BEFORE THE INDEPENDENT COMMISSIONERS

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of Variation 2 (Hinds/Hekeao Plains Area) to the Canterbury Land and Water Regional Plan by the CANTERBURY REGIONAL COUNCIL

EVIDENCE IN CHIEF OF ALISON DEWES ON BEHALF OF CENTRAL SOUTH ISLAND FISH AND GAME COUNCIL
15 MAY 2015

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QUALIFICATIONS AND EXPERIENCE

1 My name is Alison Mary Dewes.

2 I am presently Lead Consultant for Headlands, a consultancy company based in Te Awamutu, focussed on developing farm systems for optimal profit while minimising farming's environmental footprint. Headlands is undertaking several projects across NZ specifically focussed on understanding which farm systems have the highest profit and lowest environmental footprint.

3 I undertake farm analysis and strategy design plans using UDDER, Farmax Dairy Pro, Red Sky and Overseer. Headlands main role is the application of whole farm planning services for agriculture in sensitive catchments.

4 I have been a registered veterinarian for 28 years and hold a practising certificate. I hold a BVSc from Massey University (1987). I hold a Masters in Biological Science (Ecology) from Waikato University (2015).

5 My higher education in the past decade 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 2006; F) Certified Adult Trainer, Melbourne 2004; G) Dairy Leadership Course Melbourne 2004; H) Advanced Dairy Nutrition, Australia 1999; I) Dairy Nutrition Course, Lean, Massey 1990; J)Soils and Pastures Course, Massey 1993; K) Milking Machine Testers Course, Flockhouse, 1992.

6 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.

7 My parents' family established a dairy farm at Ellesmere, then at Deep Spring in Leeston. I am a fourth generation farmer and spent 20 years dairy farming in New Zealand and Australia with my husband. We sharemilked in the Waikato then bought and developed three pasture-based dairy and support farms in Victoria Australia over the 2001 to 2008 period. One was irrigated.

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

9 In 2001, I took over as Business Development Manager for Intelact Agribusiness Consultancy in Australia. The business services were based on full farm analysis for intensive pastoral farms, businesses faced with reconfiguration of systems as they faced major constraints

on their surface and ground water allocations. This challenge was amplified by two major droughts occurring between 2002 – 2007.

10 In 2006, I became Agribusiness Lender for the Commonwealth Bank of Australia and was heavily involved in the appraisal and risk assessment of new farm businesses for the bank.

11 In 2009, I returned to New Zealand, I was contracted to Agfirst at this time, and undertook the Upper Waikato Nutrient Efficiency Study. As part of that study, I analysed more than 380 overseer files for eco efficiencies for MAF farm monitoring during 2009 and 2010.

12 I have been an expert witness on agricultural matters for the Horizons One Plan, the proposed Canterbury Land and Water Plan (2013), the recent Tukituki River Catchment Plan Change 6(2013), the proposed Variation 1(Selwyn - Waihora) to the Proposed Canterbury Land and Water Regional Plan, and the South Waikato District Plan Change.

13 I hold a part time consultancy role as Sustainable Land Use Advisor to Raukawa Charitable Trust in the Upper Waikato.

14 I am a professional member and sustainability spokesperson for the NZ Veterinary Association. I am a member of NZIPIM & NZFWSS.

15 In preparing this evidence I have reviewed: Variation 2 to CLWP, and the zip addendum along with all relevant technical papers referenced and in the footnotes

16 In preparing this evidence I have reviewed:

(a) Proposed Variation 2 and the supporting technical reports provided by Environment Canterbury relevant to my area of expertise.

(b) I have read the Code of Conduct for Expert Witnesses in the Environment Court Practice Note. This evidence has been prepared in accordance with it and I agree to comply with it. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

SCOPE OF EVIDENCE

17 I have been asked by Central South Island Fish and Game Council to prepare evidence in relation to:

(a) Hinds Plains Area – Background

(b) The Agricultural “Externalities of Concern” to Receiving Ecosystems

(c) Overview of Proposed Variation 2: CLWP

(d) Will Good Management Practice (GMP) be effective at reducing nutrient loss to the required levels?

(e) Proposed further development in the catchment

(f) The use of Overseer to predict catchment loads

(g) Current dairy farm system models in Hinds Area as modelled by Everest and Macfarlane Rural Business

(h) Hinds catchment nutrient and on farm economic modelling

(i) What is realistic in terms of N loss reductions for farmers in the catchment

(j) Optimising Resource Use efficiency – allocation of water and aquatic assimilative capacity

(k) Proposed strategy to reduce catchment load – the effects on landowners

EXECUTIVE SUMMARY

18 The Hinds /Hekeao Plains catchment is significantly over allocated in regards to the key contaminants of concern from farming land uses such as nitrogen, phosphorus, sediment, and faecal contaminants. The Hinds Catchment is considered a red zone (overallocated) in the proposed Canterbury Land and Water Regional Plan and impacts of farming land uses are recognised in Variation 2. This over allocation creates risk for both business and the environment, which Variation 2 tries to address in part.

19 The Zone Committee's plan, adopted in Variation 2, seeks to allow expansion and intensification while at the same time attempting to achieve catchment wide improvements. This requires careful evaluation as no irrigation schemes, in my knowledge, in New Zealand have actually managed to reduce nutrient and contaminant loading to freshwater, while at the same time as intensifying (i.e.: adequate mitigations/reductions to counteract the net increases in discharges).

20 In order to assess the approach adopted by the Zone Committee and as reflected in proposed Variation 2, it is necessary to consider the proposed expansion and intensification of farming in the catchment and evaluate this against what can be achieved through improved management practises of existing farming. These issues need to be considered in the light of the regulatory framework, including the Freshwater NPS, which contains an objective (A2(c)) to improve water quality in over allocated water bodies and a policy (A1(b)) to avoid over allocation.

21 Variation 2 proposes that established farmers in the lower Hinds Plains Area are required to lower their total N loss to the tune of approximately 15% initially as Good Management Practice (GMP) is

implemented, and a further 30% between 2025 and 2035. However, provision is made for new irrigation of up to 30,000ha if leaching at or under 27kg/ha/yr.

22 Given that the catchment is already significantly over allocated, this approach poses significant equity and risk issues for established farmers who make up the current load (modelled to be 3,400 as the ultimate sustainable load in 2035 based on Overseer 6.0 calculations).

23 After proposed expansion and intensification and improvements in management practise are taken into account, as shown in the EiC of Mr Canning (paragraph 41), the proposed nitrogen leaching loads are likely to result in instream nutrient concentrations which exceed those required to safeguard ecosystem health, and which result in further increases in instream nitrogen concentrations and associated declines in ecosystem health rather than improvement from current state.

24 This increase in load does not appear to be consistent with the objective to improve water quality in over allocated water bodies. An increase in the load also appears inconsistent with the requirement to establish methods to avoid over allocation. The increase in load will result in additional over allocation that will exacerbate, not avoid, the over allocation issue.

25 It is not equitable for established farming operations to be have to undertake significant and expensive steps to reduce nitrogen losses, when new entrants are allowed to leach more nitrogen. The over allocation of new assimilative capacity (that doesn't actually exist) will penalise the best farmers not once – but twice. This occurs as the best farmers have already been allocated a low N loss right through the baseline grand parenting regime proposed in variation 2, and then required to reduce further to address the over allocation of the catchment and to make room for new entrants.

26 Variation 2 establishes provision to further claw back existing dairy and dairy support farming by up to 45% and 25% respectively. 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.

27 There are numerous examples of farmers and studies reducing Nitrogen loss by 20-60% in both actual and observed cases. In my opinion material reductions in leaching can be made while a farm remains profitable, and by 2023/2024 there is likely to be an even better understanding of how farms can be optimised. Based on current information, and further supported by the work of Ridler (shown in Appendix 1) it is my opinion that dairy farming can be optimised to still be economically viable while dropping N leach by

30%. This is not likely to be possible for all farm systems nor land uses to the same degree.

28 The move to "active management" for irrigation scheduling, for example, is a key mitigation delivering 30 – 50% reductions in nitrogen leaching. This has the potential to address some of the current water quality and quantity challenges. The top 10% of farmers are presently doing this, it should therefore be mandatory good management practice.

29 More advanced mitigations, when integrated in to a whole farm system incur capital costs to implement, however, they can also have significant benefits. Including increased productivity, improved efficiencies and corresponding profitability benefits if a farm system is optimised. Significant reductions, however in contaminant loss from the farm, can put some businesses at risk if they are forced to change in a short time.

30 Aside from some basic "minimum practices," mitigation options are generally not a 'one size fits all.' Rather, they should be tailored to each individual farm business to ensure recommended mitigations are suitable for the business operator. Variation 2 should provide the incentive and enable the appropriate mitigation to be applied to individual farm businesses so as to reduce nutrient losses.

31 While the target reduction of 45% leaching from farms by 2035 is a reasonable target to get farming practises heading in the right direction, better methods will be required over the longer term to achieve that target, in an equitable and efficient manner I understand that Ecan have advised this Variation will be substantively reviewed in 2023/2024 in order to fully implement the National Policy Statement for Freshwater Management 2014 (NPSFM). Given that fact, and the fact that technological advances, markets and other variables will change, I do not believe it is of assistance to try and make detailed projections out over a period of decades on this Variation as it currently stands.

CANTERBURY and HINDS PLAINS AREA: BACKGROUND

32 The Canterbury region has 70% of New Zealand's irrigated land and is one of the most dependent regions on irrigation due to its low rainfall, high temperatures, coarse textured soils, strong winds and high levels of evapotranspiration. There has been a rapid rise of dairying in the region reflected by a 51.4% increase since 2005-6. The extent of irrigation and growth of particularly dairying in the last decade has largely been on stony soils which pose the highest risk to receiving environments. It is likely that most of the future irrigation development will occur on similar stony soil types.

33 At a national level, the rise of this new development and expansion of dairy over the past decade has meant dairying has enjoyed a 60%

increase in growth (output)[1] while simultaneously an increase in debt of 300% (risk), however, net productivity[2] improvement across the industry has shown a net decline.

34 The Hinds Plains Area is characterised by a wide range of drainage behaviours and varying water holding capacities mostly characterised by a vulnerability to nitrogen leaching. The catchment is significantly over allocated in regards to the key contaminants of concern from farming land uses such as nitrogen, phosphorus, sediment, and faecal contaminants. The Hinds Catchment is considered a red zone (overallocated) in the Canterbury Land and Water Regional Plan and impacts of farming land uses are recognised in Variation 2.

35 Canterbury farming systems are more intensive on average than they are nationally. For example, 63% of dairy farm systems in Canterbury were reported as importing 20-50% of their feed (via direct supplements or off farm grazing) (Agfirst Waikato, 2009). More intensive systems also rely heavily on a high proportion of support land in order to meet their feed requirements for young stock, wintering cows, and supplementation. This situation results in the intensification of land traditionally used extensively in order to support this farm system configuration. Intensive systems are considerably more fragile than traditional pasture systems, so are more vulnerable to volatility – e.g. negative climatic or commodity price changes, and have increased risk of contaminant losses thereby requiring more advanced mitigations.

36 The Hinds River catchment lies between the Ashburton and Rangitata rivers. There is a parcel of hill country wedged between the north and south branches of the Hinds River. There are over 30 lowland water bodies (streams and drains) in the lower part of the catchment.[3] It is one of the catchments in the Ashburton WMZ. Currently, it is primarily sheep and beef, dairy, and arable. The region however is poised to intensify further, with the expansion of irrigation in the catchment through extensions to the Rangitata Diversion Race (RDR), and intensification of land use under the Barrhill Chertsey Irrigation Scheme for example, enhancing further land use change to dairy and dairy support.

37 Agriculture makes up 98% of land use in the area. In the past 15 years, the use and manner of irrigation has altered. Border dyke has been progressively changed to spray (pivot) and the regional Ashburton economy has grown (based on GDP measure) at twice the rate of other NZ regions, largely fuelled by dairy and dairy support industry.

[1] LIC reports 2000 to 2015 & RBNZ data.
[2] Dairy NZ Economic Survey 2012-2013 (50 years of economic analysis): Figure 3.5.
[3] The catchment incorporates two groundwater zones: the Mayfield Hinds and the Valetta groundwater zones.

38 The current land use in the Hinds catchment (as of 2013)[4] is around 139,000 Ha in size and land use currently consists of 37% sheep and beef, 32% dairy, 20% arable, 8% dairy support, and 3% other land use (plantation forestry, native forestry, etc.). It is estimated about 85,000 ha of the catchment is “irrigated” dairy, sheep and beef and arable enterprises. New land intensification, conversion, and development are already underway. This change will most likely result in sheep and beef land uses changing to intensive irrigated dairy and dairy support systems.

39 The effects of this intensification have been modelled by Scott et al, in the “Hinds Plains water quality modelling for the limit setting process.” In the development scenario, which is already underway: Scott modelled the development of an additional 28,500 Ha of irrigated land with dairy and dairy support farms and the additional resultant nutrient load and nitrate conc. reaching ground and spring fed waterways. The catchment load calculations suggest that the N load may increase by about 30%. This scenario means that the average N concentration exceeds the WQ target of 6.9 mg/L (table 13(k) in shallow groundwater). I discuss report No R13/93 "Hinds Plains water quality modelling for the limit setting process" later in my evidence at and I provide a critique in Appendix 3.

40 The scenario proposed by Scott combining a mix of 30,000 ha of development, combined with established farmers having to implement GMP and then subsequently Advanced Mitigations 2, is based on a wide range of as yet unvalidated assumptions and furthermore, is based on catchment loads derived from Overseer 6.0 which have now significantly changed). The increase in catchment load is likely to be a significant underestimation because the scenario assumes all GMP assumed by Overseer is in place already on farm.

41 As a starting point, any gains on farm as a result of GMP will be <u>eliminated by the new irrigation development</u> (new farming cannibalises established/improved farmers nutrient headroom). Therefore, in order to address this, it was then assumed that all farmers would be required to drop a further 30% through the implementation of advanced mitigation practices on farm in order to meet the community expectations and facilitate new intensive irrigation.

42 The Hinds Zone Committee was tasked with determining water quality limits for the Hinds catchment. Consideration of 90% aquatic species protection target and 80% species protection in the Hinds River and streams nearer the coast was set in order to achieve the National Bottom line objective (N toxicity). To achieve this however, an average nitrogen level of <6.9 mg Nitrate N per litre is required. That level is currently not being achieved.

43 Therefore, it was determined that additional water from the alpine rivers will be required to be released into the catchment to dilute the

[4] Modelling Economic Impacts of Nutrient Allocation Policies in Canterbury: Hinds Catchment: Daiegneault,A. Samarasinghe, O. Lilburne, L.(2013) prepared for MfE.

N concentrations in streams and rivers along with a total catchment N load reduction of 30%. This will both provide headroom and also augment the predicted future nitrate load expected to reach receiving water bodies. To provide for the intensification from new irrigation, a 45% N leaching reduction target was set in Variation 2.

THE AGRICULTURAL EXTERNALITIES OF CONCERN TO RECEIVING ECOSYSTEMS

44 The externalities of concern from pasture-based agriculture that Variation 2 should control are:

(a) effluent/pathogen runoff from the land, which contributes to the contamination of waterbodies (both surface and ground);

(b) erosion and soil loss from the land leading to increased sediment loads to surface waterbodies;

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

(d) erosion of stream banks, leading to stream bank 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 has adverse environmental effects.

45 Externalities contribute to declining aquatic ecosystem health (water quality and habitat) and issues of public health. Coliforms, campylobacter, cyanobacteria, and salmonella are among the potential pathogens. The increase pathogenic loads to surface and ground waters from agricultural land uses result in high rates of zoonotic and enteric disease and loss of public amenity (Mc Bride, 2011) (Larned, 2004).

46 I have read the Hinds Economic Modelling Study prepared by Everest and understand the proposed areas for irrigation in the Hinds catchment. If agriculture production continues to increase as modelled, there will be more stock per irrigated hectare, more inputs to drive pasture growth, and a high degree of off farm support. Externalities and pressure on freshwater resources will worsen.

47 When this farm system configuration occurs on more vulnerable soils (coarse texture) it results in proportionally higher rates of loss of nutrients and pathogens to the receiving environments.

48 Intensive farming on vulnerable soils results in an amplified amount of nitrate nitrogen making its way to receiving waters and aquifers in the

vicinity of 60kgN/ha/yr to 140kgN/ha/yr (up from around 20kgN/ha/yr to 30kgN/ha/yr). Wheeler et al (2013) reports losses of 120kgN/ha/yr on coarse soils for dairy (7B)1, and 134.8kgN/ha/yr for arable (5B)2.22.

49 Landcare Research suggests that intensive land use on stony soils is creating conditions with a high risk for leaching of soluble nutrients and has the greatest risk of contaminant losses including microbes (Sam Carrick, Landcare Research, pers comm.). Additionally, they state their concerns in a recent publication: in February 2013, at FLRC by Sam Carrick: "The last 20 years has witnessed large-scale conversion of alluvial soils into intensive dairy farming. In the South Island most of the expansion of dairy farming has occurred on irrigated stony soils that are vulnerable to nutrient leaching.

