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 Peter Millar (Vibration) on behalf of the **NZ Transport Agency**

Dated: 9 November 2010

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INDEX

STATEMENT OF EVIDENCE OF PETER MILLAR ON BEHALF OF THE NZ TRANSPORT AGENCY

INTRODUCTION

1 My full name is Peter James Millar.

2 I am employed by Tonkin & Taylor Ltd, an environmental and engineering consultancy firm. I have recently stepped down from the role of Managing Director and am currently a senior geotechnical engineer and Tonkin & Taylor's Business Development Manager. I am based in the company's Auckland Office.

3 I hold the degree of Masters of Engineering 1st Class from the University of Auckland. I am a Fellow of the Institution of Professional Engineers New Zealand, a member of the New Zealand Geotechnical Society Inc and New Zealand Society for Earthquake Engineering Inc. I was the joint recipient of the first NZ Geotechnical Society Award.

4 I have 37 years post-graduate experience in geotechnical engineering. My Masters' thesis work involved a study of the slope stability and strength of weathered and jointed rock. I was then employed by the Ministry of Works and Development for 17 years during which time I undertook design of the Rangipo Underground Power Station caverns and tunnels followed by a period of construction supervision on this project.

5 During the latter 10 years of my employment with the Ministry, I was section manager of the geomechanics group, and undertook investigations and geotechnical design on many major hydroelectric and roading projects throughout New Zealand. This included work on a number of tunnel projects as well as geophysical investigations and assessments of construction vibrations.

6 Since joining Tonkin & Taylor in 1987, I have provided specialist geotechnical services on many projects in New Zealand and the South-East Asia Pacific region. Over the past 23 years I have been responsible for the design of foundations of many of the major building developments in the Auckland CBD, which are constructed in similar geological conditions to the Waterview Connection Project (Project). I have also held senior technical roles in and been a Board member of the Northern Gateway Alliance, which has undertaken design and construction of both the Albany to Puhoi Motorway and the replacement of the Newmarket Viaduct.

7 I have provided technical advice on the effects of ground transmitted vibrations for many projects in the Auckland Region. This includes undertaking assessments for development of a number of quarries, including Hunua, Bombay, Whangaripo, Pokeno,

Portland, Hikurangi, Kerikeri and Three Kings. These quarry projects all included the use of blasting techniques, rock breaking and other heavy construction plant. I have also undertaken vibration assessments for a number of tunnel projects in Auckland, including the Vector tunnel and the Hobson Bay tunnel.

8 I have been responsible for determining the vibration effects for redevelopment of the Lunn Ave Quarry at Mt Wellington (also known as Stonefields).

9 I was the design engineer responsible for ground improvement works for strengthening foundations using dynamic compaction for Te Papa Museum in Wellington, Sir Edmund Hillary Retirement Village, construction at Pike's Point, and numerous oil storage tank farms around New Zealand. The effects of generated vibrations were major considerations for all of these projects.

10 I have carried out many assessments of traffic, rail and construction plant-induced vibrations. These assessments included site testing for effects of traffic on the Kerikeri Stone Store, and the effects of traffic on MRI Scanners at Auckland, Hamilton and Tauranga Hospitals. I have also assisted Councils and the NZ Transport Agency (NZTA) on many projects where traffic-induced vibrations have been significant issues for consents, and I have provided advice for preparation of proposals for District Plan rules for limiting the effects of vibrations.

11 My evidence is given in support of notices of requirement and applications for resource consents lodged with the Environmental Protection Authority (EPA) by the NZTA on 20 August 2010 in relation to the Project. The Project comprises works previously investigated and developed as two separate projects, being:

11.1 The State Highway 16 (SH16) Causeway Project; and

11.2 The State Highway 20 (SH20) Waterview Connection Project.

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

13 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

14 My evidence will deal with the following:

14.1 An executive summary of my evidence;

14.2 My background and role in the Project;

14.3 A summary of the assessment of vibration effects for the Project;

14.4 Post-lodgement events;

14.5 Comments on submissions; and

14.6 Proposed Vibration Conditions.

EXECUTIVE SUMMARY

15 My evidence addresses the likely effects of vibration that will be caused by construction and operation of the Project.

16 During construction of the Project, the principal sources of vibration will be blasting of basalt rock, tunnelling in the East Coast Bays Formation, piling, heavy truck movements and road base compaction work.

