Josephine Laing

From: Doug Rankin <dougrankinchch@gmail.com>
Sent: Thursday, 17 September 2020 2:31 PM
To: Plan Hearings
Subject: rebuttal evidence PC7
Attachments: Rebuttal evidence of Douglas Alexander Rankin.pdf

Hi Tavisha

Please find enclosed my rebuttal evidence for PC7.

Please acknowledge receipt of this evidence by return email.

Many thanks

Kind regards

Doug Rankin

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In the matter of	The Resource Management Act 1991
and	
In the matter of	Proposed Plan Change 7 to the Canterbury Land and Water Regional Plan by the Canterbury Regional Council

Rebuttal evidence of Dr Douglas Alexander Rankin

Dated: 18 September 2020

EXPERTISE

1. My name is Douglas Alexander Rankin. I have outlined my background and expertise in my evidence and submission.

SUBMISSION

2. I have presented a personal submission (Submitter number PC7-220) which has outlined my concerns about a limited aspect of the Canterbury Land and Water Regional Plan (CLWRP) Plan Change 7 (**PC7)**. This concerns the impact of PC7 on Christchurch's groundwater. Farming permitted under PC7 will subject future generations of Christchurch residents to a significant reduction in the high quality of our city's current pure drinking water supply, and to the attendant human health risks and costs, if the appropriate action is not taken now to prevent this.

EVIDENCE

3. I have submitted evidence supporting my submission.

REBUTTAL EVIDENCE

4. I have read and examined the following additional evidence and material in constructing this rebuttal evidence:
    (a) The submissions of R Hamilton (submitter 313), V Buck (submitter 525), the Christchurch District Health Board (submitter 347), Avon-Otakaro Network (submitter 91), G D Fenwick (submitter 339), Royal Forest and Bird Protection Society (submitter 472), and Federated Farmers (submitter 133)
    (b) The submission of the Christchurch City Council (**CCC**) and the evidence of the CCC including that of Dr Tim Chambers, Greg Birdling, Dr Belinda Margetts, Geoff Butcher, Mike Thorley and Janice Carter
    (c) The evidence of Charlotte Wright, Dr Graeme Doole, Dr Helen Rutter and Jennifer Leslie for Dairy NZ
    (d) The evidence of R English, P & K Schouten (submitter 136), K McArthur for DOC, T Stokes (submitter 369), and M Sparrow
    (e) The evidence of experts appearing for Federated Farmers; Fonterra; Genesis; Horticulture New Zealand; As One Incorporated; Meridian Energy; Mulligan, Kerse and Kingston; Ravensdown; Carleton Dairies Ltd; Dairy Holdings Ltd, Trust Power, and Synlait Foods Ltd

(f) The evidence of Nga Runanga (submitter 399) including that of Amanda Symon, Arapata Reuben, Barry Bragg, John Henry, Kylie Hall, Dr Rawiri Tau, Sandra McIntyre, Terawa King and Treena Lee Davidson

(g) The evidence of Dr Alister Metherell (submitter 172) for Melbury Ltd

(h) The evidence of experts appearing for Waimakariri Irrigation Limited including that of Bianca Sullivan, Brent Walton, Paul Reese, Jeremy Sanson, Laura Drummond, and Neil Thomas, and I have viewed the 2019 Darcy lecture by Dr John Doherty.

5. Whilst this is not an Environment Court Hearing, I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2014. I have complied with the Code in preparing this evidence and I agree to comply with it in presenting this evidence at this Hearing. The evidence I give is within my area of expertise, except where I state that my evidence is given in reliance on another person's evidence or published material. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

Evidence of Dairy NZ

6. **Dr Helen Rutter**, a senior groundwater hydrologist at Aqualinc Research Ltd, in her evidence in chief (**EIC**) for Dairy NZ examines uncertainty surrounding a number of aspects of the Environment Canterbury (**ECan**) model and particularly its ability to predict groundwater nitrate concentrations and trends, and the connection between farming in the Waimakariri Zone (**WZ**) and the Christchurch West Melton groundwater zone.

7. I do not agree with the final sentence in paragraph 6.10 "However, the only contours provided are for shallow wells, and the contours are, in general, in a more easterly direction, rather than south east" because it is misleading to suggest that the contours face in a more easterly direction. Examination of the piezometric contours in Figure 1[1] show a wide range of directions that they face, ranging from southwest, to south, to southeast, to east, and to northeast. Examining contours in the vicinity of the Waimakariri Gorge bridge, where some alpine water from the river will emerge as a plume into groundwater on the plains, hydraulic flow (at right angles to the piezometric contours) in shallow aquifers can be seen to move from strongly south southeast (SSE) eventually towards Lake Ellesmere/Te Waihora, through to southeast towards Christchurch, and then east towards to the current mouth of the Waimakariri River. This fits with the known path of the Waimakariri River flowing to the Canterbury coast to the north of Christchurch, towards Christchurch, and to the south of

[1] Page 12, H Rutter EIC

Christchurch (into Lake Ellesmere/Te Waihora) over geological time. On land where Eyrewell Forest (Te Whenua Hou) stood most of the contours show shallow groundwater flow moves in a south easterly direction straight towards Christchurch. This is no doubt why the model predicts that it is nitrogen from farming on this land that gets into ground water that will impact on Christchurch's groundwater.

8. I do not agree with the conclusion reached in paragraph 6.21 (and which is also carried through to a conclusion in paragraph 12.10 (b)) concerning groundwater transmissivity at depth north and south of the Waimakariri River. Paragraph 6.21, which states "The conclusion, that the SC (specific capacity) values provide evidence for the presence of permeable materials at depth, and that this is evidence for a transfer pathway in the deep aquifer within the Waimakariri zone, is therefore not supported by the data", in my opinion is misleading, as such a conclusion is only not supported by the data in the sense that there is very little data. It is not appropriate to then conclude, as is done in paragraph 12.10 (b), that "there is no evidence for high permeability deposits at depth under the Waimakariri GAZ." With little or no data one cannot say evidence for high permeability deposits or a transfer path exists or not. Furthermore the personal communication by Haycock that the Waimakariri GAZ generally happens to be less productive at depth than south of the Waimakariri River may also be due to and a reflection of a paucity of data.

9. In section 7 nitrate concentration predictions are considered. Paragraph 7.1 states "From a simple comparison of model outputs with measured, the transport model does not appear to generate results that are consistent with observations. That is, there is considerable discrepancy between measured and modelled groundwater nitrate-N concentrations. This concern could be reduced if the model outputs were used to quantify the magnitude and direction of change, rather than absolute values (see Section 5.6). This is discussed further below."

