in the matter of: the Resource Management Act 1991

and: submissions and further submissions in relation to proposed variation 1 to the proposed Canterbury Land and Water Regional Plan

and: **Central Plains Water Limited**
Submitter

Statement of evidence of Stuart John Ford (OVERSEER and economics)

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STATEMENT OF EVIDENCE OF STUART JOHN FORD

INTRODUCTION

1 My name is Stuart John Ford.

2 I am a Director of The AgriBusiness Group and work as an agricultural and resource economist based in Christchurch. I have a Diploma in Agriculture and a Bachelor of Agricultural Commerce from Lincoln University and have undertaken post graduate studies in Agricultural and Resource Economics at Massey University.

3 I am a member of the New Zealand Agriculture and Resource Economics Society and the Australian Agriculture and Resource Economics Society. I am also a member of the New Zealand Institute of Primary Industry Management.

4 I have spent over thirty years as a consultant in the primary industries, with the last fifteen years specialising in agricultural and resource economics and business analysis.

5 As part of my work I have been extensively involved in the calculation of nutrient discharges through the use of OVERSEER and the economic assessment of mitigation strategies that farmers can use to reduce their discharges and runoff. Some relevant pieces of work include "*The Impact of Water Related Management Changes*" which was written for the (then) Ministry of Agriculture and Forestry and "*Selwyn Te Waihora Nutrient Performance and Financial Analysis*" which was prepared for the Canterbury Regional Council (*the Council*) and Irrigation NZ.

6 I have prepared evidence and presented it to numerous Local and Regional Council Hearings Panels as well as the District and Environment Courts, Board of Inquiries and Special Hearing Panels (the latter in relation to Conservation Orders) throughout New Zealand.

7 In preparing my evidence I have reviewed:

7.1 proposed Variation 1 to the Proposed Canterbury Land and Water Regional Plan (*Variation 1*) and its supporting section 32 report;

7.2 Robson M (for the Council): *Technical report to support water quality and quantity limit setting in Selwyn Waihora Catchment*;

7.3 Lilburne et al (2013): *Estimating nitrate nitrogen leaching rates under rural and uses in Canterbury*. Report No R14/19 for the Council. (the *Lookup Table Report*)

7.4 Snow V et al (2008): *Steady state nitrate leaching: Predictions for selected Canterbury Plains soil types, climates and farm systems*. Report No R08/65 for the Council (*the Snow Report*).

8 I have also read the evidence of [ ] and the relevant parts of the Officers section 42A Report prepared by []

SCOPE OF EVIDENCE

9 In my evidence I have been asked to provide:

9.1 an analysis of the appropriateness of the scheme load provided for the Central Plains Water Enhancement Scheme (*the Scheme*) in Table 11(j);

9.2 an outline of the OVERSEER work undertaken on behalf of Central Plains Water (*CPWL*) as it supports the above;

9.3 a view on the appropriateness of the reduction regime contemplated by Table 11(j) and more generally the reductions contemplated in Policy 11.4.4.14 and other relevant 'reduction' provisions of Variation 1; and

9.4 comment on the relative effectiveness and the affordability of the mitigations that might be required to achieve further reductions.

10 Although this is a Council hearing, I have read the Expert Witness Code of Conduct set out in the Environment Court's Practice Note 2011. I have complied with the Code of Conduct in preparing this evidence and I agree to comply with it while giving oral evidence before the hearing committee. Except where I state that I am relying on the evidence of another person, this written evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed in this evidence.

ANALYSIS OF THE CALCULATION OF THE SCHEME LOAD

11 In the notified version of Variation 1, Table 11(j) provides a scheme load of N per year for CPWL of 1944 tonnes from 1 January 2017 which will then need to be reduced to 1742 tonnes from 1 January 2022.

12 The 1944 tonnes of N that has been calculated by the Council and allocated to CPWL is based on the total scheme area (60,000 ha generally referred to as being made up of 30,000 ha of existing irrigation and 30,000 ha of new irrigation). . This total is effectively a cap on the total amount of N allowed to leach from participants in the Scheme and which CPWL are required to manage and report against. The only available means of measuring it at present is through OVERSEER modelling.

13 The total figure was calculated by the Council using version 6.1.0 of OVERSEER and some other modelling tools. However there is nothing in Variation 1 which links the 1944 and 1742 tonne loads referred to above to that version of OVERSEER and nor is there anything in Variation 1 that will allow the load to be re-calculated as OVERSEER changes and improves in its accuracy.

14 My understanding of how the total has been calculated is based on the supporting documentation to Variation 1 and from a briefing given to CPWL by the Council and its consultants. In this regard it appears that the total tonnage was calculated by the Council by a multiplication of the results of the Lookup Table Report, which allocated N leaching results across a range of Land Uses and soil types in the catchment, against a given area of the potential land uses allocated across the available soil types in the Catchment.

15 It is therefore necessary to properly understanding the basis of the Lookup Table Report and the extent to which it might properly reflect land use within, and the development of, the Scheme.

The Lookup Table Report

16 At its simplest, the purpose of the Lookup Table Report was to provide a range of Nitrogen loss factors that could be used across a range of land uses and soil types in a known location.

17 At the time that it was initiated the Council felt that it was impossible to model the results accurately so it was decided to base the analysis of nutrient N loads on the farm systems and soils that could be modelled and then create relationships to fill in the 'gaps' (being other land uses and soil types) on the basis of estimates and assumptions around what the actual N losses might look like.

18 The relationships were created at a series of workshops which incorporated the scientific knowledge at the time. In the majority of instances the relationships were created as a consensus of opinions of those attending the meetings.

19 The report was updated when the latest version of OVERSEER (Version 6) was made available in the middle of 2013. I will discuss

the nature and accuracy of OVERSEER later in my evidence however for immediate purposes it should be noted that:

19.1 the Version 6 update of the OVERSEER files was done using the Good Management Practice (GMP) rules (so the modelling assumed good management practice was already occurring); and

19.2 in the case of irrigation it adopted the "method only" approach. By selecting "method only" OVERSEER automatically calculates the irrigation amount required to maintain soil moisture content which tends to underestimate the amount of irrigation required and therefore underestimates the amount of drainage which will occur (while providing an estimate of likely N losses based on those assumptions around moisture and drainage).

20 The farm systems used were those used in the original Snow report which was produced in 2008. These are farm systems, which were actually developed in 2007, are therefore not reflective of the current state of the systems used in Dairy farming in Canterbury. Since they were developed the Dairy farming systems have become much more intensive in terms of stocking rate and output and utilise much higher amounts of fertilisers and bought in supplementary feed from off the farm. All of these intensification activities have lifted the baseline N leaching results considerably.

21 A review of the Lookup Table Report indicates that the only land uses that were modelled in OVERSEER to make up the core data for the Lookup tables were Dairy at 3, 4 and 5 cows /ha with cows wintered on and off the farm and Sheep under both dryland and irrigated farming systems.

22 The Beef irrigation factor was taken as the "base" for the other models to be compared too. It was assumed that the N leaching for this base model was the same as the 3 dairy cow winter - on model.

23 For the remaining land uses, N leaching performance was extrapolated off the available data from the limited number of OVERSEER models run. For example, the Dairy Support figures were taken as the "base" plus 25%. This means that the Dairy Support figures are the same as those used in the low stocking rate dairy farm which winters its cows on the farm plus 25%. Given that Dairy Support represents a range of activities that include selling silage onto a dairy farm, the grazing of young stock and the wintering of dairy cows. Each of these activities have entirely different N leaching results with the wintering of Dairy cows being by far the highest in N leaching capacity. The degree of leaching is dependent on a number of factors including the intensity of the operation, the mix of

activities and the different mitigation strategies that it is possible to adopt. It is difficult to see how the results gained from adopting the base model plus 25% is a fair estimation of the N leaching factor which occurs under Dairy Support.

24 The Arable N leaching results that were used in the calculation are calculated by another modelling tool (LUCI 09). The LUCI modelling tool was developed by Crop and Food Research and at the time of its use, in 2009, it was only able to model a limited range of cropping options therefore it was not possible to model a complete arable farm rotation. Some of the information that makes up the results that you can get from modelling in OVERSEER are informed by the same science that is used in the LUCI 09 results, but how comparable the two modelling results are, is unproven.

25 Why exactly the 'short-cut' approach was taken with regard to modelling only a limited number of farms systems is not clear and it is rather disappointing when you consider that it is possible to, for example, model Dairy Support and Arable farming in OVERSEER. The approach also appears to materially undermine (what I presume) was the wider desire to calculate wider catchment loads and a reduction regime that was as accurate as possible.

26 I also have concerns about the way that the relationships were then developed as there is no explanation of the various relationships developed by the experts. In the update Lookup Table Report it states that *"these results were then extrapolated following a similar set of rules and trends as were used in the previous version of the lookup table".* I am not sure what this means by a "similar" set of rules and trends. Does this means that a whole new set of relationships were created that were similar to the ones that were developed by the experts or what? And on what basis were they developed? To me this appears to indicate that a relatively non-scientific methodology was used in developing the relationships.

