Before a Board of Inquiry
MacKays to Peka Peka Expressway Proposal

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under: the Resource Management Act 1991

in the matter of: Notice of requirement for designation and resource consent applications by the NZ Transport Agency for the MacKays to Peka Peka Expressway Proposal

applicant: **NZ Transport Agency**
Requiring Authority

Statement of rebuttal evidence of **Gavin Alexander** (Ground Settlement) for the NZ Transport Agency

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STATEMENT OF REBUTTAL EVIDENCE OF GAVIN ALEXANDER FOR THE NZ TRANSPORT AGENCY

1 My full name is Gavin John Alexander.

2 I have the qualifications and experience set out at paragraph 2 in my evidence in chief, dated 3 September 2012 (*EIC*).

3 I repeat the confirmation given in my EIC that I have read, and agree to comply with, the Code of Conduct for Expert Witnesses (Consolidated Practice Note 2011).

4 In this statement of rebuttal evidence, I respond to the evidence of:

4.1 **Ms Emily Thomson** on behalf of Kāpiti Coast District Council (KCDC) (682);

4.2 **Dr Hugh Cherrill** on behalf of Save Kāpiti Incorporated (505);

4.3 **Ms Helen Rutter** on behalf of Dr Christopher and Mrs Monica Dearden (261);

4.4 **Mr David Roil** on behalf of Waikanae on One (541);

4.5 **Ms Beth Lindsay** on behalf of Highway Occupants' Group (542); and

4.6 **Mr Philip Nordberg** on behalf of Mrs Ann Laing (337).

5 While this rebuttal statement does not respond to every ground settlement matter raised in the evidence of submitter witnesses, that should not be taken as acceptance of the matters raised. Rather, I rely on my earlier technical reports,[1] my EIC and this rebuttal statement to set out my opinion on what I consider to be the key ground settlement matters for this hearing.

6 Consistent with my EIC, I have referred to the MacKays to Peka Peka Expressway Project as "the Project" in this rebuttal evidence.

EXECUTIVE SUMMARY

7 This statement of evidence largely responds to that of Dr Cherrill, who contends that Technical Report 35 may have significantly underestimated the ground settlement effects that will result from the Project. I have examined each of the components of Dr Cherrill's argument and conclude that his underlying assumptions and hence his conclusions are not valid in this case.

[1] Technical Report 35 (Assessment of Ground Settlement Effects) and Technical Report 36 (Geotechnical Interpretive Report).

8 I have considered the matters raised in the evidence of several other submitters and respond to those items which are related to ground settlement or geotechnical engineering and which I have not already addressed through my Technical Reports or in my EIC.

EVIDENCE OF SUBMITTERS

Ms Emily Thomson for KCDC

9 Ms Thomson[2] recommends changes to proposed condition G.29 to include base level monthly groundwater level monitoring to commence at least one year prior to construction commencing. This appears to be based on the groundwater evidence of Mr Brydon Hughes.[3]

10 I do not consider that the amendment to condition G.29 is needed. That is because baseline groundwater level monitoring is already proposed in revised condition GD.2(c) annexed to the EIC of **Ms Ann Williams** (Annexure B) and a one year minimum period is proposed.

11 I support base level monitoring and make two general observations:

11.1 Firstly, representative groundwater monitoring should be carried out for as long as practical ahead of construction in areas where groundwater level changes are considered possible. One year is a practical minimum to appreciate the potential seasonal range, and is already proposed in condition GD.2(c).

11.2 Secondly, the minimum monitoring period should be tied to physical construction works that may have a measurable effect on groundwater levels commencing in any particular part of the Project, rather than to the commencement of construction of the Project as a whole. I propose that condition GD.2(c) be amended to reflect this and have included a proposed amendment in **Annexure A** to my rebuttal as follows:

> "… for a period of at least 12 months (where practicable) before the commencement of construction <u>that may affect groundwater levels in the area of monitoring</u> …" (new words underlined).

Dr Hugh Cherrill for Save Kāpiti Incorporated

12 Dr Cherrill, in his Executive Summary, considers that the magnitude and duration of ground settlement resulting from groundwater level changes may have been significantly underestimated in the Assessment of Ground Settlement Effects, Technical Report 35.[4] He

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2 Thomson evidence, paragraph 10.7.

