IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of applications for resource consent by the Central Plains Water Trust and a notice of requirement for the designation of land by Central Plains Water Limited associated with the construction and operation of the Central Plains Water Scheme

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STATEMENT OF EVIDENCE OF JOSEPH HAY ON BEHALF OF THE DIRECTOR GENERAL OF CONSERVATION AND THE NORTH CANTERBURY FISH AND GAME COUNCIL

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1. INTRODUCTION

Qualifications and experience

1.1 My full name is Joseph Hay. I am employed as a Freshwater Biologist in the Coastal/ Freshwater Group at Cawthron Institute in Nelson. I have been employed there since January 2004.

1.2 The majority of my work during this period has been focused on issues of flow management, including how changes in flow impact on instream habitat and freshwater fisheries. I have also been involved in studies and research on a range of issues related to freshwater ecosystems, mainly focusing on fish, and published more than 30 reports to clients. I have previously given evidence before the consent hearing for TrustPower's proposed hydro-electric power scheme on the Wairau River, on the potential effects of water abstraction on a population of native fish in the effected reach.

1.3 I hold a BSc. (Hons.) degree in Environmental Science from University of Canterbury, where the majority of my study was focused on ecology, including freshwater ecology. I am a member of the New Zealand Freshwater Sciences Society and the New Zealand Ecological Society.

1.4 I confirm that I have read and agree to comply with the Environment Court Code of Conduct for Expert Witnesses (31 July 2006). This evidence is within my area of expertise, except where I state that I am relying on facts or information provided by another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

Scope of evidence

1.5 The evidence that I will present focuses on fish and fisheries in foothill rivers affected by the Central Plains Water (CPW) Scheme. These rivers include:

- The Upper Selwyn River and its tributaries, being the Hororata, Hawkins, and Waianiwaniwa rivers, as well as:

- Tributaries of the Waimakariri River including the Kowai River, Hackett's Creek, and Cabbage Tree Flat Stream.

1.6 In summary, my evidence addresses:

a. The distribution of fish within these foothill rivers, and their values in terms of fisheries and conservation status.

b. Assessment of potential effects of CPW Scheme river works, permanent structures and bywash discharges on fish and fish habitat in the foothill rivers.

1.7 In assessing the potential effects, I will specifically address:

a. the potential for permanent structures to impinge on fish passage, during the construction and/ or operation of the CPW Scheme,

b. the potential impacts of bywash discharges on fish and fish habitat,

c. the likely suitability of the canals, water races and bywash soakage wetlands as habitat for fish,

d. the likely effects of inundation of the Waianiwaniwa Valley on fish and fish habitat, and the likely habitat value of the reservoir.

1.8 And I will make suggestions on how adverse effects could be avoided or mitigated.

1.9 The potential effects of the proposed scheme on Canterbury mudfish (*Neochanna burrowsius*) are not covered in my evidence. Matters relating to this species are covered in the evidence of Dr. McIntosh, on behalf of the Director General of Conservation.

1.10 My evidence also addresses the proposed design of fish screens at the three intake sites with respect to native fish found in the Waimakariri and Raikaia rivers. Mr Bejakovich will address the fish screen design with respect to salmonids.

1.11 In preparing this evidence I have primarily considered:

a. The Assessment of Environmental Effects Report (June 2006) prepared for the CPW;

b. The reports prepared by Kingett Mitchell Limited (subsequently Golder Kingett Mitchell) on the effects of construction and operation of the CPW Scheme on fish habitat, screening and ecology (Kingett Mitchell 2006 b, c, Golder Kingett Mitchell 2007a). To prevent confusion, I have used the same letters to indicate individual Kingett Mitchell Ltd reports as Dr Burrell has used in his evidence in chief;

c. Responses to Section 92 requests;

d. Statements of evidence presented on behalf of CPW by: Mr Lewthwaite, Mr Tipler, Mr Weir, Mr Brown, Ms Mulcock, Dr Burrell, Dr Allibone, Dr Glova (including supplementary evidence in response to Section 42 officers' reports, where these were provide by these authors);

e. Statements of evidence presented on behalf of ACWT by: Mr Woods, Mr Dunning;

f. Section 42 officer’s reports prepared by: Dr Meredith, Mr Duncan, Ms Hayward;

g. Scientific reports, theses and peer-reviewed scientific publications relevant to the effected area.

1.12 I have also undertaken site visits to the proposed intake sites on the Waimakariri and Rakaia rivers, and to Hackett’s Creek.

Summary of findings

1.13 In my opinion there is insufficient information available to adequately assess the effects of the proposed scheme on the foothill rivers, or to assess the adequacy or feasibility of fish screening at the proposed intakes on the ecology of the Waimakariri and Rakaia rivers. In some instances this is because the design is still at only a conceptual level, making it difficult to assess effects until the design is confirmed.

1.14 The culverts intended to convey streams beneath the headrace and canals have the potential to present a long term barrier to fish passage. This effect has not been recognised by the applicant. In most instances the effect should be able to be mitigated by appropriate design and construction. The existing availability of fish passage ought to be assessed on a case by case basis, and all culverts designed to provide a level of fish passage consistent with that available currently. Where culvert placement will result in the loss of areas of sensitive habitat, as is the case with Hackett's Creek and Cabbage Tree Flat Stream, which are recognised as salmon spawning streams, some alternative design or off-site mitigation (e.g. construction of a spawning race) will be required to avoid or mitigate the loss of habitat.

1.15 Emergency bywash discharges and even fluctuations in operational bywash discharges have the potential to trigger fish strandings in the Selwyn catchment (in the Hawkins, Hororata and Selwyn rivers). Emergency bywash discharges in general have the potential to introduce species to catchments where they do not naturally occur.

1.16 Any mitigation through the provision of habitat in the reservoir, canals, races or bywash soakage wetlands is likely to be minor, at best, due to poor water quality and large water level fluctuations (including draining of canals and races during winter). Any habitat likely to be provided by the soakage wetlands is unclear since their design is still at the conceptual phase.

1.17 There may be an increase in the quantity and permanence of habitat for trout and some native fish in the lower reaches of the Selwyn catchment. However, the extent of this is not clear, and it is likely that any positive effect would be offset by a reduction in habitat quality as a result of intensified landuse. There are also potential negative effects of an increase in baseflow, for example some species of native fish may be detrimentally affected, through increased access for large predatory fish. However, in my opinion there is insufficient information to make an adequate assessment of the magnitude or direction of such effects at this stage.

1.18 The fish screens proposed for the intakes are still at the conceptual phase, and consequently it is difficult to assess likely effects. However, there are potentially significant negative effects of inadequate fish screening. In my opinion there a several points related to fish screening that ought to receive more in-depth consideration prior to granting of consents. These include:

a. Definition of appropriate fish protection objectives – taking account of potential fishery and conservation impacts, including the impacts of reduced ecosystem productivity in the downstream reaches.

b. The fate of fish entrained with the intake water, and their potential impacts in their receiving environments.

c. The location and design parameters of the screens and associated fish bypasses.

d. The need for monitoring the efficacy of fish screens and bypasses, and potential to adapt their design, in case of poor performance.

2. BACKGROUND

2.1 As mentioned in my scope of evidence above, the foothill rivers that will be affected by the proposed CPW scheme include the Selwyn River, and its major tributaries the Hororata, Waianiwaniwa and Hawkins rivers, as well as lesser tributaries. The Kowai River, which flows into the Waimakariri just downstream of the proposed upper intake site, will also be affected, along with smaller tributary streams in this area (particularly Hackett's Creek and Cabbage Tree Flat Stream).

2.2 All of these rivers and streams will be crossed by the canals or water races of the CPW Scheme, and will potentially be affected by the construction of these crossings. There is also the potential for longer term effects depending on the design and construction of the crossings, as I will discuss.

2.3 Most of the foothill rivers will be affected by operational and emergency bywashes discharging excess water from the scheme. The Selwyn River mainstem will receive five of these bywash discharges, the Hawkins will receive two and the Waianiwaniwa and Hororata will receive one each. The Hororata discharge is proposed for emergency discharge only, while the all of the other bywash sites in the foothill rivers are proposed to be used for both operational and emergency discharges.

2.4 The upper Waianiwaniwa will have a dam constructed across it, at the point where it flows out of the foothills, immediately upstream of Coalgate, and much of its upper reaches will be flooded by the water storage reservoir for the CPW Scheme. The flow regime in the reaches of the Waianiwaniwa downstream of the dam and head race will be altered. These reaches currently experience intermittent or ephemeral flow, but it is not clear what flow will be provided in these reaches under the influence of the scheme.

2.5 Many components of the CPW Scheme have been described at only a conceptual level in the AEE and supporting documents, and in evidence presented on behalf of the applicant. This makes it difficult to assess the magnitude of potential effects of the CPW Scheme, since in many cases the effects are dependent on the specific design that will ultimately be adopted. I will indicate where this is an issue throughout my evidence.

3. FISH OF THE FOOTHILL CATCHMENTS

3.1 In this section I will provide an overview of the recorded distribution of fish in the foothill rivers and highlight those that are of conservation concern or of fishery value.

3.2 Table 1 (attached in the Appendix) shows the fish species recorded from the foothill streams and rivers, and their distribution among the affected catchments. It also shows the conservation status, fishery value, and life history migratory requirements of each species.

3.3 Much of the information on fish distribution in my evidence, and in the evidence of other expert witnesses at this hearing comes from the New Zealand Freshwater Fisheries Database (NZFFD). This database is administered by NIWA, but is contributed to by a range of organisations. While the NZFFD provides probably the best data currently available on the distribution of freshwater fish in New Zealand, it is not definitive. Sampling has not been strategically planned on a national basis, and organisations are not obliged to contribute records to the database, rather data are contributed to the database on an *ad hoc* basis from fish sampling programmes with diverse aims. Consequently, there are gaps in the distribution of sampling locations, and species that are known to be present are not always recorded as being so. Also, the most commonly used fishing technique employed is electric fishing, which is known to be less effective than some other methods (such as spotlighting and trapping) in detecting some of New Zealand's secretive native fish species (although in the Selwyn catchment netting and trapping techniques have also been used reasonably commonly). Therefore, the database should be treated as a guide to the known locations of freshwater fish species, rather than a definitive delineation of where they occur.

3.4 In the Selwyn and its tributary rivers the NZFFD records generally provide reasonable coverage of the reaches with perennial flow. However, the reaches with intermittent or ephemeral flow are sparsely represented in the database. The Kowai River is also sparsely represented through much of its length, with the majority of records clustered in the headwaters and tributaries.

3.5 The applicant has apparently undertaken some additional sampling to fill gaps in the existing data on fish distributions in the area affected by the scheme (Kingett Mitchell 2006b p4; Dr Burrell pers. comm.). However, aside from 11 sites in the upper Waianiwaniwa (shown in Kingett Mitchell 2006b Figure 3.6) it is not clear where exactly this additional sampling has occurred. I asked for clarification on this matter last November and again in mid-February 2008, but I am yet to be provided with any additional information, and no additional information on this matter was provided in evidence presented on behalf of the applicant.

3.6 In all, 16 species of fish have been recorded in the NZFFD from the affected catchments, as well as one species of crustacean, namely freshwater crayfish, koura (*Paranephrops zealandicus*). Five of these species have only been recorded from the lower reaches of the Selwyn River (below State Highway 1). I will not cover the fish of these lower reaches in my evidence. Aspects of habitat in these lower reaches will be covered in the evidence of Dr Larned. Also, there are two records of goldfish from an unnamed pond in the Hororata Catchment, and the most recent record of brook char from the catchment was in 1986. If these records are excluded, this leaves nine species which comprise the fish communities of the affected foothill rivers. Of these eight (including koura) are native to New Zealand, and one is introduced sportfish (brown trout, *salmo trutta*). Another sportsfish, Chinook salmon (*Oncorhynchus tshawytscha*), is known from several affected rivers (including the Selwyn, Hororata, and Kowai), but has not been recorded from these rivers in the NZFFD, and is consequently not shown in Table 1 (attached in the Appendix). I will discuss native fish and sportsfish separately below.

Native fish

3.7 Of the eight native species recorded from the upper catchment, three are of conservation concern nationally – these are Canterbury mudfish (*Neochanna borrowsius*), Longfin eel (*Anguilla dieffenbachii*), and koura (*Paranephrops zealandicus*).

3.8 Canterbury mudfish is considered to be acutely threatened, being listed as “Nationally endangered” (Hitchmough et al. 2007). The potential effects of the scheme on Canterbury mudfish will be covered in the evidence of Dr McIntosh.

3.9 Longfin eel is considered to be chronically threatened, and is listed as being in "Gradual decline" (Hitchmough et al. 2007). This threat is considered to be human induced. New Zealand's pre-eminent expert on eels, Don Jellyman (2005), provides a useful summary of the conservation issues related to longfin eel:

> There is increasing evidence to show that current levels of commercial fishing and habitat loss could seriously affect the sustainability of our longfinned eel fishery. Our concerns for the longfin eel are based on a number of factors, including the very low numbers of juvenile longfins in some catchments, their slow growth rates, the significant declines in catch per unit effort, and the reduction of or loss of access to waterways because of hydrodams. The number of populations dominated by males, especially in the lower half of the South Island, which supports the largest longfin eel fishery in the country, is also of particular concern.

3.10 The longfin eel is endemic to New Zealand, that is, it is found solely in this country. The shortfin eel, which has also been recorded from these foothill catchments, is also found in Australia, New Caledonia and other smaller islands in this area. Both of these species are diadromous, meaning they require access between the sea and freshwater in order to complete their life cycles. Juvenile eels enter freshwater from the sea early in life and slowly develop into adults over a lengthy period. Once in freshwater the tiny eels (elvers) feed and grow, and moving upstream they populate suitable habitats. Elvers can move large distances inland, and are known for their impressive upstream mass migrations in the summer and autumn. They spend many years growing in freshwater habitats before they reach maturity. The typical age of maturity is 25-35 years for longfins (McDowall 2000), but in some cases maturity is delayed and some have been known to live for 80-100 years or more. At maturity eels undergo a number of physical transformations, and migrate downstream to the sea in autumn. They then travel thousands of kilometres to spawn, with their spawning grounds believed to be in the south-west Pacific Ocean, probably in the vicinity of Tonga. After spawning the adult eels die. When their eggs hatch the "leptocephalus" larvae drift and swim in the ocean currents for more than 18 months, before returning to the freshwater as tiny glass eels.

3.11 Both longfin and shortfin eels support highly valued customary, recreational and commercial fisheries in Lake Ellesmere (Jellyman et al. 2003), although the contribution of longfin eels to the fishery has declined over time (Jellyman et al. 2003). Downstream migrants from the Selwyn and tributaries likely contribute to these fisheries.

