NZ TRANSPORT AGENCY
WAKA KOTAHI

TE ARA HAUĀURU NORTHWEST BUSWAY

ASSESSMENT OF CONSTRUCTION NOISE AND VIBRATION EFFECTS

SIIRI WILKENING

15 DECEMBER 2025

New Zealand Government

Qualifications and experience of the author

My name is Siiri Wilkening. I am an acoustics consultant, and a Director of Marshall Day Acoustics Ltd (MDA). MDA is a specialist acoustics consultancy of about 100 professional acoustics consultants, founded in 1981, with offices in New Zealand, Australia, Hong Kong/China, and France. I have worked at MDA for 27 years.

I hold a Master's degree in Engineering (Land Improvement and Environmental Protection) (University of Rostock, Germany). I have nearly 30 years' experience as an acoustics consultant and am a Fellow of the Acoustical Society of New Zealand. I am also a member of the Resource Management Law Association and the Institute of Directors (New Zealand).

My experience relevant to this Application includes:

- I was the expert witness on many Roads of National Significance, including State Highway 1 (SH1) East West Link, SH1 Northern Corridor Improvements, State Highway 16 (SH16) Waterview Connections, SH1 MacKays to Peka Peka (Kāpiti Expressway) and SH1 Pūhoi to Warkworth, all of which were designated through Boards of Inquiry. For each of these projects, my role involved all aspects of acoustics, noise and vibration effects from construction and traffic and (where relevant) underwater effects, and I presented expert evidence at the hearings.
- The SH1 Southern Corridor Improvements (Manukau to Papakura and Papakura to Drury), which involves considerable challenges due to high population density close to the road. The widening of the Southern Motorway, the busiest state highway in New Zealand, will affect a large number of people, both during construction and following completion. I am the lead acoustical consultant on these projects and am responsible for all works relating to noise and vibration effects, which includes ambient noise level surveys, computer noise modelling, extensive meetings and engagement with residents and Council, noise mitigation design and the formulation of noise management plans. Various stages of the Project were consented through a mixture of conventional Council hearings and the Covid Fast-track process. I appeared as expert witness at the hearings and prepared the assessments for the Fast-track process.
- I was engaged as principal acoustic consultant of the Te Tupu Ngātahi Supporting Growth Alliance, with a programme providing for the planning and consenting of transport infrastructure (active modes, rapid transit and roading) for the growth areas surrounding Auckland, with projects extending from Warkworth in the north, to Drury and Pukekohe in the south, to Huapai in the West. My role was to provide oversight and peer reviews of the assessments. The role changed to include the assessment of a number of the projects (Takaanini Level Crossings, North (Strategic), North West (Strategic), Pukekohe, and Airport to Botany Rapid Transit), which involved everything from contributing to route selection to assessment and expert witness appearance at several of the combined Council hearings.

I have undertaken many acoustic assessments for a variety of projects ranging from transportation and power generation to educational facilities, residential and commercial subdivisions, mining and plan changes. I have appeared as an expert witness at many Council hearings, before numerous Environment Courts and five Boards of Inquiry. I have also taken part in Environment Court mediation.

Although this matter is not before the Environment Court, I confirm that I have read the Code of Conduct for expert witnesses as contained in section 9 of the Environment Court Practice Note 2023. I agree to comply with that Code. My qualifications as an expert are set out above. I am satisfied that the matters which I address in this report are within my area of expertise, except where I state that I am relying on information provided by another person or expert. I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

Executive summary

This assessment addresses the actual and potential construction noise and vibration effects of Te Ara Hauāuru Northwest Rapid Transit (the Project, as described in Part 2 of the Application).

Construction activities will involve, amongst others, earthworks, bridge and retaining wall construction, roadway formation, station works, and associated demolition. These activities will generate elevated noise and vibration levels, particularly when works occur close to sensitive receivers such as dwellings and schools.

I assessed noise against New Zealand Standard 6803:1999 Acoustics – Construction Noise (NZS 6803) and vibration against German Industry Norm 4150-3 (2016) 'Structural vibration – Part 3 Effects of vibration on structures' (DIN 4150-3) and British Standard 5228-2:2009 'Code of practice for noise and vibration control on construction and open sites' (BS 5228-2) standards. For most works, compliance with the relevant criteria is achievable using best practice measures. However, when construction occurs within approximately 50 metres of buildings, noise criteria may be infringed, and high-noise activities like piling could extend this influence to about 85 metres. Similarly, vibration from vibratory piling or vibratory rollers may infringe amenity criteria at short distances, though infringement of the building protection criteria is unlikely.

To manage the effects I have identified, I recommend a Construction Noise and Vibration Management Plan (CNVMP), supported by activity-specific Schedules, is prepared prior to, and implemented throughout, the works. These tools have proven effective on other major infrastructure projects and will allow proactive and responsive management. Key measures likely to be included in CNVMPs and Schedules include communication and engagement with affected parties, timing works to minimise disturbance, using quieter equipment and methods (e.g. bored piling rather than impact piling), installing temporary noise barriers, and, in exceptional cases, offering temporary relocation. Building condition surveys and vibration monitoring will be undertaken where risk is identified.

In conclusion, while some short-term infringements of noise and vibration criteria are expected when works occur closest to receivers, these will be temporary and can be appropriately managed through the CNVMP and Schedules to a CNVMP.

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Acronyms, definitions and abbreviations

Term	Definition
AEE	Assessment of Environmental Effects
ASB	Auckland Savings Bank
AUP	Auckland Unitary Plan (Operative in Part)
BPO	Best Practicable Option
BS 5228-2	British Standard 5228-2:2009 'Code of practice for noise and vibration control on construction and open sites'
CMA	Coastal Marine Area
CNVMP	Construction Noise and Vibration Management Plan
dB	Decibel
DIN 4150-3	German Industry Norm 4150-3 (2016) 'Structural vibration – Part 3 Effects of vibration on structures'
FTAA	Fast-track Approvals Act 2024
Indicative Design	The indicative design of the Project within the Project Area as shown on the Indicative Design drawings in Part 6 that will be confirmed during detailed design
kg	Kilogram
m^2	Square metre(s)
MDA	Marshall Day Acoustics
NoR	Notice of Requirement
NZS 6803	New Zealand Standard 6803:1999 Acoustics – Construction Noise
NZTA	New Zealand Transport Agency Waka Kotahi
PPV	Peak Particle Velocity expressed in mm/s
Project	Te Ara Hauāuru Northwest Rapid Transit
Project Area	The Proposed Designation and the extent of the coastal occupation permits sought
Proposed Designation	The area defined by the Proposed Designation boundary as shown on the Proposed Designation Plans in Part 6
SH16	State Highway 16

1. Introduction

1.1 Purpose and scope of this report

This technical assessment has been prepared to inform a substantive application for the Northwest Rapid Transit Project (the Project) under the Fast-Track Approvals Act 2024 (FTAA). It forms part of a suite of specialist reports that collectively support the applications for statutory approvals.

The purpose of this report is to evaluate the actual and potential effects of the Project on the environment in relation to the construction noise and vibration. This report addresses the following matters:

- Assessment of noise and vibration effects from the construction of the Project and associated roads, on sensitive receivers along the corridor.

A framework of management and mitigation allowing proactive response to any adverse impacts throughout the construction phase. The assessment considers both the construction phase of the Project, identifying any adverse effects, and assessing their significance. I have recommended measures to avoid, remedy, or mitigate identified effects where I consider necessary.

Where this report states that I have undertaken the assessment and reached conclusions, I also rely on the work of others within my team at Marshall Day Acoustics (MDA), particularly in relation to traffic noise modelling and survey work.

This report should be read alongside the Substantive Application including the Assessment of Environmental Effects (AEE) in Part 4, which contains further details on the context of the Project. The Substantive Application also contains a description of works to be authorised and the typical construction methodologies that will be used to implement this work which are included in Part 2. I have reviewed this and have been considered as part of my assessment of 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 Project overview

The construction methodology on which I have based my assessment is as follows:

- Site establishment, such as vegetation removal, construction of site compounds and laydown areas, removal of structures such as existing noise walls, and building demolition inside the designation boundary.
- Main works, such as earthworks, construction of bridges and retaining walls, road construction, and services relocation.
- Finishing works and demobilisation, such as finalising the road surfacing, marking and landscaping.

2. Receiving environment

The Project will be located adjacent to State Highway 16 (SH16) for its entire alignment. This means the existing noise environment is already highly affected by traffic noise. Between Royal Road and Te Atatū, SH16 has substantial noise barriers that were installed as part of the Waterview Connection and SH16 widening works. These barriers provide good noise reduction for the houses behind. East of the causeway, noise barriers along SH16 extend from 1102 Great North Road in Point Chevalier to the Western Springs Garden Community Hall, and adjacent to Ivanhoe Road in Grey Lynn.

Ambient noise levels measured at positions adjacent to the Proposed Designation (the area defined by the Proposed Designation boundary as shown on the Proposed Designation Plans in Part 6), ranged from 49 dB $L_{Aeq(24h)}$ to 61 dB $L_{Aeq(24h)}$. This range reflects the different distances between the survey locations and SH16 and the variation in shielding afforded by noise barriers (where there are any) and intervening buildings and structures. The surveys are discussed in detail in the Assessment of Operational Noise and Vibration Effects report.

Overall, dwellings adjacent to the Project are next to a major transport corridor which controls the existing noise environment, and the inhabitants of the dwellings will be acclimatised to continuous traffic noise from SH16.

3. Assessment methodology

This assessment addresses the actual and potential construction noise and vibration effects arising from the Indicative Design (the indicative design of the Project within the Project Area as shown on the Indicative Design drawings in Part 6 that will be confirmed during detailed design), as well as potential movements of the Indicative Design within the Proposed Designation. The Project Area refers to the Proposed Designation and the extent of the coastal occupation permits sought.

3.1 Performance criteria

3.1.1 Noise

I have assessed construction noise in accordance with NZS 6803:1999 'Acoustics – Construction noise' (NZS 6803). This standard is referenced in the Auckland Unitary Plan (Operative in Part) (AUP) and in the NZTA 'State Highway Construction and Maintenance Noise and Vibration Guide' (NZTA Guide), V1.1, August 2019. Given the works will take longer than 20 weeks, I have applied the 'long duration' criteria of NZS 6803. The daytime noise criteria are 70 dB L_{Aeq} and 85 dB L_{AFmax}, with lower noise criteria for night-time and shoulder periods.

Table 3-1 sets out the relevant construction noise criteria on which my assessment is based.

Table 3-1: Construction noise criteria

Time of week	Time period	dB L_{Aeq}	dB L_{AFmax}
Activities sensitive to noise			
Weekdays	0630-0730	55	75
	0730-1800	70	85
	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
All other buildings occupied during the works			
All days	0730-1800	70	N/A
	1800-0730	75	N/A

3.1.2 Vibration

I have assessed construction vibration based on relevant international standards, specifically:

- German Industry Norm DIN 4150-3 (2016) 'Structural vibration – Part 3 Effects of vibration on structures', which addresses protection of buildings from any damage; and
- British Standard 5228-2: 2009 'Code of practice for noise and vibration control on construction and open sites', which takes account of people's amenity.

The vibration criteria set out in the AUP are referenced on the same standards. Criteria from the two standards have been combined and apply progressively as far as practicable. Table 3-2 sets out the construction vibration criteria on which my assessment is based.

Table 3-2: Construction vibration criteria

Receiver	Location	Details	Category A	Category B
Occupied sensitive use buildings *	Inside the building	2000-0630	0.3mm/s PPV	1mm/s PPV
		0630-2000	1mm/s PPV	5mm/s PPV
Other occupied buildings	Inside the building	0630-2000	2mm/s PPV	5mm/s PPV
Any buildings identified as particularly vibration sensitive	Inside the building	As per relevant use above	As per relevant use above	2.5 mm/s PPV
All other buildings	Building foundation	Vibration – transient	5mm/s PPV	BS 5228-2 Table B.2
		Vibration - continuous		BS 5228-2 50% of Table B.2 values

*Buildings containing sensitive uses, such as dwellings and educational buildings, but excluding buildings identified by a suitably qualified specialise as particularly vibration sensitive

The Category A criteria should be complied with wherever practicable, and exceedances should trigger additional management actions. The Category B criteria should be complied with at all times. The criteria in Table 3-2 relate to both amenity and building protection as follows:

- The amenity criteria are represented by the Category A criteria for occupied buildings. If these criteria cannot practicably be met, the exceedance should trigger engagement and further management and mitigation. The nighttime Category B criterion for “occupied sensitive use buildings” provides a secondary layer of amenity protection.
- The daytime Category B criteria are intended to protect residential buildings, and those buildings that are fitted out similarly to dwellings, e.g. with plasterboard and painted walls, from any damage.
- The daytime Category A criteria protect other buildings (not occupied) from any damage, with the Category B criteria for other buildings providing another layer of building protection.
- Buildings that, because of their particular sensitivity to vibration, cannot be assessed under the above occupied building classifications, have a Category B value of 2.5 mm/s PPV at any time, to protect sensitive building elements. These ‘vibration sensitive’ buildings are buildings specifically named in AUP Schedule 14.1 ‘Schedule of Historic Heritage’ if they have original design elements with the potential to be damaged by vibration, e.g. plaster mouldings or stain glass windows.

  There is one building outside the Proposed Designation that may fall into the ‘vibration sensitive’ category, namely the former Auckland Savings Bank (ASB) building at 1210 Great North Road, Point Chevalier, as this building has original plaster mouldings facing Great North Road. This building is noted in Schedule 14.1 of the AUP.

  The Ambassador Theatre at 1218 Great North Road in Point Chevalier would also fall under the classification of vibration sensitive should it be retained despite being inside the Proposed Designation. The Ambassador Theatre has street frontage plaster mouldings and potentially internal plaster mouldings in the theatre space. This building is noted in Schedule 14.1 of the AUP.

3.2 Assumptions

This assessment of construction noise and vibration effects is based on assumptions as to the construction activities and equipment that will form part of the Project, particularly given parts of the Project are expected to be implemented sometime in the future. I have based this assessment on the indicative construction methodology set out in the AEE and on similar construction projects I have worked on. I consider the equipment and tasks set out in this report are representative of activity that has occurred on similar projects, therefore forming a reasonable assumption for the purposes of assessment.

I have assumed that all existing buildings inside the Proposed Designation will be removed and have therefore not assessed construction noise and vibration effects on them.

I have assumed that most of the works will be undertaken during daytime only. However, some night-time works will be needed where works would affect the safe operation of SH16, e.g. where bridges are constructed across the road or where works are particularly close to active traffic lanes on SH16. These

works would be unusual and would only occur from time to time, and they will be managed through the CNVMP.

Where no sensitive receivers are in the vicinity of works (e.g. north of Westgate), night-time works may be undertaken without adversely affecting dwellings and would therefore be less restricted in timing.

3.3 Basis of effects assessment

3.3.1 Noise

My noise level predictions for the Indicative Design are based on sound power levels for different items of equipment, with each item's noise propagation characteristics modelled over distance, including the effects of ground and air absorption. I have calculated indicative noise levels in accordance with NZS 6803 and ISO 9613-2:1996 'Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation' for relevant construction scenarios, assuming multiple items of equipment operating simultaneously, but taking account of spatial separation and a time component of operation (e.g. if something only operates 50% of the time, the noise level would be 3 dB lower). This approach is deliberately conservative to represent the reasonable worst-case noise levels that may occur infrequently.

I have predicted construction noise levels based on experience with similar projects and in similar circumstances. I have assembled a list of likely equipment that would be used on a large-scale infrastructure project in New Zealand. Table 3-3 sets out this list of equipment, with each item's respective sound power levels. This list is an indication of the types of equipment that could be used on the Project and is essentially a "best estimate." Although the contractor may use different plant and equipment from what is on this list, I consider that noise emissions at the time of construction will be similar to those predicted for each activity in Table 3-3.

Based on the sound power levels (column three) in Table 3-3 I have predicted combined "activity sound power levels" (column four). Not all equipment will operate consecutively and continuously, which I considered when determining the "activity sound power levels". From the activity sound power levels, I determined the distance at which the 70 dB L_{Aeq} daytime noise criterion (see Table 3-1) can be complied with, without shielding (e.g. by noise barriers or intervening buildings or other structures) (column five).

Table 3-3: Equipment list and indicative sound power levels

Activity	Plant type	Sound power level (dB L_{WA})	Activity sound power level (dB L_{WA})	Indicative distance (m) at which compliance with day-time limit (70 dB L_{Aeq}) is likely without shielding*
Site establishment (clearance, demolition, compound construction)	Chainsaw	114	108	40
	Chipper	117		
	Dump trucks	106		
	Hydraulic excavator	103		
	Vibratory roller	103		
Earthworks (alignment works, drainage and culvert construction)	Dump truck	106	109	44
	Hydraulic excavator	103		
	Bulldozer	109		
	Compactor	108		
	Water truck	105		
Retaining wall construction	Vibration piling rig	116	116	83
	Rotary piling rig	111		
	Concrete trucks	103		
	Crane	98		
	On-road trucks	100		
Bridge foundations (piling)	Rotary piling rig	111	111	52
	Concrete trucks	103		
Rock excavation	Rock breaker	116	116	83
	Crane	106	108	40

Activity	Plant type	Sound power level (dB L_{WA})	Activity sound power level (dB L_{WA})	Indicative distance (m) at which compliance with day-time limit (70 dB L_{Aeq}) is likely without shielding*
Foundations and structures (bridge construction)	Concrete pump	103		
	Vibratory pokers	114		
	Concrete trucks	103		
Pavement preparation	Vibratory roller	103	108	40
	Water trucks	105		
Surfacing	Paving machine	103	103	25
	Road rollers	103		
	Asphalt delivery trucks	105		
Yard activities	Vehicle movements	102	100	18
	Material handling	105		
	Administration area	50		
	Workshop	80		

* Excludes shielding from temporary construction noise barriers, intervening buildings and structures and existing traffic noise barriers

3.3.2 Vibration

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 are difficult to quantify across large construction extents.

As a result, I have determined “safe distances” based on vibration measurements for high vibration sources such as vibro piling and vibratory rollers. The safe distances are based on vibration prediction tools as contained in Hassan’s ‘Train Induced Groundborne Vibration and Noise in Buildings’ (2006). These safe distances 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 ‘Groundborne vibration caused by mechanised construction works’ referenced by that standard, and previous measurements carried out by MDA.

In addition, I have applied a 100% safety margin to the regression curves derived from the measured data, to take account of ground condition uncertainty, making the predictions conservative. That means I did not use measured vibration levels directly to predict potential vibration levels, but rather the measured levels have been doubled. I have used the results from these measurements and predictions to determine risk radii.

The activities that pose the greatest risk of infringing the daytime Category A and B vibration criteria (as set out in Table 3-2) are vibratory rolling and vibro piling (should that be used). This assessment has focused on these activities. The regression curves for vibratory rollers and vibro piling are shown in Figure 3-1. The values in Figure 3-1 have a 100% safety margin applied across the range of setback distances.

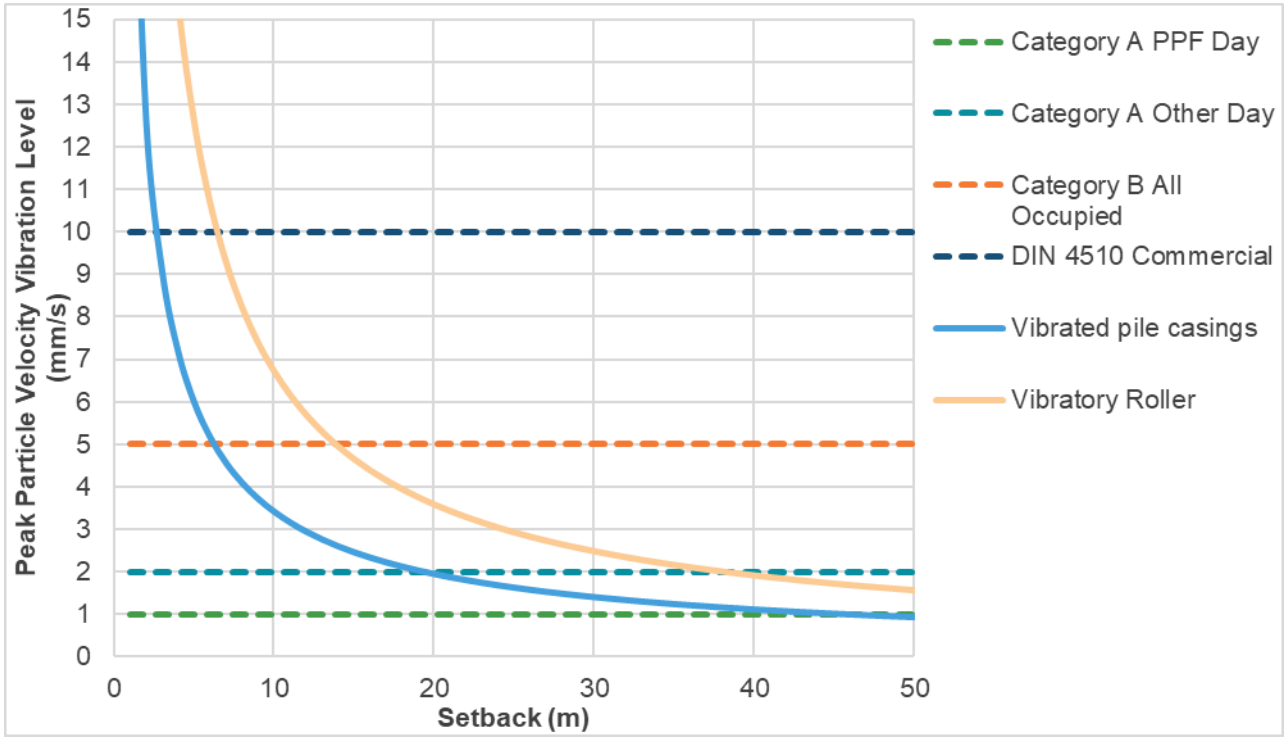


Figure 3-1: Vibration regression curves (criteria for occupied buildings)

The amenity criteria of Category A are intended as trigger levels for engagement with building owners and further management and mitigation (e.g. the offer of building condition surveys). I would expect that the building protection criteria of Category B (daytime) will be complied with as far as practicable to avoid risk of any building damage.

