Memorandum

Date: 4 December 2007

To: Walter Lewthwaite

From: Mark Mabin

Subject: Responses to ECan s92 requests for further information of 2nd November 2007

ECan's s92 request for further information (letter dated 2nd November 2006) seeks assessments of the potential effects of the Central Plains Water Enhancement Scheme on:

1. Sediment transport in the Rakaia and Waimakariri Rivers;
2. Effects on water levels in Lake Ellesmere; and
3. Effects on tidal reaches.

I note that issues 1 and 3 were covered in some depth in a memo I sent you dated March 22nd 2007, and I understand you forwarded that on to Donald Fraser at ECan on the same day. I will refer to that memo in my response below. Issue #2 is to some extent new, but I also note that the main thrust of a proposed mitigation measure in relation to possible increased numbers of Lake Ellesmere openings was discussed in Section 7 of a letter you sent to Mr Leo Fietje of ECan dated 21st March 2007.

1. Sediment transport in the Rakaia and Waimakariri Rivers

The ECan letter dated 2/11/07 s92 request for further information, *Section 4 Effects on river from reduced river flow* makes the following statements.

> "A build up of fine material in the tidal reaches of the Waimakariri and Rakaia Rivers may affect the ability for early flood waters to 'blow' open the mouth, causing flooding of low lying areas, for example the Rakaia Huts.
>
> "Please provide an assessment of the effects from reduced mean and median flows on sediment transport within both the Rakaia and Waimakariri Rivers, and how this will impact on riverbed, mouth and tidal reaches."

Taking the second of these statements, I consider that appropriate detail on bedload and suspended sediment transport in the rivers was provided in our s92 response of 22nd March 2007 (see above). This will not be repeated here, but the main points were summarised as follows:

- The Rakaia and Waimakariri Rivers are under-supplied with bedload, and are therefore more than capable of carrying all of the sediment supplied to them;
- The rivers will only be de-powered in restricted flow bands where little bed load sediment transport occurs naturally, and this will only affect sand-sized material; and

- If any reduced sediment transport occurs in these flow bands, larger flood events that occur numerous times per year it will be able to transport any sand that had temporarily accumulated.

- There will be no detectable effect on sand sediment transport at the mouth of the Waimakariri River

I therefore consider that we have already supplied the *assessment of the effects from reduced … flows on sediment transport within both the Rakaia and Waimakariri Rivers*. If the material submitted on 22nd March 2007 was inadequate I would request that more detail be supplied on the matters that remain unclear, so that I may address specific points of concern.

The first statement above refers to closures of the mouths of the Waimakariri and Rakaia Rivers. To my knowledge, neither river mouth has been known to close, thus it is assumed that the request above refers to a situation where the mouths may close as a result of the CPWES. I will address the possibility of mouth closure below. Much of this assessment has been informed by a paper by Professor Kirk: *River-beach interaction on mixed sand and gravel coasts: a geomorphic model for water resource planning* in Applied Geography 11: 267 – 287 (1991).

The mouth area of the Waimakariri River has a relatively large tidal environment and tidal influence extends some 6 km up-river from the coast to the Old Highway Bridge. The mouth does not close during periods of low flow. This results from an interaction of factors including: Pegasus Bay is a relatively low energy wave environment and thus longshore drift of sand does not block the mouth; and the tidal compartment at the Waimakariri River mouth is large (>250 ha) and a significant volume of tidal and river water passes in and out of the mouth each tidal cycle helping to keep it open. The Waimakariri River is therefore a large river in terms of the balance between river/tidal flow through the mouth and wave energy in Pegasus Bay. While some reduction in river flow will occur under the CPWES, tidal flows will not be affected. It is estimated that the discharge through the mouth at low flows with CPWES will not be less than about 100 m^3/sec, and this considerable flow will be more than adequate to keep the mouth open. In addition, the CPWES irrigation take would have ceased at 64.24 m^3/sec for most of the year and at 41 m^3/sec when filling the reservoir in winter, which are higher flows than the minimum reached by the river. Thus, as the mouth has stayed open at these previous low flows, and future extreme low flows will not be affected by the scheme, mouth closure will not occur as a result of the CPWES.

