MARSHALL DAY Acoustics

GREY LYNN TUNNEL
ASSESSMENT OF NOISE EFFECTS

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EXECUTIVE SUMMARY

This report provides an assessment of noise effects from the construction and operation of the Grey Lynn Tunnel.

Daytime construction noise emissions and night-time operational noise are the primary issues of note.

The assessment discusses the guideline noise criteria from the Auckland Unitary Plan (Operative in Part) (AUP (OP)); outlines the acoustic effects assessment methodology; predicts noise levels and assesses the potential impacts from the construction and operation of the Project.

It is recommended that the guideline criteria contained in the AUP (OP) are adopted. The aim is to achieve compliance with these criteria where practicable. In accordance with Section 16 of the Resource Management Act 1991 (RMA) the best practicable option should be adopted to ensure that noise effects do not exceed a reasonable level and where there is predicted temporary exceedance, appropriate noise mitigation measures should be put in place.

The predictions contained in this assessment are conservative and cover the anticipated envelope of potential noise effects based on the current construction methodology for the project. However, the assessment is also broad enough to cover the anticipated effects envelope, should alternative construction techniques be used.

Construction noise has been predicted using equivalent noise source data from other similar projects and from information contained in NZS 6803: 1999 and BS 5228-1: 2009. Tables are provided that show potential worst-case noise levels from the construction activities proposed. The predictions are based on assumptions and estimates detailed in the indicative construction methodology. There may be some variation in the actual methodology or equipment used to carry out the work as the final decision would be made by the lead Contractor. However, the Construction Noise and Vibration Management Plan will contain the procedures necessary for identifying, mitigating and managing any potential noise issues through an adaptive management approach, as has historically occurred on various large infrastructure projects in Auckland.

Some activities are predicted to temporarily exceed the relevant noise limits and may therefore require activity-specific management and mitigation. These will be addressed via Activity Specific Noise and Vibration Management Plans.

General acoustic management and mitigation measures are recommended to be implemented throughout the course of the Project as a best practice provision, including maintenance of equipment to a high level and the avoidance of unnecessary noise such as the use of horns, tonal reverse alarms or clearing excavator buckets by hitting the ground.

Overall, the construction of the Grey Lynn Tunnel is predicted to result in noise levels that are generally within the applicable noise limits, with some exceptions. Whilst construction noise levels are higher than ongoing operational levels, it is commonly accepted that for any construction to occur, acoustic criteria must be less stringent, with the understanding that construction is a temporary activity with a finite duration. With appropriate mitigation and management measures in place the effects of construction noise will be minor.

Operation noise from the proposed plant room has been predicted using SoundPLAN noise modelling software. With the proposed conceptual acoustic mitigation measures in place, plant room noise is predicted to comply with the relevant night-time noise limit. It is concluded that the operational noise effects would be less than minor.

1.0 INTRODUCTION

Watercare Services Limited (Watercare) is the water and wastewater service provider for Auckland. Watercare is proposing to construct a wastewater interceptor from Western Springs to Tawariki Street, Grey Lynn (Grey Lynn Tunnel). The Grey Lynn Tunnel will connect to the Central Interceptor at Western Springs.

The potential acoustic amenity impacts on residential receivers from the construction of the Grey Lynn Tunnel is the principal issue of concern. It is noted that tunnelling is a continuous activity (i.e. operates 24/7) once it commences, therefore potential night-time effects from regenerated noise have also been considered. The operation of the Grey Lynn Tunnel is anticipated to generate noise of little appreciable significance, given the absence of mechanical ventilation and air filtration systems.

This report and assessment is submitted to accompany an application for resource consents and a notice of requirement by Watercare for the construction, operation and maintenance of the Grey Lynn Tunnel.

2.0 PROJECT OVERVIEW

The Grey Lynn Tunnel involves the elements shown in the drawings and outlined in more detail in the reports which form a part of the application. These elements are summarised in the following sections.

Figure 1 indicates the proposed tunnel alignment and shaft site locations. The tunnelling will be undertaken within a 40m corridor centred on the alignment shown in the figure.

Figure 1: Overview of Indicative Tunnel Alignment

2.1 Grey Lynn Tunnel

The Grey Lynn Tunnel involves construction, operation and maintenance of a 1.6km gravity tunnel from Western Springs to Tawariki Street, Grey Lynn with a 4.5m internal diameter, at an approximate depth of between 15 to 62m below ground surface, depending on local topography. The tunnel will be constructed northwards from Western Springs using a Tunnel Boring Machine (TBM). The Grey Lynn Tunnel will connect to the Central Interceptor at Western Springs via the Western Springs shaft site.

2.2 Tawariki Street Shaft Site

The Grey Lynn Tunnel also involves construction, operation and maintenance of two shafts and associated structures at Tawariki Street, Grey Lynn ("Tawariki Street Shaft Site").

The Tawariki Street Shaft Site will be located at 44, 46 and 48 Tawariki Street where the majority of the construction works will take place. Construction works will also take place within the road reserve at the eastern end of Tawariki Street and a small area of school land (St Paul's College) bordering the end of Tawariki Street (approximately 150m^2).

The Tawariki Street Shaft Site will involve the following components:

2.2.1 Main Shaft

- A 25m deep shaft, with an external diameter of approximately 10.8m, to drop flow from the existing sewers into the Grey Lynn Tunnel;
- Diversion of the Tawariki Local Sewer to a chamber to the north of the shaft. This chamber will be approximately 12m long, 5m wide and 5m deep below ground, and will connect to the shaft via a trenched sewer;
- Diversion of the Orakei Main Sewer to a chamber to the south of the shaft. This chamber will be approximately 10m long, 5m wide and 11m deep below ground, and will connect to the shaft via a pipe-jacked sewer;
- Construction of a stub pipe on the western edge of the shaft to enable future connections (that are not part of this proposal) from the CSO network;
- Construction of a grit trap within the property at 48 Tawariki St to replace the existing grit trap located within the Tawariki Street road reserve. The replacement grit trap will be approximately 16m long, 5m wide and 13m deep below ground;
- Permanent retaining of the bank at the end of Tawariki Street to enable the construction of the chamber for the Orakei Main Sewer. The area of the bank requiring retaining will be approximately 44m long, 3m wide and 2m high; and
- An above ground plant and ventilation building that is approximately 14m long, 6m wide and 4m high. An air vent in a form of a stack will be incorporated into the plant and ventilation building and discharge air vertically via a roof vent. The vent stack will be designed with a flange to allow future extension of up to 8m in total height and approximately 1m in diameter in the unexpected event of odour issues.

Refer to Appendix B for the proposed concept design of the Tawariki Street shaft site and connection sewers.

2.2.2 Tawariki Connection Sewer Shaft – Secondary Shaft

A secondary shaft will be constructed at the Tawariki Street Shaft Site to enable the connection of future sewers (that are not part of this proposal) from the Combined Sewers Overflows ("CSO") network. This will involve the following components:

- A 25m deep drop shaft with an external diameter of approximately 10.2m; and
- A sewer pipe constructed by pipe-jacking to connect the secondary shaft to the main shaft.

2.3 Construction Timeframe

The construction works for the main shaft, chambers and tunnel will occur at the same time as works for the Central Interceptor. Construction will be up to 2 ½ years total duration. The construction of the main shaft and chambers is estimated to take approximately 12 months initially, followed by a hiatus of several months waiting for the TBM to arrive at Tawariki Street Shaft Site. This will be followed by approximately 9 months of activity to remove the TBM and complete the internal structure of the main shaft.

