TE TUPU NGĀTAHI
SUPPORTING GROWTH

VOLUME 4

Airport to Botany – Assessment of Construction Noise and Vibration Effects

December 2022

Version 1

WAKA KOTAHI
NZ TRANSPORT AGENCY

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Document Status

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Glossary of Defined Terms and Acronyms

Acronym/Term	Description
AEE	Assessment of Effects on the Environment report
AUP:OP	Auckland Unitary Plan: Operative in Part
BPO	Best Practicable Option
BRT	Bus Rapid Transit
CNVMP	Construction Noise and Vibration Management Plan
CVA	Cultural Values Assessments
HANA	High Aircraft Noise Area
MANA	Moderate Aircraft Noise Area
N/A	Not Applicable
NIMT	North Island Main Trunk railway
NoR	Notice of Requirement
NoR 1	Notice of Requirement 1: Airport to Botany Bus Rapid Transit (Botany Town Centre to Rongomai Park)
NoR 2	Notice of Requirement 2: Airport to Botany Bus Rapid Transit (Rongomai Park to Puhinui Station, in the vicinity of Plunket Avenue)
NoR 3	Notice of Requirement 3: Airport to Botany Bus Rapid Transit (Puhinui Station, in the vicinity of Plunket Avenue to SH20/20B Interchange)
NoR 4a	Notice of Requirement 4a: Airport to Botany Bus Rapid Transit (SH20/20B Interchange to Orrs Road)
NoR 4b	Notice of Requirement 4b: Alteration to NZ Transport Agency Designation 6717 – State Highway 20B
NPS:UD	National Policy Statement on Urban Development 2020
PPFs	Protected Premises and Facilities
Programme partners	Te Ākitai Waiohua, Auckland Airport, Auckland Transport and Waka Kotahi
RCA	Road Controlling Authority
RMA	Resource Management Act 1991
RP	Regional Plan
RPS	Regional Policy Statement
SEA	Significant Ecological Area
Schedules	Site Specific Noise and/or Vibration Management Schedules
SH1	State Highway 1
SH20	State Highway 20
SH20B	State Highway 20B
SWGP	Southwest Gateway Programme
Te Tupu Ngātahi	Te Tupu Ngātahi Supporting Growth
Waka Kotahi	Waka Kotahi NZ Transport Agency

Executive summary

This report provides an assessment of the construction noise and vibration effects for the Airport to Botany Bus Rapid Transit project (**the Project**) to inform the Assessment of Effects on the Environment (**AEE**) for five Notices of Requirement (**NoR**) being sought by Waka Kotahi NZ Transport Agency (**Waka Kotahi**) and Auckland Transport.

Methodology

The following methodology has been used for the construction noise and vibration assessment for all NoRs:

- We reviewed relevant Standards and guidelines appropriate for the assessment of construction noise and vibration and recommended which standards to use as follows:

  - **Construction noise:** NZS 6803:1999 Acoustics – Construction Noise. This standard is referenced both in the Auckland Unitary Plan (Operative in Part) (**AUP:OP**) and relevant Waka Kotahi guidance. The criteria are generally 70 dB LAeq and 85 dB LAFmax during daytime; and
  - **Construction vibration:** a two-tiered approach has been adopted of Category A (generally to protect amenity) and Category B (to protect buildings from any, including cosmetic, damage. The criteria are generally based on those of DIN4150-3 (1999) Structural vibration – Part 3 Effects of vibration on structures and British Standard (BS) 5228-2: 2009 "Code of practice for noise and vibration control on construction and open sites". The above criteria are referenced in AUP:OP E25.6.30 and the Waka Kotahi "State Highway Construction and Maintenance Noise and Vibration Guide" (**Guide**), V1.1, August 2019. The criteria range from 1 to 2 mm/s PPV for Category A, to 5 mm/s PPV for occupied buildings for Category B, and higher for unoccupied buildings.

- We reviewed noise and vibration emission data for each construction task / process based on equipment data previously measured by Marshall Day Acoustics for similar activities. Data from appropriate noise and vibration standards (e.g. BS5228-1:2009) has also been considered, where relevant.
- We predicted noise and vibration levels from construction based on relevant standards and guidelines and determined setback distances where compliance with the relevant standards can be achieved. These setback distances have been plotted on the Project drawings and are shown in **Appendix A** for noise and **Appendix B** for vibration.
- Where construction is predicted to exceed the noise or vibration standards, we recommend management and mitigation through a framework of a Construction Noise and Vibration Management Plan (**CNVMP**) and schedules.

Effects analysis

Construction noise and vibration is generally higher than that of ongoing continuous activities. Therefore, while effects are based on how people are likely to react to equivalent internal noise levels, one needs to keep in mind that construction is a temporary activity with a finite duration. Most people are more likely to accept increased noise or vibration levels if durations and magnitudes are well communicated prior to works occurring.

Overall, predicted noise levels for the majority of works will be able to comply with the relevant daytime limits, which means that effects are generally acceptable inside neighbouring buildings. Where high noise activities are likely (e.g. demolition of close by buildings, piling of bridges or retaining walls, and earthworks), these activities would occur for short periods only close to any one building, extending over a few days at most, before moving along the alignment or being completed.

Effects can be managed through the application of management and mitigation measures through a CNVMP and schedules as discussed below. Overall, we consider the effects will generally be reasonable for the majority of activities.

Management and mitigation recommendations

Management and mitigation measures should be implemented as a matter of good practice and are considered the baseline mitigation for most circumstances, irrespective of compliance with the limits.

Where an exceedance of the construction noise or vibration standards is likely due to a specific activity or in a specific area, and the general mitigation measures as discussed below are not sufficient to achieve full compliance, further mitigation and management should be investigated and implemented where practicable. Such information would be contained in the Schedule as an attachment to the CNVMP. Depending on the final construction methodology and receivers in the vicinity, mitigation and management measures may also include the offer of temporary relocation. The appropriate mitigation measures will be determined on a case-by-case basis throughout construction using the CNVMP and/or site specific schedules as the implementation tool.

Table 1: Summary of construction noise and vibration effects and recommendations

Effect	Assessment	Recommendation
Construction noise – all NoRs	NoRs 1, 2 and 3 traverse well established residential and commercial areas, with buildings in close proximity to construction works. NoR 4a and 4b traverses currently generally greenfield sites (some zoned FUZ). Largest effects anticipated from: • Demolition of first row houses in NoR 2 and 3, and some of NoR 1 – limited duration and localised, but very close to houses; • Earthworks to prepare alignment, service relocations – longer duration but moving along the alignment; • Bridge piling and installation in NoR 4b, 2/3 – limited duration and localised effects only, but night/weekend works likely required; and • Final surfacing – likely to be done at night-time. Limited duration.	Management and mitigation through the CNVMP Schedules for any specifically noisy activities or where receivers are particularly affected, e.g.: • Any night-time works in all NoRs in the vicinity of residential areas; and • Any specifically high noise works where they affect sensitive receivers. Communication and consultation prior to high noise works
Construction vibration – all NoRs	NoRs 1, 2 and 3 traverse well established residential and commercial areas, with buildings in close proximity to construction works. There are no close buildings in NoR 4a and 4b. Largest effects anticipated from:	Management and mitigation through the CNVMP Schedules for any specific vibration inducing activities or where

Effect	Assessment	Recommendation
	• Demolition of first row houses in NoR 2 and 3, and some of NoR 1 – limited duration and localised, but very close to houses; • Road preparation: use of vibratory rollers – along entire alignment, therefore limited duration but affecting all immediately fronting houses; and • Construction of bridge piles and retaining walls.	receivers are particularly affected, e.g.: • Piling; • Demolition of existing driveways and structures close to other houses; and • Vibratory rolling (if to be undertaken at night-time). Choice of piling methodology to be bored rather than impact or vibrated Use of non-vibratory compaction close to buildings Building condition surveys
Night-time construction noise – NoR 2	Bridge construction across SH1 will likely require night-time works as SH1 may need to be closed	Consider offer of temporary relocation to most affected residents to manage sleep disturbance, depending on duration and noise level
Construction noise – NoR 2	Works close to educational facilities (MIT and AUT South Campus)	Consult with the educational facilities and schedule works to avoid exams or other sensitive times.
Construction noise – NoR 3	Works close to Puhinui School	Consult with school and schedule works to avoid exams or other sensitive times. Potentially offer noise barrier (to be retained following construction) to mitigate traffic noise to the sports fields.
Night-time/long weekend construction noise – NoR 3	Bridge construction across the rail line and Puhinui Station will likely require night-time works or works over a long weekend, as a block of line may be required	Consider offer of temporary relocation to most affected residents to manage sleep disturbance, depending on duration and noise level
Construction noise – NoR 4a and 4b	Works close to Manukau Memorial Gardens	Consult with operator and schedule works to avoid services or other sensitive times.

1 Introduction

1.1 Purpose and scope of this Report

This Assessment of Construction Noise and Vibration report (**Report**) has been prepared to inform the AEE or five Notices of Requirement (**NoR**) being sought by Waka Kotahi and Auckland Transport for the Project under the Resource Management Act 1991 (**RMA**). Specifically, this report considers the actual and potential effects associated with the construction of the project on the existing and likely future environment as it relates to construction noise and vibration effects and recommends measures that may be implemented to avoid, remedy and/or mitigate these effects.

This Report should be read alongside the AEE, which contains further details on the history and context of the Project. The AEE also contains a detailed description of works to be authorised within each NoR, and the typical construction methodologies that will be used to implement this work. These have been reviewed by the author of this report and have been considered as part of this assessment of construction noise and vibration effects. As such, they are not repeated here. Where a description of an activity is necessary to understand the potential effects, it has been included in this report for clarity.

1.2 Report structure

In order to provide a clear assessment of each NoR, this Report follows the structure set out in the AEE. That is, each notice has been separated out into its own section, and each section contains an assessment of the actual and potential effects for the specific NoR. Where appropriate, measures to avoid, remedy or mitigate effects are recommended in a subsequent section.

Each section is arranged in geographical order, starting from the westernmost point of the proposed NoR, to the easternmost point. Table 2 below describes the extent of each section, and where the description of effects can be found in this report.

Table 2: Report structure

Sections	Section number
Description of the Project	2
Overview of the methodology used to undertake the assessment and identification of the assessment criteria and any relevant standards or guidelines	4
Identification and description of the existing and likely receiving noise environment;	6.1,7.1,8.1,9.1
Assessment of general construction noise and vibration matters for all Airport to Botany Bus Rapid Transit NoRs	5
Assessment of specific construction noise and vibration matters for Airport to Botany Bus Rapid Transit NoR 1	6
Assessment of specific construction noise and vibration matters for Airport to Botany Bus Rapid Transit NoR 2	7
Assessment of specific construction noise and vibration matters for Airport to Botany Bus Rapid Transit NoR 3	8

Sections	Section number
Assessment of specific construction noise and vibration matters for Airport to Botany Bus Rapid Transit NoR 4a and 4b	9
Determination of construction noise and vibration management and mitigation measures	10
Overall conclusion of the level of potential adverse construction noise and vibration effects of the Airport to Botany Bus Rapid Transit Project	12

1.3 Preparation for this Report

Work undertaken for this Report commenced in January 2022. In summary, the preparation for this Report has included:

- Information from other technical specialists, namely traffic, construction, design and planning amongst others;
- A site visit of all NoRs on 2 March 2022;
- Review of equipment data for similar projects;
- Computer noise modelling and vibration predictions; and
- A review of findings from a workshop with the Project technical specialists on 8 March 2022.

Where we rely on information provided by other experts, this is noted in the Report.

2 Project description

The overall Project is proposed to be an 18 km fast, high capacity, reliable, and frequent Bus Rapid Transit (**BRT**) connection with twelve stations. It is part of Auckland's wider Rapid Transit Network (**RTN**) connecting Auckland Airport and its employment areas with major urban centres including Manukau and Botany.

As set out in the AEE, this Report specifically relates to a portion of the overall Project (approximately 14.9 km) which extends from the Botany Town Centre in the vicinity of Leixlep Lane to Orrs Road in the Puhinui peninsula, off SH20B. The Project primarily involves the upgrade and widening of existing transport corridors to provide for a dedicated BRT corridor and high-quality walking and cycling facilities.

Nine BRT stations are proposed as part of the Project. These stations are generally located at signalised intersections and will be staggered on either side of the intersection.

These stations are situated in the following locations:

- Smales Road;
- Accent Drive;
- Ormiston Road – Botany Junction Shopping Centre;
- Dawson Road;
- Diorella Drive;
- Ronwood Avenue (Manukau Central);
- Manukau Station;
- Puhinui Road/Lambie Drive; and
- Puhinui Station.

As part of the Project, two new structures are proposed:

- A BRT bridge crossing the North Island Main Trunk (NIMT) and connecting to the concourse level of the Puhinui Station; and
- A southbound ramp from SH20B to SH20.

Upgrades to existing structures are proposed at the:

- Bridge over Otara Creek (NoR 1);
- Bridge over SH1 (NoR 2);
- Bridge over NIMT (NoR 3); and
- Bridge over Waokauri Creek (NoR 4a).

Figure 1: Overview of the Project and NoR extents

Table 3: Overview of NoRs

Notice	Description	Requiring Authority
NoR 1	Bus Rapid Transit corridor and high quality walking and cycling facilities from Botany Town Centre to Rongomai Park	Auckland Transport
NoR 2	Bus Rapid Transit corridor and high quality walking and cycling facilities from Rongomai Park to Puhinui Interchange, in the vicinity of Plunket Avenue	Auckland Transport
NoR 3	Bus Rapid Transit corridor and high quality walking and cycling facilities from Puhinui Interchange, in the vicinity of Plunket Avenue to SH20/SH20B Interchange	Auckland Transport
NoR 4a	Bus Rapid Transit corridor and high quality walking and cycling facilities from SH20B/20 Interchange to Orrs Road	Auckland Transport
NoR 4b	Alteration to designation 6717 to provide for the widening of SH20B, including a southbound on-ramp onto SH20, high quality walking and cycling facilities and enable a Bus Rapid Transit corridor	NZ Transport Agency

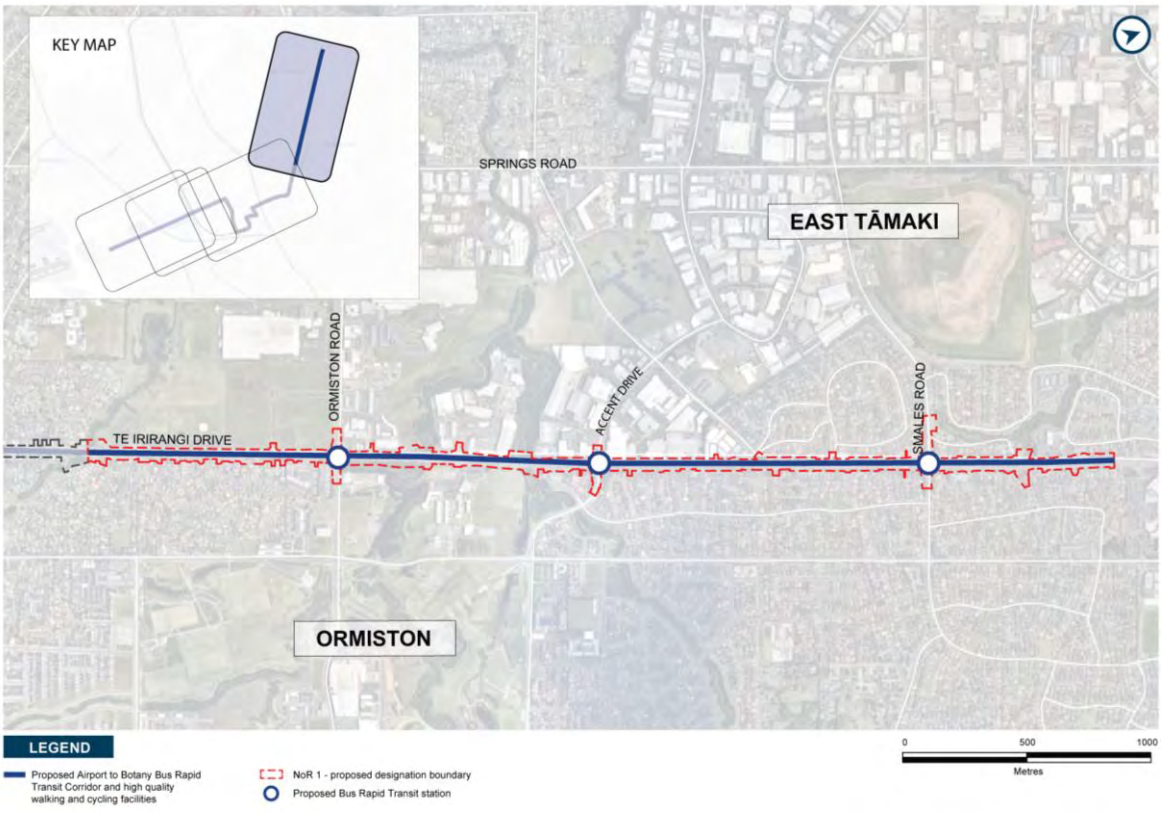
2.1 Overview and description of each NoR

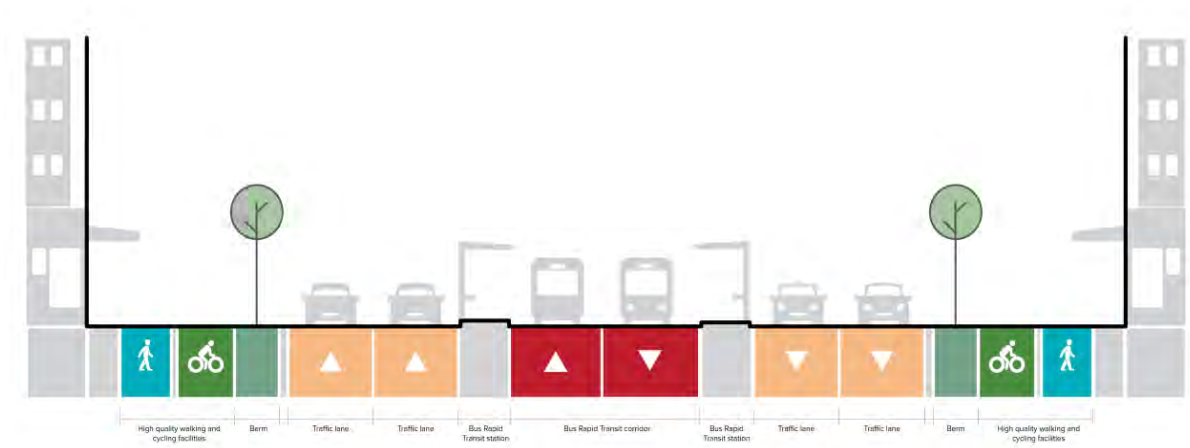
The following sections provide an overview of the NoRs that make up the Project. For more detail, refer to the AEE.

2.1.1 NoR 1

As set out in Table 4 below, the proposed works in NoR 1 include the widening of existing Te Irirangi Drive to accommodate a centre-running BRT corridor, two vehicle lanes in each direction and high quality walking and cycling facilities.

Table 4: Overview of NoR 1

NoR 1 – Botany Town Centre to Rongomai Park	
	
Key features	
BRT Corridor	Centre-running along Te Irirangi Drive
BRT Stations	• Smales Road Station; • Accent Drive Station; and • Ormiston Road Station.
Walking and cycling facilities	Walking and cycling facilities on both sides of the corridor
General traffic	Two lanes in each direction (existing)
Access	There is an existing central median along the majority of Te Irirangi Drive which restricts right-turn access
Speed environment	50km/h

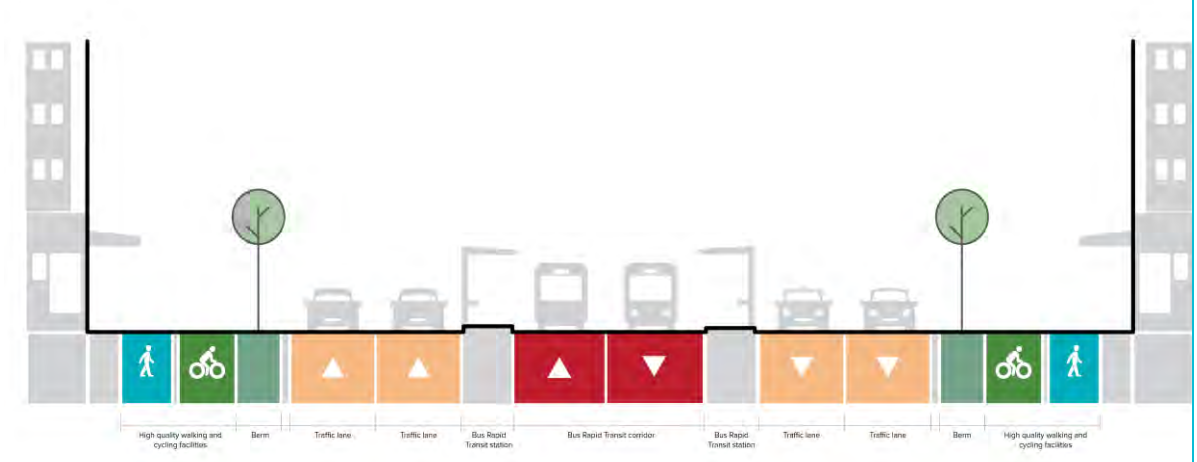
Signalised intersections	• Te Irirangi Drive and Smales Road; • Te Irirangi Drive and Accent Drive; • Te Irirangi Drive and Bishop Dunn Avenue; and • Te Irirangi Drive and Ormiston Road.
NoR 1 typical cross section	
	

2.1.2 NoR 2

As set out in Table 5 below, the proposed works in NoR 2 include the widening of several existing roads to accommodate a centre-running bus rapid transit corridor, vehicle lanes and high quality walking and cycling facilities.

Table 5: Overview of NoR 2

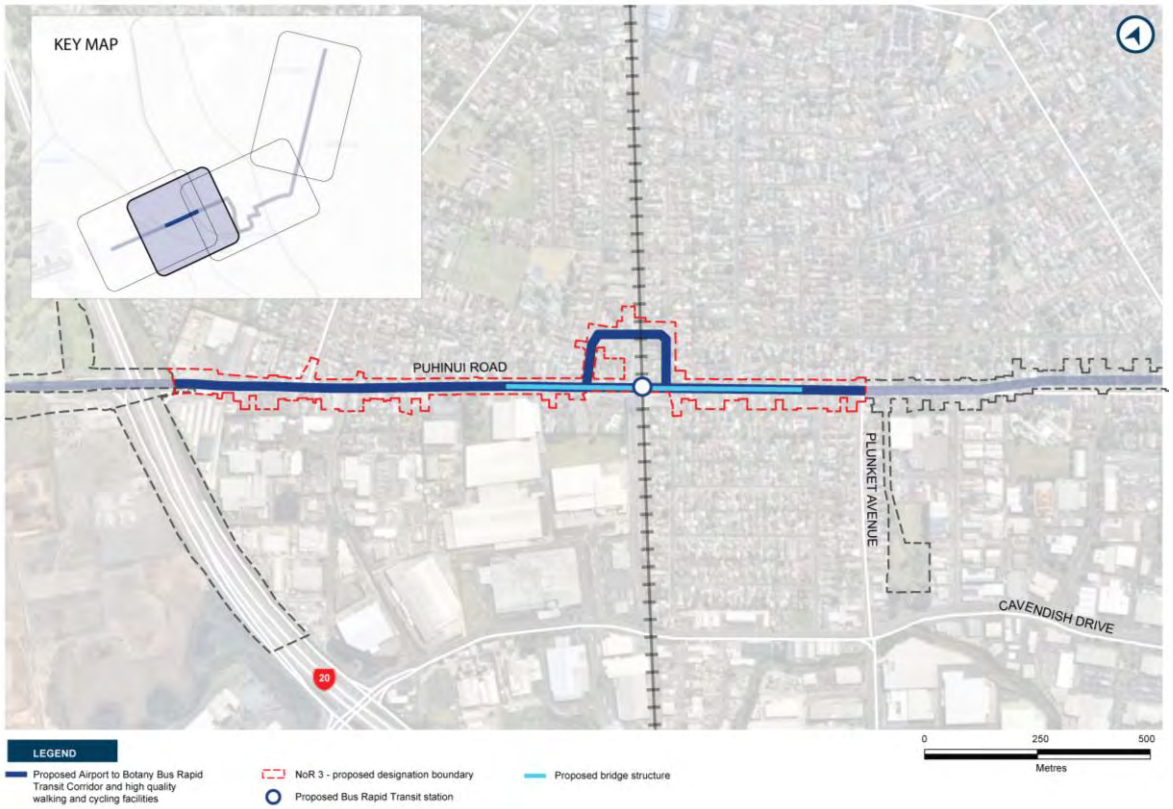
NoR 2 – Rongomai Park to Puhinui Station, in the vicinity of Plunket Avenue	
	
Key features	
BRT Corridor	Centre-running for the majority of the corridor along Te Irirangi Drive, Great South Road, Ronwood Avenue, Manukau Station Road, Lambie Drive, and Puhinui Road West-running on Davies Avenue along the edge of Hayman Park
BRT stations	• Dawson Road Station; • Diorella Drive Station; • Ronwood Avenue Station; • Manukau Station; and • Corner of Lambie Drive and Puhinui Road Station.
Walking and cycling facilities	Walking and cycling facilities on both sides of the corridor
General traffic	• Two lanes in each direction along Te Irirangi Drive, Great South Road, Ronwood Avenue, Manukau Station Road, and Lambie Drive; • One-way single lane along Davies Avenue; and

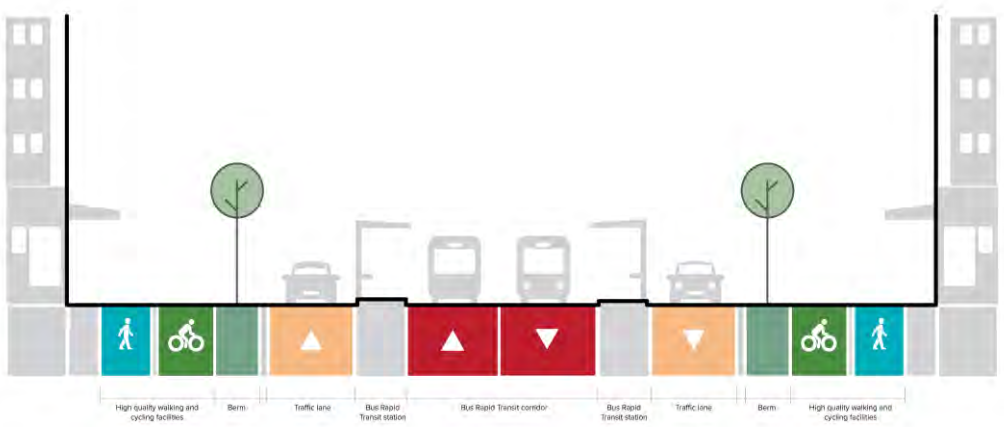
	• One lane in each direction along Puhinui Road.
Access	Existing central medians limit right turn access on Te Irirangi Drive, Great South Road, Ronwood Avenue, and Lambie Drive. New signalised intersection at Mitre 10 and Bunnings Warehouse on Lambie Drive. Priority access for fire engine movements across the BRT corridor at Papatoetoe Fire Station.
Speed environment	• 30 km/h on Ronwood Avenue and Davies Avenue; and • 50 km/h on Te Irirangi Drive, Great South Road, Manukau Station Road, Lambie Drive and Puhinui Road.
Signalised intersections (**new intersections in bold**)	• Te Irirangi Drive and Dawson Road; • Te Irirangi Drive, Boundary Road and Hollyford Drive; • Te Irirangi Drive and Diorella Drive; • Te Irirangi Drive, Great South Road and Cavendish Drive; • Great South Road and Ronwood Avenue; • Ronwood Avenue and Davies Avenue; • Davies Avenue, Wiri Station Road and Manukau Station Road; • Manukau Station Road and Lambie Drive; • **Mitre 10 and Bunnings Warehouse;** • **Lambie Drive and Ronwood Avenue;** • Lambie Drive and Cavendish Drive; • Lambie Drive and Puhinui Road; and • **Puhinui Road and Plunket Avenue.**
NoR 2 typical cross section	
	

2.1.3 NoR 3

As set out in Table 6 below, the proposed works in NoR 3 include the widening of the existing Puhinui Road to accommodate a centre-running BRT corridor, vehicle lanes and high quality walking and cycling facilities. As part of the proposed works, a BRT bridge over the NIMT is proposed to connect to the Puhinui Station.

