BEFORE THE **Waikato District Council**

IN THE MATTER OF	**The Resource Management Act 1991**
AND	
IN THE MATTER OF	**Private Plan Change 20 for a residential zoning in Te Kauwhata**

STATEMENT OF EVIDENCE OF JAMES ANDREW TRAVIS WHITLOCK NOISE AND VIBRATION

Dated 27 February 2018

1.0 QUALIFICATIONS AND EXPERIENCE

1.1 My full name is James Andrew Travis Whitlock.

1.2 I am an Associate at Marshall Day Acoustics (***MDA***) with 17 years' experience in acoustics.

1.3 I have a Bachelor of Science in Physics, and a Master of Architectural Studies in Acoustics, both from the University of Auckland.

1.4 I am the Secretary and past-President of the Acoustical Society of New Zealand, a Council Member of the National Foundation of the Deaf. I am also a member of the Australian/New Zealand Standards Joint Technical Committee AV-004 (Acoustics – Architectural) and the ISO Standards Technical Committee 43 – Acoustics Industry Reference Group for New Zealand.

1.5 I have experience in undertaking noise and vibration assessments, predicting noise and vibration levels from rail activities, and developing vibration performance controls in New Zealand. I assisted the NZ Transport Agency in developing the vibration criteria in its State Highway Construction and Maintenance Noise and Vibration Guide 2013. I have also undertaken large-scale vibration assessments and provided expert evidence on numerous significant infrastructure projects including Auckland's City Rail Link.

1.6 I was engaged by Lakeside Developments 2017 Limited (***LDL***) to respond specifically to the submission on Proposed Private Plan Change 20 (the ***plan change***) made by KiwiRail Holdings Limited (***KiwiRail***).

2.0 CODE OF CONDUCT

2.1 I have read the Environment Court's Practice Note for Expert Witnesses (2014), and I agree to comply with it as if this hearing was before the Environment Court. My qualifications as an expert are set out above. I confirm that the issues addressed in this brief of evidence are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed

3.0 SCOPE OF EVIDENCE

3.1 My evidence will summarise the concerns raised in KiwiRail's submission, describe the noise and vibration measurements my company undertook, summarise the findings, my assessment of potential effects and the advice I gave to LDL.

3.2 This evidence highlights key points from the MDA report 'Rp 001 r01 20171278', the first draft of which was prepared by my colleague Mr. Nicolas Courrier and reviewed by me on 22 December 2017. Subsequently, I made some minor amendments and approved the report on 21 January 2018. In giving this evidence, I refer to and confirm that report.

3.3 Other documents I referenced in relation to my assessment include:

3.3.1 A letter dated 10 November 2017 from Mrs. Pam Butler of KiwiRail to Mr. Vishal Ramduny (Planning and Strategy Manager at Waikato District Council) outlining the KiwiRail submission which seeks modifications to clause 21E.2.18.1 of the plan change.

3.3.2 A letter dated 9 February 2018 from Mrs. Pam Butler of KiwiRail with updated reverse sensitivity modification to clause 21E.2.18.1 of the plan change

3.3.3 Plans SCH008 and SCH009 from a potential Master Plan of the proposed Lakeside development prepared by Candor[3], dated 11 October 2017.

4.0 ASSESSMENT REPORT

4.1 The KiwiRail submission proposed noise and vibration standards to control potential reverse sensitivity effects. The proposed controls, as set out in the letter referenced in Section 3.3.1 above, are summarised in Appendix A of my evidence.

4.2 I consider that the proposed standards are generally consistent with other noise and vibration limits adopted in New Zealand.

4.3 I considered that the most pragmatic way of determining potential conflict between LDL's development proposal and KiwiRail's proposed standards was to carry out noise and vibration measurements to assess compliance with the proposed standards.

4.4 Together with the client, we agreed on three assessment positions along the western edge of the proposed new zone (which abuts the rail corridor). The positions were selected to represent the façades of dwellings which would be closest to the rail line and were at distances of between 27 and 35 metres from the track.

