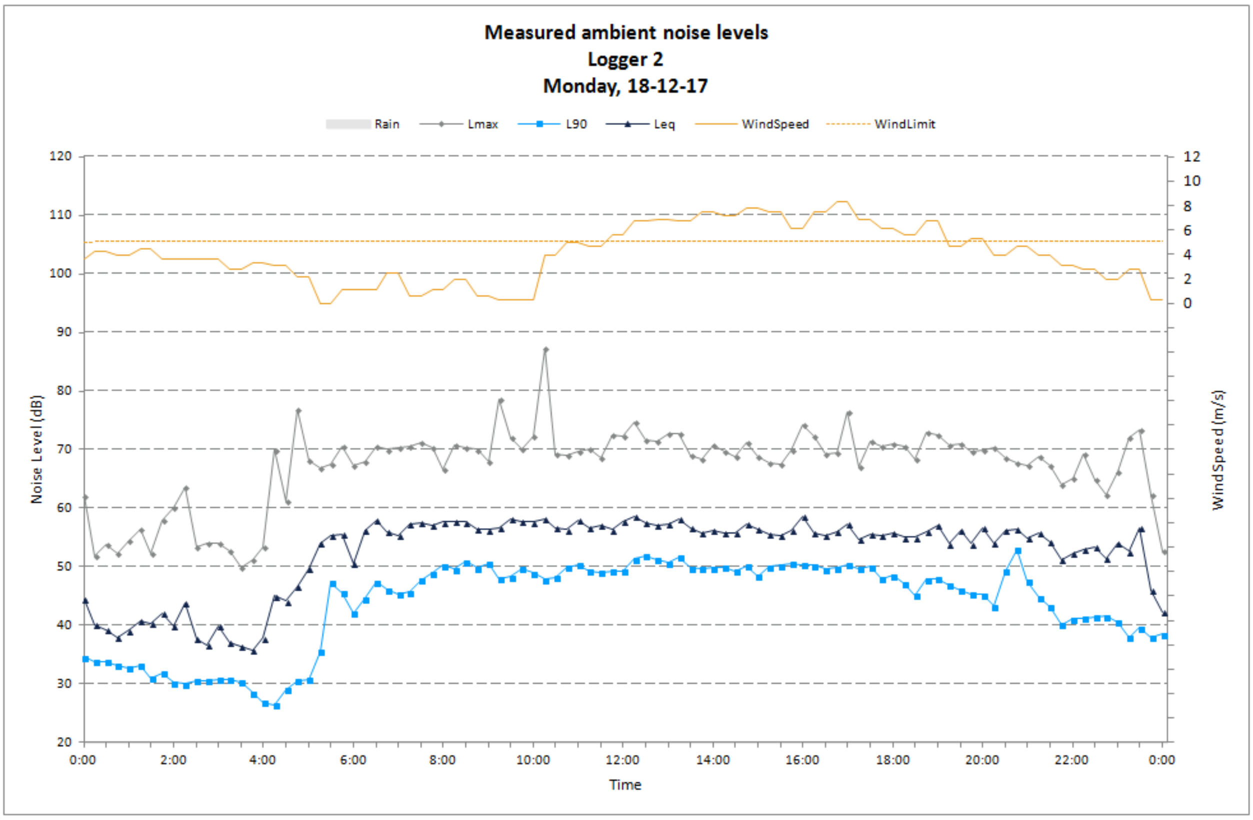
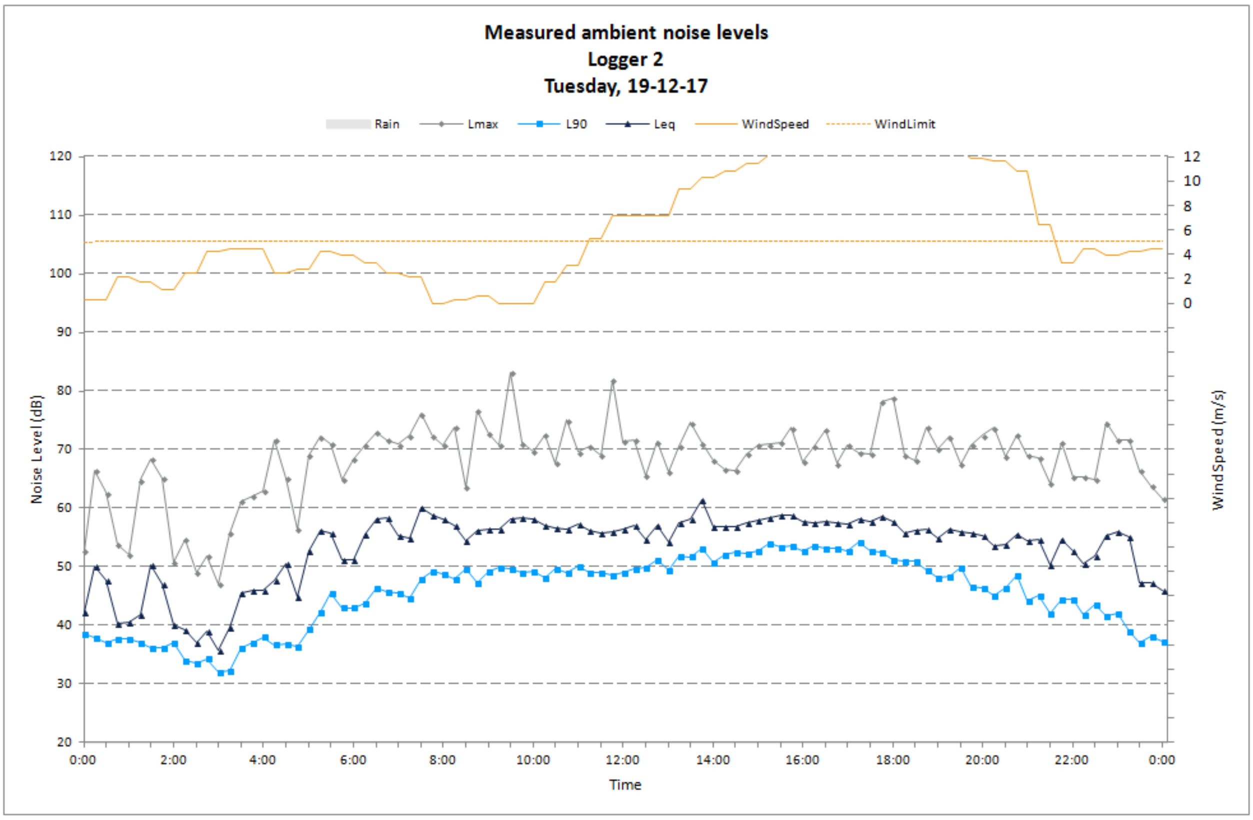
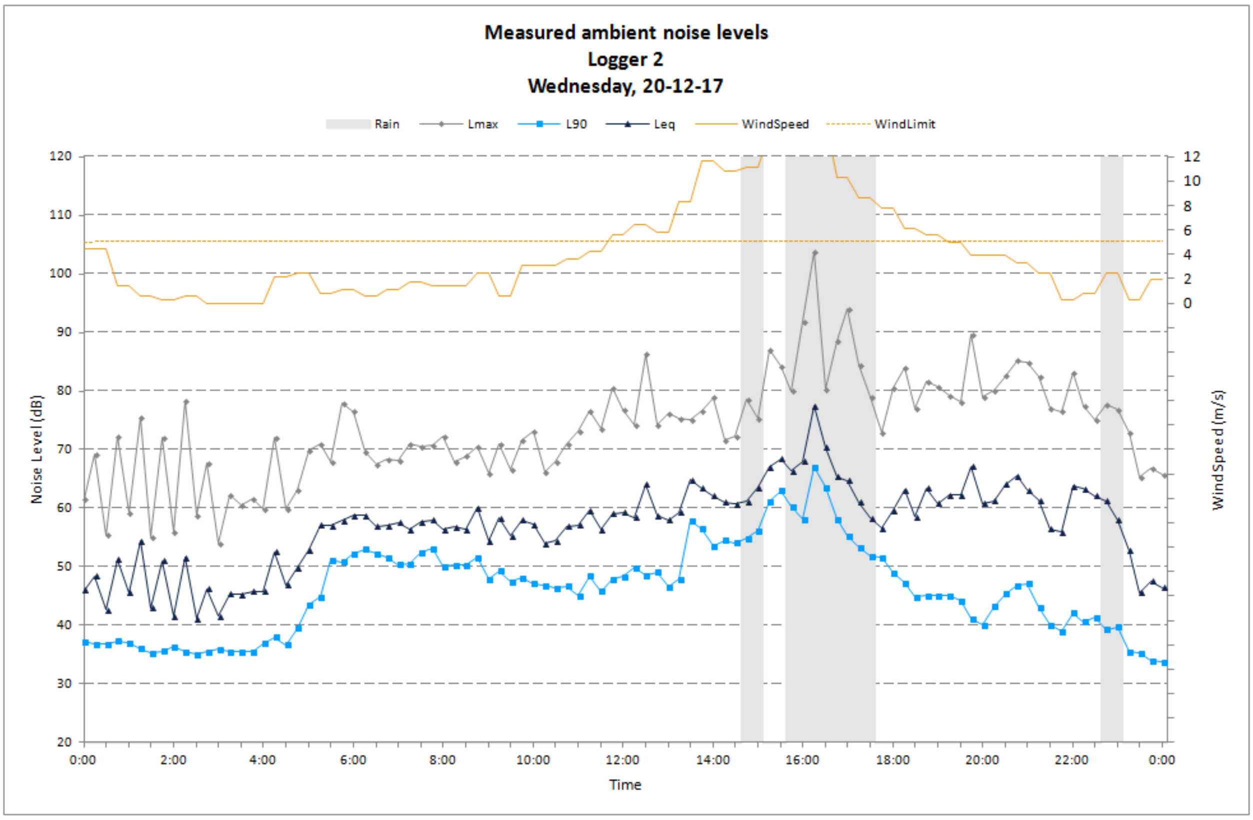
20:00
22:00
0:00

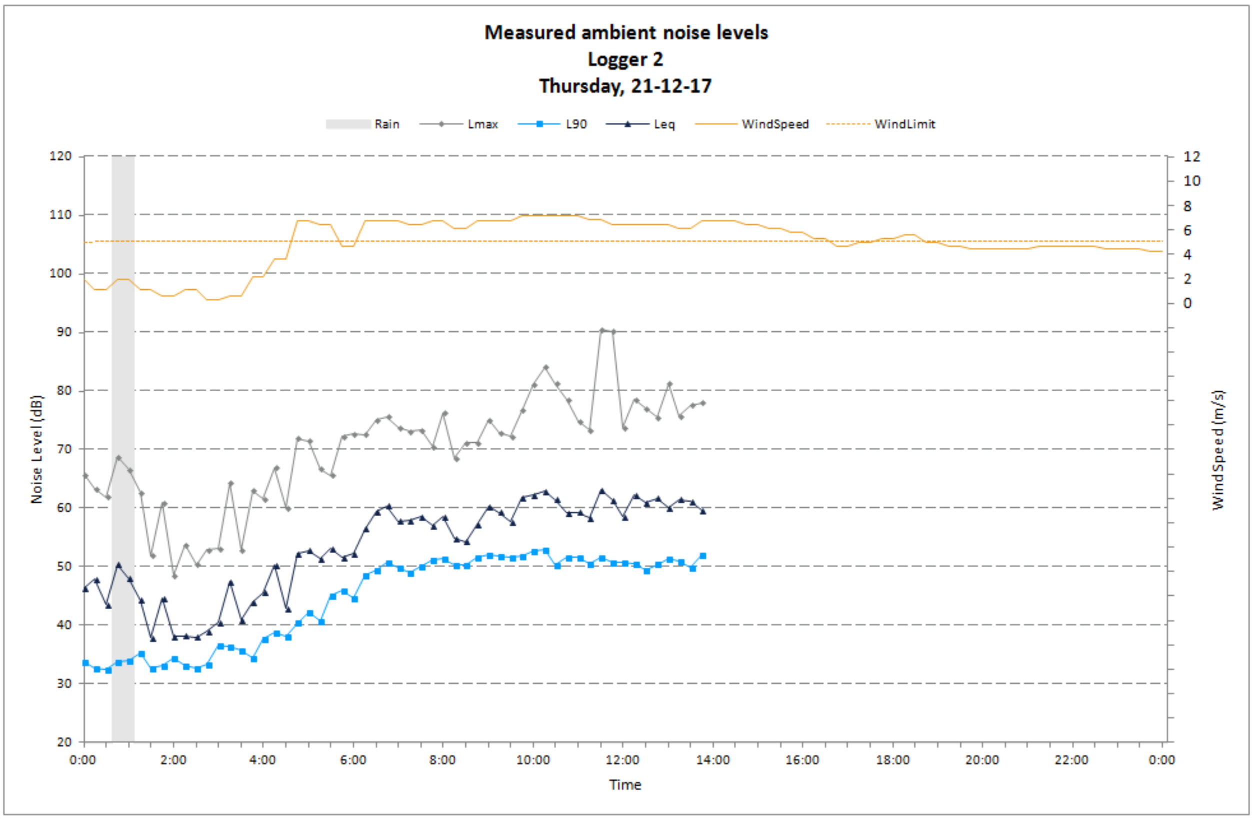


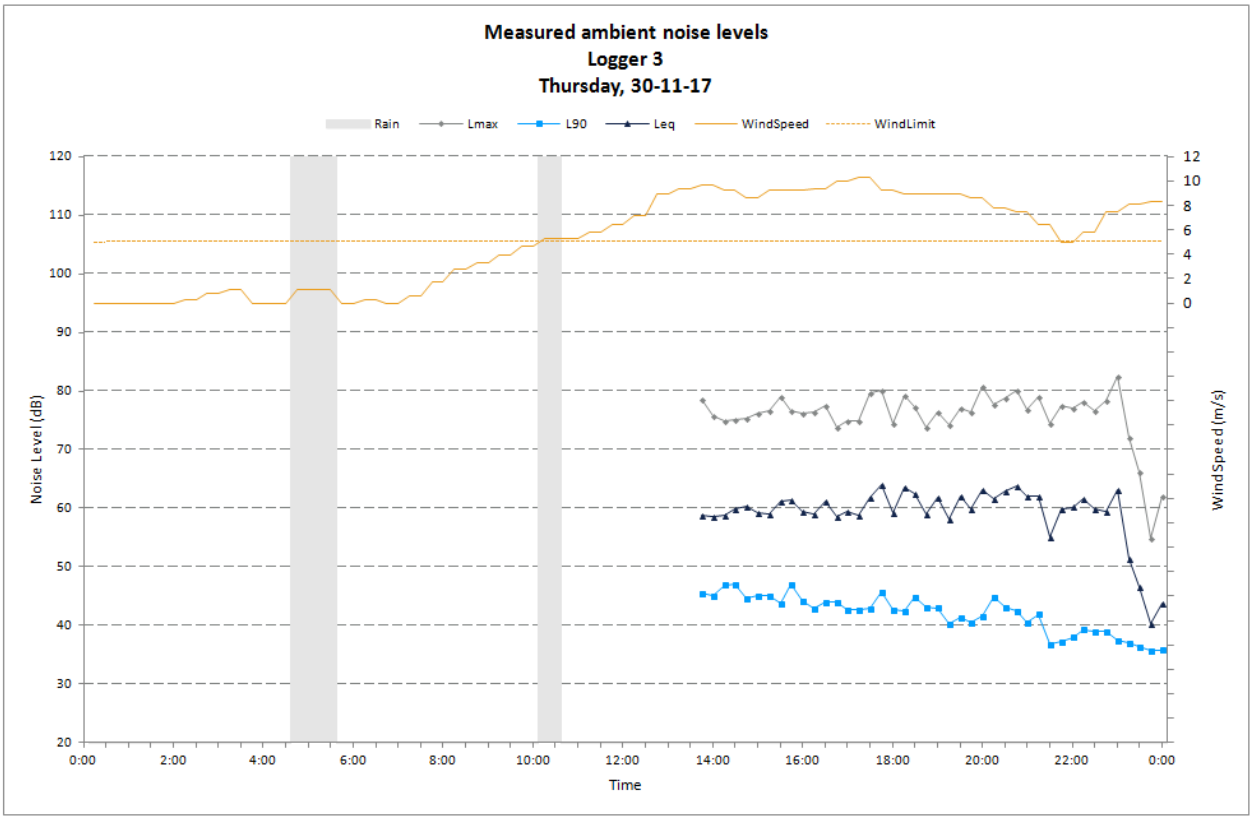
Measured ambient noise levels
Logger 2
Monday, 18-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time



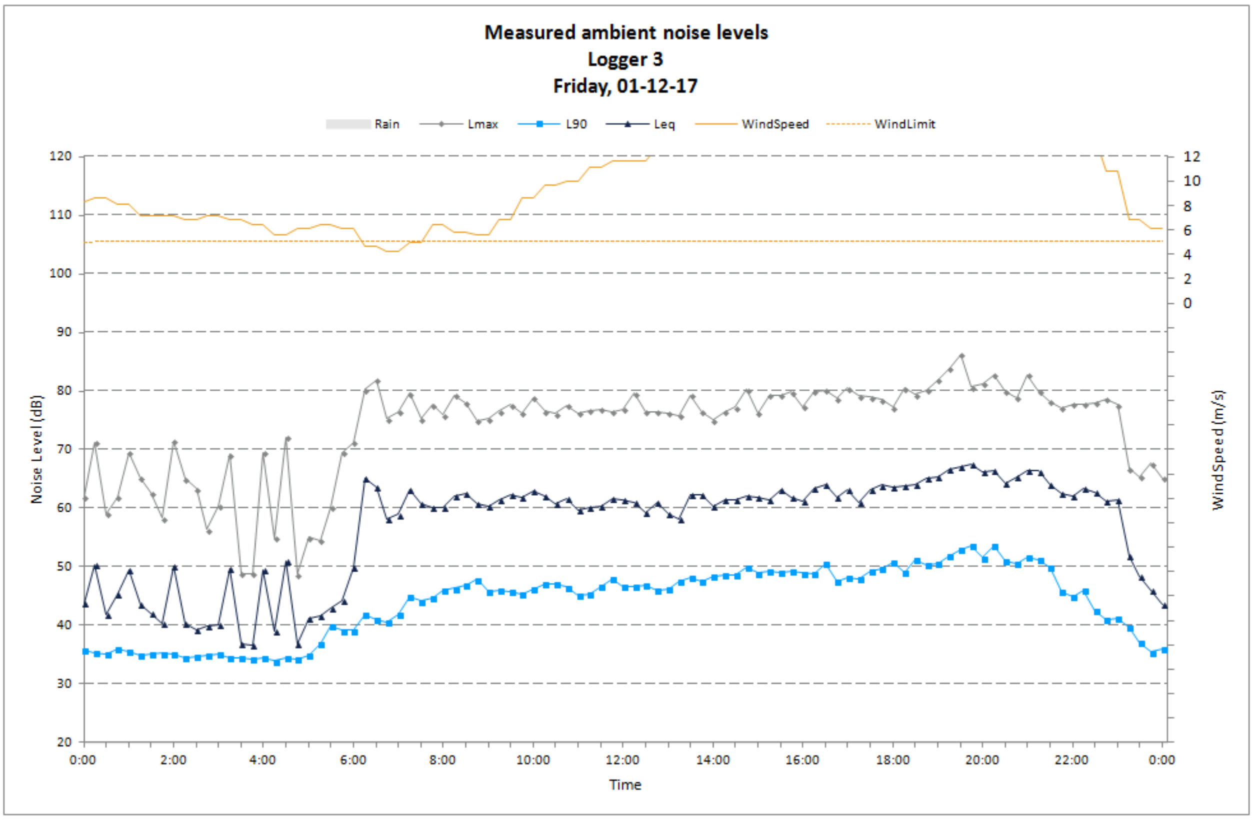
Measured ambient noise levels
Logger 2
Tuesday, 19-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 2
Wednesday, 20-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00

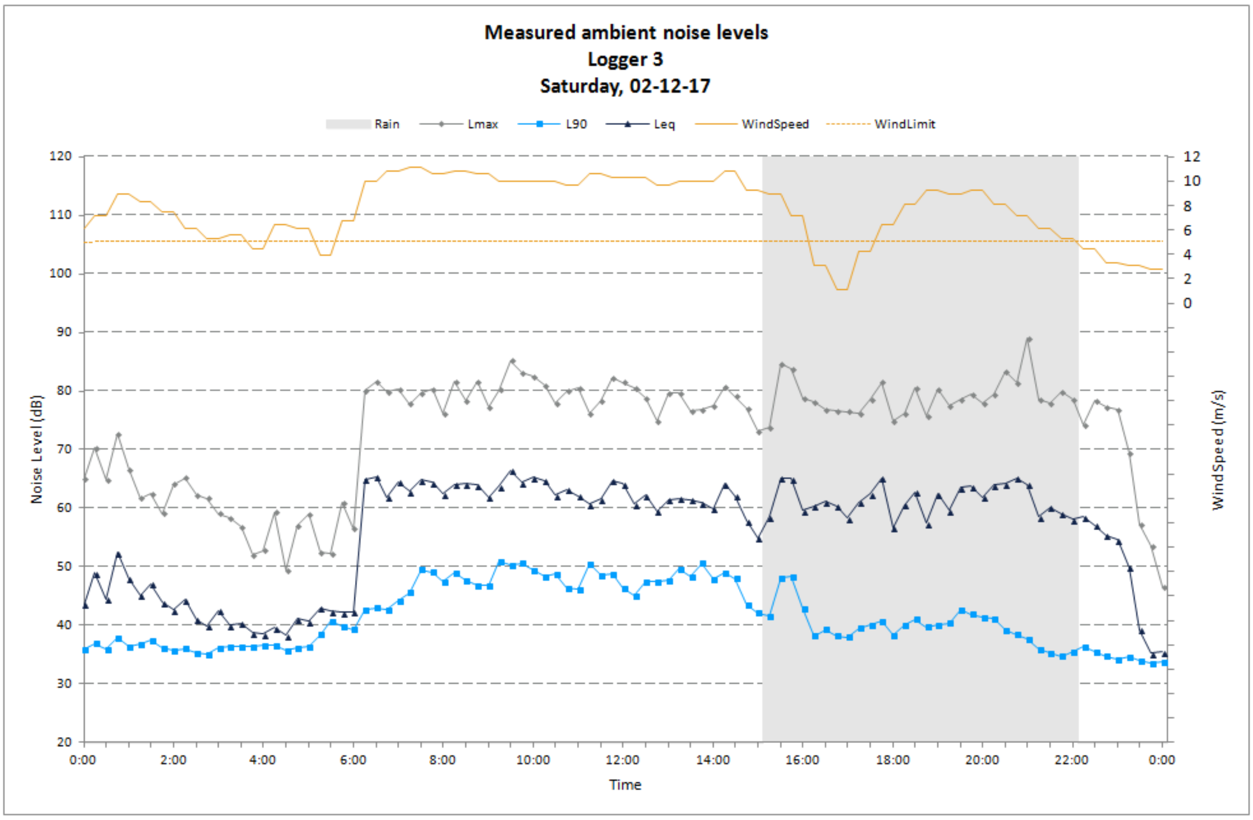

Measured ambient noise levels
Logger 2
Thursday, 21-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00



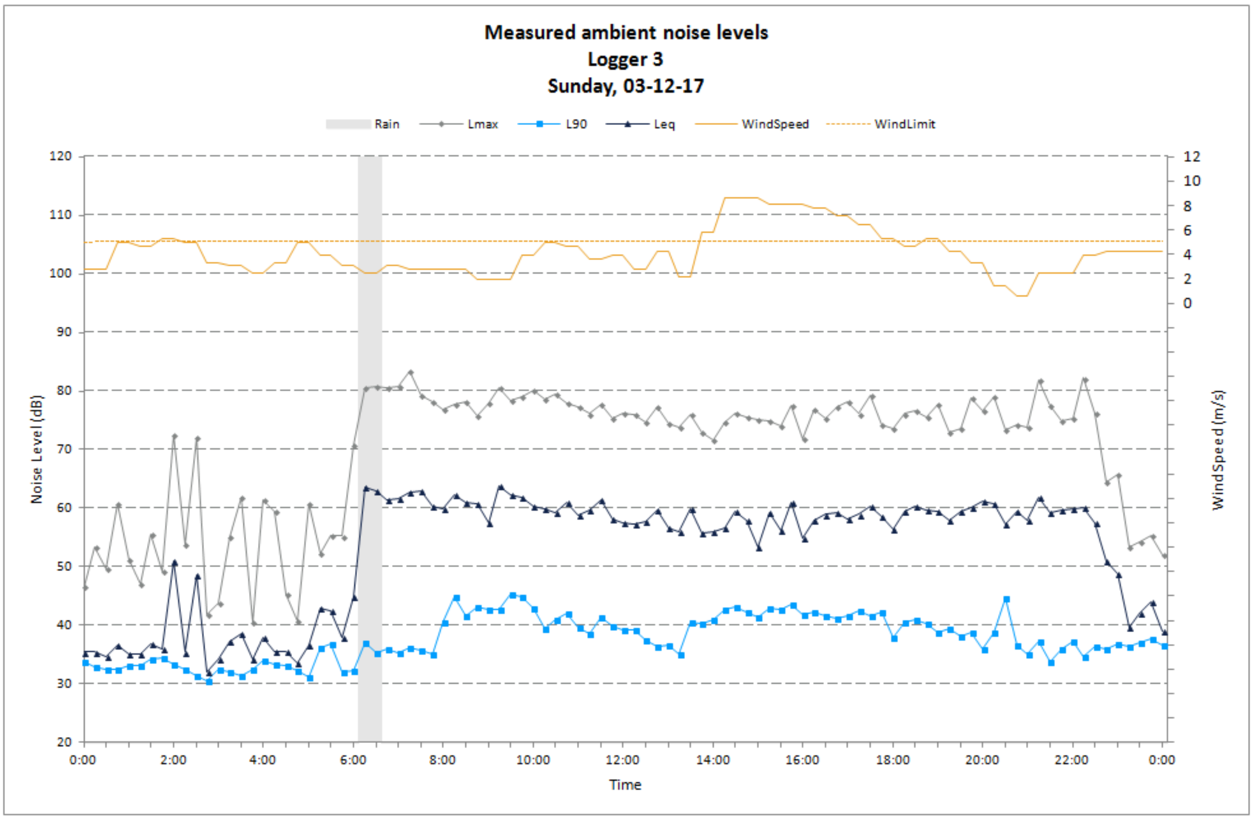
Measured ambient noise levels
Logger 3
Thursday, 30-11-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time



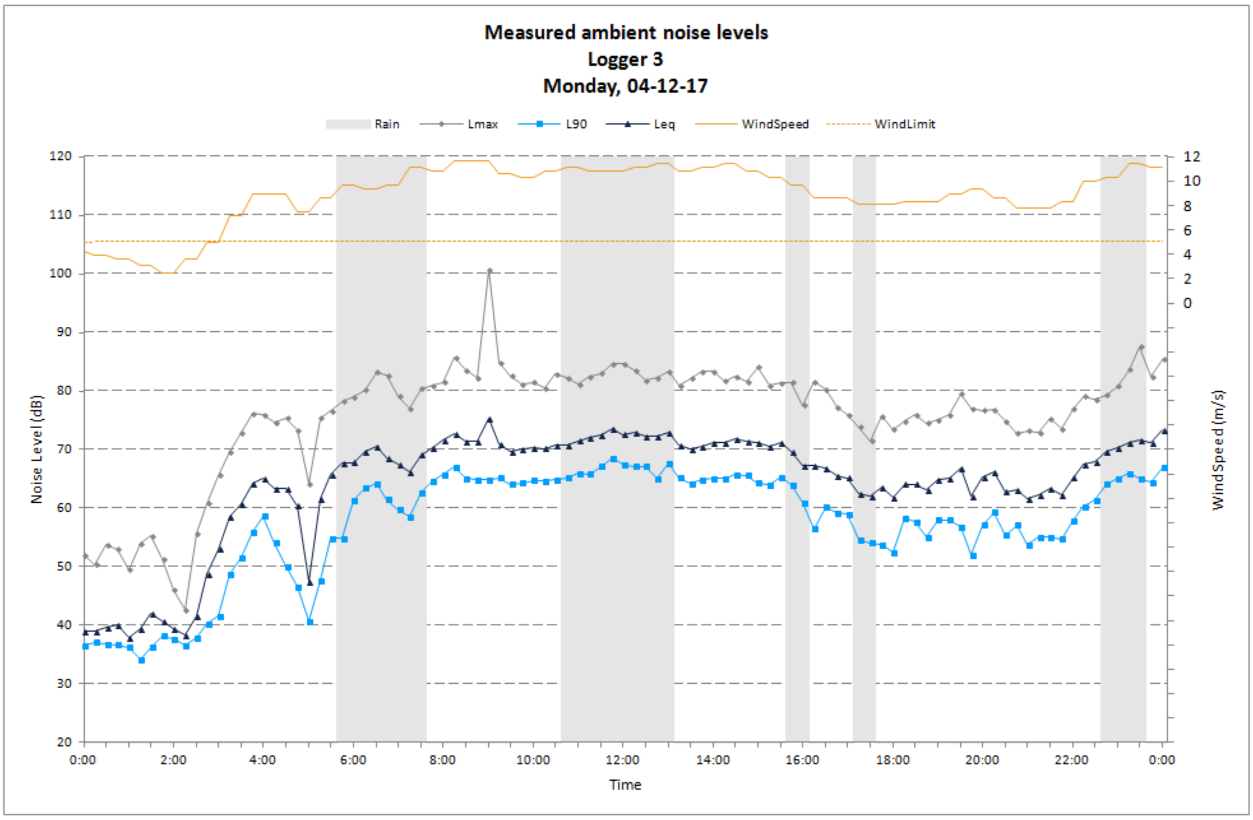
Measured ambient noise levels
Logger 3
Friday, 01-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time



Measured ambient noise levels
Logger 3
Saturday, 02-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Time
WindSpeed (m/s)



Measured ambient noise levels
Logger 3
Sunday, 03-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Time
WindSpeed (m/s)


Measured ambient noise levels
Logger 3
Monday, 04-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
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0:00
2:00
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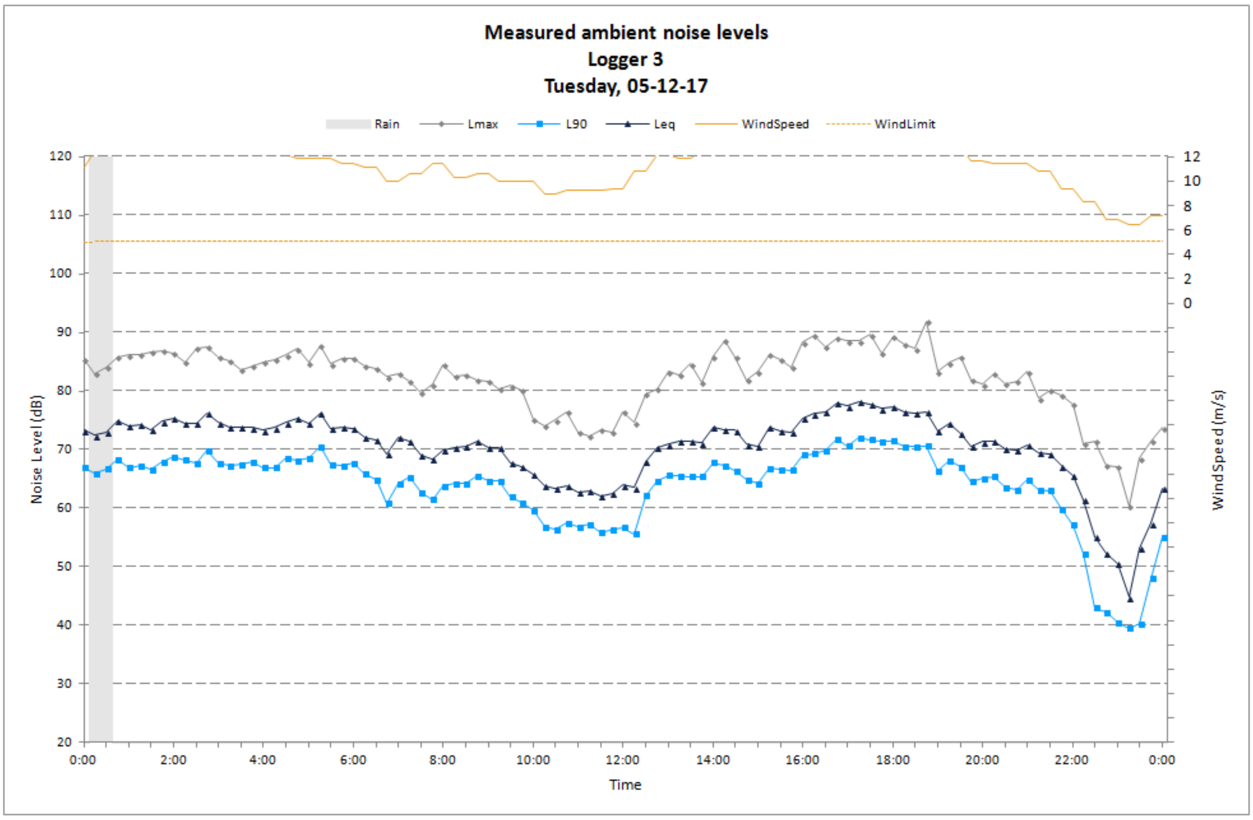
12:00
14:00
16:00
18:00
20:00
22:00
0:00


Measured ambient noise levels
Logger 3
Tuesday, 05-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
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20:00
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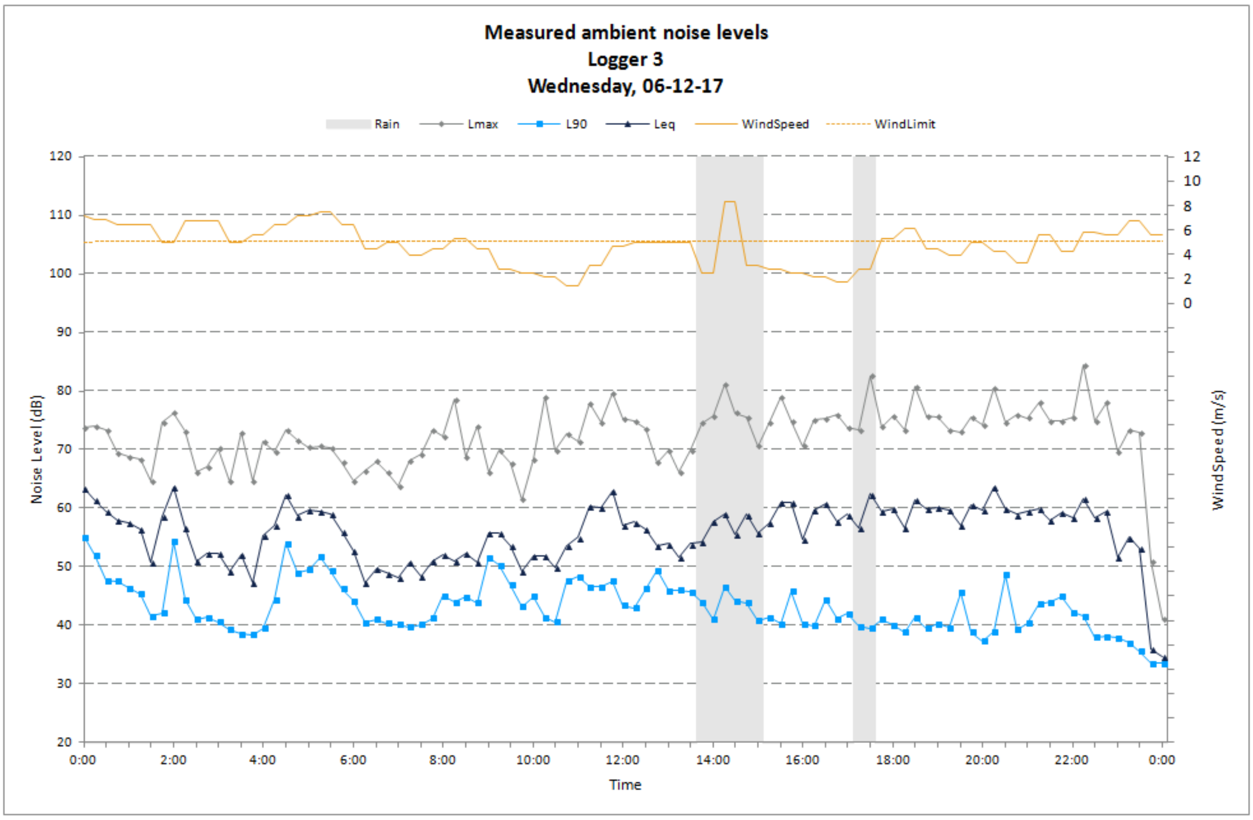
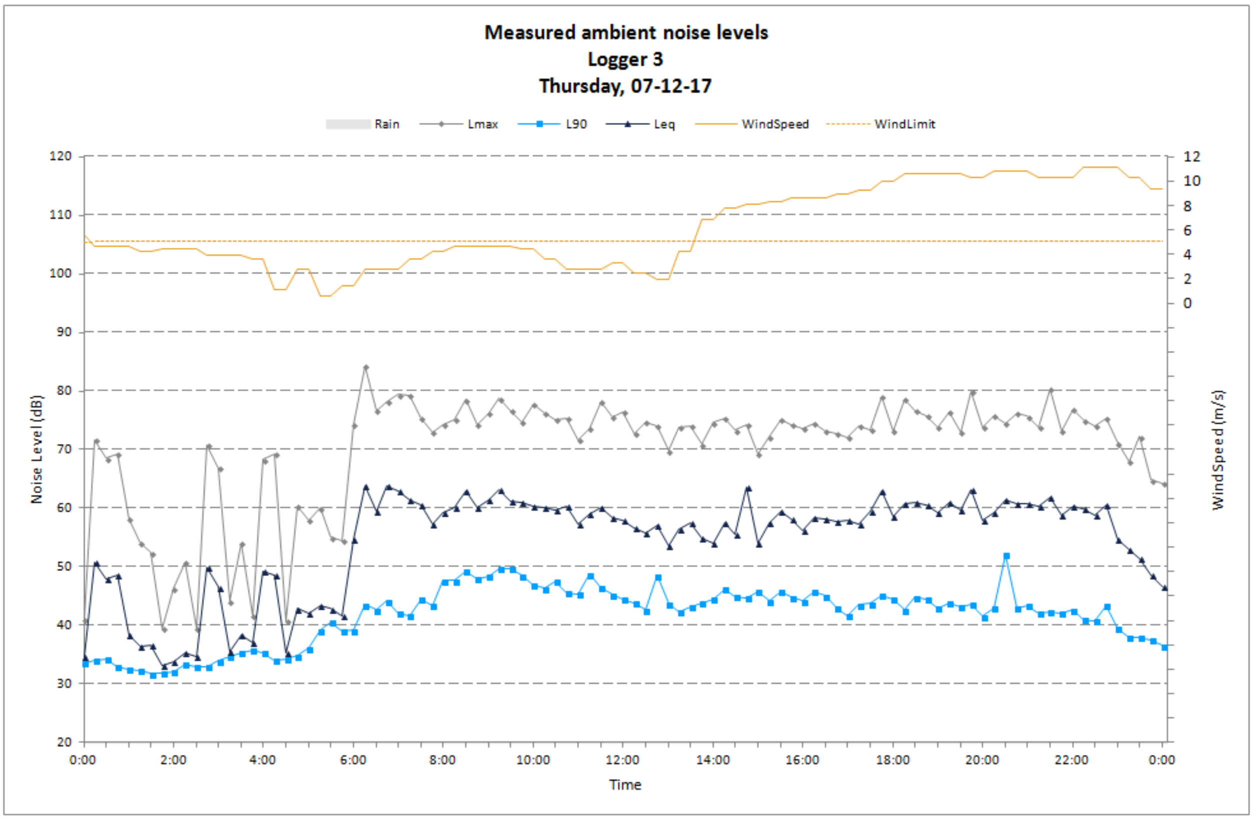
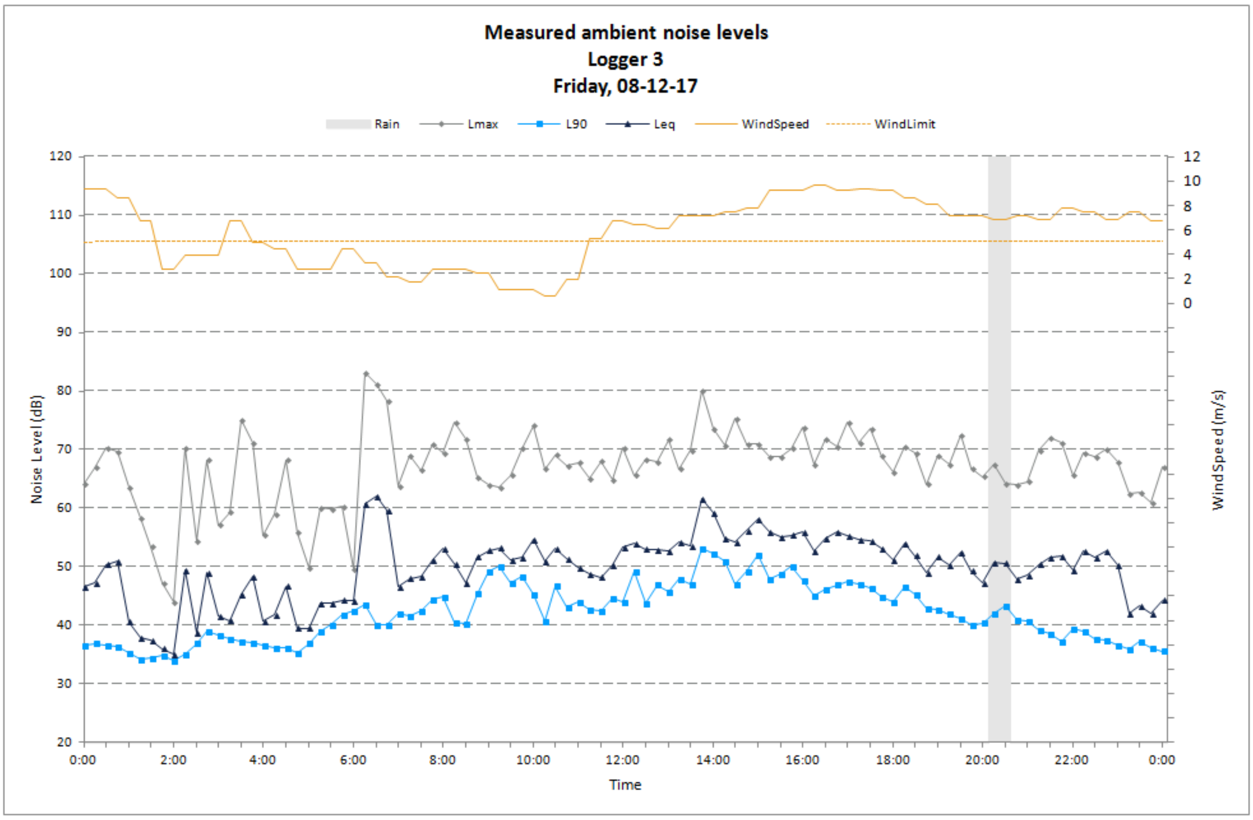
0:00