The secondary shaft will be constructed in conjunction with the future sewers at a later date but (subject to need) within a 10-year period following construction of the main shaft and tunnel. The construction period for the secondary shaft and future sewer connections is estimated to be up to 2 years total duration.

2.4 Nearest Potentially Sensitive Receivers

There are a number of receivers that may potentially be adversely affected by noise from the Tawariki Street shaft site. The following table identifies these receivers, their zoning, use and distance to site.

Table 1: Receiver Locations

Address/location	Zoning / Usage	Distance to Works (setback distance, m)[1]
Marist Catholic School	Special Purpose / Education	40
29 Tawariki Street	Residential / Dwelling	40
33 Tawariki Street	Residential / Dwelling	27
35 Tawariki Street	Residential / Dwelling	25
36 Residential / Dwelling	Residential / Dwelling	44
37 Tawariki Street	Residential / Dwelling	25
38 Tawariki Street	Residential / Dwelling	30
39 Tawariki Street	Residential / Dwelling	22
40 Tawariki Street	Residential / Dwelling	21
41 Tawariki Street	Residential / Dwelling	20
42 Tawariki Street	Residential / Dwelling	Adj. West boundary (10m to dwelling))

Notes to table:

(1) Distance is from building façade to closest shaft site boundary

3.0 EXISTING ACOUSTIC BASELINE

To gain an understanding of the existing environmental noise baseline for dwellings in proximity to the proposed above-ground plant room, an attended noise measurement was carried out on 28 November 2018 between 10:00pm and 10:30pm. The weather at the time of the survey was clear skies with a light breeze present, and therefore within the allowable meteorological window prescribed in NZS6801:2008. The measurement was undertaken in accordance with the relevant standards[1]. The position, marked MP1 in the figure overleaf, is considered a representative location to measure the existing environment of receivers located around the proposed plant room.

Figure 2: Ambient Measurement Position

Source: https://unitaryplanmaps.aucklandcouncil.govt.nz/upviewer/

The measured noise levels are shown in Table 2.

Table 2: Measured Ambient Noise Levels

Measurement Position	Measurement		Measured Level (dB) (1)				Noise Source (2)
	Start Finish Times	Duration min:sec	L_{Amax}	L_{A10}	L_{Aeq}	L_{A90}	
MP1	22:12 pm 22:27pm	15:22	50	41	38	35	Wind in trees, crickets, distant aircraft, distant traffic, household noise, dog barking

[1] AUP Standard E25.6.1 (1)

Notes to table:

(1) An explanation of technical terms is provided in Appendix A

4.0 ACOUSTIC PERFORMANCE STANDARDS AND LEGISLATION

4.1 Resource Management Act 1991 (RMA)

Under the provisions of the RMA there is a duty to adopt the best practicable option to ensure that noise (including vibration[2]) from any development does not exceed a reasonable level. Specifically, Sections 16 and 17 reference noise effects as follows.

Section 16 states that "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".

Section 17 states that "every person has a duty to avoid, remedy, or mitigate any adverse effect on the environment arising from an activity carried on by or on behalf of the person, whether or not the activity is in accordance with –

(a) Any of sections 10, 10A, 10B and 20A; or

(b) A national environmental standard, a rule, a resource consent, or a designation"

This report uses the guiding principles of Section 16 and 17 of the RMA as noted above in assessing effects and recommending mitigation measures. It considers the potential construction and operational noise effects of the Grey Lynn Tunnel. The potential vibration effects associated with the construction of the Grey Lynn Tunnel are separately assessed in the Vibration Assessment.

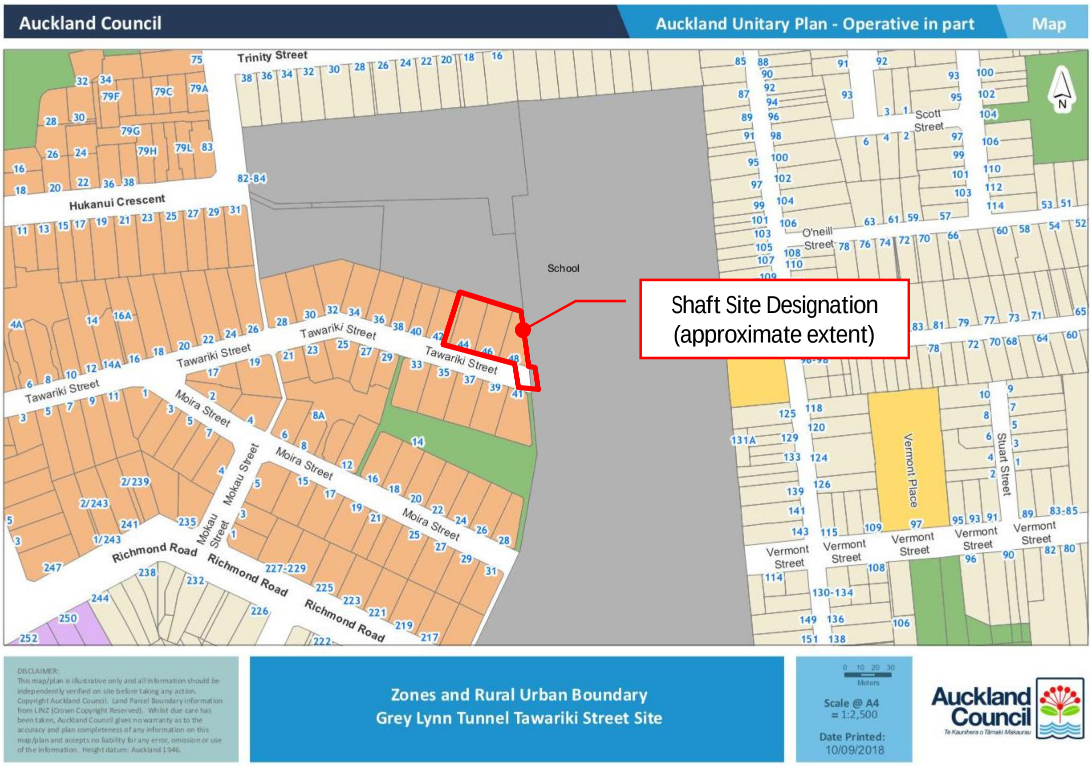
4.2 Auckland Unitary Plan Operative in Part (AUP (OP))

The Tawariki Street Shaft site is on land with an underlying zone classification of *Residential – Mixed Housing Urban Zone* in the AUP (OP). The closest potentially sensitive sites are also within this zone. Saint. Pauls School and associated playing fields are zoned *Special Purpose – School Zone.*

Figure 3 shows the relevant AUP zones for the indicative designation boundary and surrounding area.

[2] RMA 1991 Part 1 Section 2 Interpretation: Noise includes vibration

Figure 3: AUP Zones



Source: https://unitaryplanmaps.aucklandcouncil.govt.nz/upviewer/

The following details the AUP (OP) noise performance standards relevant to the identified receiving zones.

4.2.1 Construction Noise Limits

Standard E25.6.1 (3) of the AUP (OP) states that noise from any construction work activity must be measured and assessed in accordance with the requirements of New Zealand Standard NZS 6803: 1999 *"Acoustics - Construction Noise"*.

Standard E25.6.27 (1) sets out the noise limits for construction (refer to Appendix C). As the anticipated length of construction exceeds 20 weeks, Standard E25.6.7 (4) would apply, resulting in the construction noise limits set out in Table E25.6.27.1 decreasing by 5 decibels.

