North Harbour 2 Watermain and Northern Interceptor Shared Corridor

Watercare Services Limited (Watercare)

29-Apr-2016

Construction Noise and Vibration

Technical Report F

Revision F – 29-Apr-2016
Prepared for – Watercare Services Limited (Watercare) – Co No.: 03783575

Construction Noise and Vibration

Technical Report F

Client: Watercare Services Limited (Watercare)

Co No.: 03783575

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Executive Summary

An assessment of the noise and vibration effects associated with the construction of the North Harbour 2 Watermain (NH2), and the section of the Northern Interceptor (NI) project falling within the shared corridor, has been conducted. The purpose of this assessment is to assess whether effects can be sufficiently mitigated such that residual effects are at an acceptable level.

Noise and vibration criteria have been proposed from NZS 6803:1999 and DIN 4150-3 (1999), respectively, based on industry best practice. These are also referred to in the Proposed Auckland Unitary Plan and the legacy district plans. Noise and vibration criteria should provide a framework for assessment, but flexibility is needed to allow activities that cannot comply with the standard values.

Key to managing the effects is effective and integrated management processes. These processes will be detailed in a Construction Noise and Vibration Management Plan (CNVMP), which will be prepared prior to construction and implemented by the appointed contractors. For construction noise and vibration it is critical that effective management processes are followed and that these are specified in designation conditions.

Predictions of the noise and vibration levels associated with the indicative construction activities have been made at typical distances to the nearest residences. In general it has been found that, without specific mitigation or management measures, construction noise and vibration should meet the ‘short-term’ or ‘typical duration’ daytime criteria for the majority of activities. In cases where sheet piling is to be conducted close to residences, exceedance of the daytime criteria is expected, and mitigation and management will need to be implemented through a CNVMP.

Extensive night works are not anticipated; however, where these are required due to traffic management constraints the night-time noise criteria will generally be exceeded at the nearest neighbouring receivers and implementation of enhanced noise and vibration management procedures will be required.

Outline management and mitigation measures are stated below. These will be confirmed and documented in the CNVMP when the specific construction methodology and equipment are finalised:

- Managing times of activities to avoid night works and other sensitive times;
- Selecting equipment and methodologies to restrict noise and vibration;
- Using screening/enclosure/barriers;
- Liaising with neighbours so they can work around specific activities; and
- Providing periods of respite.

While there may be some disturbance and annoyance at times, with appropriate management of noise and vibration through a CNVMP, it is considered that both daytime and night-time effects can be kept at an acceptable level.

1.0 Introduction

AECOM has been commissioned by Watercare Services Limited (Watercare) to assess the potential noise and vibration effects related to the construction, operation and maintenance of Watercare's proposed North Harbour 2 Watermain (NH2) project between Titirangi and Albany and the land use effects associated with the construction, operation and maintenance of the Northern Interceptor (NI) project between Westgate and Hobsonville, where a shared corridor is proposed for both water and wastewater infrastructure.

The NH2 will convey potable water from storage reservoirs in Titirangi, via west Auckland and North Shore to storage reservoirs in Albany (a length of approximately 33km). Its purpose will be to increase capacity and resilience of the water supply network to western and northern Auckland.

The NH2 project incorporates:

- Pipeline installation, operation and maintenance of a new watermain of 1200 mm (west of Greenhithe Bridge) and 900mm (east of Greenhithe Bridge) nominal diameters (DN);
- Pipeline length of approximately 33km mostly within public road reserve; and
- Other features including valve chambers, scour valves, air valves, line valves, bulk supply points, pipe bridges, and associated works.

Most of the watermain will be constructed by open trenching, micro tunnelling or bored tunnel (the latter two referred to as "trenchless technology") within a typical construction corridor of approximately 12 – 22 m width with additional areas required for erosion and sediment control devices, traffic management, construction yards and storage areas at intervals along the route for construction purposes.

The NI project comprises of a new wastewater pipeline and associated activities to convey flows from north-west Auckland to the Hobsonville Pump Station, and then to the Rosedale Wastewater Treatment Plant (WWTP).

The proposed NI project in the shared corridor begins in the vicinity of Hobsonville Road (West Harbour), near the intersection of the Upper Harbour and North Western Motorways (SH18 and SH16). From this location, the alignment follows the southern side of the SH18, continuing northeast to the Hobsonville Pump Station. Future phases of the NI project will also include new pipelines between the Hobsonville Pump Station and the SH18 causeway.

Within the shared corridor, the NI project incorporates the following:

- A new 5km wastewater pipeline of 2100mm DN;
- 16 pits / shafts for trenchless technology construction purposes. Five of these will be permanent manholes (MT Pits 2, 7, 11, 13 & 17) while the others (MT Pits 3, 4, 5, 6, 8, 9, 10, 12, 14, 15 and 16) will be temporary only until construction / testing is completed;
- MT Pit 7 will be a drop structure with permanent access, to allow for a future wastewater pipeline connection across SH18;
- A new 50m long wastewater pipeline and manholes connecting the 2100mm ND pipeline to the existing pump station;
- A new 1750 l/s Pump Station with future capacity across the site of 3,500l/s;
- Wastewater storage (within pipeline);
- Two 800m 1500mm DN rising mains (length to the causeway); and
- A 2100mm DN pipe installed by trenchless technology at SH18.

The proposed alignment of NH2 and the location of the NI project are shown in Figure 1 below.

A full description of the proposed works and construction methodology is included in in the North Harbour 2 Watermain and Northern Interceptor Shared Corridor Assessment of Effects on the Environment (the AEE report) prepared by AECOM Consulting Services (NZ) Ltd (AECOM) and Jacobs New Zealand Limited (Jacobs).

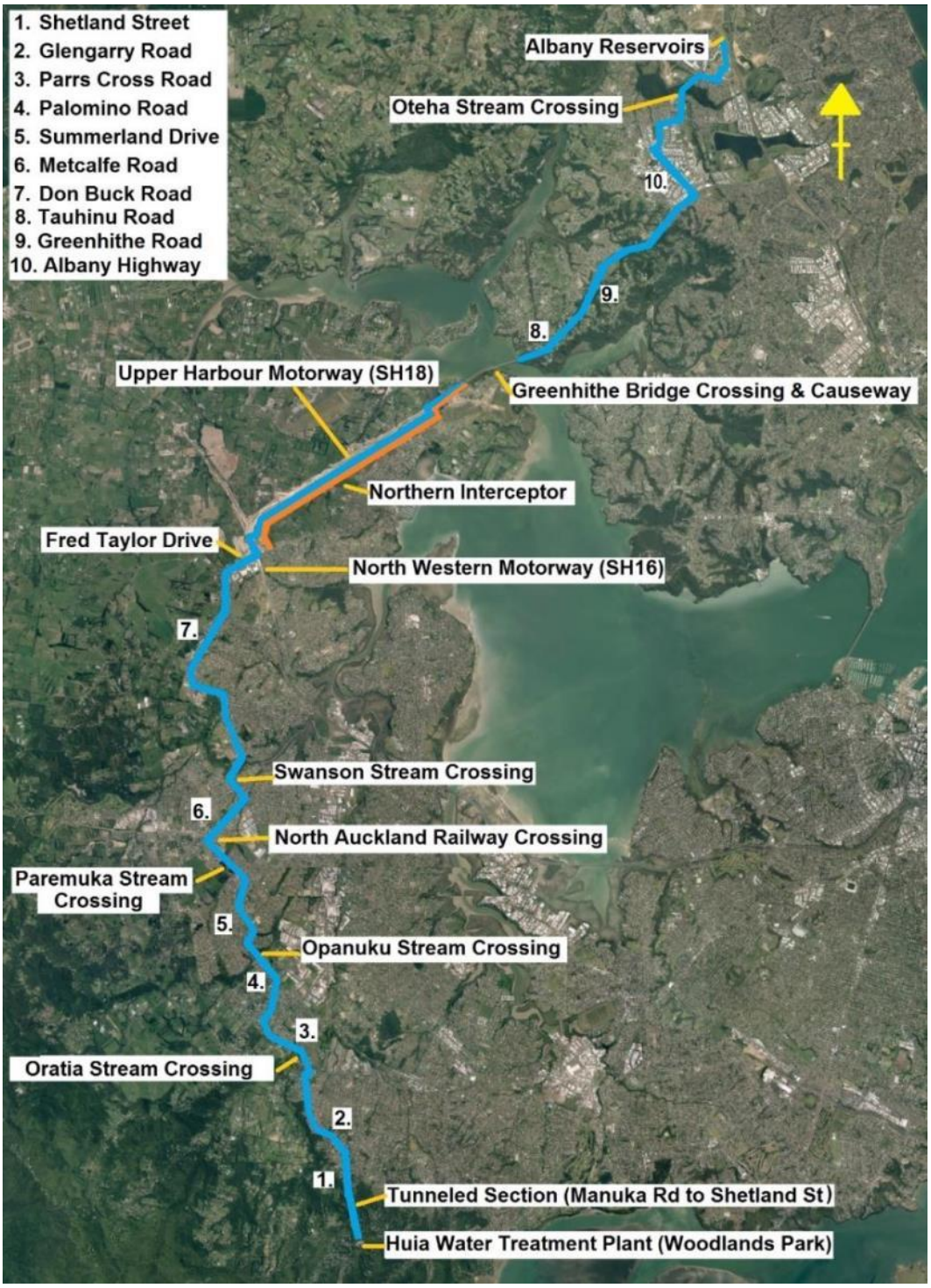

Figure 1 Blue line is the proposed NH2 route and Orange line is NI section within shared corridor

1.1 Purpose and scope

Watercare is proposing to designate land for the NH2 project between Titirangi and Albany and the NI project between Westgate and Hobsonville, and will also be seeking various resource consents for NH2 under the Resource Management Act 1991 (RMA). This technical report provides specialist input for the AEE which supports the Notices of Requirement for designation (NOR) and the resource consent applications. The alignment drawings referred to in this report are contained within Volume 3 of the AEE. Resource consents required for works associated with the NI project will be sought by Watercare at a later date, nearer to the proposed date of construction.

The purpose of the construction noise and vibration assessment is to assess whether adverse effects can be sufficiently mitigated such that residual effects are at an acceptable level. A management framework is proposed, which will be codified in conditions.

As with most construction projects, specific equipment and durations has not been finalised at this stage and will not be known until a contractor has been engaged. Indicative noise and vibration levels have been predicted for various construction activities, to develop an understanding of the extent of any adverse effects. Detailed predictions will be made during construction for the purpose of confirming the necessary mitigation.

The report provides the following:

- Noise and vibration performance standards and recommended project criteria (section 2.0);
- An outline of the construction noise and vibration management process (section 3.0);
- Details of the construction activities and construction vibration sources based on the preliminary construction methodology (sections 4.0 and 5.0);
- Identification of the nearest sensitive receivers and indicative noise and vibration levels at each (section 6.0);
- Mitigation hierarchy and locations/activities were structural mitigation should be considered (section 7.0);
- Assessment of construction noise and vibration effects for high risk locations (section 8.0); and
- Conclusions (section 9.0).

2.0 Performance standards

2.1 District plans

While this project will be authorised through designations, consideration has been given to rules from the operative district plans (Waitakere and North Shore) and the Proposed Auckland Unitary Plan. These plans refer to noise and vibration standards that are considered best practice.

2.1.1 Waitakere

Rule 1.1 of the District Plan General Noise standards states:

Noise emanating from construction, maintenance or demolition shall be a Permitted Activity where the construction, maintenance or demolition is subsidiary to the existing or intended future use of the site, and where they meet the standards in NZS6803P:1984. Noise under this rule shall be measured and assessed in accordance with NZS 6803P:1984: "The Measurement and Assessment of Noise from Construction, Maintenance and Demolition Work."

Rule 14.1 of the District Plan Living Environment standards states:

Activities meeting the following Performance Standards are Permitted Activities:

a) *Any Activity and Temporary Activities generating vibration levels (acceleration measured in metres per second squared) relative to frequency not exceeding the base curves of figure 2a (z axis), 3a (x and y axes) and 4a (combined x, y, and z axes) contained within ISO 2631-2:1989.*

Assessment of vibration shall be carried out by a suitably qualified and experienced person in accordance with Annex A and Table 2 of ISO 2631-2:1989. Instruments used to measure vibrations and the methods of measurement shall comply with a recognised standard such as Australian Standard AS2973: 1987 "Vibration and Shock – Human response vibration - measuring instrumentation."

2.1.2 North Shore

Rule 10.5(i) of the District Plan states:

"Any construction, maintenance and demolition noise shall comply with the provisions of NZS 6803 P 1984 'The Measurement and Assessment of Noise from Construction, Maintenance and Demolition Work"

Rule 10.7 of the District Plan states:

All Permitted and Controlled activities in all zones are subject to the following controls:

a) *No activity shall be permitted to create vibration levels (acceleration in metres per second squared) relative to frequency which affect occupants of adjacent buildings by exceeding the base curves of Figures 2a (z axis), 3a (x and y axis), and 4a (combined xyz axis) of International Standard ISO 2631-2:1989 - Evaluation of human exposure to whole-body vibration - Part 2: Continuous and shock-induced vibration in buildings (1 to 80 Hz).*

b) *Annex A and Table 2 of ISO 2631-2:1989 shall be used for the assessment of continuous, intermittent and transient (impulsive) vibrations.*

c) *Instruments to measure such vibration, and methods of measurement shall comply with Australian Standard AS 2973:1987 and AS 2187.2:1993.*

Explanation and Reasons

This control deals with human response to building vibration. Standards formulated to control vibration are generally related to the tolerance of a sitting or standing person.

