

Before the Board of Inquiry
Waterview Connection Project

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

Rebuttal evidence of **Gavin Alexander (Ground Settlement)** on behalf of the **NZ Transport Agency**

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REBUTTAL EVIDENCE OF GAVIN JOHN ALEXANDER ON BEHALF OF THE NZ TRANSPORT AGENCY

INTRODUCTION

- 1 My full name is Gavin John Alexander. I refer the Board of Inquiry to the statement of my qualifications and experience set out in my evidence in chief (*EIC*) (dated 9 November 2010).
- 2 I repeat the confirmation given in my EIC that I have read and agree to comply with the Code of Conduct for Expert Witnesses in the Environment Court.

PURPOSE OF EVIDENCE

- 3 The purpose of this rebuttal evidence is to respond to certain aspects of the evidence lodged by submitters. Specifically, my evidence will respond to the evidence of:
 - 3.1 Mr Jinhu Wu (Submitter No. 59-1¹) of 103 Hendon Avenue;
 - 3.2 Mr Andrew Tauber, Apartments Ltd (Submitter No. 75-1) (1510 Great North Road);
 - 3.3 Ms Angela Bull, The National Trading Company of New Zealand Ltd (Submitter No. 76-1);
 - 3.4 Mr George Richardson, Townscape Securities Auckland Ltd (Submitter No. 101-1) (1510 Great North Road);
 - 3.5 Mr Paul Conder, Unitec Institute of Technology (Submitter No. 160-1);
 - 3.6 Mr Brett Skeen, Waterview Primary School Board of Trustees and Ministry of Education (Submitters Nos. 175 and 176-3); and
 - 3.7 Ms Wendy John, Friends of Oakley Creek (Submitter No. 179-1).
- 4 In addition, I will comment on relevant aspects of the Supplementary Section 42A Report on Groundwater and Settlement prepared by Earthtech Consulting Ltd (*Earthtech*) dated 23 December 2010 (*Earthtech Section 42A Report*).

¹ References are to the Submitter's Evidence as listed on the EPA website.

- 5 This evidence also includes comments on further amendments to the proposed Ground Settlement conditions discussed and agreed during expert caucusing.²

JINHU WU – GROUND SETTLEMENT AND TILTING ADJACENT TO HENDON AVENUE

- 6 In paragraph 5(d) of his evidence, Mr Wu expresses concern that settlement resulting from nearby tunnel construction will cause the ground to slope, resulting in damage to the properties at 101, 103 and 105 Hendon Avenue. I spoke to Mr Wu on 29 January 2011 to confirm that I have correctly interpreted his ground settlement concerns.
- 7 Annexure A to my EIC shows total estimated ground settlements resulting from tunnel construction. The settlement estimated in the vicinity of 103 Hendon Avenue is around 20mm, with a change in slope (differential settlement) of 30mm in 30m (i.e. 1 in 1000). Building damage generally does not occur until differential settlements are considerably greater than this. Ground conditions and the proposed construction works adjacent to the adjoining properties are similar. As a result, I expect settlements and the resulting change in slope at 101 and 105 Hendon Avenue to be equally small.
- 8 I do not expect building damage to occur at 101, 103 and 105 Hendon Avenue as a result of these relatively small movements, and explained this to Mr Wu when we spoke on 29 January 2011.

ANDREW TAUBER AND GEORGE RICHARDSON – DAMAGE ATTRIBUTED TO THE VICTORIA PARK TUNNEL PROJECT

- 9 In paragraph 5(d) (page 9) of Mr Tauber's evidence, he refers to damage occurring to a garden area that has been attributed to the nearby construction work for the Victoria Park Tunnel. Similarly, on page 5 of Mr Richardson's evidence, he states that the Victoria Park Tunnel is causing damage beyond the area expected, due to settlement and vibration.
- 10 As stated in paragraph 2.5 of my EIC, I have an ongoing review role on the Victoria Park Tunnel project. The heavy civil construction aspects of that project are now well advanced. My geotechnical colleagues on site collect and review the monitoring data (which includes settlement, vibration and groundwater levels), and were closely involved in assessing possible linkages between the garden effects described by Mr Tauber (which relate to a property at

² As at the date my rebuttal evidence was finalised, the expert report following the Stormwater, Groundwater and Contamination caucusing session held on 26 January 2011, which I attended, had not yet been signed, so I have not attached it to my rebuttal.

