In the Environment Court
at Wellington

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: **Horticulture NZ**
(ENV-2010-WLG-000155)

and: **Wellington Fish & Game Council**
(ENV-2010-WLG-000157)

and: **Andrew Day**
(ENV-2010-WLG-000158)

Appellants

and: **Manawatu-Wanganui Regional Council**
Respondent

and: **Fonterra Co-operative Group Limited**
Section 274 Party

Statement of evidence of Dr Stewart Francis Ledgard
for Fonterra Co-operative Group Limited

Dated: 14 March 2012

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STATEMENT OF EVIDENCE OF DR STEWART FRANCIS LEDGARD FOR FONTERRA CO-OPERATIVE GROUP LIMITED

INTRODUCTION

1 My full name is Dr Stewart Francis Ledgard.

2 I hold a Bachelor of Agricultural Science (Hons.1) (1979) majoring in Soil Science, and a Ph.D. in Biological Sciences (1984) from the Australian National University.

3 I have been employed as a soil scientist with AgResearch (New Zealand Pastoral Agricultural Research Institute Ltd) at Ruakura Research Centre since 1979. I have more than 20 years experience as a scientist with a particular speciality in nitrogen (*N*) cycling in agricultural systems. During that time I have published 6 book chapters, 82 scientific journal papers and over 180 conference papers.

4 I led a multi-disciplinary research programme entitled "*Nitrogen and Lake Taupo*" that finished in 2010. This programme was funded by the main government research funding body, Foundation for Research Science and Technology ($2 million/year) and focused on the development and evaluation of technologies and management practices to reduce N leaching from farms around Lake Taupo.

5 I currently lead several research programmes focussed on development and evaluation of practices and mitigations to decrease N loss from pastoral farm systems.

6 I have been and am also currently involved in Sustainable Farming Fund research programmes, working with farmer groups around Lakes Taupo and Rotorua targeting farm systems and management practices to reduce N leaching from farms.

7 I am familiar with the agricultural and soil science issues involved in these proceedings. I was instructed by the Horizons Regional Council (*Council*) to provide s42A evidence on the use and application of OVERSEER (Wheeler et al. 2003) in the proposed One Plan (*POP*) regime (now my Evidence in Chief for the Council - from page 1965 of the Technical Evidence bundle (*TEB*)). I have also authored or co-authored several reports addressing N-loss in the Manawatu-Wanganui region (*Region*), some of which I refer to throughout this statement.

8 I have read the Environment Court's Code of Conduct for Expert Witnesses, and I agree to comply with it. My qualifications as an expert are set out above. I confirm that the issues addressed in this brief of evidence are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

SCOPE OF EVIDENCE

9 My evidence will deal with the following:

a. A description of the existing N-loss from dairy farms in the Region based on current best information that I am aware of and comparisons with other regions in New Zealand;

b. My understanding of the Land Use Capability (*LUC*) classes and their potential use in establishing N-loss limits for existing dairy farms in this case, commenting particularly on:

i. LUC's accuracy and usefulness in assessing and clarifying the qualities affecting land productivity for primary production;

ii. Knowledge and understanding of the LUC classes applicable to existing dairy farms in the Region;

iii. The relationship between N leaching and each different LUC class;

iv. The technologies and practices available to overcome the productivity limitations inherent in each LUC class and their uptake across the Region;

v. The relationship between those technologies and practices and N loss;

c. Farm management practices that can reduce N-loss, commenting particularly on:

i. The range of dairy farm environmental performance within the Region;

ii. The technologies available now or in the future to reduce nutrient leaching;

iii. The ability and feasibility of achieving reductions in N leaching on existing dairy farms, bearing in mind their existing operations, practicalities/affordability and physical constraints (e.g. rainfall, high stocking rates and high LUC classifications);

d. Conclusions and assessment of the various proposed approaches to limiting N-loss.

SUMMARY

10 A database of files from use of the OVERSEER nutrient budget model on over 3300 New Zealand dairy farms by fertiliser industry technical representatives was used to evaluate the calculated N

leaching losses from those farms. This included data from 143 dairy farms in the Region. Results gave an average N leaching of 22 kg N/ha/year, which was lower than the average for all other regions of New Zealand (national average was 34 kg N/ha/year).

11 The N leaching data from the 143 farms varied between 8 and 47 kg N/ha/year, with a 75th percentile value of 27 kg N/ha/year, which means that 25% of farms were above this level. Analysis of this and other survey data indicates that much of this variability is management-dependent. This indicates that many farms are capable of reducing their N leaching, particularly those in the upper 25th percentile of N leaching. However, the overall potential and cost-implications for reduction in N leaching is uncertain and is likely to vary between individual farms.

12 In my view, the use of the LUC system for prescribing N-loss limits has merit for regulating future land uses in that it directs higher intensity farming uses onto the land, which has fewer limitations on its productive potential.

13 However, the LUC system has some limitations when applied to existing land uses. The LUC-based N targets were determined from the estimated potential pasture production according to its inherent state. This system does not recognise that actual productivity has changed due to introduction of technologies and farm inputs. Thus, existing dairy farms on moderate-high LUC classes that have introduced technologies and intensified may be required to make major changes in order to meet their relatively low N loss targets compared to those for farms on LUC I and II.

14 Increasing LUC class numbers are broadly aligned to increased risk of loss of phosphorus (*P*) and sediment to waterways, and also to risk of occasional direct and episodic N leaching (requiring increased need for careful management of inputs such as effluent). However, increasing LUC class numbers are only weakly aligned with the average amount of N leaching which is determined mainly by the amount of N excreted by animals on soil.

15 N leaching will generally be higher on shallow, coarse-textured soils in mid LUC classes than on LUC I and II soils, but an anomaly is that it will generally be lower on poorly-drained soils in mid LUC classes due to greater gaseous N losses. Thus, there may be greater variation in N leaching within an LUC class than between LUC classes due to different soil characteristics.

16 There is a range of potential N mitigation options that vary in extent of achieving reductions in N leaching. However, in most cases their use is associated with a net cost to the farmer, particularly those mitigations with moderate-high potential for decreasing N leaching.

17 Some management/mitigation options for reducing N leaching are already commonly or increasingly being implemented by dairy

farmers. Use of some other management/mitigation options is often constrained by a range of factors including implications for reduced profitability, difficulty of use and lack-of-fit to an existing farm system. The use of management/mitigation options is also influenced by site factors that determine LUC. Thus, the appropriate management/mitigation options to reduce N leaching are highly farm specific.

18 Many of the management/mitigation options take time to implement, particularly where farm system changes are required, farmer upskilling is needed, or where there are infrastructure changes. Timing of implementation will vary from farm to farm.

19 Some N mitigation options require significant investment and may not be economically viable on some farms.

20 The Council has derived N loss targets using LUC based on inherent productivity. This approach is relatively complex and potentially inequitable for farmers on moderate-high LUC land that have invested in technologies to increase productivity. Council has set a three year timeframe to implement N loss reduction where it is required in Rule 13-1, which I believe is too tight for farms that would require large whole-farm system or infrastructure changes.

21 I recommend that reduction in catchment N leaching be focussed on the highest N leaching farms (e.g. the highest quartile). This focus could include a requirement for adoption of appropriate management/mitigation options in the tier 1 category (outlined below), reflecting ease of implementation, relatively low cost and the need for a farm-specific approach.

