APPENDIX 26

CONSTRUCTION NOISE EFFECTS

URS

Acoustics Report

Lyttelton Port of Christchurch

NEW ZEALAND

Lyttelton Port Recovery Plan

Assessment of construction noise effects

13 November 2014
42193100/002/D

Prepared for:
Lyttelton Port of Christchurch

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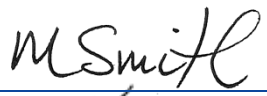
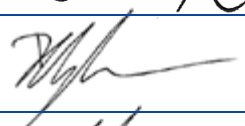
Prepared by	Michael Smith		13 Nov 14	Associate Acoustics Engineer
Checked by	Darran Humpheson		13 Nov 14	Principal Acoustics Consultant
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EXECUTIVE SUMMARY

The current provisions of the Banks Peninsula District Plan and Canterbury Regional Costal Plan require consents to be obtained whenever noise from construction activities exceed the guideline noise limits from the New Zealand Standard for construction noise, NZS 6803.

As part of the Recovery Plan for Lyttelton Port, amendments are proposed that addresses construction noise in a Construction Noise Management Plan and Construction Noise Mitigation Plan Framework, similar to that currently provided for the management of port noise.

Predictions have been made for different activities using a 3D computer acoustics model. At this stage precise activity locations and equipment are unknown, but a range of likely noise levels at local receivers has been determined. For some activities and work locations, construction noise will be potentially significant. To manage resultant effects, Lyttelton Port of Christchurch (LPC) and their contractors will need to:

- Confirm that the equipment and methodologies have been selected that reduce the overall noise from the activity;
- Sequence activities to avoid sensitive times for neighbouring residents/businesses; and
- Contact affected persons and discuss implications of the activity and take feedback into consideration.

Both LPC and appointed contractors have important roles in managing noise. All contractors will be required to prepare and implement a Construction Environmental Management Plan (CEMP) which will document the required noise management practices, amongst other things. LPC is responsible for approving this document and performing ongoing reviews. LPC has produced a guideline for preparing a CEMP, to ensure consistency amongst contractors.

These requirements will be further detailed in a port-wide Construction Noise Management Plan that is proposed to be prepared by LPC in conjunction with the existing Port Liaison Committee.

Where construction noise exceeds the 65 dB L_{dn} port noise contour, mitigation measures will need to be put in place. These are to be detailed in a Construction Noise Mitigation Plan.

With the appropriate mitigation measures in place, impacts from construction work should be acceptable and allow LPC to facilitate the recovery of the Port while at the same time managing the potential effects of the construction noise on surrounding noise sensitive receivers.

1 INTRODUCTION

The Canterbury Regional Council (Environment Canterbury) has been directed to prepare a Recovery Plan for Lyttelton Port [1] ('the Direction'). The purpose of the Recovery Plan is to identify necessary changes to the activity status of certain works to facilitate the recovery of Greater Christchurch. The Recovery Plan will direct the councils (Environment Canterbury and the Christchurch City Council) to amend statutory instruments (Regional Coastal Plan and Banks Peninsular District Plan) to facilitate the recovery of the Port.

Lyttelton Port of Christchurch (LPC) is required to provide Environment Canterbury with all necessary information to enable it to prepare the recovery plan. LPC is to provide technical reports to support the proposed amendments to statutory instruments. This report addresses construction noise effects. Vibration from the works associated with the recovery is not expected to be significant.

Operational noise effects are reported separately by Hegley Acoustic Consultants [2], and effects on marine mammals have been considered by the University of Otago [3].

The assessment framework in this Report is guided by the Direction and the purpose of the Canterbury Earthquake Recovery (CER) Act, in particular, how the Lyttelton Port of Christchurch's long-term vision for the efficient, timely and effective repair, rebuild and restoration and enhancement of Lyttelton Port can be provided in the Recovery Plan in a way that enables an expedited recovery that restores social, economic, cultural, and environmental well-being.

A traditional RMA assessment, against the purpose of the Act and relevant RMA planning documents is therefore not required under the CER Act. Nevertheless, in the context of noise emissions, the exiting District Plan and relevant New Zealand noise standards provide guidance on how to assess the effects of activities on noise at Lyttelton.

1.1 Summary of proposal

The purpose of the Recovery Plan is to facilitate the recovery of the Port. This includes the repair, rebuild and reconfiguration needs of the Port, and its restoration and enhancement, to ensure the safe, efficient and effective operation of Lyttelton Port and supporting transport networks. The proposed vision is shown in the Port Lyttelton Plan [4].

The recovery will be highly complex, involving a multitude of individual yet interrelated projects many of which will need to be carefully coordinated with each other as well as the operation activities at the Port. The ultimate outcome of this repair, rebuilding and reconfiguration work is the moving east of port operations in a timely manner, which results in:

- The container terminal being established up to 37 hectares of reclaimed land in Te Awaparahi Bay;
- The shifting of some types of general cargo from the Inner Harbour to Cashin Quay; and
- The development of public access to the Inner Harbour in two stages (Dampier Bay and potentially the Dampier Bay Extension) to provide a commercial marina and associated activities, with public access and connectivity between Lyttelton and other parts of Naval Point.

At this stage it is assumed that the direct repairs or rebuild of existing wharf structures, seawalls and hard-standing areas and the construction of the reclamation would take in the order of fifteen years, being completed in about 2028. However, the complete migration of the Port's operation to the east could well take up to 30 years.

Some of the repaired or rebuilt berths at Cashin Quay, Naval Point and the new berths at Te Awaparahi Bay will be designed to handle larger vessels with a deeper draft. The deepening and widening of the current navigation channel to enable access of these larger vessels is therefore inextricably linked to and forms an important part of the Port's recovery.

Figure 1-1 provides an outline of the proposed Recovery. The Recovery description below is discussed under four headings:

- Reclamation, Container Terminal and Quarry;
- Cashin Quay;
- Inner Harbour; and
- Cruise Berth Options.

It must be emphasised that the descriptions below are based on LPC's current understanding of the economic and commercial drivers which shape the Port's infrastructure needs. It is possible that the infrastructure needs could change over the next 15 years, in response to worldwide economic factors and industry changes. More detailed descriptions, including the project codes of each individual projects, are included in the Recovery Plan.

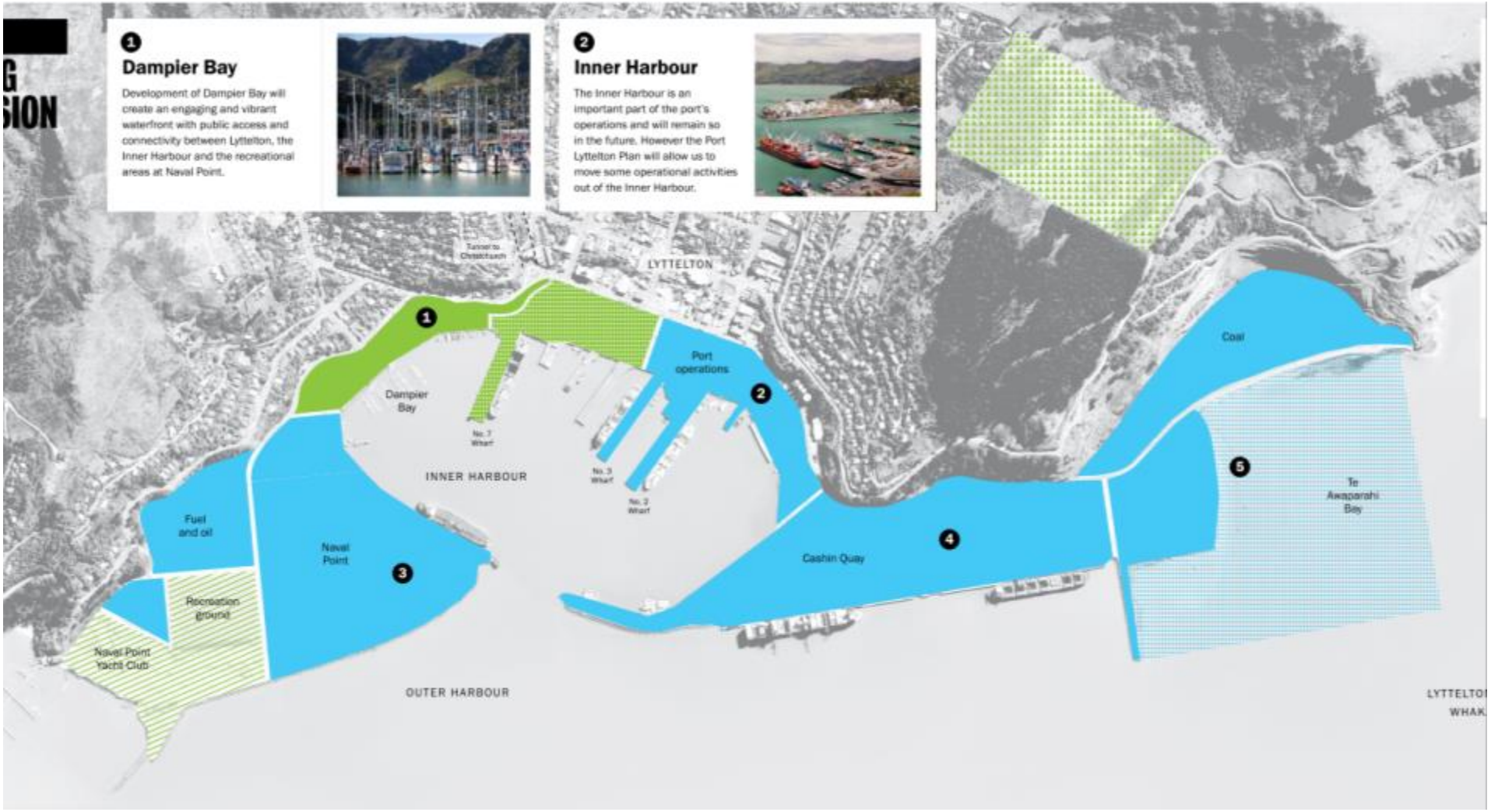

Figure 1-1 Port location with long-term vision

1.1.1 Reclamation, Container Terminal and Quarry

The additional reclamation will be developed using a range of different methodologies, which will be influenced by the type and quantity of available fill. It will initially move in a southern direction to enable the construction of a new berth line, which facilitates the development of the first stage of a terminal in behind this. It is anticipated that this part will comprise approximately 8 hectares directly south of the currently consented 10 hectare area and would be constructed from quarry sourced hardfill (Gollans Bay quarry and/or Sumner Road reopening works), end tipped in a similar way to the current 10 hectares.

Land creation would then focus on moving in an easterly direction, and it is likely that a combination of hard and marine fill will be utilized. This area could be as much as 19 hectares, and may require the construction of a containment bund if marine fill is to be utilised. Aggregate would need to be imported to form the foundation of the pavement layers. This then enables the extension to the east of the adjacent new berth line, and subsequent development of a container terminal in behind this.

This staged methodology will provide for the creation of additional container terminal capacity.

1.1.1.1 *Container Terminal*

The new terminal will include a container-handling yard connected to two modern berths designed to handle larger vessels. These are typically 6000 TEU[1] vessels that are approximately 300 m long and have a draught of up to 14.5 m. The berths will be constructed in two stages and at full completion up to eight cranes could be used to serve two vessels. The container terminal would be designed to utilize straddle carriers to move containers.

1.1.1.2 *Quarry*

The existing quarry will provide rock for the proposed reclamation in Te Awaparahi Bay, not only for fill material but also for large rocks needed to ‘armour’ the reclaimed land from the sea. The rock will also be needed to armour the rebuilt seawalls elsewhere in the Port, e.g. in the Inner Harbour. The rate of take and the extent of the quarry will be no more than what is currently consented for the 10 hectare reclamation.

1.1.2 *Cashin Quay*

Cashin Quay berth No.2 is currently subject to a major rebuild. This includes the removal and reconstruction of the wharf, seawall and associated hard standing areas. The other three berths at Cashin Quay will also require significant repair or replacement.

Cashin Quay will continue to handle containers in the medium term, however, after the container handling facilities are established in Te Awaparahi Bay, Cashin Quay’s focus will change to one of general, bulk and break bulk cargos such as logs, fertiliser, and scrap metal. Coal will continue to use Cashin Quay berth No.1.

New buildings will be developed to support the expanding port including maintenance and administration facilities.

[1] The twenty-foot equivalent unit i.e. 6000 twenty foot containers

1.1.3 Inner Harbour

1.1.3.1 *Eastern Port Operations*

The eastern part of the Inner Harbour (from Wharf No.3 eastwards) will continue to be part of the Port operational area. However, the cargo handling operations will shift towards those which are less noisy and dusty (these will be moved to Cashin Quay). Cement ships, some break bulk cargo, car vessels and the larger fishing vessels are likely to use this area as would the tugs and other support vessels used by LPC.

No. 2 and 3 wharves will need to be replaced or substantially repaired as will the No.1 breastwork.

1.1.3.2 *Dampier Bay*

The development of Dampier Bay with a mixed use commercial development and marina is anticipated to commence early on in the Recovery. This will allow for community access to the waterfront with an emphasis on activities that have wide appeal. Dampier Bay will result in improved public access and connectivity between Lyttelton Township and the western Inner Harbour. The proposed waterfront promenade will also facilitate better connectivity between Lyttelton Township and the recreational areas at Naval Point.

The first phase of the Dampier Bay development involves the construction of a modern floating pontoon marina catering for up to 200 berths. Phase 1 will also include developing the landside adjacent to the marina, this will include car parking, marina facilities, walkways and some commercial development. This is expected to be completed in 2016/2017.

The remainder of the Dampier Bay development is expected to take a further 4-7 years. This will include:

- Development of the landside with a mixed use commercial development (up to a total of 15,000 m^2 of floor space), possible uses include; marine related industries and services, retail, hospitality, office/studio.
- Retiring the use of Sutton Quay for heavy vehicle port access and shifting the security fence to the eastern side of No.7 Wharf.
- Extension of the walkway along the waterfront and linking this with pedestrian access to Norwich Quay (via or adjacent to Sutton Quay).
- Creation of a new Diamond Harbour ferry terminal which will link with public transport and walkways to the township. The most likely location for the terminal is at the base of No.7 wharf.
- Creation of some open space areas.