There is a risk that the Category B criteria (orange dashed line) may be infringed at dwellings close to retaining wall construction where vibro piling may be used, and where vibratory rollers are used for the compaction of the busway.

The risk categories in Table 3-4 relate to the risk of infringing Category A and B criteria for occupied buildings (refer to Table 3-2) at various distances from the vibration inducing works. Note that the distances for Category B (building protection) include a 100% safety factor as described above.

I have defined the risk categories as follows:

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

Table 3-4: Vibration risk radii

Activity/equipment	Risk Zones	
	Occupied sensitive use buildings	Other occupied buildings
Vibratory roller	High: <15m Med: 15 – 40m Low: >40m	High: <15m Med: 15 – 20m Low: >20m
Vibro piling	High: <7m Med: 7 – 20m Low: >20m	High: <7m Med: 7 – 10m Low: >10m

4. Assessment of construction noise and vibration effects

4.1 Whole of Project

Construction noise and vibration effects are dependent on several factors. These factors include the sensitivity of the receiving environment (e.g. an inpatient hospital or dwelling contains uses that are more sensitive than an office), the construction of buildings (e.g. a solid concrete or brick façades reduces noise significantly better than a lightweight façade with louvred windows) and the presence of people near construction (e.g. if all people in the area are at work during daytimes, they are not affected by the construction activity).

Construction effects will be considered for all occupied buildings present at the time of construction, during the preparation and implementation of the CNVMP. Therefore, the receiving environment for the Project may have changed by the time construction commences. In order to respond appropriately to the actual environment at the time of construction, a CNVMP (refer Section 5.1) and, where required, Schedules to the CNVMP (Schedules) (refer Section 5.2) will be prepared and implemented. Since these documents are prepared and finalised at the time of construction, with input from the contractor, the environment at that time of construction will form their basis. CNVMPs and Schedules have been used successfully over a number of years to manage effects of large infrastructure projects and provide proactive management of noise and vibration effects.

Nevertheless, in the following sections I provide an overview of the Project's potential effects in relation to likely responses of people to various noise and vibration levels.

4.1.1 Noise effects

Noise levels affect people in their place of residence or work. Construction noise is inherently higher than ongoing operational noise. Nevertheless, the higher construction noise levels are generally considered reasonable by the community, due to their limited duration.

Generally, construction noise is assessed in relation to people inside buildings. From experience, 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. I have assumed conservatively a noise level reduction of 20 decibels, though any new dwellings would achieve 25 to 30 decibels noise level reduction (due to new building standards required higher quality materials such as double glazing and insulation), 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 the works.

4.1.1.1 Daytime

Table 4-1 describes how people may experience noise inside or outside a building during daytime. The table does not address non-sensitive activities such as factories, storage spaces and similar uses.

Table 4-1: 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 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.

External Façade Noise Level dB L_{Aeq}	Potential Daytime Effects Outdoors	Corresponding Internal Noise Level dB L_{Aeq}	Potential Daytime Effects Indoors
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.

4.1.1.2 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 1m 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 estimated with knowledge of the façade glazing type as follows:

- Sealed (unopenable) 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 4-3 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 in Table 4-2.

Table 4-2: Potential effects colour coding definition for Table 4-3

Scale	Potential effects colour coding definition
	Typically acceptable
	Sleep disturbance for some occupants
	Sleep disturbance for most occupants

Table 4-3: 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	25 – 30	30 – 35	35 – 40
45 – 50	15 – 20	20 – 25	25 – 30	30 – 35

Table 4-2 shows that consultation and management may be required if night-time works are proposed in the vicinity of dwellings and predicted internal noise levels would affect sleep.

4.1.1.3 Predicted indicative construction noise levels

I have developed noise envelopes based on the indicative sound power levels set out in Table 3-3 above for the earthworks and retaining/bridge construction works of the Indicative Design. The envelopes represent distances at which compliance with the daytime noise criteria would be achieved without noise mitigation in place.

I have determined the noise envelopes based on activities I consider have the greatest contribution to construction noise (i.e. the loudest activities) or will be undertaken across the greatest extent of the Proposed Designation:

- Earthworks and pavement preparation will occur across the Proposed Designation and will generate elevated noise levels due to the equipment noise levels and the number of equipment items likely to be used. However, works will move along the alignment and will therefore only be in any one location for a limited time (e.g. a few weeks out of several years of construction) (refer Appendix A.1).
- Piling for the construction of bridges and retaining walls may generate high noise levels due to the likely direct line-of-sight between dwellings and machinery and the high sound power levels of the equipment – these activities will be localised, but would remain in place for a more extended period (refer Appendix A.2).

In addition to the above, demolition required for the Project will have an impact on neighbouring houses. Demolition of existing buildings and structures will occur in close proximity to many dwellings that will be retained. While demolition can generate high noise levels, the duration of each building demolition is relatively brief (days, rather than weeks or months). Demolition noise is also dependent on the type of the structure that is being removed. Lightweight dwellings are simply removed by excavator and truck, while masonry or brick buildings may require some concrete breaking or concrete shears to remove. In addition, the type of foundation will affect the noise level and duration of demolition. Concrete foundations or sub-terranean piles may require rock breaking, while timber piles are simpler, faster and quieter to remove. As there are many different buildings and structures to be removed in preparation for Project construction, I have not provided noise level predictions in the form of noise contour envelopes for demolition activities, but I note noise levels from demolition activities may need to be managed through the CNVMP and, if required, Schedules.

Station construction will be localised and will involve a combination of earthworks, retaining and building structures. While station works will not generate high noise levels, the noise levels will be experienced for more sustained periods by neighbouring dwellings. Therefore, I have addressed station construction noise through the higher-noise earthworks and piling noise envelopes discussed in the bullet points above.

I have modelled indicative locations for earthworks and piling, and prepared noise maps to indicate envelopes of compliance. These maps take account of the fact that all houses in the Proposed Designation and some existing noise walls (as identified in the Assessment of Operational Noise and Vibration Effects report) will need to be removed for the construction of the Project and will therefore not provide shielding.

Maps showing these noise levels are included in Appendix A. Buildings receiving compliant noise levels (i.e. up to 70 dB L_{Aeq}) are shown in green, those with noise levels slightly infringing the daytime criterion (i.e. up to 75 dB L_{Aeq}) are shown in orange, and those with the highest predicted noise levels (i.e. up to 80 dB L_{Aeq}) are shown in red. Buildings that are not coloured are either inside the Proposed Designation (and I have therefore assumed that they will be removed) or are more than 100m from the Indicative Design and would therefore receive compliant noise levels.

The maps indicate that there are a number of buildings that would receive elevated noise levels, ranging from 75 to 80 dB L_{Aeq} when works are close by. Bearing in mind that works will move along the alignment, these noise levels would be experienced for a few hours to days before being more distant and therefore less noisy.

While construction is closest, as would be expected, noise levels may be up to levels that may, for brief periods, affect the use of rooms facing the works. Generally, I recommend that temporary noise barriers are installed where they are effective, and with these in place, noise levels would be up to 10 decibels lower than shown in the figures in Appendix A. The location of noise barriers will be determined during the preparation of the CNVMP.

For most of the Project construction activities, construction noise levels will be able to comply with the relevant noise criteria, and common best practice measures will be employed. For all other instances, the CNVMP (refer to Section 5.1) and Schedules to the CNVMP (refer to Section 5.2) will set out the BPO noise mitigation and management measures that must be employed to manage effects as far as practicable.

4.1.2 Vibration effects

4.1.2.1 Indoor 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.

Table 4-4 shows how people may react to various vibration levels. These effects do not consider less sensitive uses such as factories and similar.

Table 4-4: 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 low frequencies, people are less sensitive to vibration.
0.3	Vibration might be just perceptible in residential environments This is the AUP 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 depend on 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 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 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 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) criterion of 1 mm/s PPV is predicted to be exceeded, residents may be disturbed by vibration if no prior warning is given. I 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.

4.1.2.2 Predicted indicative construction vibration levels

I have prepared vibration level envelope figures in Appendix B that show the potential infringement of the Category A and B criteria (refer to Table 3-2) for daytime for occupied sensitive receivers, i.e. at distances of 15 and 40 metres respectively. The vibration safe distances are shown in green (Category A, 1 mm/s PPV) and red (Category B, 5 mm/s PPV). Where there are bridges, I have not predicted vibration levels from vibratory rolling as this would not be used on the bridge structure, and in any event, would be mitigated through the bridge structure itself. For that reason, there are some areas where no vibration envelopes are shown. In these areas, I do not anticipate any significant vibration generation.

There are a number of buildings that are predicted to receive vibration levels above the amenity criterion of 1 mm/s PPV. For these buildings, occupants will be notified of the works and what can be expected while inside the building. Generally, with prior warning, such vibration levels can be tolerated. It is also important to let occupiers know that just because vibration can be felt, this does not mean that building damage will

occur. Vibration magnitudes above those perceptible to humans would be needed to cause structural, or even cosmetic, damage.

A small number of occupied receivers are predicted to receive vibration levels exceeding Category B (i.e. 5 mm/s PPV). For these receivers, mitigation will need to be undertaken. Possible mitigation options include choosing a different construction methodology (e.g. bored rather than vibratory piling), smaller equipment (e.g. a plate compactor rather than a vibratory roller), or using non-vibratory options (e.g. using a roller with the vibration function turned off).

The vibration criteria (refer to Table 3-2) are significantly more stringent at dwellings during the night (0.3 mm/s PPV) and have the potential to be infringed at distances greater than 200m from any works using vibratory rollers or piling. On this basis, I recommend that vibration intensive activities within 300m of dwellings should be scheduled for daytime wherever practicable. I consider the Project will be able to be constructed in compliance with the Category B criteria with management and mitigation in place.

4.2 Brigham Creek Rarawaru to Te Whau River

While potential construction noise and vibration effects are generally discussed in Section 4.1 above, there are specific areas between Brigham Creek and the Te Whau River where attention will be required during construction. These are discussed below.

4.2.1 Busway between Brigham Creek and Te Whau River

4.2.1.1 Subdivision at Westgate Drive to Parkwood Ave

The new subdivision extending from 28 Westgate Drive in the north to Parkwood Ave in the south has a row of double storey dwellings fronting SH16. While these dwellings have existing 1.8m (approx.) boundary fences that would provide some shielding for the ground floor, the upper floors will overlook the busway alignment. Closest construction may occur within 5m of the building façade. Given the height of the windows, temporary barriers are not an option to mitigate construction noise. These houses will be adversely affected during construction, with predicted noise levels up to 80 dB L_{Aeq} when equipment operates closest, for brief periods. The most appropriate management will be proactive engagement to find out if residents may not be home during the day, or, in exceptional circumstances, the offer of temporary relocation.

4.2.1.2 Dwellings at 28 Westgate Drive

The footbridge connecting Westgate Drive and Oreil Ave will need to be replaced. This means that night-time works will likely be required to place the bridge across SH16 as a full closure will be required. This work, while not particularly noisy, will infringe the night-time noise criteria at the closest dwellings at 28 Westgate Drive. I anticipate that such work will only take one or two nights, and therefore I recommend that the most appropriate mitigation will be engagement and communication.

4.2.1.3 Subdivision at Puihi Crescent and Tieke Lane

Similarly, the new (and still under construction) subdivision at Puihi Crescent and Tieke Lane has a few houses that are double storey and immediately abut the Proposed Designation boundary, with closest construction within 5m. Predicted noise levels are up to 80 dB L_{Aeq} but would occur only for brief periods of a few hours while works are closest. The same management as for the subdivision discussed above will be appropriate. In this case, it is likely that the subdivision will be fully developed by the time the busway is constructed. This means that any additional dwellings will be included in the mitigation and management considerations through the CNVMP.

4.2.1.4 Dwellings at Ginders Drive, Triangle Road, Marewa Street, Paton Avenue, Milich Terrace and Royal View Road

Individual dwellings along the alignment in Ginders Drive, Triangle Road, Marewa Street, Paton Avenue, Milich Terrace and Royal View Road are predicted to receive noise levels up to 80 dB L_{Aeq} when construction is undertaken closest to them. Since the works will move along the alignment, I anticipate these worst-case noise levels would only occur for brief periods of a few hours rather than consistently. Normal management and mitigation, using temporary barriers and good engagement with affected parties, will be the most

appropriate response. Most houses in these areas are single level, which makes temporary barriers an effective mitigation option here.

4.2.1.5 Dwellings at 28 Westgate Drive

The footbridge connecting Westgate Drive and Oreil Ave will need to be replaced. This means that night-time works will likely be required to place the bridge across SH16 as a full closure will be required. This work, while not particularly noisy, will infringe the night-time noise criteria at the closest dwellings at 28 Westgate Drive. I anticipate that such work will only take one or two nights, and therefore I recommend that the most appropriate mitigation will be engagement and communication.

4.2.1.6 Commercial premises

Some of the busway will be surrounded by commercial premises (e.g. at Westgate). Where this is the case, and no sensitive receivers are in the vicinity, night-time and Sunday works may be undertaken. Any such works will be detailed in the CNVMP when the existing receivers are known.

4.2.1.7 Works in the Coastal Marine Area

Construction will be undertaken in the Coastal Marine Area (CMA) at Huruhuru Creek and Henderson Creek. Here, temporary staging will be required for the construction of the bridges, including potentially temporary piles into the CMA.

I understand from the Project ecologist, with reference to a marine specialist, that there are no marine mammals in the area, and that the potential effects are low on any marine fauna (i.e. fish, invertebrates or birds).

Given the lack of sensitive receiving fauna in the area, I concur with this finding.

4.2.2 Royal Road Mānutewhau station

Royal Road Mānutewhau station will be constructed immediately beside Royal Road School. The station will sit significantly below the school, with a high retaining wall dividing the two. A number of dwellings will need to be removed (114 – 118 Royal Road), which will result in demolition noise. As the dwellings are within 3m of the closest school building, demolition will need to be undertaken with significant care. I recommend that a temporary noise barrier is installed along the school boundary. This barrier could also be retained as a permanent barrier to reduce traffic noise from SH16 at the school. Since noise levels during the demolition, and construction of the retaining wall will be sufficiently high to cause disruption to school operation in the closest building (with predicted levels up to 80 dB L_{Aeq}), I recommend these activities are scheduled to occur during school holidays and outside school hours.

The station will require a new local bus bridge adjacent to the existing Royal Road bridge across SH16. The construction of this bridge will need to be undertaken, at least in part, during night-time as the road below will need to be closed. Closest dwellings are somewhat distant (approximately 40m) and would therefore receive noise levels around 60 to 65 dB L_{Aeq}. At these noise levels, internal noise levels with windows closed may approach the upper end of acceptability. I therefore recommend that these night-time works be managed through communication and engagement, be kept to a minimum and only necessary works be undertaken at night.

4.2.3 Te Atatū Ōrangihina station

Te Atatū Ōrangihina station will include a new bridge across SH16. The construction of this bridge will need to be undertaken, at least in part, during night-time as the road below will likely need to be closed. Closest dwellings are somewhat distant (50 to 70m) and would therefore receive noise levels around 55 to 60 dB L_{Aeq}. At these noise levels, internal noise levels with windows closed would generally be acceptable and not cause sleep disturbance. I therefore recommend that these night-time works be managed through communication and engagement.

4.2.4 Sensitivity testing of Indicative Design

Should the Indicative Design change vertically, e.g. should the overpasses become underpasses, the overall construction noise and vibration effects are likely to be similar to those I have already assessed. For either over or underpass, retaining walls and similar structures will need to be constructed. This means that the noise and vibration effects will remain generally unchanged to those assessed.

The Proposed Designation does not allow for large horizontal shifts of the Indicative Design in most locations, so the noise and vibration effects will remain generally unchanged to those assessed. There is potential for the busway alignment to be on the eastern side of SH16 between Rarawaru Brigham Creek and the southern extent of the Upper Harbour Motorway ramps. Should this alignment change be implemented, there are currently very few sensitive receivers along this section of road. Closest dwellings are in Northside Drive, more than 60 metres from the Proposed Designation boundary. At that distance, common best practice construction noise and vibration management on site would be sufficient.

In any event, any construction noise and vibration effects will be appropriately managed through the CNVMP and, if required, Schedules. Any changes to the receiving environment (e.g. new buildings adjacent to the busway), busway alignment or construction methodology will be responded to by the CNVMP at the time of detailed design and throughout construction.

4.3 Waterview Interchange (east of causeway) to Ian McKinnon Drive

While potential construction noise and vibration effects are generally discussed in Section 4.1 above, there are some specific areas between the Waterview Interchange and Ian McKinnon Drive where attention will be required during construction. These are discussed below.

4.3.1 Busway between Waterview Interchange and Ian McKinnon Drive

There are four areas where construction will need to be managed and mitigated to address neighbouring land uses.

1. A new bridge east of Carrington Road is proposed to be constructed, duplicating the existing Carrington Road bridge. The extension of the designation to incorporate 26 and 28 Carrington Road, the closest dwellings will be 6 and 6A Sutherland Road. Bridge construction will include piling, which will need to be undertaken within approximately 25 metres of the closest dwelling. I recommend bored piling be used to reduce noise and vibration impacts. In addition, the construction of the bridge will likely require night-time works as SH16 may need to be closed for lifting the spans into place. These works would infringe the relevant night-time criteria. At the time of detailed design, when the CNVMP is prepared, alternative mitigation such as an offer of temporary relocation may need to be considered for 6, 6A, and 8A Sutherland Road for the nights when works need to be undertaken.

2. SH16 will need to be slightly realigned to the south to allow the busway construction to avoid the new supermarket at Great North Road. The realignment of the traffic lanes will generally be contained within the existing designation. However, the existing noise barrier in the vicinity of 34A Sutherland Street and 12 Novar Place may need to be relocated away from the new traffic lanes. In that case, the barrier will need to be removed and reinstated in close proximity to the dwellings. In addition, night-time works will be required during the works in order to avoid traffic disruption on SH16. The construction noise and vibration effects from these activities will need to be managed with the CNVMP and Schedules, particularly any night-time works. Where night-time works will be undertaken over several nights in close proximity to dwellings, I recommend that temporary relocation is offered to the affected residents.

3. While the busway construction will not disturb basalt layers for virtually its entire alignment, there is a small section in the vicinity of Western Springs and MOTAT where basalt is found. Here, some basalt excavation may be required. This excavation has been minimised by proposing an extended bridge across the basalt. This means that only the bridge piles will need to be constructed in and onto the basalt, requiring vibratory piling in addition to bored piling and some rock extraction using rock breakers. The extent of works is limited, with sensitive receivers (e.g. dwellings) at significant distances (more than 100 metres). Noise levels at these receivers would be well within the daytime noise criterion. The MOTAT buildings are more than 70 metres from the works. At that distance, any vibration levels would be below 2 mm/s PPV and therefore well within any of the amenity and building protection criteria. In any

event, these buildings are heavy commercial buildings that contain for the most part industrial activities that generate vibration in their own right and are therefore not considered vibration sensitive.

4. In the Arch Hill area (approximately from Ivanhoe Road to the busway bridge across SH16), extensive retaining walls will be required. In order to reduce noise levels received from the piling required, I recommend that any piling rigs are located at the SH16 side of the works, below the houses and engines facing towards SH16. With this additional distance and directivity of the main noise source (the diesel engine of the piling rig) away from closest houses, I predict compliance with the relevant noise criteria may be achieved, or infringements will be limited.

Apart from the above specific areas, there are individual buildings that are predicted to receive noise levels up to 80 dB L_{Aeq}. These are located on Great North Road (Point Chevalier), and the noise levels generally affect the back of businesses, where I anticipate there are less noise sensitive uses such as storage. There are also dwellings along Great North Road, Copper Street, Niger Street, King Street and Keppell Street that are predicted to receive construction noise levels up to 80 dB L_{Aeq}, generally where they are closest to the works or where they are elevated above the works and would not receive any shielding by terrain or other structures. Since the works will move along the alignment, I anticipate these worse case noise levels would only occur for brief periods of a few hours rather than consistently. Normal management and mitigation, using temporary barriers where appropriate and good engagement with affected parties, will be the most appropriate response.

