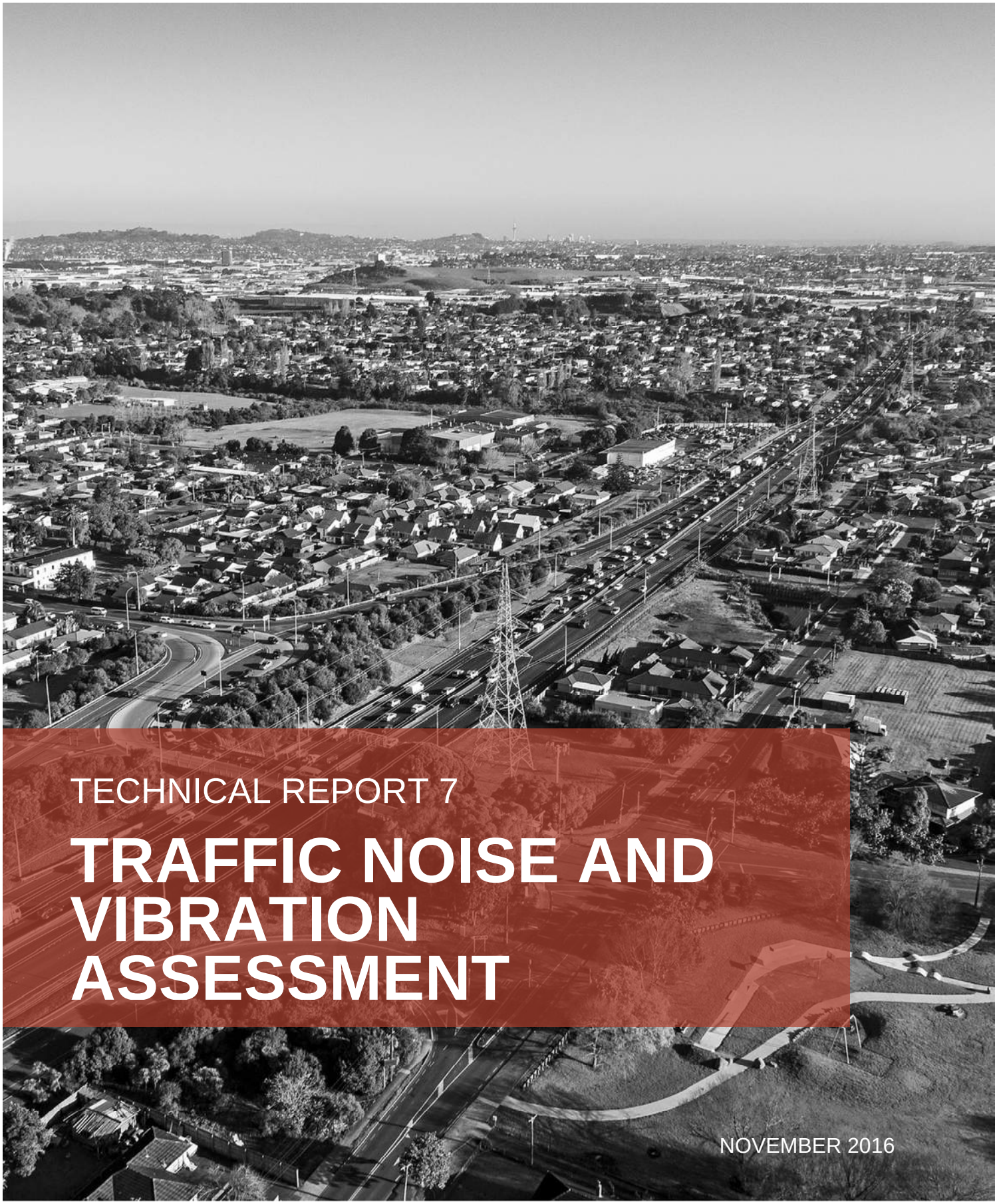

TECHNICAL REPORT 7

TRAFFIC NOISE AND VIBRATION ASSESSMENT

NOVEMBER 2016

NZ TRANSPORT AGENCY WAKA KOTAHI

East West Link

MARSHALL DAY Acoustics

Quality Assurance Statement	
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Revision schedule					
Rev. N^{o}	Date	Description	Prepared by	Reviewed by	Approved by
0	November 2016	Final for Lodgement	Siiri Wilkening	Mike Trebitsch	Patrick Kelly

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EXECUTIVE SUMMARY

1. Marshall Day Acoustics has undertaken an assessment of traffic noise and vibration effects from the East West Link Project (EWL or the Project).

2. Traffic vibration is not considered to be an issue. The Auckland Motorway Alliance has no record of traffic vibration complaints in the Project area, and with well-maintained road surfaces, vibration levels will be well within accepted limits.

3. Traffic noise has been assessed three-fold:

   - In accordance with NZS 6806:2010, the New Zealand road traffic noise standard;
   - In relation to change in noise level when comparing the Do-nothing situation (at the design year, without the Project) with the Project and preferred mitigation option; and
   - Based on the number of people potentially highly annoyed.

4. Noise barriers of varying heights have been recommended for most of the Project extent. Where no barriers are recommended, reasons include:

   - The lay of the dwelling in relation to the road (e.g. where dwellings are significantly elevated and cannot be effectively shielded;
   - Multi-storey dwellings where the upper floor cannot be mitigated; and
   - The need for barriers that may be too high in a residential context.

5. The Project will be surfaced with OGPA on the main alignment, and dense asphalt on ramps. These are low noise generating road surface materials.

6. The noise level change due to the Project (without mitigation) for any dwellings will generally be small (less than 4 decibels). For most areas, noise levels would change by no more than 2 decibels. This change is likely to be imperceptible or just perceptible for human hearing, particularly as the noise source (i.e. traffic) does not change.

7. However, due to the excessive existing noise levels which may lead to adverse health effects, extensive noise mitigation has been recommended for most areas, to rectify the current adverse noise environment where practicable.

8. With the mitigation in place, noise levels are predicted to be lower in the design year than is currently experienced. The Project would have an overall positive effect and result in significant betterment, particularly for those dwellings currently affected by the most elevated noise levels.

9. Currently (in 2016) 75 Protected Premises and Facilities are predicted to receive noise levels within Category C of the Standard (the least desirable category with the highest external noise levels). With the Project in 2036 and the recommended mitigation implemented, only 21 PPFs are predicted to remain within Category C, despite the increase in traffic volume over time. Any Category C PPFs will need to be assessed on a case-by-case basis and, in accordance with the Transport Agency's policy, building modification mitigation provided if otherwise the internal noise level in habitable rooms would be above 40 dB $L_{Aeq(24h)}$.

10. Overall, this Project will result in betterment for most people adjacent to the road. While high noise levels cannot be mitigated at all dwellings, the proposed mitigation will result in significant noise level reductions up to 9 decibels for some of the most affected dwellings.

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Glossary of Technical Terms/Abbreviations

Abbreviation	Term
AADT	Average annual daily traffic
AEE	Assessment of Effects on the Environment
Ambient Noise	Ambient Noise is the all-encompassing noise associated with any given environment and is usually a composite of sounds from many sources near and far.
ARP:C	Auckland Council Regional Plan: Coastal ARP:C
BCR	Benefit Cost Ratio
BoI	Board of Inquiry
CMA	Coastal Marine Area
dB	Decibel
$L_{Aeq(T)}$	The A-weighted time averaged sound level (on a logarithmic/ energy basis) over the measurement period.
EPA	Environmental protection authority
EWL	East West Link
EWLA	East West Link Alliance
Noise	A sound that is unwanted by, or distracting to, the receiver.
NoR	Notice of Requirement
NZS 6801:2008	New Zealand Standard NZS 6801:2008 "Acoustics – Measurement of Environmental Sound"
NZS 6802:2008	New Zealand Standard NZS 6802:2008 “Acoustics – Environmental Noise”
NZS 6806:2010	New Zealand Standard NZS 6806:2010 “Acoustics – Road-traffic noise – New and altered roads”
The NZ Transport Agency	New Zealand Transport Agency
OGPA	Open Grade Porous Asphalt
PAUP	Proposed Auckland Unitary Plan
PPFs	Protected Premises and Facilities
PPV	Peak particle velocity
RMA	Resource Management Act 1991
SH(x)	State Highway (number)

Glossary of Defined Terms used in this report

Term	Meaning
Auckland Council	Means the unitary authority that replaced eight councils in the Auckland Region as of 1 November 2010.
Designations	Means existing designation 6718 which are being altered for this Project.
Earthworks	Means the disturbance of land surfaces by blading, contouring, ripping, moving, removing, placing or replacing soil, earth, or by excavation, or by cutting or filling operations.
Indicative Business Case	Means the Indicative Business Case proposed in the Indicative Business Case Report dated 12 December 2014.
Motorway	Means a motorway declared as such by the Governor-General under section 138 of the PWA or under section 71 of the Government Roading Powers Act 1989.
New Zealand King Salmon	Means the Supreme Court's decision in Environmental Defence Society Inc v The New Zealand King Salmon Co Ltd [2014] NZSC 38.
Project	Means the East West Link Project as described in Section 6 of the AEE.
State highway	Means a road, whether or not constructed or vested in the Crown, that is declared to be a State highway under section 11 of the National Roads Act 1953, section 60 of the Government Roading Powers Act 1989 (formerly known as the Transit New Zealand Act 1989), or under section 103 of the LTMA.
BPO	Is defined in the RMA as follows: best practicable option, in relation to a discharge of a contaminant or an emission of noise, means the best method for preventing or minimising the adverse effects on the environment having regard, among other things, to: (a) the nature of the discharge or emission and the sensitivity of the receiving environment to adverse effects; and (b) the financial implications, and the effects on the environment, of that option when compared with other options; and (c) the current state of technical knowledge and the likelihood that the option can be successfully applied

1 Introduction

1.1 Purpose and scope of this report

This report forms part of a suite of technical reports prepared for the NZ Transport Agency's East West Link project (the EWL or Project). Its purpose is to inform the Assessment of Effect on the Environment Report (AEE) and to support the resource consent applications, new Notice of Requirement and an alteration to existing designation required for the EWL.

This report assesses the traffic noise and vibration effects of the proposed alignment of the Project as shown on the Project Drawings in *Volume 2: Drawing Set*.

The purpose of this report is to:

- Determine the existing noise environment that is currently received by noise sensitive buildings in the vicinity of the Project;
- Assess the change in noise level with the Project in place, both with and without mitigation;
- Determine the noise criteria category for each dwelling within 100m of the Project and determine if mitigation is required and practicable;
- Assess the number of people potentially highly annoyed from road traffic noise;
- Assess traffic vibration in general terms; and
- Provide a recommended best practicable option to mitigate traffic noise levels adjacent to the Project.

1.2 Project description

The EWL Project involves the construction, operation and maintenance of a new four lane arterial road from State Highway 20 (SH20) at the Neilson Street Interchange in Onehunga, connecting to State Highway 1 (SH1) at Mt Wellington as well as an upgrade to SH1 between the Mt Wellington Interchange and the Princes Street Interchange at Ōtāhuhu. New local road connections are provided at Galway Street, Captain Springs Road, the port link road and Hugo Johnston Drive. Cycle and pedestrian facilities are provided along the alignment.

The primary objective of the Project is to address the current traffic congestion problems in the Onehunga, Penrose and Mt Wellington commercial areas which will improve freight efficiency and travel reliability for all road users. Improvements to public transport, cycling and walking facilities are also proposed.

A full description of the Project including its design, construction and operation is provided in Part C: Description of the Project in the Assessment of Effects on the Environment Report contained in *Volume 1: AEE* and shown on the Drawings in *Volume 2: Drawing Set*.

2 Experience

Siiri Wilkening has nearly 20 years' experience in acoustic consulting work, both in Germany and New Zealand. She graduated with a Masters degree in Engineering (Landscaping and Environmental Protection) from the University of Rostock in Germany and worked in Germany for two years in the acoustics section of the TÜV Nord Umweltschultz GmbH. There, she was mainly involved with city noise mapping using the computer program LIMA.

Siiri joined Marshall Day in 1998 and has since worked predominantly in environmental acoustics, specialising in the measurement and assessment of environmental noise, computer noise modelling, traffic, industrial and construction noise assessment, management and mitigation.

Siiri has been the lead acoustic consultant for a number of significant infrastructure projects, including the Roads of National Significance MacKays to Peka Peka Expressway, Pūhoi to Warkworth, Waterview Connection, Newmarket Viaduct Improvement, Vic Park Tunnel and Hamilton Expressway. She has presented expert evidence at many Council Hearings, Boards of Inquiry, Environment Court, Environment Court Mediation and the Arbitration Court.

3 Statutory Framework and its Application to this Project

We have reviewed the following standards and guidelines in relation to road traffic noise assessment:

- NZS 6806:2010;
- NZTA Environmental Plan (June 2008);
- Proposed Auckland Unitary Plan (PAUP) (Council Decision Version, 19 August 2016);
- Auckland Regional Plan: Coastal; and
- Resource Management Act 1991.

Based on this review, we consider that NZS 6806 is the most current, integrated and appropriate document to assess road traffic noise in New Zealand, which is also referenced in the PAUP. Therefore, we recommend that NZS 6806 be used for the assessment of road traffic noise from this Project.

3.1 Resource Management Act 1991

The relevant RMA requirements relating to noise are set out in Sections 16 and 17 as follows:

Section 16: Duty to avoid unreasonable noise

1. *Every occupier of land (including any premises and any coastal marine area), and every person carrying out an activity in, on, or under a water body or the coastal marine area, shall adopt the best practicable option to ensure that the emission of noise from that land or water does not exceed a reasonable level.*
2. *A national environmental standard, plan, or resource consent made or granted for the purposes of any of sections 9, 12, 13, 14, 15, 15A, and 15B may prescribe noise emission standards, and is not limited in its ability to do so by subsection (1).*

Section 17: Duty to avoid, remedy, or mitigate adverse effects

1. *Every person has a duty to avoid, remedy, or mitigate any adverse effect on the environment arising from an activity carried on by or on behalf of that person, whether or not the activity is in accordance with a rule in a plan, a resource consent, a designation, section 10, section 10A, or section 20A.*

3.2 Auckland Council Regional Plan: Coastal

Chapter 35 contains discussion about noise emissions within the coastal marine area. While noise limits are provided in Rule 35.5.1, for all activities in the coastal marine area, these are to be measured and assessed in accordance with NZS 6801:1991 and NZS 6802:1991. These standards expressly exclude transportation noise. Therefore, noise limits in the ARP:C do not apply to traffic noise from the Project.

3.3 Proposed Auckland Unitary Plan

The Council's decisions version of the PAUP was released on 19 August 2016. The relevant wording is set out below:

Section E25.6.33 Noise levels for traffic from new and altered roads

1. *All new roads and all altered roads that are within the scope of New Zealand Standard NZS 6806:2010 Acoustics – Road traffic noise – New and altered roads must comply with the requirements of New Zealand Standard NZS 6806:2010 Acoustics – Road traffic noise – New and altered roads.*

3.4 New Zealand Standard NZS 6806:2010

Road traffic noise in New Zealand is generally assessed and controlled through NZS 6806:2010 Acoustics – Road-traffic noise – New and altered roads (NZS 6806 or the Standard).

We consider the intent of the Standard is to provide a pragmatic and sensible approach to the use of noise mitigation. This approach includes the requirement that a roading project needs to have a noticeable effect before mitigation is considered, and that any mitigation needs to achieve a noticeable reduction in noise level.

NZS 6806 applies to traffic noise assessments where a project falls within the thresholds of the Standard. These thresholds are explained in the following subsections. As the Standard is an extensive and complex document, we have included only key concepts for the purposes of this report.

3.4.1 Assessment positions

Pursuant to the Standard, noise effects need to be assessed at noise sensitive locations only, compared with the RMA which considers a broader receiving environment. The Standard specifies types of protected premises and facilities (PPFs), at which noise levels shall be assessed for changes in noise level and against noise criteria. These PPFs are:

- Dwellings (including those not yet built but having obtained building consent);
- Educational facilities and play grounds within 20m of educational facilities;
- Boarding houses;
- Homes for the elderly and retirement villages;
- Marae;
- Hospitals that contain in-patient facilities; and
- Motels and hotels in residential zones.

Noise effects are assessed at the façade (external wall) of the PPFs. The Standard does not consider commercial and business uses to be noise sensitive. Therefore they are not assessed as PPFs and are excluded from this assessment.

For this Project, we have assessed noise levels at all existing PPFs within 100m of the indicative Alignment. Our assessment is in accordance with the Standard, which, in Section 1.4.1, states that *"PPFs do not include: (g) Premises and facilities which are not yet built, other than premises and facilities for which a building consent has been obtained which has not yet lapsed."*

The Standard excludes future land use from assessment, on the basis that land use planning is the preferred tool to manage the location of PPFs rather than pre-empting the location and use of future PPFs.[1] In particular, the assessment of traffic noise levels at façades requires knowledge of the locations of PFFs onsite. For a PPF that has been granted building consent, the location on-site is known and can be used for noise level prediction. Other developments, e.g. where a future development area has been identified or where a subdivision consent has been granted, do not provide the same level of accuracy potentially leading to unnecessary or inadequate mitigation.

Once a roading project has been notified through the lodgement of the Notice of Requirement (NOR), there are several opportunities for a future development or dwelling to be designed to accommodate the future noise source. For future development areas, buffers can be provided, e.g. green belts between

1 NZS 6806:2010 Acoustics–Road-traffic noise–New and altered roads: Section C1.4.1 and Appendix B.

the road and the development. Dwellings can be located on the sites to have non-habitable[2] and noise-insensitive[3] rooms facing the road or can be located on a site at a greater distance from the road. In addition, under current Building Code requirements a new dwelling would be required to incorporate elements such as substantial glazing and insulation in its construction, which can also have incidental acoustic benefits of effectively mitigating internal noise from external sources. However, if natural ventilation is required by opening windows, internal noise levels will still be affected by external sources.

NZS 6806 stipulates that in urban areas, all PPFs within 100m of a project road alignment shall be assessed. Locations outside this area are excluded because at larger distances, noise levels will generally be below the most stringent noise criteria due to the distance attenuation of noise.

We have undertaken the noise assessment for this Project generally in accordance with this limitation because from our experience, noise levels beyond the 100m extent are below a level that we consider would require mitigation.

3.4.2 Assessment areas

The Project Alignment has been assessed in seven assessment areas. Assessment areas have been determined by choosing PPFs that are:

- Located on the same side of the Project (i.e. either adjacent to northbound or southbound lanes only);
- Cohesive or in groups (i.e. dwellings in close proximity to each other); and
- Adjacent to a section of the Project with the same traffic volume (i.e. located between ramps and not crossing over ramps).

A figure showing the assessment area is contained in Appendix A.

3.4.3 Design year

The design year is a concept that is used for several engineering disciplines. It requires that the design of a road is based on a future year, making an allowance for an increase in traffic volumes over that time. The Standard requires that the design year shall be between 10 and 20 years after the opening of a new road to the public.[4]

We have selected the year 2036 as the design year for the Project, which allows for an opening year up to 2026.

Should construction, and subsequent opening, of the Project be delayed, there is a potential for traffic volumes to increase over time. However, noise level predictions are relatively insensitive to changes in traffic volume. For instance, a 20% increase in traffic volume would result in a less than 1 decibel increase in noise level, and a 50% increase in traffic volume would result in less than 2 decibels increase. Therefore, we consider that the chosen design year of 2036 provides an appropriate indication of future traffic noise effects.

2 For instance, garage, laundry or walk in wardrobes.

3 For instance, bathrooms or hallways.

4 NZS 6806:2010: Acoustics–Road-traffic noise–New and altered roads, Section 2.2.

3.4.4 Noise criteria

The noise criteria of the Standard are dependent on traffic volume and distinguish between "new" and "altered" roads. There are three noise criteria categories (A, B and C).[5]

For the Project, the relevant category is that of the altered roads. Where the Project comprises a new road, i.e. along the Māngere Inlet foreshore, there are no PPFs within 100m of the Project.

Table 3-1: NZS 6806 Relevant Noise Criteria Categories

Category	Altered Roads
	dB $L_{Aeq(24h)}$
A (primary external noise criterion)	≤64
B (secondary external noise criterion)	64–67
C (internal noise criterion)*	40

**This criterion is triggered if habitable rooms would receive internal noise levels greater than 45 dB $L_{Aeq(24h)}$ despite structural mitigation such as bunds, barriers and road surface materials being used.*

Under the Standard, the applicable criterion at any PPF depends on the best practicable option (BPO) test. Where noise levels within Category A can be achieved with the implementation of the BPO for noise mitigation, then Category A applies. Where Category A cannot practicably be achieved, then mitigation to achieve the noise criteria within Category B is subject to the BPO test. If the noise criteria of Categories A or B are not practicably achievable, then the "backstop" Category C shall be met with the adoption of the BPO.[6]

The Standard is clear that preference is to be given to structural mitigation over building modification mitigation.[7] Structural mitigation involves the use of structural elements such as bunds, barriers or the choice of road surface material. Building modification mitigation refers to mitigation that is applied to a building, e.g. improving glazing or providing mechanical ventilation. We agree that it is preferable to install mitigation as close to the road as possible so as to provide the largest area of noise level reduction practicable. Building modification mitigation provides noise level reduction for the indoor environment only and does not protect outdoor living areas.

NZS 6806 also requires achievement of the lowest external noise level with practicable structural mitigation, before considering building modification to mitigate internal noise levels.[8]

The noise criteria category each PPF falls into for this Project is depicted on the figures in Appendix D.

3.4.5 Assessment scenarios

NZS 6806 requires several operational scenarios to be assessed and compared. These include:

- The existing noise environment: for altered roads this consists of the current road layout and traffic volume, and for new roads consists of the current ambient noise level;

5 NZS 6806:2010: Acoustics–Road-traffic noise–New and altered roads, Section 6.1.2.

6 NZS 6806:2010 Acoustics–Road-traffic noise–New and altered roads, Section 6.1.2.

7 NZS 6806:2010 Acoustics–Road-traffic noise–New and altered roads, Section 8.1.2.

8 NZS 6806:2010 Acoustics–Road-traffic noise–New and altered roads, Section 8.3.4.

- A future Do-nothing scenario: consists of the existing SH20 and SH1 at the design year, with increased traffic volume;
- A future Do-minimum scenario: consists of the Project road at the design year, but without any specific noise mitigation. This scenario means that the choice of road surface material is independent from its noise generating characteristics. It also means that the only barriers included are solid safety barriers, which are required for reasons other than noise mitigation. Local roads that are not proposed to be altered by the Project are not included in the assessment; and
- Future Project with mitigation: consists of the Project road at the design year, and includes mitigation that is designed specifically to reduce noise levels.

The mitigation option chosen as the selected option may not provide the greatest noise level reduction, but is considered optimal and practicable on balance, when evaluated against all relevant criteria.[9]

3.4.6 Mitigation requirements

As described in Section 3.4.4, the Standard adopts the BPO methodology to noise mitigation, which, in our opinion, is a pragmatic and balanced approach.

One aspect of the BPO is that a noticeable noise level reduction is to be achieved by any structural mitigation.[10]

Barriers, while often effective for noise reduction purposes, can cause adverse effects, such as shading, visual or safety issues. While these are outside the area of expertise of an acoustic consultant, and are dealt with by other disciplines through the BPO process, any structural noise mitigation measures need to be designed so that they result in meaningful noise level reductions.

Therefore, NZS 6806 includes a criterion for the effectiveness of structural mitigation measures. In areas where mitigation benefits more than one PPF, it *"should only be implemented if the combination for the structural mitigation measures used would achieve … an average reduction of at least 3 dB $L_{Aeq(24h)}$."*[11]The reason for the minimum requirement that an average of 3 decibels mitigation should be achieved is that, where many PPFs are in close proximity to each other mitigation varies for those PPFs depending on their location in relation to the mitigation (e.g. barrier).

It is noted that in some areas PPFs do not require mitigation but are still assessed within the "average" noise level reduction in accordance with the Transport Agency's tools. Because of this, the overall mitigation for an area can be artificially reduced. This has been taken into consideration when deciding on the BPO.

Section 7.2.4 of the Standard recommends that up to four mitigation options be developed for large scale projects of more than 50 PPFs. However, for this Project, the use of OGPA as the road surface material already includes significant mitigation in itself (compared with chip seal). For that reason, we have restricted our assessment to generally two mitigation options. The use of road side barriers is the next preferred mitigation option. For this Project, a combination of barriers and building modification mitigation is considered to be the best practicable option as described in Section 6.

3.5 Transport Agency Guide

The Transport Agency has released its *"Guide to assessing road-traffic noise using NZS 6806 for state highway asset improvement projects (Version 1.0, October 2011)"* (Transport Agency Guide). The

9 NZS 6806:2010 Acoustics–Road-traffic noise–New and altered roads, Section 6.3 "Best Practicable Option" sets out factors that will be considered and weighed up when determining the BPO for noise mitigation.

10 NZS 6806:2010 Acoustics–Road-traffic noise–New and altered roads, Section 8.2.2.

11 NZS 6806 Acoustics–Road-traffic noise–New and altered roads, Section 8.2.2(a), page 41.

Transport Agency Guide describes how NZS 6806 is to be implemented. In addition, some Transport Agency specific processes are described. For this Project, the Transport Agency Guide assessment procedures such as the calculation of the benefit cost ratio (BCR) are shown in Appendix B.

Overall, the Transport Agency Guide provides background on how to implement NZS 6806, and is therefore a useful complementary document to the Standard itself.

3.6 Vibration

3.6.1 District, Unitary and Regional Plans

None of the Plans contain traffic vibration performance standards.

3.6.2 Transport Agency Road Maintenance Policy

Traffic vibration is generated when the road surface is not smooth and has bumps and potholes. Traffic vibration does not generally cause adverse effects in situations where roads are well-maintained. The Transport Agency has a comprehensive road maintenance policy that ensures that roads remain smooth and any defects are fixed within short timeframes.

The responsibilities of the NZ Transport Agency are set out succinctly in Technical Memorandum Noise and Vibration No. 3, and can be found here: https://acoustics.nzta.govt.nz/sites/default/files/Tech-memo-NV3-State-highway-noise-and-vibration-management-v1.0.pdf.

Should assessment of traffic vibration be required, the Norwegian Standard NS 8176.E:2005 specifically addresses transportation vibration.

Since this is a newly-constructed and surfaced road, it is highly unlikely that any adverse traffic vibration effects would be caused. Therefore, vibration is not discussed further.

4 Assessment Methodology

4.1 Assessment of effects and compliance

We have assessed the operational noise effects on people based on a three-pronged approach:

- Assessment of compliance with NZS 6806 following the BPO process for noise mitigation and focussing on achieving the most stringent noise criteria category practicable;
- Assessment of noise effects (both beneficial and adverse) through determination of noise level changes; and
- Assessment of effects by comparing the number of people that may be highly annoyed by traffic noise with and without the Project.

The Standard requirements are discussed in Section 3.4. The other two assessment methodologies are described in Sections 4.2 and 4.3.

The reason for the three-pronged approach is that in some circumstances, compliance with the Standard does not necessarily mean that the effects of a project will be minor, and vice versa.

Potentially, the effects of a noise level increase can be small (e.g. a noise level increase of less than 3 decibels). At the same time, the resulting noise environment can be very high, particularly adjacent to SH1, and cause adverse effects for residential use.

Overall, we note that any traffic noise effects (positive or negative) are generally somewhat temporary. People typically become habituated to their environment, including noise levels, particularly where the character of the sound does not change (i.e. if existing traffic noise increases). Nevertheless, high noise levels can result in adverse health effects, and mitigation is required to avoid such levels irrespective of the change in noise level.

This report provides an assessment of all of these aspects.

4.2 Subjective perception of noise changes

The subjective impression of changes in noise can generally be correlated with the numerical change in noise level. While every person reacts differently to noise level changes, research shows a general correlation between noise level changes and subjective responses.[12] Table 4-1 shows indicative subjective responses to explain the noise level changes discussed in this report. From experience, we have found that the subjective perception of a noise level change can be translated into a RMA effect. This effect is based on people's annoyance reaction to noise level changes (refer Section 4.3).

The perception of these noise level changes generally applies to immediate changes in noise level, as would be the case for a new road, unlike for this Project which is an altered road. However, people may subjectively have an annoyance reaction to a greater or lesser degree, depending on their perception of the Project.

12 For instance, LTNZ Research Report No. 292: Road traffic noise: determining the influence of New Zealand Road surfaces on noise levels and community annoyance, Table 18.

Table 4-1: Noise level change compared with general subjective perception

Noise level change	General subjective perception[13]	Impact[14]
1–2 decibels	Insignificant change	Negligible
3–4 decibels	Perceptible change	Slight
5–8 decibels	Appreciable change	Moderate
9–11 decibels	Halving/doubling of loudness	Significant
>11 decibels	More than halving/doubling of loudness	Serious

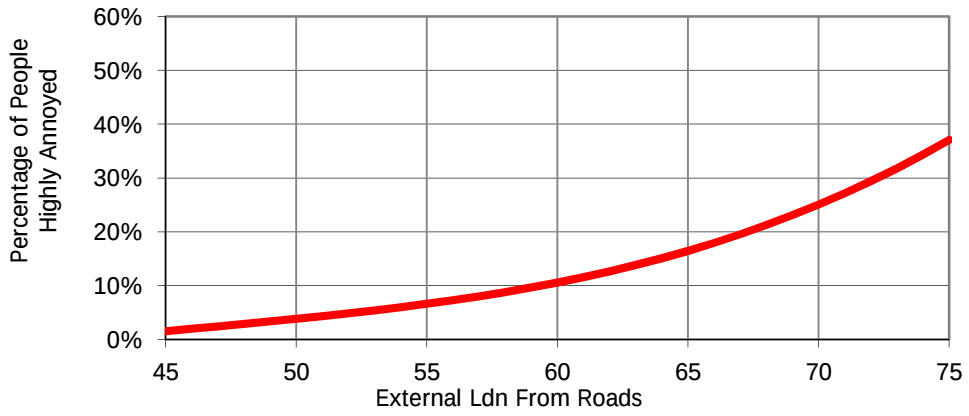
Noise is measured on a logarithmic scale, meaning that a doubling in traffic volume (e.g. from 10,000 vehicles per day to 20,000 vehicles per day) results in a noise level increase of 3 decibels, a just-perceptible change. A tenfold increase in traffic volume (e.g. from 10,000 to 100,000 vehicles per day) would result in a noise level increase of 10 decibels, which would sound twice as loud.

4.3 Annoyance effects

People's responses to a particular level of road traffic noise can vary greatly. A large number of studies have been carried out overseas in an attempt to determine a general relationship of response to noise by a residential community as a whole.

The most notable studies include those of Shultz[15] and those of Miedema and Oudshoorn[16], as shown in Figure 4-1. These studies combined the results of several different studies to produce a 'curve' of the percentage of people highly annoyed (%HA) versus external noise level (L_{dn})[17]. The studies involved a number of different transportation noise sources including trains, road traffic and aircraft. Only the curve for road traffic noise is shown below.

Figure 4-1: Miedema & Oudshoorn Dose-Response Relationship



13 Based on research by Zwicker & Scharf (1965); and Stevens (1957, 1972).

14 The descriptions in this column are based on our understanding of the perception in change in noise level. We have used these descriptions for several roading projects to explain the effects in RMA terms.

15 Schultz T J (1978) *"Synthesis of social surveys on noise annoyance"* J.Acoust. Soc. Am. 64, 2, 337-405.

16 Miedema, H M E and Oudshoorn, G M (2001) *"Annoyance from transportation noise: relationships with exposure metrics DNL and DENL and their confidence intervals."* Environmental Health Perspectives 109 (4) 409–416.

17 L_{dn} levels can be converted into $L_{Aeq(24h)}$ by subtracting 2.5 dB.

The curve shows that about 18% of people would be highly annoyed at an external road traffic noise level of 64 dB $L_{Aeq(24h)}$ (equivalent to 66 dB L_{dn}), which is the upper end of the NZS 6806 Category A for altered roads. For an external noise level of 67 dB $L_{Aeq(24h)}$ (equivalent to 69 dB L_{dn}), the upper end of Category B for altered roads, 20% of people would be highly annoyed.

Based on the graph above, we have calculated the average percentage of people highly annoyed for the noise bands shown on the drawings in Appendix E as follows:

Table 4-2: Percentage people highly annoyed

Noise band	Average percentage of people highly annoyed
55 to 60 dB $L_{Aeq(24h)}$	10%
60 to 65 dB $L_{Aeq(24h)}$	17%
65 to 70 dB $L_{Aeq(24h)}$	26%
70 to 75 dB $L_{Aeq(24h)}$	37%
Above 75 dB $L_{Aeq(24h)}$	40%

Accordingly, using BPO mitigation to achieve the lowest practicable noise levels will ensure better amenity for people and that a smaller number of people will be annoyed by road traffic noise.

In order to calculate the number of people highly annoyed, the number of dwellings (within 100m of the Project) was counted. Then, the number of people affected was estimated based on Statistics New Zealand data.[18] For the Project area, the average number of persons per dwelling have been obtained and multiplied with the assessed dwellings in each assessment area.

For each assessment area, the results are summarised in Section 6.

4.4 Noise level surveys

Noise level surveys of the ambient existing noise environment are undertaken to determine the current noise environment for the area under consideration. The results of the surveys are also used to verify the computer noise model.

Noise levels can be measured with two different methodologies:

- Short duration measurements, generally 15 minutes long, during daytime and attended throughout so that the actual environment can be observed and described; and
- Long duration measurements, generally between six and seven days (access dependent), which continuously record noise levels and are unattended (i.e. no person is with the equipment throughout the survey period).

We used both of these methodologies to determine the existing noise environment along the length of the Project. Unattended long duration measurements were undertaken using Noise Data Loggers. The loggers continuously measured $L_{Aeq(15min)}$ sound levels over the monitoring duration. We then converted these levels into $L_{Aeq(24h)}$ values, which are relevant to NZS 6806 (refer Section 3.4).

18 http://www.stats.govt.nz/StatsMaps/Home/Maps/2013-census-population-dwelling-map.aspx.

For the short duration attended surveys, the surveys were located in the vicinity of the Project and in areas of interest, i.e. close to PPFs and also in areas that may be affected by the Project to a lesser degree (e.g. Māngere Bridge).

Surveys were undertaken in accordance with the requirements of NZS 6801:2008 "Acoustics– Measurement of Environmental Sound" and NZS 6806:2010, and took account of the Transport Agency document "Noise monitoring requirements", V1.0 dated June 2012.