Measured ambient noise levels
Logger 3
Wednesday, 06-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 3
Thursday, 07-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 3
Friday, 08-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
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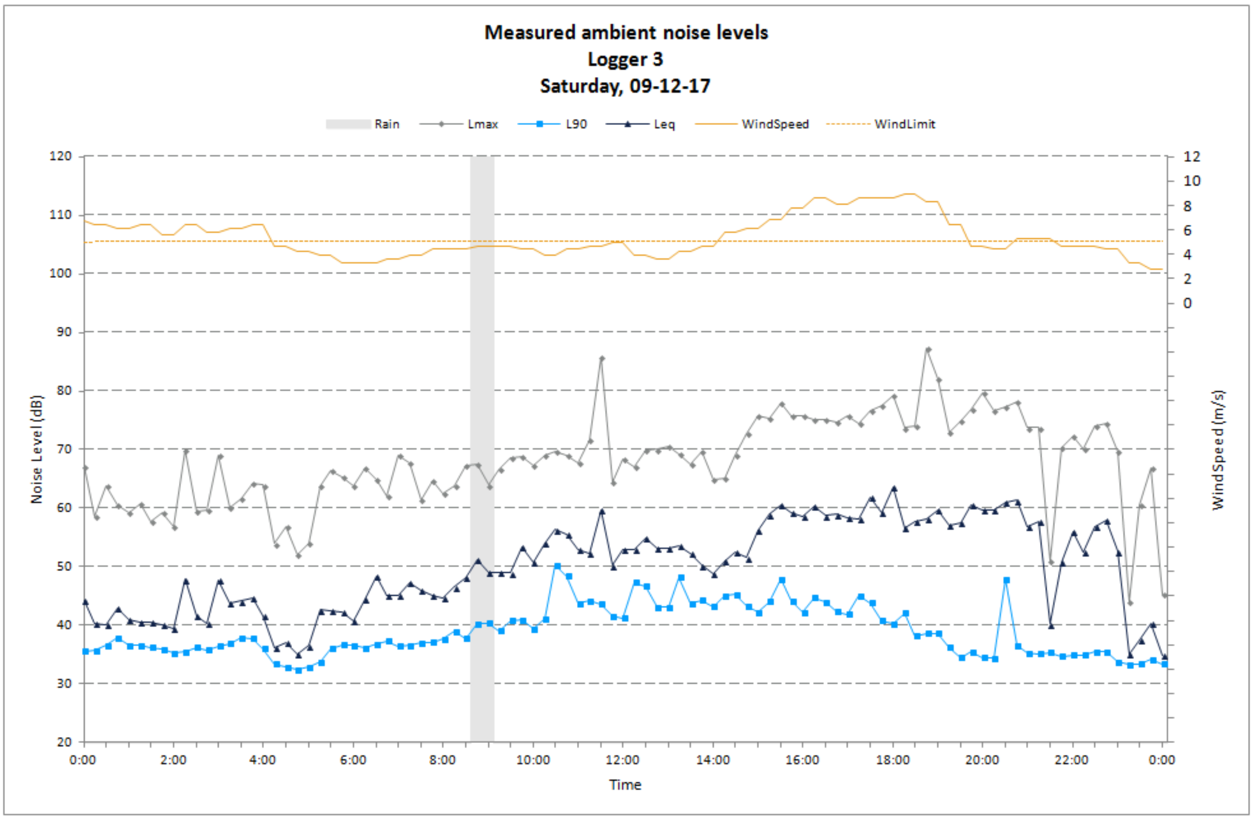
Measured ambient noise levels
Logger 3
Saturday, 09-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
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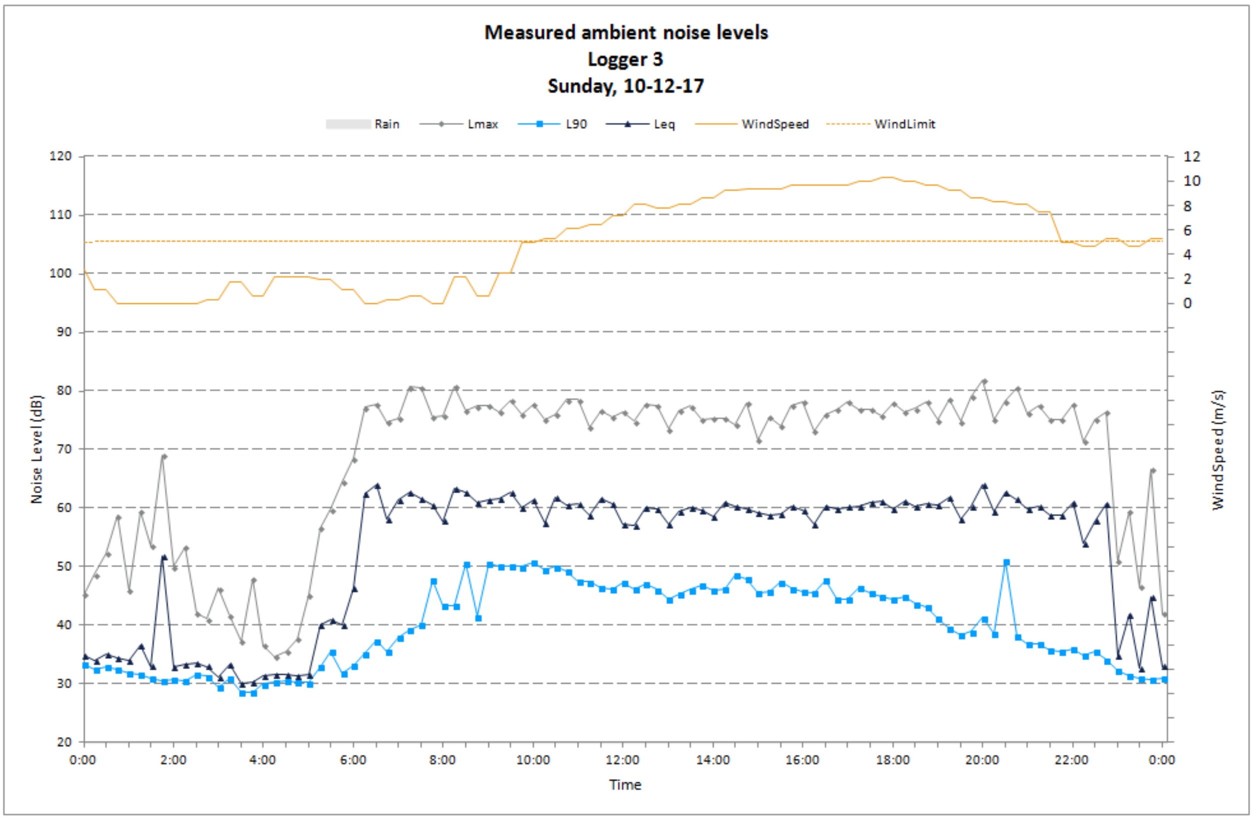
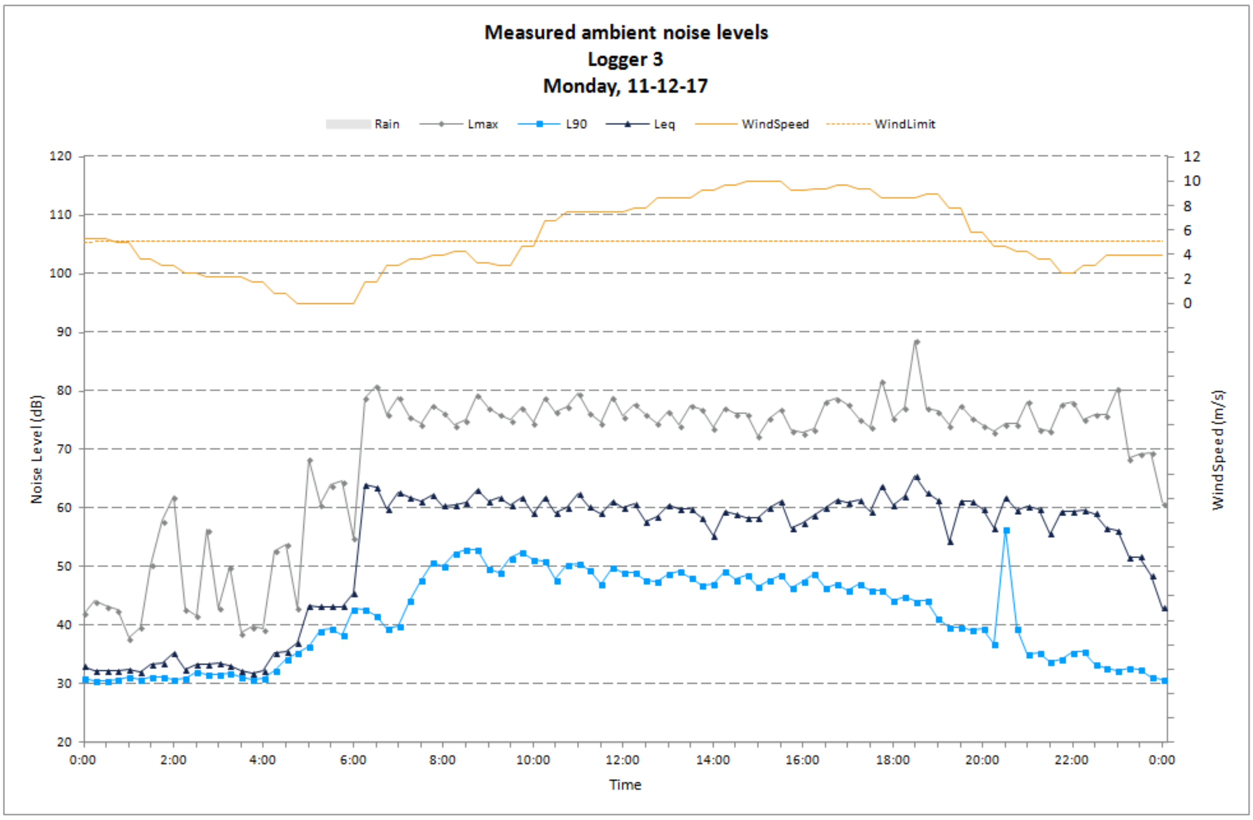
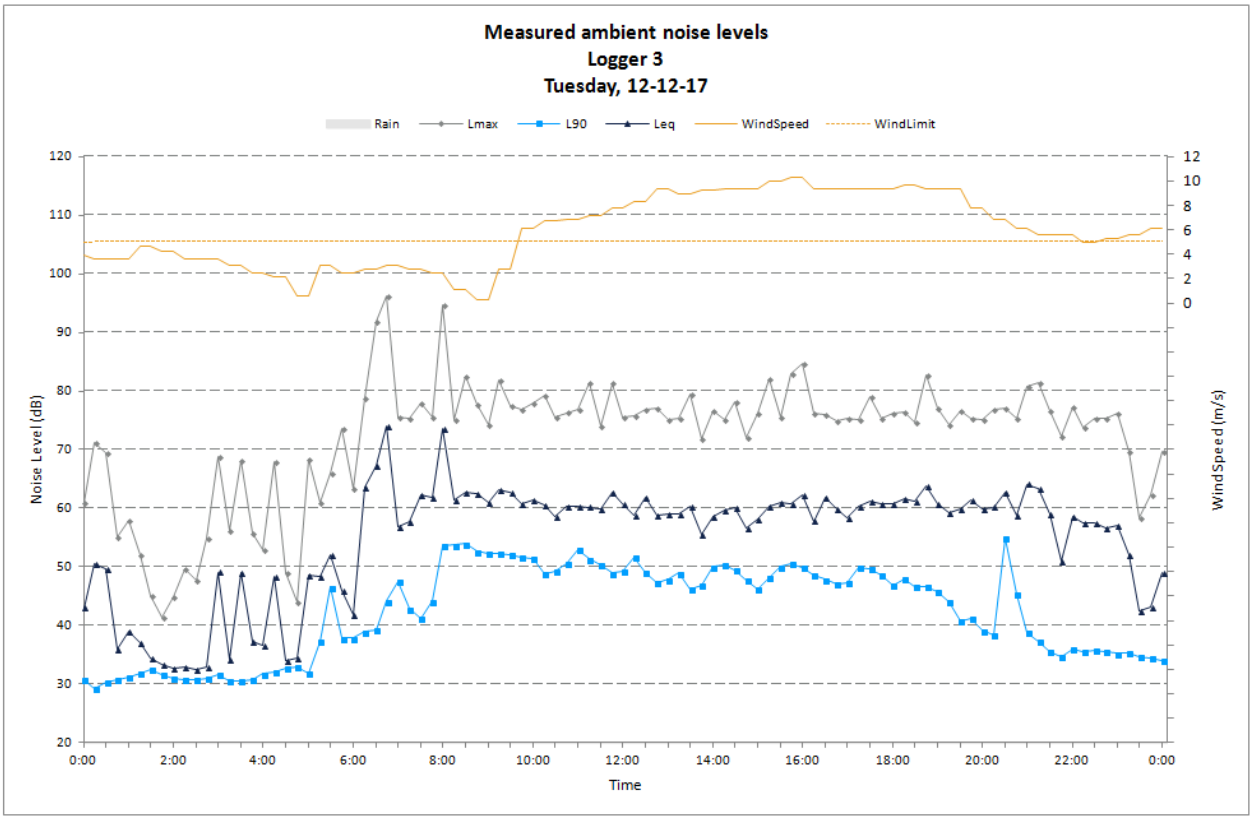

Measured ambient noise levels
Logger 3
Sunday, 10-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 3
Monday, 11-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 3
Tuesday, 12-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
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12:00
14:00
16:00
18:00
20:00
22:00
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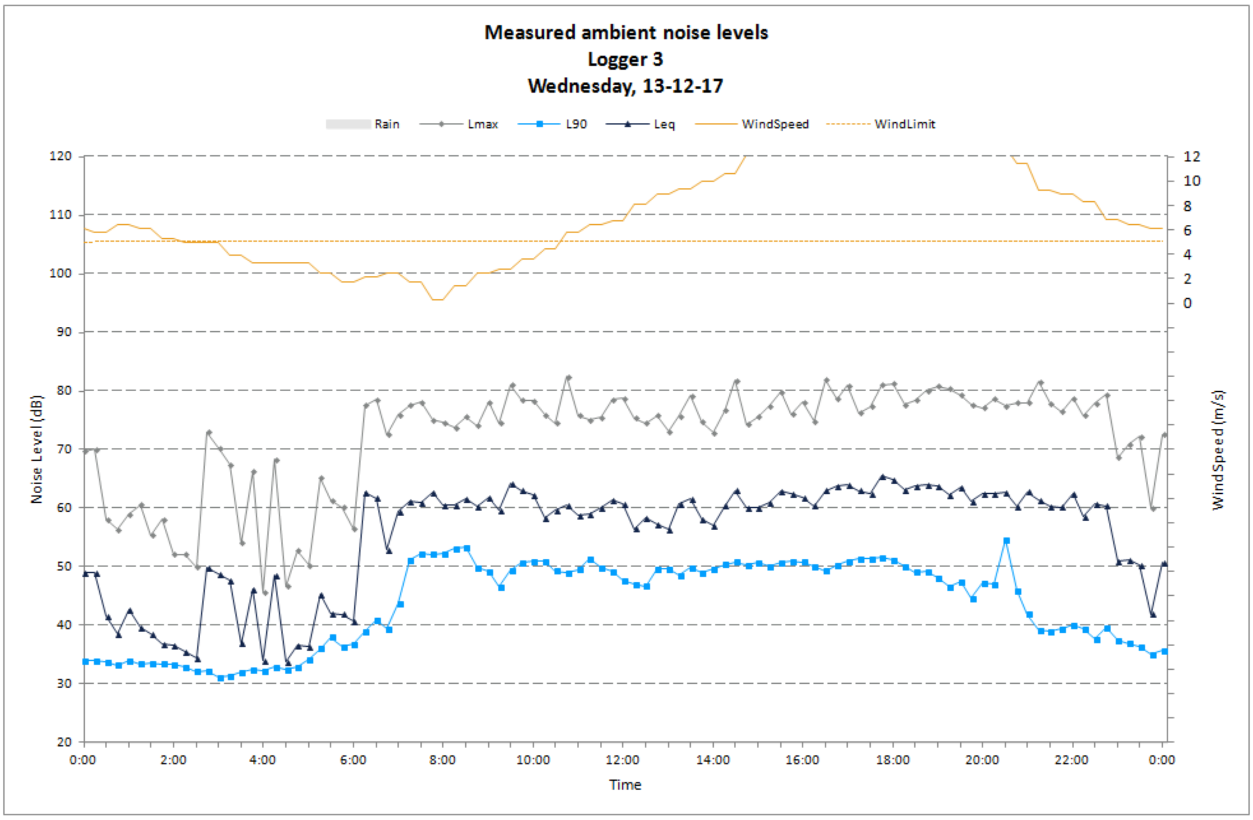
Measured ambient noise levels
Logger 3
Wednesday, 13-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
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80
70
60
50
40
30
20
12
10
8
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0:00
2:00
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12:00
14:00
16:00
18:00
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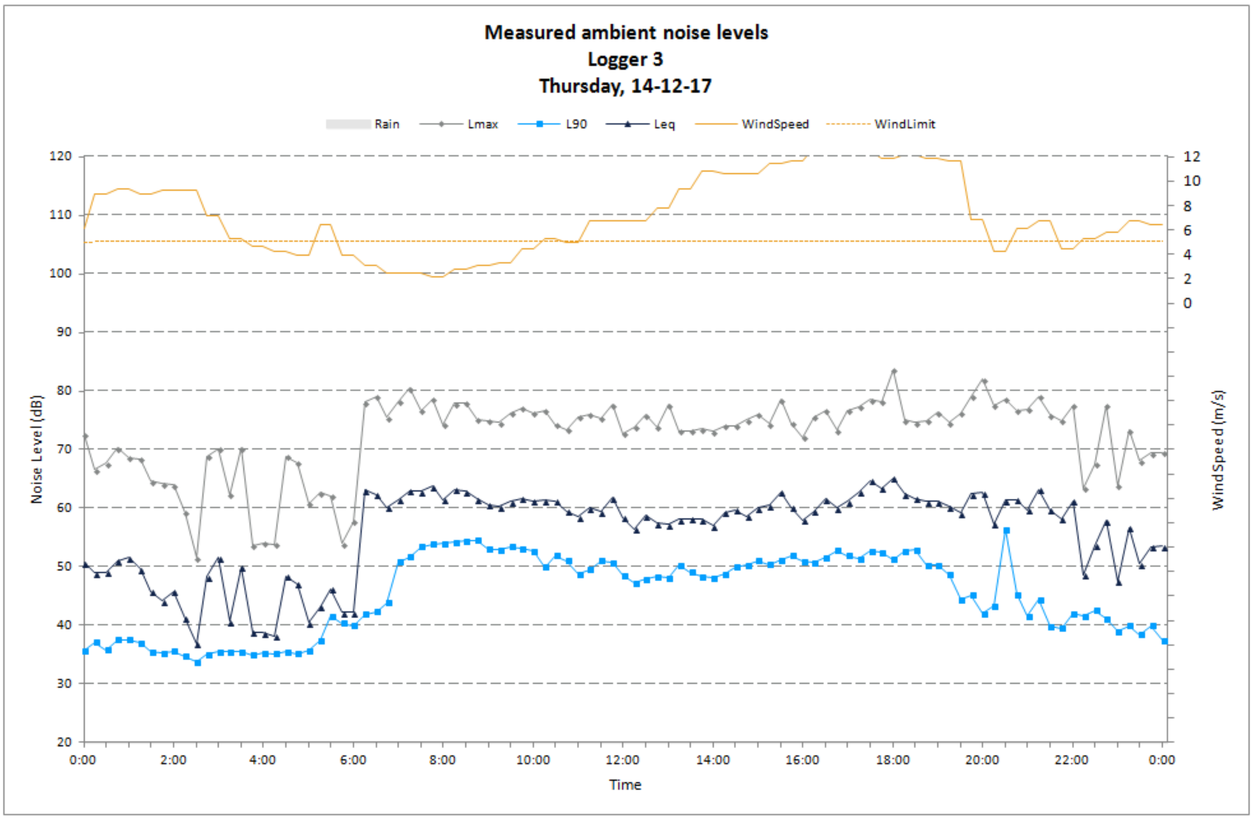
22:00
0:00


Measured ambient noise levels
Logger 3
Thursday, 14-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
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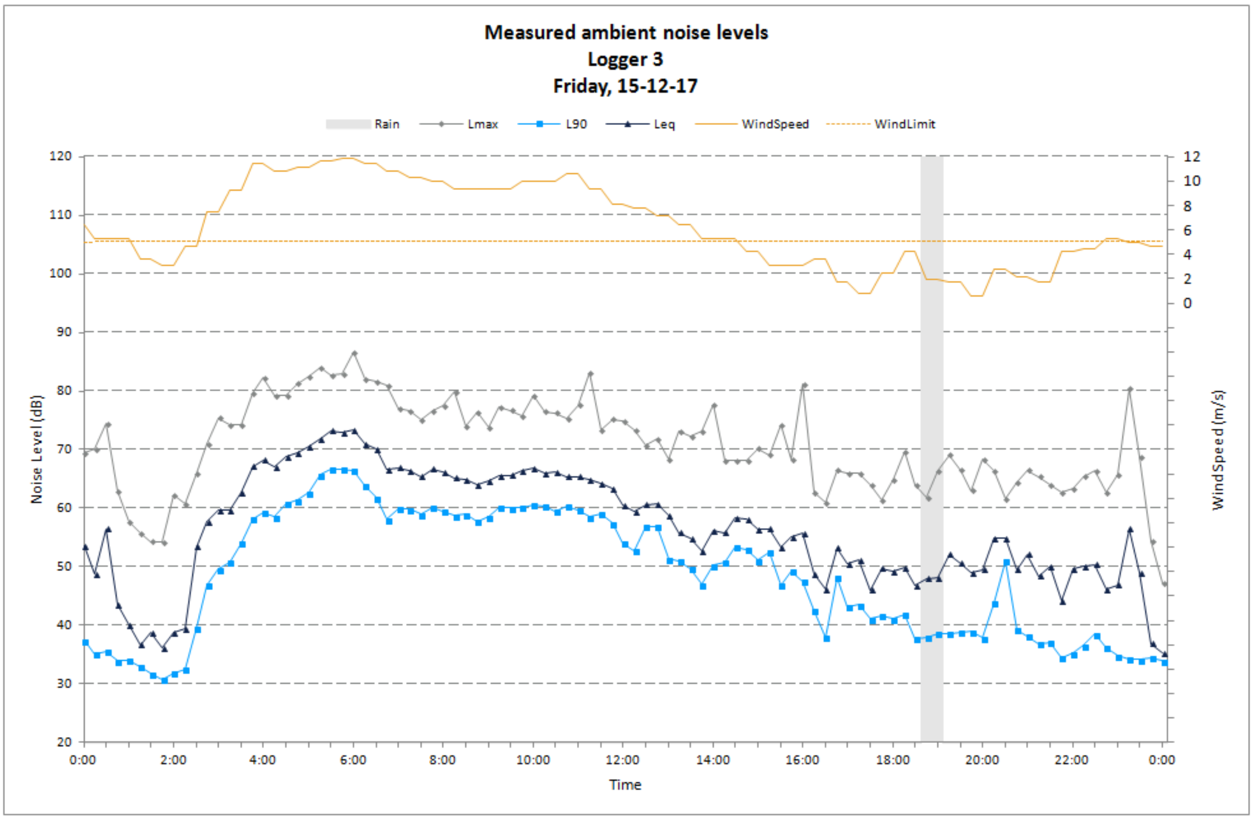
12:00
14:00
16:00
18:00
20:00
22:00
0:00


Measured ambient noise levels
Logger 3
Friday, 15-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
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0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
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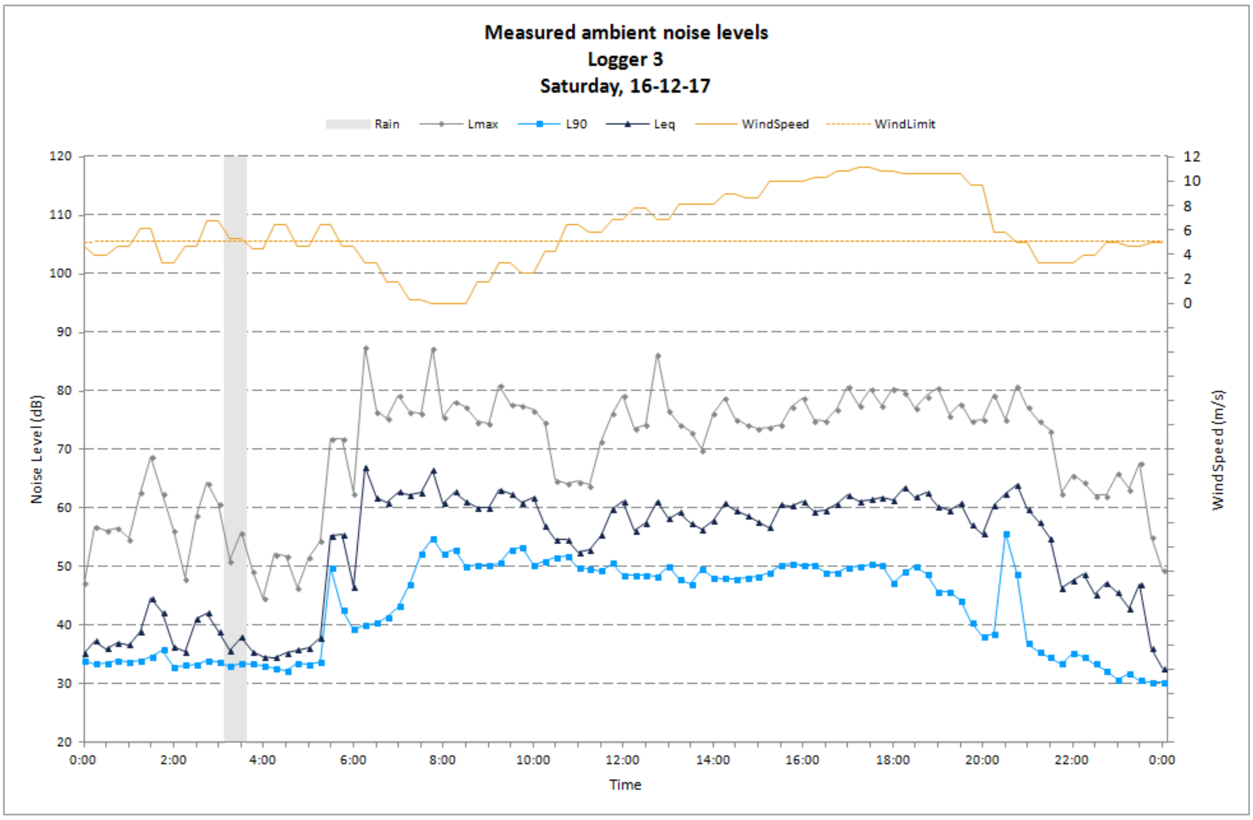
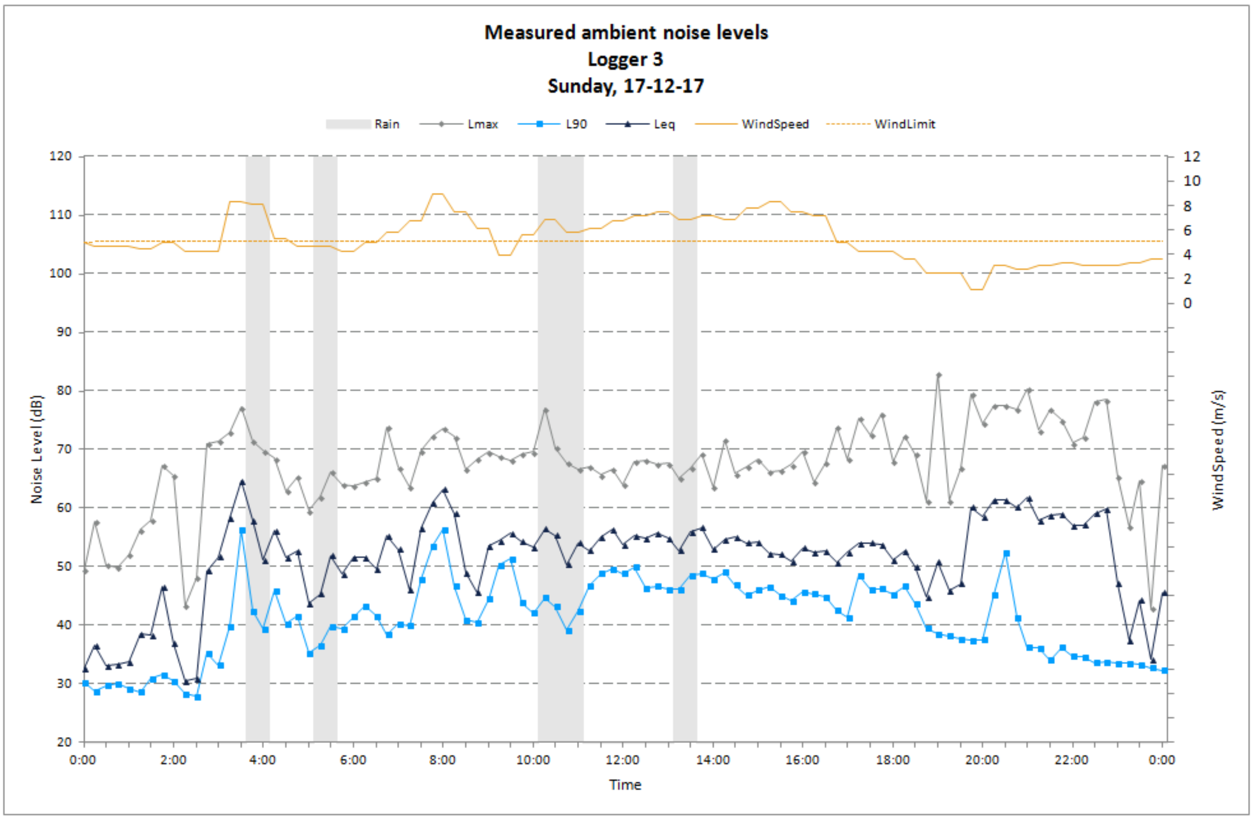
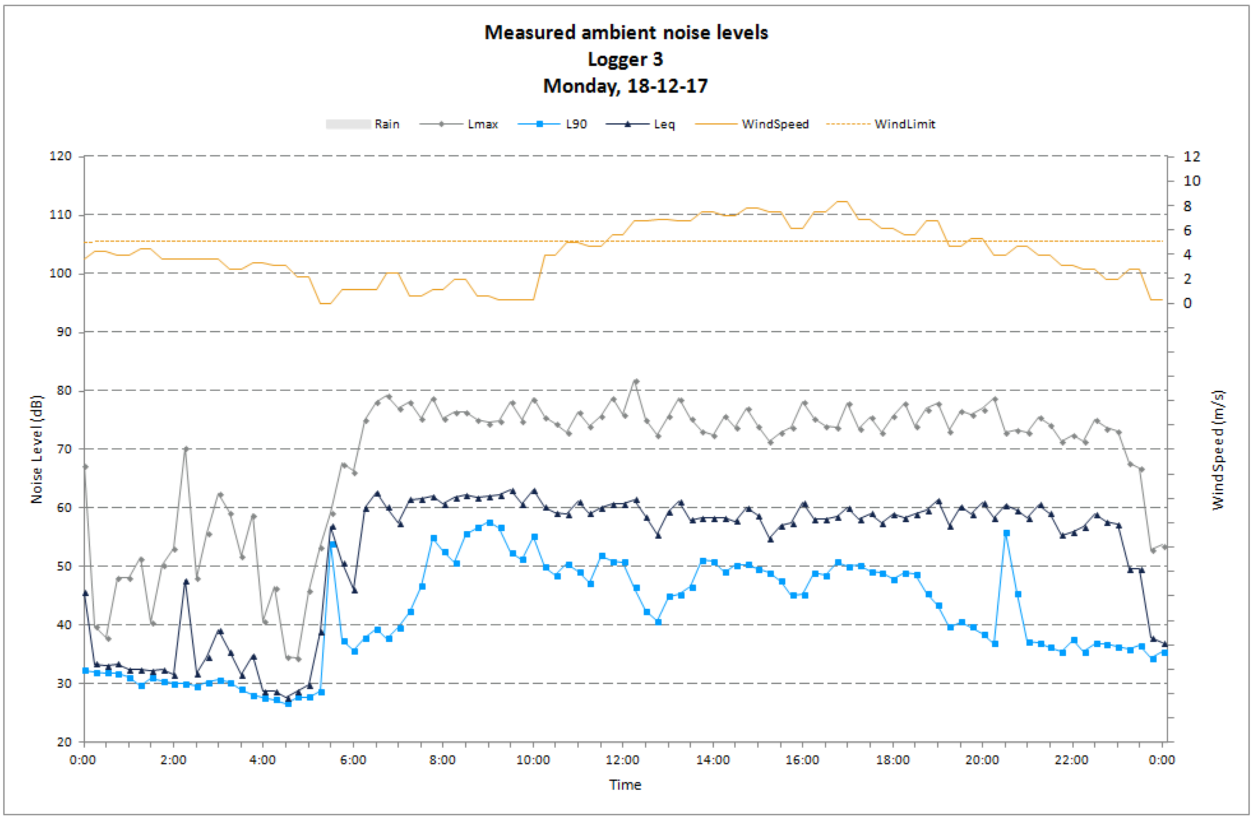
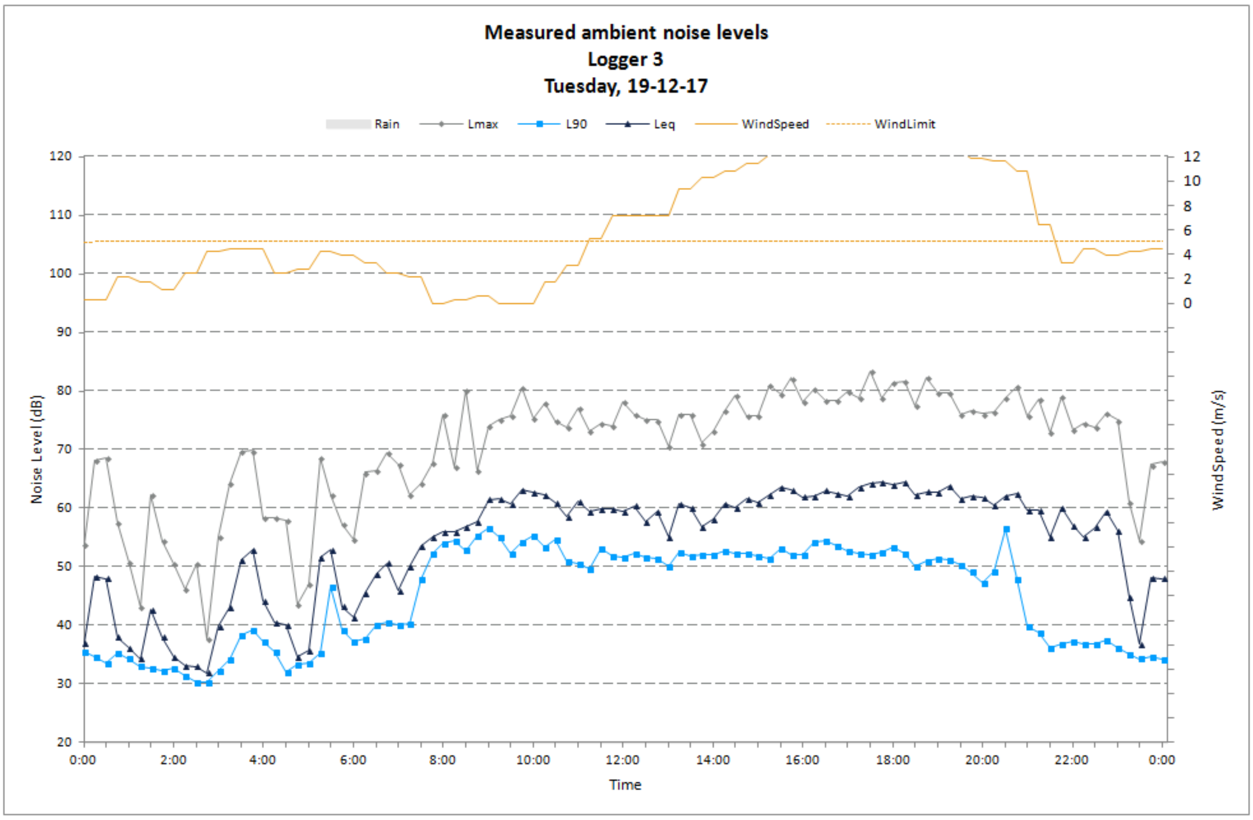

Measured ambient noise levels
Logger 3
Saturday, 16-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time

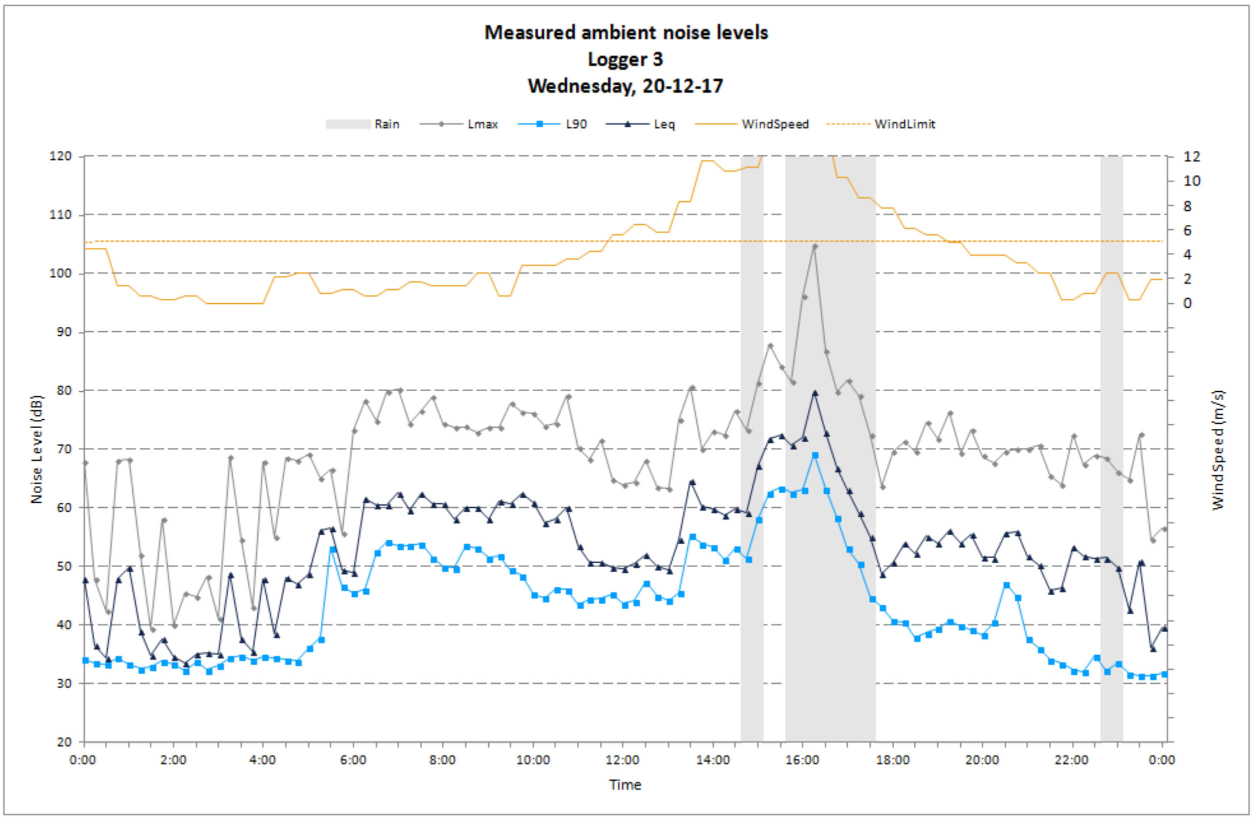

Measured ambient noise levels
Logger 3
Sunday, 17-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time



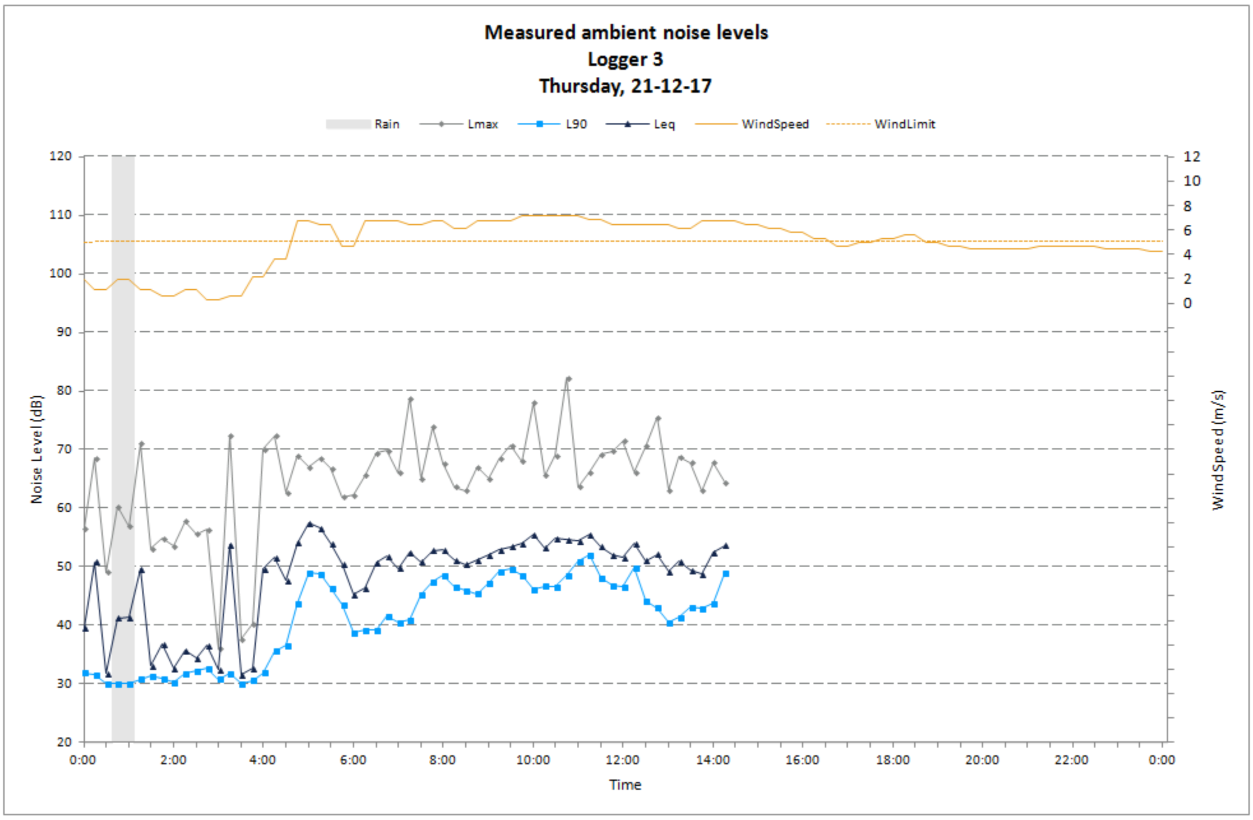
Measured ambient noise levels
Logger 3
Monday, 18-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time



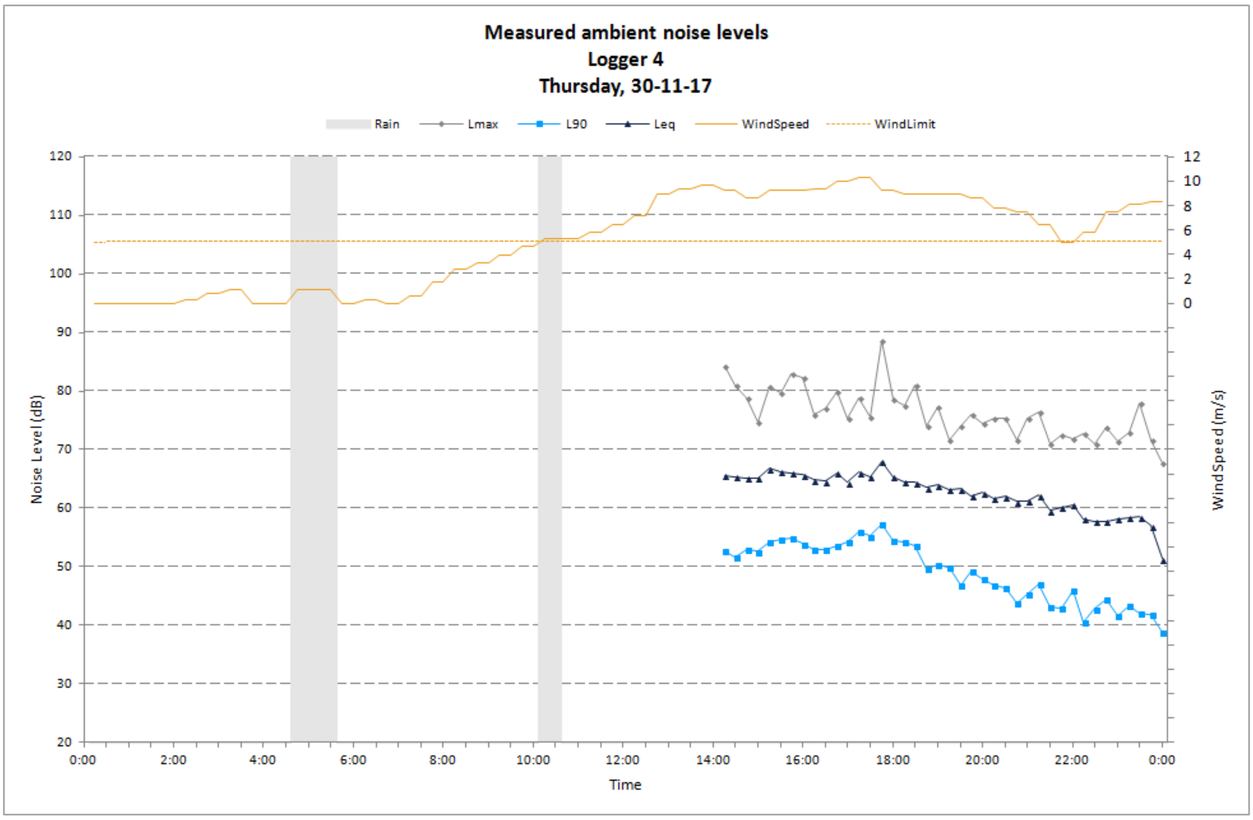
Measured ambient noise levels
Logger 3
Tuesday, 19-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time



Measured ambient noise levels
Logger 3
Wednesday, 20-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time



Measured ambient noise levels
Logger 3
Thursday, 21-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 4
Thursday, 30-11-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
120
110
100
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80
70
60
50
40
30
20
12
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0:00
2:00
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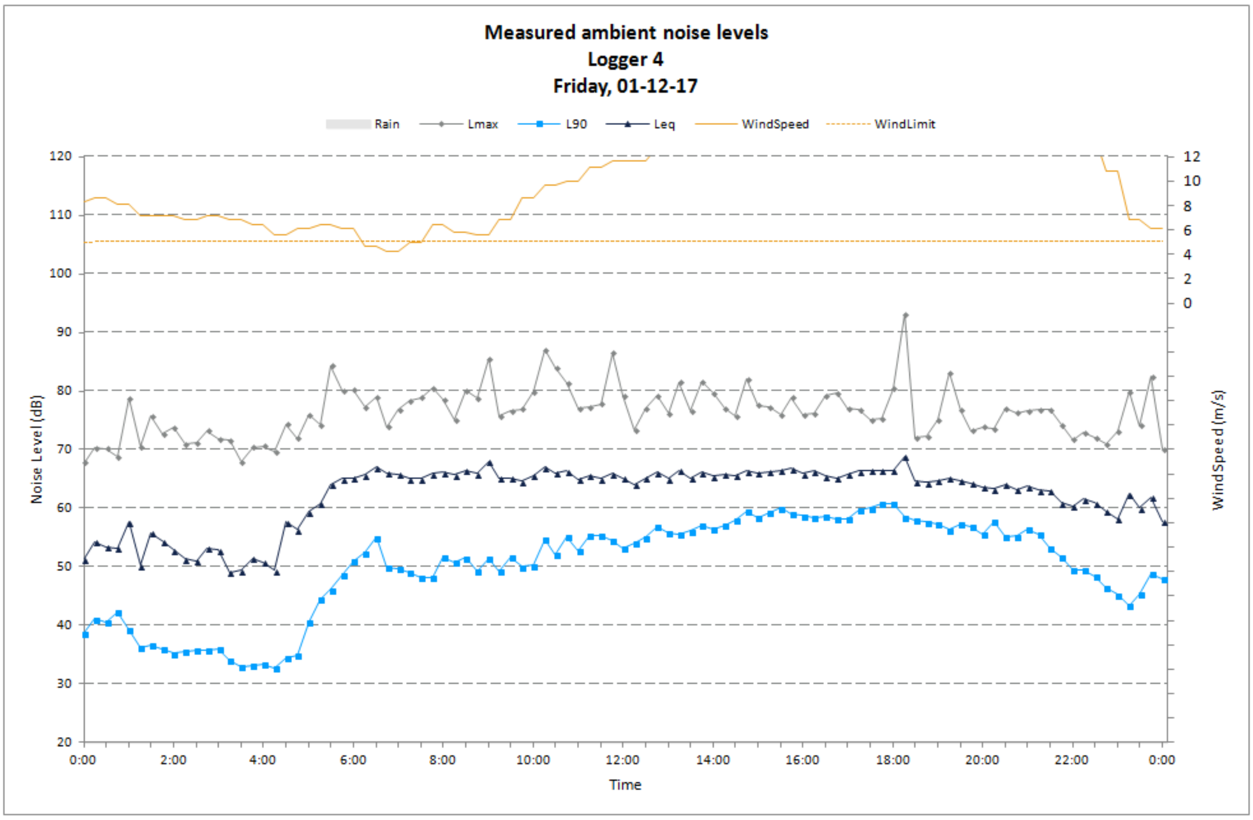
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time


Measured ambient noise levels
Logger 4
Friday, 01-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
120
110
100
90
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70
60
50
40
30
20
12
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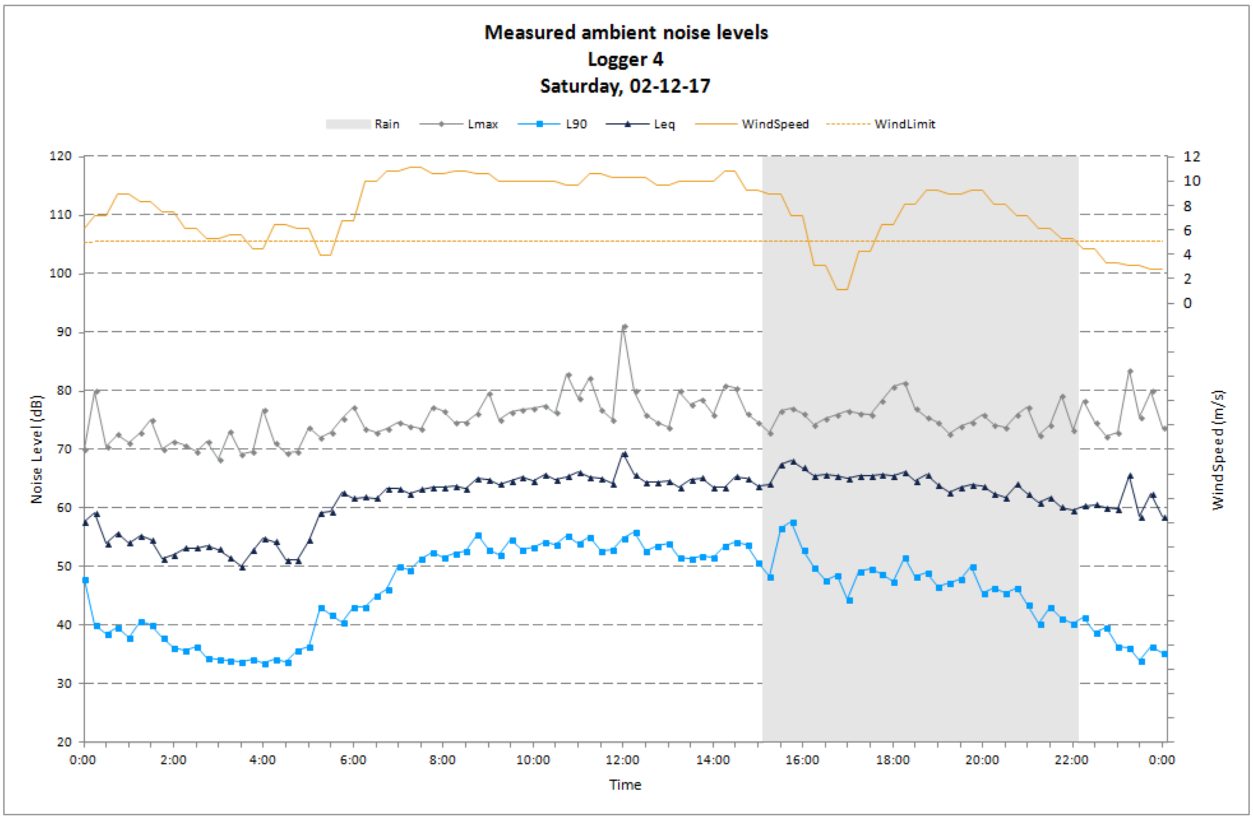
16:00
18:00
20:00
22:00
0:00
Time


