BEFORE THE	Canterbury Regional Council
IN THE MATTER OF	the Environment Canterbury (Temporary Commissioners and Improved Water Management) Act 2010
AND	
IN THE MATTER OF	Submission and Further Submission on Proposed Plan Change 5 to the Proposed Canterbury Land and Water Regional Plan

STATEMENT OF EVIDENCE OF DR LIONEL JOHN HUME ON BEHALF OF THE COMBINED CANTERBURY PROVINCES OF FEDERATED FARMERS OF NEW ZEALAND

Dated 22 July 2016

Introduction

Qualifications and experience

1. My name is Lionel John Hume. I hold B.Ag.Sc and M.Sc. (First Class Hons) degrees from Massey University and a Ph.D. (Plant Science) from Lincoln University. I am currently employed as a Senior Policy Advisor, by Federated Farmers, based in Ashburton. I am also a board member of Irrigation New Zealand.

2. I previously worked as a scientist for the Department of Scientific and Industrial Research (New Zealand Soil Bureau/DSIR Land Resources) in the areas of plant nutrition and soil fertility. Specific areas of scientific research experience include:
    a. nutrient uptake and use by plants – particular emphasis on nitrogen and phosphorus;
    b. nutrient availability from soils;
    c. effects of soil acidity (particularly aluminium toxicity) on nutrient uptake and symbiotic nitrogen fixation;
    d. nutrient, water and management factors affecting the growth and competitiveness of major weed species;
    e. effects of soil physical properties on plant growth; and
    f. experimental design and data analysis.

3. I am a member of the NZ Institute of Agricultural and Horticultural Science, the NZ Society of Soil Science and the Agronomy Society of NZ.

4. I am a member of Federated Farmers' Regional Policy team and have over ten years experience of working with regional water planning processes, including: the Canterbury Natural Resources Regional Plan process (from submission through to resolution of High Court appeals); development of the Resource Management (Measurement and Reporting of Water Takes) Regulations 2010 and membership of the implementation taskforce for those regulations; the development of catchment-based flow and allocation plans for several Canterbury catchments; the development of the Canterbury Water Management Strategy; and, recently, the Regional Policy Statement and Land and Water Regional Plan processes, including several catchment based limit-setting processes culminating in plan changes.

Code of Conduct

5. Notwithstanding that this is a Regional Council hearing, I have read the Environment Court Code of Conduct for expert witnesses and agree to comply with it. I confirm that I have not omitted to consider materials or facts known to me that might alter or detract from the opinions I have expressed.

Scope of evidence

6. My evidence covers the following matters:
   a. Potential environmental impacts of farming;
   b. Soil water and water availability to plants;
   c. Reliability of water supply and its importance to efficient water use;
   d. Fluctuation of N discharge from soils in response to climatic variation and the cyclical nature of routine farming operations;
   e. Canterbury soils – wide range of vulnerability to drainage and nutrient loss;
   f. N discharge allowance – the need to take soil type into account;
   g. Flexibility caps – to enable low N dischargers the flexibility to carry on normal farming operations and make reasonable land use changes;
   h. Sensitive Lake Zones; and
   i. Matrix of Good Management.

Potential environmental impacts of farming

7. Potential environmental impacts of farming on water quality include loss of nutrients (particularly N and P), sediment and harmful bacteria (indicated by *E. coli*) from soils.

8. N in nitrate form is highly soluble, will move anywhere that water goes and is vulnerable to loss via drainage. Therefore, the most effective methods of minimising N loss are to match N supply with plant demand (to minimise the pool of N vulnerable to leaching) and to minimise drainage (hence the importance of adopting realistic good management practices with regard to irrigation) .

9. P is less soluble and tends to move with sediment. The risk of sediment and phosphorus loss is identified in Proposed Plan Change 5. These risks are addressed via the identification of High Runoff Risk Phosphorus Zones and the use of Farm Environment Plans prepared in accordance with Schedule 7, which includes a

requirement to manage soils in order to minimise the movement of sediment, phosphorus and other contaminants to waterways. Methods to minimise sediment and P loss are to minimise surface flow of water containing suspended sediment, P and *E. coli* (where present) by avoiding over-irrigation, by maintaining vigorous vegetation cover and via riparian management aimed at intercepting sediment and phosphorus (and *E. Coli* where present) before they enter waterways.

