BEFORE COMMISSIONERS APPOINTED
BY THE WAIKATO REGIONAL COUNCIL

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of the First Schedule to the Act
AND	
IN THE MATTER	of Waikato Regional Plan Change 1- Waikato and Waipā River Catchments and Variation 1 to Plan Change 1
AND	
IN THE MATTER	of submissions under clause 6 First Schedule
BY	**BEEF + LAMB NEW ZEALAND LIMITED** **Submitter**

BRIEF OF EVIDENCE OF DR ALISON DEWES
3 May 2019

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BACKGROUND

1. I have been a registered veterinarian for 30 years. I hold a BVSc from Massey University (1987) and a Masters in Biological Science (Ecology) from Waikato University (2015).

2. My Masters in Biological Science which focussed on the impacts of policy changes on Upper Waikato Dairy farms: My Thesis “Economic resilience and environmental performance of dairy farms in the Upper Waikato region” was undertaken at Waikato University.

3. Other relevant education has included the following courses:

   (a) Intermediate Nutrient Management (Massey 2009);

   (b) Advanced Nutrient Management Course (Massey 2009);

   (c) Farm Dairy Effluent System Design and Management (Massey 2012);

   (d) Business Lending Fundamentals: Developing Client Relationships and Negotiate Client Solutions: Tier 111 registration for Agribusiness, Commonwealth Bank of Australia 2007;

   (e) In Calf Training, Certified Advisor 2006;

   (f) Certified Adult Trainer, Melbourne 2004;

   (g) Dairy Leadership Course Melbourne 2004;

   (h) Advanced Dairy Nutrition, Australia 1999; Dairy Nutrition Course, Lean, Massey 1990, Soils and Pastures Course, Massey 1993; & Milking Machine Testers Course, Flockhouse, 1992.

4. I practised as a dairy and equine veterinarian in Waikato from 1987 to 1997 and was also a Director of Hamilton Analytical Laboratories (Consultants in Animal Nutrition and Applied Science) over that time.

5. I am a fifth-generation farmer and have over 20 years dairy farming in New Zealand and Australia with my husband. We sharemilked and dairy farmed

in the Waikato from 1992-1997, and then moved to Australia and dairy farmed in Victoria over the 1997 to 2009 period.

6. I was elected to the New Zealand Veterinary Board in 2015, was sustainability spokesperson for the profession, and was part of the National Environmental Reference Group for Landcorp which is reviewing overview farm strategies (2016-2018).

7. I was a finalist for the NZI sustainability champion in 2014, received a commendation for community impact for my work with farmers, and a finalist in the 2015 Women of Influence Awards in Public Policy.

8. In the period from 1997 to 2001, I held a position in Milk Procurement, for Nestle, in Warrnambool, Western Victoria, Australia. I was involved in the development of the “on farm quality assurance programme” for Nestle Australia.

9. From 2001- 2007 I was the Business Development Manager for Intelact Agribusiness Consultancy in Australia. The business services were based on full farm analysis for intensive pastoral farms. Businesses were faced with major constraints on their surface and ground water allocations meaning reconfiguration of systems to adapt. This was amplified by two major droughts occurring between 2002 – 2007.

10. From 2006-2008 I was an Agribusiness Lender for the Commonwealth Bank of Australia and involved in the appraisal and risk assessment of new farm businesses.

11. In 2009, I returned to New Zealand, and was contracted by Agfirst. I undertook the Upper Waikato Nutrient Efficiency Study and analysed more than 380 OVERSEER files for eco efficiencies for MAF farm monitoring during 2009 and 2010.

12. From 2010-2013 I was the Sustainable Land Use Advisor to Raukawa Charitable Trust in the Upper Waikato.

13. From 2013-2016 I was lead consultant for Headlands, a sustainable agricultural consultancy business in Waikato.

14. From 2016-2018 I set up my own company, Tipu Whenua, a sustainable agricultural consultancy. A lot of our work was focussed on Low N farming studies, OVERSEER preparation and supporting farm plans for the BOPRC.

15. In January 2018, I joined Pamu, as Head of Environment.

16. Between 2011-2018 I have been an expert witness on agricultural matters for the Horizons One Plan, Proposed Canterbury Land and Water Plan (2013), Tukituki River Catchment Plan Change 6 (2013), Variation 1 (Selwyn - Waihora), Variation 2 (Hinds Hekeo Plains), Variation 5 for CLWP, Fonterra Studholme Consent Application, and South Waikato District Plan Change hearings. I have also prepared evidence on the Havelock North Drinking Water inquiry, and Greater Wellington Regional Council Plan Change.

17. My professional affiliations are New Zealand Freshwater Sciences Society and New Zealand Veterinary Association. I was the sustainability spokesperson for the NZ Veterinary Association on One World One Health and Sustainability Issues while on the Board of the NZVA (2016-2018).

18. I am familiar with the analysis and strategy planning using UDDER, Farmax Dairy Pro, Red Sky and OVERSEER.

19. This evidence is prepared on behalf of Beef and Lamb NZ, and Farmers for Positive Change.

20. In preparing this evidence I have reviewed:

    (a) The reports and statements of evidence of other experts giving evidence relevant to my area of expertise, including:

        (i) Mr Andrew Burtt

        (ii) Mr Richard Parkes;

        (iii) Dr Jane Chrystal;

        (iv) Mr Simon Stokes;

        (v) Dr Alec Mackay;

(vi) Mr Richmond Beetham;

(b) The Council Officers' section 42A report;

(c) Plan Change 1 and Variation 1; and

(d) The section 32 report.

21. I have read the Code of Conduct for Expert Witnesses in the Environment Court's 2014 Practice Note and agree to comply with it. I confirm that the opinions I have expressed represent my true and complete professional opinions. The matters addressed by my evidence are within my field of professional expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

SCOPE OF EVIDENCE

22. I have been asked by B+LNZ, and Farmers for Positive Change to prepare evidence in relation to the agricultural land uses in the Waikato, changes overtime, and environmental impacts. In particular, my evidence focusses on the dairy sector and its ability to internalise its externalities, along with the need to provide the sectors with certainty to plan for the future and time to adapt. I consider the implications of Plan Change 1 and Variation 1 (PC1) to the agricultural sectors in the Waikato.

23. I am aware of the directions of the Hearing Panel to allocate blocks of time for particular topics. This brief of evidence relates primarily to hearing stream 2 (HS 2). Specifically, this brief of evidence focuses on the approach to managing agricultural land uses through PC1, allocation, use of OVERSEER, and Good Management Practice (GMP).

EXECUTIVE SUMMARY

24. The Waikato River is considered to be degraded, and as such overallocated at some reaches in relation to water quality parameters. This over allocation creates risk for both business and the environment. This risk arises from a failure to adequately account for the current degradation of freshwater resources and appropriately allocate ecosystem (assimilation) services

provided by the catchment with a regime underpinned by robust ecological monitoring and adaptive management.

25. The approach adopted in PC1, seeks to restrict land use change to more potentially intensive farming systems through non-complying land use consent, as well as grand parenting farming systems to historic nitrogen discharge profiles as modelled by OVERSEER for the 2015/16 or 2016/17 years. This is with the exception of the highest emitting land uses which are required to reduce their nitrogen leaching down to the 75th percentile for their FMU in 10 years.

26. All farming systems are required to have a farm environment plan which seeks improvements/ reductions in losses of phosphorus, sediment, pathogens and nitrogen from the farming system, as well as requiring compliance with a limited suite of activity-based standards such as stock exclusion up to a land slope of 25 degrees, and cultivation.

27. These requirements apply across all FMU and sub catchments irrespective of the current level of instream nitrogen concentrations, or other water quality parameters, and irrespective of the level of ecosystem health of the receiving freshwater body, including whether and to what extent the sub catchment is at or over allocated.

28. It is inefficient to grandparent extensive farming systems (i.e: below 16 SU or 20 kgN/ha/yr), along with requiring expensive mitigation measures, while allowing intensive farming systems to continue to discharge nitrogen at their historic rates. Capping extensive or very low (i.e under 20 kg N per ha per year) leaching farming systems at their historic N discharge levels, provides business uncertainty, reduces the resilience and viability of the business, impacts on land values and therefore bankability of the farm. It also reduces the ability for the farm to internalise other externalities which may result in greater environmental benefits, such as, reducing erosion and phosphorus, protecting and enhancing biodiversity, and further reducing the risk of pathogen losses from the farm.

29. Grand parenting fails to send the appropriate signals in relation to changing behaviour and potentially land uses on more vulnerable soils, or which are operating beyond the natural capital of the land. It rewards poor

performance, the highest emitting land uses, while penalising the early adopters of low emitting farming systems which have matched their land uses and farming systems to the capability of their land.

30. Grand parenting penalises those farmers who have not for various reasons optimised the productive potential of their farm, and as such is economically and environmentally inefficient. The best farmers are penalised not once – but twice. This occurs as the best farmers have already been allocated a low N loss right through a grand parenting regime which rewards the polluter, and penalises the innovator.

31. Furthermore, they are expected to adopt additional mitigation for other contaminants and may be expected to drop their N emissions, further, to offset the over allocation caused by recent and more intensive land uses that were able to intensify under former permissive policy regimes.

32. In terms of possible improvements in management practises, there are a range of mitigations and changes to farming practices that can have a significant effect on achieving water use efficiency, and reducing contaminant losses to water, including N and P losses. There are numerous examples of farmers and studies reducing N loss by 20-60% in both actual and observed cases. However, significant reductions can put some businesses at risk if they are forced to change in a short time.

33. Hence, careful allocation of ecosystem services aligned with legitimate ecological monitoring regimes; and application of precautionary principles at the outset of this plan, given current uncertainties and risks, should be provided for and in my opinion is an inherent part of "good business planning".

34. Other issues that arise from PC1 include the use of OVERSEER. The modelling underpinning PC1 relied on OVERSEER to determine catchment loads, and in testing mitigation scenarios. An important point to note in the context of mitigation scenarios, is that OVERSEER already assumes some Best Management Practices (BMP), and as such some scenario testing is double counting what can be achieved through BMP. PC1 also relies on OVERSEER to set and manage land uses to historic N leaching and in relation to reducing N leaching.

35. In response to these issues, B+LNZ's suggested approach is to ensure mitigation approaches are tailored to the sub catchment and environmental issues of concern, provide flexibility for low leaching land uses to the natural capital of their land, and seek relative reductions from higher emitting land uses over time, with a long-term goal of restoring the ecological health of the catchment, while providing for resilient and sustainable communities.

36. This is to be achieved through the establishment of a nitrogen flexibility cap based on the natural capital of the land, and a sinking lid approach for higher emitting land uses. In conjunction with requirements to meet the BMP's assumed by OVERSEER, management of phosphorus, sediment, and pathogens through tailored Land Environment Plans (LEP's) based on LUC mapping, and the identification and management of critical source areas.

37. It is on this basis that I support the approach proposed by B+LNZ, which establishes a long-term plan for nutrient loss reduction and allocation combined with adaptive management and legitimate ecological monitoring.

38. I also recommend that ownership of the OVERSEER model should not be by vested interests, such as the NZ Phosphate Rock co (50-50 owned by Balance and Ravensdown). Rather, I recommend that the model should be owned by the NZ Government, and supported with appropriate funding to be validated across NZ on all soil types and under all farming systems.

39. The dairy industry is promoting better self-management and farm environment plans with Good Management Practice (GMP) as a solution, and the use of a Nitrogen Risk Scorecard (evidence of Richard Allen), to manage environmental concerns and improve water quality. While this is commendable and has good metrics associated with Nitrogen loss, it would be sensible to include broader measures and accountabilities such as biodiversity support and enhancement along with soil protection. It would also be ideal to have time bound and measurable goals in relation to reducing environmental risks including nitrogen emissions.

40. This approach will give current businesses a degree of certainty as they implement relevant mitigations and reconfigure their systems accordingly in response to ecological monitoring. These checks and balances are

necessary to ensure that existing and future land uses occur within sustainable limits, and to address present freshwater issues as a priority.

AGRICULTURAL INTENSIFICATION OVER THE LAST TWO DECADES

41. Regionally, the Waikato is more intensive than most of the other regions across NZ, apart from the irrigated soils of Canterbury which require high level of inputs and water on vulnerable soils, thus contributing to high levels of N leach in that region. Irrigated farms in the Waikato on pumice soils exhibit similar leaching levels to Canterbury, of 80-120 kg N leach per ha per year (version 6.3.1)

42. Economically dairy has made a contribution of $14 billion to the national economy in 2013-14 and is the most significant type of agriculture in the primary sector in terms of earnings. It is expected that dairy exports will continue to increase at 8% per annum to contribute $17.7 billion in 2016-17 (i.e.: >40% of the primary sector income), (Ministry for Primary Industries, 2013).

43. Dairying is now a major land use across NZ. Milk production increased by 47% in 10 years (2003-2013) to reach 1.69 billion kg of milk solids (MS) produced in 2012 and the industry now accounts for 21% of NZ's grassland area and 46% of total stock units, (Dairy NZ, 2013).

44. Nationally the environmental footprint from dairy has increased 45% since 2000. From a total of 90 Kilotonnes of nitrogen per year to 130 Kilotonnes of nitrogen per year from the root zone of pastoral systems.

45. The total amount of nitrate-nitrogen leached from livestock increased from 189,000 tonnes nationwide in 1990 to 199,000 tonnes in 2017. The contributions of different regions and livestock types to national nitrate-nitrogen leaching have changed over this time.

46. The amount of nitrate-nitrogen leached by dairy cattle was more than three times higher than beef cattle in 2017 (130,000 tonnes by dairy cattle in contrast to 37,000 tonnes by beef cattle) (Stats NZ 2019).

47. In 1990, nitrate-nitrogen leaching from sheep contributed 34% of national nitrate-nitrogen leaching, which decreased to 15% in 2017.

48. In contrast, dairy cattle contributed 39% in 1990, which rose to 65% in 2017.

49. The contribution of beef to national nitrate-nitrogen leaching has also decreased over this time period, from 26% in 1990 to 19% in 2017. Livestock nitrate-nitrogen leaching in Canterbury has increased 117% since 1990 (from 15,000 tonnes to 33,000 tonnes in 2017). 25% of all nitrate-nitrogen leached by livestock in New Zealand in 2017 was in Waikato (49,000 tonnes) (Stats NZ 2019).

50. The environmental footprint of dairy has grown, especially in the last two decades in Waikato. There has been an increase in intensity at the expense of the sheep and beef sector, as well as an increase in dairy farm area of up to an extra 30,000 ha since 2006 and further intensification and expansion since 2012 (especially in the upper Waikato FMU), which was not included in the modelling undertaken by NIWA for the Technical Leaders Group.

51. It should be noted that the N leach for the region is driven by a range of factors – mainly rainfall, soils, stocking rate and management styles (N use per hectare, cropping, and irrigation).