3 Hughes evidence, paragraph 6.8(b).

4 Cherrill evidence, paragraphs 7-9.

refers in his evidence particularly to areas where relatively small settlement (10-20mm) has been predicted, and bases his conclusion on his assessment of several components of peat settlement.

13 While the soil mechanics theory behind Dr Cherrill's conclusion is well accepted, in my view the base assumptions which lead him to his overall conclusion are erroneous. I address each of the elements of Dr Cherrill's argument below.

Groundwater Drawdown

14 Dr Cherrill (in paragraph 18) relies on the conclusions of Ms Helen Rutter in relation to groundwater modelling[5] to suggest that the groundwater drawdown that forms the basis of peat consolidation settlement assessment may only be accurate to within one metre, and that consolidation settlement based on drawdowns of less than one metre are in considerable doubt.

15 Other groundwater specialists have commented on the modelling that has been undertaken for this Project,[6] and **Ms Williams**' rebuttal evidence responds directly to those statements and to the evidence of Ms Rutter.

16 Dr Cherrill appears to base his suggestion that groundwater drawdown may be greater than predicted[7] on Ms Rutter's conclusion[8] that "*little confidence should be placed on the models in terms of interpreting water levels to within less than a metre*." While numerical groundwater modelling is not my area of specific expertise, I am experienced in applying the relevant principles to geotechnical analysis and design. In my experience, it is not credible for an excavation in conditions such as those which underlie the Project to lower groundwater levels by more than the depth of excavation. As a result, it is in my view unlikely that long term groundwater drawdowns of more than 0.5m will result from excavations of only 0.5m depth.

17 In the case of groundwater drawdown resulting from embankment construction, the generic 2D analyses performed by Ms Williams[9] (and hence the resulting calculated effects) rely mostly on the assessed permeability of the peat and the underlying sand (for which a number of sensitivity analyses were undertaken). They are not dependent on the regional 3D modelling which Ms Rutter expresses little confidence in. I am advised by Ms Williams that the findings of the 2D modelling are, in fact, consistent with the regional (3D) modelling.

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5 Ms Rutter has provided evidence on behalf of the Deardens. I address her evidence below.

6 Mr Peter Callander for GWRC and Mr Brydon Hughes for KCDC.

7 Cherrill evidence, paragraph 18.

8 Rutter evidence, paragraph 32.

9 Described in Technical Report 21.

18 These observations lead me to conclude that the groundwater level modelling that forms the basis of much of the work described in Technical Report 35 is reasonable and provides an appropriate basis for the assessment of the resulting ground settlement effects.

Consolidation of the Peat

19 In his evidence, Dr Cherrill explains consolidation theory (paragraphs 24 to 26). He then suggests (in paragraph 34) that, in a very dry summer, groundwater levels may drop below the lowest previous groundwater level, leading to the pre-consolidation pressure being exceeded and much larger settlements developing. In response, I note that such an effect has, in fact been modelled, and occurs in areas of deeper peat subject to even relatively small groundwater level changes. It is demonstrated by the extensive areas of predicted settlement at the southern and northern ends of the Project, as shown on Sheets 2, 10 and 11 of Annexure A to my EIC.

20 In areas of much shallower peat, it is not possible that loads from the soil will exceed the pre-consolidation pressure of 15kPa that has been used for my analyses, and which Dr Cherrill (in paragraph 30) agrees is reasonable. Simplistically, this is because the peat weighs around 10.5kN per cubic metre,[10] so 1.4m depth of peat can apply a maximum load of only 15kPa. In other words, 1.4m depth of peat (or less) cannot exceed the pre-consolidation pressure described by Dr Cherrill.

21 Consequently, consolidation settlement for peat of up to at least 1.4m thickness is correctly assessed using the recompression index parameter presented in Technical Report 35. The much greater settlement suggested by Dr Cherrill is not credible in such a situation, which is relevant to much of the Project.

Peat Shrinkage and Oxidation

22 Dr Cherrill (in paragraphs 46 to 48) describes the shrinkage and oxidation of peat that occurs if it is to dry out. I do not disagree that a significant reduction in mean groundwater level would lead to some degree of shrinkage and oxidation of peat. The question, in relation to this Project, is how much will occur?