17 To ensure there is no damage to residential structures and sensitive buildings from vibration during construction of the Project, I have recommended consent/designation conditions that limit the transmitted vibration levels to the criteria included in the DIN 4150 Standard, applied using a statistical design procedure. Compliance with this recognised standard will also ensure that vibrations will not cause unacceptable disturbance to residents. A draft Construction Noise and Vibration Management Plan has been developed as a tool to provide guidelines for design, monitoring and mitigation of effects of vibration during construction.

18 Once operational, vibrations generated from the road will be effectively continuous. I conclude that the levels of vibrations transmitted to residential and sensitive structures by traffic operations will be negligible such that the effects on people will be less than minor and there is no risk of damage.

BACKGROUND AND ROLE

19 The NZTA retained Tonkin & Taylor as part of a consortia team to assist with investigation and reporting on the Project, including scheme design engineering services. I was Tonkin & Taylor's key representative for this phase of the Project.

20 James Whitlock of Marshall Day Acoustics (MDA) was asked by the NZTA to prepare an Assessment of Vibration Effects Report (Report) in relation to the potential vibration effects from construction and operation of the Project. I was asked to contribute data and to peer review the Report. I also assisted with drafting the proposed vibration conditions that were lodged with the application documents.

21 The 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.19).

SUMMARY OF ASSESSMENT OF VIBRATION EFFECTS

22 In this section of my evidence I will briefly describe the methodology for the assessment underlying the Report and the Report's key conclusions.

Summary of Methodology

23 The methodology we employed to assess the effects of vibration in relation to the Project can be divided into eight broad steps:[1]

23.1 Reviewing the applicability of vibration standards (if any) currently applied by Auckland City Council, Waitakere City Council and Auckland Regional Council, and standards previously used in similar projects. Due to the variation between international standards, the NZTA commissioned a review of vibration standards as a separate body of work,[2] which was, in turn, referenced by the Report.

23.2 Adopting relevant vibration standards (based on the review of standards discussed in 23.1 above) to develop appropriate "Project Criteria" for vibration.[3]

23.3 Establishing, through measurement, the current ambient vibration conditions for receivers who may in future be affected by vibration from the Project.

23.4 Identifying those Project construction activities likely to generate significant vibration levels and considering which construction activities will occur in each Project Sector.

23.5 Sourcing vibration data from historical measurements of sources relevant to the Project.

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1 Refer Section 2.0 of the Report.

2 Refer Appendix C to the Report

3 Refer Section 3.3 of the Report.

23.6 Analysing the collected vibration data and using prediction models to calculate the ground attenuation between each construction source and any sensitive receivers.[4]

23.7 Assessing predicted vibration levels against the Project Criteria and identifying any sensitive receivers that are at risk of criteria exceedance.

23.8 Outlining mitigation options should any vibration levels be found to exceed the Project Criteria.

24 In my opinion, the above methodology was robust and provides a good basis for assessing the effects of vibrations for the Project.

Summary of Assessment

25 As described in the Report, Mr Whitlock undertook detailed assessment of construction and operation vibration effects for the Project.[5] Mr Whitlock's assessment identified and quantified potential vibration risks associated with the Project's construction activities, and the likelihood of ongoing effects from traffic vibration on the new carriageway following completion of the Project.

26 The vibration assessment draws on data obtained through on-site measurements of existing vibration environments,[6] review and implementation of historical construction vibration measurements, and the use of empirical prediction models. It also references guidelines and standards that have been developed based on practice to both limit the potential for damage to structures and to ensure the level of public disturbance is within established acceptance criteria

Construction Vibrations

27 To date, the use of the collected historical dataset of construction vibration measurements has provided general guidance on safe distances for construction plant and activities, which has, in turn, allowed identification of at-risk receivers. However, to refine the prediction models for the Project and, hence, the risk categories, site-specific measurements are going to be needed for the Project once construction equipment has been selected. To this end, I agree with the recommendation set out in the Report that a comprehensive vibration assessment will be needed during the early stages of Project construction.

28 The assessment of potential building damage, which is the focus of the assessment for the Project construction phase, is based on

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4 Refer Appendix A of the Report for definitions.

5 Refer Section 5.6 of the Report

6 Refer Section 4.0 of the Report.

German Standard DIN 4150-3:1999 (DIN). The DIN is the vibration standard most commonly used in New Zealand.