10. Paragraph 7.2 states "I compared measured and modelled nitrate-N concentrations for various WDC bores, as an indication as to whether the model outputs were consistent with measured data. There are considerable discrepancies between most measured and modelled values. Some of these may be explained by transport lag between land use change and observing the impacts. But many comparisons of measured and modelled nitrate-N concentrations appear anomalous, reducing confidence in the model results."

11. This analysis and conclusions drawn about the model are flawed. There is no *a priori* reason why comparison of modelled concentrations with measured concentrations should yield the same results, and in fact to make such comparisons is not appropriate and not valid. The

model does not predict *current* well or *trends* in groundwater nitrate concentrations, but predicts *future steady state* nitrate concentrations. Steady state concentrations are reached once the full impacts of any farming activities that they are derived from are fully expressed in groundwater or surface water bodies, and where nitrate concentrations have reached a constant value.

12. It can take a long time for nitrate contamination from farming practices to move into, and through, aquifers. Thus changes in nitrate concentrations in wells and "monitoring bores" may take many, many years to even start to appear, and further years to appear in full and reach a steady state. Much intensive farming, and particularly dairy farming, in Canterbury and the WZ has only really occurred in the last thirty years and so many changes in groundwater nitrate concentrations are not yet expected to be seen, especially in deeper wells. Therefore, throughout much of Canterbury nitrate concentrations in many bores and streams are expected to rise significantly as the nitrogen 'load to come' works its way into and through the groundwater system.
13. Dr Rutter correctly states in paragraph 8.1 "current measured nitrate-N concentrations do not account for yet-to-come lag in the system". This statement of course supports the notion that current measured nitrate groundwater concentrations will represent impacts from farming that occurred in the past, and that modelled steady state nitrate groundwater concentrations will represent impacts from farming carried out at present and once any 'load to come' has been fully realised.
14. <u>Thus comparing modelled future steady state well or aquifer concentrations with current well or aquifer concentrations and drawing conclusions from differences between them, as is considered in subsequent paragraphs 7.3 to 7.11, is meaningless and quite misleading.</u> Good agreement between such results would not be expected. One is not comparing 'apples with apples'. Hence the ECan model is not weakened or made questionable by such apparently 'contradictory' or 'anomalous' results, or 'discrepancies between observed and predicted nitrate concentrations' as suggested; the logic and argument being presented is flawed and false.
15. I do not agree with an assumption discussed in paragraph 7.4. It is stated that "The argument that there is a nitrate load to come, resulting from intensification (ECan, 2019a), does not appear to be supported by information on the history of land use intensification. While this is known in the Eyrewell Forest area, there is little known about the pattern of land use intensification elsewhere. However, the load-to-come conclusion appears to be based on an assumption that land use change has occurred."

16. The ECan model is not based on the assumption that land use change has occurred. It is based on the amount of nitrate leaving the root zone calculated for different farming practices and scenarios, and predicts where it will end up. Farming practices considered include current management practice (**CMP**) and good management practice (**GMP**), and those calculated where still more nitrogen will be released as a result of further intensive farming, such as plan change 5 permitted activities (**PC5PA**) and current pathways[2]. ECan data show that these farming scenarios all result in similar nitrate concentrations; for example, in the Christchurch aquifers[3]. Thus, the load-to-come conclusion is not at all based on an assumption that land use change has occurred; it is entirely based on land use nitrogen losses to groundwater for different farming options and the times taken for nitrate contamination loads to travel from their source on land to final points of expression, such as an aquifer or well or stream.
17. Thus where paragraph 7.12 states that this disagreement between modelled and current nitrate concentrations (or trends) will lead to "….reducing the confidence in the model predictions"[4], this conclusion is not valid or correct. Such a conclusion is misleading and therefore a significant error. The confidence in the model is not impacted on by such incorrect conclusions.
18. This same flawed logic is also used in section 9 where evidence for increasing nitrate trends in groundwater in the WZ is also considered. Past and current bore nitrate concentration data from past farming practices are examined to see if there are signs of an increasing trend indicative of the 'load to come' from the modelled impacts of current farming practices. No strong trend is observed and in paragraph 9.8 it is concluded "…. there is little evidence of a major change or increasing trend across the zone." again implying that the ECan model is somewhat deficient. However, as discussed above, as the load from current farming practices is yet to be seen and expressed in WZ bores, no major change or trend is expected and so it is not reasonable or appropriate to conclude that the ECan model is deficient.
19. In section 10 evidence for increasing nitrate trends in groundwater in the Christchurch-West Melton zone is also considered. Data primarily from different depth north eastern and south western wells in Christchurch is discussed. However, no discussion is had of current well nitrate concentrations in the west, central and east areas of the Christchurch aquifers, and in

[2] See paragraph 41, D A Rankin EIC
[3] See paragraphs 33 and 34, and 41, D A Rankin EIC
[4] Paragraph 7.12 states "In summary, based on the trends and concentrations observed compared with the modelled predictions, the results from modelling are not widely reflected in the measured data, reducing the confidence in the model predictions."

whose deep aquifers steady state nitrate concentrations are modelled by ECan. It is noted in paragraph 10.9 that the very limited deep groundwater well data "….. does not disprove the hypothesis that there may be flow under the Waimakariri River at depth, but there are other plausible hypotheses." There are some errors in the labelling on the Figures 19 (should be < 40 m deep) and 20 (should be > 40 m deep).

20. I do not agree with some of the summary analysis concerning predictions of groundwater quality, which is presented in paragraphs 12.1 – 12.4. The summary paragraph 12.1 states "Many bores, within either the Waimakariri or Christchurch-West Melton zones show a declining trend, or no clear trend, in nitrate concentrations. This is contradictory to the predictions of the groundwater model."

21. As stated before, it is not appropriate to draw any conclusions as to the validity of the model based on comparisons between current observed well nitrate concentrations, or trends in those well concentrations, and modelled steady state concentrations. It is especially not correct to say that that the current observed well nitrate concentrations are contradictory to the model. This is repeating the same significant error discussed above in paragraphs 9 – 14.

22. I do not agree with paragraph 12.2 which states "Many bores show measured nitrate concentrations that are much lower than the current management practice (CMP) modelled concentrations, in some cases by an order of magnitude. This cannot always be explained by the concept of a nitrate load to come. For example, the Waikuku bores have a long history of sampling with no trend, have a short lag time, but are predicted to show an increase." I feel this paragraph is misleading as it is repeating the same error discussed in paragraph 21.