50 This paper presents a stocktake of the distribution, state of knowledge, and agricultural development on New Zealand's stony soils and highlights the urgent need for research to be undertaken to determine the environmental risks of intensive development on this land and to find land management solutions to these risks" (Carrick. S, 2013).

51 Prior to the 1980s, it was thought that phosphorus, unlike nitrate, was so strongly held by soil particles that loss of phosphorus though drainage to natural waters was minimal. But now it is recognised that bypass flow can cause significant amounts of phosphorus to drain through soils into field drains and then surface waters (Powlson 1998). Recent research indicates discharge of phosphorus to groundwater may also be more important than previously thought (Holman et al. 2008, Abraham and Hanson 2009). Some New Zealand soils have very low P retention values, and significant phosphorus loss can occur through soil macrospores, predominately co-transported with mobile colloids (Thomas et al. 1997, McDowell et al. 2008)[5].

52 Richard McDowell (2014) has also released a stocktake of the risk of phosphorus loss under dairy systems. His conclusion suggests that a precautionary principal be adopted when the intensification of vulnerable, shallow, stony soils are proposed due to the heightened risk of phosphorus loss to groundwater, and receiving surface waters where anoxic[6] waters well up at lowland points adding to the anthropogenic phosphorus load.

53 Methods to mitigate P losses under irrigated dairying include: varying the rate of irrigation according to available water holding capacity to minimise drainage (Hedley et al., 2011); applying the minimum fertiliser-P to maintain optimal pasture growth applying less P but maintaining pasture production with N-fertiliser and not irrigating vulnerable soils or using vulnerable soils for practices that lose significant P such as effluent application or cropping for grazing in winter (McDowell, 2012). However, perhaps the most obvious would

[5] 7ECAN report: Page 13: Mapping of vulnerability of nitrate and phosphorus leaching, microbial bypass flow, and soil runoff potential for two areas of Canterbury"

[6]. Redox state: without good supplies of oxygen.

be the consideration of the vulnerability of soils and aquifers prior to land use change or development.

54 Both nitrogen and phosphorus discharges to water bodies pose a risk to aquatic health, and therefore both require management, to achieve periphyton limits and protect ecological health, as discussed in the expert evidence of Adam Canning.

55 Failure to adequately account for the current degradation of freshwater resources in the Hinds Area (Upper and Lower catchments) and ensure that a robust regime is put in place now which manages all externalities of concern including nitrogen and phosphorus, will result in further risk to both businesses and the environment.

56 These costs will be borne not just by this generation but by future generations as land and water resources are essentially managed in an unsustainable manner.

MITIGATIONS

57 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 nitrogen and phosphorus losses. My conclusions and expert opinion in this regard are based on research throughout New Zealand, Australia and Canterbury.

58 Mitigations and associated methods include:

(a) Metering water use and moving to efficient irrigation and precision application technology using spray irrigation systems.

(b) Ensuring all best management practices "assumed by Overseer" are actually implemented in their entirety.

(c) Focussing on "optimal nutrient management" across the whole property.

(d) Adoption of best management practices in regards to effluent management including adoption of best practice soil moisture deficit irrigation over an extensive area to optimise nutrient use efficiency and ensuring that effluent ponds are sealed to prevent leaching.

(e) Ensuring an "optimum stocking rate[7]" is adopted for the farm system, management and the landscape.

[7] Optimum stocking rate means that the cows are consuming as much home grown – low cost feed as possible. For a 500 kg cow, this could be 4.7 TDM of home grown forages. Headlands clients have farm systems where cows are producing 90% of bodyweight as Milk Solids on 90% home grown feed. Data available on request.

(f) Ensuring diets are well balanced including making use of mixed pasture swards to better utilize nutrients and meet animal health needs.

(g) Advanced Infrastructure improvements (e.g. feed pads, housing systems) to assist with standing off, improved feed utilisation, pasture protection, and effluent capture during inclement weather.

59 The move to "active management" for irrigation scheduling is a key mitigation delivering 30 – 50% reductions in nitrogen leaching. This has the potential to address some of the current water quality and quantity challenges. The top 10% of farmers are presently doing this; it should therefore be mandatory good management practice.

60 More advanced mitigations, when integrated into a whole farm system incur capital costs to implement; however, they can also have significant benefits including increased productivity, improved efficiencies and corresponding profitability benefits if a farm system is optimised.

61 Aside from some basic "minimum practices," mitigation options are generally not a 'one size fits all.' Rather, they should be tailored to each individual farm business to ensure recommended mitigations are suitable for the business operator. Variation 2 should provide the incentive and enable the appropriate mitigation to be applied to individual farm businesses so as to reduce nutrient losses.

62 Three "typical Canterbury farms" were assessed in 2013 using Overseer 6.0 for current performance and lowered nitrogen loss scenario plans on behalf of Fish and Game for the pCLWP. This work was undertaken to ascertain what types of farm system reconfigurations may be necessary to meet nutrient limits as proposed by the zone committees in red zones such as Hinds Plains Area. The three farms were chosen to reflect "high risk" farms in red zones on the basis of farming intensity and soil types. As such, these are worst case scenarios (Appendix 4a & 4b of Dewes EIC CLWP 2012).

63 This modelling work (above) is also supported by modelling work conducted by Ridler et al for both MAF Policy (31/07/2007), DairyNZ (Howard July 2013) and earlier work in the Hurunui area (12 October 2012) using the GSL resource allocation model. That particular work was supported by David McCall on behalf of Fonterra.[8]

[8] 3 The GSL model was chosen over Farmax (which was used for the calculations presented in Brown et al 2011, and of which the author of this evidence was a developer). This was because GSL is more efficient at finding optimal resource use allocations due to it being an optimising, rather than a simulation model. With simulation models (such as Farmax) the definition of optimal resource use requires the user to iterate their way to an optimum solution. This iteration is time consuming, not always full-proof and optima may be missed. Predictions from Farmax and GSL are very close, given similar resource inputs. This is shown in Table 1 where predicted outputs for the current configuration for three of the

64 While the target reduction of 45% leaching from farms by 2035 is a reasonable target to get farming practises heading in the right direction, better methods will be required over the longer term to achieve that target. I understand that ECan have advised this Variation will be reviewed in 2023/2024 due to their staged implementation of the National Policy Statement for Freshwater Management 2014 (NPSFM). Given that fact, and the fact that technological advances, markets and other variables will change, I do not believe it is of assistance try and make detailed projections out over a period of decades on this Variation as it currently stands.

65 In my opinion material reductions in leaching can be made while a farm remains profitable, and by 2023/2024 there is likely to be an even better understanding of how farms can be optimised. Based on current information, the work of Ridler in the dairy report provided, shows that a dairy farm can be optimised to still be economically viable while dropping N leach by 30%. This is not likely to be possible for all farm systems or land uses to the same degree.

VARIATION 2: CLWP

66 The Ashburton catchment is currently over allocated. This over allocation creates risk for both business and the environment.

67 The Ashburton Zone Committees Recommendations, adopted in Variation 2, seek to allow expansion and intensification while at the same time achieving catchment-wide improvements in water quality for the lower Hinds and attempting to achieve a 45% reduction in Nitrogen leaching by 2035. This is to be achieved in summary by:

(a) Permitting land use at or under 20kg/ha/yr

(b) Grandparenting some existing users

(c) Implementing good management practices for the baseline land use

(d) Requiring further reduction from GMP of up to 45% for Dairy farming and up to 25% for Dairy support by 2035

(e) Providing for a further 30,000ha of intensification in the lower Hinds leaching at or below 27kgN/ha/yr

68 This approach requires careful evaluation, particularly in regards to providing for further intensification of land use in a catchment which is

farms which had previously been loaded into Farmax by another user, were compared with predictions by GSL. It means that the only significant difference between the models is in the model structure (optimising – GSL, versus simulation - Farmax). Footnote Page 6 (Evidence of Mc Call on behalf of Fonterra in Hurunui + Waiau River Regional Plan.

already significantly over allocated. I am unfamiliar with any irrigation schemes that have actually managed to make improvements at the same time as intensifying (i.e.: adequate mitigations/reductions to counteract the net increases in discharges). The ability to therefore achieve reductions in catchment nitrogen loads and the associated costs fall to existing land users which are not only required to mitigate the impacts of their land uses but also create the headroom for further intensification of land use. Provision for further land use, results in negating some of the gains made by existing farmers in regards to environmental outcomes.

69 Intensive farming (dairy, irrigated dairy, etc.) will leach significantly more N than S+B (sheep and beef) farms. This means irrigation will lead to a significant increase in N at a catchment level.

70 Under current farming practices, many dairy farms are overstocked, so reducing the overstocking problem is a low cost way to reduce the N problem at a farm level.

71 While individual farms can be optimised in terms of minimising N leaching (whilst remaining profitable), there are limits to the amount of farm level abatement possible – because removing too much N renders farms unviable.

72 This implies that there is a production limit in terms of number of optimised farms in order to achieve a catchment or area leaching limit/cap.

73 Once a catchment is fully allocated then there is a trade-off – for a new activity to start or an existing activity to intensify requires another activity with a similar leaching profile to shut down or reduce.

74 This however, need not be a zero sum game: as a well designed N trading scheme will, in theory at least, shut down the least valuable activity in order that more valuable activities can start. However, the information requirements for this to function in reality are currently not readily available to current farmers.

75 The catchment is currently overallocated. The target N load to address overallocation is currently set at 3400T, but with the contemplated increase in irrigation by 30,000ha the load is likely to increase in load: up to 5900 T[9]. Scott and Everest rely on many unvalidated and unverified assumptions to support a conclusion that the target load is still achievable in this context. See my review in Appendix 3. Until validated and verified those assumptions cannot be relied upon, and a permissive approach to increasing irrigated areas in this catchment should be approached very cautiously in this

[9] Table 5.2 page 13: ECAN REPORT: R13/93

Variation, if overallocation is to be addressed. Water quality will only improve if in fact Scott and Everest assumptions can be verified in time. If the assumptions cannot be verified, water quality will continue to deteriorate. An increase in the load also appears inconsistent with the requirement to establish methods to avoid over allocation. The increase in load will result in additional over allocation that will exacerbate, not avoid, the over allocation issue. I have set out in more detail more critique of the Scott and Everest analysis on which the Variation relies in Appendix 3.

76 Variation 2 proposes that established farmers in the lower Hinds are required to lower their total N loss to the tune of approximately 15 % for dairy initially as GMP is implemented by 2020, and up to a total of 45% by 2035, while allowing for a further 30,000ha of intensification under rule 13.5.14 if the leaching rate is at or below 27kg/N/ha. This raises both economic and equity issues.

77 The Variation 2 management framework for farming land uses is based on grandparenting existing users if leaching over 20kg/N/ha/yr, followed by application of good management practice leaching rates from Jan 2017, and further reductions in leaching of up to 45% for dairy and 25% for dairy support by 2035. No further reductions in leaching are required for other farming land uses such as sheep and beef and arable.

78 The report: "Managing scarce resources: Options for allocating catchment nutrient loads" (Environment Canterbury, October 2012, page 12)[10] states the guiding principles should be as follows:

Ideally, the preferred allocation method should satisfy the following principles [1]:

- Be comprehensive and equitable. All sources of nutrients– both diffuse and point source discharges are managed with the limits.
- The allocation method ensures efficient use of nutrients and minimises losses to water.
- The inherent properties of soils and their susceptibility to nutrient loss should be considered in the allocation process.
- The allocation method should apply at different scales – enterprise, community, sub catchment and catchment in defined management zones.
- The allocation method needs to recognise social and economic importance of allowing existing businesses to continue, and to apply a transition process to allow these businesses time to implement changes. Existing businesses have made investment and undertaken their activities in compliance with relevant regulations in the absence of nutrient load limits.
- Avoid incurring undesirable economic costs and benefits on all parties, e.g. creating excessive windfall gains, creating a 'goldrush' to acquire allowances, or cause severe economic and social disruption to existing land uses or point source discharges. The broad costs and benefits of different allocation approaches need to be assessed.
- Be technically feasible, simple to operate, transparent, easily understood and accepted by the community. A credible regime is in place to verify that the allocation method is being complied with
- Not result excessive transaction costs, including administrative costs, for Environment Canterbury, land owners or dischargers.
- Not overly favour or give preference to one particular sector or interest group.

[10] 1. http://files.ecan.govt.nz/public/south-canterbury-streams/research/sccs-research-options-allocating-nutrients.pdf

- Provide an effective way of reducing loads in over allocated catchments, e.g. a proportional reduction in discharge allowances or "sinking lid"; purchase of allowances by ratepayers; or auctioning of acquired allowances.
- Remains consistent with Ngai Tahu values
- Be consistent with legislation; e.g. Resource Management Act 1991, Commerce Act 1986

79 In my opinion, Variation 2 in its current form, does not give effect to the guiding principles listed above because it does not share the nutrient allocation losses out fairly or equitably.

80 Nor does Variation 2 provide an effective way of reducing loads as it does not take into account the ability of the highest leaching resource users to make the greatest reductions. This does not demonstrate optimal resource use efficiency.

81 The Variation relies on GMP that is as yet undefined so their effectiveness at achieving desired outcomes in terms of water quality simply cannot be assessed or measured.

82 The Variation fails to ensure efficient use of nutrients through the proposed rules, nor does it minimise losses to water for all land uses within the catchment such as arable, irrigated sheep and beef etc which contribute to the current over allocation of the catchment.

83 The Variation, by facilitating the increase of 30,000 ha more of irrigated intensive dairy, clearly does not recognise the impact of adding more to an over-allocated catchment, through the notional headroom created by requesting established farmers to drop their leaching by up to 45%. For some farmers this will be extremely hard, while other farmers will enter the catchment with a windfall gain of allocated nutrient losses.

84 The above fails to acknowledge that the Variation may be incurring undesirable economic costs and benefits on all parties, e.g. creating excessive windfall gains, creating a 'gold rush' to acquire allowances, or cause severe economic and social disruption to existing land uses

WILL GMP's GET US THERE?

85 GMP in CLWP is quoted as at 3.2.4 as:

> "All activities operate at "good environmental practice" or better to optimise efficient resource use and protect the region's fresh water resources from quality and quantity degradation".

86 I have concerns about the assumption that Good Management Practice (GMP) as a mitigation tool will contribute to reduction in nutrient losses, as my understanding of GMP is that they should already be in place on farms. In my opinion, GMP includes all the assumptions already in Overseer including water and effluent application to SMD, code of practice effluent systems, full stock exclusion from all water bodies, BMP for fertiliser use, etc. Therefore, any further assumptions that a particular management practice adds

value to the overall target of reducing nutrient losses, will need to be legitimate, enduring, and over and above those already accounted for in the mass load accounting used by Overseer.

87 Good management practice: For Variation 2 to work, there is an assumption that GMP applied at farm level will deliver a 15% reduction in catchment load (Rule 13.5.17 RD). However, the catchment load numbers have already assumed many of these yet undefined GMP are already in place – thus the notion that one can count most of them again is erroneous.

From 1 Jan 2017: the use of land for a farming activity in the Lower Hinds/Hekeao Plains Area is a permitted activity provided the following conditions are met:

1. The N loss calculation for the property does not exceed 20 kg per ha per annum
2. The N loss calculation for the property excluding any area of land subject to a resource consent granted under Rule 13.5.14, does not increase above the nitrogen baseline: and either
3. The practices in Schedule 24a are being implemented and the information required is required in accordance with 24a, and supplied to Canterbury Regional Council on request: or
4. A Farm Environment Plan has been prepared and is being implemented in accordance with Schedule 7 Part A, and supplied to CRC on request.

88 However, GMP as yet – remains undefined. With no clear definition available of Industry Derived Good Management Practice, it is impossible to have any certainty around whether the proposed solutions package approach will provide a suitable and legitimate solution for the management of nitrogen loads in this catchment. If it is described by what is illustrated in the table in Everest's description of GMP that underpinned the farm and subsequently catchment modelling, then it is simply nothing more than "business as usual". It is not mitigation, and it will not cause a reduction in nutrient leaching.

89 A common sense assumption would be that "Good Management Practice" would be defined as methods and techniques found to be the most effective and practical means in achieving an objective (such as preventing or minimising pollution) while making the optimum use of the resources.

90 GMP needs to be legitimate and enduring. They need to ensure that the industry retains its social licence to operate. The latter will only occur if legitimate mitigations over and above "business as usual" are undertaken to meet community aspirations for water quality.

91 GMPs need to be flexible and adaptable enough to able to take into account the potential risks that may impact on farms in the future[11], and also account for legacies of the past.

