horizons regional council

MEMORANDUM

FILE: EWQ0306

DATE: 16 July 2018

TO: Barry Gilliland, Lynette Baish and Tom Bowen

FROM: Maree Patterson, Staci Boyte, Stephen Collins and Kate Procter

SUBJECT: **ASSESSMENT OF THE ENVIRONMENTAL OUTCOMES FROM PROPOSED PLAN CHANGE 2 - TABLE 14.2 UPDATE**

Good Afternoon,

As requested by the policy team, we have undertaken a desktop assessment to model the potential environmental outcome as a result of the proposal to change Table 14-2 of the One Plan. To test the hypothesis that "the re-adjustment of the numbers in Table 14.2 does not affect the intended water quality outcomes in terms of soluble inorganic nitrogen (SIN) load originally sought in the operative One Plan." We tested this hypothesis on the Upper Manawatu (Mana_1 to Mana_5 inclusive) sub zones, as this is the area with the greatest number of (as yet) unconsented dairy farms.

During the One Plan hearings, modelling in a number of catchments was undertaken to determine the effectiveness of a range of different nutrient management policy options (Roygard and Clark 2012a, 2012b, and 2012c). The final modelling assumed that expansion of dairy in each of the modelled catchments would continue (based on economic evidence) at rates of 11% or and 18%. The modelling presented here is a comparison of the outcomes predicted from the above analysis and the outcomes of the proposed plan change without the assumed expansion.

Data used

Land use

In the evidence provided to the environment court, land use was originally estimated by Clark and Roygard (2008) using the best information available at the time which included information from Agribase, the consenting database and the Landcover Database version 2 (LCDB2) , as shown in Table 1.

For the purposes of this assessment, we were supplied with the latest data for both consented and unconsented farms by the Rural Advice Team, the information for the unconsented farms was provided anonymously by Dairy NZ (for the unconsented farms). This information has provided a more precise land area for the Dairy footprint within the catchment (also shown in Table 1). As there have been no known conversions within the catchment since the development of the layer used in the environment court evidence it is assumed that the initial assessment underestimated the area of dairy within the catchment. The latest dataset accounts for 5,415.3 additional ha of dairy.

Limitations of this current dataset are:

- Twenty of the unconsented farms did not have land area records available. For these farms, land area is extrapolated from existing data (see appendix x).

- There was discrepancy between total land area and the total land area spread across Land Use Capability (LUC) class. LUC class information is necessary to determine the impact of changes in Table 14.2 on in-stream outcomes, we elected to use this area. This discrepancy was found to be minimal for consented (max 8ha difference) and larger for the unconsented farms. Unconsented farms information was provided by DairyNZ with no other information, hence we are unable to 'sense check' land areas for this purposes of this assessment.
- As there is currently no spatial representation of the area of land in Dairy from the unconsented farms it is assumed that the increased area of Dairy was an equal decrease in the area of Sheep and Beef in the 2008 dataset, so the additional area was removed from Sheep and Beef. This is reflected in Table 1 below.

Table 1: Area of each land use class in the Upper Manawatu catchment (Clark and Roygard 2008).

Land Use	**Area (ha)**	
	Clark and Roygard 2008	**Updated with new dairy info**
Dairy	20,138.8	25,553.5
Sheep/Beef	85,676.8	80,261.5
Horticulture	20.9	20.9
Cropping	478.9	478.9
Built-up/other	1,481	1,481
Exotic cover	3,792	3,792
Native cover	12,757	12,757
TOTAL		**124,345.4**

Leaching information

For the Environment court evidence a combination of measured load literature values and nutrient budgets supplied to Horizons Regional Council (HRC) by dairy farmers were utilised to determine the losses from each land use type. In determining the land use leaching value for each category, sensitivity testing was undertaken to determine the effect of applying different loss values for land use cover.

To update the information for this assessment we were supplied with baseline nitrogen (N) leaching data from Overseer for both the consented and unconsented farms from the Rural Advice Team in conjunction with Dairy NZ. Table 2 presents the calculated N leaching.