52. The risks from dairying are most obvious where it is intensified, without sound mitigations, and on vulnerable landscapes. High stocking rates, combined with high rates of N use and winter cropping to supplement in the winter, with or without irrigation can lead to high rates of spill over of pathogens, sediment, nitrogen and phosphorus. On this point I record that I have read and agree with the evidence for Hearing Streams 1 and 2 of Dr. Jane Chrystal.

53. In my experience, dairy N losses are around 200-400% more than that of drystock, despite the fact that the pasture harvested is only around 100% more. i.e: dairy N leach in Upper Waikato ranges from 25-110 kg N per ha per year, with a typical average of around 50 kg N leach per ha per year. Pasture harvested per ha is around 9-12 T DM including irrigated dairy.

54. This compares with drystock which typically has an N leach of 10-35 kg N per ha per year, and harvests around 4.5-6 T DM per ha per year.

55. Most typical dairy farms were leaching 36 kg N per ha in version 6.0 in 2012 in the Upper Catchment. This is 40% more than what NIWA used in the modelling (NIWA- informing reports used 26 kg as average loss for dairy).

56. When comparing datasets to present (OVERSEER version 6.3.1), as noted by Dr Jane Chrystal in her evidence, the leaching profiles of dairy, are around 70% - 100% higher (kg N leached per ha per year). This is supported by Stats NZ in their current 2019 database, suggesting that the most likely leaching from Waikato dairy averages around 45-55 kg N per ha per year in the current OVERSEEROVERSEER version (extracted from version 6.3.1 on 22 April 2019).

57. This is supported by a multitude of databases numbering over 400 files, that I have personally audited – that of Pamu NZ, Dairy Business of the year DBOY[1], clients of Tipu Whenua consultancy and the farms studied for my Masters that are located in the Upper Waikato.

58. Failing to use up to date and representative N leach figures for dairy, would have led to significant discrepancies in the allocation and mitigation assumptions and costs to mitigate for dairy, as well as spill over costs to the regional economy that were extrapolated from this. I therefore have concerns about the reliability of the conclusions that have been drawn from the modelling.

59. It was not always easy to decipher what number, and version of OVERSEER was being used and assumed in the economic test reports used to inform the TLG. Reports that linked environmental performance to economic modelling did not always provide details on version, source, integrity of OVERSEER datasets used to inform them – such as how "average farms were derived", leaving some technical reports questionable as to the overall integrity of the conclusions arrived at.

60. For mitigation scenarios for dairy, the cost of reducing emissions relates to the level of emissions, for example as with drystock farming seeking reductions from already efficient and optimised systems say from 26 kg N leached is far costlier than in seeking reductions from higher leaching farms eg dropping from 60 – 40kg or 45 - 35 kg N leached per ha. Seeking further

[1] https://www.dboy.co.nz: Dairy Business of the Year Competition – NZ Wide.

reductions from already low emitting farms is inefficient, and poses a significant risk to the ongoing viability of that farming operation.

61. Furthermore, the OVERSEER model has changed again since 2012, with changes to profile available water in soils being updated. To illustrate the significance of these changes, in some cases in the Rotorua Catchment these more recent updates to OVERSEER and soils data have led to increases in N leach on farms (when no change to farm system) of a further 30%, just as a result of soil changes in the model.

62. Apart from the cumulative errors as a result of outdated data for OVERSEER that underpin the allocation assumptions used by WRC, there has been a steady intensification of dairy as compared with sheep and beef, which results in further cumulative errors in reports when linked to macro-economic effects, allocation policy, and regional impacts. This is covered later in my evidence, and in the evidence of Dr Jane Chrystal, Dr Cox, and Andrew Burt from Hearing Stream 1.

A HEAVIER HOOFPRINT FROM DAIRY – IN NZ AND WAIKATO

63. A gradual trend of intensification on milking platforms has been observed over the past 2-3 decades. The figure below indicates that most of the dairy farms have doubled output per hectare in the past two decades. Going from an average of 650 kg MS per ha, to 1100 kg MS per ha, with more cows, more feed, more water and more fertiliser, there has also been a gradual upward trend in the environmental footprint – as supported by Figure 1.

64. This trend of increased dairy farm outputs has been made possible as a result of the following:

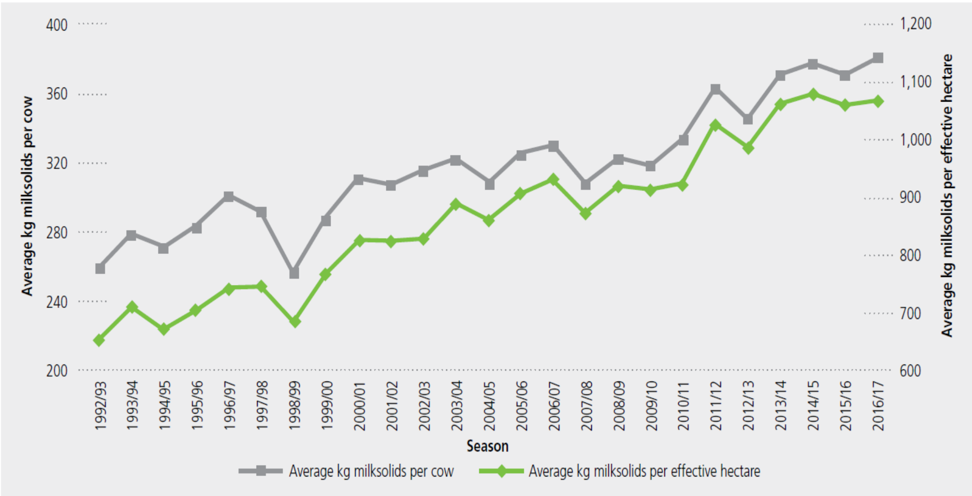
- increased urea fertiliser use over the past two decades: N use from, 50,000 T in 1990 to >600,000T imported in August 2016 plus 260,000T from Taranaki Gas fields. (An increase by a factor of 18) (OECD 2018);

- increased water procured, mainly for irrigation of pasture for dairy (now total use for irrigation is 5 billion cubic litres per year);

- Increased PKE imports (form 2003, from zero to approximately 2 million tonnes in 2016);

- The adoption of winter grazing off by dairy cows, and young stock over the same period on non-dairy farms. This footprint from dairy has been absorbed by the sheep and beef sector, while dairy output on the milking platform has doubled.

Figure 1: Graph 2.2: Milksolids production per cow and per effective hectare since 1992-93



Source NZ Dairy Statistics 2016-17

65. Intensification per hectare and per cow, has been supported by more irrigated pasture nationally, from 480,000 irrigated hectares in 1999 to 720,000 ha in 2012 (half being dairy or support), conversion of marginal land, importation of palm kernel extract to support a doubling in dairy cow numbers in just 25 years.

66. Permissive lending and resource allocation regimes have assisted the speed of growth. 78% of total water use in NZ excluding hydroelectric generation[2] is used for irrigation. 76% of this water which is used for irrigation, has been used for growing pasture – predominantly for dairy systems.

[2] Freshwater use in NZ: Parliamentary Library Research Paper Dec 2011.

Table 1: Derived from Greig (2012) Changing Dairy Farm Systems in NZ over two decades (from Dewes 2014)

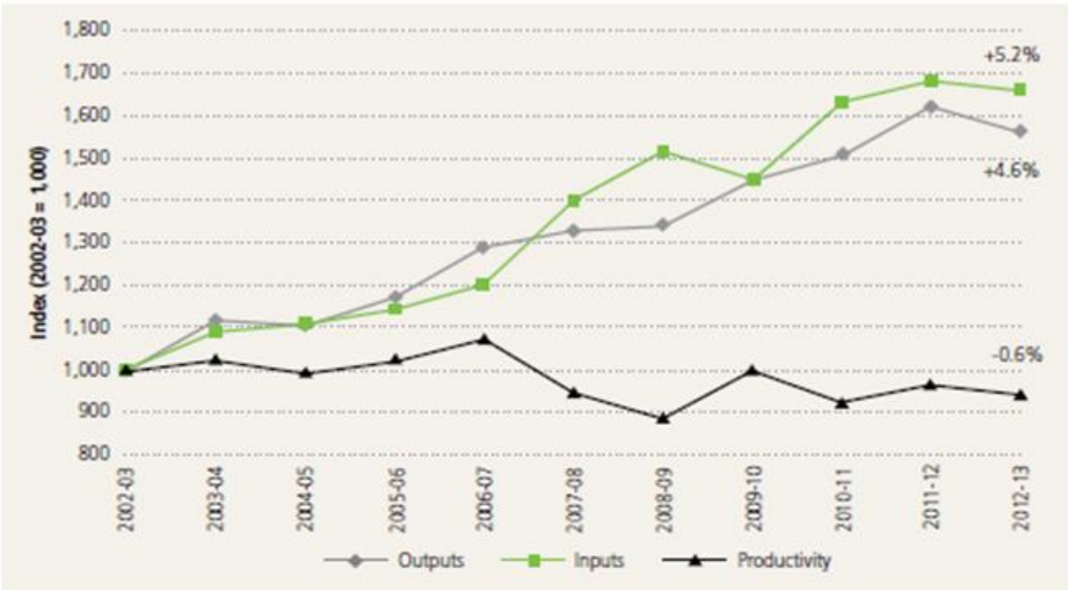
	1998-99	2008-2009	2012- 13	% change
Dairy herds	14400	11400	11798	-18%
No. cows milked	3.3m	4.2m	5.01m	+35%
Average herd size	229	364	393	+42%
Average stocking rate in cows per hectare.	2.5	2.8	2.3-3.3	
Total milksolids (MS) per herd	70000	120000	141125	100%
Tonnes of PKE + other feed imports to NZ	0	1,300,000T	1,889,000T	
PKE kg fed per cow on average	0		407 kg	
MS derived from PKE + other	0		170 m	
Value of milk derived from PKE/other	0		$1190 M	
National production (million litres)	880m	1393m	1665m	95%
Land price $/kg MS	18.4	50.8	$40.46	126%
Farm working expenses per kg MS	2.13	3.85	4.08	190%
Liabilities/kg MS	8.03	19.87	19.24	145%

	1998-99	2008-2009	2012- 13	% change
Debt servicing/gross farm revenue (%)	14.9	28.3	18.1	30%

67. Over the time that the dairy industry has intensified, output from the sector has increased while net productivity and profitability have both declined (Table 1 and Figure 2).

68. Over the same time, debt in the dairy sector rose by over 250%. Inputs increased in excess of the outputs, and productivity declined (Figure 2).

Figure 2: Extracted from Dairy NZ. (2011-2012). Dairy NZ Economic Survey 2012-13. Dairy NZ. Accessed June 2014[3]

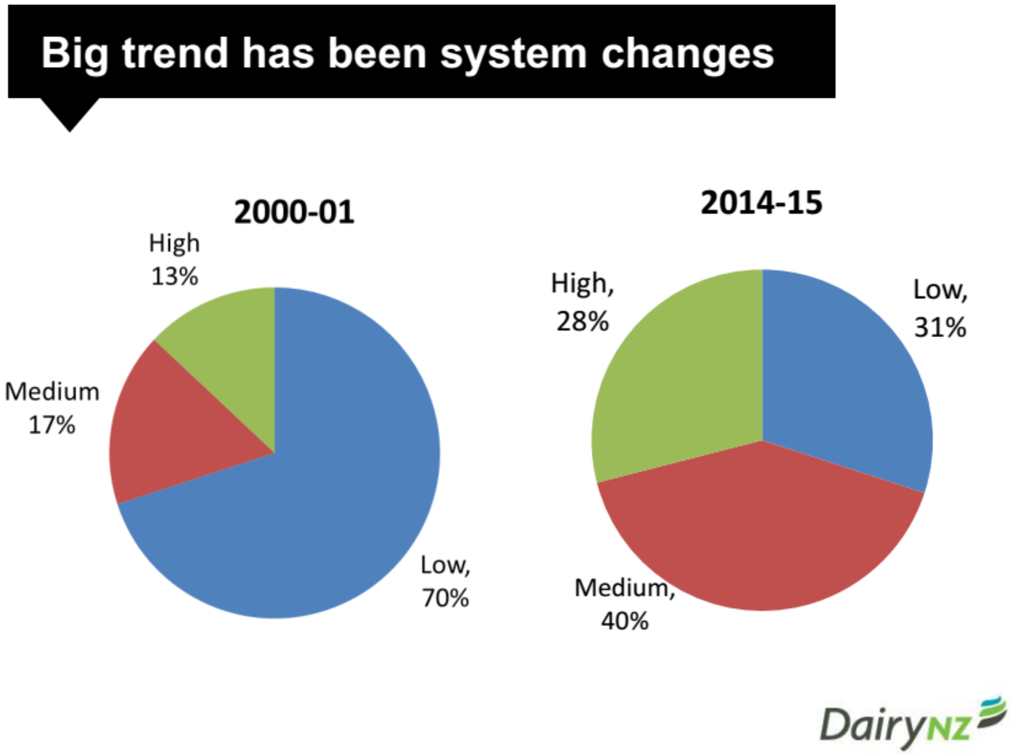


69. The footprint of dairy has been compounded by **intensification** over the past 15 years. This has compounded the risk profile of businesses as in Figure 3[4].

[3] http://www.dairynz.co.nz/publications/dairy-industry/dairynz-economic-survey-2012-13

[4] Source: Dairy NZ Economics Group: presentation of T Mackle to Strategy and Policy Committee 14 June 2016. Source Tim Mackle – presentation to CSG

Figure 3: Intensification of Dairy via System Change since 2000.



Source: DairyNZ Economics Group

70. As can be seen in Figure 3, low intensity farm systems have more than halved in number, while high intensity farm systems have more than doubled in 15 years.

CONTAMINANTS OF CONCERN

71. It is well recognised that pastoral agriculture, dairy farming, and intensive beef and arable farming, are key contributors to water quality decline in New Zealand due to the externalities associated with these activities (Allan 2004, Davies – Colley et al. 2004, Matthaei et al. 2006, Townsend et al. 2008).

72. The externalities of concern from pasture-based agriculture are:

(a) Effluent/pathogen runoff from and through the land, which contributes to the contamination of waterbodies (both surface and ground), and decline of both recreational and drinking water sources.

(b) erosion and soil loss from the land leading to increased sediment loads to surface waterbodies with the associated temporal and spatial legacy of both phosphorus and pathogens adsorbed on sediment.

(c) loss of aquatic ecosystems, though loss of wetland habitats and riparian vegetation;

(d) erosion of stream banks, leading to streambank instability;

(e) phosphate loss (effluent run off, soil loss and connectivity points);

(f) nitrate loss through the land and via run off (i.e. affecting both surface and ground water quality); and

(g) Abstraction of water for irrigation, dairy shed wash down, and stock drinking water also have adverse environmental effects.