Opposite Motions Road is the area of the former Chamberlain Park Golf Course. The Gateway to that site is noted in the Historic Heritage AUP overlay in Schedules 14.1. Its values are noted as historical, physical attributes and context. The Gateway is a stone arch adjacent to Great North Road. It is not considered to be a particularly vibration sensitive building (refer Section 3.1.2) as it was used as an entrance way for vehicles travelling through it in the past, and its walls are of sturdy construction. The roof is of mixed quality with broken tiles. This building would not be affected by construction vibration apart from heavy vehicles passing through the entrance to its west. As long as trucks are driven carefully and the roadway is well maintained, any vibration levels will be well below the 5 mm/s PPF value to protect from any building damage, and likely below 2 mm/s PPV.

The other building on the site is the former clubhouse. This building is not listed in Schedule 14.1 and is a normal building with the lower floor made of stone (similar to the Gateway), and the upper floor having plastered walls that have been repainted several times over its life. This building is also not considered particularly vibration sensitive as it does not contain the characteristics of a sensitive building (e.g. plaster mouldings or stain glass windows). Should paint crack during the construction, this can be fixed and repainted without detracting from the character of the building.

4.3.2 Point Chevalier station

There are two buildings near the Point Chevalier station that have a Historic Heritage AUP overlay in Schedule 14.1. The Ambassador Theatre is within the Proposed Designation, and the ASB which is outside the Proposed Designation. Based on information from the Project's built heritage specialist, both buildings may require application of the "sensitive buildings" vibration criterion of 2.5 mm/s PPV as they both have protruding original plaster mouldings on their façades. In addition, the Ambassador Theatre may also contain internal plaster mouldings that would need to be protected (if it is retained).

The indicative station design would directly affect the Ambassador Theatre with the closest retaining wall immediately abutting the theatre building and part of the building may be directly impacted. Bored piling would occur within 1m of the wall, likely generating vibration levels of 5 mm/s PPV. Should the Theatre be retained, I recommend using the least invasive piling method. This could be press-in piling, which, according to manufacturer's data[1], may generate less than 2 mm/s PPV at distances of less than 3.5m.

Buildings adjacent to the ASB at 1212 to 1216 Great North Road, inside the Proposed Designation, are proposed to be removed for the station. The buildings are not connected to the ASB but have an approximately 0.5m walkway between them, which means that demolition would not directly affect the ASB building. Nevertheless, any demolition will need to be undertaken carefully, reducing vibration from falling debris. Ideally, demolition would occur towards the ASB building, using hydraulic shears rather than concrete breaker attachments, with the last element to be removed the wall adjacent to the building. There should be

[1] Giken F201, e.g. https://www.giken.eu/wp-content/uploads/SilentPiler_F201_T4_ver031en01.pdf

no concrete breaking, pulling down of walls or similar individual high vibration activities. Following the demolition, care must be taken with the compaction of the station forecourt space. I recommend that a small plate compactor is used to manage vibration levels.

For both the Ambassador Theatre and the ASB building, I recommend that building condition surveys be undertaken prior to works commencing, after high vibration works and following completion of the Project, to ensure any damage that is attributable to the Project can be remedied.

4.3.3 Sensitivity testing of Indicative Design

The relatively narrow Proposed Designation makes it impracticable to horizontally shift of the Indicative Design significantly closer to receivers. However, the alignment could be at a different elevation, e.g. the bridge at Western Springs could be constructed at grade or the embankment at Arch Hill could be constructed at a different elevation, requiring higher or lower retaining walls.

Irrespective of potential horizontal or vertical changes to the Indicative Design, the construction noise and vibration effects will remain similar to those assessed as part of the Indicative Design. Any of these effects will be appropriately managed through the CNVMP and, if required, Schedules.

5. Recommended measures to avoid, remedy or mitigate effects

5.1 Construction Noise and Vibration Management Plan

Construction noise and vibration effects will be managed and mitigated using the Best Practicable Option (BPO). Management and mitigation will be applied where there is a risk of the noise or vibration criteria set out in Table 3-1 and Table 3-2 being infringed, and also as a matter of best practice irrespective of compliance.

The most effective way to control construction noise and vibration is through good on-site management and communication between managers and other staff. Management and mitigation measures are most appropriately set out in a CNVMP. The CNVMP should be used to manage works on site and should set out how the construction contractor interacts with the neighbouring affected parties.

The CNVMP will include information set out in Section 8 and Annex E2 of NZS 6803:1999 such as:

- Summary of the Project noise and vibration criteria contained in Section 3.1;
- Summary of assessments and predictions contained in this report, as well as identification of potentially affected persons;
- General construction practices, management and mitigation that will be used for the Project, such as use of specific methodologies and equipment, avoidance of unnecessary noise and common best practice measures, e.g. temporary barriers;
- Noise management and mitigation measures specific to activities and/or receiving environments, particularly for high noise or vibration activities, and any night-time works close to dwellings;
- The vibration trigger levels for building condition surveys to establish the existing building quality;
- Monitoring and reporting requirements;
- Procedures for handling community engagement and complaints;
- Training of staff regarding noise and vibration issues; and
- Procedures for review of the CNVMP throughout the period of Project works.

The mitigation and management measures discussed in the assessment section above would also be included in the CNVMP if they remain appropriate once the detailed design has been undertaken and more detail is known about the construction methodology, equipment and staging of the works.

The CNVMP should be implemented on site for each specific area of work. The CNVMP should be prepared when more detail of Project construction is available, i.e. when a contractor has been engaged.

5.2 Schedules to the CNVMP

In addition, Schedules should be prepared where noise or vibration criteria are predicted to be infringed. The Schedules should be attached to the CNVMP, providing additional information that would sit alongside the general management and mitigation options within the CNVMP.

Schedules are intended to be specific to the activity or receiver they relate to, and should 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 vibration levels towards the Category B criteria.

Schedules are prepared as works progress. While they are produced in a pre-emptive manner, they generally have a somewhat tight turnaround time of a few days, rather than weeks or months. The focus of Schedules is collaborative management of residual construction noise and vibration effects for specific activities and receiver locations, with input from affected receivers.

5.3 Mitigation and management measures

The following general noise mitigation measures will be required to be implemented throughout construction of the Project and will be detailed in the CNVMP. 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 criteria is likely due to a specific construction activity or its location 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 a Schedule as an attachment to the CNVMP.

5.3.1 Communication and consultation

The most important and effective management measure will be 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 detail, to ensure residents have the ability to plan around the works where that is practicable.

5.3.2 Training

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

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

5.3.3 Equipment selection

When selecting construction equipment, the contractor should, 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;
- Choose suitably sized equipment for the proposed task;
- Maintain equipment and fit 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).

5.3.4 Timing of works

Where practicable, I recommend that night-time works are avoided in the vicinity of dwellings. However, where project works affect existing major transport corridors (e.g. during the construction of new bridges across major roads such as SH16 and where SH16 is realigned within the existing designation) where potential closures or limitations are required to construct the projects, 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, weekend and Public Holiday works and within the setback distance for buildings receiving vibration levels meeting or exceeding 1mm/s PPV (Category A for occupied sensitive use buildings).

5.3.5 Noise barriers

Temporary noise barriers should be used where construction noise criteria are 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 6.5kg/m^2;
- a minimum height of 2m, 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.

If traffic noise barriers are recommended, e.g. as recommended in the Assessment of Operational Noise and Vibration Effects report for Royal Road School, these should be installed as early as practicable during construction as they would be effective to also mitigate construction noise.

5.3.6 Alternative mitigation options

Where noise or vibration levels are predicted to exceed relevant criteria by a significant margin (e.g. 5 dB) or for an extended period (e.g. more than two consecutive nights) despite implementation of reasonably practicable noise and vibration mitigation measures noise or vibration levels are predicted to exceed relevant criteria by a significant margin (e.g. 5 dB) 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 these projects.

5.3.7 Building condition surveys

For construction activities close to buildings within the High and Medium Risk zones (refer Section 3.3.2) I recommend that low vibration construction methods be investigated and implemented wherever practicable, with the aim of achieving compliance with the Category A criteria. This may include using bored piling methods, non-vibrating rollers or pre-drilling piles.

However, if low vibration methodologies are not deemed practicable, for dwellings in the High and Medium Risk zones I recommend the following process be implemented before construction commences:

- For buildings in both the High and Medium risk zones, engage with the building owner and occupier to discuss the proposed construction activities and likely vibration effects.
- For buildings in both the High and Medium risk zones, undertake a pre-construction and post-construction building condition survey immediately before and after the works in causing the vibration. This will be required where the proposed construction methodology is predicted to exceed the Category A vibration criteria.
- Monitor vibration levels during the construction activities which are within the High Risk distance (refer Table 3-4).

Detailed management and mitigation options for construction vibration will be contained in the CNVMP and, if required, Schedules.

Follow-up building condition surveys will need to be undertaken at all buildings that had pre-construction building condition surveys.

Additional vibration surveys and 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 was shown to have occurred as a result of Project construction activities, this should be remedied by the contractor.

6. Conclusion

The Project will be constructed adjacent to the existing SH16, a major transport corridor. The busway will be constructed in a manner similar to other large scale transport projects, using large earthmoving and construction machinery that will cause high levels of noise and, potentially, vibration when immediately adjacent to a building.

Both construction noise and vibration criteria can generally be complied with for most works. When construction occurs within approximately 50m of buildings, there is a risk of noise criteria being infringed. Some high noise activities such as rock excavation (in the Western Springs area) or vibratory piling extend this area of influence to about 85m. Where effective noise barriers can be employed, the noise envelope reduces to about 1/3 of these distances, i.e. 16m and 28m respectively.

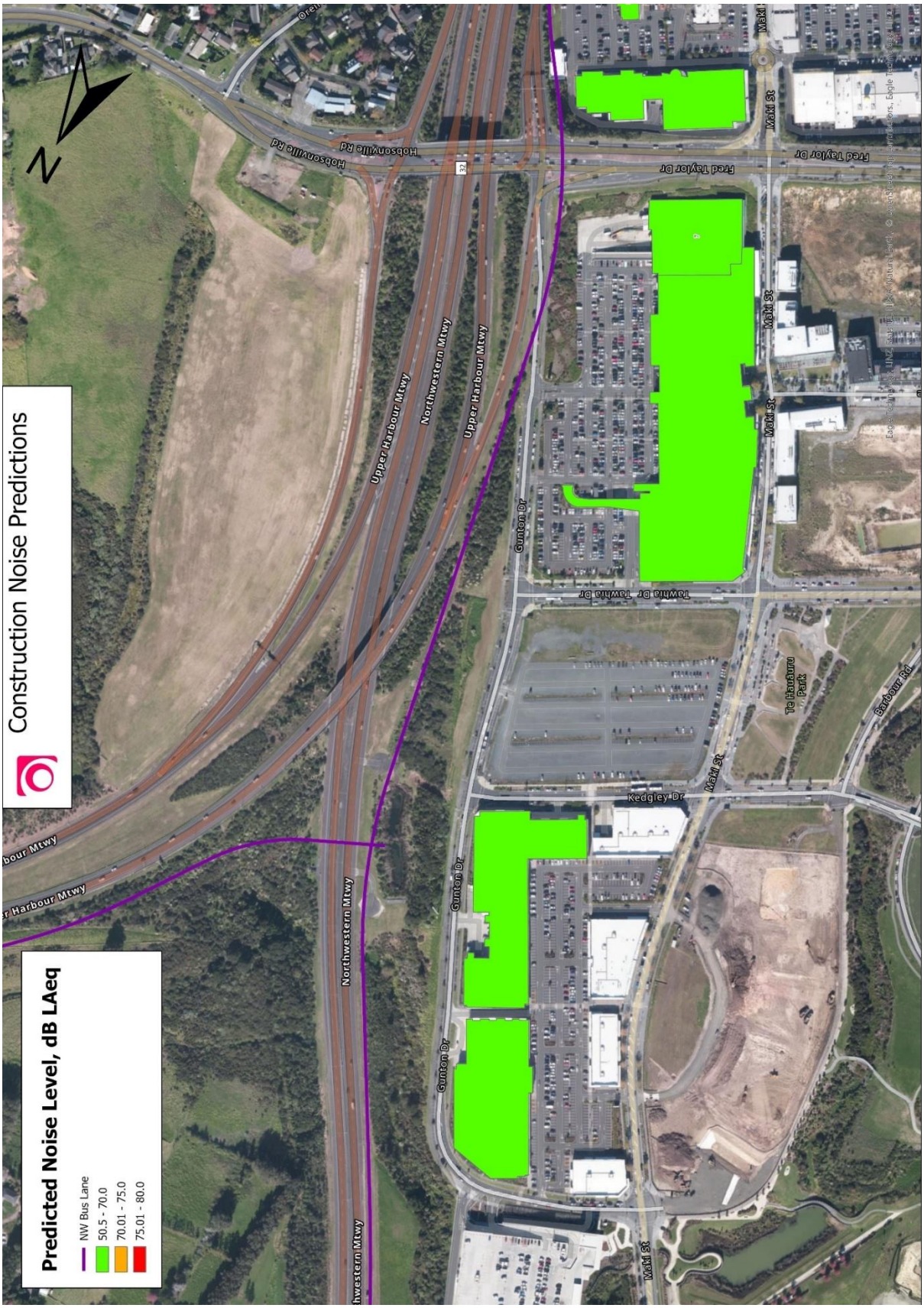
Construction will move along the alignment and therefore, works will only be close to each building for a few days or weeks. Station construction will be somewhat more contained in one location.

High vibration activities will be limited to vibratory rolling for the compaction of the busway when at grade, or where vibratory piling is employed. I recommend that all piling should be bored piling, avoiding high vibration generation.

Overall, any residual noise and vibration effects will be managed through a CNVMP and, where there is a risk of infringement of the noise or vibration criteria, Schedules to the CNVMP. With these documents, proactive and responsive management and mitigation of noise and vibration effects will result in appropriate outcomes that are similar to those of other large infrastructure projects across Auckland and New Zealand.

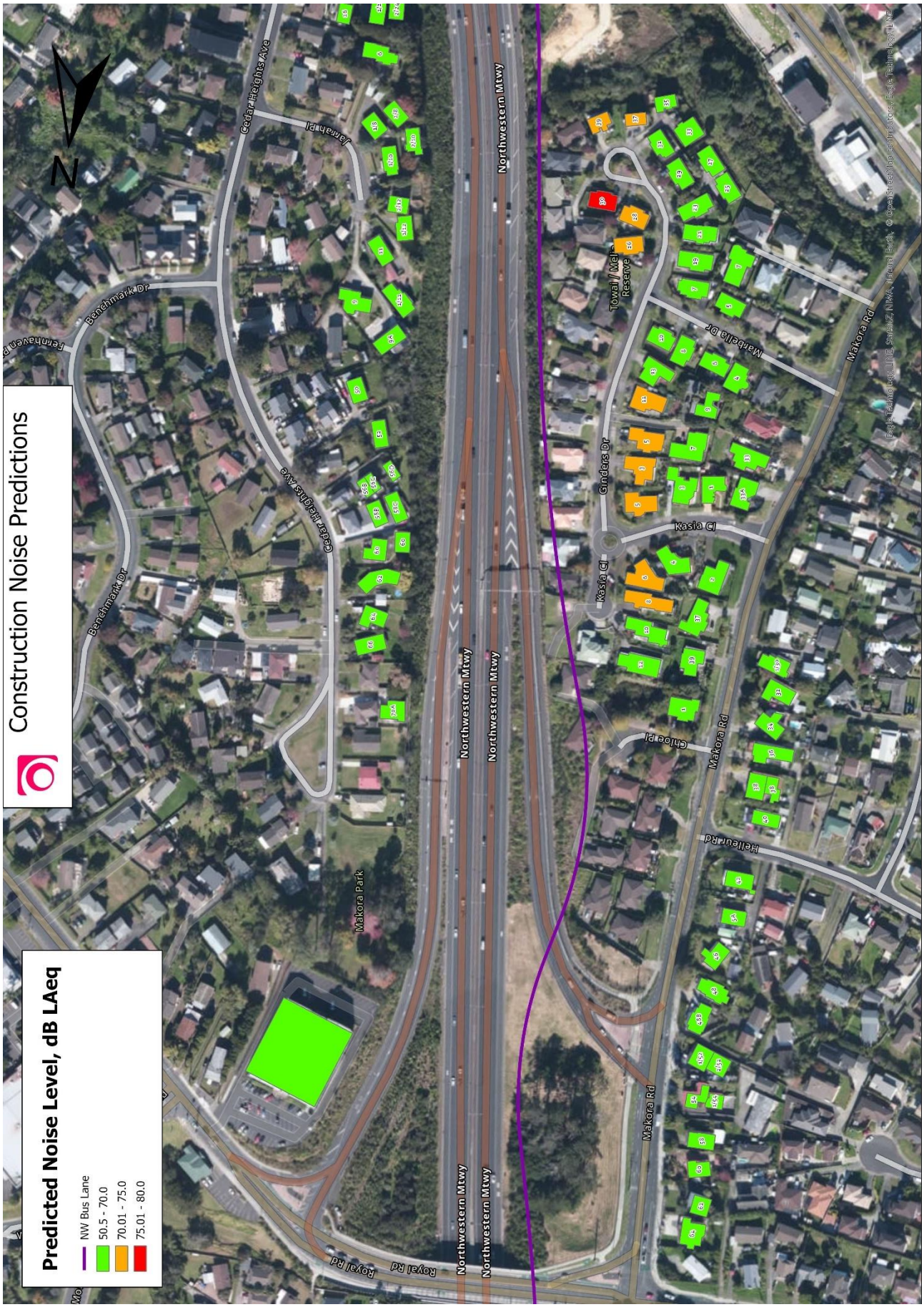
Appendix A. Construction noise indicative predictions

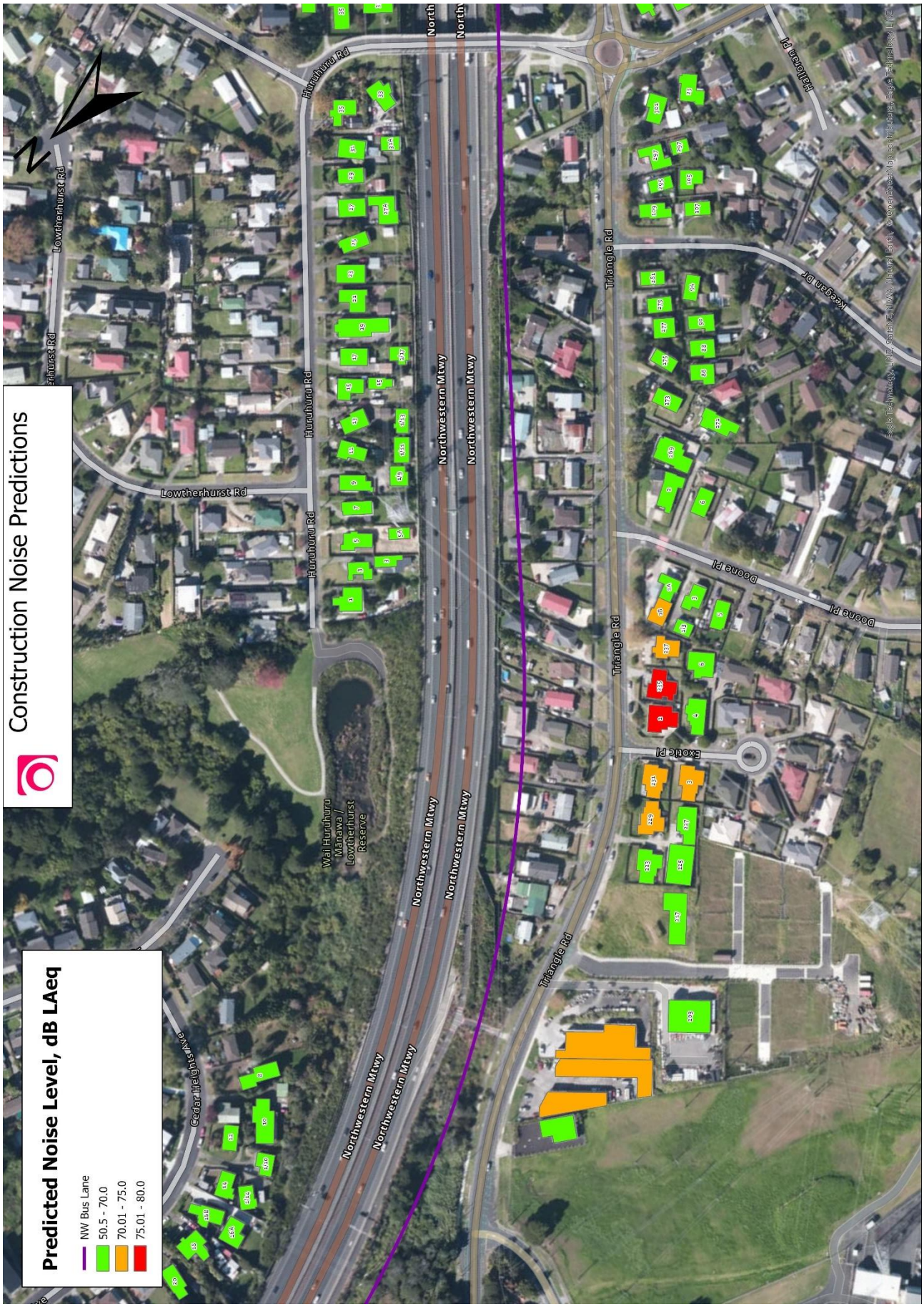
A.1 Earthworks noise levels




Construction Noise Predictions
Predicted Noise Level, dB LAeq
NW Bus Lane
50.5 - 70.0
70.01 - 75.0
75.01 - 80.0
N
Northwestern Mtwy
Upper Harbour Mtwy
Holmes Dr
Miowaka Lane
Cecil Beagecil Beatt Pl
Saint Catherine Cres
Woodburn Pl
Orell Ave
Tihema Lane
Westgate Dr
Pyrite St
Lazurite Dr
Maki St