10. Soils vary in their ability to filter *E. coli*. In strongly structured soils *E. coli* may move through the soil via bypass flow, through larger pores and structural cracks. In soils without strong structure, matrix flow predominates, with more effective filtration and retention of *E. coli*.

11. Farm Environment Plans (FEP's) are a powerful tool for addressing the loss of nutrients (mostly N and P), sediment and harmful bacteria (indicated by *E. coli*) from soils because they are able to address these issues in the context of particular land uses in particular farming environments.

12. In my opinion, FEP's are a more certain way to achieve environmental outcomes than complete reliance (in the case of N loss) on the Farm Portal numbers, particularly given current issues with the farm portal, which are detailed in other evidence presented at this hearing. However, FEP's come with a cost and capacity to produce them is limited, because of a limited number of suitably qualified personnel. Therefore, a staged approach would be appropriate, whereby the use of FEP's as a regulatory tool is first focused on properties where significant nutrient, sediment or *E. Coli* discharge issues are likely to arise.

Soil water and water availability to plants

13. Water is crucial for plant growth and to sustain agricultural production. An understanding of how water is stored in soils and its availability to plants is essential in order to be able to manage it effectively, to optimise plant growth, and minimise drainage and consequent dissolved nutrient loss.

14. Field capacity has been defined as the amount of water that a well drained soil holds against gravitational forces, when downward drainage is markedly decreased. However, it is recognised that field capacity is an imprecise term and that true equilibrium is never reached. Although it varies with both soil type and conditions such as temperature, field capacity is often estimated to be the water held at a soil water

potential (or suction) of -33 kPa. This is a measure of the energy that has to be used to extract water from the pores in a soil.

15. As soils dry out, the energy required to extract water increases to a point where plants wilt and do not recover overnight. This is known as permanent wilting point and generally occurs at about -1500 kPa. The water held in a soil between field capacity and permanent wilting point is known as plant-available water. However, water is not equally available over this entire range and extraction becomes increasingly difficult as permanent wilting point is approached. Once about the first half of plant-available water is used, the increasing energy required to extract further water results in decreased plant growth and decreased crop yield. In order to optimise plant growth, irrigation needs to be scheduled to keep plant available water above the 50% mark. Obviously there is less margin for error in this regard on soils with less plant available water.

16. The quantity of plant-available water is dependent on soil type, including factors such as:

- Soil texture – fine textured soils tend to retain more water than coarse textured soils.
- Soil structure – the degree of aggregation of primary soil particles into structural units. Organic matter assists with the development and maintenance of good soil structure and increased plant available water.
- Stones – stony soils retain less water than soils without stones (because of lesser soil volume). This is an important issue for Canterbury soils where some horizons may contain more than 50% stones.
- Soil depth – deep soils retain more water than shallow soils (because of greater soil volume).
- Impermeable or slowly-permeable layers – may prevent or reduce water movement through the soil profile and therefore drainage from it.

17. Soils which have the capacity to store less plant available water are more vulnerable to loss of water (and dissolved nutrients) via drainage compared with soils which have greater plant available water. The reason for this is that there is less ‘buffering capacity’ in soils with less water storage and therefore less capacity to store incoming rainfall without drainage losses. On soils which are irrigated, there is less capacity to deficit irrigate (leaving capacity to store incoming rainfall by not watering up to field capacity) where there is less water storage.

18. Therefore, irrigating little-and-often, using soil moisture monitoring, is likely to result in more efficient use of irrigation water for plant uptake and less potential for soils to exceed field capacity and leach nutrients, compared with less frequent application of greater quantities.

