## APPENDIX K

# Noise and Vibration Assessment (SLR Consulting Pty Ltd)

# SIX MILE CREEK DAM

## Safety Upgrade Project
## Noise and Vibration Assessment

**Prepared for:**

SMEC Australia Pty Ltd
Level 6, 480 St Pauls Tce
Fortitude Valley QLD 4006

**SLR Ref: 620.11666.20000-R01**
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# EXECUTIVE SUMMARY

SLR Consulting Australia Pty Ltd (SLR) has been engaged by SMEC Australia Pty Ltd (SMEC), on behalf of Seqwater, to prepare a noise impact assessment for the construction and operational aspects of the Six Mile Creek Dam (also known as the Lake Macdonald Dam) upgrade. The proposed works include:

- Staged and temporary lowering of the dam's water level to allow for construction works;
- Construction of a temporary coffer dam to enable removal of the dam's spillway;
- Construction of a replacement spillway;
- Reconstructing the existing earth embankments; and
- Potential construction of a saddle dam.

The upgrade Project would be mainly concerned with works at the dam spillway area, and SLR understands that the dam footprint would not otherwise be altered.

The operational noise emission characteristics from the facility as a result of the upgrade are expected not to change compared to current noise levels. On this basis, operational noise emissions are not required to be assessed. This assessment therefore focuses on the change in acoustic environment from the temporary construction activities, which are primarily associated with the demolition and rebuilding of the dam spillway.

Construction activities have been assessed against targets derived from noise criteria in the *Queensland Environmental Protection Act 1994* and the *Environmental Protection (Noise) Policy* 2008 and the *Planning for Noise Control Guideline 2004*. To quantify the existing acoustic environment and to provide context to the predicted construction emissions, continuous unattended noise monitoring was undertaken at two sites adjacent to the Project from 29 May to 7 June 2018. Construction generated ground vibration is expected to be transient in nature and was assessed against criteria for cosmetic damage from British Standard 7385.

A set of assessment construction scenarios were developed for each construction stage using typical plant items and defined areas of operation across the Project area. A three-dimensional noise model accounting for the ground terrain and built environment over the entire Project area has been assembled for each construction scenario, for both standard and non-standard working hours where relevant, as well as the respective default weather conditions. Given the scale of the Project area, airborne noise from construction activities were then predicted using industry standard numerical codes for a representative set of residential locations. These predicted noise levels were then compared to targets in accordance with the measured ambient noise levels.

Given the proximity of sensitive receptors areas to the Project and the inherently intensive nature of the construction works, potential exceedances of the noise targets have been identified for the unmitigated scenario. In accordance with the relevant regulations and standards, all reasonable and practicable mitigation and management measures have been considered. As described in this report certain construction activities, even with mitigation, have potential to exceed the nominated targets and therefore community consultation is recommended. Ground vibration emissions at the expected separation distances are predicted to be compliant with the nominated cosmetic damage criteria. It is recommended that any complaints associated with noise and vibration emissions from the construction works should be investigated as appropriate.

A detailed summary of potential noise and vibration impacts identified throughout this assessment together with the respective compliance management measures are outlined within this report.

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## APPENDICES

# 1 Introduction

SLR Consulting Australia Pty Ltd (SLR) has been commissioned by SMEC Australia Pty Ltd (SMEC) on behalf of Seqwater to prepare a Noise and Vibration Assessment of activities associated with the Six Mile Creek Dam (also known as the Lake Macdonald Dam) Safety Upgrade ("the Project"). A Noise and Vibration Assessment is a required component of the Impact Assessment Report (IAR).

The proposed works include:

- Staged and temporary lowering of the dam's water level to allow for construction works;
- Construction of a temporary coffer dam to enable removal of the dam's spillway;
- Construction of a replacement spillway;
- Reconstructing of the existing earth embankments; and
- Potential construction of a saddle dam.

The Project would be mainly concerned with works at the dam spillway area, and SLR understands that the dam footprint would not otherwise be altered.

The scope of works and methodology for the noise impact assessment includes:

- A site visit to the subject site and surrounding areas to gain an appreciation of the site and the nature of the existing noise environment surrounding the site.
- Environmental noise logging within the sensitive receptor catchment area to obtain baseline information required to establish noise criteria in accordance with the relevant guidelines.
- Development of a computer noise model for the site to predict noise emission levels from the Project at the nearest noise sensitive receptor locations.
- In-principle noise control measures, where required.

The scope of works and methodology for the vibration impact assessment includes:

- Spreadsheet calculations to determine the safe working offset distances for each of the planned vibration intensive activities.
- Assessment of the potential vibration impacts based on the construction activities being undertaken at the locations closest to the relevant receptors.
- Recommendations for in-principle vibration control measures, where required.

## 1.1 Guideline: Application requirements for activities with noise impacts

The Department of Environment and Science (DES) Guideline *Application requirements for activities with noise impacts* (DES, 2018) outlines the information to be provided to support an environmental authority application for activities with impacts to noise. A summary of the information requirements is listed below along with where they are addressed in this report.

- Identify environmental values for the area, both on and offsite, which may be impacted by noise emissions. Refer **Section 2** and **Section 4.**
- Identify the location of sensitive receptors affected by the proposed activity on an appropriately scaled map. Refer **Figure 2.**
- Provide a description of the site topography and the built environment, including features such as hills, valleys, buildings or thick stands of vegetation. Refer **Section 2.**
- Provide details of background noise levels, including a description of existing noise sources, within the vicinity of the site (eg road traffic). Refer **Section 4.**
- Identify all noise, vibration and airblast overpressure sources, including stationary and mobile sources, associated with the activity. Refer **Section 5.2** and **Section 6.2.** Note, airblast is not applicable for this Project.
- Describe in detail, the characteristics of the noise emissions produced. Refer **Appendix C.**
- Describe how noise, vibration emissions would be avoided, minimised or otherwise managed in accordance with the noise management hierarchy provided in the EPP (Noise). Refer **Section 7.**
- Provide a noise impact assessment, which identifies the likely effect of noise from the activity on nearby sensitive places. Refer **Section 5** and full table of results in **Appendix D.**
- Provide information on the proposed noise mitigation strategies, such as acoustic barriers, siting equipment appropriately, buffers, mufflers, housing noisy equipment in sealed buildings, or reducing the timing of operations. Refer **Section 7.**

For information about the acoustical terminology discussed in this report, refer to **Appendix A**.

# 2 Project Description

Six Mile Creek Dam, located on Six Mile Creek on the Sunshine Coast in Noosa Shire, requires an upgrade to meet performance requirements of the Queensland dam safety regulations into the future. The upgrade will involve lowering the lake (impoundment) level to facilitate construction, removal of the existing spillway, construction of a new concrete spillway founded on weathered rock and reconstructing the existing earth embankments.

The construction works have been split into two stages:

- **Stage 1 - Early package works (site establishment and lake drawdown):**
  - Clearing and grubbing of laydown and construction plant areas.
  - Demolition of some existing on-site buildings.
  - Formation of on-site construction roads.
  - Delivery of fill and formation of pads for laydown and construction plant areas, and delivery of equipment and materials.
  - Installation and commissioning of a concrete batch plant (CBP), diesel generators (if required) and dewatering pumps.
  - Preparation of working platform on the demolished spillway, at new spillway level, to allow for spillway foundation works and to allow for channelling of catchment low flows through the site.
  - Excavation of the existing spillway structure and preparation of a working platform on the demolished spillway, at the new spillway level, to allow for spillway foundation works as well as channelling of catchment low flows through the site.
  - Lowering of Lake Macdonald water level using dewatering pumps, including associated fish salvage.
- **Stage 2 - Dam construction and site rehabilitation:**
  - Foundation works (concrete aggregates and rip rap materials to be imported from off-site).
  - Eastern embankment construction, including demolition of the existing embankment, foundation improvement works to address seepage, piping and liquefaction risks, and major reconstruction of a flatter embankment section with a reduced slope.
  - Western embankment construction, including demolition of the existing embankment to natural foundation level and reconstructing a simpler section for ease of construction, while addressing seepage and piping risks.
  - Potential construction of a saddle dam on Collwood Road (if needed) which would involve building up a 100 – 150 m section of Collwood Road immediately east of Noosa WTP by 1 m – 2 m via an earthen embankment to ensure flood waters are channelled through the new dam spillway, rather than shortcutting through a low section.
  - Decommissioning and removal of construction infrastructure including the CBP, rehabilitation and landscaping.

The schedule indicates that the major earthworks and other construction activities with the potential for noise emissions are expected to occur over a period of approximately 18 to 24 months. The overall layout of construction activities is presented in **Figure 1.**


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# Six Mile Creek Dam Safety Upgrade Project
## Construction Site Layout

**Figure 1**

# 3 Regulatory Framework

This section presents the relevant Queensland legislation for construction and operational noise control. The construction noise level goals have been developed for the day and night time works as a means of assisting with the management of potential impacts.

## 3.1 Noise

In establishing construction and operational noise level goals the following legislative and guideline documents have been reviewed:

- *Environmental Protection Act 1994*
- *Environmental Protection (Noise) Policy 2008*
- Ecoaccess Guideline - *Planning for Noise Control Guideline 2004* (EPA, 2004).

### 3.1.1 Environmental Protection Act 1994

Environmental noise control in Queensland is governed under the *Environmental Protection Act 1994* (EP Act) and subordinate legislation, which aims to strike a balance between protecting the amenity of sensitive receptors and allowing industrial, commercial and development activities to occur in an ecologically sustainable manner.

Under the EP Act, noise is considered a contaminant and noise nuisance is considered environmental harm.

There is a general environmental duty to prevent and minimise environmental harm under the EP Act. The EP Act specifically states:

> *A person must not carry out an activity that causes, or is likely to cause, environmental harm unless the person takes all reasonable and practicable measures to prevent or minimise the harm (the general environmental duty).*

The default noise standard for Building Work is defined in Section 440R of the EP Act:

> *(1) A person must not carry out building work in a way that makes an audible noise—*
>
> *(a) on a business day or Saturday, before 6.30 am or after 6.30 pm or*
>
> *(b) on any other day, at any time.*

### 3.1.2 Environmental Protection (Noise) Policy 2008

The purpose of the *Environmental Protection (Noise) Policy* 2008 (EPP (Noise)) is to protect Queensland's acoustic environment according to the principles of ecologically sustainable development established in the EP Act. The purposes of the EPP (Noise) are achieved by:

- Identifying environmental values that are to be enhanced or protected
- Stating acoustic quality objectives for enhancing or protecting the environmental values, and
- Providing a framework for making consistent, equitable and informed decisions about the acoustic environment.

### *Environmental Values*

The environmental values described in the EPP (Noise) are:

- The qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystems.
- The qualities of the acoustic environment that are conducive to human health and wellbeing, including by ensuring a suitable acoustic environment for individuals to either sleep, or study / learn, or recreational activities (including relaxation and conversation).
- The qualities of the acoustic environment that are conducive to protecting the amenity of the community.

### *Noise Management Hierarchy*

The EPP (Noise) sets out a management hierarchy for all activities involving noise:

- Firstly, avoid
- Secondly, minimise**,** in the following order of preference –
  - Firstly, orientate an activity to minimise noise
  - Secondly, use best available technology, and
- Thirdly, manage**.**

### *Acoustic Quality Objectives*

The relevant acoustic quality objectives for residential dwellings, as specified by the EPP (Noise) are presented in **Table 1.**

**Table 1 EPP (Noise) – Acoustic Quality Objectives**

| Sensitive Receptors | Time of Day | Acoustic Quality Objectives (Measured at the Receptor, dBA) | | | Environmental Value |
|---|---|---|---|---|---|
| | | $L_{Aeq, adj, 1 hr}$ | $L_{A10, adj, 1 hr}$ | $L_{A1, adj, 1 hr}$ | |
| Dwelling (for outdoors) | Daytime and Evening | 50 | 55 | 65 | Health and wellbeing |
| Dwelling (for indoors) | Night time | 30 | 35 | 40 | Health and wellbeing, in relation to the ability to sleep |

## 3.1.3 Planning for Noise Control Guideline

The *Planning for Noise Control Guideline* (EPA 2004) provides assessment criteria for sleep disturbance. This guideline recommends that maximum instantaneous internal noise levels in sleeping areas should not exceed approximately 45 dBA more than 10 to 15 times per night. The corresponding external noise level, assuming partially closed windows, is 52dBA maxLpA, measured in the free field.

**Table 2** presents site specific intermittent noise limits apply at residential receptors surrounding the site during the night time period.

**Table 2 Sleep disturbance noise limits at residential receptors**

| Period | Time | Noise Limits at a Noise Sensitive Place Measured as the Adjusted Maximum Sound Pressure Level, dBA |
|---|---|---|
| Night time | 10pm to 7am | 52 |

### 3.1.4 Summary of Noise Targets

Project construction noise targets have been established as follows. As mentioned in **Section 3.1.1,** construction work during standard hours (6.30am to 6.30pm) are exempt from numerical noise limits. However for the purpose of identifying the risk of complaint from surrounding receptors, and thus the necessity for noise management, this assessment has nominated acoustic targets. The targets being derived the from the EPP(Noise) acoustic quality objectives listed in **Table 1**. To establish an external limit for night time activity, a conservative 5dBA reduction between outside and inside is applied assuming open windows. Sleep disturbance targets are set as per Section **3.1.3**. Any exceedance of the targets would trigger the introduction of noise management as listed in **Section 7.**

**Table 3 Project construction noise targets (outdoors external to sensitive receptors)**

| Time of Day | Noise Target |
|---|---|
| Daytime and Evening (7am to 10pm) | 50 dBA $L_{Aeq,1hr}$ |
| Night (10pm to 7am) | 35 dBA $L_{Aeq,1hr}$ |
| Sleep disturbance (10pm to 7am) | 52 dBA $L_{Amax}$ |

The noise targets presented in **Table 3** apply to construction noise. Operational noise targets are not relevant to this assessment.

## 3.2 Vibration

For this Project, only construction vibration is deemed to be potentially perceptible at surrounding receptors. Construction generated vibration is expected to be transient in nature and would be assessed against criteria for cosmetic damage only.

In the absence of a relevant Australian Standard, the British Standard (BS) 7385-2:1993 *Evaluation and measurement for vibration in buildings. Part 2 Guide to damage levels from groundborne vibration* is a reference standard against which the likelihood of building damage from ground vibration can be assessed. BS 7385 has been developed from an extensive review of UK data, relevant international documents and other published data. The standard sets levels for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration-induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

The levels from the BS7385 standard for vibration judged to result in a minimal risk of cosmetic damage to residential buildings and industrial buildings are presented numerically in **Table 4.**

**Table 4 Vibration Guide Values for Cosmetic Damage from BS7385**

| Line | Type of Building | Peak Component Particle Velocity in Frequency Range of Predominant Pulse | |
|---|---|---|---|
| | | 4 Hz to 15 Hz | 15 Hz and above |
| 1 | Reinforced or framed structures<br>Industrial and heavy commercial buildings | 50 mm/s at 4 Hz and above | |
| 2 | Non-reinforced or light framed structures<br>Residential or light commercial type buildings | 7.5 mm/s at 4 Hz increasing to 10 mm/s at 15 Hz | 10 mm/s at 15 Hz increasing to 50 mm/s at 20 Hz and above |

As the nearest identified sensitive receptors are of residential use, a vibration value of 7.5mm/s has been adopted for the Project.

# 4 Existing Environment

## 4.1 Sensitive Receptors

The DES Guideline *Application requirements for activities with noise impacts* (DES, 2018) defines a noise sensitive receptor as place potentially affected by noise from a proposed activity. Sensitive receptor types are listed in Schedule 1 of the EPP (Noise):

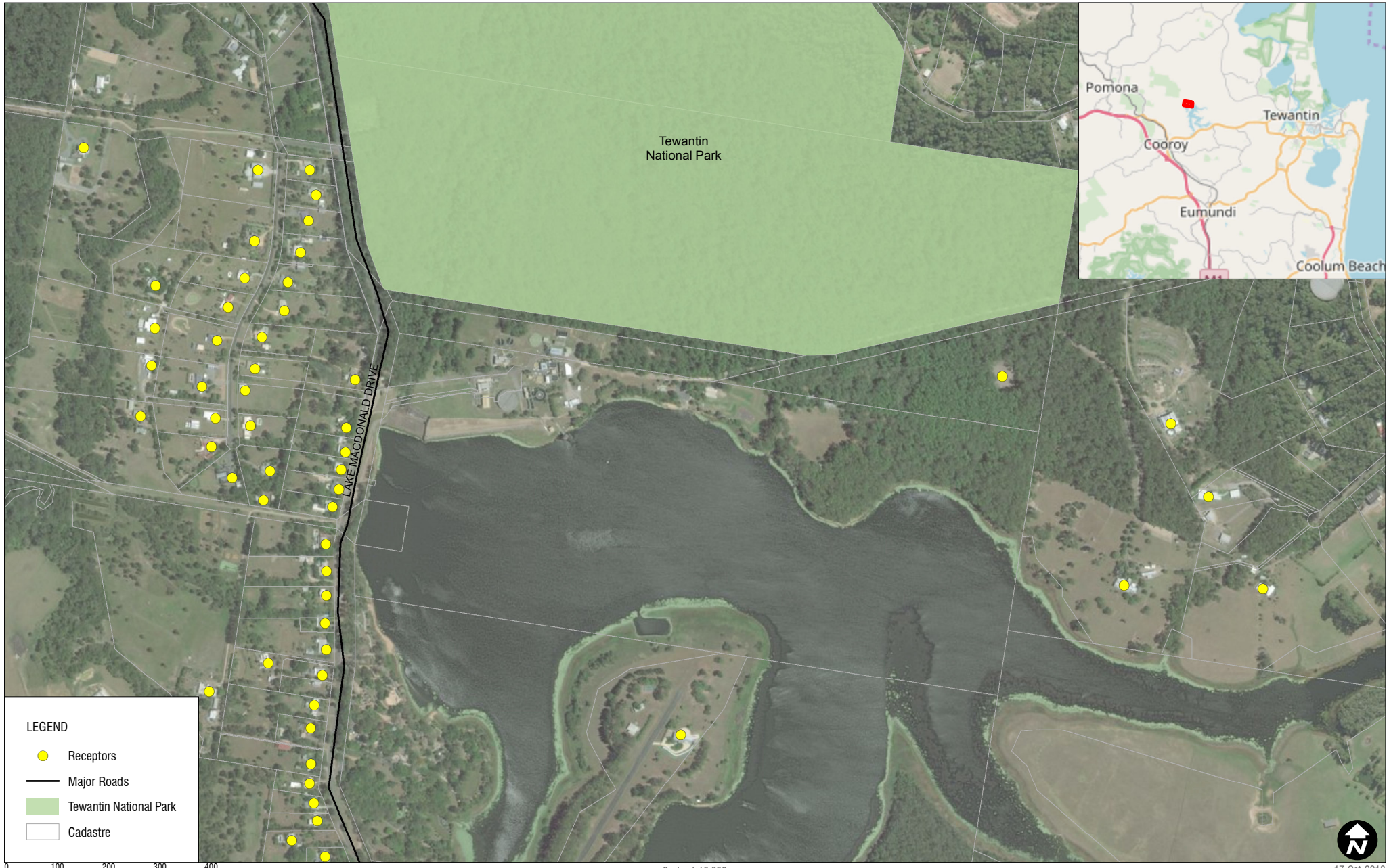
- Dwelling;
- Library and educational institution (including a school, college and university);
- Childcare centre or kindergarten;
- School or playground;
- Hospital, surgery or other medical institution;
- Commercial and retail activity;
- Protected area, or an area identified under a conservation plan under the Nature *Conservation Act 1992* as a critical habitat or an area of major interest;
- Marine park under the *Marine Parks Act 2004*; and
- Park or garden that is open to the public (whether or not on payment of an amount) for use other than for sport or organised entertainment.

The Project area is bordered to the north by Tewantin National Park and otherwise surrounded by a semi-rural residential area (Lake Macdonald suburb), see **Figure 2**. This assessment primarily focusses on the residential receptors which have been identified as the most noise sensitive noise use in the immediate area. It is expected controlling construction noise such that an acceptable level amenity is achieved this will also satisfy amenity requirements at surrounding nature reserve areas such as the Tewantin National Park. Further it is noted that construction works are temporary in nature.