Annex A and Table 2 of the Standard give consideration to the time of the day and use made of the occupied space in the building.

Situations may exist where vibration levels above those specified can be tolerated for temporary disturbances and infrequent events of short-term duration, e.g. blasting, construction and excavation projects.

The reason for adopting the ISO and Australian Standards is to ensure a consistent and internationally recognised assessment procedure is used.

2.1.3 Proposed Auckland Unitary Plan (PAUP)

Part 3 Chapter H Rule 6.2.1.4.1 of the PAUP states:

Noise from construction and demolition activities in all zones except in the City Centre and Metropolitan Centre zones must meet the requirements of Tables 2 and 3 of New Zealand Standard on Acoustics – Construction Noise (NZS 6803: 1999). The measurement and assessment of construction noise must be in accordance with New Zealand Standard on Acoustics – Construction Noise (NZS 6803: 1999) and the requirements of annex A of New Zealand Standard on Acoustics – Construction Noise (NZS 6803: 1999) must be used if it is necessary to assess the measured Leq levels in high background noise areas.

Part 3 Chapter H Rule 6.2.1.5.1 of the PAUP states:

Blasting and pile driving activities must be controlled to ensure any resulting ground vibration does not exceed the levels set out in Table 1 of DIN 4150-3 (1999): Structural vibration – Part 3 Effects of vibration on structures when measured on the foundation or the horizontal plane of the highest floor of an affected building.

2.2 New Zealand Standard NZS 6803

NZS 6803 provides a framework for managing construction noise. Part of this framework is guideline noise limits, which are shown in Table 1. For large infrastructure projects in many instances it is not practicable to meet these limits. In particular, where night works are often required when working on or near major roads due to high traffic volumes and potential delays from daytime road works. It is unlikely that the NZS 6803 guideline night-time noise limits could be achieved at residential receivers near road works. Also, where works are very close to receivers there may be times when it is not practicable to comply with the daytime limits. In such cases construction noise should still be managed to reasonable levels through good practice.

NZS 6803 provides different guideline noise limits for different activity durations. For linear infrastructure, the 'long-term' criteria (more than 20 weeks) are often appropriate as receivers are exposed to noise from multiple activities over the duration of the project despite each activity being of short duration. However, in the case of NH2, relatively rapid progression of the work area during most of the pipeline construction is anticipated and the majority of receivers will be exposed to construction noise for less than 20 weeks. Therefore the 'typical duration' criteria are appropriate for all receivers that are only exposed to noise from the open trench construction activity.

In addition to guidelines noise limits, NZS 6803 provides recommendations for good practice noise management and communication with affected parties. These should be adopted regardless of whether the guideline limits are being met. These are discussed in section 3.0.

Table 1 Construction noise criteria (at residential dwellings)

Day	Time	Less than 20 weeks (typical duration)		More than 20 weeks (long-term)	
		L_{Aeq}	L_{AFmax}	L_{Aeq}	L_{AFmax}
Weekdays	0630h - 0730h	60 dB	75 dB	55 dB	75 dB
	0730h - 1800h	75 dB	90 dB	70 dB	85 dB
	1800h - 2000h	70 dB	85 dB	65 dB	80 dB
	2000h - 0630h	45 dB	75 dB	45 dB	75 dB
Saturday	0630h - 0730h	45 dB	75 dB	45 dB	75 dB
	0730h - 1800h	75 dB	90 dB	70 dB	85 dB
	1800h - 2000h	45 dB	75 dB	45 dB	75 dB
	2000h - 0630h	45 dB	75 dB	45 dB	75 dB
Sundays and public holidays	0630h - 0730h	45 dB	75 dB	45 dB	75 dB
	0730h - 1800h	55 dB	85 dB	55 dB	85 dB
	1800h - 2000h	45 dB	75 dB	45 dB	75 dB
	2000h - 0630h	45 dB	75 dB	45 dB	75 dB

2.3 Recommended project criteria

2.3.1 Noise

As discussed in section 2.2 AECOM considers that NZS 6803:1999 is current best practice. The ‘typical duration’ (less than 20 weeks) criteria have been adopted for the open trenching activities, while the ‘long-term’ criteria have been adopted everywhere else.

2.3.2 Vibration

There are no New Zealand Standards for vibration, and there is inconsistent use between different districts. The Waitakere and North Shore District Plans both refer to ISO 2631-2:1989 for placing limits on permitted levels of vibration. This standard is focused on human response; however, it has been withdrawn and replaced with a 2003 version, which no longer includes guideline criteria. Therefore ISO 2631-1989 has not been adopted on this project.

The PAUP makes reference to DIN 4150-3,[1] which provides guideline criteria for the effects of construction vibration on structures and has been adopted for this project. These are included in Table 2.

Annoyance effects on building occupants also need to be considered. In a residential environment vibration above 0.3 mm/s will be just perceptible,[2] while annoyance will begin to set in where vibration levels exceed 1 mm/s.

Table 2 Construction vibration criteria

Type of structure	Vibration at foundation (PPV)
Buildings used for commercial purposes, industrial buildings, and buildings of similar design	20 mm/s
Dwellings and buildings of similar design and/or occupancy	5 mm/s

[1] DIN 4150-3:1999 ‘Structural vibration - Effects of vibration on structures’.
[2] BS 5228-2:2008 Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration. Table B.1.

3.0 Management process

3.1 Introduction

Key to managing effects is effective and integrated management processes. The main document that will detail these processes is the Construction Noise and Vibration Management Plan (CNVMP).

3.2 Management plan

The CNVMP will be prepared by the Project team, and implemented by the appointed contractors. Conditions should specify the contents of the CNVMP, which can be summarised as follows:

- Noise and vibration targets;
- Summary of receiver locations;
- General construction practices, management and mitigation;
- Noise management and mitigation measures specific to activities and/or receiving environments;
- Monitoring and reporting requirements;
- Procedures for handling complaints; and
- Procedures for review of the CNVMP throughout the Project.

3.3 Schedules

The CNVMP requires noise levels to be predicted for activities with the potential to cause disturbance, once details of construction equipment and locations have been confirmed. Where exceedances are predicted, a schedule to the CNVMP will be prepared. The schedules will identify the potentially affected neighbours and confirm the proposed methodology and equipment to be used, along with specific mitigation.

3.4 Stakeholder engagement

A key aspect of construction noise and vibration management is stakeholder engagement. This will be developed as part of the Communications Plan.

Specific elements of this plan relating to noise are likely to include:

- Individual notification will be provided to all neighbours within 20 m of the works;
- Regular updates on the progress of the works, and the specific activities (including locations) due to be undertaken next. A mix of methods will be used including newsletters, email, and letter. Frequency of updates will reflect the activity and potential impact;
- The nearest neighbours to any particularly noisy processes (particularly night works) identified in a schedule, will be contacted and advised of the proposed timing of the specific works. Where practicable any times which are particularly sensitive for neighbours will be taken into account; and
- The nearest neighbours to any potential construction vibration effects will be informed of the proposed timing of the specific works.

4.0 Significant construction activities

The detailed construction methodology is provided in section 2 of the AEE. Key points from the construction methodology for both NH2 and NI (shared corridor), which are directly relevant to this noise assessment, are summarised below for each activity. An inventory of the likely construction equipment that will be used for each activity is included in Appendix A.

The majority of these construction activities will occur in all three NOR areas. Indicative noise and vibration levels are included in Section 6.0 for each location within the three NOR areas.

4.1 Trenching activities

4.1.1 Overview

The majority of the NH2 will be constructed by conventional open-cut trenching methods within roads.

The trenching activities will generally be conducted during daytime hours. Extensive night works are not anticipated; however, where these are required by traffic management constraints, temporary noise barriers and other forms of mitigation will be needed. Detailed predictions and mitigation will be confirmed through the schedule process.

4.1.2 Sub-activities

For the purposes of this assessment the trenching activity has been separated into three sub-activities, which can be considered to occur in isolation. These include:

- Site establishment;
- Trenching, pipe installation and back-filling; and
- Paving.

A list of the indicative construction equipment that will be used for the trenching activities is included in Table 38 in Appendix A.

Sources of vibration will include:

- Excavator; and
- Vibratory compactor.

4.2 Trenchless construction

4.2.1 Overview

The majority of the NI will be constructed by trenchless construction methods. At certain locations along the NH2 alignment trenchless construction methods will be used in place of open trenching.

Shafts are constructed at the beginning of the tunnel section (jacking station) and at the end of the tunnel section (reception shaft) using sheet piles.

The site establishment and reinstatement activities will be conducted during daytime hours. Once started, trenchless activities are expected to be conducted 24 hours a day until completion.

4.2.2 Sub-activities

For the purposes of this assessment the trenchless construction activity has been separated into five sub-activities, which can be considered to occur in isolation. These include the construction of any shafts that are required. The sub-activities include:

- Site establishment and vegetation clearance (where required);
- Sheet piling (shafts);
- Excavation (shafts);
- Tunnel boring and pipe jacking; and other trenchless technologies and,
- Grouting.

A list of the indicative construction equipment that will be used for the trenchless construction activities is included in Table 39 of Appendix A.

Sources of vibration will include:

- Sheet piling rig;
- Excavator; and
- Tunnel boring machine.

4.3 Chamber construction and valve installation

4.3.1 Overview

Valve chambers are to be built at numerous positions along the proposed pipeline route. They vary in design depending on the particular locality requirements; however, they will generally be rectangular in shape, with walls retained by sheet piles or concrete. Scour valves, air valves and sump pumps for draining of water will be located inside the chambers

Construction of the valve chambers will be conducted during daytime hours, unless traffic management requirements restrict work to off-peak/night-time hours.

4.3.2 Sub-activities

For the purposes of this assessment the chamber construction and valve installation activity has been separated into four sub-activities, which can be considered to occur in isolation. These include:

- Site establishment and vegetation clearance (where required);
- Sheet piling;
- Excavation; and
- Chamber construction (concreting) and valve installation.

A list of the indicative construction equipment that will be used for the chamber construction and valve installation is included in Table 40 of Appendix A.

Sources of vibration will include:

- Sheet piling rig; and
- Excavator.

4.4 Stream crossings

4.4.1 Overview

Pipe bridges are proposed for several stream crossings along the pipeline alignment. These will generally comprise of column foundations being installed on either side of the stream, in locations suitable to be above estimated flood levels.

Construction of the pipe bridges will be conducted during daytime hours, unless traffic management requirements restrict work to off-peak/night-time hours.

4.4.2 Sub-activities

For the purposes of this assessment the pipe bridge construction activity has been separated into four sub-activities, which can be considered to occur in isolation. These include:

- Site establishment and vegetation clearance (where required);
- Piling;
- Bridge column construction; and
- Pipe installation.

A list of the indicative construction equipment that will be used for the pipe bridge construction is included in Table 41 of Appendix A.

Sources of vibration will include:

- Impact piling.

4.5 Cathodic protection sites

4.5.1 Overview

NH2 will be constructed in steel with protective measures used to stop it corroding. This includes the use of cathodic protection at the three locations along the pipeline route. Cathodic protection is expected to consist of an anode bed or a junction box, and transformer rectifier cabinet.

Construction of the cathodic protection sites will be conducted during daytime hours, unless traffic management requirements restrict work to off-peak/night-time hours.

4.5.2 Sub-activities

For the purposes of this assessment construction of the cathodic protection sites has been separated into four sub-activities, which can be considered to occur in isolation. These include:

- Site establishment;
- Excavation;
- Concreting; and
- Installation of cathodic protection devices.

A list of the indicative construction equipment that will be used for construction of the cathodic protection sites is included in Table 42 of Appendix A.

Sources of vibration will include:

- Excavator.

4.6 Causeway construction

4.6.1 Overview

A short causeway of approximately 200 m may be required for the section of pipeline immediately west of the Squadron Drive overbridge. Construction of the causeway will be conducted during daytime hours, unless traffic management requirements restrict work to off-peak/night-time hours.

4.6.2 Sub-activities

For the purposes of this assessment, construction of the causeway has been separated into three sub-activities, which can be considered to occur in isolation. These include:

- Site establishment and vegetation clearance;
- Causeway construction; and
- Pipe installation and back-filling.

A list of the indicative construction equipment that will be used for construction of the causeway is included in Table 43 of Appendix A.

Sources of vibration will include:

- Excavator.

4.7 Pump Station construction

4.7.1 Overview

A Pump Station will be constructed as part of the NI (shared corridor) works in NOR3. Construction of the Pump Station will be conducted during daytime hours.

4.7.2 Sub-activities

For the purposes of this assessment, construction of the Pump Station has been separated into five sub-activities, which can be considered to occur in isolation. These include:

- Site establishment;
- Sheet piling;
- Excavation;
- Pump Station construction; and
- Trenching, pipe installation and back-filling.

A list of the indicative construction equipment that will be used for construction of the Pump Station is included in Table 44 of Appendix A.

