Port of Gladstone
Gatcombe and Golding Cutting Channel Duplication Project

Environmental Impact Statement

Gladstone Ports Corporation
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Appendix K1
Terrestrial Noise and Vibration Assessment

PORT OF GLADSTONE GATCOMBE AND GOLDING CUTTING CHANNEL DUPLICATION PROJECT

Terrestrial Noise and Vibration Assessment

Prepared for:

Aurecon Australasia Pty Ltd
Level 14, 32 Turbot Street
Brisbane QLD 4000

SLR Ref: 620.10682-R01
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PREPARED BY

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
Level 2, 15 Astor Terrace
Spring Hill QLD 4000 Australia
(PO Box 26 Spring Hill QLD 4004)
T: +61 7 3858 4800 F: +61 7 3858 4801
E: brisbane@slrconsulting.com www.slrconsulting.com

BASIS OF REPORT

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

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DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
620.10682-R01-v1.0	14 February 2019	A Hansen and S Walker	M Caslin	S Walker

EXECUTIVE SUMMARY

The Port of Gladstone is a deep water natural port located on the Central Queensland coast approximately 525 km north of Brisbane and 100 km south of Rockhampton. The Port of Gladstone is located within Port Curtis and is bounded by the mainland to the west and south, Facing Island to the east and The Narrows and Curtis Island to the north.

Gladstone Ports Corporation (GPC), as the governing port authority of the Port of Gladstone, proposes to duplicate the existing Gatcombe and Golding Cutting Channels, providing a two-way passage from the open coastal waters, around East Banks, to the western side of Facing Island (the Project). The proposed Channel Duplication dredging area is located west of the existing Gatcombe and Golding Cutting Channels. The total length of the proposed duplicate channel is approximately 15 km.

An Environmental Impact Statement (EIS) for the Project is required as part of the:

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) controlled action determination for the Project.
- *State Development and Public Works Organisation 1971* (SDPWO Act) coordinated project determination for the Project.

The EIS is required to consider the potential noise and vibration impacts of the Project upon the terrestrial environment. In particular, the airborne noise levels associated with the construction and operational phases of the Project at nearby sensitive receptors.

This report provides an assessment of noise and vibration associated with the construction and operational phases of the Project. The assessment includes the monitoring of existing environmental noise levels in the Gladstone region, establishing noise and vibration assessment criteria with reference to relevant acoustic Policy, standards and guidelines and detailed calculation and prediction of noise and vibration emissions from the Project.

The assessment has determined the construction activities and maintenance dredging of the Duplicated Channels (operational works) can be undertaken whilst minimising potential noise and vibration impacts to the surrounding sensitive receptors.

Most of the Project activities are to be undertaken at a sufficient distance from sensitive receptors so that received noise levels would be very low (well below the current ambient noise levels). The proposed dredging of the Duplicated Channels during the night-time, operation of the pushbusters (marine vessels for propelling barges) and impact piling rig for the installation of new navigational aids are activities which may require the consideration of the noise management measures contained in this report to control noise at the closest sensitive receptors at Facing Island, Tide Island and Boyne Island.

Due to the separation distance of at least 3.6 km from sources of ground vibration and sensitive receptors, the assessment determined that vibration impacts are not expected to occur during the Project. Road traffic noise impacts are also not expected as the transport route between the Targinnie/Yarwun quarry and the proposed Western Basin Expansion (WBE) reclamation area for the bund wall material is 2.5 km from residential receptors.

The assessment has concluded that potential terrestrial noise and vibration impacts associated with the Project can be controlled in accordance with the relevant legislative and regulatory acoustic requirements.

Acronyms and abbreviations

The acronyms applied throughout this report are detailed in the table below.

Acronym	Definition
ARL	Acoustic Research Laboratories
BOYN	Boyne Island Roost Site
BUF	Barge unloading facility
CSD	Cutter suction dredger
dB	Decibel
dBA	A-weighted decibel
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DES	Department of Environment and Science
DMPA	Dredged material placement area
DTMR	Department of Transport and Main Roads
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EP Act	Environmental Protection Act 1994 (Qld)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
EPP (Noise)	*Environmental Protection (Noise) Policy 2008* (Qld)
FAC4	Facing Island Roost Site
FAIS	Facing Island Roost Site
GBRWHA	Great Barrier Reef World Heritage Area
GPC	Gladstone Ports Corporation
GSDA	Gladstone State Development Area
km	Kilometre(s)
LAT	Lowest astronomical tide
LNG	Liquefied Natural Gas
MNES	Matters of National Environmental Significance
Mm^3	Million cubic metres
NAR1	The Narrows Roost Site
NATA	National Association of Testing Authorities
NC Act	*Nature Conservation Act 1992* (Qld)
NR07	Hummock Hill Island Roost Site
NVMP	Noise Vibration Management Plan
PNC	*Ecoaccess Guideline: Planning for Noise Control*
PPV	Peak Particle Velocity
RBL	Rating Background Level
RL	Residual Level (ground heights)

Acronyms and abbreviations

Acronym	Definition
SDPWO Act	*State Development and Public Works Organisation Act 1971* (Qld)
SLM	Sound Level Meter
SMIS	Six Mile Island Shorebird Roost Site
TAPM	The Air Pollution Model
ToR	Terms of Reference
TSHD	Trailing suction hopper dredger
WB	Western Basin
WBE	Western Basin Expansion

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1 Introduction

1.1 Port of Gladstone Channel Duplication Project

The Port of Gladstone is a deep water natural port located on the Central Queensland coast approximately 525 km north of Brisbane and 100 km south of Rockhampton. The Port of Gladstone is located within Port Curtis and is bounded by the mainland to the west and south, Facing Island to the east and The Narrows and Curtis Island to the north.

Gladstone Ports Corporation (GPC), as the governing port authority of the Port of Gladstone, proposes to duplicate the existing Gatcombe and Golding Cutting Channels, providing a two-way passage from the open coastal waters, around East Banks, to the western side of Facing Island (the Project).

The proposed Channel Duplication area to be dredged is predominantly located west of the existing Gatcombe and Golding Cutting Channels. The total length of the proposed duplicate channel is approximately 15 km. The key features of the Project include:

- Establishing bund walls for the Western Basin Expansion (WBE) reclamation area;
- Construction of a barge unloading facility (BUF) adjacent to the existing Western Basin (WB) reclamation area;
- Initial dredging works of approximately 0.25 Mm^3 of seabed material to establish an access channel to -7m lowest astronomical tide (LAT) to allow barges to transport dredged material from the Gatcombe and Golding Cutting shipping channels to the BUF;
- Dredging approximately 12.6 Mm^3 of seabed material with a trailing suction hopper dredger (TSHD) to permanently duplicate the Gatcombe and Golding Cutting Channels;
- The proposed dredging methodology involves utilising a TSHD which loads the dredged material from the Gatcombe and Golding Cutting shipping channels into barges (four barges will be working in cycles for the entire dredging operations) which will transport the material to the BUF to be unloaded using large excavators into trucks for placement within the existing WB and WBE reclamation areas;
- Provision of services to the Project activities;
- Removal, relocation and installation of new navigation aids;
- Demobilisation of dredging operation; and
- Project operational phase activities, including:
    - Reclaimed land surface stabilisation and operational management;
    - Final land uses on reclaimed land and future wharf usage of the BUF;
    - Maritime operation within duplicated channels; and
    - Maintenance dredging within duplicated channels.

The general extent of the existing Gatcombe and Golding Cutting shipping channels, the proposed channel duplication, the barge access channel, BUF and WBE reclamation area are shown in **Figure 1**. The key stages and activities associated with the Project are discussed in further detail in **Section 2** of this report.

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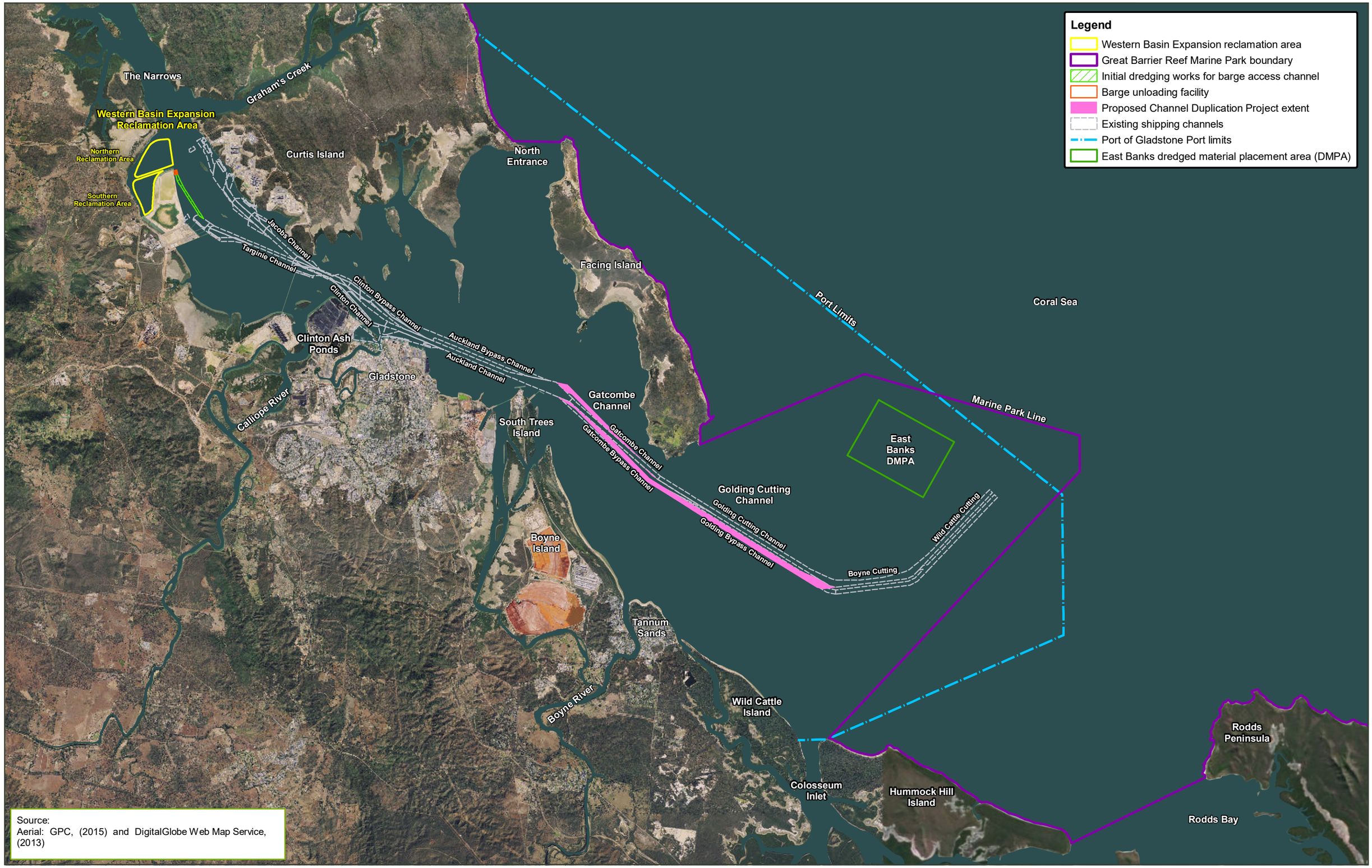

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Date: 23/11/2018 Version: 8 Job No: 237374
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Gatcombe and Golding Cutting Channel Duplication Project

Figure 1: Existing maintained shipping channels within the Port of Gladstone

1.2 Environmental impact statement

The Queensland Coordinator-General has declared the Project as a 'coordinated project' under the *State Development and Public Works Organisation Act 1971* (Qld) (SDPWO Act). The declaration initiated the statutory environmental impact assessment procedure of Part 4 of the SDPWO Act, which requires the preparation of an Environmental Impact Statement (EIS). The Project was also determined to be a 'controlled action' requiring an EIS under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act).

The EIS is required to provide an assessment of potential impacts to environmental values and detail the environmental protection and mitigation measures incorporated in the planning, construction and delivery of the Project. The Queensland Coordinator-General has issued the Terms of Reference (ToR) for the EIS, and the Commonwealth Minister for the Environment has issued the EIS Guidelines for the Project which advises the content and format for the EIS, the legislation and regulatory guidelines relevant to the Project and the environmental values to be assessed.

The EIS Guidelines do not contain specific terrestrial noise and vibration assessment requirements; however, the potential noise and vibration impacts on the Matters of National Environmental Significance (MNES) (Australian Government, 2013) and the Great Barrier Reef World Heritage Area (GBRWHA) values have been addressed in the EIS outside the scope of this report.

The ToR requirements for noise and vibration, and where they have been addressed in this report, are summarised in **Table 1**.

Table 1 Terms of Reference – Noise and Vibration

ToR section	Requirements	Addressed in this report
5.8.1	Description of environmental values:	Section 5
	Identify sensitive receptors	Section 4
	Describe existing noise and vibration environment	Section 4
	Nominate performance indicators and standards	Section 4
5.8.2	Potential impacts and mitigation measures:	Section 7 to Section 11
	Describe the impacts of noise and vibration generated during each phase of the Project	Section 7 to Section 11

1.3 Assessment of noise and vibration impacts

The ToR requires the EIS to consider the potential noise and vibration impacts of the Project upon the terrestrial environment. The airborne noise levels associated with the construction and operational phases of the Project have been assessed at nearby sensitive receptors. The assessment of ground vibration levels has considered the potential impact of vibration upon human comfort (disturbance) and cosmetic damage to buildings and structures.

The report details the assessment methodology, predicted noise and vibration levels at sensitive receptors and an assessment of potential impacts against relevant policy, standards and guidelines.

A summary of common acoustic terms is provided below to assist the interpretation and understanding of the report and the technical matters discussed.

Noise and Sound

The terms 'sound' and 'noise' are almost interchangeable, except that 'noise' commonly refers to unwanted sound. Sound (or noise) consists of minute fluctuations in atmospheric pressure capable of evoking the sense of hearing.

A-weighted sound pressure

Human hearing responds to changes in sound pressure over a wide range and the range of sound pressure is not sensed equally. To account for the sensitivity of human hearing the A-weighted filter is applied to the sound frequencies so the loudness of the sound (expressed as decibels) corresponds to human hearing.

dBA

Sound energy is expressed as a measure of decibels on the A-weighted scale. Decibels on the A-weighted scale are abbreviated as 'dBA'. A change of 1 dBA or 2 dBA in the level of sound is difficult for most people to detect. A change in sound of 10 dBA corresponds to an approximate doubling or halving of loudness.

Sound power level

This is a measure of the rate at which a source emits acoustic energy. The sound power level is expressed in decibels and is the overall acoustic energy of the source.

Low frequency noise

Commonly referenced as the sound energy at the frequency range 20 Hz to 160 Hz, low frequency sound can be a source of disturbance as it is potentially perceptible as a low rumble. Low frequency sound waves can travel relatively long distances without much attention.

Tonality

Tonal sound contains prominent tones (distinct frequency components) and is normally regarded as more offensive than broad band sound.

Impulsive sound

Typically experienced as a sudden, almost instantaneous, peak sound level event or sequence of peak sound level events. The acute change in sound level, along with the high sound level, can be a potential source of disturbance.

L_{Aeq}

The sound level (sound energy) can fluctuate over the time (duration) of an event or activity. The L_{Aeq} is used as a measure of the total sound energy of the time varying event, whereby the L_{Aeq} represents a steady sound level for the event. The L_{Aeq} level has the same acoustic energy as the time-varying sound event and can be considered as an average noise level which accounts for all the fluctuations in sound level during the event.

L_{Amax}

Maximum instantaneous sound level for an event and is commonly used in the assessment of potential sleep disturbance impacts during the night-time.

PPV

Peak Particle Velocity is used to describe ground vibrations. It is a measure of the displacement associated with the movement of the molecular particles as the energy waves propagate through the ground.

2 Methodology

The assessment of noise and vibration from the construction and operation of the Project has been based on the following strategy:

- Based on the Project description, noise and vibration assessment scenarios were established for the key stages of construction and operation of the Project.
- A baseline noise monitoring survey was undertaken to quantify and characterise the existing noise environment at locations representative of the communities near to the proposed construction and operational activities of the Project.
- Referencing relevant acoustic standards, policy and guidelines, noise and vibration assessment criteria were adopted to ensure the Project can achieve the objectives of minimising disturbance and preserving acoustic amenity within the nearby communities.
- The noise assessment criteria were determined with reference to the monitored existing noise levels to provide criteria specific to the local environment and communities.
- The principal sources of noise and vibration associated with the construction and operation of the Project were identified and each source was assigned an appropriate emission level.
- A noise prediction model was developed to calculate airborne noise levels at the noise sensitive receptors for each of the assessment scenarios. The noise model provided calculated noise levels accounting for the commonly occurring meteorological conditions in the Project areas.
- Road traffic noise levels with the inclusion of the Project road traffic were calculated to identify the potential change in the existing road traffic noise during the construction of the Project.
- Ground vibration levels were qualitatively assessed at nearby receptors based on the likely emission of vibration from plant and equipment and the separation distance to the nearby receptors.
- The predicted noise and vibration levels were evaluated against the adopted assessment criteria to demonstrate compliance to relevant acoustic standards, policy and guidelines.
- The predicted noise levels and monitored existing noise levels were referenced to identify the potential for impacts associated with audible noise from Project activities.
- The assessment of noise and vibration levels was applied to identify the measures necessary to reduce noise and vibration levels and potentially mitigate impacts.

The monitored existing environmental noise levels are detailed in **Section 4** and the noise and vibration assessment criteria applied to the Project are detailed in **Section 5**.

The assessment methodology is discussed in further detailed in **Section 6**, including; the noise prediction modelling, source noise emission levels, adopted meteorological conditions, typical vibration levels and the road traffic movements associated with the Project.

3 Project description

A detailed Project description is provided in the Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project EIS. A summary of the key Project stages applied in the assessment of noise and vibration impacts is provided below.

3.1 Barge Unloading Facility

The construction of a BUF is required to allow for dredged material from the Gatcombe and Golding Cutting shipping channels to be unloaded. Material from the dredging activities will be loaded on to barges which will transport the material to the BUF to be unloaded using large excavators into trucks for placement within the existing WB and WBE reclamation areas.

The construction of the BUF will involve the installation of sheet piles or similar earth retaining structure to form a 'U shaped' barge dock adjacent to the existing WB reclamation area (refer **Figure 1**). Two short rock bunds comprising core material and protected with armour sourced from the Targinnie/Yarwun quarry location will be installed between the sheet pile or similar earth retaining structure dock and the existing WB reclamation area bund wall. The footprint within the enclosed sheet pile structure will be filled with material to allow excavators (six in total with three each side of the dock) and trucks to transport dredged material from the barges into the existing WB and WBE reclamation areas.

The construction of the BUF will take approximately 12 months and will be constructed as part of the reclamation bund wall construction program. The sheet piling works required for the BUF construction will be 2 to 3 months in duration.

3.2 Initial dredging works

Initial dredging works of approximately 0.25 Mm^3 of seabed material is required prior to dredging works associated with the Gatcombe and Golding Cutting Channels to establish a channel to allow barges to access the BUF (refer **Figure 1**). The initial dredging works will be six and a half weeks in duration.

A small cutter suction dredger (CSD) and a TSHD are proposed for the barge access channel dredging works. The CSD is a hydraulic dredger which operates by swinging about a central spud using anchors and winches. The CSD clears an arc of cut by winching on alternative sides and moving forward by pushing against the central spud.

The principal sources of noise for the CSD would be the mechanical plant on the main deck which power the dredging plant, the hydraulics and provide suction and pumping to transfer the dredged material.

The TSHD is described in **Section 3.4**.

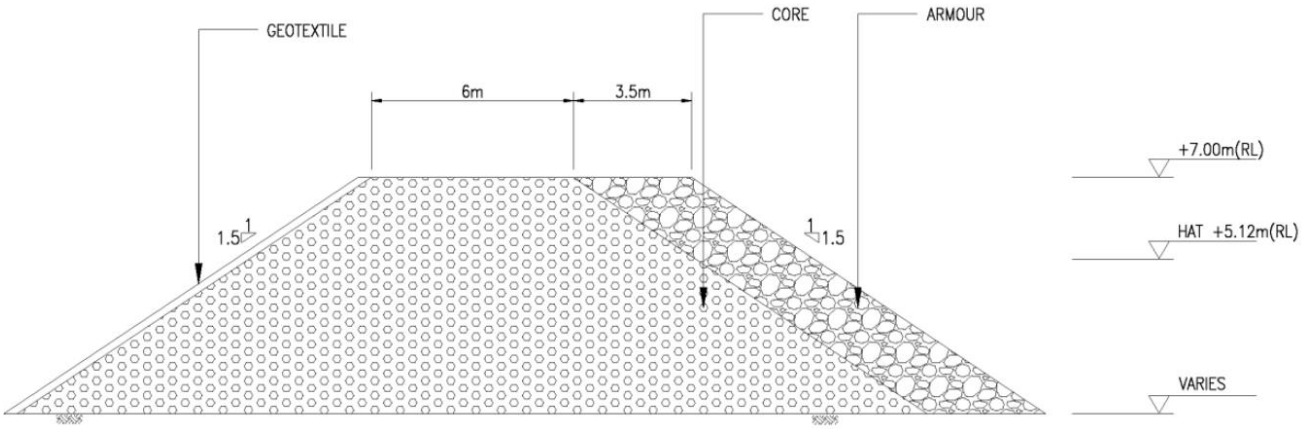
3.3 Western Basin Expansion reclamation area

The WBE reclamation area will require the construction works summarised below to establish the northern and southern reclamation areas.

The outer seaward bund walls of the reclamation areas will be constructed of rock sourced from the Yarwun/Targinnie quarry area located off Landing Road at Targinnie. The rock armour material will be transported by haul truck on the existing road network to the WBE reclamation area where it will be installed by construction plant to create the footprint of the reclamation area.

The bund walls will be topped off with earth material to bring the walls to the final design levels (i.e. minimum +7 m lowest astronomical tide (LAT)). Once complete a geotextile will be placed on the inner face of the outer bund walls to minimise migration of dredged material fines through the bund wall. An example cross section of the concept bund wall, armour, core and geotextile construction is shown in **Figure 2**.

Figure 2 Western Basin Expansion typical bund wall cross section



The dredged material will be transported into the existing WB and proposed WBE reclamation areas (i.e. northern and southern reclamation areas) and spread into primary internal cells to be filled out in turn. A secondary cell and final polishing cell will be utilised to ensure the decant water flow and facilitate discrete settling of suspended particles.

3.4 Dredging of the Gatcombe and Golding Cutting shipping channel

The existing Gatcombe and Golding Cutting shipping channel will be dredged to provide a permanent duplicated channel parallel to the main shipping channel (Channel Duplication). The proposed duplicate channel will be approximately 15 km long and dredging is proposed to be undertaken to an ultimate depth of -16.1 m LAT, width a channel width of 200 m. The channel will be of sufficient depth to allow an improved two-way passage into the Port under all weather and tidal conditions.

Two dredging campaign options are proposed and will be selected upon predicted throughput and associated vessel movements. At this stage it is envisaged that the Project dredging will be undertaken over two stages. However, should the need and/or growth for Port trade justify the need for the final design channel depth, the two stages will be combined into a singular campaign. Stage 1 is proposed to commence in 2023 or later with a duration of 33 weeks and dredging to a depth of to -13.5 m LAT. Stage 2 would follow in 2026 or later and be a further 25 weeks of dredging, resulting in an ultimate dredging depth of -16.1 m LAT. It is expected that combining Stage 1 and Stage 2, would result in a 58 week dredging campaign.

The proposed Stage 1 and Stage 2 dredging areas are shown in **Figure 3** and **Figure 4**.

A number of dredging equipment and methodology options were investigated as part of the EIS. The feasibility study identified that the TSHD is the preferred dredger for undertaking the Channel Duplication dredging. The dredged material from the TSHD would be pumped into non-motorised barges. The barges will be propelled by pushbusters to the BUF where the barges will be unloaded using excavators. The dredged material will be placed into haulage trucks which will take the material to the WB and WBE reclamation areas for placement.

The TSHD is a self-propelled, highly manoeuvrable vessel which navigates pre-planned tracks with the drag arms lowered onto the sea floor. The Project dredging methodology involves utilising a TSHD which loads the dredged material from the Channel Duplication area to be dredged into barges (four barges will be working in cycles for the entire dredging operations) which will transport the material to the BUF to unloaded using large excavators into trucks for placement with the WB and WBE reclamation areas.

The TSHD has the capacity to operate 24 hours a day, 7 days a week using multiple crews which are accommodated on board. At fortnightly intervals the TSHD would cease operations and berth for up to 24 hours to facilitate crew changes, bunkering and provisioning.

The principal sources of noise for the TSHD would be the mechanical plant on the main deck which power the dredging plant, the hydraulics and provide suction and pumping to transfer the dredged material.

