IN THE MATTER OF	the Resource Management Act 1991
AND	
IN THE MATTER OF	applications by Central Plains Water Trust to: Canterbury Regional Council for resource consents to take and use water from the Waimakariri and Rakaia Rivers and for all associated consents required for the construction and operation of the Central Plains Water Enhancement Scheme Selwyn District Council for resource consents to construct and operate the Central Plains Water Enhancement Scheme
AND	
IN THE MATTER OF	a notice of requirement by Central Plains Water Limited to: Selwyn District Council for the designation of land for works associated with the construction and operation of the Central Plains Water Enhancement Scheme

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BRIEF OF EVIDENCE OF DR GLYN STEWART FRANCIS

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QUALIFICATIONS AND EXPERIENCE

1. My full name is Glyn Stewart Francis. In presenting this brief of evidence I am also representing the expertise of Dr Peter Jamieson and Dr Frank Li. We are co-authors of two reports commissioned by AquaLinc and URS New Zealand Ltd that contain the findings detailed in this brief of evidence.

2. I have a PhD in Soil Science from Lincoln University and until December 2007 I led the Soils Team within the Sustainable Productive Environments Group at the New Zealand Institute for Crop & Food Research Limited based at Lincoln. I have more than 20 years of experience in measuring nitrate leaching losses from agricultural land.

3. Dr Peter Jamieson has a PhD in Agricultural Meteorology from Lincoln University and is the Research Leader for Agricultural Meteorology and Crop Physiology within the Sustainable Productive Environments Group at the New Zealand Institute for Crop & Food Research Limited based at Lincoln. He has more than 35 years of experience in modelling the effect of environmental variation on the performance of arable and vegetable crops.

4. Dr Frank Li has a PhD in Plant Ecology from the University of Montpellier (France) and is Farm Systems Modeller within the Sustainable Productive Environments Group at the New Zealand Institute for Crop & Food Research Limited based at Lincoln. He has more than 15 years of experience in agro-ecosystem research and computer modelling.

5. I have read the code of conduct for expert witnesses set out in the Environment Court practice note, and confirm that I have complied with the code in the preparation of my evidence.

Scope of Evidence

6. In October 2005 we were contracted by AquaLinc, for Central Plains Water, to provide estimates of seasonal leaching under arable, vegetable, dairy, sheep/beef and forestry production using the best current technologies. These estimates were needed to better understand the nature of any threat that intensive agricultural practices might represent to sustainable crop production in Canterbury.

7. In August 2007 we were contracted by URS New Zealand Ltd to repeat our estimates using the latest software versions and some revised management practices.

8. The estimates were to be expressed in terms of leached kilograms of nitrogen (N) per hectare per year and leached kilograms of phosphorus (P) per hectare per year under the land uses examined.

9. For the dairy and sheep/beef land uses we based our N and P leaching estimates on average scenarios in Canterbury. We also investigated the sensitivity of these estimates to variations in pasture conditions and selected management practices.

10. We used OVERSEER™ version 5.2.6 to estimate leaching from dairy and sheep/beef land uses because it is the *de facto* standard nutrient budgeting tool for pastoral systems in New Zealand. OVERSEER™ uses long-term average weather data and generic soil and management information, plus production data to generate estimates.

11. The average dairy scenario included:

    - 200 ha of developed ryegrass/white clover pasture, supporting 620 cows year round (no winter pads, no grazing off farm)
    - Annual fertiliser application rates of 150 kg N/ha, 38 kg P/ha and 28 kg sulphur/ha
    - Long-term average weather data for Lincoln
    - Medium effluent application rate
    - Irrigation applied to match the difference between rainfall and potential evapotranspiration (ET)
    - 700 t of supplements imported annually
    - Milk solids production of 1128 kg/ha/year

12. For dairy, we estimated the sensitivity of N leaching in response to changes in soil type, pasture development stage and winter grazing options

13. The average sheep/beef scenario included:

    - 1003 ha of developed ryegrass/white clover pasture, supporting 6242 sheep equivalents year round (71% of animals are sheep, with the remainder cattle). The farm is on rolling hill country
    - Annual average rainfall of 900 mm and air temperature of 10^{o}C

- No irrigation is applied
- Annual fertiliser application rates of 16 kg N/ha, 13 kg P/ha and 21 kg sulphur/ha
- 40 t of supplements imported annually
- Farm produces 19,812 kg wool/year

14. We used the Sirius Wheat Calculator, the Potato Calculator, and the AmaizeN Calculator to estimate N leaching losses from arable/vegetable land use. Estimates of P leaching losses were obtained from OVERSEER™ and the scientific literature.