DESCRIPTION OF THE EXISTING N-LOSS FROM FARMS IN THE REGION AND NATIONAL COMPARISONS

22 Data for 2010 from dairy farms from throughout New Zealand was collected by trained field representatives of the two major fertiliser companies (Ballance Agri-nutrients Ltd. and Ravensdown Ltd.) in the process of doing nutrient budgets for their farmer clients. This data, and outputs from the OVERSEER nutrient budget model using this data, were captured on company database systems and provided to FertResearch. The data from both companies was amalgamated and provided to AgResearch for summary and analysis (Ledgard et al., 2011). It covered over 3300 farms throughout New Zealand and included 143 dairy farms in the Region.

Manawatu data

23 From this dataset, the average N leaching loss for the 143 dairy farms in the Region was 22 kg N/ha/year. This average value is similar to the average of 22.7 kg N/ha/year for nutrient budget data for 325 farms collected by the Council and presented in the supplementary statement of Roygard and Clark (dated 24 February,

par. 127, p 5223 TEB). However, it is lower than the average of 26 kg N/ha/year from 204 dairy farms in the Region from OVERSEER files from Ravensdown Limited presented in evidence at the Council-level hearing by Mr Smeaton for Fonterra (par. 27). Mr Smeaton's evidence referred to data from several years earlier which may have included files with farm scenario analyses of possible alternative farm options as well as actual farm data (Dr A. Roberts, Ravensdown; personal communication). Dr Roberts also noted that the technical representatives that collect this farm data are more competent now having gone through Massey training courses, and that they have greater awareness of key data requirements. Another reason for the lower average may be due to annual variations. Mr Newland discusses the possibility that the 2010 year may not be representative of a typical year in his evidence, albeit it is the best available information.

24 The average N leaching loss for the 143 dairy farms is also less than the 31 kg N/ha/year calculated for a 'typical' dairy farm in the Upper Manawatu catchment, as presented in the s42A evidence of Dr Clothier (Figure 10.4, p 1557-1558 TEB) based on OVERSEER analyses using data provided by a local farm consultant. It is uncertain what soil and climate characteristics were used by Dr Clothier for the 'typical dairy farm' since this will have had some effect on the N leaching value.

25 The dataset of 143 dairy farms in the Region showed a range of 8-47 kg N/ha/year which broadly had a normal shaped distribution (see **Figure 1** below). This is similar to the 4-55 kg N/ha/year range for 325 farms in the Region reported in the supplementary statement of Roygard and Clark (dated 24 February par. 127, p 5223 TEB). The 75th percentile value of the 143 farm dataset is 27 kg N/ha/year, which means that 25% of farms were above this level.

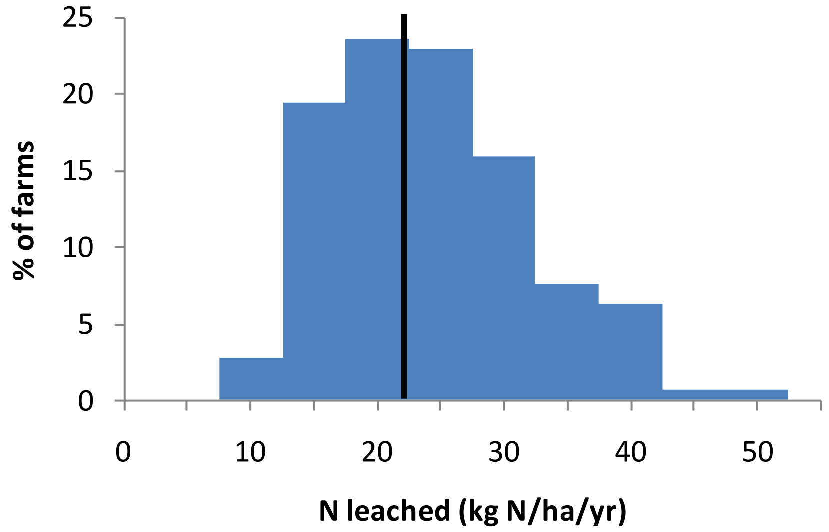

Figure 1*: Frequency distribution of N leaching values calculated for 143 dairy farms in the Manawatu/Wanganui region using OVERSEER data collected from farmers by fertiliser company representatives for nutrient budgeting (from Ledgard et al., 2011). The vertical bar is the mean value.*

26 Mr Taylor presented s42A evidence (Table 6, P 1785 TEB) relating to an analysis of 21 case farms in the Region and the N leaching calculated for dairy farms by a number of different trained users of OVERSEER was 13-37 kg N/ha/year. Dr Shepherd also presented s42A evidence (Table 6) with N leaching results of 25-28 kg N/ha/year for three case dairy farms in the Region. These case farm values are within the range of 8-47 kg N/ha/year from the 143 farm dataset.

27 The dataset of 143 dairy farms in the Region was based on farm information supplied to the fertiliser company representatives by the individual farmers. It was not obtained for regulatory purposes and therefore it should be unbiased.

28 Assumptions associated with this dataset are that the different fertiliser company technical representatives are consistent in their process of data collection and its use in OVERSEER. There should be reasonable consistency since all personnel from both companies have gone through the Massey University courses in Nutrient Management and use of OVERSEER. Nevertheless, some variability may exist in the selection of default parameters and the inclusion of some specific farm management practices. For example, in the dataset provided, there was no information on the use of N loss mitigations such as the nitrification inhibitor dicyandiamide (*DCD*), stand-off pads or animal shelters, wetlands or grass filter strips (all described in detail later) and therefore the extent to which these had been captured is uncertain.

29 Note that all values referred to above were based on use of the OVERSEER model and probably version 5.4.8. This model has just

been upgraded to incorporate a monthly time-step and had some changes (e.g. improved predictor of drainage on stony and sandy soils that will lead to changes and may increase predicted losses). Thus, the absolute values quoted above may undergo small changes if they were to be re-run through the new model. This aspect may be important to consider when specific critical N leaching loss values are being set. The effects of the upgrade of OVERSEER on calculated N leaching losses may vary with different soils and management conditions. If upgraded versions of OVERSEER are to be used when implementing the final POP regime, the possible variations need to be considered in a planning context. This point applies equally to the values in **Figure 1** and those set for LUC classes in Table 13.2 in the POP provisions as proposed by Ms Clare Barton in her evidence dated 14 February 2012 (*Council's Version*) (p 4985 TEB).

Manawatu compared with other regions

30 The average N leaching value for the Region of 22 kg N/ha/year was the lowest of that for all regions of New Zealand (Ledgard et al., 2011). The overall New Zealand average in this study of over 3300 dairy farms was 34 kg N/ha/year. The latter value is lower than the 40 kg N/ha/year value presented in s42A evidence by Dr Mackay (par. 118, p 1631 TEB) as "*often used as an average value*" for New Zealand.