25c Ring Terrace, St Mary's Bay) and the Victoria Park Tunnel project.

- 11 I am advised by my colleagues that there have been no recorded settlements beyond the trigger levels nominated in the Victoria Park Tunnel consent conditions. In other words, ground settlements resulting from that project have been well within the calculated range. Interestingly, seasonal ground movements of up to 30mm have been recorded independent of any construction activities.
- 12 There has been only one exceedance of nominated vibration limits on that project, which occurred during bored piling at the base of the remnant sea cliff along St Mary's Bay. That event was investigated and piling practices modified. No damage was attributed to that exceedance.
- 13 I have discussed the garden subsidence and collapse reported by Mr Tauber with my colleagues. I understand that the cause of the ground movement at that property (and consequent linkage to the nearby construction project) is disputed and continues to be investigated.
- 14 In my view, both Messrs Tauber and Richardson overstate the damage resulting from the Victoria Park Tunnel Project.

**ANDREW TAUBER AND GEORGE RICHARDSON –
CONSTRUCTION RISK, DAMAGE POTENTIAL AND REPORTING
FOR 1510 GREAT NORTH ROAD**

- 15 In paragraph 5(d) (pages 8 and 9) of Mr Tauber's evidence, he refers to NZTA reports indicating damage will occur as a result of the Project. That is correct. The Assessment of Ground Settlement Effects report (*Report*) specifically addresses the buildings at 1510 Great North Road (Unitec One).³
- 16 In section 3 (page 11) of Mr Richardson's evidence, he expresses concerns about the risk to occupants if the damage predictions are wrong. In section 6 (page 12), he refers to the risk of differential settlement as a result of groundwater table changes on the mixed foundation system, and requests consideration in far more detail before approval is given.
- 17 Slight (Category 2) settlement damage is predicted at Unitec One, largely as a result of the mixed foundation system supporting these buildings. The likely effects are described in Table 4.5 of the Report, and are not expected to interfere with the occupation of these buildings.

³ Section 5.3.2.4, Assessment of Ground Settlement Effects, Technical Report G.13.

18 The buildings at 1510 Great North Road are specifically identified in proposed Settlement conditions S.10 and S.11 as requiring monthly visual inspections and settlement and/or wall inclination monitoring during the period of active construction. This will provide ongoing confirmation of the appropriateness of the settlement and damage predictions and the opportunity for mitigation measures to be adopted if estimated movements or damage levels appear likely to be exceeded.

19 In paragraph 7 of his evidence, Mr Tauber requests the immediate commissioning of comprehensive foundation reports analysing the probable impact on Unitec One. In my view, the probable groundwater changes and settlements at the site have been assessed to an appropriate level for this stage of the Project development. This conclusion is supported by the Earthtech Section 42A Report which states in the Executive Summary that:

Best practice investigations, interpretation and analysis techniques have been used to assess the potential settlements arising from construction of the Waterview Connection Project (SH20 sectors).

20 In Section 4.1 (p.13), Earthtech states that:

The Application provides adequate details of the types of buildings and services within the predicted settlement zone.

21 While more detailed assessments will undoubtedly be carried out in the course of detailed design, in my opinion the proposed settlement and building damage category limits provide certainty that the related construction effects will be managed, mitigated and repaired.

22 This issue was discussed in expert witness caucusing on ground settlement on 26 January 2011, which I attended. While a caucusing statement has not yet been signed,⁴ I understand the experts to have agreed to amend Ground Settlement conditions S.1 and S.7 so that they refer to the predicted building damage category limits (from G1 to G4). I support that amendment.

ANGELA BULL – FURTHER AMENDMENTS TO GROUND SETTLEMENT CONDITIONS

23 Ms Bull, on behalf of The National Trading Company of New Zealand, proposes some further amendments to the amended proposed Ground Settlement conditions contained in Annexure D to my EIC.