1.1.3.3 *Dampier Bay Extension*

The Dampier Bay Extension project comprises the LPC owned land between No.7 wharf and the western side of No 3 wharf. It also includes the block of LPC owned land to the south of Norwich Quay and provision of public access to No.7 wharf. It does not include the railway lines and siding which are owned by Kiwirail.

The ability to develop this area is dependent on the migration of the Port to the east and can only happen once a new container terminal is operating in Te Awaparahi Bay and majority of trades have moved to Cashin Quay. Consequently timing for starting works in this area is approximately 15-25 years.

As this project is not to commence for some time, planning has yet to commence on what could be done in this area. However the following are potential options:

- The demolition of Wharfs No. 4, 5 and 6 creates the potential for an extension to the recreational marina area to the east of No. 7 Wharf, enabling the construction of further marina berths.
- Continuation of the Dampier bay waterfront walkway.
- Limited on land development to provide support services for the marina and walkway.
- Potential for some type of commercial development.

In the meantime Port land is at a premium and this area will continue to be used for cargo handling and other port-related operations.

1.1.3.4 *Naval Point (Port owned land)*

The bulk fuel berth is to remain at its existing location at Naval Point although this facility will be rebuilt, and will be constructed in a way that can be extended to accommodate larger vessels in the future, if required. The Dry Dock will continue to operate in the same location, as will those activities that rely on the dock. It is possible the old Cattle Jetty, located between the Oil Berth and the Dry Dock, could be replaced with a new wharf.

1.1.4 *Options for Cruise Ships*

Inner Harbour and Outer Harbour development options for cruise ships are being investigated. These include an option to locate the berth facilities on the harbour side of the Naval Point Tank Farm or alternatively to locate the berth at Gladstone Quay in the Inner Harbour. The new berth will be of a size to handle large cruise ships which are up to 350m in length and have draught of approximately 8.5m.

Both options would require dredging to establish the berth pocket and the Z-berth mole would need to be removed for the Inner Harbour option.

1.1.5 *Port wide repairs and reconstruction*

In addition to the specific assets that need repairing or replacement (i.e. wharfs), there is also port wide infrastructure that needs repairing or rebuilding. This is principally the pavements, roads and underground services. This work will be programmed around the need to continue operations at the Port and will occur throughout the Recovery.

1.1.5.1 *Pavements and roadways*

Much of the Port's pavement has suffered significant earthquake damage. Many of the roads and sealed surfaces in the Port will either need to be replaced or have significant repairs. This

will involve removal of the existing pavement, re-compacting the underlying material (including re-levelling) and then re-surfacing.

1.1.5.2 Services

Like other parts of the City, the Port's services, i.e. stormwater, wastewater, power and data have been damaged and need repair or replacement. Some parts will also need upgrading to provide for the reconfiguration of the Port. This work will involve the excavation and repair of the underground services including provision of relocated and discharge points into the harbour if needed. Some above ground structures, such as substations, pump stations, etc., will also need to be repaired and in some cases relocated.

1.2 Report structure

This report is structured as follows:

- Section 2 will provide an overview of the existing noise framework for both port operational noise and construction noise.
- Section 3 will propose changes to statutory documents required to enable the recovery. This includes a brief description of acoustics fundamentals and the choice between different noise metrics.
- Section 4 will review the existing environment.
- Section 5 will detail the process for noise modelling and the results.
- Section 6 describes the mitigation that will be adopted on projects, and the potential for acoustic treatment of residential dwellings.
- Sections 7 will provide assessment of environmental effects for land receivers.

1.3 Consultation

During the preparation of the report, the authors have met with representatives of Environment Canterbury and the Christchurch City Council and their noise advisors to discuss the scope of the technical assessment. Meetings were held on 12 September and 8 October 2014.

LPC has also undertaken consultation with the local communities as part of the 'Port Talk' engagement process. Although comments have been made regarding noise from the Port, principally operational noise, the impacts of construction noise have not been raised as a significant concern.

2 EXISTING NOISE FRAMEWORK

2.1 Port noise

The effects of port noise on residential activities are managed in the District Plan in two ways:

- Rules in the residential zone control residential development within the Port Influences Overlay Area. Certain residential development is allowed provided habitable rooms are constructed so that they achieve particular internal design sound levels as well as a no-complaints covenant in favour of LPC being entered into.
- Establishment and implementation of a Port Noise Management Plan and a Port Noise Mitigation Plan, which acknowledges that the Port's operation will change over time, and provides a framework for managing effects, rather than specifying a rigid noise limit.

In particular, the plan requires:

- The establishment of a Port Noise Liaison Committee, comprising members from LPC, Port customers and Port users, residents of Lyttelton Township, Christchurch City Council and Canterbury Regional Council. This Committee provides framework for community input into noise management issues at Lyttelton Port.
- A model of port operations to be developed in accordance with NZS 6809 [5] and L_{dn} contours determined for a 5-day busy period. Whenever Port operations significantly alter or on request of the Port Noise Liaison Committee, this model must be updated.
- Identify 'Noise-Affected Properties' which are residentially-zoned properties partly or wholly contained within the area seaward of the '65 dBA L_{dn} contour line'. These properties are eligible to apply for acoustics mitigation for habitable spaces (e.g. mechanical ventilation, upgraded wall linings and glazing). The process for any work on Noise-Affected Properties is detailed in the Port Noise Mitigation Plan.
- Residents of properties with the 70 dBA L_{dn} contour can request that LPC purchase their property at a fair market value, not taking into account the effect of the port noise.

2.2 Construction noise

Rule 1.7.b of Chapter 33 of the District Plan references NZS 6803P:1984 [6] as the appropriate standard for construction noise. This standard was updated in 1999 to become a full standard, NZS 6803:1999 [7]. There are no fundamental differences between the two versions, and therefore, although the version cited in the District Plan is applicable, the current 1999 version has been used here as representing good practice.

Criteria

NZS 6803:1999 includes a table of recommended noise limits, which depend on the time of day and the duration of construction noise (Table 2-1). In most cases, construction noise limits are less strict than the respective operational noise limit under the District Plan, on the basis that the effects of construction activities are of limited duration. Consents are required to be obtained whenever noise from construction activities exceeds the guideline noise limits.

Table 2-1 Guideline construction noise limits from NZS 6803

Time of week	Time period	Duration of construction work at any one location					
		less than 2 weeks		less than 20 weeks		more than 20 weeks	
		$L_{Aeq(15min)}$	L_{AFmax}	$L_{Aeq(15min)}$	L_{AFmax}	$L_{Aeq(15min)}$	L_{AFmax}
Residential							
Weekdays	0630-0730	65 dB	75 dB	60 dB	75 dB	55 dB	75 dB
	0730-1800	80 dB	95 dB	75 dB	90 dB	70 dB	85 dB
	1800-2000	75 dB	90 dB	70 dB	85 dB	65 dB	80 dB
	2000-0630	45 dB	75 dB	45 dB	75 dB	45 dB	75 dB
Saturdays	0630-0730	45 dB	75 dB	45 dB	75 dB	45 dB	75 dB
	0730-1800	80 dB	95 dB	75 dB	90 dB	70 dB	85 dB
	1800-2000	45 dB	75 dB	45 dB	75 dB	45 dB	75 dB
	2000-0630	45 dB	75 dB	45 dB	75 dB	45 dB	75 dB
Sundays and public holidays	0630-0730	45 dB	75 dB	45 dB	75 dB	45 dB	75 dB
	0730-1800	55 dB	85 dB	55 dB	85 dB	55 dB	85 dB
	1800-2000	45 dB	75 dB	45 dB	75 dB	45 dB	75 dB
	2000-0630	45 dB	75 dB	45 dB	75 dB	45 dB	75 dB
Industrial and commercial							
All days	0730-1800	80 dB	-	75 dB	-	70 dB	-
	1800-0730	85 dB	-	80 dB	-	75 dB	-

Management framework

In addition to the recommended noise limits, NZS 6803 provides a framework for managing construction noise. Where practicable, engineering controls should be used to reduce noise levels. However, for some tasks (e.g. piling) this will not be possible, and effects will need to be managed by limiting operating hours, providing respite periods, and ongoing consultation and communication with affected parties.

Mitigation measures should be properly planned and implemented in a structured hierarchy depending on the extent of predicted effects. All these measures represent best practice and regardless of the context of the proposed construction works, operational and management controls should be considered when developing proposals for construction activities.

3 CHANGES TO STATUTORY DOCUMENTS

3.1 Introduction

Construction noise is typically excluded from noise limits in a District Plan. Instead most Plans, including the Banks Peninsula District Plan section of the City Plan, simply state that construction noise must comply with NZS 6803. This means resource consent is required whenever noise from construction activities exceeds the guideline construction noise limits identified in Table 2-1. The amendments to the District Plan provisions, proposed under the Lyttelton Port Recovery Plan, instead propose to introduce a Construction Noise Management Plan and a Construction Noise Mitigation Plan.

The extended duration of the activities anticipated under this recovery plan is in many ways similar to the timescales of the port 'operation' rather than temporary 'construction'. By providing a parallel framework to the existing port noise management framework, this will require LPC to address effects in a more coordinated way, and gives oversight to the Port Noise Liaison Committee.

For the majority of construction works, the character and magnitude of the works will not be too dissimilar to existing operational noise. It is only those construction activities which have a special character, such as piling and percussive breaking, which may require specific mitigation measures. For these activities the approach will be to minimise the effects of these works using a combination of best practice as set out in the proposed Construction Noise Management Plan and which will also inform port-wide and individual project Construction Environment Management Plans (CEMPs) and additional mitigation measures as set out in the proposed Construction Noise Mitigation Plan. The existing port noise framework has the mechanism for treating Noise Affected Properties and a similar framework can be used to manage construction noise.

3.2 Staged approach

The following flow diagram illustrates the two stage approach that is proposed. As discussed in Section 6.2, all projects will have a CEMP, which will be developed using LPC's *Guideline for preparing Construction Environmental Plan* (CEMP Guideline) [8], and template. The CEMP will confirm that best practice is being adopted for all environmental topics, which includes noise management.

The CEMP Guideline provides each contractor with the necessary guidance regarding noise management and will ensure that best practice is being carried out for all projects, which includes the assessment and monitoring of noise. The CEMP makes reference to the noise limits of NZS 6803, with an amendment to the night time noise criteria, which have been specified as a means of ensuring self-regulation of the contractor's impacts by providing a set of criteria which are already established and well understood.

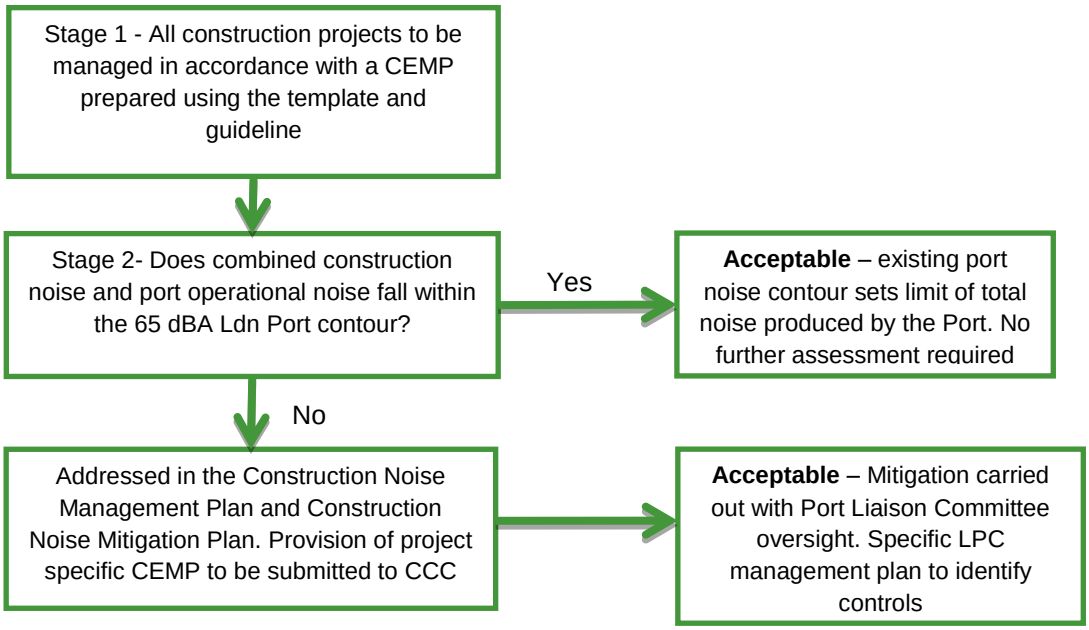

Figure 3-1 Assessment flowchart

In order to safeguard against noise effects on sensitive activities, whilst maintaining port operations and enabling construction activities, a series of recommendations are made:

1 Maintain the current provisions of the Port Noise Management Plan and their administration, including Port Noise Liaison Committee and the current suite of exceptions such as blasting, warning devices by emergency services, and impulsive noise. Dwellings within the 65 dBA L_{dn} contour as identified in the Port Noise Contour Map attached to the Port Noise Management Plan can continue to apply to the Port Liaison Committee for acoustic treatment of habitable rooms to satisfy an internal design sound level of 40 dBA L_{dn} (5 days) with mechanical ventilation installed;

2 A Construction Noise Management Plan will be established and will include:
   i. Identify construction activities that can give rise to construction noise.
   ii. Set a framework for monitoring, measuring and reporting on construction noise.
   iii. Set a framework for dealing with complaints.

3 The Construction Noise Mitigation Plan will:
   i. Set out procedures on how affected property owners are to be contacted and the documentation of feedback and proposed mitigation measures discussed.
   ii. Develop criteria that specify mitigation measures, having regard to the length of time the construction affected property is to be exposed to construction noise and the levels of construction noise involved.
   iii. Specify mitigation measures determined under the criteria that may include measures such as:
      - Provision of temporary accommodation;
      - Acoustic mitigation (dwelling upgrade) in accordance with the criteria set out in the existing Port Noise Mitigation Plan; and
      - An offer to purchase the property.

4 Where the combination of construction noise and operational port noise [5-day busy period] falls within the 65 dBA Ldn contour then no further assessment of the construction noise is required. Conversely, where the combined construction noise and operational port noise [5-day busy period] exceeds the 65 dBA Ldn contour then further assessment of the construction noise in accordance with the Construction Noise Management Plan would be required.

