REPORT

Tonkin+Taylor

Harania Flood Resilience Works - Tennessee Bridge

Construction noise and vibration technical assessment

Prepared for
Auckland Council

Prepared by
Tonkin & Taylor Ltd

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1 Introduction

1.1 Background

The January 2023 floods, followed closely by Cyclone Gabrielle, marked a period of unprecedented weather challenges for Auckland. Auckland Council is carrying out flood resilience projects with the aim of mitigating flood risk to property through a series of blue-green networks, addressing critical flood-prone areas with sustainable stormwater solutions. The Harania catchment was one of the worst affect areas of Auckland following the January 2023 floods. Healthy Waters identified significant flooding, causing risk to life, and widespread flood damage to homes. This occurred due to poor flood conveyance at the location of the current Tennessee Avenue embankment dam.

1.2 Project description

A detailed description of the full project works can be found in the Assessment of Effects on the Environment (AEE) report[1].

The Tennessee Bridge project involves removing the current embankment which carries the existing Eastern Interceptor (EI), an approximately 2.6 m diameter reinforced concrete wastewater pipe. The replacement will comprise a new pipe and pipe bridge in the coastal marine area (CMA) to open up the waterway capacity to allow increased flood conveyance. Diversion chambers are required at either end of the new pipe, connecting it to the existing pipe to facilitate the change over from the old pipe to the new pipe bridge diversion.

1.3 Scope of works

Tonkin & Taylor Ltd (T+T) has been engaged by Auckland Council's Healthy Waters to undertake an acoustic assessment related to the proposed Tennessee Bridge upgrade works (the Project) and this has been prepared to accompany a resource consent application for the Tennessee Bridge project under the Severe Weather Emergency Recovery (Auckland Flood Resilience Works) Order 2024. The purpose of this acoustic assessment is to:

- Establish the relevant noise and vibration limits for the site set out in the Auckland Unitary Plan (AUP);
- Identify the construction activities that will generate noise and vibration;
- Identify nearby receivers;
- Predict construction noise and vibration levels at identified receivers and determines compliance with relevant noise and vibration limits;
- Discuss potential noise and vibration effects; and
- Provide recommendations to avoid, remedy or mitigate these effects.

2 Project overview

2.1 Site location and description

The Tennessee culvert is located in Mangere, between the Lenore Foreshore Reserve and Blake Road Reserve. The embankment supports the existing sewer connection across the creek gully which

[1] *Harania Flood Resilience Works – Tennessee Bridge Assessment of Effects on the Environment*, Beca Limited, November 2024.

leads out to Manukau harbour to the north of the embankment. There is open space reserve to the north and east of the site, with residential dwellings to the southeast and west of the site.

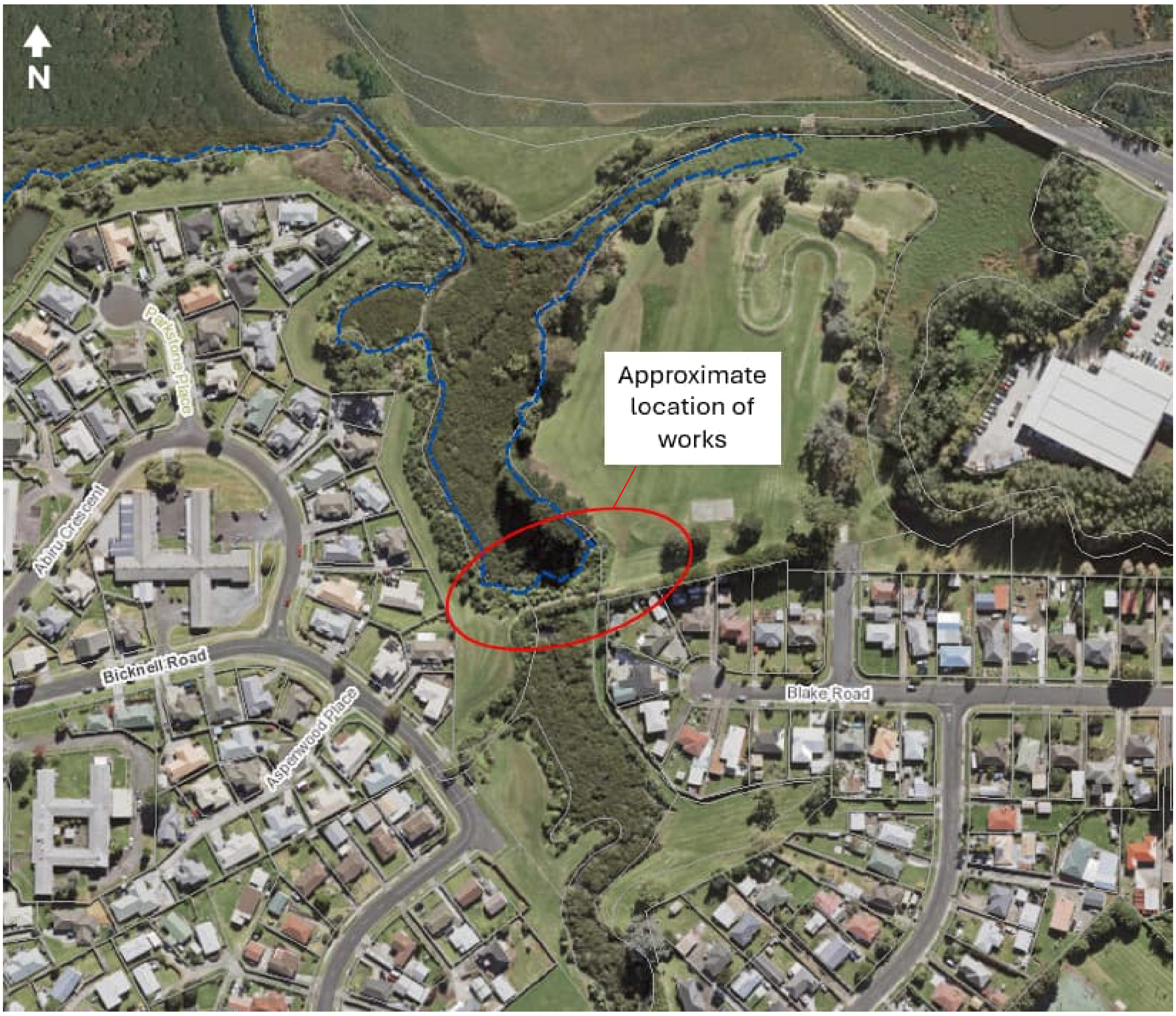

Figure 2.1: Site location and surrounding area

2.2 Proposed works

A detailed description of the proposed work is provided in the AEE prepared for the application.

The flood resilience works will include the following:

- The formation and operation of two construction laydown / compound areas. The laydowns/ compounds will be used for the storage of materials, machinery, construction related activities, site offices (e.g. portacom and containers), ablutions and carparking.
- Installation of an approximately 2700 mm internal diameter wastewater pipe parallel to the Eastern Interceptor and associated pipe bridge within the CMA. This will require piles and piers within the CMA.
- Installation of two chambers (upstream and downstream) which tie the new pipe into the Eastern Interceptor.
- Demolition and removal of the embankments, culverts and section of existing Eastern Interceptor between the two chambers.

- The construction and use of a temporary staging platform within the CMA. This will require piles within the CMA, of which will remain permanently below the bed of the CMA.
- Temporary damming and diversion of water required for construction.
- Construction of new pedestrian bridge on top of the pipe bridge to maintain walking access between Lenore Foreshore Reserve and Blake Road Reserve.
- Vegetation clearance, including within the coastal and riparian margins, and the removal of trees.
- Earthworks associated with temporary and permanent works, including within the coastal and riparian margins.
- Landscaping.

An overview of the Tennessee bridge works is shown below in Figure 2.2.