The closest dwellings to the Project construction area are located:

- Approximately 30 m to the west of the left embankment;
- Approximately 210 m to the west of the area in which the CBP may be located
- Approximately 215 m to the west of the closest proposed stockpile area; and
- Approximately 300 m to the east of the clay borrow area.

The sensitive receptor catchment in the area surrounding the Project consists of residential dwellings and public spaces. The sensitive receptor locations are shown on an aerial image in **Figure 2**.

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**Six Mile Creek Dam Safety Upgrade Project**
**Sensitive Receptors**

**Figure 2**

## 4.2 Unattended Noise Monitoring

In order to quantify the existing acoustic environment within the receptor catchment adjacent to the Project, SLR conducted attended noise surveys from 29 May to 7 June 2018 at two locations:

- Location 1: 43 Highland Drive, and
- Location 2: 407 Lake Macdonald Drive

The objective of the unattended noise monitoring was to quantify the existing "baseline" noise levels in the area surrounding the Project and to assist in determining appropriate noise targets for construction and operation of the Project.

The locations of the unattended noise monitoring are shown in **Figure 3**.

### Figure 3 Background Noise Monitoring Locations

Monitoring was carried out using a SVAN 957 Noise Logger (Serial number 23816) and a Ngara Noise Logger (Serial number 87801E). The noise loggers were configured to record a range of A-weighted fast-response statistical noise levels, including the $L_{A1}$, $L_{A10}$, $L_{A90}$, and $L_{Aeq}$ noise levels over consecutive 15 minute periods. The loggers were checked for calibration before and after the monitoring, using a Bruel and Kjaer Sound Level Calibrator (Serial number 2594716) and no significant drift in calibration was detected. The noise loggers were both located in the free-field with a microphone height of 1.5 m above the existing ground level.

A summary of baseline ambient noise levels is presented in **Table 5** with daily noise statistics presented graphically in **Appendix B**.

**Table 5 Summary of Measured Noise Levels (Baseline)**

| Parameter | Period | Average Noise Levels (dBA) | |
|---|---|---|---|
| | | 43 Highland Drive | 407 Lake Macdonald Drive |
| $L_{A1}$ | Daytime (7am-6pm) | 63 | 52 |
| | Evening (6pm-10pm) | 59 | 47 |
| | Night (10pm-7am) | 54 | 43 |
| $L_{A10}$ | Daytime (7am-6pm) | 56 | 46 |
| | Evening (6pm-10pm) | 46 | 42 |
| | Night (10pm-7am) | 45 | 36 |
| Rating Background Level (RBL) [1] | Daytime (7am-6pm) | 40 | 34 |
| | Evening (6pm-10pm) | 40 | 30 |
| | Night (10pm-7am) | 40 | 28 |
| $L_{Aeq}$ | Daytime (7am-6pm) | 55 | 47 |
| | Evening (6pm-10pm) | 47 | 47 |
| | Night (10pm-7am) | 49 | 40 |

Note 1: The RBL is the median of the 90th percentile of the daily background (LA90) noise levels in each assessment period (day, evening and night) over the duration of the monitoring.

It can be seen from **Table 5** that measured steady-state background noise level (RBL) at 43 Highland Drive was the same for all time periods. It was observed during the operator attended noise surveys that the dominant noise source in the local ambient environment was generated by water flowing over the spillway at the dam spillway, approximately 100 m from the noise monitoring location, refer **Section 4.3**. Therefore, the RBLs from 407 Lake Macdonald Drive were considered more typical, with the daytime and evening noise levels being higher than that for the night-time period.

### 4.2.1 Weather Conditions

Local weather conditions were recorded during the noise monitoring period with a weather station located near to the noise logger at 43 Highland Drive. The evening period of 30 May 2018 included a short period of rainfall of approximately 0.2 mm, and a short period in the early morning of 3 June 2018 included rainfall of approximately 0.2 mm. Consequently, two short periods of noise level data were excluded from the assessment. The measured wind speeds were less than 5 m/s during the monitoring period. The measured statistical noise levels, including the exclusion periods (shown as yellow bands), are displayed graphically in **Appendix B**.

## 4.3 Attended Noise Measurements

Operator attended noise measurements were undertaken at the noise logger locations on 29 May 2018 during the daytime period. The measurements were carried out with a Brüel and Kjær Type 2250 Sound Level Meter (SLM) (Serial number 3007914) with the microphone positioned at a height of 1.5 m above ground level. The settings of the SLM were A-weighted and fast time response. Calibration checks were performed both before and after the measurements using a Brüel and Kjær Calibrator (Serial number 2594716). Calibration drift was insignificant.

All significant noise sources were identified during the operator attended measurements and therefore the attended noise measurements allowed for the characterisation of the existing noise environment.

The results of the operator attended noise measurement are shown in **Table 6**.

**Table 6 Attended Noise Measurement Results**

| Location | Date & Time | Measured Noise Level in dBA | | | | Description of Acoustic Environment |
|---|---|---|---|---|---|---|
| | | $L_{A1}$ | $L_{A10}$ | $L_{A90}$ | $L_{Aeq}$ | |
| 43 Highland Drive | 29/05/18 1:16 pm | 62 | 54 | 46 | 51 | Noise generated by water rushing over the dam spillway was dominant (45 dBA SPL).<br>Road traffic noise audible during vehicle passby on Lake Macdonald Drive (52 to 63 dBA SPL).<br>Insect noise clearly audible.<br>Intermittent bird noise audible at times.<br>No mechanical plant noise from water treatment plant was audible. |
| 407 Lake Macdonald Drive | 29/05/18 1:50 pm | 51 | 45 | 35 | 42 | Insect noise was dominant (centred around 4KHz).<br>Road traffic noise audible during vehicle passby on Lake Macdonald Drive (44 to 46 dBA SPL).<br>Intermittent bird noise and dog bark audible at times.<br>Wind generated noise in trees audible at times.<br>No mechanical plant noise from water treatment plant was audible. |

It can be seen from **Table 6** that ambient noise environment at 43 Highland Drive was dominated by noise generated by water rushing over the dam spillway. Insect noise and road traffic noise were features of the ambient noise environment at both monitoring locations.

# 5 Noise Impact Assessment

## 5.1 Assessment Methodology

In order to calculate the noise emission levels at the various noise sensitive receptor locations, a SoundPLAN (v7.4) environmental computer model was developed. SoundPLAN is a software package which enables compilation of a sophisticated 3D computer model comprising a digitised ground map (containing ground contours), the location and acoustic sound power levels of potentially critical noise sources on site and the location of receptors for assessment purposes.

The computer model can generate noise emission levels taking into account such factors as the source sound power levels and locations, distance attenuation, ground absorption, air absorption and shielding attenuation, as well as meteorological conditions, including wind effects. The ISO9613-2 prediction methodology was utilised within SoundPLAN.

The model took into account the effects from ground topography, ground absorption, buildings and the location of the noise sources within the Project. The works were then broken into a series of construction scenarios each defined as a set of activities involving a number of scheduled equipment items, each operating within a specific area of authority. Using the individual construction noise predictions, potential construction noise levels were assessed against the nominated noise targets presented in **Section 3.1.4.**

Noise levels were calculated at 1.8 m above local ground height, in the free field. All plant and machinery have been modelled in terms of likely areas which result in the highest received noise level at each nearby receptor locations. A description of the planned works and plant items anticipated to be used were obtained from the Lake Macdonald Project Construction Logistics Plan Report by WT Partnership.

## 5.2 Construction Noise Modelling Scenarios

The program for construction of the Project will be dependent on the selected contractor and dam safety requirements. However, the preliminary program is expected to comprise the following:

- Mobilisation and site establishment;
- Staged and temporary lowering of the dam's water level to allow for construction works;
- Construction of a temporary coffer dam to enable removal of the dam's spillway;
- Installation of secant piles across nine cells based in the underlying bedrock, excavate pile caissons, and mass concrete backfill to form a mass concrete foundation;
- Construction of a new labyrinth-type spillway structure;
- Potential extraction of clay from the clay borrow area;
- Reconstructing the existing earth embankments;
- Potential construction of a saddle dam; and
- Commissioning and site disestablishment.

This schedule indicates that the major earthworks and other construction activities with the potential for noise emissions are expected to occur over a period of approximately 18 to 24 months.

Standard hours of operation for the duration of the Project would be six-days per week, 6:30 am to 6:30 pm Monday to Friday and 6:30 am to 4:00 pm on Saturdays, with no work to be carried out on Sunday or public holidays.

There is likely to be the need for extended work hours from time to time for critical construction activities. These activities are likely to include activities such as mass concrete pours and demolition works where the embankment has not been secured and are critical for public safety. It is envisaged that notification would occur prior to these activities being undertaken.

The Project construction stages considered in the noise assessment are defined in **Table 7**. A time weighting has been applied to each piece of plant equipment which represents an assumed usage factor during the above periods. Potential activities during non-standard hours have been identified in **Table 7**.

## Table 7 Construction Phases for the Dam Safety Upgrade

| Construction Stage | Typical Plant Types | Equipment usage as percentage of time (%) during the period | | Notes |
|---|---|---|---|---|
| | | Standard operating hours | Non-standard operating hours | |
| Lake Drawdown | 1200 kVA Generator x3 85 kw submersible pumps | 100 | 100 | Worst case, assumes all items operating simultaneously |
| Sheet Piling | 50T Truck Crane | 25 | n/a | Worst case, assumes all items operating simultaneously within a 50m x 50m section |
| | 40T ADT | 25 | n/a | |
| | 20T Excavator | 50 | n/a | |
| | D10 dozer | 50 | n/a | |
| | Cat966 FEL | 50 | n/a | |
| | Crawler crane | 25 | n/a | |
| | Sheet piling rig | 50 | n/a | |
| Spillway Excavation | 60T excavator | 50 | 25 | Worst case, assumes all items operating simultaneously within a 50m x 50m section |
| | Cat988 FEL | 50 | 25 | |
| | 80m H/Head Crane 5T | 25 | 25 | |
| | Mob Snorkel | - | - | |
| | 40T ADT | 25 | 12.5 | |
| | 20T Excavator | 50 | 25 | |
| | Vibratory roller | 50 | 25 | |
| | Water cart | 50 | 25 | |
| | 100T Crawler crane | 25 | 12.5 | |
| | 30T excavator | 50 | 25 | |
| | 40T excavator | 50 | 25 | |
| | 10T excavator<br>440kVA generator for sump pump[1] | 100 | 100 | |
| Spillway Construction | 40T Excavator | 50 | 25 | Worst case, assumes all items operating simultaneously within a 50m x 50m section |
| | Snorkel pumps | 50 | 25 | |
| | Concrete batch plant | 100 | 100 | |
| | Gantry Crane | 25 | 12.5 | |
| | Pressure grout pump | 100 | 100 | |
| | Air track drill rig | 50 | 25 | |
| | Crawler crane | 25 | 12.5 | |
| | 440kVA generator for sump pump[1] | 100 | 100 | |
| | Bored piling rig | 25 | 12.5 | |

| Construction Stage | Typical Plant Types | Equipment usage as percentage of time (%) during the period | | Notes |
|---|---|---|---|---|
| | | Standard operating hours | Non-standard operating hours | |
| Clay Borrow Area | 633 scraper | 50 | n/a | Worst case, assumes all items operating simultaneously within a 70m x 70m section |
| | 50T trucks x 2 | 50 | n/a | |
| | 16G Grader | 50 | n/a | |
| | FEL Cat 988 | 50 | n/a | |
| East Embankment Construction | 55T excavator | 50 | n/a | Worst case, assumes all items operating simultaneously within a 50m x 50m section |
| | 40T ADT | 50 | n/a | |
| | FEL Cat 988 | 50 | n/a | |
| | 140G Grader | 50 | n/a | |
| | Water cart | 50 | n/a | |
| | Bentonite Plant | 100 | n/a | |
| | 100T Crawler crane | 25 | n/a | |
| | Hand tool | 25 | n/a | |
| | 50T excavator | 50 | n/a | |
| | 45T excavator | 50 | n/a | |
| | D6 dozer | 50 | n/a | |
| | 140M Grader | 50 | n/a | |
| | Skid steer | 50 | n/a | |
| | Cat815 | 50 | n/a | |
| | Sheep foot roller | 50 | n/a | |
| West Embankment Construction | 55T excavator | 50 | n/a | Worst case, assumes all items operating simultaneously within a 50m x 50m section |
| | 40T ADT | 50 | n/a | |
| | FEL Cat 988 | 50 | n/a | |
| | 140G Grader | 50 | n/a | |
| | Water cart | 50 | n/a | |
| | Bentonite Plant | 100 | n/a | |
| | 100T Crawler crane | 25 | n/a | |
| | Hand tool | 25 | n/a | |
| | 50T excavator | 50 | n/a | |
| | 45T excavator | 50 | n/a | |
| | D6 dozer | 50 | n/a | |
| | 140M Grader | 50 | n/a | |
| | Skid steer | 50 | n/a | |
| | Cat815 | 50 | n/a | |
| | Sheep foot roller | 50 | n/a | |

| Construction Stage | Typical Plant Types | Equipment usage as percentage of time (%) during the period | | Notes |
|---|---|---|---|---|
| | | Standard operating hours | Non-standard operating hours | |
| Saddle Dam | 45T excavator | 50 | n/a | Worst case, assumes all items operating simultaneously within a 50m x 50m section |
| | 40T ADT | 50 | n/a | |
| | D6 Dozer | 50 | n/a | |
| | 140M Grader | 50 | n/a | |
| | Water cart | 50 | n/a | |
| | Skid steer | 50 | n/a | |
| | Cat815 | 50 | n/a | |
| | Sheep foot roller | 50 | n/a | |
| | 140G Grader | 50 | n/a | |
| | Cat988 FEL | 50 | n/a | |
| Demobilisation | D6 dozer | 50 | n/a | Worst case, assumes all items operating simultaneously within a 50m x 50m section |
| | Cat140G | 50 | n/a | |
| | Cat20T | 50 | n/a | |
| | Roller | 50 | n/a | |
| | Water cart | 50 | n/a | |
| | Delivery truck | 25 | n/a | |
| | 100T Crawler crane | 50 | n/a | |
| | Hiab truck | 50 | n/a | |
| | 55T excavator | 50 | n/a | |
| | 40T ADT | 50 | n/a | |

Note 1. Pump understood to be submersible and therefore not contributing to airborne noise.

Octave band sound power levels for the above listed equipment can be found in **Appendix C.**

## 5.3 Construction Noise Modelling Results

The following present results from the assessment of the construction scenarios against the noise targets as shown in **Section 3.1.4.** Where the noise model has predicted an exceedance of the noise target, SLR recommends use of the in-principle mitigation methods presented in **Section 7**.

An assessment of predicted construction noise emission levels has been carried out for all construction scenarios for a representative sample of noise sensitive receptors. The full list of assessment results are contained in **Appendix D**. Results are presented for:

- "standard hours", that is, core construction work conducted during the time period 6.30 am to 6.30 pm, and
- "non-standard hours", typically reduced intensity, as-required work outside of the standard hours.

Results from the nominated modelling scenarios are discussed below.

### 5.3.1 Lake Drawdown

Two potential locations have been considered for the siting of plant related to the lake drawdown. These locations are presented in **Figure 4**.

**Figure 4 Proposed Pumping Generator Location Options**

The lake drawdown may require pumps may to operate for 24 hours per day. It has been assumed the lake drawdown will occur 24 hours per day. The night time Project noise construction noise targets are applicable.

- At Location A, noise levels of up to $L_{eq}$ 62dBA are predicted at nearby noise sensitive residential receptors. With inclusion of a noise barrier this can be brought down to $L_{eq}$ 50dBA. The noise barrier is assumed to be 2 shipping containers stacked two high (approximately 5.2 m) in a horseshoe around the generators, with the open side facing the lake.
- At Location B, noise levels of up to $L_{eq}$ 50dBA are predicted at nearby noise sensitive residential receptors. With inclusion of a noise barrier this can be brought down to a predicted $L_{eq}$ 36dBA, which is a marginally 1dB over the nominated 35dBA night time target. A 1dB difference is unlikely to be discernible and is also likely to be within the tolerance of the model and therefore effective compliance with the targets may in effect be achieved. The noise barrier at Location B is assumed to be 2 shipping containers stacked two high (approximately 5.2 m) in a complete ring (all sides enclosed) around the generators.

Noise emissions from both location options are expected to exceed the nominated 35dBA night time target. The following recommendations are made:

- Conduct pumping operations from Location B.
- Install a minimum 5.2 m high noise barrier in a ring surrounding the generators
- If a barrier is not possible then install a high performance acoustic enclosure on the generators.
- Alternatively investigate other means of powering the pumps such as connection to the electrical grid.

### 5.3.2 Sheet Piling

The assessment of potential noise emission levels associated with construction activities for sheet piling during has identified the following:

- For standard daytime construction activity construction noise levels up to $L_{eq,1h}$ 60 dBA have been predicted at nearby noise sensitive residential receptors. These events could be expected to be audible over the recorded baseline ambient levels of $L_{eq}$ 42 to 51 dBA. Whilst no mandatory numeric criteria is required for construction noise between (6.30am and 6.30pm), given the prediction exceeds the 50 dBA target nominated in **Table 3**, SLR recommend that noise management principles, as nominated in **Section 7**, be applied.
- Sheet piling is not expected to occur outside of standard hours.

### 5.3.3 Spillway Excavation

The assessment of potential noise emission levels associated with construction activities for the spillway excavation has identified the following.

- For standard daytime construction hours, noise levels up to $L_{eq,1h}$ 60 dBA have been predicted at nearby noise sensitive residential receptors. These events could be expected to be clearly audible over the ambient levels of $L_{eq}$ 42 to 51 dBA measured during the baseline noise survey. Again, whilst no mandatory numeric criteria is required for construction noise between standard working hours 6.30am and 6.30pm, given the prediction exceeds the 50 dBA target nominated in **Table 3**, SLR recommend that noise management principles, as nominated in **Section 7**, be applied.

- For the reduced activity non-standard construction hours scenario, noise levels up to 57 dBA have been predicted at nearby noise sensitive residential receptors. This is in exceedance of the nominated 50 dBA evening external noise target. In addition, short term Lmax events of up to 68 dBA have been predicted which exceed the 52dBA sleep disturbance target. SLR therefore recommend that advance notice of evening construction work is provided and management procedures are implemented (as listed in **Section 7**) and that activities at night time avoided where possible.

### 5.3.4 Spillway Construction

The assessment of potential noise emission levels associated with construction activities for the spillway construction has identified the following.

- For standard daytime construction hours, construction noise levels up to $L_{eq}$ 57 dBA have been predicted at nearby noise sensitive residential receptors. These events could be expected to be clearly audible over the ambient levels of $L_{eq}$ 42 to 51 dBA measured during the baseline noise survey. Given the prediction exceeds the 50 dBA target nominated in **Table 3,** SLR recommend that noise management principles, as nominated in **Section 7**, be applied.
- For the reduced activity non-standard construction hours scenario, noise levels up to 56 dBA have been predicted at nearby noise sensitive residential receptors. This is in exceedance of the nominated 50 dBA evening target and 35dBA night time noise target. In addition, short term Lmax events of up to 62 dBA have been predicted which are in exceedance of the 52 dBA sleep disturbance target. We therefore recommend that advance notice of evening construction work is provided, management procedures are implemented (as listed in **Section 7**) and that activities at night time avoided where possible.

### 5.3.5 Clay Borrow Area

The assessment of potential noise emission levels associated with construction activities for the clay borrow area has identified the following.

- For standard daytime construction hours, construction noise levels up to $L_{eq}$ 49 dBA have been predicted at nearby noise sensitive residential receptors. These events could be expected to be comparable to ambient levels of $L_{eq}$ 42 to 51 dBA measured during the baseline noise survey. The prediction complies with the 50 dBA target nominated in **Table 3.**
- Construction activity during evening or night time periods is not expected to occur.

### 5.3.6 East Embankment Construction

The assessment of potential noise emission levels associated with construction activities for the East Embankment Construction has identified the following.

- For standard daytime construction hours, construction noise levels up to $L_{eq}$ 60 dBA have been predicted at nearby noise sensitive residential receptors. These events could be expected to be clearly audible over the ambient levels of $L_{eq}$ 42 to 51 dBA measured during the baseline noise survey. Given the prediction exceeds the 50 dBA target nominated in **Table 3,** SLR recommend that noise management principles are applied as nominated in **Section 7**.
- Construction activity during evening or night time periods is not expected to occur.