4.5 Computer noise modelling

The propagation of road traffic noise is affected by multiple factors, amongst them:

- Terrain elevations, including shielding from intervening terrain and exposure due to elevation;
- Ground condition, including absorptive ground such as meadows or reflective ground such as water;
- Atmospheric conditions, including wind or temperature inversions; and
- Road parameters, including road surface, traffic speed, vehicle types and gradient.

Because of the multiple factors and their interaction, computer noise modelling is a vital tool in predicting traffic noise impacts in the vicinity of major roads and for the determination of mitigation measures. Modelling enables a comprehensive and overall picture of noise impacts to be produced, taking into consideration all of the factors potentially affecting noise propagation.

We used the software 'SoundPLAN', which is an internationally recognised[19] computer noise modelling programme. In summary, SoundPLAN uses a digital topographical terrain map of the area as its base which for the Project included the following:

- Elevations of the Project alignment, including important aspects of the proposed road (e.g. edge of seal, median, traffic lane markings, bridges and solid safety edge barriers); and
- Elevations of the area surrounding the Project at vertical distances of 0.5m and extending generally beyond 200m from either side of the road edge.

In addition, we entered data into the model for existing buildings and structures (including auxiliary buildings and existing Transport Agency noise barriers) within the assessment area. We also digitised buildings which represent unimplemented building consents, namely dwellings in the Springpark area in Mt Wellington. The Manukau Harbour is represented by reflective ground type in the model.

We digitised road traffic noise sources, with road lanes located on the terrain file. The software then calculates traffic noise generation for multiple directions, allowing for topography, shielding, ground conditions and meteorological conditions.

The SoundPLAN model uses the calculation algorithms of the "Calculation of Road Traffic Noise" methodology which is referenced in NZS 6806 in Section 5.3.2. The calculation algorithms take account of all of the factors set out above, including relevant atmospheric and ground conditions within appropriate parameters.

The adjustments for New Zealand road conditions, specifically road surface types, are also included in the model. Therefore, modelling results can be compared with the relevant criteria without further adjustment.

19 SoundPLAN is used is used by over 5000 users in more than 40 countries.

4.6 Modelling parameters

The computer noise model includes a variety of input parameters that describe the environment in the vicinity of the Project. The main parameters, their origin and value are described below.

4.6.1 Road surface material

The major source of traffic noise is road tyre interaction for traffic speeds above 40 km/h. Therefore, the choice of road paving material has a significant effect on traffic noise generation.

A correction to a base surface of asphalt is entered into the model, which differs depending on the road surface material chosen, the speed and percentage of heavy vehicles.

The Project road is proposed to be constructed using Open Graded Porous Asphalt (OGPA). Ramps are proposed to be surfaced in dense asphalt.

4.6.2 Traffic volume and speed

The speed and volume of traffic on a road are key factors in determining the level of traffic noise generated.

The Project will have a posted speed of 60km/h. We have used this speed in the computer noise modelling. On and off-ramp speed has been modelled at between 40 and 80km/h, depending on the gradient and curve of the ramp.

Traffic flows generally increase with time. Since the assessment is based on the design year 2036, the increase over this 15-year period is included in the predictions. Traffic volumes were provided by Andrew Murray, and are discussed in *Volume 3: Technical Report 1 -Traffic and Transportation Assessment*.

4.6.3 Safety barriers

For safety requirements, all bridges and elevated structures along the Project will include edge safety barriers. These barriers provide acoustically effective shielding to PPFs in the vicinity. We have included all solid concrete safety barriers of 810mm in height on both sides of the road on bridges in our modelling.

4.7 Model verification

Computer noise models are useful tools in determining potential noise effects from a proposal. However, models are only an approximation of the real world. They are dependent on the quality of the input data and the calculation methodologies that convert the input data into predicted noise levels.

We have measured existing noise levels along the Project alignment (refer Section 5.1). In the computer model, for the measurement locations, we predicted the existing noise levels from traffic on SH1, SH20 and any major local roads. During the surveys, traffic on these roads was observed to be the controlling noise source. We then compared the measured and predicted existing noise levels for the relevant locations in order to verify the accuracy of the model.

Table 4-3 shows the comparison of measured and predicted noise levels for the Project area.

Table 4-3: Computer noise model validation–measured and predicted noise levels

Position	Measured noise level	Predicted noise level	Difference
	dB $L_{Aeq(24h)}$	dB $L_{Aeq(24h)}$	decibel
13 Kotahi Road, Mt Wellington	65	67	+2
24 Frank Grey Place, Ōtāhuhu (AMA yard)	66	68	+2
Onehunga Harbour Road, Onehunga (The Landing)	66	64	-2
88 Panama Road, Mt Wellington	75	73	-2

A comparison of the measured and predicted levels shows that for all positions there is good agreement between measured and predicted levels, with a difference of no more than 2 decibels. This accuracy fulfils the requirements of NZS 6806 which states in Section 5.3.4.2: *"The difference between measured and predicted levels should not exceed ± 2 dB."*

4.8 Individual receiver noise levels

Noise effects need to be assessed for sensitive locations, e.g. dwellings, rather than vacant land. To provide for appropriate mitigation, the location of dwellings needs to be known. As discussed in Section 3.4.1, the Standard provides protection for PPFs, including for existing dwellings and those unconstructed dwellings that have building consent.

We have included predicted noise levels for all PPFs, for all scenarios, in the tables in Appendix B. The locations of these dwellings are shown in the drawings in Appendix D.

These levels have been calculated for each PPF within 100m of the Project, as required by NZS 6806. The design of selected noise mitigation measures has been based on the application of the BPO[20] with the objective of meeting the most stringent noise criteria category practicable at all PPFs.

Noise criteria categories for the PPFs are shown as a graphic representation by colouring the buildings with a colour scale, showing NZS 6806 Category A buildings in green, Category B buildings in orange and Category C buildings in red. Any buildings not shown in these three colours on the figures are outside the assessment area of 100m from the road alignment, or are not PPFs, e.g. garages, sheds or business premises.

4.9 Noise contour plans

Noise contour plans are a useful tool to obtain a graphical overview of a project area and the potential effects of a noise source. The contours are calculated by the computer programme by interpolating a large number of individual points. Therefore, noise contour maps should not be used to determine individual noise levels for specific locations. For such individual levels, the receiver noise levels in the tables should be used (refer Appendix B).

For this Project, we used the noise level contours to show traffic noise propagation across the wider area, including to Māngere Bridge across the harbour.

The contours were prepared based on the alignment option of May 2016, with updates to the Onehunga Interchange in August 2016. Further updates to the alignment along the foreshore and at Annes Creek

20 Refer section 3.4.4

were not modelled as there are no PPFs in the vicinity. Effects on Māngere Bridge from the slightly changed alignment would be negligible.

For these reasons, not all sheets of the alignment are shown in Appendix G, as the noise level contours do not follow the latest alignment in those areas. However, no relevant information is lost as there are no noise sensitive activities in the vicinity.

Noise contour plans are contained in drawings in Appendix G. These plans show interpolated noise level bands at 5 decibel intervals from 45 dB to 75 dB $L_{Aeq(24h)}$.

4.10 Noise mitigation options

There are three general methods that can be used to control traffic noise generation or propagation. These are:

- Selecting noise reducing road surface material;
- Installing traffic noise barriers; or
- Upgrading building envelopes, e.g. by upgrading glazing, insulation or seals around doors and windows, and installing alternative ventilation options so that windows can remain closed.

We discuss these options in more detail below. (A large number of other management measures are set out in Appendix B in NZS 6806.)

4.11 Road surface material

The noise mitigation measure with the largest influence on the generation of road traffic noise is the road surface material. Mitigating traffic noise through the road surface material reduces noise at the source, i.e. the largest possible area receives the benefit of this mitigation measure. Appendix B of NZS 6806 contains extensive discussion of the application of low noise road surfaces.

The smoothness and porosity of road surface materials affect the noise generation, with smooth porous materials reducing noise generation and rough non-porous materials increasing noise generation.

Chip seal is most commonly used on the open road in lightly populated areas. It is one of the noisiest road surface materials but provides good skid resistance and is durable and cost effective.

Open Graded Porous Asphalt (OGPA) is the most common low-noise road surface used in New Zealand. It is generally used in densely populated areas and on high capacity and high speed roads. It provides good drainage due to its porosity but needs frequent maintenance and replacement from an engineering perspective. OGPA will be used for the main alignment of the Project.

For some areas where increased shear resistance for the pavement is required, e.g. for areas where vehicles brake, accelerate or turn, a more substantial structural road surface material is required. This includes the on and off-ramps. In these instances, dense asphalt (e.g. Stone Mastic Asphalt (SMA)) or similar may be utilised. This material, while also smooth and therefore generating less noise than chip seal, is non-porous. Therefore, noise levels for dense asphalt are slightly higher than those for OGPA. Dense asphalt will be used for all ramps of the Project.

4.12 Barriers and bunds

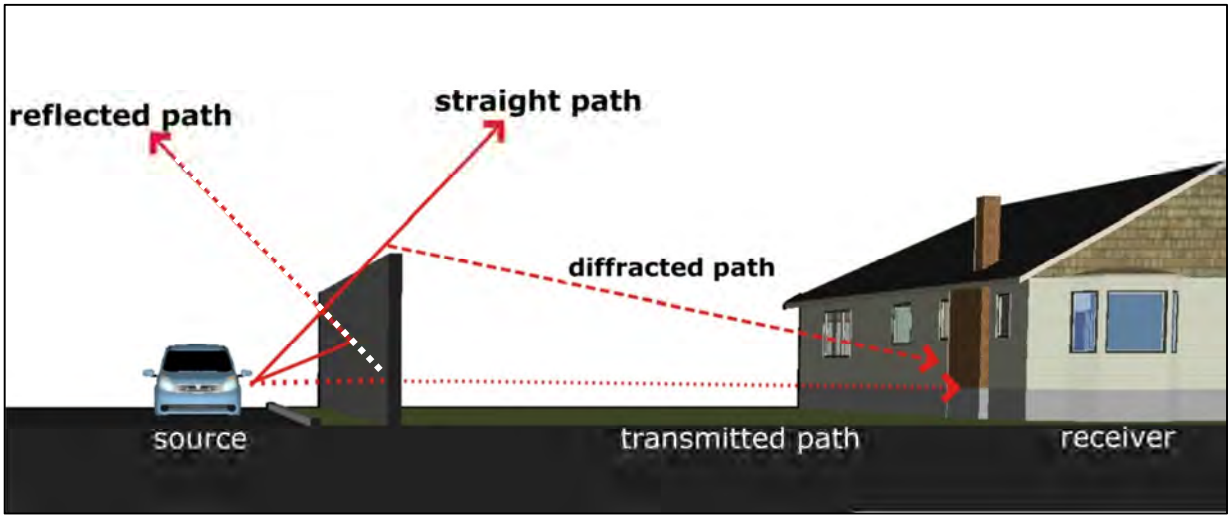
Barriers are the most common form of noise mitigation after the choice of road surface material.

Acoustic barriers work by breaking acoustic line-of-sight from the noise source to the receiver. In order to provide the most effective noise level reduction, an acoustic barrier must be of solid material (i.e. have no gaps) and have a minimum surface weight of 10 to 12kg/m^2 (e.g. 17mm ply sheeting, 9mm fibre cement, concrete etc).

Traffic noise barriers can take a variety of forms such as earth bunds (if space is available) or solid barrier walls (e.g. concrete; fibre cement). The Transport Agency has a guideline[21] for the design and longevity of noise mitigation, including barriers. This document will guide the design of noise barriers.

Figure 4-2 shows how traffic noise barriers mitigate noise by reducing its transmission through the barrier to a negligible level so that the main contribution of received noise is reduced due to bending of sound waves over and around the ends of the barrier (diffracted path).

Figure 4-2: Acoustic Barrier



Source: Transport Agency State Highway Noise Barrier Design Guide Version 1.0/August 2010

They can be installed immediately beside the road, which means that the widest surrounding area can be protected. Alternatively, barriers are installed along property boundaries close to dwellings. Such placement generally provides noise level reductions for those properties only.

There are several elevated structures along the Project that do not benefit from screening provided by topography, cuttings or ground absorption. However, bridges and viaducts are generally required to include crash barriers, which typically consist of 810mm high solid concrete barriers. These barriers can provide noticeable noise attenuation. As discussed in Section 4.6, all acoustically effective safety barriers are included in the Do-minimum scenario in the computer noise modelling. In general, bridges and viaducts generate the same level of noise from their surfacing as do on-grade roads.

The Transport Agency has in the past undertaken retrofitting of noise barriers along SH1, including one section of SH1 in Mt Wellington, which falls within the Project area. These concrete noise barriers have been included in the assessment and modelling. We have not included other, private and residential, boundary fences in our assessment. The reason is that these fences are of varying quality and in many cases not effective in reducing noise levels due to gaps and structural issues.

21 NZTA P40:2014: Specification for Noise Mitigation

4.13 Building envelope improvements

Where the relevant external noise criteria at PPFs cannot be achieved with "external" structural mitigation in the road corridor, further mitigation may be required if they are within Category C (refer Section 3.4.4).

In accordance with NZS 6806:2010, the Category C assessment is triggered if the noise level inside habitable rooms would be 45 dB $L_{Aeq(24h)}$ or more, with the implementation of the selected structural mitigation measures. In that instance, at least a five decibel noise level reduction is required to achieve an internal noise level of no more than 40 dB $L_{Aeq(24h)}$. However, the Transport Agency provides building modification mitigation for all Category C buildings where the internal noise level would otherwise be above 40 dB $L_{Aeq(24h)}$ irrespective of the internal trigger level of 45 dB $L_{Aeq(24h)}$ being reached.

The improvements required would vary from building to building. While some buildings have already been designed to achieve suitable internal noise environments, with the choice of heavy building materials, improved glazing and insulation, and well-fitting doors and windows, other building structures may not provide sufficient attenuation. Therefore, a case-by-case assessment is required for those buildings identified to fall within Category C.

Often, improvements to glazing and joinery may be sufficient to achieve the required internal noise levels. In addition, mechanical ventilation would be necessary so windows can remain closed.

Any insulation or other building envelope improvements have to be implemented concurrently with the achievement of the requirements of Clause G4 of the New Zealand Building Code, which governs the ventilation requirements for buildings. Therefore, in many instances an alternative mechanical ventilation system would be required in order to ensure sufficient ventilation is provided while maintaining suitable internal noise levels to comply with the NZS 6806 Category C requirements.

It is noted that the NZ Transport Agency guidelines provide for better ventilation than is required to be achieved by G4. Relevant information can be found here: http://nzta.govt.nz/resources/state-highway-guide-to-acoustic-treatment-of-buildings/.

4.14 Maintenance of mitigation measures

The acoustic performance of noise mitigation measures, i.e. the effectiveness and extent of noise level reduction, needs to be maintained over time. NZS 6806 states that *"structural mitigation measures should be designed in such a way that they retain the same noise-reduction properties up to the design year"*.[22]

This means that the same noise reducing qualities should be achieved as at initial installation, up to the design year 2036 for the Project. For instance, any barriers proposed should not develop gaps or other openings. In relation to barriers, this means that any damage, vandalism, or material failure resulting in openings in the barrier or between the barrier and the ground, would need to be repaired or remedied.

The Transport Agency provides maintenance of mitigation measures for the life of the road, without time limit, thus exceeding the requirements of the Standard.

22 NZS6806:2010 Acoustics–Road-traffic noise–New and altered roads, section 8.2.5.

4.15 Determination of preferred mitigation option

In accordance with NZS 6806, a number of mitigation options will be developed and evaluated by the Project team. This generally involves the following steps:

1. Mitigation options are developed for individual assessment areas as appropriate;
2. The mitigation options are discussed by relevant persons in the Project team (e.g. representatives for the urban design team, planning, construction etc), and provided to the wider Project team for comment and feedback;
3. Feedback on the options is provided in a round table discussion, enabling fine tuning of the initial mitigation options. In some instances, further mitigation options may be developed;
4. The interim preferred mitigation is chosen by the team to be put forward to community consultation. This noise mitigation is recommended to be the BPO by the team; and
5. During the detailed design prior to construction, the detailed and final mitigation will be tested if it represents the BPO at that time to ensure that the outcome is at least equivalent to that put forward with the preferred mitigation option.

A meeting and discussion of the mitigation options was undertaken on 20 October 2016. Members of the acoustic, urban design, visual and landscape, stormwater, planning, social impact and construction team were present and provided input in determining the preferred mitigation option that the team considers to constitute the BPO for traffic noise mitigation. A summary of the discussion is contained in Appendix H.

As noted in point 5 above, while a preferred mitigation option has been put forward, this option will be refined in time, with input from several parties, e.g. affected residents, design contractors etc.

5 Existing Environment

The existing noise environment from traffic on existing roads provides a baseline for assessing noise effects. Effects can be assessed by quantifying the noise levels that people would experience due to the implementation of a project. The change in noise environment can then be interpreted in relation to subjective responses of people and possible annoyance.

Existing noise levels have been determined by means of measurement (both long and short duration) and computer noise modelling. Results are discussed below. The existing noise environment at all PPFs is controlled by traffic on SH1 and SH20, and to a lesser degree by traffic on local roads and businesses in the area.

5.1 Noise level surveys

As discussed in Section 4.2, both long and short duration noise level surveys were undertaken in the vicinity of the Project and in areas more distant which may be indirectly affected by the Project.

Long duration surveys were undertaken in May 2016 in accordance with relevant guidelines. (refer Section 4.4)

Short duration attended surveys were located in the vicinity of the NOR and in other areas of interest, e.g. Māngere Bridge. As traffic distribution over the day is known, the short duration survey results can be used to derive a 24-hour traffic noise level.

All noise level survey results are shown in Table 5-1. For each long duration noise level survey, the diurnal variation in level is also shown in Appendix C. Measured and derived noise levels ranged from 45 dB $L_{Aeq(24h)}$ at Norana Park in Māngere Bridge, away from any major roads or other noise generating activities, to 72 dB $L_{Aeq(24h)}$ adjacent to Onehunga Harbour Road beside SH20.

Table 5-1: Noise level survey results

Location	Measured noise level	Derived noise level
Long duration surveys	**dB $L_{Aeq(24h)}$**	**dB $L_{Aeq(24h)}$**
13 Kotahi Road, Mt Wellington	65	n/a
24 Frank Grey Place, Ōtāhuhu (AMA yard)	66	n/a
14 Onehunga Harbour Road, Onehunga (The Landing)	66	n/a
88 Panama Road, Mt Wellington	75	n/a
Short duration surveys	**dB $L_{Aeq(15min)}$**	**dB $L_{Aeq(24h)}$**
13 Frank Grey Place, Ōtāhuhu	67	65
1 Deas Place, Ōtāhuhu	70	68
36 Mataroa Place, Mt Wellington	68	66
102 Hillside Road, Mt Wellington	69	67
96 Captain Springs Road, Onehunga	65	63
Waikaraka Cemetery (water end)	54	53
31 Onehunga Harbour Road, Onehunga	74	72
16 Mona Avenue, Māngere Bridge	51	49
31 Norana Avenue, Māngere Bridge	49	48
Norana Park, Māngere Bridge	46	45

5.2 Computer noise modelling

In addition to measuring the noise levels at a number of locations along the alignment, computer noise modelling enables the prediction of existing noise levels at all PPFs within the assessment area (100m from the edge of the carriageway for urban areas in accordance with NZS 6806–refer Section 3.4).

Due to the large number of PPFs (401), the Project has been divided into seven individual noise assessment areas are described in Table 5-2 and are shown on the figure in Appendix A.

Table 5-2: Noise assessment areas

Adjacent to	Direction	Area number	Area name
SH20	Northbound	1	Onehunga
SH1	Southbound	2	Mt Wellington
	Southbound	3	Ōtāhuhu North
	Southbound	4	Ōtāhuhu South
SH1	Northbound	5	Mt Wellington
	Northbound	6	Ōtāhuhu North
	Northbound	7	Ōtāhuhu South

For each of these areas, the noise levels received by all PPFs have been calculated. Results have been combined for each area, using two methodologies:

- Noise levels currently received by dwellings as sorted into Categories A, B and C in accordance with NZS 6806, and
- Noise levels in five decibel bands from less than 55 dB to more than 75 dB $L_{Aeq(24h)}$ to assess the number of people potentially highly annoyed by road traffic noise.

The results show that 19% of all PPFs currently receive noise levels within Category C, due to their close proximity to SH1, the busiest motorway in New Zealand. With the preferred mitigation option, this reduces to 5%.

The number of PPFs in each NZS 6806 noise criteria category have been summarised for the entire Project in Table 5-3.

Table 5-3: Number of PPFs in each NZS 6806 noise criteria category

Situation	Category A	Category B	Category C
Existing (2013)	257	69	75
Do-nothing (2036)	244	64	93
Do-minimum (2036)	239	59	103
Preferred Mitigation Option (2036)	295	85	21

Appendix D contains figures showing a graphic representation of the noise criteria categories, by colouring the buildings within NZS 6806 Category A in green, Category B in yellow and Category C in red. Any barriers are shown in turquoise.

6 Assessment of Traffic Noise Effects

This section of the report describes the assessment of operational noise effects from the Project on PPFs within 100m of the Alignment against “altered” road criteria of NZS 6806.

The Do-nothing scenario (where the Project is not built) showed that noise levels would increase by approximately one decibel along SH1 as at the design year. The Do-minimum scenario (where the Project is built with no noise mitigation) allowed for OGPA road surface on the entire alignment (except ramps). A number of PPFs currently, and in the future, would fall into Categories B and C, which is not a desirable outcome.

The main mitigation option we considered involved barriers of varying height where several PPFs will benefit from it (i.e. adjacent to SH1). This option achieved effective mitigation for most PPFs, and specifically those most affected by road traffic noise. A preferred mitigation option is put forward for each area.

Each assessment area is discussed separately in the sections below in relation to NZS 6806, change in noise level and number of people potentially highly annoyed.

6.1 Area 1–Onehunga

Assessment area 1 is located in Onehunga, with several PPFs located just north of the Project and the new Onehunga Mall and Galway Street connections. All dwellings are located on Onehunga Harbour Road and Onehunga Mall. PPFs include two and three storey apartment buildings, single old style houses and one motel. The area is affected by traffic on SH20 and its ramps, as well as local traffic and businesses in the area.

6.1.1 NZS 6806

Area 1 contains 12 PPFs (i.e. individual buildings), with existing noise levels ranging from 60 to 73 dB $L_{Aeq(24h)}$. The area is surrounded by major roads and ramps, which is reflected in the elevated ambient noise level. Noise levels remain similar in the do-nothing scenario, where only State highways and ramps are included in the model, and local roads are excluded.

All PPFs constructed in the past 15 years have been designed to achieve appropriate internal noise levels due to their close proximity to SH20 and associated ramps. This includes the PPFs at Onehunga Harbour Road 14 B and C, which are predicted to receive very high noise levels of 75 dB $L_{Aeq(24h)}$, up to 2 decibels above the existing ambient noise level. As these are multi storey dwellings overlooking the road, barriers are not considered to provide effective shielding. These PPFs will need to be assessed in relation to the Category C requirements.

The PPFs at 31, 33, 35, 35A and 50 Onehunga Mall are older style dwellings which, based on visual inspection, do not have noise control incorporated in their design. Of those, 35 and 35A Onehunga Mall are predicted to receive noise levels within Category C, with predicted noise levels up to 71 dB $L_{Aeq(24h)}$. Mitigation option 1 involves a 1.5m barrier, and Mitigation Option 2 a 2m barrier located adjacent to the SH20 southbound lanes, extending some 120m from north of the PPFs onto the bridge. This barrier achieves a noise level reduction of between 2 and 4 decibels which is a noticeable noise level reduction.

With the 2m barrier, only the PPFs at 14B and C Onehunga Harbour Road remain within Category C. This is the preferred mitigation option from a noise point of view. From discussion with the urban design specialists of this Project, the barrier should be made of transparent material above the concrete safety barrier. There are various suitable materials available for this type of barrier.

The number of PPFs in each noise category is summarised in Table 6-1, and figures showing the location of the PPFs are included in Appendix D.

Table 6-1: Area 1–Summary of NZS 6806 assessment

Situation	Number of PPFs NZS 6806 Categories			Comments
	Category A	Category B	Category C	
Existing (2013)	1	4	7	State highways, ramps and local roads
Do-nothing (2036)	3	4	5	State highways and ramps only
Do-minimum (2036)	3	4	5	State highways, ramps and roads that are affected by the Project
Mitigation Option 1 (2036)	4	5	3	1.5m barrier close to Onehunga Mall PPFs
Mitigation Option 2 (2036)	5	5	2	2m barrier close to Onehunga Mall PPFs – Preferred Option
Mitigation Option 3 (2036)	6	4	2	2m barrier close to Onehunga Mall PPFs, 5m barrier for Onehunga Harbour Road PPFs

Mitigation option 2 is the preferred option based on input from other disciplines, such as urban design. All of the older styles PPFs in Onehunga Mall are predicted to receive noise levels within Categories A or B, and only the new apartment buildings in Onehunga Harbour Road will receive noise levels within Category C.

While Mitigation option 3 would result in a better acoustic outcome, a 5m barrier along the road edge was considered to be impracticable due to its excessive height and very marginal noise level improvements.

6.1.2 Assessment of Effects

Noise effects can be described based on the change in noise level with and without the Project. In order to remove the "time factor" from now to the design year in 2036, the comparison is made between the do-nothing scenario (current roads with design year traffic volume) and the Project with the preferred mitigation option (Project with design year traffic volume).

The Project is predicted to change the overall noise level in the vicinity only marginally and generally to an unnoticeable degree. With the inclusion of a barrier shielding the PPFs at Onehunga Mall, noise levels are predicted to reduce slightly, which results in an overall positive effect.

Table 6-2: Area 1 – Change in noise level

Change in noise level (Preferred mitigation option–Do-nothing scenario)	Number of PPFs	Effect
9–11 decibels reduction	0	Significant positive
5–8 decibels reduction	0	Moderate positive
3–4 decibels reduction	3	Slight positive
1–2 decibels reduction	3	Negligible
Less than 1 decibel change	2	None
1–2 decibels increase	4	Negligible
3–4 decibels increase	0	Slight adverse
5–8 decibels increase	0	Moderate adverse

6.1.3 Number of people highly annoyed

Based on the information provided through the 2013 census, there are on average 2.6 people per dwelling in Area 1. This number has been used to determine the number of people potentially highly annoyed. Detailed number of dwellings in each noise band, and the total number of people potentially highly annoyed are shown in Table 6-3 below.

The table shows that the number of people highly annoyed will essentially remain unchanged over time. The reason is that the Project is predicted to have negligible effects on the overall noise level. This is reflected in the stable number of PPFs in each of the noise bands when comparing do-nothing and Project scenarios.

Table 6-3: Area 1–Number of people potentially highly annoyed

Situation	Annoyance band (dB $L_{Aeq(24h)}$)						Number of people potentially highly annoyed
	<55	55–60	60–65	65–70	70–75	>75	
	Number of PPFs						
Existing (2013)	0	1	1	8	2	0	8
Do-nothing (2036)	0	1	4	4	3	0	8
Do-minimum (2036)	0	0	4	5	3	0	8
Mitigation Option 1 (2036)	0	0	7	3	2	0	7
Mitigation Option 2 (2036)	0	0	8	2	1	1	7
Mitigation Option 3 (2036)	0	1	7	2	2	0	7

Figures showing the distribution of noise levels in the bands set out in Table 6-3 are included in Appendix E.

6.2 Area 2 – Mt Wellington Southbound

Assessment area 2 extends from just north of Panama Road to Ōtāhuhu Creek and is located adjacent to the southbound lanes of SH1. The area is predominantly residential in use. Dwellings are located in close proximity to SH1, and no noise barriers are present in this area.

6.2.1 NZS 6806

Area 2 contains 86 PPFs, with existing noise levels predicted to range from 53 to 75 dB $L_{Aeq(24h)}$, depending on the distance of PPFs to SH1 and shielding provided by terrain and intervening dwellings. PPFs are in close proximity to SH1, with the most affected adjacent to Panama Road intended to be removed for construction purposes.

We have tested two mitigation options and, following discussion with the project team in the BPO workshop, added a third option.

Mitigation option 1 involves a 2.4m barrier along the extent of this area, adjacent to SH1 and moving with the property boundary at 1 McLennan Road, where the dwelling is located above SH1. Mitigation option 2 allows for the same barrier extent, but at 3m height. For both mitigation options, a 1.8m high noise barrier in place of a boundary fence has been proposed adjacent to the PPFs at 130A and B and 132A to C Panama Road.

Both options provide extensive noise level reduction to most PPFs, with reductions of up to 8 and 9 decibels for Options 1 and 2 respective. For Mitigation Option 2, of the 30 PPFs in Category C in the Do-minimum scenario, only three remain in Category C.

However, discussions with the urban design specialists indicate that visibility from SH1 towards Ōtāhuhu Creek and the new shared path connecting Mataroa Road and Deas Place should be maintained. For that reason, Mitigation option 3 is similar to Option 2, but incorporates a lower barrier towards the Creek, and a 1.8m high boundary fence adjacent to the driveways to 55 and 57 Mataroa Road. This arrangement provides reasonable shielding of the properties and maintains privacy, while the shared path and Creek remain visible from SH1.

The number of PPFs in each noise category is summarised in Table 6-4, and figures showing the location of the PPFs are included in Appendix D.

Table 6-4: Area 2–Summary of NZS 6806 assessment

Situation	Number of PPFs NZS 6806 Categories			Comments
	Category A	Category B	Category C	
Existing (2013)	55	16	15	State highways, ramps and local roads
Do-nothing (2036)	51	14	21	State highways and ramps only
Do-minimum (2036)	50	6	30	State highways, ramps and roads that are affected by the Project
Mitigation Option 1 (2036)	65	16	5	2.4m barrier + 1.8m barrier
Mitigation Option 2 (2036)	71	12	3	3m barrier + 1.8m barrier
Mitigation Option 3 (2036)	70	13	3	Varying height barriers from 1.8 to 3m height. – preferred option

Mitigation option 3 is the preferred option as the least number of PPFs would receive noise levels within Category C (only 3 compared with 21 if the Project was not to go ahead), and largest significant number of PPFs would receive noise levels within Category A while balancing visual effects.

6.2.2 Assessment of Effects

The implementation of the Project (without mitigation) would have only a slight overall effect on the ambient noise level.

The Project is predicted to result in a significant improvement in noise environment for PPFs in the vicinity. The reason is that the lack of barriers will be addressed, and the preferred variable barrier ranging in height from 1.1m to 3m will result in significant noise level reductions, particularly for the most affected PPFs immediately adjacent to SH1.

One PPF (at 73 Panama Road) is predicted to receive the highest noise level increase for the Project, of just under 5 decibels. The reason is the proposed elevation of Panama Road in the vicinity for the approach of the new Panama Road bridge. This change in noise level is difficult to mitigate because of the height of the dwelling in relation to the road.

Table 6-5 shows the predicted noise level changes and improvements due to the proposed barrier.

Table 6-5: Area 2–Change in noise level

Change in noise level (Preferred mitigation option–Do-nothing scenario)	Number of PPFs	Effect
9–11 decibels reduction	1	Significant positive
5–8 decibels reduction	16	Moderate positive
3–4 decibels reduction	16	Slight positive
1 –2 decibels reduction	31	Negligible
Less than 1 decibel change	15	None
1–2 decibels increase	4	Negligible
3–4 decibels increase	2	Slight adverse
5–8 decibels increase	1	Moderate adverse

6.2.3 Number of people highly annoyed

Based on the information provided through the 2013 census, there are on average 3.7 people per dwelling in Area 2. This number has been used to determine the number of people potentially highly annoyed. Detailed number of dwellings in each noise band, and the total number of people potentially highly annoyed are shown in Table 6-6.

The table shows that the number of people highly annoyed would be increasing over time due to increased traffic volume and the Project. However, with the proposed barrier in place, there is a significant drop in people that are exposed to noise levels that may result in them being highly annoyed, to levels below existing numbers despite the increase in traffic volume.

Table 6-6: Area 2–Number of people potentially highly annoyed

Situation	Annoyance band (dB $L_{Aeq(24h)}$)						Number of people potentially highly annoyed
	<55	55–60	60–65	65–70	70–75	>75	
	Number of PPFs						
Existing (2013)	7	25	26	22	6	0	57
Do-nothing (2036)	4	32	21	18	10	1	59
Do-minimum (2036)	2	26	25	21	11	1	64
Mitigation Option 1 (2036)	3	40	31	9	3	0	49
Mitigation Option 2 (2036)	3	44	33	4	2	0	47
Mitigation Option 3 (2036)	3	42	34	6	1	0	47

Figures showing the distribution of noise levels in the bands set out in Table 6-6 are included in Appendix E.

6.3 Area 3 – Ōtāhuhu North Southbound

Assessment area 3 is located adjacent to the southbound lanes of SH1 and extends from Ōtāhuhu Creek to Princes Street East. Dwellings are located in close proximity to SH1 and the southbound off ramp, and no noise barriers are present in this area.

6.3.1 NZS 6806

Area 3 contains 48 PPFs, with existing noise levels predicted to range from 54 to 72 dB $L_{Aeq(24h)}$, depending on the distance of PPFs to SH1 and shielding provided by terrain and intervening dwellings. Most PPFs in close proximity to SH1 are beyond the southbound off-ramp and therefore somewhat separated from the traffic. This is noticeable in the overall slightly lower noise levels in this area. Only eight PPFs are predicted to be within Category C with the Do-minimum scenario.

We tested one mitigation option, which provided effective protection. Mitigation option 1 consists of a 2.4m barrier along SH1 and the ramp, extending for some 370m and shielding all PPFs in the area. This barrier achieves good noise level reduction and moves all PPFs into Categories A or B.

This option was further developed following input from the urban design team, which requested lower barriers in the vicinity of Ōtāhuhu Creek to allow visibility to the creek and the shared path. Mitigation option 2 takes account of this feedback and consists of a 2.4m barrier for most of the area, stepping down to 1.1m at the creek. In addition, a 1.8m high boundary fence is proposed to ensure the privacy of 16 and 18 Deas Place where the shared path will connect with Deas Place.

The number of PPFs in each noise category is summarised in Table 6-7, and figures showing the location of the PPFs are included in Appendix D.