31 Some of the variation between and within regions was due to climate and soil differences. In the Manawatu/Wanganui region, there was a moderate positive correlation between N leaching and annual rainfall. Similarly, there was a moderate positive correlation between N leaching and a number of management-related factors including stocking rate, milk production per hectare and rate N fertiliser application (Ledgard et al., 2011). These correlations suggest that much of the variation in N leaching between farms within the Region was due to management-dependent factors. The significance of management-dependent factors in influencing the spread in N leaching losses between farms within a region was also identified in a study of individual farms within the Lake Rotorua catchment that showed a four-fold variation in N leaching per hectare (Ledgard et al., 2010).

32 This analysis of dairy farms in the Region suggests that on the whole, dairy farmers in this Region are already relatively N-efficient and do not have high average N leaching values compared to that for other regions of New Zealand (see also paragraph 55 below). This study and others also indicate that there is potential through changing management practices to reduce N leaching at the upper end of the range estimated.

LUC CLASSES FOR DEVISING N-LOSS TARGETS

LUC's accuracy and usefulness in assessing and clarifying the qualities affecting land productivity for primary production

33 The LUC system of rating the productive capability of land is well established in New Zealand and is described objectively in the New Zealand Land Inventory Bulletin.

34 The LUC system uses "*Land Resource Inventory*" (*LRI*) as a basis for assessing a minimum of five primary physical factors considered to be critical for long-term sustainable land use. The five factors include rock type, soil, slope angle, erosion type and severity, and vegetation cover (page 12, V3 of the LUC Handbook).

35 As recorded in the LUC Handbook (V3) productive capacity depends largely on the physical qualities of the land, soil and the environment. Certain physical qualities are regarded as limitations to productivity. These limitations include susceptibility to erosion, steepness of slope, susceptibility to flooding, liability to wetness or drought, salinity, depth of soil, soil texture, structure and nutrient supply and climate. The limitations influence the number and complexity of corrective practices needed to address these limitations. The limitations also affect the intensity and type of land uses possible on the given land.

36 I note that the LUC system was not specifically designed to address N-loss. I am also not aware of the LUC system being used before to establish a base for allocating N leaching targets. However, it is possible for the LUC classes to be adapted for this purpose, subject to recognising some limitations. I comment on the Council's proposal to use LUCs to regulate N-loss later in this evidence.

Knowledge and understanding of the LUC classes applicable to existing dairy farms in the Region

37 I am aware that Roygard and Clark have compiled regional LUC data for each target catchment (described as proportions of land use categories within each LUC class in Appendix 3 of Ms MacArthur's s42A evidence; see par. 356, p 745 TEB). The figures are said to be derived from regionally available 1:50,000 scale mapping. However, Dr Roygard (s42A evidence, par. 358, p 392 TEB) acknowledged that the region wide data is not accurate at finer scales and that there are likely to be cases where the broad-scale mapping is not indicative of what is found on farms. The s. 42A evidence of Dr Roygard included information on the proportion of land in different LUC classes in example catchments (Box 59, p 376 TEB). He also summarised information that indicated little change in calculated N leaching at different mapping scales at a catchment level (Table 13, p 380 TEB) but noted that "*individual N loss limits for specific farms would likely change with the inclusion of further detail*" (par. 336, p 380 TEB).

38 As far as I am aware, there is no region-wide data available which assesses LUC classes at the farm-scale. The POP regime accounts for that lack of information by allowing dairy farmers to adjust their LUC class to a more favourable classification of the land where the LUC is assessed by a suitably qualified person applying the 3rd or 2nd edition of the LUC Survey Handbook.[1]

39 I support the proposition that, if an LUC approach is to be used, the regime should allow for more accurate estimation of LUC classes.

The relationship between N leaching and each different LUC class

40 The primary physical factors in the LUC method are likely to align reasonably well to the risk of loss of sediments and P via surface runoff to waterways, which is important for the wider water quality context. Indeed the P loss model in OVERSEER has land slope and soil characteristics related to erosion loss risk as key drivers.

41 In contrast, many of the LUC factors are relatively unimportant for N leaching or may be poorly related.

42 Leaching of N from grazed pastures is primarily driven by N excretion in animal urine. This is related to the pasture production and animal intake (as well as from brought-in feed sources). N excretion by animals associated with total feed intake is the main determinant of N leaching in OVERSEER.

43 Other secondary factors affecting N leaching in OVERSEER are rainfall (losses generally increase with increasing rainfall), soil characteristics and slope:

a. *Rainfall*. Annual N leaching generally increases with increasing annual rainfall, as observed with correlation analysis for farms in the Region by Ledgard et al. (2010) and as noted in s42A evidence by Dr Mackay (par. 128, p 1636 TEB). Thus, farms in high rainfall areas with moderate-high LUC will find it more difficult to meet their N leaching targets than farms in lower rainfall areas.

b. *Soil characteristics.* For two farms with the same level of productivity and N excretion in urine, N leaching losses will be higher on a moderate LUC site with shallow stony or sandy soils than on LUC I soils, as noted in s42A evidence by Dr Mackay (par. 136, p 1638 TEB). However, an anomaly to this pattern of increased N leaching with increased LUC class is that N leaching will generally be lower from poorly-drained soils in mid LUC classes than from LUC I soils (with the same productivity and N excretion) due to greater gaseous N losses. Thus, there may be greater variation in N leaching

[1] See definition of "Land use capability class", Glossary, One Plan.

within an LUC class than between LUC classes due to different soil characteristics.

c. Farms on coastal sand country have limited water and N retention capacity and so have a relatively high N leaching risk. However, the moisture limitation can be overcome, at least in part, by irrigation and this greatly increases potential production. In the supplementary evidence of Mr Lachie Grant dated 31 January 2012, he provided a basis to account for the effects of permanent irrigation by decreasing the LUC class number on free-draining sands, with the largest decrease on deep soils (Grant, Table 3, p 4858, TEB). This decrease in LUC (e.g. at best from LUC IV to LUC II; Grant, Table 3) would effectively increase the N leaching target on such soils, although the propensity for actual N leaching on high-producing farms on irrigated sands is likely to be relatively high. In Council evidence, Ms Barton (par. 160, p 4939 TEB) considered that this reclassification of LUC on sand country was sufficient a policy change to account for the effects of irrigation. I comment on this matter later.

d. *Land slope.* At higher LUC classes, increasing land slope is often the main limitation and is broadly aligned to potential productivity. On steeper land, urine-N may be used more efficiently on sloping land (due to greater spread) but less efficiently on animal camp sites. The overall effect of slope per se on N leaching is considered to be small, but little research on this topic means that this aspect is poorly understood. Consequently, there is no specific effect of land slope on N leaching in OVERSEER.

44 I acknowledge that with increasing LUC classes, there will generally be an increased environmental risk from poor management practices and occasional extreme climatic events. For example, a farm on LUC III with mole/pipe drains to reduce limitations of poor drainage is at greater risk of direct N drainage loss from effluent applied to land. Management practices related to rate and time of effluent application are more critical than on free-draining soils (LUC I) to avoid direct losses. These poorly-drained soils (even with mole/pipe drains) are also more prone to pugging and soil damage which can increase the risk of loss of sediment, nutrients and faecal bacteria in surface runoff (although N loss to waterways in surface runoff is generally small compared to losses from leaching).

45 In conclusion, the main drivers of N leaching are not well aligned to the LUC classes, except via differences in potential productivity. However, actual productivity on any one LUC class farm is influenced by the range of technologies and inputs used on the particular farm. Nevertheless, farms on higher LUC classes generally require more careful attention to management to avoid higher episodic risk from N leaching events than on LUC I and II farms.