27 Against the above, my main concerns about the accuracy and applicability of the use of this method to determine CPWL's N leaching total are:

27.1 the narrow base of OVERSEER models (and the number of modelled farming systems) actually used;

27.2 the use of extrapolation factors across other land uses and soil types with little or no explanation of the factors that were used in determining the relationships, particularly the lack of any scientific explanation for the choices made;

27.3 the apparently very outdated assumptions made in the setup of the OVERSEER land use models; and

27.4 the comparability of the LUCI09 results with OVERSEER.

28 To understand the full extent of concerns it is however necessary to look further to understand how the Council then used the 'method' as discussed above to create the N load for the Scheme listed out in Table 11(j).

The Council's Use of the Lookup Tables to Create the Cap

29 Following the establishment of the 'method' set out above, the Council then created a land use mix of the Scheme area which was created from the available AgriBase[1] data in the case of existing irrigators and for a mix of 40% Dairy, 40% Arable, 13% Sheep and Beef and 7% Dairy Support for the area of new irrigation. I should point out that CPW were not involved in any of the discussions that were had in making up this land use mix.

30 As I understand it the cap was then calculated by allocating the land uses across the various soil types for the existing irrigators according to where they were located. For the new irrigation area the land use was allocated randomly across the area. Based on the considerable variability in farm systems across the zone the method of allocation could severely under or over estimate the amount of N leaching that would occur in the area (according to how the allocation of the land uses matched the soil types which all have considerably different amounts of N leaching).

31 Overall I conclude that the method used to allocate the N leaching total to CPW is very theoretical in nature and is not based on a very robust method of allocation. And again, as I noted earlier in my evidence this approach is disappointing given that there is the capability within OVERSEER to actually model all of the land uses and soil types.

OVERSEER WORK UNDERTAKEN ON BEHALF OF CENTRAL PLAINS WATER

Background – a note on OVERSEER

32 An overview of OVERSEER and its use as a compliance tool is discussed in the evidence of **Mr Hamish Lowe**.

33 As expanded on in his evidence, it is important to remember that OVERSEER's greatest use is in terms of producing 'relative outputs' as opposed to 'absolute outputs' (to allow relative comparisons to be made – it is not, at least at this point in time, perfectly reflective of

[1] AgriBase data is primarily collected and compiled by staff of AgriQuality as and when they visit farms for other purposes such as animal disease testing and crop certification. The data therefore suffers from not being complete in its description of activities carried out on the farm and is only updated when staff of AgriQuality have cause to visit the farm.

actual N losses in the 'real world'.). Like all models it is also only as good as the data that is input into it and as can be seen from the discussion earlier in my evidence it is important to understand what you should actually be modelling.

34 OVERSEER is also not what I would call being in a steady state as yet and further refinements and improvements continue to be made. However, as set out by **Mr Lowe**, it is expected that in time many of the existing 'bugs' (both known and unknown) will be removed and more sophisticated ways of more accurately calculating the N leaching performance of the various land uses will be incorporated. This will provide us with much greater confidence in the results which it generates.

35 Nevertheless, for the purposes of Variation 1 (and my own evidence) it is appropriate to acknowledge that it is the only freely available modelling tool available to us at present – making it the best available (and at least to some extent, the only available) tool we have.

36 There is however one further OVERSEER matter that I wish to comment on. This is the need for the version to be updated (or an update mechanism needs to be provided for) within the planning framework.

37 In this regard, and from my experience in other Regions, most planning regimes that rely on OVERSEER results specify which version of OVERSEER that they are referring to. Each planning regime then takes one of two possible approaches:

37.1 updating the version of OVERSEER and requiring all future compliance to be assessed using that earlier version of OVERSEER (even if subsequently superseded by a later version). This might seem relatively straight forward but it is the current policy of the owners of OVERSEER to either update the online version and to date stamp downloadable versions so that old versions of the programme are not available after a relatively short time period. This means that accessing the relevant version is not possible unless an approach is made to the owners directly; or

37.2 including a mechanism within the planning framework that allows the relevant nutrient limit to be updated using the latest version of OVERSEER. This update would need to be undertaken using the same inputs (soil type, climate, farming systems etc) that were relied on when doing the original OVERSEER modelling (otherwise modelling change and confirming compliance with the revised baseline is simply a waste of time).

38 Neither approach is very straight forward when applied at a scheme level (such as that required for CPWL and the Scheme). CPWL **and** individual shareholders either need to continually assess their N losses against a version of the model that cannot be directly accessed or a recalculation of the results of OVERSEER modelling which will result from a change in the version of the model.

39 In either case, the important thing is to again remember that OVERSEER is a relative model and not an absolute model (such that the actual 'numbers' are a little meaningless in isolation – it is the comparison between the 'baseline' and the 'change' (if any) using the **same version** of OVERSEER that actually matters. Farmers (and CPWL) need certainty around their operations and the rules framework needs to be structured such that operations are not penalised simply by virtue of a change in the model.

40 At present in Canterbury we know that there are quite major changes in the results that come out of the various versions of OVERSEER.

41 This is already an issue for CPWL because there is no connection within Variation 1 between the earlier version of OVERSEER, which was used to calculate the total amount of N allowed in Table 11(j), which can no longer be accessed and the version of OVERSEER that is now available .

42 This means that as the version used to calculate the annual tonnage changes (and with that change there is an increase or decrease in the amount of N leached from each individual property) there is no change in the total amount of N allowed in the cap.

43 CPWL's sought relief in respect of the 'version issue' is discussed in the evidence of **Mr Hamish Peacock**. The issue however provides further important context to the work I have done for CPWL in respect of Variation 1.

Results of Baseline Data Collection in OVERSEER.

44 CPW contracted The AgriBusiness Group to undertake farm nutrient baseline data collection and nutrient budget preparation for 40 sample farms across the CPWL outline area, representing typical farming systems in the area. My full report on this exercise is attached as **Appendix 1**.

45 The selection of the farms was made more on their geographical representation rather than in an attempt to represent a reasonable cross section of typical farm systems. However because of the number of farms chosen (40) and the spread of locations I consider it likely that it gives a reasonable representation of the types of farm systems actually present in the area.

46 The definition of 'nitrogen baseline' (upon which Variation 1 places considerable reliance) is included in the proposed Land and Water Regional Plan (the parent document to Variation 1). It is stated that the baseline figure for existing farms should be averaged over the four years from 2009 to 2013. However in an explanatory comment it goes on to note that "*if the farm is in a steady state then just one budget covering the average situation during that period would be sufficient*" (despite the fact that OVERSEER is a long-term averaging/steady state model).

47 In consideration of the fact that there was no absolute requirement to provide four years of data and the fact that staff, as part of piloting their approach to data collection, found it practically difficult to collect enough accurate information to do four years budgets, it was decided that it would be best to concentrate on providing one year's data which was seen to represent an average year. The use of 40 farms will also assist in 'smoothing out' any issues associated with attempting to determine long-term N losses with only one year of data.

48 Further, as I noted in paragraphs [] above, OVERSEER results are unlikely to accurately reflect actual real-life N losses (it is OVERSEER's value as a 'relative' modelling tool that assists with Variation 1). Not only is the model still undergoing development in terms of its ability to assess mitigation effectiveness and actual N losses, but as I also noted there are a number of 'bugs' in the system that are being worked through.

49 There is however a further matter that I did not discuss earlier in my evidence - that is the fact there are a large number of input assumptions and options that an operator can choose that potentially have a significant impact on the nutrient emissions reported.

50 In order to get a degree of commonality in the way that OVERSEER is used the owners put out a protocol *"The Overseer Best Practice Data Input Standards (August 2013)"* which lists the recommended best practice options for entering data into OVERSEER. However it should be noted that many of these options have a number of choices of methods which are listed from first choice to last choice and again give the operator a choice of which option that they choose.

51 At the same time the Dairy industry in New Zealand also developed its own protocol as to how OVERSEER should be used. Amongst other things it recommended that the option on irrigation choice that they preferred was to choose "method only" (this is the second choice in terms of the owners best practice guidelines but I

understand it best meets the industry's requirements as specified by the Audited Nutrient Management Scheme.

52 The effect of incorporating irrigation as "method only" is, as I have noted earlier, that each irrigation system is assumed to be applying an amount of irrigation water which is calculated by OVERSEER. The amount of irrigation water applied in this system choice is very likely to be much less than that being applied in reality therefore the amount of nitrogen which is washed through the soil profile is very low.

53 As it states in the OVERSEER Best Practice Data Standards Report

> "The three methods of data entry representing irrigation potentially give widely different results, particularly with respect to N leaching. Using method only, Overseer calculates the amount of irrigation water applied based on daily water balances and replacing the estimated soil water deficit. The calculated amounts are usually considerably less than actual rates applied on a long-term basis."

54 For CPWL and the 40 farm analysis The AgriBusiness Group chose to enter the actual amount of irrigation water required by the soil as calculated by using annual rainfall and potential evapotranspiration figures which were supplied by AquaLinc for each of the three locations of Hororata, Te Pirita and Dunsandel. These were distributed on a monthly basis. The irrigation requirement was calculated as equalling rainfall minus evapotranspiration. The surveyors then chose the nearest climate station and calculated the irrigation requirement on a monthly basis based on the irrigation system being 80% efficient..