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Gatcombe Channel

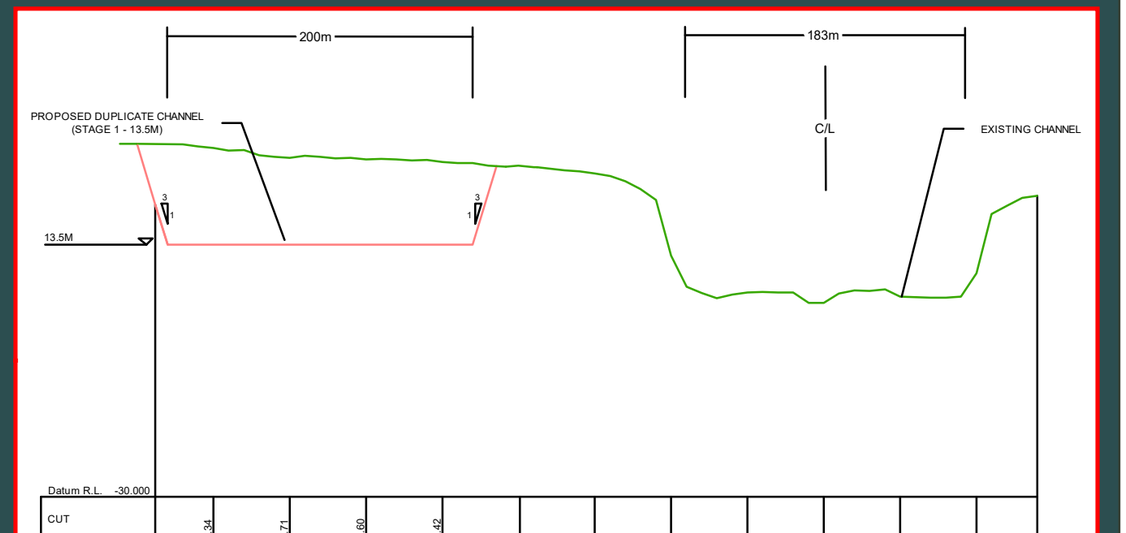
Facing Island

Boyne Island

Golding Cutting Channel

Legend

- Proposed Channel Duplication Project extent
- Existing shipping channels
- Stage 1 area to be dredged (currently above -13.5m LAT)



Datum R.L. -30.000											
CUT	-6.34	-5.71	-5.60	-5.42							
CHANNEL -10.86	-13.50	-13.50	-13.50	-13.50							
NATURAL SURFACE	-7.16	-7.79	-7.90	-8.08	-8.32	-8.82	-14.20	-16.64	-17.32	-16.90	-15.38	-10.28

STAGE 1 - 13.5M
CROSS SECTION THROUGH GOLDING CUTTING CHANNEL
NTS

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)

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Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 3: Proposed area to be dredged - Stage 1 (-13.5m LAT)

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Legend

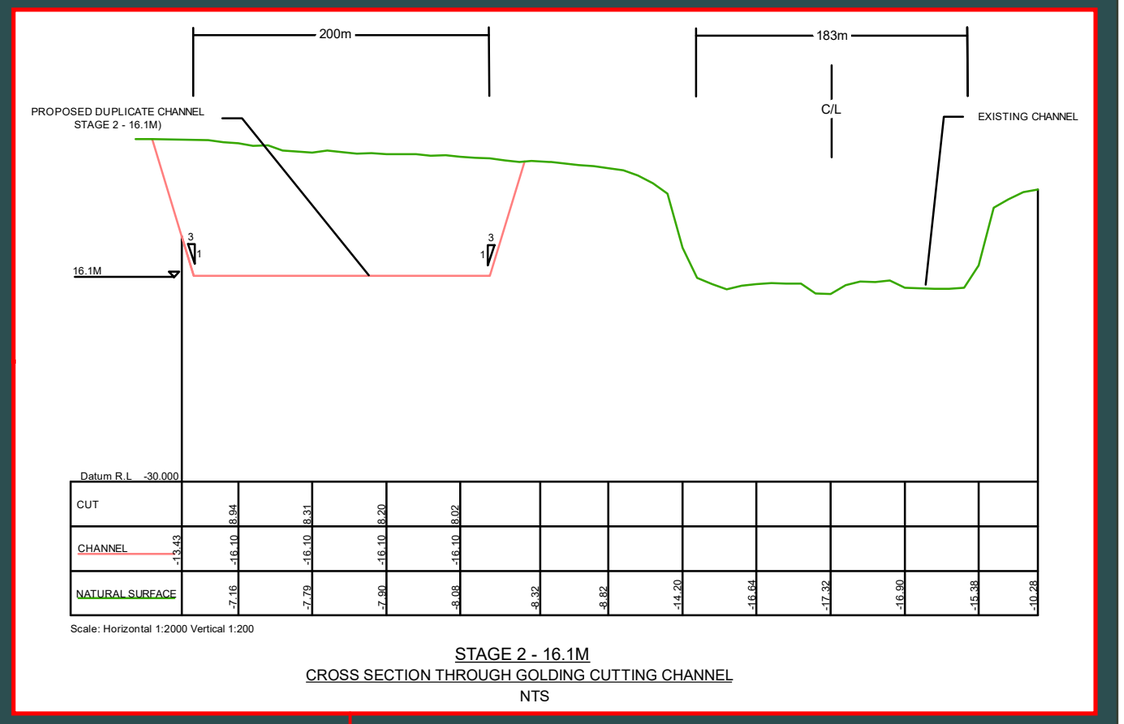
- Proposed Channel Duplication Project extent
- Existing shipping channels
- Stage 2 area to be dredged (to achieve -16.1m LAT)

Gatcombe Channel

Facing Island

Boyne Island

Golding Cutting Channel



CUT	-8.94	-8.31	-8.20	-8.02							
CHANNEL -13.43	-16.10	-16.10	-16.10	-16.10							
NATURAL SURFACE	-7.16	-7.79	-7.90	-8.08	-8.32	-8.82	-14.20	-16.64	-17.32	-16.90	-15.38	-10.28

Scale: Horizontal 1:2000 Vertical 1:200

STAGE 2 - 16.1M
CROSS SECTION THROUGH GOLDING CUTTING CHANNEL
NTS

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)

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0 500 1,000

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Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 4: Proposed area to be dredged - Stage 2 (-16.1m LAT)

3.5 Navigational aids

For the safe passage within the Gatcombe and Golding Cutting Channels, the Project will require two of the existing navigational aids in the channel to be removed, five navigational aids to be relocated and a further five new navigational aids installed. The relocation and installation of the navigational aids will be undertaken by a pile extractor and piling hammer located on a barge. The pile will be moved into a vertical position by crane then the pile hammer will be attached to the head of the pile. Using small hammer drops to ensure the penetration is vertical the pile will be driven to the design depth. The pile will be prepared, protection material applied underwater and the batteries, solar panels and specified lights installed.

3.6 Other construction activities

The Project will also require the establishment of a construction compound and the construction of internal stormwater ponds at the WBE reclamation area along with the daily mobilisation of the workforce. The temporary construction works are not expected to be noise intensive activities, and potential noise and vibration levels are not expected to result in impacts within the adjacent communities. A detailed assessment of noise and vibration has been deemed to not be necessary for those other construction activities.

3.7 Maintenance dredging

Maintenance dredging will generally be required on an annual basis for the Gatcombe and Golding Cutting duplicated channels, and the barge access channel following the Project dredging works as the sediments stabilise. Based on previous maintenance dredging in the Port of Gladstone, maintenance dredging requirements are unlikely to be significant and will be restricted to batter slipping and siltation at the toe of dredged areas.

Analysis of the sediment dynamics modelling indicates that the overall net annualised siltation rate within the shipping channels of the Port is likely to increase by approximately 7% following the completion of the Project.

Based on the previous maintenance dredging for the existing channels, the use of a TSHD is likely to be the preferred maintenance dredging methodology. The Port-wide maintenance dredging campaign, including the Channel Duplication project areas to be dredged, would place material within the existing East Banks dredged material placement area (DMPA) (until full capacity is achieved). The Port-wide maintenance dredging campaign would typically be 4 to 6 weeks per year.

3.8 Project schedule

An overview of the Project timeframe and the anticipated hours of work are provided below.

- The transport of bund wall material and the construction of the WBE reclamation area (southern and northern areas) would be completed over an 18-month period per area and is expected to be undertaken between Monday to Saturday during daytime construction hours of 6.30 am to 6.30 pm.
- The construction of the BUF is expected to be conducted over a 12-month period from Monday to Saturday during daytime construction hours of 6.30 am to 6.30 pm. Although the construction of the BUF may take approximately 12 months, the actual period of sheet pile driving or similar earth retaining structure construction is likely to be about 2 to 3 months. The BUF will be constructed simultaneously with the construction of the WBE reclamation area.
- The initial dredging of the barge access channel will be undertaken over a 6 and a half week period prior to the Channel Duplication dredging.

- The dredging of the duplicate channels and barge operations including unloading and placement of dredged material is expected to be undertaken over two dredging campaigns, with the first dredging campaign lasting approximately 33 weeks, and the second dredging campaign lasting approximately 25 weeks. If the dredging is undertaken over a single campaign the total timeframe is expected to be 58 weeks.
- All Project dredging will generally occur 24 hours per day for 7 days a week, with dredgers ceasing operation for crew changes, bunkering and provisioning.
- The placement of the dredged material within the WB and WBE reclamation areas will generally be 24 hours per day for 7 days a week throughout the dredging campaign program, with dredgers and associated barges and pushbusters ceasing operation for crew changes, bunkering and provisioning.
- The removal, relocation and new navigational aids will be installed between Monday to Saturday during standard daytime construction hours of 6.30 am to 6.30 pm.

4 Existing environment

4.1 Sensitive terrestrial noise receptors

Coastal areas of the Gladstone region include the communities of the greater city of Gladstone, Boyne Island, Tannum Sands and Facing Island. These communities are located within 3 km of Project activities and include the following noise sensitive receptors and land uses, as defined by Schedule 1 of the *Environmental Protection (Noise) Policy 2008* (Qld) (EPP (Noise)):

- Residential dwellings;
- Library and educational institutions;
- Childcare or kindergarten centres;
- Hospitals, surgery or other medical institutions;
- Commercial and retail land areas;
- Protected areas or an area identified under a conservation plan under the *Nature Conservation Act 1992* (Qld) as a critical habitat or an area of major interest; and
- Park or garden that is open to the public for the use other than for sport or organised entertainment.

The sensitive receptors listed in **Table 2** and presented in **Figure 5** and **Figure 6**, are representative of the nearest noise sensitive residential and non-residential receptors adjacent to the Project areas.

The receptors were selected as the nearest and/or potentially most affected receptors, to assess potential impacts within the surrounding communities and, as required, inform the mitigation measures to be implemented during Project activities. The selection of receptors was based on the proximity to the Project areas and providing a cross section of the different receptor types for the assessment of potential impacts at the communities on the mainland and nearby islands.

The nearest residential receptors at Facing Island are located within 1 km of the Channel Duplication area to be dredged, and the nearest residences in Targinnie are approximately 4 km from the WBE reclamation area.

Considerate of the significant separate distances from the Project areas (greater than 1 km) many of the sensitive receptors are located well away from potential sources of noise and vibration.

There are a range of industrial premises and industrial land uses at mainland Gladstone and on Curtis Island. The offices of the industrial premises can be defined as noise sensitive receptors. These offices will experience noise from their associated industrial activities and are not expected to be sensitive to noise from the construction and operation of the Project. For this reason, the industrial premises and land use have not been included as noise sensitive receptors in this assessment.

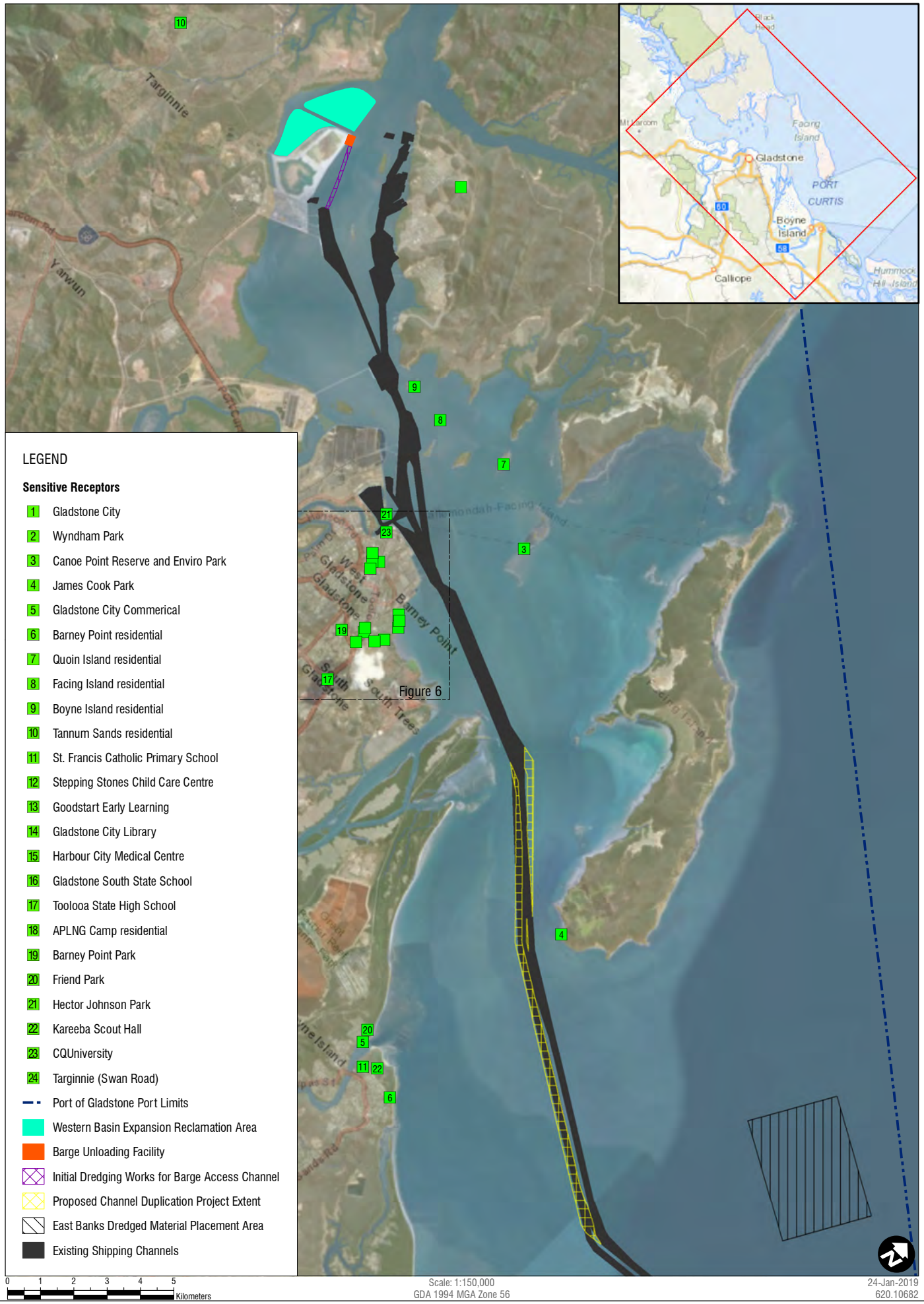
Table 2 Representative terrestrial noise sensitive receptors

ID	Sensitive receptor area/ name	Approximate distance to Project areas			
		Barge access channel	BUF	WBE reclamation areas	Channel duplication
Residential receptors and land-use					
1	Gladstone City	6.2 km	12.5 km	12.5 km	7.0 km
2	Barney Point	8.2 km	14.6 km	14.6 km	5.2 km
3	Quoin Island	7.3 km	13.2 km	13.5 km	6.0 km
4	Facing Island (northwest and south)	18.3 km	24.6 km	24.8 km	0.9 km
5	Boyne Island	20.7 km	27.0 km	26.8 km	5.1 km
6	Tannum Sands	22.4 km	28.6 km	28.5 km	4.7 km
7	Turtle Island	5.0 km	10.6 km	10.9 km	8.5 km
8	Witt Island	2.7 km	8.7 km	9.0 km	10.1 km
9	Tide Island	1.4 km	7.5 km	7.9 km	11.3 km
10	Targinnie	6.4 km	6.1 km	4.3 km	24.1 km
Library, educational, childcare or health uses.					
11	St. Francis Catholic Primary School, Tannum Sands	21.4 km	27.7 km	27.5 km	5.3 km
12	Stepping Stones Child Care Centre, Gladstone	6.5 km	12.7 km	12.7 km	7.1 km
13	Goodstart Early Learning, Gladstone	8.4 km	14.6 km	14.5 km	5.9 km
14	Gladstone City Library, Gladstone	6.0 km	12.3 km	12.2 km	7.4 km
15	Harbour City Medical Centre, South Gladstone	8.3 km	14.5 km	14.4 km	5.9 km
16	Gladstone South State School, South Gladstone	8.7 km	14.9 km	14.8 km	5.9 km
17	Toolooa State High School, Gladstone	9.9 km	16.1 km	15.8 km	6.0 km
18	Kareeba Scout Hall, Barney Point	8.6 km	14.9 km	14.8 km	5.5 km
19	CQ University Gladstone Campus, Gladstone	8.4 km	14.6 km	14.4 km	6.4 km
20	Gladstone Central State School	6.1 km	12.5 km	12.4 km	7.1 km
Park or nature conservation					
21	Wyndham Park, Boyne Island	20.3 km	26.6 km	26.4 km	4.9 km
22	Spinnaker Parklands	4.8 km	11.1 km	11.2 km	8.1 km
23	Canoe Point Botanic Reserve & Environmental Park	21.5 km	27.8 km	27.6 km	4.9 km
24	James Cook Park, Gladstone	5.4 km	11.7 km	11.7 km	7.7 km
25	Barney Point Park, Barney Point	7.9 km	14.2 km	14.6 km	5.2 km

ID	Sensitive receptor area/ name	Approximate distance to Project areas			
		Barge access channel	BUF	WBE reclamation areas	Channel duplication
26	Friend Park, Barney Point	8.0 km	14.4 km	14.4 km	5.3 km
27	Hector Johnson Park, Barney Point	8.6 km	14.9 km	14.9 km	5.3 km
Commercial/ retail					
28	Gladstone City	6.3 km	12.5 km	12.5 km	7.2 km

The coastline of Gladstone and the local islands, particularly the coastal habitats, provide migratory shorebird habitat. As confirmed in the terrestrial ecology information collated as part of the Project EIS (refer Chapter 9, nature conservation) the WBE reclamation area, the BUF and the barge access channel are generally located within 500 m of confirmed roost sites for migratory shorebirds, while other roosting areas are located at least 1 km from the Channel Duplication area to be dredged. The general areas for roosting sites are shown in **Figure 7**.

The potential habitat mapped in the figure is considered suitable habitat for both migratory and resident shorebird species, including the Beach stone curlew and other non-conservation significant resident shorebirds. Non-migratory shorebirds may utilise coastal habitats adjacent to the Project impact areas although nesting sites have not been confirmed.



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Port of Gladstone Channel Duplication
Sensitive Receptors

FIGURE 5

Scale: 1:30,000
GDA 1994 MGA Zone 56

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Port of Gladstone Channel Duplication
Sensitive Receptors

FIGURE 6

Gladstone Ports Corporation
Growth, Prosperity, Community.

aurecon

The Narrows
Graham's Creek
Friend Point
NAR1
Curtis Island
SMIS
Calliope River
FAIS
Gatcombe Channel
Golding Cutting Channel
Boyne Island
BOYN
Tannum Sands
Boyne River
Port Limits

NAR1
Western Basin Expansion Reclamation Area
Northern Reclamation Area
Southern Reclamation Area
SMIS

Legend

Potential impact areas

- Western Basin Expansion reclamation area
- Proposed Channel Duplication Project extent
- Area to be dredged
- Initial dredging works for barge access channel
- Barge unloading facility
- Construction compound
- Quarry to Western Basin Expansion reclamation area (Gladstone Regional Council controlled roads)
- Yarwun/Targinnie general quarry location
- East Banks dredged material placement area (DMPA)
- Great Barrier Reef Marine Park boundary
- Port of Gladstone Port limits
- Existing shipping channels
- Potential habitat for migratory birds
- Important roost sites (IMEMS 2013)

Important roosts on the Curtis Coast (Wildlife Unlimited Annual Summer Survey)

2013
- Roost 100-499 birds
- Roost >1000 birds

2015
- Roost 100-499 birds
- Roost >1000 birds

2016
- Roost 100-499 birds
- Roost >1000 birds

2017
- Roost 100-499 birds
- Roost >1000 birds

Note:
Birdlife Australia (2015) - note that this layer has been amended to reflect Aurecon field surveys within areas of assessment.

Source:
Aerial: GPC (2015) and DigitalGlobe Web Map Service (2013)
Important roosts on the Curtis Coast: Report for Migratory Shorebird Monitoring - Port Curtis and the Curtis Coast - Annual Summer Survey, prepared by Wildlife Unlimited (2013), (2015), (2016), (2017)

Map by: RB
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Coordinate system: GDA_1994_MGA_Zone_56

Gatcombe and Golding Cutting Channel Duplication Project

Figure 7: Potential shorebird habitat and important roost sites

4.2 Existing noise environment

In 2014, SLR carried out a noise monitoring survey in Gladstone to:

- Measure the existing daytime, evening and night-time noise levels within the vicinity of the proposed Project activities and the local communities.
- Identify the influence of existing sources of noise upon the local environment.
- Establish representative background noise levels (prior to Project activities commencing) to define representative noise assessment criteria for the Project.

Three noise monitoring sites were selected at residential areas within 3 km of the proposed Project to quantify the noise environment at locations representative of the nearest residential communities. Monitoring locations were selected for their proximity to the sensitive receptors and to be readily and safely accessible. The locations were set back from main roads and local industry to quantify the noise environment of the residential communities.

The following monitoring locations were selected, as shown in **Figure 8**:

- Location 1 – Sutton Street, Barney Point, representative of nearest receptors to the west of the Channel Duplication.
- Location 2 – Alkina Crescent at Boyne Island, approximately 4.9 km from the Channel Duplication to be representative of the residential communities near Boyne Island, Tannum Sand and Facing Island.
- Location 3 – Sea Belle Esplanade, Facing Island, located approximately 0.9 km from the Channel Duplication and the installation of new navigation aids adjacent to the shipping channels.

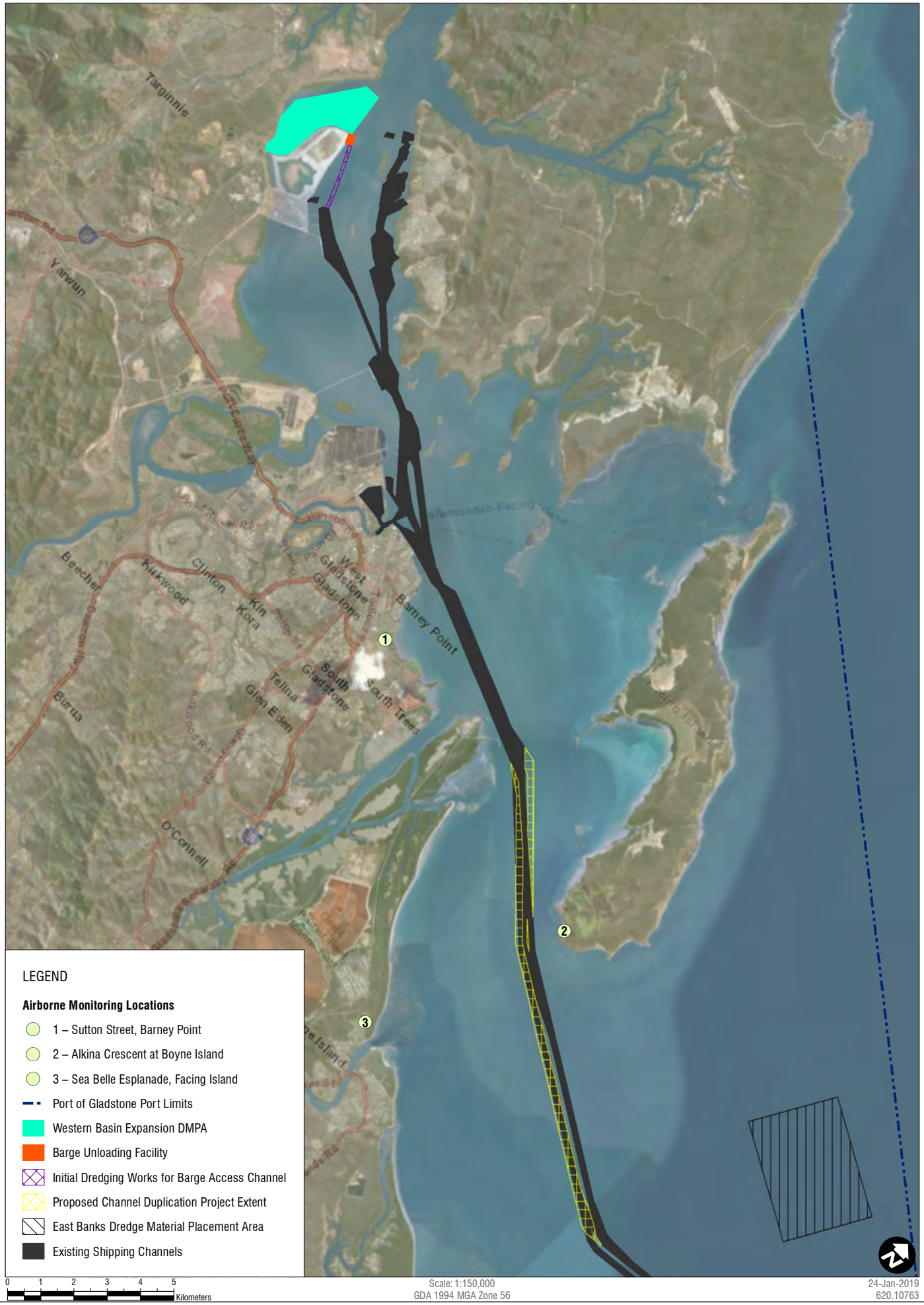
At each location the noise monitoring equipment was deployed to continuously measure ambient noise levels. The noise monitoring survey was supplemented by noise measurements made by SLR's acoustic consultant to identify and quantify local sources of noise influencing the long term measured noise levels.

Weather data from the Bureau of Meteorology Gladstone weather station was analysed to identify any periods of rainfall or wind speeds greater than 5 m/s as such weather conditions were unsatisfactory for environmental noise monitoring. Upon review with the weather data, approximately 12% of all noise measurements were excluded from the background noise survey.

To determine the existing noise environment, the monitored noise levels were analysed to define the following parameters:

- Rating Background Level (RBL) is the overall background noise level for the daytime (7.00 am to 6.00 pm), evening (6.00 pm to 10.00 pm) and night-time (10.00 pm to 7.00 am) periods and is the median of the measured hourly L_{A90} noise levels during each period.
- The RBL for each period was defined with reference to the EPP (Noise) and *Ecoaccess Guideline: Planning for Noise Control* (PNC).
- L_{Aeq} noise level is the A-weighted noise level that accounts for the total sound energy over the timeframe of interest. The L_{Aeq} noise level accounts for all fluctuations in sound to provide a single figure 'energy-average' for the considered event.

A detailed noise monitoring methodology, including equipment used and photographs of the noise monitoring set up, is provided in **Appendix A**.



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Port of Gladstone Channel Duplication Monitoring Locations

FIGURE 8

Indicative of the coastal location, the noise levels measured at each monitoring location were influenced by the local wind conditions. The wind conditions resulted in wind noise at the microphones as well as wind-blown vegetation and waves on the shoreline.

During periods when there was a lull in the wind conditions the measured noise levels were influenced by distant industrial noise from existing facilities at Gladstone. The industrial noise was characterised as an industrial 'hum' and based on the observations and measurements made during the noise survey. The current industrial operations in the Gladstone region for LNG facilities, aluminium smelter, alumina refinery and industry at Gladstone Port contributed to the measured ambient noise levels.

A measured steady-state noise level of L_{A90} 39 dBA is representative of existing daytime industrial noise at the Barney Point noise monitoring location. At the Boyne Island monitoring location, a measured noise level of L_{A90} 40 dBA is typical of existing daytime industrial noise. At the Facing Island monitoring location, the existing industrial noise was not a primary contribution to the measured noise levels.

The measured noise levels and description of existing noise sources made during the daytime by SLR's acoustic consultant are detailed in **Table 3**.

