Project Number: W-SL001.03

Queen Street Wastewater Diversion: Part 3 Works

14 June 2024

Framework Construction Noise and Vibration Management Plan

wsp

150 YEARS IN AOTEAROA

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Revision Details

Revision	Details
0	Issue to Client
1	Updated construction methodology
2	Updated basalt removal methodology and Greys Ave Support
3	Updated from Auckland Council Request for Further Information
4	Updated for shaft and construction site area layout changes, change in construction methodology, and updates to construction programme

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Abbreviation and Definitions

AC	Auckland Council
AT	Auckland Transport
AUP	Auckland Unitary Plan
CNVMP	Construction Noise and Vibration Management Plan
CNVA	Construction Noise and Vibration Assessment
CRLL	City Rail Link Limited
CSA	Construction Support Area
DCS	Design and Construction Statement
mTBM	Micro Tunnel Boring Machine
NSR	Noise Sensitive Receptor(s)
TMPs	Traffic Management Plans
Watercare	Watercare Services Limited
WSP	WSP New Zealand Limited

1 Introduction

Watercare Services Limited ("Watercare") is a lifeline utility providing water and wastewater services to a population of 1.7 million people in Auckland. Its services are vital for life, keep people safe and help communities to flourish. More specifically, Watercare is the council-controlled organisation of Auckland Council responsible for municipal water supply and wastewater treatment within Auckland, and the provider of bulk water and wastewater services to Pokeno and Tuakau in the Waikato District.

The Queen Street Wastewater Diversion Programme is proposing to upgrade the wastewater network within the upper catchment (southern) of Auckland City Centre. Watercare has established that the existing network does not have sufficient capacity to meet future demands.

This Construction Noise and Vibration Management Plan (CNVMP) covers Part 3 (the Project) of the works. Specific CNVMP's will be provided for the other Parts of the wider Diversion Programme. The objectives of this CNVMP are to:

1 Identify the Best Practicable Option (BPO) for the management and mitigation of construction noise and vibration effects.
2 Identify how Project noise and vibration limits will be met and set out the methods for scheduling and undertaking works to manage disruption.
3 Ensure engagement with affected receivers and timely management of complaints.

This plan achieves the requirements outlined in the Auckland Unitary Plan (AUP). It also follows the guidance set out in NZS 6803:1999 *Acoustics – Construction noise*.

This CNVMP outlines the predicted noise emissions and provides the best practicable options for physical and managerial mitigation measures to be considered where noise and/or vibration levels exceed the associated limits.

General details of the Project are presented in Table 1.

Table 1 Project details

General Project Details	
Property	Description
Location	Part 3 of the Queen Street Diversion Project: The works include the installation of a new wastewater gravity pipeline along Queen Street between Mayoral Drive and Victoria Street,
Contractor	Fulton Hogan
Construction Period	Q3 2024 to Q3 2025
Construction Hours	<u>Shaft Construction:</u> Monday to Saturday: 0700 – 1800 hours Sunday, Public Holiday and night work are not currently proposed. These will only be carried out if required by traffic management restrictions or Watercare operational requirements for tie ins/ connections to the existing network.
	<u>Tunnelling Works:</u> Monday to Saturday – 0700hrs to 1900hrs Sunday and Public Holidays – No construction works
	<u>Greys Avenue Construction Support Area:</u> Monday to Saturday – 0700hrs to 2000hrs Sunday and Public Holidays – No construction works

Night works will only be undertaken for de-watering works (a water pump and generator operating only), depending on the site's groundwater conditions.

The general construction staging for the overall construction works is provided in Table 2.

Table 2 Overall construction works staging

Construction Duration	
Site	Duration
Queen Street / Mayoral Drive Shaft	2 – 3 months to construct the shaft (Q3 to Q4 2024)
Queen Street/ Wellesley Street Shaft	2 – 3 months to construct the shaft (Q3 to Q4 2024)
Queen Street/ Victoria Street Shaft	3 – 4 months to construct the shaft (Q3 to Q4 2024)
Tunnelling Activity (including site establishment)	7 months including site establishment operation and take-down Q1 to Q3 2025).
Trenched tie-in works	Queen Street pipe work connections (x3) – 1 month (Q4 2024)

Items in *red italics* are important specific areas of the plan that need to be reviewed and updated as works progress.

This is a live document and will be continually updated if the construction methodology changes, when measurements have been undertaken on the specific machinery, and for specific management of impacted properties.

1.1 Contact Details

The contractor nominated Noise Liaison Officer will be responsible for ensuring that this CNVMP is correctly implemented. They will review all documentation relating to construction noise before it is issued.

As part of site induction, all personnel will be made aware of the noise sensitivity of the surrounding environment, along with the acoustic mitigation strategies outlined in this plan.

The respective authority for these works is Auckland Council.

Table 3 should be completed by the relevant person before the commencement of any construction works, this table outlines key contacts associated with the project.

Table 3 Key Contacts

Key Contract People for The Project				
Role	Name	Organisation	Phone	Email
24 – Hour Public Contact	*TBC*			
Environmental Manager	*TBC*			
Project Manager	*TBC*			
Construction Manager	*TBC*			
Community Relations Manager	*TBC*			
Noise Liaison Officer	*TBC*			
Noise and Vibration Monitoring Manager	*TBC*			
Council – Noise Officer	*TBC*			
Compliance Monitoring Officers	*TBC*			

2 Project Overview

The Project works will see the construction of a new wastewater pipeline under Queen Street, running between Mayoral Drive and Victoria Street. Connections to the existing wastewater network will be provided at Mayoral Drive, Wellesley Street and Victoria Street.

To provide for the new pipe, three temporary shafts will be provided along Queen Street (located at Mayoral Drive, Wellesley Street and Victoria Street). Once the shafts are constructed, tunnelling works will commence from Mayoral Drive, heading north along Queen Street towards Victoria Street. The Micro-Tunnel Boring Machine (mTBM) will be extracted at Victoria Street. Once tunnelling works are completed, the three shafts will be backfilled and converted to manholes.

Figure 1 shows the approximate geographic area for the project in yellow, however, construction activity at surface level will be focused on the Queen Street intersections of Mayoral Drive, Wellesley Street and Victoria Street shown approximately in red.

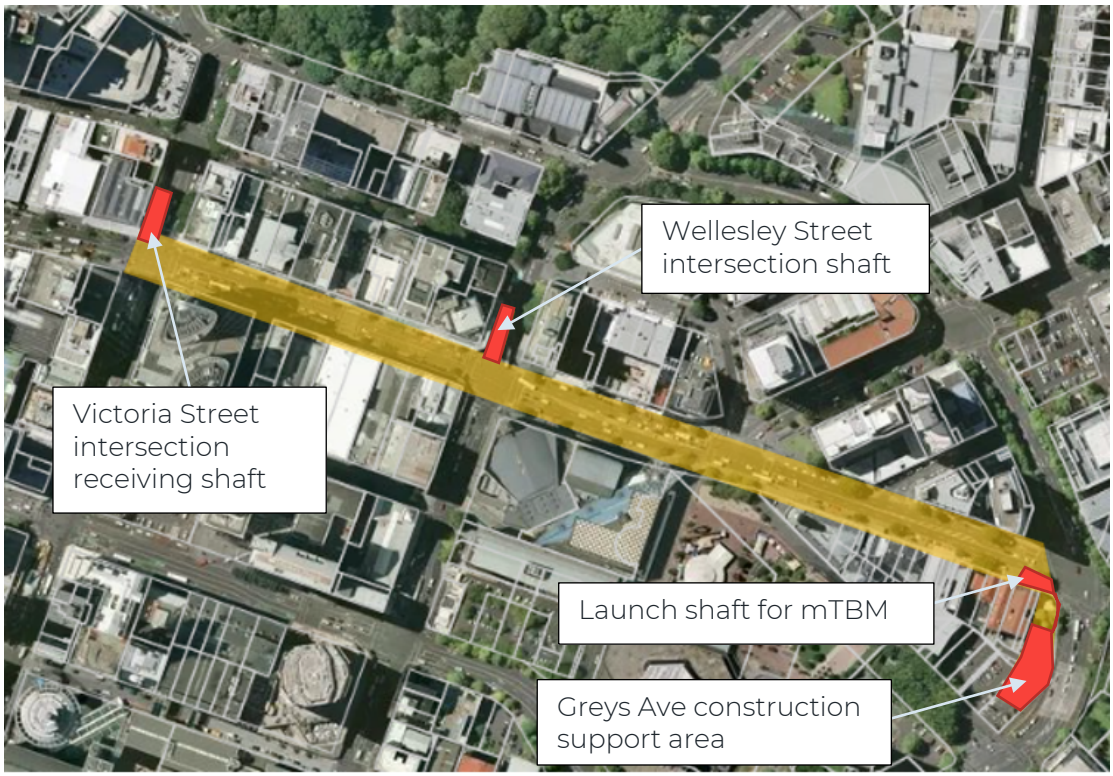


Figure 1 Project area and surface level areas used

2.1 Temporary Construction Shafts

Three temporary shafts for trenchless construction are to be provided along the alignment. These will be constructed into manholes once the trenchless construction works have finished.

Queen Street / Mayoral Drive Shaft

This shaft will be located on Queen Street, outside 323 Queen Street and once constructed will be approximately 14 metres deep, 4.5 metres wide, and 11 metres long. This shaft will be used as a launch shaft for tunnelling works. Secant piling methodology will be used to construct the extent of the shaft, which will require dewatering when open, depending on final groundwater level.

Figure 2 shows the position of the shaft (red/yellow) and the surrounding construction area (pink).

Figure 2 Mayoral Drive Shaft position and compound

Queen Street/ Wellesley Street Shaft

This shaft will be located on Wellesley Street, adjacent to 290 Queen Street and will be approximately 7.2 metres deep with an internal diameter of 3.5 metres. This shaft will be used for service connections as well as support for tunnelling works.

The shaft will be constructed using secant piling, and will be sealed once constructed. Dewatering is not required for this shaft.

Figure 3 shows the position of the shaft (light blue) and the surrounding construction area on Wellesley Street (dark blue).

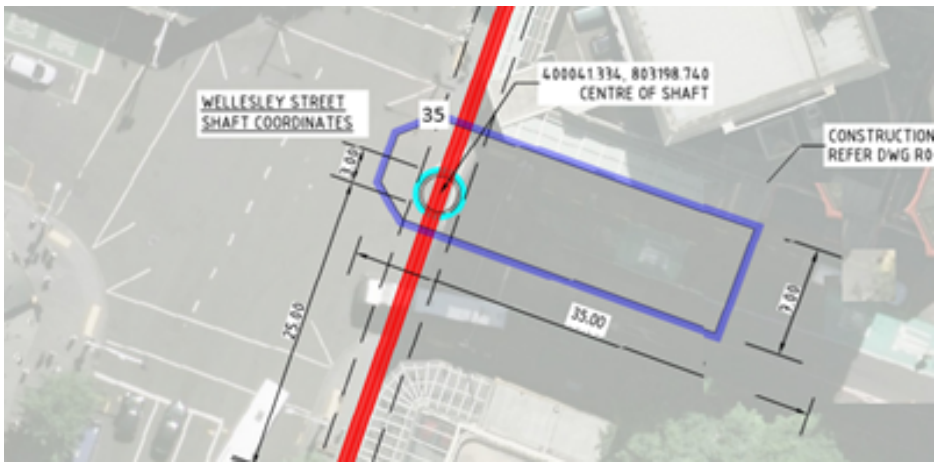


Figure 3 Wellesley Street Shaft position and compound

Queen Street/ Victoria Street Shaft

This shaft will be located on Victoria Street, adjacent to 210 Queen Street and will be approximately 7 metres deep, 5 metres wide and 7.8 metres long, in an irregular polygon shape. This shaft will be used to provide a connection to the Ōrākei Main Sewer (OMS) as well as for the recovery of the mTBM. The shaft will be of post and panel construction and as such will require continued dewatering whilst the shaft is in use.

Figure 4 shows the position of the shaft (red) and the surrounding construction support area on Victoria Street (pink).

Figure 4 Victoria Street Shaft position and compound

2.2 Tunnelling Works

Tunnelling works will commence from the shaft at Mayoral Drive and end at the shaft at Victoria Street using a mTBM.

To support tunnelling works, a CSA will be established on part of the public car park at 38 Greys Avenue that will contain ancillary equipment and functions for tunnelling. A construction area around the shaft will include equipment used for the operation of the mTBM. Figure 5 shows the proposed layout for the Greys Avenue CSA and how it relates to the construction shaft on Queen Street.

Approximately 595 metres of 1.2 metre diameter pipe will be installed between the Mayoral Drive site and Victoria Street site.