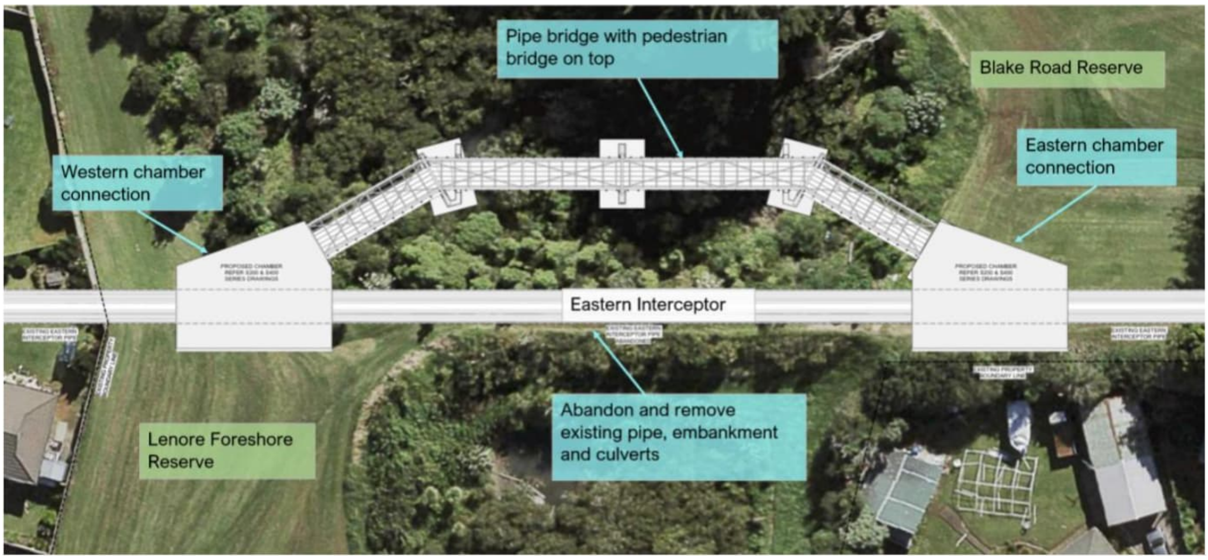

Figure 2.2: Overview of Tennessee bridge works (taken from draft description of the work dated 21/10/24)

2.3 Construction methodology

The construction methodology is detailed in the AEE. The main activities which are of relevance to this assessment are set out below.

- Site establishment – some vegetation removal will be required. Laydown areas will have 300 mm of aggregate place over geotextile cloth and will require compaction with a 14t roller for 10 days in total (both compounds). 71 truck and trailer movements will be required to deliver the aggregate to the eastern compound and 16 movements to the western compound.
- Preparatory works will require vegetation clearance within the works area including chipping.
- Construction of the access staging will be constructed progressively by vibro piling the first two 900 mm diameter steel casings, then lifting into place and installing the steel headstocks, beams and deck panels. The crane will then move onto the completed section and repeat the piling and crane lifts until the full four bays have been installed. A small amount of impact piling may be required at the end of each pile installation.
- Installation of the coffer dam is expected to take place during low tide, i.e. in minimal water depth. Sheet piles will be vibro driven for the first coffer dam. Works will continue on the first coffer dam (excavation, installation of whaler beams and casting of prop slab) while sheet

piles are driven for the second coffer dam, similarly for the third. The construction staging will be extended at each end to allow the piling and future lift positions for the crane.

- The permanent screw piles for the pipe bridge support will be installed and the material within the casings cleaned out to a depth of 4 m using a pendulum augur mounted on an excavator.
- Excavation of the western connection chamber will be undertaken from both sides, with battered slopes such that retention is not required on western edge at property boundary. Estimated 50 6-wheel truck movements to remove material from site during this phase.
- 19 screw piles installed for foundation of western connection chamber.
- Pile three pile cap and western chamber construction underway.
- Excavation for eastern connection chamber. Retention may be required adjacent to property boundary if battering is not practicable. This retention will consist of augered holes, with universal columns inserted and concreted into place with either timber cladding or steel plates and is not expected to be particularly noisy. The column nearest the sewer will be installed in a hydro-excavated hole to reduce vibration.
- 19 screw piles installed for foundation of eastern connection chamber.
- Preparation of pipe assembly bed. Welding of each joint will take 4-5 days and will be enclosed in a welding tent.
- Substructure construction complete, eastern chamber works continue, pipe assembly underway.
- Coffer dams removed and remediation around new foundations completed.
- Installation of pipe sections, chamber end walls completed around new pipe and pipe cut-over which will require concrete cutting of the old pipe at night prior to completion of the chambers. Backfill / reinstatement will require a small amount of plate compaction.
- Access staging removed.
- Removal of redundant pipe and underlying embankment. Excavation of pipe, disposal of material via 6-wheel trucks via western entrance. Removal of pipe, reinstatement (landscaping, scour protection etc).
- Works complete and site de-mobilisation complete.

The noisiest activities are expected to comprise:

- Chipping of vegetation;
- Compaction of the laydown areas;
- Vibro piling for the access staging;
- Small amount of impact driving for access staging;
- Vibro driving of sheet piles for the coffer dams;
- Connection chamber works:
  - excavation and transport of material offsite;
  - hydro excavation;
  - concrete cutting at night to remove redundant pipe;
- Truck movements for transporting material from site;
- Plate compaction of backfill around connection chambers.

2.4 Duration of works

Overall construction of the flood resilience works is expected to take approximately 15 months. The duration of the noisiest activities (as identified in Section 2.3) that are expected to be required is summarised in Table 2.1 below.

Table 2.1: Duration of specific noisy activities

Stage of works	Activity	Duration (days)	Comments
Site establishment	Wood chipping	As required	Noise can be controlled through location, i.e. further from dwellings
Laydown compaction	Compaction	10	14t roller
Access staging	Vibro driving of 900 mm steel casings	27 (not continuous)	Casing installed with vibro hammer for majority of length. Driving completed using a top mounted drop hammer
Coffer dams	Vibro driving of sheet piles	9-10	Vibrated into position using excavator mounted vibro hammer
Connection chambers	Excavation and transport of material offsite	6 at each location	Bulk excavation
Connection chambers	Hydro excavation	6 at each location	Detailed excavation
Connection chambers	Concrete cutting	1 night per chamber	Required at night due to operational requirements. Approx 2h cutting time per chamber.
Connection chambers	Plate compaction	As required	A small amount of compaction is anticipated once the connection chambers have been backfilled
Embankment excavation	Truck movements	Max 6 trucks (12 movements) per hour	Approximately 420 truck movements per 10h day during excavation of embankment

2.5 Hours of operation

Normal hours of operation will be Monday to Saturday, 7.30 am to 6 pm.

Works outside standard working hours are expected to be limited to the tie-in works to the eastern interceptor sewer. The work will need to take place during low flow period (i.e. night-time) to enable the pump stations to be turned off and the storage within the pipe network to be utilised to prevent sewer overflow. A high-level estimate is five nights at each tie-in location.

Occasional works may be required outside these times, for example working around tides, to complete a concrete pour or deliveries to site. Piling work will not take place outside normal daytime hours.

3 Performance standards

The following standards and criteria are applicable for assessing noise and vibration from construction activities associated with the Project:

- Resource Management Act 1991 (RMA) Section 16
- Auckland Unitary Plan – Operative in Part (AUP)
- NZS 6803:1999 – Acoustics – Construction noise (NZS 6803)

There is no New Zealand standard for assessing vibration effects, however the following German Industrial Standard and British Standard are typically referenced:

- DIN 4150-3:2006 Structural vibration – Part 3 Effects of vibration on structures (DIN 4150-3)

The following sections detail the requirements/recommendations of these documents.

