IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of the Proposed Plan Change 7 to the Canterbury Land and Water Regional Plan: Waimakariri
BETWEEN	DairyNZ Limited
AND	Canterbury Regional Council

HEARING STATEMENT OF HELEN KATHERINE RUTTER FOR DAIRYNZ

Dated 25 September 2020

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1. INTRODUCTION

1.1 Kia ora koutou, my name is Helen Katherine Rutter. I hold the position of Senior Groundwater Hydrologist at Aqualinc Research Limited (Aqualinc). I have been in this position since August 2007. My qualifications and experience are outlined in my Hearing Evidence.

1.2 DairyNZ has asked me to provide evidence in respect of its submission on Plan Change 7 (PC7) to the Canterbury Land and Water Regional Plan.

1.3 In my opinion, there is considerable uncertainty in the outputs of the modelling, due to the limited data available, both on groundwater levels and groundwater quality, particularly at depth. As such, I have first identified what we do know, from measured data, before summarising the main issues from the modelling.

2. MAIN ISSUES

2.1 My main concerns include:

(a) The lack of data for the deeper aquifer, including aquifer properties and piezometric data, which results in considerable uncertainty in the model results, especially in terms of the hydraulic gradient and flow directions at depth. I include the resulting work on developing the anisotropy that was then applied to the model under this topic.

(b) The difference between groundwater nitrate-N data and many of the model predictions, even allowing for transport lag times to the monitored bores. This includes the lack of widespread evidence for increasing nitrate trends both within the Waimakariri Zone and south of the Waimakariri River.

(c) The lack of documented peer review of the model, and apparent concerns from the expert panel members who provided input into the modelling.

(d) The need for specific monitoring plans, and adaptive management response to monitoring data, where the model could be updated as more data become available.

3. WHAT WE DO KNOW

Groundwater level data

3.1 Though there are very limited groundwater level data for wells deeper than 100m, from the 2017 piezometric survey, there is no evidence of flow from the Waimakariri GAZ towards Christchurch City. For wells greater than 100m depth, from the 2017 piezometric survey, flow eastwards of Halketts Corner is more towards the east or northeast, but this is based on very limited data.

3.2 Gap filling, to add in additional data points was carried out, but comes with additional uncertainties, as limited time series data can bias the results, depending on whether the points were from a period of high, low, or average water levels. In the Waimakariri GAZ, where seasonal variability can be of the order of 30m, this may be a significant issue, and may affect the match between modelled and measured data, and the predicted groundwater flow direction.

3.3 Mr Thomas has analysed the more recent data available for three sets of nested piezometers located close to the Waimakariri River, which suggests flow is parallel to the river. Whilst other experts considered that it is important to look at the wider distribution of groundwater levels across the whole dataset, rather than the detailed data at these locations, I don't consider that there is sufficient data to be able to derive flow directions with any confidence from the wider, limited data.

<u>Evidence for high permeability (and hence a nitrate transfer pathway) at depth</u>

3.4 ECan use data mainly from the Selwyn zone south of the Waimakariri River to provide evidence for high permeability zones at >250m depth. When the Waimakariri GAZ is assessed separately from the zones south of the river, there is quite a different pattern. The data from the Waimakariri GAZ do not show any evidence of high permeability at depths greater than 150m, and there is no data to support a nitrate transfer pathway in the deep aquifer (Figure 1). Conversely, when all of the data are assessed together, with the distribution being dominated by well south of the Waimakariri River, there is no evidence for higher permeability at depths greater than 250m, this effect being dominated by wells south of the river.