73. These impacts are discussed further in the expert evidence of Dr Chrystal, Dr Mueller, Dr Dada, and Mr Parkes in their evidence in chief to HS1.

74. Externalities contribute to declining aquatic ecosystem health (water quality and habitat) and issues of public health. Coliforms, campylobacter, cyanobacteria, STEC, leptospirosis and salmonella are among the harmful zoonotic pathogens (Jaros et al. 2013, Mc Bride, 2011, Larned, 2004).

75. Pathogens can reach waterways via overland flow, from over-irrigation of saturated soils with effluent, via runoff in storm events from highly stocked, pugged or cropped paddocks, from connectivity via tracks, unsealed ponds, and yards.

76. We now understand more about pathogen transport across landscapes than previously. There is an increasing risk with intensification, high animal densities especially on leaky or vulnerable (peat) soils, failure to protect critical source areas, monocultures, high rainfall and heavily drained landscapes.

77. New Zealand's Ministry of Health (Health 2017, Mc Bride et al. 2002) states river water contains a "substantial level of faecal contamination…at recreational and water supply abstraction sites". Human health risks related to pathogens associated with faecal contamination are increased by participating in recreational swimming (Mc Bride et al. 2002, Gluckman P 2017); and gathering aquatic sourced food (Perkins et al 2016, Rose 2001). With over 100 known pathogens including Leptospira, Clostridium,

Mycobacterium, and Salmonella generally are able to survive in aquatic environments (Rose 2001, Anderson et al. 2005, Byappanahalli 2011) and treaty protection for mahinga kai (W.Tribunal 2010), streamlining monitoring processes and implementing countermeasures may reduce health risks.

78. Outbreaks of livestock related waterborne diseases tripled during the 2004-13 period in New Zealand (Health 2017). The highly publicised campylobacteriosis outbreak, which affected almost 5,500 Havelock North residents in August 2016 (Water; Havelock 2017), is a pathogen commonly associated with livestock (McLeod 2013).

79. On this basis, I confirm that I have read and agree with the evidence of Dr Chris Dada for Hearing Stream 1.

N LEACH PROFILE OF DAIRY VS SHEEP AND BEEF VS DAIRY IN HEALTHY RIVERS WAI ORA PROCESS (HRWO)

80. The advisory report relied on by WRC when drafting PC1 and Variation 1 (The Overview of the Historical N leach for the Waikato and Waipa Region (2015)) was developed on the basis of assumptions made from a range of studies while omitting some studies and inserting new ones.

Figure 4: abstracted from the report HR/TLG 2015-2016/1.4

Year	Total nitrogen loss (kt/y)	Nitrogen loss by land use type (kt/y)				
		Dairy	Intensive Sheep and Beef	Hill Sheep and Beef	Pasture Total	Non-Pasture
1972	9.24	3.95	1.64	1.90	7.49	1.75
1982	10.65	4.83	1.93	1.88	8.64	2.01
1992	12.00	5.64	2.24	1.86	9.74	2.27
1996	12.53	5.95	2.37	1.84	10.16	2.37
2002	13.51	7.74	2.27	1.52	11.52	1.99
2008	14.87	8.28	2.39	1.78	12.44	2.43
2012	15.35	9.62	2.93	1.09	13.64	1.71

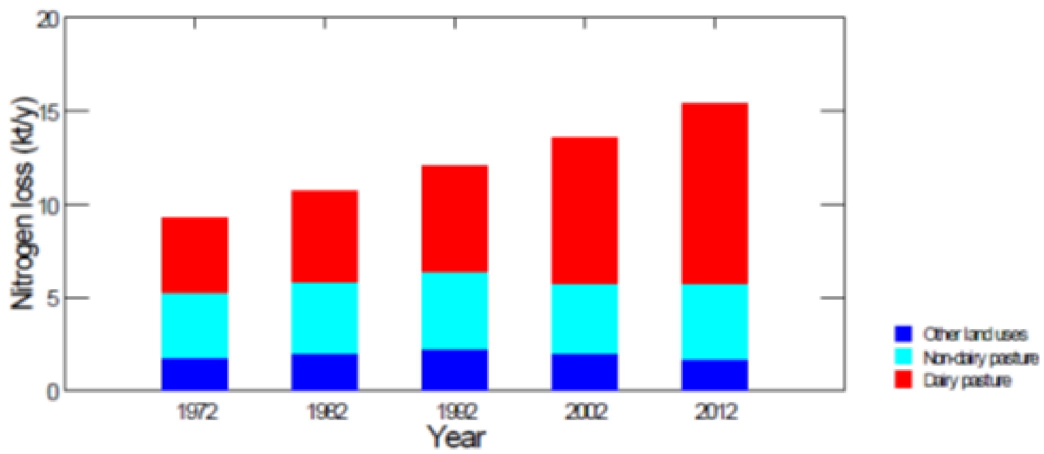


Figure 5: from N leach Report: HR/TLG 2015-2016/1.4

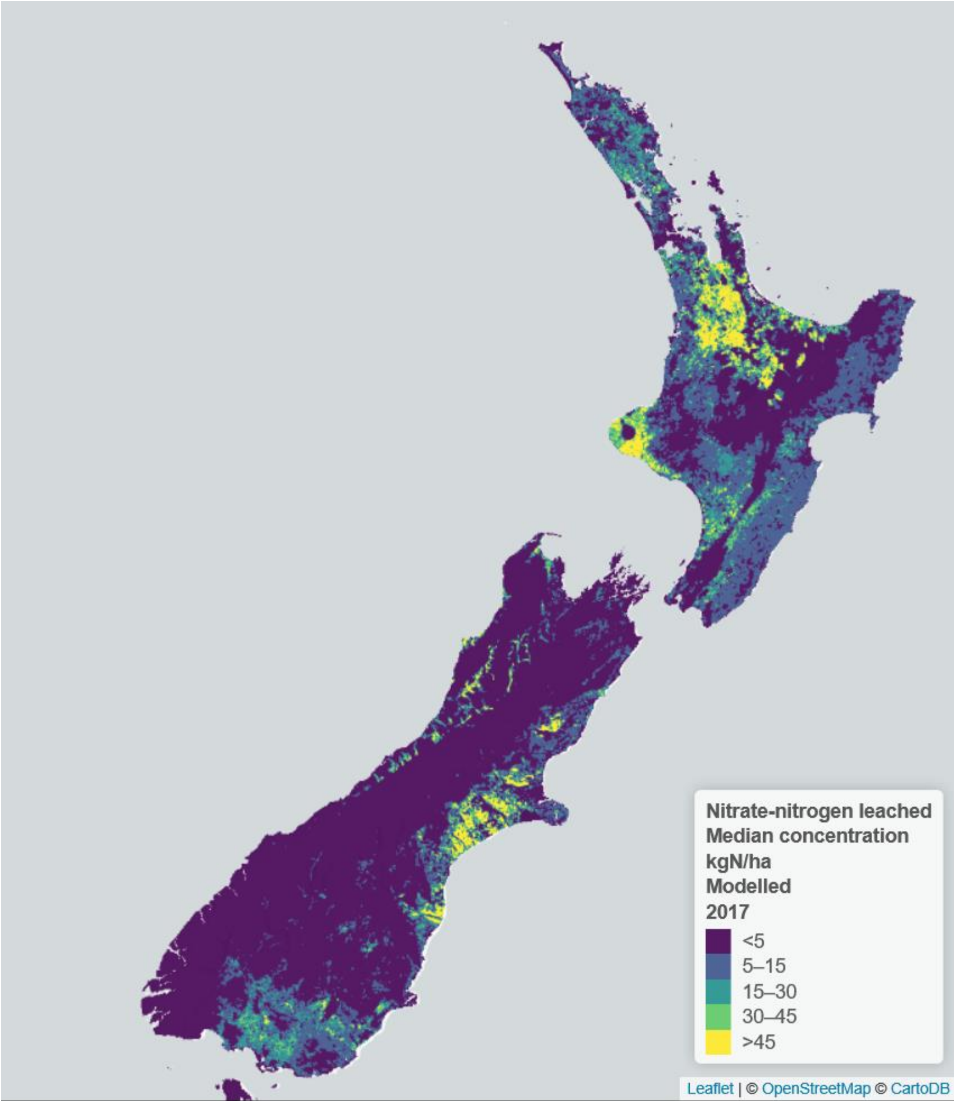
Year	Dairy yield		Sheep and Beef yield	
	Estimated (kg/ha/y)	Proportion of 2012 yield	Estimated (kg/ha/y)	Proportion of 2012 yield
2012	30.6	1	10.8	1
2008	29	0.948	10.6	0.983
2002	26.6	0.871	10.4	0.958
1996	24.3	0.794	10.1	0.933
1992	22.7	0.742	9.9	0.916
1982	18.8	0.613	9.5	0.875
1972	14.8	0.484	9	0.833

81. The use of OVERSEER for both reporting on the catchment loads, and modelling undertaken by NIWA for allocation purposes, essentially relied on “averaged farm data” from outdated models that are not reflective of current knowledge, science and scenarios.

82. The Overview of the Historical N leach for the Waikato and Waipa Region (2015) was completed after OVERSEER version 6.0 was released, yet many of the datasets did not use data from that version. Furthermore, there had been a range of sustainable milk plans done by a range of consultants, co-funded and supported by WRA, WRC and DNZ, across the Upper Waikato and Upper Waipa that could have provided more up to date data.

83. Therefore, most up to date data has not been used, this has resulted in an underestimated footprint from Dairy in the Waikato and Waipa catchments. Originally 26 kg N per ha per year, is in the more realistic range of 45-55 kg N per ha per year). By using 5.4.6, the N leach from dairy is likely to be half of what more recent versions would indicate.

Figure 6: Current N leach from Dairy across NZ – Stats NZ website(https://statisticsnz.shinyapps.io/nitrate_leached/) 17/4/2019.



84. Of nitrate leached from livestock, 65% was from dairy, and 15% from sheep. Much of the Waikato appears to be >45 kg N leach, which is also what my datasets reflect.

85. Table 2 below is a combination of the tables of N loss from the Review of historical land use and N leach: Waikato and Waipa Catchments. (Report:HR/TLG 2015-2016/1.4). This table was constructed from numbers in Table 4.14 and Table 4.15 in the Report.

86. I have included the most recent period of 2012-2016 (which appears to have been omitted in all calculations), which includes an estimate of losses from a further 20,000 ha of dairy conversions in the Upper Catchments that has not been included in the reports prepared for WRC.

87. The summation that all dairy intensification ended in 2012 is not reflective of our current situation, and underestimates the intensification of dairy farming that has occurred since 2012. Mr Andrew Burtt presented land use change data for the Waikato in his evidence in chief for HS1, and Dr Cox presents updated land use in his evidence in chief for HS2, which I support

88. It shows that since between 2006 and 2018: The area in dairy increased by 26%. Most of this increase appears to have come from the decline in areas of forestry and drystock. The number of dairy farms and sheep & beef farms decreased by 30% each, the number of deer farms by 50% and the number of grazing properties by 34%. The later could represent acquisition by intensive farming operations including dairy. Total dairy stock units increased 15% from 6.36M to 7.32M while dry-stock stock units were unchanged at 2.78M. (evidence of A Burtt: HS1 paras 16 – 20 and 36 to 46 and figure 13.

89. Between 2006 and 2018, dairy farms increased total farm area by 88,000 hectares (26%). This area represents 8% of the PC1 catchment and was supplied by a 2% decline in dry-stock area and 5% decline in other areas (largely forestry). The area in dairy increased by 26%. Most of this increase appears to have come from the decline in areas of forestry and dry-stock:

- The number of dairy farms and sheep & beef farms decreased by 30% each, the number of deer farms by 50% and the number of grazing properties by 34%. The later could represent acquisition by intensive farming operations including dairy;

- Total dairy stock units increased 15% from 6.36M to 7.32M while dry-stock2 stock units were unchanged at 2.78M.

Table 2: Combination of N loss tables from HR/TLG 2015-16/1.4

LOAD FROM DAIRY AND DRYSTOCK – Relative N loads OVP version 5.4.6								
Net Period	Year	Dairy Load per Ha kg N/ha/yr	Dairy total loss load.kTN/Yr	Dairy % share of total load	Drystock load ha kg N per ha per year.	Drystock Total Load kTN/Yr	Total Load Dairy DryStock Pastoral Load kT/Yr	Drystock Share of total Load %
4	2016(est)	30	10.48	**72.2**	10.8	4.02	14.5	**27.3**
4	2012	30	9.62	70.5	10.8	4.02	13.64	29.5
6	2008	29	8.28	66.5	10.6	4.17	12.45	33.5
6	2002	26.6	7.74	67.6	10.4	3.71	11.45	32.4
4	1996	24.3	5.95	58.6	10.1	4.21	10.16	41.4
10	1992	22.7	5.64	57.9	9.9	4.1	9.74	42.1
10	1982	18.8	4.83	55.9	9.5	3.81	8.64	44.1
	1972	14.8	3.95	52.7	9	3.54	7.49	47.3

90. This table above quantifies the intensification of dairy and enlargement of the Waikato and Waipā footprint, when measured by N loss total, using an outdated version (5.4.6) of OVERSEER up to 2012, compared with sheep and beef sector over the past 5 decades.

91. Dairy has increased N leach per ha of 100% over this period, while the sheep and been sector only increased their N leach per ha by 20%. This is covered in the evidence of Dr Chrystal.

92. Dr Chrystal has reached the same conclusion in her evidence based on the data she obtained from the sample farms she studied. Her findings are consistent, which gives me further confidence that these data sets are correct.

93. The share of total N load attributed to drystock over the same period reduced from 47.3% in 1972, to only 29% of the total catchment load in

2012. Based on these data in my opinion dairy has substituted sheep, drystock and forestry.

94. The share of the N load attributed to dairy in the Waikato and Waipā catchments has increased from being 52% of the total N load in 1972, to 70.5% of the total load in 2012. However, this is still likely to be understated, due to intensification of dairy farming in high milk price years of 2014-15.

95. Nonetheless, if we take into account the most recent conversions since 2012, the dairy load increases to around 72.2% share of total load, with drystock dropping to 27%.

96. Furthermore, the pine to pasture conversions since 2012 were not counted in this report. There has been approximately 20,000 ha of conversions since 2012, this would amount to a further approximately 880,000 kg N leaving the upper Waikato root zone.

Table 3: Approximated Externalities resulting from Conversion of Pine to Pasture (Dewes 2015)

Carbon to air	6480 T
N from root zone	880 T
P overland flow	1.5T
Pathogens (diffuse losses)	Equivalent to the population of Christchurch + Wellington living in Broadlands

97. While the dairy industry has contributed around $1 billion to the regional economy over the period of 1992-2016, the cost of pollution and effects of intensification have not been accounted for in the figures.