The technologies and practices available to overcome the productivity limitations inherent in each LUC class and their uptake across the Region

46 As noted in the s42A evidence of Dr Mackay (par. 117, p 1631 TEB), the inherent production from non-N-fertilised grass/clover pasture generally decreases with increasing LUC class associated with greater site physical limitations. This information was used to define the N leaching targets in Table 13-2 of the Council's version of POP. However, the effects of the physical limitations on pasture production can often be reduced or overcome by implementation of technologies or specific farm management practices. Mackay (par. 141, p 1640 TEB) acknowledged that "*a number of very effective technologies are available to lift the productive capacity of soils beyond their natural capital*". Examples of the various practices or mitigations used to lift the productive capacity of soils beyond their natural capital are now discussed (also described in detail in later sections).

47 *Artificial drainage.* A significant proportion of soils in the Region would be classified as naturally poor-draining which can lead to water-logging. This characteristic impacts on pasture production. These soils are also at greater risk of damage and production loss due to treading damage by grazing animals. However, the extent of these impacts is often minimised by use of artificial drainage via open drains and mole/pipe drainage systems. This serves to lower the water-table in the soil and reduce impacts of soil saturation. Artificial drainage is commonly used across poor-draining soils and is assumed to have occurred when determining LUC classes, as noted in supplementary statement of Mr Grant (pars. 33 and 75, p 4854 and 4869 TEB).

48 *Irrigation*. Shallow coarse-textured soils in the Region will have pasture production limitations due to periods of drought-stress due to their low water holding capacity. This includes the coastal sand dune areas. On these soils, these limitations to production can largely be overcome by effective irrigation systems. The effect of irrigation in changing the LUC class on these soils was recognised in the supplementary statement of Mr Grant, as noted above in paragraph 47. Another, albeit less effective, option for reducing the effect of these soil limitations is the use of alternative plant species with deeper root systems (e.g. lucerne and tall fescue) but the benefits for production are less than that from irrigation.

49 *Use of fertiliser*. N fertiliser can be applied to increase grass growth across all LUC classes. Pasture responses to added N have been measured in all areas including on steep-land pastures, although they can be low or nil during specific periods on some soils e.g. during summer droughts and on water-logged soils in winter. The cost-effectiveness of N fertiliser means that its use is widespread across dairy farms throughout New Zealand and was indicated across Manawatu farms studied by Taylor (s42A evidence, par. 105, p 1793 TEB and Table 6, p 1840 TEB).

50 Practices outlined above all relate to the farm-derived pasture production and its implications for animal productivity. However, absolute animal production from the farmed area can also be increased by bringing in feed produced in other areas or by strategic grazing off of animals during winter, thereby enabling higher stock numbers to be carried throughout the rest of the year.

51 In conclusion, the use of the various technologies on existing dairy farms means that actual production differs from the LUC-based potential production.

The relationship between those technologies and practices and N loss

52 Implementation of the various practices or mitigations can potentially influence N cycling and losses. For example, artificial drainage of poor-draining soils results in increased production of nitrate in soil and is generally associated with an increase in N leaching compared to the original undrained state. However, as noted earlier the magnitude of N leaching is still likely to be less than that from LUC I free-draining soils, everything else being the same.

53 Thus, it is recognised that on existing dairy farms, technologies have been introduced so that actual production differs from the LUC-based potential production. These technologies will have had variable effects on N leaching but in general increased production over time will have been associated with increased N excretion and increased N leaching. This issue was noted by Ms Barton (e.g. par. 118, p 4919 TEB).

54 However, there is a lack of knowledge about how actual production on existing dairy farms varies across different LUC classes and therefore uncertainty about the difficulty of farms in LUC III or IV (or higher) in meeting the relatively low N loss targets compared to those for LUC I and II (defined in Council's Version of Table 13-2 of the POP).

FARM MANAGEMENT PRACTICE

The range of dairy farm environmental performance within the Region

55 Data from Livestock Improvement Corporation (LIC 2011) indicates that the stocking rate and milksolids production per hectare and per cow for the Manawatu district is similar to that for the North Island average, and around 5% lower than that for the NZ average. However, as noted earlier, the average N leaching loss for the Region was lower than for all other regions, which may reflect good overall N environmental performance.

56 A new and increasing focus on improving dairy farm environmental performance by DairyNZ using indicators such as N use efficiency, should result in increased understanding and adoption of

management practices and mitigations to reduce N leaching in future.

57 There is little information on the variability between farms in the adoption of technologies and mitigations in the Region. This makes it difficult to know how representative the limited number of case study farms that have been used to date (such as those referred to in the s42A evidence by Manderson and Shepherd, and Taylor, and the supplementary statement by Taylor). Nevertheless, based on my previous work with individual farmers in a study with Duncan Smeaton in the Lake Rotorua catchment (Smeaton and Ledgard 2007), it is likely that there will be a considerable spread in environmental performance between farms and in the use of management practices and mitigations.

The technologies available now or in the future to reduce nutrient leaching

58 There are a wide range of management practices and mitigations that can potentially be used to reduce N leaching on farms. These are summarised in Table 1 below and most have also been referred to by other experts such as in the s42A evidence by Mackay (Figure 7, p 1640 TEB) and Manderson (Appendix 1 from p 1699 TEB and Appendix 2 from p 1711 TEB). However, these reports related to only a small number of case studies and made little comment on their likely reduction in N loss, practical aspects associated with their use, or about cost implications on a farm system basis.

59 Table 1 below is an up-to-date summary provided to DairyNZ for use in a DairyNZ Farmfacts on minimising N loss on farm, with a few additions to include options identified by the other experts noted in the last paragraph. It was adapted from original work done in the Rotorua catchment (which was presented in Table 1 in the s42A evidence by Duncan Smeaton for Fonterra).

60 This table describes mitigation options according to the management area targeted and gives an indication of the relative likely reduction in N loss and a very general guide to their relative economics (in practice, the specific reduction and economics from their use on an individual farm will depend on various factors including existing farm practices and fit to the farm system).

61 In the following paragraphs I will comment specifically on most of these mitigation options, providing context to their use and covering implications for implementation and approximate costs/benefits.