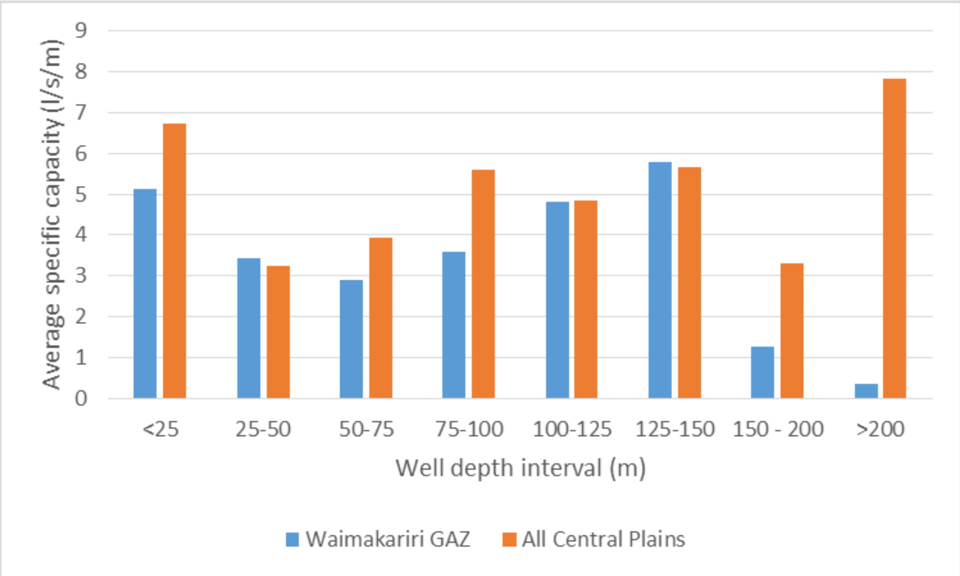

Figure 1. Specific capacity data for the Waimakariri GAZ versus data used by ECan for the wider areas (Figure 6-3 of ECan, 2019b)

Existing Groundwater Quality

3.5 Apart from localised areas, ECan observations do not provide overall support for an increase in nitrate-N concentrations across the Waimakariri GAZ, based on historic data. Their change in approach to analysis of the data between their 2018[1] and 2020[2] reports is likely the reason for the increase from one to four bores showing very likely increasing trends across the GAZ. The change also increases the number of bores with likely and very likely decreasing trends across the zone.

3.6 Scott *et al.* (2016)[3] also commented that nitrate-N concentrations in many locations within the Waimakariri GAZ had been stable for the past three decades, as shown in their Figure 6-8, reproduced below (Figure 2**Error! Reference source not found.**). The data available from ECan do not suggest there is a major change in nitrate-N concentrations over recent decades.

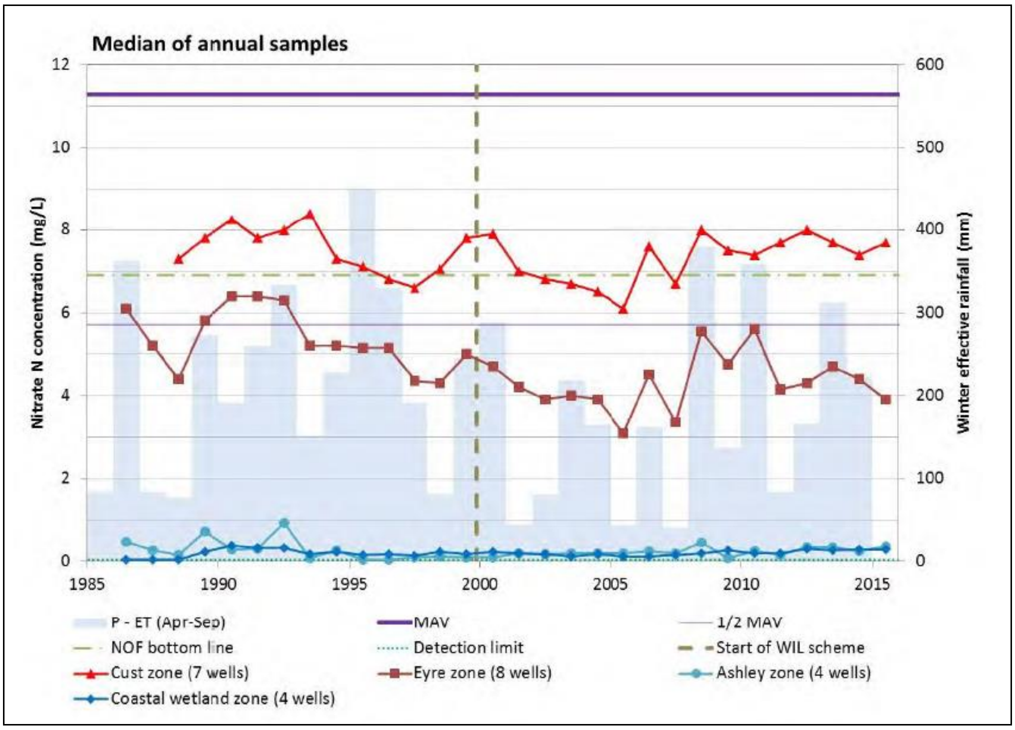

Figure 2. Median annual groundwater nitrate-N concentrations in the Waimakariri CWMS subzones aggregated from Environment Canterbury's long-term monitoring wells

