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WHENUAPAI REDHILLS WASTEWATERS SERVICING SCHEME (PACKAGE 2) – MASSEY CONNECTOR CONSTRUCTION NOISE & VIBRATION ASSESSMENT

Rp 001 20220875 | 18 January 2022

Project: **WHENUAPAI REDHILLS WASTEWATERS SERVICING SCHEME (PACKAGE 2) – MASSEY CONNECTOR CONSTRUCTION NOISE AND VIBRATION ASSESSMENT**

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Report No. : **Rp 001 20220875**

Document Control

Status:	Rev:	Comments	Date:	Author:	Reviewer:
Draft	00	Internal review	28 / 10 / 2022	Curt Robinson	Siiri Wilkening
	01	Planner review	22/ 12/ 2022		
Final	02		18 / 01 / 2023		

TABLE OF CONTENTS

SUMMARY

We have predicted noise and vibration levels at the nearest buildings to the proposed construction of the Whenuapai Redhills Wastewaters Servicing Scheme (Package 2) – Massey Connector.

We recommend the implementation of a Construction Noise and Vibration Management Plan (CNVMP) to manage the noise and vibration effects of the construction activity.

We predict compliance with the noise and vibration limits for all of the planned construction activities for the Massey Connector line. except the vibration amenity limit at 6 Spedding Road and 92 Trig Road for night operation of the TBM within 30 m of the dwelling.

Micro bore tunnelling of the route will occur continuously to ensure that the machine does not become stuck. The noise associated with the activity will comply with the nighttime noise limits and the effect of tunnelling will be imperceptible to the dwellings along the Massey Connector route.

Vibration from the TBM is predicted to exceed the 0.3 mm/s PPV nigh time amenity limit when operating underneath the property at 6 Spedding Road and 92 Trig Road and is likely to disturb sleep. It is recommended, therefore, that alternative accommodation be offered to the occupants of the dwelling if it is not possible to plan the TBM activity within 30 m of the dwelling to occur during the daytime

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

1 INTRODUCTION

Watercare Services Limited (Watercare) is proposing to install approximately 4 km of wastewater pipeline between 32 Mamari Road, Whenuapai and the existing Hobsonville Pump Station at 2A Buckley Avenue, Hobsonville. This pipeline will provide additional wastewater servicing capacity to accommodate growth in the North West region of Auckland.

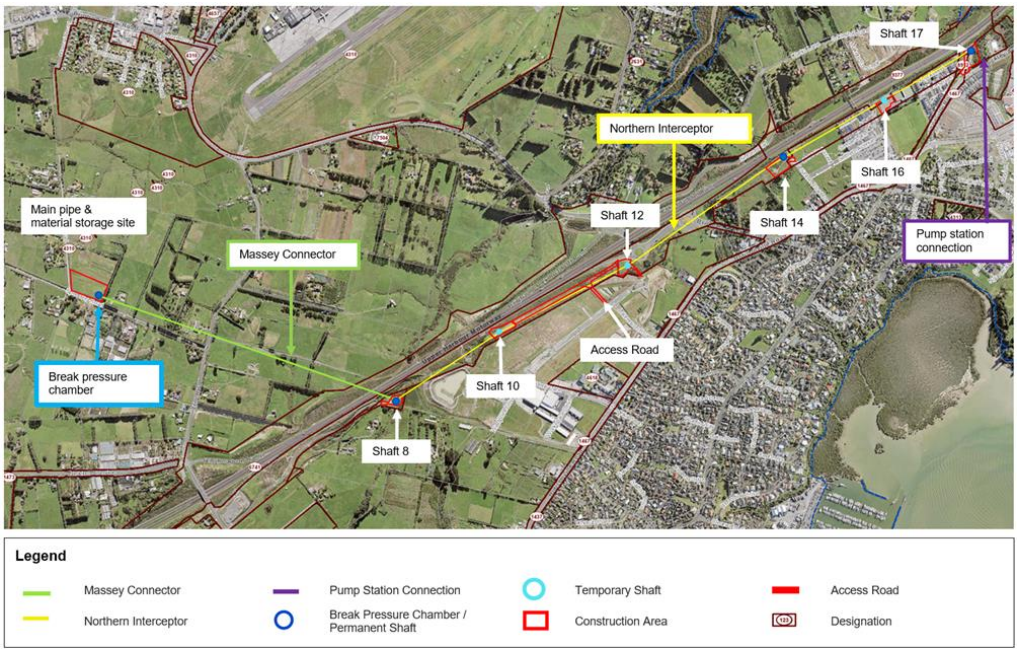
The Project includes the following four key components (see Figure 1):

