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WHENUAPAI REDHILLS WASTEWATERS SERVICING SCHEME (PACKAGE 1) CONSTRUCTION NOISE & VIBRATION REVIEW

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Project: **WHENUAPAI REDHILLS WASTEWATERS SERVICING SCHEME (PACKAGE 1)**
CONSTRUCTION NOISE AND VIBRATION REVIEW

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SUMMARY

We have predicted noise and vibration levels at the nearest buildings to the proposed construction of the Whenuapai Redhills Wastewaters Servicing Scheme (Package 1).

We recommend the implementation of a Construction Noise and Vibration Management Plan (CNVMP) to manage the noise and vibration effects of the construction activity. In addition management and mitigation measures have been recommended where practicable including the erection of an acoustic screen along the boundary of the northern laydown area with 18 Brigham Creek Road.

We predict compliance with the noise and vibration limits for the majority of the planned construction activities along the route. The noise limits may be exceeded by 5 decibels or more at 1 m from a building on the following properties during the following activities:

- 13, 17 Spedding Drive – construction of trench

The source of the noise exceedance at all the identified dwellings is vibro sheet piling associated with the construction of trenches in the rising main section.

The preferred method for the laying of pipes in open trenches is to use trench shields for shoring of the trenches. In some areas this may not be practicable, and the sheet piling would be used for that section (in areas south of Brigham Creek Road only). In this instance we recommend that temporary acoustic screening be used to screen the piling activity. Piling would occur for short periods of less than 10 days and would only occur during the daytime.

We consider that the acoustic effects could be managed appropriately using the CNVMP.

Vibration levels are predicted to comply with the cosmetic limits at all buildings. The Auckland Unitary Plan amenity limit may be exceeded for a short period, but the exceedance would be within the permitted 3 day period.

In conclusion we consider that the noise and vibration effects can be managed to be reasonable using the protocols in a CNVMP.

1 INTRODUCTION

Watercare proposes to install a new wastewater pipeline and pump station as part of the Whenuapai Redhills Wastewater Servicing Scheme.

The Whenuapai Redhills: Package 1 Project (the Project) aims to provide wastewater servicing capacity for approximately 10,240 dwellings, or 30,720 people, in the Whenuapai catchment. This growth is projected to occur by 2041.

The Project includes the following four key components (see Figure 1):

1. A **Pump Station** at a point where the Whenuapai and Redhills Catchments meet at 23-27 Brigham Creek Road
2. A **Gravity Main Pipeline** (approximately 700m long and 375 – 475 mm in diameter) between Whenuapai Village pump station on Tamiro Road and the new pump station
3. A **Rising Main** (approximately 1.4km long and 500 mm in diameter) between the Pump Station and a proposed new break pressure chamber on Mamari Road (the boundary of Package 2)[1].
4. A **Culvert** (approximately 63 m long including wing wall and rip rap) to provide for access for the rising main across Sinton Stream.
5. A **Break Pressure Chamber** which connects to the Massey Connector rising main (proposed under Package 2).

The Project extends from the existing Whenuapai Village pump station site in Tamiro Road in the north, across Brigham Creek Road, to Spedding Road in the south.

Figure 1: Whenuapai Redhills Project

2 CONSTRUCTION SEQUENCE, METHODOLOGY, AND PROGRAMME

The works would include the following activities

- Construction of three contractor staging areas: Contractor Area Hub (main yard and hub); Contractor Area North (staging for gravity main alignment); Contractor Area South (staging for rising main alignment including stockpiling area).
- Rising Main construction from the pump station to the pressure break chamber: utilising an open cut method and construction of a 63 m long culvert (including wingwall and rip rap) over Sinton Stream.
- Gravity Main construction from Whenuapai Village to the Slaughterhouse pump station utilising an open cut method with a trenchless pipe installation beneath Brigham Creek Road and underneath the Tamiro Road stormwater pond embankment at the northern end of the alignment
- Pump Station construction including excavation for inlet chambers, installation of tanks and construction of the pump building
- Break pressure chamber including the excavation of a reception pit and the installation of storage tanks.

Refer Figure 1 showing the alignment.

2.1 Proposed work programme

The construction programme would take approximately 21 months to complete with an additional period of 4.5 months for completion of contract documentation (when construction noise would be minimal). To achieve the timeframe, three separate projects would be undertaken in parallel: construction of rising main, gravity main and pump station. The location of these projects would mean that an individual dwelling is unlikely to receive noticeable accumulated noise from two or more separate work streams during construction. This is because the distance from a dwelling to the closest work stream is likely to be significantly less than that to the other concurrent activities. The increase in noise due to those activities would be no more than 2 decibels at most which is not subjectively noticeable.

It is understood that the principal construction hours would be 07:30 to 18:00 hours Monday to Saturday. Some works may be required outside these periods, but they would generally involve low noise activities. Night works have not been identified as critical at this stage.

The construction activities for each of the work stages that are likely to give rise to noise are highlighted below:

2.2 Construction and operation of laydown areas

Contractor staging areas would be located at three locations along the pipe route. The staging areas would be temporary for the construction activity only and would be decommissioned once the project has been completed. Noise generating activities at these sites would be:

- Site establishment – levelling and compaction of site
- Excavator and truck access to manage the spoil

2.3 Rising Main installation

2.3.1 Pipe installation

- Establish laydown area for stockpile of excavated material and bedding/backfill material at the Contractor Area (South): use of excavators and truck and trailers for material handling

- Removal of trees from the designation footprint including a large stand near Sinton Stream
- Construction of new temporary access road: use of bulldozers, excavators and rollers for compaction of hard fill
- Pipeline installation: excavation of trench through paved and unpaved roads and grassed paddocks, installation of pipe using mobile crane, refilling trench with material and compaction of the surface and reinstatement. Piling may be required to shore the sides of trench where the use of trench shields is not practicable.
- Construction of manholes and air valve chambers

2.3.2 Construction of Sinton Stream Culvert

A culvert is to be constructed for the pipe and Sinton Stream. The construction methodology would be similar to open cut trenching with the addition of a mobile crane to place the concrete sections into position. Sheet piles will be used for the stream diversion, and these will be installed using vibro piling.

The site would not impede any other activities so the construction process would occur during daytime.

2.4 Gravity Main Installation

The gravity main pipe installation process will be similar to the rising main installation using an open cut trenching method through grassed paddock areas. However, sheet piling will not be required north of Brigham Creek Road.

The crossing of Brigham Creek Road and the last section of the pipeline to the reception pit of the Whenuapai Village pump station will be constructed using trenchless methods as outlined in Sections 2.4.1 and 2.4.2 below.

In addition, construction of the last section of pipe between the Tamiro Road Stormwater Embankment reception pit at existing SSMH 2696093, and the existing manhole 2695980, will be undertaken by open trenching. This will include the use of a concrete saw and concrete breaking to break through the existing concrete slab for approximately 2 half days.