[11] For example the impending risks being identified with Antimicrobial resistance, as well as chemical interventions such as glysophate. The loss of these interventions from the intensively farmed systems we consider as appropriate in 2015-2020 may present the future "highly modified intensive agricultural systems" with unanticipated challenges within the next decade.

92 Many good farmers have already implemented GMP into their systems anyway (Everest's GMP description pg 39)[12].

Summary of GMP in Everest Assessment	
GMP	**Impact on N Loss**
Reduction in fertiliser in crops following large winter depositions of nitrogen.	The Fertiliser Association of New Zealand's Code of Practice for Nutrient Management requires that this practice occurs. Because Overseer assumes that the Code is being adhered to, there will be minimal reductions in N loss from implementing this practice. Rather, the farm will come in line with an already assumed standard.
Dairy to install 30+ days effluent storage and greater reduction in N use on effluent applied land.	This is compliant with rule WQL26 of the Natural Resources Regional Plan. However it is in violation of the DairyNZ Farm Dairy Effluent Code of Practice which requires that the Dairy Effluent Storage Calculator be used to determine effluent storage volumes (see appendix_).

93 In order to address this unfairness, early adopters that have implemented advanced mitigation (Level 3, Advanced & System Change: practices and system changes) should be recognised when determining additional nutrient discharge reductions (below the grand parented level).

94 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 unfortunately are penalised through a grand parenting system of N allocation.

95 These BMP farmers are leaders (top 5%) and include farms such as Cloverdale Farm, and Willie Leferink operation (with advanced mitigations and system reconfigurations in place). These farmers are providing the industry with examples of "Best Management Practice" examples for 2015; demonstrating extremely low footprint farm systems are achievable. (The Panetts Dairies example of two free stall barns are in operation with a cut and carry enterprise, and the N leaching is 34 kg N(Ovp version 6.11) per ha per year)[13] .

96 However, it is important to note that advanced mitigations and reconfigured farm systems such as Leferinks, favour a higher and stable milk price. Furthermore, I would note that these systems are expensive to reconfigure to, they require high levels of investment, skill and expertise, and rely on extremely high degrees of animal health and performance in order to keep costs at a manageable level. They can result in increased debt (risk) and erode resilience from the

[12] Hinds catchment nutrient and on-farm economic modelling. Report R13/109
[13] Fielday at Pannetts Dairies LTD (28 March 2014) NZIPIM Canterbury/Westland Branch – Introduction to Free Stall Dairy Housing in Canterbury

farming system, especially in periods of sub $6.00 milk solids price. These systems can therefore be classed as "fragile."

97 Schedule 24a suggests that a nutrient budget must be prepared using Overseer in accordance with the BMP standards (2013). This is business as usual, and will not result in any reductions in nitrogen leaching as modelled by Overseer.

98 Fertiliser is applied with the Code of Practice for Nutrient Management (2007) – Overseer 6.0 already assumes this is "in place" therefore it is no more than "business as usual" and will not reduce outputs/modelled catchment load based on Overseer outputs.

99 Records of soil nutrient tests, budgets and fertiliser applications are kept and provided where requested – Business as usual.

100 With regards to Irrigation management – All irrigation systems are to be self checked annually alongside Irrigation NZ Pre Season Checklist. This is just good practise and Overseer already assumes this, so no net reductions can be expected from this.

101 Irrigation applications are undertaken in accordance with property specific soil moisture monitoring, or a soil water budget, or an irrigation scheduling calculator. Overseer had already assumed this practice was in place (in version 6.0 and 6.1) however in version 6.2 there is an option to differentiate these GMP from earlier versions to show the benefit (reduction in leaching if soil moisture monitoring is undertaken).

102 In our experience as a consultancy, only around 10% of our clients would be using this specifically on their property. Yet Overseer has always assumed this was in place in earlier versions, when applying dairy industry protocol. Consequently, earlier versions of Overseer and subsequent catchment load calculations will only reflect what schedule 24a is asking for. This is simply business as usual.

103 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.

104 Overseer assumes:

(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;

(d) 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.

(e) Hence any improvements or application of the winter grazing, cultivation and animal effluent management recommendations in Schedule 24 a C), D), and E) are nothing more than business as usual and any benefits that may be attributed to these practices being implemented are of little consequence, as Overseer 6.0 has already accounted for these actions in N loss figures.

(f) BMP assumed by Overseer should be incorporated into Schedule 24a 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 by self interested parties.

105 Again, this is nothing more than “business as usual” and the perception that any N loss reduction will occur from the implementation of these practices is simply “double dipping.”

THE USE OF OVERSEER FOR RISK OF FARM N LOSS

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

107 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.

108 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, better reflect the drainage though soils and the effects of irrigation management.

109 Farm output results from Overseer 6.1 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 protocols. This is illustrated by Pellow (2013).

110 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.

111 There is a larger availability, and ever increasing capability than previously amongst the supporting agricultural professionals. There are 404 professionals who have completed the Advanced SNM and 1,437 have undertaken the Intermediate course. There are currently 73 Canterbury-based people who have completed the Advanced SNM and, of the 93 enrolled in this course in 2014, 24 are Canterbury-based (pers comm. Lance Currie, FLRC, Massey, Aug 2014).

112 While I acknowledge that Overseer version 6.2 still has some limitations, I do believe that Overseer is the best tool we have available to indicate nitrogen loss risk from a land use activity (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.

113 Overseer remains the most appropriate tool available to the pastoral industry to manage land use within environmental constraints, as it provides the comparative risks to the receiving environment of a management activity at a farm scale.

114 Without Overseer, farmers would be facing a cumbersome regime of unwieldy “input controls” in order to minimise their effects on the environment.

USE OF THE OVERSEER MODEL TO PREDICT CATCHMENT LOADS

115 Overseer, if validated for Farm N loss Risk – is potentially a good tool. However, in its current form, it is neither suitable nor legitimate 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.

116 However, my understanding is that the N load targets and limits set in table 13(g) were derived using Overseer.

117 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.

118 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.

119 On this basis, the use of Overseer to predict catchment loads and the potential impact on receiving water bodies is fundamentally flawed as there is simply not enough information present to be able to develop, validate nor verify a decision support tool.

120 It is not fit for the purpose of establishing nutrient loads to achieve water quality outcomes. Rather 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.

121 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.”

122 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 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.”*

123 In relation to Dr Rutherford's statement regarding adaptive management, he was referring to Nitrogen leaching standards and management framework for farming land uses within PC6.

124 For adaptive management to work in regards to the management of farming activities and their impacts on the freshwater environments, it is essential that the outcome in regards to the state of the freshwater is established. This is not a function of current land use but rather defined by the state of the health of freshwater, which the community

aspires to and which at its basis provides for ecosystem health as discussed in the evidence of Mr Canning. In my opinion the load targets and limits in table 13(g) should not have been set using Overseer, but should instead have been set based on what water quality outcome or objective is intended to be achieved. To do otherwise and rely on Overseer is not implementing the precautionary principle.

125 My concerns about the flawed analysis arising from reliance on Overseer to calculate catchment load is set out in more detail in my Appendix 3 critiquing the Scott and Everest work,

Overseer Versions

126 I note that all N loss has been calculated using Overseer (6.03) and will continue to do so unless ECan approve an equivalent or more appropriate model[14].

127 This presents several issues. Because the scientific data driving the Overseer model is constantly being updated and refined, Overseer is subject to frequent version changes. With each version change, N loss outputs have proven to fluctuate significantly (see Table 1) as the N loss model in Overseer is refined by more accurate data.

128 It fails to account for the increases in accuracy provided by each new Overseer version and ignores how any increase in N loading will affect water quality.

129 The greatest increase in N loss from an Overseer version change to date occurred between versions 6.0-6.1 (up to 100% increase, Dewes 2014) and 6.1-6.2 (63% average, see Table 1). This potentially represents a combined increase in predicted N loss from 6.0-6.2 of 163% for intensive irrigated dairying on coarse soil types[15].

[14] ECan Resource Consent CRC147697 – Pg 2. Section 5
[15] Based on overseer outputs and files for of Dairy Business of the Year 2012 .

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%**

Table 1: Change in N loss between Overseer version 6.1.1 and 6.2 of six irrigated Canterbury farms on light soils. Data was sourced from the Dairy Business of the Year Competition[16] database.

130 Table 1 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%.

131 The increase in N loss between versions originates from increased accuracy within the Overseer model.

132 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.

133 Without adjusting existing consented and allocated nutrient loads based on previous (less than accurate) Overseer versions, efforts to improve water quality will be significantly impaired.

[16] Dairy Business of the Year is an annual dairy farm competition operating across New Zealand focussing on profitability, environment, and human resources. It is administered by Intelact Ltd.

HINDS CATCHMENT NUTRIENT AND ON FARM ECONOMIC MODELLING - RIDLER APPENDIX 1 AND 2

134 Barrie Ridler was contracted on behalf of Fish and Game to model the dairy scenarios (1 and 2) presented by Everest in the Hinds catchment nutrient and on farm modelling report (R13/109).

135 In this process, using GSL[17], the dairy 1 and dairy two were optimised to make profit inside N leach constraints.

136 The report is Appendix 1.

137 In summary the findings are as follows:

138 Resource use efficiency is especially important when the resource availability is constrained for any reason. This is relevant for water as it is for appropriate soils (for intensifying).

139 Variation 2 fails to recognise the high risk of the soils when high levels of water and inputs are added, and the sheer vulnerability of the landscape to the current land uses presently in operation (more than 60% of catchment will be irrigated dairy on light or extra light soils). As better described in Mr Ridler's Sheep to Beef to Dairy Irrigation Report (report provided), adding irrigation increases feeds grown and eaten which increases N leached beyond limits and costs more than it returns.

140 The dairy farms appeared to be able to reduce N leach by 30% before further reductions began to impact on the business. It needs to be noted that the base file used by Ridler used assumed GMPs were in place. The 30% is from a base file. Whether a 15% decrease in N leach will occur from yet to be defined GMPs can be achieved is still up for question.

Sheep/Beef to irrigated dairy conversion models:

141 Ridler also undertook modelling to examine whether there would be benefits converting Sheep and Beef farms to dairy (Appendix 2): The basic methodology of establishing the comparative base then only allowing alterations to specific resources to ensure a true comparison using marginal analysis is used for the other examples.

142 The use of irrigation to intensify production increases N leach beyond the catchment and farm specific limits envisaged.

143 The costs of irrigation compared with the additional returns are unlikely to provide better profits than improved dry land systems but will increase leaching significantly beyond environmental limits.

[17] Grazing Systems Limited

Summary Sheep and beef conversion to dairy and irrigate: Conclusions:

144 If more pasture/forage is grown, more product is produced.

145 More product is therefore required to pay for the costs of irrigation infrastructure and running costs (driving intensification to satisfy debt obligations).

146 These additional forages may vary in crude protein and % of crude protein that is excreted as urine, but nitrogen excretion will increase proportionally with more feed.

147 If irrigation is added to this mix, so too must more phosphate and nitrogen as these are required to produce the response rates to water required for profitable farming (this would be well above what the inherent natural capital would provide).

148 Adding irrigation increases vulnerability by amplifying the N leach from any system. Transitioning land use from dryland sheep and beef to dairy will more than double the N leach but this will be variable based on farm system intensity, soils, and climate.

149 Unless very high response rates can be achieved for irrigation, the additional costs far outweigh the economic return as not enough additional product can be sold.

150 As dry land is improved with improved forages nitrogen leaching will increase.

151 Irrigation will almost double this again with higher forage growth rates from water.

152 If any soil is already near N leach limits it is difficult to intensify economically and remain below N leach limits.

Summary conclusions for Dairy 1 and 2: Conclusions:

153 Overseer 6.3 finds N leach figures of between 81-89 kgN leached /ha/yr. for existing dairy example.

154 Management options such as reducing herd number, grazing stock off, reducing winter crop and reducing Nitrogen application may halve this figure with some reduction in economic returns.

155 Without nitrogen and phosphate additions to irrigation water, the response rates to water from irrigation will reduce.

156 But if N and P are added, the N leach figure will exceed 50 kgN/ha/yr.

157 Mitigation strategies need to be proven and are not additive in Overseer. For example, housing animals in winter requires even more bought in feed which adds to total eaten on the farm and despite

larger effluent area used, will provide only a small decrease in N leach at a high capital and ongoing fixed costs, within the system.

158 This creates a risky farm system dependent upon consistently higher product prices.

159 Converting dry land to irrigation will double N leach due to water plus intensification (including requirement to purchase "shoulder period" feeds prior to and post irrigation response.)

160 The economics of conversion at $6.40/kgMS when using marginal analysis that includes all costs associated with change vs the additional production income mean that the model will not use irrigation even before a price of water is included.

161 This presents "Catch 22" scenarios where a number of mutually exclusive factors interplay.

162 Water grows more grass which will produce more crude protein and when eaten, produce more N leach. In order to get an economic response to water, nitrogen and phosphate must be used yet both these must be reduced to reduce N leach and nutrients into the groundwater.

163 Irrigation itself increases leaching potential when leaching requires to be reduced from current levels. Even using improved dry growing forages will increase feed eaten and increase N leach.

164 The catchment already requires decreased N leach from farms yet no proven mitigation strategies (except management options as described in this report) will reduce N leach by the required margin when Overseer options are used as per protocols now established.

165 It is difficult to envisage a much larger area of irrigation being possible under these circumstances without an inevitable increase in nitrogen load within the catchment.

166 The Figures in report Ashburton Zip addendum March 2014 Canterbury Water Report as reproduced below indicate the future difficulties Overseer 6.3 predicts will be faced if irrigation, conversions and intensification are completed as stated.

FARM SYSTEM RECONFIGURATION TO IMPROVE RESOURCE USE EFFICIENCY AND LOWER NUTRIENT LOSSES

167 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. Smeaton and Ledgard have provided evidence that reductions of between 10 – 15% can be achieved without any significant impact on farm profitability.

168 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. Smeaton (evidence 42a Horizons 2009 point 17), describes these practices that reduce leaching with minimal effects on profit: “ The results of the Rotorua catchment case studies showed that the following can reduce N leaching by 5 to 25% and have a minor negative to slightly positive effect on profit.

169 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.

170 A similar study conducted by Dairy NZ in the Horizons region[18] (2013) confirmed similar findings. If farms are to decrease leaching from their allocated LUC N discharge allowance by a further 20%[19] there will no significant impact on profitability providing the farmers have time to adapt (the starting point assumed Overseer BMP were in place).

171 A study conducted by Stuart Ford on behalf of Irrigation NZ in the Selwyn Waihora catchment (2012), investigated options for N loss. 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) 15% fewer cows with no corresponding increase in production (↓57%) (Note: there is conflicting modelling on the financial effect of reducing stocking rates & this study failed to model a benefit from lower SR) despite other studies showing an economic and ecological benefit (Dewes 2014; Dewes, Ridler & McCallum 2014).

(e) 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

[18] 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

[19] The drop expected depends on LUC. Lower class land(6-8) have a lower drop than better class land. With some farms having a mix of LUC on their farms, ave N loss reduction will vary between farms. So the net change is a case by case basis but say for a LUC mix of 1 &2, the average drop will be around 20% over 20 years

water applied was reduced from 575 mm to 380 mm a saving of 195 mm) (↓38%).

(f) On – Off Autumn Grazing (↓15%).

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

(h) 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) in the top 5% of farms using the latest technology in irrigation application but using relatively high rates of N application) (↓38%)

172 An on farm trial considering lower stocking rates with higher per cow production is occurring at Scott Farm in Hamilton. Results are confirming a leaching reduction of 40-50% when compared with a conventional farm system. A summary of the results are shown below (Clark, 2012).

173 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 3: 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 Leached/Ha	50	22 (50% DROP)

174 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. This is a positive move by the dairy industry and will assist by providing local information to farmers on what combinations or approaches[20] within an irrigated farm system can be adopted in order to reduce the risk of N loss to the receiving environment by over 20% without significantly affecting the profitability.

175 The Waikato work has also been confirmed as being possible "in the field" by a recent SFF (Tomorrows Farms Today). Dewes' (2014) study in the Upper Waikato focussed on 25 farms, which were assessed for their economic and environmental performance from 2011-2014. 25% of the farms were shown to retain good levels of profitability (ROC) at a range of milk prices ($5.50 – $7.50/kg MS) while demonstrating N losses 30% below the average. These "more profitable, lower footprint" farms were typified as having a) "low cost efficient" systems, b) not overstocking, feeding cows well on home grown feed (>4.0TDM home grown feed eaten) and having high levels of production efficiency (>90% milksolids as bodyweight).

176 The report generated by Dairy NZ in 2012 looked at mitigations possible in the Selwyn–Waihora catchment (Howard, 2012) and suggested that there might only be around a 5% reduction in profit for a 32% reduction in N leached (Table 17 of Dairy NZ Report). This study is likely to reflect the upper bounds of effects on profitability as a result of the mitigation costs estimated in this report because:

(a) Assumptions relating to N leaching have not been clearly articulated in the report and may have led to over estimation of the effects of single costs.