Construction Noise Predictions
Predicted Noise Level, dB LAeq
NW Bus Lane
50.5 - 70.0
70.01 - 75.0
75.01 - 80.0
N
Holmes Drive S
Landsdale Pl
Luxor Pl
Holmes Drive S
Korokio / Holmes Reserve
Whitshire Mews
Ruze Vida Dr
Ruze Vida Dr
dewynn Dr
Northwestern Mtwy
Northwestern Mtwy
Northwestern Mtwy
Northwestern Mtwy
Northwestern Mtwy
Royal Road School
Bonny Cres
Wharangi / Westgate Drive Park
Westgate Dr
Tileke Lane
Hekerara Way
Kuaha Rd
Arura Pl
Westgate Dr

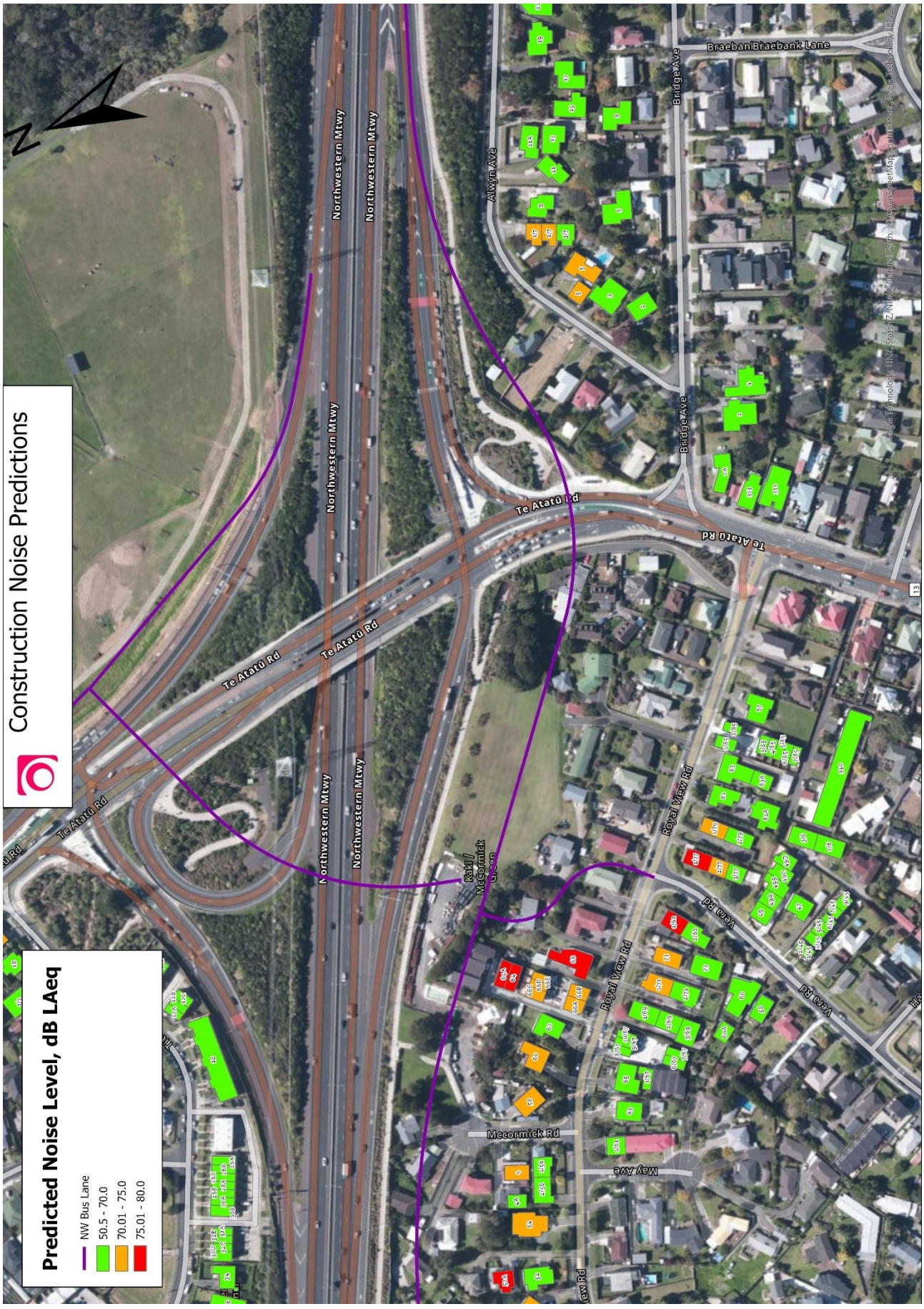

Construction Noise Predictions
Predicted Noise Level, dB LAeq
NW Bus Lane
50.5 - 70.0
70.01 - 75.0
75.01 - 80.0
N
Northwestern Mtwy
Makora Rd
Makora Park
Royal Rd
Benchmark Dr
Cedar Heights Ave
Jarrah Pl
Towai / Mel Reserve
Marbella Dr
Cinders Dr
Kasia Cl
Chloe Pl
Hellieur Rd


Construction Noise Predictions
Predicted Noise Level, dB LAeq
NW Bus Lane
50.5 - 70.0
70.01 - 75.0
75.01 - 80.0
Hūrūhuru Rd
Lowtherhurst Rd
Northwestern Mtwy
Triangle Rd
Keegan Dr
Boone Pl
Exotic Pl
Hilloran Pl
Wai Hūrūhuru Manawa / Lowtherhurst Reserve
Cedar Heights Ave


Construction Noise Predictions
Predicted Noise Level, dB LAeq
NW Bus Lane
50.5 - 70.0
70.01 - 75.0
75.01 - 80.0
Northwestern Mtwy
Hurūhuru Rd
Hurūhuru Esplanade
Triangle Rd
Waimumu Rd
Kopi Pl
Heliotrain Pl
Kererān Dr
Lowther Hurst Rd


Construction Noise Predictions
Predicted Noise Level, dB LAeq
NW Bus Lane
50.5 - 70.0
70.01 - 75.0
75.01 - 80.0
Northwestern Mtwy
Tony St
Central Park Dr
The Concourse
Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors, Eagle Technology, LINZ


Construction Noise Predictions
Predicted Noise Level, dB LAeq
NW Bus Lane
50.5 - 70.0
70.01 - 75.0
75.01 - 80.0
Karamu St
Tiaki St
Northwestern Mtwy
Jack Colvin Park
May Ave
Royal View Pde
Matai Tce
Royal View Rd
Parkon Ave
Marewa St
Flanshaw Rd


Construction Noise Predictions
Predicted Noise Level, dB LAeq
NW Bus Lane
50.5 - 70.0
70.01 - 75.0
75.01 - 80.0
Northwestern Mtwy
Te Atatū Rd
Braeban
Braebank Lane
Bridge Ave
Alwyn Ave
Royal View Rd
Vera Rd
Mccormick Rd
May Ave
Kaki / Mccormick Green


Construction Noise Predictions
Predicted Noise Level, dB LAeq
NW Bus Lane
50.5 - 70.0
70.01 - 75.0
75.01 - 80.0
Te Atatū Rd
Old Te Atatū Rd
Hataui Way
Karamu St
Tioriori St
Titoki St
Rutherford Primary School
Jack Colvin Park


Construction Noise Predictions
Predicted Noise Level, dB LAeq
NW Bus Lane
50.5 - 70.0
70.01 - 75.0
75.01 - 80.0
Northwestern Mtwy
Bridge Ave
Te Pae Kawau / Bridge Avenue Reserve
Braeban/Braebank Lane
Alwyn Ave
Te Atatū Rd

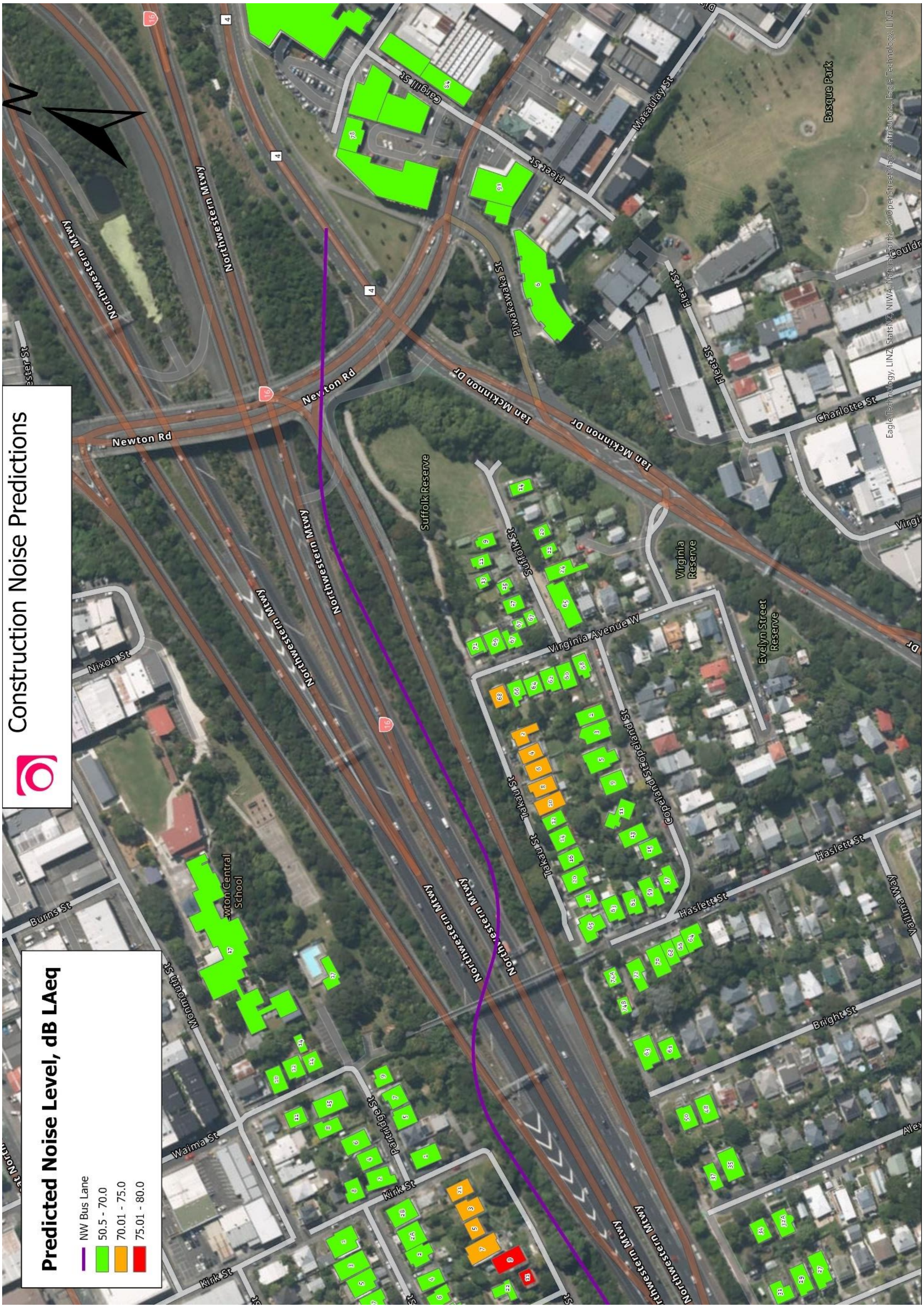

Construction Noise Predictions
Predicted Noise Level, dB LAeq
NW Bus Lane
50.5 - 70.0
70.01 - 75.0
75.01 - 80.0
Great North Rd
Northwestern Mtwy
Kiwi Rd
Parr Rd N
Sutherland Rd
Carrington Rd
Montrose St
Te Ara Pl
Novar Pl


Construction Noise Predictions
Predicted Noise Level, dB LAeq
NW Bus Lane
50.5 - 70.0
70.01 - 75.0
75.01 - 80.0
Great North Rd
Northwestern Mtwy
Western Springs Gardens
Premier Ave
Manor Pl
Motions Rd
Novar Pl
The Rumpus Room
Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors, Eagle Technology, LINZ

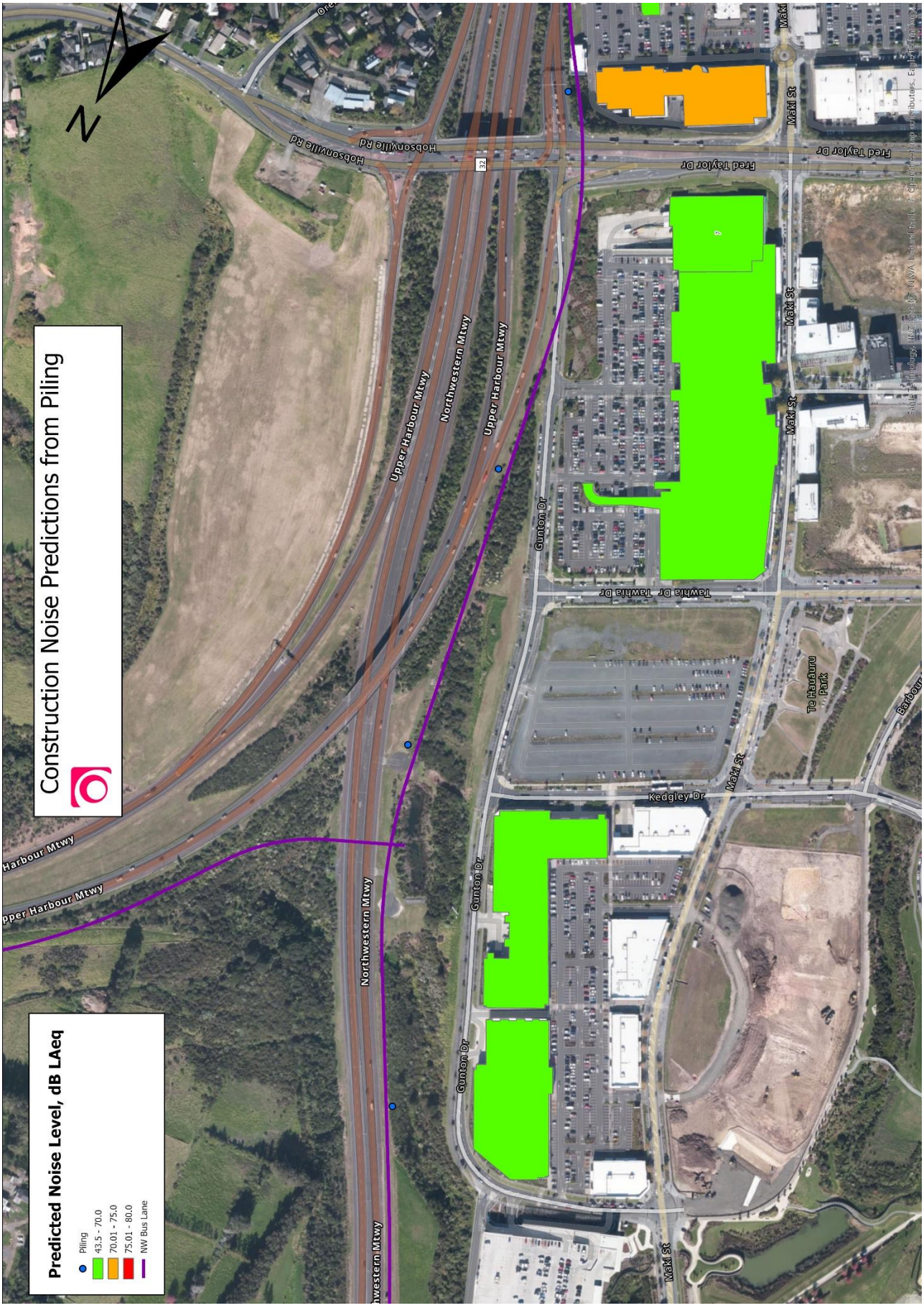

Construction Noise Predictions
Predicted Noise Level, dB LAeq
NW Bus Lane
50.5 - 70.0
70.01 - 75.0
75.01 - 80.0
Great North Rd
Tuarangi Rd
Ivanhoe Rd
Wexford Rd
Stadium Rd
Northwestern Mtwy
Mountain View Rd
Levonia St
Myrtle St
Ryde St
Cardigan St
Bannerman Rd
Western Springs Rd


Construction Noise Predictions
Predicted Noise Level, dB LAeq
NW Bus Lane
50.5 - 70.0
70.01 - 75.0
75.01 - 80.0
N
Great North Rd
Saint Joseph's School
Northwestern Mtwy
Fourth Ave
School Rd
Arch Hill Scenic Reserve
Don Croot St
Tay St
Ronal Ave
Ivanhoe Rd
Finch St
Shirley Rd
Levonia St
Mountain View Rd

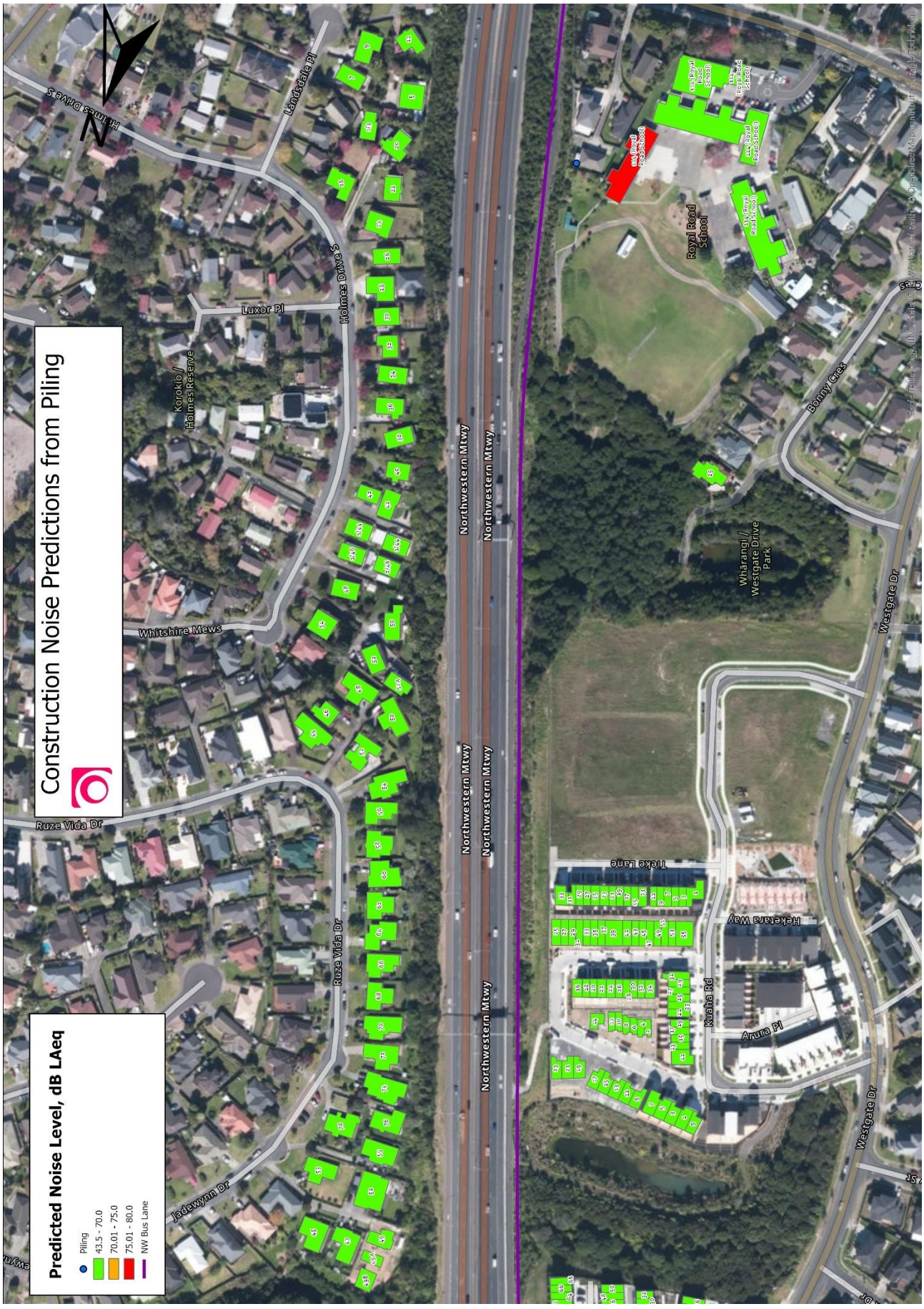

Construction Noise Predictions
Predicted Noise Level, dB LAeq
NW Bus Lane
50.5 - 70.0
70.01 - 75.0
75.01 - 80.0
Potatau St
Dean St
King St
Home St
Keppel St
Kindercare
Home Reserve
Nigel Ter
Bond St
Cooper St
Cooper Reserve
Seddon St
Commercial Rd
Northwestern Mtwy
Mostyn St
Richbourne St
Hesketh St
Aitken Tce
New Bond
Nixon Park
Central Rd
Fourth Ave
Third Ave