In summary, the reduced noise limits for noise affecting sensitive activities is 70dB L_{Aeq} / 85dB L_{Amax} between 7.30am and 6.00pm.

A Construction Noise and Vibration Management Plan (CNVMP) would be required, in accordance with Standard E25.6.29 (5).

4.2.2 Operation Noise Limits

Noise received by dwellings in residential zones

Standard E25.6.2 (1) of the AUP (OP) states that noise from any activity within the residential zone, when measured on another site in the same zone, must not exceed the limits in Table E25.6.2.1, reproduced as follows:

Table E25.6.2.1 Noise levels in residential zones

Time	Noise level
Monday to Saturday 7am-10pm	50dB L_{Aeq}
Sunday 9am-6pm	
All other times	40dB L_{Aeq} 75dB L_{AFmax}

4.3 Night-time Regenerated Noise Amenity

Night-time tunnelling beneath dwellings has the potential to cause sleep disturbance due to regenerated noise. This is where noise is generated in a room through the vibration of its walls, ceiling, floor and sometimes fittings.

MDA considers a suitable regenerated noise criterion to be 35 dB $L_{Aeq(15min)}$, which is deemed to be a satisfactory noise level for bedrooms in suburban areas or near minor roads[3]. A similar criterion has been adopted on another major infrastructure project[4] in Auckland for tunneling noise in hotel bedrooms between the hours of 10.00pm and 7.00am.

5.0 CONSTRUCTION NOISE ASSESSMENT

As typically occurs on large infrastructure projects such as the Grey Lynn Tunnel, a detailed construction programme would be developed prior to the commencement of construction activities. It is anticipated that this will be prepared by the lead contractor and incorporated into the project's Construction Management Plan. As such, the following preliminary assessment of construction noise has been based on an indicative construction methodology (refer to Appendix D).

5.1 Noise Prediction Methodology

Construction noise has been predicted in general accordance with the method detailed in Annex D[5] of NZS6803:1999. The method considers the sound power level, periods of operation, distance from source to receiver and screening of each source, as well as façade reflection and the degree of soft ground attenuation.

5.2 Predicted Noise Levels During Project Construction

The following table sets out the plant and activities anticipated to be used in the construction of the Tawariki Street Shaft and connection sewer. The table includes the per unit sound power level, a 10dB reduction from acoustic screening (refer to Appendices E and F for further details) and the minimum distance required to comply with the AUP (OP) reduced noise limit of 70dB L_{Aeq}.

The predictions are based on the assumption that work would be carried out during normal construction hours of 7.30am to 6.00pm (lower noise limits apply outside these hours).

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[3] Australian/New Zealand Standard AS/NZS 2107:2016 *"Acoustics - Recommended design sound levels and reverberation times for building interiors"*

[4] City Rail Link NoR – 35 dB $L_{Aeq\,(15\,min)}$ between 10pm and 7am

[5] Annex D refers to BS5228-1: 1997 (now superceded by BS 5228-1:2009)

Table 3: Predicted Construction Noise Levels (WITH SCREENING MITIGATION)

Activity	Equipment	Sound Power	Mitigation	Façade Noise Level (dB L_{Aeq})			Limit Setback (m)
		(dB L_{WA})	(dB)[1]	10	20	40	70dB L_{Aeq}
Tawariki Street Shaft and Chamber							
Excavation and Support	30T excavator (sheet piling)	116	0[2]	*91*	*85*	*78*	83
	30T excavator (digging)	103	-10	68	62	55	8
	3-axle truck	105	-10	70	64	57	10
	Hydraulic power pack	102	-10	67	61	54	7
	Generator	103	-10	68	62	55	8
	Shaft ventilation	102	-10	67	61	54	7
	Grout pump	107	-10	*72*	66	59	13
	Dewatering pump	97	-10	62	56	49	4
	Water treatment	95	-10	60	54	47	3
	Concrete truck + pump	107	-10	*72*	66	59	13
	Plate compactor	106	-10	*71*	65	58	11
Construction	30T excavator	103	-10	68	62	55	8
	20T mobile crane	99	-10	64	58	51	5
	50T crane	98	-10	63	57	50	4
	3-axle truck	105	-10	70	64	57	10
	Hiab truck	97	-10	62	56	49	4
	Dewatering pump	97	-10	62	56	49	4

Notes to table:

(1) Screening of -10dB provided by site acoustic barrier
(2) Due to the elevated nature of this activity the acoustic barrier would be ineffective

As set out in the table above noise from some construction activities, most notably intermittent sheet piling works, is predicted to exceed 70dB L_{Aeq}. This is not uncommon for large infrastructure projects undertaken in proximity to sensitive receivers. The predicted exceedances trigger the requirement for noise mitigation and effects management via a CNVMP.

As discussed, even with the proposed 3m high site hoarding in place, sheet piling noise would still exceed the 70dB L_{Aeq} limit at some receivers due to the elevated height of this noise source above the hoarding and would therefore need to be managed via the CNVMP to mitigate the otherwise appreciable potential noise effects from it. It is considered that with the management and mitigation measures in place effects from construction noise can be acceptably managed.

Refer to Appendix G for noise contour predictions of piling works associated with site construction. The contours indicate the 'envelope of effects'; receivers located within the 70dB L_{Aeq} contour are listed in the following table.

Table 4: Identified Receivers Predicted to Exceed Noise Limit During Sheet Piling

Receiver	Predicted Noise Level (70dB L_{Aeq} Noise Limit)
Marist Catholic School	72
29 Tawariki Street	72
33 Tawariki Street	73
35 Tawariki Street	76
36 Tawariki Street	73
37 Tawariki Street	79
38 Tawariki Street	76
39 Tawariki Street	82
40 Tawariki Street	77
41 Tawariki Street	84
42 Tawariki Street	83

Noisy construction should generally be programmed to occur between 7:30 am and 6:00 pm (normal construction hours), with no significant construction occurring outside these hours, Monday to Saturday. No construction should occur on Sundays nor outside normal construction hours unless supported by an Activity Specific Noise and Vibration Management Plan (ASCNVMP).

The CNVMP will be important in ensuring that any construction noise and resulting effects are practicably controlled.

5.3 Regenerated Noise During Night-time Tunnelling

Tunnelling beneath dwellings during the night-time will occur. To determine the potential for regenerated noise effects on residential receivers manifested as sleep disturbance, MDA has referenced previous project experience regarding regenerated noise versus slant distance[6] from tunnelling plant to receiver.

To comply with a regenerated noise criterion of 35 dB $L_{Aeq\,(15\text{-}min)}$ (refer to Section 4.3 for criterion discussion) a minimum vibration slant distance of approximately 18m from buildings with bedrooms located on the ground floor and 15m from buildings with bedrooms on the first floor (building junctions provide vibration attenuation). Any building along the proposed alignment at a closer distance is at risk of exceeding the regenerated noise criterion.

Table 5 identifies the properties which will have the shallowest depth to pipe crown and therefore the shortest slant distance, based on the pipe crown being at the top of the proposed vertical alignment window[7]. All other properties are calculated to have a depth of 20m or greater and would therefore comfortably comply with the criterion.