Table 1. Options to reduce N loss to waterways

Management Area	Options	Relative reduction in N loss*	Economics**
Soil	Apply DCD in autumn/winter. Effectiveness varies with winter temperature and rainfall	M	- to +
	Protect, or encourage the development of natural wetlands	L-M	0 to -
	Put in artificial wetland – highly site dependent	L-M	--
	Reduce soil erosion, including riparian planting	L	- to +
Fertiliser	Avoid or reduce N use over winter (particularly in cool regions)	L	0 to +
	Use more frequent low N rates (e.g. not more than 30 kg N/ha/application)	L	- to +
	Cease or greatly reduce annual N use	H	- to --
Effluent	Apply FDE to larger area and apply less N fertiliser	L-M	0 to +
	Avoid ponding/ runoff and loss from wet soils	L-M	0 to +
	If discharging to waterway from a two pond system, consider an upgrade to land application	L-M	Probably positive if capital costs are spread over time, balanced with $ benefit from effluent nutrients
Animal shelters, feed and stand-off pads	Avoid/reduce excreta on pasture in winter and/or autumn. Collect effluent and apply as per guidelines	M-H	- to +
	Link feed-pad use to cut-and-carry of pasture	M-H	- to --
Winter cows off-farm	Wintering cows off-farm. System changes required to cover costs. Transfers N loss to other areas	H	0 to ++
Management	Reduce stocking rate and increase per-cow production	L	+
	Change brought-in feed to low protein source (e.g. maize silage)	L	- to +
Brought-in feed	Reduce use	L-M	0 to -
	Avoid leakage of effluent from feed storage areas	L	0 to -
Waterways	Keep stock out of waterways using fencing, bridges and culverts	L	- to +
	Ensure runoff from tracks/lanes is not channelled to waterways	L	0 to -
	Create riparian or buffer strips in near-stream areas or gullies to trap sediment, particularly when winter grazing forage crops	L	-
Winter crops	Minimise cropping and change to nil or reduced cultivation. Use soil N tests to optimise N fertiliser rates	H (for cropped area)	- to +

* **Reduction in N loss:** L = low; M = medium; H = high

** **Economics:** ++ = very profitable; + or - = slightly profitable or costly; 0 = cost neutral; -- = very costly

62 *Nitrification inhibitor DCD*. The nitrification inhibitor DCD can be effective in reducing N leaching. In a recent grazing system study on a mole/pipe drained soil on the Massey University dairy farm, the use of DCD applied three times to pasture within a week of grazing between March and mid-late winter showed a decrease in N leaching by 21-22% (Gillingham et al., 2012). Associated measurements under mowing and grazing showed a nil-to-small (but variable) benefit from pasture growth. Responses varied from non-significant to 7% response which could partly offset the cost of the applied DCD (about $300/hectare). Other comprehensive research by Crown Research Institutes and Universities has also shown variable responses with many not being statistically significant e.g. the longest running grazing trial in Southland showed no significant pasture response over 4 years (Monaghan et al., 2009). The current industry practice involves two DCD applications per year, which can be applied by a contractor. Based on the above comments, DCD applications could be considered to have a net implementation cost of approximately $0-200/ha/year (depending on pasture growth benefit). Manderson (s42A evidence Appendix 1, p 1699 TEB) and Taylor (s42A evidence Table 12, p 1791 TEB) both identified DCD as an option for most of their case farms.

63 *N-loss interceptors*. Several options exist to intercept leached-N or excreta-N that could runoff-directly to surface waterways. These include enhancing the effectiveness of wetlands, constructing artificial wetlands, riparian planting, fencing to exclude stock from waterways and earthworks (if necessary) to ensure runoff from lanes/tracks does not directly enter waterways. The applicability of these options clearly varies with individual farms according to their landscape features and location of farm infrastructure (including lanes/tracks). Monaghan (2012) estimated costs for these at $11-110/ha with the lowest cost for fencing streams and highest cost associated with constructing wetlands. In Monaghan's case study farm, he estimated a reduction of up to 17% in N loss to waterways (see Table 2), but this will be highly dependent on the individual farm. Costs for various mitigation options were also given based on earlier data in the evidence of Monaghan (2008). In all cases it was acknowledged that such costs vary with farm and site factors and should be seen as indicative only. Infrastructure items such as these require a lead-in period to implement and preferably require additional input from an expert with hydrology knowledge in order to ensure effectiveness. They are also relatively expensive and need to fit into budgetary requirements for implementation.

Table 2. Estimates of the annualised net costs (assuming 8% opportunity cost of capital) and effectiveness of a range of mitigation measures available for reducing N losses to water from a case study dairy farm in Southland (Monaghan, 2012).

Measure	NET cost, $/ha/yr	Effectiveness, %
Farm management changes		
Low N feed substitution	-11[a]	5
Deferred effluent irrigation	8	5
Nitrification inhibitor	70	19
Nil N fertiliser	437	19
Off-paddock wintering	167	27
Restricted autumn-winter grazing	188	60
Edge-of-field measures		
Grass buffer strips	48	3
Stream fencing	11	12
Facilitated natural wetlands	104	17
Constructed wetlands	110	17
Land use change Dairy to sheep farming	1492	55

[a] negative value indicates a net financial benefit

64 *Prudent application of N fertiliser*. N fertiliser is used on the majority of dairy farms in Manawatu and New Zealand because it is recognised as a very cost-effective method for increasing pasture growth and feed supply on farm. The current average rate of application is about 110 kg N/ha/year for New Zealand. I am unsure of what this is for the Region. Various research studies have shown the effects of N fertiliser rates on N leaching in grazed systems (e.g. Ledgard et al., 1999). In the economic analysis of Monaghan (2012), cutting N fertiliser use from 80 to 0 kg N/ha/year and the associated loss in milk production was one of the more expensive N mitigation options at over $430/ha/year. This is because N-fertiliser-boosted grass is one of the cheapest sources of feed and its reduction can impact on profitability. Taylor (s42A evidence, Table 12, p 1791 TEB) identified reducing N fertiliser use as one of the more common mitigations for his group of farms but there may be other, more cost-effective options.

65 *Good practice in farm dairy effluent (FDE) application*. Application of FDE onto land instead of using two-pond processing systems can reduce N loss to waterways by up to 10% and can be cost-effective in the longer-term due to reduced fertiliser requirements. However, there has been a large shift in dairy farms towards use of land-application of FDE in all NZ regions according to surveys by DairyNZ and Fonterra. Thus, there is limited opportunity for this. However, further gains can be made, particularly on the poorly-drained soils, by use of effluent storage, deferred application and low-rate

application technology e.g. about 5% reduction in N leaching for a cost of about $8/ha/year (Monaghan 2012). It should be noted that this is a discounted cost over time. FDE systems can sometimes require considerable initial costs to establish and need to fit into planned budgets, which may require a phased-in approach. Recommendations and the environmental benefits from improved effluent management on soils with preferential flow, poor or artificial drainage, or coarse structure, or soils on sloping land, and exacerbated by high rainfall, were covered in the s42A evidence of Houlbrooke (Tables 1 and 2, p 1939-1940 TEB). These improved effluent management practices are particularly beneficial for reducing losses of P and faecal bacteria from farms to waterways.

66 *Grazing animals off farm*. Urine deposition by grazing animals in autumn and winter have been identified as the main source of N leaching in grazed dairy pastures. Various studies have shown reduction in N leaching of up to 50% by excluding grazing during this period (e.g. Ledgard 2001). This can be achieved by grazing animals off farm and if associated with some level of intensification on farm (which would mean a smaller overall reduction in N leaching of up to about 30%) it can potentially result in an increase in farm profitability (Smeaton and Ledgard 2007).

67 *Use of stand-off pads or animal shelters and excreta capture*. Reduced leaching of urine over winter could also be achieved by utilisation of stand-off pads or animal shelters. However, they require a significant change to the dairy farm system and they have a high cost associated with them (e.g. about $370/cow from Monaghan (2012), which equated in his case study to a net cost of $170-190/ha/year compared to wintering off-farm, Table 2). Effectiveness is also highly dependent on the efficient capture of excreta, storage and application to pasture during periods of low N leaching risk. Implementation of such systems require infrastructure to be established and new farmer skills to be developed. Because of the significant costs, up skilling and changes to farming systems involved, an adequate lead-in period would be required.