Table 3 Daytime noise measurements

Location	Date/ time	Measured noise level, dBA				Comments
		L_{A90}	L_{Aeq}	L_{A10}	L_{A1}	
Location 1 Barney Point	11 Sep 2014 5.30 pm	39	46	47	57	Industrial noise (hum) from existing facilities audible. Local road traffic vehicle and bird noise occasionally audible.
	4 Nov 2014 10.50 am	51	55	58	62	Noise levels affected by local wind conditions. During lull in the wind, the existing industrial premises on Curtis Island were audible as an industrial 'hum'.
Location 2 Boyne Island	11 Sep 2014 2.40 pm	40	44	46	52	Industrial noise (hum) from existing industrial plant audible. Local road traffic vehicle, bird calls and breeze blown vegetation occasionally audible.
	4 Nov 2014 12.00 pm	49	52	54	59	Noise levels affected by local wind conditions. During lull in the wind bird noise and breeze blown vegetation were dominant. Industrial noise from the existing sites just audible.
Location 3 Facing Island	12 Sep 2014 8.15 am	41	43	45	47	Beach breaks and wave noise dominant. Industrial noise (hum) from Gladstone was just audible. Other sources include recreational boats and bird calls.
	4 Nov 2014 8.50 am	48	51	54	56	Noise levels affected by local wind conditions resulting in dominant noise from waves and wind-blown vegetation.

The daily statistical noise levels measured by the noise loggers are shown graphically in **Appendix B**. The graphs show the various statistical noise levels measured over the individual 24-hour periods. The results of the analysed noise levels monitored by the noise loggers are summarised in **Table 4**.

Table 4 Long term monitoring noise levels

Location	Time period[1]	Rating Background Level, dBA	Ambient noise level, $L_{Aeq(1hour)}$ dBA
Location 1 Barney Point	Daytime	41	52
	Evening	41	46
	Night-time	43	53
Location 2 Boyne Island	Daytime	37	50
	Evening	37	46
	Night-time	35	51
Location 3 Facing Island	Daytime	36	52
	Evening	38	49
	Night-time	38	52

Table note 1: Daytime is 7.00am to 6.00pm, evening is 6.00pm to 10.00pm and night-time is 10.00pm to 7.00am

The RBLs at the three noise monitoring locations are generally consistent over the 24-hour period with a 1 dBA to 2 dBA variation in measured noise levels over the daytime, evening and night-time periods. This infers that when the coastal wind conditions are not influencing the measured noise levels, the background noise environment is relatively constant and can be considered indicative of the local ambient noise environment.

4.3 Regional meteorological conditions

The weather conditions at Gladstone have the potential to influence the propagation of noise from the proposed Project activities. The PNC guideline from the Department of Environment and Science (DES) advises that the prevailing wind conditions and temperature inversions are key weather conditions with the potential to affect noise propagation.

Wind speed and wind direction contribute to the propagation of noise within the environment. Downwind from a noise source the wind conditions can enhance the propagation of noise and equally being upwind of a noise source, the wind conditions act to suppress noise propagation.

The wind conditions can therefore influence both the level of noise experienced at a receptor location and the perception of specific sources of noise. Consistent with DES' PNC guideline, wind conditions are considered in noise assessments where the source to receptor wind speeds of 3 m/s or less (at 10 m above ground level) occur for 30% or more of the time in any assessment period (daytime, evening or night-time) in any season.

Temperature inversion weather conditions occur where the temperature of a layer of air in the atmosphere increases with height, rather than the typical conditions where air temperature decreases with height. This causes a layer of cool, still air being trapped below the warmer air. Temperature inversion conditions generally occur during the early morning and night-time periods during the winter months where little or no vertical air movement of the cool air layer can result in a refraction of sound waves and potentially enhance the propagation of noise.

The local weather conditions at Gladstone are complex due to the influence of the open water along the coastline and landmass of Curtis Island and Facing Island. To determine the wind conditions for the assessment of airborne noise at the time of establishing the noise model, weather data from the Bureau of Meteorology's Gladstone Airport weather station and the DES's South Gladstone weather station was obtained for the year 2016

SLR has reviewed current meteorological conditions and confirmed the adopted weather conditions for the noise modelling are consistent with the meteorological conditions expected in the Gladstone region during the Project activities.

The nearest monitoring stations are approximately 13 km from the WBE reclamation area and 9 km from the Channel Duplication area. Consequently, the meteorological parameters, solely derived from the weather station locations, may not be wholly representative the meteorological conditions at the locations of key noise emissions sources and local sensitive receptors.

Meteorological modelling was undertaken to provide specific meteorological conditions for the region of the WBE reclamation area (northern and southern areas) and the Channel Duplication area. Individual meteorological conditions were developed for the WBE reclamation area and Channel Duplication area because the prevailing wind conditions would vary along the coast line.

The meteorological modelling methodology is detailed in **Appendix C** and the wind conditions and atmospheric stability have been reported consistent with the requirements of the PNC. The analysis of regional meteorology determined the outcomes below which have been referenced in defining the meteorological conditions adopted in the noise propagation calculations undertaken in this assessment.

- Temperature inversion conditions are not a feature of the area because the coast location does not result in calm, stable atmospheric conditions necessary for a temperature inversion to form. The D-Class Pasquill-Gifford atmospheric stability category was the most commonly occurring event, which is representative of a 'neutral' atmospheric stability.
- In the region of the WBE reclamation area and the nearest communities at Targinnie, the wind speed conditions are commonly above 3 m/s. On this basis, the PNC guideline does not define wind as a feature for the area when assessing noise impacts.
- Based on the daytime, evening and night-time periods in each season, the most commonly occurring prevailing wind direction of east northeast for the daytime and southeast for the night-time for wind speeds up to 3 m/s have been referenced in the assessment of noise from construction and operational activities at the WBE reclamation area.
- Similarly, the coastal wind conditions in the locality of the Channel Duplication area and nearby communities at Facing Island, Boyne Island and Gladstone commonly result in wind speed conditions above 3 m/s. On this basis the PNC guideline does not define wind as a feature for the area.
- For wind speeds up to 3 m/s the prevailing wind direction of south southeast was the most commonly occurring prevailing wind direction during the night-time periods. The night-time would be the most sensitive period for the proposed 24/7 activities for the duplication of the Gatcombe and Golding Cutting Channels.

5 Environmental values and assessment criteria

The environmental values relevant to potential impacts from airborne noise are defined in the *Environmental Protection Act 1994* (Qld) (EP Act). The environmental values of public amenity, public safety and ecological health are to be maintained under the EP Act. The EPP (Noise) is subordinate legislation under the EP Act and prescribes the following environmental values, which are aligned to the environmental values of the EP Act:

- The qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystem;

- The qualities of the acoustic environment that are conducive to human health and wellbeing, including by ensuring a suitable acoustic environment for individuals to do any of the following:
    - Sleep;
    - Study or learn; and
    - Be involved in recreation, including relaxation and conversation; and
- The qualities of the acoustic environment conducive to protecting the amenity of the community.

5.1 Noise assessment criteria – maintenance activities

The operational phase of the Project includes the maintenance dredging works for the duplicate channel and barge access channel. It is important to note the Project maintenance dredging will be undertaken as part of GPC's Port-wide maintenance dredging program. As discussed in **Section 3.7**, the maintenance dredging will be undertaken 24-hours a day and require dredging over a 4 to 6-week period per year.

The EPP (Noise) contains acoustic quality objectives for receptors potentially sensitive to noise. Where the overall level of noise at the receptors, from all sources but excluding road and rail transport noise, are within the acoustic quality objectives, the environmental values are achieved.

The acoustic quality objectives for the noise sensitive receptors and land use are presented in **Table 5**. The Project operations will require continuous operation of plant; as such the assessment has adopted the 1-hour L_{Aeq} acoustic quality objectives to assess the noise emissions from fixed and mobile noise sources. Due to the steady-state noise emission associated with the maintenance dredging works, where the L_{Aeq} acoustic objectives are achieved the L_{A10} and L_{A1} acoustic objectives would be expected to be met.

The assessment of maintenance dredging noise emissions against the acoustic quality objectives has referenced a noise level from existing industrial premises of L_{Aeq} 40 dBA at residential receptors as determined by the noise monitoring survey.

Table 5 Acoustic quality objectives

Receptor type	Time of day	Acoustic quality objectives		
		$L_{Aeq,adj,(1hr)}$	$L_{A10,adj,(1hr)}$	$L_{A1,adj,(1hr)}$
Residential dwelling (outdoors)	Day time and evening	50	55	65
Residential dwelling (indoors)	Daytime and evening	35	40	45
	Night-time	30	35	40
Library and education institutions (indoors)	When open for business or when classes offered	35	-	-
Childcare centre or kindergarten (indoors)	When open for business, other than when children usually asleep	35	-	-
Childcare centre or kindergarten (indoors)	When children usually asleep,	30	-	-
School or playground (outdoors)	When the children usually play outside	55	-	-
Hospital, surgery or other medical institution (indoors)	Visiting hours	35	-	-

Receptor type	Time of day	Acoustic quality objectives		
		$L_{Aeq,adj,(1hr)}$	$L_{A10,adj,(1hr)}$	$L_{A1,adj,(1hr)}$
Hospital, surgery or other medical institution (indoors)	Anytime, other than visiting hours	30	-	-
Commercial and retail activity (indoors)	When the activity is open for business	45	-	-
Park or garden that is open to the public for use other than for sport or organised entertainment	Anytime	The level of noise that preserves the amenity of the existing park or garden		

Source Schedule 1 EPP (Noise)

To assess noise levels during the night-time periods an outdoor acoustic quality objective of L_{Aeq} 39 dBA was adopted to achieve the indoor night-time acoustic quality objective of L_{Aeq} 30 dBA. The outdoor objective assumes a conservative 9 dB difference in outdoor and indoor noise levels, where windows are open for ventilation. The 9 dB difference has been referenced from measurement of indoor and outdoor noise at residences by SLR on previous projects.

In addition to the acoustic quality objectives, the EPP (Noise) also seeks to control intrusive noise through the Policy's 'background creep' noise level requirements. Background creep occurs when the noise levels increase over time with the establishment of new development in or near an area. To ensure the level of noise in an area does not continue to increase unreasonably, background creep needs to be controlled.

To the extent that it is reasonable to do so, the $L_{Aeq,adj,T}$ noise levels from the operation of the Project must not be greater than 5 dBA above the existing acoustic environment, as measured by the $L_{A90,T}$ noise levels. Referencing the RBLs from the noise monitoring survey, the noise emissions levels to manage background creep are detailed in **Table 6**. The noise criteria apply outdoors at the noise sensitive receptors.

At Barney Point (Location 1) and Facing Island (Location 3) the evening or night-time RBLs were higher than the daytime RBL, mainly due to the wind and wave noise at the coastline. Because the night-time is the most sensitive period for noise, the lower daytime or evening or night-time RBL was referenced to establish suitably stringent night-time noise assessment criteria.

Table 6 Intrusive noise assessment criteria

Noise survey area	Rating Background Level, dBA			Intrusive noise criteria, $L_{Aeq,adj,(1hour)}$ dBA		
	Daytime	Evening	Night-time	Daytime	Evening	Night-time
Location 1 Barney Point	41	41	43	46	46	46
Location 2 Boyne Island	37	37	35	42	42	40
Location 3 Facing Island	36	38	38	41	41	41

Table note: Rating Background Levels as determined by the 2014 noise monitoring survey.

For both the acoustic quality objectives and the intrusive noise criteria, the abbreviation 'adj' refers to adjustment made for potentially annoying noise characteristics such as tonality and impulsivity.

5.2 Noise assessment criteria – construction activities

The key construction activities required for the Project are summarised below, and the construction noise emissions have been assessed against the criteria outlined in this section.

- Construction of the reclamation bund walls at the WBE reclamation area and construction of the BUF at the existing WB reclamation area;
- Dredging of the barge access channel and transfer of dredged material to the existing WB reclamation area;
- Dredging of the Channel Duplication and transfer of dredged material to the BUF;
- Unloading dredged material at the BUF and transfer of dredged material to the WB and WBE reclamation areas; and
- Installation of navigational aids.

In Queensland, the current legislation and State and Local Government policies or guidelines do not prescribe numerical noise limits or noise criteria for construction activities. The EP Act, Section 440R states the following for building works:

> *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.*

In lieu of numerical noise limits, the acoustic quality objectives from the EPP (Noise) (refer **Table 5**) have been referenced to provide target criteria for the assessment of noise during construction activities. Whilst the EPP (Noise) does not apply to construction works, for assessing construction noise in this report, the acoustic quality objectives were deemed a suitable reference, on the basis that:

- The construction plant would be operated over work stages of at least 1 year and the acoustic quality objectives would inform the long term management of noise to control potential impacts to long term health and wellbeing.
- The noise emission characteristics for construction activities using the dredgers would be similar to the noise emission characteristics of the larger dredger in use during maintenance dredging operations. The community may deem the noise emission characteristics from construction and operation activities to be similar in nature (i.e. the potential for noise impacts could be the same).
- The objectives provide noise management targets for the daytime, evening and night-time periods which are applicable to some construction activities which are proposed to be undertaken 24/7.

It is important to acknowledge that the EPP (Noise) is not applicable to construction works. In this regard, the acoustic quality objectives have only been applied to assist the assessment of construction noise and inform the need for mitigation measures to manage construction noise where noise related impacts have been identified as a potential consequence of the proposed activities.

5.3 Noise assessment criteria – road traffic

The construction phase of the Project will temporarily introduce light and heavy vehicles to the existing road network. It is appropriate to assess the potential incremental change in road traffic noise levels due to the changes in daily traffic volumes.

The Queensland Department of Transport and Main Roads (DTMR) provide guidance on the assessment of road traffic noise in the *Transport Noise Management - Code of Practice, Volume 2 – Construction Noise and Vibration* (2013).

The Code of Practice recommends that the overall road traffic noise level is controlled so that the construction traffic does not increase the existing hourly L_{A10} road traffic noise by more than 3 dBA.

The construction traffic should be generally assessed out to a minimum of 500 m beyond the project area boundary. This distance may be increased where it is reasonable to assume that the community would perceive the construction traffic is associated with the project.

The increase in road traffic noise due to construction traffic should be considered against the median minimum $L_{A10(1hr)}$ noise levels for each of the relevant hours within each work period. The assessment criteria have been developed from predicted existing road traffic noise from the proposed haulage route between the Yarwun/ Targinnie quarry area and the WBE reclamation area. The predicted existing road traffic levels and an assessment to identify if a greater than 3 dBA increase in road traffic noise will occur is provided in **Section 9**.

5.4 Noise assessment criteria terrestrial fauna

The acoustic quality objectives of the EPP (Noise) define a protected area or an area under the *Nature Conservation Act 1992* (Qld) (NC Act) as a critical habitat or an area of major interest. The noise environment of such environments needs to be managed to maintain the environmental values of health and biodiversity of ecosystems.

While the migratory shorebird habitat in proximity to the Project impact areas is not listed as a protected area under the provisions of the NC Act, it is known to regularly support migratory shorebirds, including species of conservation significance as listed under the provisions of the NC Act and the EPBC Act. As such, the EPP (Noise) objectives have been considered in the assessment of noise impacts on terrestrial fauna species.

In situations where statutory regulations or policies do not nominate numerical limits for an ecosystem, such as terrestrial fauna, it is common practice to refer to relevant Australian or internationally recognised standards and published literature that define noise criteria for similar contexts and relevant species/taxa.

Despite the difficulties associated with assessing noise impacts on terrestrial fauna, there are some studies which can assist in developing guideline noise criteria which can be used as triggers for potential noise related impacts. The literature in this field has been collated in a number of reviews which have been considered in this report, including:

- AMEC Americas Limited (2005), *Mackenzie Gas Project Effects of Noise on Wildlife* prepared for Imperial Oil Resources Ventures Limited.
- Dawe, G. and M. Goosem (2008), *Noise Disturbance along Highways: Kuranda Range Road Upgrade Project*. Report to the Marine and Tropical Sciences Research Facility. Reef and Rainforest Research Centre Limited, Cairns.
- Manci, K. M., D.N. Gladwin, R. Villella, and M.G. Cavendish (1988), *Effects of aircraft noise and sonic booms on domestic animals and wildlife; a literature synthesis*. U.S. Fish and Wildlife Service. National Ecology Research Centre, Ft Collins, CO. NERC-88/29.
- U.S. Department of Transportation Federal Highway Administration (2004), *Synthesis of Noise Effects on Wildlife Populations*. Publication No. FHWA-HEP-06-016.
- Wright, M.D., Goodman, P. and Cameron, T.C. (2010). *Exploring behavioural response of shorebirds to impulsive noise*. Wildfowl 60.

The noise criteria in **Table 7** have been developed with reference to the above literature and have been applied in this assessment as guideline thresholds for the evaluation of potential noise related impacts to shorebirds.

Table 7 Likely effects on terrestrial fauna due to noise levels

Disturbance effect	Steady or continuous noise sources L_{Aeq}	Episodic single or short-term noise sources L_{Amax}	Typical bird activities potentially impacted
Occasional alert – minor impacts on habitat use for most species	50 to 65 dBA	45 to 60 dBA	Nesting of non-migratory shorebirds and foraging of migratory and non-migratory shorebirds
Frequent alarm or flight – moderate impacts on habitat use	65 to 85 dBA	60 to 80 dBA	Nesting of non-migratory shorebirds and foraging of migratory and non-migratory shorebirds
Avoidance of area by most of the population of some species.	≥85 dBA	≥80 dBA	Nesting of non-migratory shorebirds and foraging of migratory and non-migratory shorebirds

5.5 Vibration assessment criteria

The mobile plant and equipment required for the construction of the WBE reclamation area have the potential to be a source of ground vibration. Ground vibration experienced at sensitive receptors can be associated with two main types of impacts; disturbance to occupants of buildings and cosmetic structural damage to buildings.

Most assessments of human response to vibration and the risk of damage to buildings use measurements of vibration velocity. This is often expressed as the peak particle velocity (PPV) which is the maximum instantaneous vibration velocity (without averaging).

In Queensland, the current legislation does not prescribe specific ground vibration limits. To establish ground vibration assessment criteria, the following standards and guidelines, typically adopted by industry in Australia for the assessment of impacts of ground vibration, were reviewed:

- The New South Wales (NSW) Department of Environment and Climate Change (DECC) *Assessing Vibration: A Technical Guideline*, 2006.
- British Standard BS5228-2:2009 *Code of Practice for Noise and Vibration Control on Construction and Open Site – Part 2: Vibration*.
- British Standard BS6472-2008: *Evaluation of Human Exposure to Vibration in Buildings* (1 kHz to 80 Hz).
- British Standard BS7385-1993: *Evaluation and Measurement for Vibrations in Buildings – Part 2 Guide to Damage Levels from Ground-Borne Vibration*.
- German Standard DIN 4150, Part 3-1999: *Structural Vibration in Buildings: Effects on Structures*.

5.5.1 Effect of vibration on human comfort

Humans are more sensitive to vibration than is commonly realised. They can detect and possibly even be annoyed at vibration levels which are well below those causing any risk of damage to a building or its contents. The actual perception of motion or vibration may not be disturbing or annoying.

An individual's response to that perception, and whether the vibration is 'normal' or 'abnormal', depends very strongly on previous experience and expectations. 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.

The mobile plant and equipment proposed for the construction and operational phases of the Project can considered intermittent sources of potential vibration because, being mobile and not required to be in use all the time, they will not be a continuous source of vibration emissions. British Standard 5228 provides the PPV levels of vibration in **Table 8** to assist the management of vibration to minimise the risks of adverse comment.

Table 8 Guidelines on the effects of vibration levels

Vibration levels	Potential effects of perceptible vibration
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.3 mm/s	Vibration might just be perceptible in residential environments.
1.0 mm/s	It is likely that vibration of this level in residential environments will cause complaint but can be tolerated if prior warning and explanation has been given to residents.
10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure to this level.

Based on the guidance in **Table 8**, the assessment has adopted a received vibration level of 0.14 mm/s as a trigger for the management of vibration levels and control of potential impacts from perceptible vibration at all sensitive receptors. The adopted trigger level is consistent with guidance from the NSW *Assessing Vibration: A Technical Guideline* and *German Standard DIN4150* for managing perceptible vibration.

5.5.2 Effect of vibration on structures

The BS7385 – Part 2 gives the frequency dependent vibration guideline values and assessment values for the effect on structures. The Standard sets guide values for vibration based on the lowest vibration levels above which cosmetic damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration-induced cosmetic damage, where minimal risk is usually taken as a 95% probability of no effect.

The recommended guideline limits transient vibration to minimise risk of cosmetic damage to residential and commercial buildings are presented in **Table 9**.

Table 9 Guide values for intermittent vibration – minimal risk of cosmetic damage

Type of building	Peak particle velocity (PPV) in frequency range of the predominant pulse	
	4 Hz to 15 Hz	15 Hz and above
Reinforced or framed structures. Industrial and heavy commercial buildings.	50 mm/s at 4 Hz and above	
Unreinforced or light framed structures. Residential or light commercial type buildings.	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above.

6 Assessment methodology

6.1 Assessment scenarios

The scenarios in **Table 10** were developed in consultation with GPC to assess noise and vibration during the key construction and operational stages of the Project. The scenarios, and the location of potential noise sources, consider the minimum distances between the Project areas and the nearest sensitive receptors.

Table 10 Scenario for the noise and vibration assessment

Scenario	Project stage	Project activity	Source of noise	Equipment
Construction phase				
1	WBE reclamation (southern area)	Construction of reclamation bund walls (southern area), including road transport of quarry material, rock dumping and bund wall materials.	Equipment in operation at western extent of southern reclamation area closest to mainland receptors. Trucks travelling on the haul route.	GPC Quarry: 2 x large excavators 2 x medium loaders Reclamation bund wall: 1 x medium dozer (D6) 1 x large dozer (D9) 1 x loader 1 x medium excavator 1 x small bobcat 1 x vibratory roller 1 x water cart 1 x diesel generator 2 x dump trucks (WBE reclamation area)
2	WBE reclamation (northern area)	Construction of reclamation bund walls (northern area), including road transport of quarry material, rock dumping and bund wall materials.	Equipment in operation at western extent of northern reclamation area closest to The Narrows and Kangaroo Island Trucks travelling on the haul route.	GPC Quarry: 2 x large excavators 2 x medium loaders Reclamation bund wall: 1 x medium dozer (D6) 1 x large dozer (D9) 1 x medium excavator 1 x small bobcat 1 x vibratory roller 1 x water cart 1 x diesel generator 2 x dump trucks (WBE reclamation area)

Scenario	Project stage	Project activity	Source of noise	Equipment
3	Construction of the BUF	Installation of metal sheet piles or similar earth retaining structure and road transport of quarry material and rock dumping at the BUF for two short bund walls.	Vibratory sheet piling machine and other construction vehicles. Trucks travelling on the haul route and dumping of rocks at the BUF.	GPC Quarry: 2 x large excavators 2 x medium loaders BUF area: 1 x vibratory sheet piling machine 1 x truck 1 x barge 1 x large dozer (D9) 1 x medium excavator 1 x small bobcat 1 x vibratory roller 1 x water cart 1 x diesel generator 2 x dump trucks
4	CSD and TSHD dredging of the barge access channel and direct placement into existing WB reclamation area.	Dredger operations.	Small CSD and TSHD deepening the barge assess channel and pumping material into the existing WB reclamation area. The CSD has been modelled as it is to be more frequently used than the TSHD.	1 x CSD 1 x TSHD 2 x medium dozers (D6) 1 x loader 1 x medium excavator (daytime only)
5	TSHD dredging of the Channel Duplication area, barge movements and placement of dredged material at the existing WB and WBE reclamation (southern area)	Dredging of the Gatcombe and Golding Cutting Channels and placement of dredged material at the existing WB and WBE reclamation areas (southern area) using excavators at the BUF and trucks at the BUF and on internal roads.	TSHD located at area of highest volume of dredged material which is closest to the community on Facing Island. The six large excavators are located at the BUF. The 32 haulage trucks are evenly distributed on the outer edges of the reclamation areas.	1 x TSHD 6 x large excavators 32 x haulage trucks 1 x tug 4 x pushbusters 2 x medium dozers (D6) 1 x loader 1 x medium excavator (daytime only)
6	TSHD dredging of the Channel Duplication area, barge movements and placement of dredged material at the existing WB and WBE reclamation (northern area)	Dredging of the Gatcombe and Golding Cutting Channels and placement of dredged material at the existing WB and WBE reclamation areas (northern area) using excavators at the BUF and trucks at the BUF and on internal roads.	TSHD located at area of highest volume of dredged material which is closest to the community on Facing Island. The six large excavators and the 32 haulage trucks are located as in Scenario 5.	1 x TSHD 6 x large excavators 32 x haulage trucks 1 x tug 4 x pushbusters 2 x medium dozers (D6) 1 x loader 1 x medium excavator (daytime only)

Scenario	Project stage	Project activity	Source of noise	Equipment
7	Navigational aids	Installation of new navigational aids for the Gatcombe Channel.	Impact piling for the navigation aids closest to the community on Facing Island.	1 x barge 1 x Junttan impact hydraulic hammer
Operational phase				
8	Operational maintenance dredging	TSHD for maintenance dredging.	TSHD operation at the closest location to the community on Facing Island.	1 x TSHD

6.2 Noise prediction modelling

A SoundPLAN (Version 7.4) computer noise model was used for the prediction of noise levels at sensitive receptors. The noise model comprised contours of the regional terrain, 3D designs for the Project, noise sources for the construction and operational activities as well as the location of noise sensitive receptors.

The computer model calculated the noise levels at sensitive receptors, considering:

- All noise source sound power levels and frequency spectra;
- Detailed digital terrain contours for the region, including an 8 m LAT landform to represent the Project design level for the WBE reclamation area and post Project dredging (Stages 1 and 2);
- Noise propagation variables such as distance attenuation, ground absorption, air absorption and shielding attenuation from topography, buildings or barriers;
- Defined meteorological conditions for the region; and
- The direct noise, the noise diffracting over obstacles or barriers and the noise reflected off buildings.

6.2.1 Noise sources

GPC supplied SLR with a list of plant required for the construction and operational phases of the Project. Each plant item was assigned a noise emission level with reference to SLR's in-house database of noise emissions from similar projects and supplemented by manufacturer noise emissions data.

The noise emission inventory for the noise modelling is detailed in **Appendix D**. The source sound power levels (noise emission level) assume continuous, steady-state operations for fixed plant and normal operation of mobile plant. The source noise emission levels have been directly applied in the noise prediction model, adjustments were not made for the duration of operation on the assumption that all required plant will be in continuous operation.

The plant and equipment proposed for the construction and operation of the Project such as dozers, TSHD and CSD and haul trucks, would have broadband noise emission spectra and not likely to result in noise emissions with tonal or impulsive noise characteristics or significant low frequency noise. The noise emission for the hydraulic impact hammer required for the installation of the navigation aids included a +2 dBA adjustment to account for potential impulsive noise characteristics that may be detectable at distances of 0.9 km from the impact piling rig.

The noise modelling has been based on assessing noise levels where plant and equipment would be in proximity to the sensitive receptors and undertaking noise intensive activities. The assessment scenarios in **Table 10** have been modelled to identify the worst-case (highest) potential noise levels at the noise sensitive receptors.

It is important to acknowledged that the worst-case noise levels would not be experienced always and noise levels would be lower where plant and equipment is operated further from sensitive receptors and when less intensive activities are undertaken.

