Proposed Plan Change 7 to the Canterbury Land and Water Regional Plan

Assessment of nitrogen loss reductions in the Waimakariri sub-region for different land use and nitrate-nitrogen limits

28 October 2020

Authors: Amber Kreleger and Zeb Etheridge

Introduction

In the light of questions that were asked by the Hearing Panel of submitters in the first week of hearings on Plan Change 7 to the Land and Water Regional Plan (PC7 LWRP), the Council s42A Reporting Officers wish to provide further clarification and direction as to where various technical material can be found. In particular, the Council Officers wish to direct the Hearing Panel and submitters to the relevant technical material regarding the connection between nitrogen losses in the Waimakariri Zone and nitrate-nitrogen concentrations at different receptors, and provide some additional commentary in respect of the related land uses that may result.

Nitrate-nitrogen concentration limit for groundwater in the deep aquifers of Christchurch

Land use scenarios

Following the presentation of evidence from V Buck on 29 September 2020, and subsequent questions from Commissioner van Voorthuysen regarding the type of land use required to meet the desired nitrate-nitrogen concentration in groundwater (of 1 mg N/L), Officers would like to highlight the information presented in Table 4-5 on page 61 of Kreleger and Etheridge, 2019. Based on this information, it is likely that all irrigated land in the Christchurch aquifer recharge area would need to be converted to low intensity land use (e.g. dryland sheep and beef farming and forestry) in order to achieve a nitrate-nitrogen concentration of 1 mg N/L in the deep Christchurch aquifer.

A previous model simulation with an average annual nitrogen loss rate of 8 kg/ha applied to the modelled Christchurch aquifer recharge area north of the Waimakariri River gave a median model deep aquifer concentration for nitrate-nitrogen of approximately 1 mg N/L (averaged across the whole city).

Table 17 in *Lilburne et al (2019)* gives average annual nitrogen loss rates for different land use categories in the Waimakariri Zone as follows:

- Dairy – 60 kg N/ha/yr

- Sheep, Beef, Deer – 12 kg N/ha/yr
- Forestry – 2 kg N/ha/yr
- Lifestyle Blocks – 20 kg N/ha/yr
- DOC land – 0.2 kg N/ha/yr

Average annual nitrogen loss rates for the Christchurch aquifer recharge area are likely somewhat higher than these rates, as the recharge area comprises a much higher percentage of light and very light soils than the Waimakariri zone as a whole.

Table 1 (below) shows some examples of land use combinations compatible with an average annual nitrogen loss rate of 8 kg/ha. A significant proportion of the catchment would need to be converted to a very low intensity land use (forestry in these examples), to offset the higher nitrogen leaching rates from more intensive land use such as dairy farming or dryland sheep and beef farming.

Table 1 Example of land use combinations compatible with an average annual nitrogen loss rate of 8 kg N/ha

Land use	Example 1	Example 2	Example 3
Dairy	5%	0%	0%
Sheep, Beef, Deer	28%	42%	20%
Forestry	67%	50%	60%
Lifestyle Blocks	0%	8%	20%

For reference, the modelled Christchurch aquifer recharge area is 32,500 ha.

If the higher percentage of light and very light soils in the Christchurch aquifer recharge area was accounted for, land use intensity would likely need to be even lower than the examples in Table 1.

We note that this analysis excludes nitrogen sources to the south of the Waimakariri River. A lower nitrogen loss rate would be required if these sources were also contributing nitrate to the deep Christchurch aquifer at significant rates. However, we consider this contribution to be unlikely, because the combination of flow paths required for this outcome to eventuate is not compatible with our conceptualisation of the aquifer system.

As described in Table 4-5 on page 61 of Kreleger and Etheridge (2019), we consider that if all irrigated land in the Waimakariri Zone recharge area for the Christchurch aquifers was converted to forestry, the ultimate nitrate-nitrogen concentration in the deep Christchurch aquifer (ignoring any nitrogen sources south of the Waimakariri River) would be in the order of 0.6 mg N/L.

Concentrations over time due to "load to come"

Figure 1 (below) provides an illustration of potential nitrate-nitrogen concentrations in the deep Central Christchurch aquifers over time under the assumption that an 8 kg N/ha/year average nitrogen leaching rate is implemented by 2050 (this timing assumption could be changed if required).

The data are plotted on both a linear scale (Figure 1 a) and a logarithmic scale (Figure 1 b) to show both the relatively fast initial nitrate-nitrogen concentration reduction post 2050 (after an approximate 25-year lag for initial breakthrough) and the much slower long-term decline towards 1 mg N/L.

It should be noted that the age composition assumed here is just one of a range of possibilities, and hence these plots should be viewed as an illustrative scenario rather than a projection or prediction. Alternative, but equally valid, sets of water age distribution assumptions would give different peak nitrate-nitrogen concentrations and post-mitigation concentration decline rates. Further information on the derivation of these plots is provided below.