4 EXISTING ENVIRONMENT

4.1 Qualitative description

Noise from Port operation has been part of the character of the Lyttelton Township for many years. Sources of noise include:

- reversing beepers;
- ships at berth;
- road, rail and sea traffic;
- cargo handling machinery and equipment;
- repair and maintenance machinery and equipment;
- integral refrigerated containers; and
- loading and unloading of vessels, vehicles and trains.

Short-term events occur with louder noises than usual, for example scrap metal loading, and sand blasting within the dry dock. In addition, noise from ships at sea is audible at times, but is excluded from the noise management framework and coastal plans.

Road-traffic noise

Noise from vehicles can be grouped as follows:

- Movements within the Port grounds;
- Concentrated movements along Norwich Quay up to the tunnel, where dissipation will start to occur; and
- Wider distribution to the state highway network and arterial roads.

The principal routes in and out of the Port are shown in Figure 4-1. At the time of this report, the Sumner Road route over Evans Pass is not accessible. The Direction states to assume that this road will be reopened.

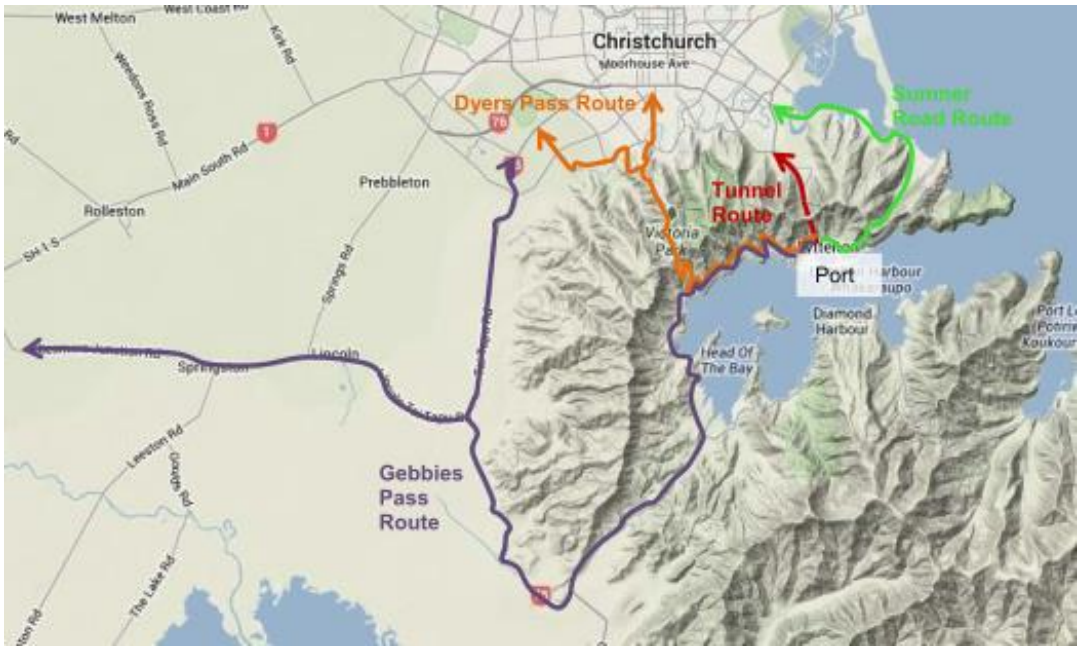

Figure 4-1 Traffic routes to and from the port (from traffic report)

4.2 Quantitative description

Attended and unattended noise monitoring has been conducted during 2014 at several locations around Lyttelton (Figure 4-2) and Diamond Harbour (Figure 4-3). Diamond Harbour is approximately 1.5 km south of Cashin Quay. Noise from certain port activities is clearly audible at times in Diamond Harbour, however is often masked by wave action or the influence of the wind direction. The average noise levels for the unattended monitoring at eight locations are shown in Table 4-1. These are based on measurements over a 48 hour period. Separate day and night levels are provided, as well as a combined L_{dn}. The results are presented graphically in Appendix B.

Table 4-1 Unattended noise monitoring results

Address	Day time 0700h to 2200h (15h)		Night time 2200h to 0700h (9h)		L_{dn}
	L_{Aeq}	Average $L_{A90(15min)}$	L_{Aeq}	Average $L_{A90(15min)}$	
20 Sumner Road	54 dB	49 dB	57 dB	53 dB	61 dB
2A Gilmour Terrace	56 dB	54 dB	57 dB	55 dB	63 dB
34A Gilmour Terrace	54 dB	50 dB	52 dB	48 dB	60 dB
Reserve Terrace	63 dB	59 dB	67 dB	61 dB	70 dB
18 Cressy Terrace	52 dB	47 dB	55 dB	46 dB	59 dB
31 Brittan Terrace	54 dB	51 dB	59 dB	56 dB	62 dB
8 Bridle Path	46 dB	41 dB	50 dB	46 dB	54 dB
19 James Drive, Diamond Harbour	53 dB	38 dB	60 dB	47 dB	61 dB

Attended short-term noise measurements at ten locations were conducted during an evening survey of the area and the measurement results are included in Table 4-2, along with a

description of the noise environment. A container ship was being unloaded in Cashin Quay with a logging ship in berth at No. 7 at the time.

Table 4-2 Attended noise monitoring results

Address	L_{Aeq}	L_{AFmax}	Noise environment
Reserve Terrace, overlooking container terminal	60 dB	68 dB	Noise from straddle carriers operating, reversing alarms, occasional horns. Banging from containers being moved.
20 Sumner Road	53 dB	63 dB	Noise from logging vehicle movements and reversing alarms. Distance beeps from container terminal.
2A Gilmour Terrace	49 dB	57 dB	Noise from logging vehicle movements and banging of containers.
34A Gilmour Terrace	47 dB	63 dB	Individual sources less dominant. Banging from container terminal audible.
Cnr Exeter Street and Canterbury Street	47 dB	57 dB	Constant drone from generator on ship in berth 7. Crane movement.
Cnr Winchester Street and Canterbury Street	46 dB	55 dB	High frequency noise from crane loading logging vehicles.
57 London Street	54 dB	62 dB	Ship generator pulsating. Crane from berth 7 dominant. Noise from coal train loco.
8 Godley Quay	52 dB	66 dB	Crane from berth 7. Traffic noise from logging trucks and clunking noise when empty.
Waipapa Street, Diamond Harbour	35 dB	48 dB	Noise from straddle carriers operating and banging from containers being moved.
43 Koromiko Crescent, Diamond Harbour	38 dB	48 dB	Noise from straddle carrier reversing alarms clearly audible. Maximum level due to banging of containers.

Figure 4-2 Monitoring locations – Lyttelton township

Figure 4-3 Monitoring locations – Diamond Harbour

5 ACOUSTICS MODELLING

5.1 Methodology

A 3D computer acoustic model of the Port area has been used to predict noise levels from anticipated construction activities at the Port at surrounding areas in Lyttelton and Diamond Harbour. Key model parameters are listed in Table 5-1.

Table 5-1 Model parameters

Parameter	Setting/source
Software	Cadna/A v4.4
Algorithm	ISO 9613-2
Reflection model	Ray tracing, order 1. 2 dB reflection loss on buildings
Parameter	$L_{Aeq(15m)}$
Ground absorption	0.0 – port areas and water 0.5 – elsewhere
Receiver height	1.5 m (4.5 m upper floors) - most exposed façade
Noise contour grid	1.5 m height, 10 m resolution
Receivers position	Façade levels with 3 dB reflection

Topographic contours have been obtained from the CCC based on LiDAR data. The contour resolution was 1 m. The footprints for all buildings and all other structures in the area have been modelled based on data from the CCC. All buildings have been modelled as 5 m uniform height. A point receiver has been placed at the most exposed façade, with a 3 dB façade correction applied, consistent with NZS 6803.

The equipment noise source levels listed in Table 5-2 have been entered into the model as point sources, with a height of 2 to 4 m above local ground level. For the indicative predictions, sources have been located at the western end of the Port closest to the receivers.

5.2 Indicative programme

Works associated with the reinstatement and redevelopment of the Port have the potential to generate noise impacts during construction. The following extract shows the list of major projects, with indicative durations and start/end dates. It is noted that this is just one possible option and it is inevitable that there will be significant changes to this indicative programme.

ID	Notes	Task Name	Duration	Start	Finish	Predecesso
1		**RECLAMATION**	**120 mons**	**Wed 2/07/14**	**Tue 12/09/23**	
2	R01	Reclamation Land - Stage One (10Ha)	24 mons	Wed 2/07/14	Tue 3/05/16	
3	R02	Reclamation Land - Stage Two	36 mons	Wed 4/05/16	Tue 5/02/19	2,49
4	R03	Reclamation Land - Stage Three	48 mons	Wed 6/02/19	Tue 11/10/22	3
5	R04	Quarry Road - Lower Access	6 mons	Thu 1/01/15	Wed 17/06/15	
6	R05	Quarry Road - Upper Access	6 mons	Fri 1/01/16	Thu 16/06/16	
7	R06	Reclamation Material - Sumner Road	18 mons	Fri 1/01/16	Thu 18/05/17	
8	R07	Reclamation - Terminal Enabling Works	48 mons	Wed 4/05/16	Tue 7/01/20	2
9	R08	Reclamation - Wharf Development	18 mons	Wed 6/02/19	Tue 23/06/20	3
10	R09	Reclamation Plant/Infrastructure - Stage One Terminal	12 mons	Wed 1/01/20	Tue 1/12/20	3
11	R10	Reclamation Infrastructure/Plant - Stage Two Terminal	12 mons	Wed 12/10/22	Tue 12/09/23	4
12		**CASHIN QUAY AND COAL**	**82.05 mons**	**Thu 23/05/13**	**Thu 5/09/19**	
13	C01	Cashin Quay 2	20 mons	Wed 1/01/14	Tue 14/07/15	
14	C02	Cashin Quay 1-2 The Gap	5 mons	Wed 15/07/15	Tue 1/12/15	13
15	C03	Cashin Quay 3 (west) and 4	12 mons	Fri 1/01/16	Thu 1/12/16	
16	C04	Port Wide Services	48 mons	Fri 1/01/16	Thu 5/09/19	
17	C05	Cashin Quay Seawall	2 mons	Mon 1/01/18	Fri 23/02/18	
18	C06	Coal Handling System	6 mons	Mon 1/01/18	Fri 15/06/18	
19	C07	Cashin Quay 1	4 mons	Fri 1/08/14	Thu 20/11/14	
20	C08	LCT Extension and Empty Container Yard	7 mons	Wed 1/01/14	Tue 15/07/14	
21	C10	Cashin Quay - Cranes and Straddles	15 mons	Thu 23/05/13	Wed 16/07/14	
22	C12	Coal Yard Stormwater Treatment System	2 mons	Thu 1/01/15	Wed 25/02/15	
23	C13	Cashin Quay Mechanical Infrastructure	9 mons	Mon 2/02/15	Fri 9/10/15	
24	C14	Cashin Quay 3 (Easterm 150m)	20 mons	Mon 3/08/15	Fri 10/02/17	13
25		**INNER HARBOUR**	**111.05 mons**	**Tue 1/04/14**	**Tue 4/10/22**	
26	H01	Inner Harbour - No.1 Breastwork	21 mons	Thu 1/01/15	Wed 10/08/16	
27	H02	Inner Harbour - Dry Dock	12 mons	Thu 3/09/20	Wed 4/08/21	
28	H03	Inner Harbour - Tugs & Ferries Stage 1	12 mons	Mon 2/03/15	Fri 29/01/16	
29	H04	Inner Harbour - Z Berth	6 mons	Fri 3/02/17	Thu 20/07/17	28
30	H05	Cruise Berth Development	24 mons	Fri 21/07/17	Thu 23/05/19	29
31	H06	Inner Harbour Oil Berth	24 mons	Mon 3/11/14	Fri 2/09/16	
32	H07	Inner Harbour Fishing Wharf	24 mons	Mon 2/03/20	Fri 31/12/21	
33	H08	Inner Harbour Marina Development - Stage One	24 mons	Thu 1/01/15	Wed 2/11/16	
34	H09	Inner Harbour Jetty 7	12 mons	Mon 2/06/14	Fri 1/05/15	
35	H10	Inner Harbour Jetty 2	12 mons	Thu 14/06/18	Wed 15/05/19	34
36	H11	Inner Harbour Jetty 3	12 mons	Thu 16/05/19	Wed 15/04/20	35
37	H12	Inner Harbour Jetty Demolition (4,5, & 6)	6 mons	Mon 3/08/20	Fri 15/01/21	
38	H13	Port Wide Pavement and Stormwater	72 mons	Tue 1/04/14	Mon 7/10/19	
39	H14	Port Wide Buildings	36 mons	Tue 1/12/15	Mon 3/09/18	
40	H15	Port Wide Roading and Transport	36 mons	Wed 1/01/20	Tue 4/10/22	
41	H16	Inner Harbour Marina Development - Stage Two	36 mons	Wed 1/01/20	Tue 4/10/22	33
42		**GENERAL PROJECTS**	**110.35 mons**	**Mon 2/06/14**	**Tue 15/11/22**	
43	G01	Inland Depot - Land Purchase	0 mons	Mon 1/09/14	Mon 1/09/14	
44	G02	Inland Depot - Development Stage One	18 mons	Tue 2/09/14	Mon 18/01/16	43
45	G03	City Depot Drainage and Pavement Upgrade	6 mons	Mon 2/03/15	Fri 14/08/15	
46	G04	Capital Dredging - 13.5m	6 mons	Fri 1/06/18	Thu 15/11/18	
47	G05	Capital Dredging - 14.5m	6 mons	Wed 1/06/22	Tue 15/11/22	46
48	G06	Inland Depot - Development Stage Two	12 mons	Mon 1/06/20	Fri 30/04/21	44
49	G07	Port Wide Recovery Plan	18 mons	Mon 2/06/14	Fri 16/10/15	

Figure 5-1 Indicative programme

5.3 Equipment

The works described in Section 5.2 have been simplified into the following classes of activities:

- Piling
- Demolition
- Sea wall rebuild
- Wharf rebuild
- Paving

- General civil works

Preliminary noise modelling has been performed using the sound levels detailed in Table 5-2. These are predominantly from generic data (Appendix C of BS 5228-1 [9]). Future noise modelling will be performed by contractors based on updated data prior to commencement of major activities.