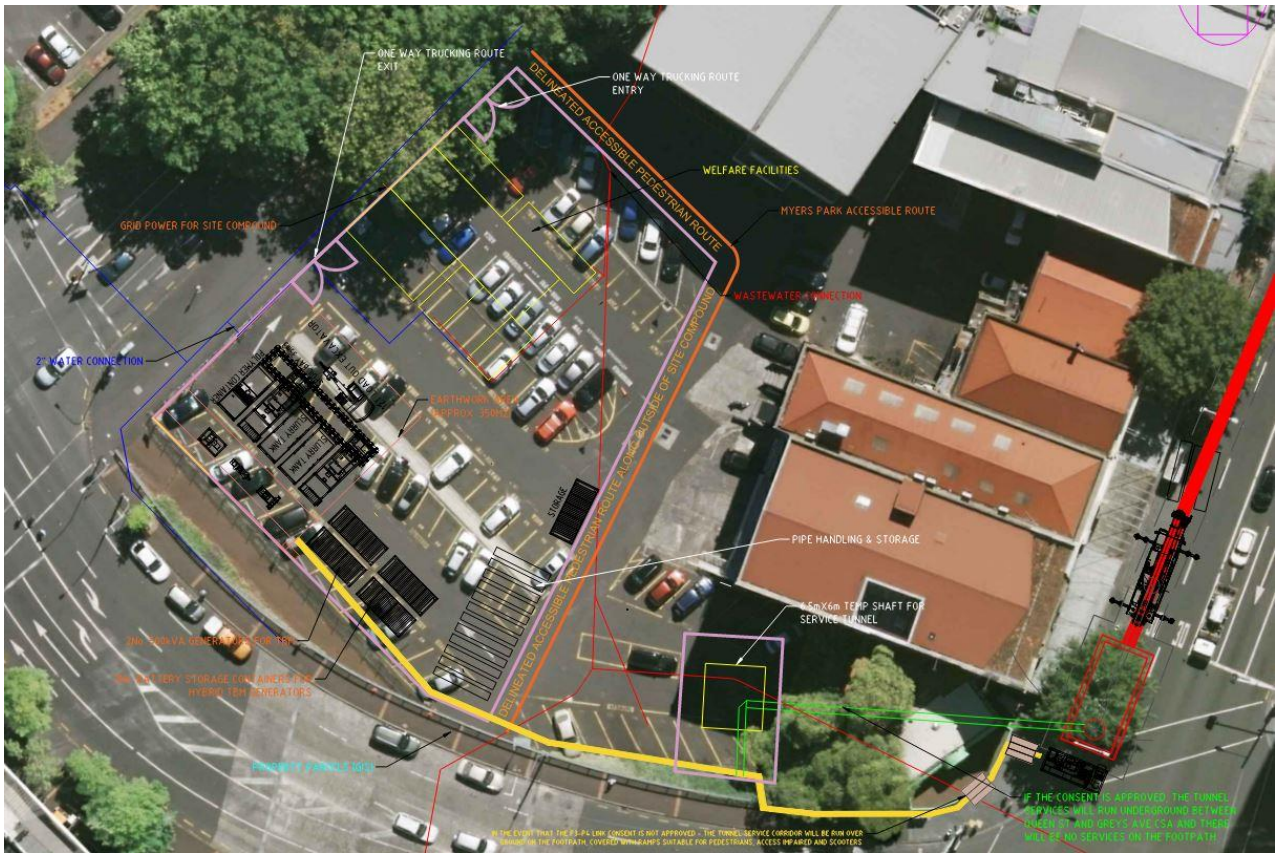


Figure 5 Greys Avenue CSA during tunnelling works

The equipment to be provided within the Greys Avenue CSA and the Mayoral Drive construction compound during tunnelling is given in Table 4.

Table 4 Equipment located at Greys Avenue CSA and Mayoral Drive site

Construction Support Areas Equipment during Tunnelling works	
Greys Avenue CSA	Mayoral Drive
• Project site office • Staff welfare facilities • 12t excavator (for removing spoil from the site and loading onto trucks) • Separation plant • Slurry tanks • Electrical container • 800kW diesel generator (only required if connection to electrical mains cannot be established) • Pumps • Site laydown area/ material storage area • Pipe fit out area	• Tunnelling control cabin • In-shaft jacking equipment • 50t mobile crane • Pipe laydown area

Once tunnelling commences, extracted material will be transported in a slurry medium to the separation plant at Greys Avenue CSA via a connection pipe between a temporary shaft in the Greys Avenue CSA and Mayoral Drive Shaft (consented separately under the Part 3-Part 4 Connector Tunnel consent). Once the solids have been removed from the slurry, it will be loaded onto trucks and disposed of off-site, with the liquid returning to the closed-loop system.

As the mTBM progresses from the Mayoral Drive shaft, 6m long sections of pipe will be installed. As the jacking rig is retracted, the next pipe section is lowered by a crane from the surface of the Mayoral Drive CSA and placed into position. The cycle continues until the drive is complete.

Once tunnelling is completed, the mTBM will be recovered at the Victoria Street Shaft.

2.3 Vehicle Movements

Vehicle movements will be occurring to and from CSAs during the project works. The following outlines the likely vehicle movements expected to occur.

Table 5 Vehicle movements

Proposed Vehicle Movements at Each Site		
Stage of Works	Likely vehicle movements (daily – average)	
Shaft Construction	Mayoral Drive site	• Light vehicles: 10 per day • Flatbed delivery trucks: 2 per day • Spoil/ aggregate trucks: 8 per day (peak)
	Wellesley Street site	• Light vehicles: 10 per day • Flatbed delivery trucks: 2 per day • Spoil/ aggregate trucks: 8 per day (peak)
	Victoria Street site	• Light vehicles: 10 per day • Flatbed delivery trucks: 2 per day • Spoil/ aggregate trucks: 8 per day (peak)
Tunnelling works	Light vehicles: 10 per day	
	Flatbed delivery trucks: 2 per day	

Please note that other vehicle movements will occur during site establishment and disestablishment activities.

2.4 Noise and Vibration Sensitive Receptors

Most buildings around the construction areas are commercial in nature. Figure 6 shows the commercial properties (yellow) hotels (blue) and apartments (pink) near each of the construction sites (red).

Many of the properties directly adjacent to the construction support areas are also located within the historic heritage overlay as outlined in the AUP. These properties are likely more sensitive to vibration and therefore should be considered in further detail.

Figure 6 Adjacent noise sensitive receptor building types – commercial (yellow), hotels (blue), apartments (pink)

As identified in the Heritage Effects Assessment Report (dated 5 July 2023 and prepared by WSP), the following buildings have been identified as buildings of heritage significance with extents of place in the AUP which extend beyond the building footprint, and into the pavement and/or road reserve. As such are to be carefully managed for vibration impacts:

- John Courts Building (210 Queen Street)
- No deposit Piano Building (307 – 319 Queen Street)
- W. A. Thompson Building (307 – 319 Queen Street)
- Auckland Sunday School Building (323 – 327 Queen Street)
- Two-Storey Commercial Building (319 Queen Street)

These properties are provided in lieu of all buildings within 20 metres of the works as required by E26.2.5.4(4), as they are specifically considered high-risk by the Heritage Consultants. There are no properties within 20 metres of the proposed works that are predicted to exceed the heritage vibration limits (2.5 mm/s PPV).

3 Construction Noise and Vibration Criteria

The construction noise and vibration criteria for the Project have been developed based on the following documents:

- Auckland Unitary Plan: Section E25.6.28 – Construction noise levels in the Business – City Centre Zone and the Business – Metropolitan Centre Zone.
- Auckland Unitary Plan: Section E25.6.29 – Construction noise and vibration levels for work within the road.
- Auckland Unitary Plan: Section E25.6.30 – Vibration.
- NZS 6803:1999 Acoustics – Construction Noise.
- DIN 4150-3:1999 Vibrations in buildings – Part 3: Effects on structures.
- BS 5228-2:2014: Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration.

3.1 Construction Noise Criteria

Table 6 outlines the trigger levels for construction noise. Where predicted or measured noise levels are above the noise criteria in Table 6, the Best Practicable Option (BPO) of mitigation will need to be implemented.

Table 6 Construction noise criteria in the Business – City Centre Zone

Construction Noise Assessment Criteria AUP Construction noise limits in the Business – Metropolitan Centre Zone, assessed 1m from the facade			
Day	Time	$L_{Aeq,30min}$ (dB)	L_{AFmax} (dB)
Monday to Friday	6.30am – 10.30pm	75	90
Saturday	7am-11pm	80	90

These noise levels apply at 1m from the façade of any building sensitive to noise.

3.2 Construction Vibration Criteria

Construction vibration criteria are provided in Table 7. Where predicted or measured vibration levels are at or above the vibration criteria in Table 7, the BPO of mitigation will be implemented.

Table 7 DIN 4150-3 long-term guideline vibration criteria

Construction Vibration Criteria DIN 4150-3 Guideline vibration limits used to assess the effects of long term-vibration on structures		
Line	Type of Structure	Guideline values for velocity, i_i, in mm/s, of vibration in the horizontal plane of highest floor, at all frequencies.
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design.	10
2	Dwellings and buildings of similar design and/or use.	5
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 or 2 and have intrinsic values (e.g., buildings under a preservation order).	2.5

The vibration criteria in Table 7 apply in any horizontal axis when measured in the corner of the floor of the storey of interest for a multi-storey building, or within 500mm of ground level at the foundation of a single storey building.

4 Assessment Methodology

This section details the assessment methodology, the assumptions and limitations used within this assessment.

4.1 Construction Activities

The construction staging for the proposed works, along with a description of the works for each phase and proposed equipment are outlined in Table 8 to Table 14.

Table 8 Shaft Construction - Queen Street / Mayoral Drive

Shaft Construction Queen Street/ Mayoral Drive		
Phase	Activity	Equipment/Materials assessed for noise and/or vibration impact.
1	Shaft extent will be saw cut and a 14t – 20t excavator used to remove pavement layers and other shallow level obstructions.	• Concrete cutter • Excavator • 6 or 8 wheeler truck
2	A SR-45 SFA drill rig will auger 600mm dia holes to 18m deep. The auger will be replaced with concrete as it extracts to surface level to prevent collapse. Hard piles will be reinforced with UC posts or helical reinforcing cages.	• SR-45 drill rig • 6 or 8 wheeler truck • Concrete truck and pump
3	Shaft extent will be excavated using a combination of a 3t excavator and 20 – 35t excavator (with a telescopic boom arm) and workers with compressor powered hand held air tools, and welder. Shaft spoil will be removed from site using a 6 or 8 wheeler truck with sealed bins. Shaft will require 24/7 dewatering and a submersible pump will be used to pump water into clarifying tank(s) for treatment, before discharging into the local wastewater network. The pump will be powered by a diesel generator (running 24/7) or local power network. Forced air ventilation will be required using a fan at surface level with ventilation ducting into the shaft.	• Excavators • Hand held power tools • 6 or 8 wheeler truck • Ventilation fan • Submersible pump • Diesel generator
4	Steel waler beams will be installed and welded together within the shaft to support the UC posts.	*This activity will occur concurrently with Phase 3. Therefore, noise generated in this phase has been assessed concurrently with Phase 3.* *The same equipment used in Phase 3 will occur within this Phase.*
5	Following tunnelling works, an in situ concrete manhole will be formed and poured within the shaft using a concrete skip and 90t crane at road level or with a concrete pump. Precast concrete riser manhole sections will be installed using a 90t crane at road level. The temporary works will be progressively removed using a gas axe and 90t crane The shaft will be backfill with compacted GAP65 or low strength concrete using the 90t crane and skip.	• Crane • Concrete truck pump and skip • Trucks • Excavator • Submersible pump • Diesel generator • Ventilation fan
6	Road pavements (GAP65 and AC) will be reinstated using a 14 – 20t excavator, 400kg plate compactor and static drum roller.	• Excavator • Static drum roller • 400 kg plate compactor

Table 9 Shaft Construction - Queen Street / Wellesley Street

Shaft Construction Queen Street/ Wellesley Street		
Phase	Activity	Equipment/Materials assessed for noise and/or vibration impact.
1	Shaft extent will be saw cut and a 20t excavator used to remove pavement layers and other shallow-level obstructions including existing redundant overflow pipe. A trench will be dug to remove the 4m deep redundant overflow pipe that runs across the shaft.	• Concrete cutter • Excavator • 6 or 8 wheeler truck
2	A concrete guide beam will be formed a poured to assist with managing pile placement and verticality. A SR-45 drill rig will be used to undertake secant piling of the shaft perimeter to a depth of approximately 14 metres.	• SR-45 drill rig • 6 or 8 wheeler truck • Concrete truck and pump
3	Shaft extent will be excavated using a combination of a 3t excavator and 20 – 35t excavator (with a telescopic boom arm) and workers with compressor powered hand held air tools. Shaft spoil will be removed from site using a 6 or 8 wheeler truck with sealed bins.	• Excavators • Hand held power tools • 6 or 8 wheeler truck • Submersible pump • Diesel generator • Ventilation fan
4	Following tunnelling works, an in situ concrete manhole will be formed and poured within the shaft using a concrete skip and 90t crane at road level or with concrete pump. Precast concrete riser manhole sections will be installed using a 90t crane at road level. The temporary works will be progressively removed using a gas axe and 90t crane The shaft will be backfill with compacted GAP65 or low strength concrete using the 90t crane and skip.	• Crane • Concrete truck pump and skip • Trucks • Excavator • Submersible pump • Diesel generator • Ventilation fan
5	Road pavements (GAP65 and AC) will be reinstated using a 14 – 20t excavator, 400kg plate compactor and static drum roller.	• Excavator • Static drum roller • 400kg plate compactor

As the shaft will be sealed, no dewatering is required for the Queen Street / Wellesley Street shaft.

