

Under the Resource Management Act 1991
In the matter of Notices of Requirement to enable the construction, operation and
maintenance of the City Rail Link

Between

Auckland Transport

Requiring Authority

and

Auckland Council

Consent Authority

Statement of Evidence of James Andrew Travis Whitlock

Qualifications and Experience

1. My full name is James Andrew Travis Whitlock.
2. I am an Associate at Marshall Day Acoustics (**MDA**) with 11 years experience in acoustics, and I have specialised in environmental vibration for the past 8 years. I have a Bachelor of Science in Physics, and a Master of Architectural Studies in Acoustics, both from the University of Auckland. I am the President of the Acoustical Society of New Zealand (**ASNZ**) and hold a position on the Council of the National Foundation of the Deaf (**NFD**).
3. I have prepared vibration assessments for many infrastructure projects, including MacKays to Peka Peka (**M2PP**), Waterview Connection, State Highway 18 Greenhithe, Auckland War Memorial Museum, Transpower North Island Grid Upgrade Project (**NIGUP**), Developing Auckland's Rail Transport (**DART**) Project and Tauranga Southern Pipeline.
4. I appeared as an expert witness at the Board of Inquiry for the MacKays to Peka Peka Project and have presented expert evidence on noise and vibration at numerous Council Hearings.
5. The City Rail Link (**CRL**) project is a 3.4km underground passenger railway (including two tracks and three underground stations) running between Britomart Station and the North Auckland Line (**NAL**) in the vicinity of the existing Mount Eden Station. CRL also requires an additional 850m of track modifications within the NAL designation. The stations included in the CRL Notice of Requirement (**NoR**) have been temporarily named Aotea Station, Karangahape Station and Newton Station.
6. I am familiar with the Project area and have undertaken site visits along the route, including identification and review of ambient noise and vibration locations to inform the Notice of Requirement.
7. I have read the Code of Conduct for Expert Witnesses as contained in the Environment Court Consolidated Practice Note (2011), 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.

Scope of Evidence

8. My evidence will address the following:
 - (a) NoR assessment of environmental vibration effects;
 - (i) Existing vibration environment
 - (ii) Vibration performance standards
 - (iii) Assessment of vibration effects for the construction phase
 - (iv) Assessment of vibration effects for the operational phase
 - (v) Response to 'pre-notification' request for further information
 - (b) Proposed mitigation;
 - (c) Response to submissions;
 - (d) Response to Planners' Report; and
 - (e) Proposed conditions.

Summary of Evidence

9. I have overseen the obtaining of and analysed data from measurements of the existing vibration environment at key receivers along the route, and used these to inform my assessment of effects in crucial areas.
10. I have undertaken a literature review of international underground rail case studies and relevant vibration performance standards, and have adopted conservative Project vibration criteria, suitable for a NoR assessment of the construction and operational phases. Compliance with these criteria will ensure effects on the environment are managed to an acceptable level.

11. To assess construction vibration effects, I discussed the construction methodology with Mr. Bill Newns and his team, identified high-vibration sources, established emission radii¹ for these sources and developed GIS-based contours along the route to indicate areas of risk. Further worksite assessments (refer Paragraph 83) have identified that these contours are particularly conservative around the station entrances and the NAL worksite.
12. In my assessment of construction effects I have identified that there are risks of both building damage and occupant annoyance along the route, and I have identified five notable receivers² for whom the construction effects may be significant if not controlled. However I anticipate these effects can be appropriately managed through a Construction Environmental Management Plan (**CEMP**) a Communication and Consultation Plan, and where required, Site Specific Vibration Management Plans (**SSCVMP**). I have recommended vibration content for these documents in the draft conditions (refer Paragraph 192).
13. In my assessment of operational effects I have identified that three of the same five notable receivers may also receive vibration levels that exceed the operational vibration criteria; I have, therefore, proposed preliminary rail mitigation measures to achieve compliance. For all other receivers along the route, I anticipate compliance with the project vibration criteria, and therefore acceptable effects.
14. Overall, with the adoption of the recommended draft conditions and proposed mitigation measures, I consider that the vibration effects of the CRL construction and operational phases can be managed to an appropriate level.
15. It is important to note that for most of the construction period, there will be no significant construction vibration. When there is, the proposed machinery (with the possible exception of TBM and roadheader) are typical of inner city construction activities so vibration

¹ The emission radius is the distance from a vibration source where the vibration level is predicted to equal the Project vibration criteria.

² Those identified in our assessment report were referred to as 'key' receivers.

levels would be similar to any other construction site (e.g. a new building next door or road works outside).

Background and role

16. MDA was engaged by Auckland Transport's Principal Advisor (**PA**) team in support of the NoR work stream. The PA is led by Aurecon NZ Ltd and comprises the principal partners of Aurecon NZ Ltd, Mott MacDonald, Jasmac and Grimshaw. The PA reports directly to Auckland Transport's Infrastructure Delivery work stream which is responsible for delivery of the CRL project. The PA is also supporting the NoR and Property work streams.
17. MDA was specifically engaged to provide an independent assessment of the noise and vibration effects associated with the proposed CRL. I co-authored the technical expert assessment, which was submitted as part of the NoR application: '*Volume 3, Part 1, Appendix 2 – Marshall Day Acoustics report*' ('assessment report').
18. Subsequently, I co-authored a letter (dated 9 November 2012) in response to a 'pre-notification' request for further information (**RFI**) received from Auckland Council (dated 23 October 2012).
19. My evidence focuses on the vibration aspects of the NoR. My colleague, Mr. Craig Fitzgerald, provides separate evidence on the noise aspects.
20. My evidence includes reference to Mr. Craig Stevenson's structural engineering report, Mr. Bruce Petry's built heritage assessment and Mr. Bill Newns' construction evidence.

SLR Review

21. The Australian engineering firm SLR was engaged to undertake peer review of my vibration assessment. SLR has experience of a number of underground rail projects and their involvement in the Project serves to review the outcomes of my assessment, and identify key areas where more information could be provided.

22. I have reviewed the SLR report and the evidence of Mr. Matthew Harrison, their Technical Discipline Manager (Acoustics and Vibration), and following this review, the key areas which I have considered are:
- Addressing the issue of ground-borne noise during construction in more detail – particularly for tunneling activities (refer Paragraph 50)
 - Proposing a vibration criterion for night-time construction works, although I note this is also raised in the Auckland Council Planners' report so I have addressed it in that Section of my evidence (refer Paragraph 164)
 - Addressing the cumulative effects of vibration annoyance over time i.e. vibration dose (refer Paragraph 41)

NoR assessment of environmental vibration effects

Existing vibration environment

23. At the start of my involvement in the Project, I identified ten possible sites along the route for vibration surveys to establish the existing ambient environment. Vibration surveys were undertaken at these sites between March and June 2012. The measurements enable the assessment of vibration effects by establishing the existing vibration levels currently experienced by receivers in these areas.
24. The survey results show that the average vibration levels at each site do not exceed the perception threshold (0.3 mm/s peak particle velocity (**PPV**))³ but there were a number of recorded peaks at most sites that did exceed this threshold. These peaks were most likely caused by isolated traffic events (e.g. heavy traffic driving over a bump or dip outside) or generated by the building occupants. The Aotea Centre's ASB Theatre was the lowest vibration environment, while the 2nd floor apartment at 10 Flower St, Eden Terrace was the highest (likely occupant generated).

³ As contained in British Standard BS 5228-2:2009, Annex B.