55 In order to check that our methodology was correct we asked a number of questions of Ants Roberts the Chief Scientific Officer at Ravensdown who also chaired the committee that developed the Best Practice Data Entry Guidelines. His written reply is attached as **Appendix 2**. The following is his response to our question on the correct method for the inclusion of irrigation:

> "This is a major issue. My opinion is that it is imperative that estimated monthly irrigation depth is entered into the model. The importance of this is that we all know that most farmers irrigate more water per month than what the OVERSEER model calculates based on daily water balance. Using Method Only in most cases underestimates N loss and better irrigation practices (and application technology) will be a big step to help reduce N loss from irrigate systems without affecting productivity negatively. There is a Landcare/Aqualinc/AgResearch project looking at ways that monthly irrigation depth can be added for the Canterbury region but we are unlikely to see that until next year in OVERSEER. While I applaud the addition of irrigation estimates, any nutrient budgets that

> we undertook for dairy farms in the CPWL area would be with Method Only and hence yield different results than yours."

56 It should be noted that this "*method only*" application of irrigation water was also adopted by the people that carried out the modelling in the Lookup Table Report. Based on the general understanding as set out above it appears that this would have resulted in an under-estimation of N losses.

57 In this exercise we attempted to produce results which are as accurate as possible. Therefore where there was a known bug in OVERSEER (climate data, soil description and irrigation water applied) and it was possible to devise a solution which worked around it then this was done. Where it was not possible to devise a solution to the problem it was noted. In all cases the first choice best practice data entry guidelines have been followed.

58 The land use mix from this survey exercise is interesting because it shows that apart from Dairy farming the remainder of the land uses are likely to change their mix of farming systems from time to time on each property. In reality (contrary to the Council modelling approach) there is much less distinction between Arable, Sheep and Beef and Dairy Support operations in terms of land use mix (with them all changing from time to time and potentially occurring on the same property to a lesser or greater extent at the same time).

59 This creates an issue when trying to compare the theoretical results created with the Lookup Table Report (which assumes one major land use for each parcel of land) with the results gained from an actual collection of data from the same farms.

60 The version of OVERSEER used in this exercise was Version 6.1.2.

61 The N leaching results obtained from this exercise which surveyed 21% of the potential new irrigated area (assumed to be 30,000 ha) and 20% of the existing irrigated area (also assumed to be 30,000 ha) are shown in

62

63

64 Table 1.

Table 1: Average N leaching for each farm system (kg N / ha / y)

Land Use	Dryland	Irrigated	Average of both dryland and irrigated
Arable + Sheep and Beef	34		34
Arable + Dairy Support		24	24
Arable + Sheep and Beef + Dairy Support	15		15
Sheep and Beef	17		17
Sheep and Beef + Dairy Support	22		22
Dairy Support	38	59	49
Dairy		54	54
Total	**23**	**41**	**32**

65 Approximately 50% of the farms surveyed were dryland and 50% are irrigated. Of the farms surveyed there is very little difference in the farm size being an average of 308 ha for the dryland properties and 303 ha for the irrigated.

66 The results indicate that for the dryland properties the allowance made by ECan of 15.6 kg N / ha is well short of the actual result of 23 kg N ha. For the existing irrigated properties the Council's initial allowance of 32.1 kg N / ha for the baseline calculation is well short of the average of 41 kg N / ha which was gained from the existing irrigators.[2]

67 What can also be taken from the results is the massive variability which we get in N leaching results from within the farm classes let alone from between the farm classes. This opens up the question of whether the ECan definitions of farms used are wide enough to allow for accurate calculation of the N leaching performance of land uses and whether CPWL will need to develop a much wider definition of land uses.

[2] Noting that the 32.1 kg N/ha/y (irrigated) is referring to a different number than the 32 kg N/ha/y (total average)

Calculating the current rate of N leaching for EXISTING irrigators

68 Overall, I consider that the use of the Lookup Table Report is an inappropriate way to calculate the current state of N leaching from the existing irrigators for a number of reasons including:

68.1 the land use models that it is based on are very out of date (2008) and do not represent the intensity of farming practiced in the area;

68.2 the models are based on the irrigator practicing "good management practices" on their properties which often is not the case at present; and

68.3 the factors have been developed by extrapolation from a very limited range of OVERSEER results and obviously do not represent the same results that are gained from carrying out the same exercise in OVERSEER.

69 I do not believe that the way the results were then taken by the Council and multiplied up by the land use and soil information to calculate the total N leaching is appropriate either for a number of reasons including:

69.1 the AgriBase information is very inaccurate as to the actual farming system and is only updated on an infrequent basis; and

69.2 the farming systems now incorporate a range of the definitions of farming systems including Dairy Support operations therefore it is impossible to accurately portray the intensity and range of farming systems from the information used.

70 Accordingly, I consider that the attempt to calculate the total amount of N leaching for the Scheme from the existing irrigators is flawed because it uses a highly technical calculation method that is proven to underestimate the current level of N leaching from existing irrigators (which was gained through more practical methods).

71 I also note that I was involved in the exercise which set the N leaching cap for irrigators in the Rangitata Diversion Race scheme for its consent. There we developed N leaching data for known ranges of farming systems off OVERSEER runs and filled in the gaps by using the relationships between the soil types (which were taken from the Lilburne Lookup Table Report). We then used the **known** land use mix and soil type data to multiply the information up to get the current level of N leaching across the scheme. This was a

reasonably simple but satisfactory way of determining the current level of N leaching. It was based on known levels of N leaching from OVERSEER runs from a range of farm types in the area.

72 For Selwyn Waihora, all other land users in the catchment have been told that the current expectation is that they are to calculate their individual "nitrogen baseline" and that they should not exceed this figure. Once the matrix of good management project (discussed later in my evidence) is complete the amount of reduction that they will have to achieve will then be able to be accurately calculated.

73 In my opinion the existing irrigators in CPW should effectively be treated in exactly the same way – i.e. they should calculate their nitrogen baseline and (subject to whatever further management controls are put in place by CPWL), they should not exceed that baseline until they are informed as to what reductions in N leaching that are required.

Calculating the N leaching performance of NEW irrigators

74 There are two aspects of the calculation of the total amount of N leaching that is allocated to new irrigators that concern me. The first is the calculation of the N leaching figures to be used and the second is the allocation of them across a land use mix of 40% Dairy, 40% Arable, 13% Sheep and Beef and 7% Dairy Support.

75 I have already expressed my concerns about the highly theoretical way in which the N leaching amounts were developed (and the fact that they do not match what practical OVERSEER exercises are producing).

76 As set out in the evidence of **Andy Macfarlane**, Macfarlane Rural Business (MRB) has calculated the N leaching performance for a range of land uses within the Scheme for new irrigation.

77 However I note: MRB have not modelled a comparable standalone dairy support options that can be used to compare with the Councils modelling so we do not have an up to date OVERSEER calculation of that land use (I have therefore adopted the Council's calculation of 38.7 kg N / ha for that land use. I am also quite happy to accept the Council's estimate for Arable land use at 22.7 kg N / ha;

78 I do not know what mix of soil types and intensity of land uses make up the Council's estimate of the dairy farming N leaching figure of 32.1 kg N / ha. However I believe that it severely underestimates the amount of N which is leached under the sort of intensive dairy farm system which farmers will need to adopt to have a viable farming operation under the current estimated cost of CPWL Scheme water.

79 MRB have modelled the sort of dairy farming operation which they see as being appropriate on the lighter soils in the area. I have adjusted MRB's estimate of N leaching for dairy farming to incorporate the use of the preferred irrigation method and have a result of 48 kg N / ha. I believe that this figure is a more appropriate figure reflective of actual dairy farming in the area.

80 Analysis of the rationale behind the land use mix adopted for the new irrigation shows that it was a compromise position adopted between the original estimate of land use given by MRB in CPW's original consent hearing and an estimate made by Simon Harris which was made at the time of the calculation (2012)

81 During the intervening years there has been a very marked improvement in the long term returns for Dairy farming and a stagnation in the returns from Arable farming. This has been borne out by the significant conversion of arable land to dairy farming in the last four years. I have observed that irrigation scheme developments typically result in a higher proportion of dairy farming in the land use mix.

82 If we take the MRB data on the expected returns and the capital required to convert and adjust them to reflect a cash position we come up with the following returns.

Table 2: Return on Capital Pre and Post Irrigation Development

	Pre Livestock	Pre Mixed Arable	Pre Dairy	Post Livestock	Post Mixed Arable	Post Dairy
Return on Capital	2.59%	3.65%	6.69%	5.0%	6.7%	6.5%

Table 3: Return on Marginal Capital Post Irrigation Development

	Livestock To Mixed	Mixed Arable To Arable	Dairy to Dairy	Livestock To Dairy	Mixed Arable to Dairy
Return on Marginal Capital	10.4%	15.5%	4.5%	9.5%	9.2%

83 All (except existing dairy farmers) are going to improve their return on capital and all (except existing dairy farmers) are going to achieve a return on marginal capital of a figure that is above the

current cost of borrowing. To put that another way, this means that they will be able to finance the conversion. If you cost the capital cost of conversion at 6% there is still sufficient left to reward the effort of conversion. Therefore all of the land uses are theoretically affordable.