98. In my opinion regional economies have focussed on GDP growth, while failing to count the cost of polluting (water and air) emissions. GDP as a metric fails to account for the pollution, the cost of clean-up and the loss of environmental integrity.

99. Similarly, the tonnage of N that has left the farms, as a result of dairy growth, in the past 40 years, if we include the most recent conversions, is 6.53 Kilotonnes of N assumed to be leaving the root zone. If we assume 50% is attenuated by environmental processes, this means an additional 3.26 Kilotonnes of N is likely to have reached receiving water bodies. Applying a buyout rate of $300 per kg N that reaches water (as in Rotorua) it amounts to an externality cost to the public of $979 million in the Waikato region alone.

100. This assumes that the BMP assumed by OVERSEER is being achieved which includes compliance with BMP for effluent management. However, Waikato Regional Council indicated in August 2017, that only 2% of all regional dairy farms achieved 100% compliance to a high level (i.e proof that there are no contaminant pathways to groundwater in storage or on application).

101. From figures released under the Official Information Act to me, the Council inspected 1174 farms, nearly twice the number inspected the previous season. Of those farms, 23 per cent achieved full compliance, 2 per cent had a high level of compliance, 43 per cent were provisionally compliant, 24 per cent were partially compliant and 9 per cent were significantly non-compliant.

102. Assuming around approximately 1800 dairy farms in the Waikato Regional Command area. If 2% are compliant, and 98% are not, then it is not inconceivable that there could be anywhere from $50,000 per farm to $500,000 per farm to get to full compliance in terms of effluent management systems. Assuming an average of $150,000 per farm. As such, there could be around $360 million cost on getting effluent systems to meet what is already assumed as BMP by OVERSEER.

103. The third significant difference between OVERSEER version 5.4 and 6.0 is the cropping model. Again, cropping is a practice that is common on dairy farms that has increased the N leach rate quite significantly over time on a dairy platform, as compared to the effect of this on a whole sheep and beef enterprise. By using the 5.4 model for reporting and modelling purposes in 2015-16, the use of N leach data is understating the effects of the dairy footprint which was then extrapolated in the study to give an overall under

estimate of dairy contribution. (Review of historical land use and N leach: Waikato and Waipa Catchments. HR/TLG 2015-2016/1.4).

104. Mitigations that were used to work out how a farm could reduce N loss, were done again in a further study called Improving water quality in Waikato-Waipa Catchment: Options for dry stock and dairy support farms: by Olubode – Awosola (Olubode et al 2014). This relied on a suite of average farms. These did not represent one farm in the B+LNZ example farms: as has been explained by Dr Chrystal.

105. It is unclear what the biophysical data used in that study was, which is so important. The mitigations tried a range of things, apart from the changing of the male to female ratio on the farm. This would have been a priority to consider for a drystock farmer because it would not have dairy grazers or dairy replacements on the farm.

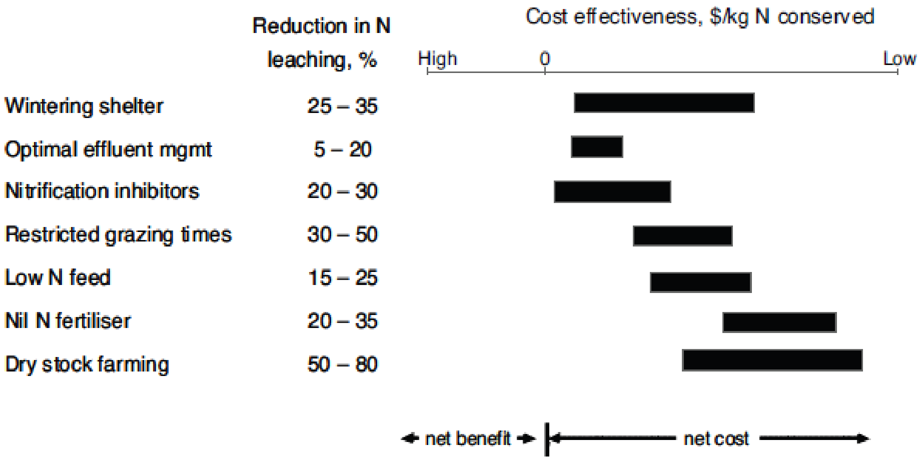
106. The mitigations utilised to test reductions by Olubode-Awosola (Olubode et al, 2014) from sheep and beef farms were: reducing stocking rate on farms characterised by high stocking rate; planting steep slopes on farms characterised with some steep slope areas as part of their effective areas; substituting maize silage cropping with pasture silage for dairy support; increasing sheep to cattle ratio on farms characterised by low sheep to cattle ratio; and substituting older/heavier cattle with younger/lighter cattle on farms characterised by older/heavier cattle.

107. Despite it being assumed that most (80%) of cattle on farm were female, (dairy grazers, breeders etc) the obvious mitigation of changing from female to male stock as an option to reduce leaching as a mitigation was not done. In my opinion this meant that a significant mitigation tool for N losses was not considered by PC1.

108. Furthermore, some studies have shown that the most effective approach for reducing N leach from dairy systems is to change to a drystock system. One could define this as an adaptive management approach as markets and operating landscapes change.

109. The work done by Quinn et al (Quinn et al, 2009) in the figure 7 below illustrates this and supports modelling that I have undertaken in the past 2 years.

Figure 7: Options for reducing N leach by changing farm system from dairy to sheep and beef.



LACK OF CERTAINTY LEADS TO PEVERSE OUTCOMES

110. In my opinion the poor water quality in the Waikato River, its tributaries and within the wider catchment is a result of a plan that did not adequately control discharges. This example, along with other regions, such as Canterbury and Selwyn, provide us with an example of how permissive regimes can result in poor and declining water quality within a few decades and the social and economic costs are borne by a community and future generations as a result of poor policy design and lag phases for change.

111. At a national level we do not have a good track record: The 2017 OECD report, notes that the nitrogen balance had deteriorated more than in any other OECD member country between the years 1998 and 2009. Over 1990 and 2012, nitrogen leaching into soil from agriculture increased by 29% and total N levels in rivers by 12%. Contamination of groundwater with nitrates and microbial pathogens is recognised as a human health risk and NZ has one of the higher rates of largely preventable enteric and gastro enteric diseases when compared with UK, Canada and Australia. (OECD 2017).

112. In the Waikato there has been a significant and rapid increase of irrigated agriculture in vulnerable landscapes. I characterise “vulnerable landscapes” as those for which considerable inputs are required (e.g. fertiliser, water, soil conservation) for them to be used for intensive pastoral farming. Worsening environmental trends are evident, yet appropriate policy that will suitably protect the receiving water bodies and drinking water sources from continued decline are still being developed and implemented.

113. This serious policy lag is compounded by overarching Government proposals to irrigate and intensify hundreds of thousands of hectares in vulnerable areas in the South Island and upper Waikato, as part of the business growth agenda which had an objective of increasing exports as a percentage of gross domestic product from 30% to 40%, which was developed by MPI. The goal was to double primary industry exports in real terms from $32 billion in June 2012 to $64 billion by 2025. (MPI website 2017).

114. The ’hangover’ that WRC is now experiencing, requiring it to propose a clawback of resources over a proposed 80 years, to give effect to the Vision and Strategy, is a result of the thinking of the years 1990-2010 where stocking rate, output (MS) and capital gains defined economic gains for dairy. In my opinion these ‘ill perceived’ gains were sought, in place of true cash returns inside what should have been a policy framework where externalities were capped and reduced.

115. To achieve the “perceived gain” in 2015 under a growth agenda Government, New Zealand's primary industries were intended to grow at a rate of 5.5% a year through to 2025 via increased irrigation, more output, and intensification of the (apparently) underutilised Maori Owned Land (PWC 2014).

116. In Selwyn, the Central Plains Water Irrigation Consent was granted in 2013 for an additional 30,000 ha of irrigation. This consent was granted with knowledge that it would contribute to a significant increase in total

catchment N load, and despite clear evidence of declining water quality in 2011[5].

117. The Canterbury example has been repeated in Waikato where continued conversion of land from forestry to pasture and dry stock to dairy has continued almost unabated in the upper Waikato on more than 40,000 ha since the early 2000s.

118. Waikato also had no restraint on land use change, and conversions from forestry to dairy in more than 50,000 ha occurred over the past two decades adding in excess of 2000T N to the Upper Waikato load of N.

119. As a result: all farmers and communities will face a higher level of clawback than if this had not happened. Meaning there is likely to be severe social and economic consequences for family farms as well as other sectors outside dairy.

120. For Selwyn, the compounding effects of poor policy design, lag phases and continued intensification mean that the cost to the Selwyn community ($300 million) of achieving the NPS-FWM requirements for Lake Ellesmere would result in significant adverse social and economic consequences. The N load would need to be reduced by 76% from current, the P load by 50%, and there to be a reduction of 84% for chlorophyll a. (Harris & Davie 2017).

121. Some sectors have therefore sought extended timeframes, because without long phase-in periods the heavy indebtedness of some industries makes a fast response economically unviable. In other words, these businesses cannot cover the costs of the environmental externalities which have been created through unsustainable intensification of their farming businesses, now cumulatively breaching environmental limits.

122. The decline of the Selwyn Catchment parallels the Waikato Region, and is an applied NZ example of the cumulative effects of failure to implement sound monitoring, failure to ascertain over-allocation, failure to apply the

[5] Over the past 10 years, nitrate nitrogen concentrations have been increasing in about 29% of those wells we sampled. The Selwyn Waihora, Ashburton and Orari Opihi Pareora zones have the highest proportion of wells with increasing nitrate nitrogen levels." (ECAN 2011)

precautionary principle, failure to mitigate adverse effects and failure to protect life supporting capacity for future generations.

123. A report by Mr Vant for WRC (Vant, 2006) (Appendix 1) over a decade ago in anticipation of Upper Waikato Conversions (in 2004-6) showed that if dairy conversion (20,000 - 40,000ha) was to continue in the upper catchment, then there would be increased frequency of algal blooms in the hydro lakes and loss of water and recreational amenity in places like Lake Karapiro.

124. Since 2002 there has been intensification of a greater area of pastoral land within the catchment with conversion of commercial forestry land into pastoral farms (over 35,000 ha by 2013, (pers comm W.N. Vant, Waikato Regional Council)).

125. A land area of 29,044 ha of land was converted from pine to pasture between 2002 and 2008 in the upper Waikato catchment, (Hill, 2011). By 2016, the total hectares converted had increased again, by around 20,000 ha.

126. This transition from pine to pasture alone, is likely to result in a 5-10 fold increase in diffuse nitrogen loss per hectare and a 5 to 10 fold increase in phosphorus loss (OVERSEER version 6.1) (PCE 2013).

127. The calculation above does not take into account the irrigated dairy across the Upper Waikato, which typically has a leaching profile of 60-110 kg N per ha per year loss.

128. Nearly all of this N is attibutable to dairy growth under a permissive, and lagging policy regime, and where the implications in relation to degradation in water quality was indicated (Appendix 1):

Conclusion (Vant): "I therefore conclude that planned increases in the scale and intensity of land use in the catchment of the Waikato River hydrolakes during the next 25 years will adversely affect the water quality of the hydrolakes, ***and are likely to result in breaches of RMA section 70 unless substantial changes are made to the management of the nutrient loads from these land uses,*** *in particular to the loads from dairying" Bill Vant – report to Environment Committee, 2005 (Appendix 3*).

129. Despite the awareness of this situation the Technical Leaders Group for WRC has elected to use a Nitrogen output number for all the NIWA and TLG catchment modelling of 26 kg N per ha (OVERSEER version 5.4) when true figure is more like 45-55 kg N loss per ha per year, and the full catchment dairy allocation of N stops in 2012, while conversions and additional loads to the Upper Waikato continued.

130. The resulting increase in nutrient loads of thousands of tonnes of nitrogen and 120 T phosphorus per year, in addition to increased sediment loads, contributes to reduce water clarity and increased coliform loads. (Woods 2010, Dewes, 2013).

131. The following Table 4 has been collated from my experience of reviewing over 400 OVERSEER files and businesses for performance of profitability, pasture harvested, stocking rate and N leach alongside overall business analysis, across NZ. This is intended to provide a profile of what is achievable under dairy systems which are relatively low input, and which have been optimised. It represents my experience over the last decade, and includes my expert opinion of what a suitable stocking rate based on a relevant pasture harvest is when it is not reliant on anthropogenic nitrogen, winter cropping, grazing off and supplementary feeds.

132. This is also based on my experience as a sharemilker/farmer in the Waikato, and my practical and analytical experience as a dairy veterinarian for 20 years which included farm system analysis in the regions of Te Aroha, Morrinsville, Otorohanga, Reporoa, Hamilton, Te Awamutu, and South Waikato (Mamaku Ranges)

133. The best farmers (high performers) I have dealt with are those with a high degree of management skill for animal health and wellbeing, they focus on

staff tenure and engagement. These farmers also tend to have a natural sensitivity for the vulnerable landscapes they reside within.

134. The best farmers in my experience are the farmers that farm to the limits of their land, they are not forced (due to debt or other pressures) to push their marginal landscapes into marginal land use systems, (that inherently rely on high inputs that result in high spill over effects on receiving water bodies).

135. In my opinion, due to indebtedness in the dairy sector (as noted in point 163.) there has been an unintended consequence and the resultant behaviour to push landscapes beyond their natural capability. This in my opinion, is due to a range of factors, permissive lending regimes, and permissive resource allocation (noted in points 120-131).

Table 4: Recommended stocking rate and N leach (v 6.3.1) based on natural carrying capacity of the land assessed from over 400 farms (my expert opinion, 2019).

FMU		**LUC Class**							
		I	II	III	IV	V	VI	VII	VIII
Upper Waikato River • Free draining pumice • 900- 1000 mm rainfall • 5 year average	Pasture eaten per ha	12	12	11	9	7	6	4	0
	KgN leached/ha dryland	40	40	38	35	30	19	10	4
	su/ha	21	21	18	16	14	12	8	
	SR Cows/Ha(7 SU/Ha)	3	3	2.6	2.2	2	1.7	-	
Middle Waikato River • Ash/Volcanic • Freer draining • 1100-1500 mm rainfall	Pasture eaten per ha	12	12	11	9	7	6	4	0
	kgN/ha	48	48	48	38	32	20	12	
	su/ha	21	21	18	17	14	11	7	
	SR – Cows/ha	3	3	2.6	2.2	2	1.6	-	
Waipa River • Heavier soil • Higher Rainfall	Pasture Eaten/ha	11	10	9	8.5	8	6	4	0
	kgN/ha	49	49	46	46	35	20	15	
	su/ha	18	18	16	16	14	11	7	
	Cows/Ha	2.5	2.5	2.2	2.2	2	1.6	-	
Assumptions – SU is 65 kg, Cow is 460 kg, All natural potential of "pasture eaten" in T DM per Ha is based on: Full year on farm, no grazing off, no imported supplement, no winter crop, no anthropogenic N fertiliser.									
Lower Waikato River • Ash, Clay, peat, sedimentary • 1000-1600 mm rainfall	Pasture harvested per ha	10	10	10	9	8	6	4	
	kgN/ha	35	35	29	28	25	22	12	
	su/ha	18	18	17	16	14	12	8	
	Cows/ha	2.5	2.5	2.2	2,2	2	1.7	-	

136. My independently derived stocking rates support the top farmer stocking rates in the LUC extended legend for the Waikato Region as presented in the evidence in chief of Dr MacKay, and the proportionality between LUC classes and relative stocking rates.

