REPORT

Tonkin+Taylor

Herne Bay Tunnel – Construction noise and vibration technical assessment

Construction noise and vibration technical assessment

Prepared for
Watercare Services Limited
Prepared by
Tonkin & Taylor Ltd
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1 Introduction

This report has been prepared by Tonkin & Taylor Ltd (T+T) to support a resource consent application by Watercare Services Ltd (Watercare) for the proposed Herne Bay Trunk Sewer Line (the Project), as part of the Western Isthmus Water Quality Improvement Programme (WIWQIP). The Project will connect to the Central Interceptor (CI) wastewater conveyance and storage tunnel that is proposed to be extended from Tawariki Street in Grey Lynn to a new drop shaft in Point Erin Park.

This report provides an assessment of the noise and vibration effects associated with the construction and operation of the Project. In particular, this report:

- Establishes the relevant noise and vibration limits for the site set out in the Auckland Unitary Plan – Operative in Part (AUP);
- Identifies the construction activities that will generate noise and vibration;
- Identifies nearby receivers;
- Predicts the construction noise and vibration levels at identified receivers and determines compliance with relevant noise and vibration limits;
- Discusses potential noise and vibration effects;
- Discusses the reasonableness of those effects; and
- Provides recommendations to avoid, remedy or mitigate those effects.

A glossary of terms is included at the end of this report (Appendix A).

This report has been prepared in accordance with T+T's proposal dated 6 December 2022.

2 Proposed works

2.1 Overview

Watercare is working jointly with Auckland Council in delivering a programme of infrastructure improvement works to reduce wastewater overflows and improve water quality at local beaches. The programme of works is known as the Western Isthmus Water Quality Improvement Programme (WIWQIP).

To build a resilient wastewater system and ensure reliability of service and reduced overflows, Watercare is proposing to construct a new wastewater trunk sewer for the Herne Bay catchment, to connect into the proposed Central Interceptor(CI) tunnel extension to Point Erin Park.

The scope of the works involves:

- Installation of approximately 1.5 km of 2.1 m internal diameter trunk sewer line, constructed via a tunnel-boring machine (TBM);
- Installation of approximately 150 m of 600 mm diameter trunk sewer within Marine Parade, constructed via open-cut trenching;
- Construction of 8x primary tunnel shafts, ranging in diameter from 3.5 m to 11 m, along with 4 x 3.5m diameter intercepting shafts;
- Installation of 4 x interception pipes and 11 x connections to existing engineered overflow points ('EOP's);
- Establishment of two construction support areas (CSAs) in public reserves; and,
- Relocation and reinstatement of utilities as required.

The resource consent application is prepared for the activities described above, hereafter referred to as 'the Project'.

The primary purpose of the Project is to reduce engineered overflow spill frequencies resulting from the aging combined sewer network in the area and to ensure ongoing compliance with Watercare's Network Discharge Consent (NDC). This is expected to lead to improvements in bathing water quality conditions at the beaches, reduction of odour from stormwater catchpits and improved overall amenity. The 'General Arrangement' plans for the Project are appended to the AEE report.

2.2 Project alignment

Figure 2.1 – 2.2 below show the proposed alignment and key features of the Project.

Figure 2.1: Eastern portion of the Project

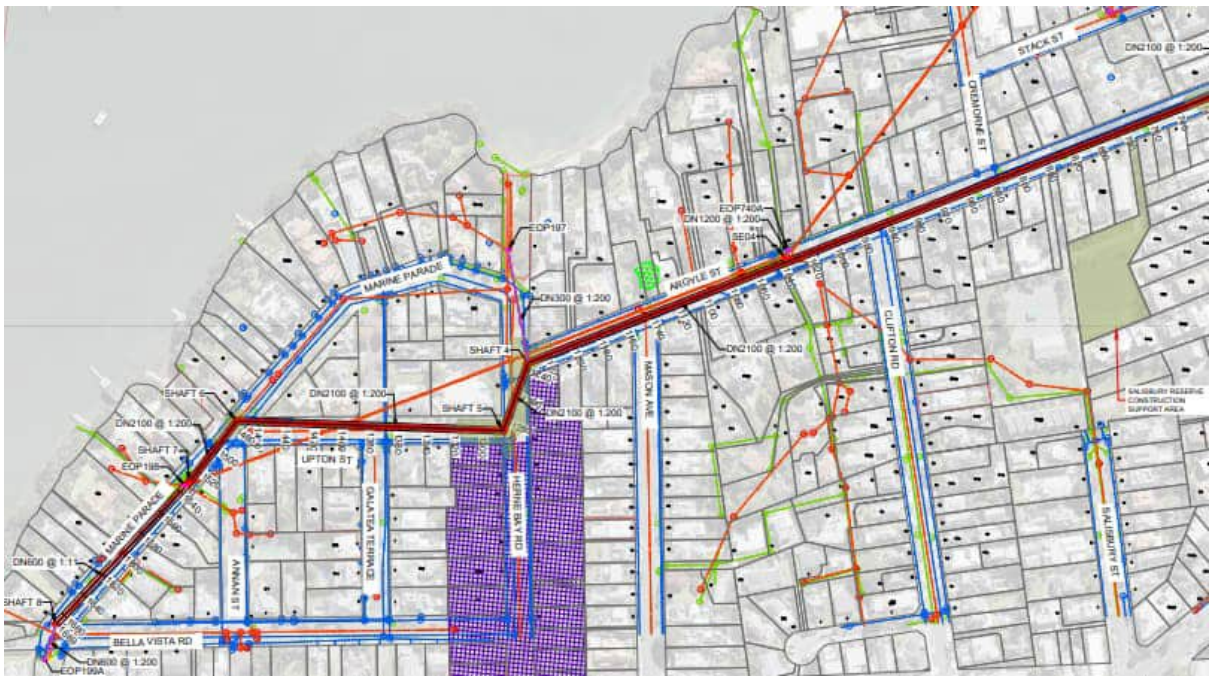


Figure 2.2: Western portion of the Project

The eastern terminus of the Project is at Point Erin Park, where it will connect to the proposed CI extension via a drop chamber, which will be constructed as part of the CI extension project.

Works within Point Erin Park that are part of the proposed CI extension resource consent application and not forming part of the 'application area' for the Project are:

- The construction of the CI tunnel terminal shaft, control chamber, and stub connection to facilitate a potential future connection to the proposed Herne Bay Trunk Sewer tunnel;
- The construction of a plant room to house equipment to control the gates;
- Connections between the terminal shaft, control chamber, vent and plant room; and

- Tree works within Point Erin Park (pruning, works in the root zone, removal, relocation), and Point Erin Park reinstatement and landscaping following completion of construction works.

2.3 Construction activities

A preliminary construction methodology[1] for the Project has been provided for review by the contractor and the proposed construction activities required are outlined in Table 2.1.

The pipeline is constructed via a series of shafts from which a tunnel boring machine (TBM) is launched (thrust shafts) and retrieved (receiving shafts). As the TBM progresses along the alignment, sections of pipe are placed in the thrust shaft and then jacked in behind the TBM as it progresses.

The tunnel will progress from Point Erin Park along the alignment to Marine Parade. Shafts are required at the changes in direction to provide entry for the TBM (thrust shafts) and to retrieve the TBM (receiving shafts) and will be constructed as the project progresses ensuring there is a receiving shaft as the TBM commences a drive towards it.

Following completion of the main drive, the interception shafts can be constructed adjacent to the main tunnel and the connections to the EOP's either drilled with trenchless technology or laid in open trenches as feasible.

Table 2.1: Construction and staging activities

Construction Elements	Activities
Establishment	Main site established – (At Salisbury Reserve): • Central construction support compound set up • Worker welfare facilities established • Temporary traffic management set out
Enabling	Enabling works at each shaft location: • Pothole services throughout the route • Service diversions
Satellite site establishment	• Traffic and fencing management • Environmental controls • Hardfill • Plant delivery
Shaft piling	Piling shaft construction: • Temporary excavation support – either casing shaft or secant piling • Removal of spoil
Shaft construction	• Concrete breaking back • Excavation • De-water shafts • Concrete construction
Interception shafts construction	• Construct drilling platform • Drill 3.5m diameter casing • Cut into main sewer

[1] Project Briefing and Request for Technical Assessments – Herne Bay Trunk Sewer, Watercare Services Ltd, Memorandum March 2023

Construction Elements	Activities
Tunnelling	• Tunnelling using a TBM • Set up tunnelling rig/equipment – supporting crane and excavator • Spoil removal • Install pipes
Manhole construction	• Install manholes within shafts • Progress backfilling of shaft around manhole • Removal of sheet piling or casing shaft as required • Break down concrete of secant shaft 1 m below ground • Reinstatement of surrounding roadway
Directional drilling	• Excavate drill pits with trench shields • Drill bore • Pull through drainage line
Open trenching	Open trench construction (limited section as needed) • Temporary excavation support – trench shields • Removal of spoil – to be loaded onto truck and removed from site • Install bedding and then new pipe, manhole backfill • Reinstatement works • Activities will be undertaken during daytime hours
Reinstatement	Road reconstruction • Concrete break out and excavation • Kerbing • Traffic Islands and footpaths • Asphalt • Line marking

2.3.1 Construction support areas

At least two CSAs will be established. One at Salisbury Reserve as the central hub and another at a location at 94a and 94b Shelley Beach Road where the bulk of the stockpile will be stored. Once established, the CSAs will be used for the following purposes:

- Bulk delivery and removal of materials;
- Storage of materials (pipes and manholes, piling equipment);
- Storage of diesel (up to 2,000 L at any one time);
- TBM spare parts and lubricants storage;
- Crane parking;
- Loading bay for truck loading and unloading;
- Worker welfare facilities; and
- Main site office.

2.4 Construction programme and durations

This assessment has been based on an indicative construction methodology and details on the duration for the construction activities as provided by the contractor. Whilst the construction methodology has not been finalised, a reasonable worst case has been assumed within this assessment to account for potential changes to the activities and programme. As such, minor changes to the final construction methodology and programme are unlikely to change the overall envelope of effects as presented in this report. A detailed construction programme and methodology will be finalised by the contractor prior to the commencement of the works. The indicative construction activities are expected to be undertaken within two years of commencement and durations are as provided in Table 2.2 and Table 2.3. Durations provided within the tables are indicative only, showing a worst case scenario, and subject to change which can be due to a variety of factors such as weather, ground conditions etc.

Table 2.2: Indicative construction durations – shaft construction

Location	Approximate shaft construction timeframes	Approximate total time at location*
Shaft One – Sarsfield Street	82 days	247 days
Shaft Two – Intersection of Sarsfield Street, Wallace Street and Stack Street	70 days	251 days
Shaft Three – Intersection of Wallace Street and Argyle Street	97 days	340 days
Shaft Four – Intersection of Argyle Street and Herne Bay Road	82 days	201 days
Shaft Five – Intersection of Herne Bay Road and Upton Street	112 days	233 days
Shaft Six – Intersection of Upton Street and Marine Parade	68 days	170 days
Shaft Seven and EOP 198 – Marine Parade	60 days	94 days
Shaft Eight and EOP 199 – Intersection of Marine Parade and Bella Vista Road	30 days	60 days
Interception Shaft SE01 and EOP 195 – Intersection of Sarsfield Street and Hamilton Road	40 days	50 days
Interception Shaft SE02 and EOP 200 – Intersection of Sarsfield Street and Sentinel Street	45 days	55 days
Interception Shaft SE03 and EOP 201 – Intersection of Sarsfield Street and Lawrence Street	37 days	47 days
Interception Shaft SE04 and EOP 740 – Argyle Street	27 days	37 days

Note: Shaft construction timeframe does not include permanent structure construction within shaft nor reinstatement as works will be undertaken using less noisy equipment within the road corridor and within the shaft itself and can be mitigated to meet the permitted activity noise limits.* Total time on location includes all activities at the shafts but construction is not expected to be continuous throughout that timeframe.

Table 2.3: Indicative construction durations – TBM drive

TBM Drive	Timeframes
Shaft 1 – 2 drive	113 days
Shaft 3 – 2 drive	35 days
Shaft 3 – 4 drive	100 days
Shaft 5 – 4 drive	31 days
Shaft 5 – 6 drive	52 days
Shaft 6 – 7 drive	33 days

Note: elements include setup, TBM installation, TBM drive, stripping of services from tunnel, TBM recovery and shaft equipment removal and tunnel annulus grouting

2.4.1 Working hours

Noise generating activities and truck movements will typically occur during standard construction hours, which are as follows:

- Monday to Friday: 7 am to 6 pm (site mobilisation and pack down works are proposed to occur 30 mins before and after these windows);
- Saturdays: 8 am to 6 pm;
- Sundays or public holidays: no works; and
- Tunnelling activities will occur during the standard construction hours only.

Due to the nature of construction and the Project's timeline, it is likely that some activities will be undertaken outside these usual hours, for example, site meetings, setup, packup, large plant delivery early in the morning or later in the evening to avoid peak traffic volumes. CCTV (Closed Circuit Television Video) inspections and service relocations and their connections will be carried out at night to reduce service disruptions. Work outside of standard hours will be limited as far as is practicable to reduce disruption as outlined above.

These activities undertaken outside work hours have been assessed as low risk, are likely to be within permitted noise levels and will be carried out to meet AUP requirements. The works outside of standard construction hours will be detailed in the Project's Construction Noise and Vibration Management Plan (CNVMP) and/or an Activity Specific Construction Noise and Vibration Management Plan (ASCNVP), with specific sections identifying management and mitigation measures (i.e. adopting the best practicable option (BPO) to minimise potential adverse effects) such as communication with surrounding properties, the use of acoustic barriers and other practicable controls.

3 Performance standards

3.1 Introduction

The Auckland Unitary Plan - Operative in part (AUP) sets out noise and vibration standards[2] for permitted activities. If noise and/or vibration above the applicable AUP limits is generated, then a resource consent is required.

In addition to this, there is a general duty under section 16 of the RMA 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.'*

This section identifies the relevant performance standards applicable for the Project.

3.2 Construction noise

Rule E25.6.1(3) of the AUP states that "*The noise from any construction activity must be measured and assessed in accordance with the requirements of New Zealand Standard NZS6803:1999 Acoustics – Construction noise*".

Rules E25.6.27(1) and E25.6.27(2) respectively contain construction noise limits for activities sensitive to noise (residential receivers) and for any other activity (commercial receivers).

In accordance with E25.6.27(4), projects with a construction duration of more than 20 weeks are to include a 5 dB reduction to the noise limits in E25.6.27(1). The applicable construction noise limits with the required 5 dB reduction applied (in accordance with NZS6803:1999) are detailed in Table 3.1 for residential receivers and Table 3.2 for non-residential receivers. The limits apply at 1 m from the façade of any building that contains an activity sensitive to noise that is occupied during the works.

Table 3.1: Construction noise limits for residential dwellings

Time of week	Time period	Noise limit dB	
		L_{Aeq}	L_{Amax}
Weekdays	6:30 am – 7:30 am	55	75
	7:30 am – 6:00 pm	70	85
	6:00 pm – 8:00 pm	65	80
	8:00 pm – 6:30 am	45	75
Saturdays	6:30 am – 7:30 am	45	75
	7:30 am – 6:00 pm	70	85
	6:00 pm – 8:00 pm	45	75
	8:00 pm – 6:30 am	45	75
Sundays and Public Holidays	6:30 am – 7:30 am	45	75
	7:30 am – 6:00 pm	55	85
	6:00 pm – 8:00 pm	45	75
	8:00 pm – 6:30 am	45	75

[2] AUP, Chapter E Auckland-Wide Built Environment - E25 Noise and Vibration

Table 3.2: Construction noise limits for noise affecting non-residential activities sensitive to noise

Time Period	Maximum noise levels (L_{Aeq} dB)
7:30 am – 6:00 pm	70
6:00 pm – 7:30am	75

3.2.1 Works in the road reserve

With the exception of the two CSAs, all construction works are within the road reserve. Planned works within the road reserve between 7 am and 10 pm are not required to comply with the construction noise limits of Table 3.1 and Table 3.2 where a CNVMP is provided to the Council no less than five days prior to the works commencing (Standard E25.6.29(3)(d)). The requirements for the CNVMP are listed in Standard E25.6.29(5) and include:

- Details of the community consultation to be undertaken to advise the occupiers of properties located within 100 m of the proposed works of relevant details of the works;
- A description of the works and duration, anticipated equipment to be used, the processes to be undertaken and the predicted noise and vibration levels; and
- 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 construction noise and vibration limits.

The removal of noise limits for works in the road reserve allows for potentially disruptive works to be completed efficiently to minimise road closures and subsequent disruption. As stated, this does not remove the requirement to manage noise levels.

3.3 Vibration from construction activities

AUP Standard E25.6.29(4A) notes that the vibration levels specified in Standard E25.6.29(1A)(b) (vibration limits in buildings) do not apply where (a) for planned works, a copy of the works access permit issued by Auckland Transport or approval from the New Zealand Transport Agency [now Waka Kotahi New Zealand Transport Agency 'Waka Kotahi'] is provided to the Council five days prior to work commencing, and (b) a CNVMP is provided to the Council no less than five days prior to the works commencing. The requirements for the CNVMP are provided in Standard E25.6.29(5). Standard E25.6.29(1A)(a) applies to all works in the road (limits contained in DIN4150-3:1999), and hence are applicable to this Project.

The AUP contains rules relating to construction vibration that cover both building damage and amenity limits[3]. Rule E25.6.30 states that construction activities must be controlled to ensure any resulting vibration does not exceed:

- The limits set out in *German Industrial Standard DIN 4150-3 (1999): Structural vibration – Part 3 Effects of vibration on structures*[4], when measured in accordance with that Standard on any structure not on the same site; and
- The limits set out in Table E25.6.30.1 [see Table 3.5] 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.

[3] There are no sources of potential vibration post-construction.
[4] Superseded by latest version DIN 4150-3:2016

Standard E25.6.29(1A) states that vibration from any construction, maintenance and demolition activities in the road must comply with the relevant vibration levels in E25.6.30(1)(a) and Table E25.6.30.1.

3.3.1 Structural vibration

DIN 4150-3:1999 is an internationally recognised standard used to assess the effects of vibration on structures. The Standard is commonly used across New Zealand and, as set out above, is adopted by the AUP. The DIN 4150-3:1999 criteria to evaluate the effects of short-term vibration on structures are shown in Table 3.3 and summarised in Figure 3.1. Short-term vibration is vibration that does not induce resonance in a building structure.

The table and figure show the recommended vibration limits in terms of Peak Particle Velocity (PPV) for potential for damage to structures. They are lowest in the frequency range of 1-10 Hz, which is the normal range of natural frequency of most structures. The limits increase at higher frequencies where the potential harmonic effects are reduced. The guideline values for PPV are at the foundation and in the plane of the highest floor of various types of building.