23. I assume 'current management practice (CMP)' in this paragraph is an error and should read 'good management practice (GMP)' or 'current pathways', as CMP data is only presented and discussed in the ECan report by Etheridge, Hanson and Harris (2018) and refers to nitrate concentrations in the Christchurch aquifers. Also 'current pathways' (see paragraph 7.8) is not the same as CMP[5]. Many predicted nitrate concentrations, some of which are more than an order of magnitude higher, such as in the deep Christchurch aquifer case, are expected and can be explained by the concept of nitrate load to come.

24. In the single example of a possible exception for the Waikuku bores, whose current concentrations are less than 0.7 mg NO_3^--N/L and are predicted to rise to about 1.7 to 1.9 mg NO_3^--N/L (see paragraph 7.8), lag times are considered to be < 6 years. However, the well depths are 22 m (M35/0474, now abandoned) and 58 m deep (M35/0444), which would not normally be consistent with such a short lag time. Thus, this data could also be explained by

[5] See Appendix 1, D A Rankin, EIC

the concept of nitrate 'load to come'. Also, as explained in paragraph 21 above, the current observed well nitrate concentration trends are not contradictory to the model, as they are not comparable with predicted model concentrations.

25. Paragraph 12.14 acknowledges "that ECan have robustly developed the flow model within the available data, which is a hugely difficult task". Paragraph 12.15 states "regardless, it is important to ensure that conclusions drawn are not beyond that which can be supported by model and field results. We consider that there is insufficient information to draw strong conclusions about the connection under the Waimakariri River. ….". I do not agree with the second sentence in this conclusion as in my opinion it is misleading and ignores the model prediction results. In my opinion this conclusion leaves an impression that we cannot be sure about the connection and implies therefore that there is possibly no connection of groundwater under the Waimakariri River. However, as stated earlier in paragraph 12.12 this hypothesis cannot be discounted. In other words a conclusion cannot be drawn either way, strongly or otherwise.
26. The ECan model predictions of increased steady nitrate concentrations in the shallow and mid depth Christchurch aquifers, and in the deep west, central and east groundwater aquifers from which Christchurch obtains the bulk of its drinking water, as a result of intensive dairy farming in the interzone transfer source area north of the Waimakariri River, are clear. The model has been calibrated against shallow groundwater levels described in paragraphs 6.9 to 6.18. A south easterly hydraulic gradient for shallow layers between the Waimakariri (interzone transfer source area) and Christchurch aquifers has been shown (paragraph 6.10[6]). There is more uncertainty about the direction of flow of deep groundwater assumed in the model and so less reliability in conclusions concerning the deep groundwater nitrate concentrations compared with those in the shallower aquifers. Unfortunately there are no field results to confirm the ECan model, as current nitrate concentrations, which reflect past farming practices, cannot be used as a proxy or to predict future steady state aquifer nitrate concentrations based on current discharges from farm land.
27. However, in my opinion, if the direction of flow of shallower groundwater and model results are accepted for the shallower Christchurch aquifers, then there is a strong case for groundwater flow under the Waimakariri River. The model results rely on a connection under the Waimakariri River. The connection may equally apply for deeper groundwater but this is less certain because of little deep groundwater hydraulic flow or transmissivity data.

[6] See discussion in paragraph 7, D A Rankin this rebuttal evidence

Nevertheless deep groundwater flow into the Christchurch aquifers is not impossible or unreasonable based on past flow directions of the Waimakariri River. The predicted steady state nitrate concentrations in the Christchurch aquifers are not unreasonable when compared with high nitrate concentrations already observed in some bores in the WZ, and in aquifers polluted from intensive farming and dairy farming overseas, where nitrate levels sometimes exceed drinking water standards.

Evidence of the Christchurch City Council

28. Various experts (Bridget O'Brien, Tim Chambers, Greg Birdling, Belinda Margetts, Geoff Butcher, Mike Thorley and Janice Carter) provide evidence for the Christchurch City Council (**CCC**) in support of a 1.0 mg NO_3^--N/L nitrate limit for Christchurch's drinking water obtained from groundwater.
29. There are some small errors in the evidence of Mr Birdling, Mr Thorley and Ms O'Brien for the CCC but these do not materially alter the overall conclusions or thrust of their and the CCC's evidence.
30. **Mr Birdling** in paragraph 29.1 of his EIC refers to the ion exchange process he presents in his evidence swapping a nitrate ion with a different ion (usually sodium). This is not correct. The nitrate ion must be swapped with an anion, not a cation such as sodium, and will be swapped with a chloride anion, based on the material (sodium chloride) used to activate the ion-exchange resin.
31. **Mr Thorley** in paragraph 90 of his EIC refers to Kreleger and Etheridge adding nitrate concentrations of modelled data to observed data in order to assess exceedances of nitrate concentrations with respect to proposed thresholds and the current drinking water standards. This is not a correct procedure nor what Kreleger and Etheridge have done, and reflects a misunderstanding of what their modelling achieves and what is summarised in their Table 4-10. The modelled nitrate concentration data in Table 4-10 are simply those calculated at steady state for different farming scenarios, and do not have other figures added to them. Similarly paragraph 91 is also in error, as the same misunderstanding is carried through into this analysis.
32. **Ms O'Brien** in paragraphs 47 and 49 of her EIC refers to the evidence of Mr Thorley and similarly misunderstands the data reported by Kreleger and Etheridge as discussed in the preceding paragraph.
33. **Mr Thorley** mentions the CCC's request that PC7 be modified so that the amount of nitrogen that can be released from farming into the interzone transfer source area is reduced by 80%

over a shorter number of years in order to achieve a 1 mg NO_3^--N/L goal in Christchurch's drinking water[7]. This reduction of nitrogen release is of a similar order to that I identified that would be required either under current pathways or under PC7 (92-94%) to retain a median nitrate concentration of 0.3 mg NO_3^--N/L in the deep Christchurch aquifers[8]. The CCC in their submission[9] also identify that the 1 mg NO_3^--N/L limit they seek is an upper limit for nitrate in the city's groundwater.

34. It is not clear whether the 80% reduction in nitrogen release proposed by the CCC will be sufficient to result in a maximum limit of 1.0 mg NO_3^--N/L in the deep Christchurch aquifers. The nitrate concentrations that will be achieved by such a reduction can be determined by reducing the nitrogen load of the farming scenarios that produced the original modelled nitrate concentrations by 80% and recalculating the groundwater concentrations that would result in various aquifers using data presented in my evidence[10] and the same methodology as applied in my EIC[11]. Results are summarised in Table 1.