Limitations and assumptions from dataset are:

- The leaching values provided were calculated using different versions of Overseer – this was particularly notable in the consented farms information (version 6.1.2 – latest version).
- Some of the unconsented farms did not have baseline leaching information. In these cases, it is assumed that the area weighted average leaching from the rest of the farms is representative of the farms where no leaching information is available.

Table 2: Area of each land use class in the Mangatainoka catchment (Clark and Roygard 2008).

Data source	**Leached kg N/ha/yr**
Original plan evidence	26.1
Updated area weighted average baseline leaching All Farms	41.2

As part of the assessment we also updated N leaching from Sheep and Beef to the new version of Overseer applying either (a) the numbers estimated by Manderson (2015) where these were available, or (b) calculated Sheep and Beef by difference (i.e. Sheep and Beef made up what was left of the load).

Cropping and Horticulture N leaching was also considered. For the purposes of this exercise, we looked at the average increase between N leaching in Table 14.2 in the operative plan versus the proposed Table 14.2 under the more recent version of Overseer across the LUC Classes that each land use would be expected to occur (Horticulture LUC 1 & 2 and Cropping LUC 1-4) and added this to the value identified by Roygard and Clark. We found that, due to the relatively small land area of these land uses, there was no measurable difference to the overall contribution from Cropping and Horticulture; as such, for this analysis the leaching values remain unchanged.

In river loads

In evidence given to the Environment Court, the total measured load of SIN in the Manawatu River at the Hopelands flow recorder was calculated to be 768.5 tonnes N per year, of which 24.1 tonnes was from authorised point sources and the remainder (762.4 tonnes) assumed to be from diffuse sources (Roygard and Clark 2012). We have used this river load for the assessment.

Transmission co-efficient

The transmission co-efficient is the proportion of nitrogen leached that is making its way into water (the opposite of which is known as the attenuation factor). In the One Plan evidence this was held at 0.5 (i.e. half of what is lost at the root zone is making its way into water). To test the hypothesis we used two different methods for attenuation:

1. We held the transmission at 0.5 by altering the leaching from Sheep and Beef to account for the gap between root zone loss and in-river outcome. This lead to very low (unrealistic)N leaching calculations for sheep and beef farming, and is not presented in the result below.
2. Calculated transmission by difference (the sum of the load from the total root zone N load (obtained by multiplying the land areas for each land use by the N leaching and then summing for the catchment), divided by the diffuse source load in the river at Hopelands (i.e. 762.4 tonnes N per year).

A literature review of Attenuation and groundwater processes for the catchment is provided in appendix 2.

Results

Table 3 below presents the results of this analysis, where the transmission co-efficient is calculated by difference (the sum of the load from the root zone divided by the diffuse sourced load in the river). For both the 2008 land area and the refined land area.

The new land area and new version of Overseer calculations have led to a transmission co-efficient similar to that calculated from attenuation factors estimated by Elwan et al (2015) as part of his PhD research (See appendix 2).

The reduction required as a result of the updated table proposed in plan change 2 is 35%. This is within the same ball park as the reduction required by dairy farms as modelled during the environment court hearings (37%).

The predicted in river outcome modelled for the environment court was a reduction of 13% or 16% with the refined land area. The table as proposed by the plan change has been modelled to reduce the in river SIN load by 15% or 17% with the refined land area.

Table 3: Comparison between the outcomes from table 14.2 compared to the proposed plan change.

			Dairy reduced by		In River Outcome		
Land area (ha)	**Table 14.2 version**	**base leaching**	**%**	**Kg/N/ha**	**% reduction**	**Tonnes saved per year**	**Transmission Co-efficient**
2008 land area							
20,139	Operative One Plan Yr 20	Evidence (overseer 5.*)	37%	9.7	13%	98	0.50
20,139	Plan change proposal Yr 20	Overseer 6.1.2 - 6.3	35%	14.3	15%	111	0.39
2018 land area							
25,554	Operative One Plan Yr 20	Evidence (overseer 5.*)	38%	9.9	16%	120	0.47
25,554	Plan change proposal Yr 20	New overseer	35%	14.5	17%	132	0.36

Conclusion

The modelling and comparison of outcomes as a result of proposed plan change 2 has shown a slightly lower % reduction from dairy as a result of the table change however, there is a slightly higher reduction in in river SIN as a result.