4.5 I attended a visit to the site with Mr. Courrier on 5 December 2017 to assess and confirm the three positions. Thereafter, Mr. Courrier undertook noise and vibration measurements at the three positions between 12 – 19 December 2017. The key objective was to capture the vibration from fifteen train passes at each location, as required by the Norwegian Standard NS 8176.E:2005. He also measured the noise levels from all train passes.

Noise Assessment

4.6 The measurements indicated that noise from train passes ranged between 58 and 67 dB $L_{Aeq,\ 1\ hour}$. This means that, in order to achieve the most stringent 35 dB $L_{Aeq,\ 1\ hour}$ control proposed by KiwiRail for residential bedrooms, the façade of the dwellings closest to the track would have to achieve a noise reduction performance of 32 decibels.

4.7 This façade performance is readily achievable for modern buildings of 'typical construction', provided ventilating windows remain shut. We calculated that train noise would attenuate with distance so that dwellings further than approximately 100 metres from the track would comply with windows open.

4.8 Therefore, I recommended that all dwellings within 100 metres of the track be fitted with mechanical ventilation systems that should be designed to comply with the KiwiRail controls set out in proposed Rule 21A.2.18.1.3(c). Furthermore, to check that the proposed dwellings are of 'typical construction', façade details should be reviewed by a suitably qualified acoustic expert.

Vibration Assessment

4.9 The vibration measurements indicated that compliance with the proposed KiwiRail vibration standards can be achieved, provided dwellings are further than 40 metres from of the track.

4.10 If dwellings are proposed within 40 metres of the track, specialist foundation design can typically enable compliance with the performance standard.

4.11 Therefore, I recommended that the foundation details of any dwellings within 40 metres of the track be reviewed by a suitably qualified acoustics specialist to confirm compliance with the KiwiRail vibration standard.

5.0 CONCLUSIONS

5.1 I consider that the noise and vibration controls proposed by KiwiRail are reasonable and, through measurement and calculation, have determined that the proposed Lakeside development can comply provided:

5.1.1 dwellings within 100 metres of the track are designed and constructed to a specified standard to achieve an acceptable indoor noise level with a ventilation system installed; and

5.1.2 any dwelling within 40 metres of the nearest track be designed and consented to achieve a specified vibration standard.

APPENDIX A – KIWIRAIL PROPOSED NOISE AND VIBRATION CONTROLS

21E.2.18.1(c)

(b) within 100m of the centre line of the nearest rail track within the NIMT and is designed and constructed to ensure the following internal noise limits shall not be exceeded with all external doors and windows closed.

Receiving Environment	***LAeq, 1 hour***
Residential – Bedrooms	*35 dB*
Residential – Other Habitable Spaces	*40 dB*
Teaching Spaces	*40 dB*
All other sensitive activity building spaces, e.g.: • *Hospital and Dementia Care Spaces* • *Commercial Spaces*	*To comply with satisfactory sound levels AS/NZS 2107:2000 (nearest specified equivalent)*

For the purpose of this rule, the noise levels generated by rail operations on the NIMT shall be as determined by a qualified acoustic specialist, using methods consistent with New Zealand standards, within five years prior to the date of the design certificate referred to at the end of this clause (b).

This rule only applies to habitable rooms, teaching spaces and sensitive activity building spaces identified in the table above where those habitable rooms or spaces fall within or partly within the specified 100m distance.

Where it is necessary to have windows closed to achieve the internal acoustic noise limits, an alternative ventilation system shall be provided. The ventilation system installed shall comply with the following:

i. *Consist of an air conditioning unit(s) provided that the noise level generated by the unit(s) must not exceed 40dB LAeq(30s) in the largest habitable room (excluding bedrooms) and 35dB LAeq(30s) in all other habitable rooms, when measured 1 metre away from any grille or diffuser; or*

ii. *ii) A system capable of providing at least 15 air changes per hour (ACH) in the largest habitable room (excluding bedrooms) and at least 5 air changes per hour (ACH) in all other habitable rooms; and*

iii. *iii) The noise level generated by the system must not exceed 40dB LAeq(30s) in the largest habitable room (excluding bedrooms) and 35dB LAeq(30s) in all other habitable rooms, when measured 1 metre away from any grille or diffuser; and*

iv. *iv) The internal air pressure must be no more than 10 Pa above ambient air pressure due to the mechanical ventilation; and*

v. *v) Where a high air flow rate setting is provided, the system shall be controllable by the occupants to be able to alter the ventilation rate with at least three equal progressive stages up to the high setting.*

