MARSHALL DAY Acoustics

WIRI TO QUAY PARK THIRD MAIN RAIL LINE NOISE AND VIBRATION ASSESSMENT

Rp 001 20200311 | 10 July 2020

84 Symonds Street
PO Box 5811
Victoria Street West
Auckland 1142 New Zealand
T: +64 9 379 7822 F: +64 9 309 3540
www.marshallday.com

Project: **KIWIRAIL WIRI TO QUAY PARK**

Prepared for: **Jacobs**
Carlaw Park
12-16 Nicholls Lane
Parnell
Auckland 1010

Attention: **Tim Hegarty**

Report No.: **Rp 001 20200311**

Disclaimer

Reports produced by Marshall Day Acoustics Limited are based on a specific scope, conditions and limitations, as agreed between Marshall Day Acoustics and the Client. Information and/or report(s) prepared by Marshall Day Acoustics may not be suitable for uses other than the specific project. No parties other than the Client should use any information and/or report(s) without first conferring with Marshall Day Acoustics.

The advice given herein is for acoustic purposes only. Relevant authorities and experts should be consulted with regard to compliance with regulations or requirements governing areas other than acoustics.

Copyright

The concepts and information contained in this document are the property of Marshall Day Acoustics Limited. Use or copying of this document in whole or in part without the written permission of Marshall Day Acoustics constitutes an infringement of copyright. Information shall not be assigned to a third party without prior consent.

Document Control

Status:	Rev:	Comments	Date:	Author:	Reviewer:
Draft	-	For team review	18 May 2020	Micky Yang	Siiri Wilkening Craig Fitzgerald
Draft	01	Client review	10 June 2020	Micky Yang	Siiri Wilkening
Draft	02	Section 7 updates	7 July 2020	Craig Fitzgerald	Siiri Wilkening
Issued	03	Update for team comments and measurement results	10 July 2020	Micky Yang	Craig Fitzgerald
Issued	04	Finalised	10 July 2020	-	Craig Fitzgerald

TABLE OF CONTENTS

1.0 INTRODUCTION 4

2.0 SITE LOCATION 5

3.0 REGULATORY CONTEXT 6

3.1 Construction Noise and Vibration 6

3.2 Operational Noise and Vibration 7

4.0 CONSTRUCTION NOISE AND VIBRATION ASSESSMENT 8

4.1 Overview 8

4.2 Programme 8

4.3 Sequencing of Works 9

4.4 Construction Noise 10

4.5 Construction Vibration 12

4.6 Construction Noise and Vibration Management Plan 15

5.0 OPERATIONS NOISE AND VIBRATION ASSESSMENT 16

5.1 Overview 16

5.2 Rail Noise 16

5.3 Rail Vibration 27

6.0 RECOMMENDATIONS 28

6.1 Construction Noise and Vibration 28

6.2 Operational Rail Noise and Vibration 29

7.0 CONCLUSION 30

APPENDIX A GLOSSARY OF TERMINOLOGY

APPENDIX B PROPOSED THIRD LINE

APPENDIX C INDICATIVE NOISE CONTOURS

APPENDIX D COMPARISON OF RAIL NOISE CRITERIA

APPENDIX E PREDICTED NOISE LEVELS

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

1.0 INTRODUCTION

Marshall Day Acoustics (**MDA**) has been engaged by Jacobs to undertake a noise and vibration assessment of construction and operation of the proposed third rail line between Wiri Junction and Middlemore Station. This section of the railway forms one part of the wider Wiri to Quay Park (**W2QP**) project. The four Packages are:

1. The construction of a 3.6km third railway line (**Third Main**) on the west side of the existing lines between Middlemore Station and Wiri Junction including upgrades and alterations to Middlemore and Papatoetoe Stations;
2. The upgrading of the rail yard at Wiri Junction;
3. The upgrading of the rail yard at Westfield; and
4. The upgrading of the Rail yard at Quay Park.

Our scope is limited to Package 1 only (the **Project**).

The Wiri to Quay Park section of railway is a key link to the national and regional rail network. It carries a mixture of passenger and freight trains. The current twin rail layout has reached maximum capacity during peak periods. Therefore, the installation of a third line is needed to increase capacity and provide resilience. Further detail on the purpose of the Project and its strategic importance to Auckland is detailed in the Assessment of Environmental Effects (**AEE**).

Works include construction of retaining walls and overhead electrified lines, as well as upgrades of Middlemore and Papatoetoe station. Works will also be undertaken on Counties Manukau Hospital Board land at Middlemore to rearrange an existing hospital car park.

Some of the works can only take place when the rail lines are blocked, because trains cannot run on the lines whilst construction is taking place. The blocks will run for extended periods and include public holidays and night times. Typical controls for construction noise and vibration are more stringent during these times, so the mitigation and management strategies employed for the works will be critical to the Project.

Our construction noise and vibration findings are:

- Works within the rail Designation are not controlled by designation conditions. Nevertheless, noise and vibration effects from the works must be reasonable. We have recommended criteria that trigger the need for mitigation and management measures to be implemented.
- Works outside of the Designation are controlled by the rules of the Auckland Unitary Plan (**AUP**).
- We have assumed that the majority of high noise and high vibration works will be carried out during daytime hours where it is safe and practicable. Due to access and safety constraints, there will be works required during the night-time as part of Block of Line works.
- Noise and vibration criteria are predicted to be exceeded at most buildings fronting the alignment to a varying degree. Therefore, mitigation measures will need to be implemented.
- We recommend that a Construction Noise and Vibration Management Plan is prepared prior to the works commencing. This will form a part of the Outline Plan of Work (**OPW**).

We have assessed the rail noise and vibration effects from the proposed new railway line outside of the existing Designation for selected receivers within our recommended effects zone. We have focused only on the effect due to the Third Main being closer to receivers, rather than a change in capacity enabled in the existing Designation due to the Third Main. In summary:

- We have recommended assessment criteria for rail noise and rail vibration enabled by the alteration to the rail Designation; and

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

- We have predicted rail noise and vibration levels for the operations enabled by the proposed alteration and recommended where mitigation should be investigated for some receivers.
- The Project would have a noticeable adverse effect arising from the change in rail noise and vibration levels. However, with recommended mitigation measures such as noise barriers and/or building upgrades (e.g. ventilation, glazing and/or façade), the rail noise and vibration levels would be reasonable.We understand that these controls will be implemented as part of the OPW for this NoR to achieve reasonable outcomes for noise and vibration effects.

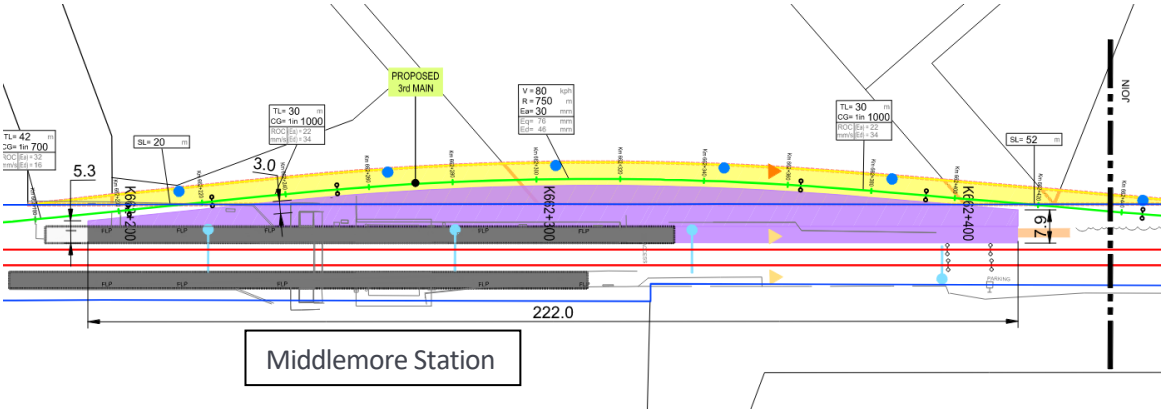
A glossary of terms is attached in Appendix A.

2.0 SITE LOCATION

The proposed Third Main for Package 1 is shown in Appendix B. It is within Designation 6302 and is zoned *Strategic Transport Corridor* by the AUP.

Most of the Third Main will be contained inside of the Designation except for the section shown in Figure 1.

Figure 1: Blue line indicates Designation. Green line indicates proposed new rail line outside Designation



Most of the receivers adjacent to the Designation are zoned *Residential* with others zoned *Business.* Two receivers are zoned *Special Purpose* (Middlemore Hospital and Kings College).

The Third Main will be on the western side of the existing lines, so the western receivers will be closer to any work site. In general, residential receivers on the western side are typically approximately 7 – 10m from the Third Main or a work site. On the eastern side, the typical setback distance is approximately 25 – 30m away. Some retaining works are less than 1m from an existing house. The closest buildings at Middlemore Hospital are at least 60m from the works.

Minor works outside the existing corridor are also proposed at Papatoetoe Station and Bridge Street. However, these works relate to new retaining walls and overhead electrification structures only, and do not result in the rail line moving outside the designation.

Construction works will require temporary occupation of land outside the designation. Closest houses are 10 to 20 metres from the proposed retaining walls. Indicative locations are shown in the figures overleaf.

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

Figure 2: Papatoetoe Station: Blue line indicates Designation. Turquois line indicates retaining walls that will be installed along the designation boundary. Pink line indicates temporary occupation during construction

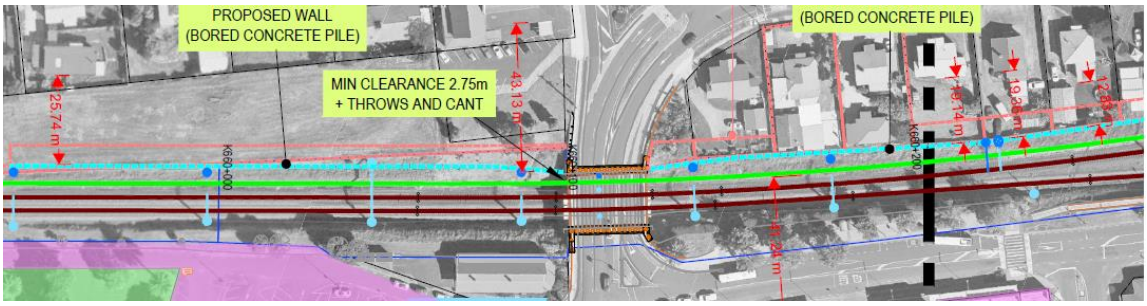
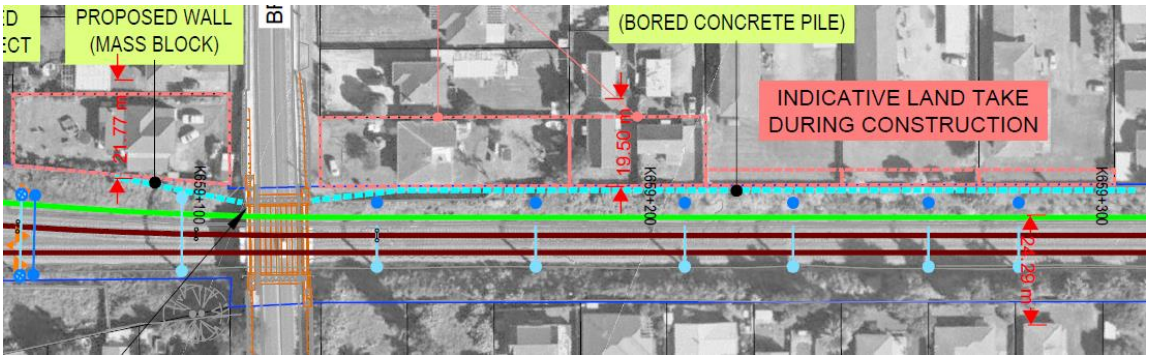


Figure 3: Bridge Street: Blue line indicates Designation. Turquois line indicates retaining walls that will be installed along the designation boundary. Pink line indicates temporary occupation during construction



Refer the Land Requirement plans in the Planner's report.

3.0 REGULATORY CONTEXT

The rail designation contains no controls for noise and vibration. However, there is an obligation required under Section 16 of the Resource Management Act (**RMA**) which states *"every person carrying out an activity… shall adopt the best practicable option to ensure that the emission of noise… does not exceed a reasonable level*".

3.1 Construction Noise and Vibration

Construction noise and vibration management is critical to ensure the emissions are reasonable.

The foreword of New Zealand Standard NZS 6803:1999 "*Acoustics – Construction Noise*" states: "*Construction noise is an inherent part of the progress of society. As noise from construction is generally of limited duration, people and communities will usually tolerate a higher noise level provided it is* ***no louder than necessary, and occurs with appropriate hours of the day****. The Resource Management Act 1991 requires the* ***adoption of the best practicable option to ensure*** *the emission of noise from premises does not exceed* ***a reasonable level****. The Act also imposes a duty on every person to avoid, remedy, or mitigate any adverse effect on the environment arising from an activity carried on by, or on behalf of, that person*."[1]

For residual works outside the rail designation, the noise and vibration controls in Chapter E25 of the AUP apply.

The following relevant AUP objectives and policies provide further guidance:

- AUP objectives in E25.2 (1) require that "*People are protected from* ***unreasonable*** *levels of noise and vibration*", while (4) states: "*Construction activities that cannot meet noise and vibration standards are* ***enabled while controlling duration, frequency and timing*** *to manage adverse*

[1] New Zealand Standard NZS 6803:1999 "*Acoustics – Construction Noise*", Foreword

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

effects". This acknowledges that there are often periods or activities where the construction noise standards cannot be met. The objective is to enable them provided they are no louder than necessary.

- AUP policies in E25.3 (2) require "*Minimise, **where practicable,** noise and vibration at its source or on the site from which it is generated to mitigate adverse effects on adjacent sites*", while (10) states: "*Avoid, remedy or mitigate the adverse effects of noise and vibration from construction, maintenance and demolition activities while having regard to:*

  a) the sensitivity of the receiving environment; and

  b) the proposed duration and hours of operation of the activity; and

  c) ***the practicability of complying** with permitted noise and vibration standards*."