Table 6: Overview of NoR 3

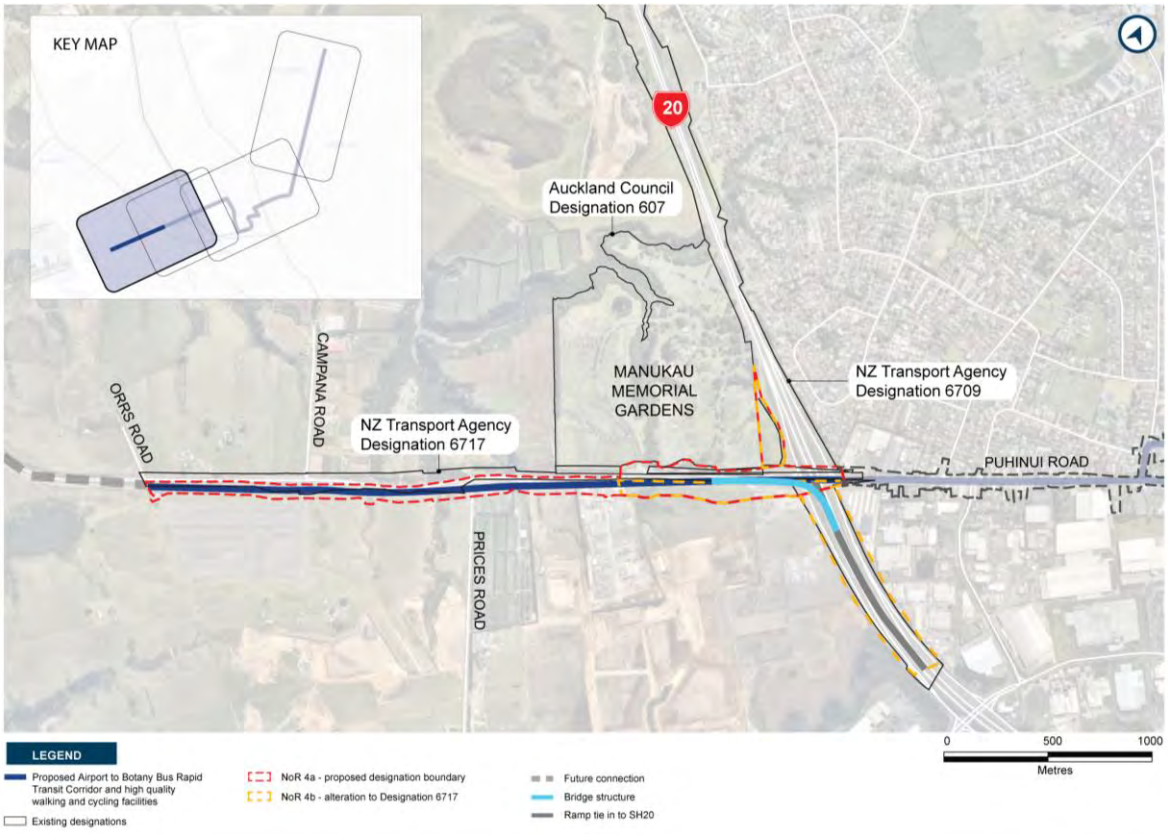
NoR 3 – Puhinui Station, in the vicinity of Plunket Avenue to SH20/20B Interchange	
	
Key features	
BRT Corridor	Centre-running along Puhinui Road connecting to the Puhinui Station concourse via a new BRT bridge structure
BRT Stations	Puhinui Station
Walking and cycling facilities	• Walking and cycling facilities on both sides of the corridor; and • Walking and cycling facilities will be provided along Cambridge Terrace, Bridge Street and Kenderdine Road.
General traffic	One lane in each direction on Puhinui Road
Access	Limited right turn access
Speed environment	50 km/h
Signalised intersections	• Puhinui Road and Noel Burnside Road; and • Puhinui Road and Wyllie Road.
NoR 3 typical cross section	


High quality walking and cycling facilities
Berm
Traffic lane
Bus Rapid Transit station
Bus Rapid Transit corridor
Bus Rapid Transit station
Traffic lane
Berm
High quality walking and cycling facilities

2.1.4 NoRs 4a and 4b

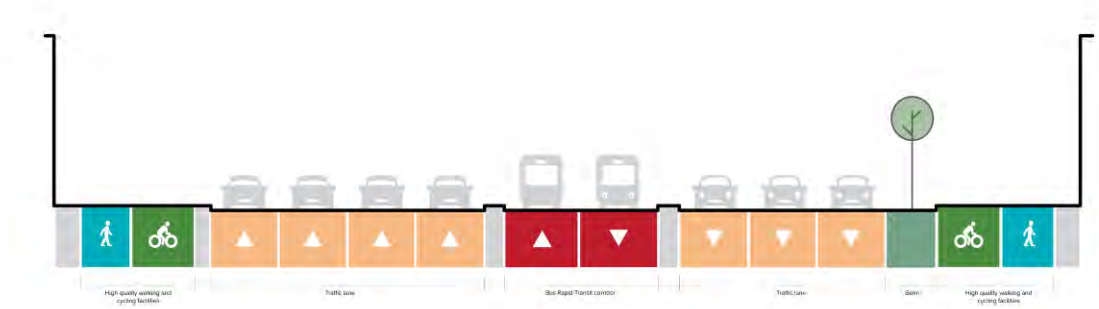
As set out in Table 7 below, the proposed works in NoRs 4a and 4b include the widening of SH20B to accommodate a centre-running BRT corridor until the Manukau Memorial Gardens. From this point, the BRT corridor shifts south of SH20B until Orrs Road. Proposed works also include high quality walking and cycling facilities, eastbound lanes to Auckland Airport and a ramp from SH20B onto SH20 for southbound traffic.

Table 7: Overview of NoRs 4a and 4b

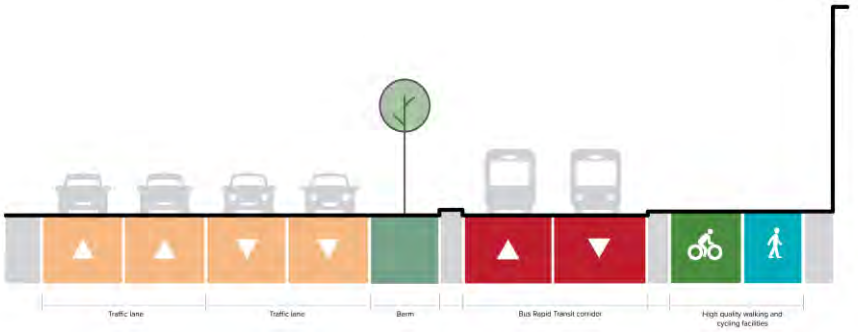
NoRs 4a and 4b – SH20/20B Interchange to Orrs Road	
	
Key features	
BRT corridor	• Centre-running on Puhinui Road through to the Manukau Memorial Gardens intersection (approx. 600 m west of SH20/20B Interchange); and • South running to Orrs Road.
Walking and cycling facilities	Walking and cycling facilities on southern side of the corridor
General traffic	• Two lanes in each direction; and • New southbound ramp from SH20B onto SH20.
Access	• Limited access; and • Access maintained via signals at Manukau Memorial Gardens and Campana Road.
Speed environment	60 km/h

Signalised intersections	• SH20/SH20B Interchange; • Puhinui Road and Manukau Memorial Gardens; and • Puhinui Road and Campana Road.

NoR 4b typical cross section



NoR 4a typical cross section



3 Performance standards

Construction noise and vibration levels are generally higher than would be expected from ongoing day to day operations of a site or transport corridor. However, higher noise and/or vibration levels are not necessarily unreasonable if they are managed and mitigated by implementing the best practicable option (**BPO**).

New designations are sought for the Project for NoR 1, NoR 2, NoR 3 and NoR 4a and an alteration to an existing designation (NoR 4b) to enable the construction operation and maintenance of the Project. Therefore, we have reviewed a variety of criteria and standards and have recommended noise and vibration performance standards that in our opinion should apply to the relevant NoRs depending on the Requiring Authority.

3.1 Noise

3.1.1 Guidelines and standards reviewed

We reviewed the following guidelines and standards for the assessment of construction noise:

- AUP:OP, specifically rule E25.6.27 relating to construction noise in all zones except the City Centre and Metropolitan Centre zones, and rule E25.6.29 relating to construction noise in the road;
- New Zealand Standard NZS6803:1999 Acoustics – Construction Noise (**NZS6803**); and
- The Waka Kotahi "State Highway Construction and Maintenance Noise and Vibration Guide" (**Guide**), V1.1, August 2019.

While NoR 4b will be under the jurisdiction of Waka Kotahi and NoRs 1 to 3 and 4a will be Auckland Transport designations, we consider that consistent construction noise limits should be applied to all NoRs. The AUP:OP and Guide construction noise criteria are largely the same, with any differences (generally night-time criteria) having no effect on the outcome of the assessment.

We recommend applying the requirements of the Guide to the NoRs. The Guide takes account of the intended application of NZS6803 criteria and provides a solid and tested management structure to achieve the best practicable outcome for construction noise.

3.1.2 Recommended criteria all NoRs

Table 8 below shows the relevant noise standards for long duration works (more than 20 weeks), which applies to all projects. These criteria are those of the Guide and NZS6803, and largely reflect the AUP:OP criteria.

Table 8: Construction noise criteria at occupied buildings (at 1m from the most affected façade)

Day of week	**Time period**	**Noise criteria**	
		dB L_{Aeq}	dB L_{AFmax}
Dwellings and other buildings containing activities sensitive to noise			
Weekdays	0630 – 0730	55	75
	0730 – 1800	70	85

Day of week	Time period	Noise criteria	
		dB L_{Aeq}	dB L_{AFmax}
	1800 – 2000	65	80
	2000 – 0630	45	75
Saturdays	0630 – 0730	45	75
	0730 – 1800	70	85
	1800 – 2000	45	75
	2000 – 0630	45	75
Sundays and public holidays	0630 – 0730	45	75
	0730 – 1800	55	85
	1800 – 2000	45	75
	2000 – 0630	45	75
Other occupied buildings			
All days	0730 – 1800	70	n/a
	1800 – 0730	75	n/a

While construction of each NoR would be generally of longer duration (several years), each individual building would likely be affected only for limited periods of high noise levels as construction moves along the alignment in a linear fashion.

3.1.3 Exceedance of criteria

During construction some activities will occur close to buildings. In some instances, there is the potential for noise levels to exceed the recommended construction noise standards. For most large-scale construction projects, exceedances of the construction noise standards for brief periods of time are common, and management will ensure that effects are reasonable.

NZS6803 anticipates that at times construction noise cannot be made to comply with the recommended criteria. Statements such as *"construction noise from any site should not generally exceed the numerical noise limits"*[1] suggest that intermittent exceedances are not unreasonable, as long as the BPO has been applied to the management and mitigation of that construction noise.

The AUP:OP in its Objectives and Policies also appropriately anticipates exceedances from construction noise and states:

> *"(4) Construction activities that cannot meet the noise and vibration standards are enabled while controlling duration, frequency and timing to manage adverse effects."* [2]

And

> *"(10) Avoid, remedy or mitigate the adverse effects of noise and vibration from construction, maintenance and demolition activities while having regard to:*

[1] NZS 6803:1999 Acoustics – Construction Noise, Section 7.1.2.
2 Chapter E25.2 of the AUP:OP.

[…]

The practicability of complying with permitted noise and vibration standards."[3]

Whether the duration of a construction activity that exceeds the standards can be considered reasonable, depends on site specific circumstances, and may vary from site to site and activity to activity. For instance, where daytime noise standards are exceeded for several days, but neighbouring residents are not at home, no one would be affected and therefore mitigation may not be required beyond communication with the residents.

If night-time works occur, this would likely only happen for few nights in any one location. In that instance, this may be acceptable if residents have been informed and a clear time frame has been provided. However, if night-time works are expected to be ongoing for several consecutive nights, and at a noise level that affects residents' ability to sleep, then alternative strategies may need to be implemented, such as offering temporary relocation for those affected residents. Such management measures are further discussed in Section 10.

3.2 Vibration

3.2.1 Guidelines and standards reviewed

We reviewed the following guidelines and standards for the assessment of construction vibration:

- AUP:OP, specifically rule E25.6.30 relating to construction vibration, with two parts: amenity and avoidance of any damage to buildings;
- German Standard DIN4150-3 (1999) Structural vibration – Part 3 Effects of vibration on structures;
- British Standard (BS) 5228-2: 2009 "Code of practice for noise and vibration control on construction and open sites"; and
- The Waka Kotahi "State Highway Construction and Maintenance Noise and Vibration Guide" (**Guide**), V1.1, August 2019.

Both the AUP:OP and the Guide reference relevant vibration standards for construction works. These criteria are similar insofar as they address two vibration responses:

- One set of standards are based on the provisions of German Standard DIN 4150-3:1999 "Structural Vibration – Part 3: Effects of Vibration on Structures" which avoids cosmetic building damage (**building standards**); and
- The other set has reference criteria for human amenity which act as trigger levels for consultation and communication (**amenity standards**).

The amenity standards of the AUP:OP are slightly less stringent than those in the Guide (2 mm/s PPV vs the 1 mm/s PPV), while the building standards of the Guide have different criteria for unoccupied buildings by allowing higher vibration levels to be generated where this is safe (but where no people are disturbed).

3 Chapter E25.3 of the AUP:OP.

3.2.2 Recommended criteria (All NoRs)

NoRs 1 to 4a are sought by Auckland Transport, and NoR 4b is sought by Waka Kotahi. Table 9 below sets out the vibration standards to be applied to all NoRs.

Table 9: Vibration standards at all buildings for all NoRs

Receiver	Details	Category A	Category B
Occupied activities sensitive to noise	Night-time 2000h-0630h	0.3 mm/s PPV	2mm/s PPV
	Daytime 0630h-2000h	2mm/s PPV	5mm/s PPV
Other occupied buildings	Daytime 0630h-2000h	2mm/s PPV	5mm/s PPV
All other buildings	At all times	Tables 1 and 3 of DIN4150-3:1999	

It is noted that Waka Kotahi generally adopts the vibration standards based on the Guide, however, for this Project, the AUP limits are applied to all NoRs as a result of the overlap between the proposed designations for NoR 4a and NoR 4b and the likelihood of construction occurring simultaneously. In addition, there are very few (if any) buildings close by to NoR 4b and the risk of exceeding the above vibration standards is low.

In general terms, the Category A standards aim to avoid annoyance of receivers. Because these criteria are conservative, there is a provision in the Guide to relax the criteria if they cannot be practicably met, provided a vibration expert is engaged to assess and manage construction vibration to comply with the Category A standards as far as practicable. In addition, affected people should receive communication about the proposed works and anticipated effects, to avoid concern.

If Category A is not practicably achievable, the focus is then shifted to avoiding building damage rather than avoiding annoyance by applying the Category B standards. If the Category B standards are complied with, then building damage is unlikely to occur. If Category B standards are predicted to be exceeded, prior to the relevant construction activities commencing, building condition surveys, must be undertaken and vibration levels must be monitored during those works. This allows an assessment of and response to any effects.

The DIN 4150-3:1999 Standard, which the 5mm/s Category B criterion is taken from, is a conservative standard designed to avoid all (including cosmetic) damage to buildings, e.g. superficial damage like cracking in plaster. Significantly higher standards would be applied if damage to structural foundations was the only consideration.

4 Assessment methodology

4.1 Overview

The following methodology has been used for the construction noise and vibration assessment for all NoRs:

- We reviewed noise and vibration emission data for each construction task / process based on equipment data previously measured by Marshall Day Acoustics (**MDA**) for similar activities. Data from appropriate noise and vibration standards (e.g. BS5228-1:2009) has also been considered, where relevant.
- We predicted noise and vibration levels from construction based on relevant standards and guidelines and determined setback distances where compliance with the relevant standards can be achieved. These setback distances have been plotted on the Project drawings and are shown in **Appendix A** for noise and **Appendix B** for vibration.
- Where construction is predicted to exceed the noise or vibration standards, we recommend management and mitigation through a framework of management plans and schedules.

4.2 Assumptions

The assessment of construction noise and vibration effects is based on assumptions of construction activities and equipment. Given that the Project will be implemented many years in the future, an indicative construction methodology has been prepared to inform the assessment of the Project and is subject to change. The construction methodology for the proposal will be confirmed during the detailed design phase and finalised once a contractor has been engaged for the work.

We have assumed that the different NoRs are not constructed concurrently (with the exception of NoRs 4a and 4b), or, where they are, that the construction activities are sufficiently separated to avoid increased noise levels at individual receivers. For NoRs that are adjacent to each other (e.g. where NoRs 1 to 4 meet), construction may occur at the same time. However, the space required for equipment to operate safely will ensure that no more than the assumed maximum construction activity would occur in any one area. Therefore, our predictions are also relevant should this occur.

We have also assumed that all existing buildings within each of the proposed designation boundaries will be removed or will be vacant during the time of construction. We have therefore not assessed these buildings. Should they be retained and occupied during construction, they will need to be assessed at the time of construction. Some of these buildings may be affected by more than one NoR. We have identified the buildings in each of the NoRs that may affect them.

The detailed methodology for works is not confirmed; therefore, we have based this assessment on similar construction projects we have worked on. Although contractors have not been appointed, it is considered that the methodology set out is representative of activity that has occurred on similar projects and forms a reasonable baseline for the purposes of assessment during the design phase of the Projects.

Information sufficient for the NoR stage has been provided in a Construction Method Statement (refer Section of this Report and Section 6.2 of the AEE for more detail) and drawings provided by the Project team, and has been incorporated in this assessment as relevant.

Given the recent National Policy Statement on Urban Development (**NPS:UD**) and the Resource Management (Enabling Housing Supply and Other Matters) Amendment Act 2021, while we comment on effects on currently existing buildings potentially affected by construction noise and vibration, we are aware that many of the sites neighbouring the corridor may be redeveloped in the future, with higher density residential development. Therefore, our recommendations require a reassessment of the buildings present at the time of construction to ensure that mitigation and management takes account of the environment as it exists at the time of construction.

4.3 Construction sequence and methodology

The construction methodology provided by the Project Team is proposed to follow the following sequence, which is similar for all NoRs. Only noise and/or vibration generating aspects are included in the list below.

4.3.1 Sequences

The general sequence of construction is likely to be as follows:

Site establishment

- Site access construction;
- Establishment of site compound and laydown areas:
    - Each Project will require site compounds and one or more laydown areas;
    - The main site compound will contain office and meeting room facilities, break rooms, ablution block and carparking facilities; and
    - Laydown areas/construction yards will contain material storage and are generally located inside the designation.
- Tree removal and vegetation clearance where required;
- Removal of footpath, streetlights, grass verge berm (where required); and
- Property/ building modification or demolition, including fencing, driveways and gates.

Main works

- Relocation of utilities services;
- Minor earthworks (cut and fill);
- Removal of verge and preparation of subgrade formation;
- Construction of new longitudinal drainage facilities;
- Construction of new pavement, widening works in available areas (following that, move traffic to newly constructed pavement areas and continue with the remaining widening works);
- Pavement reconstruction or reconfiguration of existing road furniture;
- Completion of tie in works, footpaths, cycleways, lighting and landscaping;
- Construction of permanent stormwater wetlands;
- Construction of new culverts including rip rap and headwalls;
- Install road safety barriers (if any);
- Bridge construction works (if any) as follows:
    - Mobilisation and site establishment;
    - Enabling works such as access construction, staging areas and temporary works;
    - Piling, pile caps, and abutment construction;

    - Columns and pier headstock construction;
    - Bridge beam installation;
    - Deck construction and barrier installation; and
    - Finishing works, such as approach construction, settlement slabs, and end terminals.
- Retaining wall construction (if any);
- Accommodation works; and
- Installation of signage and lighting.

Finishing works and demobilisation

- Final road surfacing and road markings; and
- Finishing works e.g. landscaping, street furniture, fencing and outstanding accommodation works.

4.3.2 Construction times

Construction hours will generally be 7am to 6pm, Monday to Saturday. During the summer earthworks seasons, extended hours may be worked (6am to 8pm, Monday to Sunday) where this can be undertaken in compliance with the relevant noise and vibration limits.

Only critical work will occur outside these hours (or on public holidays) where it cannot be undertaken safely within normal working hours.

Similarly, night-time works will only be undertaken where it is impractical to undertake the works during daytime, e.g. where road or rail closures are required.

Where works are undertaken outside normal working hours, they will need to be assessed and mitigated through a schedule (refer Section 10.4).

4.3.3 Construction duration

Construction of the Project will generally be in a linear nature, moving along the corridor. This means that high noise and/or vibration levels are experienced by individual buildings only for a short period (e.g. weeks or months) compared with the overall construction duration of the Project (generally years).

Larger structures would take longer to construct. For example, the estimated construction times for large structures are approximately:

- Three to four years for the ramp across SH20 (NoR 4b);
- Two to three years for the bridge across SH1 (NoR 2); and
- Two to three years for the bus rapid transit bridge over the rail line connecting to the Puhinui Station (NoR 3).

Puhinui Station will require more sustained construction over several months.

The exception are laydown areas and site yards, which will remain in place for generally the full duration of construction of the Project. However, these yards do not generate high noise level (refer Section 4.4.2).

4.4 Construction noise

4.4.1 Predictions

Noise level predictions for construction projects take into account the sound power levels of each item of equipment, and model the noise propagation characteristics over distance, including the effects of ground and air absorption. We have calculated indicative noise levels in accordance with NZS6803:1999 and ISO 9613-2:1996 *"Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation"* for all relevant construction scenarios, assuming multiple items of equipment operating simultaneously, but taking account of spatial separation and time component. This approach is deliberately conservative to represent the reasonable worst-case noise levels that may infrequently occur.

Other than the variations in noise level due to the factors discussed above, there are numerous additional aspects that affect construction noise generation. Some of these aspects are variations among individual items of equipment, the state of equipment repair, exact locations of each item and operator idiosyncrasies. Generally, these factors cannot be accounted for as they cannot be reasonably quantified. However, the conservative approach outlined above is considered to generally provide for these variables.

Predictions are based on existing buildings in the vicinity of the Project. However, if new buildings in the vicinity of the Project are occupied by the time of construction, these will also be assessed and considered when mitigation is determined.

4.4.2 Activity noise levels

We have predicted construction noise levels based on experience with similar projects and in similar circumstances. We assembled a list of likely equipment that would be used on a large-scale infrastructure project throughout New Zealand. Table 10 sets out this list of equipment and its respective sound power levels. It is important to keep in mind that this list is indicative only and is essentially the "best estimate" of equipment that could be used.

Table 10: Construction equipment noise levels

Activity	Plant type	Sound power level (dB L_{WA})
Site establishment (clearance, demolition, compound construction)	Chain saw Chipper Dump trucks Hydraulic excavator Vibratory roller	114 117 106 113 108
Earthworks (alignment works, drainage and culvert construction)	Dump truck Hydraulic excavator Bulldozer Compactor Water truck	106 113 114 112 105

Activity	Plant type	Sound power level (dB L_{WA})
Retaining Wall Construction	Vibration piling rig Rotary Piling Rig Concrete trucks Crane On road trucks	120 111 107 106 100
Bridge foundations (piling)	Rotary piling rig Concrete trucks	111 107
Foundations and structures (bridge construction)	Crane Concrete pump Vibratory pokers Concrete trucks	106 100 114 107
Pavement preparation	Vibratory roller Water trucks	108 105
Surfacing	Paver Road rollers Asphalt delivery trucks	113 106 108
Walking and cycling facilities	Small excavator Plate compactor Small roller Paving machine	102 108 101 103
Yard activities	Vehicle movements Material handling Administration area Workshop	102 105 50 80

Based on the sound power levels in Table 10, we predicted combined “activity sound power levels” (refer Table 11 below). We note that not all equipment will operate consecutively and continuously. For instance, for the site establishment, the chain saws and chipper will operate at the same time, but trucks and vibratory rollers will be used at a later stage of the site establishment when site compounds are constructed.

Although the contractor may use different plant and equipment from what is on this list, based on experience with other large scale infrastructure construction projects we consider that noise emissions will be similar for each activity.

From the activity sound power levels, we determined the distance at which the 70 dB L_{Aeq} day-time noise criterion can be complied with, without mitigation by noise barriers.

Table 11: Activity sound power levels and compliance distance

Activity	**Activity Sound Power Level**	**Distance at which compliance with day-time limit (70 dB L_{Aeq}) is achieved without noise barriers/ intervening buildings**
	dB L_{wA}	metres
Site establishment/demolition	115	76
Earthworks	116	83
Retaining wall construction	116	83
Bridge foundations (piling)	111	52
Foundations and structures (concreting)	108	40
Pavement preparation	108	40
Surfacing	110	48
Walking and cycling facility works	103	25
Compounds/construction yard	100	18

Some buildings, especially in NoRs 1, 2, and 3, are close to the potential works. While some may receive screening from intervening buildings, others will be exposed to the works and will need mitigation as set out in Section .

4.5 Construction vibration

4.5.1 Predictions

Construction vibration is a separate issue from construction noise. Construction equipment that produces high noise levels does not necessarily also produce high vibration levels and vice versa.

Vibration prediction is less reliable than noise prediction as it is dependent on accurate modelling of ground conditions. Ground conditions are often non-homogeneous and complex in three dimensions, and consequently difficult to quantify across large construction extents.

As a result, we have determined “safe distances” based on vibration measurements[4] previously performed for high vibration sources such as vibropiling and vibratory rollers. The safe distances are based on vibration prediction tools as contained in Hassan (2006)[5]. These have been cross-checked against empirically derived relationships as contained in BS 5228-2:2009 *Code of practice for noise and vibration control on construction and open sites* Part 2: Vibration, the Transport Research Laboratory Report referenced by that standard, and previous measurements carried out by MDA. In addition, a 100% safety margin has been applied to the regression curve derived from the measured data, to take account of ground condition uncertainty, making the predictions conservative. That

4 Measurements performed at State Highway 18, MacKays to Peka Peka, AMETI and other projects

5 Hassan, O., “Train Induced Groundborne Vibration and Noise in Buildings”, Multi-Science Publishing Co Ltd, ISBN 0906522 439, 2006.

means that measured vibration levels were not used directly to predict potential vibration levels, but rather that the measured levels have been increased by 100%.

We have used the results from these measurements and predictions to determine risk radii within which buildings are at medium or high risk of receiving vibration levels within Category B (refer Section 3.2.2). The risk radii also consider human annoyance effects.

4.5.2 Equipment vibration levels

The activities that pose the greatest risk of exceeding the vibration criteria (human annoyance and building damage as set out in Section 3.2) are vibratory rolling and vibropiling. This assessment has focused on these activities. The regression curves for vibratory rollers and vibropiling are shown in Figure 2.

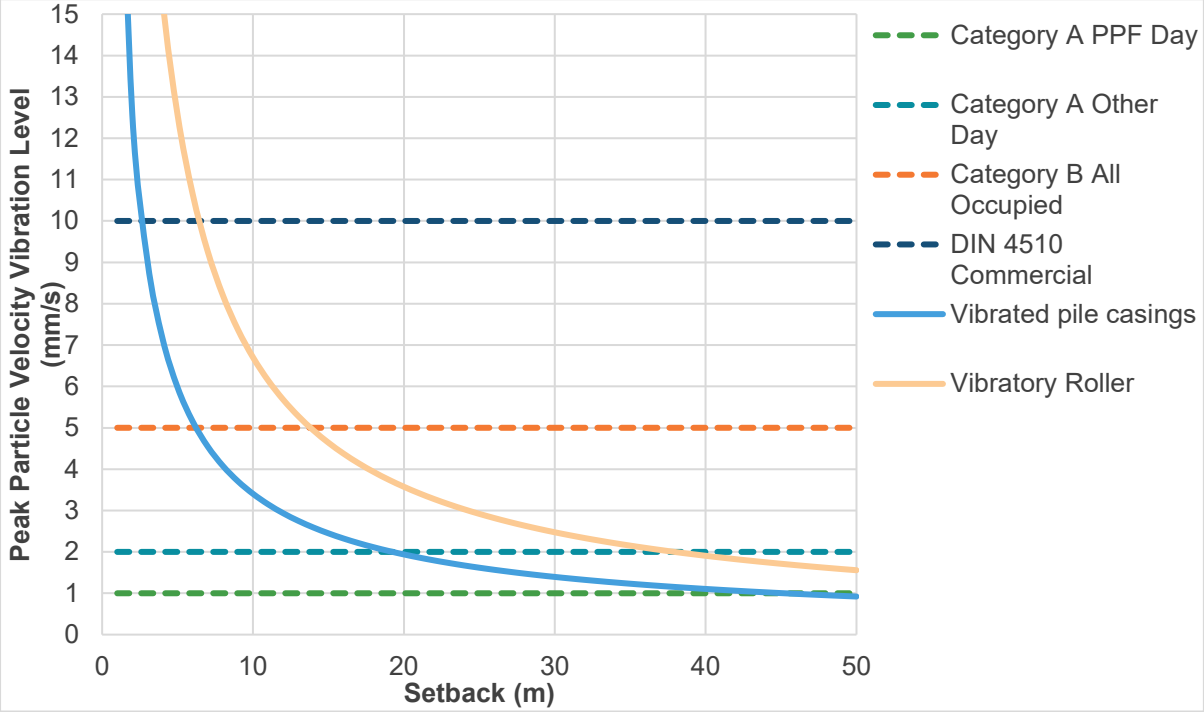


Figure 2: Vibration regression curves (criteria for occupied buildings)

5 General construction noise and vibration effects

5.1 Construction noise

5.1.1 Envelope of noise effects

We have predicted noise levels that include existing buildings (excluding those to be demolished) for shielding. Based on these predicted noise levels, we have developed effects envelopes, i.e. distances at which compliance with the daytime noise criteria can be achieved without noise mitigation in place. The envelopes have been plotted onto aerial photographs to show those areas where mitigation would need to be considered and implemented (refer **Appendix A**).