6.2.2 Meteorological conditions

The construction and operation of the Project will occur either between 6.30 am and 6.30 pm or be 24/7 depending on the specific activities undertaken. For this reason, the individual meteorological data for the WBE reclamation area and Channel Duplication area were analysed to define the daytime and (worst-case) night-time meteorological assessment parameters in **Table 11**.

Table 11 Modelled meteorological conditions

Scenarios	Time of day	Wind speed	Prevailing wind	Temperature	Atmospheric stability
Construction: scenarios 1, 2, 3 and 7	6.30 am to 6.30 pm	3 m/s	From the east northeast	20°C	D Class
Construction: scenario 4	Night-time	3 m/s	From the southeast	20°C	D Class
Construction: scenarios 5 and 6 Operation: scenario 8	Night-time	3 m/s	From the south southeast	20°C	D Class

Noise emissions for the construction and operational phases of the Project were predicted using the CONCAWE prediction model. CONCAWE is commonly implemented in industry and construction projects for environmental noise prediction. It allows for investigation of effects of wind and atmospheric stability on noise propagation.

6.3 Road traffic noise calculations

The majority of road traffic generated by the Project will be required for the construction of the WBE reclamation area bund walls, specifically the transport of core and armour material from the Yarwun/Targinnie quarry area. The transfer of this core material will be carried out by haul trucks (B-Double) which are 'heavy vehicles' under the Austroads94 Vehicle Classification.

Whilst there will be other road transport requirements for the Project workforce, the associated daily light vehicle movements will be a negligible contribution to the existing daily road traffic movements on the local road network in the Gladstone area. Accordingly, the assessment of the road traffic noise has focused on the heavy vehicles movements during the Project.

The likely haulage route from the Yarwun/Targinnie quarry area will follow the route of Guerassimoff Road and Landing Road to the WBE reclamation area at the Fisherman's Landing Precinct. There are no residential or other noise sensitive receptors within 2.5 km of the transport route. The adjacent industrial premises are themselves a source of noise and were not deemed sensitive to road traffic noise from the local road network.

The calculation of road traffic noise levels from this haulage route was undertaken to ensure a comprehensive assessment (refer **Section 9**). However, in the absence of noise sensitive receptors there would be no immediate noise impacts to the human environment.

6.3.1 Road traffic volumes

To calculate the future road traffic noise levels, the most recent (2018) existing road traffic volumes for the proposed transport routes for the WBE reclamation area were referenced from the Project EIS Chapter 15 (transport), as summarised in **Table 12**. The total traffic volumes for the total number of vehicles on Guerassimoff Road and Landing Road (north of the Guerassimoff Road intersection) consider the number of vehicles travelled in both directions.

The existing traffic data was based on six consecutive days of traffic counts at the intersection for a 14-hour period per day. The traffic volumes on Friday and the weekend were notably lower than other week days and for this reason were not adopted. The 14-hour traffic count data has been increased by a factor of 1.29 to provide road traffic data for the 18-hour period 6.00 am to midnight required for assessing road traffic noise.

Table 12 Summary of 2018 road traffic volumes

Road	Total 18-hour road traffic movements	Ratio of heavy vehicles
Guerassimoff Road	700	64%
Landing Road	1,992	48%

The temporary road traffic added to the transport routes during the construction of the Project is summarised in **Table 13**. The truck movements are based on the peak month for required material volumes to assess the potential worst-case (highest) road traffic noise levels.

Table 13 Assessed Project road traffic volumes

Project stage	Daily vehicle movements	
	Heavy vehicles	Light vehicles
Stage 1 WBE reclamation area construction (southern area)	130	20
Stage 2 WBE reclamation area construction (northern area)	198	20

Table note Road traffic data supplied by Aurecon/ GPC.

In terms of assessing road traffic noise, the existing daily road traffic volumes in **Table 12** are very low and with 2.5 km separating nearest receptors and Landing Road the road traffic will be negligible at the nearest receptors.

Commonly applied road traffic noise calculation methodologies, such as the Calculation of Road Traffic Noise methodology recommended by DTMR, are not suitable for such low traffic volumes. Accordingly, the assessment has calculated the change in the source road traffic noise emission between the existing road traffic volumes and the future road traffic volumes with the Project's road traffic contribution. The change in the source road traffic noise emissions has been assessed with reference to the following guideline on road traffic noise impacts referenced from DTMR.

Table 14 Significance of environmental noise exposure changes

Increase over existing noise level	Change in subjective loudness	Significance of change
<3 dBA	Nil	Insignificant
3 – 5 dBA	Noticeable	Marginal
10 dBA	About double	Significant
≥15 dBA	At least triple	Very significant

Table note: Referenced from the DTMR Transport Noise Management Code of Practice, Volume 1 – Road Traffic Noise

6.4 Assessment of ground vibration

The assessment of the propagation of vibration through the ground is complex. Even for a simple source, the received vibration at any point includes the combined effects of several different wave types, plus reflections and other effects caused by changes in ground conditions along the propagation path.

Given the extensive land area for the proposed WBE reclamation area, it is not practical or feasible to undertake detailed modelling of modelling of ground vibration from mobile and intermittent sources (construction plant). As such, the assessment has been based on identifying critical work locations where the proximity of sensitive receptors may trigger the Project to require specific measures to reduce and control ground vibration.

The assessment has referenced safe working distances for vibration intensive plant for the management of vibration in accordance with the vibration assessment criteria adopted for this Project. The safe working distances are the minimum recommended separation distances between plant and receptors to manage the risk of perceptible (disturbance) impacts or potential risk of cosmetic damage to buildings from ground vibration.

7 Assessment of noise during construction

This section details the noise levels predicted for the construction of the Project. As discussed in **Section 5.2**, the acoustic quality objectives from the EPP (Noise) have been applied as construction noise management levels to identify where construction noise management may be required.

7.1 Predicted construction noise levels

The noise levels predicted at the sensitive receptors during the construction activities are detailed in **Table 15**.

Table 15 Predicted noise levels from construction activities

Sensitive receptor	$L_{Aeq,adj,1hour}$ noise levels (dBA) construction scenarios						
	1	2	3	4	5	6	7
Residential receptor locations							
Gladstone City and Barney Point	<10	<10	<10	<10	31	31	13
Quoin Island	19	17	17	15	31	31	19
Facing Island (northwest and south)	<10	<10	<10	<10	44	44	43
Boyne Island and Tannum Sands	<10	<10	<10	<10	16	16	35
Turtle Island	20	19	18	16	27	27	15

Sensitive receptor	$L_{Aeq,adj,1hour}$ noise levels (dBA) construction scenarios						
	1	2	3	4	5	6	7
Witt Island	20	19	17	17	32	32	12
Tide Island	18	17	15	17	41	41	10
Targinnie	25	22	20	24	27	25	<10
Library, educational, childcare or health uses							
St. Francis Catholic Primary School, Tannum Sands	<10	<10	<10	<10	14	14	33
Stepping Stones Child Care Centre, Gladstone	<10	<10	<10	<10	23	23	11
Goodstart Early Learning, Gladstone	<10	<10	<10	<10	21	21	15
Gladstone City Library, Gladstone	10	<10	11	11	23	24	<10
Harbour City Medical Centre, South Gladstone	<10	<10	<10	<10	22	22	15
Gladstone South State School, South Gladstone	<10	<10	<10	<10	20	20	15
Toolooa State High School, Gladstone	<10	<10	<10	<10	15	15	16
Kareeba Scout Hall, Barney Point	<10	<10	<10	<10	23	23	19
CQ University Gladstone Campus, Gladstone	<10	<10	<10	<10	18	18	13
Gladstone Central State School	<10	<10	<10	<10	25	25	13
Park or nature conservation							
Wyndham Park, Boyne Island	<10	<10	<10	<10	17	17	36
Spinnaker Parklands	17	17	14	16	26	26	12
Canoe Point Botanic Reserve and Environmental Park	<10	<10	<10	<10	16	16	35
James Cook Park, Gladstone	16	15	13	15	25	25	13
Barney Point Park, Barney Point	11	12	<10	11	30	30	20
Friend Park, Barney Point	11	12	<10	11	30	30	20
Hector Johnson Park, Barney Point	<10	<10	<10	<10	25	25	17
Commercial or retail							
Gladstone City	<10	<10	<10	<10	23	23	11

The predicted noise levels for the construction works for scenarios 4, 5 and 6 (refer **Section 6.1** and **Table 16** for details) are based on the anticipated worst-case activity during the night-time period. During the daytime, construction works to manage dredged material at the reclamation areas include the additional operation of a medium sized excavator.

A review of predicted noise levels with this additional plant item and the most commonly east northeast prevailing wind conditions identified that noise levels during the daytime would not increase by more than L_{Aeq} 0.5 dBA at any of the assessed receptors.

The noise model indicates that the pushbusters generally are the noise sources that are likely to dominate the sound scape. It should however be noted that the pushbusters are not stationary noise sources, although they move along slowly. As the pushbusters operate between the Gatcombe and Golding Cutting Channels, and the BUF they will not be a continuous source of noise at the receptor locations. The above noise levels should therefore be considered as a worst-case scenario where the pushbusters work hard against the tide and progresses at a relatively slow speed.

The predicted noise levels would be below typical daytime ambient noise levels and not trigger a requirement for noise management.

7.2 Assessment of construction noise impacts

The predicted noise levels in **Table 15** have been referenced to identify the potential for the construction activities to have noise impacts, such as disturbance or loss of acoustic amenity, at the sensitive receptors. The following have been referenced when determining the likelihood for noise impacts:

- The predicted noise levels for the construction activities.
- The level of noise compared to the outdoor acoustic quality objectives, noting the objectives are referenced only as a guide when assessing noise. There is no requirement for the acoustic quality objectives to be complied with for construction activities.
- The existing background noise environment and measured RBLs in Table 4.
- Acknowledgement that the construction activities, such as installation of the navigational aids, are temporary so the predicted noise levels would not be experienced at all receptors all the time.

From the results it has been determined that the construction activities are expected to have the potential to result in noise impacts at the majority of the sensitive receptors. The TSHD dredging works, including the use of the pushbusters for manoeuvring the barges during the night-time (scenarios 5 and 6) and the installation of navigational aids (scenario 7), have the potential to result in activities that could be audible at the nearest receptors on Facing Island, Tide Island and Boyne Island.

A range of measures to assist in the management of any potential noise impacts from these activities have been provided in **Section 12**.

Table 16 Assessment of construction noise impacts

Scenario	Time	Noise impact assessment
Scenario 1 Bund wall construction at WBE reclamation area (southern area)	Daytime	Predicted noise levels at the receptors are very low and well within the referenced acoustic quality objectives. Noise impacts are unlikely to be experienced at the sensitive receptors.
Scenario 2 Bund wall construction at WBE reclamation area (northern area)	Daytime	Predicted noise levels at the receptors are very low (<25 dBA) and well within the referenced acoustic quality objectives. Noise impacts are unlikely to be experienced at the sensitive receptors.
Scenario 3 Construction of the BUF	Daytime	Predicted noise levels at the receptors are very low (<25 dBA) and well within the referenced acoustic quality objectives. Noise impacts are unlikely to be experienced at the sensitive receptors.

Scenario	Time	Noise impact assessment
Scenario 4 CSD and TSHD dredging of the barge access channel and direct placement into existing WB reclamation area	24/7	Predicted noise levels at the receptors are very low (<25 dBA) and well within the referenced acoustic quality objectives. Noise impacts are unlikely to be experienced at the sensitive receptors.
Scenario 5 TSHD dredging of the Channel Duplication area, barge movements and placement of dredged material at the WBE reclamation area (southern area)	24/7	Predicted noise levels at most receptors are low (< 35 dBA) or very low (< 25 dBA) and well within the referenced acoustic quality objectives. Noise impacts are unlikely to be experienced at the majority of sensitive receptors. The predicted noise levels are above 35 dBA at two residential areas (i.e. Facing Island and at Tide Island). At Facing Island and Tide Island, the predicted noise level during the daytime and evening are within the acoustic quality objectives. During the night-time, construction noise at Facing Island would potentially be audible at levels above the background noise environment and for this reason may cause some noise impacts. The community on the two islands may have experience with noise from existing commercial shipping and maintenance dredging activities. Familiarity with similar noise characteristics can reduce the potential for noise impacts.
Scenario 6 TSHD dredging of the Channel Duplication area, barge movements and placement of dredged material at the WBE reclamation area (northern area)	24/7	Predicted noise levels at most receptors are low (< 35 dBA) or very low (< 25 dBA) and well within the referenced acoustic quality objectives. Noise impacts are unlikely to be experienced at the majority of sensitive receptors. The predicted noise levels are above 35 dBA at two residential areas (i.e. Facing Island and at Tide Island). At Facing Island and Tide Island, the predicted noise level during the daytime and evening are within the acoustic quality objectives. During the night-time, construction noise at Facing Island would potentially be audible at levels above the background noise environment and for this reason may cause some noise impacts. The community on the two islands may have experience with noise from existing commercial shipping and maintenance dredging activities. Familiarity with similar noise characteristics can reduce the potential for noise impacts.
Scenario 7 Installation of the navigational aids near to Facing Island	Daytime	Predicted noise levels at most receptors are very low (<25 dBA) and well within the referenced acoustic quality objectives. Noise impacts are unlikely to be experienced at the majority of sensitive receptors. At Facing Island, impact piling would potentially be audible at levels above the daytime background noise environment and for this reason may cause some noise impacts. The community at Facing Island may have experience with noise from existing commercial shipping and maintenance dredging activities. Familiarity with similar noise characteristics can reduce the potential for noise impacts. At Boyne Island, impact piling may be audible during the daytime above the background noise environment, but not at levels enough to suggest noise would be a significant impact.

8 Assessment of noise during operations

This section provides an assessment of noise for the proposed maintenance dredging of the Duplicated Channels which is the operational phase of works for the Project.

8.1 Predicted noise levels during maintenance dredging

The predicted noise levels during the maintenance dredging (scenario 8) are detailed in **Table 17**.

Table 17 Predicted noise levels for maintenance dredging

Sensitive receptor	Predicted $L_{Aeq,adj,1hour}$ noise levels (dBA) maintenance dredging
Residential receptor locations	
Gladstone City and Barney Point	<10
Quoin Island	<10
Facing Island (northwest and south)	38
Boyne Island and Tannum Sands	<10
Turtle Island	<10
Witt Island	<10
Tide Island	<10
Targinnie	<10
Library, educational, childcare or health uses	
St. Francis Catholic Primary School, Tannum Sands	<10
Stepping Stones Child Care Centre, Gladstone	<10
Goodstart Early Learning, Gladstone	<10
Gladstone City Library, Gladstone	<10
Harbour City Medical Centre, South Gladstone	<10
Gladstone South State School, South Gladstone	<10
Toolooa State High School, Gladstone	<10
Kareeba Scout Hall, Barney Point	<10
CQ University Gladstone Campus, Gladstone	<10
Gladstone Central State School	<10
Park or nature conservation	
Wyndham Park, Boyne Island	<10
Spinnaker Parklands	<10
Canoe Point Botanic Reserve & Environmental Park	<10
James Cook Park, Gladstone	<10
Barney Point Park, Barney Point	<10

Sensitive receptor	Predicted $L_{Aeq,adj,1hour}$ noise levels (dBA) maintenance dredging
Friend Park, Barney Point	<10
Hector Johnson Park, Barney Point	<10
Commercial or retail	
Gladstone City	<10

8.2 Assessment of maintenance dredging noise impacts

The predicted noise levels in **Table 17** have been referenced to identify the potential for the maintenance dredging to have noise impacts, such as disturbance or loss of acoustic amenity, at the sensitive receptors. The following have been referenced when determining the likelihood for noise impacts:

- The predicted noise levels for the maintenance dredging activity.
- The existing background noise environment and measured RBLs in **Table 4**.
- The level of noise compared to the EPP (Noise) acoustic quality objectives in **Table 5** and the 'background creep' criteria in **Table 6**.

Table 18 Assessment of operational noise impacts

Scenario	Time	Noise impact assessment
Scenario 8 Maintenance dredging of the Duplicated Channel	24/7	Predicted noise levels at all the receptors comply with the EPP (Noise) 'background creep' criteria and acoustic quality objectives. On this basis noise impacts are unlikely to be experienced at most sensitive receptors. At Facing Island, operations would potentially be audible at levels commensurate of the background noise environment and for this reason may cause some perceptible noise impact where noise from the maintenance dredging is clearly audible. The community at Facing Island may have experience with noise from existing and maintenance dredging activities which can reduce the potential for noise impacts.

In summary, the maintenance dredging works have been assessed to comply with the EPP (Noise) at all sensitive receptors. It is noted that when the maintenance dredging is undertaken adjacent to Facing Island, the operations may result in noise that could be clearly audible at the nearest residences on Facing Island.

9 Assessment of road traffic noise

As discussed in **Section 6.3**, the road traffic noise assessment has been based on the change in existing road traffic noise emission levels with the introduction of additional road traffic associated with the Project. The road traffic noise emissions from Landing Road have been calculated to increase by 1.5 dBA with the additional road traffic from Stage 1 (southern WBE reclamation area) and Stage 2 (northern WBE reclamation area) of the Project. The low traffic volumes mean that Guerassimoff Road would not be a principal source of road traffic noise.

This change in noise level is deemed insignificant as per DTMR guidelines and would be generally difficult for most people to detect. At nearest receptors 2.5 km from Landing Road the potential increase in road traffic noise would likely be undetectable. On this basis, the Project would not result in road traffic noise impacts at the nearest assessed receptors.

10 Noise impact assessment for shorebirds

This section provides an assessment of the potential noise related impacts migratory shorebirds at local coastal habitat areas (including roosting and foraging habitat). The objective of the assessment is to identify whether the noise from the Project has the potential to affect the behaviour and health of the shorebirds, and based on this degree of potential impact, determining whether noise management controls are required.

10.1 Response to noise events

The potential effects of noise on terrestrial fauna include; increased energy expenditure or physical injury while responding to noise, interference with normal activities and behaviour, impaired communication and even physical damage to hearing organs. There is limited understanding of the effects of noise on fauna, which is understandable when the following points are considered:

- Responses to noise disturbance cannot be generalised across species or genera.
- Studies of one species cannot be extended to other species.
- Responses of individuals within a single species may vary.
- Hearing characteristics are species-specific.
- When studying the effects of noise on fauna, it can be difficult to separate noise effects from other sensory disturbing effects (for example visual or olfactory cues).
- Experimental research in a laboratory is not always applicable in a natural setting.

There are two relevant elements to the responses of terrestrial fauna to noise events, including:

- Masking – where noise affects communication between individuals of a species; and
- Individual reactions – ranging from mild alert response through to avoidance (or abandonment) of habitat.

The responses of individual birds to the noise events which will arise from the Project will depend in part on the timing of noise in relation to the bird activities. As discussed widely in the literature, and as regularly observed, many species become habituated to noise disturbances, particularly continuous noise. There is potential for some initial alert or alarm response to the start-up or arrival of noise sources.

It is noteworthy that the shorebirds visit to the Gladstone area as part of their migratory journey and, apart from the non-migratory Beach Stone Curlew, the shorebird species do not breed or nest during their time in the region.

Following the initial construction of the WBE reclamation area, an equilibrium is likely to be reached, involving:

- Likely changes in species composition near the work areas;
- Selection for more noise-tolerant individuals within the populations of species close to the work areas; and
- Habituation of some species and individuals to the noise impacts.

10.2 Assessment of potential impacts

The WBE reclamation area, BUF and the barge access channel are located within 500 m of important migratory shorebird roosting areas identified by the migratory shorebird surveys undertaken within the Port Curtis region. Potential noise impacts have been considered for the construction of the reclamation bund walls (Scenario 2) and the dredging of the Channel Duplication area (Scenario 6), as two of the higher noise generating work activities associated with the Project.

Other migratory shorebird roost sites are located at least 1 km from the Channel Duplication extent, which represents a sufficient distance to minimise potential Project noise levels. These sites are already exposed to similar noise sources as part of existing shipping activities and maintenance dredging in the Port. On this basis further noise assessment at these roost sites was deemed not to be required.

The noise levels predicted in the SoundPLAN noise model have been referenced based on the nearest sensitive wetlands areas being:

- The area around NAR1 which is located 200 m to 500 m from the WBE reclamation area (northern area).
- The area around Six Mile Island Shorebird Roost Site (SMIS) which is located 500 m to 2,000 m from the barge access channel and BUF, respectively.

The potential for noise impacts, based on the L_{Aeq} noise levels, is summarised in the table below. The assessment has identified that potential noise impacts to the shorebirds are likely to only be occasional alert responses, which can be considered a minor impact on the use of the habitats.

Table 19 Assessment of potential noise impacts to shorebirds

Scenario	Project stage	Predicted noise level at known potential habitat	Review of possible noise impacts to shorebirds
2	WBE reclamation (northern area) Construction of reclamation bund walls	<55 dBA to 70 dBA at wetlands NAR1	Noise levels suggest alert reactions may be experienced which would be a minor impact on the habitat use for most species at the wetlands surrounding NAR1.
		<50 dBA at wetlands SMIS	Noise levels are not expected to result in impacts to shorebirds utilising suitable habitat at SMIS.
6	TSHD dredging of the Channel Duplication area, barge movements and placement of dredged material at the WBE reclamation area (northern area)	<50 dBA to 65 dBA at wetlands NAR1	Noise levels suggest alert reactions may be experienced which would be a minor impact on the habitat use for most species at the wetlands surrounding NAR1.
		<55 dBA at wetlands SMIS	Noise levels suggest alert reactions may be experienced which would be a minor impact on the habitat use for most species at the wetlands surrounding SMIS.

For the dozers, bobcats, excavators, dump trucks and other equipment proposed to be used at the WBE reclamation area, the L_{Amax} noise levels are typically 8 dBA greater than the L_{Aeq} noise level. Applying a +8 dBA adjustment to the predicted L_{Aeq} noise levels, the potential L_{Amax} noise events have been assessed against the guideline criteria in **Table 7**.

The noise levels of up to L_{Amax} 78 dBA at the nearest shoreline to the northern WBE reclamation area identify potential for single event or sudden short-term noise events to cause alert responses and sometimes an alarm or flight reaction. Given the proposed works will involve the intermittent use of mobile equipment and rock dumping, the potential impacts would be temporary and not expected to affect all individuals of a species.

As a guide, where works are undertaken approximately 400 m from known or potential migratory shorebird habitat the noise levels are predicted to be within the guideline criteria in **Table 7** to minimise occasional alert reactions by shorebirds. Furthermore, as noted above it is likely that where the shorebirds are tolerant of the noise from the Project activities, it is expected that there would be no potential impacts to the use of the habitat.

11 Assessment of ground vibration

The dredging of the Channel Duplication area will be undertaken at least 0.9 km from the nearest sensitive receptors at Facing Island. At this distance there will be no perceptible (disturbance) impacts or cosmetic damage to buildings from ground vibration with any vibration localised to the immediate dredging area.

The assessment of potential impacts from ground vibration was based on the construction works associated with the WBE reclamation area (northern and southern areas, and BUF). The safe working distances in **Table 20** have been referenced from ground vibration measurements by SLR and Transport for NSW and are the recommended minimum separation distance between sensitive receptors and sources of vibration to manage the risk of potential impacts from ground vibration.

Vibratory roller and piling plant rigs are the principal sources of vibration other plant, such as the dozers, are not usually significant sources of vibration when operated at least 50 m from receptors. Given the nearest sensitive receptors are at least 3.6 km from the WBE reclamation area and BUF there will be no impacts from ground vibration.

The nearest sensitive receptors are located at least 2.5 km from the proposed haul route from the Yarwun/ Targinnie quarry area to the WB and WBE reclamation areas, and BUF. At this distance there would be no ground vibration impacts associated with heavy vehicle movements on the haul road.

Table 20 Safe working distances for sources of vibration

Plant item	Rating/ description	Safe working distances (m)		Reference
		Cosmetic damage	Perceptible impact	
Vibratory roller	<50 kN (Typically 1-2 tonnes)	5	15	Construction Noise and Vibration Strategy[1]
	<100 kN (Typically 2-4 tonnes)	6	20	Construction Noise and Vibration Guideline[2]
Excavator	Medium <30 tonnes	5	10	Previous assessment by SLR

Table note 1: TfNSW Construction Noise and Vibration Strategy (April, 2018)

Table note 2: NSW Roads & Maritime Services, Construction Noise & Vibration Guideline (April, 2016)

12 Mitigation measures

The assessment has determined that the majority of construction activities and the maintenance dredging can be undertaken without noise related impacts upon the sensitive receptors. Nonetheless, a range of noise management measures are provided to support the Project's environmental management plans (EMPs).

Discussed in this section are a range of noise management measures which will be incorporated as part of noise management measures that can be adopted to control, where required, the noise from the TSHD when dredging during the night-time immediately adjacent to Facing Island and where pushbusters are used near sensitive receptors. Noise management measures for the construction of the navigational aids have also been provided as the assessment identified the associated impact piling works as a potential source of noise at nearby receptors on Facing Island and Boyne Island.

The assessment has identified that impacts from ground vibration are not expected given the substantial distances between vibration sources and nearest sensitive receptors. Accordingly, ground vibration management measures have not been provided.

12.1 Construction noise management

The noise assessment predicted outdoor noise levels of up to L_{Aeq} 38 dBA at sensitive receptors on Facing Island during the night-time channel duplication dredging with the TSHD operating and up to L_{Aeq} 44 dBA where both the TSHD and a pushbuster are operating nearest to the receptors on Facing Island.

A noise level of L_{Aeq} 44 dBA is above the existing night-time background noise environment of 38 dBA at Facing Island. On this basis there is potential that noise from the TSHD and the pushbusters could be heard above the ambient environment, where this equipment is operating within 2.5 km of Facing Island.

Noise levels of up to 38 dBA are commensurate to the existing night-time background noise environment on Facing Island, notwithstanding noise from the TSHD and the pushbusters may be audible at night. For this reason, the planning and design of the dredging campaign with the TSHD will consider the following noise management/ mitigation measures:

- Design the TSHD to include noise attenuation measures for the pumps, power generation plant and motors that would be on-deck sources of noise. Such measures could include:
  - Installing plant with the lowest available noise emission;
  - Utilise on-deck structures to screen noise emissions from neighbouring plant; and
  - Installing plant with acoustic enclosures, acoustic exhaust mufflers, acoustic louvers, etc. to limit noise emission levels.
- Where practical, plan and manage the dredging program to utilise the less sensitive daytime and evening periods when dredging adjacent to residences on Facing Island. This would limit the requirement to operate the TSHD and pushbusters during the night-time at the closest distance to residences.

The noise assessment predicted that the pushbusters potentially could cause noise impacts at sensitive receptors during a passby. It is recommended that the pushbusters are not run at full speed when passing by noise sensitive receptors, if possible.