Table 3.3: DIN 4150-3 :1999 guidelines for evaluating the effects of short-term vibration on structures

Line	Type of structure	Vibration at the foundation at a frequency of			Vibration at horizontal plane of the highest floor
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	All frequencies
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design	20 mm/s	20 to 40 mm/s	40 to 50 mm/s	40 mm/s
2	Dwellings and buildings of similar design and/or occupancy	5 mm/s	5 to 15 mm/s	15 to 20 mm/s	15 mm/s
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value	3 mm/s	3 to 8 mm/s	8 to 10 mm/s	8 mm/s

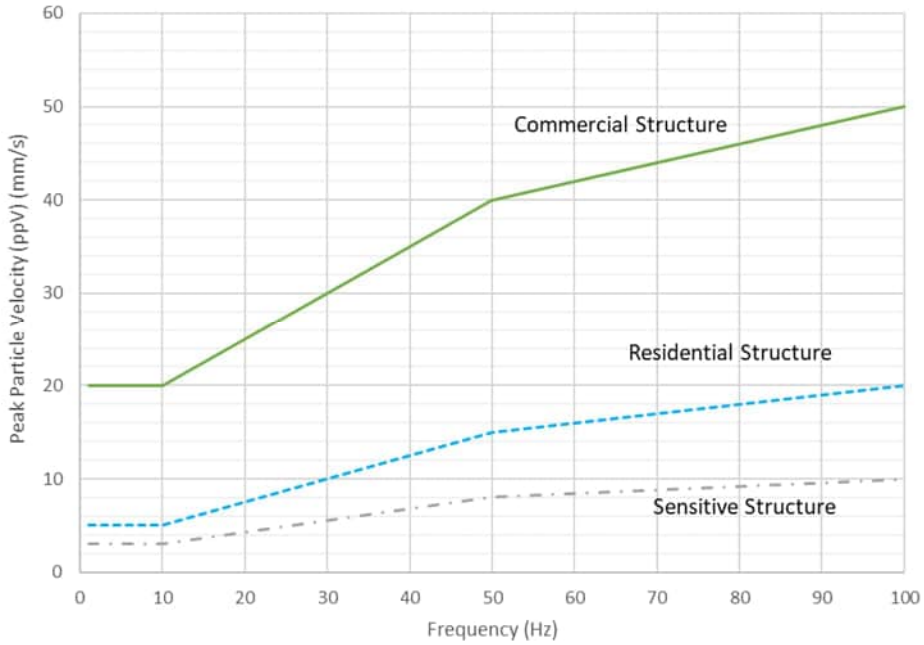


Figure 3.1: DIN 4150-3 Short-term standard baseline curves.

DIN:4150-3 gives further context to the guideline values:

> *"Experience has shown that if these values are complied with, damage that reduces the serviceability of the building will not occur. If damage nevertheless occurs, it is to be assumed that other causes are responsible. Exceeding the values in table 1 does not necessarily lead to damage; should they be significantly exceeded; however, further investigations are necessary."*

For the structures listed in lines 2 and 3 of Table 3.3, the serviceability is considered to have been reduced if:

- Cracks form in plastered surfaces of walls;
- Existing cracks in the building are enlarged; and
- Partitions become detached from loadbearing walls or floors.

These effects are deemed 'minor damage'.

The limits recommended in DIN 4150-3 provides a low probability of cosmetic damage. In reality, 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.

Vibration is not the only potential cause of cosmetic damage to buildings. Natural seasonal fluctuations in groundwater and associated ground settlement, as well as expansion and contraction of timber frames buildings, may also contribute to minor cosmetic damage.

3.3.2 Human vibration

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.

Low levels of vibration can cause fixtures and fittings, such as doors and windows, to rattle and the noise that is sometimes generated by the 'rattling' can draw an individual's attention to the original source of the vibration. Humans perceive vibration at much lower magnitudes than the levels of vibration that are likely to cause building damage and as such homeowners are likely to complain about vibration significantly below the levels likely to result in cosmetic damage of buildings.

Within New Zealand there are no national vibration standards for the effects on human exposure within buildings, however, it is accepted practice to apply the guidance from British Standard BS 5228-2:2009 *Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration* (BS 5228-2)[5].

3.3.2.1 BS 5228-2

BS 5228-2[6] discusses vibration levels at which adverse comment is likely from building occupants. The guidance values of Table B.1 of BS 5228-2 are provided in Table 3.4.

Table 3.4: Guidance on effects of vibration levels - BS 5228-2:2009

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[7]. 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.

3.3.2.2 AUP amenity vibration limits

Whilst AUP rule E25.6.29 (4A) notes that the vibration levels specified in Standard E25.6.29(1A)(b) (vibration limits in buildings) do not apply for this Project. The AUP amenity limits are set out in Table 3.5 below for reference.

Table 3.5: AUP Table E25.6.30.1 Vibration limits in buildings (amenity values)

Receiver	Period	Peak Particle Velocity (PPV) 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

AUP Rule E25.6.30 includes an allowance for up to 5 mm/s PPV being received between 7 am and 6 pm for no more than three days (for the project duration) provided that building occupants within 50 m are advised at least three days prior to works commencing.

[5] The previous version of this standard is referenced extensively throughout NZS 6803 as a method for predicting the noise levels from specific construction activities. The current version is considered appropriate.
[6] BS 5228-2:2009+A1:2014, Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration
[7] Below 50Hz

3.4 Regenerated noise

Operation of the TBM will generate vibration within the ground, which may cause regenerated noise within a building structure. Regenerated noise is typically assessed when the operation of the TBM operates 24 hours, 7 days a week, as regenerated noise during the night time period within dwelling may be audible, causing sleep disturbance, depending upon the proximity of the TBM to the dwelling and ground conditions.

For this Project, the TBM will only operate during standard daytime construction hours. We have assessed regenerated noise to understand the effects of regenerated noise during the daytime.

Whilst there are no applicable standard available for regenerated noise within New Zealand[8], it is important to understand the conditions affecting the internal acoustic environment for the users' comfort and useability.

For dwellings in suburban areas or near minor roads (Sarsfield Street, Argyle Street), a night time internal level of 30 to 35 dB L_{Aeq} is recommended. Similarly, the World Health Organisation[9] recommends a maximum internal level for dwellings of 30 dB L_{Aeq} to avoid sleep disturbance and 35 dB L_{Aeq} for moderate indoor annoyance.

It is considered that a regenerated noise criterion of 35 dB $L_{Aeq(15min)}$, as adopted for other similar infrastructure projects such as CI[10] and St Mary's Bay Pipeline[11], is accepted as standard practice, and thus appropriate for the Project.

[8] For internally regenerated ground-borne noise, the noise limits as specified in NZS 6803 are not applicable as construction noise levels are determined at a distance of 1 m from an external facade. Australian/New Zealand Standard 2107:2016 (Acoustics – Recommended design sound levels and reverberation times for building interiors) provides recommended design criteria for conditions affecting the acoustic environment within occupied spaces for new or altered buildings but specifies not to be used for assessment or prescription of acceptable recommended noise levels from variable noises outside the building (such as construction).

[9] World Health Organisation (WHO), Guidelines for community noise, 1999

[10] Appendix L, Grey Lynn Tunnel Assessment of noise effects, Marshall Day Acoustics, Rp 002 20180726, 13 Feb 2019

[11] Appendix M, St Mary's Bay Masefield Beach Water Quality Improvement Project, Noise and Vibration Effects Assessment, Aurecon, Rev 8, 26 April 2016

4 Exisiting environment

4.1 Overview

The Project is located within Herne Bay, a predominantly residential suburb on the western fringe of the Auckland City Centre. The location of the Project area within the context of Auckland is shown below in Figure 4.1.

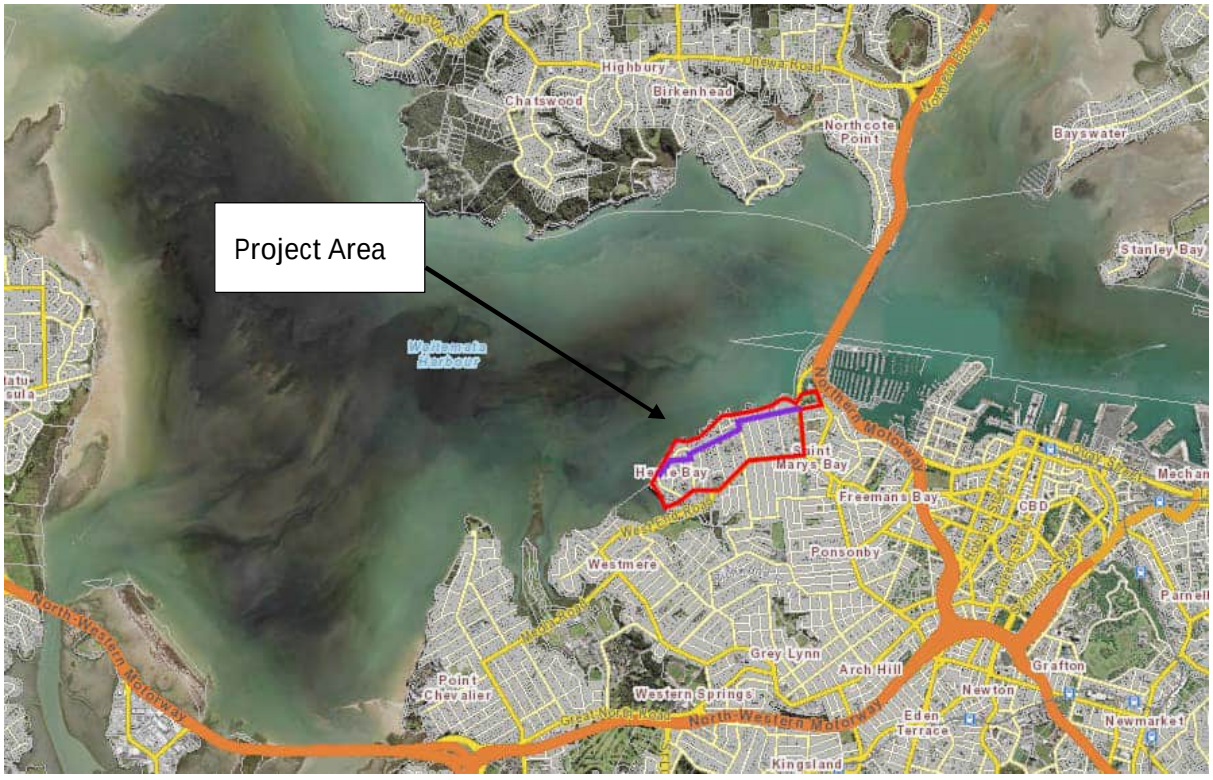


Figure 4.1: Location of the project area (Herne Bay) within the context of Auckland

The Project area is bound by Point Erin Park in the east, the edge of the Waitematā Harbour to the north and Marine Parade and Jervois Road to the south.

The Herne Bay suburb is predominately residential zones. Public open space in the Project area is present at Point Erin Park and Salisbury Reserve. Several esplanade reserves also provide connections between the road reserve and the coastal edge through the Project area. Ponsonby School is located at 50 Curran Street, approximately 65 m to the south of proposed trunk sewer line.

4.2 Sensitive receivers

Residential receivers are situated around all construction work areas of the Project. The majority of receivers are two storey high buildings, with a number of apartment blocks and three storey high buildings. A map of nearby properties that may potentially be affected by noise and/or vibration from the construction works along the road reserve have been identified in Appendix B Figure 1 and listed in Appendix C Table 1. The table identifies receivers located within 80 m radius of each shaft location[12] and their associated distance from the nearest surface construction area.

[12] No predicted exceedances of the AUP construction noise limits beyond 80 m from any construction works.

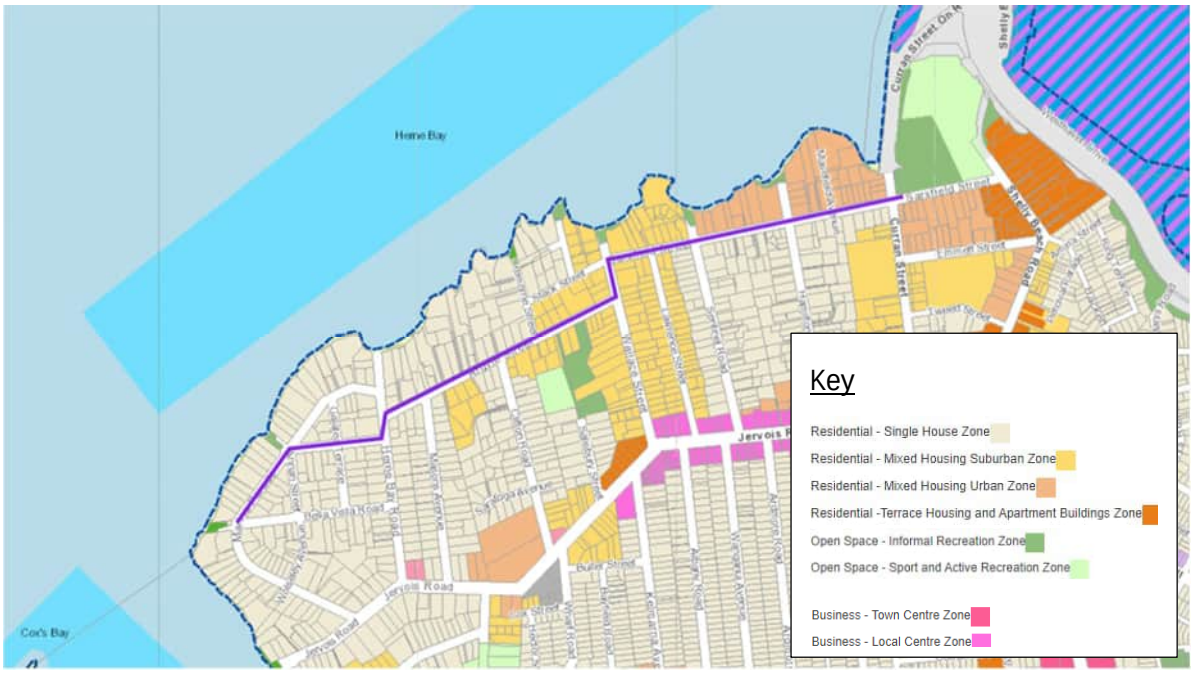


Figure 4.2: Alignment of the trunk sewer line (purple line), with the underlying zoning (Source: Auckland Council GeoMaps, accessed 2022)

The Project's tunnel alignment follows along the road reserve of Sarsfield Street, Wallace Street, Argyle Street, Herne Bay Road, Upton Street and part of Marina Parade. The TBM will operate at a depth between 3 m and 17 m below ground surface level with the shallowest depths between shaft 6 and 7. Potential receivers have been identified in Appendix B Figure 2.

Sensitive receivers for the CSA are listed in Table 5.7 and identified in Appendix B Figure 3.

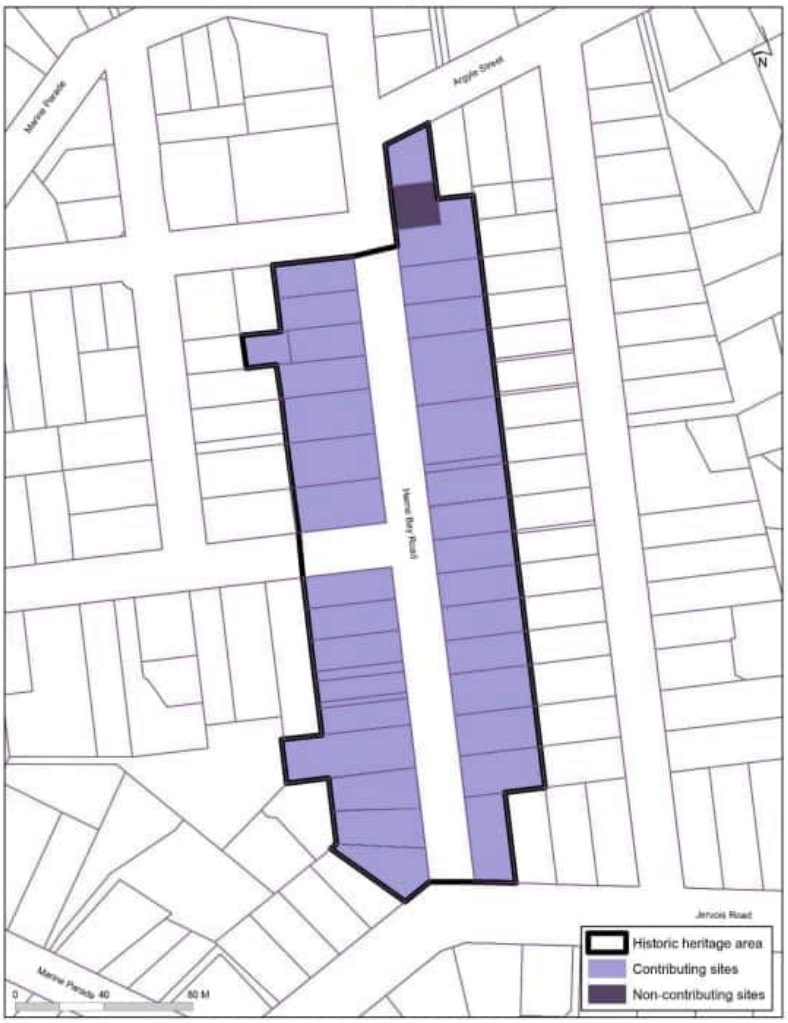
4.2.1 Heritage buildings

Two residential buildings (58 Wallace Street and 85 Sarsfield Street) are identified as listed category B historic heritage buildings under the AUP and are subjected to the heritage DIN limits (Line 3 of Table 3.3). Herne Bay Road Heritage Area was also identified near one of the satellite construction sites. On review of the AUP notes[13] for this area, it is considered the buildings are normal residential buildings with historical features and not listed buildings (and are not particularly sensitive to vibration[14]). As such they would normally be assessed under DIN (Line 2) limits for residential buildings. In agreement with the Project team, buildings within this area have been assessed against the heritage DIN limits for a conservative approach. Herne Bay Road Heritage Area includes part of Herne Bay Road as shown in Figure 4.3.

[13] AUP Schedule 14.2.5

[14] The structural elements of the buildings are similar to other residential buildings in the local area.

Map 14.2.5.1 Historic Heritage Area: Herne Bay Road



Auckland Unitary Plan Operative in part 16

Figure 4.3 AUP Schedule 14.2.5 Historic Heritage Areas (Source: Auckland Council GeoMaps, accessed 2023)

5 Noise and vibration assessment

5.1 Assessment approach

A preliminary assessment of construction noise and vibration has been based on an indicative construction methodology and durations informed by Watercare's contractors. This noise and vibration assessment is informed by other Watercare projects such as that undertaken for the current CI works due to comparable experience in relation to the type of works (tunnel and shaft) and proximity to dwellings. This provides a solid 'real-world' basis for understanding the nature of activities in Herne Bay, the actual and potential noise and vibration effects of those activities, and how the effects are best managed and mitigated to cause the least disruption to surrounding residents and to minimise environmental effects.

The assessment has been split into three distinct parts:

- Surface construction works (shaft construction and open trenching);
- Construction support area (at Salisbury Reserve); and
- Tunnelling from Point Erin Park to Marine Parade.

The Project is currently at a developed design stage with an indicative construction methodology. A conservative approach has been adopted for the assessment to consider the worst-case scenarios. As it moves through the detailed design process and as construction methodology is confirmed prior to start of works, it is likely that some details will change but remain within the envelope of effects of worst-case scenarios assessed in this assessment. All figures and dimensions provided are approximate and will be confirmed during the detailed design stage.

No operational noise is proposed for this Project and this assessment only considers construction noise and vibration effects. Due to the tunnel depth, there will be no noise to receivers from the tunnel once constructed and operational.