For those areas not included in the envelopes, we predict that noise levels will comply with the relevant limits, and no noise mitigation beyond normal best practice site management would be required (refer Section 10). In any event, Section 16 of the RMA (Duty to avoid unreasonable noise) applies and the BPO will need to be implemented to manage noise effects on all areas, irrespective of compliance.

The following activities have been used to determine the envelope of effects. These are the activities we consider have the greatest impact on construction noise or will be used across the widest part of the NoRs;

- Construction of bridges and retaining walls may generate high noise levels due to the likely direct line-of-sight between buildings and machinery and the high sound power levels of the equipment – these activities will be localised and apply only for small areas within each NoR (if at all);
- Earthworks will occur across all NoR and generate elevated noise levels due to the equipment that will likely be utilised, and the number of equipment items likely used across the network. However, works will move along the alignments and therefore only be in any one location for limited times (e.g. a few weeks out of several years of construction); and
- Surfacing may need to be undertaken at night-time. This would affect all residential receivers, however, only for a limited time of one or two nights.

5.1.2 Noise effects

Daytime

Noise levels affect people in their place of residence or work. Construction noise is inherently higher than ongoing operational noise, which is reasonable due to its limited duration.

Generally, construction noise is assessed in relation to people inside buildings. It is assumed that people will choose to not spend any extended periods in an outdoor area next to high noise construction activities. It is also assumed that people will keep their windows and doors closed to reduce internal noise levels. Generally, New Zealand dwelling facades reduce noise levels by 20 to 25 decibels. We have assumed conservatively a noise level reduction of 20 decibels, though any new dwellings would achieve 25 to 30 decibels noise level reduction, and commercial buildings with concrete or brick façades can even achieve noise level reductions of more than 35 decibels if there are no windows or doors facing to the works.

How people may experience noise inside or outside a building is described in Table 12. That table does not take account of non-sensitive activities such as factories, storage spaces and similar uses.

Table 12: Potential noise effects for varying noise levels

External Façade Noise Level dB L_{Aeq}	Potential Daytime Effects Outdoors	Corresponding Internal Noise Level dB L_{Aeq}	Potential Daytime Effects Indoors
Up to 65	Conversation becomes strained, particularly over longer distances.	Up to 45	Noise levels would be noticeable but unlikely to interfere with residential or office daily activities.
65 to 70	People would not want to spend any length of time outside, except when unavoidable through workplace requirements.	45 to 50	Concentration would start to be affected. TV and telephone conversations would begin to be affected.
70 to 75	Businesses that involve substantial outdoor use (for example garden centres such as Bunnings) would experience considerable disruption.	50 to 55	Face to face and phone conversations and TV watching would continue to be affected. Office work can generally continue.
75 to 80	Some people may choose hearing protection for long periods of exposure. Conversation would be very difficult, even with raised voices.	55 to 60	Phone conversations would become difficult, and face to face conversations would need slightly raised voices. For residential activities TV and radio sound levels may need to be raised. Continuing office work may become difficult.
80 to 90	Hearing protection would be required for prolonged exposure (8 hours at 85 dB) to prevent hearing loss.	60 to 70	Face to face conversations would require raised voices. In a residential context, people may actively seek respite if these levels are sustained for more than a period of a few hours. Concentration would start to be affected, continuing office work would be difficult and may become unproductive.

Night-time

The noise level received inside a noise sensitive space (e.g. bedroom) will depend on the external noise level, sound insulation performance of the façade (particularly the glazing) and room constants (such as the room dimensions and surface finishes). These factors can vary widely.

The Construction Noise Standard (NZS 6803) recommends noise limits assessed at 1 m from the external façade of a building, assuming a façade sound level difference of 20 decibels. However, a 20-decibel reduction is particularly conservative for modern buildings. The sound insulation performance can be measured, or generally be estimated with knowledge of the façade glazing type as follows:

- Sealed glazing: 30 decibels façade sound level difference

- Closed windows (openable): 20 – 25 decibels façade sound level difference
- Open windows: 15 decibels façade sound level difference

Table 13 provides guidance on the potential night-time effects inside sensitive spaces, depending on the external noise level and façade glazing type. The potential effects are colour coded as follows:

Typically acceptable

Sleep disturbance for some occupants

Sleep disturbance for most occupants

Table 13: Night-time noise levels in bedrooms of dwellings

External Noise Level (dB L_{Aeq})	**Estimated Internal Noise Level (dB L_{Aeq})**			
	Sealed glazing	Openable windows (modern building)	Openable windows (older style building)	Open windows
70 – 75	40 – 45	45 – 50	50 – 55	55 – 60
65 – 70	35 – 40	40 – 45	45 – 50	50 – 55
60 – 65	30 – 35	35 – 40	40 – 45	45 – 50
55 – 60	25 – 30	30 – 35	35 – 40	40 – 45
50 – 55	20 – 25	im 25 – 30	30 – 35	35 – 40
45 – 50	15 – 20	20 – 25	25 – 30	30 – 35

The above table shows that consultation and management may be required if night-time works are proposed in the vicinity of dwellings, where internal noise levels would affect sleep.

5.2 Construction vibration

5.2.1 Envelope of vibration effects

There is a risk that the Category A criteria may be exceeded at dwellings close to retaining wall construction where vibropiling may be used, and where vibratory rollers are used for the compaction of new or widened traffic lanes.

The risk categories in Table 14 relate to the risk of exceeding Category A and B criteria for occupied buildings at various distances from the vibration inducing works. Note that these distances include a 100% safety factor as described in Section 4.5.2 above.

The risk categories are defined as follows:

- High Risk — Predicted to exceed both Category A (amenity) and Category B (building) criteria (refer Section 3.2);
- Medium Risk — Predicted to exceed Category A (amenity) criteria, but comply with the Category B (building) criteria; and
- Low Risk — Predicted to comply with both Category A and B criteria.

Table 14: Activity and vibration risk zones

Activity/Equipment	Risk Zones	
	Occupied PPFs	Other Occupied Buildings
Vibratory Roller	High: <15 m Med: 15 – 80 m Low: >80 m	High: <15 m Med: 15 – 40 m Low: >40 m
Vibropiling	High: <7 m Med: 7 – 45 m Low: >45 m	High: <7 m Med: 7 – 20 m Low: >20 m

Drawings showing the approximate risk zones for the highest vibration inducing equipment (vibratory rollers) along each NoR extent are included in Appendix B. Many dwellings in NoR 1, 2 and 3 are within 15 metres from the closest extent of the works, which means that a large number of dwellings will likely be affected by construction vibration. Therefore, the construction methodology will need to be reviewed closer to the time of construction to ensure that vibration levels are managed appropriately.

Vibration criteria are significantly more stringent at dwellings during the night (0.3 mm/s PPV) and have the potential to be exceeded at distances greater than 200 m from any works using vibratory rollers. On this basis, vibration intensive activities adjacent residential areas should be generally scheduled for the daytime wherever practicable.

5.2.2 Vibration effects

Vibration levels can be perceived well below a level at which cosmetic building damage may occur. For structural damage to occur, vibration levels would need to be magnitudes higher again. People tend to react to low vibration levels, and it is important to inform residents in the vicinity of the works of the potential for construction vibration to be felt.

The below table shows how people may react to various vibration levels. These effects do not consider less sensitive uses such as factories, manual works (e.g. the concrete batching plant) and similar.

Table 15: Vibration effects

Vibration level (mm/s PPV)	Potential effects indoors
0.14	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.3	Vibration might be just perceptible in residential environments This is the AUP:OP limit for construction vibration generated at night-time for sensitive receivers.
1	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. What people feel would be subject to the source/activity (i.e., continuous motion or a one-off event) and associated frequency (i.e., fast or slow vibration), but could include a steady vibration from sources such as vibratory compaction, or a small jolt such as from the

Vibration level (mm/s PPV)	Potential effects indoors
	movement of a large digger. Vibration at this level could rattle crockery and glassware. Sleep disturbance would be almost certain for most people.
2	Vibration would clearly be felt in all situations. Can be tolerated in indoor environments such as offices, houses, and retail, where it occurs intermittently during the day and where there is effective prior engagement. This is the AUP:OP limit for occupied buildings for construction projects generating vibration.
5	Unlikely to be tolerable in a workplace or residential environment without prior warning and explanation. If exposure was prolonged, some people could want to leave the building affected. Computer screens would shake, and light items could fall off shelves. This is the AUP:OP limit for construction activities generating vibration for three days or less between the hours of 7:00 am – 6:00 pm
10	Likely to be intolerable for anything more than a very brief exposure.

For dwellings where the Category A (amenity) criteria are predicted to be exceeded, residents may be disturbed by vibration if no prior warning is given. We recommend notification to avoid such a situation. It is noted, however, that vibration inducing equipment generally moves along the alignment, i.e. vibration levels will not remain high for any length of time.

6 Airport to Botany Bus Rapid Transit – NoR 1

This section assesses construction noise and vibration matters relating to NoR 1 – the Project corridor between Botany Town Centre and Rongomai Park.

6.1 Existing and likely future noise environment

The alignment follows Te Irirangi Drive, with the BRT corridor proposed in the central median. The road was already constructed with rapid transit in mind, and therefore the existing road width will remain largely unchanged as the median can accommodate the BRT corridor.

Neighbouring sites contain a mix of established (relatively new) residential development, generally single storey, established (relatively new) commercial premises and currently vacant or developing commercial areas. In addition, there are a number of retirement villages and a school as well as childcare centres abutting the road.

Te Irirangi Drive is an 80 km/h limited access road, with driveways of dwellings connecting with slip roads before entering the main road at specific points. Traffic noise levels for houses in the first row range from mid-60 to about 70 dB L_{Aeq}, which shows that the area is impacted by high traffic noise levels.

The NPS:UD enables higher density dwellings for all sites adjacent to Te Irirangi Drive. We anticipate that:

- Zoning within a walkable catchment of BRT stations along the corridor will enable at a minimum, apartment buildings of six storeys; and
- Beyond walkable catchments, residential zoning will provide for three dwellings up to three storeys in height (subject to meeting the relevant development standards).

However, the developing commercial sites will be fully established by the time the Project is constructed and will need to be taken into consideration.

Where the environment is materially different at the time of construction, any new occupied buildings will need to be assessed against the relevant noise and vibration limits and managed at the receivers that are present at the time of construction as set out in Section 10.3.

6.2 Buildings within proposed designation

The following Table 16 shows the buildings that are within the proposed designation. We have not assessed these buildings further as the assumption is that the relevant requiring authority will acquire the parcels of land that these buildings are located on, or the buildings will be unoccupied during construction. We only note the addresses where the main building is inside designation.

Table 16: Buildings inside designation (not assessed)

Address	Address
25 Aclare Place, East Tāmaki	14 Moravale Lane, Flat Bush
1, 3 Belinda Avenue, Flat Bush	23 Place Road, East Tamaki Heights

Address	Address
15 Brittas Place, East Tamaki Heights	14, 15 Riechelmann Court, Flat Bush
20 Leixlep Lane, East Tamaki Heights	13 Tonu'U Court, Flat Bush
6 Mika Court, Flat Bush	11 Whetstone Road, Flat Bush

6.3 Construction noise effects

6.3.1 Main construction activities

Most works will occur in the existing road corridor, with lanes generally not moving out towards the houses. An exception are intersections, where additional lanes may be constructed. New walking and cycling facilities will also be constructed in the space between the road and the existing property boundaries. These works are of less intensity than those required to construct the BRT corridor but will be closer to houses. Walking and cycling facilities will require smaller equipment to be used, with less resulting effects.

This NoR does not contain any significant structures such as bridges. There are three stations in this NoR: Smales Road, Accent Drive and Ormiston Road stations. These stations are located at busy intersections in areas that are already affected by high noise levels. Accent Drive and Ormiston Road stations are bordered by residential sites to the east only, while Smales Road station is surrounded by residential sites. Construction of the stations may require a slightly longer construction duration in one location than the BRT lanes and walking and cycling lanes that will move along the corridor.

6.3.2 Daytime works

We have predicted noise levels from construction works for the entire alignment, based on likely earthworks and road formation works, with focus on the new BRT corridor in the middle of the road. Due to the distance of buildings from the works, we predict compliance with the 70 dB L_{Aeq} noise limit for the majority of buildings (2/3 of all assessed buildings). Where houses are slightly closer to the works, noise levels may be up to 73 dB L_{Aeq} when works occur in close proximity. However, these works would be temporary and unlikely to last more than a few days at a time.

The figures in **Appendix A** show which of the existing buildings may receive noise levels marginally above the relevant daytime noise limit of 70 dB L_{Aeq}.

Noise can generally be managed and mitigated through normal processes as set out in Section 10.3.

6.3.3 Night-time works

We anticipate that some limited night-time works may be required where works would affect the existing road (e.g. surfacing). These works would be similar to what can be expected across Auckland when existing major roads are resurfaced over night to avoid traffic disruption. The AUP:OP makes allowance for such works in Section E25.6.29.

Any such works will be limited in duration and can be managed through normal communication and site management (refer to Section 10.4).

6.4 Construction vibration effects

The likely highest vibration levels are predicted from the use of vibratory rollers for the compaction of the BRT corridor. Since these works are in the middle of the existing road, we predict that the 5 mm/s PPV criterion can be complied with at all times. Compliance can be achieved at 14 m from the works (assuming a 100% safety margin as discussed in Section 4.5.1.

Dwellings within 38m of vibratory roller works may experience vibration levels above the amenity criterion. For these houses, vibration levels may exceed 2 mm/s PPV for brief durations while the vibratory roller passes. This would occur for one or two days at a time only and be similar to what would be expected for road resurfacing. Such levels can be managed through communication with affected occupants to ensure they are aware of potential times of high vibration generation.

Figures in **Appendix B** show the indicative vibration envelope outside which compliance with the 5 mm/s PPV vibration limit is predicted.

7 Airport to Botany Bus Rapid Transit – NoR 2

This section assesses specific construction noise and vibration matters relating to NoR 2 – the Project corridor between Rongomai Park and Puhinui Interchange, in the vicinity of Plunket Avenue. For assessment purposes, NoR 2 has been split into three sections as shown in Figure 3 below:

Figure 3: Sections of Airport to Botany Bus Rapid Transit NoR 2

7.1 Existing and likely future noise environment

This NoR encompasses three distinct sections as shown in Figure 3 above. Sections A and C are residential in character, with generally established older housing stock and infill housing. Houses are mostly single and double storey. Section B traverses the Manukau City Centre and is commercial in nature.

The southern side of Section C and part of Section B are within the High Aircraft Noise Area (**HANA**), which means that no new noise sensitive activities will be established. The remainder of Section C, and most of Sections A and B are within the Medium Aircraft Noise Area (**MANA**), which means that any new noise sensitive activities would need to be constructed to be insulated against aircraft noise. Such improved building façades and ventilation also assist in mitigating construction noise. The northernmost part of Section A is outside the aircraft noise areas.

A number of sensitive sites such as Puhinui School, AUT South Campus, MIT and several childcare centres are adjacent to the alignment.

The presence of the HANA and MANA indicate elevated noise levels from aircraft noise. In addition, the BRT corridor will follow established major roads which also have a clear influence on the noise levels of neighbouring buildings. Measured noise levels show a range of mid-60 to low-70 dB L_{Aeq} for houses fronting the road, generally controlled by road traffic.

The NPS:UD enables higher density dwellings for sites adjacent to the BRT corridor. We anticipate that:

- Zoning within a walkable catchment of BRT stations along the corridor will enable, at minimum, apartment buildings of six storeys; and
- Beyond walkable catchments, residential zoning will provide for three dwellings up to three storeys in height (subject to meeting the relevant development standards).

Based on the above, we expect significant redevelopment along this NoR in the near to medium future, where sites are outside the HANA.

Therefore, while we have assessed existing buildings in this report, we recommend that where the existing environment is materially different at the time of construction, any new occupied buildings will need to be assessed against the relevant noise and vibration limits and managed at the receivers that are present at the time of construction as set out in Section 10.3.

7.2 Buildings within proposed designation

The following Table 17 shows the buildings that are within the proposed designation. We have not assessed these buildings further as the assumption is that the relevant requiring authority will acquire the parcels of land that these buildings are located on, or the buildings will be unoccupied during construction.

Note that all buildings to be removed, of the three sections of NoR 2, are combined in the table below.

Table 17: Buildings inside designation (not assessed)

Address	Address
1, 3 Belinda Avenue, Flat Bush	66 Othello Drive, Clover Park
19R, 104B, 104C, 131 Boundary Road, Clover Park	2, 4A, 6 Plunket Avenue, Papatoetoe
139, 141, 154 Carruth Road, Papatoetoe	67 – 79 (odd), 80, 81 – 97 (odd), 101 – 107 (odd), 122 – 162 (even) Puhinui Road, Papatoetoe
1 and 2/89 Charntay Avenue, Clover Park	2 Sandrine Avenue, Clover Park
1 and 2/141, 2/148 Dawson Road, Flat Bush	18, 19 Tavistock Street, Papatoetoe
1 – 7 (odd), 9A, 11, 13, 15A Dissmeyer Drive, Flat Bush (uneven numbers only)	44 – 50 (even), 55 – 61 (odd), 56, 60, 62, 1/67, 1/68, 69, 71, 72, 74, 76, 1/80, 82, 83, 3/86, 88, 90, 97, 100, 2/102, 106, 108, 110, 3/112, 118, 120, 124, 126, 130, 132, 134, 140, 142, 146, 147, 148, 149A and B, 152, 154, 155, 157A and B, 2/157, 158, 159, 160, 161, 164, 166, 170, 174 – 180 (even), 190, 194, 199, 210, 214, 218, 220 Te Irirangi Drive, Flat Bush/Clover Park
72C Hollyford Drive, Clover Park	11 Whetstone Road, Flat Bush

7.3 Section A: East of SH1 to Rongomai Park

7.3.1 Construction noise effects

7.3.1.1 Main construction activities

There are three activities when noise levels may potentially exceed the relevant noise limit: during the demolition of buildings inside the designation, during earthworks for the preparation of the new traffic lanes, and for bridge construction across SH1.

We predict that most dwellings adjacent to buildings to be demolished may at times receive noise levels exceeding the 70 dB L_{Aeq} noise criterion. This is due to the fact that works will be very close to neighbouring houses. Any such exceedances will likely be limited to one or two days as high noise levels from demolition are not sustained over a long period. Most houses in the area are of light weight construction, which means that generally an excavator and truck are sufficient to demolish the structures. In rare circumstances, concrete cutting may be required. In that case, temporary barriers should be used to shield neighbouring buildings from the noise.

We understand that access to residential sites will need to be maintained. This means that barriers for longer extents of the works are unlikely to be practicable mitigation. Earthworks will therefore likely be required to be managed by communication, equipment selection and timing. We predict that approximately 110 of the nearly 900 buildings in the vicinity of the works may receive noise levels up to 73 dB L_{Aeq} from earthworks, with the remaining buildings receiving compliant noise levels.

Given the large number of neighbouring houses and the shielding provided by buildings in the first row, we have prepared figures showing which buildings are predicted to receive noise levels above the daytime noise limit from earthworks and lane preparation. This activity would occur over a longer period than demolition and we have therefore based our assessment on this phase of the works.

Section A of NoR 2 includes two stations; Dawson Road and Diorella Drive stations, where works may be somewhat more sustained.

Figures in **Appendix A** show the relevant houses at which minor exceedances are predicted.

7.3.1.2 Daytime works

We predict that noise levels from demolition may be up to 78 dB L_{Aeq} at individual houses, for a few hours when demolition occurs immediately adjacent to the dwelling. However, the duration will be brief and therefore can be managed through communication and consultation.

Part of the excavation would also include the breaking up and excavation of existing concrete driveways and foundations. These may cause high noise levels at neighbouring houses. However, temporary barriers may be installed around any break site to reduce noise levels.

Earthworks will occur over a more sustained period. We predict noise levels up to 73 dB L_{Aeq} at closest houses when earthworks occur in the immediate vicinity, such levels are only marginally above the noise criteria, and given that they are likely to occur for only limited periods (a few days or weeks at most), we consider that besides normal site management, consultation and communication will be the most effective management measures.

7.3.1.3 Night-time works

We anticipate that some limited night-time works may be required where works would affect the existing road (e.g. surfacing). These works would be similar to what can be expected across Auckland when existing major roads are resurfaced over night to avoid traffic disruption. These works would be similar to what can be expected across Auckland when existing major roads are resurfaced over night to avoid traffic disruption. The AUP:OP makes allowance for such works in Section E25.6.29.

Any such works will be limited in duration and can be managed through normal communication and site management through a schedule (refer Section 10.4).

The other area where night-time works will likely be required is the new bridge across SH1. As the construction of the bridge may require closing of SH1, these works will need to be undertaken at night-time. Such works would be limited in duration. There are a small number of dwellings in the vicinity of SH1 which will likely be affected by these works, and a schedule will be required to ensure effects are appropriately managed. Should night-time works be sustained and of high intensity (e.g. should the existing bridge require demolition), an offer of temporary relocation may be considered for closest dwellings in order to manage potential sleep disturbance. This would be recorded in a schedule (refer Section 10.4).

7.3.2 Construction vibration effects

The likely highest vibration levels are predicted from the use of vibratory rollers for the compaction of the extended traffic lanes. With the BRT corridor in the middle of the road, traffic lanes will move out towards the houses. Compliance with the 5 mm/s PPV limit can be achieved at 14 m from the works (assuming a 100% safety margin as discussed in Section 4.5.1).

Due to the distance of the works from the houses remaining, we predict that compliance with the 5 mm/s PPV vibration limit can be achieved at all buildings.

Dwellings within 38m of vibratory roller works may experience vibration levels above the amenity criterion. For these houses, vibration levels may exceed 2 mm/s PPV for brief durations while the vibratory roller passes. This would occur for one or two days at a time only and be similar to what would be expected for road resurfacing. Such levels can be managed through communication with affected occupants to ensure they are aware of potential times of high vibration generation.

Figures in **Appendix B** show the indicative vibration envelope outside which compliance with the 5 mm/s PPV vibration limit is predicted without additional mitigation or management.

7.4 Section B: Ihaka Place to east of SH1

7.4.1 Construction noise effects

7.4.1.1 Main construction activities

Works through the Manukau City Centre will generally occur within the road and existing open space. No main building demolition is required. Most buildings in the area are multi storey.

Specifically, sensitive receivers include MIT and the AUT South Campus. While the AUT South Campus is located in the HANA, MIT is located in the MANA. Both sites would likely include façade

noise controls and ventilation to take account of the aircraft noise and will therefore also be somewhat protected against construction noise.

Due to the general distance to buildings, we predict that for most activities, compliance with the daytime noise limit can be achieved. A small number of buildings that are closer to the works are predicted to receive noise levels of up to 6 dB above the daytime limit when works are immediately beside them. This includes MIT, where a noise level of 76 dB L_{Aeq} is predicted. Given that the building is likely already constructed to take account of elevated noise levels, we consider that internal noise levels will be acceptable for teaching activities, with anticipated noise levels below 40 dB L_{Aeq}. The construction of the bridge across SH1 will likely have some effects on the AUT South Campus, however, the buildings are located somewhat further away from the works and therefore levels will likely be manageable.

There are two stations in this section: Ronwood Avenue and Manukau Central stations.

Figures in **Appendix A** show the relevant houses at which minor exceedances are predicted.

7.4.1.2 Daytime works

Works in this area will be similar to common road works expected with transport infrastructure upgrades across Auckland, involving footpath and kerbing works and surface widening and improvements.

Works would be moving along the alignment, which means that elevated noise levels would be experienced for only brief periods at each building. Highest noise levels are predicted where intersections are upgraded and the road moves closer to buildings (e.g. at MIT), and where bridge works are required (across SH1, in the vicinity of AUT South Campus).

Highest predicted noise levels are between 71 and 74 dB L_{Aeq}, with only MIT predicted to receive a noise level of 76 dB L_{Aeq}. However, the duration will be brief and therefore can be managed through communication and consultation. We also recommend that communication with the education facilities is ongoing throughout the construction duration to avoid sensitive times such as exams.

7.4.1.3 Night-time works

We anticipate that some limited night-time works may be required where works would affect the existing road (e.g. surfacing). These works would be similar to what can be expected across Auckland when existing major roads are resurfaced over night to avoid traffic disruption. The AUP:OP makes allowance for such works in Section E25.6.29.

Any such works will be limited in duration and can be managed through normal communication and site management through a schedule (refer Section 10.4).

The other area where night-time works will likely be required is the new bridge across SH1. As the construction of the bridge may require closing of SH1, these works will need to be undertaken at night-time. Such works would be limited in duration. Within Section B of NoR 2, there are no sensitive receivers on the western side of SH1. We anticipate that the AUT campus is not occupied at night-time. Therefore, it is unlikely that sensitive receivers will be affected by these works.

7.4.2 Construction vibration effects

The likely highest vibration levels are predicted from the use of vibratory rollers for the compaction of the extended traffic lanes, and from the bridge pile installation.

For vibratory rollers, compliance with the 5 mm/s PPV limit can be achieved at 14 m from the works (assuming a 100% safety margin as discussed in Section 4.5.1).

A small number of buildings is predicted to receive vibration levels above 5 mm/s PPV (refer Table 18 below). In the vicinity of these houses, we recommend that alternative forms of compaction are used, e.g. non-vibratory compaction, a smaller machine or plate compactors. With these measures, compliance can be achieved.

Table 18: Buildings at which 5 mm/s PPV limit is predicted to be exceeded

Address	Address
639 Great South Road	503/17 Amersham Way
58 Manukau Station Road	2 Ronwood Avenue

Dwellings within 38m of vibratory roller works may experience vibration levels above the amenity criterion. For these houses, vibration levels may exceed 2 mm/s PPV for brief durations while the vibratory roller passes. This would occur for one or two days at a time only and be similar to what would be expected for road resurfacing. Such levels can be managed through communication with affected occupants to ensure they are aware of potential times of high vibration generation.

Some buildings at the AUT South Campus and Countdown may be close to proposed retaining walls leading to the SH1 bridge. Where buildings are within 20m of retaining or bridge piling, we recommend that bored piling is used instead of impact or vibratory piling, to ensure compliance with the 5 mm/s PPV limit.

Figures in **Appendix B** show the indicative vibration envelope outside which compliance with the 5 mm/s PPV vibration limit is predicted without additional mitigation or management.

7.5 Section C: Ihaka Place to Plunket Avenue

7.5.1 Construction noise effects

7.5.1.1 Main construction activities

There are two phases of the works when noise levels may potentially exceed the relevant noise limit: during the demolition of buildings inside the designation, and during earthworks for the preparation of the new traffic lanes.

We predict that most dwellings adjacent to buildings to be demolished may at times receive noise levels exceeding the 70 dB L_{Aeq} noise criterion. This is due to the fact that works will be very close to neighbouring houses. Any such exceedances will likely be limited to one or two days as high noise levels from demolition are not sustained over a long period. Most houses in the area are of light weight construction, which means that generally an excavator and truck are sufficient to demolish the

structures. In rare circumstances, concrete cutting may be required. In that case, temporary barriers should be used to shield neighbouring buildings from the noise.

We understand that access to residential sites will need to be maintained. This means that barriers for longer extents of the works are unlikely to be practicable mitigation. Earthworks will therefore likely be required to be managed by communication, equipment selection and timing. We predict that approximately 60 of the 475 buildings in the vicinity of the works may receive noise levels up to 74 dB L_{Aeq} from earthworks, with the remaining buildings receiving compliant noise levels.

Given the large number of neighbouring houses and the shielding provided by buildings in the first row, we have prepared figures showing which buildings are predicted to receive noise levels above the daytime noise limit from earthworks and lane preparation. This activity would occur over a longer period than demolition and we have therefore based our assessment on this phase of the works.

There is one station in this section of NoR 2 at the Lambie Drive/Puhinui Road intersection

Figures in **Appendix A** show the relevant houses at which minor exceedances are predicted.

7.5.1.2 Daytime works

We predict that noise levels from demolition may be up to 78 dB L_{Aeq} at individual houses, for a few hours when demolition occurs immediately adjacent to the dwelling. However, the duration will be brief and therefore can be managed through communication and consultation.

Part of the excavation would also include the breaking up and excavation of existing concrete driveways and foundations. These may cause high noise levels at neighbouring houses. However, temporary barriers may be installed around any break site to reduce noise levels.

Earthworks will occur over a more sustained period. We predict noise levels up to 73 dB L_{Aeq} at closest houses when earthworks occur in the immediate vicinity, Such levels are only marginally above the noise criteria, and given that they are likely to occur for only limited periods (a few days or weeks at most), we consider that besides normal site management, consultation and communication will be the most effective management measures.