Measured ambient noise levels
Logger 4
Saturday, 02-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
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100
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70
60
50
40
30
20
12
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22:00
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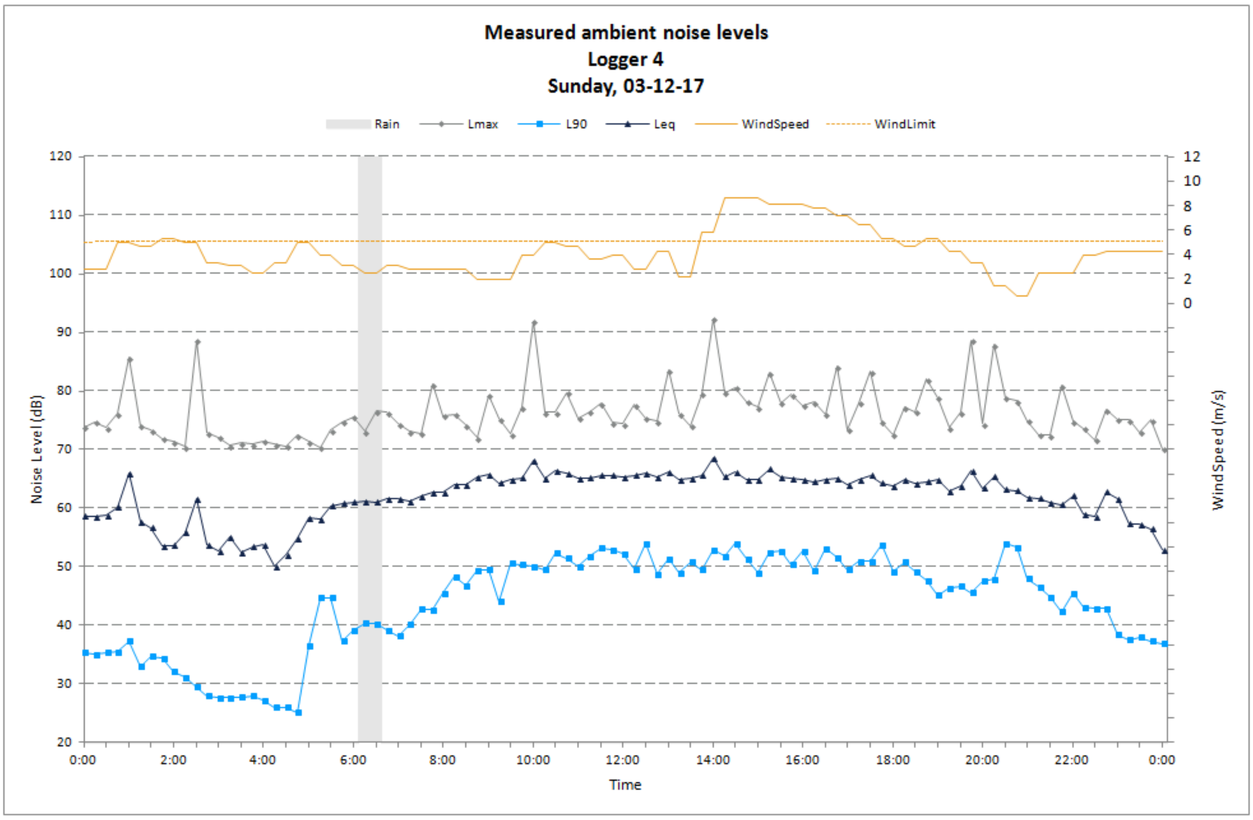
Measured ambient noise levels
Logger 4
Sunday, 03-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
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22:00
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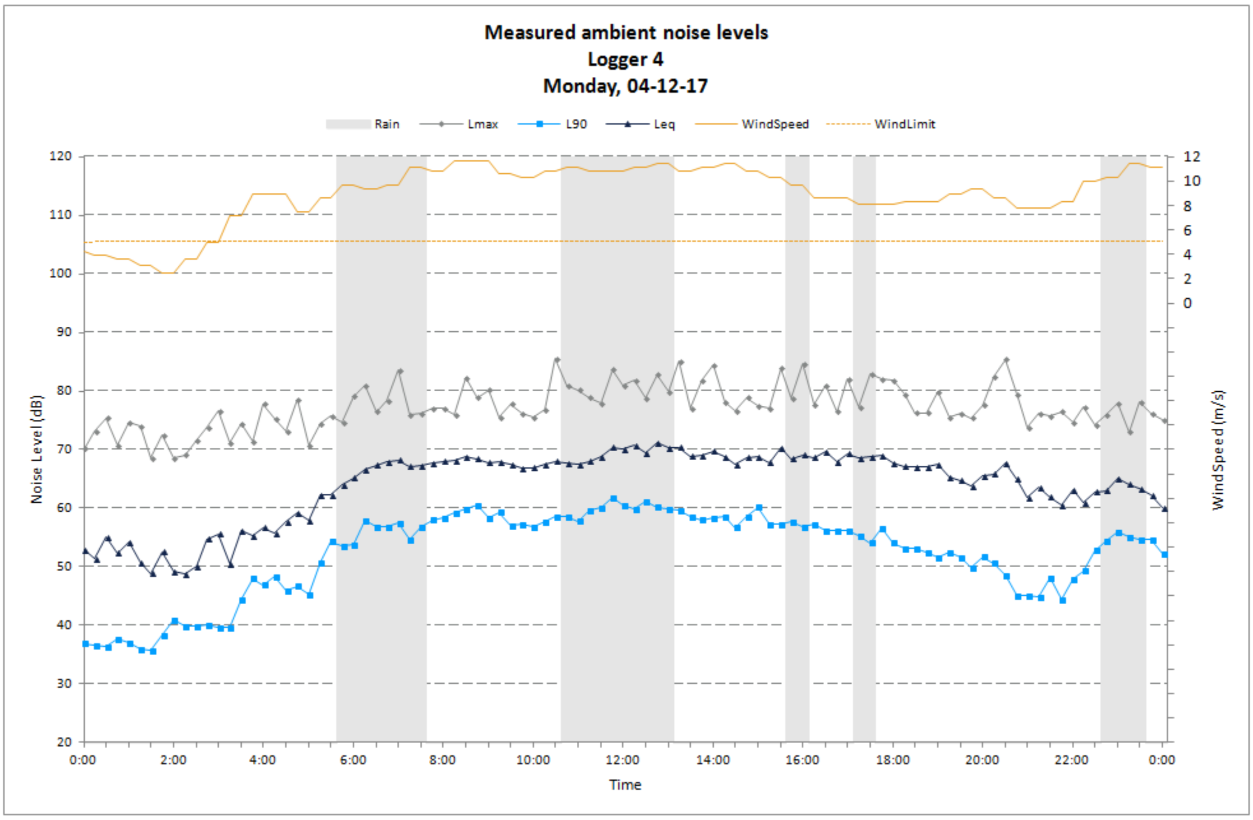
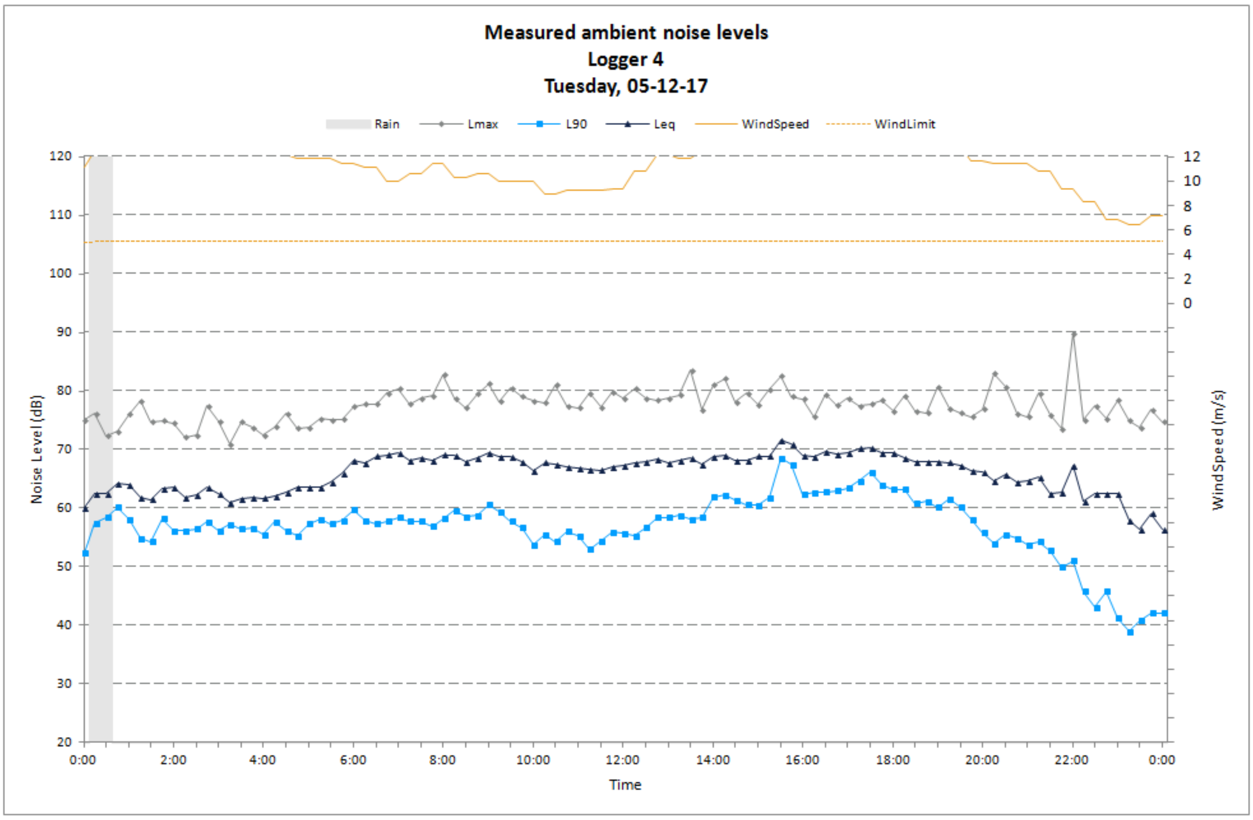
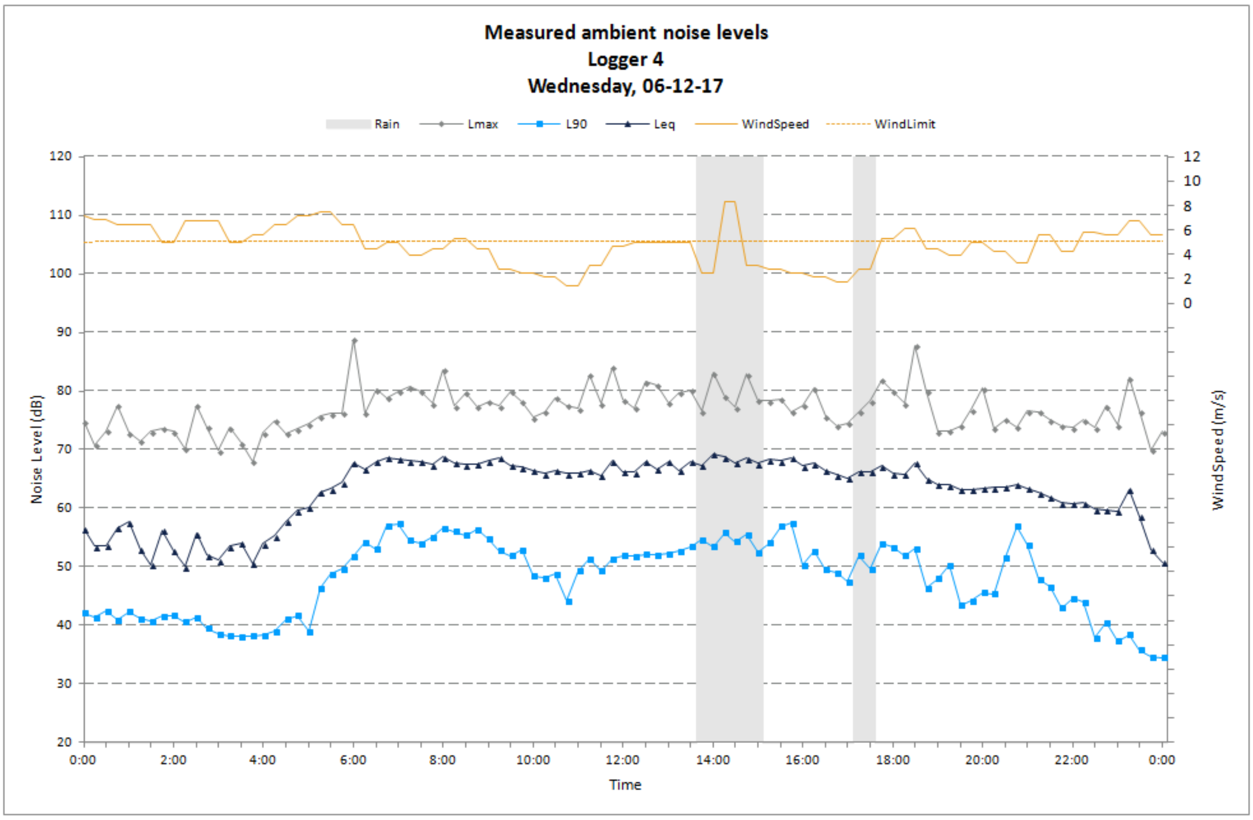

Measured ambient noise levels
Logger 4
Monday, 04-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 4
Tuesday, 05-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 4
Wednesday, 06-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
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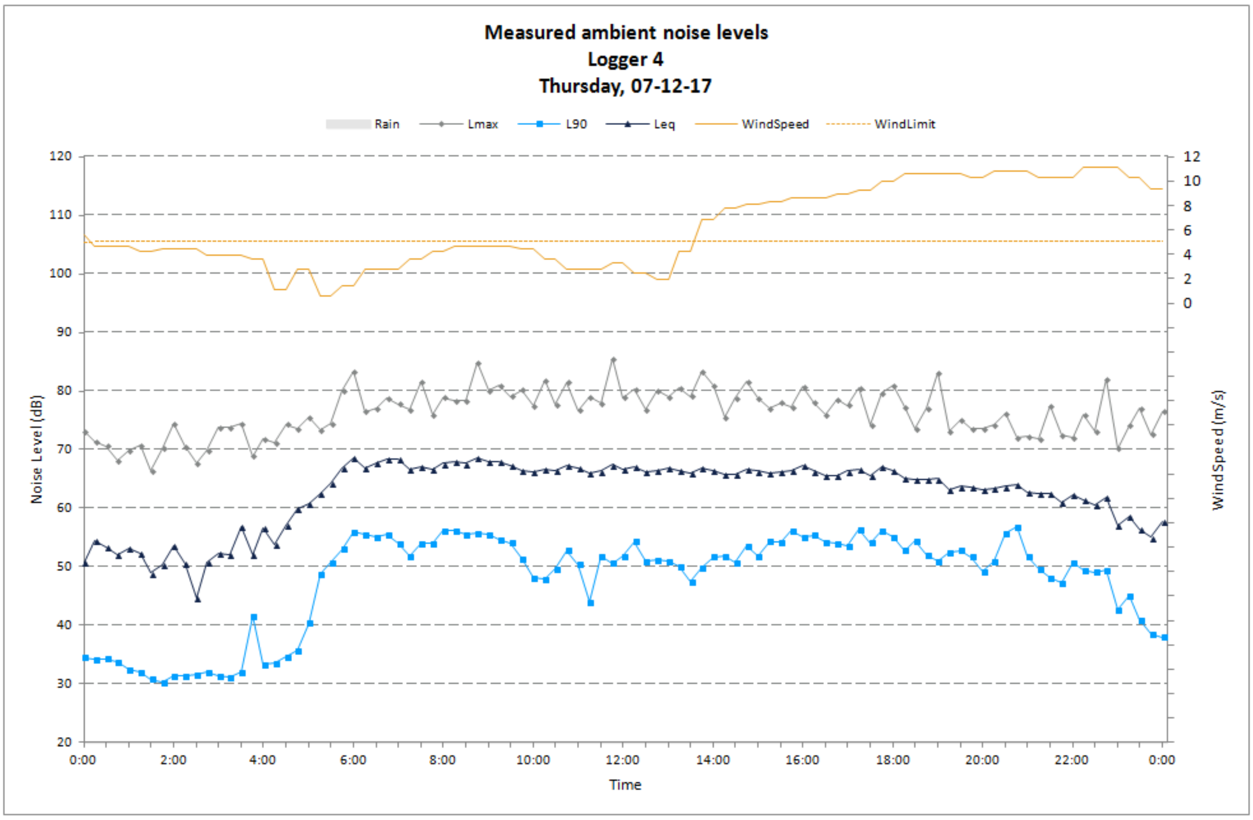
Measured ambient noise levels
Logger 4
Thursday, 07-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
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60
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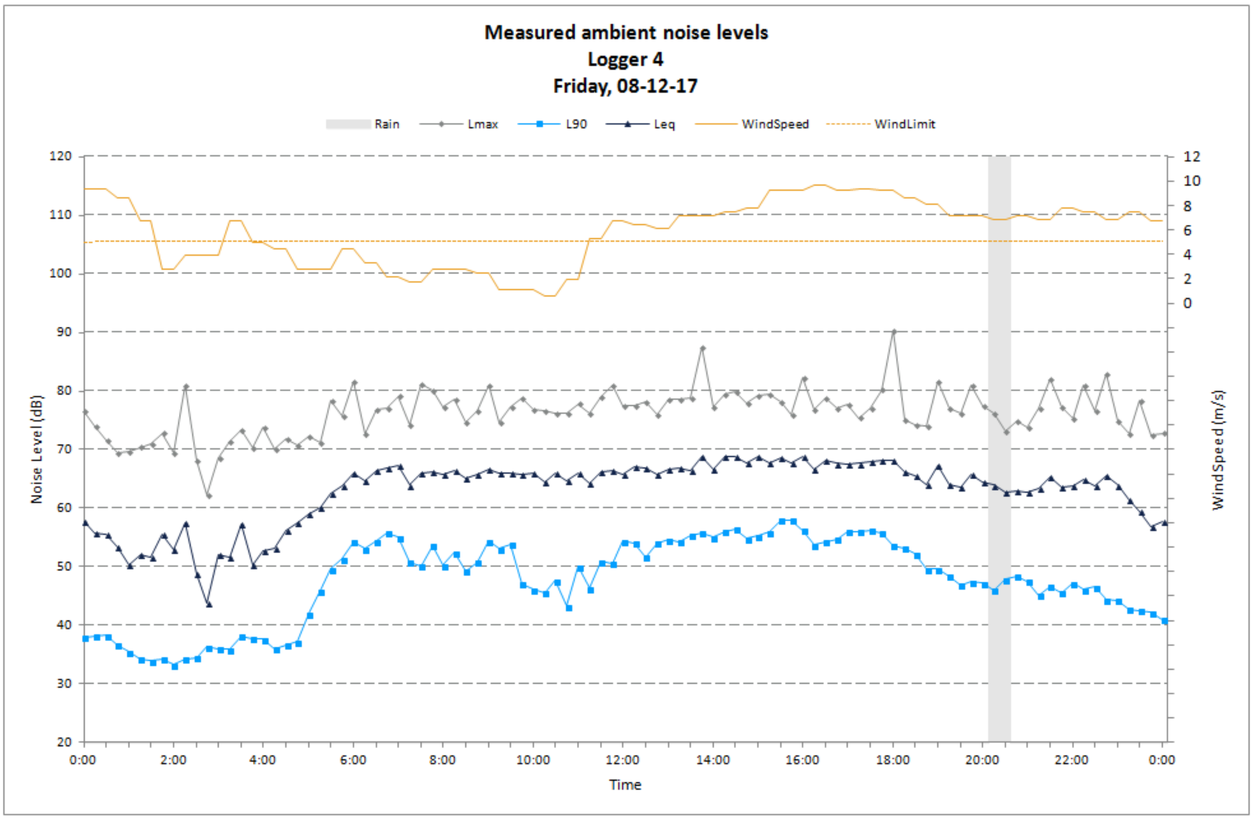
Measured ambient noise levels
Logger 4
Friday, 08-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
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20
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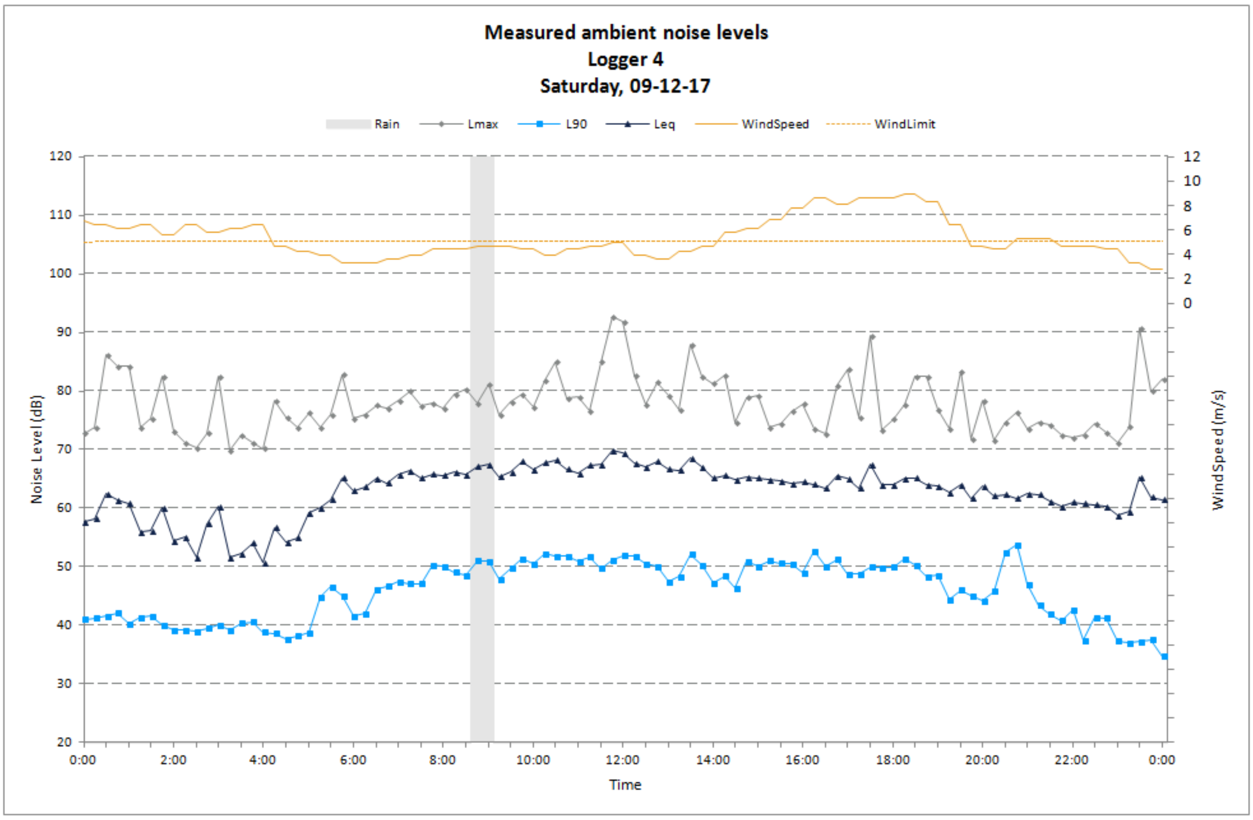
Measured ambient noise levels
Logger 4
Saturday, 09-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
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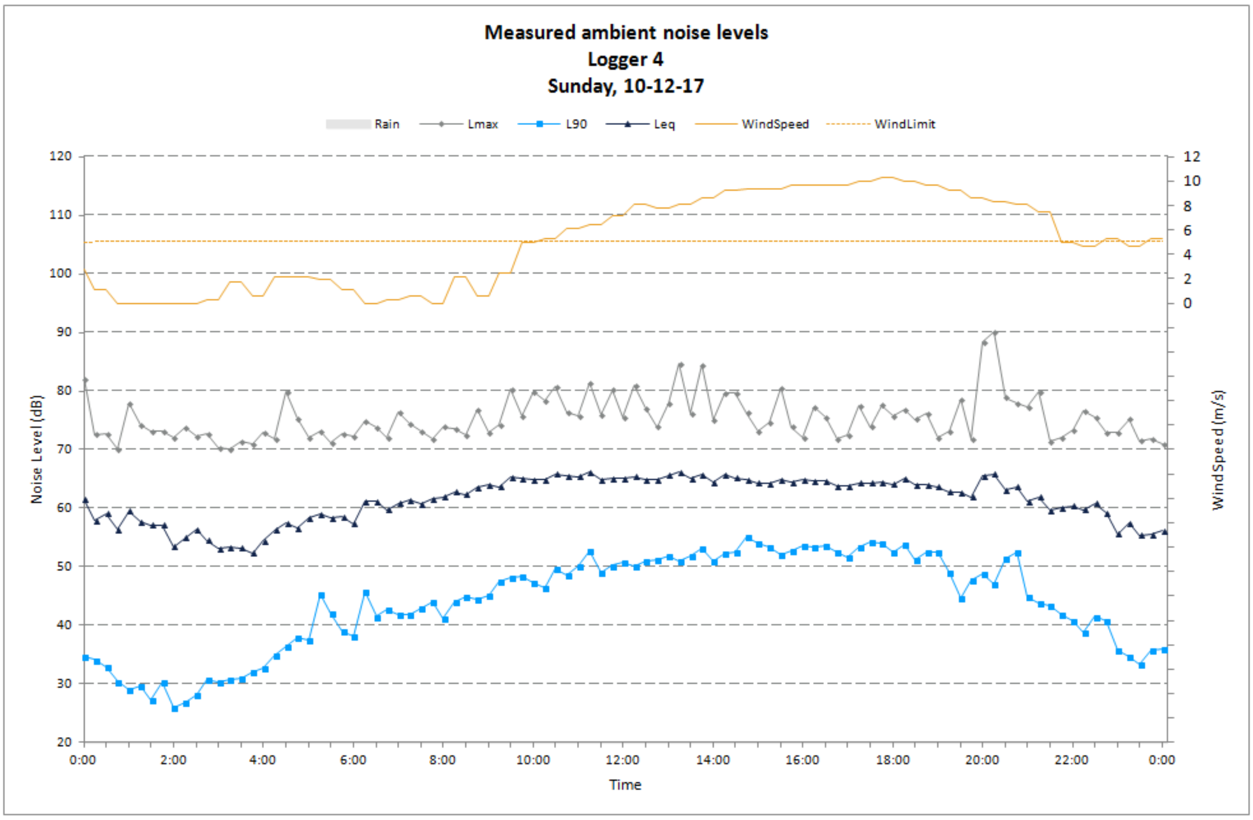
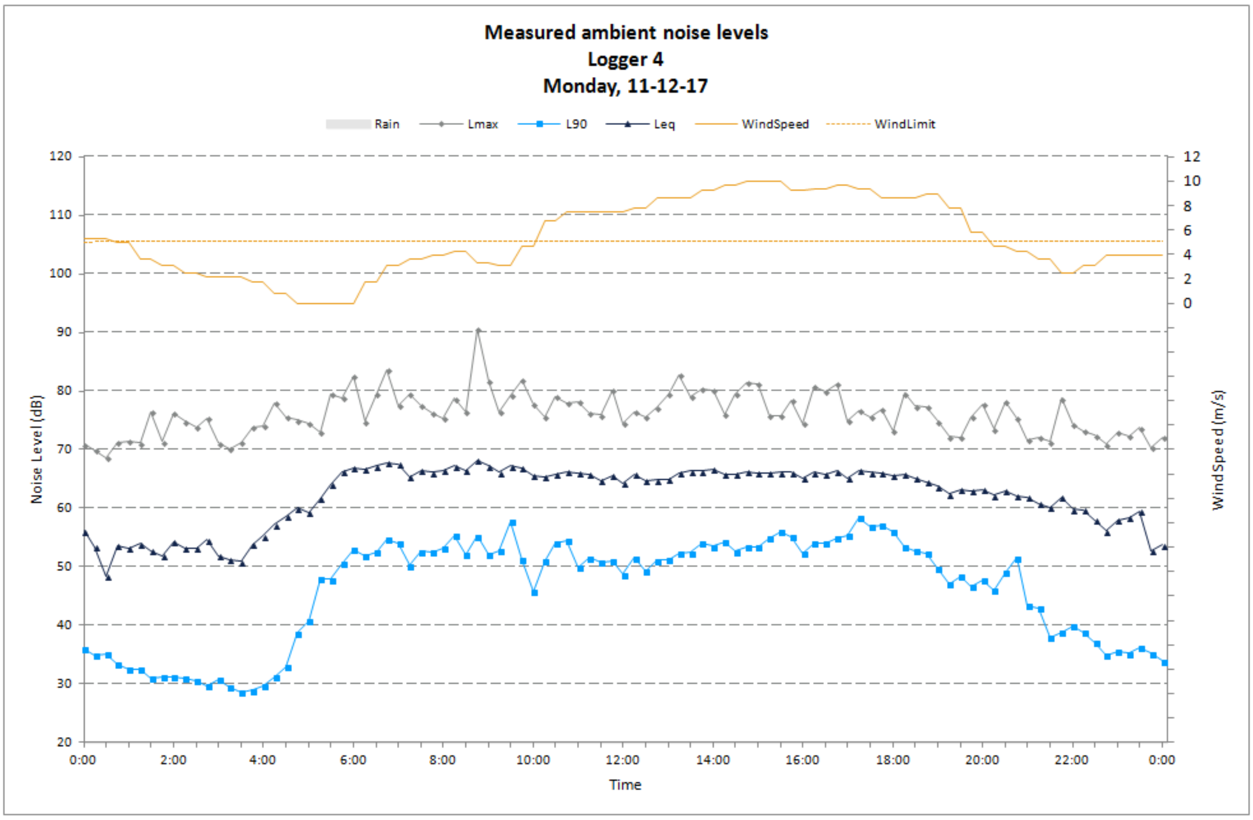
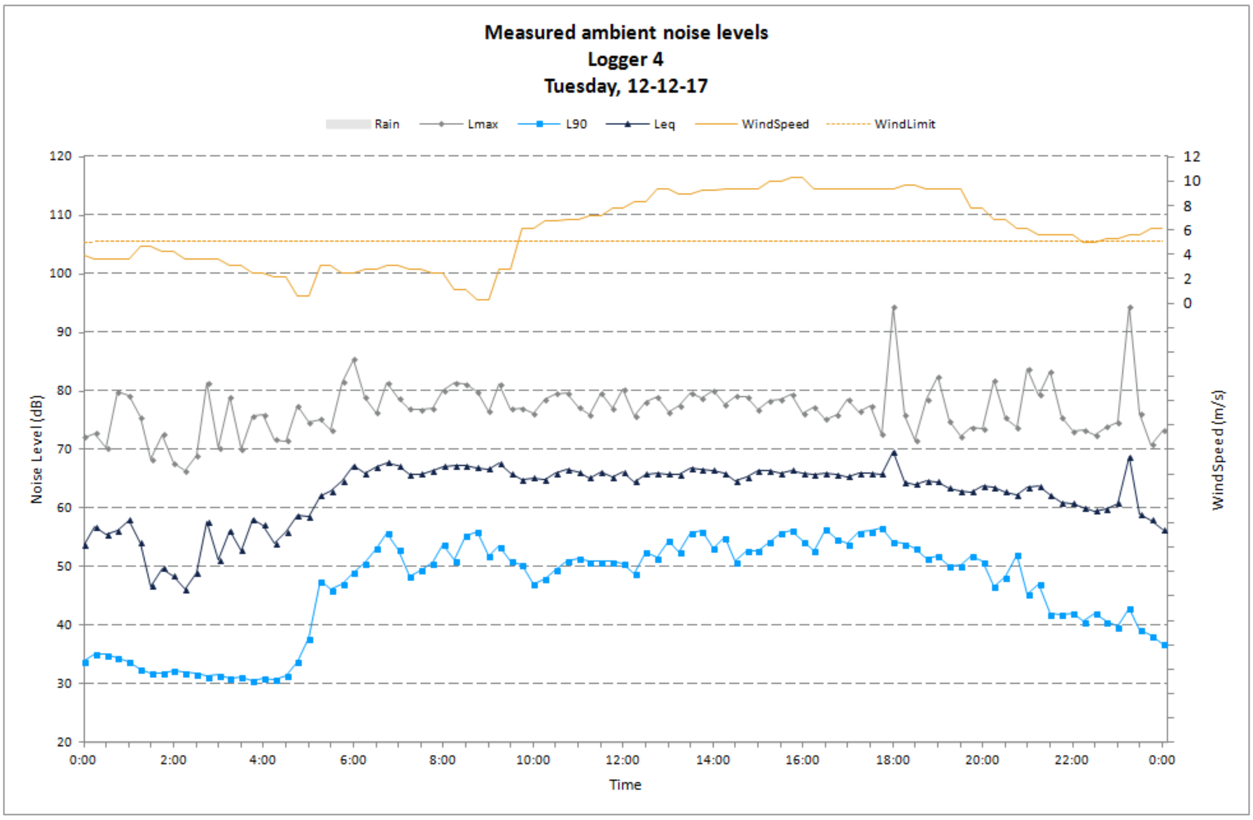
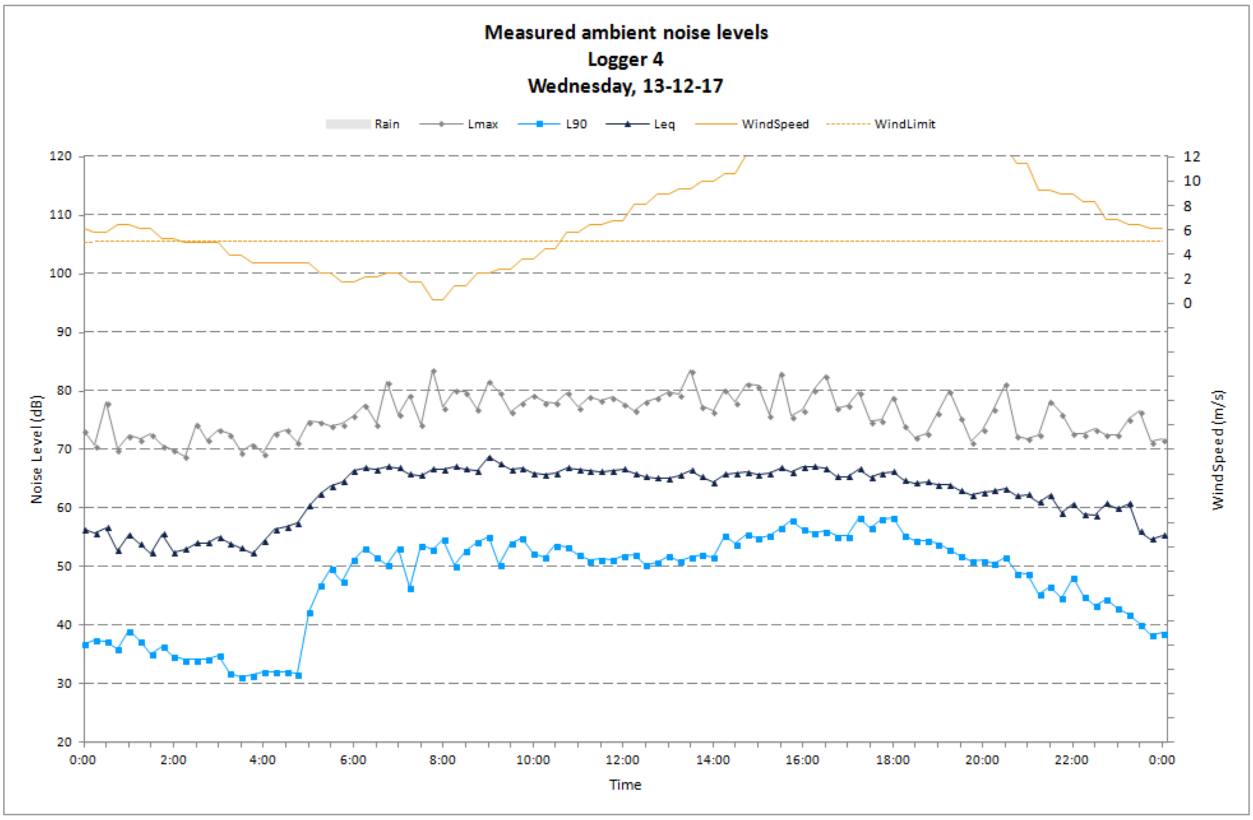
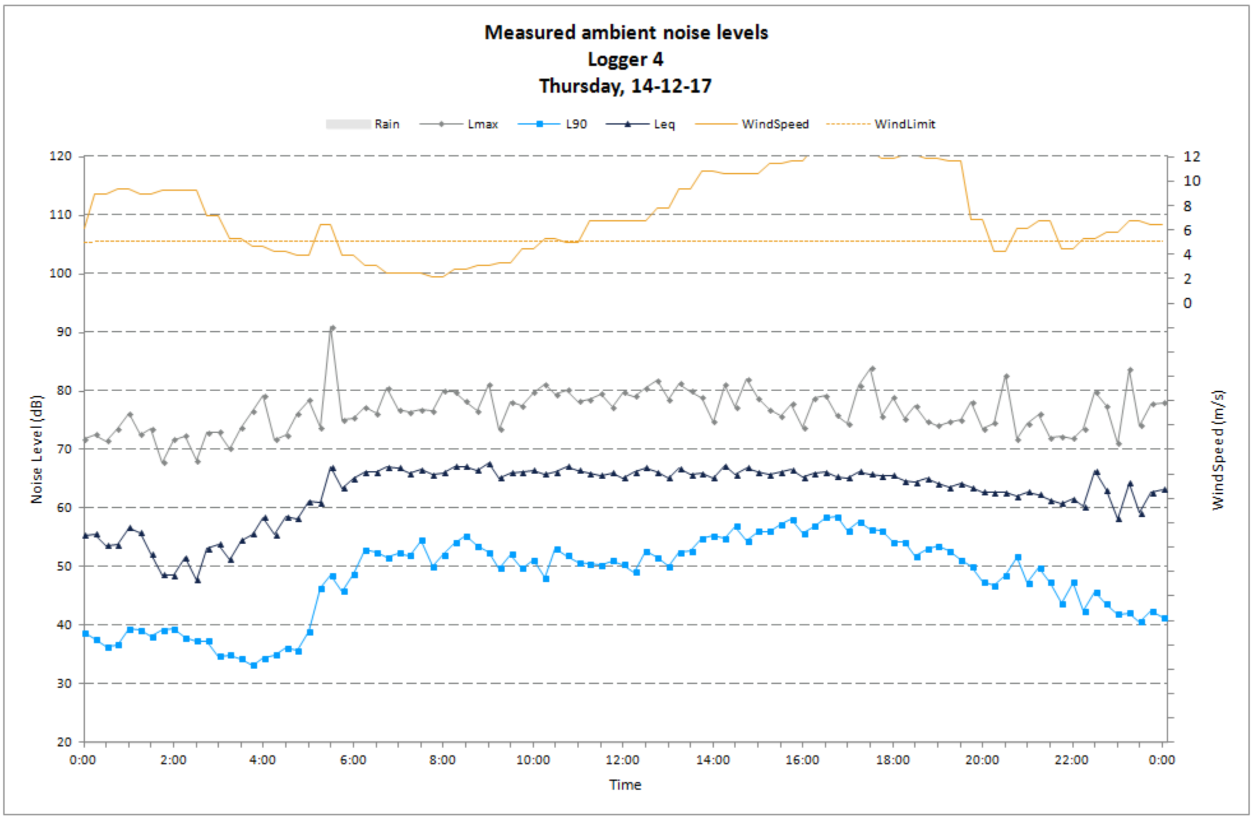

Measured ambient noise levels
Logger 4
Sunday, 10-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 4
Monday, 11-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 4
Tuesday, 12-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 4
Wednesday, 13-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 4
Thursday, 14-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
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0:00
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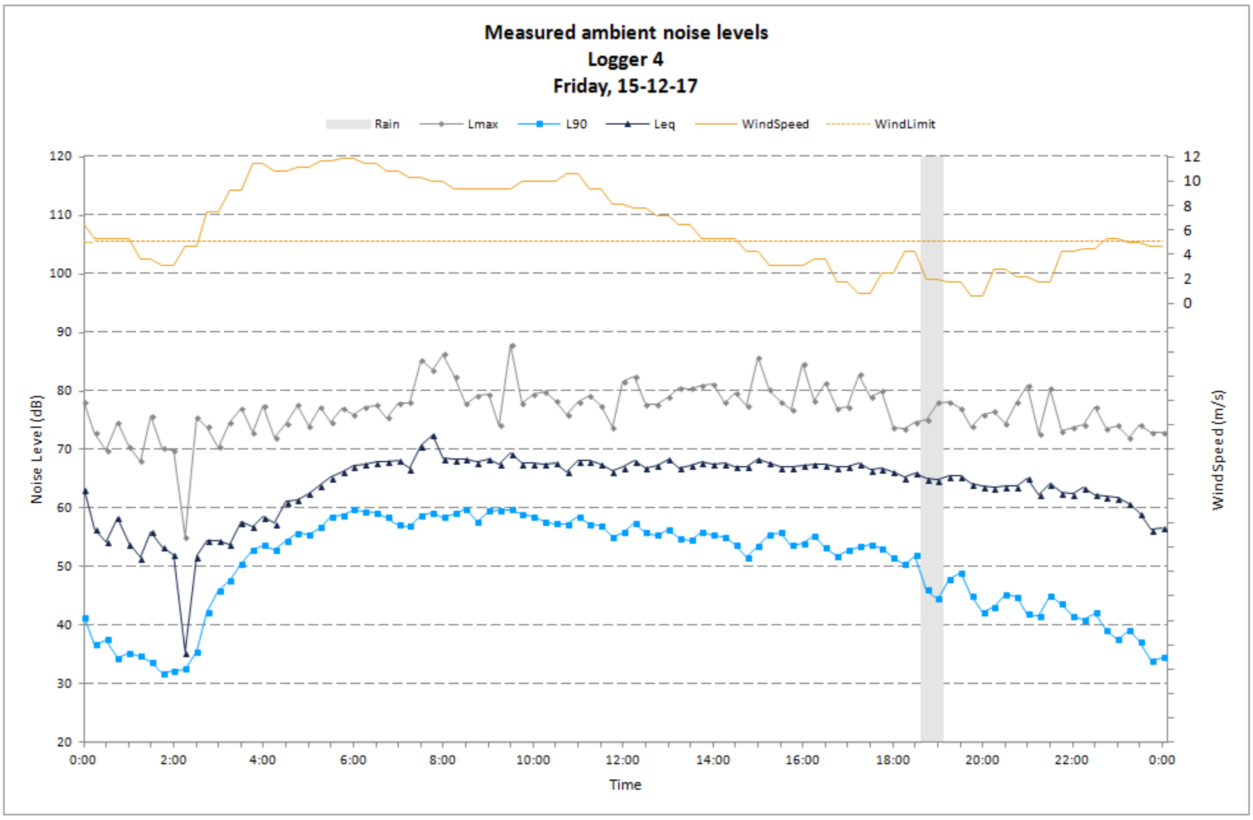
Measured ambient noise levels
Logger 4
Friday, 15-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
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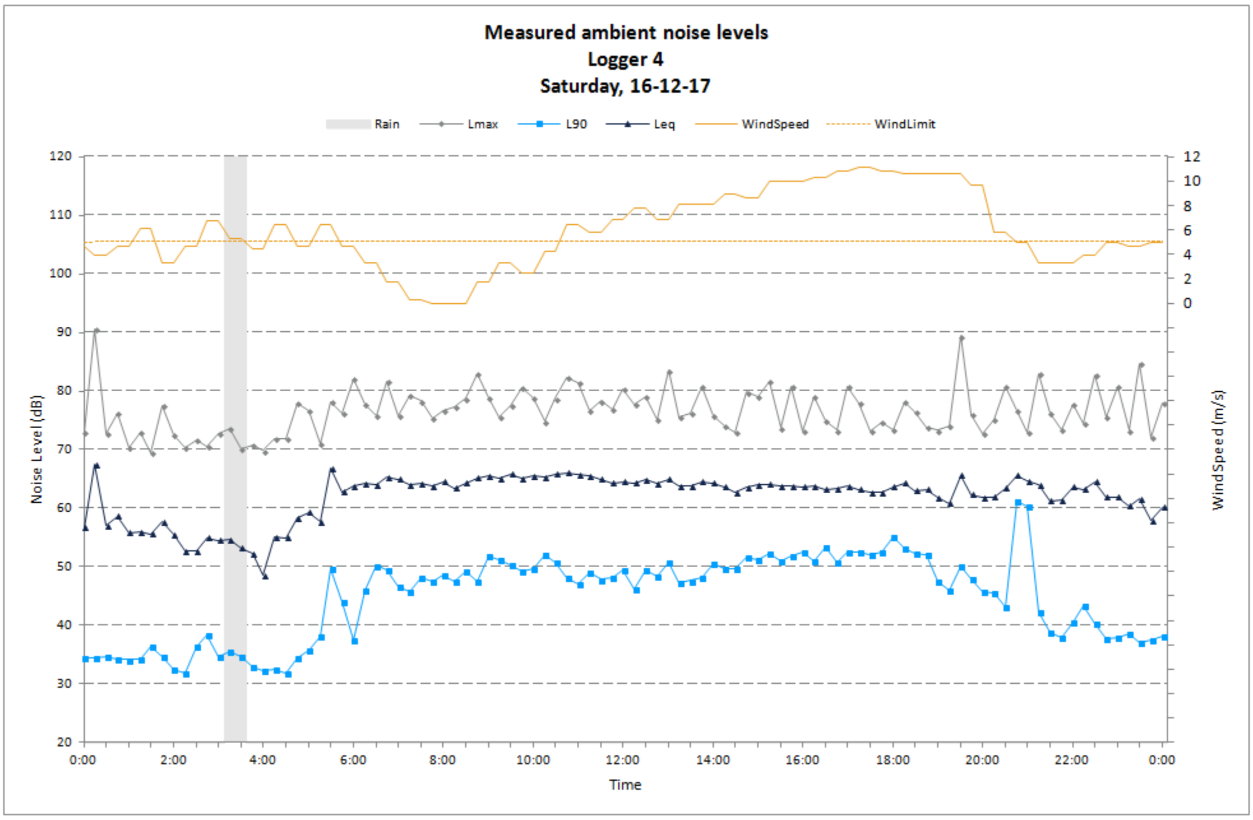
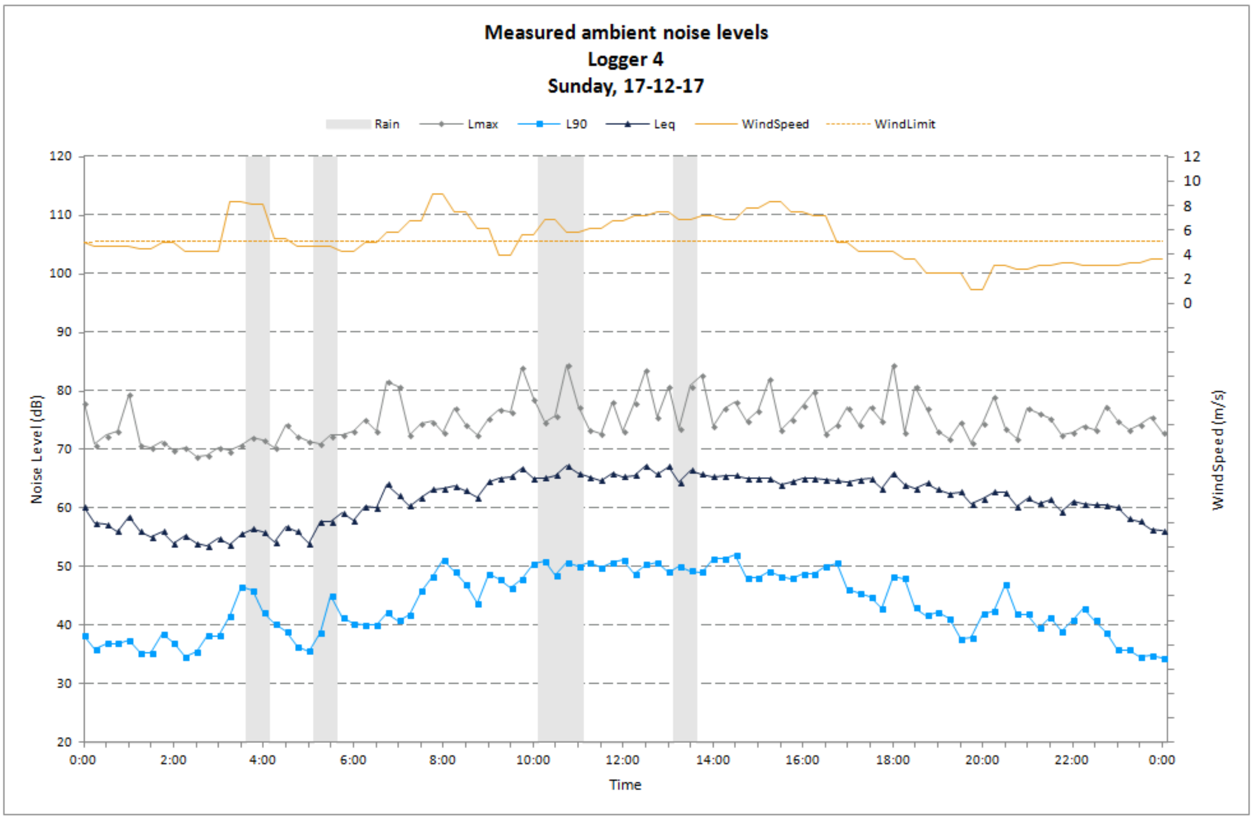
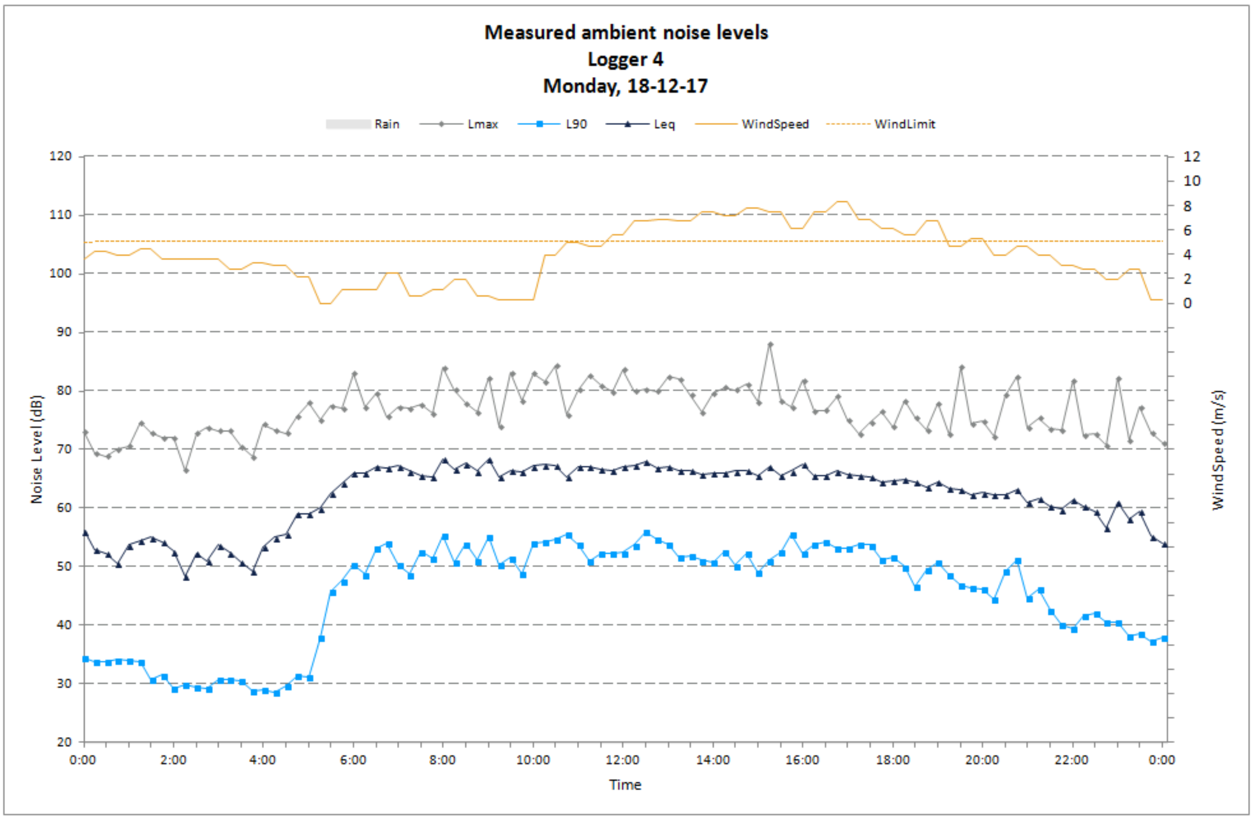
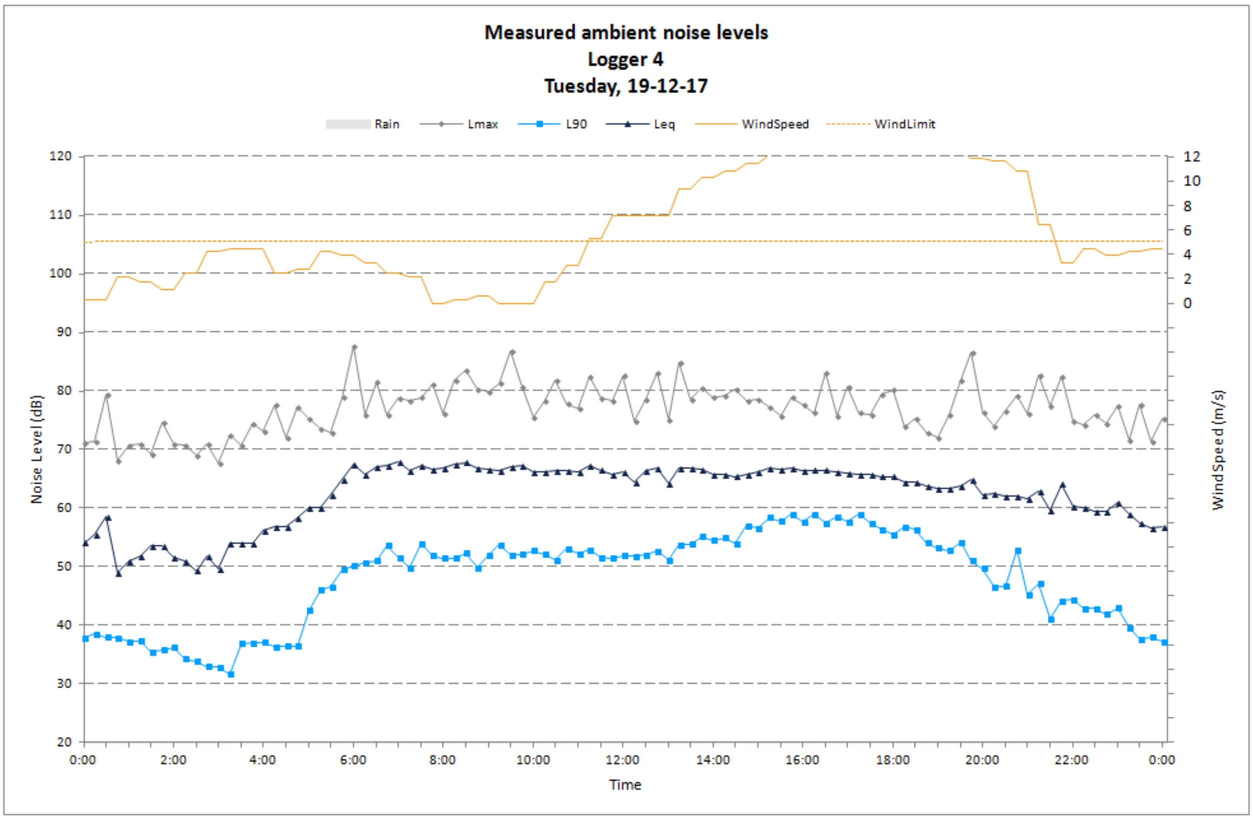
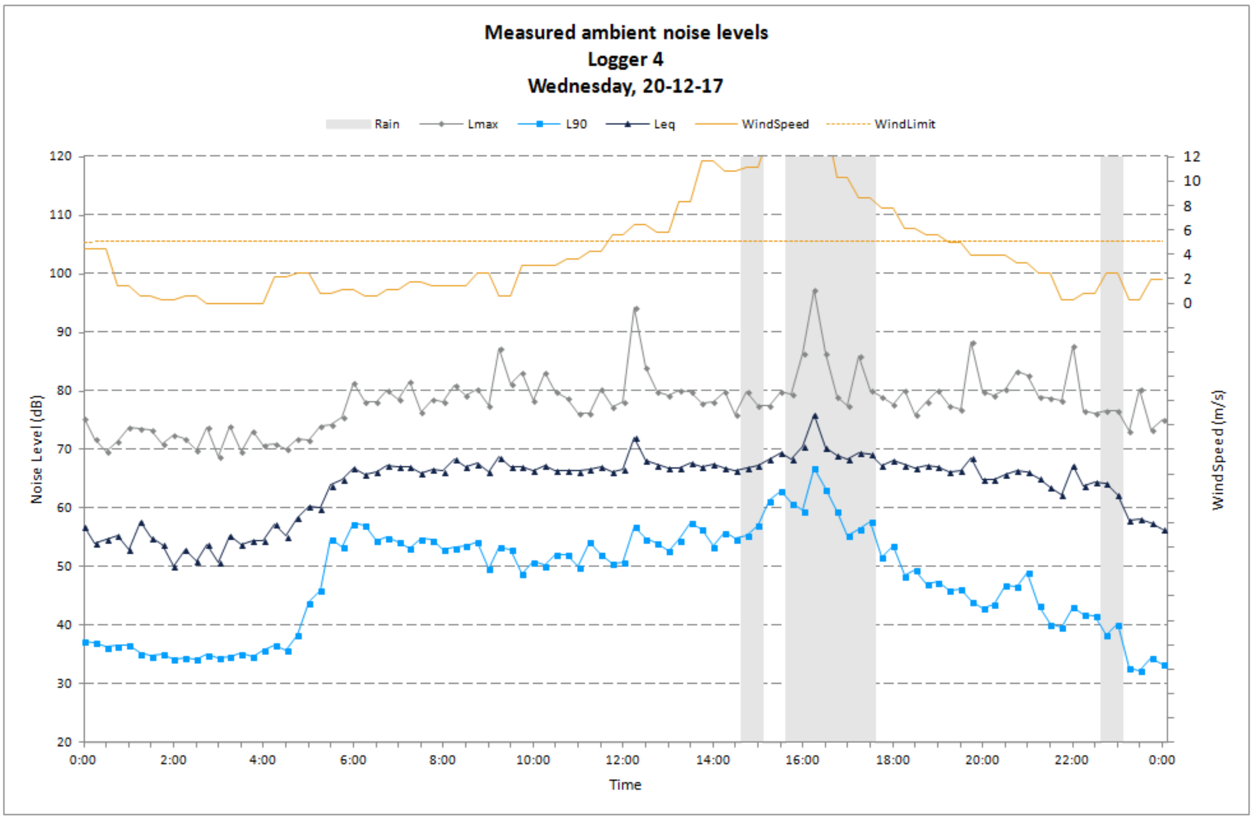