2.4.1 Brigham Creek Crossing

- Construction of driving and reception shaft either side of Brigham Creek Road: use of vibro-piling to shore trench sides of drive shaft at 23-27 Brigham Creek Road, and excavator to create the two shafts

Pipe installation: drive the pipe from drive to reception shaft using a hydraulic "pipe hammer" (

- Figure 2 and Figure 3). Use of de-watering sump pumps to keep the shafts dry

Figure 2: Picture of drive shaft with pipe hammer

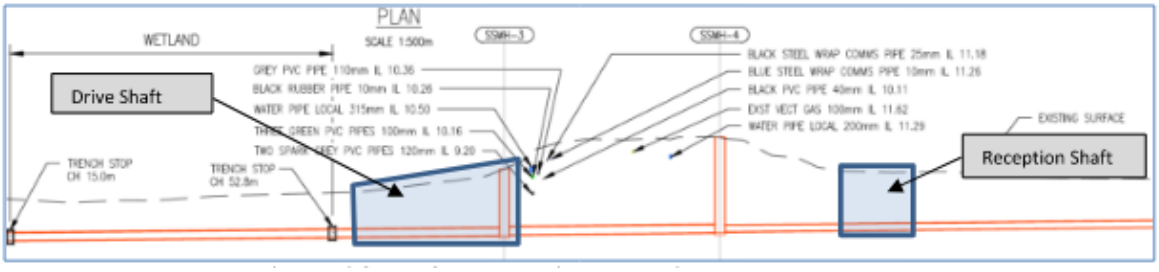


Figure 3: Picture of a pipe hammer launch shaft

Figures courtesy of Brian Perry

2.4.2 Tamiro Road Stormwater Pond Embankment

- Construction of pipe drive and reception shaft: use of excavators and concrete pump to make shaft for pipe drilling rig
- Pipe drilling: shaft constructed using drilling rig and then pipe to be pushed through to reception shaft. Concrete pump to be used to case chamber corbels in situ around the pipe.
- Temporary haul road: construction of a temporary haul road.

If the trenchless option underneath the Tamiro Road Stormwater Pond Embankment fails due to poor ground conditions, then an open trench method will be deployed.

2.5 Slaughterhouse pump station

- Mitigate the dewatering effect: 5m deep sheet piling at the northern boundary of the pump station works area
- Inlet chambers, wet wells, deep piping, storage tanks and connections: bored piling for the pump station, use of excavators and trucks to remove approx. 9,000 m^3 of material. Dewatering facilities and water treatment would be used during excavation.
- Construction of pump station: use of general construction techniques with mobile cranes to manoeuvre equipment and vessels.

2.6 Break pressure chamber

- Construction of chamber using a secant piled shaft which would subsequently be excavated out.
- Installation of a concrete base slab to be used as a tunnel boring machine (TBM) launch site for the tunnel to be constructed as part of the Whenuapai – Redhills Package 2 works, with

the chamber serving as the jacking pit for the TBM and all of the TBM service machinery operating once constructed.

- Once the tunnel is constructed the chamber lining would be installed, piping connections completed, and precast lids placed. The site would then be rehabilitated

3 NEARBY RECEIVERS

A general overview of the nearby receivers is given in overleaf. All properties and buildings are zoned and *Residential* and *Future Urban Zone* in the Auckland Unitary Plan (**AUP**).

Figure 4: Figure showing the proposed pipeline and nearest receivers

4 PERFORMANCE STANDARDS

Construction noise and vibration performance standards are given in Standard E25.6.27 and E25.6.30 respectively of the AUP. For works within the road, additional rules apply and are given in Standard E25.6.29. Sections that are within the road reserve are shown in Figure 5.

Figure 5: Figure showing sections within the road reserve

Courtesy of Beca – Detail from figure Whenuapai WW Servicing Scheme (Drawing No: GIS3180000-3)

4.1 For works outside the road

4.1.1 Noise limit for the pipe installation is 75 dB L_{Aeq}

Given that the works to install pipe will not be in one location for the entire 16 months, we consider that it would be acceptable to use the typical duration noise limits (for activities between 14 days and 20 weeks) for this activity. The relevant construction noise limits are summarised in Table 1.

The noise limits apply at 1m from external façades of occupied buildings and must be measured and assessed in accordance with the provisions of New Zealand Standard NZS 6803:1999 "*Acoustics - Construction Noise*".

Table 1: Construction noise levels for activities sensitive to noise[1] (e.g. occupied dwellings)

Time of week	Time period	dB L_{Aeq}	L_{AFmax}
Weekdays and Saturdays	0730 – 1800	75	90
Weekdays	0630 – 0730	60	75
	1800 – 2000	70	85
Sundays and public holidays	0730 – 1800	55	85
All other times		45	75

[1] Activities sensitive to noise are defined as '*Any dwelling, visitor accommodations, boarding house, marae, Papakainga, integrated residential development, retirement village, supported residential care, care centres, lecture theatres in tertiary education facilities, classrooms in education facilities and healthcare facilities with an overnight stay facility*'.

4.1.2 Noise limit for contractor staging areas and pump station construction is 70 dB L_{Aeq}

The contract staging areas would be present for the full construction period; we, therefore, consider that the long-term construction noise limits (for activities with durations of more than 20 weeks) shall apply as given in Table 2.

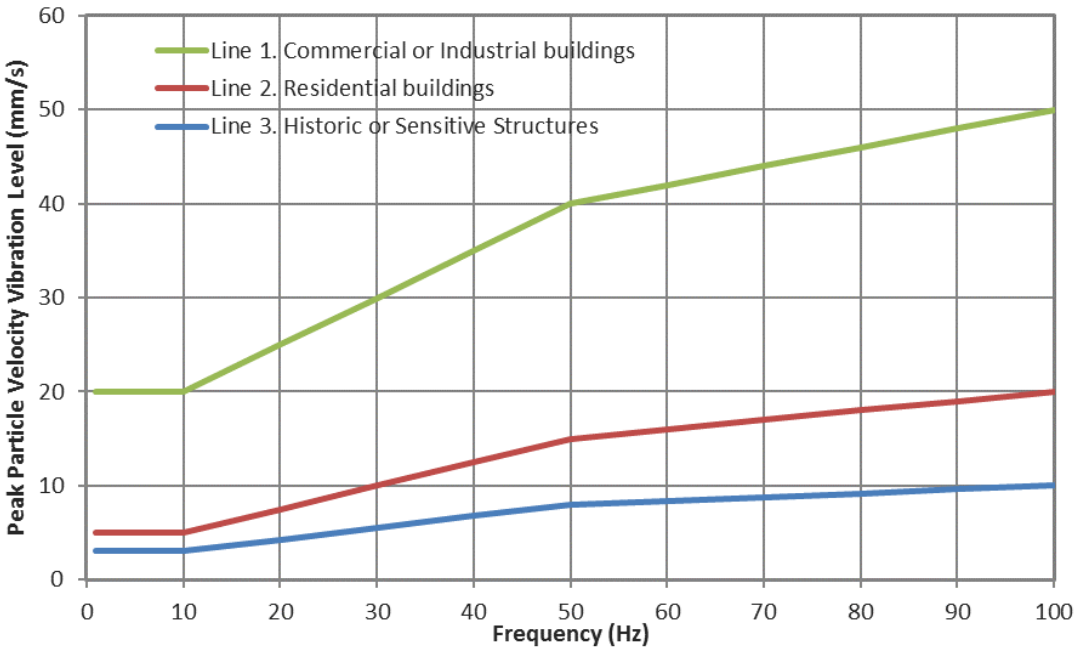
Table 2: Construction noise levels for activities sensitive to noise (e.g. occupied dwellings)