Reliability of water supply

19. Access to a reliable water supply is crucial for efficient water use, especially on the moderate to very light stony soils in Canterbury which tend to have low water storage and moderate to rapid permeability. A constantly available, reliable water supply encourages investment in modern irrigation technology and enables little-and-often approaches to the application of irrigation water (referred to previously). It also removes the need for use-it-or-lose-it approaches to irrigation which are encouraged by intermittent and unreliable supply. If it is known that water will be available when it is needed, the appropriate amount can be applied when it is needed ('just in time' rather than 'just in case'). Reliability of supply also encourages the use of deficit irrigation (e.g. to leave storage capacity for expected rainfall) by providing the assurance that further water will be available if the expected rainfall does not eventuate.

20. Reliable water supply enables communities to maximise the benefits from irrigation. For example, it enables the development of high value arable and horticultural production systems where crop loss (decrease in yield or quality) or failure could occur if water is not available in the right quantity at the right time.

21. When irrigators have less reliability they tend to use greater quantities of water when it is available, hoping that will provide sufficient soil moisture and plant growth to minimise the impacts of possible future shortage (such as restrictions on takes related to minimum flows).

Fluctuation of N discharge

22. N discharge will fluctuate from year to year under constant land use (farming activity). Fluctuations result from:

- Climatic variation, especially rainfall[1]:

[1] Long term records show that annual rainfall on the Canterbury Plains can vary by up to 100% year to year. See for example: http://resources.ccc.govt.nz/files/NaturalHazards_1758_AnnualRainfall-docs.pdf

- Variation in drainage and consequent N loss (e.g. resulting from heavy rainfall events). This will be more pronounced on soils with relatively less plant available water.
  - Surface flow events where incoming rainfall exceeds the infiltration capacity of the soil. This may result in loss of sediment and P, as well as dissolved N.
  - Variation in plant growth (crop yield), plant N uptake and urine deposition (in the case of livestock farming) as influenced by varying conditions for plant growth, availability of animal feed etc.
- Cyclical variation in farming operations, including:
  - Crop rotations.
  - Livestock changes in response to market signals.

23. In order to be workable, any regulatory regime to manage N loss, such as the nutrient management rules in proposed Plan Change 5, must recognise the seasonal fluctuations which occur as part of biophysical systems and in response to market signals. Such fluctuations may occur over an extended period, longer than four years (being the duration of the 2009-2013 “nitrogen baseline” period and the 4 year rolling average ”nitrogen loss calculation” period as defined in Section 2 of proposed Plan Change 5). These fluctuations in N loss are conceptually different from the sort of change which arises from a radical change of land use, from one with inherently low rates of N loss to another with substantially greater (perhaps several fold) rates of N loss (such as a change from dry-land sheep and beef farming to irrigated dairy farming). It is these gross changes in land use and associated N loss that will potentially have the greatest long-term impact on water quality.

Canterbury soils

24. Soil type is a key factor influencing drainage and the loss of soluble nutrients (especially N) in Canterbury[2]. Canterbury has 890,000 ha of stony soils (soil depth less than 45 cm to gravels), which are classified moderate, light or very light (in terms of their primary soil class)[3]. These soils occupy 64% of the total land area in Canterbury that could

[2] Lilburne, L.: Webb, T.; Ford, R. & Bidwell, V. 2010: Estimating nitrate-nitrogen leaching rates under rural land uses in Canterbury. Environment Canterbury Report No. R10/127.

[3] Carrick, S.; Palmer, D.; Webb, T.; Scott, J.; Lilburne, L. 2013: Stony Soils are a Major Challenge for Nutrient Management Under Irrigation Development. In: Accurate and efficient use of nutrients on farms. (Eds L.D. Currie and C.L. Christensen). Occasional Report No. 26. Fertiliser and Lime Research Centre, Massey University, Palmerston North, New Zealand.

potentially be used for intensive agriculture (less than 15 degree slope). They have moderate to rapid permeability, and a large proportion have low water storage (less than 60 mm or 60-90 mm for very light and light soils respectively). Therefore, these soils are vulnerable to drainage and consequent loss of soluble nutrients. In 2012, 143,000 ha of Canterbury's stony soils were used for dairy farming and 196,000 ha were under irrigation.