24 I support the further amendments proposed by Ms Bull in Schedule 1 to her statement of evidence. At caucusing, the experts agreed to

⁴ As of the time this rebuttal was finalised.

those amendments and agreed that they should be incorporated into the amended Ground Settlement conditions.⁵

PAUL CONDER – ADDITIONAL UNITEC BUILDINGS TO BE MONITORED

- 25 In paragraph 7.1 of Mr Conder's evidence, he requests that Unitec Buildings 310 to 313 are added to the schedule of buildings requiring monitoring. The nearby Building 76 is specifically identified in the proposed Ground Settlement condition S.7 because of its historic importance.⁶ Other buildings in the vicinity fall within a zone where total estimated settlement is greater than 50mm, and will be subject to pre- and post-construction condition assessments as a precautionary measure in accordance with the proposed Ground Settlement conditions S.7 to S.9 and S.12.
- 26 I inspected Buildings 310 to 313 in December 2010. These buildings are in good condition and appear well built. They lie in a zone where 20mm to 50mm settlement is estimated.
- 27 Negligible building damage is predicted to these buildings, as is the case for all of the Unitec buildings in this area. The monitoring proposed for the other buildings is purely precautionary.
- 28 Nonetheless, I discussed this further with Mr Conder on 27 January 2011 and accept his concerns regarding the potential effects of settlement damage to these buildings. As a result, I have added Buildings 310 to 313 to the buildings identified in Ground Settlement condition S.7 as being potentially at risk and hence subject to inspection.

BRETT SKEEN – STRENGTHENING OF THE WALLS AND FOUNDATIONS OF THE WATERVIEW PRIMARY SCHOOL HALL AND ANNEX

- 29 In paragraph 40 of Mr Skeen's evidence, he requests mitigation measures to the school hall and annex to ensure these buildings continue to be useable. At point c, he proposes strengthening of the walls and foundations.
- 30 I inspected these buildings in December 2010 and observed that they are of relatively flexible construction, broadly consistent with Building Type 2 (as described in Section 5.3.2.2 of the Report). Negligible damage from ground settlement effects is predicted.
- 31 Given the importance of these buildings to the school and community, I added them to the list of buildings to be subject to

⁵ These conditions are also included in the NZTA's latest master set of proposed conditions (attached to the rebuttal evidence of Amelia Linzey).

⁶ See Annexure D to my EIC.

monthly visual inspection during the active construction phase, as set out in proposed Ground Settlement condition S.10.⁷ Such regular inspections will allow any damage, while not expected, to be identified and mitigated in a timely manner.

- 32 In my view, precautionary strengthening of the walls and floors is only warranted when severe damage or greater (as defined in Table 4.5 of the Report) is predicted and the building is to remain occupied throughout construction. I therefore do not agree with Mr Skeen's suggestion that the walls and foundations of the School hall and annex should be strengthened.

WENDY JOHN – STABILITY OF THE BANKS OF OAKLEY CREEK

- 33 Ms John, in paragraph 7.1 of her evidence, expresses concern that:

...ground settlement may cause instability of the stream banks and trigger slips, thereby releasing sediment into (Oakley) Creek.

- 34 This issue has also been raised in the Earthtech Section 42A Report on groundwater and settlement,⁸ and was discussed during expert caucusing on 26 January 2011. The experts agreed that localised effects on stream bank stability from the Project will be no more than minor.

COMMENTS ON SECTION 42A REPORTS

Earthtech Section 42A Report on Groundwater and Settlement

- 35 Earthtech has prepared a Supplementary Section 42A Report on groundwater and settlement effects of the Project. That report formed the basis of much of the expert caucusing on ground settlement. In this section, I comment on the settlement aspects of that report.
- 36 In general, Earthtech appears to agree with the extent of the studies undertaken, the methodologies adopted for estimating settlement and the resulting damage, the conclusions reached in terms of potential settlement related damage, and the available methods for mitigation.⁹
- 37 Earthtech correctly observes¹⁰ that the plan showing total estimated settlement (Figure E14 of Technical Report G.13 reproduced as Annexure A to my EIC) is truncated at each end. I have prepared

⁷ See Annexure D to my EIC.