Blasting activities

29 I anticipate that the Project's most significant vibration effects are likely to come from the excavation of basalt rock in Sectors 6 and 9.[7] In my opinion, the blasting programme will need to be carefully designed and monitored to ensure the resulting vibration levels are kept within the Project Criteria, as far as practicable. In general, initial predictions of construction vibration levels indicate there is some degree of risk that the Project Criteria may be exceeded at the dwellings nearest to blasting activities.[8] Accordingly, I concur with Mr Whitlock's recommendation that a Construction Noise and Vibration Management Plan (CNVMP) be developed as the tool to ameliorate this risk. The CNVMP should outline the methodology for assessing, managing and mitigating the Project construction effects. A draft CNVMP is attached as Appendix K to the Report.

30 With respect to blasting activities, the CNVMP should require that, prior to construction commencing, site testing be carried out to establish attenuation relationships for peak particle velocity (PPV) of the expected vibrations based on the principal variations of distance and maximum instantaneous charge weight. The maximum instantaneous charge weight (MIC) is the maximum charge weight detonated at any instance when using an array of charged holes, which are fired in sequence with delays between charges to control fragmentation and limit the cumulative vibration effects.

31 Once a statistical relationship for PPV as a function of MIC and distance can be identified, the CNVMP should allow design of charges based on a 95% compliance level with the conservatively based DIN guidelines and a 100% compliance with a PPV of 10 mm/s. These statistical limits recognize that changes in geology and surface topography may affect blast characteristics, but the limits will still ensure there is a very low probability of any cosmetic damage to property. The recommended statistical limits provide a high level of confidence against any potential for structural damage. This statistical design approach promotes use of best practice methods while ensuring the blast design is not unnecessarily conservative.[9] The flow chart referenced in Appendix C of the draft CNVMP provides a process for establishing the statistical relationships, then monitoring and reporting of blasting activities.

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7 Refer Section 5.5.1 of the Report.

8 See **Annexure A** of my evidence (which is a copy of Appendix J of the Report).

9 It also has the consequent benefits of minimising the number of holes to be drilled and the number of changes and time required to complete the works.

Other activities

32 It is noted that for much of the construction works, including tunnelling, the works will advance relatively quickly and the effects, on any receivers, will therefore be intermittent or of relatively short duration.

33 The levels of vibration during construction will be sufficient to be detected by residents in the area but, provided the vibration levels remain below the DIN criteria (i.e. building damage criteria that will govern the levels of vibration permitted by these activities) and work is undertaken in compliance with the proposed conditions and the draft CNVMP, vibration should not cause an unacceptable level of disturbance.[10]

Operational Vibrations

34 The assessment of human response to vibration, which is most relevant to operational effects once the Project is complete, is based on the Norwegian Standard NS 8176.E:2005.[11] The operational (principally traffic) effects of the Project will be below the building damage threshold but will be continuous and therefore have a greater potential to create physiological effects (hence the use of the Norwegian 'human response' standard). People are particularly sensitive to vibrations at night when background levels of vibrations are reduced and people are in a horizontal position.

35 The assessment of operational vibration effects undertaken by Mr Whitlock has predicted these effects to be negligible, provided the road surface of the new motorway is maintained in accordance with NZTA standard policy.[12] I concur with this assessment and further note that I do not expect that operational activities complying with these human response criteria will result in any potential for damage to structures.

Recommendations

36 The assessments of construction and operational vibration (set out in detail in the Report) lead me to the following recommendations:

36.1 Prior to commencement of construction of the Project, an ambient vibration survey should be undertaken involving measurements at locations nominated by the NZTA.

36.2 A CNVMP should be developed, with contents in accordance with Section 5.2 of the Report.

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10 Refer Sections 5.6 and 5.7 of the Report.

11 Refer Section 6.2 of the Report.

12 Refer Section 6.4 of the Report.

36.3 Project construction should be measured and assessed in accordance with the DIN standard and should, as far as practicable, comply with the criteria in that Standard.

36.4 Blasting activities should generally be undertaken between 0900 – 1700hrs, Monday to Saturday, with blasting occurring on Sundays in only very specific circumstances (as set out in proposed Condition CNV.6), such circumstances may include unexpected and isolated zones of hard rock being encountered in the tunnel.

37 Overall, I consider the Project can be constructed and operated such that adverse vibration effects can be avoided, remedied or mitigated.

POST-LODGEMENT EVENTS

Addendum

38 A brief addendum[13] to the Report was lodged with the EPA on 20 September 2010, addressing regenerated noise. The type of equipment selected to excavate the tunnel will affect the levels of vibration and noise generated at the ground surface by the tunnel excavation. The relatively weak East Coast Bays Formation rock, which is expected to be encountered over the full length of the tunnel, should allow excavation with relatively low powered equipment. Therefore, transmitted vibrations at the nearest residential buildings are expected to be below perception levels.