Figure 1 provides an illustration of how the nitrate-nitrogen concentrations in the deep Central Christchurch aquifers could change over time if the conversion to forestry was achieved by 2050 (orange line).

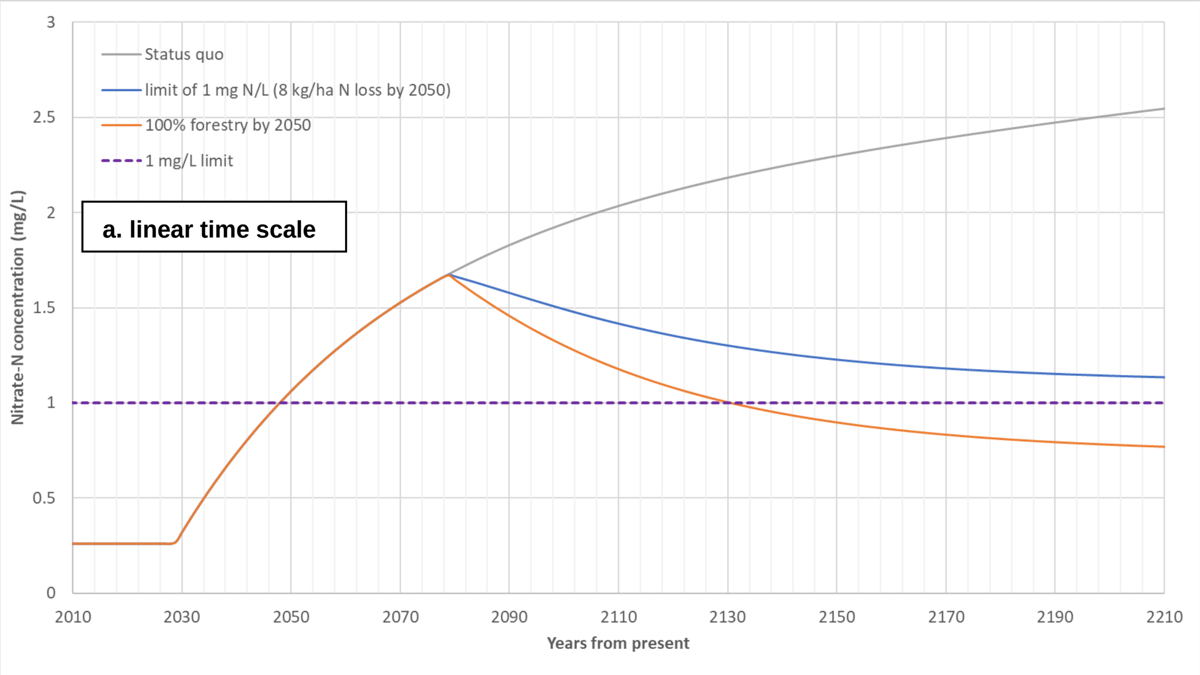
Nitrate-nitrogen concentration in groundwater in the deep Christchurch aquifers – status quo

Comparison with status quo

Following the provision of the new Figure 1, Officers consider that it may be useful to compare this information with the 'status quo'. The Current Pathways Scenario presented in the Nitrate Management Report (Kreleger and Etheridge, 2019) can be considered as the 'status quo' scenario. This scenario assumes a 50% uptake of the PC5 permitted activity rules. Table 4-10 on page 68 of the Nitrate Management Report presents a future nitrate-nitrogen concentration of 4.1 mg N/L (deep aquifers West Christchurch) and 5.4 mg N/L (deep aquifers Central and East Christchurch), which are the 50th percentile model results of the stochastic groundwater model.

Concentrations over time due to "load to come"

Figure 1 illustrates how the nitrate-nitrogen concentrations in the deep Central Christchurch aquifers could change over time under the 'status quo' or Current Pathways Scenario (grey line).



