MARSHALL DAY Acoustics

ASSESSMENT OF NOISE & VIBRATION EFFECTS
NORTHERN INTERCEPTOR PROJECT: NOR

Rp 001 2015801A | 5 August 2016

84 Symonds Street
PO Box 5811 Wellesley Street
Auckland 1141 New Zealand
T: +64 9 379 7822 F: +64 9 309 3540
www.marshallday.com

Project: **NORTHERN INTERCEPTOR**

Prepared for: **Watercare Services Limited**
C/- MWH NZ Limited
PO Box 9176
Newmarket
Auckland 1149

Attention: **Garrett Hall**

Report No.: **Rp 001 2015801A**

Document Control

Status:	Rev:	Comments	Date:	Author:	Reviewer:
Draft	00	Initial draft issued to MWH	30 Mar 2016	M. Cottle	S. Wilkening
Draft	01	Includes MWH feedback	27 April 2016	M. Cottle	Not reviewed
Draft	02	Includes final MWH feedback	12 May 2016	M. Cottle	Not reviewed
Draft	03	Includes Final Client and Legal reviews	13 June 2016	M. Cottle	S. Wilkening
Final	04	Final report issued	5 Aug 2016	M. Cottle	S. Wilkening

EXECUTIVE SUMMARY

This report provides an assessment of construction noise and vibration effects from the proposed Northern Interceptor ("the Project") for receivers located along the route detailed in the main AEE.

As the proposed commencement for construction of the Project is between 2022 and 2035+, there is potential that new methods for carrying out the proposed construction work may be developed by that time. The predictions contained in this assessment cover the anticipated envelope of potential noise and vibration effects based on current construction methodologies. However, the assessment is considered broad enough to cover the anticipated effects envelope should new construction techniques be made available.

The assessment contains a discussion of the pertinent noise and vibration ("acoustic") criteria from the relevant district plans and regional coastal plan; outlines the acoustic effects assessment methodology; predicted noise and vibration levels and potential impacts from various activities associated with the Project.

The recommended Project acoustic performance criteria are based on those contained in NZS 6803: 1999 and the relevant district plans. The aim is to achieve compliance with these criteria where practicable. In accordance with Section 16 of the Resource Management Act the best practicable option is adopted to ensure that Project noise and vibration emissions do not exceed a reasonable level. The assessment discusses the practicability of mitigation and management measures.

Through the prediction of construction noise and vibration levels, areas of post-mitigation risk have been identified where full compliance with the criteria may not be able to be achieved. These include aspects of transient trenching works during daytime and trenchless works during daytime and night-time.

Construction noise has been predicted using equivalent noise sources measured as part of previous projects and from information contained in NZS 6803: 1999 and BS 5228-1: 2009. Tables are provided that show potential worst case noise levels from the construction activities proposed. These predictions are based on assumptions and estimates detailed in the draft construction methodology provided by the Project team. There may be some variation in the actual methodology or equipment used to carry out the work, given the proposed dates for commencement of the works are in the future. However, the Project Construction Noise and Vibration Management Plan ("CNVMP") will contain the procedures necessary for identifying and mitigating/managing any potential noise issues through an adaptive management approach, as has historically occurred on various large infrastructure projects in Auckland.

General acoustic management and mitigation measures are recommended to be implemented throughout the course of the Project as a best practice provision e.g. maintenance of equipment to a high level and the avoidance of unnecessary noise and vibration such as the use of horns, tonal reverse alarms or clearing excavator buckets hitting the ground. In addition, where there is a risk that the acoustic criteria may be exceeded, recommendations for specific mitigation and management measures are provided. These recommendations are site-specific and involve additional measures such as the installation of temporary construction noise barriers, the timing of construction activities to avoid effects on receivers e.g. carrying out construction when most residents are at work or when businesses are closed, or the selection of equipment which imparts less vibrational energy into the ground.

The acoustic criteria are likely to be exceeded during some activities. While the intention is to meet the criteria as far as practicable, there will be times when construction cannot be undertaken in compliance with the criteria, and alternative management mitigation will need to be implemented. This is a common occurrence for large infrastructure projects such as this and may involve one-on-one discussions with affected stakeholders to discuss mitigation.

Night-time trenching works may be carried out to minimise traffic delays on the road network at certain locations, for instance along The Concourse in Henderson and through Rosedale Business Park. Night-time works in commercial or industrial zones is one example of the practicable mitigation (avoidance) of construction noise effects, as most, if not all, nearby businesses, would be closed.

The potential acoustic effects from construction will require active management throughout the construction period to avoid, remedy or mitigate such effects. This would be undertaken through the implementation of the CNVMP, which will be formulated and updated as appropriate to reflect the actual activities occurring. The CNVMP forms the basis of all construction noise and vibration management and mitigation. It contains detailed information regarding communication, training, maintenance, mitigation and other aspects of construction that affect noise and vibration generation. Some activities may require activity-specific management and mitigation. This will be addressed via Activity Specific Noise and Vibration Management Plans ("ASCNVMP's").

Overall, the construction of the Project is predicted to result in noise and vibration levels that are generally within the Project construction acoustic performance criteria, with some exceptions. While construction noise and vibration levels are higher than ongoing operational levels, it is commonly accepted that for any construction to occur, acoustic criteria must be less stringent, with the understanding that construction is a temporary activity with a finite duration.

It is considered that this Project can be constructed within reasonable acoustic performance criteria, provided that the best practicable option for mitigation is implemented throughout and contractors manage construction noise and vibration on an ongoing basis.

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1.0 INTRODUCTION

Marshall Day Acoustics ("MDA") has been commissioned by Watercare Services Limited ("Watercare") to assess the potential land use acoustic effects related to the construction, operation and maintenance of Watercare's proposed Northern Interceptor ("the Project").

Construction of the Project is considered to be the principle activity that will generate potential noise and vibration effects, although consideration has also been given to operational aspects.

A Glossary of technical acoustical terms is contained in Appendix A.

2.0 PROJECT DESCRIPTION

2.1 Overview

The Northern Interceptor comprises a new wastewater interceptor and associated infrastructure, from the existing storage tank located at The Concourse, Henderson to the Rosedale Wastewater Treatment Plant (WWTP). It will divert flows from three existing branch sewers (Swanson, Whenuapai and Massey) and connect flows originating from the North West Transformation Area (including Red Hills, Massey North, Kumeu, Riverhead, Huapai and Whenuapai). These flows will be transferred north to the Rosedale WWTP, rather than south to the Mangere WWTP.

Phase 1 of the Northern Interceptor was granted consent in January 2016. Phase 1 will transfer existing flows from the existing Hobsonville Pump Station to the Rosedale WWTP. The section of the Northern Interceptor between Hobsonville Road and the western abutment of the Greenhithe Bridge, is in the same corridor as a water infrastructure project, the North Harbour No. 2 Watermain. A notice of requirement for the works within the shared corridor, which include this portion of the Northern Interceptor, was lodged with the Council in June 2016.

This technical report provides specialist input for the Northern Interceptor Assessment of Effects on the Environment (AEE), prepared by MWH New Zealand Limited which supports the Notices of Requirement (NoR) for the remainder of the route (Project), these being NoR – NI (Waitakere) and NoR – NI (North Shore).

The works within NoR - NI (Waitakere) will transfer wastewater flows from The Concourse Storage Tank to Hobsonville Road, where it will connect with the works in the shared corridor.

The works within NoR - NI (North Shore) will transfer wastewater flows from the edge of the future harbour crossing at the eastern abutment of the Greenhithe Bridge to the Rosedale WWTP.

Construction will be staged in response to growth in the area.

The Project and a detailed construction methodology are described in detail in the AEE. In summary, the Project works included within NoR – NI (Waitakere) and NoR – NI (North Shore) will comprise of the following elements:

- A new Pump Station at the Concourse Storage Tank site which will divert flow north away from the Western Interceptor;

- A new Booster Pump Station at Wainoni Park to accommodate additional flows from the Northwest Transformation Area;
- A new Intermediate Pump Station at Wainoni Park North to accommodate further growth in the Northwest Transformation Area, and the diverted flows from the Concourse Storage Tank site (Swanson and Waitakere);
- Installation of a wastewater pipe from the Concourse Storage Tank to Hobsonville Road;
- Installation of a wastewater pipe from the eastern abutment of the Greenhithe Bridge, to the Rosedale WWTP;
- Duplication of the rising main section of wastewater pipe from the Intermediate Pump Station at Wainoni Park North to the Rosedale WWTP;
- Associated structures at connection points, including access shafts, drop shafts, flow control structures, etc.; and
- Installation of a pipe bridge at Manutewhau Reserve, West Harbour.

An overview of the proposed route is provided in the figure in Appendix B.

This report provides the following:

- A description of the environmental baseline for the particular receiving environment(s) potentially affected by the Project
- Description of specific aspects of the Project relating to noise and vibration
- Description of the investigations undertaken to assess noise and vibration and assessment of effects of the proposed works (without mitigation)
- Recommended mitigation and management measures and resultant post mitigation assessment of effects
- An assessment of the actual or potential effects on the environment (construction, operation and maintenance). This includes the identification of activities that could result in potential adverse effects and, in turn, identifying design refinements or construction methodologies that could avoid, remedy or mitigate such effects
- Conclusions

As the proposed commencement for construction of the Project is between 2022 and 2035+ (at least 6 years in the future from the date of this report) there is potential that new methods for carrying out the proposed construction work may be developed by that time. To allow for this, predictions contained in this assessment are considered to be sufficiently robust to cover the anticipated envelope of potential noise and vibration generation and effects.

In addition, it may be necessary for the Project to use an adaptive management approach to identify sources of potential noise and vibration effects and implement management and mitigation measures to practicably mitigate effects. The proposed consent conditions relating to general and activity specific management plans are considered to reflect this approach.

2.2 Typical Project Construction Methodologies

Refer to the AEE for a detailed description of the proposed construction methodology for the Project.

This assessment uses the construction methodology detailed in the AEE and the typical activities and plant summarised in Appendix C to predict noise and vibration levels and the resulting Project effects envelope.

2.3 General Construction Sequence

The following summarises the key activities which would typically occur on the Project:

- Site establishment
- Trenched and trenchless works and associated activities
- Materials lay down, pipe line laying and construction of minor above-ground structures
- Site demobilisation and reinstatement

A detailed construction program will be developed prior to the commencement of construction activities. It is anticipated that this would be prepared by the lead Contractor and incorporated into the Project construction management plan.

2.4 Construction Traffic Generation

In terms of construction traffic generation, pipe deliveries (trenched works) would occur at a rate of no more than 2 per week for each operating section of excavation and be by semi-trailer. Trenched works would require approximately 24-36 truckloads of spoil removal per day.

Construction traffic associated with trenchless works such as horizontal directional drilling ("HDD") operations is expected to generate about 20 movements per day (spoil removal and delivery of drilling mud). Additional movements would occur during the establishment/disestablishment of each drilling site.

For trenchless technology activities, excavated material would be removed from the site and taken to cleanfill using semi-trailer trucks. In total, spoil removal and the delivery of plant, pipes and other materials will result in approximately 10 movements per day.

2.5 Operation Noise and Vibration

The most significant source of ongoing operation noise and vibration is considered to be from the two pump stations proposed to be located in Wainoni Park, and one on The Concourse. Therefore, this report focuses on these as the primary sources of ongoing operational noise and vibration.

In any respect, it is considered that with appropriate acoustic design, the pump stations can be designed and operated so as to generate only slight/minor acoustic effects. The design of these structures will be finalised during the detailed design stage of the Project.

Additional sources of potential ongoing operation noise and vibration are the air, line and scour valves (referred to as "minor above-ground structures") at various locations along the pipeline. It is MDA's experience that the operation of these valves would not give rise to any appreciable levels of noise and vibration breaking out from inside the concrete enclosures in which they are housed. In normal operation they occasionally bleed a small amount of air which would sound like a 'hiss' or a 'splutter'.

Some audible noise may be emitted from break pressure chambers and drop shafts under high flow conditions. These events are considered to be short-term in nature, would generally occur at the same time as heavy rainfall, and would therefore result in slight noise effects. Notwithstanding this, acoustic design of the associated vents will be addressed during the detailed design stage of the project.

Another source of noise would be the arrival and departure of maintenance crews i.e. light vehicle noise, which would happen infrequently and would result in negligible noise effects.

3.0 ACOUSTIC PERFORMANCE STANDARDS

3.1 Resource Management Act

Under the provisions of the RMA there is a duty to adopt the best practicable option to ensure that the noise from any development does not exceed a reasonable level. Specifically, Sections 16 and 17 reference noise effects as follows.

Section 16 states that *"every occupier of land (including any coastal marine area), and every person carrying out an activity, shall adopt the best practicable option to ensure that the emission of noise from that land or water does not exceed a reasonable level"*.

Section 17 states that *"every person has a duty to avoid, remedy, or mitigate any adverse effect on the environment arising from an activity, whether or not the activity is in accordance with a rule in a plan, a resource consent or relevant sections of the RMA"*.

3.2 District Plans

The full extent of the Project is located within Auckland. As pipeline construction will commence in 2022 for NI – North Shore and 2035+ for NI – Waitakere, the relevant operative district plan at that time will likely be the Auckland Unitary Plan (currently referred to as the Proposed Auckland Unitary Plan ("PAUP").

As designations are being sought now, reference has been made to the relevant operative Waitakere[1] and North Shore[2] sections of the Auckland Council District Plan, as well as the PAUP.

The PAUP was notified on 30 September 2013 and is currently going through the hearings panel process. As such this report references and summarises the latest proposed relevant acoustic criteria from the PAUP hearings[3] as well as the currently operative Waitakere and North Shore plans. The full criteria as set out in the relevant sections of these documents are contained in Appendix D.

3.3 Construction Noise

3.3.1 PAUP

Part 3 Chapter H Rule 6.2.1.5 of the PAUP specifies the use of NZS 6803: 1999 (the "Construction Noise Standard") in assessing construction noise. The relevant noise limits of

[1] Auckland Council District Plan - Operative Waitakere Section (2003)
[2] Auckland Council District Plan - Operative North Shore Section (2002)
[3] PAUP acoustic criteria referenced in this report refers to Topic 040 Lighting, noise and vibration from PAUP Hearings rebuttal evidence of C Scrafton on behalf of Auckland Council (tracked changes 21 September 2015) and is therefore not the notified version of the rules but gives an indication of anticipated final version after mediation has occurred.

this Standard are set out in Appendix F, and are, in summary, 70 dB L_{Aeq} and 85 dB L_{Amax} during daytime hours, and 45 dB L_{Aeq} and 75 dB L_{Amax} night-time.

3.3.2 Waitakere

Rule 1.1 of the District Plan states that noise from construction, maintenance and demolition work shall be measured and assessed in accordance with New Zealand Standard NZS 6803P:1984 "*The Measurement and Assessment of Noise from Construction, Maintenance and Demolition Work*" ("NZS 6803P:1984").

3.3.3 North Shore

Rule 10.5 (I) of the North Shore District Plan also references NZS 6803P:1984.

3.4 Construction Vibration

3.4.1 PAUP

The control of construction vibration falls under two categories: human response to vibration; and the prevention of cosmetic building damage. Part 3 Chapter H Rule 6.2.1.6 of the PAUP specifies the following vibration criteria.

Human Response – Vibration Amenity

For occupied buildings within 50 metres of construction works generating vibration for greater than three days, and where occupants are advised details of construction work in advance, the following vibration levels are considered to be acceptable.

Table 1: Human Response Vibration Criteria (during construction lasting more than 3 days)

Receiver	Period	PPV Limit
Occupied Activity sensitive to vibration	Night-time 10pm to 7am	0.3 mm/s
	Daytime 7am to 10pm	2 mm/s
Other occupied buildings	At all times	2 mm/s

Cosmetic Building Damage[4]

For occupied buildings within 50 metres of construction works generating vibration for three days or less, and where occupants are advised details of construction work in advance, vibration must not exceed the levels in DIN 4150-3:1999 *"Structural Vibration - Effects of Vibration on Structures"* as summarised below.

Table 2: Prevention of Cosmetic Damage to Buildings DIN4150-3: 1999 Vibration Criteria

Type of Structure	Short-term vibration				Long-term vibration
	Vibration at the foundation at a frequency of			Vibration at horizontal plane of highest floor at all frequencies	Vibration at horizontal plane of highest floor at all frequencies
	1-10Hz	10-50Hz	50-100Hz		
Commercial, Industrial	20	20 to 40	40 to 50	40	10

[4] Vibration levels much higher (in the order of 5 – 10 times) than those listed in Table 2 would be needed to cause structural damage to buildings

Type of Structure	Short-term vibration				Long-term vibration
	Vibration at the foundation at a frequency of			Vibration at horizontal plane of	Vibration at horizontal plane of highest floor at
Residential, School	5	5 to15	15 to 20	15	5
Historic, Sensitive	3	3 to 8	8 to 10	8	2.5

3.4.2 Waitakere

Rule 14.1 states that any activity or temporary activity is a permitted activity where vibration levels generated do not exceed the base curves of Figure 2a, 3a and 4a contained in International Standard ISO 2631-2: 1989 *"Evaluation of human exposure to whole body vibration – Continuous and shock-induced vibration in buildings (1 to 80 Hz)"* ("ISO 2631-2:1989").

3.4.3 North Shore

Rule 10.7 of the North Shore District Plan also references ISO 2631-2: 1989.

3.5 Operation Noise (Pump Station)

3.5.1 PAUP

The proposed Wainoni Park pump stations will be located on land zoned *Recreation*. The pump station proposed for the Watercare designated site at 56 The Concourse will be located on land zoned *Heavy Industry*, as is all adjacent land.

