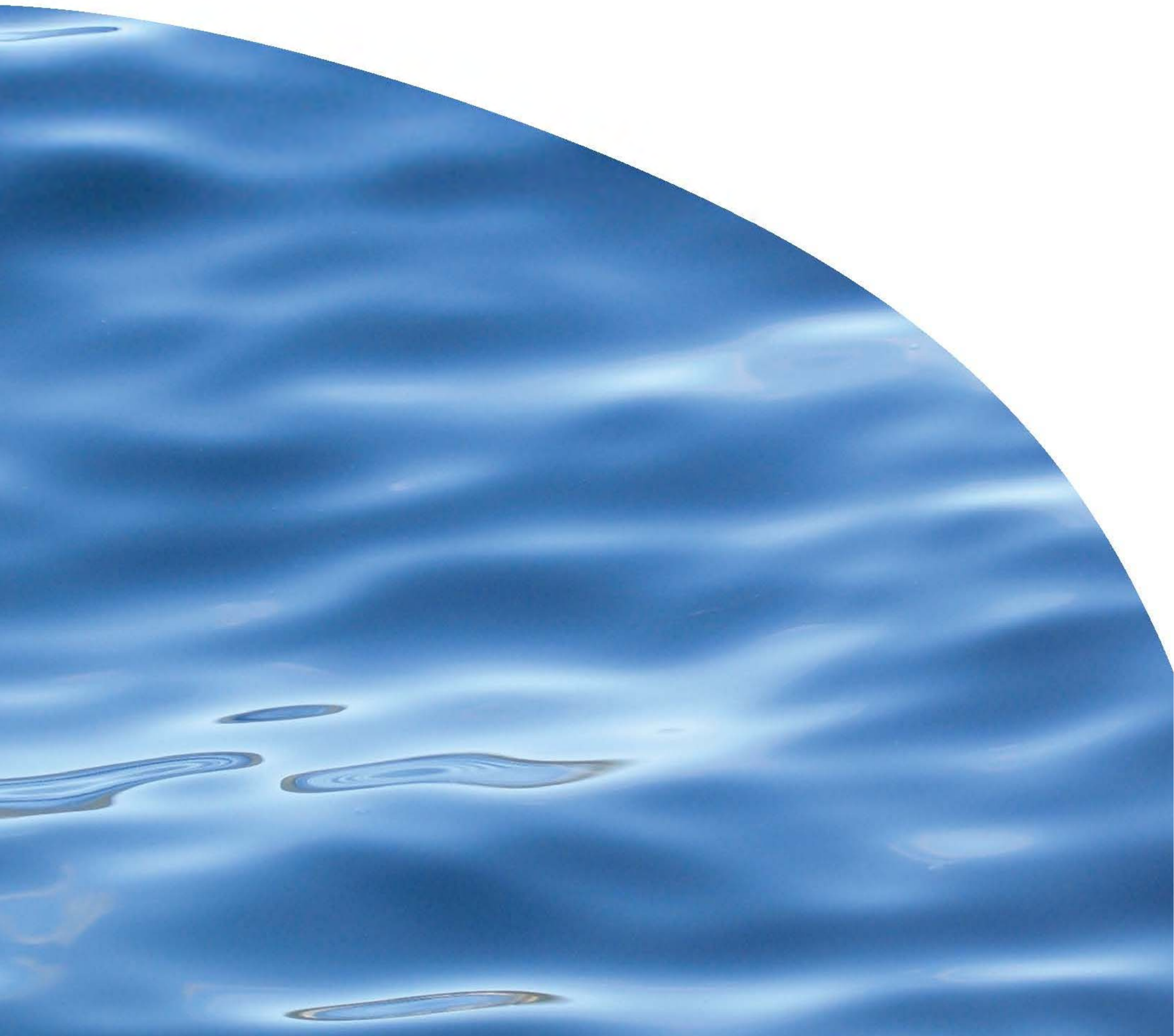
REPORT NO. 2601

FISH PASSAGE ASSESSMENT OF THE MAITAI RIVER NORTH BRANCH DAM AND SOUTH BRANCH WEIR



FISH PASSAGE ASSESSMENT OF THE MAITAI RIVER NORTH BRANCH DAM AND SOUTH BRANCH WEIR

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Prepared for Nelson City Council

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EXECUTIVE SUMMARY

Background

Nelson City Council commissioned an assessment of fish passage at the Maitai Dam and the Maitai South Branch weir, ahead of re-consenting for the dam in 2017. The Maitai Dam reservoir provides municipal water supply for Nelson and has been operational since 1987. It is located on the Maitai River North Branch at the confluence with the South Branch, and at 22 m high presents a large obstacle for migratory fish. In the South Branch, there is a weir with an alternative water intake for Nelson's municipal supply. This low head weir presents a less challenging obstacle to fish passage. When water is abstracted at the South Branch weir, it is replaced with water from the North Branch reservoir through a back feed pipe, discharging immediately below the abstraction point.

Fish distribution

Review of existing fish distribution data, as well as observations made during the 2013 / 14 migration period, show that eel elvers and juvenile kōaro (one of the five whitebait species) do successfully pass upstream over the South Branch weir and the Maitai Dam. However, the low numbers of these migratory species found above both the dam and the weir, suggest that passage success is limited. During the summer 2013 / 14 spotlighting survey, 55 elver were observed attempting to climb the dam spillway, but none were seen to successfully pass the entire spillway length into the reservoir. No fish species, other than elver, were seen attempting to climb the North Branch spillway during this survey.

The Maitai Dam

Fish passage issues

Key fish passage issues identified at the Maitai Dam include:

- Length, shape and slope of the spillway and 'apron'
- Lack of wetted margins and rest areas for migrating fish during high flow
- Lack of flow (no flow) on the spillway at times during elver and whitebait migration season
- High water temperatures in and around the Maitai Dam.

Fish passage improvement recommendations

To improve fish passage over the dam we recommend the construction of concrete bevel inserts along either side of the apron / spillway. These will provide a sloping wetted splash zone that climbing fish species can adhere to (using surface tension), to rest on and to climb. We also recommend installation of mussel spat ropes adjacent to these bevel inserts to provide additional cover, as well as resting and climbing opportunities for migratory fish. Similar measures are recommended for the apron below the flip bucket lip.
To ensure continuous flow down the spillway during summer migration periods we recommend a pump be installed, delivering water from the reservoir to the spillway crest, at times that the reservoir water level is too low for spilling to occur. Cool water from lower levels of the reservoir could be used to reduce the possibility of thermal stress for fish

attempting to climb the spillway. In addition, we recommend that the drainage outlets in the flip bucket should be plugged with bungs to maintain the pool that usually forms in this bucket when spilling occurs.

The South Branch weir

Fish passage issues

Key fish passage issues identified at the South Branch weir include:

1. The back feed discharge creating an 'attractant flow' for migratory fish species, attracting fish to a migratory dead-end rather than to upstream passage options
2. High water velocities over the intake structure and lack of smooth wetted splash zone up its edge
3. Although apparently successful for trout, the existing salmonid fish pass is likely to be difficult for native fish species that are climbers, anguilliform or swimmers to pass.

Fish passage improvement recommendations

1. The issue of the back feed discharge could be addressed by moving the discharge point close to the fish pass entrances, or could be alleviated by reducing the frequency and duration of discharge. We understand that the back feed operating procedures are under review.

2. Fish passage at the weir intake can be improved for climbing species by providing a smooth wetted margin (similar to the bevel inserts recommended for the dam spillway) along the true left side, using cobbles set in a concrete matrix.

3. We also recommend six retrofits to the existing step-pool salmonid fish pass to improve fish passage for non-jumping fish species:
   i. Reconstruct water level regulator (wooden board): Ensure that the bottom of the board forming the upper step of the pass is sealed so that water flows only over the top, to avoid the current problem of high velocity water jetting under the board.
   ii. Taper the true left side of the board down at a 5 degree angle to concentrate flow to this side during low flow periods.
   iii. Bevel the square edged concrete back on true left from the top of the board to remove hard edge (right angle) transitions for climbing fish.
   iv. Construct a sloped wetted margin on the true left immediately below the upper step to provide for non-jumping fish species. Construction of a wetted splash zone with concrete and cobble true left bank of the river, connected to the tapered lower side of the retrofitted board would provide a wetted splash zone for climbing species and shallow reduced velocity edge water for burst swimmers. The surface should be slightly rough to provide traction for ascending fish.
   v. Fill the leak adjacent to the large boulder immediately above bottom step on the true left with concrete and cobble to stop water seeping underneath this large boulder, so that flow is redirected over the v-notch native fish pass.

vi. Cut the concrete on the true left of the existing lower step at a shallow angle to allow fish passage at a range of flows. Construct a concrete and cobble rock ramp along the true left edge of the lower weir, following the methodology described above.

Ongoing consent conditions — Trap and transfer

We recommend trap and transfer of eels and kōaro from the Maitai River main stem into the Maitai River North Branch as an interim measure, until passage improvements translate into increased fish densities upstream.

Additional fish monitoring

The installation of fish passage improvements at the Maitai Dam are presently scheduled to be completed prior to June 2015. This would allow one year of pre-remediation monitoring and two years of post-remediation monitoring prior to the re-consenting hearing in 2017.