Vibration sources

25. The most significant vibration-inducing activities machinery during the construction phase are anticipated to be:
- The Tunnel Boring Machine (**TBM**)
 - Road headers
 - Vibratory rollers
 - Diaphragm wall rig
 - Blasting
 - Excavator-mounted rockbreakers
 - Piling (pre-drilled with vibrated casings)
26. Once CRL is operational, vibration may be generated by the passage of the train's wheels over imperfections or joints in the track, especially at cross-overs and turnouts⁴, or by corrugations in the wheels themselves.

Vibration performance standards

27. I have assessed what I consider to be the two primary construction vibration effects – building damage risk and human response (i.e. annoyance).
28. Under the provisions of the Resource Management Act (Sections 16 and 17) there is a duty to adopt the 'best practicable option' to ensure that noise⁵ does not exceed a reasonable level, and that any adverse effects are avoided, remedied or mitigated.
29. There are no New Zealand standards relating to construction or rail vibration. So in order to establish suitable Project criteria, I reviewed international standards, and other large New Zealand infrastructure projects (Waterview Connection, Victoria Park Tunnel and MacKays

⁴ Crossovers are where two separate tracks cross one another in an X pattern. Turnouts are where one track splits into two in a Y pattern. Both features require joints in the track, however there are mitigation options available.

⁵ Note that the definition of noise in the RMA includes vibration.

to Peka Peka) and adopted the most relevant standards for the assessment of vibration effects.

Project Criteria – Construction Vibration

30. For construction I have adopted the Standard most commonly applied in NZ for assessing building damage risk – German Standard DIN 4150-3:1999. In my experience, the primary concern of building occupants during the construction phase is damage to their building, and this Standard provides robust and conservative criteria to address this effect. It has a history of successful adoption in New Zealand⁶.
31. This German Standard is well known amongst vibration experts to be conservative. Exceeding its values does not necessarily imply that damage will occur and if it does, any damage would be expected to be superficial such as cracking plaster, lengthening of existing cracks in brickwork etc.
32. To underline its conservatism, British Standard 5228-2:2009 allows values up to three times those in DIN 4150-3:1999 for buildings of the same type.
33. For this reason, I recommend that the DIN 4150-3:1999 criteria essentially act as ‘first response’ risk assessment for CRL. Exceeding them will trigger further assessment, monitoring and liaison through SSCVMPs as required. Its criteria are transcribed overleaf.

⁶ DIN 4150-3 has been adopted for NZ projects including Waterview Connection, Victoria Park Tunnel, Newmarket Viaduct, MacKay’s to Peka Peka, Transmission Gully, AMETI and Marsden Rail Spur.

Type of Structure	Short-term vibration			PPV at horizontal plane of highest floor (mm/s)	Long-term vibration ¹
	PPV at the foundation at a frequency of				PPV at horizontal plane of highest floor (mm/s)
	1-10Hz (mm/s)	1-50 Hz (mm/s)	50-100 Hz (mm/s)		PPV at horizontal plane of highest floor (mm/s)
Commercial/ Industrial	20	20 – 40	40 – 50	40	10
Residential/ School	5	5 – 15	15 – 20	15	5
Historic or sensitive structures	3	3 – 8	8 – 10	8	2.5

Note:

1. Standard defines short-term vibration as “vibration which does not occur often enough to cause structural fatigue and which does not produce resonance in the structure being evaluated”. Long-term vibration defined as all other vibration types not covered by the short-term vibration definition.

34. When assessing a vibration source, the criteria to apply depends on the nature of the vibration produced by the source (refer Note 1 of the table above). Typical short-term vibration sources would include blasting, drop-hammer piling and dynamic consolidation (i.e. dropping a large weight to compress soil). Most other construction machinery would be classed as long-term.
35. Annoyance effects during construction can generally be avoided and/or mitigated through an effective construction management plan, usually a CNVMP, which will be contained in the CEMP. British Standard 5228-2:2009, Annex B⁷ provides guidance vibration values for assessment and management of annoyance effects during construction, and I have adopted a suitable criterion for night-time construction works in response to the Planners’ report, including a reradiated noise criterion (refer Paragraph 170).

⁷ Refer *Volume 3, Part 1, Appendix 2 – Marshall Day report* at Section 6.2.2

36. I consider that adoption of these construction vibration criteria, and requiring implementation of reasonable vibration mitigation and management measures through the CEMP, would constitute the adoption of the 'best practicable option' and would result in acceptable levels of construction vibration.

Project Criteria – Operational Vibration

37. The CRL is the first significant underground rapid transit project in New Zealand. I have reviewed a number of international case studies and assessment methods and have selected the United States' Federal Transit Administration (**FTA**) General Assessment Method. This method sets out suitable performance standards for both vibration and reradiated noise from underground and surface railways. It is well supported by academic research⁸ and has been used in many significant rapid transit projects⁹.

Building Type	Vibration Criteria		Reradiated Noise
	(dB re:1 nm/s)	Equivalent PPV (mm/s)	Criteria (dBA re: 20 µPa)
Commercial and Industrial Buildings	103	0.2	40
Dwellings	100	0.15	35
Auditoria/Theatres	97	0.1	30
TV/Recording Studios	93	0.06	25

⁸ Saurenman, H.J., Nelson, J.T., Wilson, G.P., "Handbook of Urban Rail Noise and Vibration Control", U.S. Dept of Transportation Report UMTA-MA-06-0099-82-2, 1982.

⁹ The FTA Method has been applied in projects such as Amtrack Downeaster (New England), Port MacKenzie Rail Extension (Alaska), Knowledge Corridor (Massachusetts), Cincinnati Street Car Project (Ohio), Minneapolis Metropolitan Central Corridor Light Rail Transit (Minnesota), Portal Bridge Capacity Enhancement (New Jersey), Chicago to Iowa City Project (Illinois-Iowa), California High-Speed Train Project (California), Denver-West Corridor Light Rail Transit Project (Colorado)

38. I note that these equivalent PPV values are below the level of perception (0.3 mm/s) for all building types. This indicates that compliance with the FTA standards would typically mean that train vibration is imperceptible. The very conservative values for auditoria, theatres and studios are to protect sensitive equipment rather than avoid annoyance.
39. There are criteria for reradiated noise in the right-hand column. These are the average noise levels that would be expected in a typical room that is subjected to the corresponding vibration level.
40. I consider that with the implementation of the recommended mitigation measures (refer Paragraph 77) to achieve compliance with the Project Criteria, this would constitute the adoption of the ‘best practicable option’.
41. Mr. Harrison has proposed the use of a vibration dose value (**VDV**) to assess operational vibration effects. I am familiar with this parameter and the British Standard that prescribes it¹⁰. I acknowledge the merit of a dose-response metric and consider that it could be employed to assess operational effects in a way that considers the frequency of train pass-bys.
42. However, I consider that applying VDV criteria at this stage of the Project would complicate matters because it is wholly separate from the FTA method which I have adopted in its entirety. Furthermore, BS 6472-1:2008 states that “VDV is much more strongly influenced by vibration magnitude than by duration”, so I have already considered the primary factor through the FTA method, which I consider suitable for this stage of the Project.