84 We note that MRB have used $6.50 / kg milksolids, whereas under my own method of calculation it would currently be $7.07 which would improve the dairying returns quite considerably and therefore all of the ratios reported here would improve considerably.

85 The only land use which doesn't appear to be relatively equal to the others is the conversion to a livestock option which has a lower return on capital than the others. Therefore we would expect that the move to at least dairy support would be an attractive option for those land users.

86 We know from other exercises that we have done that the returns from dairy support are very similar to the returns from dairy farming so would expect them to be at the same (or slightly better) than those calculated here.

87 Arable land use is relatively profitable on both measures of return and there is sufficient good arable land within the area to suggest that the 12,000 ha (40%) allotted to irrigated arable is a fair estimation of the current land use choice. However the speed of conversion from arable to dairying in other districts would indicate that the relativity is not as equal as that calculated by MRB. I would venture that as irrigation development occurs that much more arable land owners would wish to convert to dairy farming in order to maximise the returns to be gained from the conversion.

THE APPLICABILITY OF FURTHER PERCENTAGE REDUCTIONS

88 Policy 11.4.13(b) provides that from 1 January 2017 farming activities (over 50 ha in area and leaching more than 15kg/ha) will need to: "*meet the Good Management Practice Nitrogen and Phosphorous Loss Rates for the property's baseline land use".*

89 The Good Management Practice Nitrogen and Phosphorous Loss Rates are yet to be defined. The development of them is subject to an entirely separate work stream "the matrix of good management (MGM) practice".

90 The failure to describe what entails Good Management Practice makes it extremely difficult to comment on the inclusion of this policy in the plan. Having reviewed the section 32 report I am still not any clearer on its anticipated effectiveness or efficiency as a means to achieve the plan's purpose.

91 Although I understand CPWL are not opposed to the adoption of good management practice I believe that it would be better to wait until the MGM project had correctly defined what was required under good management practice and then incorporate the relevant requirements into the plan at a later date.

92 As I understand the use of the definition good management practice is that it describes the practices which are considered to be appropriate for all of the farmers in an area. When I carried out the analysis for the Selwyn Te Waihora Zone Committee exercise the list of good management practices was given to me by Council as:

- Compliant effluent systems
- Fertiliser applied according to the industry Code of Practice.
- Stock exclusion from water ways.
- Irrigation efficiency >80 %
- Fertiliser recommendations generated from a budgeting tool.

93 All of these (apart from the one on irrigation efficiency) are practices which are required by most industry sectors anyway so I am not too sure what will be achieved by further definition of what constitutes good management practice in terms of changes in N leaching on farm.

94 It is also not clear on the extent to which the MGM programme will prescribe levels of irrigation efficiency. Based on my survey work for the Selwyn Te Waihora Report (referred to in paragraph 5 of my evidence) it appears that much of the current practice on irrigation usage falls well short of what I generally consider to be 'good management irrigation practice'. This again means that actual existing N losses are likely to have been under-estimated compared to those derived using OVERSEER.

THE EFFECTIVENESS OF FURTHER REDUCTIONS

95 Policy 11.4.14 provides that from 1 January 2022 farming activities will need to make certain further percentage reductions in their nitrogen loss rates.

96 As I understand it after reading the document "*Estimation of on farm mitigation requirements Draft 1"*, "*the levels of mitigation were calculated subject to all landowners being subject to the same level of costs to achieve that mitigation*" and "*The operator then iterates through different EBIT costs until the desired level of total N mitigation (820tN) is achieved*".

97 While I applaud the adoption of that approach I am concerned about the accuracy of how it has been calculated. This is a very important issue for farmers and I believe that the approach taken to the modelling was very theoretical and the issue in fact deserves a far more robust method of calculation.

98 I have already discussed my views around the accuracy of the AgriBase information and adoption of the Lilburne land use calculations in determining the land uses which were modelled here.

99 Therefore my concerns are about the scope of the activities modelled and the accuracy of the mitigation costs used. While I believe that the approach taken may have been appropriate to provide decision making options for the Zone committee to choose between I do not believe that they are appropriate to be used to set a percentage reduction across land uses.

Dairy

100 Variation 1 as notified seeks to have dairy farms reduce their N losses by 30% from 1 January 2022 to meet the calculated maximum tonnage of N.

101 If we examine the table "Mitigation Options, Complexity and Costs for Various Percent Reductions in Nitrate – N." (attached as **Appendix 3**) which was provided by the Council as a means to explain how they calculated the available mitigation practices and look at the rows which represent the dairy reductions in the column which represents the reduction below 11%. The mitigation practices listed here include:

101.1 the use of DCD's which at present are not an option; and

101.2 Improved nutrient and effluent management which are both covered by the good management practices provision anyway.

102 Accordingly, there is nothing in this part of the table which is available to provide for further reductions in N leaching.

103 In the next category which is reductions of 12 – 20% they add the options of improved genetic stock and reducing autumn fertiliser. In the third category of 20 – 30% reductions they introduce on off grazing and in the next category 30 – 40% mitigation options they introduce restricted autumn grazing with winter shelter.

104 These are the same mitigation options which I was instructed to use by the Council in calculating the effectiveness and cost of mitigations in my report on Selwyn Te Waihora. My problem with them then and my continuing problem with them now is that they

are largely infrastructure based in that generally require the expenditure of capital to mitigate N leaching and do not examine the full range of options open to a dairy farmer. In particular, they all concentrate on the use of capital to alleviate the N leaching from the current farming system when my experience suggests that there are far more gains that can be made by adopting a different farming system.

105 If we look to the Lincoln Dairy Farm they are adapting their farming system to less cows producing more per cow and a whole range of small changes to the way that they operate the farm to achieve the sorts of reductions required.

106 I also don't consider that the approach taken in the analysis fully took account of the cost of the mitigations into their calculation. By my calculation the cost per unit of N reduced for a low input dairy farm was as shown in Table 4

Table 4: Change in N leaching and cost per unit of mitigation techniques

Mitigation Technique	N change	Cost ($) / kg N reduced.
Status Quo (actual)	69	1,443
DCD use	-10	4,302
Reduced Autumn N	-13	- 2,049
Improve Cow Efficiency	-5	28,192
Less Cows	-39	556
Active Water Management	-26	-876
On / off grazing.	-15	-10,960
Winter Housing	+2	-134,172

107 The point that you should further note is that at the time when I carried out this exercise the average dairy farming operation was not particularly profitable with an EBIT which is basically break even. This means that for the average dairy farm any additional cost associated with mitigation was not affordable. In the intervening years the outlook for dairy returns have improved to mean that the ability to absorb some additional cost will have improved somewhat.

108 DCD use has a positive benefit in terms of the cost of mitigation but it is at present not available to dairy farmers. Although it might

become available again in the future I don't think any reliance can be placed on that at the present point in time.

109 Of the others with positive returns improved cow efficiency has a very positive result and the option to reduce cows is basically a break even option which is not seen as attractive to farmers because it precludes any further potential growth.

110 Active water management which has a relatively low cost is, in my opinion, best regarded as a good management practice. Reduced Autumn N has a reasonable cost but the other two options of restricted Autumn grazing and Winter housing both have very high costs and are unaffordable for the average farmer.

111 In the case of the On / Off Autumn grazing (also called deferred or limited interval grazing) which requires the establishment of an off pasture standing and feeding pad, the cost of servicing the debt and the added costs of operating the feed pad associated with this option mean that the annual **loss** associated with this option totals approximately $165,000 on the average farm.

112 In the case of wintering the cows at home in a wintering barn the annual cost of this exercise comes to approximately $268,000 again a sum which is completely unaffordable for the average farmer. It should also be noted that the adoption of this option does not alter the total amount of N leaching from the farm it just replaces the N lost from wintering cows that would normally be grazed elsewhere at a much lower cost.

113 In this regard I also note that over the years I have carried out a number of modelling exercises aimed at testing the cost effectiveness of winter housing of cows as a means of reducing N leaching. This has included running the OVERSEER modelling and financial analysis of winter housing of cows on each of the MAF Farm Monitoring Models throughout the country. In carrying out these exercises I have found the same result every time - on average the adoption of winter housing causes farmers to make a financial loss (while achieving the desired reduction of N leaching).

114 I have then been able to conclude from those exercises, and this is supported by this analysis, that the use of winter housing as a means to mitigate the N leaching of a property is neither cost effective nor affordable for the vast majority of farmers.

115 The only exercise that I have seen work in terms of both N leaching and financial performance is the Canterbury example of a Hybrid system whereby the cows are housed inside the barn for the whole year and their feed is brought to them. In that system the cows are milked for the whole year and their effluent is spread over a

relatively large area. The analysis that I have seen carried out on that system results in the farm achieving a very similar return on total capital to traditional systems. It is however a farming system that would require significantly more up-front capital and I expect very few farmers would be in a position (or have the desire) to take on the increased debt associated with this mitigation option.

116 I should also note that I carried out this mitigation costing exercise across two classes of dairy farms those with low inputs and those with high levels of inputs. The relative results change as you model different farming systems.