The installation of the navigational aids will require the use of an impact piling rig within 1 km of nearest residences on Facing Island. At this distance there is potential for construction noise levels to be audible and an impulsive noise characteristic from the impact hammer to be discernible. The mitigation measures will be implemented during the installation of the navigation aids, where reasonable and feasible to do so.

The measures below will be considered where the impact piling rig is used within 1 km of nearby sensitive receptors, beyond this distance noise levels are expected to be low and potential impulsive noise characteristics not readily distinguished.

- Undertake impact trials to determine the minimum required drop height to install the piles. Small drop heights can reduce/control noise and it is noted the Project would seek to implement this approach to accurately install the piles.
- Piling 'cushions' could be installed at the point of impact to reduce the energy (sound emission) during each impact event.
- Additional noise control measures may be adopted with respect to the control of underwater noise from impact piling (refer to the Underwater Noise Assessment Report1 for the Project EIS).

The mitigation measures below are general management measures for construction noise and will be implemented to manage construction noise emissions, particularly for all construction works outside the standard day-time hours of construction (6.30 am to 6.30 pm Monday to Saturday).

- Selection of the quietest plant and equipment that can economically undertake the work.
- Regular maintenance of equipment to ensure that it remains in good working order.
- Where practical, avoid the coincidence of plant and equipment working simultaneously close together near sensitive receivers.
- Mobile plant such as excavators, front end loaders and other diesel-powered equipment to be fitted with residential class mufflers.
- Where work is proposed within at least 1 km of residences, the community should be notified at least 2 weeks prior to the commencement of works. Notifications will describe the potential noise and vibration levels and the proposed management measures to control environmental impacts.
- Broadband reversing alarms are to be used instead of tonal reversing alarms where sensitive receptors are within 1 km of proposed construction works. This will be a requirement when outside standard working hours and included as a contractual requirement for contractors.
- Equipment which is used intermittently is to be shut down when not in use and all engine covers are to be kept closed while equipment is operating.
- During site inductions and toolbox talks, all site workers (including subcontractors and temporary workforce) are to be made aware of the hours of construction and how to apply practical, feasible and reasonable measures to minimise noise and vibration when undertaking construction activities.
- The site manager (as appropriate) will provide a community liaison phone number and permanent site contact so that noise and/or vibration related complaints, if any, can be received and addressed in a timely manner. Consultation and cooperation between the site(s) and neighbours to the site(s) would assist in limiting uncertainty, misconceptions and adverse reactions to noise and vibration.

[1] SLR Consulting Australia, 2019. Port of Gladstone Gatcombe and Golding Cutting Channel Duplication Project, Underwater Noise Assessment, document 620.10682-R02.

12.2 Maintenance dredging noise management

The operational phase of the Project will include the maintenance dredging of the Duplicated Channels and barge access channel, which will be undertaken as part of GPC's Port-wide maintenance dredging program. The assessment has determined that maintenance dredging would comply with the EPP (Noise) at sensitive receptors. On this basis, no specific noise management measures need to be implemented.

12.3 Noise management for terrestrial fauna

This assessment has identified that construction works undertaken within 400 m of the WBE reclamation area to be the primary activity having potential to cause minor noise related impacts to some shorebirds that utilise The Narrows wetlands and adjoining areas. Whilst there are other factors to consider, such as the tolerance of some individuals of a species to noise, the management measures below are provided to inform the EMPs prepared for the Project works.

Generic good practice measures applicable to a project of this nature may include some, or all, of the following:

- Using mobile plant with efficient acoustic mufflers on the exhausts.
- Where possible, avoid the coincidence of noisy plant working simultaneously, close together and adjacent to observed fauna.
- Briefing the work team to create awareness of the importance of minimising noise emissions.
- Where appropriate, adjusting the reversing alarms on plant to limit the acoustic range to the immediate danger area.
- Monitoring could be undertaken to observe shorebird behaviour during noise-generating activities and the works can adapt management measures as required.

12.4 Noise and vibration management plan

A Project EMP and Dredging EMP have been prepared as part of the EIS. The EMPs will provide the framework for the management and mitigation of potential environmental impacts from the construction and operation of the Project. A Noise and Vibration Management Plan (NVMP) has been prepared as part of the EMPs to document the management and control of noise and vibration associated with the Project.

12.5 Monitoring and auditing performance

An updated baseline (background) noise monitoring survey would be undertaken during the detailed design phase of the Project, prior to the commencement of construction works. Environmental noise levels would be monitored at locations representative of the nearest residential receptors and the monitored noise levels incorporated into the updating of the EMPs.

Ongoing spot checks of noise intensive plant and equipment will be undertaken. Construction noise levels will be monitored at the commencement of the construction phase to verify the outcomes of this assessment and confirm noise would not cause unacceptable impacts at sensitive receptors. Supplementary noise and/or vibration monitoring may also be conducted to identify issues of concern in response to any complaints. As detailed in the NVMP, all monitoring will be undertaken in accordance with relevant Australian Standards and regulatory guidelines for the measurement of environmental noise.

13 Summary

The noise and vibration assessment for the Project has determined the construction activities and maintenance dredging of the Duplicated Channel (operational works) can be undertaken to minimise potential noise and vibration impacts to the surrounding sensitive receptors.

The majority of construction activities are to be undertaken at sufficient distance from the sensitive receptors so that received noise levels would be very low (well below current ambient noise). The dredging with the TSHD during the night-time, pushbusters bearing close to residential receivers and impact piling rig for the installation of the navigational aids are activities which would require the consideration of the noise management measures contained in this report to control noise at the closest sensitive receptors at Facing Island, Tide Island and Boyne Island.

Due to the separation distance of at least 3.6 km from sources of ground vibration and sensitive receptors, the assessment has determined that vibration impacts are not expected to occur during the Project. Based on a 2.5 km separation distance between the transport route between the Targinnie/Yarwun quarry and the WBE reclamation areas there would be no road traffic noise impacts at nearest sensitive receptors.

The assessment has concluded that potential terrestrial noise and vibration impacts associated with the Project can be controlled in accordance with the relevant legislative and regulatory acoustic requirements.

APPENDIX A

Noise monitoring methodology

Noise monitoring methodology

At each monitoring location, a noise logger was deployed to continuously measure ambient noise levels over the consecutive 24-hour periods between 11 September and 17 September 2014, and between 4 November and 7 November 2014. During the daytime, SLR's acoustic consultant conducted noise measurements at the monitoring locations to quantify ambient noise levels, verify the noise levels recorded by the noise loggers and identify audible sources of existing noise.

All noise monitoring was carried out in accordance with the guidance for noise measurements provided in the DES's Noise Measurement Manual and relevant Australian Standards for environmental noise monitoring.

At each location the noise monitoring equipment was deployed to ensure the monitored noise levels were not influenced by uncharacteristic localised noise sources, such as residential air conditioning units, atypical industrial or commercial noise and high road traffic noise.

The noise loggers were in the free field, at least 4 m from nearest building facades, to prevent noise reflected from adjacent building facades adversely influencing the monitoring noise levels. The equipment was located to ensure no buildings occurred between the monitoring site and the proposed dredging or reclamation activities.

Instrumentation

The monitoring of ambient noise levels was undertaken using Acoustic Research Laboratories (ARL) EL-316 statistical noise loggers and SVAN 957 Sound Level Meters (SLMs) programmed to record ("log") various statistical noise levels over consecutive 15-minute intervals. The attended noise measurements were conducted noise measurements using a RION Type NA-27 Precision Sound Level Meter (Serial Number: 00960103).

All items of acoustic instrumentation employed during the noise monitoring were fitted with a Type 1 microphone and set to 'Fast' response. Noise levels were recorded in one-third octave band frequency decibel (dB) values to enable detailed analysis of the measured noise levels.

All acoustic instrumentation complied with Australian Standard IEC 61672-2004 *Electroacoustics – Sound level meters* (Standards Australia 2004a) and Australian Standard IEC 60942-2004 *Electroacoustics – Sound calibrators* (Standards Australia 2004b), and carried current National Association of Testing Authorities (NATA) calibration certificates.

The calibration of the monitoring equipment was confirmed before and after the monitoring using a RION Type NC-73 Sound Level Calibrator (Serial Number: 10697066). The equipment calibrated to within 1 dBA, which is an acceptable accuracy in accordance with the standards.

The equipment deployed at each noise monitoring location is detailed in the table below.

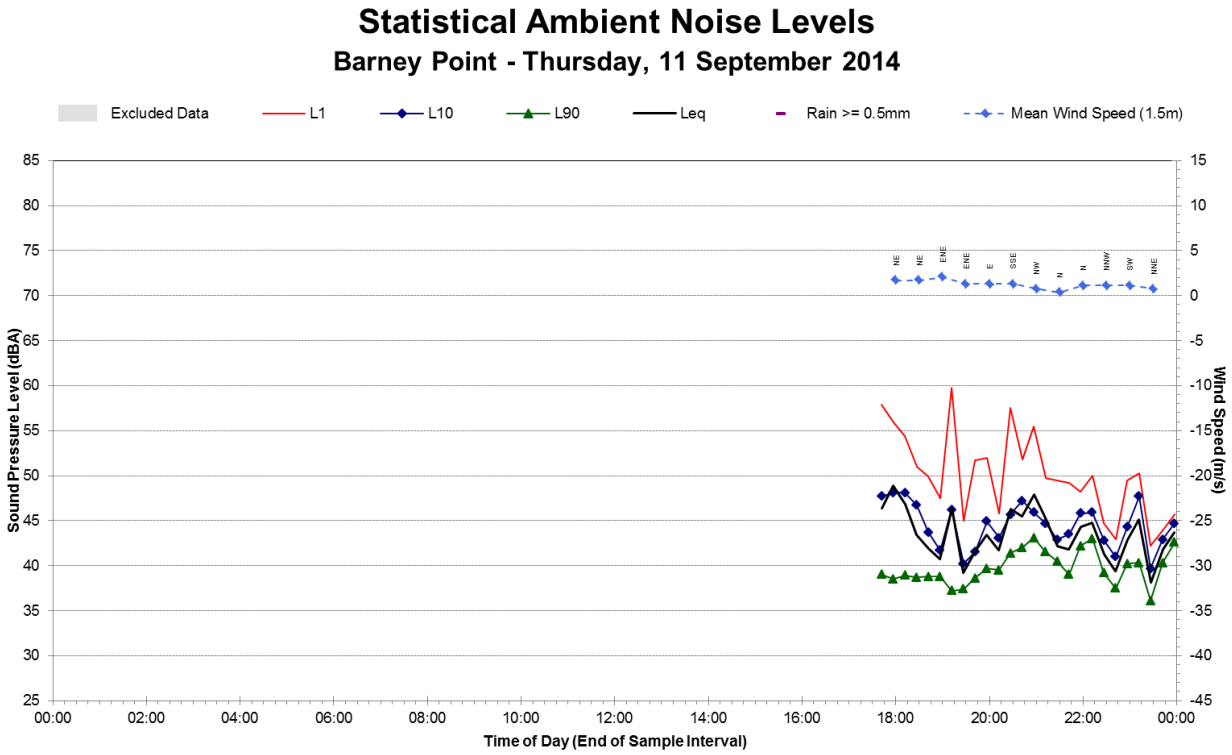
Noise monitoring locations and equipment

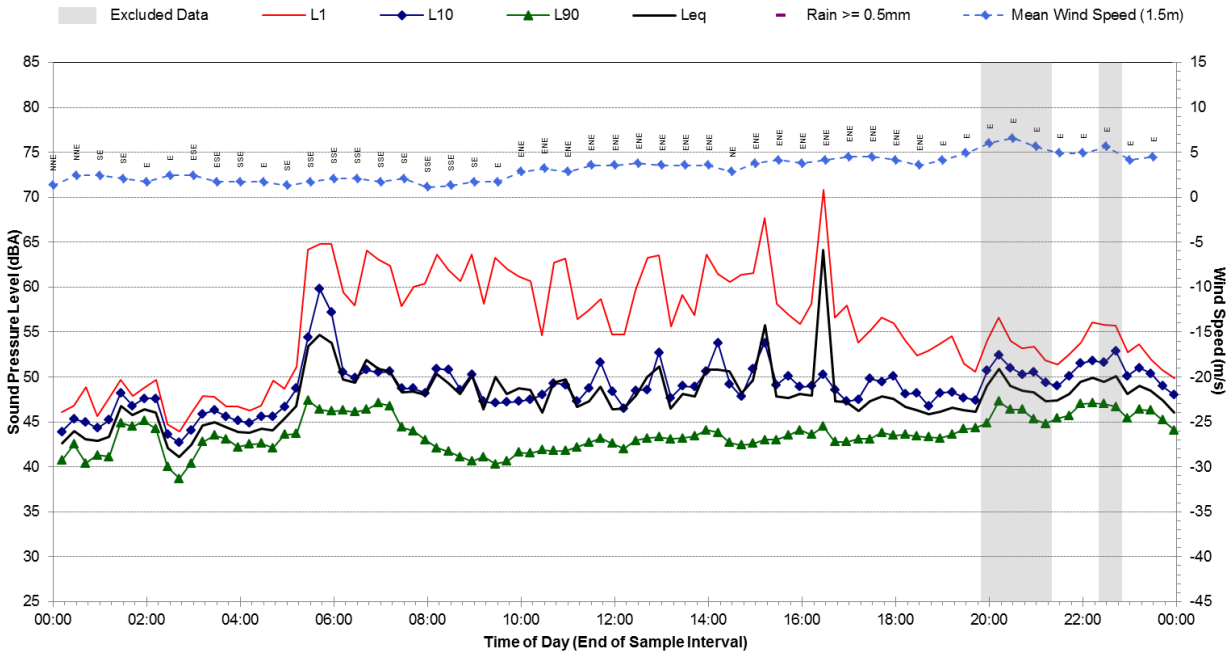
Monitoring Location	UTM Coordinate	Description	Site Photograph
Location 1 Sutton Street Barney Point	Northing: 7360668 Easting: 324412	Free field at the southern side of the property Logger serial numbers: 21425 16-207-050	
Location 2 Alkina Crescent Boyne Island	Northing: 7352114 Easting: 332119	Free field at the rear of the property Logger serial numbers: 21423 16-207-042	
Location 3 Sea Belle Esplanade Facing Island	Northing: 7360668 Easting: 324412	Free field at the rear of the property adjacent to the coastline Logger serial numbers: 20670 16-306-040	

APPENDIX B

Daily monitored noise levels

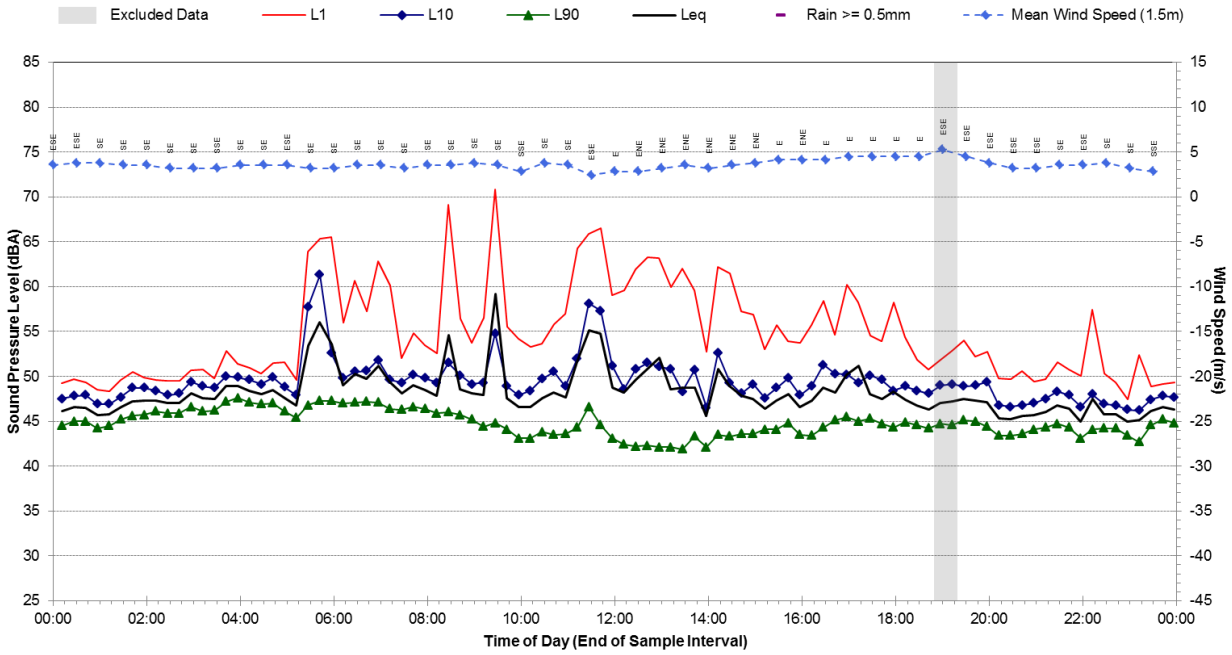
Note the excluded data was a result of unsatisfactory weather conditions being rainfall or wind speeds >5 /s.





Statistical Ambient Noise Levels

Barney Point - Saturday, 13 September 2014



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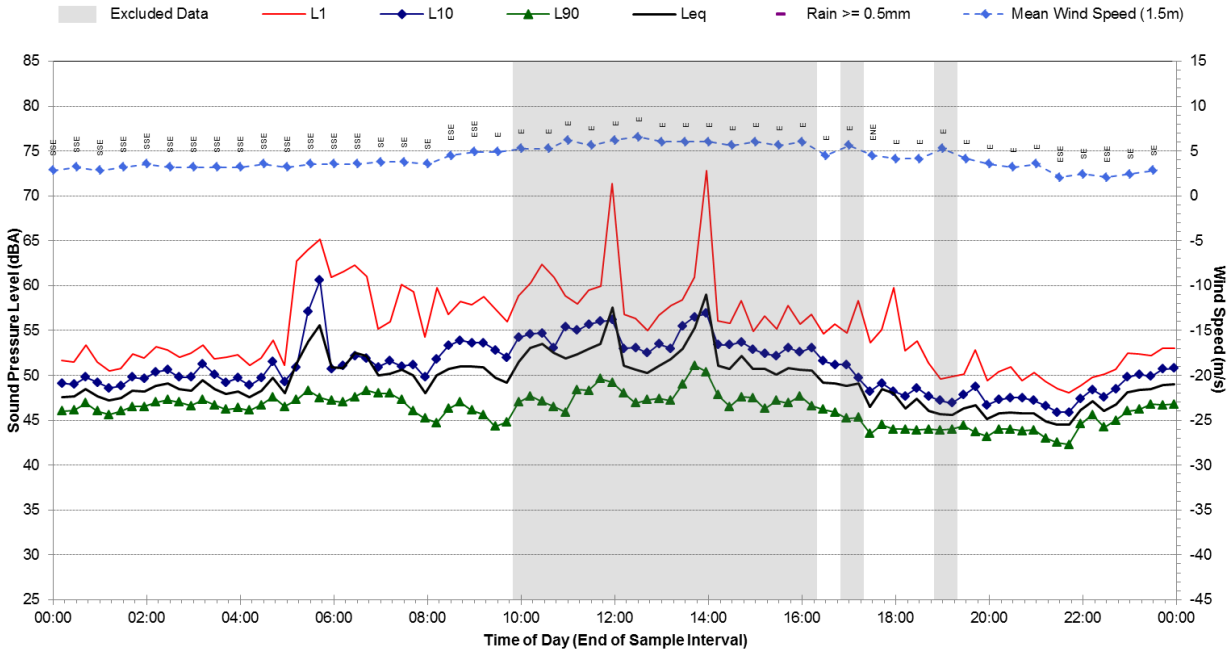

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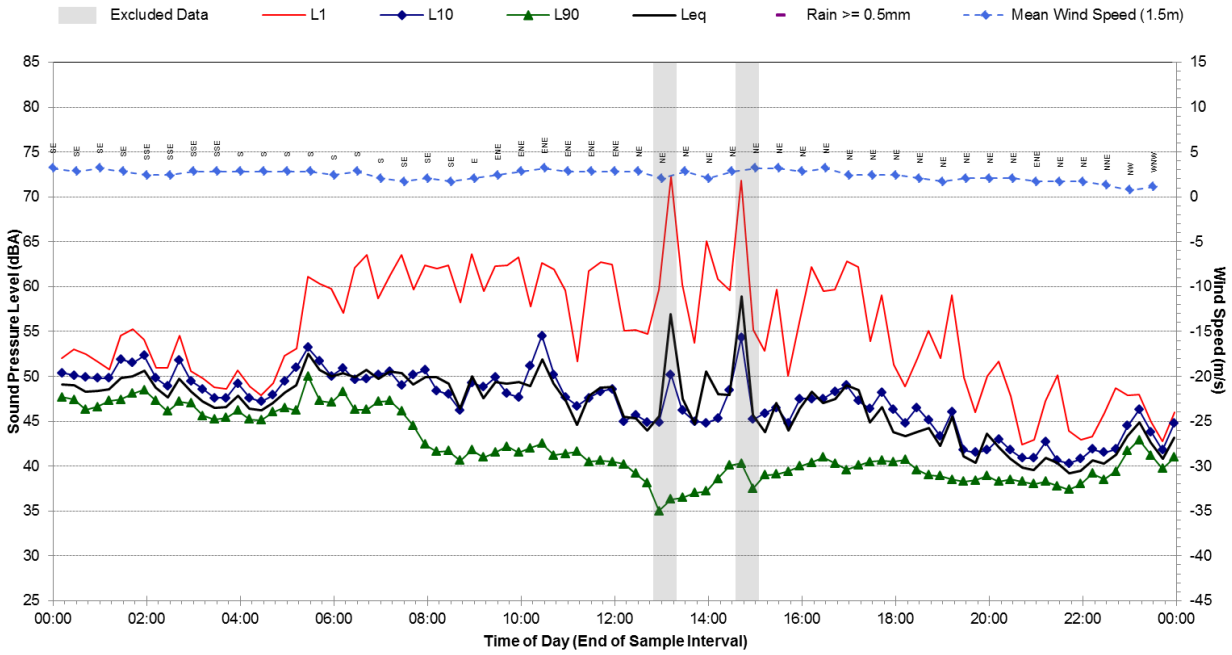
Barney Point - Monday, 15 September 2014



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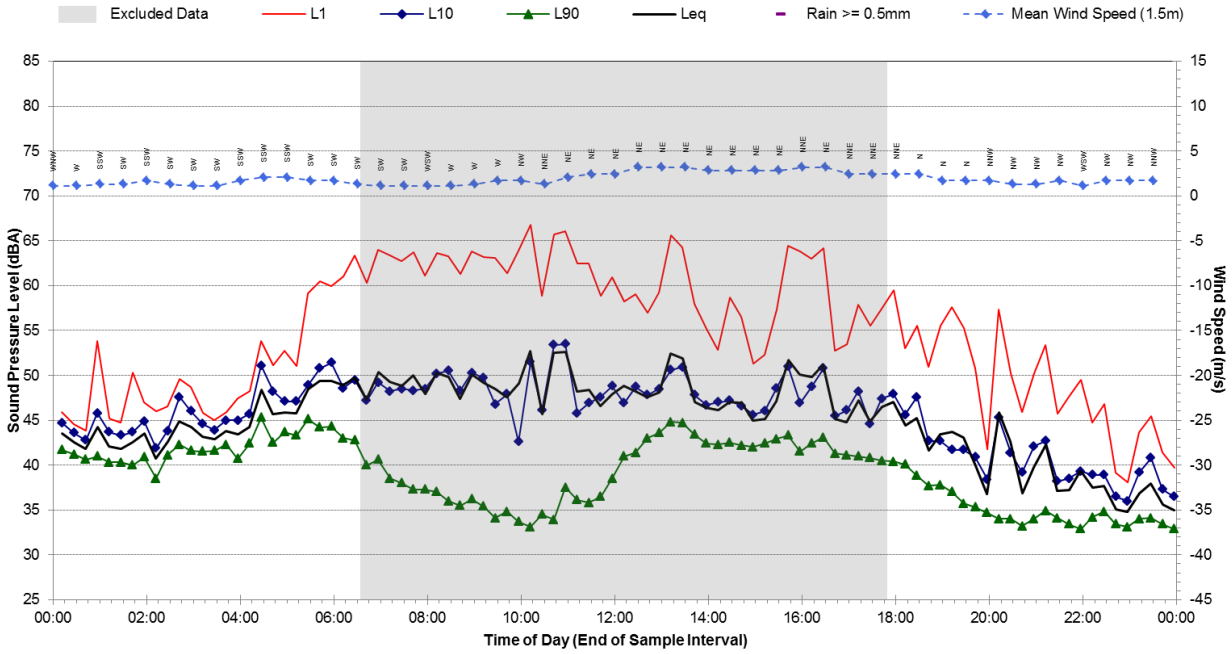