39 The addendum notes that there is potential, however, for associated regenerated noise (i.e. the faint noise or 'hum' that may be heard when equipment operating at a constant speed causes walls and floors to vibrate and radiate noise) to impact on residents, particularly if large full face tunnelling equipment is employed using a continuously rotating excavation head. The potential impact of regenerated noise is addressed in the evidence of Ms Siiri Wilkening.[14]

Flyrock

40 The use of explosive charges for excavation of the basalt rock at St Lukes (Sector 6) and the northern portal (Section 9) requires the use of controlled blasting practices. Controlled blasting will ensure that the rock fragments in the required manner and that transmitted vibrations do not exceed permitted limits. The blasting also needs to be designed to exclude any potential for ejection of rock beyond the controlled zone. This is known as flyrock.

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[13] Technical Addendum Report, G.31, Appendix 7.

[14] In her construction noise evidence, Ms Wilkening refers to regenerated noise as 'structure-borne' noise. They are the same thing.

41 Best practice to exclude flyrock involves rock face profiling (to accurately trace the rock face and ensure adequate cover to charges – burden), accurate drilling and placement of charges to ensure that the correct quantity of explosives is used, adequate stemming of the top of the charged holes, use of blast mats to contain and direct energy from the blasts, and use of accurate electronic delay detonators.

42 Subsequent to lodgement, however, I noticed that there was no condition recommended to ensure such best practice. Therefore, I have recommended that a new condition addressing flyrock be included in the proposed conditions – see **Annexure C**, new condition CNV.1(xiii).

COMMENTS ON SUBMISSIONS

43 A number of submissions have been received that reference the effects of vibration. In this section of my evidence I address these submissions, grouped by issue and/or location.

Auckland City

44 Auckland City Council[15] seeks that vibration arising from blasting and pile driving activities be monitored and not exceed the levels of German Standard DIN 4150: Part 3 (1986) as applied in the Council's District Plan, Rule 8.8.2.7 – Isthmus Section.

45 The draft CNVMP[16] recommends the use of the current (1999) DIN 4150 standard applied using a statistical basis for limiting vibration levels, rather than the outdated 1986 standard. The vibration limits recommended by the DIN 4150 standard were unchanged between the 1986 and 1999 version. The 1999 DIN standard (applied using a statistical basis) is widely used in the construction industry and has been accepted by Auckland City in the past as providing an acceptable management method that encourages use of best practice. The flow chart included in Appendix C of the draft CNVMP shows the reporting processes that are recommended for application of the DIN 4150 standard.

46 In my opinion, the Project Criteria proposed in the Report are appropriate to ensure there is a less than minor risk of damage to structures.

Vibrations above Sector 8 – the tunnel alignment

47 A number of submissions,[17] which relate to properties in Craddock Street, Hendon and Bollard Avenues and to the Pak 'n Save on New North Road, identify concerns about vibrations over the proposed

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15 Submitter No. 111.

16 Appendix K to the Report.

17 Submitter Nos. 22, 76, 102, 118, 135, 165, 184, 223 and 230.

tunnel alignment. These concerns relate to vibrations induced by construction, traffic operations and truck movements along the local streets.

48 The depth to the tunnel alignment beneath these properties is generally in the range of 20-40 m. The levels of vibrations generated by the tunnel excavation and ground support methods are not expected to result in transmitted vibration levels at ground level that will exceed the Project Criteria (particularly, DIN 4150). This lack of transmitted vibration will limit the potential for any damage to residential structures.[18] While the vibrations complying with the Project Criteria may be discernable to residents, they should not result in discomfort. It is noted that the excavation works will progress relatively quickly (3-10 m/day for each construction phase) so the exposure to any discernable vibrations will be for relatively short periods. The requirement in the draft CNVMP for notification of works generating vibrations should also assist in allaying concerns of residents.

49 It is recognised however, that some tunnelling methods may result in a level of regenerated noise (as noted earlier, this is the faint noise or 'hum' that may be heard when equipment operating at a constant speed causes walls and floors to vibrate and radiate noise). This is addressed in evidence by Ms Siiri Wilkening.

50 I expect the vibration levels generated by traffic during operation of the tunnels will be low and will not be discernable at the surface.