¹⁰ British Standard BS 6472-1:2008 *“Guide to evaluation of human exposure to vibration in buildings – Part 1: Vibration sources other than blasting”*

Assessment of vibration effects for the construction phase

43. As discussed in Paragraph 11, I have established emission radii for construction works along the route using regression curve analysis of collected vibration datasets of each proposed construction activity¹¹.
44. Through collaboration with the Beca GIS team, I have developed construction contour maps¹² which indicate those areas where the construction vibration criteria (refer Paragraph 33) may be exceeded. As noted in Paragraph 84, I have since revised the emission radii as part of a worksite assessment. Doing this has, in effect, made them more conservative, especially around the Karangahape and Newton station entrances, and the NAL worksite.
45. I have prepared two sets of maps for the construction phase, which show:
- (i) Vibration contours at ground level
 - (ii) Vibration contours at 20 metres below ground i.e. for buildings with significant basement structures
- These are contained in our assessment report at Appendix H.
46. There are three lines on each of these maps, representing the contours where compliance with the Project criteria are achieved for heritage buildings and structures (green), residential buildings (yellow) and commercial buildings (blue). Mr. Stevenson has reviewed these maps and identified which buildings along the route fall inside their respective contour, as well as assessing the potential ground settlement effects¹³. Mr. Petry has reviewed the heritage building contour in relation to potential effects on heritage buildings and structures¹⁴.
47. I note that the contours in the northern corner of the NAL worksite are incorrectly based on the emission radii of a vibratory roller. They imply a wider affected area than will be the case because a vibratory

¹¹ Refer *Volume 3, Part 1, Appendix 2 – Marshall Day report* at Section 7.2

¹² Refer *Volume 3, Part 1, Appendix 2 – Marshall Day report* at Appendix H.

¹³ Refer *Structural Engineer Report: Volume 3, Part 1, Appendix 10*.

¹⁴ Refer *Built Heritage Assessment: Volume 3, Part 1, Appendix 4*.

roller will not be used in the cut and cover section of the NAL. The vibration-inducing equipment in this area will be a piling rig and a roadheader. I have not altered the contours, but note that the sensitive receivers that were inside their respective contours (10 Flower Street apartments and MediaWorks' TV3 building) would no longer be. I have dealt with the specific effects on MediaWorks in response to their submission (refer Paragraph 126).

48. From Mr. Stevenson's building list, in our technical expert assessment I identified three notable receivers whose building use (and potentially building structure) may be significantly affected by construction vibration. These are:

- Aotea Centre
- TV3 Studios – 3 Flower St, Eden Terrace
- Roundhead Studios – 15 Newton Rd, Eden Terrace

49. Following my review of submissions, I have added two extra notable receivers to this list:

- Ministry of Justice – 65–71 Albert Street (refer Paragraph 114)
- The Mercury Theatre – 9 Mercury Lane (refer Paragraph 163)

Reradiated noise from construction

50. Reradiated noise is often a source of annoyance during construction. It occurs when vibration energy in a building structure manifests itself as a 'rattle' or 'hum' and is heard rather than felt. It can be difficult for a listener to distinguish this effect from felt vibration but either effect can lead to annoyance, and complaint.

51. During the daytime reradiated construction noise is likely to be masked by airborne noise sources (e.g. other construction sources, traffic). I consider that in situations where this is not the case, effects can be addressed on a case by case basis through complaints management.

52. The main reradiated noise effects will occur at night-time during tunnelling activities, because the ambient noise level is low and tunnelling is the only 24 hour activity. I have recommended vibration

and reradiated noise criteria for the 2200–0700 period in Paragraph 170. These criteria are 0.3 mm/s PPV and 35 dB $L_{Aeq(15min)}$ for vibration and noise respectively¹⁵.

53. It is likely that reradiated noise will be the controlling effect at night-time, a view that is strongly supported by SLR. Mr. Harrison addresses this in his evidence and discusses the slant distances required to achieve the night-time criteria.
54. Construction management, monitoring of effects, liaison with the identified stakeholders and implementation of reasonable measures to mitigate vibration effects will be very important, and are particularly crucial for the notable receivers. Wherever practicable, alternative construction methodologies should be investigated during the detailed design phase, or in response to complaints, to minimise the vibration risk. These measures will be encapsulated in SSCVMPs for each site.
55. As I noted in Paragraph 15, in the context of the entire construction period, construction vibration issues will be infrequent and the vibration levels experienced by receivers along the route will be comparable to any other inner-city construction site.
56. I note also that all high-vibration sources are moving activities and will not stay in one place for extended periods of time. Mr. News's evidence provides further detail on construction timeframes. By way of example, Mr. Harrison considers that for a typical TBM progressing at 20 metres per day at a depth of 20 metres, the envelope of night-time disturbance would be limited to 2 – 3 nights. This is valuable information when liaising with stakeholders, and I anticipate further calculations in this area during the detailed design phase when there will be a greater degree of programme certainty.

¹⁵ These values are consistent with the perception threshold value for vibration in BS 5228-2:2009 and the recommended night-time airborne noise criterion (refer Mr Fitzgerald's evidence).

Vibration effects from blasting

57. Blasting is proposed at the NAL worksite. This was not included in our initial assessment report because the extent of basalt in that area was not known at the time it was prepared.
58. Blasting is likely to generate the highest vibration levels of all construction activities, so must be accompanied by a regimented blasting programme to monitor and manage the effects.
59. Blasting is a transient vibration source, so the short-term project construction criteria would apply. The short-term criteria are less stringent than the corresponding criteria for continuous vibration sources. The criteria are also frequency dependant, with the low-frequency (1-10Hz) value being 2 – 3 times more stringent than at higher frequencies (50-100Hz). Refer Paragraph 33.
60. The vibration level generated by a blast is directly proportional to the amount of explosive used, so smaller blasts equate to lower vibration levels. But smaller blasts are less effective at fracturing rock (although the relationship is not proportional) and so more blasts would be required.
61. The most sensitive receiver in the vicinity of blasting activities is the MediaWorks TV3 studios in Flower Street, Mt Eden. Their operations require lower vibration levels than the building damage criterion (refer Paragraph 126).
62. In his evidence, Mr. Newns has undertaken some preliminary calculations of blasting vibration levels that indicate blasting trials can be reasonably undertaken in the area without causing significant effects to the MediaWorks studios or other receivers. These tests will help to refine the site-specific attenuation parameters and risk profile of the blasting programme, resulting in more accurate predictions of construction blasting levels. I support this cautious and flexible approach.
63. As a preliminary assessment, I have predicted the emission radii for a 3kg explosive charge (the upper value quoted by Mr. Newns) using

the blasting constants for basalt adopted in the Waterview Connection assessment. The emission radii are shown in the second table of Appendix A.

64. Comparing these radii to receiver distances indicates that blasting will readily comply with the commercial building damage criterion (20 – 40 mm/s PPV) for the MediaWorks Studio, but could exceed the residential criterion (5 – 15 mm/s PPV) at the 10 Flower St apartments, for the charge weights I have assumed. Reducing the charge weights would achieve compliance.
65. From my experience of blasting in other projects (such as Waterview Connection, Eden Park Construction and NIGUP), I confirm that blasting can occur in the vicinity of buildings and structures without causing damage to them. This relies on a well designed and controlled blasting programme that includes conservative charge weights, communication and monitoring.
66. I anticipate that a specialist blasting contractor will be engaged to undertake these works. It will be their responsibility to design the blasts to comply with the Project criteria, and to monitor each and every blast.
67. In terms of human response to blasting, the primary effect is the startle factor. This can be mitigated through communicating exactly when blasts will occur ahead of time, and having an audible countdown sequence (i.e. sirens at 5 minutes, 1 minute etc. before the blast).
68. As with most construction vibration issues, complaints usually relate to people's concern about building damage, rather than the perceived vibration itself. The provisions in the proposed draft Conditions (refer Paragraph 192) will address any building damage effects.