Sources of vibration will include:

- Sheet piling rig; and
- Excavator.

5.0 Construction vibration sources

Vibration will be generated by the following pieces of equipment:

- Excavator;
- Sheet piling rig;
- Impact / vibratory piling rig;
- Tunnel boring machine; and other trenchless technologies; and
- Vibratory compactor.

Vibration levels are highly dependent on the specific piece of equipment being used and the ground conditions present at the site. For the purposes of this assessment, set-back distances have been determined to identify the extent of the construction vibration effects. The set-back distances are structured to allow the receivers to be classified as High, Medium or Low risk as follows:

- High risk - vibration levels exceed 5 mm/s (above building damage criteria);
- Medium risk - vibration levels between 1 and 5 mm/s (below building damage criteria, but annoyance possible and existing building damage may be attributable to works); and
- Low risk - vibration levels are below 1 mm/s (may still be perceptible, but annoyance unlikely).

The set-back distances have been chosen based on vibration predictions using Appendix E of BS 5228-2[3] and previous measurements of microtunneling equipment. These are provided in Table 3.

Table 3 Set-back distances for significant vibration generating activities

Construction equipment	Set-back distances		
	Low risk	Medium risk	High risk
Excavator*	> 10 metres	3 – 10 metres	< 3 metres
Sheet piling rig	> 50 metres	5 – 50 metres	< 5 metres
Impact piling rig	> 70 metres	20 – 70 metres	< 20 metres
Microtunneling / TBM	> 20 metres	10 – 20 metres	< 10 metres
Vibratory compactor	> 20 metres	10 – 20 metres	< 10 metres

* AECOM estimate

[3] BS 5228-2:2009 ‘Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration’.

6.0 Indicative noise and vibration levels

Indicative noise levels for key activities and locations have been predicted separately for the three different NORs, however there is significant commonality between the areas. Cross-references have been made as appropriate.

Noise levels have not been predicted at all locations, but rather at locations which are representative of the wider areas for linear activities such as trenching and pipe laying, or at locations with more defined work areas, such as trenchless technologies.

Comparison to the relevant day or night-time noise limits from NZS 6803 are provided below.

6.1 NOR1

6.1.1 Trenching activities

Trenching activities will be conducted along the majority of the NH2 pipeline. Noise levels have been calculated in a typical residential area using the indicative construction equipment detailed in Table 38 in Appendix A.

Table 4 provides indicative noise levels for times when the construction equipment is located at its closest position to the neighbouring receivers at the first and second row of houses, along with a comparison with the 'typical duration' daytime guideline noise criteria (75 dB $L_{Aeq(15min)}$), i.e. exceedances in red and compliance in green.

Table 4 Indicative noise levels for the trenching activities

Construction activity	Task	10 m		30 m	
		First row		Second row	
Trenching activities	Site establishment	74 dB	D	65 dB	D
	Trenching, pipe installation and back-filling	84 dB	D	75 dB	D
	Paving	84 dB	D	75 dB	D

Figure 2 shows the extent of the affected properties for each sub-activity based on 'typical duration' daytime guideline noise criteria. At times, houses within the first row adjacent to the road are expected to experience noise levels exceeding 75 dB $L_{Aeq(15min)}$ for the following sub-activities:

- Trenching, pipe-installation and back-filling; and
- Paving.

Extensive night works are not anticipated. If trenching works are required at night, temporary noise barriers and other forms of mitigation will be needed. Detailed predictions and mitigation will be confirmed through the Schedule process.

Vibration will be generated by the following activities:

- Excavation; and
- Vibratory compaction.

Some properties within the first row of houses will be considered medium risk during excavation and vibratory compaction activities. At times, vibration from the excavation tracking and digging will be noticeable on the side of the properties closest to the work site, i.e. within 15 m. Similarly, vibration from vibratory compaction activities will be noticeable at properties within 20 m of the work area. No properties are considered high risk during excavation and vibratory compaction activities.

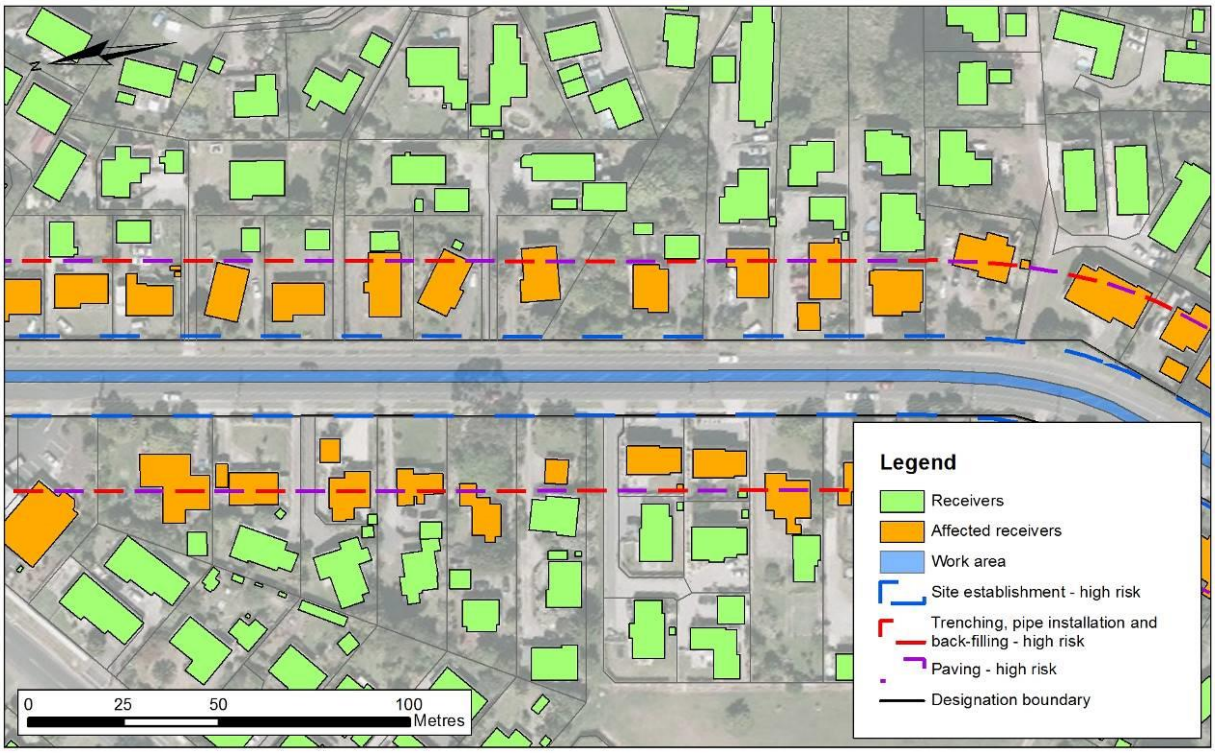

Figure 2 Extent of affected properties for the trenching activities (typical location)

6.1.2 Chamber construction and valve installation

Air and line valves will be located at regular intervals along the NH2 pipeline. The majority of these will be installed during general open trench construction and the indicative noise levels and extent of affected properties described in Section 6.1.1 will apply.

Other locations will involve the construction of permanent chambers from sheet piling or tilt slab. These will typically be at the jacking station and reception shaft locations established during trenchless construction activities. Noise levels have been calculated at a typical chamber location using the indicative construction equipment detailed in Table 40 in Appendix A.

Table 5 provides an example of the indicative noise levels at the nearest neighbouring receivers to chamber located in a typical residential area, along with a comparison with the 'long-term' daytime guideline noise criteria (70 dB $L_{Aeq(15min)}$).

Table 5 Indicative noise levels for daytime chamber construction activities (example chamber)

Construction activity	Task	15 m Nearest residence	
Chamber construction and valve installation	Site establishment and vegetation clearance	72 dB	D
	Sheet piling	88 dB	D
	Excavation	73 dB	D
	Chamber construction and valve installation	80 dB	D

Figure 3 shows an example of the extent of the affected properties for each sub-activity based on the 'long-term' daytime guideline noise criteria. At times, houses adjacent to the work areas are expected to experience noise levels exceeding 70 dB $L_{Aeq(15min)}$ for the following sub-activities:

- Site establishment and vegetation clearance (2 properties, or within 20 metres of the work area);
- Sheet piling (17 properties, or within 115 metres of the work area);
- Excavation (2 properties, or within 20 metres of the work area); and
- Chamber construction and valve installation (4 properties, or within 50 metres of the work area).

Vibration will be generated by the following activities:

- Sheet piling.

Properties located within 50 m of the work area will experience noticeable levels of vibration (equal to four properties in this example). These properties are considered medium risk.

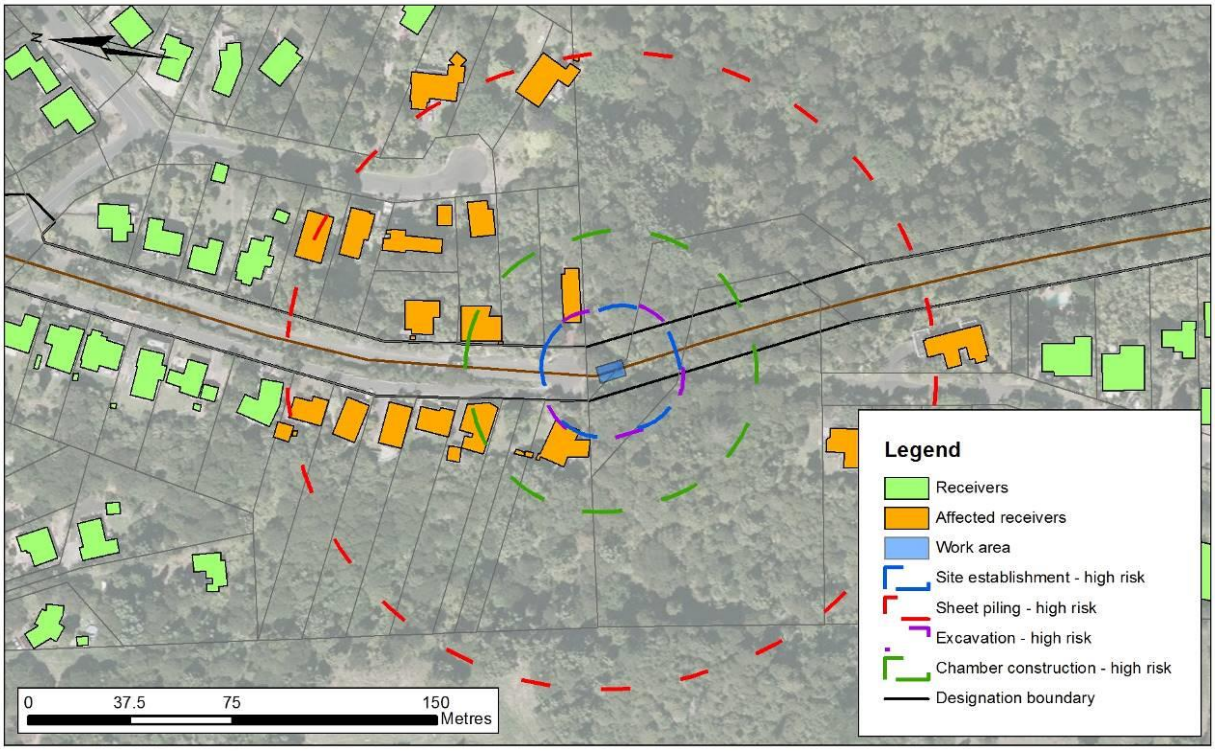

Figure 3 Extent of affected properties at a typical chamber location

6.1.3 Trenchless construction

6.1.3.1 Manuka Rd to Shetland St

Trenchless construction in the Woodlands Park area will involve construction activity in the vicinity of the jacking station and reception shaft. Noise levels have been calculated at these two locations using the indicative construction equipment detailed in Table 39 in Appendix A.

Table 6 provides indicative noise levels at the nearest neighbouring receivers to the jacking station and reception shaft, along with a comparison with the 'long-term' daytime guideline noise criteria (70 dB $L_{Aeq(15min)}$).

Table 6 Indicative noise levels for daytime trenchless construction activities

Construction activity	Task	15 m Reception shaft		60 m Jacking station	
Trenchless construction	Site establishment and vegetation clearance	85 dB	D	73 dB	D
	Sheet piling	88 dB	D	76 dB	D
	Excavation	73 dB	D	61 dB	D
	Tunnel boring and pipe jacking	N/A	--	63 dB	D
	Grouting	N/A	--	66 dB	D

Figure 4 and Figure 5 show the extent of the affected properties for each sub-activity based on the 'long-term' daytime guideline noise criteria. At times, houses adjacent to the work areas are expected to experience noise levels exceeding 70 dB $L_{Aeq(15min)}$ for the following sub-activities:

- Site establishment and vegetation clearance (15 properties);
- Sheet piling (24 properties); and
- Excavation (reception shaft only) (2 properties).

Night works are expected to be required during the trenchless technology sub-activities. Table 7 provides indicative noise levels at the nearest neighbouring receivers to the jacking station during night-works. This considers simple steps such as avoiding material deliveries and using mains power.