51 Apart from New North Road, where Pak 'n Save is located, the locations of the submitters' properties are not expected to be subject to significant heavy traffic movements during the construction phase of the Project. Hence there will be no significant effects on these residents. The level of additional heavy traffic on New North Road is not expected to be significant, relative to existing traffic levels.

52 The Stella Maris Trust[19] has particular concerns about effects of blasting on septic tanks. Most properties in the Project area are serviced with waste water collected in the Auckland City Sewer system, so any concerns regarding septic tanks will involve a very small number of properties. There will also be some properties that will rely on pumping and these systems may use an underground storage chamber. Many properties in the areas underlain by basalt rock will rely on soakage for stormwater disposal and these properties may include soakage chambers.

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[18] At vibration levels complying with the Project Criteria, it is most unlikely that buildings with any existing structural defects would sustain any structural damage.

[19] Submitter No. 135.

53 The tolerance of underground structures to vibration levels causing damage is generally greater than surface structures. Hence, vibrations that meet the DIN 4150 standard are most unlikely to result in damage to any underground services or water treatment systems.

Properties at distance from construction activities and submissions on general concerns for the community

54 Submissions[20] were received from property owners who are located at a distance where they are unlikely to be affected by vibrations generated by Project construction and operational activities. These submissions are of a general nature and are concerned that vibration levels experienced from construction and operations should not increase above current levels. I confirm that effects on these properties from vibration will be no more than minor.

55 The proposed Conditions will limit vibration levels generated by the Project construction works and traffic operations to within tested and widely accepted criteria that have previously been established as meeting the concerns of residents while permitting works and activities to progress.

Te Atatu Interchange

56 Ms Allen at 3/356a Te Atatu Road has submitted[21] that noise and vibrations during construction may affect the health of residents. 356a Te Atatu Road is located close to the western approach to the Te Atatu Interchange.

57 The upgrading of the interchange as part of the Project will involve construction works that will generate vibrations from plant operations and vehicle movements. It is proposed in the draft CNVMP to monitor and limit vibration levels to ensure the construction methods used do not exceed the Project Criteria. The levels of vibration generated by plant operating near 36a Te Atatu Road will be discernible but will occur over a relatively short period.

58 I consider the proposed Project Criteria, together with the CNVMP, will appropriately mitigate any risk of damage or impact on health due to the effects of construction vibrations at this property.[22]

1510 Great North Road

59 Submissions[23] have been made by a number of hostel apartment owners in the complex at 1510 Great South Road, which is located

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[20] Including Submission Nos. 14, 121, 185 and 186.

[21] Submitter No. 201.

[22] Refer to evidence of Dr Black.

[23] Submitters including Apartments Ltd (No. 72), Body Corp 212138 (No. 98), Townscape Securities (No. 101), Hallen Ltd (No. 106), J&R Family Trust (No. 117), Robyn Frond (No. 125), Gavin Brown (No. 149), C Kwan and L Yeoh (No. 166), Stewart Holdings (No. 181) and Lim Hak Teck (No. 240).

on the eastern side of Great North Road. The submissions are generally concerned about unacceptable levels of vibrations due to the shallow depth of construction and seek a clearance depth of at least 60 m to the works.

60 I note this property is identified in Section 5.6.8 of the Report as having medium risk from effects of vibrations.

61 The proposed northbound tunnel alignment extends beneath the eastern edge of the northern hostel building at 1510 Great North Road, with about 18 m clearance of the tunnel crown to ground level for the northern building. The southern hostel extends over the northbound tunnel and has 23m clearance.[24] The eastern leading edge of the northern building is founded on driven timber piles, while the remainder of the buildings are on shallow footings. The depth to unweathered East Coast Bays Formation rock beneath the property is approximately 5m below ground level, so it is unlikely that the piles have extended beyond this depth, i.e. clearance to the crown of the tunnel from the tip of the piles will be at least 10 m.

62 The timber piles of the hostel building will not exhibit strong vibration transmission properties, so the attenuation properties of the natural ground in the vicinity will govern.

63 The level of vibrations experienced in the buildings at 1510 Great South Road from a road header or other mining type excavation equipment are expected to be small. Such plant is expected to operate within the vibration limits of the DIN 4150 limits at about 4m from a residential building. At about 15m distance, the vibration levels will still be perceptible but should not cause disturbance provided they comply with proposed Conditions and the draft CNVMP.[25] If full face tunnelling methods are used for tunnel construction, the transmitted vibrations should still be within the recommended limits, but regenerated noise levels may occur as discussed in the evidence by Siiri Wilkening. The northbound tunnelling works will commence at a distance of about 120m from the nearest building. Accordingly, there will be time to monitor and confirm compliance for the excavation methods.