It is understood the programme for this Project is to be coordinated with the proposed CI extension project at Point Erin (both Watercare projects) to ensure alignment and construction works are scheduled so that at any given time, cumulative impacts associated with works at Point Erin Park are minimised. Whilst it is currently unknown if works near Point Erin Park will overlap, a worst-case scenario for cumulative impacts has been assessed in Section 5.3.4.

5.2 Source information

Sound power levels are provided in Table 5.1 below for the likely significant construction noise sources on site. Façade sound pressure levels at different set back distances, calculated using NZS 6803 principles, are also provided to give an indication of likely noise levels for short term activities.

Sound power levels are taken from NZS 6803 (reproduced from BS5228-1) or from T+T's library of measured levels. No form of mitigation, such as acoustic barriers or enclosures, has been included within these noise levels and they therefore represent a 'worst-case' scenario.

Not all items of construction plant associated with Project will operate simultaneously or within the same area. Hand tools have the potential to produce relatively high noise levels, however, these are typically used for short durations and are normally straightforward to screen effectively.

Table 5.1: Equipment list – Source data and indicative construction noise levels at different distances (without mitigation)

Source	Sound Power Level (dB L_{WA})	Noise Level (dB L_{Aeq}) at set back distances				Set back distance to achieve 70 dB (m)
		10 m	20 m	30 m	50 m	
Auger Pile rig (Secant pile)	111	86	80	76	71	52
Vibro pile rig (for casing)	110	85	79	75	70	48
23t Excavator with breaker attachment	112	87	81	77	72	58
15t Excavator	96	71	65	61	56	11
300t Crane	104	79	73	69	64	28
100t Mobile Crane	101	76	70	66	61	20
Hiab	98	73	67	63	58	14
Concrete pump	103	78	72	68	63	25
Concrete saw	114	89	83	79	74	69
Road miller (mini)	96	71	65	61	56	11
Road paver	104	79	73	69	64	28
8t Roller	103	78	72	68	63	25
500kg compactor (4t)	105	80	74	70	65	30
Hydrovac	111	86	80	76	71	52
3 axle- Trucks	105	80	74	70	65	30
Dewatering pump	98	73	67	63	58	14
Generator	101	76	70	66	61	20
Horizontal Directional Drill (HDD)	106	81	75	71	66	33
6-wheeler trucks	107	82	76	72	67	36

The following table shows key equipment likely to generate vibration for the Project. Where available, measurements / estimates of vibration from that equipment have been included.

Table 5.2: Construction equipment generating vibration

Equipment	PPV at 10 m
Excavator with breaker	3 – 4 mm/s
Compactor	2 – 3 mm/s
15-20t Excavator	1 – 2 mm/s
Auger bore piles	1 – 2 mm/s
Vibro casing	2 – 3 mm/s

Due to the nature and extent of the proposed works there will be a variety of construction plant used. Table 5.1 lists the expected significant items of plant. It is not feasible to provide an assessment of noise effects from all construction plant that will operate across these works.

To provide a reasonable assessment of noise exposure for individual receivers, this assessment has taken the approach of assessing the impact from the main significant noise generating activities. The sound power levels and predicted set back distances for the main construction activities have been calculated in Table 5.3 assuming construction plant operates concurrently on site at the edge of the construction area (i.e. worst case assessment).

Table 5.3: Activity sound power levels and compliance distance without mitigation

Activity	Activity sound power level (dB L_{WA})	Setback distance to achieve 70 dB without mitigation (m)
Enabling works	111	54
Secant piling for shaft	112	58
Shaft construction	112	58
Manhole construction	113	61
Open trenching	114	68
Road reinstatement	112	60
Tunnelling support	108	38
Directional drilling	106	33
Support area (stock piling, refuelling, steel cage construction)	104	28

A duty correction has been applied to equipment within each activity to account for usage of equipment over the 15-minute assessment period. (For example, secant piling & auger pile - 100% on-time, mobile crane - 75% on-time).

The presented sound power levels are indicative only, as the construction methodology has not yet been finalised. In reality, there is a low likelihood of all modelled equipment to be in one location at any given time. It is also recognised that there will be times during the day when there will be no working or minimal noise generating activities. As such, predictions present a worst case to account for any uncertainties in methodology and provide an envelope of effects. The sound power levels presented are similar to other major infrastructure projects in Auckland such as St Mary's Bay Water Quality Improvement Project and ongoing CI works.

Based on the set back distances shown in Table 5.1, receivers located over 80 m from the nearest construction area have not been included as they are unlikely to experience noise above the relevant AUP noise limits.

5.2.1.1 Noise model

A SoundPLAN computer model (version 8.2) implementing ISO 9613-2:1996 *"Acoustics – Attenuation of sound outdoors – Part 2: general method of calculation"* prediction algorithm has been used to predict noise levels from activities associated with the construction of the Herne Bay Tunnel. The noise model takes into account ground contours, ground absorption, terrain, buildings and the location of works. The building footprints have been obtained from the LINZ database and adjusted for the number of floors (assuming 2.8 m height per floor with an average height of 8 m for double storey buildings).

For each receiver, the worst-case noise level has been calculated, which is typically when equipment is operating at the closest location.

The following scenarios have been modelled for the activities closest to receivers, with the construction plant operating 100% of the 15-minute assessment period at the edge of the construction location (i.e. worst case assessment):

- Shaft construction: source height of 1.8 m;
- Open Trenching: source height 1.2 m;
- Horizontal Directional Drilling (HDD): source height 1.5 m; and
- Construction support area: moving line source, concrete pump, stockpiling and generators.

Secant piling, shaft construction and road reinstatement all have the same activity sound power level of 112 dB(A) and generally undertaken within the same locations around the shaft areas. As such, assessing one of the activities (shaft construction) gives an indication of the noise level and effects for the other activities. Tunnelling support will occur around shaft 1, 3 and 5 for extraction of spoil removal from the TBM and is expected to generate 4 dB less noise than shaft construction. As such, shaft construction will illustrate a worst case for tunnelling support activities at the shafts.

Proposed construction techniques for different sections of the alignment are shown in Figure 5.1. Open trenching and HDD are proposed for connections from the main alignment only. In practice, HDD will be used instead of open trenching to reduced noise impacts where possible, but open trenching has been assessed for the majority of connections to represent a worst case.

Figure 5.1: Construction method type along Project alignment

5.3 Surface construction works

5.3.1 Predicted construction noise levels

Façade noise maps for each modelled scenario have been calculated for nearby sensitive receivers. The full graphical façade noise maps are presented in Appendix D. The façade noise maps show the highest sound level experienced at each building, i.e. the closest, highest floor and most exposed façade to the source. Colour coding has been used to highlight the range of construction noise levels.

Grid noise maps are modelled at 1.5 m above ground level in line with noise survey measurements undertaken in accordance with NZS 6801:2008 to enable comparison. As buildings in and around

Herne Bay are typically more than one storey high, predicted façade levels may be greater than those shown on the grid noise contours. Due to the height of surrounding residential buildings and the restricted distance from construction works, effective screening is often difficult to provide against construction noise. For this reason, this assessment assumes no screening is effective for receivers, i.e. a worst case prediction.

Appendix C Table 1 summarises the predicted worst-case noise levels for receivers without screening for the construction activities. The number of properties experiencing noise greater than 70 dB L_{Aeq} (in 5 dB bands) is provided in Table 5.4. Noise level effects are discussed in Section 6.

All surface construction activities are solely within the road reserve and exceedances of the AUP noise limits will be managed via the CNVMP.

Table 5.4: Summary table of predicted noise exceedances

Construction Activity	Highest predicted levels (LAeq,15min)	Number of properties			
		≥85dB	80-84 dB	75-79 dB	70-74 dB
Shaft Construction	83 dB	0	3	17	36
Intercept Shaft construction	84 dB	0	3	16	41
Open trenching	92 dB	3	22	48	80
HDD	74 dB	0	0	0	5

Note properties could be affected by more than one activity i.e 50 Sentinel Road exceeds 70dB for both open trenching and intercept shaft construction

5.3.2 Construction traffic movements

Although the AUP does not require noise from construction truck movements to be assessed[15], noise impacts have been considered due to the close proximity (less than 20 m) of the construction areas to nearby receivers.

Due to the spatial extent of the project, main construction traffic is anticipated to transverse between the CSAs and construction sites mainly along collector roads. Existing traffic count[16] data shows most of the roads potentially impacted by the Project have low traffic volumes of typically less than 1,800 vehicles a day with the exception of Sarsfield Street, which is estimated to be 3,940 - 4,168 vehicles per day with 3.7% being heavy vehicles.

Based on predicted total vehicles[17], additional Project vehicle movements will contribute between 2% – 7% increase for the route east of Salisbury Reserve compound (Argyle Street/Wallace Street/Sarsfield Street) and between 3% - 13% increase for the routes to the west of the compound (Argyle Street /Herne Bay Road/Upton St/Marine Parade).

A change in traffic volume data by +25% or – 20% volume only results in 1 dB change in predicted noise level, which would be imperceptible. As such, the noise contribution from additional traffic movements for the Project is considered to be negligible.

The existing environment around Sarsfield Street is such that the local environment is already dominated by traffic noise from Curran Street. Construction truck movements will generally be

[15] The AUP excludes traffic noise – see AUP E25.1. Background.
[16] Estimated traffic counts from Table 2.4 -2.6, Herne Bay Tunnel – Integrated Transport Assessment(ITA), T+T, March 2023
[17] Daily anticipated maximum construction vehicles Table 5.1 & Traffic impact of construction traffic Table 6.1, Herne Bay Tunnel – Integrated Transport Assessment(ITA), T+T, March 2023

inseparable from general traffic on the existing roads during the day for Sarsfield Street but may be distinguishable along the local roads such as Marine Parade, Upton Street and Herne Bay Road where heavy vehicles do not typically go. At an average of 17 heavy vehicles/day (~1 vehicle per hour), the effect of this is considered to be less than minor.

It is understood Sarsfield Street may be closed for a period during works at Shaft 1. In this scenario, the traffic assessment indicates traffic will be diverted onto Emmett Street (local road) and Curran Street which will result in a potential traffic volume increase of greater than 50%. The diversions will be temporary but will result in a perceptible noise change. Heavy traffic noise for residents along Emmett Street will be clearly distinguishable for the period of time diversions are in place.

As set out in the Construction Traffic Effects Assessment, there may be some circumstances where out of hours traffic movements will be required, including for removal of the TBM. These movements will generally be low speed and will not be a regular occurrence. Again, the noise generated by construction vehicles will generally be inseparable from other vehicle movements that may occur in the local area. The noise of these movements will be managed by the CNVMP.

5.3.3 Predicted construction vibration levels

The generation of vibration is dependent on the local site geology, the equipment being used, the nature of the works, and even the operator. To account for this, the likely worst-case vibration has been calculated based on the equipment from excavator with breaker attachment and hard ground geology to provide predicted vibration levels at the closest receivers.

The use of an excavator with a breaker attachment is expected across all activities (to break road surface) and is predicted to generate the highest level of vibrations in comparison to other equipment. Dwellings within 27 m from a construction site may experience vibration levels of up to 2 mm/s PPV. For properties between 27 m and 5 m from the construction site, vibration levels are likely to be greater than 2 mm/s PPV but expected to be below the DIN 4150-3 limit for cosmetic damage building of 5 mm/s PPV for residential buildings. Properties located further away are predicted to experience vibration levels of less than 2 mm/s.

Whilst the DIN 4150-3 vibration limit (5 mm/s PPV for residential and 3 mm/s PPV for sensitive buildings) is applicable for works within the road reserve, all properties predicted to exceed the AUP amenity level of 2 mm/s PPV are listed in Appendix C. Vibration contour maps are presented in Appendix F. Properties predicted to potentially exceed the DIN 4150-3 limits are presented in Table 5.5. Vibration effects are discussed in Section 6.1.3.

Table 5.5: Properties predicted to exceed Project vibration criteria

Address	Building Classification	Predicted vibration level, PPV
1 Marine Parade	Residential	> 10 mm/s
8 Wairangi Street	Residential	5 - 6 mm/s
34 Herne Bay Road	Historical / Sensitive	4 - 5 mm/s
72 Argyle Street	Historical / Sensitive	3 - 4 mm/s

Properties which are immediately adjacent to construction of a shaft or open trench are predicted to experience vibration levels of greater than 2mm/s PPV but below the DIN 4150-3 limit for cosmetic damage building of 5 mm/s PPV for residential buildings across the whole project alignment.

Private swimming pools have not been specifically assessed but in the absence of relevant guidance for structural vibration sensitivity for swimming pools, the DIN 4150-3 residential threshold has been adopted. We consider this is a suitable threshold to trigger structural investigation if required. If

vibration concerns arise when construction starts then they will be managed via the CNVMP through monitoring and investigation if required.

Two buildings are predicted to exceed the DIN limit of 5 mm/s PPV for cosmetic damage.

Two buildings within the Herne Bay Heritage area at 72 Argyle Street and 34 Herne Bay Road are predicted to exceed the DIN 4150-3 limit of 3 mm/s PPV for sensitive buildings.

5.3.3.1 Underground services

Underground services include high voltage power lines and water pipes. High voltage power lines are typically in a 150 mm PVC duct and the cable itself is typically of a more flexible material and not generally impacted by vibration. The condition and type of water pipes present is currently unknown but plastic or masonry pipes of good condition will be more resistant to potential vibration induced damage.

DIN 4150-3 includes guideline vibration limits for utility protection, see Table 5.6. According to DIN 4150-3, rigid plastic/masonry pipes have a vibration tolerance of 50 mm/s PPV.

Table 5.6: DIN 4150-3 - Guidelines for allowable vibration level for utility protection

Pipe Material	Guideline values for allowable vibration levels (velocity measured on the pipe)
Steel (including welded pipes)	100 mm/s
Clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80 mm/s
Masonry, plastic	50 mm/s

Based on the use of an excavator with breaker, vibration levels of less than 10 mm/s are predicted at 1 m away from any services, indicating a low risk for vibration damage to underground services.

To further reduce the risk, services will be exposed using hydro-excavation during enabling works prior to any high vibration activities taking place. Piling and other works near the services should be carried out in consultation with the asset owner's agreement and at any agreed set back distances. Stand over from the asset owners may also be necessary and managed accordingly within the CNVMP.

5.3.4 Cumulative noise impacts at Point Erin

Watercare is proposing to extend the CI wastewater conveyance and storage tunnel from Tawariki Street in Grey Lynn to a new terminal shaft in Point Erin. The CI project involves the construction, commissioning, operation and maintenance of a wastewater interceptor and associated activities at Point Erin Park in Herne Bay. The work at Point Erin Park includes the construction of a terminal shaft located south of the Point Erin Pool, and a control chamber, plant room towards the southwest corner of Point Erin Park near the intersection of Curran and Sarsfield Streets. The Herne Bay Tunnel will connect to the proposed CI chamber at the southwest corner of Point Erin Park. Shaft 1 is proposed to be located on the road reserve at the southwest corner close to the CI chamber and some overlap of construction programme is anticipated.

These CI works have the following indicative programme:

- Site establishment - first half of 2024;
- Terminal Shaft excavation- Sept 24 to Feb 25;
- Control Chamber construction - Jan 25 to Oct 25; and
- TBM removal and complete terminal Shaft – May 2025 to Feb 2026.

At present there is no work programme for this Project, but it is understood that the Project construction programme will be scheduled in a way that cumulative effects for receivers around Point Erin Park are minimised as far as practicable. Since site establishment works are not anticipated to be noisy activities and will be located away from the southwest corner of Point Erin Park, cumulative noise and vibration effects are likely to be less than minor.

As we do not currently know if the future programmed works will overlap with the proposed CI extension works and to what duration, three worst case scenarios are considered realistically possible to generate cumulative noise levels. The scenarios are:

- Shaft 1 construction and CI extension chamber construction;
- Shaft 2 construction and CI extension chamber construction; and
- TBM drive at Shaft 1 and CI extension works.

All other works are located further away from CI extension works and not predicted to result in cumulative noise impacts. The three scenarios have been assessed below.

Shaft 1 and CI Extension chamber

Whilst both Shaft 1 construction and sheet piling works for CI chamber are expected to take place in the south-west corner of Point Erin Park, it is understood concurrent works at this location will be avoided through close co-ordination with the CI team to schedule out any potential concurrent noisy works in this area due to limitations of space. Cumulative noise and vibration effects due to this scenario are likely to be less than minor and can be managed via the CNVMP and scheduling.

Shaft 2 and CI Extension chamber

Predicted noise levels for this worst-case scenario indicates that nearby receivers along Sarsfield Street are mainly effected by either the CI or Herne Bay works, as shown by the noise contour map in Figure 5.2. For receivers greater than 250 m from the two activities, they may experience a less than 1 dB increase (e.g. 54 Sarsfield Street has a predicted noise level of 49 dB for Shaft 2 construction works and a cumulative predicted noise level of 50 dB). A less than 1 dB noise increase is not perceivable and noise levels are well below the permitted levels. It is considered these works are clearly distinguishable and result in negligible cumulative effects.

Figure 5.2: Predicted cumlative impacts from CI and Herne Bay – Shaft 2 and CI sheet piles

TBM drive from Shaft 1 and CI Extension works

Another construction activity undertaken around Shaft 1 is the TBM drive for the terminal shaft. The TBM drive is expected to occur within the main shaft below surface level (works shielded by the shaft itself) and support works will be shielded by a 1.8 m barrier around the proposed CI site. Closest receivers to Shaft 1 at the Curran Street and Sarsfield Street junction are within 50 m from Herne Bay works, and over 100 m from the proposed CI works. Distance alone attenuates noise levels from the CI works at the closest Project receivers and no cumulative effects due to concurrent works around Point Erin Park are anticipated.

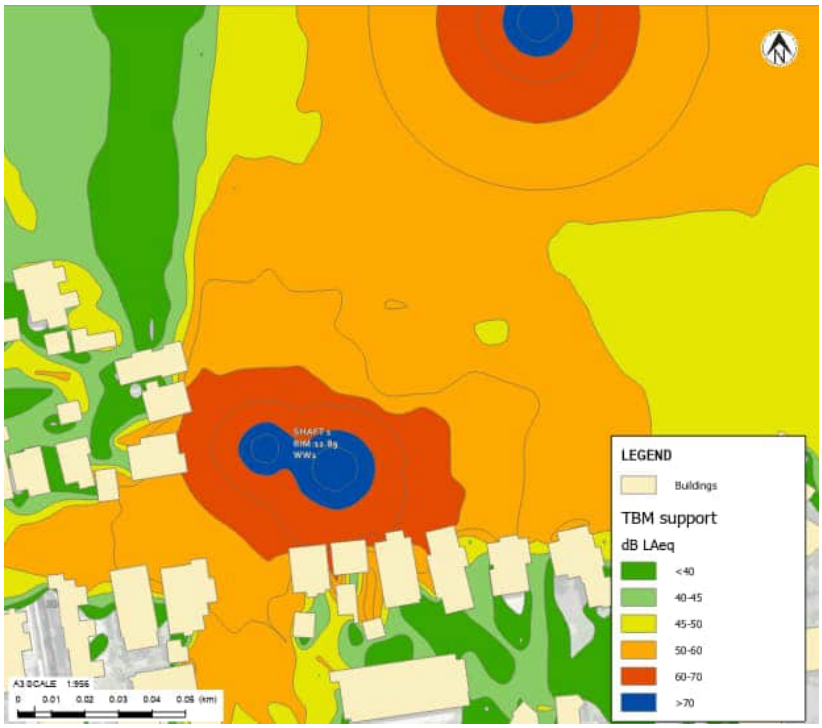


Figure 5.3: Predicted cumlative impacts from CI and Herne Bay – TBM support and CI main shaft construction

Whilst every effort will be made to avoid potential cumulative noise effects, there may be occasions when works overlap due to unexpected events and delays. In case of such events, noise from this Project will be managed via the CNVMP by restricting noisy activities to coordinate with CI works to ensure noisy activities from both Projects are not carried out at the same time. Assessment of possible overlaps indicates cumulative effects are likely to be negligible or less than minor regardless of overlap duration.

