BEFORE THE ENVIRONMENT COURT

In the matter of	appeals under clause 14 of the First Schedule to the Resource Management Act 1991 concerning proposed One Plan for the Manawatu-Wanganui region.
between	**FEDERATED FARMERS OF NEW ZEALAND** **ENV-2010-WLG-000148**
and	**MINISTER OF CONSERVATION** **ENV-2010-WLG-000150**
and	**DAY, MR ANDREW** **ENV-2010-WLG-000158**
and	**HORTICULTURE NEW ZEALAND** **ENV 2010-WLG-000155**
and	**WELLINGTON FISH & GAME COUNCIL** **ENV-2010-WLG-000157**
	Appellants
and	**MANAWATU-WANGANUI REGIONAL COUNCIL** *Respondent*

RESPONSE TO DR LEDGARD'S SECOND SUPPLEMENTARY STATEMENT OF EVIDENCE BY DR JON ROYGARD AND MS MAREE CLARK

Dated: 16th May 2012

horizons regional council

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Terms

TEB	=	technical evidence bundle
NV	=	notified version of POP
DV	=	decisions version of POP
MV	=	mediated version of POP
MCB	=	mediated compilation bundle

Comparison of catchment based outcomes from different Policy approaches.

Introduction

1. This evidence has been prepared by Dr Roygard and Ms Clark, we repeat the confirmation given our S42A reports that we have read and agree to comply with the Code of Conduct for expert witnesses. We have complied with this code throughout our presentation of information to the Court process.

Overview

2. This information forms the third and final step to model the approach proposed by Fonterra to catchment level outcome for SIN load. The first step was the further statement of evidence by Dr Roygard and Ms Clark to provide the information on the more detailed nutrient budget data set available to the Council. The second step was for Dr Ledgard to determine his interpretation of the potentially achievable reductions on a per hectare basis for each of the categories of the Fonterra proposal. This third and final step in this modelling is for Dr Roygard and Ms Clark to extrapolate these reductions to a catchment level outcome.

3. It is noted that the modelling of Dr Ledgard's estimated reductions does not in any way indicate agreement that these levels of reduction will occur as a result of implementing the proposed Fonterra Policy approach. This modelling has been done to inform the Court of an accurate extrapolation of Dr Ledgard's estimated reductions to a sub catchment/catchment level. In the event that comment is not made around a specific component of Dr Ledgard's modelling, this does not imply agreement with that aspect of the evidence.

Comments on assumptions for catchment modelling

4. There are several aspects of modelling the Fonterra approach to the catchment level that require further/different assumptions than the modelling of the other proposed approaches based on LUC or single

number limits. These include assumptions around the level of expected reductions that will occur from the Policy/Rule stream and dealing with different areas of dairy farming having differing responses to the Policy/Rule stream. These are discussed further in the paragraphs below.

5. The modelling of the Fonterra approach requires different assumptions to the Land Use Capability (LUC) and single number limit approaches about the interpretation of the level of reductions, if any, that will occur as a result of the Policy/Rule stream. For example:

    a. For the proposed LUC and single number limits approaches, the maximum N-loss rate for dairy farming is specified in the Policy/Rule approach. To model catchment outcomes, it is assumed that all dairy farms with N-loss rates less than the limit intensify to a point where they have N-loss rates equivalent to the limit and correspondingly all dairy farms above the limit reduce N-loss rates to the specified limit.

    b. For the proposed Fonterra approach, the N-loss rate achieved after the implementation of the Policy/Rule stream is not specified in the Policy/Rule stream. To address this for modelling catchment outcomes, the potentially achievable changes in N-loss rate have been estimated by Dr Ledgard. We understand the nature of the approach taken by Dr Ledgard to estimate the levels of reductions, but are unclear as to how likely these levels of reduction will be achieved under the regime proposed by Fonterra as the regime does not specify a particular level of reduction.

6. Some of the uncertainty as to the level of reductions that will be achieved by the Fonterra approach relate to the proposed benchmarking process. For example:

    a. One consideration with modelling the benchmarking approach for the 2007-2010 years is the uncertainty around what value from the three years will be utilised as the benchmark number e.g. if its the worst of the three years how would the modelled catchment outcomes differ and if the average, or the minimum were used?

    b. Further, we understand that some farms have only had nutrient budgets prepared once every three years as a part of the clean streams accord work by the fertiliser companies (Dr Ants Roberts of Ravensdown pers. comm.) This means that there may only be one nutrient budget for a range of dairy farms during the proposed period.

    c. Another item to consider is that it is unclear as to whether there is sufficient information to benchmark all farms for the period 2007 to 2010. The Fertiliser Industry, DairyNZ and Fonterra have only been able to compile 143 nutrient budgets (out of 950 dairy farms in the Region) for the One Plan process. We acknowledge that Fonterra have communicated to Horizons that they do not hold this information and therefore have not been able to provide it. We also note that Horizons has obtained approximately twice as many budgets by simply asking farmers for them or requiring them through consent processes or conditions. We do not know how many more we would have obtained had the request for nutrient

budgets been jointly from Horizons and Fonterra, as Fonterra declined to be involved in this type of exercise. The key point being, it remains unclear if the knowledge to benchmark from 2007 to 2010 exists and how if that process is adopted the modelled outcomes would compare to the modelled outcomes from the knowledge of the distribution of dairy farms N-Loss rates used in this process. If the knowledge does exist to benchmark over this period does exist, we have would have found it useful to have that information for the One Plan process.