Appendix One

To calculate the area for the farms that did not have information we worked out the average area of a dairy farm in the catchment from the 110 farms that had area information (table xx) and multiplied this average by 20 to fill in an approximate area for the farms missing this information this equated to 3,931 ha.

Total Area (ha)	21,620.52
No of Farms with Land Area	110
Average area per farm	197

To spread this over the LUC classes we added the total area in each LUC class for the consented and unconsented footprint and worked out the proportion of land area in each of the LUC classes and then multiplied the missing area in dairy (3,931 ha) by the proportions to spread across the LUC classes.

	LUC								
	1	2	3	4	5	6	7	8	total
Consented (ha)	0.0	2,205.4	2,792.9	918.4	39.6	1,579.3	393.0	1.5	7,930.1
Yet to be consented (ha)	4.6	3,718.9	5,126.9	2,464.3	11.0	1,624.7	742.0	0.0	13,692.4
Total consented and yet to be consented (ha)	4.6	5,924.3	7,919.8	3,382.7	50.6	3,204.0	1,135.0	1.5	21,622.5
proportion of total	0%	27%	37%	16%	0%	15%	5%	0%	
Area missing dairy (ha)	0.8	1,077.1	1,439.8	615.0	9.2	582.5	206.3	0.3	3,931.0
Total including area of missing dairy (ha)	5.4	7,001.4	9,359.6	3,997.7	59.8	3,786.5	1,341.3	1.8	25,553.5

Appendix Two – Nitrogen attenuation in the Upper Manawatū

By linking root zone loads with instream loads, some estimate of the rate of attenuation occurring between the two zones can be made. The nitrogen attenuation factor (AF_N) is defined as the decrease in nitrogen leaving the root zone (by different processes in the subsurface environment) to the river sampling site at the outlet of the catchment (Elwan et al., 2015). In OVERSEER, the terms is known as the transmission coefficient, defined as the proportion of N leached from the soil root zone, as estimated by OVERSEER, that is measured in the river. The two terms are the same, but the inverse of each other.

The AF_N for each sub-zone within the Upper Manawatū catchment was calculated based on the root zone nitrogen leaching and the river nitrogen load at the outlet of the sub-zone. The AF_N was calculated as follows:

$$AF_N = \frac{L_d - L_r}{L_d}$$

L_d = Nitrogen leaching from the root zone
L_r = Soluble inorganic nitrogen load in the river

The flow stratified (FS) method (see Roygard & McArthur, 2008; Roygard et al., 2012; Roygard & Clark, 2012) was used to calculate the average annual soluble nitrogen river load L_r (ton yr^{-1}) for each sub-zone. These calculations were based on available monthly water quality data (ammoniacal-nitrogen, nitrate-nitrogen, and nitrite-nitrogen concentrations) and 15-minute river flow data from 1990 to 2014 for the study sites in the Upper Manawatū.

The nitrogen leaching from the root zone (L_d) was calculated through:

- assigning average annual nitrogen loss rates N (kg ha^{-1} yr^{-1}) for each land use type;
- multiplying the assigned average annual nitrogen loss rate N (kg ha^{-1} yr^{-1}) by the area (ha) of each land use in the sub-zone; and
- adding up all the land uses' contribution for each sub-zone to get the total average annual nitrogen leaching from the root zone (L_d, ton yr^{-1}) for the sub-zone).

The average annual nitrogen leaching rates N (kg ha^{-1} yr^{-1}) for each land use were obtained from Roygard & Clark (2012), i.e. 2.4 from native cover; 4 from exotic cover; 50.5 from cropping; 80 from horticulture; 3 from built up/other areas; and 16 from sheep/beef. The average annual leaching rate N (kg ha^{-1} yr^{-1}) from dairy was assigned as 33.9 based on the average value from all simulated N loss (kg ha^{-1} yr^{-1}) from the dairy farms in the Mangatainoka catchment (HRC, 2015).