5.4 Construction support areas

Two CSAs are required for the Project. One is proposed at Salisbury Reserve and another at 94a and 94b Shelley Beach Road to support noisier activities such as secant piling support and stockpiling. The main CSA is proposed at Salisbury Reserve with residential properties on all sides (Appendix B Figure 3). The sites will be fully fenced with solid hoarding and during construction the compound will be predominately used for site offices, minor material, plant and equipment storage.

Two scenarios have been assessed for the CSAs, with secant piling support only undertaken at the 94a/94b Shelley Beach Road:

- Stockpile activities – general dump truck movements carried out for the whole Project duration; and
- Secant piling support – pile cages will be stored and prepared at the CSA to be brought to the site as and when ready to be lifted direct from the truck and into the pile bore. The CSA being used as a marshalling yard for where there is no capacity onsite for waiting concrete trucks. (i.e. crane, concrete truck, delivery truck and generator).

Receivers within 10 m of the compound site boundary may experience truck movement noise above the daytime limit of 70 dB L_{Aeq} at first floor level.

Predicted noise levels and distances from site boundary at most receivers directly adjacent to the compound are identified in Table 5.7 below.

Table 5.7: Predicted noise level at nearest receivers from CSAs site

Address	Distance from compound site boundary (m)	Predicted noise level at first floor level (L_{Aeq}, dB)
		Stock piling activities
14 Argyle Street	5	75
4/40 Wallace Street	7	72
6 Argyle Street	7	72
32D Wallace Street	10	69
5/26 Wallace Street	10	69
6/26 Wallace Street	10	69
42A Wallace Street	11	68
4/36 Wallace Street	14	66
26 Argyle Street	16	65
16 Argyle Street	26	61
Point Erin Swimming pool	90	47
121C Shelly Beach Road	180	40

The CSA at 94a/94b Shelley Beach Road is located over 90 m from the nearest receiver (Point Erin Swimming Pool) and over 180 m from the nearest residential receiver. The distance alone effectively mitigates noise associated with activities at this site.

5.5 Tunnelling

Tunnelling using the TBM is proposed between shafts as described in Section 2.2. During TBM drives, soil spoils will be extracted and removed from the respective 'thrust' shaft (Shaft 1, 3 and 5). Surface works assessments due to the tunnelling have been considered within the construction activity 'shaft construction'. This section assesses the regenerated noise and vibrations levels generated by the TBM excavation.

The TBM information provided by the contractor indicates the equipment is expected to operate at a rate of around 7-10 m per day depending on optimal ground conditions with continuous tunnelling through the daytime construction hours only. The TBM is not expected to operate at night for this Project.

5.5.1 Predicted vibration levels

There are two options proposed for the vertical tunnel alignment, with the shallowest design (representing a worst case from a vibration effects perspective) proposed at vertical depths between 3 m and 17 m below surface ground level[18] directly under the road reserve. This is representative of the worst-case scenario.

Where the tunnel alignment is below 10 m, it predominately transverses through where East Coast Bays Formation rock (ECBF) is present[19]. At shallower depths, geology makeup comprises weathered ECBF and residual soil above (i.e. softer ground). As mentioned above, the generation of vibration is dependent on the local site geology, the equipment being used, the nature of the works, and even the operator. To account for this, a worst-case vibration level at receivers is predicted assuming hard ground geology (ECBF rock) for all depths.

Vibration assessment and testing of ground conditions carried out by T+T[20] for the CI locations across Auckland including Point Erin identified a best fit ground attenuation for vibration along the Auckland alignment in the form of $PPV = 9.26(d)^{-1.44}$ where d is distance from the source to the receiver. The attenuation exponent (-1.44) is reflective of the properties of soft soils overlying rock.

It is considered appropriate to adopt the same ground attenuation relationship as the proposed CI extension project due to the similar geology makeup across the Project area. As CI Point Erin tunnelling will commence before this Project, further data can be collected and the ground attenuation parameters updated if required to refine predictions.

Vibration data from other Auckland infrastructure projects (such as City Rail Link) using a larger TBM at shallow depths have not resulted in any significant vibration issues with management practices in place. This provides assurance that vibration effects from operation of the TBM are low risk and levels are generally in line with the adopted ground attenuation relationship.

It is acknowledged that for the Herne Bay area, house foundation piles may be situated at 2-3 m into ground reaching the ECBF rock layer, resulting in a shorter slant distance[21] between the TBM and foundation due to the shallow depths of the alignment. As the type of foundation for each house is

[18] Measured between surface ground level and top of tunnel. Option 2 depths between 8 – 23 m.
[19] Herne Bay Connector project Stage 1: Screening level Assessment of Effects, Tonkin + Taylor Ltd, 3 Feb 2023
[20] Central Interceptor – Vibration Assessment for Main Tunnels and Link Sewers, Tonkin + Taylor Ltd, July 2012, Ref 27993
[21] The straight line distance between the top of the tunnelling source (below ground) and receiver (building's foundation)

an unknown factor, a more conservative approach using the horizontal distance[22] with the above equation has been undertaken.

The tunnel is located entirely below ground at depths typically between 9 and 17 m for the majority of the alignment and reaches its shallowest points of 3 m around Shaft 7 and SE04. The closest receiver (98 Sarsfield Street) is located approximately 4 m horizontal distance from the tunnel near Shaft 2.

All receivers are predicted to comply with the daytime amenity limit of 2 mm/s and DIN 4150-3 limits for both residential buildings (5 mm/s) and sensitive structures (3 mm/s).

A selection of residential receivers along the alignments, with the distance and predicted vibration levels are provided in Table 5.8. A full list of receivers is included in Appendix E.

Table 5.8: Predicted vibration levels at receivers - tunnelling

Type	Receiver	Approx horizontal distance to tunnel alignment	Predicted PPV range
Residential	98 Sarsfield Street	3.9 m	1.3 mm/s
Residential	96 Sarsfield Street	4.1 m	1.2 mm/s
Residential	94 Sarsfield Street	4.4 m	1.1 mm/s
Residential	12 Galatea Terrace	4.6 m	1.0 mm/s
Residential	70 Curran Street	4.7 m	1.0 mm/s
Residential	2 Argyle Street	5.7 m	0.8 mm/s
Residential	61 Sarsfield Street	5.9 m	0.7 mm/s
Residential (Listed Heritage)	85 Sarsfield Street	14.6 m	0.2 mm/s
Residential (Listed Heritage)	58 Wallace Street	23.1 m	0.1 mm/s
Residential (Heritage Area)	34 Herne Bay Road	10.4 m	0.3 mm/s

5.5.2 Tunnelling regenerated noise

Based on experience from the existing CI tunnelling works, a minimum slant distance of 18 m from buildings with bedrooms on the ground floor to the TBM will achieve compliance with a regenerated noise criterion of 35 dB L_{Aeq}.

The shallowest slant distance between the tunnel and ground surface level is 11 m. Assuming building foundations at rock level, and by adopting the horizontal distance rather than the slant distance, 99 properties are calculated to exceed the 35 dB L_{Aeq} criterion for regenerated noise. Whilst night time works are not expected for this Project, the properties less than 18 m from the TBM alignment are shown in Appendix G. Noise from daytime tunnelling works are unlikely to noticeable from normal day to day activities.

[22] Example: 22 Marine Parade has a vertical distance (depth) of 3 m and a horizontal distance of 11 m from the tunnel, resulting in a slant distance of 11.4 m. 98 Sarsfield Street has depth of 11 m, horizontal distance of 3.9 m and slant distance 12 m. Worst case predictions therefore discounts the depth.

6 Assessment of effects

6.1 Surface construction

6.1.1 Potential noise effects

The degree of the Project's noise effects will depend upon the magnitude, frequency of occurrence and duration of the noise exposure. Residents will experience noise inside and outside their dwellings if they are at home. An indication of the potential effects is provided in Table 6.1. Depending on the construction of the house, facades may provide a 25 – 30 dB reduction, therefore assumptions and effects provided below are based on a conservative approach.

Table 6.1: Subjective response to environmental noise (daytime) – residential building occupiers

External sound level (L_{aeq})	Potential daytime effects outdoors	Corresponding internal sound level (L_{aeq})	Potential daytime effects indoors
Up to 65 dB	Conversation becomes strained, particularly over longer distances.	Up to 45 dB	Noise levels would be noticeable but unlikely to interfere with residential activities.
65 to 70 dB	People would not want to spend any length of time outside.	45 to 50 dB	Concentration would start to be affected. TV and telephone conversations would begin to be affected.
70 to 75 dB	Outdoor users would experience considerable disruption.	50 to 55 dB	Phone conversations would become difficult. Personal conversations would need slightly raised voices. For residential activity, TV and radio sound levels would need to be raised.
75 to 80 dB	Some people may choose hearing protection for long periods of exposure. Conversation would be very difficult, even with raised voices.	55 to 60 dB	People would actively seek respite when exposed for a long duration.
80 to 90 dB	Hearing protection would be required for prolonged exposure (8 hours at 85 dB) to prevent hearing loss.	60 to 70 dB	Untenable for residential environments. Unlikely to be tolerated for any extent of time.

Note: The adjustment factor between the external noise level and the internal noise level is based on a 20-decibel reduction as allowed for in NZS 6803. The table does not correct for façade effects – to simplify the presentation of internal noise levels.

This table relates to noise experienced during non-sleeping hours.

6.1.2 Construction noise effects

With the exception of the CSAs, all construction activities are to be undertaken within the road reserve and are thus a permitted activity. Overall construction works will generally comply with the daytime noise criterion of 70 dB $L_{Aeq.}$ Where specific activities are predicted to exceed the noise criterion, the effects can be minimised and managed within a CNVMP.

6.1.2.1 Shaft construction

All shaft construction works are within the road reserve and external noise levels without any mitigation in place may exceed the construction noise criterion of 70 dB L_{Aeq} at 41 receivers due to secant/auger piling works to construct the main and intercept shafts along the alignment. Six receivers (46 Argyle Street, 45 Argyle Street, 91 Sarsfield Street, 96 Sarsfield Street, 98 Sarsfield Street and 34 Herne Bay Road) are predicted to exceed 80 dB L_{Aeq} with a maximum noise level of 84 dB L_{Aeq} predicted at 46 Argyle Street, located less than 15 m from the piling works.

Noise levels will vary during construction of the various shafts. The maximum noise levels presented in Appendix C Table 1 are only likely to occur when the pile works are nearest to the receivers. It is estimated a maximum of 112 days is required to construct the larger shafts and 20-30 days for the smaller intercept shafts. Noise will not be continuous through the construction period and will not be at the closest point throughout. In reality, maximum noise levels may only occur for a relatively short period and intermittently within the total duration of the works. Once the shaft has been constructed, works will move away to the next location and tunnel support will be undertaken reducing maximum noise levels by at least 4 dB which is a perceptible reduction.

Due to the height of the properties within the Herne Bay area being predominately two storeys, noise from piling works cannot be effectively mitigated as 6 m high noise barriers would be required to achieve the Project's noise criterion. Temporary barriers this high would be impracticable to construct and maintain.

With a standard 1.8 m barriers around the localised construction areas in place as part of the recommended mitigation, a 1 – 2 dB partial reduction can potentially be achieved at first floor with and an 8 – 10 dB reduction at ground floor locations.

A maximum predicted piling noise level of 84 dB L_{Aeq} would usually equate to an internal noise level 20 – 25 dB lower, i.e. 64 – 59 dB L_{Aeq} depending on the glazing and façade construction. An internal noise level between 60 – 65 dB L_{Aeq} may interfere with normal residential activities for extended periods of time but may be tolerable for short intermittent durations with prior notice. Mitigation management via consultation for receivers predicted to experience external noise levels over 80 dB L_{Aeq} will be required. If people are aware of the presence of a noise source, they are less likely to be adversely affected when it occurs.

High external noise levels for piling are not uncommon for this type of work close to residential receivers and has been successfully managed on other Auckland based projects, such as CI sites, through implementation of an ASCNMP, which includes industry standard practice for piling mitigation such as avoiding unnecessary noise, selecting suitable equipment size for the task and advance communication and consultation with receivers around timing and duration. Similar management using a CNVMP will be adopted for this Project.

With the exception of the six receivers discussed above, due to the relatively limited duration and intermittent nature of piling, along with the implementation of the CNVMP to appropriately manage piling activities, it is considered that noise effects from piling on surrounding residents will be reasonable, i.e. within an acceptable range of construction noise levels (75 – 80 dB L_{Aeq}) for the majority of receivers.

Open trenching and/or HDD is proposed for shallower pipe connections between the main shafts and local EOP connection points. Whilst every effort has been considered within the construction methodology to use HDD instead of open trenching near most affected receivers, it has not been possible to use the less noisy HDD activity everywhere due to shallow depths of connections, geology and practicability.

Where open trenching within the road reserve is proposed, 80 receivers are predicted to exceed the 70 dB L_{Aeq} daytime construction noise criterion. Six receivers are situated less than 10 m from the

nearest trenching works and are predicted to experience noise levels above 85 dB $L_{Aeq,}$ with a maximum noise level of 92 dB L_{Aeq} at 8 Wairangi Street located less than 5 m from the trenching works. As works move further from particular properties, noise levels will decrease.

Where HDD is proposed, a maximum 74 dB L_{Aeq} is predicted at 96 and 98 Sarsfield Street, with a total of five receivers exceeding the 70 dB L_{Aeq} daytime limit. Noise levels below 75 dB are considered acceptable for the limited duration of works and effects will be reasonable and less than minor in magnitude.

Open trenching noise levels will reduce as construction works move along the alignment and away from each receiver. The maximum noise levels presented in Appendix C Table 1 are only likely to occur when the open trenching works are nearest to the receivers. During physical works, maximum noise levels may only occur for a relatively short period of 3-4 days and intermittently within the total duration of the works. Due to the height of the receivers, barriers will not provide effective screening at first floor and alternative mitigation such as only carrying out works at the nearest distance from the receiver when the property is unoccupied will be required.

As works within the road reserve are a permitted activity, any receivers with predicted noise levels over 80 dB L_{Aeq} will require close communication and consultation which will be managed via the CNVMP.

6.1.2.2 Construction support areas

The CSA at Salisbury Reserve and 94a/94b Shelley Beach Road will be established for the full duration of the Project.

For Salisbury Reserve, a maximum noise level of 75 dB L_{Aeq} is predicted at 14 Argyle Street. With a 2 m hoarding in place, noise levels can be effectively mitigated at this one storey property to comply with the daytime noise criterion. Two receivers at 4/40 Wallace Street and 6 Argyle Street are two storey buildings and predicted to experience a maximum noise level of 72 dB L_{Aeq}. At an external level of 72 dB L_{Aeq}, an internal noise level of 52 – 57 dB L_{Aeq} is expected and considered acceptable and may result in minor disturbance for receivers. The maximum noise level of 72 dB assumes activities occur at the site boundary, whilst in practice noisy activities will be undertaken nearer the centre of the site, along with intermittent vehicles movements near the properties. It is likely that noise levels will comply with the 70 dB L_{Aeq} daytime noise criterion. Noise effects due to CSA activities at Salisbury Reserve are considered to be less than minor.

All nearby receivers for 94a/94b Shelley Beach Road are expected to comply with the daytime noise criterion. Noise effects due to CSA activities at Shelley Beach Road are considered to be negligible.

6.1.2.3 Cumulative effects

Whilst every effort will be made to schedule noisy works for the Project outside of the CI extension expected programme of works for sheet piling, there will be short durations where the two programmes may overlap.

Predictions for the noisiest activity from both CI extension (sheet piling) and Herne Bay (shaft 2 construction) indicated receivers situated between the two sites may experience less than 1 dB cumulative increase, which is not perceptible.

During TBM drive support activity around Shaft 1, no cumulative impacts are predicted due to CI works at the main shaft being more than 100 m from the closest receivers around the Curran Street and Sarsfield Street intersection. Whilst noise may still be heard from CI works, TBM support activities will be the dominant noise source due to the closer proximity to receivers. On both occasions where the programme of works could potentially overlap, predictions indicate concurrent

works from Herne Bay and CI works are located at sufficient separation distances that there will be a less than minor to negligible effect.

6.1.3 Potential vibration effects

Construction activities may generate vibration. The assessment shows that 96 properties are predicted to experience vibrations above the 2 mm/s amenity level but under the 5 mm/s DIN 4150-3 threshold for cosmetic damage. Vibration levels of 2 mm/s may be perceivable by occupants and they may be disturbed by such occurrences, but based on experience with other construction projects, vibrations at this level will generally be acceptable to receivers provided they have received prior warning (this is so that the receivers are not surprised or startled when the vibrations occur).

Two properties at 33 Marine Parade and 6 River Terrace are predicted to experience vibration levels of between 4 – 5 mm/s as a worst case but not anticipated to exceed the 5 mm/s DIN threshold for cosmetic damage. At these levels, vibration is likely to be perceivable by the occupants and may be tolerable for very short periods of time with prior warning and explanation.

Two properties at 1 Marine Parade and 8 Wairangi Street are situated less than 5 m from works and are predicted to experience vibration greater than 5 mm/s. Additionally, two properties within the Herne Bay Heritage area at 72 Argyle Street and 34 Herne Bay Road are predicted to exceed the DIN 4150-3 3 mm/s PPV limit for sensitive buildings. These worst case exceedances are predicted during use of the breaker to remove the top layer of road; vibration levels will be short in duration and not cause continuous vibration levels. If the property is occupied, vibration is likely to be tolerable for a short period and consultation and mitigation measures as set out in Section 7.1.6 will be required.

The DIN 4150-3 thresholds are set to be protective of cosmetic damage (refer to section 3.3.1) and 5 mm/s is applicable for frequencies between 1 – 10 Hz. Equipment used for this Project are likely to operate at frequencies greater than 10 Hz resulting in a higher threshold as illustrated in Figure 3.1. In reality, structural damage is unlikely to occur in residential buildings at less than 50 mm/s. Therefore, a worst case predicted vibration level for the Project of over 10 mm/s at 1 Marine Parade is unlikely to cause structural damage but a building condition survey will be required and monitoring undertaken during closest works to minimise any adverse effects where possible.

Effects will be managed via the CNVMP through the use of monitoring and appropriate construction practices to minimise the potential to exceed 5 mm/s when properties are occupied. For all properties identified in Table 5.5, a pre-construction building condition survey shall be undertaken as described in Section 7.1.6.1 before main construction works begin.

Consultation with the building occupants will be carried out prior to construction work starting. Effects will be managed through vibration monitoring and consultation with the occupants prior to construction works starting.

With the exception of the six properties described above which may experience minor vibration effects with management in place, the vibration effects due to the Project are generally no more than minor at the majority of receivers.