7. The modelling of catchment outcomes from the Fonterra approach also requires different assumptions to the LUC and single number approaches around the interpretation of how the area of dairy farming responds to the different Policy/Rule streams as outlined below.

    a. For the modelling of the proposed LUC and single number limit approaches, all of the dairy farming area is treated as having an N-loss rate equivalent to the specified limits in the Policy/Rule stream. This is due to the assumption that farms that currently have N-loss rates less than the specified N-loss rate limit intensify to have an N-Loss limit equivalent to the specified N –loss limit. Similarly, the farms currently over the specified limit reduce down to be equivalent to the N-loss limit. The assumption that all farms come up to the limit is a conservative one and therefore the modelled outcomes from this approach may underestimate the reductions in in-river loads of Soluble Inorganic Nitrogen (SIN) that may occur if all farms do not intensify to a rate equivalent to the specified N-loss limit. This may be offset by any proposed Policy streams where there is a "challenged farm" Policy approach and some farms are not required to reduce fully to the specified limit. For the catchment level SIN load outcomes from the proposed LUC and single number limit approaches on existing farms, a single calculation of the area of dairy farms multiplied by an average N-loss rate for that area was completed.

    b. Modelling of the catchment level SIN load outcomes from the proposed Fonterra approaches on existing farms requires consideration of two areas of dairy farming and two different N-loss rates. This is due to the two different responses for the area of dairy farms put forward by Dr Ledgard, the area of the farms that have N-loss rates of 27 or more kg N/ha/year and the area of dairy farms that have N-loss rates of less than 27 kg N/ha/year. For the modelling, Dr Ledgard has requested (and been supplied) the number of farms with N-loss rates equal to or above 27 kg N/ha/year and the number of farms with N-loss rates below 27 kg N/ha/year. There is an extra assumption required for extrapolating the number of farms with a particular level of N-loss rate to the area of farms with that level of N-loss rate. As an example, Dr Ledgard's assumption follows the logic that 25% of the farms with the highest N-loss rates cover 25% of the area. This does not necessarily hold true, and this assumption contributes to the uncertainty about the outcome of the modelling results of the proposed Fonterra result.

8. To effectively model the outcomes of any of the proposed approaches with consideration of the rate of conversions, requires an estimation of the change in N-loss rate from the area that is converted. For the modelling by Dr Roygard and Ms Clark, we have consistently assumed

that all conversions are from sheep and/beef farms and we have reduced the contribution from sheep and/beef farms and increased the N-loss rate from dairy farming to account for both the new area in dairy farming and the N-Loss rate from the dairy conversions. In modelling the various proposed Policy/Rule approaches, different assumptions for the N-loss rate for the area converted to dairy farming are required, for example

a. For the single number limit approach the area converted to dairy farming is modelled as having an N-loss rate equivalent to the maximum N-loss rate value for the single number limit.

b. For the LUC based approaches, the average N loss rate for the converted farms is calculated based on the existing proportional split of dairy farms across various LUC units, and the LUC limits for each of these classes. The assumption is that any future conversions will follow the same proportional split across the LUC units as the existing dairy farms in that area. As the proportion of dairy farms across the LUC classes differs in the different areas of the catchments, there are variations in the average rate of N-loss rate per hectare for the various approaches (Table 1). It is noted that the Horizons modelling of the proposed approaches of Fonterra, Horizons and Wellington Fish and Game/Minister of Conservation use this approach to calculate contributions from the converted dairy farms.

Modelling of Dr Ledgard's estimates of reductions

9. Dr Ledgard's further supplementary evidence seeks to estimate the reductions based on the implementation of the proposed Fonterra regime. The new modelling includes modelling of the larger data set of nutrient budget information from the Regional Council, and also presents the regional average from Dr Ledgard's data set. The reductions in the regional average presented by Dr Ledgard seem to assume the Policy mechanism applies to the whole of the region. However, the Rule is targeted to specific water management sub-zones as outlined in Table 13.1. Dr Ledgard's modelling of the regional averages therefore over represents the efficacy of the Fonterra regime.

10. The assumption around the areas of the catchment where the Rule applies appears to carry over to some of the specific sites that are modelled. It appears that Dr Ledgard's modelling considers all of the area of dairy farms upstream of the modelled sites to be included as a part of the Rule. This is the case for two of the three sites in the Manawatu catchment (Manawatu at Hopelands and Mangatainoka at SH2). However, is not true for the other sites modelled (Manawatu at Upper Gorge, Rangitikei at McKelvies and the regional average). As an example, the area upstream of the Manawatu at Upper Gorge site does include some large areas that are not included in the Rule. Dr Roygard and Ms Clark's modelling has provided for this within the calculations of SIN load outcomes for the Manawatu at Upper Gorge site. As Dr Ledgard's calculations for the Manawatu at Upper Gorge site and Rangitikei at McKelvies consider all dairy farms as a part of the Rule, any extrapolation of these will overestimate the efficacy of the Rule. For this reason, we limit the extrapolation of Dr Ledgard's approach to SIN load outcomes to two sites (Manawatu at Hopelands and Mangatainoka at SH2).