3.12 Tributaries of Lake Ellesmere, including the Selwyn catchment are closed to commercial eeling, although there is apparently a small customary eel fishery in the lower reaches of the Selwyn (D. Jellyman, NIWA, pers. comm.).

3.13 Eels are rare in the intermittently flowing reaches of the Selwyn and tributaries, but more common in the perennial reaches (Hardy 1989).

3.14 The species of freshwater crayfish, or koura, found in these foothill stream catchments is considered chronically threatened, in “Gradual decline” (Hitchmough et al. 2007). This species (*Paranephrops zealandicus*), which occurs in eastern and southern parts of the South Island, is one of two freshwater crayfish species endemic to New Zealand. Despite customary fisheries, and a recent interest in aquaculture and even commercial wild harvest of these species, surprisingly little study has been done on them. They grow to about 70 – 80 mm in carapace length. They appear to breed in autumn. The female carries the developing eggs, which adhere under her abdomen, and once hatched the juveniles continue to cling to their mother until after their third moult (Chapman & Lewis 1976). After this time they become free living on the streambed. Their activity and life history appear to be highly temperature dependent. They may live as long as 30 or more years, and mature at 2-7 years old, depending on the thermal regime (Whitmore et al. 2000).

3.15 Most of the other native fish found in the upper plains and foothill sections of the Selwyn Catchment and the Kowai River are non-diadromous, spending their entire lives in freshwater. Aside from Canterbury mudfish, there are two other non-migratory galaxiids (Canterbury galaxias, *Galaxias vulgaris*, and alpine galaxias, *Galaxias paucispondylus*) and one non-migratory bully (upland bully, *Gobiomorphus breviceps*), which have been recorded from the foothill streams in the affected area. Among these foothill rivers, alpine galaxias has been recorded from the Kowai catchment only. None of these species is considered to be threatened (Hitchmough et al. 2007), with the notable exception of Canterbury mudfish.

3.16 Two other diadromous fish species have been recorded from the Kowai Catchment. These are koaro (*Galaxias brevipinnis*) and common bully (*Gobiomorphus cotidianus*). Neither of these fishes is considered to be threatened (Hitchmough et al. 2007). However, juvenile koaro returning from the sea to rivers in spring contribute to the “whitebait” fishery. Koaro are generally the second most important species in the whitebait catch, after inanga (*Galaxias maculatus*), but is thought to contribute a relatively low proportion of whitebait fisheries in the South Island East Coast.

Sportfish

3.17 Brown trout (*Salmo trutta*) is the most commonly recorded sportfish from the foothill rivers in the area affected by the proposed scheme.

3.18 The Selwyn River was among the earliest release sites of brown trout when they were introduced to New Zealand in the 1860s and 70s.

3.19 Brown trout found in these rivers today include both river resident populations and migratory trout (including “sea run” fish), which use the spawning and rearing habitat provided by these rivers. The majority of migratory trout in this catchment probably spend most of their time in Lake Ellesmere. However, a proportion of them do in fact move into the sea to feed, as evidenced by tagged fish from the Selwyn, which have subsequently been found in other catchments (Hardy 1989).

3.20 Historically the Selwyn catchment has provided spawning and rearing habitat for large runs, comprising tens of thousands of migratory trout from Lake Ellesmere, but these runs appear to have diminished in more recent times, apparently beginning to decline in the mid-1970s (Hardy 1989).

3.21 Brown trout support an accessible recreational fishery, close to Christchurch, in these foothill streams, and the Selwyn and Hororata rivers in particular have traditionally supported highly valued fisheries, as attested by the glowing reports in the popular press. For example, an article in “The Press” suggested that at its peak the upper Selwyn system attracted fishermen from around the world, and provided some of the finest fly fishing in the South Island (Rooney 1978, cited in Hughey 1980).

3.22 In the most recent national angler survey (based on the 2001/02 season) the Selwyn River attracted an estimated 2130 angler days (Unwin & Image 2003), ranking 8th of 77 water bodies in the North Canterbury Region, and in the top 10 % of water bodies nationwide, although most of the fishing effort apparently occurs in the lower reaches. The Kowai and Hawkins rivers ranked 14th and 54th, respectively, among North Canterbury water bodies (with approximately 270 and 80 angler days, respectively), though at least part of the fishing effort in the Kowai is likely to have been targeting salmon, near its confluence with the Waimakariri, rather than brown trout.

3.23 Although the Hororata had attracted an estimated 160 angler days in the previous national angler survey (1994-1996), and was historically described by an anonymous author as "…*at one time probably the finest fly [fishing] stream in the world… It positively swarmed with heavy fish*." (Anon 1949, cited in Hardy 1989), it was not fished by respondents to the most recent national angler survey.

3.24 The Hororata and Hawkins rivers are both mentioned in the most recent South Island Sports Fishing Regulations (2007-2008), indicating that they are still considered to have some value as trout fishing rivers by Fish and Game. The Selwyn River is also recognised in these regulations, where it is divided into three separate reaches, each with different legal fishing methods and opening seasons.

3.25 Chinook salmon (*Oncorhynchus tshawytscha*) have occasionally been reported from the Selwyn Catchment (Hardy 1989), but have not been recorded in the NZFFD from this catchment. Historically spawning of Chinook salmon in the Selwyn appears to have been sporadic, and this system is not generally recognised as a salmon fishing river.

3.26 There are also no records of Chinook salmon from the Kowai River in the NZFFD. This is a classic example of the NZFFD not being definitive, as Fish & Game and North Canterbury Acclimatisation Society reports clearly identify salmon as using the Kowai River, and often in quite large numbers (see below). There are several tributary streams in the vicinity of the Kowai River confluence with the Waimakariri, which are recognised as providing salmon spawning habitat (see Figure 2, attached in the Appendix). The NZFFD also contains a record of salmon from one of these streams (Hackett's Creek), along with lamprey, upland bully, and shortfin and longfin eels.

3.27 Salmon spawning activity in these streams was surveyed quite frequently between 1967-1994 by W.F. Elson – who was a locally based Wildlife Ranger during this time. Based on the records he kept, it has been estimated that the streams in this area combined would have accounted for approximately 5-25 % of the annual returns of spawning fish to the Waimakariri catchment (Athol Price, NZ Salmon Anglers Association (NZSAA), pers. comm.). The extent to which each of these streams is used by spawning salmon varies from year to year, and is dependent on the configuration of flow in the Waimakariri mainstem and on water levels at the stream mouths.

3.28 Volunteers from the NZSAA have carried out a substantial amount of stream enhancement work in these streams, periodically, over the last 35 years (Athol Price, NZSAA, pers. comm.). This work has included clearing obstructions and debris from the streams, as well as planting salmon ova.

3.29 In a recent inventory of the instream values in the Canterbury region undertaken by Environment Canterbury, the Kowai and Rubicon rivers were listed as providing some relatively low value habitat for Chinook salmon (Daly 2004). However, the fact that the “Kowai and its tributaries” and “Hackett’s Creek” are specifically identified, in the most recent South Island Sports Fishing Regulations (2007-2008), as waters closed to salmon fishing between 1 March and 30 April, demonstrates that these streams are valued for salmon spawning by Fish and Game.

3.30 As I mentioned earlier, brook char (*Salvelinus fontinalis*), have also been recorded historically from the Hawkins Catchment. However, the most recent record of brook char in the NZFFD is from 1986, so it is not clear whether this population persists to the present day. Furthermore, brook char generally grow to only a small size in most of the foothill streams that they inhabit in New Zealand, and tend to be relegated to less favourable habitat by brown trout where these species co-occur. Consequently, although brook char were established in the Selwyn Catchment (Hawkins River) they do not appear to have attracted much, if any, angling effort.

4. INSTREAM HABITAT IN THE FOOTHILL STREAMS

4.1 All of the Selwyn’s tributary rivers are ephemeral or intermittent[1], where they flow across the alluvial gravels of the Canterbury Plains (see Figure 1, attached in the Appendix). However, there is perennial flow in the headwater sections, and even parts of the intermittent reaches have surface flow for a reasonable proportion of the time. For example, the Hororata has surface flow at the confluence with the Selwyn for approximately 80 % of the year (Larned et al. 2008). However, the other major tributaries of the Selwyn (Hawkins and Waianiwaniwa) generally have surface flow at their confluences for less than 5 % of the year (Larned et al. 2008).

4.2 Variation in flow permanence in the Selwyn River has been studied as part of NIWA’s research programme in this river (unfortunately, no similar information is available for the other foothill rivers in the area). Their analyses suggest that the flow

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[1] The terms ephemeral and intermittent are used to distinguish two types of temporary reaches: ephemeral reaches receive runoff only, as the channel is always above the water table; intermittent reaches receive groundwater when the water table intersects the channel, and may also receive runoff.

permanence begins to decline rapidly below the point where the river emerges onto the plains, near Coalgate (Larned et al. 2008). The decline continues downstream towards the confluence with the Hororata, reaching a low point approximately 4km upstream of the confluence. At this point there is predicted to be surface flow approximately 45% of the time. There is an increase in flow permanence around the Hororata confluence, back up to about 80% at the confluence itself, before declining again downstream to reach a minimum of predicted surface flows approximately 34 % of the time. In the lower reaches flow permanence increases again as water enters the channel from groundwater, so the lower reaches around the Coes Ford recorder site have perennial flow.[2]

4.3 Therefore, the headwater reaches provide more consistent habitat, while habitat availability in the ephemeral and intermittent mid to lower reaches is variable over time. These reaches are likely to be of most value to species that are adapted to cope with intermittent flow, for example Canterbury galaxias, which are known to be able to survive short duration drying events by burrowing into the gravels of the bed (Dunn 2003)) and Canterbury mudfish in some places (discussed in the evidence of Dr McIntosh). However, reaches that remain dry for prolonged periods are likely to provide only sporadic fish habitat, when they are flowing.

4.4 In the Selwyn River, Canterbury galaxias, upland bullies and brown trout have been observed to move upstream into perennial headwaters from drying midstream reaches during summer low flows (Davey & Kelly 2007). Subsequently, Canterbury galaxias and juvenile brown trout have been seen to move back downstream to re-colonise rewetted habitat quite rapidly, at least to reaches that are reasonably close to their perennially flowing refuge habitat (Davey & Kelly 2007).

4.5 For brown trout some deep water holding habitat is provided for adult trout within the perennial reaches of the Selwyn River and its tributary rivers, and intermittently elsewhere, where and when there is surface flow (Langlands & Elley 2000).

4.6 As mentioned earlier, the Selwyn catchment has provided spawning and rearing habitat for large runs for migratory brown trout historically, as well as for river resident fish. The principal recognised spawning areas for brown trout in the Selwyn catchment have historically been in the lower reaches near Lake Ellesmere, in the Hororata River, and in the Selwyn around the confluence with the Hororata (Hardy 1989), as well as in the upper perennial reaches of the Selwyn River (Langlands &

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[2] These analyses were based on flow records between January 1984 and December 2005.

Elley 2000). The upper catchment spawning area is likely to be mainly used by river resident fish, due to the difficulty for migratory fish of negotiating the ephemeral middle reaches. However, the Hororata and lower Selwyn have also been used extensively by migratory fish from Lake Ellesmere and the sea (Hardy 1989), at least historically.

4.7 The distribution of suitable trout spawning habitat in the Selwyn catchment appears to be constrained by the availability of surface flow (Hardy 1989). Hughey (1980) suggested that if hydrological conditions allowed, the brown trout spawning area would cover almost the entire length of the Selwyn River and much of the Hororata.

4.8 The provision of habitat for trout in the ephemeral reaches on the plains is obviously intermittent, depending on surface flow. There has been a long history of salvaging trout from these reaches as flow declines over summer (Hardy 1989). Since the mid 1930s trout have been rescued from stranding by the 100s or 1000s in many years, mainly from the mainstem of the Selwyn, and the Hororata, but also occasionally from the Hawkins. Fish salvage has not been as common in recent times, at least in part because there are apparently fewer fish to be rescued. Although this salvage work has usually been required during late summer and autumn, it has occasionally been required in winter as well, when fish have become stranded following upstream spawning migrations.

Comment [j1]: Footnote 2 on the previous page has slipped from the preceding page.

4.9 As discussed earlier, the Kowai River and tributaries in this area have recognised value as Chinook spawning habitat (Langlands & Elley 2000, Athol Price, NZSAA pers. comm.). The springfed tributaries in this area (e.g. Hackett's Creek, "Bill's" Stream and Cabbage Tree Flat) arguably provide better spawning habitat than the Kowai, or the larger tributaries, due to more stable flow regimes in the former.

5. POTENTIAL IMPACTS OF THE SCHEME

Fish passage obstruction at crossings

5.1 Based on the AEE (Sections 3.5.3, 3.9.5, and 3.9.8), and Mr Lewthwaite's evidence (Paragraphs 42, 126, 134, 136, and Appendix E) the proposed scheme's various canals and races will require a total of approximately 50 piped, culverted or siphoned crossings of streams and rivers. Four of these are to be siphons passing canal flow under the Selwyn, Hororata, Hawkins and Kowai rivers (3 for the headrace canal and 1 for the Waianiwaniwa storage dam intake canal before it enters the tunnel).

5.2 Approximately 20 of these crossings are to be culverts to pass smaller tributaries of these rivers, and of the Waianiwaniwa, under the headrace canal. These will be relatively long culverts, given the proposed footprint width of the canals, of approximately 40-50m (AEE Section 3.5.2). Similar crossings will be required to pass Hackett's Creek and Cabbage Tree Flat Stream beneath the Waianiwaniwa storage dam intake canal (although the Cabbage Tree Flat Stream is not mentioned in the evidence presented on behalf of CPW).

5.3 The remaining crossings will be presumably shorter culverts, associated with streams crossed by the distribution water race network.

5.4 Each of these crossings has the potential to present at least a temporary barrier to fish passage during construction, and if not designed and constructed correctly the culverts and piped crossings may present an ongoing fish passage issue. Although the potential for fish passage to be disrupted during the construction phase has been recognised by the applicant (e.g. Kingett Mitchell 2006b p89), there is no mention of the potential for ongoing fish passage issues at stream crossings in the AEE, in the supporting documents, nor in evidence presented on behalf of the applicant.

5.5 Maintaining fish passage may not be a necessary culvert design consideration for every crossing. Some of the small tributary streams that are proposed to be culverted under the canal may be so small that they may not provide appreciable habitat for fish, and in some instances it may even be desirable to maintain the exclusion of larger predatory fish from some tributaries were they are not currently found, to protect populations of Canterbury mudfish, for example. This could be achieved by stipulating as a consent condition that the applicant should ensure all culverts are designed to provide a level of fish passage consistent with that available currently. In my opinion fish passage management objectives should be assessed on a stream by stream basis, in consultation with interested parties, which has not been done at this stage.