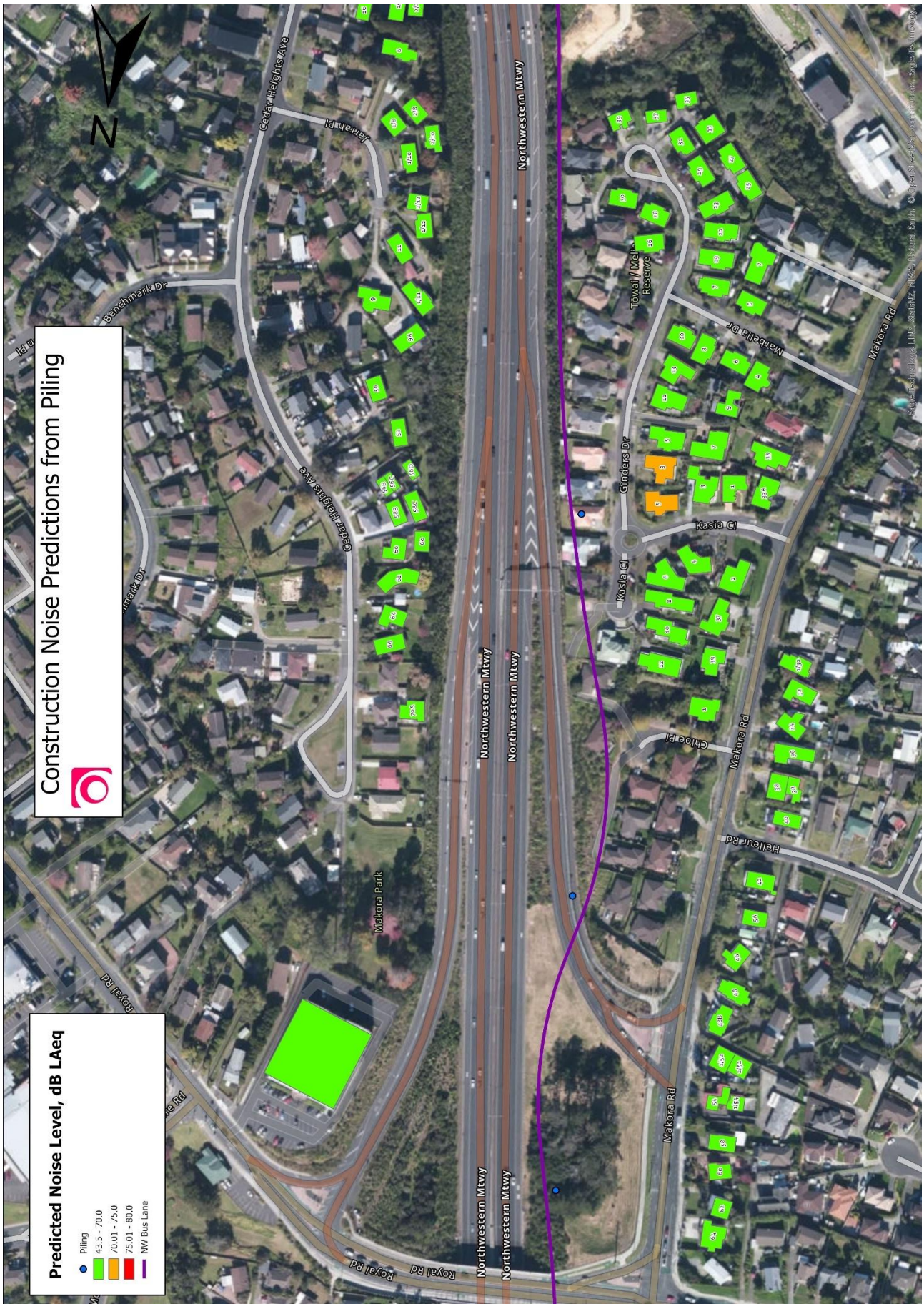

Construction Noise Predictions
Predicted Noise Level, dB LAeq
NW Bus Lane
50.5 - 70.0
70.01 - 75.0
75.01 - 80.0
Newton Rd
Ian McKinnon Dr
Northwestern Mtwy
Cargill St
Fleet St
Macaulay St
Basque Park
Piwakawaka St
Suffolk Reserve
Suffolk St
Virginia Reserve
Virginia Avenue W
Evelyn Street Reserve
Charlotte St
Copeland St
Takau St
Haslett St
Bright St
Nixon St
Burns St
Monmouth St
Walma St
Kirk St
Partridge St
Vallima Way

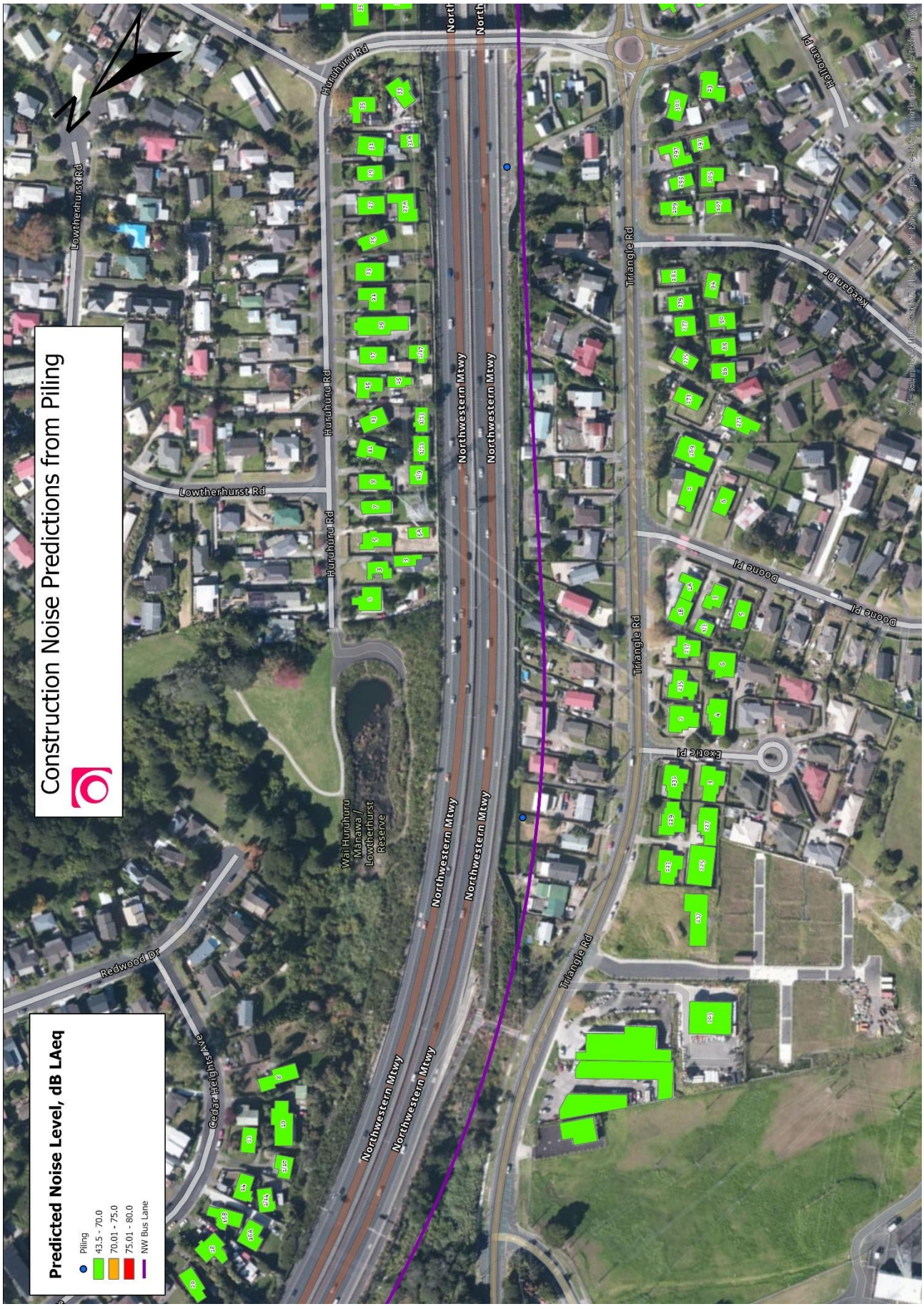
A.2 Piling noise levels




Construction Noise Predictions from Piling
Predicted Noise Level, dB LAeq
Piling
43.5 - 70.0
70.01 - 75.0
75.01 - 80.0
NW Bus Lane
N
Northwestern Mtwy
Upper Harbour Mtwy
Holmes Dr
Miowera Lane
Cecil Bea Cecil Beach Pl
Saint Catherine Cres
Woolcombe Pl
Orcell Ave
Tihama Lane
Westgate Dr
Pyrite St
Lazurite Dr
Maki St


Construction Noise Predictions from Piling
Predicted Noise Level, dB LAeq
Piling
43.5 - 70.0
70.01 - 75.0
75.01 - 80.0
NW Bus Lane
N
Holmes Drive S
Landsdale Pl
Luxor Pl
Karokio / Holmes Reserve
Whitshire Mews
Ruze Vida Dr
Jadewynn Dr
Northwestern Mtwy
Royal Reed School
Bonny Cres
Whārangi / Westgate Drive Park
Westgate Dr
Tleke Lane
Hekeiara Way
Kuaha Rd
Aruru Pl

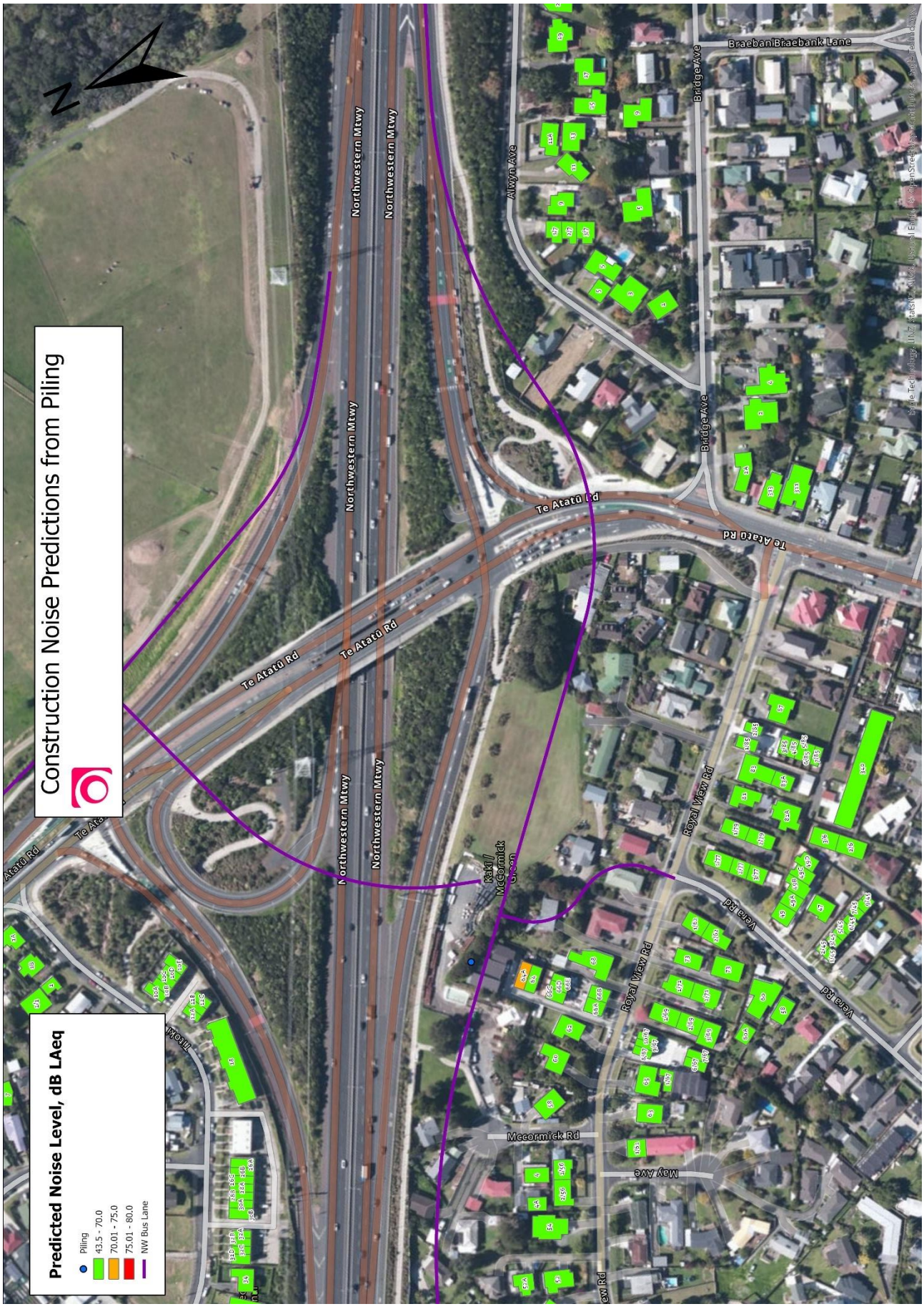

Construction Noise Predictions from Piling
Predicted Noise Level, dB LAeq
Piling
43.5 - 70.0
70.01 - 75.0
75.01 - 80.0
NW Bus Lane
N
Northwestern Mtwy
Royal Rd
Makora Park
Makora Rd
Cedar Heights Ave
Benchmark Dr
Jamah Pl
Tovai / Mehi Reserve
Marbella Dr
Ginders Dr
Kasia Cl
Chloe Pl
Hellaur Rd


Construction Noise Predictions from Piling
Predicted Noise Level, dB LAeq
Piling
43.5 - 70.0
70.01 - 75.0
75.01 - 80.0
NW Bus Lane
Hūruhuru Rd
Lowtherhurst Rd
Northwestern Mtwy
Triangle Rd
Boone Pl
Exotic Pl
Keegan Dr
Redwood Dr
Cedar Heights Ave
Wai Hūruhuru Manawa / Lowtherhurst Reserve


Construction Noise Predictions from Piling
Predicted Noise Level, dB LAeq
Piling
43.5 - 70.0
70.01 - 75.0
75.01 - 80.0
NW Bus Lane
Northwestern Mtwy
Hurūhurū Esplanade
Triangle Rd
Waimumu Rd
Hūhurū Rd
Kopi Pl
Hāmoana Pl
Keegan Dr


Construction Noise Predictions from Piling
Predicted Noise Level, dB LAeq
Piling
43.5 - 70.0
70.01 - 75.0
75.01 - 80.0
NW Bus Lane
Northwestern Mtwy
Tony St
Central Park Dr
The Concourse


Construction Noise Predictions from Piling
Predicted Noise Level, dB LAeq
Piling
43.5 - 70.0
70.01 - 75.0
75.01 - 80.0
NW Bus Lane
Karamu St
Titoki St
Northwestern Mtwy
Jack Colvin Park
May Ave
Royal View Rd
Millen Tce
Patoa Ave
Marewa St
Flanshaw Rd


Construction Noise Predictions from Piling
Predicted Noise Level, dB LAeq
Piling
43.5 - 70.0
70.01 - 75.0
75.01 - 80.0
NW Bus Lane
Northwestern Mtwy
Te Atatū Rd
Bridge Ave
Alwyn Ave
Braebani Braebank Lane
Royal View Rd
Vera Rd
Mccormick Rd
May Ave


Construction Noise Predictions from Piling
Predicted Noise Level, dB LAeq
Piling
43.5 - 70.0
70.01 - 75.0
75.01 - 80.0
NW Bus Lane
Te Atatū Rd
Tateu Way
Old Te Atatū Rd
Karamu St
Tiroki St
Rutherford Primary School
Jack Colvin Park


Construction Noise Predictions from Piling
Predicted Noise Level, dB LAeq
Piling
43.5 - 70.0
70.01 - 75.0
75.01 - 80.0
NW Bus Lane
Northwestern Mtwy
Bridge Ave
Te Pae Kawau / Bridge Avenue Reserve
Braebank Lane
Alwyn Ave
Te Atatū Rd

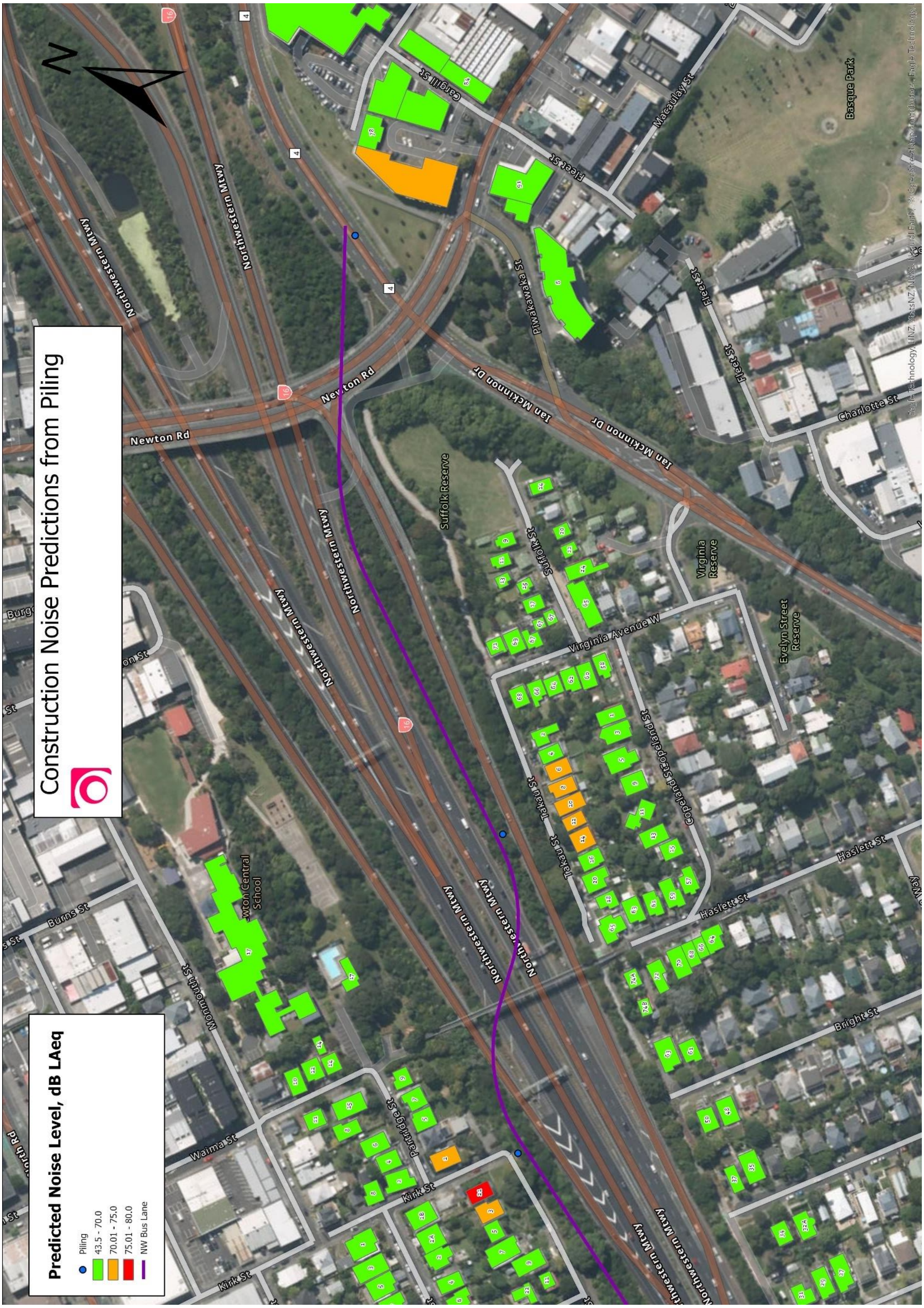

Construction Noise Predictions from Piling
Predicted Noise Level, dB LAeq
Piling
43.5 - 70.0
70.01 - 75.0
75.01 - 80.0
NW Bus Lane
Walmer Rd
Great North Rd
Northwestern Mtwy
Nova Pl
Sutherland Rd
Penny Louis Grn
Parr Rd N
Carrington Rd
Te Ara
Te Ara Pokai
Montrose St