11. The following sections present a comparison of different Policy/Rule approaches of Ms Barton, Fonterra, Wellington Fish and Game & Minister of Conservation) and a single number limit approach (27kg N /ha/year). Modelled outcomes for the Manawatu at Hopelands and Mangatainoka at SH2 sites are presented for:

    a. a 10 year period with 5.5% dairy expansion;
    b. a 20 year period with 11% dairy expansion; and
    c. a 20 year period with 18% dairy expansion.

Catchment outcomes of the different Policy approaches over a 10 year timeframe with 5.5% expansion.

12. Modelling of the Manawatu at Hopelands site and the Mangatainoka site (Table 2 and 3) has been completed using a similar methodology to that presented in the evidence statement of Dr Roygard (27 April 2012). The only adaption to the calculation was the ability to vary the N-Loss rate of the existing farms separately from the N-loss rate of the conversions, and to then sum the results after allowing for the changes in area of dairy farming and sheep/beef farming due to conversions. Catchment outcomes (SIN load changes) were modelled over a 10 year timeframe including:

    a. Ms Barton's approach for the Manawatu Wanganui Regional Council, using the DVPOP LUC N-loss rate limits for conversions implemented over the 10 years for all existing farms and dairy conversions;

    b. Mr Willis's approach for Fonterra with N-loss rate reductions for existing dairy farms as estimated by the assumptions of Dr Ledgard and N-loss rates for conversions equivalent to the DVPOP LUC N-loss rate limits for conversions;

    c. Wellington Fish and Game/Minister of Conservations approach assuming the NVPOP LUC N-loss rate year 10 limits implemented over the 10 years for all existing farms and dairy conversions; and

    d. A single N-loss number of 27 kg N/ha/yr.

13. The results from the modelling for the Manawatu at Hopelands site are shown in Table 2. The results show that over the 10 year period that:

    a. Ms Barton's approach is predicted to result in a decrease in N-loss rate from existing dairy farms over the 10 year period of 16.4%, which in turn reduces the in-river SIN-load contribution of dairy by 11.8% after adjusting for conversions. This is predicted to result in a reduction of overall in-river SIN loads at the Manawatu at Hopelands site of 5.0%;

    b. The Fonterra approach is predicted to result in a decrease in N-loss rate from existing dairy farms over the 10 year period of 14.9%, which in turn reduces the in-river SIN-load contribution of dairy by 10.3% after adjusting for conversions. This is predicted to result in a reduction of overall in-river SIN loads at the Manawatu at Hopelands site of 4.4%;

    c. The Wellington Fish and Game/Minister of Conservation approach is predicted to result in a decrease in N-loss rate from existing dairy

farms over the 10 year period of 34.1%, which in turn reduces the in-river SIN-load contribution of dairy by 30.4% after adjusting for conversions. This is predicted to result in a reduction of overall in-river SIN load at the Manawatu at Hopelands site of 11.6%; and

d. The single number approach of 27 kg N/ha/yr is predicted to result in an increase in N-loss rate from existing dairy farms over the 10 year period of 3.5%, which in turn increases the in-river SIN-load contribution of dairy by 9.2% after adjusting for conversions. This is predicted to result in an increase of overall in-river SIN load at the Manawatu at Hopelands site of 2.4%.

14. The results for the two sites modelled over the 10 year period are summarised in Table 3. In summary for the Hopelands site:

a. The single number approach of 27 kg N/ha/yr results in an increase of SIN load. In contrast the approaches of Ms Barton, Fonterra and Wellington Fish and Game/Minister of Conservation result in a decrease in SIN Load;

b. The approaches of Ms Barton and Fonterra result in broadly similar percentage reductions of overall SIN load. However, the similarity of the results from Ms Barton's approach and the Fonterra approach should be considered in the context of the further uncertainty about the predicted level of reductions occurring for the Fonterra approach (as outlined above); and

c. The Wellington Fish and Game and Minister of Conservation's approach is predicted to result in more than double the level of the reductions from Ms Barton's and the Fonterra approach over a 10 year period.

Table 1: Area of existing dairy (2008) on each LUC class within the specified zones with the average N-loss rate for each zone under current and different Policy approaches on a N-loss rate kg N/ha/year basis.