25. The numbers quoted in the previous paragraph refer to the whole of Canterbury. However, the percentages of stony soils quoted are largely indicative of what will be present in the Upper and Lower Waitaki catchments, indicating a wide diversity of soils in terms of their potential to leach nutrients, ranging from extremely light through to fine-textured, deep, and poorly drained soils.

26. The contrast between very light to moderate stony soils and heavier soils is stark. In a study of nitrate leaching from cow urine patches in Canterbury, leaching from a Lismore shallow and stony soil (at the better end of stony soils in terms of its water storage capacity) was double that from a stone-free Templeton soil[4&5].

27. Therefore, it is crucial that soil type is taken into account when establishing N discharge limits or thresholds in a planning context.

N discharge allowance

28. The desired outcomes stated in the Upper Waitaki ZIP Addendum (July 2015) have a strong focus on maintaining water quality while providing reliable irrigation water (95% specified) and maintaining or increasing the contribution to the Zone's economy from agriculture and aquaculture, particularly from sustainable farming systems. Similarly, desired outcomes stated in the Lower Waitaki ZIP addendum (July 2015) include a focus on maintaining or improving water quality while providing reliable water for irrigation, viable and diverse farming opportunities, further development opportunities for all farms, strong local economies and growing, vibrant communities. To achieve these outcomes, a large proportion of the productive potential of the Waitaki Catchment and

[4] Di, H.J. and Cameron, K.C. 2005: Reducing environmental impacts of agriculture by using a fine particle suspension nitrification inhibitor to decrease nitrate leaching from grazed pastures. Agriculture, Ecosystems & Environment 109, 202-212.

[5] Di, H.J. and Cameron, K.C. 2007: Nitrate leaching losses and pasture yields as affected by different rates of animal urine nitrogen returns and application of a nitrification inhibitor – a lysimeter study. Nutrient Cycling in Agroecosystems 79, 281-290.

its soils will need to be maintained. In order for the productive potential of soils to be expressed, it will need to be accepted that, even with a high standard of management, there will be greater drainage of water and soluble nutrients (especially N) from some soils than others. Therefore, I support, in principle, the approach taken in Proposed Plan Change 5 to base N discharge limits on Baseline GMP Loss Rate and GMP Loss Rate, which take into account soil type, climate and topography and allow for greater discharge from light soils with greater propensity for drainage. If we wish to maintain the productive potential of all Canterbury soils, and particularly those in the Upper and Lower Waitaki Zones, it is important for the Plan to allow for greater rates of N discharge from those soils with a greater vulnerability to drainage (i.e. the soils classified very light through to moderate). These soils have the potential to be highly productive and make up a significant proportion of the area of the land with potential for intensive land use.

Flexibility caps

29. The purpose of flexibility caps (as used in Plan Change 1 and Proposed Plan Changes 2 and 3 of the LWRP) is to allow low N dischargers the flexibility to carry on with their normal farming operations, which are typically cyclical in nature, and to make reasonable changes in land use (without converting to a high N discharge land use) in response to market signals and climatic variation.

30. Flexibility caps are needed in proposed Plan Change 5, in addition to the narrative permitted activity thresholds (50 ha irrigation and 20 ha winter grazing), because farming activities at the low end of the N discharge range can be captured by these thresholds, and be very limited in their farming options, while continuing to have low N discharge rates. The winter grazing threshold (partly because of the way in which it is defined) is particularly problematic in this regard. It is estimated (Beef + Lamb NZ) that at least half of all Canterbury sheep and beef farmers will be caught by the winter grazing threshold. The 50 ha of irrigation threshold is also potentially problematic; for viticulture and horticulture activities, and for extensive sheep and beef farming on larger hill and high country properties.

31. An advantage of flexibility caps is that they apply on a per hectare basis, unlike the proposed 50 ha of irrigation and 20 ha of winter grazing thresholds which take no account of property area.

