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

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SUPPLEMENTARY EVIDENCE OF RICHARD MARK ALLIBONE

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INTRODUCTION

1. My full name is Richard Mark Allibone. My qualifications and experience, and the basis on which I prepared this brief, are set out in my main brief of evidence prepared for the Central Plains Water Enhancement (CPW) hearing (dated January 2008). I have prepared this supplementary brief of evidence to address matters raised by the commissioners in their minute (dated 6 June 2008) with respect to Canterbury mudfish.

2. This evidence presents additional information regarding:

   - Goals for Canterbury mudfish protection and mitigation;
   - Significant habitat in the Waianiwaniwa valley;
   - The mitigation proposed for the loss of Canterbury mudfish habitat in the Waianiwaniwa valley;
   - Protection of mudfish in other areas of the CPW command area; and
   - Mitigation for effects on Canterbury mudfish.

Goals for Canterbury mudfish within the CPW area

3. CPW have set three management goals for Canterbury mudfish:

   - Provision of new high quality habitat for mudfish in the Waianiwaniwa Valley;
   - Protection and enhancement of the habitat of existing populations in the CPW scheme command area and, in particular, the populations in the Hororata catchment; and
   - No net loss of Canterbury mudfish in the CPW area.

Ecological Significance of the Waianiwaniwa Valley

4. The majority of the existing Canterbury mudfish habitat in the Waianiwaniwa Valley will be flooded by the proposed reservoir. The protection of this existing habitat is not possible if the reservoir is created.

5. The stream habitat to be flooded is significant habitat due to the presence of Canterbury mudfish. The nationally endangered threat status of Canterbury

mudfish and the size of the population are the factors that make this population and its habitat nationally significant.

6. The stream habitat itself, in the absence of the Canterbury mudfish within it, is not significant. The streams are generally in pastoral farmland with stock access and with degraded riparian margins. Stream bank erosion, limited stream shading, nutrient inputs from stock, and low flow water quality issues all contribute to this degradation. The riparian vegetation present is also generally exotic pasture or exotic tree species and has a limited contribution to supporting indigenous fauna.

Waianiwaniwa Valley habitat creation

7. I have reviewed the mitigation options for the loss of Canterbury mudfish habitat in the Waianiwaniwa Valley in conjunction with the scheme engineers and CPW Trust. The mitigation proposed will create a replacement habitat for the Canterbury mudfish which will be displaced from their existing habitat. It has been further developed since my earlier evidence, in order to address concerns raised by submitters and to provide evidence regarding the area of new habitat to be provided by CPWES.

8. The creation of Canterbury mudfish habitat will entail the construction of at least 20 kilometres of artificial waterway above the shoreline of the proposed Waianiwaniwa Valley reservoir.

9. It is proposed to construct multiple stream channels that start adjacent to the two ends of the Waianiwaniwa Dam (Figure 1). Water will be pumped from the Waianiwaniwa reservoir into header ponds situated adjacent to the dam but approximately 40 m above the maximum lake level. Water will be released from these header ponds into the stream channels, which will be constructed around the hillsides. Flow rates from the ponds will mimic natural flows in the Waianiwaniwa Valley up to a maximum rate of 200 l/s.

10. The channels will be constructed around the hill slopes of the reservoir with gradients that are within the natural range of those presently in the Waianiwaniwa River and its tributaries. These stream gradients are estimated (from maps and GIS data) to range from 1 in 60 to 1 in 300. The majority of the natural habitat in the Waianiwaniwa Valley has a gentler gradient (i.e., closer to 1 in 300). The constructed channels will also provide a gentle gradient of

approximately 1: 300 more frequently than the steeper gradients. At this low gradient the channels will extend for around 5.5 km for every twenty metres of fall.

11. The ability to provide good mudfish habitat in constructed habitats can be debated. This is due, in part, to there having been little effort in developing constructed habitats for native fish and especially for mudfish and also due to the failure of some previous translocations attempts for mudfish. However, there are some very positive indicators that a constructed habitat approach will be successful. Canterbury mudfish are often found in drains and stock water races throughout Canterbury and these are artificial habitats. Currently stock water races are managed as water supply routes, but not as fish habitat. These races do, in my opinion, show that artificial or constructed habitats can support Canterbury mudfish and what can be achieved without a deliberate effort to provide good habitat.

12. A constructed channel approach is currently being pursued to provide habitat for Canterbury mudfish in the lower Ashburton Hinds area. I recently viewed the early stages of the development of this project (Figures 2, 3) to see the channel form and riparian planting that had been undertaken. Therefore, the proposed constructed channels in the Waianiwaniwa Valley are not a unique or new approach to Canterbury mudfish management.

13. The constructed channels proposed here would include the following features that have been identified by submitters and me as important for maintaining healthy population densities and individual fish sizes:

    - Run and pool habitat similar to that observed in the Waianiwaniwa Valley;
    - Protection from invasive predators; and
    - A mix of stream gradients that match those observed in the Waianiwaniwa Valley.

14. An additional range of attributes would be provided in the created channels that will improve the quality of the water and habitat compared with the current Waianiwaniwa valley populations:

    - Permanent water;

- Indigenous riparian planting to provide an appropriate mix of shaded and open water, as well as providing additional biodiversity benefits;
- Instream macrophytes to provide appropriate spawning habitat for Canterbury mudfish; and
- Fencing to provide protection from stock, thereby reducing nutrient inflows, bank erosion and suspended sediment impacts.

15. In my opinion the outcome of this habitat creation will be the provision of habitat of approximately the same area as that flooded to provide for the significant component of the Waianiwaniwa Valley, being Canterbury mudfish. This new habitat will provide the additional benefits of increased protection from landuse impacts, drought, invasive fish species, and further biodiversity benefits from indigenous plantings. It is also my experience that the successful habitat creation or restoration is dependent on the commitment of the operators when undertaking the planting, fencing and long term management.

Management and Protection of the new Canterbury mudfish habitat in Waianiwaniwa Valley

16. The proposed constructed channels will incorporate a series of features that are designed to provide stable long term habitat for Canterbury mudfish. These features address the security of water supply, riparian management and predator control.