3.1 RMA

Section 16(1) of the Resource Management Act 1991 (RMA) sets out the duty to avoid unreasonable noise:

> *Every occupier of land (including any premises and any coastal marine area), and every person carrying out an activity in, on, or under a water body or the coastal marine area, shall adopt the best practicable option to ensure that the emission of noise from that land or water does not exceed a reasonable level.*

Noise should be interpreted to include vibration (s2). The best practicable option (BPO) is also defined in Section 2:

> *In relation to a discharge of a contaminant or an emission of noise, means the best method for preventing or minimising the adverse effects on the environment having regard, among other things, to—*
>
> a *the nature of the discharge or emission and the sensitivity of the receiving environment to adverse effects; and*
>
> b *the financial implications, and the effects on the environment, of that option when compared with other options; and*
>
> c *the current state of technical knowledge and the likelihood that the option can be successfully applied.*

The relevant noise limits for the Project site are detailed in the following sections.

3.2 AUP

3.2.1 Construction noise

The AUP contains limits for construction noise (E25.6.27) which are reproduced in Table 3.1. These limits apply at 1 m from the façade of any building that contains an activity sensitive to noise that is occupied during the works. Times and days outside normal working hours have been greyed out.

Table 3.1: Construction noise levels in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone (AUP Table 25.6.27.1)

Time of week	Time period	Noise limit dB	
		L_{Aeq}	L_{Amax}
Weekdays	6:30 am – 7:30 am	60	75
	7:30 am – 6:00 pm	75	90
	6:00 pm – 8:00 pm	70	85
	8:00 pm – 6:30 am	45	75
Saturdays	6:30 am – 7:30 am	45	75
	7:30 am – 6:00 pm	75	90
	6:00 pm – 8:00 pm	45	75
	8:00 pm – 6:30 am	45	75
Sundays and public holidays	6:30 am – 7:30 am	45	75
	7:30 am – 6:00 pm	55	85
	6:00 pm – 8:00 pm	45	75
	8:00 pm – 6:30 am	45	75

These limits are for works of between 15 calendar days and 20 weeks. The limits are be reduced by 5 dB in all cases in accordance with Standard E25.6.27(4) where the duration of works is greater than 20 weeks, which is the case for this project.

3.2.2 Construction vibration

The AUP (E25.6.30(1)) requires construction activities to not exceed the vibration limits set out in German Industrial Standard DIN 4150-3:1999 when measured in accordance with that Standard on any structure not on the same site. The applicable vibration limit for a residential receiver is 5 mm/s PPV at the lowest frequencies.

Table E25.6.30.1 of the AUP provides amenity vibration limits in buildings in any axis when measured in the corner of the floor of the storey of interest for multi-storey buildings, or within 500 mm of ground level at the foundation of a single storey building. The applicable amenity vibration criterion is 2 mm/s PPV between 7 am and 10 pm, or 0.3 mm/s PPV between 10 pm and 7 am for occupied dwellings. Exceedance of this criterion should result in management and mitigation measures being implemented such as communication and consultation.

The AUP allows that works generating vibration for three days or less between the hours of 7 am to 6 pm may exceed the amenity limits in Table E25.6.30.1 but must comply with a limit of 5 mm/s. All occupied buildings within 50 m of the extent of the work generating vibration must be advised no less than three days prior to the vibration-generating works commencing, and the written advice must 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.

3.3 NZS 6803

NZS 6803:1999 *Acoustics – Construction noise* sets out procedures for the measurement and assessment of noise from existing and proposed construction work, including maintenance and demolitions. The Standard is referenced in the AUP and recommends noise limits for construction noise which the AUP construction noise limits align with (see Table 3.1) and provides guidance on methods of predicting and managing construction noise. These noise limits are specified in terms of the time of day and the duration of work, recognising that residential receivers will be more sensitive to noise at night, and that lower limits are appropriate for longer duration works.

For typical daytime working hours, construction noise limits are less restrictive than the typical operational noise limits, on the basis that the effects of construction activities are of limited duration. The Standard's noise limits apply at 1 m from external façades of occupied buildings, hence noise limits are not applicable if a building is unoccupied. Noise is typically assessed over a representative 15-minute period of construction activity, recognising that construction noise sources will vary with the types and numbers of equipment operating for the activities being undertaken.

3.4 DIN 4150-3:2016

The German Standard DIN 4150:2016-12 *Vibration in buildings – Part 3: Effects of vibration on structures* (DIN 4150-3:2016) is an internationally recognised standard used to assess the effects of vibration on structures. The Standard is commonly used across New Zealand as there are no vibration standards specific to New Zealand. The DIN 4150-3:2016 criteria to evaluate the effects of short-term vibration on structures are shown in Table 3.2 and summarised in Figure 3.1. Short-term vibration is vibration that does not occur often enough to cause structural fatigue, and which does not induce resonance in a building structure.

The table and figure show the recommended vibration limits in terms of Peak Particle Velocity (PPV) as this is directly related to strain, and hence potential for damage to structures. They are lowest in the frequency range of 1-10 Hz, which is the normal range of natural frequency of most structures. The limits increase at higher frequencies where the potential harmonic effects are reduced. The guideline values for PPV are at the foundation and in the plane of the highest floor of various types of building.

Table 3.2: DIN 4150-3:2016 guidelines for evaluating the effects of short-term vibration on structures

Line	Type of structure	Vibration at the foundation at a frequency of			Vibration at horizontal plane of the highest floor
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	All frequencies
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design	20 mm/s	20 to 40 mm/s	40 to 50 mm/s	40 mm/s
2	Dwellings and buildings of similar design and/or occupancy	5 mm/s	5 to 15 mm/s	15 to 20 mm/s	15 mm/s
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value	3 mm/s	3 to 8 mm/s	8 to 10 mm/s	8 mm/s

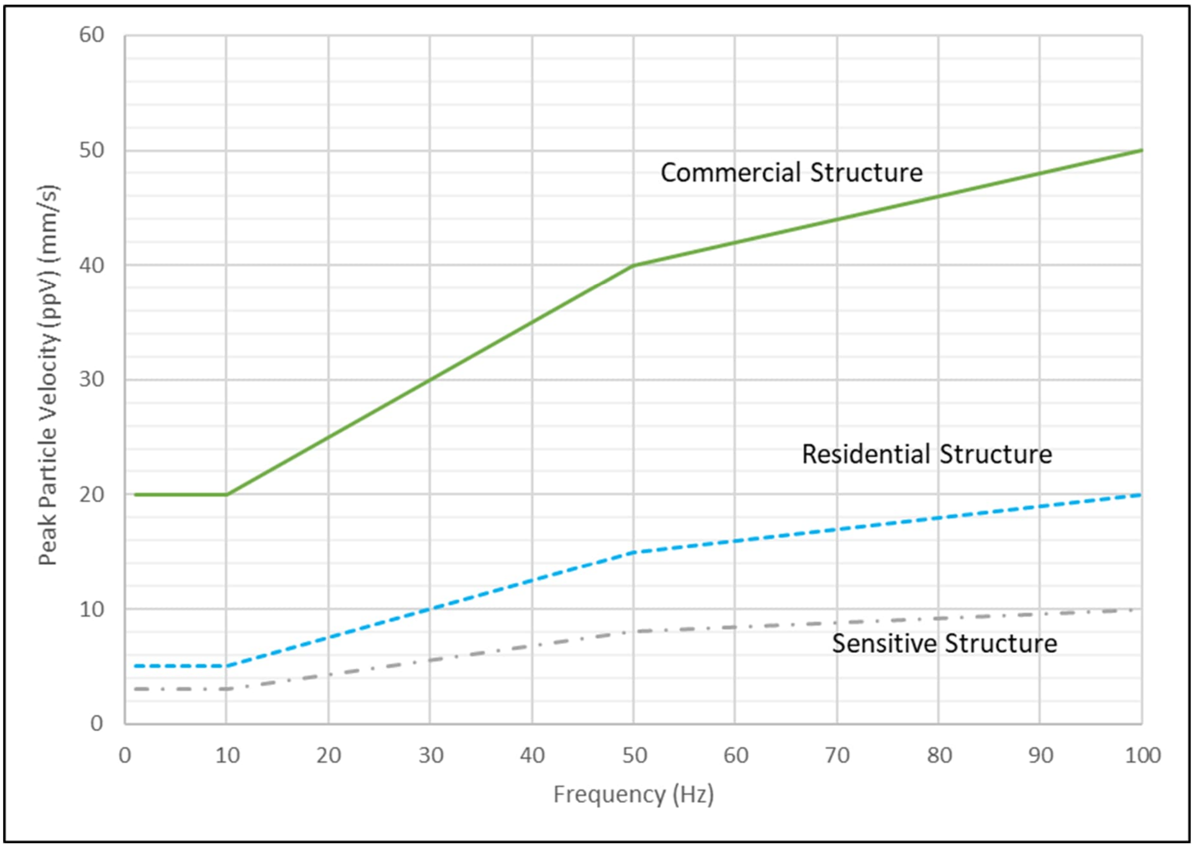

Figure 3.1: DIN 4150-3:2016 Short-term standard baseline curves.