5.6 Most of the species recorded from the foothill streams are non-migratory (with the most obvious exception being eels). Consequently, maintaining free passage may initially seem unnecessary. However, being able to move up and down stream may be important to the survival of some of these non-migratory species, especially those occupying reaches with ephemeral or intermittent flow. For example, Canterbury galaxias and upland bullies (as well as trout) have been observed to move upstream into perennial reaches to avoid desiccation, as intermittent middle reaches of the Selwyn dry up (Davey & Kelly 2007).

5.7 If fish passage is to be maintained the culvert design and installation will need to take fish passage design criteria into account. Criteria for culvert design to maintain passage for many New Zealand species has been described in a book produced by NIWA and DoC in 1999, entitled “Fish Passage at Culverts - A review, with possible solutions for New Zealand indigenous species” (Boubée et al. 1999).

5.8 Ideally flow conditions through the culvert should be maintained as close as possible to the natural conditions in the stream. The key points to achieve this are to ensure that the culvert is wider than the natural streambed, sloped no steeper than the existing streambed, aligned as closely as possible with the natural stream channel, and placed so that the base of the culvert is below the natural streambed (to allow the natural bed material to fill the lower portion of the culvert’s cross-sectional area). These design criteria should avoid excessive water velocities or vertical drops developing in, or immediately below the culvert, which could present a barrier to upstream migrants.

5.9 Another consideration for long culverts, such as those proposed to pass beneath the headrace canal, is whether lighting may be required to encourage fish to move into and through them. There is conflicting evidence on the need for, or usefulness of, lighting in fish passage facilities and culverts (Larinier 2002), but in general it is not considered necessary for most species. However, one key consideration is to ensure that a sudden transition in light intensity between the outside and inside of the culvert is avoided. This can be achieved by using overhead vegetation at the entrance and exit to the culvert, or by providing artificial lights or windows in the first section of the culvert, or widening the culvert opening, to provide a gradient in lighting conditions through the transition (Larinier 2002).

5.10 Some degree of temporary fish passage obstruction will be unavoidable during the construction of the various culverts involved in the scheme. However, this could be mitigated by targeting the timing of construction activities to avoid times when fish are likely to be attempting to migrate through the construction area, and requiring such works to be completed within a short timeframe.

5.11 In the Selwyn and its tributaries this would include upstream spawning migrations of brown trout in the autumn and early winter, downstream migrations of mature eels in the autumn, and upstream movement of Canterbury galaxias, upland bully and brown trout from drying reaches, which could occur at any time of year, but would be most likely in the summer months.

5.12 In the Kowai River and neighbouring streams it would also include upstream migration of spawning Chinook salmon, in late summer and autumn, and downstream migration of juvenile salmon fry, from August through to December, inclusive. Again the need to consider these potential migration times should be assessed on a stream by stream basis, according to the species known or expected to use each stream.

5.13 My understanding from the AEE (Section 3.13.7) and the evidence of Mr Lewthwaite (Paragraph 126) is that a staged approach to the construction of siphons under the larger rivers has been proposed, with any flow in the river at the time being diverted around the construction zone as it moves systematically across the river, and the natural grade of the riverbed being reinstated behind the construction zone. This approach should minimise the potential disruption of fish passage, although there is the potential for localised fish stranding where the flow is diverted away from construction zones, or if pumping of water from the construction zone affects adjacent surface flow.

5.14 The construction of culverts and siphons will also have unavoidable temporary effects on sediment loading downstream of the construction zone, although these effects may be reduced to some extent by the best practise measures suggested by the applicant (e.g. see Appendix I to the evidence of Mr Lewthwaite).

5.15 High loads of fine sediment in rivers are known to impact fish, both through direct physical effects, and less directly as a result of effects on habitat and food availability. Suspended sediments can scour and abrade fish, particularly the gill-rakers and gill filaments, making fish in turbid waters more susceptible to disease and even causing mortality in extreme cases (Wood & Armitage 1997). Deposited fine sediments can cause a reduction in suitable spawning habitat, reducing survival or hindering development of eggs and fry, and can reduce habitat and cover for juvenile and adult fish. Growth rates of fish are also commonly decreased in rivers with high fine sediment loads, due to a reduction in the feeding efficiency of visual-feeders (such as trout) in low clarity waters, as well as reductions in the invertebrate food-supply for drift-feeders.

5.16 If sedimentation occurs while sensitive fish eggs are incubating in the gravels of the streambed, then there could be a greater impact at least on the cohort for that year. Given that the construction phase is expected to last for approximately three years, the cumulative effects on a given population could be significant.

5.17 For brown trout and Chinook salmon this sensitive period would extend from winter through to spring (approximately April to November), and Canterbury galaxias eggs would also be incubating in spring (with fry emerging in November and early December). Upland bully would be of less concern because they are prolific breeders and spawn repeatedly over summer.

5.18 The applicant has suggested that detailed instream surveys will be carried out prior to construction activities to determine if any significant or sensitive habitats (such as salmonid or native fish spawning areas, or Canterbury mudfish habitat) exist in the area (e.g. Dr Allibone in evidence Paragraph 83; Kingett Mitchell 2006c p43). However, there has been no indication of what action might be taken to avoid, remedy or mitigate potential impacts on these sensitive habitats if they are found.

5.19 Hackett’s Creek provides an illustration of this issue. It is known to have high salmon spawning habitat value, and this has been recognised by the applicant (e.g. Kingett Mitchell 2006c p12). The proposed route for the headrace canal would cross the reach of this stream that is most heavily used by spawning salmon (see Figure 2 attached in the Appendix). Yet no specific solutions have been suggested to mitigate this, other than to consult with relevant parties, such as ECan and Fish & Game on the final design of the scheme works in this area (Mr Lewthwaite in evidence Paragraph 46).

5.20 As discussed, timing construction activities to avoid spawning and incubation periods is the most obvious first step, and this has been recognised by Mr Lewthwaite (in evidence Paragraph 46).

5.21 However, there are other obvious mitigation solutions to the potential loss of spawning habitat in the long term, which in my opinion ought to have been tabled at this stage to allow for an adequate assessment of effects.

5.22 Ideally any long term effect could be avoided by not culverting the stream under the canal, but rather passing the canal beneath the stream. This could perhaps be achieved by extending the siphon that is intended to pass under the Kowai River, so that it also passes beneath Hackett's Creek, and preferably also beneath Cabbage Tree Flat Stream, which is another recognised salmon spawning stream in this area (see Figure 2 attached in the Appendix).

5.23 If avoiding the habitat loss was shown to be impractical, another option would be to mitigate by providing a constructed spawning channel nearby. A spawning channel of this type was built in association with the Aviemore Dam on the Waitaki in the mid 1960s and has proven to be very successful, being used by approximately 600 rainbow and brown trout from Lake Waitaki per season, being largely credited with maintaining the trout fishery in this lake, and historically also being used by Sockeye salmon (*Oncorhynchus nerka*) (G. Hughes, Fish & Game, pers. comm.). To be effective in mitigating the loss of spawning habitat in Hackett's Creek the water in the spawning channel would have to be sourced from this creek, to attract returning fish – due to the strong homing effect of salmon.

5.24 In other sites where sensitive habitats are found in the path of the proposed construction activities, similar avoidance or mitigation options may be available. However, it has not been made clear at this stage whether such options will be considered, or what action is likely to be taken. In my opinion, mitigation options ought to have been developed on a case by case basis, in pre-hearing consultation with stakeholders, to allow the likely effects of the scheme to be realistically assessed.

Bywash effects

Operation bywash discharges

5.25 According to the description of proposed activities there are to be a total of 15 bywash discharge points incorporated in the water race system (in evidence of Mr Lewthwaite, Paragraph 241 and Figure 46). These bywashes are required to dispose of excess water from the scheme and to ensure that enough water is available for the last irrigation take on each water race. During normal operation 12 of these bywashes are expected to discharge continuously to ensure that there is a surplus flow past the last abstraction point in each water race system. This operational bywash discharge has been assumed to be equivalent to 10 % of the projected instantaneous irrigation demand within the scheme (AEE Section 3.14.8, and evidence of Mr Lewthwaite Paragraph 243). During normal operation, bywash discharge is expected to fluctuate around a seasonal average of about 2 m^3/s (AEE

Section 8.3.3), with the expected maximum operational discharge at individual bywash sites ranging between 0.1 to 1.5 m^3/s. The theoretical maximum combined operational bywash discharge could be approximately 6 m^3/s, if all of the proposed bywash sites were discharging their maximum expected operational discharge simultaneously.

5.26 It is proposed that all but one of the operational bywashes will be discharged into wetlands (one will discharge to a stockwater race), with the intent that the excess water will soak into the ground, rather than flowing directly into adjacent rivers.

5.27 These wetland soakage fields are described on a conceptual basis only. Consequently, it is difficult to assess the potential effects of these proposed bywash discharges, with regard to fish and fish habitat.

5.28 Mr Lewthwaite (Paragraph 246) stated in evidence that it was intended that bywash discharges would be by way of “constructed wetlands”. This cleared up uncertainty that had previously existed as to whether the bywash wetlands would be existing wetlands, artificially created wetlands (developed by simply discharging bywash to areas of land adjacent to the river bed, relying on the existing substrate for drainage and on the natural establishment of wetland vegetation), or specifically designed and constructed wetlands, as indicated.

5.29 However, the habitat that these soakage areas are likely to provide for fish remains unclear.

5.30 The approximate area of each soakage wetland is provided, varying from 1000 m^2 to 5000 m^2 (Appendix H to Mr Lewthwaite’s evidence). This represents a 5 fold increase in the size of the smallest proposed soakage wetlands compared to those proposed in the AEE (i.e. 200 m^2, AEE Section 8.3.3). However, there is no indication of the likely depth, nor the degree of permanence, of surface water in them.

5.31 I note that, in his Section 42 report, Mr Duncan pointed out that the areas stipulated for the soakage wetlands appeared to be too small to accommodate the intended bywash inflows, by a substantial margin, based on conservative estimates of soil infiltration rates (Paragraphs 56-59). However, I also note that this contention is disputed by Mr Lewthwaite (in supplementary evidence Paragraphs 24-26). On this basis it is unclear whether surface ponding is likely to occur in the soakage areas.

Mr Duncan (Paragraph 58) suggested that infiltration rates may be higher if ponding did occur, presumably due to increased hydraulic head.

5.32 The best indication provided by the applicant of the likely habitat to be provided by these bywash soakage areas appears to be Figure 47 in the evidence of Mr Lewthwaite. This photograph depicts "*the type of wetland that is likely to be built for CPWES bywash sites*", and appears to have no surface water to speak of. If this is the design adopted for the bywash soakage areas, then it is unlikely that they will provide any suitable habitat for fish.

5.33 On the other hand, if they are designed appropriately, with sufficient depth and permanence of surface water it seems possible that some of these areas may provide suitable habitat for eels (particularly shortfin eels), and possibly also for upland bullies, as well as water birds. They may also provide suitable habitat for Canterbury mudfish, again depending on their design and operation. However, the suitability for Canterbury mudfish is likely to be low due to the potential accessibility for predators, such as eels, via the water race network. In my opinion it is unlikely that they would provide much, if any, suitable habitat for any other fishes found in the affected area.

5.34 A potential effect of the operational bywashes, in combination with larger volumes entering the water table from irrigated land under the scheme, is an increase in the baseflow of the Selwyn River (and possibly other tributaries). This may have both positive and negative effects on fish in these foothill streams.

5.35 Increased base flow could increase the area of wetted habitat available for much of the year in the parts of these rivers where flow is currently intermittent or ephemeral. However, the magnitude of the likely increase is not clear at this stage. The lower Selwyn is expected to experience a "*significant*" (i.e. >100%) increase in average base flow (AEE Table 8-9, and Appendix L to the evidence of Mr Weir, and Figure 20 in the evidence of Dr Burrell). However, it is not clear how far up the Selwyn this effect will be evident, and it appears that it is not expected to extend to the other foothill rivers, since they are not mentioned.

5.36 Depending on the magnitude and extent of this change, an increase in baseflow could presumably be beneficial for trout, eels and bullies. In particular, more trout spawning and rearing habitat may become available, assuming that the higher baseflows are maintained during the winter spawning and incubation season, as well as through the spring and summer fry rearing period.

5.37 However, it is also conceivable that there could be negative impacts of an increase in baseflow, particularly if it is seasonally variable. For example, if flows were higher than the existing situation in summer and autumn, but declined in winter (as sometimes occurs in streams influenced by irrigation runoff), then trout spawning, in autumn to early winter, could be enticed into spawning in habitat that otherwise would not have been available to them under the existing regime, only to have it dry out during the winter incubation period, resulting in the loss of their eggs.

5.38 Increased flow permanence may also be detrimental for Canterbury galaxias and Canterbury mudfish. Increased predator access may be a potential negative effect (especially for non-migratory galaxiids), as discussed in the evidence of Dr McIntosh, with increased accessibility for predatory eels and large trout (in the size range likely to be piscivorous[3]) potentially leading to a decline in Canterbury mudfish populations (in the Hororata, for example). This negative effect is likely to also extend to Canterbury galaxias and maybe even upland bully populations upstream of currently ephemeral sections of these rivers.

5.39 As stated above the likely extent of any such increase in baseflows, and the likely timing and degree of permanence, are apparently unknown. Consequently, it is impossible to adequately assess the magnitude of potential effects on instream habitat availability in the foothill rivers on the basis of the available evidence.

5.40 Any potential gains in habitat quantity may be offset by reductions in habitat quality associated with increased landuse intensity. For example, sedimentation, and increased nutrient loading and associated changes in plant and algal communities, as well as associated macroinvertebrate communities which fish rely on for food (as discussed in the evidence of Dr Olsen). Adverse effects of this type are likely to be most strongly felt in the lower reaches of the Selwyn and in other lowland streams. However, all streams in the footprint area of the proposed scheme are likely to be impacted to some extent. Avoidance or mitigation of these effects relies on the efficacy of the proposed sustainable farm management plans (discussed in the evidence of Ms Mulcock), which are currently in draft form and require further detail before their potential efficacy can be adequately assessed (this is discussed further in the evidence of Dr Larned).

Emergency bywash discharges

5.41 In the case of emergency, fourteen of the 15 bywash locations could be used to dump excess water from the canal and race system (there is one bywash which is proposed to discharge to a stockwater race, which is not tagged for emergency discharge). However, it has not been decided at this stage how emergency discharges will be handled, and routing water through the existing operational bywash discharges, or an adaptation of them, is only one concept discussed in the AEE and in the evidence of Mr Lewthwaite (Paragraph 253), with other options including discharge to land, or internal storage weirs.