1. A break pressure chamber located on the corner of Mamari and Spedding Roads which connects to the Package 1 works.
2. The Massey Connector, a gravity pipeline (approximately 1km long and 1800mm in diameter) between the break pressure chamber and the Northern Interceptor at 27 Trig Road, Whenuapai.
3. Phase 2 / Stage 1 of the Northern Interceptor, comprising of a new gravity tunnel (approximately 2.8km long and 2100mm in diameter), which will run adjacent to SH18 between 27 Trig Road, Whenuapai, and 2 Buckley Avenue, Hobsonville.
4. A pump station connection (approximately 40 m in length, and 800 mm in diameter), between the Northern Interceptor and the Hobsonville Pump Station
5. Three permanent shafts along the Northern Interceptor alignment.

For the purposes of this assessment, the Project also includes construction activities, including three temporary shafts (in addition to the three permanent shafts and Break Pressure Chamber), construction yards/laydown areas at each shaft site, and a temporary access road. The alignment of the Northern Interceptor, pump station connection, all shaft sites and construction yards, and the majority of the access road are located within designation 9377 (North Harbour No. 2 Watermain and Northern Interceptor Shared Corridor). The Massey Connector, and two portions of access road which connect to Westpoint Drive, will be located outside of the designation.

The Project extends from Spedding Road in the south, across State Highway 18 (SH18) and then northwards to the Hobsonville Pump Station

Figure 1: Whenuapai Redhills Project (Package 2): Massey Connector and Northern Interceptor Sections



This report considers the noise and vibration effects of construction activities for the Massey Connector portion (Component 2).

2 CONSTRUCTION SEQUENCE, METHODOLOGY, AND PROGRAMME

The Massey Connector works would include the following activities

- Construction of Contractor Area Hub at 32 Mamari Road: Installation of temporary site offices and storage areas for up to 1,000 metres of pipe for the tunnel boring machine (TBM) and parking for heavy vehicles as required.
- Break Pressure Chamber (BPC) construction: including the excavation of a reception shaft and the installation of a break pressure chamber.
- Gravity Main construction from 27 Trig Road (Shaft 8) to the BPC using a TBM launched from Shaft 8 and received at the BPC.

Refer Figure 1 showing the alignment.

2.1 Proposed work programme

The construction programme for Package 2 would take approximately 36 months to complete. The Contractor Area Hub at Mamari Road would be active throughout the construction process. Works at the site would principally be undertaken during normal working hours (07:30 to 18:00 hours Monday to Saturday).

The operation of the TBM would occur continuously from Shaft 8 to the BPC as it is not possible to halt the TBM without risk of it becoming stuck. There would be no significant night-time activities, above ground, associated with the TBM that would give rise to noise or vibration along the Massey Connector line.

The construction activities for the work stages, identified above, 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.
- Pipe storage and movement.

2.3 Break Pressure Chamber

The BPC would be constructed as follows:

- Construction of BPC using a secant piled shaft which would subsequently be excavated out.
- Installation of a concrete base slab to be used as the TBM reception site.
- Once the tunnel is constructed the chamber lining would be installed, piping connections completed, and precast lids placed. The site would then be rehabilitated.

2.4 Massey Connector Gravity Main Installation

The gravity main pipe installation process will commence from Shaft 8 to the east of SH18, through micro-tunnelling underneath multiple properties at Trig Road and Spedding Road. The approximate depth of the tunnel will be approximately 7 m at the BPC, 26 m at its deepest and 10 m at Shaft 8. Construction activity at the BPC will be to receive the TBM and remove it from the shaft.