15. These three crop calculators are a set of simulation model-based tools for precise crop management that have been developed by Crop & Food Research. They require detailed soil descriptions and daily weather data for their calculations and produce daily estimates of leaching from which the seasonality of leaching patterns can be estimated.

16. Nitrogen leaching losses from **arable/vegetable land use** were estimated for 4 soil types (with soil water-holding capacities of 60, 90, 120 or 150 mm), under 4 weather conditions (annual rainfall amounts of 640, 750, 800 or 840 mm), and either with or without irrigation. In each case the soil profile contained 90 kg N/ha at the beginning of the cropping season. The crop suffered no shortage of the elements P, K, sulfur, calcium and magnesium during its growth. After harvest of the main crop, another catch crop was immediately sown.

17. Wheat was sown on 8 May each year, and managed according to the recommendations of Sirius Wheat Calculator. That is, N fertiliser was applied to coincide with high crop demand, and irrigation was applied to match the soil moisture deficits. The average N fertiliser application rate was 125 kg N/ha in the dryland scenario and 240 kg N/ha in the irrigated scenario. In the irrigated scenarios, annual irrigation amounts varied from 220 to 430 mm.

18. Sweet corn was sown on 20 October each year, and managed according to the AmaizeN Calculator. That is, N fertiliser was applied to coincide with high crop demand, and irrigation was applied to match the soil moisture deficits. The average N fertiliser application rate was 65 kg N/ha in the dryland scenario and 107 kg N/ha in the irrigated scenario. In the irrigated scenarios, annual irrigation amounts varied from 217 to 400 mm. An exceptionally high

amount of irrigation (1090 mm) would have been required on shallow soils. As farmers are unlikely to apply this amount of irrigation to this crop an estimate for this scenario was not completed.

19. Potatoes were planted on 10 October each year, and managed according to the Potato Calculator. That is, N fertiliser was applied to coincide with high crop demand and irrigation was applied to match the soil moisture deficits by frequent small irrigations (10 mm per application). The average N fertiliser application rate was 150 kg N/ha in the dryland scenario and 350 kg N/ha in the irrigated scenario. In the irrigated scenarios, annual irrigation amounts varied from 260 to 760 mm.

20. We used the published scientific literature to estimate N and P leaching losses from forestry.

21. Our key findings follow.

22. **Dairy farming:** Under the average irrigated scenario the amount of N leached was 32 kg/ha/year. When all animals were kept off the pasture during winter (Jun-Aug), the average loss was 18 kg N/ha/year. When half of the animals were kept off the pasture for the same period, the average loss was 24 kg N/ha/year. A change in the pasture development stage, the amount of irrigation applied or the amount of N fertiliser applied produced a range of N leaching estimates from 22 to 43 kg N/ha/year. The risk of P leaching was estimated to be low in most scenarios. When excess irrigation was applied, the risk of P leaching was estimated to be medium.

23. **Sheep/beef farming:** Under the average scenario the amount of N leached was 6 kg/ha/year. A change in the pasture development stage or the amount of N fertiliser applied produced a range of N leaching estimates from 5 to 16 kg N/ha/year. The risk of P leaching was estimated to be low in all scenarios.

24. **Arable/vegetable land:** The average amount of N leached under dryland wheat production was 29 kg N/ha/year (range = 22–36 kg N/ha/year) and under irrigated production it was 34 kg/ha/year (range = 22–47 kg N/ha/year). The average amount of N leached under dryland sweetcorn production was 12 kg N/ha/year (range = 5–19 kg N/ha/year) and under irrigated production it was 23 kg N/ha/year (range = 12–35 kg N/ha/year; this excluded the shallowest soil). The average amount of N leached under dryland potato production was 7 kg N/ha/year (range = 4–8 kg N/ha/year) and under irrigated production it was 39 kg N/ha/year (range = 16–70 kg N/ha/year).

The risk of P leaching is estimated to be low and this agreed with published literature values.

25. **Forestry land:** Published literature values suggest that the amount of N leached from pine and native forests is 1 to 2 kg N/ha/year.

Glyn Stewart Francis