Part 3 Chapter H Rule 6.2.1.3.3 currently proposes the following noise limits for any activity in open space zones, when measured within the boundary of a site in a residential zone:

Table 3: PAUP (Table 14B) Open Space Noise Limits

Period	Noise Limit
Monday to Saturday 7am – 10pm Sunday 9am – 6pm	50 dB L_{Aeq}
All other times	40 dB L_{Aeq} 75 dB L_{AFmax}

Rule 6.2.1.3.3 also proposes the following noise limits for industrial activities on The Concourse.

Table 4: PAUP (Table 4) Heavy Industry Noise Limits

Period	Noise Limit
At all times	70 dB L_{Aeq}

3.5.2 Waitakere

The proposed pump station on the Watercare designated site at 56 The Concourse Henderson, will be located on land with an underlying zone (as with all adjacent sites) of *Working Environment.* Rule 8.1 (b) stipulates a noise limit of 65 dB L_{A10} measured on any part of any other site within the Working Environment at any time of the day.

3.5.3 North Shore

The proposed Wainoni Park pump stations will be located on land zoned *Recreation 4* (i.e. open space). Adjacent land is zoned *Residential 1* and *Standard Residential (Albany and Greenhithe)*. Therefore, the noise limits set out in Table 10.2.A.(i) apply to non-residential activities in any zone as measured at any residential zone boundary.

Table 5: Operative North Shore (Table 10.2) Noise Limits All Zones Except Residential

Table 10.2 Maximum Permitted Noise Levels by Zone					
		Mon-Sat inclusive 0700hrs-2000hrs	***Mon-Sat inclusive 2000hrs-2300hrs***	***Sun & Public Holidays 0700hrs-2400hrs***	***All Other Times***
A: All Zones Except Residential					
(as measured at any residential zone boundary)					
i)	*As measured at any residential zone boundary except for those within the high background noise area identified in Appendix 10E*	*50 dBA L_{10}*	*45 dBA L_{10}*	*45 dBA L_{10}*	*40 dBA L_{10}* *75dB L_{Amax}*

3.6 Operation Vibration (Pump Station)

Vibration from the operation of the pump station is not anticipated to cause adverse effects, provided the equipment is well maintained, and typical best practice is utilised for vibration isolation of rotating or reciprocating machinery as required.

3.7 Recommended Project Acoustic Criteria

3.7.1 Construction Noise

As can be seen from the summary of the construction noise criteria from the Waitakere and North Shore district plans, the use of NZS 6803P: 1984 is stipulated. This version of NZS 6803 is a 32-year old provisional Standard which was subsequently replaced in 1999 by the current version, NZS 6803: 1999. The PAUP refers to this current version.

The NZS 6803: 1999 Standard is widely acknowledged as being appropriate for construction noise management and is therefore recommended to be applied to this Project in place of the 1984 standard.

The duration of total Project works would be greater than 20 weeks and is therefore classified as 'long-term duration' construction according to the Construction Noise Standard[5]. The long-term noise criteria of the Construction Noise Standard, as set out in Appendix F, form the basis of the assessment of land-based construction activities in this report.

In summary, land-based construction works should comply with 70 dB L_{Aeq} and 85 dB L_{Amax} during daytime hours (0730 to 1800 hours).

[5] NZS 6803: 1999 Clause 7.2.1

3.7.2 Construction Vibration

With regard to ISO2631-2:1989, it is noted that this Standard has been withdrawn by the International Standards Committee and has been replaced with a newer version which does not contain any vibration criteria. Therefore, the use of this Standard in assessing vibration effects is not considered best practice.

As such, MDA recommends the limits from DIN 4150-3: 1999 are adopted for the Project. Refer to Section 3.4.1 for specific criteria from the Standard.

3.7.3 Construction Vibration Building Damage and Night-time Amenity

People will perceive vibration at levels much lower than the DIN Standard limits (Table 2 Section 3.4.1), so they may feel vibration in a building long before there is any damage risk to the building itself. Concern over building damage is by far the most common vibration-related objection raised by affected parties, followed by sleep disturbance.

Applying the DIN 4150-3:1999 Standard, and monitoring to confirm compliance with its criteria, is considered sufficient to address the first concern (building damage), and this will be managed as far as practicable through communication and liaison outlined in the CNVMP.

Addressing the second concern (sleep disturbance) requires a different set of criteria because the effect is dominated by regenerated noise[6] rather than perceived vibration i.e. a room inhabitant is likely to hear a noise before they feel the vibration.

MDA considers a suitable regenerated noise criterion to be 35 dB $L_{Aeq(15min)}$, which is deemed to be a 'satisfactory' noise level for bedrooms near minor roads in the Australian / New Zealand joint standard AS/NZS 2107:2000[7]. A similar criterion has been adopted on another major infrastructure project[8] for hotel bedrooms between the hours of 10pm and 7am.

3.7.4 Operation Noise

The limits as set out in Part 3 Chapter H Rule 6.2.1.3.3 of the PAUP are recommended. Refer to Section 3.5.1 for specific criteria.

4.0 DESCRIPTION OF THE RECEIVING ENVIRONMENT AND PROPOSED WORKS

The following sections describe the proposed works in the context of the receiving environment i.e. the existing and likely future acoustic environments, along the pipeline route. The relevant underlying zones of the PAUP and operative district plans are also identified as they give a good indication of permitted activity development that can occur on land adjacent to the pipeline route as of right and, therefore, the likelihood for the future acoustic environment to change from what currently exists can be inferred.

To quantify the existing acoustic receiving environment, two pipeline route inspections were carried out on 24 February 2016 and 22 April 2016 in the daytime, during which existing ambient and background noise levels were measured, generally in accordance with the relevant standards.

[6] Regenerated noise is generated in a room through the vibration of its walls, ceiling, floor and sometimes fittings.
[7] Australian/New Zealand Standard AS/NZ 2107:2000 *"Acoustics - Recommended design sound levels and reverberation times for building interiors"*
[8] City Rail Link NoR – 35 dB $L_{Aeq(15\ min)}$ between 10pm and 7am

To assist with quantifying the night-time ambient and background noise environment in the vicinity of residential receivers around the proposed Wainoni Park pump stations, long-term noise logging was carried out. Long-term logging was not carried out at the proposed pump station location on The Concourse for the following reasons; given the already high ambient noise environment; the fact that it is an industrial zone; and given the high noise limit applicable to the zone (refer to Sections 3.5.1 and 3.5.2).

As the pipeline will pass through road corridors predominantly in residential zones, the environmental baseline for vibration will be suitably low and is therefore considered to be zero in this report.

Although the NoR - NI (Waitakere) will not commence construction until at least 2035, it is anticipated (referring to the relevant PAUP planning maps) that the receiving environment along the majority of the route, including the NI - North Shore section, is unlikely to alter in a permanently significant way (notwithstanding the fact that there will be temporary construction works for NI Phase 1) because the pipeline route passes through / adjacent to land already built upon[9] or zoned open space.

MDA understands there is no land designated for major transportation infrastructure in the vicinity of the route (transportation activities can significantly alter the ambient environment). As such, the reported results are considered to be generally representative of the likely future acoustic environment along the route except where noted below. Further specific discussion in relation to the future acoustic environment is contained in Sections 4.1 and 4.2.

Refer to Appendix E for a complete table of measurement / long-term noise logging results.

4.1 NoR-NI (Waitakere)

4.1.1 The Concourse to Selwood Road

A new pump station will be constructed on the Watercare owned property at 59 The Concourse. The indicative concept design notes that construction of this section of pipeline will be by trenched technologies. The trenching works will occur entirely within the road corridor and on land zoned *Working* (adjacent land also zoned Working or *Heavy Industry* in PAUP). Works have an anticipated duration of 2-5 months. The estimated duration of pump station construction is 18-24 months.

The minimum setback distance for receivers and buildings immediately adjacent to the pipeline route is 10 metres. However, for the majority of receivers the distance is significantly greater. The depth of the trench is shallow (sheet piling retention is thus unlikely) therefore, the works will progress at a fast rate.

The existing ambient and background environment along this section of the pipeline is 62 dB L_{Aeq} and 55 dB L_{A90} and is characterised by industrial noise sources such as extract fans, waste disposal (from the Waitakere Transfer Station), and heavy traffic movements on the road.

The existing ambient vibration environment in the vicinity of the pipeline is controlled by heavy vehicle movements on the road.

[9] The exception would be around the Third Fairway proposed residential development located in part of the North Shore Golf Course. It is considered in this case that the ambient acoustic environment, once developed, would be comparable to measurement result MP16

MDA considers there to be little scope for any change to the existing acoustic environment, given the already developed nature of adjacent land to the pipeline route. Therefore, future noise and vibration levels as at the date of construction are anticipated to be similar.

4.1.2 Selwood Drive to Huruhuru Road

At the intersection of The Concourse and Selwood Road, the indicative concept design notes that the pipeline passes through the Radio New Zealand property at 2-12 Selwood Road and travels toward the eastern embankment of Henderson Creek.

Resource consent for the crossing of Henderson Creek will be sought at a later date; therefore potential acoustic effects have only been assessed at either end of the CMA crossing.

On the western embankment of Henderson Creek the trenched pipeline travels through Taitapu Park before proceeding along Kopi Place (passing between 21 and 23 & 16 and 35 Kopi Place) to Huruhuru Road. The trenching works will occur on land zoned *Working,* or *Open Space (Light Industrial* or *Public Open Space* in PAUP)*,* within the road corridor*,* and on residential land zoned *Living (Single House* in PAUP)*.* The anticipated duration of these works is 2-5 months.

All residential receivers are located 10 metres or more from the proposed works with the exception of the four dwellings located on Kopi Place described above.

The existing ambient and background environment in the vicinity of the dwellings located on Kopi Place and near the intersection of Huruhuru Road and Taitapu Street is 55 dB L_{Aeq} and 48 dB L_{A90} and is characterised by traffic noise from State Highway 16 ("SH16").

The existing ambient vibration environment in the vicinity of the aforementioned dwellings is considered to be low. However, some low-level vibration from heavy vehicles on SH16 may be perceptible to Kopi Place dwellings backing onto the motorway.

The future acoustic environment in the vicinity of these receivers at the time of construction is anticipated to be approximately 1.5 dB higher, based on an estimated >30% increase in traffic volume for SH16[10]. Vibration would be similar to existing levels, i.e. imperceptible to low.

4.1.3 Huruhuru Road to Cedar Heights Avenue

The indicative concept design notes that the pipeline travels along the Huruhuru Road corridor and passes through Lowtherhurst Reserve at its western end. Trenching then continues up the incline of Redwood Drive before turning left onto Cedar Heights Avenue and continuing uphill until the intersection with Jarrah Place. The concept design also indicates that a break pressure chamber may be constructed near the intersection.

The trenching works will occur predominantly within the road corridor adjacent to land zoned *Living (Mixed Housing Urban / Suburban* in PAUP)*.* Lowtherhurst Reserve is zoned *Open Space (Public Open Space – Informal Recreation* in PAUP)*.* The anticipated duration of trenching works is 2-5 months.

The existing ambient and background environment in the vicinity of dwellings adjacent to the pipeline route is 57 dB L_{Aeq} and 53 dB L_{A90} and is characterised by traffic noise from SH16.

[10] SH16 Western Ring Route Huruhuru Road Bridge to Westgate – MDA Report RP 001 R05 2009585A 1 September 2010

The existing ambient vibration environment for dwellings adjacent to the pipeline route is considered to be low.

The future acoustic environment for the identified receivers at the time of construction is predicted to be approximately 1.5 dB higher, as discussed in Section 4.1.2. Ambient vibration levels are predicted to remain low for these receivers.

4.1.4 Cedar Heights Avenue to Holmes Reserve

The pipeline will be installed via trenchless technology along this section. The current best practice trenchless construction method is by pipe-jacked tunnel boring machine ("TBM"). Above-ground works will be confined to the shafts that will be required along the pipeline route. The primary noise sources associated with the construction of the shafts will be a piling rig, excavators and truck movements. Other ancillary above ground activities and sources will include a generator, ventilation fan, crane, hydraulic power pack, pumps and drilling fluid recycling during TBM operation.

The indicative concept design notes that shafts will be constructed at six locations; three on Cedar Heights Avenue, one in Makora Park, one in a residential zone, and one in Holmes Reserve. A drop structure may need to be constructed in Holmes Reserve and will be approximately 14 metres deep.

The pipeline will predominantly pass through road corridors and open space land although there will be adjacent dwellings zoned *Living (Mixed Housing Urban* in PAUP) for the majority of the route. The pipeline passes directly under the dwelling located at 8 Holmes Drive South (13.5 metres approximate depth).

Varying depths of between 7 to 25 metres below surface level will be encountered along the route. The anticipated duration of works at each shaft site is 4-5 months.

The existing ambient and background environment in the vicinity of dwellings adjacent to the pipeline shafts along Cedar Heights Avenue is 54 dB L_{Aeq} and 50 dB L_{A90} and is characterised by traffic noise from SH16.

For the section of pipeline between Royal Road and Holmes Reserve the existing ambient and background environment is 55 dB L_{Aeq} and 41 dB L_{A90} and is characterised by traffic noise from SH16.

The existing ambient vibration environment for dwellings adjacent to the pipeline route is considered to be low.

The future acoustic environment for the identified receivers at the time of construction is predicted to be approximately 1.5 dB higher, as discussed in Section 4.1.2. Ambient vibration levels are predicted to remain low for these receivers.

4.1.5 Holmes Reserve to Holmes Drive

This section of pipeline will be installed via a combination of trenchless and trenched methods but will also use a pipe bridge. The pipe bridge will be approximately 20 metres long and will be at a low elevation relative to adjacent dwellings. The anticipated duration of various construction work is as follows:

- Approximately 4 – 5 months at each shaft site
- Approximately 5 months for construction of the pipe bridge

- Approximately 2 – 3 months for trenching activities

The indicative concept design notes that shafts will be constructed at four locations; one each adjacent to 13 / 15 Berkshire Terrace, Ruze Vida Drive, Jaedwyn Drive, and Manutewhau Reserve adjacent to the playground.

The proposed pipeline will predominantly pass through road corridors and public open space land; adjacent dwellings along the route are zoned *Living (Mixed Housing Urban* and *Single House* in PAUP). The pipeline passes directly under 13 and 15 Berkshire Terrace and through the properties located at 33 and 35 Jaedwyn Drive. It is understood that some of these properties may be acquired for the Project, thereby avoiding potential noise and vibration effects.

The existing ambient and background environment in the vicinity of dwellings adjacent to the shafts in Berkshire Terrace and Jaedwyn Drive is 47 dB L_{Aeq} and 46 dB L_{A90} and is characterised by distant traffic noise from SH16 and general urban noise sources.

For the section of the pipeline which passes through Manutewhau Reserve via trenching and pipe bridge the existing ambient environment is 57 dB L_{Aeq} and 55 dB L_{A90} and is controlled by traffic noise on SH16.

The existing ambient vibration environment for dwellings adjacent to the pipeline route is considered to be low.

The future acoustic environment for receivers in Berkshire Terrace and Jaedwyn Drive at the time of construction is anticipated to be similar to the existing measured noise levels. The future acoustic environment for receivers closer to Manutewhau Reserve is predicted to be approximately 1.5 dB higher, as discussed in Section 4.1.2. Ambient vibration levels are predicted to remain low for all receivers.

4.1.6 Holmes Drive to Hobsonville Road

The pipeline for this section will be predominantly constructed using trenchless technology. However, a small section will be trenched in order to avoid a large stormwater pipe located near to 8 Holmes Drive. The anticipated duration of works is 4 - 5 months per shaft site.

A total of five shafts will be constructed along the route; three on Holmes Drive, and two in St Margaret's Park.

Up until the second shaft in St Margaret's Park, the pipeline will pass through the road corridor or public open space land. The section from the northern end of St Margaret's Park to the northern side of Hobsonville Road will pass under eight existing dwellings zoned *Living (Mixed Housing Urban* in PAUP) at a depth of between 10 to 20 metres, as well as under land zoned *Countryside (Future Urban* in PAUP) (houses are likely to be built by the time construction commences). The pipeline terminates at this point and connects to works being undertaken as part of the shared corridor works.

For receivers located adjacent to shafts on Holmes Drive the measured ambient and background noise environment is 57 dB L_{Aeq} and 55 dB L_{A90} and is controlled by traffic noise on SH16.

For the receivers located adjacent to the shafts in St Margaret's Park the noise environment is quieter, although traffic noise from SH16 is still audible. The measured ambient and background noise environment is 48 dB L_{Aeq} and 45 dB L_{A90}.

The existing ambient vibration environment for dwellings adjacent to the shafts is considered to be low.

The future acoustic environment for receivers adjacent to the St Margaret's Park shafts at the time of construction is anticipated to be similar to the existing measured noise levels. The future acoustic environment for receivers adjacent to the shafts on Holmes Drive is predicted to be approximately 1.5 dB higher, as discussed in Section 4.1.2. Ambient vibration levels are predicted to remain low for all receivers.

4.2 NoR-NI (North Shore)

4.2.1 Eastern abutment of the Greenhithe Bridge to Collins Park

The pipeline crossing of the Upper Waitemata Harbour will utilise trenchless technology, travelling under the western bank near the eastern abutment of Greenhithe Bridge to a break pressure chamber. Resource consent for the crossing of Upper Waitemata Harbour will be sought at a later date; therefore potential acoustic effects have only been assessed at either end of the CMA crossing.

The indicative concept design notes that a shaft and break pressure chamber will be constructed at the eastern abutment of the Greenhithe Bridge. Trenchless technology will be used to construct this section of the pipeline; a reception shaft will be constructed on private property at 15 The Knoll; trenched excavation may be employed for a small section of pipeline (this is option dependent); however, the predominant construction method for this section will be trenchless technology.

The indicative concept design notes a total of seven shafts will be constructed; as noted, one at eastern abutment of the Greenhithe Bridge; five within the Tauhinu Road corridor and one located in the southern corner of Collins Park. Adjacent receivers to the pipeline route are zoned *Residential (Large Lot* in PAUP).