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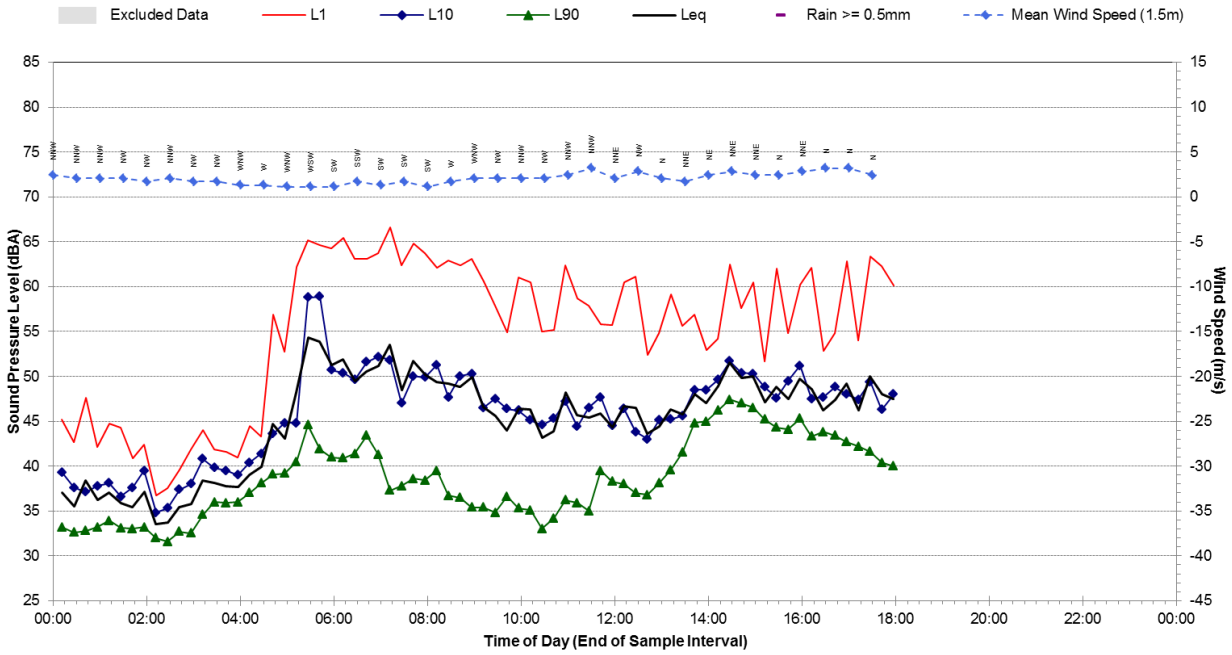
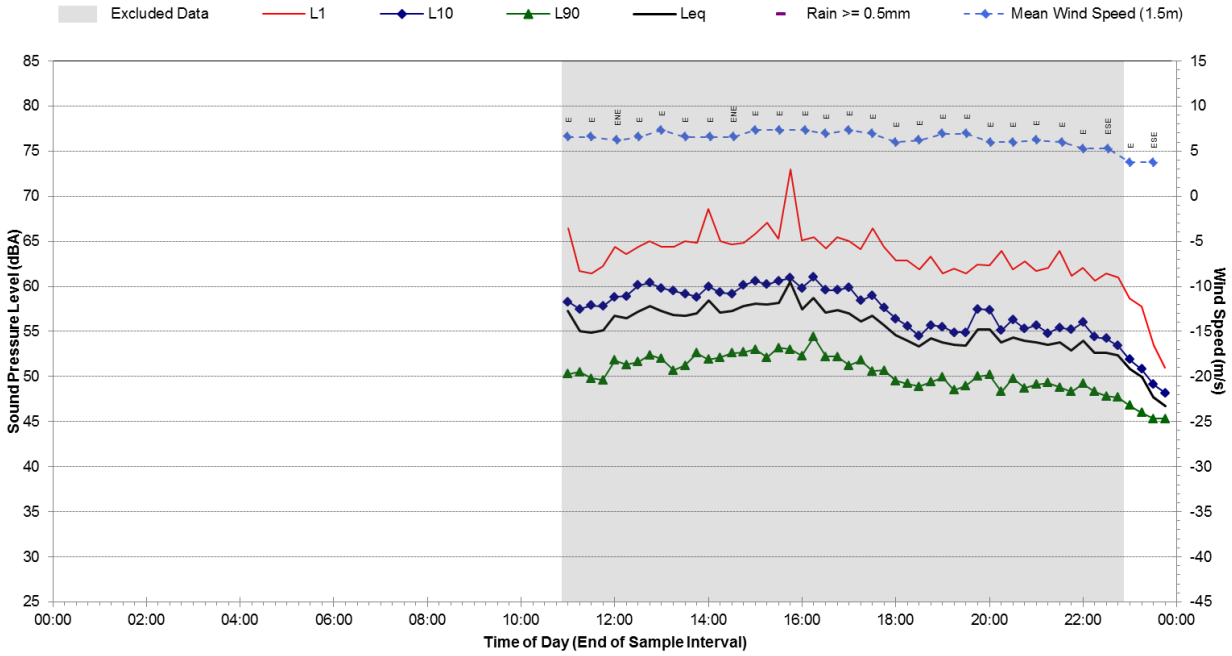


Statistical Ambient Noise Levels

Barney Point - Tuesday, 4 November 2014



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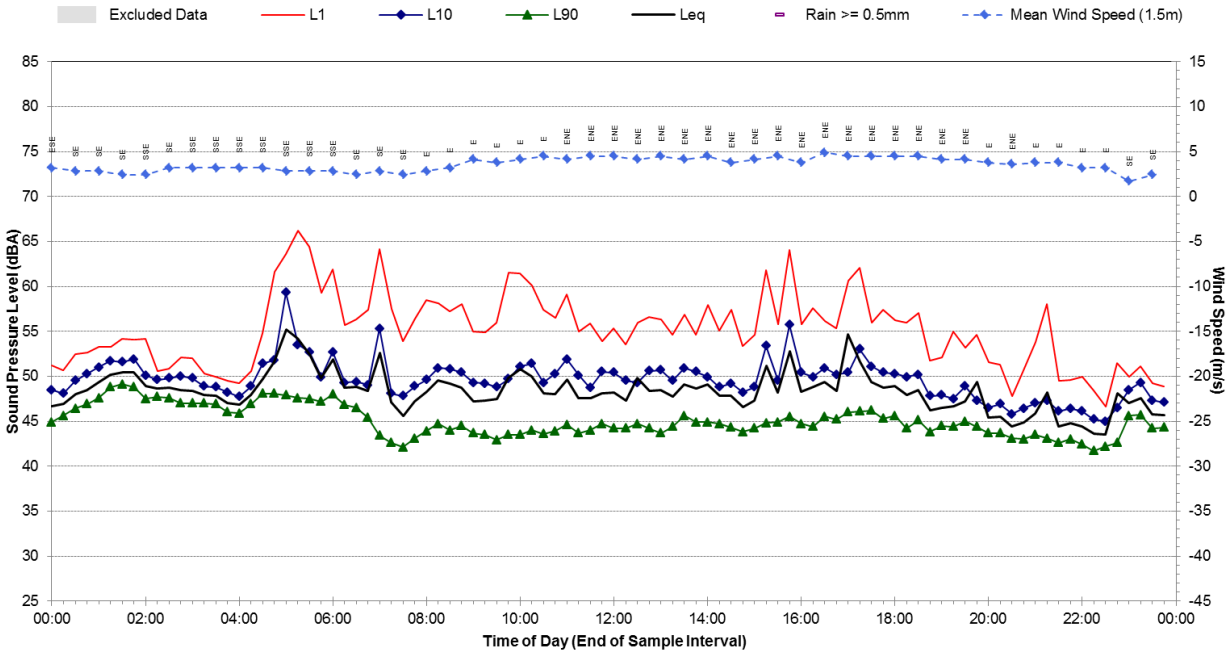

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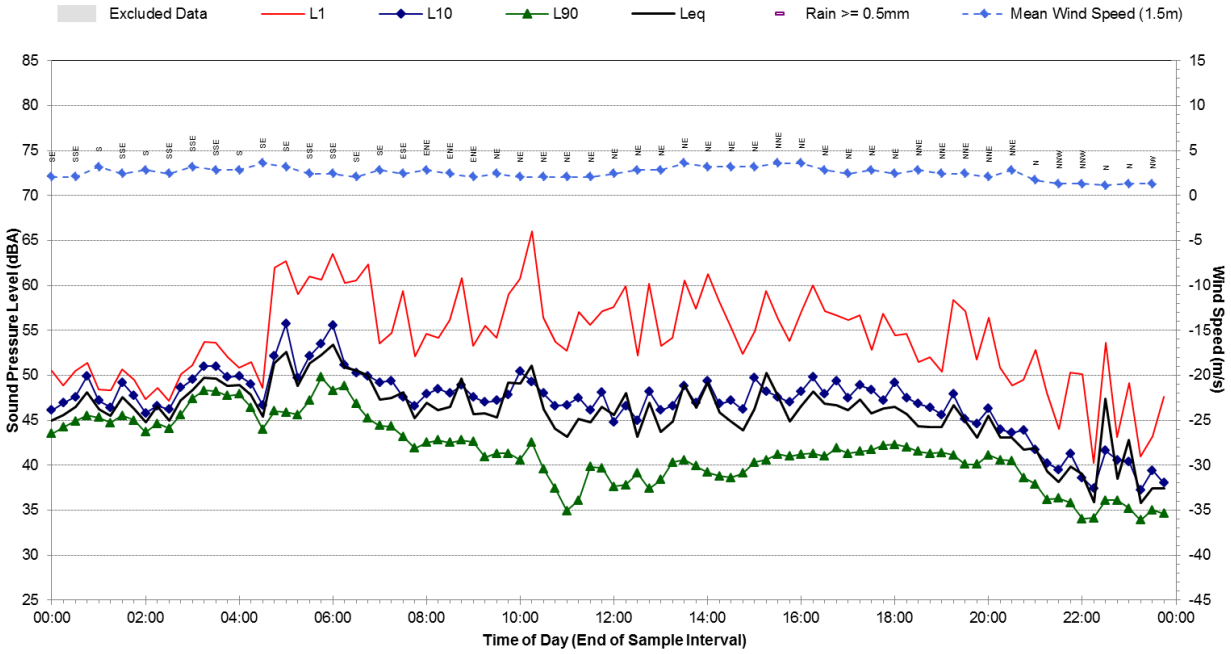
Barney Point - Thursday, 6 November 2014



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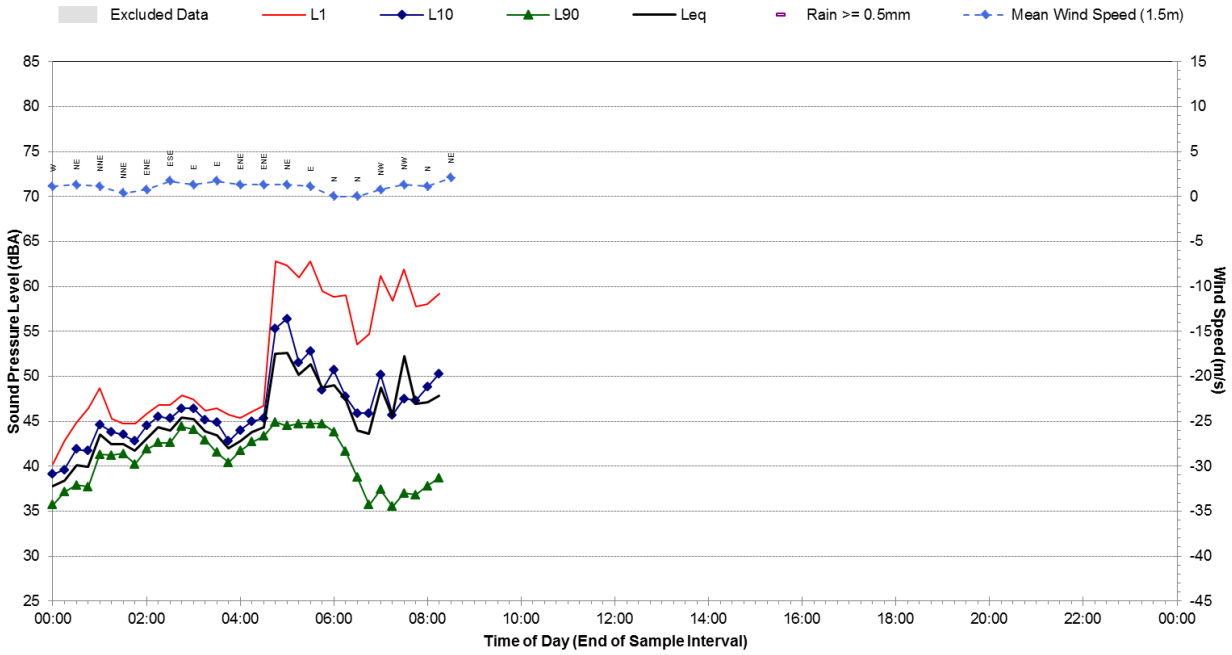
Barney Point - Friday, 7 November 2014



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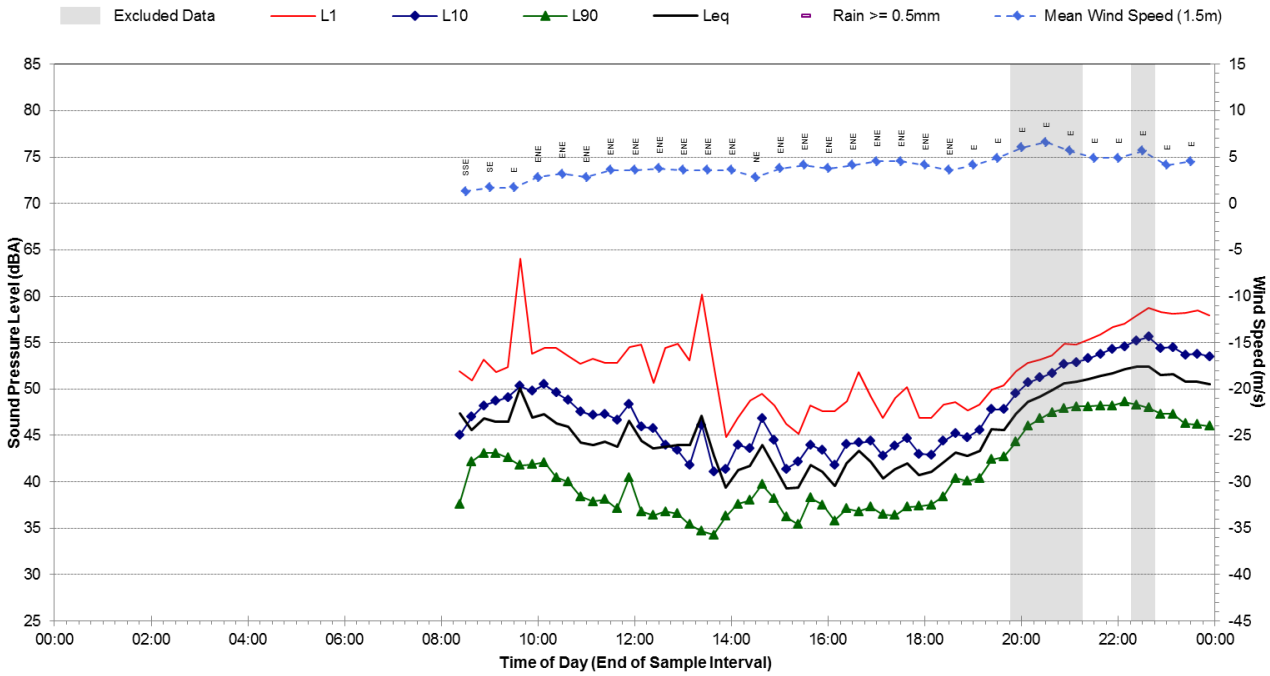

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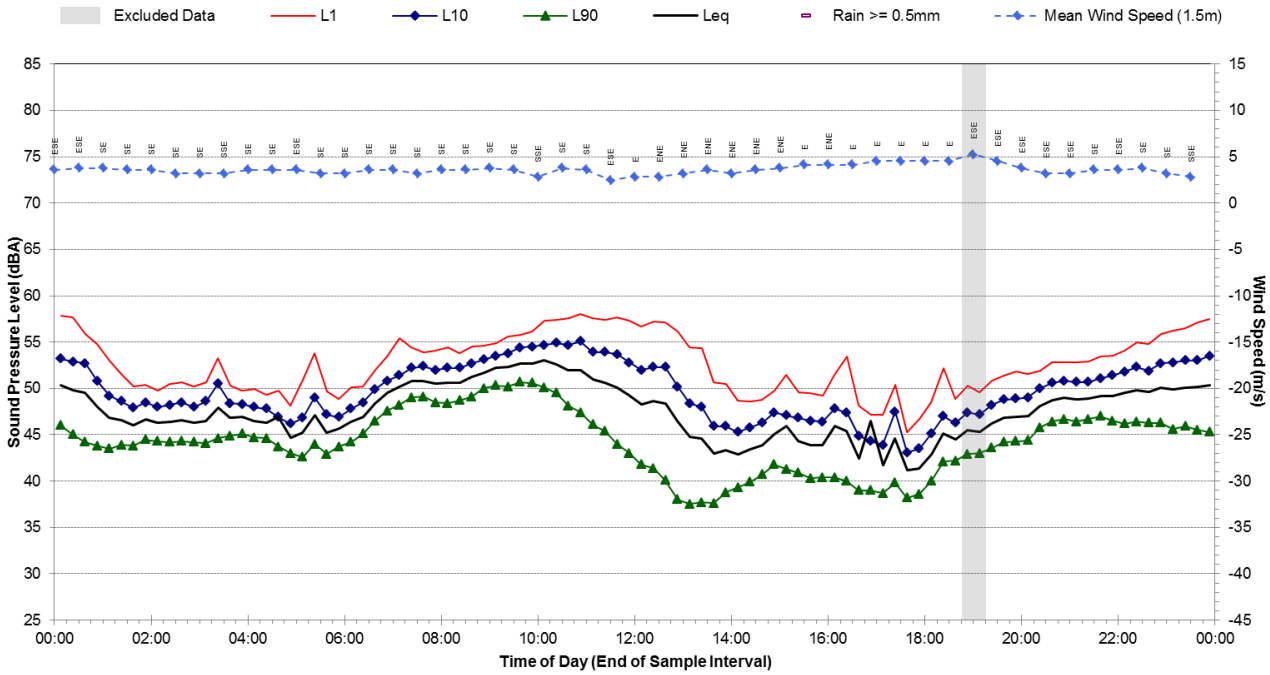
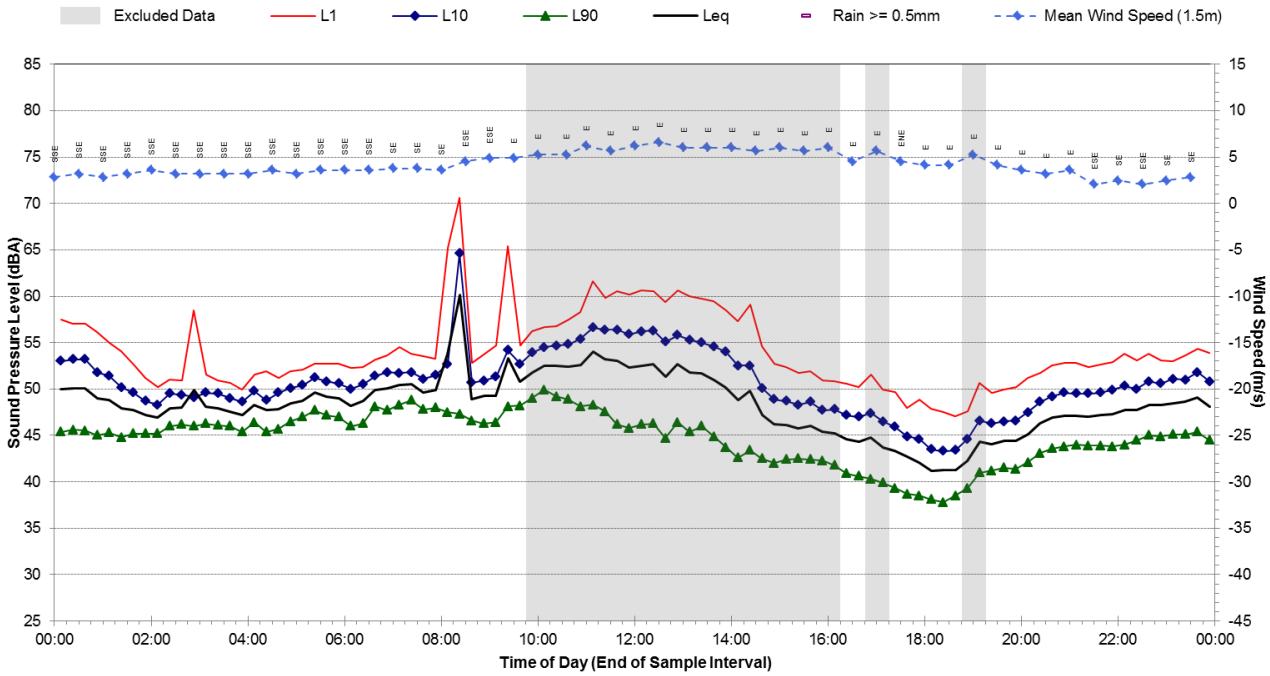


Statistical Ambient Noise Levels

Facing Island - Sunday, 14 September 2014



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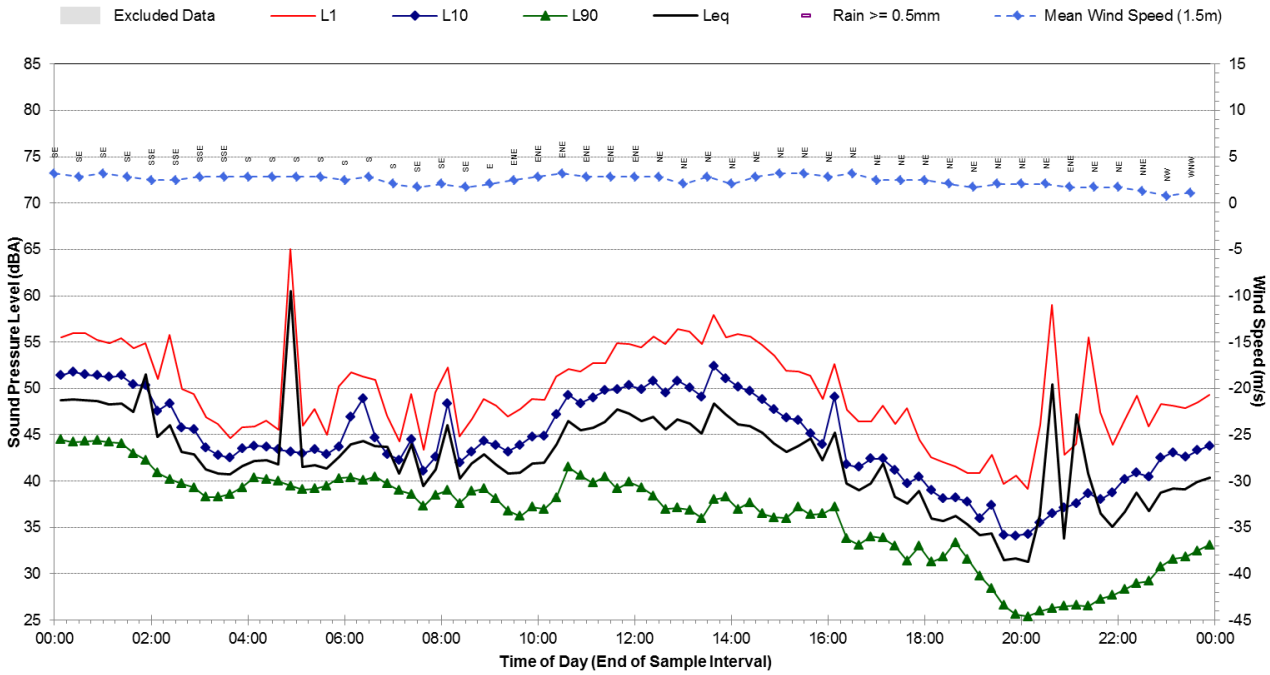

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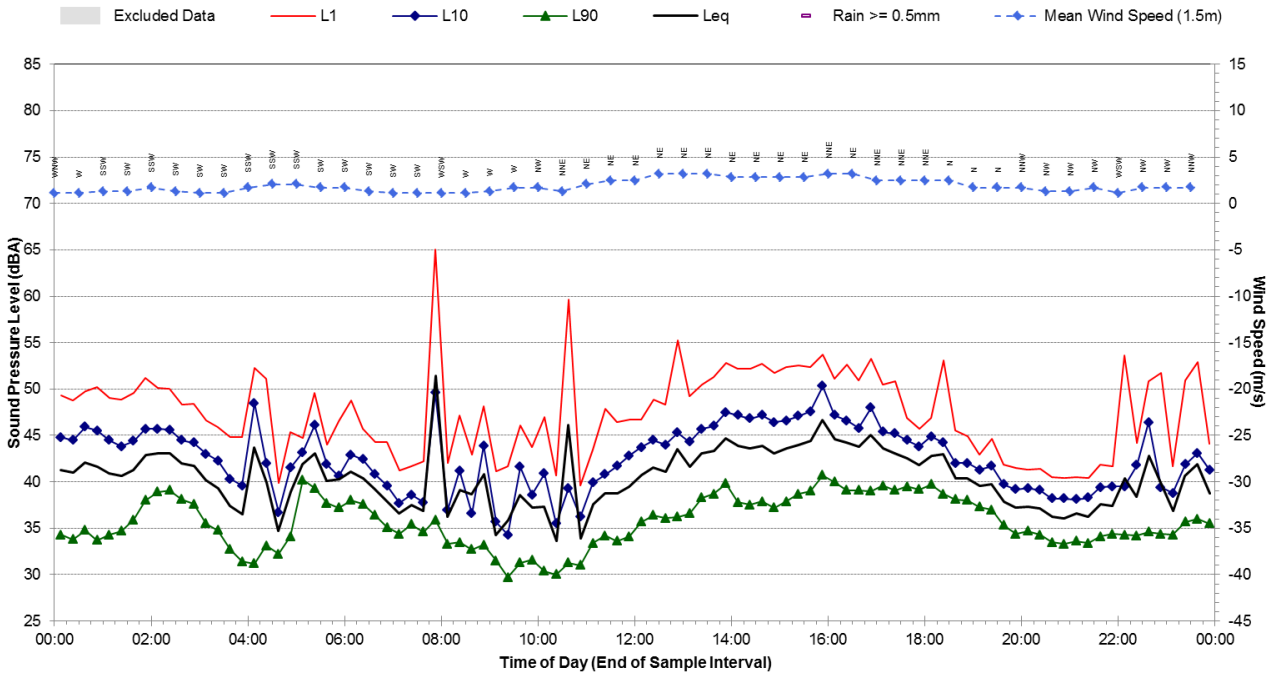

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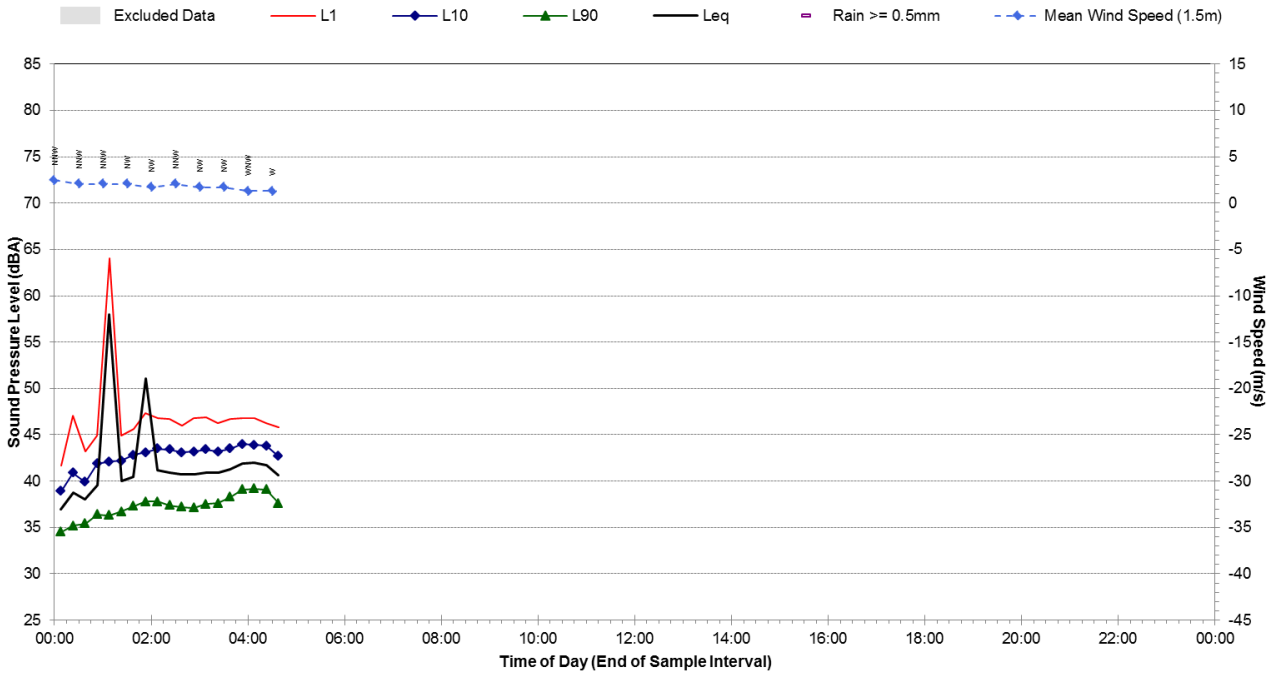