17. The water intakes that will supply the constructed channels in the Waianiwaniwa Reservoir will be situated along the dam face at a level that will always be submerged regardless of the reservoir level. This will allow water to be supplied to the constructed streams at all times.

18. The intakes will be suspended in the water column rather than being on the lake bed, to ensure water taken is well oxygenated. The intake will be screened to prevent the intake of larger fish, such as trout, that might inhabit the lake at some stage.

19. The pumped water will be released into header ponds that will in turn feed the constructed channel. The outlets from the header ponds will also be screened with a fine mesh to prevent small fish that may have entered the pump at the lake intakes from entering the constructed channel habitat.

20. The channels will flow back into the Waianiwaniwa Reservoir through two perched culverts at the end of each channel. Perched culverts are a well recognised fish passage barrier to all fish species whether they are climbing fish or jumping/swimming species.

21. In his statement of evidence, Associate Professor McIntosh states that the exclusion of eels and koaro from the valley will be difficult (section 4.4). In conjunction with the Department of Conservation I have experimented with koaro barriers for some years now, including the use of perched culverts. In my experience, the provision of two consecutive barriers will provide sufficient security to prevent fish passage, as it allows for the failure of the lower barrier. This method has been used to exclude eels, koaro and trout from upstream areas in a water race in Otago (Figure 4, Golder Associates in prep). It is also important to note that one of the two driving reasons Dr Robert McDowall and I promoted longfin eel on to the threatened species list was the loss of fish passage around New Zealand due to the presence of dams and culverts (the second reason was commercial overfishing driving significant population declines). Thus, it is my opinion that it is feasible to exclude unwanted fish species from entering the mudfish habitat created in the Waianiwaniwa Valley.

22. As I have already mentioned, the constructed waterways will be fenced to prevent stock assess, which will help protect water quality and protect riparian vegetation from being grazed.

23. Within each stream, control gates will be put in place that will include fish screens and water tight gates. The control gates will be able to be lowered into the race at appropriate intervals as a contingency to allow management of the stream habitat. Under normal operating conditions the fish screen and water tight gates would always be open. The gates will, however, allow sections of the stream habitat to be isolated from other sections of the stream for management purposes. Management action that may be undertaken in sections, while considered very unlikely, is the removal of invading trout, eels or other unwanted species. By isolating sections of the waterway with control gates, unwanted fish will be removed from the targeted sections, whilst restricting unwanted fish movement into other sections. Control gates would also allow for repair work to be undertaken on the banks or other structures, and would prevent the full waterway dewatering.

Will protection be achieved?

24. The creation of mudfish habitat on this scale has not been previously attempted and as noted in my evidence in chief translocation projects to existing habitats have not enjoyed as much success as hoped. Therefore it is important to explain why this habitat creation proposal has merit and why and when I would expect it to succeed.

25. As noted above and in evidence presented by others in this hearing (e.g., S. Charteris, Department of Conservation, paragraph 4.4), Canterbury mudfish are know to exist in stock water races and channelised drains in Canterbury. These populations have established themselves in artificial habitats without that habitat being specifically designed to support mudfish or necessarily managed in a manner that promotes large fish populations. Despite this, mudfish persist in these habitats. This demonstrates that relatively poorly managed, artificial habitats are capable of supporting Canterbury mudfish.

26. Fisheries surveys in other parts of New Zealand, and in my personal experience in Otago, have located other threatened native fish species in water races. Threatened galaxiids, close relatives to the mudfish, are found in water races that were established in the gold mining era in the late 1800s and continue to carry water in the present day. Two such water races have been the subject of studies I have undertaken: Shepherd Stream and Totara Creek.

27. Shepherd Stream water race (Figure 5) in the Waipori Catchment supplies water to Lake Mahinerangi, a hydro-electric reservoir. The 3.5 km water race provides habitat for brown trout, koaro (a native fish) and Eldon’s galaxias (a threatened native fish). In 2001, when I worked for the Department of Conservation, we commenced a removal operation to eliminate brown trout and koaro from the water race to provide competition and predator-free habitat for Eldon’s galaxias. The removal operation was not successful but the initial removal operation over four days in March 2001 removed over 650 brown trout (Figure 6) and located approximately 30 Eldon’s galaxias in the water race. The water race is not managed as fish habitat and as such provided less than ideal habitat but still supported a large population of fish.

28. The Totara Creek water race takes water from Totara Creek and conveys water for approximately 10 km before discharging into the Pool Burn catchment. The abstraction is, intermittent and generally shutdown over the summer months.

Despite large sections of the water race drying each year, remnant pools (Figure 7) provide refuge habitat and galaxiids permanently occupy the race. The refuge pools in the race provide poor habitat and were generally overcrowded during periods with no flow. Therefore fish growth and survival is limited. Despite this, the fish can successfully spawn when water is present in spring and fish captured in the race include the largest individual galaxiid found in the Totara Creek catchment (160 mm long). Growth rates for galaxiids in Totara Creek have been assessed and larger fish over 100 mm grow less than 5 mm a year. If the 160 mm has resided in the race for most of it life then it has survived in relatively hostile conditions for between one and two decades.

29. These two water race systems in Otago demonstrate that native galaxiids and salmonids can utilise artificial water courses as habitat and populations can persist long term in these races. These studies coupled with the knowledge of Canterbury mudfish in stock water races leads me to conclude that the proposed artificial water courses at Waianiwaniwa Valley will provide habitat for mudfish. Therefore the potential for the artificial waterway to support large mudfish populations is a concern to address rather than can the water way support mudfish at all.

30. The fish screens and fish passage barriers at either end of the constructed channels, will in my opinion, provide a high degree of protection for the mudfish from predatory fish. This protection is likely to be more reliable for the exclusion of eels from the mudfish habitat than the current restriction on migration due to low or no flow in the lower Waianiwaniwa River. This is because the barriers will maintain exclusion even during high flow events. Environment Canterbury (ECan) flow data (Table 1) does show flood events occur in the Waianiwaniwa Valley and at these times the exclusion of eels cannot be guaranteed under existing conditions.