Travelling along Tauhinu Road until a point near 6 Tauhinu Road, the pipeline turns eastwards toward Collins Park, where it passes under twelve dwellings located on Tauhinu Road, Greenhithe Road and Shiloh Way at a depth of between 7 to 15 metres. The anticipated duration of works at each shaft site is 4 – 6 months.

For receivers located adjacent to shafts on Tauhinu Road, the measured ambient and background noise environment is 57 dB L_{Aeq} and 40 dB L_{A90} and is controlled by traffic noise during the daytime.

For the receivers located adjacent to the shaft in Collins Park the noise environment is quieter. The measured ambient and background noise environment is 42 dB L_{Aeq} and 38 dB L_{A90}.

The existing ambient vibration environment for dwellings adjacent to the shafts is considered to be low.

The future acoustic environment for receivers adjacent to pipeline shafts as at the date of construction is anticipated to be similar to what currently occurs, given the already developed nature of surrounding residential land; some temporary short-term construction works associated with NI Phase 1 will occur (scheduled to commence in 2017).

4.2.2 Collins Park to Wainoni Park

From the Collins Park launch shaft the indicative concept design notes that the pipeline will tunnel in a north-easterly direction under Collins Park and in the Greenhithe Road corridor before entering Wainoni Park South. One shaft will be constructed at the southern end of the Park. A baffle drop structure will also be constructed in Collins Park to a depth of 20 metres.

The pipeline will pass at depth under two dwellings located at 2 Churchouse Road and 62 Greenhithe Road. All adjacent dwellings along the route are zoned *Residential*. The anticipated duration of works is between 3 – 4 and 6 - 8 months per shaft site (depending on location).

For the receivers located adjacent to the shaft in Collins Park the noise environment is relatively quiet. The measured ambient and background noise environment is 42 dB L_{Aeq} and 38 dB L_{A90} and is characterised by traffic movements on Greenhithe Road and noise from the nearby skate park.

For receivers located adjacent to the shaft in Wainoni Park South the measured ambient and background noise environment is 54 dB L_{Aeq} and 46 dB L_{A90} and is controlled by traffic noise on Greenhithe Road.

The existing ambient vibration environment for dwellings adjacent to the shafts is considered to be low.

The future acoustic environment for receivers adjacent to pipeline shafts as at the date of construction is anticipated to be similar to what currently occurs, given the already developed nature of surrounding residential land and no significant planned major infrastructure in the area.

4.2.3 Wainoni Park South

From the launch shaft at the southern end of Wainoni Park South the indicative concept design notes that the pipeline will continue to be installed via trenchless technologies (tunnel invert depths of between 6 and 26 metres) to a point at the northern end of Wainoni Park North. The works will all occur within land zoned *Open Space (Public Open Space – Sport and Active Recreation* in PAUP). Adjacent residential receivers located around the border of the Park are all zoned *Residential (Large Lot, Mixed Housing Suburban, Single House* in PAUP).

A total of five shafts will be constructed within the Park for tunnelling purposes. A new shallow booster pump station will be constructed at the south-eastern corner of Wainoni Park South, off Orwell Road. The anticipated duration of works at each shaft site is between 2 – 4 and 6 - 8 months per shaft site (depending on location) and 12 – 18 months for pump station construction.

For the receivers located adjacent to the shaft at the southern end of Wainoni Park South the ambient and background noise environment is 54 dB L_{Aeq} and 46 dB L_{A90} and is characterised by traffic noise on Greenhithe Road.

For receivers located further away from Greenhithe Road the acoustic environment is quieter; 42 dB L_{Aeq} and 40 dB L_{A90} and is characterised by general ambient noise.

As the proposed pump station will operate 24-hours per day and will generate noise from various mechanical equipment, a long-term noise logger was deployed in the general vicinity

of receivers located nearby the pump station, in order to provide a high level of accuracy in quantifying the night-time ambient and background noise environment. The detailed results are provided in Appendix E. The summarised results indicate that the ambient and background noise environment during the daytime is 46 dB L_{Aeq} and 42 dB L_{A90} and 40 dB L_{Aeq} and 31 dB L_{A90} during the night-time.

Based on the summarised noise logging results, the recommended operation noise limits detailed in Section 3.5.1 are considered appropriate.

The future acoustic environment for nearby receivers is unlikely to alter significantly at this location, for the reasons outlined in previous sections.

4.2.4 Wainoni Park North to North Shore Memorial Park

A pump station is proposed adjacent to the existing North Shore Air Gun Club ("NSAGC"), toward the northern end of Wainoni Park North. From this location the pipeline will cross under Te Wharau Creek using trenchless technologies and will land at a point within North Shore Memorial Park ("NSMP"). Any regional consents for the crossing of the CMA will be sought at a later date when all regional consents are sought; however this report assesses the noise effects from this activity to ensure a comprehensive assessment is undertaken.

The anticipated duration of works is 9 – 11 months trenchless construction and 12 – 24 months for pump station construction.

As with the Wainoni Park South pump station location discussed in Section 4.2.3, a long-term noise logger was deployed in the general vicinity of receivers to the proposed Wainoni Park North pump station. The summarised results indicate that the ambient and background noise environment during the daytime is 47 dB L_{Aeq} and 35 dB $L_{A90}$and 37 dB L_{Aeq} and 28 dB L_{A90} during the night-time.

Based on the summarised noise logging results, the recommended operation noise limits detailed in Section 3.5.1 are considered appropriate.

The future acoustic environment for nearby receivers is unlikely to alter significantly at this location either.

4.2.5 North Shore Memorial Park to Schnapper Rock Road

This section of the pipeline will be installed by trenched technologies under future and existing internal roads and paths within NSMP, trenching in a general north-easterly direction towards Schnapper Rock Road. The anticipated duration of trenching works is approximately 2 - 5 months.

Works in NSMP are not considered noise sensitive in terms of residential amenity, given the significant setback distances to the closest dwellings. However, given the obvious sensitivity of visitors to the site, this stakeholder should be consulted with prior to any work being carried out and all works managed via a Site Specific CNVMP so as to ensure minimal disturbance.

4.2.6 Schnapper Rock Road to North Shore Golf Course

The trenched pipeline will intersect Schnapper Rock Road at approximately 266 Schnapper Rock Road (adjacent dwellings to the pipeline works are zoned *Standard Residential* in operative plan and *Single House* in PAUP) before turning northwards and continuing within the road corridor to the end of the road, entering Wharepapa Reserve (zoned *Recreation 3*

in operative plan and *Public Open Space – Informal Recreation* in PAUP). From this location the pipeline will be constructed using trenchless technology below a tributary of Lucas Creek (resource consent for the crossing will be sought at a later date) before entering North Shore Golf Club ("NSGC") grounds. The pipeline will run adjacent to the northern boundary of the consented 'Third Fairway' residential development (zoned *Structure Plan Area A* in operative plan and *Large Lot Residential* in PAUP) where a trenchless technology reception site may also be located.

The anticipated duration of trenching work is 2 – 5 months and 5 – 6 months for trenchless construction.

For the receivers located adjacent to trenching works on Schnapper Rock Road the measured ambient and background noise environment in the generally vicinity is 41 dB L_{Aeq} and 37 dB L_{A90}. The site and surrounding area does not receive significant traffic noise; with bird, insect and general residential activity characterising the ambient environment.

4.2.7 North Shore Golf Course to Appleby Road

At the connection with the section of the pipeline constructed via trenchless technologies, the remainder of the pipeline within the NSGC grounds will be constructed via trenched technologies. The pipeline will follow the southern boundary before turning north-east and passing through the carpark and along the private access road to Appleby Road, where it remains within the road corridor. The anticipated duration of trenching works is approximately 2 - 5 months.

The receivers adjacent to trenching works are located on St Andrews Way, Appleby Road (including Albany Junior High School) (dwellings are zoned *Residential* in operative plan and *Mixed Housing Suburban* in PAUP).

The measured existing ambient and background noise environment in the vicinity of receivers on St Andrews Way and Appleby Road is 54 dB L_{Aeq} and 52 dB L_{A90}. Traffic noise is the controlling source of sound for receivers closer to Albany Highway.

The ambient environment in the vicinity of the 'Third Fairway' residential development is estimated to be 41 dB L_{Aeq} and 37 dB L_{A90}, once the development is completed and occupied.

4.2.8 Appleby Road to William Pickering Road

The trenched pipeline continues along Appleby Road until it reaches Albany Highway, where it turns northwards; from Albany Highway to John Glenn Avenue, heading toward William Pickering Drive. The pipeline will remain within the road corridor for the entirety of this section; the anticipated construction duration is 2 - 5 months.

The receivers near trenching works are located adjacent to Albany Highway, or in Rosedale Business Park (zoned *Residential* and *Business* in operative plan and *Mixed Housing Suburban* and *Light Industry* in PAUP*).*

The measured ambient daytime noise levels near Unity Drive North are 48 dB L_{Aeq} and 44 dB L_{A90}.

4.2.9 William Pickering Drive to Bush Road

The trenched pipeline continues in a south-easterly direction along William Pickering Drive and then turns east onto Piermark Drive, where it continues to the intersection with Bush

Road. The pipeline will remain within the road corridor for the entirety of this section until reaching 169 and 179 Bush Road; the anticipated construction duration is 2 - 5 months.

Receivers adjacent to the trenching works are zoned *Business (Light Industry* in PAUP).

Noise levels of 52 dB L_{Aeq} and 49 dB L_{A90} have been measured along Piermark Drive, with the controlling noise source considered to be traffic.

4.2.10 Bush Road to Rosedale WWTP

The pipeline for this section will be predominantly constructed via trenched technologies however the section under Alexandra Stream from 179 Bush Road to the Rosedale Park carpark will be constructed using trenchless technology. Receivers along this section of the pipeline are zoned *Business (Light Industry* in PAUP)*;* Rosedale Park is zoned *Open Space (Public Open Space – Sport and Active Recreation* in PAUP. The anticipated duration of trenching work is 2 – 4 months and 5 – 6 months for trenchless construction.

The ambient noise level near the nearest commercial receivers is 57 dB L_{Aeq} and 55 dB L_{A90} measured during the daytime and is characterised by industrial noise sources in nearby business zones.

5.0 ASSESSMENT METHODOLOGY

The following methodology was used in predicting noise and vibration levels generated by the Project and assessing potential effects on nearby receivers:

- MDA walked sections of the indicative pipeline route as well as inspected sections via satellite imagery; factors which would affect noise and vibration propagation from work areas to surrounding receivers were noted; such as ground roughness, elevations and shielding by terrain forms. These factors were included in predictions
- The relevant sections of the operative and proposed plans were reviewed, including planning maps, to ascertain underlying zones and applicable acoustic performance criteria
- Recommendations were made as to appropriate acoustic performance standards (the "recommended Project acoustic criteria")
- Noise and vibration levels were predicted at nominal setback distances representative of the source-to-receiver distances for all identified receivers considered to be potentially affected by the Project
- Noise contours were predicted for sustained construction activities and receivers falling inside the 70dB L_{Aeq} and 45 dB L_{Aeq} contours (the respective daytime and night-time Construction Noise Standard limits) were identified
- An assessment of compliance with the recommended project acoustic criteria was made
- An assessment of potential acoustic effects on the environment was made by comparing predicted noise and vibration levels to existing acoustic baselines (where relevant). This included the identification of activities that could result in potential adverse effects and, in turn, identifying design refinements or construction methodologies that could avoid, remedy or mitigate such effects

6.0 ASSESSMENT OF EFFECTS

6.1 Overview of Predicted Noise and Vibration Levels

In carrying out an assessment of Project acoustic effects it is necessary to identify the sources and activities that will generate significant noise and vibration levels and therefore potential adverse effects. The potential for adverse effects is dependent upon source-to-receiver setback distances, ground type, the existence of any intervening structures that provide shielding, and duration / timing of works.

6.1.1 Construction Noise

Construction noise levels have been predicted for nominal receiver setback distances based on the source noise levels provided in Appendix G, and are set out in Table 6. It should be noted that the predicted levels do not take into account screening effect from buildings or other structures, therefore only apply to receivers that have direct line-of-sight to construction works.

Where receivers along the route are located at similar distances, they would generally receive equivalent noise levels and effects. Receivers that do not have line-of-sight would receive noise levels significantly below those predicted in Table 6 for a given distance and generally compliant with the recommended Project noise criteria.

In Table 6, predicted levels highlighted:

- Red indicates that mitigation and management measures will need to be adopted
- Orange indicates that minor exceedances of the Construction Noise Standard will occur – triggering mitigation or management measures
- Green indicates compliance without the need for management and mitigation measures.

Table 6: Construction Noise Predictions at Nominal Setback Distances (without mitigation or screening)

Activity	Plant	Plant L_{WA}	Noise Level (70dB L_{Aeq} noise limit)			
			10m	15m	20m	40m
Site Prep	Diamond Road Saw	111	83	79	77	71
	Compressor	106	78	74	72	66
	Jack Hammer	120	92	88	86	80
Trenching	Excavator	103	75	71	69	63
	Sheet piling	115	87	83	81	75
	Bored piling (alternate piling method)	112	84	80	78	72
	Dewatering pumps	97	69	65	63	57
	Compactor	106	78	74	72	66
	Truck deliveries	105	77	73	71	66
PE pipe string	Excavator	103	75	71	69	63
	Containerised Generator	103	75	71	69	63
	Tractor	91	63	59	57	51
Trenchless technology (MTBM)	Cumulative	107	-	75	73	67
Trenchless technology (HDD)	Cumulative	115	-	-	-	75
Pump Station construction	Excavator	103	-	-	-	63
	Tipper trucks	107	-	-	-	67
	50T tracked crane (moving)	114	-	-	-	74
	Containerised generator	103	-	-	-	63
	Pumps	107	-	-	-	67
	Vibro-hammer piling	115	-	-	-	75
	Plate compactor	106	-	-	-	66
	Truck deliveries	107	-	-	-	67
	Concrete truck and pumping	107	-	-	-	67
Drop Shaft construction	Excavator	103	-	71	69	63
	12m Hiab truck	97	-	65	63	57
	20T mobile crane	99	-	67	65	59
	Concrete trucks and pumping	107	-	75	73	67

Activity	Plant	Plant L_{WA}	Noise Level (70dB L_{Aeq} noise limit)			
			10m	15m	20m	40m
Pipe Bridge construction	Excavator	103	-	71	69	63
	Continuous flight auger piling	112	-	80	78	72
	100T Mobile crane (moving)	114	-	82	80	74
	Truck deliveries	105	-	73	71	66
	Concrete trucks and pumping	107	-	75	73	67
Road surface reinstatement	Excavator	103	75	71	69	63
	Tipper truck	107	79	75	73	67
	Asphalt truck	109	81	77	75	69
	Vibrating roller	106	78	74	72	66
	Plate compactor	106	78	74	72	66

Noise levels and associated effects

Daytime noise levels between 80-90 dB L_{Aeq} from activities such as sheet piling and saw cutting and break-up of the road (where they occur 10 m from receivers) are likely to interfere with activities occurring at the time and may cause discomfort.

Noise levels between 70-80 dB L_{Aeq} will be highly audible and are likely to cause annoyance and would not provide for outdoor amenity.

Construction activities which have lower noise levels of between 60-70 dB L_{Aeq} will be clearly audible and may cause some annoyance, but should not interfere with domestic activities, particularly where prior written communication is given (e.g. letter drop).

6.1.2 Construction Vibration

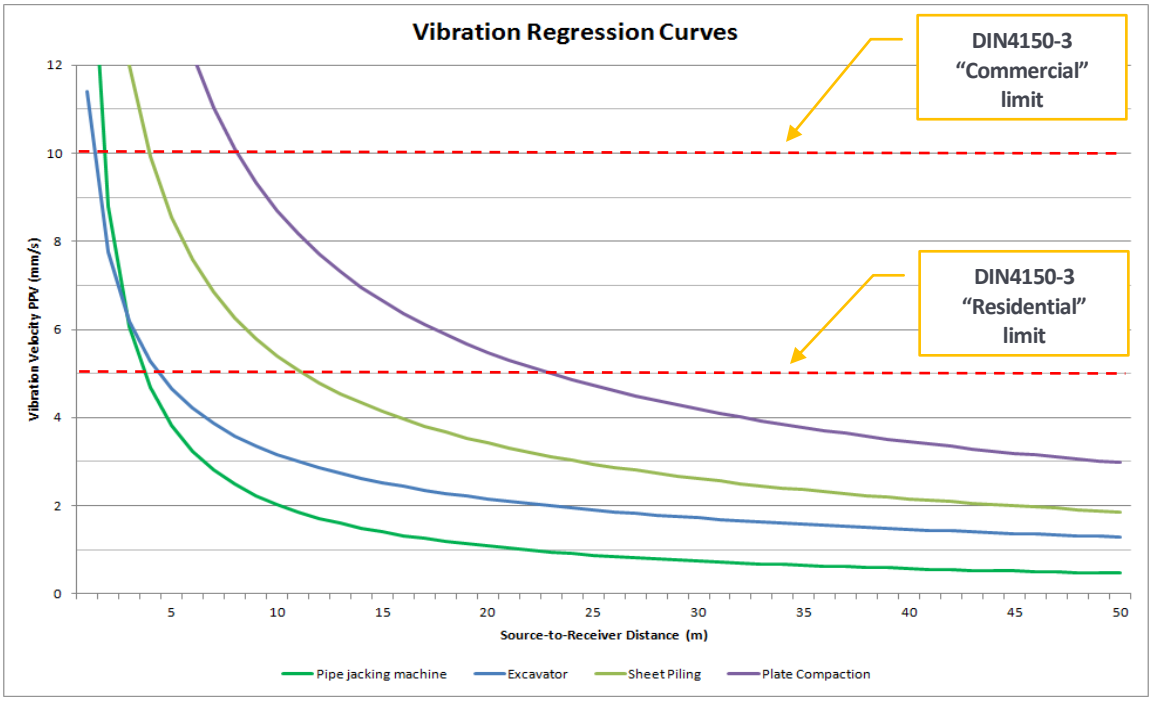
The following plant and activities have been identified as high-vibration sources:

- Excavation of trenches and micro-tunnel shafts using excavators
- Plate compactors (trenching, shaft construction and road surface reinstatement activities)
- Vibro-placement of trench shields
- Pipe-jacking (trenchless technologies)

Vibration data from the identified sources have been obtained from BS 5228-2:2009[11], measurements made by MDA, and other relevant projects where equivalent activities and plant have been used.