5.42 The most recent information on likely bywash design (Mr Lewthwaite in evidence, Paragraph 253) suggests that if the option of disposing of excess water in emergencies to adjacent riverbeds is ultimately adopted in the design of the scheme, then it is likely that the emergency bywash points will be designed to bypass the soakage wetlands used for the operational bywashes, although how the diversion of emergency discharges away from the soakage areas could be achieved has not been suggested.

5.43 Emergency bywash (and possibly even variation in operational bywash) may have the potential to cause fish strandings.

5.44 In this regard I note that Mr Duncan (Section 42 report, Paragraph 54) suggests that the likelihood of operational bywash exceeding the designed or intended rate, at times, is relatively high, due to the potential for mistiming of the release of water into the water races for an irrigator and the uptake of water by the irrigator. Presumably this additional bywash water will have to be discharged to adjacent riverbeds, as intended for emergency bywash discharges, to avoid damage to the soakage wetlands.

5.45 Juvenile trout and post spawning adults have been observed moving downstream with advancing flood flow into previously dry reaches of the Selwyn, and becoming stranded as the flood wave petered out (Hardy 1989). The emergency bywashes have the potential to cause similar strandings, as they will essentially produce artificial flood flows of limited duration (in the order of a few hours according to the AEE). According to Mr Lewthwaite (in supplementary evidence Paragraph 13) the

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[3] Salmonids living in rivers and streams tend to begin eating fish once they grow to about 27-31 cm (Keeley & Grant 2001).

maximum cumulative emergency bywash discharge to the Selwyn River and its tributaries is predicted to be approximately 21 m^3/s, which is more than six times the mean flow at the Whitecliffs flow recorder site (3.3 m^3/s [4]), but a little more than quarter of the mean annual flood at this site (79 m^3/s). The flows experienced in the ephemeral reaches, where the bywashes will discharge are lower than those at the Whitecliffs flow recorder (for example the estimated 7 day MALF at Scotts Road, which is about 3 km downstream of where the Selwyn River emerges onto the plains, is only about 42 % of the equivalent statistic for the Whitecliffs site (Smith 2004)), so the bywash discharges would likely represent a larger increase in discharge for these reaches.

5.46 Emergency bywash events are expected to be rare. Although no estimate of how rare has been provided, it is suggested that they would only be required if an unexpected heavy rainfall or widespread power cut coincides with high intakes to the scheme (evidence of Mr Lewthwaite, Paragraph 248), or if flooding and/or a blocked stream culvert causes unexpectedly high intakes to outstrip irrigation demand (AEE Section 3.12.3).

5.47 It is conceivable that large fluctuations in operational bywash discharge could have a similar effect, particularly given Mr Duncan's contention, mentioned earlier, that the intended operational bywash discharge rates are highly likely to be exceeded at times, due to mistiming between provision and use of irrigation water in the race system. Even under the intended operational bywash regime the maximum cumulative discharge to the Selwyn and its tributaries from operation bywashes is approximately 3.7 m^3/s, which is more than the mean flow of the Selwyn at either the Whitecliffs or Coes Ford recorder sites (3.3 m^3/s), and substantially greater than the mean annual low flow at these sites (0.8 m^3/s and 0.63 m^3/s, respectively).

5.48 On the other hand, because the uppermost of these bywashes enter the river below the perennially flowing upper reaches, they may not always precipitate downstream fish movement. That is to say, if the bywash water is discharged into a section of river that is dry at the time, there may be no fish in the vicinity to be triggered into moving downstream with the flow. So any potential effect would depend on how far downstream into the ephemeral reaches surface flow persists at the time.

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[4] Flow statistics are from Environment Canterbury's website http://www.ecan.govt.nz/Our+Environment/Water/Rivers/RiverFlows/ North-low-flow-statistics.htm (accessed 29/11/07)

5.49 However, upstream migration of brown trout spawners from Lake Ellesmere, and subsequent stranding, could also be triggered in a similar way.

5.50 The need for operational bywash could presumably be reduced or eliminated by onsite water storage, or by using piped supply, rather than water races, at least toward the periphery of the supply network. Piped supply would also reduce evaporative losses and probably also leakage to groundwater, which together are estimated to account for approximately 10 % of the water abstracted by the scheme under the current proposal (Mr Lewthwaite in evidence, Paragraph 229). As I mentioned, the proposed bywash soakage areas are to range in size from 1000 m^2 to 5000 m^2 (but note that these may be too small for the intended discharge rates). If these areas were instead dedicated to 2 m deep water storage pits, sealed against leakage, for example, they would be capable of storing 2000 – 10,000 m^3 of water close to the ends of the supply network, which the last abstractors in the network could then pump from.

5.51 An alternative approach may be to manage the bywash discharges with the aim of enhancing instream habitat availability, by augmenting flow in the Selwyn catchment. This approach would require flow management objectives to be set (e.g. what species and lifestages would be targeted in the habitat enhancement), and further investigation would be required into the flows required to achieve these objectives. However, developing flow management objectives would not be straight forward, since there are likely to be conflicting interests. For example, flows that may enhance habitat availability for trout are also likely to provide greater access for trout and eels to remnant Canterbury mudfish populations.

5.52 By way of example of how the scheme could be managed to enhance instream habitat for trout, it may be possible to provide ‘connector’ flow between the upper and lower Selwyn River, or from spawning areas in the Hawkins and Hororata to the Selwyn. This would require sufficient flow between the upper and lower reaches to be provided during winter and spring to cover the spawning and incubation period. However, for any benefit to accrue to the population, it may also be necessary to provide flows for juvenile trout rearing habitat in the intermittent reaches of the Selwyn, perhaps year round. It may also be possible to provide or enhance habitat for adult trout, if sufficient flow was available. However, any of these management options would require substantial additional investigation into the flows required to provide enhanced habitat, the feasibility of achieving these flows under the CPW Scheme, and the potential impacts on other parts of the ecosystem.

Habitat value of canals, water races

5.53 The canals and water races of the scheme will provide some additional aquatic habitat in the central plains area. The applicant's appraisal (Kingett Mitchell 2006c, Table 6.1) suggests that the additional habitat provided by these waterways is likely to represent a minor positive effect. Although this could be the case if these waterways were managed with provision of habitat in mind, I consider it is more likely that any additional habitat provided will be of poor quality and temporally variable, and therefore likely to be of negligible value.

5.54 Water races and canals are generally designed and maintained to maximise hydraulic efficiency, rather than to provide instream habitat. There tends to be limited instream cover for fish, for protection from predators and to give relief from relatively high water velocities, and the habitat available for macroinvertebrate food production also tends to be relatively low (Bloomberg & Graynoth 1991). Growth of macrophyte beds along canal and water race margins can improve this situation, but is generally undesirable in terms of hydraulic efficiency.

5.55 The habitat value of water races is also dependent on flow permanence. Stockwater races generally provide relatively consistent habitat, for juvenile trout rearing, for example, because year round demand for stock drinking water means that they are likely to have perennial flow, while fluctuating irrigation demands mean that that flow in irrigation races is relatively variable and consequently they tend to provide less consistent habitat (L. Davey, Fish & Game, pers. comm.).

5.56 It is intended that the CPW Scheme's water races will be emptied in winter to aid maintenance and conserve water (Mr Lewthwaite in evidence, Paragraph 233). Therefore, any habitat provided by the races is likely to be transitory.

5.57 For these reasons I would expect the habitat available in the water races and canals to be of limited value. However, this is not to say that it could not be of any use. As shown in Table 1 attached to the Appendix, a similar suite of fish species have been recorded from the existing water races in the Selwyn catchment to those found in the foothill rivers in this catchment, including brown trout and Canterbury mudfish. But to be of any real value they would need to retain surface water for the majority of the time.

5.58 The potential for creating angling opportunities in the canal system was discussed by Kingett Mitchell (2006b Section 7.4.2). However, this prospect was not discussed in the AEE or in evidence presented on behalf of the applicant (although I understand that the prospect was mentioned in verbal evidence by Mr O'Rourke). Angling is not mentioned as one of the potential recreational activities listed as being likely to be associated with the headrace in the evidence of Mr Lewthwaite (Paragraph 155), nor with regard to the Waianiwaniwa reservoir (Paragraph 176). Perhaps this is based on an assumption that the fish screens at the intakes will be 100% effective in excluding salmonid fry, and consequently there will be no trout in the canals. However, I consider this assumption to be unfounded, given that no fish protection objectives have been established for the screens at this stage (as I will discuss later), and the 5 mm screen mesh size most recently suggested by the applicant (Mr Lewthwaite Paragraph 56 & 97, and Dr Glova Paragraph 42 & 45) is likely to be too large to effectively exclude salmonid fry (see evidence of Mr Bejakovich).

5.59 If managed appropriately, the larger raceways and canals in particular could conceivably provide angling opportunity, although this would also depend on access being provided for anglers (see the evidence of Mr Canham).

5.60 Brown trout in the Rangitata Diversion Race canal support a relatively highly valued fishery. In the most recent National Angler Survey (Unwin & Image 2003) it attracted an estimated 960 angler days, which would have placed it 13th among trout fishing waters in the North Canterbury Fish & Game Region, had it been located in that region. On this basis I consider that the proposed headrace canal for the CPW Scheme would theoretically have a similar potential to provide some trout angling amenity, depending on how it is ultimately managed.

5.61 However, the Rangitata Diversion Race is not drained routinely, because it is used for electricity generation as well as irrigation, and has no fish screening facilities at its intakes, although one is being installed at the Rangitata intake, so fish densities in the RDR canal are likely to be much higher than can reasonably be expected in the CPW Scheme.

5.62 If the intention to drain the water races in winter, for maintenance and water saving (Mr Lewthwaite in evidence Paragraph 233), extends to the canals as well, then it is unlikely that a fishery could be maintained in them.

5.63 Water quality in the canals may also be relatively low at times when it is sourced from the reservoir, which may also diminish the potential to support a fishery. High water temperatures and low dissolved oxygen concentrations, in particular would be detrimental.

Inundation of the Waianiwaniwa valley

5.64 As acknowledged by the applicant, the inundation of Waianiwaniwa Valley will be a "*significant negative effect*" of the CPW Scheme (Kingett Mitchell 2006c; AEE Section 7.9). According to the AEE (Section 7.9):

> "Inundation of the Waianiwaniwa Valley will result in the loss of approximately 37 km of moderately diverse but heavily modified hill-fed stream habitat and the creation of between 4 – 13 km^2 (depending on reservoir levels) of still water aquatic habitat."

5.65 The applicant also concedes that the habitat provided by this lake will be of poor quality, due to low water quality and large fluctuations in water level (AEE Sections 8.4.2 & 8.7.5).

5.66 Water in the reservoir is expected to become stratified and have low dissolved oxygen content, especially during the first few years of operation. This may actually continue over the life of the CPW Scheme, as discussed by Dr Meredith in his Section 42 report (Paragraph 125).

5.67 Fluctuating water levels in the proposed Waianiwaniwa impoundment are likely to retard the establishment of macrophytes and associated macroinvertebrate communities around the shallow margins, which are generally recognised to be the most diverse and productive component of lake fauna (Kelly & McDowall 2004). Those plants that do establish around the shallow margins of the reservoir will periodically be exposed and killed during periods of draw down. The water level in the reservoir is expected to fluctuate by approximately 11m in a typical year and up to 35m in a dry year (Kingett Mitchell 2006c). Figure 29 in the evidence of Mr Lewthwaite illustrates the potential extent of reservoir margins that could be exposed by water level fluctuation between the maximum and minimum reservoir levels. Without the stabilising influence of vegetation cover the reservoir margins are likely to be muddy and prone to erosion.

5.68 Inundation of the Waianiwaniwa valley will cause habitat loss for Canterbury mudfish and Canterbury galaxias, since neither of these fish is known to inhabit lakes (refer to the evidence of Dr McIntosh for further discussion of effects of the Waianiwaniwa reservoir on Canterbury mudfish).

5.69 In evidence Dr Allibone suggests that Canterbury galaxias will not be affected by the proposal to flood the Waianiwaniwa Valley, because they exist upstream of the reservoir footprint area (Paragraph 29). However, Canterbury galaxias have been recorded in the NZFFD from within the reservoir footprint area, and more importantly the flooding of the Waianiwaniwa Valley with water sourced from the Waimakariri River has the potential to impact on Canterbury galaxias populations in the valley through the introduction of predators or competitors.

5.70 This potential was initially recognised by the applicant:

> ”Flooding of the valley with the reservoir for the Central Plains irrigation scheme would render the habitat in the area unsuitable for Canterbury mudfish. Moreover, with inflow of water from the Waimakariri River into the reservoir, the riverine habitat upstream of the reservoir would become invaded with eels, which are a predator of the Canterbury mudfish." (AEE 2006 p. 8-11).

In my opinion these concerns would also apply to Canterbury galaxias.

5.71 In evidence Dr Allibone downplays this possibility (paragraphs 94-96). However, in my opinion this possibility remains, as I will discuss later in relation to fish screening.

5.72 As well as eels, it is almost certain that larval koaro will enter the reservoir through the intake, and if they establish a land locked population based in the reservoir, they would be another potential predator and competitor for Canterbury mudfish in the catchment. I understand that in verbal evidence Dr Allibone suggested that fish passage barriers would be constructed in the tributaries to the Waianiwaniwa reservoir, to limit access for potential predatory fish to mudfish habitat upstream. However, eels and koaro are adept climbers, and when young are able to pass through relatively fine mesh (as I will discuss later in relation to fish screening), so ensuring their exclusion with physical barriers is likely to be difficult, as discussed in the evidence of Dr McIntosh.

5.73 Consequently, I cannot agree entirely with the applicant's assessment that:

> "the creation of a large amount of stillwater habitat… …is expected to result in a minor positive effect on the instream habitat values of the Waianiwaniwa valley overall." (Kingett Mitchell 2006c, p.iii).

In my opinion, any positive effect is likely to be small, due to the poor water quality and large water level fluctuations expected in the reservoir, and would only apply to some species, such as eels, brown trout, upland bullies and koaro, if and when these fish find their way into the reservoir via the intake canal and tunnel.

5.74 For Canterbury mudfish and Canterbury galaxias it will constitute a negative effect. While the existing habitat is obviously at least tolerable for these fishes, which live there now, the habitat provided by the reservoir will not be. So from the perspective of these species, the dam represents a significant negative effect, not a minor positive.