3.7 As shown in my evidence, with regard to measured nitrate-N concentrations under Christchurch, there is a distinct pattern across the city, with the north-eastern part of the city showing consistently low nitrate-N concentrations over the past 60 years, where the groundwater is dominated by river recharge (see Figure 3, which shows data for the 2000s and 2010s: this pattern is replicated in all decades from

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[1] Scott L (2019) Annual groundwater quality survey 2018, Environment Canterbury Report, 18 pages

[2] Van Ness K (2020) Annual Groundwater Quality Survey 2019, Environment Canterbury Report R20/19

[3] Scott L, Wong R & Koh S (2016) The current state of groundwater quality in the Waimakariri CWMS zone, Report No. R16/48,

the 1960s). Land surface recharge is dominant in the southwest of the city, as evidenced by the increasing nitrate-N concnetrations over the past 6 decades[4].

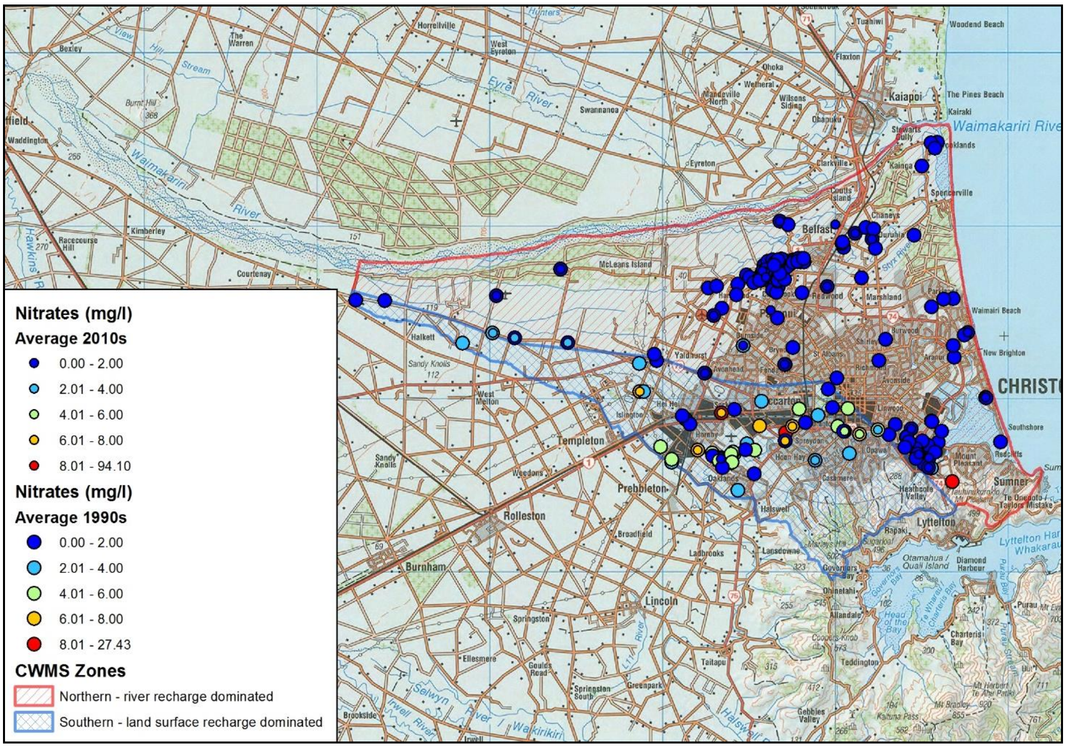

Figure 3. ***Nitrate-N concentrations in the Christchurch-West Melton zone***

3.8 Some of the measured data has raised some concerns, including:

(a) The deep monitoring data from the Russley Road area (M35/6791 and M35/6040), which shows low concentrations of nitrate-N, but with a gradual upward trend. I note that this bore is situated on the dividing line between the land surface recharge (LSR) and river recharge-dominated areas shown above, and the trend could be due to LSR within the Christchurch-West Melton zone, rather than any influence from north of the river.