35. An 80% reduction in nitrogen released from all farming in the interzone transfer source area for the current consented at GMP farming scenario will achieve a median nitrate concentration of 0.94 mg NO_3^--N/L in the deep aquifers, and 95th and 99th percentile nitrate concentrations of 1.46 mg NO_3^--N/L and 1.7 mg NO_3^--N/L, respectively. In addition, this reduction will produce median, 95th and 99th percentile nitrate concentrations of 0.74, 1.58 and 1.88 mg NO_3^--N/L in the shallow Christchurch aquifers, and 0.82, 1.48 and 1.80 mg NO_3^--N/L in the mid Christchurch aquifers, respectively. This data clearly shows that the <u>80% reduction in nitrogen load is not sufficient</u> to reduce the 95th or 99th percentile nitrate concentrations to 1.0 mg NO_3^--N/L in any of the Christchurch aquifers. A <u>greater reduction</u> in the nitrate load released is required to ensure aquifer nitrate concentrations will not exceed the proposed 1.0 mg NO_3^--N/L CCC limit.

36. The percentage reductions in nitrogen load actually needed to produce a 99th percentile nitrate concentration of 1.0 mg NO_3^--N/L sought by the CCC[12] in the Christchurch aquifers have been calculated using a similar methodology. The corresponding median and 95th percentile concentrations that will result in each of the aquifers have also been calculated.

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[7] Paragraph 139, M Thorley EIC for Christchurch City Council
[8] Paragraph 66 (and Appendix 2), D A Rankin EIC
[9] Paragraph 4, page 1, Submission 337, Christchurch City Council
[10] Table 2, D A Rankin EIC
[11] Appendix 2, D A Rankin EIC
[12] Normally a 99.9th percentile concentration would be used in this role, and such concentrations would be higher than the 99th percentile. However, without any data on such levels in the data reported by ECan, the 99th percentile will be sufficient to illustrate the point. The 99th percentile data will form a lower bound of the actual reductions needed to meet a 99.9th percentile 1.0 mg NO_3^--N/L concentration limit. In other words, larger reductions still would be necessary to meet a 99.9th percentile 1.0 mg NO_3^--N/L concentration limit

Results of examples of the calculations are summarised in Tables 2 and 3. Data are only presented for the current consented at GMP farming scenario to illustrate the situation[13].

Table 1: Comparison of modelled nitrate concentrations, including where there is an 80% reduction in nitrogen release, under different farming scenarios in the interzone transfer source area in the NPA with current observed aquifer concentrations in different depth Christchurch aquifers

Aquifer/ Scenario	Median (50th percentile)			95th percentile			99th percentile		
	Current concen-trations	Modelled from farming in WZ	Modelled with 80% N reduction	Current concen-trations	Modelled from farming in WZ	Modelled with 80% N reduction	Current concen-trations	Modelled from farming in WZ	Modelled with 80% N reduction
Shallow aquifer nitrate (mg NO_3^--N/L)									
A; Current practice (CMP)	2.5	3.4	0.68	7.6	7.5	1.5	-	9.1	1.82
C; Current consented at GMP	2.5	3.7	0.74	7.6	7.9	1.58	-	9.4	1.88
H; Dryland farming	2.5	1.7	0.34	7.6	3.7	0.74	-	4.3	0.86
Mid aquifer nitrate (mg NO_3^--N/L)									
A; Current practice (CMP)	2.4	3.8	0.76	6.1	7.1	1.42	-	8.6	1.72
C; Current consented at GMP	2.4	4.1	0.82	6.1	7.4	1.48	-	9	1.8
H; Dryland farming	2.4	1.3	0.26	6.1	2.4	0.48	-	3.2	0.64
Deep aquifer nitrate (mg NO_3^--N/L)									
A; Current practice (CMP)	0.3	4.5	0.9	1.6	7	1.4	-	8.1	1.62
C; Current consented at GMP	0.3	4.7	0.94	1.6	7.3	1.46	-	8.5	1.7
H; Dryland farming	0.3	1.3	0.26	1.6	1.9	0.38	-	2.3	0.46

Table 2: Modelled 99th percentile nitrate concentrations (mg NO_3^--N/L) for the current consented at GMP farming scenario in the interzone transfer source area in the NPA and the percentage reductions in nitrogen load required to achieve a 99th percentile nitrate concentration limit of 1.0 mg NO_3^--N/L in different depth Christchurch aquifers

Aquifer	Modelled nitrate concentrations	Percent N reduction
Shallow	9.4	89.36
Mid depth	9.0	88.89
Deep	8.5	88.24

[13] ECan does not provide a worst case scenario of what farming would actually be permitted in the WZ under PC7 leaving this open-ended, so greater reductions in nitrogen released may be needed than those illustrated here

37. Larger reductions in nitrogen release ranging from 88.24% to 89.36% are needed to achieve a 99th percentile 1.0 mg NO_3^--N/L limit in the different depth Christchurch aquifers (Table 2). If there was a requirement that all Christchurch aquifers were to meet a 99th percentile 1.0 mg NO_3^--N/L nitrate concentration then an 89.36% reduction in nitrogen released from farming in the interzone transfer source area would be required.

Table 3: Comparison of calculated nitrate concentrations for the current consented at GMP farming scenario in the interzone transfer source area in the NPA with current observed aquifer concentrations (mg NO_3^--N/L) in different depth Christchurch aquifers for the percentage reductions in nitrogen load required to achieve a 99th percentile nitrate concentration limit of 1.0 mg NO_3^--N/L

Aquifer	Median (50th percentile)		95th percentile		99th percentile		
	Current concen-trations	Model nitrate concentrations	Current concen-trations	Model nitrate concen-trations	Current concen-trations	Model nitrate concen-trations	Percent N reduction
Shallow	2.5	0.39	7.6	0.84	-	1.0	89.36
Mid depth	2.4	0.46	6.1	0.82	-	1.0	88.89
Deep	0.3	0.55	1.6	0.86	-	1.0	88.24

38. The data in Table 3 show the expected lower median and 95th percentile nitrate concentrations in the Christchurch aquifers when the 1.0 mg NO_3^--N/L nitrate concentration limit is required to be met at the 99th percentile level. As expected the median concentration in the deep aquifers at 0.55 mg NO_3^--N/L is higher than the current median of 0.3 mg NO_3^--N/L, as in order to retain the current median concentration a reduction of nitrate nitrogen release of 94% is required[14].

Evidence of Waimakariri Irrigation Limited

Mr Neil Thomas

39. Mr Neil Thomas, a groundwater hydrogeologist with Pattle Delamore Partners, presents evidence on groundwater quality in the WZ, a model constructed by ECan to predict future nitrate concentrations in the WZ (and also in Christchurch aquifers), and the results and implications of this model. The results from the model are really only discussed with regards to impacts in the WZ; impacts on Christchurch's groundwater aquifers are not traversed in depth. Central themes in the evidence are that the there is no evidence for a nitrate load to

[14] Scenario 4, Table 10, D A Rankin EIC

come in the WZ based on current bore monitoring data, and that the ECan groundwater model that predicts such a load to come is flawed in part as a result.