Table 6-7: Area 3–Summary of NZS 6806 assessment

Situation	Number of PPFs			Comments
	NZS 6806 Categories			
	Category A	Category B	Category C	
Existing (2013)	33	11	4	State highways, ramps and local roads
Do-nothing (2036)	35	6	7	State highways and ramps only
Do-minimum (2036)	31	9	8	State highways, ramps and roads that are affected by the Project
Mitigation Option 1 (2036)	37	11	0	2.4m barrier
Mitigation Option 2 (2036)	37	11	0	1.1m to 2.4m variable height barriers – preferred option

6.3.2 Assessment of Effects

The preferred barrier provides noise level reduction for those PPFs closest to SH1. Therefore, while only few PPFs are predicted to receive a benefit from the barrier, those are the ones currently most affected by traffic noise.

Table 6-8: Area 3–Change in noise level

Change in noise level (Preferred mitigation option–Do-nothing scenario)	Number of PPFs	Effect
9–11 decibels reduction	0	Significant positive
5–8 decibels reduction	3	Moderate positive
3–4 decibels reduction	4	Slight positive
1–2 decibels reduction	9	Negligible
Less than 1 decibel change	19	None
1–2 decibels increase	11	Negligible
3–4 decibels increase	2	Slight adverse
5–8 decibels increase	0	Moderate adverse

6.3.3 Number of people highly annoyed

Based on the information provided through the 2013 census, there are on average 4 people per dwelling in Area 3. This number has been used to determine the number of people potentially highly annoyed. Detailed number of dwellings in each noise band, and the total number of people potentially highly annoyed are shown in Table 6-9.

The table shows that the number of people highly annoyed would be slightly increasing over time with increased traffic volume and the ramp moving closer to dwellings. With the installation of the barrier, the number of people highly annoyed would reduce slightly due to the lower noise levels at those houses more affected by traffic noise.

Figures showing the distribution of noise levels in the bands set out in Table 6-9 are included in Appendix E.

Table 6-9: Area 3–Number of people potentially highly annoyed

Situation	Annoyance band (dB $L_{Aeq(24h)}$)						Number of people potentially highly annoyed
	<55	55–60	60–65	65–70	70–75	>75	
	Number of PPFs						
Existing (2013)	2	21	14	9	2	0	31
Do-nothing (2036)	0	23	12	11	2	0	32
Do-minimum (2036)	0	16	17	13	2	0	35
Mitigation Option 1 (2036)	0	21	23	4	0	0	29
Mitigation Option 2 (2036)	0	21	23	4	0	0	30

6.4 Area 4 – Ōtāhuhu South Southbound

Assessment area 4 is located adjacent to the southbound lanes of SH1 and extends from Princes Street East to just north of Water Street in Ōtāhuhu (approximately 100m south of the Project extent). Dwellings are located in close proximity to SH1 and the southbound on ramp, and there are presently no noise barriers in this area.

6.4.1 NZS 6806

Area 4 contains 39 PPFs, with existing noise levels predicted to range from 56 to 75 dB $L_{Aeq(24h)}$, depending on the distance of PPFs to SH1 and shielding provided by terrain and intervening dwellings. While most dwellings are separated from SH1 by the southbound onramp, noise levels are elevated with nine PPFs within Category C.

We tested a 2.4m barrier, located along the new on-ramp and extending past the PPFs and across Trenwith Street bridge. This barrier would achieve good noise level reductions and move all but two PPFs into Categories A and B. PPFs at 132 Avenue Road and 72 Frank Grey Place are predicted to still receive noise levels within Category C.

A higher barrier of 3m was tested in the vicinity of these two PPFs. The Avenue Road dwelling would receive noise levels within Category B, while 72 Frank Grey Place cannot practicably be shielded, unless a barrier in excess of 3m is installed. Therefore, Mitigation option 2 involves a 2.4m high barrier for the extent of this assessment area, with a 3m barrier in front of the Avenue Road dwelling only.

Further refinement after feedback from the urban design team resulted in barriers on top of Trenwith Street overbridge being removed (only the concrete safety barriers are required). In addition, the 2.4m barrier has been stepped down either side of Trenwith Street overbridge to allow a more graduated change in barrier height. This Mitigation option 3 is the preferred mitigation option in relation to noise.

The number of PPFs in each noise category is summarised in Table 6-10, and figures showing the location of the PPFs are included in Appendix D.

Table 6-10: Area 4–Summary of NZS 6806 assessment

Situation	Number of PPFs			Comments
	NZS 6806 Categories			
	Category A	Category B	Category C	
Existing (2013)	23	7	9	State highways, ramps and local roads
Do-nothing (2036)	21	9	9	State highways and ramps only
Do-minimum (2036)	21	9	9	State highways, ramps and roads that are affected by the Project
Mitigation Option 1 (2036)	31	6	2	2.4m barrier
Mitigation Option 2 (2036)	31	7	1	2.4m barrier and 3m barrier at 132 Avenue Road
Mitigation Option 3 (2036)	31	7	1	1.8 to 3m barrier – preferred option

6.4.2 Assessment of Effects

Overall, with the preferred barrier arrangement implemented, a significant reduction in noise level can be achieved, of up to 8 decibels. Dwellings closest to SH1 and the barrier benefit the most, with a significant improvement of noise environment for those most affected PPFs.

Table 6-11: Area 4–Change in noise level

Change in noise level (Preferred mitigation option–Do-nothing scenario)	Number of PPFs	Effect
9–11 decibels reduction	0	Significant positive
5–8 decibels reduction	10	Moderate positive
3–4 decibels reduction	8	Slight positive
1–2 decibels reduction	18	Negligible
Less than 1 decibel change	3	None
1–2 decibels increase	0	Negligible
3–4 decibels increase	0	Slight adverse
5–8 decibels increase	0	Moderate adverse

6.4.3 Number of people highly annoyed

Based on the information provided through the 2013 census, there are on average 3.3 people per dwelling in Area 4. This number has been used to determine the number of people potentially highly annoyed. Detailed number of dwellings in each noise band, and the total number of people potentially highly annoyed are shown in Table 6-12.

The table shows that the number of people highly annoyed can be reduced with the introduction of the preferred mitigation option, and a significant number of people would move from the higher noise brackets into the 55-60 dB $L_{Aeq(24h)}$ bracket, which is appropriate for residential use.

Table 6-12: Area 4–Number of people potentially highly annoyed

Situation	Annoyance band (dB $L_{Aeq(24h)}$)						Number of people potentially highly annoyed
	<55	55–60	60–65	65–70	70–75	>75	
	Number of PPFs						
Existing (2013)	0	6	21	6	6	0	26
Do-nothing (2036)	0	8	16	7	8	0	27
Do-minimum (2036)	0	8	15	8	7	1	27
Mitigation Option 1 (2036)	0	18	16	4	1	0	20
Mitigation Option 2 (2036)	0	20	14	4	1	0	20
Mitigation Option 3 (2036)	0	18	16	4	1	0	20

Figures showing the distribution of noise levels in the bands set out in Table 6-12 are included in Appendix E.

6.5 Area 5–Mt Wellington Northbound

Assessment area 5 is located adjacent to the northbound lanes of SH1 and extends from just north of Panama Road to Ōtāhuhu Creek. Dwellings are located in close proximity to SH1 and are in parts elevated above SH1. The Transport Agency has installed concrete noise barriers in the vicinity of Hillside Road which provide shielding for approximately four residential sites. These barriers have been included in our assessment of the existing situation.

The new Springpark development, while currently not implemented, has obtained building consent. Two dwellings in Hillside Road (numbers 98 and 100) are part of the development and will be removed in the future to provide access to the site and additional building platforms. In accordance with NZS 6806, we have assessed the building platforms for the proposed future buildings within the development. The layout and height of the future buildings is based on building consent drawings obtained from Auckland Council.

6.5.1 NZS 6806

Area 5 contains 109 PPFs, with existing noise levels predicted to range from 56 to 74 dB $L_{Aeq(24h)}$, depending on the distance of PPFs to SH1 and shielding provided by terrain, existing noise barriers and intervening dwellings. A number of dwellings are in close proximity to and above SH1 and therefore difficult to shield. A significant number of PPFs receive noise levels within Category C, which increases from 27 currently to 37 with the Project without mitigation.

We initially developed two mitigation options. Mitigation option 1 involves a 1.8m noise barrier in place of a boundary fence beside 84 and 86 Panama Road, and 2.4m barriers connecting with the existing noise barriers beside Hillside Road, extending from Panama Road to Ōtāhuhu Creek. This option achieves reasonable noise level reductions, but is not sufficient for those PPFs located above or at some distance from SH1. Category C noise levels are still predicted for 20 PPFs.

Mitigation option 2 involved targeted higher barriers. At 84 and 86 Panama Road, a 2.4m barrier was tested, which moves those PPFs into Categories A or B. Additionally, noise barriers of up to 3 metres were tested for those areas where PPFs are above SH1. While this option provides better mitigation, feedback from the urban design team resulted in the development of a third mitigation option, taking into consideration sight lines to Ōtāhuhu Creek and more uniform barriers.

Therefore, it was proposed to step barriers up in height from 1.1m connecting with the bridge barriers at Ōtāhuhu Creek, to 3m in the vicinity of Kotahi Road. The existing 2.4m high noise barriers would remain unchanged, but be flanked by 3m barriers. PPFs at 15 Coppins Road cannot practicably be shielded from road traffic noise as their main view is along SH1 to the south, across Ōtāhuhu Creek. Any barrier would need to be higher than 3m, and extend across the Ōtāhuhu Creek. Even with such a barrier, noise levels would remain within the high end of the Category B criteria. Due to urban design feedback, no high barriers are proposed in this area.

Mitigation option 3 moves a further seven PPFs out of Category C when compared with Mitigation option 1, and achieves a better outcome in terms of BCR (1.2, refer Appendix B) and structural mitigation (for those PPFs that benefit from the barriers). Mitigation option 3 is the preferred option.

The number of PPFs in each noise category is summarised in Table 6-13, and figures showing the location of the PPFs are included in Appendix D.

Table 6-13: Area 5–Summary of NZS 6806 assessment

Situation	Number of PPFs NZS 6806 Categories			Comments
	Category A	Category B	Category C	
Existing (2013)	58	24	27	State highways, ramps and local roads, existing barrier
Do-nothing (2036)	53	20	36	State highways, ramps and roads that are affected by the Project, existing barrier
Do-minimum (2036)	50	22	37	State highways, ramps and roads that are affected by the Project, existing barrier
Mitigation Option 1 (2036)	60	29	20	2.4m barrier
Mitigation Option 2 (2036)	69	27	13	2.4m barrier and 3m barrier
Mitigation Option 3 (2036)	65	31	13	1.1m to 3m barrier – preferred option

6.5.2 Assessment of Effects

The existing noise level in Area 5 is elevated, with a large number of dwellings receiving noise levels above 65 dB $L_{Aeq(24h)}$. The introduction of any barrier will result in positive effects, with the potential for significant betterment in the residential noise environment. Table 6-14 shows that the preferred barrier would result in moderate to significant noise level reductions for 11 dwellings. Those are dwellings currently most affected by road traffic noise. A further 16 dwellings would receive slight noise level reductions – generally dwellings one row removed from SH1 or elevated.

Overall, the introduction of the preferred barrier would result in a positive effect in this area.

Table 6-14: Area 5–Change in noise level

Change in noise level (Preferred mitigation option–Do-nothing scenario)	Number of PPFs	Effect
9–11 decibels reduction	0	Significant positive
5–8 decibels reduction	11	Moderate positive
3–4 decibels reduction	16	Slight positive
1–2 decibels reduction	29	Negligible
Less than 1 decibel change	46	None
1–2 decibels increase	6	Negligible
3–4 decibels increase	1	Slight adverse
5–8 decibels increase	0	Moderate adverse

6.5.3 Number of people highly annoyed

Based on the information provided through the 2013 census, there are on average 3.1 people per dwelling in Area 5. This number has been used to determine the number of people potentially highly annoyed. Detailed number of dwellings in each noise band, and the total number of people potentially highly annoyed are shown in Table 6-15.

The table shows that the number of people highly annoyed would reduce noticeably with the introduction of either barrier, specifically by 14 people for Mitigation option 2 compared with the Do-minimum scenario. It is also noted that dwellings receiving noise levels of 70 dB $L_{Aeq(24h)}$ or more can be significantly reduced from 17 in the Do-minimum scenario to only two dwellings.

Table 6-15: Area 5–Number of people potentially highly annoyed

Situation	Annoyance band (dB $L_{Aeq(24h)}$)						Number of people potentially highly annoyed
	<55	55–60	60–65	65–70	70–75	>75	
	Number of PPFs						
Existing (2013)	0	26	42	34	7	0	67
Do-nothing (2036)	0	26	34	40	9	0	73
Do-minimum (2036)	0	25	30	37	16	1	76
Mitigation Option 1 (2036)	0	28	45	34	2	0	66
Mitigation Option 2 (2036)	0	33	48	26	2	0	62
Mitigation Option 3 (2036)	0	31	49	28	1	0	63

Figures showing the distribution of noise levels in the bands set out in Table 6-15 are included in Appendix E.

6.6 Area 6 – Ōtāhuhu North Northbound

Assessment Area 6 is located adjacent to the northbound lanes of SH1 and extends from Ōtāhuhu Creek to Princes Street in Ōtāhuhu. Dwellings are located in close proximity to the Ōtāhuhu northbound on-ramp. PPFs are generally below the ramp level and are therefore generally well shielded from direct noise from SH1. One dwelling (98E Luke Street) is proposed to be removed for construction purposes.

One of the buildings in the assessment area is a Sikh Temple (Gurdwara Temple) at 120 Princes Street. The temple offers permanent and temporary accommodation, and is therefore considered a PPF.

6.6.1 NZS 6806

Area 6 contains 49 PPFs, with existing noise levels predicted to range from 55 to 70 dB $L_{Aeq(24h)}$, depending on the distance of PPFs to SH1 and shielding provided by terrain and intervening dwellings. PPFs are generally below the level of the northbound onramp.

The number of PPFs in each noise category is summarised in Table 6-16, and figures showing the location of the PPFs are included in Appendix D.

We developed three mitigation options.

Mitigation option 1 consists of a 1.8m high barrier along the ramp edge, increasing in height of 2.4m from 85 Luke Street north. The reason is that at 85 Luke Street SH1 and the ramp are level and slightly below the dwelling height, and a higher barrier is required to achieve any meaningful noise level reduction. This barrier, while generally achieving reasonable noise level reductions, does not provide sufficient mitigation to move all PPFs out of Category C.

Mitigation option 2 provides for a slightly longer and higher (3m) barrier in the vicinity of 85 Luke Street. With this barrier, all PPFs are predicted to receive noise levels in Categories A and B.

After feedback from the urban design team, Mitigation option 3 was developed. This option consists of a 2.4m barrier along the extent of the onramp. The barrier is slightly pulled back from the ramp to allow for planting on the road side. This is the preferred mitigation option.

Table 6-16: Area 6–Summary of NZS 6806 assessment

Situation	Number of PPFs NZS 6806 Categories			Comments
	Category A	Category B	Category C	
Existing (2013)	43	1	5	State highways, ramps and local roads
Do-nothing (2036)	42	1	6	State highways, ramps and roads that are affected by the Project
Do-minimum (2036)	41	3	5	State highways, ramps and roads that are affected by the Project
Mitigation Option 1 (2036)	45	3	1	1.8m and 2.4m barrier
Mitigation Option 2 (2036)	45	4	0	1.8m and 3m barrier
Mitigation Option 3 (2036)	45	4	0	2.4m barrier – preferred option

6.6.2 Assessment of Effects

Of the 49 PPFs, 14 are predicted to receive a noticeable reduction in noise level. This includes all PPFs that are currently most affected by road traffic noise (i.e. in Categories B or C). Overall, the Project will have a positive effect on the noise environment in this assessment area.

Table 6-17: Area 6–Change in noise level

Change in noise level (Preferred mitigation option–Do-nothing scenario)	Number of PPFs	Effect
9–11 decibels reduction	0	Significant positive
5–8 decibels reduction	4	Moderate positive
3–4 decibels reduction	10	Slight positive
1–2 decibels reduction	11	Negligible
Less than 1 decibel change	21	None
1–2 decibels increase	3	Negligible
3–4 decibels increase	0	Slight adverse
5–8 decibels increase	0	Moderate adverse

6.6.3 Number of people highly annoyed

Based on the information provided through the 2013 census, there are on average 3.3 people per dwelling in Area 6. This number has been used to determine the number of people potentially highly annoyed. Detailed number of dwellings in each noise band, and the total number of people potentially highly annoyed are shown in Table 6-18.

While the overall number of people highly annoyed only changes marginally, it can be seen that there is a noticeable shift as the high noise PPFs in areas of 65 dB $L_{Aeq(24h)}$ or higher move into lower noise level bands, with only one PPF remaining in the "above 65 dB $L_{Aeq(24h)}$" noise band.

Table 6-18: Area 6–Number of people potentially highly annoyed

Situation	Annoyance band (dB $L_{Aeq(24h)}$)						Number of people potentially highly annoyed
	<55	55–60	60–65	65–70	70–75	>75	
	Number of PPFs						
Existing (2013)	0	33	10	6	0	0	22
Do-nothing (2036)	0	29	14	6	0	0	24
Do-minimum (2036)	0	38	5	5	1	0	23
Mitigation Option 1 (2036)	0	40	6	3	0	0	20
Mitigation Option 2 (2036)	0	40	6	3	0	0	20
Mitigation Option 3 (2036)	0	40	8	1	0	0	20

Figures showing the distribution of noise levels in the bands set out in Table 6-18 are included in Appendix E.

6.7 Area 7 – Ōtāhuhu South Northbound

Assessment area 7 is located adjacent to the northbound lanes of SH1 and extends from Princes Street, Ōtāhuhu to just north of Water Street (approximately 100m south of the Project extent). Dwellings are generally located at some distance from the northbound Ōtāhuhu off ramp. When the Highbrook Interchange was constructed, timber fences were installed adjacent to the site at 113 Albert Street. These barriers are of board and batten nailed timber construction and are unlikely to retain their acoustic performance as required by the Transport Agency's specification for noise mitigation P/40:2014. This can be seen by the vegetation that can grow through the panel, which is a sign of gaps in the barrier. While this is currently not the case, the longevity of the barrier in regards to effective noise reduction is questionable. In addition, the barrier has a visible and significant gap at the bottom of the panel as shown in Figure 6-1.

Figure 6-1: Barrier Ōtāhuhu northbound off-ramp

Source: Google Maps Street View

For the above reasons, we have not included the barrier in the existing situation modelling as it is unlikely to remain acoustically effective in future years.

6.7.1 NZS 6806

Area 7 contains 58 PPFs, with existing noise levels predicted to range from 52 to 74 dB $L_{Aeq(24h)}$, depending on the distance of PPFs to SH1 and shielding provided by terrain and intervening dwellings. Up to nine PPFs are predicted to receive noise levels within Category C with and without the Project, and without any noise mitigation.

We assessed a noise barrier varying in height from 3m (in front of 113 Albert Avenue) to 2.4m in front of the dwellings at 48 Water Street. PPFs in Trenwith Street would be shielded by 1.8m high barriers. This barrier moves all but two dwellings into Categories A and B.

The dwelling at 113 Albert Street is double storey and elevated above SH1. Therefore, noise mitigation for the upper floor is impracticable, and noise levels would be addressed through other measures such as building modification mitigation. Similarly, a dwelling at 48 Water Street is elevated above SH1 and difficult to shield with barriers.

Following urban design feedback, an additional barrier arrangement was tested that mirrors that of Area 4. This means that there would be no barrier on the Trenwith Street bridge apart from the 1.1m high concrete edge barrier (this barrier is a safety barrier rather than a noise barrier.

For the remainder of the area, barriers ranging in height form 1.8m to 3m are proposed. While 14 PPFs are predicted to receive noise levels within Category B, these are generally marginal increases in noise levels of less than 1 decibel when compared with Mitigation option 1. Mitigation option 2 is the preferred option by the Project team.

The number of PPFs in each noise category is summarised in Table 6-19, and figures showing the location of the PPFs are included in Appendix D.

Table 6-19: Area 7–Summary of NZS 6806 assessment

Situation	Number of PPFs			Comments
	NZS 6806 Categories			
	Category A	Category B	Category C	
Existing (2013)	44	6	8	State highways, ramps and local roads
Do-nothing (2036)	39	10	9	State highways, ramps and roads that are affected by the Project
Do-minimum (2036)	43	6	9	State highways, ramps and local roads
Mitigation Option 1 (2036)	49	7	2	1.8 to 3m barriers
Mitigation Option 2 (2036)	42	14	2	1.8 to 3m barriers – preferred option

6.7.2 Assessment of Effects

Existing noise levels for PPFs from Avenue Road south are elevated because of their proximity to SH1. The preferred barrier arrangement would result in betterment for these PPFs.

PPFs between Princes Street and Avenue Road are predicted to receive no or only marginal noise level reduction. That is because these PPFs are sufficiently distant from SH1 to not require mitigation.

Table 6-20: Area 7–Change in noise level

Change in noise level (Preferred mitigation option–Do-nothing scenario)	Number of PPFs	Effect
9–11 decibels reduction	0	Significant positive
5–8 decibels reduction	6	Moderate positive
3–4 decibels reduction	3	Slight positive
1–2 decibels reduction	17	Negligible
Less than 1 decibel change	21	None
1–2 decibels increase	11	Negligible
3–4 decibels increase	0	Slight adverse
5–8 decibels increase	0	Moderate adverse

6.7.3 Number of people highly annoyed

Based on the information provided through the 2013 census, there are on average 3.8 people per dwelling in Area 7. This number has been used to determine the number of people potentially highly annoyed. Detailed number of dwellings in each noise band, and the total number of people potentially highly annoyed are shown in Table 6-21.

The table shows that the number of people highly annoyed would be slightly increasing over time due to increase in traffic volume and the road moving closer. However, with the implementation of the proposed barrier, fewer people would be affected by noise levels that could leave them highly annoyed.

Table 6-21: Area 7–Number of people potentially highly annoyed

Situation	Annoyance band (dB $L_{Aeq(24h)}$)						Number of people potentially highly annoyed
	<55	55–60	60–65	65–70	70–75	>75	
	Number of PPFs						
Existing (2013)	5	18	23	8	4	0	38
Do-nothing (2036)	6	18	20	6	8	0	40
Do-minimum (2036)	3	22	21	4	8	0	40
Mitigation Option 1 (2036)	4	24	25	4	1	0	34
Mitigation Option 2 (2036)	2	25	25	2	1	0	35

Figures showing the distribution of noise levels in the bands set out in Table 6-21 are included in Appendix E.

7 Recommended Traffic Noise Mitigation

We have assessed traffic noise mitigation for all assessment areas in the vicinity of the Project, and have recommended mitigation that we consider to represent the BPO when weighing up benefits and adverse effects of acoustics, urban design and other disciplines.

As low noise road surface is already proposed to be used as the base surface, no further noise mitigation was able to be incorporated into the road surface design.

Barriers are the next preferred mitigation measure and have been recommended at varying heights and lengths everywhere along the Project where there are PPFs in close proximity. Where these barriers are not sufficient to achieve noise levels within Categories A and B, building modification mitigation may also have to be implemented if the internal trigger level of 45 dB $L_{Aeq(24h)}$ is reached inside habitable rooms facing the Project.

The following table summarises the recommended barrier heights and lengths for each assessment area, as well as the number of PPFs that are predicted to receive noise levels within Category C. A figure showing the preferred barrier locations and heights is included in Appendix F.

Table 7-1: Preferred noise mitigation measures

Area	Mitigation Option	Barrier heights and lengths	PPFs considered for building modification mitigation (Category C)
1	2	1.8m height: 120m	2
2	3	1.1m height: 40m 1.8m height: 201m 2.4m height: 242m 3m height: 421m	3
3	2	1.1m height: 41m 1.8m height: 100m 2.4m height: 305m	0
4	3	1.8m height: 30m 2.4m height: 306m 3m height: 40m	1
5	3	1.1m height: 39m 1.8m height: 64m 2.4m barrier: 299m 3m barrier: 356m	13
6	3	2.4m height: 240m	0
7	2	1.8m height: 44m 2.4m height: 127m 3m height: 105m	2

8 Assessment of Traffic Vibration Effects

The Auckland Motorway Alliance is responsible for the maintenance of the Auckland State highway network and receives any complaints in regards to these roads. We have requested complaints data for the Project area. We understand that no complaints have been received in regards to traffic vibration, which indicates that the current level of traffic vibration is likely appropriate.

Traffic vibration is usually only generated when heavy commercial vehicles (HCV) drive over bumps or dips in the road.

Traffic vibration risk has been assessed by reviewing data of HCVs travelling on existing roads with a range of surface conditions. Assessing this data against the Project traffic vibration criterion (Class C of the Norwegian Standard NS 8176.E:2005) indicates that compliance with the criteria can be achieved at 25m from the road edge, even for roads in a degraded state. For a newly sealed OGPA pavement, the risk contour is less than 2m from the road edge. There are no receivers this close to the traffic lane edge.

With the implementation of the Transport Agency road maintenance policy, it is unlikely that the Project road surface will ever degrade significantly so effects are predicted to be negligible for all receivers. However, if the road does degrade, the effects would still only be minor provided that compliance with the Project traffic vibration criterion is maintained.

9 Conclusion

Marshall Day Acoustics has undertaken an assessment of traffic noise and vibration from the East West Link between SH20 at Onehunga and SH1 at Mt Wellington and Ōtāhuhu. All noise sensitive receivers within 100m of the Project alignment have been assessed. The assessment is based on the relevant Standard (NZS 6806), the potential subjective response of people to the change in noise level and the number of people likely to be highly annoyed by the traffic noise levels received.

Noise barriers of varying heights have been recommended for those sections of the Project alignment in the vicinity of PPFs. The heights of the barriers may be revised in the final design, with input from affected residents, the detailed design team and the Transport Agency.

Where no barriers are recommended, reasons include:

- The lay of the dwelling in relation to the road (e.g. where dwellings are significantly elevated and cannot be effectively shielded);
- Multi storey dwellings where the upper floor cannot be mitigated; and
- The need for barriers that may be too high in a residential context.

The Project will be surfaced with OGPA on the main alignment, and dense asphalt on ramps. These are low noise generating road surface materials.

The noise level change due to the Project (without mitigation) for any dwellings will generally be small (less than 4 decibels). For most areas, noise levels would change by no more than 2 decibels. This change would be imperceptible for human hearing, particularly as the noise source (i.e. traffic) does not change.

However, due to the excessive existing noise levels which may result in adverse health effects, extensive noise mitigation has been recommended for most areas, to rectify the current adverse noise environment where practicable.

With the mitigation in place, noise levels are predicted to be lower in the design year than is currently experienced. The Project would have an overall positive effect and result in significant betterment, particularly for those dwellings currently affected by the most elevated noise levels.

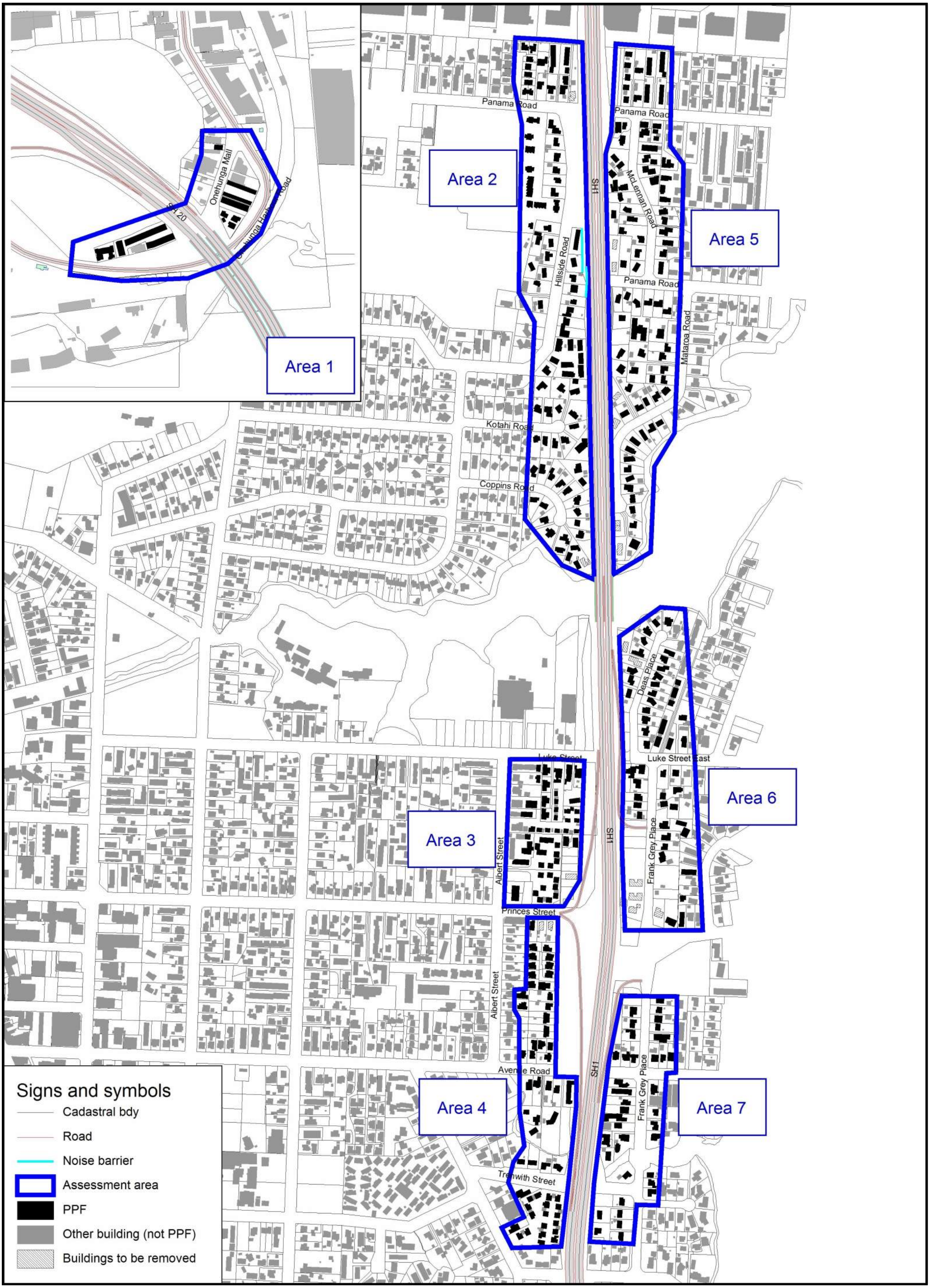
While currently (in 2016) 75 PPFs are predicted to receive noise levels within Category C, with the Project in 2036 and the recommended mitigation implemented, only 21 PPFs are predicted to remain within Category C, despite the increase in traffic volume over time.

Traffic vibration has been addressed through review of complaints about current traffic vibration from SH1 in the assessment area. No complaints have been recorded by the Auckland Motorway Alliance. Maintaining a smooth road surface will reduce traffic vibration. The Transport Agency has appropriate measures in place that ensures the quality of the road will be maintained to a high level.

Overall, this Project will result in betterment for most people adjacent to the road, with a 76% reduction in PPFs within Category C (93 PPFs for the Do-nothing scenario compared with 22 PPFs with the preferred mitigation option). While high noise levels cannot be mitigated at all dwellings, the proposed mitigation will result in significant noise level reductions up to 9 decibels for some of the most affected dwellings.

Appendix A

Assessment Areas



No	Issued Status	Drawn	App'd	Check'd	Date
A	ISSUED FOR INFORMATION ONLY	SW	SW	Draft	09/08/16

DISCLAIMER

The information shown on this drawing is solely for the purpose of supporting application under the RMA for resource consents and/ or designations.
All information shown is subject to final design and review for compliance with any approved consents and/ or designations.
This Drawing must not be used for construction.