Time of week	Time period	dB L_{Aeq}	L_{AFmax}
Weekdays and Saturdays	0730 – 1800	70	85
Weekdays	0630 – 0730	55	70
	1800 – 2000	65	80
Sundays and public holidays	0730 – 1800	50	80
All other times		45	75

4.1.3 Vibration limits to protect against cosmetic building damage

Standard E25.6.30 (1) (a) refers to the German Standard DIN 4150-3:1999 "*Structural vibration – Part 3: Effects of vibration on structures*" to control construction vibration. The short-term (transient)[2] vibration limits in Figure 6 apply at building foundations in any axis. The vibration limits in all other cases are summarised in Table 3.

Figure 6: Short-term (transient) vibration at building foundations (DIN 4150-3 1999: Figure 1)



[2] Short-term (transient) vibration is "*vibration which does not occur often enough to cause structural fatigue and which does not produce resonance in the structure being evaluated*"

Table 3: Vibration at horizontal plane of highest floor (DIN 4150-3 1999: Tables 1 and 3)

Structure Type	Peak Particle Velocity Vibration Level (mm/s)	
	Short-term (transient)[1]	Long-term (continuous)[3, 4]
Line 1. Commercial buildings (such as sheds)	40	10
Line 2. Residential buildings/greenhouses	15	5

The criteria relate to the avoidance of cosmetic building damage, such as cracking in paint or plasterwork. Cosmetic building damage effects are deemed 'minor damage' in the Standard and can generally be easily repaired. The cosmetic building damage thresholds are much lower than those that would result in structural damage. The Standard states: "*Experience has shown that if these values are complied with, damage that reduces the serviceability of the building will not occur*."

4.1.4 Vibration limits to protect amenity

Standard E25.6.30 (1) (b) sets the amenity vibration limits to avoid adverse effects from construction vibration lasting for more than three days in one location (Table 4). They apply in any axis when measured in the corner of the floor of the storey of interest for multi-storey buildings, or within 500mm of ground level at the foundation of a single storey building.

Table 4: Vibration amenity at horizontal plane of floor level of interest (modified from AUP Table E25.6.30.(1)

Receiver	Period	Peak Particle Velocity Vibration Level (mm/s)
Occupied activity sensitive to noise	Daytime 0700 – 2200 hrs	2
Other occupied buildings	At all times	2

Where construction vibration from daytime works (0730 to 1800 hrs) is predicted to exceed 2mm/s PPV for no more than three consecutive days, the occupants of all buildings within 50m must be advised of the works no less than three days prior to the works commencing and the vibration level must not exceed 5mm/s for residential receivers (10mm/s for commercial receivers).

While the primary vibration concern is cosmetic building damage, people may be disturbed at levels significantly below the limits for cosmetic building damage in Section 4.1.3. British Standard BS 5228-2:2009 "*Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration*" provides the following guidance on the amenity effects of vibration:

- 0.14mm/s PPV Just perceptible in the particularly sensitive environments
- 0.3 mm/s PPV Just perceptible in normal residential environments
- 1 mm/s PPV Typically acceptable with prior notification
- 10 mm/s PPV Likely to be intolerable for any more than a very brief period

[3] Long-term (continuous) vibration includes types not covered by the short-term vibration definition

[4] The long-term (continuous) criteria can apply at all floor levels, but levels are normally highest at the top floor

4.2 For works within the road

4.2.1 Noise is exempt from complying provided a CNVMP is prepared

The following specific rules for works within the road apply:

1. E25.6.29 (1) states that noise from any construction, maintenance and demolition activities in the road must comply with the noise limits in Table 1
2. E25.6.29 (2) states that noise levels specified in E25.6.29 (1) does not apply to planned works in the road between the hours of 2200 and 0700 hrs where:
    1. The number of days where the noise generated by the works exceeds the Table 1 at any one receiver is 3 days or less, or;
    2. The works cannot practicably be carried out during the day or because the road controlling authority requires this work to be done at night
    3. The nature of the works and proximity to receivers means that the noise generated cannot practicably be made to comply with Table 1, or;
3. E25.6.29 (3) states that the noise levels specified in E25.6.29 (1) does not apply to planned works in the road between 0700 – 2200 hrs where:
    1. The number of days where the noise generated by the works exceeds the Table 1 at any one receiver is 10 days or less, or;
    2. The nature of the works and proximity to receivers means that the noise generated cannot practicably be made to comply with Table 1, or;
4. Both E25.6.29 (2) and E25.6.29 (3) require:
    1. 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 five days prior to work commencing, or;
    2. For planned works where the works take more than 8 hours to complete, a CNVMP is provided to the Council no less than five days prior to the works commencing in accordance with the applicable provisions of E25.6.29 (5)
5. E25.6.29 (5) states that a CNVMP must be prepared by a suitably qualified and experienced person and provides guidelines for what must be included

Our predictions show that in some instances, the nature of the works and proximity to receivers means that the noise generated cannot practicably be made to comply with E25.6.29 (1). Therefore, this report may be used as a draft CNVMP to satisfy E25.6.29 (3).

4.2.2 Vibration is exempt from complying with amenity limits provided a CNVMP is prepared

The following specific rules for works within the road apply:

6. E25.6.29 (1A) states that vibration from any construction, maintenance and demolition activities in the road must comply with the relevant vibration levels in:
    1. Standard E25.6.30 (1) (a) and
    2. Standard E25.6.30 (1) (b)
7. E25.6.29 (4A) states that the vibration levels specified in E25.6.29 (1A) (b) do not apply to planned works provided that the works access permit and a CNVMP, in accordance with E25.6.29 (5), is provided to Council no less than five days prior to the works commencing

5 CONSTRUCTION ASSESSMENT

5.1 Indicative construction noise levels

In general, most of the plant can comply with the noise limits with mitigation, except for where the vibro installation of sheet piling is required.

Table 5 presents the typical operating sound power levels of assumed equipment required for this Project. We have predicted noise levels at 1m from a façade at various distances from the works. The distances specified have been calculated without mitigation in place, shielding provided by natural terrain or consideration for duration of activities. The predictions are, therefore, considered to be conservative.

The indicative noise levels for the equipment assumed have been sourced from our database of measured noise sources or BS 5228-1:2009 "*Code of practice for noise and vibration control on construction and open sites Part 1: Noise*". This list is not exhaustive and forms the basis of the assessment.