Table 5-2 Equipment source levels

Activity	Description	Reference	Octave band sound pressure level (dB at 10 m)								L_{Aeq}, dB at 10 m
			63	125	250	500	1k	2k	4k	8k	
Piling	Impact hammer, pile rig power pack & tracked mobile crane (55t)	On site-survey	97	98	100	102	98	97	89	81	104
Demolition	Petrol hand-held circular saw cutting concrete floor slab (3kW)	BS 5228-1 C.4.70	72	89	81	80	80	82	86	85	91
	Backhoe mounted hydraulic breaker (69kW)	BS 5228-1 C.5.6	90	79	75	78	78	83	91	92	88
	Tracked excavator (35t)	BS 5228-1 C.5.18	76	79	75	75	76	73	70	65	80
	Dump truck idling	Estimate	63	63	63	63	63	63	63	63	70
	Angle grinder grinding steel (2.3 kW)	BS 5228-1 C.4.93	57	51	52	60	70	77	73	73	80
	Diesel generator (4 kW)	BS 5228-1 C.4.85	69	69	67	60	59	60	56	53	66
Seawall rebuild	Tracked excavator (35t)	BS 5228-1 C.5.18	76	79	75	75	76	73	70	65	80
	Dump truck tipping fill (29t)	BS 5228-1 C.2.30	85	74	78	73	73	74	67	63	79
Wharf rebuild	Tracked mobile crane (55t)	BS 5228-1 C.3.29	81	77	69	67	62	60	61	51	70
	Hand-held welder (welding piles)	BS 5228-1 C.3.31	67	68	69	68	69	66	61	56	73
	Angle grinder grinding steel (2.3 kW)	BS 5228-1 C.4.93	57	51	52	60	70	77	73	73	80
	Diesel generator (4 kW)	BS 5228-1 C.4.85	69	69	67	60	59	60	56	53	66
Paving	Vibratory roller (8.9t)	BS 5228-1 C.5.20	90	82	73	72	70	65	59	54	75
	Asphalt paver + tipper lorry (18t)	BS 5228-1 C.5.31	72	77	74	72	71	70	67	60	77
General civil works	Tracked mobile crane (55t)	BS 5228-1 C.3.29	81	77	69	67	62	60	61	51	70
	Hand-held welder (welding piles)	BS 5228-1 C.3.31	67	68	69	68	69	66	61	56	73
	Diesel generator(4 kW)	BS 5228-1 C.4.85	69	69	67	60	59	60	56	53	66

5.4 Results

Representative receivers have been placed in the noise model at representative locations in Lyttelton Township and Diamond Harbour. Locations situated in Lyttelton are shown in Figure 5-2.

Results for the six scenarios are presented in Table 5-3. These are considered upper bounds of predicted noise levels, based on the activity being at the most likely closest location possible to the receiver. The table does not take into account the temporal duration of the works and hence the presented levels would reflect the upper $L_{Aeq(15min)}$ and not the long term construction sound level.

Noise levels are colour coded based on the triggers for additional assessment and enhanced management listed in the CEMP Guideline.

- Red: >70 dB. Does not meet CEMP daytime (Mon-Sat) criteria.
- Orange: 55-70 dB. Meets CEMP daytime (Mon-Sat) criteria, but not Sunday.
- Green: < 55 dB. Meets all CEMP criteria.

Table 5-3 Predicted construction sound levels, dB $L_{Aeq(15min)}$

Address	Piling	Demolition	Seawall Rebuild	Wharf Rebuild	Paving	General Civil
8 Godley Quay	81	70	62	55	58	51
5 Brittan Tce	76	59	52	45	49	41
2 Brittan Tce	71	53	48	40	44	37
36 Simeon Quay	67	42	39	31	35	28
4 Walker Rd	67	47	43	35	39	32
43 Voelas Rd	67	44	41	33	37	30
40 Norwich Quay	80	72	63	56	59	52
52 London St	64	37	35	27	33	26
30 Winchester St	66	43	39	31	36	29
32 Exeter St	61	34	32	24	29	22
61 Sumner Rd	76	57	51	44	47	40
1 Reserve Tce	72	48	44	36	40	32
2 Gilmour Tce	72	49	44	36	40	33
10 Gilmour Tce	67	47	43	35	39	32
2 Reserve Tce	67	44	41	33	38	31
46 Koromiko Cres	49	26	24	16	22	15

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Figure 5-2 Noise prediction locations

Construction noise contours have also been prepared for two situations:

- Impact piling at Cashin Quay (Figure 5-3); and
- Wharf reconstruction in the inner harbour (Figure 5-4).

Unlike the predictions in Table 5-3, only a single activity has been modelled, at the location of the cross in the figures. The purpose of the contours is to demonstrate the area of influence for a single activity, and the level of detail that a contractor could establish when preparing their CEMP. From the contours it is possible to see the significant screening provided by terrain and buildings.

For piling activities at Cashin Quay, the contour plot in Figure 5-3 shows that red (>70 dB $L_{Aeq(15min)}$) contour extends to the first row of house on Sumner Road and Reserve Terrace, but then noise levels quickly diminish due to screening provided by the embankments and buildings. It can be seen that the Sunday daytime CEMP criteria (55 dB) will be exceeded at a large number of properties

For wharf repair works in the inner harbour, Figure 5-4 shows that the noise impact is localised and compliance with the night time noise criteria is achieved at most locations.

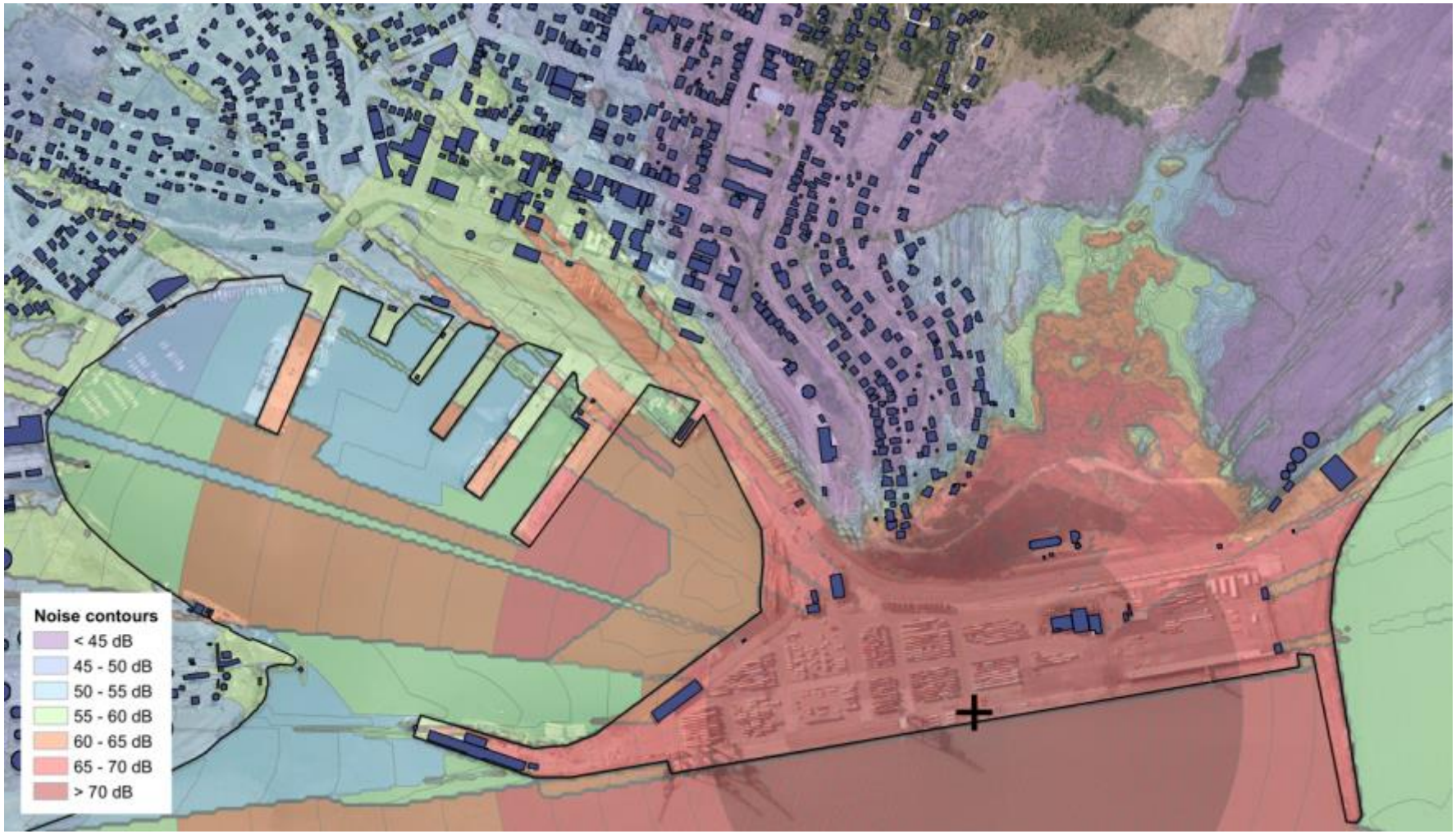

Figure 5-3 Noise contours – impact piling at Cashin Quay ($L_{Aeq(15min)}$)

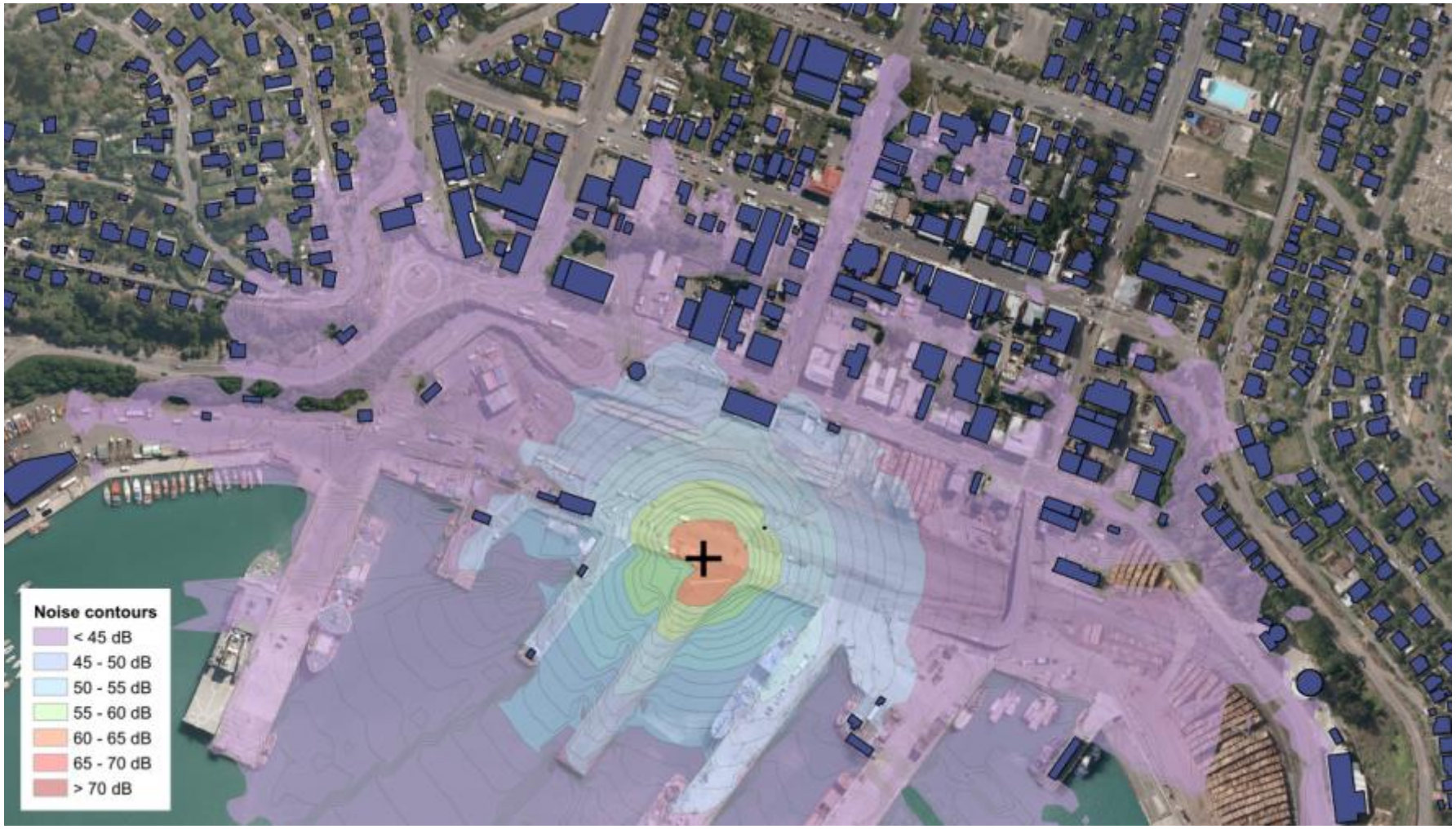

Figure 5-4 Noise contours – wharf reconstruction in inner harbour ($L_{Aeq(15min)}$)

5.5 Screening assessment

To provide an initial screening assessment, a series of figures have been prepared for typical construction activities which provide an indication of where noise is considered acceptable, i.e., where construction activities can occur in order to be within the proposed noise limits of the CEMP. The assessment also considers time of day restrictions.

An example illustrating the extent of paving impacts is presented in Figure 5-5. The figure illustrates the zones within which paving works may occur. The light blue shows locations where paving would comply with the daytime noise limits. The beige colour shows where paving can also occur on Sundays and the remaining coloured zone shows where paving can also occur during the night. These figures have been included in the CEMP Guidelines.

Figure 5-5 Example figure showing zoning of site for paving works

6 MITIGATION

Both operational and management controls are required to minimise the impacts of noise from construction works. In particular, noise from piling is considered one of the activities most likely to result in disturbance and therefore this activity has been singled out for specific attention.