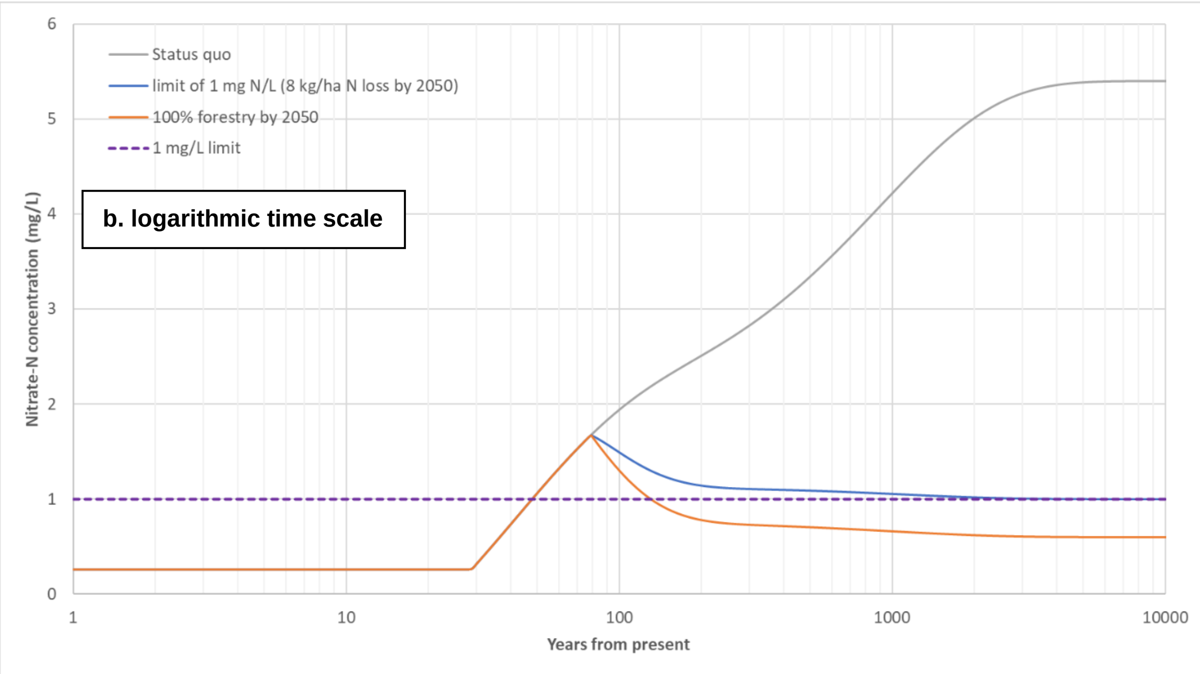


Figure 1 Illustrative nitrate concentration over time plot for the three management scenarios based on the BMM model with a 50/50 distribution of young groundwater (MRT of 50 years) and old groundwater (MRT of 1200 years)

Some notes regarding the derivation of these plots:

- We have used the Binary Mixing Model (BMM) as per paragraphs 2.3 – 2.7 in Appendix D.2 of the S42a report. The BMM model uses a mixture of younger and older fraction groundwater to account for variation in faster and slower transport pathways.
- We used the assumption that deep Christchurch aquifer water comprises a 50/50 mixture of relatively young water (mean residence time (MRT) of 50 years) which travels through the most permeable parts of the aquifer and much older water (MRT of 1,200 years), which travels through the less permeable parts of the aquifer. This gives a mean water age of 600 years, which broadly aligns with the results of age tracer interpretation for central Christchurch.

Standards for statistical modelling, risks and consequence

Kreleger and Etheridge (2019) describe in the Nitrate Management Report that the modelled nitrate-nitrogen concentrations are an estimate of what the future true concentration will be under a given scenario. The uncertainty involved in this estimate is a combination of uncertainty with the input files (for example nitrogen loss rates derived from OVERSEER) and uncertainty within the groundwater model itself (aquifer parameters, water levels, et cetera). Also, groundwater models are a simplification of the real-world hydrological system and due to this simplification not all biophysical processes (like nitrate attenuation) in the aquifers can be accurately mimicked. This adds another level of uncertainty to the model outcomes. Kreleger and Etheridge describe that the overall model uncertainty is explored via a stochastic or statistical approach, which allows us to present nitrate-nitrogen modelling results in terms of the percentage likelihood that the true value will be less than the modelled value. This is presented in the tables and graphs that report the 5th, 50th and 95th percentile model results.

95th percentile model results are often used as a basis for statistical modelling-based decision making where a precautionary approach is preferred, for example in situations where environmental impact of nutrient concentrations being higher than the median model results is considered unacceptable. Median (50th percentile) model results are often used where the consequences of model overestimates and underestimates are more evenly balanced. Ultimately, the percentile used is informed by risks and consequences.

For PC7 LWRP, it is therefore important to consider if using the 95th percentile results instead of the 50th percentile model results would reduce the likelihood of greater than expected environmental impacts (e.g. Christchurch aquifer nitrate concentrations). Assuming the 15% and 5% staged nitrogen loss reductions proposed in PC7 LWRP were retained, use of the 95th percentile nitrate-nitrogen projections would equate to more stages of nitrogen loss reduction in the future. This means that the only benefit of using these precautionary results under proposed PC7 LWRP rules would be to signal that larger nitrogen loss reductions (and hence more significant land use change) may ultimately be required to meet the proposed nitrate-nitrogen concentration targets.

Further information on this matter is provided in paragraphs 3.13 and 3.14 of Appendix D.3 of the S42a report and paragraphs 8.155 – 8.157 of Part 5 (Submissions on PC7 Part C, page 496) of the S42a report.

References

Kreleger, A. and Etheridge, Z, 2019: Waimakariri land and water solutions programme Nitrate Management Options and Solutions Assessment. Environment Canterbury Report No. R19/68.

Lilburne L., Mojsilovic O., North H. and Robson, M. 2019. Preparation of land use and nitrogen-loss data for the Waimakariri Zone limit-setting process. Landcare Research. May 2019.