3 NEARBY RECEIVERS

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

Figure 2: Contractor Staging Hub and BPC with nearest receivers

Table 1: Nearest receivers and distance to construction activity

Receiver		Distance (m)			
		Site construction	BPC shaft	Piping storage	TBM[1]
01	6 Spedding Road	60	90	145	14
02	5 Spedding Road	60	80	120	>50
03	5A Spedding Road	40	60	90	>50
04	9 Spedding Road	85	170	90	>50
05	15 Mamari Road	95	235	110	>50
06	32 Mamari Road	110	200	150	>50
	92 Trig Road[2]	>200	>200	>200	27

NOTE [1] The TBM distance is the closest slant distance from the TBM tunnel to the dwelling
[2] 92 Trig Road is located a significant distance from the BPC but the watermain is routed beneath the dwelling

4 PERFORMANCE STANDARDS

Construction noise and vibration performance standards are given in Standard E25.6.27 and E25.6.30 respectively of the AUP.

4.1 Noise limit for the pipe installation is 70 dB L_{Aeq}

Given that the works at the Contractor Staging Hub will occur for the entire project, we consider that the long-term construction noise limits (for activities with durations of more than 20 weeks) shall apply as given in Table 2.

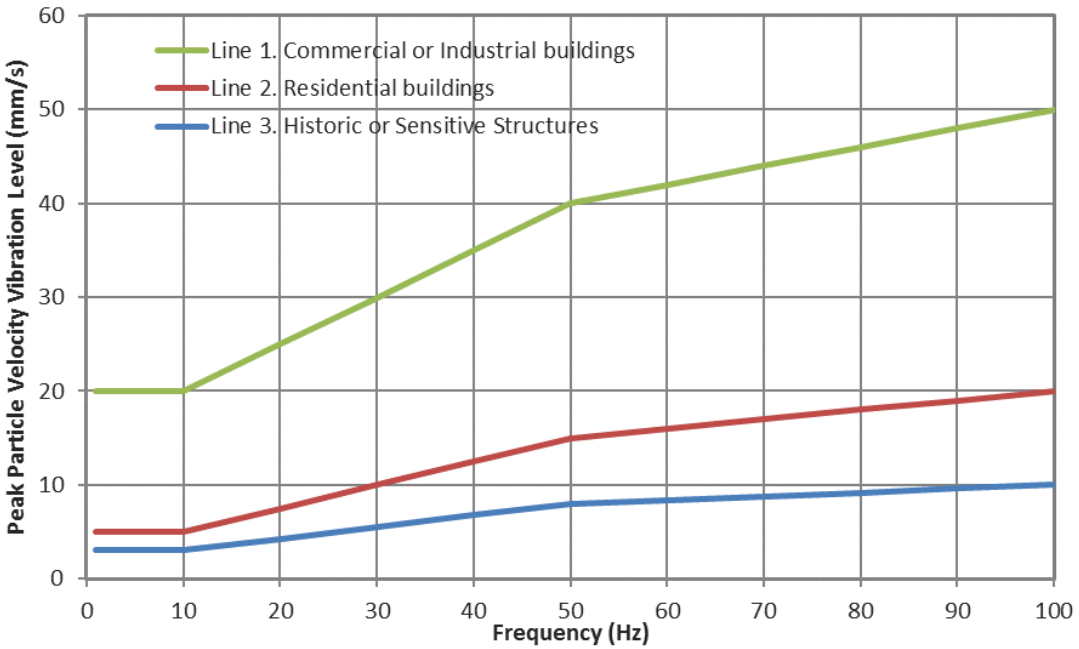
Table 2: Construction noise levels for activities sensitive to noise (e.g. occupied dwellings)

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

4.2 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)[1] vibration limits in Figure 3 apply at building foundations in any axis. The vibration limits in all other cases are summarised in Table 3.

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



[1] 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)[2, 3]
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*."

4.3 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 or occurring at night (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 Night-time 2200 – 0700 hrs	2 0.3
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 4.2. 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

4.4 Vibration limits to protect existing buried pipework

The vibration limits from Table 2 of DIN4150 are provided in the Table 5. The limits are designed to prevent damage from occurring to existing buried pipework constructed from various materials.