DAIRY CAN REDUCE N EMISSIONS

137. The drystock sector has been working on eco-efficiencies for over two decades now as described by Dr Jane Chrystal and Andrew Burt in their Hearing Stream 1 evidence.

138. Dairy can also reduce its footprint, but to date, there has been a lower compulsion to do so under regional plans that have utilised grandparenting regimes for allocation.

139. Numerous studies have been conducted to demonstrate that dairy has significantly more ability to reduce its ecological footprint than drystock. In my experience farms can reduce leaching by 10 to 40%, or in some cases more, with some farm system modifications and time to adapt. The degree of reduction is dependent on their level of intensity with higher configured systems having more ability to reduce emissions.

140. Smeaton and Ledgard have provided evidence that reductions of between 10–15% can be achieved without any significant impact on farm profitability. Smeaton (evidence 42a Horizons 2009) also notes that, in his experience in Rotorua (dryland dairy farming), farmers were able to reduce nitrogen leaching by 5-25% which had a minor negative to slightly positive effect on profit. He also noted that case studies demonstrated that it would be possible to reduce nitrogen leaching to the catchment by 12% without having a negative effect on profit.

141. A study conducted in 2009 (Agfirst Waikato, 2009) investigated the impact of change on profitability as a result of gradual nutrient loss requirements being placed on dairy businesses in the Upper Waikato. The net impact on return on total capital (ROC) of having to meet 40% lower levels of nutrient loss was in the range of 4-8% provided the businesses could optimise their performance. However, the impact of a $1.00 reduction in milk solids payout resulted in a 100% reduction in return on capital for the businesses in the

study. A similar study conducted by Dairy NZ in the Horizons region[6] (2013) confirmed similar findings.

142. A study conducted by Stuart Ford on behalf of Irrigation NZ in the Selwyn Waihora catchment (Ford, 2014), investigated options for N loss. His work demonstrated there were options for irrigated dairy to reduce its N leach footprint by up to 50% and more, at a cost. The priority options chosen to reduce N loss were the following, in order of preference:

(a) DCD use in Autumn (not applicable but ↓N loss by 14%).

(b) Reduce Autumn N use (↓19%).

(c) Improve Cow Efficiency (to 95% of Bwt as MS) (↓7%).

(d) Active Water Management (This is achieved by setting the irrigation settings to this option in OVERSEER. This then calculates the amount of water applied if the irrigation system is responsive to what the plant needs. In this model/study annual water applied was reduced from 575 mm to 380 mm a saving of 195 mm) (↓38%).

(e) On – Off Autumn Grazing (↓15%).

(f) Wintering shelter and housed at home (↑2%).

(g) Top BMP of "pastoral only farms" (adopting a best practice): A system of no supplementation of the farm, and farm operating at performance levels (grass and milksolids production)[7] in the top 5% of farms using the latest technology in irrigation application but using relatively high rates of N application) (↓38%)

143. An on-farm trial considering lower stocking rates with higher per cow production is occurring at Scott Farm in Hamilton. Results are confirming a

[6] Bell, B., Brook, B., Fairgray, D., McDonald, G., & Smith, N. (2013). Section 32 Analysis of Horizons One Plan Cost Benefit and Economic Impact Analysis: A report prepared for DairyNZ

[7]

leaching reduction of 40-50% when compared with a conventional farm system. A summary of the results are shown in Table 5 (Clark, 2012).

144. The Scott Farm trial aims to lower the nutrient footprint from the (dryland pastoral) system while retaining similar profitability. To do this the farm system has dropped stocking rate and associated costs with running more cows at lower productivity, and lifted the feed consumed per cow per annum to close to 5 T DM of home-grown feed eaten per cow. These higher genetic merit cows have largely converted this to milk solids resulting in a lower cost system with similar milk solid outputs, and a significant reduction in nitrogen leached (approximately 50% lower) when compared with the Waikato average.

Table 5: Lower Footprint Farm Systems Study: Presented by Dave Clark, Principal Scientist, to Intelact Consultancy Conference Nov 2012 & updated by Chris Glassey in March 2013 (Scott Farm - Waikato)

	CURRENT	**EFFICIENT**
Pasture Harvested	15.6	14.4
Stocking Rate	3.2	2.6
MS per Ha	1202	1207
Operating Profit/Ha	$3109	$3004
Nitrogen	50	22 (50% DROP)
Leached/Ha		

145. Furthermore, the Lincoln University Dairy Farm also developed an “efficient farm model” denoted as “Low Stocked Efficient”. This farm system trial is aiming to assess whether leaching can be reduced significantly through a range of mitigations within the farm system.

146. Recent media on the Lincoln University Dairy Farm is close to achieving a 30 per cent reduction in nitrate leaching, through stocking rate reduction, more milk per cow, less nitrogen use - while maintaining its profitability.

“*What we want to do is maximise sustainable profit - so do most people - but we want to do that within what we used to call our historical environmental* *footprint and now is more appropriately thought of in terms of within future environmental regulations*," Pellow says [8]

147. Despite the clear conclusions that have emerged from these studies, the debt and vulnerability of the dairy sector may hamper rapid response times to environmental compliance by the industry, in the absence of regulatory imperative.

148. New Zealand's dairy sector debt nearly tripled over the past decade, to $30.5 billion in 2012, (Ministry for Primary Industries, 2013) to around $40 billion debt in 2017. This equates to around $22 debt per kg MS, or a cost of around $1 per kg MS in debt servicing[9]. (RBNZ 2018), (pers comm Peter Fraser Economist May 2019)

149. Extended and more frequent periods of dry weather in some regions increases the vulnerability of dairy farmers through lower milk revenues and higher feed costs (Kalaugher et al, 2013). It was estimated that 40% of North Island dairy farmers could not meet their expenses and debt obligations as a result of the 2012-13 drought (Ministry for Primary Industries, 2013).

150. Extensive debt, declining productivity and converted dairy systems on vulnerable country, are not a reason not to internalise externalities, but rather should be the impetus for reducing overall business risk by a redesign of systems. Referring to my point 119, where Quinn et al (2009) showed that it may be more profitable to change production systems, in order to also have a "win win" of achieving lower N losses, - the best mitigation may be to convert to a drystock system. While I understand there may be stranded capital in this case, in cases where large N reductions are required, and an unprofitable system is in existence, it may be the most sensible pathway to take.

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[8] https://www.stuff.co.nz/business/farming/97071476/demonstration-dairy-farm-cuts-nitrate-leaching-30-per-cent-and-stays-profitable

[9] (RBNZ 2018), (pers comm Peter Fraser Economist May 2019)

151. In modelling that I have undertaken in the past two years, it is possible to have wins of significantly lower N leach, similar or better EBIT, have zero bobby calves, by moving to a hybrid dairy – beef system.

152. A "hybrid dairy system" is along the lines of: "half the dairy herd, having fewer better fed cows on the better land and retire the more marginal land to beef production (offspring from the dairy herd)". In the modelling undertaken in the past 18 months: demonstrates a significant reduction in N leach while still retaining profitability, and increasing resilience (modelling study able to be provided upon request).

153. It is evident that farm systems reconfiguration will be required in order to meet desired environmental outcomes. Dairy NZ work has demonstrated that an 18-40% reduction in N loss is possible through farm system change without adversely affecting profitability in some cases. (Beukes et al, 2012; Clark 2012, Dairy NZ 2013). This may involve lower bodyweight (stocking rates) carried per hectare, (Beukes et al 2012) reducing replacement rates combined with high genetic- merit cows on well balanced diets, enhanced feed conversion efficiency and improved effluent capture with widespread low risk application to pasture (>40% of farm area), reducing the need for soluble fertiliser use.

154. The approach taken by PC1 is to use a grandparenting approach to allocate nitrogen losses. The plan does not establish an allocation framework which will achieve the limits or targets. The proposed plan does not provide assistance to the Council in determining how individual discharge proposals will influence the achievement of the Freshwater Objectives (and limits/targets) when accounting for all other discharges in a catchment. Nor does it provide a framework which incentivises the changes required in farming systems and in some cases land uses to achieve a trajectory of improvement to achieve the water quality outcomes. No framework is provided by which farmers can make investment decisions about their long-term farming futures.

155. The approach required now in terms of allocation of resources, has to be values based: encompassing balance, sustainability, regeneration, reciprocity, and belonging for all the farmers and communities in the

Waikato Catchment. This will require both fairness and equity for future generations underpinned by ethics.

156. On this basis, farm systems in the Waikato River Catchment will require to have the load of pollutants shared fairly across the capability of their land, and take into account the vulnerabilities of that land. Land Use Capability, as a proxy for natural capital, while not perfect, is founded in over 30 years of information, has well established systems for assessing the opportunities and vulnerabilities of the landscape, with management interventions, and introduces a precautionary principle in the face of resource allocation overshoot (example Selwyn, Upper Waikato).

157. Just as OVERSEER is not perfect – it too has a place in risk analysis, as does Land Use Capability, in the management of an overallocated regime of resource use, the management of risk in relation to land use and practices given environmental limitations, assimilation capability of receiving water (Waikato water) bodies, surface water abstractions, and (planetary atmospheric assimilation).

158. Furthermore, we must recognise that whilst the science may not be perfect, it is sufficient to create management frameworks which incentivise and empower land use decisions and practice change which drivers' trajectories of environmental improvement.

159. On this basis, the proposed regime by BLNZ is that of a N flexibility cap – whereby low emitting land uses can emit more, based on their inherent capability, while high emitting land uses on vulnerable land may be required to reduce emissions in order to establish a trajectory of improvement towards freshwater outcomes. For higher emitting land uses reductions of 30-40% are possible without significant land use change.

160. A regime such as this would allow the resources and life support capacity for future generations to be preserved.

ALLOCATION

161. If appropriate and clear regulatory signals are sent to our agricultural sector, farmers are more likely to strategically plan to improve their output without

the corresponding increase in environmental effects, and configure their businesses within environmental limits. It also ensures the development occurs in a sustainable manner and does not therefore impact on existing land users.

162. In my opinion, clear and equitable resource allocation to prevent "nutrient limit overshoot" at the outset of a plan would provide certainty and allow new businesses to design their farm systems accordingly at "business start up".

163. All dairy farms for example should have been configured with the best N and P and effluent mitigations in place, in accordance with the Dairy NZ BMP for Effluent (Dairy NZ FDE system design and COP 2015) so they can meet land-based nutrient loss thresholds that are equitable across all industries.

164. This enables them to operate a "no surprises" relationship with their lenders with respect to requirements for further capital expenditure (debt) to secure mitigations at a later date.

165. Where farmers themselves are unclear that their actions will result in improved catchment outcomes and where the burden of responsibility is unable to be allocated equitably, they will be unlikely to engage in soft regulatory or management approaches in a meaningful way.

166. As stated by Judge Thompson in his recent decision on Horizons One Plan "Voluntary approaches … need the reinforcement of a regulatory regime to set measurable standards and to enforce compliance with them by those who will not do so simply because… it is the right thing to do" (para 5-9). I concur with his statement.

GRANDPARENTING, FEPs and GMPs

167. The approach in PC1 relies on use of the following encouragements:

(a) Farm environment plans, which are to be signed off by a certified farm environment planner.

(b) A limited suite of input standards which are to be applied through the FEP, or through permitted activities such as stock exclusion.

(c) Nitrogen reference point as the grand parented allocation on the basis of the average of 2014 and 2015 years: one of which was the highest milk price year. This favours the dairy sector, as well as the most intensive farm systems, as it is likely to be the year representing the highest intensification of dairy systems.

(d) Allocating the NRP to dairy milking platform, while all other sectors are bound to a NRP of the total enterprise (thereby lowering the overall total discharge limit for other sectors, except dairy and favouring dairy over other sectors).

168. In my view:

(a) Where over-allocation has been identified in the Plan, the rules in the Plan will not result in an improvement of the quality of fresh water in those catchments. This is due to the enabling of current rates of nutrient discharges from higher discharging operations to continue, up to the 75th percentile.

(b) There is an overreliance on GMPs – Good management practice is supported by the Canterbury MGM for Waikato. These are practices in many cases that are already assumed by OVERSEER to be in place on farm. I refer to the Appendix 2: comment on MGM and the flaws in the assumptions of GMPs – especially for irrigation, and why they are not suitable to use as a foundation for FEP (I also discuss it later under OVERSEER Assumptions).

(c) Innovative (leading) farmers are operating at levels significantly above good management (best management) – leaching around 40-50% below the average, and have invested heavily in advanced mitigation structures on their farms in order to reduce their environmental impact. These leading farmers are penalised through a grand parenting system of N allocation.

(d) Furthermore, the use of the NRP as a grand parented allocation with different treatment of different sectors (milking platform for dairy) vs whole enterprise for sheep and beef is both unfair and inequitable on a number of fronts.

169. Grandparenting rewards polluters for being less efficient with their nutrient usage and losses, while penalising the innovators. In my experience, there are many farmers who have diffuse nutrient losses well below the average, running efficient farm systems and have invested in mitigation for their externalities.

170. Under the grandparenting system, these low-loss, often better farmers, would be penalised by being allocated less resource than other less efficient farmers.

171. Grandparenting as an allocation system rewards poor management decisions to operate high risk farming systems on vulnerable landscapes, contributing to high externalities.

172. The current grandparenting approach adopted by PC1 fails to take into account the sustainable productive capability of soil.

173. As proposed, PC1 promotes inefficient allocation and use of natural resources in that the plan proposes reductions in leaching and all freshwater parameters (sediment, and phosphorus) irrespective of current losses from the farm system, the soils being farmed, the vulnerability of the landscape, and the state of freshwater within the sub catchment.

174. In response to these issues, B+LNZ's suggested approach is to ensure mitigation approaches are tailored to the sub catchment and issues of concern, provide flexibility for low leaching land uses to the natural capital of their land, and to seek relative reductions from higher emitting land uses over time, with a long-term goal of restoring the ecological health of the catchment.

