Before the Board of Inquiry
Waterview Connection Project

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in the matter of: the Resource Management Act 1991

and

in the matter of: a Board of Inquiry appointed under s 149J of the Resource Management Act 1991 to decide notices of requirement and resource consent applications by the NZ Transport Agency for the Waterview Connection Project

Statement of evidence of Siiri Wilkening (Construction Noise) on behalf of the **NZ Transport Agency**

Dated: 10 November 2010

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INDEX

STATEMENT OF EVIDENCE OF SIIRI WILKENING ON BEHALF OF THE NZ TRANSPORT AGENCY

INTRODUCTION

1 My full name is Siiri Wilkening.

2 I am an acoustical consultant employed by Marshall Day Acoustics Ltd (*MDA*). I have had twelve years experience in acoustic engineering in Germany and New Zealand, specialising in environmental noise control and computer noise modelling. I hold a Masters degree in Environmental Engineering (Land Improvement and Environment Protection) from the University of Rostock, Germany.

3 Over the last twelve years I have been involved in investigating and reporting on traffic noise effects of numerous roading projects, including local roads and State highways. My work has involved all aspects of traffic noise assessments, from route selection and evaluation, through noise level surveys, computer noise modelling, reporting and community consultation.

4 I have given evidence at Council planning hearings and have been involved in Environment Court mediation. Roading projects I have been involved with include the following:

4.1 Victoria Park Tunnel;

4.2 Newmarket Viaduct Improvement Project;

4.3 SH16/18 Realignment;

4.4 SH1 Northern Motorway Extension Orewa to Puhoi;

4.5 SH22 Drury Widening;

4.6 North Shore Busway;

4.7 SH20 to SH1 Manukau Link;

4.8 SH20 Manukau Harbour Crossing;

4.9 SH1 Improvement Projects Warkworth;

4.10 East Taupo Arterial Road; and

4.11 Additional Waitemata Harbour Crossing.

5 My evidence is given in support of notices of requirement and applications for resource consents lodged with the Environmental

Protection Authority (*EPA*) by the NZ Transport Agency (*NZTA*) on 20 August 2010 in relation to the Waterview Connection Project (*Project*). The Project comprises works previously investigated and developed as two separate projects, being:

5.1 The State Highway 16 (*SH16*) Causeway Project; and

5.2 The State Highway 20 (*SH20*) Waterview Connection Project.

6 I am familiar with the area that the Project covers, and the State highway and roading network in the vicinity of the Project.

7 I have read the Code of Conduct for Expert Witnesses as contained in the Environment Court Consolidated Practice Note (2006), and agree to comply with it. In preparing my evidence, I have not omitted to consider material facts known to me that might alter or detract from my opinions expressed.

SCOPE OF EVIDENCE

8 My evidence will deal with the following:

8.1 An executive summary of my evidence;

8.2 My background and role;

8.3 A summary of my assessment of construction noise effects;

8.4 Post-lodgement events;

8.5 Comments on submissions; and

8.6 Proposed construction noise conditions.

EXECUTIVE SUMMARY

9 I, and my colleagues at MDA, have undertaken an assessment of construction noise effects potentially arising from the Project. Our assessment was based on accepted construction noise standards and criteria.

10 Due to the size of the Project and construction methodologies proposed, noise levels and effects will vary. I assessed each Project Sector individually, predicted construction noise levels from likely equipment at sensitive receiver positions, compared the prediction results with appropriate criteria and recommended mitigation options, where required.

11 I also produced a draft Construction Noise and Vibration Management Plan (in conjunction with vibration experts), which

provides an outline for management and mitigation of construction noise, both in relation to noise generation and receiver positions.

12 I consider that with the implementation of suitable management and mitigation measures, the construction noise effects from the Project can be managed appropriately.

BACKGROUND AND ROLE

13 The NZTA retained MDA as part of a consortia team to assist with the investigation, engineering and planning of the Project. I was asked to prepare an Assessment of Construction Noise Effects Report (*Report*) in relation to the construction noise effects of the Project. Peter Ibbotson of MDA assisted me with the preparation of the Report and it was peer reviewed by Stephen Chiles of URS.

14 My Report was lodged with the EPA in August 2010 as part of the overall Assessment of Environmental Effects (*AEE*) (specifically, Part G, Technical Report G.5).

15 I have been involved with the SH20 part of the Project in its various forms since 2000, and the SH16 part since 2009. My input has involved the evaluation of noise effects of various route options, scheme assessments and the assessment of noise effects for previously considered alignments.

16 The effects of operational noise require separate consideration from the effects of construction noise and I have prepared a separate brief of evidence on the former.

SUMMARY OF ASSESSMENT

17 In this section of my evidence I will describe the methodology and key conclusions of my Report.

Methodology

18 The methodology for assessing construction noise effects involves several steps,[1] including the determination of appropriate noise performance standards, prediction of equipment noise levels and recommendation of suitable mitigation and management measures. These steps are summarised below.

Noise Performance Standards

19 The New Zealand Standard NZS6803:1999 "Acoustics – Construction Noise" (*Standard*) is the current and most widely adopted Standard in New Zealand for the assessment of noise from construction operations, excluding blasting. It is referenced in many

[1] Refer Section 4 of my Report.

District Plans and forms the basis of numerous designations and consents.

20 The Standard sets out different construction noise criteria depending on the time, day, receiving environment and duration of the construction. For example, lower noise criteria are set for Sundays in residential areas and for projects of durations greater than 20 weeks, such as this Project.

21 The Standard sets out external noise criteria at 1 metre from the most exposed façade. Daytime noise criteria range from 60 to 70 dB L_{Aeq} for residential positions and 70 dB L_{Aeq} for businesses. The night-time criterion for businesses is 75 dB L_{Aeq}.

22 For residential receivers, the night-time noise criterion is 45 dB L_{Aeq}. This level means that none but the quietest construction activities could be carried out at night-time. Sectors 8 and 9 of the Project are located in areas with low ambient noise levels, and I consider that the 45 dB night-time noise criterion is appropriate for these Sectors.

23 In Sectors 1 to 7 the ambient noise level is controlled by noise from the existing roading network, particularly SH16 and Great North Road. This means that current night-time noise levels in these Sectors are already elevated above the Standard's night-time noise criterion.

24 The Standard enables the use of alternative noise criteria where extraneous sources cause the ambient noise levels to be raised above the noise criteria set out in the Standard, e.g. in areas adjacent to the existing SH16 at night-times.

25 Using the "background noise level (L_{95} or L_{90}) plus 10 decibels" approach referenced in the Standard, I determined appropriate construction noise criteria for each Sector of the Project.[2] Based on noise survey data of the Project area, I recommended a night-time noise criterion of 60 dB L_{Aeq} for Sectors 1 to 7 and a night-time noise criterion of 45 dB L_{Aeq} for Sectors 8 and 9.

