

**Before the Commissioners appointed by Canterbury
Regional Council**

IN THE MATTER OF The Resource Management Act
1991

AND

IN THE MATTER OF Applications by the Central Plains
Water Trust and Central Plains
Water Ltd. to Take and Use Water
for Irrigation in the Central Plains
area.

Section 42A Officer's Report

Date of Hearing: 25 February 2008

Report of SHIRLEY ANN HAYWARD

1. My full name is SHIRLEY ANN HAYWARD.
2. I acknowledge that I have read the code of conduct for expert witnesses contained in the Environment Court's Practice Note dated 31 March 2005. I have complied with it when preparing my written statement of evidence and I agree to comply with it when I give this oral evidence.

Qualifications and Experience

3. My full name is Shirley Ann Hayward. I hold the degrees of Bachelor of Science in Plant and Microbial Sciences and Master of Science in Environmental Science. I have been employed by the Canterbury Regional Council for the past 14 years in a succession of roles including Microbiologist, Groundwater Quality Officer, Environmental Quality Analyst and am currently employed as a Surface Water Quality Scientist. Over the past 9 years with Environment Canterbury I have been involved with river water quality and stream ecology investigations and authored several peer reviewed technical reports on river water quality and aquatic ecosystem health. I am responsible for a number of surface water quality monitoring and investigation programmes including a long-term investigation of water quality in Lake Ellesmere/Te Waihora and its tributaries. I am a member of the New Zealand Freshwater Sciences Society (formerly the NZ Limnological Society) and a member of the International Water Association.

Scope of evidence

4. The scope of my evidence will address the effects of the proposed activities on water quality and ecological health of rivers, streams, water races and coastal lakes below the dam outlet and downstream of the main canals.
5. There are three main issues that I will address. These are:
 - (a) Impacts of changes in groundwater levels on ecological values of streams and coastal lakes within and downstream of the dam as a result of the take and use of irrigation water
 - (b) Impacts of changes in water quality on ecological values of streams and coastal lakes within and downstream of the dam and as a result of the use of irrigation water
 - (c) Water quality of race water and impacts of discharges of by-wash water to the streams within and downstream of the irrigation area.
6. In preparing my report I have reviewed a range of documents provided by the applicant. These are listed in the reference section of this statement.
7. Such evidence is within my area of expertise. In forming the opinions I have expressed in this evidence, I have relied in part upon the evidence of other witnesses who are giving evidence for the Canterbury Regional Council, namely: Dr Meredith, Mr Scott, Dr Williams, Dr Grove, Mr Duncan and Mr Hanson.

Summary

8. The base flows of many lowland streams downgradient of the proposed irrigation supply area are likely to increase, with the centrally located rivers being most severely affected. While this may have some beneficial effect of improving aspects of the aquatic habitat, other adverse effects may offset this benefit. These include increased drainage and drain maintenance resulting in increased discharge of sediment, nutrients, and micro-organisms into streams and rivers via the drainage network.
9. The considerable change in base flow predicted for the lower Selwyn River/Waikirikiri may well result in a dramatic change in the overall character of the river. It is an oversimplification to assume that increasing flow permanence of a naturally intermittent river is beneficial.
10. There is considerable uncertainty in the predictions of changes in nitrate loading and concentrations to the lowland streams and coastal lakes. If nitrate concentrations do increase in lowland rivers, it is likely that they may at times exceed toxicity thresholds and could result in loss of sensitive species.

