Project Number: W-SL001.03

Construction Noise and Vibration Assessment

25 October 2023

PUBLIC

Queen Street Wastewater Diversion Programme (Part 3-Part 4 Connector)

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Document Details:

Date: 25 October 2023
Reference: APP I_CNVA_V2. 25OCT23
Status: Revision 2

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Document History and Status

Revision	Date	Author	Reviewed by	Approved by	Status
0	11 August .23	G. van Hout	K. Lloyd	K. Lloyd	Draft
1	27 Sept .23	G. van Hout	E. Taylor	C. Bradley	Revision 1
2	25 Oct .23	G. van Hout	E. Taylor	C. Bradley	Update from Client

Revision Details

Revision	Details
0	Issue to Client
1	Updated for a change in the location of the equipment
2	Update from Client feedback

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Abbreviations

AC	Auckland Council
AEE	Assessment of Environmental Effects
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
NES	National Environmental Standard
NPS	National Policy Statement
NSR	Noise Sensitive Receptor(s)
TMPs	Traffic Management Plans
Watercare	Watercare Services Limited
WSP	WSP New Zealand Limited

Glossary

Term	Description
A-weighting, dBA	The unit of sound level, weighted according to the A-scale, which considers the increased sensitivity of the human ear at some frequencies at low levels.
Ambient noise	The all-encompassing sound, at a given place at a certain time, is usually a composite of sounds from many 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 $20 \log_{10} (s_1 / s_2)$. The decibel can also be 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 time T. This is the level of a notional steady sound that would contain the same amount of sound energy as the actual, possibly 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 little effect on the overall L_{eq} noise level but will still affect the noise environment. Unless described otherwise, it is measured using the 'fast' sound level meter response.
L_{Peak}	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 (20×10^{-6} Pascals) on a decibel scale.

Executive Summary

WSP New Zealand has been engaged by Watercare Services Limited to assess the noise and vibration impacts of the service tunnel/pipe which will connect Parts 3 and 4 of the Queen Street Wastewater Diversion Programme of Works, in Auckland.

Noise and vibration criteria have been developed based on the Auckland Unitary Plan (AUP). Noise from construction works within the roading corridor is exempt from the construction noise limits, provided that a Construction Noise and Vibration Management Plan (CNVMP) is developed with the measures being implemented. While a CNVMP will be adopted by the contractor, we have assessed noise that is not captured under other Resource Consent Applications from within the roading corridor.

The construction methodology for the installation of the wastewater pipework has been provided by Fulton Hogan, McConnell Dowell (the proposed tunnelling contractors) and the WSP design team. This methodology has been used to develop the phases of construction and equipment used as part of the construction.

Physical mitigation is proposed by the contractor by using solid site hoardings around construction equipment. However, as many of the surrounding buildings are multi-story, the screens are unlikely to be effective above ground level.

Managerial mitigation measures such as controlling high-vibration equipment from operating near buildings within the Historic Heritage Overlay of the AUP and vibration monitoring will minimise the vibration risk generated during construction.

Based on the construction methodology, location of equipment, and managerial and physical mitigation measures, it is predicted that the following property will receive noise levels greater than the AUP construction noise limits:

- 323 Queen Steet

An exceedance of the 75 dB $L_{Aeq,T}$ noise limit by 2 – 7 dB is predicted for up to 35 days at this property, depending on the activity and phase of the works. These exceedances are predicted to be primarily during shaft construction where:

- Phase 1 (saw cutting) and Phase 4 (shaft lining) for 1 – 2 days where noise levels are expected to exceed at any point that it is used on the site, with exceedances up to 6 dB higher than the noise criteria.
- Phase 2 (piling) for 2 – 3 days where levels 2 dB higher than the criteria are predicted during boring of the holes with the piling rig only. At other times (such as taking the equipment out of the hole and moving the piling rig to the next location), noise levels are expected to be lower. A 2 dB exceedance is an imperceptible increase over the construction noise criteria.
- Phase 3 (excavation) for the remainder of the 15 days of shaft construction where levels 3 dB higher than the criteria are predicted. This exceedance is predicted to occur only when all equipment on site is operating. During times when less equipment is operating the noise levels are predicted to be lower, and would also be compliant.
- Phase 5 – 7 (backfilling and rehabilitation) which are predicted to take 10 days, and exceed the criteria by 5 – 7 dB when all equipment is operating.

Exceedances from tunnel boring on the Greys Avenue CSA can be mitigated using physical mitigation (site hoardings) and managerial mitigation (location of equipment) measures to control noise.

Additionally, the predicted noise levels are conservative as it is assumed all assessed plant is operating concurrently and at ground level. Where equipment is not operating concurrently or

at the bottom of the pit (such as the plate compactor in Phase 4) noise levels are predicted to be lower. All practicable options of mitigation are also proposed to be adopted including plant selection, plant location, hours of operation, and noise mitigation.

The level of noise generated is not likely to occur at all times on all 35 days. Managerial mitigation will be undertaken, such as advising the neighbours of the works 10 working days prior to commencement, working with the occupiers to determine suitable times when construction can occur to minimise impact, and communicating the programme duration with the occupiers throughout construction. Taking this into account, and with the adoption of a CNVMP, the noise effects are predicted to be reasonable.

Based on the construction methodology and managerial mitigation measures no properties are predicted to exceed the DIN 4150-3 vibration limits outlined in Section E25.30(1(a) of the AUP. The following properties are predicted to exceed the 2 mm/s PPV amenity criteria of the AUP:

- 323-327 Queen Street
- 329 Queen Street

The noise and vibration impacts on the above properties can be managed effectively using a CNVMP. With the implementation of this Plan by the contractor, vibration effects are predicted to be reasonable.

Therefore, we have not identified any parties that receive obvious or unreasonable levels of noise and vibration based on this analysis.

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.

Watercare is proposing to upgrade the wastewater network within the upper catchment (southern) of Auckland City Centre. It has been established by Watercare that the existing network does not have sufficient capacity to meet future demands. WSP New Zealand (WSP) has been engaged by Watercare to design and consent a new wastewater mainline through Auckland city centre.

This report provides an assessment of the construction noise and vibration impacts of the service tunnel/pipe which will connect Part 3 and Part 4 of the Queen Street Wastewater Diversion Project (the Project). Resource consent for the separate Part 3 and Part 4 of the wider programme of works will be sought separately from these connecting works, and therefore excluded from this assessment.

This Project involves the early construction of a section of the pipeline to enable the tunnelling works required for the Part 3 alignment of the wastewater pipeline. These works will consist of constructing one shaft (P4MH4), shown as the yellow square at the Greys Avenue carpark in Figure 1.1, and a 43m length of tunnel from this shaft to the Part 3 launch shaft at the intersection of Mayoral Drive and Queen Street (Mayoral Drive Shaft).

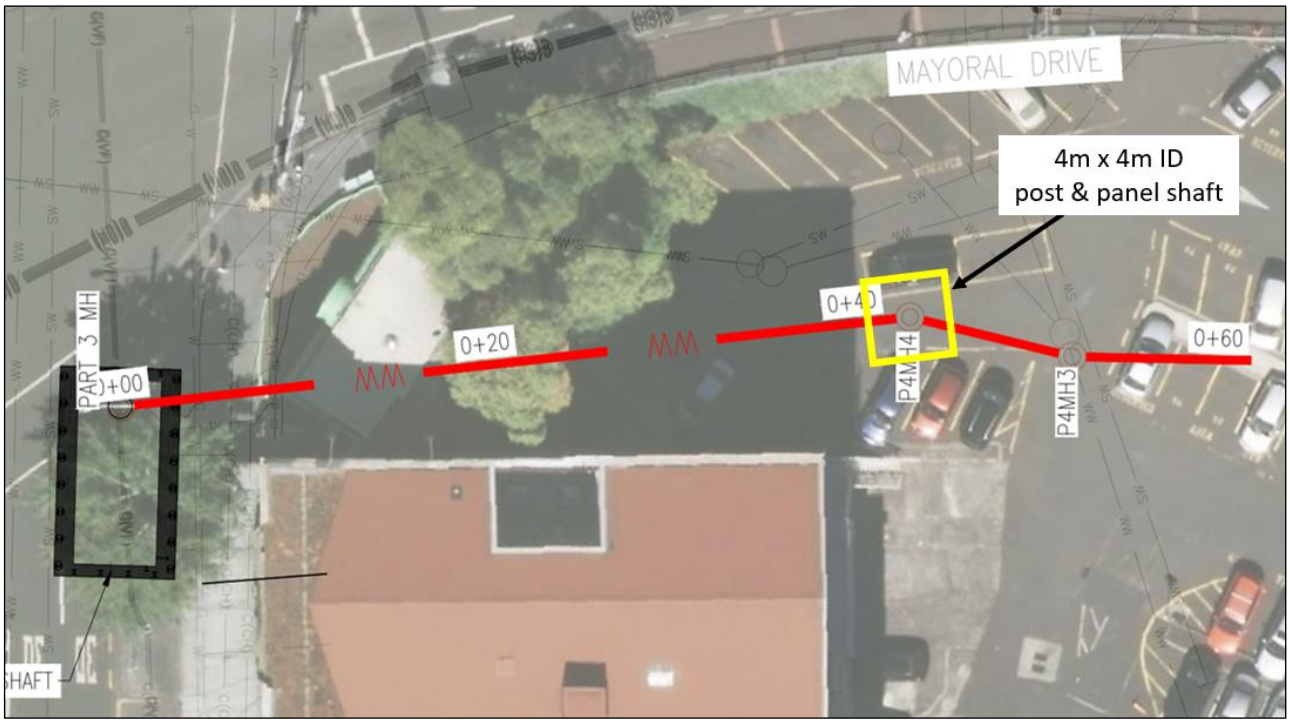

Figure 1.1: Site plan of the P3-P4 connector tunnel and shaft

The purpose of this tunnel is to service the micro-tunnel boring machine (mTBM) which will be used to construct the Part 3 alignment of the pipeline from the Mayoral Drive Shaft north along Queen Street. During the Part 3 construction phase, the P3-P4 connector tunnel will carry all required power, hydraulic and other fluid cables and hoses from the staging area in the Greys Avenue Carpark into the bottom of the Mayoral Drive Shaft to support the operation of the mTBM.

Upon completion of the Part 3 construction works, the P3-P4 connector tunnel will no longer be needed to service the mTBM. The tunnel will then assume its primary role as the section of wastewater pipe which will convey wastewater from the new Mayoral Drive wastewater pipe (Part 4) into the newly installed Queen Street wastewater pipe (Part 3).

This report is based on discussions with the design team along with the following information:

- Design and construction statement titled *Queen St – Part 3 to 4 Service Tunnel Methodology* document ID FHLIB-1677224255-56839, revision 1, dated 4 August 2023.

2 Description of Existing Environment

The following describes the existing environment applicable to the application.