  This acknowledges the practicability of compliance. A Construction Noise and Vibration Management Plan (**CNVMP**) should address all three elements. Such a CNVMP would be employed through the OPW process.

- The relevant noise and vibration rules are detailed in Sections 4.4.1 and 4.5.1 respectively.

- AUP matters of discretion in E25.8.2 (1) parts (a) and (b) are (note other parts are not relevant to construction noise):

  *a) "whether activities can be managed so that they **do not generate unreasonable noise and vibration levels** on adjacent land uses particularly activities sensitive to noise*

  b) the extent to which the noise or vibration generated by the activity:

  i. will occur at times when disturbance to sleep can be avoided or minimised; and

  ii. will be compatible with activities occurring or allowed to occur in the surrounding area; and

  iii. will be limited in duration, or frequency or by hours of operation; and

  iv. will exceed the existing background noise and vibration levels in that environment and the reasonableness of the cumulative levels; and

  v. *can be carried out during daylight hours, such as road works and works on public footpaths"*

  A further statement in E25.8.2 (2) is: "***for works in the road or rail corridor**, whether the **effects on amenity values and sleep quality** generated by construction activity in the road or rail corridor are reasonable taking into account the background noise levels*."

3.2 Operational Noise and Vibration

For rail activities extending outside the existing designation, the noise and vibration controls in Chapter E25 of the AUP apply. There are no noise and vibration criteria in the AUP that apply to rail noise and neither is there a New Zealand standard for such criteria.

The objectives and policies balance the need to protect people from unreasonable levels while enabling essential infrastructure such as road and rail. The most relevant AUP objectives and policies are reproduced below:

- AUP objectives in E25.2 (1) and (2) require that people are protected from **unreasonable** levels of noise and vibration, while (3) states: "*Existing and authorised activities and infrastructure, which by their nature produce high levels of noise, are appropriately protected from **reverse sensitivity effects** where it is reasonable to do so*."

- AUP policies in E25.3 (1), (2), (4) and (5) are reproduced below (others less relevant)*:*

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

1) ***Set appropriate noise and vibration standards*** *to reflect each zone's function and permitted activities, while ensuring that the potential adverse effects of noise and vibration are avoided, remedied or mitigated.*

2) ***Minimise, where practicable, noise and vibration at its source*** *or on the site from which it is generated to mitigate adverse effects on adjacent sites.*

4) *Use area or activity specific rules where the* ***particular functional or operational needs*** *of the area or activity make such rules appropriate.*

5) ***Prevent significant noise-generating activities other than roads and railway lines from establishing in or immediately adjoining residential zones****.*

- The relevant noise and vibration rules are detailed in Sections 5.2 and 5.3.1 respectively.
- AUP matters of discretion in E25.8.2 (1) parts (a) and (b) are have already been discussed in Section 3.1 above and are also relevant to operational rail noise and vibration.
- A further statement in E25.8.2 (3) is: "for reverse sensitivity effects, whether the activity or ***infringement proposed will unduly constrain the operation of existing activities***."

4.0 CONSTRUCTION NOISE AND VIBRATION ASSESSMENT

4.1 Overview

The construction assessment relies on the W2QP Business Case Design Report (Rev 2), including project alignment, construction method, programme, sequence and timing. We have supplemented this with representative noise and vibration source data and management assumptions based on MDA experience from similar projects (e.g. Auckland Electrification Project (AEP), Developing Auckland's Rail Transport (DART), City Rail Link (CRL) and Puhinui Interchange Upgrade).

4.2 Programme

The Third Main construction duration is approximately 44 months (including a 6-month contingency period). The key components of the programme are:

- Civil retaining walls ~15 months
- Pedestrian bridge and Access Provision at Middlemore ~12 months
- Civil construction earthworks and drainage ~12 months
- Overall Programme Physical Works ~36 months

Works would be carried out in a linear fashion. The average completion rate is 100m per month (based on 3.6 km track over and 36-month construction duration). As such, most receivers would only be exposed to high construction noise and vibration levels for a short duration.

The works will generally be undertaken while maintaining an operational rail corridor. To ensure the safety of those involved, activity timing restrictions are categorised as follows:

- **Normal Access**: Works can be undertaken while trains are operating normally.
- **Restricted Access**: Works that can be safely carried out while trains are operating but require rail protection and/or Electrical Safety Observers.
- **Isolation Hours**: Works that cannot be undertaken while trains are operating but can be undertaken in a short timeframe at night.
- **Block of Line (BOL):** Works that cannot be carried out while trains are operating and require a longer duration to complete. Blocks of Line are required to be planned at least 12 months in advance of the work being undertaken and must follow the BOL Planning process.

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

BOL are required for earthworks and formation activities adjacent to the existing Up Main. Scheduled BOL periods are as follows[2]:

- Labour weekend 2020
- Christmas-New Year 2020-2021
- Anniversary Weekend 2021
- Easter 2021
- Queen's Birthday 2021

The refined timing of works will be further developed in later design stages and form part of the Outline Plan for Works (**OPW**) for each site. We assume the following:

- Normal Access or Restricted Access works will be undertaken during normal day evening periods due to either proximity of works or implementation of Single Line Running.
- Isolation Hours and BOL works will prioritise high noise and vibration activities before 2230 hrs where practicable (e.g. piling and rail tamping), with the remaining scheduled activities extending across the remaining night-time period if required (e.g. surveying, OLE, signal and utility works).
- Some residual, local, short-term, high noise and vibration activities may be required during the night-time period (e.g. to ensure worker safety or to minimise rail, road or utility disruption). Operating procedures will be implemented, including communication with affected residents and businesses, to minimise any potential disturbance.

4.3 Sequencing of Works

The overall sequence of works for the Third Main can be divided into three parts:

- Wiri Junction – Outside the scope of this assessment
- Puhinui to Middlemore Third Main construction:
  - Enabling Works – Service diversions and construction access points
  - Stage 1 – Civils and retaining walls
  - Stage 2 – Earthworks and drainage
  - Stage 3 – OLE Foundations and mast erection
  - Stage 4 – Track laying
  - Stage 5 – OLE dressing and wiring
  - Stage 6 – Signals and OLE commissioning
- Middlemore Station:
  - Enabling Works – Service diversions, carpark rearrangement, and construction access
  - Stage 1 – Retaining walls
  - Stage 2 – Bridge works
  - Stage 3 – Earthworks and drainage
  - Stage 4 – Platform construction
  - Stage 5 – Rail systems installation

[2] Based on Section 1.4 of the W2QP Business Case Design Report (Rev 2) dated 17 September 2019

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

- Stage 6 – OLE and signals commissioning

4.4 Construction Noise

4.4.1 Performance Standards

Most works are within the rail designation. It is assumed this includes all necessary night works. As discussed in Section 3.0, the rail designation contains no controls for noise and vibration.

For residual works outside the rail designation (e.g. utility relocations), the noise and vibration controls in Rule E25.6.27 of the AUP applies. Rule E25.6.27.1 requires that construction activities shall meet the relevant noise limits in Table 1. The noise criteria shall apply at 1 metre from the façade of a building that is occupied during the works. Although the duration of the project exceeds 20 weeks we consider that the typical duration noise limits would be appropriate as the works will move in a linear fashion and no one receiver would be exposed to construction noise for more than 20 weeks.

Table 1: Noise limits at occupied buildings sensitive to noise

Time of week	Time period	Noise criteria	
		dB L_{Aeq}	dB L_{Amax}
Activities Sensitive to Noise			
Weekdays	0630-0730	60	75
	0730-1800	75	90
	1800-2000	70	85
	2000-0630	50	80
Saturdays	0630-0730	50	80
	0730-1800	75	90
	1800-2000	50	80
	2000-0630	50	80
Sundays and public holidays	0630-0730	50	80
	0730-1800	60	90
	1800-2000	50	80
	2000-0630	50	80
All other buildings			
	0730-1800	75	-
	1800-0730	80	-

However, we consider that the Auckland Unitary Plan Rule E25.6.29 "*Construction noise levels for work within the road"* is more appropriate rule for benchmarking effects of necessary works associated with a transport corridor (i.e. both within and outside the rail designation, which is classed as a "strategic transport corridor"). More specifically, E25.6.29 (4) relates to "*road rehabilitation works that comprise the substantial removal and replacement of the road structural base and pavement in the road*". It refers to the noise limits in E25.6.27 reproduced above, but notes these Standards do not apply where:

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

- The number of nights where the noise limits are exceeded at any one receiver is 20 days or less;
- High noise activities, such as concrete cutting and breaking, are completed by 10.30pm;
- The works cannot practicably be undertaken during the day, or the requiring authority requires the works to be undertaken at night;
- A works access permit from the requiring authority is provided to Council; and
- A CNVMP is provided to the Council no less than five days prior to the works commencing in accordance with the applicable provisions of Standard E25.6.29 (5).

The construction methodology notes that some construction activities will be required at night to ensure worker safety and/or to minimise disruption to ongoing rail services, as is normal for major road and rail maintenance activities. High noise activities would be minimised at night where practicable. Residual events would typically occur for a short duration on a small number of occasions near any one receiver. These events would generally exceed the 45 dB L_{Aeq} limit at night.

The Australian/New Zealand Standard AS/NZS 2107:2000 *"Acoustics – Recommended design sound levels and reverberation times for building interiors"* provides recommended design sound levels for dwellings near major roads. This is considered to be equivalent to dwellings adjacent to the rail corridor with freight movements occurring at night. The recommended maximum design limit for sleeping areas is 40 dB L_{Aeq}. Given that a typical lightweight NZ dwelling façade construction provides 20 to 25 decibels noise reduction with the windows closed, this would be equivalent to a maximum external noise level of 60 – 65 dB L_{Aeq}.

We consider that a CNVMP should be prepared in accordance with E25.6.29 (5) as part of the OPW phase. The content of the CNVMP is discussed in Section 4.6. It should identify any predicted or measured exceedance of 60 dB L_{Aeq} at night. This should then trigger engagement with potentially affected parties to understand what additional mitigation or management measures are necessary. A similar approach was undertaken for the Auckland Electrification Project (AEP), City Rail Link (CRL) and recent Puhinui Interchange Upgrade projects.

4.4.2 Predicted noise levels

Table 2 provides representative noise levels for activities based on previous experience on rail projects without mitigation.

Table 2: Noise levels of identified machinery – No mitigation

Equipment	Sound Power Level (dB L_{Aeq})	Noise Level (dB L_{Aeq})			Setback (m)	
		10 m	20 m	50 m	75 dB L_{Aeq}	60 dB L_{Aeq}
Vibratory sheet piling	116	91	85	76	52	209
Rail Tamper/Regulator	116	91	85	76	52	209
Bored/screw piling	103	78	72	63	14	63
Roller (static or vibratory)	103	78	72	63	14	63
Excavator (12T)	103	78	72	63	14	63
Excavator (8T)	102	77	71	62	13	58
Mobile Crane (35T)	98	73	67	58	8	40
Truck idling	91	66	60	51	4	20

We assume that temporary noise barriers will be used where a construction noise limit is predicted to be exceeded (Section 4.4.1) and the barriers would noticeably reduce the construction noise level.

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

They should be installed prior to works commencing in that area and maintained throughout the works.

Effective noise barriers typically reduce the received noise levels in Table 2 by 10 decibels where they block line-of-sight from source to receiver, reducing the setbacks in in Table 2 by approximately 66% (e.g. 30m without screening versus 10m with screening). Most nearby dwellings are single storey, so noise barriers should generally be effective.

Construction noise contours for representative activities and locations are included in Appendix C. Construction noise limits will generally be exceeded at any time (day, night, and weekend) depending on the activity, at many receivers adjacent to the Third Main. This is because the source to receiver distances are typically short (7 to 10m average for the receivers west of the Third Main).

The frequency and magnitude of exceedances will depend on where the high-noise machines are working, whether they are working simultaneously, and whether they are being operated considerately.

4.5 Construction Vibration

4.5.1 Performance Standards

As discussed in Section 3.0, the rail designation contains no vibration controls.

For residual works outside the rail designation, the vibration controls in Rule E25.6.30.1 of the AUP applies. Part (a) of the rule relates to cosmetic building damage, while part (b) relates to amenity effects.

Standard E25.6.30.1 (a) of the AUP states that construction vibration must be controlled to ensure it does not exceed the limits set out in *German Standard DIN 4150-3:1999 "Structural Vibration - Effects of Vibration on Structures"*. The limits are designed to avoid cosmetic damage, such as cracking plaster, and are much lower than those that cause structural damage. The most stringent limits are summarised in Table 3. There are no heritage buildings identified nearby, so Line 3 criteria are disregarded hereafter.

Table 3: DIN – 4150 Cosmetic Building Damage Vibration Thresholds

Line	Type of structure	Guideline values for velocity, v_i, in mm/s of vibration in horizontal plane of highest floor, at all frequencies
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design	10
2	Dwellings and buildings of similar design and/or occupancy	5
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g. listed buildings under preservation order)	2.5

People can be disturbed at vibration levels significantly below the cosmetic building damage thresholds above. The vibration amenity limits from E25.6.30.1(b) are summarised in Table 4. The rule allows for up to three days of intensive daytime works with a vibration limit of 5mm/s provided receivers within 50 m of the works receive prior communications.

We note that the night-time limit of 0.3mm/s is already exceeded by existing train movements at some receivers.