23 There are two aspects to this – how great a change in mean groundwater conditions will there be, and how much shrinkage and oxidation of peat will result from that change?

24 To put this issue in perspective, it is useful to use (as an example) the conditions and modelled groundwater changes in the vicinity of Offset Storage Area 2 and Rata Rd. This area of the Project includes the largest extent of permanent groundwater lowering and has high groundwater levels. I have described this area and the findings from recent investigations in paragraph 66 of my EIC. I now attach as

[10] Refer Table 8 of Technical Report 35.

Annexure B a simplified sketch showing the inferred existing and modelled groundwater levels. This shows as follows:

24.1 Assuming a winter high groundwater level at 0.5m depth and a possible summer low derived from monitoring earlier this year at 1.3m depth, the mean groundwater level lies at around 0.9m depth. The winter high and the summer low are most likely beyond this range, but I consider that the mean is reasonable.

24.2 Groundwater modelling of the effects of Offset Storage Area 2 is conservatively based on a groundwater level close to the surface, and indicates a maximum groundwater drawdown of 0.5m (from that high level).

24.3 The excavated Storage Area extends only a small distance below a reasonable winter high groundwater level at 0.5m depth beyond the Project footprint, so cannot, in my view result in sufficient change to initiate significant shrinkage and drying.

25 Given the small modelled groundwater changes, I expect the situation described above to be broadly similar elsewhere on the Project.

26 In the unlikely event that drying was to occur, leading to shrinkage and oxidation of the peat, then it is useful to consider the likely quantum and extent of the resulting ground settlement. In paragraph 51, Dr Cherrill refers to oxidation as the largest contributor to settlement of agricultural land over many years. He then refers to a study in the Waikato which estimated oxidation to have contributed 37% of the total settlement of agricultural peat lands. While I do not disagree that drying of peat will lead to oxidation and settlement, I consider that comparison with agricultural experience can lead to erroneous conclusions when applied to other environments and activities, and in particular to this Project. I reach this conclusion for two reasons.

27 First, agricultural production requires regular tilling of the soil, breaking it up and hence enhancing aerobic decomposition. Ultimately, the total thickness of peat can be converted to mineral soil if this continues. Any drying of peat that might occur as a result of this Project will occur at a much slower rate than is reported in an agricultural situation.

28 Secondly, drainage for agricultural purposes, and the resulting groundwater changes and potential for drying, is typically much deeper than has been proposed for the Project. For example, a 2005 study for Environment Waikato presents case studies on

subsidence near drains that are up to more than 5m deep.[11] That is ten times the depth of groundwater changes modelled for the Project. I have applied the recommendations of that study to a 0.5m deep drain for this Project and found that no subsidence is predicted.

Combined Settlement

29 Dr Cherrill (in paragraphs 55 to 57) combines his assessment of potential settlements to conclude that actual settlements may be "ten times" more than estimated in Technical Report 35. For the reasons that I have set out above, I consider that Dr Cherrill's assumptions, and therefore his conclusions, are not valid in this case.

30 In summary:

30.1 The groundwater level modelling that forms the basis of the Ground Settlement Assessment is reasonable;

30.2 The much greater settlements suggested by Dr Cherrill due to virgin consolidation of peat (rather than recompression) are not credible for the great majority of the Project, and appropriate larger values have been predicted where ground conditions indicate that they are relevant;

30.3 There will not be a significant change in mean groundwater conditions;

30.4 There will not be significant shrinkage and oxidation of the peat; and

30.5 Comparison with agriculture experience is not valid for this Project.

Effects of Settlement

31 Dr Cherrill states (in paragraph 71) that settlement of the magnitude that he has assessed (and with which I disagree) is unacceptable and likely to result in building damage. I share Dr Cherrill's view that settlement many times greater than that assessed in Technical Report 35 is more likely to result in building damage, and (as he notes in paragraph 73) may also result in changes in the gradients of drains and distortion to road surfaces. However, such settlement is not, in my view, likely to result from this Project for the reasons I have outlined above.

32 I agree with Dr Cherrill that differential settlement across a building or within buried or surface infrastructure is more likely to cause damage than uniform total settlement. In peat soils, it is not practical to predict differential settlement because of marked

[11] Fitzgerald et al, (2005), "Peat subsidence near drains in the Waikato Region", Environment Waikato Technical Report 2005/40.

variations in the nature and thickness of peat that may occur over small distances. However, if total settlement is relatively small, then it is reasonable to assume that negligible to no damage resulting from differential movements will occur. This is the basis of my conclusions, and Dr Cherrill appears (in paragraph 67) to agree with this reasoning.