64 Several submitters sought a 60m clearance for the tunnel works in general. I understand this depth is not possible at 1510 Great North Road given geometric constraints and the proximity of the tunnel

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[24] Information derived from Riley Consultants Report "Geotechnical Investigation, Unitec Residential Village, 1510-1544 Great North Road, Waterview", Ref 99298-B, 18 May 2001.

[25] Section 12.10 of the draft CNVMP (Appendix K to the Report) notes "At commencement of construction, noise levels from tunnelling are expected to be above the Project night-time noise criteria. Where the tunnelling has not yet progressed deep inside the tunnel, a restriction to daytime operation may be required until sufficient depth is obtained to mitigate noise."

portal, but in any event I consider that such a clearance is unnecessary to ensure vibration levels are within acceptable limits, particularly as the period of excavation should be relatively short. I consider the tunnel excavation, lining and fit-out works may be completed with the transmitted vibrations at the ground level foundations of the buildings at 1510 Great North Road being limited to those recommended in the proposed Conditions.

170 Stoddard Road – Auckland Samoan Assembly of God[26]

65 The Auckland Samoan Assembly of God is located adjacent to the proposed Maioro Road Interchange. This submitter is concerned that vibrations will seriously affect the enjoyment of religious services and other activities on its property. Ground conditions at this property are expected to comprise deep alluvial soil deposits. Construction equipment required to undertake the construction works for the Maioro Road Interchange will involve conventional road building plant as well as piling equipment for founding of elevated structures. The absence of hard rock, such as basalt, in this area will mean that vibration levels generated by construction equipment will not be high and the soils will cause rapid attenuation of energy.

66 I consider that the levels of vibrations from construction activities that will be experienced in the buildings at 170 Stoddard Road will not exceed the Project Criteria.

Waterview Primary School and Kindergarten

67 The Ministry of Education, the Waterview Primary School Board of Trustees, and the Auckland Kindergarten Association submissions[27] note concerns with the effect of vibrations on the school and kindergarten. The Waterview Primary School is located at 19 Oakley Avenue. The closest school buildings are about 20 m from the proposed SH20 alignment. It is understood that it is also proposed to relocate the Waterview Kindergarten to Oakley Avenue, but not closer to the Project construction works. The submissions identify concerns about intrusive levels of vibration during construction and particularly mention effects on activities in the School Hall.

68 The construction of the walls for the cut-and-cover tunnel section of the Project will involve large piling and diaphragm wall equipment. The vibration levels generated by this plant are expected to be within the DIN 4150 limits at the school boundary, which will ensure there is no damage to the school buildings. Vibrations from these operations will be discernible, but should not cause discomfort. Works will progress relatively quickly, at a rate of about 2m/day, so

[26] Submitter No. 177.

[27] Submission Nos. 153, 175 and 176.

the period of any potential disruption to school activities due to any vibration effects should be limited.

Auckland Regional Public Health[28]

69 The submission of Auckland Regional Public Health notes general concerns about the impacts of vibrations due to construction and operations of the Project, seeking to ensure that there is no effect on public health.

70 The vibration limits that have been recommended for construction of this Project (i.e. the Project Criteria) provide a margin to ensure that there is no damage to residential buildings, such as cracking of plastered joints let alone any structural damage, which would require a higher level of vibration. Provided these limits are met, vibrations may be perceptible, but should not result in significant disturbance to people and will be well below the levels of vibration required to cause a risk to health.[29] I note, however, that when construction activities are continuous over long periods, limits should be reduced to improve tolerance to disturbance. Limits for continuous vibrations are provided in the DIN standard, which is included in the recommended Project Criteria for control of vibration levels during construction.

71 During operations of the new motorway, the levels of vibrations generated by traffic are expected to be low, provided the road surface is maintained in good condition. Based on my experience of measuring vibrations caused by heavy traffic on motorway systems, I do not expect the levels of transmitted vibrations at the edge of the road designation to exceed the physiological or structural limit criteria that have been recommended as part of the Project Criteria for sensitive receivers.

72 Auckland Regional Public Health also suggested a 'hotline' to allow people who consider themselves affected by activity on site (especially at night) to speak directly to a person with authority to moderate activities. Such a 24 hour 'hotline' is provided for in the draft CNVMP.[30]

Unitec[31]

73 Unitec has expressed concern about vibrations caused by plant operating in Construction Yard 7, which is adjacent to the student hostel, and about potential damage to Building 1 (former Oakley Hospital Building), which is a heritage structure.