The following figure shows the regression curves (PPV vs. distance) for each high-vibration source identified.

Figure 1: Vibration regression curves



Reading the relevant vibration limits (refer to the 'long-term' vibration limits from Table 2 in Section 3.4.1) off these regression curves (building types are either commercial or residential) gives an indication of the emission radius of each vibration source. This is the distance inside of which exceedance of the criteria may occur at the foundation of receiving buildings.

The emission radii are summarised in Table 7.

[11] BS 5228-2:2009 references Hiller, D.M and Crabb, G.I., *"Groundborne vibration caused by mechanised construction works",* Transport Research Laboratory Report 429, England, 2000

Table 7: Vibration emission radii to comply with cosmetic building damage criteria

Vibration Source	Emission radius (m)	
	Residential/School	Commercial
Excavator	4	2
Vibro sheet piling	11	4
Plate compactor	22	8
Pipe jacking (micro-tunnelling)	4	2

The identified activities can generate high vibration levels at source, although it is noted that levels at the nearest receiver locations would quickly attenuate through the ground during propagation. Based on experience with other current infrastructure projects, the vibration limits for "residential, school" buildings can be readily complied with at distances of 4-22metres or greater. For commercial buildings the distances are significantly shorter at 2-8 metres.

Vibration from excavation down to invert depth is predicted to readily comply with the "Residential" building type criterion of 5mm/s at distances of 4 metres or greater. Vibration from plate compaction during road remediation will comply at operating distances of approximately 22 metres or greater.

Vibration from excavation down to invert depth is predicted to readily comply with the "Commercial" building type criterion of 10mm/s at distances of 2 metres or greater. Vibration from plate compaction during road remediation will comply at operating distances of 8 metres or greater.

The noise and vibration levels set out above are referred to in the following sections, where specific receiver assessments of potential noise and vibration effects have been carried out.

6.1.3 Night-time Amenity

Pipe-jacked tunnelling under dwellings during the night-time has the potential to occur on this Project. In order to determine its potential effects on residential receivers, MDA has referenced work carried out for the City Rail Link enabling works[12] with regard to regenerated noise vs. slant distance from plant to receiver, to enable a similar assessment to that undertaken for vibration damage risk above. Refer to Appendix C for background information about tunnelling.

In order to comply with a regenerated noise criterion of 35 dB L_{Aeq} discussed in Section 3.7.3, a minimum vibration slant distance of 18 metres for buildings with bedrooms located on the ground floor will be required; this drops to 15 metres for buildings with bedrooms on the first floor. These slant distances are analogous to the emission radii described in Table 7. Any building along the route meeting these conditions is at risk of exceeding the regenerated noise criterion of 35 dB L_{Aeq}, resulting in potential sleep disturbance effects for some members of the public.

[12] Albert Street Stormwater Realignment *"Construction Noise and Vibration Assessment"* Rp 001 R07 2014391A dated 13 November 2014

6.1.4 Noise and Vibration Effects / Risk Profile Summary

The following table summarises nominal setback distances and resulting effects / risk profiles for key construction activities along the pipeline route.

Table 8: Effects / Risk Profile Overall Summary

Receiver Group	Source Activity	Effect / Risk Profile
Residential Receivers & Buildings		
Noise		
Residential 10 m from works	Excavation, piling, truck movements, tunnelling ops	Exceeds NZS6803 for short periods, may interfere with activities occurring, and may cause discomfort.
Residential 20 m from works	Excavation, piling, truck movements, tunnelling ops	Generally complies with NZS6803, may cause some annoyance
Vibration		
10 m from works	Excavation, piling, compaction	Compaction may exceed DIN4150-3.
20 m from works	Excavation, piling, compaction	Comply with DIN4150-3, low risk of building damage
Vibration – Regenerated Noise during tunnelling		
Bedrooms within 15 metres (first floor) to 18 metres (ground floor) slant distance of tunnelling	Trenchless technology plant	Low risk of building damage; may exceed 35dB L_{Aeq} internal noise criterion resulting in slight sleep disturbance effects for some

6.2 NoR-NI (Waitakere) – Construction Noise and Vibration Effects

The tables in the following sections should be read in conjunction with the noise contour overlays in Appendix I. The predicted noise contours are considered to be conservative in that they do not include structural screening from houses and therefore provide a worst case effects envelope for sustained construction activities. In addition, the predicted contours include mitigation in the form of the use of secant piling rather than vibro-sheet piling.

6.2.1 The Concourse to Selwood Road

Short-term (minor) exceedances of the Construction Noise Standard are predicted during trenching (refer to Figure I5 Appendix I), which may cause some annoyance. These annoyance effects can be avoided by carrying out trenching in the business zone during the night-time, when the majority of businesses are closed.

There is a low risk of building vibration damage due to trenching works along this section of the pipeline.

6.2.2 Selwood Drive to Huruhuru Road

Short-term exceedances of the Construction Noise Standard are predicted during trenching (refer to Figure I6 Appendix I) for dwellings immediately adjacent to works. More significant effects are predicted for four dwellings located on Kopi Place, given the close proximity of works. The following table identifies the most-affected receivers.

Table 9: Effects / Risk Profile Summary Selwood Drive to Huruhuru Road

Receiver Group	Source Activity	Effect / Risk Profile
Most-affected Residential Receivers & Buildings		
Noise		
16, 21, 23, 35 Kopi Place	Excavation	Significantly exceeds NZS6803 for short periods; may interfere with activities occurring; may cause discomfort.
Dwellings 10-20 m from works (refer Figure I6)	Excavation	Exceeds NZS6803 for short periods; may cause annoyance and would not provide for outdoor amenity
Vibration		
16, 21, 23, 35 Kopi Place	Excavation	Excavation may generate vibration close to DIN4150-3 limit. Vibration will be perceptible inside dwellings, albeit short-term.
Dwellings 10-20 m from works (refer Figure I6)	Compaction	Compaction may generate vibration close to DIN4150-3 limit. Vibration may be perceptible inside dwellings, albeit short-term only.

In conclusion, there is a low risk of building damage due to trenching works along this section of the pipeline except where the works are in close proximity to the identified dwellings on Kopi Place where the risk is higher. Vibration monitoring will be required at initiation of this activity for the identified Kopi Place dwellings. Short-term exceedances of the Construction Noise Standard are predicted, resulting in interference of activities or general annoyance for receivers located close by. However overall, given the speed of progress, the effects will be short-term and can be managed / mitigated via the CNVMP.

6.2.3 Huruhuru Road to Cedar Heights Avenue

As this section of the pipeline will continue to be constructed via trenched technologies and at similar setback distances to Section 6.2.2 (10-20 metres), similar short-term noise and vibration levels and resulting effects will be experienced by receivers. The following table identifies the most-affected receivers.

Table 10: Effects / Risk Profile Summary Huruhuru Road to Cedar Heights Avenue

Receiver Group	Source Activity	Effect / Risk Profile
Most-affected Residential Receivers & Buildings		
Noise		
1-35 Huruhuru Rd, 1-30 Cedar Heights Ave (10-20m from works refer Figure I7)	Excavation	Exceeds NZS6803 for short periods, may interfere with activities occurring.
Vibration		
1-35 Huruhuru Rd, 1-30 Cedar Heights Ave (10-20m from works refer Figure I7)	Compaction	Compaction may generate vibration close to DIN4150-3 limit. Vibration may be perceptible inside dwellings, albeit short-term only.

6.2.4 Cedar Heights Avenue to Holmes Reserve

Exceedances of the Construction Noise Standard are predicted during construction of the micro-tunnel pit shafts. As the shafts will require extensive excavation and wall retention in relatively close proximity to dwellings, a quieter, less vibration-intensive form of piling such as secant piling should be used as a best practice provision. If possible, 2.5 metre high site hoardings should be erected as soon as possible to minimise noise effects on adjacent receivers (not required for Pit 5).

Night-time tunnelling operations above-ground at shaft sites will require management via the CNVMP and will require implementation of enhanced noise mitigation measures.

Vibration from pipe-jacking within 18 metres slant distance of single storey dwellings (15 metres for 2-storey dwellings with bedrooms on upper level), occurring during the night-time, has the potential to exceed the regenerated noise criterion of 35 dB L_{Aeq}. An ("Activity Specific CNVMP or ASCNVMP") will be required where night-time tunnelling occurs within these distances.

Table 11: Effects / Risk Profile Summary Cedar Heights Avenue to Holmes Reserve

Receiver Group	Source Activity	Effect / Risk Profile
Residential Receivers & Buildings		
Noise – Shaft Construction		
Dwellings 10 m from shafts (refer Figure I8 and I9)	Excavation, bored piling, truck movements, tunnelling ops	Exceeds NZS6803 for short periods, may interfere with activities occurring.
Dwellings 20 m from shafts (refer Figure I8 and I9)	Excavation, bored piling, truck movements, tunnelling ops	Generally comply with NZS6803, may cause some annoyance
Vibration – Shaft Construction		
10 m from works	Excavation, compaction	Compaction may exceed DIN4150-3.
20 m from works	Excavation, compaction	Comply with DIN4150-3, low risk of building damage

Receiver Group	Source Activity	Effect / Risk Profile
Vibration – Regenerated Noise during tunnelling (night-time)		
44,47,48,49,51,53,55,70,72,74,76,77 Cedar Heights Ave	Trenchless technology plant	Low risk of building damage; may exceed 35dB L_{Aeq} internal noise criterion resulting in slight sleep disturbance effects for some

In conclusion, there is a low risk of building damage due to shaft excavation works along this section of the pipeline. In addition, there is a low risk of building damage during tunnelling. No more than slight sleep disturbance effects are predicted where tunnelling occurs during the night-time within 15-18 metres of dwellings. Given the complexity in predicting vibration in buildings due to the number of variables involved and their interaction (building junctions, quality of materials and construction, and ground type), MDA recommends the following management approach (as part of an ASCNVMP) is adopted during tunnelling:

1. Use the DIN 4150-3 damage criteria in first instance (people's concerns are generally to do with worry about damage to their home);
2. If a complaint is received during night-time tunnelling, this would trigger the management measures i.e. measurements, determination of compliance with regenerated noise criterion (refer to Section 3.7.3), possible temporary relocation.

Construction of shaft site hoardings will ensure that noise is practicably reduced although some annoyance may still result.

MDA recommends the following mitigation measures for night-time TBM support operations:

1. Use of silenced generator
2. Acoustic enclosure for pumps and hydraulic power pack
3. No truck deliveries to / from site during night-time period
4. The stockpiling of tunnelling spoil during night-time period
5. Schedule heavy crane lifts to occur during daytime/evening if possible

6.2.5 Holmes Reserve to Holmes Drive

Exceedances of the Construction Noise Standard are predicted during construction of the micro-tunnel pit shafts, given the close proximity to dwellings. If possible, 2.5 metre high site hoardings should be erected as soon as possible to minimise noise effects on adjacent receivers. Trenched works will occur in this section at similar setback distances to Section 6.2.2 (10-20 metres), similar (short-term) noise and vibration levels and resulting effects will be experienced by adjacent receivers.

It is recommended that the bored piling method is used for the construction of foundations for the proposed pipe-bridge through Manutewhau Reserve. The construction of 2.5 metre high hoardings along the western and eastern site boundary lines of 35 and 33 Ruze Vida Drive respectively are recommended.

Table 12: Effects / Risk Profile Summary Holmes reserve to Holmes Drive

Receiver Group	Source Activity	Effect / Risk Profile
Residential Receivers & Buildings		
Dwellings 10 m from shafts (refer Figure I10 and I11)	Excavation, bored piling, truck movements, tunnelling ops	Exceeds NZS6803 for short periods, may interfere with activities occurring.
Dwellings 20 m from shafts (refer Figure I10 and I11)	Excavation, bored piling, truck movements, tunnelling ops	Generally comply with NZS6803, may cause some annoyance
Vibration – Regenerated Noise during tunnelling (night-time)		
21, 23, 26 Ruze Vida Drive 1,3,5,7,9,11 Jaedwyn Place	Trenchless technology plant	Low risk of building damage; may exceed 35dB L_{Aeq} internal noise criterion resulting in slight sleep disturbance effects for some

In conclusion, there is a low risk of building damage due to trenching works within the road corridor. Exceedances of the Construction Noise Standard are predicted; however the effects will be short-term and can be managed / mitigated via the CNVMP.

Night-time tunnelling under dwellings on Ruze Vida Drive and Jaedwyn Place (Pit 8 and Pit 9) has the potential to result in a slight sleep disturbance effects. The recommended management approach set out in Section 6.2.4 will be required for any tunnelling operations during the night-time.

6.2.6 Holmes Drive to Hobsonville Road

As the majority of this section of the pipeline will be constructed via trenchless technologies at similar setback distances as receivers in Section 6.2.4 (10-20 metres horizontal distance from shafts; 10 metres or greater slant distance to tunnelling), similar (short-term) noise and vibration levels and resulting effects will be experienced by adjacent receivers.

Short-term exceedances of the Construction Noise Standard are predicted. Mitigation measures in the form of 2.5 metre high shaft site hoardings (not required for Pit 14) and adopting a quieter form of piling are recommended for shafts close to dwellings. Enhanced noise mitigation and management measures at shaft sites will be required for night-time tunnelling support operations so as to avoid more than minor effects.

Table 13: Effects / Risk Profile Summary Holmes Drive to Hobsonville Road

Receiver Group	Source Activity	Effect / Risk Profile
Residential Receivers & Buildings		
Dwellings 10 m from shafts (refer Figure I12)	Excavation, bored piling, truck movements, tunnelling ops	Exceeds NZS6803 for short periods, may interfere with activities occurring.
Dwellings 20 m from shafts (refer Figure I12)	Excavation, bored piling, truck movements, tunnelling ops	Generally comply with NZS6803, may cause some annoyance
Vibration – Regenerated Noise during tunnelling		

Receiver Group	Source Activity	Effect / Risk Profile
5,10,12,16,18,20 Holmes Drive 38,40,71,73,75 Oriel Ave	Trenchless technology plant	Low risk of building damage; may exceed 35dB L_{Aeq} internal noise criterion resulting in slight sleep disturbance effects for some

In conclusion, there is a low risk of building damage due to shaft excavation works along this section of the pipeline. In addition, there is a low risk of building damage during tunnelling.

Night-time tunnelling under dwellings on Holmes Drive and Oriel Ave has the potential to result in no more than slight sleep disturbance effects for some. The recommended management approach will be required for any tunnelling operations during the night-time.

6.3 NoR-NI (North Shore) – Construction Noise and Vibration Effects

6.3.1 Eastern abutment of the Greenhithe Bridge to Collins Park

Short-term exceedances of the Construction Noise Standard are predicted during construction of the micro-tunnel pit shafts, given the close proximity to some dwellings. If possible, 2.5 metre high site hoardings should be erected as soon as possible to minimise noise effects on adjacent receivers (not required for Pit 3).

Enhanced noise mitigation and management measures at shaft sites will be required for night-time tunnelling support operations so as to avoid more than minor effects.

Table 14: Effects / Risk Profile Summary Greenhithe Bridge to Collins Park

Receiver Group	Source Activity	Effect / Risk Profile
Residential Receivers & Buildings		
Dwellings 10 m from shafts (refer Figure I13)	Excavation, bored piling, truck movements, tunnelling ops	Exceeds NZS6803 for short periods, may interfere with activities occurring.
Dwellings 20 m from shafts (refer Figure I13)	Excavation, bored piling, truck movements, tunnelling ops	Generally comply with NZS6803, may cause some annoyance
Vibration – Regenerated Noise during tunnelling (night-time)		
6 Tauhinu Rd, 5B,7B,25,27,29 Greenhithe Rd,	Trenchless technology plant	Low risk of building damage; may exceed 35dB L_{Aeq} internal noise criterion resulting in slight sleep disturbance effects for some

In conclusion, there is a low risk of building damage due to shaft excavation works along this section of the pipeline. In addition, there is a low risk of building damage during tunnelling. No more than slight sleep disturbance effects are predicted where tunnelling occurs during night-time within 15-18 metres of dwellings. The recommended management approach will be required for any tunnelling operations during the night-time.

6.3.2 Collins Park to Wainoni Park

Deep shaft excavations will occur in this section of the pipeline, therefore excavation and piling operations will occur for extended periods of time. Mitigation measures in the form of 2.5 metre high shaft site hoardings and adopting a quieter form of piling (bored) are recommended to practicably reduce noise levels. Enhanced noise mitigation and management measures at shaft sites will be required for night-time tunnelling support operations so as to avoid more than minor effects.

Night-time tunnelling activities may occur however, given the significant tunnel invert depths to the nearest receivers, negligible sleep disturbance effects are predicted from regenerated noise.

Table 15: Effects / Risk Profile Summary Collins Park to Wainoni Park

Receiver Group	Source Activity	Effect / Risk Profile
Residential Receivers & Buildings		
Dwellings 25-30 m from shafts (refer Figure I14)	Excavation, bored piling, truck movements, tunnelling ops	Generally comply with NZS6803, may cause some annoyance
Orwell Rd and Greenhithe Rd dwellings (refer Figure 15)	Pump station construction	Generally comply with NZS6803, may cause some annoyance

In conclusion, there is a low risk of building damage due to shaft excavation works along this section of the pipeline. In addition, there is a low risk of building damage during tunnelling and construction of the pump station. Negligible sleep disturbance effects are predicted during night-time tunnelling.