Mitigation

33 Dr Cherrill concludes (in paragraph 88.4) that "*there are no practical contingency measures proposed that can be implemented, following construction and in response to monitoring, to mitigate or avoid unacceptable adverse effects."* I disagree with this conclusion.

34 The mitigation measures that have been proposed for this Project are most appropriately adopted in the course of construction to avoid possible adverse effects in critical areas.[12] They are routinely adopted techniques in New Zealand. Following construction, for example, in relation to groundwater drawdown related effects, recharge wells or trenches can be employed if needed at any time to reverse unacceptable groundwater changes. I also note that the proposed Ground Settlement conditions require identification and monitoring of at risk buildings and structures, and the implementation of appropriate remedial works.[13] Such an approach is an accepted form of mitigation of effects which occur during or following construction, and has been adopted for the recent Waterview Connection tunnel project.

Ms Helen Rutter for Dr Christopher and Mrs Monica Dearden

35 Ms Rutter (at paragraph 54) draws attention to apparently contradictory statements regarding the effects of the proposed Wetland 9 on groundwater levels. **Ms Williams**' rebuttal evidence responds in relation to Ms Rutter's items 54b and 54c which relate to Technical Report 21.[14]

36 Item 54a correctly quotes from Table 2 of Technical Report 35 that groundwater mounding is expected at Wetland 9, and item 54d identifies that Section 5.2.7 of Technical Report 35 states that the stormwater pond at Wetland 9 will be lined and no groundwater drawdown is predicted.

37 In response, I note that there are several different effects in the vicinity of Wetland 9, and these occur at different times and for differing durations:

37.1 Expressway embankment construction is predicted to result in the greatest groundwater drawdown, and this is evident on

[12] As described in sections 7.2.1 to 7.2.3 of Technical Report 35.

[13] Being proposed conditions E.18 to E.21.

[14] Assessment of Groundwater Effects.

Figure F8C in Technical Report 21. The effect of this extends beyond Wetland 9.

37.2 Wetland 9 itself results in mounding above the drawn down groundwater profile from embankment construction, leading to a net groundwater change of less than 0.1m. This can be seen from the white area on Figure F8C of Technical Report 21.

37.3 I understand that the stormwater pond at Wetland 9 will be lined. It is shown on Drainage Layout Sheet 10 of 37 as having a permanent water surface level of 3.5m, only 0.5m below existing ground level, and as a result no groundwater drawdown is predicted to result from pond operation.

38 Consequently, while the statements identified by Ms Rutter appear on first reading to be contradictory, they all reflect a reasonable interpretation of the modelling and likely groundwater effects of Wetland 9 and the surrounding works.

Mr David Roil for Waikanae on One

39 Mr Roil's evidence places particular emphasis on the Waikanae River to Waimeha Stream section of the Project. He correctly points out (paragraph 12.3) that much of the geotechnical investigation data contained in Technical Report 36 was gathered for the previous WLR alignment. I note that access restrictions prevented specific investigation of part of the current route at the time the effects assessment was being prepared (i.e. mid to late 2011).

40 However, as part of a subsequent round of geotechnical investigations undertaken earlier this year, we have put down 8 machine boreholes, 2 cone penetration tests and 5 hand auger bores along the alignment between the Waikanae River and Waimeha Stream. The recent investigations identified conditions to be broadly consistent with our original interpretation from landform and existing data. These investigations will be used to further develop the Project design in due course.

41 Mr Roil also suggests (paragraph 12.3) that GWRC well bore logs adjacent to the alignment provide "*a different set of ground conditions*" to those in the Geotechnical Interpretive Report prepared for the Project (Technical Report 36). It is my experience that well logs are not usually prepared with the same rigour as geotechnical bore logs. Commonly they reflect the driller's observations. While we have used this resource (i.e. the well bore logs) to develop our geotechnical model at depth, particularly around the potential presence of silt lenses which may affect pile foundation capacity at bridges, they do not on their own constitute a reliable alternative ground model.