2.1 Location

The Project is located within Auckland City Centre in the surface carpark at 329 Queen Street/34, 36-38 Greys Avenue (Greys Avenue Carpark) and a portion of the road reserve (footpath) below ground on Queen Street. Adjacent to the construction works are a mix of modern buildings as well as important heritage structures. At street level, the buildings are retail, hospitality, and commercial premises.

The tunnel to be constructed will connect to the Construction Support Area (CSA) in the Greys Avenue Carpark to the Mayoral Drive CSA. Figure 2.1 shows the wider environment in which the connector tunnel will be constructed along with the proposed new manhole, pipeline and CSAs. The green spot represents the location of the shaft/manhole while the yellow line shows the path of the underground tunnelling.

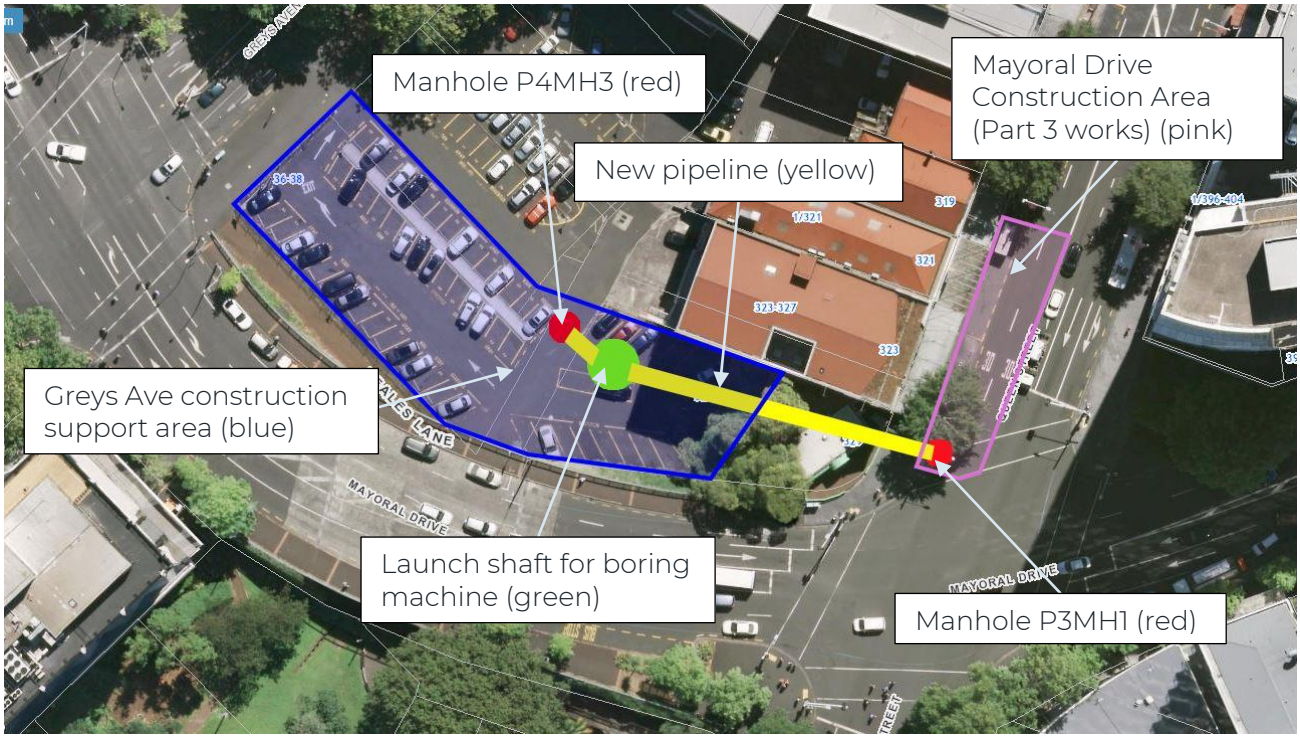

Figure 2.1: Project area and surface level areas used

2.2 Zoning and Overlays

The majority of the site is located within the Greys Ave CSA, which is zoned Business – City Centre Zone. The receiving location (manhole P3MH1) is located within the road corridor. Some adjacent buildings are also protected by the Historic Heritage overlay of the AUP.

The zoning of the construction area and surrounding areas are shown in Figure 2.2.

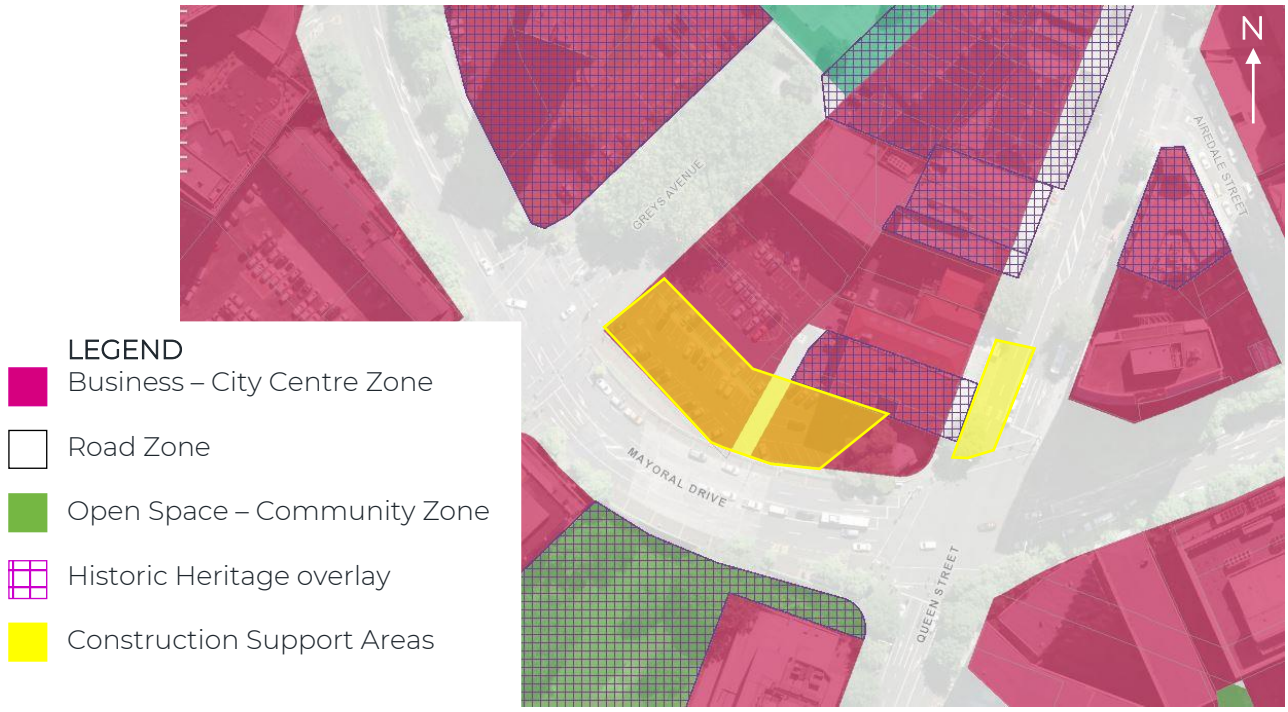

Figure 2.2: Sites (yellow) and surrounding zoning

2.3 Ambient Noise Environment

The existing ambient noise environment around the site includes noise emissions from activities on adjacent sites, road traffic noise, pedestrian noise, noise from activities within the street or recreation areas (Mayers Park or Aotea Square) and other environmental noise.

A desktop review has been undertaken to estimate baseline noise levels in proximity to the proposed construction works. Baseline noise predictions have been based on traffic data[1] and the Auckland Unitary Plan noise standards.

The maximum permissible noise level from noise generated from one site impacting an adjacent site zoned Business – City Centre Zone when assessed at the façade of the receiving site are outlined in noise standard E25.6.8. The maximum permitted noise level in E26.6.8 is 65 dB $L_{Aeq,T}$ between 0700 – 2300 hours Monday to Sunday.

Traffic noise predictions have been undertaken using the Calculation of Road Traffic Noise (CoRTN)[2] algorithm, modified for New Zealand road conditions, with a 1-hour time-weighted noise level ($L_{Aeq,1hr}$) calculated based on Waka Kotahi Research[3]. This is to provide an indication for the noise environment from traffic on Mayoral Drive and Queen Street.

Table 2–1 indicates the parameters used for the calculation and the predicted sound pressure level in terms of $L_{Aeq,24hr}$.

Table 2–1: Baseline traffic noise level prediction on surrounding roads

Road	Average Daily Traffic	Speed (km/hr)	Heavy Vehicles	Road surface
Mayoral Drive	11,450	30	7%	Asphalt Concrete Grade 14*
Queen Street	14,205	30	9%	Asphalt Concrete Grade 14

* Location near the site is a bridge and so additional noise will be generated due to joints

1 Traffic data available from mobileroad.org
2 Department of Transport Welsh Office, Calculation of Road Traffic Noise, 1988
3 Waka Kotahi NZTA Noise Metric Tool

Sound pressure levels from road traffic ranges from 68 dB $L_{Aeq,1hr}$ to 70 dB $L_{Aeq,1hr}$ at buildings adjacent to Mayoral Drive and Queen Street.

The rear of 323-327 Queen Street is a car-park and will therefore receive noise from vehicles decelerating, accelerating, and parking in the carpark throughout the day. This will likely increase the noise in this area.

Therefore, when considering the AUP noise rules, road traffic, and other environmental noise, around the site, it is likely that noise levels will be at or above 70 dB $L_{Aeq,30min}$ during the daytime.

2.4 Noise and Vibration Sensitive Receptors

The land use around the Project is a mixture of retail, commercial, hospitality, civic, and residential, representing a highly developed urban environment. For the most part, retail activity is provided at street level with other uses provided above. Commercial properties (yellow), hotels (blue), and apartments (pink) near each of the construction sites (red) are provided in Figure 2.3.

Many of the properties directly adjacent to the construction works are also located within the Historic Heritage overlay of the AUP. These properties are likely to be more sensitive to vibration and therefore specific management procedures will need to be adopted by the contractor to minimise vibration impacts. These management procedures will be captured in a Construction Noise and Vibration Management Plan (CNVMP).