Table 5: Indicative construction noise levels at 1m from the facade with effective mitigation

Equipment	Sound Power	Façade Noise Level (dB L_{Aeq})				Limit Setback (m)	
	(dB L_{WA})	10m	15m	30m	50m	75dB L_{Aeq}	45dB L_{Aeq}
Open Cut Trenching (Strip surface, excavate trench, lay pipe, backfill, reinstate surface)							
Concrete/rock breaker (20-30T)	121	86	82	76	71	33	>100
Vibro piling[1, 2]	116	91	87	81	76	52	>100
Pavement saw	115	90	86	80	85	50	>100
Concrete cutting	115	80	76	70	65	18	>100
Plate compactor	108	73	69	63	58	8	>100
Haul truck	106	81	77	71	76	20	>100
20T excavator	103	78	74	68	63	15	>100
7T vibratory roller	103	78	74	68	63	15	>100
PE pipe welding machine	101	76	72	66	61	10	>100
Mobile Crane (35T) operating	98	73	69	63	58	8	>100
Mobile Crane (35T) idling	88	63	59	53	48	2	80
Trenchless installation (excavate trench, carry out drilling, backfill)							
Vibro piling[1, 2]	116	91	87	81	76	52	>100
Pipe hammer	110	85	81	75	70	32	>100
Plate compactor	108	73	69	63	58	8	>100
20T excavator	103	78	74	68	63	15	>100
Concrete truck + pump	103	68	64	58	53	4	>100

Drilling rig hydraulic power pack	102	77	73	67	62	13	>100
Dewatering pump	97	72	68	62	57	7	>100
Tamiro Road stormwater pond embankment trenchless installation (excavate trench, use TBM, backfill)							
TBM	108	83	79	73	68	25	>100
20T excavator	103	78	74	68	63	15	>100
Concrete truck + pump	103	68	64	58	53	4	>100
Mobile Crane (35T) operating	98	73	6	53	58	8	>100
Culvert construction							
Vibro piling[1]	116	91	87	81	76	52	>100
Concrete truck + pump	103	68	64	58	53	4	>100
Mobile Crane (35T) operating	98	73	6	53	58	8	>100
Slurry treatment							
Mud cleaning machine	103	88	84	78	73	15	>100
Generator/power pack	97	82	78	72	67	7	>100
Vibro screen shaker table	91	76	72	66	61	3	100
Slurry pump	93	78	74	68	63	5	>100
Contractor staging area						**70dB L_{Aeq}**	**45 dB L_{Aeq}**
Excavator	103	78	74	68	63	25	>100
Truck	106	81	77	71	66	35	>100
Pump station construction							
Vibro piling[1]	116	91	87	81	76	100	>100
Bored piling	111	76	72	66	61	11	>100
Truck	106	81	77	71	66	35	>100
Excavator	103	78	74	68	63	25	>100
Concrete truck + pump	103	68	64	58	53	4	>100
Mobile Crane (35T) operating	98	73	69	63	58	14	>100
Dewatering pump	97	72	68	62	57	12	>100
Break pressure chamber							
Secant piling	110	85	81	75	70	50	>100
Concrete truck + pump	103	68	64	58	53	4	>100

Mobile Crane (35T) operating	98	73	6	53	58	15	>100

NOTE [1] It is assumed that vibro piling is the preferred method for installing the sheet piles

[2] No vibro piling is required north of Brigham Creek Road

5.2 Predicted noise emission

The worst case (60 minute) predicted noise levels at the nearest potentially sensitive dwellings are given in the following table. These levels are also compared with the compliance noise limits. Those shown in green are predicted to comply with the relevant noise limits. All other noise levels exceed the relevant noise limits by varying degrees.

Table 6: Potentially affected receivers

Receiver	Activity						
	Contractor staging	Trenching (trench shield)	Trenching (sheet piling[2])	Trenching (concrete breaking[3])	Trenchless	Pump station	Break pressure chamber
Sound power	107 dB L_{WA}	108 dB L_{WA}	116 dB L_{WA}	121 dB L_{WA}	116 dB L_{WA}	116 dB L_{WA}	110 dB L_{WA}
28 Joseph McDonald Drive	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<70dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}
30 Joseph McDonald Drive	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<70dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}
2 Tamiro Road	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<70dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}
40 Tamiro Road	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<70dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}
42 Tamiro Road	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<70dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}
46 Tamiro Road	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<70dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}
107 Whenuapai Drive	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<70dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}
18 Brigham Creek[1] Road	<70 dB L_{Aeq}	75 dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}
26 Brigham Creek Road	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}
31 Brigham Creek Road	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}
5 Spedding Road	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}
6 Spedding Road	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}
9 Spedding Road	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}
10 Spedding Road	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}
11 Spedding Road	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}

Receiver	Activity						
	Contractor staging	Trenching (trench shield)	Trenching (sheet piling[2])	Trenching (concrete breaking[3])	Trenchless	Pump station	Break pressure chamber
13 Spedding Road	<70 dB L_{Aeq}	78 dB L_{Aeq}	86 dB L_{Aeq}	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}
14 Spedding Road	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}
19 Spedding Road	<70 dB L_{Aeq}	77 dB L_{Aeq}	85 dB L_{Aeq}	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}
15 Mamari Road	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}
32 Mamari Road	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<75 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}

NOTE [1] Acoustic screening will be erected to provide protection from works associated with contractor staging and trenchless activity

[2] Sheet piling required south of Brigham Creek Road only

[3] Concrete breaking only required at existing manhole 2695980 for 2 half days.

For the majority of the work activities, the highest predicted noise levels are associated with vibro piling of sheet piles for temporary shoring of the open cut trench. It should be noted that if the preferred method of using trench-shields can be utilised and piling is not required, the construction noise levels would reduce by 6 decibels. Construction noise would then comply with the noise standards for all buildings.

5.3 How are these noise levels experienced?

The noise level received inside a noise sensitive space (e.g. office or living room) will depend on the external noise level, sound insulation performance of the façade (particularly the glazing) and room constants (such as the room dimensions and surface finishes). These factors can vary widely.

The Construction Noise Standard (NZS 6803) recommends noise limits assessed at 1m from the external façade of a building, assuming a façade sound level difference of 20 decibels. However, 20-decibels is particularly conservative for modern buildings. With knowledge of the façade glazing type, the sound insulation performance can generally be estimated as follows:

- Sealed glazing 30 decibels façade sound level difference
- Openable windows (closed) 20 – 25 decibels façade sound level difference
- Open windows 15 decibels façade sound level difference

Table 7 sets out the likely internal noise levels in neighbouring buildings.