⁸ Earthtech Section 42A Report at paragraphs 4.2.2 and 4.4.

⁹ Earthtech Section 42A Report Executive Summary.

¹⁰ Page 12 of the Earthtech Section 42A Report.

an updated version of this plan to correct this, and attach it as **Annexure A** to my rebuttal evidence.

- 38 Earthtech recommends that definitive limits be placed on ground settlement resulting from the Project, and on the consequent damage, in order to provide certainty to all parties. This reflects concerns identified by EMS,¹¹ that evaluation of compliance with conditions should be against clear objectives and performance measures. Earthtech proposes modifications to the NZTA's proposed Ground Settlement conditions in this regard, and recommends¹² that the Ground Settlement conditions adopt the currently estimated settlements (Figure E14, as updated in **Annexure A** to my rebuttal evidence and building damage categories, Figures G1- G4 as limits, to provide certainty that the effects will be no more than predicted. I accept the reasoning for this recommendation, and consider that the suggested alert level (75% of the predicted total settlement at the monitoring location) and alarm level (100% of the predicted total) recommended by Earthtech (as a new sentence at the end of condition S.2) are reasonable.
- 39 During expert caucusing, I understand the experts agreed to refer specifically to updated Figure E14 and G1 to G4 in Ground Settlement conditions S.1 and S.7, to provide greater certainty.
- 40 Allowance for seasonal movements must, however, be incorporated in finalised trigger levels. I understand that the experts agreed at caucusing to add the following new wording to Ground Settlement condition S.2 to incorporate this allowance.

Each Framework Marker shall have an alert and alarm level set in relation to Figure E14, where alert = 75% of the theoretical value and alarm = 100% of the of the theoretical value with due consideration of the seasonal range of ground movement identified by pre-construction monitoring.

- 41 Earthtech identifies two areas of concern where local conditions may result in different (and possibly greater) damaging effects than might be predicted from (what it terms) the "smoothed" geological model that forms the basis of the current assessment.¹³ These areas of concern relate to the effects of:
- 41.1 Marked localised changes in the underlying geology causing greater differential settlement beneath buildings, and;
- 41.2 Existing areas of marginal slope stability along and above the banks of Oakley Creek.

¹¹ Paragraph 3.9.3 of EMS' Addendum Report.

¹² Section 6.3 of the Earthtech Section 42A Report.

¹³ See Section 4.2 of the Earthtech Section 42A Report.

42 I will address each in turn.

Local variations in ground conditions and resulting differential settlement

43 While over 300 machine bores have been put down in the course of geotechnical investigations for the Project, there are gaps where access has not been possible. Further, there is a finite amount of detail that can reasonably be investigated and modelled at this (or in fact any) stage of the Project. The current geological model is a simplified approximation of reality that is designed to identify the likely effects of the Project. That is appropriate (and not unusual) for a project of this nature and size at this stage of its development.

44 The general settlement monitoring programme (comprising framework and intermediate markers) is intended to validate the design assumptions and allow predictions of ground settlement, and enable the resulting effects to be updated and refined as the Project proceeds. Areas where local variations in ground conditions lead to larger settlements than predicted can be identified from that monitoring, and appropriate responses developed.

45 It will be important to predict (in the course of detailed design), and then monitor, differential settlement at critical locations during construction. The selection of those critical locations should, in my view, target particular elements (buildings or infrastructure) that are considered to be particularly sensitive to differential settlement. For this reason, the NZTA's proposed Ground Settlement condition S.11 identifies structures where monthly level and/or wall inclination monitoring is to be undertaken.¹⁴

46 This monitoring will quantify the differential settlement occurring at those locations. As a result of expert caucusing, additional differential settlement monitoring is proposed in those areas where there are no currently identified sensitive buildings.¹⁵ When combined with monthly visual inspections (Ground Settlement condition S.10), differential settlement (and any resulting damage) will be identified as it develops, allowing mitigation measures to be implemented.

47 In Earthtech's proposed amendment to Ground Settlement condition S.2(a), it suggests that pairs of settlement markers are installed either side of the alignment on each cross section used for settlement estimates to determine differential movements. These markers are to be within 20m of each other and no more than 150m from the alignment.¹⁶

¹⁴ See Annexure D to my EIC. I note that Earthtech recommends no changes to that condition S.11.