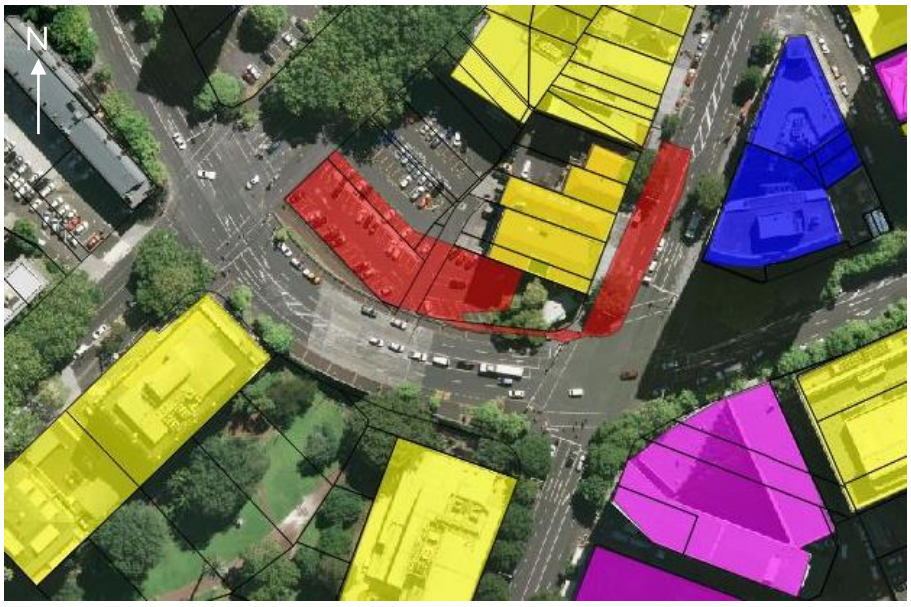

Figure 2.3: Adjacent noise sensitive receptor building types – commercial (yellow), hotels (blue), apartments (pink)

3 Project Works

The Project works will see the construction of a new tunnel/pipe that connects the southwestern manhole in Part 4 (P4MH4) and the southern manhole in Part 3 (P3MH1) in the wider Queen Street Wastewater Diversion Programme of Works.

To provide for the new pipe, two temporary shafts will be created within the existing Greys Avenue Carpark (Greys Avenue shaft), and at the intersection of Mayoral Drive and Queen Street (Mayoral Drive shaft). The construction of the temporary shaft at the Mayoral Drive/Queen Street intersection will be developed as part of the Part 3 Queen Street Diversion Works, and therefore is excluded from this assessment.

Once the Greys Avenue shaft is constructed, tunnelling works will commence. Once tunnelling works are completed, the tunnel will be used as a service tunnel for Part 3 of the Queen Street Diversion Works. The Greys Avenue shaft will be backfilled and converted into a manhole once the use of this shaft for the Queen Street Wastewater Diversion Programme of works is complete.

The following is a summary of the Project works.

3.1 Construction Hours and Duration

The anticipated construction hours are noted in Table 3–1.

Table 3–1: Construction hours

Activity	Hours
Shaft construction	Monday to Saturday – 0700hrs to 1900hrs
Tunnelling works	Monday to Saturday – 0700hrs to 1900hrs

Works outside of the hours listed above only include dewatering pumps which may be required when the shaft is open.

The duration of construction works is provided in Table 3–2.

Table 3–2: Construction duration

Activity	Duration
Greys Avenue shaft construction at P4MH4	15 days
Tunnel construction	20 days
Construction of the manhole at P4MH4	10 days
Total	*45 days (approx. 9 weeks)*

There will be a delay between “tunnel construction” and “construction of the manhole at P4MH4”, as the Greys Avenue Carpark shaft will be used during other Parts of the wider Queen Street Diversion Programme of Works. Connections from two other projects (not covered under this Application) within the programme (Mayoral Drive alignment and Queen Street Part 6 alignment) will be made to this shaft, after which the manhole will be installed.

3.2 Temporary Construction Shaft

A temporary shaft will be provided to undertake the trenchless installation of a pipe between this new shaft and the proposed Mayoral Drive shaft (located on Queen Street). While the construction of the Mayoral Drive shaft is assessed under a separate assessment (and resource

consent package), the use of this shaft for the connection works has been assessed as part of this report.

Greys Avenue Carpark Shaft

This shaft will be located within the Grey Avenue Carpark. It will have a depth of 5.5 metres. The construction of the shaft will take 15 days. This shaft will be used for service connections as well as support for tunnelling works.

Figure 3.1 shows the approximate position of the shaft (green) and the Greys Avenue support area (blue).

Figure 3.1: Wellesley Street Shaft position and construction support area

The necessary plant equipment for this construction has been included in Table 3–3.

Table 3–3: Plant list for shaft construction works

Activity	Plant List
Drilling and installing steel posts	10-20t excavator and/or GEAX EK-40
Excavating Shaft	10-20t excavator
Spoil removal	6-wheeler or articulated truck
Concrete base	Plate compactor Concrete truck and pump

The shaft will be constructed into a manhole over a work period of 10 days using a concrete pump/truck and excavator.

3.3 Trenchless Construction Works

Trenchless construction works will occur between the shaft at the Mayoral Drive/Queen Street intersection and Greys Avenue Carpark using a pipe jack.

The Greys Avenue CSA established as part of the Part 3 resource consent application will be used as part of the works. This will contain ancillary equipment and functions for tunnelling. The Mayoral Drive CSA site provided in Part 3 will include equipment used for the operation of the pipe jack.

Approximately 43 metres of 600 mm diameter pipe will be installed between the two sites.

The equipment to be provided within the Greys Avenue CSA and Mayoral Drive compound as part of this project is given in Table 3–4.

Table 3–4: Equipment located at Greys Avenue CSA and Mayoral Drive site for trenchless construction of pipe

Greys Avenue CSA	Mayoral Drive CSA
• Crane • Power pack container • Pipe jack • Sucker truck or 6-wheeler • Tool truck • Ventilation Fan	• Crane • Power Pack container • Pipe jack • Tool truck

The tunnelling works are proposed to take 20 working days to complete.

3.4 Vehicle Movements

Based on the volume of the shaft and the volume of the proposed pipe, the following total truck movements will be required:

- 20 truck movements for removing spoil from shaft construction.
- 8 truck movements for removing spoil from pipe installation.

4 Performance Standards

Section 16 of the Resource Management Act (RMA) requires occupiers of land to avoid unreasonable noise:

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

Guidance as to what a reasonable level of noise and vibration when assessed at adjacent noise sensitive receptors is taken from Chapter E25 – Noise and Vibration of the AUP. This chapter sets out noise and vibration standards for permitted activities. Where the AUP noise and/or vibration standards are exceeded, then resource consent is required as a restricted discretionary activity.

4.1 Construction Noise Criteria

This section outlines guidance as to what constitutes a reasonable level of noise.

4.1.1 Auckland Unitary Plan

Where construction works occur outside of the road corridor, the noise standards outlined in section E25.6.28 of Chapter E25 (AUP) apply. Section E25.6.29 applies to works that occur within the road corridor.

The construction of the Greys Avenue Carpark shaft and equipment associated with the tunnel connection (such as power packs and tunnel equipment) are assessed under E25.6.28 of the AUP. Equipment associated with the connection tunnel, which is utilised at the Mayoral Drive CSA (such as power packs and tunnel equipment), are within the road corridor. Therefore, Rule E25.6.29 of the AUP applies. The relevant sections of these noise standards are reproduced below.

E25.6.28. Construction noise levels in the Business – City Centre Zone and the Business – Metropolitan Centre Zone

(1) Construction activities in the Business – City Centre Zone and the Business –Metropolitan Centre Zone must comply with Standard E25.6.27(1) above for any receiver not in a Business – City Centre Zone or a Business –Metropolitan Centre Zone and must not exceed the levels in Table E25.6.28.1 Construction noise levels for construction less than 15 consecutive calendar days duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone and Table E25.6.28.2 Construction noise levels for the construction of 15 consecutive calendar days or more duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone when measured for any 30 minute period 1m from the façade of any building in the Business – City Centre Zone or the Business – Metropolitan Centre Zone that is occupied during the work.

Where external measurement of construction noise is impractical or inappropriate, the upper limits for the noise measured inside the building will be 20dB less than the relevant levels.

Whilst construction works are only proposed on Monday to Saturday, and therefore will always be less than 15 consecutive calendar days in duration, we have conservatively applied the noise limits in Table E25.6.28.2 (for works that occur for more than 15 consecutive days), which are reproduced below.

Table 4–1: AUP Construction noise limits in the Business – City Centre Zone

Time	$L_{Aeq,30\ min}$ (dB)	L_{AFmax} (dB)
Monday to Friday 6.30am – 10.30pm	75	90
Saturday 7am-11pm	80	90

The most stringent noise limit during this time is 75 dB $L_{Aeq(30min)}$ / 90 dB L_{AFmax} from construction activities. We have therefore assessed noise against these criteria.

E25.6.29. Construction noise and vibration levels for work within the road

(3) The noise levels specified in Standard E25.6.29(1) above do not apply to unplanned repair or maintenance works or planned works in the road corridor between the hours of 7am and 10pm where:

(b) because of the nature of the works and the proximity of receivers the noise generated cannot be practicably made to comply with the relevant noise levels of the following tables:

(i) Table E26.6.27.1 Construction noise limits for activities sensitive to noise in all zones except the Business - City Centre Zone and the Business – Metropolitan Centre Zone;

(ii) Table E25.6.27.2 Construction noise levels for noise affecting any other activity; or

(iii) Table E25.6.28.1 Construction noise levels for construction less than 15 consecutive calendar days duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or

(iv) Table E25.6.28.2 Construction Noise levels for construction of 15 consecutive calendar days or more duration in the Business – City Centre Zone and the Business – Metropolitan Centre Zone; or

(c) for planned works, a copy of the works access permit issued by Auckland Transport or approval from the New Zealand Transport Agency is provided to the Council five days prior to work commencing; or

(d) for planned works where the works will take more than 8 hours to complete a construction noise and vibration management plan is provided to the Council no less than five days prior to the works commencing in accordance with the applicable provisions of Standard E25.6.29(5) below

(4A) The vibration levels specified in E25.6.29(1A)(b) do not apply to works within the road where:

(b) a construction noise and vibration management plan is provided to the Council no less than five days prior to the works commencing in accordance with the applicable provisions of Standard E25.6.29.(5) below.

(5) construction noise and vibration management plan must be prepared by a suitably qualified and experienced person and include the following:

(a) details of the community consultation to be undertaken to advise the occupiers of properties located within 100m of the proposed works of all of the following:

(i) the area affected by the work;

(ii) why the work is required to be undertaken at night (where relevant);

(iii) the times and days when the noise and vibration is likely to be generated;

(iv) a contact name and number of the works supervisor who can be contacted if any issues arise and

(v) how noise and vibration complaints will be managed and responded to;

(b) a description of the works and its duration, anticipated equipment to be used, the processes to be undertaken, and the predicted noise and vibration levels; and

(c) identification of the best practicable options that will be undertaken to mitigate and minimise any noise and vibration being produced that is likely to exceed the relevant levels of the following tables:

(i) Table E26.6.27.1 Construction noise limits for activities sensitive to noise in all zones except the Business - City Centre Zone and the Business – Metropolitan Centre Zone;

(6) For the purpose of Standards E25.6.29(1) to E25.6.29(4A) above:

(a) planned work means work that has been planned to take place at least seven days before the work commences;

(b) the measurement and assessment of all construction noise must be in accordance with New Zealand Standard NZS 6803:1999 Acoustics – Construction noise; and

(c) the measurement of all vibration must be in accordance with E25.6.30 Vibration.