Compliance with this rule shall be demonstrated by providing the Council with a design report and a design certificate prepared by an experienced and qualified acoustic specialist, at the time of building consent application.

c) located within 40m of the centreline of the nearest rail track within the NIMT and is designed and constructed to ensure the following levels of vibration from trains shall not be exceeded based on the procedures specified in the Norwegian Standard NS 8176E: 2nd edition September 2005 Vibration and Shock Measurement of Vibration in Buildings from Land Based Transport and Guidance to Evaluation of its Effects on Human Beings.

Receiving Environment	***Maximum weighted velocity, V^w95***
Sensitive activities/ buildings	*0.3mm/s*

(d) located within 20m of the centre line of the nearest rail track within the NIMT and is designed and constructed to ensure the level of vibration from trains shall not exceed the criteria set out in the British Standard BS 7385-2:1993.

Compliance with clause (c) and (d) shall be demonstrated by providing the Council with a design report and a design certificate prepared by an experienced and qualified vibration specialist, at the time of building consent application. Vibration generated by rail operations on the NIMT shall be as determined by a qualified vibration specialist, using methods consistent with New Zealand standards, within five years prior to the date of the design certificate.

21E2.18.2 by adding the following provision:

Noise sensitive activities within 100m of a Rail Track:

a) The degree of noise attenuation achieved at the noise sensitive activity.

b) The effects of reverse sensitivity on the operation of the rail network, and the ability and suitability of mitigation measures to enable the continued and uninterrupted operation of the rail network.

c) A reverse sensitivity covenant.

Vibration sensitive activities within 40m of a Rail Track:

a) The size, nature and location of the building on the site.

b) Special topographical, building features or ground conditions which will mitigate vibration impacts.

c) Any characteristics of the proposed use which make compliance with the standard unnecessary.

d) A reverse sensitivity covenant.

APPENDIX B – LAKESIDE DEVELOPMENTS RAIL MOVEMENTS ASSESSMENT OF ACOUSTIC EFFECTS PREPARED BY MARSHALL DAY ACOUSTICS

MARSHALL DAY Acoustics

LAKESIDE DEVELOPMENT
RAIL MOVEMENTS
ASSESSMENT OF ACOUSTIC EFFECTS

Rp 001 20171278 | 23 January 2018

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Project: **LAKESIDE DEVELOPMENT**

RAIL MOVEMENTS – ASSESSMENT OF ACOUSTIC EFFECTS

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Report No.: **Rp 001 20171278**

Document Control

Status:	Rev:	Comments	Date:	Author:	Reviewer:
Draft			22/12/2017	N.Courrier	J. Whitlock
Approved		Client feedback	23/1/2018	J. Whitlock	

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1.0 INTRODUCTION

Marshall Day Acoustics (MDA) has been engaged by Lakeside Developments 2017 Ltd to carry out a noise and vibration assessment of rail movements on the main trunk line situated immediately to the west of the Lakeside Development Project. The Lakeside Development involves the construction of new residential buildings including aged care residences along the western boundary.

It is understood that Kiwirail have submitted on the plan change proposal (refer letter to Waikato District Council dated 10 November 2017 – the *Kiwirail Letter*), outlining their standard reverse sensitivity guidelines. Measurements have assessed train passes against those guidelines and provided context to potential noise and vibration effects for dwellings in the development.

This report is based on plans from Candor3, dated 11 October 2017.

Appendix A contains a glossary of acoustic terminology.

2.0 PERFORMANCE STANDARDS

2.1 Noise Standards

Noise standards and policies are set out in the Kiwirail Letter in relation "*Proposed Private Change 20 to the Waikato District Plan Lake Developments (Te Kauwhata)*". Submission Number 6 sets out the proposed noise and vibration criteria, including the changes to clause 21E.2.18.1 requested by Kiwirail.