Table 10 Shaft Construction - Queen Street / Victoria Street

Shaft Construction Queen Street/ Victoria Street		
Phase	Activity	Equipment/Materials assessed for noise and/or vibration impact.
1	Shaft extent will be saw cut and a 5 to 20t excavator used to remove pavement layers and other shallow-level obstructions.	• Concrete cutter • Excavator • 6 or 8 wheeler truck
2	SR-45 drill rig will be used to bore 400 to 600mm diameter holes to 10 metres depth and backfilled with concrete	• SR-45 drill rig • 6 or 8 wheeler truck • Concrete truck and pump
3	Steel UC posts will be lowered into each bore using a 14 to 20t excavator and the bores backfilled with sand.	• Excavator • 6 or 8 wheeler truck
4	The shaft extents will be excavated using an 5 and 35t excavator and workers with compressor powered hand held air tools. A 25t crane and skip will be used to remove hand held excavated materials when the excavator runs out of reach. Shaft spoil will be removed from site using a6 to 8 wheeler trucks. Shaft will require 24/7 dewatering and a submersible pump will be used to pump water into clarifying tank(s) for treatment, before discharging into the local wastewater network. The pump will be powered by a diesel generator (running 24/7) or local power network. Forced air ventilation will be required using a fan at surface level with ventilation ducting into the shaft.	• 5t Excavator • 35t excavator • Hand held power tools • Crane • Welder • Submersible pump • Ventilation fan • Diesel generator • 6 or 8 wheeler truck
5	Timber lagging will be cut to fit and installed between UC posts as the excavation progresses to retaining the surrounding ground. At least two steel waler beams will be installed and welded together within the shaft to support the UC posts.	*This activity will occur concurrently with Phase 4. Therefore, noise generated in this phase has been assessed concurrently with Phase 4.* *The same equipment used in Phase 4 will occur within this Phase.*
6	Solid basalt will be found within this shaft at approximately 5.5m below road level. The basalt layer will be broken out using coring, cutting and rock splitting techniques. Shaft will require 24/7 dewatering and a submersible pump will be used to pump water into clarifying tank(s) for treatment, before discharging into the local wastewater network. The pump will be powered by a diesel generator (running 24/7) or local power network. Forced air ventilation will be required using a fan at surface level with ventilation ducting into the shaft. Concrete piles installed at tunnel entry for breakthrough of mTBM	• Excavator • Rock diamond drill • Crane • Submersible pump • Ventilation fan • Diesel generator • Concrete truck and pump
7	After mTBM extraction, an in situ concrete manhole will be formed and poured within the shaft using a concrete skip and 90t crane at road level or with concrete pump. Precast concrete riser manhole sections will be installed using a 90t crane at road level. The temporary works will be progressively removed using a gas axe and 90t crane The shaft will be backfill with compacted GAP65 or low strength concrete using the 90t crane and skip.	• Crane • Concrete truck pump and skip • Trucks • Excavator • Submersible pump • Diesel generator • Ventilation fan
8	Road pavements (GAP65 and AC) will be reinstated using a 14 – 20t excavator, 400kg plate compactor and static drum roller.	• Excavator • Static drum roller • 400kg plate compactor

Table 11 Open Cut Trench Pipe Installation

Open Cut Pipe Laying Queen Street/ Wellesley Street		
Phase	Activity	Equipment/Materials assessed for noise and/or vibration impact.
1*	Temporary traffic management set up in accordance with approved Traffic Management Plans (TMPs). TMPs will be staged, allowing only short sections of pipeline to be constructed at any one time.	• Traffic management equipment
2	Approximately 20 to 30m of trenching will be open at any one time. Open earthworks would be up to 300m^3. Depth of trenches are not known, however for any trench deeper than 1.5m, a trench shield will be used.	• Trench shield • Flatbed truck • Excavator • Submersible pump • Diesel generator
3	Pipe lengths and precast manholes will be delivered to site on flatbed trucks and unloaded within the site using HIAB or excavators.	*This activity will occur concurrently with Phases 2 - 5. Therefore, noise generated in this phase has been assessed concurrently with Phases 2 – 5.* *The same equipment used in Phase 2 will occur within this Phase.*
4	Excavator will be used to trench to the required depth and install trench shields as the excavations advance. Wider trench boxes will be provided at manhole locations. Excavated material will be removed from site as clean, managed or contaminated fill subject to contamination testing results.	*This activity will occur concurrently with Phases 2 - 5. Therefore, noise generated in this phase has been assessed concurrently with Phases 2 – 5.* *The same equipment used in Phase 2 will occur within this Phase.*
5	If dewatering is required (subject to ground investigation outcome), a two-inch submersible pump and hole will be used to remove water from excavations. Water will be pumped into clarifying tanks/ containers for treatment before discharge. The pumps will be powered by a diesel generator which will run continuously while the trench is open, dependent on water ingress rates. Dewater is not anticipated to be required in a single location for more than three weeks.	*This activity will occur concurrently with Phases 2 - 5. Therefore, noise generated in this phase has been assessed concurrently with Phases 2 – 5.* *The same equipment used in Phase 2 will occur within this Phase.*
6	Pipe bedding material will be carted to the worksite directly from source in 6 or 8 wheeler trucks, spread into the trench using an excavator and compacted using 400kg plate compactors. Excavators will be used to lift 2.4m pipe lengths into the trench.	• 6 to 8 wheeler truck • Excavator • Plate compactor
7	Side haunch, overlay bedding and hard fill to pavement level will be constructed as per pipe bedding material (refer above). Pavement layer will be stepped out from trench excavation to provide key into the existing pavement layers. Pavement aggregates will be spread using excavators and compacted using drum rollers, apart from where within 15m of a heritage structure.	• Excavator • Static drum roller • Plate compactor

The location of the open-trench construction works are shown in Table 12.

Table 12 Location and Length of Three Wastewater Connections

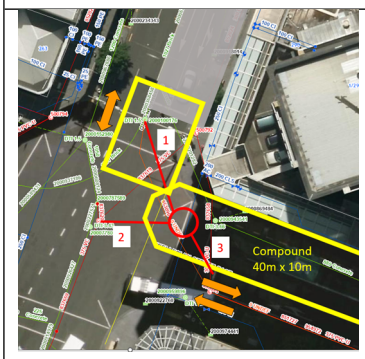
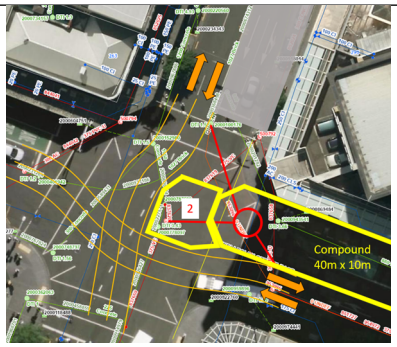
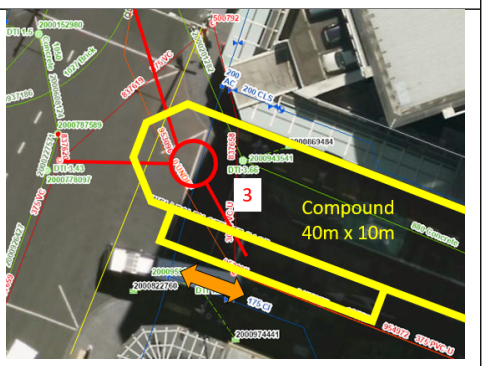
Connection 1	Connection 2	Connection 3
14.76m in length	10m in length	11.4m in length
Adjacent to the north approach on Queen Street	In the middle of the intersection	Adjacent to the east approach on Wellesley Street
		

Table 13 Trenchless Pipe Installation – shaft areas

Queen Street/Victoria Street and Queen Street/Mayoral Drive Trenchless Construction		
Stage	Activity	Equipment/Materials
1*	Insertion of mTBM into the shaft in multiple stages. A 25t crane at surface level will be used to drop mTBM into the shaft. Handheld power tools will be used to connect all parts and move to the required position. The shaft will require 24/7 dewatering and a submersible pump will be used to pump water into clarifying tank(s) for treatment, before discharging into the local wastewater network. The pump will be powered by a diesel generator which will run continuously while the shaft is open (subject to water ingress rates). Please note that, if possible, a connection the local power network would be used over a generator. Forced air ventilation will be required using a fan at surface level with ventilation ducting into the shaft.	• Submersible pump • Diesel generator • Ventilation fan • Crane • Handheld power tools
2*	Operation of the mTBM including noise from the operation, control cabin and 50t crane to insert new 6m lengths of pipe. It is predicted that up to 12 metres of pipe installation will occur each day requiring the use of the crane twice for insertion of new pipework. Pumps will be required at the surface level to remove the slurry from the bore face and bring water back, along with the pumping bentonite slurry around the drill head for lubrication for the pipes. Forced air ventilation will be required using a fan at surface level with ventilation ducting into the shaft. Dewatering of the shaft will be required 24/7 with a submersible pump with a clarifying tank, powered by a diesel generator.	• mTBM machine • Control cabin • Crane • Diesel generator • Ventilation fan • 6-inch mTBM pump • Submersible pump
3^	Victoria Street intersection will receive the mTBM. Hand power tools will be used to dismantle the drill head to allow extraction from the shaft. A 30t mobile crane will be used to lift the mTBM parts from the shaft onto a truck and trailer unit. Each shaft will then be backfilled as per the tables above.	• Submersible pump • Diesel generator • Ventilation fan • Crane • Handheld power tools • Truck and trailer

*Noise generated at Wellesley Street shaft only
^Noise Generated at Victoria Street shaft only

Table 14 Noise from Construction Compound Area and haul road

Greys Avenue Construction Support Area	
Activity	Equipment/Materials
The Greys Avenue Construction Support Area will be established around June 2024. This will require multiple hiabs delivering site office, staff welfare facilities, separation plant and slurry tanks, and generators. Trucks will deliver large machinery. Temporary traffic management and site hoardings will enclose the site.	• Hiabs, • Trucks • Excavator • Crane
During the mTBM operation, the separation plant and slurry tank will be operational. An excavator will be used to remove slurry from the tank into arriving and departing 6 wheeled trucks. Excavators will be used to move pipes from the compound to the Mayoral Drive shaft location via the service corridor (twice daily).	• Separation plant • Generator • Pumps • Excavator • Trucks
Operation of the Greys Ave CSA and mayoral Drive shaft during concurrently during trenchless construction.	• Stage 2 in Table 18 and Stage 2 in Table 19

* Noise generated in the Greys Ave CSA only
^ Cumulative noise from Greys Ave CSA and Mayoral Drive Shaft operating concurrently

Appendix B provides a list of the expected equipment to be used during construction, the associated sound power of that equipment, and the percentage of time in use over a worst-case 30-minute period. The equipment selection and associated sound power levels are based on BS 5228-1:2009 *Code of practice for noise and vibration control on construction and open sites*, NZS 6803:1999 *Acoustics – Construction noise*, or previous measurements of similar equipment.

Appendix B also presents the vibration levels for specific high vibration equipment taken from the NZTA *State highway construction and maintenance noise and vibration guide,* BS 5228 *Code of practice for noise and vibration control on construction and open sites*, or previous measurements of similar equipment.

WSP undertook vibration measurements of a plate compactor at the proposed Victoria Street / Queen Street shaft location. The plate compactor operated on a single spot, with the vibration measurements made at various distances away from the plate compactor including on the foundation (on ground level) and within the basement of 210 Queen Street. The measurements of the plate compactor operating and the specific foundation reduction for 210 Queen Street have been used in our analysis. The evaluation and assessment have been conducted under the assumption that the equipment or plant will not exceed the levels outlined in Appendix B. It is the contractor's responsibility to ensure that all equipment and/or plant on site is equivalent to or less than the assumed sound power levels.

Light construction works (such as light handheld tools, manual digging, line painting etc.) are also expected to occur on site. These activities are not expected to produce excessive noise or vibration levels and have therefore not been included, unless otherwise specified.

4.2 Noise Prediction Methodology

A noise prediction model has been prepared using SoundPLAN Version 8.2 3D computational noise modelling software. A series of scenarios have been analysed in conjunction with the calculations and are presented to support the acoustic assessment.