The ability to exceed noise limits for works in the road reserve, as per item 3(d), allows for road corridor works to be completed efficiently to minimise road closures and subsequent disruptions.

However, under Section 16 of the RMA, there is still a requirement for construction noise (and vibration) to not exceed a reasonable level. There is also a requirement for the CNVMP to indicate the area impacted by the works. Therefore, we have predicted noise generated by the construction activities regardless of where the works occur.

4.1.2 New Zealand Standard NZS 6803:1999

New Zealand Standard NZS 6803:1999 provides guidance for the prediction and measurement of noise from construction sites. Where no noise limits are provided in planning standards, NZS 6803:1999 provides guidance on noise limits. The AUP has specific noise limits for set zones, and therefore the AUP limits override the recommended limits in NZS 6803:1999.

Table 2 and Table 3 of NZS 6803:1999 outlines the recommended upper limits for construction noise for noise received at residential receptors and commercial or industrial receptors.

The proposed works are to occur over a 9 week period. This is split into two periods:

1 The construction of the shaft and operation of the pipe jack for the pipe between the Greys Avenue Carpark shaft and Mayoral Drive shaft
2 Construction of the manhole at P4MH4.

The construction of both these elements are a total of 9 weeks, as such fall within the ‘typical duration’ noise limits recommended in Table 2 and Table 3 of NZS 6803:1999, which are reproduced in Table 4–2.

Table 4–2: NZS 6803 Recommended upper limits for construction noise

Day	Time	$L_{Aeq,30min}$ (dB)	L_{AFmax} (dB)
Residential and Hotel receptors			
Weekdays	0630-0730	60	75
	0730-1800	75	90
	1800-2000	70	85
	2000-0630	45	75
Saturday	0630-0730	45	75
	0730-1800	75	90
	1800-2000	45	75
	2000-0630	45	75
Sundays and public holidays	0630-0730	45	75
	0730-1800	55	85
	1800-2000	45	75
	2000-0630	45	75
Commercial and Industrial receptors			
All days	0730-1800	75	-
	1800-0730	80	-

These noise limits apply 1 m from the wall most exposed to construction activity and 1.2 to 1.5 m above the relevant floor level.

NZS 6803:1999 notes that a measurement sample time should not exceed one hour, and 15 minutes will often be adequate.

4.1.3 Regenerated Noise

Regenerated noise from a trenchless boring machine is typically assessed only when it operates during the night-time period, as this is when receptors are more sensitive, the background levels are lower, and sleep disturbance can cause health impacts (either if the boring machine operates 24-hours a day or only during the night-time period).

For this Project, the trenchless boring machine will only operate between 0700 to 1900 hours, Monday to Saturday, which is during a less sensitive time (during daytime hours only), in comparison to nighttime hours.

New Zealand Standard NZS 2107:2016 *Acoustics – Recommended design sound levels and reverberation times for building interiors* (NZS 2107) presents recommended internal noise levels with the aim of providing *a healthy, comfortable and productive environment for the occupants and users,* which apply to spaces which are unoccupied but ready for occupancy. It is noted that the occupied noise levels are typically higher than the recommended limits in NZS 2107 when considering the operation/activity within spaces.

Based on the recommended internal noise levels in NZS 2107, the proposed criteria for regenerated noise are presented in the table below based on the surrounding noise-sensitive spaces.

Table 4–3: Recommended internal noise levels from regenerated noise from trenchless boring

Space	Recommended Internal Noise Level for Regenerated Noise from Trenchless Boring Activities
Office, retail, or hospitality	45 dB $L_{Aeq,T}$
Residential sleeping or living area in the inner city (including hotels)	35 dB $L_{Aeq,T}$

A 35 dB $L_{Aeq,T}$ internal noise level in residential settings has been adopted for other similar projects such as Grey Lynn Tunnel (Grey Lynn Tunnel Assessment of Noise Effects, reference Rp 002 201880726, prepared by Marshall Day Acoustics and dated 13 February 2019), and Hearne Bay Tunnel (Hearne Bay Tunnel – Construction Noise and Vibration Technical Assessment, reference 1090120.3000 v1, prepared by Tonkin & Taylor Ltd, dated June 2023). Therefore, the above criteria are deemed suitable for this activity.

4.2 Construction Vibration Criteria

This section outlines guidance as to what constitutes a reasonable level of vibration.

4.2.1 Auckland Unitary Plan

Section E25.6.30 of the AUP outlines the relevant vibration limits, which are reproduced below.

E25.6.30. Vibration

(1) Construction and demolition activities must be controlled to ensure any resulting vibration does not exceed:

a. the limits set out in German Industrial Standard DIN 4150-3 (1999): Structural vibration – Part 3 Effects of vibration on structures when measured by that Standard on any structure not on the same site; and

b. the limits in Table E25.6.30.1 vibration limits in buildings in any axis when measured in the corner of the floor of the storey of interest for multi-storey buildings, or within 500 mm of ground level at the foundation of a single-storey building.

4.2.2 German Standard DIN 4150-3:1999

The German Standard DIN 4150:1999 *Structural Vibration – Part 3: Effects of Vibration on Structures* (DIN 4150-3) is an internationally recognised standard used to assess the effects of vibration on structures. The Standard is widely used throughout New Zealand and is referenced by many District Plans (or similar) including the AUP.

DIN 4150-3 criteria to evaluate the effects of short-term vibration on structures (such as impact piling or blasting which occurs instantaneously) that do not induce resonance in a building structure, or long-term vibration (such as from vibratory piling or traffic).

The vibration limits in DIN 4150-3 relate to avoiding cosmetic damage to buildings (such as cracking in paint). This is framed as 'minor damage' in DIN 4150-3, meaning it can easily be repaired. DIN 4150-3 states:

> *'Experience has shown that if these values are complied with, damage will not occur. Exceeding the values in table 3 slightly does not necessarily lead to damage.'*

The vibration limits outlined in DIN 4150-3 are set such that there is a low probability of cosmetic damage. These apply at the plane of the highest floor of various types of buildings. Structural damage is unlikely to occur in both residential and commercial structures at less than 50 mm/s and for in-ground structures and infrastructure services at less than 100 mm/s.

The long-term vibration limits outlined in Table 3 of DIN 4150-3 are outlined in Table 4–4.

Table 4–4: DIN 4150-3 long-term guideline vibration limits

Line	Type of Structure	Guideline values for velocity, i_i, in mm/s, of vibration in the horizontal plane of the 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

4.2.3 Auckland Unitary Plan Vibration Amenity Limits

The vibration amenity limits outlined in Table E25.6.30.1 of the AUP are reproduced below.

Table 4–5: AUP Amenity vibration limits (E25.6.30.1)

Receiver	Period	Maximum Peak Particle Velocity (PPV) Limit, mm/s
Occupied activity sensitive to noise	Night-time 10pm to 7am	0.3
	Daytime 7am to 10pm	2.0
Other occupied buildings	At all times	2.0

The vibration limits in Table 4–4 apply to any axis when measured in the corner of the floor of the storey of interest for a multi-storey building, or within 500 mm of ground level at the foundation of a single storey building. An allowance for properties to receive up to 5 mm/s is provided for, only if prior notification was given, at least three days in advance, within 50 m of the works.

The vibration limits in Table 4–5 are useful in considering whether an adjacent resident or occupant is likely to have their amenity reasonably affected by vibration, however, they should not generally be used as an absolute threshold. Exceeding these limits is a call to action, that requires certain management measures to be set in place, i.e., through a CNVMP.

4.2.4 British Standard BS 5228-2:2014

British Standard BS 5228-2:2014 *Code of Practice for noise and vibration control on construction and open sites – Part 2: Vibration* (BS5228-2) provides guidance on human perception of vibration. However, we note that human perception and response to vibration varies depending upon the sensitivity of the individual, the tasks being performed, the magnitude, frequency and duration of the vibration, whether the vibration is expected, and whether there is concern that structural damage may occur.

Humans perceive vibration at much lower magnitudes than the levels of vibration that are likely to cause building damage. Occupants of buildings are therefore likely to complain about vibration significantly below the levels likely to result in cosmetic damage to buildings.

The guidance values in BS5228-2 are provided in Table 4–6. These levels are provided as a means of acknowledging that humans perceive vibration well before vibration venerated from construction activities would impact the building structure. However, these levels can be used to provide guidance as to what level certain management measures should be adopted.

Table 4–6: BS 5228-2 vibration human perception of vibration

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

4.3 Acoustic Impact Terminology

We have used the following terminology when considering the impacts on adjacent properties.

Table 4–7: Noise impact terminology

Noise impact wording	Description
Acceptable	The predicted noise or vibration level is at or below the AUP criteria.
Reasonable	The predicted noise or vibration level is above the AUP criteria, but due to timing, assessment location, hours of operation, receiver, or other factor the level of noise or vibration impact on the receiver is low.
Obvious	The predicted noise or vibration level is above the AUP criteria and is likely to have a low or medium impact on adjacent receptors. Noise-sensitive activities are likely to be disturbed.
Unreasonable	The noise or vibration level is likely to have a high impact on adjacent receptors. All but the least sensitive activities are likely to be disturbed.

5 Assessment Methodology

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

5.1 Construction Methodology and Staging

A construction methodology has been developed by Watercare's selected contractor. This assessment has been based on the proposed works, equipment, methodology, and timing within this construction methodology document.

The general construction duration for the overall works is provided in Table 3–2.

The construction staging for the shafts and trenchless pipe installation are outlined in Table 5–1 and Table 5–2. Some phases do not include noise-generating activities. These phases have not been assessed as they will generate noise levels lower than the remainder of the phases assessed. Phases marked with a hash (#) indicate those which occur outside of the road corridor (within the Greys Avenue Carpark CSA), and those marked with an asterisk (*) indicate phases which occur within the road corridor.