(b) Precision irrigation was not considered as mitigation, yet this could have yielded the most profitable mitigation approach.

(c) Benefits of some mitigations may not have been fully accounted for and have not been clearly stated.

(d) Focus on a net change in operating profit rather than full return on capital (ROC) may also lead to underestimation of the benefits of some mitigations.

177 In my own experience, when investigating cases of impaired dairy herd performance on irrigated dairy pastures in the Millicent region of South Australia in the period 1997 to 2004, it was not uncommon to find crude protein levels in the pasture of 35-45%. This was effectively as a result of high nitrates in the groundwater which was being used for irrigation. It is now recognised there was a flume of high nitrate groundwater in this particular region (Bolger. P, 1999).

178 This is a risk for Canterbury. As noted in the report by Ford in 2012: "Attenuation of Nutrients": - Once nutrients enter a river, lake or wetland, they may be taken up by plants, temporarily retained, and released back into the water column as growth ceases ("nutrient spiralling"). As little is known about the extent of this process, the net assimilation of nutrients is assumed to be zero. Nutrients may also be permanently removed by denitrification, burial or be flushed from the catchment. The scale and extent to which these processes reduce nutrient concentrations is not known. For the Canterbury Plains

aquifers, denitrification processes are unlikely to significantly reduce[21] nitrate concentrations as drainage water moves down through the soil profile and gravels are overlying the aquifers.

179 Better productivity from fewer better fed cows at a more optimal stocking rate is a sound option for some farms when reconfiguring a farm system. This philosophy is being demonstrated by the most recent “efficient dairy trials at Scott Farm and LUDF and the recent TFT study (Dewes 2014).

180 The average New Zealand cow would need to lift production by around 25% and consume more home grown feed in order to achieve this result, as noted in the study. This can occur in a relatively short time frame (18 month period of altered management). This “reconfiguration option and the associated profitability” was demonstrated in the Farm System Modelling studies done by Ridler et al, Dewes, Ridler & Mc Callum 2014, and also was demonstrated in the Fish and Game farm system modelling study (Dewes EIC CLWP 2012).

181 In my opinion we need to relate stocking rates to pasture harvested and subsequent profitability rather than production. Note that increased milk production per hectare does not necessarily align with more profit per hectare. However farm optimisation does align with improved profit and the “sweet zone concept” (Dewes 2014).

182 Many of the assumptions underpinning technical reports that have advised the Zone Committee are on the premise that increasing stocking rates leads to increased profit and dropping stocking rates reduces both output and profit. Both Feitje[22] and Ford[23] made these assumptions in their N mitigation modelling, which was used by Harris (2014)[24] to underpin the macro-economic assumptions for the region. The above analysis needs to be interpreted with caution in my opinion.

183 Lower stocking rates do not always eventuate in lower production and lower profits as noted by Smeaton 2009, the Dairy NZ Scott Farm Trial, The Lincoln Low Stocked Efficient trial, the findings of Ridler's work, the Fish and Game modelling EIC Dewes CLWP (2013), and also demonstrated in the TFT study by Dewes 2014.

184 In my experience, this is the case only when properties are under stocked. That is not the case on most farms now. Many farms are overstocked by 10-30%, a level that does not allow cows to be fully fed in order to reach optimal performance. A 500kg cow can consume over 4.5 - 5 T DM of home grown forage per cow per year and

[21] Refer to (Case Study 1 – page 54: Pasture, Mixed Agriculture and Forestry – South East, South Australia in Contamination of Australian Groundwater with Nitrate (Bolger.P, 1999).
[22] Modelling of N mitigation costs 2013 by Feitje – ECAN
[23] Selwyn Te Waihora Nutrient Performance and Financial Analysis - Prepared for: Irrigation NZ and ECan
Prepared by: The AgriBusiness Group -September 2012
[24] Predicting the consequences of future economic scenarios – Economic Impact Assessment – Simon Harris. 2014

produce >90% of her bodyweight as milk-solids. This has been demonstrated by the more profitable, resilient farm systems.

185 Dairy NZ has just confirmed publicly (11 May 2015) that many NZ farms may be overstocked to the tune of 30%, where Dr. John Roche suggests that in the past 6 years, most average farms have gone up by 100 cows (that is 100 extra cows on a 330 cow farm) and that this has been supported by high cost feed which has made farms more risky due to the increased cost of production.[25]

186 Harris notes in his report (page 14) for Selwyn-Waihora, that he used the packages from the solutions options that were reflective of reductions in revenue, but increases in expenditure (i.e. mitigations that cost - rather than optimise farms) in order to demonstrate the regional economic effects. He also notes that his modelling should be used with caution however, as it does not recognise that the "most effective on farm mitigation may be through practices that reduce the intensity of operation and expenditure" rather than the approach he proposed. Harris acknowledges that Dairy NZ is aware there are better solutions for farmers, solutions offering improved business and environmental performance. He has however elected not to use this in his macro-economic modelling because "*these solutions result in lower revenue and reduced regional outcomes."* Substantiation of this claim was unavailable for us to review.

187 There is no 'one size fits all' approach to mitigating nitrogen and phosphorus losses from farms, as these factors need to be considered on a farm-specific and farm systems basis.

188 The single cost and single mitigation approach used by Everest in his modelling is "out of step" when reviewed against recent evidence and modelling studies (Dewes 2014: Ridler et al) that show farm system reconfiguration to more efficient, lower footprint systems can occur without significant impacts on farm profitability and when farm systems are optimised.

189 Consequently, costing of single mitigations is continually being adapted downwards as scientists endeavour to keep up with innovative farmers such as those mentioned in this evidence who are developing new and innovative systems to "meet and beat the rules" and stay ahead of the game in NZ.

OPTIMISING RESOURCE USE EFFICIENCY – ALLOCATION OF WATER AND AQUATIC ASSIMILATIVE CAPACITY

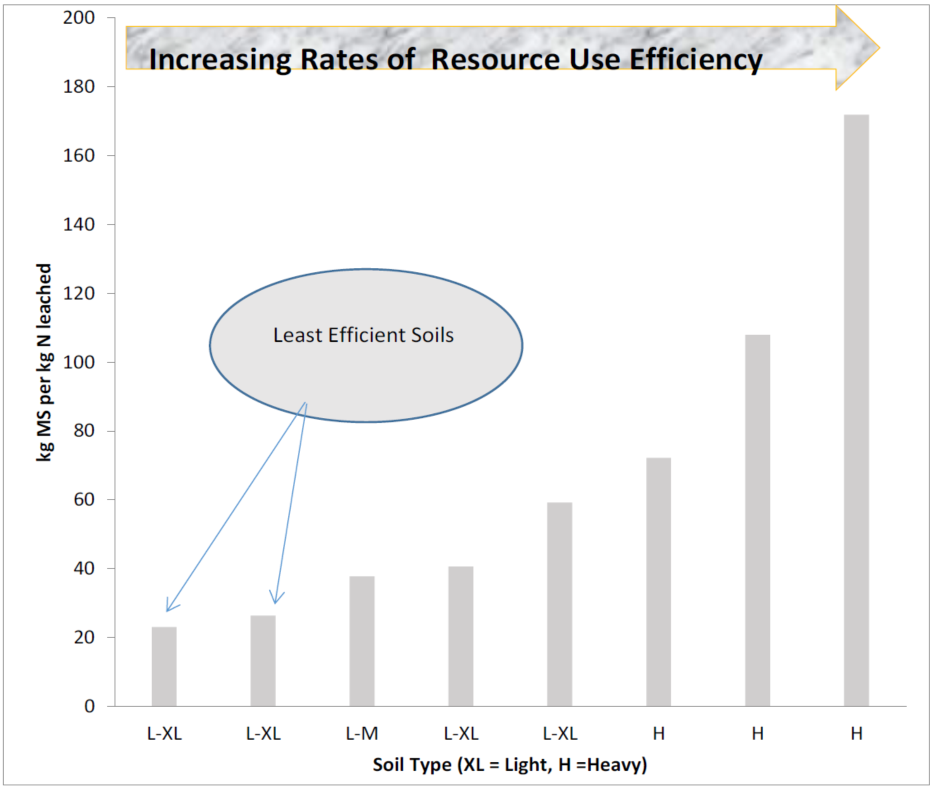
190 In Smeaton's EIC for Variation 1 to CLWP point 15.3, he makes a claim that mostly those farms that are N use efficient, have low levels of N loss (for their soil type and climate) and are profitable, and cannot easily reduce N losses further without significant negative effects on their profitability. The most "resource efficient farms" appear to be on the heavier soils (Figure 1).

[25]http://www.stuff.co.nz/business/farming/dairy/68144618/rising-feed-costs-eroding-nz-dairyings-competitive-advantage

191 Variation 2 fails to recognise the high risk of the soils when high levels of water and inputs are added, and the sheer vulnerability of the landscape to the current land uses presently in operation (more than 60% of catchment will be irrigated dairy on light or extra light soils). Mr Smeaton refers to kg N loss per kg MS (nutrient use efficiency) which also reflects “resource use efficiency” – the most efficient use of a finite resource for production.

Figure 1: Kilograms of Milksolids per kg N leached calculated from the eight farms: Smeaton (Dairy NZ)EIC: Var 1 CLWP.

The most “resource efficient farms” appear to be on the heavier soils



192 GRANDPARENTING: 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.

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

194 With a grandparenting allocation approach, farmers are essentially rewarded for poor management or choosing to operate high risk farming systems on vulnerable landscapes, contributing to high externalities.

195 The current grandparenting approach adopted by proposed Variation 2 fails to take into account the sustainable productive capability of

soil. As proposed, Variation 2 promotes inefficient allocation and use of natural resources in that the plan proposes significant reductions in leaching irrespective of current leaching and soils being farmed.

LAND USE CAPABILITY AS AN ALLOCATION REGIME TO PREVENT OVERSHOOT

196 I support the use of Land Use Capability as an allocation regime to prevent over allocation. I understand there is not scope for this to be implemented in Variation 2, but given the fact this part of the Plan will be reviewed and amended in 2023/24 to give full effect to the NPSFM, I have included as an Appendix 4 my explanation of how use of the LUC classification could assist.

197 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.

198 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.

199 Furthermore, the plan requires existing dairy and dairy support farmers to significantly reduce leaching while allowing new intensification in a catchment that is already overallocated. This means that established farming operations will be forced to undertake significant and expensive steps to reduce nitrogen losses, while new entrants are allowed to leach more nitrogen than baseline land use.

200 The over allocation of new assimilative capacity (that doesn't actually exist) will penalise the best farmers 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. Secondly, they are expected to drop further from a BMP position to facilitate the allocation of an already "over allocated" catchment.

201 A possible outcome from this situation is "stranded capital" on new and existing farms in the future. An almost inevitable result of the provision of an additional 1232 tonnage of nitrogen in an already over allocated catchment is an "overshoot" of ecological capacity. This may result in more painful claw-backs in the future.

202 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.

203 There are numerous examples of farmers and studies reducing N loss by 20-60% in both actual and observed cases.

204 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.

205 Hence, careful allocation of ecosystem services aligned with legitimate ecological monitoring regimes, along with applying a precautionary principle at the outset of this plan given current uncertainties and risks, is just part of "good business planning."

PHOSPHATE AND PATHOGEN MITIGATIONS

206 Phosphorus and faecal losses from the farm largely occur through overland flow pathways. The most common being: effluent run off into surface water; stock in waterbodies; sediment released from the land through poor farm practices; run off from farm drains, tracks, or stock crossing points; from soil run off from intensively grazed pastures; dung deposits; and fertiliser additions. The amount of phosphorus lost from the farm depends heavily on spatial factors and the type of on farm management practices.

207 Winter cropping and winter grazing management practices for stock can have significant impacts on the risk level of phosphate loss from a farm system. Feed pads and “standing herds off” during inclement weather, herd homes, and wintering structures are all part of mitigating the risk of phosphate loss to the receiving environment.

208 Recommend riparian setback distances from waterbodies (of which Mr Canning will refer to in his evidence) and recommend amendments to schedule 7 and schedule 24 to address riparian setbacks and your points on P management.

DATED this 15 day of May 2015

DR. ALISON DEWES

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APPENDIX 1

BARRIE RIDLERS MODELLING _ DAIRY

APPENDIX 2

BARRIE RIDLERS MODELLING SHEEP AND BEEF>

Appendix 1Report to Fish and Game Hinds: Dairy 1 and Dairy 2

Hinds Farms Tables 1 and 2 and notes of explanation.

Description Hinds Dairy Pivot irrigation	Hinds Dairy 1	Reduce cows	Optimise N & cows	Range Kale Allow grazeoff	Limit Nx to 100,000 kgNx	Limit Nx to 90,000 kgNx	Limit Nx to 85,000 kgNx	Limit Nx To 80,000 kgNx
Hectare	210 ha	210 ha	210 ha	210 ha	210 ha	210 ha	210 ha	210 ha
Run no.	Base	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8
No Cows	840	721	735	750	750	690	647	607
kgMS/cow	452	455	455	456	456	455	456	455
R1yrRepl								
R2yRep	193	160	169	173	173	159	156	147
KgN/hatotal	276	290	208	172	106	0	0	0
KgNspr	?	135	78	52	44	0	0	0
KgNaut	?	155	130	120	62	0	0	0
Supplmade	0	40,000	9,000	28,000	59,000	165,000	67,000	20,000
Pastdiscard	0	0	0	0	0	20,000	150,000	240,000
SIlagebuy	87,500	0	0	0	0	0	0	0
Hay/Straw	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000
Wheat	576,000	103,370	0	0	0	0	0	0
Carcase wt	35,400	30,190	31,040	31,685	31,685	29,135	27,440	25,550
Calf sales	585	500	512	523	523	481	451	423
MSprodn	379,500	328,305	334,681	342,000	342,007	314,255	294,767	276,400
$Income @ $6.40MS	2,541,621	2,198,278	2,240,962	2,289,907	2,289,907	2,104,166	1973665	1,850,700
$costs	1,628,650	1,206,283	1,239,510	1,189,284	1213083	1103427	1035562	978126
$Surplus	912,971	991,995	1,001,452	1,100,622	1,076,824	1,000,739	938,103	872,574
kgNleach/ha	89	87	81	error	62	48	45	43
	3155	2881	2660	2510	2386	2171	2060	1961
N excreted (urine)	124,760	117,395	110,382	105,000	100,000	90,000	85,000	80,000
N retained	28,507	24,654	24,250,	247,796	23974	21,872	2,060	1,961
Crop area grown	25ha Kale winter	25 Kale winter	25 Kale winter	2ha Kale winter	0	0	0	0
Total eaten kgDM	4,055 tonne	3,354 tonne	3,257 tonne	3,051 tonne	2,915 tonne	2,671 tonne	2,491 tonne	2,329
Graze off R1	0	0	45	0	All off	All off	All off	All off
Graze off R2	0	0	0	All off	All off	All off	All off	All off
Grazecows	0	0		All off	All off	All off	All off	All off

Description Hinds Dairy 2 Pivot, Rotorainer & BDyke	Hinds Dairy 2	Opt Herd Target N Lmt graze off	Opt Herd Fix N graze off 200 cows	Range Kale Allow grazeoff	Limit Nx to 100,000 kgNx	Limit Nx to 90,000 kg Nx	Limit Nx to 85,000 kgNx
Hectare	210 ha	210 ha	210 ha	210 ha	210 ha	210 ha	210 ha
Run no.	Base	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7
No Cows	710	702	665	649	611	579	506
kgMS/cow	410	417	417	417	418	417	417
R1yrRepl							
R2yRep	162	160	153	149	141	133	116
KgN/hatotal	253	198	198	15	0	0	0
KgNspr	120	110	110	Spring 15	0	0	0
KgNaut	133	88	88	0	0	0	0
Supplmade	100,000	350,000	450,000	100,000	90,000	60,000	75,000
Pastdiscard	0	0	0	0	240,000	140,000	460,000
Maize SIlagebuy	34,000	0	0	0	0	0	0
PKE	49,480	0	0	0	0	0	0
Wheat	122,000	0	0	0	0	0	0
Carcase wt	29,637	29,555	28,291	27,436	25,763	24,495	21,535
Calf sales	495	489	464	452	426	404	353
MSprodn	290,297	293,096	277,695	270,948	255,210	241,617	211,550
$Income @$6.40MS	1,957,291	1,970,395	1,866,817	1,821,499	1,715,713	1,624,269	1,422.084
$costs	1.188,442	1,178,473	1,112,078	814,560	926,318	878,306	783,461
$Surplus	768,849	791,921	754,739	814,560	789,395	745,963	638,623
kgNleach/ha	71	63	59	44	41	39	34
Total CO2 Tonne	2747	2384	2274	2088	1981	1895	1690
N excreted	102,905	95,000	90,000	85,000	80,000	75,000	65,000
N retained	22,057	20,544	19,462	18,938	17,831	16,876	14,766
Crop area grown	0	0	0	0	0	0	0
Total eaten kgDM	3,407 tonne	2,804 tonne	2,630 tonne	2,507 tonne	2,347 tonne	2,,203 tonne	1,880 tonne
Graze off R1	0	All	All	All	All	All	All
Graze off R2	0	All	All	All	All off	All off	All off
Grazecows off	0	200	200	350	350	350	350

Notes to explain aspects of Table:

All analysis is based on the GSL resource allocation model which uses a series of interlinked functions of production (“Resources” such as pasture, feeds, animal requirements) linked mathematically through energy equations. All these production functions are “tagged” with a $ value.