### 5.3.7 West Embankment Construction

The assessment of potential noise emission levels associated with construction activities for the West Embankment Construction has identified the following.

- For standard daytime construction hours, construction noise levels up to $L_{eq}$ 64 dBA have been predicted at nearby noise sensitive residential receptors. These events could be expected to be clearly audible over the ambient levels of $L_{eq}$ 42 to 51 dBA measured during the baseline noise survey. Again, given the prediction exceeds the 50 dBA target nominated in **Table 3,** SLR recommend that noise management principles are applied as nominated in **Section 7**.
- Construction activity during evening or night time periods is not expected to occur.

### 5.3.8 Saddle Dam

The assessment of potential noise emission levels associated with construction activities for the Saddle Dam has identified the following.

- For standard daytime construction hours, construction noise levels up to $L_{eq}$ 45 dBA have been predicted at nearby noise sensitive residential receptors. These events could be expected to be comparable to ambient levels of $L_{eq}$ 42 to 51 dBA measured during the baseline noise survey. The prediction complies with the 50 dBA target nominated in **Table 3.**
- Construction activity during evening or night time periods is not expected to occur.

### 5.3.9 Demobilisation

The assessment of potential noise emission levels associated with construction activities for Demobilisation has identified the following.

- For standard daytime construction hours, construction noise levels up to $L_{eq}$ 62 dBA have been predicted at nearby noise sensitive residential receptors. These events could be expected to be clearly audible over the ambient levels of $L_{eq}$ 42 to 51 dBA measured during the baseline noise survey. Again, given the prediction exceeds the 50 dBA target nominated in **Table 3,** SLR recommend that noise management principles are applied as nominated in **Section 7**.
- Construction activity during evening or night time periods is not expected to occur.

### 5.3.10 Construction traffic

On-site vehicle noise has been included in the modelled scenarios and assessed accordingly.

For off-site vehicle movements associated with the Project, staff movements (mostly light vehicles) and haulage of material to/from the site (heavy vehicle movements) would add to the traffic on the existing road network. These movements are assumed to occur during daytime working hours only, except where over-size regulations require transit at other times and for delivery of plant. SLR understands that the majority of heavy vehicles required for the Project (ie for deliveries and removal/delivery of spoil) would utilise Lake Macdonald Drive.

The Project information shows that there will be a maximum peak of 110 people at the site during the construction period. For the purposes of a worst-case assessment, it is assumed that all 110 staff will be driving into the site in the peak hour and 25% of the vehicles will be heavy vehicles.

It is also assumed that during the peak construction months an additional 10 heavy vehicles (eg concrete trucks) will be generated during the peak hour. This equates to approximately 120 vehicle movements per peak period during the peak construction period. The traffic generated to and from the site has been distributed based on the existing traffic survey data.

Peak traffic counts for AM and PM periods for the existing year 2018 (pre construction) have been obtained from the Project Traffic Report. The change in traffic volumes (inclusive of both light vehicle movements and heavy vehicle movements) and the resultant change in noise level are presented in **Table 8.**

**Table 8 Traffic volumes changes and noise emissions**

| Lake Macdonald Drive | Year 2018 (without construction) | Year 2019 (with construction) | % increase | Resultant change in noise emission, dBA |
|---|---|---|---|---|
| AM Peak | 148 | 268 | 81 | 2.6 |
| PM Peak | 151 | 271 | 80 | 2.5 |

Based on existing traffic volumes on these roads, the introduction of construction or operational traffic to and from the work site is not expected to result in an increase to existing road traffic noise of no more than 2.6 dBA. This falls below the 3dBA threshold normally adopted for assessment of construction traffic.

## 5.4 Operational Noise Impacts

The operational noise emission characteristics from the facility as a result of the upgrade are expected not to differ from existing noise levels. On this basis operational noise emissions are not required to be assessed. This assessment therefore focuses on the change in acoustic environment from the temporary construction activities as listed in the previous section.

# 6 Vibration Impact Assessment

The following section addresses the potential vibration impacts associated with construction of the dam spillway. The dominant sources of vibration emissions from the construction are:

- Excavator fitted with rock hammer (for demolition);
- Sheet piling;
- Compaction of embankments with vibratory rollers; and
- Heavy vehicle movements.

Blasting or drop piling is not anticipated to occur during the demolition or construction of this Project.

## 6.1 Assessment Methodology

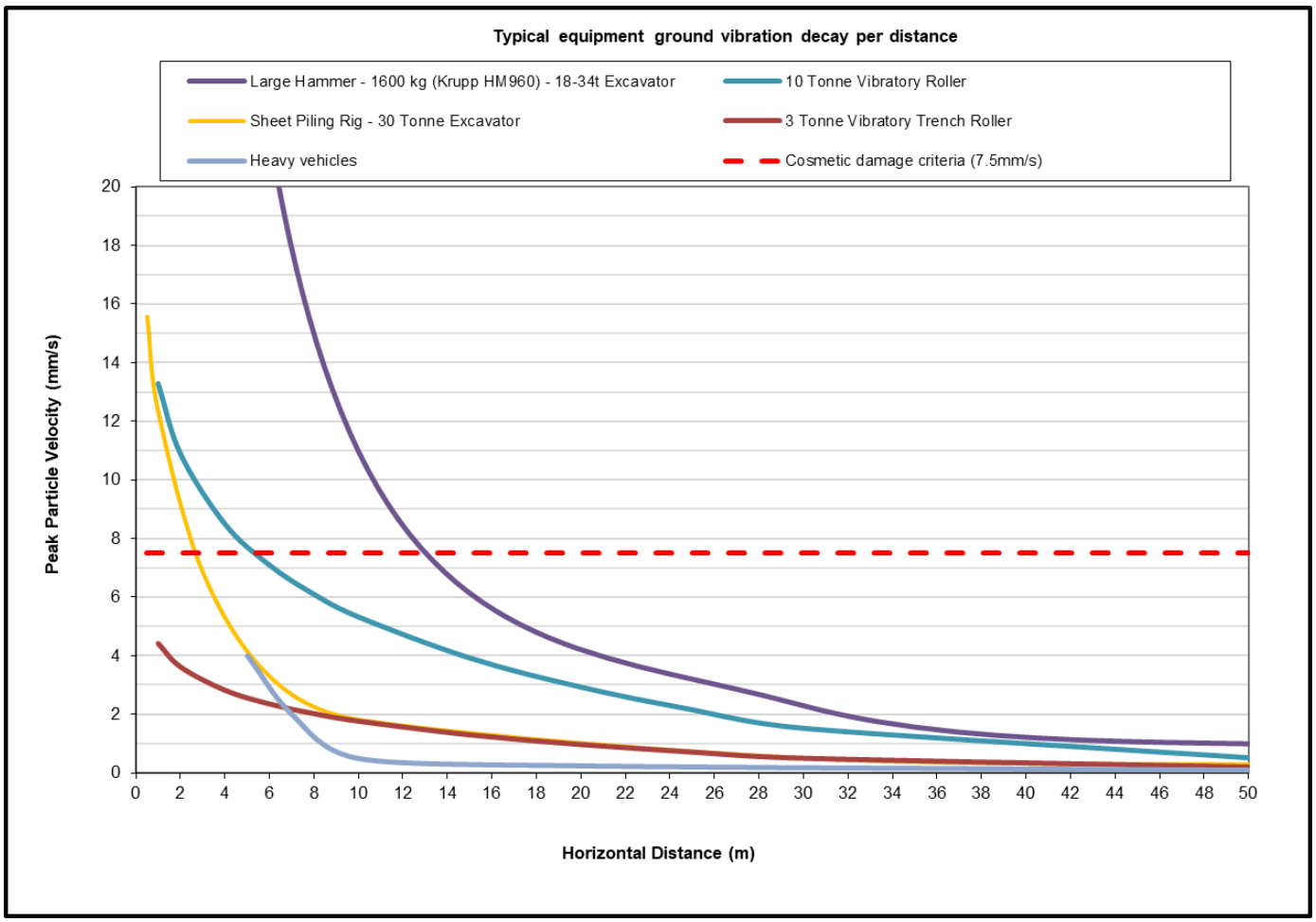
The methodology for the vibration impact assessment included spreadsheet calculations to determine the safe working offset distances for each of the planned vibration intensive activities. Potential vibration emissions to sensitive receptors are assessed by considering:

- The construction methodology listed in **Section 2**;
- Distance between identified construction zones shown in **Figure 1** and existing receptors identified in **Figure 2**; and
- Equipment vibration data sourced from SLR's Vibration Measurement Database.

## 6.2 Construction Vibration

The typical maximum levels of ground vibration from construction vibration sources (listed in **Section 6**) were sourced from the SLR Vibration Measurement Database and are shown in **Figure 5**. Vibration levels are listed in terms of Peak Particle Velocity (PPV).

**Figure 5 Typical Ground Vibration Levels for various equipment**




The above levels can be taken as indicative. The actual vibration decay rates may vary due to variances in local geological conditions. The above chart indicates that the minimum distance required to achieve the building damage criterion is approximately 15 m from construction work. The nearest vibration sensitive receptors are located approximately 50 m away from the construction area, and therefore vibration levels are expected to be below the nominated cosmetic damage thresholds. At 50 m, vibration levels from the high energy events may be in the order of 1 mm/s PPV which may be perceptible by building occupants. General vibration management and control recommendations are listed in **Section 7.2.**

## 6.3 Operational Vibration

The operational vibration emission characteristics from the facility as a result of the upgrade are expected not to differ from existing vibration levels. On this basis operational vibration emissions are not required to be assessed.

# 7 Noise and Vibration Management

## 7.1 Construction Noise Control

Noise impacts are expected to combine a variety of plant and equipment. Good practice noise mitigation measures proposed for the construction activities are summarised in **Table 9**.

**Table 9 Summary of Good Practice Construction Noise Mitigation Measures**

| Item | Description |
|---|---|
| Construction Hours | Noise generating construction works to be carried out within daytime hours. (6.30 am to 6.30 pm Monday to Friday, and 6.30 am to 4.00 pm Saturday). No noise generating construction works to be undertaken on Sundays or Public Holidays. |
| Deliveries | Deliveries should be carried out generally within daytime hours with loading and unloading carried out as far as possible away from sensitive receptors. |
| Quietest Suitable Equipment | Plant and equipment should be selected to minimise noise emission, in-so-far-as possible whilst maintaining efficiency of function. Residential grade mufflers to be fitted and all noise control equipment should be maintained in good order. Trucks are not to use engine brakes on site. |
| Truck Noise (off site) | Trucks not to queue ion public roads in residential areas, in vicinity of dwellings prior to 6.30am. All trucks regularly used for the Project (eg tip trucks) are to have mufflers and any other noise control equipment in good working order. |
| Site Layout and Site Access | Where possible, plant should be located / orientated to direct noise away from sensitive receptors. Site sheds and materials are to be used to increase acoustic shielding, where feasible. Site access roads to be located as far as practicable away from noise sensitive areas. |
| Reversing Alarms | Mobile plant and trucks operating on site for a significant portion of the Project shall have broadband squawker alarms where practicable (as opposed to tonal type), recognising the need to maintain occupational safety. |
| PA System | No externally mounted public address systems to be used. |
| Noise Monitoring | Noise monitoring to be carried out as requested. |
| Community Liaison | A programme of community liaison and complaint response should be implemented. |
| Training | Site induction training should include a noise awareness component. |

This section identifies noise mitigation measures which are recommended in accordance with environmental noise practices set out in Section 4 of AS 2436-2010.

In order to minimise noise impacts during the works, the construction contractor would be required take all reasonable and practicable measures to minimise noise effects.

### 7.1.1 Equipment or Processes

Reducing noise emissions at the source is often the most effective and efficient method. The following measures are recommended to reduce emissions from construction equipment or processes:

- All equipment used on site should be quietest reasonably available.
- All mobile plant and tools are regularly serviced and checked to ensure that they are running correctly and therefore not producing excessive noise emissions.
- All engine and enclosure panels on plant are to be kept closed.
- Additional silencing can in some instances be applied to fixed or mobile plant, eg retrofitted exhaust silencers and panel linings.
- Machines found to produce excessive noise should be removed from site or stood down until repairs or modification can be made; if repairs or modification are not possible then a suitable replacement should be found.
- As much as practical the use of hand tools such as grinders, impact wrenches, hammers and the like are to be used in specifically designated areas as far as possible from residential receptors, and preferably separated by barriers. Metal on metal contact should be avoided where possible.
- Stationary plant should be located as far from sensitive receptors as possible, and
- Processes should ideally be strategically positioned to such that direct line of site to the receptor is obstructed.

In many instances the options available for reducing noise emissions are limited, given that much of the plant and equipment required for a Project of this type is large and inherently noisy. Furthermore, the mobility of much of the equipment limits the use of enclosures which are often very effective in reducing noise emissions from fixed noise sources.

### 7.1.2 Acoustic Barriers

Where practical, the erection of acoustic barriers on site at the source, should be considered to reduce the impacts of noise at receptors. Section 4.4.5 of AS 2436-2010 identifies the options for barriers to reduce noise emissions from construction sites, such as the use of temporary building and materials stockpiles as noise barriers, installing purpose built noise barriers and maintaining any existing barriers for as long as possible.

### 7.1.3 Work Scheduling

The impacts of construction noise on the surrounding community can be reduced by scheduling noisy work for periods when people are less likely to be affected by it.

The following work scheduling recommendations should be considered where practicable:

- Scheduling noisy work such that it is undertaken during hours that would least adversely affect sensitive receptors (eg daytime for dwellings);
- Scheduling noisy work such that it would coincide with high levels of ambient noise, for example during daytime traffic periods, so that construction noise is partially masked by road traffic;
- Planning truck movements with consideration to the nearest receptors, and also minimising drive and idle time on site;
- Designating, designing and maintaining access routes to the site to minimise impacts;
- Loading and unloading should be scheduled during hours that would least affect sensitive receptors, and at locations away from sensitive receptors;
- Scheduling should avoid the coincidence of noisy plant work simultaneously close together, and should aim to minimise consecutive works in the same locality; and

### 7.1.4 Reversing Alarms

Reversing alarms have the potential to create annoyance. The use of the following alternatives would need to be considered:

- Broadband reversing alarms;
- Variable-level alarms;
- Non-audible warning systems such as flashing lights, reversing cameras or spotters; and
- Proximity alarms which detect the distance from objects and generate an audible alarm in the cabin for the driver.

Please note, the ability of the alarm system to provide a safe system of work should be considered when selecting an alternative to tonal reversing alarms.

### 7.1.5 Administrative Controls

#### *Community and Stakeholder Consultations*

The contractor would be required to undertake various consultative activities with the community and local stakeholders. The contractor would provide a publicly visible and accessible point of contact for complaint handling and community consultation. The contact person would have an adequate level of responsibility to respond to the complaint, and there would be a publicly accessible reception area outside controlled site area for administration.

#### *Administration*

All noise complaints received would be recorded as per the Contractor's Community Engagement Plan and include the following:

- Unique identification number for future reference;
- Time and date of complaint as received by proponent;
- Approximate time and date of event associated with the complaint;
- Complainant(s) location; and
- Short description of the noise/vibration (if possible), such as location, activity, duration.

***Investigation***

- Justifiable complaints, substantiated complaints or widespread complaints to be investigated to determine level of extent and review any mitigation options;
- An appropriate number of short-term attended noise measurements would be undertaken to accurately determine the cause of substantiated complaint/incidents and to determine how to rectify the situation;
- Review any unattended noise measurement data obtained relevant to the complaint or incident;
- Apply noise and/or vibration mitigation;
- Assess the effectiveness of the mitigation
- File incident report; and
- Supply a response in writing within 10 working days of the complaint.

***Training***

Inductions of all employees and subcontractors would be need to be provided as per the Project-specific Environmental Management Plan for which the contractor would provide, this plan would:

- Highlight the importance of reducing noise and vibration emissions from construction activity to as low as reasonably practicable in the wider environmental context; and
- Educate staff as to the Project environmental noise and vibration controls in place.

A record of all training is to be maintained.

***Variance to Works***

Prior to commencement of significantly varied or additional works, or changes to the hours of those works, addenda or revised noise management plans would be submitted to Authorities for comment.

### 7.1.6 Construction Noise Monitoring

The monitoring of noise is an essential part of assessing impacts and determining compliance with approval conditions and community concerns. AS 2436 recommends that on-site noise levels are monitored regularly by a suitably qualified person appointed specifically for that purpose.

If required, the location and final extent of the planned attended noise monitoring should be determined in consultation with Project staff and would be dependent on the activities taking place.

Unattended noise monitoring should be completed at a minimum of two locations throughout construction period to monitor noise levels the Project construction noise targets (**Table 3**). It is recommended that noise monitoring is undertaken at sensitive receptor to east and to the west of the Project site. Noise logging should be conducted in accordance with procedures outlined in Australian Standard Australian Standard AS1055-1997 – *Acoustics – Description and measurement of environmental noise*.

Results obtained from the measurements should be summarised in reports, and stored in accordance with the Project data management systems.

### 7.1.7 Noise Management and Noise Control

An important component of the noise management of the Project involves comprehensive community consultation. The community would be kept informed as to the nature, timing and duration of impending works, the nearest sensitive receptors likely to be affected and the monitoring program associated with the impending works.

## 7.2 Construction Vibration Control

Based upon previous experience SLR recommend that where vibration levels from construction activities are projected to exceed 1 mm/s, a dilapidation survey of all potentially affected structures be undertaken (if not already completed) prior to construction. Additional surveys may be undertaken where the building or asset is particularly sensitive or already in a state of significant disrepair.

Each dilapidation survey report must include at least the following:

- A visual inspection of all buildings and structures (more specifically all internal and external walls, ground level floors and pavements, any exposed foundations, connections to other structures above ground level and their connection at ground level);
- Photographs of all cracks and/or defects observed; and
- A record of the location of all cracks and/or defects observed, and measurements of the crack width/defect size.

For reference, recommended orders of distance from equipment are presented in **Table 10**.

**Table 10 Recommended Dilapidation Survey Distances**

| Activity | Distance from Vibration Source (m) |
|---|---|
| Impact pile driving | 100 |
| Vibratory sheet piling | 30 |
| Vibratory roller, compactor, hydraulic breakers, excavator | 20 |
| Trucks, Graders Bulldozers, (irregular surfaces) | 10 |
| Trucks and mobile equipment (sealed road surfaces) | 5 |
| All other equipment | 5 |

For this Project, receptor distances for relevant activities are expected to be greater than those listed above. Also, vibration levels at the nearest receptors are expected to be approximately 1mm/s. Therefore at the discretion of the construction contractor, dilapidation surveys need not be conducted.

If, during the construction period, vibration complaints are received then it is recommended that attended vibration monitoring should be conducted. All vibration measurements should be conducted using laboratory calibrated equipment. Performance characteristics for the measurement instrumentation should meet the requirements set out in BS 7485 Part 2.

# 8 Conclusion

The potential noise impacts associated with construction activities for the Project have been assessed against the EP Act, the EPP (Noise) and BS 7385.

Noise monitoring was undertaken at two sites adjacent to the Project from 29 May to 7 June 2018 to quantify the existing acoustic environment and to provide context to the predicted construction emissions.

Construction scenarios with the potential to generate noise impacts were and assessed using typical plant items and areas of operation defined across the entire Project area. A three dimensional noise model accounting for the ground terrain has been developed for each construction scenario, for both standard and non-standard working hours where relevant, as well as the respective default weather conditions. Given the scale of the Project area, airborne noise from construction activities were then predicted to identified noise sensitive receptors. The predicted noise levels were then compared to the Project construction noise targets.

Given the close proximity of sensitive receptors areas to the Project and the inherently intensive nature of the construction works, potential exceedances of the noise targets have been identified. In accordance with the relevant regulations and standards, all reasonable and practicable mitigation and management measures have been considered in these cases. As described in **Section 5**, certain construction activities have potential to exceed the Project construction noise targets (**Table 3**) (even with mitigation) and therefore community consultation is recommended. Ground vibration at the distances is expected to be compliant with the nominated cosmetic damage criteria, nevertheless any complaints from receptors throughout the construction period should be investigated.