117 I conclude that the range of mitigation techniques modelled by the Council were either inappropriately included as mitigation options when they are better classified as Good Management Practices or in total were a very limited range of options available to mitigate the loss of N on dairy farms.

118 Other options include the use of grain feeding in the shed as an alternative to silage feeding in the paddock. Overall, I believe that the only options which are cost effective for the dairy industry are related to system changes which take advantage of efficiency gains from growing, irrigating pastures and from more efficient animals.

Arable

119 Variation 1 as notified seeks to have arable farms reduce their N losses by 7% from 1 January 2022 to meet the calculated maximum tonnage of N.

120 As I noted in my report on Selwyn Te Waihora, there is typically

> "… very low, levels of N leaching from arable farm systems. This is due to the heavy soils that they are predominantly carried out on, the continuous nature of the cropping rotation, the adoption of minimum tillage techniques, the application of N and irrigation during the growing season (spring) of the crop, the application of N and irrigation at rates that meet the growing demands of the crop, the use of cover crops during the winter and the relative lack of animals on the property".

121 This led me to the conclusion that the only mitigation techniques that were worth pursuing on Arable properties was the reduction of animals.

122 If we examine the table "*Percentage reduction in Selwyn Waihora catchment*" (attached as **Appendix 3**) on reductions used for Arable we see that they list a range of mitigation options which I consider to be part of good management practice already apart from the reduction of inputs by 15%.

123 I have carried out a number of exercises looking at options to mitigate N leaching from arable cropping regimes and have found every time that a reduction of about 10% in inputs for an arable farming system causes the whole operation to go into a deficit situation.

124 I note that if we go across further into the table they state that the costs are unknown.

125 I do not know how the Council modelling exercise can then determine that the appropriate level of mitigations from the arable sector should be 7%.

Conclusions on further mitigation provisions.

126 I consider that the way in which the further mitigation amounts have been calculated is not accurate or appropriate on the basis of,

126.1 the mix of land uses it was calculated across;

126.2 the relatively narrow ranges of land uses considered;

126.3 the absence of a clear definition of what was in good management practices and what was in mitigation;

126.4 providing insufficient scope of the mitigation practices evaluated; and

126.5 calculating the degree of impact that the adoption of some of the mitigation practices has on the whole farm financial returns of the average farm.

127 Accordingly, the mitigation amounts calculated are not an accurate reflection of the relative costs of mitigation by each sector and on that basis I believe that time should be taken between now and 2022 to develop a more accurate method to allocate the mitigation options that are open to farmers.

Considerations for MGM.

128 As a final matter I consider it appropriate to briefly comment on MGM – especially if Variation 1 is amended to provide more detail on MGM is intended to achieve.

129 Any regime which is developed must take into account the current level of efficiency of the individual farm in terms of N leaching efficiency. As our analysis indicates there is a huge range of N leaching across a farm type within the CPWL Scheme area. This is driven by things out of the individuals control like the soil and climate factors but also is greatly influenced by the choices made by

the individual farmer as to things such as stocking rate, crop rotation, fertiliser use, management regime etc.

130 There is much to be gained from the development of measures of efficiency such as kg N leached / kg milksolids produced or /grain output or / kg meat produced etc. From these measures targets for farms could be produced and the development of farming systems which were able to achieve those targets.

131 Then there is the concept of 'not penalising an efficient operator'. There is much variability amongst dairy farmers at present for example. A standard measure of a mitigation target across all dairy farmers has the potential to set unrealistic targets for the current highly efficient farmers but provide relatively easy gains for the currently inefficient famer.

132 The approach that is used by the Council in Variation 1 to try and equalise the mitigation costs as much as possible should therefore be taken down into each sector and needs to include consideration of things such as the soil type, climatic conditions as well as the costs of mitigation relative to the individual farm circumstances.

133 In CPWL's case this will be made worse by the fact that they will have approximately half of their irrigators being existing and half that are new (with only the latter having had the immediate opportunity to include a lot of the infrastructure and farming system mitigation techniques into their farming systems).

134 The other economic concept is to seek to maintain the profitability of each operation. This is partly managed by the concept of minimising the mitigation costs. But I believe that it requires far more work than that which has been done to date.

135 I believe that it would be best to calculate the total tonnage required to be mitigated against the total load in the Lake and then allocating that tonnage to CPW to manage and report against. In this way CPW will have the ability to calculate how difficult or easy it is to achieve and will be able to distribute the mitigation load in a way that reflects consideration of the factors considered here.

136 This is necessary for a number of reasons not the least being to provide some degree of long term certainty to CPWL and its shareholders so that they can proceed with making the considerable investment decisions necessary to proceed with the scheme.

CONCLUSION

137 I have concerns about the accuracy and applicability of the use of The Lookup Report to determine CPWL's N leaching total because of:

137.1 the narrow base of OVERSEER models (and the number of modelled farming systems) actually used;

137.2 the use of extrapolation factors across other land uses and soil types with little or no explanation of the factors that were used in determining the relationships, particularly the lack of any scientific explanation for the choices made;

137.3 the apparently very outdated assumptions made in the setup of the OVERSEER land use models;

137.4 the comparability of the LUCI09 results with OVERSEER.

138 The method used to allocate the N leaching total to CPW is very theoretical in nature and is not based on a very robust method of allocation. And again, as I noted earlier in my evidence this approach is disappointing given that there is the capability within OVERSEER to actually model all of the land uses and soil types.

139 OVERSEER is not what I would call being in a steady state as yet and further refinements and improvements continue to be made. These will provide us with much greater confidence in the results which it generates in the future.

140 Farmers (and CPWL) need certainty around their operations and the rules framework needs to be structured such that operations are not penalised simply by virtue of a change in the version of OVERSEER which they are calculated under.

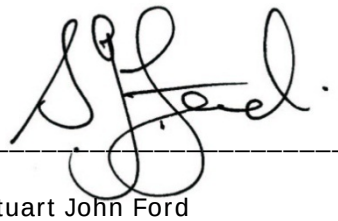
141 The results that we gained from surveying 40 farms from within the CPWL shareholders indicate that for the dryland properties the allowance made by ECan of 15.6 kg N / ha is well short of the actual result of 23 kg N ha. For the existing irrigated properties the Council's initial allowance of 32.1 kg N / ha for the baseline calculation is well short of the average of 41 kg N / ha which was gained from the existing irrigators.

142 I consider that the attempt to calculate the total amount of N leaching for the Scheme from the existing irrigators is flawed because it uses a highly technical calculation method that is proven to underestimate the current level of N leaching from existing irrigators (which was gained through more practical methods).

143 In my opinion the existing irrigators in CPW should effectively be treated in exactly the same way as all other existing land owners that they should calculate their nitrogen baseline and (subject to whatever further management controls are put in place by CPWL), they should not exceed that baseline until they are informed as to what reductions in N leaching that are required

144 I believe that it would be best to calculate the total tonnage required to be mitigated against the total load in the Lake and then allocating that tonnage to CPW to manage and report against. In this way CPW will have the ability to calculate how difficult or easy it is to achieve and will be able to distribute the mitigation load in a way that reflects consideration of the factors considered here

Dated 29 August 2014



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Stuart John Ford

"Achieving Outcomes by Building Capability"

The AgriBusiness Group™

Report on Collection of Nutrient Baseline Data for CPWL

Prepared for: Central Plains Water Limited

Contents

Collection of Nutrient Baseline data for CPWL.

Please Read

Executive Summary

Central Plains Water Limited (CPWL) has a critical need to understand their shareholders existing nutrient loss baselines as this will inform a number of areas across both their planning and implementation. CPWL contracted The AgriBusiness Group in order to undertake farm baseline data collection and nutrient budget preparation for 40 sample farms across the CPW catchment, representing typical farming systems in the area.

Farm Selection

The selection of the farms was made more on their geographical representation rather than in an attempt to represent a reasonable cross section of typical farm systems. However because of the number of farms chosen (40) and the spread of locations it is expected that it gives a reasonable representation of the types of farm systems present in the area.

Calculating the Baseline

In the Land and Water Regional Plan it is stated that the baseline figure for existing farms should be averaged over the four years from 2009 to 2013. However in an explanatory document it states that if the farm is in a steady state then just one budget covering the average situation during that period would be sufficient.

In consideration of the fact that there was no absolute requirement to provide four years of data and the fact that staff as part of piloting their approach found it practically difficult it was decided that it would be best to concentrate on providing one year's data which was seen to represent an average year.

Nutrient Budgeting in OVERSEER

A number of solutions to known problems with the accuracy of the OVERSEER calculations were developed to try and improve the accuracy of the results. The results reported here should be considered as interim until an as yet unresolved issue with the way that the model computes the results for Kale is resolved.

Land Use Mix

The land use mix from this exercise is interesting because it shows that apart from Dairy farming the remainder of the land uses are very interchangeable. There is no apparent distinction between Arable, Sheep and Beef and Dairy Support in terms of land use mix with them all being very interchangeable to a lesser or greater extent.

N leaching

The results to date indicate that for the Dryland properties the allowance made by ECan of 15.6 kg N / ha is well short of the actual result of 23 kg N ha. For the existing irrigated

properties the initial allowance of 32.1 kg N / ha for the baseline calculation is well short of the average of 41 kg N / ha.