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

Table 4: Occupied Building Amenity Vibration Limits

Receiver	Period	Peak Particle Velocity Limit (mm/s)
Occupied activity sensitive to noise (e.g. dwelling, hospitals, schools)	Night-time 10pm to 7am	0.3
	Daytime 7am to 10pm	2
Other occupied buildings	At all times	2

As per Section 4.4 for noise, we consider that the Auckland Unitary Plan Rule E25.6.29 "*Construction noise levels for work within the road"* is more appropriate rule for benchmarking effects of necessary works associated with a transport corridor (i.e. both within and outside the rail designation). More specifically, E25.6.29 (4A) relates to vibration. It removes the obligations relating to vibration amenity in E25.6.30 (b) where:

- A works access permit from the requiring authority is provided to Council; and
- A CNVMP is provided to the Council no less than five days prior to the works commencing in accordance with the applicable provisions of Standard E25.6.29 (5).

Additionally, and similarly to Section 4.4, we consider that a CNVMP should be prepared E25.6.29 (5) as part of the OPW phase. The CNVMP content is discussed in Section 4.6. It should identify any predicted or measured exceedance of the vibration standards. This should trigger engagement with potentially affected parties to understand what additional mitigation or management measures are necessary.

4.5.2 Predicted Vibration Levels

Table 5 provides representative vibration levels for activities with the potential to generate high vibration levels. It includes predicted setback distances from the source to achieve compliance with the relevant criteria. Where practicable, none of these activities should be undertaken at night to minimise vibration amenity effects.

Table 5: Indicative distances to comply with vibration limits at building foundations

Equipment	Amenity Setback (m)		Cosmetic Building Damage Setback (m) [3]	
	Night 0.3 mm/s PPV	Day 2 mm/s PPV	Residential 5 mm/s PPV	Commercial 10 mm/s PPV
Sheet Piling	>100	43	11	4
Vibratory roller	>100	38	14	6
Rail Tamper	25	12	5	2

Excavators have not been included in Table 5. Whilst they can produce vibration in various ways, e.g. dropping heavy objects, running over ledges, snagging submerged items etc., most of the time they are unlikely to generate significant vibration. Vibration events can be minimised or avoided through considerate use and as part of management protocols.

All *Business* zoned sites are outside of the cosmetic and daytime amenity setback distances. However, there are many Residential zoned sites within both.

Where the cosmetic building damage thresholds are predicted to be exceeded, we recommend:

[3] Based on regression analysis of available vibration measurements, plus a 100% safety factor

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

- KiwiRail makes every practicable effort to consult with those receivers to understand their sensitivities; and
- Carry out a pre-construction building condition survey prior to commencing activities with the potential to exceed the cosmetic building damage thresholds; and
- Monitoring undertaken to verify the predicted levels and compliance (or otherwise)

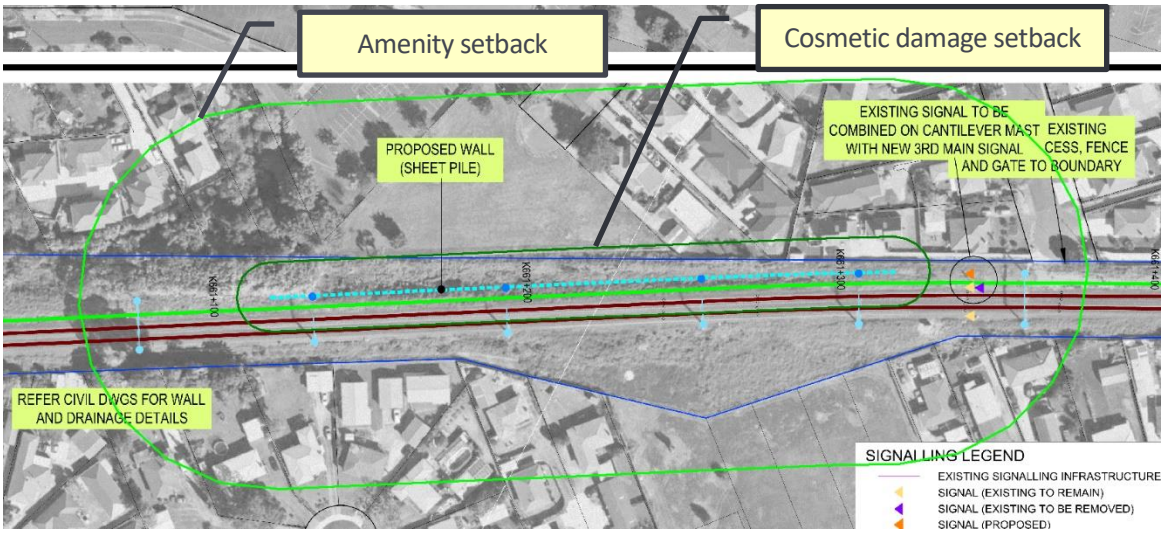
If measurements confirm an exceedance of the cosmetic building damage thresholds, then the works should stop, and a condition survey carried out. If no new damage has been found, then the vibration limit at that receiver can be increased. If attributable damage is identified, then the contractor must commit to repairing the damage. A post-construction building condition survey should also be carried out to ensure all potential damage has been identified.

While the primary vibration concern is typically cosmetic building damage, people may be disturbed at significantly lower levels. Potentially affected parties should be informed about the vibration levels they may experience, and assured that vibration damage can only occur at magnitudes well above the threshold of perception. Particular focus should be to managing night-time effects.

Sheet Piling in Existing Corridor

Bored piling methods produce low vibration levels and are proposed for most retaining works. However, sheet piling is proposed to create a wall between K661 + 100 and K661 + 400 within the designation. As such, management of these will be covered by the OPW. Figure 4 shows the cosmetic damage and daytime amenity setback contours for sheet piling. We predict that there is potential for an exceedance of the cosmetic building damage limit at four dwellings: 1 and 2 Portage Road, and 14B and 16 Gordon Road. Where practicable, we recommend that an alternative method is used (e.g. bored piling) within 11m of these dwellings, noting that these works will be addressed by the future resource consent and OPW (i.e. they are inside the existing rail designation and are not within the scope of the NoR.

Figure 4: Vibration contours for sheet piling



Vibratory Rolling

We predict that there will be no exceedance of the cosmetic building damage limits at any receiver east of the Third Main. However, there is predicted to be an exceedance of the daytime amenity criterion of 2mm/s for the front row of dwellings that face the railway lines.

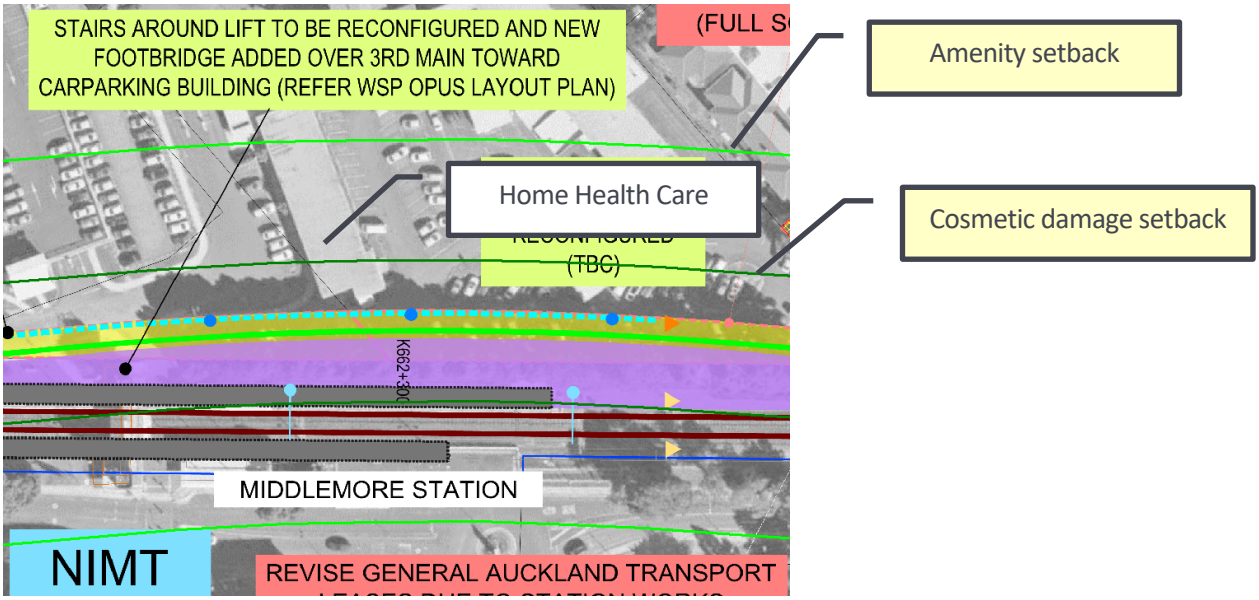
West of the proposed Third Main, we predict that there is potential for exceedance of the cosmetic building damage thresholds within 14m. This captures many of the front row of properties that face the railway along Kenderdine Road, Ashlynn Avenue, Gordan Road, Portage Road, Nogat Avenue,

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

Gray Avenue, and Barrie Avenue. In general, exceedances of the daytime amenity criterion would also be confined to this front row of dwellings, but may extend to the second row in Gordan Road, Portage Road, Nogat Avenue, and Gray Avenue. Effects will need to be managed through the OPW.

The healthcare facility (Home Health Care which is a part of Middlemore Hospital) at 38 Orakau Road is in very close to the Third Main. Works may be as close as 6m from the closest building. At this setback distance, vibration levels are predicted to be very high (>10 mm/s), and alternative construction methods may need to be implemented. Potential mitigation and management measures are discussed in Section 5.6.

Figure 5: Vibration contours for Home Health Care



Rail Tamping

We predict that compliance with the cosmetic building damage limit can be achieved at all buildings except at 12 Orakau Road. This building appears to be just within the 5m setback distance.

The daytime amenity criterion is predicted to be exceeded at a number of dwellings. The catchment is similar to that of vibratory rolling, albeit slightly smaller.

Construction vibration management during rail tamping will be covered by the existing NoR.

4.6 Construction Noise and Vibration Management Plan

There are predicted exceedances of the noise and vibration standards for several nearby receivers. However, these are considered reasonable provided they are of limited duration and BPO measures are implemented through a CNVMP to avoid, remedy and mitigate the effects as far as practicable.

A CNVMP is a recommended as a designation condition (Section **Error! Reference source not found.**). The objectives of the CNVMP are:

- Identify and adopt the Best Practicable Option (BPO) for the management of construction noise and vibration;
- Define the procedures to be followed when construction activities cannot comply with the noise and vibration standards;
- Inform the duration, frequency and timing of works to manage disruption;
- Require engagement with affected receivers and timely management of complaints; and

The CNVMP must include the relevant measures from:

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

- NZS 6803:1999 "Acoustics - Construction Noise" Annex E2 "Noise management plans" and;
- DIN 4150-3:1999 "Structural vibration - Part 3 Effects of vibration on structures" Appendix B "Measures for limiting the effects of vibration".

These include, but are not limited to the following components:

- The performance standards that must, as far as practicable, be complied with to enable a consistent approach for adaptive management protocol
- Predicted noise and vibration levels for relevant equipment and/or activities
- Construction noise and vibration mitigation and management measures
- Noise and vibration monitoring requirements
- Communication, consultation and complaints response procedures

5.0 OPERATIONS NOISE AND VIBRATION ASSESSMENT

5.1 Overview

Two lines currently operate through the Project extent. They carry a mixture of passenger and freight trains. The installation of the third line is needed to increase capacity and provide resilience.

The majority of the Third Main will be contained inside of the Designation except for a section near Middlemore Station, described in Section 2.0. The new line at this location extends west over part of the existing hospital car park (*Special Purpose – Healthcare Facility and Hospital Zone*) and one property to the north used for residential purposes (*Business – Mixed Use Zone*). There will be some land take, the scope of which is to be confirmed. Our assessment is limited to this change, and its effect on the existing environment.

Elsewhere, the Third Main will be west of the existing lines, so rail operations on the new line will be closer to the receivers on that side. Furthermore, the new line will likely enable express and freight trains to bypass the stations, potentially at higher speeds.

5.2 Rail Noise

5.2.1 Auckland Unitary Plan

As discussed in Section 3.0, there are no noise limits specified in the existing designation or applicable to the underlying Strategic Transport Corridor zone.

For new rail activities near Middlemore Station that extend outside the existing rail designation, the relevant noise controls in AUP Rule E25.6 apply. These rules specifically exclude noise from road traffic movements, and a similar exclusion for rail movements would be appropriate if the noise effects of the new designation extension are reasonable. The determination of what is reasonable noise from rail movements is addressed in the following sub sections.

In our opinion, the noise limits should apply to other station activities in the Designation extension, such as the station PA system and mechanical services. However, we consider the *Residential Zone* rules are too stringent for this rail corridor interface.

New Zealand Standard NZS 6802:2008 *"Acoustics - Environmental Noise"* Section 8 (*Guidelines for the protection of health and amenity"*) sets guidance for residential upper noise limits of 55 dB L_{Aeq} during the daytime and 45 dB L_{Aeq} during the night. Based on the existing daytime background noise levels (48 to 51 dB L_{A90} in Table 1 in Section 5.2.8) it is considered that these upper limits would be appropriate for acoustic design of any station modifications within designation extension, including mechanical plant and PA system.

Table 6 overleaf summarises the permitted noise limits for the relevant receiving zones.

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

These rules specifically exclude noise from road traffic movements, and a similar exclusion for rail movements would be appropriate if the noise effects of the new designation extension are reasonable. The determination of what is reasonable noise from rail movements is addressed in the following sub sections.

In our opinion, the noise limits should apply to other station activities in the Designation extension, such as the station PA system and mechanical services. However, we consider the *Residential Zone* rules are too stringent for this rail corridor interface.

New Zealand Standard NZS 6802:2008 *"Acoustics - Environmental Noise"* Section 8 (*Guidelines for the protection of health and amenity"*) sets guidance for residential upper noise limits of 55 dB L_{Aeq} during the daytime and 45 dB L_{Aeq} during the night. Based on the existing daytime background noise levels (48 to 51 dB L_{A90} in Table 1 in Section 5.2.8) it is considered that these upper limits would be appropriate for acoustic design of any station modifications within designation extension, including mechanical plant and PA system.