# 9 References

Australian Standard AS1055-1997 – *Acoustics – Description and measurement of environmental noise*

Australian Standard AS2436-2010 – *Guide to noise and vibration control on construction, demolition and maintenance sites*

British Standard BS 7385-2:1993 *Evaluation and measurement for vibration in buildings. Part 2 Guide to damage levels from groundborne vibration*

ISO9613-2-1996 *Acoustics -- Attenuation of sound during propagation outdoors -- Part 2: General method of calculation*

*Queensland Environmental Protection Act 1994*

*Queensland Environmental Protection (Noise) Policy 2008*

Environment Protection Agency (EPA) 2004Queensland Ecoaccess Guideline - *Planning for Noise Control Guideline*

Department of Environment and Science (DES) (2018) *Application requirements for activities with noise impacts* version 3.01

WT Partnership (2018) *Lake Macdonald Project Construction Logistics Plan Report* by (WTP Ref 170863), dated 12 June 2018.

# APPENDIX A

Noise and Vibration Terminology

## 1 Sound Level or Noise Level

The terms 'sound' and 'noise' are almost interchangeable, except that in common usage 'noise' is often used to refer to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure capable of evoking the sense of hearing. The human ear responds to changes in sound pressure over a very wide range. The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (abbreviated as dB) scale reduces this ratio to a more manageable size by the use of logarithms.

The symbols SPL, L or $L_P$ are commonly used to represent Sound Pressure Level. The symbol $L_A$ represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is $2 \times 10^{-5}$ Pa.

## 2 'A' Weighted Sound Pressure Level

The overall level of a sound is usually expressed in terms of dBA, which is measured using a sound level meter with an 'A-weighting' filter. This is an electronic filter having a frequency response corresponding approximately to that of human hearing.

People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4,000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dB or 2 dB in the level of a sound is difficult for most people to detect, whilst a 3 dB to 5 dB change corresponds to a small but noticeable change in loudness. A 10 dB change corresponds to an approximate doubling or halving in loudness. The table below lists examples of typical noise levels.

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

Other weightings (eg B, C and D) are less commonly used than A-weighting. Sound Levels measured without any weighting are referred to as 'linear', and the units are expressed as dB(lin) or dB.

## 3 Sound Power Level

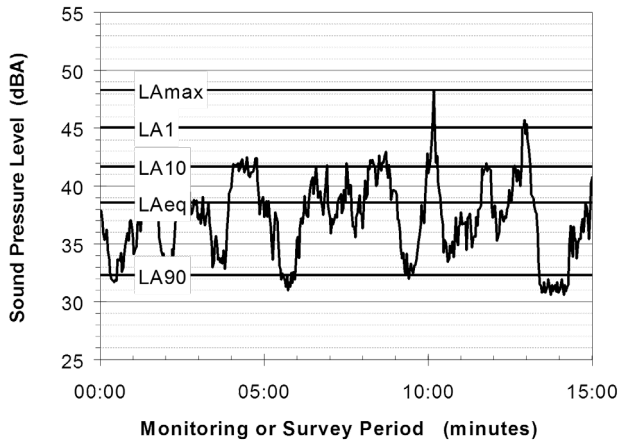
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or Lw, or by the reference unit $10^{-12}$ W.

The relationship between Sound Power and Sound Pressure may be likened to an electric radiator, which is characterised by a power rating, but has an effect on the surrounding environment that can be measured in terms of a different parameter, temperature.

## 4 Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels $L_{AN}$, where $L_{AN}$ is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the $L_{A1}$ is the noise level exceeded for 1% of the time, $L_{A10}$ the noise exceeded for 10% of the time, and so on.

The following figure presents a hypothetical 15 minute noise survey, illustrating various common statistical indices of interest.




Of particular relevance, are:

$L_{A1}$ The noise level exceeded for 1% of the 15 minute interval.

$L_{A10}$ The noise level exceeded for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

$L_{A90}$ The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

$L_{Aeq}$ The A-weighted equivalent noise level (basically, the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

When dealing with numerous days of statistical noise data, it is sometimes necessary to define the typical noise levels at a given monitoring location for a particular time of day. A standardised method is available for determining these representative levels.

This method produces a level representing the 'repeatable minimum' $L_{A90}$ noise level over the daytime and night-time measurement periods, as required by the EPA. In addition, the method produces mean or 'average' levels representative of the other descriptors ($L_{Aeq}$, $L_{A10}$, etc).

## 5 Tonality

Tonal noise contains one or more prominent tones (ie distinct frequency components), and is normally regarded as more offensive than 'broad band' noise.

## 6 Impulsiveness

An impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.

## 7 Frequency Analysis

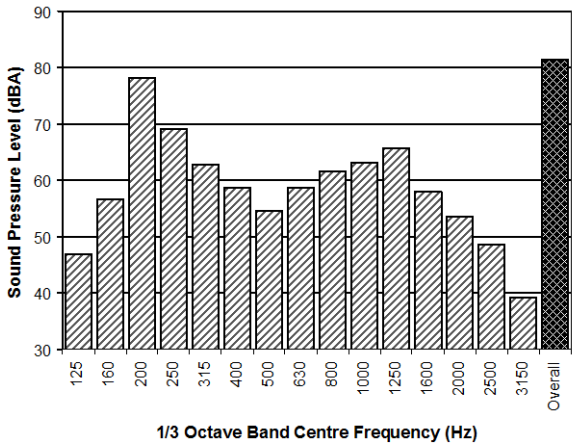
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

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

Frequency analysis can be in:

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

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




## 8 Vibration

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

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

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

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level V, expressed in mm/s can be converted to decibels by the formula 20 log ($V/V_o$), where $V_o$ is the reference level ($10^{-9}$ m/s). Care is required in this regard, as other reference levels may be used by some organisations.

## 9 Human Perception of Vibration

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

## 10 Over-Pressure

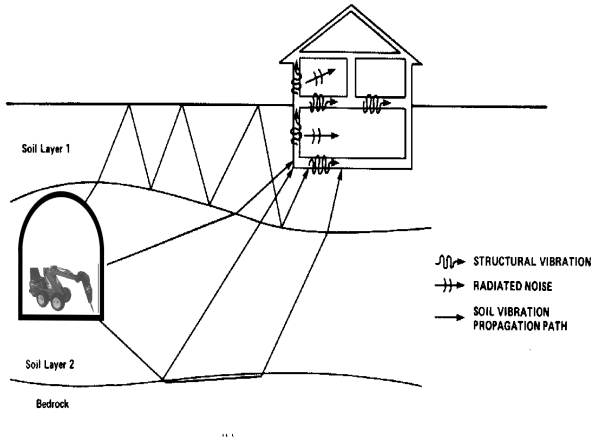
The term 'over-pressure' is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

## 11 Ground-borne Noise, Structure-borne Noise and Regenerated Noise

Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed 'structure-borne noise', 'ground-borne noise' or 'regenerated noise'. This noise originates as vibration and propagates between the source and receptor through the ground and/or building structural elements, rather than through the air.

Typical sources of ground-borne or structure-borne noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

The following figure presents an example of the various paths by which vibration and ground-borne noise may be transmitted between a source and receptor for construction activities occurring within a tunnel.



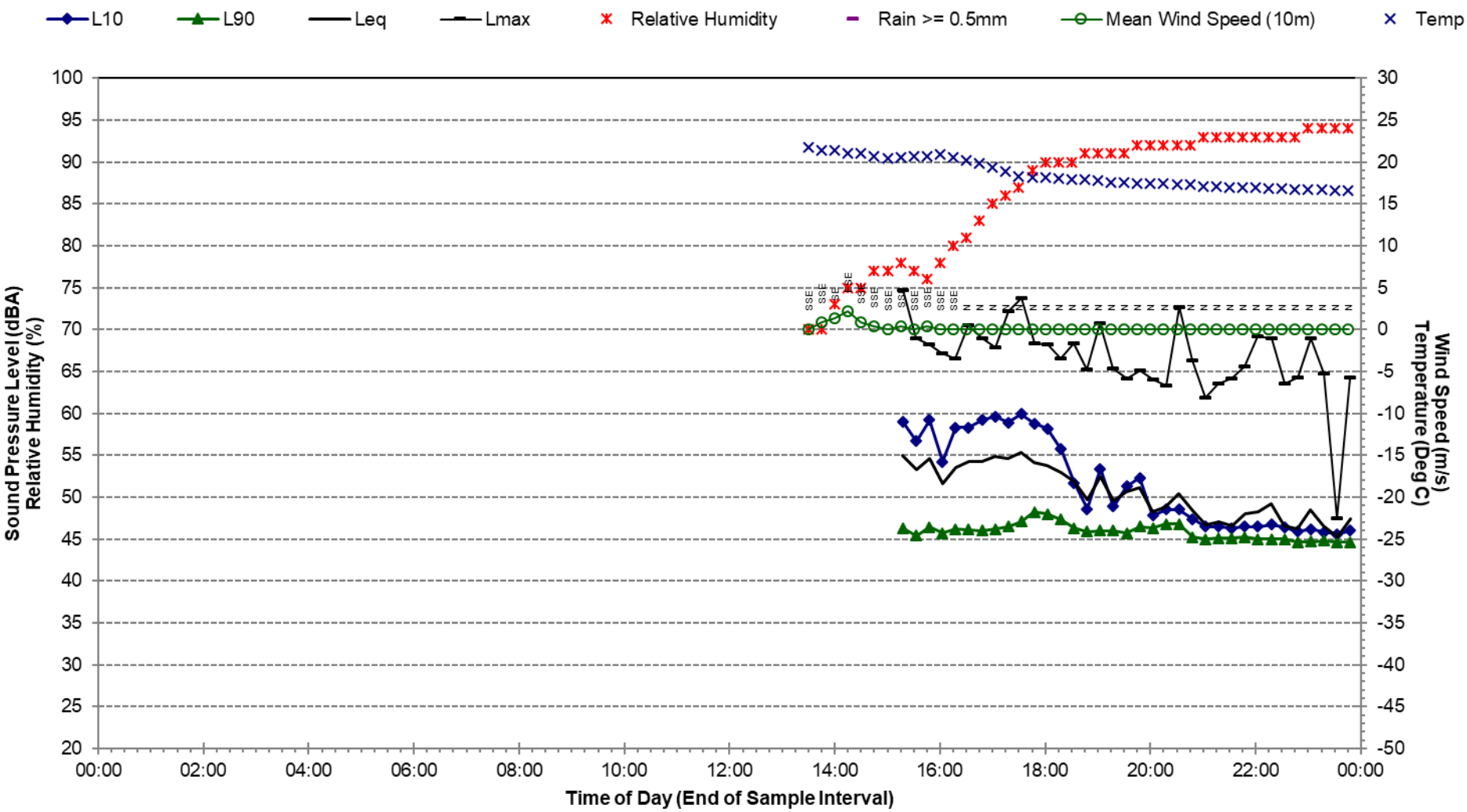

The term 'regenerated noise' is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect of the discharge grill in the airstream. This secondary noise is referred to as regenerated noise