The final analysis uses linear programming which consists of a specific mathematical algorithm that allows a comparative analysis between each available resource using marginal analysis of the additional (marginal) costs/saving versus additional (marginal) value of the product as any change occurs within the system.

The Linear programming (LP) ensures resources are substituted within the model (more or less used; one resource substituted for another) as an integral part of this marginal analysis. This is not a function of operator control unless constraints are specified. This makes the GSL model distinctly different to other models.

- Marginal analysis which allows substitution.
- Fully integrated feed-back loops
- LP to provide iterative solutions until the optimal combination is achieved.
- Limited only by specified constraints not user selection.
- Constraints can be applied to either inputs or outputs. This allows output constraints to limit N leach in a structured manner.
- Economic outcome linked to production throughout the iterations which determines resource use. Other models calculate production scenarios then attribute a gross margin based on feeds used and product quantity x price. Such results are one off. They do not signify a best result, just a result that may or may not be close to best.

(Ref: McCall; 2012)

The Method is to establish the Base Farm from original data as best possible.
In this case, data has been used from the Hinds dairy and dry stock farms supplied within the report completed by Mark Everest of MRB.

Each of the subsequent Runs in the Tables can be linked directly back to the Base run where base resources and costs prices were established. If any change occurs between one Run and another, the reasons can be tracked by comparing how the resource use has altered from the Rows data.

NOTE the costs and MS price **($6.40/kgMS**) as used in the MRB report have been used to ensure a true comparison of economic outcomes as Nitrogen constraints are applied.

Being LP, the GSL model can be used to constrain both inputs and outputs.
The GSL model calculates feed required from all sources to achieve production levels achieved. These feed sources are linked to factors that create both Green House Gases and Nitrogen leaching potential through the amount of nitrate being excreted into the farm system. This GHG layer was added to the model in 2007-2008. The work was both paid for and validated from work contracted by MAF Policy. (Ref: MAF Policy).

The GSL model has subsequently been validated by monitored data on Lincoln University Dairy Farm which altered management policy based on GSL model analysis in 2010 and implemented 2011. (LUDF Farm Walk notes 2012).

Base Run.
Same resources, costs, prices and production as in MRB report ($6.40/kgMS).
Overseer Leaching figures 87 kg Nitrogen leach / ha/ year for MRB and 89 kgN/ha/yr. for GSL. (Overseer values determined by Joe Edlin, Headlands.)
Subsequent Runs all adjusted within GSL to better (more efficiently allocate resources) management options rather than immediately introduce capital intensive mitigations.

Run 2
LP allowed to adjust herd number, Nitrogen use, area of crop and ensure all energies balance and pasture covers remain at appropriate levels for every 2 weeks of the year.
The model can substitute between resources (feeds, herd numbers, nitrogen use) depending upon the marginal returns that are available to improve overall farm profit.
The model reduced herd number at same production per cow by 119 cows.
The model altered nitrogen applications to 295 kgN/ha with the majority (4x40kgN/ha 1x February, 2 x March, 1x April) and 1x40 August, 1x 40 September, 1 x 25 October and 1x 30 November. Some surplus pasture was made into silage in early November.

Reduced bought in feeds.
This was due to the nitrogen being more economic than wheat and purchased silage.
This provided a reduction in inputs (bought in feeds, rearing and replacements costs, cow costs and some labour costs – no capital savings from less debt required were included).

The logic of this herd reduction would be that instead of rationing pasture to a larger herd and feeding high amounts of wheat to fully feed animals, the herd number (and replacements) reduction freed up the opportunity to feed a higher proportion of pasture to each cow and this reduces the need for as much wheat.

The response rate to Nitrogen was left at 12:1 as per the report but will vary in reality. This aspect can be used to further refine nitrogen application. The model is already indicating where nitrogen is most important by applying to the limit in autumn and reducing in later spring.

These simple management changes were not explored at all in the MRB report yet will lead to improved profits (reduced MS income but a much greater reduction in costs) as the herd of 721 cows fed more pasture make $991,995 whereas the extra 119 cows of the 840 cow herd lost $79,000. This is an example of marginal analysis which the GSL LP uses. Other models cannot distinguish where herd number marginal cost (MC) exceeds marginal return (MR). The point where next additional cow costs more than that animal returns: MC>MR.

The added bonus is that the reduced feed used reduces the Nx (calculated within GSL model and which correlates to N leach figures) and N leach figure (calculated through Overseer). This Nx constraint within the GSL model allows a structured logic to reduce Overseer N leach in the most economical manner. In this case Overseer N leach reduced to 87 kgN/ha.

Run 3
Allowed the model some options for use of kale and also to graze animals off farm. In this case only replacements had the option to be grazed off. The MRB report notes that more land will be used for dairy support so this becomes an opportunity.

This use of off farm grazing will not add to N leach for the catchment (see later analysis). The model chose to graze all R2yr replacements off but only 45 of the R1yr. Grazing off costs included transport ($3-4) and grazing costs (R1yr $8.50/hd/week; R2yr $12.50/hd/week).

This reduction in replacement stock balanced the feed supply/required better (combination of reduced herd numbers and fewer stock at critical autumn/winter and early spring periods with replacements grazed off). Although the total amount of feed eaten remained similar (see Total feed eaten kgDM of 3,257,000 kgDM in Table) 735 cows could now be milked with no requirement for wheat. This will no doubt create a debate about whether this could be possible and was the argument used by some at the LUDF Advisory Board during the opposition to the GSL instigated herd and feed input reduction versus higher herd numbers and wheat feeding in-shed, debate. (See LUDF reference.)

LUDF have shown that pasture in sufficient quantity and quality is capable of fully providing the energy for milking cows at up to 500 kgMS/cow. Run 3 provided more $surplus again with reduced Nx and N leach of 81 kgN/ha due to reduced feed eaten and Nitrogen used (208 kgN) but all kale area was still retained.

Run 4
Extended the option for grazing off to all stock (mature cows $24/hd/week).
The model grazed all stock off (except R1yr replacements) to balance feed supply and demand better. This allowed herd number to increase to 750 and removed the need to grow a crop of kale. Nitrogen use reduced to only those times most economic (August and September at 28 and 24 kgN/ha) and autumn when 3 applications of 40kgN/ha were applied March and April. Some farm made silage transferred feed to late lactation and also helped retain pasture quality. The grazing off of all the herd and R2yr stock, reduction in crop area and reduction in N use reduced feed required on farm. Once again $surplus increased with reduction in costs and decrease in Nx but Overseer had an unresolved error.

Run 5
This was the first run that required the model to decrease the amount of Nx (specified not to exceed 100,000kgN). The model altered some resource use but herd number remained at 750 cows. All stock were grazed off and some N use decreased (28kgN August, 16 kgN September 30 kgN/ha February, 32 kgN/ha March). Although this reduced N leach, it also resulted in the first decrease in $surplus which had hit a maximum of $1,100,622 now reduced to 1,076,824 (compared to $912,971 for Base Farm). No kale crop again used but 59,000 kgDM as farm silage transferred from November to late autumn (hence reduction in N requirement for April). The constraint imposed on Nx within the model resulted in a reduction in N leach to 62 kg N/ha.

Run 6

Nx reduced to 90,000kgN. This resulted in a need to drop herd number to 690 cows with no nitrogen use and all stock grazed off. Indeed, by this stage, the constraint on feed allowed to be fed (to reduce Nx from feed eaten) resulted in high quantities of feed being transferred from spring (no Nitrogen used as excess feed for 690 cows) to autumn. This aids autumn feeding. However this is not enough feed reduction. If the pasture continues to grow at Base Farm levels (less nitrogen influence) too much feed is produced and the model must "discard" 20,000kgDM from an excess in January. This may have the option as being sold or stored. Although N leach reduces slightly, $surplus drops to $1,000,740, still higher than the Base Farm but at a much reduced N leach of 48 kgN/ha.

However it is doubtful that this can occur. Research has shown that for irrigation water to be effective at the level MRB require, additional nitrogen and phosphate must be applied. This cannot happen and remain below the 48 kgN/ha leaching found by Overseer.
Effectively, this is the minimum N leach that an irrigated dairy farm on this soil type can reduce to with the current Overseer. If other mitigation strategies are now introduced, capital expenditure increases markedly and farm expenses as well.
The GSL model can be used to better balance irrigation, use of Nitrogen and herd number production but time prevents this at present. However there will be a better balance achievable but even then it will be unlikely N leach can be reduced economically below 40 kgN/ha with current Overseer and irrigation.

NOTE: Unsure if any cost for actual water price has been used for MRB costs.

Run 7

Nx reduced to 85,000Nx.
Reduction in herd to 647 cows all other stock off.
This small additional reduction in Nx (N leach) and N leach (45 kgN/ha) has an increased impact on $surplus which reduces to $978,103.
Discarded feed rises to 150,000kgDM.

Run 8

Nx reduced to 80,000kgN.
Herd reduces to 607 cows.
Although only a small reduction in N leach has been achieved (43 kgN/ha or only a 2kgN leach reduction***) the marginal cost of each additional kg of N leach has cost $52,700 /kg N leach.***

It is because of this ability to price each successive decrease in N leach and link it to the associated change in $profit that GSL can produce an N leach vs. $cost that actually makes sense. As stated before, this scenario may still not be possible as no nitrogen can be used and feed eaten cannot exceed a level that the farm is already exceeding.

<u>Hinds 2 Dairy.</u>

Similar methodology has been used for these Runs using the MRB base data.
In this case, 3 areas were used each with differing irrigation types and yields.
As the Nx (N leach) constraints were applied, the model eliminated the least efficient type of irrigation (border-dyke) then 50% of the Rotorainer. This reduced feed grown and N use but once again even with this less productive scenario, achieving N leach limits below about 40 cannot be achieved economically with current version of Overseer. Once again, when about this level of N leach is reached, each additional reduction in N leach increases.
Between Run 4 and 5 the cost of each additional reduction in N leach is $8,000 but from Run 5 to 6 this increases to $22,000 per kg N leach.
This is the impact of marginal change when the factors being examined are non-linear. Averaging N leach reduction and cost without understanding that the marginal decrease in economics of reduction is increasing at an increasing rate does not convey the correct message.

These irrigated dairy farms cannot achieve N leach figures below a critical "tipping point" and remain viable. Only marginal analysis can identify this point.

<u>Sheep/Beef to dairy conversion models.</u>

The basic methodology of establishing the comparative base then only allowing alterations to specific resources to ensure a true comparison using marginal analysis is used for the other examples. The reasons for the changes can be deduced from the Tables as completed above.

The ability to compare across farm types (dairy vs sheep vs sheep and beef, irrigated and unirrigated) can be justifiably questioned. (Alison Dewes Pers comm). The capital involved between each intensification from dryland sheep to sheep/beef to part irrigated beef plus dairy to dryland dairy then irrigated dairy requires varying amounts of capital and thus contingent increases in interest, depreciation, repairs, insurances, labour, effluent, shed, houses, feed pads or enclosed feed areas, shares, stock, management and administration costs.
In all these schemes that involve such intensification these costs vary in terms of being correctly identified for correct marginal analysis between systems. Costs go from variable to what are really fixed and fixed/variable costs. Once the investment is made, the costs must continue as both direct (interest, R&M) and indirect costs (depreciation) that must be accounted between systems.

This also makes the whole system far more fragile and any downturns (product price, reduction in water due to drought) has a much larger impact than on a more balanced system designed for such variations.

Capital costings are difficult to introduce between farm types. The GSL model treats irrigation like a crop so that *most* of the costs are attributed to the additional feed grown.
But no cost for water has been included. If this was done, the irrigation costs would increase by about 30-50% and reduce apparent "profit" by a similar amount.

The model will not accept irrigation unless forced to do so.
The figures that relate to dryland vs irrigated may not be directly compared as the differing capital involved must be fully accounted. This is beyond the scope of the work completed here as full farm production and financial budgets must be completed for each run including deprecition. Although this is possible within an additional layer of GSL, it requires some assumptions as to values of improvements required on sheep vs sheep beef vs dairy support vs dryland dairy vs intensive fully irrigated dairy.

Suffice to state that full costs between dryland base farm and intensified irrigated dairy have not been completed and caution needs to be taken if trying to compare between initial dry land and irrigated.

It seems an obvious option that dry land farms could be developed with some of the dryland pastures and forages now being widely used. More importantly, these are now being managed more successfully. The GSL model found little difference between dry land and irrigated land when water was "free". Once the water has a price, the model would not choose irrigated pastures over reasonably managed dry land options.

However the way Overseer works, as forage mass increases, production will also increase and so will N leach. The GSL model shows this is inevitable. But the N leach limits will be attainable at a higher economic return with such dry land techniques than with irrigation.

The only discussion then becomes whether animal production can be achieved as assumed and whether the model changes (reducing herd numbers and inputs) can be implemented on real farms.
This debate must be framed around the reality that LUDF have used this technology to implement a changed management policy that has been found to be very successful in creating larger profits.

- (GSL was used to design and implement new policy (reducing herd number, improved production/cow yet no increase in GHG emissions or N leach) then aid monitoring actual commercial and R&D farm (Lincoln University Dairy Farm) http://www.siddc.org.nz/assets/LUDF-Focus-Days/10-May-2012-.pdf page 8/9

The same effect has been documented on a far less productive farm in the Rotorua area where 320 cow herd was reduced to 280 cows along with other changes to resource use. Bought in feed reduction, less N use and increased per cow production. Cow production increased from 342 kgMS/cow to 412 kgMS/cow despite some observers predicting it could not work as reducing herd number would lead to reduced feed utilisation and poorer quality pasture. Some researchers certainly rely on such findings in constructing their models (Doole 2014) yet other researchers have not found that effect (Glassey).
Commercial farmers are showing increases in per cow performance when herd numbers are reduced with appropriate subsequent management. (Alison Dewes 2014).
Of more relevance would be the effect on irrigated pasture when N and P are reduced. Recent New Zealand Research work has indicated that to get the response rates to water as quoted in

the MRB report much higher levels of N and P must be used. Any reductions to these inputs reduces the response to irrigation to non-profitable levels.
This brings into question the response to water when GSL is forced to remove all nitrogen use as N leach constraints are increased. If this reduces, the economics reduce at a faster rate.

No attempt has been made to assess the economic viability of the whole scheme. Production economic analysis (Fraser 2014) has shown that much irrigation water is not profitable below MS prices of $8 even with the best response of pasture and when no N limits are in place.

Previous work looking at feed barns have shown them to be uneconomic options to reduce N leach figures, especially if the leaching needs to be reduced more than 3kgN/ha.

Forages, optional bought in feeds, different pasture species have only a limited effect due to their normally small impact on total feed used.

Conclusions:

- **Management options of reducing herd number are the most economic first stage mitigation.**
- **The use of irrigation to intensify production increases N leach beyond the limits allowed.**
- **The costs of irrigation compared to the additional returns are unlikely to provide better profits than improved dry land systems but will leach far more nitrogen.**
- **Each of the systems reach a critical point beyond which the increasing cost of achieving an additional N leach reduction will make the farm unviable.**
- **Mitigation strategies that involve large capital expenditure add even more fragility to any system and are of little value in reducing N leach as stock numbers must be reduced as well and this makes such structures redundant.**

References:

Doole; Graeme J. Doole , Alvaro J. Romera , and Alfredo A. Adler. An optimization model of a New Zealand dairy farm J. Dairy Sci. 96 :2147–2160

Chris Glassey, DairyNZ, Hamilton, Sean McCarthy, DairyNZ, Palmerston North, and Virginia Serra, DairyNZ, Lincoln. STOCKING RATE: MORE IS NOT ALWAYS BETTER. DairyNZ address Research Day Hamilton

Fraser P, Ridler, B.J, Anderson, W.J. The Intensification of the NZ Dairy Industry. NZARES Nelson August 2014

McCall:

Before Hearing Commissioners at Christchurch
and:
Statement of evidence of **David Graeme McCall** (Farm management) for Fonterra Co-operative Group Limited and Dairy NZ Dated: 12 October 2012 REFERENCE: John Hassan (john.hassan@chapmantripp.com) Luke Hinchey (luke.hinchey@chapmantripp.com)
Before Hearing Commissioners at Christchurch

under:	the Resource Management Act 1991
in the matter of:	Submissions on the Proposed Hurunui and Waiau River Regional Plan
between:	**Fonterra Co-operative Group Limited** *Submitter*
and:	**Dairy NZ** *Submitter*
and:	**Canterbury Regional Council** *Local Authority*

33 The four farms were analysed through the GSL linear programming (*LP*) model.[3] The GSL model was developed, and is operated, by Mr Barrie Ridler a former senior lecturer in farm management at Massey University. The model calculates the maximum profit for a farm for a given level of input-resource use. Resulting leaching loss predictions were calculated on Overseer version 5.4.10.