Ideally, monitoring would compare the proportion of fish successfully passing the spillway between pre- and post-remediation installation. This requires monitoring numbers of fish that start the ascent (at the bottom of the spillway) as well as numbers successfully passing the spillway crest.

The survey could include the installation of some form of a bucket / net at the top of the spillway that traps any fish that successfully passed the spillway, and / or cameras with night vision installed on either side of the spillway, recording fish beginning their ascent of the spillway.

An additional semi-quantitative fish survey in the upper South and North branches would be useful to fill knowledge gaps regarding the distribution of fish species in the upper catchments. For example, the shortjaw kōkopu has not previously been recorded in the Maitai River catchment, despite model predictions that it has a medium to high probability of occurrence in the South and North branches and their tributaries.

Although not directly relevant to re-consenting of the dam additional fish surveys in the main tributaries of the Maitai River (*e.g.* Groom and Sharland creeks) would also be useful to fill existing knowledge gaps.

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1. PURPOSE AND SCOPE OF THIS REPORT

The consents held by Nelson City Council (NCC) for the operation of the Maitai Dam reservoir expire in 2017. In anticipation of the re-consenting process, NCC has requested an assessment of fish passage over the Maitai Dam and the South Branch weir, with the aim of providing for the ecological health of the Maitai River catchment.

This report summarises the findings of all fish surveys that have been conducted to date as part of the 2017 re-consenting process. In particular, five surveys were undertaken during summer 2013 / 14 to assess fish passage over the Maitai River South Branch weir and the Maitai Dam. Monitoring was conducted during the expected peak migration time of juvenile eels (elver) and juvenile kōaro (*Galaxias brevipinnis*; whitebait) between November 2013 and February 2014.

This report aims to:

- summarise presence / absence of fish species downstream and upstream of the Maitai Dam and South Branch weir.
- report on elver and juvenile kōaro fish passage success over these barriers.
- recommend feasible fish passage improvement options for these barriers.
- recommend suitable monitoring strategies to assess the success of fish passage improvements.

2. BACKGROUND INFORMATION

2.1. The Maitai Dam and South Branch weir

The Maitai Dam is located immediately upstream of the junction of the Maitai North and South Branch confluence. It was built by Nelson City Council to augment the Nelson municipal water supply, and has been operational since 1987. The reservoir behind the dam is approximately 32 hectares in area, has a maximum depth of 29 m near the dam wall, a mean depth of 7.6 m, and a total volume of 4.3 Mm^3 (Payne 2007).

The reservoir water quality can be poor at times compared with that of the South Branch of the Maitai River. Consequently, under normal flow conditions, drinking supply water is usually abstracted directly from the South Branch of the Maitai River at the intake weir. This water is replaced into the South Branch by water from the Maitai Reservoir (termed the ‘back feed’), which is discharged at the foot of the intake weir (Figures 1 and 2). When the river is turbid (*i.e.* during floods), the Nelson City supply is fed directly from the North Branch reservoir and some water is also drawn from the reservoir during normal river flow to meet Nelson City’s peak demand.

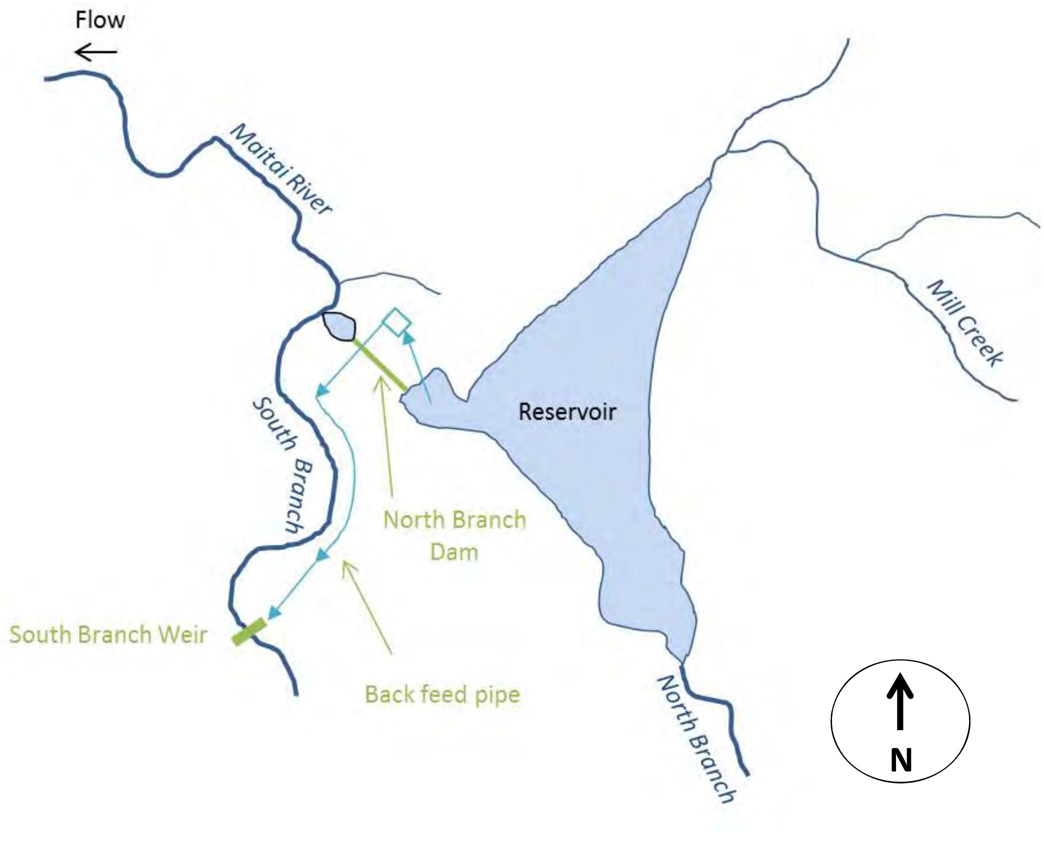


Figure 1. Schematic diagram of the Maitai Water Supply Scheme showing the locations of the Maitai Dam, the South Branch weir and the back feed pipe in relation to the reservoir (not to scale).

The back feed pipe is permanently fixed into a concrete / rock wall at a height of at least 300 mm above the water level downstream of the weir, with the actual height varying depending on the water level of the river at any given time (Figure 2; Appendix 1). Water velocities and discharge from the pipe into the South Branch are not recorded. However, the back feed water replaces water taken by the intake at a rate of approximately 1:1 (pers. comm. Paul Fisher, NCC).

Figure 2. The Maitai River South Branch weir has a central intake screen (1), an existing salmonid fish pass (2) and the back feed discharge (3).

The existing fish pass was installed in the early 1980s by the Nelson Acclimatisation Society for the purpose of providing fish passage past the weir for trout (pers. comm. Lawson Davey [Fish & Game] and Alex Miller [NCC]). The presence of trout upstream of the weir suggests that the fish pass is successful for salmonids. However, passage past the weir for non-jumping fish species (see Table 1 for definition), such as kōaro, bully species and eels is likely to be compromised.

Fish passage issues related to the weir and fish pass remediation options are discussed in detail in Section 5.

2.2. The Maitai Dam

The Maitai Dam is located at the confluence of the North and South branches of the Maitai River, with the reservoir to the east (Figure 1). The dam has a spillway, which acts as an overflow when the inflow from the Maitai River North Branch is greater than the amount of water extracted from the dam for Nelson City's water supply. Whether water is spilled down the spillway depends on the balance between inflow, Nelson City's water demand at the time, and the pre-existing water level in the reservoir, Consequently, NCC cannot directly control the timing and magnitude of water spilling down the spillway (pers. comm. Alex Miller, NCC).

Physical characteristics of the dam include a weir, spillway chute (Appendix 2), flip bucket and apron downstream of the flip bucket (Figure 3; Appendix 3). The entire spillway is 22 m high, has a total length of 151 m and is 20 m wide at the upstream end, and 10 m wide at the downstream end. The chute is made up of seven individual floor panels of varying length that have been joined together (Appendix 1). The chute gradient varies with the steepest sections being at the bottom and the top (Appendix 1).

The spillway surface is concrete and partly covered by moss in areas on the true right that are almost permanently shaded by the spillway chute walls. The flip bucket and apron are also concrete but are usually free of moss growth.