Measured ambient noise levels
Logger 4
Saturday, 16-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 4
Sunday, 17-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 4
Monday, 18-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 4
Tuesday, 19-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 4
Wednesday, 20-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
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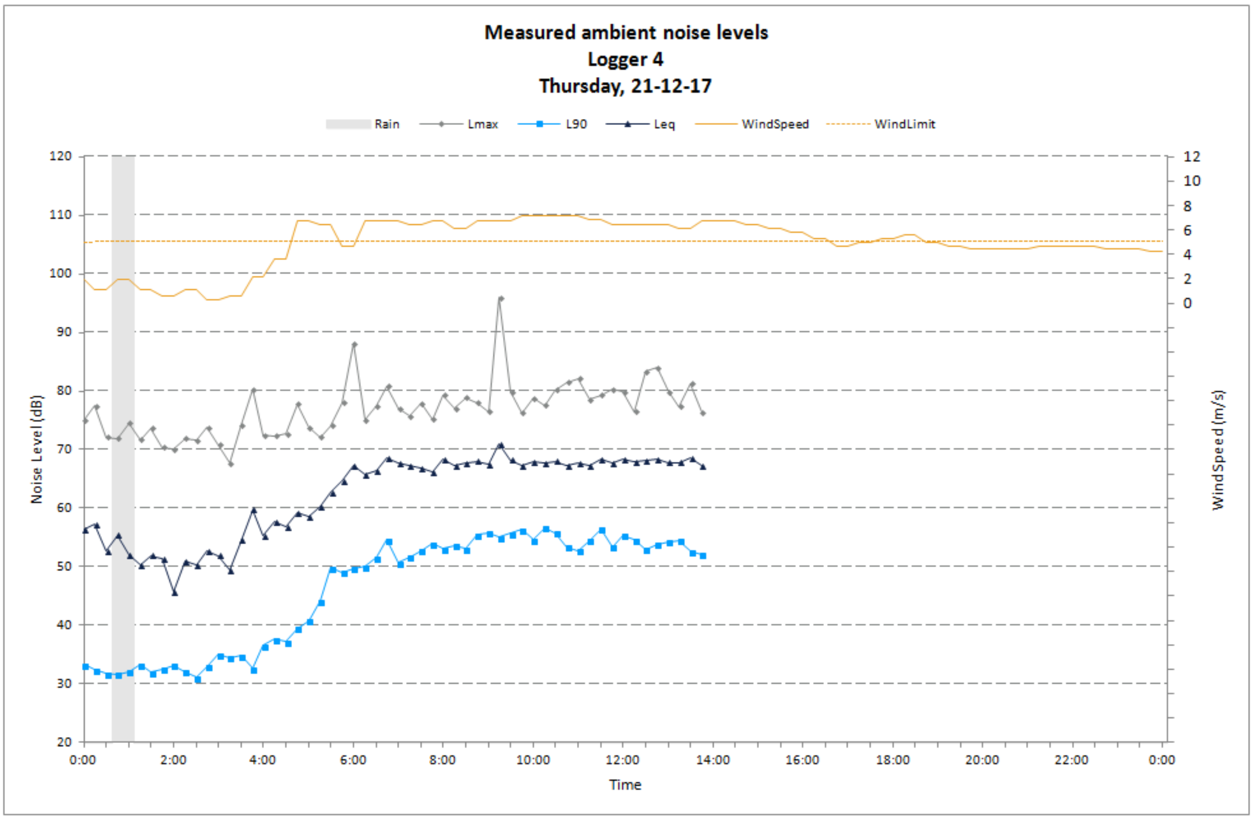
Measured ambient noise levels
Logger 4
Thursday, 21-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
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0:00
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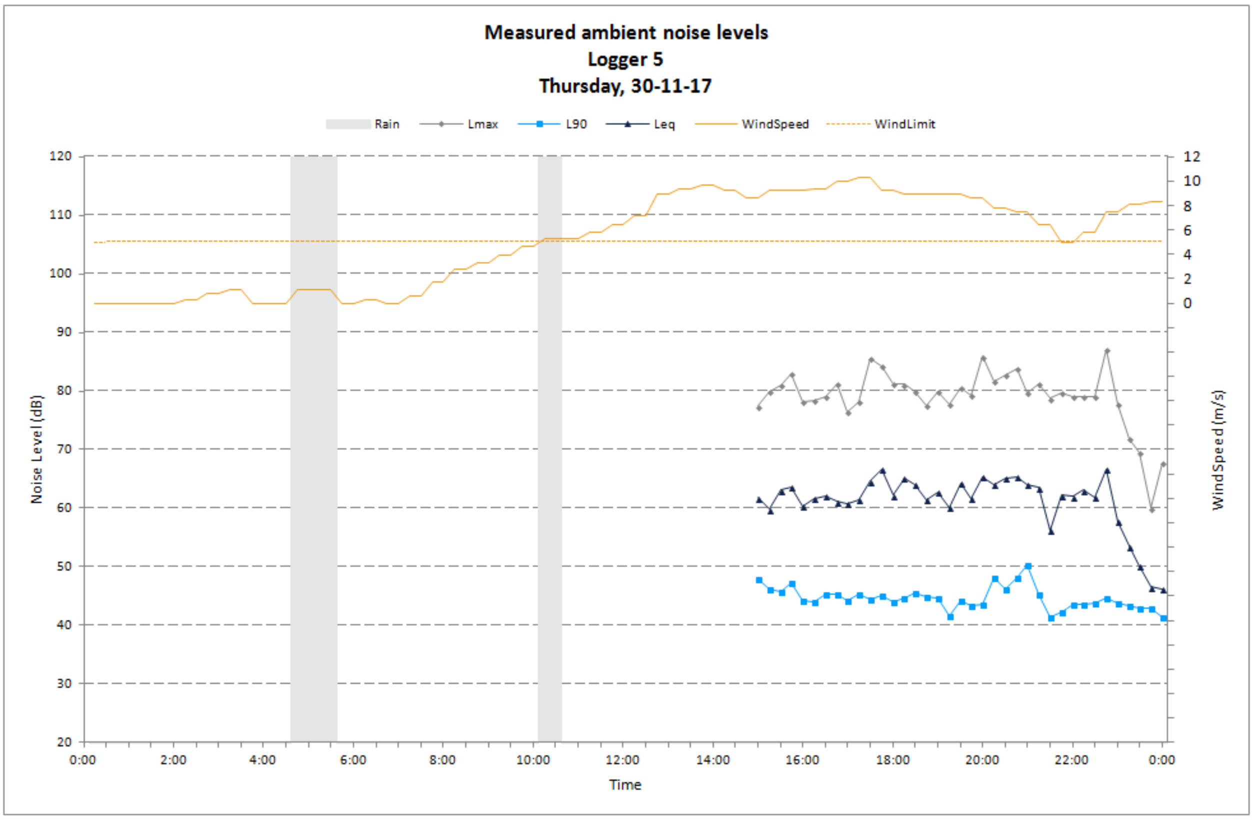
Measured ambient noise levels
Logger 5
Thursday, 30-11-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
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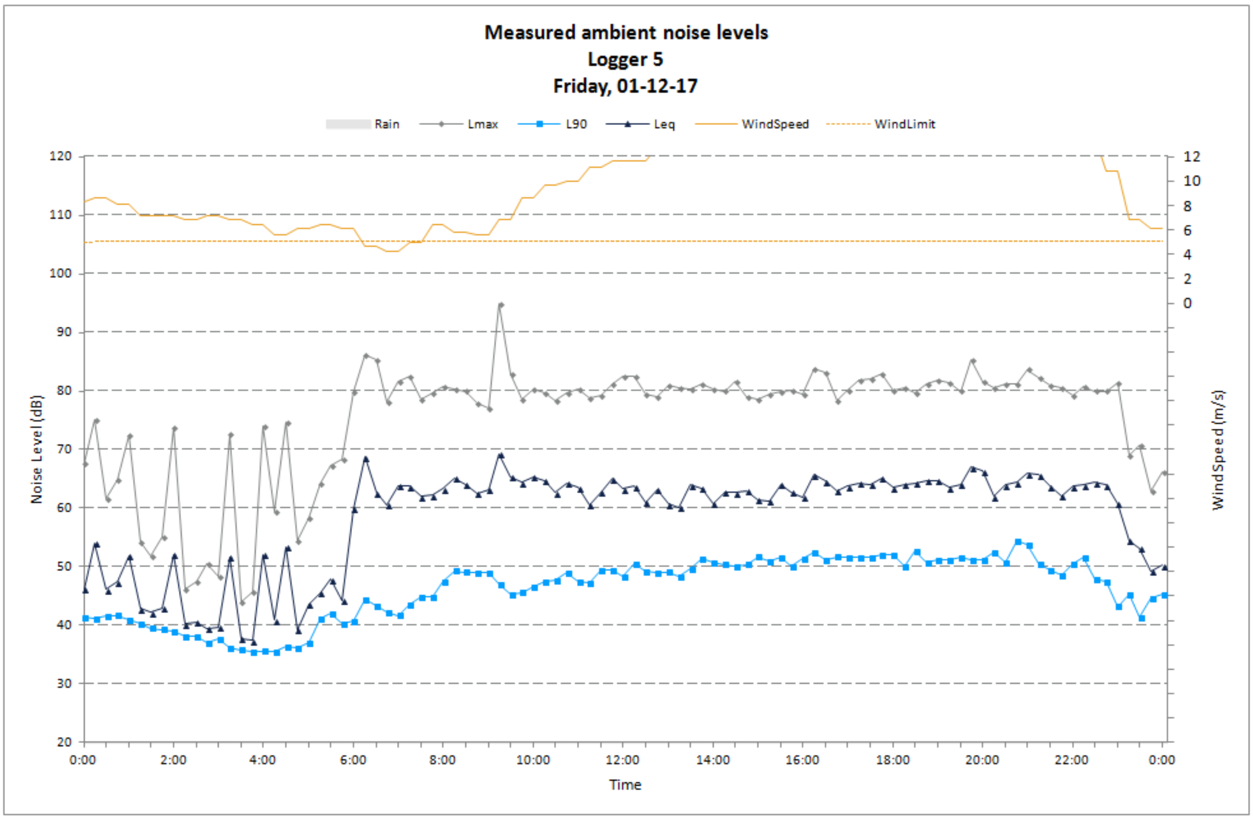
Measured ambient noise levels
Logger 5
Friday, 01-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
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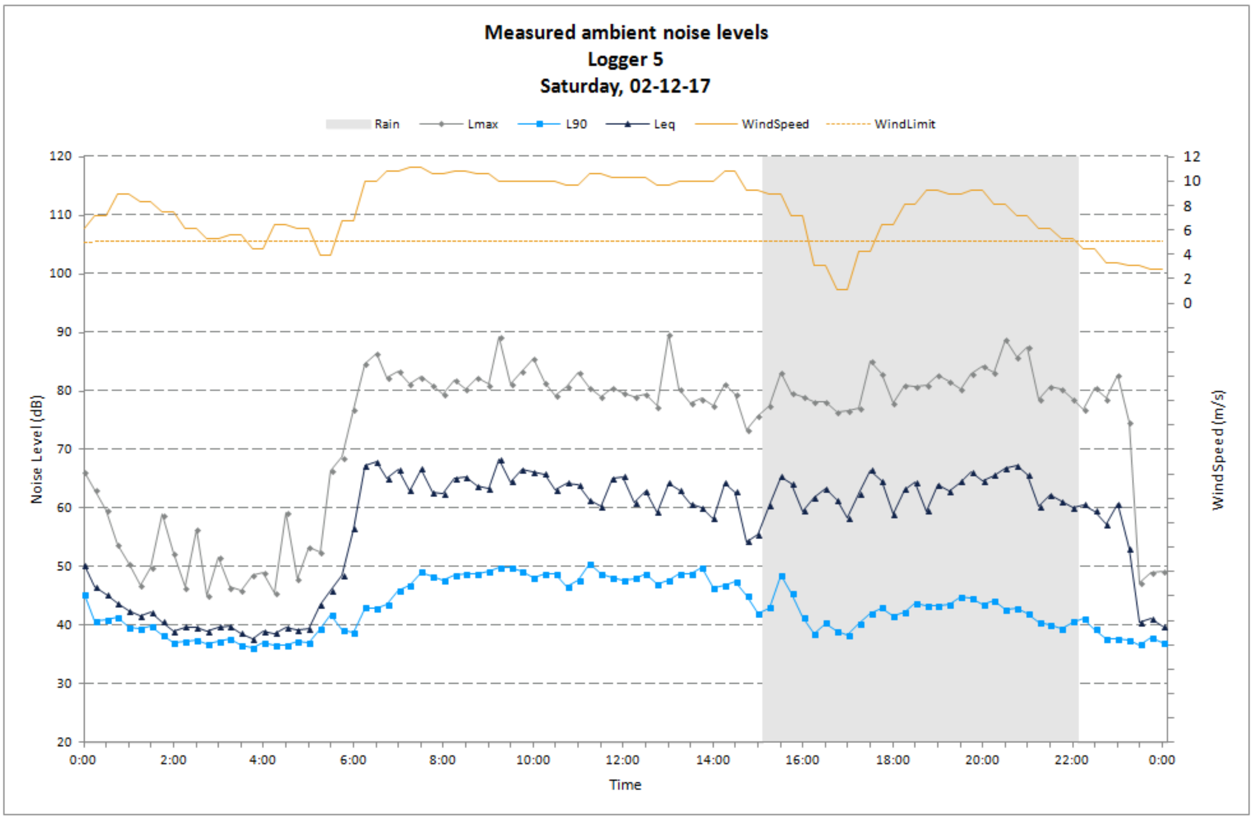
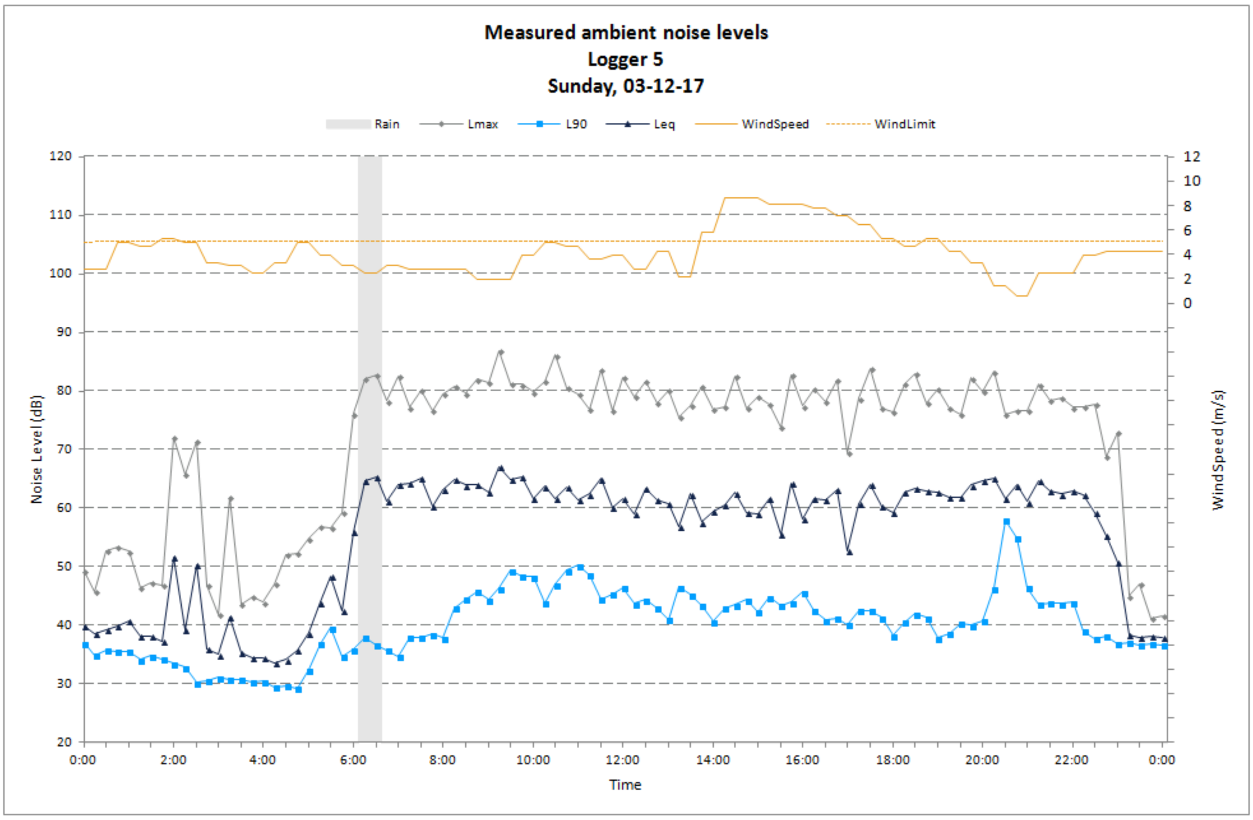
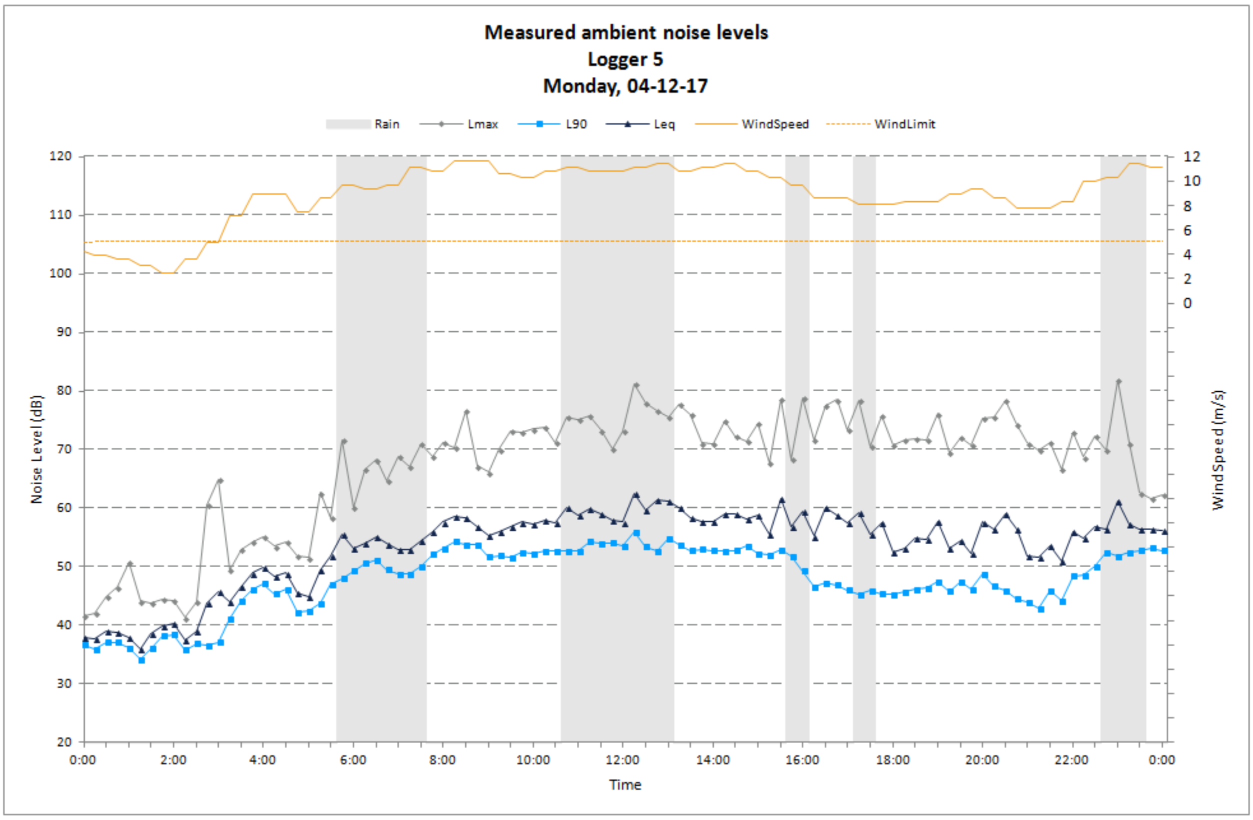

Measured ambient noise levels
Logger 5
Saturday, 02-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 5
Sunday, 03-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 5
Monday, 04-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
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0:00
2:00
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18:00
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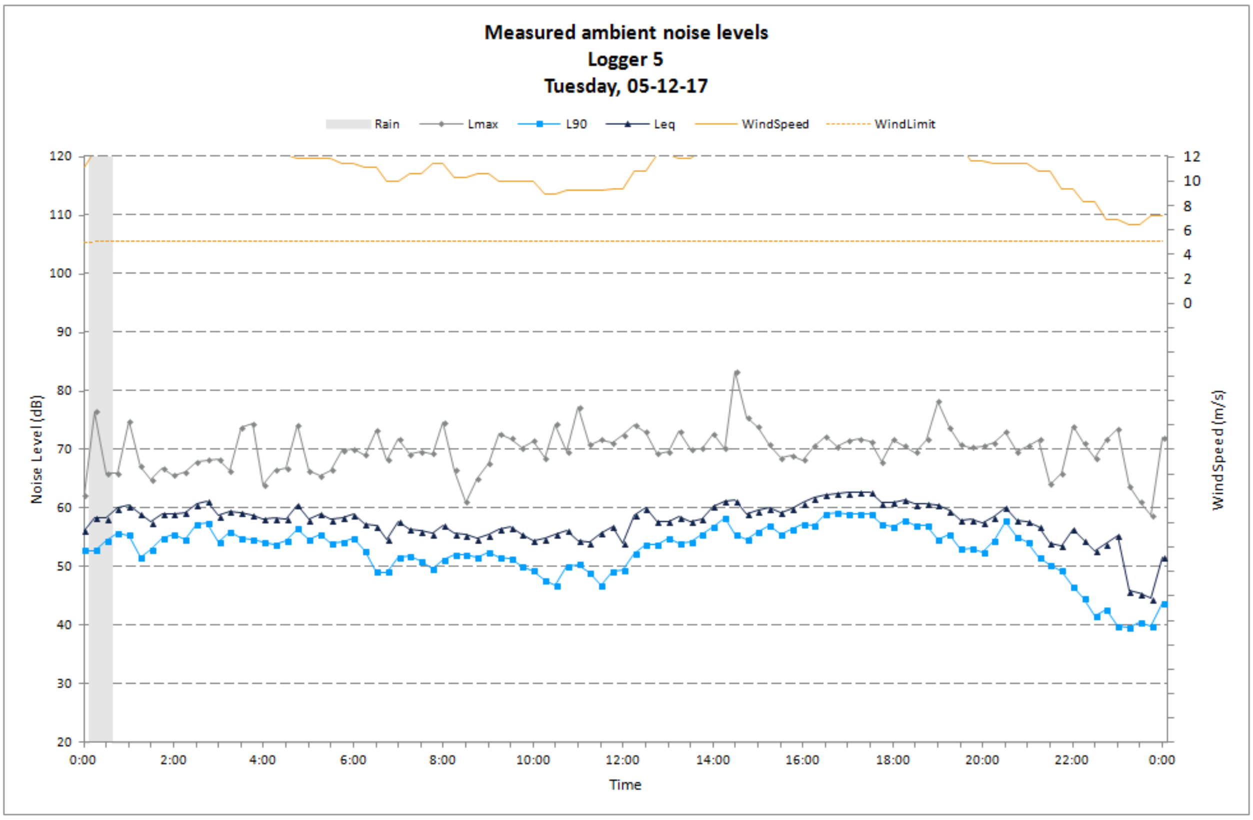
Measured ambient noise levels
Logger 5
Tuesday, 05-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
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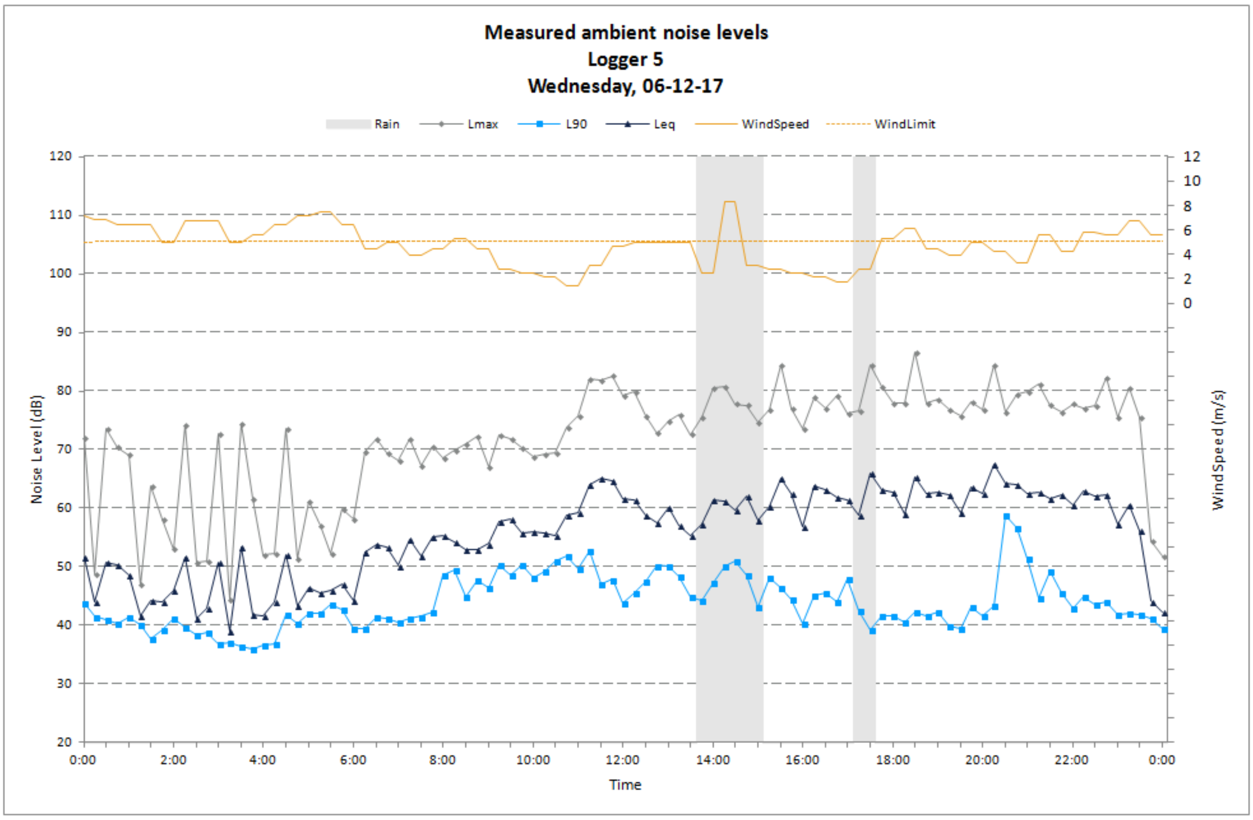
Measured ambient noise levels
Logger 5
Wednesday, 06-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
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0:00
2:00
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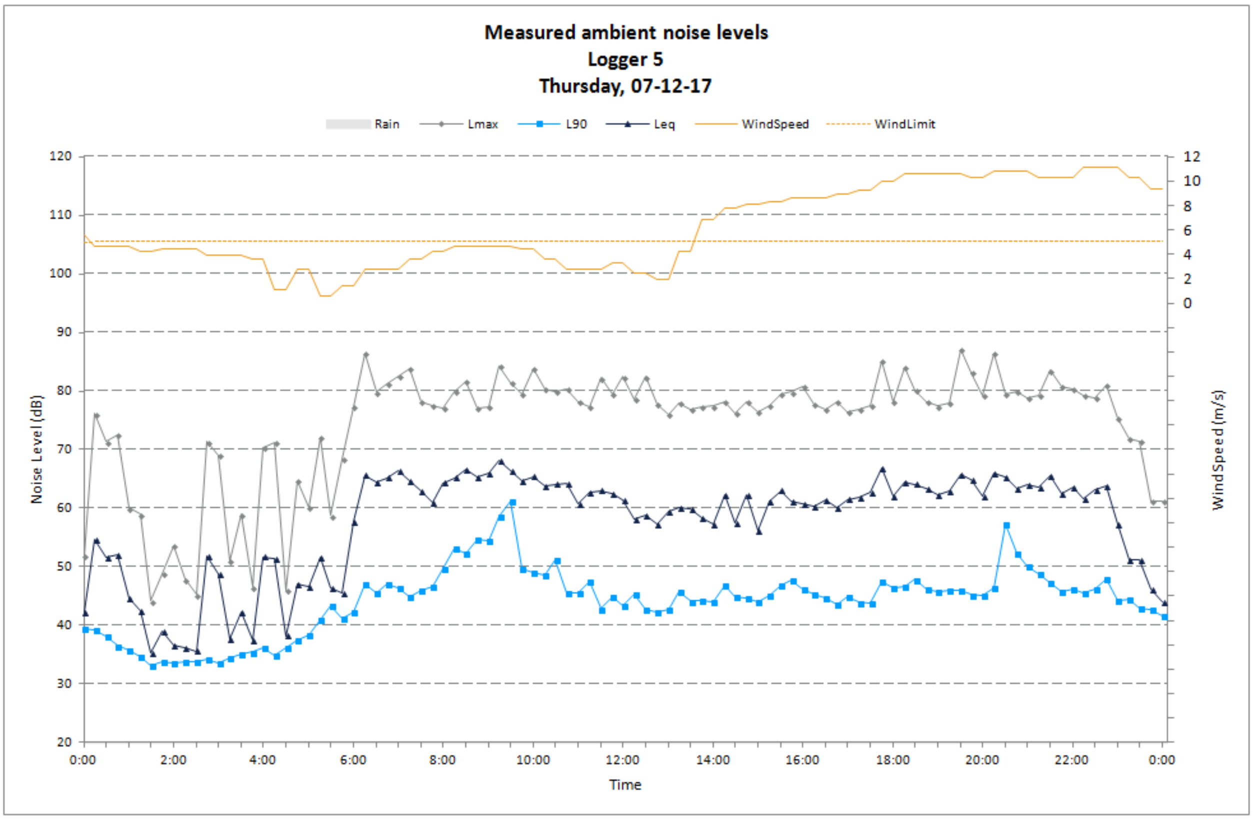
Measured ambient noise levels
Logger 5
Thursday, 07-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
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4
2
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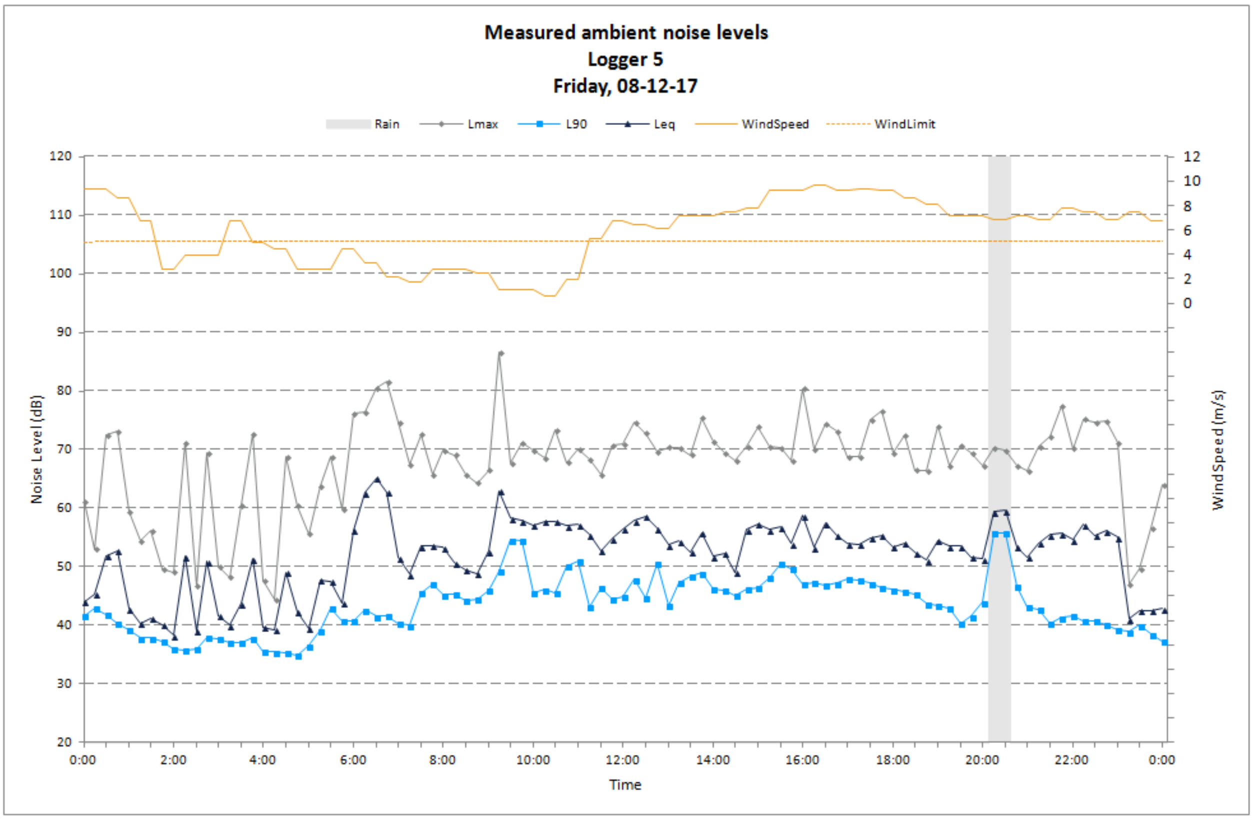
Measured ambient noise levels
Logger 5
Friday, 08-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
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0:00
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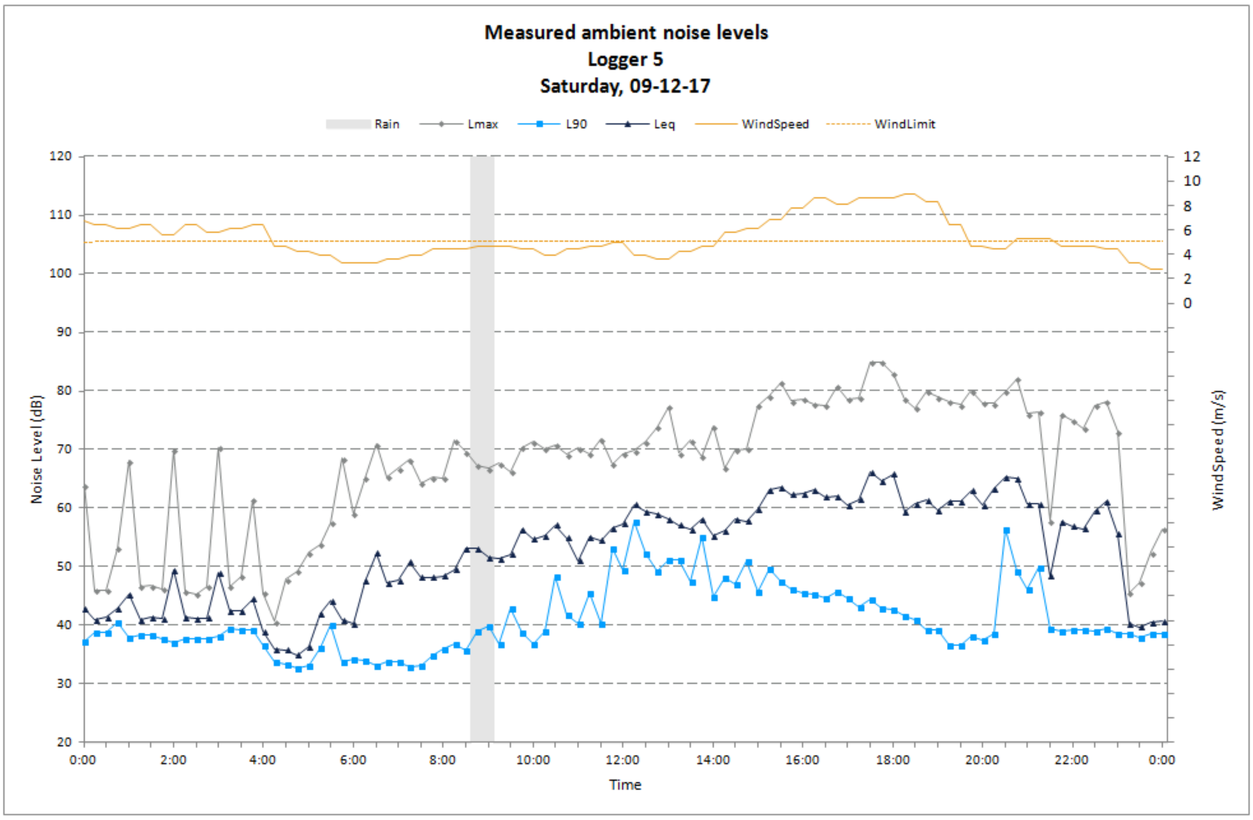
Measured ambient noise levels
Logger 5
Saturday, 09-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
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4
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0:00
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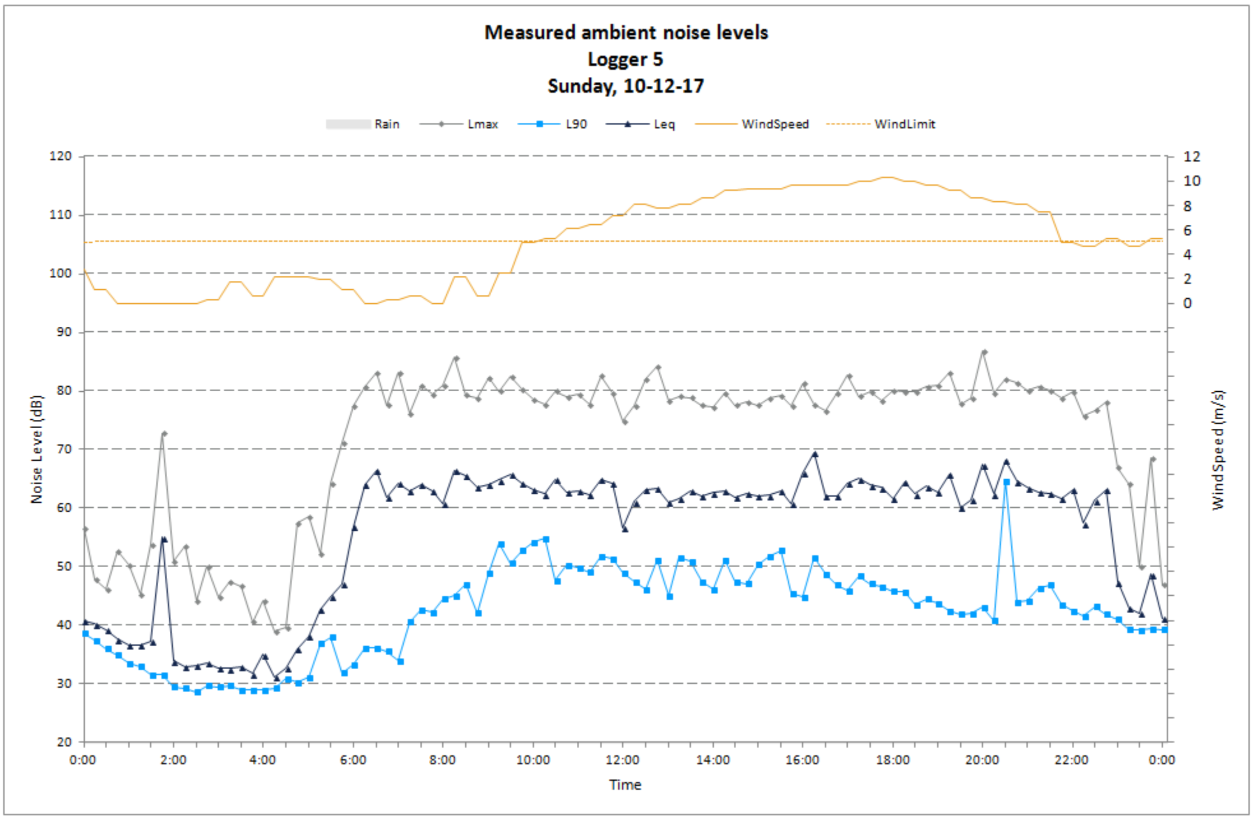
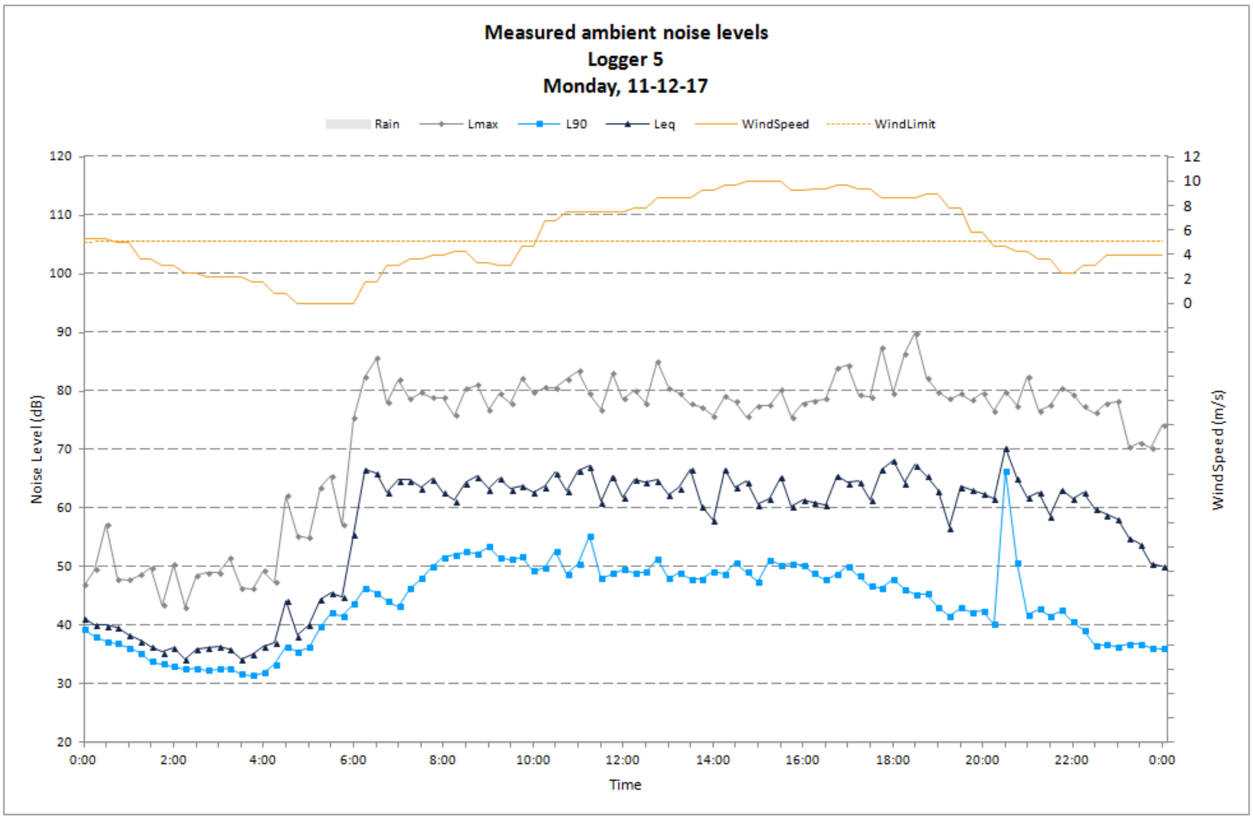