What can also be taken from the results to date is the massive variability which we can get in N leaching results from within the farm classes let alone from between the farm classes.

This opens up the question of whether the ECan definitions of farms are wide enough to allow accurate calculation of the N leaching performance of land uses and whether CPWL will need to develop a much wider definition of land uses.

1 Methodology

Central Plains Water Limited (CPWL) has a critical need to understand their shareholders existing nutrient loss baselines as this will inform a number of areas across both their planning and implementation. CPWL contracted The AgriBusiness Group in order to undertake farm baseline data collection and nutrient budget preparation for 40 sample farms across the CPW catchment, representing typical farming systems in the area.

1.1 Background

CPWL issued a project brief plan to carry out this work as follows;

Purpose:

Understanding CPWL shareholders existing nutrient baselines is critical as it informs a number of areas across both planning and implementation.

1.1.1 Secure CPWL's Nutrient allocation = providing certainty that the scheme can develop to 60,000ha

Check actual baselines against the model used by ECan (to determine CPWL existing baseline and additional N allocation for new irrigators) – does it align? CPWL needs to know this prior to the mid-year sub regional plan hearing – the more we know the less we are putting at risk by guessing.

1.1.2 Inform the Nutrient Allocation Methodology

The sub regional plan proposes to allocate 850t of Nitrogen to CPWL to enable land use change for new irrigators. MPI are funding a separate project to establish the optimal nutrient allocation methodology for CPWL. However, understanding existing baseline Nitrogen discharges is important as this will help determine how far CPWL can stretch the 850t Nitrogen resource across new irrigation. Is there any left over for existing irrigators to intensify? The existing baseline numbers are needed to inform the Nutrient Allocation methodology.

The results of this work package will enable CPWL to answer re-occurring questions from CPWL shareholders in relation to '*is the 850t enough and how will it be allocated?*'

CPWL need to have a good understanding of the baselines and a confirmed Nutrient Allocation Methodology before any meaningful 'marketing' can occur for Stages 2/3 uptake.

Land Use Change scenarios - Once CPWL knows the existing baselines for both irrigators and non-irrigators, we can then start to model (based on farmer feedback of intended irrigated land use), the degree of intensification possible within the scheme area. Soil data (SMap) and climate/rainfall data, which are readily available, will form the basis of this work.

1.1.3 Farm Environmental Management Plans

CPWL have programmed to commence the FMP training process Q2 2014. Having the baseline data/nutrient budget is the foundation of the FMP.

CPWL engaged The AgriBusiness Group to undertake the baseline data collection and nutrient budget preparation work for the sample farms across the CPWL catchment. The AgriBusiness Group has three staff that have completed the Advanced Nutrient Management course using OVERSEER and also contracted another consultant who had also completed the appropriate qualifications to assist in collecting data and carrying out the modelling.

1.2 Farm Selection

It was originally specified that the farms would be selected by CPWL based on their ability to represent typical farm systems of the area. However CPWL's information on the current land uses and the potential future use of the land under irrigation was somewhat limited in that it had been collected a while ago or was somewhat sparse in its content. In the end the farm selections were made more on their geographical representation rather than in an attempt to represent a reasonable cross section of typical farm systems. However because of the number of farms chosen (40) and the spread of locations it is expected that it gives a reasonable representation of the types of farm systems present in the area. Because there is no reliable data on the range or type of farm systems in the subject area it is impossible to comment definitively on whether the chosen sample of farms is a close fit with what is there at present.

1.3 Information Management

It was decided to engage AquaLinc to provide a system to manage both the raw input data and the resultant output information and results. They did this through the provision of Quantum GIS. This is an Open Source Geographic Information Systems program. Into this program AquaLinc have loaded all of the relevant data that they have in the catchment of CPWL. This includes:

- Land survey information.
- Farm ownership information
- NIWA climate data
- S map soil descriptions.

TAG created an OVERSEER information template that the farm surveyors were able to use to collect the required information on the farm to complete the OVERSEER analysis. This was felt necessary as a data base in order to carry out further development runs in the future. This template has been uploaded into the Quantum GIS database along with any other notes

created as part of the data gathering exercise. The OVERSEER files of the analysis have also been uploaded into the Quantum GIS program.

In this way all of the information utilised in this task, both inputs and outputs, is available to be sourced from the "cloud" through Quantum GIS and so is able to be freely shared with all of the people involved in the project. This had the added advantage of all of the current information being freely available in real time.

1.4 Determining the "Baseline".

There has been much discussion and debate around how best to calculate the nutrient baseline data for CPW. The following discussion leads to a conclusion of how best that TAG thought it could carry out the exercise in the best interests of CPWL.

1.4.1 Legal Framework

The issue of the legal status of the Nitrogen Baseline is determined by ECan's Land and Water Regional Plan (LWRP).

In the LWRP it states in the definition of Nitrogen Baseline that it should be "…. As modelled with OVERSEER….. averaged over the period of 1 July 2009 – 30th June 2013"

In the nutrient management section of the LWRP on the nutrient management rules which operate in irrigation schemes (sect 5.60 to 5.62) there is no reference to the requirement to report a baseline calculation. It states that "until 1 Jan 2017 discharges …… onto land …. Is a permitted activity" as long as the following conditions are met "there is an existing consent ….. that has conditions that specify the maximum amount and rate at which nutrient may be leached from the subject land".

Therefore there is no legal requirement for CPWL to have any concern over the level of nutrient emissions for properties that have not as yet taken up water in the irrigation scheme. However CPWL are tasked with managing the total load of the Nutrient emissions from their scheme constituents therefore they have an interest in knowing the levels of emissions pre the scheme in order for them to allocate and manage the loads on an individual and a total scheme basis.

As we interpret the legal framework there isn't actually the requirement for CPW to carry out Nitrogen Baseline calculations on each farm. There is however an implied requirement that they will have to prove to ECan that they can achieve the maximum levels of discharge under their consent. This could conceivably be done by modelling a whole lot of indicative farming systems and just multiplying them up by the areas of each land use. This would conceivably require that irrigators conformed to some scheme wide regulations around N timing and use,

irrigation practices, stocking rates, the use of supplementary feeds and the use of mitigation practices such as feed pads etc. There would presumably be the requirement that Ecan was prepared to accept this means of reporting.

In a publication “Canterbury land and water regional plan – What does it mean?” the following question is asked and answered.

Question: Do I need to prepare a nitrogen budget for each of the four years or can I prepare just one covering all four years?

Answer: Either method should give the same result if the farm is “steady state”, meaning the way it is farmed and production level’s haven’t changed much. If it has changed, annual budgets are the only way to ensure an accurate baseline.

Therefore we believe that the only requirement to do individual four years of budgets would be if there was a significant farming system change during the four years stipulated. In that instance, considering that it takes a number of years for system changes to have an effect in terms of Nutrient leaching we believe that it was best to do an up to date OVERSEER model to reflect the impact of the total system change.

1.4.2 Practical Considerations

In order to test the practicality of carrying out four years of modelling on a property a number of pilot farms were modelled with the surveyors trying to collect sufficient information to be able to carry out accurate modelling in OVERSEER. Our staff encountered the following problems with collecting data on the four years:

- Poor farmer memory of exactly what was achieved in each of the four years,
- Significant change in infrastructure (farm size, irrigation practice etc) over time,
- Significant time and frustration from the farmers in the time taken to collect the data.

Considering that there was no absolute requirement to provide four years of data and the fact that staff found it practically difficult it was decided that it would be best to concentrate on providing one year’s data which was seen to represent an average year.

1.5 Nutrient Budgets

The nutrient budgets were modelled in OVERSEER as specified by ECan. Although OVERSEER is the only practical means to model nutrient emissions in New Zealand farming systems it does however provide inaccurate results at present. These causes of inaccuracy are twofold. The first is that there are still a number of bugs within the program which mean that the

results produced are inaccurate. Although many of these bugs are known to the programmers it takes some time before they are fixed. There are probably still unidentified bugs in the program that are affecting the results. The second factor is that there are a large number of assumptions and options that an operator can choose that have a significant impact on the nutrient emissions reported. For example most of the nutrient budgets that have been done in the past few years have been carried out by Fertiliser sales representatives. Their prime objective is to produce a nutrient budget from which they can calculate the annual fertiliser requirements. Therefore the assumptions and options that they choose in order to get that result is much less than that which is required to accurately calculate the nutrient emissions.

In order to get a degree of commonality in the way that OVERSEER is used the owners put out a protocol *"The Overseer Best Practice Data Input Standards (August 2013)"* which lists the recommended best practice options for entering data into OVERSEER. However it should be noted that many of these options have a number of choices of methods which are listed from first choice to last choice and give the operator a choice of which option that they choose. At the same time the Dairy industry in New Zealand also developed their protocol as to how OVERSEER should be used. Amongst other things it recommended that the option on irrigation choice was the lowest choice in terms of the owners best practice guidelines. The effect of this is that the irrigation system is assumed to be working at full efficiency therefore the amount of nitrogen which is washed through the soil profile is very low. It is believed that the Dairy industry is going to come in line with the owners recommended practice but in the meantime all of the existing nutrient budgets carried out on dairy farms under report the level of nutrient emissions.