Table 7 Indicative noise levels for night-time trenchless construction activities

Construction activity	Task	60 m Jacking station	
Trenchless construction	Tunnel boring and pipe jacking	59 dB	N
	Grouting	65 dB	N

Based on the screening that will be provided by terrain, which is not taken into account by the above calculations, it is expected that the extent of the affected properties for night-time activities will be similar to that shown in Figure 4 for daytime activities.

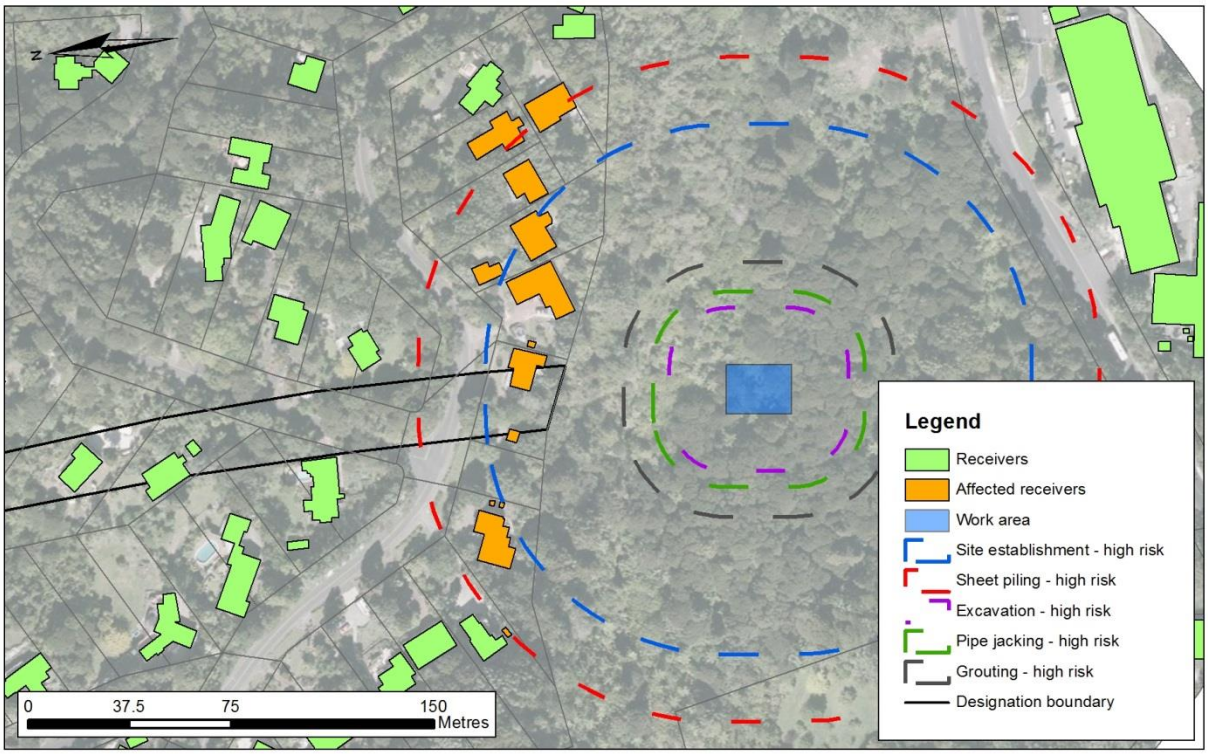

Figure 4 **Extent of affected properties at the Woodlands Park trenchless construction jacking station**

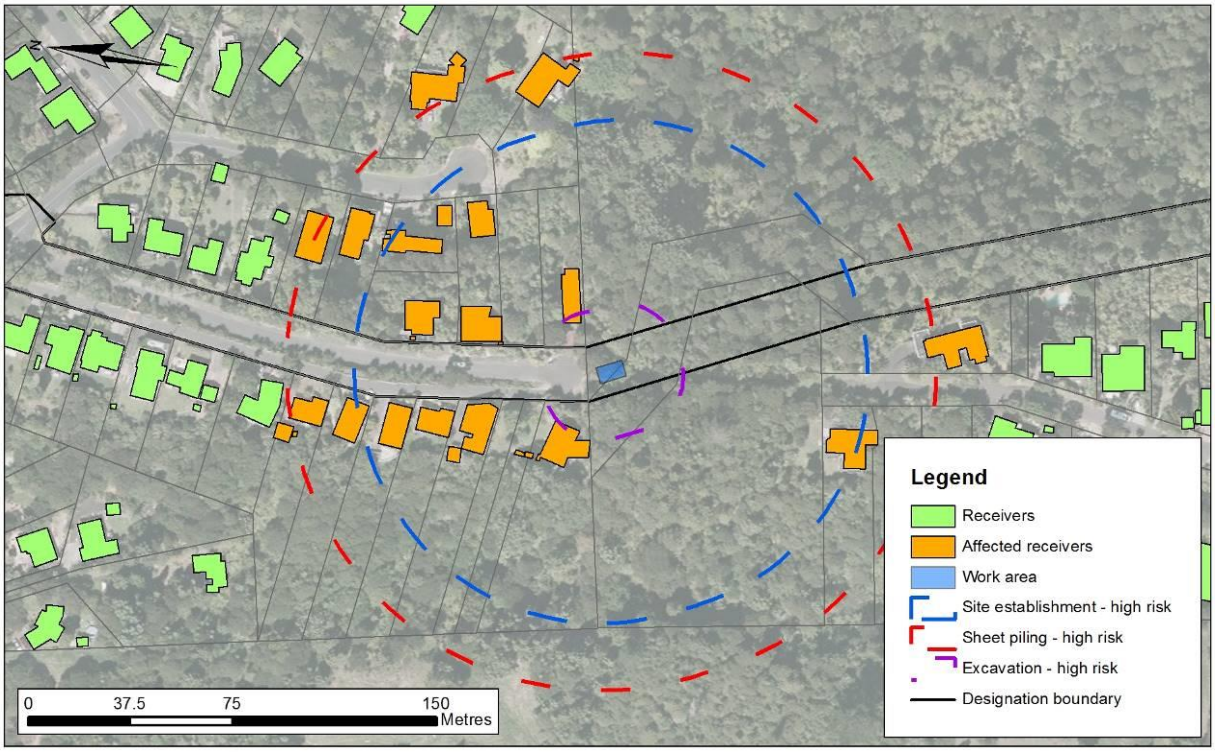

Figure 5 **Extent of affected properties at the Woodlands Park trenchless construction reception shaft**

Vibration will be generated by the following activities:

- Sheet piling; and
- Tunnelling.

Table 8 summarises the number of potentially affected properties from construction vibration at Woodland Park Tunnel location, based on the low, medium and high risk setback distances identified in Table 3.

Table 8 Number of properties affected by construction vibration

Construction activity	Task	Risk	
		Medium	High
Trenchless construction	Sheet piling	4 properties	none
	Tunnel boring	5 properties	none

The section of the tunnel under the properties at Konini Road is at a depth of more than 32 metres; therefore, these properties fall within the low risk zone. Disturbance of occupants of these properties is unlikely.

6.1.3.2 North Auckland railway crossing (option)

Trenchless construction has been proposed as an option for the North Auckland railway crossing on Metcalfe Road. The jacking station and reception shaft are located on either side of railway line. Noise levels have been calculated in the vicinity of the railway crossing using the indicative construction equipment detailed in Table 39 in Appendix A. Pipe jacking at the North Auckland railway crossing is expected to advance by excavation behind an open face shield, although the use of a tunnel boring machine is possible.

Table 9 provides indicative noise levels at the nearest neighbouring receivers to the jacking station and reception shaft, along with a comparison with the 'long-term' daytime guideline noise criteria (70 dB $L_{Aeq(15min)}$).

Table 9 Indicative noise levels for daytime trenchless construction activities

Construction activity	Task	9 m Reception shaft		16 m Jacking station	
Railway crossing	Site establishment	77 dB	D	72 dB	D
	Sheet piling	92 dB	D	87 dB	D
	Excavation	77 dB	D	72 dB	D
	Tunnel boring and pipe jacking	N/A	--	74 dB	D
	Grouting	N/A	--	78 dB	D

Figure 6 shows the extent of the affected properties for each sub-activity based on long-term daytime guideline noise criteria. At times, houses adjacent to the work areas are expected to experience noise levels exceeding 70 dB $L_{Aeq(15min)}$ for the following sub-activities:

- Site establishment (3 properties);
- Sheet piling (~100 properties);
- Excavation (3 properties);
- Tunnel boring and pipe jacking (3 properties); and
- Grouting (7 properties).

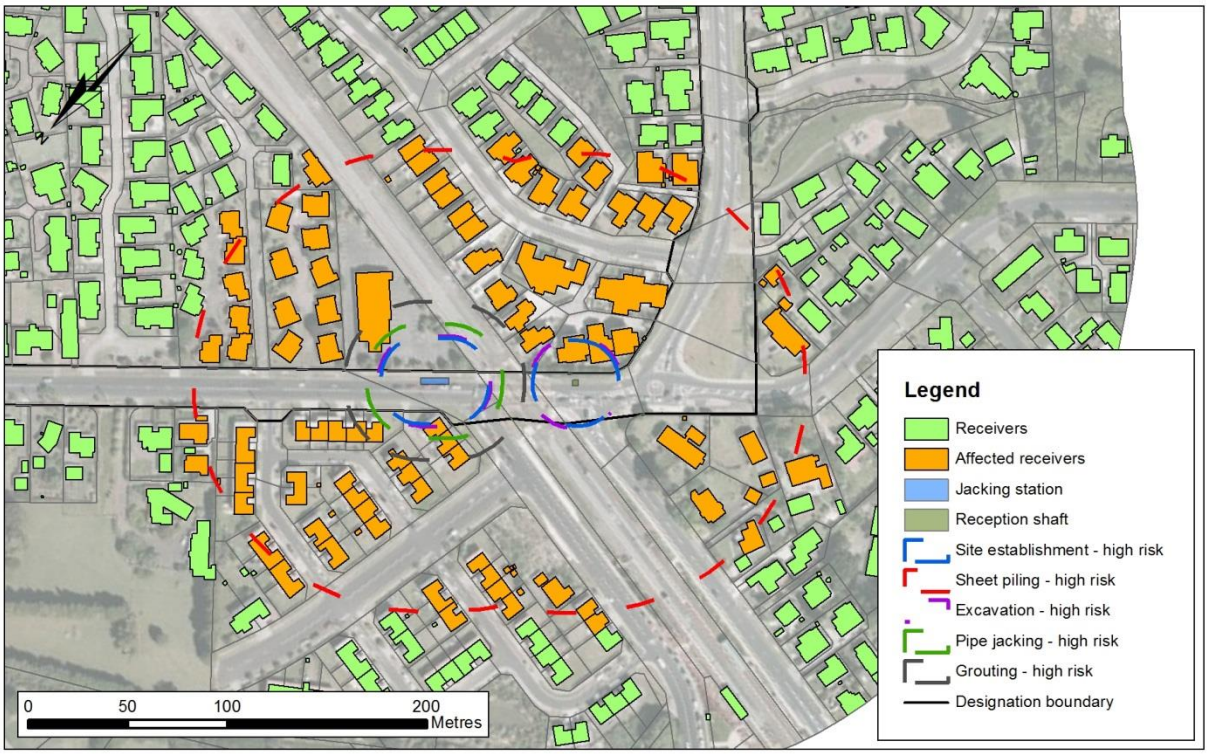

Figure 6 Extent of affected properties at the North Auckland railway crossing due to trenchless construction activities

Vibration will be generated by the following activities:

- Excavation, including excavator assisted pipe jacking; and
- Sheet piling.

Table 10 summarises the number of potentially affected properties from construction vibration, based on the low, medium and high risk setback distances identified in Table 3.

Table 10 Number of properties affected by construction vibration

Construction activity	Task	Risk	
		Medium	High
Railway crossing	Excavation	1 property	none
	Sheet piling	21 properties	none

6.1.4 Stream crossing

6.1.4.1 Oratia Stream crossing

A pipe bridge has been proposed for the crossing at Oratia Stream. This is expected to be a separate to the road bridge, requiring its own support structure. Noise levels have been calculated in the vicinity of the pipe bridge using the indicative construction equipment detailed in Table 41 in Appendix A.

Table 11 provides indicative noise levels at the nearest neighbouring receiver to the work area, along with a comparison with the 'long-term' daytime guideline noise criteria (70 dB $L_{Aeq(15min)}$).

Table 11 Indicative noise levels for daytime pipe bridge construction activities

Construction activity	Task	28 m Nearest residence	
Pipe bridge construction	Site establishment and vegetation clearance	77 dB	D
	Piling	78 dB	D
	Bridge column construction	71 dB	D
	Pipe installation	69 dB	D

Figure 7 shows the extent of the affected properties for each sub-activity based on long-term daytime guideline noise criteria. At times, houses adjacent to the work area are expected to experience noise levels exceeding 70 dB $L_{Aeq(15min)}$ for the following sub-activities:

- Site establishment (11 properties);
- Piling (18 properties); and
- Column construction (2 properties).