6.1 Piling

Due to the character and level of noise from pile driving, piling will generally be limited to between the hours of 0730h–1800h Monday to Saturday. Piling outside of these hours will require documentation in the project CEMP, and be approved by the LPC Environment Manager.

6.2 Management practices

The CEMP Guidelines outlines best practice that should be adopted on all projects. It includes many aspects recommended by NZS 6803. A CEMP for a specific project will include:

- noise targets;
- summary of assessments/predictions;
- noise management and mitigation measures specific to activities and/or receiving environments;
- monitoring and reporting requirements; and
- procedures for handling complaints.

Control of construction noise can be undertaken using both management and engineering controls. Mitigation measures should be properly planned and implemented in a structured hierarchy depending on the extent of predicted effects. In general, the hierarchy should be in the order of the following:

1. Is it imperative that evening or night works are undertaken, or can works be rescheduled to daytime?
2. Can the works be sequenced to avoid sensitive times for neighbouring residents/businesses?
3. Have affected persons been contacted and implications been discussed/feedback been taken into consideration in the planning of this activity?
4. Have equipment and methodologies been chosen that reduce the overall noise from the activity? Can quieter alternative equipment or methodologies be practicably implemented?
5. Can temporary construction noise barriers or screens be erected within the Port that provides effective acoustic shielding of the equipment/activity?

6.3 Building treatment

The existing Port Noise Mitigation Plan provides an adequate framework and criteria for treating Noise Affected Properties. Treatment will be designed by an acoustics specialist, appointed by the Port Noise Liaison Committee, and will be designed such that all habitable rooms shall achieve an internal design sound level of 40 dBA L_{dn} (5-day).

If this internal noise level cannot be achieved within the $60,000 cap per property (plus GST and inflation), noise levels will be minimised as far as practicable.

6.4 Marine-based piling

Any marine-based piling shall be performed in accordance with a marine-based pile driving noise management plan. The adoption of ‘soft starting’ or acoustic deterrents will be used to minimise any adverse effects on marine mammals.

7 ASSESSMENT OF ENVIRONMENTAL EFFECTS

7.1 Human response

Excessive noise can interfere with speech communication, it can interrupt a wide range of different types of work, particularly activities requiring sustained concentration and it can disturb rest and relaxation and disrupt normal patterns of sleep. High sound levels continued for extended periods of time can contribute to noise induced hearing loss, whilst at the generally lower sound levels typically found outside houses, residents often report varying degrees of annoyance. The World Health Organisation (WHO) defines noise annoyance as '*a feeling of displeasure evoked by a noise*'.

Reported annoyance is known to be affected by:

- sound level and character - including whether the sound is constant, fluctuating, impulsive (startle), has low frequency components (e.g. rumble/boom) or is high pitched (e.g. whine/whoosh); and
- occurrence of exposure - reported annoyance varies depending on the frequency of events and whether they are anticipated or randomly occur;

The effects of noise are also dependent upon the time of day at which it occurs. This is due to acoustic factors, such as the relative level of background noise, and non-acoustic factors, such as the activities being disturbed and people's expectations of noise levels at different times of the day.

It is commonly accepted that a change in noise level of 3 dB is just perceptible. The “loudness” of a noise is a purely subjective parameter but it is generally accepted that an increase/decrease of 10 dB corresponds to a doubling/halving in perceived loudness.

7.2 Existing environment

As discussed in Section 34, there is a significant amount of ambient noise (port noise) in the Lyttelton Township. Night time noise levels have been measured at a number of locations in the order of 55 dB $L_{Aeq(15min)}$, which is well above maximum noise levels recommended by the WHO [10] and NZS 6802 [11].

The character of the noise is variable and comprises many different sources, however tonal reversing beepers and other alarms is a significant part of the environment.

7.3 Port noise management

Properties within the existing 65 dBA L_{dn} contour represent the extent of port noise within which no specific measures are required to be implemented by LPC.

7.4 Adaptive management

Resource consents and designations often authorise long-term construction activities where the precise construction methodology and resultant noise levels are not known up front. Having criteria that trigger management actions under a comprehensive framework has been demonstrated to produce satisfactory outcomes. Model construction noise conditions for roading designations prepared by the NZ Transport Agency [12] are a good example of this

framework approach. Another example is contained within the Proposed Auckland Unitary Plan, which has provisions for essential work within road carriageways at night, which allow contractors to perform work which exceeds the construction noise criteria. Work can only proceed with a work permit issued by Auckland Transport or the Transport Agency, and requires a construction noise and vibration management plan to be prepared by an acoustics specialist and submitted to council. This is a similar approach to that proposed as part of this project.

7.5 Future noise environment

As discussed earlier, construction noise and port noise will be combined to determine whether both sources fall within, or exceed, the existing 65 dBA L_{dn} port noise contour. This will establish whether construction noise is acceptable without the need for enhanced management of specific offsite noise mitigation.

The predicted construction noise levels in Table 5-3 have been converted to L_{dn} values as shown in Table 7-1 . Locations where the predicted construction noise levels exceed 65 dBA L_{dn} are highlighted. These levels assume that work is continuous during daytime hours (0700h–2200h) and that there is no work at night (2200h–0700h). This is considered conservative, as there is likely to be variation and downtime at different periods. For piling, it has been assumed that operations only occur for 50% of a smaller time period, 0730h–1800h. At this stage, the assessment does not include the contribution from operational port noise. It should therefore be used as a guide until such time that construction noise levels have been determined for specific projects, which can then be combined with the existing operational port noise levels.

As already highlighted piling and demolition works (percussive breaking) are two activities which will require specific attention and all best available techniques should be investigated and implemented to minimise the potential for disturbance. The proposed Construction Noise Management Plan and the proposed Construction Mitigation Plan provides sufficient processes for additional assessment and mitigation.

All other activities are likely to be acceptable.

Table 7-1 Predicted construction noise levels, dBA L_{dn}

Address	Piling	Demolition	Seawall Rebuild	Wharf Rebuild	Paving	General Civil
8 Godley Quay	74	68	60	53	56	49
5 Brittan Tce	69	57	50	43	47	39
2 Brittan Tce	65	51	45	38	42	35
36 Simeon Quay	60	40	36	28	33	26
4 Walker Rd	61	45	41	33	37	30
43 Voelas Rd	60	42	38	31	35	28
40 Norwich Quay	74	69	61	54	57	49
52 London St	57	35	33	25	31	24
30 Winchester St	60	41	37	29	34	27
32 Exeter St	54	32	30	22	27	20
61 Sumner Rd	69	55	49	41	45	37
1 Reserve Tce	65	46	41	34	38	30

Address	Piling	Demolition	Seawall Rebuild	Wharf Rebuild	Paving	General Civil
2 Gilmore Tce	65	47	41	34	38	30
10 Gilmor Tce	61	45	41	33	37	30
2 Reserve Tce	60	42	39	31	36	29
46 Koromiko Cres	42	24	22	14	20	14

7.6 Vehicle noise

The Direction requires issues and effects that may occur outside of the geographic extent of the Recovery Plan to be assessed, including matters relating to land use and transport associated with the recovery of Lyttelton Port, the social, economic, cultural and environmental well-being and effects on surrounding communities and Lyttelton harbour, and wider transportation issues across greater Christchurch.

Additional traffic generated by construction activities will be negligible in comparison to freight traffic. Any unusual activities (e.g., significant number of deliveries at night) will be assessed within a project CEMP.

7.7 Marine impacts

In addition to noise effect there is also the potential for vibration disturbance and impacts in the marine environment. Piling works have the potential to cause disturbance to protected Hector's Dolphins and other noise sensitive marine species (see Otago University assessment [3] .

Construction vibration is generally not anticipated to be an issue due to the setbacks between construction activities and offsite receivers. Nevertheless, appropriate vibration limits are proposed.

8 CONCLUSIONS

URS has identified likely construction activities associated with the recovery of Lyttelton Port. Many activities will produce noise of similar level and character to the existing port operation. Other activities (noticeably piling) will produce noise levels over and above other activities.

Contractors are required to prepare a Construction Environment Management Plan for their project, which includes predicting noise levels and identifying necessary mitigation. Regardless of compliance with any criteria, best practices should always be adopted to minimise any unnecessary noise.

Amendments to the District and Coastal Plans are proposed to require the establishment of a Construction Noise Management Plan and Construction Noise Mitigation Plan that mirror the port noise documents currently in place. Where combined activities expose additional dwellings to greater than 65 dBA L_{dn}, they will have access to the Construction Noise Mitigation Plan.

With the above measures in place, impacts from construction work will be will allow LPC to facilitate the recovery of the Port while at the same time, balance the potential effects of the works on the amenity of the surrounding noise sensitive receivers.

9 REFERENCES

[1] New Zealand Gazette, *No 65,* 2014.

[2] Hegley Acoustic Consultants, “Operational Noise Assessment,” 2014.

[3] University of Otago, “Marine Mammals and the Port Lyttelton Development - An Environmental Impact Assessment,” 2014.

[4] Lyttleton Port of Christchurch, “Port Lyttelton Plan,” 2014.

[5] Standards New Zealand, “NZS 6809:1999 Acoustics – Port noise management and land use planning,” 1999.

[6] Standards New Zealand, “Provisional New Zealand Standard NZS 6803P:1984, The Measurement and Assessment of Noise From Construction, Maintenance, and Demolition Work,” 1984.

[7] Standards New Zealand, “New Zealand Standard NZS 6803:1999, Acoustics – Construction Noise,” 1999.

[8] Lyttelton Port of Christchurch, “Guideline for preparing a Construction Environmental Management Plan,” 2014.

[9] BSI British Standards, “BS 5228-1:2008 – Code of practice for noise and vibration control on construction and open sites – Part 1: Noise,” 2008.

[10] World Health Organisation, “Guidelines for Community Noise,” 1999.

[11] Standards New Zealand, “New Zealand Standard NZS 6802:2008 Acoustics – Environmental Sound,” 2008.

[12] NZ Transport Agency, “State highway construction and maintenance noise and vibration guide,” 2013.

[14] World Health Organisation, “Night Noise Guidelines for Europe,” 2009.

10 LIMITATIONS

URS New Zealand Limited (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Lyttelton Port of Christchurch.

It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this Report. It is prepared in accordance with the scope of work and for the purpose outlined in the contract dated 30 May 2014.

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Any estimates of potential costs which have been provided are presented as estimates only as at the date of the Report. Any cost estimates that have been provided may therefore vary from actual costs at the time of expenditure.

APPENDIX A VALIDATION OF NOISE MODEL – PILING AT CQ2

A.1 Introduction

The preliminary computer acoustics model was based on generic noise level data from BS 5228-1 for piling activities. Based on this model, allowable operating times were determined. Noise monitoring was performed at both source and receiver after the activity commenced. Minor adjustments to the source level were required. After these adjustments were made, good agreement at the receiver locations was achieved.

A.2 Source and receiver measurements

Source measurements were conducted on several pieces of construction equipment operating in the Cashin Quay work site. These include:

- impact piling rig,
- stone column piling rig, and
- rock placement during the seawall rebuild.

Source measurements conducted on the actual construction equipment being used on the work sites was incorporated into the computer acoustics model to improve the quality of the prediction results.

Table-A-1 Measured source noise levels

Site	Construction Equipment	L_{Aeq} at 10m	Notes
Wharf	Impact hammer (~20m above work platform)	107 dB	Hydraulic pump and generators operating. Frequency of piling approximately every two seconds.
	Impact hammer (~5m above work platform)	106 dB	Hydraulic pump and generators operating. Frequency of piling approximately every two seconds
	Hydraulic pump (impact hammer)	77 dB	GenA and GenB operating nearby
	Small generators	75 dB	GenA and GenB operating together
	Hydraulic pump (vibratory piling)	84 dB	

A.3 Validation

The piling activity was chosen to validate the model based on it being distinctly audible at a number of the residential locations visited, and being clearly visible in the unattended noise monitoring time traces (Figure-A-1).

Running the acoustics model, with an impact piling source located on Cashin Quay, resulted in a noise level of 74 dB L_{Aeq} at the Reserve Terrace location overlooking the work site. The results from the impact piling prediction are consistent with the highest 15 minute L_{Aeq} measured at the same location. This shows that the model is capable of correctly predicting the noise levels from construction works at the Port when realistic source measurement data is available.