3 The GSL model was chosen over Farmax (which was used for the calculations presented in Brown et al 2011, and of which the author of this evidence was a developer). This was because GSL is more efficient at finding optimal resource use allocations due to it being an optimising, rather than a simulation model. With simulation models (such as Farmax) the definition of optimal resource use requires the user to iterate their way to an optimum solution. This iteration is time consuming, not always full-proof and optima may be missed. Predictions from Farmax and GSL are very close, given similar resource inputs. This is shown in Table 1 where predicted outputs for the current configuration for three of the farms which had previously been loaded into Farmax by another user, were compared with predictions by GSL. It means that the only significant difference between the models is in the model structure (optimising – GSL, versus simulation - Farmax).

LUDF Farm Walk notes 2012: http://www.siddc.org.nz/assets/LUDF-Focus-Days/10-May-2012-.pdf

LUDF May 2015: http://www.stuff.co.nz/business/farming/dairy/68263916/B-plus-grade-for-profits-at-Lincoln-University-dairy-farm

MAF Policy:

- GSL model specifically adapted with an IPPC specified "GHG layer" to provide analysis for both GHG and N leaching reductions with least economic impact (MAF POL 0809-11027 Mike Jebson/Gerald Rys)

- Used for MAF empirical analysis for TAG Agriculture Component of the NZ ETS Wellington 2008.

which was then validated over a number of farm types (Hard Hill, Hill and Intensive sheep and beef North and South Islands) and farm systems Sheep, Beef, Sheep and Beef plus Mixed Finishing and Dairy (Waikato, Taranaki, Canterbury.) (MAF POL 0910-11701 Feb 2010 for Minister of Agriculture per Andrew Hume).

Published paper of part of this work. *Proceedings of the 4th Australasian Dairy Science Symposium 2010* : The effect of increasing per cow production and changing herd structure on economic and environmental outcomes within a farm system using optimal resource allocation.

Appendix 2: Report to Fish and Game Hinds: Dry stock intensified to irrigated dairy.

HINDS Synthetic 340 ha;8,000 kgDM sheep flock beef trading weaner change to graze heifers then graze winter cows support block. Objective: N leach change.

Description	Base	Sheep	S&B + Graze R1yr heifer	Beef + Graze cows	Beef Graze cows
Hectare	340	340	340	340	340
Run no.	Base	Sheep	S&B Fixed area Irrigate 150ha	Beef/graze Irrigate 150ha	Opt irrigate 79ha@$500cost
Number ewes lambing	1000 includes hoggets	3,900 includes hoggets	1000 includes hogget's	0	0
Lamb%	136%	136%	136%	-	-
Replacements	347	1,351	347	-	-
KgN/ha total	32 av	0	32N /150ha 150N/150ha irrigated	150N /150ha irrigated	150/79ha irrigated
Spring/Aut N	16 +16 av	0	Spring autumn	Spring Autumn	Spring Autumn
Crop N	18N/58	18/58	18/58	18/58	18/58
Suppl made	0		400,000	520,000	580,000
Concentrate	15,000	40,000	19,000	0	0
Sell store	217 Jan	1294 Mar	217 Jan	-	-
Sell works	776 Mar	2580 May	776 Mar	-	-
Date/Weight	25-41kgLW	26-41 kgLW	25-41kgLW	-	-
Beef buy	620	0	750	1110	1000
Date/weight	Mar 222kgLw	0	Mar 222kg	Mar 222kg	Mar 222kgLW
Beef sell	617	0	746	1100	998
Date/weight	Feb/Mar 520kgLW	0	Feb/Mar 520kgLW	March 530kgLW	Early March 520kgLW
Graze cows	0	0	0	500 June July 10weeks	500 June July 10 weeks
GrazeR1yrHfr	0	0	970 Nov-June	0	0
Date weight	0	0	80Nov220kgJne	452-502	452-502
Price	-		$8/week	$22/week	$22/week
$Income	855,730	464,900	1,213,790	1,479,998	1,136,840
$costs	523,533	217,800	968,554	1,178,444	628,116
$Surplus	332,196	247,100	245,240	301,554	508,724
N excreted	**70,110**	**70,400**	**102,387**	**101,590**	**83,798**
N leached					
N retained	7,358	6,262	13,096	11,543	10,196
Total kgDM use	2,487 tonne	2,536 T	3,328 T	3,309 T	2,883 T
Crop area ha.	20 winterkale 10 Barley	28winterkale 10 barley	20winterkale 10barley	20winterkale 10barley	20winterkale 10 barley

The objective of this work was to establish a Sheep and Beef Base Run using all MRB figures as closely as possible ("Sheep Beef & Deer Current") but dropping all deer and allowing beef buy / sell to take their place with a small increase in flock number to 1000ewes.
All buy sell dates and predicted weights in line with MRB data.
Used all MRB schedule and store prices but GSL model sold lambs at slightly lighter weights and stored some as this was more profitable than taking all through to 18.2kgCW when many are past their most efficient conversion of feed to live weight.

This area of land (340 ha growing 8,000 kgDM/ha/yr.) was then used as an example of how such dry land may be developed with the opportunity for irrigation (at some capital cost) or improved forage species.

These changes were then attempted to be run through Overseer to track the likely increase in N leach between the current base and the change in N leach as each step of intensification or change of resource was implemented. However Overseer 6.3 would not solve for these mixed scenarios. The GSL model provides a figure termed "Nx" from the specialised GHG layer within the model (commissioned by MAF Policy 2008-09) which usually has a very close correlation to Overseer N leach. (Pers com. Alvaro Romero: DairyNZ.)

Base Run

Is close to MRB for feed produced and total product.
GSL made more profit but is not strictly comparable in this with MRB as different numbers and class of stock and unsure of details on all costs included.
The GSL numbers for profit in this case are indicative only between runs as varying levels of capital are required between systems. Sheep require 8 wire fence standards, yards and woolshed including press whereas beef and grazing require only very good yards, weighing systems and cheaper electric fences. Capital, repairs and maintenance, depreciation and interest on extra costs of capital will differ between systems.
The model required more energy than could be supplied for hogget lambs and some 2th twins and all triplets to achieve required LWG. The model sold all these lambs store at weaning from 24-28kgLW. The model "concentrates" are merely indicating this shortfall in energy and flagging that such production may not be achievable rather than recommending the widespread use of supplements. If alternative forages could be grown, many of these will have the higher energy to cater for such ewes and their lambs.

This run sets the current figure for N leaching from this type of basic dry land system.
The emphasis is to follow the changes in N leach (GSL Nx) between changes in stock type and feed use as the opportunity for irrigation (or better growing dry land forages) presents.

Run 2

Sheep only. Flock only limit. GSL model calculated 3,900 could be run with feed available and production figures and system as stated.
This Run altered the farm to an all sheep breeding and sale farm using the same pasture growth, product values, costs and production criteria as the Base farm.
The model found that with the same feed and only sheep, the farm could run 3,900 ewes and lambing hoggets.

Note that there was not enough energy to grow the smaller hogget and twin lambs as fast as required for sale dates. The GSL model required varying levels of "concentrate" to make up this larger shortfall with higher flock and hogget lambing figures.
In reality, some lambs will just not meet live weight targets and be sold at lighter weights on the store market. The $profit will therefore be lower (although there is a cost attributed to the concentrates required within the model.)
1350 replacement lambs
1287 hoggets
1049 2 yr
819 3yr
581 4yr
104 5yr culled March

No nitrogen used by model as not economic.
N excreted (N Leach proxy) same as mixed Base Run as just slightly more total kgDM feed used. More winter crop (kale/fodder beet) to winter more stock numbers so maybe N leach will be higher.
Cash crop of barley remains.

<u>Run 3</u>
Sheep (1000 fixed flock) plus variable beef trade and grazing R 1yr heifers 80 kgLW Late October to 220 kg LW June (Kiwi cow.)
Intensify system by forcing irrigation of 150ha. Model would not use irrigation until forced to do so as costs ($1600 of additional costs associated with irrigation but no water cost) exceed returns. The Flock was fixed at 1000 lambing with a range for buying beef March at 222 kg LW and sales in February March at about 516-526 kg LW.
A range of R 1yr heifers was also allowed into the model.

Result was that with 150 ha irrigation (add 6000kgDM/ha over base 8000 kgDM pasture) the model chose to trade 750 beef animals and graze 970 dairy heifers at $8/ week (plus some health costs).
This allowed the model to utilise most of the added irrigated pasture grown but 150kgN /ha was required on irrigated pasture.
Despite this there was a mis-match of feed grown at certain times of the year and about 400,000 kgDM as silage was harvested to feed in late autumn.
About 900,000 kg more feed was grown with N excreted increasing to 102,390 kgNx or about +30% for less money than the base farm due to irrigation costs.

<u>Run 4</u>
Beef + trade beef +graze cows with 150 ha irrigation fixed at $1600 cost/ha (no cost for water). Sheep were the least profitable option and when allowed to choose between sheep, beef trading and grazing dairy cows for 10 weeks over winter, the model rejected sheep and used all the feed for 1110 beef traders and 500 (limited number) of dairy cows for 10 weeks at $22/week gaining weight from 452-500kg LW over this period.
Profit increased without sheep and as the model could only use resources available as in Run 3, this combination resulted in more profit with similar feed eaten and N excreted.
Once again the irrigated pasture created an unbalanced feed profile (feed grown vs feed required by stock) and 520,000 kgDM of silage was made and fed with the Kale crop in the winter. The

dairy cows required this feed plus the model adjusted beef number and sale dates to allow increased autumn saved pasture as a higher Average Pasture Cover (APC) to ensure more feed for the cows.

Run 5

Beef trading and winter 500 cows. Reduce price of irrigation until model uses irrigation. Used 79 ha of irrigation only when cost per hectare decreased to $500/ha. This shows that irrigation will not be the most profitable option for these production systems.
150 kgN used on the 79 ha irrigated. None on unirrigated.
At $500/ha this option made an increased profit even though less beef trading occurred. Again a large amount of feed was transferred from spring to winter but as less feed overall, N excreted reduced.
Note that this $profit cannot be compared across the other runs as the irrigation price was reduced to find where irrigation became competitive.

GSL model found 78ha only was worthwhile for only one of these production systems (beef trading/finish and winter grazing) if the costs were no more than $500/ha.
This is due to the unbalanced matching of feed between irrigated pasture and beef plus winter grazing of cows and the product price vs. costs involved.
Large quantities of silage need to be transferred from October and November into winter (along with 20ha winter forage) to match feed grown to feed required.
This is due to the unbalanced feed profile created by irrigation in many marginal climatic regions where lower winter growth and slower spring growth occur.
This transfer of feed between seasons is also a costly process.

“Conversion” of dryland farm from base of mixed beef buy/sell and some dairy, converted to all dryland dairy (8,000kgDM MRB) then allowing the model to choose or be forced to use irrigation with full dairy conversion. No attempt to introduce alternative forage species into a system (Moot 2003) was attempted but would seem a logical exercise to better compare profitability.

The GSL model is a mathematical model which uses specific algorithms to interlink any resources available.
This means that a number of options can be included in the model. The mix of options is chosen by the model during the marginal analysis process. This is quite different to all other models where inputs are chosen, a result is generated, then the process continues for as long as the operator decides. GSL system using LP chooses the best mix of resources during a feedback iterative process and is therefore the best model for any comparative analyses such as required in most agricultural systems (McCall 2012).
The GSL model has the added advantage that it can be constrained to then choose on the basis of the best economic outcome that complies with any N leach constraints.
The operator can leave this process entirely up to the model (optimise) or choose to constrain the model within specified ranges.

This makes this type of model extremely useful for accurate comparisons when making any alteration to a system.
The term “system” is correctly used in this context as the GSL model requires all inputs to balance and integrate correctly due to the linkages between all resources.

The model is not a single run model but follows a marginal costing routine for each option to provide an economic outcome, which it then revises by adjusting and revising resource uses or combinations to work towards the best result.
These continual re-evaluations are termed “iterations” and rely on feed-back loops between all resources and input/output values.
Each result is therefore the result of many thousands of iterations to select the best combination.
This process establishes the best combination or system for any circumstance.
The marginal analysis also allows the ability to perform sensitivity analyses rapidly by altering a selected cost or product price to ascertain how important each change to that cost or price change will be.

So there is this mix of feeds and animals that should be managed to provide the best resource allocation efficiency by way of marginal costs and returns, but overriding these economic and production solutions are the requirement to also limit N leach.
LP cuts through this constrained multiple use resource use issue to provide clear *solutions without requiring any guesswork.*

For this final Table, this optimisation with specific constraints function was used many times. Only 3 final runs are presented.
Sensitivity analysis within the GSL model allows quite accurate commentary on how fragile or non-fragile any other combination or cost/price fluctuation will be.

TABLE 3 “Conversion” of 340 ha to dairy and beef dryland, dairy dryland, dairy irrigated.

Description	Hinds		
340ha	Dry land Dairy/Beef Turnips	Dry Dairy All cows Turnips	Irrigated 250ha Dairy
Hectare	340	340	340
Run no.	1	2	3
NoCows	540	552	1023
kgMS/cow	398	398	425
Replacements	115	120	235
KgN/ha	25 SPR	25 SPR	70 SPR 68 AUT
Supp made	0	0	0
Buy Silage		43,000	250,000
PKE	0	0	300,000
Buy/sell beef	250	0	0
Wt date	222kgmar- 520kgmar	0	0
Carcase wt cows	24643	24868	45481
Calf sales	381	390	722
MSprodn kgMS	215,400	220,436	434,565
Income $	1,618,043	1,513,350	2,971,275
Costs $	927,492	821,802	2,328,462
Surplus $	690,550	691,549	642,813
Total CO2 Tonne	551	558	1130
N retained	15647	15896	30812
N excreted (urine)	**74,430**	**75,500**	**156,443**
N leached KgN/ha			
Crop area grown	40ha sum turnip	40ha sum turnip	25ha sum turnip
Total kgDM	2,595,620	2,633,914	4,828,430
Graze off cows	All	All	All
Graze off replacements	All r1yr 75R2yr	All R1yr 80 R2yr	All

Run 1
Allowed the model to buy and sell up to 250 weaner (222kg LW purchase March at $2.40/kgLW or $533; sell 12 months later at 516 kg LW or $1170. Figures from MRB report) or to run as many dairy cows producing 398 kgMS/cow as feed allowed.

The model chose to run the maximum allowed beef for 2 reasons.

- 1 the beef operation was quite profitable with these buy sell and LWG figures
- 2 the beef operation allowed a better balanced feed demand profile as in the dryer months there was less demand for feed.

The model did not choose to use any irrigation at $1600 full cost/hectare for any of the sensitivity constrained combinations. It was only below $500/ha irrigation was used and then only 79 ha.
All R 1yr heifers and all cows were grazed off, but R2yr heifers remained on the farm to balance out the feed supply vs feed required.
The GSL model preferred to transfer feed from late spring to summer by using up to 40 ha turnips (or equivalent forage) rather than making silage (some topping occurred) as the turnips yielded 11 tonne and were higher energy than summer grass or silage.
This area provided the option to replant into alternative forages.
There is considerable research work on dryland forages now available (Moot 2008; 2011; 2012; Mills 2006; Brown 2003; 2004; 2005). Time prevented using these options where Lucerne, cocksfoot, clovers, Prairie Grass, Chicory and Plantains have been shown to grow up to 4,000kgDM/ha more than existing pasture even in dryer conditions.
Such forages will therefore supply about 2/3 of that from irrigation with far less cost and leaching.
Figures of 11-16,000 kgDM/ha for Chicory; 18,000kgDM/ha for Lucerne; 14,000kgDM/ha for Prairie Grass/Red Clover Caucasian Clover are quoted but will be less under commercial conditions.
(This is an area that needs more work in terms of modelling through this resource allocation model linked to economics and N leaching. It would appear that irrigation will not be required to improve production in many circumstances.)

Run 2
Constrained the GSL model to only dairy cows producing at 398 kg MS/cow.
Without the beef option, more dairy cows were run but the model required to buy supplement to fill a feed gap late winter.
Summer crop still used. Some spring nitrogen used.
Again, all stock except R 2yr heifers grazed off.