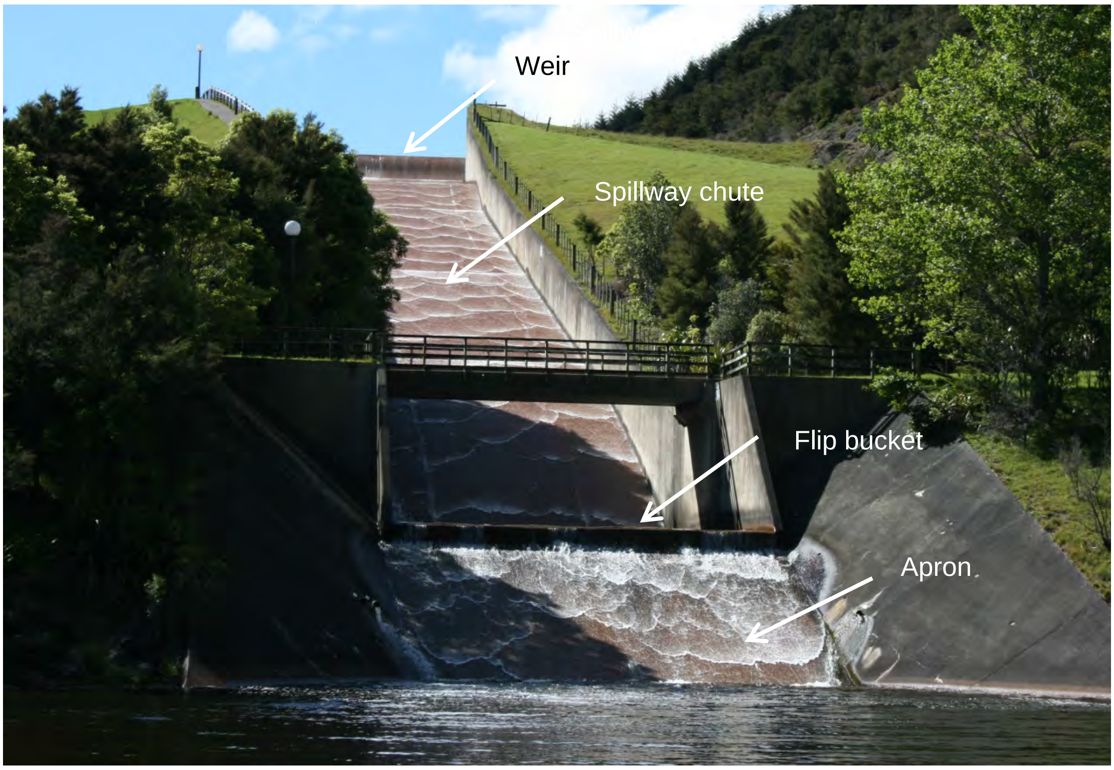


Figure 3. The Maitai Dam with the weir, spillway, flip bucket and apron.

2.3. Historical fish monitoring

Historical fish monitoring in the upper Maitai River catchment and reservoir has primarily focused on the collection of water quality data. This has included documenting thermal stratification, de-oxygenation cycles and metal concentrations in the reservoir (Holmes 2009; Holmes 2010; Olsen 2010; Holmes 2012). A more detailed ecological survey was conducted by Kelly and Shearer (2013) in the reservoir and the North Branch, assessing metal concentrations, aquatic communities (including fish) and habitat in the context of the Maitai Dam operations.

Fish communities have previously been assessed in the Maitai River catchment (*e.g.* Young & Clark 2006; Kelly & Shearer 2013; Allen *et al*. 2014). However, no reports specifically focus on fish passage assessment for the dam and the South Branch weir.

2.4. New Zealand's freshwater fish species

The passage requirements of New Zealand fish species are dependent on their life history. A large proportion of New Zealand's native fish species require access to and from the sea to complete their life cycles, while some live their entire lives in freshwater (*e.g.* upland bullies). Of those that migrate to the sea, some spawn at sea (*e.g.* eels), while others are carried downstream to the sea in their early larval phase immediately after hatching (*e.g.* whitebait galaxiid species and some bully species), and spend some time living and growing in the sea before returning to rivers to grow to adulthood. In either case, the relatively small juveniles migrate upstream seeking suitable habitat to grow to adulthood. By contrast, some introduced sport fish (*e.g.* trout and salmon), migrate upstream as adults, often seeking spawning habitat. Also, river resident fishes (both native and introduced) often move between parts of a catchment during their life.

This means that any kind of barrier (whether physical [*i.e.* dams, weirs] or chemical [*i.e.* poor water quality]) to their up and / or downstream migration may disrupt their life cycle. Not all barriers to migration are necessarily man-made, for example, waterfalls can act as naturally occurring migration barriers. However, over time, some of New Zealand's native fish species have adapted their swimming ability and developed specific climbing skills to overcome natural barriers, which today also assists them to overcome man-made physical migration barriers. Juvenile eels (elvers), kōaro and some bully species (*e.g.* redfin bully) are particularly adept at migrating or 'climbing' large physical barriers. The upstream migration of juveniles of these species usually occurs at night during the summer months.

Despite their strong migratory ability, 'climbers' still require some assistance over passage impediments. Fish passage modifications to structures require monitoring, maintenance and an adaptive approach to ensure the fish passage facility is effective.

To address fish passage problems at the Maitai River Dam and South Branch weir, an understanding of swimming abilities (Table 1) and migratory life-cycles (Table 2) of the fish species occurring in the river is necessary.

There are four main swimming ability categories for New Zealand freshwater fish species:

1. **Anguilliform** are fish that are able to ‘worm’ their way through interstitial spaces among stones or vegetation either in or out of the water. They can respire atmospheric oxygen if their skin remains damp.
2. **Climbers** can climb the wetted margins of waterfalls, rapids and spillways. They adhere to the substrate using the surface tension and can have roughened ‘sucker-like’ pectoral and pelvic fins.
3. **Jumpers** are able to leap using the waves at waterfalls and rapids. As water velocity increases it becomes energy saving for these fish to jump over obstacles.
4. **Swimmers** are fish that swim around obstacles. They rely on areas of low velocity to rest and ‘burst’ swim past high velocity obstacles.

As an alternative to overcoming large physical barriers, some native fish have adapted their life cycle to form ‘land locked’ populations. For example, kōaro and some species of bully (that would normally migrate to and from the sea) sometimes use lakes, instead of the sea, for early juvenile rearing. Whether this occurs in the Maitai Dam reservoir has not been determined. Nevertheless, there is a small chance that this may be the life-cycle strategy for some kōaro found in the North Branch.

Table 1. Swimming classifications and sustained swimming speeds (m/s) of migratory freshwater fish species found in the Maitai River and their likely location of occurrence in the catchment (modified from Mitchell 1989; Boubée *et al*. 1999; Charteris 2007; David *et al*. 2014) * = based on overseas data.

Species	**Swimming classification**	**Sustained swimming velocity (m/s)**	**Location of occurrence**
Shortfin eel (adult)	Anguilliform	< 1.50–2.00	Entire catchment
Shortfin eel (elver)	Anguilliform / Climber	0.15–> 0.60	
Longfin eel (adult)	Anguilliform	< 1.50–2.00	Entire catchment
Longfin eel (elver)	Anguilliform / Climber	< 0.15–>1.00	
Kōaro (adult, >50 mm)	Climber / Swimmer	< 0.80	Entire catchment
Kōaro (juvenile, < 50 mm)	Climber	0.10–0.24	
Redfin bully (adult)	Swimmer	< 0.15–0.60	Entire catchment
Redfin bully (juvenile)	Swimmer / Climber	unknown	
Bluegill bully (adult)	Swimmer	0.30–> 1.00	Lower catchment
Common bully (adult)	Swimmer	0.15–0.60	Lower to middle catchment
Common bully (juvenile)	Climber	0.24–0.28	
Giant bully	Swimmer	unknown	Lower catchment
Brown trout (adult, >200 mm)*	Swimmer / Jumper	0.90–> 2.00	Entire catchment
Brown trout (juvenile, < 200 mm)*	Swimmer / Jumper	0.50–0.70	
Īnanga (adult > 50 mm)	Swimmer	< 0.15–0.36	Lower and middle catchment
Īnanga (juvenile, < mm)	Swimmer	0.007–0.39	
Torrentfish	Swimmer	0.30–< 1.10	Lower catchment
Common smelt (adult)	Swimmer	0.15–0.60	Lower and middle catchment
Common smelt (juvenile)	Jumper	0.19–0.27	
Freshwater shrimp	Climber	< 0.24	Entire catchment
Kōura (freshwater crayfish)	Climber	unknown	Entire catchment
Grey mullet *	Swimmer	0.12–0.20	Lower catchment
Mean: NZ fish species (juvenile)		**0.20–0.32**	

Table 2. Fish migration calendar for migratory fish species found in the Maitai River catchment, showing peak (dark blue) and range (light blue) periods for migration activity, migration status and life stage at time of migration are shown (modified from Hamer 2004 to account for regional differences). u/s = upstream, d/s = downstream.

Species	**Direction**	**Life stage**	**Summer**			**Autumn**			**Winter**			**Spring**		
			Dec	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**
Longfin eel	u/s	Juvenile												
	d/s	Adult												
Shortfin eel	u/s	Juvenile												
	d/s	Adult												
Both eel species	from sea	Glass eel												
Kōaro	u/s	Juvenile												
	d/s	Larvae												
Redfin bully	u/s	Juvenile												
	d/s	Larvae												
Bluegill bully	u/s	Juvenile												
	d/s	Larvae												
Common bully	u/s	Juvenile												
	d/s	Larvae												
Giant bully	u/s	Juvenile												
	d/s	Larvae												
Brown trout	u/s	Adult												
Īnanga	u/s	Juvenile												
	d/s	Larvae												
Torrentfish	u/s	Juvenile												
	d/s	Larvae												
Common smelt (sea run)	u/s	Juvenile												
	d/s	Larvae												

3. FISH PASSAGE SURVEY SUMMER 2013 / 14

3.1. Sampling methodology and study sites

This report synthesises fish community sampling results from three separate surveys conducted in the Maitai River as part of the 2017 re-consenting process, including:

- Allen *et al*. (2014)
- Kelly and Shearer (2013)
- five fish passage surveys conducted during summer 2013 / 14 (this report)

Survey methods included a combination of electric-fishing, trapping and night-time spotlighting.