NZ TRANSPORT AGENCY WAKA KOTAHI

East West Link

Drawn: Siiri Wilkening	Drafting Check:	Design Manager Reviewed: Siiri Wilkening	Approved Alliance Manager:
Designed: Siiri Wilkening	Design Check:		
Scale: 1:2500	Original Size: A3	Contract No: PA4041	

Drawing Title: NOISE & VIBRATION NZS 6806 Assessment Areas

Drawing Number: GIS-NV-AEE-001

Rev No.: A

Plot Date: 09/08/2016 Plotted by: Siiri Wilkening

Appendix B

NZS 6806 Assessment: BCR and BPO

Project

East West Link
1 - Onehunga

Protected Premises and Facilities

	Existing	Do-nothing	Do-minimum	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Selected solution			○	○	◉	○	○	○	○
Category A	1	3	3	4	5	6	0	0	0
Category B	4	4	4	5	5	4	0	0	0
Category C	7	5	5	3	2	2	0	0	0
Total	12	12	12	12	12	12	0	0	0

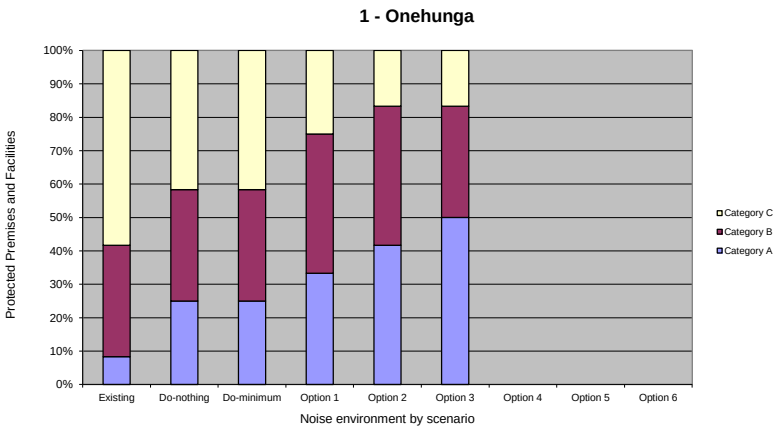
Benefit-Cost Ratio

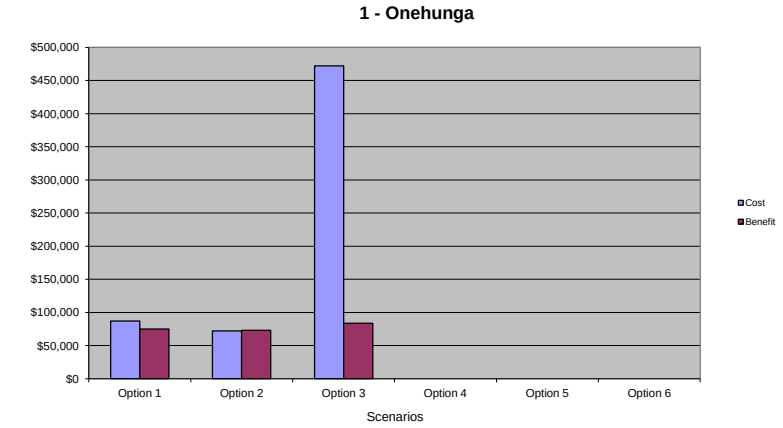
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Cost	$87,000	$72,000	$472,000	$0	$0	$0
Benefit	$74,844	$73,224	$83,592	$0	$0	$0
BCR	**0.86**	**1.02**	**0.18**	-	-	-
Structural	2.1 dB	2.5 dB	2.4 dB			

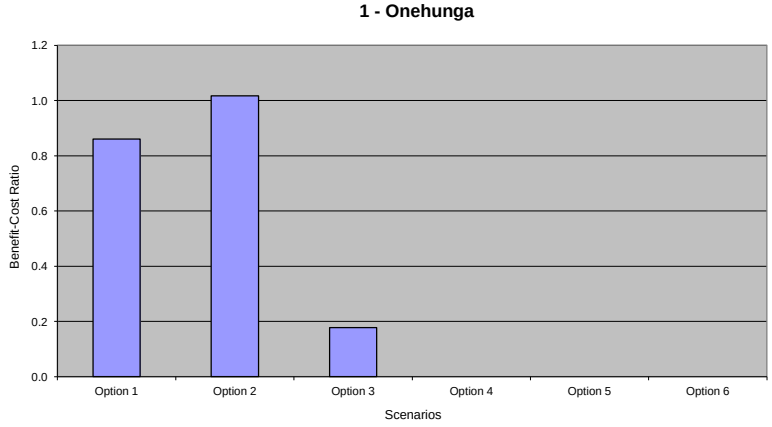
Assessment matrix

	Option 1	Option 2	Option 3
NZS 6806 compliance	---	---	---
Structural mitigation	-	o	-
BCR	o	+	- - -

Graphs







Project: East West Link
Area: 1 – Onehunga
AADT: (•) 2,000 to 75,000 vehicles per day
( ) More than 75,000 vehicles per day

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Protected Premises and Facilities			New or Altered	Existing $L_{Aeq(24h)}$ dB	Results from noise model for design year							
Reference	Street address	Floor			Do-nothing $L_{Aeq(24h)}$ dB	Do-minimum $L_{Aeq(24h)}$ dB	Option 1 $L_{Aeq(24h)}$ dB	Option 2 $L_{Aeq(24h)}$ dB	Option 3 $L_{Aeq(24h)}$ dB	Option 4 $L_{Aeq(24h)}$ dB	Option 5 $L_{Aeq(24h)}$ dB	Option 6 $L_{Aeq(24h)}$ dB
1	Onehunga Harbour Road 008	1.FL	Altered	69.4	64.7	65.0	65.1	65.1	63.6			
2	Onehunga Harbour Road 014A	2.FL	Altered	66.9	66.9	67.1	67.2	67.2	65.1			
3	Onehunga Harbour Road 014B	2.FL	Altered	73.1	74.9	75.3	75.3	75.4	73.4			
4	Onehunga Harbour Road 014C	2.FL	Altered	72.7	74.4	74.9	74.9	75.0	70.6			
5	Onehunga Mall 031	GF	Altered	66.5	65.2	66.8	63.6	63.3	63.5			
6	Onehunga Mall 033	GF	Altered	65.4	60.5	60.5	60.1	60.2	60.3			
7	Onehunga Mall 035	1.FL	Altered	66.3	68.3	68.4	64.8	64.1	64.4			
8	Onehunga Mall 035A	1.FL	Altered	68.8	70.7	71.0	67.5	66.9	67.1			
9	Onehunga Mall 037	2.FL	Altered	67.7	67.8	68.2	65.9	65.3	65.5			
10	Onehunga Mall 039	2.FL	Altered	68.2	63.7	64.1	63.0	62.7	62.8			
11	Onehunga Mall 039A	2.FL	Altered	67.7	65.8	66.3	65.1	64.7	64.9			
12	Onehunga Mall 050	GF	Altered	60.3	60.1	60.3	60.4	60.4	60.6			

Project

East West Link
2 - Mt Wellington Sthbd

Protected Premises and Facilities

	Existing	Do-nothing	Do-minimum	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Selected solution			○	○	○	◉	○	○	○
Category A	55	51	50	65	71	70	0	0	0
Category B	16	14	6	16	12	13	0	0	0
Category C	15	21	30	5	3	3	0	0	0
Total	86	86	86	86	86	86	0	0	0

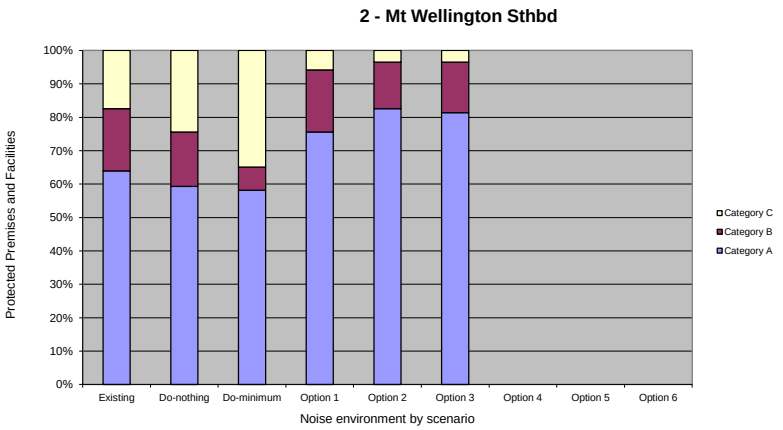
Benefit-Cost Ratio

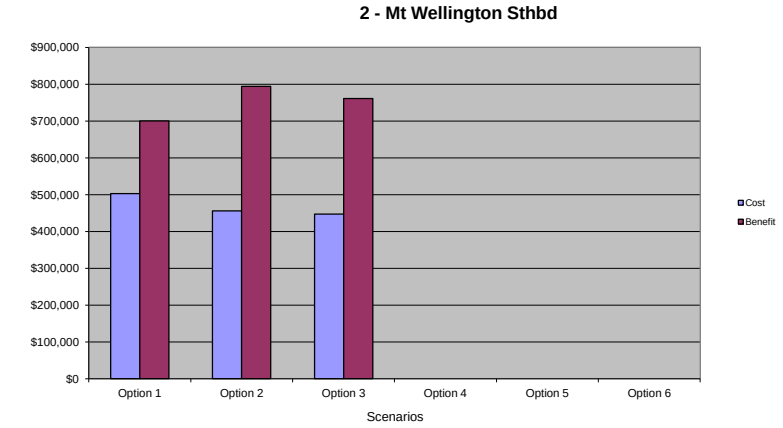
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Cost	$503,060	$455,780	$447,590	$0	$0	$0
Benefit	$700,380	$794,448	$761,292	$0	$0	$0
BCR	**1.39**	**1.74**	**1.70**	-	-	-
Structural	3.2 dB	3.8 dB	3.6 dB			

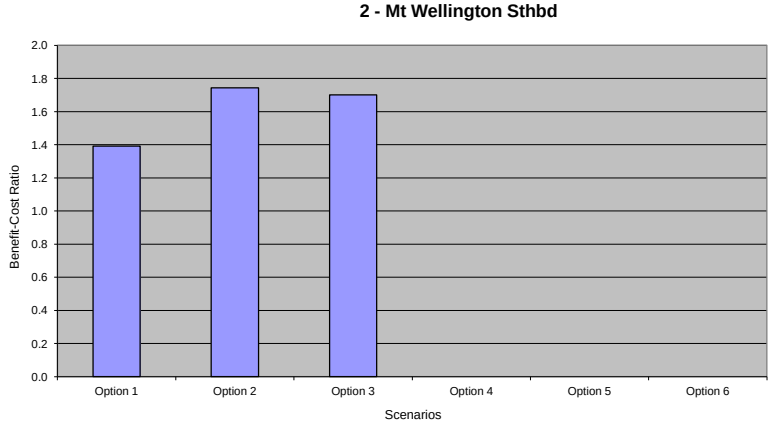
Assessment matrix

	Option 1	Option 2	Option 3
NZS 6806 compliance	--	-	-
Structural mitigation	o	+	+
BCR	+ +	+ + +	+ + +

Graphs







Project: East West Link
Area: 2 – Mt Wellington Sthbd
AADT: ○ 2,000 to 75,000 vehicles per day
● More than 75,000 vehicles per day

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Protected Premises and Facilities			New or	Existing	Results from noise model for design year							
Reference	Street address	Floor	Altered	$L_{Aeq(24h)}$ dB	Do-nothing $L_{Aeq(24h)}$ dB	Do-minimum $L_{Aeq(24h)}$ dB	Option 1 $L_{Aeq(24h)}$ dB	Option 2 $L_{Aeq(24h)}$ dB	Option 3 $L_{Aeq(24h)}$ dB	Option 4 $L_{Aeq(24h)}$ dB	Option 5 $L_{Aeq(24h)}$ dB	Option 6 $L_{Aeq(24h)}$ dB
1	Mataroa Road 004	GF	Altered	56.4	57.4	57.8	57.6	57.5	57.5			
2	Mataroa Road 008	GF	Altered	54.8	55.7	56.2	55.9	55.8	55.8			
3	Mataroa Road 010	GF	Altered	55.8	56.7	57.5	56.8	56.7	56.7			
4	Mataroa Road 012	GF	Altered	60.1	61.0	61.3	60.1	59.5	59.5			
5	Mataroa Road 014	GF	Altered	61.9	62.8	64.0	60.7	60.3	60.7			
6	Mataroa Road 016	GF	Altered	55.3	56.2	56.8	56.2	56.1	56.2			
7	Mataroa Road 018	GF	Altered	54.3	55.3	55.8	55.7	55.7	55.7			
8	Mataroa Road 018A	GF	Altered	58.5	59.4	59.9	58.4	58.1	58.2			
9	Mataroa Road 020	GF	Altered	54.6	55.6	56.2	55.8	55.5	55.8			
10	Mataroa Road 022	GF	Altered	57.8	58.8	59.6	57.2	57.0	57.2			
11	Mataroa Road 024	GF	Altered	59.1	60.1	60.7	57.6	56.9	57.6			
12	Mataroa Road 026	1.FL	Altered	65.1	66.1	67.9	64.0	63.2	64.0			
13	Mataroa Road 028	GF	Altered	65.9	66.8	68.6	62.6	61.6	62.6			
14	Mataroa Road 030	GF	Altered	69.7	70.6	71.2	64.0	62.8	63.3			
15	Mataroa Road 033	GF	Altered	55.3	56.2	58.3	56.5	56.1	56.5			
16	Mataroa Road 034	GF	Altered	66.9	67.8	71.4	65.7	64.4	65.7			
17	Mataroa Road 035	GF	Altered	57.7	58.7	60.7	58.3	57.8	58.3			
18	Mataroa Road 037A	GF	Altered	60.9	61.9	63.9	60.2	59.4	60.2			
19	Mataroa Road 037B	GF	Altered	58.3	59.2	61.4	59.0	58.4	59.0			
20	Mataroa Road 039	GF	Altered	64.1	65.0	66.4	61.5	60.4	61.4			
21	Mataroa Road 041	GF	Altered	66.7	67.6	67.7	62.3	61.2	62.3			
22	Mataroa Road 043	GF	Altered	68.1	69.1	69.1	63.8	62.8	63.7			
23	Mataroa Road 045	GF	Altered	68.8	69.7	69.5	63.9	62.9	63.7			
24	Mataroa Road 047	GF	Altered	68.2	69.1	69.1	62.9	61.7	62.9			
25	Mataroa Road 049	GF	Altered	69.3	70.3	70.9	64.9	63.8	64.7			
26	Mataroa Road 051	GF	Altered	66.7	67.7	69.0	64.2	63.1	64.1			
27	Mataroa Road 053	GF	Altered	67.1	68.1	69.6	65.4	64.5	64.6			
28	Mataroa Road 055	GF	Altered	65.9	66.9	69.6	65.8	64.8	64.3			
29	Mataroa Road 057	GF	Altered	64.0	65.0	67.9	64.1	62.9	62.4			
30	McLennan Road 001	1.FL	Altered	71.2	72.1	72.8	71.6	71.2	70.9			
31	McLennan Road 001A	1.FL	Altered	67.1	67.2	68.0	67.8	67.8	67.8			
32	McLennan Road 003	GF	Altered	69.8	70.7	71.9	65.4	63.8	63.8			
33	McLennan Road 003A	GF	Altered	60.6	61.5	62.3	58.8	58.3	58.3			
34	McLennan Road 004	1.FL	Altered	65.0	64.7	65.2	64.2	63.7	63.7			
35	McLennan Road 005A	1.FL	Altered	74.7	75.6	76.6	72.1	69.6	69.6			
36	McLennan Road 005B	GF	Altered	61.8	62.6	62.6	58.6	57.9	57.9			
37	McLennan Road 005C	GF	Altered	72.3	73.1	74.5	65.5	63.9	63.9			
38	McLennan Road 006B	1.FL	Altered	65.4	65.3	65.9	64.7	64.2	64.2			
39	McLennan Road 006C	GF	Altered	56.2	56.8	57.2	57.1	56.9	56.9			
40	McLennan Road 007	1.FL	Altered	69.7	70.6	71.4	66.1	64.8	64.8			
41	McLennan Road 008	GF	Altered	63.3	62.8	63.5	61.9	61.4	61.4			
42	McLennan Road 010	GF	Altered	61.8	61.8	62.8	61.0	60.3	60.3			
43	McLennan Road 012	GF	Altered	60.5	59.9	61.0	59.1	58.7	58.7			
44	McLennan Road 013	GF	Altered	62.8	63.6	64.0	60.4	59.6	59.6			
45	McLennan Road 014	GF	Altered	59.7	59.1	60.3	58.6	58.0	58.0			
46	McLennan Road 015	GF	Altered	72.8	73.7	74.7	67.6	65.9	65.9			
47	McLennan Road 017	GF	Altered	59.5	60.4	60.9	58.6	58.1	58.1			
48	McLennan Road 019	GF	Altered	66.9	67.8	68.5	62.9	61.8	61.8			
49	McLennan Road 020	GF	Altered	60.6	58.8	59.4	58.1	57.6	57.6			
50	McLennan Road 021	GF	Altered	60.4	61.3	64.0	60.0	59.3	59.3			
51	McLennan Road 022	GF	Altered	58.8	57.6	58.5	57.4	57.0	57.0			
52	McLennan Road 023	GF	Altered	61.8	62.7	63.7	60.1	59.4	59.4			
53	McLennan Road 024	GF	Altered	59.2	57.6	58.5	57.4	56.9	56.9			
54	McLennan Road 025	GF	Altered	61.8	62.7	64.3	60.3	59.4	59.4			
55	McLennan Road 026	GF	Altered	60.1	58.8	59.3	57.4	56.8	56.8			
56	Panama Road 069	GF	Altered	71.4	72.3	72.9	67.2	67.1	67.2			
57	Panama Road 071	GF	Altered	63.8	61.3	64.3	64.1	64.1	64.1			
58	Panama Road 071A	GF	Altered	63.6	61.2	61.8	61.1	60.8	60.8			
59	Panama Road 073	GF	Altered	61.7	57.1	61.9	61.8	61.8	61.8			
60	Panama Road 073A	GF	Altered	54.3	54.2	54.9	54.9	54.9	54.9			
61	Panama Road 073B	GF	Altered	52.7	53.2	53.7	53.6	53.6	53.6			
62	Panama Road 075	GF	Altered	53.0	53.6	54.1	54.1	54.1	54.1			
63	Panama Road 081A	GF	Altered	53.7	54.4	54.9	54.3	54.2	54.2			
64	Panama Road 081B	GF	Altered	59.7	60.2	61.3	59.5	58.9	58.9			
65	Panama Road 081C	GF	Altered	59.7	59.8	60.9	59.3	58.7	58.7			
66	Panama Road 130A	GF	Altered	66.1	66.9	67.4	64.6	64.6	64.6			
67	Panama Road 130B	GF	Altered	66.5	67.5	68.2	65.0	65.0	65.0			
68	Panama Road 132A	GF	Altered	65.9	66.8	67.7	65.3	65.3	65.3			
69	Panama Road 132B	GF	Altered	66.1	67.0	68.0	64.8	64.8	64.8			
70	Panama Road 132C	GF	Altered	65.8	66.7	67.7	64.8	64.8	64.8			
71	Panama Road 134B	GF	Altered	55.6	56.4	56.8	56.8	56.8	56.8			
72	Panama Road 136	GF	Altered	60.7	59.1	58.8	58.7	58.6	58.6			
73	Panama Road 138	GF	Altered	60.5	58.2	58.7	58.6	58.6	58.6			
74	Panama Road 140	GF	Altered	56.1	57.0	57.4	57.4	57.4	57.4			
75	Panama Road 142	GF	Altered	54.2	54.9	55.5	55.5	55.5	55.5			
76	Panama Road 144	GF	Altered	60.6	55.3	58.6	58.6	58.6	58.6			
77	Panama Road 369	GF	Altered	64.1	65.0	68.7	63.2	62.1	62.1			
78	Panama Road 440	GF	Altered	54.4	55.1	55.5	55.3	55.1	55.1			
79	Panama Road 442	GF	Altered	56.8	57.1	58.5	56.2	55.8	55.8			
80	Panama Road 444	GF	Altered	58.1	58.2	59.8	57.2	56.7	56.7			
81	Panama Road 446	GF	Altered	63.2	64.2	64.9	62.3	61.4	61.4			
82	Panama Road 448	1.FL	Altered	62.2	63.2	63.1	61.6	60.8	60.8			
83	Panama Road 450	GF	Altered	63.8	64.7	65.4	60.8	59.9	59.9			
84	Panama Road 452	GF	Altered	70.2	71.1	71.2	66.1	64.7	64.7			
85	Panama Road 454	GF	Altered	70.2	71.2	70.4	68.8	67.1	67.2			
86	Panama Road 456	GF	Altered	70.5	71.4	72.4	65.6	64.2	64.2			

Project

East West Link

3 - Otahuhu North Sthbd

Protected Premises and Facilities

	Existing	Do-nothing	Do-minimum	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Selected solution			○	○	◉	○	○	○	○
Category A	33	35	31	37	37	0	0	0	0
Category B	11	6	9	11	11	0	0	0	0
Category C	4	7	8	0	0	0	0	0	0
Total	48	48	48	48	48	0	0	0	0

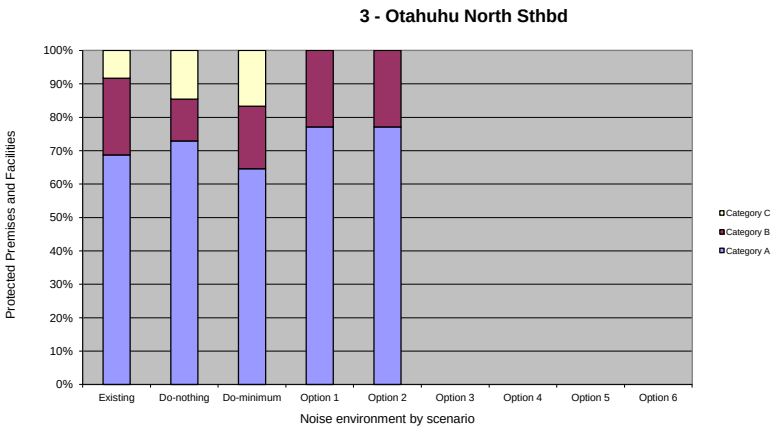
Benefit-Cost Ratio

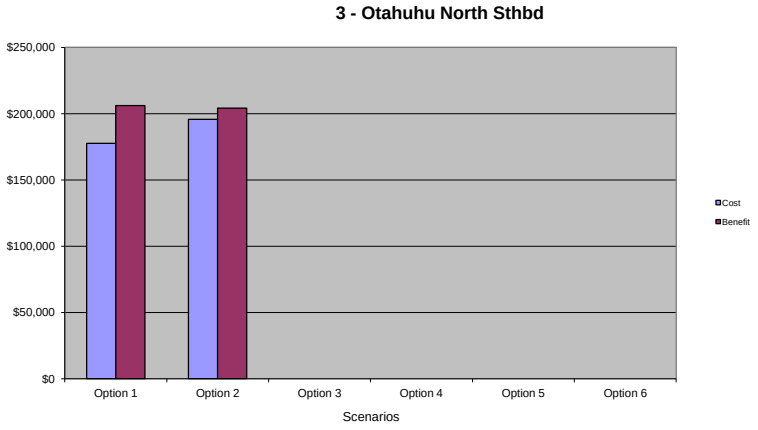
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Cost	$177,600	$195,750	$0	$0	$0	$0
Benefit	$206,064	$204,120	$0	$0	$0	$0
BCR	**1.16**	**1.04**	-	-	-	-
Structural	2.0 dB	2.2 dB				

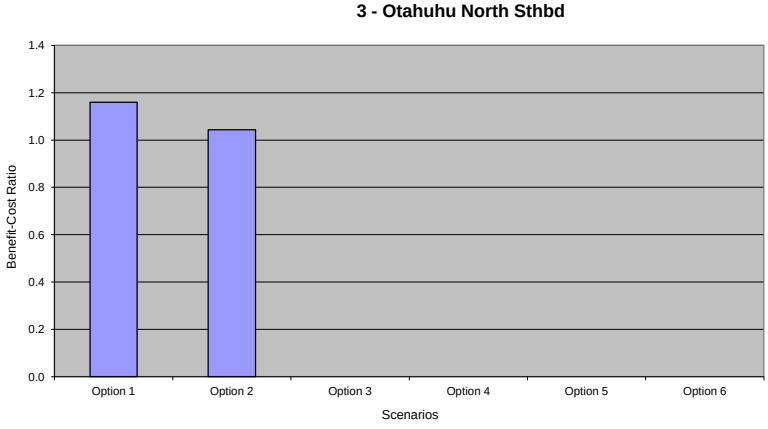
Assessment matrix

	Option 1	Option 2
NZS 6806 compliance	+	+
Structural mitigation	-	-
BCR	+	+

Graphs







Project: East West Link
Area: 3 – Otahuhu North Sthbd
AADT: ○ 2,000 to 75,000 vehicles per day
● More than 75,000 vehicles per day

Paste up to 200 rows of data | Reformat | New | Altered

Protected Premises and Facilities			New or Altered	Existing $L_{Aeq(24h)}$ dB	Results from noise model for design year							
					Do-nothing $L_{Aeq(24h)}$ dB	Do-minimum $L_{Aeq(24h)}$ dB	Option 1 $L_{Aeq(24h)}$ dB	Option 2 $L_{Aeq(24h)}$ dB	Option 3 $L_{Aeq(24h)}$ dB	Option 4 $L_{Aeq(24h)}$ dB	Option 5 $L_{Aeq(24h)}$ dB	Option 6 $L_{Aeq(24h)}$ dB
Reference	Street address	Floor										
1	Deas Place 001	GF	Altered	66.0	66.4	66.8	63.8	63.8				
2	Deas Place 003	GF	Altered	66.5	66.9	67.4	64.4	64.4				
3	Deas Place 004	GF	Altered	70.6	71.5	72.8	67.2	67.2				
4	Deas Place 005	GF	Altered	66.0	66.3	67.0	64.0	64.0				
5	Deas Place 007	GF	Altered	65.4	65.7	66.4	63.5	63.5				
6	Deas Place 008	GF	Altered	68.3	69.3	70.4	65.2	65.2				
7	Deas Place 009	GF	Altered	62.8	63.0	63.7	61.5	61.5				
8	Deas Place 010	GF	Altered	66.5	67.5	69.2	65.2	65.4				
9	Deas Place 011	GF	Altered	62.8	62.8	63.6	61.6	61.4				
10	Deas Place 013	GF	Altered	61.7	61.5	62.7	60.8	61.1				
11	Deas Place 015	GF	Altered	59.5	58.9	60.0	58.9	59.3				
12	Deas Place 016	GF	Altered	63.0	64.0	68.8	66.0	65.2				
13	Deas Place 017	GF	Altered	60.0	59.2	60.8	59.4	59.5				
14	Deas Place 018	GF	Altered	62.4	63.9	63.7	63.3	63.6				
15	Deas Place 019	GF	Altered	59.9	59.1	60.6	59.3	59.4				
16	Deas Place 020	GF	Altered	63.9	65.5	65.7	65.4	65.6				
17	Deas Place 021	1.FL	Altered	60.8	60.6	61.8	61.4	61.5				
18	Deas Place 022	GF	Altered	60.2	61.5	62.2	62.1	62.2				
19	Deas Place 026	GF	Altered	59.9	61.5	61.8	61.8	61.8				
20	Fencible Place 004	GF	Altered	56.9	56.8	60.1	60.1	60.1				
21	Fencible Place 010	GF	Altered	58.9	59.1	60.8	60.7	60.7				
22	Frank Grey Place 001	GF	Altered	61.2	60.2	61.2	60.4	60.4				
23	Frank Grey Place 002	GF	Altered	72.0	72.9	74.2	66.4	66.4				
24	Frank Grey Place 003	GF	Altered	60.7	60.1	61.0	60.4	60.4				
25	Frank Grey Place 003A	GF	Altered	59.8	59.5	60.6	60.4	60.4				
26	Frank Grey Place 004	GF	Altered	67.2	68.2	68.9	63.0	63.0				
27	Frank Grey Place 005	GF	Altered	64.2	63.6	64.3	63.6	63.6				
28	Frank Grey Place 005A	GF	Altered	56.4	57.0	57.5	57.2	57.2				
29	Frank Grey Place 006	GF	Altered	67.6	68.6	69.2	63.8	63.8				
30	Frank Grey Place 007	GF	Altered	64.5	64.1	65.3	64.5	64.5				
31	Frank Grey Place 007A	GF	Altered	57.1	57.6	57.9	57.2	57.2				
32	Frank Grey Place 008	GF	Altered	67.3	68.2	68.9	64.6	64.6				
33	Frank Grey Place 009	GF	Altered	64.7	64.2	65.4	64.8	64.8				
34	Frank Grey Place 010	GF	Altered	66.3	66.7	67.0	65.1	65.1				
35	Frank Grey Place 011	GF	Altered	65.2	64.4	65.9	65.5	65.5				
36	Luke Street East 082	GF	Altered	59.2	58.6	59.3	58.0	58.0				
37	Luke Street East 082A	GF	Altered	55.6	56.4	56.9	56.7	56.7				
38	Luke Street East 082B	GF	Altered	54.3	55.1	55.6	55.6	55.6				
39	Luke Street East 082C	GF	Altered	54.6	55.5	55.9	55.9	55.9				
40	Luke Street East 082D	GF	Altered	54.0	54.8	55.6	55.4	55.5				
41	Luke Street East 084	GF	Altered	58.8	58.5	59.2	57.9	57.9				
42	Luke Street East 086	GF	Altered	55.4	56.2	56.7	56.6	56.6				
43	Luke Street East 088	GF	Altered	56.3	56.8	57.3	57.3	57.3				
44	Luke Street East 101	GF	Altered	57.8	57.9	58.5	57.9	57.9				
45	Luke Street East 101A	GF	Altered	56.9	57.4	58.0	57.8	57.8				
46	Luke Street East 101B	GF	Altered	59.1	59.0	59.7	59.4	59.4				
47	Princes Street East 142	GF	Altered	60.1	59.6	61.3	61.2	61.2				
48	Princes Street East 144	GF	Altered	57.4	56.8	59.9	59.9	59.9				

Project

East West Link

4 - Otahuhu South Sthbd

Protected Premises and Facilities

	Existing	Do-nothing	Do-minimum	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Selected solution			○	○	○	◉	○	○	○
Category A	23	21	21	31	31	31	0	0	0
Category B	7	9	9	6	7	7	0	0	0
Category C	9	9	9	2	1	1	0	0	0
Total	39	39	39	39	39	39	0	0	0

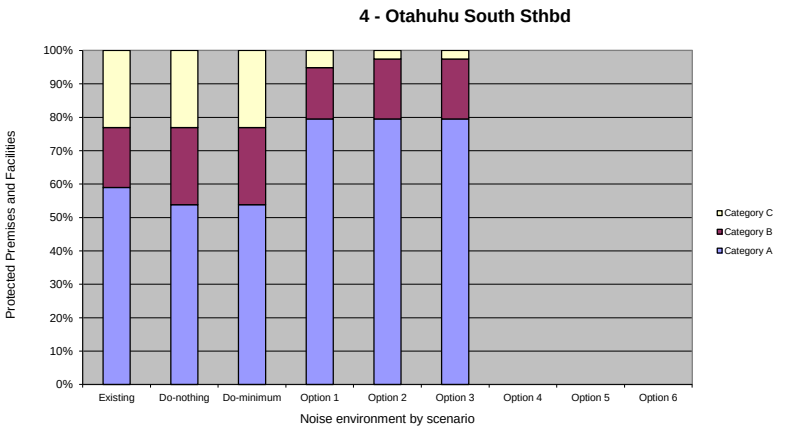
Benefit-Cost Ratio

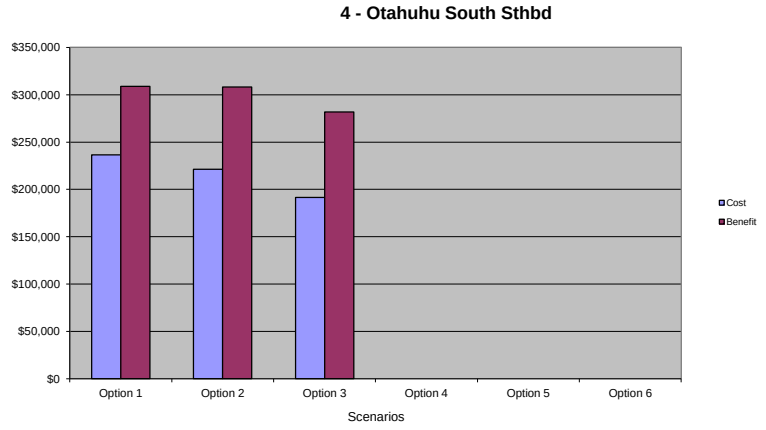
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Cost	$236,400	$221,400	$191,580	$0	$0	$0
Benefit	$308,772	$308,232	$281,772	$0	$0	$0
BCR	**1.31**	**1.39**	**1.47**	-	-	-
Structural	3.3 dB	3.4 dB	3.1 dB			

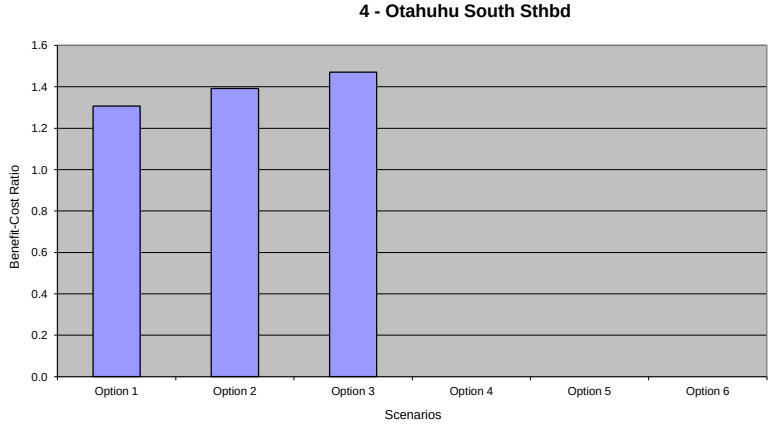
Assessment matrix

	Option 1	Option 2	Option 3
NZS 6806 compliance	--	-	-
Structural mitigation	o	o	o
BCR	+ +	+ +	+ +

Graphs







Project: East West Link
Area: 4 – Otahuhu South Sthbd
AADT: ○ 2,000 to 75,000 vehicles per day
● More than 75,000 vehicles per day