6.2 Tunnelling

6.2.1 Potential vibration effects

Vibration from tunnelling along the alignment is predicted to be significantly less than vibration that would be generated by surface works.

The tunnel is located entirely below ground within the road reserve at depths typically between 9 and 17 m for the majority of the alignment and reaches its shallowest points of 3 m around Shaft 7 and SE04. The closest receiver is located approximately 4 m horizontal distance from the tunnel at

98 Sarsfield Street near Shaft 2. All other properties are situated at greater horizontal distances from the TBM.

At 4 m, predicted vibration levels[23] are expected to meet the daytime amenity criteria of 2 mm/s at all receivers. A maximum vibration levels of 1.3 mm/s PPV is anticipated at the shortest distance from the TBM. Even when potential basements and pool depths are taken into consideration, vibration from tunnelling may just be perceptible at the closest residential receivers (refer to Appendix E) but not likely to interfere with day to day activities. With the TBM anticipated advancement rate of 7 – 10 m per day, maximum vibration levels are likely be experienced for up to 2 days per receiver.

Predicted vibration levels are significantly below the DIN 4150-3 limit for cosmetic building damage at all receivers and thus compliant against AUP vibration criterion for works within the road reserve.

Whilst tunnelling works within the road reserve do not need to be assessed again the AUP amenity thresholds, effects from tunnelling will be managed via the CNVMP to include notification of upcoming works prior to commencement of tunnelling activities to mitigate potential concerns or disturbance. With adequate notification and consultation, vibration levels from tunnelling are considered to be reasonable. Furthermore, with tunnelling activities commencing at Point Erin Park, vibration from tunnelling can be monitored and predictions updated to account for local conditions prior to equipment reaching the closest properties. If night time emergency works is required, the effects will be managed via the CNVMP and affected properties will be identified.

Overall, the effects of vibration on receivers along the tunnel alignment from the TBM are expected to be negligible to less than minor.

6.2.2 Regenerated tunnelling noise

Daytime indoor noise at 35 dB L_{Aeq} is unlikely to be noticeable from normal indoor activities and well below the AUP daytime limits. With the TBM moving at a rate of 7 - 10 m a day, the potential for regenerated noise while the TBM passes underneath individual properties will only occur for 1-2 days. Advance communication and consultation when the TBM approaches within 50 m of receivers is recommended to ensure receivers are informed in advance of any potential for regenerated noise.

Whilst not an AUP requirement and night time works are not anticipated as part of the construction methodology, it is considered appropriate to assess the potential for sleep disturbance for unexpected night time emergency works as a possible worst case scenario. Regenerated noise levels due to tunnelling are predicted to exceed the adopted 35 dB L_{Aeq} night time criterion at 99 receivers along the tunnel alignment. Actual noise levels experienced within a dwelling will be dependent on the location of bedrooms, ground transmission and the structure of the dwelling and are likely to be lower than the predicted noise levels. Regenerated noise will likely be tolerable with advance notification and the effects will be managed via the CNVMP if emergency night time works are required.

Overall, daytime noise effects on receivers along the tunnel alignment from the TBM are predicted to be negligible.

[23] Based on previously monitored levels of a similar project and detailed ground investigations across CI sites as described in Section 5.5.1

7 Noise and vibration management

7.1 Construction Noise and Vibration Management Plan

It is common practice for infrastructure projects to implement a CNVMP as part of the construction management plan. Implementing noise management and mitigation measures via a CNVMP is the most effective (and best practice) way to control construction noise and vibration impacts. The objective of the CNVMP should be to provide a framework for the development and implementation of best practicable options to avoid, remedy or mitigate the adverse effects on receivers of noise and vibration resulting from construction. A draft CNVMP identifying the minimum level of information as set out in AUP E25.6.29(5) for the works has been prepared in support of the resource consent.

A CNVMP will be implemented for the work site with specific sections on activities that are predicted to exceed the Project's adopted noise and vibration limits. The CNVMP will be updated to reflect detailed design before commencement of work and kept up to date regarding actual timing/equipment used and methodologies.

The CNVMP should include, but not be limited to, the following recommended mitigation and management measures.

7.1.1 General noise mitigation

- Avoid unnecessary noise, such as shouting, the use of horns, loud site radios, rough handling of material and equipment, and banging or shaking excavator buckets;
- Orient machinery to maximise the distance between the engine exhaust and the nearest sensitive building façade (e.g. excavators);
- Selection of equipment and methodologies to restrict noise;
- Locate equipment at a distance greater than the minimum set back distances where practicable;
- Utilise noise barriers and/or enclosures where appropriate. Noting that there will be negligible benefit if there is line of sight between the receiver and the source of noise; and
- Liaising with neighbours so they can work around specific activities.

7.1.2 Communication and consultation

The key element of noise and vibration management is ensuring that appropriate communication occurs with affected neighbours. Such measures include:

- Prior notification of the works via a letterbox drops or supplemented by other means (news article, website, emails etc) to affected neighbours and properties along the tunnel alignment. The letterbox drop will provide contact details and will detail the overall nature and expected duration of the works; and
- Prior to any particularly noisy process being identified, the most affected neighbours as identified in Appendix C Table 1 will be contacted individually. Neighbours will be informed of the proposed timing of the specific works. Ongoing consultation and communication with neighbours less than 50 m from any construction works or tunnelling works should be undertaken.

7.1.3 Noise barriers

Where practicable, panels should be positioned as close as possible to the construction activity to block line-of-sight between the activity and noise sensitive receivers. Additional local barriers may be necessary near the activity to ensure effective mitigation for sensitive receivers on upper floor

levels. The panels should be a minimum height of 1.8 m, and higher if practicable to block line-of-sight[24]. The panels must be abutted or overlapped to provide a continuous screen without gaps at the bottom or sides of the panels.

Examples of temporary noise barriers include the following proprietary 'noise curtains':

- Echo Barrier Temporary Acoustic Noise Barrier (http://www.supplyforce.co.nz/);
- Duraflex 'Noise Control Barrier – Performance Series' (www.duraflex.co.nz);
- Soundex 'Acoustic Curtain – Performance Series' (NZ); and
- Flexshield 'Sonic Curtain with 4 kg/m^2 mass loaded vinyl backing' (NZ).

7.1.4 Specific construction support area mitigation

It is recommended that a 1.8 – 2 m high hoarding is located around the parameter of the CSA at Salisbury Reserve and stock piling activities to be undertaken at the 94a/94b Shelley Beach Road CSA only.

Construction of pile cages must use localised screening on a minimum of three sides and use a low noise generating cutter such as a hydraulic bar cutter at Salisbury Reserve.

7.1.5 Works outside of standard construction hours

Where practicable all works should be undertaken during the standard construction hours (see Section 2.4.1).

Where there are no practicable alternative options to complete works prior to 7 pm and noise level exceedances are anticipated, it will be necessary to implement enhanced noise and vibration management measures. For example:

- Increase the frequency of communications with stakeholders;
- Carry out regular noise and vibration monitoring to confirm noise and vibration levels; or
- Offer temporary relocation to affected residents if unreasonable noise and/or vibration levels cannot be avoided.

7.1.6 Vibration mitigation

A hierarchy of vibration mitigation measures should be adopted through the CNVMP as follows:

- Managing times of activities to avoid night works and other sensitive times where practicable (communicated through community liaison);
- Liaising and consultation with neighbours prior to commencing works for vibration generating activities;
- Selecting equipment and methodologies to minimise vibration;
- Monitoring of vibration during activities predicted to exceed the 2 mm/s amenity limit and at heritage buildings; and
- Where vibration levels are predicted to exceed the applicable DIN 4150-3 limit (5 mm/s for residential, 3 mm/s for heritage) then a building condition survey shall be undertaken in general accordance with the parameters set out in Section 7.1.6.1.

Mitigation will therefore focus on effective communication with neighbours, and selection of appropriate equipment and methods.

[24] Temporary barriers greater than 3-4 m are generally impracticable to construct due to wind loading constraints.

7.1.6.1 Building condition surveys

A pre-construction building condition survey will be undertaken at all of the identified buildings detailed in Table 5.5 before the main construction works begins.

The building condition surveys will generally be undertaken as follows:

- The building surveys will be undertaken by a suitably qualified and experienced practitioner;
- Seek permission from the owner of a building, structure or service for a suitably qualified and experienced practitioner to prepare a report that:
  - describes any information about the type of foundations;
  - the existing levels of damage (cosmetic, superficial, affecting levels of serviceability);
  - any observed damage is associated with structural damage;
  - identifies the potential for further damage to occur and describes actions that will be taken to avoid further damage; and
  - photographic evidence.
- The Project team will provide the building condition survey report to the property owner; and
- A post condition survey will be undertaken after construction works has been completed, unless the landowner agrees otherwise, or if monitoring determines the post condition survey is unnecessary (ie below the DIN4150-3 threshold).

During construction if complaints are made about vibration or if monitoring determines it necessary, further building condition surveys may be undertaken. Where further surveys identify damage has been encountered, relevant suitably qualified specialists will be engaged to investigate the cause. This may include the vibration specialist, building inspector and building condition author. The outcome of the investigation will be shared with the complainant/affected receiver. If it is determined that the Project is responsible for the damage, a plan will be made to rectify it at Watercare's cost.

8 Conclusions

An assessment of noise and vibration has been carried out for the construction of the proposed Herne Bay Branch 5 Sewer comprising a 2.1 m diameter pipe tunnel between Point Erin Park and Marine Parade in Herne Bay and connection pipelines. The surface construction and tunnelling alignment works are all proposed within the road reserves and as such are a permitted activity in accordance with the AUP Section E25.6.29 (3)(b) for noise and Section E25.6.29(4A) for vibration with the submission of a CNVMP. The works described in this report are typical for construction works carried out at other large-scale infrastructure works across Auckland and at consented CI sites.

Predicted noise and vibration levels have been assessed against relevant AUP performance standards to assess the potential effects for management and mitigation purposes. The assessment is based on an indicative construction methodology for a worst-case scenario. It is also informed by practical on-the-ground experience gained through the CI project to date.

The assessment has been split between surface construction works (shaft construction, open trenching), tunnelling and construction support areas.

8.1 Surface construction works

Predictions indicate worst-case noise levels of between 88 – 84 dB at six properties and the property at 8 Wairangi Street will experience noise levels of up to 92 dB L_{Aeq} during open trenching activities when at the closest point. The maximum noise levels at façades are not expected to be continuous (it will be intermittent in nature and temporary) and are only likely to occur as a worst-case scenario when trenching or piling is occurring immediately adjacent to the property boundaries. Where possible HDD will be used around most affected receivers to reduce the impacts of open trenching, but may be restricted due to geology, depth and logistics of connection.

High external noise levels from piling are not uncommon for works close to residential receivers and the resulting effects has been successfully managed on existing CI sites. As required by the proposed conditions of consent, the Project will address these controls through the CNVMP (an activity specific section or addendum) which details the level of mitigation, management and consultation that is required to manage disruption.

Noise mitigation measures and consultation will be required to manage noise. With mitigation in place, overall effects can be appropriately managed and reduced to ensure construction noise effects are acceptable and no more than minor.

With the exception of four properties, construction vibration at the majority of receivers is not likely to exceed the relevant DIN 4150-3 limits for cosmetic building damage. Two properties (1 Marine Parade, 8 Wairangi Street) may experience vibration levels above the 5 mm/s during the use of the breaker and two properties within the Herne Bay Heritage area (34 Herne Bay Road and 72 Argyle Street) are predicted to experience vibration over the 3 mm/s DIN threshold for sensitive structures. Vibration at these properties will be managed via consultation and monitoring addressed in the CNVMP and building condition surveys will be undertaken prior to the commencement of any main construction works. A resource consent is required to exceed the DIN 4510-3 limits at the four properties. The vibration effects due to the Project is generally no more than minor at the majority of receivers.

8.2 Tunnelling

Tunnelling works are proposed for daytime operations only. Predictions for regenerated noise during unexpected night time works indicate that when the TBM is approximately 18 m or less from dwellings there is the potential to exceed the recommended night-time noise level in bedrooms of

35 dB L_{Aeq}. While this is not an AUP requirement, it is considered that this is a suitable measure to address any affected parties' concerns regarding sleep disturbance. 35 dB L_{Aeq} is not likely to be perceptible during the daytime.

A maximum vibration level of 1.3 mm/s is predicted at the closest receiver (98 Sarsfield Street) due to the TBM operation and vibrations are likely to be perceivable but well below the DIN limit of 5 mm/s. Whilst amenity vibration thresholds are not applicable to this Project, properties above the night time criterion will be managed via a section within the CNVMP to address any concerns if night time emergency works is required.

8.3 Construction support areas

Two construction support areas are proposed, one at Salisbury Reserve and another at 94a/94b Shelley Beach Road. The Shelley Beach Road site is anticipated to be located over 90 m from the nearest receiver and is predicted to comply with the 70 dB L_{Aeq} daytime noise limit for all supporting site work based on distance attenuation alone.

The site at Salisbury Reserve is surrounded by one to two storey residential properties at the boundaries. With general support activities undertaken at the Salisbury Reserve, noise levels can be effectively mitigated with a 2 m high solid hoarding around the site boundary to achieve a maximum noise level of below 75 dB L_{Aeq} at all receivers. A resource consent is required to exceed the daytime limit of 70 dB L_{Aeq} at 4/40 Wallace Street and 6 Argyle Street for works proposed at Salisbury Reserve.

9 Recommendations for consent conditions

Should consent be granted for this application we recommend the following conditions relating to noise and vibration:

1 The Consent Holder shall prepare a Construction Noise and Vibration Management Plan (CNVMP) for the Project, or each stage of the Project, that addresses the management of construction noise and vibration from the works. The CNVMP shall be consistent with the draft CNVMP (dated XX/XX/XX) referenced in Condition 1.

The CNVMP shall be submitted to the Council no less than twenty (20) working days prior to works on that stage commencing for certification by Council that the CNVMP complies with the requirements of Conditions 3 to 9, as applicable.

The objectives of the CNVMP are to:

a Identify the Best Practicable Option (BPO) for the management and mitigation of construction noise and vibration effects.

a Identify how Project noise and vibration limits will be met and set out the methods for scheduling and undertaking works to manage disruption.

b Ensure engagement with affected receivers and timely management of complaints.

2 The CNVMP shall be prepared by a suitably qualified and experienced practitioner and shall set out, as a minimum:

a The relevant construction noise and vibration criteria/limits set out in these conditions;

b Description and duration of the works, predicted construction noise and vibration levels, anticipated equipment and hours of operation (including specific times and days when construction activities causing noise/vibration would occur);

c The processes to be undertaken including general acoustic management and mitigation measures proposed to be implemented throughout the course of the Project consistent with best practice and the triggers or thresholds for implementing them (if relevant);

d Physical noise mitigation measures, including prohibiting the use of tonal reverse alarms, maintenance of access roads (to ensure they are smooth), plant selection and maintenance procedures, orientation of plant and machinery, and site layout. Physical noise mitigation measures shall also include the following, as required to ensure a BPO approach to the management of noise: setting minimum setback distances from sensitive receivers (dwellings); acoustic screening shaft site construction area; open trenching;

e The identification of activities (e.g. piling, open trenching, HDD) and locations that will require specific noise mitigation measures (including scheduling of works, location and orientation of works and/or the use of temporary acoustic barriers), consultation undertaken with affected properties to develop the proposed noise management measures, any feedback received from those stakeholders along with the noise management measures that will be adopted based on this consultation;

f Identification of any activities particularly sensitive to vibration and noise in the vicinity of the proposed works (e.g. XXXXX) along with the details of consultation with the land owner(s) of the sites where the sensitive activities are located and any management measures that will be adopted, where required, based on this consultation;

g Details of noise and vibration monitoring to be undertaken and reporting requirements;

h Communication requirements with stakeholders including notice to owners and occupiers of adjacent buildings prior to construction activities commencing on the site;

i A complaint management system with contact numbers for key construction staff responsible for the implementation of the CNVMP and complaint investigation.

j The process for changing, updating, and certifying any changes to the CNVMP; and

k Training procedures for construction personnel.

The CNVMP shall be implemented and maintained by the Consent Holder throughout the construction period for the Project or relevant Project stage to manage potential adverse noise and vibration effects arising from construction activities. The CNVMP or any specific component of the CNVMP shall be updated as necessary and provided to the Council for certification prior to being implemented.

3 Construction noise shall be measured and assessed in accordance with NZS6803:1999 Acoustics – Construction Noise.

4 Construction noise in the Construction Support Areas (CSAs) shall comply with the following noise limits, except where authorised by an ASCNVMP (Condition 5):

Time of week	Time period	Noise limit dB	
		L_{Aeq}	L_{Amax}
Weekdays	6:30 am – 7:30 am	55	75
	7:30 am – 6:00 pm	70	85
	6:00 pm – 8:00 pm	65	80
	8:00 pm – 6:30 am	45	75
Saturdays	6:30 am – 7:30 am	45	75
	7:30 am – 6:00 pm	70	85
	6:00 pm – 8:00 pm	45	75
	8:00 pm – 6:30 am	45	75
Sundays and Public Holidays	6:30 am – 7:30 am	45	75
	7:30 am – 6:00 pm	55	85
	6:00 pm – 8:00 pm	45	75
	8:00 pm – 6:30 am	45	75

Advice note: i. These limits are contained in Table E25.6.27(1) of the AUP and modified by Standard E25.6.27(4).

ii. Project construction hours are subject to Condition xx.

5 An Activity Specific Construction Noise and Vibration Management Plan (ASCNVMP) shall be prepared for works predicted to exceed the project construction noise or vibration limits. For the avoidance of doubt, an ASCNVMP may be a separate management plan or may be included as a section in the CNVMP or otherwise appended to the CNVMP.

6 In preparing an ASCNVMP, the Consent Holder shall consult with those parties likely to be exposed to noise levels exceeding the relevant noise limit(s) and shall submit the results of this consultation to Auckland Council, including any response by the Consent Holder to a matter raised in consultation. The ASCNVMP(s) shall be submitted to the Council for review and approval at least 7 working days prior to the proposed works commencing.

Works subject to the ASCNVMP(s) shall not commence until approval is received from the Council. If monitoring shows that levels specified in an ASCNVMP are being exceeded, work

generating the exceedance shall stop and not recommence until further mitigation is implemented in accordance with an amended ASCNVMP approved by the Council.

An ASCNVMP must:

a describe the activity (including duration), plant and machinery that is expected not to comply with the noise limits in Condition 4;

b describe the mitigation measures proposed to reduce the noise levels as far as practicable, including any options that have been discounted due to cost or any other reason;

c provide predicted noise levels for all receivers where the noise levels will not be compliant with the limits in Condition 4, including the effect of mitigation specified in (b) above;

d provide a set of noise limits that are Activity – Specific;

e describe the noise monitoring that will be undertaken to determine compliance with the Activity – Specific noise limits; and

f describe any additional noise mitigation measures that may be implemented to maintain compliance with Activity Specific noise limits.

Advice Note: It is accepted that the noise limits in Condition 4 may not be met at all times, but that the Consent Holder will adopt the Best Practicable Option to achieve compliance.

7 An ASCNVMP shall be submitted to Auckland Council no less than seven (7) working days prior to works on that stage commencing for certification that the ASCNVMP complies with the requirements of Conditions 5 and 6, as applicable.