31. The flow data provided by ECan also highlights an important flow characteristic of the Waianiwaniwa River in the Valley. In most summer periods when flow monitoring has been undertaken periods of almost no flow or no flow have been recorded. The geographic extent of the no flow areas is not known but these flow measurements do indicate that the Waianiwaniwa River and some tributary sections do not provide perennial flows, as suggested by Associate Professor McIntosh (e.g., Sections 2.8, 2.10 of his evidence).

32. The constructed channels will also be supplied with water from the reservoir, and as such the very low or no flow periods that occur naturally in the Waianiwaniwa River (ECan data) and its tributaries can be avoided, or at least controlled. Flow measurements at a number of sites in the Waianiwaniwa Valley indicate very low flow or no flow in summer. These low flows certainly preclude brown trout and probably Canterbury galaxias from occupying mudfish areas, but as noted low flows or no flows do impact on mudfish by reducing habitat, water quality and during dry events requiring the fish to aestivate (with its associated mortality). The constructed channels can provide year round flow, and the water volume can be managed to provide flow variation if required for mudfish population management.

33. As noted previously the constructed channels will be fenced and stock excluded from the water. This provides a further improvement to the habitat being provided when compared with the current habitat.

34. Finally, the managed nature of the waterways will allow for flows to be managed adaptively, to the best advantage of the mudfish populations present. With the construction of two or three separate water courses, water supply regimes can be modified, if required, to better provide for Canterbury mudfish. For example, if waterway monitoring reveals that water velocities are too swift, then the rate of discharge into one or all of the waterways can be reduced.

35. In summary, it is my opinion that the approximately 20 km of constructed waterways will provide habitat of at least equal quality to that already present in the valley, but with the additional benefits of better water quality, better control over flows, and protection from predators. This will provide for and protect a large Canterbury mudfish population in the Waianiwaniwa Valley.

36. The time taken to develop a large population of mudfish in the constructed water way will depend on a number of factors. The initial population introduced into the water way will be important; the initial habitat quality as aquatic fauna establishes; and the time taken for the riparian planting programme take effect. The introduction of a desired suite of aquatic plants, prey species and instream cover material in the first few months after construction and water beginning to flow will establish the initial conditions to support mudfish. I would not expect to observe a population of mudfish with a large size range that are widespread in the water way for some ten years after the initial seeding of the water way with

adult and larval mudfish. This time period is required as individual mudfish grow to attain a large size from the larvae introduced and the smaller number of adults introduced. The speed at which a large population could be achieved may be improved is large numbers of mudfish are transferred from the existing population to the constructed water way.

Dispersal of Canterbury mudfish

37. The constructed waterways in the Waianiwaniwa Valley will not provide for dispersal of the Waianiwaniwa Valley mudfish downstream to the Hororata Catchment. As noted in my evidence in chief, genetic studies (Davey et al 2001, 2003) to date do not support the notion that mudfish currently disperse from the Waianiwaniwa Valley to the populations in the Hororata area. The Hororata population sampled in the Davey et al (2001) study had a haplotype (genetic marker) that was distinct from the two haplotypes found at Auchenflower Road in the Waianiwaniwa Valley (Table 2). If mudfish were dispersing downstream to the Hororata the haplotypes present in the Waianiwaniwa population should be present in the Hororata population.

38. The distribution of mudfish in the Hororata River area also indicates that a dispersal link between the Waianiwaniwa Valley and the Hororata is limited. The confluence of the two rivers occurs downstream of all but two known population of mudfish in the Hororata River (Kingett Mitchell 2006 Figure 3.7).

39. Notwithstanding these facts, if future research does indicate that downstream mudfish dispersal has occurred, or if other parties wish to see larval mudfish dispersed from the Waianiwaniwa population, human assisted transfer can be undertaken.

40. Dispersal within the Hororata River area will however be maintained as none of the proposed activities will preclude mudfish larvae dispersing during flood events as desired.

Hororata Protection and Mitigation

41. Protection of Canterbury mudfish in the Hororata area is proposed. This will be required as a condition of the contract to supply water to water shareholders and will be monitored under the biodiversity and ecosystem management section of the Farm Management Plans that water users must complete and comply with. This will entail the fencing of wetlands and streams to protect

habitat from the impacts of stock, bank erosion and to filter contaminants from surface runoff. This is expected to lead to an improvement in habitat from the current state where stock assess is possible at many sites. This will in turn lead to improved habitat and consequently to more abundant or better quality mudfish populations

42. The trout and eel monitoring at Hororata sites is a monitoring and protection activity to ensure these mudfish populations are not adversely affected by increases to groundwater levels that allow these predators to invade mudfish habitat. Any predator removal work undertaken at these mudfish population sites would also be part of a protection programme for the existing Hororata populations.

43. Riparian planting should also be considered a habitat improvement process (rather than protection) for mudfish and for indigenous biodiversity in general, but is also required as a weed management technique; otherwise fenced areas will grow weed species such as gorse and broom.

44. Creation of additional habitat in the Hororata area may be required to offset any habitat loss in Hororata River from invasion from eels and trout (Sections 47-52) if removal and management is not successful.

45. Long-term protection of mudfish habitat could be by securing covenants on both the created Waianiwaniwa habitat and the Hororata habitat on CPW shareholder land. For the Hororata area CPW will encouraged and support landowners that undertake to covenant mudfish habitat.

Invasion of Hororata Canterbury mudfish habitat by eels and trout

46. The groundwater modeling undertaken by Aqualinc shows that groundwater levels will rise in the Selwyn catchment and flow permanence will increase at some sites.

47. In his evidence in chief Mr Julian Weir presents a number of key conditions with respect to the groundwater level rises. His evidence (paragraph 135, 138) indicates that the expected peak ground water levels will be in late winter and early spring. Invasion of mudfish habitat is most likely during the highest ground water periods as surface flows are most likely to be present at these times.