[6] The vector distance between the tunnelling source and the receiving building's foundation or floor level

[7] Watercare is seeking resource consent for a 40m wide horizontal corridor and 4m vertical corridor for the tunnel alignment

Table 5: Slant Distance Summary

Receiver Address	Zone/Use	Building Type	Min Depth to Pipe Crown (Slant Distance)[1]	Complies with Criterion? / Comment
Dwelling:				
30 Sackville Street	Residential – Single House Zone / Dwelling	Single-storey	18.0	Complies
2/30 Sackville Street	Residential – Single House Zone / Dwelling	Single-storey	18.0	Complies
32 Sackville Street	Residential – Single House Zone / Dwelling	Double-storey	16.9	Exceeds criterion. Consultation required
34 Sackville Street	Residential – Single House Zone / Dwelling	Double-storey	15.5	Exceeds criterion. Consultation required
37 Tawariki Street	Residential – Mixed Housing Urban Zone / Dwelling	Single-storey	18.4	Complies
39 Tawariki Street	Residential – Mixed Housing Urban Zone / Dwelling	Single-storey	18.0	Complies
No Dwelling:				
36 Sackville Street	Open Space / Hakanoa Reserve	None	15.3	No dwellings
38 Sackville Street	Residential – Single House Zone / Daycare	Single-storey	15.9	Not a dwelling

Notes to table:

(1) 2m has been subtracted off the baseline depths provided by McMillen Jacobs Associates to calculate the worst-case pipe crown distance within the vertical alignment window Watercare is seeking

Table 5 shows that two properties with dwellings located at 32 and 34 Sackville Street have a calculated worst-case slant distance of less than the 18m threshold and may therefore potentially experience regenerated noise above 35dB L_{Aeq} for no more than 1-2 days (based on an estimated tunnelling rate of 10-20m per day). The remaining properties in the table with a dwelling have a calculated worst-case slant distance of 18.0m or greater and are predicted to experience a regenerated noise level of or slightly below 35dB L_{Aeq}. The two properties without a dwelling, namely 36 and 38 Sackville Street, do not have dwellings therefore, there is no potential for adverse effects.

Based on the above, regenerated noise resulting from tunnelling vibration during the night-time will generally not result in any appreciable sleep disturbance effects. However, there may be instances where tunnelling noise is audible. Advance communication and consultation with the identified stakeholders is recommended to address any concerns. Pre and post construction building condition surveys may also need to be offered to alleviate resident's concern about potential building damage upon hearing the tunnelling noise.

5.4 Construction Traffic Movements on Road Network

Although not explicitly required by AUP (OP) provisions, given the size of the project, MDA has considered the potential noise impact of increased truck movements on the surrounding road network during construction.

The Commute Transportation Assessment[8] states that the highest number of truck movements will be during Stage 1 – the main shaft and chambers excavation, with an estimate of 64 peak movements per day (average of five movements per hour over a 12-hour working day) over a period of 12 months. Comparatively, Stage 2will generate significantly less truck movements. Stage 3 and secondary shaft construction is estimated to generate a similar or lower level of movements compared to Stage 1.

Stage 1 is estimated to generate the highest number of truck movements and therefore forms the basis of the following effects assessment.

The following scenarios have been modelled to ascertain the effect of construction traffic on road noise levels:

- Existing Baseline: Existing traffic counts and heavy vehicle volumes
- Scenario 1: An additional 64 heavy vehicle movements per day on each of the roads

Using traffic count data and trip generation estimates sourced from Commute, MDA has predicted traffic noise levels for two scenarios using the CoRTN algorithm[9]. The resulting change in traffic noise level for a receiver nominally located at 15m from road's edge is set out in the following table. Comparison to the Existing Baseline scenario indicates the change in noise level resulting from project construction traffic operating on surrounding roads.

Table 6: Predicted Change in Traffic Noise on Road Network

	AADT / HCV % / Predicted Road Traffic Noise Level (dB $L_{Aeq\ 1\text{-}hour}$)[1, 2,3]		Change in Level
Road	Existing Baseline	Scenario 1	
Tawariki Street	208 / 3% / 50	264 / 25.5% / 55	+5dB
Parawai Crescent	7,132 / 3% / 63	7,188 / 3.8% / 63	No change
Richmond Road	11,748 / 4% / 66	11,804 / 4.5% / 66	No change
Surrey Crescent	11,200 / 4.8% / 70	11,256 / 5.3% / 70	No change
Great North Road	24,420 / 5.5% / 69	24,476 / 5.7% / 69	No change

Notes to table:

(1) Predictions are based on a nominal receiver distance from the road of 15m and a speed of 50km/h

(2) AADT = Annual Average Daily Traffic; HCV % = Heavy Commercial Vehicle (expressed as a percentage of total daily flow)

(3) Data sourced from mobileroad.org

The results in the table indicate that the increased truck movements and number of heavy vehicles on the identified roads would result in an imperceptible increase in noise when assessed over a daytime hour for all roads except for Tawariki Street. For Tawariki Street, noise levels are predicted to increase by approximately 5 decibels. A 5-decibel increase is an appreciable change in noise level.

MDA concludes that, given the relatively moderate number of trips generated during construction works and where these movements occur during normal construction hours of 7.30am to 6.00pm, no adverse traffic noise effects are anticipated.

[8] Commute Transportation Assessment Section 3.7

[9] An adjustment has been applied to the output to convert from L_{10} to L_{eq} descriptor

The inclusion of the management of truck traffic should be included in the CNVMP to avoid trucks sitting outside the site for extended periods with engines running. This should also consider addressing and mitigating truck reverse beeper noise.

6.0 OPERATION NOISE

6.1 Noise Prediction Methodology

Operation noise has been predicted in general accordance with the algorithm detailed in ISO 9613-2:1996[10] as implemented in SoundPLAN® environmental noise modelling software.

ISO 9613 considers a range of frequency dependent attenuation factors, including spherical spreading, atmospheric absorption, ground effect and acoustic screening.

6.2 Noise Modelling Inputs, Assumptions and Proposed Mitigation

The operational noise emission from the project will be minimal. An above-ground single-storey plant room will house the power supply and controls for the penstocks. A passive air vent will be required for continuous air entry into the tunnel for ventilation purposes. Air exhaust may be passive or mechanical although noise from this event would occur infrequently i.e. only when the tunnel is nearly full during severe wet weather events.

The noise source sound power levels used in the assessment are listed in Appendix H.

The following details the assumed conceptual mitigation measures needed to ensure that operation noise complies with the relevant AUP (OP) limits and to ensure that noise remains reasonable.

Above Ground Plant Room

- Walls facing dwellings assumed to be constructed from precast concrete or an alternative material / design giving equivalent performance;
- Ceiling lined with an absorptive product;
- Plant room roof constructed from an insulated roofing product with a minimum performance of R_w 24dB;
- Roller door (where it faces a dwelling) to be acoustic with a minimum performance of R_w 24dB;
- Solid core access doors facing dwellings; and
- Where the air exhaust is by mechanical means the outlet-stack should be fitted with an attenuator to limit the sound power level leaving to no more than 78dB L_{WA}.

The above measures would be confirmed during the detailed design stage.

6.3 Operation Noise Predictions

Noise emissions from the proposed plant room and shaft ventilation system have been predicted to adjacent receiver locations and assessed against the relevant night-time noise limit.

The following table sets out the predicted operation noise levels. Refer to Appendix I for the predicted night-time noise contour.