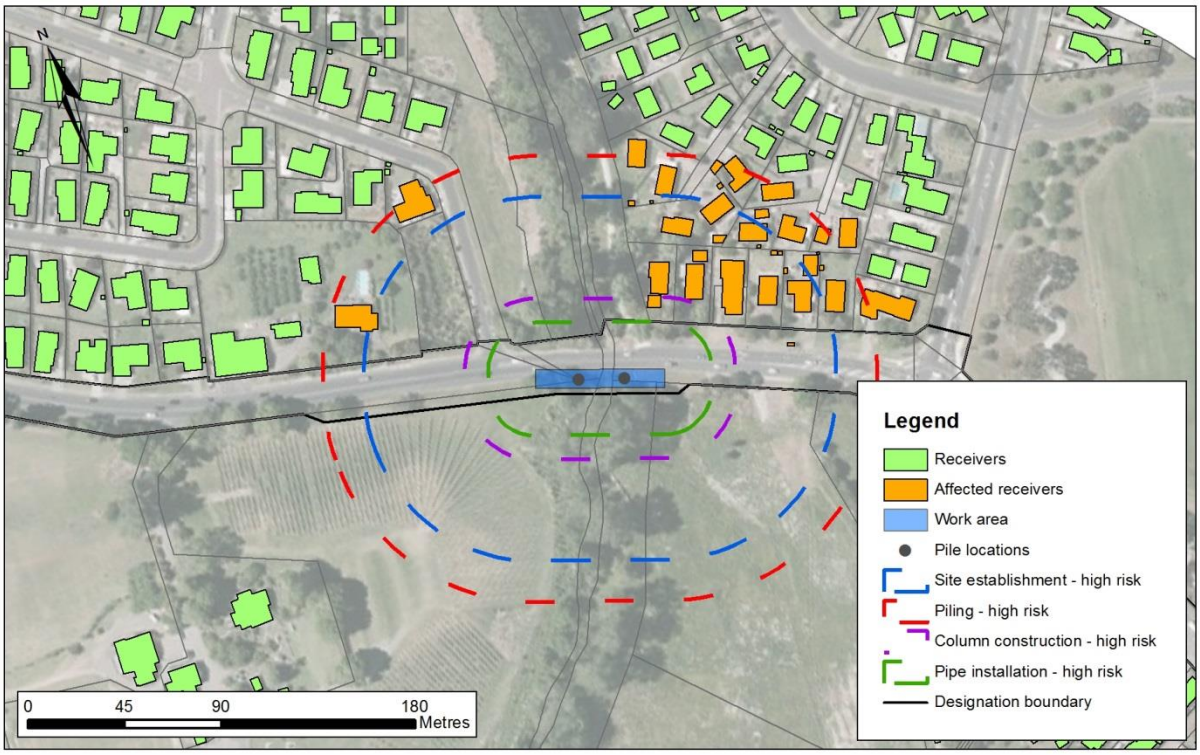

Figure 7 Extent of affected properties at the Oratia Stream crossing due to bridge construction activities

Vibration will be generated by the piling activity. Table 12 summarises the number of potentially affected properties from construction vibration, based on the low, medium and high risk setback distances identified in Table 3.

Table 12 Number of properties affected by construction vibration

Construction activity	Task	Risk	
		Medium	High
Pipe bridge construction	Piling	4 properties	none

6.1.4.2 Opanuku Stream crossing

A pipe bridge has been proposed for the crossing at Opanuku Stream, similar to the Oratia Stream crossing described above. Noise levels have been calculated in the vicinity of the pipe bridge using the indicative construction equipment detailed in Table 41 in Appendix A.

Table 13 provides indicative noise levels at the nearest neighbouring receiver to the work area, along with a comparison with the 'long-term' daytime guideline noise criteria (70 dB $L_{Aeq(15min)}$).

Table 13 Indicative noise levels for daytime pipe bridge construction activities

Construction activity	Task	15 m Nearest residence	
Pipe bridge construction	Site establishment and vegetation clearance	81 dB	D
	Piling	82 dB	D
	Bridge column construction	74 dB	D
	Pipe installation	72 dB	D

At times, houses adjacent to the work area are expected to experience noise levels exceeding 70 dB $L_{Aeq(15min)}$. The extent of the effected affected properties will be similar to the Oratia Stream crossing.

Vibration will be generated by the piling activity. The extent of the effected affected properties will be similar to the Oratia Stream crossing.

6.1.4.3 Paremuka Stream crossing

A pipe bridge has been proposed for the crossing at Paremuka Stream, similar to the Oratia Stream crossing described above. Noise levels have been calculated in the vicinity of the pipe bridge using the indicative construction equipment detailed in Table 41 in Appendix A.

Table 14 provides indicative noise levels at the nearest neighbouring receiver to the work area, along with a comparison with the 'long-term' daytime guideline noise criteria (70 dB $L_{Aeq(15min)}$).

Table 14 Indicative noise levels for daytime pipe bridge construction activities

Construction activity	Task	9 m Nearest residence	
Pipe bridge construction	Site establishment and vegetation clearance	83 dB	D
	Piling	84 dB	D
	Bridge column construction	77 dB	D
	Pipe installation	74 dB	D

Figure 8 shows the extent of the affected properties for each sub-activity based on long-term daytime guideline noise criteria. At times, houses adjacent to the work area are expected to experience noise levels exceeding 70 dB $L_{Aeq(15min)}$ for the following sub-activities:

- Site establishment (19 properties);
- Piling (33 properties);
- Column construction (4 properties); and
- Pipe installation (2 properties).

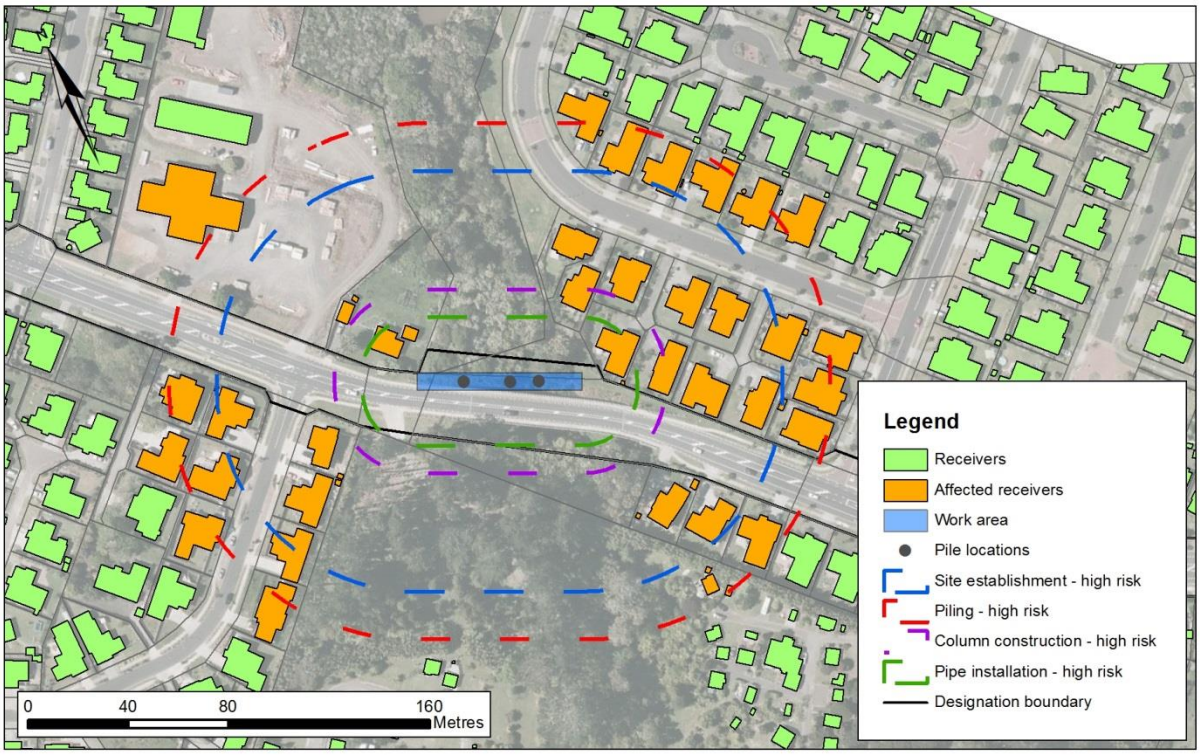

Figure 8 Extent of affected properties at the Paremuka Stream crossing due to bridge construction activities

Vibration will be generated by the piling activity. Table 15 summarises the number of potentially affected properties from construction vibration, based on the low, medium and high risk setback distances identified in Table 3.

Table 15 Number of properties affected by construction vibration

Construction activity	Task	Risk	
		Medium	High
Pipe bridge construction	Piling	11 properties	none

6.1.4.4 Swanson Stream crossing

A pipe bridge has been proposed for the crossing at Swanson Stream, similar to the Oratia Stream crossing described above. Noise levels have been calculated in the vicinity of the pipe bridge using the indicative construction equipment detailed in Table 41 in Appendix A.

Table 16 provides indicative noise levels at the nearest neighbouring receiver to the work area, along with a comparison with the 'long-term' daytime guideline noise criteria (70 dB $L_{Aeq(15min)}$).

Table 16 Indicative noise levels for daytime pipe bridge construction activities

Construction activity	Task	25 m	
		Nearest residence	
Pipe bridge construction	Site establishment and vegetation clearance	78 dB	D
	Piling	79 dB	D
	Bridge column construction	72 dB	D
	Pipe installation	69 dB	D

At times, houses adjacent to the work area are expected to experience noise levels exceeding 70 dB $L_{Aeq(15min)}$. The extent of the effected affected properties will be similar to the Oratira Stream crossing.

Vibration will be generated by the piling activity. The extent of the effected affected properties will be similar to the Oratia Stream crossing.

6.1.5 Other

6.1.5.1 Palomino Dr cathodic protection

Cathodic protection will be installed adjacent to Opanuku Stream. Noise levels have been calculated in the vicinity of the cathodic protection site and the cabling through Plumer Domain using the indicative construction equipment detailed in Table 42 in Appendix A.

Table 17 provides indicative noise levels at the nearest neighbouring receiver to the work area, along with a comparison with the 'long-term' daytime guideline noise criteria (70 dB $L_{Aeq(15min)}$).

Table 17 Indicative noise levels for daytime cathodic protection construction activities

Construction activity	Task	10 m		20 m	
		Cable laying		Cathodic protection site	
Cathodic protection sites	Site establishment	71 dB	D	67 dB	D
	Excavation	75 dB	D	69 dB	D
	Concreting	N/A	--	74 dB	D
	Installation of cathodic protection devices	75 dB	D	70 dB	D

At times during the cathodic protection activity properties adjacent to the work area are expected to experience noise levels exceeding 70 dB $L_{Aeq(15min)}$. This will be limited to approximately nine properties within 40 m of the work area.

All neighbouring properties are considered low risk in terms of construction vibration.

6.2 NOR2

6.2.1 Trenching

Trenching activities within NOR2 will be conducted along the majority of the NH2 pipeline. The construction noise and vibration levels and the extent of the affected properties will be similar to that of NOR1 (refer to Section 6.1.1).

6.2.2 Chambers

Valve chambers within NOR2 will be constructed at multiple locations along the NH2 pipeline. The construction noise and vibration levels and the extent of the affected properties will be similar to that of NOR1 (refer to Section 6.1.2).

6.2.3 Trenchless

6.2.3.1 Tauhinu Rd (option)

Trenchless construction has been proposed as an option for the Tauhinu Road crossing, similar to the trenchless construction activities described in Section 6.1.3 as part of NOR1. Noise levels have been calculated in the vicinity of the jacking station and reception shaft using the indicative construction equipment detailed in Table 39 in Appendix A.

Table 18 provides indicative noise levels at the nearest neighbouring receivers to the work area, along with a comparison with the 'long-term' daytime guideline noise criteria (70 dB $L_{Aeq(15min)}$).

Table 18 Indicative noise levels for daytime trenchless construction activities

Construction activity	Task	25 m Reception shaft		60 m Jacking station	
Trenchless construction	Site establishment and vegetation clearance	68 dB	D	60 dB	D
	Sheet piling	83 dB	D	76 dB	D
	Excavation	69 dB	D	61 dB	D
	Tunnel boring and pipe jacking	N/A	--	63 dB	D
	Grouting	N/A	--	66 dB	D

During sheet piling, houses adjacent to the work area are expected to experience noise levels exceeding 70 dB $L_{Aeq(15min)}$. The extent of the effected affected properties will be similar to that of the Manuka Rd to Shetland St trenchless construction, described in Section 6.1.3 as part of NOR1.

Night works are expected to be required during the tunnelling and grouting sub-activities. Table 19 provides indicative noise levels at the nearest neighbouring receivers to the jacking station during night-works. This considers simple steps such as avoiding material deliveries and using mains power.

Table 19 Indicative noise levels for night-time trenchless construction activities

Construction activity	Task	60 m Jacking station	
Trenchless construction	Tunnel boring and pipe jacking	59 dB	N
	Grouting	65 dB	N

Vibration will be generated by the following activities:

- Sheet piling; and
- Tunnelling.

Properties adjacent to reception shaft and tunnelled section will experience noticeable levels of vibration from sheet piling and tunnelling activities, respectively. Based on the distances between the neighbouring properties and the work area, all properties affected by vibration are considered medium risk.