48. Eels and brown trout both undertake migrations up and downstream during their life cycles. Elvers (juvenile eels) migrate upstream during the summer and early autumn. Annual migrations inland from the sea begin in spring and upstream migration in freshwater is triggered by rising water temperatures in late spring. The peak migration period is mid to late summer. This migration period for elvers is essentially six months out of step with the predicted peak groundwater levels. In my opinion, this substantially reduces the potential for elvers to move into isolated Canterbury mudfish habitat.

49. Adult brown trout migrate upstream for spawning in late autumn, which again is not the period of highest groundwater increase. The migrant trout are also searching for spawning habitat and generally return when possible to natal streams. Therefore, behavioural cues will lead the majority of trout to established spawning areas. Some straying is always likely, but unless the mudfish habitat is also good spawning habitat for trout the areas of mudfish habitat will not be attractive to trout.

50. Juvenile trout will disperse downstream after hatching in mid-spring. The majority of these fish will be moving downstream seeking progressively deeper water adult habitat during the spring and summer period. Preferred habitat changes as they grow, with increasing water depth and water velocity being preferred (Figures 8-10). Wetland areas and shallow, low flow streams will be utilised by trout, but will be less preferred than deeper, swifter areas. Therefore areas of mudfish habitat become increasingly less preferred as trout grow.

51. Local resident fish, both eels and trout, will at times search for new habitat. However, while the Selwyn River is expected to have surface flow more frequently, it is still expected to remain an intermittent waterway. This will force eels and trout either upstream or downstream in the Selwyn River (or perish) to find permanent water.

52. The monitoring of at-risk mudfish habitat in the Hororata area has been proposed, to detect invasion events by trout and eels. Removal operations are proposed to manage these invasions. If the frequency of invasion is high then mudfish habitat would be lost and the creation of additional habitat in the Hororata, as proposed, would maintain the goal of no net loss of mudfish.

53. Removal operations for trout and eels are not easy and in my experience require careful planning. I have led a trout removal project in Otago for four

years and assisted in the design of a trout exclusion project for the Department of Conservation. Commercial eel fishing is highly effective at catching large eels (and one of the reasons longfin eels are a threatened species). Using commercial fishermen that catch eels for a living to remove populations of large eels in the Hororata area would be utilizing people who have had many years experience catching eels in a declining fishery, and is therefore likely to be a successful strategy. It is also important to note that eels become piscivorous at a length of 30 - 40 cm (an age of 10-20 years). Detection of eels using gee minnow traps can occur at sizes much smaller than this (10 cm) and removals can be started upon first detection and eels removed before they reach a piscivorous size.

54. The ability of CPWES to ensure the protection and monitoring activities are undertaken in the Hororata area is dependent on the ability of CPWES to work with landowners who have mudfish on their properties. Currently CPWES shareholders own by far the majority of land known to have mudfish populations resident in this area (New Zealand Freshwater Fish Database records, March 2008, Figure 11). This will provide CPWES a direct link to the landowners and the ability to implement the proposed protection and monitoring work over a significant number of known sites of mudfish habitat. Where such protection cannot actively be pursued because the sites are not owned by shareholders, it remains the case that only the raised groundwater levels from CPWES activities can affect these populations and their location at the extreme upslope limit of CPWES area will mean that the effects should be limited or absent.

55. In conclusion CPWES has a direct relationship to the majority of mudfish property owners and can require (through the terms of shareholder and supply agreements) that protection and mitigation be achieved. This will include protection by fencing to exclude stock impacts; general habitat improvement including riparian planting; monitoring and removal of predators as proposed and additional habitat created to guarantee the goal of no net loss.

Additional mitigation

56. The mudfish rearing facility (described in my evidence in chief) is proposed as both a mitigation option and as a management tool for protection of mudfish and other native fish populations. In my experience, a facility designed

specifically to hold small threatened native fish is lacking in New Zealand and this proposal would provide significant opportunities for native fish management. This is an additional benefit provided by CPW.

Conclusion

52. The Waianiwaniwa Valley population is nationally significant.

53. The creation of approximately 20 km of constructed channel habitat with regulated flows, fencing and indigenous plantings and fish passage barriers will serve to provide for a large, healthy and therefore significant mudfish population to be retained in the Waianiwaniwa Valley. With a long term commitment to management the habitat provided in the constructed channels will match or exceed the quality of the current Waianiwaniwa Valley habitat, it can be expected that the mudfish population will also match or exceed the current population. I therefore consider that the significance of the habitat of Canterbury mudfish within the valley will be protected, noting that its significance relates solely to the fact this endangered species is present there.

54. The Hororata River populations will gain additional protection from stock and riparian habitat enhancement. Monitoring of predatory fish will allow for predators to be detected and cue predator removal operations. In the event of the failure to achieve exclusion of predators, the additional habitat created seeks to achieve the goal of no net loss of mudfish. Therefore, the Hororata populations and their habitat on CPW shareholder land will be protected and enhanced.

55. It is therefore my opinion that if the proposed protection, management and mitigation programme is implemented this will ensure that the significant populations of Canterbury mudfish will be retained and protected in the Hororata area and Waianiwaniwa Valley.