Measured ambient noise levels
Logger 5
Sunday, 10-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 5
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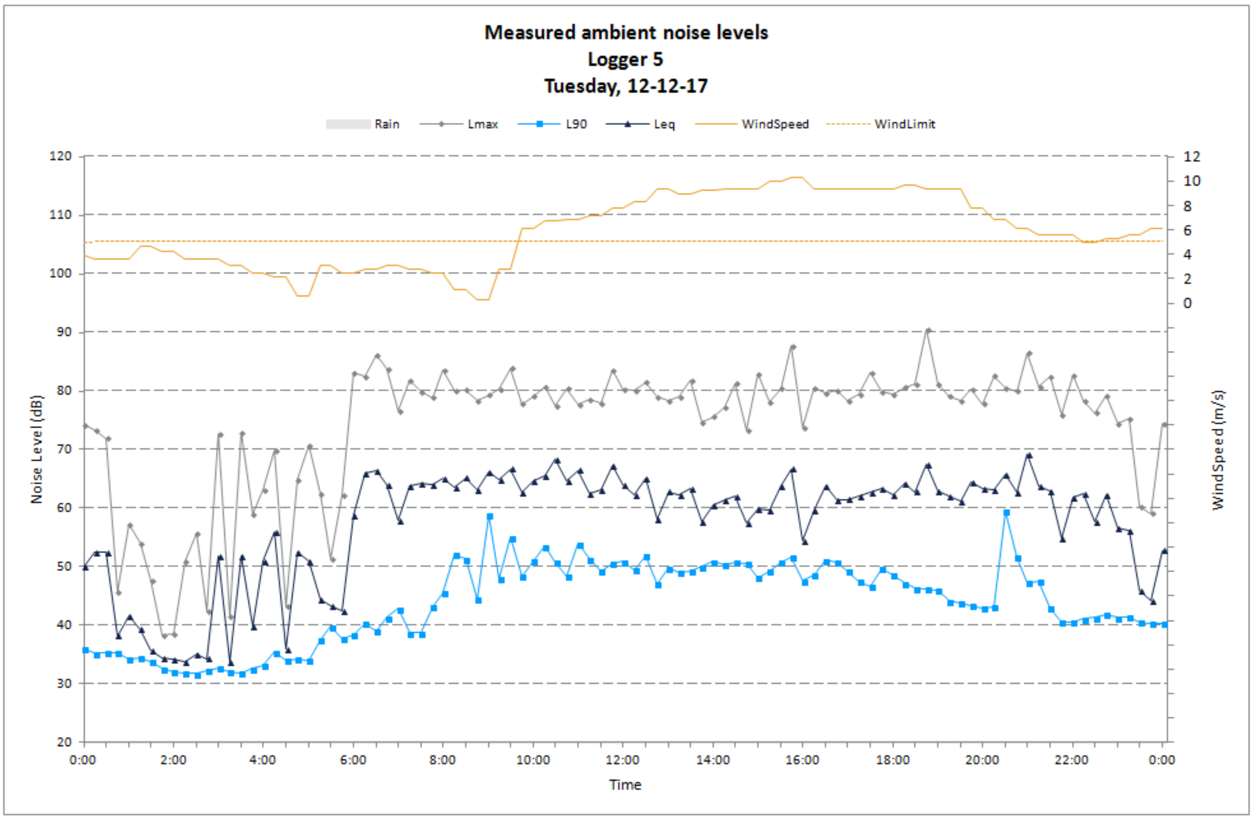
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 5
Tuesday, 12-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
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2
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0:00
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16:00
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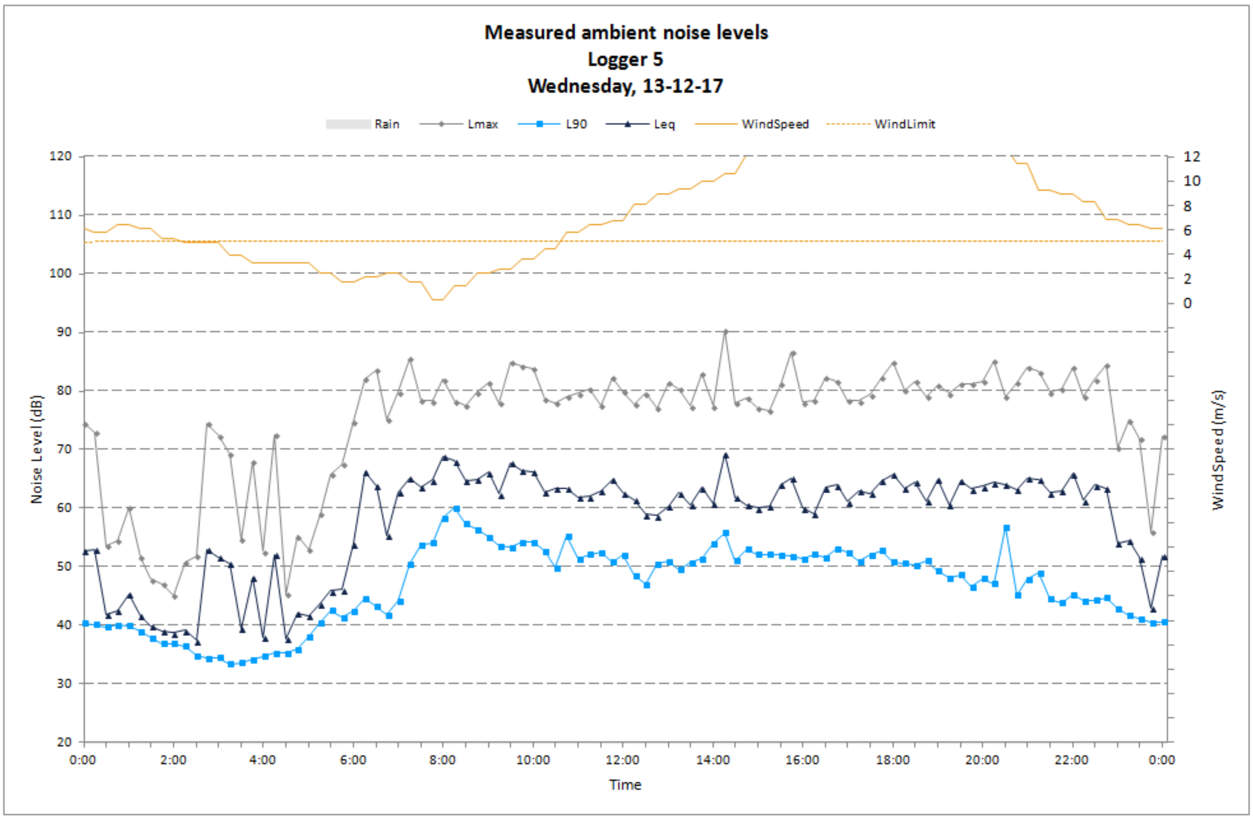
20:00
22:00
0:00


Measured ambient noise levels
Logger 5
Wednesday, 13-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
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16:00
18:00
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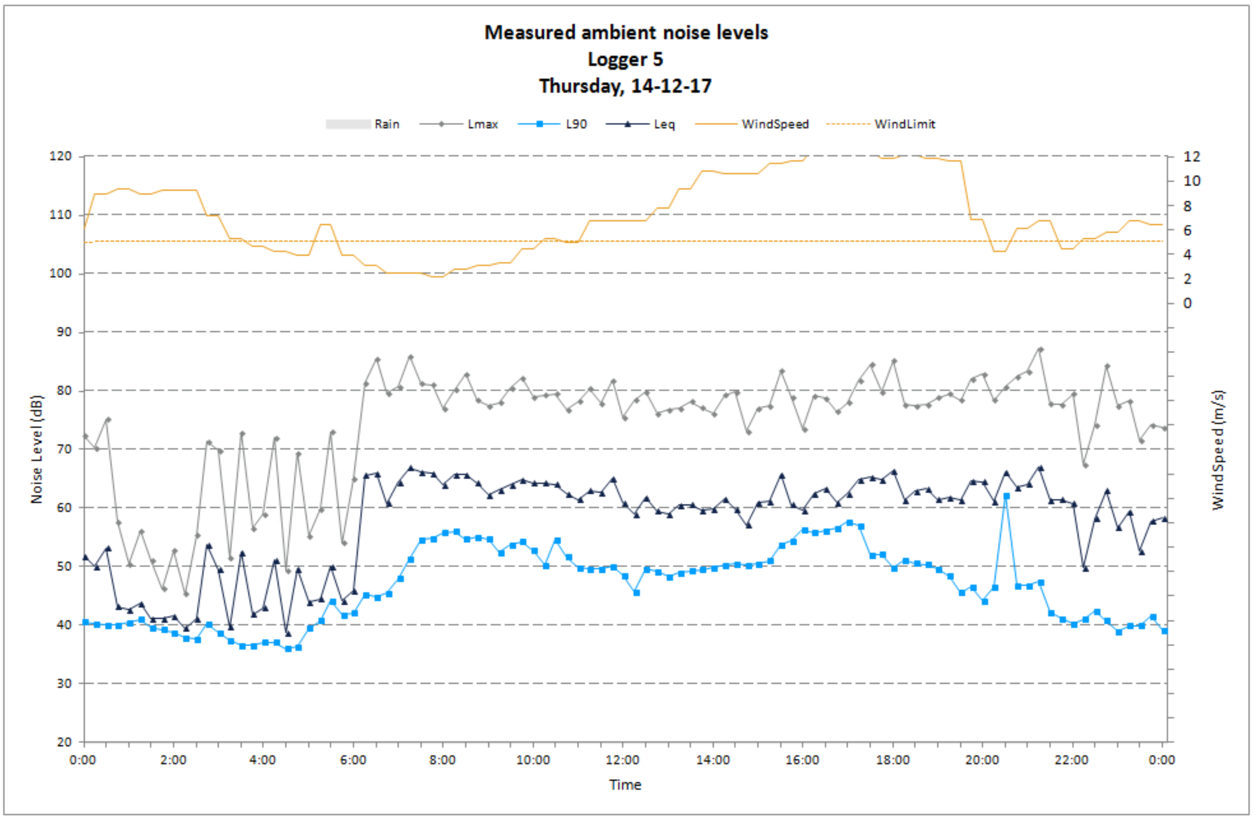
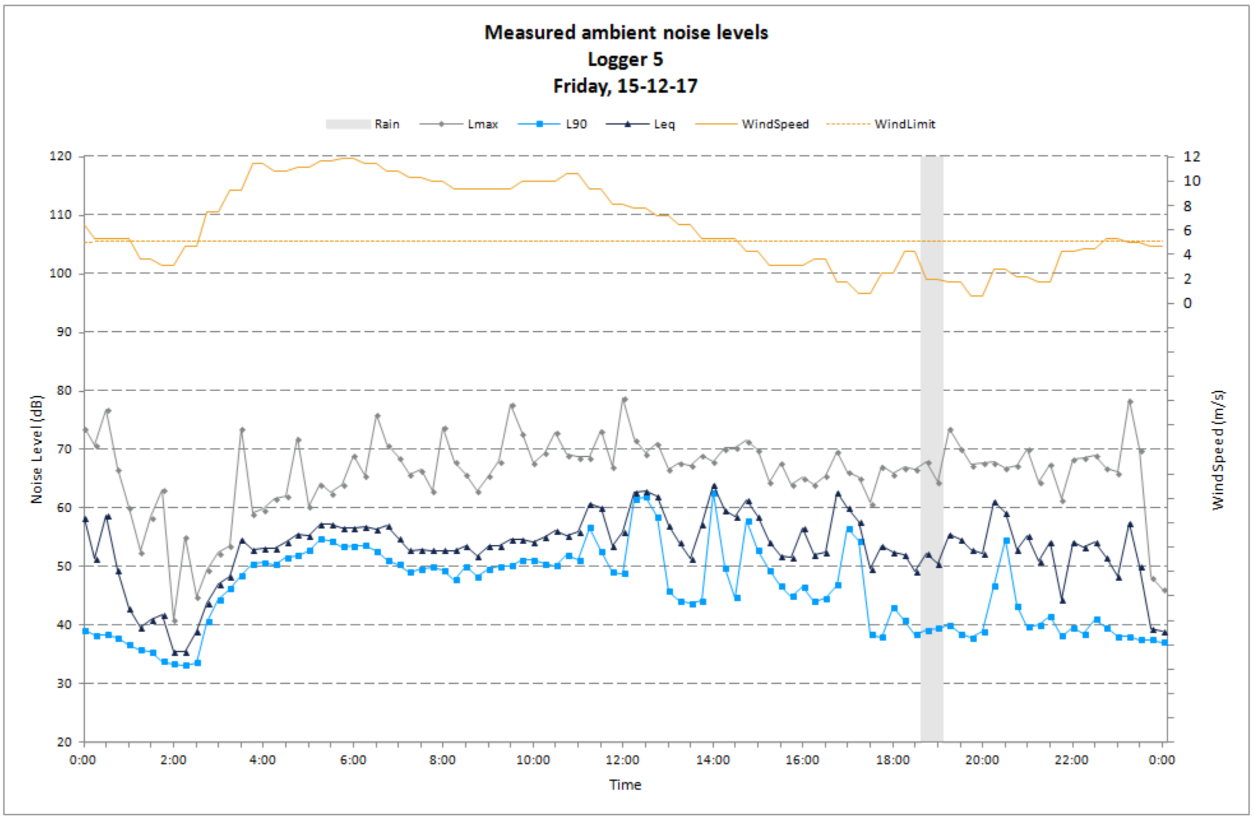
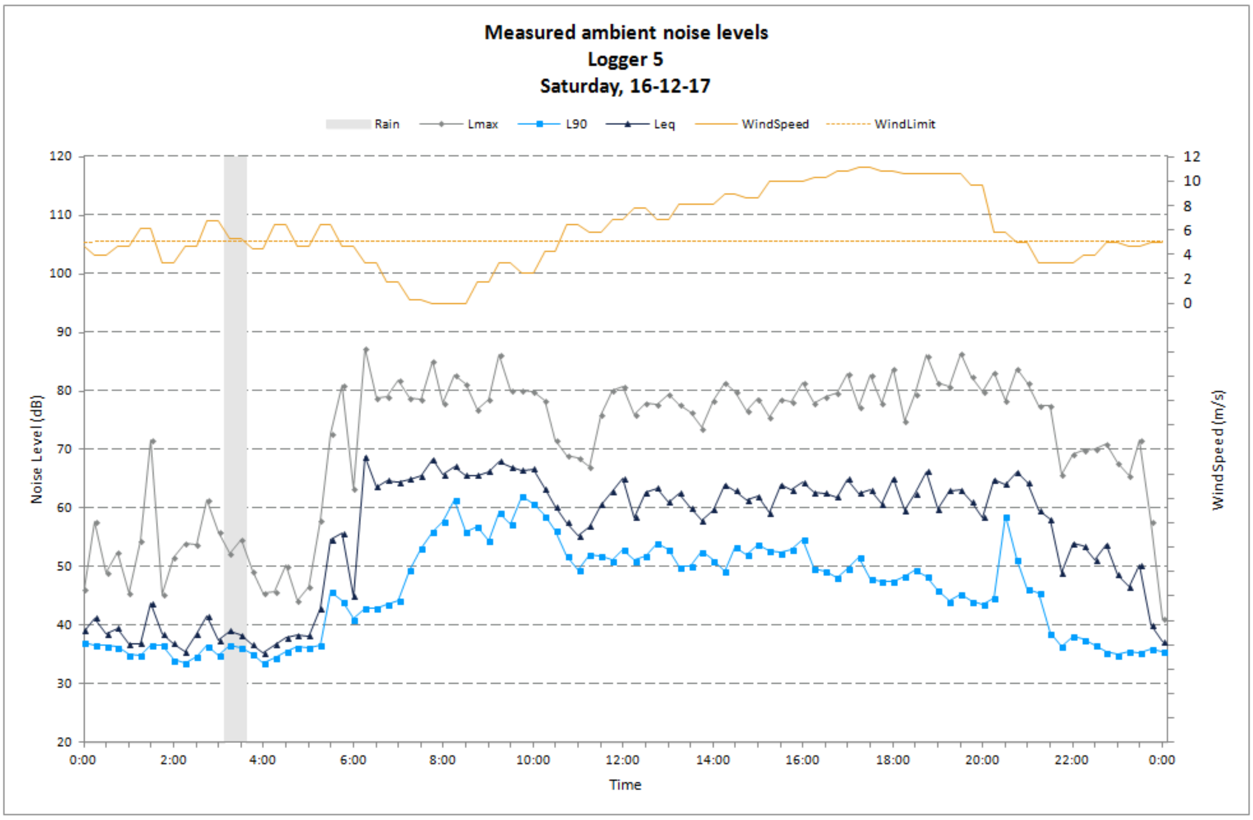

Measured ambient noise levels
Logger 5
Thursday, 14-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 5
Friday, 15-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
Logger 5
Saturday, 16-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
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0
0:00
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4:00
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16:00
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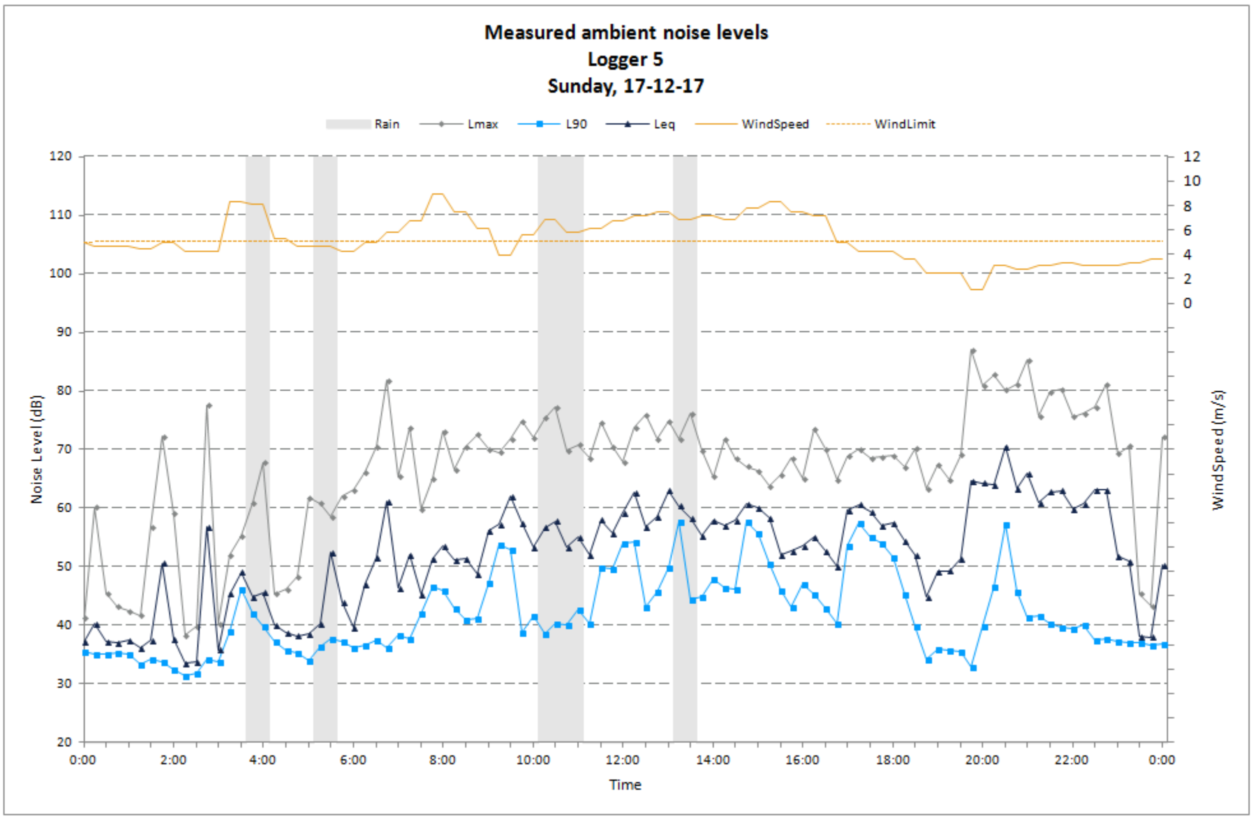
22:00
0:00


Measured ambient noise levels
Logger 5
Sunday, 17-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
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10:00
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16:00
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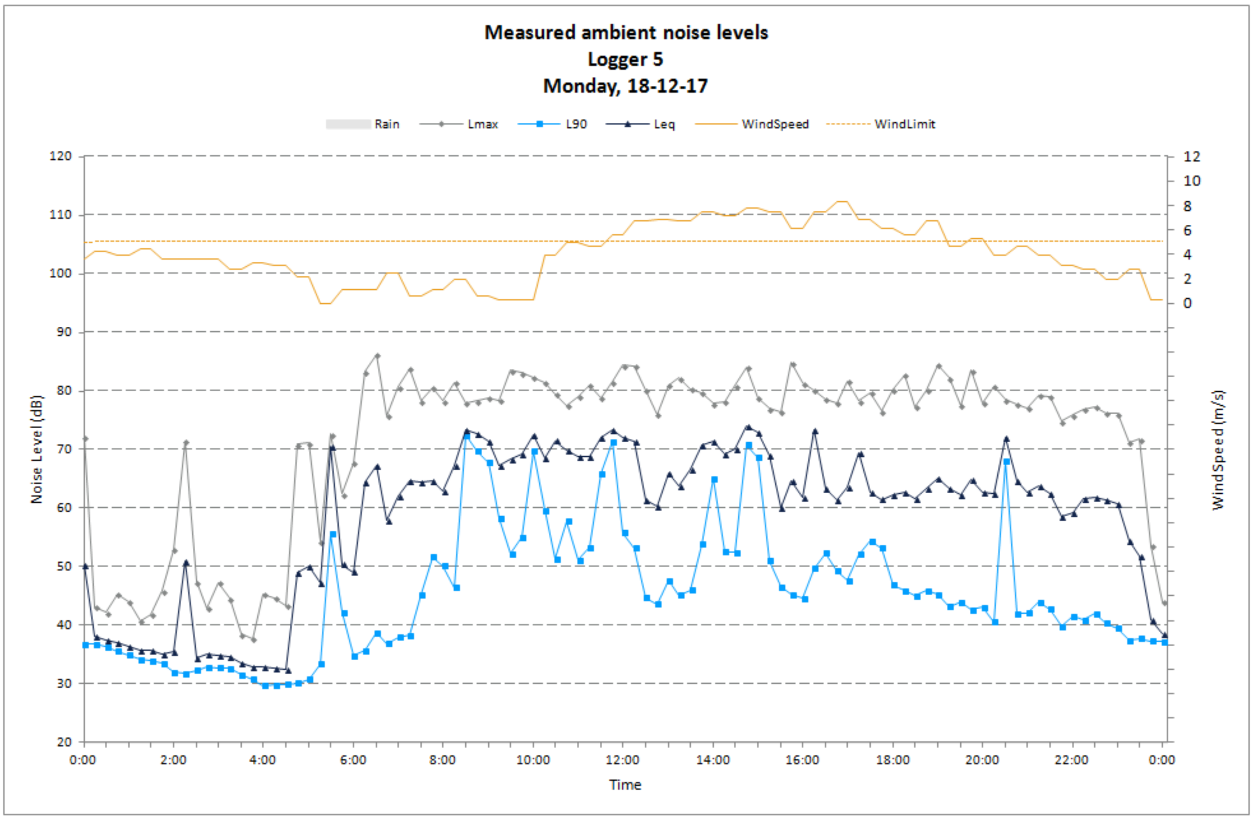
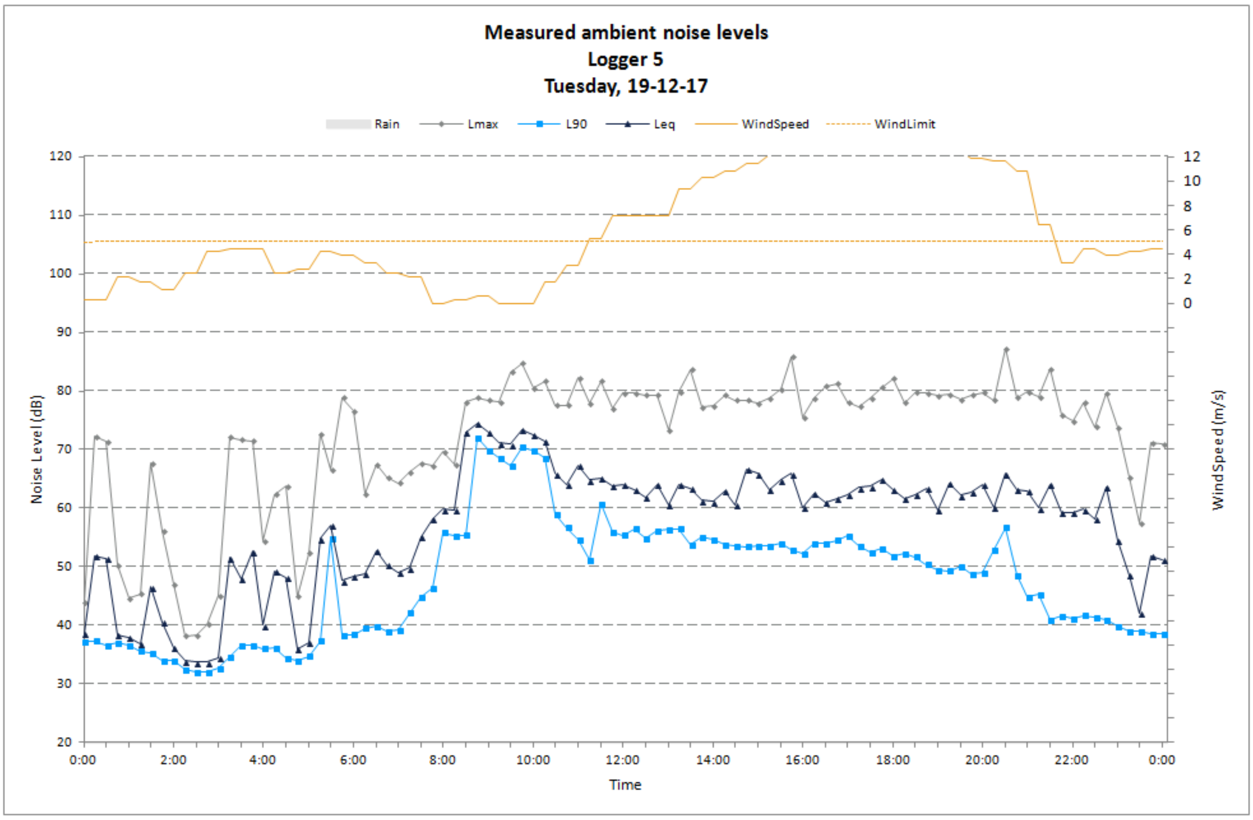
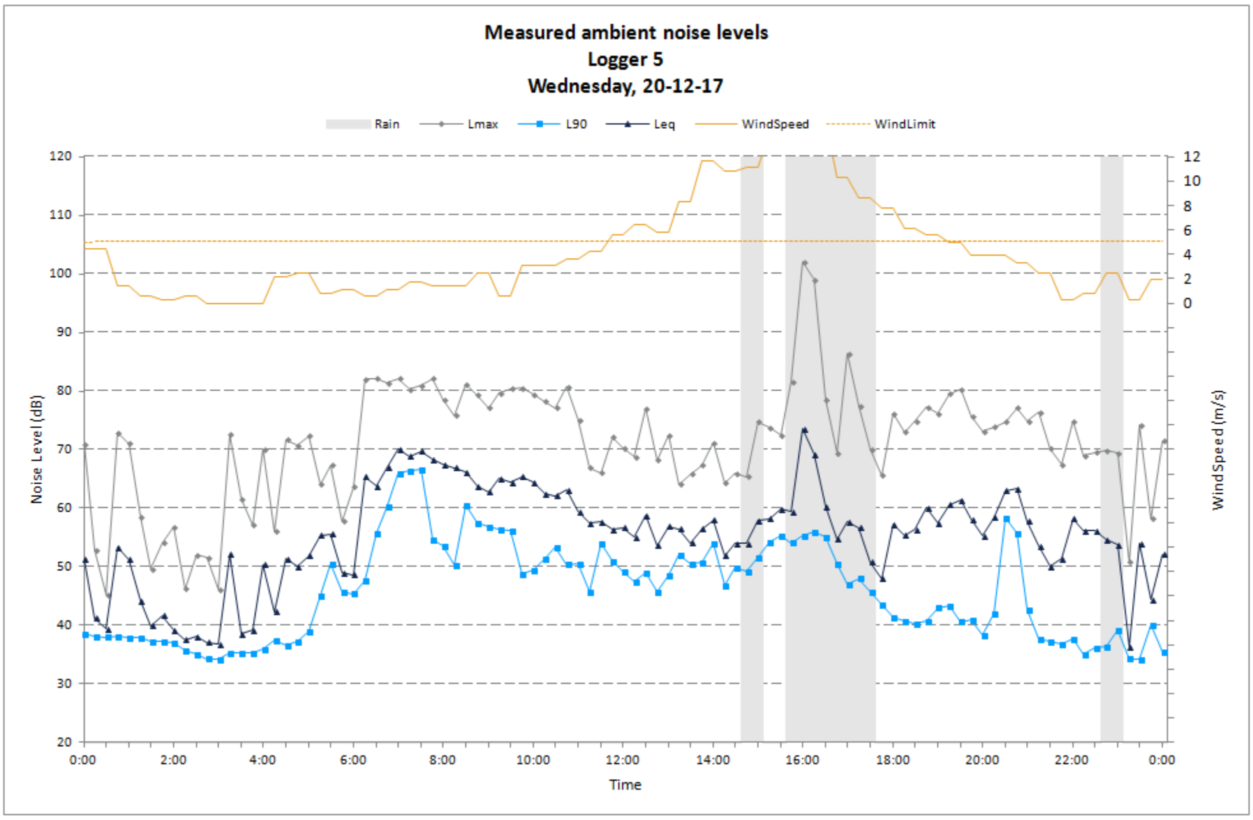
0:00



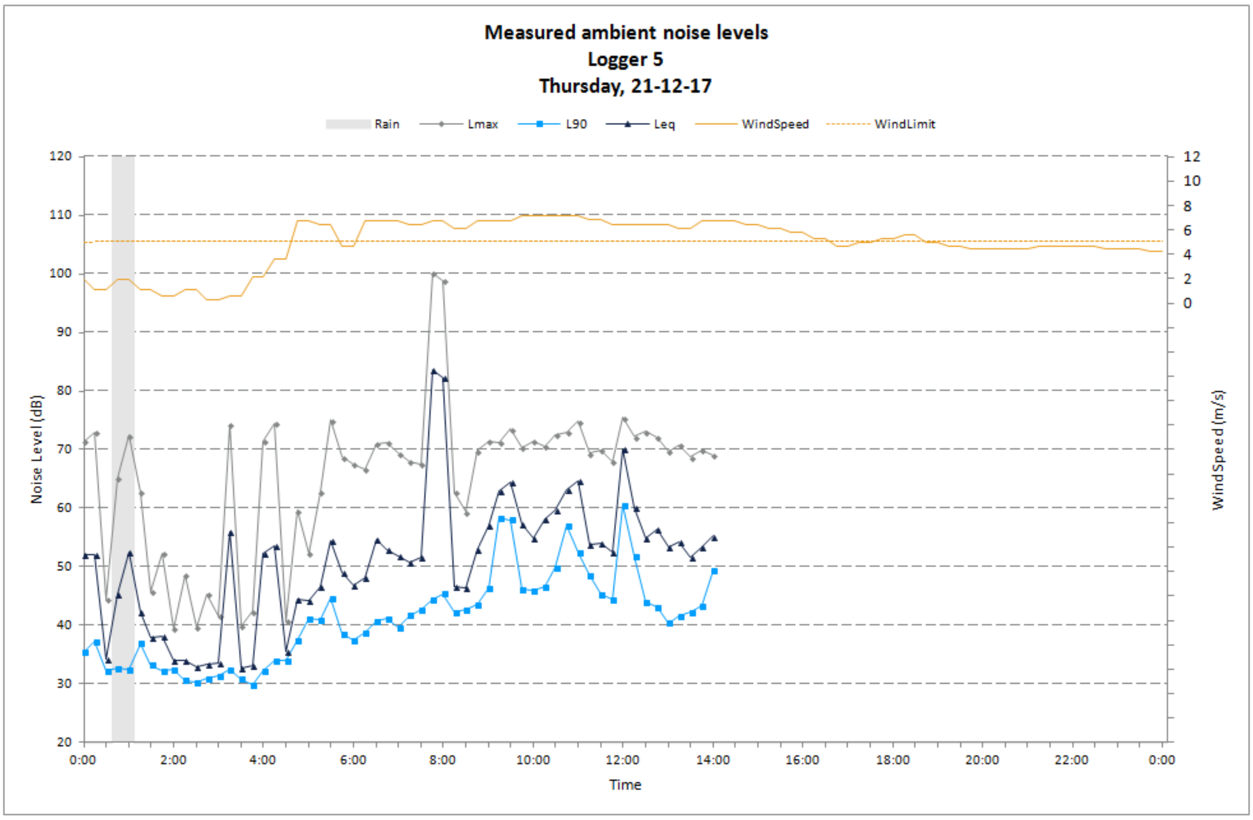
Measured ambient noise levels
Logger 5
Monday, 18-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time



Measured ambient noise levels
Logger 5
Tuesday, 19-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time



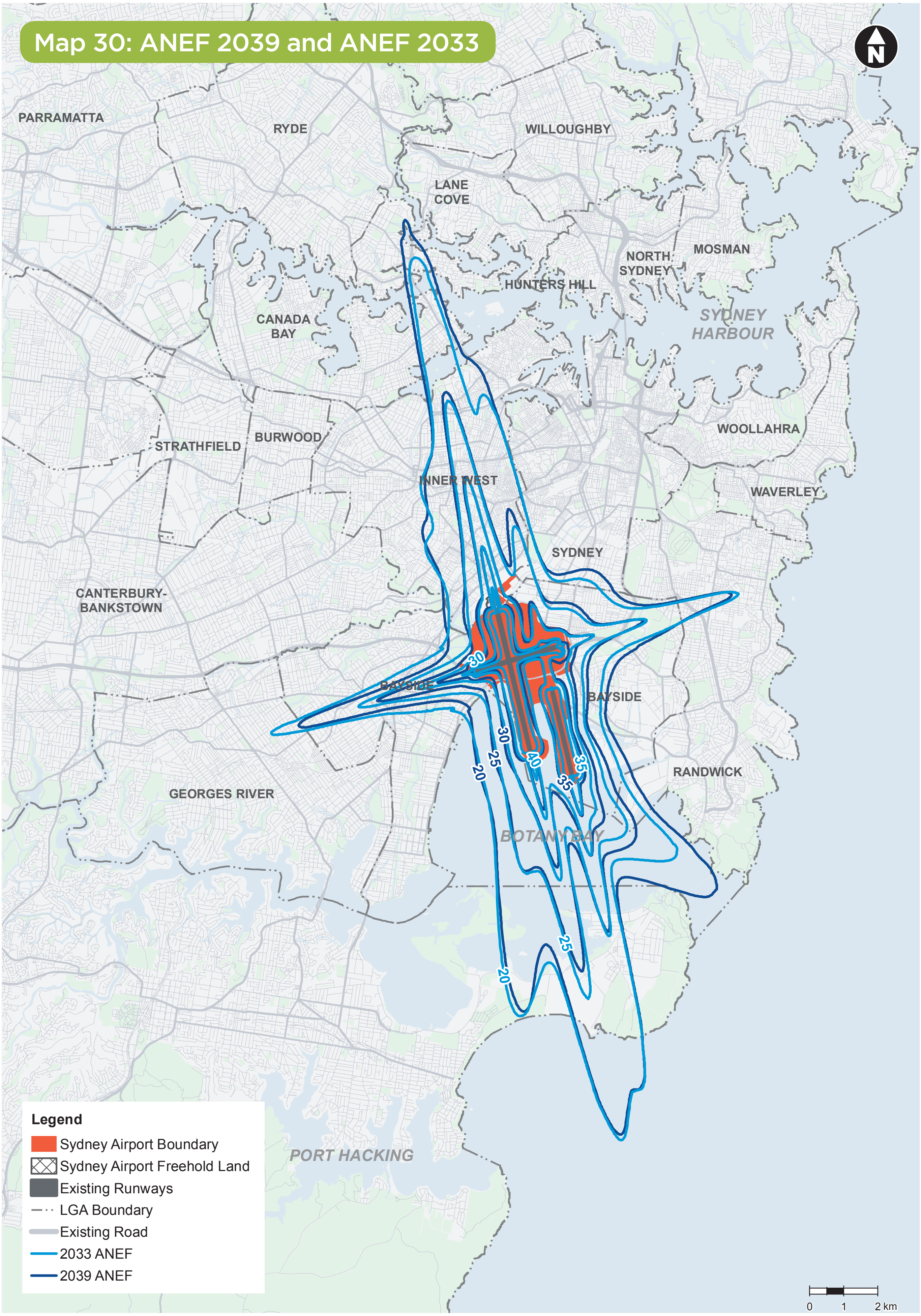
Measured ambient noise levels
Logger 5
Wednesday, 20-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time



Measured ambient noise levels
Logger 5
Thursday, 21-12-17
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time

Appendix B

Sydney Kingsford Smith Airport ANEF 2039 and ANEF 2033 Contours


Map 30: ANEF 2039 and ANEF 2033
PARRAMATTA
RYDE
WILLOUGHBY
LANE COVE
NORTH SYDNEY
MOSMAN
HUNTERS HILL
CANADA BAY
SYDNEY HARBOUR
STRATHFIELD
BURWOOD
WOOLLAHRA
INNER WEST
WAVERLEY
SYDNEY
CANTERBURY-BANKSTOWN
BAYSIDE
BAYSIDE
RANDWICK
GEORGES RIVER
BOTANY BAY
PORT HACKING
20
25
30
35
40
Legend
Sydney Airport Boundary
Sydney Airport Freehold Land
Existing Runways
LGA Boundary
Existing Road
2033 ANEF
2039 ANEF
0
1
2 km

Appendix C

EMM Aircraft noise study

Aircraft noise study

Besmaw Kurnell Site

September trends for 2011, 2014, 2015 and 2017

Prepared for Besmaw Pty Limited | 6 June 2018

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Aircraft noise study

Draft Report

Report J17220RP1 | Prepared for Besmaw Pty Limited | 6 June 2018

Approved by	**Najah Ishac**
Position	Director
Signature	
Date	

Document Control

Version	Date	Prepared by	Reviewed by
V01	6 June 2018	Najah Ishac	Daniel Weston

EMM

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www.emmconsulting.com.au

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1 Introduction

1.1 Purpose

EMM Consulting Pty Limited (EMM) was engaged by Besmaw Pty Limited to study the trend over time of aircraft noise from Sydney Kingsford Smith Airport (the airport) operations on the company's land (the site), located on the Kurnell Peninsula. The site is currently being used for sand extraction, rehabilitation, horse boarding and equestrian facilities.

Aircraft noise from the airport affects a number of Sydney metropolitan areas, as identified in the Sydney Airport Master Plan 2033 (the Master Plan). This includes the Kurnell Peninsula.

The purpose of this study is to understand the trends in aircraft noise and movements from the airport at particular locations in Kurnell and across four similar periods in time. The periods of monitoring and analysis are four lots of September calendar months for 2011, 2014, 2015 and 2017. This report presents the details of the latest data set captured in September 2017 and compares this data to prior years.

Data from Air services Australia (ASA) has been combined with the results of short term attended and long term unattended noise surveys. This was then used to establish any evidence of trends in data between the four (September) periods of sampling.

1.2 Methodology

The approach to analysing aircraft noise for the site included on-site measurement of aircraft noise levels using attended and unattended methods.

The noise monitoring program focused on the three flight path runway ends that are the most influential to the noise environment at the site, namely:

- 16R – Departures;
- 34L – Arrivals; and
- 34R – Arrivals.

The site in relation to the above runway ends is shown in Figure 2.1. In undertaking this study of aircraft noise, ANEF maps were reviewed in accordance with the method described in Australian Standard AS 2021 - 2015 - Acoustics - Aircraft noise intrusion - Building siting and construction (Standards Australia Limited 2015). The ANEF system within AS 2021 is the fundamental planning tool used in Australia when decision makers are assessing a development application.

An evaluation of noise data collected in September 2011, September 2014, September 2015 and most recently September 2017 forms the basis of this study. The aim of this analysis has been to identify any trends in data collected. Airservices Australia (ASA) provided aircraft movement data over the suburb of Kurnell as well as noise data from their own Kurnell noise monitor.

Five noise monitors captured data across the Besmaw site and an additional monitor was located at Kurnell Public School (adjacent to ASA's monitoring station). The data was collected over day, night and curfew hours to better understand impacts for these time periods. Appendix E provides further details on the method used to analyse unattended monitoring data.

1.3 Glossary of acoustic terms

A number of technical acoustic descriptions are used in this report. A list of terms and a brief explanation are provided in Table 1.1.

Table 1.1 Glossary of acoustic terms

Term	Descriptions
ANAc	Aircraft noise attenuation required of each building component
ANR	Aircraft noise reduction
BCA	Building Code of Australia
Curfew	Defined as the hours 11pm to 6am for Sydney Kingsford Smith Airport aircraft operations
dB	Unit of sound in decibels
dB(A)	A unit of sound measurement which has its frequency characteristics modified by a filter (A-weighted) so that it approximates the frequency response of the human ear.
DL	The distance in metres from the closer end of the runway to the intersection of the extended runway centre-line and a line drawn perpendicular to the extended runway centre-line and passing through the building site, known as the 'sideline projection' (refer to AS2021-2015 Figure 3.1).
DS	The perpendicular distance in metres from the building site to the extended runway centre-line (refer to AS2021-2015 Figure 3.1).
DT	The distance in metres from the further end of the runway to the intersection of the runway centre-line and a line drawn perpendicular to the extended runway centre-line and passing through the building site, known as the 'sideline projection' (refer to AS2021-2015 Figure 3.1).
EPN (EPNL or EPNdB)	Effective Perceived Noise level is a modification of the Perceived Noise Level (PNL) to take into account tone components in aircraft broad band noise as well as the duration of the noise. It is measured in EPNdB, and defined as the PNL in PNdB plus a tone correction and a duration correction.
L_{Smax}	Maximum noise level with slow time response (measured in dB(A))
L_{eq}	The “equivalent continuous noise level” is the summation of noise events integrated over a selected period of time. This noise metric is the energy-averaged noise level over the measurement period and is commonly used to correlate noise exposure and human annoyance.
N70	The number of daily aircraft noise events that are above a maximum noise threshold of 70 dB(A) L_{Smax} . Similarly for N60 etc.
NEC	Noise Exposure Concept, is a single number index for predicting the cumulative exposure to aircraft noise during a specified time period (normally one future year) during consideration of options for development, based on a hypothetical set of conditions. This shows the average daily aircraft noise exposure for that period and is usually presented graphically in the form of noise contours.
NEF (or ANEF)	Noise Exposure Forecast, is an index for predicting the cumulative exposure to aircraft noise during a particular future year, generally 10 to 20 years from the date of issue, based on a firm forecast of aircraft operations. This shows the average daily aircraft noise exposure for that period and is usually presented graphically in the form of noise contours.
NEI (or ANEI)	Noise Exposure Index, is an index for calculating the cumulative exposure to aircraft noise during a specified time period, based on historical data, where exact types and numbers of aircraft, which used the aerodrome, are known. This shows the average daily aircraft noise exposure for that period and is usually presented graphically in the form of noise contours.
NMT	Noise monitoring terminal
PCA	Point of Closest Approach is the aircraft's position when it is closest (in plan view) to the nominated ground position, defined for this project as the ASA's noise monitor location which is at the Kurnell Public School.
Rw	Weighted sound reduction index
Daytime	For aircraft noise modelling purposes, the day period is 7am to 7pm.
Evening/Night	For aircraft noise modelling purposes, the evening/night period is 7pm to 7am.
Movement	One pass of an aircraft as it takes off or lands.

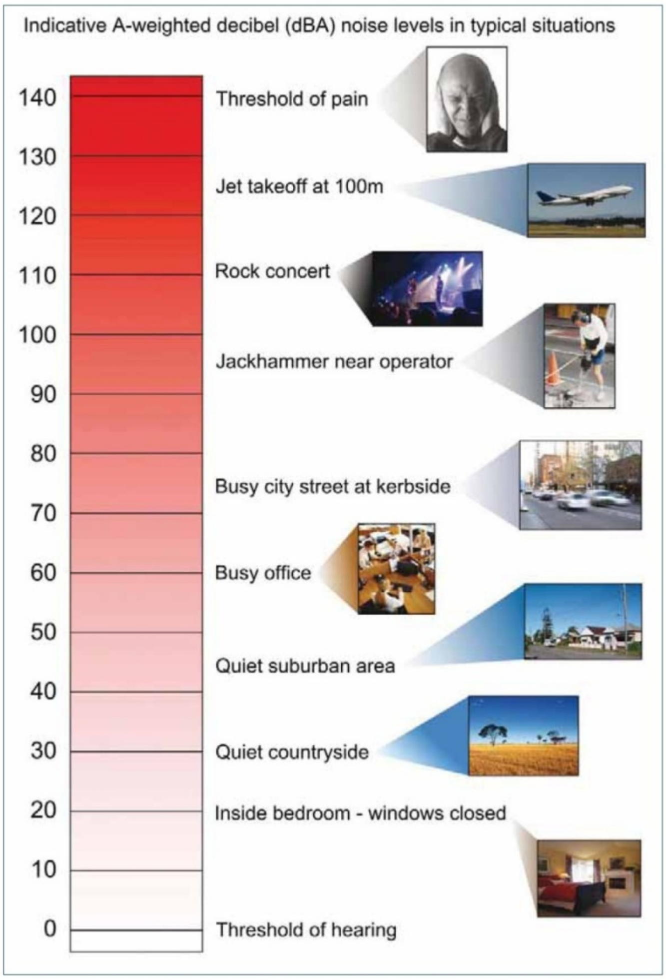
1.4 Common noise levels

It is useful to have an appreciation of decibels (dB), the unit of sound measurement when reading this assessment. Table 1.2 gives some practical indication of what an average person perceives about changes in noise levels.

Table 1.2 Perceived change in noise

Change in sound level (dB)	Perceived change in noise
3	just perceptible
5	noticeable difference
10	twice (or half) as loud
15	large change
20	four times as loud (or quarter) as loud

Examples of common noise levels are provided in Figure 1.1.



Source: RTA Environmental Noise Management Manual (RTA 2001).

Figure 1.1 Common noise levels

1.5 Site location

The approximate location of noise loggers, the site, flight paths of interest and ASA's noise monitor are shown in Figure 1.2.

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EMM

Site locality and noise monitoring locations

Besmaw Kurnell Site

Aircraft Noise Study

Figure 1.2

2 Relevant aircraft noise criteria and Sydney Airport Master Plan

This section details current land use planning tools for aircraft noise and relevant information from the Sydney Airport Master Plan 2033.

2.1 Australian Standard AS 2021

The fundamental tool used for building site acoustic planning purposes around aerodromes is Australian Standard *AS 2021 - 2015 Acoustics - Aircraft noise intrusion - Building siting and construction*. This standard is at its fifth edition with the original published in 1977 and it replaces the prior edition which was published in 2000. The fundamental principles for land use planning did not change between the 2000 and 2015 versions. AS2021 states:

> "*The aircraft Noise Exposure Forecast (NEF) technique was first developed in the United States of America in the late 1960s. It was subsequently redefined in Australia in 1982. The NEF system is a scientifically based computational procedure for determining aircraft noise exposure levels around aerodromes. It can be used for assessing average community response to aircraft noise and for land use planning around aerodromes. In the Australian NEF system, noise exposure levels are calculated in Australian Noise Exposure Forecast (ANEF) units, which take into account the following features of aircraft noise:*
>
> *(a) The intensity, duration, tonal content and spectrum of audible frequencies of the noise of aircraft take offs, approaches to landing, and reverse thrust after landing (for practical reasons, noise generated on the aerodrome from aircraft taxiing and engine running during ground maintenance is not included).*
>
> *(b) The forecast frequency of aircraft types and movements on the various flight paths, including flight paths used for circuit training.*
>
> *(c) The average daily distribution of aircraft arrivals and departures in both daytime and night-time (daytime defined as 0700 hours to 1900 hours, and night-time defined as 1900 hours to 0700 hours).*
>
> *ANEF charts are provided for most aerodromes throughout Australia. The charts are simply plans of the aerodrome and the surrounding localities on which noise exposure contours of 20, 25, 30, 35 and 40 ANEF units have been drawn. These contours indicate land areas around an aerodrome which are exposed to aircraft noise of certain levels as defined by Clause 1.5.6; the higher the ANEF value the greater the noise exposure.*
>
> *In the areas outside 20 ANEF, noise from sources other than aircraft tends to predominate over aircraft noise, although individual reactions to aircraft noise may differ markedly. Within the area from 20 ANEF to 25 ANEF, aircraft noise exposure starts to emerge as an environmental problem, while above 25 ANEF the noise exposure becomes progressively more severe.*
>
> *The land use compatibility recommendations made in this Standard relate to the above ANEF contours.*"

Item (a) above relating to 'on or near aerodrome' specific issues is not relevant given the distance between the airport and the site (ie at least 7km to the nearest runway end).