40. I do not agree with the statement in paragraph 17 that "there is no clear evidence that there is a substantial load of nitrate still to come within the Waimakariri Zone" as I feel it could be misinterpreted and/or misleading. As discussed in paragraphs 12-14[15] there is clear evidence that there is load to come and this is accepted by other experts such as Dr Rutter[16]. This will be particularly the case where widespread intensive irrigated dairy farming has only recently been started in the WZ on land where Eyrewell Forest once stood. Intensive dairy farming typically releases large amounts of nutrients to groundwater when compared with many other dryland farming options and so there will be a substantial load of nitrate to come and to be expressed in increases in groundwater and surface water nitrate concentrations in the future. Modelling by ECan suggests a certain amount of the load from this farming in the interzone transfer source area in the Nitrate Priority Area (**NPA**) will end up in the Christchurch aquifers.

41. I do not agree with the statement in paragraph 22 referring to time series plots for seven Waimakariri Irrigation Limited (**WIL**) monitoring bores that "the long term trends in these bores … are all relatively stable." (see plots in Figure 2[17]) Trend lines for nitrate concentrations for three bores, M35/5440, M35/5869 and M35/6385, are all rising. Trend lines for three bores, M35/4682, M35/4757 and M35/4795, are all decreasing. Only one monitoring bore, L35/0349, appears to remain stable, although close examination of the data also shows that its concentrations are also decreasing. No data is given to show whether these trends are statistically significant or not but it is likely that they are, as discussed below. The changes in nitrate concentrations derived from the bore data in Figure 2 are summarised in Table 4.

42. In my opinion such results are expected. The changes and percentage changes are likely to be significant given their magnitude. Bore nitrate concentrations are expected to show increasing, static or decreasing trends depending on the complex interaction of the quantity of nitrate nitrogen entering aquifers from land use activity; rainfall and irrigation water use impacting on aquifer concentrations; and lag times between when changes to nitrogen loads on land are then able to be expressed and seen as changes in nitrate concentrations in bores. An expectation of no change in bore nitrate concentrations over time could only be

[15] D A Rankin, this rebuttal evidence

[16] For example, in paragraph 7.2 in her EIC, Dr Rutter explains that the 'discrepancy' between some measured and modelled values can be explained by transport lag between land use change and observing the impacts. This statement supports and relies on the notion of 'load to come'

[17] N Thomas EIC

realised if there happened to be a perfect balance between the total amount of nitrogen input into an aquifer over time (even if this were changing as a result of changes in farming or farming inputs) and the quantity of water being injected into and present in an aquifer over time (including that from variable rainfall and application of irrigation water) giving rise to a constant bore nitrate concentration.

Table 4: Nitrate concentrations (mg NO_3^--N/L) and changes derived from time series plot trend lines for WIL monitoring bores from 1999 to 2019 during which WIL has been operating

Bore	Nitrate concentration			Percentage change
	1999	2019	Difference	%
L35/0349	1.1	1.0	-0.1	-9.1
M35/4682	5.0	3.5	-1.5	-30.0
M35/4757	7.3	6.6	-0.7	-9.6
M35/4795	7.2	6.7	-0.5	-6.9
M35/5440	6.6	7.1	0.5	7.6
M35/5869	7.4	8.4	1.0	13.5
M35/6385	4.8	6.0	1.2	25.0

43. Where bores currently show a decreasing nitrate concentration trend this may be due to irrigation water/rainfall diluting nitrate from land or reductions in nitrogen leaching from land from changed land use practices, or combinations thereof. Where bores currently show an increasing nitrate trend this may be due to increased nitrogen leaching from land use changes, or where less irrigation water is being applied to land, or again combinations thereof. In my opinion, none of these current trend results necessarily reflect the large amount of nitrogen from 'load to come' expected from the widespread dairy farming now in the WZ, and that is yet to arrive, as is discussed later. The magnitude of the 'load to come' from the dairy farming in the WZ is reflected in the rough doubling of the bore nitrate concentrations that is predicted by the ECan model and summarised in Figure 5 of Mr Neil's evidence[18].

44. I am concerned that there is ambiguity in paragraph 24 about ECan reports giving a misleading impression of groundwater nitrate-N concentrations in groundwater in the WZ. The cited report by Etheridge et al (2019) does not appear in the reference list, so it is unclear what 'impression' is being referred to. If this refers to the fact that various ECan reports do predict increases in steady state nitrate concentrations in various sites and aquifers compared with current observed groundwater (bore/well) concentrations, and that

[18] Paragraphs 35 to 37, N Thomas EIC

this data and this notion seems to 'conflict' with relatively 'stable' nitrate concentrations in the WZ, then in my opinion, as is discussed previously and later, this is not a valid comparison to make or conclusion to draw.

45. I do not agree with the interpretation in paragraph 31 where in general terms the outcomes from the simulations investigating changes in groundwater quality in the WZ (and outside the WZ) are discussed. It is concluded that the modelling and simulations and range of possible outcomes are based on incomplete understanding of the groundwater system and that none of the simulations should be assumed to accurately predict what might happen in the future. A number of these statements in isolation are true. Groundwater systems are hugely complex and difficult to understand and model, and can never be fully understood or described (they are underground and not visible). However, what is not said here, for example, in the case of the Christchurch groundwater aquifers and other aquifers, is that the model predicts the median and many other percentile steady state nitrate concentrations rise significantly from most of those that are currently observed. It would be a different matter if the model predicted that steady state nitrate concentrations did not rise but remained the same. But the model doesn't; it predicts that most nitrate concentrations will rise.

46. Such predictions rest well with the observations that as a result of recent increased intensification of farming in various areas in the WZ there is a significant 'load to come', as discussed in paragraph 40[19]. Thus the model simulations of steady state nitrate concentrations in the Christchurch aquifers, which the model predicts originate from nitrogen released from farming in the interzone transfer source area in the NPA in the WZ, all show significant increases in median and other percentile nitrate concentrations when compared with those currently observed in the aquifers. What one inputs into a system will add to that system, and unless it is removed or lost from the system, it will remain in the system. The predicted increases in groundwater and surface water concentrations are also entirely in line with what has happened overseas where intensive dairy farming has consistently led to significant increases in groundwater and surface water nitrate concentrations in regions where such farming is conducted.