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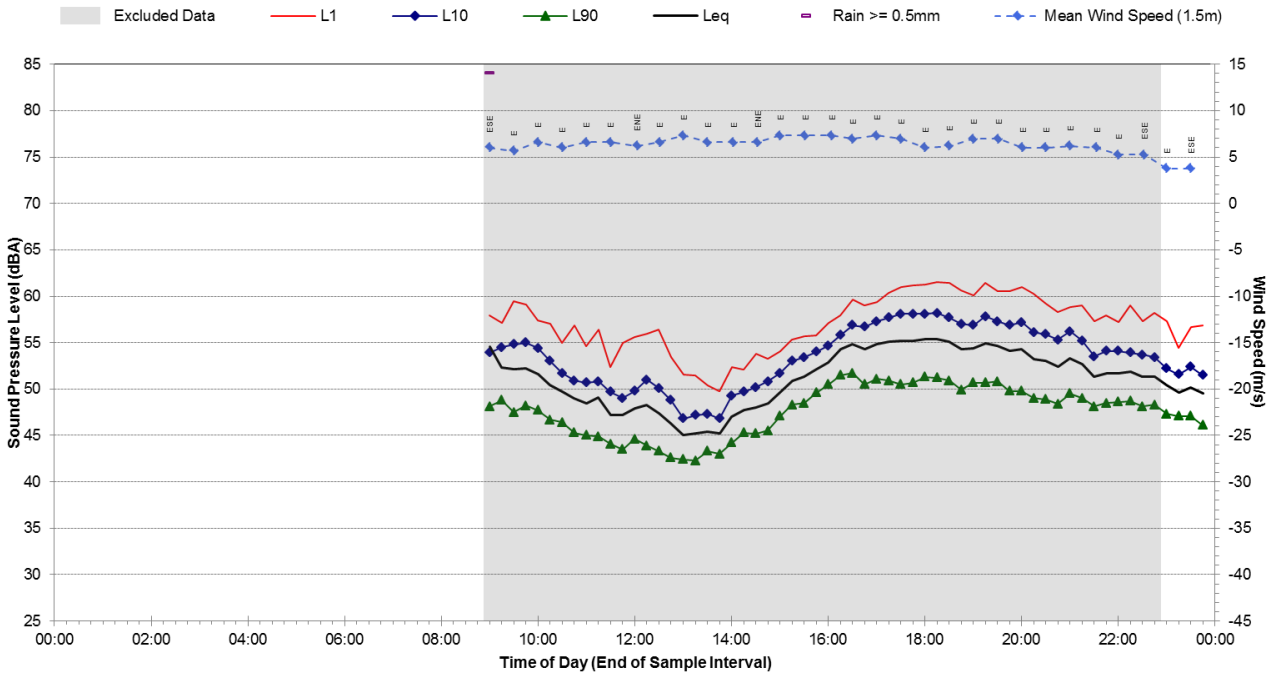

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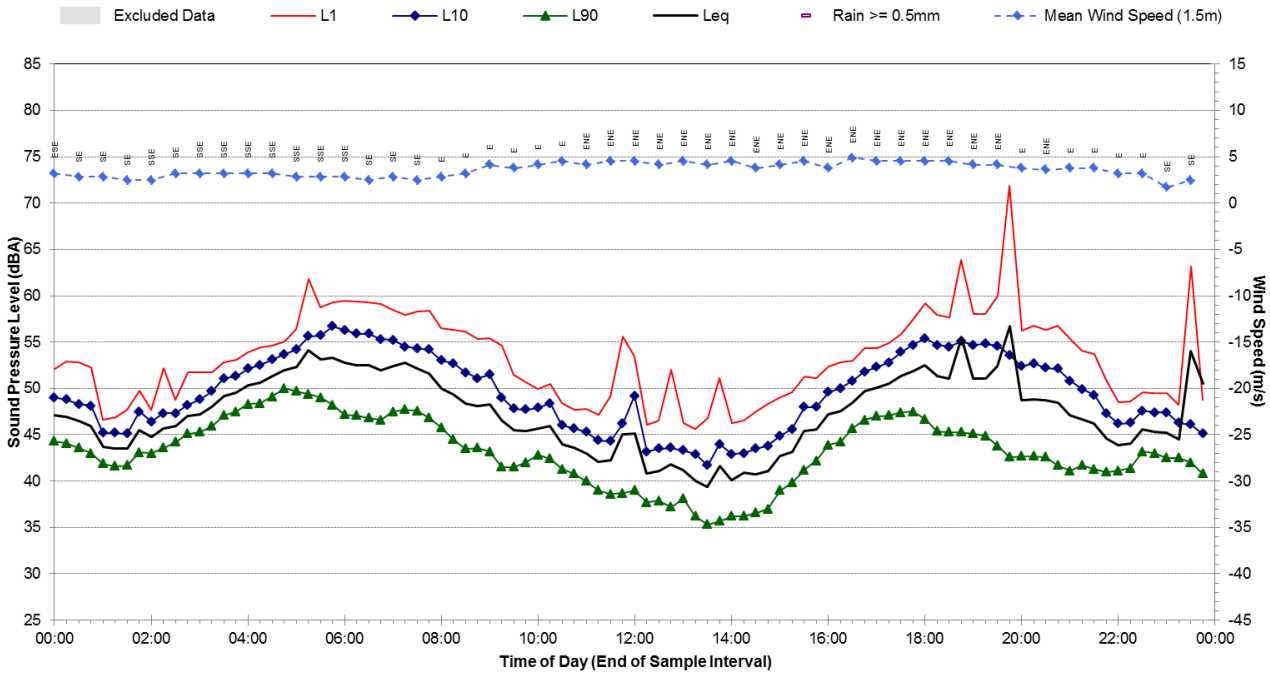

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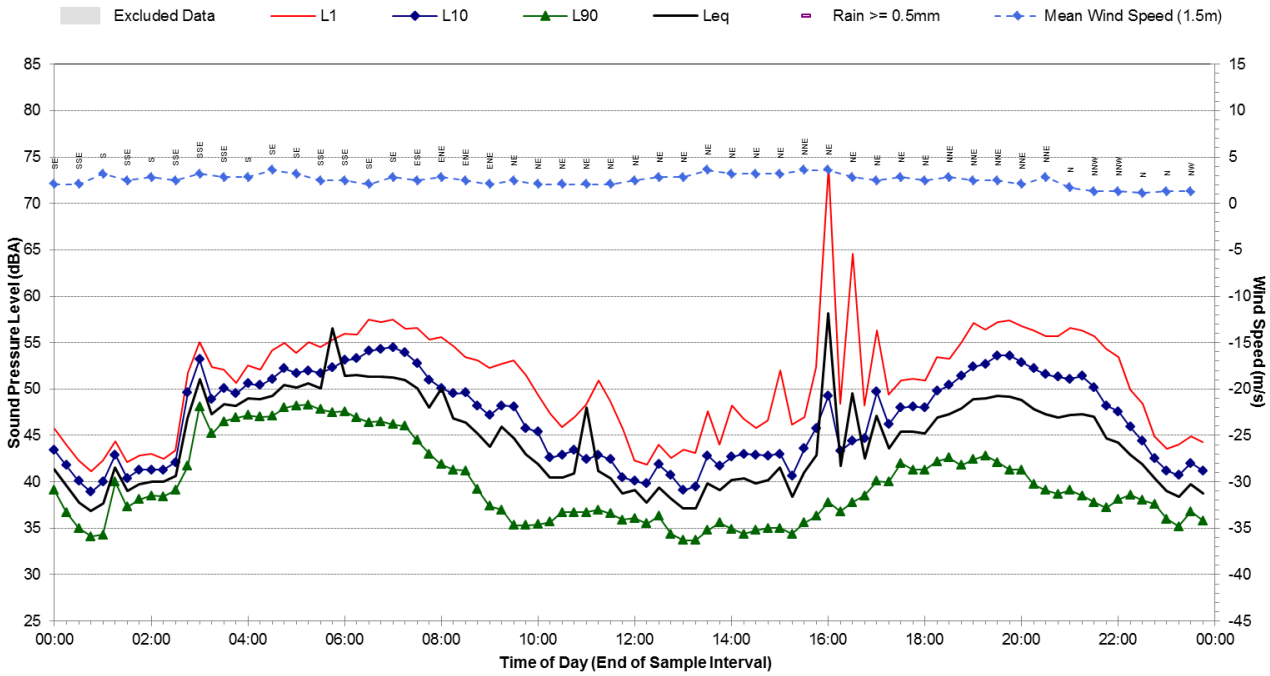
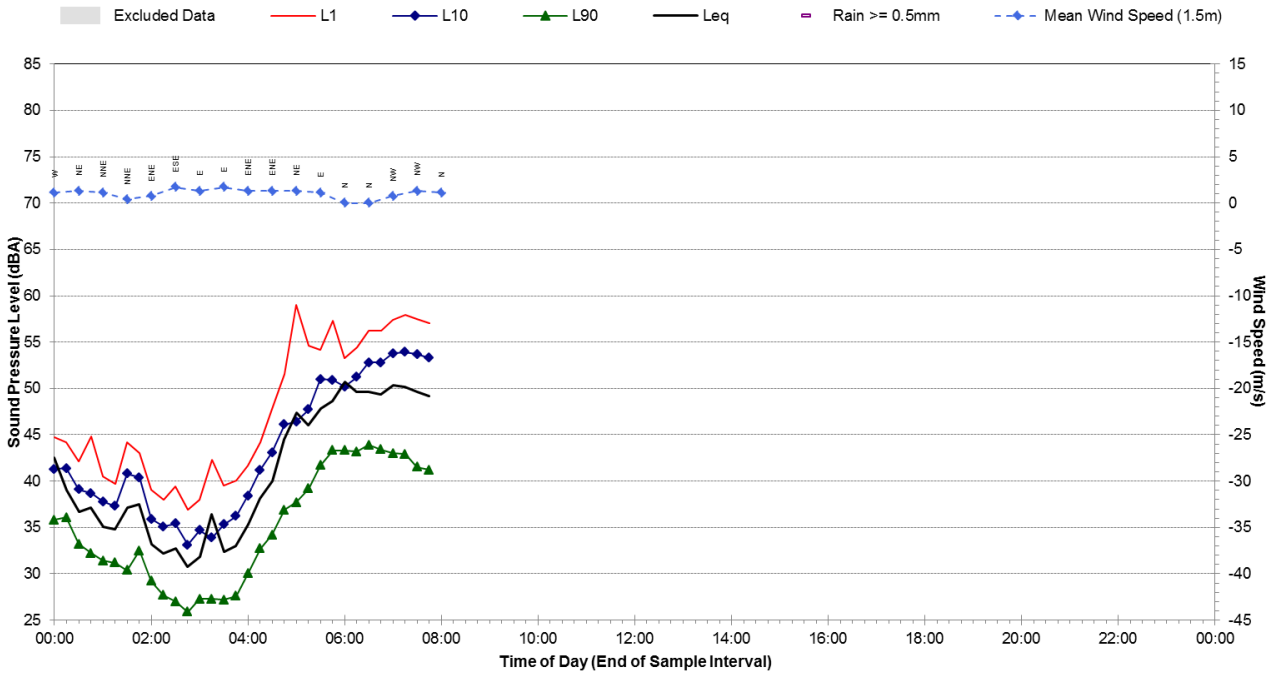


Statistical Ambient Noise Levels

Facing Island - Friday, 7 November 2014



Statistical Ambient Noise Levels

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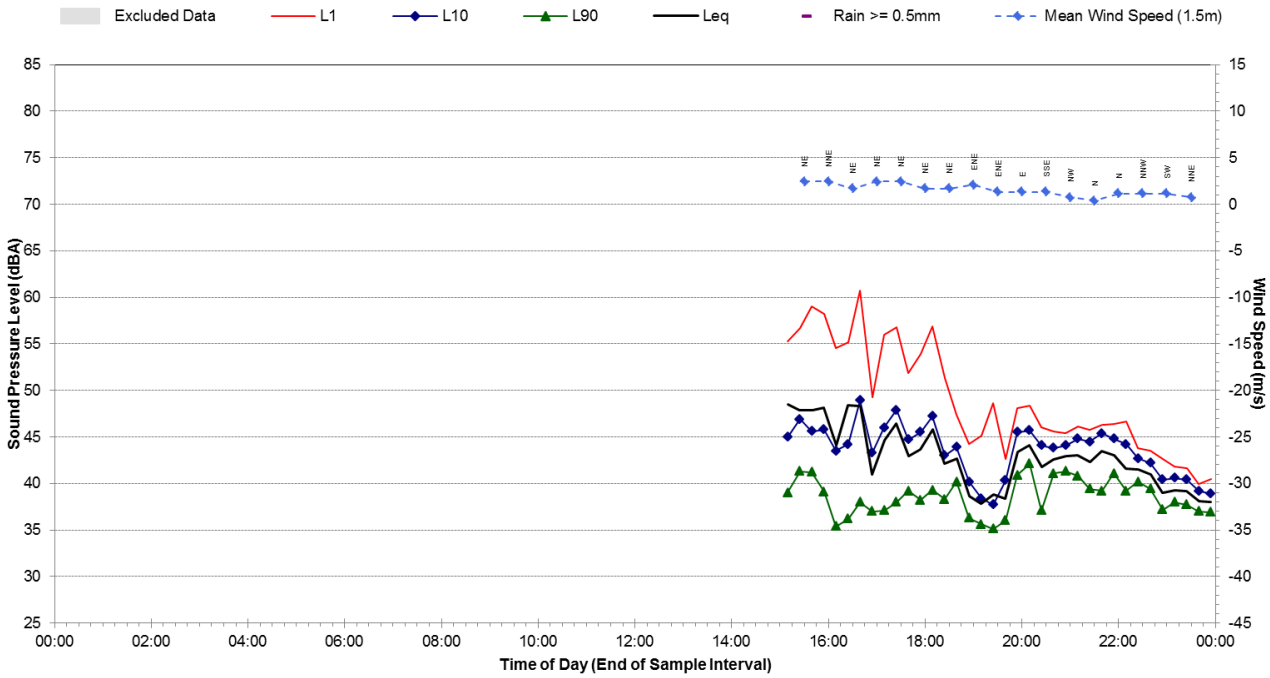

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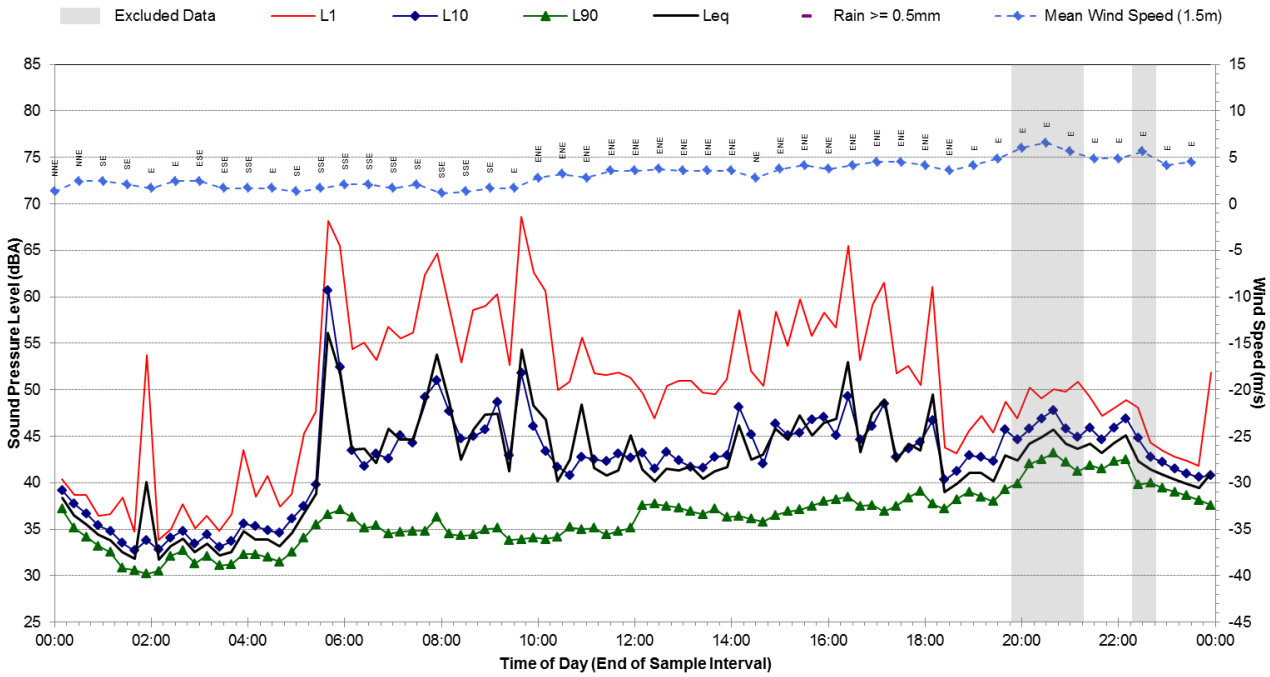

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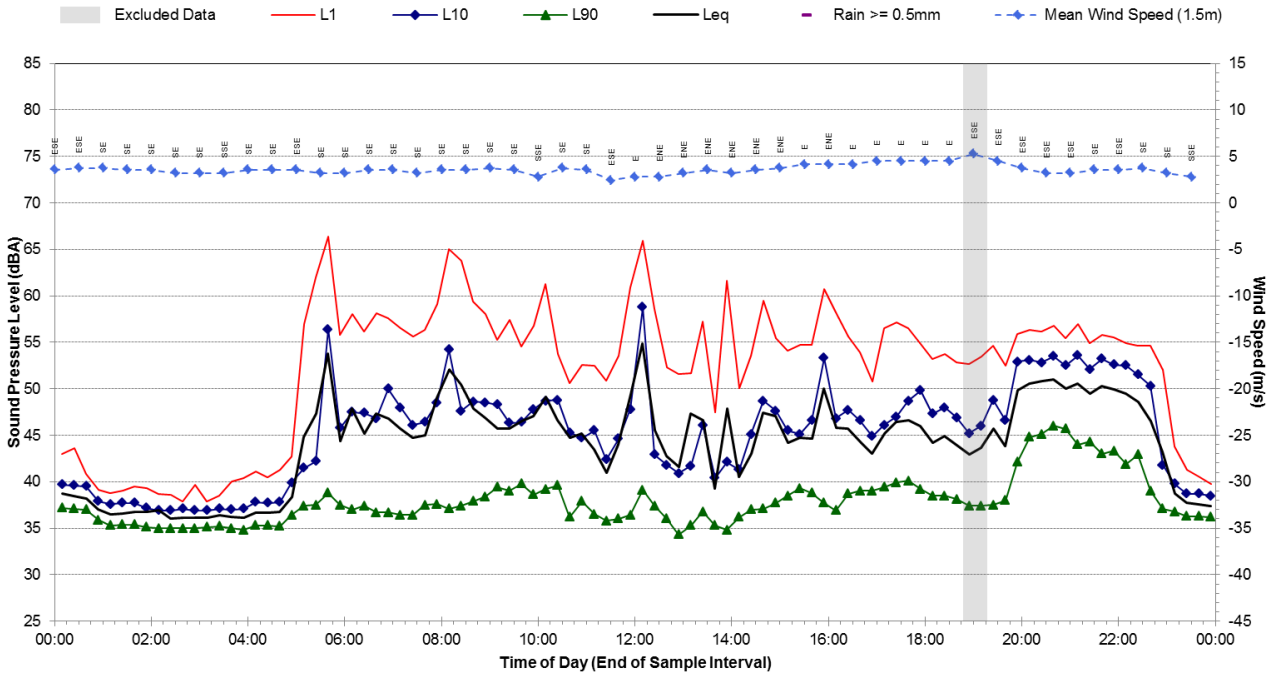
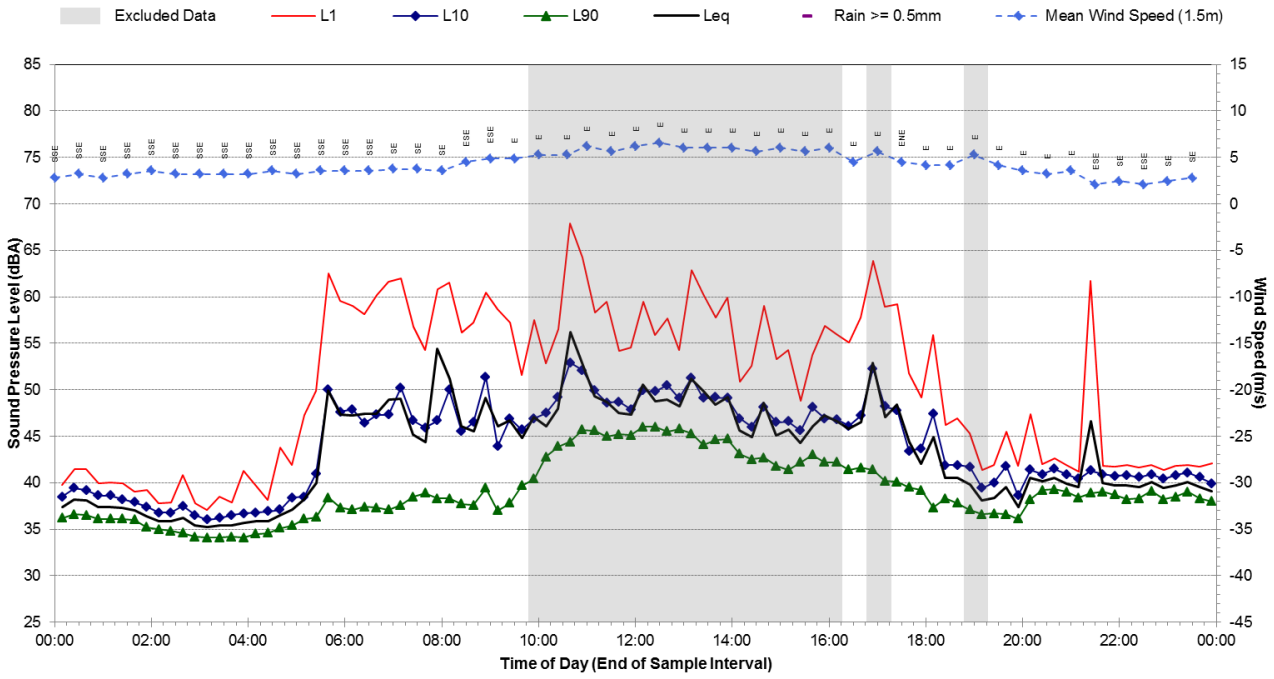