26 Educational facilities are not specifically mentioned in the Standard, however, I have assessed these facilities based on external residential daytime noise criteria. In addition, I have recommended internal noise criteria for classrooms and associated noise sensitive rooms in educational facilities. These criteria are based on the maximum recommended design criteria of AS/NZS2107:2000 and range from 40 dB to 45 dB L_{Aeq}.

[2] Refer to Section 5.1.2 of my Report.

27 For noise generated by blasting, AS 2187.2:2006[3] sets out relevant noise limits, which include limits to avoid structural damage (133 dB L_{Zpeak}) and maintain human comfort (115 to 125 dB L_{Zpeak}). I consider these criteria to be appropriate for the Project.

28 Tunnel construction is intended to be undertaken 24 hours per day, 7 days per week. Vibration from tunnelling can cause dwellings and other structures to excite, causing structure-borne[4] noise. I consider that it is not appropriate to assess internal noise levels due to structure-borne noise based on the provisions of the Standard. Instead, I have applied the more stringent internal noise criteria of the World Health Organisation (*WHO*), which are 35 dB $L_{Aeq(16h)}$ for living areas during daytime, and 30 dB $L_{Aeq(8h)}$ for bedrooms at night-time. In my opinion, these levels are acceptable to avoid sleep disturbance.[5]

29 A full set of recommended construction noise criteria for the Project are included in my Report at Section 5.6[6] and the proposed Construction Noise Conditions are attached to this evidence as **Annexure A**.[7] Project noise criteria are provided for external noise levels for residential and business/industrial buildings, internal noise levels from structure-borne noise for residential buildings, internal noise levels from general construction noise for educational facilities and external airblast noise levels. It is my recommendation that the contractor comply with these criteria, where practicable. There will, however, be times when full compliance with the criteria is not possible. I discuss this issue in more detail later in my evidence.

Predicted Construction Noise Levels

30 Equipment noise levels can be determined by survey. However, at this stage of the Project, construction methodology and the equipment to be used have not been finalised. Therefore, I have used previously measured noise levels of equipment that is likely to be used, and equipment noise levels provided in the Standard to form a suitable basis of assessment.

31 Based on those equipment noise levels, I, and my colleagues at MDA, calculated noise levels anticipated to be received at the closest noise sensitive locations. Comparing the resultant noise levels with the noise criteria, I determined which activities may require mitigation of some form, and which activities are likely to exceed the criteria. Noise level prediction results for each Sector and the

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3 NZS6803:1999 references AS 2187.2:2006. The criteria of NZS6803:1999 are not applicable to blast noise. Refer Section 5.1.3 of my Report.

4 Structure-borne noise can also be termed "re-radiated noise".

5 Refer to Section 5.2 of my Report.

6 Tables 5.5 to 5.8.

7 The conditions cover "Construction Noise and Vibration" and so include vibration related conditions that are discussed in the evidence of Mr Peter Millar.

expected construction activities and equipment are listed in the tables in Section 8 of my report.

Management and Mitigation

32 In my Report,[8] I provided details relating to suitable mitigation options, both general options to be implemented Project-wide and specific mitigation options for certain Project Sectors or activities.

33 However, since my assessment was based on reasonable assumptions, e.g. in relation to construction methodology, equipment and timing, I recommend that construction noise effects from the Project are managed through the use of a Construction Noise and Vibration Management Plan (*CNVMP*).[9] The CNVMP can be updated as methodology and equipment are determined and finalised, and equipment noise levels measured on site. I discuss the CNVMP later in my evidence.

Assessment of construction noise effects

34 Due to the size of the Project and the variety of construction activities and equipment proposed, I have assessed construction effects for each Sector separately.

35 For the entire Project, two aspects of construction need to be differentiated: ongoing stationary activities occurring almost throughout the whole duration of the works in one location, such as construction yards and concrete batch plants; and activities moving along the alignment with the road formation.

36 Construction yards that may affect residential buildings are located in Sectors 1, 5, 6, 7, 8 and 9. Concrete batch plants are located in Sectors 5 and 9, and a rock crusher is also located in Sector 9. Construction Yards 1, 7, 9 and 10 are likely to be operational 24 hours per day, seven days per week. I have been advised by the NZTA that safety requirements for tunnelling activities will require concrete to be available at any time.[10] Therefore, the concrete batch plants will need to be able to operate at any time when concrete is required, day or night. However, they will not operate continuously because concrete will generally be provided from off-site batch plants. The rock crusher in Sector 9 will operate during daytime only.

37 Construction activities moving along the alignment as construction progresses include the formation of the road and surrounding

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8 Section 7 of my Report contains recommended general mitigation measures, which should be applied Project-wide, and Section 8 contains recommended mitigation measures for individual Project Sectors.

9 A draft CNVMP is attached as Appendix C to my Report.

10 Refer evidence of Mr Walter.

facilities, such as construction of operational noise mitigation measures and landscaping, and tunnelling.

Sector 1

38 Construction activities in Sector 1 will involve widening of SH16 and realignment of the Te Atatu Interchange on- and off-ramps.[11]

39 I predict that typical average noise levels from construction in Sector 1 will generally comply with the daytime noise criteria. Where equipment is required to operate close to receivers, such as for the construction of the traffic noise barriers, some activities may exceed these limits without the implementation of mitigation.

40 Some very limited night-time activities may be required in Sector 1, specifically where construction in the motorway corridor would result in disruption to traffic. These activities should be restricted as much as possible. Mitigation for Sector 1 will involve the construction of temporary (construction) and permanent (traffic) noise barriers.

41 In Sector 1, the potentially most affected receivers are located in Marewa Street, Milich Terrace, McCormick Road, Royal View Road and Alwyn Avenue.

Sector 2

42 Construction activities in Sector 2 will involve the construction of the Whau bridges. These works will be undertaken during daytime only, and daytime noise criteria will be complied with.[12]

Sector 3

43 Construction activities in Sector 3 will potentially affect commercial receivers only, specifically the Rosebank Industrial Area. The majority of construction noise will be able to comply with the relevant noise criteria. Noise from construction works in close proximity to receivers can be managed by being carried out during the less sensitive night-time, or with the installation of temporary barriers.[13]

Sector 4

44 The causeway construction in Sector 4 will be at considerable distances from sensitive receivers, and I predict that all works will comply with the relevant construction noise criteria.[14]

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[11] Refer to Section 8.1 of my Report.

[12] Refer to Section 8.2 of my Report.

[13] Refer to Section 8.3 of my Report.

[14] Refer to Section 8.4 of my Report.

Sector 5

45 Construction in Sector 5[15] will potentially affect a large number of noise sensitive receiver locations, due to the close proximity of the densely populated suburban areas of Waterview and Point Chevalier, and of Unitec.

46 However, current noise levels in the area are elevated due to traffic on SH16 and Great North Road, and therefore the increase in overall noise levels due to construction will be less noticeable than in other areas of the alignment.