11. The Selwyn River/Waikirikiri is considered one of the most vulnerable streams because it is already experiencing trends of increasing nitrate concentrations that are approaching, but not exceeding, nitrate toxicity thresholds. It also currently sustains a healthy aquatic fauna, which could be significantly adversely affected by nitrate toxicity. Furthermore, the Selwyn River/Waikirikiri is the singularly most important trout spawning river in the Ellesmere catchment, and consequently, nitrate toxicity may threaten the success of trout spawning effort.
12. Increased nitrogen loading to Lake Ellesmere/Te Waihora has been predicted but the effects of this are considered by the applicant not to be significant because of the already enriched state of the lake. I disagree with this conclusion. Although the lake is nutrient rich and phytoplankton growth is generally considered limited by light availability rather than nutrient availability, some studies have indicated that nitrogen may be a limiting nutrient at times. Therefore, any increase in nitrogen may have observable effects on lake phytoplankton production. Furthermore, there is a clear community vision for long-term improvement of the overall health of the lake, which could be compromised by increased contaminant inputs.
13. The proposed sustainable farm management plans to mitigate effects of increase nitrogen loadings require careful scrutiny to ensure nutrient budget and stocking rate targets are going to achieve an acceptable level of mitigation. The level of detail of farm plans is currently insufficient to provide confidence that adequate mitigation of the risk of increased nitrate concentrations in lowland rivers will be achieved.
14. Water quality of the distribution races will be very dependant on the quality of the source water. In particular, high concentrations of suspended sediments are predicted. Exclusion of stock access and fully vegetated riparian buffer zones along races will considerably reduce accumulation of nutrients, sediment, micro-organisms and pesticides.
15. The discharge of by-wash water to the Selwyn River/Waikirikiri and its tributaries has the potential to have significant adverse effects. These rivers have very low suspended solid concentrations at base flows and typically have very clear water. There is considerable uncertainty that the proposed wetlands will effectively treat the by-wash water. Adequate sizing of the wetlands will be important in ensuring they effectively mitigate potential adverse effects.
16. It is important to note that the general experience is that land use intensification will inevitably result in some adverse effect on the aquatic environment. Should the commissioners choose to grant these consents, adequate conditions to reduce contaminant discharges by ensuring best farming practices, monitor effects and where appropriate provide remediation will reduce the severity of the impact but are unlikely to completely remove the risk of some adverse effect on the freshwater environment.

Impacts of take and use of water on water quality and ecological health of rivers and streams within the proposed irrigation supply area

17. The general conclusions of the applicant is that rivers within the proposed irrigation supply area may experience increased sediment, nutrient, pesticide and microbial contaminant inputs as a result of land use intensification (Kingett Mitchell, 2006b, 2006d). Furthermore, they conclude that providing appropriate sustainable land management practices are implemented as proposed, the direct effects of the CPW scheme on surface water quality should be less than minor (Kingett Mitchell, 2006d).
18. I largely agree with this conclusion in that increased land use intensification is likely to result in increased contamination of adjacent waterways, and that appropriate land use management practices can mitigate most of these effects to an acceptable level. However, a greater level of detail of the proposed farm management plans are needed to provide confidence that they will be effective mitigation.

Impacts of take and use of water on water quality and ecological health of rivers and streams downgradient of the proposed irrigation supply area

Impacts of changes in stream flows on ecological health

19. Kingett Mitchell (2006c) used estimated changes in lowland stream flows provided by Aqualinc (2006) to model changes in instream habitat for various fish species as a result of CPW. An updated modelling simulation by Weir (2008) provided new estimates of stream flows resulting from CPW. In some cases, there are considerable differences in the estimated flows between those used by Kingett Mitchell (2006c) and the more recent estimates. However, in most cases the differences in flows between status quo and CPW are similar between the two modelled outputs, and this is the most important consideration for understanding changes in habitat given the uncertainty in predicting actual stream flows as discussed by Mr Scott and Dr Williams.
20. I agree with the habitat modelling approach used by Kingett Mitchell (2006c) and largely agree with the fish species considered although inclusion of habitat assessments for longfin eel and common bully would have been a more complete assessment.
21. The greatest changes in stream flows are predicted to be in the streams most centrally located downgradient of the proposed irrigation supply area, such as the Selwyn and Irwell rivers. Interestingly, Doyleston Drain, which is also centrally located, was predicted to have an increase median flow of less than 10% by Aqualinc (2006), while an increase of 1300% in median flows is predicted by the updated model simulation (Weir 2008). The changes in flows predicted by both modelling exercises for streams located close to the Waimakariri and Rakaia rivers (e.g., Avon R, Tent Burn) are generally less than 20%.
22. Despite the uncertainty in predicting changes in stream flows, the general consensus is that the greatest change in flows are likely to be experienced in the centrally located streams, with effects decreasing towards the northern and southern boundaries of the affected area.
23. For most streams, the habitat modelling by Kingett Mitchell (2006c) predicted increases in habitat availability for key species such as adult trout and shortfin eels as a result of increases in base flows. Habitat availability for native species such inanga and upland bullies may decrease in some cases at higher flows.
24. The general conclusions of Kingett Mitchell reports (2006a, 2006b, 2006c) of the effects of increased stream flow are an overall positive effect on aquatic habitat, specifically in increased adult fish habitat quality and quantity, spawning habitat, and suitability for brown trout angling. The updated report of Golder Associates (December 2007) similarly concluded 'Increased stream flows and greater flow permanence will generally increase habitat available for aquatic species'.
25. The lowland streams of Lake Ellesmere/Te Waihora have suffered from low flows over the past 10 years, resulting in significant adverse effects on water quality and overall health of the aquatic ecosystems (e.g., Hayward 2007a). Intermittency of reaches (reaches with periods of no flow) in the Selwyn and Irwell rivers has increased in physical extent and duration. As a result, a decline in habitat quality, and the diversity and abundance of aquatic fauna has been observed (Hayward, 2007a). Studies by NIWA on the Selwyn River/Waikirikiriri also illustrate the relationship between flow permanence and aquatic biota diversity and abundance (Davey et al., 2005).
26. Therefore, I agree with general conclusion that many of the lowland streams in the affected area currently suffering from low flows may well benefit from a higher base flow. However, there are other impacts of the CPW that may negate this benefit.