DIN 4150-3:2016 recommends that vibration levels in buildings used for residential purposes should be limited to less than 5 mm/s at low frequencies, increasing up to 20 mm/s at higher frequencies, and for intermittent or short-term vibrations are less than 5 mm/s for continuous activities. The limits recommended in the DIN 4150-3:2016 standard provides a low probability of cosmetic damage while structural damage is unlikely to occur in both residential and commercial structures at less than 50 mm/s, and for in-ground structures and infrastructure services at less than 100 mm/s. The application of this standard using a statistically based criteria for the DIN 4150 limits has been regularly applied in New Zealand [Structural damage] to encourage use of best practice.

3.5 Human vibration

Human perception and response to vibration varies depending upon the sensitivity of the individual, the tasks being performed, the magnitude, frequency and duration of the vibration, whether the vibration is expected, and whether there is concern that structural damage may occur.

Low levels of vibration can cause fixtures and fittings, such as doors and windows, to rattle and the noise that is sometimes generated by the 'rattling' can draw an individual's attention to the original source of the vibration. Humans perceive vibration at much lower magnitudes than the levels of vibration that are likely to cause building damage and as such homeowners are likely to complain about vibration significantly below the levels likely to result in cosmetic damage of buildings.

Within New Zealand there are no national vibration standards for the effects on human exposure within buildings, however, it is accepted practice to apply the guidance from British Standard BS

5228-2:2009 *Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration* (BS 5228-2)[2].

3.5.1 BS 5228-2:2009

BS 5228-2:2009[3] discusses vibration levels at which adverse comment is likely from building occupants. The guidance values of Table B.1 of BS 5228-2:2009 are provided in Table 3.3.

Table 3.3: Guidance on effects of vibration levels - BS 5228-2:2009

Vibration level (PPV)	Effect
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction[4]. At lower frequencies, people are less sensitive to vibration.
0.3 mm/s	Vibration might be just perceptible in residential environments.
1.0 mm/s	It is likely that vibration of this level in residential environments will cause complaint but can be tolerated if prior warning and explanation has been given to residents.
10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure to this level in most building environments.

3.6 Project criteria

The relevant permitted activity standards for noise and vibration for the proposed hours of operation (Monday to Saturday 7:30 am to 6 pm) are:

- 70 dB LAeq and 85 dB LAmax
- 2 mm/s PPV, 5 mm/s for up to three days

Where night works are required, these will be subject to the noise limits in Table 3.1. No vibratory works are proposed at night.

[2] The previous version of this standard is referenced extensively throughout NZS 6803:1999 as a method for predicting the noise levels from specific construction activities. The current version is considered appropriate.
[3] BS 5228-2:2009+A1:2014, Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration
[4] Below 50Hz

4 Existing environment

4.1 Description

The surrounding land is relatively flat, with the exception of the gully in which much of the works will take place. To the west and southeast of the site are residential areas, typically with one- or two-storey detached dwellings. Immediately to the east of the site is Blake Road Reserve, an open recreation area with a bike track and a basketball court. To the east of this reserve is an industrial area, with warehouse buildings at least 200 m from the works. Due to the low noise sensitivity of these buildings and the distance from works these have not been considered further.

The existing noise environment is expected to be typical of a residential area within a large urban area.

4.2 Receivers

All surrounding receivers are residential dwellings which are classed as a noise sensitive activity under the AUP. If dwellings are not occupied at the time of works there will be no noise sensitivity. The nearest surrounding receivers with direct line of sight to the site are shown in Figure 4.1 and listed in Table 4.1, together with the approximate distance to the nearest part of site.

Figure 4.1: Location of receivers

Table 4.1: Nearest receivers

Address	Nearest distance to works, m				
	Compounds (compaction)	Access staging	Coffer dam	Western connection chamber	Eastern connection chamber
32 Bicknell Road	3	35	40	15	80
34 Bicknell Road	2	55	55	30	90
46 Abiru Crescent	65	85	90	95	130

Address	Nearest distance to works, m				
	Compounds (compaction)	Access staging	Coffer dam	Western connection chamber	Eastern connection chamber
48 Abiru Crescent	55	75	85	85	120
52B Abiru Crescent	35	55	65	65	110
58 Abiru Crescent	10	40	50	40	100
60 Abiru Crescent	5	30	40	20	90
76 Archboyd Avenue	25	110	110	90	130
79 Archboyd Avenue	60	140	130	120	150
80 Blake Road	35	55	50	60	35
87 Blake Road	20	65	65	100	40
89 Blake Road	10	45	50	85	25
91 Blake Road	15	40	40	65	20

5 Construction noise and vibration assessment

5.1 Assessment approach

An assessment of construction noise and vibration has been undertaken based on the draft construction methodology as presented in Section 2.3.

The assessment approaches for the noisiest equipment or activities (as identified in Section 2.3) are as follows:

- Chipping of vegetation: identification of setback distance for a woodchipper;
- Compaction of the laydown areas: identification of setback distance for a 14t roller and a plate compactor;
- Vibro piling for the access staging: predicted noise and vibration levels at surrounding receivers;
- Impact driving for access staging: predicted noise and vibration levels at surrounding receivers;
- Vibro driving of sheet piles for the coffer dams: predicted noise and vibration levels at surrounding receivers;
- Connection chamber works:
  - excavation and transport of material offsite: prediction of noise levels from excavators and 6-wheeler trucks;
  - hydro excavation: discussion of setback distance;
  - concrete cutting at night: prediction of noise levels from four concrete wire saws;
- Truck movements for transporting material from site: predicted worst-case noise levels;
- Plate compaction of backfill around connection chambers: discussion of setback distance.

In addition to these specific activities, sound power levels and setback distances are provided for the equipment anticipated to be used on site for these works.

5.2 Plant list

Sound power levels are provided in Table 5.1 below for the likely significant construction noise sources on site. Façade sound pressure levels at different set back distances, calculated using NZS 6803:1999 principles, are also provided to give an indication of likely noise levels for short term activities.

Not all items of plant will operate simultaneously and therefore a number of representative scenarios have been considered in this assessment, see Section 0. Table 5.1 below provides sound power levels for the anticipated equipment for each stage of works, as well as the setback distance at which a façade level of 70 dB LAeq is predicted (no screening assumed). These are taken from NZS 6803:1999 (reproduced from BS5228-1) or from T+T's library of measured levels.