Table 6: Maximum noise levels permitted in various zones

Zone	Time	Noise Limit (dB L_{Aeq})
Strategic Transport Corridor zone	-	None
Residential Zones (E25.6.2)	Monday to Saturday 0700 – 2200 hrs Sunday 0900 – 1800 hrs	50 dB L_{Aeq}
	All other times	40 dB L_{Aeq} 75 dB L_{AFmax}
Business – Mixed Use Zone (E25.6.8)	0700 – 2300 hrs	65 dB L_{Aeq}
	2300 – 0700 hrs	55 dB L_{Aeq} 65 dB $L_{eq\ (63Hz)}$ 60 dB $L_{eq\ (125Hz)}$ 75 dB L_{AFmax}
Special Purpose – Healthcare Facility and Hospital Zone (E25.6.13)	Monday to Saturday 0700 – 2200 hrs Sunday 0900 – 1800 hrs	55 dB L_{Aeq}
	All other times	45 dB L_{Aeq} 75 dB L_{AFmax}

5.2.2 KiwiRail Reverse Sensitivity Guidelines

KiwiRail has a preferred set of criteria to avoid reverse sensitivity effects from new noise sensitive activities establishing close to existing rail lines. The Guidelines do not have statutory weight unless adopted by a District Plan. They have not been included in the AUP. In summary, these guidelines:

- Are recommended to apply to buildings within 100 meters of a railway corridor
- Are based on a standardised external rail noise level of 70 dB $L_{Aeq(1h)}$ at 12 metres from the closest track
- Require an internal noise level of 40 dB $L_{Aeq(1h)}$ to be achieved inside any noise sensitive activity and inside habitable rooms except bedrooms
- Require an internal noise level of 35 dB $L_{Aeq(1h)}$ to be achieved inside any bedroom

Reverse sensitivity guidelines usually apply to new activities establishing in an existing area. These values indicate what KiwiRail would like new neighbouring noise sensitive activities and dwellings to achieve in order to avoid reverse sensitivity effects. In this instance, we consider it is reasonable that these criteria can be used as a basis to assess the significance of the noise effects of the alteration to the railway designation boundary and closer proximity to dwellings in this location.

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

5.2.3 New Zealand Rail Noise Performance Standards

New Zealand does not have standard rail noise assessment criteria. Most rail designations do not have any noise performance standards at all. There are only a small number of new rail lines in New Zealand where a noise limit has been applied to the project. An example is the Marsden Rail spur, where the following noise limits were applied to the new rail line:

- For existing low noise areas (where the ambient noise level is less than 50 dB $L_{Aeq(24h)}$) an external noise limit of 60 dB L_{dn}
- For existing high noise areas (where the ambient noise level is more than 50 dB $L_{Aeq(24h)}$) an external noise limit of 65 dB L_{dn}
- A night-time maximum noise limit at the façade of 80 dB L_{AFmax} (in order to avoid sleep disturbance)

5.2.4 International Rail Noise Performance Standards

The relevant project criteria depend on the stage of the railway development (i.e. if an existing line is to be redeveloped or if a new line is to be constructed).

International criteria may be applied to existing or altered railway lines (such as in Switzerland) or may be used to determine when mitigation actions need to be implemented to reduce noise levels (such as in Denmark, Switzerland, Norway, and the UK). In most countries, the criteria are protected in regulations or Standards. In the majority of situations, the noise criteria for a new railway line is 5 decibels more stringent than the criteria for an alteration to an existing railway line.

Appendix D has been extracted from the NSW EPA Rail Infrastructure Noise Guideline[4] document which provides a comparison across a wide range of countries. Two examples are expanded further in the following subsections. They set out the situations when mitigation investigations may be required to be carried out due to an alteration of an existing railway line.

British Context

The Calculation of Railway Noise (**CRN**) is the UK procedure for measurement and assessment of railway noise. CRN is similar to the Calculation of Road Traffic Noise, which is the calculation method referenced by NZS6806 (the New Zealand road noise standard). CRN provides reference noise levels at 25m from the nearside edge of the track, plus a set of corrections for rolling stock type, speed, track ballast etc. The KiwiRail guidelines provide a simpler set of assumptions at 12m but is similar in concept.

The Noise Insulation (Railways and Other Guided Transport Systems) Regulations 1996 is UK legislation that requires building sound insulation for dwellings that are affected by noise from new or altered railways (or roads). It is reliant on CRN for calculation of the maximum façade noise levels. For an existing dwelling to qualify, the following conditions must be met:

- Day (6am – midnight): 68 dB L_{Aeq} and increase of 1 dBA
- Night (midnight – 6am): 63 dB L_{Aeq} and increase of 1 dBA

Australian Context

The Victorian State Government 'Passenger Rail Infrastructure Noise Policy' sets policy that "*aims to help transport planners and communities to understand rail noise and balance the benefits of new passenger rail with the impacts on those living nearby*". It applies specifically to new or altered passenger railway operations. The policy does not cover impacts from existing passenger or freight

[4] https://www.epa.nsw.gov.au/resources/noise/20130018eparing.pdf

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

operations. Mitigation investigation thresholds for redevelopment of existing passenger rail infrastructure are as follows:

- Day (6am – 10pm): 65 dB L_{Aeq} and increase of 3 dBA, or 85 dB L_{AFmax} and increase of 3 dBA
- Night (10pm – 6am): 60 dB L_{Aeq} and increase of 3 dBA, or 85 dB L_{AFmax} and increase of 3 dBA

The NSW Environmental Protection Agency 'Rail Infrastructure Noise Guideline' specifies noise and vibration trigger levels for assessing heavy and light rail infrastructure projects to protect the community from the adverse effects of noise and vibration from rail infrastructure projects. The guidelines distinguish between new and redeveloped rail line. Mitigation investigation thresholds for redevelopment of existing heavy rail infrastructure are as follows:

- Day (7am – 10pm): 65 dB L_{Aeq} and increase of 2 dBA, or 85 dB L_{AFmax} and increase of 3 dBA
- Night (10pm – 7am): 60 dB L_{Aeq} and increase of 2 dBA, or 85 dB L_{AFmax} and increase of 3 dBA

5.2.5 Changes in Rail Noise Level

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[5]. Table 7 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 an RMA effect. This effect is based on people's annoyance reaction to noise level changes.

Table 7: Noise level change compared with general subjective perception

Noise level change	General subjective perception[6]	Impact[7]
1–2 decibels	Insignificant/imperceptible change	Negligible
3–4 decibels	Just perceptible change	Slight
5–8 decibels	Appreciable to clearly noticeable change	Moderate
9–11 decibels	Halving/doubling of loudness	Significant
>11 decibels	More than halving/doubling of loudness	Substantial

The perception of these noise level changes generally applies to immediate changes in noise level, and generally relate to road traffic noise rather than rail noise. Rail is not a consistent source as is the case for roads with traffic volumes of more than 2,000 vehicles per day. Therefore, people react differently to the change in noise level. Each rail pass generally results in a similar noise level, but it is the number of rail passes that affects the overall noise level. Between each rail pass, there is generally no noise from the rail line.

We acknowledge that people may subjectively have an annoyance reaction to a greater or lesser degree, depending on their perception of the Project, however these individual and subjective

[5] 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.

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

[7] 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.

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

variances are not used as a basis for assessing and controlling noise effects – instead an objective approach based on population level sensitivities is used.

Noise is measured on a logarithmic scale, meaning that a doubling in train numbers results in a noise level increase of 3 decibels, a just-perceptible change. A tenfold increase in rail numbers would result in a noise level increase of 10 decibels, which would sound twice as loud.

5.2.6 Recommended Noise Assessment Criteria

Based on the discussions in the preceding sub-sections, we recommend the following noise management thresholds be applied to this Project:

- Day (0700 – 2200): 65 dB L_{Aeq} and increase of 3 dBA, or 85 dB L_{AFmax} and increase of 3 dBA
- Night (2200 – 0700): 60 dB L_{Aeq} and increase of 3 dBA, or 85 dB L_{AFmax} and increase of 3 dBA
- Applied at the façade of any dwelling or care facility within 100m of any new railway line outside of the existing designation. This captures any new rail activity outside of the designation and the effect from this.
- Where this criterion cannot be complied with, we recommend mitigation either in the form of a noise barrier (where this is practicable) or improved sound insulation and/or mechanical ventilation to achieve an internal noise level of no more than:
  - 40 dB $L_{Aeq(0700 - 2200)}$ and 35 dB $L_{Aeq(2200 - 0700)}$ or
  - 60 dB L_{AFmax} at all times

This recommendation is based on several elements:

- The 100m effects zone is the setback distance in KiwiRail's reverse sensitivity guideline. This defines the effects zone and enables identification of relevant affected parties.
- The limits are based on the Victorian noise limits. We consider that these are reasonable limits to protect amenity without being prohibitively stringent.
- The increase in noise level trigger aligns with the subjective response in Table 7.
- The daytime/night-time periods are aligned with the Residential Zone weekday noise rules.
- The internal noise limits are based on the KiwiRail Reverse Sensitivity Guidelines, albeit applied over the night-time period rather than the 1-hour period. Additionally, our recommended internal limits are required only if the external noise limit is exceeded as well.
- Consistency with noise limits of other rail projects and the Port operations. The 60/65 dB L_{Aeq} day/night criteria are also comparable to the 65 dB L_{dn} threshold used by the Marsden spur consent and for the Port Inner Noise Control Boundary for port operations (based on the New Zealand Port Noise Standard NZS6809).

5.2.7 Noise Sensitive Receivers

There are a number of noise sensitive receivers within the effects zone (refer Figure 6). These include those listed below:

- 37, 52, 54, 56, 58, 60, 62, 64A, 3/64A, 66, 68, 1/70, 72, 4/72 Rosella Road (dwellings)
- 8, 10, 10A, 12 Orakau Road (dwellings)
- Middlemore Hospital and Home Health Care

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

Figure 6: Yellow area showing rail effects zone (i.e. 100m from rail Designation change shown in green)

5.2.8 Existing Noise Environment

We have based this section on two sets of measurements. One carried out for a recent rail project on 17 January 2019 between 1350 and 1510 hrs. We consider that those measurements can be used for this Project as well. Measurement locations for those are shown in Figure 7 overleaf and Table 1 overleaf shows the results at those locations.

The second set of measurements were carried out on 17 June 2020 between 1130 and 1350 hrs. Measurement positions are shown in Appendix B and results are presented in Table 1. At the same time, we had set up a long-term noise monitor at Middlemore Station at MP5 shown in Figure 6 (picture in Appendix B) to measure the daily variation over a week. MP5 was approximately 9.5m from the closest rail. In summary, we find that the average levels at MP5 were:

- Daytime (0700 – 2200 hrs) 65 dB L_{Aeq} 99 dB L_{AFmax}
- Night-time (2200 – 0700 hrs) 63 dB L_{Aeq} 97 dB L_{AFmax}

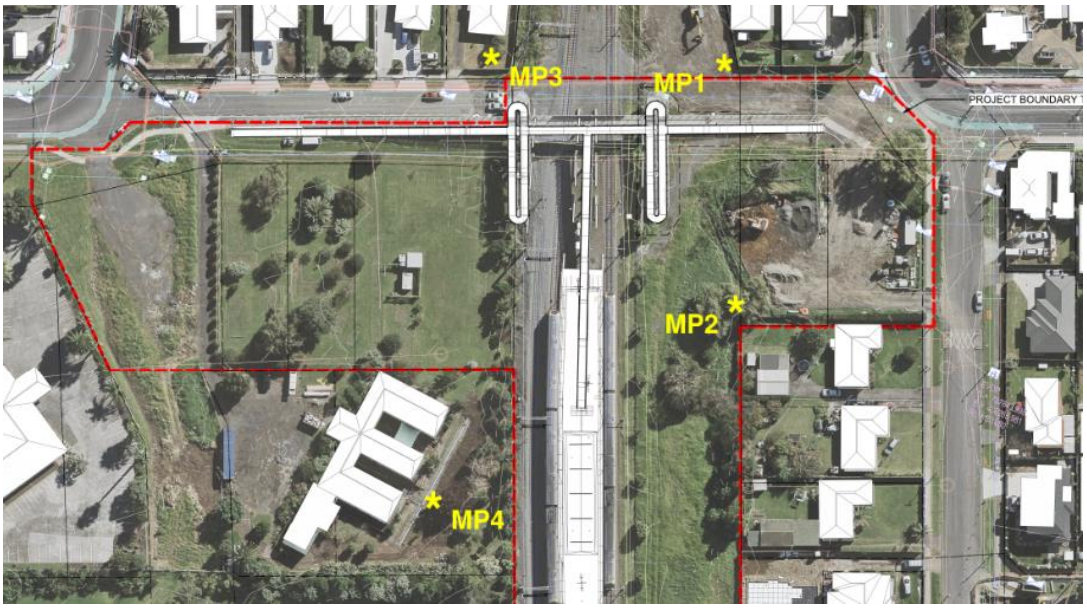
The noise environment at Middlemore Station within 9.5m of the closest existing rail is at or above our recommended thresholds in Section 5.2.6. Therefore, mitigation eligibility will likely depend on the change in noise level due to the new railway line being closer to receivers only.