47. I do not agree with the representation in paragraph 32 of Dr John Doherty's summary in the 2019 Darcy lecture to groundwater practitioners. Dr Doherty[20] states this summary early in the lecture, then uses this as a 'straw man' to elaborate at length throughout the remainder of the lecture on different facets of groundwater modelling, and particularly the 'do's and

[19] D A Rankin, this rebuttal evidence
[20] https://www.youtube.com/watch?v=Gb_bx6Ui3vA; accessed Sunday 6 September 2020

don't's' of good modelling. He reflects on the fact that many models can be useless, and over complicated to the extent that their predictions can be totally false. He does, however, remind us to reflect on and to be honest about simple truths, such as if groundwater levels are falling because pumping has increased out of an aquifer, you don't need a model to prove it (the comparison to the current expectations of increasing bore nitrate concentrations from nitrogen losses from dairy farming in the WZ where previously there was only forestry (Eyrewell Forest) springs to mind, somewhere increases in nitrate concentrations ('load to come') will occur in receiving bodies in the future).

48. In paragraph 36 I do not agree that modelled concentrations are "a significant extrapolation beyond what is currently observed". They are predictions, not extrapolated from current measured concentrations. Furthermore, such increases are entirely reasonable given the significant increases in intensive and particularly dairy farming in the WZ in the last twenty years, and the expectation that diffuse discharges from such operations will therefore have yet to work their way through aquifers and therefore to be expressed in many bores and streams as significant increases in nitrate concentrations.

49. I do not agree with the view expressed in paragraph 54 that "there is no clear evidence that there is a significant load to come within the Waimakariri zone" for the reasons I have already discussed in paragraphs 12, 40 and 46 of this evidence.

50. In paragraph 56[21], and also in paragraph 60, I do agree that there are no large upwards trends in nitrate concentrations or other indications of nitrogen load migrating through shallow aquifers due to the WIL scheme. As I have discussed in paragraphs 41 and 42, there may be evidence of small impacts from the WIL scheme already evident in both the increasing and decreasing trends in nitrate concentrations seen in the seven WIL monitoring bores to date. However, because of the long residence times even in shallow groundwater referred to in paragraph 58[22], this must mean that the bulk of the impacts from the 'load to come' would not yet be expected to be seen. In other words greater increases in nitrate concentrations than already seen will occur into the future as more nitrogen lost from below the root zone moves through and finally exits different aquifer systems.

51. In paragraphs 61 to 66[23] the possibility of denitrification as a mechanism for removal of nitrate from groundwater in the WZ and in the Christchurch aquifers is discussed. It is posited that anammox reactions (anaerobic ammonium oxidation) cited in Smith et al. (2015) might be involved. As a chemist I would add a note of caution about such a

[21] N Thomas EIC
[22] N Thomas EIC
[23] N Thomas EIC

proposition. The study by Smith et al. (2015) was for a pollution plume from a concentrated industrial source in groundwater, with appreciable nitrate and ammonia concentrations and organic matter at the injection point and downstream of the source. Anammox bacteria in the environment, typically found in biodigesters for processing sewage in waste water plants (McCarty, 2018), were identified as the microbes in the shallow groundwater plume zone driving the process. A significant amount of organic matter is essential to feed the microbes in this process. In contrast, the nitrate released from soil microbe oxidation of fertiliser urea or cattle urine patches will enter a low organic matter environment below the root zone, where ammonia will be virtually non-existent as will soluble organic matter to feed anammox bacteria, should any such organisms be present. Given the large differences between these processes, constituent concentrations and environments such a denitrification process may not play a significant role in nitrate reduction in relatively clean groundwater environments, such as in the Christchurch aquifers.

52. I do not agree with the statement in paragraph 66[24] that "…. for such a deep flow path to contribute water to the Christchurch aquifers it [groundwater] will almost certainly encounter low oxygen environments and organic matter which will remove the nitrogen from groundwater". There is no evidence provided to justify the claim that nitrogen will be removed by this process. In particular, the observation that nitrate concentrations in the shallow, mid and deep Christchurch groundwater wells, likely originating all or in part from deep groundwater, currently range from concentrations close to zero up to 27, 7.3 and 2.6 mg NO_3^--N/L, respectively, clearly suggest that this is not necessarily the case[25].
53. I do not agree with the summary in paragraph 67 that "… the view expressed in many of the Environment Canterbury reports for PC7 about the contamination problems from agricultural land use and a future significant worsening trend are considerably uncertain." As reflected in the preceding discussion, there is certainly extra nitrogen load expected in the WZ, most of which has not yet been seen.
54. I do not understand the meaning of the conclusion in paragraph 69 that although the "…. overall (ECan) model appears conceptually reasonable, the way in which the nitrate modelling has been carried out, and the way in which the conclusions drawn from the modelling are presented are not, in my opinion, reasonable".
55. Further discussion of this matter is had in paragraph 70. It is correct that the nitrate nitrogen concentrations used in the model are based on Overseer but I do not agree with the view that the nitrate concentrations are "…. inconsistent with observed data". There is no

[24] N Thomas EIC
[25] Table 1, D A Rankin EIC

'observed' data available with which to ground truth the predicted model concentrations, as there is significant nitrogen load to come, and so comparisons between current observed data and predicted future concentrations are, as explained previously, meaningless[26].

56. I do not agree with the further conclusion in paragraph 71 that "…. the reliance on the 'load to come' …. is poorly justified and leaves significant questions around the modelling process to estimate future nitrate concentrations, ….". This view is not justified or substantiated as discussed earlier. As a scientist, looking at the level of detail in hypothesis development around the model, groundwater system and data analysis, stochastic model development, modelling process development and description, uncertainty analysis, ground truthing; peer group analysis, review, feedback and discussion; and final results, it is my view that the model and its results are entirely plausible, and that the overall model is the result of an elegant and very thorough comprehensive study.