27. In the case of the Selwyn River/Waikirikiriri, the predicted mean annual low flow of 3.1 m³/s¹ is about a 500% increase compared to the status quo. While this may be perceived as beneficial for the aquatic ecosystem, it will in fact change the natural character of this river, and may result in a significant change in the terrestrial/aquatic ecosystem of a naturally intermittent river (Larned *et al.*, 2007).
28. Issues around seasonality of high flows, physical habitat quality, and spatial extent and connectedness of increased permanently flowing reaches should be considered before making a simple assumption that increased flow will be beneficial to a river system. However, I acknowledge there is currently limited knowledge available to allow meaningful discussion around predicting the severity of impacts of this issue.

Impacts on water quality

29. I agree with the general assessment of water quality and aquatic ecology of the lowland streams by Kingett Mitchell (2006a, 2006d).
30. The general conclusion of the applicant of the impact of CPW on water quality of the lowland streams are that contaminants such as phosphorus, pathogens and pesticides are unlikely to increase in groundwater and therefore, are not likely to directly affect lowland waterways (Kingett Mitchell, 2006d). Based on my own knowledge and that of Mr Hanson's I agree with this general conclusion that these contaminants are unlikely to significantly increase in groundwater, where they may affect lowland waterways.
31. However, as a result of increased groundwater levels and stream flows, drainage networks throughout the lowland areas may require expansion and increased maintenance. This may have a significant effect on water quality of the lowland waterways.
32. The URS memorandum regarding groundwater mounding (URS, 14th December 2007) acknowledged the potential for some additional drainage works but has not considered the impact of this on surface water quality.
33. Increase drainage requirements will inevitably result in increased discharges of sediment to streams or coastal lagoons during drain expansion and maintenance works. It is also likely to result in increased sediment, nitrogen, phosphorus and microbial contaminants entering streams because of the greater volume of drainage water being discharged and because farm drains are typically unprotected from adjacent land use activities (e.g., stock access, fertiliser applications). In urban areas, increased drainage can also result in increased input of urban contaminants such as sediment, metals and hydrocarbons to urban streams.
34. I consider the effects of increased drainage works and drain discharges to be one of the major potential adverse effects on instream values on the lowland streams. Therefore, should the commissioners choose to grant these consents, monitoring and mitigation of adverse effects of increase drainage requirements on surface waterways is strongly advised.
35. One of the potential effects of land use intensification as a result of CPW on lowland water quality is of increased nitrogen loads to groundwater, and therefore, to lowland streams.
36. Kingett Mitchell (2006d) predicted increased nitrate concentrations in lowland streams based on modelling from Aqualinc (2006). Centrally located streams were predicted to experience the greatest

¹ Note that the first row in Appendix L of Weir (2008) should be in units of m³/s, not L/s.

increase in concentrations, while those streams near the northern and southern boundaries were less likely to be affected. Based on more recent modelling by URS (2007), no increases in nitrate concentrations in groundwater or lowland streams are predicted. Mr Hanson provides his opinion on this work and concludes that there is likely to be an increase in nitrate concentrations in groundwater and in lowland streams.