At the Rakaia River mouth the situation is different. It has a smaller tidal environment area (~60 ha), and the Canterbury Bight wave environment is high energy and there is substantial longshore drift of gravel along the beach. The Rakaia River is therefore a relatively small river in terms of the balance between river/tidal outflow through the mouth, and wave energy along the shoreline. However, as noted above, the Rakaia River has never been known to close. Using available flow records Kirk (1991) suggested that flows of 45 - 50 m^3/sec should maintain an open mouth. In the 1967 – 2001 Rakaia River flow data the minimum flow never reached 50 m^3/sec, and was only below 60 m^3/sec on 5 days (0.04 % of the time). However, these extreme low flows in the Rakaia River would not be affected by a CPWES irrigation take as the minimum flow at which a take can occur is ~90.2 m^3/sec. Thus the CPWES scheme will have no effect on flows that are sufficiently low to be of a magnitude that might result in mouth closure.

I therefore conclude that a build up of fine material in the tidal reaches of the Waimakariri and Rakaia Rivers is unlikely to occur as the flow bands most affected by the CPWES water takes carry very little sediment and no detectable build-up of silt will occur. Closure of the Rakaia and Waimakariri River mouths does not occur at present, and there is no likelihood that it will occur under the CPWES as the absolute minimum river flows at which closure has not occurred in the past will not be affected by the CPWES. Therefore concerns regarding the ability for early flood waters to ‘blow’ open the mouth, causing flooding of low lying areas are not considered to be relevant to the CPWES application.

2. Effects on water levels in Lake Ellesmere

Increased flows into Lake Ellesmere will result from the CPWES. This increased water will come from increased flow in streams that drain into the lake, and increased groundwater seepage into the bed of the lake. At present the estimated inflow of surface and groundwater to the lake is 12.35 m^3/sec, of which 99 % is surface water. Based on outputs from the Aqualinc groundwater model, it is estimated that under the CPWES the inflow would increase to 16.52 m^3/sec, of which 96 % will be surface water.

Monthly estimates of increased groundwater and surface water inflows have been derived, and these were supplied to Mr G. Horrell who re-ran his model of the Lake Ellesmere Water Balance (Graeme Horrell *pers comm.* Emails dated 9th July 2007 and 27th July 2007). The output from the model gave the modelled change in the number of lake openings, and estimates of the changes in mean monthly water level in Lake Ellesmere.

The mean annual level of Lake Ellesmere for the modelled period (1970 – 1991) was 782 mm before CPWES and 840 mm after the scheme, an increase of 58 mm or 7.4 %. The highest increase in level was in August (+150 mm) and the lowest was in June (-5 mm). Significantly the months that in pre CPWES conditions had the highest levels (June and July) showed no change or a slight fall in level under the post CPWES scenario. Thus, although lake levels would increase slightly under the CPWES, there is not expected to be any increase in the high winter season lake levels. In other words, the modelling shows that under the proposed CPWES the expected increase in Lake Ellesmere level is small and would occur within the range of present mean monthly levels, and no new land would be inundated.

The slight increase in lake level would increase the lake area. From the lake level:area relationship shown in Taylor (1996, ECan Report 96(7)) it is estimated that under the CPWES scenario the mean lake area will increase from 191 km^2 to 194 km^2. This 2 % increase in area is slight, and would be well within the natural range of variability of lake area. From the 1994 – 2007 lake level data it can be seen that the lake area has varied from about 150 km^2 to 217 km^2. For these reasons we do not expect there to be any need for a change in management regimes around the lake margins.

The increased inflow and slightly higher average water levels in the lake will increase the number of lake openings required by on average 0.98 per year. CPW Ltd proposes to fund the cost of these extra openings as discussed in the letter of 21st March 2007 to Mr Leo Fietje.

3. Effects on tidal reaches

The ECan letter dated 2/11/07 s92 request for further information, *Section 5 Effects on tidal reaches* makes the following statements.