6.2.3.2 Greenhithe Rd crossing

Trenchless construction will be used for the Greenhithe Road crossing, similar to the trenchless construction activities described in Section 6.1.3 as part of NOR1. Noise levels have been calculated in the vicinity of the jacking station and reception shaft using the indicative construction equipment detailed in Table 39 in Appendix A.

Table 20 provides indicative noise levels at the nearest neighbouring receivers to the work area, along with a comparison with the 'long-term' daytime guideline noise criteria (70 dB $L_{Aeq(15min)}$).

Table 20 Indicative noise levels for daytime trenchless construction activities

Construction activity	Task	25 m Reception shaft		42 m Jacking station	
Trenchless construction	Site establishment and vegetation clearance	68 dB	D	64 dB	D
	Sheet piling	83 dB	D	79 dB	D
	Excavation	69 dB	D	64 dB	D
	Tunnel boring and pipe jacking	N/A	--	66 dB	D
	Grouting	N/A	--	69 dB	D

During sheet piling, houses adjacent to the work area are expected to experience noise levels exceeding 70 dB $L_{Aeq(15min)}$. The extent of the affected properties will be similar to that of the Manuka Rd to Shetland St trenchless construction, described in Section 6.1.3 as part of NOR1.

Night works are expected to be required during the tunnelling and grouting sub-activities. Table 21 provides indicative noise levels at the nearest neighbouring receivers to the jacking station during night-works. This considers simple steps such as avoiding material deliveries and using mains power.

Table 21 Indicative noise levels for night-time trenchless construction activities

Construction activity	Task	42 m Jacking station	
Trenchless construction	Tunnel boring and pipe jacking	62 dB	N
	Grouting	69 dB	N

Vibration will be generated by the following activities:

- Sheet piling; and
- Tunnelling.

Properties adjacent to the reception shaft and jacking station will experience noticeable levels of vibration from sheet piling. Properties adjacent to the tunnelled section will experience noticeable levels of vibration from tunnelling activities. Based on the distances between the neighbouring properties and the work area, all properties affected by vibration are considered medium risk.

6.2.3.3 Greenhithe embankment

Trenchless construction will be used along part of the embankment on the northern side of SH18, similar to the trenchless construction activities described in Section 6.1.3 as part of NOR1. Noise levels have been calculated in the vicinity of the jacking station and reception shaft using the indicative construction equipment detailed in Table 39 in Appendix A.

Table 22 provides indicative noise levels at the nearest neighbouring receivers to the work area, along with a comparison with the 'long-term' daytime guideline noise criteria (70 dB $L_{Aeq(15min)}$).

Table 22 Indicative noise levels for daytime trenchless construction activities

Construction activity	Task	40 m Reception shaft		80 m Jacking station	
Trenchless construction	Site establishment and vegetation clearance	64 dB	D	58 dB	D
	Sheet piling	79 dB	D	73 dB	D
	Excavation	64 dB	D	58 dB	D
	Tunnel boring and pipe jacking	N/A	--	60 dB	D
	Grouting	N/A	--	64 dB	D

During sheet piling, houses adjacent to the work area are expected to experience noise levels exceeding 70 dB $L_{Aeq(15min)}$. The extent of the effected affected properties will be similar to that of the Manuka Rd to Shetland St trenchless construction, described in Section 6.1.3 as part of NOR1.

Night works are expected to be required during the tunnelling and grouting sub-activities. Table 23 provides indicative noise levels at the nearest neighbouring receivers to the jacking station during night-works. This considers simple steps such as avoiding material deliveries and using mains power.

Table 23 Indicative noise levels for night-time trenchless construction activities

Construction activity	Task	80 m Jacking station	
Trenchless construction	Tunnel boring and pipe jacking	56 dB	N
	Grouting	63 dB	N

Vibration will be generated by the following activities:

- Sheet piling; and
- Tunnelling.

Properties adjacent to the reception shaft and tunnelled section will experience noticeable levels of vibration from sheet piling and tunnelling activities, respectively. Based on the distances between the neighbouring properties and the work area, all properties affected by vibration are considered medium risk.

6.2.3.4 Albany industrial area

Trenchless construction will be used to cross the Albany highway, extending past several commercial properties located adjacent to SH18. This is similar to the trenchless construction activities described in Section 6.1.3 as part of NOR1. Noise levels have been calculated in the vicinity of the jacking station and reception shaft using the indicative construction equipment detailed in Table 39 in Appendix A.

Table 24 provides indicative noise levels at the nearest neighbouring receivers to the work area, along with a comparison with the 'long-term' daytime guideline noise criteria (70 dB $L_{Aeq(15min)}$).

Table 24 Indicative noise levels for daytime trenchless construction activities

Construction activity	Task	22 m Reception shaft		14 m* Jacking station	
Trenchless construction	Site establishment and vegetation clearance	69 dB	D	73 dB	D
	Sheet piling	84 dB	D	88 dB	D
	Excavation	70 dB	D	74 dB	D
	Tunnel boring and pipe jacking	N/A	--	75 dB	D
	Grouting	N/A	--	79 dB	D

* Commercial property, closest residential property is 74 m away.

During sheet piling, houses adjacent to the work area are expected to experience noise levels exceeding 70 dB $L_{Aeq(15min)}$. The commercial properties adjacent to the jacking station will also experience noise levels exceeding 70 dB $L_{Aeq(15min)}$ during other activities. The extent of the effected affected properties will be similar to that of the Manuka Rd to Shetland St trenchless construction, described in Section 6.1.3 as part of NOR1.

Night works are expected to be required during the tunnelling and grouting sub-activities. Table 25 provides indicative noise levels at the nearest neighbouring receivers to the jacking station during night-works. This considers simple steps such as avoiding material deliveries and using mains power.

Table 25 Indicative noise levels for night-time trenchless construction activities

Construction activity	Task	14 m* Jacking station		74 m Jacking station	
Trenchless construction	Tunnel boring and pipe jacking	71 dB	N	57 dB	N
	Grouting	78 dB	N	64 dB	N

* Commercial property, closest residential property is 74 m away.

Vibration will be generated by the following activities:

- Sheet piling; and
- Tunnelling.

Properties adjacent to the reception shaft and jacking station will experience noticeable levels of vibration from sheet piling. Properties adjacent to the tunnelled section will experience noticeable levels of vibration from tunnelling activities. Based on the distances between the neighbouring properties and the work area, all properties affected by vibration are considered medium risk.

6.2.3.5 Oteha Stream crossing (option) and Albany expressway crossing

Trenchless construction will be used to cross the Albany expressway and possibly Oteha Stream, similar to the trenchless construction activities described in Section 6.1.3 as part of NOR1. Noise levels have been calculated in the vicinity of the jacking station and reception shaft using the indicative construction equipment detailed in Table 39 in Appendix A.

Table 26 provides indicative noise levels at the nearest neighbouring receivers to the work area, along with a comparison with the 'long-term' daytime guideline noise criteria (70 dB $L_{Aeq(15min)}$).

Table 26 Indicative noise levels for daytime trenchless construction activities

Construction activity	Task	28 m Reception shaft		35 m Jacking station	
Trenchless construction	Site establishment and vegetation clearance	67 dB	D	65 dB	D
	Sheet piling	82 dB	D	80 dB	D
	Excavation	68 dB	D	66 dB	D
	Tunnel boring and pipe jacking	N/A	--	67 dB	D
	Grouting	N/A	--	71 dB	D

During sheet piling and grouting, houses adjacent to the work area are expected to experience noise levels exceeding 70 dB $L_{Aeq(15min)}$. The extent of the effected affected properties will be similar to that of the Manuka Rd to Shetland St trenchless construction, described in Section 6.1.3 as part of NOR1.

Night works are expected to be required during the tunnelling and grouting sub-activities. Table 27 provides indicative noise levels at the nearest neighbouring receivers to the jacking station during night-works. This considers simple steps such as avoiding material deliveries and using mains power.

Table 27 Indicative noise levels for night-time trenchless construction activities

Construction activity	Task	35 m Jacking station	
Trenchless construction	Tunnel boring and pipe jacking	63 dB	N
	Grouting	70 dB	N

Vibration will be generated by the following activities:

- Sheet piling; and
- Tunnelling.

Properties adjacent to the reception shaft and tunnelled section will experience noticeable levels of vibration from sheet piling and tunnelling activities, respectively. Based on the distances between the neighbouring properties and the work area, all properties affected by vibration are considered medium risk.

6.2.4 Stream crossing

6.2.4.1 Oteha Stream crossing (option)

A pipe bridge has been proposed for the crossing at Oteha Stream, similar to the Oratia Stream crossing described in Section 6.1.4 as part of NOR1. Noise levels have been calculated in the vicinity of the pipe bridge using the indicative construction equipment detailed in Table 41 in Appendix A.

Table 28 provides indicative noise levels at the nearest neighbouring receiver to the work area, along with a comparison with the 'long-term' daytime guideline noise criteria (70 dB $L_{Aeq(15min)}$).

Table 28 Indicative noise levels for daytime pipe bridge construction activities

Construction activity	Task	100 m	
		Nearest residence	
Pipe bridge construction	Site establishment and vegetation clearance	69 dB	D
	Piling	70 dB	D
	Bridge column construction	63 dB	D
	Pipe installation	61 dB	D

Noise levels at all houses adjacent to the work area are expected to be below 70 dB $L_{Aeq(15min)}$.

All neighbouring properties are considered low risk in terms of construction vibration.

6.2.5 Other

6.2.5.1 Albany cathodic protection

Cathodic protection will be installed adjacent to Rosedale Road in Albany. Noise levels have been calculated in the vicinity of the cathodic protection site and the cabling along Rosedale Road using the indicative construction equipment detailed in Table 42 in Appendix A.

Table 29 provides indicative noise levels at the nearest neighbouring receiver to the work area, along with a comparison with the 'long-term' daytime guideline noise criteria (70 dB $L_{Aeq(15min)}$).

Table 29 Indicative noise levels for daytime cathodic protection construction activities

Construction activity	Task	28 m		17 m*	
		Cable laying		Cathodic protection site	
Cathodic protection sites	Site establishment	65 dB	D	68 dB	D
	Excavation	67 dB	D	71 dB	D
	Concreting	N/A	--	78 dB	D
	Installation of cathodic protection devices	68 dB	D	71 dB	D

* Commercial property, nearest residential property is 28 m away.

At times, commercial properties adjacent to the work area are expected to experience noise levels exceeding 70 dB $L_{Aeq(15min)}$. Only a small number of residential properties will experience noise levels exceeding 70 dB $L_{Aeq(15min)}$, which will be limited to the concreting activity.

All neighbouring properties are considered low risk in terms of construction vibration.

6.3 NOR3 (NH2 construction works)

6.3.1 Trenching

Trenching activities within NOR3 will be conducted along the majority of the NH2 pipeline. The construction noise and vibration levels and the extent of the affected properties will be similar to that of NOR1 (refer to Section 6.1.1).

6.3.2 Chambers

Valve chambers within NOR3 will be constructed at multiple locations along the NH2 pipeline. The construction noise and vibration levels and the extent of the affected properties will be similar to that of NOR1 (refer to Section 6.1.2).

6.3.3 Trenchless

6.3.3.1 SH16 Motorway crossing

Trenchless construction techniques have been proposed at the SH16 Motorway crossing. Both the jacking station and reception shaft are well removed from residential and commercial receivers, with the nearest building being located 300 m away. Both daytime and night-time (pipe jacking) noise levels are expected to be below the 'long-term' guideline noise criteria (70 dB $L_{Aeq(15min)}$ and 45 dB $L_{Aeq(15min)}$, respectively).

6.3.3.2 SH18 motorway crossing

Trenchless construction will be used for the SH18 motorway crossing. The jacking station and reception shaft are located on either side of motorway. Noise levels have been calculated in the vicinity of the railway crossing using the indicative construction equipment detailed in Table 39 in Appendix A.

Table 30 provides indicative noise levels at the nearest neighbouring receivers to the work area, along with a comparison with the 'long-term' daytime guideline noise criteria (70 dB $L_{Aeq(15min)}$).

Table 30 Indicative noise levels for daytime trenchless construction activities

Construction activity	Task	38 m Nearest residence	
Motorway crossing	Site establishment and vegetation clearance	64 dB	D
	Sheet piling	80 dB	D
	Excavation	65 dB	D
	Tunnel boring and pipe jacking	67 dB	D
	Grouting	70 dB	D

Figure 9 shows the extent of the affected properties for each sub-activity based on long-term daytime guideline noise criteria. At times, houses adjacent to the work areas are expected to experience noise levels exceeding 70 dB $L_{Aeq(15min)}$ for the following sub-activities:

- Sheet piling (1 property).

Night works are expected to be required during the tunnelling and grouting sub-activities. Table 31 provides indicative noise levels at the nearest neighbouring receivers to the jacking station during night-works. This considers simple steps such as avoiding material deliveries and using mains power.

Table 31 Indicative noise levels for night-time trenchless construction activities

Construction activity	Task	38 m Nearest residence	
Motorway crossing	Tunnel boring and pipe jacking	63 dB	N
	Grouting	69 dB	N

Vibration will be generated by the following activities:

- Sheet piling; and
- Tunnelling.

The nearest property to the jacking station is more than 20 m away and is considered low risk.