The model prediction considers attenuation due to distance, terrain, absorption by the atmosphere and ground, and reflections from building facades (including a contribution of the receiver façade).

The assessment assumes worst-case theoretical downwind conditions in all directions from all sources, which provides a conservative approach for assessment.

Table 15 presents the noise modelling parameters adopted for this assessment.

Table 15 Noise modelling parameters

Parameters for computational noise modelling		
Property	Value	Source
Calculation method	NZS 6803 for construction noise ISO 9613-2 for propagation	-
Terrain contours	0.25 m vertical heights	Auckland Council GeoMaps
Buildings	Outlines of Building footprints Heights set to 3.m for each story	Auckland Council GeoMaps, Heights via Google Street View.
Land parcels	Property land and road extent	Auckland Council GeoMaps
Ground Absorption Coefficient	0.1 – acoustically hard ground	Street View
Number of Reflections	3	-
Assessment location	1.0 metres from any façade	NZS 6803

All equipment is assumed to operate at the closest point to any adjacent site for our analysis.

The L_{AFmax} was calculated using the maximum noise level generated by any piece during any phase when undertaken at the closest point from the site to the receptor building. This approach provides a worst-case assessment of noise levels.

4.3 Vibration Prediction Methodology

Appendix B presents the vibration levels for specific high-vibration equipment. Vibration propagation between the source equipment and receiving locations has been predicted based on the methodology outlined in the Waka Kotahi NZ Transport Agency's *State Highway Construction and Maintenance Noise Vibration Guide* (version 1.1, dated August 2019). This method assumes hard soil conditions (compacted clay, exposed rock), and slab-on-grade foundations type of all adjacent properties. This is a conservative assessment of the ground conditions and foundation types. Actual vibration levels are likely to be lower.

4.4 Assumptions and Limitations

The following assumptions and limitations apply to this construction noise and vibration assessment:

- Construction activity locations are based on the contractors documentation, including proposed methodology, construction plant and master schedule.
- An assessment period of 30-minutes has been applied.
- It is conservatively assumed that all equipment will operate within a worst-case 30-minute period for each construction stage.
- There is always a level of uncertainty in predicting noise from construction activities. Numerous variables including variations in the specific models of equipment, the exact location of each item on site, and how the operator uses the equipment, will affect the accuracy of the noise predicted.

5 Predicted Noise and Vibration Levels

This section outlines the predicted noise and vibration levels.

5.1 Predicted Noise Levels

5.1.1 Average Noise Levels ($L_{Aeq,30min}$)

The predicted noise levels at each noise-sensitive receptor for each construction phase and stage are presented in Appendix C.

In Appendix B, properties that receive noise levels exceeding the 75 dB $L_{Aeq,30\ min}$ noise limit are highlighted in red, indicating a potential non-compliance with the noise limits set by the council. Furthermore, properties marked with a hash (#) indicate those affected by noise levels generated from activities within the road corridor designation only.

It is important to note that works associated with the shaft construction, open trenching, and trenchless construction are located within road reserve, and so are exempt from the wider Auckland Unitary Plan (AUP) construction noise limits. This exemption is based on the understanding that construction activities within the road reserve are subject to separate noise regulations and considerations.

Greys Avenue CSA is the only area of the construction works which is located outside of the road reserve. Therefore, noise generated in this area must adhere to the broader AUP construction noise limits unless a Resource Consent is granted.

The construction works at Mayoral Drive/Queen Street intersection and at Greys Avenue CSA has been assessed when operating independently and concurrently. All other work has been assessed independently.

Assessing all stages independently and assessing the Mayoral Drive/Queen Street Intersection stage and Greys Avenue CSA stage concurrently, allows specific assessment of compliance at all construction operating scenarios. This is then compared to the compliance requirements related to the road reserve and non-road reserve areas, ensuring alignment with the Auckland Council's regulations and guidelines.

Through this assessment with consideration to the exemptions and applicable regulations, this allows the predicted construction noise levels to be compared against the applicable AUP noise standards and maintain a responsible approach to construction noise management.

The table below outlines the properties which exceed the AUP 75 dB $L_{Aeq,30\ min}$ noise limit irrespective of the noise source being within the road corridor or within any other zoned land.

Table 16 Properties predicted to exceed the construction noise limits

Properties Predicted to Exceed the AUP Construction Noise Limits								
Stage of Works	Properties exceeded at each phase							
	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8
Shaft Construction: Queen Street/Mayoral Drive #	313 Queen St 317 Queen Street 319 Queen Street 321 Queen Street 323 Queen Street 329 Queen Street 380 Queen Street 396 Queen Street 430 Queen Street	313 Queen St 317 Queen Street 319 Queen Street 321 Queen Street 323 Queen Street 329 Queen Street 380 Queen Street 396 Queen Street	313 Queen St 317 Queen Street 319 Queen Street 321 Queen Street 323 Queen Street 329 Queen Street 380 Queen Street 396 Queen Street		313 Queen St 317 Queen Street 319 Queen Street 321 Queen Street 323 Queen Street 329 Queen Street 380 Queen Street 396 Queen Street	313 Queen St 317 Queen Street 319 Queen Street 321 Queen Street 323 Queen Street 329 Queen Street 380 Queen Street 396 Queen Street	n/a	n/a
Shaft Construction: Queen Street/Wellesley Street #	253-261 Queen St 263 Queen St 269-297 Queen St 280 Queen St 290 Queen St 300 Queen St 10 Wellesley St	263 Queen St 290 Queen St 300 Queen St 10 Wellesley St	253-261 Queen St 263 Queen St 269-297 Queen St 280 Queen St 290 Queen St 300 Queen St 10 Wellesley St 18-26 Wellesley St East	253-261 Queen St 263 Queen St 290 Queen St 300 Queen St 10 Wellesley St	253-261 Queen St 263 Queen St 290 Queen St 300 Queen St 10 Wellesley St	n/a	n/a	n/a
Shaft Construction: Queen Street/Victoria Street #	59-67 High St 203 Queen St 205-225 Queen St 214 Queen St 9 Victoria St E	59-67 High St 214 Queen St 9 Victoria St E	59-67 High St 214 Queen St 9 Victoria St E	59-67 High St 203 Queen St 214 Queen St 9 Victoria St E		59-67 High St 2 Lorne St 186 Queen St 191 Queen St 203 Queen St 205-225 Queen St 214 Queen St 222 Queen St 238 Queen St 9 Victoria St E	59-67 High St 203 Queen St 214 Queen St	59-67 High St 203 Queen St 205-225 Queen St 214 Queen St 9 Victoria St E
Open Trench Construction: Queen Street/Wellesley Street #	290 Queen St 300 Queen St	253-261 Queen St 263 Queen St 290 Queen St 300 Queen St				253-261 Queen St 263 Queen St 290 Queen St 300 Queen St 10 Wellesley St	253-261 Queen St 263 Queen St 290 Queen St 300 Queen St	n/a
Trenchless construction: Shaft locations only#	317 Queen St 319 Queen St 321 Queen St 323 Queen St 329 Queen St	317 Queen St 319 Queen St 321 Queen St 323 Queen St 329 Queen St	59-67 High St 214 Queen St 9 Victoria St E	n/a	n/a	n/a	n/a	n/a
Greys Ave CSA.	-	-	48 Greys Ave^ 100 Mayoral Dr^ 317 Queen St^ 319 Queen St^ 321 Queen St^ 323 Queen St^ 329 Queen St^	n/a	n/a	n/a	n/a	n/a

#Noise generated within the roading corridor impacting properties only.
^Noise generated by Greys Avenue CSA and Mayoral Drive operating concurrently.

5.1.2 Maximum Noise Levels (L_{AFmax})

The predicted maximum noise levels have been undertaken for the loudest construction activities; including piling, excavation, and rock drilling. All these activities are located within the road corridor.

The predicted maximum noise levels at each receptor based on the worst-case equipment without any noise mitigation are presented in Appendix B.

The following properties are predicted to exceed the maximum noise limit outlined in the AUP, with the exceedance decibel level provided in brackets:

- 59-67 High Street (13 dB)
- 2 Lorne Street (2 dB)
- 186 Queen Street (2 dB)
- 191 Queen Street (2 dB)
- 203 Queen Street (5 dB)
- 205-225 Queen Street (4 dB)
- 214 Queen Street (11 dB)
- 222 Queen Street (3 dB)
- 239 Queen Street (1 dB)
- 253-261 Queen Street (6 dB)
- 263 Queen Street (8 dB)
- 269-297 Queen Street (3 dB)
- 280 Queen Street (4 dB)
- 290 Queen Street (17 dB)
- 300 Queen Street (10 dB)
- 313 Queen Street (9 dB)
- 317 Queen Street (12 dB)
- 319 Queen Street (17 dB)
- 321 Queen Street (14 dB)
- 323 Queen Street (13 dB)
- 329 Queen Street (12 dB)
- 380 Queen Street (3 dB)
- 396 Queen Street (9 dB)
- 430 Queen Street (4 dB)
- 9 Victoria Street East (8 dB)

Maximum noise levels from construction activities outside of the road corridor (generated within the Greys Ave CSA) are predicted to comply with the maximum noise limits of the AUP.

5.2 Predicted Vibration Levels

The key vibration activities are from excavators breaking ground, piling or drilling of holes, operation of the mTBM, and compaction.

Table 17 outlines the stand-off distance of each piece of high vibration equipment likely used to achieve the various vibration limit. The stand-off distance is the distance from any vibration generating equipment at which the vibration limits are reached. Any building within the stand-off distance is predicted to exceed the vibration criteria.

Other equipment will also be used on site but generate lower levels of vibration or installed on manufacturer's vibration isolation (such as the separation unit). Therefore, vibration levels will be lower than the equipment provided below.

Table 17 Vibration stand-off distances

Predicted vibration stand-off distances to achieve the relevant vibration criteria						
No.	Equipment	The vibration level of equipment (mm/s PPV @10m)	Stand-off distance to achieve vibration criteria (metres)			
			10 mm/s	5 mm/s	2.5 mm/s	2 mm/s*
1	Excavator breaking ground	1.9	0.5	1.8	6.5	10
2	Secant piling 600mm diameter piles.	0.5	0.1	0.2	0.5	1
3	mTBM Tunnel Boring	2.0	2	4	8	10
4	Plate Compactor**	1	0.1	0.2	0.7	1

*AUP vibration amenity limit
**From WSP measurements at Victoria St site

The 10 mm/s criteria apply at any commercial building, or structure commercial in nature (high-rise concrete or steel residential buildings for instance). The 5 mm/s applies to single or two-storey residential dwellings.

Heritage properties are subject to more onerous vibration limits because of their structural sensitivity to vibration and their intrinsic value. We have considered that the 2.5 mm/s PPV limit applies to all buildings within the heritage building overlay under the AUP. The 2.5 mm/s PPV setback distance shall be used as an assessment distance rather than the 20 metre distance provided in E26.2.3.2 of the AUP, as this is a specific analysis undertaken for these works.

Managerial mitigation measures have been adopted by the contractor to minimise the impacts of vibration. These include:

- Only static rollers or plate compactors to be used at the Mayoral Drive and Victoria Street compounds.
- Using low/no vibration rock fracturing methods to remove basalt from the Victoria Street shaft.
- Providing excavator operator training on specific measures to reduce vibration (such as slowly lowering the bucket onto the ground).
- Undertaking vibration measurements during the first operation of each piece of high-vibration equipment to quantify the level of vibration generated on site.

Based on the setback distances and mitigation measures adopted above, there are no properties predicted to exceed the DIN 4150-3 vibration criteria.

There are also no properties within the 2 mm/s AUP amenity limit setback distance from vibration generated outside of the road corridor.

6 Mitigation and Management

This section describes the managerial and physical mitigation measures which should be implemented as far as reasonably practicable. This is to protect against unreasonable noise and reduce the effects of noise and vibration at receptors in line with the Resource Management Act (RMA). *This section shall be kept up to date by the contractor throughout the construction process.*

6.1 Principles of Mitigation

Proactive noise mitigation is the most effective method to control construction noise and vibration. Noise and vibration events that the community deem to be unnecessary are more likely to generate complaints.

Guiding Principles:

- The BPO shall be identified and implemented to manage and mitigate potential adverse effects of noise and vibration. The BPO of mitigation will need to be constantly reviewed during construction.
- Construction noise and vibration effects need to be managed, even when levels are within the limits, and management needs to be intensified if the limits are approached.
- Ongoing assessment of all construction activities and continual consideration of potential noise and vibration effects and appropriate mitigation shall be undertaken.
- Ongoing effective stakeholder engagement shall be provided, making available information on what, when and why construction works are happening.