(b) Figure 2-9 of ECan Report R19/68[5] (reproduced below in Figure 4) plots nitrate-N concentrations in Christchurch City Council (CCC) bores, but the increase of nitrate-N concentrations in wells at the 100-150m depth range is entirely based on one well, M35/10632, and is not indicative of declining groundwater quality across the city. [6]The apparent increase in nitrate-N concentrations at this depth is due to the inclusion of a new monitoring point. I note that this north east area of Christchurch does show evidence of land surface recharge in deeper groundwater, but there is no way of assessing whether this is a result of LSR north or south of the Waimakariri River, a fact that was recognised at the 2017 workshop, when PC stated that LSR could be from south side of the river.

[4] Rutter, K and Rutter, H. 2019. An assessment of nitrate trends in groundwater across Canterbury: Results from a science fair project. Journal of Hydrology (New Zealand), Vol. 58, No. 2, 65-80.
[5] Kreleger and Etheridge. Waimakariri Land and Water Solutions Programme Options and Solutions Assessment: Nitrate Management. Report No. R19/68
[6] Note that this does not appear to be anomalous in Figure 3, as the average over the 2010 period is 2 mg/l.

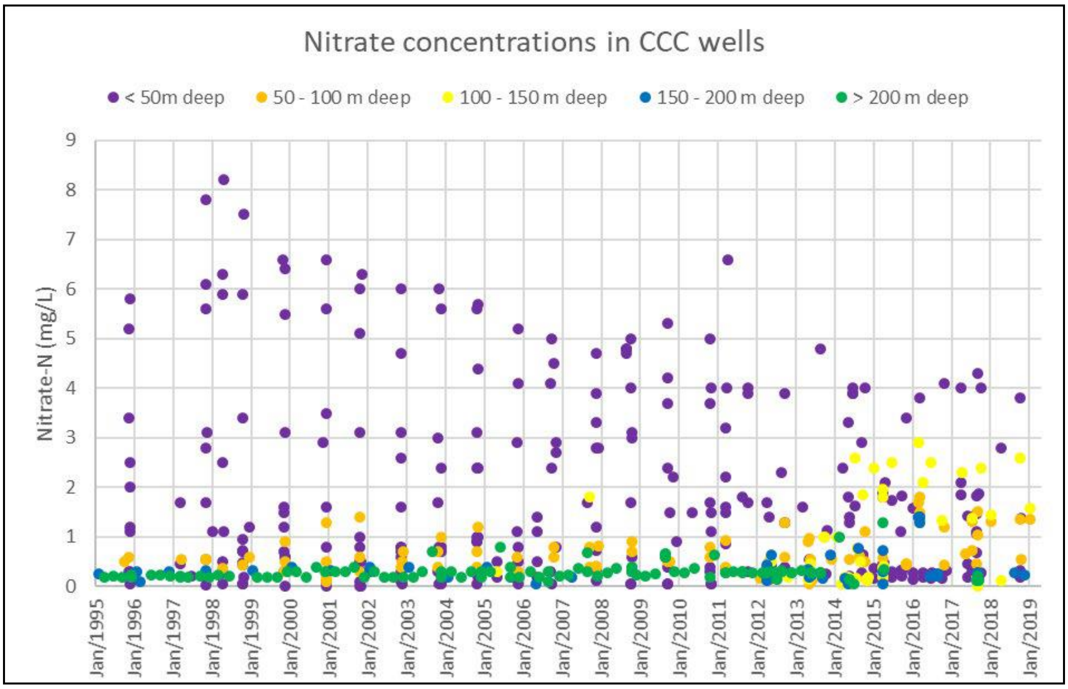

Figure 4: Nitrate-N concentrations in CCC bores, reproduced from ECan (2019a)

3.1 The geochemistry data has highlighted the north east of Christchurch (Belfast area) as having a LSR component in deep groundwater, but this does not imply that the LSR signature was from north of the Waimakariri River. It could equally be a local source. It cannot be determined by geochemistry alone if LSR-dominated groundwater is sourced from either area.