Puhinui School fronts the works. The playing fields are located immediately beside the road. During earthworks, communication on the playing fields may be difficult. In consultation with the school, we recommend that a barrier is discussed for the school. This barrier may be retained to reduce traffic noise on the playing fields in the future.

We also recommend that communication with the school is ongoing throughout the construction duration to avoid sensitive times such as exams.

7.5.1.3 Night-time works

We anticipate that some limited night-time works may be required where works would affect the existing road (e.g. surfacing). These works would be similar to what can be expected across Auckland when existing major roads are resurfaced over night to avoid traffic disruption. The AUP:OP makes allowance for such works in Section E25.6.29.

Any such works will be limited in duration and can be managed through normal communication and site management through a schedule (refer Section 10.4).

7.5.2 Construction vibration effects

The likely highest vibration levels are predicted from the use of vibratory rollers for the compaction of the extended traffic lanes. With the BRT corridor in the middle of the road, traffic lanes will move out towards the houses. Compliance with the 5 mm/s PPV limit can be achieved at 14 m from the works (assuming a 100% safety margin as discussed in Section 4.5.1).

A small number of buildings is predicted to receive vibration levels above 5 mm/s PPV (refer Table 19 below). In the vicinity of these houses, we recommend that alternative forms of compaction are used, e.g. non-vibratory compaction, a smaller machine or plate compactors. With these measures, compliance can be achieved.

Table 19: Buildings at which 5 mm/s PPV limit is predicted to be exceeded

Address	Address
2/73, 77A, 2/101, 109, 124B Puhinui Road	4 Plunket Avenue
639 Great South Road	

Dwellings within 38m of vibratory roller works may experience vibration levels above the amenity criterion. For these houses, vibration levels may exceed 2 mm/s PPV for brief durations while the vibratory roller passes. This would occur for one or two days at a time only and be similar to what would be expected for road resurfacing. Such levels can be managed through communication with affected occupants to ensure they are aware of potential times of high vibration generation.

Figures in **Appendix B** show the indicative vibration envelope outside which compliance with the 5 mm/s PPV vibration limit is predicted without additional mitigation or management.

8 Airport to Botany Bus Rapid Transit – NoR 3

This section assesses construction noise and vibration matters relating to NoR 3 – the Project corridor between Puhinui Station, in the vicinity of Plunket Avenue and SH20/20B Interchange.

8.1 Existing and likely future noise environment

NoR 3 traverses largely established residential areas with single and double storey dwellings. To the south of Puhinui Road are a number of commercial and business premises. A significant extent of the sites adjacent to the alignment are within the HANA (all sites south of Puhinui Road), with the remainder in the MANA. This means that existing buildings in the HANA should already have been insulated to reduce aircraft noise, and have ventilation installed. In the MANA, all new dwellings, and some of the existing ones, would also have sound insulation and ventilation incorporated.

The presence of the HANA and MANA indicate elevated noise levels from aircraft noise. In addition, the BRT Corridor will follow an established major road which also has a significant influence on the noise levels of neighbouring buildings. Measured noise levels are in the mid-60 dB L_{Aeq} for houses fronting the road, generally controlled by road traffic.

The NPS:UD enables higher density dwellings for sites adjacent to the BRT corridor outside the HANA (i.e. to the north of the road). We anticipate that zoning within a walkable catchment of BRT stations along the corridor will enable, at minimum, apartment buildings of six storeys.

Therefore, while we have assessed existing buildings in this report, we recommend that where the existing environment is materially different at the time of construction, any new occupied buildings will need to be assessed against the relevant noise and vibration limits and managed at the receivers that are present at the time of construction as set out in Section 10.3.

8.2 Buildings within proposed designation

The following Table 20 shows the buildings that are within the proposed designation. We have not assessed them further as the assumption is that the relevant requiring authority will acquire the parcels of land that these buildings are located on, or these buildings will be unoccupied during construction.

Table 20: Buildings inside designation (not assessed)

Address	Address
3, 5, 7 – 10 Bridge Street, Papatoetoe	2, 4A Plunket Avenue, Papatoetoe
6, 8, 18, 20, 22, 26 Cambridge Terrace, Papatoetoe	146 – 150 (even), 156, 166 – 202 (even), 199, 203,230, 232, 252, 262 – 266 (even), 272 – 280 (even), 281, 284, 286, 290 – 294 (even), 298, 300 – 306 (even), 310, 312 Puhinui Road, Papatoetoe
4, 6, 8 Noel Burnside Road, Papatoetoe	1, 2, 2/3, 5 Ranfurly Avenue, Papatoetoe
98, 104 Kenderdine Road, Papatoetoe	

8.3 Construction noise effects

8.3.1 Main construction works

There are three activities when noise levels may potentially exceed the relevant noise limit: during the demolition of buildings inside the designation, during earthworks for the preparation of the new traffic lanes, and the construction of the bus bridge across the rail line at Puhinui Interchange.

We predict that most dwellings adjacent to buildings to be demolished may at times receive noise levels exceeding the 70 dB L_{Aeq} noise criterion. This is due to the fact that works will be very close to neighbouring houses. Any such exceedances will likely be limited to one or two days as high noise levels from demolition are not sustained over a long period. Most houses in the area are of light weight construction, which means that generally an excavator and truck are sufficient to demolish the structures. In rare circumstances, concrete cutting may be required. In that case, temporary barriers should be used to shield neighbouring buildings from the noise.

We understand that access to residential sites will need to be maintained. This means that barriers for longer extents of the works are unlikely to be practicable mitigation. Earthworks will therefore likely be required to be managed by communication, equipment selection and timing. We predict that approximately 100 of the 673 buildings in the vicinity of the works may receive noise levels up to 77 dB L_{Aeq} from earthworks, with the remaining buildings receiving compliant noise levels.

Given the large number of neighbouring houses and the shielding provided by buildings in the first row, we have prepared figures showing which buildings are predicted to receive noise levels above the daytime noise limit from earthworks and lane preparation. This activity would occur over a longer period than demolition and we have therefore based our assessment on this phase of the works.

The construction of the BRT bridge will occur in close proximity to a small number of dwellings. Some of the bridge works will likely need to be undertaken at night or over a long weekend as rail closures may be required.

There is only one station proposed for this NoR, at Puhinui Station. The station construction is unlikely to materially add to the already intensive works at Puhinui Station associated with the construction of the new BRT bridge structure.

Figures in **Appendix A** show the relevant houses at which minor exceedances are predicted.

8.3.2 Daytime works

We predict that noise levels from demolition may be up to 78 dB L_{Aeq} at individual houses, for a few hours when demolition occurs immediately adjacent to the dwelling. However, the duration will be brief and therefore can be managed through communication and consultation.

Part of the excavation would also include the breaking up and excavation of existing concrete driveways and foundations. These may cause high noise levels at neighbouring houses. However, temporary barriers may be installed around any break site to reduce noise levels.

Earthworks will occur over a more sustained period. We predict noise levels up to 77 dB L_{Aeq} at closest houses when earthworks occur in the immediate vicinity of the Project. Such levels are only marginally above the noise criteria, and given that they are likely to occur for only limited periods (a

few days or weeks at most), we consider that besides normal site management, consultation and communication will be the most effective management measures.

8.3.3 Night-time works

We anticipate that some limited night-time works may be required where works would affect the existing road (e.g. surfacing). These works would be similar to what can be expected across Auckland when existing major roads are resurfaced over night to avoid traffic disruption. The AUP:OP makes allowance for such works in Section E25.6.29.

The other area where night-time works will likely be required is the new BRT bridge across the rail line at Puhinui Station. As the construction of the bridge may require a block of line, these works will need to be undertaken at night-time or on a long weekend. Such works would be limited in duration. There are a small number of dwellings in the vicinity of Puhinui Station which will likely be affected by these works, and a schedule will be required to ensure effects are appropriately managed. Should night-time works be sustained and of high intensity (e.g. should the existing bridge require demolition), an offer of temporary relocation may be considered for closest dwellings in order to manage potential sleep disturbance. This would be recorded in a schedule.

Any such works will be limited in duration and can be managed through normal communication and site management through a schedule (refer Section 10.4).

8.4 Construction vibration effects

The likely highest vibration levels are predicted from the use of vibratory rollers for the compaction of the extended traffic lanes. With the BRT corridor in the middle of the road, and on a bridge, traffic lanes will move out towards the houses. Compliance with the 5 mm/s PPV limit can be achieved at 14 m from the works (assuming a 100% safety margin as discussed in Section 4.5.1).

A small number of buildings is predicted to receive vibration levels above 5 mm/s PPV (refer Table 21). In the vicinity of these houses, we recommend that alternative forms of compaction are used, e.g. non-vibratory compaction, a smaller machine or plate compactors. With these measures, compliance can be achieved.

Table 21: Buildings at which 5 mm/s PPV limit is predicted to be exceeded

Address	Address
153, 155, 226, 246, 294A, 316 Puhinui Road	Puhinui Station building
4 Plunket Avenue	

Dwellings within 38m of vibratory roller works may experience vibration levels above the amenity criterion. For these houses, vibration levels may exceed 2 mm/s PPV for brief durations while the vibratory roller passes. This would occur for one or two days at a time only and be similar to what would be expected for road resurfacing. Such levels can be managed through communication with affected occupants to ensure they are aware of potential times of high vibration generation.

Some dwellings are in close proximity to the proposed new BRT bridge across Puhinui Station. Where buildings are within 20m of retaining wall or bridge piling, we recommend that bored piling is used instead of impact or vibratory piling, to ensure compliance with the 5 mm/s PPV limit.

Figures in **Appendix B** show the indicative vibration envelope outside which compliance with the 5 mm/s PPV vibration limit is predicted without additional mitigation or management.

9 Airport to Botany Bus Rapid Transit – NoRs 4a and 4b

This section assesses construction noise and vibration matters relating to NoRs 4a and 4b – the Project corridor between the SH20/20B Interchange and Orrs Road.

As set out in Section 2.1.4 above, NoR 4a involves the widening of Puhinui Road between west of the SH20/20B Interchange and Orrs Road. This NoR is under the jurisdiction of Auckland Transport and overlaps the proposed alteration to the existing Waka Kotahi designation 6717.

NoR 4b involves the proposed widening of State Highway 20B from the SH20/20B Interchange to Manukau Memorial Gardens, a new southbound ramp from SH20B to SH20, high quality walking and cycling facilities and the provision of a Bus Rapid Transit Corridor. This NoR is under the jurisdiction of Waka Kotahi.

9.1 Existing and likely future noise environment

The Project traverses a currently sparsely developed area with intermittent dwellings at distance from the existing road. Most of the area is located within the HANA, with the remainder in the MANA. This means that the area is already affected by aircraft noise, and for the most part noise sensitive activities are not permitted to be developed.

In addition, the existing Puhinui Road (SH20B) and SH20 are major roads that affect the ambient noise environment.

To the north, sites are zoned Future Urban. Should this zone be developed prior to construction of the NoRs, any existing occupied buildings at the time of road construction will need to be assessed for construction noise and vibration impact. Commercial premises have similar protection from construction noise as dwellings. Any future use of the neighbouring sites should be reviewed, and appropriate criteria applied to be commensurate with the sensitivity of the receiving environment (e.g. a concrete batching plant is significantly less sensitive to construction noise than an office).

The Manukau Memorial Gardens are adjacent to the Projects. This cemetery is still operating at present. We recommend that any contractor coordinates work times with the cemetery management to avoid sensitive times such as during funerals or memorials.

Overall, the noise levels at existing houses in the area range from mid-50 to mid-60 dB L_{Aeq} from road traffic only. We measured noise levels of 62 to 65 dB L_{Aeq} including aircraft noise. This shows that the area is clearly affected by traffic and aircraft noise.

Where the existing environment is materially different at the time of construction, any new occupied buildings will need to be assessed against the relevant noise and vibration limits and managed at the receivers that are present at the time of construction as set out in Section 10.3.

9.2 Buildings within proposed designation

The following Table 22 shows the buildings that are within the proposed designation. We have not assessed them further as the assumption is that the relevant requiring authority will acquire the parcels of land that these buildings are located on, or these buildings will be unoccupied during

construction. We only note the addresses where the main building is inside designation, and not those where auxiliary buildings such as sheds, or garages may be removed. For some addresses, several buildings are on the site, however, the address is only shown once.

In addition, auxiliary buildings are not generally occupied, so are not considered to be relevant receivers in relation to this assessment.

Table 22: Buildings inside designation (not assessed)

Address	Address
402 Puhinui Road	440 Puhinui Road
408 Puhinui Road	

9.3 Construction noise effects

9.3.1 Main construction works

We predict that noise levels can generally be complied with at all buildings adjacent to the works. Some limited exceedances (up to 73 dB L_{Aeq}) may occur when the walking and cycling facility in the vicinity of Hillside Road and Sabi Place is constructed, when works are immediately adjacent to dwellings. However, given the existing noise level from SH20 is already around 68 to 73 dB L_{Aeq} at houses fronting the road, the works will not generally be unreasonable.

Night-time works may be required for the construction of the ramp across SH20 as the road may need to be closed. These works are likely to cause noise limit exceedances as discussed below.

No stations are proposed for this NoR.

Figures in **Appendix A** show the relevant houses at which minor exceedances are predicted.

9.3.2 Daytime works

The main noise source for the construction of NoR 4a and 4b will be earthworks. We predict noise levels up to 73 dB L_{Aeq} at closest houses when earthworks occur in the immediate vicinity of the Project. Such levels are only marginally above the noise criteria and similar to the existing ambient noise levels in the vicinity of SH20. Given that the earthworks are likely to occur for only limited periods (a few days or weeks at most), we consider that besides normal site management, consultation and communication will be the most effective management measures.

9.3.3 Night-time works

We anticipate that some limited night-time works may be required where works would affect the existing road (e.g. surfacing). These works would be similar to what can be expected across Auckland when existing major roads are resurfaced over night to avoid traffic disruption. The AUP:OP makes allowance for such works in Section E25.6.29.

The other area where night-time works will likely be required is the new bridge for the ramp across SH20. As the construction of the bridge may require the closing of SH20, these works will need to be undertaken at night-time. Such works would be limited in duration. There are a small number of dwellings in the vicinity the bridge which may be affected by these works, and a schedule will be

required to ensure effects are appropriately managed. Should night-time works be sustained and of high intensity, an offer of temporary relocation may be considered for closest dwellings in order to manage potential sleep disturbance. This would be recorded in a schedule.

Any such works will be limited in duration and can be managed through normal communication and site management through a schedule (refer Section 10.4).

9.4 Construction vibration effects

The likely highest vibration levels are predicted from the use of vibratory rollers for the compaction of the bus lanes, and from bridge and retaining wall piling. Since these works are at sufficient distance from any buildings, we predict that the 5 mm/s PPV criterion can be complied with at all times. Compliance can be achieved at 14 m from the works (assuming a 100% safety margin as discussed in Section 4.5.1).

Dwellings within 38m of vibratory roller works may experience vibration levels above the amenity criterion. For these houses, vibration levels may exceed 2 mm/s PPV for brief durations while the vibratory roller passes. This would occur for one or two days at a time only and be similar to what would be expected for road resurfacing. Such levels can be managed through communication with affected occupants to ensure they are aware of potential times of high vibration generation.

Figures in **Appendix B** show the indicative vibration envelope outside which compliance with the 5 mm/s PPV vibration limit is predicted.

10 Mitigation and management measures

The most effective way to control construction noise and vibration is through good on-site management and communication between managers, staff and affected receivers. We have included recommended measures in this Report, based on the assumed construction equipment and methodologies.

Good noise and vibration management is essential in reducing adverse effects as far as practicable, irrespective of the low number of dwellings potentially affected or if noise levels may already be compliant with the relevant criteria.

The following sections set out the mitigation and management measures that could apply to each of the Project NoRs. Section 11 sets out the recommended mitigation measures for the NoRs

10.1 General mitigation and management measures

The following general noise mitigation measures will be required to be implemented throughout the construction of the Project. These measures should be implemented as a matter of good practice and are considered the baseline mitigation for most circumstances.

Where an exceedance of the construction noise or vibration standards is likely due to a specific activity or in a specific area, and the general mitigation measures as discussed below are not sufficient to achieve full compliance, further mitigation and management should be investigated and implemented where practicable. Such information would be contained in the Schedule as attachment to the CNVMP.

10.1.1 Communication and consultation

The most important and effective management measure is public liaison and communication with people occupying buildings in the vicinity of the Project. Providing timely and detailed information to those potentially affected helps to alleviate uncertainty and concerns and builds trust between the contractor and the receivers.

A contractor environmental manager or appointed representative should be available for residents to contact by phone and/or email at times when construction occurs. Communication also includes complaints responses, which should be included in the CNVMP.

At sensitive times (e.g. when night-time or public holiday works are required), communication is particularly important, and needs to increase in frequency and content, to ensure residents have the ability to plan around the works where that is practicable.

10.1.2 Training

All staff should participate in an induction training session prior to the start of construction, with attention given to the following matters:

- Construction noise and vibration limits;
- Activities with the potential to generate high levels of noise and/or vibration;
- Noise and vibration mitigation and management procedures; and

- The sensitivity of receivers and any operational requirements and constraints identified through communication and consultation.

Awareness of current noise and vibration matters on, or near active worksites, should be addressed during regular site meetings and/or 'toolbox' training sessions.

10.1.3 Equipment selection

When selecting construction equipment, where practicable:

- Prioritise quieter construction methodologies (e.g. bored piling instead of drop hammer piling);
- Prioritise electric motors over diesel engines;
- Prioritise rubber tracked equipment over steel tracked equipment;
- Equipment will be suitably sized for the proposed task;
- Equipment will be maintained and fitted with exhaust silencers and engine covers; and
- Avoid tonal reversing or warning alarms (suitable alternatives may include flashing lights, broadband audible alarms or reversing cameras inside vehicles).

10.1.4 Timing of works

Where practicable, we recommend that night-time works are avoided. However, where projects affect existing major transport corridors (e.g. at tie ins and intersections or during the construction of new bridges) where potential closures or limitations are required to construct the Project, night-time works will likely be required from time to time. Where necessary, noisy works should be prioritised early in the evening or night-time period to avoid sleep disturbance. People tend to be less disturbed by low frequency, continuous engine noise, than intermittent noise or activities with special audible character (e.g. reversing beepers, whistling, banging tailgates or shouting).

Stakeholder engagement should be undertaken for occupiers of properties within 200m of any high noise night (and weekend) works and within the setback distance for buildings receiving vibration levels meeting or exceeding 1 mm/s PPV (Category A for occupied PPFs).

10.1.5 Noise barriers

Temporary noise barriers should be used where a construction noise limit is predicted to be exceeded and the barriers would noticeably reduce the construction noise level. They should be installed prior to the relevant works commencing and maintained throughout those works. Effective noise barriers typically reduce the received noise level at ground level by up to 10 decibels.

Where practicable, the following guidelines should be incorporated in the design and utilisation of temporary noise barriers:

- To be constructed from materials with a minimum surface mass of 6.5 kg/m2;
- A minimum height of 2 m, and higher if practicable to block line-of-sight;
- Abutted or overlapped to provide a continuous screen without gaps at the bottom or sides of the panels; and
- Positioned as close as practicable to the noisy construction activity to block line-of-sight between the activity and noise sensitive receivers. Where positioned on the site boundary, additional local barriers will be considered near the activity to ensure effective mitigation for sensitive receivers on upper floor levels.

10.1.6 Alternative mitigation options

Where all practicable noise and vibration mitigation measures have been implemented and considered, and noise or vibration levels are predicted to exceed relevant limits by a significant margin or for an extended period (e.g. more than two consecutive nights), an offer of temporary resident relocation should be considered. Such a measure should be considered as a last resort as it will generally inconvenience the building occupiers. Note that temporary relocation offers are generally associated with night-time works and sleep disturbance rather than daytime noise levels, and that this will be similar for the Project.

10.1.7 Best practice general measures

Complaints can arise irrespective of compliance with the noise and vibration limits. To minimise complaints, general mitigation and management measures include, but are not limited to, the following:

- 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;
- Avoid high engine revs through appropriate equipment selection and turn engines off when idle;
- Maintain site accessways to avoid potholes and corrugations;
- Mitigate track squeal from tracked equipment, such as excavators (may include tensioning and watering or lubricating the tracks regularly);
- Minimise construction duration near sensitive receivers;
- Stationary equipment (e.g. generators) will be located away from noise sensitive receivers and site buildings and material stores used to screen them;
- Orient mobile machinery to maximise the distance between the engine exhaust and the nearest sensitive building façade (e.g. excavators);
- Utilise noise barriers where appropriate;
- Implement specialised mitigation measures for particularly high noise and vibration generating activities such as concrete breaking, piling and vibratory roller use;
- Ensure advanced communication is complete prior to commencing activities that are predicted to exceed the noise and vibration performance standards; and
- Undertake monitoring as appropriate.

10.2 Building condition surveys

For construction activities where buildings are predicted to receive vibration levels approaching or within Category B (refer Section 3.2.2) we recommend that low vibration construction methods be investigated and implemented wherever practicable, with the aim of achieving compliance with Category A vibration criteria. This may include using screw piling methods, non-vibrating rollers or pre-drilling piles.

However, if low vibration methodologies are not deemed practicable, for dwellings identified within the vibration risk radii, we recommend that the following process be implemented before construction commences;

- Engage with the building owner and occupier to discuss the proposed construction activities and likely vibration effects;

- Undertake a pre-construction building condition survey. This will be required where the proposed construction methodology is predicted to approach or exceed the Category B vibration limits, and should be undertaken at a trigger level lower than the Category B limits; and
- Monitor vibration levels during the construction activities which are within the High Risk distance (refer Table 14).

If low vibration methodologies are not deemed practicable for buildings in the Medium Risk Zone of a construction activity, we recommend that all buildings within the Medium Risk Distance be notified of the works in advance via a letter drop which outlines the proposed construction activities and likely vibration effects.

Detailed management and mitigation options for construction vibration will be contained in the CNVMP but follow the guidelines in Section 10 of this report.

Additional vibration monitoring and follow-up building condition surveys will need to be undertaken at all buildings that had pre-construction building condition surveys. The Building Condition Surveys should also be undertaken in response to complaints, to ensure construction activities comply with the Category B criteria and that no building damage has occurred. If any construction-induced damage were shown to have occurred as a result of Project construction activities, this should be remedied by the contractor.

10.3 Construction Noise and Vibration Management Plan

All appropriate mitigation and management are generally set out in a CNVMP, which would be used to manage works on site and sets out how the construction contractor interacts with the neighbouring affected parties.

The CNVMP should include information set out in NZS6803:1999 in Section 8 and Annex E, and the requirements of the AUP:OP such as:

- Summary of noise and vibration standards;
- Summary of assessments/predictions;
- General construction practices, management and mitigation that will be used for the Project;
- Noise management and mitigation measures specific to activities and/or receiving environments, particularly for high noise and/or vibration activities, and all night-time works;
- Monitoring and reporting requirements;
- Procedures for handling complaints; and
- Procedures for review of the CNVMP throughout the works.

Where appropriate, the CNVMP should also follow the approach outlined in the Guide.[6] This includes a requirement for high noise and vibration risk construction projects to have an independently peer reviewed CNVMP and include a comprehensive risk-based quality assurance programme to ensure risks are appropriately managed.

Each NoR should have its own CNVMP. While the base information in each CNVMP will be similar, management and mitigation depend on the works undertaken and the receiving environment. The construction methodology is not yet finalised, therefore, the CNVMPs should be prepared when more

6 https://www.nzta.govt.nz/assets/Highways-Information-Portal/Technical-disciplines/Noise-and-vibration/Standards/Templates/Construction-noise-and-vibration/NZTA-Construction-noise-and-vibration-management-plan-v1.2.doc

detail is available. In addition to the CNVMPs, Waka Kotahi standard procedures for the management of noise and vibration should be implemented. These will be relied on to avoid, remedy and mitigating adverse effects where appropriate.

10.4 Schedules

In addition, Site Specific Noise and/or Vibration Management Schedules (**Schedules**) are a useful tool in determining how the noise and vibration effects from specific activities or in specific areas will be managed and potentially affected parties communicated with. Schedules would generally be prepared where there is a high risk of exceeding the noise and/or vibration standards.

The Schedules are specific to the activity or receiver they relate to, and would therefore contain detailed information on communication, management and mitigation specific to a certain task or area.

The following information would normally be included in a Schedule:

- The activity start and finish dates;
- The nearest neighbours to the activity;
- A location plan;
- The activity equipment and methodology;
- Predicted noise/vibration levels;
- Recommended BPO mitigation;
- Documented communication and consultation with affected persons;
- Monitoring details; and
- Any pre-activity building condition survey for any buildings predicted to receive vibration levels exceeding the Category A criteria and receiving noise levels towards the Category B criteria.

They would be attached to the CNVMP, providing additional information that would sit alongside the general management and mitigation options within the CNVMP.

11 Recommended specific measures to avoid, remedy or mitigate construction noise and vibration effects

Based on the above, we recommend that common/general best practice mitigation and management should be implemented across all NoRs and this should be documented in the CNVMP. For activities that are predicted to exceed the criteria, a Schedule needs to be prepared.

11.1 Summary of proposed mitigation and management measures

Effect	Assessment	Recommendation
Construction noise	NoRs 1, 2 and 3 traverse well established residential and commercial areas, with buildings in close proximity to construction works. NoR 4a and 4b traverses currently generally greenfield sites (some zoned FUZ). Largest effects anticipated from: demolition of first row houses in NoR 2 and 3, and some of NoR 1 – limited duration and localised, but very close to houses earthworks to prepare alignment, service relocations – longer duration but moving along the alignment bridge piling and installation in NoR 4b, 2/3 – limited duration and localised effects only, but night/weekend works likely required Final surfacing – likely to be done at night-time. Limited duration.	Management and mitigation through the CNVMP Schedules for any specifically noisy activities or where receivers are particularly affected, e.g.: • Any night-time works in all NoRs in the vicinity of residential areas; and • Any specifically high noise works where they affect sensitive receivers. Communication and consultation prior to high noise works
Construction vibration	NoRs 1, 2 and 3 traverse well established residential and commercial areas, with buildings in close proximity to construction works. There are no close buildings in NoR 4a and 4b. Largest effects anticipated from: demolition of first row houses in NoR 2 and 3, and some of NoR 1 – limited duration and localised, but very close to houses. Road preparation: use of vibratory rollers – along entire alignment, therefore limited duration but affecting all immediately fronting houses Construction of bridge piles and retaining walls	Management and mitigation through the CNVMP Schedules for any specifically vibration inducing activities or where receivers are particularly affected, e.g.: • Piling; • Demolition of existing driveways and structures close to other houses; and • Vibratory rolling (if to be undertaken at night-time). Choice of piling methodology to be bored rather than impact or vibrated Use of non-vibratory compaction close to buildings Building condition surveys

11.2 Specific management measures

There are a small number of construction activities that should be addressed specifically in relation to noise and vibration generation. Those are discussed below:

- NoR 2: night-time bridge construction across SH1. Consider offer of temporary relocation to most affected residents to manage sleep disturbance, depending on duration and noise level;
- NoR 2: works in the vicinity of MIT and AUT South Campus. Consult with the educational facilities and schedule works to avoid exams or other sensitive times;
- NoR 3: night-time and/or long weekend bridge construction across Puhinui Station and rail line. Consider offer of temporary relocation to most affected residents to manage sleep disturbance, depending on duration and noise level;
- NoR 3: works close to Puhinui School. Consult with school and schedule works to avoid exams or other sensitive times. Potentially offer noise barrier (to be retained following construction) to mitigate traffic noise to the sports fields; and
- NoRs 4a and 4b: works close to Manukau Memorial Garden. Consult with operator and schedule works to avoid services or other sensitive times.

12 Conclusions

An assessment of construction noise and vibration effects was prepared for the Project based on indicative information available at the NoR stage. The assessment will need to be updated in the future during detailed design considering the receivers as they exist at the time of construction and the confirmed construction methodology.

Assessment across all NoRs indicates exceedances of the noise and vibration criteria for residential and commercial receivers where works are close to buildings, and where large structures such as bridges are required. Exceedances are also predicted for any night-time works such as where bridges are constructed across SH20, SH1 and the rail line at Puhinui Station.

Mitigation measures are required to manage effects on receivers in the vicinity of the Project. Common measures have been recommended, such as the use of barriers, communication and consultation with affected receivers, appropriate choice of equipment and timing of works. All of these measures will be included in the CNVMP, with the details responding to the detailed design works and equipment to be used, and the receiving environment how it exists at the time of construction.

I have recommended that a CNVMP is prepared for all NoRs as this is the most effective way to manage construction noise and vibration effects on sensitive receivers with the necessary agility and responsiveness required by large construction projects. Where further exceedances are predicted or determined throughout the construction phase, schedules will be prepared. Schedules are mini-CNVMPs that respond to a specific activity or area and set out detailed measures for that activity or area. Any schedules would be attached to the CNVMP.