175. This is to be achieved through the establishment of a nitrogen flexibility cap based on the natural capital of the land, and a sinking lid approach for higher emitting land uses. In conjunction with requirements to meet the BMPs assumed by OVERSEER, management of phosphorus, sediment, and pathogens through tailored FEP's based on LUC mapping and the identification and management of critical source areas.

176. It is on this basis that I support the approach proposed by B+LNZ, which establishes a long-term plan for nutrient loss reduction and allocation combined with adaptive management and legitimate ecological monitoring. This is discussed further under paragraphs 213 as set out below.

177. To repair catchments and water quality, there will have to be an allocation mechanism. While the science is not perfect nor the detailed knowledge of land vulnerability nor attenuation, it is not a reason to delay. Farmers and businesses need certainty, they need to know what they are aiming for in rules, allocation, and targets. Without this, no meaningful plans can be done.

178. There is only a few choices for allocation at present. While OVERSEER is still not fit to be used in a trading environment due to the constant changes, version upgrades and bug fixes, there is a very limited choice in approaches that could be adopted.

(a) **Averaging i**s a form of grandparenting and is based on existing land uses as seen in the example of Rotorua it results in some land uses being essentially divorced for use, and as such fails to recognise the flexibility required to achieve sustainable long-term outcomes dependent on the ability for communities and land uses to adjust to changes in environment, climate, personal values, and markets

(b) **Grandparenting** – This also is not an option due to the inequities associated with it as discussed above in my evidence.

(c) **Cap and Trade –** Again, until OVERSEER is fit for purpose, where it is reliable enough to be used in a trading environment, this is not an option at present.

(d) **Land Use Capability** – Allows a more equitable and flexible allocation system based on the inherent capability of the biophysical asset. It allows flexibility for land use change into the future, and is not an allocation system that is based on historical styles of land use.

GRANDPARENTING ENCOURAGES PERVERSE BEHAVIOURS

179. It is open to sector advisors to assist farms to amplify their N leach and NRP and thereby “game” the system.

180. For example, the provision of fertiliser invoices requires no detail about what fertiliser has been applied where, to what management block in OVERSEER, and on what date. This is a gaping hole in provision of information and also provides significant opportunity for gaming of the NRP by applying 100 units of N in May – June – July versus in summer months, as a slow strategic application. This alone, can amplify a NRP by 10-30% depending on how much fertiliser was applied where, and in what months, to what soils.

181. There are generally no records of what was applied where or at what location (on milking platform or on the lease block?), and this can be gamed again, to amplify NRP in a perverse manner to enhance grand parented rights.

THE USE OF OVERSEER FOR RISK OF FARM N LOSS

182. OVERSEER is a model developed by AgResearch initially for the purposes of fertiliser recommendations. It is now extensively used by the pastoral industry as a nutrient budgeting tool, and for the estimation of nutrient losses from farming systems. It is also currently used to benchmark pastoral industries for nutrient loss and efficiency.

183. OVERSEER assumes that the farm system is in “quasi–equilibrium,” that inputs are commensurate with productivity, users supply actual and reasonable inputs, that the input data is correct, and that the farm data used is “sensible”.

184. As noted above, OVERSEER assumes that points of connectivity (added fertiliser, effluent, soil runoff etc.) are well mitigated on any farm when nitrogen and phosphate loss outputs are calculated.

185. The nutrient losses, nitrogen leaching, phosphorus runoff and gaseous emissions are calculated to edge of stream, below rooting depth. More recent versions of OVERSEER have been modified to more accurately

represent the soil type, PAW, texture and better reflect the drainage though soils and some more effects of irrigation management.

186. Farm output results from OVERSEER 6.3.1 are dependent on input accuracy and the protocol that is expected of the operator for desired outcome. Expert users of OVERSEER are faced with the challenge that OVERSEER files may be produced or populated using a range of input interpretations of data provided from farmers. This is especially so for fertiliser records and placement.

187. The range of protocols affecting OVERSEER output is illustrated by Pellow (2013). It is essential that the data for OVERSEER is collected and entered with a high degree of rigour to ensure the most accurate farm system is represented. Hence, suitably qualified accredited nutrient advisors are an essential part of the reporting process. Without this, reliable, transparent and credible reporting of information will not be achieved. This factor is fundamental to any form of legitimate self-management or self- reporting for N baseline purposes and FEPs.

188. There is a larger availability and ever-increasing capability than previously amongst the supporting agricultural professionals. Up to and inclusive of 2017: Intermediate SNM since 2002 = 2018 enrolments (with 90% pass rate). 156 of these were in 2017. Advanced SNM since 2005 = 754 (with 97% pass rate), 156 of these from Waikato region. In 2017, there were 78 enrolments – 21 of these were from the Waikato. (pers comm. Lance Currie, FLRC, Massey, Oct 2017).

189. While I acknowledge that OVERSEER version 6.3.1 still has some limitations, I do believe that OVERSEER is a suitable tool to demonstrate "net change in nitrogen loss". (dairy, dairy support, sheep and beef intensive, sheep and beef extensive, deer) providing that the actual farm data is used and soil types and irrigation methodology is validated urgently, and ownership is not by parties with vested interests.

190. While I support higher risk farms and above 45 kg N leach per ha being constrained, I do not support that innovative farmers are penalised under the regime proposed in PC1

191. OVERSEER already assumes many good management practices are in place, so just implementing these assumptions will have no effect on total N loads. Examples include: no connectivity of effluent to ground or surface water, effluent applied only via precision irrigation methods, all streams and waterways protected from stock and soils and crops managed to avoid critical source area loss.

192. These GMP assumed are:

(a) That surface runoff of effluent from land to water is minimal;

(b) That connectivity of effluent with groundwater is not occurring through irrigation of effluent to saturated soils, leakage from ponds, or holding facilities, and that all stock are excluded from wetlands and waterways

(c) That stock crossings or tracks near waterways do not provide any sort of connectivity from surface deposition or runoff to water bodies;(e) In terms of winter cropping, OVERSEER assumes there are no critical risk areas (hot spots) where runoff from wintering practices occurs, (i.e., – pugging is “rare") and that a buffer zone operates to break points of connectivity.

193. Hence any improvements or application of the winter grazing, cultivation and animal effluent management recommendations in GMP are nothing more than business as usual. Any benefits that may be attributed to these practices being implemented are of little consequence, as OVERSEER 6.2.3 has already accounted for these actions in N loss figures.

194. In my view GMP assumed by OVERSEER should be incorporated into a GMP protocol as minimum management practice and to ensure that the output as modelled by OVERSEER is as reflective of real farm management practices and to reduce any chance of gaming of the model.

195. Promoting GMP is nothing more than “business as usual” because the practice is already counted and expected by the public and the perception that any N loss reduction will occur from the implementation of these practices is simply “double dipping.”

USE OF THE OVERSEER MODEL TO PREDICT CATCHMENT LOADS

196. OVERSEER, if validated for farm N loss risk is potentially a good tool. However, in its current form, it is challenging to use for the mass calculation of catchment loads for the purposes of ascertaining whether a catchment will be able to meet limits or ultimately ecosystem health. It can however indicate relative farm system risk in my view.

197. The complexity lies in the fact that OVERSEER only “estimates” N loss as it leaves the root zone. This means that the model does not provide a measure of the current nutrient load entering water body nor the current nutrient load in the water body, as the model does not account for the temporal and spatial lag between the root zone and a receiving water body, nor attenuation. This is discussed further in the evidence of Dr Cox and Dr Chrystal.

198. Although N and P in many cases make their way to receiving water bodies, this is complex and there is so much uncertainty as to the degree of denitrification (attenuation), temporal and spatial behaviours once they have enriched subsurface and ground waters.

199. Water quality outcomes should be based on instream requirements for ecosystem health. Nutrient loads can then be assessed based on what is required to achieve the desired state (nutrient concentration) instream. OVERSEER can then be used to model relative change in leaching from land uses towards the desired load and water quality state.

200. Pathogens can travel both across surface flows and also via preferential pathways. OVERSEER does not account for preferential flow, therefore will underestimate the effects of contaminants and nutrients reaching groundwater via vulnerable soils that exhibit preferential pathways. These are stony and coarse soils, peats, and those which are modified – such as mole and tile drained soils. Work by Carrick (2014) in Canterbury demonstrates the effects of preferential pathways on coarse soil types.

201. Lillburne et al (2013) also caution against relying too heavily on the OVERSEER calculated loads to determine ecological outcomes: “There are many difficult issues in estimating nitrate N leaching rates for the main land

uses on different soils and rainfall zones including the rarity of good long term measured data which means that models cannot be reliably calibrated for Canterbury conditions nor Waikato."

202. Recent experience with the reliance of the use of OVERSEER to predict catchment loads is of relevance to this case. A quote from the Evidence in Chief of Dr. Kit Rutherford in the decision on the recent plan change for the Tukituki River is quoted as: Dr. Rutherford acknowledges uncertainties in his Evidence in Chief, and in points 8.2 and 8.3 he states the following "I have estimated upper and lower bounds on key model coefficients and used these to make predictions which, I believe, cover the likely true values. However, uncertainty remains in many predictions meaning that there is a risk that nutrient and biomass limits may not be met. Faced with uncertainty, the best strategy in my view is to put in place effective monitoring and make provision for adaptive management." As explained by Dr McDowell and Mr Wheeler, there is also uncertainty in the OVERSEER estimates of annual N and P losses from farmland."

203. As yet, in New Zealand comprehensive trials implementing good farming practices or GMP best practice at a sub-catchment scale in intensively farmed areas have failed to show that they can achieve water quality standards. Studies in the "best dairying catchments" of Waiokura and Toenepi over ten years have shown that stock exclusion and effluent management changes have not yet achieved contact recreation standards (Waikato Regional Council, 2010). McDowell and Hamilton (2013) note that there is a gap in the literature, linking action at the farm gate to an effect in the receiving environment to support land owners to make sound management changes on and to their land. This will require mixing multiple disciplines and research across a range of temporal and spatial sites. (McDowell, 2013)

204. A watershed project in the Pokaiwhenua catchment in the mid-2000s was undertaken but with a focus on preventing stream bank erosion and stock exclusion. It was not enough to prevent continued deterioration in water quality in that catchment. All parameters for water quality are still declining except for phosphorus. (WRC 2019) In my view, GMP alone, is not enough to protect long term river health.

VERSION CHANGES IN OVERSEER MEAN INPUT DATA IS ESSENTIAL

205. Table 5 clearly illustrates the degree to which OVERSEER has been underestimating N loss on Canterbury irrigated dairy farms. On average there was a 63% increase in N loss from these farms. Some farms experienced an N loss increase of over 120%. The increase in N loss between versions originates from increased accuracy within the OVERSEER model. Again, it must be stressed that OVERSEER version changes highlight new sources of N loss risk on farm and re-calibrates how N loss is calculated by OVERSEER. Version changes therefore represent an improved snapshot of reality and highlight the shortcomings of previous N load allocations.

Table 6: Change in N loss between OVERSEER version 6.1.1 and 6.2 of six: Example prepared for CLWP evidence – Hinds Plan Change[10].

N Leaching Variation Between Overseer Version 6.1.1 & 6.2 on Dairy Business of the Year Farms

Farm	Soil type	Base file version 6.1.1	Base file version 6.2	% Change in N leaching between versions	Net % difference between overseer versions
DBOY Farm 1	Light (Lismore)	14	32	128.6%	**128.6%**
DBOY Farm 2	Light (Lismore)	69	72	4.3%	**4.3%**
DBOY Farm 3	Medium (Ashwick)	62	65	4.8%	**4.8%**
DBOY Farm 4	Light (Lismore)	86	121	40.7%	**40.7%**
DBOY Farm 5	Sandy (Templeton)	39	53	35.9%	**35.9%**
DBOY Farm 6	Light (Lismore)	11	29	163.6%	**163.6%**
				Average	**63.0%**

206. Without adjusting existing consented and allocated nutrient loads based on previous (less than accurate) OVERSEER versions, such as version 5.4, efforts to improve water quality will be significantly impaired.

[10] Source Data: Business of the Year Competition 16 database.

207. In the Rotorua Lakes catchment for example: every time there is a new version of OVERSEER, reference files and adjustments must be made to everything, including the NDA for each farm, and allocation.

208. The other issue to highlight is the presence of bugs in OVERSEER, and how when allocation is done on the basis of a version with a bug, this has to be corrected, leading to a new allocation being done in Rotorua.

209. In Rotorua, farms with a high historical NDA (nitrogen discharge allowance) are able to sell N from the farm to an incentive scheme, based on what N they are not using. This N they are 'not using' is the difference between their grand parented N loss right and their current or future farm system. The N is bought from the farmer, calculated ex root zone plus an adjustment for attenuation by the N Incentives Board, who hold funding for the purchase of N.

210. Nitrogen has a value between $200-400 per kg in the Lake. Meaning grand parenting by sector in Rotorua (which is similar to PC1's proposal) has resulted in the dairy land being allocated around 3-5 times more N loss rights than the drystock sector. Typical dairy NDAs in the catchment are 70-80kg/ha/yr, while un-benchmarked drystock properties have been locked in at 18, with benchmarked drystock properties are in the range of 20-30 kg/N/ha/year by 2032.

211. In the case of Rotorua anything below your allocated 2032 target (40% below the original base allocation) is able to be sold and liquefied. The intent was to allow and encourage land use change. However, this approach has also had the undesired effect of creating perverse behaviours, where farms were able to amplify their N output status in order to protect their historical status, and provide headroom for N sale or trading at a later date.

212. This is why all farms need to provide a parameter file, and validation (ie proof of placement of fertiliser etc) of the interpretation of the data provided in Schedule B (page 53) by a suitably qualified advisor, who also takes responsibility for noting how they have interpreted and built the farm system between 2014 – 2016**.**

213. It is also essential that the farm planners and OVERSEER specialists are regularly audited for competency to ensure best practice standards are being met.

214. Validation of the interpretation of records will need to also have a record – that is of how the professional has interpreted production data, stock reconciliation from annual accounts, as well as records of where stock have grazed, and been shifted to (on off property and on off crops etc). This is a grey area and can lead to up to 20-30% difference in N output – due to operator input data interpretation range that can occur, because the invoices and stock reconciliation in accounts do not provide the necessary data required for OVERSEER, and this in many cases must be interpreted, or assumed by the advising professional.

LAND USE CAPABILITY/VULNERABILITY AS AN ALLOCATION REGIME TO PREVENT OVERSHOOT

215. I support the use of Land Use Capability and Vulnerability as an allocation regime to prevent over allocation.

216. An allocation regime that is future-proofed and equitable is important for farmers. Cycles of investment on farm mean that not all land is able used to its maximum efficiency at the same time, so farmers need to have long-term surety that their ability to maximise the benefit from their land into the future remains.