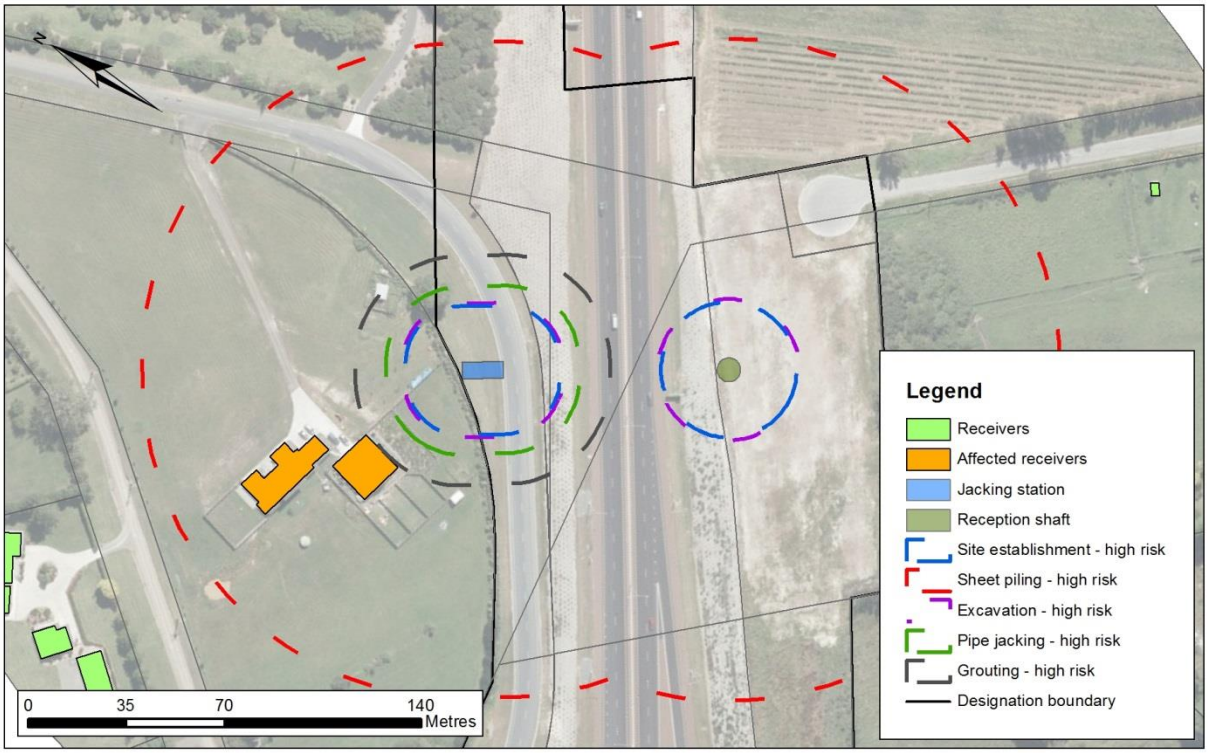

Figure 9 Extent of affected properties at the SH18 motorway crossing due to trenchless construction activities

6.3.4 Other

6.3.4.1 Hobsonville causeway (option)

A short causeway of approximately 200 m may be required for the section of pipeline immediately west of the Squadron Drive overbridge. Noise levels have been calculated in the vicinity of the causeway using the indicative construction equipment detailed in Table 43 in Appendix A.

Table 32 provides indicative noise levels at the nearest neighbouring receiver to the work area, along with a comparison with the 'long-term' daytime guideline noise criteria (70 dB $L_{Aeq(15min)}$).

Table 32 Indicative noise levels for daytime causeway construction activities

Construction activity	Task	70 m Nearest residence	
Causeway construction	Site establishment and vegetation clearance	71 dB	D
	Causeway construction	67 dB	D
	Pipe installation and back-filling	66 dB	D

At times during the vegetation clearance activity, the nearest house to the work area is expected to experience noise levels exceeding 70 dB $L_{Aeq(15min)}$.

All neighbouring properties are considered low risk in terms of construction vibration.

6.3.4.2 Hobsonville pipe bridge (option)

An alternative to the causeway outlined in Section 6.3.4.1 is the use of a pipe bridge, similar to that proposed for the Oratia Stream crossing described in Section 6.1.4 as part of NOR1. Noise levels have been calculated in the vicinity of the pipe bridge using the indicative construction equipment detailed in Table 41 in Appendix A.

Table 33 provides indicative noise levels at the nearest neighbouring receiver to the work area, along with a comparison with the 'long-term' daytime guideline noise criteria (70 dB $L_{Aeq(15min)}$).

Table 33 Indicative noise levels for daytime pipe bridge construction activities

Construction activity	Task	70 m Nearest residence	
Pipe bridge construction	Site establishment and vegetation clearance	71 dB	D
	Piling	73 dB	D
	Bridge column construction	65 dB	D
	Pipe installation	63 dB	D

At times during the vegetation clearance and piling activities, the nearest house to the work area is expected to experience noise levels exceeding 70 dB $L_{Aeq(15min)}$.

All neighbouring properties are considered low risk in terms of construction vibration.

6.4 NOR3 (NI construction works)

6.4.1 Trenchless

Trenchless construction will be used for this section of NI pipeline, similar to the trenchless construction activities described in Section 6.1.3 as part of NOR1. Multiple jacking stations and reception shafts have been proposed. These are well removed from residential and commercial receivers, with the nearest building being located approximately 100 m away. Noise levels have been calculated in the vicinity of the jacking station and reception shaft for this nearest receiver using the indicative construction equipment detailed in Table 39 in Appendix A.

Table 34 provides indicative noise levels at the nearest neighbouring receiver to the work area, along with a comparison with the 'long-term' daytime guideline noise criteria (70 dB $L_{Aeq(15min)}$).

Table 34 Indicative noise levels for daytime trenchless construction activities

Construction activity	Task	100 m Nearest residence	
Trenchless construction	Site establishment and vegetation clearance	56 dB	D
	Sheet piling	71 dB	D
	Excavation	57 dB	D
	Tunnel boring and pipe jacking	58 dB	D
	Grouting	62 dB	D

At times during the sheet piling activity the nearest properties to the work area may experience noise levels exceeding 70 dB $L_{Aeq(15min)}$ during the day.

Night works are expected to be required during the tunnelling and grouting sub-activities. Table 35 provides indicative noise levels at the nearest neighbouring receivers to the jacking station during night-works. This considers simple steps such as avoiding material deliveries and using mains power.

Table 35 Indicative noise levels for night-time trenchless construction activities

Construction activity	Task	100 m Nearest residence	
Trenchless construction	Tunnel boring and pipe jacking	54 dB	N
	Grouting	61 dB	N

The tunnelled section at 51 Trig Road is 11 m below the nearest dwelling. At this distance, disturbance of occupants of buildings is unlikely, however there may be perceptible levels of ground-borne noise and/or vibration. Due to the nature of the activity and that the source of the noise / vibration can be seen, this property is considered medium risk. Standard management techniques of communicating when tunnelling activities will occur is required to sufficiently mitigate this risk (refer section 7). Further detail will be developed in the CNVMP.

6.4.2 Other

6.4.2.1 Hobsonville Pump Station

A new Pump Station is proposed at the site of the existing Hobsonville Pump Station on Buckley Avenue. The Pump Station is not expected to be required before 2030. Noise levels have been calculated in the vicinity of the Pump Station using the indicative construction equipment detailed in Table 44 in Appendix A.

Table 36 provides indicative noise levels at the nearest neighbouring receiver to the work area, along with a comparison with the 'long-term' daytime guideline noise criteria (70 dB $L_{Aeq(15min)}$).

Table 36 Indicative noise levels for daytime pump station construction activities

Construction activity	Task	25 m Nearest residence	
Pump Station construction	Site establishment	67 dB	D
	Sheet piling	80 dB	D
	Excavation	66 dB	D
	Pump Station construction	73 dB	D
	Trenching, pipe installation and back-filling	76 dB	D

At times during the sheet piling, pump station construction (grinding) and pipe installation activities, the nearest houses to the work area are expected to experience noise levels exceeding 70 dB $L_{Aeq(15min)}$.

Properties located within 50 m of the work area will experience noticeable levels of vibration. These properties are considered medium risk.

7.0 Mitigation

Mitigation measures should be planned and implemented in a structured hierarchy depending on the extent of predicted effects. In general, the hierarchy should be:

- Managing times of activities to avoid night works and other sensitive times;
- Selecting equipment and methodologies to minimise noise and vibration where practicable:
- Using screening/enclosure/barriers;
- Liaising with neighbours so they can work around specific activities; and
- Providing periods of respite.

Good practice for noise mitigation is detailed in NZS 6803 and the Transport Agency's Construction Guide,[4] and any specific mitigation required will be documented in the CNVMP and schedules.

In general, limiting work to daytime hours will avoid the need for structural mitigation (such as temporary noise barriers) as in the majority of cases residents will not be present. Specific locations and activities where it may be necessary to implement structural mitigation are listed below; these will be confirmed through the CNVMP / Schedule process.

NOR1

- Chamber construction and valve installation:
  - Sheet piling activities, where receivers are located within 35 metres of the work area, Section 6.1.2.
- Trenchless construction:
  - Sheet piling and night-time tunnelling activities at Manuka Rd to Shetland St, Section 6.1.3.1; and
  - Sheet piling activities at North Auckland railway crossing, Section 6.1.3.2.
- Pipe bridge construction:
  - Piling activities at Opanuku Stream crossing, Section 6.1.4.2; and
  - Piling activities at Paremuka Stream crossing, Section 6.1.4.3.

NOR2

- Chamber construction and valve installation:
  - Sheet piling activities, where receivers are located within 35 metres of the work area, Section 6.2.2.
- Trenchless construction:
  - Sheet piling (reception shaft) and night-time tunnelling activities at Tauhinu Rd crossing, Section 6.2.3.1;
  - Sheet piling (reception shaft) and night-time tunnelling activities at Greenhithe Rd crossing, Section 6.2.3.2;
  - Night-time tunnelling activities at the Greenhithe embankment, Section 6.2.3.3;
  - Sheet piling and night-time tunnelling activities at the Albany industrial area, Section 6.2.3.4; and
  - Sheet piling and night-time tunnelling activities at the Oteha Stream and Albany expressway crossing, Section 6.2.3.5.

NOR3

- Chamber construction and valve installation:
  - Sheet piling activities, where receivers are located within 35 metres of the work area, Section 6.3.2.
- Trenchless construction:
  - Sheet piling and night-time tunnelling activities at the SH18 motorway crossing (jacking station only) , Section 6.3.3.2; and

[4] NZTA (2014) Construction and Maintenance Noise and Vibration Guide (V1.0).

- Sheet piling and night-time tunnelling activities for NI (shared corridor), Section 6.4.1.

- Pump Station construction:
  - Sheet piling activities at the Hobsonville Pump Station, Section 6.4.2.1.

8.0 Assessment of effects

8.1 Existing environment

The majority of the residential areas affected by the project presently have a considerable exposure to road traffic noise. Indicative traffic volumes are presented in Table 37 based on data from Auckland Transport and the Transport Agency.[5] This list is not complete, and traffic volumes will vary at different locations along the road; however, it is useful for establishing the existing noise environment. Road-traffic noise during the daytime is likely to reduce the perception of noise from construction activities. This will be both in terms of potential masking noise from construction activities, and also the sensitivity of the community to environmental noise may be low as they are already exposed to high noise levels from local road traffic.

Table 37 Traffic volumes on roads

NOR area	Road	Traffic volume (vpd AADT)
NOR1	Glengarry Road	3,800
	Parrs Cross Road	16,000
	Forrest Hill Road	12,700
	Palomino Drive	11,900
	Summerland Drive	1300
	Monroe Road	5300
	Metcalfe Road	11,400
	Don Buck Road	16,000
	Fred Taylor Drive	18,876
NOR2	William Pickering Drive	2000-4000
	Rosedale Road	14,413
	Bush Road	15,527
	Albany Expressway	25,000
	Corinthian Drive (industrial)	425
NOR3	SH18 (Upper Harbour Motorway)	20,500

8.2 Typical works

Daytime works in compliance with noise and vibration criteria (either NZS 6803 ‘typical duration’ or ‘long-term’ noise limits) should be compatible with normal domestic activities.

In many situations it might not be practicable to achieve compliance at all times. This is due to the nature of work generally in a constrained road corridor in close proximity to residences. Provided the community is made aware of the construction process and timeframes, annoyance will be minimal due to the short durations involved.

Where piling is required, the high noise levels may result in short periods of disruption to residents. Direct communication and consultation with affected residents will be required at these locations, and the nearest neighbours may wish to vacate their property during the hours when piling is taking place.

With appropriate noise mitigation and management measures structured through a CNVMP, construction noise is considered to be acceptable.

Ground vibration from excavation, piling, trenchless construction and compaction operations may be felt by residents. Where the levels are below the 1 mm/s level no annoyance or complaints would be expected. At locations where the nearest neighbours are subjected to vibration levels above 1 mm/s, but below 5 mm/s action level, disturbance to residents may occur and if residents are not expecting these works to be occurring,

[5] http://mobileroad.org/desktop.html.

complaints are likely. In these cases it should be possible to minimise annoyance through communication and consultation with the affected residents. Activities generating vibration above 1 mm/s are expected to be limited to daytime hours.