	Hectares of dairy farming in 2008									Average loss rate (kg N/ha/year) for existing dairy farms under various Policy approaches					
	LUC 1	**LUC 2**	**LUC 3**	**LUC 4**	**LUC 5**	**LUC 6**	**LUC 7**	**LUC 8**	**Total**	DVOP - rates	NVOP - Year 1 rates	NVOP - Year 1 0 rates	NVOP - Year 20 rates	Current Average N-loss Rate	Weighted average proposed by Dr Ledgard for the Fonterra approach after estimated improvements for existing farms
Manawatu Catchment														23.4	
Manawatu at Weber Rd	0.0	2184.8	1000.1	1042.8	71.1	671.9	499.8	0.0	5470	21.4	20.6	16.9	16.1	26.9	
Manawatu at Hopelands	0.0	5704.3	7489.6	3207.3	116.8	2409.6	1210.6	0.0	20138	21.8	20.6	17.2	16.3	26.1	22.2
Tiraumea at Ngaturi	0.0	190.7	216.9	0.0	0.0	573.6	279.2	0.0	1260	16.8	14.1	12.5	12.2	28.6	
Mangatainoka at Larsons	0.0	77.7	31.3	0.0	0.0	146.5	12.3	0.0	268	19.2	16.7	14.4	13.9		
Makakahi at Hamua	0.0	1874.1	567.2	452.9	0.0	1875.3	159.4	81.3	5010	20.3	18.8	15.6	15.0	24.1	
Mangatainoka at SH2	407.9	5470.0	2374.7	634.0	0.0	3666.7	248.6	81.3	12883	22.2	21.1	17.3	16.6	24.7	21.7
Mangahao at Balance	0.0	722.8	577.7	181.1	0.0	936.3	161.2	0.0	2579	20.2	18.2	15.4	14.8	34.8	
Manawatu at Upper Gorge	407.9	15809.3	13277.3	5684.4	116.8	10444.4	2551.8	83.9	48376	21.5	20.2	16.8	16.0	25.3	21.9
Waikawa Catchment														16.0	
Waikawa at North Manakau Road	1.3	15.0	81.0	40.0	0.0	33.0	0.0	0.0	170	21.2	19.0	16.4	15.6		
Waikawa at Huritini	148.4	257.8	879.2	72.7	0.0	233.3	1.3	0.0	1593	23.4	22.0	18.6	17.7		
Manakau at SH1	0.7	0.0	14.5	0.0	0.0	0.0	0.0	0.0	15	24.3	22.5	19.3	18.3		
Rangitikei Catchment														21.8	
Rangitikei at Mangaweka	0.0	35.7	483.7	29.8	0.0	383.5	50.9	31.3	1015	19.0	16.1	14.4	13.8		
Rangitikei at Onepuhi	1208.8	760.2	670.4	68.7	0.0	511.9	50.9	49.4	3320	24.8	24.7	20.3	19.5	26.4	
Rangitikei at Mckelvies	1741.4	8451.7	2451.5	790.6	0.0	1274.0	119.9	49.4	14879	25.1	25.6	20.3	19.4	22.0	

Table 2: Comparison of outcomes from potential policies for nutrient management for the area upstream of the Manawatu at Hopelands monitoring site. Modelling was completed for a 10 year period with 5.5% expansion of dairy farming. Cells shaded blue indicate percentage changes in N-loss rate from existing farms. Cells shaded yellow indicate percentages changes in in-river SIN loads from dairy farming. Cells shaded green indicate percentage changes in overall in-river SIN load. Calculations of in-river SIN loads contributions assume an attenuation factor of 0.5.

Manawatu at Hopelands		Ms Barton's approach - DVPOP LUC limits applied to existing dairy farms and new dairy farm conversions				Fonterra approach – existing farms reduce as per Dr Ledgard's revised estimates and - DVPOP LUC limits apply to new conversions				Wellington Fish and Game/Minister of Conservation approach NVPOP yr 10				Single number limit for dairy farming of 27 kg N/ha/year			
		Sheep/beef	**Dairy**	**Other**	**Total catchment**	**Sheep/beef**	**Dairy**	**Other**	**Total catchment**	**Sheep/beef**	**Dairy**	**Other**	**Total catchment**	**Sheep/beef**	**Dairy**	**Other**	**Total catchment**
Land area in 2008	ha	85677	20139	18530	124345	85677	20139	18530	124345	85677	20139	18530	124345	85677	20139	18530	124345
Land area in 2018 (5.5% dairy expansion from Sheep/beef)	ha	84569	21246	18530	124345	84569	21246	18530	124345	84569	21246	18530	124345	84569	21246	18530	124345
Change in area	ha	-1108	1108	0	0	-1108	1108	0	0	-1108	1108	0	0	-1108	1108	0	0
Change in area	%	-1.3%	5.5%			-1.3%	5.5%			-1.3%	5.5%			-1.3%	5.5%		
N-loss rate 2008 existing farms	kg N/ha/yr	10.8	26.1	2.0	12.0	10.8	26.1	2.0	12.0	10.8	26.1	2.0	12.0	10.8	26.1	2.0	12.0
N-loss rate 2018 existing farms	kg N/ha/yr	10.8	21.8	2.0	**11.4**	10.8	22.2	2.0	**11.4**	10.8	17.2	2.0	**10.6**	10.8	27.0	2.0	**12.3**
Percentage change in N-Loss rate 2008 to 2018 (existing farms)	%	0.0%	-16.4%	0.0%	-5.0%	0.0%	-14.9%	0.0%	-4.4%	0.0%	-34.1%	0.0%	-11.6%	0.0%	3.5%	0.0%	2.4%
N-loss rate 2018 dairy conversions	kg N/ha/yr		21.8				21.8				17.2				27.0		
Tonnes SIN contributed 2008 (in-river)	Tonnes SIN/yr	462.0	262.7	18.8	743.5	462.0	262.7	18.8	743.5	462.0	262.7	18.8	743.5	462.0	262.7	18.8	743.5
Tonnes SIN contributed 2008 (in-river)	Tonnes SIN/yr	456.1	231.7	18.8	706.5	456.1	235.6	18.8	710.7	456.1	182.7	18.8	657.6	456.1	286.8	18.8	761.7
Decrease in SIN load (2018-2008)	Tonnes SIN/yr	6.0	31.0	0.0	37.0	6.0	27.1	0.0	32.8	6.0	80.0	0.0	86.0	6.0	-24.1	0.0	-18.1
percentage change in in-river SIN load contribution 2008 to 2018	%	-1.3%	-11.8%	0.0%	-5.0%	-1.3%	-10.3%	0.0%	-4.4%	-1.3%	-30.4%	0.0%	-11.6%	-1.3%	9.2%	0.0%	2.4%

Table 3: Comparison of modelling outcomes from potential policies for nutrient management for two sites in specified zones. Modelling was completed over a 10 year period with 5.5% expansion. Cells shaded green indicate changes in overall in-river SIN load.