5.75 In the AEE (p7-11) it is suggested that enhanced flows in lowland streams (discussed above and in the evidence of Dr Larned) will mitigate the effect of habitat lost in the drowned section of the Waianiwaniwa to some degree, although it was conceded that the magnitude of this mitigation was unclear at the time of writing. In my opinion this does not represent reasonable mitigation, since the lowland streams are not suitable habitat for species currently found in the upper Waianiwaniwa (especially Canterbury mudfish), due at least in part to higher predation risk in these lower reaches.

5.76 The dam is likely to present a barrier to downstream passage for seaward migrating eels, if they become established behind it. This was recognised as an issue by Kingett Mitchell (2006b p69), although it has not been discussed in evidence presented on behalf of the applicant. This issue would also apply to any salmon fry entrained into the dam, as they would not be able to complete their lifecycle without access to the sea.

5.77 In evidence Mr Lewthwaite proposes occasional releases into the Waianiwaniwa River bed below the dam to maintain groundwater recharge (Para 135 & Para 256), and suggests larger flows could be provided if some reason is identified. I would suggest that this is one such reason, and that discharges should be considered during autumn to facilitate downstream migration of eels from the reservoir.

However, this needs to be weighed against the potential negative impacts of such releases on Canterbury mudfish populations downstream of the dam.

5.78 I anticipate however, that it will be difficult to design an outlet that would function effectively to facilitate eel passage from a water storage dam of this type. Downstream migrating eels tend to be surface oriented, travelling close to the water surface, although when confronted with an obstacle they will search for a way through (Watene et al. 2003). Consequently, if the outlet is designed to release water from close to the bottom of the dam it is likely to be difficult for surface oriented downstream migrants to find it. However, if it is surface release, the water level behind the dam may be too low for it to be functioning in autumn, when seaward eel migration occurs, since stored water is likely to have been drawn down to met high irrigation demand during summer. The flow release would have to be large enough to provide continuous surface flow down the Waianiwaniwa and Selwyn, long enough for the eels to migrate through these reaches. Notwithstanding these difficulties, such a release may still be a worthwhile considering as a mitigation option, in my opinion.

5.79 Another mitigation option may be to trap eels attempting to migrate downstream and transfer them further down the catchment, although this option may also be difficult to implement in practice.

5.80 These options could also be considered for any salmon fry entrained behind the dam. However, I anticipate that they may be even more difficult to implement for salmon fry, given their much smaller size, potentially much higher numbers (if the intake fish screens are inadequate to exclude them) and relatively broad range of downstream migratory timing (McDowall 1990).

5.81 In my opinion, the best solution is to aim to avoid having these fish entrained into the reservoir in the first place, by providing adequate fish screening at the intake, as discussed below (and in the evidence of Mr Bejakovich).

5.82 Without flow releases the Waianiwaniwa would presumably be permanently dewatered below the dam. Most of this section of the river does not carry permanent flow. However, it does still have some fish habitat value. For example, in the reaches immediately below the proposed dam Kingett Mitchell Ltd. recorded Canterbury mudfish and upland bullies at five out of eight sites sampled, and also found longfin and shortfin eels at one of these sites (Figure 3.6 in Kingett Mitchell Ltd

2006b). In my opinion, flow releases should also be considered to maintain these values.

6. FISH SCREENING AT THE SCHEME INTAKES

6.1 There are three fish screens proposed as part of the CPW scheme. These are associated with the three proposed intakes, two in the Waimakariri and one in the Rakaia.

6.2 The plans for these fish screens and associated structures are still at the conceptual phase, and if anything seem to have become less definite in evidence presented on behalf of the applicant, than they were in the AEE.

6.3 A fish screen is also proposed by the ACWT as part of its application to take water from the Rakaia River. The plans for this screen, as described in the evidence of Mr Woods, are at a similar conceptual level to those put forward by CPW, although ACWT have proposed consent conditions for the design and operation of their fish screen facility (refer to the evidence of Mr Dunning, Appendix B - Proposed Consent Conditions - Condition 2). However, the discussion below on fish screening and associated issues is also relevant to the ACWT proposal.

6.4 NIWA have recently prepared a report on good practise guidelines for fish screening, with a focus on the Canterbury area, for a working group including Ecan, F&G NZ, Irrigation NZ, and DoC (Jamieson et al. 2007). Although the guidelines suggested in that report were intended for intakes of up to 10 m^3/s, the principles are also useful for larger takes, as recognised by the applicant (Mr Lewthwaite in evidence Paragraph 49).

6.5 These guidelines suggest establishing fish protection objectives as an initial step in the design process. It is suggested that this should be done with regard to the composition of the fish community, including possible seasonal changes, and the potential impact on the fishery of the diversion, and include consultation with interested parties.

6.6 Fish protection objectives for the proposed CPW fish screens have not yet been established. Rather it has been proposed that these should be developed later, following consent, in consultation with stakeholders and experts in the field and be approved by Environment Canterbury, as consenting authority (Mr Lewthwaite in evidence Paragraph 47).

6.7 In my opinion these objectives should have been developed already, prior to consenting, to allow the likely effects of the scheme to be realistically assessed. The magnitude and likelihood of adverse effects in other parts of the scheme are dependent on the fish protection objectives adopted (as discussed by Dr Meredith in his Section 42 report, Paragraph 80), and on the feasibility of implementing the fish protection objectives.

6.8 For example, the likely success of any attempt to maintain remnant Canterbury mudfish populations in the Waianiwaniwa Valley, upstream of the reservoir footprint area, hinges on whether or not there is access to the reservoir and its tributaries for predatory fish such as eels or trout. Consequently, the magnitude and likelihood of an adverse effect on these Canterbury mudfish populations depends, at least in part, on whether the screens will be designed with the objective of excluding these species, and whether it is possible to construct and operate screens to achieve this on an intake of the size proposed. The fish passage barriers proposed by Dr Allibone (in verbal evidence) for the reservoir tributaries, to exclude potential predatory fish from mudfish habitat refuges upstream, may provide a second line of defence, but may also be difficult to achieve (as mentioned earlier, and discussed further in the evidence of Dr McIntosh).

6.9 The magnitude of ecological effects, particularly on ecosystem productivity, in the Waimakariri and Rakaia rivers depends on the fish protection objectives adopted for the fish screens.

6.10 In the absence of any objectives, I will give my opinion on matters that ought to be considered when assessing what might constitute appropriate levels of protection.

6.11 I suggest that there are three key reasons for attempting to avoid entrainment of a given species of fish into a water diversion or abstraction, and these are likely to have a bearing on the level of fish protection that is deemed to be appropriate.

a. The intrinsic existence value of the species. Higher levels of protection are likely to be deemed appropriate for rare or threatened species, since these are likely to be more susceptible to negative population impacts as a result of fish being lost into the diversion.

b. The fishery value of the species. Fish entrained into the diversion are likely to be lost to the fishery, and therefore species with high fishery value are likely to be afforded higher levels of protection.

c. Ecosystem productivity. Any fish entrained into a diversion represents a loss of biomass from the system, and therefore a reduction in the productivity of the system, with potential flow on effects to higher order consumers, including other fish (perhaps with higher fishery or conservation value) or birds.

Since the number of fish entrained is likely to increase with the size of the diversion, in the absence of appropriate screening, these considerations will arguably also increase in importance.

6.12 The third of these points, in particular, is directly related to what is described in the RMA (1991) as “life supporting capacity”. Even though the loss of a proportion of the total population of a given species in a river may have no more than a minor effect on the persistence of that population, it may have a more marked effect on the overall productivity of the river ecosystem.

6.13 There is potentially a fourth reason for effective screening in a situation where water taken from a given catchment will be discharged into other catchments, as is the case with the CPW scheme. Effective screening may be deemed necessary in this case to avoid introducing species beyond their existing, or natural, ranges.

6.14 With these points in mind I suggest there are four further issues related to the design and operation of the fish screens that warrant further consideration at this stage. These are:

a. The species of fish, and size classes, that are likely to come into contact with the screen, which will inform the choice of screen mesh size, appropriate approach velocity, and whether screening would be required only during certain periods or all year round.

b. The potential for fish passed through the screen to return to their river system of origin, or to be introduced to other catchments.

c. The location of the screens, and location, design and maintenance of the fish bypass channels, including minimising entrainment and the potential for increased predation risk for fish passed through the fish bypass channel, and avoiding attracting upstream migrants up the bypass channel.

d. The need for monitoring of the efficacy of the screens and bypass facilities, and the potential to alter the design in light of the monitoring results.

Species of concern and screen design parameters

6.15 I suggest that the next step should be to consider what fish species, and life stages, are likely to encounter the diversion, and what screen design requirements might be required to avoid entraining these species into the diversion, and to avoid having them impinged on the screen.

6.16 The two key points to consider in this regard are the screen material opening size (e.g. mesh, profile bar, or perforated plate) required to exclude the appropriate species, and the approach velocity required to allow the fish to avoid coming into contact with the screen, where they could become impinged or injured. The approach velocity is the velocity perpendicular to the screen face (i.e. flowing directly through the screen), this should be less than the sweeping velocity (flowing parallel to the screen face) which can be achieved by angling the screen at less than 45° to the oncoming flow at the intake.

6.17 Other design requirements, such as sweeping velocity, screen angle, and exposure time will follow from these key points, and can be addressed at the detailed design phase.

6.18 Obviously, consideration of screen material opening size is based on an assumption that a physical screen is likely to be employed. I believe that this assumption is reasonable because physical screening is generally recognised as the most effective and reliable method of excluding fish from water intakes (Boubée & Haro 2003, Jamieson et al. 2007), and because the evidence presented on behalf of the applicant suggests that a flat physical screen is the most likely style to be provided for the CPW intakes (e.g. Mr Lewthwaite Paragraph 58a).

6.19 Although no screen material or opening size has been settled on yet, 5 mm has been discussed in evidence (e.g. Mr Lewthwaite Paragraph 56 & 97, and Dr Glova

Paragraph 42 & 45). The implication of discussion around this point is that any smaller opening size may be impractical for an intake of the size proposed, although the AEE (p3-10) implied that a smaller opening size, about 3 mm, was being considered (see also discussion of the feasibility of screens with finer than 5 mm openings in the evidence of Mr Bejakovich). I will use both of these options as my baseline for comparison in the discussion below. A maximum of 5 mm mesh aperture size has been put forward by ACWT for their intake on the Rakaia, but reducing to 3.8 mm between 1 August and 15 November (refer to the evidence of Mr Dunning, Appendix B - Proposed Consent Conditions - Condition 2).

6.20 The opening sizes that I refer to in the rest of my evidence refer to the side length of square mesh openings. The equivalent opening sizes for other screen materials may be slightly smaller or larger, as discussed in the evidence of Mr Bejakovich.

6.21 With regard to approach velocity, the recent NIWA fish screen report (Jamison et al. 2007) suggested that this should not exceed 0.12m/s. This value was derived to account for the smallest salmonid fry likely to be found in most situations in Canterbury. However, the authors suggest that this criterion should also account for discrepancies in the swimming performance of various native species, which is supported by the findings of a recent Department of Conservation review of fish screening criteria (Charteris 2006). This approach velocity was also endorsed by Dr Glova in his evidence (Paragraph 45). In my opinion an approach velocity of 0.12 m/s is a pragmatic criterion, although it is likely to exceed the sustained swimming ability of very small fry (Charteris 2006, Jellyman 2004). I will use this criterion as my baseline for comparison in the discussion below.

6.22 I used data from the NZFFD to assess the native fish species likely to come into contact with the proposed CPW intakes. Fish screening issues with respect to salmonids are covered in the evidence of Mr Bejakovich, and I note that the general criteria that he lists in Paragraphs 5.2 and 5.5 would also cater for the majority of native fish. Table 2 (attached in the Appendix) illustrates the distribution of native fish species recorded from the Waimakariri and Rakaia rivers relative to the proposed intake locations, and also indicates those with migratory life history requirements.

6.23 The migratory life history of many of New Zealand's freshwater fishes mean that they may be exposed to water intakes as they move to or from the sea. However, most fish will also move about the river independently of these major life phase migrations. All moving fish are at risk of becoming entrained into intakes, which can lead either to their death (e.g. in pumps, turbines or irrigation systems) or to habitat that is unfavourable for completing their lifecycles (e.g. canals, irrigation channels and races).

6.24 Based on the NZFFD records I suggest that there are a total of ten species of native fish whose known distributions are likely to bring them into contact with the proposed intakes in the Waimakariri, and nine species in the Rakaia. On the basis of a similar analysis Dr Allibone concluded that there were only nine native species that occur in the vicinity of the proposed abstractions. I will discuss the reason for the discrepancy in our findings shortly.

6.25 Seven of these species have migratory life history requirements, which would see them potentially exposed to the proposed intakes as they move to, or from, the sea. The migratory species that have been recorded from upstream of the proposed intakes are; shortfin and longfin eels, koaro, lamprey, torrentfish, common bully and bluegill bully. Torrentfish have been recorded upstream of the proposed intake site in the Rakaia and the lower intake on the Waimakariri, but not from above the upper intake in the Waimakariri, although this is not to say that they do not occur further upstream. Bluegill bully have been recorded from adjacent to the lower Waimakariri intake site, and so may also occur upstream of it as well, although presumably they are not common in this area.

6.26 In addition to these migratory species, the recorded ranges of four non-migratory native fish species overlap with the proposed intake sites. Consequently, there is the potential for these species to be entrained into the scheme as they move about in the vicinity of the intakes. Downstream of the upper Waimakariri intake Alpine galaxias are only known from the Kowai River system. However, in the Rakaia they have been recorded from several locations in the mainstem above and below the proposed intake. Canterbury galaxias have also been recorded from the Kowai River system, as well as the mainstem Waimakariri below the upper intake, although the records suggest they are mainly restricted to tributary streams in the reaches affected by the proposed intakes on both the Waimakariri and Rakaia rivers. Upland bullies are widespread throughout both catchments, including the mainstem. Upland longjaw galaxias have been recorded from above and below the proposed intake on the Rakaia, although they are more commonly found higher in the catchment, and they are not known to occur in the Waimakariri catchment.

6.27 The main point of difference between my appraisal of species likely to come into contact with the intakes and that of Dr Allibone is that his did not include koaro or common bully, which have both been recorded from upstream and downstream of the proposed intakes on the Waimakariri and Rakaia rivers. His rationale for excluding koaro was that he considered that this species was restricted to landlocked populations associated with lakes in the upper catchments in these rivers (Paragraph 95), and his mention of common bully suggests that they are restricted to the lower reaches only (Paragraphs 20 & 57).

6.28 However, there are records of both of these species above the proposed intake sites on the Waimakariri, and for koaro in the Rakaia also, in locations that suggest at least some of the populations in these upper catchments are truly diadromous (i.e. run to and from the sea), rather than lake based (see Figures 3 & 4 attached in the Appendix). For example, there are several records of koaro from the Broken River and Kowai River catchments, which have no lakes downstream. It is possible that some of these records may be miss-identifications. However, there is no way to verify this. Consequently, I have included them in my assessment.