Assessment of vibration effects for the operational phase

69. In assessing the operational vibration effects I have adopted a similar approach as for the construction phase. I have, through collaboration with the Beca GIS team, developed operational contour maps based on the FTA General Assessment Method¹⁶.
70. There are four lines on these maps, representing the contours for receiver types: studios, theatres, residential and commercial.
71. Three of the five notable receivers for the construction phase (refer Paragraph 48) are also the same notable receivers for the operational phase (the Ministry of Justice and Mercury Theatre are not at risk of exceeding their operational criteria¹⁷). I have recommended specific mitigation in the vicinity of these three receivers (refer Paragraph 77).
72. I note that portions of two commercial buildings (14 Haultain Street and 32 Normanby Road) and one mixed-use zoned apartment block (1 Akiraho Street) along the NAL lie within their corresponding operational vibration contours¹⁸. Given these receivers are adjacent to the existing rail line (and therefore subject to similar levels of train vibration already) I consider the effects of CRL on these receivers to be minor and have not included them in the notable receivers list.
73. Vibration levels for some receivers in the vicinity of NAL may increase slightly due to realigned tracks coming closer. I note that this can be done as of right where the tracks would lie within the NAL designation, so these effects are not due to the CRL (and therefore have not been assessed).
74. There is no risk of building damage during the operational phase.

¹⁶ Refer *Volume 3, Part 1, Appendix 2 – Marshall Day report* at Appendix I.

¹⁷ *Ibid.*

¹⁸ *Ibid.*

Response to Auckland Council's RFI

75. A 'pre-notification' RFI was received from Auckland Council, dated 23 October 2012. I discussed the points that related to vibration with the reviewer, and made minor changes to our technical expert assessment report to address them, to the reviewer's satisfaction.

Proposed mitigation

76. The vibration management provisions in the CEMP, which will be required as a condition of consent (refer Paragraph 192), will be the primary mitigation tool. They should highlight areas where mitigation is likely to be required, provide a structure for its implementation, and address general mitigation options to achieve the Project criteria. More specific assessments and mitigation options for notable receivers will be developed in SSCVMPs, refer Condition 21B (Paragraph 192).
77. I have recommended preliminary mitigation for the operation phase in the vicinity of the three notable receivers where I predicted exceedance with the Project criteria, as follows:
- Floating slab track within 30 metres of Aotea Centre, and resilient rail fasteners or continuously welded rail out to 50 metres either side of the building.
 - Resilient rail fasteners or continuously welded rail out to 50 metres either side of Roundhead Studios.
 - Floating track slab within 15 metres of the TV3 building and resilient rail fasteners or continuously welded rail out to 30 metres either side of the building.

Note that the distances given above are plan distances (i.e. measured horizontally), not slant distances (i.e. incorporating differences in depth).

78. In all cases, management of wheel and track corrugations through implementation of a rolling stock maintenance programme is strongly recommended. This has been reiterated in the Planners' report.

79. With mitigation measures such as these in place (and subject to further refinement in the detailed design phase), I predict that compliance with the Project criteria can be achieved for all receivers, and so the operational effects of the Project will be acceptable.

Response to submissions

80. I have reviewed all submissions that I am aware of, that relate to vibration from CRL. I have grouped these submissions according to the concerns raised, and address each concern in the sub-headings below. In each sub-heading I also indicate which submitters raised that concern.
81. In addition, there are eight submissions that I feel should be specifically addressed¹⁹, and have done so.
82. I note that of the five notable receivers I highlighted in Paragraphs 48 and 49 only MediaWorks (TV3), the Ministry of Justice and the Karangahape Road Business Association (on behalf of Mercury Theatre) have made submissions.
83. Also in response to submissions, and to provide further clarity on construction noise and vibration effects, we have undertaken assessments of six key worksites based on detailed constructability information contained in a memorandum by the PA ('Aurecon memo')²⁰.
84. I have detailed the findings of these assessments as they apply to submissions below. However, the additional constructability detail prompted me to revise the vibration source data in our assessment report, resulting in a modified set of regression curves and emission radii.

¹⁹ Submissions: Ministry of Justice (122), Stamford Plaza (71), Quay West Suites (95), MediaWorks (79), Precinct Properties NZ Ltd (81), Sky City Entertainment Group (88), East Family Trust (249) and Karangahape Rd Business Association (68)

²⁰ Refer Aurecon Memorandum 228072-AC-MEM-028, dated 30 May 2013, appended to Mr News' evidence.

85. Appendix A contains tables showing the revised emission radii. To summarise the changes:
- Additional data has been added to both the TBM and Roadheader curves. This has had the effect of reducing the emission radii for these sources (i.e. a smaller effects area); and
 - I have added three sources so that all high-vibration operations described in Mr. News' evidence are included: Piling (pre-drilled with vibrated casings), excavator-mounted rock breaker, and blasting.

Construction Vibration

86. The most common issue raised was construction vibration, with thirty seven submitters expressing concern²¹. Some specify the nature of their concern (e.g. building damage, effects on business) which I have addressed separately, but others do not.
87. In response to these submissions, I emphasise that the sole purpose of the vibration management provisions in the CEMP is to identify and address the noise and vibration effects of the construction phase as far as is reasonably achievable. The CEMP will identify those buildings at-risk of exceeding the Project criteria and put in place SSCVMPs that include monitoring, mitigation and management framework to deal with actual and potential effects for them. It will also link to a Communication and Consultation Plan to ensure stakeholders are kept informed, and are aware of the steps to make a complaint. These plans are required by proposed draft Conditions 8 and 13-15 (refer Paragraph 192).
88. I note that the term "Site" in SSCVMP can relate to a worksite, or a particular receiver i.e. they will be developed to address a particular issue whether it affects one or more receivers.
89. I consider that implementation of these tools will generally address submitters' concerns about construction vibration.

²¹ Submissions: 61, 118, 121, 120, 122, 71, 65, 186, 95, 79, 221, 100, 97, 103, 139, 140, 141, 142, 143, 144, 245, 70, 81, 246, 87, 219, 88, 249, 236, 68, 4, 54, 74, 238, 257, 240, 116.

Vibration Effects on Business

90. Twenty-seven submitters have expressed concern that vibration effects from construction may affect their business²². These include owners of residential and commercial premises who consider that construction vibration may lead to their tenants not renewing their lease, or requesting a reduced rate for the construction period. I note that no submitters expressed the same concerns about operational vibration.
91. I consider that the CEMP and Communication and Consultation Plan, which are both required as conditions of consent (refer Paragraph 192), will adequately address this issue. Receivers for whom the Project criteria may be exceeded will be given an opportunity to discuss their individual concerns, have input into mitigation strategies, and be kept informed of construction timeframes through a SSCVMP.

Building Damage

92. Concern over potential building damage has been raised in twenty-three submissions²³. Most of these submissions associate damage risk with the construction phase, but others imply that train vibration may also cause damage.
93. To address the second point, my assessment of train vibration levels indicates there is no risk of building damage. The highest operational vibration levels are predicted along the NAL section (which is surface rail), and are an order of magnitude below levels which would cause building damage. I note that the vibration level from underground rail is lower than surface rail because the solid structures of the tunnels and stations essentially act as vibration barriers.
94. With regards to construction-induced building damage, I reiterate that the Project criteria are stringent and that even buildings that lie within

²² Submissions: 118, 122, 71, 186, 79, 221, 103, 139, 140, 141, 142, 143, 144, 245, 70, 81, 246, 88, 249, 236, 68, 4, 54, 74, 238, 257, 116.

²³ Submissions: 51, 118, 122, 71, 186, 95, 221, 100, 97, 70, 81, 87, 219, 88, 249, 236, 68, 4, 54, 74, 238, 257, 116.

their corresponding construction contour²⁴ have a low risk of sustaining even superficial damage. Furthermore, the CEMP will manage this risk by instigating SSCVMPs, as required by Conditions 40 and 41.

95. The purpose of the building condition surveys is to enable a reliable assessment of whether or not damage has been caused by construction vibration. If proven, it is Auckland Transport's responsibility to repair or compensate for the damage.
96. Fifteen submitters²⁵ have requested building condition surveys. Of these, seven²⁶ lie outside their corresponding construction risk contour¹⁷ but could on a case-by-case basis be included in the building condition survey schedule upon request, through the complaints management provisions (refer Condition 9 in Paragraph 192).