6.1.1 Development of Best Practicable Options for Mitigation

A general hierarchy of mitigation measures to reduce the impact of noise and vibration is:

1 Scheduling construction activities to avoid sensitive times, particularly in the case of night works.
2 Use equipment and construction methods that minimise noise and vibration at the source, including the use of quieter machinery and tools.
3 Including physical mitigation measures to reduce the noise and vibration levels at receivers, such as noise barriers at the boundary of the Site and for specific items of plant.
4 Maintain open communication with the community and inform them about the schedule, duration, and potential noise impacts of the construction work. Respond promptly to any complaints and adjust the work plan as needed.
5 Deploying trained workers in noise management practices and encourage them to minimise noise by following best practices, such as avoiding unnecessary idling of equipment and using proper tools for the job. Hold regular toolbox talks and site inductions which discuss potential noise and vibration impacts.
6 Temporary relocation of potentially affected parties during high noise/vibration night works.

6.2 Physical Mitigation

Where practicable, physical mitigation shall be used to reduce the noise emissions from the construction works. In some instances, the use of physical mitigation may not be practicable (due to space requirements, or machinery utilised).

For this site, the key physical mitigation measures for noise and vibration are:

- Equipment selection, operation, and siting of equipment.
- Adoption of equipment specific enclosures, or other physical barriers.

Where new or improved physical mitigation measures are available, these will be considered by the team and added as a best practicable option to this section, if they can be utilised for this project.

6.2.1 Equipment Selection, Siting and Operation

Equipment and plant for the Project will, as far as reasonably practicable:

- Prioritise quieter and newer technologies/models over noisier and older equipment/plant.
- Avoiding using excavator buckets and/or dropping from height as a methodology for breaking surface concrete to minimise vibration levels.
- Will have periodic inspections and be well-maintained, so noise and vibration emissions are within expectations for that equipment or plant.
- Be the appropriate power, size, or type for the proposed task/activity.
- All vehicles that are fitted with audible reversing warning sirens will be fitted with broadband reversing beepers.
- Equipment that is used intermittently to be shut off when not in use.
- Where practicable, power shall be provided from mains power rather than generators.
- Use of electric equipment over petrol/diesel alternatives including saws, hand power tools, chainsaws, and the like.
- Minimise the number of periods of vibration activity (e.g. complete all piling in one extended period rather than two shorter periods with the same overall duration)
- Start/stop vibratory function at furthest possible point away from sensitive structures and pass by while the vibration level is stable
- Switch off the vibration function within safe setback distance
- Limit and/or not use any compression/engine breaking on site as far as practicable; and
- Plan traffic flow, parking, and loading/unloading area to reduce reversing movements of trucks and equipment. Forward-in/forward-out movements are preferred.

6.2.2 Specific Physical Mitigation Measures

To reduce noise from that predicted from the equipment and plant to adjacent receptors, the following physical noise reduction measures are to be incorporated as far as reasonably practicable:

- The contractor is proposing to use temporary concrete barriers with plywood hoardings around most of the perimeter of each of the construction areas, except where a gate is required for access at one end. The proposed site hoardings are shown in Figure 7.

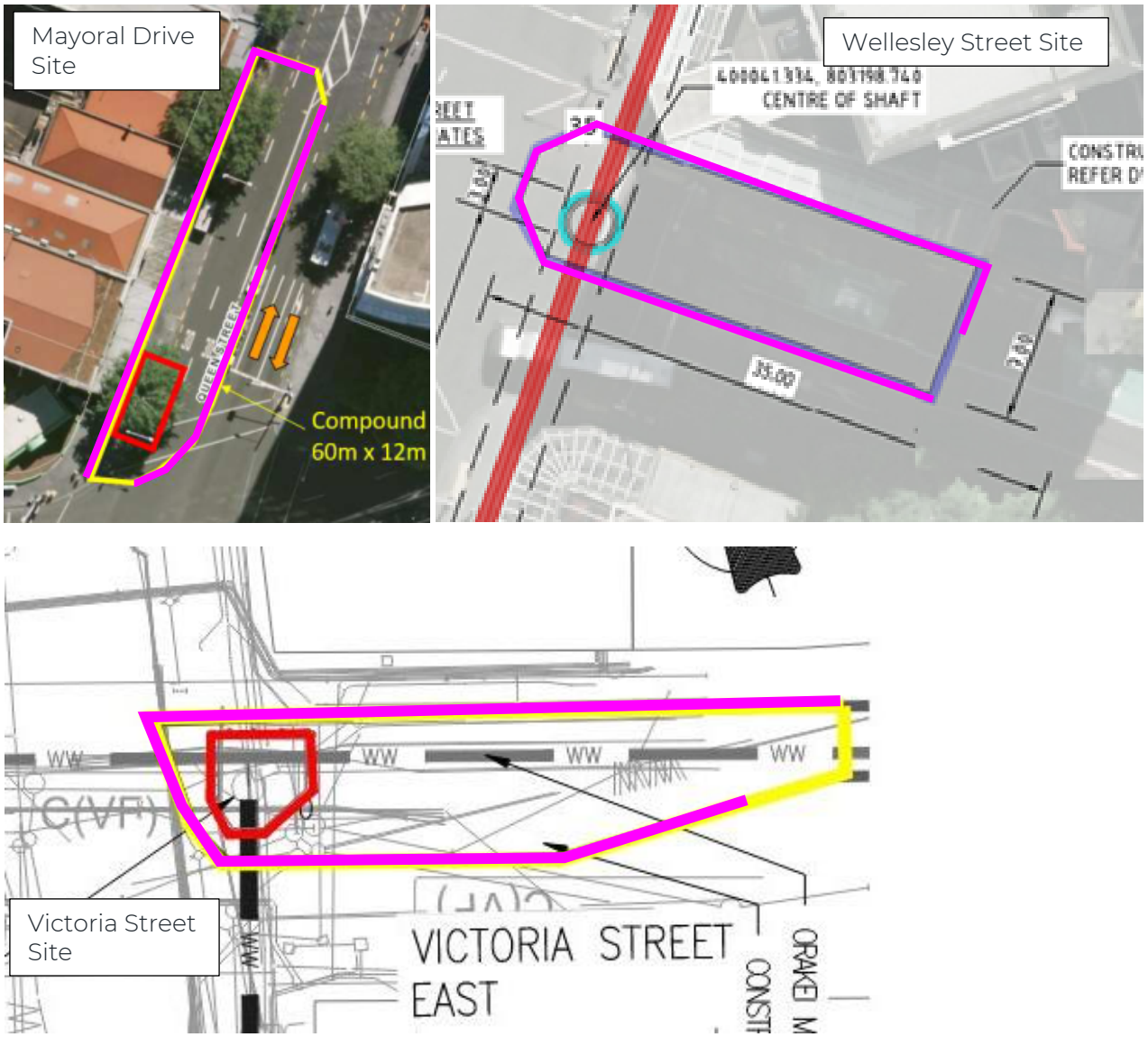
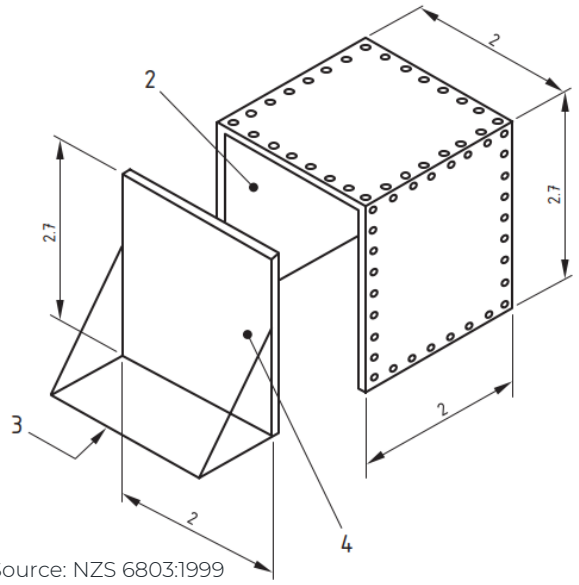


Figure 7 Proposed locations of site hoardings (pink)

- The acoustic site hoardings shall achieve the following minimum specification.
    - Height: >2.0metres
    - Surface mass: >10 kg/m^2
    - The hoardings shall be constructed and maintained such that there are no gaps or cracks in the fence.
    - Where timber is used, the paling shall be overlapped by a minimum of 25 mm, or a board and batten system implemented. A sleeper rail will be required to seal the bottom of the fence to the ground. If timber is used, this would be constructed of 25 mm pine (or equivalent) to resist warping.

  Alternatively, "noise mats" such as Duraflex Hushtec construction noise barriers can be used, ensuring that there are no gaps between panels, and between the panel and ground.

- Temporary localised barriers will be used where practicable over the shaft during rock drilling of the basalt, and around generators and/or pumps used for dewatering during the night-time. An example of temporary enclosures that could be constructed over the shaft opening during rock breaking or compaction is shown in Figure 8.



Source: NZS 6803:1999

Source: https://blog.echobarrier.com/

Figure 8 Example of temporary acoustic enclosure

- Where practicable, localised movable acoustic screens/barriers/hoardings shall be used around high noise-generating equipment when in use, such as a concrete saw. The movable site hoardings shall achieve the minimum specifications listed above.
- Where practicable, vibratory piling attachments to excavators and sheet piling rigs shall have an acoustic piling cover (such as Hushtec or Duraflex Piling attachment or rock breaker attachment). These are likely to reduce noise up to 8 dB.
- Generators and/or water pumps are to be selected that have acoustic enclosures to reduce the noise radiated by these units. The reduction the acoustic enclosures provide over standard units depends on the manufacturer. Where generators are required, these shall be installed on site as far as practicable away from sensitive receptors. Where possible, dedicated localised acoustic barriers will be constructed around any generators and water pumps.

The above provides the best practicable option for physical mitigation measures to control noise and/or vibration from the proposed construction works.

6.3 Managerial Mitigation Measures

This section describes the best practicable option for managerial mitigation measures which can be implemented to reduce the effects of noise and vibration at adjacent properties.

For this site, the key managerial mitigation for noise and vibration are:

- Noise and vibration monitoring and validation
- Training of staff
- Site conduct of staff on site

This section shall be kept up to date by the contractor throughout the construction process.

6.3.1 Validation and Monitoring

Acoustic validation measurements for specific parts of the works shall be undertaken to ensure acoustic predictions are accurate and in line with site noise levels.

In particular:

- Noise and vibration monitoring of piling activities are to be measured on-site during the first activity to confirm noise and vibration levels emitted.
- Noise and vibration monitoring of tunnel boring activity including the separation plant are to be measured on-site during the first activity to confirm noise and vibration levels emitted.

6.3.2 Training

Site-specific training shall be given to site personnel including management and workers involved in construction activities that have the potential to generate noise and vibration effects. Site inductions for these personnel will include a briefing on relevant aspects of the CNVMP, including:

- The roles and responsibilities of all site personnel in the management of noise and vibration effects.
- Identification of the sensitive receivers and activities that have the potential to cause noise and vibration effects.
- Procedures and operational considerations associated with those sensitive receivers and activities, to manage the noise and vibration effects. This may include the understanding of minimum set-back distances, physical mitigation requirements, the understanding of allowable hours of operation and appropriate use of equipment.
- Contacts for site personnel to gain information related to noise and vibration including the limits, equipment on site, mitigation measures, and management procedures.
- How plant equipment and methodologies may impact noise and vibration effects, and the relevant procedures to follow for the selection of appropriate plant and methodologies.
- How site behaviours and conduct may affect noise and vibration effects, and procedures to follow for appropriate site behaviours and conduct.
- Maintaining goodwill amongst the community.

Toolbox/tailgate meetings throughout the construction will also include consideration of noise and vibration effects, refreshing the training information given in the site induction and/or updating training information.

Site specific training will be given to all excavator operators such that they understand how operation of the plant may impact vibration generated. This training will include minimising ground impacts with the bucket, minimising scraping of the bucket over rock, placement of the excavator away from any vibration sensitive buildings.

Site specific training must be provided to site personnel involved in monitoring noise and vibration and development of procedures for management and mitigation of noise and vibration effects, where required.

This includes where noise and/or vibration monitoring is required to investigate any complaint. Site induction for these personnel will include a briefing on relevant aspects of the CNVMP as above, plus procedures for recording monitoring results and where noise and vibration effects are identified to comply or not comply with the limits.

6.3.3 Scheduling of Works

The final scheduling of particularly loud activities shall be decided once consultation with the community has been undertaken.

Occupied buildings are sensitive to the timing of construction works. Currently no night-time works are proposed under the construction methodology. As such there is a low risk of sleep disturbance to residential or hotel receptors.

While construction activities should be prioritised when buildings are not occupied (and less sensitive to noise), with residential and commercial properties nearby, there will unlikely be a period where all buildings are unoccupied.

Cumulative noise emissions should always be considered by the contractor when scheduling the works, noise emitting from multiple items of the plant will summate and cause a greater overall noise level. Only one item of particularly loud plant should be used at any one time on site, to reduce the cumulative noise and vibration from multiple items of equipment operating concurrently.