Table 7: Daytime noise levels in habitable rooms in dwellings

External Noise Level (dB L_{Aeq})	Estimated Internal Noise Level (dB L_{Aeq})			
	Sealed glazing (modern building)	Closed windows (modern building)	Closed windows (older building)	Open windows (all buildings)
80 – 85	50 – 55	55 – 60	60 – 65	65 – 70
75 – 80	45 – 50	50 – 55	55 – 60	60 – 65

External Noise Level (dB L_{Aeq})	Estimated Internal Noise Level (dB L_{Aeq})			
	Sealed glazing (modern building)	Closed windows (modern building)	Closed windows (older building)	Open windows (all buildings)
70 – 75	40 – 45	45 – 50	50 – 55	55 – 60
65 – 70	35 – 40	40 – 45	45 – 50	50 – 55

Table 8 provides guidance on the potential daytime noise effects inside buildings based on the predicted external noise levels and the façade glazing type. Assuming advanced communication of the works and their duration, the residual noise effects are summarised as follows:

Table 8: Subjective response to internal noise levels

Internal noise level	Likely subjective response
< 45 dB L_{Aeq}	Noticeable, but unlikely to interfere with daily activities
45 – 50 dB L_{Aeq}	Typically acceptable, but concentration and communication would begin to be affected
50 – 55 dB L_{Aeq}	Annoyance for some occupants, personal conversations would require slightly raised voice
55 – 60 dB L_{Aeq}	Generally unacceptable, occupants would actively seek respite for any extended periods
> 60 dB L_{Aeq}	Unacceptable for extended periods

The above means that during vibro piling of the sheet piles, noise levels for neighbouring buildings within 30 m of the activity would be at a level that may cause annoyance. These are:

- 13 Spedding Drive
- 17 Spedding Drive

The use of temporary acoustic screening (Section 6.1), if practicable, would reduce the piling noise at all receiver locations to within the recommended noise limits. In order for the screening to be effective it must provide visual screening from the receiver to the source.

Other management options to reduce the acoustic effects are discussed in the following sections.

The noise effects at the identified dwellings are considered in the following sections.

5.3.1 18 Brigham Creek Road

The dwelling at this site is close to the Contractor Staging area, pump station construction and trenchless reception area for the trenchless construction of the main beneath Brigham Creek Road. The noise level for compacting the open cut trench are predicted to remain under the noise limit only if applying an acoustic screen along the boundary of the North Laydown Area. It is noted that the property is also close to Brigham Creek Road itself and ambient levels in the vicinity of the house are likely to reach 70 dB L_{Aeq}.

After applying the acoustic screen, the construction noise for most noisy activities would only be just noticeable at the dwelling. The acoustic effects at this dwelling are considered to be reasonable.

5.3.2 Spedding Road dwellings

Most buildings within 30 m of the designated route along Spedding are considered to be uninhabited and not noise sensitive. Two dwellings have been identified within the 30 m contour at 13 and 17-19 Spedding Road.

The preferred construction methodology for the open trenching along Spedding Road is with the use of trench-shields. The predicted noise at the dwellings from the use of trench-shields would comply

with the noise standards. Only where the use of trench shields is impracticable, sheet piling will be required, and the noise is predicted to exceed the limits.

Any exceedance is likely to occur for no more than 3 days and temporary acoustic screening will be erected where practicable. The acoustic effect is likely to be annoying for any persons within 30 m of the piling activity but given the very brief period of exceedance and, as it will only occur when it is not possible to use the preferred method, the effect is considered reasonable with the implementation of the management plan.

5.4 Indicative Vibration

In general, there is no risk of cosmetic damage of any building along the project works.

Table 9 provides indicative construction vibration levels for proposed activities that have the potential to result in vibration in building structures. Note, it applies the long-term limits which are more conservative. It should be used by the Project Manager (or nominated person) prior to construction to inform what equipment will require mitigation and/or management and when. It should be kept up to date by the Acoustic Specialist when new information becomes apparent through vibration monitoring (Section 8.3) or other means.

Table 9: Indicative distances to comply with vibration limits at building foundations

Equipment	Amenity Setback (m)		Cosmetic Building Damage Setback (m)	
	AUP night 0.3 mm/s PPV	AUP day 2 mm/s PPV	Residential 5 mm/s PPV	Farm Building 10 mm/s PPV
Vibro-sheet piling	>100	43	11	4
Vibratory roller	>100	38	14	6
Compactor	23	5	3	2
Trenchless drilling	30	10	4	2

While the primary vibration concern is typically cosmetic building damage (Section 4.1.3), people may be disturbed at significantly lower levels (Section 4.1.4). Potentially affected parties should be informed about the vibration levels they may experience, and assured vibration damage can only occur at magnitudes well above the threshold of perception (Section 4.1.4).

It should be noted though that whilst the vibration levels of the vibro sheet piling and roller may exceed the AUP amenity level, this would only occur for a short period (ie. less than 3 consecutive days) which is permitted by the vibration rules provided notice is given to any occupied buildings within 50 m of the activity.

No construction activities have been identified that could give rise to exceedance of the cosmetic building damage limits.

6 MITIGATION AND MANAGEMENT

6.1 Acoustic Screening

Acoustic screening can be used to reduce noise effects for both long-term construction areas (contractor staging areas and trenchless pits and pump station construction) and short-term pipe trenching works such as sheet piling. We recommend noise barriers to be used where practicable for activities predicted to exceed the construction noise limits (Section 5.1). They should be installed prior to works commencing and maintained throughout the works. Effective noise barriers typically reduce the received noise level by 10 decibels.

Where practicable, the following guidelines should be incorporated in the design and utilisation of temporary noise barriers:

- The panels will be constructed from materials with a minimum surface mass of 6.5 kg/m^2. Suitable panels include 12 mm plywood or the following proprietary 'noise curtains':
  - Hushtec 'Noise Control Barrier - Performance Series' (www.duraflex.co.nz)
  - Soundex 'Acoustic Curtain - Performance Series' (www.ultimate-solutions.co.nz)
  - Flexshield 'Sonic Curtain with 4 kg/m^2 mass loaded vinyl backing' (www.flexshield.co.nz)
  - Alternatives will be approved by a suitably qualified acoustic specialist because some proprietary noise curtains have insufficient surface mass for general use
- The panels will be a minimum height of 2m, and higher if practicable to block line-of-sight
- The panels will be abutted or overlapped to provide a continuous screen without gaps at the bottom or sides of the panels
- The panels will be positioned as close as practicable to the noisy construction activity to block line-of-sight between the activity and noise sensitive receivers.

6.2 Training

All staff will participate in an induction training session prior to the start of construction, with attention given to the following matters:

- Construction noise and vibration limits
- Activities with the potential to generate high levels of noise and/or vibration
- Noise and vibration mitigation and management procedures
- The sensitivity of receivers and any operational requirements and constraints identified through communication and consultation
- All operators of tracked machinery must be skilled and through the toolbox sessions made aware of the need to operate the machine in a manner that minimises vibration effects. This includes very slow tracking with no abrupt direction changes; careful operation during excavation to avoid impacts with the ground; and any unnecessary banging or impacts of the bucket or attachment
- Awareness of current noise and vibration matters on, or near active worksites, will be addressed during regular site meetings and/or 'toolbox' training sessions.