68 *Cut and carry pasture.* Cut and carry refers to the harvesting of pasture and feeding it to animals indoors or on a feed-pad rather than letting the animals graze pasture directly. If combined with efficient capture of excreta and application to land using optimum practice (e.g. Tables 1 and 2 in Dr Houlbrooke's s42A evidence, p 1939-1940 TEB), it can reduce N leaching. However, cut and carry is a very costly and time-consuming option to be using for a long period of time. This option was identified in the list of "*reasonably practicable practice*" in Appendix 2 (Policy 13-2C) in the statement of evidence by Ms Barton (p 4981 TEB) as was "herd homes with effluent capture". I believe that costly practices and infrastructure (such as cut and carry, and herd homes with effluent capture) should not be considered as a "*reasonably practicable practice*" for existing dairy farms because of their costs and complexity.

69 *Optimising animal productivity*. Optimising animal productivity on farm such as by increasing milksolids production per cow and lowering the stocking rate has potential to increase profitability and give a small decrease (e.g. < 5%) in N leaching on some farms. This is due to more of the N consumed in feed being converted into milk and correspondingly less is excreted onto soil and prone to loss.

70 *Use of low N supplementary feed.* Using supplementary feed with a low N concentration (e.g. maize silage) to replace other higher-N supplements (e.g. pasture silage) or to replace N-fertiliser boosted pasture (thereby reducing N fertiliser use) can result in low-moderate reductions in N leaching depending on the amounts used. Cost implications to the farmer depend on relative prices of the supplementary feed sources (e.g. in Table 2, barley was assumed to be cheaper than pasture silage and has a lower N concentration), although these are invariably greater than the cost of N-fertiliser boosted pasture.

71 *Reducing N loss from winter forage crops*. Winter forage crops can represent a hot-spot for N leaching with recent research indicating losses from grazed crops ranging from 55 to 114 kg N/ha/year (de Klein et al., 2010). These losses can be reduced by practices to reduce N release from soil on cultivation and to decrease N fertiliser use or by adding mitigations such as DCD. Nevertheless, N leaching from such grazed crops will still be higher than from grazed pasture (e.g. Shepherd et al., 2010).

72 *Change of land use*. Monaghan's analysis indicated a large reduction in N leaching by switching from dairying to sheep farming but it was associated with a large decrease in farm profitability (Table 2).

73 *Future N-mitigations*. In future, there will be other N mitigations available that are currently at a proof-of-efficacy stage of testing. This includes new grasses with improved characteristics such as greater root mass, tannins or low N concentrations for increasing N efficiency and decreasing N leaching in a grazing system. These are at various stages of testing and are likely to be 5+ years before commercial availability. Others that look promising and are undergoing field evaluation include targeting "hot-spot" areas of high N leaching to reduce costs of mitigations and strategic animal mitigations such as feeding animals directly with diuretics (e.g. salt) or inhibitors.

74 The management/mitigation options in Table 2 are not necessarily additive since many are targeting the same mechanism of N loss reduction.

75 In conclusion, there is a range of potential N mitigation options that vary in extent of reduction in N leaching. However, in most cases they are associated with a net cost to the farmer in their use, particularly those with moderate-high potential for decreasing N

leaching. A summary of the main N mitigation options available to farmers is given in Table 3 by categorising them according to whether they have nil-low or medium-high net implementation costs. Most tier 1 options in Table 3 could be expected to be adopted by farmers with high N leaching losses, unless impracticable (e.g. full cultivation of soil for a crop may sometimes be necessary). Note that options relating to excluding animals from waterways and avoiding runoff from farm lanes are not included in Table 3 because they are already defined within other areas of the policy.

Table 3: Summary of the main N mitigation options categorised according to whether they have nil-low or medium-high net implementation costs

1. **Tier 1 mitigations with low net implementation costs:**

N fertiliser use:

- Apply N fertiliser according to FertResearch Fertiliser Code-of-Practice
- Avoid winter N applications
- Use frequent low N rates (e.g. < 30 kg N/ha during slower growth and < 50 kg N/ha at other times)
- Reduce N fertiliser use and replace lost production by low-protein brought-in feed

FDE:

- Use land application rather than two-pond discharge systems
- Ensure application area is sufficient to achieve < 150 kg N/ha/year (and reduce fertiliser-N accordingly)
- Use of storage (sealed for leakage), deferred application and low rate application methods as required according to soil risk

Brought-in feed:

- Use low-protein feed sources rather than brought-in pasture silage
- Reduce N fertiliser use and replace lost production by low-protein brought-in feed

Winter forage crops:

- Minimise use of forage crops (particularly winter forage crops)
- Use minimal or nil cultivation for establishment
- Minimise N fertiliser use by soil N testing to define requirements

Soil management:

- Apply DCD according to industry specifications

Farm management options:

- Optimise per-cow efficiency (e.g. increase milksolids production per cow and decrease stocking rate; reduce replacement rate)
- Winter cows off-farm (preferably in low-N-sensitive catchment)

2. **Tier 2 mitigations with medium to high net implementation costs:**

- Installing constructed or artificial wetlands
- Create riparian or buffer strips beside stream margins
- Cease use of N fertiliser
- Use stand-off pads or animal shelters (lined for effluent collection) during autumn/winter with effluent storage system and optimised land-application system for effluent use in low-risk periods
- Introducing ungrazed pasture or treed areas

NOTE*: These practices are not additive. Where they target the same N loss process there may be limited advantage to using more than one option (e.g. wintering-off, winter stand-off pads or animal shelters, DCD use).*

The ability and feasibility of achieving reductions in nutrient leaching

76 Some management/mitigation options for reducing N leaching are already commonly or increasingly being implemented. For example, as noted earlier, frequent use of low rates of N fertiliser application is widespread, and land application of FDE is now used on over 90% of dairy farms. However, there is potential by integrating various practices outlined previously into a farm system context to achieve higher productivity with lower N leaching losses. This was identified in a recent DairyNZ analysis for Waikato (Beukes et al., 2012) by integrating cow efficiency measures (high per-cow production, low cow replacement rate) with FDE utilisation, low N fertiliser use, low protein feeds, DCD and strategic standing off during winter. DairyNZ has an extension programme that is focussed on raising awareness and training farmers in nutrient use efficiency within farm systems, with a target of DairyNZ Consulting Officers running the training at 200 Farm System Discussion Groups throughout NZ by May 30 2012.

77 The use of some other management/mitigation options is often constrained by a range of factors including implications for reduced profitability, difficulty of use (e.g. requirements for greater skills and labour), and lack-of-fit to an existing farm system (e.g. physical constraints such as land area suitable for widespread easy-use FDE application, or wetland installation).

78 Nevertheless, some management/mitigation options can be associated with increased profitability e.g. increased productivity/animal and decreased stocking rate, enlarging the area for land application of FDE and reducing fertiliser accordingly, and wintering cows off-farm in a non-N-sensitive catchment (in conjunction with changes on-farm).