Run 3
Irrigation forced into model.
Cow production increased to 425 kgMS/cow. Herd number almost doubled from previous dryland run (552 cows now 1023 cows.)
In order to sustain this herd number with 250 ha irrigation (14,000kgDM/ha requiring more nitrogen and phosphate) all stock were grazed off.
To balance the feed flow (4.8 million kgDM now used compared to 2.64 for dryland with the additional 2 million kg DM growing in a period November through to mid-March) 550,000kgDM was purchased and fed late July to early October and April until cows grazed off.
25 ha of turnips were grown to top up later summer (some pasture transferred forward.)
280,000kg of surplus feed as silage was transferred from November to be fed along with purchased feeds in April-June and some early August.
The irrigated option showed large increases in production and Nx (N leaching) but no advantage in final $profit as the additional costs of irrigation plus bought in feeds was marginally higher than the return from additional production (MS, calves, cull meat.)
Summary:

As the dry land farm is converted to mixed beef and dairy to dry land dairy then to irrigated dairy, the GSL Nx increases as more feed is grown and eaten.
It is likely that N leaching will increase by a margin greater than that indicated by the GSL Nx as irrigation increases N leaching within Overseer.
Without including all costs of irrigation, the model does not find irrigation as profitable as other alternatives.

The results clearly show that the complexity of constraining N leach whilst juggling with a combination of resources with varying marginal values cannot easily be solved.
LP provides solutions that account for each of the requirements, matching them in the best way possible given the overriding constraint of limiting or reducing N leach.

The reality is that as more feed is grown and eaten, the potential for increased N leach grows.
If irrigation is added to this mix, the extra feed grown, fertiliser required for that additional growth, almost doubling of stock numbers, requirement for "shoulder period" and bought in feeds to balance demand with feed grown, will double N leach and at no increased profit.

Although more production ensues, this additional income may be of little benefit to the local community as it largely disappears as interest and depreciation on the infrastructure required for intensification.

It would seem that a better course would be to encourage uptake of alternative dry land forages which require little additional capital and are far less fragile than high cost irrigation. Alternative forages ensure a more reliable balance between feeds grown and required at a very low price. This in itself lowers risk.

Even if alternative forages are used, there is the strong probability that N leaching will increase as more forage is eaten and therefore N excreted and leached.
Overseer 6.3 applied to dairy shows an increase in N leaching with irrigation compared to 6.02.
This increase plus some intensification seems likely to increase catchment load above that permitted without adding 30,000 ha of irrigation.

Conclusions:

- Overseer 6.3 finds N leach figures of between 81-89 kgN leached /ha/yr. for existing dairy example.
- Management options such as reducing herd number, grazing stock off, reducing winter crop and reducing Nitrogen application may halve this figure with some reduction in economic returns.
- Without nitrogen and phosphate additions to irrigation water, the response rates to water from irrigation will reduce.
- But if N and P are added, the N leach figure will exceed 50 kgN/ha/yr.
- Mitigation strategies need to be proven and are not additive in Overseer. For example, housing animals in winter requires even more bought in feed which adds to total eaten on the farm and despite larger effluent area used, will provide only a small decrease in N leach at a high capital and ongoing fixed costs, within the system.
- This creates a risky farm system dependent upon consistently higher product prices.
- Converting dry land to irrigation will double N leach due to water plus intensification (including requirement to purchase "shoulder period" feeds prior to and post irrigation response.)
- The economics of conversion at $6.40/kgMS when using marginal analysis that includes all costs associated with change vs the additional production income mean that the model will not use irrigation even before a price of water is included.

This presents "Catch 22" scenarios where a number of mutually exclusive factors interplay.
Water grows more grass which will produce more crude protein and when eaten, produce more N leach.
In order to get an economic response to water, nitrogen and phosphate must be used yet both these must be reduced to reduce N leach and nutrients into the groundwater.
Irrigation itself increases leaching potential when leaching requires to be reduced from current levels.
Even using improved dry growing forages will increase feed eaten and increase N leach.

The catchment already requires decreased N leach from farms yet no proven mitigation strategies (except management options as described in this report) will reduce N leach by the required margin when Overseer options are used as per protocols now established.

It is difficult to envisage a much larger area of irrigation being possible under these circumstances without an inevitable increase in nitrogen load within the catchment.

The Figures in report Ashburton Zip addendum March 2014 Canterbury Water Report as reproduced below indicate the future difficulties Overseer 6.3 predicts will be faced if irrigation, conversions and intensification are completed as stated.

(Summary of work:

Cannot be completed until get Overseer files producing sensible figures. No time to fully recreate these from scratch.
Rely on GSL generated N excreted figures which show a strong correlation with most Overseer runs except where:
Nitrogen use alters
Forage Crops are introduced
Forage crops are removed
Changes to stock type occur (dry stock to mixed dairy/dry stock then dairy).)

Appendix. (Per hectare costs assuming existing "dry" farm)
Yearly per ha cost irrigation.

DairyNZ irrigation conversion figures per/ha.
Water, re-fencing, tree removal works including earthworks, races and culverts
$2050/ha
Pivot system (includes some charge for pipeline to farm and allowance for irregular shapes and contour) **$5000/ha**

$550 cost of finance (7%. Interest only.)
$675 depreciation and insurance of irrigation equipment + required infrastructure
$150 depreciation other assets
Total added cost **$1375/ha/year**.

Add: cost of power ($78) and insurance and pumping costs ($150) = **$228/ha/year**

Total assumed costs for required irrigation (no water charge) $1600/ha/year.

Should also cost N required for response to N and add into Farm system.
This is not done in these Runs.
Research has clearly indicated that nitrogen is required to gain full benefits from irrigation. In this case an additional 6000 kgDM (8000kgDM to 14000kgDM/ha) is grown and will require in excess of 200 kgN /ha. This is not included in these costs nor in the N leach calculation. The N leach in reality will be higher than that found. When time permits, this additional work can be completed. See Moot and Mills. And Sumenasema Ref.

If this is additional 150kgN/ha this would add $255/ha to this cost figure.
However in irrigation Runs $1600 was maximum additional cost for irrigation.
No additional charge for water was included either.
If 15 cents/cubic meter, N required and running costs for infrastructure as above are all included as additional costs involved for extra 6000kgDM from irrigation, this totals about $2700 /ha (400mm/ha at 15 cents/ cubic meter).

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http://mro.massey.ac.nz/bitstream/handle/10179/1769/02_whole.pdf?sequence=1
Thesis of Massey University Soil Science Doctoral 2003

McCall 2012

McCall:

Before Hearing Commissioners at Christchurch
and:
Statement of evidence of **David Graeme McCall** (Farm management) for Fonterra Co-operative Group Limited and Dairy NZ Dated: 12 October 2012 REFERENCE: John Hassan (john.hassan@chapmantripp.com) Luke Hinchey (luke.hinchey@chapmantripp.com)

Before Hearing Commissioners at Christchurch

under:	the Resource Management Act 1991
in the matter of:	Submissions on the Proposed Hurunui and Waiau River Regional Plan
between:	**Fonterra Co-operative Group Limited** *Submitter*
and:	**Dairy NZ** *Submitter*
and:	**Canterbury Regional Council** *Local Authority*

33 The four farms were analysed through the GSL linear programming (*LP*) model.[3] The GSL model was developed, and is operated, by Mr Barrie Ridler a former senior lecturer in farm management at Massey University. The model calculates the maximum profit for a farm for a given level of input-resource use. Resulting leaching loss predictions were calculated on Overseer version 5.4.10.

3 The GSL model was chosen over Farmax (which was used for the calculations presented in Brown et al 2011, and of which the author of this evidence was a developer). This was because GSL is more efficient at finding optimal resource use allocations due to it being an optimising, rather than a simulation model. With simulation models (such as Farmax) the definition of optimal resource use requires the user to iterate their way to an optimum solution. This iteration is time consuming, not always full-proof and optima may be missed. Predictions from Farmax and GSL are very close, given similar resource inputs. This is shown in Table 1 where predicted outputs for the current configuration for three of the farms which had previously been loaded into Farmax by another user, were compared with predictions by GSL. It means that the only significant difference between the models is in the model structure (optimising – GSL, versus simulation - Farmax).

Ashburton ZIP Addendum 4 March 2014 page 20

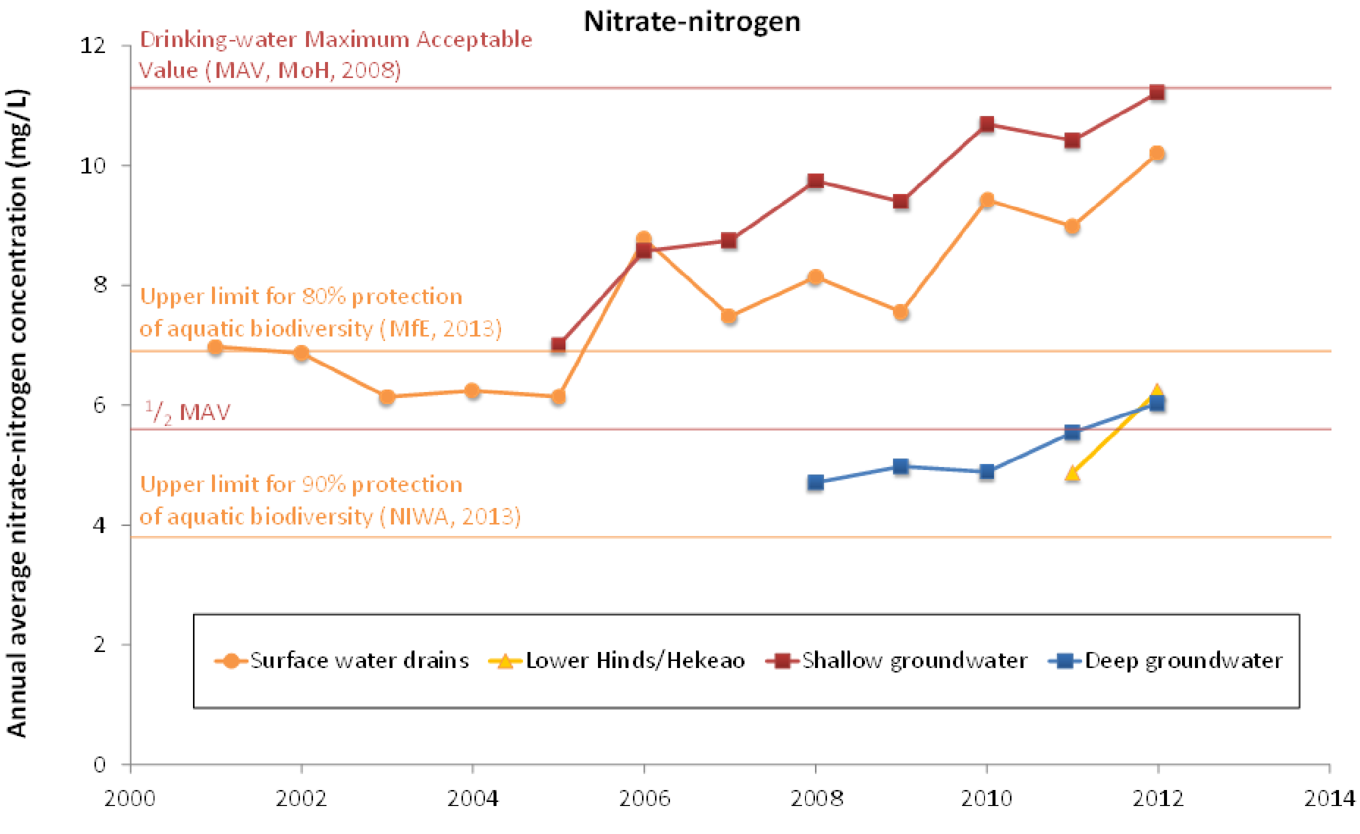
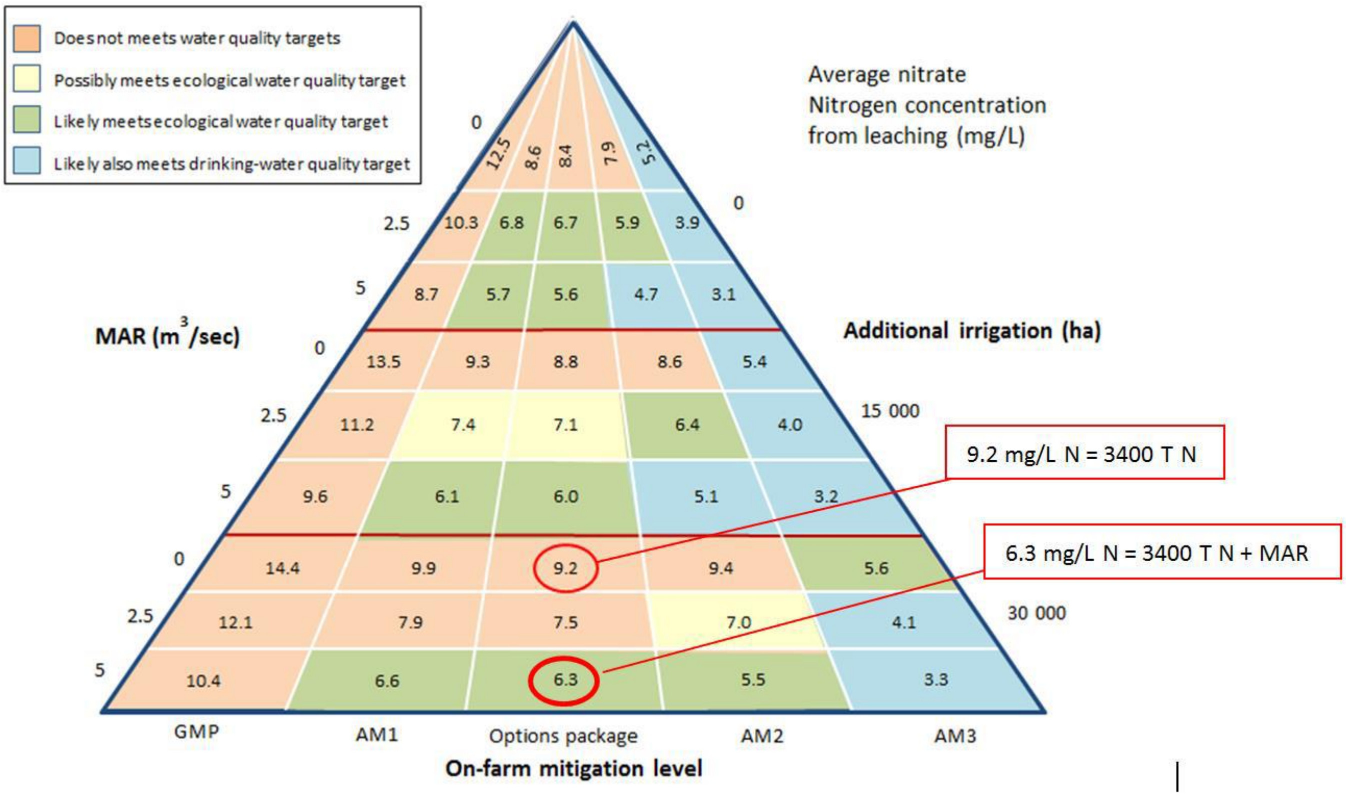


Figure 4: Annual average concentrations of nitrate in monitoring wells and spring-fed waterways in the Hinds Plains.

Figure 5: Hinds Plains Area Nutrient Decision Tool **Figure 5: Hinds Plains Area Nutrient Decision Tool**



APPENDIX 3– SCOTT AND EVEREST ANALYSIS – LOADS AND GMP (ECan Report No R13/93)

Loads

1. Page 13: Scott report: para 4: states that the development of an additional 28.500 ha of irrigated land with dairy and dairy support …Will increase the nutrient load and nitrate concentrations reaching the groundwater and spring fed waterways…. The catchment load calculations suggest the load may increase by 30%.. but there will be more drainage due to increased irrigation so the nitrate concentrations in soil drainage may increase about 15%...... BUT page 18 Scott Report: Para 2: However many of the modelled advanced mitigation measures rely on irrigation management that dramatically reduces the volume of drainage especially at AM2 and AM3: This means that there is not a proportional decrease in the average nitrate concentration, which only reduced by 35%. The development scenario concerned was 14 mg/L and the combination of on farm mitigation levels in the Potential Options Scenario reduced this to 9 mg/L without managed aquifer recharge (MAR) A further reduction to 6.5 mg/L is achieved through dilution using MAR….

2. Scott makes the assumptions on many tenuous and unsubstantiated assumptions factors in my view. These include;

3. A clear reliance on Everest's modelling work in Overseer 6.0 as being valid and reflective of true catchment load.

4. She makes the assumption that the use of MAR will deliver a pure source of water infused directly at the root zone – this takes no account of the bio amplification that can occur over time of shallow and deeper groundwater sources. This is flawed. One cannot assume that surface, shallow and deeper groundwater sources have infinite assimilative capacity. Evidence is already clear that shallow groundwater assimilative ability is becoming diminished after a period of 10 years.(Figure 6.1 page 23)

5. There is no account of N from Upper Plains.

6. The degree of N attenuation in soils is still unclear. It is assumed lower rates of drainage from more precise irrigation practices (AM2) will not increase the load in the soil. This assumption is yet to be validated. If accumulation and saturation of the N in soil occurs, as C:

N ratios become eroded, then saturation of the assimilative capacity of the soil also diminishes[1]. It is not evident that this phenomenon has been taken into account.