6.3 Equipment Selection

When selecting construction equipment, where practicable:

- Prioritise quieter construction methodologies (e.g. bored piling instead of drop hammer piling)
- Prioritise electric motors over diesel engines

- Prioritise rubber tracked equipment over steel tracked equipment
- Equipment should be suitably sized for the proposed task
- Equipment should be maintained and fitted with exhaust silencers and engine covers
- Avoid tonal reversing or warning alarms (suitable alternatives may include flashing lights, broadband audible alarms or reversing cameras inside vehicles)

6.4 General Measures

Complaints can arise whether or not noise and vibration levels comply with the Project limits. To avoid complaints, general mitigation and management measures include, but are not limited to, the following:

- Use of temporary acoustic screening where practicable
- 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
- Avoid steel on steel contact such as during the loading of scaffolding on trucks
- Avoid high engine revs through appropriate equipment selection and turn engines off when idle
- Maintain site accessways and construction yards to avoid potholes and corrugations
- Mitigate track squeal from tracked equipment, such as excavators (may include tensioning and watering or lubricating the tracks regularly)
- Minimise construction duration near sensitive receivers
- Stationary equipment (e.g. generators) should be located away from noise sensitive receivers and site buildings and material stores used to screen them
- Orient mobile machinery to maximise the distance between the engine exhaust and the nearest sensitive building façade (e.g. excavators)
- Implement specialised mitigation measures for sheet piling (Section 6.5) and vibratory rollers (Section 6.6)
- Ensure communication is completed (Section 6.0) prior to commencing activities that are predicted to exceed the noise and vibration performance standards (Section 4)
- Undertake monitoring as appropriate (Section 8)

Advisory Note: The best practicable option shall be adopted to ensure that noise and vibration do not exceed a reasonable level with respect to s16 of the Resource Management Act 1991. This is required irrespective of compliance with relevant limits.

6.5 Specific Measures: Vibratory Sheet Piling

Vibratory sheet piling may be required to shore up trenches. We predict that there will be exceedances of the daytime noise limit of 75 dB L_{Aeq}. The following measures shall be adopted:

- Communication (via the CNVMP protocols - refer to Section 6.8) shall occur with the owners / occupiers identified in Section 5.2 prior to works commencing
- Scheduling the works so that it minimises effects on nearby receivers

6.6 Specific Measures: Vibratory Roller

For vibratory roller activities:

- Prioritise the use of static rollers over vibratory rollers, or switch off the vibration function within predicted safe setback distances (Section 5.4)
- Match the size of roller to the scale of the works (i.e. large enough to undertake the works efficiently, but avoiding oversized units)
- Match the vibration output to the scale of the works (i.e. combination of minimising the amplitude of the drum vibration and/or maximising the vibration frequency of operation)

6.7 Specific Measures: Concrete and Rock Breaking

- Minimise the amount of breaking needed (e.g. use a crushing shear or pulveriser attachment in place of a breaker, or use a cut and lift approach to enable breaking offsite)
- Match the size of breaker to the scale of the works. It should be large enough to carry out the work efficiently, but not over-sized (avoiding unnecessary noise and vibration)
- For concrete breaking, make an initial perimeter saw cut at the perimeter to reduce vibration transfer to nearby buildings
- Ensure effective noise mitigation is in place using noise barriers and enclosers and/or a breaker blanket (e.g. Hushtec 'breaker attachment' – www.duraflex.co.nz)
- Minimise the breaking period (e.g. remove larger boulders for breaking offsite), and/or the number of breaking periods (e.g. complete all breaking in one extended period rather than two shorter periods with the same overall duration)
- Match the chisel/tip type to the material and use a dampened bit to avoid ringing
- Avoid 'blank' firing by placing the chisel on the rock or concrete before starting, and minimising firing after it breaks through

6.8 Construction Noise and Vibration Management Plan

All appropriate mitigation and management are generally set out in a CNVMP, which would be used to manage works on site and sets out how the construction contractor interacts with the neighbouring affected parties.

The CNVMP should also include information set out in NZS6803:1999 in Section 8 and Annex E, and the requirements of the AUP:OP such as:

- Summary of noise and vibration standards;
- Summary of assessments/predictions;
- General construction practices, management and mitigation that will be used for the Project;
- Noise management and mitigation measures specific to activities and/or receiving environments, particularly for high noise and/or vibration activities, and all night-time works;
- Monitoring and reporting requirements;
- Procedures for handling complaints; and
- Procedures for review of the CNVMP throughout the works.

7 ENGAGEMENT

7.1 Communication

Written communication as per the accepted communications plan should be provided to occupiers of buildings within 50 m of works at least 1 week prior to the Project commencing. It should acknowledge that some activities are predicted to generate high noise and/or vibration levels that may result in disturbance for short periods. It should include details of the overall works, its timing, duration and contact details where complaints and enquiries should be directed.

Written communication during the works should include:

- Public site signage should include contact details
- Regular project updates should include details of impending activities that may result in disturbance, such as vibratory rollers. It should include scheduled timing and duration of these activities and contact details where complaints and enquiries should be directed.
- Occupants of buildings predicted to receive vibration levels exceeding 2mm/s PPV for more than three days should be advised at least three days prior to the works commencing (Section 4.1.4)

7.2 Consultation and Contingency Measures

Consultation should be undertaken with the receivers identified in Section 5.3 to address reasonable concerns about noise and / or vibration on a case-by-case basis. The Project Manager should address any concerns and complaints in accordance with Section 7.3. When discussing vibration concerns, it is important to convey that vibration can be felt at levels well below those that pose a risk of cosmetic building damage (refer Section 4.1.4). A copy of all correspondence should be made available to Council upon request.

The following process will be implemented by the Project Manager (or nominated person) for any construction activity measured to exceed the relevant construction noise and vibration performance standards:

- For exceedances of the construction vibration standards, activities should cease as soon as safe and practicable to do so
- Review the construction methodology, mitigation measures and management strategies to ensure they represent the BPO. This should consider affected parties' interests, practicability and material benefit of further measures, and implications to Project timing, duration and cost
- Undertake consultation with affected parties to understand their sensitivities, including times, activities and locations. Consultation should focus on a collaborative approach to managing the adverse effects from construction noise and vibration. A project representative should be contactable during works. A record of consultation should be kept at the site office and be available to the affected parties and Council if requested.
- Implement measures to avoid significant adverse effects as agreed with the affected party and monitor the activity to verify the extent of any adverse effects
- For exceedances of the construction vibration cosmetic building damage thresholds in Section 4.1.3, a detailed building condition survey will be undertaken (Section 8.4). If damage has not occurred, then that activity can continue provided the measured vibration level is not exceeded further and the construction methodology is the BPO. If damage has occurred, alternative construction methods should be investigated, and the consent holder should commit to repairing the damage within a reasonable timeframe.