2.1.1 Operational Noise Limits

The development shall comply with the rule 21.E.2.18.1(c) as follows:

"21.E.2.18.1 (c)

Within 100m of a Rail Network and designed, constructed and maintained to ensure the following internal design noise limits shall not be exceeded, and shall take into account future use of the rail corridor by the addition of 3dB to existing measured or calculated sound levels.

Table 1: Internal noise criteria

Receiving Environment	***Noise Criteria [dB $L_{Aeq,1\ hour}$]***
Residential – Bedrooms	*35*
Residential – Habitable spaces / Teaching spaces	*40*
All other sensitive activity building spaces, e.g.: - *Hospital and Dementia Care Spaces* - *Commercial Spaces*	*To comply with satisfactory sound levels AS/NZS 2107:2000 (nearest specified equivalent)"*

2.1.2 Ventilation

The development shall comply with the rule 21.E.2.18.1(c)(i – v) as follows:

"21.E.2.18.1 (c)

Where it is necessary to have windows closed to achieve the acoustic design requirements, an alternative ventilation system shall be provided. The ventilation system installed shall comply with the following:

i) Consist of an air conditioning unit(s) provided that the noise level generated by the unit(s) must not exceed 40dB $L_{Aeq(30s)}$ in the largest habitable room (excluding bedrooms) and 35dB $L_{Aeq(30s)}$ in all other habitable rooms, when measured 1 metre away from any grille or diffuser; or

ii) A system capable of providing at least 15 air changes per hour (ACH) in the largest habitable room (excluding bedrooms) and at least 5 air changes per hour (ACH) in all other habitable rooms; and

iii) The noise level generated by the system must not exceed 40 dB $L_{Aeq(30s)}$ in the largest habitable room (excluding bedrooms) and 35 dB $L_{Aeq(30s)}$ in all other habitable rooms, when measured 1 metre away from any grille or diffuser; and

iv) The internal air pressure must be no more than 10 Pa above ambient air pressure due to the mechanical ventilation; and

v) Where a high air flow rate setting is provided, the system shall be controllable by the occupants to be able to alter the ventilation rate with at least three equal progressive stages up to the high setting.

Compliance for noise shall be demonstrated by providing the Council with a design report and a design certificate prepared by an experienced and qualified acoustic specialist, and an experienced and qualified mechanical engineer with respect to the ventilation system, at the time of building consent application."

Note that only rules (i) and (iii) above relate to noise. Rules (ii), (iv) and (v) must be addressed by a ventilation engineer.

2.2 Vibration Standards

2.2.1 Vibration Limits - Building Amenity (annoyance)

The development shall comply with the rule 21.E.2.18.1(d) as follows:

"21.E.2.18.1(d) – Building Amenity

Where within 60m of the rail corridor boundary if designed and constructed to ensure the following levels of vibration from trains shall not be exceeded based on the procedures specified in the Norwegian Standard NS 8176.E.2005.

Table 2: Vibration – Building Amenity

Receiving Environment	***Vibration Criteria (Maximum Value for Weighted Velocity, $v_{w,95}$) (1) [mm/s]***	***Vibration Criteria (Statistical Maximum Value for Weighted Acceleration, $a_{w,95}$) (1) [mm/s²]***
Sensitive activities/ buildings	*0.3*	*11"*

(1) Our assessment is based on Statistical Maximum Value for Weighted Acceleration ($a_{w,95}$) which is provided for in the Standard.

NS 8176 Class C design standard is $v_{w,95}$ 0.3 mm/s (or $a_{w,95}$ 11 mm/s). This corresponds to the "*recommended limit value for vibration in new residential buildings and in connection with the planning and building of new transport infrastructures*". It notes that "*About 15% of the affected persons in Class C dwellings can be expected to be disturbed by vibration*". MDA consider this to be a suitable vibration amenity design standard.