6.3.3 Wainoni Park South

Given the significant setback distances of works within Wainoni Park to dwellings, compliance with the daytime noise limit of the Construction Noise Standard is predicted to readily occur.

Although night-time tunnelling is likely to occur, given the appreciable depths and distances to the nearest dwellings, negligible sleep disturbance effects are predicted from regenerated noise. However, night-time tunnelling support operations located above ground at shaft sites within the park will require ASCNVMP's so as to avoid more than minor effects. The construction of 2.5 metre high site hoardings is recommended.

The construction of the pump station is predicted to generate noise levels in excess of the Construction Noise Standard for Greenhithe Pony Club and North Shore Dog Training Club[13], even with 2.5 metre high hoardings between works and these receivers.

The mitigating factor is that these receiver-activities only occur for limited periods of the week as set out in Table 16. Based on this, and provided there is consultation with these receivers, it is considered that the effects will either be avoided (due to sites being unoccupied during certain periods of work) or can be managed to acceptable levels (when occupied).

[13] The noise limits relevant to Commercial receivers as set out in Table 3 of NZS6803: 1999 are considered relevant here

Table 16: Effects / Risk Profile Summary Wainoni Park South

Receiver Group	Source Activity	Effect / Risk Profile
Residential Receivers & Buildings		
Dwellings 60-70 m from shafts (refer Figures I16 and I17)	Excavation, bored piling, truck movements, tunnelling ops	Readily complies with daytime limit of NZS6803 resulting in slight effects.
	Night-time tunnelling support plant including pumps, generator, hydraulic power pack, mud recycling unit, tracked crane	With enhanced mitigation measures in place may be some slight exceedances of NZS6803 resulting in minor effects
Birchwood Grove dwellings (refer Figures I16 and I17)	Pump station construction	Generally comply with NZS6803, may cause some annoyance
Greenhithe Pony Club (Open variable times)	Pump station construction	Will exceed limits of NZS6803. May cause annoyance effects where site occupied
North Shore Dog Training Club (Tuesday – Thursday evenings only)	Pump station construction	Will exceed limits of NZS6803. May cause annoyance effects where site occupied

In conclusion, there is a low risk of building damage due to shaft excavation works along this section of the pipeline. In addition, there is a low risk of building damage during tunnelling and construction of the pump station. There is also a low risk of sleep disturbance during night-time tunnelling.

Stakeholder engagement with Greenhithe Pony Club and North Shore Dog Training Club will be required, as will the management of pump station construction via the CNVMP to ensure effects are controlled to acceptable levels.

Enhanced mitigation and management measures will be required for night-time tunnelling support operations within the park.

6.3.4 Wainoni Park North to North Shore Memorial Park

Trenchless technology will be used for the crossing under Te Wharau Creek. To predict noise levels, MDA has assumed that this will be by HDD or a similar method.

It has been assumed that all plant such as the HDD drill rig, generator, hydraulic power packs, pumps and recycling units, and tracked crane would be operating continuously and simultaneously. The predicted levels (up to 52 dB L_{Aeq} on Birchwood Grove and 50 dB L_{Aeq} on Monkton Close) are therefore considered to be worst case. Given the rig will operate during the night-time, there is potential for night-time noise effects as discussed below. Negligible vibration effects are predicted to occur.

The rig would be relocated to NSMP to perform the pipe pull-through. Given the site is located a significant distance from residential receivers, MDA does not predict any adverse acoustic effects from the operation at this location.

The construction of the pump station is predicted to generate noise levels in excess of the Construction Noise Standard for NSAGC and Greenhithe Riding for the Disabled, even with 2.5 metre high hoardings between works and these receivers.

The mitigating factor is that these activities only occur for limited periods of the week as set out in Table 16. Based on this, and provided there is consultation with these receivers, it is considered that the effects will either be avoided (due to sites being unoccupied during certain periods of work) or can be managed to acceptable levels (when occupied).

Table 17: Effects / Risk Profile Summary Wainoni Park North to NSMP

Receiver Group	Source Activity	Effect / Risk Profile
Residential Receivers		
Trenchless drilling ops noise		
Birchwood Grove and Monkton Close dwellings	Trenchless support plant incl. pumps, generator, hydraulic power pack, mud recycling unit, tracked crane	Readily complies with daytime limit of NZS6803 resulting in slight effects. With enhanced mitigation measures in place may be some slight exceedances of NZS6803 during night-time resulting in minor effects
Pump station construction		
Birchwood Grove and Monkton Close dwellings (refer Figures I16 and I17)	Excavation, piling, truck movements	Generally comply with NZS6803, may cause some annoyance
North Shore Air Gun Club (Open variable times)	Pump station construction	Will exceed limits of NZS6803. May cause annoyance effects
Greenhithe Riding for the Disabled (Saturday 8.45am to 12.15pm)	Pump station construction	Will exceed limits of NZS6803. May cause annoyance effects

Mitigation measures would be required for night-time drilling operations and consist of using super-silenced generators, enclosing the hydraulic power packs and mud/slurry pumps. Constructing a 2.5 metre high hoarding is also recommended.

With the noise mitigation measures implemented, night-time noise levels are predicted to comply with the night-time noise criterion or only slightly exceed. As the pipe-string pull would be a short-term duration event it is considered that the effects are minor and could be managed through the CNVMP.

Stakeholder engagement with NSAGC and Greenhithe Riding for the Disabled will be required, as will the management of pump station construction via the CNVMP, to ensure effects are controlled to acceptable levels.

6.3.5 North Shore Memorial Park to Schnapper Rock Road

Given the significant setback distances of works within NSMP to dwellings, compliance with the daytime noise limit of the Construction Noise Standard is predicted to readily occur (refer to Figure I18 Appendix I). Negligible vibration effects are predicted.

With regard to the sensitivity of NSMP, it is recommended that early and ongoing engagement with this stakeholder occurs to ensure that noise and general disruption is minimised as far as practicable. Night-time works may be a suitable management strategy for avoiding effects on funeral parties and mourners. However, this would require consultation with the stakeholder.

6.3.6 Schnapper Rock Road to North Shore Golf Course

Short-term exceedances of the Construction Noise Standard are predicted during trenching (refer Figure I18 Appendix I). However overall, given the speed of progress, the effects will be short-term and can be managed / mitigated via the CNVMP.

Trenchless technology will be used for the crossing under a tributary of Lucas Creek. Given the rig will operate during the night-time, there is potential for night-time noise effects for some dwellings on Schnapper Rock Road, Aberley Road, and Third Fairway residential development (refer to Figure I19 Appendix I). Therefore, enhanced mitigation and management measures will be required (see Section 6.3.4). Negligible vibration effects are predicted to occur.

Table 18: Effects / Risk Profile Summary Schnapper Rock Road to NSGC

Receiver Group	Source Activity	Effect / Risk Profile
Residential Receivers & Buildings		
Noise		
266-286 Schnapper Rock Rd, 115 Aberley Rd	Excavation, piling	Exceeds NZS6803 for short periods, may interfere with activities occurring.
Trenchless drilling noise		
286 Schnapper Rock Rd dwellings, 'Third Fairway' residential development (refer Figure I18)	Trenchless ops plant incl. pumps, generator, hydraulic power pack, mud recycling unit, tracked crane	Readily complies with daytime limit of NZS6803 resulting in slight effects. With enhanced mitigation measures in place may be some slight exceedances of NZS6803 during night-time resulting in minor effects
Vibration		
266-286 Schnapper Rock Rd, 115 Aberley Rd	Compaction during road remediation	Compaction may exceed DIN4150-3, risk of damage

In conclusion, there is a low risk of building damage due to trenching works along this section of the pipeline except where road remediation works are undertaken with a plate compactor close to Schnapper Rock Road and Aberley Road dwellings. Vibration monitoring will be required at initiation of this activity in this location.

The risk of vibration effects including regenerated noise from trenchless drilling on this section is negligible.

6.3.7 North Shore Golf Course to Appleby Road

Short-term exceedances of the Construction Noise Standard are predicted during trenching (refer Figure I20 Appendix I). However overall, given the speed of progress, the effects will be short-term and can be managed / mitigated via the CNVMP.

Table 19: Effects / Risk Profile Summary NSGC to Appleby Road

Receiver Group	Source Activity	Effect / Risk Profile
Residential Receivers & Buildings		
Noise		
St Andrews Way dwellings	Excavation	Exceeds NZS6803 for short periods, may interfere with activities occurring.
10, 10A Appleby Road	Excavation	Exceeds NZS6803 for short periods, may interfere with activities occurring
Albany Junior High School	Excavation	Generally comply with NZS6803, may cause some annoyance
ABC Childcare	Excavation	Generally comply with NZS6803, may cause some annoyance
1,3,5,7,9,11 Fearnely Grove, 317,319,321 Albany Highway	Excavation	Generally comply with NZS6803, may cause some annoyance
Vibration		
St Andrews Way dwellings	Compaction during road remediation	Compaction may exceed DIN4150-3, risk of damage
10, 10A Appleby Road	Compaction during road remediation	Compaction may exceed DIN4150-3, risk of damage
Albany Junior High School	Compaction during road remediation	Comply with DIN4150-3, low risk of building damage
ABC Childcare	Compaction during road remediation	Comply with DIN4150-3, low risk of building damage
1,3,5,7,9,11 Fearnely Grove, 317,319,321 Albany Highway	Compaction during road remediation	Comply with DIN4150-3, low risk of building damage

In conclusion, there is a low risk of building damage due to trenching works along this section of the pipeline except where road remediation works are undertaken with a plate compactor close to the St Andrews Way and 10 Appleby Road dwellings. Vibration monitoring will be required at initiation of this activity in this location. Trenching noise may exceed the Construction Noise Standard for works adjacent to these dwellings, albeit for short periods only. The effects are short-term and considered acceptable overall where prior communication undertaken with stakeholders.

It is recommended that stakeholder engagement with the school and daycare occurs to ensure that effects from close proximity work are reduced / avoided as far as practicable.

6.3.8 Appleby Road to William Pickering Road

There is a low risk of building vibration damage due to trenching works along this section of the pipeline. Short-term (minor) exceedances of the Construction Noise Standard are predicted during trenching (refer to Figure I21 Appendix I), which may cause some annoyance. These annoyance effects can be avoided by carrying out trenching in the business zone (Rosedale Business Park) during the night-time, when the majority of businesses are closed.

6.3.9 William Pickering Drive to Bush Road

Works are similar to those described in Section 6.3.8 above. Refer to Figure I21 Appendix I for predicted noise contours. Effects can be avoided in the main by trenching during night-time.

6.3.10 Bush Road to Rosedale WWTP

No adverse acoustic effects are predicted from the use of trenched and trenchless technologies for this section of the pipeline. Consultation with stakeholders is recommended to ensure that they are aware of timings and durations of key activities so as to minimise disruptions as far as practicable.

7.0 MITIGATION AND MANAGEMENT OF CONSTRUCTION NOISE AND VIBRATION

Potential management and mitigation measures are discussed below.

7.1 Communication and Consultation

The most important tool for managing construction noise is consultation and communication. For this Project, the recommended daytime criterion is predicted to generally be achieved at dwellings which are located 20 metres or more distance from general trenching works. For short-term activities such as saw cutting and asphalt breakup this distance increases, although, is dependent upon intervening screening.

Any residents affected by noise levels higher than the recommended Project noise criteria would need to be communicated with in relation to the proposed works, and given the opportunity to provide feedback / input. Communication should occur with stakeholders prior to works being carried out, by means of letter drop or face-to-face contact.

7.2 Timing of activities

It is noted that general construction hours span two time periods in the Project construction noise criterion, namely 0630 – 0730 hours and 0730 – 1800 hours. Of these periods, the 0630 - 0730 hours period, often termed the 'morning shoulder', has a significantly lower noise limit than the daytime period. Therefore, a potential risk exists for construction activities to exceed the morning shoulder criterion by a significant margin, unless early morning site activities are appropriately managed. Two examples would be where trucks with engines running queue up outside worksites prior to site opening, and also crane lift of heavy items delivered by truck during this period.

The management of these issues could take the form of preventing trucks from queuing/idling outside worksites, prohibiting the use of tonal reverse beepers, and scheduling heavy deliveries to occur after 0730 hours.

7.3 Noise Barriers

In general, placing solid barriers, such as sheets of plywood, between dwellings and the construction activities can reduce noise levels by up to 10 decibels. However, the second floor of a two-storey dwelling would not be protected due to its elevated nature. This would also be the case for dwellings naturally elevated above construction sites.

7.4 Avoidance of Unnecessary Noise and Vibration

At many construction sites it can be observed that some construction practices unnecessarily increase noise levels. Those include the sounding of horns when a truck is fully laden, the air break release of trucks, the utilisation of audible, often tonal, reversing alarms, and the unnecessary banging of excavator buckets on the ground.

Those issues can be avoided or noise and vibration levels reduced by means of changed construction site management; fitting of mufflers to trucks; maintenance of equipment to a high level, the replacement of audible reversing alarms with visual or lower noise broadband audible reversing alarms, and through the increased vigilance of heavy equipment operators. It is considered that where these measures are implemented they would form a part of best practice management and mitigation of construction noise and vibration.

Other unnecessary noise may include shouting, loose tail gates and noise from radios played loudly. All of these can be avoided with good site management and are generally addressed in any management plan.

7.5 Construction Noise and Vibration Management Plan

It is common practice for infrastructure projects of significant size to have a CNVMP as part of the construction management plan which contains information on site management, mitigation, communication, complaints procedures and similar issues.

The required contents of a CNVMP are set out in NZS6803:1999 Section 8 and Annex E. As a minimum, the CNVMP will contain, but not be limited to:

- A summary of the project noise criteria
- A summary of construction noise assessments/predictions
- General construction practices, management and mitigation
- Noise management and mitigation measures specific to activities and/or receiving environments
- Monitoring and reporting requirements
- Procedures for handling complaints
- Procedures for review of the CNVMP throughout the project

A CNVMP will be implemented on site for general work and some specific activities i.e. an ASCNVMP where exceedance of the relevant criteria is likely, and will be kept up-to-date regarding actual timing/equipment use and methodologies, should these change at any point during the construction process. The ASCNVMP will also detail enhanced mitigation measures where practicable.

Refer to Appendix J for flow charts setting out the recommended response plan for handling complaints / exceedances of the project construction noise and vibration criteria.

Some specific examples of construction noise and vibration mitigation / management are contained in the tables in Appendix J.

8.0 SUMMARY AND CONCLUSIONS

An assessment of acoustic effects for the proposed Northern Interceptor project has been carried out. Construction noise and vibration are considered the principal sources of acoustic emissions and therefore potential effects.

Several pump stations located near to residential zones have the potential to result in operation noise effects unless mitigated. It is considered that with appropriate acoustic design, the pump stations can be designed and operated so as to generate less than minor acoustic effects. The design of these structures will be finalised during the detailed design stage of the Project prior to construction.

The Construction Noise Standard (NZS 6803:1999) is the most appropriate standard for the assessment and management of day-to-day construction noise effects. Where the noise criteria of this standard are predicted to be exceeded, noise management and mitigation measures will be required.

The structural vibration criteria contained in the DIN 4150-3: 1999 Standard are considered appropriate for the prevention of any building damage, including cosmetic building damage, resulting from construction vibration.

A regenerated noise criterion of 35dB L_{Aeq} from night-time tunnelling vibration is recommended.

Noise and vibration levels from the proposed construction activities described in Appendix C have been predicted for receivers adjacent to the works, as well as at nominal setback distances that will be encountered across the Project.

Various construction activities have been identified as being likely to generate noise levels in excess of the daytime noise criterion of 70 dB L_{Aeq}. Construction activities occurring at night that utilise trenchless technologies are predicted to generate noise levels in excess of the night-time external noise criterion of 45 dB L_{Aeq} and would require noise mitigation, and management via an ASCNVMP.

Potential exists for night-time tunnelling vibration to exceed the recommended regenerated noise criterion of 35dB L_{Aeq} at certain points along the route that are relatively shallow (i.e. are less than 15-18 metres slant distance from dwellings), resulting in slight sleep disturbance effects for some. The management of this activity using the recommended approach set out in Section 6.2.4 (as part of an ASCNVMP) will be required.