6.3.4 Behaviour and Conduct

Site personnel shall understand that their behaviours and conduct can affect noise and vibration effects. Conduct that is perceived as unnecessarily noisy can influence the community's perception of the overall noise generated by the project.

During the site induction for contractor staff, the following management mitigation measures will be acknowledged and addressed where practicable and safe to do so:

- When arriving at work, please drive slowly on site and keep revs to a minimum. Keep stereos at a low volume (or off) and do not slam doors.
- No shouting on site. Either walk over and talk to somebody or use a radio/phone.
- Be careful with tools and equipment. Place them down and do not drop them.
- Do not drag materials on the ground. Place them down when you arrive at the work area.
- Equipment and vehicles shall be switched off when not in use.
- When loading trucks do not drop material from a height.
- Noise enclosures should also have doors/hatches closed when the equipment is in use.
- All equipment is to be well maintained.
- If staff, see anything/anyone making unnecessary noise then stop it/them. If the source cannot be stopped, then report it to the Noise Liaison Officer.

It is essential that good relationships are maintained with the local community. Any queries from members of the public shall be responded to politely and referred to the Noise Liaison Officer / Stakeholder and Engagement Manager. Staff shall assist the public to contact this person. Staff shall not enter a debate or argue with members of the public.

6.3.5 Vibration Management

Specific vibration management will be required to control vibration generating plant, particularly near buildings within the Historic Heritage Overlay in the AUP. The following vibration managerial mitigation measures are to be followed to reduce the likelihood of high vibration levels impacting heritage buildings:

- Only static rollers or plate compactors to be used at the Mayoral Drive and Victoria Street compounds.

- Using low/no vibration rock fracturing methods to remove basalt from the Victoria Street shaft.
- Providing excavator operator training on specific measures to reduce vibration (such as slowly lowering the bucket onto the ground).
- Undertaking vibration measurements during the first operation of each piece of high-vibration equipment to quantify the level of vibration generated on site.

6.3.6 Temporary Relocation

Temporary relocation is only required for construction works during the night where, even with the BPO physical and managerial mitigation measures incorporated, noise levels may impact sleep to a level where there will be health impacts. The following procedure will need to be undertaken to action temporary relocation:

- Where noise levels are above the AUP noise standards, undertake community consultation to determine the level of impact this may have (i.e., are bedrooms facing away from construction areas and therefore will receive lower noise levels when assessed within bedroom spaces, or will people be home during this period).
- Analyse the noise level within bedrooms to determine whether noise from night works may cause sleep disturbance.
- If the above analysis shows that noise levels within bedrooms may disrupt sleep, then consultation will be required with the impacted property to determine when and where temporary relocation of the occupiers can be undertaken.
- Once night works associated with the temporary relocation are complete, follow up with the occupants who were temporarily relocated to determine what impacts that may have caused and to revise the methodology for any future relocation.

6.4 Receptor Specific Measures

Additional receptor specific noise and/or vibration mitigation measures may be required due to changes in the use of adjacent buildings, or complaints received. This section will be updated with a list of properties which specific management schedules are developed. All Receptor Specific Measures will be included as appendices to this CNVMP.

6.4.1 Specific Management Schedules

A specific management schedule is likely needed for vibration activities that are predicted to exceed the 2.5 mm/s PPV vibration criteria at buildings within the historic heritage overlay in the AUP. The best practicable option of mitigation shall be considered in the specific management schedule and may include specific measures for mitigation and management of the effects. A specific management schedule should include:

- Identification of potentially affected neighbours and confirms the proposed methodology and equipment to be used;
- Details specific physical mitigation measures to be adopted based on the predicted noise and vibration levels; and
- Details any specific monitoring or communication requirements.

Heritage listed buildings may be considered particularly noise and/or vibration sensitive and therefore a specific management schedule should be undertaken for these sensitive receptors. Details around specific pre and post-construction survey required and/or monitoring requirements throughout construction.

7 Community Engagement

A key component in minimising the impact of noise and vibration effects is early community engagement. Prior to the start of construction, a Community Relations Manager role (or equivalent) will be established. This representative for the Project will advise (in person or by writing) all properties within 100 metres of any construction site. This advice will include:

- Description of the wider construction works
- The activity that the occupants/landowners may be impacted by.
- Why the works are required to occur.
- Duration of these specific activities.
- Timing of when they will occur.
- Contact details (including telephone number and email) for the Noise Liaison Officer which the public can contact to find out information or lodge a complaint.
- How any noise and vibration complaints will be handled by the contractor.

Regular direct communication (in person or by writing) will be undertaken with the properties that potentially could receive noise levels greater than the noise limits outlined in this report at any point during the construction.

7.1 Consultation

The objective of consultation with neighbouring properties is to foster positive communication and relationships between the contractors, clients, and potentially affected parties. It also provides a platform for residents to learn about the Project.

Consultation will be undertaken with all properties that are potentially impacted by construction noise and/or vibration to determine:

- Hours that higher noise and/or vibration activities would have the lowest impact (such as times when all residential occupants are at work).
- Days/times when occupants are the most sensitive (during key religious events, at night if small children are going to bed, etc.).
- If there are any special needs relating to noise and/or vibration within the construction window (i.e., children birthday parties), that may require key management of construction noise and/or vibration.

Where practicable, high noise and/or vibration construction activities will occur at times when the adjacent occupants are least noise sensitive.

7.2 Notification Procedures

For buildings that are to receive noise or vibration levels greater than the required criteria, the following procedure to notify these properties is to be undertaken:

- Identification of properties that would receive levels greater than the AUP noise and vibration criteria for the specific equipment being used.
- A minimum of 10 working days prior to any noise or vibration equipment being used that would lead to potential exceedances, communication will be undertaken to adjacent receptor buildings to notify them of upcoming high noise and/or vibration works. This communication is to include:

- Description of the specific activity being undertaken
- Why the works are required to occur.
- Duration of these specific activities.
- Timing of when they will occur.
- Contact details (including telephone number and email) for the Noise Liaison Officer which the public can contact to find out information or lodge a complaint.
- How any noise and vibration complaints will be handled by the contractor.
- If pre and post construction inspections will be undertaken (if not already) and when likely times these will occur.

- Any noise and/or vibration monitoring is to be undertaken during activities where practicable to confirm the received levels and to determine future mitigation for the equipment.

8 Complaints Handling Protocol

The Contractor will adopt the following protocol for handling complaints. This protocol is intended to ensure that the issues are addressed, and that appropriate corrective actions are identified and implemented as necessary.

Contact details of the Noise Liaison Officer and/or other key staff will be available (either during regular communication with affected parties and/or available on site boards) such that a member of the public can contact the contractor.

The Noise Liaison Officer will record all verbal and telephone complaints in writing within a Noise Complaint Register. Details to be recorded should include:

- Full details of the complaint (complainant's name and address)
- Time and date of the event.
- Location of the event.
- What was felt/heard (can they identify the plant or process).
- If it was felt/heard outside or inside.
- If inside, were windows/doors open.
- Impact of the event (e.g., woken from sleep, couldn't hear the TV, disturbed whilst reading etc.).
- Weather conditions at the time (if known) including cloud cover, temperature, wind strength and direction.
- Any specific requests.
- What activities were occurring at the time of the complaint, including the items of equipment operating and where they were operating.
- Any additional acoustic data, including any noise or vibration measurements that are relevant to the complaint.

An initial response will be made and recorded. Depending on the nature of the complaint, the initial response could be to immediately cease the activity pending investigation, to replace an item of equipment, or screen the activity. However, it might not be practicable to provide immediate relief in some cases. The complainant and Council will be informed of actions taken. Contact details for the Council are recorded above.

Where the initial response does not address the complaint, further investigation, corrective action, and follow-up monitoring shall be undertaken as appropriate within 5 working days. The complainant [and Council] will be informed of actions taken.

Complainants will be informed of the implementation of the corrective action that has been taken to mitigate the adverse effects.

All actions will be recorded on a Noise Complaint Register, and the complaint will then be closed. The Contractors' complaint response line will be always attended to during out of hours works. It will be kept up to date and made available to the Environmental Health Officer (or equivalent) of Auckland Council if requested.

9 Monitoring

It is recommended that acoustic monitoring is undertaken at key milestones to confirm that the actual noise emissions are no greater than those predicted, or to investigate any noise and/or vibration complaints.

9.1 Noise

Noise monitoring shall be conducted by one of the following staff in accordance with NZS 6801:2008 and NZS 6803:1999.

- George van Hout, Chris Bradley, Leonard Terry, William Zhu, Sandeep Manilal, Raj Prasad; WSP
- *Contractor to include appropriately qualified staff*

Noise monitoring will be undertaken by a suitably qualified person using a Class 1 or 2 Sound Level Meter (SLM) and associated kit. The calibrator will be verified by an accredited laboratory annually, and the sound level meter and microphone biannually (every two years) during the construction programme.

The contractors may undertake noise monitoring with an SLM that does not have any class classification; however, it must be noted that this approach would not be in accordance with noise measurement guidance and standards. If this approach is adopted and measured noise levels exceed the predicted noise levels, noise monitoring by a suitably qualified person using a Class 1 or 2 SLM shall be undertaken.

Noise monitoring is recommended to be conducted:

- Noise measurements will be undertaken to validate the noise emissions of the equipment on site.
- To address any reasonable noise complaints.

Measurement sample time should not exceed one-hour and 15-minutes is likely to be adequate. Measurements will be used to validate or refine the noise level predictions and determine which receivers may be at risk of noise levels exceeding the criteria.

Following each noise survey, the results will be evaluated and reported on a noise survey report template. If noise monitoring indicates an exceedance of the noise criteria, then the noise management of the works will be reviewed and updated. All noise survey reports will be kept on file and available to the territorial authority on request.

9.2 Vibration

Attended vibration monitoring shall be undertaken when high vibration generating equipment first operate at the site. This is to confirm the site-specific vibration propagation and number of properties that are likely to exceed the vibration criteria.

Where access is granted by the owners and/or occupiers, vibration levels shall be measured inside the following properties at the closest point to the construction works:

Monitoring of building vibration will be performed in accordance with *DIN 4150-3 Structural Vibration – Effects of vibration on structures* by the following trained staff:

- George van Hout, Chris Bradley, Leonard Terry, William Zhu, Sandeep Manilal, Raj Prasad; WSP
- *Contractor to include appropriately qualified staff*

For all vibration measurements, vibration levels and frequencies will be recorded at a known distance from the plant item of interest using a vibration logger that satisfies the requirements of DIN 45669-1[1] and operated in accordance with DIN 45669-2[2]. Vibration recordings will be made for each item of plant operating normally on its own, where practicable.

The methodology to determine when vibration monitoring is to be undertaken is as follows:

1 Measure the vibration level of the equipment used on site and compare with the levels provided in Table 17.
2 Calculate the vibration stand-off distance of the equipment based on the site specific measurements. Compare to the stand-off distances provided in Table 17.
3 Where buildings are within the stand-off distances, continuous vibration monitoring on the foundation of these buildings will be undertaken during construction works within the stand-off distances.
4 In addition to undertaking vibration measurements of equipment, vibration monitoring will also be conducted at the following occasions:

- At the start of piling or other high vibration generating activities outlined in Table 17 to validate predictions.
- During the first pipe jacking operation to confirm the vibration level from this activity and reassess any mitigation measures required to control vibration.
- When equipment is located at the closest point to the heritage buildings indicated in Section 2.4 to confirm vibration levels on the foundations of the building,
- To address reasonable complaints relative to construction vibration.

Where continuous vibration monitoring is required as assessed in step 3 above, the selected continuous vibration monitoring system is to have an automatic warning system. A vibration threshold will be set (2.5 mm/s PPV within the building), and immediate warnings to key personnel will be sent. If a warning is received., works are to stop while the source of the vibration is determined. If it is found that the exceedance was caused by construction activity, the building should be inspected by a suitably qualified and experienced person, and any damage should be documented via sketches and photographs. Mitigation measures (either physical or managerial) will be put in place such that exceedances are not predicted to be experienced in future.

We note that it is predicted that the six properties which have been highlighted as being a high-risk to vibration impacts by the Heritage Consultants (buildings outlined in Section 2.4) are outside of the 2.5 mm/s PPV heritage building vibration limit outlined in DIN 4150-3 and the 2 mm/s PPV amenity limit when considering the implemented mitigation. However, due to the perceived heritage nature of these buildings, continuous vibration monitoring will be undertaken at these buildings when construction works are nearby.

All vibration survey reports will be kept on file and available to the territorial authority upon request.

It is also recommended that because high-risk vibratory construction methods (such as piling) will be implemented within this project, chosen the best practicable mitigation means should be taken into consideration, such as using smaller items of plant to reduce ground-borne vibration.