47 Three construction yards will be located in Sector 5, one in Waterview Park and the other two within the existing Great North Road Interchange towards Point Chevalier.[16] While each of the construction yards will generally be used for storage, equipment maintenance and offices, the construction yard in Waterview Park will include a concrete batch plant. The plant will need to be able to operate at any time, when required.

48 The concrete batch plant is located as far away from residences as possible, and positioned such that main noise sources are well shielded. In addition, the plant and associated operations, such as conveyors, will be fully enclosed to reduce noise levels. The management and operation of both the Sector 5 and the Sector 9 batch plants are further discussed in the Draft Concrete Batch and Crushing Plant Management Plan (*CBCPMP*), which is attached to my Report as Appendix E.

49 Other construction activities in Sector 5 involve the construction of the Great North Road Interchange ramp structures, which will involve piling.

50 I have predicted that most construction activities in Sector 5 will typically be below the daytime noise criteria. However, where activities will be required in close proximity to dwellings, or at night-time, such as the construction of the ramp bridges crossing SH16, mitigation will need to be implemented. Such mitigation may involve the construction of temporary noise barriers, the restriction of where night-time activities can be conducted, and potentially temporary relocation of residents.

51 These measures will be developed in detail once a contractor has been appointed, and the CNVMP will be updated when relevant decisions regarding construction methodology and equipment have been made.

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15 Refer to Section 8.5 of my Report.

16 Refer to Section 8.5.4 of my Report.

Sector 6

52 The road widening of SH16 into Sector 6[17] will include the construction of traffic noise barriers, piling and rock breaking for construction of the Carrington Road bridge and general road construction.

53 While the majority of these works can be undertaken during daytime, construction that may affect traffic flows on SH16 may need to be undertaken during night-time. These night-time activities, and daytime activities immediately adjacent to residences, are likely to exceed the relevant noise limits. Early construction of permanent traffic noise barriers will assist in reducing noise levels at these dwellings, but ultimately, alternative mitigation measures will need to be implemented, such as restriction of night-time activities or temporary relocation of residents.

54 Areas potentially most affected by construction works in Sector 6 include dwellings in Carrington, Sutherland and Great North Roads.

Sector 7

55 Construction activities in Sector 7 will involve noise intensive construction activities, specifically the construction of the cut-and-cover tunnel section.[18] In order to accommodate the alignment, a number of dwellings will need to be removed adjacent to Great North Road, which will leave dwellings behind less shielded from traffic on Great North Road and construction noise.

56 Construction activities in Sector 7 will involve piling for the diaphragm wall for the tunnel, excavation and the realignment and resurfacing of Great North Road. These activities, particularly the piling and excavation works, will generate high noise levels. However, these activities will not occur throughout the entire construction period.[19] Once the lid has been placed on the tunnel, excavation inside the tunnel will be well shielded from noise sensitive sites.

57 Construction noise in Sector 7 will potentially have the greatest effects on residences in Great North Road and Waterbank Crescent. Waterview Primary School and Kindergarten are also located in Sector 7 and will be affected by the noise from tunnelling activities and construction activities in Sector 5.[20]

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17 Refer to Section 8.6 of my Report.

18 Refer to Section 8.7 of my Report.

19 Construction of the cut-and-cover tunnel and ventilation building is anticipated to take 18 months to 2 years.

20 Refer to Section 8.5.7 of my Report for further discussion relating to Waterview Primary School and Kindergarten.

58 The Kindergarten activity will be temporarily relocated to avoid adverse construction effects, including noise. The school will be affected by construction noise during intermittent periods. In order to avoid undue adverse effects on the school during those times when construction is carried out in the vicinity of the school, I have recommended that suitable internal noise criteria[21] are met in teaching and associated noise sensitive spaces. There are a number of specific mitigation measures that could be employed to achieve compliance with these criteria, such as substantial construction noise barriers and mechanical ventilation for those classrooms where windows would need to remain closed to achieve the criteria.

59 I predict that daytime and night-time construction noise criteria will be exceeded at times in Sector 7 when construction is being undertaken in close proximity to noise sensitive locations. I have recommended mitigation where this occurs; nonetheless it is likely that some temporary relocation of residents may be required. For other times, the construction of substantial temporary construction noise barriers will be required.

Sector 8

60 Construction in Sector 8[22] will be located below ground. Tunnelling, while unlikely to generate high noise levels above ground, can result in structure-borne noise in buildings above the works. Accordingly, residents in dwellings located above the tunnel alignment may experience some noise as the tunnelling work moves past their properties.

61 When tunnelling reaches a greater depth, the WHO internal noise criteria are likely to be achieved. Therefore, at the commencement of tunnelling, I have recommended that monitoring be undertaken to determine actual internal noise levels from structure-borne noise and that night-time construction should not be undertaken below dwellings in the early stages of tunnelling.

62 There is some uncertainty about predicting structure-borne noise levels in dwellings; nonetheless I consider that the WHO criteria (discussed in paragraph 28 above) may be exceeded at times. Therefore, I recommend a regime of monitoring, notification and, potentially, temporary relocation, for the worst affected residents. Due to the temporary nature of the construction noise, which will move along the alignment as tunnel construction progresses, I consider this regime to be a viable management measure.

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[21] Refer to new Condition CNV.2 iv in **Annexure A** of my evidence.

[22] Refer to Section 8.8 of my Report. I note that the emergency ventilation stack, which would have required above-ground construction, is no longer proposed.

Sector 9

63 Sector 9 involves the construction of the surface road, ventilation building, ramps to the Maioro Street Interchange and establishment of open spaces, playing fields, a cycleway and traffic noise barriers. In addition, a number of dwellings will be demolished to enable access to the construction site.

64 Five construction yards will be located in Sector 9,[23] one of which will contain a concrete batch plant and another, a rock crusher. Both the batch plant and rock crusher will be fully enclosed and located such that any opening will face away from residential sites.

65 Construction activities in Sector 9 will include some limited blasting,[24] drilling, piling and rock breaking for the tunnel portal, with most activities being undertaken during daytime.

66 Prior to construction of the tunnel approach, a grout curtain[25] will be installed along the southern boundary of adjoining Hendon Avenue properties. Construction of this curtain will involve the drilling of holes and the filling of them with concrete. Due to the close proximity of the curtain to dwellings, the recommended noise criteria are likely to be exceeded at times, and mitigation, such as temporary construction noise barriers and potential temporary relocation, may be required.

67 I have been advised by the NZTA that the construction of the Richardson Road Bridge will need to be undertaken at night-time in order to avoid disruption of traffic. Since the noise generated by the bridge construction activity will exceed the night-time noise criteria, mitigation will need to be provided for affected residents.

68 Areas most affected by construction in Sector 9 are dwellings in Hendon Avenue and Methuen Road, and, to a lesser degree, Christ the King School and dwellings in Richardson Road. Traffic noise is not a significant part of the background noise level in these areas. Therefore, I recommend that the night-time noise criterion of the Standard not be revised for this area, i.e. the night-time criterion of 45 dB L_{Aeq} should be adhered to as far as practicable.