8 Construction activities shall comply with the Guideline vibration limits set out in the German Industrial Standard DIN 4150-3 (1999) Structural Vibration – Part 3 Effects of Vibration on Structures (DIN 4150)

9 All tunnelling and construction works must be designed and undertaken to ensure that vibration from the Project does not exceed the guideline vibration limits as set out in the DIN 4150-3:1999 Standard.

Note: Works generating vibration for three days or less between the hours of 7 am to 6 pm may exceed these limits subject to compliance with Condition 8 and provided that all occupied buildings within 50 m of the extent of the works generating vibration are advised in writing no less than three days prior to the vibration-generating works commencing. The written advice must include details of the location of the works, the duration of the works, a phone number for questions and complaints and the name of the site manager.

Advice note: These limits are contained in Table E25.6.30.1 of the AUP

10 Applicability

This report has been prepared for the exclusive use of our client Watercare Services Ltd, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

We understand and agree that our client will submit this report as part of an application for resource consent and that Auckland Council as the consenting authority will use this report for the purpose of assessing that application.

Tonkin & Taylor Ltd
Environmental and Engineering Consultants

Report prepared by:

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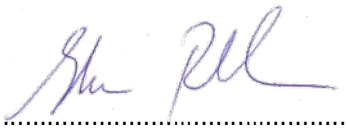
Sharon Yung
Senior Acoustic Consultant

Authorised for Tonkin & Taylor Ltd by:



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Appendix A Glossary

Term	Definition
dB	A unit of measurement on a logarithmic scale which describes the magnitude of sound pressure with respect to a reference value (20 µPa)
$L_{Aeq(t)}$	The A-weighted time-average sound level over a period of time (t), measured in units of decibels (dB)
L_{WA}	Sound power level
PPV	Peak particle velocity. This is the instantaneous maximum velocity reached by the vibrating surface as it oscillates about its normal position
Noise	Unwanted sound

Every 10 dB increase in sound level doubles the perceived noise level. A sound of 70 dB is twice as loud as a sound level of 60 dB and a sound level of 80 dB is four times louder than a sound level of 60 dB. An increase or decrease in sound level of 3 dB or more is perceptible. A change in sound level of less than 3 dB is not usually discernible.

As sound level is measured on a logarithmic scale, the following chart provides examples of typical sources of noise.

Decibel (dB)	Example
0	Hearing threshold
20	Still night-time
30	Library
40	Typical office room with no talking
50	Heat pump running in living room
60	Conversational speech
70	10 m from edge of busy urban road
80	10 m from large diesel truck
90	Lawn mower - petrol
100	Riding a motorcycle at 80 kph
110	Rock band at a concert
120	Emergency vehicle siren
140	Threshold of permanent hearing damage

Appendix B Sensitive receivers

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CLIENT **WATERCARE SERVICES LIMITED**

PROJECT **HERNE BAY SEWER BRANCH 5**

TITLE SENSITIVE RECEIVERS

SCALE (A3) 1:2,000 FIG No. APPENDIX B FIGURE 1.1 REV 0

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TITLE SENSITIVE RECEIVERS

SCALE (A3) 1:2,000 FIG No. APPENDIX B FIGURE 1.2 REV 0

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TITLE SENSITIVE RECEIVERS

SCALE (A3) 1:2,000 FIG No. APPENDIX B FIGURE 1.3 REV 0

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TITLE SENSITIVE RECEIVERS

SCALE (A3) 1:1,500 FIG No. APPENDIX B FIGURE 1.4 REV 0

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PROJECT **HERNE BAY SEWER BRANCH 5**
TITLE VIBRATION SENSITIVE RECEIVERS
SCALE (A3) 1:1,000 FIG No. APPENDIX B FIGURE 2.1 REV 0

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TITLE VIBRATION SENSITIVE RECEIVERS

SCALE (A3) 1:1,000 FIG No. APPENDIX B FIGURE 2.2 REV 0

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TITLE CSA - SALISBURY RESERVE SENSITIVE RECEIVERS

SCALE (A3) 1:1,000 FIG No. APPENDIX B FIGURE 3. REV 0

Appendix C Predicted noise and vibration levels – surface construction

The following table provides the highest predicted noise and vibration level for various surface construction acitivities when works are at the closest location to each receiver. Highest noise levels are typically at first floor level or above.

Appendix C Table 1: Predicted noise and vibration levels for surface construction activities at receivers without mitigation

Receiver ID	Address	Nearest work location	Distance from works (m)	Open Trenching (L_{Aeq}, dB)	Shaft Construction (L_{Aeq}, dB)	Intercept Shaft construction (L_{Aeq}, dB)	HDD (L_{Aeq}, dB)	Vibration levels (PPV)
1	1 Marine Parade	HDD	1	-	65	-	71	> 10 mm/s
2	8 Wairangi Street	Open Trench	5	92	46	-	66	5 - 6 mm/s
3	34 Herne Bay Road*	Shaft 5	6	-	82	-	59	4 - 5 mm/s
4	33 Marine Parade	Shaft 6	7	69	-	-	-	4 - 5 mm/s
5	6 River Terrace	Open Trench	7	88	55	-	58	4 - 5 mm/s
6	67 Hamilton Road	HDD	8	-	-	-	69	3 - 4 mm/s
7	22 Marine Parade	Open Trench	8	87	69	-	-	3 - 4 mm/s
8	72 Argyle Street*	Shaft 4	8	-	-	-	-	3 - 4 mm/s
10	54 Sarsfield Street	SE01	9	-	-	78	72	3 - 4 mm/s
11	49 Marine Parade	Open Trench	10	84	57	-	-	3 - 4 mm/s
12	91 Sarsfield Street	SE03	10	65	65	81	-	3 - 4 mm/s
13	32 Sentinel Road	Open Trench	10	85	46	-	-	3 - 4 mm/s
14	34 Sentinel Road	Open Trench	10	84	42	-	-	3 - 4 mm/s
15	53 Marine Parade	Open Trench	11	79	45	-	-	3 - 4 mm/s
16	36 Sentinel Road	Open Trench	11	83	44	-	-	3 - 4 mm/s
17	40 Sentinel Road	Open Trench	11	81	43	-	-	3 - 4 mm/s

Receiver ID	Address	Nearest work location	Distance from works (m)	Open Trenching (L_{Aeq}, dB)	Shaft Construction (L_{Aeq}, dB)	Intercept Shaft construction (L_{Aeq}, dB)	HDD (L_{Aeq}, dB)	Vibration levels (PPV)
18	45 Argyle Street	SE04	11	-	57	81	-	3 - 4 mm/s
19	45 Marine Parade	Open Trench	12	83	61	-	-	3 - 4 mm/s
20	53 Sentinel Road	Open Trench	12	83	-	-	-	3 - 4 mm/s
21	45 Sentinel Road	Open Trench	12	83	-	-	-	3 - 4 mm/s
22	3 Wairangi Street	Open Trench	12	83	56	-	67	3 - 4 mm/s
23	50 Wallace Street	Shaft 3	12	56	79	-	59	3 - 4 mm/s
24	36 Herne Bay Road	Shaft 5	12	47	80	-	68	3 - 4 mm/s
25	48 Wallace Street	Shaft 3	13	63	79	-	56	3 - 4 mm/s
26	44 Sentinel Road	Open Trench	13	82	52	66	-	3 - 4 mm/s
27	5 Stack Street	HDD	13	74	65	-	72	3 - 4 mm/s
28	28 Sentinel Road	Open Trench	13	81	42	-	-	3 - 4 mm/s
29	39 Wallace Street	Shaft 3	13	67	80	-	56	3 - 4 mm/s
30	26 Marine Parade	Open Trench	13	82	62	-	-	3 - 4 mm/s
31	46 Argyle Street	SE04	13	-	-	84	-	3 - 4 mm/s
32	38 Bella Vista Road	Open Trench	14	79	-	-	-	2 - 3 mm/s
33	10 Wairangi Street	Open Trench	14	80	56	-	64	2 - 3 mm/s
34	48 Sentinel Road	Open Trench	14	81	57	69	-	2 - 3 mm/s
35	64 Hamilton Road	SE01	15	-	-	76	69	2 - 3 mm/s
36	66 Hamilton Road	HDD	15	-	-	70	63	2 - 3 mm/s
37	69 Hamilton Road	HDD	15	-	-	-	65	2 - 3 mm/s
38	50 Sentinel Road	Open Trench	15	81	47	72	-	2 - 3 mm/s
39	54 Sentinel Road	Open Trench	16	81	52	75	-	2 - 3 mm/s
40	2/49 Sentinel Road	Open Trench	16	80	-	-	-	2 - 3 mm/s

Receiver ID	Address	Nearest work location	Distance from works (m)	Open Trenching (L_{Aeq}, dB)	Shaft Construction (L_{Aeq}, dB)	Intercept Shaft construction (L_{Aeq}, dB)	HDD (L_{Aeq}, dB)	Vibration levels (PPV)
41	56 Sentinel Road	Open Trench	16	81	57	79	-	2 - 3 mm/s
42	24 Marine Parade	Open Trench	16	81	58	-	-	2 - 3 mm/s
43	28 Marine Parade	Open Trench	16	80	61	-	-	2 - 3 mm/s
44	96 Sarsfield Street	Shaft 2	16	81	83	-	74	2 - 3 mm/s
45	98 Sarsfield Street	Shaft 2	16	81	83	-	74	2 - 3 mm/s
46	30 Sarsfield Street	Shaft 1	17	-	78	-	-	2 - 3 mm/s
47	11 Cremorne Street	Open Trench	17	79	45	-	42	2 - 3 mm/s
48	57 Sentinel Road	Open Trench	17	80	-	68	-	2 - 3 mm/s
49	2/49 Sentinel Road	Open Trench	17	80	-	-	-	2 - 3 mm/s
50	42 Sentinel Road	Open Trench	17	79	48	-	-	2 - 3 mm/s
51	56 Sarsfield Street	SE01	17	-	-	73	67	2 - 3 mm/s
52	28 Sarsfield Street	Shaft 1	18	-	76	-	-	2 - 3 mm/s
53	57 Marine Parade	Open Trench	18	79	-	-	-	2 - 3 mm/s
54	39 Marine Parade	Shaft 7	18	79	66	-	-	2 - 3 mm/s
55	41 Wallace Street	Shaft 3	18	67	77	-	47	2 - 3 mm/s
56	31 Herne Bay Road	Shaft 5	18	-	76	-	68	2 - 3 mm/s
57	35 Sentinel Road	Open Trench	19	77	-	-	-	2 - 3 mm/s
58	12 Stack Street	HDD	19	64	62	-	68	2 - 3 mm/s
59	47 Marine Parade	Open Trench	19	79	54	-	-	2 - 3 mm/s
60	2/59 Sentinel Road	Open Trench	19	80	-	71	-	2 - 3 mm/s
61	31 Marine Parade	Shaft 6	19	63	76	-	-	2 - 3 mm/s
62	80 Sarsfield Street	Open Trench	19	80	-	77	-	2 - 3 mm/s
63	43 Wallace Street	Shaft 3	19	66	78	53	59	2 - 3 mm/s

Receiver ID	Address	Nearest work location	Distance from works (m)	Open Trenching (L_{Aeq}, dB)	Shaft Construction (L_{Aeq}, dB)	Intercept Shaft construction (L_{Aeq}, dB)	HDD (L_{Aeq}, dB)	Vibration levels (PPV)
64	49A Argyle Street	SE04	19	-	46	78	-	2 - 3 mm/s
65	29 Herne Bay Road	Shaft 5	19	-	76	-	63	2 - 3 mm/s
66	37A Sentinel Road	Open Trench	20	78	-	-	-	2 - 3 mm/s
67	58 Heritage Wallace Street	Shaft 2	20	67	74	-	67	2 - 3 mm/s
68	32 Marine Parade	Open Trench	20	78	57	-	-	2 - 3 mm/s
69	79 Argyle Street	Shaft 4	20	-	76	-	69	2 - 3 mm/s
70	103 Sarsfield Street	Shaft 2	21	74	74	53	66	2 - 3 mm/s
71	41 Sentinel Road	Open Trench	21	78	-	-	-	2 - 3 mm/s
72	88 Sarsfield Street	SE03	21	63	64	77	-	2 - 3 mm/s
73	30 Marine Parade	Open Trench	21	78	58	-	-	2 - 3 mm/s
74	32 Herne Bay Road	Shaft 5	21	-	76	-	57	2 - 3 mm/s
75	26 Sentinel Road	Open Trench	21	76	40	-	-	2 - 3 mm/s
76	42 Herne Bay Road	Shaft 4	21	39	75	-	67	2 - 3 mm/s
77	3 River Terrace	Open Trench	22	80	44	-	45	2 - 3 mm/s
79	50 Argyle Street	SE04	22	-	57	79	-	2 - 3 mm/s
80	70 Argyle Street	Shaft 4	22	-	75	-	67	2 - 3 mm/s
81	99 Sarsfield Street	SE03	22	68	68	75	59	2 - 3 mm/s
82	38 Bella Vista Road	Open Trench	23	77	46	-	-	2 - 3 mm/s
83	35 Marine Parade	Shaft 7	23	74	74	-	-	2 - 3 mm/s
84	44 Argyle Street	SE04	23	-	-	75	-	2 - 3 mm/s
85	15 Cremorne Street	Open Trench	24	75	44	-	49	2 - 3 mm/s
86	46 Wallace Street	Shaft 3	24	62	75	-	53	2 - 3 mm/s
87	52 Wallace Street	Shaft 3	24	55	75	-	65	2 - 3 mm/s

Receiver ID	Address	Nearest work location	Distance from works (m)	Open Trenching (L_{Aeq}, dB)	Shaft Construction (L_{Aeq}, dB)	Intercept Shaft construction (L_{Aeq}, dB)	HDD (L_{Aeq}, dB)	Vibration levels (PPV)
88	70 Curran Street	Shaft 1	25	-	72	-	-	2 - 3 mm/s
89	65 Hamilton Road	HDD	25	-	-	57	54	2 - 3 mm/s
90	57 Argyle Street	SE04	25	-	49	76	-	2 - 3 mm/s
91	26 Sarsfield Street	Shaft 1	26	-	72	-	-	2 - 3 mm/s
92	83 Sarsfield Street	SE02	26	73	48	74	-	2 - 3 mm/s
93	89 Sarsfield Street	SE03	26	66	63	77	-	2 - 3 mm/s
94	86 Sarsfield Street	SE03	26	61	63	77	-	2 - 3 mm/s
95	46 Sentinel Road	Open Trench	26	76	57	56	-	2 - 3 mm/s
96	6 Stack Street	HDD	26	66	69	-	67	2 - 3 mm/s
97	43 Marine Parade	Open Trench	26	76	62	-	-	2 - 3 mm/s
98	79 Sarsfield Street	SE02	26	74	-	75	-	2 - 3 mm/s
99	27 Herne Bay Road	Shaft 5	26	-	75	-	58	2 - 3 mm/s
100	33 Sentinel Road	Open Trench	26	75	-	-	-	2 - 3 mm/s
101	52 Sentinel Road	Open Trench	27	77	50	69	-	2 - 3 mm/s
102	61 Sarsfield Street	SE01	27	-	-	79	68	2 - 3 mm/s
103	1 Stack Street	HDD	27	72	67	-	68	2 - 3 mm/s
104	60 Hamilton Road	SE01	28	-	-	72	64	1 - 2 mm/s
105	54 Wallace Street	Shaft 2	28	60	76	-	69	1 - 2 mm/s
106	94 Sarsfield Street	Shaft 2	28	72	72	-	65	1 - 2 mm/s
107	37 Wallace Street	Shaft 3	29	61	72	-	38	1 - 2 mm/s
108	16 Upton Street	Shaft 6	29	72	73	-	-	1 - 2 mm/s
109	84 Sarsfield Street	SE03	30	68	64	77	-	1 - 2 mm/s
110	3 Wairangi Street	Open Trench	30	76	56	-	64	1 - 2 mm/s

Receiver ID	Address	Nearest work location	Distance from works (m)	Open Trenching (L_{Aeq}, dB)	Shaft Construction (L_{Aeq}, dB)	Intercept Shaft construction (L_{Aeq}, dB)	HDD (L_{Aeq}, dB)	Vibration levels (PPV)
111	2 Argyle Street	Shaft 3	31	63	74	-	42	1 - 2 mm/s
112	47 Wallace Street	Shaft 2	31	71	72	62	60	1 - 2 mm/s
113	37 Marine Parade	Shaft 7	31	75	64	-	-	1 - 2 mm/s
114	53B Sentinel Road	Open Trench	31	75	-	46	-	1 - 2 mm/s
115	90 Sarsfield Street	SE03	31	61	60	74	49	1 - 2 mm/s
116	63 Hamilton Road	HDD	31	-	-	75	66	1 - 2 mm/s
117	49A Argyle Street	SE04	31	-	43	73	-	1 - 2 mm/s
118	7 Stack Street	HDD	32	72	61	-	66	1 - 2 mm/s
119	85 Heritage Sarsfield Street	SE02	33	73	59	74	-	1 - 2 mm/s
120	58 Wallace Street	Shaft 2	33	58	74	-	64	1 - 2 mm/s
121	41 Marine Parade	Open Trench	33	75	57	-	-	1 - 2 mm/s
122	39 Argyle Street	SE04	33	-	-	75	-	1 - 2 mm/s
123	2/49 Sentinel Road	Open Trench	34	71	-	-	-	1 - 2 mm/s
124	87 Sarsfield Street	SE03	34	68	61	73	-	1 - 2 mm/s
125	45A Argyle Street	SE04	34	-	47	74	-	1 - 2 mm/s
126	59 Hamilton Road	SE01	35	-	39	76	66	1 - 2 mm/s
127	2/59 Sentinel Road	Open Trench	35	75	-	66	-	1 - 2 mm/s
128	2 Upton Street	Shaft 5	35	46	71	-	57	1 - 2 mm/s
129	52 Argyle Street	SE04	35	-	59	75	-	1 - 2 mm/s
130	39 Marine Parade	Shaft 7	36	73	59	-	-	1 - 2 mm/s
131	101 Sarsfield Street	SE03	37	69	70	71	62	1 - 2 mm/s
132	60 Wallace Street	Shaft 2	37	69	68	-	61	1 - 2 mm/s
133	31 Sentinel Road	Open Trench	37	71	-	-	-	1 - 2 mm/s