Area/Site	**Ms Barton's approach**			**Fonterra approach remodelled using Dr Ledgard's revised predicted reductions**			**Wellington Fish and Game/Minister of Conservation Approach**			**Single number limit for dairy farming of 27 kg N/ha/year**		
	Percentage change in			Percentage change in			Percentage change in			Percentage change in		
	N-loss rate 2008 to 2018	In-river SIN load from dairy	Overall in-river SIN load	N-loss rate 2008 to 2018	In-river SIN load from dairy	Overall in-river SIN load	N-loss rate 2008 to 2018	In-river SIN load from dairy	Overall in-river SIN load	N-loss rate 2008 to 2018	In-river SIN load from dairy	Overall in-river SIN load
Manawatu at Hopelands	-16.4%	-11.8%	-5.0%	-14.9%	-10.3%	-4.4%	-34.1%	-30.4%	-11.6%	3.5%	9.2%	2.4%
Mangatainoka at SH2	-10.3%	-5.4%	-4.1%	-12.2%	-7.2%	-4.6%	-30.0%	-26.1%	-10.3%	9.3%	15.3%	2.1%

Catchment outcomes of the different Policy approaches over a 20 year timeframe with 11% expansion.

15. The original modelling presented by Dr Roygard and Ms Clark (24 February 2011) forecasts over a 20 year period. This time frame was selected to be consistent with the timeframes of NVPOP that has limits specified for Year 1, Year 5, Year 10 and Year 20 after implementation of the proposed Rule. The 20 year period was also consistent with the intensification forecasts by the economists (Mr Newman for Fonterra, and Neild and Rhodes for the Manawatu- Wanganui Regional Council). To recast the revised modelling back to the body of modelling work that was completed prior to caucusing, the following section presents the four approaches modelled above over a 20 year period assuming a 11% expansion of the area of dairy over the 20 year period. To do this required consideration as to whether the approaches included "step downs" in the N-loss rates over time. The approaches of Ms Barton, Fonterra and the single number approach do not contain any step down in limits or forecast any further reductions over the second 10 year period of the Plan. By contrast, the approach of Wellington Fish and Game and Minister of Conservation does provide a further set of reductions to year 20 limits. The other consideration for the longer term (20 year) modelling is the greater number of conversions predicted.

16. Adaptions were made to the calculations to enable modelling of the four approaches over the 20 year time frame with an 11% expansion. In summary, the four approaches were:

    a. Ms Barton's approach for the Manawatu Wanganui Regional Council, the DVPOP LUC N-loss rate limits for conversions implemented over the 20 year timeframe for all existing farms and dairy conversions;

    b. Mr Willis's approach for Fonterra with N-loss rate reductions for existing dairy farms as estimated by the assumptions of Dr Ledgard and N-loss rates for conversions equivalent to the DVPOP LUC N-loss rate limits for conversions;

    c. Wellington Fish and Game/Minister of Conservations approach assuming the NVPOP LUC N-loss rate year 20 limits implemented over the 20 year timeframe for all existing farms and dairy conversions; and

    d. A single N-loss limit of 27 kg N/ha/yr.

17. The modelling approach and results from the scenarios for the Manawatu at Hopelands site are shown in Table 4. The results show that over the 20 year period assuming 11% expansion:

    a. Ms Barton's approach is predicted to result in a decrease in N-loss rate from existing dairy farms over the 20 year period of 16.4%, which in turn reduces the in-river SIN-load contribution of dairy by 7.2% after adjusting for conversions. This is predicted to result in a reduction of overall in-river SIN loads at the Manawatu at Hopelands site of 4.2%;

    b. The Fonterra approach is predicted to result in a decrease in N-loss rate from existing dairy farms over the 20 year period of 14.9%, which in turn reduces the in-river SIN-load contribution of dairy by

5.7% after adjusting for conversions. This is predicted to result in a reduction of overall in-river SIN loads at the Manawatu at Hopelands site of 3.6%;

c. The Wellington Fish and Game and Minister of Conservation approach is predicted to result in a decrease in N-loss rate from existing dairy farms over the 20 year period of 37.4%, which in turn reduces the in-river SIN-load contribution of dairy by 30.5% after adjusting for conversions. This is predicted to result in a reduction of overall in-river SIN loads at the Manawatu at Hopelands site of 12.4%; and

d. The single number approach of 27 kg N/ha/yr is predicted to result in an increase in N-loss rate from existing dairy farms over the 20 year period of 3.5%, which in turn increases the in-river SIN-load contribution of dairy by 14.9% after adjusting for conversions. This is predicted to result in an increase of overall in-river SIN load at the Manawatu at Hopelands site of 3.6%.

18. The results for the two sites modelled over the 20 year period are summarised in Table 5. In summary for the Hopelands site,

a. The single number approach of 27 kg N/ha/yr results in an increase of SIN load. In contrast the approaches of Ms Barton, Fonterra and Wellington Fish and Game/Minister of Conservation result in a decrease in SIN Load.

b. The approaches of Ms Barton and Fonterra result in broadly similar percentage reductions of overall SIN load. However, the similarity of the results from Ms Barton's approach and the Fonterra approach should be considered in the context of the further uncertainty about the predicted level of reductions occurring for the Fonterra approach (as outlined above).

c. The Wellington Fish and Game/Minister of Conservation's approach is predicted to result in more than double the level of the reductions from Ms Barton's and the Fonterra approach over the 20 year period.