Ms Beth Lindsay for Highway Occupants' Group

42 In her evidence (paragraph 12.6), Ms Lindsay questions the use of hand auger bores to investigate peat depth, as described in paragraph 81 of my EIC. The thickness of peat and the groundwater level within it are the main considerations when both designing and assessing the effects of a Project of this nature in these conditions. Hand augers are only one of the tools we have used to determine the underlying ground conditions for this Project. We have found probing using a hand auger to determine the thickness of peat and the groundwater level very effective in these materials. The technique is also extremely low impact, as it does not require heavy equipment, and allows us to reach locations that would otherwise be inaccessible. As a result, I consider use of hand augers acceptable for the Project.

Mr Philip Nordberg for Mrs Ann Laing

43 Mr Nordberg relates anecdotal evidence that removal of peat will worsen flooding issues.[15] I agree with Mr Nordberg to the extent that peat removal and its replacement with a lower permeability material that dams groundwater flow may cause groundwater mounding upstream. This effect has, in fact, been studied in Technical Report 21.[16] With appropriate design,[17] it is my opinion that the effects of peat removal can be managed to an acceptable level.

CONCLUSION

44 I have read all of the statements of evidence provided by submitters in relation to my area of expertise. That evidence has not caused me to depart from the opinions expressed in my EIC, and I re-confirm the conclusions reached in my EIC.

Gavin Alexander
24 October 2012

[15] Nordberg evidence, pages 2-3.

[16] Assessment of Groundwater Effects, section 4.8 2D Modelling of Expressway.

[17] In particular considering the relative permeability between pre-existing and post construction conditions and adding drainage measures or more permeable layers to prevent groundwater damming, as described in section 7.2 (iv) of Technical Report 21.

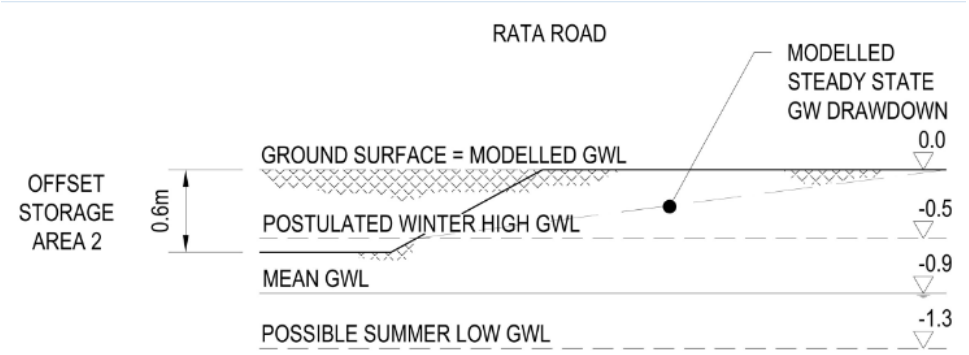
ANNEXURE A – PROPOSED AMENDED CONDITION GD.2

The underlined words are my proposed additions to condition GD.2(c).

I note that **Ms Williams** has proposed additional changes to condition GD.2 in her rebuttal evidence.

GD.2	The consent holder shall: a) Install and maintain the groundwater monitoring boreholes shown in Appendix A of the Groundwater Management Plan (GMP) (CEMP, Appendix I) for the period of monitoring specified in this consent. b) Monitor groundwater levels in the groundwater monitoring boreholes shown in Appendix A of the GMP (CEMP, Appendix I) and keep records of the water level measurement and corresponding date in accordance with the GMP. These records shall be compiled and submitted to GWRC at three monthly intervals. c) Monitor groundwater levels monthly in existing boreholes and in newly installed monitoring boreholes shown in Appendix A of the GMP (CEMP, Appendix I) (required as part of this consent) for a period of at least 12 months (where practicable) before the commencement of construction <u>that may affect groundwater levels in the area of monitoring</u>. The variability in groundwater levels recorded over this period, together with the monitoring trends obtained during the investigation and detailed design phases, will be used to establish seasonal groundwater level variability and establish triggers.

ANNEXURE B - SIMPLIFIED SECTION AT RATA ROAD SHOWING GROUNDWATER CONDITIONS AND MODELLING



SIMPLIFIED SECTION AT RATA ROAD SHOWING GW CONDITIONS & MODELLING