> "A build up of fine material in the tidal reaches of the Waimakariri and Rakaia Rivers may affect the riverbed, mouth and tidal reaches.
>
> "Please provide an assessment of the effects from reduced mean and median flows on sediment transport within both the Rakaia and Waimakariri Rivers, and how this will impact river ecology of tidal reaches, including Rakaia Lagoon and Brooklands Lagoon."

These issues traverse the same ground as the matters discussed above in Section 1. The statements refer to "fine material" which I understand to mean the fine sand, silt and clay material carried by a river in suspension in the water. In most rivers, suspended load makes up the bulk of the sediment load carried, and the Rakaia and Waimakariri Rivers are no exception carrying 85 – 95 % of their solid sediment load in this manner (Hicks (1998)[1].

Suspended load dominates sediment transport in rivers because only lower flow velocities are required to keep it in motion. Thus at this broad first principles level, we would expect the CPWE scheme to affect fine sediment transport rates if it were to significantly affect low flow regimes in the two rivers.

Kingett Mitchell (2006)[2] show that the Waimakariri River median discharge is 90 m^3/sec, thus the FRE3 discharge will be a flood of 270 m^3/sec, which occurs on average 15 times per year. They document the changes in flow regime that will occur as a result of the CPWE scheme, and one of their findings is directly relevant to fine sediment transport issues:

- The flow band most affected by CWPE is from 65 - 115 m^3/sec.

The 65 – 115 m^3/sec flow band will be affected, and an assessment of the potential effect of de-powering the river in this flow band is appropriate. This flow band represents mainly low baseflow conditions, but does include some of the small "fresh" events. It is expected that very little sediment transport will be occurring in this flow band, as can be demonstrated from an analysis of suspended sediment data.

Suspended sediment data collected from the Waimakariri River (Hicks, *pers. comm.* 2006) allows the relationship between discharge and total suspended solids (TSS) to be estimated as follows:

$y = 0.0896x^{1.5588}$ ($R^2 = 0.90$) Where y = suspended sediment concentration in g/m^3, and x = river discharge in m^3/sec.

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[1] *Sediment budgets for the Canterbury Coast – a review, with particular reference to the importance of river sediment* NIWA Client Report CHC98/2, ECan Report # U98/12, 85p.

[2] *Central Plains Water Scheme: effects of water abstraction on the Waimakariri River* Report # URSNZ CHC 005, 62 p.

At present, the mean flow in the 65 – 115 m^3/sec flow band is 86.5 m^3/sec (1967 – 2001 data). Using the above relationship, TSS would be 24.3 g/m^3. After CWPE the mean flow in this band would be 74.4 m^3/sec, and TSS would be 19.2 g/m^3. As a general rule of thumb, TSS concentrations of around 20 g/m^3 appear to naked eye to be clear or at most only slightly discoloured. These values may be compared to the measured mean TSS concentration for the Waimakariri River at Ferry Road (site CRC3000249, 1992 – 2005 data, n = 182), which is 87.0 g/m^3. It can be seen that the suspended solids concentrations in the affected flow band are well below this average value for the Waimakariri River, and the ~ 5 g/m^3 reduction in TSS concentration resulting from the CWPE is unlikely to be detectable.

The Rakaia River shows a similar relationship between discharge and TSS concentration (Hicks *ibid*), although in this case the TSS concentrations are a little lower for the same discharges. The equation is as follows:

> y = -2E-06x3 + 0.005x2 - 0.6887x + 16.724   R2 = 0.934. Where y = suspended sediment concentration in g/m^3, and x = river discharge in m^3/sec.

Given the Rakaia River carries even less TSS at low flows than the Waimakariri River, I consider that effects of the CPWES on fine sediment transport and deposition processes will also be very small in the Rakaia River.

I therefore conclude that the CPWES will have a very slight effect on fine sediment transport and deposition processes in both the Waimakariri and Rakaia Rivers. This arises from the fact that the affected flow bands already carry only a very small load of suspended sediment, and the reduced flow in these flow bands would result in an undetectable change in fine sediment transport.

Dr Mark Mabin
Senior Environmental Scientist