[10] ISO 9613-2: 1996 “Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation”

Table 7: Plant Room Noise Levels

Receiver Location	Zone/AUP Night-time Limit [dB L_{Aeq}]	Predicted Noise Level (dB L_{Aeq})
33 Tawariki Street	Residential [40]	33
35 Tawariki Street	Residential [40]	34
37 Tawariki Street	Residential [40]	36
39 Tawariki Street	Residential [40]	38
41 Tawariki Street	Residential [40]	38
42 Tawariki Street	Residential [40]	38

Notes to table:

(1) An explanation of technical terms is provided in Appendix A

Based on the levels in the table, operation noise is predicted to comply with the AUP (OP) night-time noise limit at the closest dwellings, with the conceptual acoustic mitigation measures in place.

The noise levels generated by the plant room are predicted to be similar to the existing background noise level (refer to Table 2). As such, no adverse noise effects are anticipated from its operation.

7.0 MITIGATION AND MANAGEMENT OF CONSTRUCTION NOISE

Potential management and mitigation measures are discussed below.

7.1 Communication and Consultation

The most important tool for managing construction noise is consultation and communication. For the Grey Lynn Tunnel, the recommended daytime criterion is predicted to generally be achieved at dwellings which are located 20m distance and screened from general works.

Communication is needed in relation to the proposed works and their timing with any stakeholders potentially affected by noise levels higher than specified in the AUP (OP). Communication should occur with stakeholders prior to works being carried out, by means of letter drop or face-to-face contact.

7.2 Timing of activities

It is noted that general construction hours may span two periods, namely 06:30am to 07:30am and 07:30am to 6:00pm. Of these periods, the 06:30am to 07:30am period, often termed the 'morning shoulder', has a significantly lower noise limit than the daytime period. Therefore, a potential risk exists for construction activities to exceed the morning shoulder criterion by a significant margin, unless early morning site activities are appropriately managed. Two examples would be where trucks with engines running queue up outside the site gates prior to site opening, and crane lift of heavy items delivered by truck during this period.

The management of these issues could take the form of preventing trucks from queuing/idling adjacent to dwellings, prohibiting the use of tonal reverse beepers, and scheduling heavy deliveries to occur after 07:30am. These and others would be addressed via the CNVMP.

7.3 Noise Barriers

In general, placing temporary noise barriers, such as plywood sheets or proprietary 'noise curtains', between dwellings and the construction activities can reduce noise levels by up to 10 decibels. It is considered that 3-metre-high site hoardings are sufficient to act as effective noise barriers for ground-based receivers. The barriers should be placed as close as practicably possible to noise sources.

7.4 Avoidance of Unnecessary Noise

At many construction sites it can be observed that some construction practices unnecessarily increase noise levels. Those include the sounding of horns when a truck is fully laden, truck air-brake release and the use of audible, often tonal, reversing alarms.

Those issues can be avoided, or noise levels reduced, by means of changed construction site management; fitting of mufflers to trucks; maintenance of equipment to a high standard and the replacement of audible reversing alarms with visual or lower noise broadband audible reversing alarms. Where these measures are implemented they would form part of best practice management and mitigation of construction noise.

Other unnecessary noise may include shouting, loose tail gates and noise from music / radios played loudly. These can be avoided with good site management and are generally addressed in any CNVMP.

7.5 Construction Noise and Vibration Management Plan

It is common practice for infrastructure projects of significant size to implement a CNVMP as part of the construction management plan. These contain information on site management, mitigation, communication, complaints procedures and similar issues.

The purpose of such a plan is to reduce construction noise and vibration effects through selecting the best practicable option in terms of timing of activities, equipment selection and mitigation measures (or a combination thereof).

The minimum requirements of a CNVMP are set out in NZS6803:1999 Section 8 and Annex E.

The CNVMP should contain, but not be limited to:

- A summary of the project noise criteria;
- A summary of construction noise assessments/predictions;
- General construction practices, management and mitigation;
- Noise management and mitigation measures specific to activities and/or receiving environments;
- The requirement for pre and post-construction building condition surveys;
- Monitoring and reporting requirements;
- Procedures for handling complaints; and
- Procedures for review of the CNVMP throughout the project.

A CNVMP would be implemented for the work site and ASCNVMPs for some specific activities where exceedance of the AUP (OP) limits is predicted and will be kept up-to-date regarding actual timing/equipment use and methodologies, should these change at any point during the construction process.

8.0 SUMMARY AND CONCLUSIONS

MDA has undertaken an assessment of construction and operation noise effects for the Grey Lynn Tunnel.

The relevant acoustic performance standards in the AUP (OP) have been used in the assessment.

The works described in this report are typical construction works in an urban area and are carried out almost daily within Auckland. Construction noise (and vibration, assessed separately) are the principal acoustic issues that may result in potential effects. These effects have been successfully mitigated and managed on many other comparable construction projects, and the Grey Lynn Tunnel will adopt similar management and mitigation measures to ensure a similar outcome.

Noise from the proposed construction activities has been predicted at nominal setback distances from works. Predictions show that certain activities such as sheet piling will temporarily exceed the construction noise limits. The best practicable option (for noise) for this project is to ensure that construction noise effects are managed with the aim of meeting the relevant noise limits and any potential exceedances are identified and addressed through noise management and mitigation.

A project CNVMP is recommended which would be formulated and submitted to Council for certification prior to construction starting. Some activities, such as sheeting piling, would likely require an ASCNVMP.

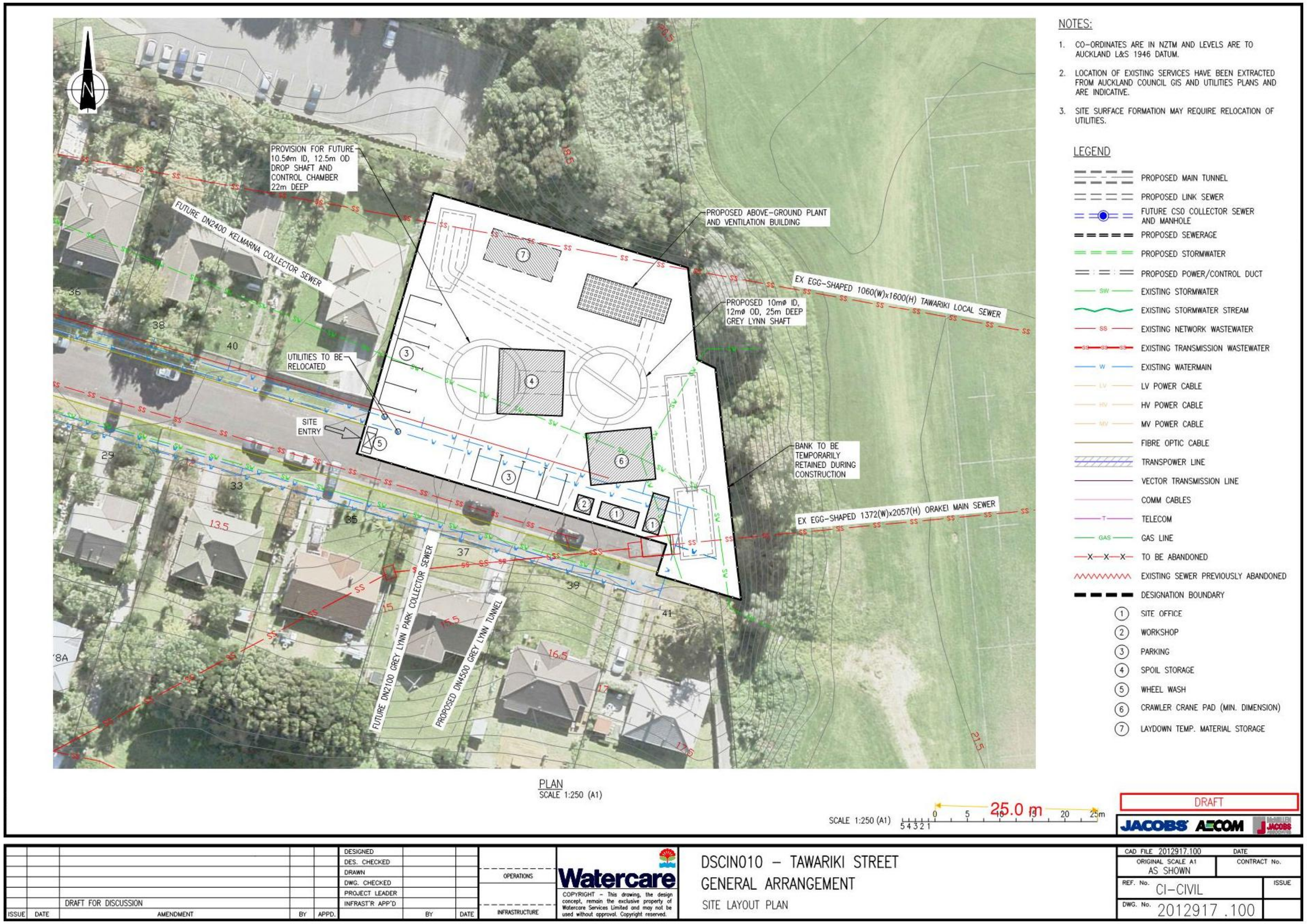
MDA concludes that construction noise can be controlled to acceptable levels with appropriate mitigation and management measures in place. Communication with receivers located adjacent to the site is recommended so that they are kept informed of the project’s progress.