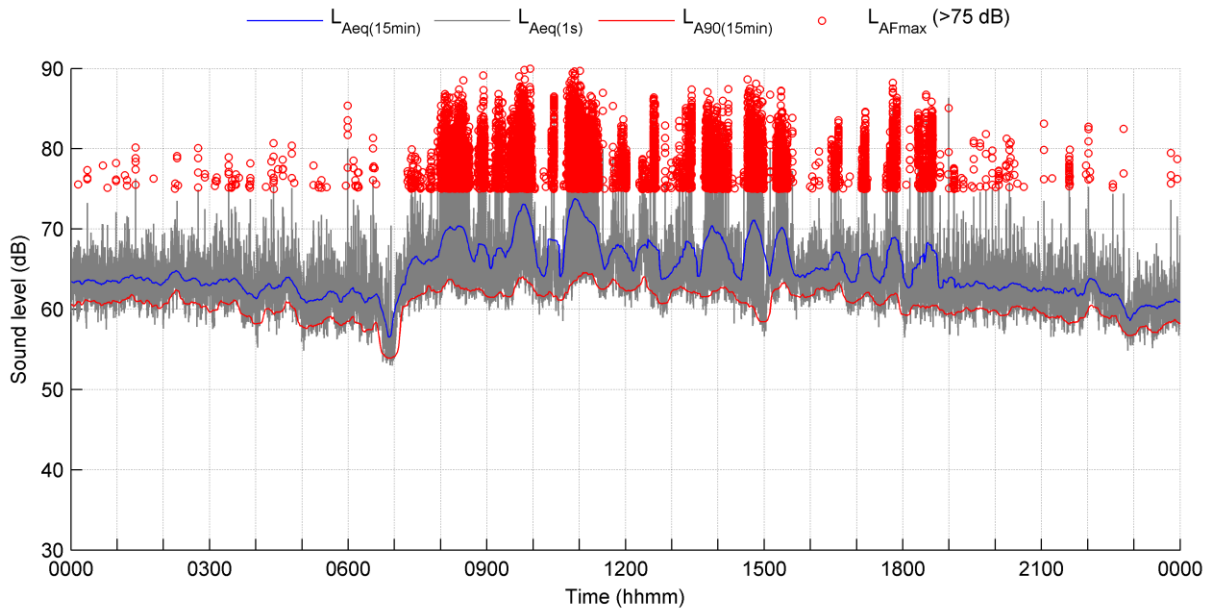

Figure 10-1

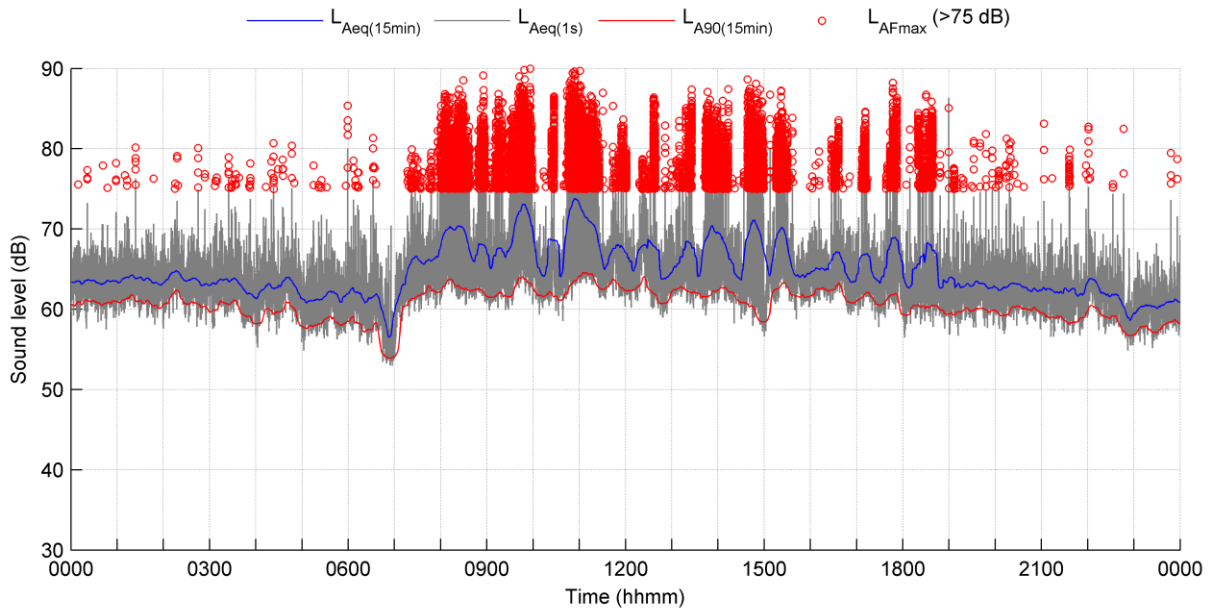

Figure-A-1 Sound levels on Reserve Terrace overlooking Cashin Quay, on 10 July 2014

APPENDIX B UNATTENDED MONITORING RESULTS

B.1 20 Sumner Road

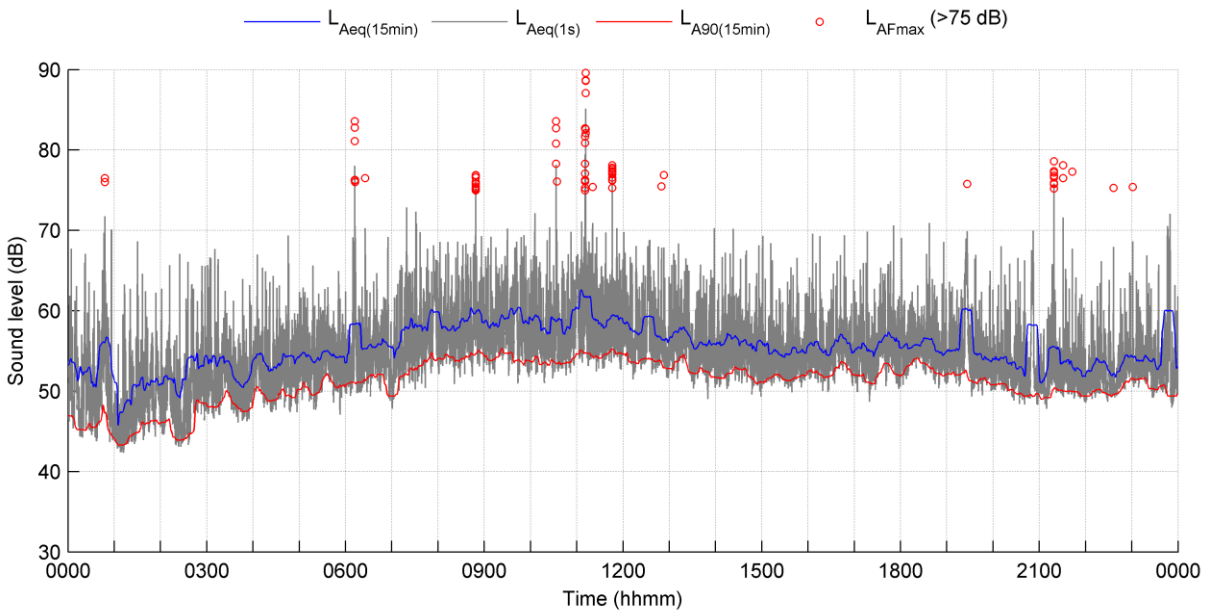

Figure-B-1 Sound levels at 20 Sumner Road on 9 August 2014

B.2 2A Gilmour Terrace

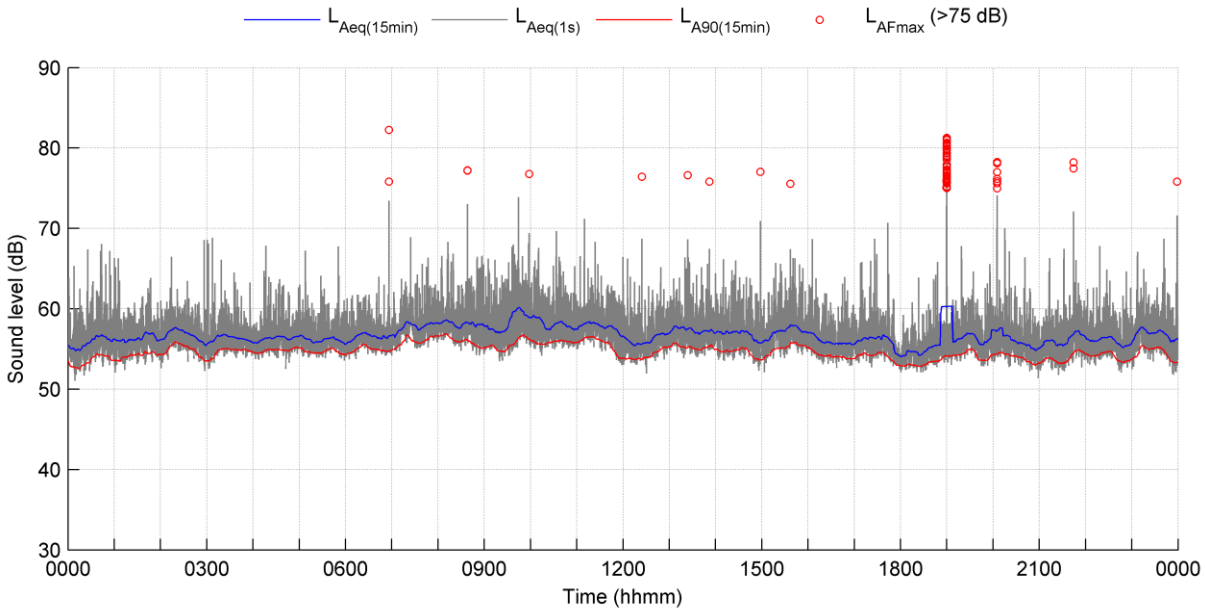

Figure-B-2 Sound levels at 2A Gilmour Terrace on 19 June 2014

B.3 34A Gilmour Terrace

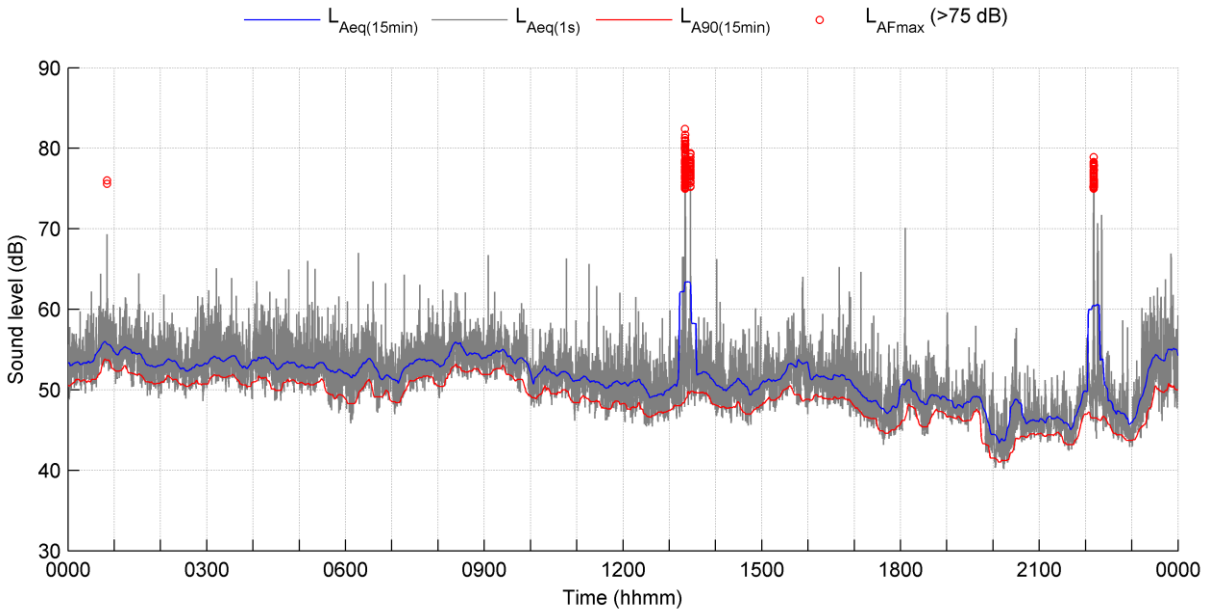

Figure-B-3 Sound levels at 34A Gilmour Terrace on 13 August 2014

B.4 Reserve Terrace

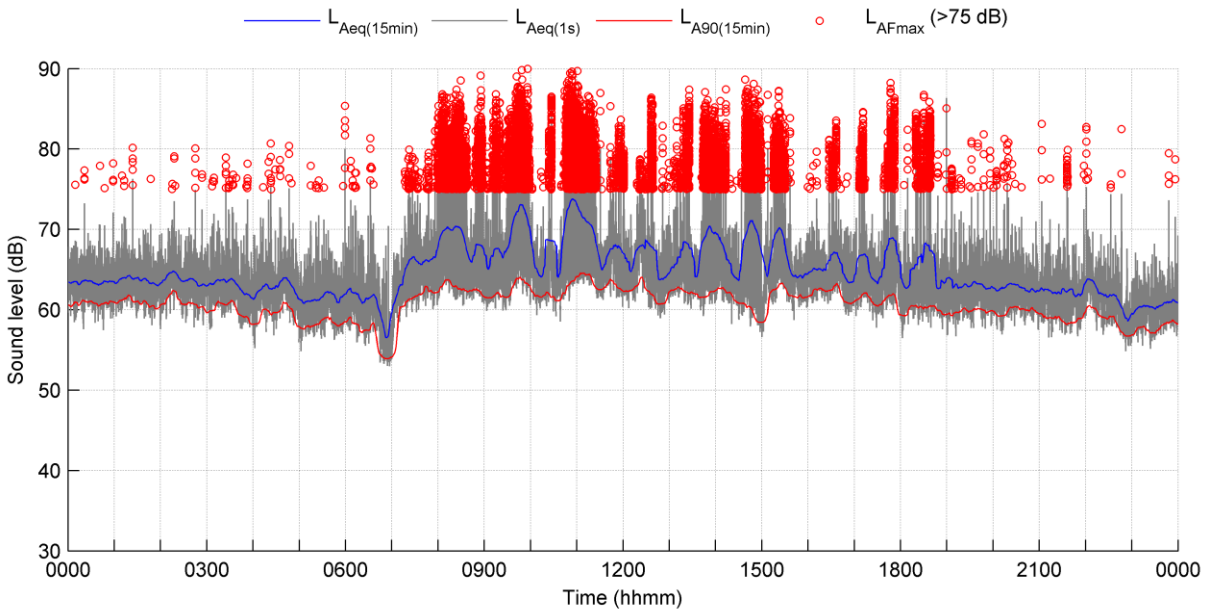

Figure-B-4 Sound levels on Reserve Terrace overlooking the container yard, on 10 July 2014