57. I do not completely agree with the suggestion made in paragraph 73 that the modelling shows "there is a very wide range of uncertainty regarding the potential for flow beneath the Waimakariri River and the impacts it could have on the Christchurch aquifers" and that "the modelling study has not provided new insights into this issue". The modelling shows that farming inputs and activities in Area A (the interzone transfer source area) in the NPA in the WZ will be essentially responsible for increases in nitrate concentrations in all of Christchurch's aquifers. For this to occur, contaminated groundwater from the NPA must flow beneath the current Waimakariri River bed to reach and get into the Christchurch aquifers. It is also clear from the model that water does not flow from other areas in the WZ and into the Christchurch aquifers, as no simulations using the model produced such a result[27]. This means the model is therefore providing significant certainty that contaminated groundwater must flow beneath the Waimakariri River; the model relies on it to reach its conclusions concerning impacts on nitrate concentrations in Christchurch aquifers in the future. The model also clearly shows that there is uncertainty in the magnitude of the steady state nitrate concentrations that will be reached in all the Christchurch aquifers. The model also shows that there are long time frames, 200 to 1200 years, to reach steady state in the deep aquifers. The model predicts the deep Christchurch aquifers will be those most

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[26] See the discussion of Dr H Rutter's evidence and similar analysis above

[27] This isn't to say that groundwater contaminated with nitrate from farming on the south side of the Waimakariri River does not also get into the Christchurch aquifers. It doesn't appear as though such a scenario has been considered or modelled by ECan. If such a groundwater model was developed by ECan, in the same way as the WZ groundwater model was produced, this possibility could be checked. If additional nitrate was predicted to also come from such other sources I would expect it would add to the nitrate concentrations predicted to have come from the WZ. Thus Christchurch's groundwater concentrations could rise to still higher levels

affected with regards to changes in current nitrate concentrations. Thus my view is that the modelling study has provided new insights into groundwater flow beneath the Waimakariri River and into the Christchurch aquifers, contrary to what appears to be stated in paragraph 73.

58. I do not completely agree with the suggestion made in paragraph 74 that the period from now until 2030 provides an opportunity to gather monitoring data that provides more certainty about land use effects. It will take a very long time for the impacts and effects of land use to be realised and visible in the deep Christchurch aquifers (and other aquifers) according to the current model. Therefore in 2030, even with another 10 years' data, we most likely will be in no better a position than we are now to have any greater certainty about the impacts of current land use effects, because many of those effects will still not have yet manifested themselves to any significant degree. There might be some noticeable impacts in the WZ but none, for example, would be expected in the deep Christchurch aquifers.

Jeremy Sanson

59. Mr Jeremy Sanson, a water resources engineer with Pattle Delamore Partners Ltd, provides evidence on a WIL solution package that offers alternatives to the nitrate reduction farming restrictions required by PC7. WIL suggest PC7 requirements are overly restrictive and economically untenable for their farmers. Central to the WIL Solution, as is also discussed in the evidence of Mr Brent Walton and Ms Bianca Sullivan, is agreement to:
    (a) limited nitrogen discharge reductions from WIL farmers (15% for dairy and 5% for other) for one planning cycle
    (b) possibly doing one more cycle of similar nitrogen reductions if shown to be necessary
    (c) the development of on farm water storage in the future to facilitate the selective use of irrigation water to dilute some of the nitrogen pollution from their farming activities via targeted stream augmentation (**TSA**) and managed aquifer recharge (**MAR**) to meet proposed WZ limits
    (d) habitat improvement measures
    (e) an improved monitoring programme.

60. WIL will require significant changes to PC7 and amendments to the policy framework for this to be possible. These issues, justification for the proposal and ramifications are discussed in the evidence of other WIL experts.

61. I do not agree with the analysis and statement in paragraph 17[28] "that measurements of groundwater quality in groundwater bores provide a much better basis for defining any sub-areas and that information does not support the sub-areas that Environment Canterbury have defined for this area of PC7". Unfortunately, as modelling shows, the bores throughout the WIL area, which currently show a variable pattern of nitrate concentrations, do not reflect or show the steady state nitrate concentrations that will result once the full impacts of nitrogen released from the farming in the WIL area are realised. Therefore, current bore nitrate concentrations are totally unsuitable for such a purpose. That is why ECan has done the modelling of the overall impacts of farming on groundwater in the region, so that there is a rational basis available upon which to base decisions around changes in land use that might be required.

62. I do not agree that the analysis of MAR and TSA in paragraphs 27 to 44[29] addresses all the issues identified in the WZ that are summarised in paragraph 23[30]. The analysis only estimates the quantity of water (1,351 L/s; 1.351 m^3/s) required for MAR to achieve median nitrate concentration limits of 5.65 mg NO_3^--N/L within the shallow aquifer system across nine public water supply areas with projected exceedances. It is not clear how this will affect other bores in the zone that also have projected exceedances. The analysis only estimates the quantity of water (2,530 L/s; 2.53 m^3/s) required for TSA to achieve median nitrate concentration limits below PC7 limits for the seven northern Waimakariri tributaries.

63. In addition, <u>the quantities of water required for MAR and TSA, as determined by Mr Sanson, entirely rely on the endpoint steady state nitrate concentration data produced by the ECan groundwater model</u>. However, WIL have consistently suggested (in the evidence of Mr Neil, Mr Sanson, Ms Sullivan, Mr Walton) that the basis and outputs of the ECan model are entirely questionable and inaccurate[31]. Therefore, what is WIL's position around the ECan model? Do WIL accept the data from the model or do they not accept the data from the model? <u>WIL cannot have it both ways.</u>

64. No estimates are provided by Mr Sanson for the quantity of water required for MAR to meet the proposed median nitrate concentration limit of 3.8 mg NO_3^--N/L in the deep Christchurch aquifers, or lower limits, if lower limits were to be met. The 3.8 mg NO_3^--N/L limit will not be met after only one 15% reduction in dairy farming nitrogen loss in the NPA in one planning cycle as the WIL Solution proposes; two such plan change cycles or a roughly 30% reduction

[28] J Sanson EIC
[29] J Sanson EIC
[30] J Sanson EIC
[31] For example, paragraph 83, J Sanson EIC

in dairying is required[32]. Therefore the quantity of water required for MAR to meet WZ objectives and targets is seriously underestimated, as none has been included for meeting limits for Christchurch's deep groundwater.

65. There is most likely an error in the second sentence of paragraph 28. The word 'groundwater' needs to be replaced by the words 'surface water' for this paragraph to make sense.

66. The use of TSA or MAR discussed by WIL, ECan, submitters and in evidence[33], which are 'dilution of pollution' techniques, will not offer any real significant relief to help fix the elevated ground water nitrate concentrations predicted for Christchurch.

67. As a simple example, the volume of zero nitrate MAR water that would be required to reduce the median or 99th percentile current consented at GMP farm scenario steady state nitrate concentration in the deep Christchurch aquifers to different proposed limits is summarised in Table 5. The calculations assume that 150 billion litres of low nitrate deep aquifer groundwater would be required each year[34] for drinking water supply, a flow of 4.76 m^3/s.