6.29 Another point of difference between Dr Allibone's assessment and my own is that he discounted the need to consider bluegill bully in relation to the screen design, on the basis that it occurs only downstream of the proposed takes (Paragraph 71), although he still counted them as one of his nine species occurring in the vicinity of the intakes (his Table 4 c.f. Paragraph 71). As I have already stated, bluegill bully have been recorded from adjacent to the lower Waimakariri intake site, and so may also occur upstream of it as well, although presumably they are not common in this area. Consequently, I have taken the conservative approach of assuming that they may come into contact with the intakes in my assessment.

6.30 As alluded to earlier, screen design requirements depend on the size and swimming abilities and behaviour of the fish that come into contact with the intake. These characteristics depend on the life history stage of the fish that are likely to be exposed to the intake. For non-migratory species that live in the vicinity of the intake both juvenile and adult fish need to be considered. Whereas, for fish with migratory life histories the life stage most likely to come into contact with the screen depends on the particular life history timing of river residency and migration in each species. However, it is not necessarily only the migratory phase that must be considered, since the day to day movements of fish living in the vicinity of the intakes have the potential to bring them into contact with the screen throughout the year.

6.31 In the following paragraphs I briefly discuss the life histories of the species which I consider likely to come into contact with the screen, and compare the likely mesh size and approach velocity requirements to exclude each species with those discussed above (i.e. 3 mm or 5 mm mesh, and 0.12 m/s approach velocity). The relative risk of entrainment associated with different mesh sizes which I cite below are mainly based on the analysis presented by Jamieson et al. (2007).

6.32 As discussed earlier in my evidence, eels migrate to the sea as large adults and migrate upstream from the sea as juveniles. Longfin eels are of conservation concern, listed as being in “Gradual decline” (Hitchmough et al. 2007), and both shortfin and longfin eels support commercial, customary and recreational fisheries. The suggested design criteria are likely to be more than adequate to protect seaward migrating adult eels. Either proposed mesh size (i.e. 3 or 5 mm) would easily exclude mature eels of both species, and the approach velocity of 0.12 m/s is well within their swimming capabilities.

6.33 However, 5 mm mesh is too large to ensure the exclusion of small upstream migrating juvenile eels. Given the distance upstream from the sea to the proposed intakes, very small glass eels are unlikely to come into contact with them. But upstream migrating elvers are likely to, and mesh opening of 3 mm or less would be required to ensure exclusion of the majority of elvers (Jamieson et al. 2007), with some sources suggesting mesh as fine as 1.5 mm may be required for very small elvers (Charteris 2006). Elvers actively migrating upstream are unlikely to voluntarily enter the diversion channel from the river, since they would be preferentially moving upstream, although they could be sucked in if the intake velocities were too high. However, upstream migration by elvers does not take place in a single large push. Rather they proceed incrementally upstream, over a period of years (McDowall 1990). Between bouts of active upstream migration they reside in the river. Therefore, I consider it is likely that elvers will enter the intake when not actively migrating upstream. Others are likely to attempt to migrate up the fish bypass channel, if this option was presented to them, which would ultimately bring them into contact with the screens. The applicant suggests a perched outlet from the fish bypass channel into the river, or a velocity barrier, to avoid this (Section 92 Response p17 Paragraph 3.2.3 Return channels), although how this could be engineered and maintained in the relatively unstable environment of a braided river is not clear, as I will discuss further below. Although the active upstream migration of elvers is generally concentrated in the summer and autumn, they are present in rivers all year round. Consequently, screening would be required all year to minimise entrainment of elvers into the scheme.

6.34 Lamprey migrate upstream as adults and move incrementally downstream as juveniles. Lamprey are listed as “Sparse” in the most recent threat classification issued by the Department of Conservation (Hitchmough et al. 2007). Much like adult eels, upstream migrating adult lamprey are large enough that they should be easily excluded by either proposed screen mesh size. However, a mesh opening size any larger than 3 mm is likely to present a high risk of entrainment to riverine juvenile life stages of this species, and the earliest life stage is likely to be at a moderate risk of entrainment through even smaller mesh. However, lamprey are sparsely distributed and very little is known about their behaviour, so it is difficult to assess the likelihood of entrainment into the scheme. It is possibly that the juvenile ammocoete life stage may inhabit the sediment settling traps, given its preference for sandy or silty sediment (McDowall 2000). Again screening is likely to be required all year round, and the attractant flow from the fish bypass may present an issue for upstream migrating adults if a method of excluding them from this is not included in the design.

6.35 Koaro spawn close to their adult habitat, predominantly in forested headwater streams, in autumn and winter, laying their eggs among bankside gravels and leaf litter during elevated flows. Their eggs hatch when re-inundated three to four weeks later and the newly hatched fry are swept out to sea, where they spend several months growing before returning to rivers as part of springtime runs of whitebait. Koaro are generally the second largest contributor numerically to the whitebait catch, after inanga (McDowall 2000), although I know of no data to address what proportion of the Waimakariri and Rakaia fisheries koaro represent[5]. However, unlike inanga, which generally live for only 1 or 2 years, koaro may live for fifteen years or more, and grow to around 200 mm long (McDowall 2000). The tiny size of seaward moving koaro fry, which are <10 mm long, make it impractical to screen these out of the intake. Consequently, fry are likely to be entrained approximately in proportion to the volume of abstraction. A screen with 3 mm mesh is likely to exclude the majority of whitebait and older juvenile and adult koaro that may come into contact with the intake, but the risk of entrainment will increase with larger mesh size. Koaro whitebait generally return in September and October, so this will be the key season

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[5] The only published data that I am aware of on the species composition of whitebait runs on the East Coast of the South Island is from the 1964 season (McDowall 1965). In that season inanga comprised 98.5 % of the whitebait in 29 samples taken from rivers in Canterbury and Otago, with koaro comprising only 1.1%. However, the contribution of koaro to the catch in some individual rivers was higher (e.g. Waitaki 10.6%, Clutha 8.5 %). No mention was made of the Waimakariri or Rakaia. I have asked Dr McDowall, New Zealand’s pre-eminent freshwater fish expert, if he is aware of any information on the composition of whitebait runs in the Waimakariri or Rakaia, but he was not aware of any either.

for screening for this species. The proposed screen approach velocity of 0.12 m/s should be suitable for all life stages of koaro, except the seaward migrating fry. Again the attractant flow of the fish bypass return could be an issue for upstream migrants.

6.36 Torrentfish exhibit partial sexual habitat segregation, with the females generally living further upstream than males. The available evidence suggests that the females migrate downstream to spawn in summer or autumn (McDowall 2000). When ripe the females become extremely bloated, although whether this impacts on their swimming ability has not been studied. In any case, the proposed approach velocity should be well within the swimming capability of adult torrentfish, and even a 5 mm mesh should be more than adequate to exclude adults. The fry go to sea upon hatching and return in the spring and summer as approximately 20 mm long juveniles (McDowall 2000). Since the females are thought to move downstream to spawn the newly hatched fry may originate below the proposed intakes and consequently not be at risk of entrainment. However, as with the newly hatched fry of other species it would probably be impractical to screen them in any case. Newly returning juveniles are likely to be able to pass through mesh screen with an opening size greater than 3 mm (Jamieson et al. 2007), but are probably unlikely to enter the scheme intake, unless they gain access through the bypass channel, since they would presumably be oriented to move preferentially upstream. The proposed screen approach velocity of 0.12 m/s is likely to be low enough to avoid these juvenile fish being entrained through the screen involuntarily.

6.37 Bluegill and common bully are also diadromous, living most of their lives in freshwater, but with newly hatched fry going to the sea where they spend several months growing before returning as juvenile fish less than 20 mm long (McDowall 2000). By contrast, upland bullies spend their entire lives in freshwater. The small size of the juveniles of all of these species probably precludes effective screening, and even small adult fish may be reasonably susceptible to entrainment, especially with mesh openings greater than 3 mm. However, they are all relatively prolific breeders, and none are regarded as being of particular conservation concern, so some losses to the scheme are likely to be acceptable, although this would constitute a loss of productivity from the source rivers, as discussed earlier.

6.38 Like upland bully, the three species of non-migratory galaxiids (alpine galaxias, Canterbury galaxias and upland longjaw galaxias), whose recorded ranges overlap the proposed intake sites, present difficulties for effective fish screening due to the small size of juveniles and even small adult fish that are likely to come into contact with the intake. However, unlike upland bully, upland longjaw and alpine galaxias are not such prolific breeders. So far as is known they spawn only once per year and lay only about 100-300 eggs each (McDowall 2000), compared with the several hundred to a thousand eggs laid at each of several spawning occasions during summer by upland bullies.

6.39 The upland longjaw in particular is of conservation concern, listed as being in “Gradual decline” (Hitchmough et al. 2007). They grow to only about 60-70 mm in length, and mature at about 55 mm. They are mainly found in marginal shollows of fast-flowing riffles and runs of streams and lateral channels of larger braided rivers (McDowall 2000), including the Rakaia, but they are not known from the Waimakariri. They live for two to three years and spawn during the spring and possibly also the autumn. Upland longjaw galaxias have been recorded from below the proposed intake on the Rakaia, although they are more commonly found higher in the catchment. Based on head width to body length ratios from the literature (McDowall 1970), even relatively large juvenile upland longjaw galaxias, up to approximately 32 mm long, would fit through a 3 mm mesh without having to squeeze through, and even small mature fish, 55 mm long, would fit through 5 mm mesh.

6.40 In summary, a 3 mm mesh size (for discussion of other screen material opening sizes see the evidence of Mr Bejakovich) would be required to ensure that the majority of native fish that are likely to come into contact with the screen would be excluded from the intakes. Even this sized mesh would not exclude larval koaro, bullies or non-migratory galaxiids. However, it is probably impractical to do so using a physical screen, and the efficacy of other screen types have not been demonstrated for New Zealand species.

6.41 If the larger 5 mm mesh suggested is adopted, then eel elvers, juvenile lampreys and juvenile torrentfish, and all life stages of the non-migratory galaxids likely to come into contact with the intakes, and bluegill bully adults would also be at high risk of being entrained through the screen (Jamieson et al. 2007). Even small adult koaro, and common and upland bullies may be at a moderate risk of entrainment through a 5 mm mesh screen (Jamieson et al. 2007).

6.42 I agree with Dr Allibone that the loss of some larval non-migratory galaxiids and upland bullies into the scheme is unlikely to have any more than a minor effect on the populations of these fish in the Rakaia and Waimakariri rivers. The loss of some larval koaro, bluegill and common bullies, and torrentfish, into the intake would also be unlikely to affect the persistence of these populations.

6.43 Loss of longfin eels and upland longjaw galaxiids may exacerbate the threat to these species, which are already considered to be in “Gradual decline”. Although the effect of the proposed scheme in isolation may be minor, the cumulative effect of the scheme, in combination with existing threats and other likely developments, may ultimately be more significant.

6.44 The loss of fish into the intakes represents a reduction in ecosystem productivity in the reaches downstream of the intakes, the magnitude of which is not clear. The flow-on effects of such a loss of prey production for riverine birds and predatory fish in these reaches warrant further consideration, in my opinion. Any loss of fish into the intake would exacerbate the effects of reduced invertebrate prey abundance expected to result from reductions in habitat availability and/or quality occurring as a consequence of the proposed abstraction (refer to the evidence of Dr Hayes and Dr Olsen).

6.45 If it a screen mesh size smaller than 5 mm is impractical to operate on the proposed intakes for the CPW Scheme, as suggested in the evidence by Mr Lewthwaite (Paragraphs 56 & 97), then this effect may not be able to be avoided or mitigated. The evidence of Mr Bejakovich discusses the feasibility of screens with finer than 5 mm mesh further.

Fate of fish entrained through the fish screens

6.46 Given that some fish are likely to be entrained regardless of the mesh size adopted, the question of what will become of those fish presents itself. Some of the entrained fish are likely to have been injured due to contact with the screen, potentially reducing fitness or even causing mortality. Surviving fish of some species are likely to establish populations within the canals, reservoir and water races of the scheme, although as I discussed earlier the habitat quality, and permanence, in these artificial water ways is likely to be relatively low.

6.47 In the AEE (p8-39) it was claimed that “those fish that do become entrained will not necessarily be ‘lost to the system’, as it is likely that these fish will make it back to either the Rakaia, Waimakariri or Selwyn River as a result of operational or emergency bywash discharges.” However, it seems unlikely to me that many of them actually will, given that the operational bywash discharges are proposed to be via wetlands, which are proposed to be "located adjacent to existing water courses but will not have any surface water connection to prevent overflow" (AEE p3-55).

6.48 I concede however that some fish may make it back, either to their river of origin, or into another catchment during the supposedly rare event of emergency bywash discharges, or possibly more frequent occasions when operational bywash exceeds soakage wetland design inflows (see Mr Duncan's Section 42 report Paragraph 54). This raises the possibility of species introduction to new catchments, where they do not currently exist.

6.49 As I mentioned, upland longjaw galaxias has been recorded from the Rakaia catchment, but is not known from the Selwyn or Waimakariri catchments. Because this species is more commonly found higher in the Rakaia Catchment, losses through entrainment to the proposed intake are not likely to be a significant issue for the population as a whole. However, there is a possibility of this species being introduced to either the Selwyn or Waimakariri catchments through bywash discharges.

6.50 I consider it is unlikely that upland longjaw galaxias would establish in the Selwyn River, on the basis of its known habitat use. However, it is possible that they could establish in the Waimakariri River, especially if they moved upstream toward the upper catchment.

6.51 Alpine galaxias could be introduced to the Selwyn Catchment in the same way, although again I consider it is doubtful whether a population would establish in this catchment.

6.52 The only way that I can conceive to avoid the possibility of inter-catchment species exchange is to opt for a piped supply network, which would presumably eliminate the need for bywash discharge into other catchments.

Screen location and bypass design

6.53 Ultimately, the objective of any fish screening facility is to minimise the loss of fish from the source river. The most obvious way that fish can be lost is by entrainment through the screen into the canal system. However, mortality can also be increased for fish as they pass through the intake and screening facilities and the fish bypass.

This increased mortality can occur through exposure to predation risk, mechanical damage, or through stranding and desiccation, for example.

6.54 To minimise these risks the ideal situation is to locate the screen at the point of intake, or as close as possible, to avoid diverting fish from the mainstem at all. The current proposal has the fish screens located approximately 1.5 to 2 km downstream of the point where water is initially diverted from each river (Annexure D to the AEE). By the time fish reach the screen they will already have had to negotiate a substantial distance through the diversion channel, intake structure and sediment traps. During this time they may be exposed to elevated predation risk, as these artificial channels, particularly the sediment trap, are likely to have less instream cover than would be available in a natural river channel. In my opinion it would be beneficial if the fish screen could be located closer to the point of take.