3.1.1. Electric-fishing

Electric-fishing is the most common fish survey technique used in small to moderate sized streams in New Zealand and involves passing an electric current through the water to stun fish, allowing them to be captured. Once the electric current is turned off, fish generally recover quickly. Electric-fishing is an effective method on larger species that are predominantly found in the water column (*e.g.* trout), but less effective on small species and/or those that seek cover among the substrate during the day (*e.g.* kōaro, bully species, eels).

Single pass electric-fishing was undertaken using a 2,800 W battery-powered backpack machine (Smith-Root, LR-24 Electrofisher). This fishing was conducted at eight sites in the Maitai River main stem and South Branch (Allen *et al*. 2014) and one site in the Maitai River North Branch (Kelly & Shearer 2013; Figure 4). Fish were stunned and swept downstream into a hand-held stop net. They were then identified, counted, measured and released.

3.1.2. Trapping

Trapping was conducted by Kelly and Shearer (2013) in April 2013 at three sites in the Maitai Dam reservoir (Figure 4). This included the setting of two lines of 10 Gee-minnow traps (mesh size ~ 5 mm) that were deployed overnight in April 2013. The lines were perpendicular to the shoreline and extended over a distance of 50 m (Kelly & Shearer 2013). In addition, three 4 m fyke-nets were also deployed at each of the three reservoir sites. Fish captured were identified, counted and measured.

3.1.3. Spotlighting

Presence / absence of fish species was assessed by night-time spotlighting. This is a rapid survey method generally used to target small areas of interest for nocturnallyactive fish (such as kōaro and eel species) and complemented the electric-fishing of riffle areas and the netting conducted in the reservoir. The spotlighting method is most effective in pool and run habitats where the calm water surface allows good visibility into the water. These night-time spotlight surveys did not involve fish capture and were conducted on five occasions; 14 November 2013, 3 December 2013, 23 January 2014, 5 and 21 February 2014 at four key locations (Figure 4):

1. the Maitai River South Branch (150m below the weir, at the weir and up to 150 m above the weir)
2. the Maitai River main stem (150 m downstream of the spillway)
3. the Maitai Dam spillway (top and bottom of spillway, flip bucket and apron)
4. the Maitai River North Branch (from north end of reservoir to 300 m upstream).

3.1.4. Other information gathered

In addition to the three surveys described above, any historical fish records in the New Zealand Freshwater Fish Database (NZFFD; National Institute of Water & Atmospheric Research [NIWA]) for the upper Maitai River catchment were also included in the results.

Figure 4. Freshwater fish sampling sites in the Maitai River Main stem, South and North branches that were surveyed as part of the summer 2013 / 14 fish passage assessment (spotlighting; seven sites; white triangle), Allen *et al*. 2014 (electric-fishing; seven sites; yellow circle) and Kelly and Shearer 2014 (trapping or electric-fishing; four sites; purple circle).

3.2. Fish species distribution

Seven species of fish and two crustaceans have been recorded from the upper Maitai River catchment (Table 3) with five of those species recorded in the vicinity of the Maitai Dam and South Branch weir (Table 4).

The summer 2013 / 14 survey found that adult longfin eel (*Anguilla dieffenbachii*) numbers were highest in the Maitai River South Branch and main stem. Shortfin eel (*Anguilla australis*) distribution was confined to the main stem and North Branch with only three medium-sized individuals found in the North Branch during the summer 2013 / 14 fish passage survey. Fifty-five eel juveniles (elver) were found on the spillway (with both species represented), but only two elver were recorded below and above the South Branch weir (Table 4). Eel were the only fish species found attempting to climb the Maitai Dam during the summer 2013 / 14 survey.

Kōaro (*Galaxias brevipinnis*) were sparsely distributed in the upper catchment with only two medium-sized adults found in the North Branch. At the South Branch weir, two juvenile kōaro were seen attempting to climb the true left of the weir. However, the most recent record of adult kōaro upstream of the South Branch were recorded in 2003 (NZFFD; National Institute of Water & Atmospheric Research (NIWA)). There are no records of kōaro from the Maitai River main stem in the vicinity of the dam. Brown trout (*Salmo trutta*) were found in all areas surveyed with medium-sized fish representing the majority of records. Medium-sized upland bullies (*Gobiomorphus breviceps*) were found present in the Maitai South and North branches and the crustacean kōura (*Paranephrops planifrons*) was found in low numbers in the South and North branches.

Table 3. Fish species found in the upper Maitai River catchment, including the main stem of the Maitai River 1.6 km downstream of the dam, the North and South branches and the reservoir. Fish species listed are a summary of the findings of the summer 2013 / 14 fish passage survey[1], Allen *et al*. (2014)[2], Kelly and Shearer (2014) [3], Olley (2014) [4] and New Zealand Freshwater Fish Database (NZFFD; National Institute of Water & Atmospheric Research (NIWA)) [5]. The latest New Zealand conservation status is also shown (Grainger *et al.* 2013; Goodman *et al.* 2014).

Common name	**Scientific name**	**Location present**	**Conservation status**
Longfin eel	*Anguilla dieffenbachii*	Main Stem[1,2,4,5] South Branch[1,2,4,5] North Branch[1,2,3,4,5] Reservoir[3,5]	At Risk - Declining
Shortfin eel	*Anguilla australis*	Main Stem[1,2,4] North Branch[1]	Not Threatened
Kōaro	*Galaxias brevipinnis*	South Branch[1,5] North Branch [1,2,3,4,5]	At Risk - Declining
Brown trout	*Salmo trutta*	Main Stem[1,2,5] South Branch[1,2,3,5] North Branch[1,2,3,4,5] Reservoir[3,5]	Introduced and Naturalised
Upland bully	*Gobiomorphus breviceps*	Main Stem [5] South Branch[1,3,5] North Branch[1,2,3,4] Reservoir [3,5]	Not Threatened
Redfin bully	*Gobiomorphus huttoni*	Main Stem [2] South Branch [2,3,5] Reservoir [5]	At Risk - Declining
Common bully	*Gobiomorphus cotidianus*	South Branch [5] Reservoir [3]	Not Threatened
kōura (Freshwater crayfish)	*Paranephrops planifrons*	Main Stem[1,2,5] South Branch[1,2,5] North Branch[1]	At Risk - Declining
Freshwater shrimp	*Paratya curvirostris*	Main Stem[1]	Not Threatened

Table 4. Number of fish species and their size classes found as part of the 2013 / 14 spotlighting fish passage survey. Fish length size class categories are in mm and are based on Joy *et al* (2013), except for kōura. S = Small, M = Medium, L = Large.

	South Branch		Main stem	Spillway			North Branch	
Fish species	**150 m U/S weir**	**150 m D/S weir**	**150 m D/S spillway**	**On spillway D/S end**	**On spillway U/S end**	**U/S flip bucket**	**North end of reservoir**	**300 m North of reservoir**
Elver (both eel species) (≤ 100)	1	1	-	15	28	12	-	-
Longfin eel S (101–300)	6	1	5	-	-	-	1	3
Longfin eel M (301–500)	12	3	11	-	-	-	-	2
Longfin eel L (501+)	3	5	13	-	-	-	2	1
Shortfin eel M (301–500)	-	-	-	-	-	-	3	-
Kōaro SM (51–100)	1	2	-	-	-	-	-	-
Kōaro M (101–150)	-	-	-	-	-	-	-	2
Brown trout 0+ (≤ 80)	8	2	19	-	-	-	11	5
Brown trout S (81–220)	24	-	38	-	-	-	3	-
Brown trout M (221–500)	-	4	30	-	-	-	2	3
Brown trout L (501+)	1	-	-	-	-	-	1	-
Upland bully M (21–40)	9	11	-	-	-	-	10	-
Kōura S (40–60)	-	4	-	-	-	-	-	-
Kōura M (61–100)	-	-	-	-	-	-	1	-
Kōura L (101+)	-	2	-	-	-	-	-	-

4. FISH PASSAGE REMEDIATION

4.1. Maitai Dam

4.1.1. Fish distribution

Given the height of the Maitai Dam, fish passage over the dam is likely to be achievable only for strong migratory climbing fish species (Table 1). Overall, migratory fish numbers were noticeably lower above (compared with below), the dam. This suggests there is compromised fish passage and recruitment over the dam. The length and steepness of the spillway is considered a serious fish passage barrier and only climbing fish species, such as juvenile eel and juvenile kōaro, are expected to overcome this structure. Any non-climbing fish species found upstream of the dam are either resident and non-migratory (*e.g.* upland bully, trout), or able to use the reservoir as juvenile rearing grounds (*e.g.* common bully, trout). It would be interesting to investigate whether North Branch migratory fish species, such as kōaro, use the reservoir for rearing.