Paste up to 200 rows of data | Reformat | New | Altered

Protected Premises and Facilities			New or Altered	Existing $L_{Aeq(24h)}$ dB	Results from noise model for design year							
Reference	Street address	Floor			Do-nothing $L_{Aeq(24h)}$ dB	Do-minimum $L_{Aeq(24h)}$ dB	Option 1 $L_{Aeq(24h)}$ dB	Option 2 $L_{Aeq(24h)}$ dB	Option 3 $L_{Aeq(24h)}$ dB	Option 4 $L_{Aeq(24h)}$ dB	Option 5 $L_{Aeq(24h)}$ dB	Option 6 $L_{Aeq(24h)}$ dB
1	Avenue Road 132	GF	Altered	72.8	73.7	74.1	67.5	65.8	65.9			
2	Avenue Road 136	GF	Altered	65.4	66.3	66.3	62.6	62.1	62.2			
3	Avenue Road 136A	GF	Altered	62.8	63.2	63.5	60.7	60.4	60.5			
4	Avenue Road East 138	1.FL	Altered	64.1	62.0	62.3	61.4	61.3	61.4			
5	Avenue Road East 139	GF	Altered	62.2	60.4	60.8	59.7	59.5	59.6			
6	Avenue Road East 140	GF	Altered	58.1	58.0	58.4	57.4	57.3	57.4			
7	Avenue Road East 142	GF	Altered	55.7	56.1	56.6	56.1	56.1	56.1			
8	Frank Grey Place 051	GF	Altered	63.1	62.0	61.2	60.9	60.9	60.9			
9	Frank Grey Place 053	GF	Altered	62.8	61.4	60.7	60.4	60.4	60.4			
10	Frank Grey Place 054	GF	Altered	66.3	67.3	66.6	62.6	62.6	62.6			
11	Frank Grey Place 055	GF	Altered	62.7	60.6	60.0	59.8	59.8	59.8			
12	Frank Grey Place 056	GF	Altered	65.0	65.9	65.5	61.4	61.4	61.4			
13	Frank Grey Place 057	GF	Altered	61.5	59.4	59.0	58.9	58.9	58.9			
14	Frank Grey Place 058	GF	Altered	63.6	64.6	64.6	60.6	60.4	60.4			
15	Frank Grey Place 059	GF	Altered	61.9	59.3	59.3	58.8	58.8	58.8			
16	Frank Grey Place 060	GF	Altered	70.2	71.2	71.2	66.3	66.0	66.1			
17	Frank Grey Place 061	GF	Altered	60.4	59.6	60.0	58.6	58.6	58.8			
18	Frank Grey Place 062	GF	Altered	71.0	72.0	71.6	66.2	66.1	66.1			
19	Frank Grey Place 063	GF	Altered	61.7	60.5	60.9	59.1	59.1	59.5			
20	Frank Grey Place 064	GF	Altered	65.8	66.7	66.8	62.8	62.8	62.8			
21	Frank Grey Place 065	GF	Altered	61.6	60.5	60.9	58.9	58.9	59.6			
22	Frank Grey Place 066	GF	Altered	65.6	66.5	66.6	62.7	62.7	62.7			
23	Frank Grey Place 068	GF	Altered	72.1	72.9	72.8	65.3	65.3	65.3			
24	Frank Grey Place 069	GF	Altered	62.5	60.8	61.3	58.9	58.9	59.6			
25	Frank Grey Place 070	GF	Altered	58.5	59.2	59.8	57.9	57.9	57.9			
26	Frank Grey Place 071	GF	Altered	61.9	60.8	61.3	58.8	58.8	59.8			
27	Frank Grey Place 072	1.FL	Altered	74.5	75.3	75.9	73.2	73.2	73.3			
28	Frank Grey Place 072A	GF	Altered	71.1	72.0	72.8	64.5	64.5	64.7			
29	Frank Grey Place 072B	GF	Altered	68.1	69.0	69.5	63.0	63.0	64.2			
30	Frank Grey Place 073	GF	Altered	61.8	60.9	61.4	58.9	58.9	60.2			
31	Frank Grey Place 074	GF	Altered	59.7	59.7	59.8	57.5	57.5	57.5			
32	Frank Grey Place 076	GF	Altered	60.9	61.4	61.4	58.8	58.8	58.8			
33	Frank Grey Place 080	1.FL	Altered	64.3	64.9	65.4	61.5	61.5	62.8			
34	Frank Grey Place 082	GF	Altered	65.2	65.9	66.6	61.2	61.2	63.0			
35	Frank Grey Place 084	GF	Altered	70.6	71.6	72.2	65.6	65.6	66.3			
36	Frank Grey Place 086	GF	Altered	64.6	65.4	65.9	61.1	61.1	62.6			
37	Frank Grey Place 088	GF	Altered	59.8	60.9	61.2	58.9	58.9	58.9			
38	Frank Grey Place 090	GF	Altered	70.0	71.0	71.6	64.5	64.5	64.8			
39	Frank Grey Place 092	GF	Altered	61.2	62.2	62.6	60.3	60.3	60.5			

Project

East West Link
5 - Mt Wellington Nthbd

Protected Premises and Facilities

	Existing	Do-nothing	Do-minimum	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Selected solution			○	○	○	◉	○	○	○
Category A	58	53	50	60	69	65	0	0	0
Category B	24	20	22	29	27	31	0	0	0
Category C	27	36	37	20	13	13	0	0	0
Total	109	109	109	109	109	109	0	0	0

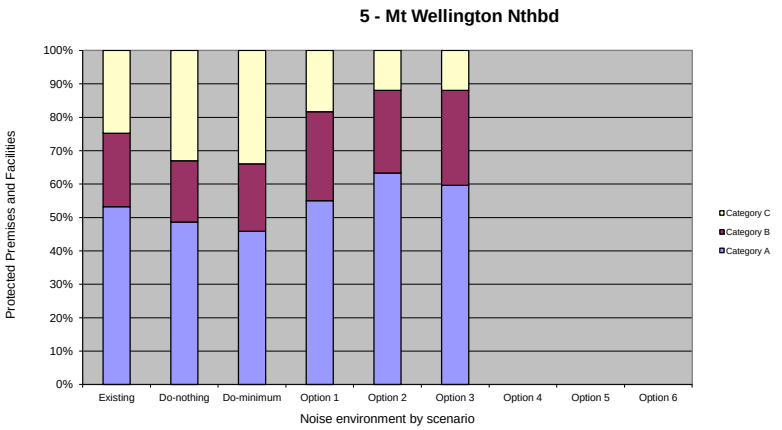
Benefit-Cost Ratio

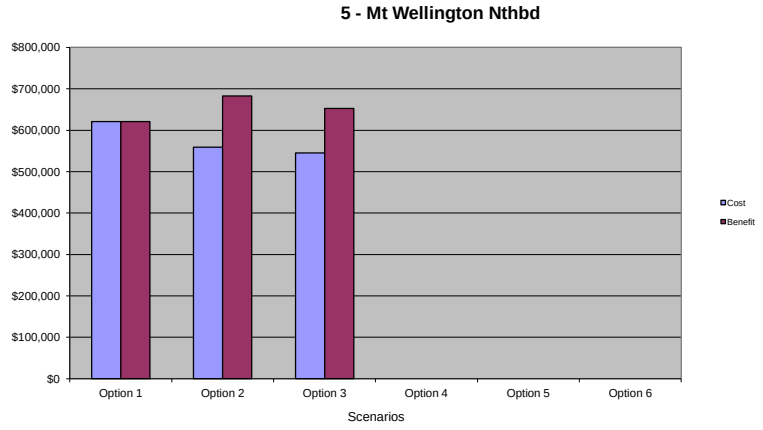
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Cost	$620,840	$558,840	$545,450	$0	$0	$0
Benefit	$621,216	$682,560	$652,428	$0	$0	$0
BCR	**1.00**	**1.22**	**1.20**	-	-	-
Structural	1.9 dB	2.5 dB	2.4 dB			

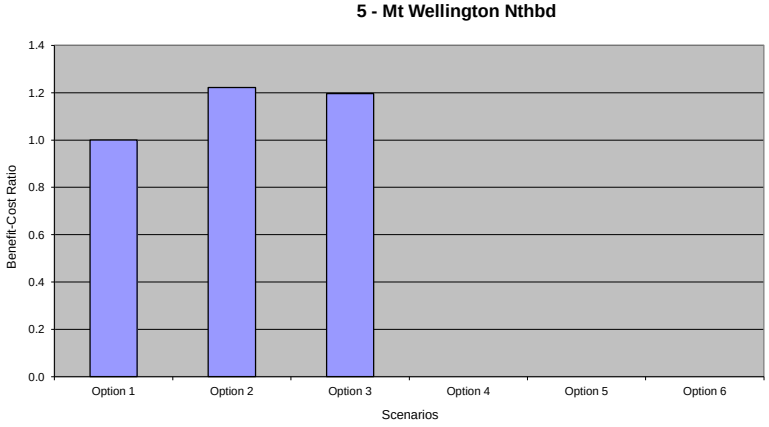
Assessment matrix

	Option 1	Option 2	Option 3
NZS 6806 compliance	---	---	---
Structural mitigation	-	o	-
BCR	+	+	+

Graphs







Project: East West Link
Area: 5 - Mt Wellington Nthbd
AADT: ○ 2,000 to 75,000 vehicles per day
● More than 75,000 vehicles per day

Paste up to 200 rows of data — Reformat — New / Altered

Protected Premises and Facilities					Results from noise model for design year								
Reference	Street address	Floor	New or Altered	Existing $L_{Aeq(24h)}$ dB	Do-nothing $L_{Aeq(24h)}$ dB	Do-minimum $L_{Aeq(24h)}$ dB	Option 1 $L_{Aeq(24h)}$ dB	Option 2 $L_{Aeq(24h)}$ dB	Option 3 $L_{Aeq(24h)}$ dB	Option 4 $L_{Aeq(24h)}$ dB	Option 5 $L_{Aeq(24h)}$ dB	Option 6 $L_{Aeq(24h)}$ dB
1	Coppins Road 009	GF	Altered	56.3	57.2	57.7	57.4	57.4	57.4			
2	Coppins Road 010	GF	Altered	58.5	59.4	59.8	58.9	58.5	59.0			
3	Coppins Road 011	GF	Altered	57.9	58.8	59.2	58.4	58.0	58.5			
4	Coppins Road 013	GF	Altered	58.4	59.4	59.6	59.6	59.6	59.6			
5	Coppins Road 014	1.FL	Altered	64.8	65.7	66.3	64.7	64.3	65.3			
6	Coppins Road 014A	GF	Altered	61.5	62.6	62.8	62.8	62.8	62.8			
7	Coppins Road 015A	GF	Altered	68.3	69.3	71.2	68.8	67.9	70.2			
8	Coppins Road 015C	GF	Altered	68.3	69.7	69.9	69.0	68.8	69.9			
9	Coppins Road 015D	GF	Altered	62.1	63.2	66.2	65.4	65.0	66.0			
10	Coppins Road 016	GF	Altered	69.3	70.3	71.5	67.4	66.4	68.7			
11	Coppins Road 017	GF	Altered	66.9	67.9	68.6	63.6	62.1	64.2			
12	Coppins Road 018	GF	Altered	67.8	68.8	69.6	65.4	63.9	65.4			
13	Coppins Road 019	GF	Altered	69.2	70.2	71.2	66.5	65.2	66.6			
14	Coppins Road 020	GF	Altered	63.3	64.3	65.0	61.9	61.0	61.9			
15	Coppins Road 021	GF	Altered	69.2	70.2	71.0	65.4	64.0	65.4			
16	Coppins Road 021A	GF	Altered	71.1	72.1	73.2	66.9	65.1	66.9			
17	Coppins Road 022	GF	Altered	60.5	61.4	62.1	60.0	59.4	60.0			
18	Coppins Road 023	GF	Altered	58.9	59.8	60.3	58.5	58.1	58.5			
19	Coppins Road 024	GF	Altered	56.8	57.7	58.1	58.0	58.0	58.0			
20	Coppins Road 025	GF	Altered	56.5	57.4	58.0	57.9	57.8	57.9			
21	Deborah Hatton Lane 001	1.FL	Altered	64.6	65.6	65.7	65.4	65.3	65.3			
22	Deborah Hatton Lane 002	GF	Altered	64.0	65.0	65.1	61.8	61.7	61.5			
23	Deborah Hatton Lane 003	GF	Altered	73.3	74.3	73.7	70.1	67.7	67.7			
24	Deborah Hatton Lane 004	GF	Altered	73.4	74.4	73.3	69.3	66.9	66.9			
25	Deborah Hatton Lane 005	GF	Altered	73.1	74.1	74.0	68.1	66.0	66.0			
26	Deborah Hatton Lane 006	GF	Altered	62.0	63.0	63.9	61.0	60.3	60.3			
27	Deborah Hatton Lane 007	GF	Altered	61.7	62.7	62.8	61.6	61.2	61.3			
28	Deborah Hatton Lane 008	1.FL	Altered	62.9	63.9	64.2	64.0	63.9	63.9			
29	Hillside Road 043	1.FL	Altered	63.1	64.1	64.5	64.1	63.8	64.1			
30	Hillside Road 053	1.FL	Altered	68.5	69.4	69.6	68.2	67.9	67.5			
31	Hillside Road 055	GF	Altered	66.8	67.7	67.6	64.1	63.9	63.3			
32	Hillside Road 057	GF	Altered	68.3	69.3	69.3	65.7	65.6	65.0			
33	Hillside Road 059	1.FL	Altered	71.4	72.4	72.6	70.9	70.9	70.3			
34	Hillside Road 061	1.FL	Altered	71.9	72.9	73.1	72.5	72.5	72.3			
35	Hillside Road 063	GF	Altered	68.2	69.2	69.1	68.9	68.6	68.6			
36	Hillside Road 065	GF	Altered	65.4	66.3	66.7	66.7	64.8	64.8			
37	Hillside Road 067	GF	Altered	66.8	67.8	68.3	68.0	66.0	66.0			
38	Hillside Road 067A	GF	Altered	68.9	69.9	70.9	67.9	65.6	65.6			
39	Hillside Road 068	GF	Altered	59.9	60.8	61.1	60.6	60.4	60.3			
40	Hillside Road 074	GF	Altered	58.2	59.1	59.5	59.3	59.1	59.1			
41	Hillside Road 086	GF	Altered	60.7	61.6	62.0	61.6	61.0	61.0			
42	Hillside Road 088	GF	Altered	56.2	57.0	57.5	57.5	57.4	57.4			
43	Hillside Road 090	1.FL	Altered	64.7	65.7	66.1	65.7	65.3	65.3			
44	Hillside Road 092	1.FL	Altered	65.2	66.1	66.6	66.1	65.5	65.4			
45	Hillside Road 094	GF	Altered	59.7	60.6	61.1	60.7	60.0	60.0			
46	Hillside Road 096	GF	Altered	64.1	65.1	65.6	64.2	63.3	63.2			
47	Hillside Road 102	1.FL	Altered	68.6	69.5	70.1	68.6	67.7	67.3			
48	Hillside Road 104	GF	Altered	67.1	68.1	68.8	64.4	63.8	63.3			
49	Hillside Road 106	GF	Altered	66.8	67.7	68.3	64.0	63.5	62.9			
50	Hillside Road 108	GF	Altered	66.8	67.7	67.9	64.2	64.0	63.2			
51	Hillside Road 110	GF	Altered	66.6	67.5	67.3	64.5	64.3	63.5			
52	Hillside Road 112	1.FL	Altered	68.3	69.2	69.4	68.4	68.3	67.6			
53	Kotahi Road 008	GF	Altered	56.8	57.7	58.3	57.3	57.2	57.3			
54	Kotahi Road 009	GF	Altered	57.0	57.9	58.3	58.2	58.1	58.1			
55	Kotahi Road 010	GF	Altered	58.4	59.3	59.7	58.0	57.6	58.0			
56	Kotahi Road 011	GF	Altered	62.5	63.5	64.2	60.9	60.3	60.9			
57	Kotahi Road 012	GF	Altered	74.1	75.1	77.0	67.1	65.2	67.1			
58	Kotahi Road 013	GF	Altered	68.0	68.9	69.8	64.6	63.4	64.6			
59	Kotahi Road 014	GF	Altered	67.3	68.3	69.1	63.5	62.3	63.2			
60	Kotahi Road 015	GF	Altered	69.5	70.5	71.3	65.2	63.7	64.2			
61	Kotahi Road 015A	GF	Altered	68.2	69.2	70.1	64.6	63.2	63.5			
62	Kotahi Road 016	GF	Altered	62.3	63.2	64.0	60.7	60.1	60.6			
63	Kotahi Road 017	GF	Altered	61.8	62.7	63.6	60.2	59.6	59.9			
64	Kotahi Road 018	GF	Altered	57.7	58.7	59.0	58.6	58.5	58.6			
65	Kotahi Road 019	GF	Altered	60.6	61.5	61.8	61.2	60.9	61.1			
66	Kotahi Road 020	GF	Altered	57.0	58.0	58.3	58.2	58.2	58.2			
67	Panama Road 070	GF	Altered	61.9	59.4	57.4	57.4	57.4	57.2			
68	Panama Road 072	GF	Altered	62.1	60.4	59.5	59.5	59.4	59.3			
69	Panama Road 076	GF	Altered	56.2	57.1	57.5	57.6	57.6	57.6			
70	Panama Road 078	GF	Altered	59.3	59.3	58.7	58.7	58.7	58.7			
71	Panama Road 080	GF	Altered	59.7	60.2	59.5	59.6	59.5	59.5			
72	Panama Road 082	GF	Altered	59.3	60.2	60.6	60.2	60.0	60.0			
73	Panama Road 084A	GF	Altered	67.8	68.7	69.7	67.5	65.3	65.3			
74	Panama Road 084B	GF	Altered	68.7	69.7	70.5	68.8	66.1	66.1			
75	Panama Road 086	GF	Altered	63.8	64.7	66.5	65.8	64.3	64.3			
76	Panama Road 086A	GF	Altered	66.0	67.0	67.8	68.5	66.1	66.1			
77	Sophia Close 005	GF	Altered	58.5	59.4	59.6	59.4	59.5	59.3			
78	Sophia Close 007	GF	Altered	58.7	59.5	59.9	59.9	59.9	59.9			
79	Sophia Close 009	GF	Altered	58.5	59.3	59.8	59.9	59.8	59.8			
80	Sophia Close 011	GF	Altered	58.0	58.9	59.3	59.4	59.4	59.4			
81	Sophia Close 013	GF	Altered	58.8	59.7	60.1	60.2	60.2	60.2			
82	Sophia Close 015	GF	Altered	58.0	58.9	59.3	59.3	59.3	59.3			
83	Springpark 001	2.FL	Altered	67.2	67.9	68.4	68.1	68.0	67.9			
84	Springpark 002	2.FL	Altered	65.3	64.6	64.5	64.6	64.6	64.6			
85	Springpark 003	2.FL	Altered	65.1	64.3	64.1	64.2	64.1	64.1			
86	Springpark 004	2.FL	Altered	65.7	66.5	67.1	66.6	66.5	66.3			
87	Springpark 005	2.FL	Altered	61.0	61.9	62.6	61.7	61.5	61.2			
88	Springpark 006	2.FL	Altered	66.1	67.0	67.7	67.1	66.9	66.7			
89	Springpark 007	2.FL	Altered	62.5	63.4	64.0	63.3	63.2	63.0			
90	Springpark 008	2.FL	Altered	62.0	63.0	63.6	62.9	62.5	62.2			
91	Springpark 009	2.FL	Altered	65.8	66.8	67.4	66.7	66.5	66.3			
92	Springpark 010	2.FL	Altered	62.5	63.3	63.8	63.4	63.3	63.0			
93	Springpark 011	2.FL	Altered	65.5	66.4	67.0	66.3	66.1	65.9			
94	Springpark 012	2.FL	Altered	65.2	66.1	66.7	66.1	65.9	65.6			
95	Springpark 013	2.FL	Altered	64.9	65.8	66.4	65.8	65.6	65.3			
96	Springpark 014	2.FL	Altered	64.6	65.5	66.1	65.5	65.3	65.0			
97	Springpark 015	2.FL	Altered	64.4	65.3	65.8	65.2	65.1	64.8			
98	Springpark 016	2.FL	Altered	64.0	64.9	65.5	65.0	64.8	64.5			
99	Springpark 017	2.FL	Altered	63.6	64.5	65.0	64.5	64.4	64.1			
100	Springpark 018	1.FL	Altered	60.9	61.8	62.1	62.0	61.8	61.7			
101	Springpark 019	1.FL	Altered	61.4	62.3	62.5	62.3	62.1	61.9			
102	Springpark 020	1.FL	Altered	61.4	62.3	62.7	62.4	62.2	61.9			
103	Springpark 021	1.FL	Altered	61.3	62.2	62.6	62.1	61.9	61.6			
104	Springpark 022	2.FL	Altered	62.6	63.5	63.9	63.5	63.4	63.1			
105	Springpark 023	2.FL	Altered	60.5	61.3	61.9	61.2	61.0	60.6			
106	Springpark 024	2.FL	Altered	69.5	70.5	71.0	70.4	69.9	69.8			
107	Springpark 025	2.FL	Altered	69.3	70.2	70.8	70.2	69.8	69.7			
108	Springpark 026	2.FL	Altered	68.9	69.9	70.5	69.8	69.4	69.3			
109	Springpark 027	2.FL	Altered	61.4	62.3	62.9	62.7	62.3	62.3			

Project

East West Link

6 - Otahuhu North Nthbd

Protected Premises and Facilities

	Existing	Do-nothing	Do-minimum	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Selected solution			○	○	○	◉	○	○	○
Category A	43	42	41	45	45	45	0	0	0
Category B	1	1	3	3	4	4	0	0	0
Category C	5	6	5	1	0	0	0	0	0
Total	49	49	49	49	49	49	0	0	0

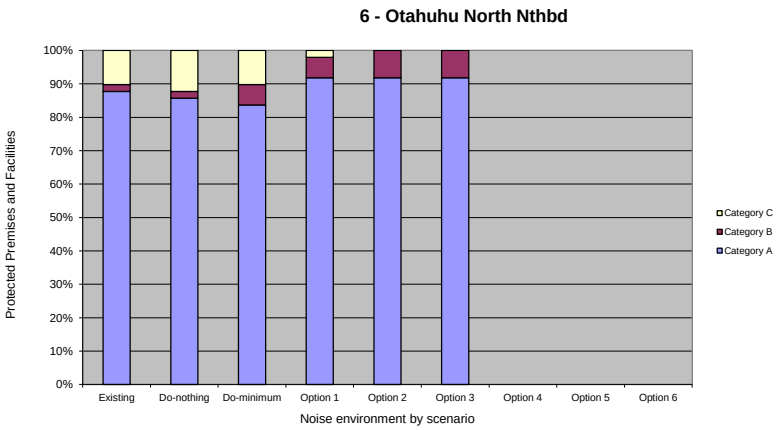
Benefit-Cost Ratio

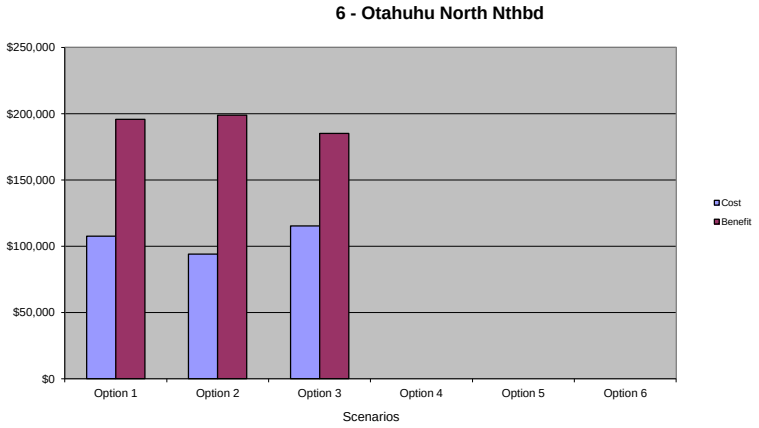
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Cost	$107,630	$94,100	$115,200	$0	$0	$0
Benefit	$195,696	$198,936	$185,112	$0	$0	$0
BCR	**1.82**	**2.11**	**1.61**	-	-	-
Structural	1.5 dB	1.7 dB	1.6 dB			

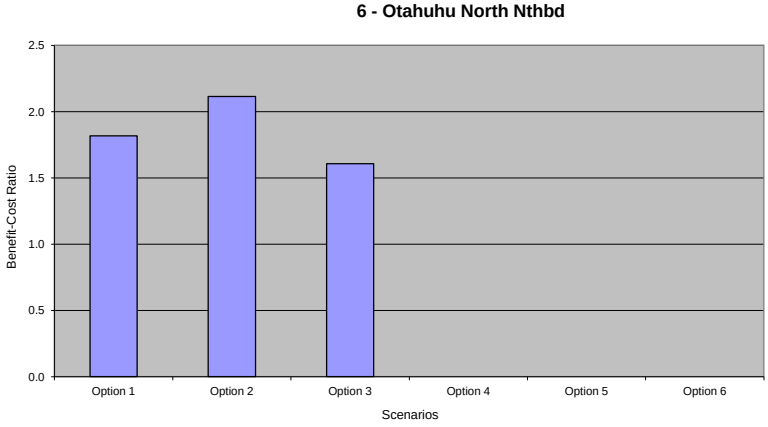
Assessment matrix

	Option 1	Option 2	Option 3
NZS 6806 compliance	-	+	+
Structural mitigation	- -	-	-
BCR	+ + +	+ + +	+ + +

Graphs







Project: East West Link
Area: 6 – Otahuhu North Nthbd
AADT: ○ 2,000 to 75,000 vehicles per day
● More than 75,000 vehicles per day

Paste up to 200 rows of data | Reformat | New | Altered

Protected Premises and Facilities			New or Altered	Existing $L_{Aeq(24h)}$ dB	Results from noise model for design year: Do-nothing $L_{Aeq(24h)}$ dB	Do-minimum $L_{Aeq(24h)}$ dB	Option 1 $L_{Aeq(24h)}$ dB	Option 2 $L_{Aeq(24h)}$ dB	Option 3 $L_{Aeq(24h)}$ dB	Option 4 $L_{Aeq(24h)}$ dB	Option 5 $L_{Aeq(24h)}$ dB	Option 6 $L_{Aeq(24h)}$ dB
Reference	Street address	Floor										
1	Albert Street 006A	GF	Altered	55.0	56.0	56.4	56.4	56.4	56.3			
2	Albert Street 010A	GF	Altered	56.3	57.2	57.6	57.6	57.6	57.6			
3	Albert Street 012A	GF	Altered	56.4	57.3	57.7	57.7	57.7	57.7			
4	Albert Street 014B	GF	Altered	55.3	56.2	56.6	56.3	56.3	56.3			
5	Albert Street 014C	GF	Altered	55.4	56.2	56.7	56.2	56.2	56.3			
6	Albert Street 014D	GF	Altered	55.8	56.7	57.1	56.5	56.5	56.6			
7	Albert Street 014E	GF	Altered	56.5	57.4	57.8	57.0	57.0	57.1			
8	Albert Street 014F	GF	Altered	58.0	58.9	59.0	57.4	57.4	57.6			
9	Albert Street 014H	GF	Altered	68.2	69.1	67.7	64.3	64.1	64.4			
10	Albert Street 014I	GF	Altered	68.4	69.3	69.1	65.4	65.3	65.4			
11	Albert Street 014J	GF	Altered	68.4	69.4	69.6	65.9	65.7	65.5			
12	Albert Street 014K	GF	Altered	62.8	63.7	64.6	61.7	61.5	61.0			
13	Albert Street 014L	GF	Altered	59.0	59.9	60.4	58.9	58.9	58.9			
14	Avalon Court 010	GF	Altered	56.4	57.3	56.8	56.7	56.7	56.8			
15	Avalon Court 011	GF	Altered	56.1	56.7	55.7	55.6	55.6	55.6			
16	Avalon Court 013	GF	Altered	62.4	63.0	59.2	59.2	59.2	59.5			
17	Avalon Court 014	GF	Altered	64.1	64.8	59.9	59.9	59.9	60.0			
18	Avalon Court 015	GF	Altered	61.2	61.9	58.9	58.8	58.8	59.0			
19	Avalon Court 015A	GF	Altered	63.0	63.8	59.2	59.4	59.4	59.6			
20	Avalon Court 016	GF	Altered	61.8	62.6	59.7	59.2	59.2	59.5			
21	Avalon Court 017	GF	Altered	59.5	60.3	58.7	58.0	58.0	58.2			
22	Avalon Court 018	GF	Altered	55.7	56.5	56.4	56.4	56.4	56.4			
23	Avalon Court 019A	GF	Altered	55.7	56.6	56.8	56.8	56.8	56.8			
24	Avalon Court 019B	GF	Altered	59.0	59.9	58.0	57.5	57.5	57.7			
25	Avalon Court 021A	GF	Altered	61.5	62.4	60.0	59.1	59.1	59.4			
26	Avalon Court 021B	GF	Altered	60.9	61.7	59.9	58.9	58.9	59.2			
27	Avalon Court 021C	GF	Altered	60.1	61.0	59.1	58.4	58.4	58.6			
28	Avalon Court 025	GF	Altered	56.3	57.2	57.6	57.6	57.6	57.6			
29	Avalon Court 027	GF	Altered	56.7	57.6	57.8	57.7	57.7	57.8			
30	Avalon Court 028	GF	Altered	56.2	57.1	57.2	57.0	57.0	57.2			
31	Avalon Court 034B	GF	Altered	55.5	56.3	56.6	56.4	56.4	56.5			
32	Avalon Court 036	GF	Altered	54.7	55.6	55.7	55.6	55.6	55.6			
33	Luke Street 077	GF	Altered	57.3	58.1	58.9	58.8	58.7	58.7			
34	Luke Street 079	GF	Altered	58.8	59.7	60.4	59.9	59.7	60.0			
35	Luke Street 079A	GF	Altered	57.7	58.6	59.1	58.4	57.9	58.1			
36	Luke Street 079B	GF	Altered	55.1	56.0	56.4	56.5	56.5	56.4			
37	Luke Street 079C	GF	Altered	55.3	56.2	56.6	56.5	56.5	56.5			
38	Luke Street 081	GF	Altered	59.0	60.0	60.7	60.6	60.6	60.5			
39	Luke Street 081B	GF	Altered	58.2	59.1	59.7	58.4	58.1	58.0			
40	Luke Street 081C	GF	Altered	59.9	60.8	61.4	60.3	59.7	59.9			
41	Luke Street 081D	GF	Altered	60.2	61.1	61.9	60.2	59.6	59.9			
42	Luke Street 081E	GF	Altered	58.1	59.0	59.7	58.8	58.7	58.6			
43	Luke Street 081F	GF	Altered	56.2	57.1	57.6	57.6	57.6	57.6			
44	Luke Street 083	GF	Altered	63.4	64.4	65.2	64.2	63.9	64.1			
45	Luke Street 085	GF	Altered	69.5	70.4	71.4	67.8	66.8	67.1			
46	Luke Street 085A	GF	Altered	68.6	69.5	70.1	66.4	65.9	65.7			
47	Luke Street 089A	GF	Altered	67.4	68.3	66.1	62.8	62.7	62.9			
48	Luke Street 089B	GF	Altered	60.2	61.0	59.3	58.3	58.3	58.6			
49	Princes Street 120 (Gurdwara Tem	1.FL	Altered	63.7	63.7	60.4	60.4	60.4	60.4			

Project

East West Link

7 – Otahuhu South Nthbd

Protected Premises and Facilities

	Existing	Do-nothing	Do-minimum	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Selected solution			○	○	◉	○	○	○	○
Category A	44	39	43	49	42	0	0	0	0
Category B	6	10	6	7	14	0	0	0	0
Category C	8	9	9	2	2	0	0	0	0
Total	58	58	58	58	58	0	0	0	0

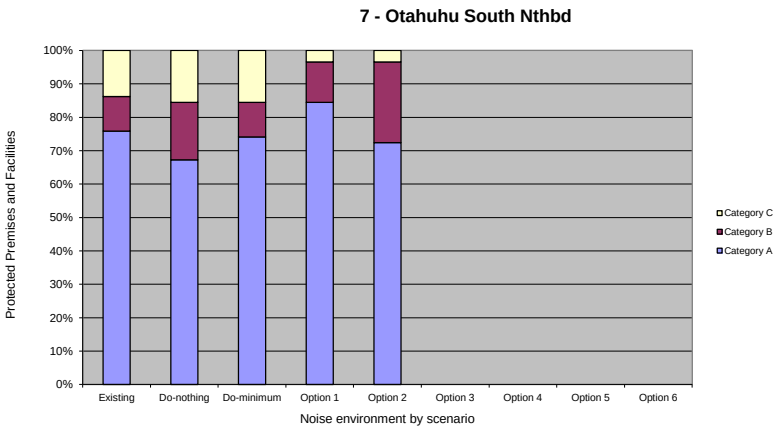
Benefit–Cost Ratio

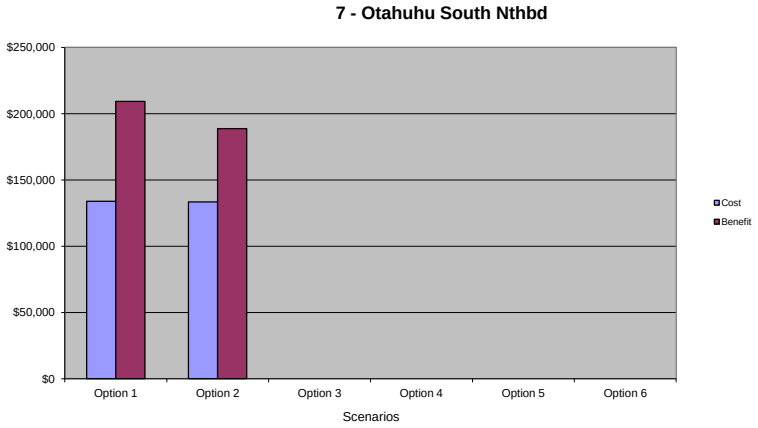
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Cost	$134,000	$133,360	$0	$0	$0	$0
Benefit	$209,196	$188,676	$0	$0	$0	$0
BCR	**1.56**	**1.41**	–	–	–	–
Structural	2.6 dB	2.6 dB				

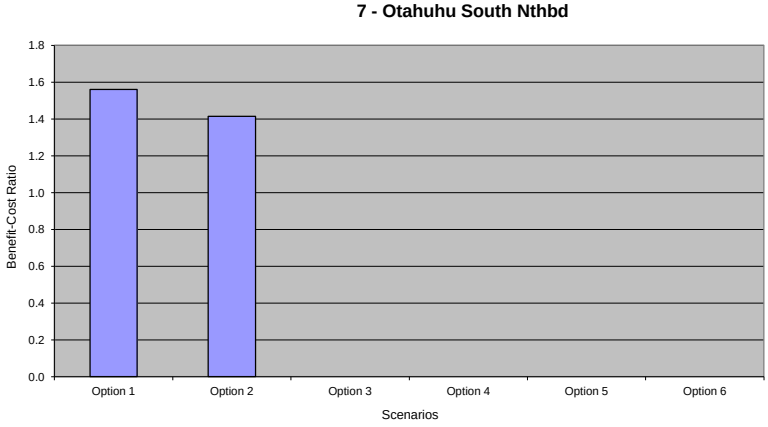
Assessment matrix

	Option 1	Option 2
NZS 6806 compliance	–	–
Structural mitigation	o	o
BCR	+ + +	+ +

Graphs







Project: East West Link
Area: 7 – Otahuhu South Nthbd
AADT: ○ 2,000 to 75,000 vehicles per day
● More than 75,000 vehicles per day