3.2 In my evidence, I presented two Figures (19 and 20) that showed decade-averaged nitrate-N concentrations in different Christchurch-West Melton GAZ bores. I would like to point out that the Figure titles were incorrect. Figure 19 shows data for wells less than 40m depth, and Figure 20 shows those greater than 40m depth. These are reproduced here with the correct titles (Figure 5 and Figure 6), and clearly show the influence of local land surface recharge in the shallow wells in the south west of the city, compared with the river water-dominated recharge in the north east of the city. They do not show any convincing evidence of an increase in nitrate-N concentrations at depth or in the northeast of the city, and the most influenced wells are shallow ones in the southwest, where they are likely to be affected by local land surface recharge.

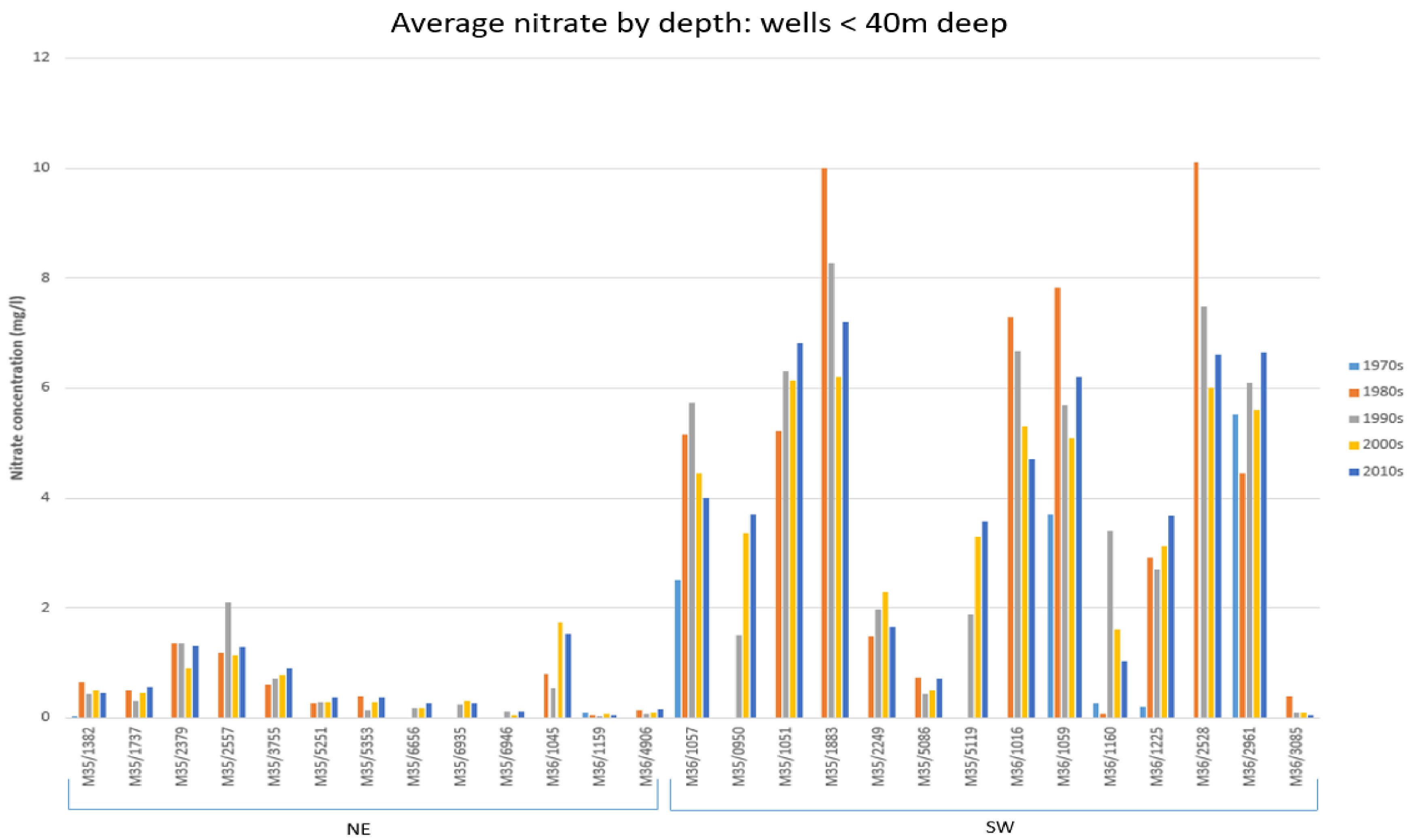

Figure 5. Decade-averaged nitrate-N concentrations for different Christchurch bores (less than 40m depth)