B.5 18 Cressy Terrace

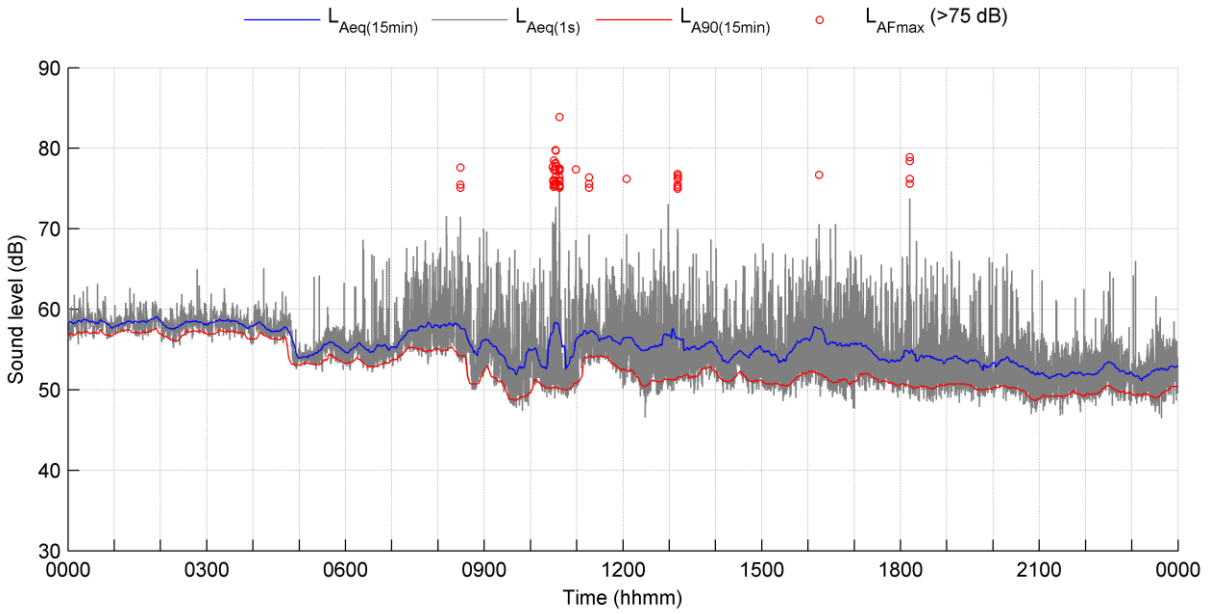

Figure-B-5 Sound levels at 18 Cressy Terrace on 19 August 2014

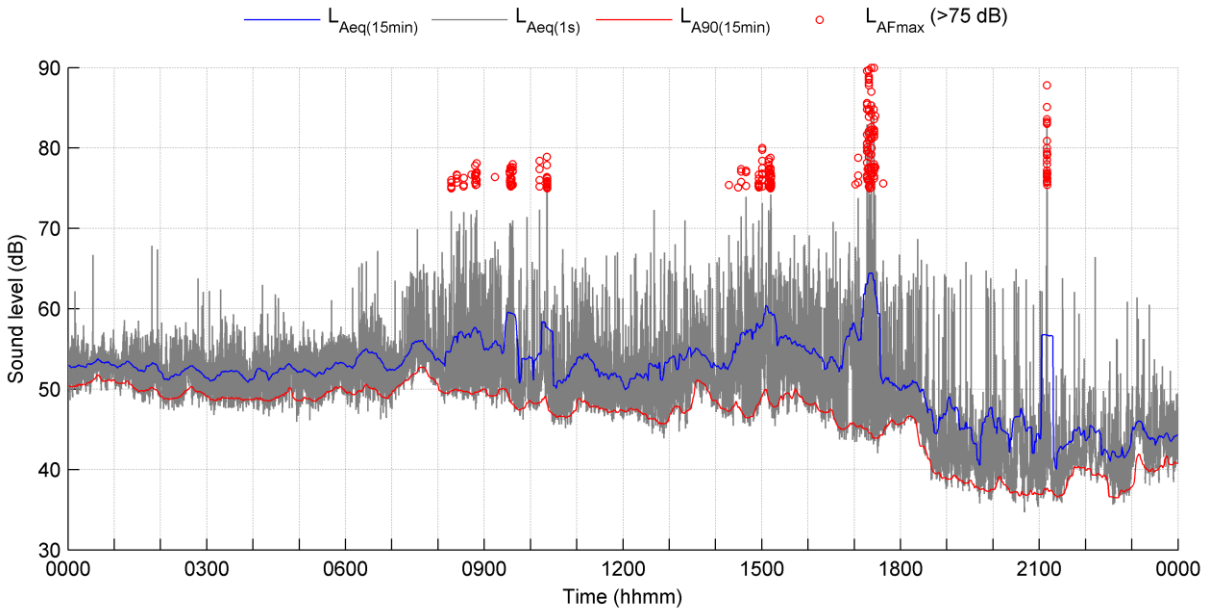

Figure-B-6 Sound levels at 18 Cressy Terrace on 20 August 2014

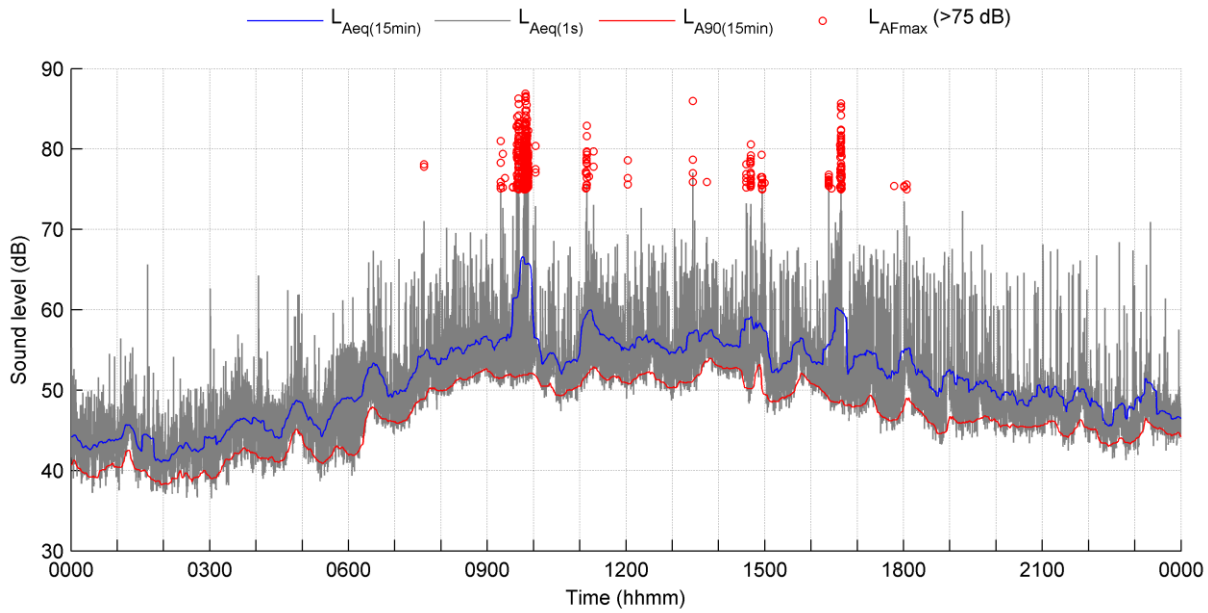

Figure-B-7 Sound levels at 18 Cressy Terrace on 21 August 2014

B.6 31 Brittan Terrace

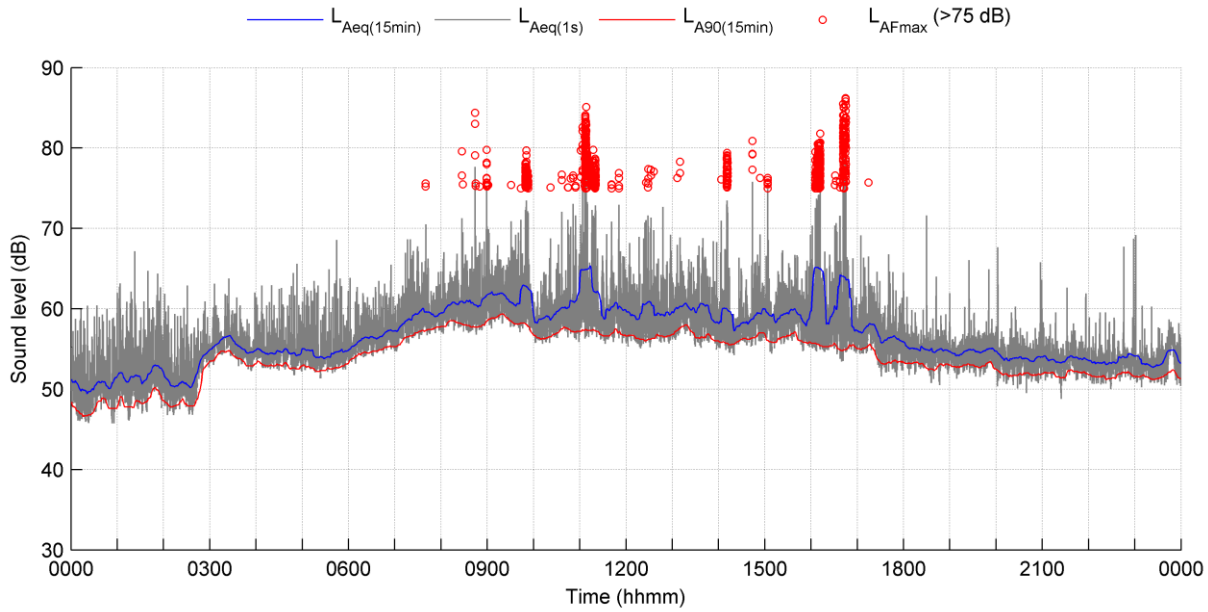

Figure-B-8 Sound levels at 31 Brittan Terrace on 12 September 2014

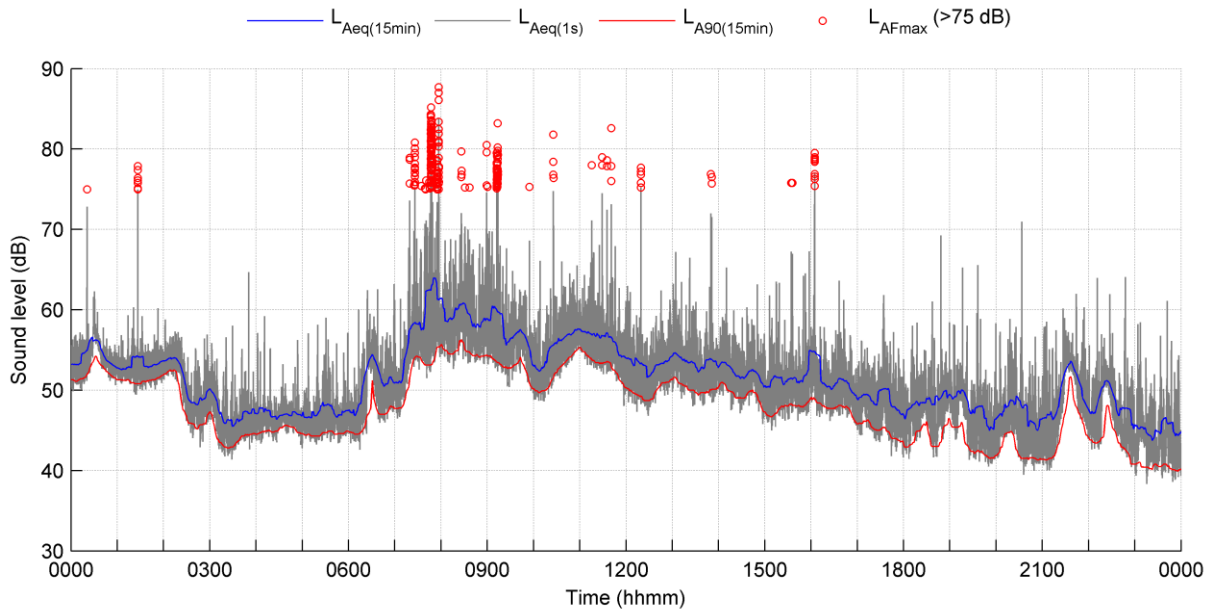

Figure-B-9 Sound levels at 31 Brittan Terrace on 13 September 2014

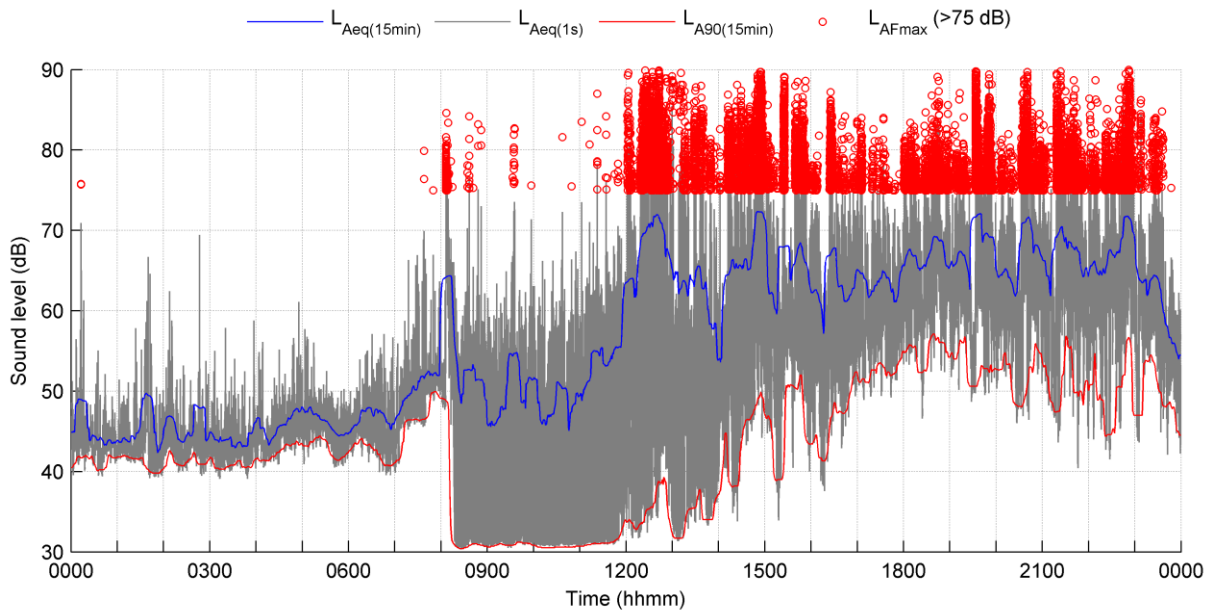

Figure-B-10 Sound levels at 31 Brittan Terrace on 14 September 2014