NoR specific recommendations are set out below.

12.1 NoR 1

NoR 1 will be constructed in the central median of Te Irirangi Drive, which has already made allowances for future rapid transit. Therefore, works will be well contained and away from dwellings and commercial buildings.

We expect daytime construction noise to generally comply with the limits, with potential minor exceedances up to 3 dB for some houses that are slightly closer to the works. Overall, we consider the construction noise effects to be reasonable. Construction vibration may exceed the amenity criterion for some buildings by a small margin. However, such exceedances would be limited in duration and magnitude and can be managed through communication with affected parties.

We recommend that a CNVMP is prepared and implemented throughout construction, and that, for specific activities such as night-time works, a schedule is prepared.

Overall, the construction noise and vibration impact of NoR 1 is relatively benign and unlikely to cause significant adverse effects.

12.2 NoR 2

12.2.1 Section A

Section A of NoR 2 extends through established residential areas with mainly single and double storey dwellings. This area may be redeveloped as several sections are owned by Kāinga Ora. The NPS:UD allows for significantly higher density dwellings for all sites adjacent to the alignment with a move from low density residential zones to Terraced Housing and Apartment buildings. If these changes have occurred by the time the Project is constructed, any buildings existing and occupied at the time of construction will need to be assessed and construction noise and vibration effects managed.

We predict that general compliance can be achieved at the majority of houses. The exceptions are demolition of existing houses, where neighbouring dwellings may receive elevated noise levels for a few hours when main demolition occurs, general earthworks where a limited number of dwellings is predicted to receive noise levels up to 73 dB L_{Aeq} and potentially bridge works across SH1, which may need to occur at night time.

Vibration levels are predicted to comply with the 5 mm/s PPV limits at all times. However, the amenity criterion may be exceeded for dwellings when vibratory rollers are used to compact the new traffic lanes.

We recommend that a CNVMP is prepared and implemented throughout construction, and that, for specific activities such as night-time works, a schedule is prepared.

Overall, the construction noise and vibration impact of Section A of NoR 2 is reasonable and manageable and unlikely to cause significant adverse effects.

12.2.2 Section B

Section B of NoR 2 traverses the Manukau City Centre. Generally, no building demolition will be required as there is sufficient space within the existing road and open space to construct the bus lanes.

Most of this Section is within the HANA with the remainder in the MANA. This means that buildings are likely to already incorporate sound insulation and ventilation in the building envelope, which will also mitigate construction noise.

Most activities are predicted to comply with the daytime noise limits at all buildings, with only a small number of buildings predicted to receive noise levels up to 76 dB L_{Aeq} for times when works are closest. Such noise levels would result in internal noise levels of generally less than 40 dB L_{Aeq} in this area, which are appropriate internal daytime noise levels for residential and commercial use.

Vibration levels can be managed by choosing non-vibratory compaction within 15m of buildings and choosing bored piling for retaining walls and bridge supports as well as good communication with affected parties. Some buildings at the AUT South Campus and Countdown may be close to proposed retaining walls leading to the SH1 bridge. Where buildings are within 20m of retaining or bridge piling, we recommend that bored piling is used instead of impact or vibratory piling, to ensure compliance with the 5 mm/s PPV limit.

We recommend that a CNVMP is prepared and implemented throughout construction, and that, for specific activities such as night-time works, a schedule is prepared.

Overall, the construction noise and vibration impact of Section B of NoR 2 is reasonable and manageable and unlikely to cause significant adverse effects.

12.2.3 Section C

Section C of NoR 2 will be constructed by demolishing a number of dwellings adjacent to Puhinui Road to create the space for the BRT. Removing buildings which provided shielding to those buildings behind, means that the second row will be more affected by the works.

Highest noise levels are anticipated from the demolition of buildings in close proximity to other buildings, and from earthworks necessary to prepare the new traffic lanes. Highest vibration levels are anticipated from the use of vibratory rollers for the compaction of the new lanes.

We expect daytime construction noise to generally comply with the limits, with potential minor exceedances up to 3-5 dB for some houses that are slightly closer to the works. Demolition works may result in exceedances of up to 10 dB for individual houses, for some hours or days at most. Overall, we consider the construction noise effects to be reasonable. Construction vibration may exceed the amenity criterion for some buildings by a small margin. However, such exceedances would be limited in duration and magnitude and can be managed through communication with affected parties.

Vibration levels can be managed by choosing non-vibratory compaction within 15m of buildings and good communication with affected parties.

We recommend that a CNVMP is prepared and implemented throughout construction, and that, for specific activities such as night-time works, a schedule is prepared.

Overall, the construction noise and vibration impact of Section C of NoR 2 is reasonable and manageable and unlikely to cause significant adverse effects.

12.3 NoR 3

NoR 3 traverses an established residential area, with some commercial premises to the south of the road. All of the neighbouring sites are either in the HANA or MANA, which means that new noise sensitive activities cannot be established in the HANA, and in the MANA sound insulation and ventilation will be required for any new dwellings. This means that our assessment assumes that dwellings are already somewhat protected from construction noise.

We predict that general compliance with the relevant noise limits can be achieved at the majority of houses. The exceptions are demolition of existing houses, where neighbouring dwellings may receive elevated noise levels for a few hours when main demolition occurs, general earthworks where a limited number of dwellings is predicted to receive noise levels up to 77 dB L_{Aeq} and potentially bridge works at Puhinui Station, which may need to occur at night-time.

Vibration levels are predicted to comply with the 5 mm/s PPV limits at all but 5 buildings. There, compliance can be achieved by using non-vibratory compaction and bored piles rather than impact or vibrated piling. However, the amenity criterion may be exceeded for dwellings when vibratory rollers are used to compact the new traffic lanes.

We recommend that a CNVMP is prepared and implemented throughout construction, and that, for specific activities such as night-time works, a schedule is prepared.

Overall, the construction noise and vibration impact of NoR 3 is reasonable and manageable and unlikely to cause significant adverse effects.

12.4 NoRs 4a and 4b

NoRs 4a and 4b will be constructed in a currently little developed area with the exception of the SUP and ramp at SH20. Therefore, works will be well contained and generally away from buildings.

We expect daytime construction noise to generally comply with the limits, with potential minor exceedances up to 3 dB for some houses that are slightly closer to the works. Night-time works will need to be managed in the vicinity of bridge works. Overall, we consider the construction noise effects to be reasonable.

Construction vibration may exceed the amenity criterion for some buildings by a small margin. However, such exceedances would be limited in duration and magnitude and can be managed through communication with affected parties.

We recommend that a CNVMP is prepared and implemented throughout construction, and that, for specific activities such as night-time works, a schedule is prepared.

Overall, the construction noise and vibration impact of NoRs 4a and 4b is slight and unlikely to cause significant adverse effects.

TE TUPU NGĀTAHI
SUPPORTING GROWTH

Appendix A

Noise compliance envelope

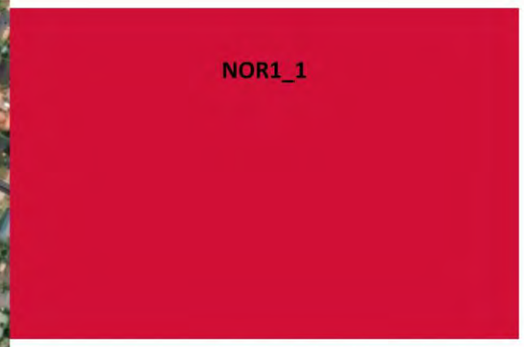
WAKA KOTAHI
NZ TRANSPORT AGENCY

New Zealand Government

Appendix A – Noise compliance envelope

NoR 1


CONSTRUCTION NOISE
Ra Ora Dr
Neilpark Dr
Cryers Rd
Kerwyn Ave
Otara Creek Reserve
Otara Creek Reserve
Mayfield Park
Ferguson Rd
East Tamaki Rd
Johnstones Rd
Pearl Baker Reserve
Zelanian Dr
Allens Rd
Crooks Rd
Neales Rd
Cryers Rd
Kudu Rd
East Tamaki War Memorial Park
Springs Rd
Springs Rd
East Tamaki arris Rd
Collett Rd
Preston Road Reserve
Jarvis Way
Ormiston Rd
East Tamaki Rd
Hampton Park
Smales Rd
Greenmount Dr
Accent Dr
Redcastle Dr
Kelvin Hart Dr
Big Swing Golf
Te Irirangi Dr
Te Irirangi Dr
Te Irirangi Dr
Te Irirangi Dr
30
Accent Dr
Wayne Francis Dr
Chapel Rd
Flat Bush
Chapel Heights
Chapel Rd
Chapel Rd
East Tamaki Heights
Cyrill French Dr
Bronwylian Dr
Middlefield
MacNean Dr
Kilkenny Dr
Broadhurst Rd
Flat Bush School Rd
Barry Curtis Park
Ormiston Rd
Stancombe Rd
Baverstock Rd
Lansell Dr
Point View Dr
Moyrus Cres
Unney Dr
Riviera Dr
Hughs Way
Clady Dr
Flat Bush School R
Kerrykeo
Gracechurch Dr
Point View Dr
Calmuir R
0 95 190 380 570 760 950 1,140 1,330
Meters
NOR1 OVERALL
Construction Noise
≤ 70 dB LAeq (24h)
≥ 70 dB LAeq (24h)
Building to be removed
Project Roads
Project Bus Lane
Bairds Rd
Preston Rd
Harris Rd
30
Chapel Heights
East Tamaki Heights
Client:
Map
Authors:
owen.li
Date of Issue:
28/11/2022 3:08 pm
Drawing Details:
Scale: 1:15,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -75.650668°
Map Notes / Comments:



Construction Noise

- ≤ 70 dB $L_{Aeq\ (24h)}$
- ≥ 70 dB $L_{Aeq\ (24h)}$
- Building to be removed
- Project Roads
- Project Bus Lane

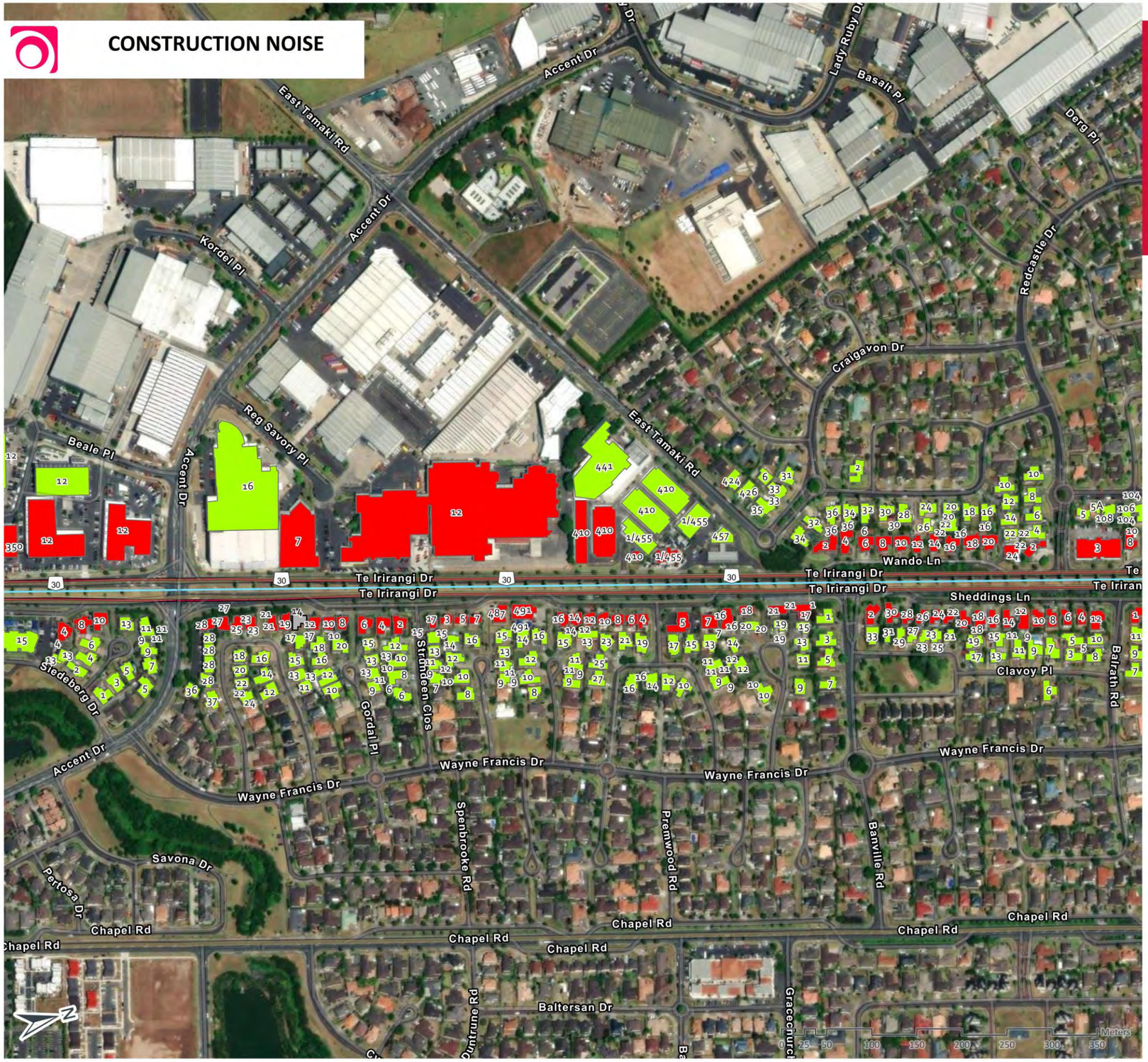
Client:
Map

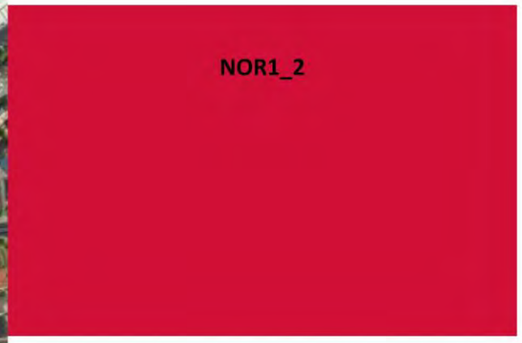
Authors:
owen.li

Date of Issue:
28/11/2022 3:08 pm

Drawing Details:
Scale: 1:4,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -75.650668°

Map Notes / Comments:
This map is for graphical purposes only. While every eff ort has been made to ensure that the data are accurate and reliable, Marshall Day Acoust cs cannot assume liability for errors or omissions in the data graphically represented.
The noise contours were obtained by interpolat ons of calculated grid points (spacing typically 5-25m), with varying interpolat on accuracy. Precise noise levels at specif c locat ons, can be made available at request if not included in the projects point receiver calculat ons.





Construction Noise

- ≤ 70 dB $L_{Aeq\ (24h)}$
- ≥ 70 dB $L_{Aeq\ (24h)}$
- Building to be removed
- Project Roads
- Project Bus Lane

Client:
Map

Authors:
owen.li

Date of Issue:
25/11/2022 4:24 pm

Drawing Details:
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Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -75.650668°

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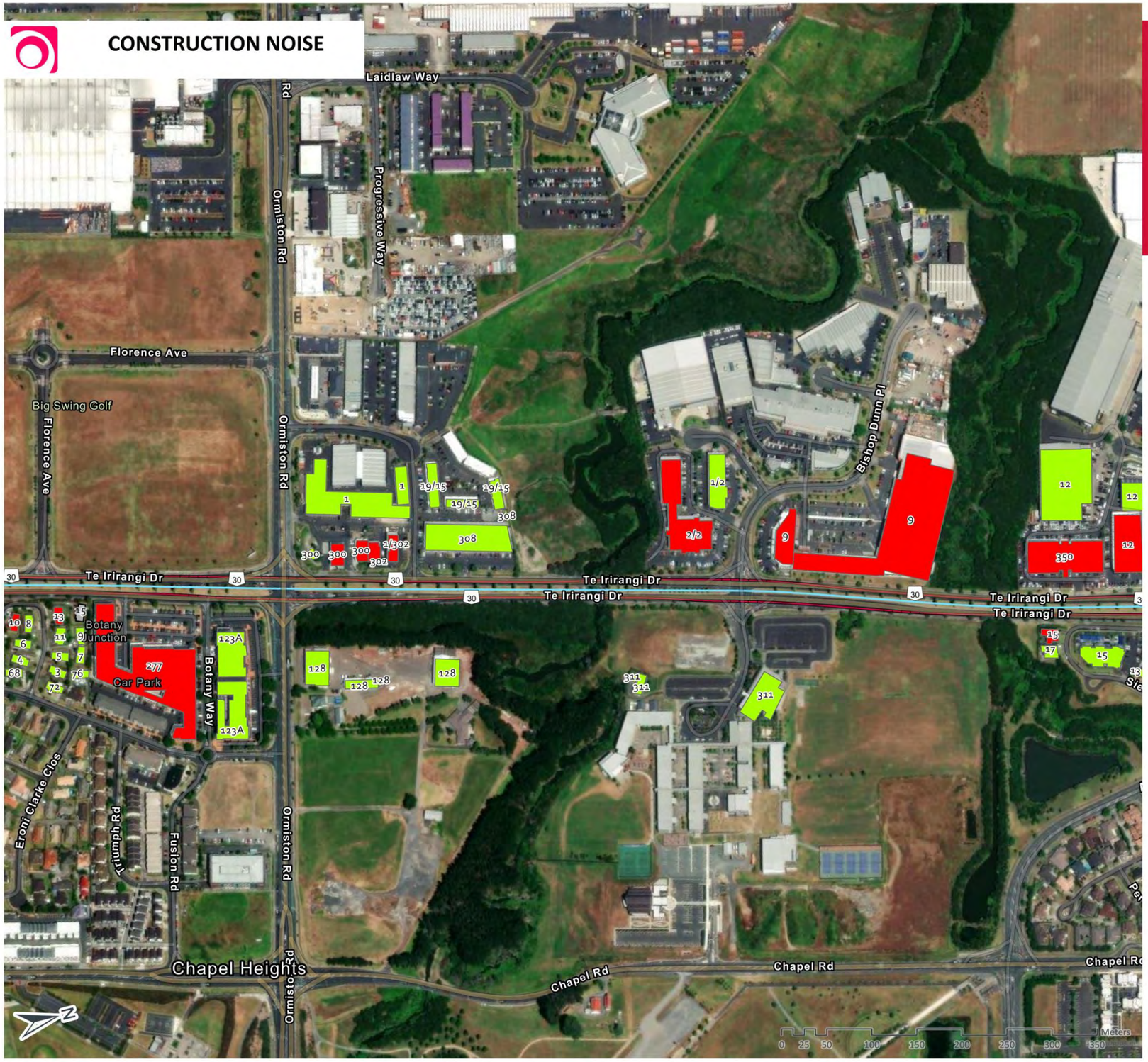
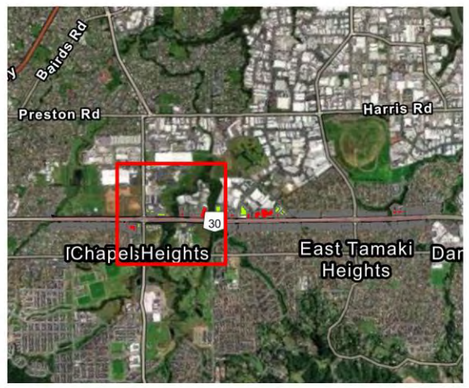


Construction Noise

- ≤ 70 dB $L_{Aeq\ (24h)}$
- ≥ 70 dB $L_{Aeq\ (24h)}$
- Building to be removed
- Project Roads
- Project Bus Lane



Client:
Map

Authors:
owen.li

Date of Issue:
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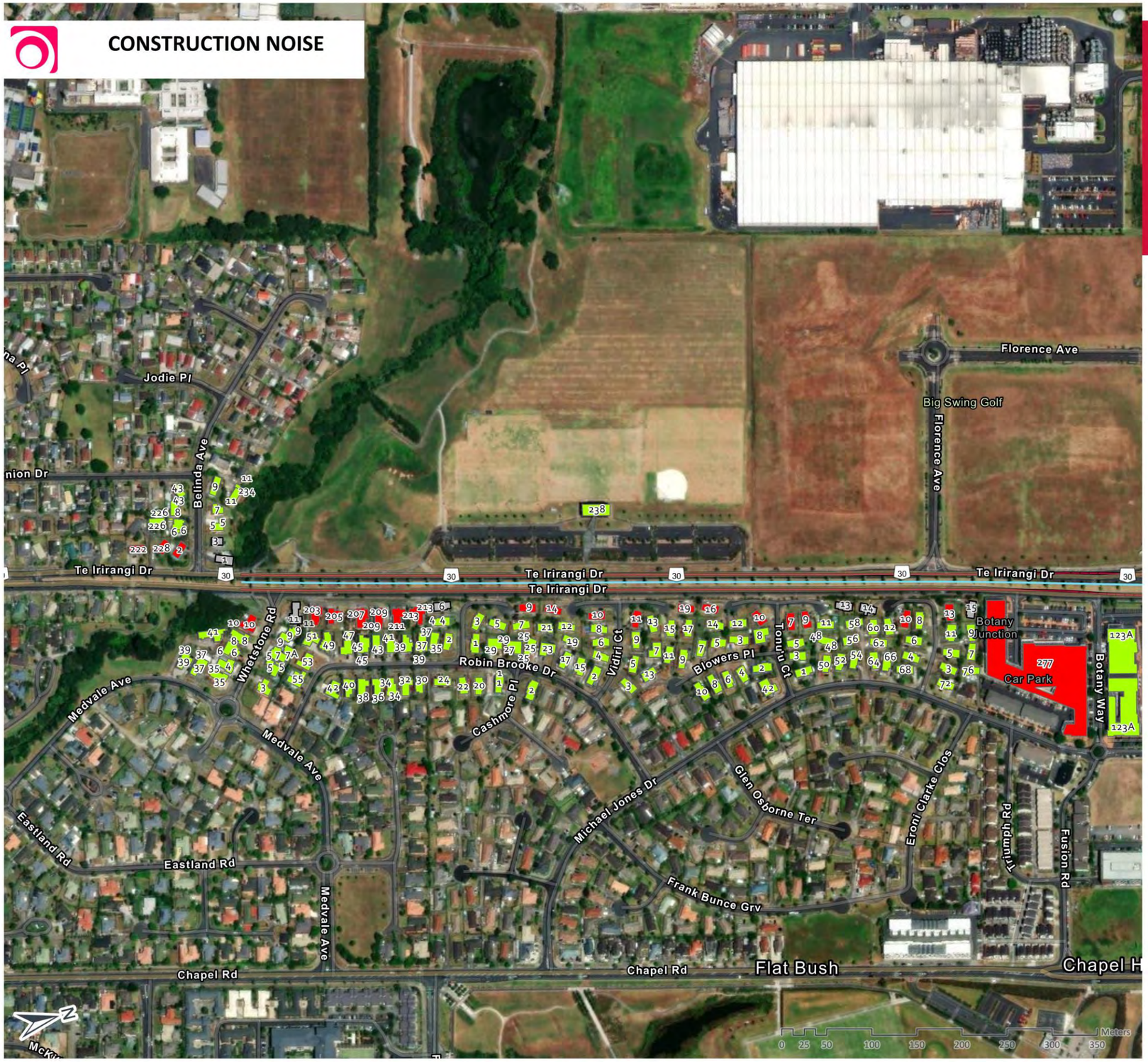

NOR1_4

Construction Noise

- ≤ 70 dB $L_{Aeq\ (24h)}$
- ≥ 70 dB $L_{Aeq\ (24h)}$
- Building to be removed
- Project Roads
- Project Bus Lane

Client:
Map

Authors:
owen.li

Date of Issue:
25/11/2022 4:24 pm

Drawing Details:
Scale: 1:4,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -75.650668°

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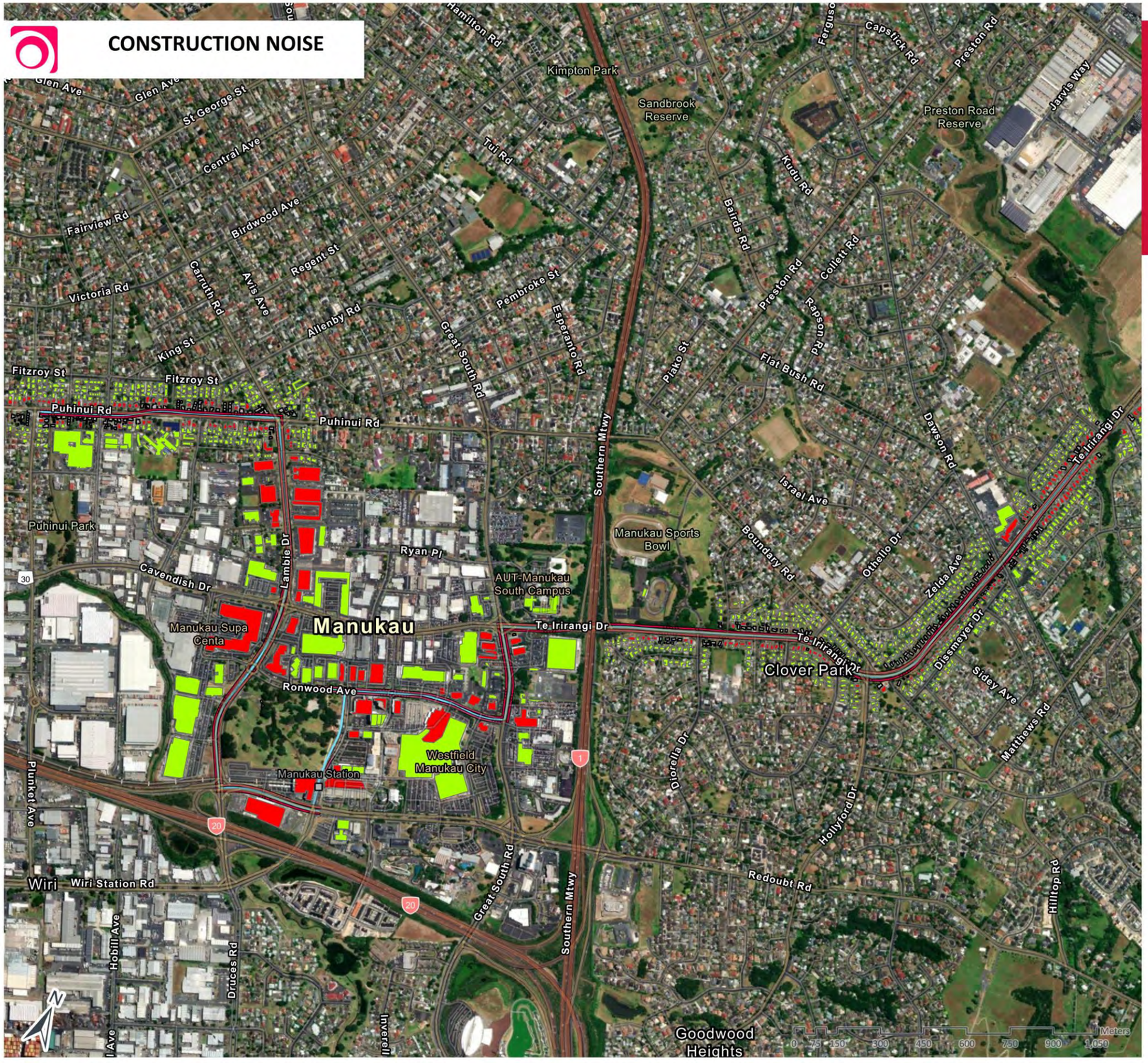
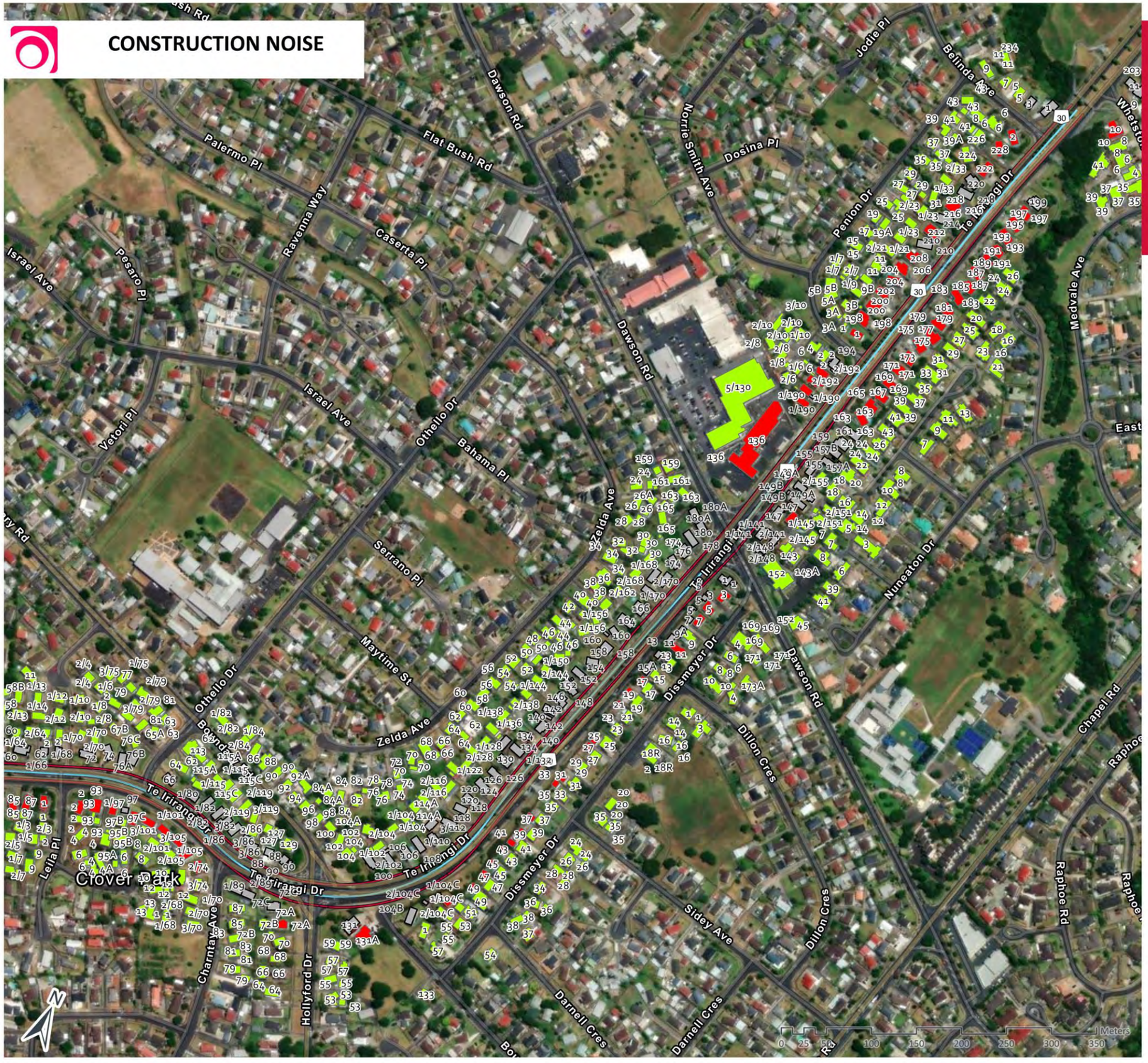
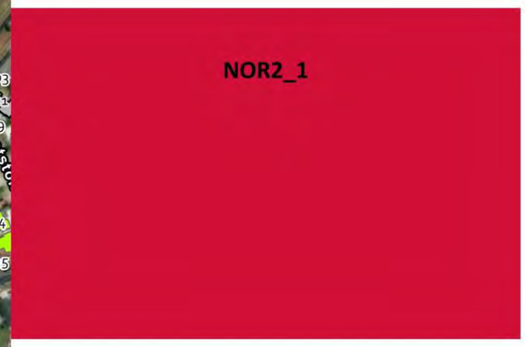
NoR 2