Operational Vibration

97. Sixteen submitters²⁷ have expressed concern about vibration from train passes, once CRL is operational. I have assessed train vibration using the FTA General Method (refer Paragraphs 69 – 74) and the receivers I have identified as exceeding their criteria are the 3 notable receivers listed in Paragraph 48. I have recommended track mitigation (in Paragraph 77) in order to comply with the criteria.
98. In Paragraph 72 I noted that 3 buildings along the NAL lie within their corresponding operational vibration contours²⁸, however I consider that the effects of CRL on these receivers would be minor because they are adjacent to the existing rail line.
99. All other receivers along the route are predicted to comply with the Project operational criteria.

²⁴ Refer *Volume 3, Part 1, Appendix 2 – Marshall Day report* at Appendix H.

²⁵ Submissions: 114, 71, 95, 221, 100, 225, 97, 70, 81, 87, 68, 4, 54, 74, 116,.

²⁶ Submissions: 221, 100, 225, 97, 87, 54, 116.

²⁷ Submissions: 61, 51, 121, 65, 79, 97, 139, 140, 141, 142, 143, 144, 245, 81, 88, 236, 74.

Designation Conditions

100. Thirteen submitters²⁹ have emphasised that designation conditions must be developed to ensure that vibration effects from CRL are avoided, remedied or mitigated.
101. At the time the NoR was submitted conditions had not yet been drafted, so were not included in the NoR documentation reviewed by submitters. Draft designation conditions have now been developed that address both construction and operational vibration, the Project criteria for each, the identification of notable receivers and management plan requirements (refer Paragraph 192).

Construction Traffic on Local Roads

102. Three submitters³⁰ have expressed concern over vibration from heavy vehicles i.e. trucks using local roads in the vicinity of construction sites. One submitter (I Love Ugly Ltd – Submission 103) states that this may result in loss of amenity, but the other two do not specify whether their concern relates to amenity or building damage.
103. I consider that the risk of road trucks causing building damage is negligible for all receivers, especially where vehicles are driven at appropriate speeds and in a sensible manner.
104. In terms of annoyance or loss of amenity, traffic vibration issues tend to arise when heavy vehicles pass over imperfections (i.e. bumps and dips) in the road surface. If the road surface is kept smooth, little or no vibration is generated.
105. If a complaint is received about this issue, then the management procedures of the CEMP would be instigated. I consider that reasonable management steps would include engaging a suitable vibration expert to measure and assess the vibration issue. If the expert deems that vibration levels exceed a reasonable level, the road

²⁸ Refer *Volume 3, Part 1, Appendix 2 – Marshall Day report* at Appendix I.

²⁹ Submissions: 122, 71, 95, 221, 97, 70, 81, 87, 88, 74, 238, 257, 240.

³⁰ Submissions: 114, 103, 240.

surface could be improved and/or speed restrictions imposed on construction traffic in that area.

Track Isolation

106. Three submitters³¹ requested that the tracks be isolated to reduce vibration from trains passing.
107. I have predicted and assessed the operation vibration levels using the FTA General Method, and have proposed preliminary track isolation options for those receivers where vibration is predicted to exceed their corresponding criterion (refer Paragraph 77). This includes one of the submitters concerned about this issue (MediaWorks 79).
108. I anticipate that a study on trackform mitigation would be undertaken as part of the detailed design phase, but at this stage I confirm that methods exist that will achieve compliance.
109. Another submitter (James Kirkpatrick Group Ltd – Submitter 236) claims to have a recording studio located in their building which I was not aware of at the time of my assessment. This receiver would be captured by Condition 11 which includes recording studios as 'notable receivers'. It would then be subject to the same management and mitigation procedures as other studios such as Roundhead and MediaWorks.
110. The third submitter (George Court Body Corporate – Submitter 121) lies outside the residential contours, so I do not anticipate any effects.
111. Notwithstanding these highlighted areas, I understand that some forms of track isolation such as resilient pads and fasteners can be retrofitted, so any unforeseen issues could be addressed as and when required.

Health Effects

112. Three submitters³² expressed some concern about health effects due to vibration. Submission 221 specifies their concern relates to the construction phase, but Submissions 238 and 257 (which are identical) do not.

113. I am not a health expert, and am not qualified to predict or assess the effects of vibration on health. I do note, however, that British Standard BS 5228-2:2009 states:

“Guidance on the effects of physical health of vibration at sustained high levels is given in BS 6841, although such levels are unlikely to be encountered as a result of construction and demolition activities”

Furthermore, the operational criteria have been set below the limit of perception (refer Paragraph 38), so it is reasonable to assume that compliance with these criteria will provide adequate protection from health effects.

Ministry of Justice (122)

114. The Ministry of Justice’s building at 65–71 Albert Street houses the Auckland District Court and Departmental Building. They have concerns about building damage and disturbance to their operations during the construction phase.

115. The building lies inside the commercial construction contour³³ and I understand that sensitive recordings are made in the building, so it would be captured by Conditions 11 and 21 as being notable receiver, and subject to management through the CEMP and an SSCVMP. I have added them to my list of notable receivers (refer Paragraph 49).

116. I consider that the implementation of these management tools will address their concerns about construction vibration effects.

³¹ Submissions: 121, 79, 236.

³² Submissions: 221, 238, 257.

³³ Refer *Volume 3, Part 1, Appendix 2 – Marshall Day report* at Appendix H.

Stamford Plaza (71)

117. The Stamford Plaza submission is identical to those received from The Stamford Residences (Submission 70) and The Grasshopper Bar & Restaurant (Submission 74) who share the same premises, so my comments relate to all three.
118. They have general concerns about the effects of CRL, and raise two particular concerns relating to construction vibration: effects on guests (and in the case of The Stamford Residences, residents), and effects on the building structure and chattels.
119. Their building lies inside both the residential and commercial contours in the construction vibration maps³⁴, so there is a risk that vibration may exceed the building damage Project criteria, and also cause disturbance to its occupants.
120. Building damage risk will be addressed through a SSCVMP which could include an “adaptive management regime” and monitoring, as suggested by the submitter. The same monitoring will also give context to the effects of vibration on amenity of the building occupants, using the British 5228-2:2009 Standard for guidance on suitable thresholds³⁵.
121. I undertook measurements of existing ambient vibration levels in a 5th floor apartment of Quay West Suites³⁶, which is a similar receiver in a nearby location (refer Paragraph 123). The measurements indicated low existing vibration levels generally below the threshold of perception (0.3 mm/s).
122. I anticipate it would be very difficult to mitigate vibration levels to comply with the annoyance criteria in all habitable rooms at all times - particularly when piling, diaphragm walling or vibratory rolling activities are occurring outside. Therefore communication is paramount to discuss the activities well before they occur, as well as

³⁴ Refer *Volume 3, Part 1, Appendix 2 – Marshall Day report* at Appendix H.

³⁵ Refer *Volume 3, Part 1, Appendix 2 – Marshall Day report* at Section 6.2.2

³⁶ Refer *Volume 3, Part 1, Appendix 2 – Marshall Day report* at Appendix F.

during construction. Monitoring is another tool that will help to manage the effects on amenity. The submitter suggests that some guests may have to be relocated, and I agree that this may be necessary for certain periods where high-vibration machinery is working close by. This would be determined through consultation with Stamford, as required by Proposed Condition 8.