Other useful context from AS2021 includes:

> "*Prior to 1982, Australian land use recommendations were essentially similar to the criteria used in the U.S. NEF system. However, with the availability of an Australian dose/response function derived from the NAL social survey, the U.S. criteria were revised to take into account the general reaction of Australian communities to aircraft noise.*
>
> *In essence, this revision was limited to a firmer definition of the criterion for residential land use compatibility. In the NEF system as originally adopted in Australia, the U.S. criterion of 30 NEF was adhered to, but, in accordance with a recommendation of the House of Representatives Select Committee on Aircraft Noise made in 1970, cautious restraint was urged to be applied by land zoning authorities when applying the system to Australian conditions. Where possible, the 25 NEF contour was used rather than the 30 NEF as a conservative safeguard until the system was validated in Australia.*
>
> *The NAL Report provided substantial evidence to support the use of 25 ANEF as the appropriate criterion for residential land usage. The 25 ANEF as a residential land usage criterion was recommended in 1985 by the House of Representatives Select Committee on Aircraft Noise, and subsequently adopted as policy by the Commonwealth Government. The only qualification which arises from the findings of the NAL Report is that some people will find that the noise exposure at 25 ANEF is still unacceptable (refer to Figure A1 for the percentage of people affected in the 20 ANEF to 25 ANEF zone). Accordingly, the issuing authorities enter the 20 ANEF contour on all ANEF charts. It is to be stressed, however, that the actual location of the 20 ANEF contour is difficult to define accurately, because of variations in aircraft flight paths, pilot operating techniques, and the effect of meteorological conditions on noise propagation. For that reason, the 20 ANEF contour is shown as a broken line on ANEF charts*."

2.1.1 Site acceptability

The standard considers whether a building site is 'acceptable', 'conditionally acceptable' or 'unacceptable' on acoustic grounds. To do this, an Australian Noise Exposure Forecast (ANEF) noise contour map is needed, which shows the aerodrome's noise footprint on the surrounding environment. The ANEF map is a function of noise levels from various aircraft that are forecast to use the airport and the number of aircraft movements. The ANEF values are used for land use planning around Airports in Australia. Most councils around the airport adopt this approach, and in the absence of such guidance in local or state policies, advice in AS 2021 is the most authoritative available.

The Australian Standard recommends an initial screening approach to determine the acceptability of a site for nominated land uses. Table 2.1 provides a reproduction of Table 2.1 from AS 2021 and the associated notes that follow the table.

Table 2.1 Building site acceptability based on ANEF zones (AS 2021)

Building Type	ANEF Zone of site		
	Acceptable	Conditionally Acceptable	Unacceptable
House, home unit, flat, caravan park	Less than 20 ANEF	20 to 25 ANEF	Greater than 25 ANEF
Hotel, motel, hostel	Less than 25 ANEF	25 to 30 ANEF	Greater than 30 ANEF
School, university	Less than 20 ANEF	20 to 25 ANEF	Greater than 25 ANEF
Hospital, nursing home	Less than 20 ANEF	20 to 25 ANEF	Greater than 25 ANEF
Public building	Less than 20 ANEF	20 to 30 ANEF	Greater than 30 ANEF
Commercial building	Less than 25 ANEF	25 to 35 ANEF	Greater than 35 ANEF
Light industrial	Less than 30 ANEF	30 to 40 ANEF	Greater than 40 ANEF
Other industrial		Acceptable in all ANEF zones	

Notes: *1. The actual location of the 20 ANEF contour is difficult to define accurately, mainly because of variation in aircraft flight paths. Because of this, the procedure of Clause 2.3.2 may be followed for building sites outside but near to the 20 ANEF contour.*

2. Within 20 ANEF to 25 ANEF, some people may find that the land is not compatible with residential or educational uses. Land use authorities may consider that the incorporation of noise control features in the construction of residences or schools is appropriate (see also Figure A1 of Appendix A).

3. There will be cases where a building of a particular type will contain spaces used for activities which would generally be found in a different type of building (e.g. an office in an industrial building). In these cases Table 2.1 should be used to determine site acceptability, but internal design noise levels within the specific spaces should be determined by Table 3.3.

4. This Standard does not recommend development in unacceptable areas. However, where the relevant planning authority determines that any development may be necessary within existing built-up areas designated as unacceptable, it is recommended that such development should achieve the required ANR determined according to Clause 3.2. For residences, schools, etc., the effect of aircraft noise on outdoor areas associated with the buildings should be considered.

5. In no case should new development take place in green field sites deemed unacceptable because such development may impact airport operations.

AS 2021 defines the terms in Table 2.1 as follows:

Acceptable

> *If from Table 2.1, the building site is classified as 'acceptable', there is usually no need for the building construction to provide protection specifically against aircraft noise. However, it should not be inferred that aircraft noise will be unnoticeable in areas outside the ANEF 20 contour. (See Notes 1, 2 and 3 of Table 2.1).*

Conditionally acceptable

> *If from Table 2.1, the building site is classified as 'conditionally acceptable', the maximum aircraft noise levels for the relevant aircraft and the required noise reduction should be determined from the procedure of Clauses 3.1 and 3.2, and the aircraft noise attenuation to be expected from the proposed construction should be determined in accordance with Clause 3.3 (See Notes 1 and 3 of Table 2.1).*

If an area is found to be 'conditionally acceptable' this typically means that any proposed buildings could require an improved level of building fabric above standard or light weight materials to achieve internal noise goals set by AS 2021.

Unacceptable

> *If, from Table 2.1 the building site is classified as 'unacceptable', construction of the proposed building should not normally be considered. Where in the community interest redevelopment is to occur in such areas, e.g. a hotel in the immediate vicinity of an aerodrome, refer to the notes to Table 2.1.*

2.1.2 Requirements for construction

If buildings are constructed in "conditionally acceptable" areas, AS 2021 sets out required internal noise levels, based on L_{Smax} values from the loudest operating aircraft type.

A procedure is described in AS 2021 for determining the required performance of building elements to meet these levels, but this is not a requirement of the Standard and alternate and a more accurate method is used by practitioners – measurements to determine external noise levels, and accurate frequency based calculations to determine resulting internal levels.

2.1.3 Maximum noise levels

If a building is within a 'conditionally acceptable' ANEF zone, it is necessary to quantify the typical L_{Smax} noise level from aircraft passing over that site. The representativeness of noise data should reflect typical events at the aerodrome, which can be ambiguous in some cases, particularly when trying to estimate future operations and associated impacts. For Sydney Airport this is relatively straightforward because of its well established flight path movements, runways and aircraft types.

For aerodromes with a relatively high number of movements (defined as an airport), it is suggested by AS 2021 that data tabulated in the standard be supplemented by site-specific field measurements. A significant amount of onsite field measurements were collected for this study to provide an accurate way of assessing impacts.

Where a site is 'conditionally acceptable', AS 2021 recommends that buildings be designed to achieve internal noise levels no greater than identified maximum values from aircraft.

Table 2.2 reproduces recommended internal maximum noise levels for various spaces as categorised in AS 2021. These are the L_{Smax} or maximum noise inside buildings. The spaces with the most onerous criteria are theatres, cinemas and recording studios, although these are often designed and constructed with highly noise attenuating building elements.

For residential buildings, it is necessary to consider aircraft noise levels of greater than L_{Smax} 60 dB(A) L_{Smax} as an external level of 60 dB(A) is typically reduced to 50 dB(A) inside a room with a partially open window or door. This satisfies the strictest residential criterion, applicable to sleeping areas and dedicated lounges.

Table 2.2 Indoor design sound levels

Building type and activity	Indoor L_{Smax} Design Sound Level, dB(A)
Houses, home units, flats, caravan parks	
Sleeping areas, dedicated lounges	50
Other habitable spaces	55
Bathroom, toilets, laundries	60
Hotels, motels, hostels	
Relaxing, sleeping	55
Social activities	70
Service activities	75
Schools, universities	
Libraries, study areas	50
Teaching areas, assembly areas	55
Workshops, gymnasia	75
Hospitals, nursing homes	
Wards, theatres, treatment and consulting rooms	50
Laboratories	65
Service Areas	75
Public buildings	
Churches, religious activities	50
Theatres, cinemas, recording studios	40
Court houses, libraries, galleries	50
Commercial buildings, offices and shops	
Private offices conference rooms	55
Drafting, open offices	65
Typing, data processing	70
Shops, supermarkets, showrooms	75
Industrial	
Inspection, analysis, precision work	75
Light machinery, assembly, bench work	80
Heavy machinery, warehouse, maintenance	85

AS 2021 defines the 'aircraft noise level' at Section 1.5.2 as:

The arithmetic average of the maximum sound levels occurring during a series of flyovers by a specific aircraft type and load conditions measured in A-weighted decibels (dB(A))using the S time-weighting of a sound level meter.

2.1.4 Additional information

AS 2021 states:

ANEF values average noise exposure over a year and do not take account of variations in noise exposure patterns to which the community reacts on an hourly, daily, weekly or seasonal basis. To address this issue, other parameters such as maximum noise levels and frequency of noise events may be included in noise assessment of airports to supplement ANEF levels.

Additional noise metrics were also provided, including Number Above values (e.g. N60, N70 etc.), movement data, flight path information and respite analysis to provide a comprehensive suite of information. This enables occupants to have a better understanding of the noise exposure on a particular site.

2.2 Sydney Airport Master Plan 2033

The Master Plan is the vision for Sydney Airport, forecasting growth in air travel for tourism and trade to and beyond 2033. The Master Plan assumes that the night time curfew, aircraft movement cap, noise sharing arrangements, flight paths, runways and regional airline access arrangements will be maintained. These factors are important for informing land use planning generally around the airport.

2.2.1 Describing aircraft noise

Descriptors of aircraft noise exposure are useful to potential occupants of a site. The Sydney Airport Master Plan 2033 provides the most current airport operations and related noise information. Relevant aircraft noise exposure information from this document is summarised below.

2.2.2 Flight paths

One factor in determining aircraft noise impacts under AS 2021 is site location relative to runways.

Chapter 14 'Noise Management' of the Master Plan includes actions and strategies for managing aircraft noise. It shows aircraft flight paths, noise measurement methods and provides information on ground-based noise. Sydney Airport acknowledges its noise impacts on the community and it commits to working with the community, governments and the aviation industry to manage and mitigate these impacts. The Master Plan states that aircraft in Australian skies are some of the most modern in the world and with quieter aircraft replacing older ones, the impacts from aircraft will continue to reduce. This is confirmed by the published ANEF contours for 2033, which cover a significantly smaller area than in previous ANEF contours (i.e. 2029 and earlier).

2.2.3 Available noise maps

The Master Plan includes typical maps for various airport operations. These are essential for planning land use developments under AS 2021 and are discussed later in this report as they relate to the site.

2.2.4 Other noise descriptors

Another useful noise metric that is often used in airport noise impact assessments is Number Above (NA) indices. Whilst there are no formal standards or policies that adopt these indices for land use planning, they do provide another perspective on impacts. The Master Plan, for example, cites that an internal noise level greater than 60 dB(A) is likely to interfere with conversation or with listening to radio or television (refer to Master Plan 2033 Appendix H Dictionary, for N70 contours). The corresponding outdoor noise level would be 70 dB(A), considering windows or doors are partially open. The Master Plan therefore advocates the use of N70 as another way of informing the community about aircraft noise; however this does not necessarily imply that N70 or other similar metrics should be used for land use planning.

Similarly, Airservices Australia in its publication “Sydney Airport N477 Australian Noise Exposure Index 1 January to 31 March 2012”, states the following:

> *“‘Number Above’ (Nxx) noise maps are an approach which provides additional information on aircraft noise in a form that is more easily understood by the community. The contours provide a visual depiction that shows the number of noise events during a given period that are louder than a selected threshold level. The N70 Aircraft Noise Map for Sydney Airport shows for all areas around the airport how many aircraft noise events louder than 70 dB(A) there were, on a daily average, during the period from 1 January to 31 March* 2012 ANEI (N477).
>
> 70 dB(A) is generally considered to be the external sound level below which no difficulty with reliable communication from radio, television or conversational speech in a typical room with windows open is expected. (Reference - Department of Transport and Regional Services, 2000, Expanding Ways to Describe and Assess Aircraft Noise, pp23-35).”

This is because internal noise is reduced by about 10 dB, even with light weight building construction and windows partially open.

2.2.5 Other relevant information

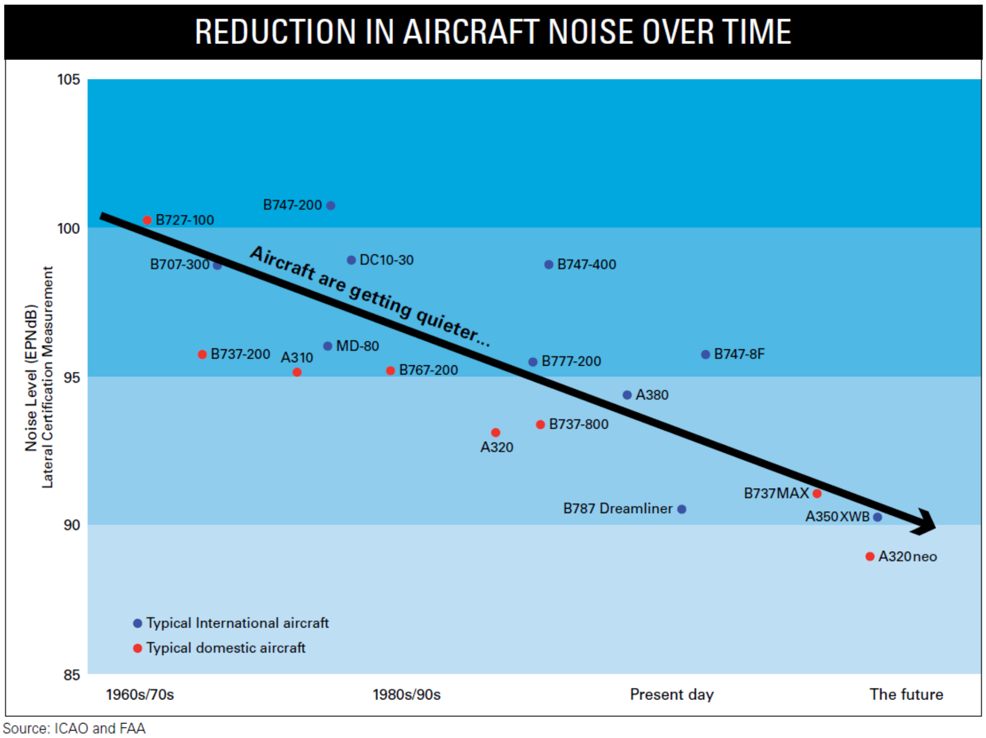
This study highlights a number of relevant references from The Master Plan which should be considered. This will further assist in understanding future operations and the associated impacts from aircraft noise.

For example, it is stated that airlines expect to see continued increases in seating density across the industry. Further, Qantas "...intends to replace B767s with the 20 to 25% larger A330s".

In Section 14.2.1, page 179, the Master Plan states:

> *"Sydney Airport welcomes the introduction of the new generation of quieter aircraft like the Airbus A380, Boeing B777, B787 Dreamliner and B747-8F. It is expected that other new generation quieter aircraft like the A350XWB, B737 MAX and A320neo will be introduced within the planning period of this Master Plan.*
>
> *Sydney Airport's past, present and future investment in infrastructure to accommodate these new generation aircraft is designed to ensure residents living close to the airport or under flight paths will continue to benefit from their introduction. For example, to accommodate the A380, which is both larger and much quieter than the older aircraft type it is replacing, Sydney Airport has invested significantly to upgrade infrastructure."*

Figure 14.2 of the Master Plan 2033 depicts how improved technology has resulted in quieter aircraft (reproduced as Figure 2.1). It is expected that aircraft noise will continue to reduce into the future.



Source: Sydney Airport Master Plan 2033 (2014).

Figure 2.1 Reduction in aircraft noise over time

On page 182, the Master Plan states:

> *In 2008, Airservices Australia released a report showing that an Airbus A380 departing from or arriving at Sydney Airport is between 2.1 and 6.7 decibels quieter than the 747-400, the older aircraft type it typically replaces.*
>
> *Airservices Australia indicates in its report that "a three decibel reduction is regarded as a halving of an aircraft's noise energy".*

Figure 2.2 reproduces actual measured noise reductions from comparable aircraft, as reported in the Master Plan in Table 14.6. The A380 has a smaller noise footprint on take-off and landing and hence reduces the impact on the community. It should be noted that departure and arrival flight paths are at variable distances to the noise monitoring terminal (NMT); hence this is a factor in the difference between departure and arrival noise levels.

Location of NMT	Aircraft type	Arriving or departing	Average LA max [dB(A)]	Reduction in decibels	Reduction in noise energy
Sydenham	A380	Departing	87.7	- 4.4	- 64%
	B747-400	Departing	92.1		
	A380	Arriving	93.9	- 2.6	- 45%
	B747-400	Arriving	96.5		
Leichhardt	A380	Departing	81.7	- 3.9	- 59%
	B747-400	Departing	85.6		
	A380	Arriving	84.4	- 2.1	- 38%
	B747-400	Arriving	86.5		
Annandale	A380	Departing	71.5	- 5.5	- 72%
	B747-400	Departing	77.0		
St Peters	A380	Departing	73.6	- 6.7	- 79%
	B747-400	Departing	80.3		
Croydon	A380	Departing	76.7	- 2.3	- 41%
	B747-400	Departing	79.0		

Source: Airservices Australia

Source: Sydney Airport Master Plan 2033 (2014).

Figure 2.2 Noise monitoring around Sydney Airport

On page 182, the Master Plan states:

> *In July 2012, Virgin Australia announced an agreement with Boeing to order 23 of its new generation 737 MAX aircraft, the first airline in Australia to do so. Boeing has said that the noise footprint of this aircraft is 40% smaller than today's B737s."*
>
> *The B787 Dreamliner began flying to Sydney in August 2013. Qantas has selected the B787 Dreamliner as the cornerstone of its domestic and international fleet renewal program. Under the fleet plan, the Qantas Group has orders for 15 Boeing 787 aircraft, with the first aircraft having arrived in the second half of 2013. Qantas has options and purchase rights for a further 50, available for delivery from 2016. Powered by General Electric's GEnx engines, Qantas indicates that it has a 50% smaller noise footprint. The B787 will, over time, replace older aircraft like the B767-300. Cathay Pacific already flies the new generation B747-8F freighter to Sydney and has said that its noise footprint is 30% smaller than the older freight aircraft type it replaced.*

2.3 SEPP Kurnell Peninsula

SEPP Kurnell Peninsula is the applicable planning resource for the Besmaw site. Note that it has not been amended to adopt the Standard Instrument clause for aircraft noise. AS 2021 is the relevant land use planning tool for assessing future development proposals as referenced in clause 23 of SEPP Kurnell Peninsula.

Development in areas subject to aircraft noise:

(1) The objectives of this clause are as follows:

(a) to prevent certain noise sensitive developments from being located near the Sydney (Kingsford Smith) Airport and its flight paths,

(b) to assist in minimising the impact of aircraft noise from that airport and its flight paths by requiring appropriate noise attenuation measures in noise sensitive buildings,

(c) to ensure that land use and development in the vicinity of that airport do not hinder or have any other adverse impacts on the ongoing, safe and efficient operation of that airport.

(2) This clause applies to development that:

(a) is on land that:

(i) is near the Sydney (Kingsford Smith) Airport, and

(ii) is in an ANEF contour of 20 or greater, and

(b) the consent authority considers is likely to be adversely affected by aircraft noise.

(3) Before determining a development application for development to which this clause applies, the consent authority:

(a) must consider whether the development will result in an increase in the number of dwellings or people affected by aircraft noise, and

(b) must consider the location of the development in relation to the criteria set out in Table 2.1 (Building Site Acceptability Based on ANEF Zones) in AS 2021—2000, and

(c) must be satisfied the development will meet the indoor design sound levels shown in Table 3.3 (Indoor Design Sound Levels for Determination of Aircraft Noise Reduction) in AS 2021—2000.

(4) In this clause:

ANEF contour *means a noise exposure contour shown as an ANEF contour on the Noise Exposure Forecast Contour Map for the Sydney (Kingsford Smith) Airport prepared by the Department of the Commonwealth responsible for airports.*

AS 2021—2000 *means AS 2021—2000 Acoustics - Aircraft noise intrusion - Building siting and construction.*

It should be noted that the clause above references the previous revision of AS 2021 and not the latest revision in 2015. Further, Sutherland LEP 2015, which applies to the Sutherland local government area identifies the site as a deferred matter and so SEPP Kurnell Peninsula is applicable to the site.

3 Aircraft noise at Besmaw site

The main influences on the Besmaw site noise environment are from aircraft approaches on runway end 34L, and to a lesser extent, departures on runway end 16R and arrivals on 34R. These operations occur on the two parallel (main) north-south runways at Sydney Airport. These two runways handle the majority of Sydney airport air traffic, the majority of which are jet aircraft. Site impacts can be assessed with an adequate sample of aircraft noise data; and there was ample opportunity to capture representative data for the site.

The most relevant departure runway end is 16R, where take-offs occur towards and adjacent to the site. This runway end is over 10.5 km from the northern (closest) site boundary. The parallel departure runway end is 16L and the corresponding flight path is to the east of the site and the whole of the Kurnell Peninsula over Botany Bay. Hence, aircraft noise on this flight path is not an influence at the site. The arrival path of runway end 34L passes directly over part of Besmaw land and is approximately 7 km from the site. Arrival path 34R is less signified but operations are measureable at some monitoring stations (refer to Figure 1.2 for flight paths associated with runways).

Besmaw land is marked on the following maps to highlight relationships between the site and airport operations (refer to Appendix A herein):

- Master plan Figure 14.7 - ANEF 2033 and ANEF 2029 (Figure A.3). This shows a marked reduction in noise exposure for the site, depicted by a change in the position of the 20 ANEF contour between ANEF 2033 and ANEF 2029. From this map it is clear that part of the site will be less than 20 ANEF according to ANEF 2033. All building types would therefore be acceptable on acoustic grounds without modifying normal construction methods. This in itself allows a significant high level planning assessment. However, as described in AS 2021 it is good practice to further assess sites adjacent to 20 ANEF.

  In 2033 the remainder of the site will be between 20 ANEF and 25 ANEF. AS 2021 states that a wide range of land uses are 'acceptable' or ‘conditionally acceptable’ in this range. This indicates that residential land use is permissible in this area on acoustic grounds and further study is required to ascertain the level of noise mitigation that is appropriate. This is done by measuring maximum noise levels (L_{Smax}) as described below. In summary, the site is partially acceptable and partially conditionally acceptable for a variety of land uses on acoustic grounds.

- Master plan Figure 14.8 - ANEF 2033 and ANEI 2011 (Figure A.4). This figure demonstrates that actual airport operations in 2011 (ie ANEI) were very similar to the 2033 noise exposure forecast generally and at the site in particular.

- Master plan Figure 14.10 - Average daily jet aircraft movements 2033 (Figure A.5). Flight paths H and I are relatively unchanged from current operations. These two paths are the most relevant to the site as arrival path H is east of or over an eastern portion of the site and departure path I is to the west. Departure aircraft are over 10.5 km from the corresponding runway end by the time they pass the site (e.g. 16R departures). Arrival aircraft adjacent to the site on path H are almost 7 km from runway ends (e.g. 34L).

- Master plan Figure 14.11 - Average daily jet aircraft respite periods 2033 (Figure A.6). This figure shows a daily average respite of 51% and 48% for jet aircraft on paths H and I respectively. It is noted that respite on path H (used for arrivals) would typically imply no respite on path I (used for departures) and vice-versa. As shown on the figure, path H influences noise on the eastern side of the site while path I influences the western side, leaving an area in between that is relatively less exposed.

Flight path figures for jet and non-jet aircraft are also reproduced with the site in Appendix A for reference (Figures A.1 and A.2).

3.1 Noise monitoring - September 2017

EMM conducted short term attended and long term unattended noise monitoring at several locations throughout the site. This report presents the analysis of data collected for the most recent September (monitoring commenced 31 August and ended 6 October, 2017) and provides a comparison with the data collected in September 2011, September 2014 and September 2015 to identify trends across these periods.

Measurement techniques recommended in Appendix D of AS 2021 were adopted for both attended and unattended monitoring. Attended monitoring was completed twice during the September 2017 monitoring period, on the 18 and 30 of September, 2017; whereas unattended monitoring was continuous throughout the study period. Monitoring locations are shown in Figure 1.2.

3.2 Attended measurements - September 2017

Attended noise measurements and observations were made during two site visits, including installation, calibration and servicing of the six unattended monitors (five at the site and one at Kurnell Public School). The data are presented in Appendix C and are summarised below in Table 3.1.

Runway end and aircraft type were confirmed using ASA movement data. In strict accordance with AS 2021, the considerably less frequent operations of older Boeing 747-400 (B747-400) aircraft were used for driving design requirements for any new building at the site. Data for this aircraft are therefore specifically noted in Table 3.1. Data for the most frequent jet aircraft operating from the airport (B737-800) are also provided in Table 3.1. Key points from the data were:

- the monitoring did not capture all movements where associated noise levels were below ambient levels or were otherwise inaudible. For example, observations confirmed that arrivals on 34R were generally not measurable at location 1 given the distance separation, and otherwise levels were observed to be below 60 dB(A);
- 71 samples were collected at the Besmaw site which included 69 arrivals and 2 departure events;
- the highest L_{Smax} noise levels from aircraft on the Besmaw land was up to 78 dB(A) and 79 dB(A) at location 3 (landings) and 5 (take-offs) respectively;
- the mean L_{Smax} noise levels from aircraft across the Besmaw land ranged from 60 to 69 dB(A);
- location 3 was relatively more exposed to aircraft noise than others, being beneath flight path 34L;
- departure events influenced noise levels at the site's western locations 1 and 4, being closer to departure path 16R in the vicinity of the site; and

- conversely, arrivals on runway end 34L influenced noise at eastern locations 3 and 5. Arrivals on runway end 34R affected noise at location 5 and at location 3 to a lesser degree.

Table 3.1 Summary of attended noise measurements – 18 and 30 September 2017

Summary description	Location 1 (Lot 2 South)	Location 2 (Lot 2 South)	Location 3 (Lot 2 South)	Location 4 (Lot 2 North)	Location 5 (Lot 2 South)
			All Aircraft		
Highest L_{Smax}, dB(A)[1]	65	72	78	79	72
Event	Arr (34L)	Arr (34L)	Arr (34L)	Dep (16R)	Arr (34L)
[2]Aircraft type	A388	B737-800	B737-800	B747-400	B737-800
Mean L_{Smax}, dB(A)	60	65	67	63	69
No. samples	16	16	16	8	6
			B747-400 ('Typical' noisiest aircraft as per AS 2021)		
Highest L_{Smax}, dB(A)	n/a	n/a	n/a	79	n/a
Event	n/a	n/a	n/a	Dep (16R)	n/a
No. samples	0	0	0	1	0
			B737-800 (Most frequent aircraft)		
Highest L_{Smax}, dB(A)	62	72	78	65	72
Event	Arr (34L)	Arr (34L)	Arr (34L)	Arr (34L)	Arr (34L)
Mean L_{Smax}, dB(A)	59	67	68	65	71
No. samples	7	6	7	1	4

Notes: 1. Refer Appendix C for full list of measurements.

2. This is the aircraft that corresponds to the highest L_{Smax} shown.

3.3 Unattended measurements - September 2017

Six noise monitors (five at the Besmaw site) were set-up to record noise continuously throughout the monitoring period of 31 August to 6 October, 2017. Each monitor stored data at a rate of 10 samples per second. Refer to Appendix D for a tabulated summary of the data (data capture exceeded 99.7% of all September hours for locations 1, 2, 4, 5 and 6). It should be noted that hardware failure meant no data could be retrieved from logger location 3. Historical data shows location 3 (closest to the approach flight path for runway end 34L) is exposed to the highest levels of aircraft noise of all monitoring sites adopted at the Besmaw property. However, data from the nearby monitor at location 5 would provide an adequate representation of any trends in the vicinity of location 3.

The analysis of noise level data captured at each of the locations involved the following:

- correlating the noise data with the ASA flight operations data;
- assigning an L_{Smax} noise level to all listed ASA aircraft movements for Kurnell (as supplied by ASA);
- the 'Point of Closest Approach' (PCA) timestamp provided in the ASA dataset was correlated with each noise monitor's timestamps. ASA advised that the PCA is the shortest 'plan view' distance between the aircraft and ASA's noise monitor at Kurnell Public School;
- the data was split into day, night and curfew operations; and

- the N60, N65, N70 to N90 were calculated for days where a full data set was collected. This ensured a representative average was determined for each category.

Refer to Appendix E for details on the purpose designed software used to match aircraft events with maximum noise levels measured at each location.

The unattended monitoring data provided in Appendix D Table D.1 relate to all operations recorded by ASA from its Kurnell flight operations beacon over the monitoring period. It should be noted that quoted Number Above metrics (e.g. N60) are the average daily quantities (hence the fractional values presented). The results indicated the following:

- mean aircraft noise levels were equal to or below 68 dB(A) L_{Smax} at all locations for all periods;

- generally, aircraft noise levels were below 80 dB(A) L_{Smax} during all periods (daytime, night time and curfew);

- it is expected that the N85 and N90 events were atypical and likely to not be aircraft related. This is supported by attended measurements which did not exceed 79 dB(A)L_{Smax} at any location;

- generally, aircraft noise levels were below 75 dB(A)L_{Smax} at all site monitoring locations during the night;

- generally, aircraft noise levels were below 70 dB(A)L_{Smax} at all monitoring locations during the curfew;

- curfew operations accounted for approximately 3% of total movements and 11% of night time movements;

- the N70 metric represents the amount of interference with internal communications with open windows. This was highest at Location 5 beneath the flight path, with 142.5 events on average per day, and

- the central and western areas of the site (locations 1, 2 and 4) averaged considerably fewer N70 values of between 23 to 40 events.

The unattended data could include extraneous sources (non aircraft) given the filtering processes adopted cannot remove all non-aircraft related noise, particularly at the higher levels quoted. Hence, unattended noise data should be treated as conservative, as the analysis method tends to overestimate higher aircraft noise levels.

3.4 Representative noise levels

To determine what land uses and therefore buildings are compatible with a site, AS 2021 requires a representative aircraft noise level exposure to establish the aircraft noise reduction required of a building. To do this the arithmetic average of the maximum noise levels for flyovers from a specific aircraft type is calculated. An analysis of all aircraft types operating at the airport was completed by scrutinising the ASA movement data. This analysis is shown in Appendix B, Figure B.1 for the month of monitoring. The main results are as follows:

- The most frequent daytime aircraft type according to ASA was the B738, or the Boeing 737-800. This was consistent with the attended data shown in Table 3.1.

- During the monitoring period, B737-800 aircraft accounted for 3,792 movements, with nine of these events (0.2%) occurring in the curfew period.
- In the monitoring period, 68 different aircraft types were identified over Kurnell, and the B737-800 comprised 31% of all movements.
- For the curfew period, the ASA data showed B463 or British Aerospace BAe-146-300 aircraft were the most frequent. In fact this aircraft type was rarely observed outside the curfew period according to ASA's movement data.

The above findings are consistent with prior period studies (ie September 2011, September 2014 and September 2015).

Notwithstanding the above analysis of movement data, according to AS 2021, the noisiest typical aircraft must be used for impact assessment and to design buildings. That aircraft is the B747-400. The movement data from the monitoring period indicated:

- 234 events for Kurnell overall;
- 1 event occurred (0.4%) during the curfew, comprising 1 departure (16R); and
- The departure occurred at 11:50pm.

The average noise from these aircraft types by location and runway are shown in Appendix D Table D.2 to Table D.4. The B747-400 mean maximum noise levels are higher than the those in Table D.1, which account for all aircraft types. This confirms that these aircraft types are noisier than the average across all operations. The attended measurements (Table 3.1) are comparable to unattended monitoring data, giving further confidence in the analysis process. Attended measurements were taken from approximately 1.5 m above ground and are likely to record higher readings due to ground reflection when compared to unattended monitors which use microphones at heights of approximately 6 m above ground, as required by AS 2021. The main results are summarised as follows:

- The highest mean L_{Smax} values across all assessed periods for each location are shown shaded in Table D.2 to Table D.4.
- For the B747-400 aircraft, Table D.2 shows noise levels of 63 to 74 dB(A), which are relatively consistent across locations 1, 2, 4 and 5.
- For the B737-800 aircraft, Table D.3 shows that noise levels are 60 to 69 dB(A). These levels are materially lower than those attributed to B747-400 aircraft.
- Departures recorded higher noise levels at locations 1 and 4, while arrivals influenced other locations.
- For the B463 aircraft, Table D.4 shows noise levels are 56 to 65 dB(A) across all locations. Most of these movements occurred during the curfew period.

4 Measured aircraft noise level and trends (Septembers 2011, 2014, 2015 and 2017)

The study reviewed noise and movement data for the same month for four separate years so that trends or patterns could be identified. The periods were September 2011, September 2014, September 2015 and September 2017.

4.1 Movement data comparisons

Table 4.1 summarises movement data relevant to Kurnell for each September that noise monitoring was completed. The data shows the following:

- total movements increased;
- arrival movements decreased in the first three September periods, which is highly relevant to the site as arrivals dominate the aircraft noise exposure, particularly 34L operations;
- arrivals increased while departures decreased in 2017;
- overall total 24hour volumes increased over this time period.

The changes described above could be related to weather conditions or the Long Term Operating Plan (LTOP) used to share the noise across Sydney.

Table 4.1 Aircraft movements overKurnell (34L, 34R, 16R only)

Period	All aircraft movements			
	Arrivals		Departures	Totals
	34L	34R	16R	34L/34R/16R
September 2011	4892 (195 in curfew)	2237 (0 in curfew)	3029 (135 in curfew)	10158 (330 in curfew)
September 2014	4155 (173 in curfew)	2177 (0 in curfew)	4492 (110 in curfew)	10824 (283 in curfew)
September 2015	3904 (160 in curfew)	1847 (0 in curfew)	5267 (139 in curfew)	11018 (299 in curfew)
September 2017	6675 (240 in curfew)	3356 (0 in curfew)	2298 (177 in curfew)	12329 (417 in curfew)

Sources: 1. ASA

The above data is presented graphically in *Figure 4.1*. Note that the curfew (ie 11pm to 6am) movements are a subset of night (7pm to 7am), but have been split out in the chart to demonstrate changes in that period.

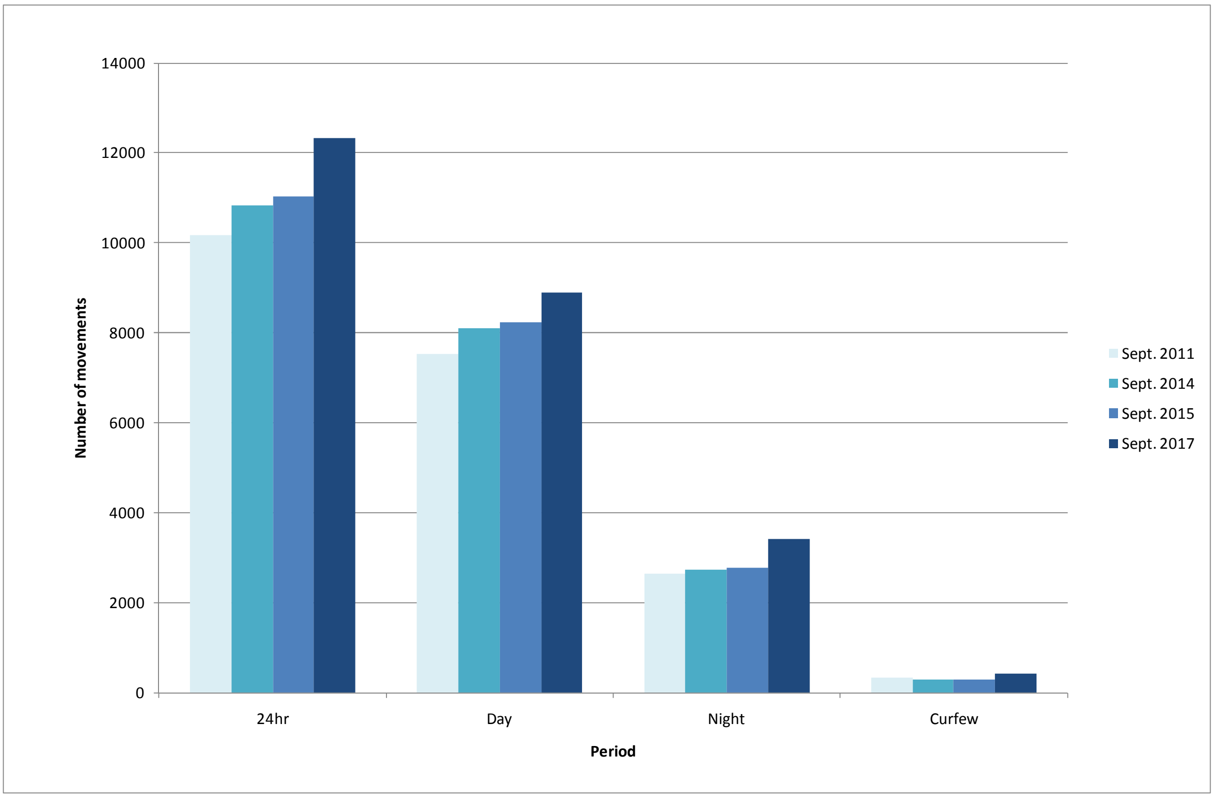


Figure 4.1 September movements (34L, 34R and 16R only) at Sydney Airport (Source: ASA)

The step increase in the data between the 2015 and 2017 total volumes required further consideration. Hence, an analysis of all runways and movements for the airport was completed for annual data as available on Airservices Australia's (ASA) website for all years. These are presented in Figure 4.2 for the years noise sampling was completed (darker columns) and for the years in-between (lighter columns). Most interestingly is the stagnation of volumes (in fact a reduction) depicted when comparing 2016 and 2017 volumes. This is important and is an indication that operations at the airport may have reached a threshold.

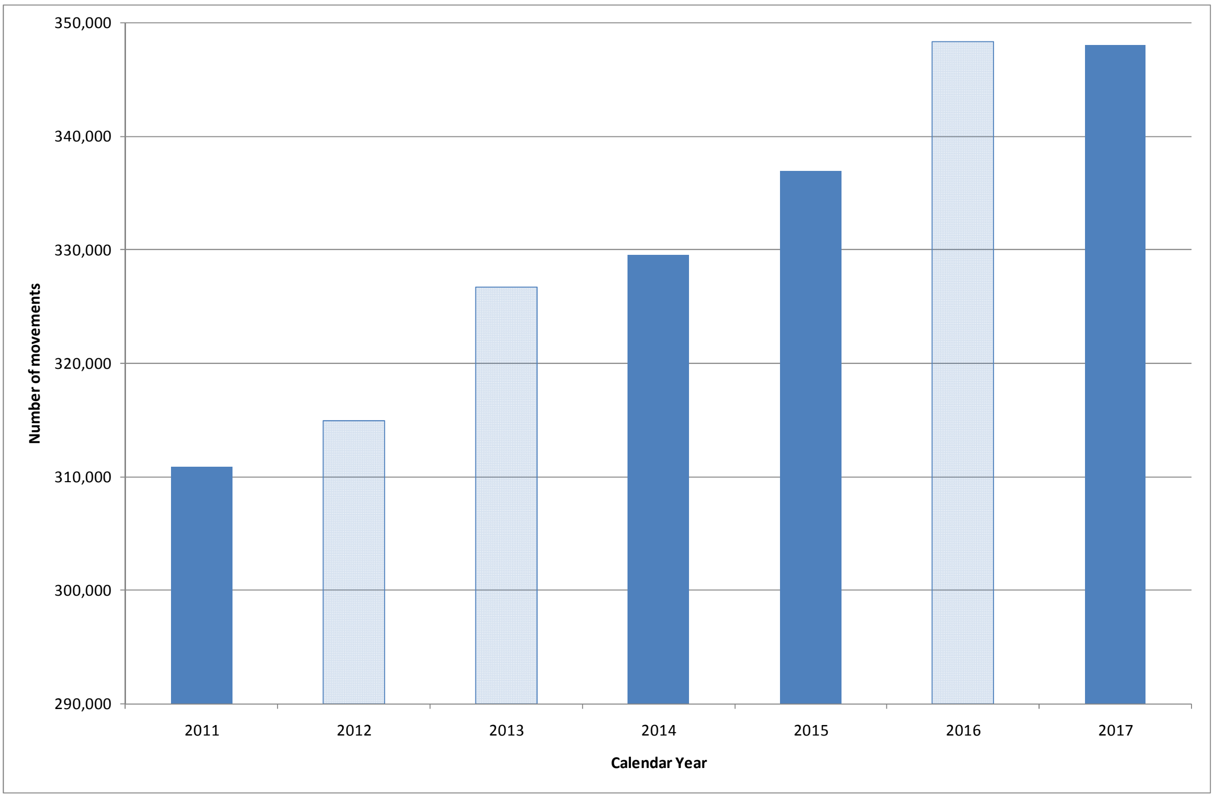


Figure 4.2 Total annual movements (all runways) at Sydney Airport (Source: ASA)

4.2 Attended noise measurements

Table 4.2 summarises attended noise measurements across the Besmaw site for the four periods. It should be noted that monitoring locations 1, 2 and 4 were approximately consistent for all periods. However, the 2014, 2015 and 2017 monitoring included two locations well east of those adopted in 2011. This included location 3 which is approximately beneath one of the main flight paths (34L). Hence, for this reason arrival noise levels were higher in latter years as compared to 2011. The upper end of departure noise levels were relatively consistent.

Table 4.2 Attended noise measurements at Besmaw site

Period	No. Samples			Noise levels, L_{Smax}, dB(A)		
	Arrivals	Departures	Total	Arrivals	Departures	Highest B747-400
[1]September 2011 (4 locations)	43	106	149	49-73	52-83	83 at Location 1 75 at Location 4
[2]October 2014 (5 locations)	34	0	34	59-80	n/a	n/a
September 2015 (5 locations)	0	47	47	n/a	58-82	80 at Location 1 81 at Location 2
September 2017 (5 locations)	69	2	71	48-78	78-79	79 at Location 5

Notes: *1. Samples include data from 31 August and 1 October 2011 (in addition to three days in September 2011) to provide a comparable quantity of data as other periods. Altogether there were 5 days of sampling.*

2. September 2014 did not include any attended monitoring. Hence, October was used as a surrogate. Note that no B747-400 aircraft were captured on the day of monitoring (27/10/14).

The attended noise monitoring data in Table 4.2 is presented graphically for the highest noise level of all monitoring locations on site in Figure 4.3. These data generally relate to the B747-400 aircraft (the representative or 'design' aircraft for the airport as per AS2021). The trend in maximum noise levels is downward over the periods samples were recorded, although when considering accepted field measurement tolerances of ±2dB, the changes are marginal.

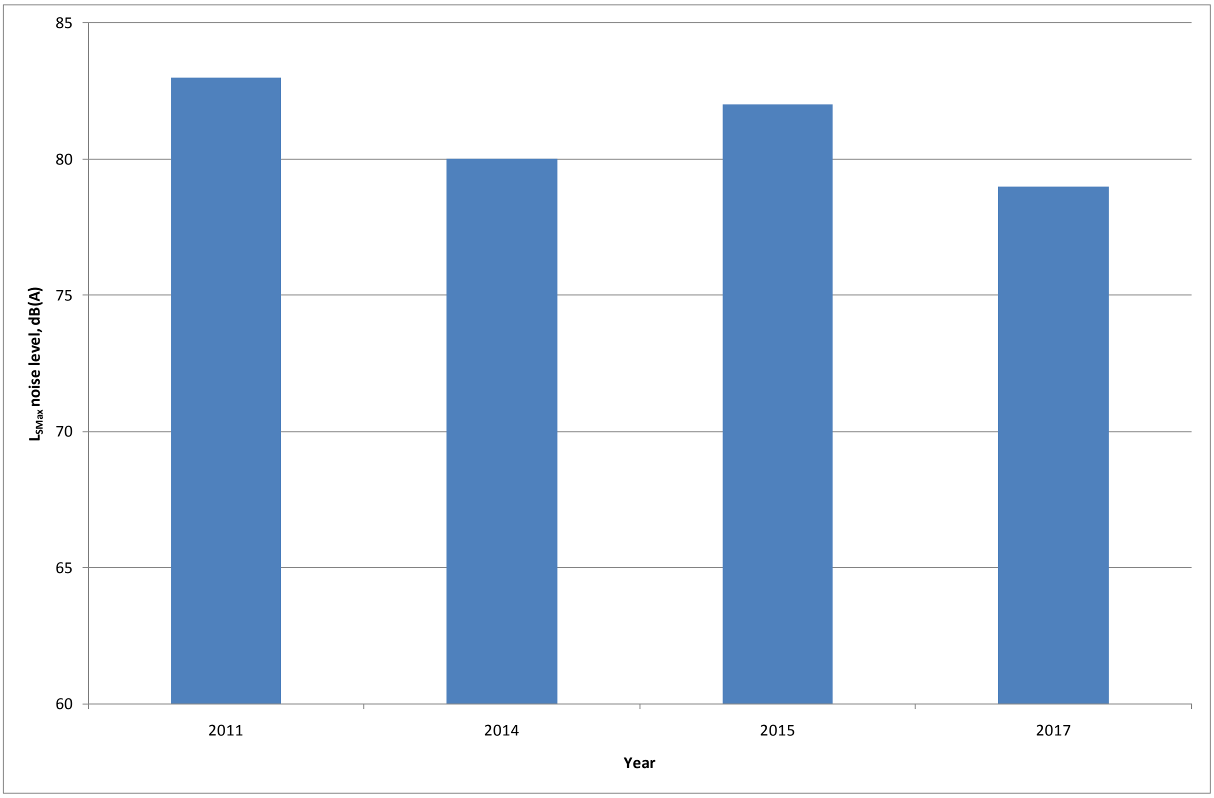


Figure 4.3 Highest maximum noise level from attended monitoring at Besmaw site (any location)

4.3 Unattended noise measurements

Appendix D Table D.8 presents a summary of unattended noise monitoring data for the four periods September 2011, September 2014, September 2015 and September 2017.

It should be noted that the analysis in 2011 included a coarser measurement sampling rate (1 minute) than the 2014, 2015 and 2017 data (sampling 10 records a second). This is likely to have affected the comparisons for the 2011 data somewhat.

4.3.1 L_{Smax} noise levels

Data was analysed for the purposes of identifying any trends in the unattended data, including for maximum noise, N60 (relevant to night time) and N70 (relevant to daytime). These are shown in the series of tables and corresponding figures below.

Table 4.3 and Figure 4.4 provide an analysis of mean maximum noise levels for all aircraft types and runways over Kurnell. Assessing this information by location, shows that the most recent data (2017) is generally lowest (quieter) of all years, but otherwise no apparent trend from year to year.

Table 4.3 Mean L_{Smax} noise level, 24hr, all aircraft & runways (unattended data), dB(A)

Location	**2011**	**2014**	**2015**	**2017**
1	65	67	63	63
2	67	69	71	66
3	-	68	77	-
4	66	65	73	62
5	-	67	66	68

Notes: 1. The quantity of data from which this data is determined for each year is shown in Table 4.1.

2. In 2011 locations 3 and 5 as per latter years were not monitored (a fourth location was monitored but was not consistent with latter year locations).

3. Data was not captured at Location 3 in 2017 due to equipment malfunction.

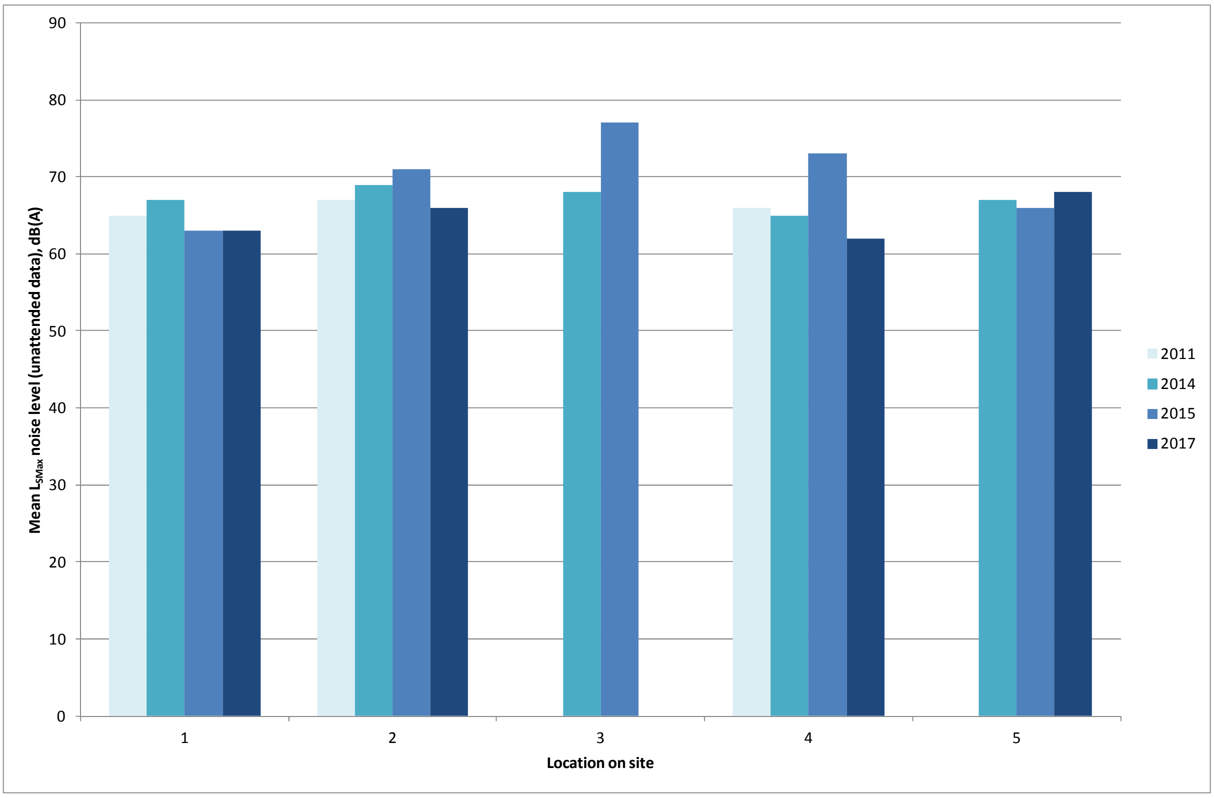


Figure 4.4 **Mean L_{Smax} noise level, 24hr, all aircraft & runways (unattended data)**

Table 4.4 and Figure 4.5 present an analysis of the airport's noisiest typical aircraft as per AS2021, ie the Boeing 747-400. The data for locations 1 and 5 exhibits a downward trend in noise, and as for the all aircraft analysis in Figure 4.4, the 2017 data is the lowest (quietest) of all years. However a consistent trend is not otherwise apparent.