217. In the future, as our systems improve for quantifying P loss risk there is no reason why P loss risk cannot be linked to the LUC. This allocation framework could provide a proxy for more than just N loss risk.

218. In terms of possible improvements in management practises, there are a range of mitigations and changes to farming practices that can have a significant effect on achieving water use efficiency and reducing contaminant losses to water including N and P losses. There are numerous examples of dairy farmers and studies reducing N loss by 20-60% in both actual and observed cases.

219. However, significant reductions can put some businesses at risk if they are forced to change in a short time or and are starting from a position of an already optimised farming business operating at low leaching and maximising profitability.

220. Hence, careful allocation of ecosystem services (for example using LUC) aligned with legitimate ecological monitoring regimes (for example the use of LUCI at subcatchment and farm scale) along with applying a precautionary principle at the outset of this Plan given current uncertainties and risks, is just part of "good business planning."

CONCLUSION AND RECOMMENDATION

221. Farmers need certainty to plan and get on with mitigating risks to the environment and their business for the future.

222. PC1 gives no certainty and is based on flawed numbers to work out an outdated and inequitable allocation system.

223. Relying on GMP (or MGM from Canterbury) is unsuitable. Most of the general descriptions used fail to be quantifiable, measurable and therefore, unable to be monitored and enforced. (Appendix 2)

224. Allocation will need to happen to meet in river values. Also, all farmers will need a target to work towards in a farm plan. Hence OVERSEER is useful in this case to help demonstrate relative risk to the environment from a farm or system.

225. OVERSEER may be required to assist farmers to reduce their N leach, however any allocation system needs to account for future land versatility, right land use in the right place, and reward innovators in the industry whose farming systems align with land capability/vulnerability.

226. It is imperative for the Government to take full ownership of OVERSEER, make it a transparent model, advised by independent technical specialists and take data ownership away from vested interests.

227. Farmers will require support to mitigate environmental risks, with farm plans based on land use capability allowing versatility of the best land being used

for the best purpose, and high-risk land being retired from high risk activities. Similarly, mitigations should be linked to the land vulnerability. These services should be provided for by independent, accountable, audited and suitably qualified professionals that are regularly audited for competency.

228. Farm plans as a supporting tool for compliance to meet land-based loads, need to be systematised and prioritised based on Land Use Capability, and Pollution Loss Risk.

229. Good farmers and good industry sectors that are doing the right land uses on the right classes with minimal externalities should be incentivised rather than penalised as this current plan does.

230. Furthermore, the inequity of grand parenting that penalises the good farmers should be replaced by a fairer and more versatile allocation system, that links to the natural capability of the land, and one that protects the versatility of the land for future generations.

Alison Dewes
3 May 2019

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APPENDIX 1

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Water quality effects of land use changes in the catchment of the Waikato River hydrolakes

Bill Vant, December 2006, revised May and July 2007

This note summarizes my assessment of the eventual effects on water quality of planned increases in the scale and intensity of land use in the catchment of the Waikato River hydrolakes, in particular the effects of the "pine-to-pasture" conversions. It compares the size of expected changes in the nitrogen loads to the hydrolakes with those at which breaches of the standards in section 70 of the RMA are likely to occur.

Previous work

In late 2004 we asked NIWA to model the water quality effects in the hydrolakes that were expected to result from the land use changes that were anticipated at that time. Levels of nitrogen and phosphorus in the river were expected to increase, resulting in higher levels of algae (average 15% more) and poorer underwater clarity (6% worse). I described these changes as "a moderate-sized deterioration in water quality". Appendix 1 to this note is my summary of the modeling that was presented to the Policy Committee in February 2005.

In April 2006 we advised the Environment Committee that ongoing increases in the loads of nitrogen and phosphorus entering the Region's freshwaters meant it was likely that in due course section 70 of the RMA would be breached. In particular, we advised that the water clarity standard would be breached in the hydrolakes if loads increased by more than about 25 percent, while adverse ecological effects could be expected if loads increased by more than 10-to-40 percent. Appendix 2 to this note is a copy of the report to the Committee.

Recently I have been calculating the changes to the loads of nitrogen that would be expected to enter the hydrolakes as a result of the pine-to-pasture conversions. Appendix 3 to this note summarizes the assumptions and the main conclusions of this work. A key assumption is that "steady-state" conditions apply; that is, I have taken no account of any delays in the soil/groundwater systems.

Nitrogen loads from land use changes

Using the approach outlined in Appendix 3, I have calculated the current nitrogen load from the catchment between Taupo Gates and Karapiro dam, and the changes to this load to 2030 that are associated with the following five scenarios:

- **W1**, pine-to-pasture conversions proceed as planned;[1] furthermore, as a result of the expected intensification of dairying, the nitrogen losses increase at a rate of 1.5% per year compounding (from the current 36 kg/ha/yr; but note that the losses from sheep & beef are assumed to remain constant at 13 kg/ha/yr).

- **W2**, as in W1, but without the pine-to-pasture conversions (i.e. no conversions, growth of dairy at 1.5% p.a.).

- **W3**, pine-to-pasture conversions proceed, but with no intensification above current levels (i.e. nitrogen losses from dairying capped at 36 kg/ha/yr).

- **W4**, as in W3, but with the losses from dairying and sheep & beef capped at 33 kg/ha/yr and 12 kg/ha/yr, respectively (equivalent to current "best practice").

- **W5**, as in W3, but with the losses from dairying and sheep & beef capped at ~~25~~ 26 kg/ha/yr and 12 kg/ha/yr, respectively.

[1] I have based this assessment on the areas of pine-to-pasture conversions outlined in the November 2006 presentations to Environment Committee by WPL (document #1130090) and CHH (document #1130091 and pers. comm. to D Crequer).

Table 1: Changes in the load of nitrogen entering the Waikato River hydrolakes resulting from land use changes to 2030 under five scenarios, compared to the current (2006) load. Note: ignores any delays in groundwater.

Scenario	Change by 2030
W1, conversions, intensification of dairy at 1.5% p.a.	~~+71%~~ +70%
W2, no conversions, intensification of dairy at 1.5% p.a.	~~+32%~~ +33%
W3, conversions, capping at 36 (dairy)/13 (S&B)	~~+27%~~ +26%
W4, conversions, capping at 33 (dairy)/12 (S&B)	~~+18%~~ +17%
W5, conversions, capping at ~~25~~ 26 (dairy)/12 (S&B)	0%

Table 1 summarizes the changes to the nitrogen loads to the hydrolakes under these scenarios. For scenario W1, the nitrogen loads resulting from (1) the conversions and (2) continued intensification of dairying to 2030 are calculated to be substantially larger than at present, namely ~~71~~ 70 percent higher. Comparing this result with that for scenario W2, it is clear that about half of the increase is due to the continued intensification of dairying (at 1.5% per year).

If nitrogen loads are capped at their current level, as in scenario W3, the combined loads from the land use changes to 2030 still increase, but to a smaller extent (by ~~27~~ 26 percent). This increase reflects the additional contributions from the areas that are currently in pine forest.

Capping loads at current "best practice", as in scenario W4, further reduces the size of the increase (to ~~18~~ 17 percent). But to have no increase—that is, to maintain nitrogen loads at their current (2006) level—both capping and major reductions in the nitrogen loss from dairying are necessary, as in scenario W5 which involves capping dairy at ~~25~~ 26 kg/ha/yr. That is, apart from W5, all the scenarios produce moderate-to-large increases in the load of nitrogen entering the hydrolakes. These would result in poorer water quality in the hydrolakes than at present.

Implications for RMA section 70

By way of comparison, the increases in nutrient loads at which breaches to RMA section 70 are expected in the Waikato River hydrolakes are as follows (see Appendix 2 for details):

- 10-to-40 percent increase: exceedance of Ministry for the Environment guideline for adequate underwater lighting to maintain a healthy ecosystem

- 25 percent increase: exceedance of Ministry for the Environment guideline for changes in visual clarity in waterbodies where clarity is an important characteristic

- 50-to-100 percent increase: exceedance of Ministry for the Environment guideline for changes in visual clarity in other waterbodies.

These increases are of similar size to those that are expected to result from several of the land use change scenarios, implying that the land use changes are likely to result in breaches of RMA section 70.

Conclusion

I therefore conclude that planned increases in the scale and intensity of land use in the catchment of the Waikato River hydrolakes during the next 25 years will adversely affect the water quality of the hydrolakes, and are likely to result in breaches of RMA section 70 unless substantial changes are made to the management of the nutrient loads from these land uses, in particular to the loads from dairying.[2]

[2] Note, however, that I have not attempted to predict when these breaches are likely to occur. My calculations were based on the timing and magnitude of the land use changes themselves, and take no account of the time taken for the resulting nitrogen loads to reach the hydrolakes.

Appendix 1: Summary of water quality modeling results

Land Use Changes in the Waikato River Catchment—Effects on Water Quality

Bill Vant, Resource Information Group, January 2005

This note summarises the predicted effects on river water quality of the conversion to farmland of some 36,500 hectares of pine plantation in the catchment of the Waikato River hydrolakes.

As part of the Waikato River hydrolakes consents, Mighty River Power asked NIWA to develop a computer model of river water quality.[3] By taking account of climate, river flows, catchment land use and point source inputs, as well as in-river processes such as particle settling and algal growth, the model calculates water quality throughout the length of the river. Predictions are made of levels of the plant nutrients nitrogen and phosphorus, levels of algae and suspended sediment, and water colour and clarity. This provides an efficient and robust means of examining the effects of various different "what if?" scenarios (e.g. "what if the dams were removed?", "what if all point sources were removed?", "what if major changes to land use occurred?").

During October-to-December 2004 Environment Waikato asked NIWA to model a number of "what if?" scenarios, including several that addressed proposed land use changes within the catchment of the hydrolakes. In particular, we asked NIWA to model the effects of the conversion to pasture of 22,500 hectares of pine forest in the Wairakei Pastoral holding, together with 14,000 hectares of pine forest in the Carter Holt Harvey area. The modelling has now been completed, and a technical report[4] has been received (together with MS Excel files containing the detailed output from the modeling runs).

Table 1 summarises the main changes to river water quality that are predicted to result from the pine-to-pasture conversions. It shows that at summer low flow, the average increase in levels of nitrogen throughout the hydrolakes is predicted to be about 18 percent, with a maximum increase of 23 percent (in the upper reaches of Lake Ohakuri). The increase in levels of phosphorus is predicted to be considerably smaller (average 3 percent).

Table 1: Predicted deterioration in water quality at summer low flow in the large Waikato River hydrolakes as a result of conversion from pines to pasture in two areas of the catchment. Both the average and the maximum percentage changes are shown.

	Average	Maximum
Total nitrogen	18%	23%
Total phosphorus	3%	4%
Algal biomass	15%	18%
Water clarity	6%	8%

Notes

1. "Hydrolakes" = the region of the Waikato River between Orakei Korako and the Karapiro dam (i.e. ignoring conditions in relatively-small Lake Aratiatia).
2. The flow regime modelled was the 1-in-5-year 7-day low flow, Q_5. Similar, but somewhat smaller changes were obtained using a less extreme low flow (260 m^3/s at Mercer, cf. 185 m^3/s at Q_5).
3. "Average" = simple average of the changes in each of the 117 hydrolake segments modelled, i.e. ignoring minor differences in the volumes of these segments.
4. The development of the Wairakei Pastoral land was modelled as the conversion of 22,500 hectares of pines in the catchment upstream of the point where the Wharekaka Stream enters the Waikato River to 10,000 hectares of dairy (at 2.8 cows/ha) and 12,500 hectares of sheep and beef.
5. The development of the CHH land was modelled as the conversion of both (a) 7,000 hectares of pines in the catchment between the Ohakuri dam and the Maraetai dam and (b) 7,000 hectares of pines in the catchment between the Maraetai dam and the point where the Pokaiwhenua Stream enters the river to dairy (at 2.8 cows/ha).

[3] Rutherford, J.C. & others 2001: Waikato catchment water quality model. *NIWA Client Report ELE90229/3*. NIWA, Hamilton.

[4] Rutherford, K. 2004: The effect on Waikato River water quality of changes to river flow and catchment land use, including the December addendum. *NIWA Client Report HAM2004-148*. NIWA, Hamilton. See EW DOCS #973384.

The increases in levels of plant nutrients in the river will support an increase in algal biomass, averaging about 15 percent throughout the hydrolakes (with a maximum increase of about 18 percent occurring in Lake Arapuni).[5,6] As a result, the clarity of the water will decrease by about 6 percent on average. I consider that overall these changes represent a moderate-sized deterioration in river water quality.

The model is unable to make predictions about the occurrence of blooms of potentially-toxic blue-green algae in the river. However, I consider that water quality changes as large as those described here mean that the pine-to-pasture conversion will result in an increased risk that such blooms will occur.

[5] The fact that levels of N are predicted to increase to a greater extent than are those of P means that the N:P ratio will increase slightly—from about 8 to about 9, on average. However, both these values are close to the range for balanced algal growth (10–17), so the nutrient demands of the algae are not expected to be affected much by this.

[6] Note that the model results show that algal growth continues in the river downstream of the hydrolakes, so that levels of algae in this part of the river increase still further. However, background levels of algae are already high here, so nowhere in this lower section of the river does the percent increase exceed 18% (range 9–18%).

Appendix 2: Report to Environment Committee

Report to Environment Committee

File No:	47 03 05
Date:	30 March 2006
To:	Chief Executive Officer
From:	Group Manager - Resource Information
Subject:	**Nitrogen and phosphorus in our freshwaters: effects and targets**

In August 2005, Policy Group asked us to provide information on the effects of the plant nutrients nitrogen and phosphorus in the Region's freshwaters. In particular, they sought information on (1) the likely adverse effects of nutrients entering freshwaters as a result of the Regional Plan's permitted activity rule for fertilizer use, and (2) possible targets for the loads of nitrogen and phosphorus entering the Waikato River.

These information requests arose from:

- The need to enquire into the veracity of concerns raised by Ecologic Foundation that the rule framework in the Proposed Waikato Regional Plan did not comply with the requirements of s70 of the RMA, and

- The December 2005 resolution by Council that
  "Council direct staff to prepare draft water quality targets for the Waikato River, consult with stakeholders regarding the draft targets and assess the costs and benefits of the inclusion of these targets in the Regional Plan as part of Variation 6 Water Allocation when it is notified in late 2006."

In February this year we finalized a memo that addressed these issues. A copy of the memo is attached to this report. The key conclusions of our assessment are summarized below.

Effects of nutrient inputs resulting from WRP permitted activity rule on fertilizer use
Section 70 of the RMA identifies five types of adverse effects in waterbodies which permitted activities should not result in. In essence these are (1) the production of conspicuous scums or foams, (2) the production of conspicuous changes in water colour or clarity, (3) the emission of objectionable odours, (4) the rendering freshwater unsuitable for consumption by farm animals, and (5) any significant adverse effects on aquatic life.