¹⁵ I understand this is to be reflected in an additional Ground Settlement condition S.17, which specifically addresses differential settlement.

¹⁶ See Appendix C2 to the Earthtech Section 42A Report.

- 48 For condition S.4, Earthtech proposes an alert level for differential settlement across a pair of markers of 1 in 1000, and an alarm level of 1 in 500.
- 49 I see little value in terms of managing and minimising damage resulting from differential settlement from these proposed amendments. Figure E14 of Technical Report G.13 shows considerable areas where the orange coloured 100mm to 200mm settlement zone is less than 30m wide. This implies an average gradient of 100mm or more in 30m, equivalent to 1 in 333 or steeper. The alarm level proposed by Earthtech would be triggered by the predicted settlement, an event that the proposed monitoring regime is already designed to manage.
- 50 The approach suggested by Earthtech in its Report, while appropriate and valuable in many types of applications, is less sophisticated (in terms of identifying the potential for building damage) than that originally proposed for this Project in the conditions contained in Annexure D to my EIC. Accordingly, I do not agree with Earthtech's proposed amendments to conditions S.2 and S.4 as far as they relate to differential settlement.
- 51 If additional monitoring of differential settlement is proposed, then trigger values should be assessed in relation to predicted movements and the sensitivity of the particular structure to differential movement. I understand that new condition S.17 was agreed in expert caucusing to address this issue. That condition will require alert and alarm levels to be set based on the calculated differential settlements at the monitoring location and consistent with the relevant calculated Building Damage Category (Figures G1-G4).
- Stability of the banks of Oakley Creek***
- 52 In section 4.2.2 of Earthtech's Section 42A Report, it notes that the effects of tunnel related settlements on the Oakley Creek slopes have not been addressed in the technical reports or evidence to date. Ms Wendy John also expresses concern about stream bank stability.¹⁷
- 53 Of particular relevance to this issue, and not previously described in my EIC, is work I undertook from 1994 to 1996 (for Auckland City Council) assessing bank stability of Oakley Creek and then designing and implementing stabilisation measures along selected portions of Oakley Creek throughout and beyond the area affected by the Project. That work has provided me with a detailed understanding of the conditions along either side of Oakley Creek.
- 54 I share Earthtech's view that there are "over-steepened slopes" that have, in places, been built on or over. Some locations have been

¹⁷ Paragraph 7.1 of Ms John's evidence.

pointed out to me during consultation meetings, and I (or my colleagues) have inspected them. I have also re-inspected particular areas below Waterview Downs and at 1590A Great North Road that I was aware of from my earlier work.

- 55 The potential effect of settlement on the landfill slopes at Phyllis and Harbutt Reserves, which occupy much of the elevated eastern side of the Creek along the driven tunnel portion, was assessed as part of the work supporting Technical Report G.13, and is discussed in Section 5.3.5.2 of that Report. I understand the experts to have agreed at caucusing that ground settlement effects on these landfills are no more than minor.
- 56 In general, the estimated settlement trough is extremely flat in relation to the existing slopes, so effects are expected to be minor to none. The Creek lies to the east of the alignment from approximately Ch2500 to Ch3150 (which Earthtech refers to as Waterview Heights), so the estimated settlement will, if anything, reduce the steepness of the existing western slopes, increasing (slightly) their stability.
- 57 From approximately Ch3150 to Ch3400, the Creek lies to the west of the alignment and the settlement trough will slightly steepen the existing western slopes, potentially slightly reducing their stability. The slope at 1590A Great North Road lies in this area. Beyond Ch3400, the Creek returns to lie east of the alignment, so settlement effects on the western slopes will be beneficial, if anything.
- 58 Tunnel construction is predicted to result in lowering of groundwater levels, with a gradual recovery to near present levels. This groundwater lowering can be expected to have a beneficial (rather than detrimental) effect on slope stability, if anything.
- 59 Proposed Ground Settlement condition S.16 (Annexure D to my EIC), identifies all properties where owners have expressed concerns about slope stability or particular susceptibility to movement. Geotechnical investigations of those slopes or sites are required, along with monitoring throughout the active construction period and remedial action, if necessary. Condition S.16 does not limit the investigations and monitoring to just the properties listed in condition S.16. All slopes or sites that are identified as being susceptible to movement will need to be addressed. The amendments to Ground Settlement condition S.16 agreed at expert caucusing provide greater assurance that potentially affected slopes or sites will be identified during the initial pre-construction assessments and will be appropriately managed.
- 60 Section 4.4 of the Earthtech Section 42A Report requires a specific assessment of the effects of settlement on stability of the Oakley Creek banks. I understand that the experts agreed in caucusing