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Protected Premises and Facilities			New or Altered	Existing $L_{Aeq(24h)}$ dB	Results from noise model for design year							
					Do-nothing $L_{Aeq(24h)}$ dB	Do-minimum $L_{Aeq(24h)}$ dB	Option 1 $L_{Aeq(24h)}$ dB	Option 2 $L_{Aeq(24h)}$ dB	Option 3 $L_{Aeq(24h)}$ dB	Option 4 $L_{Aeq(24h)}$ dB	Option 5 $L_{Aeq(24h)}$ dB	Option 6 $L_{Aeq(24h)}$ dB
Reference	Street address	Floor										
1	Albert Street 046	GF	Altered	54.5	55.4	55.6	55.6	55.8				
2	Albert Street 050A	GF	Altered	55.4	56.2	56.4	56.4	56.7				
3	Avenue Road 098	GF	Altered	61.8	55.1	55.6	55.3	55.6				
4	Avenue Road 100	GF	Altered	61.9	56.0	56.5	56.5	56.8				
5	Avenue Road 100A	GF	Altered	55.9	56.2	56.7	56.7	57.0				
6	Avenue Road 102	GF	Altered	64.0	64.9	65.2	65.0	65.3				
7	Avenue Road 103	GF	Altered	61.2	55.4	55.7	55.8	56.1				
8	Avenue Road 105	GF	Altered	64.1	60.9	61.3	61.2	61.6				
9	Avenue Road 105A	GF	Altered	53.4	53.5	54.0	53.7	54.0				
10	Avenue Road 105B	GF	Altered	51.9	52.5	53.0	52.8	53.2				
11	Avenue Road 105C	GF	Altered	60.6	61.5	61.9	60.2	60.1				
12	Avenue Road 107	GF	Altered	63.0	63.2	63.5	63.4	63.6				
13	Avenue Road 107A	GF	Altered	66.6	67.5	68.1	65.3	65.2				
14	Avenue Road 109	GF	Altered	63.8	64.8	65.2	64.4	64.6				
15	Avenue Road 113	1.FL	Altered	73.9	75.0	75.4	75.3	75.5				
16	Princes Street 091	GF	Altered	62.4	63.2	60.3	60.3	60.3				
17	Todd Place 002	GF	Altered	62.3	63.2	60.4	60.4	60.5				
18	Todd Place 002A	1.FL	Altered	58.7	59.6	59.4	59.4	59.5				
19	Todd Place 004	1.FL	Altered	65.6	66.6	64.2	64.2	64.3				
20	Todd Place 004A	1.FL	Altered	58.1	59.0	58.8	58.8	59.0				
21	Todd Place 006	1.FL	Altered	65.1	66.1	64.2	64.1	64.2				
22	Todd Place 006A	1.FL	Altered	58.1	59.0	58.9	58.9	59.1				
23	Todd Place 008	1.FL	Altered	65.8	66.8	65.1	65.0	65.1				
24	Todd Place 008A	1.FL	Altered	59.2	60.1	59.7	59.7	59.9				
25	Todd Place 010	1.FL	Altered	58.3	59.2	59.2	59.2	59.4				
26	Todd Place 012	GF	Altered	62.7	63.7	62.5	62.5	62.7				
27	Todd Place 014	GF	Altered	63.9	64.8	64.0	63.9	64.1				
28	Todd Place 016	GF	Altered	64.0	65.0	64.4	64.3	64.6				
29	Todd Place 018	GF	Altered	63.2	64.2	64.0	63.9	64.2				
30	Todd Place 020	GF	Altered	63.3	64.3	64.2	64.1	64.3				
31	Todd Place 022	GF	Altered	63.4	64.4	64.4	64.3	64.6				
32	Todd Place 024	GF	Altered	63.4	64.4	64.4	64.3	64.7				
33	Todd Place 026	GF	Altered	64.4	65.5	65.7	65.5	65.8				
34	Todd Place 028	GF	Altered	59.7	60.6	60.7	60.6	60.9				
35	Trenwith Street 003	GF	Altered	62.1	62.3	62.8	61.3	61.6				
36	Trenwith Street 005C	GF	Altered	56.8	57.7	58.1	57.7	57.9				
37	Trenwith Street 005D	GF	Altered	56.8	57.6	58.0	57.5	57.9				
38	Trenwith Street 005E	GF	Altered	57.8	58.4	58.9	57.8	57.5				
39	Trenwith Street 005F	GF	Altered	64.6	65.2	65.5	63.2	63.8				
40	Trenwith Street 008	GF	Altered	59.8	59.4	59.8	57.4	58.7				
41	Trenwith Street 010	GF	Altered	60.4	61.3	61.8	60.0	60.2				
42	Trenwith Street 012	GF	Altered	63.7	64.0	64.3	60.5	61.8				
43	Trenwith Street 014	GF	Altered	70.0	70.9	70.8	65.1	65.7				
44	Water Street 005B	GF	Altered	56.1	57.1	57.4	57.2	57.5				
45	Water Street 044	GF	Altered	57.4	55.9	56.2	56.0	56.3				
46	Water Street 048A	GF	Altered	62.3	63.5	63.7	62.4	62.6				
47	Water Street 048B	GF	Altered	58.6	59.7	60.0	58.9	59.1				
48	Water Street 048C	GF	Altered	57.0	58.0	58.3	58.3	58.6				
49	Water Street 048D	GF	Altered	57.7	58.7	59.0	58.4	58.7				
50	Water Street 048E	GF	Altered	59.5	60.4	60.9	58.5	59.2				
51	Water Street 048F	GF	Altered	66.4	66.9	67.3	64.3	65.1				
52	Water Street 048G	GF	Altered	71.9	72.8	73.2	68.0	69.2				
53	Water Street 048H	GF	Altered	71.9	72.9	73.4	66.8	67.4				
54	Water Street 048I	GF	Altered	70.3	71.4	71.7	64.2	64.6				
55	Water Street 048J	GF	Altered	69.7	70.9	71.2	64.0	64.3				
56	Water Street 048K	GF	Altered	70.2	71.4	71.6	64.3	64.6				
57	Water Street 048L	GF	Altered	71.2	72.5	72.6	66.4	66.6				
58	Water Street 050A	GF	Altered	54.7	55.2	55.4	55.4	55.7				

Appendix C

Noise level surveys–Diurnal variation

Logger Measurements

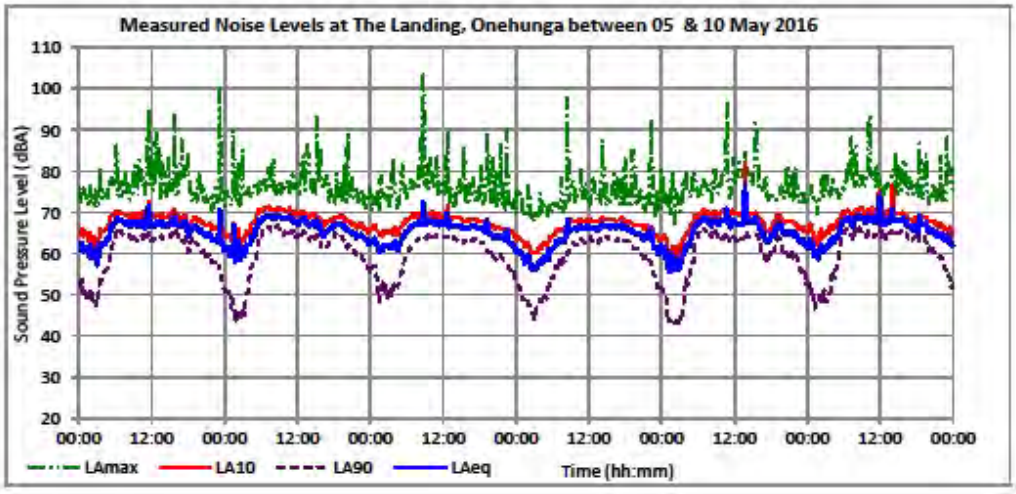
MARSHALL DAY Acoustics

Date:	Thursday, 26 May 2016
File name:	J:\JOBS\2016\2016010A\03 Survey Data & Measurements\[EWL - Onehunga Harbour Road Landing.xlsx]Logger_Summary
Job number:	2016010A
Job name:	East West Link
Initials:	SW
Measurement Dates:	Thursday, 05 May 2016 to Tuesday, 10 May 2016
Weather during Measurement:	No adjustment due to adverse weather was necessary
Notes:	The Landing, Onehunga

OVERVIEW SUMMARY SHEET

	Noise Level, dB	L_{Aeq}	L_{A10}	L_{A90}	L_{Amax}
Day (0700-1800)	Lowest	63	65	56	70
	Average	68	70	64	78
	Highest	77	82	69	103
Evening (1800-2200)	Lowest	64	66	58	70
	Average	66	68	61	76
	Highest	69	70	65	89
Night (2200-0700)	Lowest	56	58	42	67
	Average	63	66	54	75
	Highest	71	71	66	100

$L_{Aeq\ 24\text{-}hr}$ 66 dB



Logger Measurements

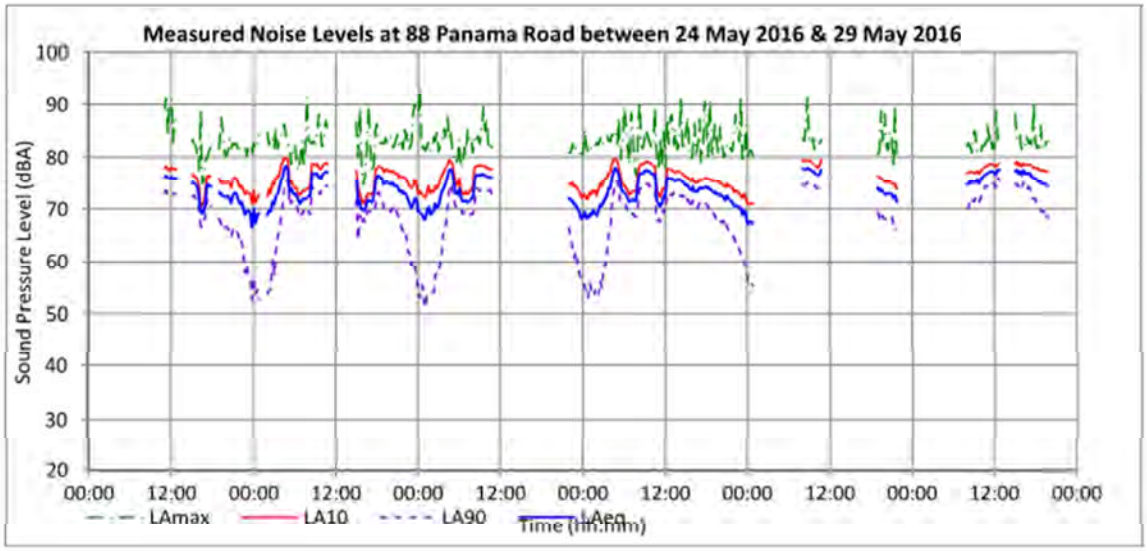
MARSHALL DAY Acoustics

Date:	Friday, 24 June, 2016
File name:	J:\JOBS\2016\2016010A\03 Survey Data & Measurements\[EWL - 88 Panama Road 24-29 May 2016 Logger Summary.xlsx]Logger_Summary
Job number:	2016010A
Job name:	East West Link
Initials:	BL
Measurement Dates:	Tuesday, 24 May 2016 to Sunday, 29 May 2016
Weather during Measurement:	Adjustment for adverse weather condition - relevant survey periods excluded
Notes:	Measurements effected by Wind (≥ 5 m/s) and Rain (≥ 6mm/h) have been excluded

OVERVIEW SUMMARY SHEET

	Noise Level, dB	L_{Aeq}	L_{A10}	L_{A95}	
Day	Lowest	69	70	64	75
(0700-1800)	Average	76	77	72	84
	Highest	78	80	76	91
Evening	Lowest	71	74	65	78
(1800-2200)	Average	74	76	68	69
	Highest	77	78	73	91
Night	Lowest	67	71	51	77
(2200-0700)	Average	72	74	62	55
	Highest	78	80	76	94

$L_{Aeq\ 24\text{-}hr}$ 75 dB



Logger Measurements

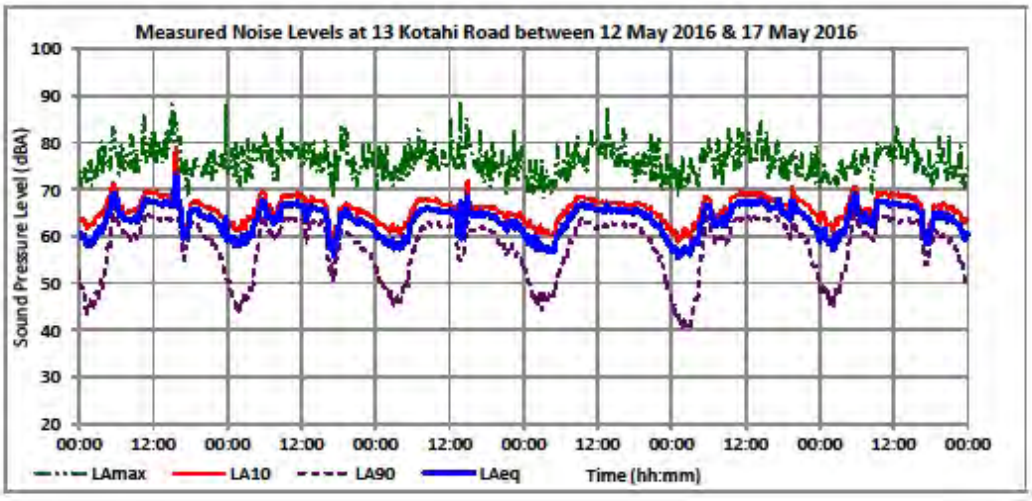
MARSHALL DAY Acoustics

Date:	Thursday, 26 May 2016
File name:	J:\JOBS\2016\2016010A\03 Survey Data & Measurements\[EWL - 13 Kotahi Road Logger Summary.xlsx]Logger_Summary
Job number:	2016010A
Job name:	East West Link
Initials:	SW
Measurement Dates:	Thursday, 12 May 2016 to Tuesday, 17 May 2016
Weather during Measurement:	No adjustment due to adverse weather was necessary
Notes:	13 Kotahi Road, Mt Wellington

OVERVIEW SUMMARY SHEET

Noise Level, dB		L_{Aeq}	L_{A10}	L_{A90}	L_{Amax}
Day (0700-1800)	Lowest	56	59	50	68
	Average	66	68	62	77
	Highest	73	79	65	89
Evening (1800-2200)	Lowest	61	62	56	69
	Average	64	66	60	75
	Highest	68	71	63	84
Night (2200-0700)	Lowest	55	59	41	68
	Average	62	65	52	75
	Highest	69	71	66	88

$L_{Aeq\ 24\text{-}hr}$ 65 dB



Logger Measurements

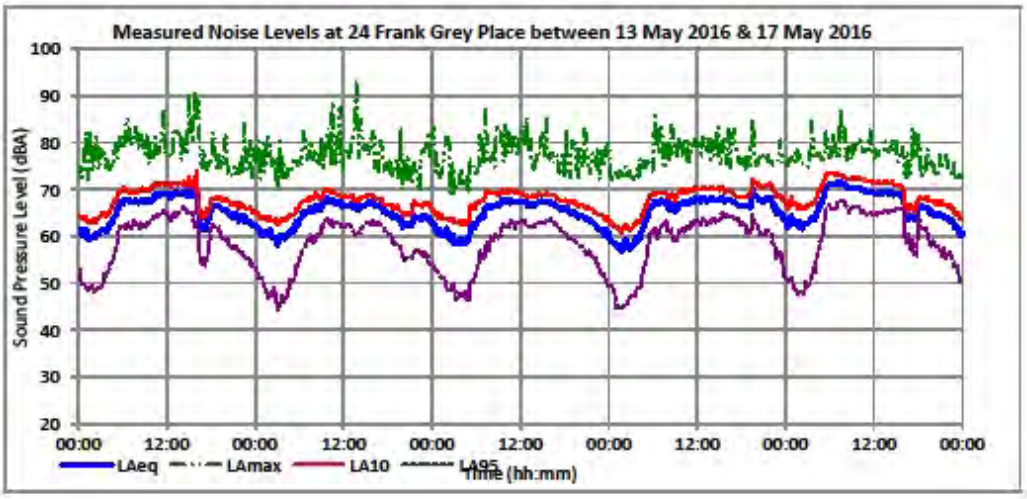
MARSHALL DAY Acoustics

Date:	Thursday, 19 May 2016
File name:	J:\JOBS\2016\2016010A\03 Survey Data & Measurements\[Sp 002 2016010A BL EWL - 24 Frank Grey Place (AMA Yard).xlsx]Logger_Summary
Job number:	2016010A
Job name:	East West Link
Initials:	BL
Measurement Dates:	Friday, 13 May 2016 to Tuesday, 17 May 2016
Weather during Measurement:	No adjustment due to adverse weather was necessary
Notes:	24 Frank Grey Place

OVERVIEW SUMMARY SHEET

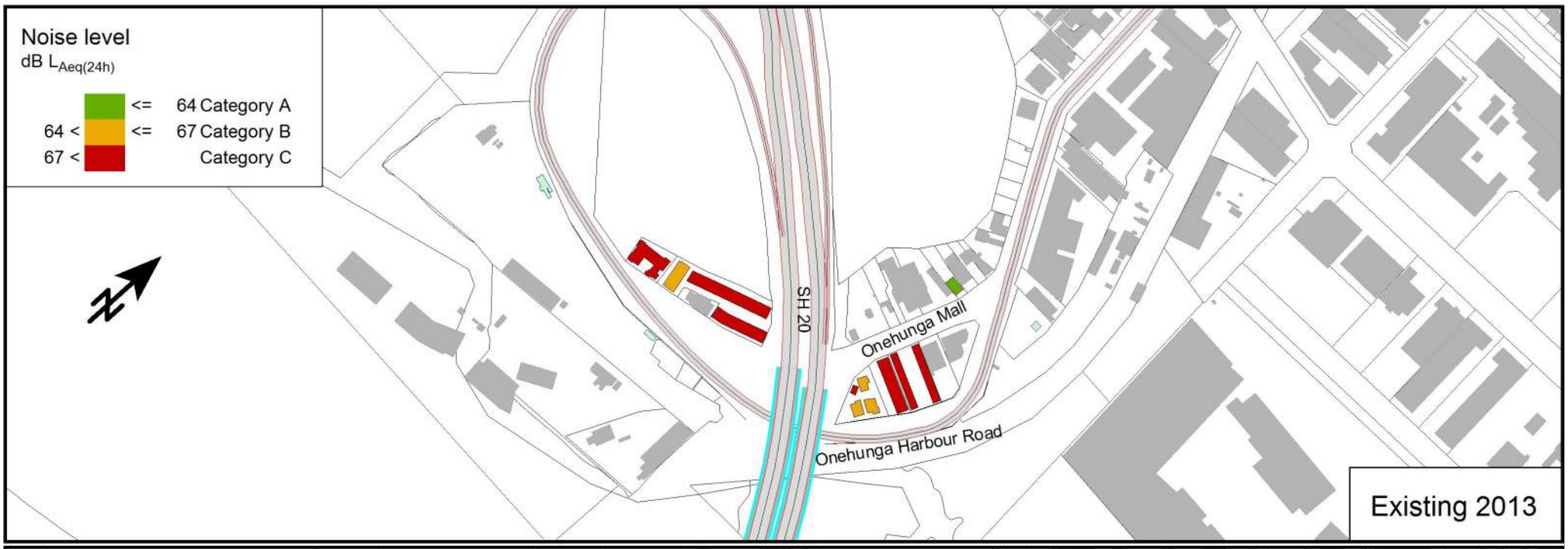
Noise Level, dB		L_{Aeq}	L_{A10}	L_{A95}	L_{Amax}
Day (0700-1800)	Lowest	61	64	54	72
	Average	68	70	63	79
	Highest	72	74	68	93
Evening (1800-2200)	Lowest	62	65	55	70
	Average	66	68	59	76
	Highest	70	72	65	85
Night (2200-0700)	Lowest	57	61	44	69
	Average	64	66	52	76
	Highest	71	74	67	86

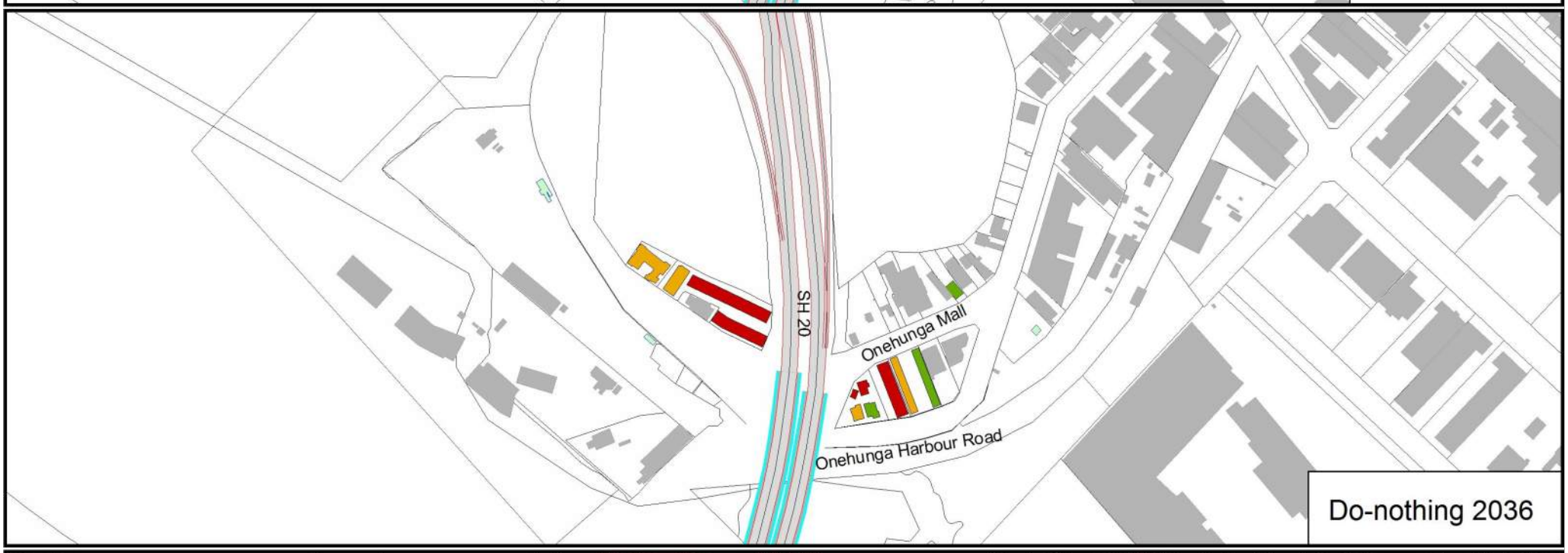
$L_{Aeq\ 24\text{-}hr}$ 66 dB

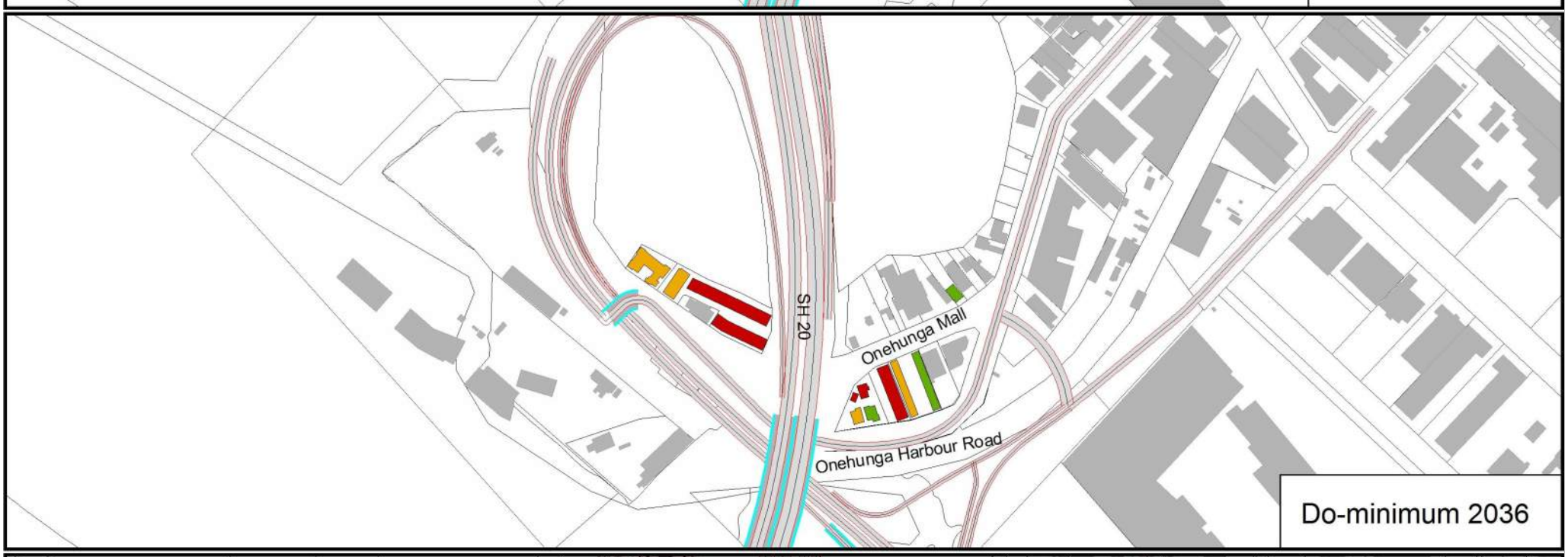


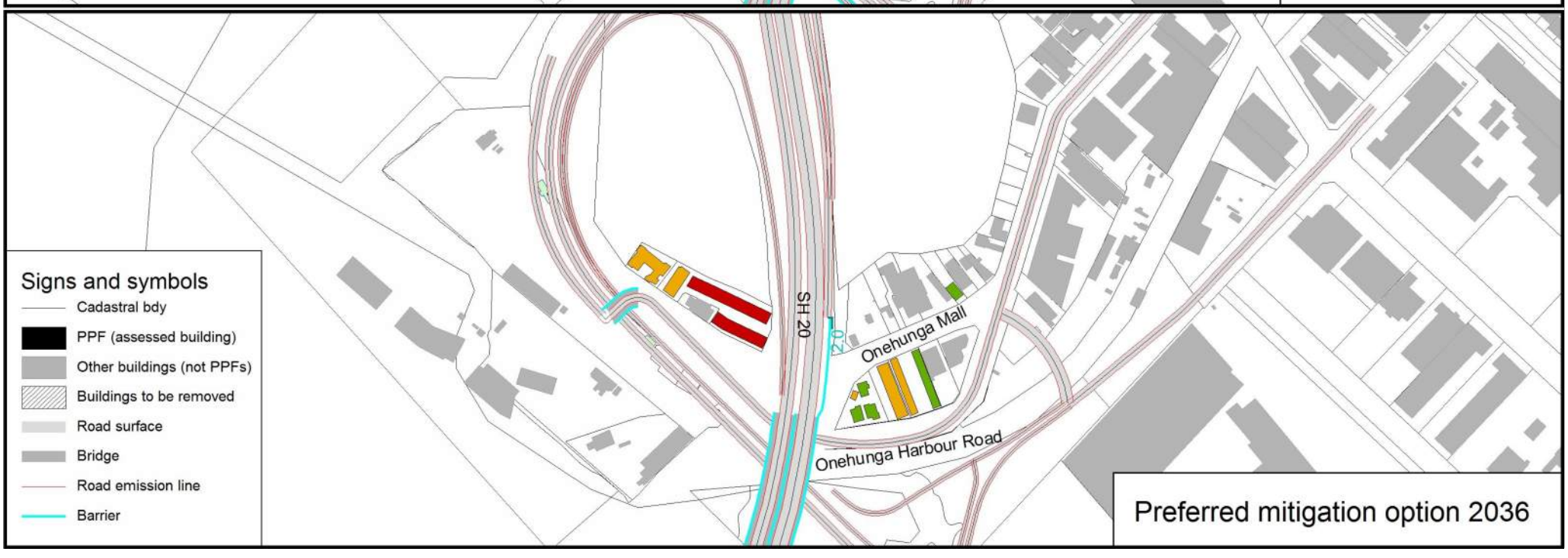
Appendix D

Noise level predictions–NZS 6806:2010 Categories









No	Issued Status	Drawn	App'd	Check'd	Date
A	ISSUED FOR INFORMATION ONLY	SW	SW	Draft	26/10/16

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NZ TRANSPORT AGENCY WAKA KOTAHI

East West Link

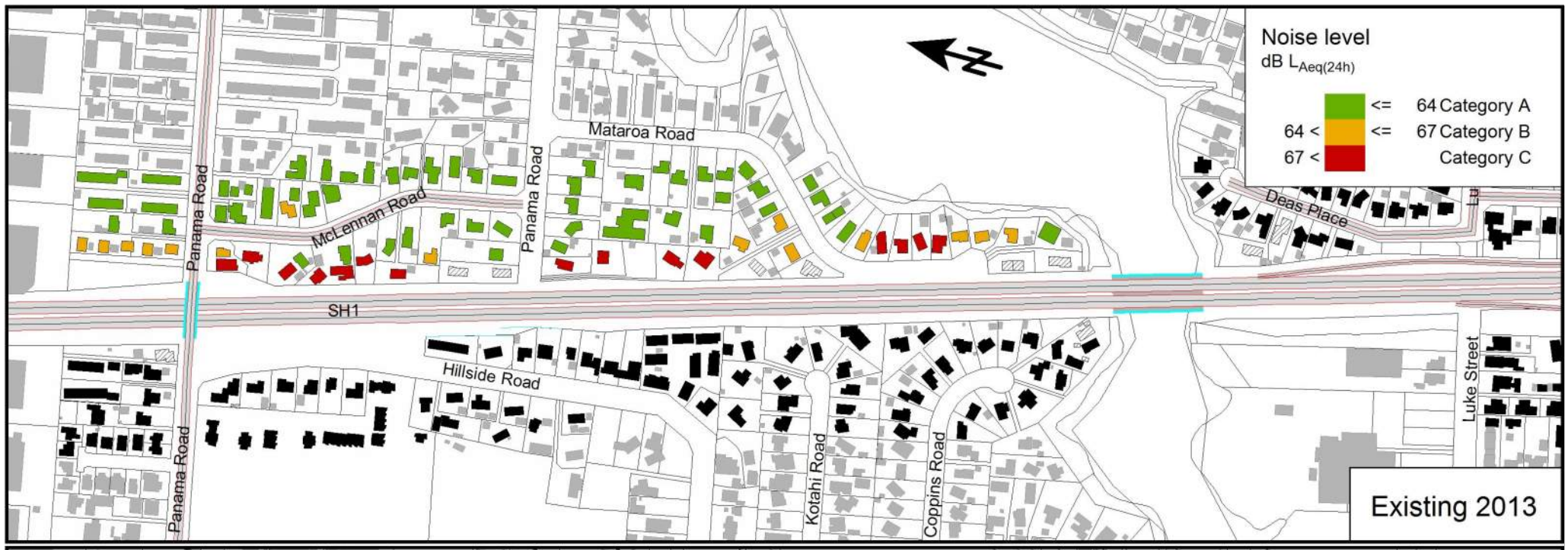
Drawn: Siiri Wilkening	Drafting Check:	Design Manager Reviewed: Siiri Wilkening	Approved Alliance Manager:
Designed: Siiri Wilkening	Design Check:		
Scale: 1:5000	Original Size: A3	Contract No: PA4041	

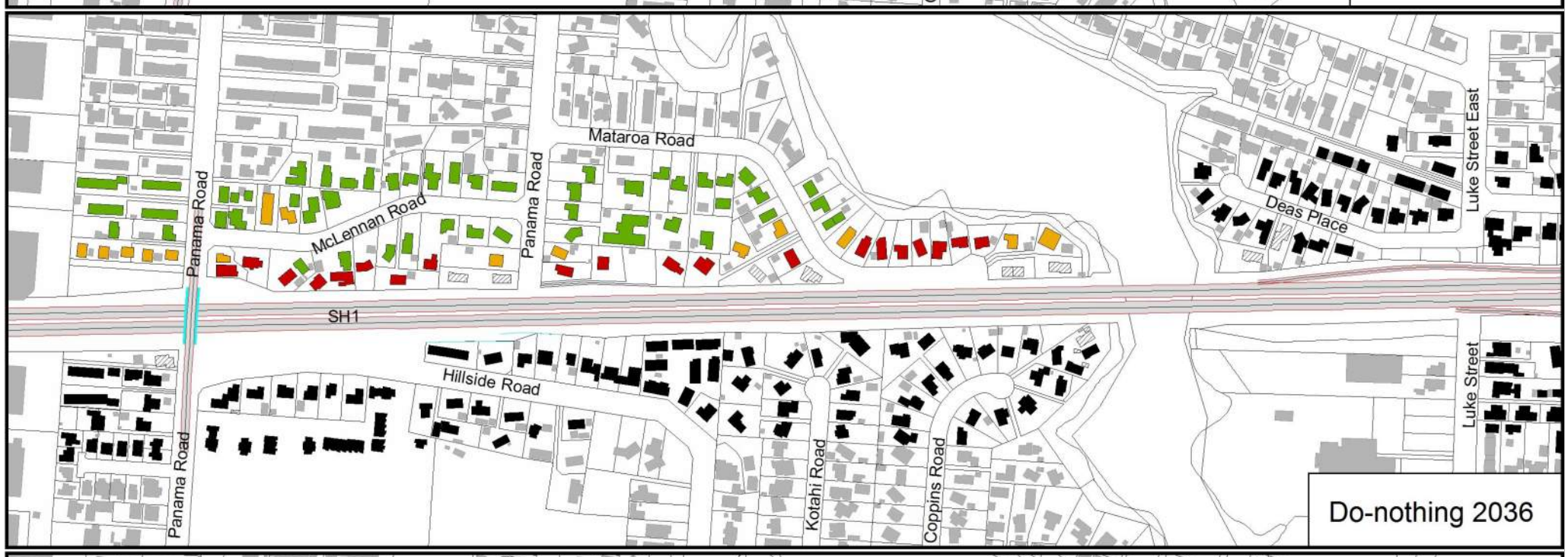
Drawing Title: NOISE & VIBRATION NZS 6806 Categories Area 1