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Table 1. Waianiwaniwa River flows (data supplied by Environment Canterbury)

Site Name	Map Reference	Date	Flow (m³/s)	Visual Observation
Auchenflower Road	L35:2792-5201	27-Mar-80	**0.086**	
Auchenflower Road	L35:2792-5201	24-Apr-80	**0.131**	
Auchenflower Road	L35:2792-5201	28-Oct-80	**0.038**	
Auchenflower Road	L35:2792-5201	4-Mar-81	**0.002**	
Auchenflower Road	L35:2792-5201	5-May-81	**0.021**	
Auchenflower Road	L35:2792-5201	13-Oct-82	**0.094**	
Auchenflower Road	L35:2792-5201	27-Mar-85	**0.005**	
Bealeys Rd Bridge	L36:34484-39525	14-Sep-06		**Flowing**
Bealeys Rd Bridge	L36:34484-39525	18-Oct-06		**Dry**
Bealeys Rd Bridge	L36:34484-39525	15-Nov-06		**Dry**
Bealeys Rd Bridge	L36:34484-39525	15-Dec-06		**Dry**
Bealeys Rd Bridge	L36:34484-39525	19-Jan-07		**Dry**
Bealeys Rd Bridge	L36:34484-39525	17-Apr-07		**Dry**
Bealeys Rd Bridge	L36:34484-39525	17-May-07		**Dry**
Bealeys Rd Bridge	L36:34484-39525	12-Jun-07		**Dry**
Bealeys Rd Bridge	L36:34484-39525	18-Jul-07		**Dry**
Bealeys Rd Bridge	L36:34484-39525	15-Aug-07		**Dry**
Bealeys Rd Bridge	L36:34484-39525	14-Sep-07		**Dry**
Bealeys Rd Bridge	L36:34484-39525	17-Oct-07		**Ponding**
Bealeys Rd Bridge	L36:34484-39525	15-Nov-07		**Dry**
Bealeys Rd Bridge	L36:34484-39525	13-Dec-07		**Dry**
Bealeys Rd Bridge	L36:34484-39525	17-Jan-08		**Dry**
Bealeys Rd Bridge	L36:34484-39525	14-Feb-08		**Dry**
Bealeys Rd Bridge	L36:34484-39525	12-Mar-08		**Dry**
Bealeys Rd Bridge	L36:34484-39525	15-May-08		**Dry**
Bealeys Rd Bridge	L36:34484-39525	12-Jun-08		**Dry**
Coaltrack Road	L36:35165-35755	16-Oct-07		**Dry**
Downstream Bush Gully Stream Confl	L35:2686-5061	10-Jun-04	**0.062**	
Downstream Bush Gully Stream Confl	L35:2686-5061	4-Aug-04	**0.216**	
Downstream Bush Gully Stream Confl	L35:2686-5061	28-Oct-04	**0.078**	
Downstream Bush Gully Stream Confl	L35:2686-5061	13-Jan-05	**0.104**	
Downstream Bush Gully Stream Confl	L35:2686-5061	24-Feb-05		**Ponding**
Downstream Bush Gully Stream Confl	L35:2686-5061	11-May-05	**0.071**	
Downstream Bush Gully Stream Confl	L35:2686-5061	29-Jun-05	**0.042**	
Downstream Bush Gully Stream Confl	L35:2686-5061	25-Aug-05	**0.035**	
Downstream Bush Gully Stream Confl	L35:2686-5061	20-Oct-05	**0.093**	
Downstream Bush Gully Stream Confl	L35:2686-5061	1-Dec-05	**0.034**	
Downstream Bush Gully Stream Confl	L35:2686-5061	21-Feb-06		**Estimate 3 l/s**
Downstream Bush Gully	L35:2686-5061	28-Apr-06	**0.110**	

Stream Confl				
Downstream Bush Gully Stream Confl	L35:2686-5061	14-Jul-06	**0.280**	
Downstream Bush Gully Stream Confl	L35:2686-5061	14-Sep-06	**0.057**	
Downstream Bush Gully Stream Confl	L35:2686-5061	24-Nov-06	**0.165**	
Downstream Bush Gully Stream Confl	L35:2686-5061	24-Jan-07	**0.057**	
Downstream Bush Gully Stream Confl	L35:2686-5061	28-Mar-07		**Estimate 1 l/s**
Downstream Bush Gully Stream Confl	L35:2686-5061	31-May-07	**0.018**	
Downstream Bush Gully Stream Confl	L35:2686-5061	10-Aug-07	**0.234**	
Downstream Bush Gully Stream Confl	L35:2686-5061	24-Oct-07	**0.097**	
Downstream Bush Gully Stream Confl	L35:2686-5061	10-Jan-08	**0.000**	**Dry**
Downstream Bush Gully Stream Confl	L35:2686-5061	19-Mar-08	**0.009**	
Downstream Bush Gully Stream Confl	L35:2686-5061	5-Jun-08	**0.090**	
Essendon Road	L35:33981-40227	16-Oct-07		**Ponding**
Homebush Road Bridge	L35:2937-4725	23-Sep-03	**0.330**	
Homebush Road Bridge	L35:2937-4725	18-Nov-03	**0.000**	**Dry**
Homebush Road Bridge	L35:2937-4725	4-Feb-04	**0.000**	**Dry**
Homebush Road Bridge	L35:2937-4725	14-Apr-04	**0.000**	**No Flow**
Homebush Road Bridge	L35:2937-4725	10-Jun-04	**0.000**	**Dry**
Homebush Road Bridge	L35:2937-4725	4-Aug-04	**0.191**	
Homebush Road Bridge	L35:2937-4725	28-Oct-04	**0.015**	
Homebush Road Bridge	L35:2937-4725	13-Jan-05	**0.032**	
Homebush Road Bridge	L35:2937-4725	24-Feb-05	**0.000**	**Dry**
Homebush Road Bridge	L35:2937-4725	11-May-05	**0.000**	**Dry**
Homebush Road Bridge	L35:2937-4725	29-Jun-05		**Estimate 0 l/s**
Homebush Road Bridge	L35:2937-4725	25-Aug-05		**Estimate 0 l/s**
Homebush Road Bridge	L35:2937-4725	20-Oct-05	**0.013**	
Homebush Road Bridge	L35:2937-4725	1-Dec-05	**0.000**	**Dry**
Homebush Road Bridge	L35:2937-4725	21-Feb-06	**0.000**	**Dry**
Homebush Road Bridge	L35:2937-4725	28-Apr-06	**0.006**	
Homebush Road Bridge	L35:2937-4725	14-Jul-06	**0.266**	
Homebush Road Bridge	L35:2937-4725	14-Sep-06	**0.022**	
Homebush Road Bridge	L35:2937-4725	24-Nov-06	**0.091**	
Homebush Road Bridge	L35:2937-4725	29-Jan-07	**0.000**	**Dry**
Homebush Road Bridge	L35:2937-4725	28-Mar-07	**0.000**	**Dry**
Homebush Road Bridge	L35:2937-4725	31-May-07	**0.000**	**Dry**
Homebush Road Bridge	L35:2937-4725	10-Aug-07	**0.192**	
Homebush Road Bridge	L35:2937-4725	24-Oct-07	**0.085**	
Homebush Road Bridge	L35:2937-4725	10-Jan-08	**0.000**	**Dry**
Homebush Road Bridge	L35:2937-4725	19-Mar-08	**0.000**	**Dry**
Homebush Road Bridge	L35:2937-4725	5-Jun-08	**0.009**	
Homebush Station Road	L35:287-475	24-Apr-80	**0.078**	
Homebush Station Road	L35:287-475	12-Oct-82	**0.114**	
Malvern Hills Road	L35:2759-5344	3-Sep-74	**3.196**	