Table 4: Comparison of outcomes from potential policies for nutrient management for the area upstream of the Manawatu at Hopelands monitoring site. Modelling was completed for a 20 year period with 11% expansion of dairy farming. Cells shaded blue indicate percentage changes in N-loss rate from existing farms. Cells shaded yellow indicate percentages changes in in-river SIN loads from dairy farming. Cells shaded green indicate percentage changes in overall in-river SIN load. Calculations of in-river SIN loads contributions assume an attenuation factor of 0.5.

Manawatu at Hopelands		Ms Barton's approach - DVPOP LUC limits applied to existing dairy farms and new dairy farm conversions				Fonterra approach – existing farms reduce as per Dr Ledgard's revised estimates and - DVPOP LUC limits apply to new conversions				Wellington Fish and Game/Minister of Conservation approach NVPOP yr 10				Single number limit for dairy farming of 27 kg N/ha/year			
		Sheep/beef	**Dairy**	**Other**	**Total catchment**	**Sheep/beef**	**Dairy**	**Other**	**Total catchment**	**Sheep/beef**	**Dairy**	**Other**	**Total catchment**	**Sheep/beef**	**Dairy**	**Other**	**Total catchment**
Land area in 2008	ha	85677	20139	18530	124345	85677	20139	18530	124345	85677	20139	18530	124345	85677	20139	18530	124345
Land area in 2028 (11% dairy expansion from Sheep/beef)	ha	83462	22354	18530	124345	83462	22354	18530	124345	83462	22354	18530	124345	83462	22354	18530	124345
Change in area	ha	-2215	2215	0	0	-2215	2215	0	0	-2215	2215	0	0	-2215	2215	0	0
Change in area	%	-2.6%	11.0%			-2.6%	11.0%			-2.6%	11.0%			-2.6%	11.0%		
N-loss rate 2008 existing farms	kg N/ha/yr	10.8	26.1	2.0	12.0	10.8	26.1	2.0	12.0	10.8	26.1	2.0	12.0	10.8	26.1	2.0	12.0
N-loss rate 2028 existing farms	kg N/ha/yr	10.8	21.8	2.0	**11.5**	10.8	22.2	2.0	**11.5**	10.8	16.3	2.0	**10.5**	10.8	27.0	2.0	**12.4**
Percentage change in N-Loss rate 2008 to 2028 (existing farms)	%	0.0%	-16.4%	0.0%	-4.2%	0.0%	-14.9%	0.0%	-3.6%	0.0%	-37.4%	0.0%	-12.4%	0.0%	3.5%	0.0%	3.6%
N-loss rate 2028 dairy conversions	kg N/ha/yr		21.8				21.8				16.3				27.0		
Tonnes SIN contributed 2008 (in-river)	Tonnes SIN/yr	462.0	262.7	18.8	743.5	462.0	262.7	18.8	743.5	462.0	262.7	18.8	743.5	462.0	262.7	18.8	743.5
Tonnes SIN contributed 2028 (in-river)	Tonnes SIN/yr	450.1	243.8	18.8	712.7	450.1	247.7	18.8	717.0	450.1	182.6	18.8	651.5	450.1	301.8	18.8	770.7
Decrease in SIN load (2028-2008)	Tonnes SIN/yr	11.9	19.0	0.0	30.9	11.9	15.0	0.0	26.5	11.9	80.1	0.0	92.0	11.9	-39.1	0.0	-27.1
percentage change in in-river SIN load contribution 2008 to 2028	%	-2.6%	-7.2%	0.0%	-4.2%	-2.6%	-5.7%	0.0%	-3.6%	-2.6%	-30.5%	0.0%	-12.4%	-2.6%	14.9%	0.0%	3.6%

Table 5: Comparison of modelling outcomes from potential policies for nutrient management, for two sites in specified zones. Modelling was completed for a 20 year period with 11% expansion of dairy farming. Cells shaded green indicate changes in overall in-river SIN load.

Area/Site	**Ms Barton's approach**			**Fonterra approach remodelled using Dr Ledgard's revised predicted reductions**			**Wellington Fish and Game/Minister of Conservation Approach**			**Single number limit for dairy farming of 27 kg N/ha/year**		
	Percentage change in			Percentage change in			Percentage change in			Percentage change in		
	N-loss rate 2008 to 2028	In-river SIN load from dairy	Overall in-river SIN load	N-loss rate 2008 to 2028	In-river SIN load from dairy	Overall in-river SIN load	N-loss rate 2008 to 2028	Overall in-river SIN load	Overall in-river SIN load	N-loss rate 2008 to 2028	In-river SIN load from dairy	Overall in-river SIN load
Manawatu at Hopelands	-16.4%	-7.2%	-4.2%	-14.9%	-5.7%	-3.6%	-37.4%	-30.5%	-12.4%	3.5%	14.9%	3.6%
Mangatainoka at SH2	-10.3%	-0.4%	-5.0%	-12.2%	-2.3%	-5.6%	-30.0%	-22.3%	-11.6%	9.3%	21.3%	1.5%

Catchment outcomes of the different Policy approaches over a 20 year timeframe with 18% expansion.