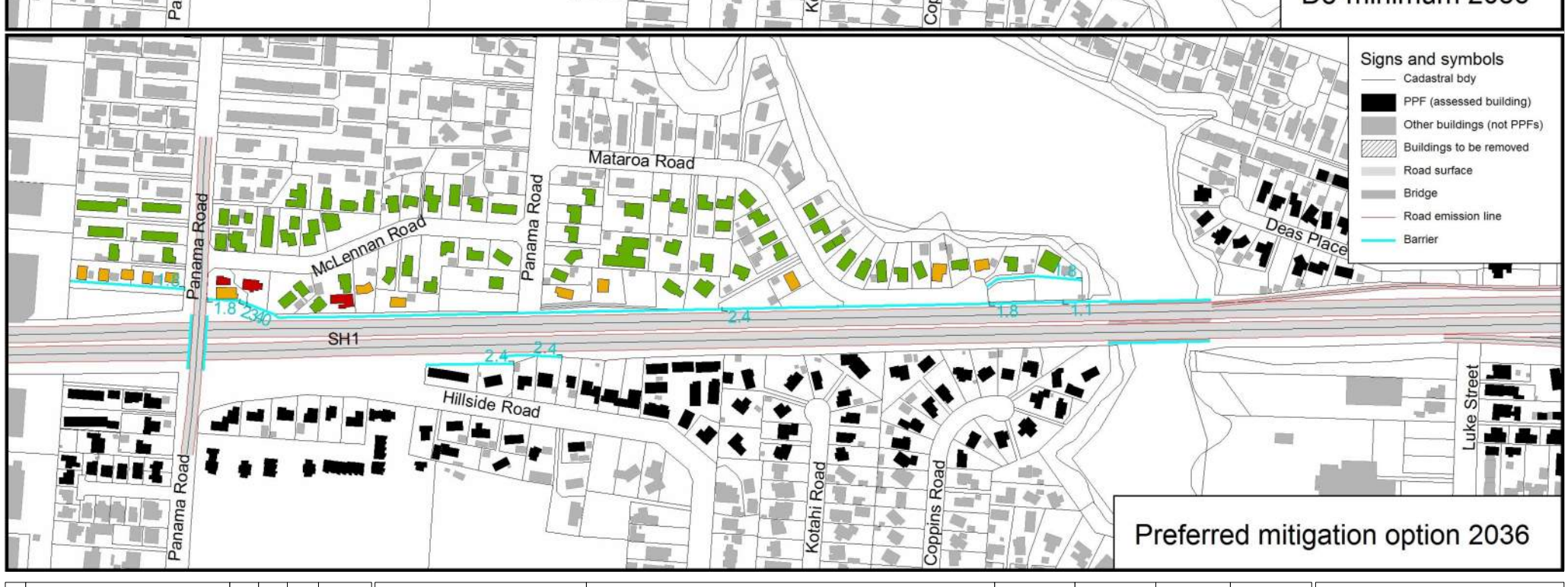
Drawing Number: GIS-NV-AEE-002

Rev No.: A

Plot Date: 26/10/16 Plotted by: Siiri Wilkening







No	Issued Status	Drawn	App'd	Check'd	Date
A	ISSUED FOR INFORMATION ONLY	SW	SW	Draft	26/10/16

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NZ TRANSPORT AGENCY WAKA KOTAHI

East West Link

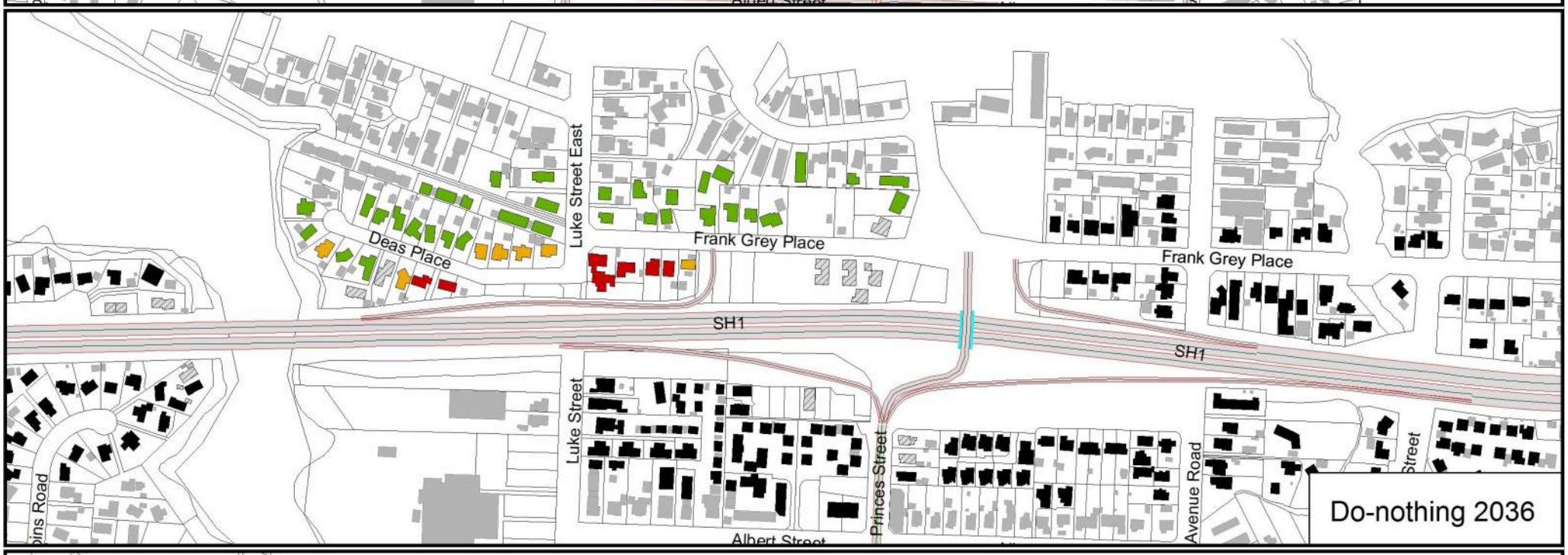
Drawn: Siiri Wilkening	Drafting Check:	Design Manager Reviewed: Siiri Wilkening	Approved: Alliance Manager
Designed: Siiri Wilkening	Design Check:		
Scale: 1:5000	Original Size: A3	Contract No: PA4041	

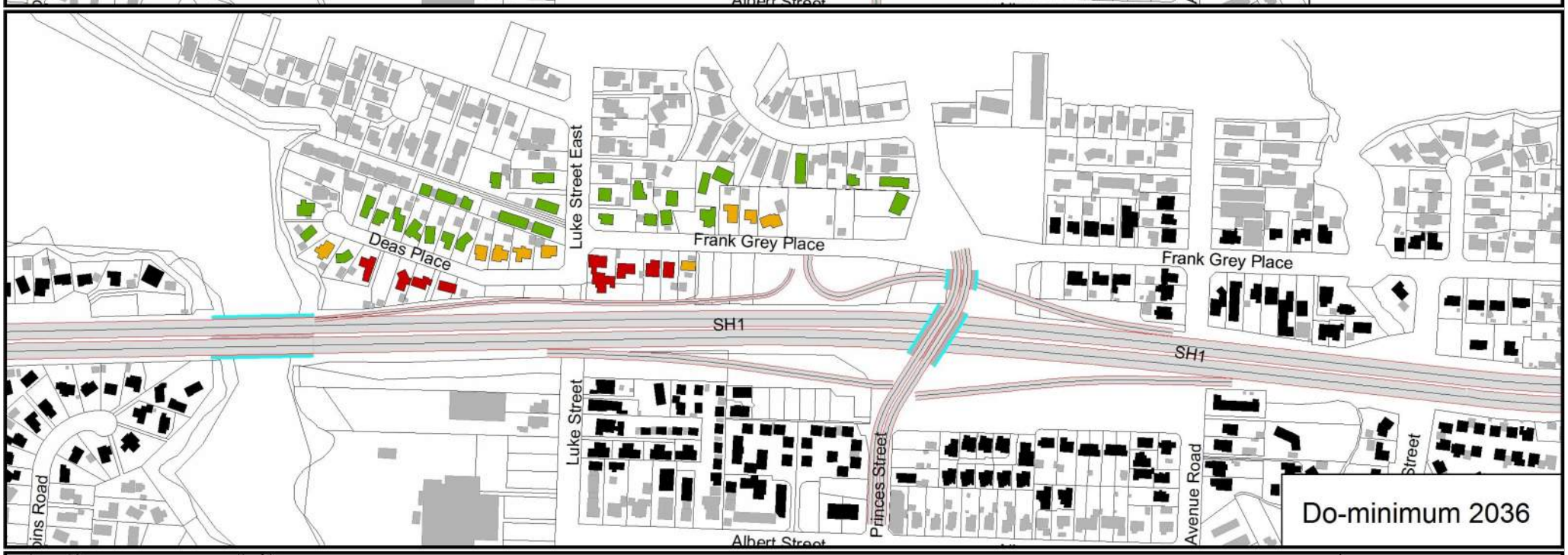
Drawing Title: NOISE & VIBRATION NZS 6806 Categories Area 2

Drawing Number: GIS-NV-AEE-003

Rev No.: A

Plot Date: 26/10/16 Plotted by: Siiri Wilkening





No	Issued Status	Drawn	App'd	Check'd	Date
A	ISSUED FOR INFORMATION ONLY	SW	SW	Draft	26/10/16

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NZ TRANSPORT AGENCY WAKA KOTAHI

East West Link

Drawn: Siiri Wilkening	Drafting Check:	Design Manager Reviewed: Siiri Wilkening	Approved Alliance Manager:
Designed: Siiri Wilkening	Design Check:		
Scale: 1:5000	Original Size: A3	Contract No: PA4041	

Drawing Title: NOISE & VIBRATION NZS 6806 Categories Area 3

Drawing Number: GIS-NV-AEE-004

Rev No.: A

Plot Date: 26/10/16 Plotted by: Siiri Wilkening

Noise level
dB $L_{Aeq(24h)}$

<= 64 Category A
64 < <= 67 Category B
67 < Category C

Frank Grey Place
SH1
Luke Street
Princes Street
Albert Street
Avenue Road
Trenwith Street
Luke Street East

Existing 2013

Do-nothing 2036

Do-minimum 2036

Signs and symbols
- Cadastral bdy
- PPF (assessed building)
- Other buildings (not PPFs)
- Buildings to be removed
- Road surface
- Bridge
- Road emission line
- Barrier

2.4 3.0 2.4 8 1.8 2.4

Preferred mitigation option 2036

No	Issued Status	Drawn	App'd	Check'd	Date
A	ISSUED FOR INFORMATION ONLY	SW	SW	Draft	26/10/16

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NZ TRANSPORT AGENCY WAKA KOTAHI
East West Link

Drawn: Siiri Wilkening	Drafting Check:	Design Manager Reviewed: Siiri Wilkening	Approved Alliance Manager:
Designed: Siiri Wilkening	Design Check:		
Scale: 1:5000	Original Size: A3	Contract No: PA4041	

Drawing Title: NOISE & VIBRATION NZS 6806 Categories Area 4

Drawing Number: GIS-NV-AEE-005

Rev No.: A

Plot Date: 26/10/16 Plotted by: Siiri Wilkening

Noise level
dB $L_{Aeq(24h)}$

	<=	64	Category A
64 <	<=	67	Category B
67 <			Category C

N

Mataroa Road
Deas Place
McLennan Road
Panama Road
SH1
Hillside Road
Kotahi Road
Coppins Road

Existing 2013

Do-nothing 2036

Do-minimum 2036

Signs and symbols
- Cadastral bdy
- PPF (assessed building)
- Other buildings (not PPFs)
- Buildings to be removed
- Road surface
- Bridge
- Road emission line
- Barrier

3.0
2.4
3.0
2.4
1.8
1.1

Preferred mitigation option 2036

No	Issued Status	Drawn	App'd	Check'd	Date
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NZ TRANSPORT AGENCY WAKA KOTAHI
East West Link

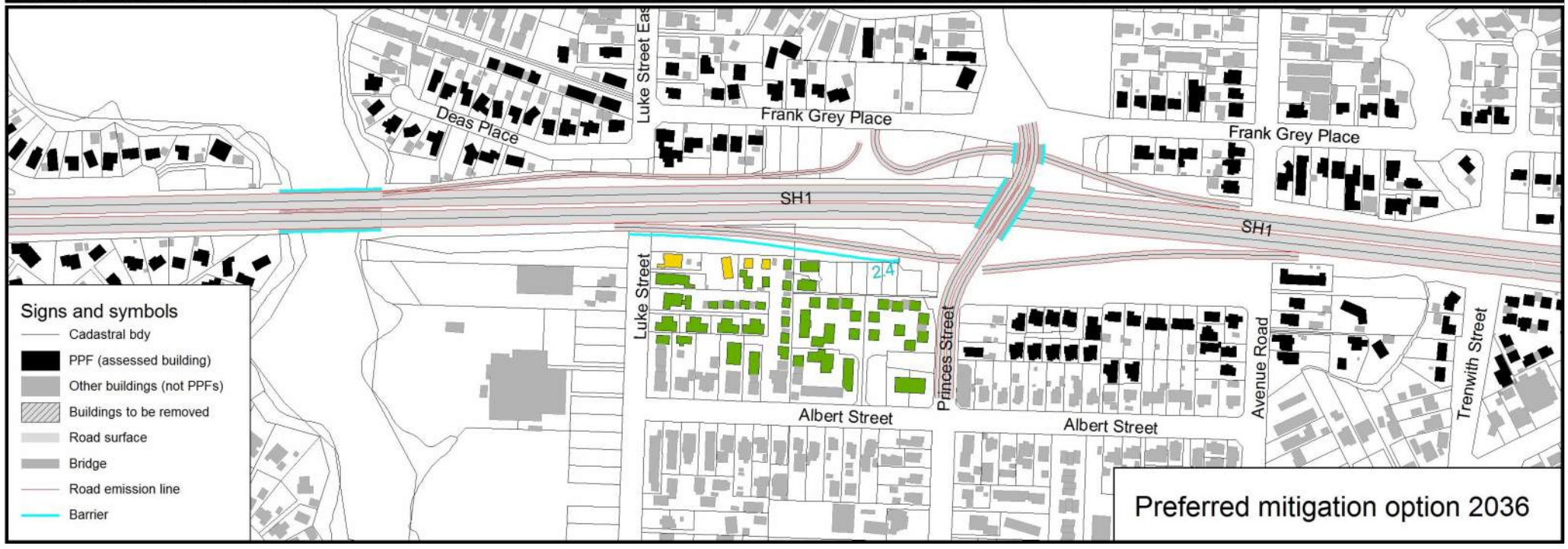
Drawn: Siiri Wilkening	Drafting Check:	Design Manager Reviewed: Siiri Wilkening	Approved Alliance Manager:
Designed: Siiri Wilkening	Design Check:		
Scale: 1:5000	Original Size: A3	Contract No: PA4041	

Drawing Title: NOISE & VIBRATION NZS 6806 Categories Area 5

Drawing Number: GIS-NV-AEE-006

Rev No.: A

Plot Date: 26/10/16 Plotted by: Siiri Wilkening



No	Issued Status	Drawn	App'd	Check'd	Date
A	ISSUED FOR INFORMATION ONLY	SW	SW	Draft	26/10/16

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NZ TRANSPORT AGENCY WAKA KOTAHI

East West Link

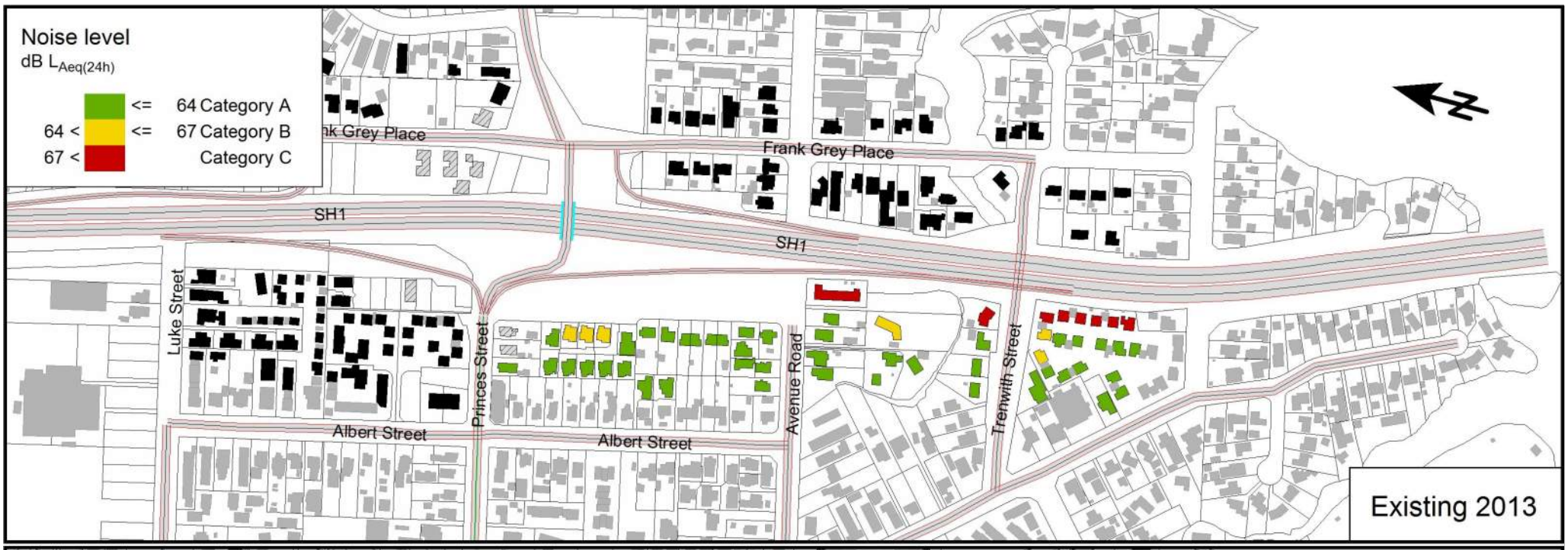
Drawn: Siiri Wilkening	Drafting Check:	Design Manager Reviewed: Siiri Wilkening	Approved Alliance Manager:
Designed: Siiri Wilkening	Design Check:		
Scale: 1:5000	Original Size: A3	Contract No: PA4041	

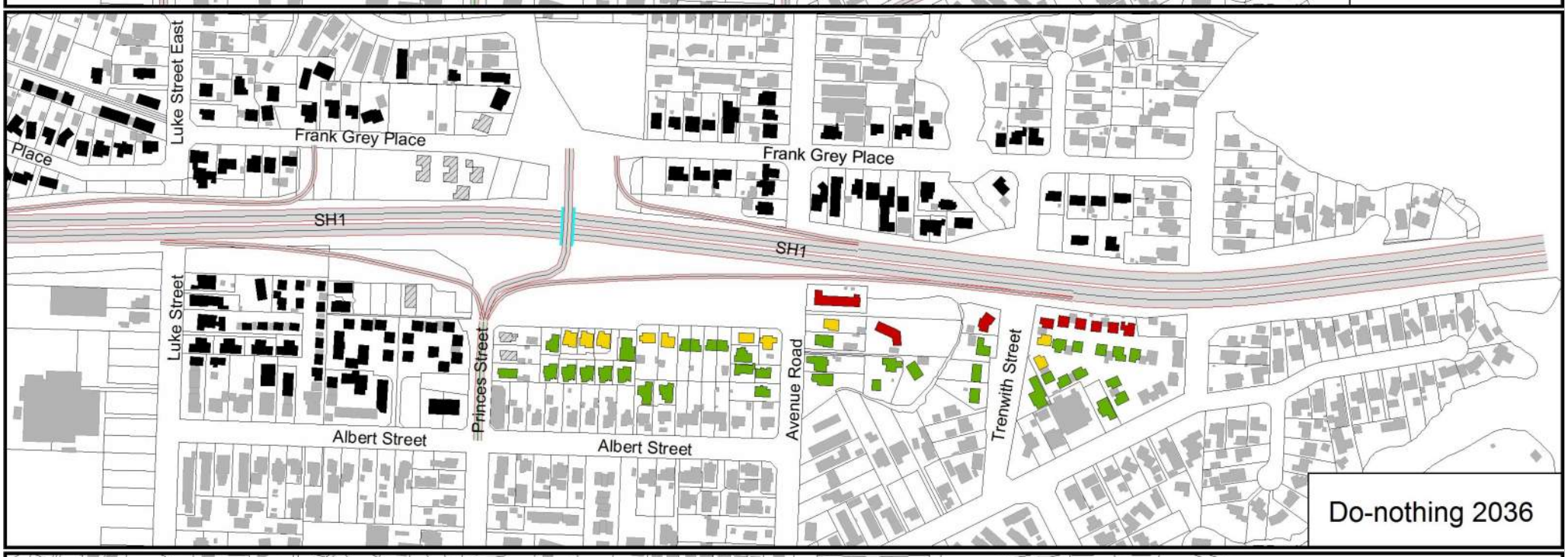
Drawing Title: NOISE & VIBRATION NZS 6806 Categories Area 6

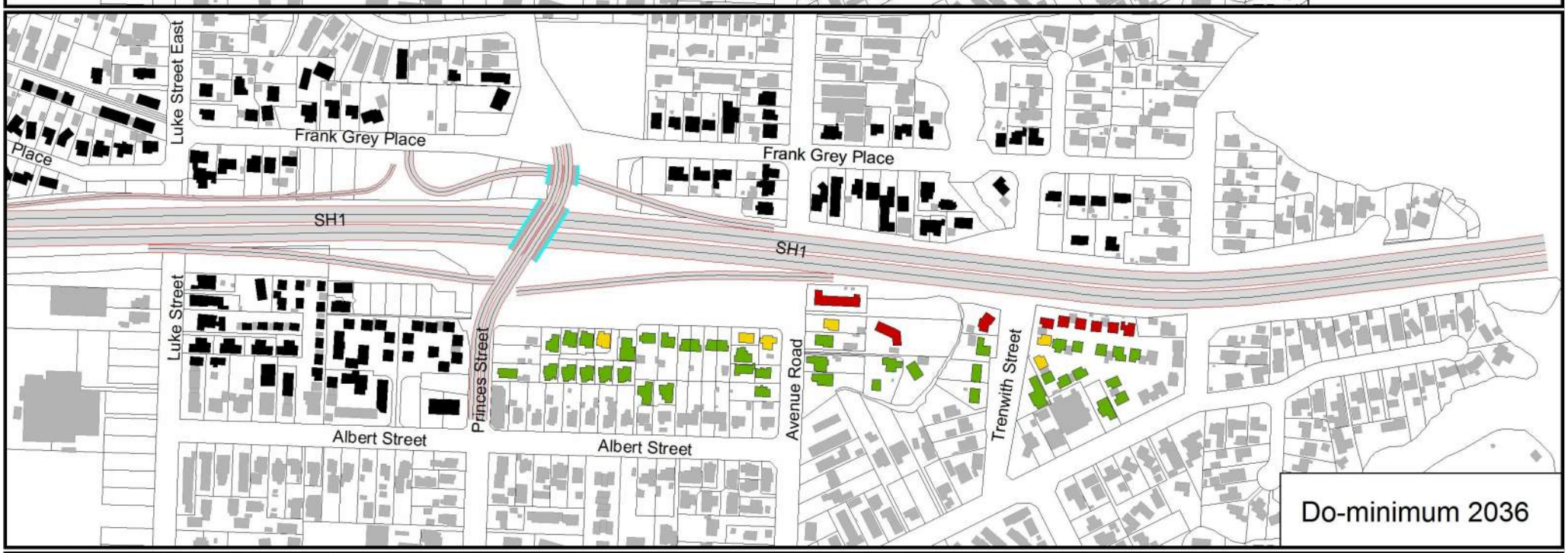
Drawing Number: GIS-NV-AEE-007

Rev No.: A

Plot Date: 26/10/16 Plotted by: Siiri Wilkening







No	Issued Status	Drawn	App'd	Check'd	Date
A	ISSUED FOR INFORMATION ONLY	SW	SW	Draft	26/10/16

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NZ TRANSPORT AGENCY WAKA KOTAHI

East West Link

Drawn: Siiri Wilkening	Drafting Check:	Design Manager Reviewed: Siiri Wilkening	Approved Alliance Manager:
Designed: Siiri Wilkening	Design Check:		
Scale: 1:5000	Original Size: A3	Contract No: PA4041	

Drawing Title: NOISE & VIBRATION NZS 6806 Categories Area 7

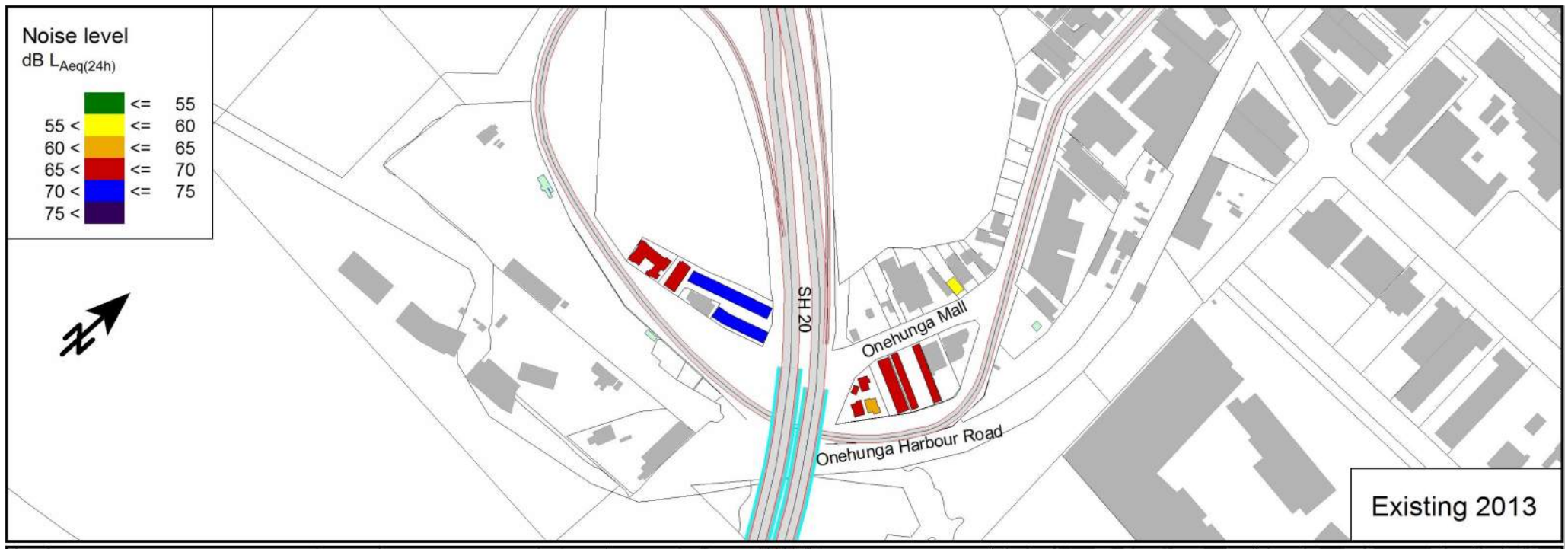
Drawing Number: GIS-NV-AEE-008

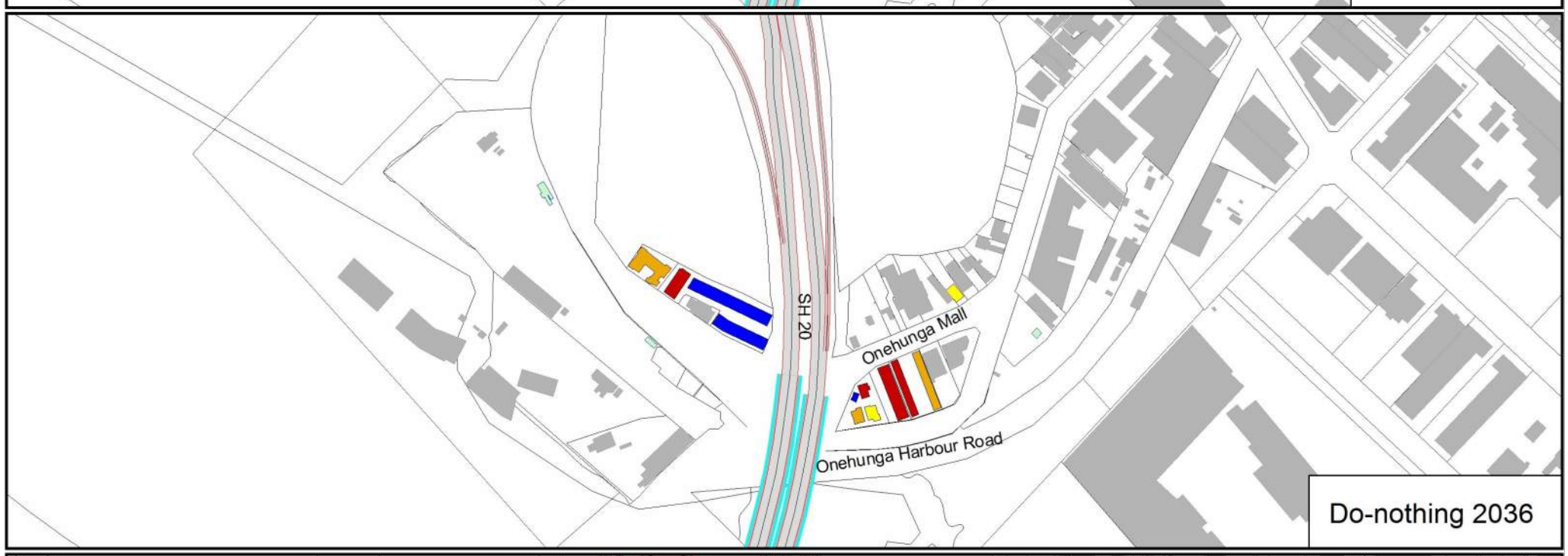
Rev No.: A

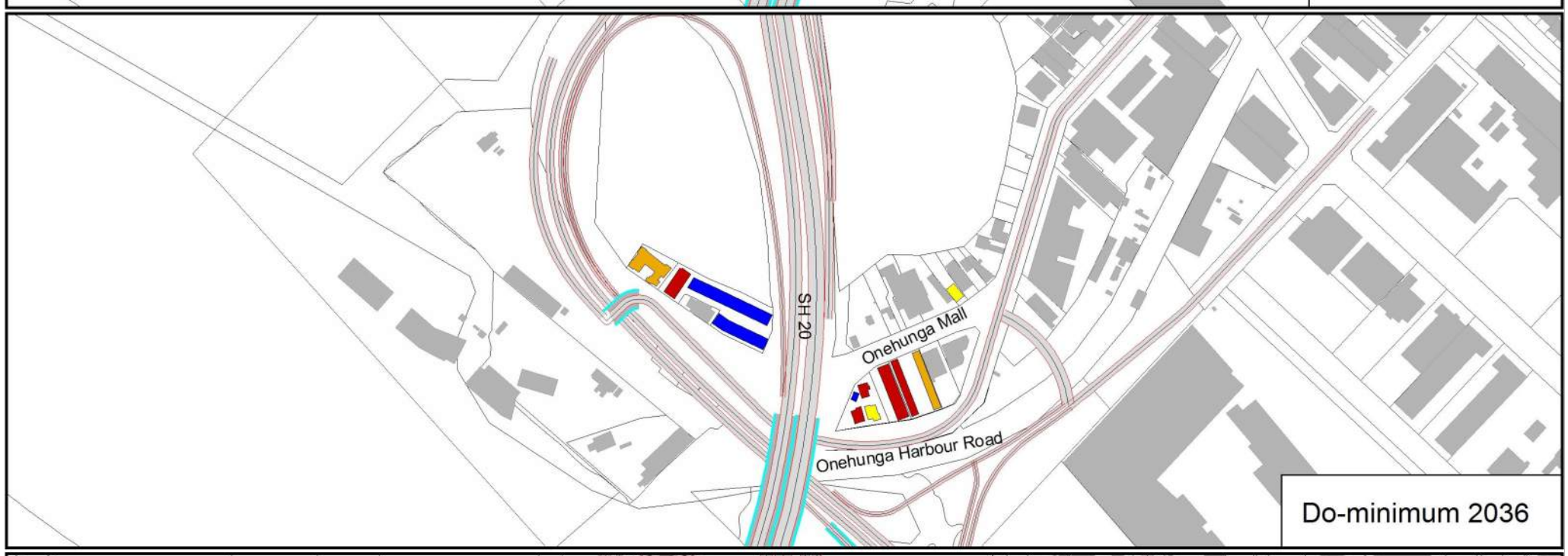
Plot Date: 26/10/16 Plotted by: Siiri Wilkening

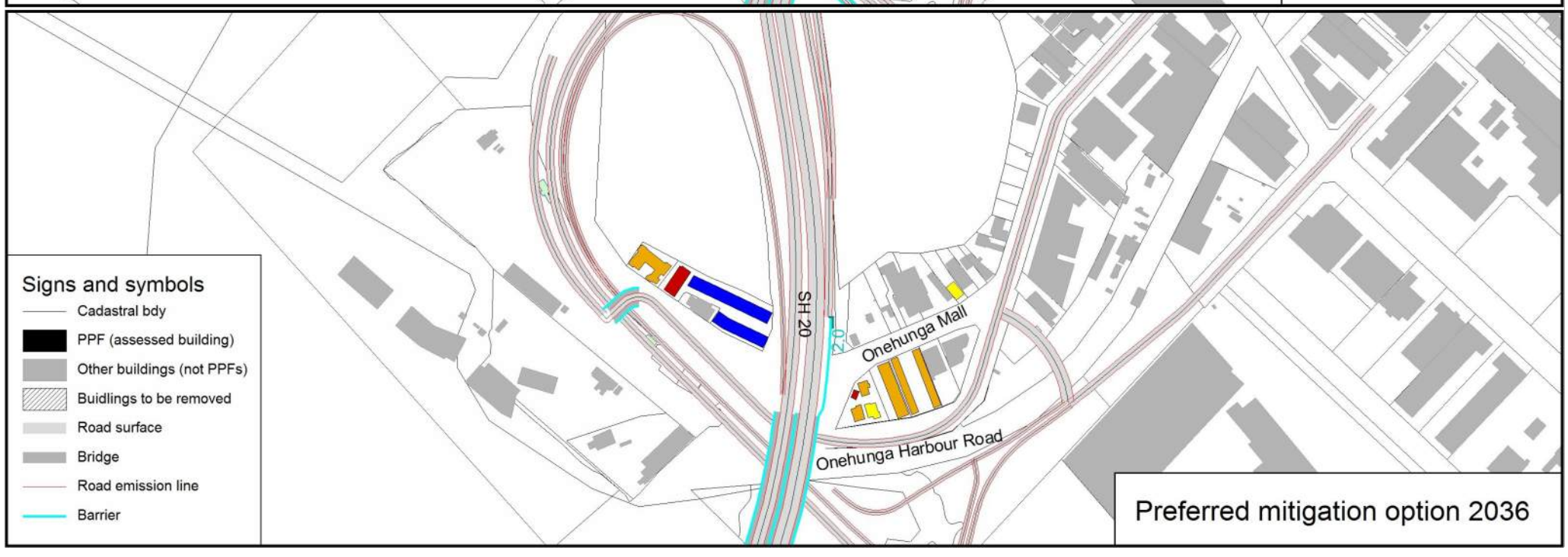
Appendix E

Noise level predictions–Annoyance bands









No	Issued Status	Drawn	App'd	Check'd	Date
A	ISSUED FOR INFORMATION ONLY	SW	SW	Draft	26/10/16