37. As indicated by Kingett Mitchell (2006d), lowland streams exhibit a range of nitrate concentrations. Overall, they tend to have concentrations above guidelines² for the prevention of nuisance algae but generally below aquatic toxicity thresholds. Because of other factors such as substrate type, macrophyte domination and phosphorus limitation, nuisance algal proliferations are rare in these streams. However, there have been indications of trends of increasing nitrate concentrations in a number of streams, particularly in the Ellesmere catchment (Hayward, 2007b). In the case of Boggy Creek, concentrations have recently exceeded the toxicity threshold for freshwater ecosystems (Hayward, 2007b). Land use intensification is likely to be one of the key drivers of these trends.
38. In Mr Hanson's evidence, he considers it likely that nitrate concentrations in groundwater will increase as a result of the CPW scheme but is unable to predict the magnitude of change.
39. If nitrate concentrations in groundwater do increase, the frequency and duration of nitrate concentrations exceeding toxicity thresholds is also likely to increase in some lowland streams. I consider rivers such as the Selwyn River/Waikirikiri, Boggy Creek and Harts Creek to be the most vulnerable because they already have nitrate concentrations that approach the toxicity guidelines (or exceed in the case of Boggy Creek). Furthermore, the Selwyn River/Waikirikiri currently sustains a healthy aquatic fauna and is the singularly most important trout spawning river in the Ellesmere catchment, which may be compromised by excessively high nitrate concentrations.
40. The greatest potential mitigation is the implementation of farm management plans that achieve efficient use of water and nutrients and appropriate stock management. However, as Mr Hanson stated, the effectiveness of this mitigation cannot be predicted with any accuracy.

Impacts on Lake Ellesmere/Te Waihora ecology

Impacts of increased freshwater inflows

41. The general conclusion of effects of increased groundwater levels on Lake Ellesmere/Te Waihora is that in order to maintain the existing lake level regime, the frequency of lake openings will need to be increased on average by one extra opening per year (Kingett Mitchell 2006c, Golder Associates December 2007, URS 4th December 2007).
42. The general conclusions about the effects of increased freshwater inflows and frequency of lake openings are;
 - (a) Greater opportunities for migratory freshwater fish species
 - (b) Increased overall salinity, although water may become more freshwater dominated around tributary inflows (Golder Associates 2007).
43. Lake Ellesmere/Te Waihora is recognised as one of New Zealand's most important wetland systems, particularly in regard to wildlife habitat, which is considered to be of international importance (Taylor, 1996). It also retains high cultural and fishery values. However, because of its complexity, it is very difficult to predict effects of change with any confidence.

² New Zealand periphyton guidelines: detecting, monitoring and managing enrichment of streams. MfE 2000
Australian and New Zealand guidelines for fresh and marine water quality 2000. ANZECC 2000

44. I agree that an increase in opening frequency is likely to provide greater migratory opportunities for native fish and trout. This is dependant on timing and duration of openings.
45. However, there is considerable uncertainty about predicting other effects of changes in lake opening frequency and overall lake level. In particular, there are a number of factors controlling the salinity regime of Lake Ellesmere/Te Waihora, which is a key feature of its diversity. For example, freshwater inflows provide zones of low salinity in the lake near river outlets, thus providing valuable habitat for plants, fish and birdlife with preferences for low salinity environments. In contrast, the salt marsh vegetation is dependant on regular inundation of saline waters.
46. I agree with the applicant's conclusion that an increase in freshwater inflows, and thus an increase in frequency of lake openings, is likely to increase the overall salinity of the lake (Golder Associates, 2007). The duration and frequency of lake openings to the sea is one of the primary drivers of the lake's salinity regime.
47. An increase in the variation of salinity across the lake can be expected as a result of both increases in lake openings and increases of freshwater inflows. This may have a mixture of positive and negative effects on the lake ecosystem. Certainly lower salinities around the river outflows may beneficially increase the opportunities for some salt intolerant plant species to grow, such as raupo. However, this also increases the risk of encroachment of weeds such as willows. This issue is addressed more fully by Dr Grove.
48. Other issues with high lake levels is the increased potential for lakeshore erosion. The applicants have not addressed this issue but the extension of the proposed Environment Enhancement Fund to include planting of vulnerable lakeshore areas to reduce erosion would aid in mitigating this potential effect.