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28 Submitter No. 91.

29 Refer to evidence of Dr Black.

30 CNVMP (Appendix K to the Report), section 10.

31 Submitter No. 160.

74 The plant operating in Yard 7 will be subject to the same vibration controls as the rest of the Project, with vibrations limited to the levels recommended by the DIN standard. These include controls for intermittent and continuous vibrations sources that will ensure there is no damage to structures and that the levels are generally acceptable to people. These levels have been determined from international experience and, while they are likely to be perceptible, should not cause disturbance to residents or other occupants.

75 The former Oakley Hospital Building is identified in the Report as a low to medium risk building as the northern corner is located about 10 m from the edge of the designation. Widening of the cut in this area may require excavation of basalt rock, which may be achieved through the use of a rock breaker or through blasting. These works will need to be carefully controlled to ensure there is no damage to the structures.

76 The DIN standard includes lower criteria for sensitive and historic structures. If the condition survey (required by proposed condition CNV.1(v) and outlined in the draft CNVMP) identifies that the former Oakley Hospital Building is sensitive to vibrations, I recommend that the lower DIN criteria be applied. If any blasting occurs in this Sector (Sector 6) it will need to start in an area remote from the Oakley Hospital Building to enable the attenuation characteristics of the rock to be established and the charge arrays to be optimised before commencing blasting close to the building.

77 I consider that the application of "The Sensitive Building Recommended Limits" of DIN 4150 included in the Project Criteria for blasting will ensure there is less than minor risk of damage to the former Oakley Hospital Building.

Transpower Submission

78 Transpower seeks conditions to ensure there is no potential for damage to transmission lines caused by vibrations during construction. The transmission lines traverse Sectors 1 and 2 and include a number of transmission towers in the vicinity of proposed construction works. The scope of works expected for these areas includes piling, bridge construction, general earthworks and pavement construction. I consider the proposed Conditions will be adequate to ensure there is no risk of damage to these lines.

PROPOSED VIBRATION CONDITIONS

79 In the documentation lodged with the AEE, the NZTA included a set of Proposed Consent Conditions (see Part E, Appendix E.1). These conditions included proposed vibration conditions, relating to both the operation and construction periods, which I and Mr Whitlock (the Report author) recommended would be appropriate to attach as conditions to the designations and consents sought. A copy of the

'Proposed Vibration Conditions - Operation' is contained in **Annexure B** to my evidence, and the 'Proposed Noise and Vibration Conditions – Construction' are attached as **Annexure C**. (The latter conditions also include conditions to address construction noise, which are discussed in the evidence of Ms Siiri Wilkening.)

80 I consider that the proposed vibration conditions are still appropriate, with the exception, as previously noted, of the need to add a new condition to address flyrock to ensure best practice methods are used. Also, Ms Wilkening and I have amended the proposed Conditions to clarify their application to blasting activities, particularly on Sundays.

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Peter Millar
November 2010

Annexure A: Blast Risk Diagrams for Sectors 6 and 9

Annexure B: Proposed Vibration Conditions - Operation

Annexure C: Proposed Noise and Vibration Conditions - Construction (with amendments)

ANNEXURE A: BLAST RISK DIAGRAMS FOR SECTORS 6 AND 9

Alignment

Base Alignment (December 2009)

Planning Information

SH20 Draft Footprint (01/07/10)

Risk

- High Risk
- Medium Risk
- Non-residential receivers: Low - Medium Risk due to more heavyweight structure