Table 5.1: Construction equipment noise levels without mitigation

Equipment	Sound power level dB LWA	Noise level dB LAeq					Set back distance to achieve 70 dB LAeq (m)
		10 m	20 m	30 m	40 m	50 m	
45t bore pile	111	86	80	76	73	71	52
Vibro piles	114	89	83	79	76	74	69

Equipment	Sound power level dB LWA	Noise level dB LAeq					Set back distance to achieve 70 dB LAeq (m)
		10 m	20 m	30 m	40 m	50 m	
10t hydraulic hammer piles	117	92	86	82	79	77	91
6-wheeler tipper truck	106	81	75	71	68	66	35
Concrete truck	103	78	72	68	65	63	30
Concrete boom pump	106	81	75	71	68	66	35
Chain saw	96	71	65	61	58	56	15
Woodchipper	118	93	87	83	80	78	100
Welding machine	93	68	62	58	55	53	10
Drill rig	111	86	80	76	73	71	55
Crawler crane (120t)	101	76	70	66	63	61	20
Vibro hammer	114	89	83	79	76	74	70
Excavator (20t)	102	77	71	67	64	62	25
Roller (14t)	112	87	81	77	74	72	60
Plate compactor	108	83	77	73	70	68	40
Hydro excavator	101	76	70	66	63	61	20

The following table shows key equipment likely to generate vibration for the Project. Where available, measurements / estimates of vibration from that equipment have been included.

Whilst the hydraulic hammer piles generate higher vibration levels of approximately 10 – 15 mm/s PPV at 10 m, the dominant frequency of this source is between 12 – 24 Hz. DIN 4150-3:1999 criteria is frequency dependent and a higher PPV level is allowable at higher frequencies. As the dominant frequency from piling can vary dependent on factors such as the depth of the pile and ground conditions, the lower frequency criterion for 12 Hz will be used to present a worst-case assessment when considering impacts from hydraulic hammer piles.

Table 5.2: Key construction equipment generating vibration

Equipment	PPV at 10 m
Vibro piles	4 – 5 mm/s
10t hydraulic hammer piles	10 – 15 mm/s
Large roller (vibratory)	2 – 3 mm/s
20 - 30 t Excavator	1 – 2 mm/s

5.3 Noise model

SoundPLAN noise prediction software has been used to predict sound pressure levels from activities associated with this project. The noise model takes into account ground absorption, buildings and the location of works. The assumptions and settings in the model are shown in Table 5.3.

Table 5.3: SoundPLAN noise model parameters

Parameter	Setting / assumption
Topography	Flat terrain, no topographic screening – worst case
Buildings	Building outlines downloaded from LINZ Data Service. Height set to 4.5 m
Ground absorption	Blanket assumption of 0.6 across model
Screening	Screening due to buildings only. No screening from acoustic barriers assumed as these may not be practicable on site.
Equipment on-time	100% for worst-case 15-minute assessment period

For each receiver, the worst-case façade noise level has been calculated, which is typically when equipment is operating at the closest location. When equipment is operating further away noise levels will be lower.

The following scenarios have been modelled as representative of the noisiest activities during the construction works:

Table 5.4: Modelled scenarios

#	Scenario	Noise source	Modelled source	Sound power level dB LwA
1	Access staging	Vibro driving of 900 mm pile casings	4 m high point source at closest location	114
2	Access staging	Impact driving of 900 mm pile casings	4 m high point source at closest location	117
3	Coffer dam	Vibro driving of sheet piles	4 m high point source at closest location	116
4	Western connection chamber	2x excavators 2x 6-wheel trucks	Area source	102 (each) 106 (each)
5	Eastern connection chamber	2x excavators 2x 6-wheel trucks	Area source	102 (each) 106 (each)
6	Truck movements	6x 6-wheel trucks per hour	Line source	106 (each)
7	Western connection chamber	4x concrete wire saws*	Area source	96 (each)
8	Eastern connection chamber	4x concrete wire saws*	Area source	96 (each)

* Generator assumed not to contribute to overall noise level based on discussions with contractor

5.4 Predicted noise levels

Table 5.5 and Table 5.6 summarise the predicted worst-case noise levels from the modelled scenarios on surrounding properties, together with the anticipated durations for these stages of work. In Table 5.5 (daytime), results greater than 70 dB LAeq (the permitted noise level) are shown in bold and results over 75 dB LAeq are highlighted.

Table 5.5: Predicted façade noise levels at receivers (daytime)

Receiver	Predicted façade noise level, dB LAeq					
	Access staging - vibro	Access staging - impact	Coffer dam	Western connection chamber	Eastern connection chamber	Trucks
32 Bicknell Road	73	76	77	77	62	58
34 Bicknell Road	69	72	73	70	58	58
46 Abiru Crescent	64	67	67	60	58	41
48 Abiru Crescent	65	68	68	61	58	42
52B Abiru Crescent	69	72	71	64	59	42
58 Abiru Crescent	74	77	74	68	61	45
60 Abiru Crescent	76	79	77	73	61	49
76 Archboyd Avenue	61	64	65	60	57	59
79 Archboyd Avenue	59	62	64	58	56	55
80 Blake Road	68	71	74	65	68	46
87 Blake Road	67	70	63	43	59	53
89 Blake Road	71	74	74	61	73	52
91 Blake Road	72	75	77	64	76	51

There is also the potential for noise levels above 70 dB LAeq from woodchipping and compaction when these occur within the setback distances in Table 5.1, i.e. woodchipping within 100 m (unscreened), compaction with a 14t roller within 60 m or with a plate compactor within 40 m of dwellings.

Table 5.6 shows the predicted façade noise levels at the closest receivers during concrete cutting. This will be undertaken at night due to operational requirements when the 45 dB LAeq noise limit is applicable. Received levels over 45 dB LAeq are in bold and those over 55 dB LAeq (potential for sleep disturbance, see Section 6) are highlighted. Screening of 10 dB is assumed, which is readily achievable when line of sight is lost between noise source and receiver.

Table 5.6: Predicted façade noise levels at receivers during concrete cutting (night-time)

Receiver	Predicted façade noise level, dB LAeq			
	Western connection chamber		Eastern connection chamber	
	Unscreened	Screened	Unscreened	Screened
32 Bicknell Road	69	59	54	44
34 Bicknell Road	62	52	50	40
46 Abiru Crescent	52	42	50	40
48 Abiru Crescent	53	43	50	40
52B Abiru Crescent	56	46	51	41
58 Abiru Crescent	60	50	53	43
60 Abiru Crescent	65	55	53	43
76 Archboyd Avenue	52	42	49	39

Receiver	Predicted façade noise level, dB LAeq			
	Western connection chamber		Eastern connection chamber	
	Unscreened	Screened	Unscreened	Screened
79 Archboyd Avenue	50	40	48	38
80 Blake Road	57	47	60	50
87 Blake Road	35	25	51	41
89 Blake Road	53	43	65	55
91 Blake Road	56	46	68	58

5.5 Predicted vibration levels

Table 5.7 summarises the predicted worst-case vibration levels for receivers. Exceedances of the DIN 4150-3:2016 criterion (5 mm/s PPV for residential buildings) are highlighted, with exceedances of the AUP amenity limit of 2 mm/s PPV identified in bold.

Table 5.7: Maximum predicted vibration levels at nearest receivers

Address	PPV mm/s					
	Compounds (compaction)	Access staging - vibro	Access staging - impact	Coffer dam - vibro	Western connection chamber	Eastern connection chamber
32 Bicknell Road	4 – 6*	2	5 - 7	2	1 - 2	0 - 1
34 Bicknell Road	5 – 7*	1 - 2	4 - 6	1 - 2	1	0 - 1
46 Abiru Crescent	1	1	3 - 4	1	0 - 1	Negl.
48 Abiru Crescent	1	1 - 2	3 - 5	1	0 - 1	Negl.
52B Abiru Crescent	1	1 - 2	4 - 6	1 - 2	0 - 1	Negl.
58 Abiru Crescent	2 – 3*	2	5 - 7	2	0 - 1	Negl.
60 Abiru Crescent	3 – 4*	2 - 3	5 - 8	2	1	0 - 1
76 Archboyd Avenue	1 – 2	1	2 - 3	1	0 - 1	Negl.
79 Archboyd Avenue	1	1	2 - 3	1	Negl.	Negl.
80 Blake Road	1	1 - 2	4 - 6	2	0 - 1	0 - 1
87 Blake Road	1 - 2	1 - 2	3 - 5	1 - 2	Negl.	0 - 1
89 Blake Road	2 – 3*	2	4 - 6	2	0 - 1	1
91 Blake Road	2	2	5 - 7	2	0 - 1	1

* Vibratory function to be turned off within 10 m

A calculation of the setback distance for vibration during piling has also been undertaken. During impact piling for the access staging, where piles are driven to refusal there is the potential for the DIN 4150-3:2016 limit (5 mm/s PPV) to be exceeded within 85 m which would affect approximately 17 houses. There is the potential for the AUP amenity limit (2 mm/s PPV) to be exceeded within approximately 170 m. Dwellings within these buffer zones are listed in Appendix B.