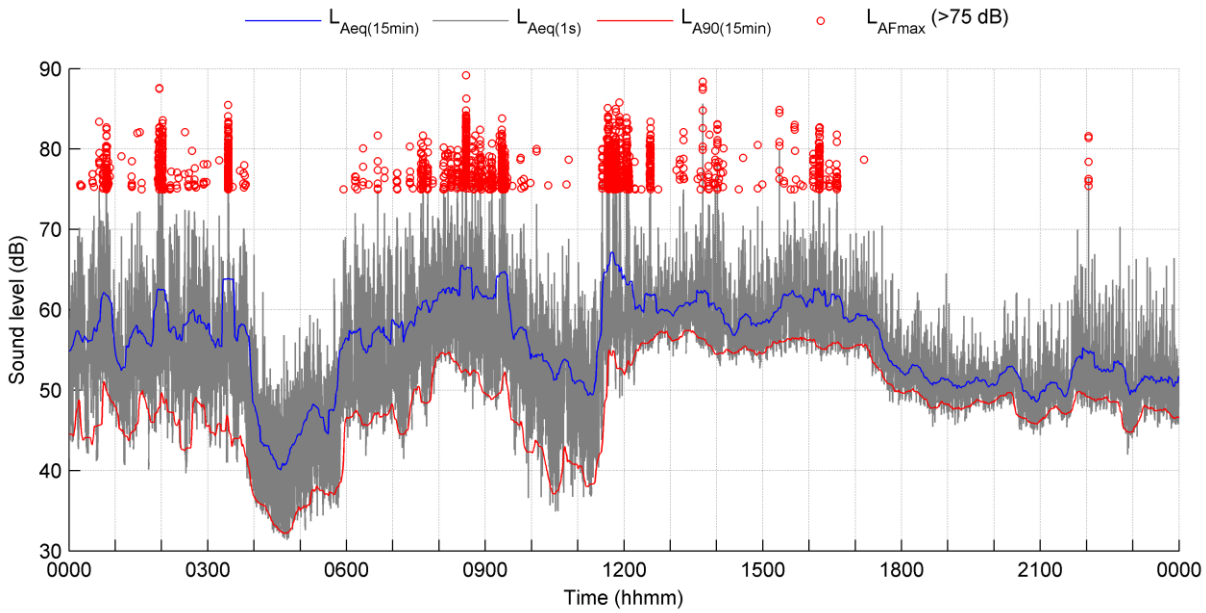

Figure-B-11 Sound levels at 31 Brittan Terrace on 15 September 2014

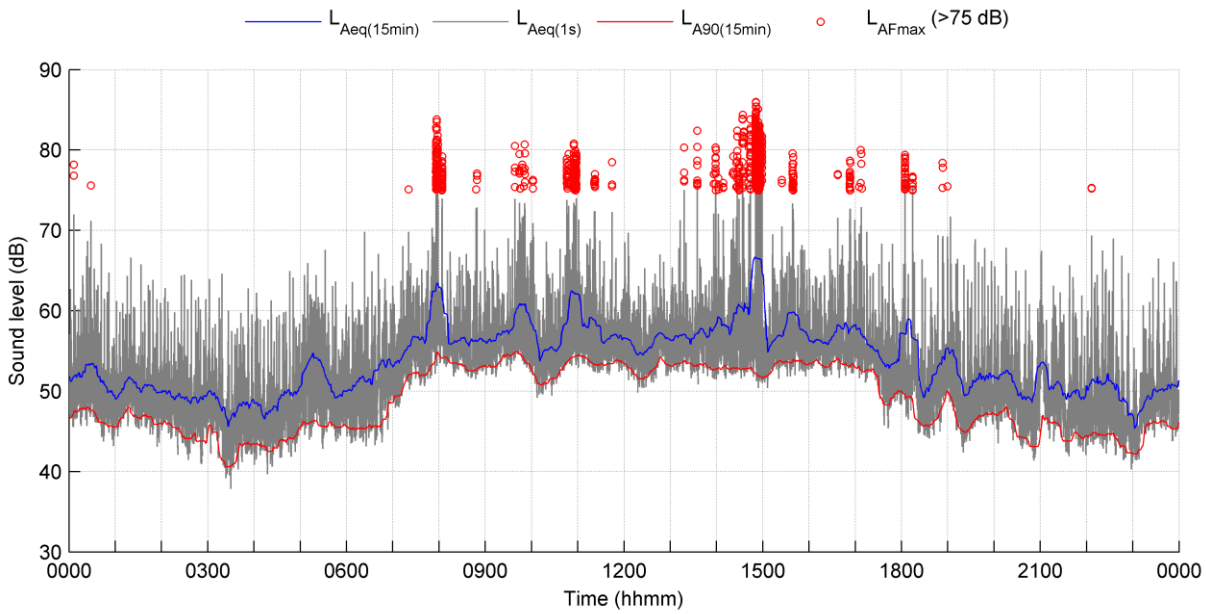

Figure-B-12 Sound levels at 31 Brittan Terrace on 16 September 2014

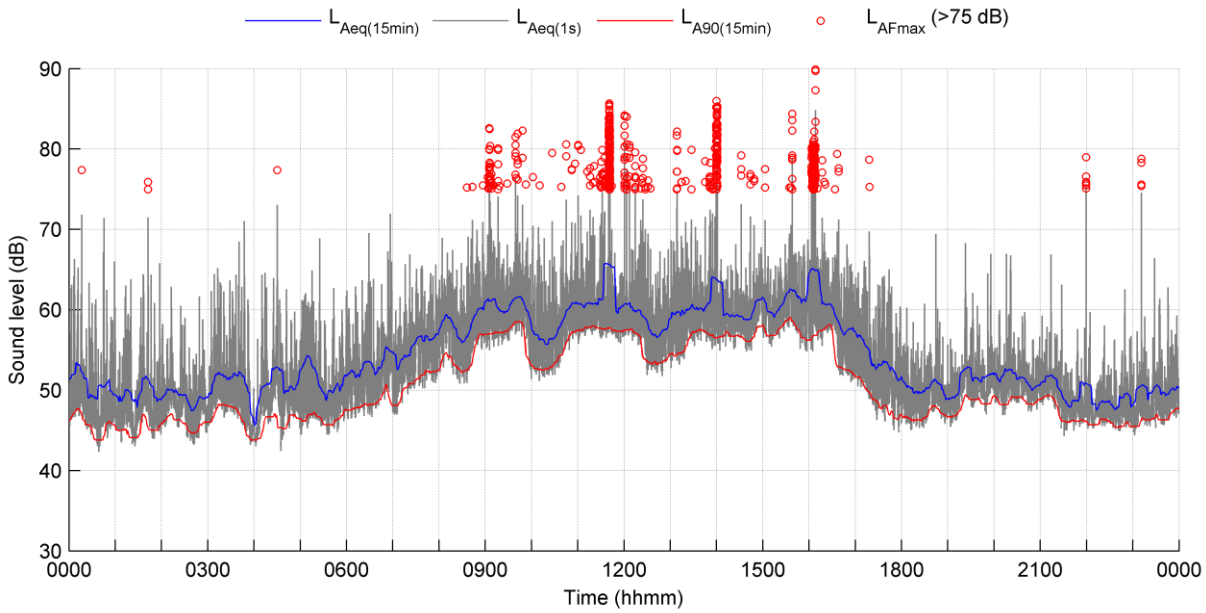

Figure-B-13 Sound levels at 31 Brittan Terrace on 17 September 2014

B.7 8 Bridle Path

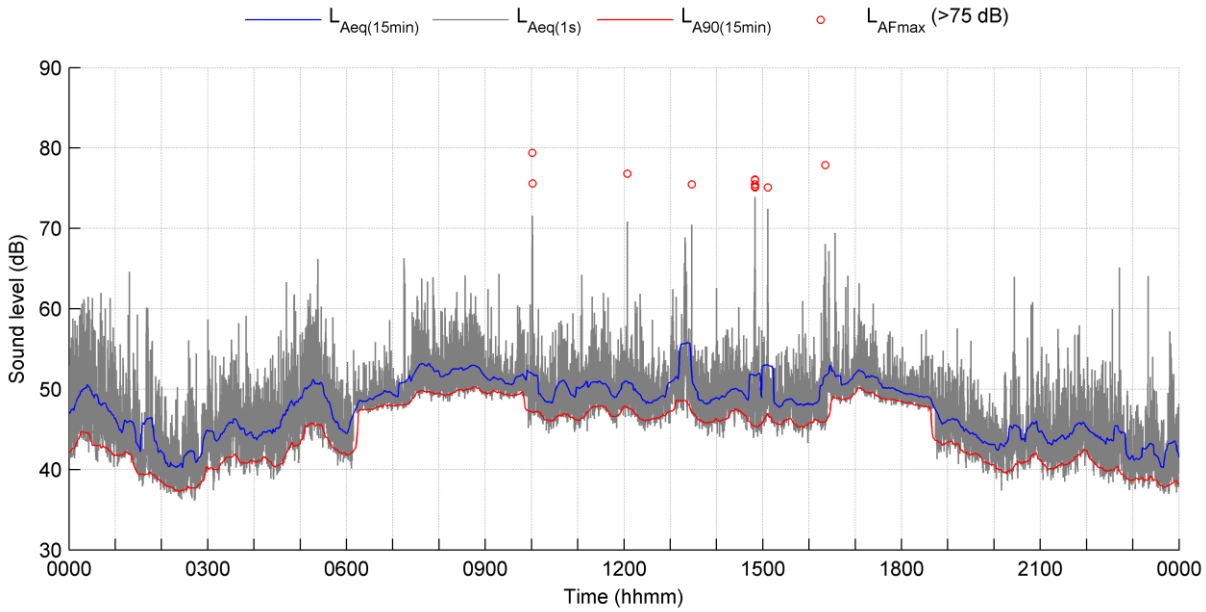

Figure-B-14 Sound levels at 8 Bridle Path on 23 August 2014

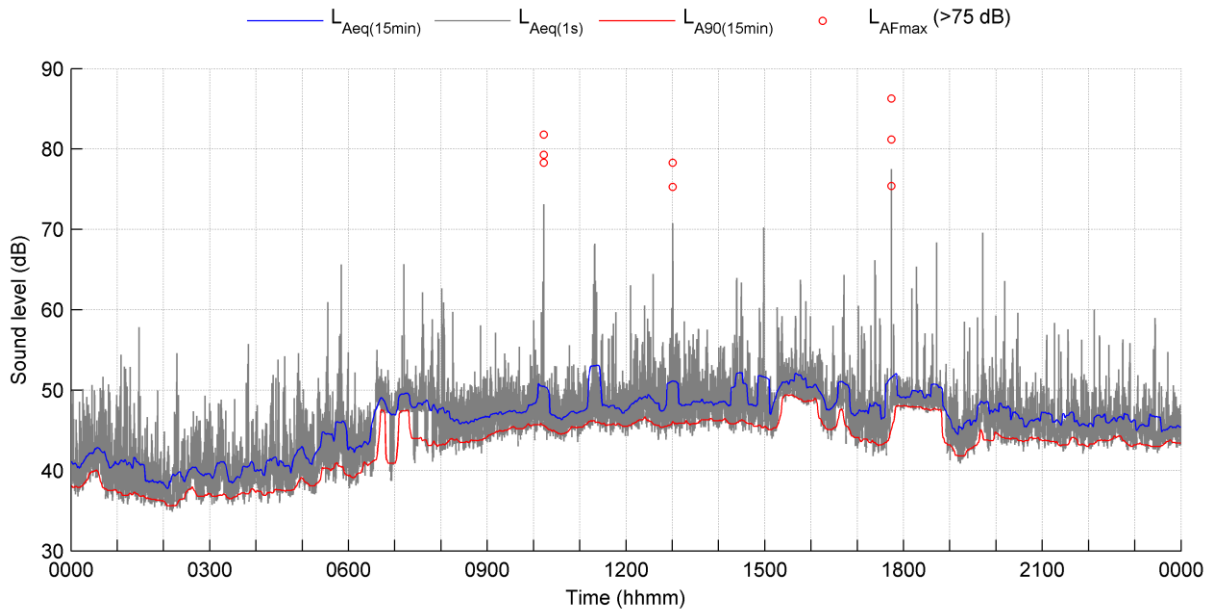

Figure-B-15 Sound levels at 8 Bridle Path on 24 August 2014

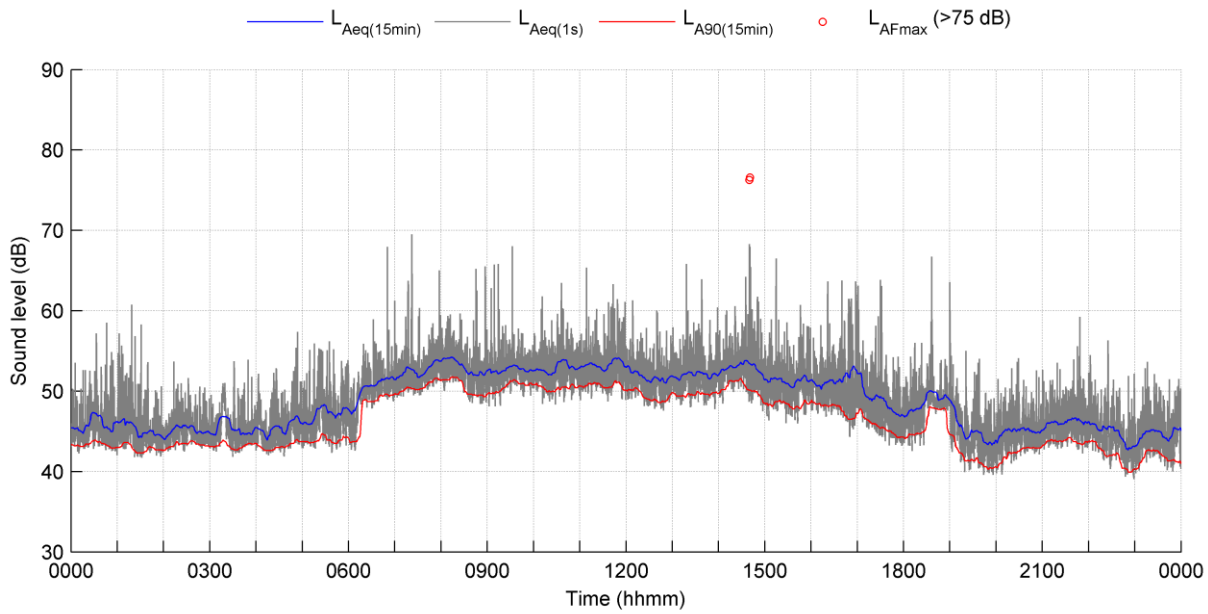

Figure-B-16 Sound levels at 8 Bridle Path on 25 August 2014

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