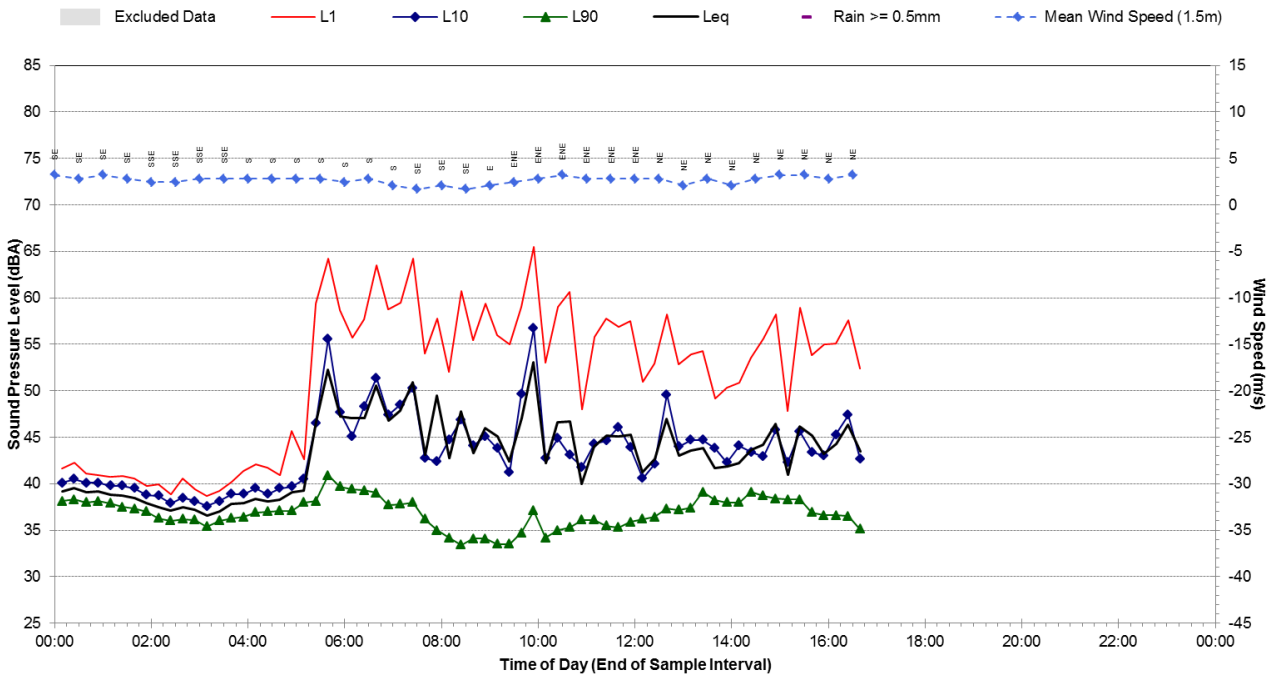
Statistical Ambient Noise Levels

Boyne Island - Sunday, 14 September 2014



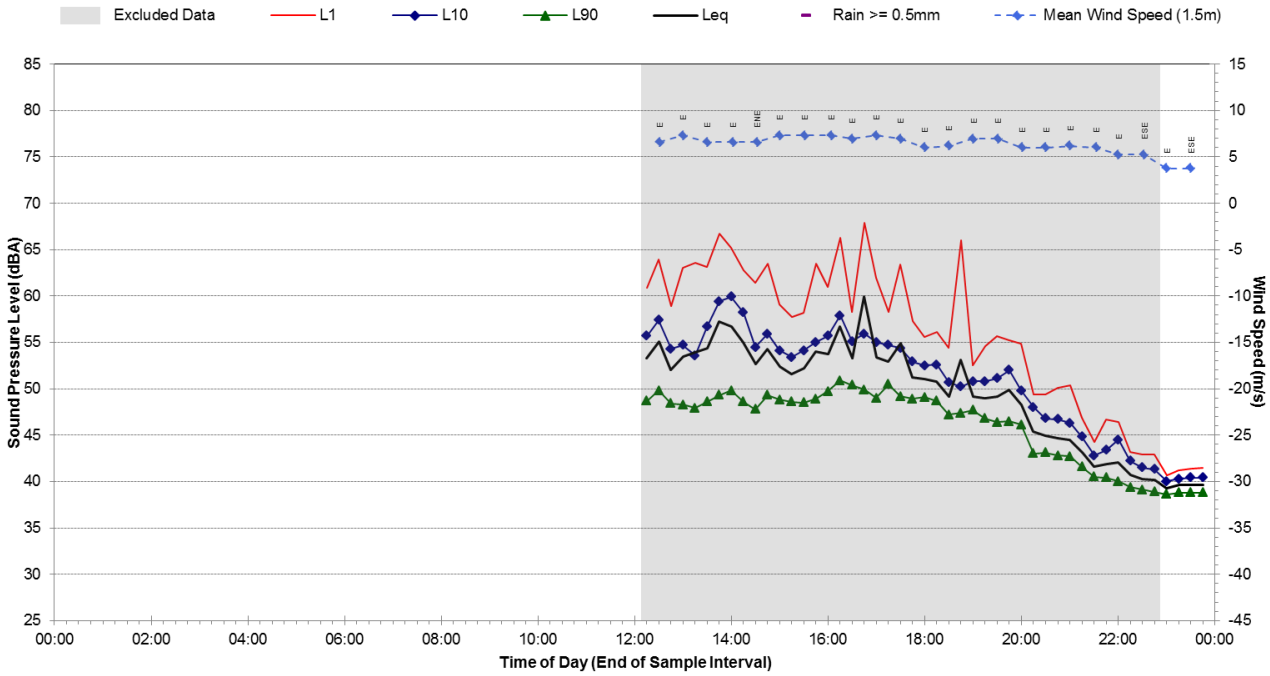
Statistical Ambient Noise Levels

Boyne Island - Monday, 15 September 2014



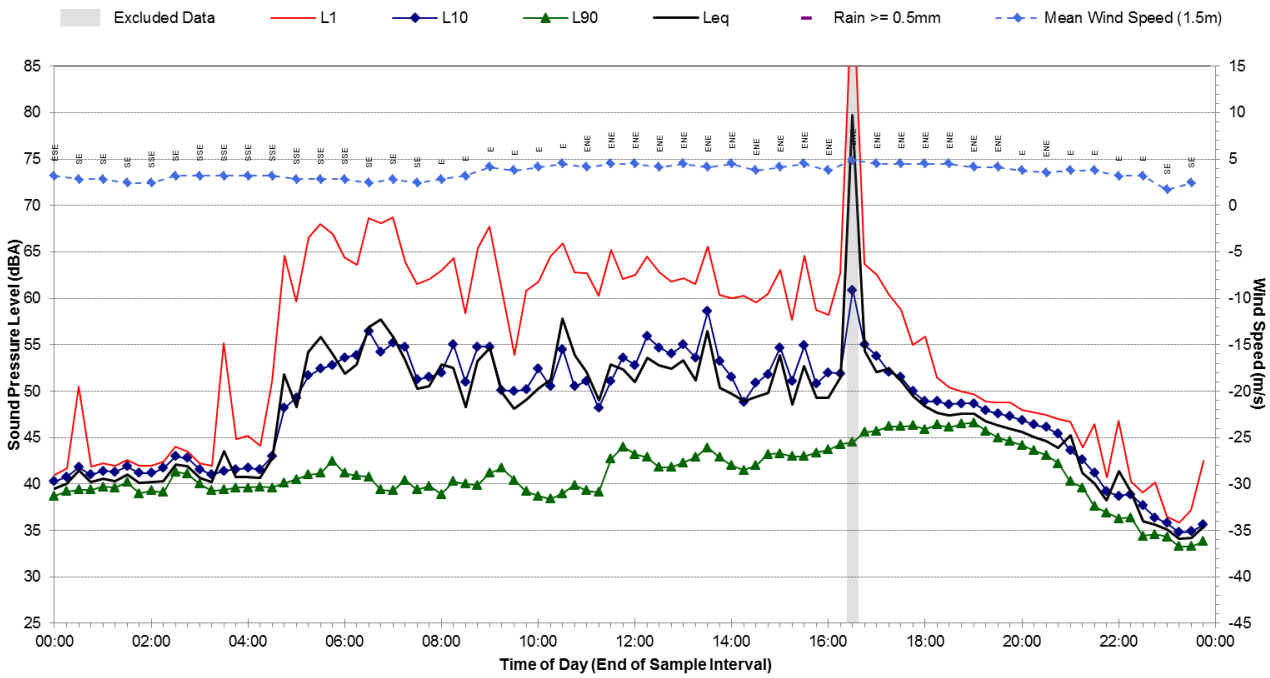
Statistical Ambient Noise Levels

Boyne Island - Tuesday, 4 November 2014

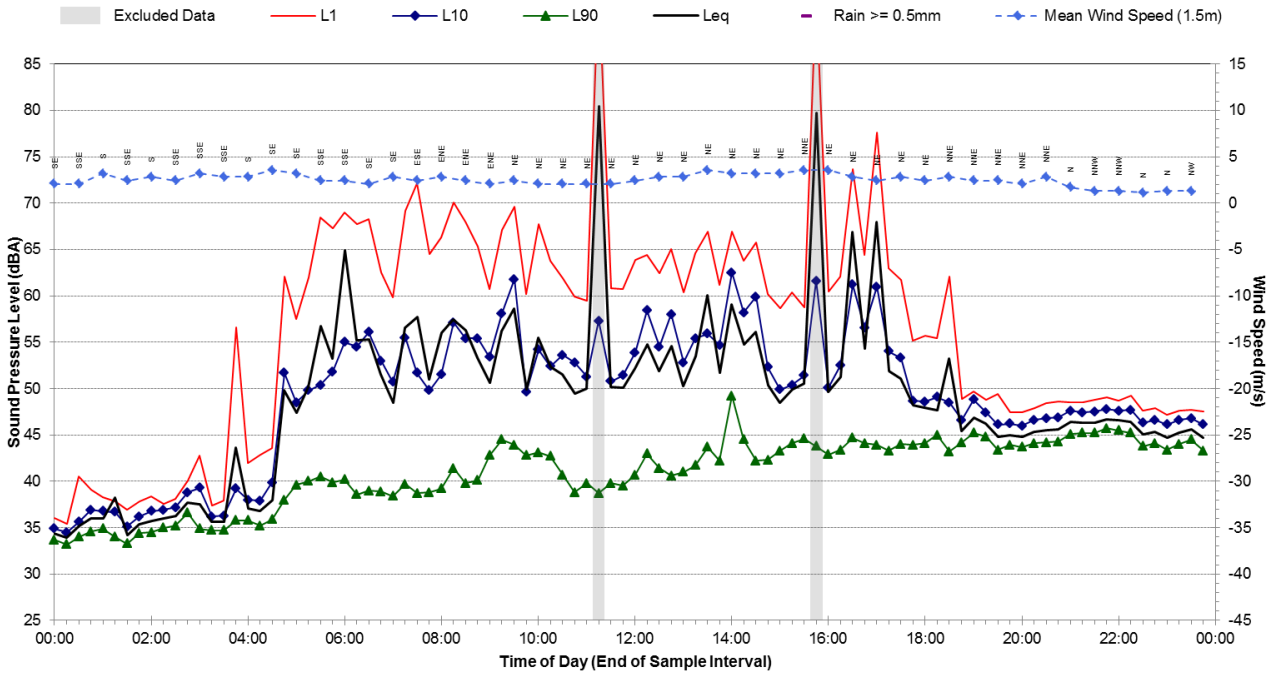


Statistical Ambient Noise Levels

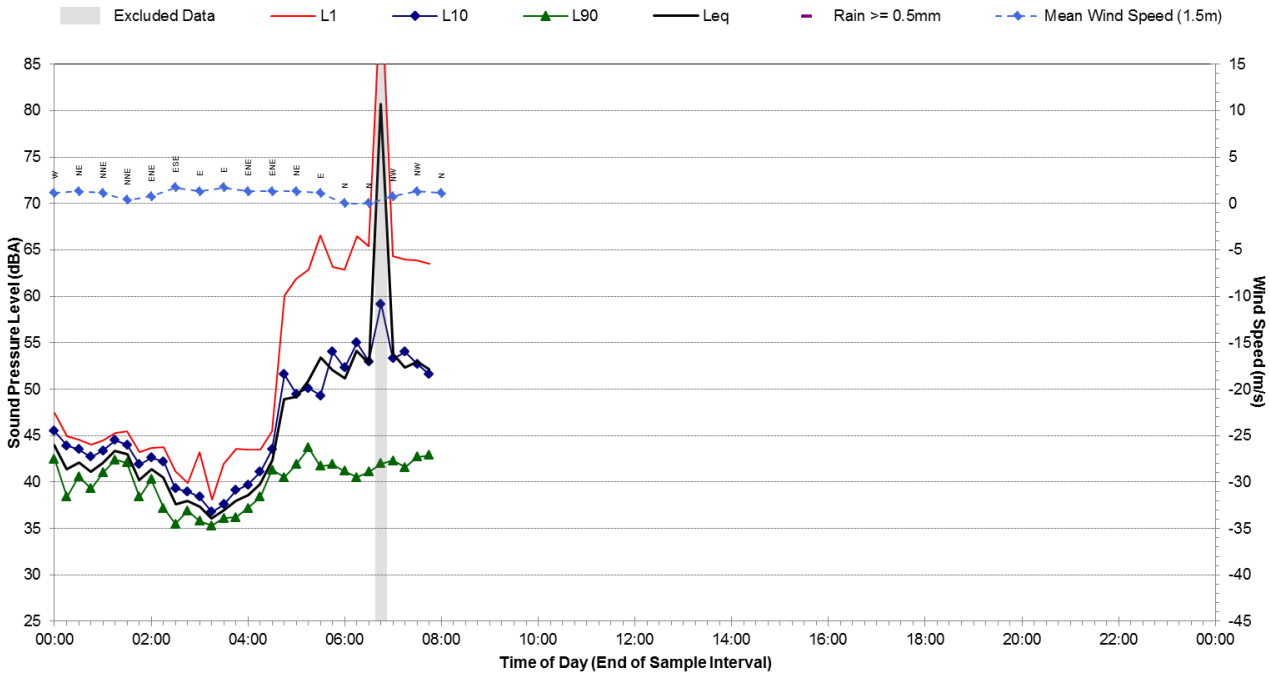
Boyne Island - Wednesday, 5 November 2014



Statistical Ambient Noise Levels
Boyne Island - Thursday, 6 November 2014



Statistical Ambient Noise Levels
Boyne Island - Friday, 7 November 2014



APPENDIX C

Meteorological data

Weather Modelling Methodology

TAPM Modelling

The TAPM prognostic model, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) was used to generate the upper air data required for CALMET modelling.

TAPM predicts wind speed and direction, temperature, pressure, water vapour, cloud, rain water and turbulence. The program allows the user to generate synthetic observations by referencing databases (covering terrain, vegetation and soil type, sea surface temperature and synoptic scale meteorological analyses) which are subsequently used in the model input to generate one full year of hourly meteorological observations at user-defined levels within the atmosphere.

Additionally, TAPM may assimilate actual local wind observations so that they can optionally be included in a model solution. The wind speed and direction observations are used to realign the predicted solution towards the observation values. Wind data from Bureau of Meteorology Station located at Gladstone Airport (Station ID 39326) and Queensland DES's monitoring sites located at South Gladstone and Targinie were used to nudge the TAPM predictions. The table below details the parameters used in the TAPM meteorological modelling for this assessment.

Meteorological Parameters used for this Study – TAPM

TAPM (v4.0)	
Number of grids (spacing)	4 (30 km, 10 km, 3 km and 1 km)
Number of grid points	25 x 25 x 35
Year of analysis	2016
Centre of analysis	314,908 m E 7,367,655 m S
Data assimilation	Gladstone Airport (BOM site), Targinie (QLD EPA site) & South Gladstone (QLD EPA site)

CALPUFF Modelling

In the simplest terms, CALMET is a meteorological model that develops hourly wind and other meteorological fields on a three-dimensional gridded modelling domain. Associated two dimensional fields such as mixing height, surface characteristics and dispersion properties are also included in the file produced by CALMET.

The interpolated wind field is then modified within the model to account for the influences of topography, sea breeze, as well as differential heating and surface roughness associated with different land uses across the modelling domain. These modifications are applied to the winds at each grid point to develop a final wind field. The final hourly varying wind field thus reflects the influences of local topography and land uses.

TAPM-generated three-dimensional meteorological data was used as the initial guess wind field and the local topography and available surface weather observations in the area were used to refine the wind field predetermined by TAPM data.

Hourly surface meteorological data from Bureau of Meteorology (BOM) stations located at Gladstone Airport, and the QLD DES's monitoring stations located at Targinnie were incorporated in the meteorological model.

The table below details the parameters used in the CALMET model.

Meteorological Parameters used for this Study – CALMET (v 6.1)

CALMET parameters	
Meteorological grid	28 km × 28 km
Meteorological grid resolution	0.2 km
Surface station data	Gladstone Airport and Targinie
Initial guess filed	3D output from TAPM modelling

Analysis of ≤3 m/s prevailing wind conditions

The following tables detailed the statistical analysis of the regional wind speed and wind directions specific to the modelled domains for the WBE reclamation area and the Duplicated Channels.

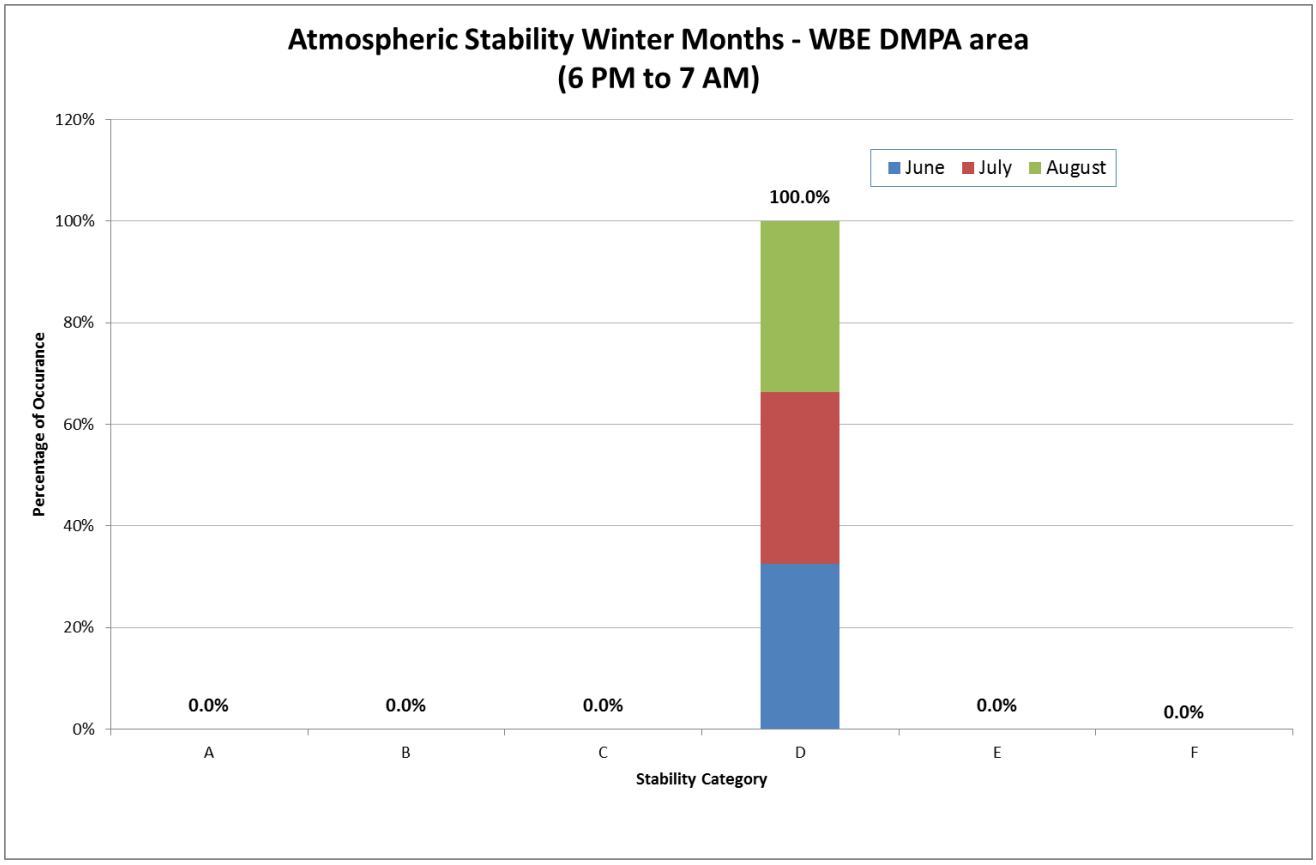
Wind analysis for the region of the WBE reclamation area and BUF

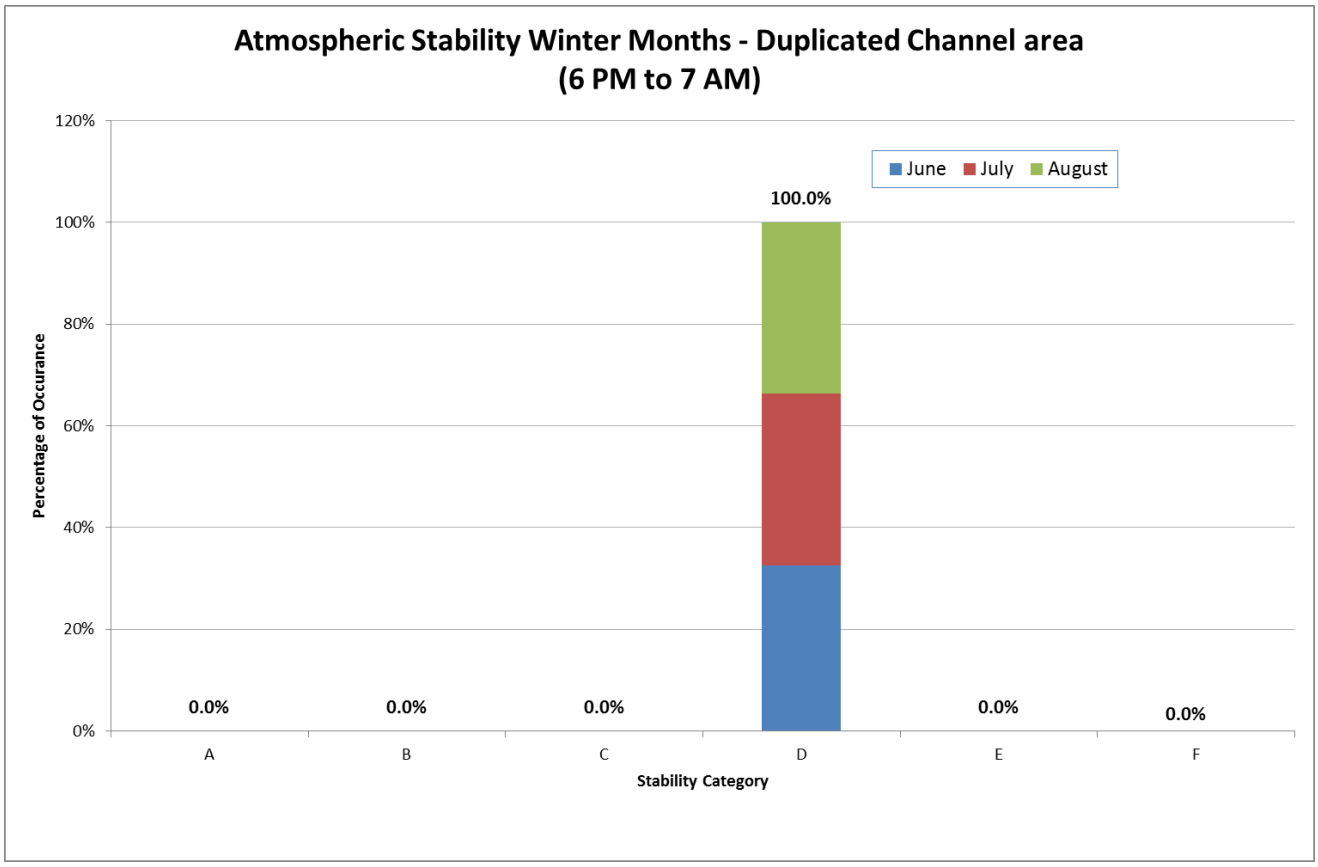
Direction	Frequency of wind speed events ≤3 m/s out of total wind speed events per period											
	Summer			Autumn			Winter			Spring		
	Day	Even	Night	Day	Even	Night	Day	Even	Night	Day	Even	Night
N	4%	9%	8%	1%	6%	1%	2%	19%	6%	6%	23%	15%
NNE	3%	10%	8%	2%	6%	4%	4%	8%	9%	7%	8%	11%
NE	4%	11%	7%	3%	7%	5%	7%	4%	5%	7%	9%	6%
ENE	4%	10%	4%	6%	8%	5%	7%	2%	2%	7%	7%	4%
E	2%	2%	4%	4%	12%	4%	4%	9%	3%	4%	4%	5%
ESE	1%	3%	5%	4%	14%	10%	4%	9%	8%	2%	3%	10%
SE	3%	3%	21%	5%	10%	33%	4%	9%	13%	2%	2%	12%
SSE	1%	1%	9%	5%	4%	18%	6%	4%	10%	1%	1%	8%
S	1%	0%	3%	5%	1%	7%	8%	2%	11%	2%	1%	5%
SSW	1%	0%	2%	2%	0%	1%	5%	2%	6%	2%	1%	2%
SW	1%	1%	2%	1%	1%	1%	2%	2%	3%	1%	1%	2%
WSW	1%	1%	2%	0%	1%	1%	4%	3%	4%	2%	1%	2%
W	0%	1%	1%	1%	0%	0%	3%	2%	3%	2%	1%	1%
WNW	1%	0%	1%	1%	0%	0%	2%	2%	2%	2%	1%	1%
NW	2%	1%	3%	1%	1%	0%	1%	4%	1%	2%	4%	4%
NNW	3%	2%	7%	1%	2%	1%	2%	6%	3%	5%	14%	8%

Wind analysis for the region of the channel duplication

Direction	Frequency of wind speed events ≤3 m/s out of total wind speed events per period											
	Summer			Autumn			Winter			Spring		
	Day	Even	Night	Day	Even	Night	Day	Even	Night	Day	Even	Night
N	1%	2%	4%	1%	1%	0%	1%	2%	1%	2%	7%	3%
NNE	2%	4%	4%	3%	0%	0%	4%	1%	0%	4%	3%	3%
NE	4%	4%	5%	3%	1%	0%	6%	2%	1%	5%	6%	6%
ENE	2%	4%	3%	3%	6%	0%	6%	2%	0%	3%	7%	4%
E	1%	2%	2%	2%	5%	1%	2%	2%	2%	2%	4%	4%
ESE	1%	1%	3%	2%	5%	1%	2%	6%	2%	1%	2%	4%
SE	0%	1%	6%	3%	12%	6%	3%	7%	4%	1%	1%	4%
SSE	0%	1%	3%	4%	7%	22%	4%	8%	4%	1%	3%	5%
S	0%	0%	2%	2%	3%	13%	3%	5%	12%	1%	1%	6%
SSW	1%	0%	3%	1%	2%	5%	3%	5%	10%	2%	1%	8%
SW	0%	1%	2%	1%	1%	3%	4%	7%	10%	1%	4%	5%
WSW	0%	0%	3%	0%	1%	3%	3%	4%	5%	2%	1%	4%
W	0%	0%	2%	0%	1%	1%	2%	4%	3%	1%	1%	3%
WNW	0%	1%	1%	0%	1%	0%	2%	3%	2%	1%	1%	3%
NW	1%	1%	5%	1%	1%	0%	1%	4%	2%	1%	6%	4%
NNW	1%	2%	3%	1%	2%	0%	1%	1%	1%	3%	8%	4%

Atmospheric stability (temperature inversion) analysis





APPENDIX D

Source noise emission levels

Source sound power levels for plant and equipment

Plant/ equipment	Source sound power level, dBA[1]
Large excavator	115
Medium excavator	115
Medium loader	107
Medium dozer (D6)	111
Large dozer (D9)	110
Small bobcat	105
Vibratory roller	105
Water cart	113
Diesel generator	89
Dump truck (truck & dog configuration)	110
CSD	110
TSHD	109
TSHD booster pump	108
Barge	93
Pushbuster	111
Vibratory sheet piling rig	116
Junttan impact hydraulic hammer[2]	124

Note 1: The emission level is the sound power level of the noise source representative of continuous operation.

Note 2: The sound power level for the hydraulic impact hammer includes a +2 dBA adjustment for impulsive noise.

ASIA PACIFIC OFFICES

BRISBANE
Level 2, 15 Astor Terrace
Spring Hill QLD 4000
Australia
T: +61 7 3858 4800
F: +61 7 3858 4801

CANBERRA
GPO 410
Canberra ACT 2600
Australia
T: +61 2 6287 0800
F: +61 2 9427 8200

DARWIN
5 Foelsche Street
Darwin NT 0800
Australia
T: +61 8 8998 0100
F: +61 2 9427 8200

MACKAY
21 River Street
Mackay QLD 4740
Australia
T: +61 7 3181 3300

MELBOURNE
Suite 2, 2 Domville Avenue
Hawthorn VIC 3122
Australia
T: +61 3 9249 9400
F: +61 3 9249 9499

NEWCASTLE
10 Kings Road
New Lambton NSW 2305
Australia
T: +61 2 4037 3200
F: +61 2 4037 3201

PERTH
Ground Floor, 503 Murray Street
Perth WA 6000
Australia
T: +61 8 9422 5900
F: +61 8 9422 5901

ROCKHAMPTON
rockhampton@slrconsulting.com
M: +61 407 810 417

SYDNEY
2 Lincoln Street
Lane Cove NSW 2066
Australia
T: +61 2 9427 8100
F: +61 2 9427 8200

TAMWORTH
PO Box 11034
Tamworth NSW 2340
Australia
M: +61 408 474 248
F: +61 2 9427 8200

TOWNSVILLE
Level 1, 514 Sturt Street
Townsville QLD 4810
Australia
T: +61 7 4722 8000
F: +61 7 4722 8001

AUCKLAND
68 Beach Road
Auckland 1010
New Zealand
T: +64 27 441 7849

NELSON
5 Duncan Street
Port Nelson 7010
New Zealand
T: +64 274 898 628

NEW PLYMOUTH
Level 2, 10 Devon Street East
New Plymouth 4310
New Zealand
T: +64 0800 757 695