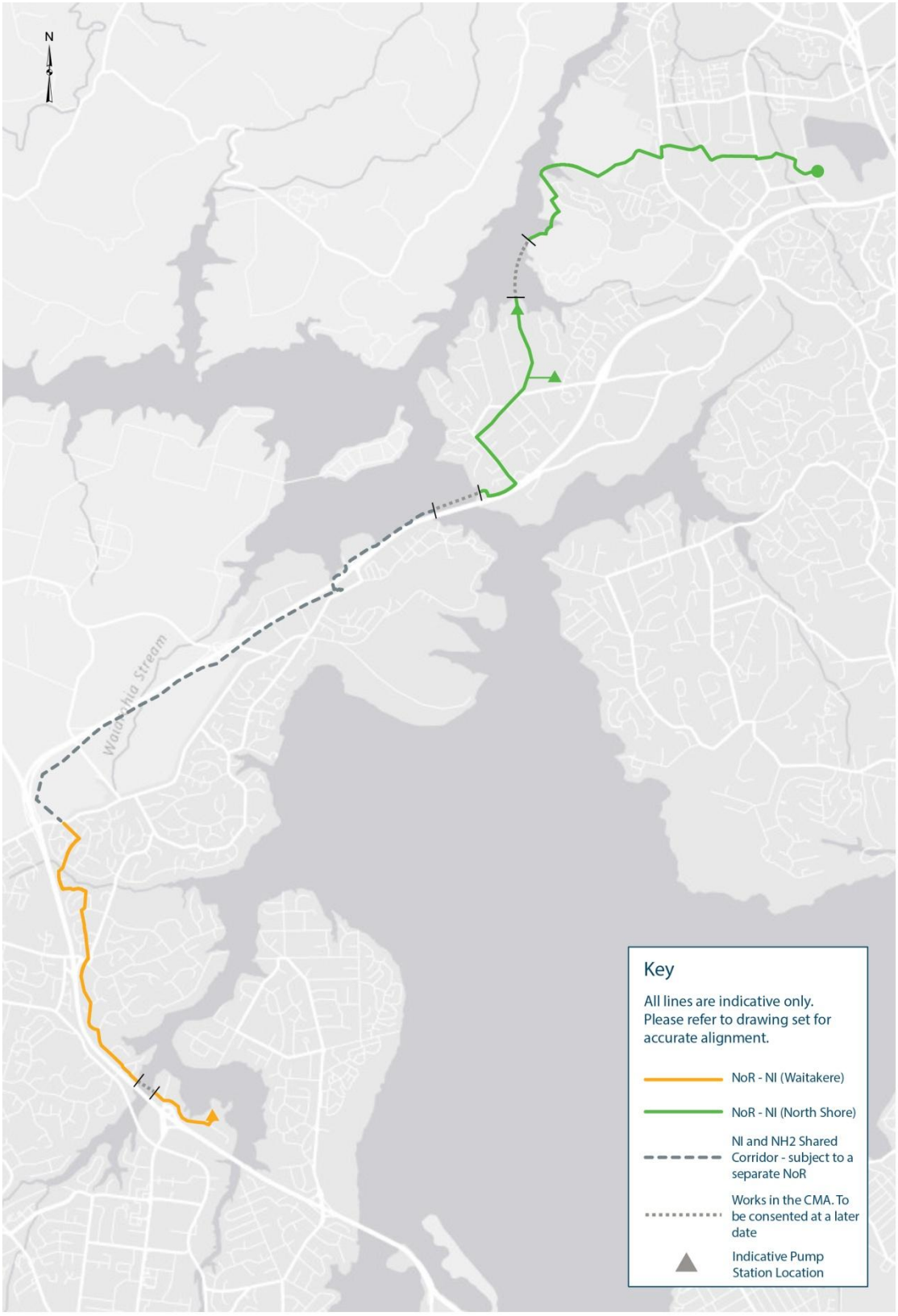
For the activities identified as potentially exceeding the Project construction acoustic criteria, an adaptive mitigation / management approach will be adopted to avoid, remedy or mitigate adverse effects as far as practicable. The specifics of the required measures would be detailed in the Project CNVMP and ASCNVMP, which would be formulated and submitted to Council for approval prior to construction commencement.

It is considered that the best practicable option for this Project is to ensure that construction acoustic effects are managed with the aim of meeting the recommended Project Acoustic Criteria set out in Section 3.7 and Appendix F of this report and any potential exceedances are addressed via the CNVMP / ASCNVMP process so as to mitigate / manage effects on stakeholders to acceptable levels.

APPENDIX A GLOSSARY OF TERMINOLOGY

dB	Decibel. The unit of sound level. Expressed as a logarithmic ratio of sound pressure P relative to a reference pressure of Pr=20 μPa i.e. dB = 20 x log(P/Pr)
dBA	The unit of sound level, which has its frequency characteristics modified by a filter (A-weighted) to approximate the frequency bias of the human ear.
$L_{Aeq\,(t)}$	The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level. The suffix "t" represents the period to which the noise level relates, e.g. (8 h) would represent a period of 8 hours, (15 min) would represent a period of 15 minutes and (2200-0700) would represent a measurement time between 10 pm and 7 am.
$L_{A10\,(t)}$	The A-weighted noise level equalled or exceeded for 10% of the measurement period. This is commonly referred to as the average maximum noise level.
$L_{A90\,(t)}$	The A-weighted noise level equalled or exceeded for 90% of the measurement period. This is commonly referred to as the background noise level.
L_{Amax}	The A-weighted maximum noise level. The highest noise level that occurs during the measurement period.
SWL or L_W	Sound Power Level A logarithmic ratio of the acoustic power output of a source relative to 10^{-12} watts and expressed in decibels. Sound power level is calculated from measured sound pressure levels and represents the level of total sound power radiated by a sound source.
Noise	A sound that is unwanted by, or distracting to, the receiver.
Ambient	The ambient noise level is the noise level measured in the absence of the intrusive noise or the noise requiring control. Ambient noise levels are frequently measured to determine the situation prior to the addition of a new noise source.
NZS 6803P:1984	New Zealand Standard NZS 6803P:1984 *"The Measurement and Assessment of Noise from Construction, Maintenance and Demolition Work"*
NZS 6803:1999	New Zealand Standard NZS 6803: 1999 *"Acoustics - Construction Noise"*
DIN 4150-3:1999	DIN 4150-3:1999 *"Structural Vibration - Effects of Vibration on Structures"*

APPENDIX B PROJECT ROUTE AERIAL



APPENDIX C TYPICAL PROJECT CONSTRUCTION METHODOLOGIES

Refer to the detailed construction methodology described in the AEE. The following tables summarise the typical activities and plant used on Projects such as this that may generate noise and vibration.

Typical Activities and Equipment

Construction of Pump Stations

Key Activities	Typical Equipment
Site Establishment	6-30T excavators 20-30T tipper trucks 20T mobile crane Truck deliveries
Pump station construction	50T tracked crane Excavator Concrete trucks and pumping Containerised generator Compressors Truck deliveries
Pipework and connections	12-30T excavators 20T tipper trucks 50T tracked crane Containerised generators Pumps Vibro-hammer piling Plate compactor 12m truck deliveries Concrete trucks and pumping
Site remediation	12T excavator 20T tipper trucks Asphalting Vibrating/static roller Plate compactor Compressors 12m truck deliveries Concrete trucks and pumping

Trenchless technology - TBM

Key Activities	Typical Equipment
Jacking shaft construction and ops	20T long-arm excavator 50T mobile crane Containerised drilling mud reservoir Containerised generator MTBM and jacks Ventilation fans Concrete trucks and pumping
Receival shaft construction and ops	20T long-arm excavator Pile drilling rig 50T mobile crane Ventilation fans Dewatering pumps
Slip-lining trench excavation and ops	20T excavator Dewatering pumps Compactor
Polyethylene (PE) pipe string welding	20T excavator Fusion welder Generator 100T winch
Installation of pipes, grouting, backfilling	20T long-arm excavator 100T winch Grout pump 50T mobile crane Dewatering pump Compactor

Trenchless Technology - Horizontal Directional Drilling

Key Activities	Typical Equipment
Fencing	6T excavator 20T tipper truck Post borer 8m rigid Hiab truck Chain saws
Site Establishment (each site)	12m Hiab truck 20T mobile crane Mini road roller Mini excavator
HDD Pit 1	250-500T HDD rig 100T mobile crane Continuous flight auger rig Mud separator units/storage Containerised generator
PE pipe string welding	20T excavator Fusion welder Generator Tractor/bulldozer 100T mobile crane

Trenched technologies, chamber and pipe bridge construction

Key Activities	Typical Equipment
Saw cutting of existing road surfaces, removal of kerbs	Diamond road saw Compressor Jack hammer
Trench excavation, support, removal/stockpile of spoil, deliveries	20T excavator Dewatering pumps Compactor Trucks
PE pipe string welding	20T excavator Fusion welder Generator Tractor
PE pipe install, backfilling, reinstatement	20T long-arm excavator Dewatering pumps Compactor
Drop Shaft / Break Pressure Chamber	20T excavators 12m Hiab truck 20T mobile crane Truck deliveries Concrete trucks and pumping
Pipe bridge construction	20T excavator Continuous flight auger piling 100T mobile crane Truck deliveries Concrete trucks and pumping
Road surface reinstatement	12T excavator 20T tipper trucks Asphalt truck Vibrating/static roller Plate compactor

APPENDIX D DISTRICT PLAN ACOUSTIC RULES

PAUP

Part 3 Chapter H Rule 6.2.1.5[14]

1.5 Construction noise

Construction noise – all zones except City Centre and Metropolitan Centre zones

1. Noise from construction and demolition activities in all zones except in the City Centre and Metropolitan Centre zones must meet the ~~requirements of~~ noise limits in Tables 2 and 3 of New Zealand Standard ~~on~~ NZS 6803: 1999 Acoustics – Construction Noise (NZS 6803: 1999). The measurement and assessment of construction noise must be in accordance with ~~New Zealand Standard on Acoustics – Construction Noise~~ (NZS 6803: 1999). ~~and the requirements of annex A of New Zealand Standard on Acoustics – Construction Noise (NZS 6803: 1999) must be used if it is necessary to assess the measured Leq levels in high background noise areas.~~

[14] PAUP acoustic criteria referenced in this report refers to rebuttal evidence of C Scrafton on behalf of Auckland Council (tracked changes 21 September 2015) in Topic 040 Lighting, noise and vibration and is therefore not the notified version of the rules but gives an indication of anticipated final version.

3. The measurement and assessment of construction noise must be in accordance with New Zealand Standard ~~on~~ NZS 6803:1999 Acoustics – Construction Noise ~~(NZS 6803: 1999) and the requirements of annex A of New Zealand Standard on Acoustics – Construction Noise (NZS 6803: 1999) must be used if it is necessary to assess the measured Leq levels in high background noise areas.~~
4. Where external measurement of construction noise is impractical or inappropriate, the upper limits for the noise measured inside the building ~~must~~ shall be 20dB less than the ~~appropriate~~ relevant limits ~~levels~~ in tables 13 and 14 above.

Construction noise: ~~essential~~ work within the road ~~carriageways~~

5. Noise from construction, maintenance and demolition activities in the road ~~corridor~~ must meet the relevant noise limits in Tables 2 and 3 of New Zealand Standard NZS6803:1999 Acoustics – Construction Noise ~~(NZS 6803: 1999) and~~ **or** Tables 13 and 14.

6. The noise limits specified in (5) do not apply to unplanned repair or maintenance works or ~~minor~~ planned works in the road ~~corridor, state highway or motorway~~ between the hours of 10pm and 7am where:

    a. The number of nights where the noise generated by the works exceeds the relevant noise limits in NZS 6803:1999 or tables 13 and 14 above at any one receiver is 3 or less ~~in any 12 month period~~;
    b. The works cannot practicably be carried out during the day or because the road controlling authority requires this work to be done at night time;
    c. Because of the nature of the works the noise produced cannot be practicably be made to comply with the relevant noise limits of NZS 6803:1999 or tables 13 and 14 above;
    d. ~~5 days prior to works commencing~~ For planned works, a copy of the works access permit issued by Auckland Transport or approval from the New Zealand Transport Agency is provided to the Council 5 days prior to work commencing;
    e. For ~~minor~~ planned works a construction noise and vibration management plan is provided to the Council ~~within~~ no less than 5 days ~~of~~ prior to the works commencing in accordance with the applicable provisions of (8) below.

7. The noise limits specified in (5) do not apply to unplanned repair or maintenance works or ~~minor~~ planned works in the road ~~corridor, state highway or motorway~~ between the hours of 7am and 10pm where:

a. The number of days where the noise generated by the works exceeds the relevant noise limits in NZS 6803:1999 or tables 13 and 14 above at any one receiver is 10 or less ~~in any 12 month period~~; and
b. Because of the nature of the works and the proximity of receivers the noise generated cannot practicably made to comply with the relevant noise limits of NZS 6803:1999 or tables 13 and 14 above;
c. ~~5 days prior to works commencing a~~ For planned works, a copy of the works access permit issued by Auckland Transport or approval from the New Zealand Transport Agency is provided to the Council 5 days prior to work commencing;
d. For ~~minor~~ planned works where the works will take more than 8 hours to complete a construction noise and vibration management plan is provided to the Council ~~within~~ no less than 5 days ~~of~~ prior to the works commencing in accordance with the applicable provisions of (8).

7A. The noise limits specified in (5) do not apply to road rehabilitation works that comprise the substantive removal and replacement of the road structural base and pavement in the road where:

a. Any receiver has not been exposed to noise levels exceeding the noise limits in section (5) from previous road rehabilitation works within the 20 years of the programmed start date for the works subject to this rule;
b. The number of nights where the noise generated by the works exceeds the relevant noise limits in NZS 6803:1999 or tables 13 and 14 above at any one receiver is 20 days or less;
c. Milling, concrete cutting, percussive demolition are completed by 10.30pm;
d. The works cannot practicably be carried out during the day or because the road controlling authority requires this work to be done at night time;
e. Because of the nature of the works the noise produced cannot be practicably be made to comply with the relevant noise limits of NZS 6803:1999 or tables 13 and 14 above;
f. A copy of the works access permit issued by Auckland Transport or approval from the New Zealand Transport Agency is provided to the Council 5 days prior to work commencing;
g. A construction noise and vibration management plan is provided to the Council no less than 5 days prior to the works commencing in accordance with the applicable provisions of (8) below.

8. A construction noise and vibration management plan must be prepared by a suitably qualified and experienced person and include the following:
    a. Details of the community consultation to be undertaken to advise the occupiers of properties located within 100m of the proposed works of the following:
        i. The area affected by the work;

ii. Why the work is required to be undertaken at night (where relevant);
iii. The times and days when the noise and vibration is likely to be generated;
iv. A contact name and number of the works supervisor who can be contacted if any issues arise; and
v. How noise and vibration complaints will be managed and responded to.

b. A description of the works and its duration, anticipated equipment to be used and the processes to be undertaken; and
c. Identification of the best practicable options that will be undertaken to mitigate and minimise any noise being produced that is likely to exceed the relevant limits of NZS 6803:1999 or tables 13 and 14 above.

9. For the purpose of 5, 6, 7 and 7A:
    a. Planned work means work that has been planned to take place at least 7 days before the work commences.
    b. The measurement and assessment of all construction noise must be in accordance with NZS 6803:1999.

Part 3 Chapter H Rule 6.2.1.6

1.6 Vibration

1. Construction and demolition activities ~~including rock breaking, blasting and pile driving activities~~ must be controlled to ensure any resulting ~~ground~~ vibration does not exceed the:
    a. ~~levels~~ limits set out in ~~Table 1 of~~ DIN 4150-3 (1999): Structural vibration – Part 3 Effects of vibration on structures when measured in accordance with that Standard on any structure not on the same site**; and** ~~on the foundation or the horizontal plane of the highest floor of an affected any unoccupied building.~~
    ~~Construction and demolition activities including rock breaking, blasting and pile driving activities must be controlled~~
    b. following limits when measured in any axis in the corner of the floor of the storey of interest for multi-storey buildings, or at the foundation of a single storey building:

Table 15

Receiver	**~~Location~~**	**Period**	**Peak Particle Velocity Limit**
Occupied Activity Sensitive to Noise	~~Inside the building~~	Night-time 10pm to 7am	0.3 mm/s
		Daytime 7am to 10pm	~~1~~ 2 mm/s
Other occupied buildings	~~Inside the building~~	~~Daytime 7am to 10pm~~ At all Times	2 mm/s

    c. Works generating vibration for 3 days or less between the hours of 7am to 6pm may exceed the limits in Rule 1**b**~~**A**~~ above, but must comply with a limit of 5mm/s PPV when measured in any axis in the corner of the floor of the storey of interest for multi-storey buildings, or at the foundation of a single storey building, where:
        i. All occupied buildings within 50m of the extent of the works generating vibration are advised ~~notified~~ in writing no less than 3 days prior to the vibration-generating works commencing;
        ii. The written ~~notification~~ advice shall include details of the location of the works, the duration of the works, a phone number for complaints and the name of the site manager.

    d. Permanently installed stationary vibrating, reciprocating and rotating machinery and all piping, ducting and other equipment attached to such machinery must be installed and maintained so that any resulting vibration does not exceed the ~~levels~~ limits of the following table when measured in any occupied room ~~or on~~ of any building on ~~any~~ another site or in any occupied unit ~~in adjacent buildings or areas of buildings~~ under different ownership from the source of the vibration. Vibration shall be measured in accordance with ISO2631-2:2003 Mechanical Vibration and Shock – Evaluation of

Human Exposure to Whole-body Vibration – Part 2:Vibration in Buildings (1Hz to 80Hz).

Table 16

Affected occupied building or area	Time of day	Maximum vibration level in rms velocity (mm/s) between 8 and 80Hz
~~Buildings in a Heavy Industry or Light Industry zone~~	~~All~~	~~0.80~~
~~Buildings for commercial activities~~	~~All~~	~~0.40~~
~~Habitable rooms of buildings designed for residential use~~ Noise Sensitive Spaces ~~within Activities Sensitive to Noise~~	7am-10pm	0.20
Bedrooms and sleeping areas only ~~of buildings designed for residential use~~ within Activities Sensitive to Noise	10pm-7am	0.14
~~Surgery Operating rooms of health care facilities, rooms with microscopes and cameras for television broadcast~~	~~All~~	~~0.10~~

~~1. Construction and demolition activities including rock breaking, blasting and pile driving activities must be controlled to ensure any resulting ground vibration does not exceed the levels limits set out in Table 1 of DIN 4150-3 (1999): Structural vibration – Part 3 Effects of vibration on structures when measured on the foundation or the horizontal plane of the highest floor of an affected any unoccupied building.~~

~~1A. Construction and demolition activities including rock breaking, blasting and pile driving activities must be controlled to ensure any resulting vibration does not exceed the following limits:~~

Table 17

~~**Receiver**~~	~~**Location**~~	~~**Period**~~	~~**Peak Particle Velocity Limit**~~
~~Occupied Activity Sensitive to Noise~~	~~Inside the building~~	~~Night-time 10pm to 7am~~	~~0.3 mm/s~~
		~~Daytime 7am to 10pm~~	~~1 mm/s~~
~~Other occupied~~	~~Inside the building~~	~~Daytime 7am to 10pm~~	~~2 mm/s~~

Part 3 Chapter H Rule 6.2.1.3.3

Residential zone interface

3. The ~~L~~$_{Aeq(15\ min)}$ noise (rating) level and maximum noise level (~~L~~$_{AFmax}$) arising from:
    a. any ~~non-residential~~ activity not in a residential zone measured ~~at or~~ within the boundary of a ~~property~~ site in a residential zone, or
    b. any activity, other than farming, agriculture, horticulture, or forestry measured ~~at~~ within the notional boundary ~~of any dwelling~~ on rural zoned property must not exceed the following ~~levels~~ limits.