Table 5–1: Shaft Construction and Rehabilitation Stage – Greys Avenue Carpark

Phase	Activity	Equipment/Materials
1#	Shaft extent will be saw cut and a 5t to 20t excavator used to remove pavement layers and other shallow-level obstructions.	• Concrete cutter • Excavator
2#	An Auger attachment on a 10 – 20 t excavator or small piling rig (GEAZ EK-40) will be used to drill 300 to 400-diameter holes. Steel H-beams will be set into each with sand or concrete backfill	• Excavator or GEAX EK-40 piling rig
3#	The shaft will be excavated from the top using an excavator at surface level to a depth of approximately 1m below the pipe invert (5.5m deep shaft). Six-wheeler trucks will be used to remove spoil off site. Approx shaft spoil volume will be 100m^3 (20 return truck trips). Steel road plates or timber lagging will be installed between H-beams as the excavation advances	• Excavator • 6-wheeler trucks • Ventilation fan
4#	The shaft base will be lined out with 500mm of aggregate or blinding concrete to provide a solid and level working platform.	• Concrete pump • Concrete truck • Plate compactor • Ventilation fan
-	If dewatering is required, a 2-to-4-inch submersible pump will be used to remove water from the excavation. The water will be pumped into a clarifying tank for treatment before discharging. The pumps will run continuously while the trench is open and will be powered by a diesel generator or grid power. *This activity has been assumed as part of Phases 3 and 4.*	• Submersible pump • Diesel generator
5#	Following the completion of tunnelling works, an in situ concrete manhole will be formed and poured within the shaft using a concrete pump. The shaft will be backfilled with compacted GAP65 or low strength concrete.	• Concrete pump • Concrete truck
6#	Temporary works will be progressively removed using a 5t to 20t excavator as the shaft is backfilled.	• Excavator
7#	Road pavement (GAP65 and AC) will be reinstated using a 5 to 20t excavator and plate compactor.	• Excavator • Plate compactor

For this stage, dewatering will be required all day and night for up to 15 days. This is expected to be the only activity requiring night works.

Table 5–2: Trenchless Pipe Installation Stage - Greys Avenue Shaft to Queen Street/Mayoral Drive

Phase	Activity	Equipment/Materials
1#	Set up power pack, pump, and water tank on the surface adjacent to Greys Avenue shaft.	• Hiab/crane truck • Ventilation fans
2#	Lift pilot bore rig into pit and survey into position	• Hiab/crane truck • Ventilation fans
3#	Drill pilot hole to Mayoral Drive/Queen Street shaft using laser guided steering head	• Power pack container • Pipe jack • Sucker truck • Tool truck • Ventilation fans
4*#	Install cutting reamer in the Mayoral Drive/Queen Street shaft and backreaming/cut back to the Greys Avenue Shaft. A vacuum sucker truck will be used to remove spoil from the drive, and it will be disposed of offsite using 6 wheelers or sucker trucks. Approx wet tunnel spoil volume will be 20m^3 (8 return truck trips).	• Hiab/crane truck • Power pack container • Pipe jack • Sucker truck • Tool truck • Ventilation fans
5*#	Using pipe jacking methodology, install GRP pipes from the Greys Avenue shaft to the Mayoral Drive/Queen Street shaft.	• Hiab/crane truck • Power pack container • Pipe jack • Sucker truck • Tool truck • Ventilation fans
6#	Clean up and flush the drill slurry out of the pipe with a vacuum truck. Inspect and test pipe	• Sucker truck

5.2 Construction Equipment and Mitigation

5.2.1 Construction Equipment

Appendix A 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* (BS5228-1), NZS 6803:1999 *Acoustics – Construction noise* (NZS6803), or previous measurements of similar equipment.

Appendix A also presents the vibration levels for specific high-vibration equipment taken from the NZTA *State Highway Construction and Maintenance Noise and Vibration Guide,* BS5228-2, or previous measurements of similar equipment.

The evaluation and assessment have been conducted under the assumption that the equipment or plant will not exceed the levels outlined in Appendix A. 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.

5.2.2 Physical Site Mitigation

The contractor is proposing to use temporary concrete barriers with plywood hoardings around the perimeter of each of the construction support areas, except where a gate is required for access, as shown in Figure 5.1.

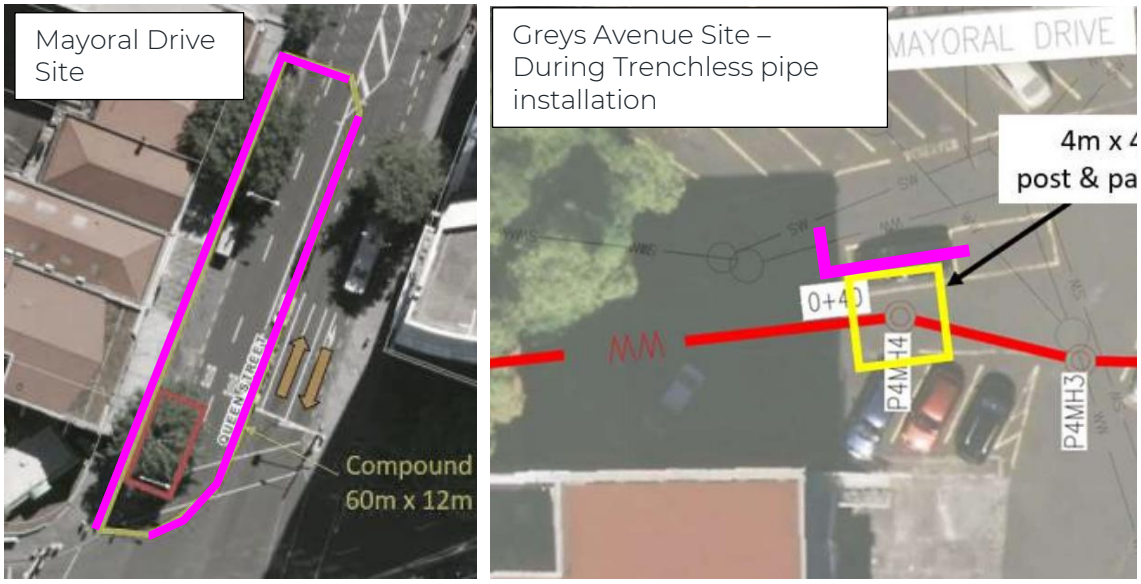

Figure 5.1: Proposed locations of site hoardings (pink)

The site hoardings are to be constructed to a height of no less than 2.0 metres with a surface mass of 10 kg/m^2 (such as 18 mm plywood) and have no gaps or cracks.

5.2.3 Managerial Mitigation

Managerial mitigation measures will be adopted by the contractor to further help reduce the noise and vibration and the impacts of any exceedances.

Based on discussions with the contractor, the following managerial mitigation measures will be undertaken to control noise at the closest properties:

- Equipment associated with the pipe jack (such as power packs) are to be installed on the Mayoral Drive side of the shaft, as shown in blue in Figure 5.2.
- The excavator used for piling the Greys Avenue Shaft will be set up on the side of the shaft adjacent to Mayoral Drive.
- During the excavation of the Greys Avenue shaft, the excavator will be set up in the area in blue or green in Figure 5.2.

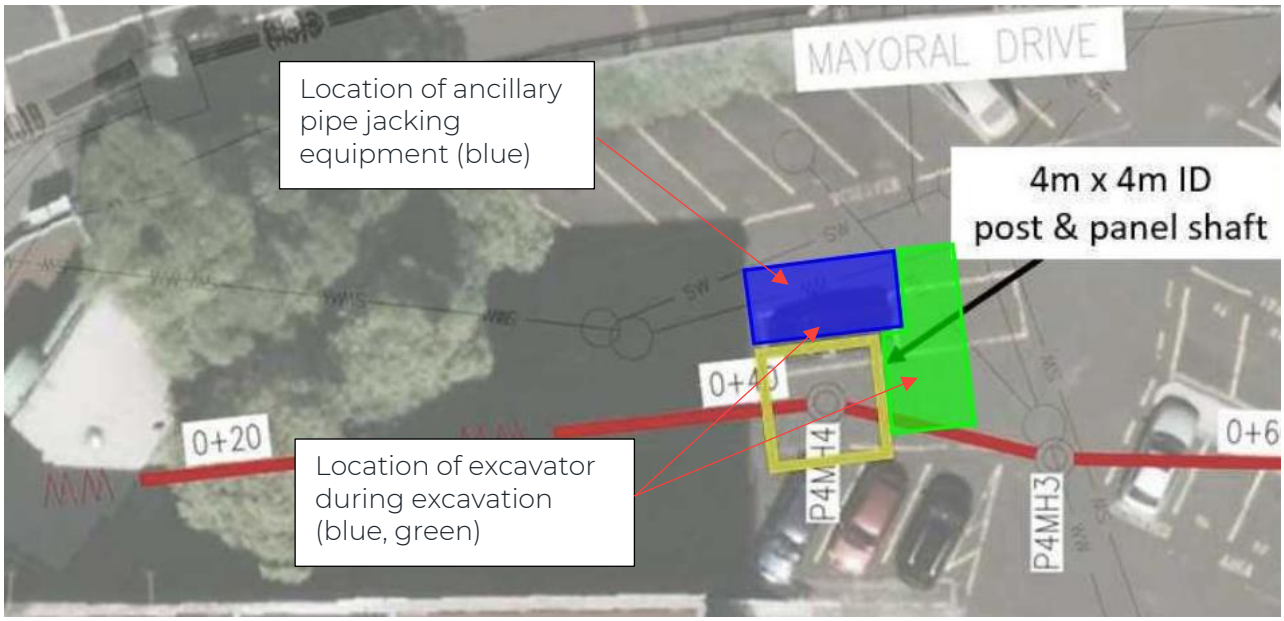

Figure 5.2: Location of equipment setup on site

The following managerial mitigation measures have been adopted by the contractor to reduce the impacts of vibration:

- Plate compactors to only be used for compaction activities.
- 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.

Further information on managerial mitigation measures is provided in Section 10.3.

A Construction Noise and Vibration Management Plan (CNVMP) is recommended as a condition of consent such that these mitigation options are adopted by the contractor.

5.3 Noise Prediction Methodology

Appendix A presents the noise levels for high noise-generating equipment that has been assessed within each stage of the construction methodology. Noise propagation between the source equipment and 1m from the façade of all adjacent buildings has been undertaken in accordance with the method provided in BS5228-1 and *ISO 9613-2:1996 Acoustics — Attenuation of sound during propagation outdoors — Part 2: General method of calculation* (ISO9613-2).

SoundPLAN Version 8.2 3D computational noise modelling software has been used to develop a noise prediction model. A series of scenarios have been analysed with the calculations and 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 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 5–3 presents the noise modelling parameters adopted for this assessment.

Table 5–3: Noise modelling parameters

Property	Value	Source
Calculation method	BS5228 for construction noise ISO9613-2 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	Google Street View
Number of Reflections	3	-
Assessment location	1.0 metres from any façade	NZS6803

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.

5.4 Vibration Prediction Methodology

Appendix A 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 foundation types of all adjacent properties.

5.5 Assumptions and Limitations

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

- Construction activity locations are based on the preliminary design and contractor 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.

6 Predicted Noise Levels

This section outlines the minimum distances from any building to comply with the noise criteria along with the predicted noise level from each construction stage.

6.1 Noise Setback Levels

A list of the key equipment used for these works and the operating sound power level is given in Table 6–1. Table 6–1 also provides the predicted noise level at various distances and the distance to achieve the 75 dB $L_{Aeq,T}$ daytime weekday noise limit without any noise limits.