Mitigation

69 I have recommended general[26] and specific[27] noise mitigation measures throughout my Report and in the draft CNVMP. Examples

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23 Refer to Section 8.9.4 of my Report.

24 Refer to Section 8.9.8 of my Report.

25 The grout curtain will ensure that the retaining walls on the tunnel approach are protected from groundwater pressure. Refer to Section 3.2, page 7 of Technical Report G.7.

26 Refer to Section 7 of my Report.

27 Refer to Sections 8.5 to 8.9 of my Report.

of the specific mitigation measures proposed are: the location of batch plants to avoid reversing of trucks, the restriction of blasts to daytime only and the enclosure of high noise generating equipment and equipment that is required to operate at night-time.

70 One of the most commonly used and effective construction noise mitigation measures is the placement of temporary construction noise barriers. I have recommended the use of temporary construction noise barriers for almost all Project Sectors, generally around the construction yards, stationary high noise equipment and adjacent to dwellings that are in close proximity to proposed construction works.

71 Construction noise barriers need to be placed so that they interrupt acoustic line-of-sight from the noise source to the receiver location. Therefore, barriers are more suitable for areas where dwellings are level with the construction site. For other areas, such as Methuen Road in Sector 9 and Montrose Road in Point Chevalier (Sector 5), residences are elevated above the construction site and yards, and will therefore be difficult to shield. For these areas, barriers will need to be very high, which could be achieved by the temporary use of stacked shipping containers or similar constructions.

72 In Sectors 1, 5, 6 and 9, permanent traffic noise barriers will be constructed to reduce operational noise from the completed motorway. These traffic noise barriers will in some instances also be useful in controlling construction noise, and I recommend that these barriers are constructed early in the construction programme, if practicable.

73 Enclosure of particularly noisy items of plant, such as basalt crushing and concrete batching, will be required. Further management measures for the crusher and batch plants are set out in the Concrete Batching and Crushing Plant Management Plan[28].

74 In addition, other mitigation, such as temporary resident relocation and potential installation of alternative ventilation in order to allow windows to remain shut, will need to be considered on a case-by-case basis. Where it has been determined that and which Building Modification Mitigation[29] is required for particular dwellings, implementation of such mitigation early in the construction programme will provide effective mitigation of construction noise.

75 Subsequent to the implementation of best practicable noise management measures, I consider that the Project construction noise criteria can generally be achieved. However, certain high

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[28] Refer Appendix E of my Report.

[29] As required to achieve compliance with the internal traffic noise criterion of Noise Category C of NZS 6806:2010. Refer Technical Report G.12.

noise generating activities are essential to the successful construction of the Project and night-time construction is critical in some Sectors. Some of these works have the potential to exceed the noise criteria even with noise mitigation in place.

76 In most construction projects, occasional exceedances of construction noise criteria are expected and would not necessarily be unreasonable. However, where exceedances are expected to occur within the Project alignment for an extended duration, it will be important that the best practicable noise control and mitigation options are implemented on site and alternative measures are implemented, such as temporary relocation of residents or provision of mechanical ventilation to affected properties.

77 There are considerable constraints on the Project construction and, given the established environment around the proposed route, elevated construction noise levels at nearby receivers are inevitable at times.

78 I consider that the best practicable option for this Project is to ensure that construction noise effects are managed with the aim of meeting the Project construction noise criteria set out in Section 5.6 of my Report and any exceedances are addressed through noise management. Therefore, in my opinion, the CNVMP will play a pivotal role in ensuring that noise management for the Project is updated and relevant at all times.

POST-LODGEMENT EVENTS

79 As of 28 October 2010, the emergency ventilation building will not be required in Sector 8. Therefore, I have excluded the assessment of construction noise effects relating to these facilities[30] from my evidence.

COMMENTS ON SUBMISSIONS

80 I have read submissions lodged on the Project that raise construction noise and, in this section of my evidence, I will address these submissions.

Duration of construction noise effects

81 A number of submitters[31] are concerned about the long construction duration of the Project, and the associated ongoing noise issues with this period.

[30] Refer Section 8.8 of my Report.

[31] Including Submitter Nos. 10, 55, 72, 88, 117, 135, 136, 177, 191, 201 and 221.

82 As discussed both in my Report[32] and earlier in this evidence,[33] most construction activities will not occur continuously in the vicinity of individual receiver locations throughout the Project's entire construction process.

83 High noise generating equipment and activities, such as earthmoving machinery, piling and rock breaking, will be used during specified times only as required by the Project methodology. With the construction of the State highway, construction equipment will move along the alignment and thus be in the vicinity of noise sensitive locations for limited time periods only.

84 Some activities, such as the construction yards, will remain in the same location throughout the entire Project construction. These yards do not generally contain high noise generating equipment, with the exception of Construction Yards 6 and 10, which contain the concrete batch plants. I have recommended that the concrete batch plant equipment be fully enclosed[34] to reduce noise effects on neighbouring residences.

85 My assessment is based on a conservative scenario. Accordingly, noise levels will be below the levels I have predicted for most of the time.

86 Some submitters,[35] for noise mitigation reasons, seek to restrict construction activities to certain times of the day and certain days of the week. As noted above, construction will not occur continuously in the vicinity of individual dwellings. I consider that it is not practicable to allow for construction only during certain times of the day and that effects can generally be reasonably mitigated or managed.

87 Night-time works will generally be restricted to those related to tunnelling, where they are required to take advantage of the tide (Sectors 2 to 4) and avoid disruption to existing roads (Sectors 1 to 7). Other above-ground construction, especially in Sectors 8 and 9, will largely be restricted to daytime operations to avoid disturbance.

88 The aim is to achieve compliance with the Project noise criteria[36] as far as practicable, and manage exceedances appropriately by implementing the CNVMP.

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32 Refer Section 8 of my Report.

33 Paragraph 37.

34 Refer Sections 8.5.6, 8.9.9 and the Draft Concrete Batch and Crushing Plant Plan attached to my Report as Appendix E.

35 Including Submitter Nos. 55, 72, 98, 117, 166, 197, 201 and 240.

36 Refer Section 5.6 of my Report.

High levels of construction noise

89 A recurring concern of submitters[37] is the issue of high construction noise levels. The Standard recognises that construction noise levels are higher than those of normal ongoing operations and that there is a general acceptance that construction needs to be carried out without undue restrictions. Therefore, the criteria contained in the Standard are higher than the operational noise limits in the District Plan and the traffic noise criteria in NZS 6806:2010.

90 The construction noise criteria of the Standard reflect the need for times of rest, e.g. night-time and Sundays. However, where ambient noise levels are elevated due to extraneous noise sources, alternative criteria may be appropriate; I have determined construction noise criteria that I consider appropriate for the circumstances and locations where they are to be applied.[38]

91 As explained in paragraphs 81 to 85 above, for most areas, noise will not occur constantly throughout the entire duration of construction of the Project. However, while construction is being undertaken in the vicinity of dwellings, noise levels will be elevated.