Table 8

Monday to Saturday 7am-10pm	55dB $L_{Aeq(15\ min)}$
Sunday 9am-6pm	
All other times	45dB $L_{Aeq(15\ min)}$ 60dB $L_{eq(15\ min)}$ at 63 Hz 55dB $L_{eq(15\ min)}$ at 125 Hz 75dB L_{AFmax}

APPENDIX E AMBIENT NOISE MEASUREMENT LOCATIONS AND RESULTS


MP16
MP15
MP14
MP13
MP12
MP11
MP10
MP9
MP18
MP19
MP17
Rosedale Rd
E Coast Rd
Constellation Dr
Sunset Rd
Upper Harbour Hwy
Albany Hwy
Greenhithe Rd
Upper Harbour Dr
Nairau Rd
Tristram Ave
Glenfield Rd
Kapalki Rd
Archers Rd
Google earth
© 2016 Google
Image © 2016 Terralink International Ltd
Image © 2016 DigitalGlobe
2 km
N

Table E1: Ambient Noise Measurement Results Summary Table

Measurement Position	Measurement		Measured Level (dBA)[1]				Description of Sound Sources[(2)]
	Date Start/Finish	Duration (min:sec)	L_{Amax}	L_{A10}	L_{Aeq}	L_{A90}	
MP1	24/02/2016 13:41 / 13:50	9:20	78	64	62	55	Waitakere Refuse Centre, HVAC noise, vehicles on The Concourse, general industrial noise
MP2	22/04/2016 11:29 / 11:46	10:00	-	58	55	48	Traffic noise on SH16, Triangle Rd and Huruhuru Rd (occasional)
MP3	24/02/2016 14:07 / 14:15	8:11	71	59	57	53	SH16 traffic, cicadas, birds
MP4	24/02/2016 14:21 / 14:28	6:38	63	56	54	50	SH16 traffic, cicadas
MP5	22/04/2016 11:59 / 12:17	10:00	-	53	55	41	Traffic on Moire Rd and Holmes Drive South, general urban noise
MP6	24/02/2016 14:37 / 14:42	4:12	52	48	47	46	SH16 traffic, cicadas in distance
MP7	24/02/2016 15:05 / 15:10	5:09	64	59	57	55	SH16 traffic, cicadas
MP8	24/02/2016 15:20 / 15:26	5:33	61	49	48	45	SH16 traffic, cicadas in distance
MP9	24/02/2016 15:43 / 15:50	5:30	79	59	57	40	Traffic on Tauhinu Rd, birds, cicadas
MP10	22/04/2016 12:41 / 12:53	10:00	-	44	42	38	Traffic on Greenhithe Rd, general urban noise
MP11	22/04/2016 12:06 / 13:17	10:00	-	56	54	46	Traffic on Greenhithe Rd, and surrounding roads
MP12	22/04/2016 13:30 / 13:51	10:00	-	44	42	40	Intermittent traffic, wind in trees, general urban sounds
MP13	22/04/2016 14:50 / 15:08	10:00	-	41	39	36	Distant traffic, bird and insect noise, wind in trees
MP14[3]	14:07 / 14:13	5:00	65	51	48	39	Construction noise (pipe scaffolding), birds, frogs, wind in trees
MP15[3]	14:24 / 14:29	5:00	64	43	41	36	Birds, distant cars
MP16[3]	14:34 / 14:40	5:00	61	47	44	40	Electric power tool in distance, gusty wind
MP17[3]	12:05 / 12:14	5:00	62	56	54	52	Distant traffic on Albany Highway, insect noise
MP18[3]	14:57 / 15:06	5:00	62	50	48	44	INMARSAT site "hum", traffic on road network, construction noise
MP19	22/04/2016 14:34 / 14:45	10:00	-	59	57	55	Factories (HVAC noise), general noise including intermittent traffic noise

Notes to Table 1:

(1) Definitions of technical terms is provided in Appendix A

(2) Underlined noise sources controlling measurement

(3) Measurements carried out during NI Phase 1

Table 20: Wainoni Park North Long-term Noise Logging

OVERVIEW SUMMARY SHEET

Noise Level, dB		L_{Aeq}	L_{A10}	L_{A90}	L_{Amax}
Day	Lowest	33	33	29	45
(0700-1800)	Average	47	43	35	63
	Highest	61	68	43	76
Evening	Lowest	28	29	25	38
(1800-2200)	Average	40	35	30	51
	Highest	53	43	38	74
Night	Lowest	25	26	23	35
(2200-0700)	Average	37	34	28	51
	Highest	49	46	37	74

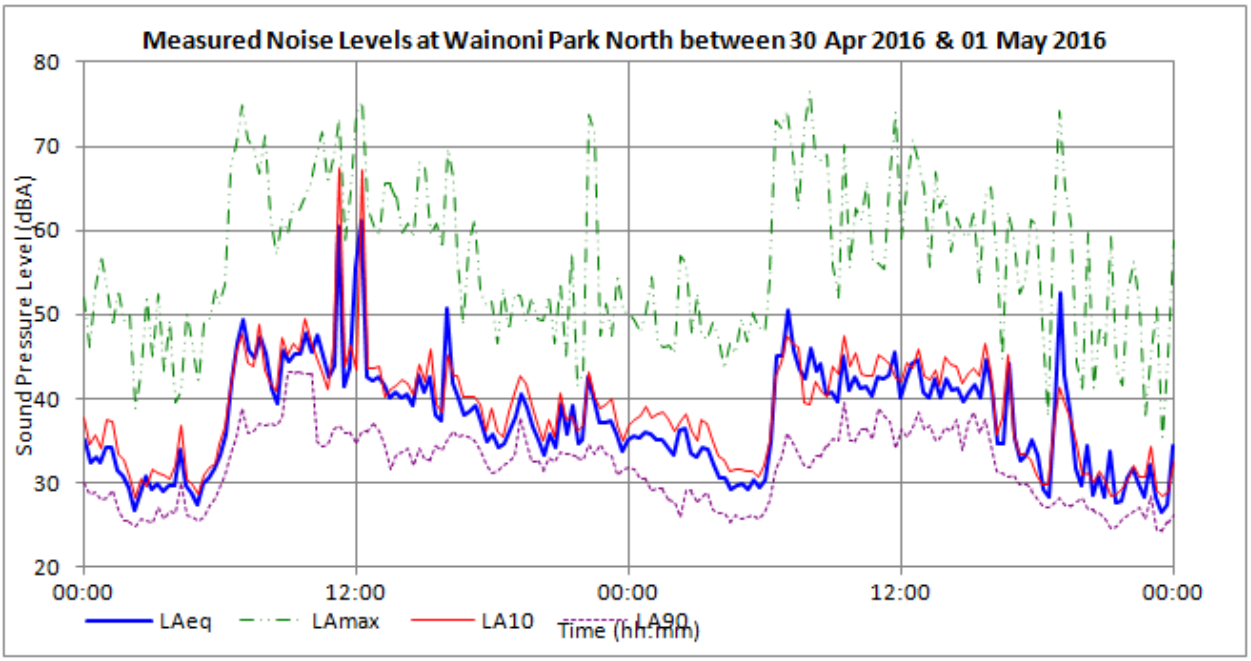
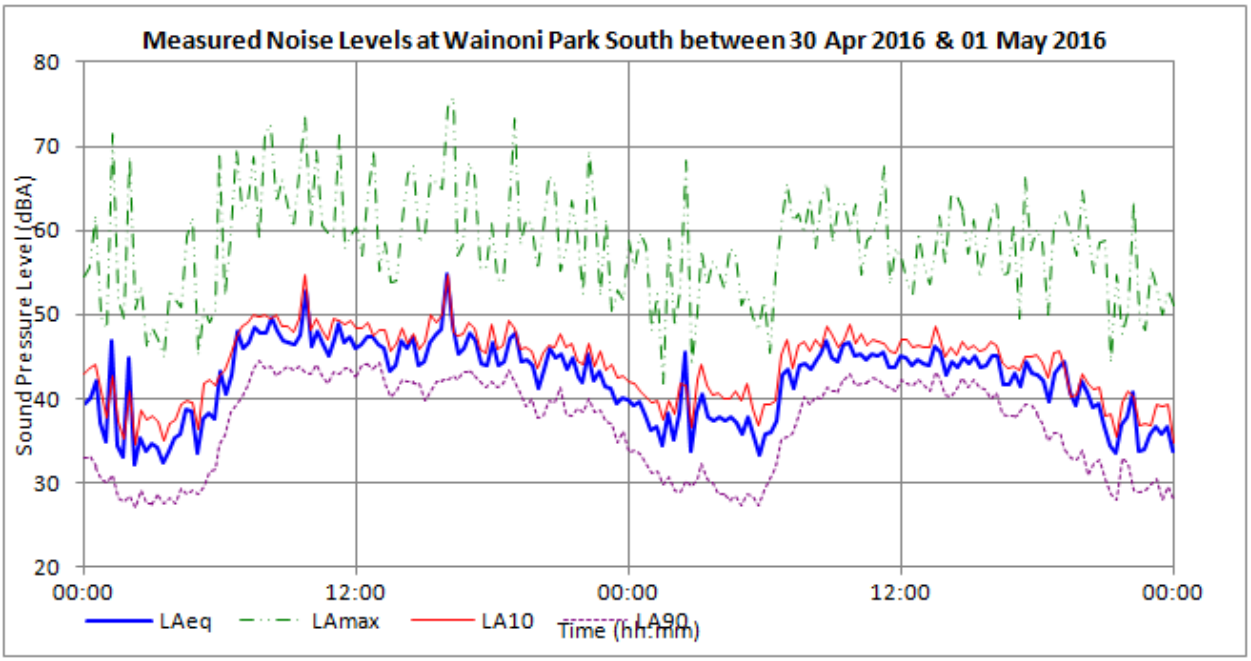


Table 21: Wainoni Park South Long-term Noise Logging

OVERVIEW SUMMARY SHEET

Noise Level, dB		L_{Aeq}	L_{A10}	L_{A90}	L_{Amax}
Day	Lowest	41	43	36	50
(0700-1800)	Average	46	47	42	61
	Highest	55	55	45	76
Evening	Lowest	34	36	28	44
(1800-2200)	Average	43	44	37	59
	Highest	48	49	43	73
Night	Lowest	28	29	27	36
(2200-0700)	Average	40	39	31	53
	Highest	49	51	47	79



APPENDIX F CONSTRUCTION NOISE STANDARD LIMITS

NZS 6803: 1999 "*Acoustics – Construction Noise*" sets out the following noise limits

"Residential zones and dwellings in rural areas:

Table 2 – Recommended upper limits for construction noise received in residential zones and dwellings in rural areas

Time of week	Time period	Duration of work					
		Typical duration (dBA)		Short-term duration (dBA)		Long-term duration (dBA)	
		L_{eq}	L_{max}	L_{eq}	L_{max}	L_{eq}	L_{max}
Weekdays	0630-0730	60	75	65	75	55	75
	0730-1800	75	90	80	95	70	85
	1800-2000	70	85	75	90	65	80
	2000-0630	45	75	45	75	45	75
Saturdays	0630-0730	45	75	45	75	45	75
	0730-1800	75	90	80	95	70	85
	1800-2000	45	75	45	75	45	75
	2000-0630	45	75	45	75	45	75
Sundays and public holidays	0630-0730	45	75	45	75	45	75
	0730-1800	55	85	55	85	55	85
	1800-2000	45	75	45	75	45	75
	2000-0630	45	75	45	75	45	75

Industrial or commercial areas:

Table 3 – Recommended upper limits for construction noise received in industrial or commercial areas for all days of the year

Time period	Duration of work		
	Typical duration	Short-term duration	Long-term duration
	L_{eq} (dBA)	L_{eq} (dBA)	L_{eq} (dBA)
0730-1800	75	80	70
1800-0730	80	85	75"

Notes in the standards to the tables above:

7.2.5

The night time limits in Table 2 shall apply to activities carried out in industrial or commercial areas where it is necessary to prevent sleep interference, specifically where there are residential activities, hospitals, hotels, hostels, or other accommodation facilities located within commercial areas. The limits in Table 2 may also be used to protect other specific noise sensitive activities at certain hours of the day.

7.2.6

One major factor which should be considered is whether there is a relatively high background sound level (L_{90}) due to noise from sources other than construction work at the location under investigation. In such cases limits should be based on a determination of the existing level of noise in the area (a "background plus" approach).

7.2.7

Where there is no practicable method of measuring noise outside a building, the upper limits for noise measured inside the building shall be the levels stated in tables 2 and 3 minus 20 dBA. This is considered to be a typical value for the sound reduction normally achieved in New Zealand buildings with doors and windows closed."

Discussion

The Construction Noise Standard provides for noise criteria that are higher than criteria for ongoing operational noise levels. This is because it is commonly accepted that for any construction to occur, noise criteria must be less stringent, with the understanding that construction is a temporary activity with a finite duration. The Standard states in the Foreword:

> *"The generally acceptable level of intrusive noise in the community is assessed under the provisions of NZS6802:1999. However, construction noise is outside the scope of NZS6802:1999 because it usually cannot be kept within the specified limits. Although this may mean that the noise is undesirable, it is not necessarily unreasonable when all the relevant factors are taken into consideration. Construction noise is an inherent part of the progress of society.*
>
> *As noise from construction projects is generally of limited duration, people and communities will usually tolerate a higher noise level provided it is no louder than necessary, and occurs within appropriate hours of the day."*

It is considered that the Northern Interceptor can be constructed within reasonable noise criteria, provided that the best practicable option of mitigation is implemented throughout and contractors are committed to managing construction noise on an ongoing basis. It is noted that ambient noise levels in the areas under consideration range from 39-62 L_{Aeq} during the daytime. Therefore, even when achieving compliance with the daytime construction noise criteria, there will be appreciable increases in overall noise level during the construction phase at some locations. This is, as recognised by the Construction Noise Standard, an expected and inevitable result of large construction projects near receivers.

Construction would occur in close proximity to some receivers and in some instances, noise emissions have the potential to exceed the Construction Noise Standard. It is generally noted that for most large-scale construction projects, exceedances of construction noise limits occur from time-to-time. Provided all reasonable mitigation steps are taken, the exceedance is of limited duration, and the community is consulted prior to commencement, noise may not be unreasonable.

The reasonableness or otherwise of noise from a construction activity exceeding the criteria may vary from site-to-site and activity-to-activity. The impact of any exceedance will be dependent upon the circumstances in which it occurs. For instance, where the daytime noise criterion is exceeded for several days, but neighbouring residents are not at home, no one would be affected and therefore mitigation may not be required beyond communication with residents.

In the event that night-time works occur for one or two nights, this may be acceptable provided that residents have been informed and a clear period provided. However, should night-time works be ongoing for several consecutive nights, and at a noise level that affects residents' ability to sleep, then alternatives should be found, such as, for example, temporary relocation. This would be determined on a case-by-case basis throughout the construction process when construction equipment, methodologies and timing have been ascertained. Any such measures would be found in the project CNVMP that provides detail as to the methodology for pro-actively avoiding, or responding to noise issues.

APPENDIX G CONSTRUCTION NOISE SOURCE SOUND POWER LEVELS[15]

	Octave Band Centre Frequency (Hz)							
Source	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**dBA**
Excavator	100	99	102	101	97	94	91	103
Bulldozer	102	111	100	100	107	105	98	110
Tipper Truck	110	108	105	103	102	99	94	107
Mobile Crane	96	99	96	90	94	94	83	99
Truck Idling	84	89	86	87	86	86	79	91
Truck Moving	99	103	100	101	100	100	93	105
Containerised Generator	107	111	107	101	94	91	86	103
Compressor	94	94	94	97	100	100	100	106
Compressor (small)	88	88	88	91	94	94	94	100
Mobile Crane Moving	111	114	111	105	109	109	98	114
Vibro Sheet Piling	119	115	114	113	111	106	98	115
Concrete Truck Pumping	97	112	110	104	100	98	96	107
Vibrating Roller/Compactor	110	115	105	102	101	97	90	106
Asphalt Laying	109	109	106	106	104	100	98	109
Dewatering Pump	98	93	94	92	92	91	84	97
MTBM Ventilation Fan	94	96	100	99	98	94	90	102
Bored Piling	112	120	109	108	106	104	96	112
Pumping Slurry	83	85	92	91	90	88	84	95
Chainsaw	99	107	100	94	90	96	97	102
Diamond Road Saw	101	95	98	96	101	106	106	111
Jack Hammer	115	121	117	113	114	114	111	120
HDD Rig (Drilling)	99	105	95	91	95	102	106	109
Mud and Slurry Pump	112	120	109	108	106	104	96	112
Hydraulic Power Pack	76	81	88	92	97	90	82	99
Mud Treatment	103	100	106	97	98	102	93	106
HDD Pipe Pull	102	102	101	101	98	93	88	103

[15] Data was obtained from measurements undertaken by MDA for similar construction activities, and from British Standard BS5228-1:2009 *"Code of practice for noise and vibration control on construction and open sites – Part 1: Noise"*.