Table 6–1: Proposed Equipment sound power levels, the noise level at various distances and setback distances without mitigation

Source	Sound Power Level (dB L_{WA})	Predicted noise level at distance (dB $L_{Aeq,T}$)				Setback distance in metres to achieve 75 dB $L_{Aeq,T}$
		5	10	15	20	
Concrete Saw	113	94	88	84	82	45
20T Excavator	105	86	80	76	74	18
Truck	104	85	79	75	73	15
Piling Rig (GEAZ EX40/60)	105	86	80	76	74	18
Ventilation fan	100	81	75	71	69	10
Concrete truck and pump	103	84	78	74	72	14
Plate compactor	108	89	83	79	77	25
Hiab	104	85	79	75	73	15
Power Pack	97	78	72	68	66	7
Pipe jack	82	63	57	53	51	2
Sucker Truck	107	88	82	78	76	22

6.2 Construction Staging Noise Levels

The following sections provide the predicted noise level for each of the stages outlined in Table 5–1 and Table 5–2 based on the prediction methodology outlined in Section 5.3 and mitigation outlined in Section 5.2.

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

The predicted noise levels at each noise-sensitive receptor for each construction phase and stage listed in Table 5–1 and Table 5–2 are presented in Appendix B, assuming the physical mitigation measures described in Section 5.2.2 are provided, unless otherwise specified.

In Appendix B, properties that receive noise levels exceeding the 75 dB $L_{Aeq,30\ min}$ noise limit with the mitigation included in Section 5.2.2 are highlighted in red, indicating a potential non-compliance with the AUP noise limits. Furthermore, properties marked with a hash (#) indicate those affected by noise levels generated outside of the roading corridor from the construction or use of the Greys Avenue Carpark CSA only.

As noted earlier in this assessment, construction works that are located within the road reserve are exempt from the 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 and a CNVMP is implemented by the contractor.

Greys Avenue CSA, the manhole construction, and the removal of the pipe jack are 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 noise generated from the tunnelling works at the Greys Avenue Shaft and Mayoral Drive Shaft have been assessed independently and cumulatively. This 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.

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

The table below outlines the properties that 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 6–2: Properties predicted to exceed the construction noise limits

Stage of Works	Properties subject to exceedances of noise standards at each phase						
	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7
Shaft Construction: Greys Avenue Carpark	323 Queen St#						
Trenchless construction: Shaft locations only	-	-	323 Queen St#	319 Queen St* 323 Queen St# 329 Queen St*	319 Queen St* 323 Queen St# 329 Queen St*	323 Queen St#	n/a

#Noise impacts from works outside the roading corridor.
*Noise impacts from works within the roading corridor

6.2.2 *Maximum Noise Levels (L_{AFmax})*

The maximum sound level (L_{AFmax}) is the highest noise level measured during a time-weighted period. It is generated by single events such as the dropping of spoil into an empty truck, impact of an excavator bucket on asphalt to break it up, and the like.

The predicted maximum noise levels have been undertaken for the loudest construction activities that occur outside the road corridor (construction of the Greys Avenue Shaft).

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

Based on the predicted maximum noise events, no properties are predicted to exceed the maximum noise limit of 90 dB L_{AFmax} outlined in the AUP.

6.3 Regenerated Noise

Table 6–3 provides the stand-off distance which is the slope distance between the tunnel boring machine and adjacent buildings which is predicted to achieve the internal regenerated noise criteria. This assumes competent soil types, masonry buildings on spread footings, noise levels assessed at ground levels, typical residential (furnished room with carpet) or office/retail/hospitality environment (furnished room with carpet and ceiling tiles), and current tunnel alignment.

Table 6–3: Predicted stand-off distance for regenerated noise from trenchless boring

Regenerated Noise Criteria	Stand-off Distance
45 dB $L_{Aeq,T}$	7 metres
35 dB $L_{Aeq,T}$	15 metres

When considering the slope distance (vertical and horizontal distance) from the trenchless boring machine to the adjacent buildings, there are no properties within the setback distance. Therefore, regenerated noise is not predicted to cause adverse effects.

7 Predicted Vibration Levels

This section outlines the setback vibration levels and properties that are predicted to receive vibration levels greater than the vibration criteria.

7.1 Vibration Setback Distances

The key vibration activities are from excavators breaking ground, piling or drilling of holes, pipe jacking, and compaction.

Table 7–1 outlines the stand-off distance of each piece of high vibration equipment used to achieve the various vibration limits. 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 are installed on the manufacturer's vibration isolation (such as the separation unit). Therefore, vibration levels will be lower than the equipment provided below.

Table 7–1: Vibration stand-off distances to achieve the relevant acoustic 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	1.5	1.5	3	6	8
2	CFA piling, auguring, small or similar	0.5	1	2	3	4
3	Pipe jacking	1.5	1.5	3	6	8
5	Plate Compactor**	1	1	2	4	5

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

The 10 mm/s criteria apply at any commercial building, or structures that are commercial in nature (high-rise concrete or steel residential buildings for instance). The 5 mm/s applies to single, or two-storey detached or semi-detached 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 Historic Heritage overlay of the AUP.

7.2 Construction Staging Vibration Levels

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

The following properties are predicted to be within the 2 mm/s AUP amenity limits setback distance from the operation of the pipe jack when it is operated outside of the road corridor for phases 4 and 5 of the trenchless construction only:

- 323 Queen Street
- 329 Queen Street

The impact of these exceedances is discussed in Section 9.

8 Proposed Activity/s and Triggered Rules

The following section sets out the AUP Chapter E25 rules which are predicted to be exceeded.

8.1 Noise

Noise generated from construction activity within the road corridor is exempt from achieving the AUP construction noise limits if a CNVMP is adopted, as outlined in Section E25.6.29 of the AUP.

A CNVMP will be developed by the contractor prior to the works commencing and provided to Auckland Council before works start on site. The adoption of a CNVMP by the contractor allows for specific exemptions or deviations from the standard AUP construction limits for works within the road corridor. These exemptions are based on the mitigation strategies outlined in the CNVMP, which are designed such that noise and vibration levels are managed within acceptable levels.

Noise generated from the construction of the shaft at the Greys Avenue Carpark and the operation of the pipe jack is outside the road corridor and therefore the noise limits outlined in Section E25.6.28 of the AUP apply. The following properties are predicted to exceed the noise limits from works outside the road corridor:

- 323 Queen Street

8.2 Vibration

Vibration generated within the roading corridor is exempt from achieving the vibration limits outlined in Section E25.6.30(1)(b) where a CNVMP is adopted. A CNVMP is provided as part of this application.

A CNVMP will be developed by the contractor prior to the works commencing and provided to Auckland Council before works start on site. The adoption of a CNVMP by the contractor allows for specific exemptions or deviations from Section E25.6.30(1)(b) vibration limits for works within the road corridor. These exemptions are based on the mitigation strategies outlined in the CNVMP, which are designed such that noise and vibration levels are managed within acceptable levels.

The vibration limits outlined in Section E25.6.30(1)(a) are required to be achieved regardless of location and if a CNVMP is adopted.

Based on the setback distances and specific managerial mitigation measures outlined in Section 7, **no properties are predicted to exceed the AUP Section E25.6.30(1)(a) vibration limits**.

Vibration generated outside of the road corridor is predicted to exceed the 2mm/s PPV AUP Section E25.6.30(1)(b) amenity vibration limits at the following properties:

- 323 Queen Street
- 329 Queen Street

Based on the above, resource consent is required under activity Rule E25.4.1 (A2) as a **restricted discretionary activity**, as the permitted activity standard cannot be met.

9 Effects Assessment

The following sections provide an assessment of the construction noise and vibration generated by the proposed activities.

9.1 Construction Noise Effects

Noise from construction works will likely dominate the surrounding areas at times. In addition, most adjacent buildings are multi-storey or elevated compared to the work sites. Whilst physical barriers will mitigate noise effects at street level, this will not sufficiently reduce noise for receptors above ground level due to the unobstructed line of sight.

We have the following comments regarding the effects of the noise associated with construction:

- Many of the construction activities that lead to non-compliance with the construction noise criteria occur within the roading corridor. These are however exempt from the noise limits if a CNVMP is adopted. Therefore, this level of noise could be generated as a permitted activity from any permitted works.

- All equipment is unlikely to be used for all of the day every day. These fluctuations in the noise levels through the construction phases have been considered during the assessment of the noise effects.

- The assessment assumes that all equipment within each phase operates within a worst-case 30-minute period. This is unlikely to occur for most of the construction period as equipment is not used or is used less than assumed for the worst-case. Therefore, it is likely that for much of the construction period, noise levels received at adjacent properties will be lower than those predicted.

- The above analysis assumes that all equipment is located at the surface. Where machinery is located below ground level, the equipment will benefit from acoustic screening from the pit itself (this could include a plate compactor working at the bottom of shafts.

- The predicted noise levels for the trenchless construction for Phases 4 and 5 are the equipment at the Greys Avenue Shaft and Mayoral Drive Shaft operating concurrently. This may not occur in practice, as when the pipe jack is operating from Mayoral Drive to Greys Avenue Carpark, the Greys Avenue Carpark equipment may not be used. Therefore, the total time when buildings are exposed to the predicted noise levels will be less than the 20 working day period where trenchless construction of the pipe will occur.

- The Greys Avenue Carpark Shaft is predicted to take 15 working days to construct, with construction works only occurring Monday to Saturday. There will therefore be a respite day on Sundays where no construction works will be undertaken through this 15 working day period.

- While it is predicted that at 323 Queen Street, the construction noise limits will be exceeded (by up to 7 dB) during the shaft construction, it is unlikely these exceedances will be for the entire construction period. For example, the predicted noise from the insertion of the H-beams is when the excavator is inserting these only. There will be periods where little to no noise is generated when a new H-beam is fitted for installation to the excavator or piling rig.

- The noise levels presented in Appendix B are the worst-case levels on the most exposed façade. This level of noise is not received over the entire façade when the highest level of activity occurs. Figure 9.1 provides an indicative visual representation of the noise levels over the façade of 323 Queen Street from Phase 1 of the Greys Avenue shaft construction with acoustic mitigation installed in Section 5.2.2. This shows that noise levels decrease up the height of the building.