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

Table 8: Measured Noise Levels

Position	Location	Noise Level (dB)			Comment
		L_{AFmax}	L_{Aeq}	L_{A90}	
Measurement Set 1 - Puhinui Station					
MP1	Outside corner of fence line at 8 Cambridge Terrace	81	68	50	Train movement (including one freight) and planes, distant traffic
MP2	Outside corner of fence line at 5 Clendon Avenue	67	55	51	Train movement and planes, distant traffic
MP3	Outside fence line of 203 Puhinui Road	79	62	51	Train movement and planes, distant traffic
MP4	East façade/playground area of Te Kohanga Reo Childcare Centre	82	65	48	Train movements and planes; conversations, distant traffic
Measurement Set 2					
MP5	Southern end of Middlemore Station but measured on western platform	94	69	52	Train movements (mostly passenger electric coming into or leaving station with one freight movement straight through), distant traffic, occasional announcement
MP6	Gordon Park	86	66	42	Train movements (mostly passenger electric with one freight), distant traffic, distant construction, birds
MP7	Northern end of Papatoetoe Station but measured on Shirley Road	89	65	48	Train movements (mostly passenger electric coming into or leaving station with one freight movement straight through), traffic on Shirley Road

Figure 7: Measurement Locations



This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

5.2.9 Predicted Rail Noise Levels

The propagation of rail 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; and
- Atmospheric conditions, including wind or temperature inversions.

Because of the multiple factors and their interaction, computer noise modelling is a vital tool in predicting rail noise impacts. Modelling enables a comprehensive and overall picture of noise impacts to be produced, taking into consideration all the factors potentially affecting noise propagation.

We used the software SoundPLAN, which is an internationally recognised computer noise modelling programme. In summary, SoundPLAN uses a three-dimensional digital topographical terrain map of the area as its base. In addition, we entered data into the model for existing buildings and structures within the assessment area. We digitised rail noise sources, with rail tracks located on the terrain file.

The SoundPLAN model uses the calculation algorithms of ISO 9613. The calculation algorithms take account of all factors set out above, including relevant atmospheric and ground conditions within appropriate parameters.

We have assumed the following as model inputs:

- Rail speed travelling past Middlemore station of 80 km/h for the existing rail lines and the future scenario with the Third Main. We have not taken into account trains stopping at Middlemore as generally, pass-by events are louder than trains coming to a stop and starting off again
- The Third Main will be 0.5m above the existing terrain
- Night-time:
  - 13 freight movements (based on movement data supplied for monitoring period):
    - For the current scenario, we have assumed that seven travels north, and six travels south
    - For the future scenario, we have assumed that all travel along the Third Main (this is the most conservative assumption, allowing for all trains to travel on the line closest to the receivers)
  - 14 commuter train movements on each of the existing lines for both the current and future scenarios
- Daytime
  - 22 freight movements (based on movement data supplied for monitoring period):
    - For the current scenario, we have assumed that 11 travel north, and 11 travel south
    - For the future scenario, we have assumed that all travel along the Third Main
  - 115 commuter train movements on each of the existing lines for both the current and future scenarios
- Freight train sound power level of 133 dB L_{WA} (based on measurements)
- Commuter train sound power level of 116 dB L_{WA} when travelling at speed (i.e. 80 kph) trains. Slower moving trains are around 105 dB L_{WA} (based on measurements). We have used the trains travelling at speed as a conservative approach.

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

- Note that we have not considered any increase in intensity/capacity due to the Third Main. We are only looking at change in effects from the change in alignment (i.e. the effect from having a railway line outside the existing Designation move closer to buildings at Middlemore Station).

We have assessed noise effects at all buildings noted in Section 5.2.7 above. We have shown predicted noise levels for all buildings for the existing and future scenarios in Table 9 and Table 10 overleaf. The locations of these dwellings are shown in the drawings in Figure 6.

We have produced noise contour plans in Appendix E. Contours are calculated in SoundPLAN by interpolating many individual points. Therefore, noise contour maps should not be used to "read" noise levels for specific locations. Individual noise levels for each building are the receiver noise levels in the tables shown overleaf.

In addition, we show the noise level change when comparing the existing and future rail noise scenarios, in the subjective response bands.

5.2.10 Assessment of Rail Noise Levels

This section of the report describes the assessment of rail noise effects from the Project against the criteria recommended in Section 5.2.6, at the receivers listed in Section 5.2.7.

To calibrate the model, we compared the predicted noise level using our measured sound power levels above and supplied train control graphs for both the night-time (17 June 2200 hrs to 18 June 0700 hrs) and daytime (18 June 0700 hrs to 2200 hrs) to our measurement at MP5 (Middlemore Station). We find that the difference is within 3 decibels. Therefore, we consider that the model is acceptable for predicting train noise.

Current noise levels at the facades are predicted to range from 38 to 63 dB L_{Aeq} during the night-time and 39 to 63 dB L_{Aeq} during the daytime at the assessment receivers. In both cases, 12 Orakau Road is predicted to receive the highest noise levels.

We predict that seven buildings will be eligible for mitigation. Mitigation options may include construction of a noise barrier, mechanical ventilation, and/or building envelope upgrades such as improved window seals or glazing. The option selected for a receiver will depend on the final design of the railway and outcome of engagement with the owners of buildings. As such, we have not recommended a specific option at this stage. With mitigation measures in place as required for selected buildings, we consider the noise effects from rail noise can be controlled to a reasonable level at all other properties.

With respect to the L_{AFmax} criterion, these are often caused by track squeal noises rather than horns, which are used near level crossings. We measured events of up to 94 dB L_{AFmax} during train passings (highest event was caused by freight train south-bound; commuter trains were up to 78 dB L_{AFmax}). Based on this, we predict that there would be a change of up to 12 decibels due to the Third Main outside of the existing Designation. This triggers our recommended threshold for mitigation and applies at receivers already identified in the tables above.

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

Table 9: Predicted noise levels – night-time

PPF Address	Existing	Future	Noise level change (range across the façades)	Mitigation options recommended to be considered (i.e. noise barrier, ventilation, building envelope upgrade)
	dB $L_{Aeq(night)}$	dB $L_{Aeq(night)}$	dB	
37 Rosella Road	48	49	1	None Required
52 Rosella Road	62	67	5	Mitigation required
54 Rosella Road	57	60	3	Mitigation required
56 Rosella Road	55	57	2	None Required
58 Rosella Road	56	59	3	None Required
60 Rosella Road	58	62	4	Mitigation required
62 Rosella Road	54	57	3	None Required
64A Rosella Road	53	56	3	None Required
3/64A Rosella Road	56	60	4	Mitigation required
66 Rosella Road	48	50	2	None Required
68 Rosella Road	42	42	0	None Required
1/70 Rosella Road	38	39	1	None Required
72 Rosella Road	40	43	3	None Required
4/72 Rosella Road	38	41	3	None Required
8 Orakau Road	46	47	1	None Required
10 Orakau Road	47	49	2	None Required
10A Orakau Road	59	63	4	Mitigation required
12 Orakau Road	63	69	6	Mitigation required
Home Health Care	59	68	9	Mitigation required
Middlemore Hospital	57	58	1	None Required

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

Table 10: Predicted noise levels – daytime

PPF Address	Existing	Future	Noise level change (range across the façades)	Mitigation options recommended to be considered (i.e. noise barrier, ventilation, building envelope upgrade)
	dB $L_{Aeq(night)}$	dB $L_{Aeq(night)}$	dB	
37 Rosella Road	48	50	2	None Required
52 Rosella Road	62	68	6	Mitigation required
54 Rosella Road	58	61	3	None Required
56 Rosella Road	55	58	3	None Required
58 Rosella Road	56	60	4	None Required
60 Rosella Road	58	63	6	None Required
62 Rosella Road	54	58	4	None Required
64A Rosella Road	53	56	3	None Required
3/64A Rosella Road	56	60	4	None Required
66 Rosella Road	49	51	2	None Required
68 Rosella Road	42	43	4	None Required
1/70 Rosella Road	39	40	1	None Required
72 Rosella Road	41	44	3	None Required
4/72 Rosella Road	39	41	2	None Required
8 Orakau Road	47	48	1	None Required
10 Orakau Road	48	50	2	None Required
10A Orakau Road	60	64	4	None Required
12 Orakau Road	63	69	6	Mitigation required
Home Health Care	59	68	9	Mitigation required
Middlemore Hospital	58	59	1	None Required

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

5.3 Rail Vibration

5.3.1 Performance Standards

As discussed in Section 3.0, the rail designation contains no vibration controls.

For new rail activities near Middlemore Station that extend outside the existing rail designation, the relevant vibration controls in AUP Rule E25.6 apply. The objectives and policies (Section 3.2 require the vibration effects to be reasonable, but there are no vibration limits for rail vibration.

The determination of what is reasonable vibration from rail movements is addressed in the following sub sections.

5.3.2 KiwiRail Reverse Sensitivity Guidelines

KiwiRail has developed vibration criteria to avoid reverse sensitivity issues. The Guidelines do not have statutory weight unless adopted by a District Plan. They have not been included in the AUP.

KiwiRail Guidelines recommend new buildings or alterations to existing buildings within 60 metres of the boundary of a rail network should achieve Norwegian Standard NS 8176.E:2017 Class C (0.3mm/s $v_{w,95}$). However, the Guidelines do not apply to this Project because the new rail line is being built closer to existing houses.

The NS 8176 Standard is for measurement of vibration, not prediction. It also provides guidance to determine annoyance levels based on the measured vibration levels.

The U.S-based Federal Transit Administration (FTA) Impact Assessment is the best tool for predicting rail vibration. We understand that the train speeds passing Middlemore station would be up to 80 km/h (based on drawing number 601001-DR-NIMT-PUHOTU-TR-PL-100-01). This means that this method can be used to estimate vibration levels. However, it is dependent on several factors such as ground propagation conditions, suspension parameters, and track conditions and treatment.

No one rail assessment method is the right fit for this Project. We recommend applying the KiwiRail guideline value of 0.3 mm/s $v_{w,95}$ as a target value, and assessing risk using conservative calculations based on the existing $v_{w,95}$ data we measured on site (refer Section 5.3.3). As for the rail noise assessment, we have considered an assessment envelope to be 100m from the new railway line outside of the existing Designation (refer Section 5.2.6).

5.3.3 Existing Vibration Environment

In addition to the long-term noise measurements at Middlemore Station, we also carried out long-term vibration measurements at MP5, 9.5m from the closest rail (Section 5.2.8). We assessed the vibration levels from rail for the night-time period from in accordance with NS 8176. We used the measurement period from 2200 hrs on 17 June 2020 until 0700 hrs the following morning as a representative night-time period, which is the period of greatest effect for amenity (i.e. sleep disturbance). Based on these findings, we also derived a value for the daytime period based on the overall count of train movements.

At the Middlemore measurement position (MP5) we find:

- Night-time vibration: 0.6 mm/s $v_{w,95}$ (in accordance with NS 8176)
- Daytime vibration: 0.3 – 0.4 mm/s $v_{w,95}$ (derived value from above results)

The measured levels are categorised in the Class D (upper limit of 0.6mm/s $v_{w,95}$) of NS 8176 . NS 8176 states that Class D provides "*vibration conditions in which the majority of exposed people can be expected to be disturbed*".

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

5.3.4 Rail Vibration Assessment

We have predicted the vibration levels due to the proposed layout based on our measurement results and the FTA vibration prediction tool. We have concentrated night-time period as this is the period of greatest effect. In summary:

- NS 8176 Class C (0.3mm/s $v_{w,95}$) is predicted at 27m from the existing rail lines. This is the recommended design threshold for new buildings (refer Section 5.3.2).
- NS 8176 Class D (0.6mm/s $v_{w,95}$) is predicted at 10m from the existing rail lines.
- This means that receivers within 10m to 27m of the existing rail lines are Class D

Assuming similar propagation for the new lines, receivers within 27m of the new rail line (Class D) are identified in Table 11.

Table 11: Receivers predicted to be exposed to high vibration

Receiver	Distance to new railway line (m)	Predicted vibration level (mm/s $v_{w,95}$)
52 Rosalia Road	7	0.9
54 Rosalia Road	21	0.4
60 Rosalia Road	18	0.4
10A Orakau Road	12	0.6
12 Orakau Road	5	1.1
Home Health Care	5	1.1

To ensure the vibration effects are reasonable, we consider the OPW design should consider vibration mitigation for the receivers in Table 11 to enable compliance with NS 8176.E:2017 Class C. The measures may include track isolation, an alteration to the design of the railway line layout, or creation of a discontinuity between the new railway line and the buildings so that vibration cannot as readily transfer from source to receiver.

6.0 RECOMMENDATIONS

6.1 Construction Noise and Vibration

We understand the following controls will be implemented as part of the Outline Plan for this NoR:

1. Construction noise will be measured and assessed in accordance with the provisions of New Zealand Standard NZS 6803:1999 "Acoustics - Construction Noise" and comply with the following Project Standards at any occupied building unless otherwise provided for in the Construction Noise and Vibration Management Plan (CNVMP) in part 3 below.

Receiving Environment	Day (0700 – 2000 hrs)	Night (2000 – 0700 hrs)
Occupied activities sensitive to noise	75 dB $L_{Aeq\ (30\ min)}$	60 dB $L_{Aeq\ (30\ min)}$ 75 dB L_{AFmax}
All other occupied buildings	75 dB $L_{Aeq\ (30\ min)}$	80 dB $L_{Aeq\ (30\ min)}$

2. Construction vibration shall be measured and assessed in accordance with German Standard DIN 4150-3:1999 "Structural Vibration – Part 3: Effects of Vibration on Structures", and comply with the following limits unless otherwise provided for in the CNVMP in part 3 below:

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

Line	Type of structure	Guideline values for velocity, v_i, in mm/s of vibration in horizontal plane of highest floor, at all frequencies
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design	10
2	Dwellings and buildings of similar design and/or occupancy	5

3. A Construction Noise and Vibration Management Plan (CNVMP) will be prepared. The objectives of the CNVMP are to:
   a) Identify and adopt the Best Practicable Option (BPO) for the management of construction noise and vibration to avoid, mitigate or remedy adverse effects;
   b) Define the procedures to be followed when construction activities cannot meet the noise and vibration standards in parts 1 and 2 above;
   c) Inform the duration, frequency and timing of works to manage disruption; and
   d) Require engagement with affected receivers and timely management of complaints.
4. The CNVMP will include, but not be limited to, the following:
   a) The relevant measures from NZS 6803:1999 "Acoustics - Construction Noise", Annex E2 "Noise management plans";
   b) The relevant measures from DIN 4150-3:1999 "Structural vibration - Part 3 Effects of vibration on structures", Appendix B "Measures for limiting the effects of vibration"; and
   c) The Requiring Authority will offer a pre-construction condition survey for any building where the construction vibration levels are predicted to exceed the cosmetic building damage limits in part 2 above.