7. Finally: active management of irrigation was assumed in Everest Base Files using Overseer 6.0. This was used to underpin Scott's modelling work. Since then, Overseer has had the drainage model upgraded. Significant shifts (of up to 100%) have occurred as the version has moved from 6.0 to 6.2 especially on irrigated farm systems such as the dairy and dairy support models used by Everest to underpin Scott's work.

8. Good Management Practice

(a) In accordance with section 13.4.13 of Variation 2, Everest, et. al. (2013) has pursued the use of Good Management Practice (GMP) on farms. This has been defined by Everest as "reductions in fertiliser on winter crops", 30+ days of effluent storage, and reductions in N fertiliser applied to effluent land[2]. These mitigations, whilst positive, I consider inadequate.

(b) The GMP's proposed by Everest do not account for many of the GMP's specified by ECan[3], nor do they provide any real gains in reducing nitrogen losses on farms.

(c) Ensuring effluent storage is capable of holding 30+dys of effluent is the wrong approach for defining effluent storage on farms. This gives the impression that a defined set of storage days is adequate effluent management. In reality, this approach of defining effluent storage is outdated.

(d) In accordance with the DairyNZ Farm Dairy Effluent Design Code of Practice (specified in 13.4.13 of Variation 2), the Dairy Effluent Storage Calculator (DESC) designed by Massey University should be used to generate required effluent pond volumes. The DESC ensures that there is enough effluent storage available to account for a farms climatic conditions, soil types, effluent system hydraulics, and catchment area. This helps minimise losses of N and faecal matter from a farm effluent block.

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[1] N ratio of less than 20 will mineralise N, while those with a C:N ratio of more than 25 will immobilise N. Most agricultural soils tend towards organic matter C:N ratios of 10–12, while forest and native bush soils tend to have C:N ratios more than 15–20. (http://earth.waikato.ac.nz/staff/schipper/download/soilnitrogen.pdf)

[2] M. Everest, et. al. 2013. Hinds catchment nutrient and on-farm economic modelling. Pg. 39.

[3] Ashburton ZIP Addendum. Pg. 60

(e) The DESC is endorsed by Fonterra and its use is also endorsed by Regional Councils (including Waikato, Horizons, and Otago).

(f) Everest (2013) should have specified the use of the DESC when defining GMP.

(g) Everest's GMP fails to address the N applied from stock urine, rather it focuses on fertiliser management and effluent storage. Because stock urine is the greatest source of N leaching on farm (according to Overseer), mitigations outside addressing the urine issue will have minimal effect on N leaching. This is reflected in the Everest's Overseer modelling[4] where GMP reduced N loss on the two dairy farm models by 1 KgN/ha/yr and 0 KgN/ha/yr.

(h) Based on the minimal influence GMP has on N loss, it is reasonable for GMP to be considered ***business as usual***.

(i) Variable rate irrigation (VRI) is used by Everest (2013) as part of the proposed "Advanced Mitigation Options" (AMO). Water irrigated using VRI is applied at different rates across the irrigated area to best reflect the water holding characteristics of the soil types being irrigated. This increases water use efficiency and decreases N leaching through a reduction in soil drainage.

(j) I find VRI to be a meaningful mitigation option for N loss, however I do question its use when Overseer is unable to accommodate it.

(k) In both Overseer Version 6.0.3 and 6.2 VRI is unable to be defined as a mitigation. When implementing VRI in Overseer 6.0.3 Everest has selected the "actively managed" option which does not reflect the use of VRI. "Actively managed" is actually defined as deficit irrigation which is assumed to be used by Overseer 6.0.3 when monthly irrigation data is not fed into the model.

"Overseer ® defines actively managed irrigation as the application method and management that results in no direct additional drainage from the irrigation application (ie no leakages, overlaps etc) and presumes no rain within 5 days after application" [5].

(l) In Overseer version 6.2 the "actively" managed option has been removed and replaced with a suite of mitigation options. None of which include VRI. That is not to say that it

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[4] M. Everest. 2013. Hinds catchment nutrient and on farm modelling. Pg. 45.

[5] R. Pellow *et al:* 2013. Assessing the impact of input choices within Overseer v6 on the modelled N losses to water from the Lincoln University Dairy Farm.

will not be included in a later version, however I consider it impossible to accurately predict the mitigation potential VRI will demonstrate in later Overseer versions. Because of the complex interactions between the sub-models within Overseer, it would be error to claim any certainty when predicting the impact of future mitigation options.

(m) Whilst the effect VRI has on nitrogen loss cannot be quantified in Overseer, its use as an N loss reduction technology is sound. VRI is known to decrease N leaching by reducing drainage events caused by irrigation. This increases the residence time of nutrients (incl. N) in the root zone which increases the proportion of nutrient taken up by plants. VRI's use as a mitigation is warranted, however it needs to be included in Overseer before predicted reductions in N loss can be validated.

(n) The use of variable rate fertiliser technology by Everest (2013) in his AMO scenarios also cannot be defined in Overseer (6.0.3 and 6.2), however this can be somewhat compensated for by predicting reductions in fertiliser use.

(o) The use of Gibberellic Acid as a substitute for some spring and autumn N fertiliser and nitrification inhibitors are part of Everest's AMO's. Combined, it is estimated by Everest (2013) that nitrification inhibitors have the potential to reduce N leaching by 27% and Gibberellic Acid by 5% in AMO's 1, 2, and 3.

(p) However this reference to nitrification inhibitors is not of assistance. New Zealand's only available nitrification inhibitor is dicyandiamide (DCD). Its use was suspended in 2013 because of milk contamination issues and is considered unsafe. There are currently no alternative nitrification inhibitor products and as stated by Everest (2013) none have been publically notified[6].

(q) Nitrification inhibitors should have been omitted from the Everest assessment until a reliable and safe alternative to DCD has been developed.

(r) Gibberellic acid cannot be entered into Overseer and therefore its effect on an Overseer derived N leaching figure cannot be quantified.

(s) The use of a mixed pasture sward is prescribed by Everest (2013) as an AMO. The rationale being that "unpublished data" from a Lincoln University study in its first year suggests that adding chicory and plantain to a standing pasture mix can dilute urinary

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[6] M. Everest. 2013. Hinds catchment nutrient and on farm modelling. Pg. 57.

N by 25% and therefore reduce N leaching by at least 20% (although 7% is used by MRB).

(t) Again, studies in their initial stages produce anecdotal evidence and require further testing and validation. These results should not be used in a definitive and factual context.

(u) Additionally mixed pasture swards cannot at present be modelled in Overseer. Therefore the true reduction in N leaching remain further unvalidated. Therefore the estimated N loss reduction calculated for this mitigation is based on anecdotal evidence and cannot be used with any certainty at this point in time.

(v) Short rotation ryegrass and white clover pastures are another AMO presented by Everest (2013). It is estimated by Everest based on "recent, unpublished Lincoln University studies", that a reduction in N leaching of 25% can be achieved. Much like the mixed pasture sward mitigation, this research is in its infancy (2yrs) and cannot be modelled in Overseer. Its use as a robust and legitimate mitigation option is inappropriate.

(w) In total, six of the thirteen mitigation options offered by Everest as Level 1 AMO's (VRI and fertiliser, soil yield maps, Gibberellic Acid, nitrification inhibitor, mixed pasture sward) cannot be validated in Overseer nor have their associated N leaching reduction potentials been validated by long term research.

(x) Whilst I welcome advancements in N loss mitigations, we cannot rely on mitigations that lack validation, legality, and the ability to be modelled in Overseer to exaggerate N loss reduction potential on farms. This approach provides no certainty that the defined N loss mitigations in Everest (2013) will result in the Hinds/Hekeao Plains Area achieving the 3,400TN/yr load target by 2035 specified in Variation 2, 13.4.12.

(y) By ensuring N loss mitigation options are available in Overseer, farmers will be able to model the effect of each mitigation on their farm. This will empower them to make sound management decisions for their business and provide evidence of N loss changes via their nutrient budget (as required by 13.4.13a in Variation 2).

(z) Attention should also needs be given to the significant increase in predicted N loss between the version of Overseer used by Everest (version 6.0.3) and the latest version (6.2).

(aa) Headlands Ltd ran the base Overseer 6.0.3 files provided by Everest (2013) in Overseer version 6.2 to demonstrate the variation in N loss between versions. Because the predominant land use type in the Hinds catchment is to be irrigated dairy and dairy support, these scenarios were selected for remodelling.

(bb) It should be noted that the base files provided by MRB frequently modelled improperly in Overseer 6.2 and significant errors were present in these files. The source of the errors are either attributable to fundamental errors in the files themselves or due to changes in Overseer versions having rendered them untenable.

(cc) Dave Horne of Massey University (an Overseer expert) was unable to changes the files into a workable format. As a result, a total of two dairy scenarios and one dairy support scenario was able to be run in Overseer 6.2.

(dd) The dairy scenario base files supplied by MRB employed the use of dicyandiamide (DCD's) or "nitrification inhibitors". This is contrary to DCD"s only being described in the "Advanced Mitigation Options Level 1" by MRB. Again, DCD's are banned from use in New Zealand at present. Therefore DCD's were removed from the Everest's base files to best reflect reality.

(ee) The irrigation module in Overseer version 6.2 is significantly different to the module in version 6.0.3 used by Everest (2013). The irrigation scheduling was changed from "mm per month" to "soil water balance" to best reflect common practice in Canterbury[7]. This option was not available to Everest (2013) in version 6.0.3.

KgN/ha/yr Loss Comparison of Everest's Overseer Assessments Using Version 6.0 & 6.2					
Farm	**Soil type**	**Base file version 6.0** (Everest report)	**Base file version 6.2**	**% Change in N leaching between versions**	**Net % difference between overseer versions**
Dairy Scenario 1	Very Light (Lismore)	65	71	8.5%	**9.2%**
Dairy Scenario 2	Very Light (Lismore)	71	56	-26.8%	**-21.1%**
Dairy Support Scenario 2	Very Light (Lismore)	43	89	107.0%	**107.0%**
				Average	**31.7%**

[7] An audit of Headlands Ltd client base indicated that the majority of Canterbury dairy farmers schedule their irrigation days using a soil water balance method.

Table 2: The above table compares the nitrogen loss rates from two dairy farms and one dairy support farm used in Everest's (2013) report. The 6.0 nitrogen loss figures have been sourced from Everest (2013) and the current leaching rates were calculated using overseer 6.2.

(a) Table 2 demonstrates the degree in N loss variation that can be expected when converting Overseer 6.0.3 modelling into 6.2. The greatest increase observed in this small sample was 107% which represents a doubling in N loss.

(b) This is significant as the increased accuracy of Overseer as the model evolves is not considered in Variation 2. As indicated by Tables 1 & 2, the predicted N loss in the Hinds/Hekeao Plains Area is likely to be much greater than when first calculated in Overseer 6.0.

(c) If a conservative increase of 100% in N loss on irrigated Canterbury light soils from a dairy farm or dairy support is applied, the true target N load for the Hinds/Hekeao Plains Area is around 6,800TN/yr instead of the proposed 3,400TN/yr in Variation 2.

(d) Such a revelation in N loss load from Canterbury farms can only conclude that more stringent N loss measure will be required if a 3,400TN/yr is to be achieved and shallow water nitrogen concentrations limited to 6.9mg/L. Without this conclusion, the 80% protection limit for aquatic species in low land spring-fed streams and 90% limit for Lower Hinds river/Hekeao in Variation 2 will be unattainable.

APPENDIX 4 – LAND USE CAPABILITY

1. An LUC regime for allocation of nitrogen loss rights provides three fundamental requirements for business over the ensuing decade. A) Improved certainty for business to operate and plan within (new and established) thereby reducing the risk of stranded capital[8]. B) provision of certainty for current farmers, that the resources and ecosystem services (assimilative capacity of water bodies) that they rely on will be managed through the allocation of pollution rights being linked to the receiving environment and C) that nutrient headroom (if there is any) in the receiving catchment will be allocated in a way that links to the inherent productivity and vulnerabilities associated with the land based approach for allocating nutrients, is that it brings to land ownership the concept of moral hazard ("moral hazard occurs when a party insulated from risk behaves differently than it would behave if it were fully exposed to the risk. You don't necessarily need to know your actual leaching rates at any point in time but you need to know that in time you will be held to account for your intensity relative to your share of the catchment allocation." (Andrew

2. A LUC based allocation system essentially allocates Nitrogen allowances across a catchment regardless of land use. In that respect, land uses that may not be currently caught within the management framework can easily be brought into the framework over time

3. It is important to note that the LUC Nitrogen allocation system is not just about setting a limit on nitrogen emissions. It is also about allocating a resource to land uses. In this respect it should be viewed as the same as a water permit/consent. It is an allocation of a resource to someone for their use. The capital value of land, and often its productive capabilities are enhanced through the ability of the land manager to access natural resources for example water for irrigation, or through essentially pollution rights

[8] Stranded capital is a term that denotes where a farm system is designed under a permissive policy

4. In my opinion, the LUC based standards are one of the more equitable approaches to allocate nitrogen emissions. It offers a way to allocate a right to emit that correlates well with the productive capacity and vulnerabilities of the land. In most cases, the pasture harvested from various LUC classes is typically closely correlated to the natural carrying capacity and the subsequent suitability of that land to carrying a certain stocking rate.

5. The LUC approach is not linked to current land use but to the potential of the land resource for sustainable production, it provides for continuous economic growth, on-going flexibility of land use on the lowest risk soil types, and potentially most importantly it does not penalise those farms on the most resilient soil types.

APPENDIX 5

Extent of ECan Good Management Practice Assumed in Overseer		
Good Management Practice	**Assumed In Overseer?**	**Reductions in Farm Environmental Impact**
Nutrient Management		
Nutrient budget completed annually	NA	Overseer is nutrient budgeting tool
Fertiliser applied in accordance with the Code of Practice for Nutrient Management 2007.	Yes	Overseer assumes this mitigation is in place. Therefore the implementation of this mitigation will bring farms up to an already assumed standard. This will not improve Overseer nutrient outputs.
Irrigation Management		
Irrigation systems installed or replaced to meet Irrigation NZ Piped Irrigation Systems Design Code of Practice, Irrigation New Zealand Piped Irrigation Standards Systems Design Standards 2013, and the Irrigation New Zealand Piped Irrigation Systems Installation Code of Practice.	No	Overseer does not consider the hydraulic and design components of an irrigation system. Should a farmer become more efficient in their use of irrigation water as a result of these standards, nutrient loss reductions will be achieved. The extent of the nutrient reductions will depend on the types or irrigation efficiencies employed by the farmer.
Irrigation application depth and uniformity are self-checked annually in accordance with relevant IrrigationNZ Pre-Season Checklist and IRRIG8Quick Irrigation Performance Quick Test.	No	Overseer does not monitor farm maintenance. However Overseer does assume that the application depths, return periods, and soil moisture monitoring systems on farm are functional and accurate at all times. Poor maintenance can lead to deviations in irrigator performance and therefore violate the user defined data within Overseer. This can result in increased nutrient loss.
Irrigation applications are undertaken in accordance with property specific soil moisture monitoring, or a soil water budget, or an irrigation scheduling calculator.	No	Overseer allows the user to define irrigation scheduling methods on farm. Provided the defined methods are in agreeance with current practice then there will be no impact to farm nutrient loss.
Intensive Winter Grazing		
Intensive winter grazing adjacent to any river, lake, artificial water course, or wetland, will employ a 5m vegetative strip from which stock are excluded, is maintained around the water body.	No	Overseer allows the user to define riparian areas on farm waterways. This decreases losses in sediment/phosphorus in Overseer and nitrogen to a lesser extent.

Cultivation		
For all cultivation adjacent to any river, lake, or artificial watercourse or a wetland, a 2m uncultivated vegetative strip is maintained around the waterbody.	No	Overseer does not allow the user to specify whether land is cultivated beside a water body. Overseer will assume this is the case if riparian areas have been defined for a farm.
Collected Animal Effluent		
All collection, storage and treatment systems for animal effluent installed or replaced to meet the DairyNZ Farm Dairy Effluent Design Standard and Code of Practice 2013.	No	Overseer assumes that animal effluent systems are fully compliant with Council rules. Some of the Council defined rules will be contained in the DairyNZ Farm Dairy Effluent Design Standard and Code of Practice 2013, but effluent systems designed to these standards will usually exceed Council regulation.
The animal effluent disposal system application separation distances, depth, uniformity and intensity are self-checked annually in accordance with Section 4 'Land application' in the DairyNZ Farm Dairy Effluent Design Standards 2013.	Yes	Overseer assumes that all effluent systems components are in working order and functioning normally.