Table 4.4 Mean L_{Smax} noise level, 24hr, B747-400 (noisiest event), all runways (unattended data), dB(A)

Location	2011	2014	2015	2017
1	65	67	63	63
2	67	69	71	66
3	-	68	77	-
4	66	65	73	62
5	-	67	66	68
No. of samples	541	267	247	234

Notes: 1. In 2011 locations 3 and 5 as per latter years were not monitored (a fourth location was monitored but was not consistent with latter year locations).

2. Data was not captured at Location 3 in 2017 due to equipment malfunction.

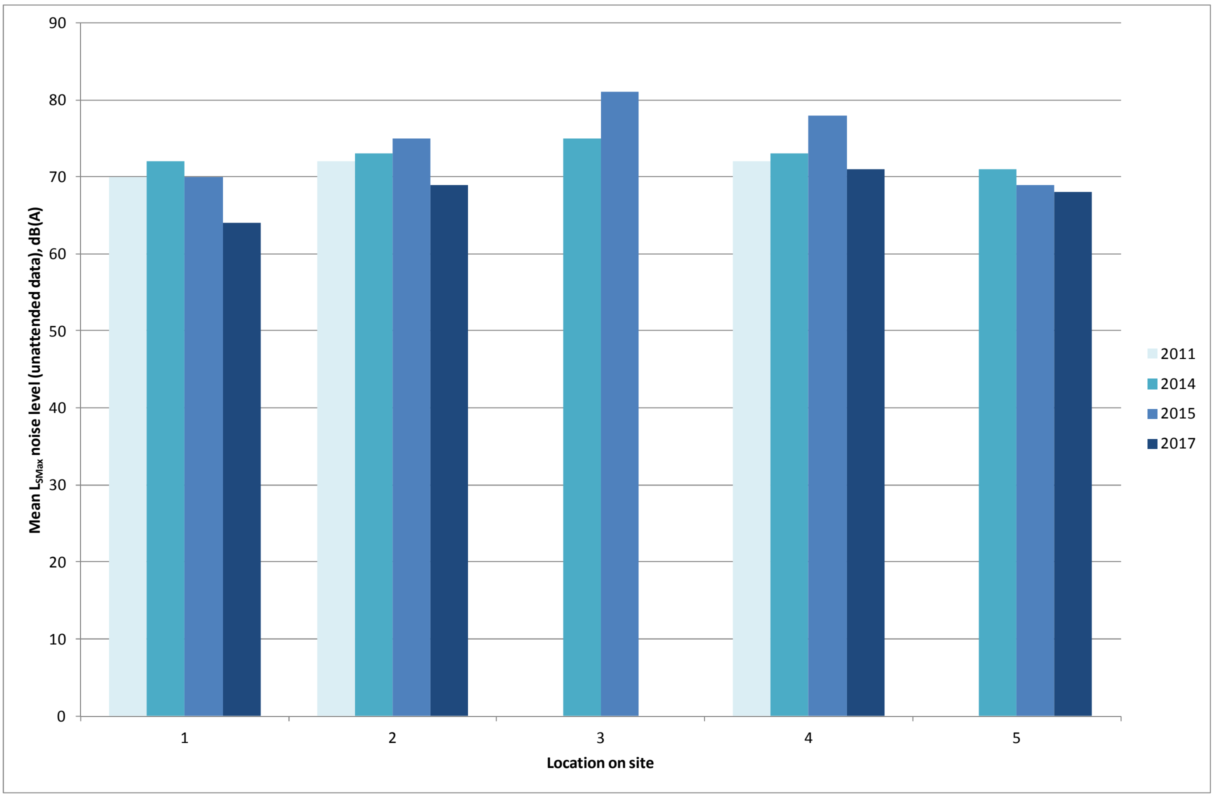


Figure 4.5 Mean L_{Smax} noise level, 24hr, B747-400 & all runways (unattended data)

The same analysis was completed for the most prominent aircraft (by quantity), the B737-800 aircraft (ID B738) as presented in Table 4.5 and Figure 4.6. A consistent pattern as for the B747-400 aircraft is observed, ie downward trend in noise for locations 1 and 5, but not for others. Similarly, the most recent sampling in 2017 is the lowest (quietest) for most locations.

Table 4.5 Mean L_{Smax} noise level, 24hr, B737-800 (ie most prominent aircraft), all runways (unattended data), dB(A)

Location	**2011**	**2014**	**2015**	**2017**
1	64	66	63	62
2	67	68	71	65
3	-	69	78	-
4	66	65	74	68
5	-	68	66	62
No. of samples	2182	2689	2999	3792

Notes: *1. In 2011 locations 3 and 5 as per latter years were not monitored (a fourth location was monitored but was not consistent with latter year locations).*

2. Data was not captured at Location 3 in 2017 due to equipment malfunction.

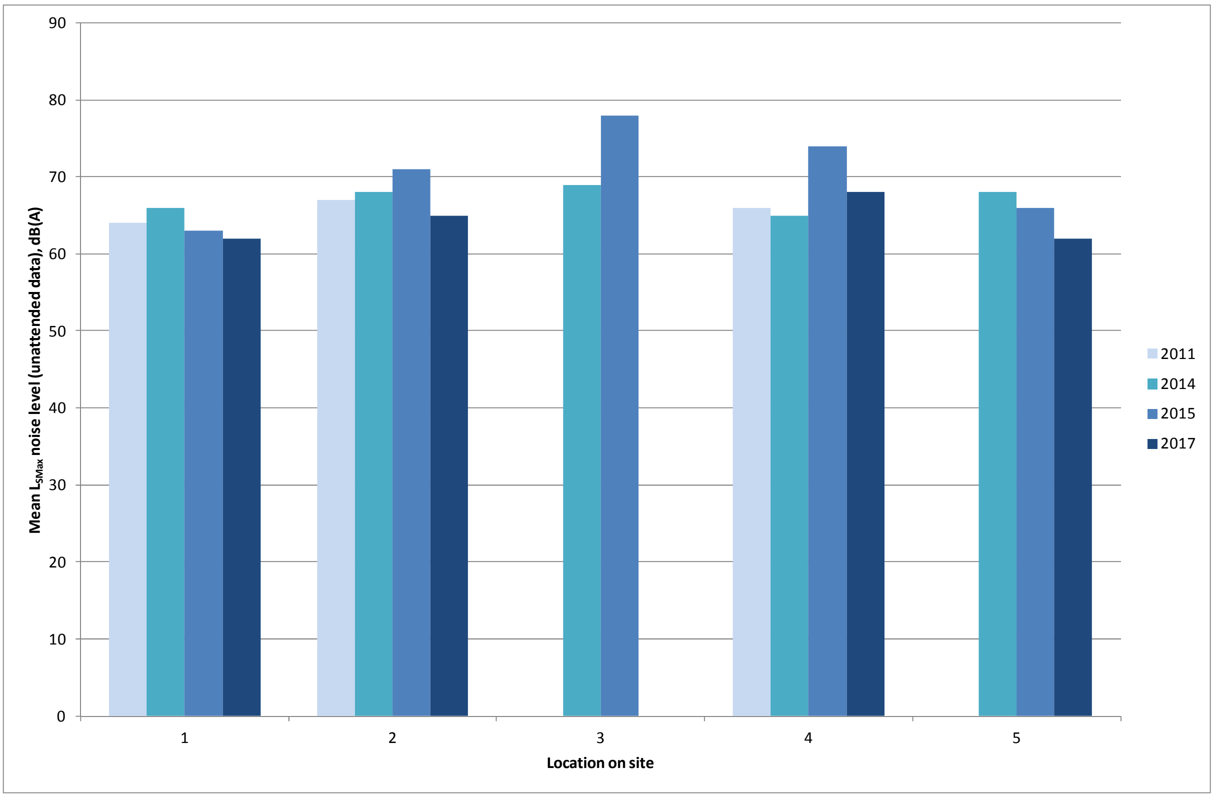


Figure 4.6 Mean L_{Smax} noise level, 24hr, B737-800 & all runways (unattended data)

4.3.2 Number Above levels

i N70

The average daily number above 70 dB(A) L_{Smax} (ie N70) is relevant to the daytime period and is provided for the sampling periods in Table 4.6 and Figure 4.7. The fluctuations in these figures from year to year do not exhibit a trend for this metric. An observation is that the 2015 year is highest at most locations, and that the latest sample (2017) is the lowest for locations 1, 2 and 4, a similar finding to mean noise levels described above.

Table 4.6 Average daily N70 Day (unattended data)

Location	2011	2014	2015	2017
1	62	98.6	41.1	24.7
2	67.4	78.2	161.4	27.4
3	-	94.4	200.8	-
4	69.9	43	163.1	17.9
5	-	61.3	48.3	109.8

Notes: 1. In 2011 locations 3 and 5 as per latter years were not monitored (a fourth location was monitored but was not consistent with latter year locations).

2. Data was not captured at Location 3 in 2017 due to equipment malfunction.

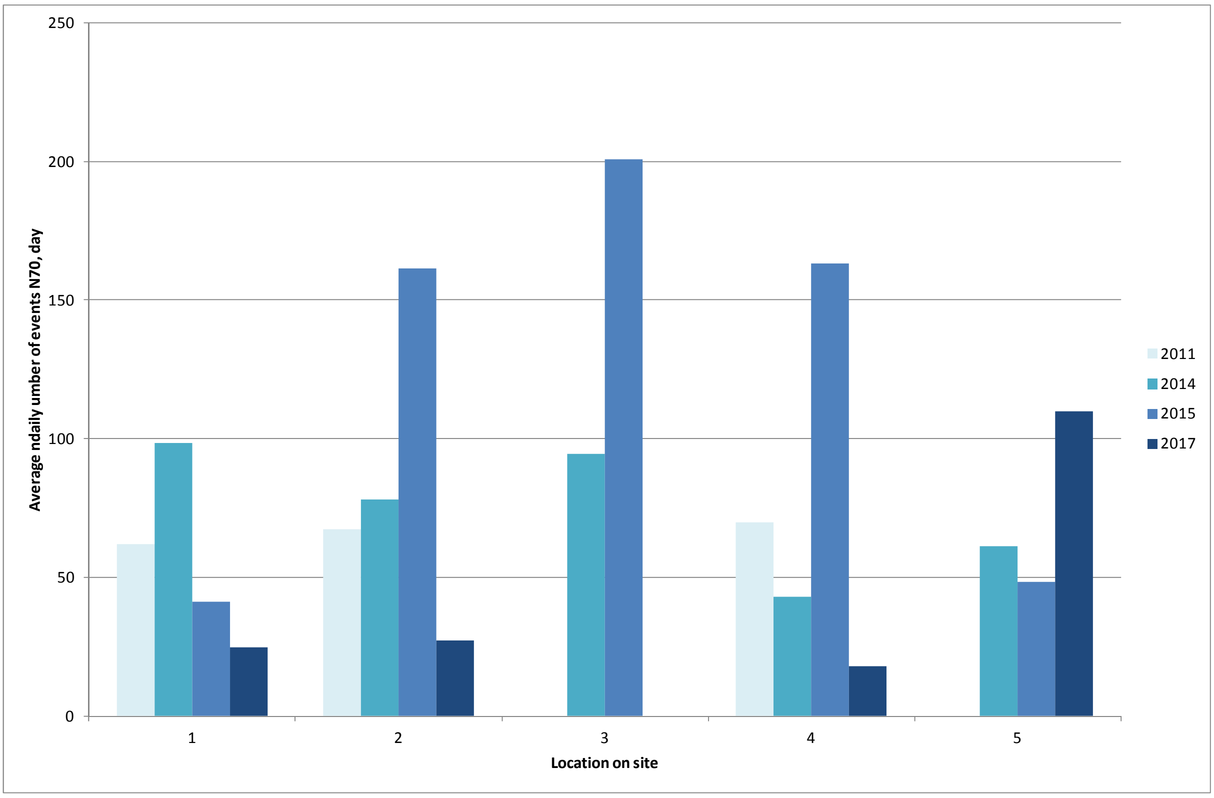


Figure 4.7 Average daily N70 day (unattended)

ii N60

The average daily number above 60 dB(A) L_{Smax} (ie N60) is relevant to the night time period and is provided for the sampling periods in Table 4.7 and Figure 4.8. The fluctuations in these figures from year to year confirm no trend for this metric. One observation however is that the latest sample (2017) is the highest for locations 1, 2 and 5 (and by extrapolation, location 3).

Table 4.7 Average daily N60 Night (unattended data)

Location	2011	2014	2015	2017
1	67.6	75.0	59.2	79.1
2	80.9	88.2	84.4	99.1
3	-	78.5	74.9	-
4	81.7	70.9	79.1	68.2
5	-	78.6	60.2	85.2

Notes: 1. In 2011 locations 3 and 5 as per latter years were not monitored (a fourth location was monitored but was not consistent with latter year locations).

2. Data was not captured at Location 3 in 2017 due to equipment malfunction.

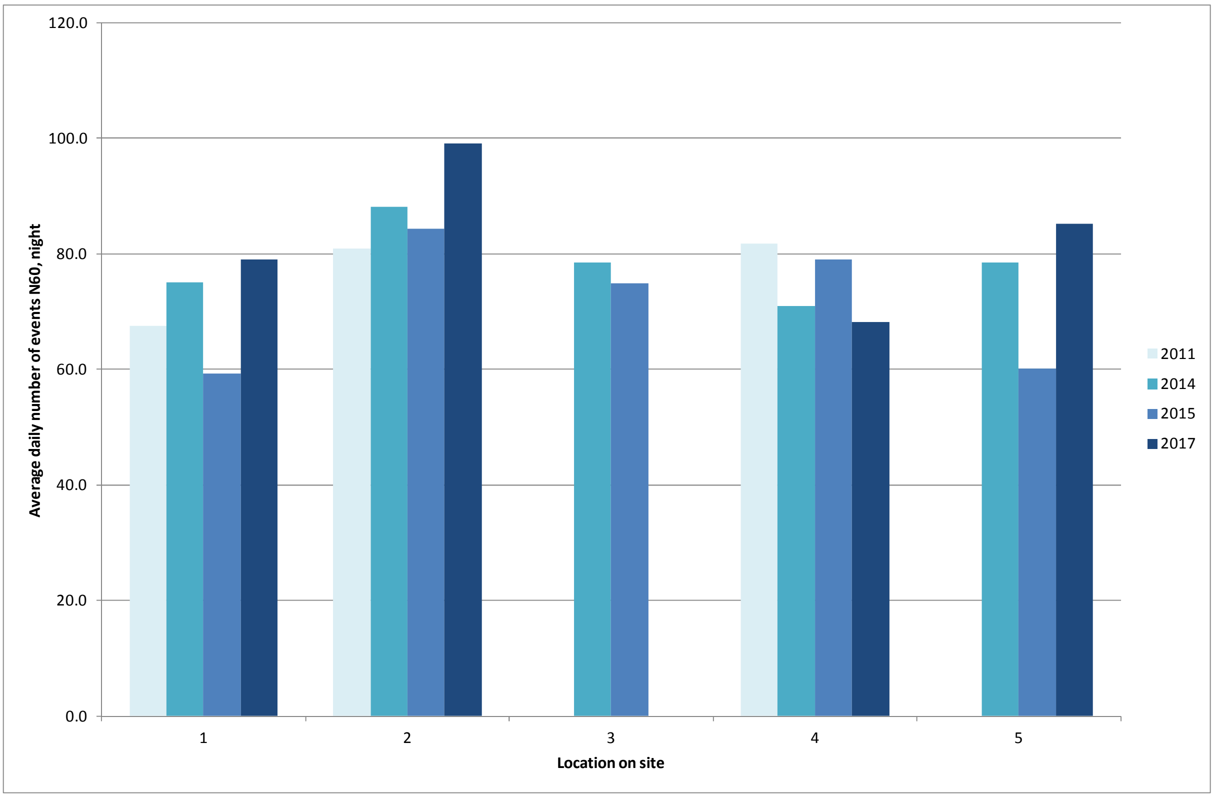


Figure 4.8 Average daily N60 night (unattended)

In summary, the data do not show any consistent trends in mean noise levels nor in the Number Above (ie N60 and N70) metrics between years for the same location. However, some consistent observations were found. Location 3 (beneath the arrival flight path 34L) had higher mean noise levels of all locations for all data sets presented (ie for all aircraft types, all noisiest aircraft movements (ie B747-400) and the most prominent aircraft (ie 737-800)). This is one trend that is apparent and consistent with expectations given its location relative to the flight paths. A similar observation is apparent for location 3 in respect of N70 daytime (ie highest of all locations), however is not extended to the N60 night values. The latter is not unexpected given what is known about the airport's modes of operations for restricted night flying above Kurnell generally. The relatively larger fluctuation in mean noise level is apparent for locations 3 and 4 as compared to other locations (Figure 4.4). The mean noise level changes at the other locations were not as pronounced and generally within accepted field measurement tolerances of ±2dB. Hence, a logical conclusion is that these locations had equally small changes in noise over time. Finally, there is a consistent outcome that shows the latest (2017) data generally presents less of an impact on the site than prior years even though movement volumes were higher.

5 Conclusion

EMM has completed an aircraft noise study of the Besmaw site, analysing noise monitoring data collected at five fixed stations during September 2017 and analysed trends over time based on this data and that collected in September 2011, September 2014 and September 2015. The quantity of data used in the assessment is extensive in our experience and is representative of movements at Sydney Airport for both arrival and departures on runways that potentially impact the Besmaw site. The assessment is a comprehensive and an accurate reflection of historic, existing and potential aircraft noise exposure.

The study considered the guidelines in Australian Standard (AS 2021 - 2015) as well as extensive on-site measurement of aircraft noise to assess the likely noise exposure of different areas across the site. Additional contemporary noise metrics are also provided as well as movement information and flight path patterns to provide a comprehensive suite of information. This was aided by existing noise contour maps for Sydney Kingsford Smith Airport as published in the Sydney Airport Master Plan 2033.

The study found the following:

- According to Sydney Airport Master Plan ANEF 2033 contours, all of the site is below 25 ANEF, while some parts are below 20 ANEF. Based on Table 2.1 of AS 2021, for the most sensitive land uses, the area below 25 ANEF is 'conditionally acceptable', while areas below 20 ANEF are acceptable. An initial AS 2021 test indicated that the full range of land uses is appropriate for the developable areas of the site. This site specific study determined representative levels of aircraft noise affecting the site.

- The ANEF 2033 contours cover a smaller area than the ANEF 2029 contours, indicating a calculated and expected improvement in aircraft noise performance over time according to SACL's 2033 Master Plan. To that end, the relatively small time period considered in this study of six years does indicate an improvement over time based on the data for 2017 as compared to prior years.

- In cases where the site is 'conditionally acceptable', AS 2021 recommends that buildings include specific acoustic design to achieve appropriate internal noise levels, based on maximum noise levels during representative operations.

- As expected, the number above metric of interest (N70) thought to interfere with internal communications when windows are open is highest nearest the flight path 34L with about 100 events on average per day (shown by data at location 5 for September 2017). The central and western areas of the site average considerably fewer N70 values. This finding corresponds broadly with 25 ANEF and 20 ANEF areas of the site.

- For the latest data set (2017), the representative typical external aircraft noise level determined through this study and in accordance with AS 2021 was between 65 dB(A) L_{Smax} and 79 dB(A) L_{Smax}, depending on the location. This was associated with the relatively infrequent and noisier B747-400 aircraft, with virtually all these movements occurring during the daytime.

- The ASA movement volumes show a steady increase from 2011 to 2016, and then a plateau in 2017 indicating a stagnation in the airport's volumes possibly meaning saturation threshold has been reached.

- A downward trend in maximum aircraft noise was observed in attended monitoring data, although when considering accepted field measurement tolerances of ±2dB, the changes are marginal.

- The 2017 (most recent sampling) noise data was generally the lowest (least impact on the Besmaw site) of all years sampled even though movements were higher.

- Location 3 (beneath the arrival flight path 34L) had higher mean noise levels of all locations for all data sets presented. This is one trend that is apparent and consistent with expectations given its location relative to the flight paths.

- Night time impacts at Kurnell are measurably lower than daytime, which is not unexpected given what is known about the airport’s modes of operations for restricted night flying above Kurnell generally.

The above findings are expected to improve in the future as newer and quieter aircraft come into service all over the world. This is consistent with the contraction of ANEF 2033 and ANEF 2029 contours as compared to ANEF 2024 shown in the Sydney Airport Master Plan 2033. This is also a logical outcome when Sydney's second airport opens in the future.

The conclusions of this study from the extensive monitoring carried out, are that on acoustic grounds the developable areas of the Besmaw site is acceptable or conditionally acceptable for the full range of land use building types.

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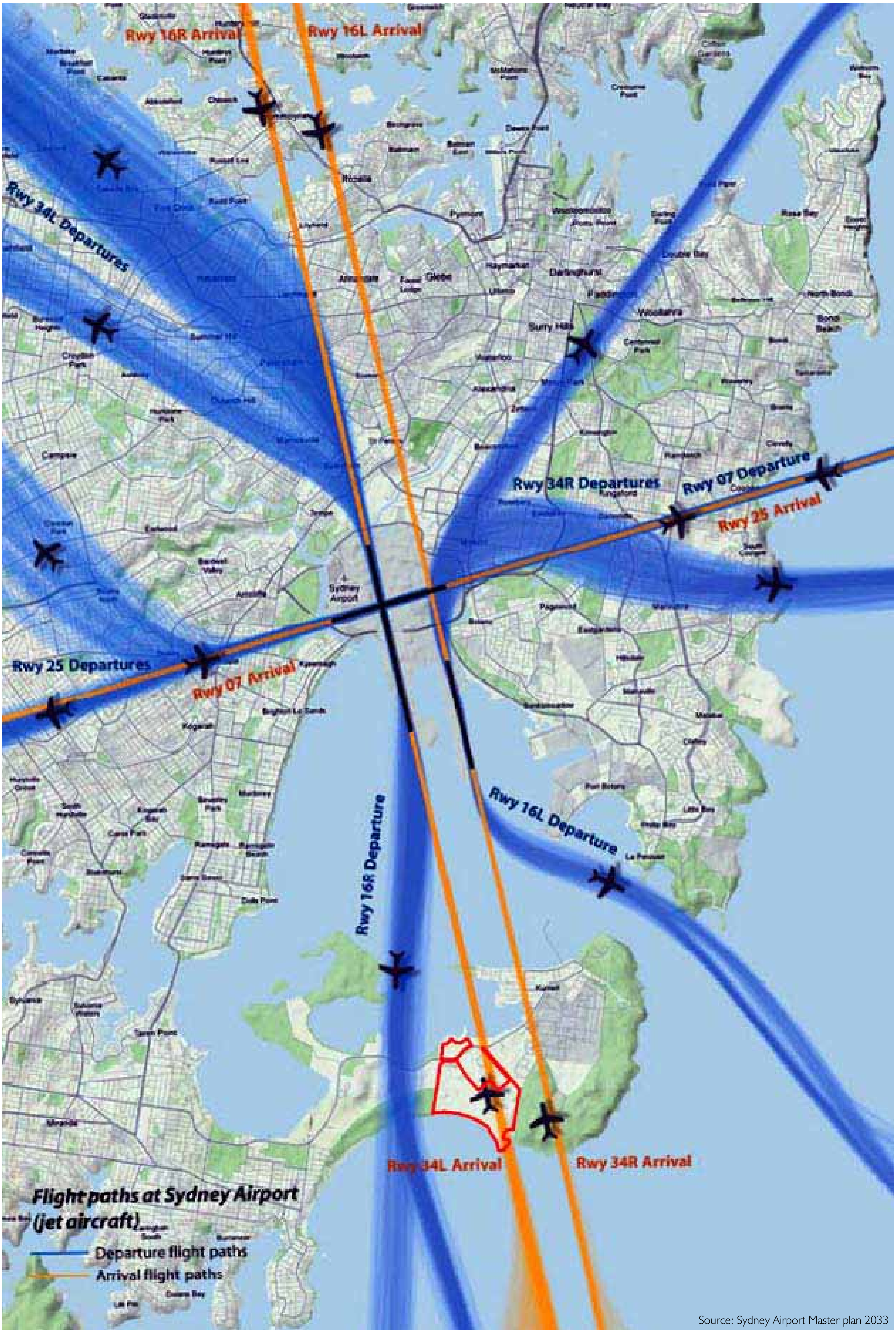
Sydney Airport Master Plan maps

Appendix A

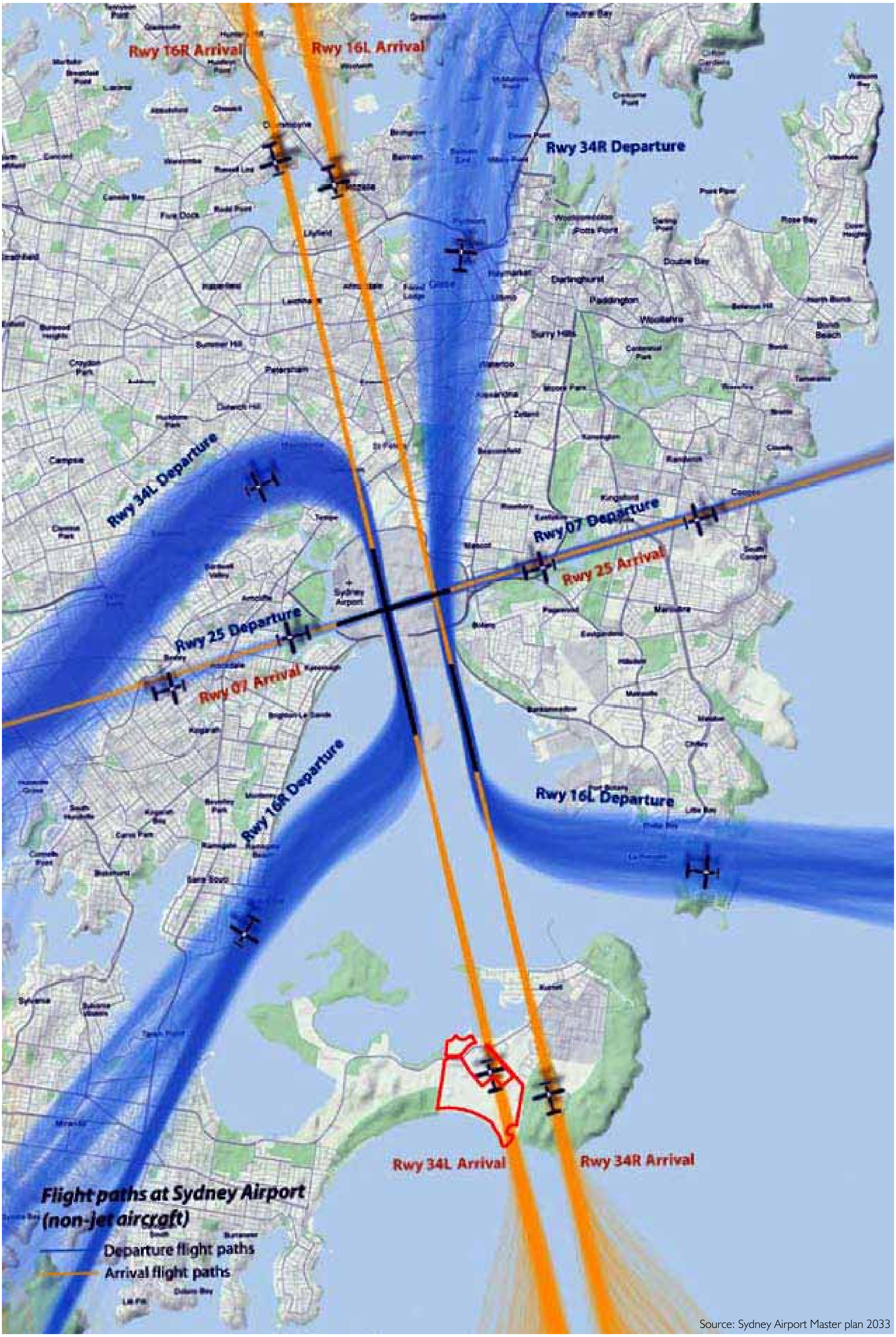
Sydney Airport Master Plan maps



Flight paths at Sydney Airport (jet aircraft)

Figure A.1

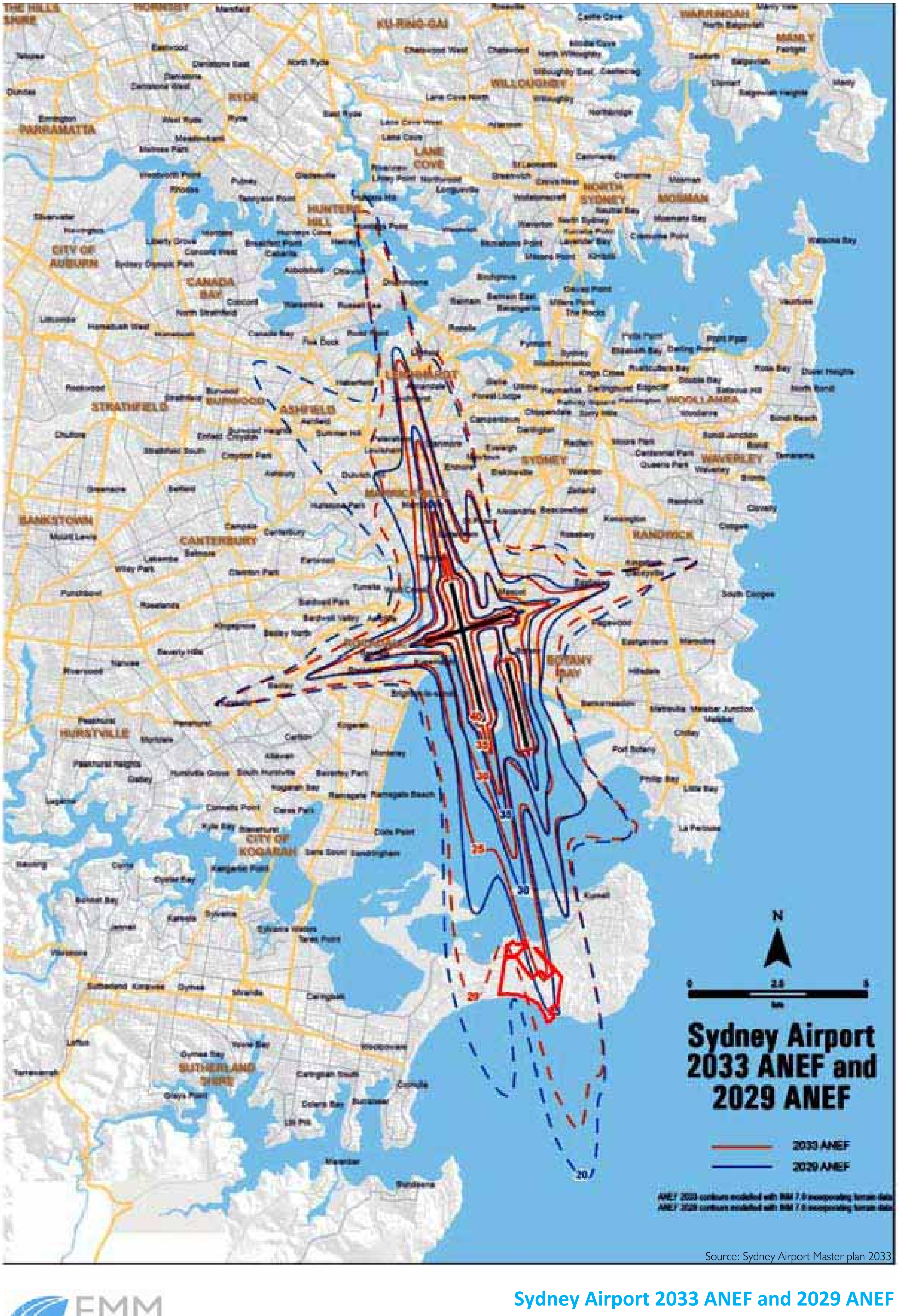
EMM
EMGA Mitchell McLennan



EMM

Flight paths at Sydney Airport (non-jet aircraft)

Figure A.2

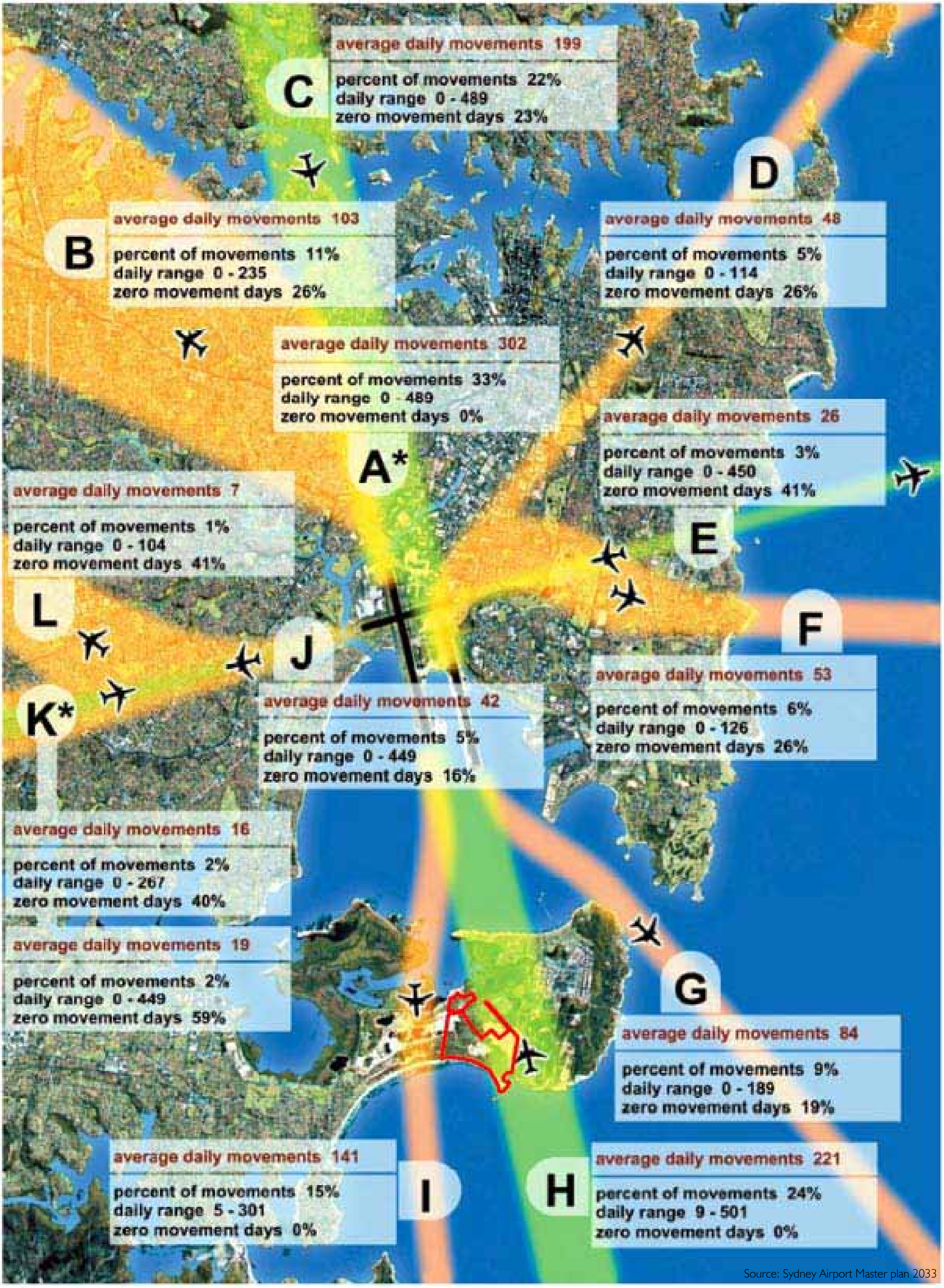


Sydney Airport 2033 ANEF and 2029 ANEF

Figure A.3

Sydney Airport 2033 ANEF and 2011 ANEI

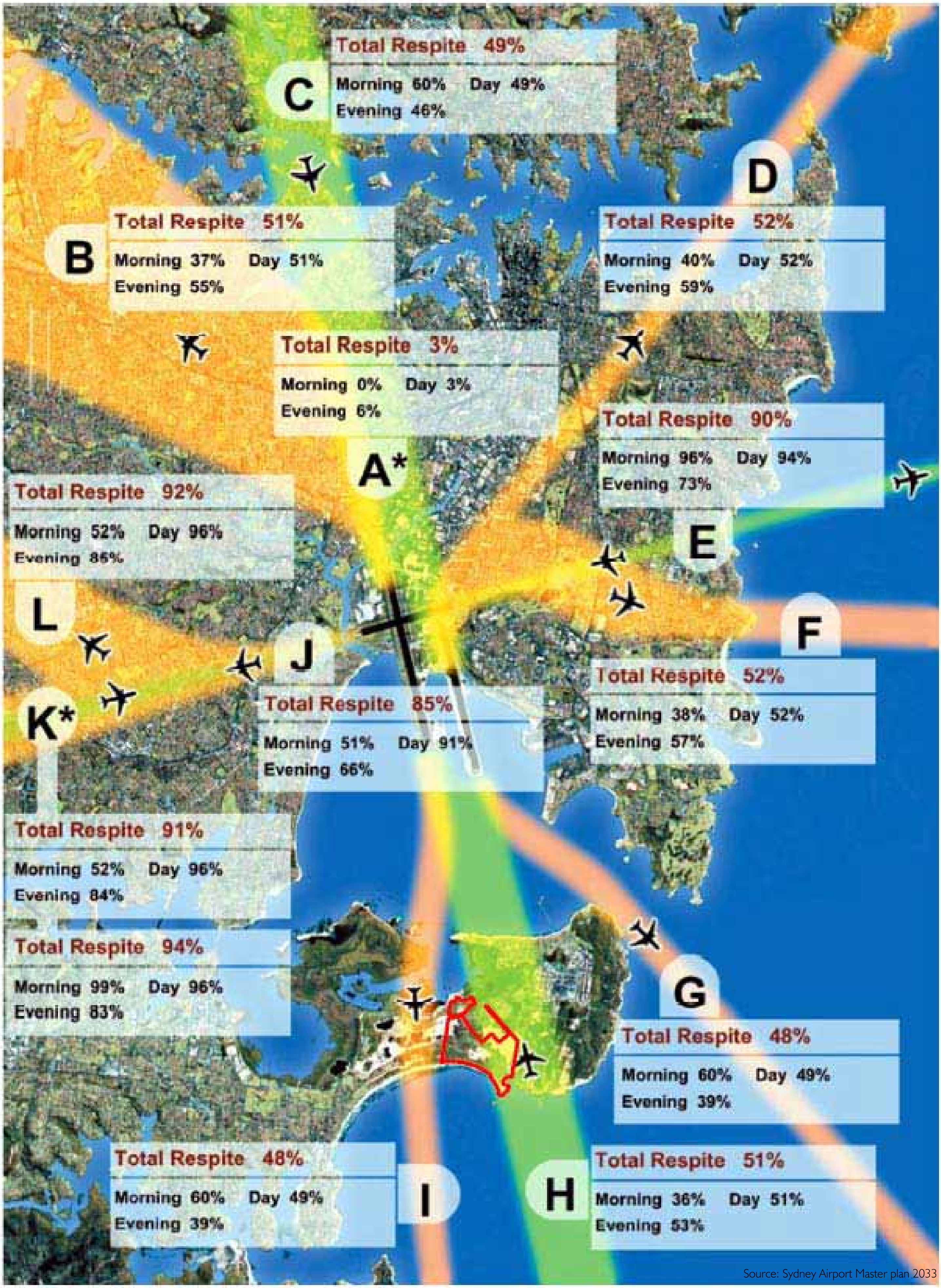
Figure A.4



EMM

Average daily jet aircraft movements 2033

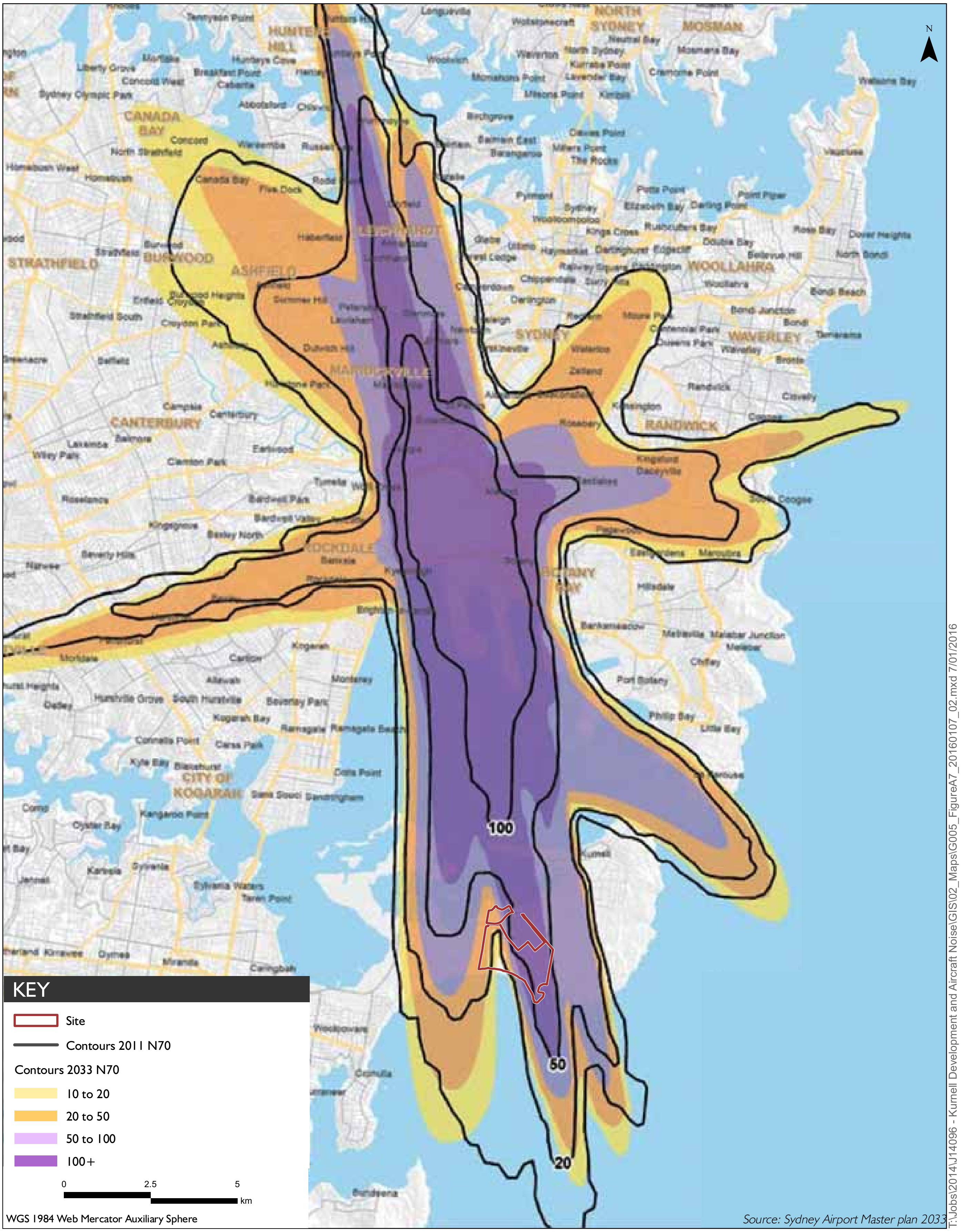
Figure A.5



Source: Sydney Airport Master plan 2033

Average daily jet aircraft respite periods 2033

Figure A.6



EMM

N70 contours 2033 and N70 contours 2011

Besmaw Kurnell Site
Aircraft Noise Study
Figure A.7

Appendix B

ASA September 2017 movement data

The following chart in Figure B.1 presents each aircraft type and the number of movements over Kurnell to demonstrate relative quantities between aircraft for the daytime, night time and curfew periods. Note that the curfew movements are counted twice (ie included in the night movements) for illustrative purposes. Furthermore, due to the scale of the chart, relatively small quantities may not appear clearly but are included in the data.

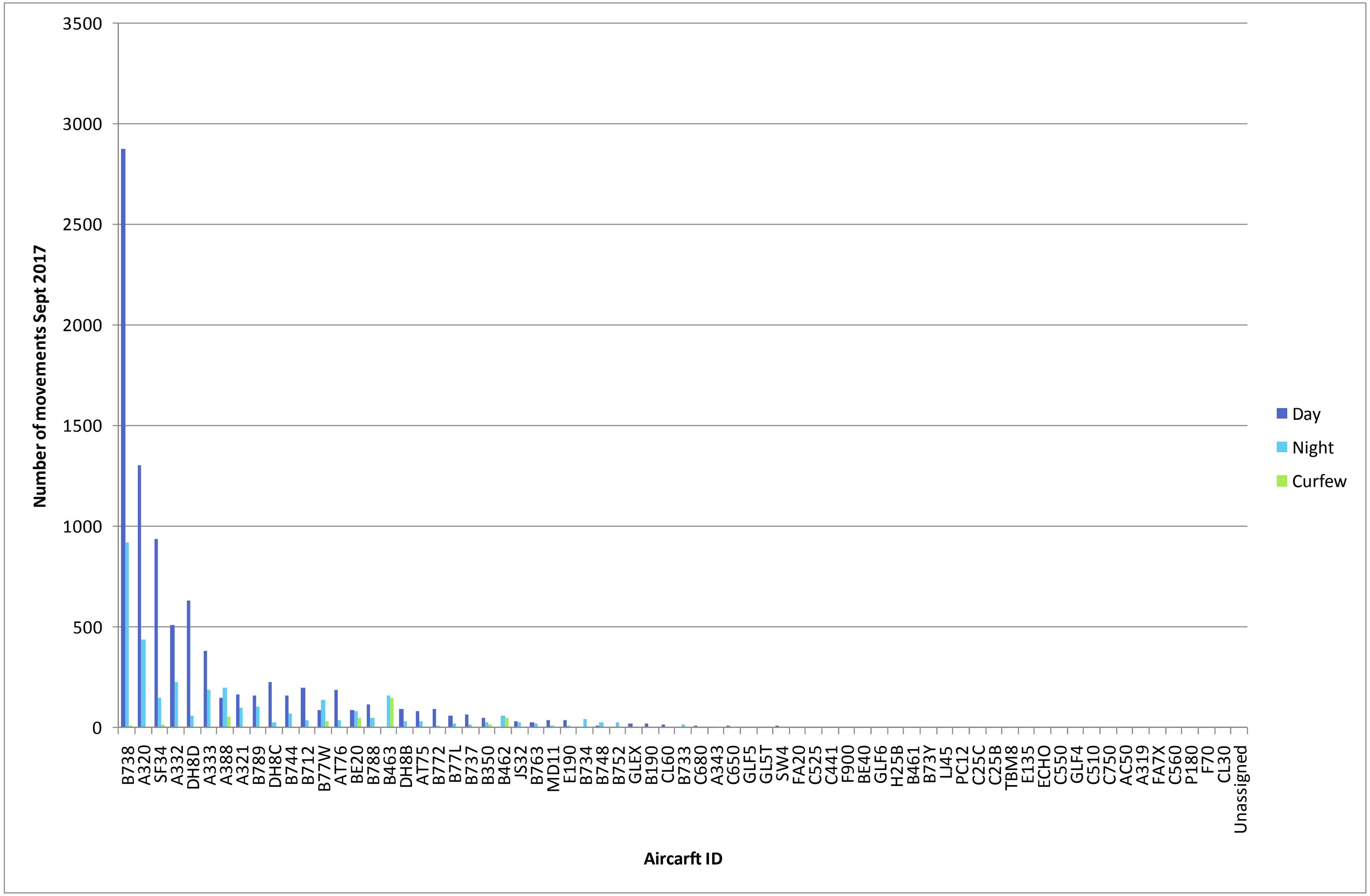


Figure B.1 Movements by aircraft - September 2017 (34L, 34R & 16R only)

Attended noise monitoring data

Appendix C

Attended noise monitoring data

Attended monitoring data at the six monitoring locations (five on the Besmaw site and one at the Kurnell Public School) are provided in Table C.1.