Overall, adult longfin eel were recorded more frequently from the Maitai River main stem downstream of the dam compared with upstream of the dam and Kelly and Shearer (2013) reported that longfin eel density was the lowest of the species caught during their netting survey. Compared to three other lakes in the Tasman District, the Maitai Reservoir had the second lowest catch per unit effort (CPUE). This suggests that the reservoir provides suitable habitat for eel species to some degree, however, the low CPUE indicates that either habitat quality or food availability is compromised for eel species or recruitment into the reservoir is low[1]. The summer 2013 / 14 fish passage survey was the first survey that found shortfin eel elver on the spillway and medium sized adults in the North Branch, despite predicted probabilities of occurrence being very low (< 1%) for this species above the dam (Leathwick *et al.* 2008).

During the summer 2013 / 14 spotlighting surveys, 55 elver were observed attempting to climb the spillway (Figure 5). However, none were seen to successfully pass the entire spillway length and make it into the reservoir during any of the 2-hour surveys, suggesting only a limited amount of eel recruitment past the dam. No fish species, other than elver, were seen attempting to climb the North Branch spillway and none of the surveys found kōaro present in the main stem downstream of the dam. Records of kōaro in the North Branch, however, suggest that fish are able to overcome the dam, albeit in low numbers, or that this species has established a land-locked population using the reservoir, although the low densities observed make this seem unlikely (but this is based on sparse sampling efforts).

Current NCC consent conditions for the dam (condition RM025151/1) imply that a manual trap and transfer programme for eel species over the dam is in place. Given

[1] Interestingly there were no fish caught at depths of more than 5 m in the reservoir (Kelly & Shearer 2013).

that the habitat in the North Branch upstream of the Reservoir is suitable for eels and kōaro with modelled probabilities of occurrence high for both species (up to 68.7% and 82.0%, respectively; Leathwick *et al.* 2008), trap and transfer options for both species should be considered as part of the 2017 re-consenting process (see Section 5.1 for more details).

Predictions of occurrence for other migratory fish species show that the presence of shortjaw kōkopu (*Galaxias postvectis*) is highly likely in the North Branch (*i.e.* 85% accounting for the dam; Leathwick *et al.* 2008), although no occurrences of this species have been recorded in any of the fish distribution surveys discussed in this report. This species is similar to kōaro in that it spawns in autumn, with larvae going to sea upon hatching and juveniles return to freshwater in spring as whitebait. Thus, it requires access to and from the sea to complete their life cycle. It occupies distinctive habitats in small, stable, bouldery streams and prefers riffle habitat, such as provided in the Maitai River North Branch. Targeted sampling in the upper reaches of the Maitai River North Branch is recommended to determine whether this fish species is present or absent in the catchment (see Section 5.2).

Figure 5. Elver climbing their way up a wetted margin past the apron of the Maitai Dam during low flow in the summer of 2013 / 14.

4.1.2. Fish passage issues

Fish sampling surveys above the dam recorded low numbers of eel and kōaro, suggesting restriction of fish passage over the Maitai Dam. Characteristics of the dam identified as potential issues for fish passage include:

1. size, shape and slope of the spillway and apron
2. lack of wetted margins and rest areas for migrating fish during high flow
3. lack of flow (no flow) on the spillway during elver and whitebait migration season
4. high water temperatures in the Maitai Dam reservoir and spillway.

Further details of the fish passage issues associated with each of these four points are provided below, and suitable remediation recommendations for these issues are discussed in Section 4.1.3.

1. Size, shape and slope of the spillway and apron

The total length and height of the spillway, including the apron, are 167 m and 22 m, respectively (Appendices 2 and 3). Non-climbing fish species (such as salmonids) or adult life-stages of climbing fish species are unlikely to migrate upstream over the dam, unless they are capable of migrating over land (such as eels).

The floor of the spillway chute is made up of seven individual concrete panels of varying length, joined together (Appendix 2; Figure 6). Fish sampling on the spillway showed that elver accumulated downstream of these joints, suggesting that fish use them as resting locations during their attempts to migrate upstream, as long as a wetted surface is provided between the joints. Elver were found most of the way up the spillway (to immediately below the short steep section at the crest; Appendix 2), suggesting that the joints do not present a major fish passage barrier. We did, however, observe elver struggling to overcome the joints, particularly in faster flowing water, indicating that they present a minor fish passage barrier.

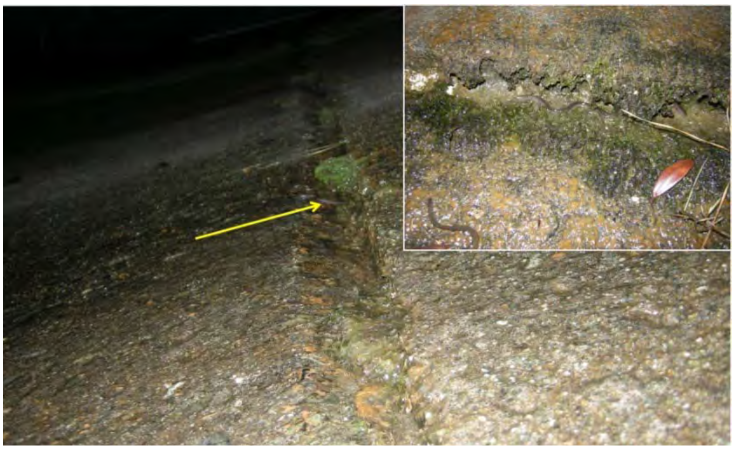


Figure 6. Spillway section joints in the Maitai Dam spillway provide resting areas for upstream migrating fish during low flows.

2. Lack of wetted margins and rest areas for migrating fish during high flow

The spillway surface is concrete, with the true right of the chute partly covered by moss due to almost continuous shading (Figure 7). The established moss assists upstream fish passage as it slows down water velocities on the chute, creating a water velocity refuge, allowing fish to rest and potentially improving traction for climbing species. This, however, is only expected to be the case during relatively low flows, where water velocities are not excessive, so eel and kōaro are able to 'cling' onto the substrate. During high-flow events, the moss's ability to act as a water velocity refuge will be limited and upstream migration will be compromised.

Figure 7. Established moss on the true-right of the Maitai Dam spillway assists fish passage during low flows.

3. Lack of flow (no-flow) on the spillway during elver and whitebait migration season

Reservoir water level recordings over the last two years showed that lake water levels dropped below the height of the spillway by up to 1.3 m, resulting in the spillway drying up. More than half of these spillway drying events occurred during eel and kōaro upstream migration periods (Figure 8). However, the dam would have been spilling for much of the time in both years during the migration periods.

In addition to spillway drying the pool formed by the flip bucket can also sometimes dry out contributing to a significant barrier to fish passage. There are two 100 mm pipes with 50 mm entries, one each side of the flip bucket, which drain water from the flip bucket to the apron above the plunge pool during periods of no, or very low flow (Figure 9; Appendix 3). These drains seem to be blocked most of the time, but are cleared from periodically, between April and September each year (pers. comm. Alex Miller, NCC). When this is done the pool of water in the flip bucket dries up. Fish passage is not possible until the drains become re-blocked and the flip bucket pool refills and begins spilling water down the apron. Constant water flow over the spillway and the apron and maintaining the flip bucket pool full of water during fish migration periods is recommended to provide continuous fish passage over the dam (see Section 4.1.3 for more details).

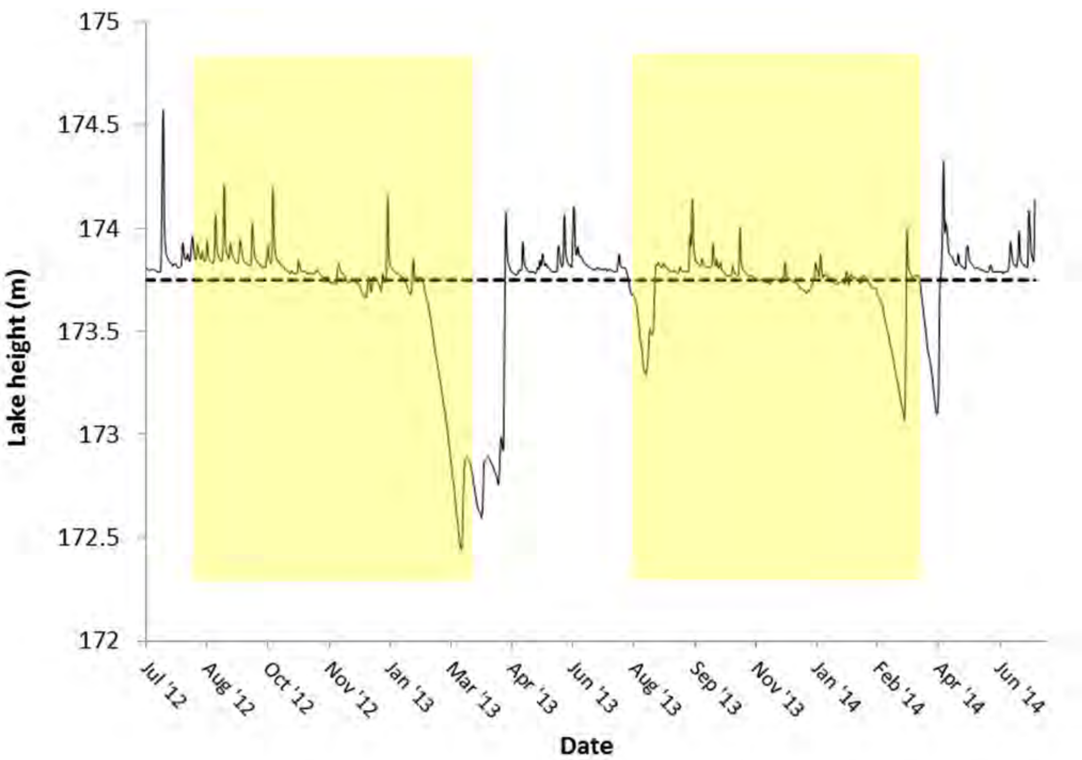


Figure 8 Water level fluctuations in the Maitai Reservoir between July 2012 and June 2014. Upstream migration periods for eel and kōaro are highlighted in yellow, the dashed line indicates the height of the spillway crest (when the lake height exceeds the spillway crest water will be spilling, when it is below this level the spillway will be dry).