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

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

Table 5: Prevention of Damage to Buried Pipework DIN4150-3: 1999 Vibration Criteria (mm/s PPV)

Line	Pipe Material[4]	Peak Particle Velocity Vibration Level (mm/s)	
		Short-term (transient)[5]	Long-term (continuous)[6]
1	Steel (including welded pipes)	100	50
2	Clay, concrete, reinforced concrete, pre-stressed concrete, metal	80	40
3	Masonry, plastic	50	25

[4] Assumes pipes have been manufactured and laid using current technology.

[5] 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*"

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

5 CONSTRUCTION ASSESSMENT - NOISE

5.1 Indicative construction noise levels

Table 6 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 6: Indicative construction noise levels at 1m from the facade with effective mitigation

Equipment	Sound Power	Façade Noise Level (dB L_{Aeq}) @ distance				Limit Compliance Setback (m)	
	(dB L_{WA})	10m	15m	30m	50m	70dB L_{Aeq}	45dB L_{Aeq}
Site Construction							
Excavator	103	78	74	68	63	25	>100
Haul Truck	106	81	77	71	66	35	>100
Mobile Crane (35T)	98	73	69	63	58	15	80
Break Pressure Chamber Shaft							
Secant piling	110	85	81	75	70	56	>100
Concrete truck + pump	107	82	78	72	67	40	>100
Piping Storage							
Reach stacker	107	82	78	72	67	40	>100
Truck	105	80	76	70	65	38	>100
TBM (underground)							
TBM[1]	85						>5

Note [1] TBM noise is generated within the ground. Ground borne radiated noise is predicted to be less than 45 dB L_{Aeq} at distances greater than 5 m

5.2 Predicted noise emission

The worst case (30 minute) predicted noise levels at the nearest potentially sensitive dwellings are given in Table 7 overleaf. These levels are also compared with the compliance noise limits. Those shown in green are predicted to comply with the relevant noise limits.

Compliance is shown for all activities undertaken during normal working hours at the façades of all dwellings. It should be noted that whilst the gravity main construction will occur continuously when the TBM is operating, the boring machine is underground and the ancillary equipment such as generator, hydraulic power pack and pipe handling equipment will be located at Shaft 8 some distance from theses dwellings.

Experience has shown with the operation of the TBM , that structure-borne noise within dwellings is imperceptible at distances exceeding 10 m from the TBM to the dwelling. There are no dwellings within 10 m of the pipe route and so structure-borne re-radiated noise is considered to be insignificant.

Table 7: Potentially affected receivers

Receiver	Activity			
	Contractor staging	Break Pressure Tank	Gravity Main (above ground)	TBM (structure-borne)
Sound power	107 dB L_{WA}	110 dB L_{WA}	106 dB L_{WA}	
6 Spedding Road	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<45 dB L_{Aeq}
5 Spedding Road	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<45 dB L_{Aeq}
5A Spedding Road	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<45 dB L_{Aeq}
9 Spedding Road	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<45 dB L_{Aeq}
15 Mamari Road	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<45 dB L_{Aeq}
32 Mamari Road	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<45 dB L_{Aeq}
92 Trig Road	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<70 dB L_{Aeq}	<45 dB L_{Aeq}

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 a particularly conservative assumption 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 8 sets out the likely internal noise levels in neighbouring buildings.

Table 8: 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
70 – 75	40 – 45	45 – 50	50 – 55	55 – 60
65 – 70	35 – 40	40 – 45	45 – 50	50 – 55

Table 9 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 9: 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 predicted noise at all dwellings is considered to be noticeable but unlikely to interfere with daily activities.

6 CONSTRUCTION ASSESSMENT – VIBRATION

6.1 Indicative Vibration

We consider that there is no risk of cosmetic damage of any building near the Massey Connector construction.

Table 10 provides indicative construction vibration levels for proposed activities that have the potential to result in vibration in building structures. Note, the table applies the long-term limits which are more conservative. This table 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 9.3) or other means.