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NZ TRANSPORT AGENCY WAKA KOTAHI

East West Link

Drawn: Siiri Wilkening	Drafting Check:	Design Manager Reviewed: Siiri Wilkening	Approved Alliance Manager:
Designed: Siiri Wilkening	Design Check:		

Scale: 1:5000 Original Size: A3

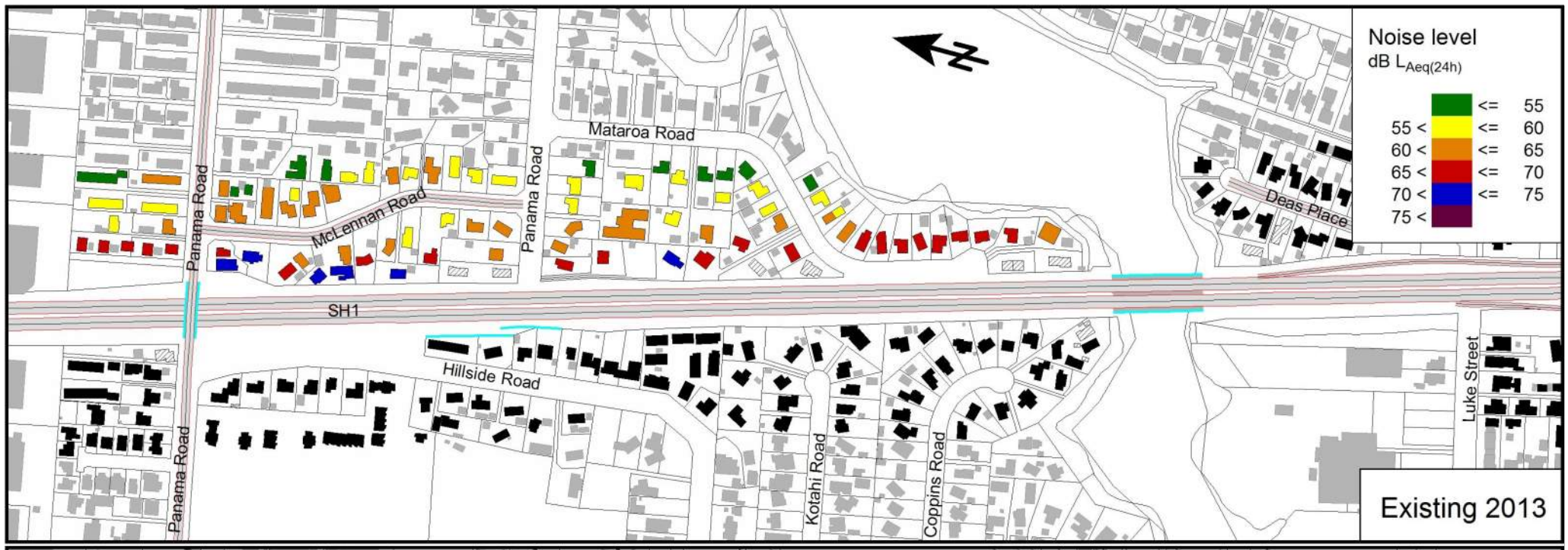
Contract No PA4041

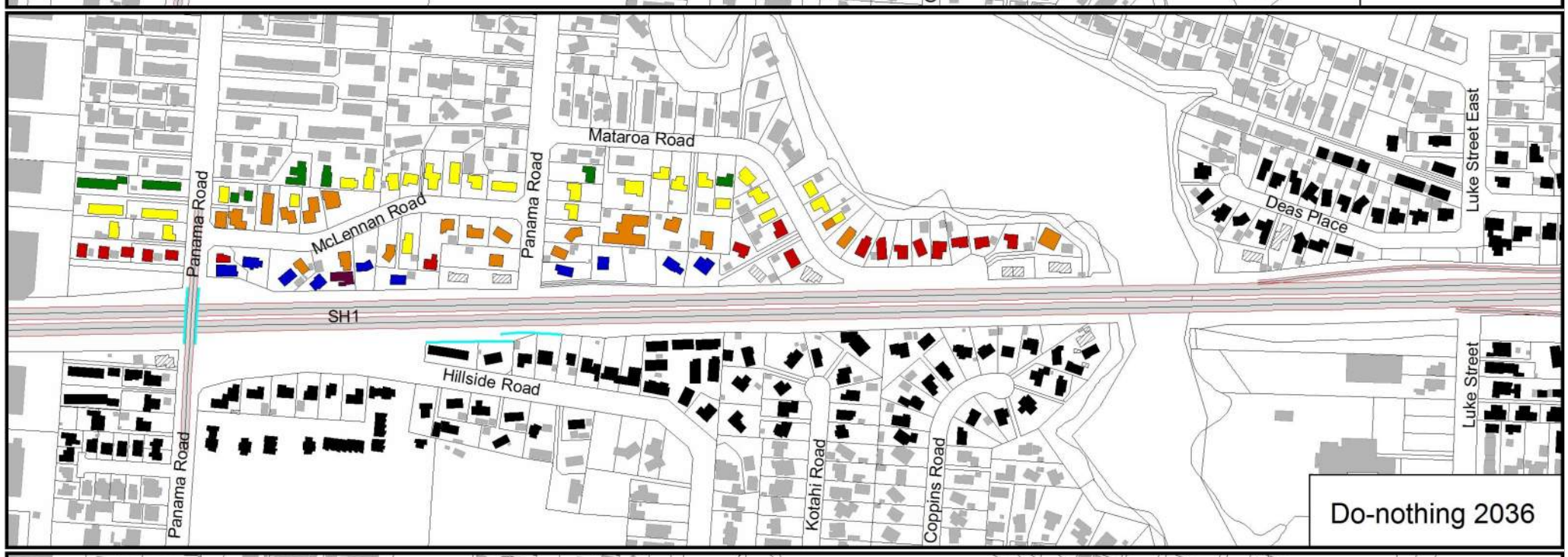
Drawing Title: NOISE & VIBRATION Annoyance Bands Area 1

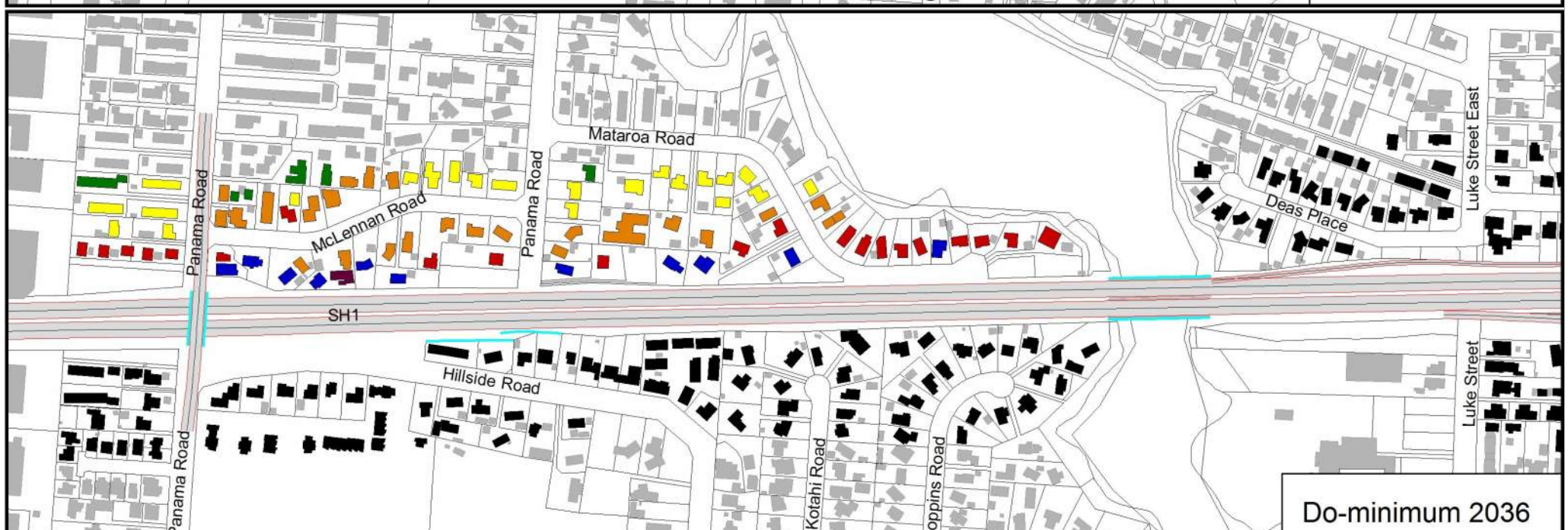
Drawing Number: GIS-NV-AEE-009

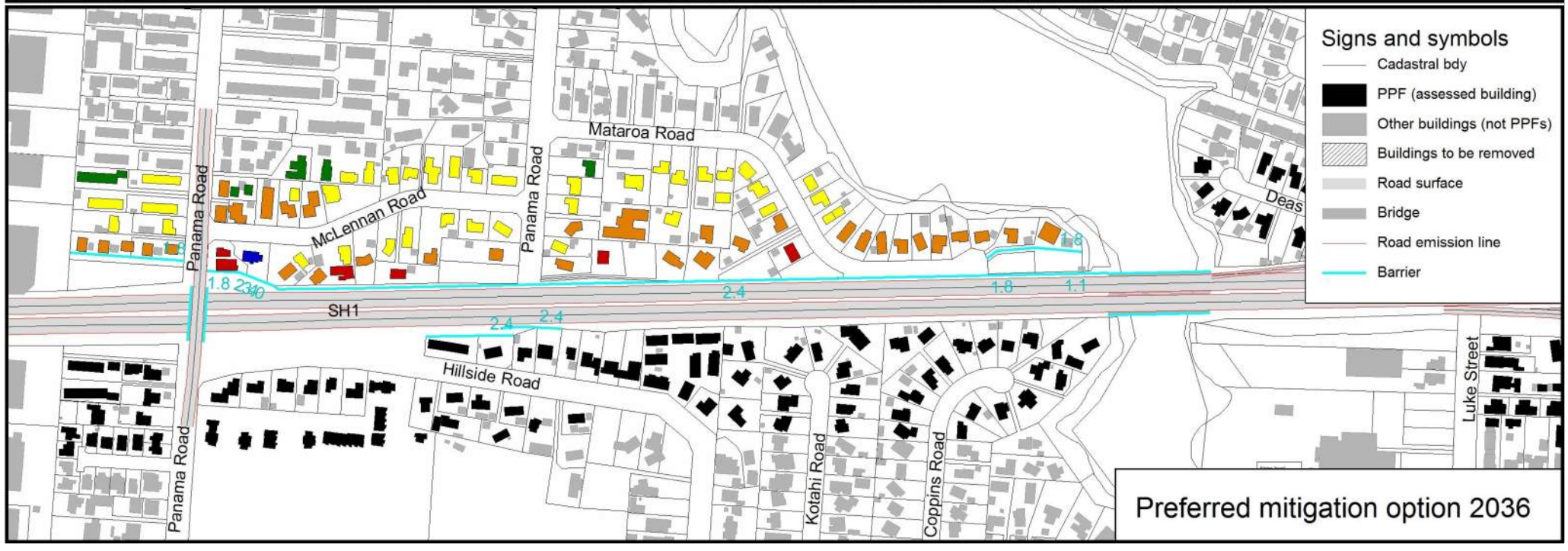
Rev No.: A

Plot Date: 26/10/16 Plotted by: Siiri Wilkening









No	Issued Status	Drawn	App'd	Check'd	Date
A	ISSUED FOR INFORMATION ONLY	SW	SW	Draft	26/10/16

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NZ TRANSPORT AGENCY WAKA KOTAHI

East West Link

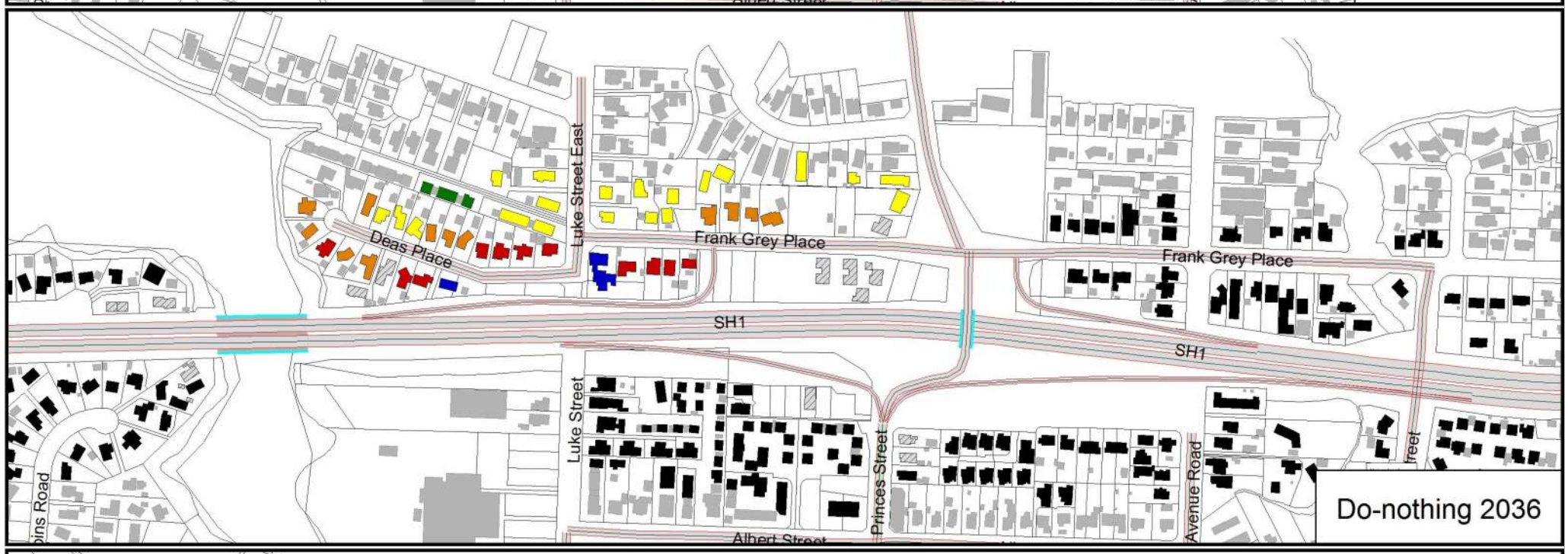
Drawn: Siiri Wilkening	Drafting Check:	Design Manager Reviewed: Siiri Wilkening	Approved Alliance Manager:
Designed: Siiri Wilkening	Design Check:		
Scale: 1:5000	Original Size: A3	Contract No: PA4041	

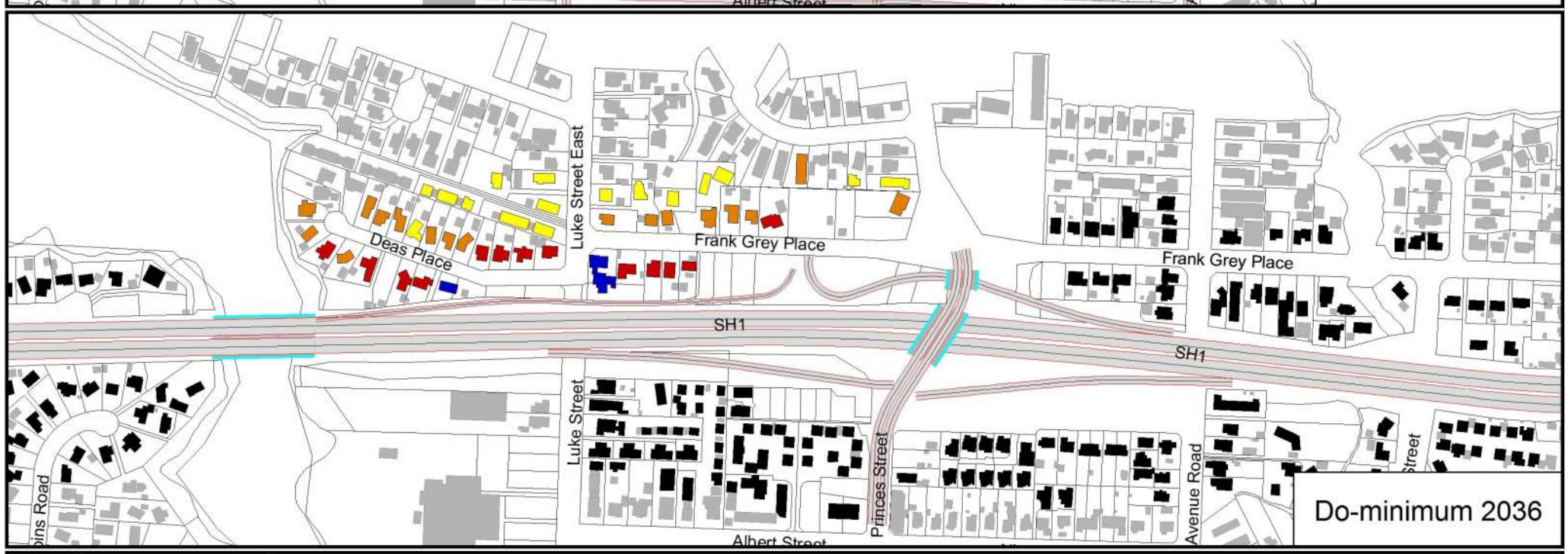
Drawing Title: NOISE & VIBRATION Annoyance Bands Area 2

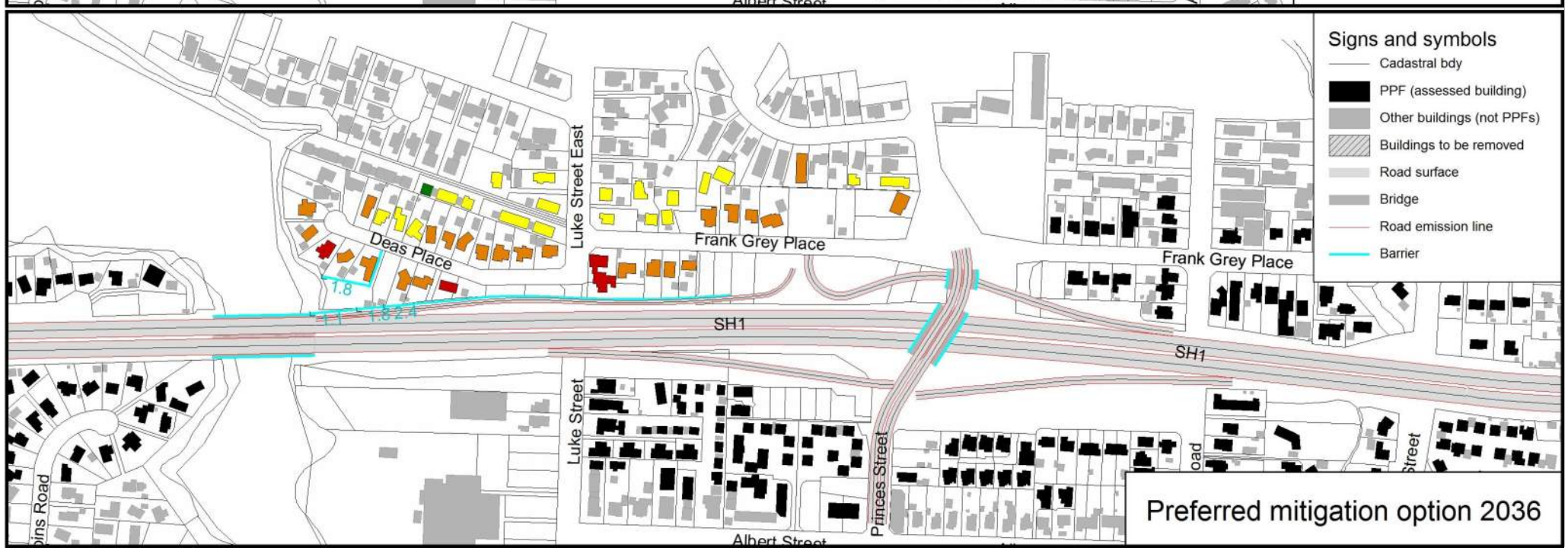
Drawing Number: GIS-NV-AEE-010

Rev No.: A

Plot Date: 26/10/16 Plotted by: Siiri Wilkening







No	Issued Status	Drawn	App'd	Check'd	Date
A	ISSUED FOR INFORMATION ONLY	SW	SW	Draft	26/10/16

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NZ TRANSPORT AGENCY WAKA KOTAHI

East West Link

Drawn: Siiri Wilkening	Drafting Check	Design Manager Reviewed: Siiri Wilkening	Approved Alliance Manager
Designed: Siiri Wilkening	Design Check		
Scale: 1:5000	Original Size: A3	Contract No: PA4041	

Drawing Title: NOISE & VIBRATION Annoyance Bands Area 3

Drawing Number: GIS-NV-AEE-011

Rev No.: A

Plot Date: 26/10/16 Plotted by: Siiri Wilkening

Noise level
dB $L_{Aeq(24h)}$

	<=	55
55 <	<=	60
60 <	<=	65
65 <	<=	70
70 <	<=	75
75 <		

Frank Grey Place
SH1
Luke Street
Princes Street
Albert Street
Avenue Road
Trenwith Street

Existing 2013

Luke Street East
Frank Grey Place
SH1
Luke Street
Princes Street
Albert Street
Avenue Road
Trenwith Street

Do-nothing 2036

Luke Street East
Frank Grey Place
SH1
Luke Street
Princes Street
Albert Street
Avenue Road
Trenwith Street

Do-minimum 2036

Luke Street East
Frank Grey Place
SH1
2.4
3.0
2.4
1.8
1.8
2.4
Luke Street
Princes Street
Albert Street
Avenue Road
Trenwith Street

Signs and symbols
- Cadastral bdy
- PPF (assessed building)
- Other buildings (not PPFs)
- Buildings to be removed
- Road surface
- Bridge
- Road emission line
- Barrier

Preferred mitigation option 2036

No	Issued Status	Drawn	App'd	Check'd	Date
A	ISSUED FOR INFORMATION ONLY	SW	SW	Draft	26/10/16

DISCLAIMER

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This Drawing must not be used for construction.

NZ TRANSPORT AGENCY WAKA KOTAHI
East West Link

Drawn: Siiri Wilkening	Drafting Check	Design Manager Reviewed: Siiri Wilkening	Approved Alliance Manager
Designed: Siiri Wilkening	Design Check		
Scale: 1:5000	Original Size: A3	Contract No: PA4041	

Drawing Title: NOISE & VIBRATION Annoyance Bands Area 4

Drawing Number: GIS-NV-AEE-012

Rev No.: A

Plot Date: 26/10/16 Plotted by: Siiri Wilkening

Noise level
dB $L_{Aeq(24h)}$

	<=	55
55 <	<=	60
60 <	<=	65
65 <	<=	70
70 <	<=	75
75 <		

N

Mataroa Road
Deas Place
Panama Road
McLennan Road
Panama Road
SH1
Hillside Road
Panama Road
Kotahi Road
Coppins Road

Existing 2013

Mataroa Road
Deas Place
Panama Road
McLennan Road
Panama Road
SH1
Hillside Road
Panama Road
Kotahi Road
Coppins Road

Do-nothing 2036

Mataroa Road
Deas Place
Panama Road
McLennan Road
Panama Road
SH1
Hillside Road
Panama Road
Kotahi Road
Coppins Road

Do-minimum 2036

Mataroa Road
Panama Road
McLennan Road
Panama Road
SH1
3.0
2.4
3.0
2.4
1.8
1.1
Hillside Road
Panama Road
Kotahi Road
Coppins Road

Signs and symbols
- Cadastral bdy
- PPF (assessed building)
- Other buildings (not PPFs)
- Buildings to be removed
- Road surface
- Bridge
- Road emission line
- Barrier

Preferred mitigation option 2036

No	Issued Status	Drawn	App'd	Check'd	Date
A	ISSUED FOR INFORMATION ONLY	SW	SW	Draft	26/10/16

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NZ TRANSPORT AGENCY WAKA KOTAHI
East West Link

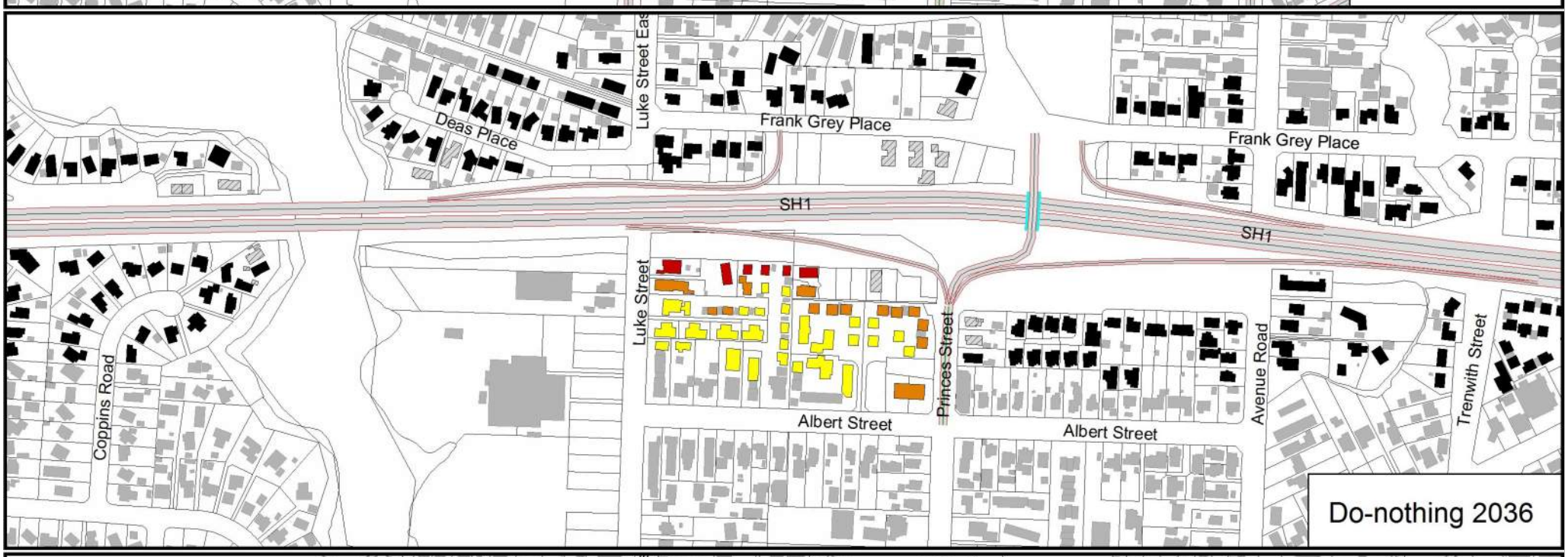
Drawn: Siiri Wilkening	Drafting Check:	Design Manager Reviewed: Siiri Wilkening	Approved Alliance Manager:
Designed: Siiri Wilkening	Design Check:		
Scale: 1:5000	Original Size: A3	Contract No: PA4041	

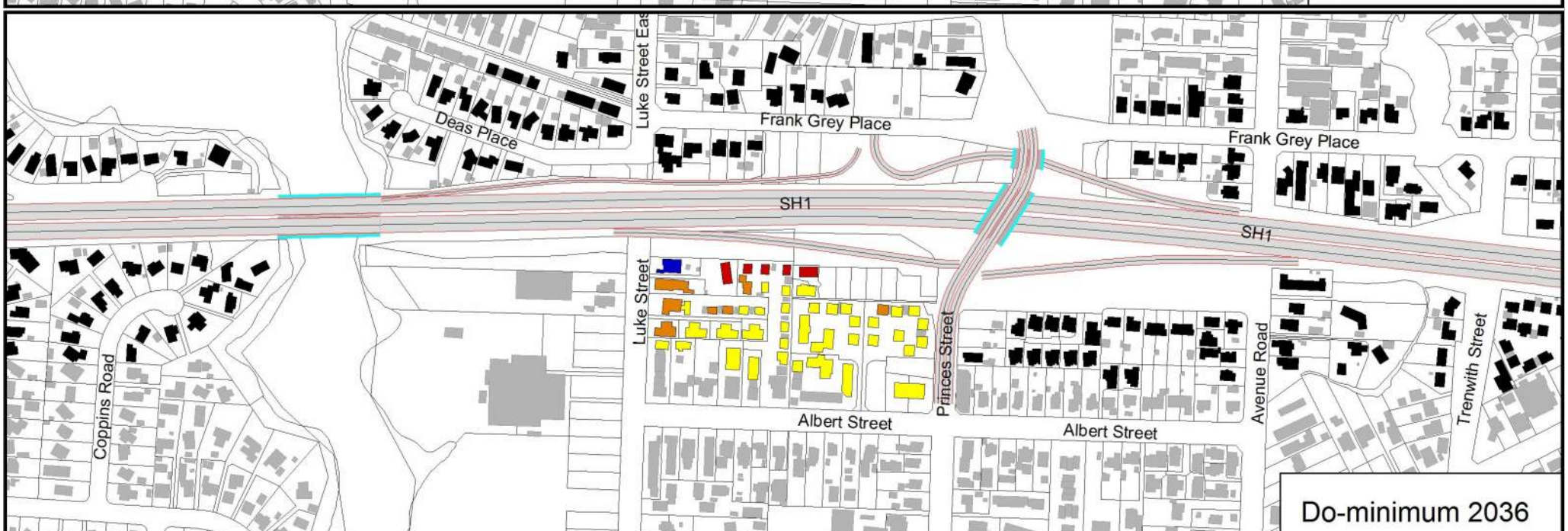
Drawing Title: NOISE & VIBRATION Annoyance Bands Area 5

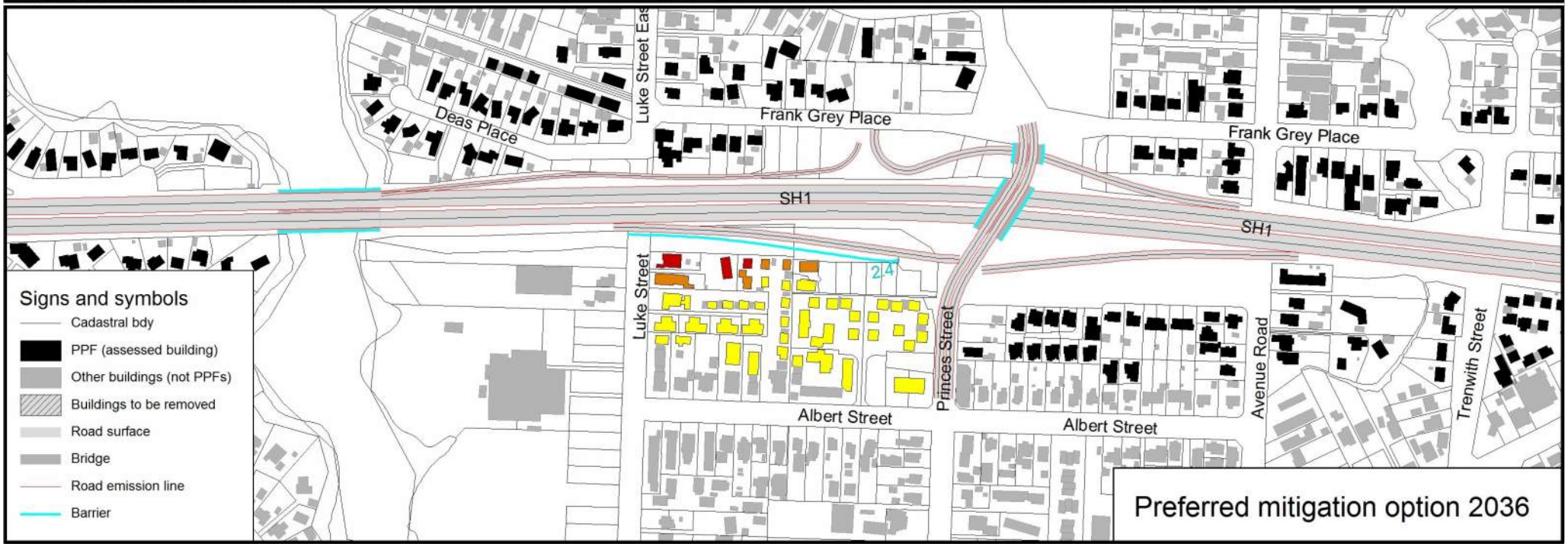
Drawing Number: GIS-NV-AEE-013

Rev No.: A

Plot Date: 26/10/16 Plotted by: Siiri Wilkening







No	Issued Status	Drawn	App'd	Check'd	Date
A	ISSUED FOR INFORMATION ONLY	SW	SW	Draft	26/10/16

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NZ TRANSPORT AGENCY WAKA KOTAHI

East West Link

Drawn: Siiri Wilkening	Drafting Check:	Design Manager Reviewed: Siiri Wilkening	Approved Alliance Manager:
Designed: Siiri Wilkening	Design Check:		
Scale: 1:5000	Original Size: A3	Contract No: PA4041	

Drawing Title: NOISE & VIBRATION Annoyance Bands Area 6

Drawing Number: GIS-NV-AEE-014

Rev No.: A

Plot Date: 26/10/16 Plotted by: Siiri Wilkening

Noise level
dB $L_{Aeq(24h)}$

	<=	55
55 <	<=	60
60 <	<=	65
65 <	<=	70
70 <	<=	75
75 <		

Frank Grey Place
SH1
Luke Street
Princes Street
Albert Street
Avenue Road
Trenwith Street

Existing 2013

Do-nothing 2036

Do-minimum 2036

Preferred mitigation option 2036

Signs and symbols
- Cadastral bdy
- PPF (assessed building)
- Other buildings (not PPFs)
- Buildings to be removed
- Road surface
- Bridge
- Road emission line
- Barrier

No	Issued Status	Drawn	App'd	Check'd	Date
A	ISSUED FOR INFORMATION ONLY	SW	SW	Draft	26/10/16

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NZ TRANSPORT AGENCY WAKA KOTAHI
East West Link

Drawn: Siiri Wilkening	Drafting Check:	Design Manager Reviewed: Siiri Wilkening	Approved Alliance Manager:
Designed: Siiri Wilkening	Design Check:		
Scale: 1:5000	Original Size: A3	Contract No: PA4041	

Drawing Title: NOISE & VIBRATION Annoyance Bands Area 7

Drawing Number: GIS-NV-AEE-015

Rev No.: A

Plot Date: 26/10/16 Plotted by: Siiri Wilkening