Figure 9. Maintenance drains in the Maitai Dam spillway flip bucket (top) and drain outlets (bottom) at the apron cause the pool of water in the flip bucket to dry up during summer months, inhibiting fish upstream migration into the reservoir.

4. High water temperatures in and around the Maitai Dam

Water temperature is a key factor controlling the distribution, abundance, physiology and behaviour of fish. High water temperature can act as barrier to migration, potentially causing fish to avoid entering a certain waterway and is therefore important to consider when assessing fish passage.

Kōaro are a cold water fish species and relatively sensitive to high water temperatures. In South Westland the 'probability of occurrence' for kōaro reportedly increased as water temperature decreased (Taylor 1988, cited in Rowe & Kusabs 2007). Olsen *et al*. (2011) calculated a thermal growth optimum for juvenile kōaro of 18.8°C, based on an upper lethal temperature of 28°C. So while kōaro are able to survive short-term exposure to relatively high temperatures, their preference is for relatively cool water. Water temperature has been shown to act as a migration barrier for another whitebait species, īnanga (Galaxias maculatus). For example, the 27°C thermal plume of Huntly Thermal Power Station presented a migration barrier, which īnanga avoided by moving to the other side of the river (Stancliff *et al*.1989). Īnanga have higher thermal tolerance limits than kōaro (Olsen *et al*. 2011, Richardson *et al*. 1994). Therefore, kōaro may be expected to exhibit a behavioural avoidance response at lower temperatures than īnanga, perhaps even in the 20°C–25°C range.

Eels are generally less temperature sensitive than other native fishes with longfin eels being slightly more sensitive than shortfin eels. Richardson *et al*. (1994) reports the preferred temperatures for shortfin elvers to be 26.9°C (25.6°C–28.5°C) and for longfin elvers to be 24.4°C (22.6°C–26.2°C), when acclimated to 15°C. Upper lethal temperatures are higher still, being 35.7°C and 34.8°C for shortfin and logfin eel, respectively (Richardson *et al.* 1994).

Water temperature recordings in the reservoir at 3 m depth showed that maximum daily temperatures reached 22.6°C. These temperatures are close to lethal limits for kōaro and may have been high enough to trigger a behavioural response to interrupt migration in the species. But they are unlikely to be affecting elver migration.

Water temperatures are likely to be higher at the surface of the reservoir; high temperatures on the spillway and in the flip bucket/ plunge pool could present a thermal migration barrier to elver as well as juvenile kōaro. However, while daily maximum water temperatures exceeded 20°C in February 2014 (Figure 10), our summer 2013 / 14 survey showed that elvers were still attempting to climb the spillway. This indicates that eel species, at least, are still able to continue their upstream migration during periods even when water temperatures were elevated.

Council staff have noted that "when the drains are blocked and water is present in the plunge pool, this water can be subject to significant heating by the sun. Water temperatures in the flip bucket have not been recorded but the water is reported as being 'very warm', possibly well above 20°C" (pers. comm. Alex Miller, NCC). We recommend installing a temperature logger in the flip bucket to shed more light on this issue. If this reveals excessive temperatures in the flip bucket, then potential options to control temperatures may need to be explored.

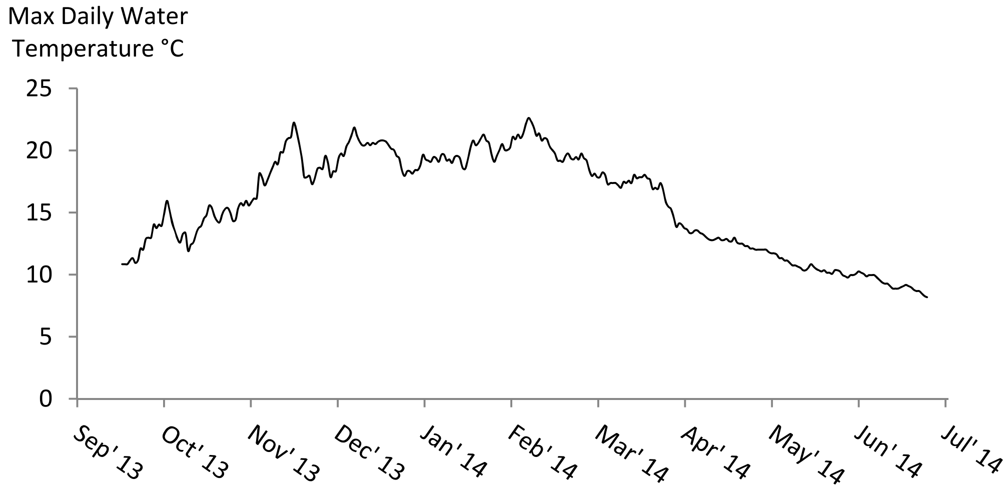


Figure 10. Maximum daily water temperatures (°C) at 3 metre depth in the Maitai Reservoir between September 2013 and July 2014.

4.1.3. Fish passage recommendations

The remediation options discussed in this section target 'climbing' fish species, such as eel and kōaro, only. We recommend that an experienced fish ecologist be present to provide guidance and clarification during the installation of fish passage remediation structures. A Cawthron Institute ecologist could fulfil this role.

Provision of wetted margin and resting areas on the apron and spillway

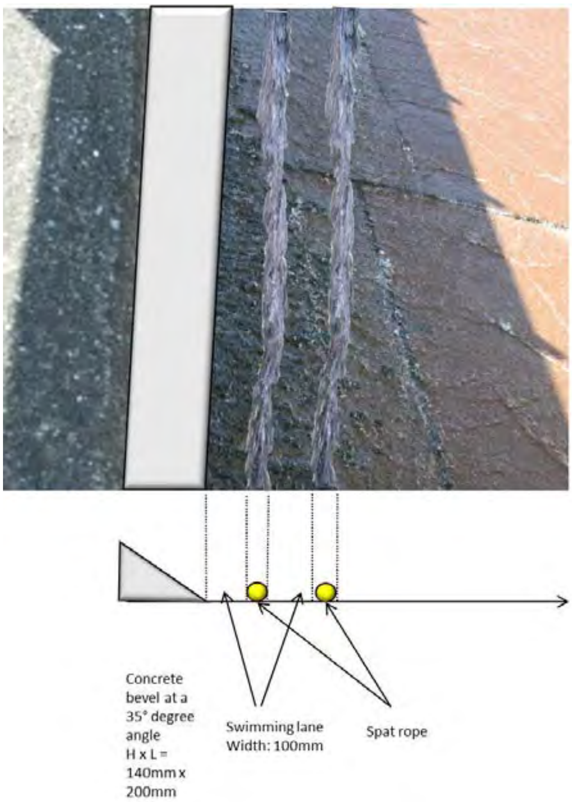
To improve fish passage over the apron and spillway we recommend the construction of a concrete bevel insert on either side of the apron/spillway. Climbing fish species require a wetted edge that they can adhere to, rest on, and climb. This will be provided by the sloping wetted margin and the splash zone created on the bevel insert. We recommend the bevel be installed at approximately 35° (*i.e.* 140 mm × 200 mm; Figure 11). The bevel should be constructed along the entire length of the apron and spillway, preferably on both sides. However, if this is not feasible, the true right hand side of the spillway should be prioritised, because it is shaded and has established moss that potentially assists passage of climbing species. The surface of the concrete should be slightly rough to provide increased traction for ascending fish. Construction joints required along the length will require filling (*e.g.* silicon) to ensure a smooth transition between sections. Construction should be conducted in either winter or early spring (*i.e.* September–early November) prior to eel and kōaro peak migration periods. High pH associated with concrete placement is known to be toxic for many aquatic organisms and any flow over the spillway/apron should be stopped or diverted during construction until the concrete had at least a 24-hour drying period. Ideally, the established moss on the true right of the spillway should be disturbed as little as possible during fish pass construction work.

In addition to the wetted margin, the installation of multiple mussel spat ropes (minimum of two) along the true right of the structure is also recommended (Figure 11A and B). These ropes will break-up high velocity surface flow, providing a range of flow velocities, resting opportunities, as well as some form of cover for protection from predation by birds during the ascent.