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[1] DIN 45669-1:2020-06 *Measurement of vibration immissions – Part 1: Vibration meters – Requirements and tests, English translation of DIN 45669-1:2020-06.*

[2] DIN 45669-2:2005-06 *Measurement of vibration immission – Part 2: Measuring method.*

9.3 Building Surveys

Currently, no buildings are predicted to exceed the vibration criteria, and therefore, there is no requirement to undertake pre and post building condition surveys. However, it is recommended that both a pre-construction and post-construction assessment of the specific at-risk heritage buildings listed in Section 2.4 is undertaken, as these buildings are at the most risk of damage due to vibration generating activities occurring within the shafts.

Additionally, where vibration measurements are undertaken and are shown to be above the vibration criteria, all works on site will cease, and a building condition survey will be undertaken.

All building surveys will be accompanied by a suitably qualified and experienced Heritage Consultant and/or Conservation Architect to ensure that the best-practice conservation guidelines are followed and all appropriate measures are implemented to protect the buildings at risk of vibration as outlined in Section 2.4.

Qualified building surveyor staff who will conduct building condition surveys are:

- *TBC*
- *TBC*

Qualified Heritage Consultant and/or Conservation Architect who will conduct heritage building surveys are:

- *TBC*
- *TBC*

A report will be prepared for each building surveyed including:

- A description of the building condition including construction materials and the present condition;
- Any existing cosmetic or structural damage, or other building-related defects;
- Sketches showing the location and extent of any existing damage such as cracks; and
- Photographs of the entire building prior to works, before and after high-vibration activity near the building, and after the construction works are complete.
- Verification of the report by the surveyor and building owner.

Following the works all building condition surveys will be repeated. In addition, where vibration monitoring records vibration levels exceeding the criteria from construction activities, building condition surveys will be repeated. The any further building condition report will be prepared including:

- Sketches and new photographs of any new damage, and
- Verification of the report by the surveyor and building owner.

Where building condition surveys are undertaken after exceedances of the vibration level, and building damage is observed this is to be recorded photographically, and an appropriately qualified and experienced structural engineer is to inspect and ascertain the extent of the damage, and impacts that continuing work may have on the building before works progress.

Pre and post-construction building condition surveys will be held on record and provided to the building owner, Heritage New Zealand Pouhere Taonga, and/or relevant territorial authority if requested.

9.4 Seismic Building Assessments

An Initial Seismic Assessment (ISA) should be undertaken for the following buildings identified within the Heritage Effects Assessment. This is to determine the structural integrity of the building to confirm the likelihood of damage to the building from vibration due to construction equipment:

- John Courts Building (210 Queen Street)
- No deposit Piano Building (307 – 319 Queen Street)
- W. A. Thompson Building (307 – 319 Queen Street)
- Auckland Sunday School Building (323 – 327 Queen Street)
- Two-Storey Commercial Building (319 Queen Street)

Qualified staff who can undertake ISA's are:

- *TBC*
- *TBC*

The structural performance of each building given as percentage of New Building Standard (%NBS) shall be recorded and a conclusion will be developed around the likelihood of building damage (cosmetic or structural) with the developed vibration limits. Specific limits may need to be developed for buildings that have not been recently strengthened.

Appendix A
Glossary

TERM	DESCRIPTION
A-weighting, dBA	The unit of sound level, weighted according to the A-scale, which takes into account the increased sensitivity of the human ear.
Ambient noise	The all-encompassing sound, at a given place at a certain time, being usually a composite of sounds from sources near and far.
Decibel (dB)	A scale for comparing the ratios of two quantities, including sound pressure and sound power. The difference in level between two sounds s_1 and s_2 is given by 20 log10 (s_1 / s_2). The decibel is used to measure absolute quantities by specifying a reference value that fixes one point on the scale. For sound pressure, the reference value is 20µPa.
Façade Level	A noise level measured/assessed at 1 metre in front of a sound reflecting object such as a building façade and including the contribution of the sound reflection.
Free-Field Level	Far from the presence of sound reflecting objects (except the ground), usually taken to mean at least 3.5 metres.
$L_{eq,T}$	A noise level index called the equivalent continuous noise level over the time T. This is the level of a notional steady sound that would contain the same amount of sound energy as the actual, fluctuating, sound that was recorded.
$L_{10,T}$	A statistical analysis noise descriptor being a sound pressure level exceeded for 10% of the measurement period.
L_{max}	A noise level index is defined as the maximum noise level during the period T. L_{max} is sometimes used for the assessment of occasional loud noises, which may have a negligible effect on the overall L_{eq} noise level but will still affect the noise environment. Unless described otherwise, the sound level meter is set to a 'fast' response.
L_{eak}	The instantons peak pressure level was recorded during the measurement period.
Octave Band	A range of frequencies whose upper limit is twice the frequency of the lower limit.
PPV	Peak Particle Velocity: Measure of the greatest instantaneous velocity change in a specific spot during a measurement period.
Sound Power Level (SWL)	The logarithmic measure in decibels of the sound power (P) generated by a source.
Sound Pressure	Sound, or sound pressure, is a fluctuation in air pressure over the static ambient pressure.
Sound Pressure Level (SPL)	The sound level is the sound pressure relative to a standard reference pressure of 20µPa ($20x10^{-6}$ Pascals) on a decibel scale.

Appendix B
Construction Equipment Schedule

Equipment List						
Site	Stage	Activity	Equipment	SWL L_{Aeq}	SWL L_{AFmax}	% on time
Queen Street/Mayoral Drive Shaft Construction	1	Road surface breakout	Concrete saw	113	-	50
			20T Excavator	105	120	100
			Truck	107	120	50
	2	Secant piling	SR-45 drill rig	107	-	100
			Truck	107	120	50
			Concrete truck and pump	103	-	100
	3,4	Excavation of shaft	35T Excavator	107	120	100
			3T Excavator	102	120	100
			Hand-held power tools	100	-	100
			Truck	107	120	50
			Ventilation fan	100	-	100
			Submersible pump	96	-	100
			Diesel generator	94	-	100
	5	Installation of manhole and backfilling	90T Crane	105	-	75
			Concrete truck and pump	103	-	100
			Truck	107	120	50
			20T Excavator	105	120	100
			Submersible pump	96	-	100
			Diesel generator	94	-	100
			Ventilation fan	100	-	100
	6	Reinstatement	20T Excavator	105	120	100
			Static drum roller	107	-	100
			Plate compactor	108	-	100
Queen Street/Wellesley Street Shaft Construction	1	Road surface breakout	Concrete saw	113	-	50
			20T Excavator	105	120	100
			Truck	107	120	50
	2	Secant Piling	SR-45 drill rig	107	-	100
			Trucks	107	120	50
			Concrete truck and pump	103	-	100
	3	Excavation of shaft	35T Excavator	107	120	100
			3T Excavator	102		100
			Hand-held power tools	100	-	100
			Trucks	107	120	50
			Submersible pump	96	-	100
			Diesel Generator	94	-	100
			Ventilation fan	100	-	100
	4	Installation of manhole and backfilling	90T Crane	105	-	75
			Concrete truck and pump	103	-	100
			Truck	107	120	50
			20T Excavator	105	120	100
			Submersible pump	96	-	100
			Diesel generator	94	-	100
			Ventilation fan	100	-	100
	5	Reinstatement	20T Excavator	105	120	100
			Static drum roller	107	-	100
			Plate compactor	108	-	100
Queen Street/Victoria Street Shaft Construction	1	Road surface breakout	Concrete saw	113	-	50
			20T Excavator	105	120	100
			Truck	107	120	50
	2	Boring holes	SR-45 drill rig	107	-	100
			Trucks	107	120	50
			Concrete truck and pump	103	-	100

	3	Installing UC beams into holes	20T Excavator	105	120	100
			Truck	107	120	50
	4,5	Excavation of shaft	35T Excavator	107	120	100
			5T Excavator	102		100
			Hand-held power tools	100	-	100
			90T Crane	102	-	100
			Welder and generator	101	-	50
			Submersible pump	96	-	100
			Ventilation fan	100	-	100
			Diesel generator	94	-	100
			Truck	107	120	50
	6	Excavation of Bassalt	35T Excavator	107	120	100
			Rock diamond drill	115	125	100
			90T Crane	105	-	75
			Submersible pump	96	-	100
			Ventilation fan	100	-	100
			Diesel generator	94	-	100
			Concrete truck and pump	103	-	100
	7	Installation of manhole and backfilling	90T Crane	105	-	75
			Concrete truck and pump	103	-	100
			Truck	107	120	50
			35T Excavator	107	120	100
			Submersible pump	96	-	100
			Diesel generator	94	-	100
			Ventilation fan	100	-	100
	8	Reinstatement	20T Excavator	105	120	100
			Static drum roller	107	-	100
			Plate compactor	108	-	100
Open cut pipe installation	1	Temporary traffic management setup	Truck	107	120	50
	2,3,4,5	Excavation of trench	Truck	107	120	50
			20T Excavator	105	120	100
			Submersible pump	96	-	100
			Diesel generator	94	-	100
	6	Installation of pipe	Truck	107	120	50
			20T Excavator	105	120	100
			Plate compactor	108	-	100
	7	Backfilling and reinstatement	20T Excavator	105	120	100
			Static drum roller	103	-	100
			Plate compactor	107	120	50

Trenchless pipe installation	1*	Insertion of mTMB into shaft	90T Crane	105	-	75
			Ventilation fan	100	-	100
			Hand-held power tools	100	-	100
			Submersible pump	96	-	100
			Diesel generator	94	-	100
	2*	Operation of mTMB at Mayoral Drive Site	mTMB machine	103	-	100
			Control cabin	86	-	100
			90T Crane	105	-	75
			Diesel generator	94	-	100
			Ventilation fan	100	-	100
			Submersible pump	96	-	100
			mTBM Pump	96	-	100
	3^	Extraction of mTMB at Victoria Street site	Submersible pump	96	-	100
			Diesel generator	94	-	100
			Ventilation fan	100	-	100
			90T Crane	105	-	75
			Hand-held power tools	100	-	100
			Truck	107	120	50
Greys Avenue Construction Support Compound	1	Set-up	Hiab trucks	107	120	50
			20T Excavator	105	120	100
			Truck	107	120	50
			90T Crane	105	-	75
	2	Operation of mTMB	20T Excavator	105	120	100
			Separating tanks, slurry tanks with generator	117	120	100
			Truck	107	120	50

Vibration Equipment List		
No.	Equipment	PPV (mm/s) @10m
1	Excavator breaking ground	1.9
2	CFA piling, auguring, drilling of holes, or similar	0.5
3	Tunnel Boring	2.0
4	Plate compactor	1.0

Appendix C
Predicted Noise Levels

Queen Street/Mayoral Drive Shaft Construction					
Property	Predicted Façade Noise Level (dB $L_{Aeq,30min}$) During Phase				
	1	2	3,4	5	6
3 Airedale Street	71	69	70	69	71
22 Durham Street West	45	43	43	43	45
3 Greys Avenue	58	56	57	56	58
48 Greys Avenue	67	65	65	65	67
95 Greys Avenue	62	60	60	60	62
59-67 High Street	46	44	45	44	46
2 Lorne Street	44	42	42	42	43
4 Lorne Street	44	42	42	42	44
44-48 Lorne Street	51	48	49	49	50
100 Mayoral Drive	62	60	60	60	62
175 Queen Street	48	46	46	46	48
182-184 Queen Street	51	49	49	49	50
186 Queen Street	51	49	49	49	51
187-189 Queen Street	44	42	42	42	44
191 Queen Street	45	43	44	44	45
203 Queen Street	47	44	45	45	46
205-225 Queen Street	51	49	49	49	50
214 Queen Street	49	47	48	47	49
222 Queen Street	49	47	48	47	49
229 Queen Street	52	49	50	50	51
233-237 Queen Street	52	50	50	50	52
238 Queen Street	55	53	53	53	54
239 Queen Street	53	50	51	51	52
253-261 Queen Street	53	51	52	51	53
262 Queen Street	54	52	52	52	54
263 Queen Street	56	53	54	54	55
269-297 Queen Street	58	56	57	56	58
280 Queen Street	54	51	52	52	53
290 Queen Street	53	51	52	51	53
300 Queen Street	56	54	54	54	55
301 Queen Street	71	69	70	69	71
304-308 Queen Street	58	56	56	56	58
313 Queen Street	81	79	79	79	81
317 Queen Street	84	81	82	82	83
319 Queen Street	89	87	88	88	89
321 Queen Street	86	84	84	84	86
323 Queen Street	85	83	84	83	85
329 Queen Street	84	81	82	82	83
361 Queen Street	71	69	69	69	70
380 Queen Street	75	73	74	73	75
396 Queen Street	81	78	79	79	80
430 Queen Street	76	74	74	74	75
3 Victoria Street East	37	34	35	35	36
9 Victoria Street East	45	42	43	43	44
27-31 Victoria Street East	41	39	39	39	40
19 Victoria Street West	44	41	42	42	43
10 Wellesley Street	51	49	49	49	51
18-26 Wellesley St East	44	41	42	42	43