19. The original modelling presented by Dr Roygard and Ms Clark (24 February 2012) forecasts over a 20 year period assuming the more conservative prediction by the economists of the likely area of expansion of dairy farming onto new area. This modelling forecasts the 20 year time period, under an 18% expansion scenario which is the higher level of expansion predicted by Nield and Rhodes.

20. Adaptions were made to the calculations to enable modelling of the four approaches over the 20 year time frame with 18% expansion. In summary the four approaches are:

    a. Ms Barton's approach for the Manawatu Wanganui Regional Council, the DVPOP LUC N-loss rate limits for conversions implemented over the 20 year timeframe for all existing farms and dairy conversions;

    b. Mr Willis's approach for Fonterra with N-loss rate reductions for existing dairy farms as estimated by the assumptions of Dr Ledgard and N-loss rates for conversions equivalent to the DVPOP LUC N-loss rate limits for conversions;

    c. Wellington Fish and Game/Minister of Conservation's approach assuming the NVPOP LUC N-loss rate year 20 limits implemented over the 20 year timeframe for all existing farms and dairy conversions; and

    d. A single N-loss limit of 27 kg N/ha/yr.

21. Table 6 presents the results from modelling the catchment outcome for the Manawatu at Hopelands site under the four Policy scenarios. These results show:

    a. Ms Barton's approach is predicted to result in a decrease in N-loss rate from existing dairy farms over the 20 year period of 16.4%, which in turn reduces the in-river SIN-load contribution of dairy by 1.4% after adjusting for conversions. This is predicted to result in a reduction of overall in-river SIN loads at the Manawatu at Hopelands site of 3.1%;

    b. The Fonterra approach is predicted to result in a decrease in N-loss rate from existing dairy farms over the 20 year period of 14.9%, which in turn increases the in-river SIN-load contribution of dairy by 0.1% after adjusting for conversions. This is predicted to result in a reduction of overall in-river SIN loads at the Manawatu at Hopelands site of 2.5%;

    c. The Wellington Fish and Game/Minister of Conservation approach is predicted to result in a decrease in N-loss rate from existing dairy farms over the 20 year period of 37.4%, which in turn reduces the in-river SIN-load contribution of dairy by 26.1% after adjusting for conversions. This is predicted to result in a reduction of overall in-river SIN loads at the Manawatu at Hopelands site of 11.8%; and

    d. The single number approach of 27 kg N/ha/yr is predicted to result in an increase in N-loss rate from existing dairy farms over the 20 year

period of 3.5%, which in turn increases the in-river SIN-load contribution of dairy by 22.1% after adjusting for conversions. This is predicted to result in an increase of overall in-river SIN load at the Manawatu at Hopelands site of 5.2%.

22. The results for the two sites modelled over the 20 year period with 18% expansion are summarised in Table 7. In summary for the Hopelands site:

    a. The single number approach of 27 kg N/ha/yr results in an increase of SIN load. In contrast the approaches of Ms Barton, Fonterra and Wellington Fish and Game/Minister of Conservation result in a decrease in SIN Load.

    b. The approaches of Ms Barton and Fonterra result in broadly similar percentage reductions of overall SIN load. However, the similarity of the results from Ms Barton's approach and the Fonterra approach should be considered in the context of the further uncertainty about the predicted level of reductions occurring for the Fonterra approach (as outlined above).

    c. The Wellington Fish and Game/Minister of Conservation's approach is predicted to result in approximately 2 to 3 times the level of the reductions from Ms Barton's and the Fonterra approach over the 20 year period.

Table 6: Comparison of outcomes from potential policies for nutrient management for the area upstream of the Manawatu at Hopelands monitoring site. Modelling was completed for a 20 year period with 18% expansion of dairy farming. Cells shaded blue indicate percentage changes in N-loss rate from existing farms. Cells shaded yellow indicate percentages changes in in-river SIN loads from dairy farming. Cells shaded green indicate percentage changes in overall in-river SIN load. Calculations of in-river SIN loads contributions assume an attenuation factor of 0.5.