Table C.1 Attended noise measurements

Logger Location	Date	Time	L_{Smax}, dB(A)	Aircraft Type	Activity	Runway End
Round one of attended monitoring						
1	18/09/2017	12:21:04	51	Landing	B738	34R
1	18/09/2017	12:22:44	59	Landing	B738	34L
1	18/09/2017	12:26:30	60	Landing	B738	34L
1	18/09/2017	12:32:10	60	Landing	B738	34L
1	18/09/2017	12:34:34	58	Landing	A321	34L
1	18/09/2017	12:37:10	58	Landing	A320	34L
2	18/09/2017	11:54:10	64	Landing	SF34	34L
2	18/09/2017	11:57:50	67	Landing	B738	34L
2	18/09/2017	12:01:08	64	Landing	DH8D	34L
2	18/09/2017	12:04:24	65	Landing	SF34	34L
2	18/09/2017	12:08:10	66	Landing	DH8D	34L
2	18/09/2017	12:10:58	68	Landing	B738	34L
3	18/09/2017	12:45:24	60	Landing	A321	34R
3	18/09/2017	12:50:24	65	Landing	B738	34R
3	18/09/2017	12:53:14	66	Landing	B738	34R
3	18/09/2017	12:54:46	74	Landing	B738	34L
3	18/09/2017	12:56:06	61	Landing	A320	34R
3	18/09/2017	12:57:28	71	Landing	A320	34L
4	18/09/2017	13:32:42	72	Landing	B738	34L
4	18/09/2017	13:34:42	70	Landing	B738	34R
4	18/09/2017	13:36:10	70	Landing	B738	34L
4	18/09/2017	13:37:54	70	Landing	B738	34R
4	18/09/2017	13:39:18	65	Landing	SF34	34L
4	18/09/2017	13:42:40	67	Landing	SF34	34L
5	18/09/2017	14:02:18	48	Landing	DH8D	34R
5	18/09/2017	14:03:42	58	Landing	DH8C	34L
5	18/09/2017	14:05:58	51	Landing	A320	34R
5	18/09/2017	14:07:22	65	Landing	DH8D	34L
5	18/09/2017	14:09:58	65	Landing	B738	34L
5	18/09/2017	14:12:22	62	Landing	A320	34L
6	18/09/2017	15:01:28	78	Landing	B738	34R
6	18/09/2017	15:04:58	77	Landing	A321	34R
6	18/09/2017	15:06:38	59	Landing	SF34	34L
6	18/09/2017	15:11:50	60	Landing	B738	34L
6	18/09/2017	15:27:16	61	Landing	B738	34L
6	18/09/2017	15:28:42	76	Landing	DH8B	34R
6	18/09/2017	15:32:16	59	Landing	A320	34L
6	18/09/2017	15:33:36	72	Landing	DH8D	34R

Table C.1 Attended noise measurements

Logger Location	Date	Time	L_{Smax}, dB(A)	Aircraft Type	Activity	Runway End
6	18/09/2017	15:35:16	62	Landing	B738	34L
Round two of attended monitoring						
1	30/09/2017	9:31:32	61	Landing	SF34	34L
1	30/09/2017	9:35:10	62	Landing	B772	34L
1	30/09/2017	9:41:52	61	Landing	A333	34L
1	30/09/2017	9:45:08	60	Landing	A320	34L
1	30/09/2017	9:47:38	62	Landing	B738	34L
1	30/09/2017	9:50:34	65	Landing	A388	34L
1	30/09/2017	9:54:52	59	Landing	A320	34L
1	30/09/2017	9:58:28	60	Landing	A320	34L
1	30/09/2017	10:02:50	62	Landing	B738	34L
1	30/09/2017	10:05:04	61	Landing	B738	34L
2	30/09/2017	10:16:02	72	Landing	B738	34L
2	30/09/2017	10:21:22	61	Landing	DH8D	34L
2	30/09/2017	10:25:14	65	Landing	B738	34L
2	30/09/2017	10:27:44	64	Landing	SF34	34L
2	30/09/2017	10:29:54	62	Landing	B737	34R
2	30/09/2017	10:32:22	69	Landing	DH8D	34L
2	30/09/2017	10:36:26	65	Landing	B738	34R
2	30/09/2017	10:38:12	64	Landing	B738	34R
2	30/09/2017	10:40:50	65	Landing	A333	34L
2	30/09/2017	10:42:30	64	Landing	AT76	34R
3	30/09/2017	11:08:32	73	Landing	A320	34L
3	30/09/2017	11:10:34	75	Landing	A332	34L
3	30/09/2017	11:12:14	55	Landing	DH8B	34R
3	30/09/2017	11:17:40	61	Landing	SF34	34R
3	30/09/2017	11:18:58	69	Landing	DH8C	34L
3	30/09/2017	11:23:06	71	Landing	A320	34L
3	30/09/2017	11:24:18	63	Landing	B738	34R
3	30/09/2017	11:25:28	72	Landing	B738	34L
3	30/09/2017	11:27:56	78	Landing	B738	34L
3	30/09/2017	11:29:00	61	Landing	B738	34R
5	30/09/2017	13:13:42	78	Take-off	A332	16R
5	30/09/2017	13:33:06	79	Take-off	B744	16R

Appendix D

Unattended noise monitoring data summary

The unattended noise monitoring data analysis for the six monitoring locations at the Besmaw site is provided in Table D.1.

Table D.1 Analysis of unattended noise monitoring data (September 2017)

Location	Period	[1]Total aircraft movements		[2]Average Daily Number Above noise metrics						
		(ASA Kurnell data)	Mean L_{Smax}, dB(A)	N60	N65	N70	N75	N80	N85	N90
Location 1	Daytime	8,903	62	166.7	45.4	24.7	6.1	0.7	0.2	0.1
	Night time	3,425	63	79.1	20.7	8.5	2.0	0.2	0.1	0.1
	24 hour	12,329	62	245.8	66.1	33.2	8.1	0.8	0.2	0.2
	Curfew	417	63	10.6	3.3	1.4	0.1	0.0	0.0	0.0
Location 2	Daytime	8,903	65	239.5	142.8	27.4	2.7	0.3	0.1	0.1
	Night time	3,425	66	99.1	63.4	11.9	0.6	0.1	0.0	0.0
	24 hour	12,329	65	338.6	206.2	39.2	3.3	0.5	0.1	0.1
	Curfew	417	65	12.8	6.3	1.4	0.0	0.0	0.0	0.0
Location 3	Daytime	8,903	Nil data	Nil data	Nil data	Nil data	Nil data	Nil data	Nil data	Nil data
	Night time	3,425	Nil data	Nil data	Nil data	Nil data	Nil data	Nil data	Nil data	Nil data
	24 hour	12,329	Nil data	Nil data	Nil data	Nil data	Nil data	Nil data	Nil data	Nil data
	Curfew	417	Nil data	Nil data	Nil data	Nil data	Nil data	Nil data	Nil data	Nil data
Location 4	Daytime	8,903	62	183.6	80.2	17.9	1.9	0.2	0.0	0.0
	Night time	3,425	61	68.2	30.0	5.5	0.7	0.0	0.0	0.0
	24 hour	12,329	62	251.8	110.2	23.4	2.6	0.2	0.0	0.0
	Curfew	417	60	7.4	4.9	1.2	0.2	0.0	0.0	0.0
Location 5	Daytime	8,903	68	263.1	208.0	109.8	33.2	6.2	0.5	0.0
	Night time	3,425	65	85.2	68.7	32.6	4.7	0.3	0.0	0.0
	24 hour	12,329	67	348.4	276.7	142.5	37.9	6.5	0.5	0.0
	Curfew	417	60	8.1	4.9	2.8	0.4	0.0	0.0	0.0

Notes: *1. Daytime = 7am to 7pm; Night time = 7pm to 7am; Curfew = 11pm to 6am.*

2. It should be noted that quoted Number Above metrics (eg N60) are the average daily quantities (hence the fractional data presented).

3. Location 3 monitor malfunctioned in 2017 and hence no data was collected at this location in that period.

Table D.2 provides the analysis of unattended noise monitoring data for the B747-400 aircraft.

Table D.2 Analysis of unattended noise monitoring data for B747-400 (September 2017)

Period	[1]Total aircraft movements				L_{Smax} Mean, dB(A)				
	(ASA Kurnell data)	16R	34L	34R	Location 1	Location 2	Location 3	Location 4	Location 5
Daytime	162	46	116	0	64	69	n/a	68	71
Night time	72	17	55	0	63	69	n/a	67	70
Curfew	1	1	0	0	74	71	n/a	74	68

Notes: 1. Location 3 monitor malfunctioned in 2017 and hence no data was collected at this location in that period.

Table D.3 provides the analysis of unattended noise monitoring data for the B737-400 aircraft.

Table D.3 Analysis of unattended noise monitoring data for B737-800 (September 2017)

Period	[1]Total aircraft movements				L_{Smax} Mean, dB(A)				
	(ASA Kurnell data)	16R	34L	34R	Location 1	Location 2	Location 3	Location 4	Location 5
Daytime	2,873	440	1431	1002	62	65	n/a	62	69
Night time	918	138	573	207	62	65	n/a	60	66
Curfew	9	5	4	0	64	68	n/a	63	66

Notes: 1. Location 3 monitor malfunctioned in 2017 and hence no data was collected at this location in that period.

Table D.4 Analysis of unattended noise monitoring data for B463 (September 2017)

Period	[1]Total aircraft movements				L_{Smax} Mean, dB(A)				
	(ASA Kurnell data)	16R	34L	34R	Location 1	Location 2	Location 3	Location 4	Location 5
Daytime	0	0	0	0	n/a	n/a	n/a	n/a	n/a
Night time	158	83	75	0	64	65	n/a	57	59
Curfew	147	83	64	0	64	65	n/a	56	59

Table D.5 Unattended noise measurements - September comparisons

September	Location	Period	Mean L_{Smax}, dB(A)	[2]Average Daily Number Above noise metrics						
				N60	N65	N70	N75	N80	N85	N90
2011	1	Daytime	65	195.3	n/a	62.0	17.4	2.1	0.1	0.0
	1	Night time	64	67.6	n/a	16.8	4.4	0.3	0.0	0.0
2014	1	Daytime	67	209.0	127.8	98.6	41.2	3.4	0.1	0.0
	1	Night time	67	75.0	41.3	29.4	10.5	1.3	0.0	0.0
2015	1	Daytime	63	157.1	98.2	41.1	8.4	0.9	0.1	0.1
	1	Night time	63	59.2	30.6	13.4	3.3	0.5	0.0	0.0
2017	1	Daytime	62	166.7	45.4	24.7	6.1	0.7	0.2	0.1
	1	Night time	63	79.1	20.7	8.5	2.0	0.2	0.1	0.1
2011	2	Daytime	67	237.3	n/a	67.4	6.0	0.2	0.1	0.0
	2	Night time	67	80.9	n/a	24.7	1.6	0.1	0.1	0.0
2014	2	Daytime	68	255.4	199.3	78.2	18.4	1.4	0.0	0.0
	2	Night time	69	88.2	71.8	27.4	4.8	0.3	0.0	0.0
2015	2	Daytime	71	249.8	220.1	161.4	54.0	12.5	2.8	1.1
	2	Night time	71	84.4	75.2	52.7	15.5	4.5	1.6	0.7
2017	2	Daytime	65	239.5	142.8	27.4	2.7	0.3	0.1	0.1
	2	Night time	66	99.1	63.4	11.9	0.6	0.1	0.0	0.0
2011	3	Daytime	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	3	Night time	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2014	3	Daytime	67	221.7	155.7	94.4	25.8	3.9	0.3	0.0
	3	Night time	68	78.5	58.5	39.0	14.0	1.3	0.0	0.0
2015	3	Daytime	77	244.0	226.6	200.8	147.7	100.9	56.2	19.3
	3	Night time	75	74.9	68.9	59.5	41.3	26.2	15.5	4.6
2017	3	Daytime	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table D.5 Unattended noise measurements - September comparisons

September	Location	Period	Mean L_{Smax}, dB(A)	[2]Average Daily Number Above noise metrics						
				N60	N65	N70	N75	N80	N85	N90
	3	Night time	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2011	4	Daytime	66	233.8	n/a	69.9	9.3	1.6	0.1	0.0
	4	Night time	66	81.7	n/a	21.2	4.4	0.3	0.0	0.0
2014	4	Daytime	64	192.9	120.7	43.0	8.0	2.9	1.1	0.0
	4	Night time	65	70.9	46.4	14.1	2.4	0.5	0.2	0.0
2015	4	Daytime	73	247.0	213.2	163.1	107.7	61.3	29.0	8.9
	4	Night time	71	79.1	65.7	41.7	24.6	13.6	6.0	1.9
2017	4	Daytime	62	183.6	80.2	17.9	1.9	0.2	0.0	0.0
	4	Night time	61	68.2	30.0	5.5	0.7	0.0	0.0	0.0
2011	5	Daytime	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	5	Night time	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2014	5	Daytime	64	192.9	120.7	43.0	8.0	2.9	1.1	0.0
	5	Night time	65	70.9	ass	14.1	2.4	0.5	0.2	0.0
2015	5	Daytime	66	220.9	114.0	70.2	42.0	5.9	0.2	0.0
	5	Night time	63	60.2	21.7	11.4	7.9	0.9	0.0	0.0
2017	5	Daytime	68	263.1	208.0	109.8	33.2	6.2	0.5	0.0
	5	Night time	65	85.2	68.7	32.6	4.7	0.3	0.0	0.0

Notes: *1. Daytime = 7am to 7pm; Night time = 7pm to 7am.*

2. It should be noted that quoted Number Above metrics (eg N60) are the average daily quantities (hence the fractional data presented).

3. The 2011 locations 1, 2 and 4 correspond to the same numbering in other years. Location 3 in the 2011 data does not correspond to any location in subsequent years and hence data is not provided. Similarly, location 5 was not sampled in 2011.

4. Location 3 monitor malfunctioned in 2017 and hence no data was collected at this location in that period.

Appendix E

Unattended noise data analysis methodology

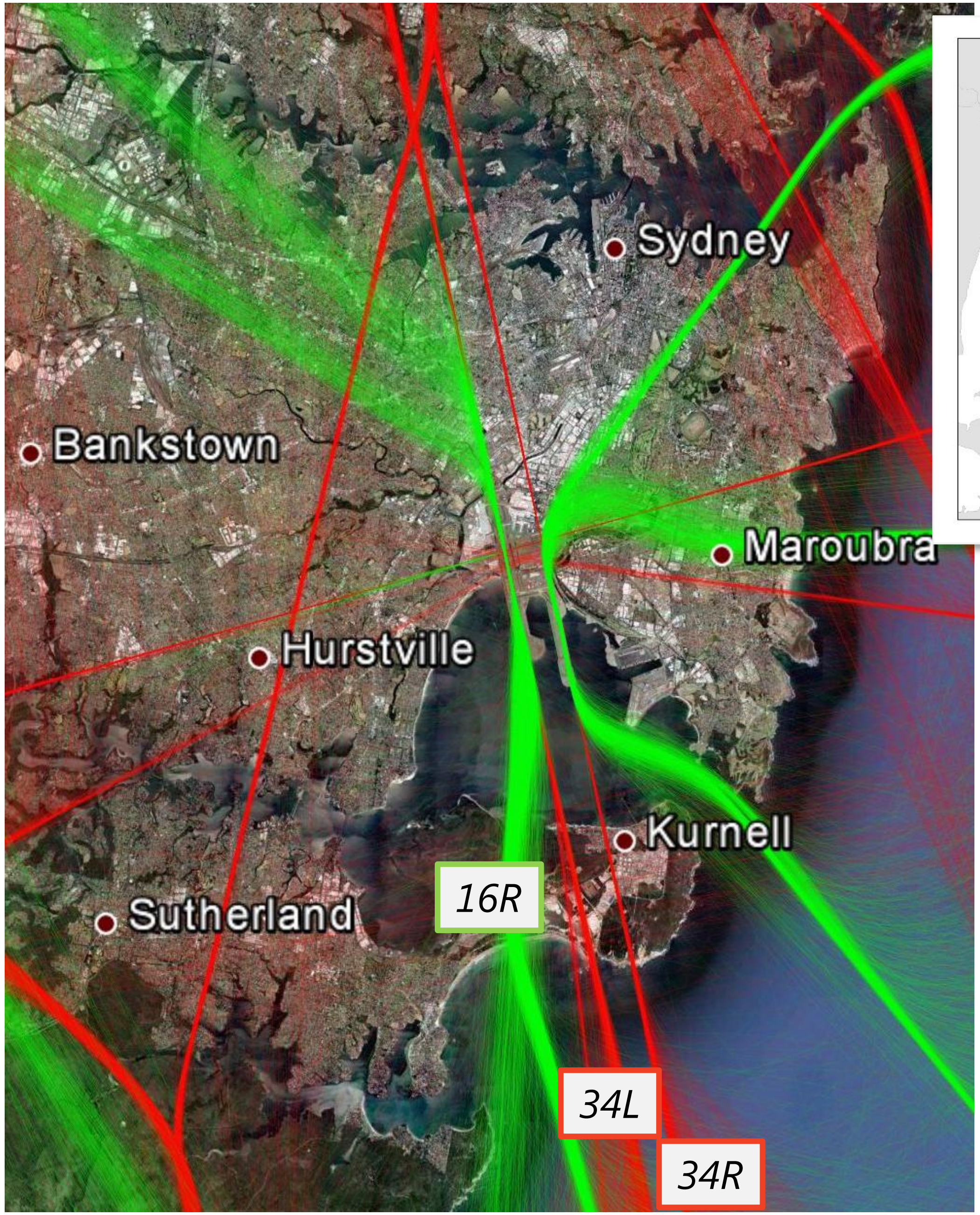
Purpose

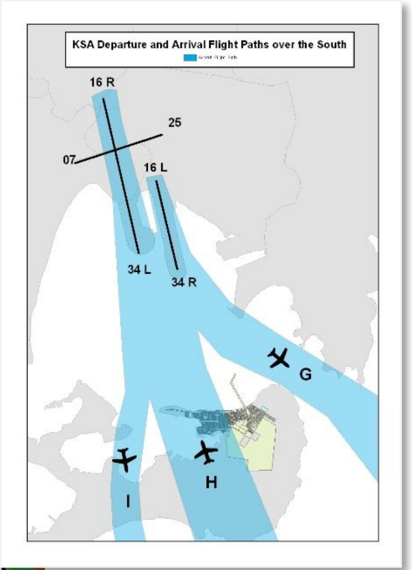
Understand the noise impact of aircraft movements from Sydney Airport in particular locations in Kurnell by utilising ASA data combined with data from five loggers between the 1st of September 2014 – 30th November 2014

Flight Paths

The three relevant flight paths to Kurnell are:

- 16R - Departures
- 34L - Arrivals
- 34R - Arrivals



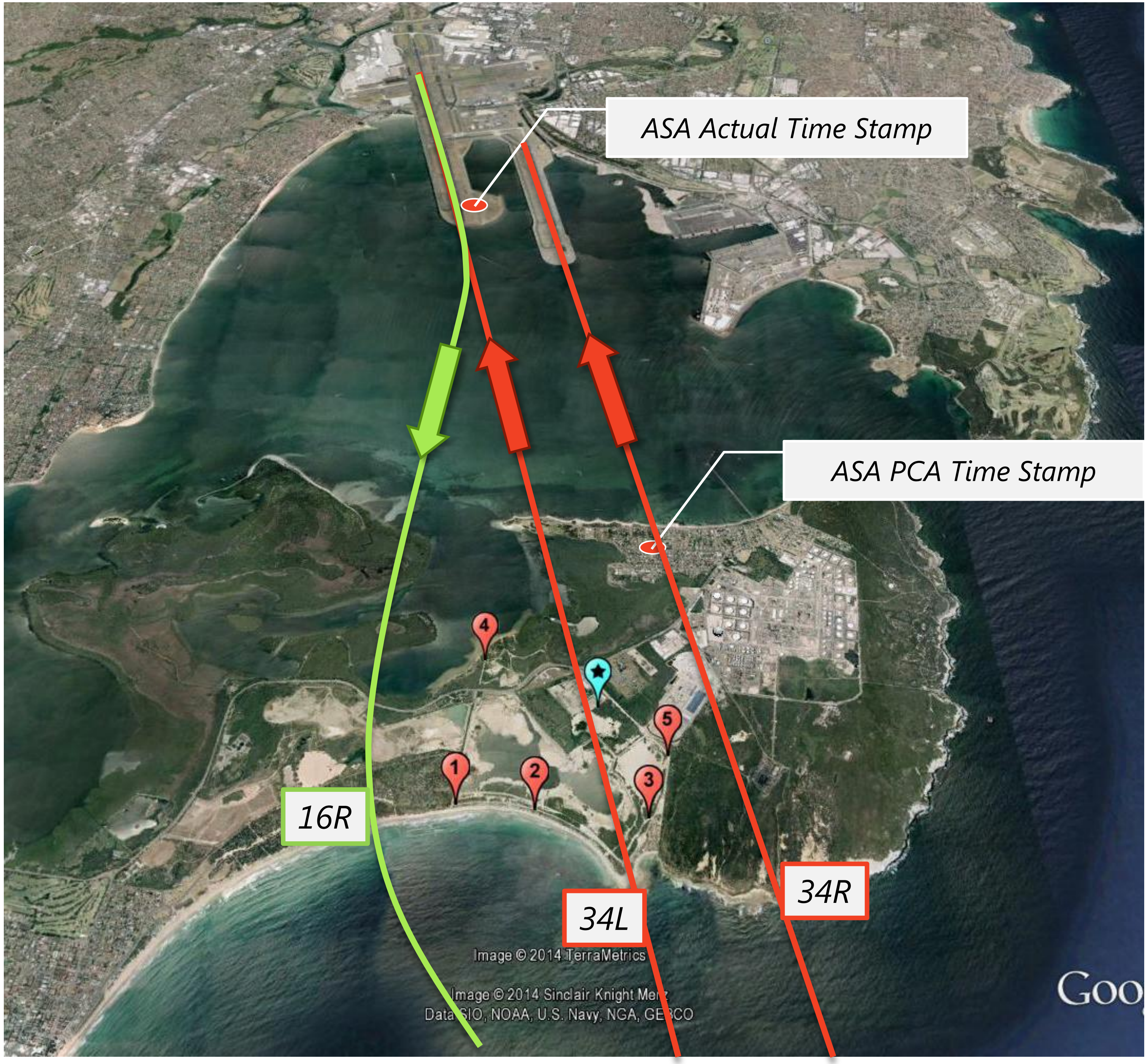


http://aircraftnoise.com.au/working-together/managing-noise-at-airports/sydney-airport/
Legend: Red = Jet Arrivals, Green = Jet Departures
https://sscebp.ssc.nsw.gov.au/ebp/webpapr.nsf/0/d52a66a75a91cdffca2571e0007c98d8?OpenDocument&ExpandSection=-3

Loggers / ASA

The five loggers are placed around a sand quarry in Kurnell to measure the impact of flights from the three Flight Paths.

ASA data which provide time stamps of all of the aircraft movements are recorded at the runway (Actual Time Stamp) and at Kurnell Public School (PCA Time Stamp).



Data

The data collected as part of this project consisted of:

- Logger Noise Data (5)
- ASA Aircraft Data
- Weather Data

Logger Noise Data

- For the 5 different loggers noise levels are measured every decisecond (10 per second)
- Each hour for each logger creates a file with 36,000 measurements
- For the time period of the analysis this would mean a maximum of:
  - 5 Loggers x 91 days x 24 hours = 10,920 files for the period
  - 10,920 files x 36,000 measures per file = 393m measures for the period

KURNELL DATA

SEPTEMBER

Data Files Missing	Total	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Logger 1	0																														
Logger 2	0																														
Logger 3	0																														
Logger 4	0																														
Logger 5	0																														

Minutes Corrupted	Total	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Logger 1	6.0																										6.0				
Logger 2	0.0																														
Logger 3	19.0																										19.0				
Logger 4	4.9																										4.9				
Logger 5	11.9								1.1		2.3							0.5									8.0				

September 08,10,17*: Data appears corrupted in files*

September 26*: Data was downloaded and logger clocks reset*

Logger Data Review

September Review

DATA

KURNELL DATA

OCTOBER

Data Files Missing	Total	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Logger 1	0																															
Logger 2	0																															
Logger 3	0																															
Logger 4	0																															
Logger 5	0																															

Minutes Corrupted	Total	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Logger 1	213.6																								79.7	24.0	31.9	78.0				
Logger 2	67.8																											67.8				
Logger 3	64.7																											64.7				
Logger 4	59.1																											59.1				
Logger 5	68.3															2.0												66.3				37.6

October 27*: Data was downloaded and logger clocks reset. An hour was lost to Daylight Saving reset*

Logger Data Review

October Summary

DATA

KURNELL DATA

NOVEMBER

Data Files Missing	Total	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Logger 1	0																														
Logger 2	185				5	24	24	24	24	24	24	24	12																		
Logger 3	0																														
Logger 4	0																														
Logger 5	12	8	2	2																											

Minutes Corrupted	Total	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Logger 1	3152.8					8	26	54	56	96	151	56	96	263	282	85	131	327	231	272	237	239	343	199							
Logger 2	99.1				26								9											64							
Logger 3	0.0																														
Logger 4	7.9					3																		5							
Logger 5	325.2	91	110	44																				81							

November 05-23*: Data appears corrupted in files*

November 24 onwards*: Data not included in analysis*

Logger Data Review

November Summary

ASA Data

The ASA data contains information about all the aircraft movements for the period of the analysis. This data includes:

- Runway time stamp (Actual Time Stamp)
- PCA Time Stamp
- Runway Type (e.g. 16R)
- Operation Type (e.g. Arrival)
- Aircraft Type (e.g. Boeing 747-400)

Process

1

Analysis to determine Time Offset per Runway / Operation Type between data sets

2

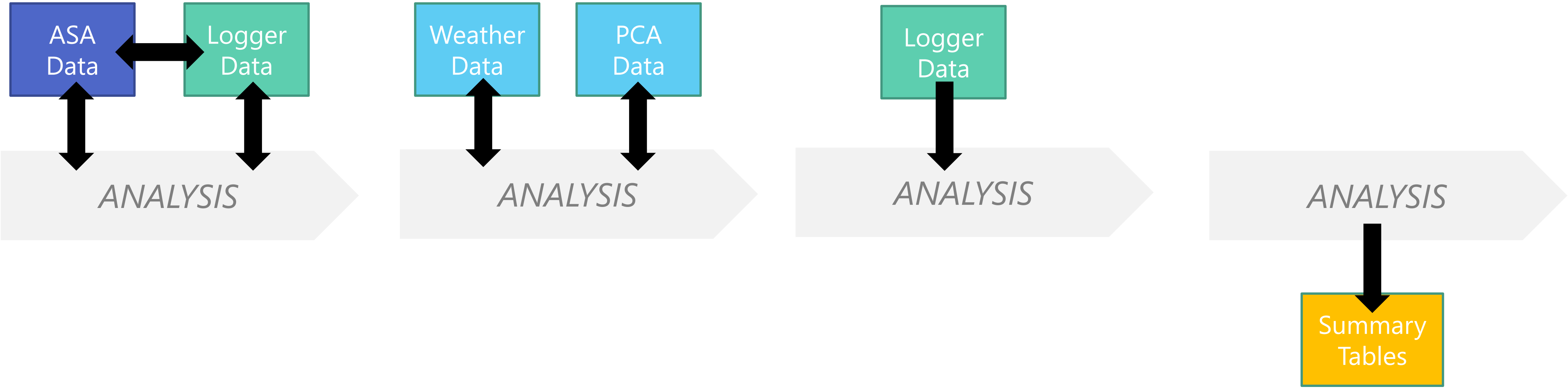
Details of 33,000+ aircraft movement combined with PCA and Weather data

3

Lmax dBA for 30 s surrounding event drawn from all five logger data

4

Output Summary by Runway, Location, Month, Aircraft Type



Offset Process

In order to correctly apply the noise levels for each aircraft movement the clocks of the ASA data and each logger need to be matched to determine the correct difference (or offset).

In theory this would be a single number for the entire period for each clock encapsulating both the time aircraft take to travel between the two measurement points (assuming same speed) and the clocks of the two measuring devices.

This assumes that all clocks 'keep time' properly. However, it was found that the offset required changed over the period indicating that adjustments are required. The required offset was increasing by 5-8 seconds per day depending on the logger.

It was assumed that the ASA data uses 'correct time'.

Also, daylight savings was introduced in the period (5th October) necessitating a further intervention in the data matching process.

Offset Process

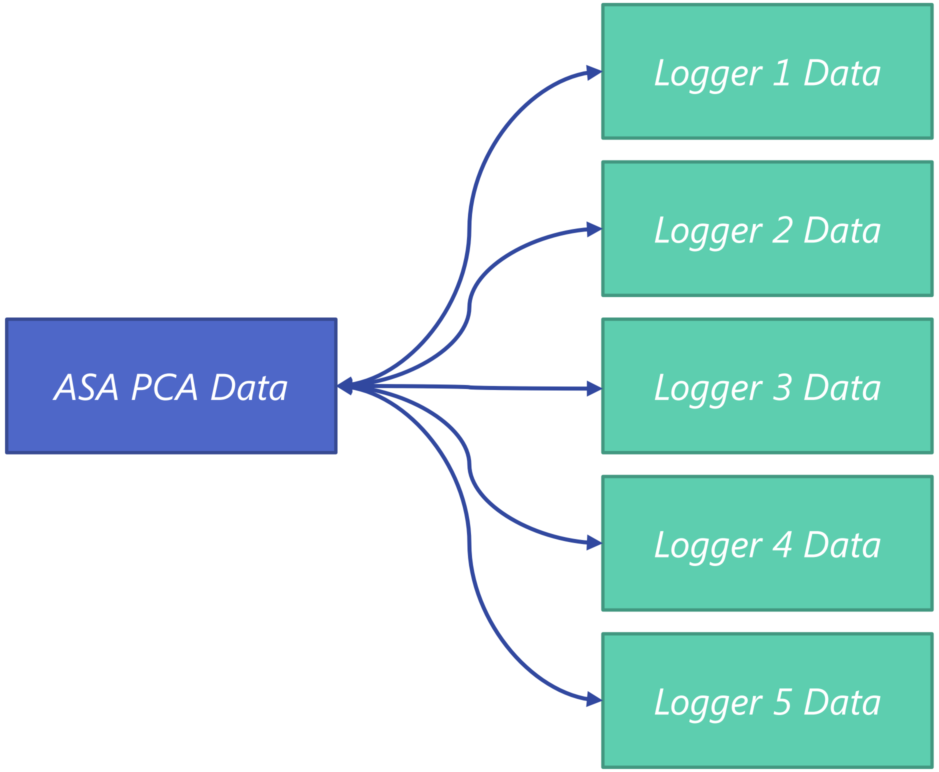
Determining the correct offset required for each day required the following process:

Compiled all of the data in one spreadsheet by taking the maximum for each 5 second interval across the time period. This created a table of 500k rows by 5 columns (loggers) for each month.

Divided the ASA aircraft data into ~500 combinations of:

- Day (30-31)
- Runway (3)
- Logger (5)

The best offset was determined by picking each of the 450 combinations and testing offsets between -360 and +360 seconds to see what get the most matches of +60dBA alignments within 10 seconds of an aircraft timestamp.



Offset Results

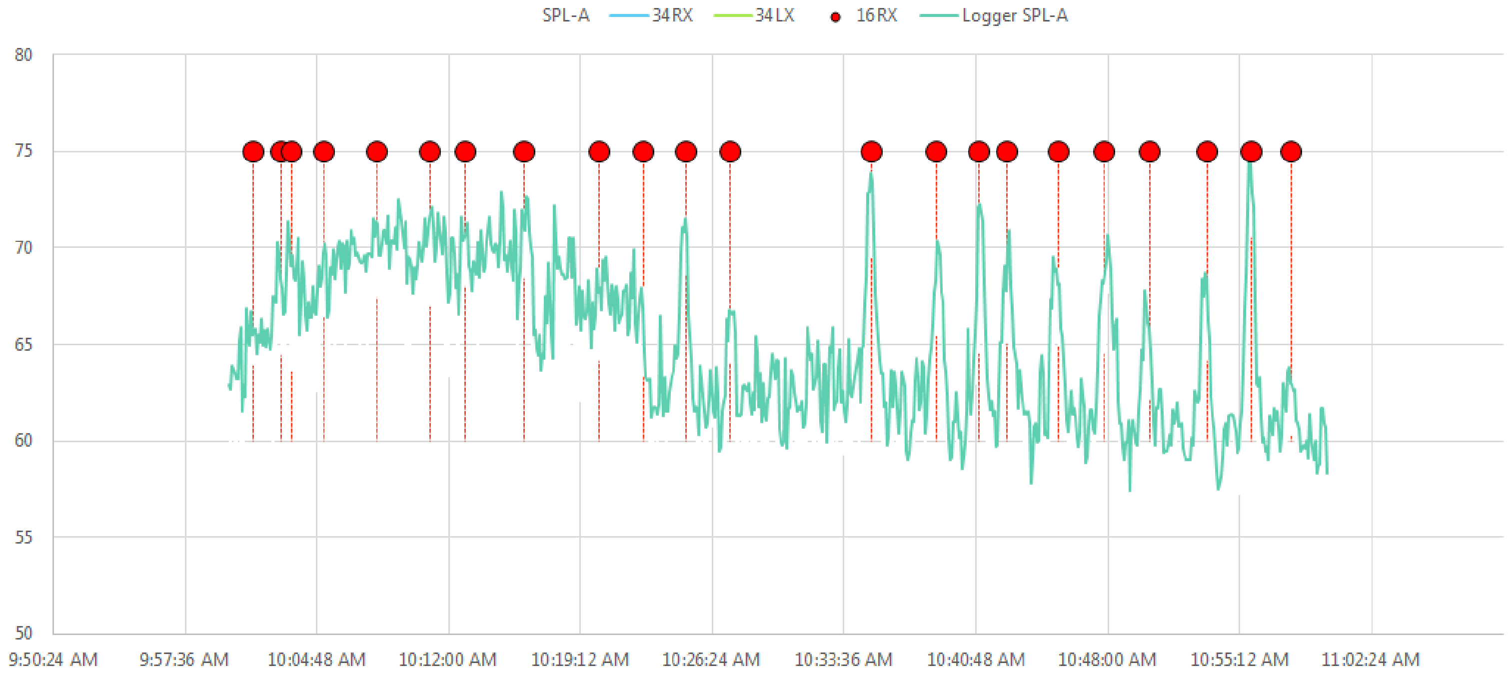
EXAMPLE:

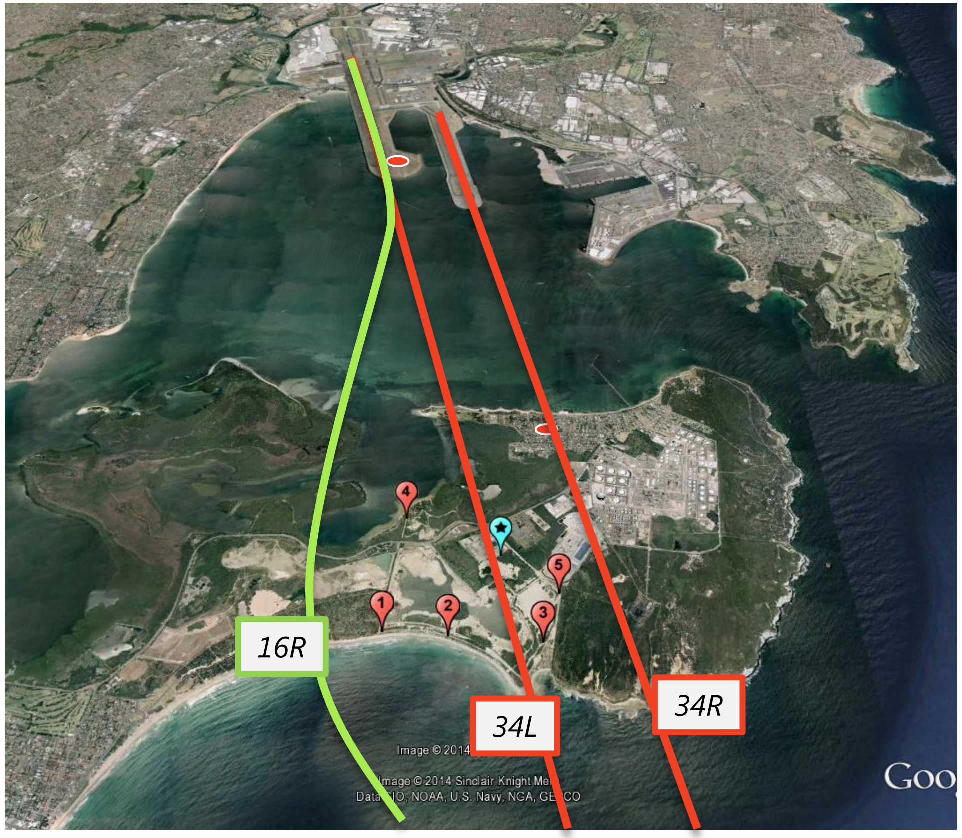
The example to the right shows the alignment of PCA timestamp of aircraft events and the Logger 2 noise recording.

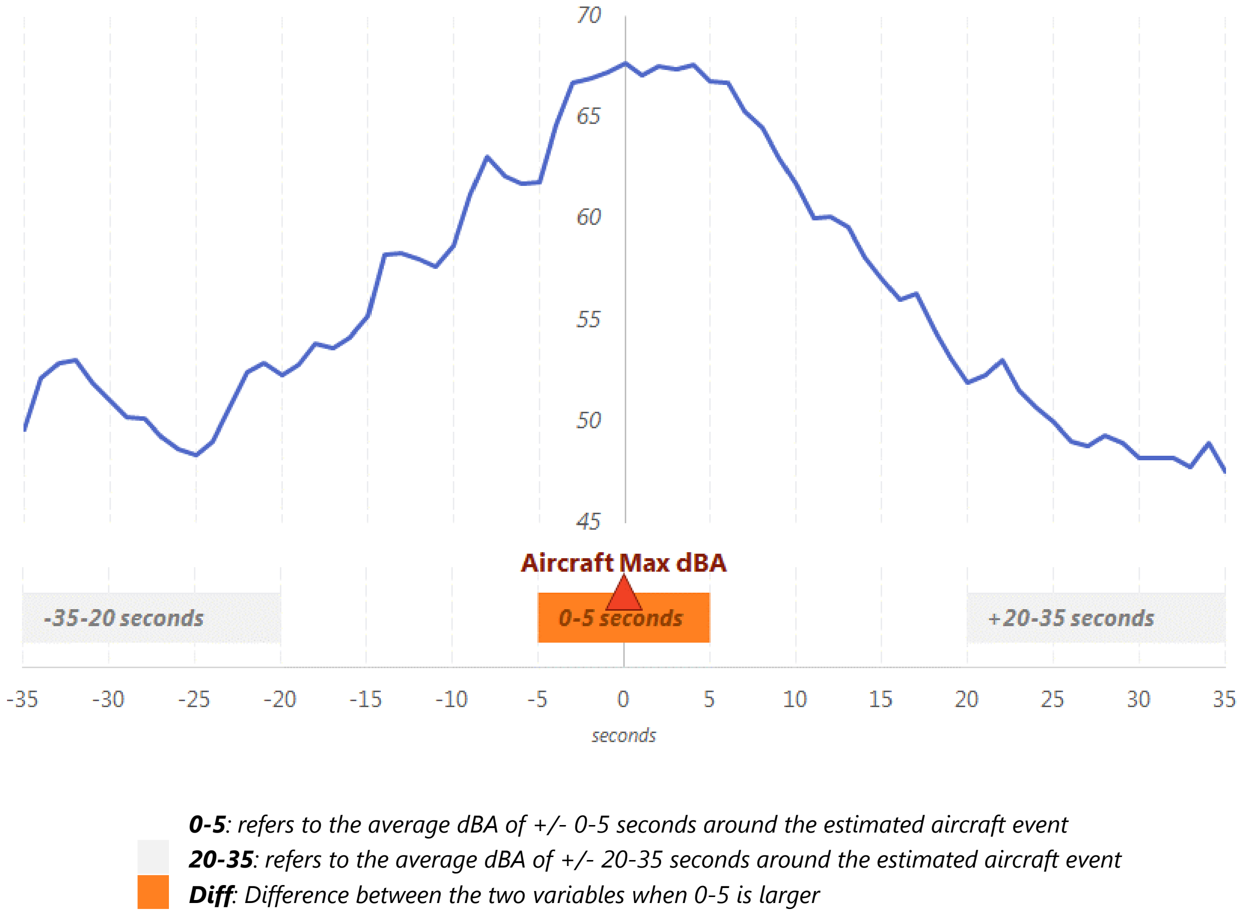
By offset the PCA data by seconds we can see almost perfect alignment of aircraft movement on Runway 16R to the logger data.

ALIGNING LOGGER DATA & ASA DATA

LOGGER 2 vs PCA DATA | 02/09/2014 | 10AM-11AM | 60 SECOND OFFSET







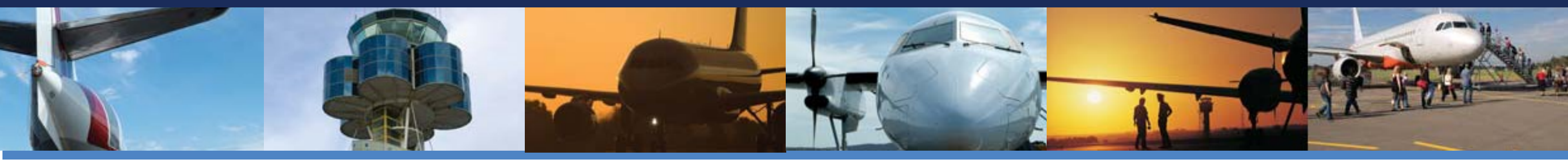
Change in Noise Levels

To get an understanding of the impact that aircraft from each runway was having on each logger, a sample of the 10 seconds around the maximum of each flight at site was calculated and compared to the average of measured noise 20-35 seconds away from the maximum.

Appendix D

LTOP General Information fact sheet

Australian Government
Department of Infrastructure
and Regional Development



Long Term Operating Plan —General Information

Why does Sydney Airport have a Long Term Operating Plan (LTOP)?

The fairest way to manage the noise impacts of Sydney Airport is to share the noise. LTOP puts in place noise sharing arrangements developed in consultation with the Sydney community.

How was LTOP developed?

LTOP was developed in response to community pressure to share the noise generated by Sydney Airport.

Airservices Australia developed options for operating the Airport in a way that shares the noise as fairly as possible. These options were released for public comment in late 1996 and formed the basis for LTOP.

What does LTOP involve?

LTOP provides 10 different ways of using the Airport's three runways and associated flight paths. These are known as Runway Modes of Operation (see attached diagrams).

How does LTOP work?

Under LTOP, when making runway selections each day, Airservices Australia must ensure that, subject to safety and weather conditions:

- as many flights as practical come and go using flight paths over water or non-residential areas where aircraft noise has the least impact on people
- the rest of the air traffic is spread or shared over surrounding communities as fairly as possible
- Runway Modes change throughout the day so individual areas have some break (or respite) from aircraft noise on most days.

What are LTOP targets?

LTOP has noise sharing targets for the amount of aircraft movement to the north, south, east and west of the Airport.

The plan is designed to place as many flights as possible over water (55 per cent to the south) and for the remaining flights to be shared between the other three directions as equally as operationally feasible.

How is LTOP managed?

Airservices Australia implements LTOP. An Implementation and Monitoring Committee, which includes community representation, reports through Airservices to the Federal Minister on how LTOP is being implemented.

What is the Sydney Airport Community Forum?

The Sydney Airport Community Forum (SACF) provides broad community representation across all areas around the airport, the three levels of government and the aviation industry.

SACF reports to the Minister and provides advice on noise sharing and managing the noise impacts of Sydney Airport. You can find more information on the Forum at http://www.sacf.infrastructure.gov.au/

Are there other noise controls at Sydney Airport?

The Sydney Airport Curfew and the Movement Cap, which are enforced through Commonwealth legislation, are two other key measures for managing the level of aircraft noise exposure for Sydney residents. You can find more information about the curfew at https://www.infrastructure.gov.au/aviation/environmental/curfews/SydneyAirport/index.aspx

Are there reports on noise sharing?

Airservices Australia publishes monthly reports on the number of aircraft movements on the runways and flight paths. It also publishes noise monitoring reports each quarter. You can access these reports at

http://www.airservicesaustralia.com/reports/

Where can I get more information about aircraft noise?

Airservices Australia's Noise Complaints and Information Service (NCIS) can provide information about current and past aircraft movements and explain why aircraft fly where they do.

The NCIS can be contacted by telephone on 1800 802 584 or http://www.airservicesaustralia.com/aircraftnoise/about-making-a-complaint/.

Long Term Operating Plan — General Information

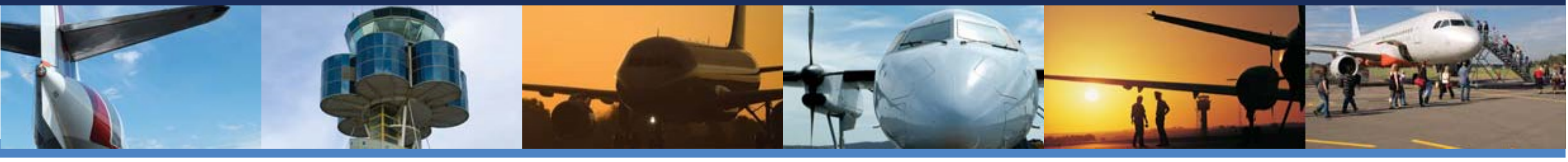


Diagram of LTOP Runway Modes and flight paths

Runway Modes of Operation

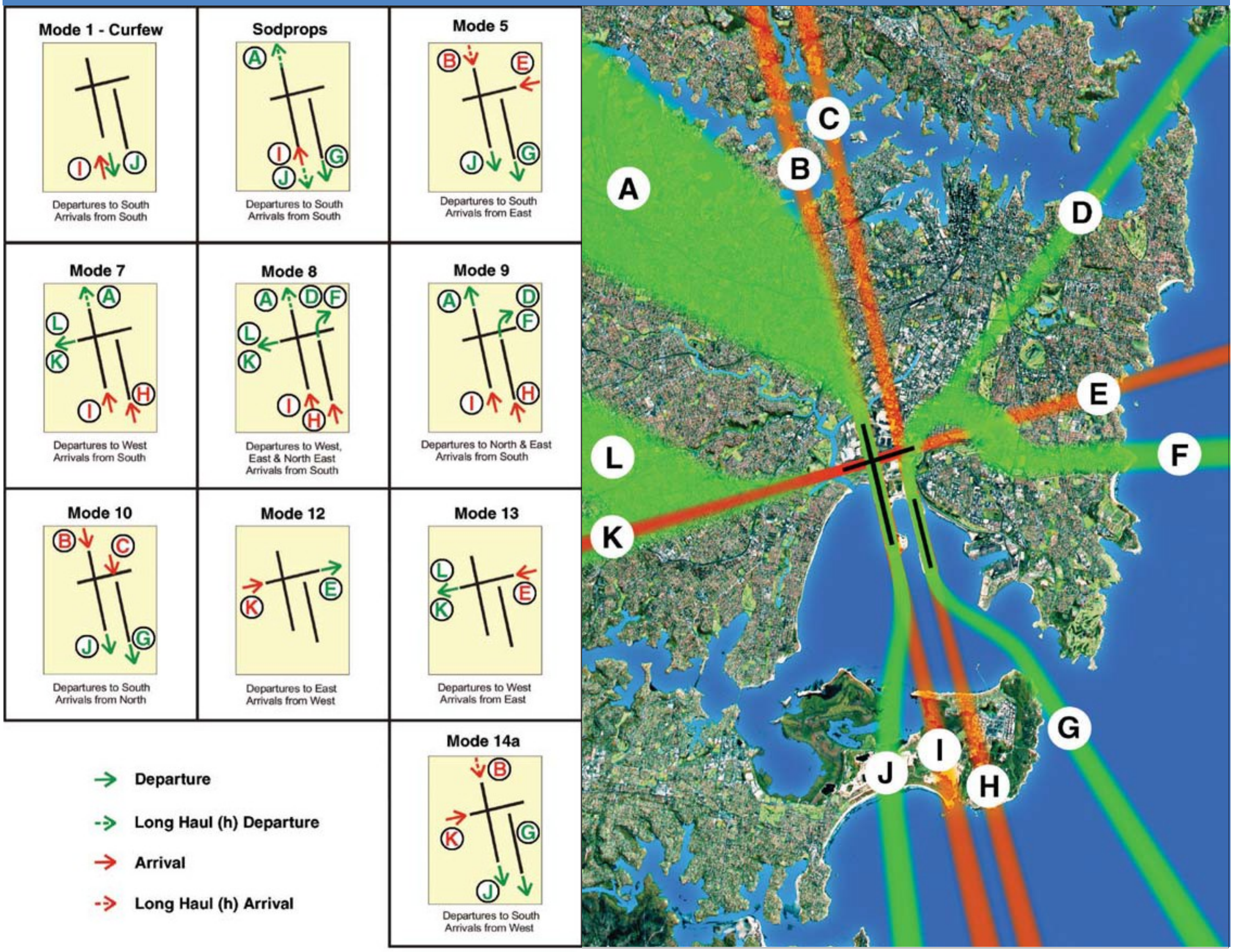


Illustration of the 10 different ways of using the Airport's three runways, called Runway Modes of Operation, under the Long Term Operating Plan (LTOP). The associated flight paths for aircraft arriving and departing from Sydney Airport are labelled A to L.

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