Polypropylene mussel spat ropes are a low-maintenance, cost-effective solution for addressing fish passage issues for some climbing species such as eels and kōaro (David *et al*. 2014). As the name suggests, they are typically used in marine mussel farm aquaculture to provide a settlement substrate for mussel larvae. The ropes are made of woven polypropylene which makes them very robust and able to support large weights, and most are treated to be resistant to ultra-violet light, for increased longevity. In the marine environment, mussel spat ropes have a life expectancy of 10–15 years. In the freshwater environment, mussel spat ropes have been tested for five years, and to date there have been no signs of weathering (pers. comm. Bruno David, Waikato Regional Council). The two most commonly-used types are 'Russet Loop' and 'Super Xmas Tree' (Figure 12). A 200 m length of the latter has already been purchased by Nelson City Council (pers. comm. Alex Miller, NCC) to be installed on the spillway. However, more rope will be required if multiple lanes are to be installed along the entire length of the spillway and apron.

Correct installation of the ropes is critical to ensure low-maintenance effort once installed. The ropes should be installed parallel to each other with a 100 mm gap between them to provide 'swimming lanes' for ascending fish (Figure 11A). We recommend that the rope is fixed at the top and the bottom of the spillway / apron and tensioned as much as possible to avoid excessive abrasion of the ropes on the concrete surface and trapping of debris. Further anchor points will be needed along the upper part of the spillway to ensure that the ropes are tightly fixed to the varying spillway surface slopes with the very top anchor points to be installed on the reservoir side of the dam face (Figure 11B). Final location of the ropes and their anchor points may need to be adapted and finalised during construction based on functionality.

A



B

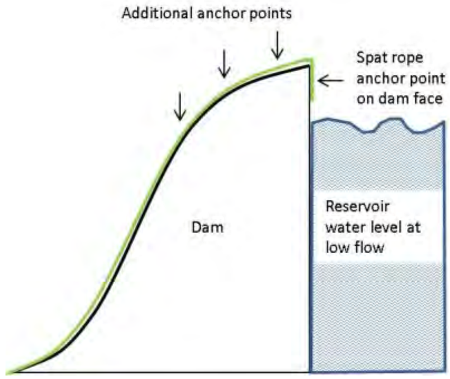


Figure 11. A) Schematic details of the concrete bevel and the two spat ropes and B) potential anchor points for the spat ropes on the spillway and dam face. Note: Drawings are not to scale.

A

B

Figure 12. Examples of A) Russet loop (left) and Super Xmas tree (right) mussel spat ropes and B) an example of correct installation of spat ropes in a culvert, showing the 'swimming lanes' between the ropes.

The installation of mussel spat ropes is a relatively new methodology, which has been successfully used to assist fish passage through long and/or perched culverts. Their ability to assist fish passage past a 167 m long dam spillway is untested. Our primary recommendation is, therefore, the provision of a splash zone created by a wetted margin to improve passage and recommend the installation of mussel spat ropes as an additional measure. This combination is considered the best solution for fish passage issues over the spillway / apron as it deals with the length issue of the apron and spillway, but also addresses the fish passage issue created by the concrete floor joints, providing resting areas and slow-flow refugia between and underneath the mussel spat ropes.

The spillway remediation recommendations also apply for improving fish passage past the apron. In particular, the provision of a bevel insert to create a smooth transition wetted margin over the 90°degree flip bucket lip, on both sides of the structure (Figure13).

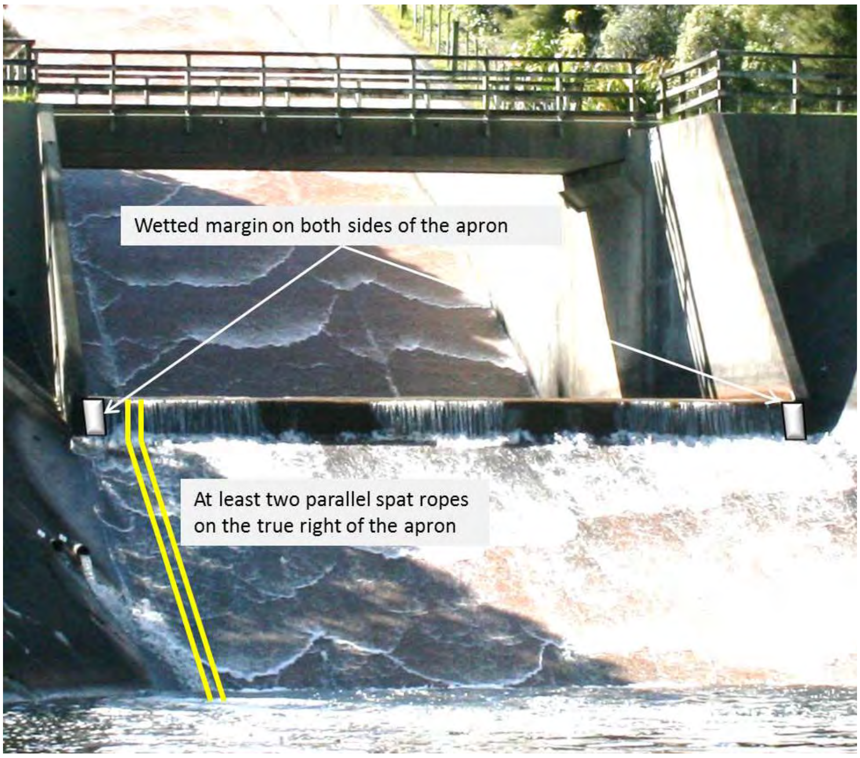


Figure 13. Fish passage improvement recommendations for the apron of the Maitai Dam.

Provide constant flow over spillway / apron and through the flip bucket

To provide constant water flow over the spillway during non-spilling periods, we recommend the installation of a water pump delivering reservoir water onto the true right of the spillway crest. We suggest 5 l/s for the pump discharge rate to begin with. Adaptive management will be required to ensure sufficient discharge is provided for a continuous wetted surface on the spillway and apron, and appropriate attractant flow for migrating fish. Whether the pumped flow is sufficient to allow fish passage up the spillway could be tested by releasing elver at the bottom of the spillway and observing their passage success. This should also be followed up with effective monitoring (see Section 5.2).

Pumping onto the spillway crest should ensure that a continuous wetted surface is provided for fish to enter the reservoir (*i.e.* water would be flowing in both directions from the crest). As long as a constant wetted surface is maintained, climbing fish are expected to continue their ‘upstream’ movement and drop into the reservoir once they pass the spillway crest. Ideally, cooler water from lower reservoir levels should be pumped onto the spillway crest to reduce thermal stress on migrating fish.

To ensure constant water flow through the flip bucket (and thus down the apron) during non-spilling periods, we recommend plugging the two drain outlets in the flip bucket with rubber bungs.

4.2. South Branch weir

4.2.1. Fish distribution

The South Branch weir is relatively low, so it ought to be possible to provide fish passage for migratory and non-migratory fish species from all swimming classifications (*i.e.* swimming, climbing, jumping and anguilliform; Table 1). Overall, six fish species have been found in the South Branch during fish distribution surveys (Table 3), with brown trout and upland bully the most frequently recorded species. The summer 2013 / 14 fish passage survey showed that fish are able to pass the weir, with all fish species seen below the weir also being found above the weir (Table 4), suggesting that the structure is not a complete barrier for resident South Branch fish species.

Similar to the North Branch, predicted probability of occurrence in the South Branch is high for longfin eel (Leathwick *et al.* 2008), indicating suitable habitat for this species upstream of the weir. However, the low number of records found during the various surveys for this species, which is listed as ‘At risk - Declining’ in the most recent threat listings (Goodman *et al*. 2014), is of concern and any improvements to native fish passage over the weir would be beneficial.

There were no records for shortfin eel in the South Branch in any of the recent fish distribution surveys conducted and predicted probability of occurrence is consistently low (< 1%) for reaches above the weir. Shortfin eel are equally good climbers as longfin eels and less sensitive to water quality pollution, although they do not tend to migrate as far inland. Although the probability of occurrence in the upper Maitai Catchment is low for shortfin eel, three individuals were found in the North Branch and targeted sampling to confirm the absence of this species in the upper South Branch would be interesting (see Section 5.2).

Kōaro were found in low numbers below and above the weir, which is more likely to be related to unsuitable habitat in the direct vicinity of the weir, rather than to major fish passage issues over the weir. Predicted probability of occurrence for kōaro was low in reaches adjacent to the weir (*i.e.* 24% below the weir and 22% above the weir), but was high (*i.e.* up to 80%; Leathwick *et al*. 2008) for reaches further upstream the South Branch and associated tributaries.

Although no shortjaw kōkopu were found during any of the fish distribution surveys, predicted probability of occurrence for this species is medium to high (69%; Leathwick *et al*. 2008) in the upper South Branch, indicating suitable habitat is present for this species. This species, like eel, kōaro, common bully and trout, is migratory and would require barrier-free access to the sea to complete its life cycle. Any modification to the weir to improve fish passage for the fish species currently recorded from the river is also expected to be beneficial for shortjaw kōkopu (see Section 4.2.3).
Upland bullies were found below and above the weir and along with kōaro, were seen actively attempting to climb the existing fish pass on the true left of the weir during the summer 2013 / 14 survey (Figure 14). Brown trout were well distributed throughout the South Branch with a range of sizes found above and below the weir, suggesting that the existing salmonid fish pass is functioning.