Table 10: 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
TBM (underground)	30	10	4	2

6.2 How are these vibration levels experienced?

While the primary vibration concern is typically cosmetic building damage (Section 4.2), people may be disturbed at significantly lower levels (Section 4.3). 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 4.3).

No construction activity or equipment has been identified that could give rise to exceedance of either the amenity limits during the daytime and cosmetic building damage limits. Nevertheless, we recommend that closest receivers are informed of the works to avoid any concern.

Vibration levels due to TBM activity are predicted to exceed the 0.3 mm/s PPV night-time noise limit at the 6 Spedding Road dwelling (where the closes slant distance from the tunnel to the dwelling is 14 m and at 92 Trig Road (27 m) when the TBM is within 30 m of the building. This night limit relates to amenity (not cosmetic damage) as vibration levels would be noticeable, and is likely to disturb sleep for the period where vibration exceeds 0.3 mm/s. Specific management measures to mitigate this effect are discussed in Section 7.6.

7 MITIGATION AND MANAGEMENT

While we predict compliance with both the construction noise and vibration criteria for the majority of the planned works (excepting the potential exceedance of night-time vibration amenity limits at 6 Spedding Road and 92 Trig Road), best practice on site management should be applied in any event, to fulfil the requirements of Section 16 of the RMA. The following sections set out common mitigation and mitigation measures that we recommend should be implemented on site throughout the works.

7.1 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.

7.2 Equipment Selection

When selecting construction equipment, where practicable:

- Prioritise quieter construction methodologies
- 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)

7.3 Acoustic Screening

Temporary acoustic screening can be used to reduce noise effects for some construction activities. Effective noise barriers typically reduce the received noise level by 10 decibels. The necessity for temporary acoustic screening has not been identified during this assessment but if a new activity is required that does give rise to an exceedance in noise limits, then the following guidelines shall be followed.

- The panels shall 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 shall be a minimum height of 2m, and higher if practicable to block line-of-sight
- The panels shall be abutted or overlapped to provide a continuous screen without gaps at the bottom or sides of the panels
- The panels shall be positioned as close as practicable to the noisy construction activity to block line-of-sight between the activity and noise sensitive receivers.

7.4 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:

- 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)
- 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)
- Ensure communication is completed (Section 8) prior to commencing activities that are predicted to exceed the noise and vibration performance standards (Section 4)
- Undertake monitoring as appropriate (Section 9)

7.5 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 and vibration 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

7.6 Management Measures where TBM exceeds 0.3 mm/s during the night period

Vibration levels due to TBM activity that exceed the 0.3 mm/s PPV in bedrooms at night may give rise to sleep disturbance. The calculated slant distance from TBM to building where 0.3 mm/s PPV would be exceeded is 30 m.

To mitigate the effect of TBM vibration disturbing sleep the following measures are recommend:

- Measure ground vibration of the TBM machine at the earliest opportunity when the slant distance is approximately 30 m to calibrate the prediction model and determine the 0.3 mm/s PPV contour
- Plan the operation of the TBM to ensure that the period where the TBM is within 30 m (or the revised compliance distance based on the on site measurements) to occur during the day time
- Offer alternative accommodation to the occupants of the dwelling for periods where it is unavoidable for the TBM to exceed 0.3 mm/s at night.

8 ENGAGEMENT

8.1 Communication

Written communication as per the accepted communications plan should be provided to occupiers of buildings within 100 m of the Contractor Staging Area 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.

8.2 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. 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.

9 MONITORING

9.1 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 7).

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 5.1. Attended monitoring will also be undertaken in response to a reasonable complaint (Section 8.2).