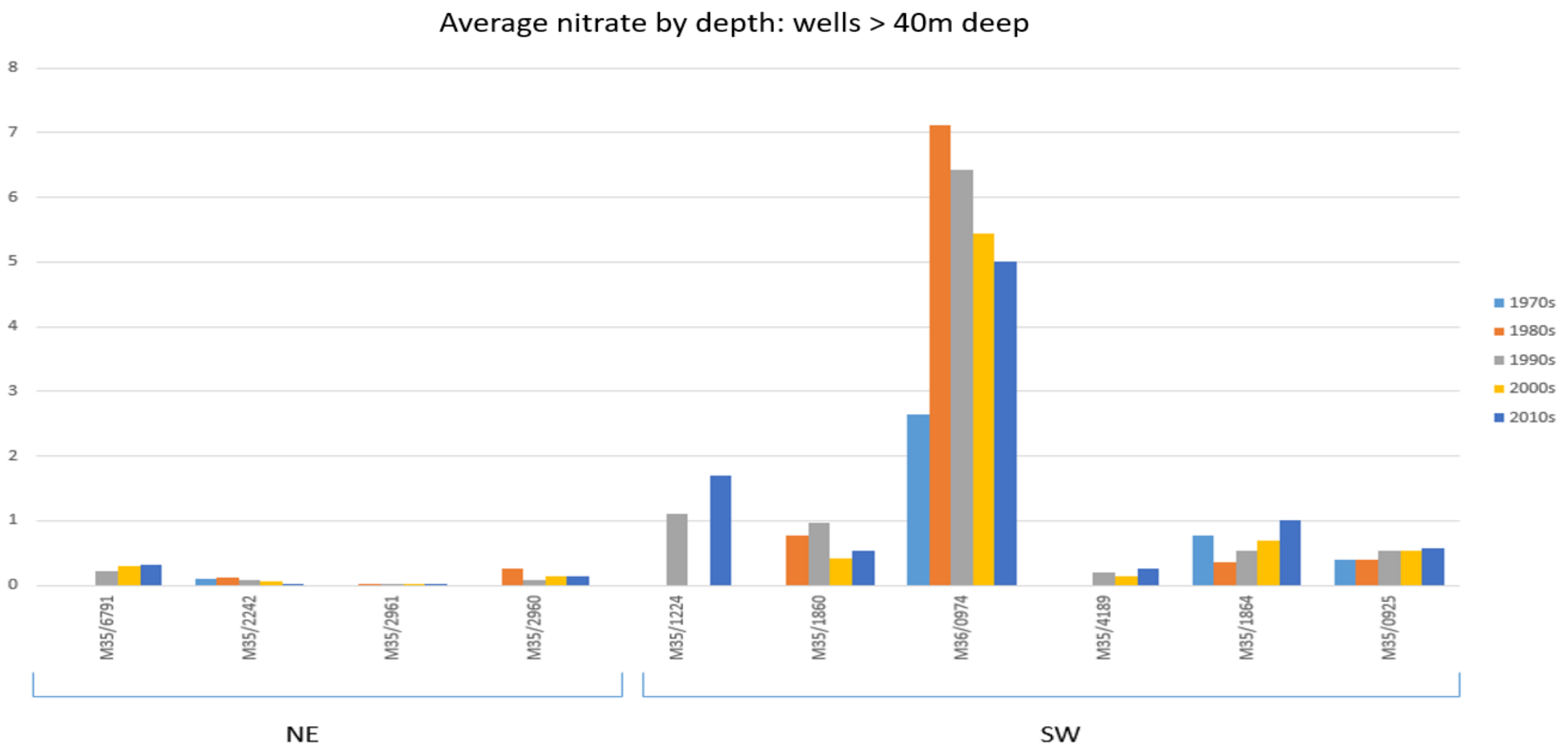

Figure 6: Decade-averaged nitrate-N concentrations for different Christchurch bores (Note M36/0974 is 40.5m deep, with a mid-screen depth of less than 40m, so is sampling water from predominantly less than 40m depth)

4. DATA AVAILABILITY AND IMPACTS ON THE MODELLING

4.1 Much of the work presented by ECan is based on data from shallow aquifer layers. In reality, there is very little data from deeper layers, within which the transport of nitrates from north of the Waimakariri River is predicted to occur.