2.2.2 Vibration Limits - Building Damage

The development shall comply with the rule 21.E.2.18.1(e) as follows:

"21.E.2.18.1(e) – Building Damage

Within 20m of the rail corridor boundary shall be designed and constructed to ensure the level of vibration from trains shall not exceed the criteria set out in the British Standard BS 7385-2:1993.

Table 3: Vibration – Building Damage

Receiving Environment	***PPV component in frequency range of predominant pulse [mm/s] (1) (2)***	
	4 Hz to 15 Hz	***15 Hz and above***
Residential or light commercial type buildings (2)	*15 @ 4 Hz, increasing to 20 @ 15 Hz*	*20 @ 15 Hz, increasing to 50 @ 40 Hz and above"*

(1) Values referred to are at the base of the building. Where this is not feasible, measurement should be obtained on the ground, outside of the building.
(2) At frequencies below 4 Hz, a maximum displacement of 0.6mm (zero to peak) should not be exceeded

3.0 EXISTING ACOUSTIC ENVIRONMENT

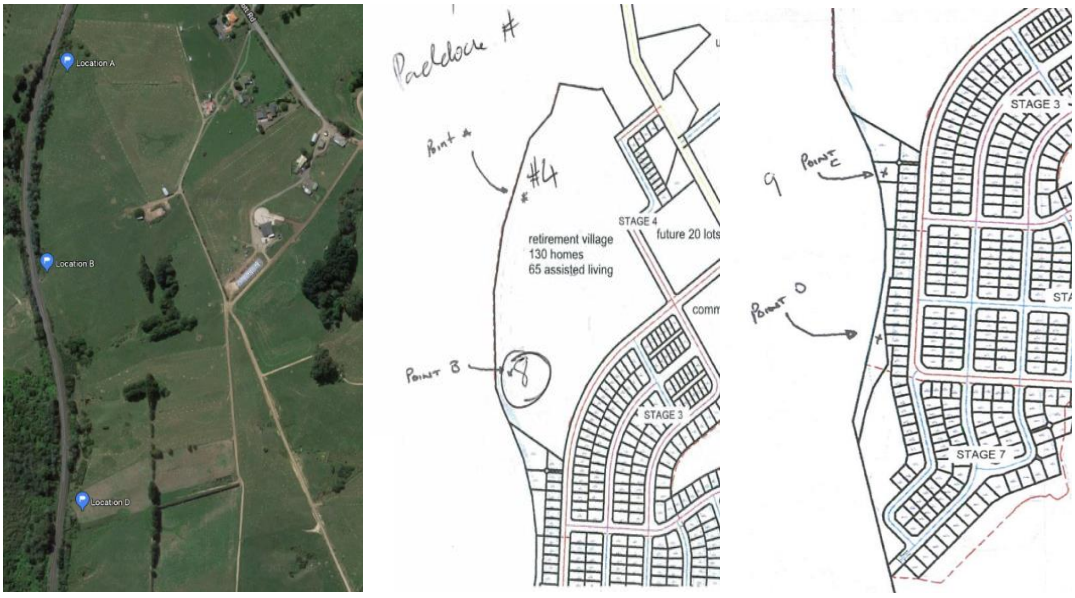
3.1 Survey Methodology

An acoustic survey was undertaken over a period spanning 12-19 December 2017. The surveys consisted of attended noise and vibration measurements at survey positions provided by the client, shown in Figure 2 below. These positions representative the façade of proposed dwellings in areas spanning the length of the western boundary.

Distances are quoted with respect to the rail track itself rather than the rail corridor.

Details of the equipment used in the measurements are provided in Appendix B.

Figure 2: Acoustic Survey Measurement Positions



(Source: Google Maps)

The measurements were undertaken in general accordance with the relevant New Zealand standards (NZS 6801:2008 & NZS 6802:2008) for noise, and Norwegian Standard NS8176.E:2005 for vibration.

Calibration checks were carried out prior to and post the survey period with no notably change in level. Weather conditions were fine and there was a slight breeze of 2 – 3 m/s.

These conditions were within the allowable parameters for measuring outdoor noise.