Our assessment showed the following:

- Algal scums are already produced by nutrient-supported algal growth in some of the Region's shallow Lakes (including Lakes Hakanoa, Ngaroto and Rotongaro). Increases in the nutrient loads to these lakes may mean these scums become larger and occur more often and for longer.
- It is likely that a conspicuous change in visual water clarity will occur in the Waikato River hydrolakes if nutrient loads from the catchment increase substantially (e.g. by more than about 25 percent, corresponding to an increase from farmed areas of about 40 percent).
- In 2005 an algal bloom in one of the shallow lakes resulted in the deaths of nine cattle. Increases in the nutrient loads to the shallow lakes may mean that toxic algal blooms are larger and occur more often.

- The Ministry for the Environment's guideline for adequate underwater lighting to maintain a healthy ecosystem is likely to be exceeded in the hydrolakes if nutrient loads in the Waikato River catchment increase substantially (e.g. by more than about 10-to-40 percent).

We also made an estimate of how long it might take for nutrient loads to increase to the point where RMA section 70 is likely to be breached. In recent years, nutrient levels in streams in areas of the Region in pasture have increased by about 1 percent per year. If levels continue to increase at this rate, then we estimate that adverse effects on water clarity and underwater lighting are likely to occur one or more decades from now.

These estimates lead us to conclude that whilst water quality is declining, there is time to act before the statutory bottom lines in s70 of the RMA are breached. The comprehensive work programme addressing the effects of agriculture on water and soil quality in the Long Term Council Community Plan is designed to ensure that the water quality objectives in the Plan are met.

Target loads of nitrogen and phosphorus for the Waikato River
A range of possible policy goals for the Waikato River were identified, and the nutrient load targets associated with each of these were determined. The targets ranged from (1) major reductions in nutrient loads, through (2) no change in loads, to (3) major increases in loads. Table 2 from the memo is reproduced below. It broadly identifies the nutrient load targets associated with each of the possible policy goals.

Table 2: Nutrient management targets associated with different policy goals for the water quality of the Waikato River. The sizes of the changes in nutrient loads shown are approximate and indicative only.

Goal	Basis	Change in N and P loads
1. Maintain current water quality	RPS 3.4.5, Protection of Outstanding Waterbodies	No increase
2. Meet WRP visual clarity standard throughout river	WRP Contact Recreation class	50 percent reduction
3. Meet MfE irrigation guideline throughout river	MfE guideline	30 percent reduction
4. Meet MfE euphotic depth guideline (<10% change)	RMA s70(1)(g)	10–40 percent increase
5. Meet MfE conspicuous change in clarity guidelines A, <20% change B, <33–50% change	RMA s70(1)(d)	 A, 25 percent increase B, 50–100 percent increase
6. Meet WRP contaminant standard as interpreted for blue-green algal toxins	WRP Contact Recreation class	Unclear

The memo also lists the nutrient loads currently carried by the river.

The water allocation discussion document approved for release at Council's March meeting incorporates targets for consideration of the effects of water allocation that aim to maintain current water quality. The work presented here will support the s32 analysis for the use of those targets in the Water Allocation variation when it is notified in October 2006.

Recommendation
Recommended that the Environment Committee receive the report "Nitrogen and phosphorus in our freshwaters: effects and targets" (Doc #1063839) dated 30 March 2006 for its information.

Bill Vant
Water scientist
Resource Information

Tony Petch
Group Manager
Resource Information

Appendix 3: Summary of nitrogen load calculations

Pastoral farming and nitrogen loads to the Waikato River hydrolakes: results of four new scenarios including CHH conversions

Bill Vant, Environment Waikato, November 2006

In July this year I calculated the current and future possible loads of nitrogen from the catchment of the Waikato River hydrolakes. I summarized the results of this in EW document #1094238, a copy of which is attached to this document.

Since then further information has become available on conversions of pine forest to pasture, namely information on the areas and likely use of forests owned by Carter Holt Harvey (CHH; with a total of 27,000 ha of forest in the catchment available for conversion).[7] I have therefore generated additional scenarios which include the CHH conversions.[8]

Note that the new scenarios are not directly comparable with the earlier scenarios, with the key differences being (1) all areas of pasture are now treated equally, regardless of whether they resulted from pine conversions or not, (2) management to reduce nitrogen losses is used on dairy pasture, but not on sheep and beef pasture, and (3) the AgResearch information on reductions in nitrogen losses possible from dairy pasture is regarded as referring to absolute reductions (rather than percentage changes).

I have calculated the nitrogen loads at present (2006), and those associated with the following four scenarios (see EW document #1120437 for details):

- **S1**, WPL and CHH conversions proceed as planned. The yields from all areas of dairy pasture in the catchment are capped at 36 kg/ha/yr, while those from all areas of sheep and beef are capped at 13 kg/ha/yr. (Areas of CHH pine converted to "lifestyle" are assumed to yield 10 kg/ha/yr.)

- **S2**, as in scenario S1, but with N leaching from all dairying capped from 2007 at 33 kg/ha/yr, corresponding to AgResearch's estimate of "best practice".

- **S3**, as in scenario S1, but with N leaching from all dairying capped from 2007 at 20 kg/ha/yr, corresponding to AgResearch's estimate of "potential practice".

- **S4**, as in scenario S3, but with farming on all areas of pasture (i.e. dairy and sheep and beef) intensifying from 2007 at 1.5% per year compounding (i.e. "potential practice" required from 2007, but growth from there permitted).

Table 1(new) shows the changes in the overall load of nitrogen entering the hydrolakes under these scenarios when compared with the current load. For scenario S1, WPL and CHH conversions occur, the nitrogen loads in 2015 and 2030 are calculated to be higher than at present, by 14% and 22%, respectively. Scenario S2, all dairy areas subject to best practice, shows that while some of the increase resulting from the pine conversions can be offset, overall loads are still higher than at present (by 15% in 2030). Requiring all dairy areas to implement AgResearch's "potential" practice, however, means the increase resulting from the conversions can be more than offset (scenario S3). But this gain is lost if intensification of pastoral landuse also occurs, with the net effect being a 16% increase in the nitrogen load to the hydrolakes in 2030.

Table 1(new): Changes in load of nitrogen entering the Waikato River hydrolakes under four development scenarios, compared to the current (2006) load.

Year	S1	S2	S3	S4
2015	+14%	+9%	–16%	–8%
2030	+22%	+15%	–12%	+16%

[7] Tony Petch (EW), pers. comm., 31/10/2006.

[8] I have also included the load of (attenuated) N in the outflow from Lake Taupo in these calculations (c. 500 t/yr): I inadvertently omitted this from the July calculations.

ATTACHMENT: Pastoral farming and nitrogen loads to the Waikato River hydrolakes: results of four scenarios

Bill Vant, Environment Waikato, July 2006

I have calculated the current and possible future loads of nitrogen from the catchment of the Waikato River hydrolakes (see EW document #1073485 for details). My calculations were based on:

1. current landuse in the catchment (EW document #1005450),
2. estimates of the rate at which pine forest owned by Wairakei Pastoral Limited, WPL, will be converted to either dairy pasture or sheep and beef pasture,[9]
3. the specific yields of nitrogen leached from different landuses at present,[10]
4. the rate at which pastoral farming is expected to intensify between now and 2030 (namely 1.5% per year, compounding),[11] and
5. the extent to which the current nitrogen loads from pastoral landuses in the Waikato Region could be reduced by using "potential management practices".[12]

I have assumed steady-state conditions apply throughout (i.e. no account has been taken of possible lags in the soil/groundwater systems).

I have calculated the nitrogen loads at present (2006), and those associated with the following four scenarios:

- F1, WPL conversion proceeds as planned, with the yields from its dairy, and sheep and beef areas capped until 2030 at 32 and 13 kg/ha/yr, respectively; all non-WPL areas of dairy in the catchment intensify, with the yields increasing at 1.5% per year compounding; all non-WPL areas of sheep and beef continue to leach nitrogen at 2006 levels (i.e. no increase).

- **F2**, as in scenario F1, but with N leaching from all dairying (i.e. including WPL) progressively managed between 2006 and 2030, so that the yield in 2030 is 44% lower than it otherwise would have been.

- F3, as in scenario F1, but with N yields from non-WPL areas of sheep and beef also increasing at 1.5% per year compounding.

- **F4**, as in scenario F3, but with N leaching from all dairying managed as in scenario F2, and with the leaching rate from all sheep and beef also progressively managed between 2006 and 2030, so that the yield in 2030 is 38% lower than it otherwise would have been.

Table 1 shows the changes in the overall load of nitrogen leached from the catchment under these scenarios when compared with the current load. For scenario F1, intensifying dairy, the nitrogen loads in 2015 and 2030 are calculated to be higher than at present, by 14% and 35%, respectively. However, scenario F2, intensifying dairy but with progressive improvement, shows that these predicted increases in the nitrogen loads can be offset by enhanced management practices. Similarly, the predicted increases associated with intensification of sheep and beef as well as dairy (scenario F3), can also be offset by enhanced management practices (scenario F4).

I repeated the calculations using other rates of intensification. At rates of about 2.5% per year and greater, the enhanced management practices were not sufficient to offset the increased leaching of N, and the overall nitrogen loads in 2030 were greater than in 2006.

Table 1: Changes in load of nitrogen leached from land in the catchment of the Waikato River hydrolakes under four development scenarios, compared to the current (2006) load.

Year	F1	F2	F3	F4
2015	+14%	+2%	+18%	+1%
2030	+35%	–7%	+46%	–11%

[9] Information provided by S Lodge, Fonterra, on 19 April 2006 and 9 May 2006.

[10] Yields in kg/ha/yr as follows: 3 (pine forest and undeveloped land), 13 (sheep and beef pasture), 32 (WPL dairy pasture) and 36 (all other dairy pasture). Values refer to nitrogen leached below the root zone in the catchment, that is un-attenuated nitrogen (as opposed to the attenuated nitrogen delivered to the hydrolakes).

[11] Information provided by S Lodge, Fonterra, on 19 April 2006 and 20 July 2006.

[12] Namely by about 44% for dairy pasture and 38% for sheep and beef pasture (Ledgard & Power 2006, *Environment Waikato technical report 2006/37*).

APPENDIX 2

Report on Canterbury Regional Councils Good Management Practice Variation 5

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GMP (author Rachel Mudge)

The ‘Good Management Practice’ (GMP) narratives produced by the Matrix for Good Management Project provide high level outlines of farm management aspects. They do not provide specific measurable or quantifiable guidance to effectively guide on farm practices. ‘Grey areas’ in the GMP narratives permits individual interpretation which leads to confusion and potential conflict.

Due to the lack of clarity of the GMP definition, improvement in practices, such as investment in soil moisture monitoring technology, accurate on farm water metering or improved irrigation systems are not receiving wide uptake. Leading farmers embracing innovation are using these irrespective of industry GMP narratives. Perversely these same farmers are penalised under plans where nutrient loss rates are grandparented.

In the case where a farmer is managing irrigation inputs, to ‘minimise’ losses within the constraints of his current labour and infrastructure, even if the losses are high, GMP does not provide clear signals to encourage improvement in farm practices. Measurable targets such as deficit irrigation to soil moisture targets would provide clearer direction and definition.

The term irrigation efficiency (application efficiency) attempts to provide a ‘measure’ of irrigation system performance. Policy 4.68 in the Canterbury Land and Water Regional Plan (LWRP) states “water used for irrigation is applied using good practice that achieves and irrigation application efficiency of not less than 80%.” The definition of efficiency to support this is “the volume of water stored in the plant root zone following irrigation, as a percentage of the total volume applied.”

This measure fails to provide accurate and quantifiable guidance. The amount of water ‘remaining in the root zone’ is an estimate, underpinned by several substantial assumptions.

The assumption applied that water is applied with 100% uniformity, evenly along the length of the irrigator. When the distribution uniformity factor is applied ‘irrigation efficiency’ is undermined by a factor or between 0.6-0.85 as measured in the ECan Summer Irrigation Efficiency Pilot Programme Report 2016/17 which studied 131 farms and 244 irrigation systems.

Irrigation and water use

Our intent: To apply irrigation water efficiently to meet plant demands and minimise risk of leaching and runoff.

GMP: Manage the amount and timing of irrigation inputs to meet plant demands and minimise risk of leaching and runoff.

Implementation guidance:

There is a demonstrable reason why irrigation is to be applied, for example:

- to replace soil moisture deficit
- for the purpose of herbicide activation
- to prepare soil for cultivation
- frost protection
- for fertigation

Fertiliser

GMP: Manage the amount and timing of fertiliser inputs, taking account of all sources of nutrients, to match plant requirements and minimise risk of losses.

Implementation guidance:

• Manage nutrients supplied from all sources including the soil, brought in feed, previous grazing and crops and any organic sources applied.

• Nitrogen … fertiliser is applied strategically to meet agronomic requirements, and to avoid adverse environmental impacts …

• Nutrient budgets as a tool to manage nutrient loss can be helpful. Dairy: All farmers have and use a predictive nutrient budget (OVERSEER®) as the basis for managing nutrients on their farm

TABLE 1. Irrigation Performance Indicators and Their Application

Indicator (1)	Boundaries (2)	Time covered (3)	Other (4)
Irrigation efficiency, *IE* (%)	Field, farm, district, project, or basin	Time interval (between two dates such as a complete irrigation season).	Only measured after fact; makes no assumptions of future beneficial use. For defined time interval, requires accurate assessment of what portion of irrigation water was ultimately beneficially used. Does not assume uniform water requirement or use across field. Values depend on start and end times chosen.
Irrigation consumptive use coefficient, *ICUC* (%)	Field, farm, district, project, or basin.	Time interval.	Quantifies unrecovered water.
Irrigation sagacity, *IS* (%)	Field, farm, district, project, or basin.	Time interval.	Includes the concept of reasonable use as well as beneficial use.
Distribution uniformity, *DU* (ratio)	Field-wide, but sometimes applied to a smaller unit, for example, a single furrow, area between four sprinklers, or lateral.	One irrigation event.	
Application efficiency, *AE* (%)	Field or smaller unit.	One irrigation event.	Usually assumes uniform target water depth across field. Implicit assumption that all water destined for beneficial use will ultimately be utilized beneficially.
Adequacy, *AD* (ratio)	Field or smaller unit.	One irrigation event.	Provides estimate of adequacy of irrigation (underirrigation, proper timing, or overirrigation). Usually assumes uniform target water depth across field, just as *AE* does.
Potential application efficiency, *PAE* (%)	Field or smaller unit.	One irrigation event.	Provides estimate of what level of *AE* is possible, assuming proper timing of irrigation event and accounting for *DU* and unrecovered surface losses (evaporation and runoff). Usually assumes uniform target water depth across field, just as *AE* does.