In this exercise we attempted to produce results which are as accurate as possible. Therefore where there was a known system error in OVERSEER and it was possible to devise a solution which worked around it then this was done. Where it was not possible to devise a solution to the problem it was noted. In all cases the first choice best practice guidelines have been followed, apart from in the instances detailed in the next section.

1.5.1 Dealing with known system errors in OVERSEER

The following work around solutions are shown in Table 5. The first column describes the category addressed. The second column describes the best practice recommendations and the third column describes the work around solution devised.

Table 5: Departure from the Best Practice Guidelines

Category	Overseer Best Practice Data Input Standards	CPWL nutrient budgeting
4.2 Climate		
Mean Annual Rainfall	Climate station tool - Overseer	GeoOVERSEER spatial database - NIWA
Mean Annual	Climate station tool -	GeoOVERSEER spatial

Temperature	Overseer	database - NIWA
Annual Potential Evapotranspiration (PET)	Climate station tool - Overseer	GeoOVERSEER spatial database - NIWA
4.3 Soil description	Either farm specific soil map or Soil Order data - sourced from S-map	GeoOVERSEER spatial database – S-map
4.11 Irrigation	Either 5-year average data for rainfall and irrigation or Method and months only (leave rate blank)	Modelled irrigation based on monthly rainfall, PET and 80% irrigation efficiency - Aqualinc Research[3]

Climate

It is known that the data supplied by NIWA to OVERSEER is incorrect. Therefore the mean annual rainfall, temperature and evapotranspiration are all incorrect. These are all very important in the calculation of emissions. Therefore we chose to input the accurate data provided by AquaLinc to the Quantum GIS system instead of choosing the inaccurate data supplied in OVERSEER. Annual mean temperature, rainfall and potential evapotranspiration figures, which are the average of 50 years NIWA data, were taken from the Aqualinc Research derived GeoOVERSEER spatial database software.

Since this report was written the version of OVERSEER has been changed and one of the corrections in it is that the correct climatic information is now incorporated in the program. We tested this change with a few of the farms and have found that it did not materially change the result.

Soil

We know that there is a disconnect between the way the data is recommended to be inputed by the best practice guidelines and the resultant plant available water calculations in OVERSEER. This has the potential to cause big discrepancies in the amount of moisture which pours through the soil profile and therefore the calculated emissions. We therefore chose to enter the soil order descriptions and texture as detailed in the S map file to overcome this inaccuracy. Soil series was used as a descriptor taken from S-map, which had also been incorporated into the GeoOverseer database. Page 3 of the S-map pdf descriptor file was used to describe soil texture in the soil profile section.

Irrigation

[3] Aqualinc Research - CPW flow rate requirements - Report C12001/5

We entered the average annual irrigation requirement as calculated by the following means. Annual rainfall and potential evapotranspiration figures were supplied by AquaLinc for each of the three locations of Hororata, Te Pirita and Dunsandel. These were distributed on a monthly basis. The irrigation requirement was calculated as equalling rainfall minus evapotranspiration. The surveyors then chose the nearest climate station and calculated the irrigation requirement on a monthly basis based on their system being 80% efficient.

The treatment of Kale

The one area of concern that we know of that we have not been able to resolve is the treatment of Kale as a winter feed crop. It is extensively used in dairy support operations. Our concerns come from the wide variation in individual crops in terms of N discharges with the range going from approximately 35 kg N / ha / annum to 145 kg N / ha / annum. Although some of the variation in results will be caused by things such as crop yield and the amount of N applied as fertiliser much of the variability cannot be explained by these variations.

Kale can be treated as a Fodder Crop until it exceeds 25% of the available area of the property. When this happens it must be entered as an arable crop. It is also widely used on arable properties where it is natural to include it as part of the arable rotation which is then harvested by livestock. For some reason the way you include it causes the amount of N discharge to be calculated differently. We suspect that this is caused by the losses from the grazing cattle not being included in the calculation appropriately.

The results reported here should be considered as interim until we resolve this issue.

Industry Dialogue

This CPWL Nutrient Baseline project has initiated interest and discussion amongst rural professionals (consultants, fertiliser account managers, bankers, real estate agents) and regional council staff. As described above there has been interest in the processes used in nutrient budgeting to establish nutrient loss figures for any particular farm and the resultant variation in results by those achieved by different operators of OVERSEER for different purposes. An example is the voicing of concern at the variation of results when compiling nutrient budgets, using Overseer, in the CPWL command area.

2 Results

3.1 Ecan's Requirements

ECan has calculated the average N leaching for a range of land uses for existing irrigated and dryland and for the CPWL area once conversion to irrigation has been completed. They have calculated them for 2011 (the baseline) and then for 2017 and 2022. The results of this exercise are shown Table 6.

Table 6: ECan's Requirements for Baseline N leaching.

Land Use	2011	2017	2022
Existing Irrigated.	32.1	34.8	28
Existing Dryland	15.6		
New irrigated Dairy Support		38.7	
New irrigated Sheep and Beef		22.8	
New irrigated Dairy		32.6	
New irrigated Arable		22.7	

What interests us for this part of the exercise is the calculated allowance for existing dryland (15.6) and existing irrigation properties (32.1). Obviously the current land use will influence the results but we do not have the land use mix used by ECan to calculate these results.

3.2 Land Use Mix

A significant proportion of the farm classes had a mix of several of the farm classes which ECan defines in its apportionment of N leaching allocations. In the following table they are classified as their primary farm class first and then the other mixes are added onto the definition. It should be noted that Dairy Support operations are now an integral part of the Arable farming mix with a high proportion of Arable farms having some form of wintering of dairy cows.

The land use mix from this exercise is interesting because it shows that apart from Dairy farming the remainder of the land uses are very

interchangeable. There is no apparent distinction between Arable, Sheep and Beef and Dairy Support in terms of land use mix with them all being very interchangeable to a lesser or greater extent. It should be noted that the irrigated farms are predominantly Dairy and Arable properties at present.

The land use mix from the surveyed farms is shown in Table 7.

Table 7: Land Use Mix for Surveyed Farms

Land Use	Numbers of Farms	Dryland	Irrigated
Arable + Sheep and Beef	3	3	
Arable + Dairy Support	6		6
Arable + Sheep and Beef + Dairy Support	3	3	
Sheep and Beef	2	2	
Sheep and Beef + Dairy Support	10	10	
Dairy Support	4	2	2
Dairy	12		12
Total	**40**	**20**	**20**

The areas of the various land uses that were surveyed are shown in Table 8. They are split up into Dryland and irrigated farms in the next two columns across. It is interesting to note that all of the Arable farms that have dairy Support are also irrigated as are half of the dairy Support properties and all of the Dairy farms are irrigated.

Table 8: Area of Farms

Land Use	Area of Farms	Dryland	Irrigated
Arable + Sheep and Beef	857	857	

Arable + Dairy Support	2,572		2,572
Arable + Sheep and Beef + Dairy Support	1,224	1,224	
Sheep and Beef	360	360	
Sheep and Beef + Dairy Support	3,352	3,352	
Dairy Support	803	370	433
Dairy	3,053		3053
Total	**12,221**	**6,163**	**6,058**

It is interesting to note that we have surveyed 21% of the potential new irrigated area (30,000 ha) and 20% of the existing irrigated area (30,000 ha) to date. Approximately 50% of the farms surveyed to date are dryland and 50% are irrigated. Of the farms surveyed to date there is very little difference in the farm size being 308 ha for the dryland properties and 303 ha for the irrigated.

3.3 N leaching

The N leaching results which are weighted by the area in each land use category are shown in

Table 1. The split between Dryland and Irrigated is then shown in the next two columns.

Table 9: N Leaching Results

Land Use	Total Results	Dryland	Irrigated
Arable + Sheep and Beef	34	34	

Arable + Dairy Support	24		24
Arable + Sheep and Beef + Dairy Support	15	15	
Sheep and Beef	17	17	
Sheep and Beef + Dairy Support	22	22	
Dairy Support	49	38	59
Dairy	54		54
Total	**32**	**23**	**41**

The results to date indicate that for the Dryland properties the allowance made by ECan of 15.6 kg N / ha is well short of the actual result of 23 kg N ha. For the existing irrigated properties the initial allowance of 32.1 kg N / ha for the baseline calculation is well short of the average of 41 kg N / ha.

If we look further into the results we can see the variability of N leaching results across the individual farm classes. Variability in leaching results can be caused by a multitude of reasons. Factors such as soil type, irrigation practices, mix of farm types, intensity of operations (particularly the amount of N applied) and the mix of stock types can all have a significant impact on the N leaching performance of an individual property. The most dominant factor is however the amount of N leached from the urine patch of Dairy cows. Therefore Dairy farming and Dairy Support are naturally high in the amount of N leaching. Dairy Support can take three forms of operation, the sale of silage to a Dairy farm which is low in N leaching, the grazing of young stock which is also low in N leaching and the wintering of mature Dairy cows, intensively on a feed crop, which is very high in N leaching.

The Number of Farms in each category the Total Average Results and then the maximum and minimum results for each farm class are shown in Table 10. What can be taken from these results is the massive variability which we can get from within the farm classes let alone from between the farm classes.