92 The CNVMP[39] will contain mitigation and management measures that will be implemented to achieve compliance with the noise criteria recommended in my Report. Where full compliance is not practicable, appropriate responses will be formulated in the CNVMP, which will be communicated to the affected parties, including, for example, the temporary relocation of residents affected by high structure-borne noise levels from tunnelling and the notification of people within 200 metres of scheduled blasts.

Early placement of operational mitigation

93 Submitters[40] seek the placement of noise barriers required for the mitigation of operational (traffic) noise early in the construction process. I recommend the same mitigation several times in my Report.[41] Where traffic noise barriers can practicably be constructed early during the construction phase, they will provide shielding from construction noise.

Construction noise mitigation

94 Submitters[42] seek construction noise mitigation by means of barriers and planting. While I recommend the use of barriers as the most

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37 Including Submitter Nos. 13, 14, 23, 41, 55, 59, 61, 62, 65, 72, 98, 102, 106, 117, 125, 135, 149, 156, 165, 166, 184, 191, 192, 197, 201, 203 and 240.

38 Refer Table 5.5 in Section 5.6 of my Report.

39 Refer Draft CNVMP in Appendix C of my Report.

40 Including Submitter Nos. 179 and 211.

41 Sections 7.3, 8.1, 8.6.3, 8.6.6, 8.6.7, 8.9.3 and 9 of my Report.

42 Including Submitter Nos. 14 and 61.

common and widely used mitigation measure, planting of trees and other vegetation would act only as a visual shield and would not reduce noise levels.

Auckland Regional Public Health Service

95 The Auckland Regional Public Health Service (*ARPHS*) submission[43] discusses a number of issues, which I address in the following paragraphs.

Construction noise nuisance posing a risk to public health

96 Noise from construction is higher than from other noise sources. However, the noise criteria I have recommended in my Report, including the internal construction noise criteria (refer paragraph 28) are designed to manage noise effects to a reasonable level and are below those referenced by the Occupational Health and Safety Act, i.e. 80 dB $L_{Aeq(8h)}$[44]. The internal criteria proposed for the Project are as recommended by the WHO and are more stringent than those set out in the Standard.

97 Dr Black in his evidence discusses the potential effects of construction noise in relation to public health issues.

Low Frequency Noise

98 ARPHS notes that low frequency noise, which describes the range of 20 Hz to 160 Hz, is recognised as an environmental pollutant.

99 Construction noise, while containing a low frequency component, is generally a broadband noise source, with different equipment generating noise in all frequencies. I recommend using the construction noise criteria of the Standard, which have been used and tested on many large construction projects. In doing so, I consider any concerns regarding low frequency noise are appropriately addressed.

100 For internal noise criteria, I recommend using the guidelines of the WHO. The WHO guidelines are stringent and, in my opinion, will ensure that noise effects from all noise, including the low frequency component, will be appropriate.

Strict adherence to noise criteria

101 I recommend a set of internal and external noise criteria relating to construction noise, blast noise and structure-borne noise. While the aim for the contractor should be to adhere to these criteria at all times, there will be times when this is not practicable.

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[43] Submission No. 91.

[44] I note that for noise levels between 80 and 85 dB $L_{Aeq(8h)}$ hearing protection should be made available, and for noise levels above 85 dB dB $L_{Aeq(8h)}$ wearing of hearing protection is required.

102 Where exceedances occur, alternative strategies of noise management will be employed. Such strategies may include the temporary relocation of residents or the timing of activities to avoid sensitive times of the day. These management issues are anchored in the CNVMP,[45] which will be formulated and implemented by the contractor to respond to specific issues, such as high noise activities in the vicinity of hospitals, kindergartens, schools and dwellings.

Construction noise effects on Waterview Primary School

103 Construction noise effects on Waterview Primary School and Waterview Kindergarten are the subject of several submissions,[46] including from the School's Board of Trustees,[47] the Ministry of Education[48] and the Auckland Kindergarten Association.[49]

104 Waterview Primary School is in close proximity to the proposed cut-and-cover construction in Sector 7. I, and other members of the Project team, have met with representatives of Waterview Primary School and the Ministry of Education and discussed issues relating to the construction and operation of the Project, including noise effects.

105 To address noise from the cut-and-cover construction in Sector 7, I have recommended that the internal noise criteria of AS/NZS2107:2000 are used as a basis of assessment for internal noise levels from construction noise in classrooms.[50] I consider compliance with these criteria will require the installation of mitigation, e.g. a temporary construction noise barrier along the eastern school boundary (which would need to be at least 4 metres high to fully shield the school site) and the Herdman Street boundary (which would need to be approximately 3 metres above the school site, attached to the retaining wall and property fence currently existing along the street boundary, to shield the school buildings and fields from truck traffic on Herdman Street and the proposed construction yard in Waterview Park).

106 Since construction is a temporary activity, and will not be ongoing throughout the 5 to 7 years anticipated to be required for the entire Project, I recommend that the upper end of the internal noise criteria (AS/NZS2107:2000) be used for the construction noise assessment, i.e. 45 dB $L_{Aeq(6hr)}$. This level is appropriate, in my opinion, for a primary school teaching environment and has been

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45 Refer Draft CNVMP in Appendix C of my Report.

46 Including Submission Nos. 55, 136, 153, 175, 176 and 205.

47 Submission No. 175.

48 Submission No. 176.

49 Submission No. 153.

50 Refer Section 8.5.7 of my Report.

deemed acceptable for (ongoing) traffic noise for other roading projects.

107 In order to meet this internal noise criterion, external doors and windows may need to remain closed at times. For those classrooms where this would be required, alternative ventilation would need to be provided. However, with the installation of the temporary construction noise barriers recommended above, I anticipate that only those classrooms closest to the Sector 7 construction site are likely to need any further mitigation.

108 If construction noise does exceed the 45 dB $L_{Aeq(6hr)}$ noise criterion during school hours, alternative mitigation and management will need to be developed. Such mitigation may include the provision of improved glazing and alternative ventilation to those classrooms that would otherwise experience noise levels in excess of 45 dB $L_{Aeq(6hr)}$.

109 Any mitigation measures will need to be developed through ongoing consultation and communication with the school, and will be contained in the CNVMP.

110 A further issue raised by this group of submitters is the adverse effect of construction noise on outdoor play areas at the school. With the implementation of the temporary noise barriers, particularly along Herdman Street and the eastern school boundary, noise levels on the playing field will be similar to those currently experienced by children at other schools in the area, including St Francis School.

111 External noise levels on the playing fields will temporarily increase above existing levels during construction immediately adjacent to the school. However, with the implementation of noise mitigation measures as set out above and included in the CNVMP, I consider noise levels can be managed to be acceptable.