# APPENDIX B

Noise Logging of Existing Environment

# Statistical Ambient Noise Levels

## 43 Highland Drive - Tuesday, 29 May 2018

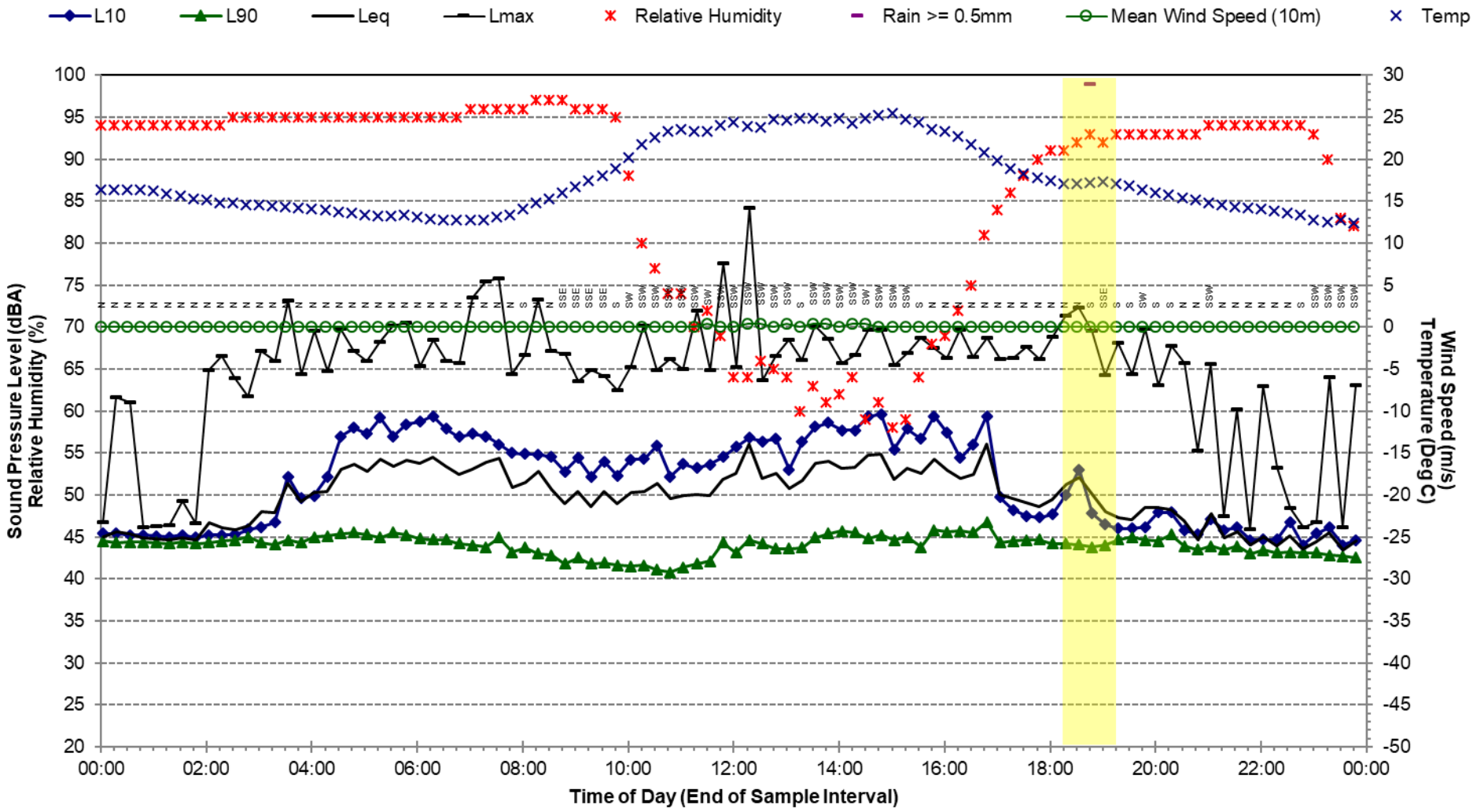





SLR

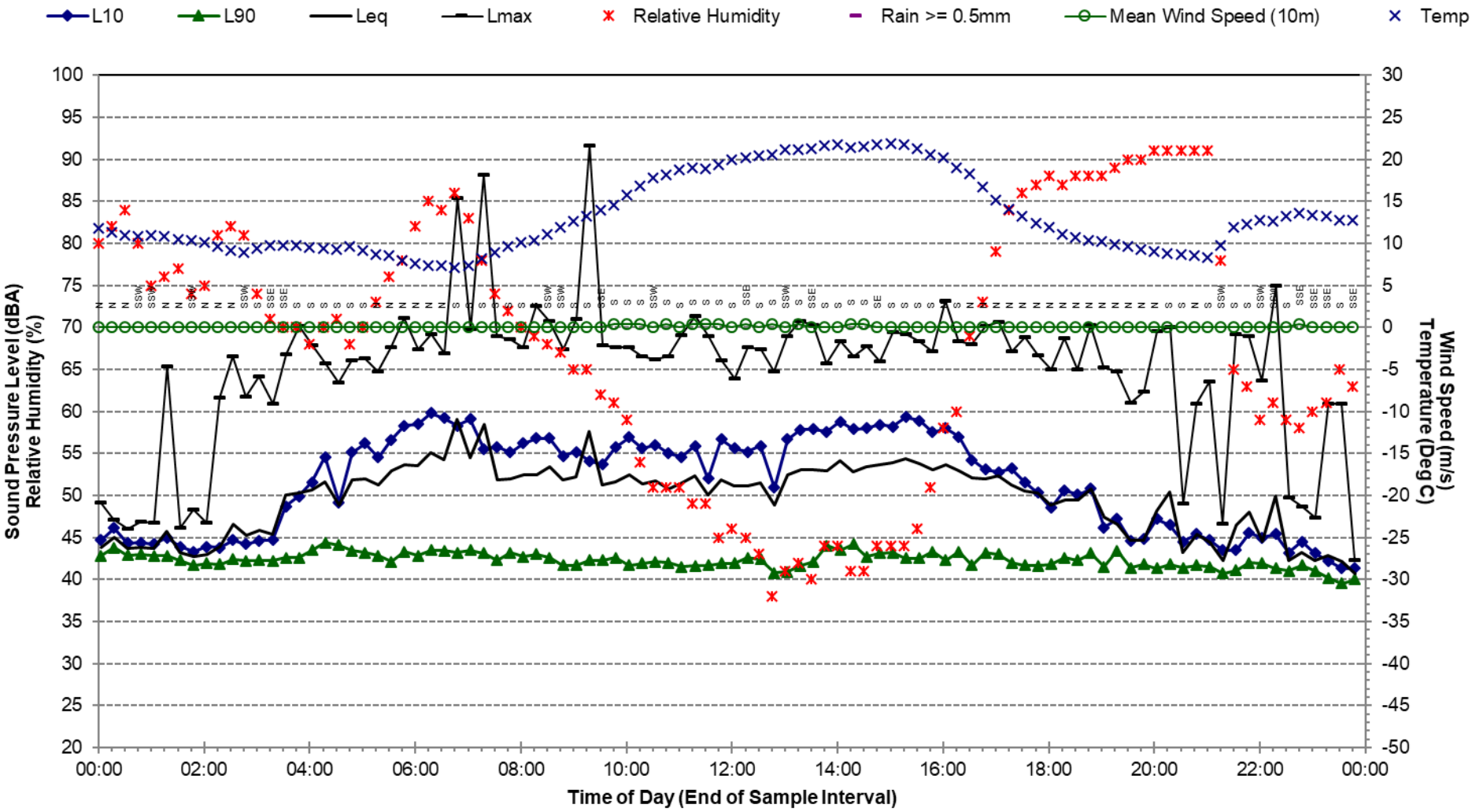
# Statistical Ambient Noise Levels

## 43 Highland Drive - Wednesday, 30 May 2018



# Statistical Ambient Noise Levels

## 43 Highland Drive - Thursday, 31 May 2018

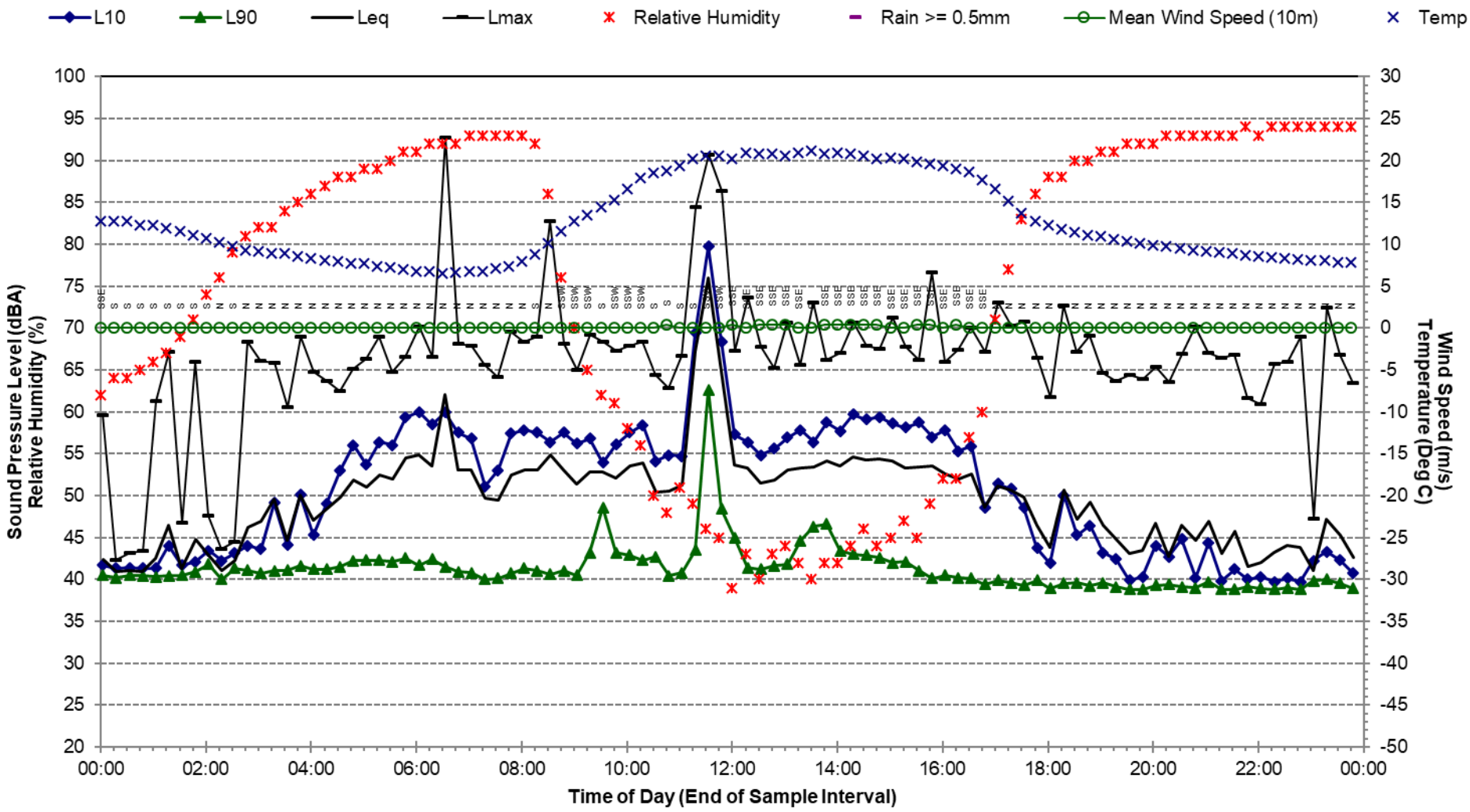





SLR

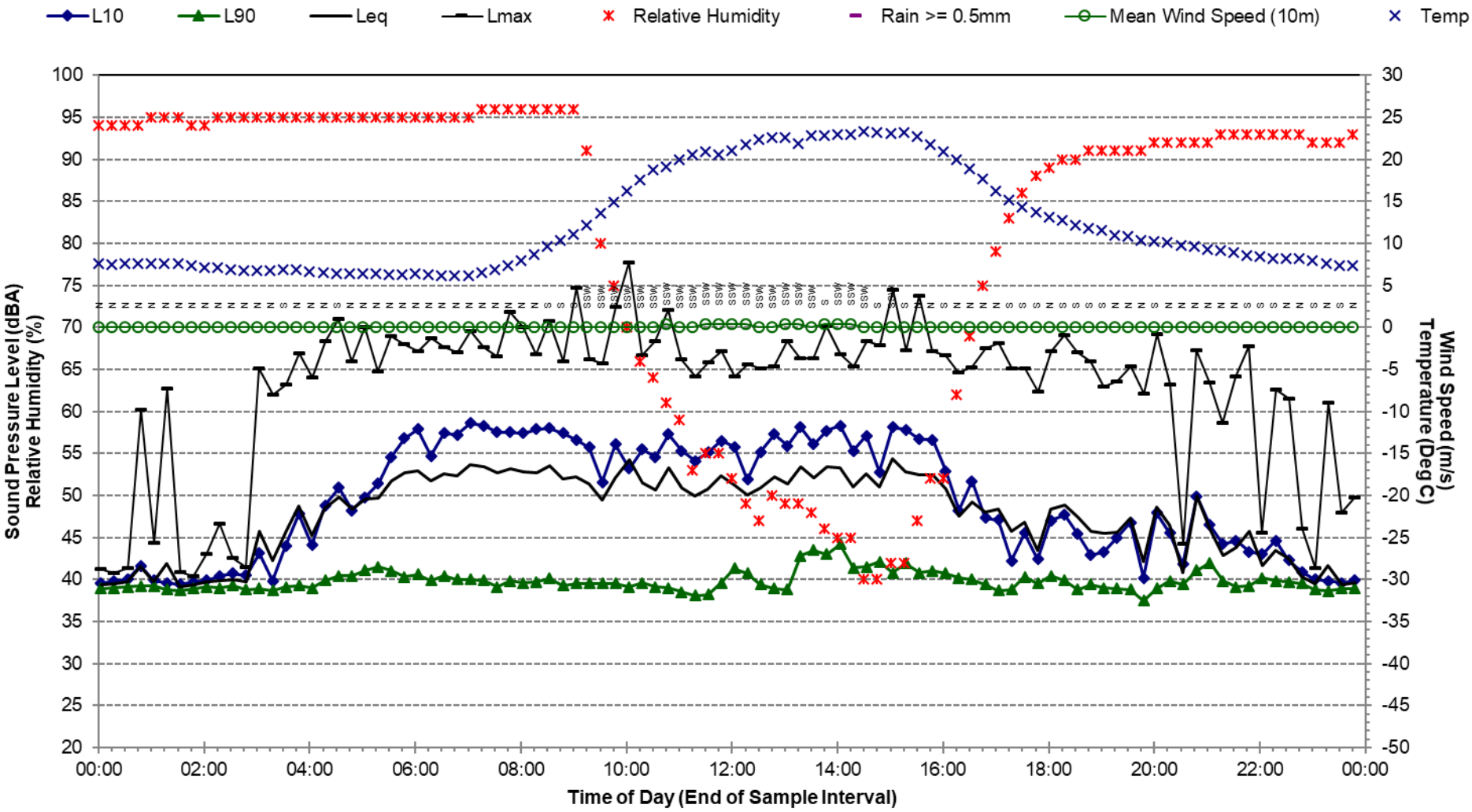
# Statistical Ambient Noise Levels

## 43 Highland Drive - Friday, 1 June 2018



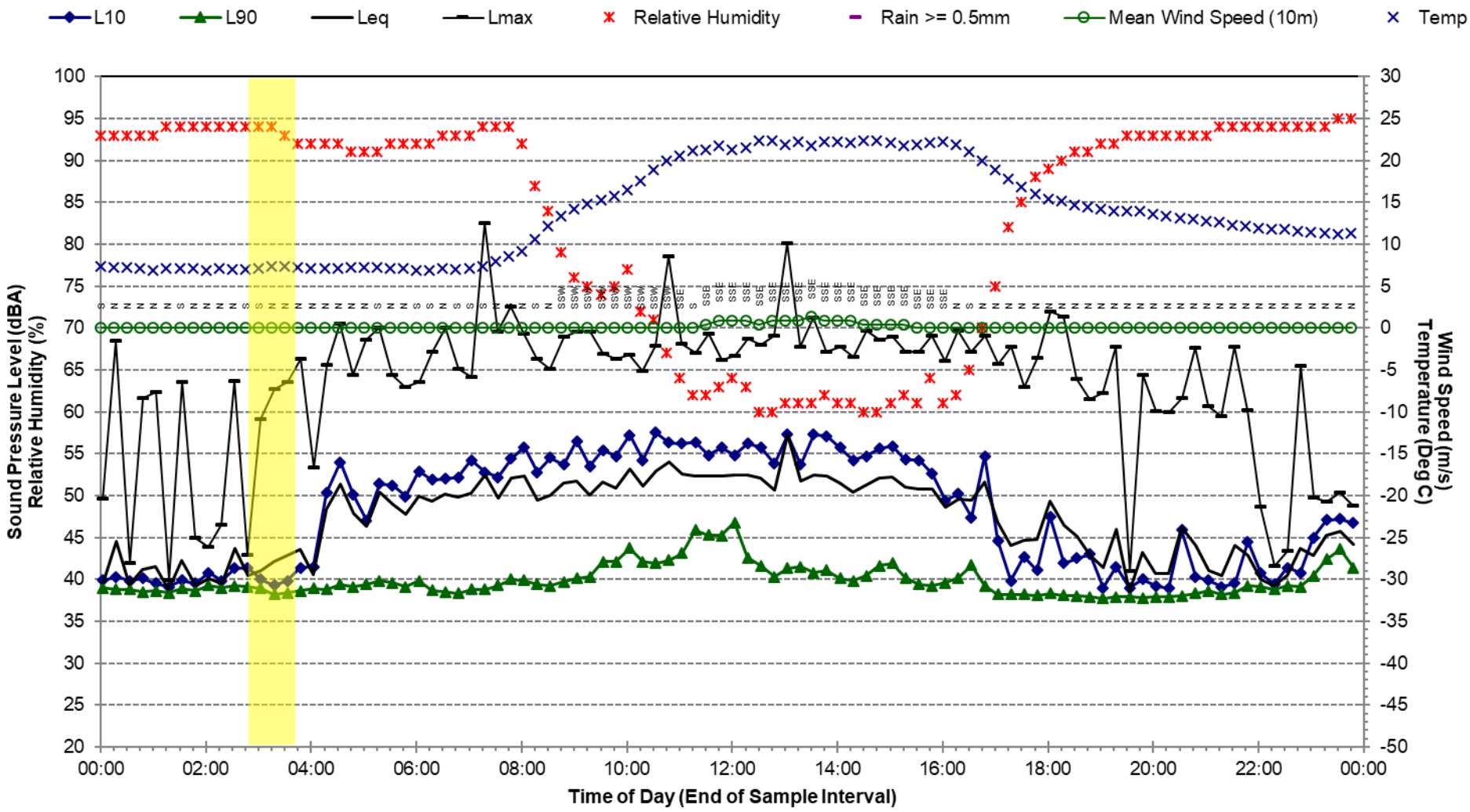
# Statistical Ambient Noise Levels

## 43 Highland Drive - Saturday, 2 June 2018



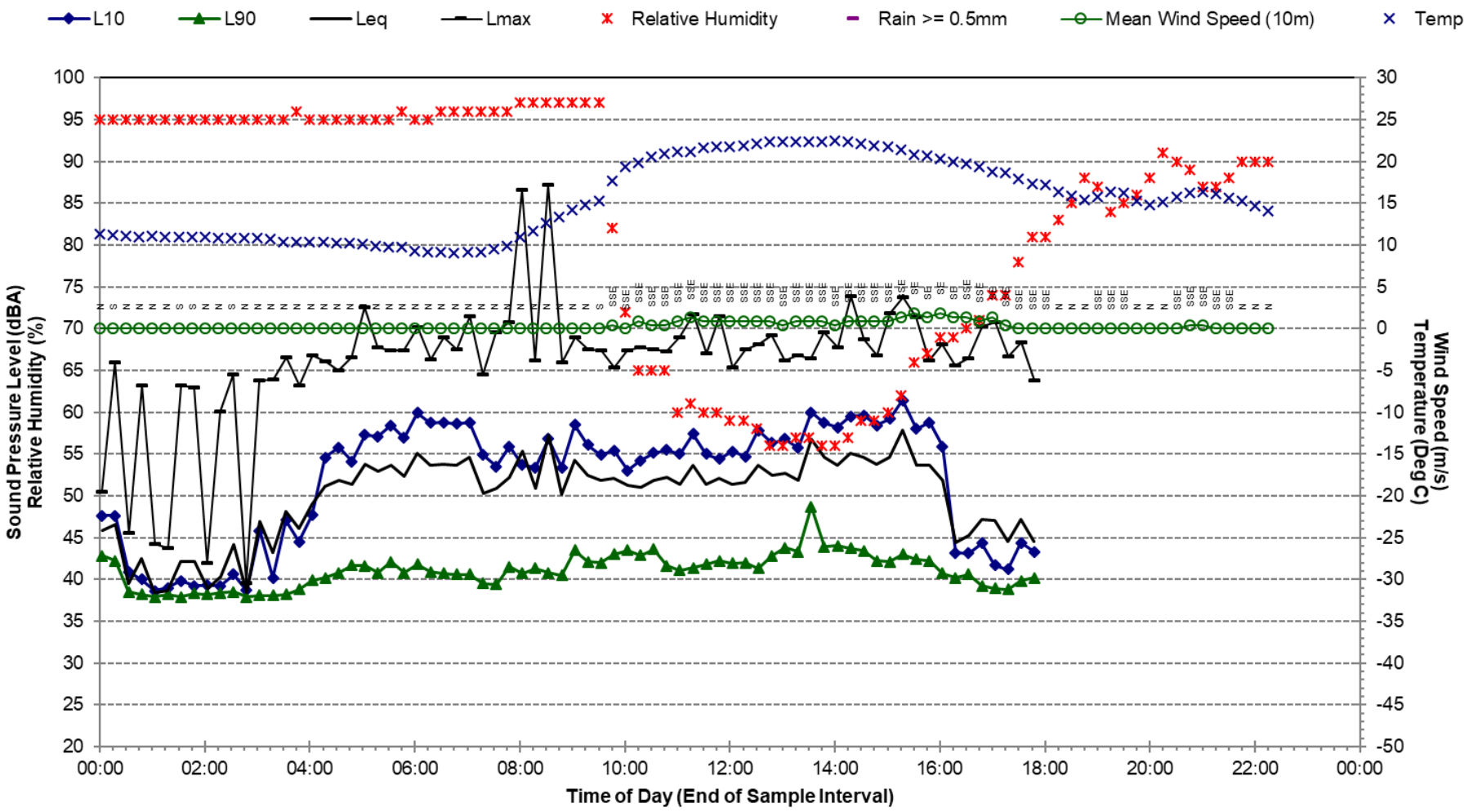
# Statistical Ambient Noise Levels

## 43 Highland Drive - Sunday, 3 June 2018



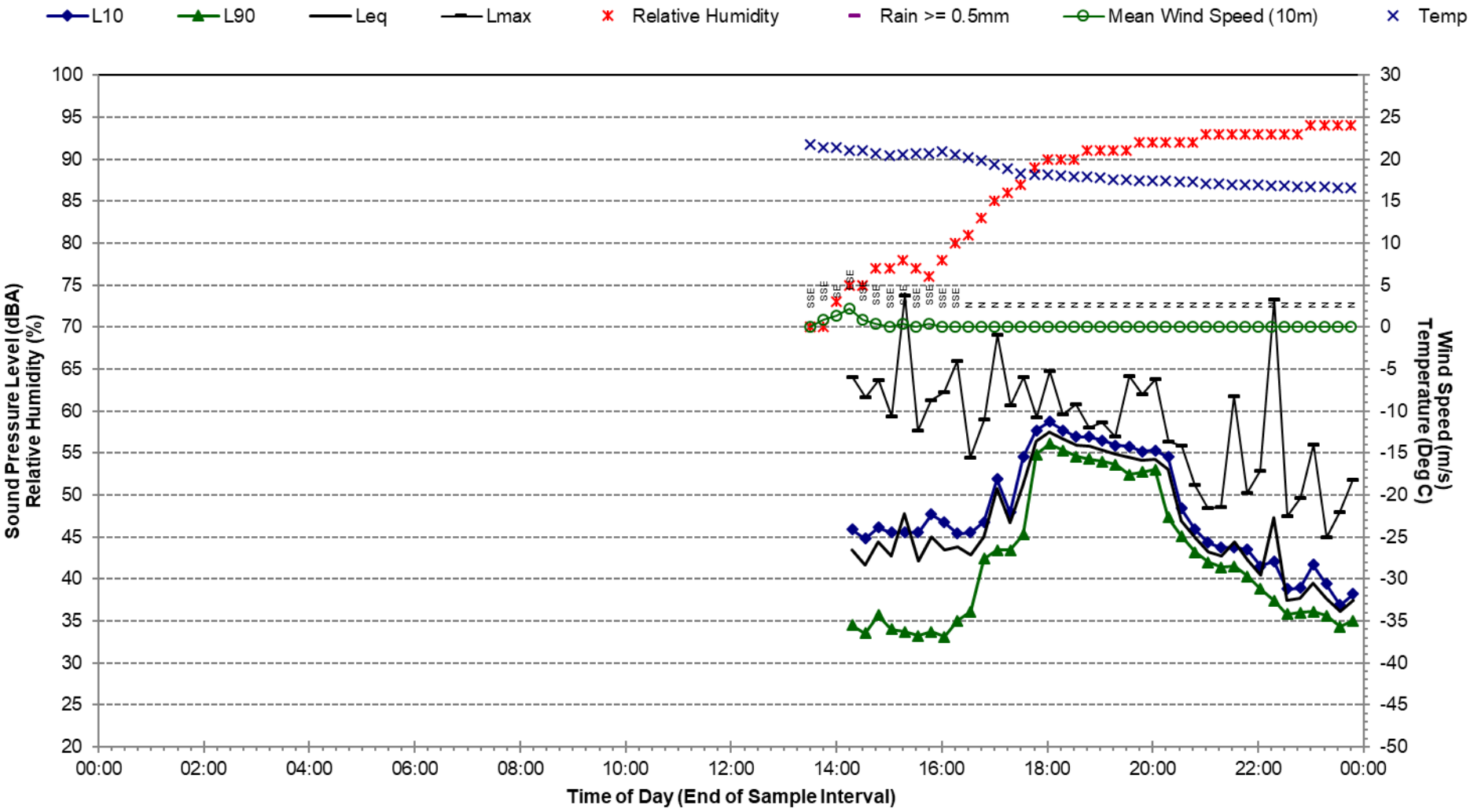
# Statistical Ambient Noise Levels

## 43 Highland Drive - Monday, 4 June 2018



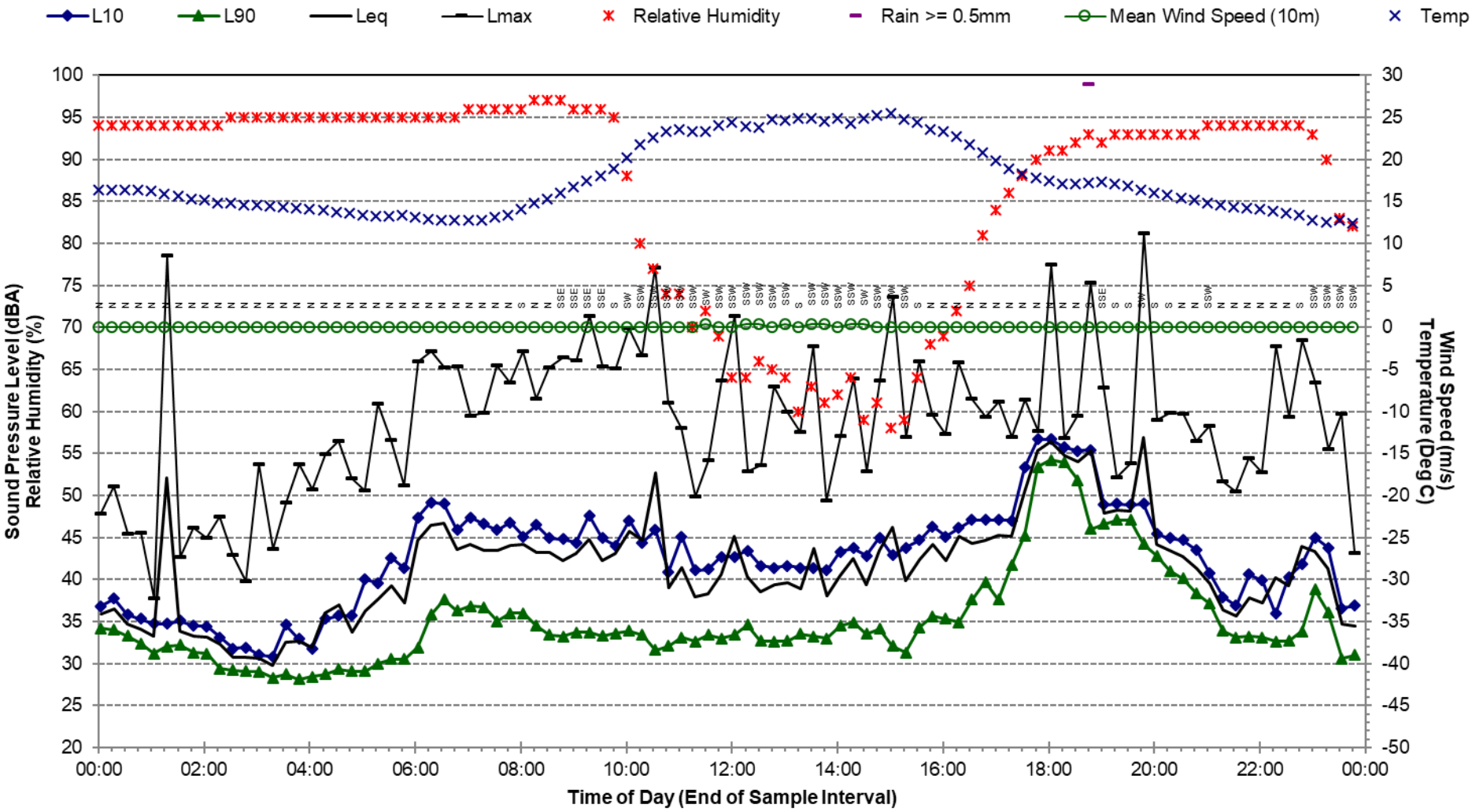
# Statistical Ambient Noise Levels

## 407 Lake MacDonald Drive - Tuesday, 29 May 2018



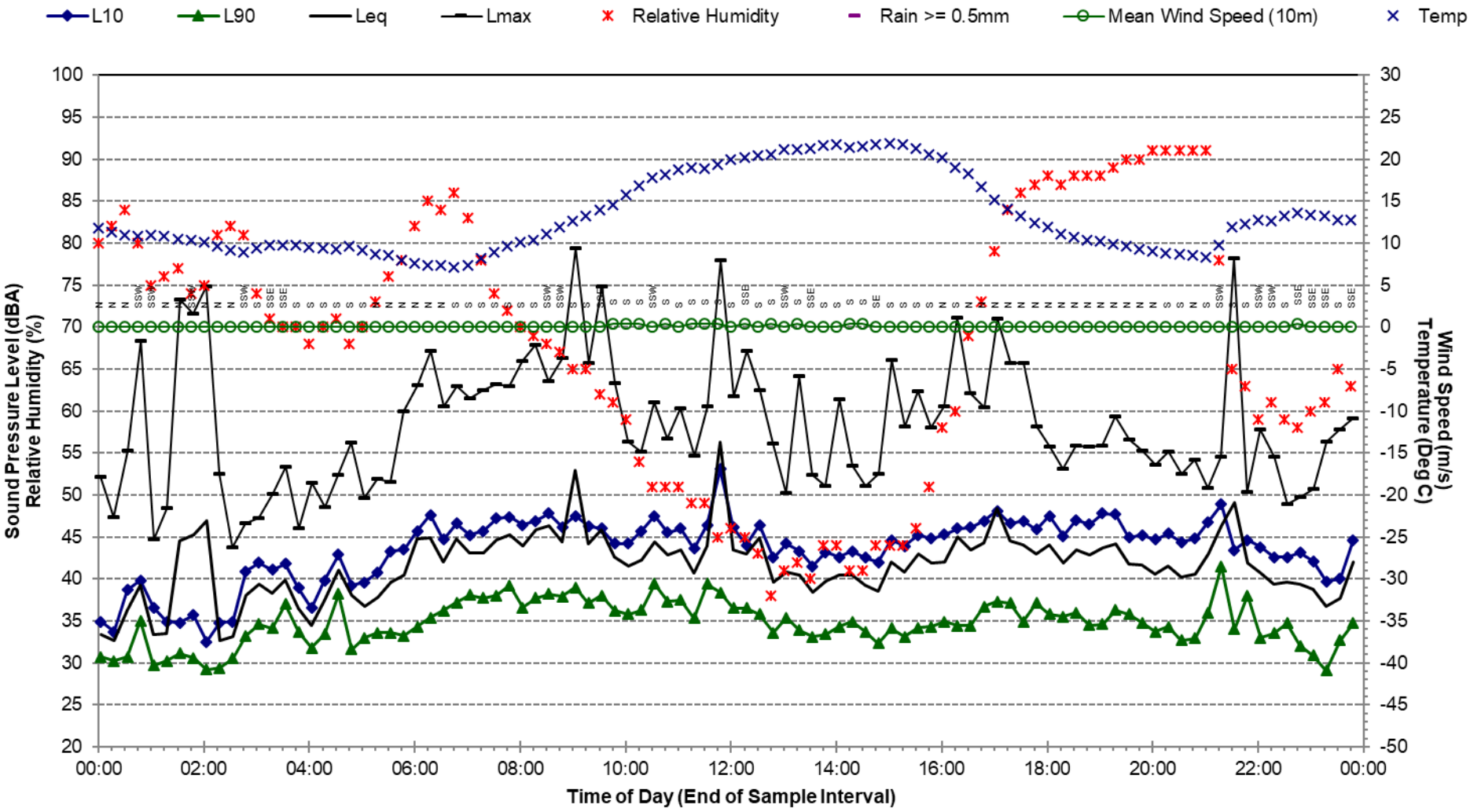
# Statistical Ambient Noise Levels

## 407 Lake MacDonald Drive - Wednesday, 30 May 2018



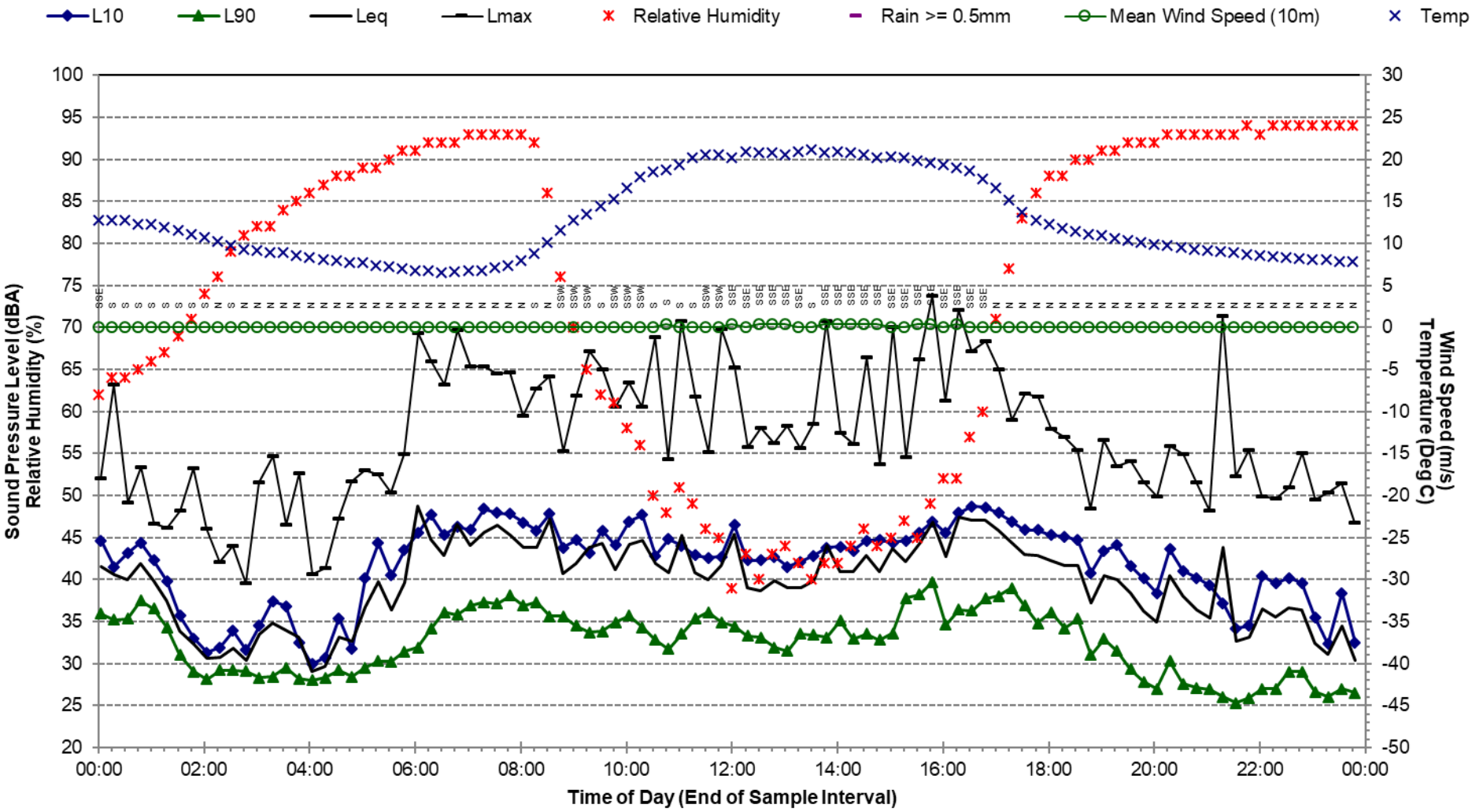
# Statistical Ambient Noise Levels

## 407 Lake MacDonald Drive - Thursday, 31 May 2018



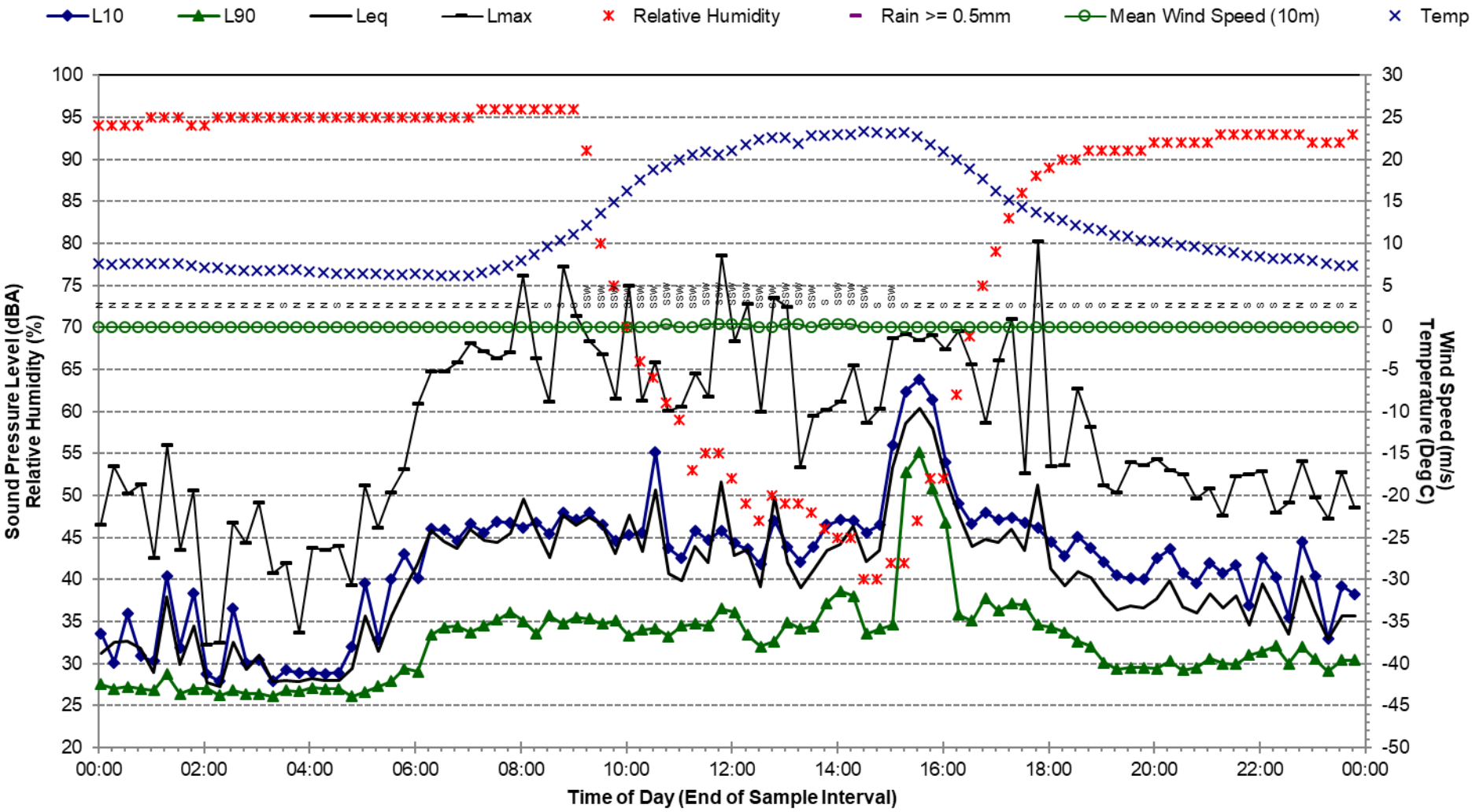
# Statistical Ambient Noise Levels

## 407 Lake MacDonald Drive - Friday, 1 June 2018



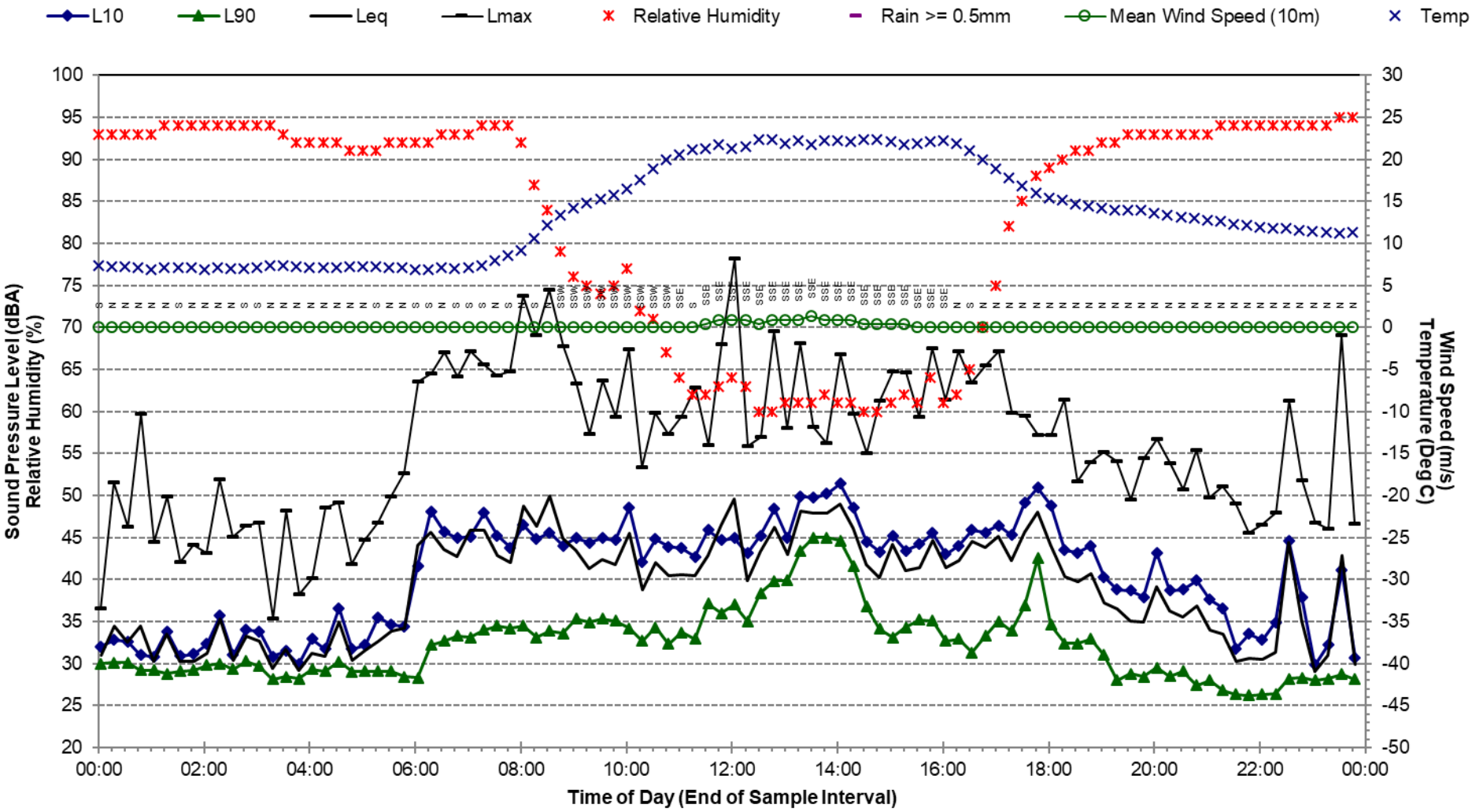
# Statistical Ambient Noise Levels

## 407 Lake MacDonald Drive - Saturday, 2 June 2018



# Statistical Ambient Noise Levels

## 407 Lake MacDonald Drive - Sunday, 3 June 2018

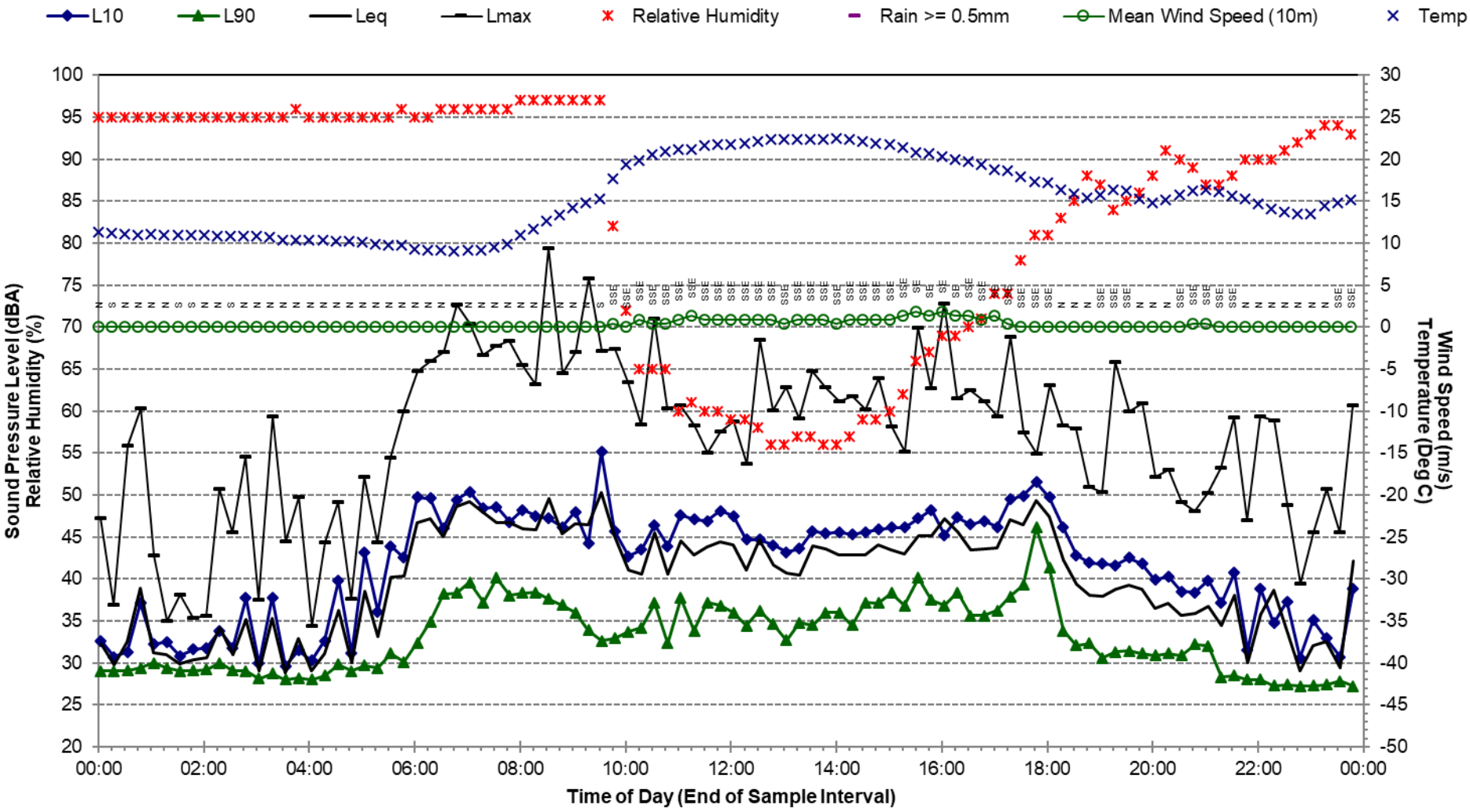





SLR

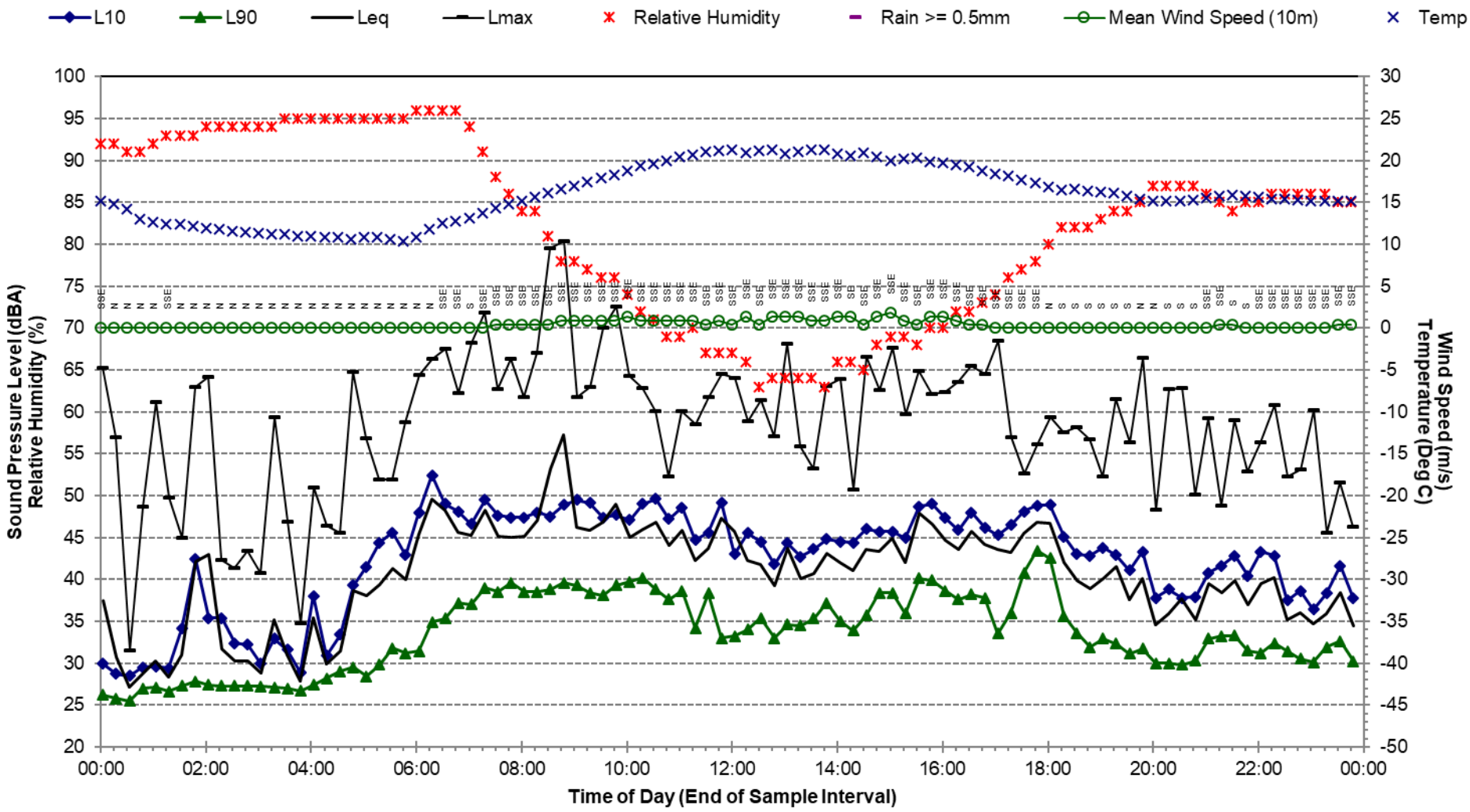