79 Case study work with 26 dairy farmers in the Rotorua catchment by Duncan Smeaton and myself (Smeaton and Ledgard 2007) evaluated a range of N mitigation options and suggested a possible reduction in N leaching of 4% (optimising N fertiliser and FDE use and stocking rate) by implementing these potentially-profitable options. This increased to a 12% reduction if the level of wintering cows off-farm was increased on all farms and farm changes made to compensate for wintering-off costs. In practice, some farmers had a greater potential reduction, whereas other farmers were already implementing these options and little could be done to reduce their N leaching without incurring significant costs.

80 Work with these Rotorua dairy farmers has continued and while policy has not yet been introduced there has been a 15% decrease in average N leaching per hectare on dairy farms in the catchment in 2010 compared to the original benchmarking in 2001-2004 (see Table 3 in Kingi et al., 2012). This will be due in part to increased

awareness of the issue and mitigation options available, as well as concern about the looming N leaching targets.

81 Research in Waikato by DairyNZ compared different farmlets with increasing levels of intensification using brought-in feed with focus on maize silage as a low-protein feed (Ledgard et al., 2006). This showed that an increase in milk production per hectare of about 30% with maize silage at 5 t dry matter per hectare resulted in no-significant increase in N leaching on the dairy farm. However, associated measurements in the maize growing area showed high N leaching (70 kg N/ha) and on a whole-system basis there was a small increase in N leaching per kg milksolids produced. This highlights the need to also account for N leaching from forage crops grown for dairy cows (as well as arable crops in general), particularly if grown within N-sensitive catchments.

82 The management/mitigation options in Table 2 include some that could be easily implemented with limited disruption to the farm system (e.g. DCD use, reduced N fertiliser use and change to low-N feed source), as alluded to in s42A evidence by Monaghan (par. 13, p 1949 TEB) and Taylor (par. 15, p 1762 TEB). However, other options are more complex in requiring significant infrastructure investment (e.g. deferred FDE application; feed pads and animal shelters, and constructed wetlands) or farm system changes (e.g. ceasing winter cropping, and feed-pad and animal shelter use resulting in increased supplementary feeding requirements). These more complex options require planning with expert consultancy input, fitting into budgetary constraints and may require other management changes (e.g. changing practices such as calving dates). These latter options require sufficient time to plan, upskill staff and implement.

83 I agree with the concluding comment in Monaghan's s42A evidence (Table on, p 1962 TEB) that there will be an increased need for extension (e.g. awareness raising, case demonstrations, consultancy) relating to farm management/mitigation options to achieve N reduction on farms, and that there is currently limited expert capability in this area.

84 A key issue in achieving this reduction or greater reductions via adoption of mitigations is the recognition that appropriate management/mitigation options are highly farm specific (as noted in s42A evidence by other experts including Monaghan (par. 7, p 1946 TEB) and council level evidence of Duncan Smeaton for Fonterra. Consequently, skilled extension personnel are needed to work with farmers to identify appropriate options and determine how they are best implemented. This need was recognised in the recent supplementary statement of Taylor (par. 25, p 4797 TEB). Additionally, many of the options in Table 2 take time to implement and in some cases this can be a number of years. The latter applies particularly where there are farm system changes required and farmer upskilling is needed, or where there are infrastructure

changes such as with animal shelters or wetlands, as noted earlier. On some existing farms, some of the tier 2 options in Table 2 will be financially unviable to implement.

Ability/feasibility to change depending on LUC factors

85 The site-specificity of management/mitigation options are also influenced by LUC site characteristics, as noted by other experts including in the s42A evidence of Mackay).

86 For example:

a. While many options in Table 2 could be used across all LUC classes, the ability to apply DCD in winter is more difficult on heavy-textured poor-draining soils.

b. Similarly, sloping land and mole/pipe drained soils make FDE management more difficult in terms of avoiding direct loss (by runoff or by preferential flow). More expensive systems are needed for storage and application-scheduling (see evidence of Houlbrooke par. 13, Tables 1 and 2).

c. Conversely, the increased risk of soil pugging and pasture damage on sloping land and mole/pipe drained soils can make infrastructure such as stand-off pads or animal shelters more justifiable in ease-of-management and cost/benefit terms. These soils are also more likely to have areas that would enable introduction of edge-of-field options such as facilitated or artificial wetlands or riparian management compared to LUC I and II soils.

87 Many of the above issues also apply to sites with high rainfall. For example, under high rainfall, DCD is less effective and specific management of inputs such as N fertiliser, FDE and forage crops is more critical to avoid direct N losses.

88 Of the 143 farms described earlier where N leaching estimates were obtained, it was not possible to get supporting data on what their LUC class would be. Thus, it is not possible to comment on where these farms would sit on average in relation to their LUC-based N targets.

89 Thus, the only current data available to consider this aspect and implications for meeting the target is the recent evidence of Taylor (par. 10-12, p 4792 TEB). His summary of 18 current dairy farms indicated that 10 would need to reduce N leaching, for two farms it would be "possible but with some difficulty" to meet their N loss target, while for three farms it would be "very difficult". It is unclear how representative this small sample would be. Also, there were no economic analyses done and therefore it is difficult to know what the implications are for achieving N loss reductions across the 10 farms. However, the N reduction options identified for these farms in Table 12 of the earlier Taylor report (2008) indicates that in most cases

there would be some reduction in profitability expected (many included decreased N fertiliser use and DCD use), based on earlier data presented on net costs of various options.

90 In the earlier evidence of Taylor (par. 109, p 1794 TEB), he referred to an analysis based on about one-third of farms in priority catchments with rainfall >1200 mm and LUC of IV or higher. He stated that these farms could "*implement recommended mitigation options to achieve between 58 and 62% of the amount they are required to lose to meet year 1 permissible N-loss targets*". He also noted that some farms "*would need substantial change to their current operation*" to meet full compliance. However, it was unclear how the 58-62% was estimated nor of the economic implications of these comments. Nevertheless, these statements suggest changes may be required on a significant proportion of farms in the catchments to conform to the LUC-based N targets.

91 In conclusion, the N mitigation options for a farm to meet N targets need to be identified on a farm-specific basis, preferably using an experienced consultant. Such an evaluation would need to determine the suitable N mitigation options, their cost effectiveness, and the fit to the farm system. The timeframe for implementation should depend on whether there are significant farm system changes or infrastructure requirements.

Proposed 'exception' categories

92 I note that Ms Barton states in her evidence (par. 83, p 4903 TEB) that the Council's LUC allocation method has been criticised for:

a. Resulting in unachievable N loss limits for areas of high rainfall on LUC Class IV and above; and

b. Being unduly restrictive in the Region's sand country (predominantly along the west coast around Foxton).

93 In essence, Ms Barton proposes to address these two issues by:

a. Providing an 'exception' category for high rainfall on LUC Class IV and above; and

b. On the basis of Mr Grant's evidence, reclassifying the LUC classes for the sand country to acknowledge re-contouring and irrigation, thus making N-leaching targets less restrictive for farms in that area.

94 In my view, these two categories and the associated planning methods to implement them raise a number of issues. Generally speaking, both categories do not overcome the issues I raised earlier with regard to the high variability of N-leaching characteristics between farms.