4.2 The lack of data, and limitations of available data, were commented on at the 2017 workshop by the original panel of experts who had input into the development of the model[7].

4.3 The model has areas with systematically higher modelled groundwater levels than observations, one of which is beneath the Eyrewell region (where modelled levels appear to be around 20m higher than observations). If it is over-predicting groundwater levels in this area and not elsewhere, the result could be that the model predicts flow towards the city, which is not borne out by the limited data available.

4.4 The variography that was used to infer that there was preferential flow towards the south east, under the Waimakariri River, also has limitations. Dr Hayley explained (Appendix A of my Evidence in Chief) that with the available data, there is considerable uncertainty in terms of what can be derived from the results, including the conclusion of deep flow paths towards Christchurch. The variography does not prove a direction of preferential flow.

4.5 Whilst Mr Etheridge considered that the application of lateral anisotropy had limited influence on the model results (see Paragraph 26 of Joint Witness Statement), there has been no actual assessment of this, and the model structure was not subjected to sensitivity analysis. Hence the level of influence is simply unknown.

5. NITRATE-N CONCENTRATION PREDICTIONS

5.1 Whilst acknowledging that no model will perfectly predict concentrations at individual wells, 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, with modelled concentrations consistently being significantly higher than measured (in 10 out of 12 WDC bores; see Figure 8 of my evidence), and similar results presented by Mr Thomas for community water supply areas.

[7] Appendix 5 of Etheridge and Hanson. Waimakariri Land and Water Solutions Programme Numerical Groundwater Model conceptualisation, design, development and deployment. ECan Report R19/77

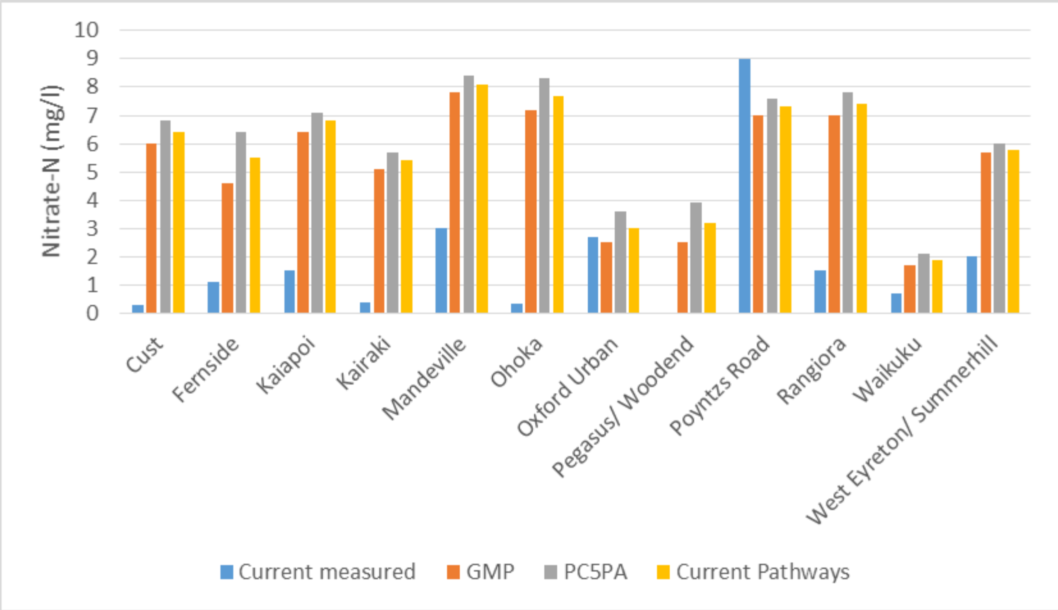

Figure 7. Measured vs modelled nitrate-N concentrations for WDC supply bores (based on data from ECan, 2019b)

5.2 The outputs presented under various tables in ECan's Report R19/68[8]) demonstrate small changes in concentrations between future scenarios. This is relative to much larger differences between measured and modelled concentrations, even when allowing for potential transport lag times and trends. That is, there is generally a large difference (up to an order of magnitude, or more) between measured and modelled values, and then very limited difference under different land use change scenarios.