Malvern Hills Road	L35:2759-5344	9-Sep-74	**2.198**	
Malvern Hills Road	L35:2759-5344	10-Sep-74	**0.358**	
Malvern Hills Road	L35:2759-5344	12-Sep-74	**0.270**	
Malvern Hills Road	L35:2759-5344	25-Sep-74	**0.078**	
Malvern Hills Road	L35:2759-5344	1-Oct-74	**0.502**	
Malvern Hills Road	L35:2759-5344	10-Oct-74	**5.762**	
Malvern Hills Road	L35:2759-5344	14-Oct-74	**0.492**	
Malvern Hills Road	L35:2759-5344	5-Nov-74	**0.121**	
Malvern Hills Road	L35:2759-5344	5-Feb-75	**0.155**	
Malvern Hills Road	L35:2759-5344	7-Mar-75	**0.243**	
Malvern Hills Road	L35:2759-5344	4-Apr-75	**0.051**	
Malvern Hills Road	L35:2759-5344	17-Jun-75	**1.689**	
Malvern Hills Road	L35:2759-5344	17-Jul-75	**0.203**	
Malvern Hills Road	L35:2759-5344	8-Aug-75	**0.458**	
Malvern Hills Road	L35:2759-5344	1-Oct-75	**0.123**	
Malvern Hills Road	L35:2759-5344	5-Nov-75	**0.246**	
Malvern Hills Road	L35:2759-5344	23-Sep-03	**0.242**	
Malvern Hills Road	L35:2759-5344	18-Nov-03	**0.056**	
Malvern Hills Road	L35:2759-5344	4-Feb-04		**Estimate 1l/s**
Malvern Hills Road	L35:2759-5344	14-Apr-04	**0.072**	
Malvern Hills Road	L35:2759-5344	10-Jun-04	**0.041**	
Malvern Hills Road	L35:2759-5344	4-Aug-04	**0.176**	
Malvern Hills Road	L35:2759-5344	28-Oct-04	**0.082**	
Malvern Hills Road	L35:2759-5344	13-Jan-05	**0.082**	
Malvern Hills Road	L35:2759-5344	24-Feb-05		**Estimate 2 l/s**
Malvern Hills Road	L35:2759-5344	11-May-05	**0.057**	
Malvern Hills Road	L35:2759-5344	29-Jun-05	**0.029**	
Malvern Hills Road	L35:2759-5344	25-Aug-05	**0.026**	
Malvern Hills Road	L35:2759-5344	20-Oct-05	**0.062**	
Malvern Hills Road	L35:2759-5344	1-Dec-05	**0.027**	
Malvern Hills Road	L35:2759-5344	21-Feb-06	**0.006**	
Malvern Hills Road	L35:2759-5344	28-Apr-06	**0.074**	
Malvern Hills Road	L35:2759-5344	14-Jul-06	**0.182**	
Malvern Hills Road	L35:2759-5344	14-Sep-06	**0.044**	
Malvern Hills Road	L35:2759-5344	24-Nov-06	**0.144**	
Malvern Hills Road	L35:2759-5344	24-Jan-07	**0.049**	
Malvern Hills Road	L35:2759-5344	28-Mar-07	**0.005**	
Malvern Hills Road	L35:2759-5344	31-May-07	**0.018**	
Malvern Hills Road	L35:2759-5344	10-Aug-07	**0.168**	
Malvern Hills Road	L35:2759-5344	24-Oct-07	**0.094**	
Malvern Hills Road	L35:2759-5344	10-Jan-08		**Estimate 0.25 l/s**
Malvern Hills Road	L35:2759-5344	19-Mar-08	**0.013**	
Malvern Hills Road	L35:2759-5344	5-Jun-08	**0.068**	
McLaughlins Road	L35:32525-41795	16-Oct-07		**Low Flow**

Table 2. Collection locations and haplotypes present at each location for Canterbury mudfish (Data from Davey et al 2001).

Population	**NZMS 260 reference**	**Haplotypes Code**	**Haplotype percentage**
View Hill	L35 350684	1	100%
Hororata	L36 243573	2	58.3%
		3	41.7%
Lake Eldon (translocated pop.)	M35 782418	1	77.7%
		2	22.3%
Auchenflower	L35 278510	4	44.4%
		5	55.6%
Saint Andrews	J39 668311	6	90.0%
		7	10.0%
Tepuna Pond	J40 584153	8	100.0%
Dog Kennel Stream	J40 539929	8	100.0%