Queen Street/Wellesley Street Shaft Construction					
Property	Predicted Façade Noise Level (dB $L_{Aeq,30min}$) During Phase				
	1	2	3	4	5
3 Airedale Street	40	37	41	38	39
22 Durham Street West	51	48	52	49	51
3 Greys Avenue	42	39	43	40	42
48 Greys Avenue	49	45	50	47	48
95 Greys Avenue	48	45	49	46	47
59-67 High Street	48	44	48	45	47
2 Lorne Street	49	45	50	47	48
4 Lorne Street	50	46	50	47	49
44-48 Lorne Street	73	69	73	71	72
100 Mayoral Drive	50	46	50	48	49
175 Queen Street	52	48	52	49	51
182-184 Queen Street	54	51	55	52	53
186 Queen Street	55	51	55	52	54
187-189 Queen Street	53	49	54	51	52
191 Queen Street	57	54	58	55	56
203 Queen Street	57	54	58	55	57
205-225 Queen Street	63	60	64	61	62
214 Queen Street	60	57	61	58	59
222 Queen Street	62	58	62	59	61
229 Queen Street	67	63	67	65	66
233-237 Queen Street	69	65	69	66	68
238 Queen Street	66	63	67	64	66
239 Queen Street	73	69	74	71	72
253-261 Queen Street	79	75	79	77	78
262 Queen Street	72	68	72	69	71
263 Queen Street	80	77	81	78	79
269-297 Queen Street	76	72	76	74	75
280 Queen Street	76	73	77	74	75
290 Queen Street	89	86	90	87	88
300 Queen Street	82	79	83	80	82
301 Queen Street	60	56	60	57	59
304-308 Queen Street	74	71	75	72	73
313 Queen Street	51	48	52	49	51
317 Queen Street	51	48	52	49	50
319 Queen Street	51	47	51	48	50
321 Queen Street	51	47	51	48	50
323 Queen Street	51	47	51	48	50
329 Queen Street	41	38	42	39	40
361 Queen Street	51	47	52	49	50
380 Queen Street	54	51	55	52	54
396 Queen Street	50	47	51	48	50
430 Queen Street	51	48	52	49	50
3 Victoria Street East	44	40	44	42	43
9 Victoria Street East	47	44	48	45	47
27-31 Victoria Street East	48	44	49	46	47
19 Victoria Street West	49	46	50	47	48
10 Wellesley Street	85	81	85	82	84
18-26 Wellesley St East	75	71	76	73	74

Queen Street/Victoria Street Shaft Construction							
Property	Predicted Façade Noise Level (dB $L_{Aeq,30min}$) During Phase						
	1	2	3	4,5	6	7	8
3 Airedale Street	43	40	38	41	47	42	42
22 Durham Street West	67	64	62	66	71	66	66
3 Greys Avenue	40	37	35	38	44	39	39
48 Greys Avenue	44	41	39	43	48	43	43
95 Greys Avenue	45	43	40	44	50	44	45
59-67 High Street	86	83	81	84	90	84	85
2 Lorne Street	74	72	69	73	78	73	73
4 Lorne Street	69	67	65	68	74	68	69
44-48 Lorne Street	47	45	42	46	51	46	46
100 Mayoral Drive	46	43	41	44	50	44	45
175 Queen Street	67	64	62	66	71	66	66
182-184 Queen Street	68	66	63	67	73	67	68
186 Queen Street	74	72	70	73	79	73	74
187-189 Queen Street	70	67	65	68	74	69	69
191 Queen Street	74	71	69	73	78	73	73
203 Queen Street	77	74	72	76	81	76	76
205-225 Queen Street	76	74	71	75	81	75	76
214 Queen Street	83	81	78	82	87	82	82
222 Queen Street	75	72	70	74	79	74	74
229 Queen Street	68	66	63	67	72	67	67
233-237 Queen Street	67	64	62	65	71	66	66
238 Queen Street	72	69	67	70	76	71	71
239 Queen Street	65	62	60	63	69	63	64
253-261 Queen Street	62	59	57	61	66	61	61
262 Queen Street	64	61	59	62	68	62	63
263 Queen Street	60	57	55	58	64	58	59
269-297 Queen Street	55	52	50	53	59	54	54
280 Queen Street	62	60	57	61	67	61	62
290 Queen Street	58	56	54	57	63	57	58
300 Queen Street	56	54	51	55	60	55	55
301 Queen Street	52	49	47	50	56	51	51
304-308 Queen Street	56	53	51	54	60	54	55
313 Queen Street	47	45	42	46	52	46	47
317 Queen Street	47	45	42	46	51	46	46
319 Queen Street	47	44	42	45	51	46	46
321 Queen Street	47	44	42	45	51	46	46
323 Queen Street	47	44	42	45	51	45	46
329 Queen Street	39	36	34	37	43	38	38
361 Queen Street	48	45	43	46	52	47	47
380 Queen Street	50	47	45	48	54	48	49
396 Queen Street	47	44	42	45	51	46	46
430 Queen Street	46	43	41	44	50	45	45
3 Victoria Street East	70	67	65	68	74	68	69
9 Victoria Street East	80	78	75	79	85	79	80
27-31 Victoria Street East	70	67	65	68	74	68	69
19 Victoria Street West	70	67	65	68	74	68	69
10 Wellesley Street	46	43	41	45	50	45	45
18-26 Wellesley St East	52	49	47	50	56	51	51

Queen Street/Wellesley Street Open Trench Construction				
Property	Predicted Façade Noise Level (dB $L_{Aeq,30min}$) During Phase			
	1	2,3,4,5	6	7
3 Airedale Street	33	37	40	38
22 Durham Street West	43	47	50	48
3 Greys Avenue	31	35	38	36
48 Greys Avenue	41	45	48	46
95 Greys Avenue	40	44	46	45
59-67 High Street	39	43	45	44
2 Lorne Street	39	43	45	44
4 Lorne Street	41	45	47	46
44-48 Lorne Street	61	65	67	66
100 Mayoral Drive	39	43	46	44
175 Queen Street	43	47	50	48
182-184 Queen Street	46	50	53	51
186 Queen Street	49	53	55	54
187-189 Queen Street	46	50	53	51
191 Queen Street	50	54	57	55
203 Queen Street	51	55	57	56
205-225 Queen Street	57	61	64	62
214 Queen Street	53	57	60	58
222 Queen Street	55	59	62	60
229 Queen Street	59	63	66	64
233-237 Queen Street	61	65	68	66
238 Queen Street	59	63	66	64
239 Queen Street	65	69	72	70
253-261 Queen Street	74	78	80	79
262 Queen Street	64	68	70	69
263 Queen Street	75	79	82	80
269-297 Queen Street	69	73	75	74
280 Queen Street	68	72	75	73
290 Queen Street	77	81	84	82
300 Queen Street	77	81	84	82
301 Queen Street	53	57	60	58
304-308 Queen Street	66	70	72	71
313 Queen Street	43	47	50	48
317 Queen Street	43	47	50	48
319 Queen Street	42	46	49	47
321 Queen Street	42	46	49	47
323 Queen Street	42	46	48	47
329 Queen Street	37	41	43	42
361 Queen Street	45	49	51	50
380 Queen Street	47	51	54	52
396 Queen Street	44	48	51	49
430 Queen Street	43	47	50	48
3 Victoria Street East	34	38	41	40
9 Victoria Street East	39	43	45	44
27-31 Victoria Street East	40	44	46	45
19 Victoria Street West	39	43	46	44
10 Wellesley Street	69	73	76	75
18-26 Wellesley St East	64	68	70	69

Queen Street/Victoria Street and Queen Street/Mayoral Drive Trenchless Construction			
Property	Predicted Façade Noise Level (dB $L_{Aeq,30min}$) During Phase		
	1*	2*	3^
3 Airedale Street	65	65	38
22 Durham Street West	37	37	62
3 Greys Avenue	50	49	35
48 Greys Avenue	59	59	39
95 Greys Avenue	54	53	41
59-67 High Street	39	38	82
2 Lorne Street	36	36	70
4 Lorne Street	37	36	65
44-48 Lorne Street	44	43	43
100 Mayoral Drive	54	54	41
175 Queen Street	41	36	62
182-184 Queen Street	44	43	64
186 Queen Street	44	43	70
187-189 Queen Street	36	35	66
191 Queen Street	38	37	70
203 Queen Street	39	38	73
205-225 Queen Street	44	43	72
214 Queen Street	42	41	79
222 Queen Street	42	41	71
229 Queen Street	44	44	64
233-237 Queen Street	45	44	63
238 Queen Street	46	46	67
239 Queen Street	46	45	60
253-261 Queen Street	46	46	57
262 Queen Street	45	45	59
263 Queen Street	48	48	55
269-297 Queen Street	51	51	50
280 Queen Street	45	44	57
290 Queen Street	45	45	54
300 Queen Street	48	47	51
301 Queen Street	64	64	47
304-308 Queen Street	51	50	51
313 Queen Street	74	75	42
317 Queen Street	77	76	42
319 Queen Street	83	83	42
321 Queen Street	80	79	42
323 Queen Street	79	78	42
329 Queen Street	76	76	34
361 Queen Street	64	63	43
380 Queen Street	68	68	45
396 Queen Street	73	73	42
430 Queen Street	69	68	41
3 Victoria Street East	29	28	65
9 Victoria Street East	37	36	76
27-31 Victoria Street East	34	33	65
19 Victoria Street West	36	36	65
10 Wellesley Street	44	43	41
18-26 Wellesley St East	36	36	47

Greys Avenue Construction Support Compound			
Property	Predicted Façade Noise Level (dB $L_{Aeq,30min}$) During Phase		
	1	2	3
3 Airedale Street	60	68	68
22 Durham Street West	45	53	53
3 Greys Avenue	65	73	73
48 Greys Avenue	69	75	77
95 Greys Avenue	64	72	72
59-67 High Street	39	47	47
2 Lorne Street	39	47	47
4 Lorne Street	39	47	47
44-48 Lorne Street	41	49	49
100 Mayoral Drive	68	75	76
175 Queen Street	34	44	44
182-184 Queen Street	39	47	47
186 Queen Street	39	47	47
187-189 Queen Street	33	41	41
191 Queen Street	31	39	39
203 Queen Street	39	47	47
205-225 Queen Street	42	50	50
214 Queen Street	40	48	48
222 Queen Street	40	48	48
229 Queen Street	36	44	44
233-237 Queen Street	42	50	50
238 Queen Street	42	50	50
239 Queen Street	41	49	49
253-261 Queen Street	41	49	49
262 Queen Street	43	51	51
263 Queen Street	43	51	51
269-297 Queen Street	57	65	65
280 Queen Street	45	53	53
290 Queen Street	44	52	52
300 Queen Street	44	52	52
301 Queen Street	61	69	69
304-308 Queen Street	44	52	52
313 Queen Street	67	75	75
317 Queen Street	67	75	77
319 Queen Street	66	74	83
321 Queen Street	69	75	80
323 Queen Street	70	75	79
329 Queen Street	67	75	76
361 Queen Street	65	73	73
380 Queen Street	59	67	68
396 Queen Street	62	70	73
430 Queen Street	62	70	70
3 Victoria Street East	36	44	44
9 Victoria Street East	39	47	47
27-31 Victoria Street East	36	44	44
19 Victoria Street West	42	50	50
10 Wellesley Street	42	50	50
18-26 Wellesley St East	39	47	47

Predicted Façade Maximum Noise Levels from Any Construction Equipment	
Property	Predicted Façade Maximum Noise Level (dB L_{AFmax})
3 Airedale Street	84
22 Durham Street West	80
3 Greys Avenue	71
48 Greys Avenue	80
95 Greys Avenue	75
59-67 High Street	98
2 Lorne Street	87
4 Lorne Street	82
44-48 Lorne Street	85
100 Mayoral Drive	75
175 Queen Street	81
182-184 Queen Street	81
186 Queen Street	87
187-189 Queen Street	82
191 Queen Street	87
203 Queen Street	90
205-225 Queen Street	89
214 Queen Street	96
222 Queen Street	88
229 Queen Street	81
233-237 Queen Street	79
238 Queen Street	84
239 Queen Street	86
253-261 Queen Street	91
262 Queen Street	84
263 Queen Street	93
269-297 Queen Street	88
280 Queen Street	89
290 Queen Street	102
300 Queen Street	95
301 Queen Street	84
304-308 Queen Street	71
313 Queen Street	94
317 Queen Street	97
319 Queen Street	102
321 Queen Street	99
323 Queen Street	98
329 Queen Street	97
361 Queen Street	84
380 Queen Street	88
396 Queen Street	94
430 Queen Street	89
3 Victoria Street East	82
9 Victoria Street East	93
27-31 Victoria Street East	82
19 Victoria Street West	82
10 Wellesley Street	59
18-26 Wellesley Street East	65

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