APPENDIX H CONSTRUCTION VIBRATION SOURCE LEVELS

Activities	Equipment	Equipment details	Vibration data
Excavation	Excavator	21T	5mm/s @ 5m
Excavation	Sheet piling	-	5mm/s @ 11m
Excavation	Bored piling	-	5mm/s @ <2m
Road remediation	Plate compactor	Walk-behind	5mm/s @ 22m
Pipe-jacking (tunnelling)	MTBM	-	5mm/s @ 4m

APPENDIX I TRENCHING AND SHAFT EXCAVATION NOISE CONTOUR OVERLAYS

Figure I2: The Concourse Trenching

Figure I3: Huruhuru Rd Trenching

Figure I4:Cedar Heights Ave Trenching

Figure I5: Pits 1 to 4 Secant Piling / Excavation

Figure I6: Pits 5 and 6 Secant Piling / Excavation

Figure I7: Pits 7 to 10 Secant Piling / Excavation

Figure I8: Jaedwyn Drive Trenching

Figure I9: Pits 11 to 15 Secant Piling / Excavation / Trenching

Figure 10: North Shore Pits 3 to 9 Secant Piling / Excavation

Figure I11: North Shore Pits 10 to 11 Secant Piling / Excavation

Figure I12: North Shore Pits 12 to 15 Secant Piling / Excavation

Figure I13: Wainoni Park North and South Pump Station Construction

Figure 14: Tunnelling Support Ops Noise

Figure 15: NSMP Trenching

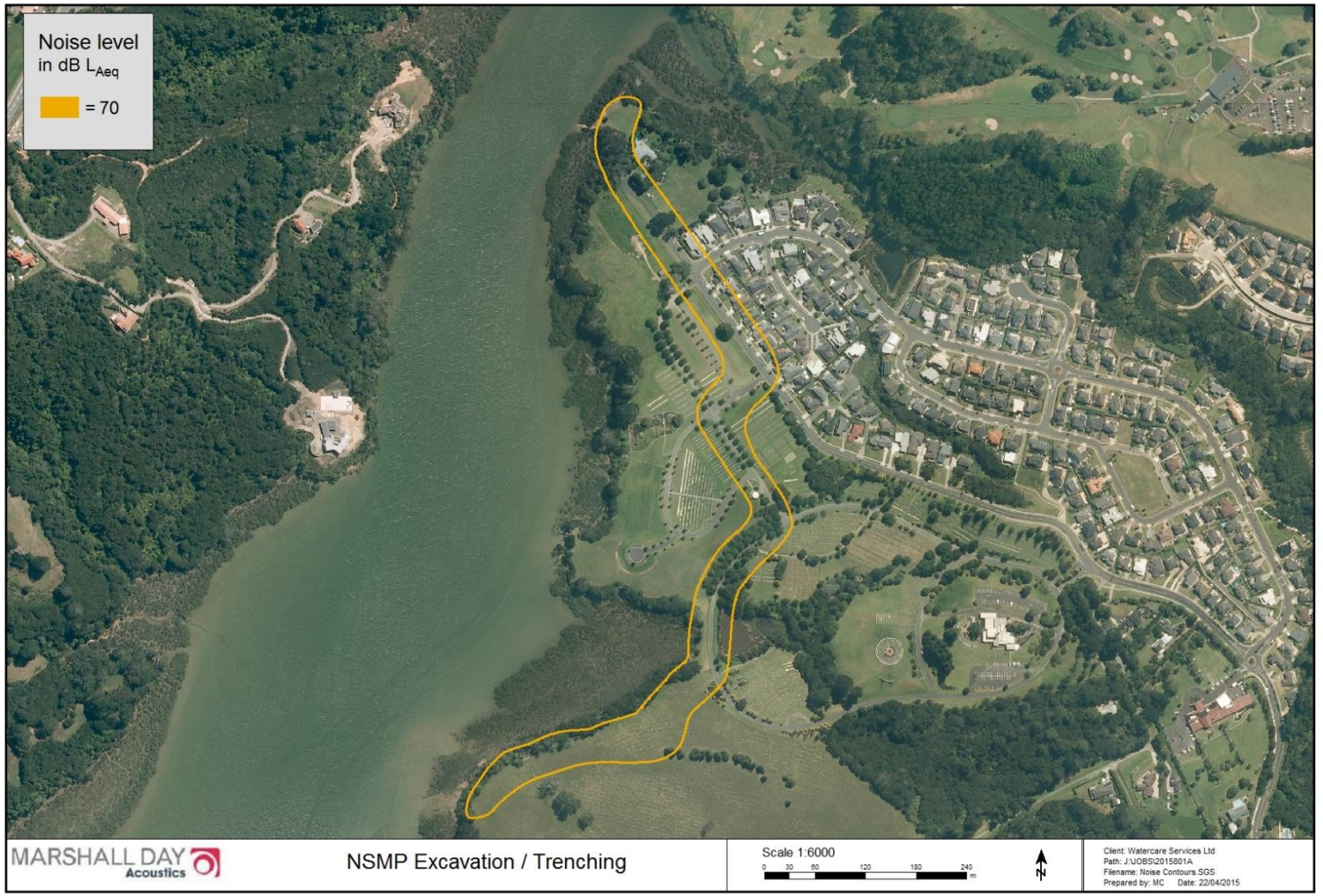


Figure 16: Night-time HDD Drilling at HDD Pits 3 and 4

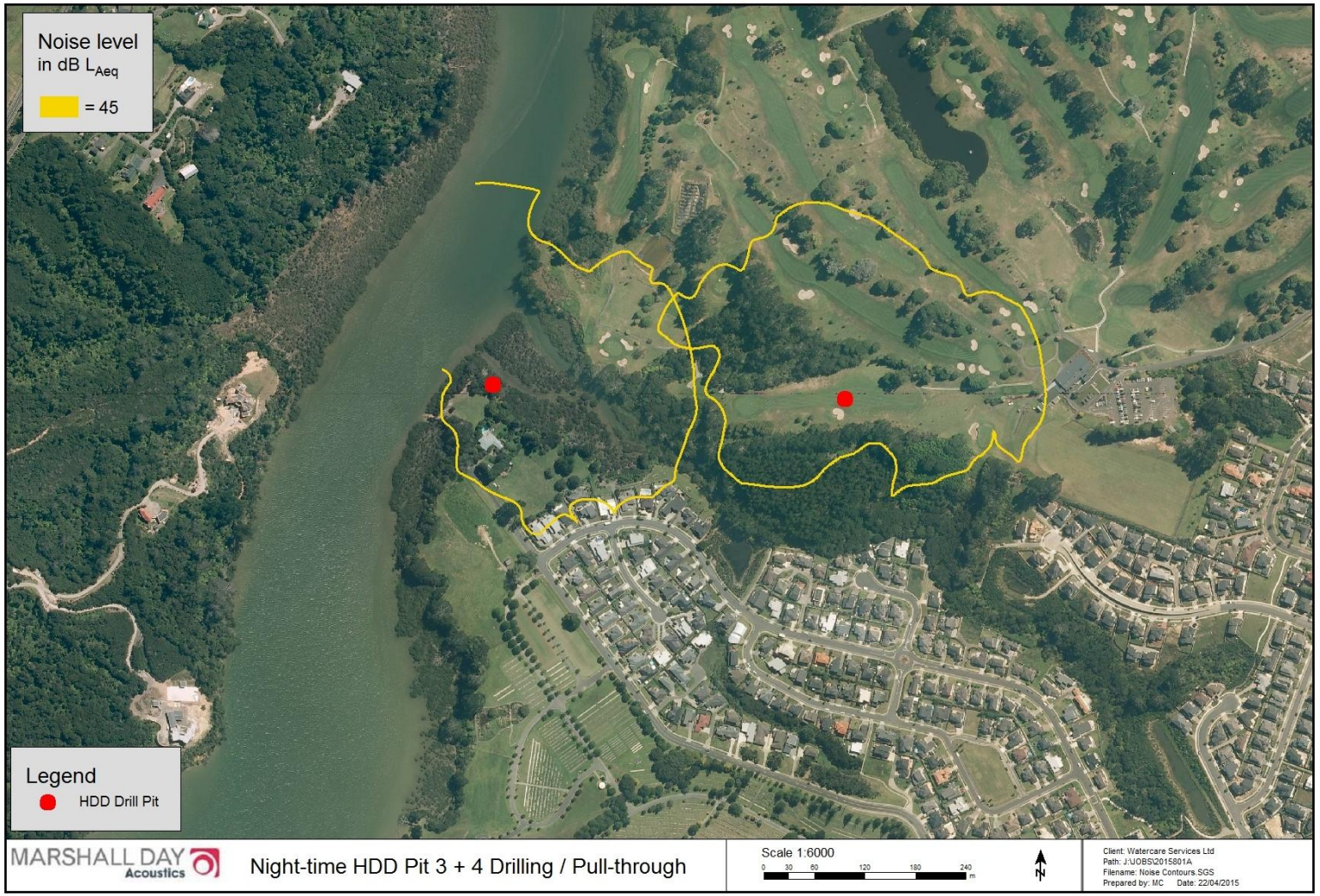


Figure 17: NSGC to Albany Highway Trenching

Figure 18: Albany Highway to Bush Road Trenching

APPENDIX J RESPONSE PLAN FLOW CHARTS

Figure J19: Response Plan Flow Chart for Noise Issues

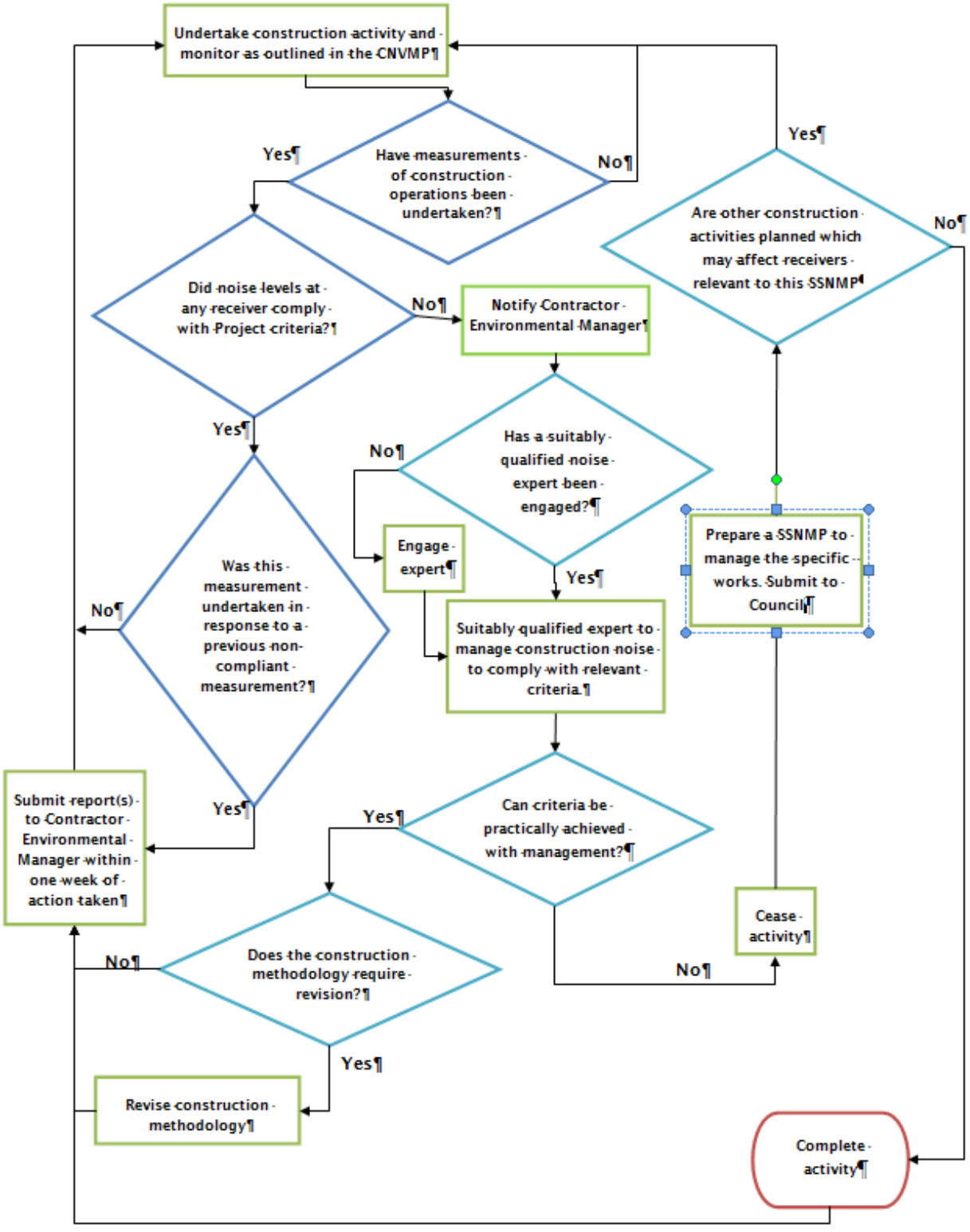


Figure J20: Response Plan Flow Chart for Vibration Issues

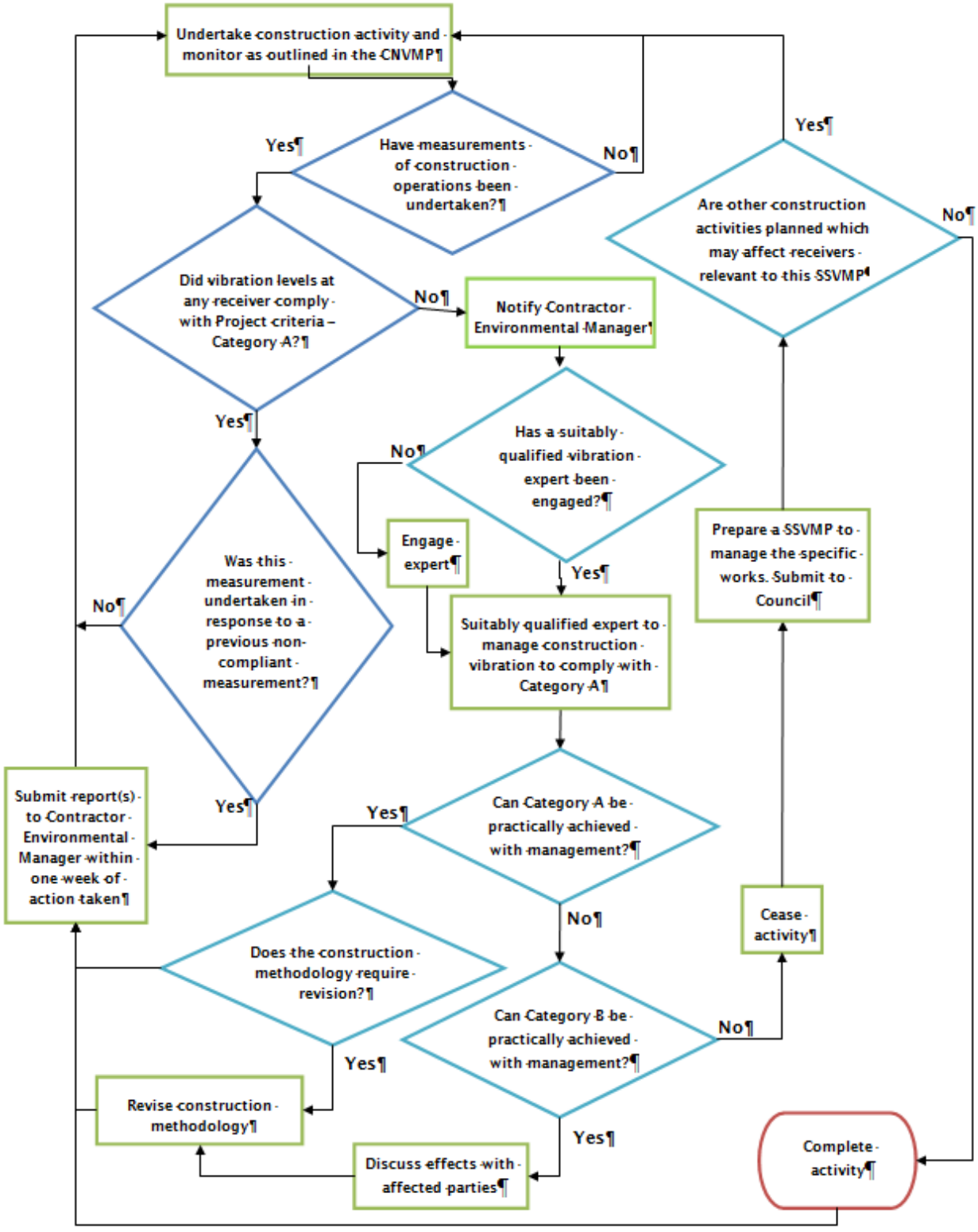


Table 22: Noise Mitigation and Management

Equipment/process	General noise control measures
Piling	Communication with affected parties prior to activity; use of bored piling instead of vibratory piling should be used where practicable; site hoardings
Earthworks	Use small equipment where required to achieve compliance with limits e.g. use a small excavator in close proximity to residential boundaries; site hoardings
Construction yards	Solid site hoardings of minimum 2.5 metres height positioned to block line-of-sight between the activity and receiving positions; Hoardings should be as close as practicable to the source and abutted or overlapped to provide a continuous screen where required. Layout of yard to position noise intensive activities away from noise sensitive sites; avoid unnecessary noise generation (e.g. radios, shouting, loose tailgates)
All works	Keep equipment well maintained and specify quieter models where possible; use straps rather than chains; use silencers for exhausts and enclosures for generators (night-time operation) It is the responsibility of the construction contractor to maintain a tight timeframe and keep the construction time near noise sensitive areas to a minimum; avoid unnecessary noise (e.g. loose tailgates, idling, horns and tonal reverse alarms) Toolbox training sessions to inform contractors of noise sensitivities

Table 23: Vibration Mitigation and Management

Equipment/process	General vibration control measures
Piling	Communication with affected parties prior to activity; use of bored piling instead of vibratory piling should be used where practicable; using an appropriately sized rig to do the job
Earthworks	Selection and use of small equipment where required to achieve compliance with limits e.g. use a small excavator in close proximity to residential boundaries