6.2 Operational Rail Noise and Vibration

We understand KiwiRail will undertake reasonable efforts to engage with affected parties. This will include existing occupied buildings within 100m of the new railway line outside of the existing designation at Middlemore Station. The eligibility for mitigation will be where noise exceeds the recommended noise assessment criteria in Section 5.2.6 or vibration exceeds NS 8176.E:2017 Class C.

The following properties are predicted to be eligible for mitigation:

Table 12: Receivers predicted to require mitigation for rail noise and vibration

Receiver	Mitigate Noise	Mitigate Vibration
52 Rosella Road	Yes	Yes
54 Rosella Road	Yes	Yes
60 Rosella Road	Yes	Yes
3/64A Rosella Road	Yes	No
10A Orakau Road	Yes	Yes
12 Orakau Road	Yes	Yes
Home Health Care	Yes	Yes

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

7.0 CONCLUSION

Marshall Day Acoustics has carried out a noise and vibration assessment for the construction and operation of the proposed Third Main railway line between Wiri Junction and Middlemore Station.

We have assessed construction noise and vibration effects. In summary:

- Construction noise and vibration within the rail designation are not controlled by designation conditions. Nevertheless, noise and vibration effects from the works must be reasonable. We have recommended criteria that trigger the need for mitigation and management measures to be implemented.
- Works outside of the Designation are controlled by the rules of the Auckland Unitary Plan.
- We have assumed that most of high noise and high vibration works will be carried out during daytime hours. There will be limited works required during the night-time as part of Block of Line works.
- Noise and vibration criteria are predicted to be exceeded at a number of buildings along the alignment to a varying degree. Therefore, mitigation measures will need to be implemented.
- We recommend that a Construction Noise and Vibration Management Plan is prepared prior to the works commencing.

We have assessed the rail noise and vibration effects from the proposed alteration to the railway designation for selected receivers within our recommended effects zone. In summary:

- We have recommended noise assessment criteria for rail noise and vibration enabled by the alteration to the rail designation; and
- We have predicted noise and vibration levels for the rail operations enabled by the proposed alteration and recommended where mitigation should be investigated for some receivers.
- The Project would have a noticeable adverse effect arising from the change in rail noise and vibration levels. However, with recommended mitigation measures such as noise barriers and/or building upgrades, the rail noise and vibration levels would be reasonable.

We have provided recommendations that should be implemented in the Outline Plan of Works for the Notice of Requirement.

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

APPENDIX A GLOSSARY OF TERMINOLOGY

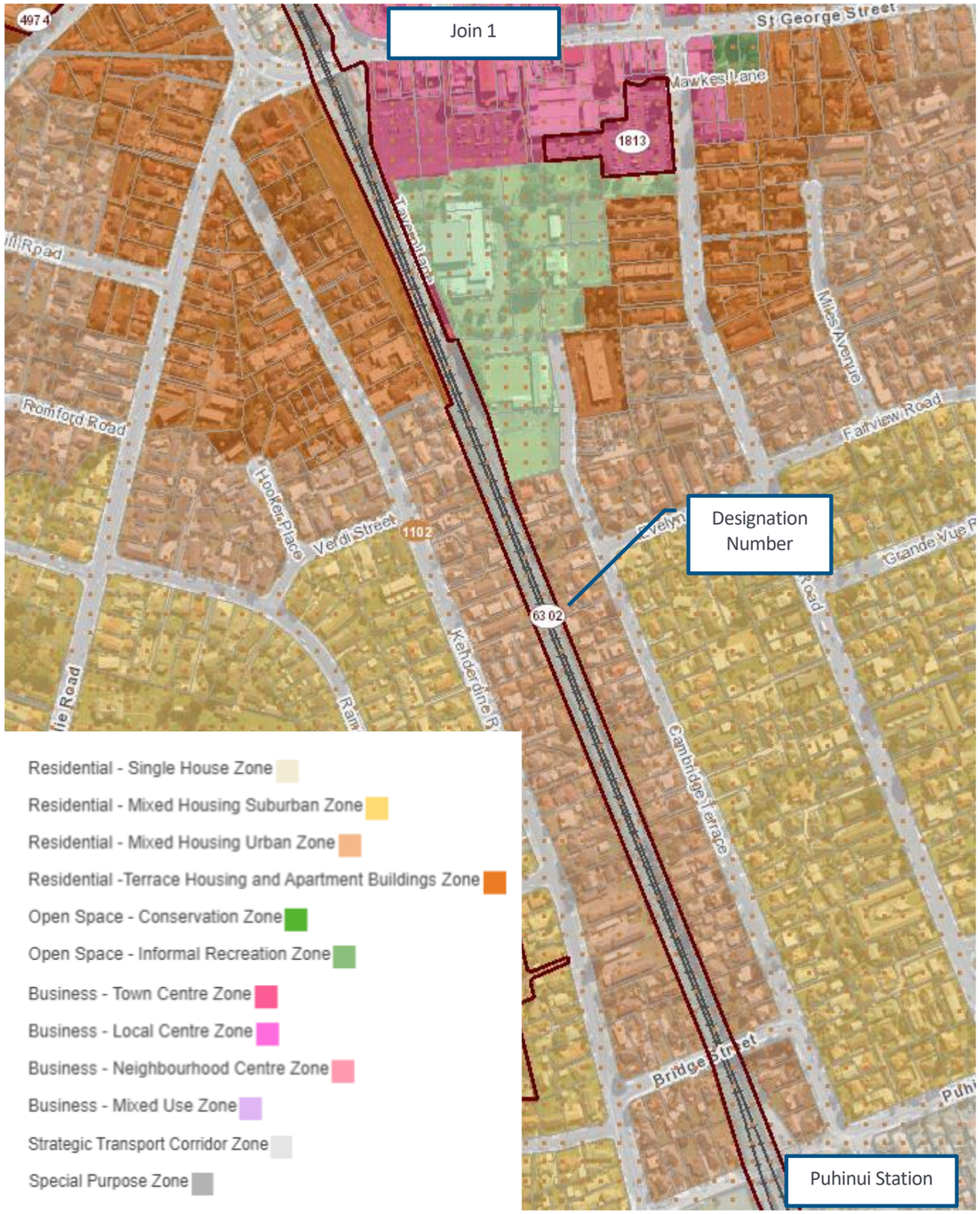
A-weighting	The process by which noise levels are corrected to account for the non-linear frequency response of the human ear.
AUP	The Auckland Unitary Plan – Operative in Part
Block of Line	Works that cannot be carried out while trains are operating and require a longer duration to complete. Blocks of Line are required to be planned at least 12 months in advance of the work being undertaken.
BS 5228-2:2009	British Standard BS 5228-2:2009 "*Code of practice for noise and vibration control on construction and open sites Part 2: Vibration"*
CNVMP	Construction Noise and Vibration Management Plan
dB	Decibel The unit of sound level. Expressed as a logarithmic ratio of sound pressure P relative to a reference pressure of Pr=20 μPa i.e. dB = 20 x log(P/Pr)
DIN 4150-3:1999	German Standard DIN 4150-3:1999 *"Structural Vibration - Effects of Vibration on Structures"*
Hertz (Hz)	Hertz is the unit of frequency. One hertz is one cycle per second. One thousand hertz is a kilohertz (kHz).
Isolation Hours	Work cannot be undertaken while trains are operating but can be undertaken in a short time frame at night. For our assessment, we've assumed that these works will be before 2230 hrs
$L_{Aeq\,(t)}$	The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level. The suffix "t" represents the time period to which the noise level relates, e.g. (8 h) would represent a period of 8 hours, (15 min) would represent a period of 15 minutes and (2200-0700) would represent a measurement time between 10 pm and 7 am.
L_{Amax}	The A-weighted maximum noise level. The highest noise level which occurs during the measurement period.
Noise	A sound that is unwanted by, or distracting to, the receiver.
L_W	Sound Power Level A logarithmic ratio of the acoustic power output of a source relative to 10^{-12} watts and expressed in decibels. Sound power level is calculated from measured sound pressure levels and represents the level of total sound power radiated by a sound source.
NS 8176:2017	Norwegian Standard NS 8176:2017 "*Vibration and shock; Measurement of vibration in buildings from land-based transport, vibration classification and guidance to evaluation of effects on human beings".*
NZS 6803:1999	New Zealand Standard NZS 6803: 1999 *"Acoustics - Construction Noise"*
PPV	Peak Particle Velocity For Peak Particle Velocity (PPV) is the measure of the vibration aptitude, zero to maximum. Used for building structural damage assessment.
Restricted Hours	Works that can be safely carried out while trains are operating but require rail protection and/or Electrical Safety Observers
Vibration	When an object vibrates, it moves rapidly up and down or from side to side. The magnitude of the sensation when feeling a vibrating object is related to the vibration velocity. Vibration can occur in any direction. When vibration velocities are described, it can be either the total vibration velocity, which includes all directions, or it can be separated into the vertical direction (up and down vibration), the horizontal transverse direction (side to side) and the horizontal longitudinal direction (front to back).

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

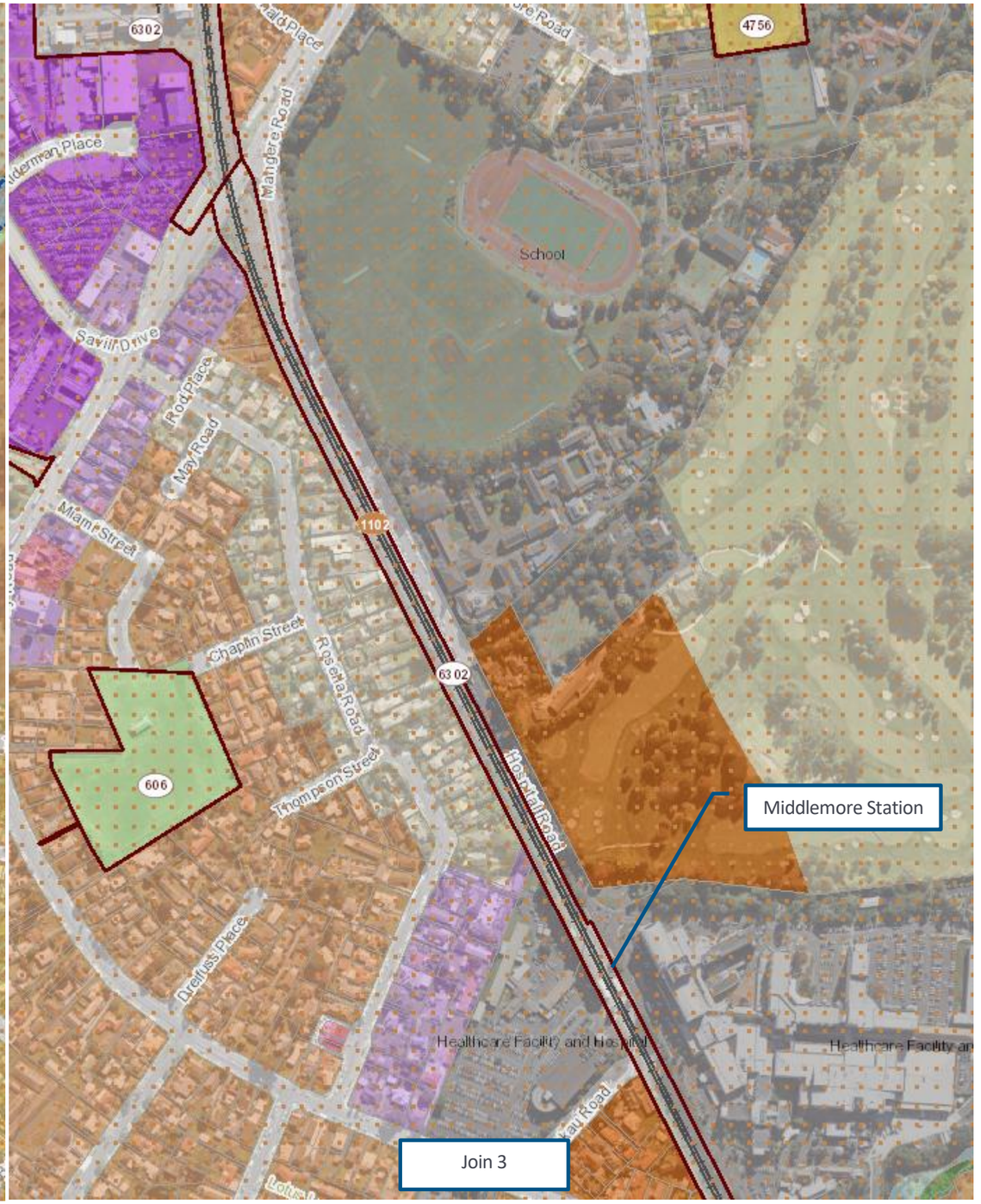
APPENDIX B PROPOSED THIRD LINE

The alignment is shown below, and the wider community and zoning is shown over leaf