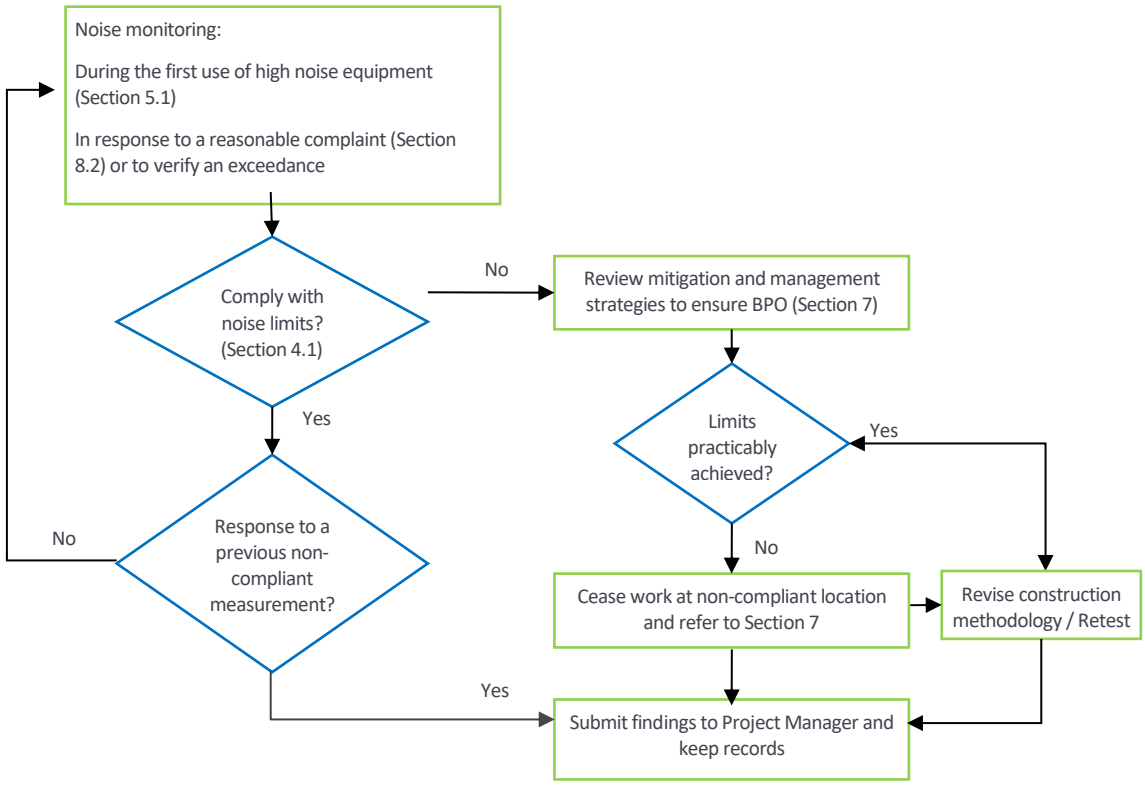
9.2 Noise

Construction noise levels should be monitored:

- In response to a reasonable noise complaint (Section 8.2)
- 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 4.