5.3 The modelled increases in nitrate-N concentrations are not being observed, even in areas, such as Waikuku and Kairaki, where the modelled lag times are short (6 and 10 years respectively). In the case of Waikuku, there are 45 years of data that show low and stable nitrate-N concentrations, and no evidence that concentrations will increase to those predicted by modelling.

5.4 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 outputs.

6. PEER REVIEW

6.1 The lack of peer review of the model is a concern, as was agreed through caucusing. It appears that there were concerns with data from various members of the original expert panel, as have been discussed in my evidence. At expert caucusing, it was discussed that there had been further peer review, but that this was not sufficiently documented, and in the absence of this, or of evidence from the panel members, it reduces the level of confidence that we can have in the outputs of the model.

6.2 It appears that experts on the panel providing input into the modelling, questioned the potential for flow under the Waimakariri River. There does not appear to have been unanimous agreement about the direction of groundwater flow (despite the statement in the Officers' Report that there was), particularly at depth, nor whether there is flow under the Waimakariri River. Based on the comments in the minutes of ECan Report R19/77[9], that the experts raised similar issues to the ones I have discussed.

6.3 Input from the panel members is limited to the brief notes from the workshop in 2017. Further feedback, or further evidence of peer review, might go some way to addressing the issue of lack of peer review. Alternatively, external peer review might be considered.

7. LACK OF CLEAR PLANS FOR MONITORING AND ADAPTATION

7.1 There is a critical need for a specifically designed monitoring programme to assess whether targets are being met, or are likely to be met, to determine when no further nitrate loss reductions are required. The experts all agreed on this point, and also agreed that the current monitoring programme is unlikely to be suitable for this purpose.

7.2 I note that, in spite of there being nine specifically drilled observation bores on either side of the Waimakariri River, there have only been 2 samples taken from each over a two year period.

8. SUMMARY

8.1 With the evidence provided:

(a) The hydraulic gradients for deeper horizons are based on uncertain and sparse data, and, while flow towards the south east from the Waimakariri GAZ cannot be ruled out, it is just one of several possibilities.

(b) There is no evidence for high permeability deposits at depth under the Waimakariri GAZ.

(c) The variography is uncertain, and the outcome that has been reported is one of several possibilities. The uncertainties associated with the variography are then carried through into the groundwater model.

(d) The geochemistry data has highlighted the north east of Christchurch as having a LSR component in deep groundwater, but this does not imply that the LSR signature was from north of the Waimakariri River. It could equally be a local source. It cannot be determined by geochemistry alone if LSR-dominated groundwater is sourced from either area.

8.2 However, as noted above, there are few deep groundwater level measurements with which to calibrate the deeper layers (and therefore deep flow directions) of the groundwater model. Hence, any conclusions drawn about flow and transport through deeper layers are based on limited data, and are less reliable than for shallower layers (that can be better calibrated through more field data).

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[8] Kreleger and Etheridge. Waimakariri Land and Water Solutions Programme Options and Solutions Assessment: Nitrate Management. Report No. R19/68

[9] Appendix 5 of Etheridge and Hanson, Waimakariri Land and Water Solutions Programme Numerical Groundwater Model conceptualisation, design, development and deployment. ECan Report R19/77

8.3 I consider that what that has been proven is that we cannot discount the hypothesis that there is flow at depth under the Waimakariri River. Conversely, the work has not proven that there is, and it is not the only hypothesis that is a possibility with the available data. The resulting stochastic model will be biased by using the anisotropy ratios derived from the assumptions and uncertainties in the supporting data.

8.4 Additional work that could be carried out to assist with assessing whether land use change is achieving the objectives, could include:

(a) New and ongoing monitoring of deep and shallow groundwater levels, particularly with the addition of measurements in areas of missing data;

(b) New aquifer tests in both shallow and deep areas of missing data;

(c) Ongoing monitoring of nitrate-N groundwater concentrations, both deep and shallow;

(d) Ongoing monitoring of nitrate-N surface water concentrations;

(e) Further development of model taking into account the new data;

8.5 When there is confidence that the objectives are being achieved, review rules with regards to nitrate loss reductions that are required.

Dated 25/9/2020

Helen Rutter