95 Mr Taylor's supplementary evidence (par. 34 and 35, p 4801-4802 TEB) on the ability of farms to meet Ms Barton's LUC classes is illustrative of this point. For two of the farms he assesses he finds that it would be possible but with some difficulty to comply, and for three farms it would be very difficult to comply in the suggested time recommended by Ms Barton. Two of the farms Mr Taylor refers to are not apparently in the defined exceptions categories and would find it "very difficult" to meet the LUC maxima.

96 In addition, I am not aware that there has been any testing on the extent to which the exceptions would allow the farms which meet the relevant criteria to then meet Ms Barton's LUC N-loss targets.

97 Some issues relating to the 'high rainfall on LUC Class IV and above' exception are as follows*:*

a. The reason for setting the proposed rainfall threshold of 1500 mm is unknown. I am aware that Mr Taylor assessed the number of properties within targeted catchments with more than 1200 mm rainfall per year and more than 60% LUC class IV and higher (Table 13), but cannot find any reference to the 1500 mm threshold in other evidence. It is therefore unclear as to how many farms the exception would apply.

b. I note that Ms Barton proposes that farms in this category would be entitled to achieve the relevant nitrogen leaching rates by the first ten year common catchment anniversary date (Table 3 in her recent evidence, p 4910 TEB). However, it appears Ms Barton would expect farms in this category to implement Tier 2 mitigations with moderate to high net implementation costs to do that. As noted earlier, Tier 2 mitigations may be impractical or unviable on some existing farms and do not readily meet the classification of "*reasonably practicable practice*".

c. The exception only targets two of the three main farm factors that will influence the limitations to reducing N-loss, the other one being high stocking rates. The fact that a combination of any two of those three factors may limit the ability to make N reductions is described variously by Council witnesses, but is summarised in the s. 42A evidence of Roygard (para 19, P 207 TEB) as follows:

> In very broad terms, it may be difficult to meet the proposed N loss limits with current technologies where high rainfall, high proportions of the farm in LUC class 4 and above, and high stocking rate coincide. This may also be the case where only two of these variables coincide. Some farms in these situations have been able to meet the proposed N loss limits by incorporating associated support blocks to the farm, the adjustment of LUC class in relation to overcoming the limitation of water through

irrigation, and through improved information in relation to on farm LUC mapping.

On the basis of that evidence, it appears that some farms on LUC I-III land with high stocking rates and high rainfall may find it difficult to make significant N-loss reductions. Similarly, some farms on LUC IV-VIII land with high stocking rates may also face difficulties. Those farms would not meet Ms Barton's' proposed exception. It therefore seems likely that at least some of those farms would be expected to adopt Tier 2 mitigations (including potentially destocking) to meet Ms Barton's proposed LUC limits within the 3 years that she proposes.

98 Additionally, Mr Grant's re-classification of the coastal sand country introduces a further layer of complexity for dairy farmers, which is likely to require expert consultant input for dairy farmers to understand and use.

CONCLUSIONS AND ASSESSMENT OF PROPOSED APPROACHES TO LIMITING N-LOSS

99 Horizons' existing dairy farmers have a relatively low average N leaching loss by national standards, which may reflect good overall N environmental performance. Based on best available information, there is, however, a wide range of N leaching from dairy farms within the Region (between 8 and 47 kg N/ha/year, as modelled using OVERSEER).

100 Although studies are relatively limited, it is likely that there will be a considerable spread in environmental performance between farms and in the use of management practices and mitigations.

101 Studies show that the spread of N leaching variability is moderately correlated with various management-related practices across different farms.

102 The principles behind LUC classes have a sound fundamental basis. From a resource efficiency perspective, there is merit in seeking to encourage intensive production (with likely higher N-leaching) on the more productive land in the Region with less limitations (i.e. on land with LUC I and II than on land with high LUC and greater limitations).

103 However, the LUC approach has several limitations in its application to existing dairy farms. For example, the main drivers of N leaching are not well aligned to the LUC classes, except via differences in potential productivity. This is because:

a. Leaching of N from grazed pastures is primarily driven by N excretion in animal urine. The amount of associated N-loss is related to the pasture production and animal intake (as well as from brought-in feed sources). Productivity is influenced by the range of technologies and inputs used on a particular farm. These technologies and inputs can be used to overcome the physical limitations on pasture production inherent in the LUC classes. The range of technologies and inputs used on a farm by farm basis are likely to be variable.

b. Rainfall and soil characteristics also affect N-loss. Losses generally increase with increasing rainfall. Shallow stony soils have the highest N leaching risk and free-draining soils have higher N leaching than poor-draining soils. There are likely be variations in rainfall and soil characteristics between farms across the Region, even within the same LUC classes.

104 An additional limitation of the LUC approach to regulating N-loss is that there is little understanding of the actual production on dairy farms across the different LUC classes. The limited testing that has been completed confirms that there is high N-loss variability between farms. Therefore the implications of an LUC approach to regulating N-loss are also unknown, and may impact unfairly particularly on intensively-managed moderate-high LUC farms that will be required to meet relatively low N loss targets.

105 There are a range of management practices and mitigations that can potentially be used to reduce N leaching on farms. In most cases, they are associated with a net cost to the farmer in their use.

106 Appropriate management and mitigation options are highly farm specific. There will therefore be an increased need for extension (increasing farmer awareness) relating to farm management/mitigation options to achieve N reduction on farms. There is currently limited expert capability in this area.

107 Some of the practices and mitigations (the 'Tier 1' options discussed earlier) could be expected to be adopted by farmers with high N leaching losses, given their relative ease to implement and low cost. There will, however, be circumstances where adoption is limited by site characteristics and current farm management. Some practices may also need time to be implemented to allow for changes to current farm practices.

108 There are a range of other practices and mitigations (the 'Tier 2' options discussed earlier) which because of their relative difficulty to implement and high costs mean that their viability will be very farm specific and should not be classed as "reasonably practical practices" for existing dairy farmers.

109 In the future, there will be other N mitigations available that are currently at a proof-of-efficacy stage of testing. In my view, uptake of these N-mitigations will assist in increasing N-efficiencies and reducing losses over time.

110 Based on the above, my view is that the following considerations should inform the POP's regulation of existing dairy farms:

112.1 There is a good case for focussing management action on the farms with high N-leaching losses. I recommend that farms in the highest quartile of N-leaching in the Region (those above 27 kg N/ha/year) be required to undertake a range of Tier 1 options.

112.2 N targets based on inherent potential productivity have some limitations due to the weak relationship with N leaching and lack of recognition of introduced technologies that determine actual productivity. Nevertheless, the LUC concept is useful from a wider water quality perspective in its alignment with risk of P and sediment loss.

112.3 I support the requirement in the Decisions Version of POP that all existing dairy farmers in targeted catchments should be required to:

(a) Prepare and comply with annual Nutrient Management Plans (Rule 13-1);

(b) Exclude cows from waterways (Rule 13-1);

(c) Avoid direct runoff from farm lanes into waterways (Rule 13-1);

(d) Manage their use of fertilisers (Rule 13-2); and

(e) Comply with stock feed and feedpad use rules (Rule 13-3), biosolids discharge requirements (Rule 13-4) and farm animal effluent discharge requirements (Rule 13-6).

112.4 The design of the regulatory framework also needs to contain sufficient flexibility to recognise that appropriate N loss reduction options vary with individual farm circumstances and that their use requires a farm-specific approach.

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14 March 2012

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