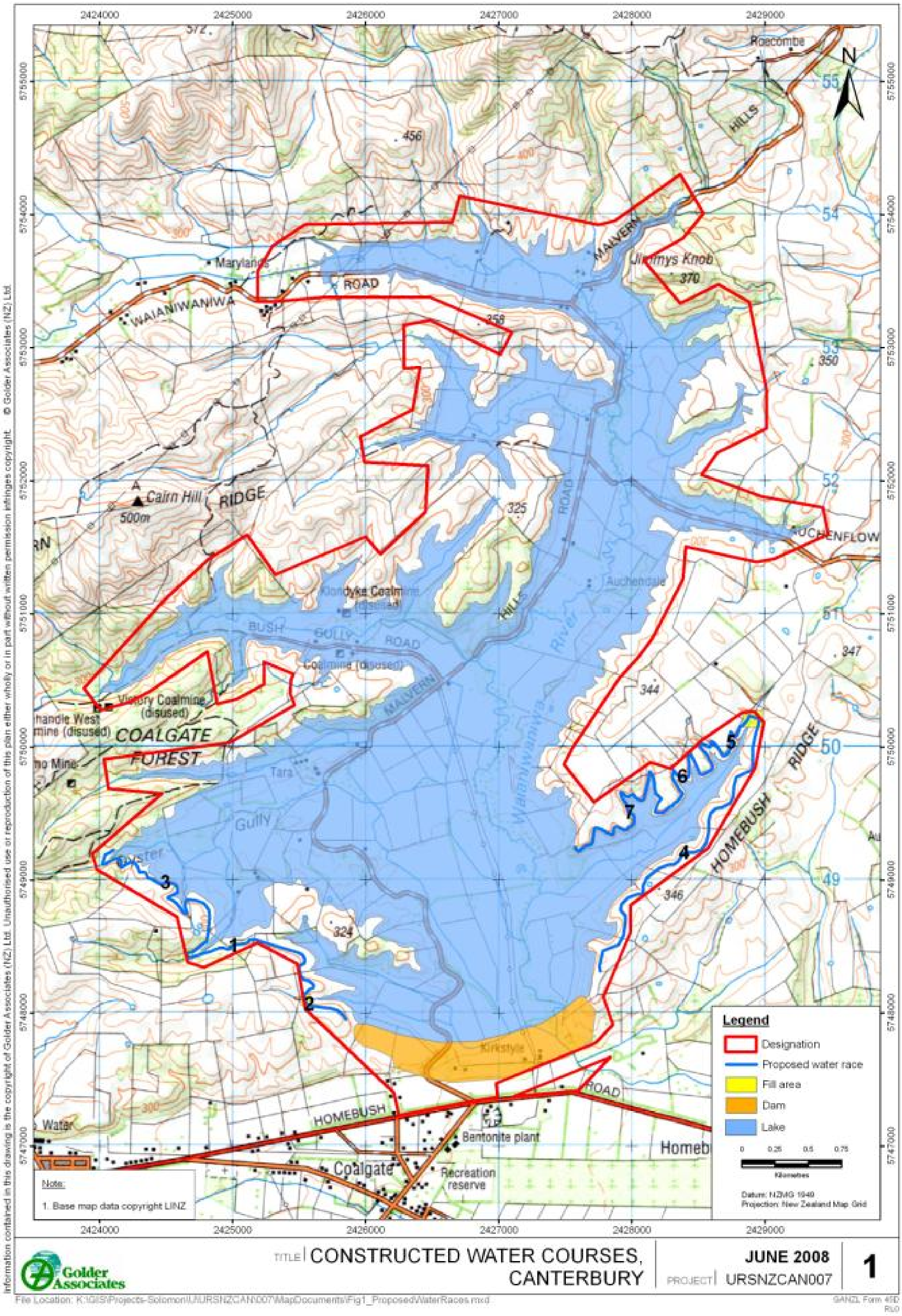

Figure 1. The approximate location of the constructed channels flowing from the Waianiwaniwa Dam around the reservoir.

Figure 2. A constructed channel for Canterbury mudfish

Figure 3. Riparian plantings along side the constructed Canterbury mudfish channel

Figure 4. A retro-fitted free fall drop on the Shepherd Stream water race culvert to prevent upstream fish passage.

Figure 5. Fish habitat in the Shepherd Stream water race at low flow

Figure 6. A sample of the brown trout residing in the Shepherd Stream water race collected in March 2001.

Figure 7. The Totara Creek water race, remnant pool and dry race sections.

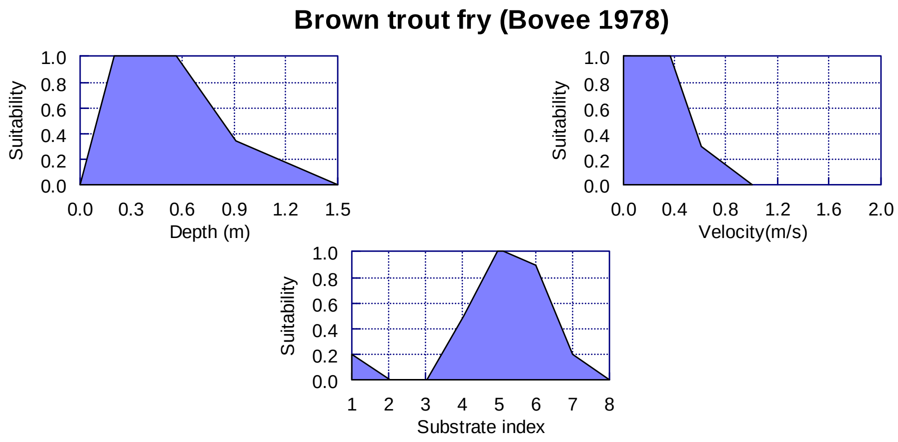

Figure 8. Habitat preferences for brown trout fry (Bovee 1978)

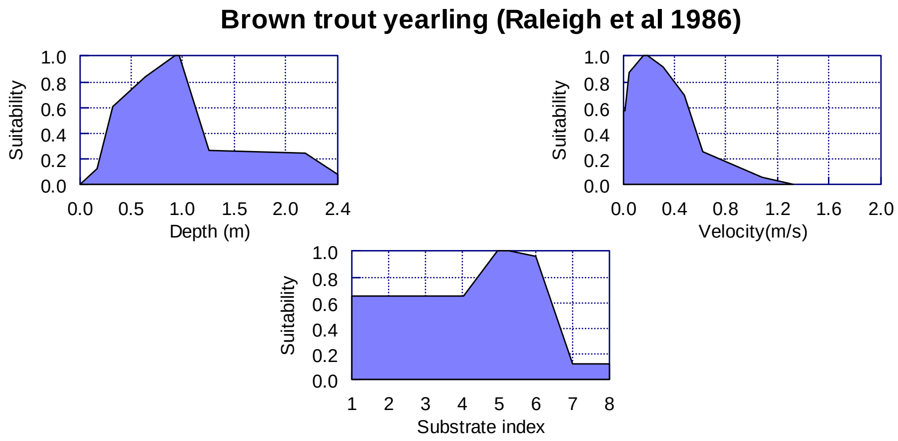

Figure 9. Habitat preferences for juvenile brown trout (Raleigh et al 1978).