# Statistical Ambient Noise Levels

## 407 Lake MacDonald Drive - Monday, 4 June 2018



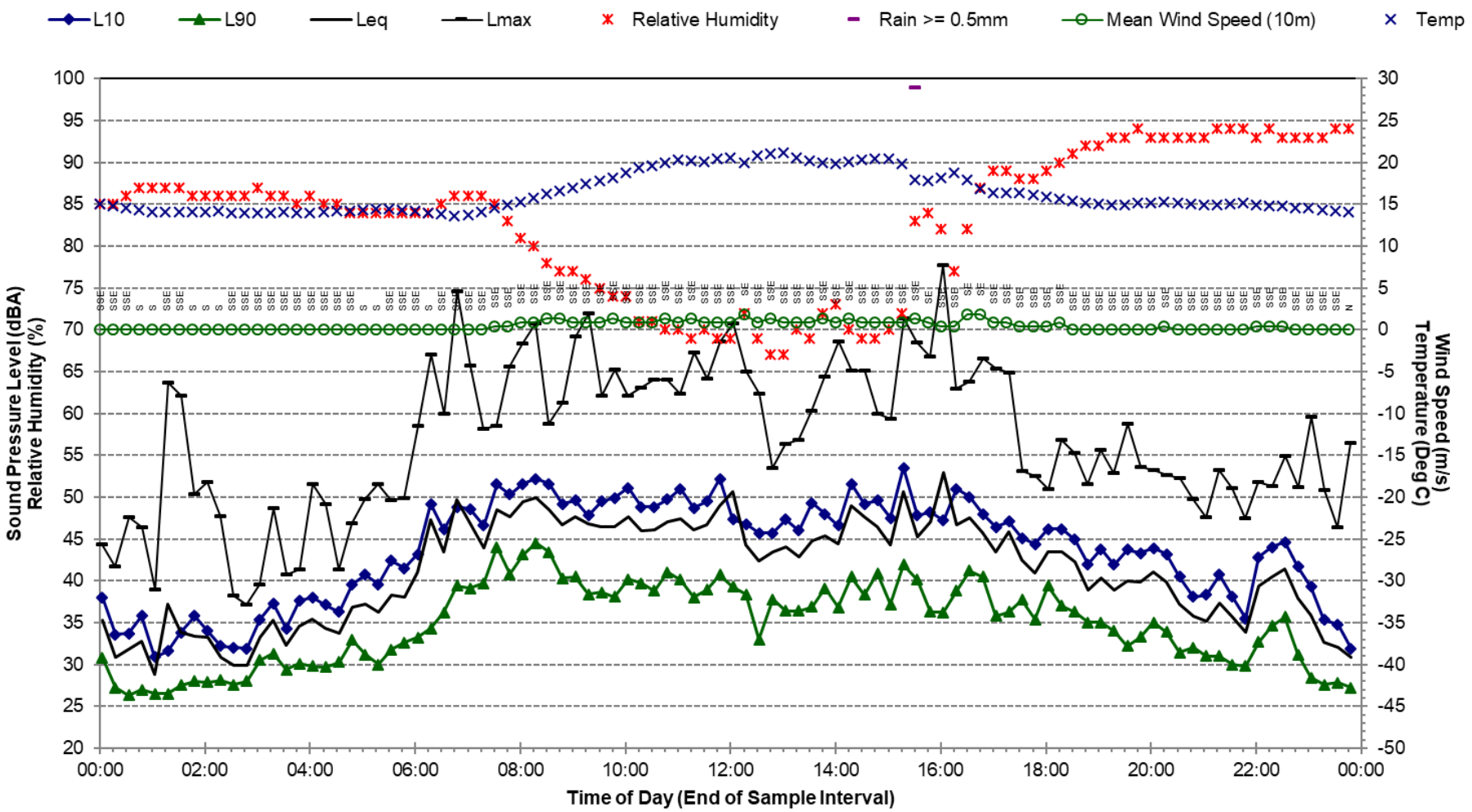
# Statistical Ambient Noise Levels

## 407 Lake MacDonald Drive - Tuesday, 5 June 2018



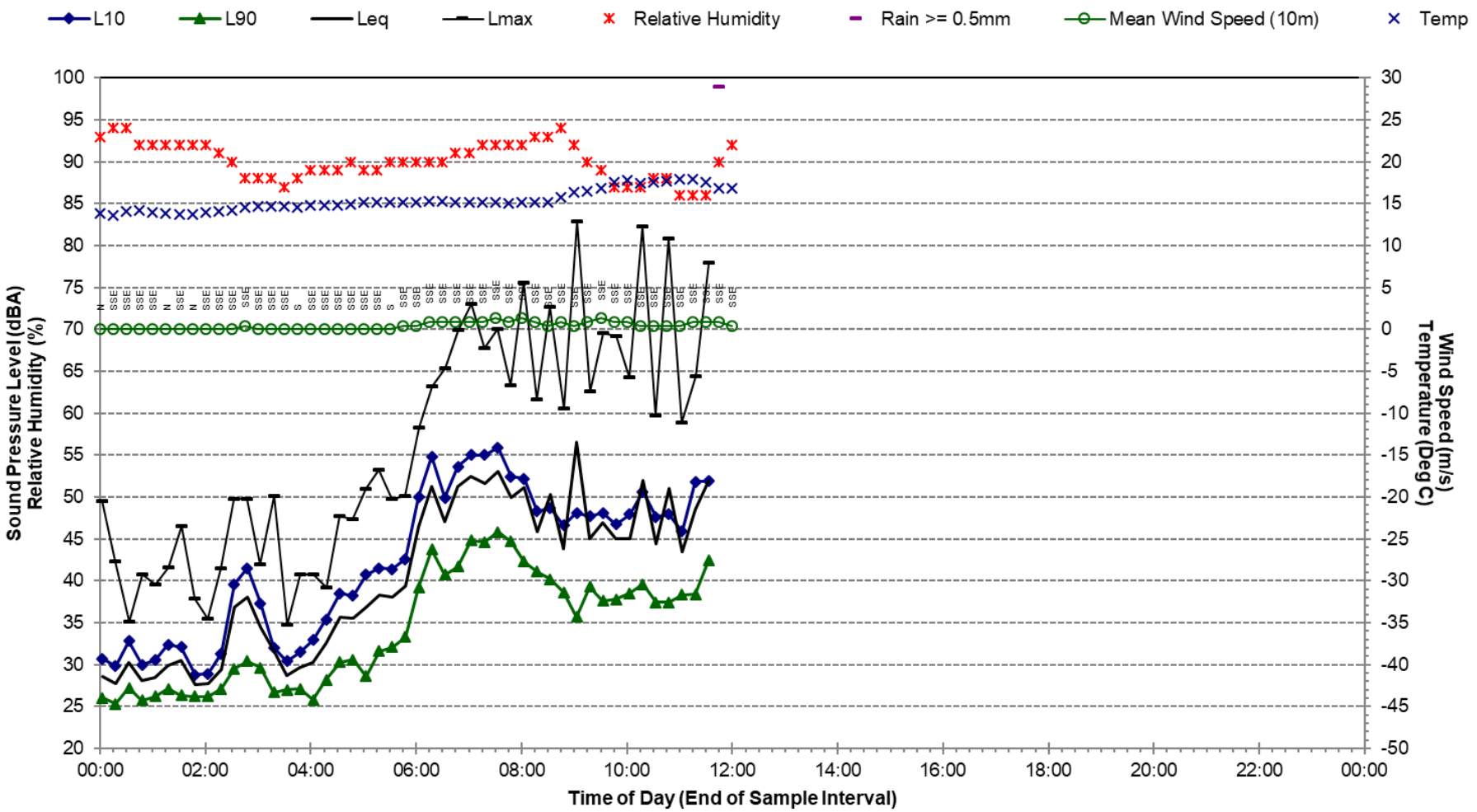
# Statistical Ambient Noise Levels

## 407 Lake MacDonald Drive - Wednesday, 6 June 2018



# Statistical Ambient Noise Levels

## 407 Lake MacDonald Drive - Thursday, 7 June 2018



# APPENDIX C

Plant sound power data

| Equipment plant | SWL[1] LAeq,adj, dBA | Octave Band Frequency Spectrum (Hz), dB | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
| 20 tonne excavator | 105 | 97 | 96 | 98 | 98 | 98 | 97 | 93 | 93 |
| 40 tonne excavator | 115 | 113 | 106 | 105 | 105 | 101 | 99 | 96 | 91 |
| 55 tonne excavator | 115 | 113 | 106 | 105 | 105 | 101 | 99 | 96 | 91 |
| 60 tonne excavator | 115 | 113 | 106 | 105 | 105 | 101 | 99 | 96 | 91 |
| Cat 988 front end loader | 108 | 87 | 95 | 95 | 100 | 103 | 101 | 101 | 88 |
| Cat D6 dozer | 115 | 104 | 106 | 103 | 111 | 107 | 105 | 100 | 100 |
| Cat D10 dozer | 112 | 78 | 90 | 94 | 108 | 107 | 106 | 101 | 91 |
| 40 tonne Articulated Dump truck (ADT) | 113 | 88 | 96 | 105 | 108 | 107 | 105 | 101 | 94 |
| Truck and Dog | 103 | 84 | 88 | 94 | 99 | 96 | 97 | 93 | 93 |
| Generator 400 kVA | 94 | 66 | 79 | 87 | 90 | 86 | 83 | 78 | 78 |
| Concrete truck and pump | 103 | 81 | 92 | 92 | 97 | 97 | 97 | 88 | 88 |
| Concrete batch plant | 110 | 86 | 97 | 99 | 104 | 105 | 103 | 100 | 95 |
| Vibratory roller (Cat 14G) | 100 | 90 | 95 | 88 | 83 | 85 | 94 | 91 | 86 |
| Sheet pile rig | 116 | 85 | 94 | 98 | 107 | 112 | 111 | 106 | 94 |
| Snorkel pump (use pump SWL) | 104 | 67 | 77 | 83 | 92 | 98 | 99 | 97 | 92 |
| Delivery Truck | 106 | 87 | 86 | 97 | 98 | 100 | 102 | 96 | 90 |
| Hand tools | 111 | 62 | 84 | 94 | 100 | 105 | 103 | 106 | 104 |