- Temporary relocation should be considered for sensitive receivers where all practicable noise and vibration management and mitigation measures have been implemented and significant adverse noise effects are predicted. This will be in exceptional cases only, where ongoing noise and/or vibration effects cannot be mitigated.
- Works may only recommence when they can be demonstrated to comply with the project noise and vibration limits.

7.3 Complaints Response

All construction noise and/or vibration complaints should be recorded in a complaints file that is available to Council on request. For each complaint, an investigation should be undertaken involving the following steps as soon as practicable:

- Acknowledge receipt of the concern or complaint within 24-hours and record:
  - Time and date the complaint was received and who received it
  - Time and date of the activity subject to the complaint (estimated where not known)
  - The name, address and contact details of the complainant (unless they elect not to provide)
  - The complainant's description of the activity and its resulting effects
  - Any relief sought by the complainant (e.g. scheduling of the activity)
- Identify the relevant activity and the nature of the works at the time of the complaint
- Review the activity noise and/or vibration levels to determine if the activity is predicted to comply with the relevant performance standards (Section 4) at the complainants building. Consider addended monitoring to verify the underlying reference level assumptions.
- Review the mitigation and management measures in to ensure the activity represents the BPO. Review the relief sought by the complainant. Adopt further mitigation and management measures as appropriate.
- Review the potential residual effects of activities that are predicted to exceed the relevant performance standards (Section 5.1). Re-test noise levels to ensure compliance is achieved with Section 4.
- Report the findings and recommendations to the Project Manager, implement changes and update the CNVMP as appropriate
- Report the outcomes of the investigation to the complainant, identifying where the relief sought by the complainant has been adopted or the reason(s) otherwise.

In most cases, ceasing the activity would provide immediate relief. In some cases, this may not be practicable for safety or other reasons. The complainant shall be kept updated regularly during the time it takes to resolve the matter.

8 MONITORING

8.1 Overview

Attended monitoring enables measurement of noise and vibration levels, and review of the residual environment, nature of activities and application of the best practicable option measures (Section 6).

Attended monitoring will be undertaken for the first occurrence of activities that generate high noise and/or vibration levels close to receptor sites. The purpose is to validate the predicted levels in Section 5.2. Attended monitoring will also be undertaken in response to a reasonable complaint (Section 7.3).

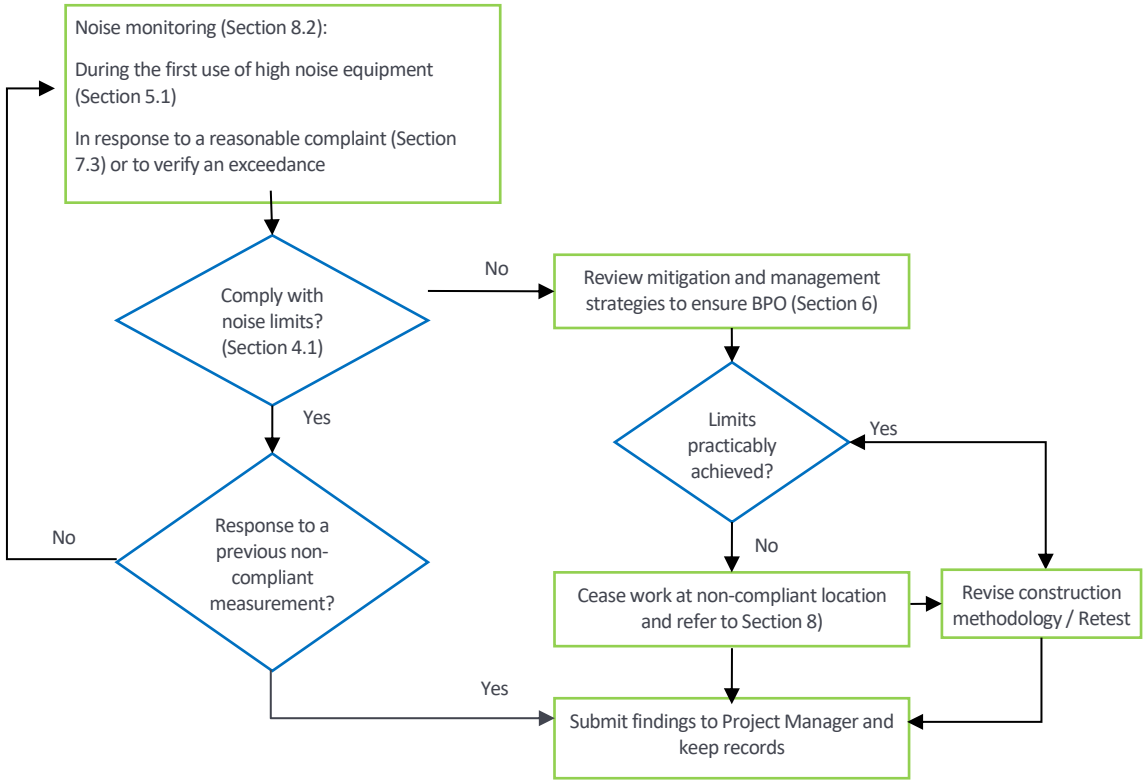
8.2 Noise

Construction noise levels should be monitored:

- During the first occurrence of activities that are predicted to exceed the noise limits (Section 4.1.1 and Section 4.1.2)
- In response to a reasonable noise complaint (Section 7.3)
- At 1m from the most affected building façade, or proxy position and adjusted for distance and façade reflections where appropriate
- By a suitably qualified and experienced specialist (e.g. Member of the Acoustical Society of New Zealand) in accordance with the requirements of New Zealand Standard NZS 6803: 1999 *"Acoustics - Construction Noise"*
- For a representative duration, reported with the measured level (e.g. 65 dB $L_{Aeq\ (30min)}$)
- The results should be used to update Section 5.1 if appropriate

A noise monitoring flowchart is presented in Figure 7.