Manawatu at Hopelands		Ms Barton's approach - DVPOP LUC limits applied to existing dairy farms and new dairy farm conversions				Fonterra approach – existing farms reduce as per Dr Ledgard's revised estimates and - DVPOP LUC limits apply to new conversions				Wellington Fish and Game/Minister of Conservation approach NVPOP yr 10				Single number limit for dairy farming of 27 kg N/ha/year			
		Sheep/beef	**Dairy**	**Other**	**Total catchment**	**Sheep/beef**	**Dairy**	**Other**	**Total catchment**	**Sheep/beef**	**Dairy**	**Other**	**Total catchment**	**Sheep/beef**	**Dairy**	**Other**	**Total catchment**
Land area in 2008	ha	85677	20139	18530	124345	85677	20139	18530	124345	85677	20139	18530	124345	85677	20139	18530	124345
Land area in 2028 (18% dairy expansion from Sheep/beef)	ha	82052	23764	18530	124345	82052	23764	18530	124345	82052	23764	18530	124345	82052	23764	18530	124345
Change in area	ha	-3625	3625	0	0	-3625	3625	0	0	-3625	3625	0	0	-3625	3625	0	0
Change in area	%	-4.2%	18.0%			-4.2%	18.0%			-4.2%	18.0%			-4.2%	18.0%		
N-loss rate 2008 existing farms	kg N/ha/yr	10.8	26.1	2.0	12.0	10.8	26.1	2.0	12.0	10.8	26.1	2.0	12.0	10.8	26.1	2.0	12.0
N-loss rate 2028 existing farms	kg N/ha/yr	10.8	21.8	2.0	**11.6**	10.8	22.2	2.0	**11.7**	10.8	16.3	2.0	**10.5**	10.8	27.0	2.0	**12.6**
Percentage change in N-Loss rate 2008 to 2028 (existing farms)	%	0.0%	-16.4%	0.0%	-3.1%	0.0%	-14.9%	0.0%	-2.5%	0.0%	-37.4%	0.0%	-11.8%	0.0%	3.5%	0.0%	5.2%
N-loss rate 2028 dairy conversions	kg N/ha/yr		21.8				21.8				16.3				27.0		
Tonnes SIN contributed 2008 (in-river)	Tonnes SIN/yr	462.0	262.7	18.8	743.5	462.0	262.7	18.8	743.5	462.0	262.7	18.8	743.5	462.0	262.7	18.8	743.5
Tonnes SIN contributed 2028 (in-river)	Tonnes SIN/yr	442.5	259.1	18.8	720.4	442.5	263.1	18.8	725.1	442.5	194.2	18.8	655.4	442.5	320.8	18.8	782.1
Decrease in SIN load (2028-2008)	Tonnes SIN/yr	19.5	3.6	0.0	23.1	19.5	-0.3	0.0	18.5	19.5	68.6	0.0	88.1	19.5	-58.1	0.0	-38.6
percentage change in in-river SIN load contribution 2008 to 2028	%	-4.2%	-1.4%	0.0%	-3.1%	-4.2%	0.1%	0.0%	-2.5%	-4.2%	-26.1%	0.0%	-11.8%	-4.2%	22.1%	0.0%	5.2%

Table 7: Comparison of modelling outcomes from potential policies for nutrient management, for two sites in specified zones. Modelling was completed for a 20 year period with 18% expansion of dairy farming. Cells shaded green indicate changes in overall in-river SIN load.

Area/Site	**Ms Barton's approach**			**Fonterra approach remodelled using Dr Ledgard's revised predicted reductions**			**Wellington Fish and Game/Minister of Conservation Approach**			**Single number limit for dairy farming of 27 kg N/ha/year**		
	Percentage change in			Percentage change in			Percentage change in			Percentage change in		
	N-loss rate 2008 to 2028	In-river SIN load from dairy	Overall in-river SIN load	N-loss rate 2008 to 2028	In-river SIN load from dairy	Overall in-river SIN load	N-loss rate 2008 to 2028	In-river SIN load from dairy	Overall in-river SIN load	N-loss rate 2008 to 2028	In-river SIN load from dairy	Overall in-river SIN load
Manawatu at Hopelands	-16.4%	-1.4%	-3.1%	-14.9%	0.1%	-2.5%	-37.4%	-26.1%	-11.8%	3.5%	22.1%	5.2%
Mangatainoka at SH2	-10.3%	5.8%	-6.3%	-12.2%	4.0%	-6.9%	-30.0%	-17.4%	-13.2%	9.3%	28.9%	0.7%

Summary of results

23. Catchment outcomes from four proposed Policy approaches have been calculated for the Manawatu at Hopelands and Mangatainoka at SH2 monitoring sites over different time periods (10 and 20 years) and with different rates of intensification for the 20 year time period. In summary the results of this modelling (Table 8) indicate:

    a. The single number N-loss limit of 27kgN/ha/yr is the only approach that is not predicted to reduce the SIN load at either of the sites (increases in loads are predicted for this approach).

    b. The approach of Ms Barton and the revised approach of Fonterra provide similar outcomes at both sites although there are further uncertainties associated with the modelling of the Fonterra approach. As outlined above, the further uncertainty in the modelled outcomes from the Fonterra approach include the Fonterra approach modelling a potentially achievable outcome (not a specified limit). This requires extra assumptions around the level of reductions that will occur on a on a per hectare basis. Extra assumptions are also required for extrapolating the Fonterra approach to catchment level outcomes (in-river SIN loads).

    c. The approach proposed by Wellington Fish and Game and the Minister of Conservation provides the greatest reduction in overall in-river SIN loads.

24. The results for other scenarios over a 20 year period assuming 11% expansion can be found in the Evidence of Dr Roygard and Ms Clark (24 February 2012). The modelling in that evidence includes a wider range of sites and scenarios.

Table 8: Summary of the predicted percentage changes in in-river SIN loads over the different time periods and Policy approaches.

Site	Policy Approach	Predicated percentage change in in-river SIN load		
		10 Year 5.5% expansion	20 Year 11% expansion	20 Year 18% expansion
Manawatu at Hopelands	Ms. Barton	-5.0%	-4.2%	-3.1%
	Fonterra	-4.4%	-3.6%	-2.5%
	Wgtn FNG/MOC	-11.6%	-12.4%	-11.8%
	27 kg N/ha/yr	2.4%	3.6%	5.2%
Mangatainoka at SH2	Ms Barton	-4.1%	-5.0%	-6.3%
	Fonterra	-4.6%	-5.6%	-6.9%
	Wgtn FNG/MOC	-10.3%	-11.6%	-13.2%
	27 kg N/ha/yr	2.1%	1.5%	0.7%

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Dr Jon Roygard

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Ms Maree Clark