32. If the area thresholds are to be relied upon, they need to be related to property area and recognise the constraints and needs of different farming systems. One reason for this is

that productivity (including that of winter forage crops) and stocking rate vary widely with soil type, altitude, climate and other biophysical factors. Stocking rates may vary from 25 – 20 stock units per ha in more intensive situations to 1 – 2 stock units per ha in extensive hill country. Therefore, an extensive farming system will potentially require a greater area of fodder crop than a more intensive system, but may not necessarily have greater total production of fodder crop.

33. For the reasons stated previously, a single number flexibility cap across all soil types would give greater flexibility to those on deep, fine textured soils or poorly drained soils (which have less vulnerability to drainage) than to those on shallow, coarse textured soils (which have greater vulnerability to drainage).

34. Care must be taken to ensure that flexibility caps give all land users a reasonable degree of flexibility and enable them to farm normally, taking into account the factors which may result in fluctuation of N discharge, discussed above. To this end it would be advantageous to have a two (or more) tiered system of flexibility caps based on soil type, similar to the approach used for the maximum caps in proposed Plan Change 3 (Table 15(n)).

35. Recognising the linkage between soil type and potential N loss would enable the management of N loss in a way that is more equitable to land users. If the thresholds are set appropriately, this would enable reasonable flexibility of land use on all soil types, without allowing for conversion to high N loss activities without further scrutiny.

36. When using flexibility caps, care must also be taken to ensure that changes in Overseer version do not erode their effectiveness. This is problematic in a planning context because of the difficulty of changing numbers in a plan via the RMA plan change process. A way around this has been attempted (at the suggestion of the Matrix of Good Management (MGM) Working Group) via the use of narrative permitted activity thresholds for irrigated area and area of winter grazing. Unfortunately these thresholds are capturing a large proportion of low N dischargers and not removing the need for flexibility caps.

37. Another option would be to tie flexibility cap N loss rates to a particular version of Overseer. Given that the role of flexibility caps in the plan would be to provide an alternative permitted activity threshold (to the narrative thresholds), it may not be so crucial to use the latest version of Overseer as it would be for farming activities with greater N losses. (Use of the latest version of Overseer would be more important for

farming activities with greater N losses because these are managed through the consent process and may be required to make reductions beyond GMP loss rates in over-allocated catchments.) In addition, my understanding is that the more recent Overseer version changes have focused on improving modelling for irrigated farms and have generally not made substantial differences to the estimated N loss rates for those at the low end of the N discharge range.

Sensitive Lake Zones

38. There is no flexibility within Plan Change 5 for farmers in Sensitive Lake Zones to accommodate the normal cyclical nature of farming and specifically to adjust land use in response to market signals or physical circumstances such as climatic variation. There are neither permitted activity narratives (50 ha irrigation or 20 ha winter grazing, as for other zones) or a flexibility cap. Farmers are simply held to their N Baseline (until 30 June 2020) or their Baseline GMP Loss Rate (from 1 July 2020). This is neither practical nor reasonable, particularly for those currently at the low end of the N discharge range, who need some flexibility for the reasons given above and who may have little or no scope for reducing their discharge.

39. There seems to be little justification for the total lack of flexibility in rate of N loss. In Appendix 1 to the Section 32 Report for the Proposed Canterbury Land and Water Regional Plan (August 2012), it is stated that: “A meaningful analysis of the nitrate leached in the sensitive catchments is not possible at this point in time given the quality of data that is currently available.” In particular, it was stated that “the soil layer (S-map) was not available for most of these catchments.

40. There are several concerns/questions about the planning approach to the Sensitive Lake Zones, including:

   a. The lack of reliable information about N loss, and the potential for it, as above.
   b. Lack of information about what proportion of the N discharged below the root zone (definition of N baseline) would end up in the lakes.
   c. The relative importance of N leaching below the root zone compared with lateral flow (either surface or sub-surface) carrying sediment and nutrients (particularly P).