Figure 7: Noise Monitoring Flow Chart



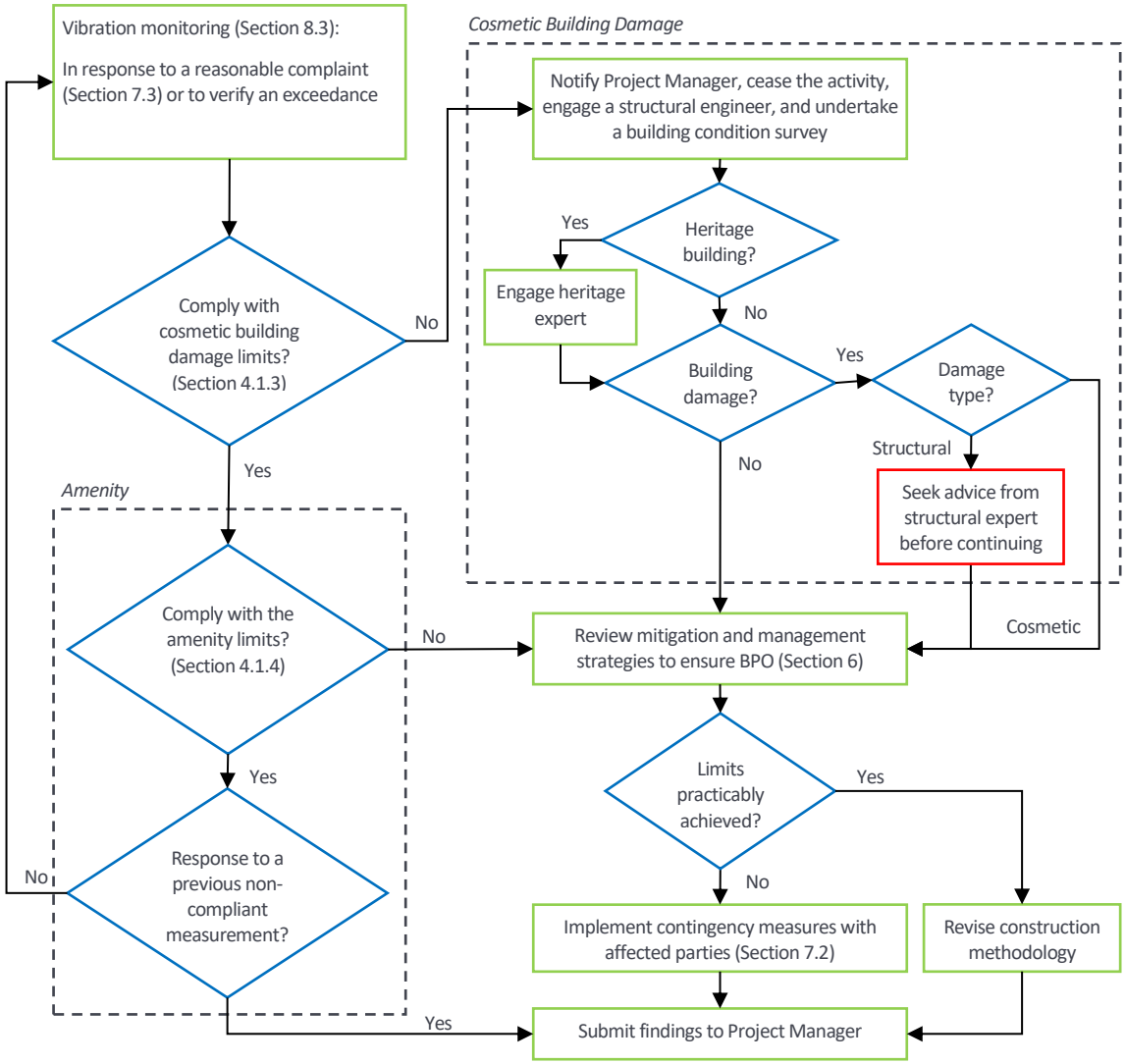
8.3 Vibration

Construction vibration is predicted to comply with the relevant performance standards. However, if a reasonable vibration complaint is received then the following monitoring strategy shall be implemented.:

- Measure at the closest building foundations and/or the top floor level as appropriate where consent to access the building of interest has been requested and granted
- By a suitably qualified and experienced specialist (e.g. Member of the Acoustical Society of New Zealand) in accordance the requirements of German Standard DIN 4150-3:1999 "*Structural vibration – Part 3: Effects of vibration on structures*"
- For a representative construction duration, measured in 2-second intervals
- The results should be used to update the predicted vibration compliance contours if appropriate

A vibration monitoring flowchart is presented in Figure 8.

Figure 8: Vibration Monitoring Flow Chart



8.4 Building Condition Surveys

If vibration monitoring shows that vibration levels have been measured to exceed the cosmetic limit of 5 mm/s PPV, we recommend that the following process be implemented before construction re-commences:

- Engage with the building owner and occupier to discuss the proposed construction activities and likely vibration effects;
- Undertake a building condition survey;
- Monitor vibration levels after re-commencing the activity.
- A follow-up building condition surveys will need to be undertaken after the activity has been completed. If any construction-induced damage were shown to have occurred as a result of Project construction activities, this should be remedied by the contractor.

9 CONCLUSION

We have predicted noise and vibration levels at the nearest buildings near the proposed construction of the Whenuapai Redhills Wastewaters Servicing Scheme (Package 1).

We predict compliance with the noise and vibration limits for the majority of the planned construction activities along the route. Buildings on the following properties may exceed the noise

- 13 Spedding Drive – construction of trench
- 17 Spedding Drive – construction of trench

The source of the noise exceedance at Spedding Drive dwellings is vibro sheet piling. The sheet piling would only occur if the preferred methodology of shoring by trench-shields proves not to be practicable. In this instance, it is recommended that temporary acoustic screening be used to screen the piling activity. Piling would occur for short periods of less than 10 days and would only occur during the daytime. We consider that the acoustic effects could be managed appropriately using the Construction Noise and Vibration management Plan.

An acoustic screen shall be constructed at 18 Brigham Creek Road along the boundary of the North Laydown Area to provide screening to the dwelling. The screen should be used for all construction activities associated with the project especially for compaction.

Vibration levels are predicted to comply with the cosmetic limits at all buildings. The Auckland Unitary Plan amenity limit may be exceeded for a short period, but the exceedance would be within the permitted three day period.

In conclusion we consider that the noise and vibration effects can be managed to be acceptable using the protocols in a CNVMP.

APPENDIX A GLOSSARY OF TERMINOLOGY

dB	Decibel (dB) is the unit of sound level. Expressed as a logarithmic ratio of sound pressure (P) relative to a reference pressure (Pr), where dB = 20 x log(P/Pr).
dBA	The unit of sound level which has its frequency characteristics modified by a filter (A-weighted) to more closely approximate the frequency bias of the human ear. A-weighting is used in airborne acoustics.
$L_{Aeq\ (t)}$	The equivalent continuous (time-averaged) A-weighted sound level commonly referred to as the average level. The suffix (t) represents the period, 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_{AFmax}	The A-weighted maximum noise level. The highest noise level which occurs during the measurement period.
NZS 6803:1999	New Zealand Standard NZS 6803: 1999 "Acoustics - Construction Noise"
Vibration	When an object vibrates, it moves rapidly up and down or from side to side. The magnitude of the sensation when feeling a vibrating object is related to the vibration velocity. Vibration can occur in any direction. When vibration velocities are described, it can be either the total vibration velocity, which includes all directions, or it can be separated into vertical (up and down vibration), horizontal transverse (side to side) and horizontal longitudinal direction (front to back) components.
PPV	Peak Particle Velocity (PPV) is the measure of the vibration amplitude, zero to maximum, measured in mm/s.
BS 5228:2009	British Standard BS 5228:2009 "Code of practice for noise and vibration control on construction and open sites, Part 1: Noise, Part 2: Vibration"
DIN 4150-3:1999	German Standard DIN 4150-3:1999 *"Structural Vibration - Effects of Vibration on Structures"*