Vibratory compaction within 10 m of dwellings is predicted to exceed the amenity limit of 2 mm/s and potentially the DIN 4150-3:2016 limit of 5 mm/s and it is recommended that the vibratory function on the roller is switched off within 10 m as best practice to reduce vibration to a reasonable level for residents.

A small exceedance of the amenity limit (up to 3 mm/s PPV) is predicted at 60 Abiru Crescent during vibro piling for the access staging.

6 Assessment of effects

6.1 Potential effects

The degree of the noise effects will depend upon the magnitude, frequency of occurrence and duration of the noise exposure. If residents are home, they will experience noise inside and outside their dwellings. An indication of typical effects due to a range of potential noise levels is provided in Table 6.1.

Table 6.1: Subjective response to environmental noise levels

External Noise Level (LAeq)	Potential Daytime Effects Outdoors	Corresponding Internal Noise Level (LAeq)	Potential Daytime Effects Indoors
Up to 65 dB	Conversation becomes strained, particularly over longer distances.	Up to 45 dB	Noise levels would be noticeable but unlikely to interfere with residential activities.
65 to 70 dB	People would not want to spend any length of time outside	45 to 50 dB	Concentration would start to be affected. TV and telephone conversations would begin to be affected.
70 to 75 dB	Outdoor users would experience considerable disruption.	50 to 55 dB	Phone conversations would become difficult. Personal conversations would need slightly raised voices. For residential activity, TV and radio sound levels would need to be raised.
75 to 80 dB	Some people may choose hearing protection for long periods of exposure. Conversation would be very difficult, even with raised voices.	55 to 60 dB	People would actively seek respite when exposed for a long duration.
80 to 90 dB	Hearing protection would be required for prolonged exposure (8 hours at 85 dB) to prevent hearing loss.	60 to 70 dB	Untenable for residential environments. Unlikely to be tolerated for any extent of time.

Note: The adjustment factor between the external noise level and the internal noise level is based on a 20-decibel reduction as allowed for in NZS 6803.

This table relates to noise experienced during non-sleeping hours. If construction noise occurs during the night (10 pm to 7 am), external sound levels greater than 45-50 dB L_{Aeq} will have the potential to result in sleep disturbance if residents sleep with windows open.[5] If residents have windows closed, external noise levels can be up to 55-65 dB L_{Aeq} before adverse effects occur.[6]

6.2 Activity assessment

Unless otherwise stated, a reduction between external and internal noise levels of 20 dB LAeq has been assumed as per NZS 6803:1999.

Laydown compaction

Compaction of the laydown areas within the compounds is required close to dwellings (2-3 m at the closest point) and high noise levels are expected at times. The roller will progress around the area to be compacted, covering the entire area several times. Hence the noise from the roller will not be consistent; however when the roller is operating within 25 m of a dwelling noise levels are predicted to exceed 80 dB LAeq. This is the permitted construction noise level for short duration works and can be used as an indicative guide as to a reasonable level of effects. Compaction is anticipated within 25 m of the following dwellings: 32 and 34 Bicknell Road, 58 and 60 Abiru Crescent, 87, 89 and 91 Blake Road.

A 2 m high barrier along the eastern property boundary of 32 and 34 Bicknell Road is predicted to reduce the noise level to approximately 80 dB LAeq (5 m distance, 50 % on-time as the roller will be traversing) which equates to an internal noise level of around 60 dB LAeq. At this level, residents would actively seek respite when exposed for a long duration.

The total duration of compaction is 10 days; as there is a large area to be compacted (3000 m^2 in the eastern compound and 700 m^2 in the western compound) the duration of compaction close to these dwellings is likely to be relatively short. The effects on residents are best managed through engagement and managing expectations.

If the vibratory function on the roller is switched off when operating within 10 m of dwellings, vibration levels are predicted to remain below 2 mm/s and be reasonable for residents.

Access staging – vibro and impact piling

Noise levels between 76 and 79 dB LAeq are predicted at 32 Bicknell Road (76 dB LAeq), 58 Abiru Crescent (77 dB LAeq) and 60 Abiru Crescent (79 dB LAeq) during impact piling, and 76 dB LAeq at 60 Abiru Crescent during vibro piling. These noise levels are the worst-case scenario when works are at the closest location, with no topographical screening assumed in the calculation. This level of noise may cause residents indoors to actively seek respite when exposed for a long duration.

An additional four dwellings are predicted to receive worst-case noise levels of between 70 and 75 dB LAeq for both vibro and impact piling (32 Bicknell Road, 58 Abiru Crescent, 89 and 91 Blake Road during vibro piling and 34 Bicknell Road, 80, 89 and 91 Blake Road during impact piling).

Piling for the staging works will progress along the alignment with the overall works taking approximately 27 days. For much of this time noise levels are expected to be lower than the worst-case levels predicted. The topography around the existing gully and sewer pipe may provide some level of screening. Impact piling is expected to be for a short period of time for each pile (if required).

Vibration from vibro piling may exceed the amenity limit at 60 Abiru Crescent when works are at the closest location but are otherwise expected to remain within the amenity limit at all other dwellings.

[5] Based on an internal design level of 30-35 dB L_{Aeq} for bedrooms and a typical sound reduction of 15 dB for a partially open window.
[6] Based on an internal design level of 30-35 dB L_{Aeq} for bedrooms and a typical sound reduction of 25-30 dB for a closed façade.

During impact piling, it is predicted that the DIN 4150-3 limit may be exceeded at up to 17 dwellings if piles are driven to refusal.

The DIN 4150-3:1999 thresholds are set to be protective of cosmetic damage (refer to Section 3.4) and 5 mm/s is applicable for frequencies between 1 – 10 Hz. Equipment used for this Project are likely to operate at frequencies greater than 10 Hz resulting in a higher threshold as illustrated in Figure 3.1. In reality, structural damage is unlikely to occur in residential buildings at less than 50 mm/s. Therefore, a worst case predicted vibration level for the Project of up to 8 mm/s at 60 Abiru Crescent is unlikely to cause structural damage but building condition surveys will be required where exceedances are predicted and monitoring undertaken during the closest works to minimise any adverse effects where possible.

Effects will be managed via the CNVMP through the use of monitoring and appropriate construction practices to minimise the potential to exceed 5 mm/s when properties are occupied. For all properties predicted to exceed the DIN 4150-3:2016 identified in Appendix B, pre- and post-construction building condition surveys are recommended as described in Section 7.6 before piling works begin.

Consultation with the building occupants and owners will be carried out prior to construction work starting. Effects will be managed through vibration monitoring and consultation with the occupants prior to construction works starting.

Coffer dam

Three dwellings are predicted to receive up to 77 dB LAeq during the closest sheet piling for the closest coffer dam (32 Bicknell Road and 60 Abiru Crescent during piling of the westernmost coffer dam and 91 Blake Road during piling of the easternmost coffer dam). The sheet piling for each coffer dam is expected to take around three days. Noise from piling the other coffer dams is expected to be lower as they are further away. When exposed to this level of noise for an extended duration residents indoors may activity seek respite.

An additional five dwellings slightly further from the works are predicted to receive noise levels between 70 and 75 dB LAeq (34 Bicknell Road, 52B and 58 Abiru Crescent, 80 and 89 Blake Road).

Vibration is predicted to remain below the amenity limit during sheet piling for the coffer dam.