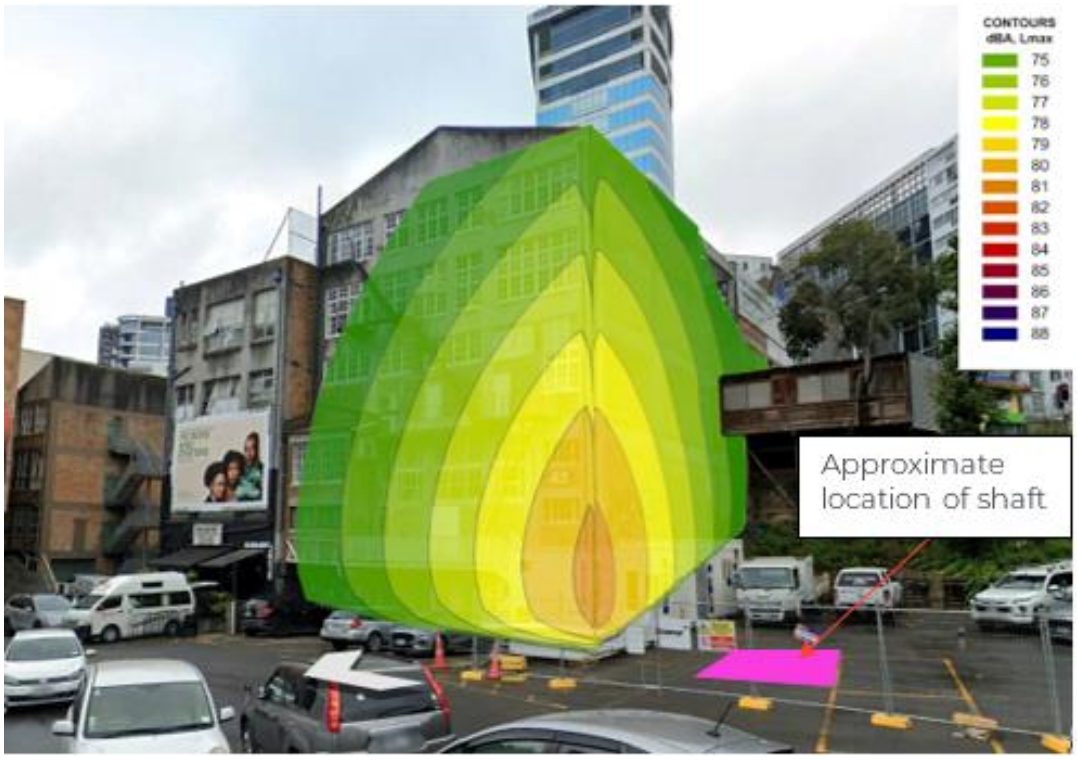

Figure 9.1: Visual representation of the predicted noise level on the facades of 323 Queen Street (indicative only)

- Based on a desktop review, Level 3 (ground level on Queen Street side) is a retail store, with offices located on the upper two floors. The Level 3 retail store receives levels between 75 – 79 dB $L_{Aeq,T}$ at 1m away from the facade. Noise levels between 74 – 78 dB $L_{Aeq,T}$ on level 4 and 74 – 77 dB $L_{Aeq,T}$ on Level 5 are predicted. Levels 1 and 2 receive levels above 80 dB $L_{Aeq,T}$ on the façade; however it cannot be determined from a desktop review the use of these spaces.

- The existing ambient noise level on the façade of 323 Queen Street building is predicted to be above 70 dB $L_{Aeq,30min}$. Therefore, high levels of noise are not uncommon in this area. While the proposed construction activity is not in an area with receivers that are expected to be particularly noise sensitive, construction noise is of a different character than other sources, so likely to be noticeable, even if it is at a similar level to other ambient noise.

- The predicted noise levels are assessed at 1 metre from the façade of the building and at 1.5 metres above each floor level in the building. At levels above the ground that wouldn't be screened by the proposed site hoardings, a noise level 1 metre from the façade is not an appropriate location to assess the noise effects from construction works. Inside a building at levels above the ground is a more relevant location to assess the impacts of construction noise. Table 9–1 has been developed based on current guidance and our professional experience. This assumes a 25 dB reduction as windows in these buildings adjacent are likely to be closed.

Table 9–1: Construction noise subjective effects

External noise level, 1m from the facade	Effects with windows closed
≥90 dB $L_{Aeq,T}$	This level is unlikely to be tolerated for any extent of time indoors.
80 dB $L_{Aeq,T}$	Disruption is likely for quiet activities. Likely to require the volume on TV or radio to be turned up to be intelligible over background noise.
75 dB $L_{Aeq,T}$	Noise from construction is likely just perceptible over background noise. May be disruptive for quiet activities such as reading. Not likely to disrupt fewer sensitive activities such as watching TV; however, these may require more concentration.
70 dB $L_{Aeq,T}$	Little disruption. Noise is likely to be perceptible over background noise during quiet activities (such as reading). Unlikely to disrupt less sensitive activities such as watching TV.
65 dB $L_{Aeq,T}$	Unlikely to disrupt activity. May be audible within the building if quiet activities are occurring

- During dewatering works for the shaft construction only, a low-noise generator and pump will run 24 hours a day to keep water out of the shafts. To provide a worst-case estimate of effects, a sound power level of 97 dB L_{wA} has been assumed, operating at ground level without any additional hoardings or enclosures. Noise from this equipment operating at night near the Greys Avenue shaft is predicted to be no greater than 35 dB $L_{Aeq,30min}$ within any adjacent residential apartment.

- No other night works are proposed as part of this construction works.

With the adoption of all practicable physical mitigation measures, the assessment of noise described above, and the implementation of a CNVMP, noise effects from construction are predicted to be **reasonable**.

9.2 Construction Vibration Effects

Vibration from the proposed construction activities is predicted to be below the vibration criteria outlined in Section E25.6.30(1)(a) of the AUP both for works within the road corridor and outside of the road corridor.

Two properties are predicted to receive vibration levels greater than 2 mm/s PPV (323 Queen Street and 329 Queen Street). We have the following comments regarding these exceedances:

- The exceedances only occur during the pipe jacking phases of the trenchless pipe installation when the pipe jack is within 8 metres of 323 and 329 Queen Street.

- Trenchless pipe installation is only predicted to occur for 20 working days. Less than half of the pipe installation is within 8 metres of 323 and 329 Queen Street, and therefore these buildings will be exposed to less than 10 days of vibration levels greater than 2 mm/s.

- The 2 mm/s PPV vibration levels are likely to be felt but given prior warning are expected to be tolerable for the majority of people. Therefore, managerial mitigation and community consultation will be key to reducing any effects associated with vibration.

- The specific vibration levels generated by the pipe jack are dependent on the speed of the pipe jack, specific ground conditions, and the head type used. Vibration levels

shall be measured during the first activity to confirm the level of vibration generated and update any mitigation requirements.

The following mitigation measures shall be incorporated within a CNVMP: which is to be followed by the contractor:

- Notify 323 Queen Street and 329 Queen Street a minimum of 10 working days prior to high vibration activities listed in Table 7–1 are started on site.

- Undertake vibration measurements of the high vibration equipment listed in Table 7–1 when it first is undertaken on-site to confirm the vibration levels generated. If permission is granted by the owners and occupiers of 323 Queen Street and 329 Queen Street, vibration measurements shall also be undertaken in the foundations of these buildings.

With these management procedures developed within a CNVMP, the vibration impacts are predicted to be **reasonable**.

10 Mitigation Measures

The construction noise and vibration assessment has determined that mitigation measures are required to reduce the noise and/or vibration impacts on adjacent properties.

Additionally, as noted in the RMA, mitigation measures should be adopted in any case to protect against unreasonable levels of noise and vibration where practically possible.

This section provides details of the specific mitigation measures that shall be applied to the construction works.

10.1 General Mitigation Measures

A CNVMP is recommended to be adopted as a condition of consent. The CNVMP shall be followed and updated by the contractor for the duration of the Project. The CNVMP shall be developed in accordance with E25.6.29(5) of the AUP and Annex E2 of NZS 6803.

Chiefly, the CNVMP shall include an outline of how communications will be undertaken between the consent holder (and its contractors) and the neighbouring properties, particularly those that are predicted to exceed the recommended noise and/or vibration limits. The CNVMP shall include:

- How communication by the consent holder will occur about certain construction works expected to exceed the noise levels in NZS 6803:1999, including scheduling/timing of works and the identification of potential temporary nuisance effects.
- How residents may communicate any enquiries or complaints about construction noise.
- Procedures for directly notifying neighbouring properties at least 10 working days in advance of programmed noise events that are predicted to exceed the noise limit for each property such as piling, including the duration that they will occur for, and times they will occur between.
- Procedures for notifying neighbouring properties within the 2 mm/s PPV setback distance at least 10 working days in advance of the equipment outlined in Table 7–1 operating. This includes the duration that the equipment will operate and the times that it will operate between. Noting that vibration is unlikely to be at this level for the entire period.
- The contact details of the lead contractor/project manager and a representative of the consent holder.

10.2 Physical Mitigation Measures

10.2.1 Acoustic Site Hoardings

Site hoardings are only effective as noise mitigation where they block the line of sight from the plant to the receptor. In many cases, the surrounding buildings are multi-story and therefore when assessing noise at 1 metre from the façade of the building, physical mitigation will have a limited impact.

However, physical mitigation measures are recommended as they can effectively reduce the impact on receptors who traverse along the footpath adjacent to the construction sites.

Site hoardings are proposed to be installed around the construction sites, as outlined in Section 5.2.2. The acoustic site hoardings shall achieve the following minimum specifications.

- 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 palings 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.
- Where practicable, localised movable acoustic screens/barriers/hoardings shall be used around high noise-generating equipment when in use, such as a concrete saw.

Dedicated localised acoustic barriers are also to be used around any plant/equipment operated during outside of the 0730-1800 hours Monday to Saturday period (pumps, generators).

The movable site hoardings shall achieve the minimum specifications listed above.

10.2.2 Selection of Equipment

Equipment is to be selected with the generated noise level in mind. This includes:

- Vehicles with audible reversing warning sirens will be fitted with broadband reversing beepers.
- 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 from sensitive receptors.
- Use of electric equipment over petrol/diesel alternatives including saws, hand power tools, chainsaws, and the like.
- Selection of equipment that is an appropriate power for the use (i.e., not using more powerful equipment than needed.

10.3 Managerial Mitigation Measures

10.3.1 General

The following managerial mitigation measures are to be adopted by the contractor as far as reasonably practicable:

- Site-specific training shall be given to site personnel including management and workers involved in construction activities or equipment operators that have the potential to generate noise and vibration effects. This also includes training for personnel involved in monitoring noise and vibration.
- Equipment outlined in Appendix A (or other high noise generating equipment) is to be operated only between 0730 and 1800 hours Monday to Saturday, with no works occurring on Sundays or Public Holidays.
- All machinery to be used on site will be acoustically tested to determine the sound power level of the machinery and compared to the sound power levels in Appendix B of this Assessment. Where the tested sound power level is greater, either this machinery shall be fitted with acoustic noise reduction measures (mufflers), or additional noise modelling was undertaken to determine whether further mitigation is required to attenuate noise to adjacent properties to achieve desired noise levels.
- Preferential selection of sub-contractors that use a lower noise-generating demolition, piling, compaction, and construction methodologies.
- No unnecessary idling of equipment on site (such as trucks and excavators) when not in use.

10.3.2 Vibration Management

Specific vibration management shall be undertaken for the properties outlined in Section 8.2 which exceed the 2 mm/s PPV amenity limit. These properties have the potential to experience vibration levels from the pipe installation works (total period of 20 days). 10 working days prior to the start of the pipe jacking, communication will be undertaken with the properties in Section 8.2 via physical or electronic mail. This communication is to include why the works are occurring, the timing of the works, duration, equipment used, and contact information for the noise liaison officer for any feedback.