The operation of the plant room is predicted to comply with the relevant noise criteria at all times with the recommended conceptual acoustic measures in place. Any residual noise effects from its operation would be less than minor.

APPENDIX A GLOSSARY OF TERMINOLOGY

A-weighting	The process by which noise levels are corrected to account for the non-linear frequency response of the human ear. All noise levels are quoted relative to a sound pressure of $2x10^{-5}$Pa
dB	Decibel. The unit of sound level. Expressed as a logarithmic ratio of sound pressure P relative to a reference pressure of Pr=20 mPa i.e. dB = 20 x log(P/Pr)
dBA	The unit of sound level, which has its frequency characteristics modified by a filter (A-weighted) to approximate the frequency bias of the human ear.
$L_{Aeq (t)}$	The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level. The suffix "t" represents the measurement time interval to which the noise level relates, e.g. (8 h) would represent a period of 8 hours, (15 min) would represent a period of 15 minutes and (2200-0700) would represent a measurement time between 10 pm and 7 am.
$L_{A10 (t)}$	The A-weighted noise level equalled or exceeded for 10% of the measurement period. This is commonly referred to as the average maximum noise level.
$L_{A90 (t)}$	The A-weighted noise level equalled or exceeded for 90% of the measurement period. This is commonly referred to as the background noise level.
L_{AFmax}	The A-weighted maximum noise level. The highest noise level that occurs during the measurement period.
NZS 6801:2008	New Zealand Standard NZS 6801:2008 "Acoustics – Measurement of environmental sound"
NZS 6802:2008	New Zealand Standard NZS 6802:2008 *"Acoustics - Environmental Noise"*
NZS 6803:1999	New Zealand Standard NZS 6803: 1999 *"Acoustics - Construction Noise"*
SWL or L_W	Sound Power Level A logarithmic ratio of the acoustic power output of a source relative to 10^{-12} watts and expressed in decibels. Sound power level is calculated from measured sound pressure levels and represents the level of total sound power radiated by a sound source.

APPENDIX B SHAFT SITE GENERAL LAYOUT



APPENDIX C AUP CONSTRUCTION NOISE LIMITS

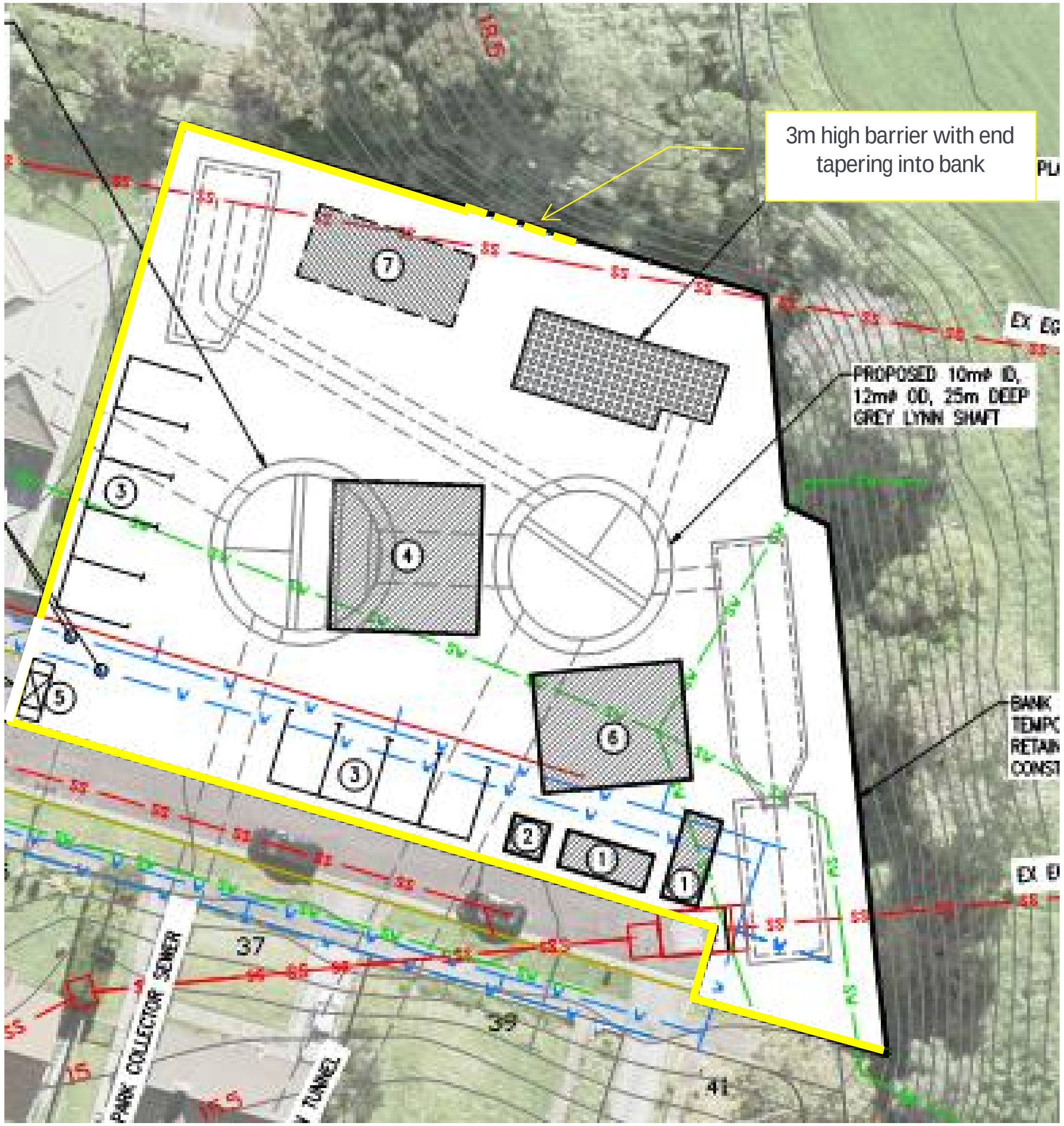
Table E25.6.27.1 Construction noise levels for activities sensitive to noise in all zones except the Business – City Centre Zone and the Business – Metropolitan Centre Zone