6.55 The design of fish bypasses associated with the fish screens is not clear at this stage. The AEE stated that the bypasses are to be open channels (Section 3.14.3 Fish Screens, p3-73). However, in the design drawings provided with the AEE (Annexure D to the AEE) they are labeled “fish return pipes”.

6.56 If they are to be open channels it will be important to ensure that they are deep and/or fast flowing enough to avoid increased predation, particularly by birds, on fish travelling through the bypasses.

6.57 In regard to this issue, Dr Glova (in evidence Paragraph 44) has recommended a 5 m^3/s bypass flow at each of the intakes to ensure safe passage for fish back to a major channel in the river. Mr Lewthwaite (in evidence Paragraph 62) has indicated that this would be practical for scheme operation. This is a departure from the 2 m^3/s suggested in the AEE. I agree that the higher bypass flow is more likely to provide for safe fish passage. Unfortunately, it is also likely to exacerbate the effects of flow reduction in the residual river between the diversion and the point of return of the bypass flow, and possibly breach the minimum flow conditions in this reach, as discussed in the evidence of Dr Hayes.

6.58 Alternatively, overhead cover could be provided, by nets for example, to prevent predator access, at least over permanent sections of the channels.

6.59 Another key consideration for the fish bypass is that it discharges into an appropriate location. Ideally this should be to an actively flowing section of river channel.

Discharge into still or slow flowing water should be avoided because it is likely to increase the risk of predation, as aquatic predators can more easily hold station below the discharge point, and avian predators are likely to be better able to see through the surface of slow flowing water.

6.60 In the Section 92 response regarding fish screening (Golder Kingett Mitchell p17 Section 3.2.3), it was implied that there are to be settling ponds at the bypass discharge points. In my opinion this should be avoided.

6.61 In the design drawings the fish return pipes do not appear to have extended far enough to ensure they reach actively flowing channels (Annexure D to the AEE). If a 5 m^3/s bypass flow is adopted then this is not likely to be an issue, because such a large flow would presumably create and maintain its own channel and ultimately coalesce with the main river.

6.62 However, if lower bypass flows are opted for, it may be difficult to ensure that the fish bypass channels are consistently able to discharge into an actively flowing channel in the dynamic system of a braided river. At the very least they may require frequent maintenance to ensure they still reach a flowing channel, especially following floods. In evidence Mr Lewthwaite (Paragraph 77) suggests that river training works associated with the intakes might have to be repaired about 10 times per year, on average, following significant changes in the river bed caused by large freshes. I would anticipate that a similar frequency of repair work would be required for the fish bypass discharge points.

6.63 This would be of particular concern because fish migration is often triggered by flood events, so on the descending limb of a flood event, when the bypass channel and discharge point is likely to be in most need of maintenance, and may even need to be totally reformed, is also when it is most likely to be required to be working well to facilitate fish passage. Ultimately, the bypass flow required to maintain an open and actively flowing channel back to the mainstem is a question for a fluvial geomorphologist or engineer.

6.64 Another issue of the layout proposed in the design drawings (Annexure D to the AEE) is that the sediment sluice at each site is located a short distance upstream of the respective fish bypass outlets. This suggests that there is the potential for sediment flushed from the sediment traps to build up in the vicinity of the bypass outlet. This may make it even more difficult to ensure that the bypass consistently discharges into an actively flowing channel. It may also cause the substrate in the vicinity of the bypass outlet to become embedded, thereby reducing the availability of instream cover for fish discharged from the bypass.

6.65 I have already highlighted the potential issue of fish being attracted by the bypass discharge flow and attempting to move up the bypass. This is of particular concern for upstream migrating fish. If fish are able to move up the bypass they will be exposed to the risk of entrainment through the screens and also potentially to increased predation risk as they move through the bypass and intake and associated structures. Consequently, the outfall point from the bypass must be designed to prevent or discourage fish from entering.

6.66 As mentioned above, the Section 92 response regarding fish screening issues (Golder Kingett Mitchell 2007a, Section 3.2.3) suggests either a vertical drop or a smooth velocity barrier to achieve this. However, I cannot conceive how either of these could be engineered or maintained at the outlets from the fish bypasses, given that they will all supposedly be discharging into active channels of dynamic braided rivers systems.

6.67 These deterrents to upstream migrants could be constructed closer to the top of the bypass channels, in a section that is less likely to be damaged by floods. However, if the velocity barrier is located some distance up the bypass, then migrants are likely to still be attracted away from the mainstem, only to find their way blocked by the velocity barrier, essentially creating a migratory dead end.

6.68 One possible answer to this might be to trap upstream migrants where they accumulate below the drop or velocity barrier in the bypass and manually transfer them upstream. However, these fish would still be exposed to a high risk of predation while they wait at the trap to be transferred, and this area would also provide an opportunity for predators to sit in ambush for fish coming downstream through the bypass. Handling of fish during trap and transfer operations would also expose them to additional stress and potential health risks, and delaying upstream migration would leave fish with reduced energy reserves.

Monitoring and adaptation of design

6.69 Whatever design is ultimately adopted, I suggest there will be a need for monitoring of its efficacy, and for this monitoring to be of any value there would need to be an avenue for the design to be adapted to improve its performance, should it prove to be lacking, or at least for some alternative mitigation options to be available. In my opinion the monitoring regime would need to be able to quantify the proportion of fish entering the intake facility that are successfully passed out via the bypass and back into the river.

6.70 Ideally the fish protection objectives developed for the screens would be quantifiable (e.g. to exclude a given proportion of fish in a certain size range, or of a certain species – perhaps as high as 100% exclusion for highly valued species) so that compliance with these objectives could then be measured through monitoring.

6.71 The objective put forward by ACWT (in the evidence of Mr Dunning, Appendix B - Proposed Consent Conditions - Condition 2b), “The fish screen shall as far as practical prevent the entrainment, impingement and entrapment of fish…”, is not quantifiable, unless “prevent the entrainment…” is interpreted to represent a goal of 100% exclusion.

7. CONCLUSION

7.1 There are several potential effects of the proposed scheme, both beneficial and adverse, for which the magnitude and likelihood occurrence can not be adequately assessed on the basis of the information available.

7.2 Construction of culverts associated with streams in the scheme area will have unavoidable temporary impacts on fish passage, and potential adverse effects of released sediment on fish and habitat, although these can be reduced by appropriate timing of construction activities.

7.3 These culverts also have the potential to present a permanent barrier to fish passage, if not designed or constructed correctly.

7.4 The longer culverts, in particular, may also represent a loss of significant habitat. Loss of high value salmon spawning habitat in Hackett’s Creek as a result of a culvert under the scheme intake canal is a recognised negative effect of the scheme. Similar effects on Cabbage Tree Flat Stream have been overlooked by the applicant. It may be possible to avoid or mitigate these effects. However, the applicant has elected to address this issue following consent, which makes it difficult to assess the likely magnitude of post-mitigation effects at this stage.

7.5 Emergency bywash discharges (and possibly large fluctuations in operational discharges) have the potential to cause fish stranding in the Selwyn Catchment. This potential effect would depend on the preceding flow conditions in the affected reaches.

7.6 There is expected to be an increase in baseflow in the Selwyn catchment as a result of irrigation, and soakage to groundwater, including from bywash discharges, under the scheme. This increase in baseflow has the potential to have both positive and negative effects on fish. There may be an increase in the quantity of habitat for trout and some native fish predominately in the lower reaches of the Selwyn catchment due to an increase in flow. However, increased predator access may have a detrimental affect on remnant Canterbury mudfish populations in the effected area, and temporal variation in augmented baseflows have the potential to cause stranding of spawning fish and juveniles, and desiccation of trout eggs, for example.

7.7 The physical and temporal extent of the expected increase in flow in the Selwyn catchment is not clear, and further investigation is required to adequately assess the potential effects. Furthermore, intensified landuse has the potential to cause a reduction in instream habitat quality, which may offset any gain in quantity. Mitigation of this adverse effect relies on the efficacy of sustainable farm management plans, which are currently in draft form and require further detail before their potential efficacy can be adequately assessed.

7.8 The operational bywash soakage wetlands, canals and reservoir all have the potential to provide some habitat for fish, although this is generally likely to be of relatively low quality. However, these potential beneficial effects depend on the design and operation of the scheme components, much of which is still unclear at this stage.

7.9 The fish screens proposed for the intakes are still at the conceptual phase, and consequently it is difficult to assess likely effects. However, there are potentially significant negative effects of inadequate fish screening. In my opinion there a several points related to fish screening that ought to receive more in-depth consideration prior to granting of consents. These include:

a. Definition of appropriate fish protection objectives – taking account of potential fishery and conservation impacts, including the impacts of reduced ecosystem productivity in the downstream reaches.
b. The fate of fish entrained with the intake water, and their potential impacts in their receiving environments.
c. The location and design of the screens and associated fish bypasses.
d. The need for monitoring the efficacy of fish screens and bypasses, and potential to adapt their design, in case of poor performance.

J Hay
May 2008

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APPENDIX

Table 1 Fish recorded from the foothill rivers in the scheme area (i.e. the Selwyn River and tributaries and the Kowai River) based on the New Zealand Freshwater Fisheries Database, with their conservation status, fishery value and migratory life history indicated. (Note: Chinook salmon (*Oncorhynchus tshawytscha*) has not been recorded in the database from any of these rivers, but are known from the Selwyn, Hororata, and Kowai Rivers)

Common name	Scientific name	Selwyn	Hororata	Hawkins	Waianiwaniwa	Water races	Kowai River	Conservation status	Fishery value	Migratory life history
Brown trout	*Salmo trutta*	X & L	X	X		X	X		Sportfish	Diadromous/ Non-diadromous
Brook char	*Salvelinus fontinalis*			X***					Sportfish	Non-diadromous
Longfin eel	*Anguilla dieffenbachii*	X & L	X	X	X	X+	X	Gradual decline	Customary/ recreational/ comercial	Diadromous
Canterbury mudfish	*Neochanna burrowsius*	X*	X		X**	X		Nationally endangered		Non-diadromous
Upland bully	*Gobiomorphus breviceps*	X & L	X	X	X	X	X			Non-diadromous
Canterbury galaxias	*Galaxias vulgaris*	X	X	X	X	X	X			Non-diadromous
Alpine galaxias	*Galaxias paucispondylus*						X			Non-diadromous
Koaro	*Galaxias brevipinnis*						X		Customary/ recreational/ comercial	Diadromous
Common smelt	*Retropinna retropinna*	L							Customary	Diadromous
Giant bully	*Gobiomorphus gobioides*	L								Diadromous
Inanga	*Galaxias maculatus*	L							Customary/ recreational/ comercial	Diadromous
Torrentfish	*Cheimarrichthys fosteri*	L				X+			Customary	Diadromous
Shortfin eel	*Anguilla australis*	L	X		X		X		Customary/ recreational/ comercial	Diadromous
Lamprey	*Geotria australis*	L						Sparse	Customary	Diadromous
Common bully	*Gobiomorphus cotidianus*	L	X				X			Diadromous
Goldfish	*Carassius auratus*		X++							Non-diadromous
Koura	*Paranephrops zealandicus*	L	X			X		Gradual decline	Customary	Non-diadromous

L = below SH1
* Recorded from an unnamed pond in the upper catchment
** Also recorded from Blacks Stream
*** Last recorded 1986
\+ Table 3.6 in KML says longfin and torrentfish also found in water races
\++ Two records from unnamed ponds in the Hororata catchment

Figure 1 Approximate extent of ephemeral and intermittent reaches of the Selwyn River (after Larned et al. 2007).

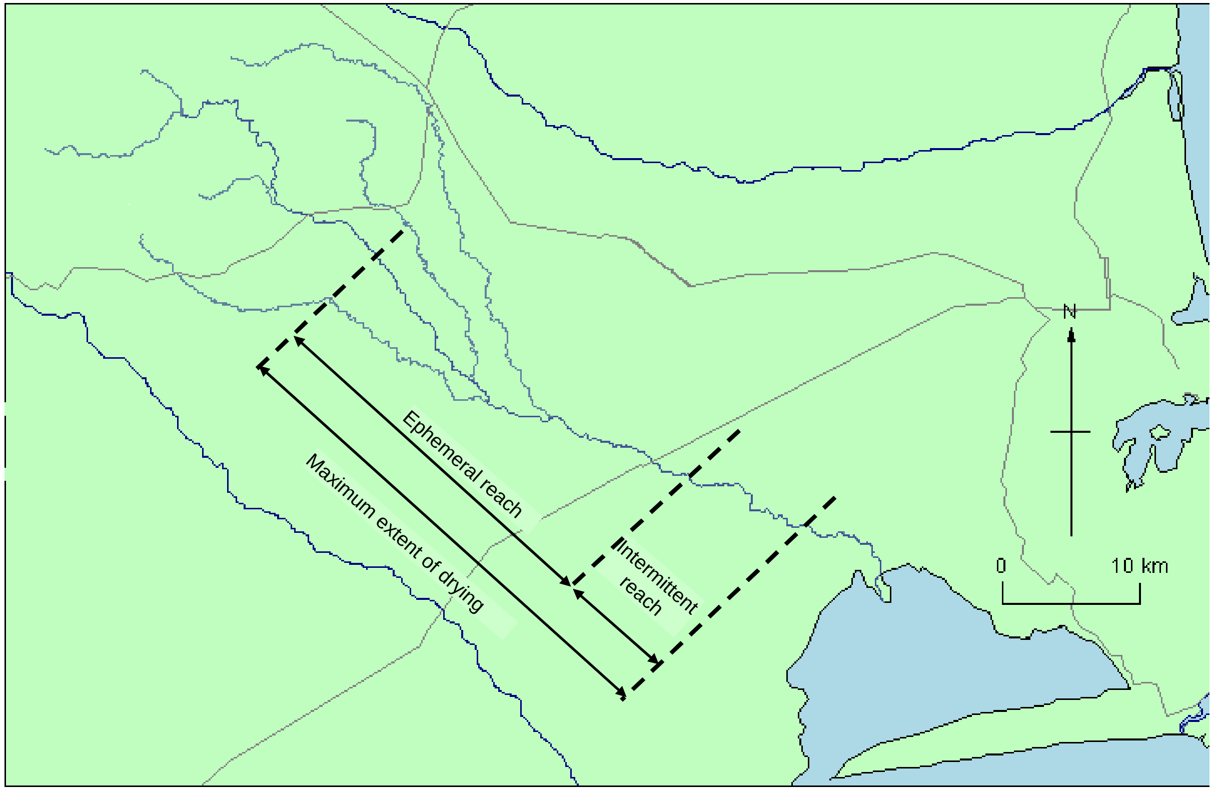

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Figure 2 Salmon spawning streams in the vicinity of the Kowai River confluence with the Waimakariri River, in relation to the proposed intake. The part of Hackett's Creek where most spawning activity is concentrated is marked by the red oval.