| Dewatering unit | 104 | 67 | 77 | 83 | 92 | 98 | 99 | 97 | 92 |
| Tip truck | 105 | 93 | 91 | 96 | 99 | 99 | 98 | 93 | 88 |
| 100 tonne crawler crane | 98 | 82 | 84 | 90 | 92 | 93 | 91 | 86 | 76 |
| 50T Truck Crane | 102 | 79 | 88 | 91 | 97 | 97 | 94 | 85 | 75 |
| 1200 kVA Gen | 113 | 84 | 101 | 105 | 106 | 107 | 107 | 100 | 91 |
| Work boat | 117 | 101 | 108 | 110 | 112 | 111 | 106 | 97 | 85 |
| Cat966 FEL | 109 | 91 | 96 | 101 | 104 | 102 | 104 | 95 | 86 |
| 30 tonne excavator | 115 | 113 | 106 | 105 | 105 | 101 | 99 | 96 | 91 |
| Skidsteer | 106 | 83 | 89 | 90 | 97 | 102 | 100 | 93 | 82 |
| 80m H/head crane 5T | 102 | 79 | 88 | 91 | 97 | 97 | 94 | 85 | 75 |
| Water cart | 113 | 84 | 101 | 105 | 106 | 107 | 107 | 100 | 91 |
| Bored piling rigs | 113 | 84 | 101 | 105 | 106 | 107 | 107 | 100 | 91 |
| Rock blade attached excavator | 105 | 97 | 96 | 98 | 98 | 98 | 97 | 93 | 93 |
| 10T excavator | 105 | 97 | 96 | 98 | 98 | 98 | 97 | 93 | 93 |
| Batch plant | 113 | 84 | 101 | 105 | 106 | 107 | 107 | 100 | 91 |
| Air track drill rig | 110 | 86 | 97 | 99 | 104 | 105 | 103 | 100 | 95 |
| Pressure grout pump | 104 | 67 | 77 | 83 | 92 | 98 | 99 | 97 | 92 |
| Gantry Crane | 102 | 79 | 88 | 91 | 97 | 97 | 94 | 85 | 75 |
| 140G Grader | 103 | 70 | 86 | 86 | 96 | 99 | 97 | 94 | 90 |
| Bentonite Plant | 110 | 86 | 97 | 99 | 104 | 105 | 103 | 100 | 95 |
| 140M Grader | 105 | 72 | 88 | 88 | 98 | 101 | 99 | 96 | 92 |
| Cat815 | 111 | 99 | 104 | 107 | 102 | 100 | 99 | 93 | 85 |
| Sheep foot roller | 107 | 75 | 90 | 100 | 101 | 102 | 100 | 94 | 86 |
| Roller | 107 | 75 | 90 | 100 | 101 | 102 | 100 | 94 | 86 |
| Scraper | 111 | 99 | 104 | 107 | 102 | 100 | 99 | 93 | 85 |

Note 1: Sound power levels sourced from SLR's in-house library have been used for his assessment.