N

Approximate Map Scale 1:3883 at a3

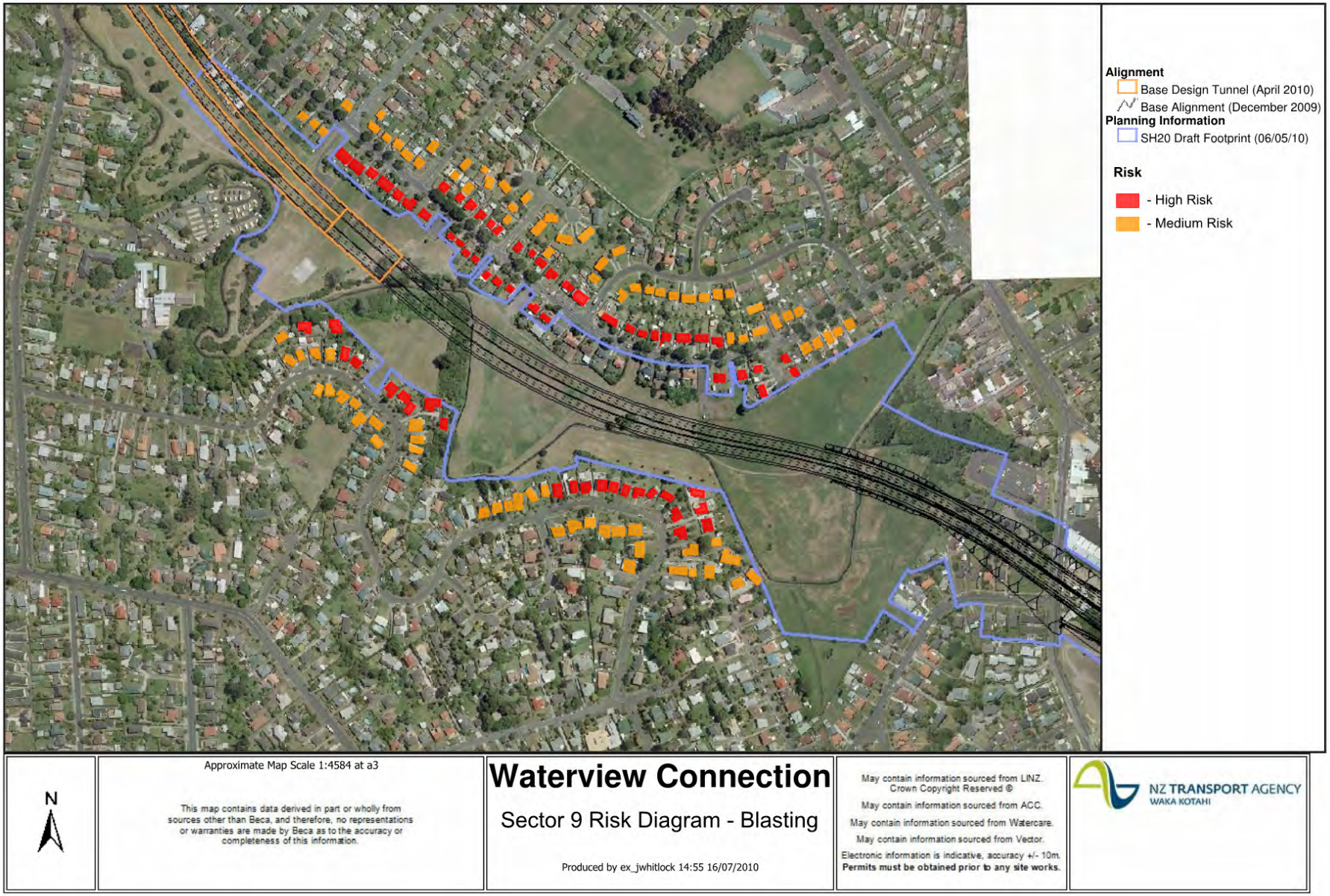
This map contains data derived in part or wholly from sources other than Beca, and therefore, no representations or warranties are made by Beca as to the accuracy or completeness of this information.

Waterview Connection

Sector 6 Risk Diagram - Blasting

Produced by ex_jwhitlock 09:12 20/07/2010

NZ TRANSPORT AGENCY
WAKA KOTAHI


Alignment
Base Design Tunnel (April 2010)
Base Alignment (December 2009)
Planning Information
SH20 Draft Footprint (06/05/10)
Risk
- High Risk
- Medium Risk
N
Approximate Map Scale 1:4584 at a3
This map contains data derived in part or wholly from sources other than Beca, and therefore, no representations or warranties are made by Beca as to the accuracy or completeness of this information.
Waterview Connection
Sector 9 Risk Diagram - Blasting
Produced by ex_jwhitlock 14:55 16/07/2010
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Permits must be obtained prior to any site works.
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ANNEXURE B: PROPOSED VIBRATION CONDITIONS – OPERATION

V.1	Existing ambient vibration levels shall be measured at critical locations nominated by the NZTA, and submitted to the [Auckland Council] prior to the commencement of works. These baseline measurements will establish pre-Project vibration levels for comparison with future vibration levels.

ANNEXURE C: PROPOSED NOISE AND VIBRATION CONDITIONS – CONSTRUCTION (WITH AMENDMENTS)[32]

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).

[32] 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)~~(18hr)	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.