that this requirement is adequately addressed by the (new) amended condition S.16.

- 61 Ms John's concern appears to be more related to the stability of the immediate stream banks. These are susceptible to erosion, undermining and collapse during times of high flow, a natural occurrence which deposits sediment into the stream. Much of my earlier work on Oakley Creek related to reducing the potential for such damage. In my view, it is highly unlikely that the extremely minor changes in bank steepness resulting from the estimated settlements will adversely affect bank stability such that the extent or frequency of this naturally occurring instability is increased to any measurable degree. I understand the experts agreed with this view during caucusing.

Other condition changes recommended by Earthtech

- 62 I do not agree with Earthtech's complete rewrite of Ground Settlement condition S.4 which removes the requirement to use settlement and groundwater monitoring results to update the settlement and damage prediction.¹⁸ The intention of the initial condition wording was to develop increasingly refined predictions as the Project proceeds, and to regularly test these predictions against the initial expectations. In my view, Earthtech's suggested amendments diminish the value of the monitoring programme and I therefore do not agree with them. The amended conditions agreed by the experts at caucusing retain this requirement.
- 63 Earthtech recommends (in condition S.4) immediate resurvey of markers that exceed alert or alarm levels. I agree with this, and suggest defining immediate as "within 24 hours" to provide certainty.
- 64 Earthtech proposes in condition S.4 that these exceedances are reported to the Manager (Auckland Council). In my view, the reporting is most appropriately and effectively done monthly, in accordance with condition S.6.
- 65 Earthtech has also added requirements for interpretation and discussion of exceedances to condition S.6. I agree with this suggestion, and it is incorporated in the amended conditions agreed by the experts during caucusing.
- 66 Earthtech proposes adding reference to Figures E14 and Figures G1–G4 in condition S.7. I agree with this suggestion, and as I explained earlier in my rebuttal, the experts agreed in caucusing to incorporate this reference in Ground Settlement condition S.7.
- 67 In condition S.10, Earthtech recommends adding a requirement that inspections shall only be undertaken with the approval of the owner.

¹⁸ See Section 6.3, page 22 of the Earthtech Section 42A Report.

I disagree with this addition, as all of the identified buildings are listed in condition S.7 and owner permission is a requirement of condition S.8.

- 68 I note that Earthtech recommends no changes to Ground Settlement conditions S.3, S.5, S.8, S.9, and S.11 to S.16.

Section 42A Report and Addendum Report

- 69 In paragraph 10.10.103 of the Section 42A Report, and in the table of matters requiring consideration in section 3.7 of the Addendum Report, EMS seeks technical consideration of possible adverse effects on operational septic tanks. This issue was discussed at expert caucusing, both in regard to the property located at 7 Bollard Avenue and to other septic tanks in general.¹⁹
- 70 The experts agreed in caucusing that operational septic tanks should be assessed in areas where 50mm or more ground settlement is predicted. I understand that operational septic tanks will be added to the list of "at risk" buildings and structures in Ground Settlement condition S.7.
- 71 With reference to Figure E14, total ground settlement of 5-10mm is estimated at 7 Bollard Avenue. The experts agreed that the potential ground settlement effects on the septic tank at that property will be no more than minor.



Gavin Alexander
February 2011

¹⁹ The Stella Maris Trust of 7 Bollard Avenue (Submitter No. 135) raised this issue in its submission.

**ANNEXURE A: UPDATED FIGURE E14 FROM TECHNICAL REPORT
G.13**