Time of week	Time Period	Maximum noise level (dBA)	
		L_{eq}	L_{max}
Weekdays	6:30am - 7:30am	60	75
	7:30am - 6:00pm	75	90
	6:00pm - 8:00pm	70	85
	8:00pm - 6:30am	45	75
Saturdays	6:30am - 7:30am	45	75
	7:30am - 6:00pm	75	90
	6:00pm - 8:00pm	45	75
	8:00pm - 6:30am	45	75
Sundays and public holidays	6:30am - 7:30am	45	75
	7:30am - 6:00pm	55	85
	6:00pm - 8:00pm	45	75
	8:00pm - 6:30am	45	75

APPENDIX D OUTLINE CONSTRUCTION METHODOLOGY

Tawariki Street	
Construction site	44-48 Tawariki St
Anticipated construction access	From Richmond Rd, via Mokau St and Moira St into Tawariki St.
Earthworks	10,000 – 15,000 m^3
Duration of construction	Stage 1: 2.5 years Stage 2 (secondary shaft): 2 years
Principal temporary construction activities	· Shaft excavation and construction – 26-27 m deep shaft, 12m diameter · Shaft excavation support - either secant piles, sheet piles, ring beams with lagging, steel liner plate, precast segmental rings, caisson or similar · TBM retrieval · Excavations for underground permanent works · Blasting will not be used for construction of the shaft as basalt is not anticipated in the shaft excavation · Construction of connections to Orakei Main Sewer and Tawariki CSO (likely trenchless methods)
Key features/equipment	· Shaft excavation with mechanical equipment e.g. CAT 330 medium hydraulic excavator or similar) through overburden soils and East Coast Bay Formation (ECBF) bedrock · One or more cranes · Blasting will not generally be used for construction of the shaft as basalt is not anticipated in the shaft excavation · Water treatment equipment · Storage areas for construction materials · Construction base, including: site access roading, security fencing, site offices · Wheel wash · Grout equipment · Materials storage area · Ventilation equipment · Compressor/generator · Site lighting
Permanent works	· Site to be reinstated upon completion of construction and surfaced with permeable paving ("Surepave" or similar) in the vicinity of shafts/chambers/accessways and grass for the remainder of the site. · The shaft roof slabs (i.e., lids) will be buried except for manholes and hatches at the ground surface which will be secured from public entry. At the completion of construction, the ground surface will be restored to the pre-existing conditions. · Connection to Orakei Main Sewer and Tawariki CSO. · Underground chambers fitted with penstocks · Above-ground plant room to house power supplies and controls for penstocks (90m^2, single-storey) · Air vent –an underground 1.5 m diameter air duct from the shaft to an air intake/exhaust ranging from a vent about 3m high integrated with the plant room, to a 1.5 m diameter 8 m high stack.
Future works	· Combined Sewers Overflow shaft (constructed adjacent to the tunnel shaft at a later date; approx. 10 m diameter and 25 m deep.

APPENDIX E CONSTRUCTION NOISE ACOUSTIC BARRIER LOCATION



APPENDIX F ACOUSTIC SCREEN CONSTRUCTION OPTIONS

Type	Constructions [Refer Notes (1) to (4) below]	
Timber (6)	Supporting Structure:	Timber, steel or aluminium posts and rails.
	Cladding Option 1:	*Plywood* panelling (5) with a minimum surface mass of 10 kg/m^2 (18mm minimum thickness).
	Cladding Option 2:	*Timber Palings* (minimum thickness of 20-25mm) either overlapped or close-boarded with battens over gaps between palings (6).
Fibre Cement	Supporting Structure:	Timber, steel or aluminium.
	Cladding Option 1:	9mm (min. thickness) *Fibre Cement* sheet (1 layer)
	Cladding Option 2:	7mm (min. thickness) *Compressed Fibre Cement* sheet (1 layer)
Acrylic	Supporting Structure:	Steel, aluminium or concrete.
	Infill panels:	12mm thick *Acrylic panels*.
Glass	Supporting Structure:	Steel, aluminium or concrete.
	Infill Panels:	Laminated glass (6mm minimum thickness).
Brick	Supporting Structure:	Concrete footing.
	Infill:	70mm mortared brick
Concrete	Supporting Structure:	Concrete footing.
	Infill:	Reinforced concrete or mortared concrete block (filled or unfilled).
Earth Bund		Earth or suitable fill material.

Notes:

(1). Any proposed acoustic screen shall be designed and certified by a suitably qualified structural engineer and relevant consents sought from the local council and other interested parties prior to its construction

(2). Acrylic and glass sections can be used to provide an acoustic screen while retaining visual transparency

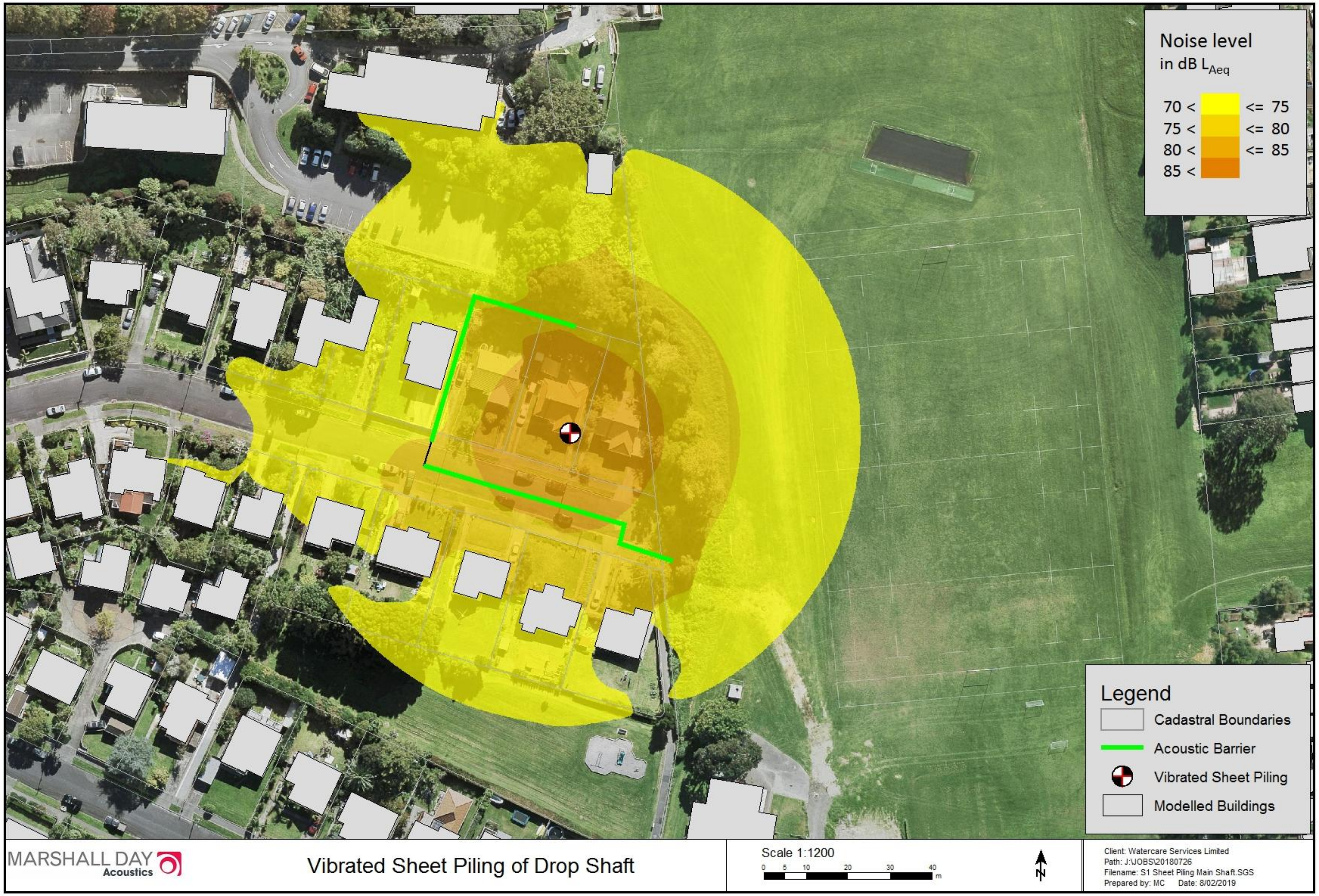
(3). For all fence constructions, ensure that there are no gaps in the screen or between the ground and the bottom of the screen