CONSTRUCTION NOISE
Hamilton Rd
Kimpton Park
Sandbrook Reserve
Preston Road Reserve
Jarvis Way
Capstick Rd
Preston Rd
Kudu Rd
Bairds Rd
Collett Rd
Preston Rd
Rapson Rd
Flat Bush Rd
Dawson Rd
Israel Ave
Boundary Rd
Othello Dr
Zelda Ave
Te Irirangi Dr
Dissmeyer Dr
Sidey Ave
Matthews Rd
Clover Park
Glen Ave
St George St
Central Ave
Tui Rd
Fairview Rd
Birdwood Ave
Victoria Rd
Carruth Rd
Avis Ave
Regent St
Allenby Rd
Pembroke St
Esperanto Rd
Great South Rd
King St
Fitzroy St
Puhinui Rd
Southern Mtwy
Plako St
Puhinui Park
Lambie Dr
Ryan Pl
Cavendish Dr
AUT-Manukau South Campus
Manukau Sports Bowl
Manukau Supa Centa
Manukau
Ronwood Ave
Westfield Manukau City
Manukau Station
Plunket Ave
Wiri
Wiri Station Rd
Hobill Ave
Druces Rd
Redoubt Rd
Hilltop Rd
Diorella Dr
Hollyford Dr
Goodwood Heights
Meters
0 75 150 300 450 600 750 900 1,050
NOR2 OVERALL
Construction Noise
≤ 70 dB $L_{Aeq\ (24h)}$
≥ 70 dB $L_{Aeq\ (24h)}$
Building to be removed
Project Roads
Project Bus Lane
Puhinui Rd
Great South Rd
Southern Mtwy
Preston Rd
Cavendish Dr
Clover Park
Client:
Map
Authors:
owen.li
Date of Issue:
25/11/2022 12:17 pm
Drawing Details:
Scale: 1:12,500
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -25.016893°
Map Notes / Comments:
This map is for graphical purposes only. While every effort has been made to ensure that the data are accurate and reliable, Marshall Day Acoust cs cannot assume liability for errors or omissions in the data graphically represented.
The noise contours were obtained by interpolat ons of calculated grid points (spacing typically 5-25m), with varying interpolat on accuracy. Precise noise levels at specif c locat ons, can be made available at request if not included in the projects point receiver calculat ons.





Construction Noise

- ≤ 70 dB $L_{Aeq\ (24h)}$
- ≥ 70 dB $L_{Aeq\ (24h)}$
- Building to be removed
- Project Roads
- Project Bus Lane

Client:
Map

Authors:
owen.li

Date of Issue:
25/11/2022 12:17 pm

Drawing Details:
Scale: 1:4,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -25.016893°

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NOR2_2

Construction Noise

- ≤ 70 dB $L_{Aeq\ (24h)}$
- ≥ 70 dB $L_{Aeq\ (24h)}$
- Building to be removed
- Project Roads
- Project Bus Lane

Client:
Map

Authors:
owen.li

Date of Issue:
25/11/2022 12:17 pm

Drawing Details:
Scale: 1:4,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -25.016893°

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Construction Noise

- ≤ 70 dB $L_{Aeq\ (24h)}$
- ≥ 70 dB $L_{Aeq\ (24h)}$
- Building to be removed
- Project Roads
- Project Bus Lane

Client:
Map

Authors:
owen.li

Date of Issue:
25/11/2022 12:17 pm

Drawing Details:
Scale: 1:4,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -25.016893°

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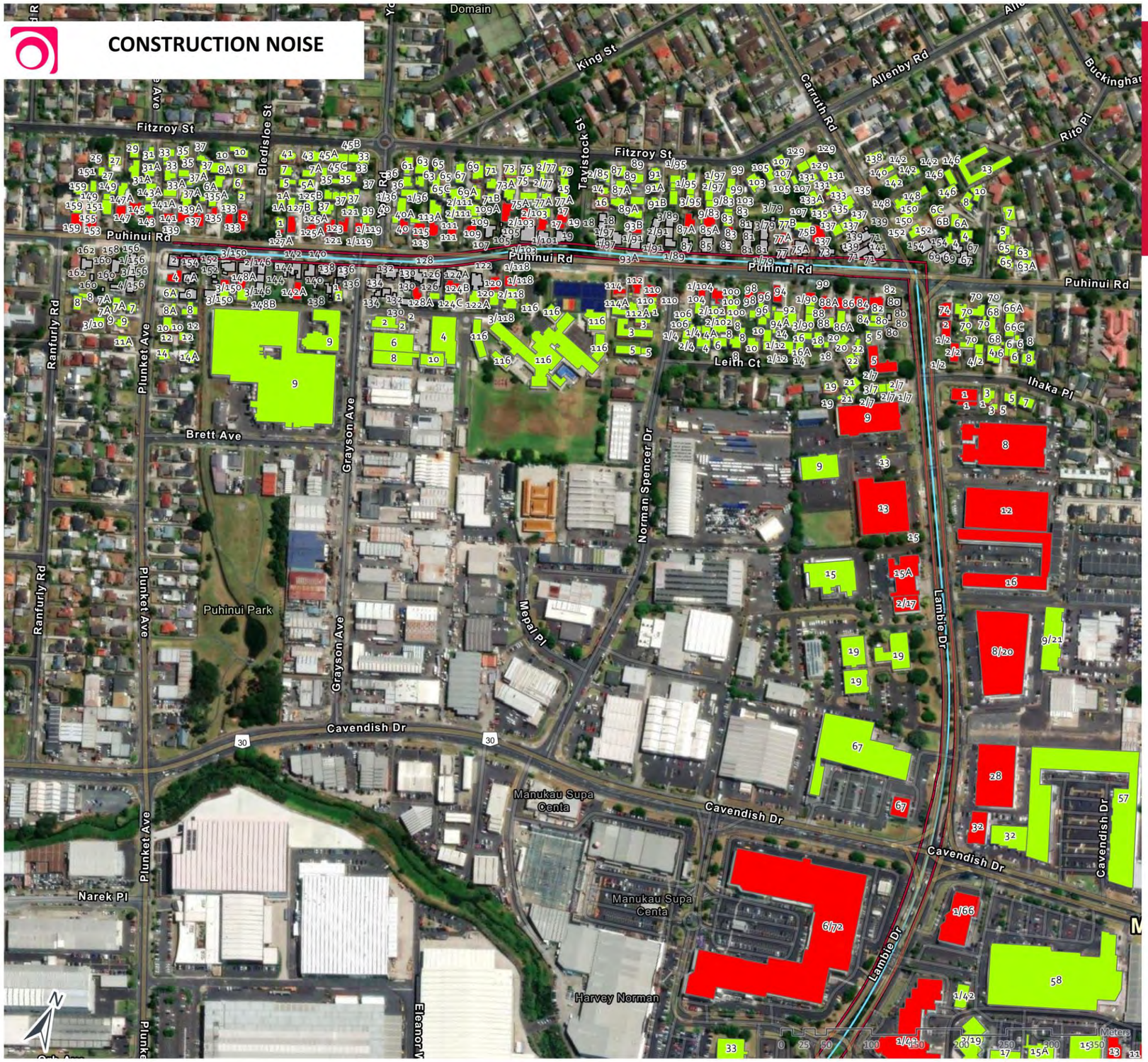
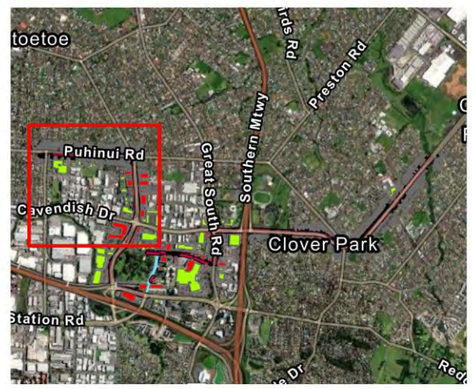


NOR2_4

Construction Noise

- ≤ 70 dB $L_{Aeq\ (24h)}$
- ≥ 70 dB $L_{Aeq\ (24h)}$
- Building to be removed
- Project Roads
- Project Bus Lane



Client:
Map

Authors:
owen.li

Date of Issue:
25/11/2022 12:17 pm

Drawing Details:
Scale: 1:4,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -25.016893°

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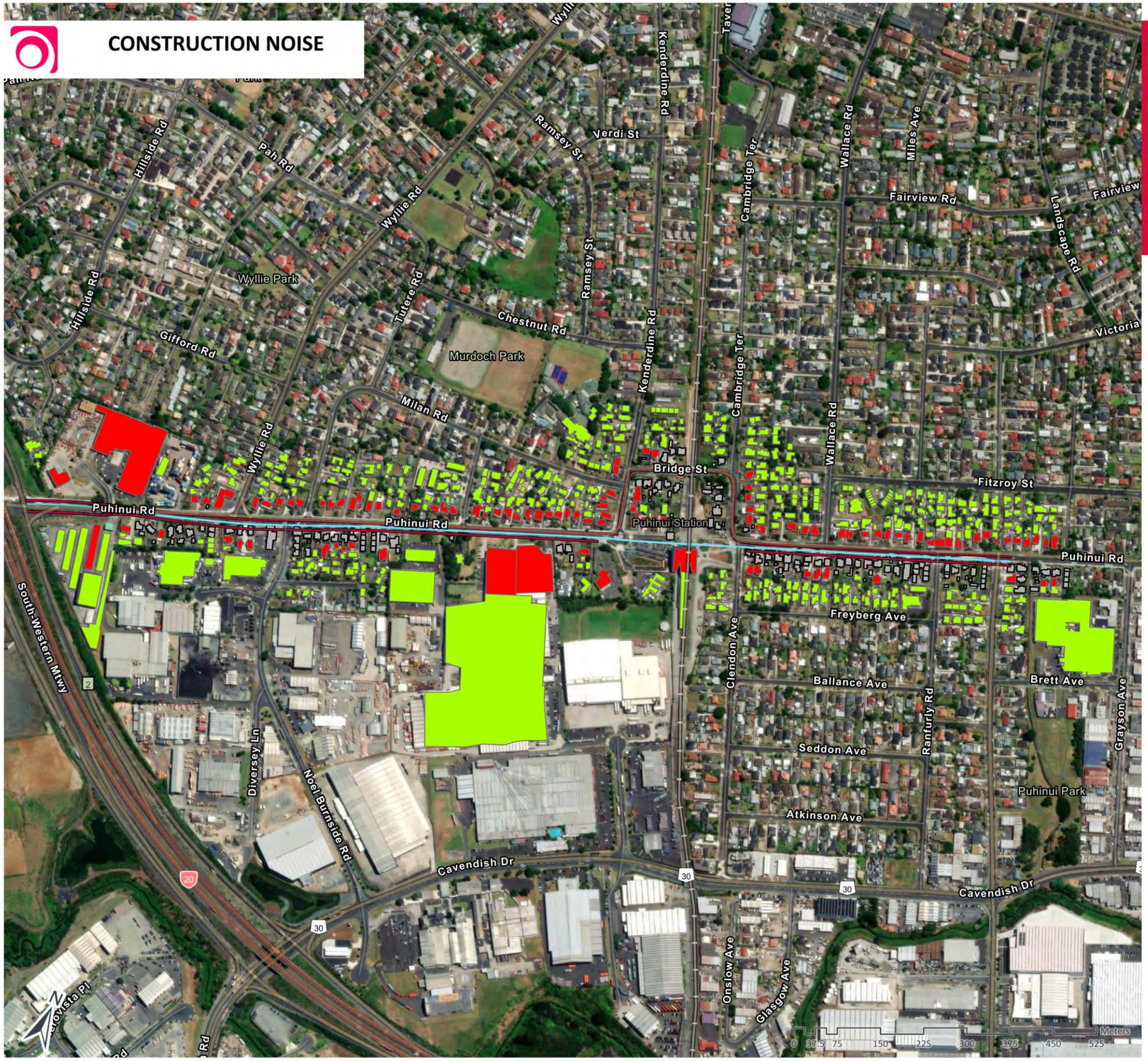
NoR 3



NOR3 OVERALL

Construction Noise

- ≤ 70 dB $L_{Aeq\ (24h)}$
- ≥ 70 dB $L_{Aeq\ (24h)}$
- Building to be removed
- Project Roads
- Project Bus Lane

Client:
Map

Authors:
owen.li

Date of Issue:
25/11/2022 12:17 pm

Drawing Details:
Scale: 1:6,250
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -25.016893°

Map Notes / Comments:
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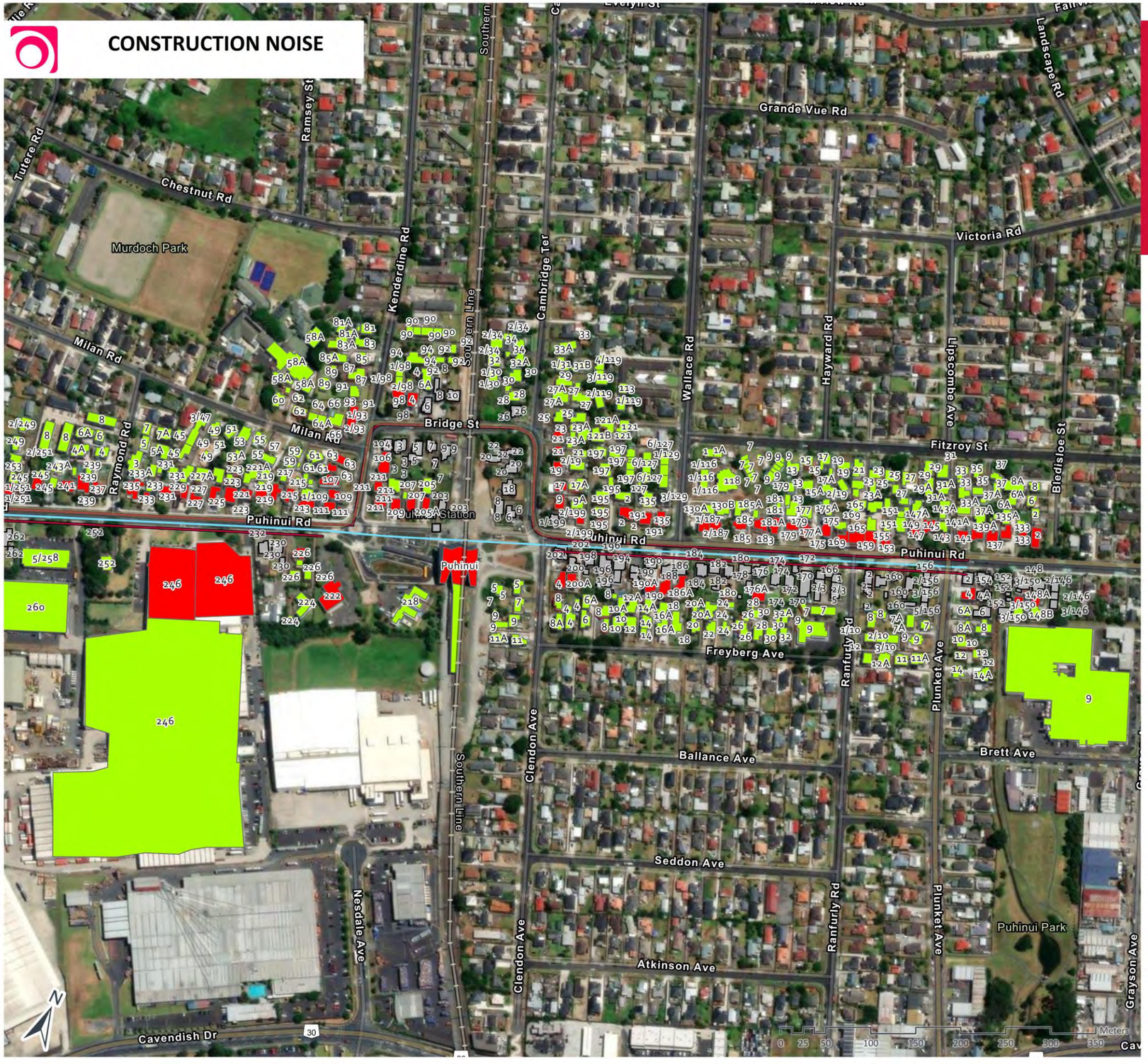
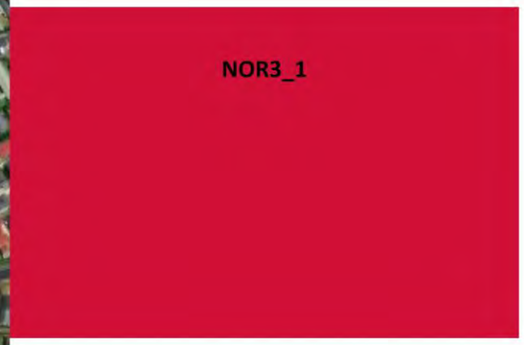
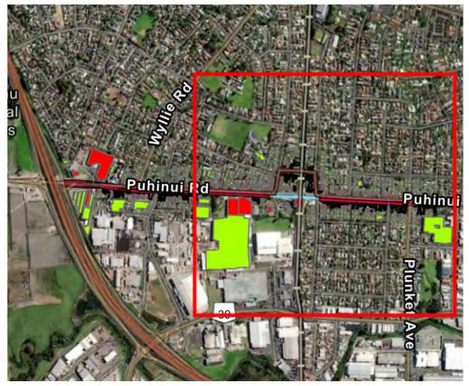




Construction Noise

- ≤ 70 dB $L_{Aeq\ (24h)}$
- ≥ 70 dB $L_{Aeq\ (24h)}$
- Building to be removed
- Project Roads
- Project Bus Lane



Client:
Map

Authors:
owen.li

Date of Issue:
25/11/2022 12:17 pm

Drawing Details:
Scale: 1:4,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -25.016893°

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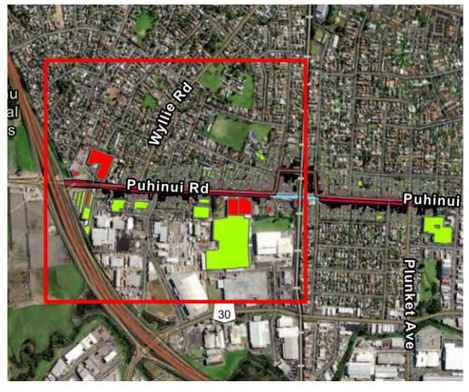
NOR3_2

Construction Noise

- ≤ 70 dB $L_{Aeq\ (24h)}$
- ≥ 70 dB $L_{Aeq\ (24h)}$
- Building to be removed
- Project Roads
- Project Bus Lane



Client:
Map

Authors:
owen.li

Date of Issue:
25/11/2022 12:17 pm

Drawing Details:
Scale: 1:4,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -25.016893°

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NoRs 4a and 4b

NOR4 OVERALL

Construction Noise

- ≤ 70 dB $L_{Aeq\ (24h)}$
- ≥ 70 dB $L_{Aeq\ (24h)}$
- Building to be removed
- Project Roads
- Project Bus Lane

Client:
Map

Authors:
owen.li

Date of Issue:
25/11/2022 12:17 pm

Drawing Details:
Scale: 1:9,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -25.016893°

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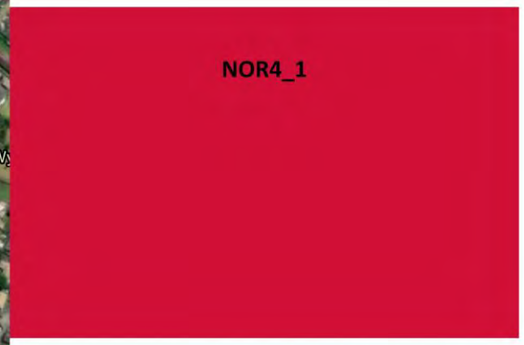

Construction Noise

- ≤ 70 dB $L_{Aeq\ (24h)}$
- ≥ 70 dB $L_{Aeq\ (24h)}$
- Building to be removed
- Project Roads
- Project Bus Lane

Client:
Map

Authors:
owen.li

Date of Issue:
25/11/2022 12:17 pm

Drawing Details:
Scale: 1:4,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -25.016893°

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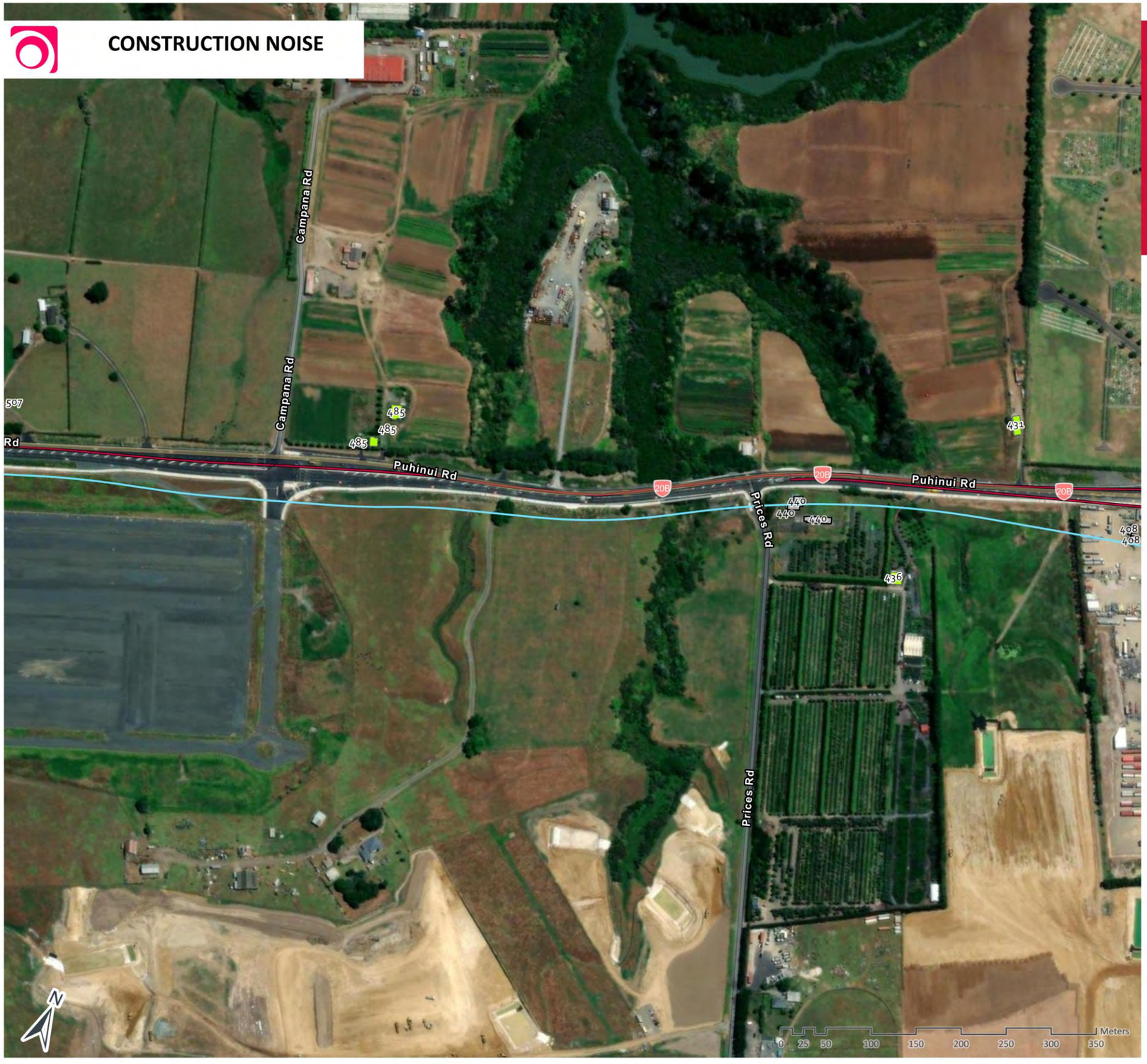

NOR4_2

Construction Noise

- ≤ 70 dB $L_{Aeq\ (24h)}$
- ≥ 70 dB $L_{Aeq\ (24h)}$
- Building to be removed
- Project Roads
- Project Bus Lane

Client:
Map
Authors:
owen.li
Date of Issue:
25/11/2022 12:17 pm

Drawing Details:
Scale: 1:4,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -25.016893°

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NOR4_3

Construction Noise

- ≤ 70 dB $L_{Aeq\ (24h)}$
- ≥ 70 dB $L_{Aeq\ (24h)}$
- Building to be removed
- Project Roads
- Project Bus Lane

Client:
Map

Authors:
owen.li

Date of Issue:
25/11/2022 12:17 pm

Drawing Details:
Scale: 1:4,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -25.016893°

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TE TUPU NGĀTAHI
SUPPORTING GROWTH