Table 5: Flow of zero nitrate MAR water required to dilute predicted nitrate concentrations in deep Christchurch aquifers to meet chosen drinking water nitrate concentrations

Predicted deep aquifer nitrate concentration, mg NO_3^--N/L		Flow (m^3/s) to dilute groundwater to meet different nitrate concentration limits[a]		
		Current median, 0.3 mg NO_3^--N/L	Proposed CCC limit, 1.0 mg NO_3^--N/L	Proposed WZC limit 3.8 mg NO_3^--N/L
Median	4.7	74.5	22.4	5.9
99th percentile	8.5	-	40.4	10.6

[a] Data in the first row assume all nitrate concentration limits are median values, whereas those in the second row assume all are upper limit (99th percentile) values

68. For example, to retain the current median nitrate concentration of 0.3 mg NO_3^--N/L in the deep aquifers, or meet the proposed CCC 1.0 mg NO_3^--N/L limit (assuming it was a median limit) or a proposed Waimakariri Zone Committee (**WZC**) median limit of 3.8 mg NO_3^--N/L, then 74.5, 22.4 or 5.9 m^3/s (74,500; 22,400 or 5,900 L/s) of zero nitrate water would need to be found and somehow injected into the deep Christchurch aquifers, respectively. If the requirement was that the proposed CCC 1.0 mg NO_3^--N/L limit was an upper limit (99th percentile), or a proposed WZC limit of 3.8 mg NO_3^--N/L was also an upper limit (99th percentile), then 40.4 or

[32] Paragraph 49, D A Rankin EIC
[33] For example, paragraph 48, J Carter EIC for Christchurch City Council
[34] Paragraph 22, D A Rankin EIC

10.6 m^3/s (40,400 or 10,600 L/s) of zero nitrate water would be needed, respectively. Such options would require very large amounts of additional pure water, infrastructure and cost, which in most cases would be totally impractical and unable to be achieved. These calculations suggest that the options of MAR and TSA are unlikely to be realistic solutions to achieve large reductions in groundwater or surface water nitrate concentrations in zones where water is already scarce and over allocated.

69. Therefore, overall, it is clear the current takes from the Waimakariri River for WIL will not provide the solution suggested – meeting groundwater and surface water limits in the WZ and nitrate limits in Christchurch deep aquifers, given that a significant amount of the take is needed for irrigation.
70. In addition, the WIL analysis and MAR and TSA proposition hides two key negative issues. PC7 requires reductions of nitrogen inputs or load into the WZ, and, as they are removed from the WZ environment, this will lead to real improvement in its poor environmental state. However, the WIL proposal will mean the nitrogen inputs and load into the WZ environment will largely remain the same and therefore mean the environment in the WZ will not really improve. This is a downside of using MAR and TSA; dilution of pollution does not fix a pollution problem or resolve issues, treatment of the pollution to significantly lower it or removal of the pollution in the first place does rectify such issues.
71. A second issue is that if in the future more water is taken from the Waimakariri River using the WIL and any other relevant consents for the purposes of storage for MAR or TSA, then a situation may arise where a greater volume of water overall is able to be taken from the Waimakariri River. This may then impinge further on the residual flow regime in the Waimakariri River, and especially reduce flows in the river needed to support the ecosystem services that river flow provides, and key flows that other river users, such as jet boaters or fishers, really need.
72. Therefore a significant conclusion from this analysis of the WIL proposal is that it will lead to far poorer environmental outcomes for the WZ environment, contrary to what the WZC have proposed, and will do nothing to address the threat to Christchurch's groundwater quality. Any suggestion that the WIL proposal can be tinkered with to address any of the concerns outlined above will require careful scrutiny and analysis before accepting any such proposals and making a decision.
73. I do not agree with many aspects of the suggestions in paragraphs 62 to 75 to support adoption of the WIL improved monitoring programme.

74. I don't agree with the fatuous and false argument and logic presented in paragraph 63. It is totally incorrect and misleading to suggest or imply that widespread reductions in nitrogen lost from farms will not collectively lead to improvement or achievement of water quality outcomes. Such an attempt to discredit the basis upon which the ECan model underpinning PC7 has been constructed (by taking into account all the losses of nitrogen from all farms in the WZ and then examining what will happen under various scenarios) is nonsensical.
75. I do agree that more monitoring will be helpful, but this by itself will do nothing to improve the poor state of the environment or water quality in the WZ. Focussing on this alone as a solution to the 'load to come' issue as suggested in paragraph 65 will mean that it will be many more years before the trends and impacts of current farming become visible and are finally 'confirmed', particularly because of the long residence times of nitrate loads in different aquifers, and therefore arguably for action to be taken to reduce such load contributions from farms. Furthermore, as it will take hundreds of years before the impacts of WZ farming will be able to be seen yet alone fully realised in the Christchurch aquifers, such a 'wait and see' approach is just a recipe for procrastination and contributing to the further degradation of the environment in the WZ and the Christchurch aquifers.
76. Based on the analysis and evidence presented above I therefore do not agree with Mr Sanson's conclusions in paragraphs 82 to 84 that the WIL solution "will achieve the proposed water quality targets", that "any additional actions to be set for 2050 can be based on actual monitoring data instead of the inaccurate models that are currently being relied on", or that "In practice, water quality targets are expected to be met quicker because the WIL Solution incorporates MAR and TSA." There is no evidence or data presented to show the basis of this last statement, nor how, or to what if any level, the WIL Solution will address nitrate contamination issues for the deep Christchurch aquifers and Christchurch's drinking water supply. Where similar conclusions are expressed in other WIL experts' evidence[35], I likewise do not agree with them.

Evidence of other parties

77. I do not agree with the analysis of **Dr Alister Metherell** (Submitter 172), an expert in Overseer and who, until recently, worked for Ravensdown and was also a farmer in the WZ, presented in paragraph 4.5[36]. Dr Metherell discusses data from a key draft report on the state of the Christchurch aquifers and impact from farming in the WZ. The data under

[35] Such as that of B Walton and B Sullivan, EIC
[36] Dr A Metherell EIC

discussion is the same as that in my EIC[37]. Dr Metherell concludes “This analysis shows that under current land management there is likely to be a small increase in median equilibrium nitrate concentrations in comparison to current measured nitrate concentrations (Table 1)”.

78. However, this conclusion is completely at odds with the current measured median nitrate concentration of 0.3 mg NO_3^--N/L in the deep Christchurch aquifers rising to the predicted equilibrium median of 4.5 mg NO_3^--N/L, a fifteen fold or 1400% increase in nitrate concentration, as a result of the current farm management practice in the WZ. This is an exceptionally large increase in nitrate concentration in the deep groundwater that supplies much of Christchurch’s drinking water, and does not constitute “a small increase”. Increases in median nitrate concentrations in the shallow and mid aquifers from current concentrations of 2.5 and 2.4 mg NO_3^--N/L to future steady state concentrations of 3.4 and 3.8 mg NO_3^--N/L, respectively, under current management practice are 36% and 58%, respectively, and are likewise not ‘small’ increases.

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[37] See Tables 1 and 2 (and 3), D A Rankin EIC