112 I understand from the NZTA that the Waterview Kindergarten will be relocated temporarily during construction. The new location of the kindergarten[51] will be sufficiently distant from Project construction so as to avoid adverse noise effects.[52]

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[51] Currently planned to be 17/19 Oakley Avenue, which is approximately 190 metres from Great North Road and shielded by several dwellings along Oakley Avenue.

[52] Refer evidence of Ms Linzey.

Construction noise effects on St Francis School

113 Construction noise effects on St Francis School are the subject of submissions,[53] including by the Principal of St Francis School,[54] and the St Francis School Board of Trustees.[55]

114 St Francis School classrooms are approximately 50 metres from the closest construction site (the ramp structure for the SH20-to-SH16 city-bound ramp). Construction at this location will be well shielded from the school by the terrain and the need for the ramp to be at a low level below Carrington Road bridge.

115 The construction yard closest to St Francis School is located 450 metres from the school in the Great North Road Interchange. At this distance, I anticipate that the school will not be affected by noise from the yard. With traffic noise from the existing SH16, construction noise from the yard will be mostly inaudible.

116 Further discussions with the Project team have resulted in the NZTA's post-lodgement proposal to include a 2 metre high boundary fence along the southern side of the St Francis School playing field. This boundary fence, in addition to shielding the school from traffic noise from Great North Road and SH16and providing mitigation from construction noise during the construction of the ramp, will improve the safety aspect of the school adjacent to the road.

117 Overall, I consider construction noise effects can be managed to have no more than minor effect on St Francis School.

Construction noise effects on 1510 Great North Road

118 The apartment complex at 1510 Great North Road contains student flats associated with Unitec. A number of submitters,[56] principally property owners and Unitec (the lessee of the property) have commented on the close proximity of Construction Yard 7 to the apartment complex, and the tunnelling below the apartment complex.

119 Construction Yard 7, while in close proximity to the apartments, will be laid out such that most noisy activities and equipment will be located at the northern end of the yard. The final yard layout will be determined by the contractor, with regard to the CNVMP. The yard's perimeter fencing, required for safety reasons, will consist of solid hoarding, which will act as a temporary construction noise barrier.

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53 Including Submission Nos. 92, 93 and 136.

54 Submission No. 92.

55 Submission No. 93.

56 Including Submitter Nos. 72, 98, 101, 106, 125, 149, 160, 166 181 and 240.

120 The apartments are used for residential use, therefore, the noise criteria of Table 5.5 of my Report will apply. Due to the existing elevated noise levels from traffic on Great North Road received by the apartments, I consider the recommended noise criteria of 70 dB L_{Aeq} daytime and 60 dB L_{Aeq} night-time are appropriate.

121 I note that works in the vicinity of 1510 Great North Road will not occur constantly over the entire (5 to 7 year) construction period, but will be intermittent. During extended periods, Construction Yard 7 will only be used for storage, and little noise will be generated during such times.

122 Tunnelling underneath 1510 Great North Road has been predicted to constitute a medium risk of vibration levels reaching building damage levels,[57] depending on the construction methodology. Consequently, structure-borne noise may also be high, and, depending on the construction methodology, may exceed the recommended internal criteria of Table 5.7 in my Report.

123 The northbound tunnelling works will commence at a distance of about 120 metres from the nearest building and there will be sufficient time to monitor and confirm compliance with the internal structure-borne noise criteria and be proactive in dealing with potential non-compliance. Should non-compliance be shown by monitoring, I recommend that alternative mitigation measures be implemented for this complex. Such measures may involve residents of 1510 Great North Road being temporarily relocated[58] until compliance can be achieved. If works below the building coincide with a time period such as the summer holidays, no residents may be present in the complex and effects could therefore be avoided.

North Western Community Association

124 The submission of the North Western Community Association[59] raises a number of noise issues, including concern about general construction noise effects (duration[60] and levels[61]), and specific construction noise effects on the Waterview Primary School and Kindergarten,[62] which are addressed above.

125 Noise effects arising from the construction of the Great North Road Interchange is also raised by this submitter. This construction work will generally be undertaken during daytime only. However, at

57 Refer Technical Report G.19, Section 5.6.8.

58 I anticipate that this should not exceed one week.

59 Submission No. 185.

60 Refer paragraph 81.

61 Refer paragraph 89.

62 Refer paragraphs 103 to 112.

times when connection to the existing SH16 is required and where construction works need to span across SH16, such as for the construction of the ramps, work will need to be undertaken at night-time so as to reduce disruption to motorway traffic. The construction of the Interchange will not occur continuously, and will not commence until further in the construction programme. The management and mitigation measures implemented throughout construction will be set out in the CNVMP.

Unitec

126 Unitec[63] is concerned about the effect of construction noise on the Unitec residential village at 1510 Great North Road. This site is discussed above.

127 Other matters raised in the Unitec submission include concerns regarding construction noise effects on Unitec Building 76, located east of Oakley Creek. This building is approximately 70 metres from the closest construction site. As noted in the discussion about 1510 Great North Road above, the perimeter fence of Construction Yard 7 will be a solid site hoarding, which will provide noise mitigation for activities inside the yard.

128 While construction yards are operated 24 hours per day, 7 days per week, not all activities will occur at all times, and night-time activities will be reduced. The contractor will develop and implement a CNVMP which will set out yard activities, equipment and layout and will take into consideration the location of noise sensitive receiver positions in the vicinity, such as the Unitec buildings and the residential village.

129 Unitec Building 1 will be in close proximity to some Project construction works, specifically the construction of the SH16 to SH20 southbound ramp. Construction in this area will be limited to the widening of SH16 and the connection of the ramp to SH16. Some of the works will need to be undertaken during night-time so as not to interrupt motorway traffic. Most of the construction works will be well shielded from Building 1 by topography.

130 I anticipate that construction noise effects at Building 1 will be minor. Nevertheless, when formulating the CNVMP, the contractor will be required to take into account all noise sensitive activities in the vicinity, including Unitec.

[63] Submitter No. 160.

Auckland City Council

131 Auckland City Council's (*ACC*) submission[64] discusses the following construction noise issues: receivers assessed, use of alternative construction noise criteria, use of barriers and improved building insulation for construction noise mitigation and assessment of L_{eq} compared with L_{max}. I address these issues individually below.

Receivers assessed

132 ACC requests that additional receiver locations are included in the assessment of construction noise effects, specifically those in Herdman Street, Parr Road, Bannerman Road and Cardigan Street. Table 3.1 in my Report sets out an overview of assessed locations, but is not intended to be a comprehensive list of all receivers. The closest positions in each Sector have been set out in Table 3.1, but others have also been assessed and will be included in the construction noise management and mitigation through the schedules in the CNVMP.[65]

Alternative Construction Noise Criteria

133 ACC requests clarification regarding the use of alternative noise criteria and the interpretation of the Standard.

134 The Standard notes, in Section 7.2.6, that for residential activities in commercial and industrial areas, site specific limits should be determined and existing high background sound levels should be considered. While the Standard references the "background plus" approach for residential activities in business areas, it acknowledges the influence of extraneous noise on the expectation of people in a given area.