Construction Noise Predictions from Piling
Predicted Noise Level, dB LAeq
Piling
43.5 - 70.0
70.01 - 75.0
75.01 - 80.0
NW Bus Lane
Great North Rd
Northwestern Mtwy
Western Springs Gardens
Motions Rd
Manor Pl
Premier Ave
The Rumpus Room
Novar Pl

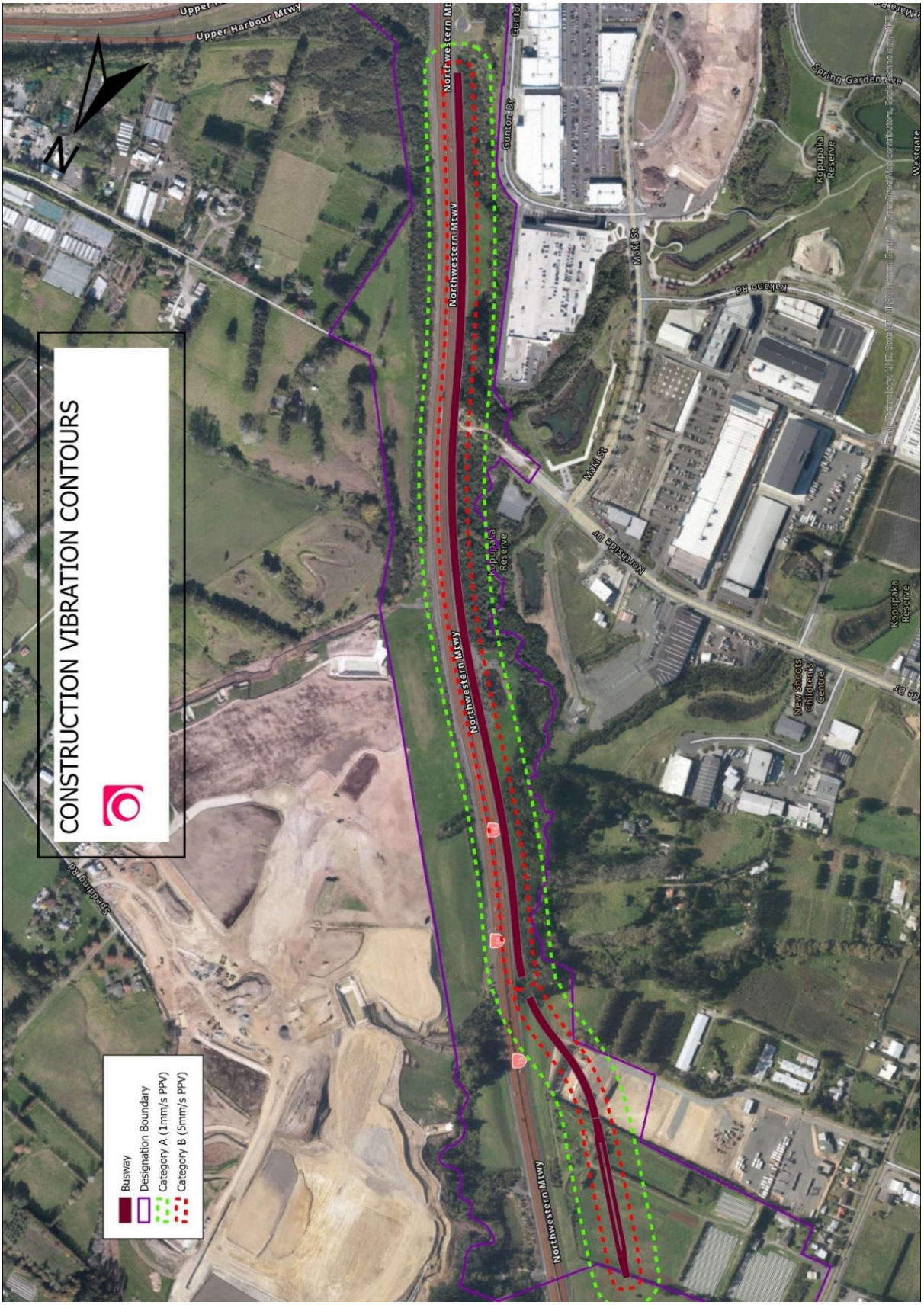

Construction Noise Predictions from Piling
Predicted Noise Level, dB LAeq
Piling
43.5 - 70.0
70.01 - 75.0
75.01 - 80.0
NW Bus Lane
Great North Rd
Stadium Rd
Tuarangi Rd
Ivanhoe Rd
Wexford Rd
Northwestern Mtwy
Mountain View Rd
Myrtle St
Ryde St
Cardigan St
Bannerman Rd
Western Springs Rd

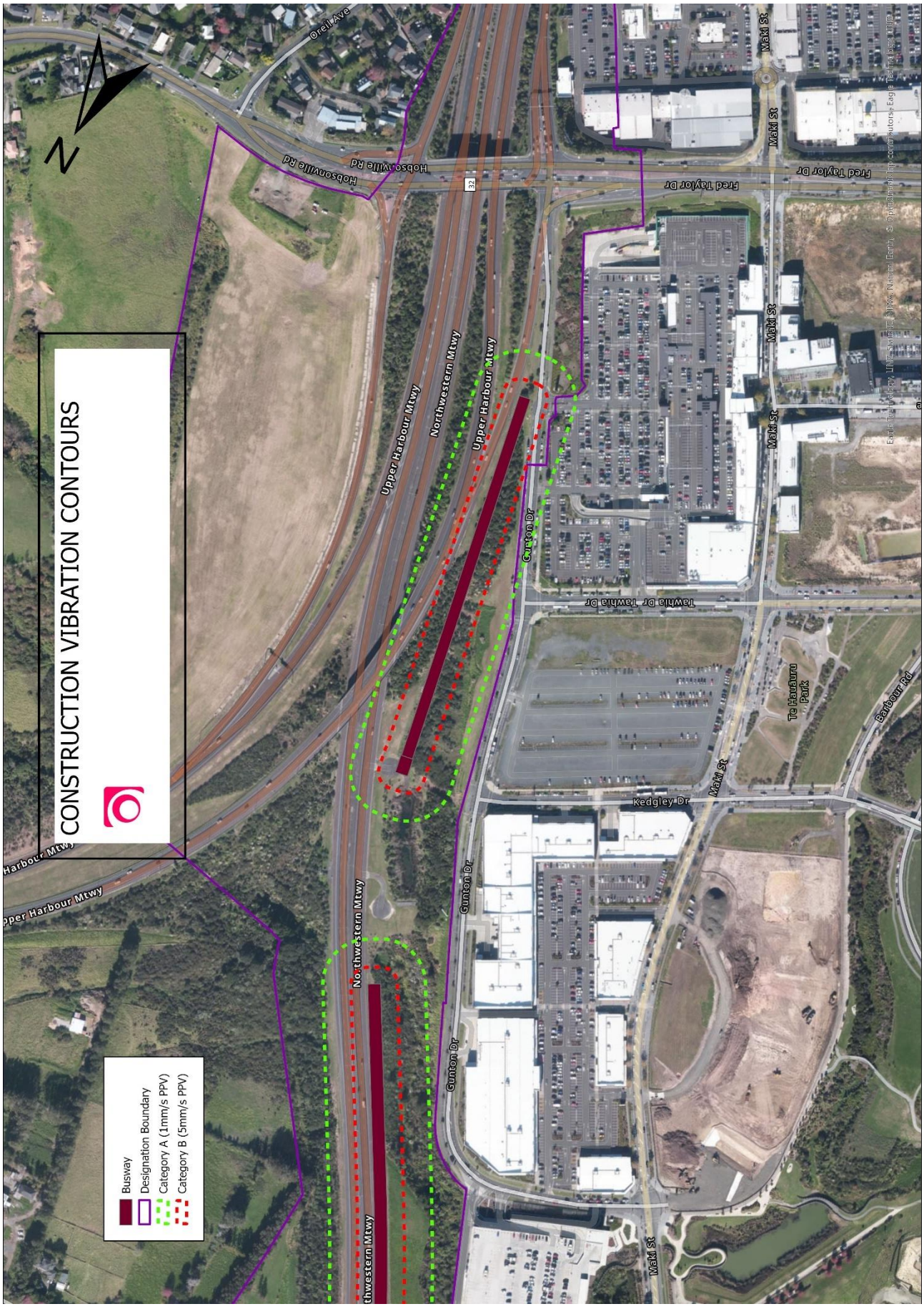

Construction Noise Predictions from Piling
Predicted Noise Level, dB LAeq
Piling
43.5 - 70.0
70.01 - 75.0
75.01 - 80.0
NW Bus Lane
Northwestern Mtwy
Great North Rd
Saint Joseph's School
Arch Hill Scenic Reserve
Fourth Ave
School Rd
Don Croot St
Finch St
Tay St
Ivanhoe Rd
Rona Ave
Herringson Ave
Shirley Rd
Levonia St
Mountain View Rd

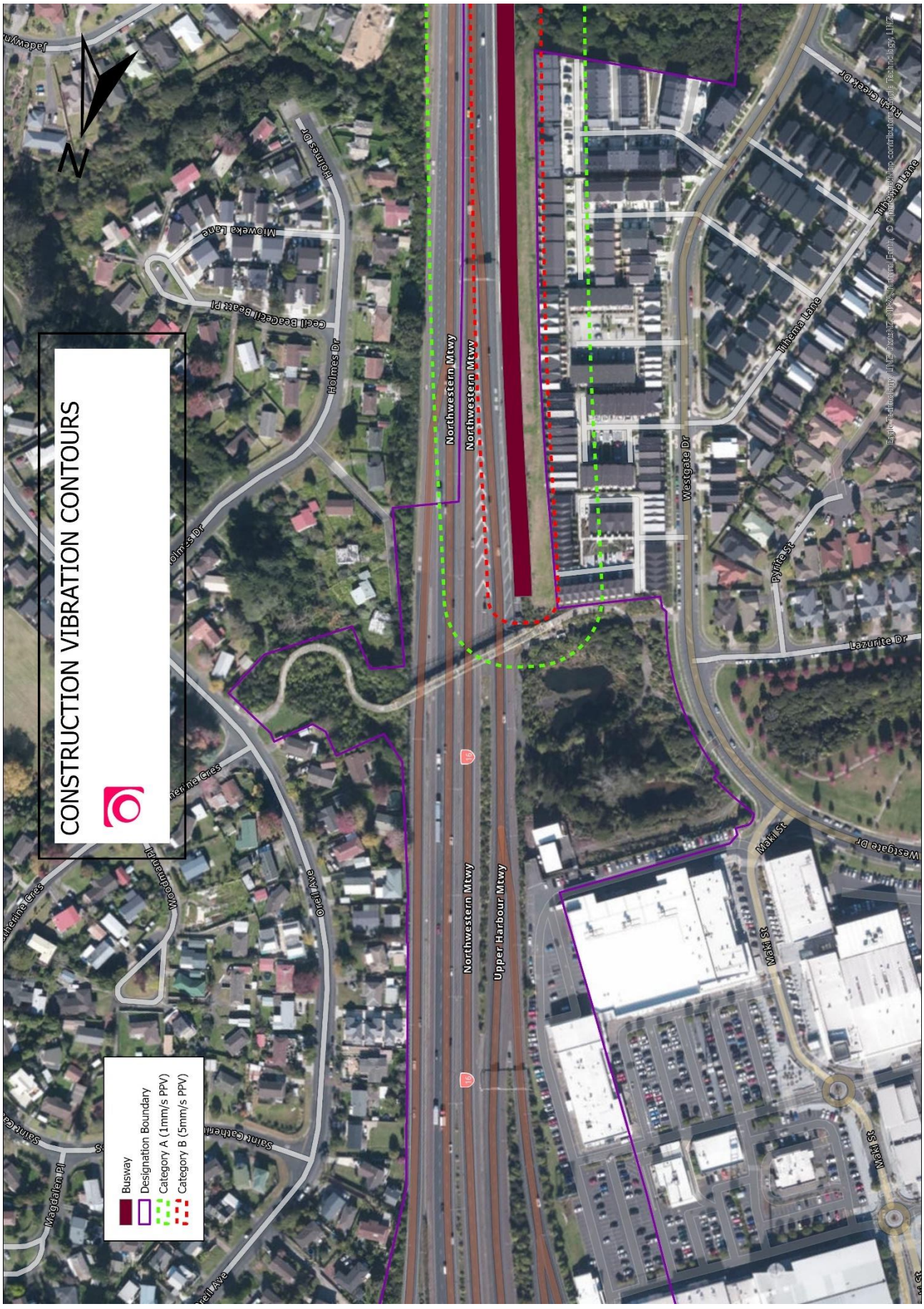

Construction Noise Predictions from Piling
Predicted Noise Level, dB LAeq
Piling
43.5 - 70.0
70.01 - 75.0
75.01 - 80.0
NW Bus Lane
Auckland Army Centre
Potatau St
Dean St
Home St
Keppell St
Mostyn St
Richbourne St
Hesketh St
King St
Kindercare
Home Reserve
Nigel Ster St
Bond St
Cooper St
Cooper Reserve
Seddon St
Commercial Rd
Nixon Park
Central Rd
Fourth Ave
Third Ave
Northwestern Mtwy

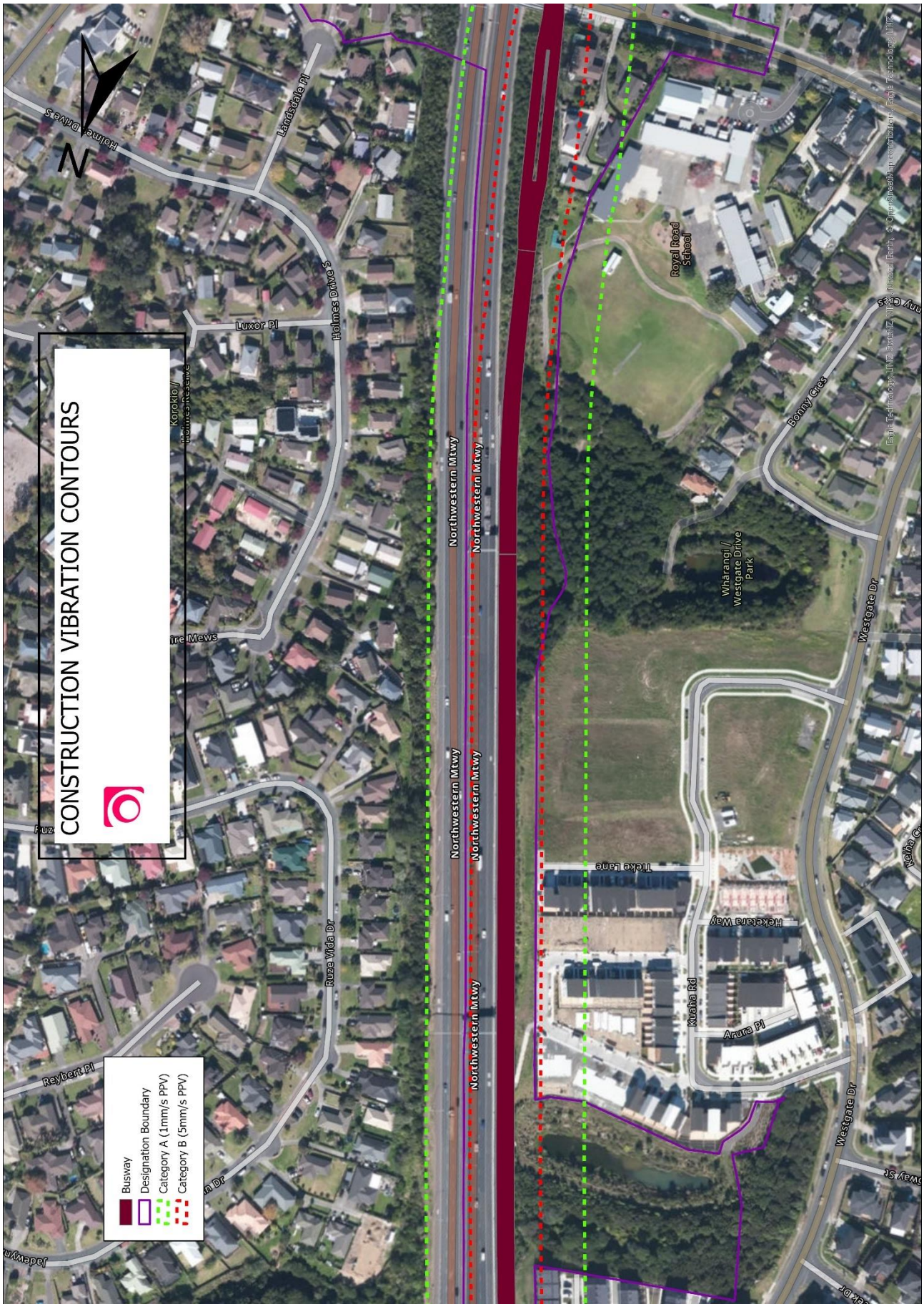

Construction Noise Predictions from Piling
Predicted Noise Level, dB LAeq
Piling
43.5 - 70.0
70.01 - 75.0
75.01 - 80.0
NW Bus Lane
Northwestern Mtwy
Newton Rd
Ian Mckinnon Dr
Suffolk Reserve
Suffolk St
Virginia Avenue W
Virginia Reserve
Evelyn Street Reserve
Copeland St
Takau St
Haslett St
Bright St
Charlotte St
Fleet St
Macaulay St
Basque Park
Cargill St
Piwakawaka St
Monmouth St
Burns St
Waima St
Partridge St
Kirk St

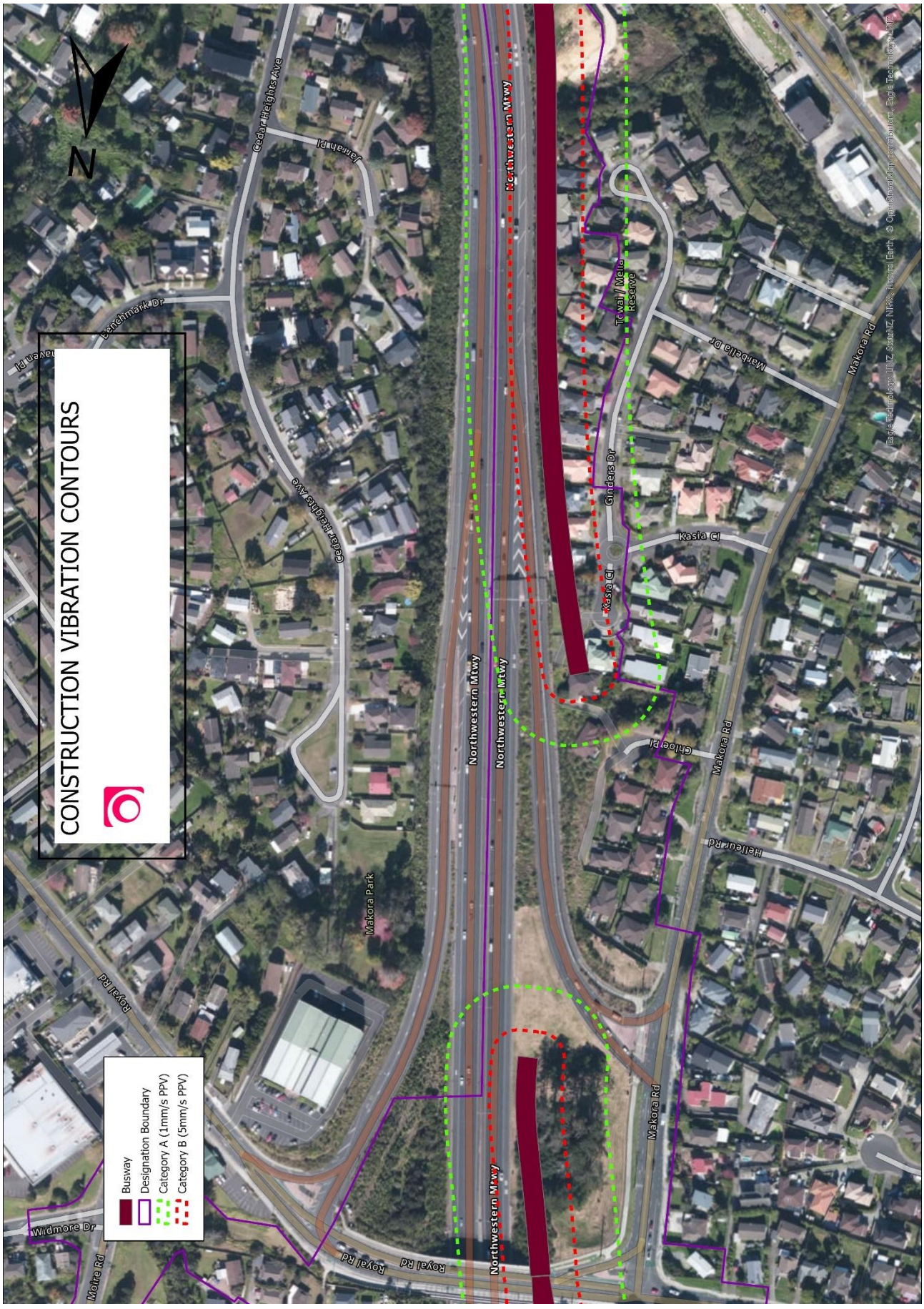
Appendix B. Construction vibration indicative predictions (based on vibro rollers compacting along the alignment)