# APPENDIX D

Predicted Noise Results

| Receiver | Noise targets | | | Pumping Water at Location A | | | | | | Pumping Water at Location B | | | | | | Sheet Piling | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Day and Evening (7am-10pm) Leq target dBA | Night time (10pm-7am) Leq target dBA | Sleep disturbance (10pm-7am) Lmax target dBA | Predicted standard/non-standard hours Leq dBA | Day/Evening exceedance Leq dBA | Night exceedance Leq dBA | Predicted standard/non-standard hours **with barrier** Leq dBA | Day /evening exceedance with barrier Leq dBA | Night exceedance with barrier Leq dBA | Predicted standard/non-standard hours Leq dBA | Day/Evening exceedance Leq dBA | Night exceedance Leq dBA | Predicted standard/non-standard hours **with barrier** Leq dBA | Day /evening exceedance with barrier Leq dBA | Night exceedance with barrier Leq dBA | Predicted Standard hours Leq dBA | Day/Evening exceedance Leq dBA |
| 5 Highland Drive | 50 | 35 | 52 | 23 | - | - | 22 | - | - | 32 | - | - | 23 | - | - | 26 | - |
| 7 Figbird Court | 50 | 35 | 52 | 29 | - | - | 31 | - | - | 30 | - | - | 21 | - | - | 28 | - |
| 8 Figbird Court | 50 | 35 | 52 | 28 | - | - | 32 | - | - | 32 | - | - | 24 | - | - | 30 | - |
| 9 Highland Drive | 50 | 35 | 52 | 42 | - | 7 | 30 | - | - | 44 | - | 9 | 31 | - | - | 48 | - |
| 10 Figbird Court | 50 | 35 | 52 | 27 | - | - | 29 | - | - | 30 | - | - | 16 | - | - | 28 | - |
| 15 Highland Drive | 50 | 35 | 52 | 43 | - | 8 | 30 | - | - | 45 | - | 10 | 31 | - | - | 49 | - |
| 17 Hamilton Road | 50 | 35 | 52 | 27 | - | - | 22 | - | - | 38 | - | 3 | 24 | - | - | 36 | - |
| 18 Highland Drive | 50 | 35 | 52 | 39 | - | 4 | 25 | - | - | 41 | - | 6 | 30 | - | - | 45 | - |
| 19 Highland Drive | 50 | 35 | 52 | 44 | - | 9 | 31 | - | - | 45 | - | 10 | 31 | - | - | 49 | - |
| 25 Highland Drive | 50 | 35 | 52 | 45 | - | 10 | 32 | - | - | 46 | - | 11 | 32 | - | - | 48 | - |
| 26 Highland Drive | 50 | 35 | 52 | 43 | - | 8 | 31 | - | - | 44 | - | 9 | 30 | - | - | 45 | - |
| 31 Hamilton Road | 50 | 35 | 52 | 37 | - | 2 | 20 | - | - | 38 | - | 3 | 26 | - | - | 38 | - |
| 31 Highland Drive | 50 | 35 | 52 | 45 | - | 10 | 34 | - | - | 46 | - | 11 | 32 | - | - | 49 | - |
| 32 Highland Drive | 50 | 35 | 52 | 39 | - | 4 | 26 | - | - | 44 | - | 9 | 30 | - | - | 47 | - |
| 36 Highland Drive | 50 | 35 | 52 | 35 | - | 0 | 23 | - | - | 37 | - | 2 | 22 | - | - | 42 | - |
| 38 Highland Drive | 50 | 35 | 52 | 35 | - | - | 24 | - | - | 37 | - | 2 | 23 | - | - | 42 | - |
| 39 Highland Drive | 50 | 35 | 52 | 46 | - | 11 | 34 | - | - | 46 | - | 11 | 31 | - | - | 51 | 1 |
| 42 Highland Drive | 50 | 35 | 52 | 38 | - | 3 | 27 | - | - | 40 | - | 5 | 31 | - | - | 47 | - |
| 43 Highland Drive | 50 | 35 | 52 | 49 | - | 14 | 39 | - | 4 | 50 | - | 15 | 36 | - | 1 | 60 | 10 |
| 47 Highland Drive | 50 | 35 | 52 | 44 | - | 9 | 30 | - | - | 46 | - | 11 | 32 | - | - | 52 | 2 |
| 48 Highland Drive | 50 | 35 | 52 | 45 | - | 10 | 33 | - | - | 41 | - | 6 | 26 | - | - | 44 | - |
| 52 Highland Drive | 50 | 35 | 52 | 34 | - | - | 25 | - | - | 37 | - | 2 | 23 | - | - | 40 | - |
| 53 Highland Drive | 50 | 35 | 52 | 44 | - | 9 | 30 | - | - | 45 | - | 10 | 33 | - | - | 49 | - |
| 54 Highland Drive | 50 | 35 | 52 | 36 | - | 1 | 26 | - | - | 38 | - | 3 | 24 | - | - | 37 | - |
| 57 Highland Drive | 50 | 35 | 52 | 48 | - | 13 | 37 | - | 2 | 42 | - | 7 | 33 | - | - | 46 | - |
| 58 Highland Drive | 50 | 35 | 52 | 38 | - | 3 | 29 | - | - | 39 | - | 4 | 26 | - | - | 39 | - |
| 59 Highland Drive | 50 | 35 | 52 | 48 | - | 13 | 36 | - | 1 | 43 | - | 8 | 32 | - | - | 47 | - |
| 60 Highland Drive | 50 | 35 | 52 | 45 | - | 10 | 32 | - | - | 40 | - | 5 | 32 | - | - | 43 | - |
| 62 Highland Drive | 50 | 35 | 52 | 33 | - | - | 30 | - | - | 40 | - | 5 | 25 | - | - | 45 | - |
| 114 Collwood Road | 50 | 35 | 52 | 31 | - | - | 34 | - | - | 36 | - | 1 | 21 | - | - | 33 | - |
| 140 Collwood Road | 50 | 35 | 52 | 33 | - | - | 35 | - | - | 36 | - | 1 | 24 | - | - | 31 | - |
| 332 Lake MacDonald Drive | 50 | 35 | 52 | 40 | - | 5 | 43 | - | 8 | 44 | - | 9 | 36 | - | 1 | 38 | - |
| 359 Lake MacDonald Drive | 50 | 35 | 52 | 42 | - | 7 | 30 | - | - | 38 | - | 3 | 22 | - | - | 41 | - |
| 363 Lake MacDonald Drive | 50 | 35 | 52 | 43 | - | 8 | 32 | - | - | 39 | - | 4 | 29 | - | - | 43 | - |
| 367 Lake MacDonald Drive | 50 | 35 | 52 | 40 | - | 5 | 31 | - | - | 36 | - | 1 | 23 | - | - | 38 | - |
| 371 Lake MacDonald Drive | 50 | 35 | 52 | 45 | - | 10 | 33 | - | - | 44 | - | 9 | 30 | - | - | 43 | - |
| 373 Lake MacDonald Drive | 50 | 35 | 52 | 41 | - | 6 | 29 | - | - | 39 | - | 4 | 23 | - | - | 41 | - |
| 375 Lake MacDonald Drive | 50 | 35 | 52 | 47 | - | 12 | 39 | - | 4 | 44 | - | 9 | 30 | - | - | 44 | - |
| 379 Lake MacDonald Drive | 50 | 35 | 52 | 48 | - | 13 | 35 | - | - | 41 | - | 6 | 30 | - | - | 45 | - |
| 385 Lake MacDonald Drive | 50 | 35 | 52 | 50 | - | 15 | 37 | - | 2 | 42 | - | 7 | 31 | - | - | 46 | - |
| 389 Lake MacDonald Drive | 50 | 35 | 52 | 53 | 3 | 18 | 42 | - | 7 | 47 | - | 12 | 31 | - | - | 48 | - |
| 395 Lake MacDonald Drive | 50 | 35 | 52 | 57 | 7 | 22 | 45 | - | 10 | 47 | - | 12 | 35 | - | - | 50 | 0 |
| 403 Lake MacDonald Drive | 50 | 35 | 52 | 59 | 9 | 24 | 46 | - | 11 | 45 | - | 10 | 34 | - | - | 52 | 2 |
| 407 Lake MacDonald Drive | 50 | 35 | 52 | 62 | 12 | 27 | 49 | - | 14 | 46 | - | 11 | 34 | - | - | 54 | 4 |
| 411 Lake MacDonald Drive | 50 | 35 | 52 | 59 | 9 | 24 | 50 | - | 15 | 46 | - | 11 | 30 | - | - | 52 | 2 |
| 415 Lake MacDonald Drive | 50 | 35 | 52 | 59 | 9 | 24 | 50 | - | 15 | 46 | - | 11 | 29 | - | - | 54 | 4 |
| 419 Lake MacDonald Drive | 50 | 35 | 52 | 54 | 4 | 19 | 46 | - | 11 | 46 | - | 11 | 31 | - | - | 51 | 1 |

| Receiver | Noise targets | | | Spillway Excavation | | | | | | Spillway Construction | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Day and Evening (7am-10pm) Leq target dBA | Night time (10pm-7am) Leq target dBA | Sleep disturbance (10pm-7am) Lmax target dBA | Predicted Standard hours Leq dBA | Day /evening exceedance Leq dBA | Predicted Non-standard hours Leq dBA | Night exceedance Leq dBA | Lmax from loudest event Lmax dBA | Sleeping disturbance exceedance Lmax dBA | Predicted Standard hours Leq dBA | Day/Evening exceedance dBA | Predicted Non-standard hours Leq dBA | Night exceedance Leq dBA | Lmax from loudest event Lmax dBA | Sleeping disturbance exceedance Lmax dBA |
| 5 Highland Drive | 50 | 35 | 52 | 31 | - | 28 | - | 40 | - | 26 | - | 25 | - | 32 | - |
| 7 Figbird Court | 50 | 35 | 52 | 31 | - | 28 | - | 38 | - | 28 | - | 26 | - | 33 | - |
| 8 Figbird Court | 50 | 35 | 52 | 33 | - | 30 | - | 40 | - | 29 | - | 28 | - | 35 | - |
| 9 Highland Drive | 50 | 35 | 52 | 49 | - | 46 | 11 | 54 | 2 | 46 | - | 45 | 10 | 49 | - |
| 10 Figbird Court | 50 | 35 | 52 | 30 | - | 27 | - | 38 | - | 27 | - | 25 | - | 31 | - |
| 15 Highland Drive | 50 | 35 | 52 | 50 | - | 47 | 12 | 55 | 3 | 47 | - | 46 | 11 | 49 | - |
| 17 Hamilton Road | 50 | 35 | 52 | 39 | - | 36 | 1 | 42 | - | 35 | - | 33 | - | 35 | - |
| 18 Highland Drive | 50 | 35 | 52 | 47 | - | 44 | 9 | 52 | 0 | 44 | - | 42 | 7 | 46 | - |
| 19 Highland Drive | 50 | 35 | 52 | 49 | - | 47 | 12 | 57 | 5 | 47 | - | 46 | 11 | 51 | - |
| 25 Highland Drive | 50 | 35 | 52 | 49 | - | 46 | 11 | 58 | 6 | 47 | - | 45 | 10 | 51 | - |
| 26 Highland Drive | 50 | 35 | 52 | 46 | - | 43 | 8 | 53 | 1 | 43 | - | 42 | 7 | 47 | - |
| 31 Hamilton Road | 50 | 35 | 52 | 40 | - | 37 | 2 | 49 | - | 37 | - | 36 | 1 | 42 | - |
| 31 Highland Drive | 50 | 35 | 52 | 50 | 0 | 47 | 12 | 57 | 5 | 47 | - | 46 | 11 | 52 | 0 |
| 32 Highland Drive | 50 | 35 | 52 | 48 | - | 45 | 10 | 56 | 4 | 45 | - | 44 | 9 | 50 | - |
| 36 Highland Drive | 50 | 35 | 52 | 44 | - | 41 | 6 | 52 | - | 41 | - | 40 | 5 | 47 | - |
| 38 Highland Drive | 50 | 35 | 52 | 43 | - | 40 | 5 | 47 | - | 40 | - | 39 | 4 | 46 | - |
| 39 Highland Drive | 50 | 35 | 52 | 52 | 2 | 49 | 14 | 59 | 7 | 49 | - | 48 | 13 | 53 | 1 |
| 42 Highland Drive | 50 | 35 | 52 | 48 | - | 45 | 10 | 56 | 4 | 45 | - | 44 | 9 | 50 | - |
| 43 Highland Drive | 50 | 35 | 52 | 60 | 10 | 57 | 22 | 68 | 16 | 57 | 7 | 56 | 21 | 62 | 10 |
| 47 Highland Drive | 50 | 35 | 52 | 51 | 1 | 48 | 13 | 59 | 7 | 49 | - | 47 | 12 | 54 | 2 |
| 48 Highland Drive | 50 | 35 | 52 | 42 | - | 39 | 4 | 48 | - | 38 | - | 36 | 1 | 49 | - |
| 52 Highland Drive | 50 | 35 | 52 | 37 | - | 34 | - | 43 | - | 33 | - | 32 | - | 44 | - |
| 53 Highland Drive | 50 | 35 | 52 | 46 | - | 43 | 8 | 54 | 2 | 43 | - | 41 | 6 | 53 | 1 |
| 54 Highland Drive | 50 | 35 | 52 | 40 | - | 37 | 2 | 44 | - | 37 | - | 35 | 0 | 40 | - |
| 57 Highland Drive | 50 | 35 | 52 | 48 | - | 45 | 10 | 50 | - | 45 | - | 43 | 8 | 53 | 1 |
| 58 Highland Drive | 50 | 35 | 52 | 40 | - | 37 | 2 | 45 | - | 36 | - | 35 | - | 42 | - |
| 59 Highland Drive | 50 | 35 | 52 | 49 | - | 46 | 11 | 53 | 1 | 46 | - | 44 | 9 | 43 | - |
| 60 Highland Drive | 50 | 35 | 52 | 47 | - | 44 | 9 | 49 | - | 44 | - | 43 | 8 | 45 | - |
| 62 Highland Drive | 50 | 35 | 52 | 47 | - | 44 | 9 | 48 | - | 44 | - | 43 | 8 | 42 | - |
| 114 Collwood Road | 50 | 35 | 52 | 36 | - | 33 | - | 43 | - | 32 | - | 31 | - | 37 | - |
| 140 Collwood Road | 50 | 35 | 52 | 34 | - | 31 | - | 41 | - | 30 | - | 28 | - | 35 | - |
| 332 Lake MacDonald Drive | 50 | 35 | 52 | 40 | - | 37 | 2 | 47 | - | 37 | - | 36 | 1 | 42 | - |
| 359 Lake MacDonald Drive | 50 | 35 | 52 | 43 | - | 40 | 5 | 44 | - | 40 | - | 39 | 4 | 45 | - |
| 363 Lake MacDonald Drive | 50 | 35 | 52 | 44 | - | 41 | 6 | 46 | - | 42 | - | 40 | 5 | 45 | - |
| 367 Lake MacDonald Drive | 50 | 35 | 52 | 40 | - | 37 | 2 | 43 | - | 37 | - | 35 | 0 | 37 | - |
| 371 Lake MacDonald Drive | 50 | 35 | 52 | 45 | - | 42 | 7 | 46 | - | 42 | - | 41 | 6 | 43 | - |
| 373 Lake MacDonald Drive | 50 | 35 | 52 | 43 | - | 40 | 5 | 43 | - | 40 | - | 38 | 3 | 37 | - |
| 375 Lake MacDonald Drive | 50 | 35 | 52 | 45 | - | 42 | 7 | 46 | - | 43 | - | 41 | 6 | 46 | - |
| 379 Lake MacDonald Drive | 50 | 35 | 52 | 46 | - | 43 | 8 | 46 | - | 44 | - | 42 | 7 | 45 | - |
| 385 Lake MacDonald Drive | 50 | 35 | 52 | 48 | - | 45 | 10 | 49 | - | 46 | - | 44 | 9 | 47 | - |
| 389 Lake MacDonald Drive | 50 | 35 | 52 | 50 | 0 | 47 | 12 | 52 | 0 | 48 | - | 46 | 11 | 49 | - |
| 395 Lake MacDonald Drive | 50 | 35 | 52 | 53 | 3 | 50 | 15 | 51 | - | 51 | 1 | 49 | 14 | 48 | - |
| 403 Lake MacDonald Drive | 50 | 35 | 52 | 54 | 4 | 51 | 16 | 54 | 2 | 51 | 1 | 50 | 15 | 47 | - |
| 407 Lake MacDonald Drive | 50 | 35 | 52 | 55 | 5 | 52 | 17 | 55 | 3 | 53 | 3 | 52 | 17 | 49 | - |
| 411 Lake MacDonald Drive | 50 | 35 | 52 | 54 | 4 | 51 | 16 | 56 | 4 | 51 | 1 | 50 | 15 | 46 | - |
| 415 Lake MacDonald Drive | 50 | 35 | 52 | 56 | 6 | 53 | 18 | 60 | 8 | 53 | 3 | 51 | 16 | 48 | - |
| 419 Lake MacDonald Drive | 50 | 35 | 52 | 54 | 4 | 51 | 16 | 59 | 7 | 50 | - | 48 | 13 | 56 | 4 |

| Receiver | Noise targets | | | Clay Borrow Area | | ast Embankment Constructio | | est Embankment Constructio | | Saddle Dam | | Demobilisation | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Day and Evening (7am-10pm) Leq target dBA | Night time (10pm-7am) Leq target dBA | Sleep disturbance (10pm-7am) Lmax target dBA | Predicted Standard hours Leq dBA | Day/evening exceedance Leq dBA | Predicted standard hours level Leq dBA | Day/evening exceedance Leq dBA | Predicted Standard hours Leq dBA | Day/evening exceedance Leq dBA | Predicted Standard hours Leq dBA | Day/evening exceedance Leq dBA | Predicted Standard hours Leq dBA | Day/evening exceedance Leq dBA |
| 5 Highland Drive | 50 | 35 | 52 | 35 | - | 31 | - | 31 | - | 25 | - | 29 | - |
| 7 Figbird Court | 50 | 35 | 52 | 39 | - | 33 | - | 32 | - | 34 | - | 31 | - |
| 8 Figbird Court | 50 | 35 | 52 | 42 | - | 34 | - | 34 | - | 37 | - | 33 | - |
| 9 Highland Drive | 50 | 35 | 52 | 39 | - | 50 | - | 51 | 1 | 39 | - | 49 | - |
| 10 Figbird Court | 50 | 35 | 52 | 40 | - | 32 | - | 31 | - | 34 | - | 30 | - |
| 15 Highland Drive | 50 | 35 | 52 | 37 | - | 52 | 2 | 52 | 2 | 40 | - | 51 | 1 |
| 17 Hamilton Road | 50 | 35 | 52 | 34 | - | 40 | - | 40 | - | 33 | - | 38 | - |
| 18 Highland Drive | 50 | 35 | 52 | 35 | - | 48 | - | 48 | - | 38 | - | 47 | - |
| 19 Highland Drive | 50 | 35 | 52 | 37 | - | 52 | 2 | 51 | 1 | 40 | - | 51 | 1 |
| 25 Highland Drive | 50 | 35 | 52 | 37 | - | 50 | 0 | 52 | 2 | 40 | - | 51 | 1 |
| 26 Highland Drive | 50 | 35 | 52 | 36 | - | 48 | - | 48 | - | 39 | - | 47 | - |
| 31 Hamilton Road | 50 | 35 | 52 | 32 | - | 41 | - | 42 | - | 35 | - | 41 | - |
| 31 Highland Drive | 50 | 35 | 52 | 37 | - | 52 | 2 | 52 | 2 | 40 | - | 51 | 1 |
| 32 Highland Drive | 50 | 35 | 52 | 36 | - | 49 | - | 51 | 1 | 39 | - | 49 | - |
| 36 Highland Drive | 50 | 35 | 52 | 33 | - | 45 | - | 46 | - | 35 | - | 45 | - |
| 38 Highland Drive | 50 | 35 | 52 | 33 | - | 45 | - | 45 | - | 35 | - | 43 | - |
| 39 Highland Drive | 50 | 35 | 52 | 36 | - | 52 | 2 | 54 | 4 | 40 | - | 54 | 4 |
| 42 Highland Drive | 50 | 35 | 52 | 35 | - | 49 | - | 51 | 1 | 37 | - | 48 | - |
| 43 Highland Drive | 50 | 35 | 52 | 38 | - | 60 | 10 | 64 | 14 | 42 | - | 62 | 12 |
| 47 Highland Drive | 50 | 35 | 52 | 36 | - | 53 | 3 | 56 | 6 | 40 | - | 53 | 3 |
| 48 Highland Drive | 50 | 35 | 52 | 35 | - | 46 | - | 48 | - | 38 | - | 42 | - |
| 52 Highland Drive | 50 | 35 | 52 | 33 | - | 41 | - | 44 | - | 33 | - | 37 | - |
| 53 Highland Drive | 50 | 35 | 52 | 36 | - | 51 | 1 | 53 | 3 | 39 | - | 48 | - |
| 54 Highland Drive | 50 | 35 | 52 | 33 | - | 43 | - | 42 | - | 35 | - | 41 | - |
| 57 Highland Drive | 50 | 35 | 52 | 36 | - | 50 | 0 | 50 | 0 | 39 | - | 49 | - |
| 58 Highland Drive | 50 | 35 | 52 | 36 | - | 42 | - | 45 | - | 38 | - | 40 | - |
| 59 Highland Drive | 50 | 35 | 52 | 37 | - | 50 | 0 | 51 | 1 | 40 | - | 50 | 0 |
| 60 Highland Drive | 50 | 35 | 52 | 35 | - | 49 | - | 47 | - | 38 | - | 48 | - |
| 62 Highland Drive | 50 | 35 | 52 | 29 | - | 48 | - | 48 | - | 37 | - | 48 | - |
| 114 Collwood Road | 50 | 35 | 52 | 49 | - | 38 | - | 37 | - | 41 | - | 36 | - |
| 140 Collwood Road | 50 | 35 | 52 | 43 | - | 35 | - | 35 | - | 38 | - | 34 | - |
| 332 Lake MacDonald Drive | 50 | 35 | 52 | 46 | - | 42 | - | 41 | - | 45 | - | 41 | - |
| 359 Lake MacDonald Drive | 50 | 35 | 52 | 35 | - | 43 | - | 44 | - | 37 | - | 44 | - |
| 363 Lake MacDonald Drive | 50 | 35 | 52 | 35 | - | 45 | - | 46 | - | 37 | - | 46 | - |
| 367 Lake MacDonald Drive | 50 | 35 | 52 | 35 | - | 41 | - | 41 | - | 37 | - | 40 | - |
| 371 Lake MacDonald Drive | 50 | 35 | 52 | 37 | - | 47 | - | 47 | - | 40 | - | 46 | - |
| 373 Lake MacDonald Drive | 50 | 35 | 52 | 35 | - | 45 | - | 46 | - | 37 | - | 44 | - |
| 375 Lake MacDonald Drive | 50 | 35 | 52 | 38 | - | 47 | - | 47 | - | 41 | - | 46 | - |
| 379 Lake MacDonald Drive | 50 | 35 | 52 | 37 | - | 48 | - | 48 | - | 38 | - | 47 | - |
| 385 Lake MacDonald Drive | 50 | 35 | 52 | 36 | - | 50 | - | 50 | - | 39 | - | 49 | - |
| 389 Lake MacDonald Drive | 50 | 35 | 52 | 40 | - | 52 | 2 | 52 | 2 | 44 | - | 51 | 1 |
| 395 Lake MacDonald Drive | 50 | 35 | 52 | 41 | - | 55 | 5 | 53 | 3 | 43 | - | 53 | 3 |
| 403 Lake MacDonald Drive | 50 | 35 | 52 | 38 | - | 55 | 5 | 55 | 5 | 40 | - | 55 | 5 |
| 407 Lake MacDonald Drive | 50 | 35 | 52 | 38 | - | 56 | 6 | 57 | 7 | 41 | - | 56 | 6 |
| 411 Lake MacDonald Drive | 50 | 35 | 52 | 37 | - | 55 | 5 | 55 | 5 | 41 | - | 55 | 5 |
| 415 Lake MacDonald Drive | 50 | 35 | 52 | 38 | - | 57 | 7 | 57 | 7 | 42 | - | 57 | 7 |
| 419 Lake MacDonald Drive | 50 | 35 | 52 | 38 | - | 54 | 4 | 56 | 6 | 41 | - | 55 | 5 |

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