Appendix B

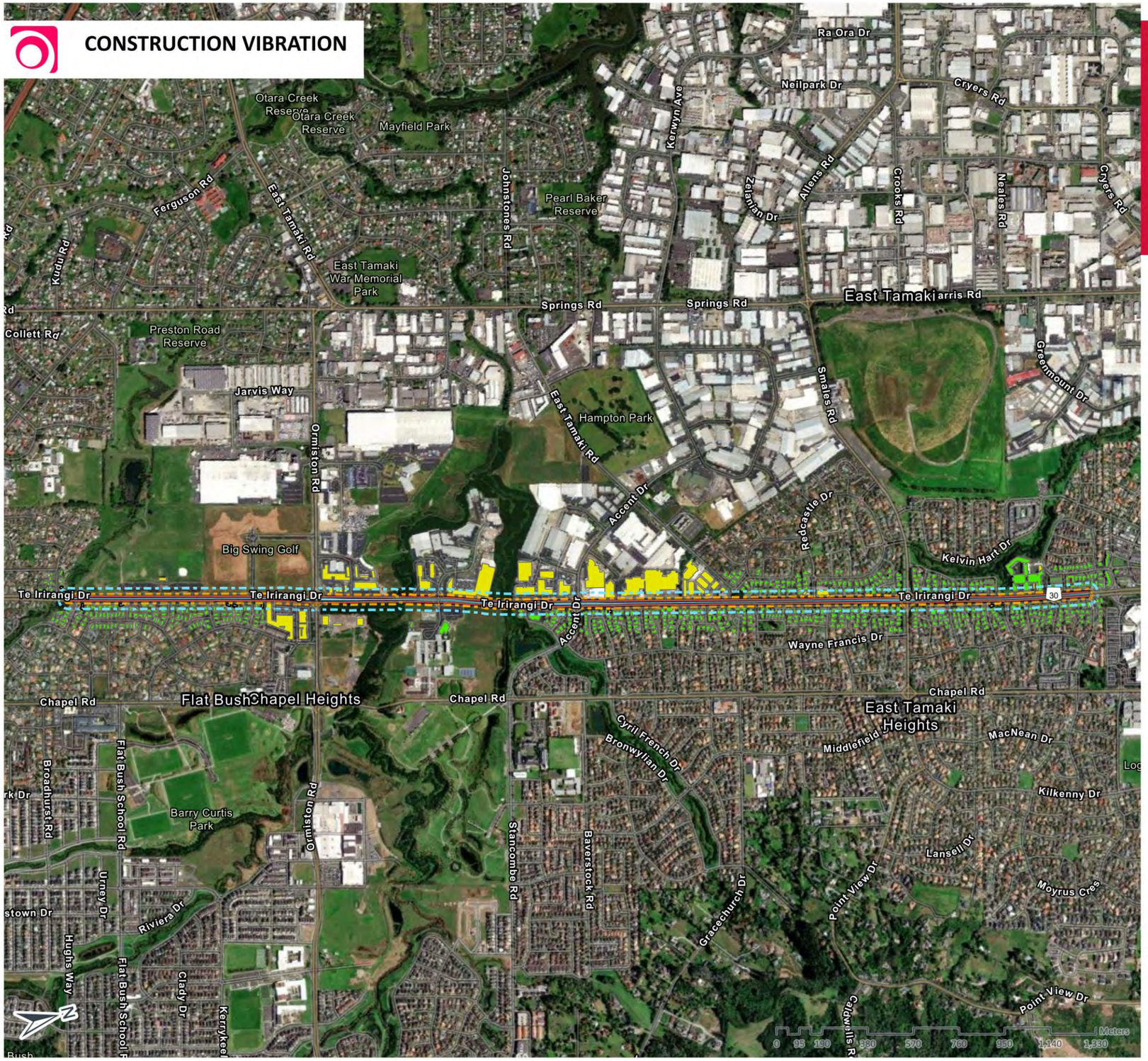
Vibration compliance envelope

WAKA KOTAHI
NZ TRANSPORT AGENCY

New Zealand Government

Appendix B – Vibration compliance envelope

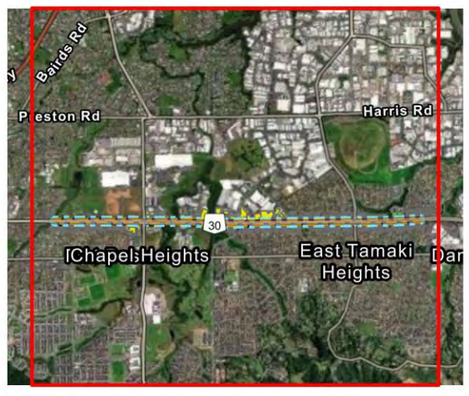
NoR 1



NOR1 OVERALL

Nearby Buildings
- PPF
- Non PPF
- Project Roads
- Project Bus Lane

Vibration level
- 2 mm/s
- 5 mm/s



Client:
Map

Authors:
owen.li

Date of Issue:
28/11/2022 3:08 pm

Drawing Details:
Scale: 1:15,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -75.650668°

Map Notes / Comments:
This map is for graphical purposes only. While every eff ort has been made to ensure that the data are accurate and reliable, Marshall Day Acoust cs cannot assume liability for errors or omissions in the data graphically represented.
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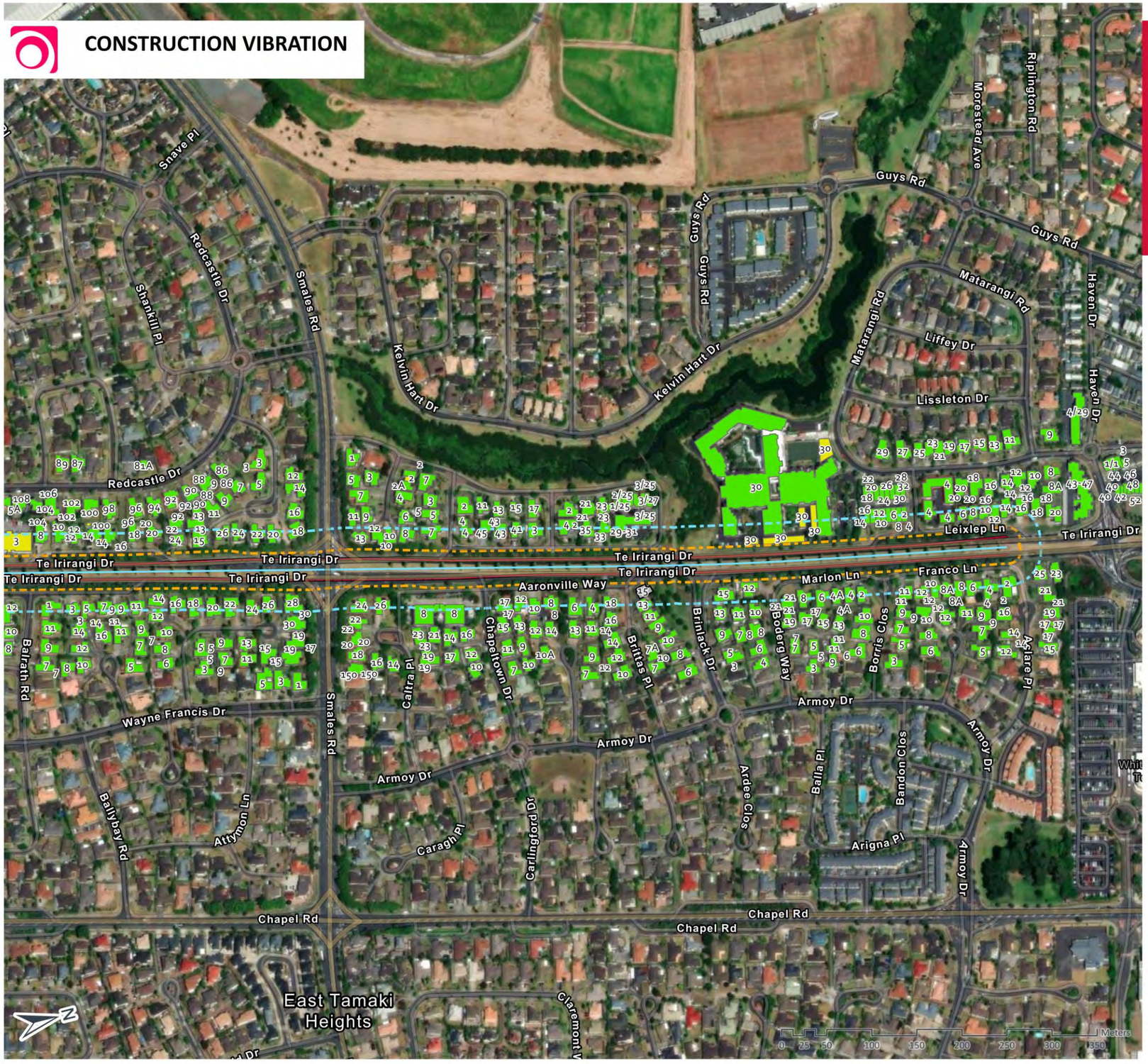

NOR1_1

Nearby Buildings
- PPF
- Non PPF
- Project Roads
- Project Bus Lane

Vibration level
- 2 mm/s
- 5 mm/s

Client:
Map

Authors:
owen.li

Date of Issue:
28/11/2022 3:08 pm

Drawing Details:
Scale: 1:4,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -75.650668°

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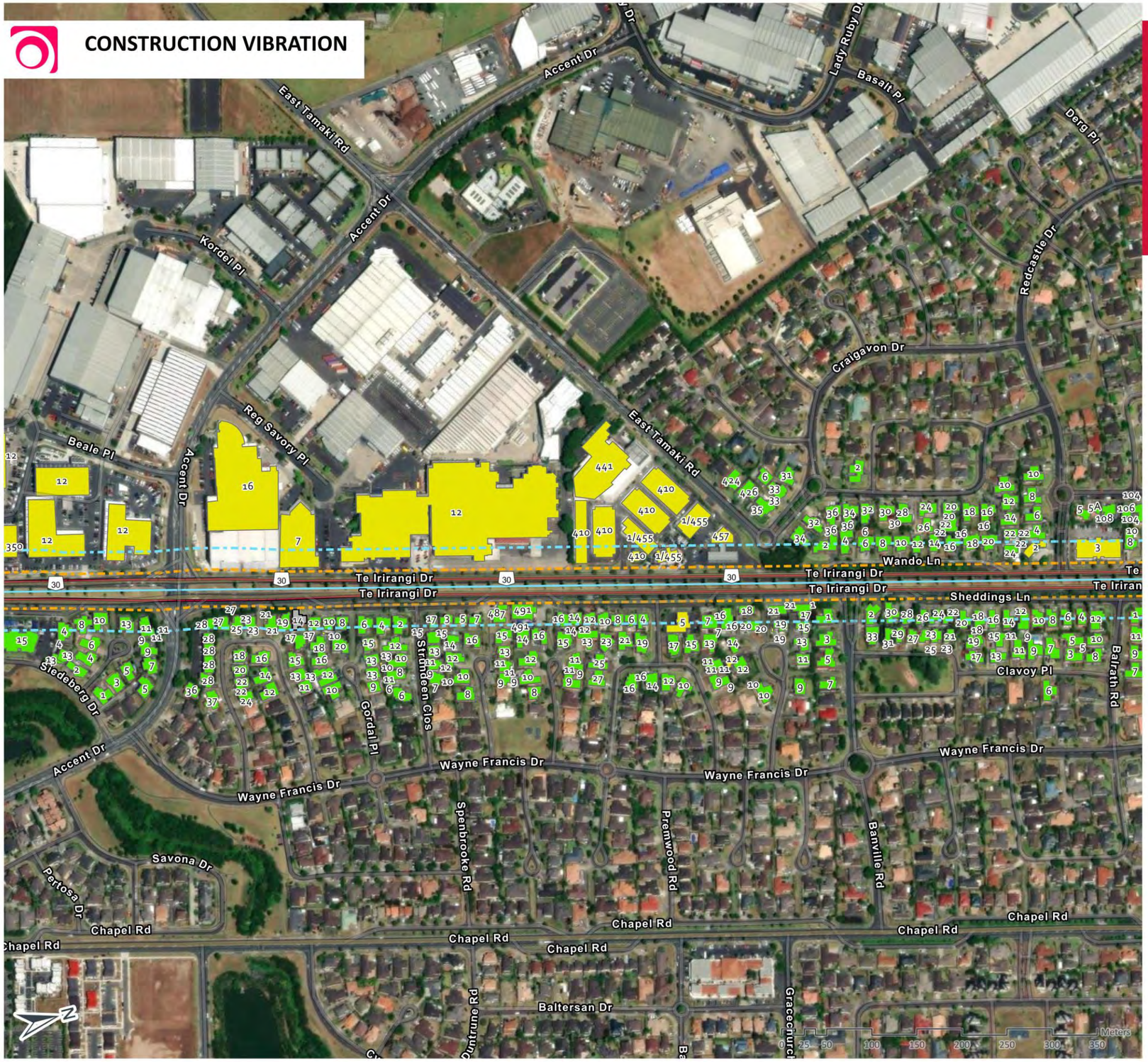

NOR1_2

Nearby Buildings
- PPF
- Non PPF
- Project Roads
- Project Bus Lane

Vibration level
- 2 mm/s
- 5 mm/s

Client:
Map

Authors:
owen.li

Date of Issue:
25/11/2022 4:24 pm

Drawing Details:
Scale: 1:4,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -75.650668°

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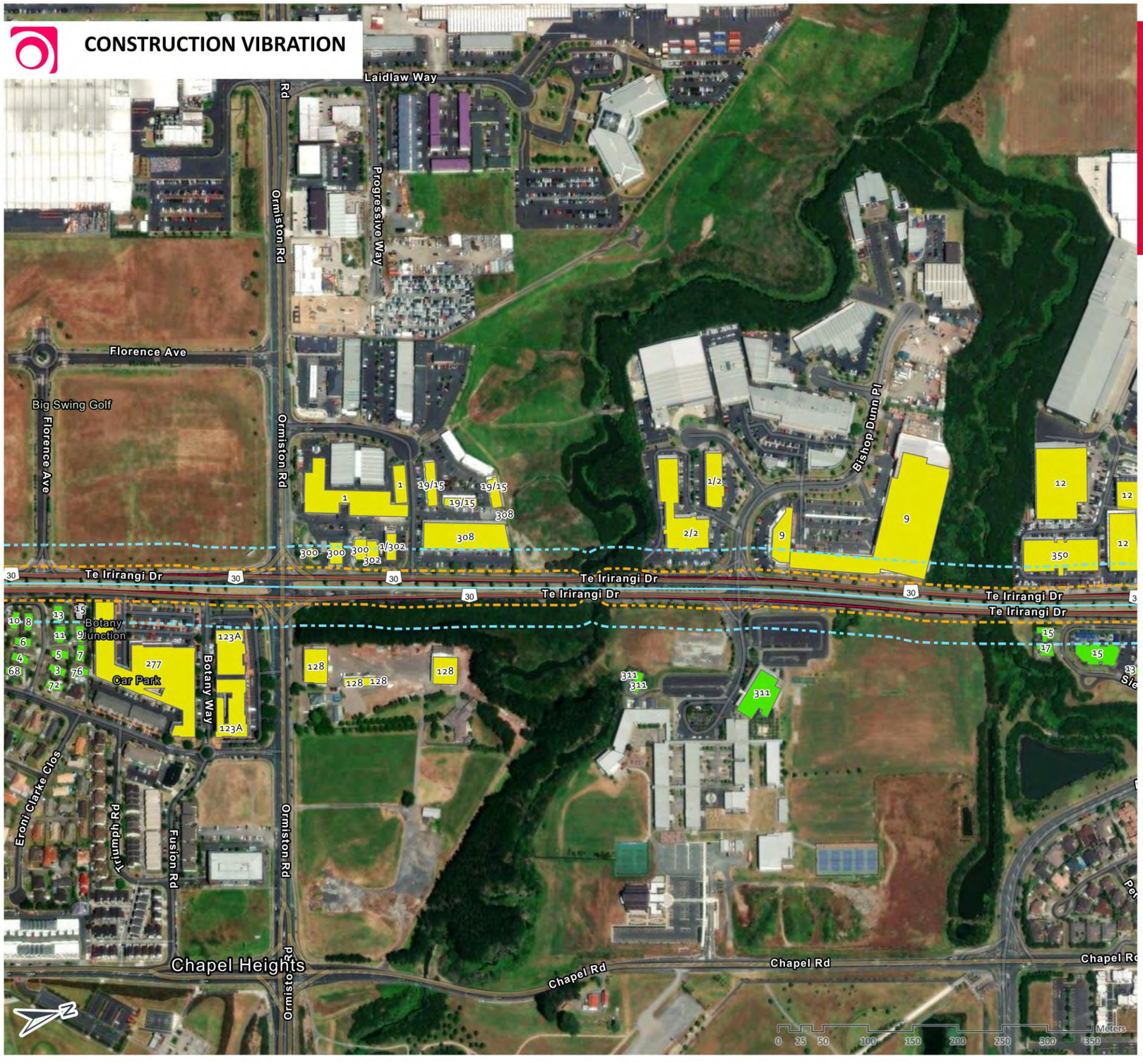
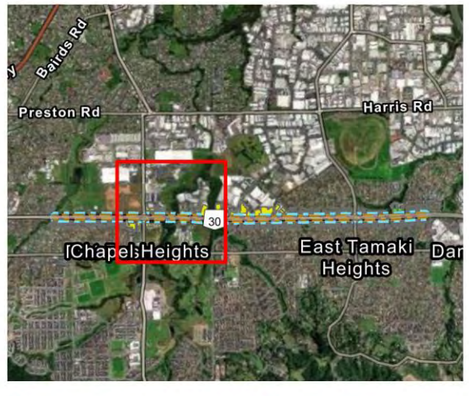


Nearby Buildings
- PPF
- Non PPF
- Project Roads
- Project Bus Lane

Vibration level
- 2 mm/s
- 5 mm/s



Client:
Map

Authors:
owen.li

Date of Issue:
25/11/2022 4:24 pm

Drawing Details:
Scale: 1:4,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -75.650668°

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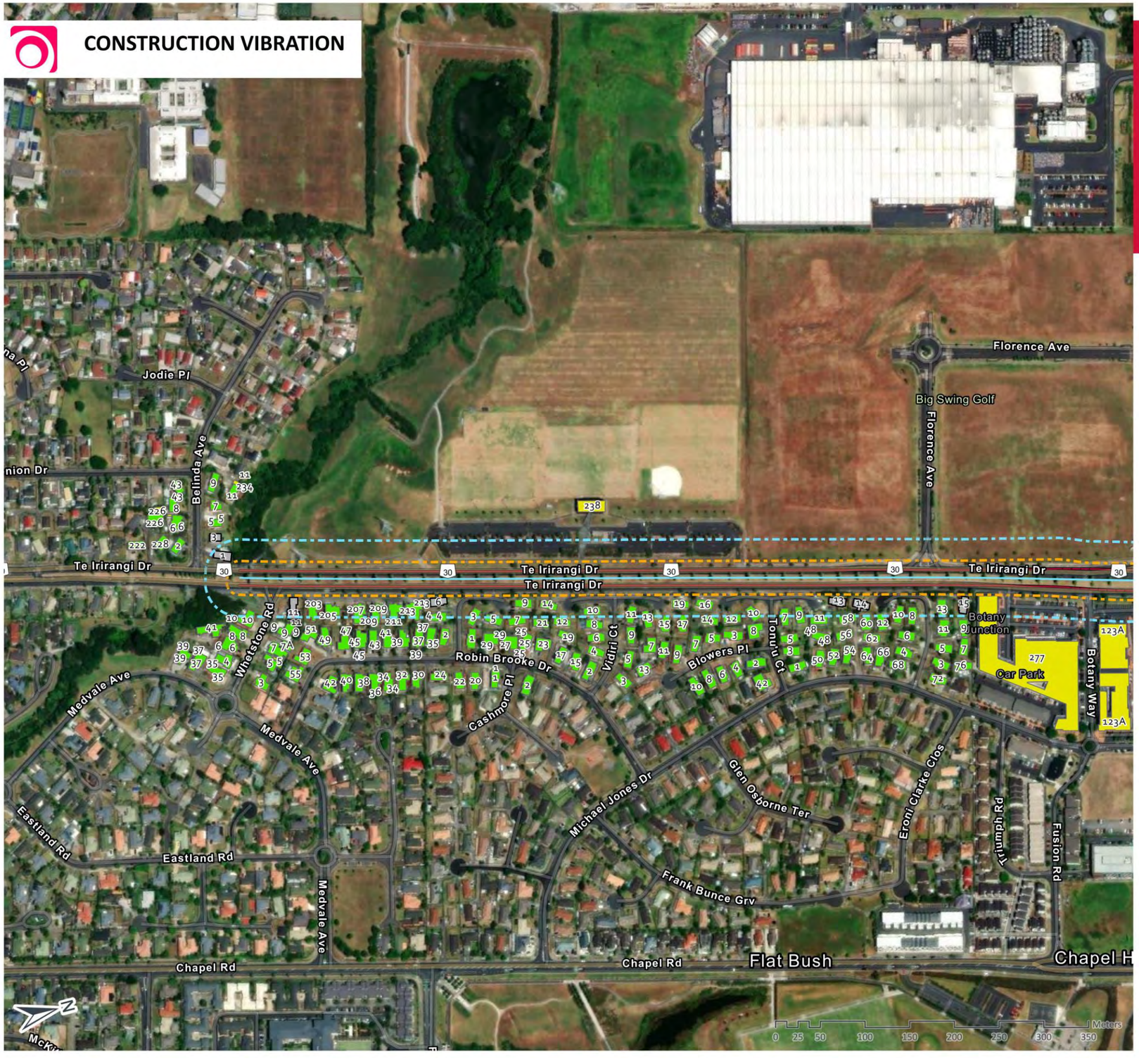

NOR1_4

Nearby Buildings
- PPF
- Non PPF
- Project Roads
- Project Bus Lane

Vibration level
- 2 mm/s
- 5 mm/s

Client:
Map
Authors:
owen.li
Date of Issue:
25/11/2022 4:24 pm

Drawing Details:
Scale: 1:4,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -75.650668°

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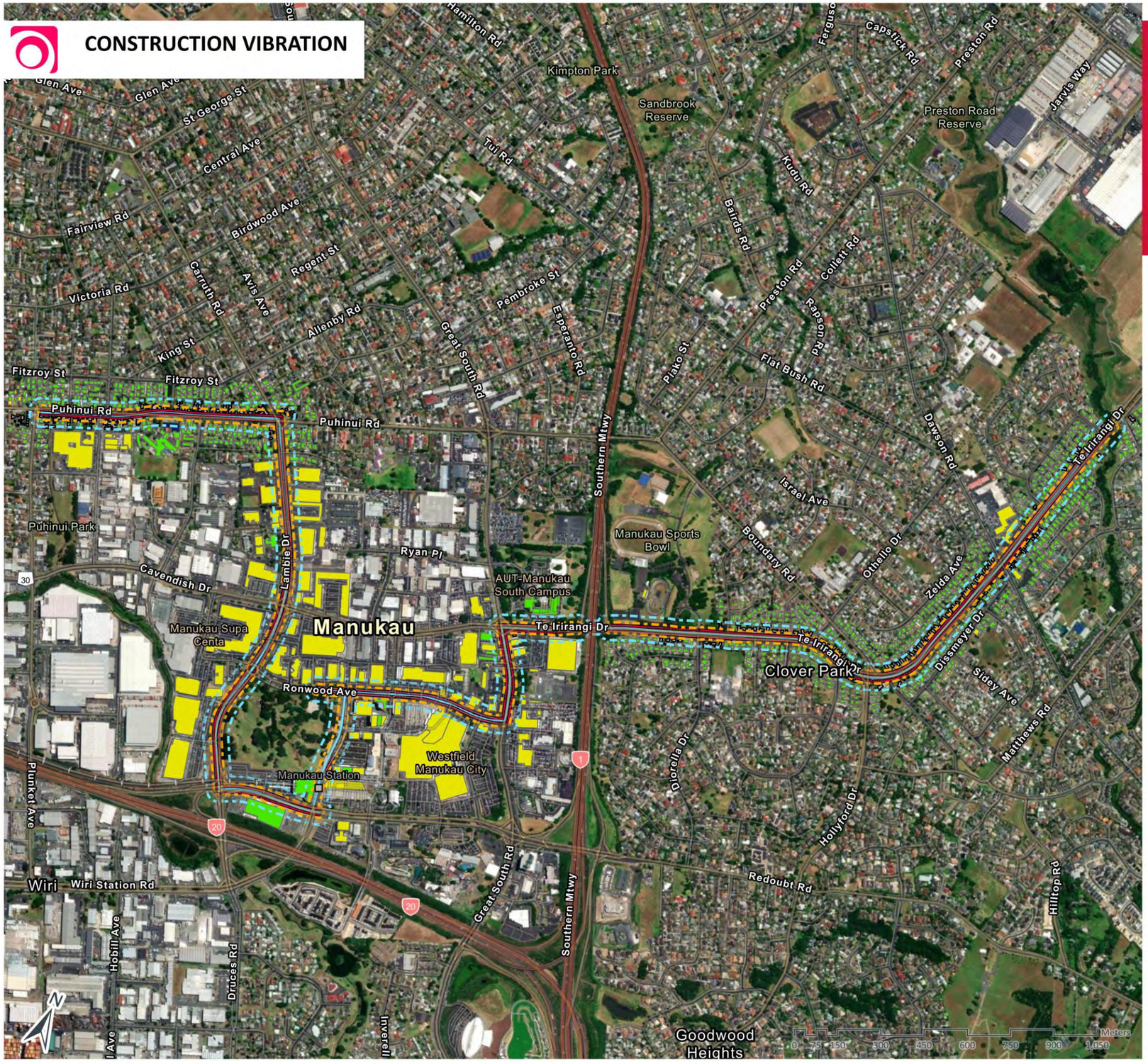
NoR 2



NOR2 OVERALL

Nearby Buildings
- PPF
- Non PPF
- Project Roads
- Project Bus Lane

Vibration level
- 2 mm/s
- 5 mm/s

Client:
Map

Authors:
owen.li

Date of Issue:
25/11/2022 4:24 pm

Drawing Details:
Scale: 1:12,500
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -25.016893°

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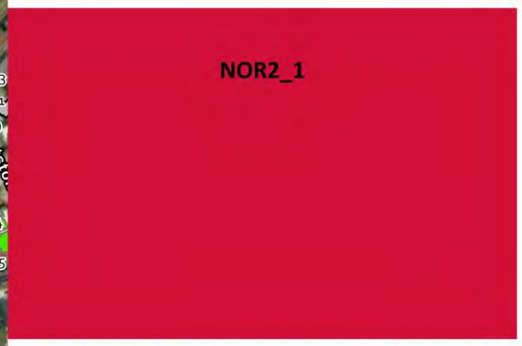

Client:
Map

Authors:
owen.li

Date of Issue:
25/11/2022 4:24 pm

Drawing Details:
Scale: 1:4,000
Project on: NZGD 2000 New Zealand Transverse Mercator
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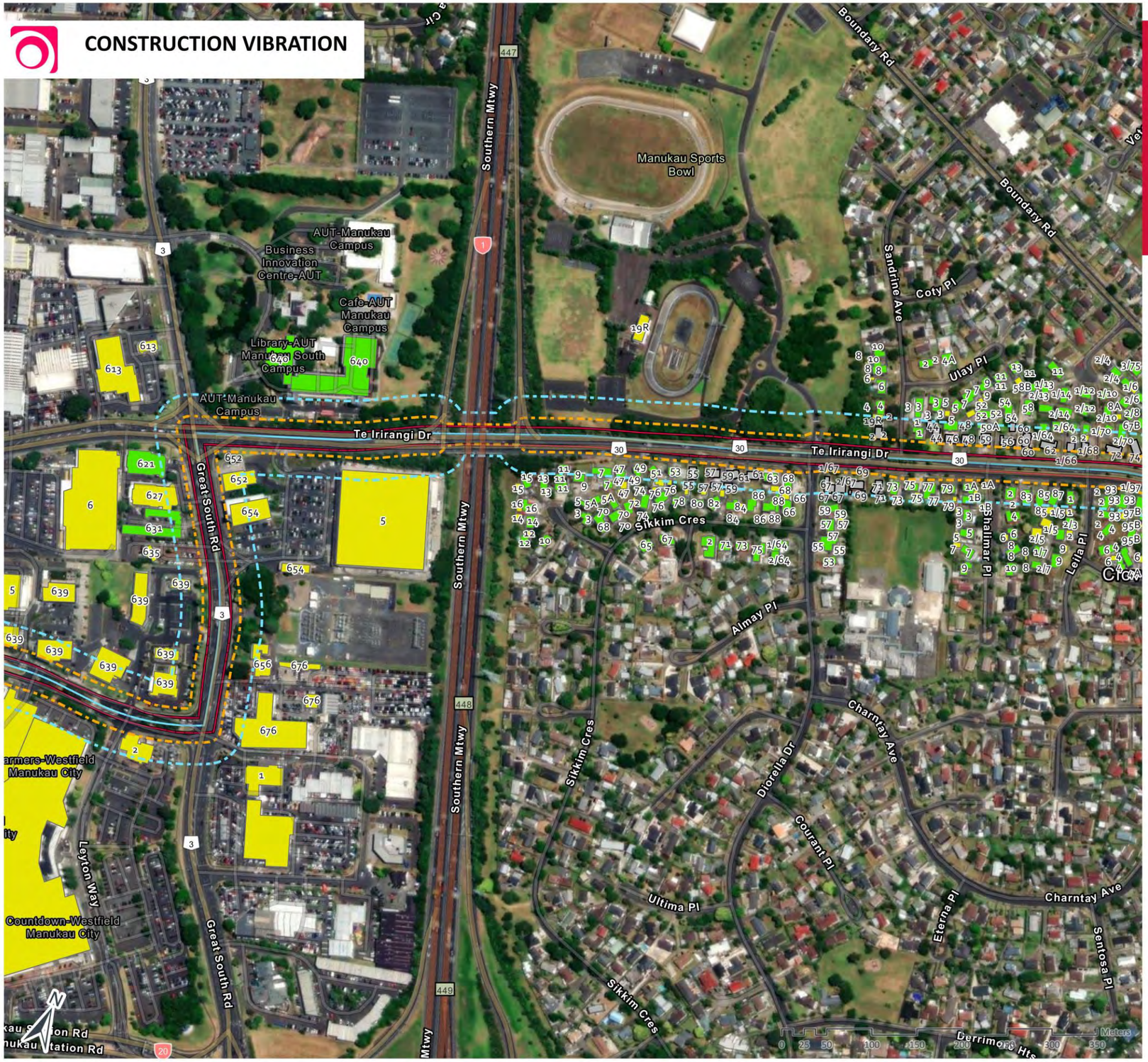