Receiver ID	Address	Nearest work location	Distance from works (m)	Open Trenching (L_{Aeq}, dB)	Shaft Construction (L_{Aeq}, dB)	Intercept Shaft construction (L_{Aeq}, dB)	HDD (L_{Aeq}, dB)	Vibration levels (PPV)
134	9 Argyle Street	Shaft 3	38	63	70	-	64	1 - 2 mm/s
135	25 Herne Bay Road	Shaft 5	38	-	71	-	58	1 - 2 mm/s
136	59 Argyle Street	SE04	38	-	58	74	52	1 - 2 mm/s
137	92 Sarsfield Street	Shaft 2	38	70	70	73	63	1 - 2 mm/s
138	52 Wallace Street	Shaft 3	39	62	53	-	63	1 - 2 mm/s
139	34 Bella Vista Road	Open Trench	39	72	48	-	-	1 - 2 mm/s
140	78 Sarsfield Street	Open Trench	39	73	-	72	33	1 - 2 mm/s
141	11 Cremorne Street	Open Trench	39	71	46	-	57	1 - 2 mm/s
142	40 Marine Parade	Open Trench	40	71	-	-	-	1 - 2 mm/s
143	88 Sarsfield Street	SE03	40	57	56	72	-	1 - 2 mm/s
144	59 Marine Parade	Open Trench	41	72	-	-	-	1 - 2 mm/s
145	14 Stack Street	HDD	41	65	61	-	65	1 - 2 mm/s
146	11 Bella Vista Road	Open Trench	42	72	59	-	-	1 - 2 mm/s
147	30 Masons Avenue	Shaft 5	42	-	70	-	59	1 - 2 mm/s
148	42 Argyle Street	SE04	42	-	-	72	-	1 - 2 mm/s
149	37B Sentinel Road	Open Trench	44	71	-	-	-	1 - 2 mm/s
150	61 Marine Parade	Open Trench	46	71	-	-	-	1 - 2 mm/s
151	9/57 Sarsfield Street	HDD	46	73	-	64	48	1 - 2 mm/s
152	5 Upton Street	Shaft 5	46	53	71	-	37	1 - 2 mm/s
153	72 Sarsfield Street	Open Trench	47	72	-	65	39	1 - 2 mm/s
154	95 Sarsfield Street	SE03	49	57	51	73	37	1 - 2 mm/s
155	9 Cremorne Street	Open Trench	49	71	59	-	58	1 - 2 mm/s
156	57 Hamilton Road	SE01	51	-	48	72	61	1 - 2 mm/s

Receiver ID	Address	Nearest work location	Distance from works (m)	Open Trenching (L_{Aeq}, dB)	Shaft Construction (L_{Aeq}, dB)	Intercept Shaft construction (L_{Aeq}, dB)	HDD (L_{Aeq}, dB)	Vibration levels (PPV)
157	39 Lawrence Street	Open Trench	52	71	43	-	-	1 - 2 mm/s
158	42 Marine Parade	Open Trench	52	70	-	-	-	1 - 2 mm/s
160	61 Sarsfield Street	SE01	54	-	-	62	44	1 - 2 mm/s
161	72 Sarsfield Street	Open Trench	54	70	-	44	37	1 - 2 mm/s
162	31 Lawrence Street	Open Trench	60	67	39	-	-	1 - 2 mm/s
163	67 Sarsfield Street	SE01	60	-	-	52	51	1 - 2 mm/s
164	49 Lawrence Street	SE03	62	65	60	70	-	1 - 2 mm/s
165	11 Galatea Terrace	Shaft 5	62	53	60	-	45	1 - 2 mm/s

* Listed Heritage Building/Heritage Area

Appendix D Noise contour maps

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PROJECT **HERNE BAY SEWER BRANCH 5**

TITLE PREDICTED NOISE LEVELS SHAFT CONSTRUCTION

SCALE (A3) 1:1,000 FIG No. APPENDIX D FIGURE 1.1 REV 0

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Waitangi Wharf Reserve
Home Bay
Sentinel Beach Reserve
River Tce
Waitangi St
Wallace St
Sarsfield St
Sentinel Rd
Lawrence St
Stack St
Argyle St
EOP1019 WWMH02
RIM:15.74
WW1
EOP1019 WWMH01
RIM:17.54
WW1
EOP201
RIM:12.75
WW1
SE03
RIM:13.05
WW1
SE02
RIM:17.8
WW1
SHAFT 2
RIM:18.44
WW1
SHAFT 3
RIM:22.35
WW1

A3 SCALE 1:1,000
0 0.01 0.02 0.03 0.04 0.05 (km)

LEGEND

Receivers

dB LAeq

<70

>70

Shaft Construction

dB LAeq

< 60

60 - 70

> 70

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CLIENT **WATERCARE SERVICES LIMITED**

PROJECT **HERNE BAY SEWER BRANCH 5**

TITLE PREDICTED NOISE LEVELS SHAFT CONSTRUCTION

SCALE (A3) 1:1,000 FIG No. APPENDIX D FIGURE 1.2 REV 0

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PROJECT **HERNE BAY SEWER BRANCH 5**

TITLE PREDICTED NOISE LEVELS SHAFT CONSTRUCTION

SCALE (A3) 1:1,000 FIG No. APPENDIX D FIGURE 1.3 REV 0

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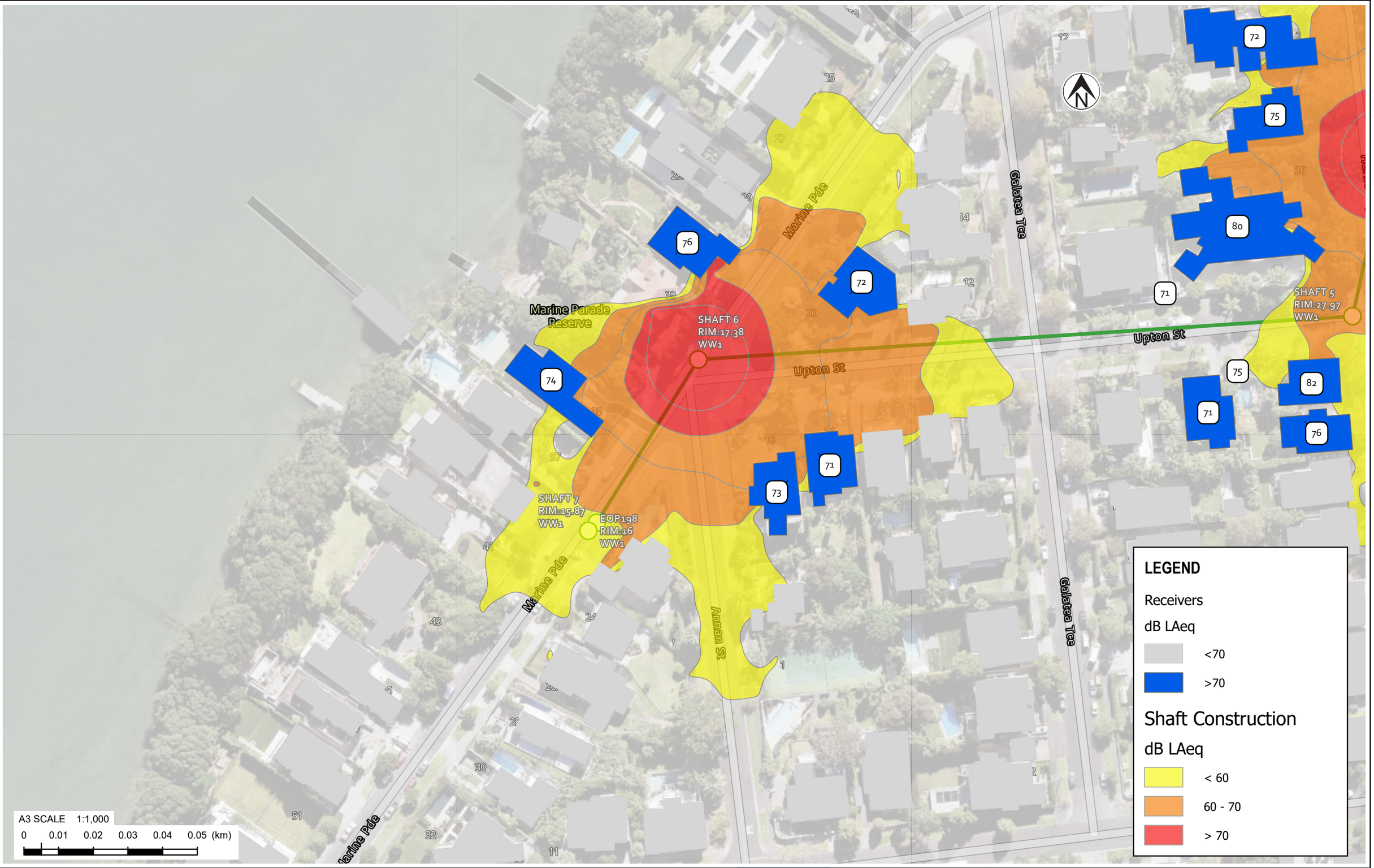

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PROJECT **HERNE BAY SEWER BRANCH 5**

TITLE PREDICTED NOISE LEVELS SHAFT CONSTRUCTION

SCALE (A3) 1:1,000 FIG No. APPENDIX D FIGURE 1.4 REV 0

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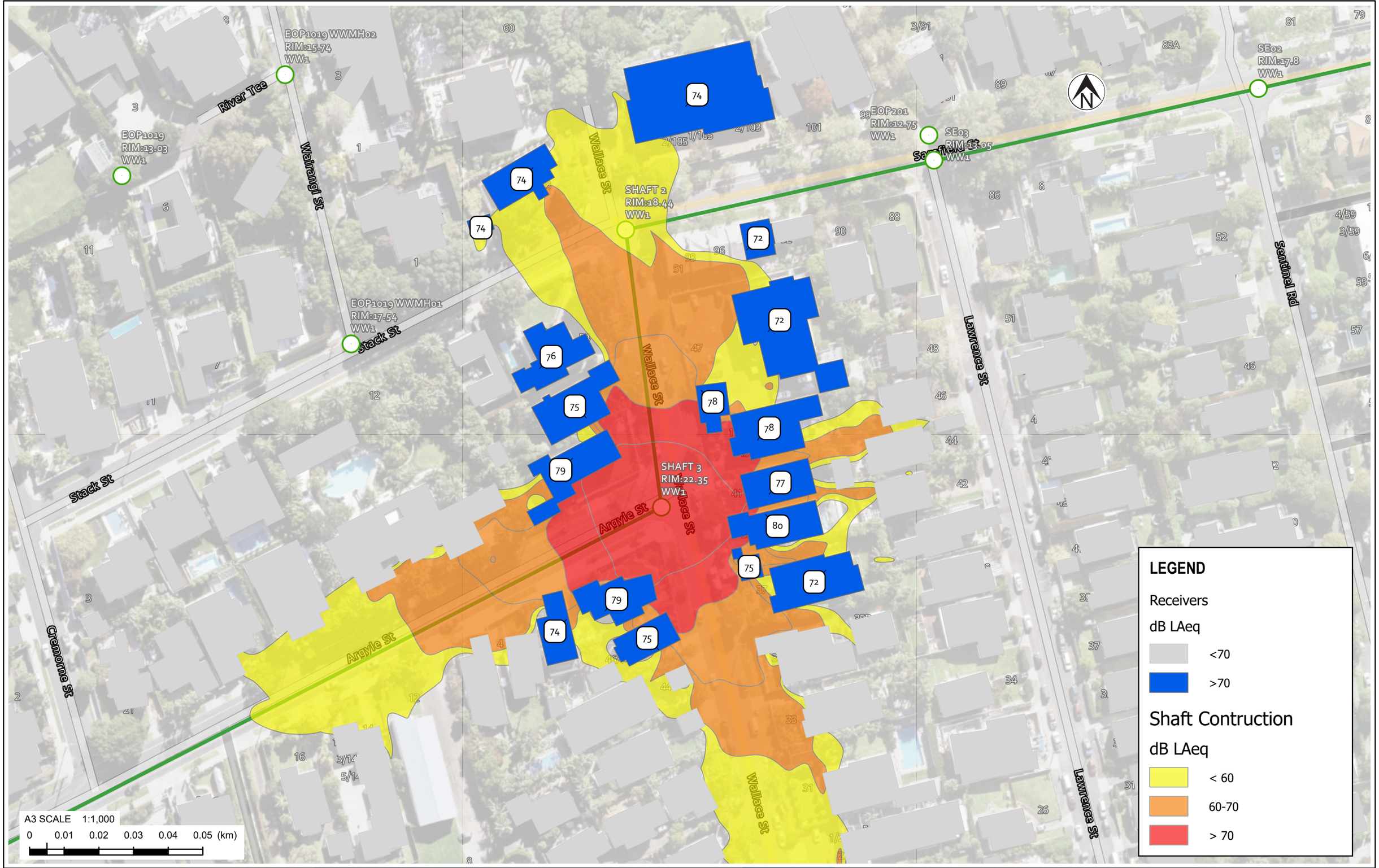

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CLIENT WATERCARE SERVICES LIMITED
PROJECT HERNE BAY SEWER BRANCH 5
TITLE PREDICTED NOISE LEVELS SHAFT CONSTRUCTION
SCALE (A3) 1:1,000 FIG No. APPENDIX D FIGURE 1.5 REV 0

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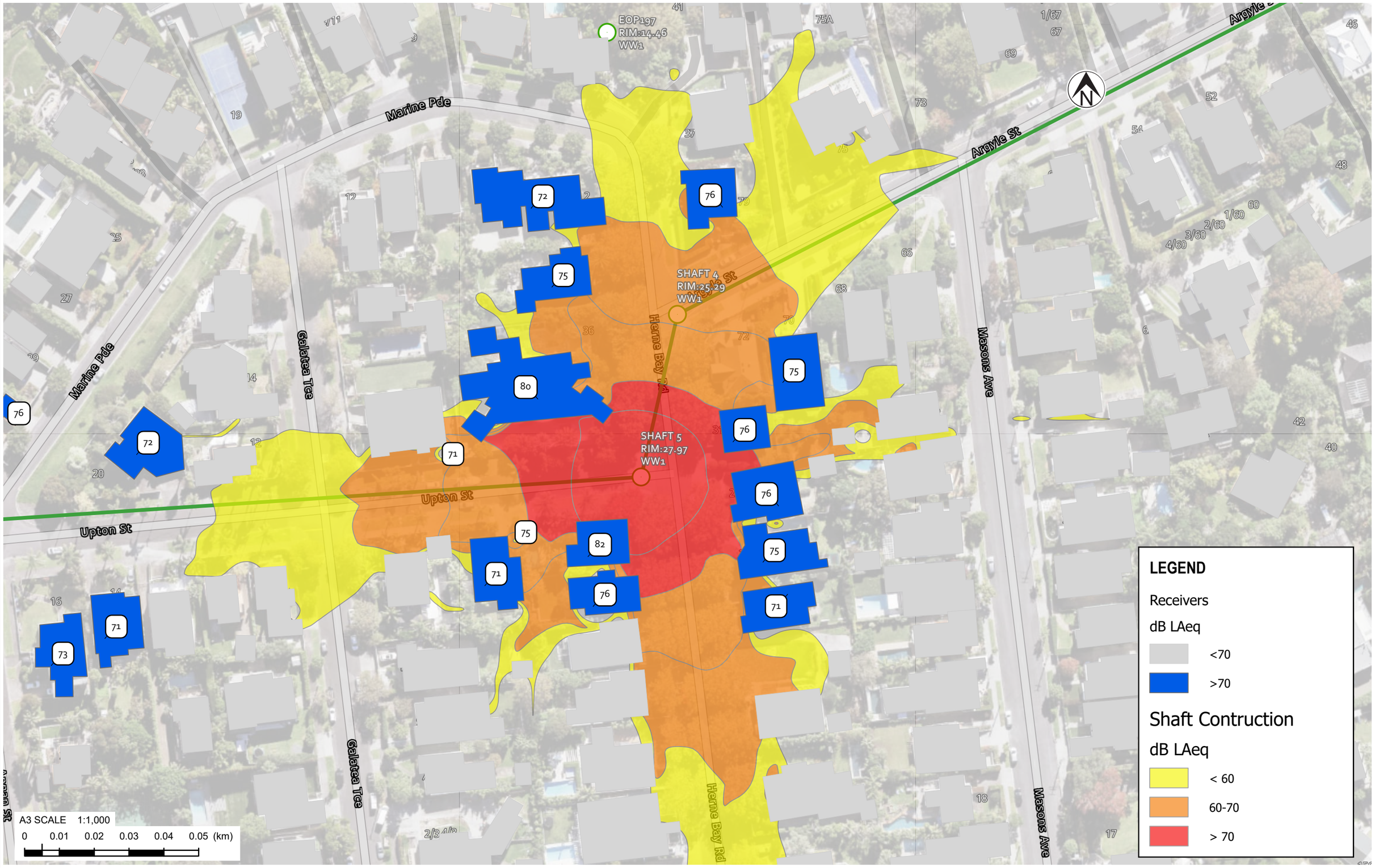

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PROJECT **HERNE BAY SEWER BRANCH 5**

TITLE PREDICTED NOISE LEVELS SHAFT CONSTRUCTION

SCALE (A3) 1:1,000 FIG No. APPENDIX D FIGURE 1.6 REV 0

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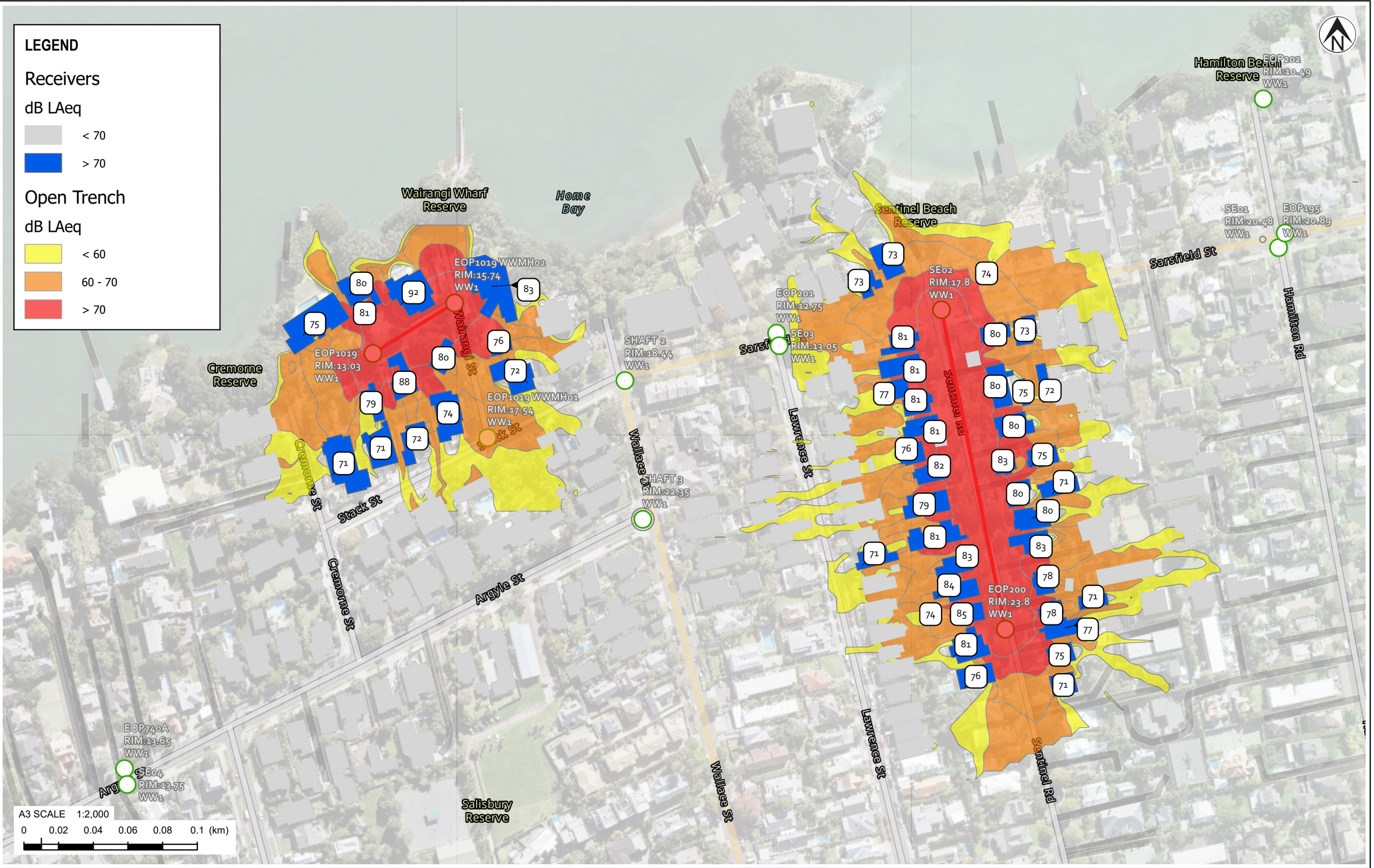