Quay West Suites (95)

123. The Quay West Suites' submission is very similar to that of the Stamford Plaza above (and its two associated submissions – Refer Paragraph 117) but I have listed it separately because they are located in a different premises. I note the ambient monitoring referred to in Paragraph 121 applies to this receiver.
124. The main point of difference in this submission, compared to Stamford's, is that it mentions the construction site on Customs Street West. I don't anticipate any vibration issues to come directly from that construction site.
125. As such, I consider that my comments in Paragraphs 117 to 122 relate to this submitter also.

MediaWorks (79)

126. MediaWorks' TV3 Studios in Flower Street, Eden Terrace is one of the notable receivers I have identified (refer Paragraph 48). They have expressed concern about the effects construction and operational vibration may have on their building and their business.
127. The CRL alignment runs directly beneath the building with a slant distance of approximately 13 metres between the tunnel crown and the building's footings at its closest point. As noted in Paragraph 47, the risk contours³⁷ in this area are incorrect, as they assumed a vibratory roller would operate in the cut and cover section.

³⁷ Refer *Volume 3, Part 1, Appendix 2 – Marshall Day report* at Appendix H.

128. The relevant vibration activities for MediaWorks are piling and roadheader excavation, which will operate approximately 20 metres and 13 metres from the building respectively.
129. At these distances, I predict vibration levels of approximately 2 mm/s PPV from piling and 0.7 mm/s PPV from the roadheader (refer Appendix A).
130. Both these values readily comply with the building damage risk criterion for continuous vibration sources of 10 mm/s PPV, but this is not the primary issue for MediaWorks.
131. The primary issue is the potential for construction vibration to disturb equipment and employees in the studios whilst recording shows and broadcasting live coverage – particularly in the main studios on the ground floor.
132. In their submission, MediaWorks quotes several excerpts from our assessment report and comment on the conclusions and recommendations therein.
133. In general, I agree with their commentary and confirm that there are significant management and mitigation issues to overcome in order to ensure the effects on MediaWorks' activities are reasonable. The management approach will be developed in an SSCVMP for the site which will document their site-specific criteria, sensitive locations, times and activities, and establish a management and mitigation framework to achieve these, to the extent reasonably achievable.
134. However before addressing that overarching issue, I would like to address three specific points made in their submission.
135. First, there is an incorrect statement. In paragraph 4(a)(iv) of their submission they claim that *“there are no measures in place to control or eliminate vibration and the attendant regenerated noise entering through the floor due to the construction of the tunnel or due to the trains passing through the tunnel and portal.”* This assertion is incorrect. As discussed in Paragraph 77, I have recommended track isolation underneath the studios, and consider that this will mitigate

operational vibration levels to achieve the criteria set out in the FTA General Method. Construction vibration levels will be addressed through the SSCVMP.

136. Second, the submission refers to appropriate noise and vibration criteria for the studio being 25 dBA and 0.05 mm/s respectively. These values align well with the FTA criteria for studios (refer Paragraph 37) so I agree with them in principle. However, during our ambient monitoring survey of the TV3 main studio I recorded vibration peaks up to levels of almost 0.9 mm/s³⁸. These peaks were presumably generated by studio activity, and their timing appears to have been centred on typical news broadcast times of midday and 6pm.
137. If peaks of this magnitude are generated as part of the studio's current operations then I feel there is a strong argument for a higher baseline criterion. This could be investigated further by controlled monitoring studies of vibration in the studio and its real effects on the studio operations.
138. Third, the submission states in paragraph 4(d)(i) that the studios are in use for 19 hours during weekdays and 9 hours during weekends, which leaves only a five hour window for construction (if it were scheduled to avoid studio use).
139. Most construction activities in the NAL worksite will not generate noticeable vibration or reradiated noise in the studios, and the actual effects of vibration-inducing activities with respect to a site-specific on the studio are not yet known. Furthermore, once a site-specific criterion is established (refer Paragraph 136) the time windows where construction and studio activities can occur simultaneously may be larger than suggested by the submitter.
140. The site-specific vibration criteria should be determined through consultation and monitoring (as per the SSCVMP provisions in the CEMP), and these would replace the Project construction criteria for this receiver.

³⁸ Refer *Volume 3, Part 1, Appendix 2 – Marshall Day report* at Appendix F11.

141. If exceedance of these site-specific criteria are predicted or measured, mitigation measures (which could include vibration isolation, damping of reradiating structures or temporary relocation of sensitive activities) could be implemented.
142. I note that this approach of developing site-specific vibration criteria and construction time windows can be applied to any receiver before or during construction, as per the SSCVMP framework in Condition 21B (refer Paragraph 192) and is particularly relevant to sensitive spaces like studios.
143. As discussed in Paragraph 57, blasting is proposed in the NAL worksite adjacent to the studios and has the potential to generate high, but transient, vibration levels.
144. I have reviewed the evidence of Mr. Newns who has undertaken preliminary blasting calculations for that area. He states that reasonable trials for blasting can be undertaken within the worksites that comply with 0.9mm/s at the MediaWorks Studios (refer Paragraph 136). From my own blasting calculations I can confirm this is the case for a 1 kg charge.
145. Monitoring the vibration levels from each blast at the studio – and assessing any corresponding vibration effects – will build up a site-specific profile of effects, which will refine the safe distances and enable more accurate predictions of subsequent blasts. This will in turn enable mitigation measures to be identified and implemented to the extent these are required and reasonably achievable.
146. To summarise, the key aspects to manage the vibration effects on the MediaWorks studios are:

- Initial and on-going consultation with MediaWorks
- Preparation of a SSCVMP, including development of site-specific vibration criteria
- Detailed monitoring of the vibration effects on the studios and their operations, both before and during construction, to correlate vibration levels with real effects
- A commitment by AT to offer mitigation and/or management strategies (ideally to the satisfaction of both parties)

147. I understand that MediaWorks and AT have agreed that this approach to identifying and exploring mitigation options is appropriate.

Precinct Properties NZ Ltd (81)

148. The Precinct Properties submission relates to six buildings in the vicinity of the CRL alignment, specifically:

- Zurich House – 21 Queen St
- AMP Centre – 29 Customs St West
- ANZ Centre – 23-29 Albert St
- PwC Tower – 188 Quay St
- SAP Tower – 151 Queen St
- Downtown Shopping Centre – 7 Queen St

149. The primary concern raised by this submitter is that there may be no opportunity for their input into developing management plans and mitigation strategies.

150. I note that the Communication and Consultation Management Plan will require consultation with affected stakeholders and this will provide opportunities for the desired input. I note also the CEMP will be a “living document” which will be subjected to review and potentially updated as the construction progresses. This process would be informed by stakeholder consultation.

151. The first three buildings (listed in Paragraph 148) are situated within their corresponding vibration contour³⁹, so they are considered to be sensitive receivers and as such will be engaged with directly through the Communication and Consultation Plan. I note that there was a child care facility at the AMP Centre, but I understand this is now closed.
152. The remaining three buildings are either outside the construction vibration contours or scheduled for removal. I consider that the effects on these buildings and building occupants can be addressed as required through the complaints management provisions (refer Condition 135)

Sky City Entertainment Group (88)

153. The buildings on Albert Street belonging to Sky City Entertainment Group lie inside the residential and commercial contours in the construction vibration maps⁴⁰, so there is a risk that vibration may exceed the Project construction criteria, and also cause disturbance to its occupants.
154. The effects on this receiver (as with many in lower Albert St) are to be addressed through SSCVMPs and the monitoring and mitigation provisions in the CEMP.
155. The submitter specifically comments on the lack of certainty around management and mitigation measures contained in NoR 1 and like Precinct Properties NZ Ltd, is concerned that they will have no input into the development of these tools. I consider that I have addressed this particular concern in Paragraph 150.
156. The submitter also expresses concern about train vibration effects, which I have addressed in Paragraph 97. I note that the submitter's

³⁹ Refer *Volume 3, Part 1, Appendix 2 – Marshall Day report* at Appendix H.