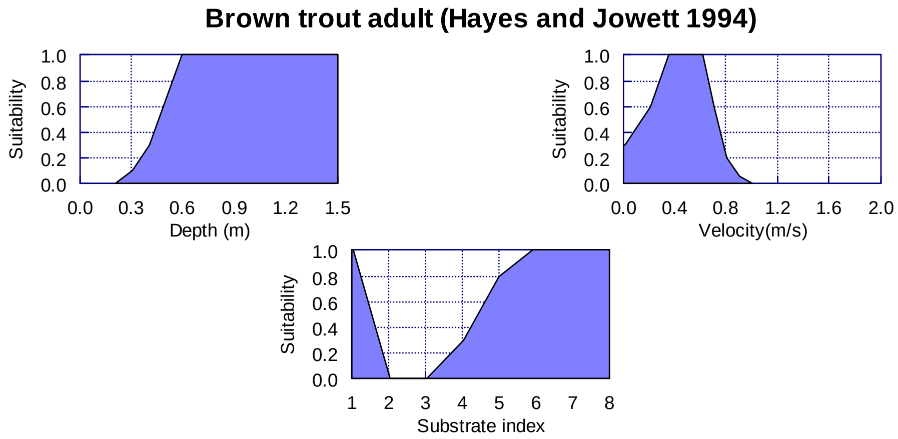

Figure 10. Habitat preferences for adult brown trout (Hayes and Jowett 1978).

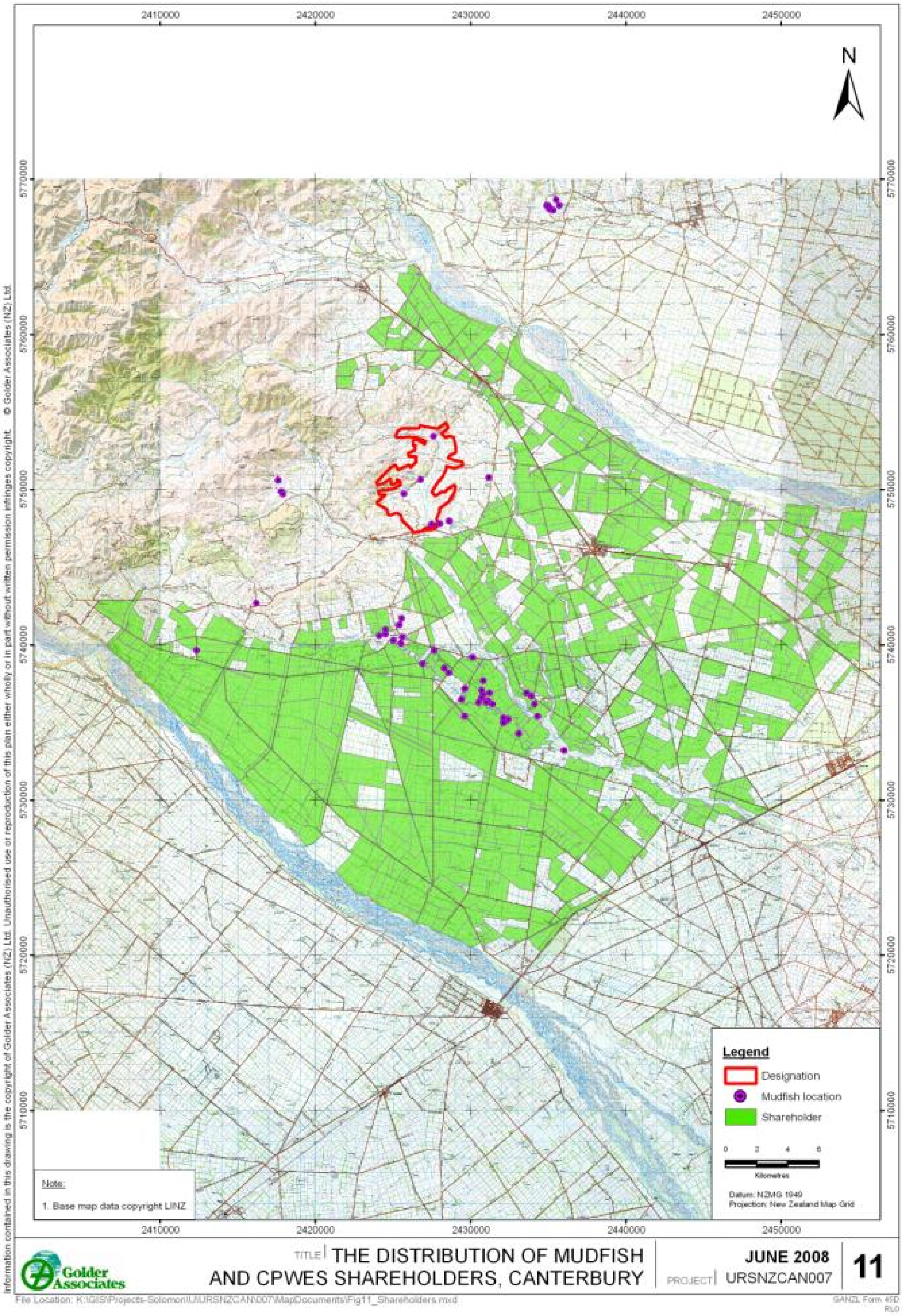

Figure 11. The distribution of Canterbury mudfish in the CPWES area overlaid on the shareholder properties.