Table 4: Measurement position descriptions

Measurement Position	Description	Distance to track [m]
MP1	Location A – Parcel 4	30
MP2	Location B – Parcel 8	27
MP3	Location D – Parcel 14	35

As the three measurement positions are within 60m of the rail corridor boundary (refer Section 2.2.1), the NS 8176 Class C design standard ($a_{w,95}$ 11 mm/s) applies.

3.2 Noise

The measured sound levels are summarised in Table 5.

Table 5: Summary of Sound Level Measurements

Measurement Position (1) (2)	Measurement		Measured Level (3) [dB $L_{Aeq,\ 1\ hour}$]	Noise Source (5)
	Day	Duration [hours]		
MP1 – Location A *MH=1.2m*	Day 1	4	60	Train movements. Distant traffic from SH1. Distant roadworks. Birds. Cicadas. Crickets. Wind moving through the trees.
	Day 2	8	62	Train movements. Distant traffic from SH1. Distant roadworks. Birds. Cicadas. Crickets. Wind moving through the trees.
	Day 3	2	58	Train movements. Distant traffic from SH1. Distant roadworks. Birds. Cicadas. Crickets. Wind moving through the trees.
MP2 – Location B *MH=1.2m*	Day 3	24	66	Train movements. Distant traffic from SH1. Distant roadworks. Birds. Cicadas. Crickets. Wind moving through the trees.
MP3 – Location D *MH=1.2m*	Day 2	7	64	Train movements. Distant traffic from SH1. Distant roadworks. Birds. Cicadas. Crickets. Wind moving through the trees.
	Day 3	5	67	Train movements. Distant traffic from SH1. Distant roadworks. Birds. Cicadas. Crickets. Wind moving through the trees

(1) Refer to Appendix C for photos of measurement positions
(2) MH = microphone height above ground level
(3) An explanation of technical terms is provided in Appendix A
(4) A 3dB correction has been applied, to consider future rail traffic, as per Rule
(5) The controlling noise source is underlined

As shown in Table 5, the 1 hour measurements that incorporated train movements at the three locations ranged from 58 to 67 dB $L_{Aeq,\ 1\ hour}$. Therefore, to comply with the proposed rule, noise reductions of up to 32 decibels would be required – see Section 4.1.

3.3 Vibration

The measured vibration levels are summarised in Table 6.

Table 6: Summary of Vibration Level Measurements

Measurement Position[1]	Number of Trains	Distance to track (m)	Statistical Maximum Measured Acceleration[2] [mm/s^2]	Class (as per NS8176.E:2005)
MP1 – Location A	15	30	16.6	D
MP2 – Location B	15	27	17.6	D
MP3 – Location D	15	35	11.3	D

(1) Refer Appendix C for photos of measurement positions
(2) An explanation of technical terms is provided in Appendix A

As shown in Table 6, vibration levels at the three measurement positions exceeded the criteria stated in Section 2.2.2, albeit at a small margin at Location D. Vibration levels are inversely proportional to the distance from the track. Calculations to determine compliance distances have been carried out, and are summarised in Section 4.2.

4.0 ASSESSMENT

4.1 Sound

With reference to Section 2.1, the external façade of all residential units shall be designed and constructed to achieve 35 dB $L_{Aeq,\ 1\ hour}$ in bedrooms and 40 dB $L_{Aeq,\ 1\ hour}$ in other habitable spaces based on the measured rail traffic noise level and the noise limits in Rule 21.E.2.18.1(c).

Based on the noise measurements in Section 3.2, improvements to sound insulation performance would be required for the western-most line of dwellings. The requirement of 35 dB $L_{Aeq\ 1hr}$ in bedrooms is the most stringent control, requiring a façade performance of 32 decibels. This could be achieved by a typical dwelling with windows closed (a ventilation system would be required), but it is recommended that the façade details of the dwellings (once designed) be reviewed by a suitably qualified acoustic specialist to confirm this performance is achievable.

It is estimated that all dwellings within 100 metres of the track be reviewed in this capacity.

4.2 Vibration

With reference to Section 3.3, the dwellings shall be designed and constructed to achieve both:

- Class C criterion (as specified in NS 8176-E:2005) for apartments within 60m of the rail corridor
- Vibration limits (as specified in BS 7385-2:1993) for apartments within 20m of the rail corridor

The measurements indicate that compliance with NS 8176.E:2005 Class C is unlikely in the ground just outside dwellings within 40 metres of the track.