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited



This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

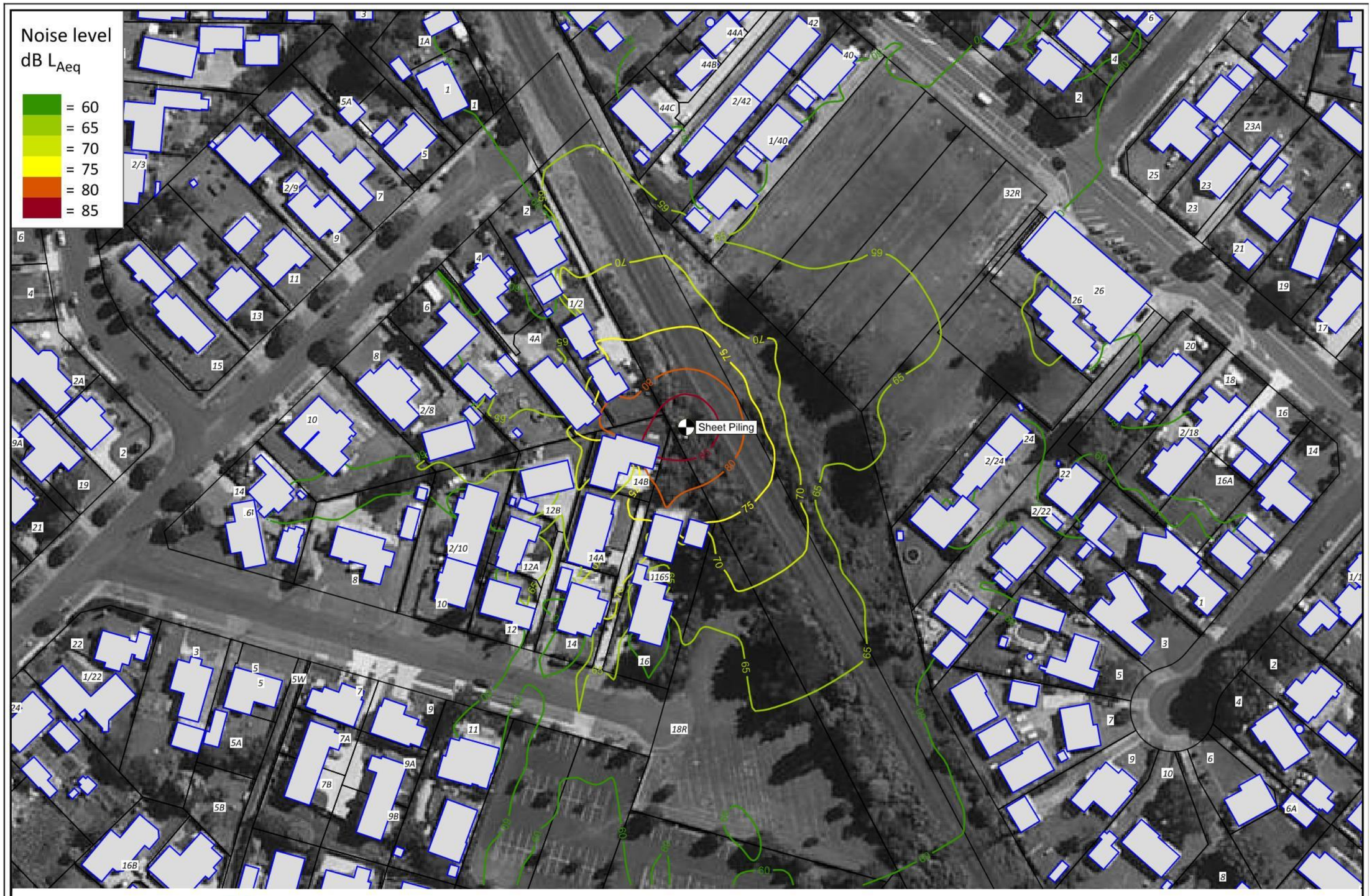


This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

APPENDIX C INDICATIVE NOISE CONTOURS

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited



This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

Predicted noise level - Vibration Tamping (unmitigated)

Date: 18/05/2020
Project No: 20200311
Client: Jacobs New Zealand Ltd
Run No.: 3

0 10 20 40 60 80 m

The noise contours in this Figure were obtained by computer interpolation between caculated grid points. There is an interpolation accuracy of +/- 1.5 dB.

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

APPENDIX D COMPARISON OF RAIL NOISE CRITERIA

Appendix 4 Comparison of airborne noise levels for rail operations in Australia and overseas

Criteria are generally set for new or planned developments but may also be applied to existing operations (as in Switzerland) as well as to guide when action is required to reduce noise levels (see the alarm/priority criteria used in Denmark, the Netherlands, Norway, the United Kingdom, Switzerland and Canada). The criteria for existing operations are typically set at 5 dB above those for new or planned developments. Where alarm/priority criteria are set, these are 5–10 dB above the criteria for existing operations; where criteria have not been set for existing situations, the alarm/priority criteria are 5–10 dB above those set for new or planned developments.

Alarm/priority criteria shown in the table below are typically the legislated noise levels that require ameliorative action by government agencies or proponents, such as noise barriers or building treatments.

The levels used overseas are mostly legislated levels, whereas NSW noise trigger levels are non-mandatory targets that can be used to initiate an assessment of noise impacts and consideration of feasible and reasonable mitigation measures.

Table 7 Comparison of airborne rail noise criteria

Country	Existing rail line or redevelopment of existing line, dB	New rail line, dB	Alarm/ priority, dB	Comments
Australia				
New South Wales	65 $L_{Aeq(day)}$ 60 $L_{Aeq(night)}$ 85 L_{Amax}	60 $L_{Aeq(day)}$ 55 $L_{Aeq(night)}$ 80 L_{Amax}	n/a	Triggers for assessment purposes. Light rail triggers are set at 60/50 dB $L_{Aeq\ (day/night)}$ and 80 dB L_{Amax}
Victoria	65 $L_{Aeq(day)}$ 60 $L_{Aeq(night)}$ 85 L_{Amax}	60 $L_{Aeq(day)}$ 55 $L_{Aeq(night)}$ 80 L_{Amax}		The *Passenger Rail Infrastructure Noise Policy* (April 2013) aims to guide transport bodies and planning authorities in their consideration of rail noise and identifies thresholds above which action should be taken to minimise or mitigate noise.
South Australia	65 $L_{Aeq(day)}$ 60 $L_{Aeq(night)}$ 85 L_{Amax}	60 $L_{Aeq(day)}$ 55 $L_{Aeq(night)}$ 80 L_{Amax}	n/a	The *Guidelines for the assessment of noise from rail infrastructure* (April 2013) provide guidelines for the assessment of noise from rail operations. They give advice for development proposals and local plans, and underpin operating conditions for activities licensed under the *Environment Protection Act 1993*.
Queensland	*Planning levels* (to be progressively achieved) 65 $L_{Aeq(24h)}$ 87 L_{Amax} * *Interim levels* (to be achieved now) 70 $L_{Aeq(24h)}$ 95 L_{Amax}*	Planning Levels 65 $L_{Aeq(24h)}$ 87 L_{Amax} *	n/a	The *Code of practice for railway noise management, 2007* (version 2) was developed by Queensland Rail to demonstrate compliance with general environmental duty under the *Environment Protection Act 1994*. The code has been approved for use by the State Minister for Environment under section 548 of the Act. New noise-sensitive developments proposed alongside rail corridors need to meet criteria set out in the Queensland Development Code (MP 4.4) which includes internal noise limits. *The L_{Amax} is assessed as a single event maximum level and is defined as the arithmetic average of the highest 15 maximum levels over a given 24-hour period.

Rail Infrastructure Noise Guideline 31

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

Country	Existing rail line or redevelopment of existing line, dB	New rail line, dB	Alarm/ priority, dB	Comments
Tasmania	*Planning levels* 65 $L_{Aeq(24h)}$ 87 L_{Amax} *Interim levels* 70 $L_{Aeq(24h)}$ 95 L_{Amax}	65 $L_{Aeq(24h)}$ 87 L_{Amax}	n/a	No formal criteria relating to rail. Freight services only operate in Tasmania and these use current Queensland criteria.
Western Australia	Major upgrades are dealt with on a case basis.	55–60 $L_{Aeq(day)}$ 50–55 $L_{Aeq(night)}$	n/a	Under *WA State Planning Policy 5.4 Sept. 2009*, assessment is triggered at the lower level known as the *noise target*. The upper levels are *noise limits* above which noise-reduction measures need to be implemented. Assessments need to assume one train per hour at night which indirectly reduces maximum noise. New noise-sensitive development near existing rail lines needs to meet criteria for new rail lines.
European countries				
Austria	n/a	65–70 $L_{Aeq(day)}$ 55–60 $L_{Aeq(night)}$	n/a	Includes 5 dB bonus[1]
Denmark	n/a	63 $L_{Aeq(24h)}$ 85 L_{Amax}	68 $L_{Aeq(24h)}$ – insulation trigger	Includes 5 dB bonus. At 68 dB(A) the owner must contribute 50 per cent to cost of insulation, 25 per cent at 73 dB(A) and 10 per cent at < 78 dB(A).
Finland	n/a	58 $L_{Aeq(day)}$ 53 $L_{Aeq(night)}$	n/a	
France	n/a	63 (60) $L_{Aeq(day)}$ 58 (55) $L_{Aeq(night)}$	n/a	Bracketed values are for TGV lines.
Germany	Planning values for new dwellings: 58–63 $L_{Aeq(day)}$ 48–53 $L_{Aeq(night)}$	67 $L_{Aeq(day)}$ 57 $L_{Aeq(night)}$	n/a	Includes 5 dB bonus.
The Netherlands	n/a	63 $L_{Aeq(day)}$ 58 $L_{Aeq(evening)}$ 53 $L_{Aeq(night)}$	68 L_{Aeq} (at this level the state is responsible for correcting noise problem) 73 L_{Aeq} absolute maximum level allowed and only provided an indoor level of 40 L_{Aeq} can be met.	Includes 5 dB bonus.

[1] Criteria for rail are generally 5 dB higher than those for road as rail is considered less annoying.

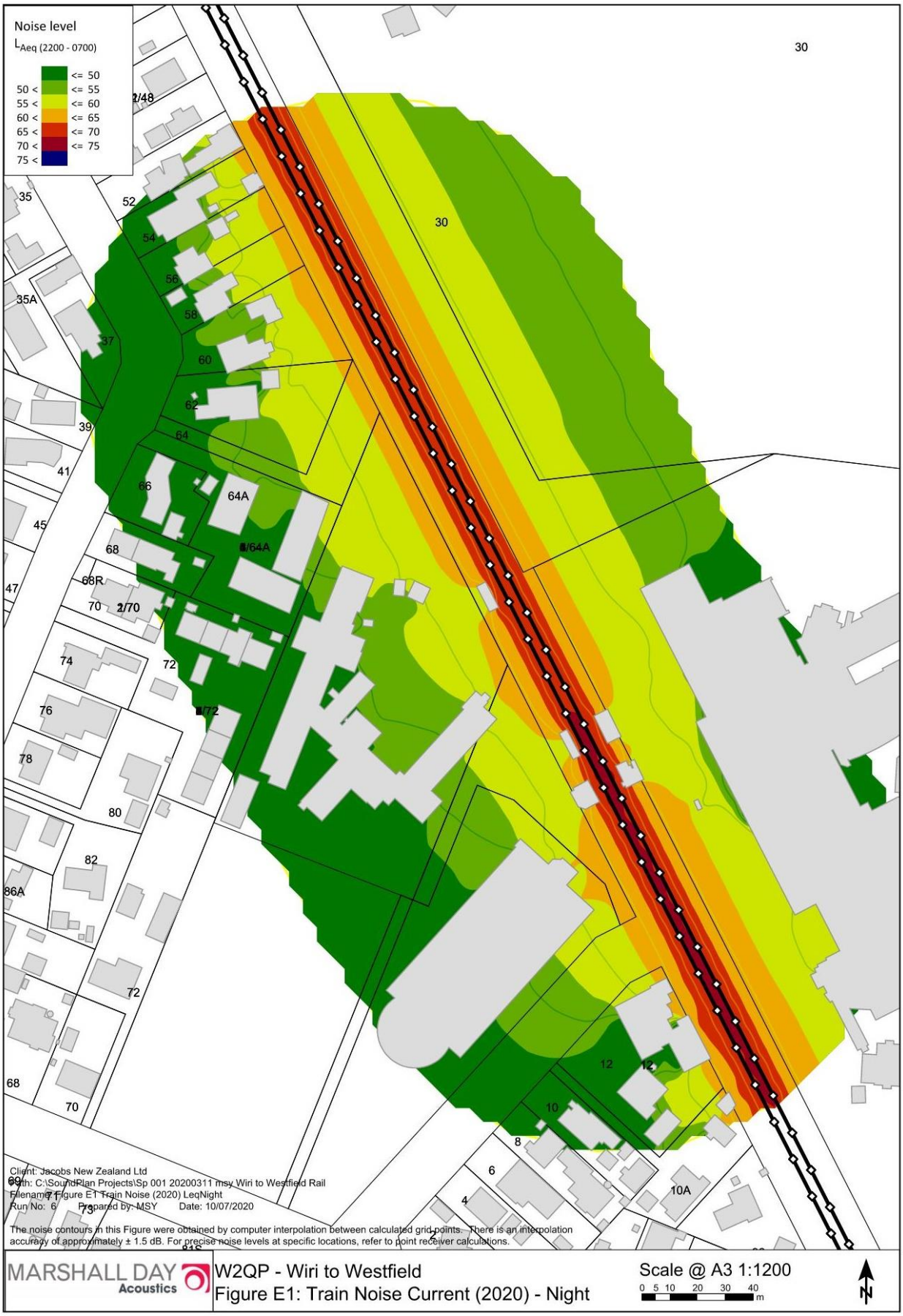
This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