⁴⁰ Refer *Volume 3, Part 1, Appendix 2 – Marshall Day report* at Appendix H.

buildings lie outside the operational vibration contours for residences and businesses⁴¹.

East Family Trust (249)

157. The residential dwelling at 18 East Street is directly adjacent to the construction shaft for the southern K Road station entrance. I consider that the effects on this dwelling and its occupants could be significant at times during the construction phase.
158. Consultation with the owner and tenant is recommended, to discuss construction details with a view to reaching an agreement as to whether the dwelling is habitable during periods of high vibration and/or noise. Monitoring of vibration levels and building condition are also recommended prior to, and throughout construction of that station entrance.

Karangahape Road Business Association (68)

159. The Karangahape Road Business Association submission focuses primarily on the potential for vibration and settlement damage to occur to heritage buildings and structures in the area during the construction of CRL.
160. The work undertaken by Mr. Bruce Petry and his colleagues⁴² is the primary reference in this matter, as it identifies at-risk heritage buildings in the area based on the heritage contours I produced in my construction vibration contours⁴³.
161. I confirm that a number of the buildings specified by the submitter lie within the heritage contour, and the effects must be managed through the CEMP and SSCVMPs where appropriate, applying the Project criteria for heritage buildings.
162. Annoyance from vibration does not appear to be a concern for this submitter. I measured the existing ambient vibration environment in

⁴¹ Refer *Volume 3, Part 1, Appendix 2 – Marshall Day report* at Appendix I.

⁴² Refer *Built Heritage Assessment: Volume 3, Part 1, Appendix 4*.

⁴³ Refer *Volume 3, Part 1, Appendix 2 – Marshall Day report* at Appendix H.

one of these – George Court Apartments⁴⁴ and identified frequent peaks of vibration at levels above the Project operation criteria. These indicate that the occupants currently experience elevated vibration due to traffic on Karangahape Road or Mercury Lane.

163. The submitter identifies the construction vibration effects on the Mercury Theatre as being of particular concern. I agree and have added it as a notable receiver in my evidence (refer Paragraph 49) due to its historical significance and that part of the building lies within the heritage construction contour⁴⁵.

Response to Planners' Report

164. I have read the Auckland Council Planners' "Report for Hearing Commissioners" (Planners' report) dated 11 June 2013, and the associated expert reviews by Styles Group Ltd (Styles report) in Appendix F of the Planners' report. The Planners' report quotes heavily from the Styles report and states that it accepts its conclusions in their entirety⁴⁶, so unless specified otherwise my responses address both reports.
165. The Styles report is generally complimentary of our assessment but has highlighted some specific issues which I have addressed in this evidence. The Planners' report echoes this and states that "*with the exception of the matters raised by MediaWorks... we are satisfied that all matters raised in submissions... have been covered off in the preceding assessment*". I have addressed the MediaWorks issues in my response to their submission (refer Paragraph 126) and address the other issues below.

Assessment criteria

166. Section 9.2.5.2 of the Planners' report refers to the Styles Group recommendation that a vibration criterion of 0.3 mm/s PPV be adopted between the hours of 2200 – 0700, for all days of the week.

⁴⁴ Refer *Volume 3, Part 1, Appendix 2 – Marshall Day report* at Appendix F.

⁴⁵ Refer *Volume 3, Part 1, Appendix 2 – Marshall Day report* at Appendix H.

⁴⁶ Planners' report Section 9.3.5, Page 85.

It suggests parameters by which this criterion could be applied but also states that it *“could be imposed only on the basis that it is assessed where there are complaints or concern”*

167. As I stated in Paragraph 35, I consider that British Standard BS 5228-2:2009 Annex B contains suitable guidance values for construction annoyance. It states that 0.3 mm/s PPV “might just be perceptible in residential environments”, so I agree that this is a suitable (indeed conservative) night-time criterion for the 2200 – 0700hrs period to avoid sleep disturbance.
168. I note that SLR recommended a higher value of 0.5 mm/s as a night-time criterion, but the basis for this value is not clear so I prefer to use the 0.3 mm/s value from the British Standard.
169. SLR also states that ground-borne noise is likely to be the controlling effect and recommends noise criteria of 40 dB $L_{Aeq(15min)}$ for evening and 35 dB $L_{Aeq(15min)}$ for night-time.
170. I consider that for the avoidance of sleep disturbance, the following criteria should apply to residences between 2200 – 0700 hrs:
- Vibration: 0.3 mm/s PPV
 - Noise: 35 dB $L_{Aeq(15min)}$
171. These criteria should be imposed in response to complaints or concern as recommended in the Planners’ report. I expect, however, that during the detailed design phase any dwellings that may exceed the criteria would be identified through prediction, and SSCVMPs would be developed to manage the effects.

Matters of clarification

172. There are some comments in the Planners’ report that seem to have resulted from misunderstandings of our assessment. I address each of these comments below.
173. Section 9.2.5.2 of the Planners’ report refers to building condition surveys, and implies that I recommended they be carried out only at

those receivers that lie within their vibration contour in Appendix H of our assessment report.

174. Building condition surveys should be undertaken wherever there is a risk of exceeding the Project construction criteria. The areas of risk have been predicted and displayed for the purposes of our assessment, but they are not definitive. If the risk areas are modified in the detailed design phase, or other buildings are identified through the complaints process (refer Paragraph 96), then the list of buildings subject to condition surveys should change accordingly.
175. Section 9.3.4.5 of the Planners' report states that "*Building damage caused by vibration as a result of the operation of the CRL is unlikely if there is compliance with the FTA criteria.*" This statement is true, but implies that the FTA criteria are the determining factor in whether building damage is likely.
176. As stated in our assessment⁴⁷, the FTA criteria are in fact an order of magnitude (i.e. 10 times) below the Project construction criteria which deal with building damage risk. Compliance with the FTA criteria means there is *no risk* of vibration damage from the operation of CRL.
177. Section 9.3.4.6.1 of the Planners' report reiterates the rail mitigation measures I proposed in Section 8.3.2 of our assessment report, but for each notable receiver adds a bullet-point requiring "*Continued use of the floating track slab and resilient rail fasteners for the operational life of the CRL unless another future technique becomes available which achieves the same mitigation of the operational vibration effects.*"
178. I interpret this statement to mean that any installed rail mitigation shall be kept in place in perpetuity, but can be replaced with alternative mitigation options that provide equivalent or better performance. I agree with this statement.

⁴⁷ Refer *Volume 3, Part 1, Appendix 2 – Marshall Day report* at Section 6.3.2.

179. Also in Section 9.3.4.6.1 is the statement “*Continued implementation via the District Plan of reverse sensitivity rules which apply mechanisms such as minimum set back distances.*” I am not aware of any reverse sensitivity rules relating to transport vibration in the Operative District Plan, nor the Draft Unitary Plan.
180. Notwithstanding this, I understand that the purpose of NoR 3 is to provide a depth protection layer (or buffer) above the CRL tunnel. If designated, this NoR would supercede any such District Plan requirements and provide protection.
181. Section 9.3.5 of the Planners’ report raises the issue of assessment period of reradiated train noise. It notes that in Section 6.3.2 of our assessment report, I stated that the FTA reradiated noise criteria match those contained in the Kiwirail Reverse Sensitivity Guidelines.
182. I agree that my use of the word ‘match’ was not suitable because while the values match, their associated assessment periods are different (FTA requires a L_{Amax} assessment, whereas the Kiwirail guideline is a $L_{Aeq(1hr)}$).
183. Section 9.3.5 of the Planners’ report also refers to the rail mitigation I recommended in Section 8.3.2 of our assessment report, and observes that I did not state that the adoption of this mitigation would result in compliance with the Project operation criteria.
184. This is correct, and was an oversight on my part. I confirm that, according to the FTA method, the recommended rail mitigation will achieve compliance with the criteria for the three receivers identified in Section 8.3.2. Furthermore, similar mitigation can be applied as required along the route (subject to detailed design) so that compliance can be achieved at all receivers (refer Paragraph 79).