It is understood that no dwellings are proposed within 40 metres of the track. If this is not the case, it is noted that there would typically be a loss in vibration energy as it transfers from the ground into building structures, so the foundation type is key to achieving compliance with the performance standard. It is recommended that the foundation details of any dwellings within 40 metres be

reviewed by a suitably qualified acoustic specialist. It is noted that poured concrete foundations are well tied into the ground, so vibration losses are minimal. A piled foundation may be preferable.

With reference to Section 2.2.2, compliance with British Standard BS 7385-2:1993 is expected at 15 metres from the track. All proposed dwellings are further than 15 metres, so vibration induced building damage is unlikely.

5.0 SUMMARY

MDA has carried out noise and vibration measurements of train movements at three proposed dwelling locations in the Lakeside Development, Te Kauwhata.

The noise measurements indicate that dwellings within 100 metres of the track will require ventilation systems in order to achieve compliance with the Kiwirail reverse sensitivity guidelines. The façade design of dwellings should be reviewed by a suitably qualified acoustic expert to confirm compliance or otherwise with the guidelines.

Vibration measurements indicate compliance with the Kiwirail reverse sensitivity guidelines provided dwellings are further than 40 metres from the track.

APPENDIX A GLOSSARY OF TERMINOLOGY

Noise

Ambient	The ambient noise level is the noise level measured in the absence of the intrusive noise or the noise requiring control. Ambient noise levels are frequently measured to determine the situation prior to the addition of a new noise source.
A-weighting	The process by which noise levels are corrected to account for the non-linear frequency response of the human ear.
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)
dBA	The unit of sound level which has its frequency characteristics modified by a filter (A-weighted) so as to more closely approximate the frequency bias of the human ear.
$L_{Aeq\ (t)}$	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.
Noise	A sound that is unwanted by, or distracting to, the receiver.
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 2107:2000	New Zealand Standard NZS 2107:2000 "*Acoustics—Recommended design sound levels and reverberation times for building interiors"*

Vibration

Amplitude	The measurement of energy or movement in a vibrating object. Amplitude is measured and expressed in three ways: Displacement (commonly in mm); Velocity (commonly in mm/s); and Acceleration (commonly in m/s2). Amplitude is also the y-axis of the vibration time waveform and spectrum, it helps define vibration severity.
BS 7385-2:1993	British Standard BS 7385-2:1993 *"Evaluation and measurement for vibration in buildings – Part 2. Guide to damage levels from groundborne vibration"*
NS 8176-E:2005	Norwegian Standard NS 8176.E 2nd edition September 2005"*Vibration and shock – Measurement of vibration in buildings from landbased transport and guidance to evaluation of its effects on human beings"*
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.
RMS Velocity	For most applications where there is continuous vibration, vibration is measured in terms of root mean square RMS velocity (mm/sec), measured in any direction. Used for vibration annoyance.

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).

APPENDIX B NOISE SURVEY DETAILS

The key details of the noise survey are as follows:

Date: 12, 13 and 19 December 2017

Personnel: Nicolas Courrier, Marshall Day Acoustics
Rebecca Chan, Marshall Day Acoustics

Instrumentation: 01dB Noise Logger Type DUO, serial number 10863, calibration due 21/08/2019
01dB Noise Logger Type DUO, serial number 10302, calibration due 12/01/2019
01dB Vibration Transducer Type WLS, serial number 10248
01dB Vibration Transducer Type WLS, serial number 10510
01dB Vibration Transducer Type ORION, serial number 10155

Calibration: Field calibration of the equipment was carried out before measurements, and the calibration checked after measurements. Observed change was less than 0.1 dB.

APPENDIX C PHOTOGRAPHS - MEASUREMENT POSITIONS

Photo 1: Measurement Position MP1 (Location A)

Photo 2: Measurement Position MP2 (Location B)

Photo 3: Measurement Position MP3 (Location D)