Western connection chamber

Excavation of the western connection chamber is expected to take six days and result in an average noise level of 77 dB LAeq at 32 Bicknell Road and 73 dB LAeq at 60 Abiru Crescent. With screening in place at 32 Bicknell Road the noise level would reduce to 67-72 dB LAeq. Equipment may also be screened by the topography as the excavation progresses.

Vibration is predicted to remain below the amenity limit at all times.

Eastern connection chamber

Excavation of the western connection chamber is expected to take six days and result in an average noise level of 76 dB LAeq at 91 Blake Road and 73 dB LAeq at 89 Blake Road. Equipment may also be screened by the topography as the excavation progresses.

Vibration is predicted to remain below the amenity limit at all times.

Connection chambers – hydro excavation, plate compaction

Six days of hydro excavation are anticipated for each connection chamber. Where the hydro excavator is further than 20 m from dwellings (not screened by topography) noise levels are predicted to be within permitted levels. As the bulk excavation will already have been completed, topographical screening is likely and no major exceedances of the permitted noise levels are anticipated.

Plate compaction will take place once the connection chambers have been backfilled, i.e. topographical screening is unlikely. 32 and 34 Bicknell Road are within the 40 m setback (15 m and 30 m respectively from the closest point). With screening in place around the boundary of these properties, noise levels are expected to remain within permitted levels at all times. 60 Abiru Crescent, 89 and 91 Blake Road are 20-25 m from the closest point where the plate compactor is expected to be working and noise levels of up to 77 dB LAeq are predicted for short durations.

Connection chambers – concrete cutting at night

Concrete cutting is required to remove the redundant pipe as part of the tie-in works at both connection chambers and must be undertaken at night. Noise levels have been predicted for the noise source both unscreened and screened (10 dB of attenuation, assumes no line of sight). 10 dB is expected to be readily achievable with standard acoustic screening or localised screening.

During concrete cutting at the western connection chamber, seven dwellings are predicted to receive night-time noise levels over 45 dB LAeq (see Table 5.6), with only one of those over 55 dB LAeq assuming that the noise source can be effectively screened. During concrete cutting at the eastern connection chamber, three dwellings are predicted to exceed 45 dB LAeq, only one of which is predicted to exceed 55 dB LAeq. As discussed in Section 6.1, sleep disturbance is more likely at night-time noise levels greater than 55 dB LAeq. There may be some sleep disturbance for residents at 32 Bicknell Road during concrete cutting at the western connection chamber, and 91 Blake Road during concrete cutting at the eastern connection chamber if the wire saws are effectively screened. This would be for approximately two hours in one night for each connection chamber.

Residents will require advance notice of these works, including the reason for night-time works, and the timing and duration of concrete cutting. If sleep disturbance is possible (i.e. noise levels above 55 dB LAeq) they may choose to stay elsewhere during these works to avoid sleep disturbance. Noise management may include offering temporary accommodation to these residents.

Truck movements

The predicted average noise level over a representative hour (12 truck movements) is 59 dB LAeq at 76 Archboyd Avenue, which is considered to be representative of the worst-case receivers along the truck route as it is on a corner (i.e. exposed to sound on two sides, no reduction in speed is assumed around the corner). Although this is within the permitted construction noise levels (which do not apply to noise on public roads), the volume of construction traffic is expected to be noticeable on quiet residential roads. Perceived noise effects can best be managed by managing expectations of residents, e.g. through prior notification, including providing indications of timescale of works, reasons, timing etc.

Wood chipping

Noise levels above permitted levels are predicted to be received at dwellings within 100 m of a woodchipper operating. There is likely to be flexibility around where this is located; we recommend it is located as far from dwellings as practicable, and is oriented so the hopper (noisiest aspect) faces away from dwellings, with screening if practicable. The noise source is intermittent, relatively short-term and consistent with expected activities in an open space area and is unlikely to adversely affect residents.

7 Noise and vibration management

7.1 Construction Noise and Vibration Management Plan (CNVMP)

It is common practice for infrastructure projects to implement a CNVMP as part of the construction management plan. Implementing noise management and mitigation measures via a CNVMP is the most effective (and best practice) way to control construction noise and vibration impacts. The objective of the CNVMP should be to provide a framework for the development and implementation of best practicable options to avoid, remedy or mitigate the adverse effects on receivers of noise and vibration resulting from construction. A draft CNVMP identifying the minimum level of information as set out in AUP E25.6.29(5) for the works has been prepared in support of the resource consent.

A CNVMP will be implemented for the work site with specific sections on activities that are predicted to exceed the Project's adopted noise and vibration limits. The CNVMP will be updated to reflect detailed design before commencement of work and kept up to date regarding actual timing/equipment used and methodologies.

The CNVMP should include, but not be limited to, the following recommended mitigation and management measures.

7.2 General noise mitigation

- Avoid unnecessary noise, such as shouting, the use of horns, loud site radios, rough handling of material and equipment, and banging or shaking excavator buckets;
- Orient machinery to maximise the distance between the engine exhaust and the nearest sensitive building façade (e.g. excavators);
- Selection of equipment and methodologies to restrict noise;
- Locate equipment at a distance greater than the minimum set back distances where practicable;
- Utilise noise barriers and/or enclosures where appropriate. Noting that there will be negligible benefit if there is line of sight between the receiver and the source of noise; and
- Liaising with neighbours so they can work around specific activities.

7.3 Community engagement

Good communication / consultation with surrounding residents will be essential, and as a minimum should consist of an initial letter drop to inform residents / occupants of upcoming works, with updates to advise when specific noisy or vibratory phases of works will be starting. This should include contact details for any complaints, estimated duration of works, and times and days when there may be high noise or vibration levels. As a minimum, we recommend that residents at the following nine dwellings are provided with this information:

- 32 and 34 Bicknell Road
- 52B, 58 and 60 Abiru Crescent
- 80, 87, 89 and 91 Blake Road

Prior to impact piling taking place, the 17 dwellings identified in Appendix B will also need to be engaged with.

Concrete cutting at night as part of the tie-in works is expected to affect nearby residents with the potential for sleep disturbance in the two closest dwellings. All residents who are predicted to receive night-time noise levels above 45 dB LAeq should be notified of the upcoming works.

7.4 Specific noise mitigation

Mitigation for installation of piles is generally limited to managing the hours of works and the duration, as screening of an elevated noise source will not be practicable in most cases.

Screening of other noise sources may be possible; given the nature of the site, screening along property boundaries is likely to be the preferred solution. 32 and 34 Bicknell Road are very close to the boundary with the site, adjacent to the compound. Screening along this boundary is recommended. As both these dwellings are single storey, a 2 m high screen will be required.

Screening along the northern property boundaries of 87, 89 and 91 Blake Road may benefit residents, although it is further from dwellings and therefore likely to be less effective. It would screen activity in the compound area but not works within the gully. There may already be partial screening from garages and other buildings adjacent to the eastern compound. Screening along this boundary can be considered if there are complaints from residents.

Specific mitigation recommended is as follows:

- 2 m high acoustic barriers along the eastern property boundaries of 32 and 34 Bicknell Road.
- Consider 2 m high acoustic barriers along northern boundaries of 87, 89 and 91 Blake Road.
- No vibratory compaction within 10 m of dwellings – vibratory function should be turned off when roller is compacting within 10 m of 32 and 34 Bicknell Road.
- If woodchipping is required on site, the woodchipper should be located away from noise sensitive receivers, with the hopper oriented away from properties and screened if practicable.
- Maintain access routes / haul roads for trucks and promptly repair potholes or corrugation of the surface.
- Considerate driving of trucks transporting material to / from site along residential roads.

7.4.1 Night-time works

For concrete cutting at night as part of the tie-in works, it will be important to screen works such that there is no line of sight to dwellings. Reflections / reverberation from the connection chamber will contribute to the overall noise level and should be reduced as much as practicable, for example by lining the connection chamber with absorptive material such as acoustic blankets. Localised screening of the concrete cutter should be implemented if practicable. If a generator is required to operate the concrete wire saw this should be fully enclosed and located further from dwellings where practicable.