(4). Any proposed acoustic screen shall be designed with input from a suitably qualified acoustic consultant

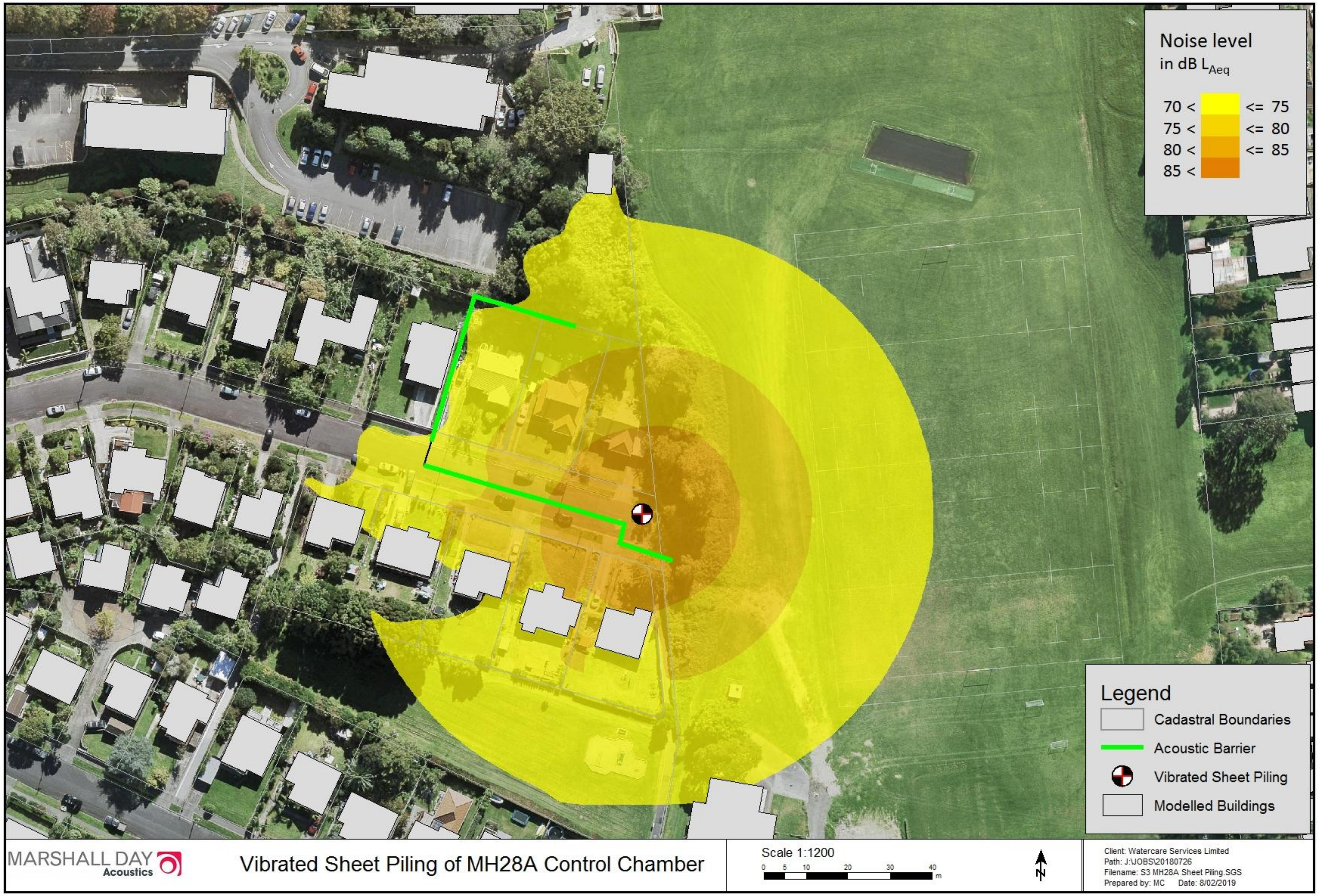
(5). Grooved plywood, manufactured to resemble a timber paling fence design, can be used to achieve a similar look to a close boarded fence design

(6). Plywood panelling is preferred to a close boarded fence design for long-term durability

APPENDIX G WORST CASE CONSTRUCTION NOISE CONTOUR PREDICTIONS




Noise level
in dB LAeq
70 < <= 75
75 < <= 80
80 < <= 85
85 <
Legend
Cadastral Boundaries
Acoustic Barrier
Vibrated Sheet Piling
Modelled Buildings
MARSHALL DAY Acoustics
Vibrated Sheet Piling of MH01 Control Chamber
Scale 1:1200
0 5 10 20 30 40 m
N
Client: Watercare Services Limited
Path: J:\JOBS\20180726
Filename: S2 MH01 Sheet Piling.SGS
Prepared by: MC Date: 8/02/2019


Noise level
in dB L_{Aeq}
70 < <= 75
75 < <= 80
80 < <= 85
85 <
Legend
Cadastral Boundaries
Acoustic Barrier
Vibrated Sheet Piling
Modelled Buildings
MARSHALL DAY Acoustics
Vibrated Sheet Piling of MH28A Control Chamber
Scale 1:1200
0 5 10 20 30 40 m
N
Client: Watercare Services Limited
Path: J:\JOBS\20180726
Filename: S3 MH28A Sheet Piling.SGS
Prepared by: MC Date: 8/02/2019

APPENDIX H OPERATION NOISE SOURCE SOUND POWER LEVELS

	Octave Band Centre Frequency (Hz)							
Source	63	125	250	500	1000	2000	4000	dBA
Odour Control Fan	106	96	94	92	92	89	85	96
Exhaust Stack (attenuated)	88	78	76	74	74	71	67	78
Plant Room (L_{prev})	90	89	83	81	78	74	70	83

APPENDIX I NIGHT-TIME OPERATION NOISE CONTOUR PREDICTION (WITH MITIGATION)