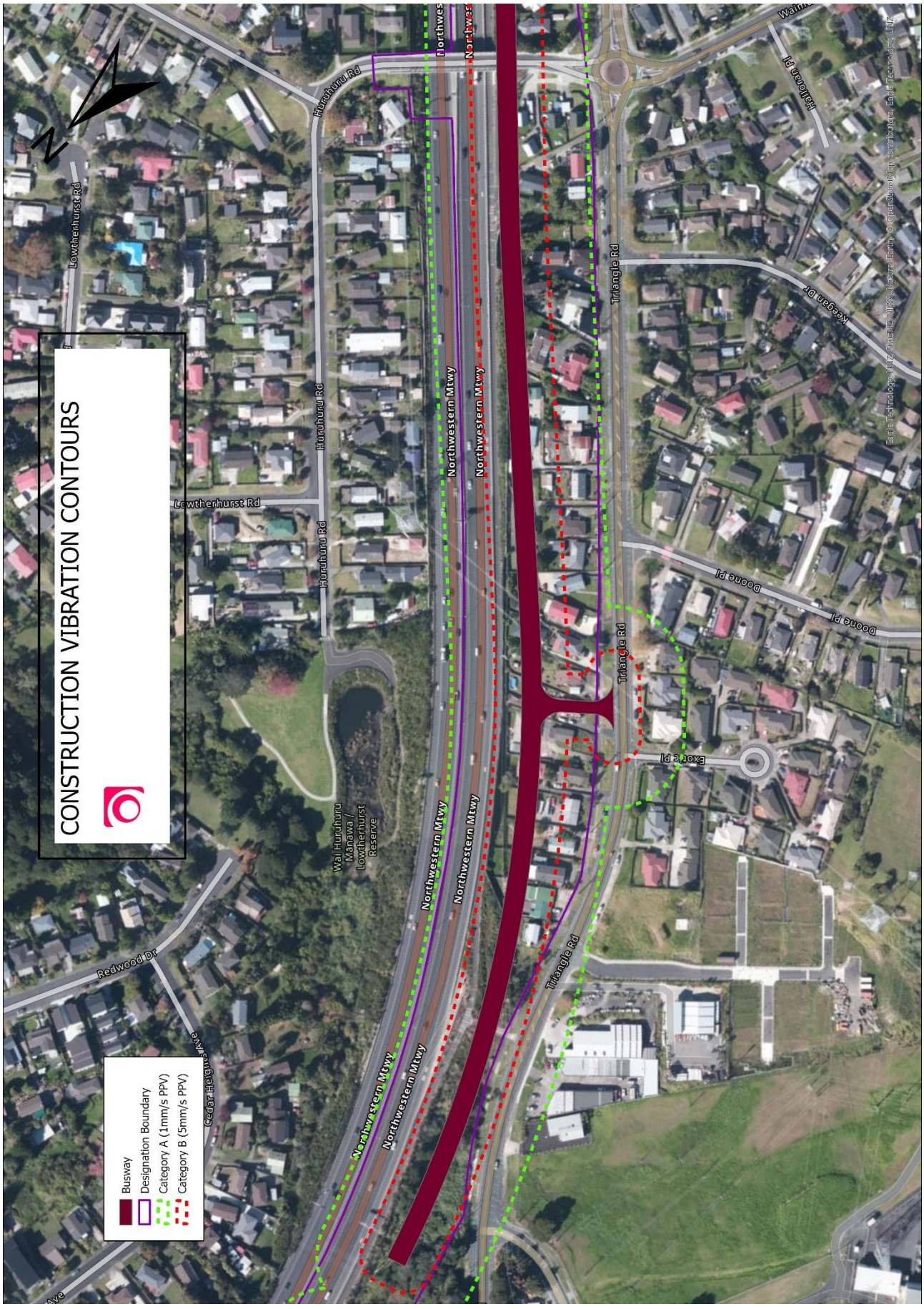


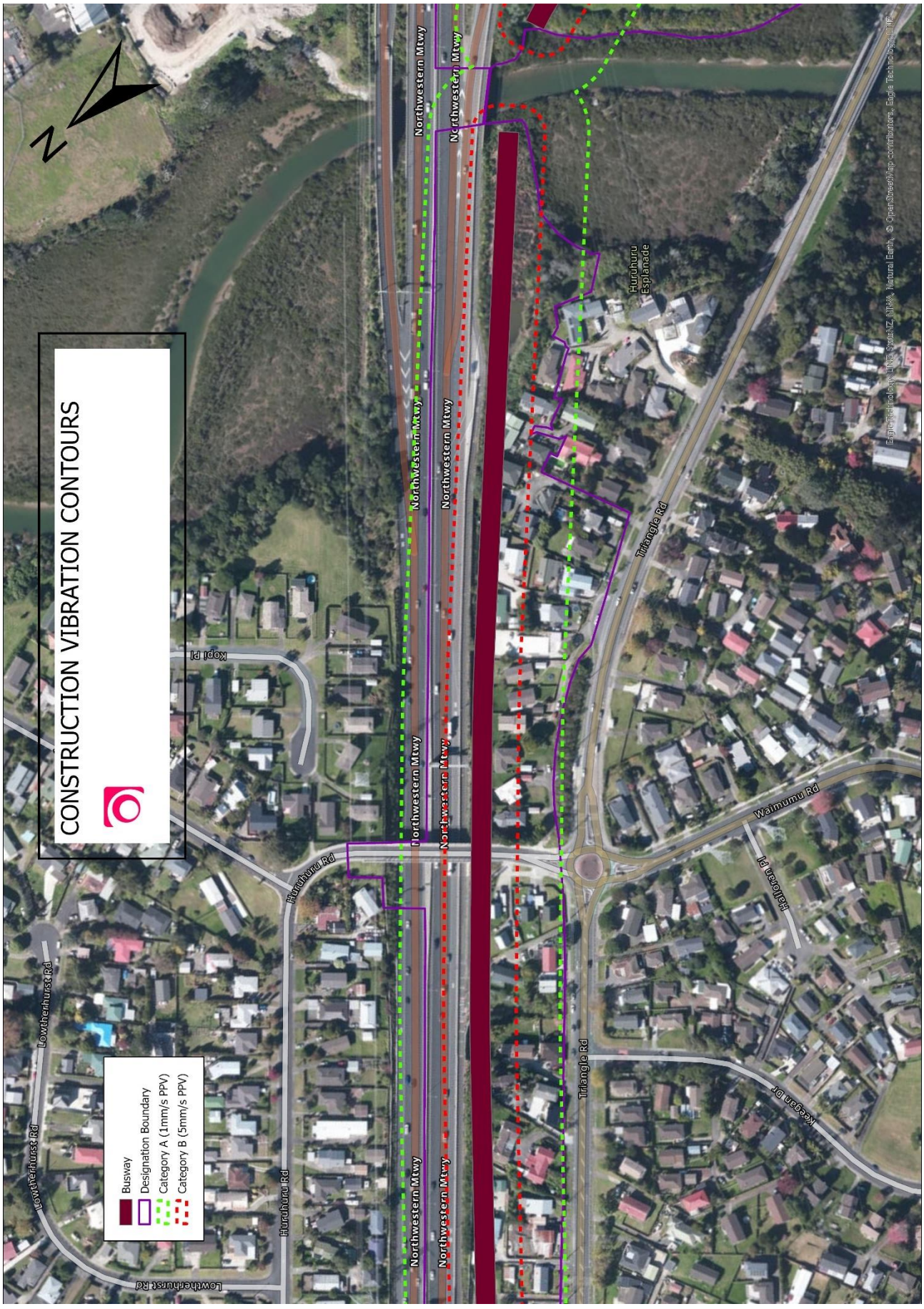

CONSTRUCTION VIBRATION CONTOURS
Busway
Designation Boundary
Category A (1mm/s PPV)
Category B (5mm/s PPV)
Orel Ave
Hobsonville Rd
Fred Taylor Dr
Maki St
Upper Harbour Mtwy
Northwestern Mtwy
Gunton Dr
Tawhia Dr
Te Haurāuru Park
Barbour Rd
Kedgley Dr


CONSTRUCTION VIBRATION CONTOURS
Busway
Designation Boundary
Category A (1mm/s PPV)
Category B (5mm/s PPV)
N
Holmes Dr
Cecil Beagrie Beatt Pl
Northwestern Mtwy
Upper Harbour Mtwy
Westgate Dr
Tihema Lane
Pyrite St
Lazurite Dr
Maki St
Orrell Ave
Magdalen Pl

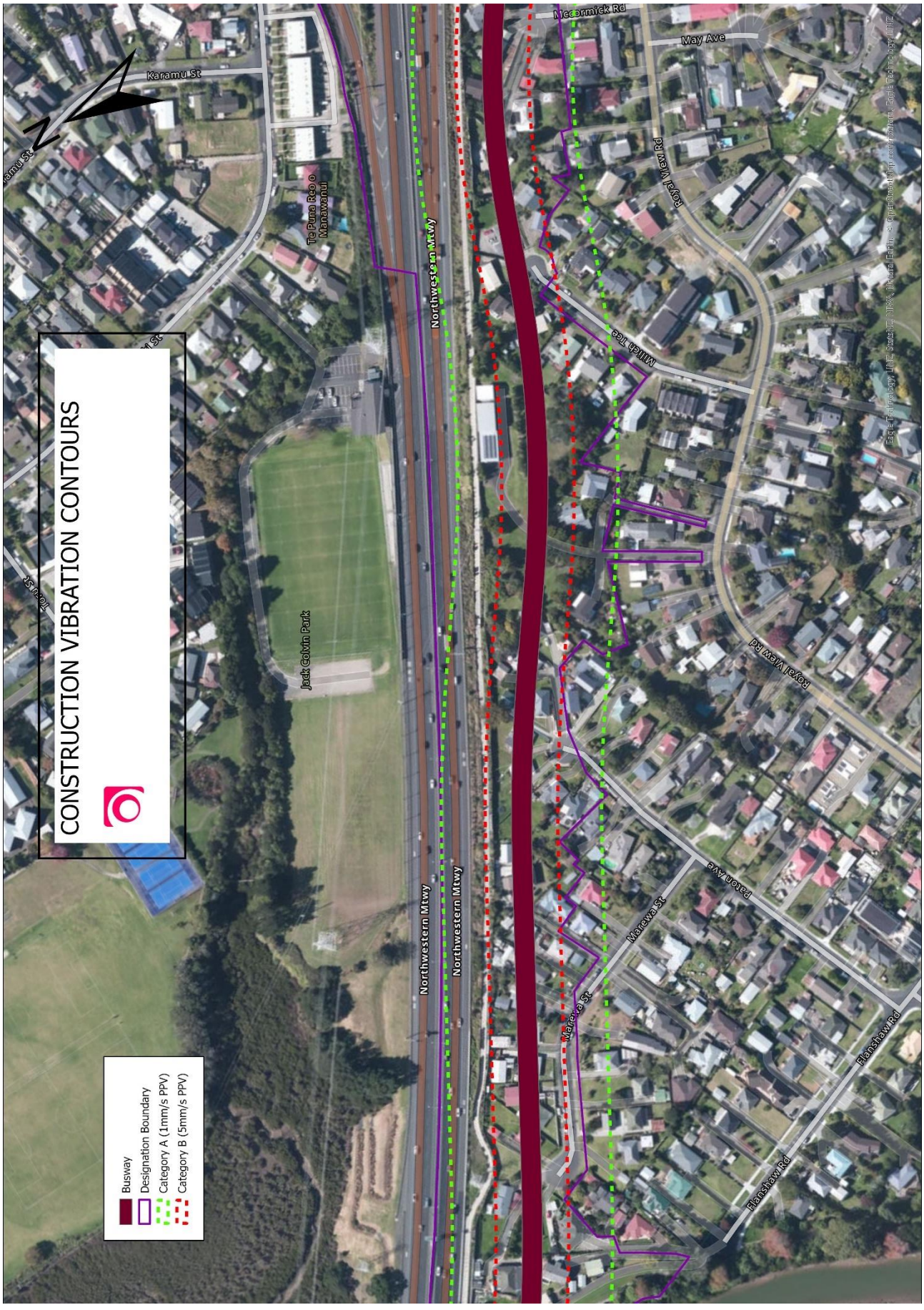

CONSTRUCTION VIBRATION CONTOURS
Busway
Designation Boundary
Category A (1mm/s PPV)
Category B (5mm/s PPV)
N
Holmes Drive S
Landsdale Pl
Luxor Pl
Korokio / Holmes Reserve
Northwestern Mtwy
Royal Road School
Bonny Cres
Whārangi / Westgate Drive Park
Westgate Dr
Tleke Lane
Hoekerara Way
Kuaha Rd
Aruna Pl
Ruze Vida Dr
Reybert Pl

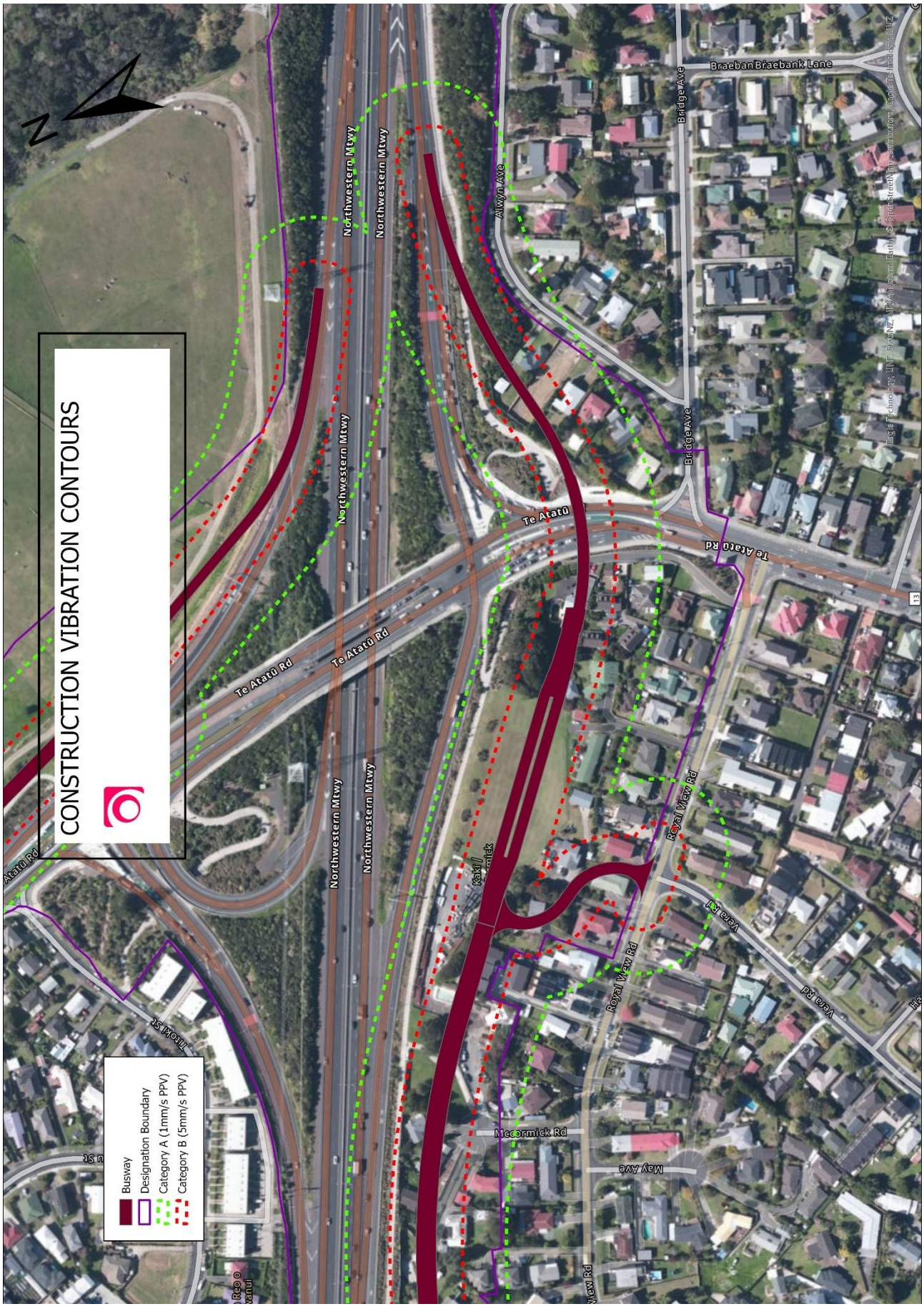

CONSTRUCTION VIBRATION CONTOURS
Busway
Designation Boundary
Category A (1mm/s PPV)
Category B (5mm/s PPV)
N
Cedar Heights Ave
Jarrah Pl
Benchmark Dr
Northwestern Mtwy
Te Wai / Mello Reserve
Merbella Dr
Makora Rd
Ginders Dr
Kasia Cl
Chloe Pl
Hellieur Rd
Makora Park
Royal Rd
Widmore Dr
Moira Rd


CONSTRUCTION VIBRATION CONTOURS
Busway
Designation Boundary
Category A (1mm/s PPV)
Category B (5mm/s PPV)
Hurunui Rd
Lowtherhurst Rd
Northwestern Mtwy
Triangle Rd
Keegan Dr
Doone Pl
Exeter Pl
Redwood Dr
Wai Hurunui Manawa / Lowtherhurst Reserve


CONSTRUCTION VIBRATION CONTOURS
Busway
Designation Boundary
Category A (1mm/s PPV)
Category B (5mm/s PPV)
Northwestern Mtwy
Huruhuru Esplanade
Triangle Rd
Waimumu Rd
Huruhuru Rd
Lowtherhurst Rd
Kopi Pl
Heliotrop Pl
Keegan Dr

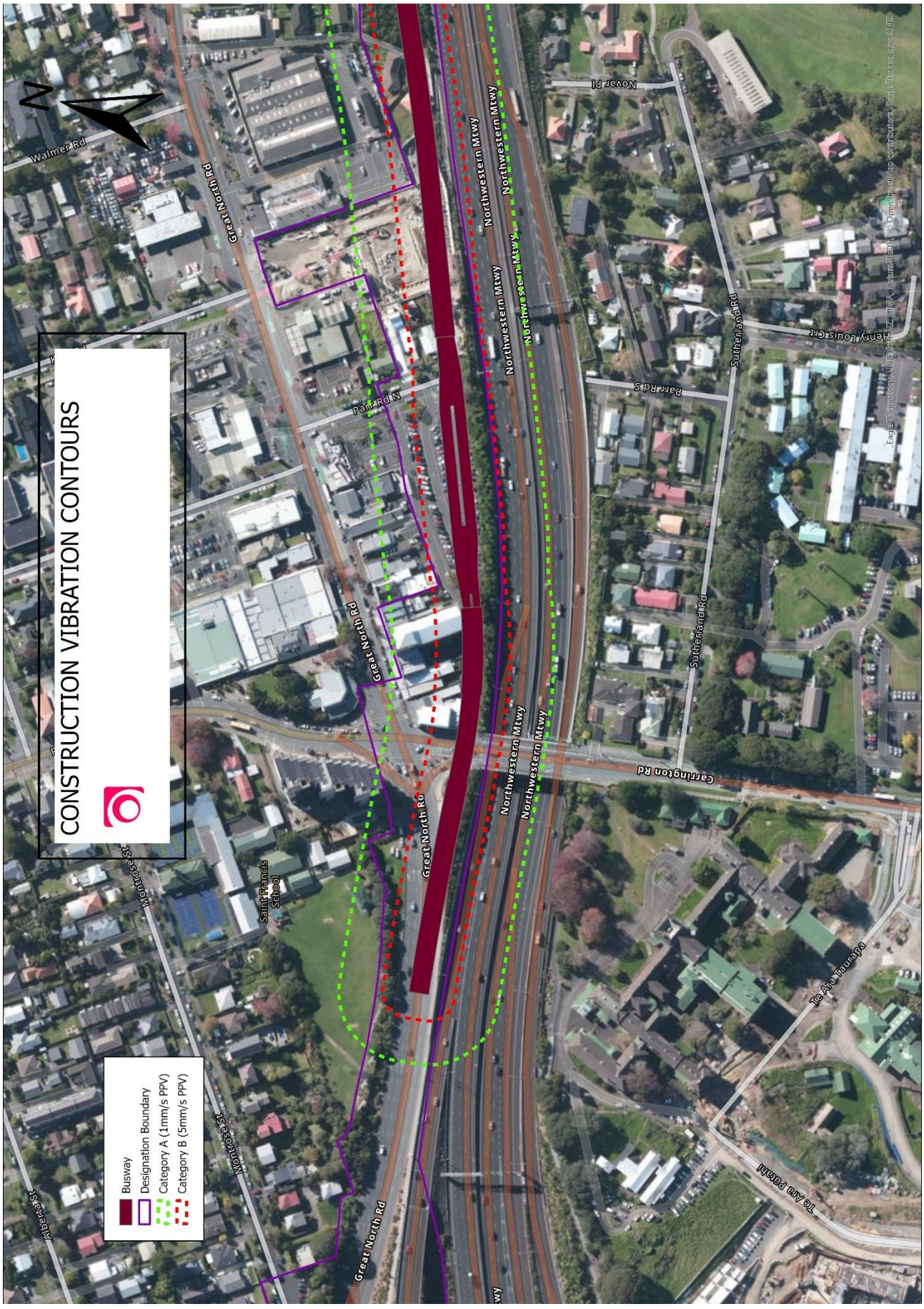

CONSTRUCTION VIBRATION CONTOURS
Busway
Designation Boundary
Category A (1mm/s PPV)
Category B (5mm/s PPV)
Northwestern Mtwy
Central Park Dr
Tony St
The Concourse
The Concourse
Strand