Impacts of increase nitrate loading

49. Golder Associates (December 2007) reported that 'Land use intensification under CPW will increase the median loading of nitrate nitrogen to groundwater from the CPW irrigation area by 81%'. They also stated that nitrate loading to Lake Ellesmere would increase but to a lesser extent. Their general conclusion of the impact of this was 'Increased nitrogen loading into Lake Ellesmere is unlikely to result in significant increases in phytoplankton productivity, toxic algal blooms or anoxia because....'.
50. The lake is an extremely complex system, and there is some uncertainty in the understanding of drivers of lake phytoplankton production. Phytoplankton growth in the lake is predominately limited by light availability because of the shallow, wind exposed nature of the lake and the readily suspended bed sediments means the lake typically has poor clarity. I agree that the lake already has excessively high nutrient concentrations. However, there is also an indication that at times, nitrogen could be a limiting nutrient (Hawes and Ward, 1996). This may occur during periods of calm, warm weather and high lake levels, when low levels of suspended sediment may result in increase light penetration and therefore greater opportunity of phytoplankton growth and potential algal blooms.
51. Kingett Mitchell (2006d) suggested there may be a weak positive relationship between nutrient concentrations of tributary inflows (the example given was for the Selwyn River/Waikirikiri) and lake phytoplankton biomass (chlorophyll a concentrations). This further indicates the potential negative effect of increased nutrient inputs to the lake on phytoplankton production.
52. Furthermore, there is a clear community vision for long-term improvement of the overall health of the lake, which could be compromised by increased contaminant inputs (WET, 2004, DOC & TRONT, 2004).

Water quality of water races

53. I agree with the general conclusion of Kingett Mitchell (2006d) that water quality of the distribution races will be very dependant on the quality of the source water. Those that are distributing direct run-of-river water will generally have low nutrients but may have elevated fine suspended sediment and therefore, low water clarity because of the source water. Furthermore, depending on the canal and water race construction, increases in suspended sediment may occur along the length of the races from abrasion of the race lining.
54. Exclusion of stock access and fully vegetated riparian buffer zones along races will considerably reduce the risk of accumulation of nutrients, sediment, micro-organisms and pesticides along the races.

Impacts of discharges of by-wash and emergency discharges on the Selwyn River and its tributaries

55. The applicant describes the use of wetlands to treat by-wash water (URS (2006a, 2006b)). They comment that by-wash will be discharged to wetland and soak to ground with no direct connection to the natural waterway. Mr Duncan provides an assessment on the likelihood of 'normal' by-wash and excessive (not emergency) by-wash discharge being effectively treated by the wetlands as described in URS (2006b). His view is that the size of the wetlands may not be big enough to allow full soakage of by-wash water. If that is the case, then presumably the by-wash will overflow to the river or stream.
56. As described above and stated by Kingett Mitchell (2006d), race water may have elevated concentrations of suspended sediment, nutrient and microbial contaminants depending of the source of water. Elevated suspended solid concentrations are likely to be the main contaminant of concern.
57. The discharge of by-wash water containing elevated suspended sediments to the Selwyn River/Waikirikiri and its tributaries has the potential to have significant adverse effects. These rivers have very low suspended solid concentrations at base flows and typically have very clear water. They will have limited capacity to dilute and flush out accumulated sediments. Therefore, adequately sized wetlands that enable full capture and treatment of by-wash water are the most logical mitigation of these potentially significant effects.

Other impacts

Spread of aquatic pests

58. There are a number of aquatic pests (including algae, plants and fish) which could be introduced or spread as a result of the operation of the CPW. This is addressed largely by Dr Meredith but I briefly comment on one issue below.
59. *Didymosphenia geminata* (Didymo) is an unwanted organism (algae), which is now present in the Rakaia River. Although Didymo was not known to be present in the Rakaia River at the time of preparing the AEE reports, the impact of it and other aquatic pests need to be considered. The operation of the CPW is very likely to result in transference of Didymo from the Rakaia River into other waterways, if they are not already infected by the time the scheme starts operation. Didymo is now present in the Rakaia River because of transference via the Rangitata Diversion Race.
60. While Didymo is likely to continue spreading throughout Canterbury regardless of CPW, it highlights the issue of transference and mixing of waters and, potentially, of pests. The consequences of the spread of aquatic pests and unwanted organisms can be severe but not easily mitigated. However, options for reducing these risks need to be considered.

Impacts on coastal marine environment

61. There is emerging concern that increasing nutrient loads to the coastal marine environment, especially the near shore areas, have the potential to contribute to increased phytoplankton growth and blooms (Bolton-Ritchie 2006).
62. Given the predicted increase in nitrate loadings to groundwater from CPW as well as potential increase of other contaminants in the lowland areas, consideration of impacts on the ultimate receiving environment i.e., the coastal marine environment, is needed. While, there is currently inadequate understanding of the impacts of increased nitrate loadings (and other contaminants) to the marine environment it should not be ignored as a potentially affected component of the environment.

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