NOR2_2

Nearby Buildings
- PPF
- Non PPF
- Project Roads
- Project Bus Lane

Vibration level
- 2 mm/s
- 5 mm/s

Client:
Map

Authors:
owen.li

Date of Issue:
25/11/2022 4:24 pm

Drawing Details:
Scale: 1:4,000
Project on: NZGD 2000 New Zealand Transverse Mercator
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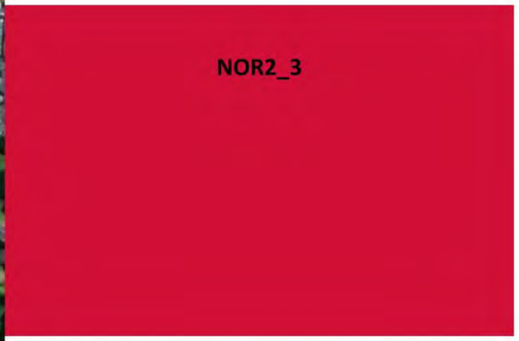

Client:
Map
Authors:
owen.li
Date of Issue:
25/11/2022 4:24 pm

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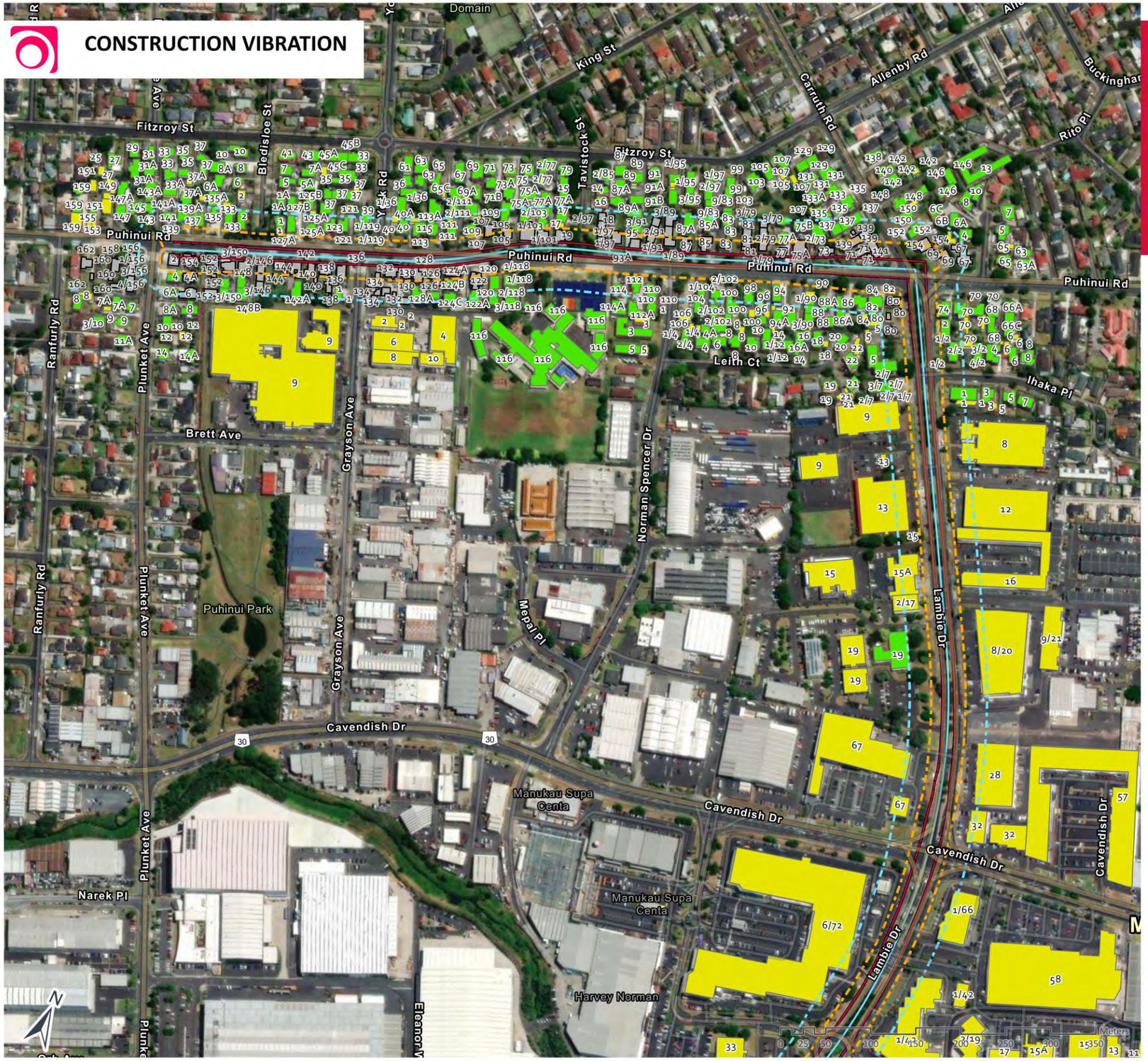

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Scale: 1:4,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -25.016893°

Map Notes / Comments:
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NoR 3

NOR3 OVERALL

Nearby Buildings
- PPF
- Non PPF
- Project Roads
- Project Bus Lane

Vibration level
- 2 mm/s
- 5 mm/s

Client:
Map

Authors:
owen.li

Date of Issue:
25/11/2022 4:24 pm

Drawing Details:
Scale: 1:6,250
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -25.016893°

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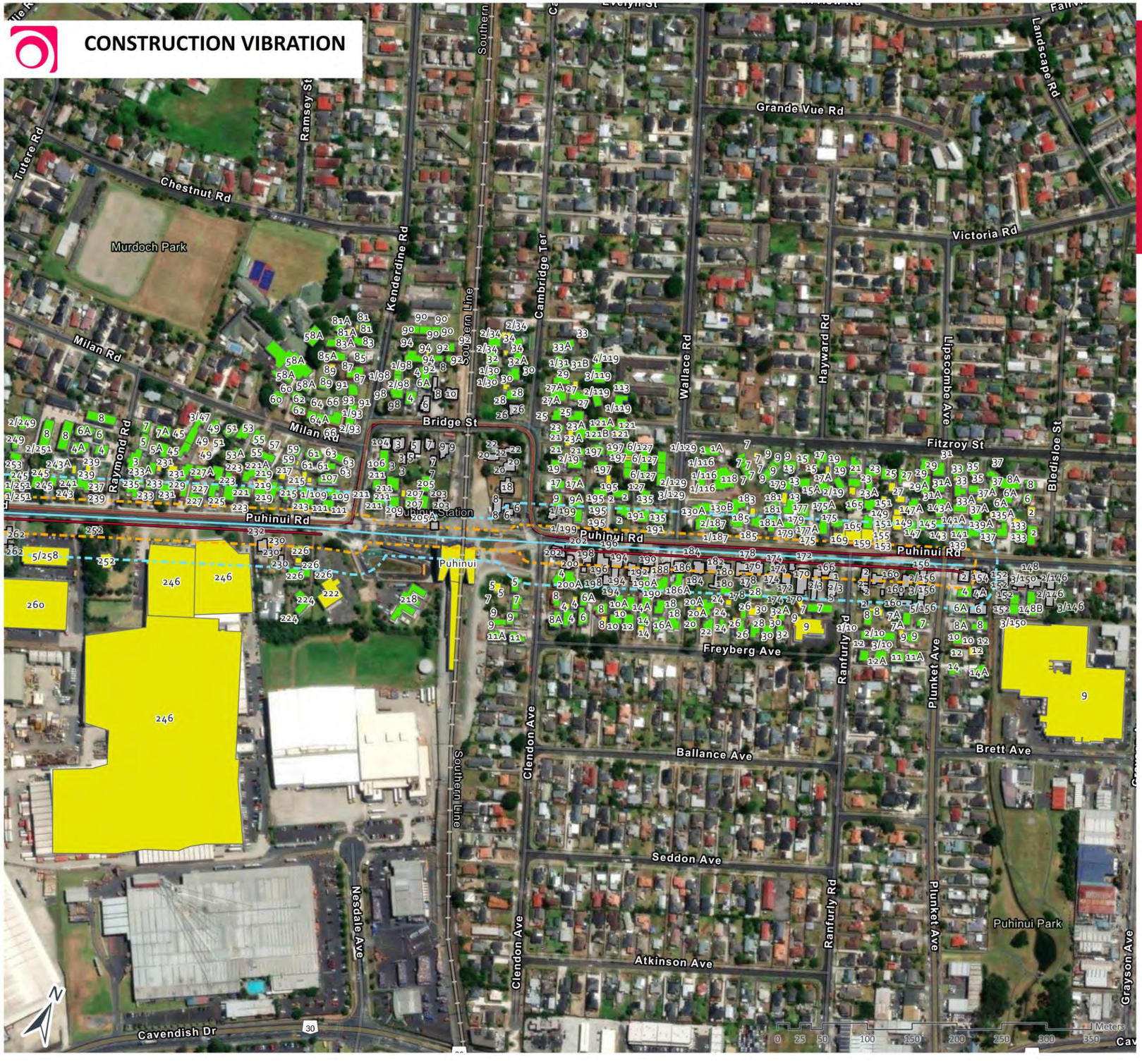
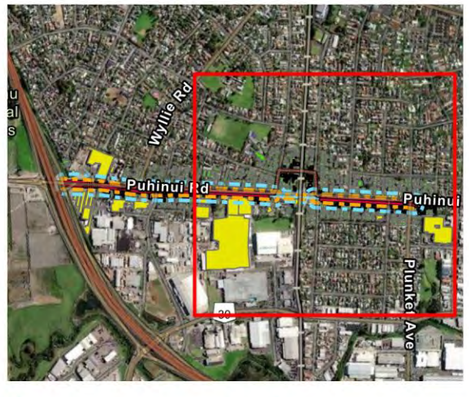


NOR3_1

Nearby Buildings
- PPF
- Non PPF
- Project Roads
- Project Bus Lane

Vibration level
- 2 mm/s
- 5 mm/s



Client:
Map

Authors:
owen.li

Date of Issue:
25/11/2022 4:24 pm

Drawing Details:
Scale: 1:4,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -25.016893°

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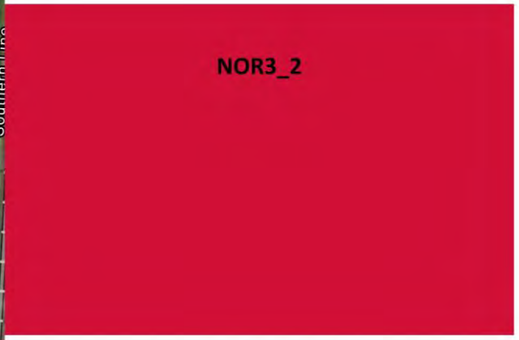

Client:
Map

Authors:
owen.li

Date of Issue:
25/11/2022 4:24 pm

Drawing Details:
Scale: 1:4,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -25.016893°

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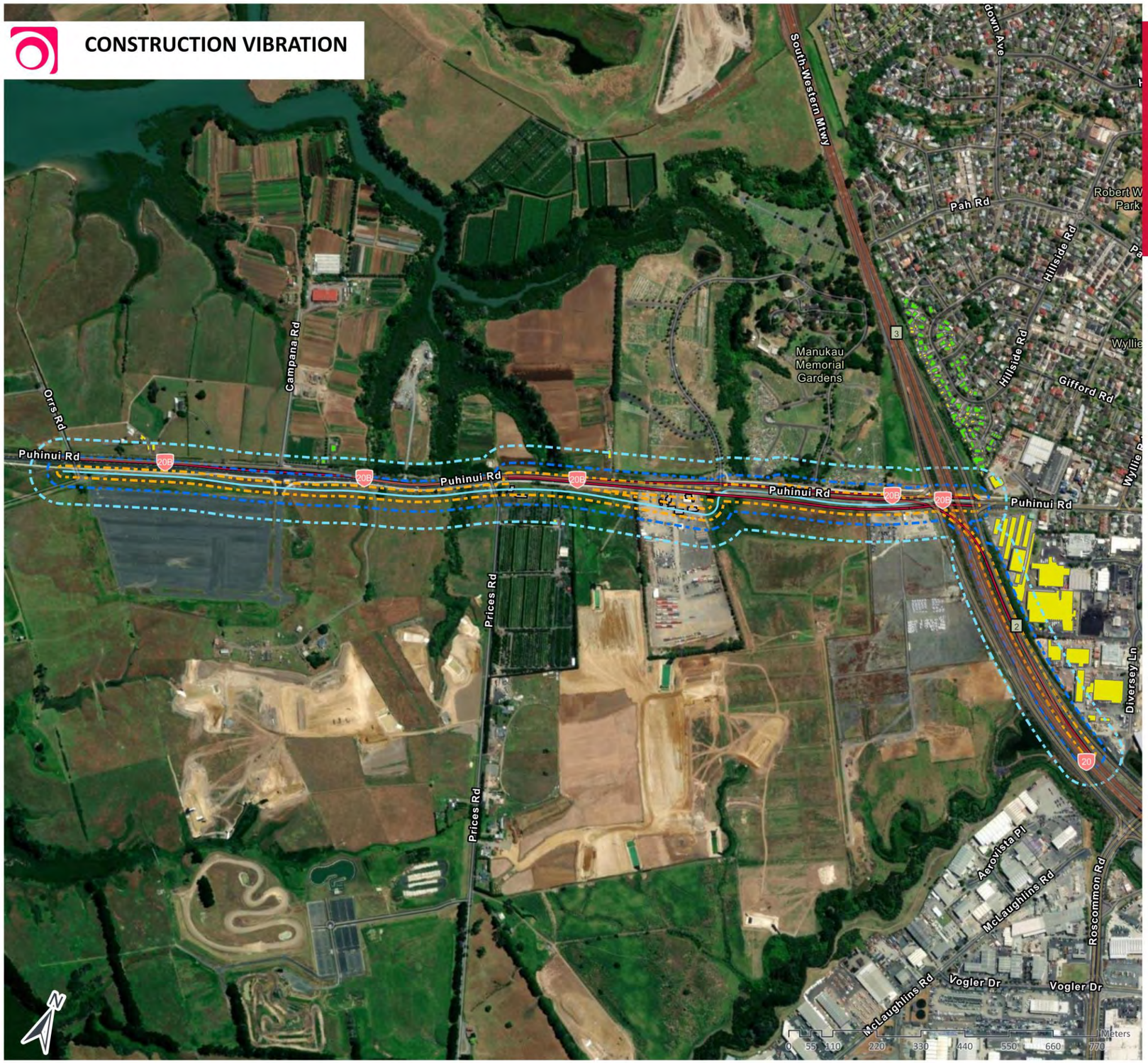
NoRs 4a and 4b



NOR4 OVERALL

Nearby Buildings
- PPF
- Non PPF
- Project Roads
- Project Bus Lane

Vibration level
- PPF Category A
- nonPPF Catagory A
- PPF Category B

Client:
Map

Authors:
owen.li

Date of Issue:
25/11/2022 4:24 pm

Drawing Details:
Scale: 1:9,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -25.016893°

Map Notes / Comments:
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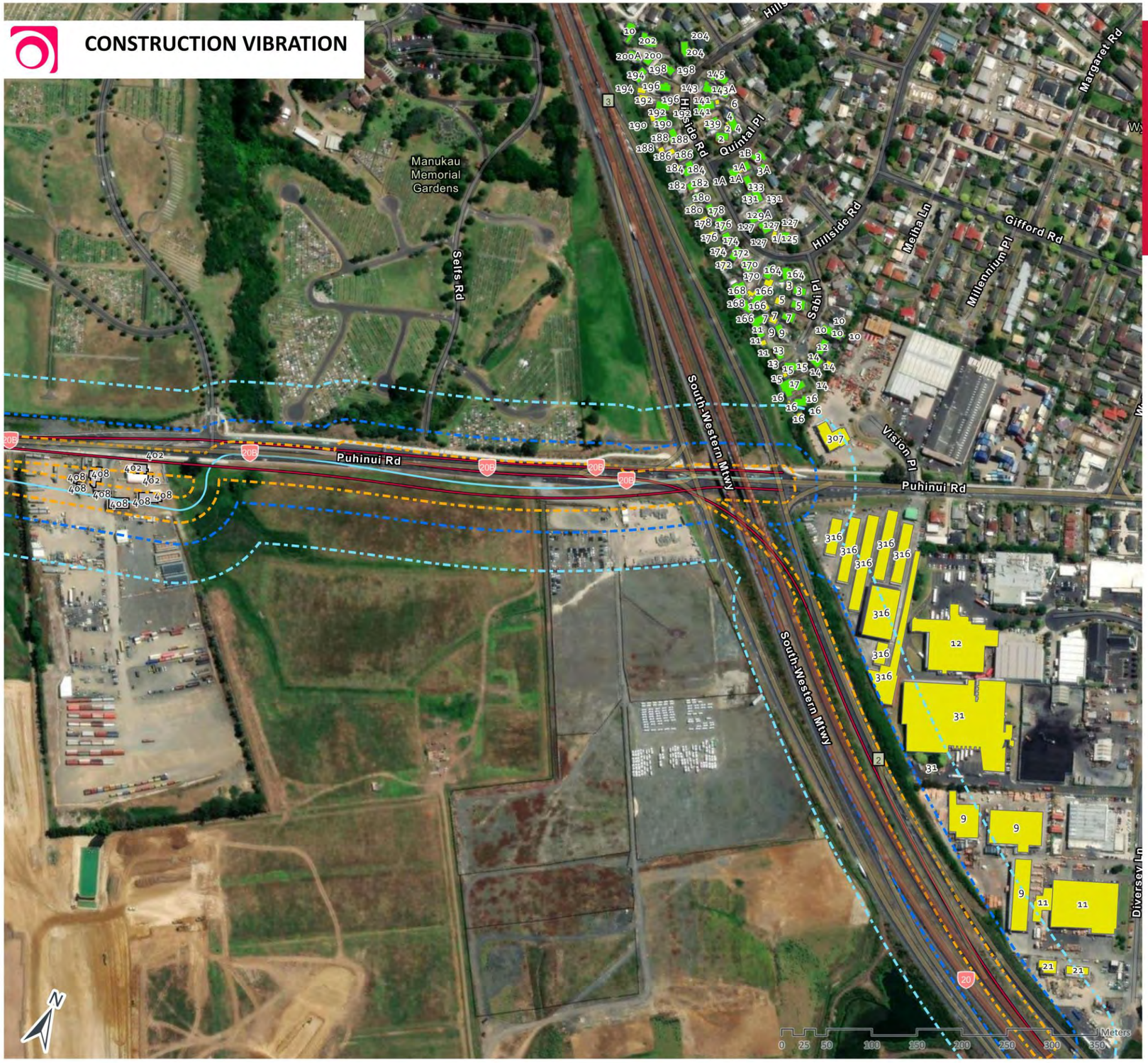

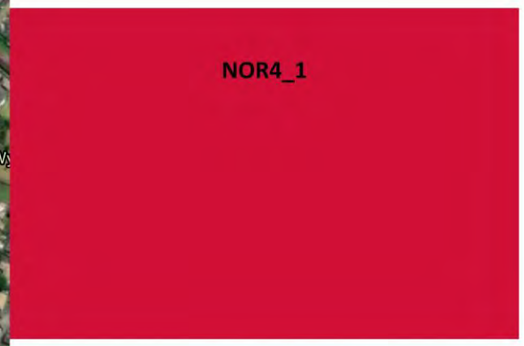

Client:
Map

Authors:
owen.li

Date of Issue:
25/11/2022 4:24 pm

Drawing Details:
Scale: 1:4,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -25.016893°

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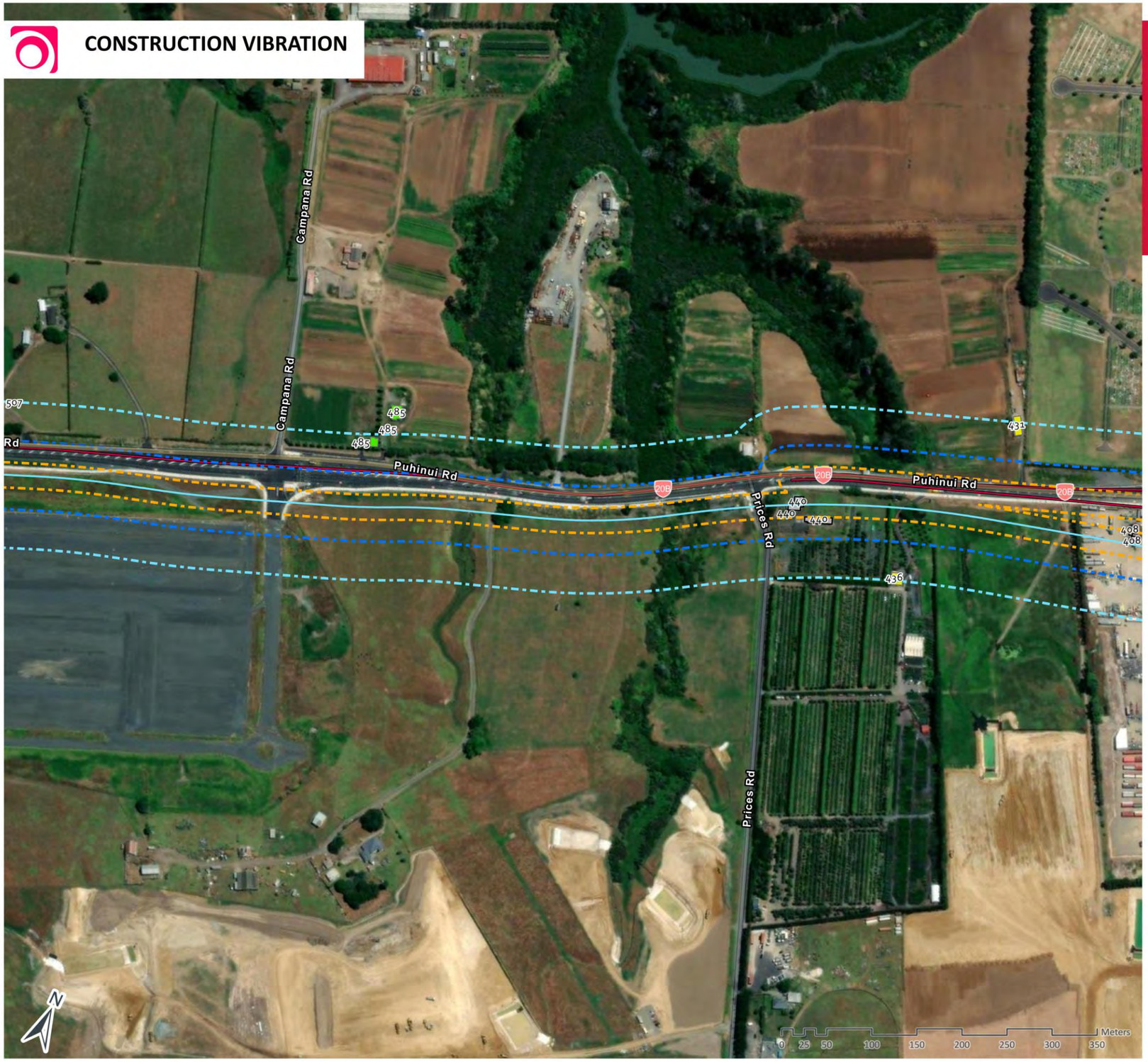

NOR4_2

Nearby Buildings
- PPF
- Non PPF
- Project Roads
- Project Bus Lane

Vibration level
- PPF Category A
- nonPPF Catagory A
- PPF Category B

Client:
Map
Authors:
owen.li
Date of Issue:
25/11/2022 4:24 pm

Drawing Details:
Scale: 1:4,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -25.016893°

Map Notes / Comments:
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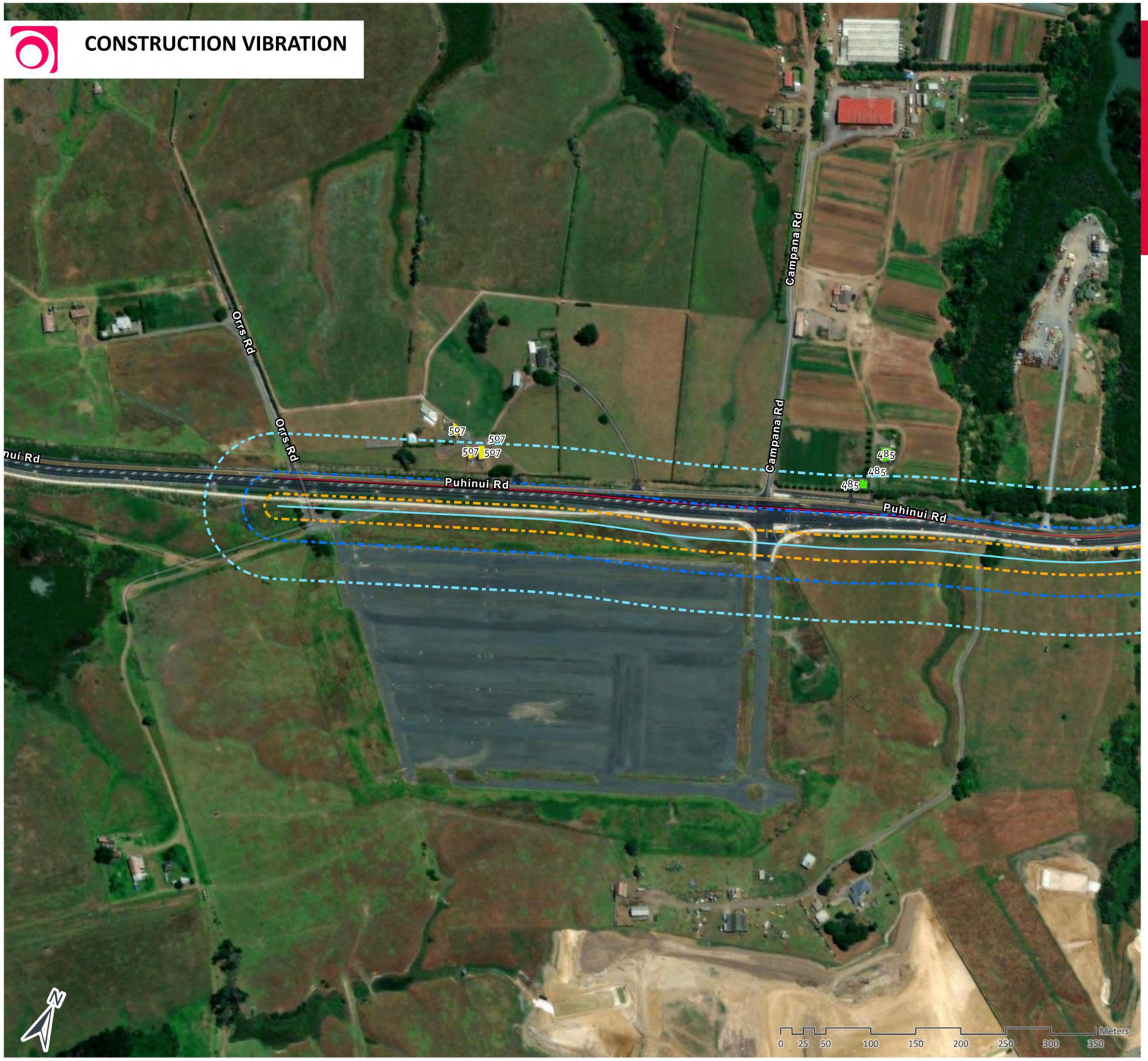
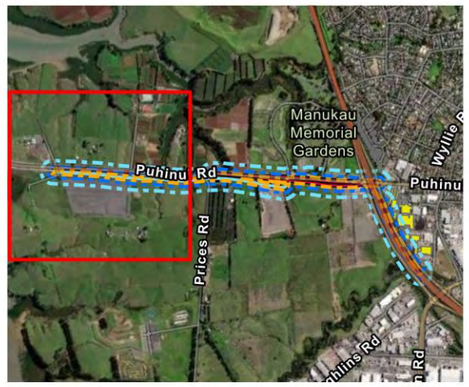


NOR4_3

Nearby Buildings
- PPF
- Non PPF
- Project Roads
- Project Bus Lane

Vibration level
- PPF Category A
- nonPPF Catagory A
- PPF Category B



Client:
Map
Authors:
owen.li
Date of Issue:
25/11/2022 4:24 pm

Drawing Details:
Scale: 1:4,000
Project on: NZGD 2000 New Zealand Transverse Mercator
Map Rotat on: -25.016893°

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