135 The adoption of alternative construction noise criteria in such circumstances has occurred previously for numerous construction projects, including the Newmarket Viaduct, Vic Park Tunnel and ACC's own projects, such as resurfacing of roads during night-time in areas of high background noise.

136 The 'background plus' approach is a widely used and accepted tool for determining appropriate noise criteria for activities that are of limited duration, such as construction. I have noted previously that, while the overall construction period for the Project is 5 to 7 years, in the vicinity of individual dwellings, construction will only be undertaken during limited times.

137 I have undertaken noise level surveys of existing noise levels along the alignment, and have determined that noise levels in the vicinity of SH16 and Great North Road are elevated day and night, due to high traffic volumes on these roads. Therefore, setting a night-time

[64] Submission No. 111.

[65] Refer Draft CNVMP in Appendix C of my Report.

noise criterion of 45 dB L_{Aeq} as set out in the Standard would mean that the existing ambient noise level would be well above the criterion, which is not appropriate. Therefore, for areas already impacted by noise from other sources, i.e. Sectors 1 to 7, I have determined an appropriate noise criterion for night-time of 60 dB L_{Aeq}.

138 Noise level survey results are contained in Appendix D of my Operational Noise Effects report.[66] The survey values show that, generally, average night-time background noise levels for dwellings in Sectors 1 to 7 are above 45 dB L_{A90}.[67] Average noise levels L_{Aeq} for these positions are all elevated above the 45 dBA L_{Aeq} night-time noise criterion, and are as high as 68 dB L_{Aeq}. Therefore, I consider that requiring a construction noise criterion of 45 dB, as sought by ACC, is not appropriate for these locations.

139 Sectors 8 and 9 are less affected by extraneous noise sources, and therefore, I have recommended retaining the Standard night-time noise criterion of 45 dB L_{Aeq} for those Sectors.

Barriers and improved building insulation for construction noise mitigation

140 ACC requests that temporary or permanent noise barriers be used for sensitive receivers likely to be exposed to night-time construction noise levels of 60 dB or more. I already recommend the use of construction noise barriers as the main mitigation measure for all construction work, not only works occurring at night or for dwellings potentially receiving noise levels of more than 60 dB at night.

141 The contractor will be required to generate the lowest noise levels practicable at all times and achieve, as far as practicable, compliance with the criteria set out in the recommended construction noise conditions.[68]

142 I note that only limited night-time works are proposed. While tunnelling and associated works will need to occur continuously, and some works along the Causeway and in the vicinity of SH16 will need to occur at night, other construction activities will be undertaken during daytime only.

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66 Technical Report G.12.

67 L_{A90} levels are generally 1 decibel higher than L_{A95} levels. Previous versions of New Zealand Standards referenced L_{A95} levels as background noise levels, therefore, the noise level surveys include the L_{A95} levels rather than the L_{A90} levels.

68 Refer recommended condition CNV.2 in **Annexure A** of my evidence.

143 ACC seeks the installation of double glazing and/or ventilation for sensitive receivers likely to be exposed to night-time construction noise levels of 60 dB or more. I do not consider that this approach is suitable to be applied across the entire Project as a blanket measure. Providing building envelope improvements constitutes a major intrusion in people's lives and homes, and should only be applied on a case-by-case basis, as it is not as simple as installing upgraded glazing and ventilation. In some instances, buildings may already have suitable building envelopes and achieve reasonable internal noise levels, in other instances wall and ceiling insulation may be required in addition.

144 As noted above, night-time construction will be of limited duration in the vicinity of individual residences, and will generally be below the 60 dB criterion I have recommended. Insulation is a mitigation measure generally considered for permanent noise sources only, e.g. operational or traffic noise. Where building modification mitigation is required as the best practicable option for operational noise mitigation, this can be installed prior to construction and would therefore mitigate construction noise also.

145 However, I recommend the potential upgrade to building envelopes[69] for dwellings in Sector 9 where these are in close proximity to the proposed concrete batch plant. I have recommended such mitigation because the proposed batch plant will need to be able to operate at any time as required in order to ensure the safe construction of the tunnel. Therefore, in Sector 9 there is the potential for elevated night-time construction noise levels in an area of low ambient noise level where people have an expectation of quiet.

146 Another site where potential building envelope improvements may be considered is Waterview Primary School, but only with respect to daytime construction noise (refer paragraph 108 above).

L_{eq} versus L_{max}

147 ACC notes in its submission that the "group average sound power level" for each activity has been used to assess compliance. This is not correct. My Report, in Section 8, explains that the "maximum average" noise levels, i.e. at the nearest receiver, and the "Group L_{Aw}", i.e. the noise level from all equipment combined operating in a reasonable worst case circumstance, have been used to assess potential compliance with the criteria. I note that noise levels will generally be lower than those set out in the "maximum average" columns of the tables in Section 8 of my Report.

[69] Refer Sections 7.8, 8.9.10 and Appendix D of my Report.

148 The maximum noise levels (L_{max}) have not been included in the assessment tables. Maximum noise levels vary widely, depending on operator behaviour, maintenance and other factors. Therefore, my assessment has focussed on those noise levels that can be predicted with a degree of accuracy.

149 My recommendations relating to noise management on site, including personnel training and maintenance of equipment, are set out in Sections 7.1 and 7.2 of my Report and are included in the draft CNVMP attached to my Report.[70] I consider that these recommendations are the most appropriate measures to reduce maximum noise levels from construction works.

150 Barriers and enclosures, which are recommended in my Report and in the CNVMP for the mitigation of overall construction noise levels, will also mitigate noise from particular activities which cause maximum noise levels.

PROPOSED CONSTRUCTION NOISE CONDITIONS

151 In the documentation lodged with the AEE, the NZTA included a set of Proposed Consent Conditions (see Part E, Appendix E.1). The conditions included "Proposed Noise and Vibration Conditions – Construction", which I recommend would be appropriate to attach as conditions to the designations sought. A copy of the proposed conditions is contained in **Annexure A** to my evidence. The conditions contained in Annexure A cover both construction noise and construction vibration. Accordingly, some of the conditions are discussed in the evidence of Mr Peter Millar. I note also that I have prepared a separate set of conditions to address operational noise, which I discuss in my separate statement of evidence on operational noise.

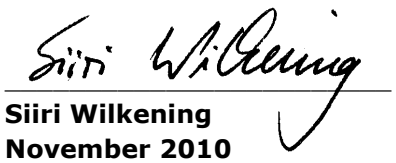
152 I consider that the proposed (construction) noise and vibration conditions are still appropriate. However, Mr Millar has added a new condition, CNV.1 xiii, and amended condition CNV.5(c), which are discussed in his evidence. Additionally, I have recommended alterations to the conditions as set out below.

153 In response to submissions received, and as discussed above, I have added a new condition CNV.2 iv which sets out internal construction noise criteria for licensed educational facilities in the vicinity of the Project. These criteria are taken from

[70] See Appendix C to my Report.