41. It appears that N loss is being used as a proxy for land use intensification in the Sensitive Lake Zones. I believe that a more effective way to manage nutrient enrichment issues in Sensitive Lakes, where they actually exist, would be via Farm

Environment Plans, with a focus on practices to minimise N loss and intercept lateral flow (both surface and sub-surface). Consistent with that approach, I believe that a flexibility cap could be used to provide low N loss farms with the flexibility they need to manage their day-to-day operations while preventing change from low N loss farming systems to potentially high N loss systems.

Matrix of Good Management

42. The Matrix of Good Management (MGM) project was undertaken by Environment Canterbury in partnership with the primary sector. The main purpose of the project was to quantify and benchmark nutrient (especially N) losses from farms across Canterbury's soils and climates, when following Industry-agreed Good Management Practices. The aim was to define what can reasonably be expected in terms of nutrient discharges from various combinations of land use, soil type, climate and topography, and to inform policy and limit setting processes.

43. Implementation of the MGM project will provide a great deal of useful information to assist with managing N loss, setting catchment limits and establishing N reduction regimes where these are required. It will provide key information about which combinations of land use and land use practices are likely to meet various N loss targets and, therefore, about the likely social and economic effects of different catchment limits and N reduction regimes.

44. There is potential for the MGM project to provide a rational basis for planning rules which:
    - Recognise the investment in existing land use.
    - Enable the productive potential of all land to be expressed – within the constraints of soil type, climate and topography, recognising that water and nutrient deficiencies can, and mostly will, be overcome.
    - Allow for nutrient discharge only where it cannot be avoided without frustrating reasonable land use.
    - Assume an appropriate level of good management practice.
    - Facilitate flexibility of land use and enable regional economic wellbeing.
    - Assist with achieving the desired outcomes stated in the Upper Waitaki ZIP Addendum (July 2015) and the Lower Waitaki ZIP Addendum (July 2015).

45. In my opinion, it is the use of good management practices on-farm that will ultimately have a positive environmental impact. While establishment of GMP Loss Rates for farming activities would help with establishing good management practices, they would only do so if they could be reliably calculated for a range of farm systems and were reasonably accurate. Given current issues with the Farm Portal, this is not the case. Therefore, I would encourage a planning regime that focuses on good farm management practices to minimise nutrient losses. As a bare minimum, there needs to be an alternative planning pathway to that which relies on outputs from the Farm Portal.

Dr Lionel Hume
22 July 2016

References:

Carrick, S.; Palmer, D.; Webb, T.; Scott, J.; Lilburne, L. 2013: Stony Soils are a Major Challenge for Nutrient Management Under Irrigation Development. In: Accurate and efficient use of nutrients on farms. (Eds L.D. Currie and C.L. Christensen). Occasional Report No. 26. Fertiliser and Lime Research Centre, Massey University, Palmerston North, New Zealand.

Cornforth, I. S. 1998: Practical Soil Management. Lincoln University Press with Whitireia Publishing and Daphne Brasell Associates Ltd.

Di, H.J. and Cameron, K.C. 2005: Reducing environmental impacts of agriculture by using a fine particle suspension nitrification inhibitor to decrease nitrate leaching from grazed pastures. Agriculture, Ecosystems & Environment 109, 202-212.

Di, H.J. and Cameron, K.C. 2007: Nitrate leaching losses and pasture yields as affected by different rates of animal urine nitrogen returns and application of a nitrification inhibitor – a lysimeter study. Nutrient Cycling in Agroecosystems 79, 281-290.

Lilburne, L.: Webb, T.; Ford, R. & Bidwell, V. 2010: Estimating nitrate-nitrogen leaching rates under rural land uses in Canterbury. Environment Canterbury Report No. R10/127.

McLaren, R.G. and Cameron, K.C. 1990: Soil Science - An introduction to the properties and management of New Zealand soils. Oxford University Press.

Kirkham, M. B. 2014: Principles of Soil and Plant Water. Academic Press.

Sutcliffe, J. 1968: Plants and Water. Edward Arnold (Publishers) Ltd.