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PROJECT **HERNE BAY SEWER BRANCH 5**

TITLE PREDICTED NOISE LEVELS OPEN TRENCH

SCALE (A3) 1:2,000 FIG No. APPENDIX D FIGURE 2. 1 REV 0

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PROJECT **HERNE BAY SEWER BRANCH 5**

TITLE PREDICTED NOISE LEVELS OPEN TRENCH

SCALE (A3) 1:2,000 FIG No. APPENDIX D FIGURE 2. 2 REV 0

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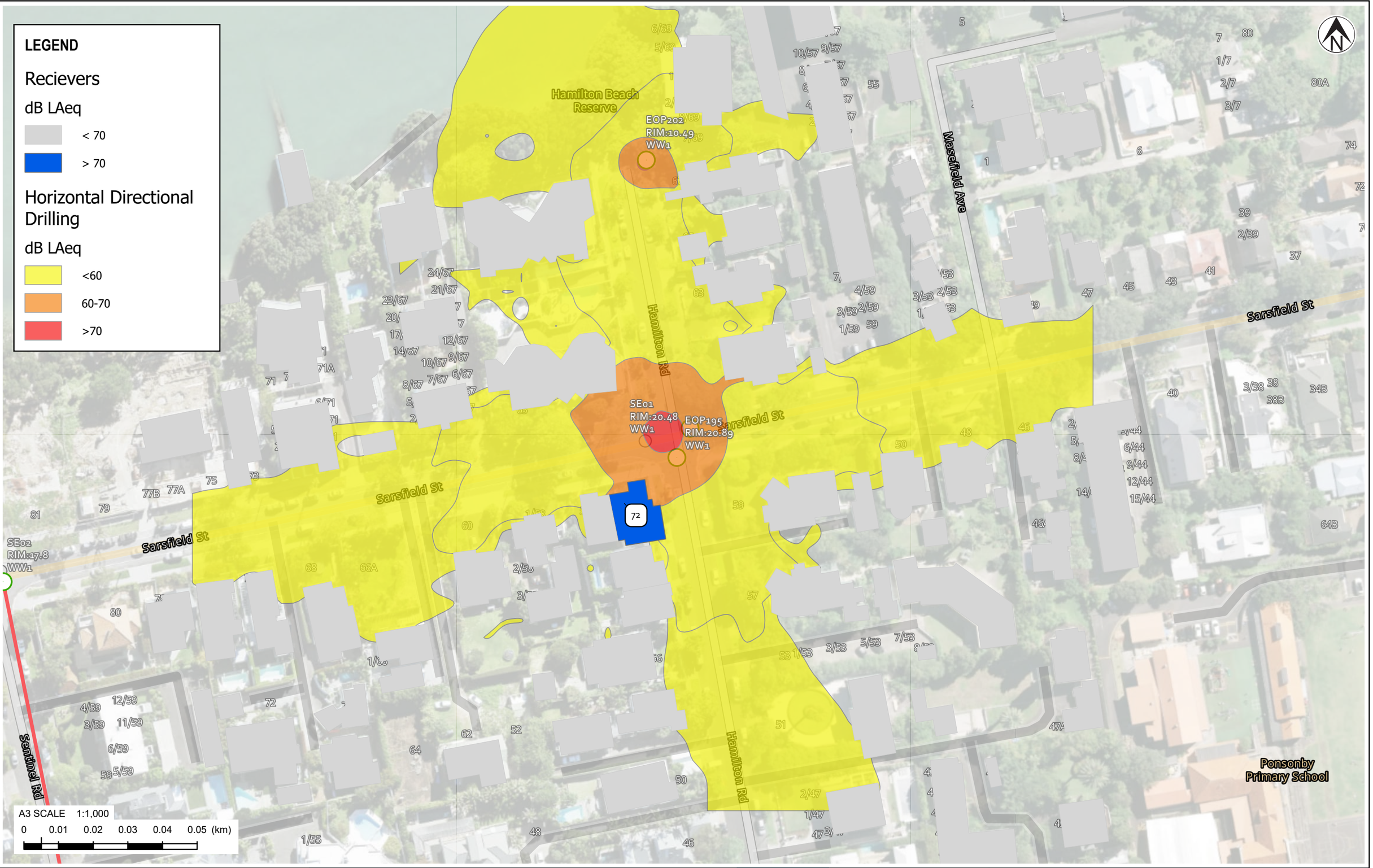

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PROJECT **HERNE BAY SEWER BRANCH 5**

TITLE PREDICTED NOISE LEVELS HDD

SCALE (A3) 1:1,000 FIG No. APPENDIX D FIGURE 3. 1 REV 0

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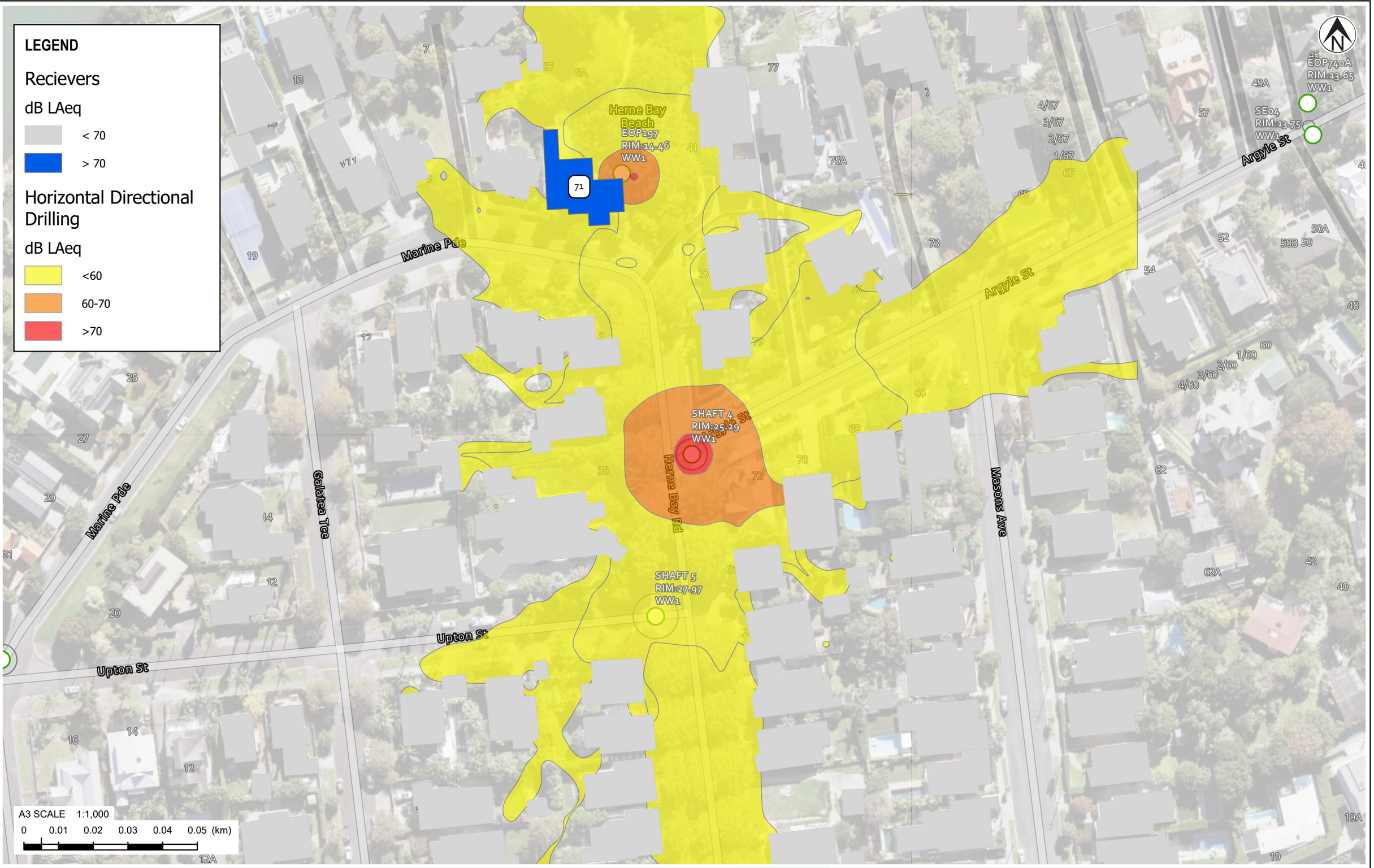
PROJECT **HERNE BAY SEWER BRANCH 5**

TITLE PREDICTED NOISE LEVELS HDD

SCALE (A3) 1:1,000 FIG No. APPENDIX D FIGURE 3. 2 REV 0

C:\Users\shyu\Documents\ArcGIS\Projects\Watercare Herne Bay\Herne Bay.aprx Layout: Herne_Bay_A3L_Noise_HDD 2023-Mar-13 12:27 pm Drawn by SHYU



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PROJECT **HERNE BAY SEWER BRANCH 5**

TITLE PREDICTED NOISE LEVELS HDD

SCALE (A3) 1:1,000 FIG No. APPENDIX D FIGURE 3. 3 REV 0

Appendix E Predicted vibration levels - tunnelling

Address	Approx horizontal distance to Tunnel alignment (m)	Predicted vibration level (mm/s PPV)
98 Sarsfield Street	3.9	1.3
96 Sarsfield Street	4.1	1.2
94 Sarsfield Street	4.4	1.1
12 Galatea Terrace	4.6	1.0
70 Curran Street	4.7	1.0
2 Argyle Street	5.7	0.8
61 Sarsfield Street	5.9	0.7
52 Wallace Street	6.0	0.7
92 Sarsfield Street	6.1	0.7
56 Sentinel Road	6.2	0.7
61 Sarsfield Street	6.4	0.6
39 Sarsfield Street	6.8	0.6
5 Upton Street	6.8	0.6
6 Argyle Street	7.2	0.5
49 Sarsfield Street	7.2	0.5
53 Sarsfield Street	7.6	0.5
45 Sarsfield Street	7.7	0.5
20 Marine Parade	7.7	0.5
43 Sarsfield Street	7.8	0.5
41 Sarsfield Street	7.8	0.5
46 Argyle Street	7.9	0.5
40 Argyle Street	8.0	0.5
32 Argyle Street	8.1	0.5
64 Argyle Street	8.2	0.4
72 Argyle Street*	8.2	0.4
50 Wallace Street	8.2	0.4
48 Wallace Street	8.5	0.4
5 Upton Street	9.4	0.4
71 Sarsfield Street	9.5	0.4
1/34 Argyle Street	9.5	0.4
22 Marine Parade	9.6	0.4
34 Argyle Street	9.9	0.3
54 Sarsfield Street	10.1	0.3
34 Herne Bay Road	10.4	0.3
2 Cremorne Street	10.4	0.3
73 Sarsfield Street	10.5	0.3

Address	Approx horizontal distance to Tunnel alignment (m)	Predicted vibration level (mm/s PPV)
45 Argyle Street	10.6	0.3
56 Sarsfield Street	10.7	0.3
36 Herne Bay Road	10.7	0.3
33 Marine Parade	10.7	0.3
56 Sarsfield Street	10.7	0.3
36 Herne Bay Road	10.7	0.3
33 Marine Parade	10.7	0.3
28 Argyle Street	10.7	0.3
44 Argyle Street	10.8	0.3
17 Argyle Street	10.8	0.3

Appendix F Vibration contour maps

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PROJECT **HERNE BAY SEWER BRANCH 5**

TITLE PREDICTED VIBRATION SETBACK DISTANCES

SCALE (A3) 1:1,000 FIG No. APPENDIX F FIGURE 1.1 REV 0

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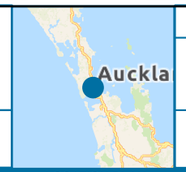

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TITLE PREDICTED VIBRATION SETBACK DISTANCES

SCALE (A3) 1:1,000 FIG No. APPENDIX F FIGURE 1.2 REV 0

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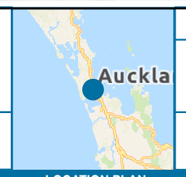

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TITLE PREDICTED VIBRATION SETBACK DISTANCES

SCALE (A3) 1:1,000 FIG No. APPENDIX F FIGURE 1.3 REV 0

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PROJECT **HERNE BAY SEWER BRANCH 5**

TITLE PREDICTED VIBRATION SETBACK DISTANCES

SCALE (A3) 1:1,000 FIG No. APPENDIX F FIGURE 1.4 REV 0

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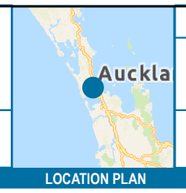

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PROJECT **HERNE BAY SEWER BRANCH 5**

TITLE PREDICTED VIBRATION SETBACK DISTANCES

SCALE (A3) 1:1,000 FIG No. APPENDIX F FIGURE 1.5 REV 0

Appendix G Tunnelling contour maps

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PROJECT **HERNE BAY SEWER BRANCH 5**

TITLE TUNNELING - NOISE AND VIBRATION

SCALE (A3) 1:1,000 FIG No. APPENDIX G FIGURE 1.1 REV 0

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PROJECT **HERNE BAY SEWER BRANCH 5**

TITLE TUNNELING - NOISE AND VIBRATION

SCALE (A3) 1:1,000 FIG No. APPENDIX G FIGURE 1.2 REV 0

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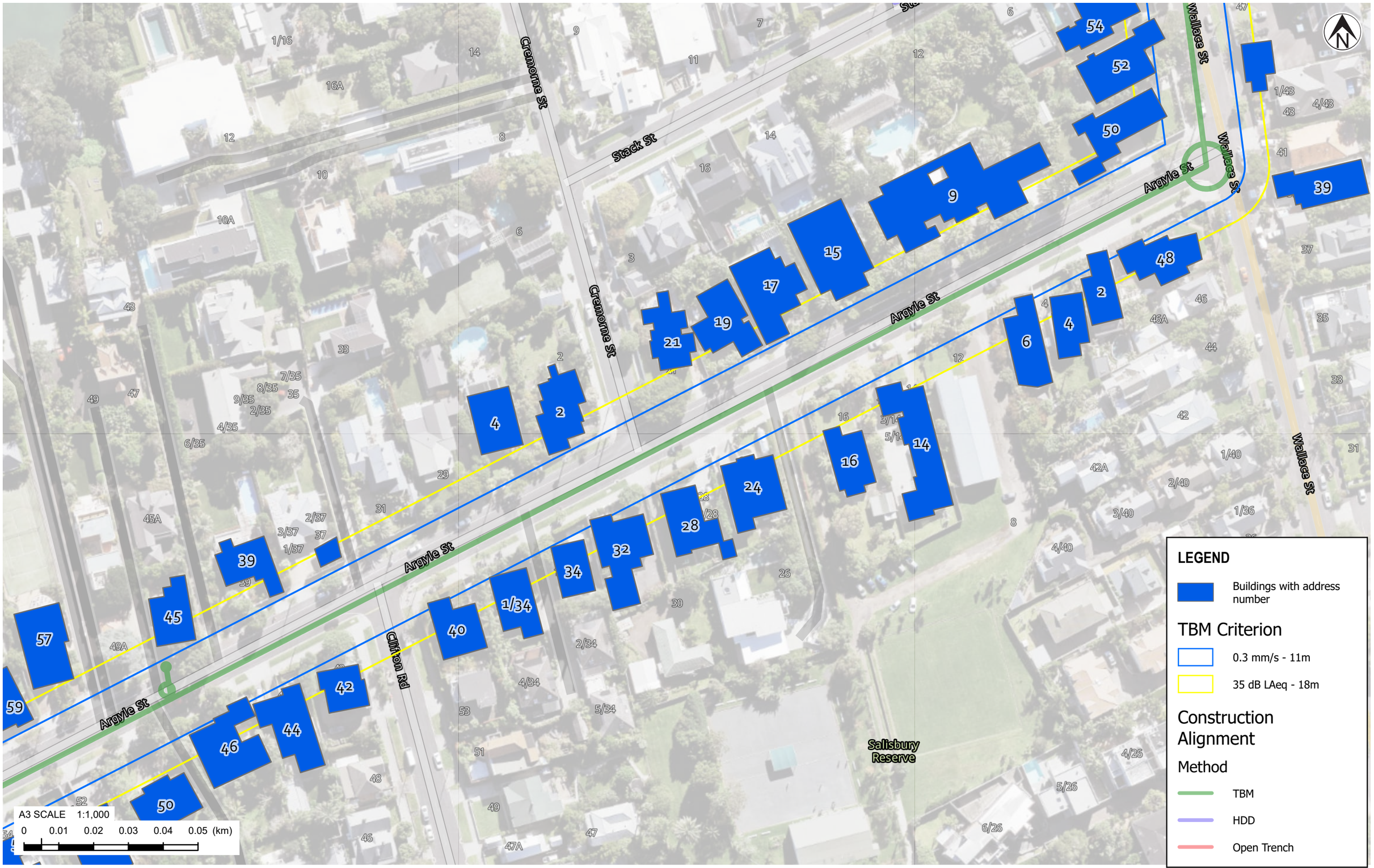

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PROJECT HERNE BAY SEWER BRANCH 5

TITLE TUNNELING - NOISE AND VIBRATION

SCALE (A3) 1:1,000 FIG No. APPENDIX G FIGURE 1.3 REV 0

C:\Users\shyu\Documents\ArcGIS\Projects\Watercare Herne Bay\Herne Bay.aprx Layout: Herne_Bay_A3L_Vibration 2023-Mar-10 2:44 pm Drawn by SHYU

Herne Bay Beach
Marine Pde
Argyle St
Clifton Rd
Herne Bay Rd
Masons Ave
Galatea Tce
Upton St

A3 SCALE 1:1,000
0 0.01 0.02 0.03 0.04 0.05 (km)

LEGEND

Buildings with address number

TBM Criterion

0.3 mm/s - 11m

35 dB LAeq - 18m

Construction Alignment

Method

TBM

HDD

Open Trench

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REV	DESCRIPTION	GIS	CHK	DATE
0	First version			D/M/Y

LOCATION PLAN

PROJECT No.	1090120		
DESIGNED	SHYU	MAR.23	
DRAWN	SHYU	MAR.23	
CHECKED			
APPROVED		DATE	

CLIENT **WATERCARE SERVICES LIMITED**

PROJECT **HERNE BAY SEWER BRANCH 5**

TITLE TUNNELING - NOISE AND VIBRATION

SCALE (A3) 1:1,000 FIG No. APPENDIX G FIGURE 1.4 REV 0

C:\Users\shyu\Documents\ArcGIS\Projects\Watercare Herne Bay\Herne Bay.aprx Layout: Herne_Bay_A3L_Vibration 2023-Mar-10 2:44 pm Drawn by SHYU

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SCALE (A3) 1:1,000 FIG No. APPENDIX G FIGURE 1.5 REV 0

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