Figure 4: Noise Monitoring Flow Chart



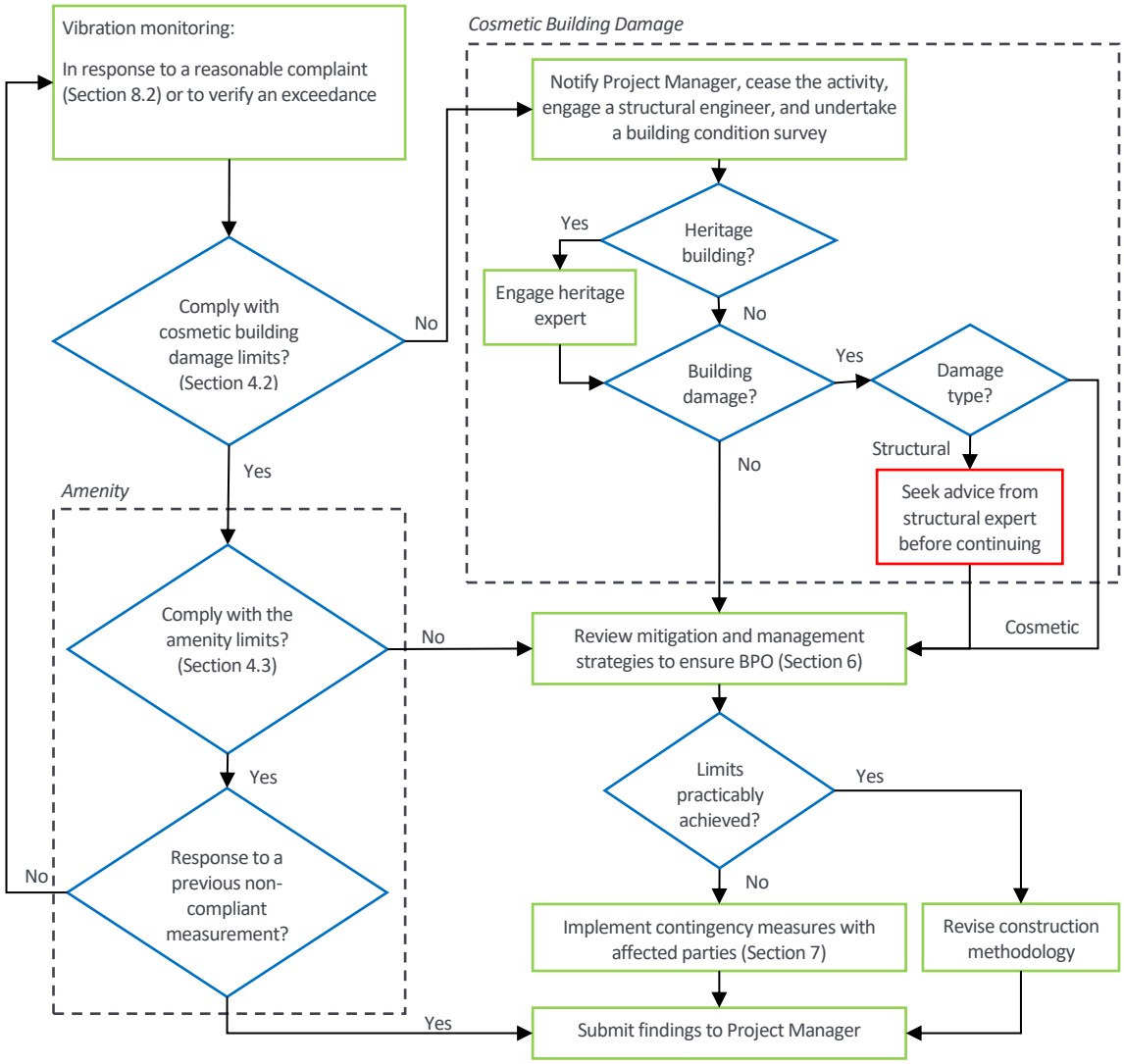
9.3 Vibration

Construction vibration is predicted to comply with the relevant performance standards, excepting the potential exceedance of night-time amenity limits at 6 Spedding Road and 92 Trig Road. 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 5.

Figure 5: Vibration Monitoring Flow Chart



9.4 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.

We note that it is highly unlikely that vibration levels from this project will approach a level of 5 mm/s PPV, and are likely to be closer to 1 to 2 mm/s PPV at most.

10 CONCLUSION

We have predicted noise and vibration levels at the nearest buildings near the proposed construction of the Whenuapai Redhills Wastewaters Servicing Scheme (Package 2) – Massey Connector Line. The Northern Interceptor tunnel and the connection to the Hobsonville Pump Station, which also forms part of Package 2, will be addressed in a separate report

We recommend the implementation of a Construction Noise and Vibration Management Plan (CNVMP) to manage the noise and vibration effects of the construction activity.

We predict compliance with the noise and vibration limits for the majority of the planned construction activities for the Massey Connector line.

Micro bore tunnelling of the route will occur continuously to ensure that the TBM does not become stuck. The noise associated with the activity, however, will comply with the night time noise limits and the noise effect of tunnelling will be imperceptible to the dwellings along the Massey Connector route.

Vibration from the TBM is predicted to exceed the 0.3 mm/s PPV night-time amenity limit at the 6 Spedding Road and 92 Trig Road dwellings and is likely to disturb sleep during those periods. It is recommended, therefore, that alternative accommodation be offered to the occupants of the dwelling if it is not possible to plan the TBM activity within 30 m of the dwelling to occur during the daytime

In conclusion we consider that the noise and vibration effects can be managed to be reasonable 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"*