Areas of disagreement

185. Section 9.2.4.13 of the Planner’s report states that “*In terms of the standard (DIN 4150-3:1999) being used to assess structural damage, TV3 as a television studio is classed as a sensitive building (and therefore the criteria to meet is 2.5 mm/s PPV.)*”

186. This is an incorrect use of the 2.5 mm/s criterion which applies to building structures only, not the building use. The MediaWorks Studio is a commercial building structure and so the appropriate building damage criterion is 10 mm/s PPV.
187. Section 9.3.5 of the Planners' report references the Styles Group recommendation, in relation to the Project operation criteria, that *"the metric equivalents are appropriate to use but that the derivation of reradiated noise criteria as set out in the FTA method must be done using the original imperially-based VdB values."*
188. I consider that this requirement adds an unnecessary level of complication to compliance assessments, as imperial units are not the New Zealand standard and errors could be introduced if the calculations were undertaken by lay people. The metric values in Table 6.3.2 of our report were provided for the sake of familiarity and to avoid such complications. I also note the importance of stating the reference velocity⁴⁸ of the VdB value because unlike noise, a range of values are used in practice.
189. The Styles Group report states in its *Assessment of Construction Vibration Effects*⁴⁹ section that *"carrying out the works as proposed whilst maintaining the successful operation of the (MediaWorks) studio will be impossible."*, then later *"With particular regard to section J13, the draft CNVMP... does not prescribe any readily-adoptable resolution to the likely conflict between the continuation of the works and the effect on receivers. I acknowledge however that the provision of such resolution is likely impossible at this stage."*
190. I consider that the use of the word "impossible" is inappropriate and premature given the Project is at an early stage, and the fact that the CNVMP was a draft only. There is much work to be done in the detailed design phase with respect to understanding the potential for mitigating the effects on receivers, especially notable ones including

⁴⁸ A VdB level defined as the ratio of velocity against a reference velocity, in this case 1nm/s (nanometre per second)

⁴⁹ Refer Styles Group "Review of Noise and Vibration Effects during Construction" report (Appendix F of the Planners' report) at Page 10.

MediaWorks, and I am of the opinion that a resolution is far from impossible.

Planners' proposed changes to Conditions

191. In addition to the Planners' report, Auckland Council has issued a set of revised conditions, based on AT's proposed conditions. The changes are underlined in that document and their intention is summarised in the Planners' report⁵⁰. These changes have been adopted into the conditions, where appropriate and further modifications have been made by Auckland Transport. I have summarised and commented on the conditions relating to vibration overleaf.

Proposed conditions

192. The proposed designation conditions relating to my evidence (which include alterations following comments in the Planners' report) are listed overleaf:
- 8: Communication and Consultation Plan
This condition sets out the methods and framework for what shall be included in the Communication and Consultation Plan, including the monitoring of adverse vibration effects and linkages and cross references to the CEMP (refer Condition 13).
 - 9: Concerns and Complaints Management
This condition details the process for recording and responding to concerns and complaints, including those regarding vibration.
 - 11: Communications – Notable Noise and Vibration Receivers
This is a specific Communication and Consultation condition for activities that are recognised as having a more elevated sensitivity to noise and/or vibration compared with other sensitive receivers. This includes theatres and activities that rely on vibration sensitive equipment such as recording studios, medical facilities and scientific laboratories. Receivers currently identified which are expected to be captured by this condition are Aotea

⁵⁰ Refer Planners' report at Page 73.

Centre, MediaWorks Studios, Roundhead Studios, Ministry of Justice and Mercury Theatre (refer Paragraphs 48 – 49).

- 13 – 15: Construction Environmental Management Plan (CEMP)
The CEMP is the main mechanism for managing adverse effects during the construction period. These conditions provide the general framework and content of the CEMP.
- 21: Construction Noise and Vibration Management Plan (CNVMP)
Sets out the specific CEMP framework for the implementation of vibration management procedures, vibration mitigation measures and links to the Communications and Consultation Plan. The Planners' report recommends that the buildings that should be subject to building condition surveys should be specified in this condition. I agree with this addition.
- 21A: Collaboration with Notable Receivers
This condition sets out a process for collaborating with notable receivers, and the steps that should be taken if the parties cannot agree.
- 39: Building Damage from Construction Vibration
This condition presents the Project Criteria relating to building damage from construction vibration. It states that vibration shall be measured and assessed in accordance with German Standard DIN 4150-3:1999.
- 39A: Site Specific Construction Vibration Management Plans (SSCVMPs)

This condition requires that further assessment be undertaken as part of a SSCVMP where modelled or measured construction noise levels are predicted to exceed the Project construction criteria. Note that the Planners' report recommended a 50% relaxation of the criteria as the trigger for SSCVMPs, however their basis for this is not clear, nor is it provided for in the Standard on which it is based (DIN 4150-3:1999).

I acknowledge that on this basis, the number of SSCVMPs could

be considerable. This number (and/or the scale and complexity of the task) would be reduced if there is an understanding that each SSCVMP establishes management techniques that can later be applied to similar situations.

- 39B: Night-time Construction Vibration

This condition was recommended in the Planners' report to manage sleep disturbance from reradiated noise. I agree with this condition, and have also added a vibration criterion (refer Paragraph 170).

- 40: Construction Vibration

This condition requires monitoring to comply with Condition 39 and where predicted or measured to exceed, a SSCVMP shall be prepared. It also includes a provision that the Project construction criteria can be adjusted for certain receivers, subject to a SSCVMP, assessment by a structural engineer and ongoing monitoring. I note that the Planners' report mentioned increasing, but not decreasing criteria. I consider that either could be deemed appropriate, so both should be allowed for in this condition.

- 41: Building Condition Survey in relation to Vibration Effects

This condition sets out the Building Condition Survey process and requirements.

- 43: Operational Rail Vibration

This condition presents the Project Criteria relating to operational rail vibration and reradiated noise levels.

- 44: Operational Noise and Vibration Management Plan (ONVMP)

This condition requires the development of an ONVMP to ensure the CRL tracks are maintained so as to (among other things) minimise noise and vibration emissions. I note that the Planners' report referred to it as an Operational Noise Management Plan, but I consider that vibration should be included in its title.

193. I agree with the proposed conditions as drafted and modified by Auckland Transport, which include the recommendations and comments I have made in my evidence.

James Whitlock

1 July 2013

APPENDIX A VIBRATION EMISSION RADII

Continuous (long-term) vibration sources

Source	Emission radii for each building type (to comply with DIN 4150-3:1999 long-term criteria)		
	Heritage (2.5 mm/s)	Residential (5 mm/s)	Commercial (10 mm/s)
Road Header	5 m	3 m	2 m
TBM	8 m	3 m	2 m
D-Wall Rig/Excavator	15 m	4 m	< 2 m
Piling (Bored with vibrated casings)	15 m	6 m	3 m
Vibratory Roller	30 m	14 m	6 m
Rockbreaker	16 m	10 m	7 m

Transient (short-term) vibration sources

Source	Emission radii for each building type (to comply with the most stringent short-term criteria i.e. 1-10Hz from DIN 4150-3:1999)		
	Heritage (3 mm/s)	Residential (5 mm/s)	Commercial (20 mm/s)
Blasting (3kg charge)	60 m	40 m	13 m