Table 10: N Leaching Results Showing Variability.

Land Use	Number of Farms	Total Results	Maximum	Minimum
Arable + Sheep and Beef	3	34	46	13
Arable + Dairy Support	6	24	43	7
Arable + Sheep and Beef + Dairy Support	3	14	17	11
Sheep and Beef	2	17	18	12
Sheep and Beef + Dairy Support	10	22	37	10
Dairy Support	4	49	70	26
Dairy	12	54	89	42
Total	**40**	**34**		

APPENDIX TWO: LETTER FROM ANTS ROBERTS AS TO METHODOLOGY ADOPTED.

Hello Stuart

Thank you for the information and discussion regarding the OVERSEER analyses TAG are doing for CPWL. You have asked me to specifically address the issues around the 'work arounds' you have had to adopt which are outlined in Table 1.

Please let me state up front that these are my professional opinions informed by my knowledge of OVERSEER, although I am not privy to the inner most workings of the algorithms the model contains.

Firstly, for consistency between OVERSEER users it is important that the OVERSEER Best Practice Data Input Standards are followed. However, in the latest version here are some COMPULSORY inputs that are fixed for dairy farms and which we are following. This is part of the Audited Nutrient Management Scheme devised by DairyNZ and being used by Fonterra and Synlait.

1. Climate data: The climate station tool was flawed when it was first tied into the OS6.1.1 release in that NIWA provided median monthly and total rainfall not average monthly and total rainfall. PET was using the Priestly Taylor equation not the Penman equation. You have elected to use data provided directly by NIWA (50 year average) which I see no problem with, except that OS uses 30 year average data. I understand that Aqualinc has said to you that the results should be similar when the climate station tool is fixed. This is not unreasonable given that we are allegedly using the same database!

2. Soil description: S-map is the soil data of choice at the soil order level, and I understand that that is what you are using. There is a project at Landcare looking to provide the actual hard data required at the soil sibling level to assist the model to work out the relevant AWCs. Using page 3 data is the best source until this project is finalised.

3. Irrigation: This is a major issue. My opinion is that it is imperative that estimated monthly irrigation depth is entered into the model. The importance of this is that we all know that most farmers irrigate more water per month than what the OVERSEER model calculates based on daily water balance. Using Method Only in most cases underestimates N loss and better irrigation practices (and application technology) will be a big step to help reduce N loss from irrigate systems without affecting productivity negatively. There is a Landcare/Aqualinc/AgResearch project looking at ways that monthly irrigation depth can be added for the Canterbury region but we are unlikely to see that until next year in OVERSEER. While I applaud the addition of irrigation estimates, any nutrient budgets that we undertook for dairy farms in the CPWL area would be with Method Only and hence yield different results than yours.

4. A couple of other compulsory inputs for dairy include the exclusion of wetlands as blocks on farms, the exclusion of support blocks unless they are contiguous with the dairy platform and the use of peak cow numbers rather than monthly cow numbers.

5. The issues around arable crops when animals graze and irrigation of arable crops are I believe serious 'bugs' in the model itself. I assume that the OS development team are aware of these and are working on fixing them.

Regards

Ants Roberts

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APPENDIX THREE:

Mitigation Options, Complexity and Costs for Various Percent Reductions in Nitrate-N

ystem	Parameters	Estimated % reduction in N losses (kg/ha) above good practice in Selwyn Waihora catchment					
		<11%	12-20%	20-30%	30-40%	40-50%	>50%
Dairy	Interventions	1-3 interventions (e.g. DCD, improved nutrient and effluent management) [a,b,c,d]	2-3 interventions (e.g. DCD, improved nutrient, irrigation and effluent management, improved genetic stock, reducing autumn fertiliser) [a,b,c,d]	1-4 interventions (e.g. DCD, improved nutrient and effluent management, on off grazing, improved cow efficiency, reduced autumn N) [a,b,c,d]	2-4 interventions (e.g. DCD, improved nutrient, irrigation and effluent management, on off grazing, improved cow efficiency, reduced autumn N, restricted autumn grazing with winter shelter) [a,b,c,d]	3-4 interventions (e.g. DCD, improved nutrient, irrigation and effluent management, on off grazing, improved cow efficiency, reduced autumn N, restricted autumn grazing with winter shelter) [a,b,c,d]	3-4 interventions (e.g. DCD, improved nutrient, irrigation and effluent management, on off grazing, improved cow efficiency, reduced cow numbers, reduced autumn N, restricted autumn grazing with winter shelter) [a,b,c]
	Complexity	Simple	Simple/moderate	Simple to complex	Simple to complex	Mainly moderate to complex	Mainly moderate to complex
	Annual cost	~ 1% reduction in EBIT (+1 % to -3%) [b] /~ 1 % reduction in EBIT [d] / <1% in EBIT [a]	~ 2-4% reduction in EBIT (0 to -6%) [b] /<1-4% reduction in EBIT [d] / 1-2% in EBIT [a]	~ 2-10% reduction in EBIT (0 to -22%) [b] / 1 -5% reduction in EBIT [d] /1 to 27 % > in EBIT [a]	~ -4-13% reduction in EBIT (-6 to -22%) [b] up to 21 % reduction in EBIT [d] / 3 to 27 % > in EBIT [a]	~ 10-13% reduction in EBIT (-6 to -22%) [b] / up to a 25 % reduction in EBIT [d] / 10 to 60 % > in EBIT [a]	> 13% reduction in EBIT (-6 to -22%) [b] / 23 to >60 % > in EBIT [a]
Irrigated drystock	Interventions	1-2 interventions (e.g. DCD, improved nutrient and irrigation management) [a,c]	1-4 interventions (e.g. DCD, improved nutrient, irrigation and effluent management, reduced N fertiliser, low N feed) [a,c]	Target reduction only possible if on farm wetland 1-4 interventions(e.g. DCD, improved nutrient, irrigation and effluent management, low N feed, wetland) [a,c]	Target reduction only possible if on farm wetland 1-4 interventions(e.g. DCD, improved nutrient, irrigation and effluent management, low N feed, wetland) [a,c]	Target reduction only possible if on farm wetland 1-4 interventions(e.g. DCD, improved nutrient, irrigation and effluent management, low N feed, wetland) [a,c]	Target reduction only possible if on farm wetland 1-4 interventions(e.g. DCD, improved nutrient, irrigation and effluent management, low N feed, wetland) [a,c]
	Complexity	Simple/moderate	Simple to moderate	Simple to moderate	Simple to moderate	Simple to moderate	Simple to moderate
	Annual cost	~23 %reduction in EBIT [d] / 11-22 % > in EBIT [a]	up to 20 % reduction in EBIT [d/~] 23-47% > in EBIT [a]	~45 % reduction in EBIT [d/~] > 60 % reduction in EBIT [a]	~45 % reduction in EBIT [d/~] > 60 % reduction in EBIT [a]	~ > 60 % reduction in EBIT [a]	~ > 60 % reduction in EBIT [a]
Dryland drystock	Interventions	1-2 interventions (e.g. DCD, improved nutrient and effluent management) [a,c,d]	1-4 interventions (e.g. DCD, improved nutrient and effluent management, low N feed, wetland if possible) [a,c,d]	Target reduction only possible if on farm wetland 1-4 interventions(e.g. DCD, improved nutrient management, low N feed, wetland) [a,c]	Target reduction only possible if on farm wetland 1-4 interventions(e.g. DCD, improved nutrient, irrigation and effluent management, low N feed, wetland) [a,c]	Target reduction only possible if on farm wetland 1-4 interventions(e.g. DCD, improved nutrient, irrigation and effluent management, low N feed, wetland) [a,c]	Target reduction only possible if on farm wetland 1-4 interventions(e.g. DCD, improved nutrient, irrigation and effluent management, low N feed, wetland) [a,c]
	Complexity	Simple/moderate	Simple to moderate	Simple to moderate	Simple to moderate	Simple to moderate	Simple to moderate
	Annual cost	~ 31% reduction in EBIT [d] /11-22 % > in EBIT [a]	~ 31% reduction in EBIT [d] / ~ 17-47% > in EBIT [a]	~ > 60 ^ reduction in EBIT [a]	~ > 60 ^ reduction in EBIT [a]	~ > 60 ^ reduction in EBIT [a]	~ > 60 ^ reduction in EBIT [a]
Arable	Interventions	multiple interventions (e.g. tillage, fallow, soil testing, improved nutrient and irrigation management, reduced inputs by 15 %, DCD) [b,d]	multiple interventions (e.g. tillage, fallow, soil testing, improved nutrient and irrigation management) [b]	multiple interventions (e.g. tillage, fallow, soil testing, improved nutrient and irrigation management) [b]	multiple interventions (e.g. tillage, fallow, soil testing, improved nutrient and irrigation management) [b]	multiple interventions (e.g. tillage, fallow, soil testing, improved nutrient and irrigation management) [b]	multiple interventions (e.g. tillage, fallow, soil testing, improved nutrient and irrigation management) [b]
	Complexity	Simple to complex	Simple to complex	Simple to complex	Simple to complex	Simple to complex	Simple to complex
	Annual cost	~ 10% reduction in EBIT [d]	unknown	unknown	unknown	unknown	unknown