AS/NZS2107:2000 and represent the maximum recommended design sound levels for particular spaces in educational facilities.[71]

154 Condition CNV.2 iii is intended to apply to structure-borne noise generated by tunnelling below dwellings. I have clarified this in the heading of the table. Also, the time reference for the structure-borne noise criteria contained an error, which I have corrected.



Siiri Wilkening
November 2010

Annexure A: Proposed Noise and Vibration Conditions – Construction (with amendments)

[71] Refer Table 1 "Recommended design sound levels for different areas of occupancy in buildings" in AS/NZS 2107:2000.

ANNEXURE A: PROPOSED NOISE AND VIBRATION CONDITIONS – CONSTRUCTION (WITH AMENDMENTS) [72]

CNV.1	The NZTA shall implement and maintain a Construction Noise and Vibration Management Plan (CNVMP) throughout the entire construction period of the Project. The CNVMP shall describe the measures adopted to, as far as practicable, meet: (a) the noise criteria set out in Condition CNV.2 and 3 below; and (b) the vibration criteria set out in Condition CNV.~~3~~4 below. The CNVMP shall, as a minimum, address the following: i. Construction noise and vibration criteria; ii. Hours of operation, including times and days when noisy and/or vibration inducing construction activities would occur; iii. Machinery and equipment to be used; iv. Vibration testing of equipment to confirm safe distances to buildings prior to construction; v. Preparation of building condition surveys of critical dwellings prior to, during and after completion of construction works; vi. Roles and responsibilities of personnel on site; vii. Construction operator training procedures; viii. Methods for monitoring and reporting on construction noise and vibration; ix. Mitigation options, including alternative strategies where full compliance with the relevant noise and/or vibration criteria cannot be achieved; x. Management schedules containing site specific information; xi. Measures for liaising with and notifying potentially affected receivers of proposed construction activities; ~~and~~ xii. Methods for receiving and handling complaints about construction noise and vibration~~.~~; and xiii. Measures for preventing the occurrence of rogue fly rock, including management of charge weights and face loading procedures, stemming of charge holes and profiling of the face to maintain minimum burden (face cover).

[72] Amendments to the proposed conditions as lodged are shown in underline and strikethrough.

CNV.2

Construction noise (excluding noise from blasting Monday to Saturday inclusive) shall be measured and assessed in accordance with NZS 6803:1999 "Acoustics - Construction Noise" and shall, as far as practicable, comply with the following criteria:

i. Project Construction Noise Criteria: Residential Receivers

Time of week	**Time period**	**Project Construction Noise Criteria (Long Term Construction) dB**		
		Sectors 1 to 7	Sectors 8 and 9	All Sectors
		$L_{Aeq(10–60\ min)}$	$L_{Aeq(10–60\ min)}$	L_{AFmax}
Monday – Saturday	0630-0730	60	45	75
	0730-1800	70	70	85
	1800-2000	65	65	80
	2000-0630	60	45	75
Sundays and Public Holidays	0630-0730	45	45	75
	0730-1800	60	45	85
	1800-2000	45	45	75
	2000-0630	45	45	75

ii. Project Construction Noise Criteria: Commercial and Industrial Receivers

Time period	**Project Construction Noise Criteria (Long Term Construction) dB**
	$L_{Aeq(10\ to\ 60\ min)}$
0730-1800	70
1800-0730	75

CNV.2 cont.

iii. Project Construction Noise Criteria: Internal Structure-borne Noise for Residential Receivers

Time period	Project Construction Noise Criteria Inside Habitable Rooms	
0600-2200 ~~0730-1800~~	35 dB $L_{Aeq(16hr)}$	All habitable rooms
2200-0600 ~~1800-0730~~	30 dB L_{Aeq}~~(16hr)~~(8hr)	Bedrooms

iv. Project Construction Noise Criteria: Internal Noise for Licensed Educational Facilities

Time period	**Project Construction Noise Criteria Inside**	
0900–1500	45 dB $L_{Aeq(6hr)}$	Classrooms, libraries, offices
0900–1500	40 dB $L_{Aeq(6hr)}$	School halls

CNV.3

Project Construction Noise Criteria: Airblast (excluding Sundays)

Category	Type of Blasting Operations	Peak Sound Pressure Level (L_{Zpeak} dB)
Human Comfort Limits		
Sensitive Site	Operations lasting longer than 12 months or more than 20 Blasts	**115 dB** for 95% blasts per year. **120 d**B maximum unless agreement is reached with occupier that a higher limit may apply
Sensitive Site	Operations lasting less than 12 months or less than 20 Blasts	**120 dB** for 95% blasts per year. **125 dB** maximum unless agreement is reached with occupier that a higher limit may apply
Occupied non-sensitive sites such as factories and commercial premises	All blasting	**125 dB** maximum unless agreement is reached with the occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specifications of levels that can be shown to adversely affect the equipment operation
Damage Control Limits		
Structures that include masonry, plaster and plasterboard in their construction and also unoccupied structures of reinforced concrete or steel construction	All Blasting	**133 dB** unless agreement is reached with owner that a higher limit may apply.
Service structures such as pipelines, powerlines and cables located above ground	All Blasting	Limit to be determined by structural design methodology

CNV.~~3~~ 4	Construction vibration received by any building shall be measured and assessed in accordance with the German Standard DIN 4150-3:1999 "Structural vibration – Part 3: Effects of vibration on structures", and shall, as far as practicable, comply with the criteria set out in that Standard.
CNV.~~4~~ 5	Notwithstanding Condition CNV.~~3~~4 above, (a) Blasting activities shall be conducted so that 95% of the blasts undertaken (measured over any twenty blasts on the foundation of any building outside the designation boundary) shall produce peak particle velocities not exceeding 5mm/s and 100% of the blasts undertaken shall produce peak particle velocities not exceeding 10mm/s irrespective of the frequency of the blast measured. (b) Construction activities, which occur within Sectors 1, 6, 8 and 9 and, which are identified in Technical Report no. G.19 Assessment of Vibration Effects, as being at a 'High Risk' of exceeding the DIN 4150-3:1999 criteria (being excavation, piling, compaction and drilling) shall be conducted so that 95% of the activities undertaken (measured over at least 20 representative samples of the relevant activity on any residential building) shall produce peak particle velocities not exceeding the relevant criterion in DIN 4150-3:1999 and 100% of the activities undertaken shall not exceed 10mm/s irrespective of the frequency of the activity measured.
CNV.~~5~~ 6	Blasting shall be undertaken between 09:00h and 17:00h, Monday to Saturday, except that blasting may be undertaken between 09:00h and 17:00h on Sundays where: (a) The blasting is at least 50m inside the Sector 8 tunnel; (b) The blasting produces peak particle velocities at any residential building not exceeding 0.5mm/s; and (c) The Project construction noise criteria set out in CNV.2 (i)–(iv) ~~(iii)~~ for Sundays is complied with.