Country	Existing rail line or redevelopment of existing line, dB	New rail line, dB	Alarm/ priority, dB	Comments
Norway	n/a	55–60 $L_{Aeq(24h)}$ 80 L_{Amax} 45–55 L_{Amax} (indoors)	Pay out at $L_{Aeq(24h)}$ > 65 or L_{Amax} > 90 Otherwise if resident does not agree, then insulate to $L_{Aeq(24h)}$ < 35 and L_{Amax} < 55	
Sweden	n/a	58 $L_{Aeq(24h)}$ 45 L_{Amax} (indoors)	n/a	
Switzerland	60-65 $L_{Aeq(day)}$ 50-55 $L_{Aeq(night)}$ 'Impact threshold' Levels below this considered to have no impacts.	55-60 $L_{Aeq(day)}$ 45-50 $L_{Aeq(night)}$ 'Planning value' Levels for design of new developments	70 $L_{Aeq(day)}$ 65 $L_{Aeq(night)}$ 'Alarm values' levels at which assessment of remediation is required.	Levels presented are for residential classifications of which there are two – more sensitive zones are 5 dB lower than the less sensitive zones. For commercial and industrial add 5 and 10 dB, respectively. Railway bonus 5 to 15 dB depending on number of trains: the higher the number the lower the bonus. The levels quoted allow a 5 dB bonus.
United Kingdom	n/a	n/a	68 $L_{Aeq(day)}$ 63 $L_{Aeq(night)}$	Criteria used to determine insulation requirements.
North America				
Canada	n/a	35 $L_{Aeq(night)}$ (bedroom) 40 $L_{Aeq(day)}$ (living areas) 55 $L_{Aeq(day)}$ (outdoor)	n/a	
United States	n/a	52–65 $L_{Aeq\ (1h)}$ (serenity) 52–65 L_{Adn} (residences) 57–70 $L_{Aeq\ (1h)}$ (schools etc.) (5 dB onset adjustment for high-speed maglev [magnetic levitation] operations)	n/a	Depends on existing noise levels. Criteria stated vary, as corresponding existing noise levels vary from 43–63 dB(A). Criteria represent onset of impact and also are cumulative levels (i.e. existing plus new).
Asia				
Hong Kong	n/a	60 $L_{Aeq(30\ min)}$ (day and evening) 50 $L_{Aeq(30\ min)}$ (night) 85 L_{Amax} (night)	n/a	Values given for residential areas not affected by other noise sources. For increasingly affected areas add 5 and 10 dB to the L_{Aeq} criteria.
Japan	n/a	70 L_{Apeak} (residential) 75 L_{Apeak} (commercial, industrial with residences)	n/a	For the Shinkansen Superexpress railway. Measured as the energy mean of the highest 10 out of 20 successive train measurements between 6 am and midnight (with meter set to slow response).

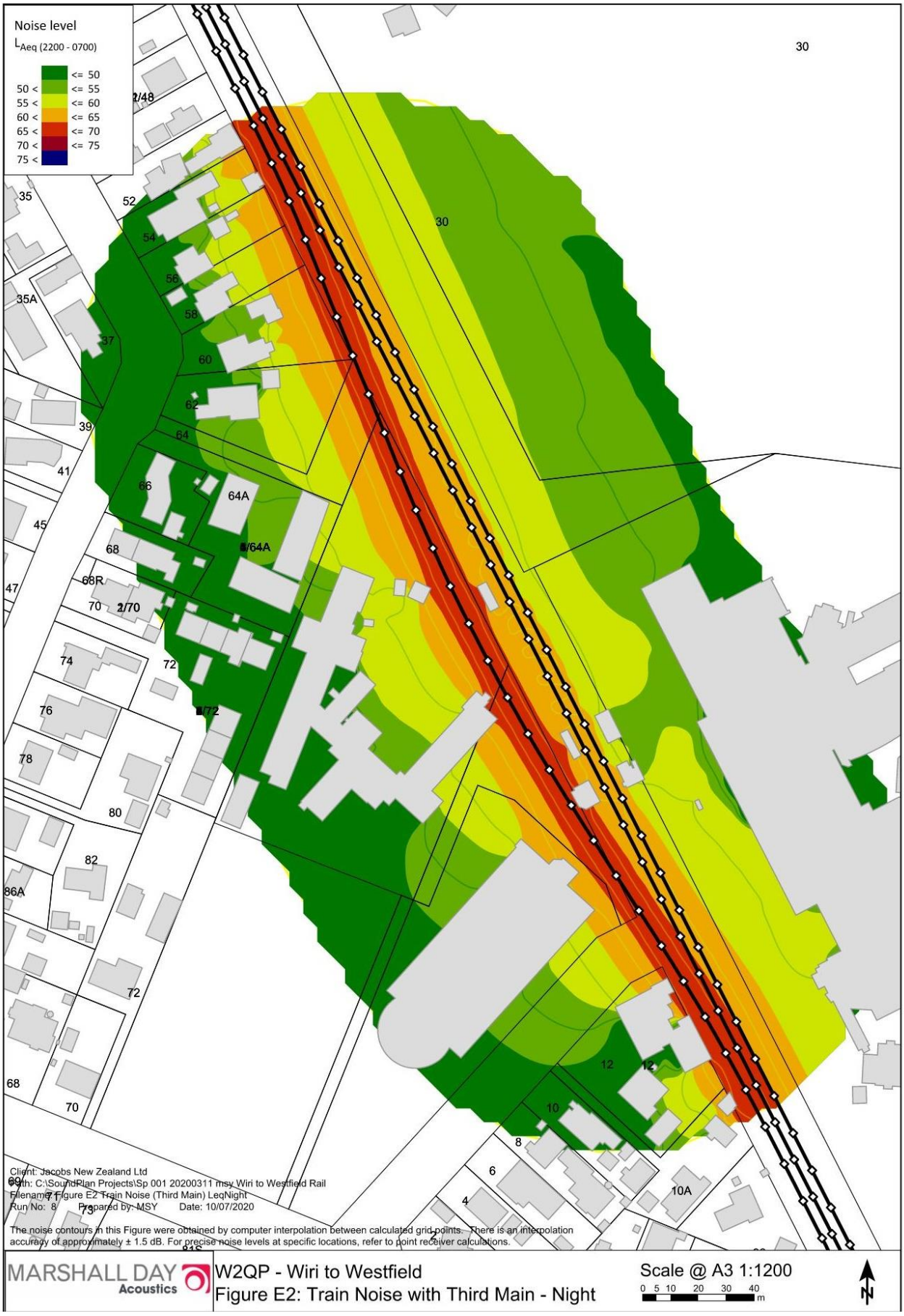
[1] Criteria for rail are generally 5 dB higher than those for road as rail is considered less annoying.

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

APPENDIX E PREDICTED NOISE LEVELS

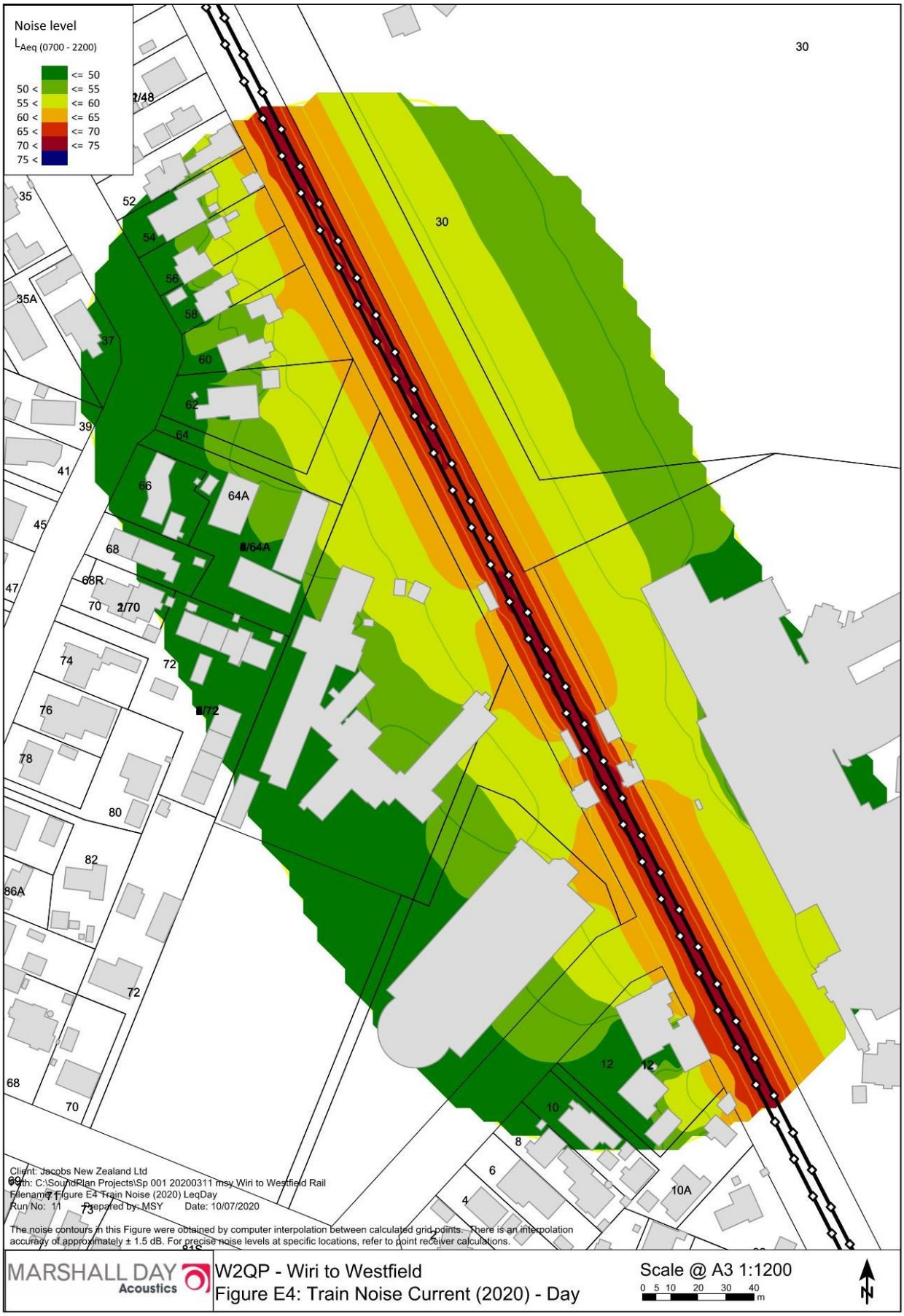


This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

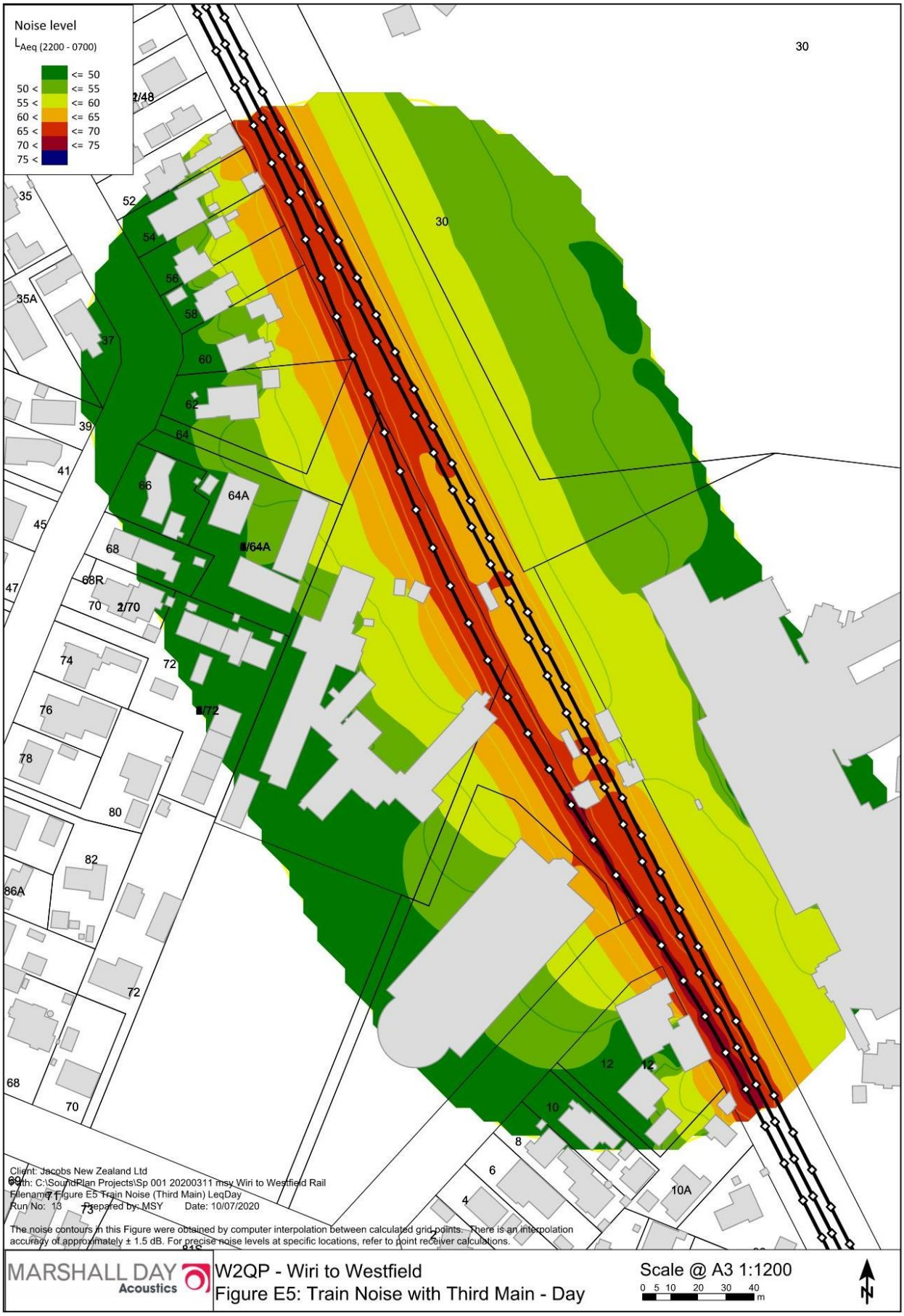


This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited



This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited



This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited

This document may not be reproduced in full or in part without the written consent of Marshall Day Acoustics Limited