The estimated AF_N for the Upper Manawatū sub-zones ranges from 0.29 (Kumeti at Te Rehunga) to 0.75 (Raparapawai at Jackson Rd and Manawatū at Weber Rd).

Table 4: Range of Nitrate Attenuation Factors for the Upper Manawatu.

Flow Site	Sub-zone	Nitrogen Attenuation Factor	Transmission coefficient
Manawatu at Weber Rd	Mana_1a	0.75	0.25
Mangatoro at Mangahei Rd	Mana_1c	0.74	0.26
Kumeti at Te Rehunga	Mana_4	0.29	0.71
Manawatu at Hopelands	**Mana_5a**	**0.65**	**0.35**
Tamaki at Stephensons	Mana_5b	0.37	0.63
Oruakeretaki at SH2	Mana_5d	0.3	0.7
Raparapawai at Jackson Rd	Mana_5e	0.75	0.25

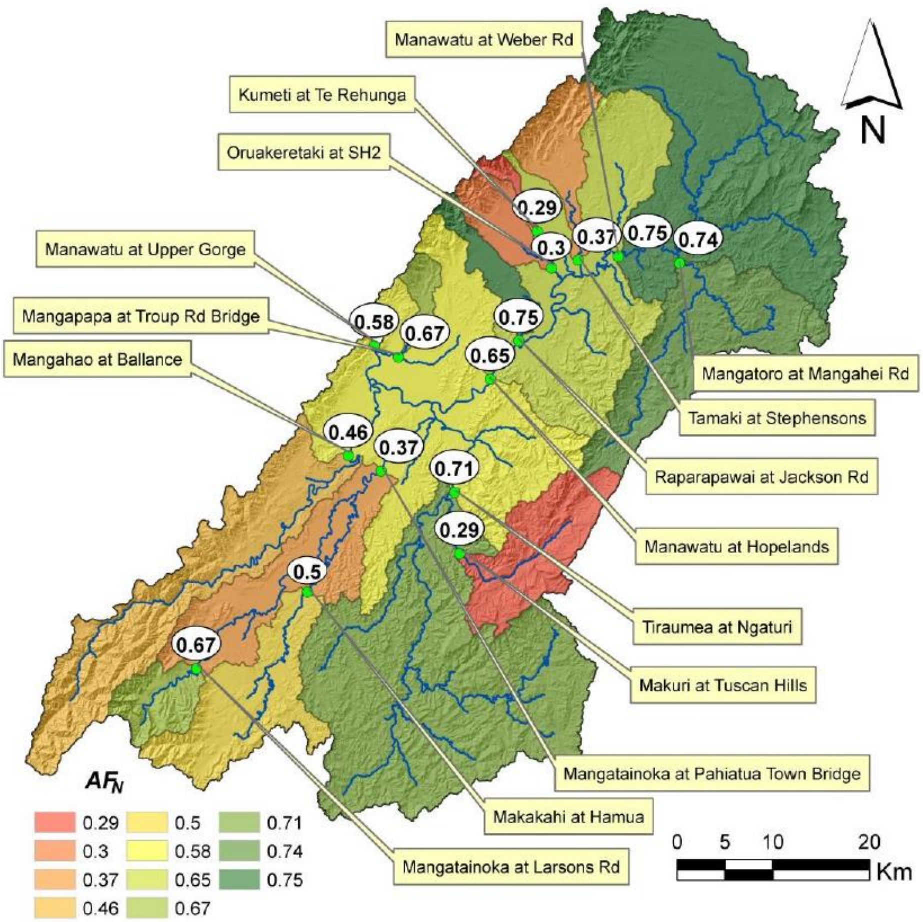

Figure 1: Spatial distribution of the nitrogen attenuation factor for 15 sub-zones in the Tararua GMZ (Elwan, et al. 2015).

References

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