For all works, the vibration managerial mitigation measures outlined in Section 7 are to be adopted as part of the CNVMP to reduce the likelihood of high vibration levels impacting heritage buildings.

10.3.3 Monitoring

While managerial mitigation measures are to be adopted by the contractor to reduce the impact of vibration received at buildings, it is recommended that vibration monitoring is undertaken during the first high-vibration equipment operating to confirm the setback distances.

Where vibration levels are measured to be above 2.5mm/s near any building within the Historic Heritage overlay or 5 mm/s at any other building, works on site will stop until the vibration source is identified and any/all mitigation measures are implemented to reduce the received vibration level within the buildings.

Vibration monitoring will also be undertaken during the first operation of pipe installation using trenchless construction. Vibration measurements are to be undertaken to confirm the vibration levels meet the required acoustic criteria. Where levels are measured to be above 2.5mm/s from the pipe jacking, continuous vibration monitoring will be undertaken.

11 Identification of Affected Parties – Noise and Vibration

Affected Parties are those which receive noise or vibration levels above the AUP criteria and the exceedances are likely to have an obvious or unreasonable impact on adjacent receptors when considering the actual noise level received, the proposed mitigation measures, and duration of the works (including the time each day the exceedance may occur, the total days the exceedances are to occur for and duration of the overall construction).

This section identifies any potentially affected parties when considering the above.

11.1 Noise

323 Queen Street exceeds the construction noise limits outlined in the AUP. However, mitigation measures to reduce the noise level and effects of any further exceedances has been discussed with the proposed contractor and adopted as part of this assessment. Therefore, the best practicable mitigation measures are to be incorporated by the contractor to reduce the noise impacts as far as reasonably practicable.

The impacts of the exceedances are discussed in Section 9.

Based on a CNVMP implemented by the contractor with the mitigation measures outlined in Section 10, there are no properties that are predicted to have effects that are unreasonable, and therefore no properties identified as affected by noise from these works.

11.2 Vibration

There are no buildings within the DIN 4150-3 vibration limits. While 323 and 329 Queen Street are predicted to exceed the amenity vibration limits, with the managerial mitigation measures outlined in Section 10, there are no properties identified as affected by vibration from these works.

The impacts of the exceedance of the amenity vibration limits are discussed in Section 9.

12 Conclusion and Recommendations

WSP has been engaged by Watercare to assess the noise and vibration impacts from the construction of a new wastewater mainline through Auckland City Centre for the Queen Street Wastewater Diversion programme of works. This report provides an assessment of the construction noise and vibration in relation to the connection works between Part 3 and Part 4 (manhole P4MH4 and P3 MH1) of the Project.

Noise and vibration criteria have been developed based on the AUP. Noise from construction works within the roading corridor are exempt from the construction noise limits, provided that a CNVMP is developed. However, for completeness, noise generated in the road corridor specifically associated with this Project has been predicted.

The construction methodology for the Part 3 to Part 4 Connector Project has been provided by Fulton Hogan, the proposed contractor. This methodology also includes duration of activities, equipment used, and location of works on site.

Based on the construction methodology and proposed mitigation, the following properties are predicted to exceed the noise limits within the AUP from construction works outside the road corridor:

- 323 Queen Street

No properties are predicted to exceed the Section E25.6.30(1)(a) vibration limits. However, the following properties are predicted to exceed the Section E25.6.30(1)(b) 2mm/s PPV vibration limits:

- 323 Queen Street
- 329 Queen Street

Physical and managerial mitigation measures are to be adopted in a CNVMP to manage the impacts of these exceedances. It is therefore recommended that as a conditions of consent a CNVMP is adopted to ensure that the best practicable option of physical and managerial noise and vibration mitigation is implemented as far as reasonably practicable.

With the adoption of the conditions of consent below, the best practicable option of mitigation is to be used by the contractor. Therefore, the effects associated with the construction of the shafts and installation of the wastewater pipe is predicted to be reasonable. We have not identified any parties which are impacted by noise or vibration to an obvious or unreasonable level based on this analysis.

12.1 Recommended Consent Conditions

The following conditions of consent are recommended:

1 A CNVMP shall be implemented, in line with Section E25.6.29(5) of the AUP and Annex E2 of NZS 6803:1999. This is to include:

   (a) Construction methodology and proposed equipment by the contractor.

   (b) Updated noise predictions based on the final construction methodology.

   (c) Outline practicable physical and managerial mitigation measures to reduce the effects of noise on adjacent noise-sensitive receptors, site mitigation to equipment on site, and community liaison methodology.

2 Where access is granted, attended vibration measurements are to be undertaken during the first high-vibration equipment operating close to the following properties:

(a) 323 Queen Street

Where measured vibration levels from the pipe jack exceed the 2.5mm/s PPV in 323 Queen Street building, continuous vibration monitoring must also be undertaken throughout the installation of the pipework within the same building, and appropriate mitigation measures are to be undertaken as outlined in the CNVMP.

Appendix A
Construction Equipment Schedule

Equipment List						
Site	Phase	Activity	Equipment	SWL (dB L_{Aeq})	SWL (dB L_{Amax})	% on time
Greys Avenue Shaft Construction	1	Saw cut and removal pavement	Concrete Cutter	113	-	30
			20T Excavator	105	120	80
			6-wheeler truck	104	120	30
	2	Auguring and installing H-Beams	Excavator or GEAX EK-40 piling rig	105	-	100
	3	Excavation of shaft	20T Excavator	105	120	80
			6-wheeler truck	104	120	30
			Ventilation fans	100	-	100
			Submersible pump	90	-	100
			Generator	95	-	100
	4	Lining base of shaft with concrete	Concrete truck and pump	103	-	100
			Plate compactor	108	-	100
			Ventilation fans	100	-	100
			Submersible pump	90	-	100
			Generator	95	-	100
			6-wheeler truck	104	120	30
	5	Installation of manhole	Concrete truck and pump	103	-	100
			20T Excavator	105	120	80
			6-wheeler truck	104	120	30
			Ventilation fans	100	-	100
	6	Backfilling trench	20T Excavator	105	120	80
			6-wheeler truck	104	120	30
			Plate compactor	108	-	100
	7	Reinstatement of road pavement	20T Excavator	105	120	80
			Plate compactor	108	-	100
			6-wheeler truck	104	120	30
Trenchless pipe construction (Greys Avenue to Queen Street/Mayoral Drive)	1	Site setup	Hiab/crane truck	104	-	80
			Ventilation fans	100	-	100
	2	Lift boring rig into pit and survey	Hiab/crane truck	104	-	80
			Ventilation fans	100	-	100
	3	Drill pilot hole to Queen Street/Mayoral Drive shaft	Power pack container	97	-	100
			Pipe jack	82	-	100
			Sucker truck	107	115	100
			Tool truck	104	120	30
			Ventilation fans	100	-	100
	4	Install reamer and cutback	Hiab/crane truck	104	-	80
			Power pack container	97	-	100
			Pipe jack	82	-	100
			Sucker truck	107	115	100
			Tool truck	104	120	30

			Ventilation fans	100	-	100
	5	Install wastewater pipe	Hiab/crane truck	104	-	80
			Power pack container	97	-	100
			Pipe jack	82	-	100
			Sucker truck	107	115	100
			Tool truck	104	120	30
			Ventilation fans	100	-	100
	6	Clean-up, inspection and testing	Sucker truck	107	115	100

Works within the road reserve

^ Works outside of the road reserve

Vibration Equipment List		
No.	Equipment	PPV (mm/s) @10m
1	Excavator breaking ground	1.5
2	CFA piling, auguring, drilling of holes, or similar	0.5
3	Pipe jacking	1.5
4	Plate compactor	1.0

Appendix B
Predicted Noise Levels

The following tables provide the predicted noise level at each construction location for each phase and stage. Hash (#) means noise level is received from works outside the road corridor (noise generate within Greys Avenue Carpark). The caret (^) means noise is received from within the road corridor (Mayoral Drive/Queen Street shaft site).

Greys Avenue Carpark Shaft Construction						
Property	Phases					
	1#	2#	3#	4#	5#	6, 7#
3 Airedale Street	57	53	54	58	56	57
3 Greys Avenue	61	57	58	62	60	61
48 Greys Avenue	65	61	62	66	64	65
95 Greys Avenue	61	57	58	62	60	61
100 Mayoral Drive	63	59	60	64	62	63
120 Mayoral Drive	50	46	47	51	49	50
301 Queen Street	59	55	56	60	58	59
313 Queen Street	66	62	63	67	65	66
315 Queen Street	66	62	63	67	65	66
317 Queen Street	58	54	55	59	57	58
319 Queen Street	58	54	55	59	57	58
321 Queen Street	73	69	70	74	72	73
323 Queen Street	81	77	78	82	80	81
329 Queen Street	73	69	70	74	72	73
361 Queen Street	68	64	65	69	67	68
380 Queen Street	54	50	51	55	53	54
396 Queen Street	58	54	55	59	57	58
438 Queen Street	63	59	60	64	62	63

Queen Street/Mayoral Drive and Greys Avenue Carpark Trenchless Construction						
Property	Phases					
	1#	2#	3#	4#^	5#^	6#
3 Airedale Street	47	47	54	67	67	52
3 Greys Avenue	52	52	59	59	59	57
48 Greys Avenue	58	58	65	65	65	63
95 Greys Avenue	54	54	61	61	61	59
100 Mayoral Drive	56	56	63	63	63	61
120 Mayoral Drive	43	43	50	62	62	48
301 Queen Street	52	52	59	69	69	57
313 Queen Street	59	59	66	71	71	64
315 Queen Street	58	58	65	72	72	63
317 Queen Street	45	45	52	74	74	50
319 Queen Street	50	50	57	77	77	55
321 Queen Street	65	65	72	73	73	70
323 Queen Street	74	74	81	81	81	79
329 Queen Street	67	67	74	80	80	72
361 Queen Street	61	61	68	68	68	66

380 Queen Street	48	48	55	70	70	53
396 Queen Street	52	52	59	75	75	57
438 Queen Street	56	56	63	64	64	61

Predicted Maximum Noise Levels from Any Construction Equipment	
Property	Predicted Maximum Noise Level L_{AFmax} (dB)
3 Airedale Street ^	77
3 Greys Avenue ^	69
48 Greys Avenue^	75
95 Greys Avenue^	71
100 Mayoral Drive^	73
120 Mayoral Drive ^	72
301 Queen Street ^	79
313 Queen Street ^	81
315 Queen Street^	82
317 Queen Street ^	84
319 Queen Street ^	87
321 Queen Street ^	83
323 Queen Street #	90
329 Queen Street ^	90
361 Queen Street ^	78
380 Queen Street^	80
396 Queen Street ^	85
438 Queen Street ^	74

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