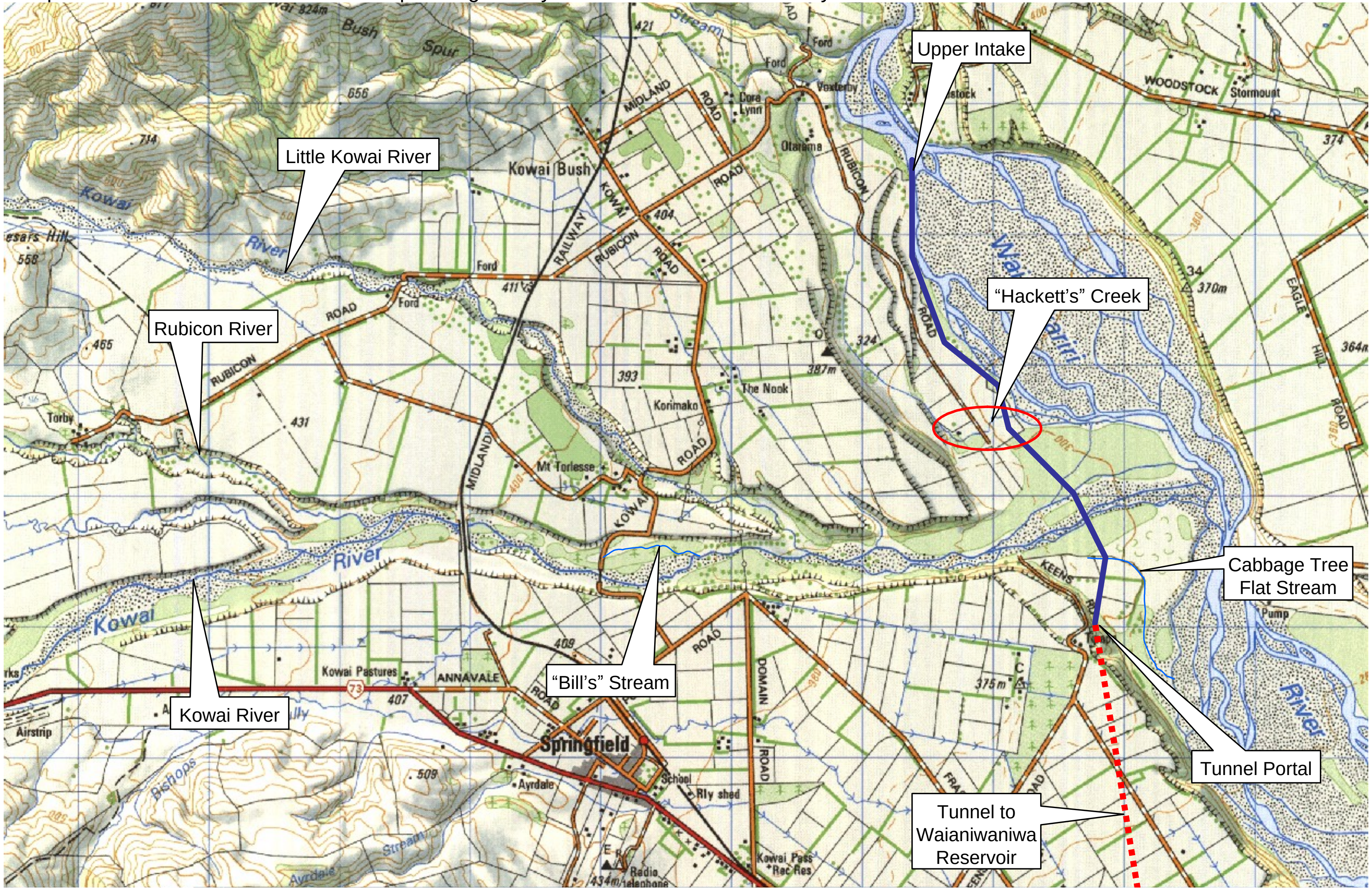


Table 2 Native fish records from the Waimakariri and Rakaia rivers in relation to the proposed intakes, with reference to the fishery value, conservation status and migratory life history of each species.

Common name	Scientific name	Wamakariri	Rakaia	Conservation status	Fishery value	Migratory life history
Shortfin eel	*Anguilla australis*	U & D	U & D		Customary/ recreational/ commercial	Diadromous
Longfin eel	*Anguilla dieffenbachii*	U & D	U & D	Gradual decline	Customary/ recreational/ commercial	Diadromous
Torrentfish	*Cheimarrichthys fosteri*	U+++ & D	U & D		Customary	Diadromous
Koaro	*Galaxias brevipinnis*	U & D**	U & D		Customary/ recreational/ commercial	Diadromous
Alpine galaxias	*Galaxias paucispondylus*	U & D**	U & D			Non-diadromous
Canterbury galaxias	*Galaxias vulgaris*	U & D	U & D**			Non-diadromous
Lamprey	*Geotria australis*	U & D	U & D	Sparse	Customary	Diadromous
Upland bully	*Gobiomorphus breviceps*	U & D	U & D			Non-diadromous
Common bully	*Gobiomorphus cotidianus*	U & D	U*** & D			Diadromous
Bluegill bully	*Gobiomorphus hubbsi*	U* & D	D			Diadromous
Upland longjaw galaxias	*Galaxias prognathus*		U & D	Gradual decline		Non-diadromous
Common smelt	*Retropinna retropinna*	D	U++ & D		Customary	Diadromous
Inanga	*Galaxias maculatus*	D	D		Customary/ recreational/ commercial	Diadromous
Giant bully	*Gobiomorphus gobioides*	D	D			Diadromous
Redfin bully	*Gobiomorphus huttoni*	D	D			Diadromous
Black flounder	*Rhombosolea retiaria*	D	D		Recreational/ commercial	Diadromous
Stokells smelt	*Stokellia anisodon*	D	D	Range restricted	Customary/ commercial (historical)	Diadromous
Canterbury mudfish	*Neochanna burrowsius*	D**		Nationally endangered		Non-diadromous
Yelloweyed mullet	*Aldrichetta forsteri*	D	D		Commercial	Marine/ esturine
Koura	*Paranephrops zealandicus*	D**	U+	Gradual decline	Customary	Non-diadromous

* Furthest upstream record is at the proposed lower intake site
** Not in mainstem downstream of intakes
*** Associated with lakes
\+ Recorded from Lake Gorgina in Rakaia Catchment
++ Recorded from Lake Heron in Rakaia Catchment
+++ Not recorded above upper intake

Figure 3 Recorded distribution of koaro and common bully in the Waimakariri River catchment, with koaro records that are unlikely to be from land locked populations marked.

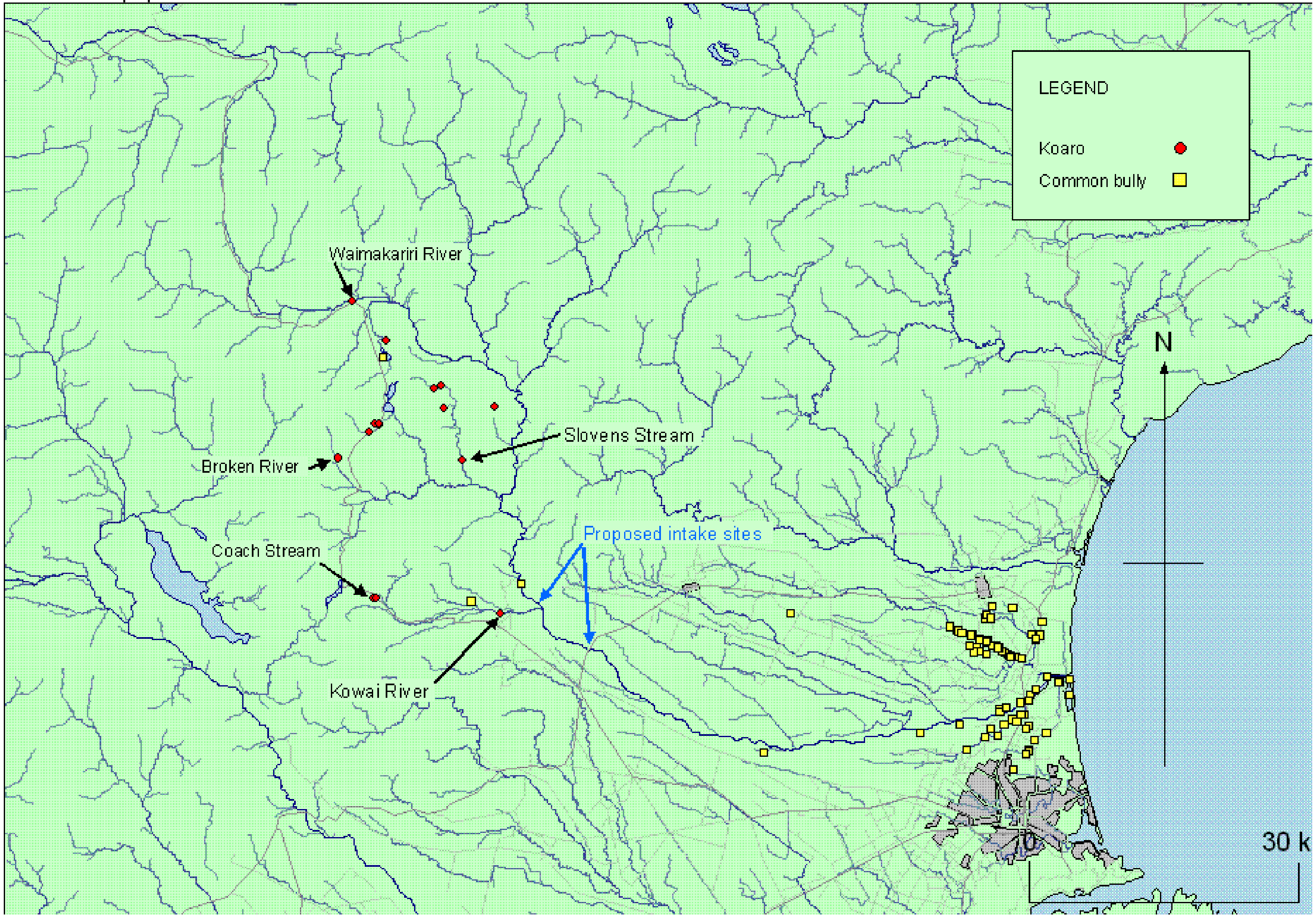
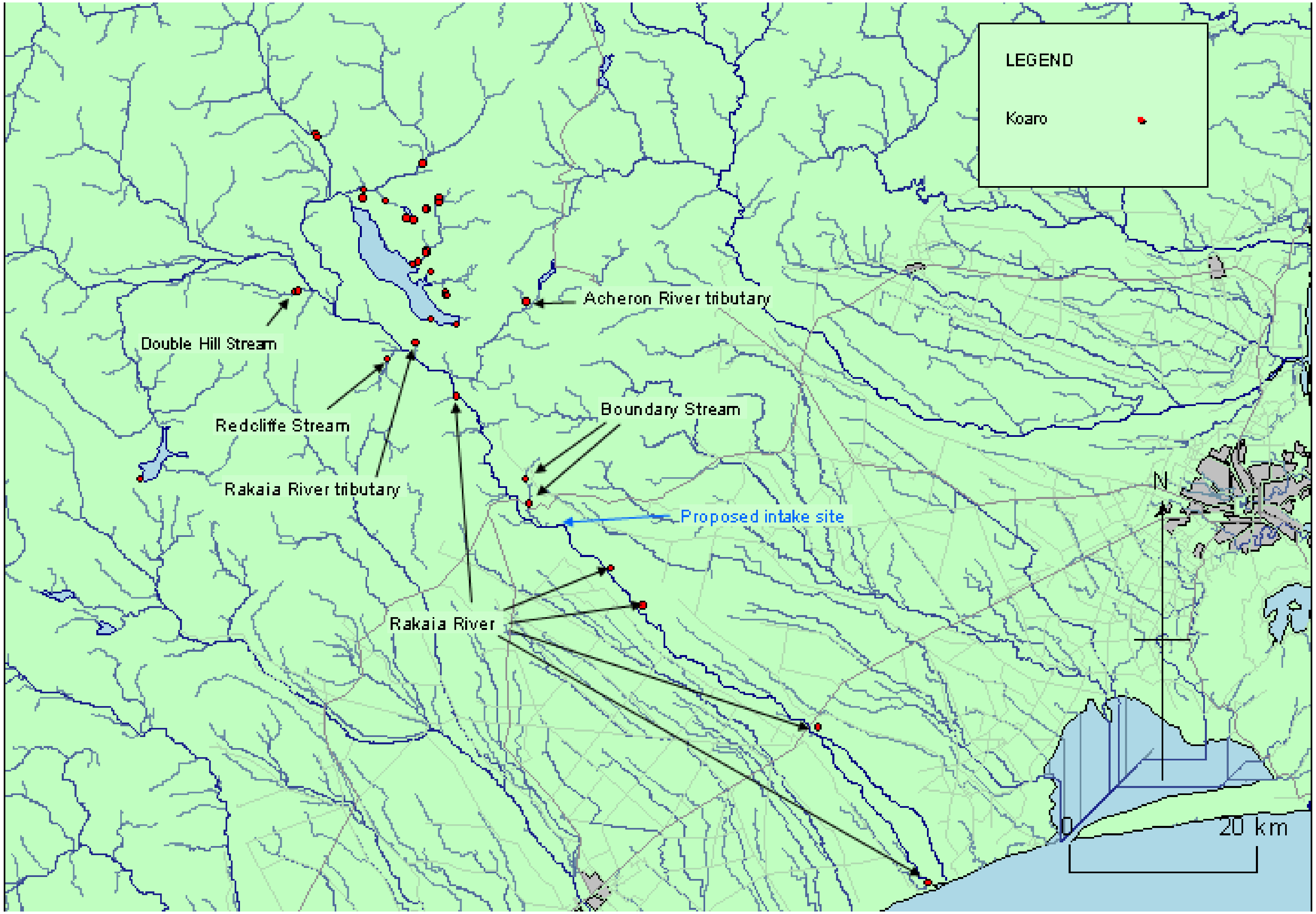


Figure 4 Recorded distribution of koaro in the Rakaia River catchment, with koaro records that are unlikely to be from land locked populations marked.



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