CONSTRUCTION VIBRATION CONTOURS
Busway
Designation Boundary
Category A (1mm/s PPV)
Category B (5mm/s PPV)
Karamu St
Te Puna Reo o Manawenui
Jack Colvin Park
Northwestern Mtwy
McCormick Rd
May Ave
Royal View Rd
Mill Tce
Royal View Rd
Pelton Ave
Marewa St
Flanshaw Rd

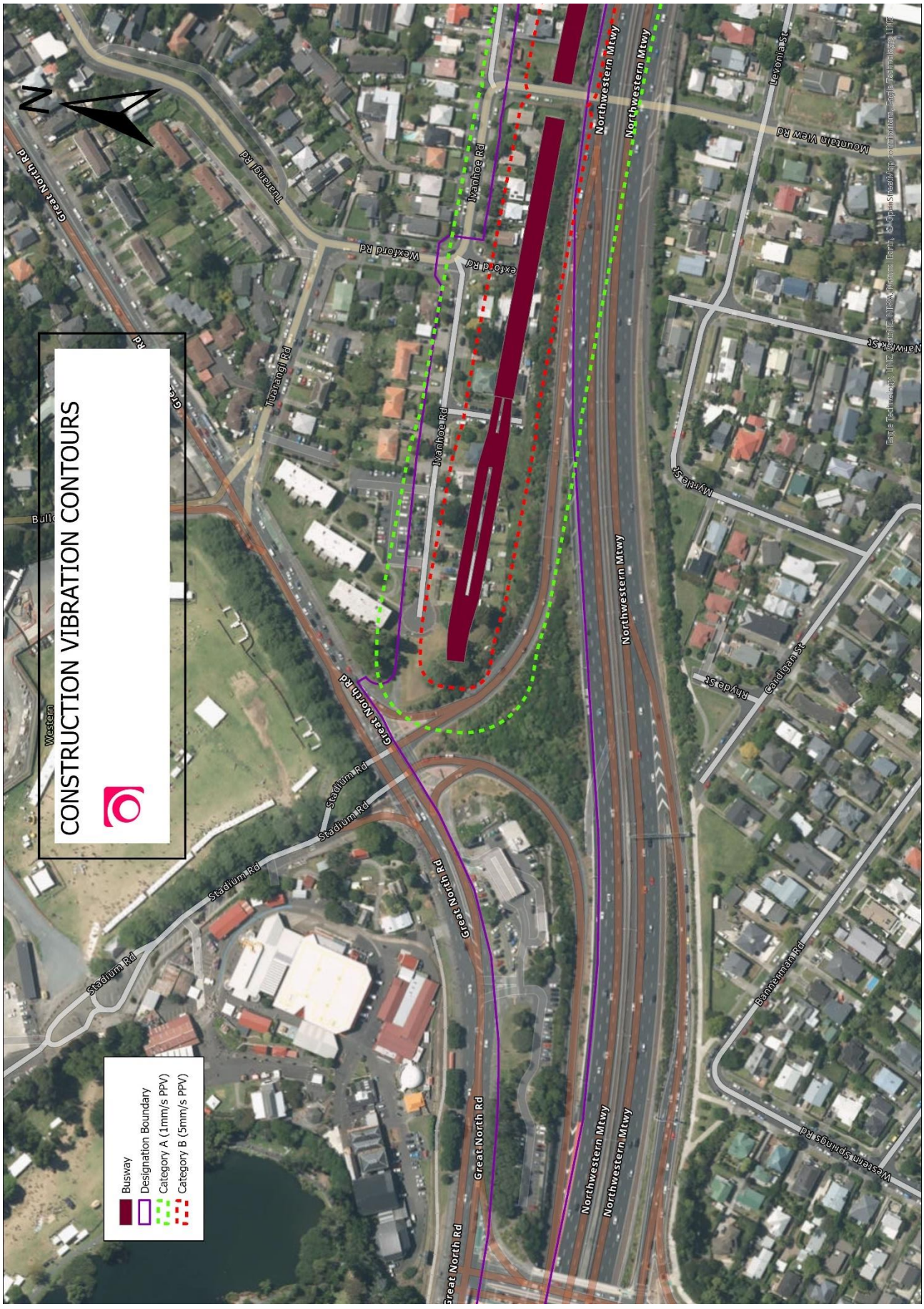

CONSTRUCTION VIBRATION CONTOURS
Busway
Designation Boundary
Category A (1mm/s PPV)
Category B (5mm/s PPV)
Braeban Braebank Lane
Bridge Ave
Alwyn Ave
Northwestern Mtwy
Te Atatū
Te Atatū Rd
Te Atatū Rd
Te Atatū Rd
Royal View Rd
Royal View Rd
Vera Rd
Vera Rd
Kaka
Mccormick Rd
May Ave
Tiaroa St

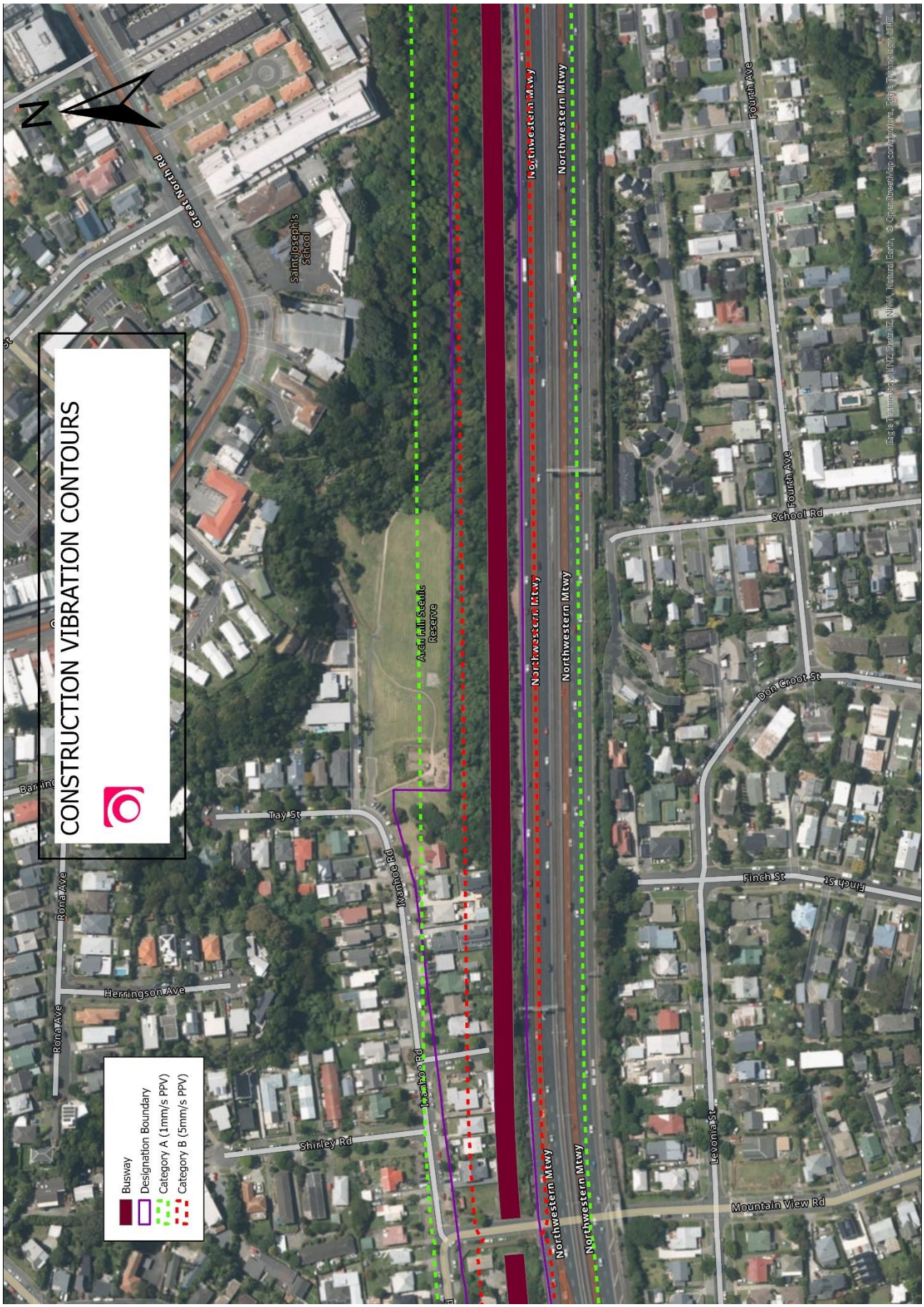

CONSTRUCTION VIBRATION CONTOURS
Busway
Designation Boundary
Category A (1mm/s PPV)
Category B (5mm/s PPV)
Te Atatū Rd
Te Atatū Rd
Te Atatū Rd
Te Atatū Rd
Te Atatū Rd
Tiriwa St
Karamu St
Karamu St
Tiataū Way
Old Te Atatū Rd
Toru St
Toru St
Toru St
Toru St
Parkmaie Gry
Tiroki St
Te Puna Reo o Manawanui
Rutherford Primary School
Jack Colvin Park

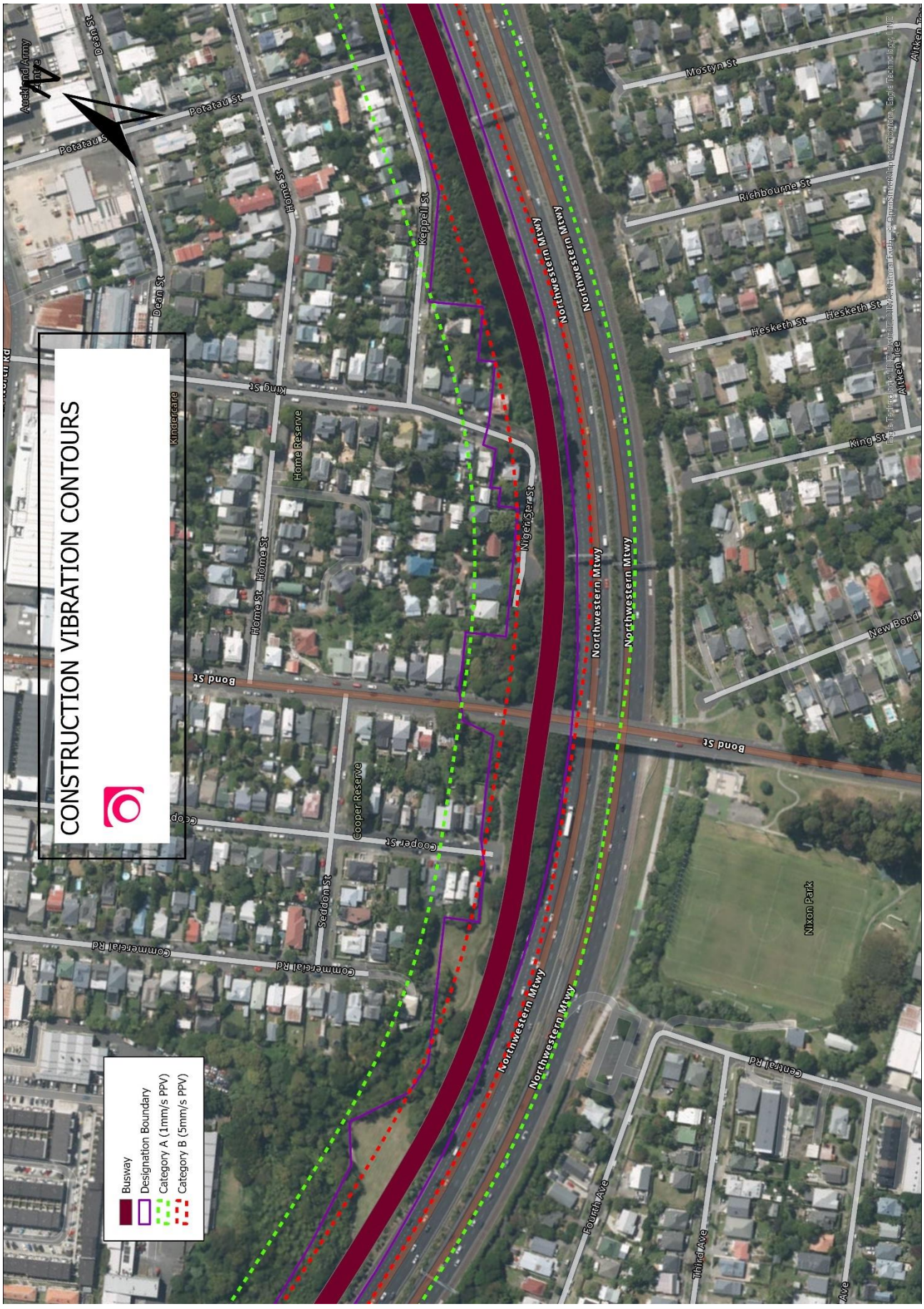

CONSTRUCTION VIBRATION CONTOURS
Busway
Designation Boundary
Category A (1mm/s PPV)
Category B (5mm/s PPV)
Northwestern Mtwy
Northwestern Mtwy
Northwestern Mtwy
Northwestern Mtwy
Northwestern Mtwy
Bridge Ave
Bridge Ave
Bridge Ave
Te Pae Kawau / Bridge Avenue Reserve
Braeban Braebank Lane
Alwyn Ave
Te Atatū
To Atatū Rd

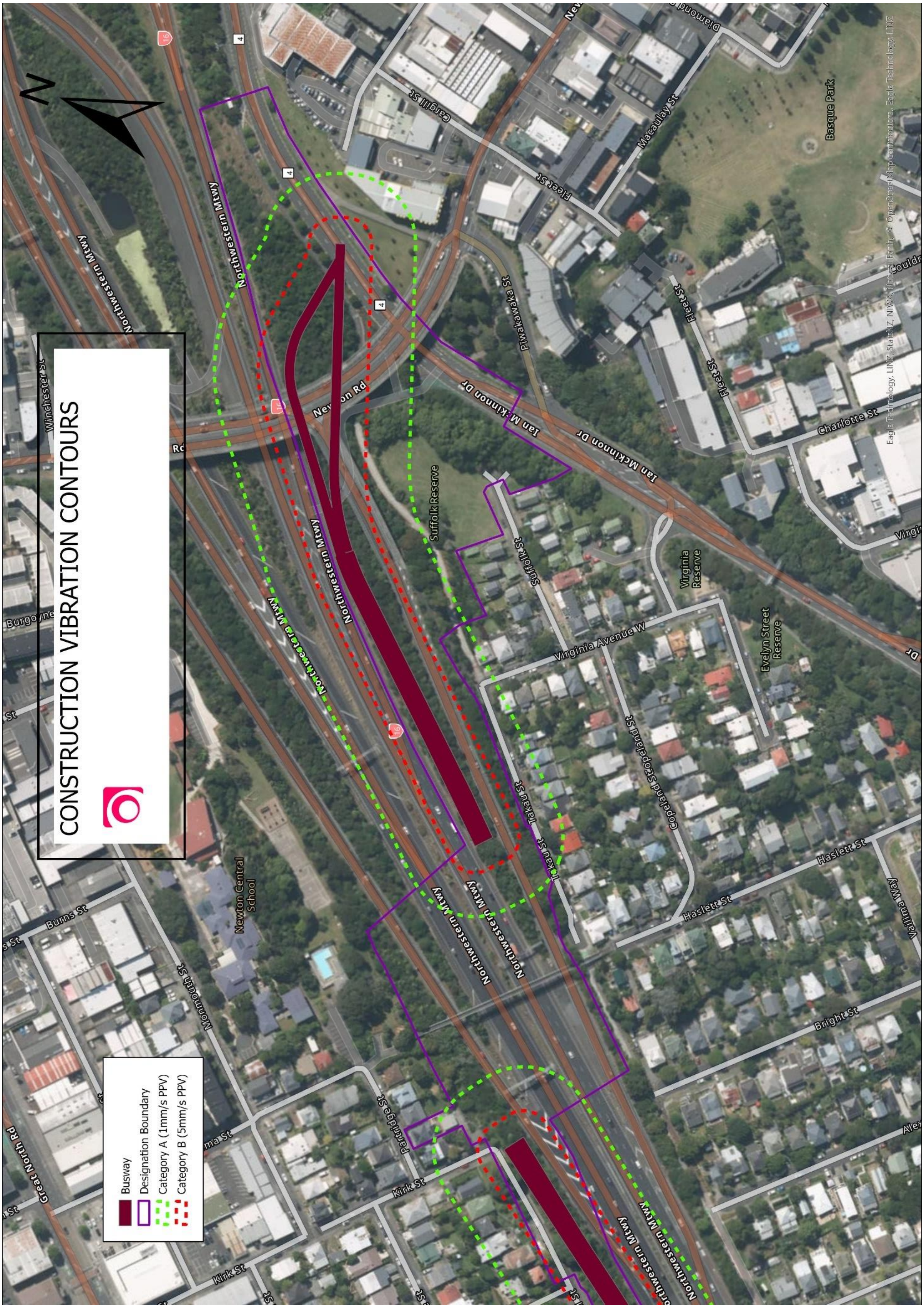

CONSTRUCTION VIBRATION CONTOURS
Busway
Designation Boundary
Category A (1mm/s PPV)
Category B (5mm/s PPV)
Walmer Rd
Great North Rd
Northwestern Mtwy
Novar Pl
Sutherland Rd
Henry Louis Gr
Parr Rd S
Parr Rd N
Carrington Rd
Great North Rd
Saint Francis School
Montrose St
Alberta St
Te Ara Tauranga
Te Ara Puteki


CONSTRUCTION VIBRATION CONTOURS
Busway
Designation Boundary
Category A (1mm/s PPV)
Category B (5mm/s PPV)
Great North Rd
Northwestern Mtwy
Western Springs Gardens
Motions Rd
Manor Pl
Premier Ave
Kiwi Rd
Novar Pl
Tinakumpus Room


CONSTRUCTION VIBRATION CONTOURS
Busway
Designation Boundary
Category A (1mm/s PPV)
Category B (5mm/s PPV)
Great North Rd
Northwestern Mtwy
Ivanhoe Rd
Wexford Rd
Tiarangi Rd
Stadium Rd
Western
Levonia St
Mountain View Rd
Myrtle St
Rhyde St
Cardigan St
Bannerman Rd
Western Springs Rd


CONSTRUCTION VIBRATION CONTOURS
Busway
Designation Boundary
Category A (1mm/s PPV)
Category B (5mm/s PPV)
N
Great North Rd
Saint Joseph's School
Northwestern Mtwy
Fourth Ave
School Rd
Don Croot St
Finch St
Ardmillan Scenic Reserve
Tray St
Ivanhoe Rd
Rona Ave
Herringson Ave
Shirley Rd
Levonia St
Mountain View Rd


CONSTRUCTION VIBRATION CONTOURS
Busway
Designation Boundary
Category A (1mm/s PPV)
Category B (5mm/s PPV)
Auckland Army
Dean St
Potatau St
Home St
Keppell St
Northwestern Mtwy
Mostyn St
Richbourne St
Hesketh St
Aitken Tce
King St
Kindercare
Home Reserve
Nigel Ave
New Bond
Bond St
Cooper Reserve
Seddon St
Commercial Rd
Nixon Park
Central Rd
Fourth Ave
Third Ave


CONSTRUCTION VIBRATION CONTOURS
Busway
Designation Boundary
Category A (1mm/s PPV)
Category B (5mm/s PPV)
Northwestern Mtwy
Newton Rd
Ian McKinnon Dr
Suffolk Reserve
Virginia Reserve
Virginia Avenue W
Evelyn Street Reserve
Basque Park
Newton Central School
Great North Rd
Kirk St
Haslett St
Bright St
Burns St
Monmouth St
Partridge St
Copeland St
Pakau St
Suffolk St
Fleet St
Charlotte St
Macaulay St
Cargill St
Piwakawaka St
Winchester St
Vaitiuma Way