Noise levels during concrete cutting at night may cause sleep disturbance for nearby residents. The offer of temporary accommodation should be considered for the worst-affected residents. Eligible dwellings / residents may be identified through a combination of engagement and prediction of noise levels once more details are known regarding the methodology.

7.5 Vibration mitigation

A hierarchy of vibration mitigation measures should be adopted through the CNVMP as follows:

- Managing times of activities to avoid night works and other sensitive times where practicable (communicated through community liaison);
- Liaising and consultation with neighbours prior to commencing works for vibration generating activities;
- Selecting equipment and methodologies to minimise vibration;

- Monitoring of vibration during activities predicted to exceed the 5 mm/s PPV and at heritage buildings; and
- Where vibration levels are predicted to exceed the applicable DIN 4150-3:2016 limit (5 mm/s for residential) then building condition surveys shall be undertaken in general accordance with the parameters set out in Section 7.6.

Mitigation will therefore focus on effective communication with neighbours, and selection of appropriate equipment and methods.

7.6 Building condition surveys

A pre-construction building condition survey is recommended to be undertaken at all of the identified buildings exceeding the applicable DIN 4150-3:2016 limit detailed in Appendix B before the main construction works begins.

The building condition surveys will generally be undertaken as follows:

- The building surveys will be undertaken by a suitably qualified and experienced practitioner;
- Seek permission from the owner of a building, structure or service for a suitably qualified and experienced practitioner to prepare a report that:
  - describes any information about the type of foundations;
  - the existing levels of damage (cosmetic, superficial, affecting levels of serviceability);
  - any observed damage is associated with structural damage;
  - identifies the potential for further damage to occur and describes actions that will be taken to avoid further damage; and
  - photographic evidence.
- The Project team will provide the building condition survey report to the property owner; and
- A post condition survey will be undertaken after construction works has been completed, unless the landowner agrees otherwise, or if monitoring determines the post condition survey is unnecessary (i.e. below the DIN4150-3:2016 threshold).

During construction if complaints are made about vibration or if monitoring determines it necessary, further building condition surveys may be undertaken. Where further surveys identify damage has been encountered, relevant suitably qualified specialists will be engaged to investigate the cause. This may include the vibration specialist, building inspector and building condition author. The outcome of the investigation will be shared with the complainant/affected receiver. If it is determined that the Project is responsible for the damage, a plan will be made to rectify it at the consent holder's cost.

8 Summary

The main noisy and vibratory activities have been assessed from the flood resilience works at the Tennessee culvert in the Harania catchment. Works are expected to take place within normal daytime hours with the exception of the tie-in works which will take place within the connection chambers and are not expected to be noisy.

Exceedances of the permitted daytime construction noise levels are predicted at nine dwellings adjacent to the site during various activities on site. These are 32 and 34 Bicknell Road, 52B, 58 and 60 Abiru Crescent, and 80, 87, 89 and 91 Blake Road.

Compaction is required on the western compound close to 32 and 34 Bicknell Road. Screening is recommended along the eastern boundary of these properties; with this in place noise levels are not predicted to exceed 80 dB LAeq.

During all other daytime activities, noise levels are not predicted to exceed 79 dB LAeq in the worst case. For much of the works noise levels will be lower than this.

During the tie-in works, concrete cutting will be required at night. Relatively high noise levels are predicted, with several dwellings close to the works receiving noise levels above the 45 dB LAeq night-time permitted level. One dwelling for each connection chamber is predicted to receive a noise level above 55 dB LAeq which is likely to result in sleep disturbance. Noise management and mitigation and stakeholder engagement will be important during these works and is fully addressed in the draft CNVMP.

With the exception of impact piling, vibration levels are generally predicted to remain within the AUP amenity level of 2 mm/s provided that no vibratory compaction is undertaken within 10 m of dwellings. During impact piling, if piles are driven to refusal, there is the potential for vibration to exceed the DIN 4150-3:2016 limits at 17 dwellings within 85 m. As cosmetic damage is possible at these levels, building condition surveys are recommended pre- and post-construction. The amenity limit of 2 mm/s may be exceeded at up to 62 dwellings within 170 m. If piles are not driven to refusal, the levels of vibration will be lower and fewer dwellings affected.

9 Applicability

This report has been prepared for the exclusive use of our client Auckland Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

We understand and agree that our client will submit this report as part of an application for resource consent and that Auckland Council as the consenting authority will use this report for the purpose of assessing that application.

Tonkin & Taylor Ltd
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Appendix A Glossary

Term	Definition
dB	A unit of measurement on a logarithmic scale which describes the magnitude of sound pressure with respect to a reference value (20 µPa)
$L_{Aeq(t)}$	The A-weighted time-average sound level over a period of time (t), measured in units of decibels (dB)
L_{WA}	Sound power level
PPV	Peak particle velocity. This is the instantaneous maximum velocity reached by the vibrating surface as it oscillates about its normal position
Noise	Unwanted sound

Every 10 dB increase in sound level doubles the perceived noise level. A sound of 70 dB is twice as loud as a sound level of 60 dB and a sound level of 80 dB is four times louder than a sound level of 60 dB. An increase or decrease in sound level of 3 dB or more is perceptible. A change in sound level of less than 3 dB is not usually discernible.

As sound level is measured on a logarithmic scale, the following table provides examples of typical sources of noise.

Decibel (dB)	Example
0	Hearing threshold
20	Still night-time
30	Library
40	Typical office room with no talking
50	Heat pump running in living room
60	Conversational speech
70	10 m from edge of busy urban road
80	10 m from large diesel truck
90	Lawn mower - petrol
100	Riding a motorcycle at 80 kph
110	Rock band at a concert
120	Emergency vehicle siren
140	Threshold of permanent hearing damage

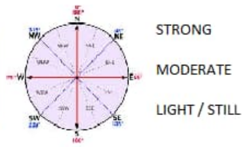
Appendix B Vibration buffers

SITE EROSION & SEDIMENT CONTROL INSPECTION CHECKLIST

Site: Harania Tennessee Bridge **Project No:** 1017033.2002

Inspection by: …………………………………………………… **Date:** ………………… **Time:** ………………

Current Weather Condition: (circle) **Wind Direction / Conditions**



Area Inspected (tick)**:** ☐ Cleanfill ☐ Clay extraction ☐ Other (please specify):

……………………………………………………………

ITEM / SCOPE OF INSPECTION	(circle)	COMMENTS
EROSION & SEDIMENT CONTROL		
- Are there any signs of scour at the piped outlet into the receiving environment?	Y N N/A	
- Does the visual appearance of the water in the receiving environment appear overly turbid or otherwise?	Y N N/A	
- Is there any evidence of uncontrolled dirty water discharge from the site?	Y N N/A	
- Is there any visible discolouration of waters leaving the site?	Y N N/A	
- Are there any rips, tears or holes over the length of silt fence fabric?	Y N N/A	
- Is there damage to silt fence waratahs and returns from machinery?	Y N N/A	
- Are previous repair to rips, tears and holes in silt fence fabric forming tight seal?	Y N N/A	
- Is the bottom edge of the silt fence fabric trenched in the required depth?	Y N N/A	
- Is the minimum height of the silt fence maintained?	Y N N/A	
- Are there bulges due to silt build ups? Has silt build up reached 50% of the fence height? Is so, de-silt is required.	Y N N/A	
- Has the silt fence fabric degraded or collapsed? If so, replace immediately.	Y N N/A	
- Has the area been appropriately stabilised where silt fence has been removed?	Y N N/A	
Are the catchment areas above clean water diversions maintained as clean?	Y N N/A	
Is the stabilised entrance needing maintenance to ensure the surface remains clean?	Y N N/A	

RECOMMENDATIONS			
Priority (H/M/L)	**Action**	**By whom**	**By when**

Reviewed and Accepted by **Date:**...............................

………

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