8.3 Night works

In general, construction activities will be conducted during standard work hours. Where night works are necessary due to traffic management constraints, these will be of limited duration and involve minimal construction equipment. In these cases noise levels are still expected to exceed the guideline noise criteria at the nearest neighbouring properties and there remains the potential for night works to cause sleep disturbance for these neighbours. Close liaison with the affected residents will be required to manage this effect if night-time construction activities are required.

The trenchless construction activities will generally require tunnel boring to continue 24 hours a day for the duration of the pipe installation process. This will involve a limited number of stationary hydraulic power packs and generators, resulting in noise levels that are lower than for daytime trenchless activities. The stationary nature of the equipment will allow mitigation in the form of noise barriers and equipment positioning to be used to further reduce night-time noise levels.

With management measures structured through a CNVMP the residual effects are considered acceptable.

9.0 Conclusions

An assessment of the construction noise and vibration effects has been conducted for the proposed NH2 and NI Shared corridor pipeline works. Predictions of the noise and vibration levels associated with the indicative construction activities have been made at the typical distances of the nearest residences.

Several distinct construction activities have been identified for the project, with each construction activity generally occurring at least once in each NOR area. While the total number of affected receivers will be lowest in NOR2, the nature of the effects (i.e. annoyance or sleep disturbance) will be consistent across all NOR areas for receivers at similar distances from a given construction activity. Construction activities are typical for this type of project, and it is common for these to occur in residential areas.

In general it has been found that, without specific mitigation or management measures, construction noise and vibration should meet the ‘short-term’ or ‘typical duration’ daytime criteria for the majority of activities, even for the closest residences.

For all three NOR areas (NOR 1, 2 and 3) there will be cases where sheet and impact piling is to be conducted close to residences, and exceedance of the daytime criteria is expected. Mitigation and management will need to be implemented through a CNVMP in all three NOR areas. Where necessary, night-time works will exceed the criteria and will require implementation of enhanced noise and vibration management procedures. Outline management and mitigation measures have been identified, along with specific areas where structural mitigation should be considered.

Appropriate mitigation and management measures will be confirmed when the specific construction methodology and equipment are known, and will be documented in a CNVMP. Communication and consultation with potentially affected residents makes up an important part of the CNVMP process.

With appropriate management of noise and vibration through a CNVMP, it is considered that annoyance from construction activities will be limited, and overall effects will be acceptable in the three NOR areas.

Appendix A

Construction Activities and Equipment

Table 38 Indicative construction equipment for the trenching activity

Construction equipment	***Description***	***Noise source data***		***Site establishment***		***Trenching, pipe installation and back-filling***		***Paving***	
		LAeq at 10 m	***Reference***	*Quantity*	*Duty*	*Quantity*	*Duty*	*Quantity*	*Duty*
Mobile crane	55t tracked	70 dB	BS 5228-1 C.3.29	1	100%	1	100%	-	-
Trucks (idle)	Material delivery, spoil removal	70 dB	Estimate	1	100%	-	-	-	-
Excavator	22t tracked	71 dB	BS 5228-1 C.2.21	-	-	1	50%	-	-
Articulated dump truck b	Tipping fill	79 dB	BS 5228-1 C.2.30	-	-	1	50%	-	-
Compaction	Dozer towing roller	81 dB	BS 5228-1 C.2.36	-	-	1	50%	1	100%
Welding machine	Hand-held	73 dB	BS 5228-1 C.3.31	-	-	1	50%	-	-
Generator (welding)	Diesel (4 kW)	66 dB	BS 5228-1 C.4.85	-	-	1	50%	-	-
Concrete pump	59 kW, 180mm diameter	78 dB	BS 5228-1 C.4.24	-	-	1	50%	-	-
Paver	Asphalt paver and tipper lorry	75 dB	BS 5228-1 C.5.33	-	-	-	-	1	100%

Table 39 Indicative construction equipment for the trenchless construction activity

Construction equipment	***Description***	***Noise source data***		***Site establishment and vegetation clearance***		***Sheet piling***		***Excavation***		***Tunnel boring and pipe jacking***		***Grouting***	
		LAeq at 10 m	***Reference***	*Quantity*	*Duty*	*Quantity*	*Duty*	*Quantity*	*Duty*	*Quantity*	*Duty*	*Quantity*	*Duty*
Chainsaw*	-	81 dB	Measurement	2	50%	-	-	-	-	-	-	-	-
Mulcher*	-	90 dB	Estimate	1	25%	-	-	-	-	-	-	-	-
Trucks (idle)	Material delivery, spoil removal	70 dB	Estimate	1	100%	-	-	1	100%	2	100%	1	100%
Mobile crane	55t tracked	70 dB	BS 5228-1 C.3.29	1	100%	1	100%	-	-	-	-	-	-
Sheet piling rig	52t	88 dB	BS 5228-1 C.3.8	-	-	1	100%	-	-	-	-	-	-
Sheet piling power pack	147 kW	68 dB	BS 5228-1 C.3.10	-	-	1	100%	-	-	-	-	-	-
Excavator	22t tracked	71 dB	BS 5228-1 C.2.21	-	-	-	-	1	100%	-	-	-	-
Pipe jacking plant	Hygraulic pump	70 dB	Estimate	-	-	-	-	-	-	1	100%	-	-
Separator plant	Water pump, 20 kW	65 dB	BS 5528-1 C.2.45	-	-	-	-	-	-	1	100%	-	-
Concrete pump	59 kW, 180mm diameter	78 dB	BS 5228-1 C.4.24	-	-	-	-	-	-	-	-	1	100%

* where vegetation clearance required

Table 40 Indicative construction equipment for the chamber construction and valve installation activity

Construction equipment	***Description***	***Noise source data***		***site establishment and vegetation clearance***		***Sheet piling***		***Excavation***		***Chamber construction and valve installation***	
		LAeq at 10 m	***Reference***	*Quantity*	*Duty*	*Quantity*	*Duty*	*Quantity*	*Duty*	*Quantity*	*Duty*
Chainsaw*	-	81 dB	Measurement	2	50%	-	-	-	-	-	-
Mulcher*	-	90 dB	Estimate	1	25%	-	-	-	-	-	-
Trucks (idle)	Material delivery, spoil removal	70 dB	Estimate	1	100%	-	-	1	100%	1	100%
Mobile crane	55t tracked	70 dB	BS 5228-1 C.3.29	1	100%	1	100%	-	-	1	100%
Sheet piling rig	52t	88 dB	BS 5228-1 C.3.8	-	-	1	100%	-	-	-	-
Sheet piling power pack	147kW	68 dB	BS 5228-1 C.3.10	-	-	1	100%	-	-	-	-
Excavator	22t tracked	71 dB	BS 5228-1 C.2.21	-	-	-	-	1	100%	-	-
Angle grinder	Grinding steel (2.3 kW)	80 dB	BS 5228-1 C.4.93	-	-	-	-	-	-	1	50%
Welding machine	Hand-held	73 dB	BS 5228-1 C.3.31	-	-	-	-	-	-	1	50%
Generator (welding/grinding)	Diesel (4 kW)	66 dB	BS 5228-1 C.4.85	-	-	-	-	-	-	1	50%
Concrete pump	59 kW, 180mm diameter	78 dB	BS 5228-1 C.4.24	-	-	-	-	-	-	1	50%

* where vegetation clearance required

Table 41 Indicative construction equipment for the stream crossing / bridge construction activity

Construction equipment	***Description***	***Noise source data***		***site establishment and vegetation clearance***		***Piling***		***Bridge column construction***		***Pipe installation***	
		LAeq at 10 m	***Reference***	*Quantity*	*Duty*	*Quantity*	*Duty*	*Quantity*	*Duty*	*Quantity*	*Duty*
Chainsaw	-	81 dB	Measurement	2	50%	-	-	-	-	-	-
Mulcher	-	90 dB	Estimate	1	25%	-	-	-	-	-	-
Trucks (idle)	Material delivery	70 dB	Estimate	1	100%	-	-	-	-	1	50%
Mobile crane	55t tracked	70 dB	BS 5228-1 C.3.29	1	100%	1	100%	1	100%	-	-
Piling	Hydraulic hammer rig	88 dB	BS 5228-1 C.3.3	-	-	1	100%	-	-	-	-
Sheet piling power pack	147kW	68 dB	BS 5228-1 C.3.10	-	-	1	100%	-	-	-	-
Concrete pump	59 kW, 180mm diameter	78 dB	BS 5228-1 C.4.24	-	-	-	-	1	50%	-	-
Angle grinder	Grinding steel (2.3 kW)	80 dB	BS 5228-1 C.4.93	-	-	-	-	1	50%	1	50%
Welding machine	Hand-held	73 dB	BS 5228-1 C.3.31	-	-	-	-	1	50%	1	50%
Generator (welding/grinding)	Diesel (4 kW)	66 dB	BS 5228-1 C.4.85	-	-	-	-	1	50%	1	50%

Table 42 Indicative construction equipment for the cathodic protection sites

Construction equipment	***Description***	***Noise source data***		***site establishment***		***Chamber construction***		***Concreting***		***Installation of cathodic protection devices***	
		LAeq at 10 m	***Reference***	*Quantity*	*Duty*	*Quantity*	*Duty*	*Quantity*	*Duty*	*Quantity*	*Duty*
Mobile crane	55t tracked	70 dB	BS 5228-1 C.3.29	1	100%	-	-	-	-	1	100%
Trucks (idle)	Material removal	70 dB	Estimate	1	100%	1	100%	1	100%	1	100%
Excavator	22t tracked	71 dB	BS 5228-1 C.2.21	-	-	1	100%	-	-	-	-
Minor works	Manual tasks	70 dB	Estimate	-	-	-	-	1	100%	1	100%
Concrete pump	59 kW, 180mm diameter	78 dB	BS 5228-1 C.4.24	-	-	-	-	1	100%	-	-

Table 43 Indicative construction equipment for the causeway construction

Construction equipment	***Description***	***Noise source data***		***site establishment and vegetation clearance***		***Causeway construction***		***Pipe installation and back-filling***	
		LAeq at 10 m	***Reference***	*Quantity*	*Duty*	*Quantity*	*Duty*	*Quantity*	*Duty*
Chainsaw	-	81 dB	Measurement	2	50%	-	-	-	-
Mulcher	-	90 dB	Estimate	1	25%	-	-	-	-
Trucks (idle)	Material delivery	70 dB	Estimate	1	100%	-	-	1	100%
Mobile crane	55t tracked	70 dB	BS 5228-1 C.3.29	1	100%	-	-	1	100%
Excavator a	Long reach	71 dB	BS 5228-1 C.2.21	-	-	1	100%	-	-
Articulated dump truck a	Driving	70 dB	Estimate	-	-	1	50%	-	-
Articulated dump truck b	Tipping fill	79 dB	BS 5228-1 C.2.30	-	-	1	50%	-	-
Compaction	Dozer towing roller	81 dB	BS 5228-1 C.2.36	-	-	1	50%	1	50%
Excavator b	22t tracked	71 dB	BS 5228-1 C.2.21	-	-	-	-	1	100%
Welding machine	Hand-held	73 dB	BS 5228-1 C.3.31	-	-	-	-	1	50%
Generator (welding)	Diesel (4 kW)	66 dB	BS 5228-1 C.4.85	-	-	-	-	1	50%

Table 44 Indicative construction equipment for the pump station construction

Construction equipment	***Description***	***Noise source data***		***Site establishment***		***Sheet piling***		***Excavation***		***Pump station construction***		***Trenching, pipe installation and back-filling***	
		LAeq at 10 m	***Reference***	*Quantity*	*Duty*	*Quantity*	*Duty*	*Quantity*	*Duty*	*Quantity*	*Duty*	*Quantity*	*Duty*
Mobile crane	55t tracked	70 dB	BS 5228-1 C.3.29	1	100%	1	100%	-	-	1	100%	1	100%
Trucks (idle)	Material delivery, spoil removal	70 dB	Estimate	1	100%	-	-	1	100%	1	100%	-	-
Sheet piling rig	52t	88 dB	BS 5228-1 C.3.8	-	-	1	100%	-	-	-	-	-	-
Sheet piling power pack	147 kW	68 dB	BS 5228-1 C.3.10	-	-	1	100%	-	-	-	-	-	-
Excavator	22t tracked	71 dB	BS 5228-1 C.2.21	-	-	-	-	1	100%	-	-	1	50%
Articulated dump truck b	Tipping fill	79 dB	BS 5228-1 C.2.30	-	-	-	-	-	-	-	-	1	50%
Compaction	Dozer towing roller	81 dB	BS 5228-1 C.2.36	-	-	-	-	-	-	-	-	1	50%
Angle grinder	Grinding steel (2.3 kW)	80 dB	BS 5228-1 C.4.93	-	-	-	-	-	-	1	50%	-	-
Welding machine	Hand-held	73 dB	BS 5228-1 C.3.31	-	-	-	-	-	-	1	50%	1	50%
Generator (welding/grinding)	Diesel (4 kW)	66 dB	BS 5228-1 C.4.85	-	-	-	-	-	-	1	50%	1	50%
Concrete pump	59 kW, 180mm diameter	78 dB	BS 5228-1 C.4.24	-	-	-	-	-	-	1	50%	1	50%