Figure 14. The upper part of the existing Maitai South Branch weir salmonid fish pass showing where kōaro and upland bully attempted to overcome the structure during low flow conditions (yellow arrow). Note: At high-flow periods (as seen in this picture), water velocity presents a passage barrier to all non-jumping fish species, such as kōaro and bully species.

4.2.2. Fish passage issues

Water temperature downstream of the back feed did not exceed 20.0°C for more than a total of 6.75 h between August 2013 and March 2014 and is therefore unlikely to restrict fish passage. However, we identified three other fish passage issues associated with the South Branch weir:

1. The back feed pipe creates an ‘attractant flow’ for migratory fish species

Migratory fish species are generally attracted to concentrated flow during their upstream migration as these, under natural conditions, indicate upstream passage. For this reason, it is generally recommended that fish pass entrances be located close to the main body of flow discharging from in-stream structures, to help fish with finding the entrance. Where large discharges enter a river, such as tributary streams they can act as an attractant flow for migrating fish. However, with artificial discharges, such as the back feed pipe at the South Branch weir, fish can be lead into a migratory ‘dead-end’.

Fish passage improvement recommendations are discussed in Section 4.2.3.

Figure 15. The back feed pipe discharges water from the Maitai Reservoir into the South Branch potentially acting as an attractant flow for migratory fish species.

2. High water velocities at the intake and lack of smooth wetted splash zone at its edge

Water from the South Branch is abstracted at an intake grid to supply Nelson City with drinking water (Figure 16). The drop over the weir at the intake results in high water velocities at and downstream of the structure. In combination with the lack of smooth wetted margin along the edges of the intake, that climbing species could adhere to this part of the weir probably presents an insurmountable fish migration barrier to all fish species present in the South Branch.

Figure 16. High water velocities over the Maitai River South Branch weir present a fish migration barrier.

3. The existing salmonid fish pass is likely to be difficult for native fish species that are climbers, anguilliform or swimmers.

The existing fish pass located on the true left of the river was built in the early 1980s to provide passage for salmonid fish species (*i.e.* trout and salmon) past the intake structure. It is a step-pool type pass, consisting of a bottom 'v-notch' weir and an upper step formed with a removable wooden board to maintain water levels in the upstream pool (Figure 17). The fish pass appears to be functioning well in its current state for salmonids, allowing upstream and downstream passage for trout of all size classes and ages, given the observed trout numbers upstream. However, our knowledge about fish passage requirements has considerably changed in the last 30 years and regional councils have specific responsibilities to manage fish passage in New Zealand's waterways under the Freshwater Fisheries Regulations (1983) and the Resource Management Act (1991) for all fish species.

Currently, the existing fish pass provides passage for jumping fish species that are able to leap using the recirculating water below each fall. It may also provide for non-jumping upstream migrating fish species to gain access up the first step on the true left along a wetted margin, during some flows (Figure 17). However, once non-jumping fish make it into the upper pool, their chance of overcoming the ‘upper step’ is very low, since water often jets out under the wooden board and there is a lack of wetted margins along the edges for climbing species to cling to. Remediation of these issues is described in detail in Section 4.2.3.

Figure 17. The existing fish pass installed at the true left of the Maitai River South Branch intake Weir was purpose-built for salmonid fish species (*i.e.* trout and salmon) that can jump over the ‘v-notch’ and the upper step, but will provide compromised passage for native fish species that are climbers, anguilliform or swimmers.

4.2.3. Fish passage recommendations

The fish passage improvement suggestions made for the South Branch weir relate to requirements for jumping, swimming and climbing fish species. During installation and construction of the fish passage structures, we recommend that an experienced fish ecologist is present to provide guidance and clarification on the fish passage improvements discussed below.

Reduce the attractant flow from the back feed pipe

The fish passage issues associated with the attractant flow created by the back feed pipe at the South Branch weir could be addressed in one of two ways. Either the discharge point could be moved closer to the fish pass location so that it would help attract fish to the pass, or the magnitude and duration of the water discharged from the back feed could be reduced. Having discussed this option with a Council engineer and environmental officer, we understand that the current back feed operating procedures are under review as part of the 2017 re-consenting process and discharge volume and periods are likely to be reduced. If this was the case, it would alleviate the issue caused by the attractant flow from the back feed.

Provision of smooth wetted margin at the weir intake

Fish passage at the weir intake can be improved for climbing species by providing a smooth wetted margin along the true left (Figure 18). The wetted margin should be constructed from concrete, incorporating existing rocks embedded in a concrete matrix. Additional cobble sized rocks (150 mm–200 mm) should be embedded haphazardly, rather than in uniform lines. The cobbles will not only lower water velocities, but also provide small pockets of water on the wetted margins that can act as resting areas for swimming fish species such as bullies. The wetted margin should ideally have a lateral slope of 35 degrees if possible. The splash zone created by the wetted margin should begin as far downstream of the intake as possible and reach all the way to the top, to minimise the slope.

During construction, water levels at the intake should be dropped as low as possible. Sandbag coffer dams may need to be used for the construction area to be dewatered. This would reduce the likelihood of high pH water poisoning aquatic organisms in the vicinity through concrete contamination. Nelson City Council should also consider the appropriate management of the drinking water supply to avoid contamination during any construction activities.

Figure 18. Providing a smooth wetted margin on the true left of the weir will facilitate upstream fish passage for climbing fish species during all flow conditions.

Retrofit existing salmonid fish pass to provide passage for non-jumping fish species

We recommend six retrofits to the existing step-pool salmonid fish pass to improve fish passage for non-jumping fish species (Figure 19).

1. Reconstruct water level regulator (wooden board): Ensure that the bottom of the board forming the upper step of the pass is sealed so that water flows only over the top. This would remedy the current problem of high velocity water jetting under the board.
2. In addition to point 1, taper the true left of the board to an angle of 5 degrees to concentrate flow to this side during low flow periods.
3. Bevel the square edged concrete back on true left from the top of the board to remove hard edge (right angle) transitions for climbing fish.
4. Construct a sloped wetted margin on the true left immediately below the upper step: To enable non-jumping fish species to pass the upper step, construct a splash zone with a concrete and cobble wetted margin on the true left bank of the river which is connected to the tapered lower side of the retrofitted board. The surface of the concrete and cobble ramp should be slightly rough to provide traction for ascending fish and should be at a lateral slope at an approximate angle of 35 degrees. Existing rock structures should, if possible, be incorporated when constructing the wetted edge, or else, the same methodologies described for the weir rock ramp should be followed.
5. Fill in the leak, adjacent to the large boulder, immediately above the bottom step on the true left. Concrete and cobble infill should be used to stop water seeping

underneath this large boulder so that flow is redirected over the v-notch native fish pass.

6. Cut the concrete on the true left of the existing lower step to a 35 degree angle to allow fish passage at a range of flows. Construct a concrete and cobble rock ramp along the true left edge of the lower weir, following the methodology described above.

Figure 19. Suggested retrofits to the existing salmonid fish pass to allow fish passage for non-jumping fish species.

5. ONGOING CONSENT CONDITIONS AND FISH MONITORING RECOMMENDATIONS

5.1. Trap and transfer of eel and kōaro over the Maitai Dam

Current NCC Maitai Consent conditions RM025151/1 state that the consent holder:

> "*shall in each year […] carry out a relocation from the lower reaches of the Maitai River to the dam reservoir of up to 200 eels of differing size. […] This condition shall not apply if the Department of Conservation advises the consent holder that it is not to apply for any particular year or years*".

Apart from three eel transfers over the dam in 2007, 2008 and 2014 (*i.e.* 70, 50 and 23 eels, respectively), no further transfers have taken place due. This has been due to unsuitable river conditions and not acquiring a replacement permit (pers. comm. Alex Miller, NCC).

Sampling indicated that eel and kōaro numbers upstream of the Maitai Dam are low and biased towards medium (kōaro) and small (longfin eel) size classes. Eel and kōaro populations are expected to grow in the Maitai River North Branch after fish passage improvements have been put in place. However, until further fish population assessments have been conducted (see Section 5.2), we recommend additional transfer of both these species from the Maitai River main stem into the Maitai River North Branch as an interim measure. This will provide information as to whether to continue to support fish passage into the future.

Eel transfer

We recommend the transfer of at least 100 eels of varying sizes (*i.e.* < 100 mm–> 500 mm). Current consent conditions recommended trapping as a sampling methodology to catch eel species. However, high river flows over the migration period have previously inhibited this, resulting in no fish (or very low numbers) being transferred over the last seven years. We therefore recommend a combination of electric-fishing and trapping / netting downstream of the dam (Maitai River main stem) during summer months (*i.e.* November–February). In addition, we recommend the collection of elver by hand-picking them off the spillway / apron as they attempt to migrate upstream. This was done during the summer 2013 / 14 fish passage survey and 55 elver were collected and transferred into the reservoir. Elver upstream migration peaks in December–February (Table 2) and the summer 2013 / 14 fish passage survey showed that juvenile eels congregated at the apron and below the spillway construction joints at the end of January / beginning of February, where they could easily be collected for transfer.

Kōaro transfer

Currently, kōaro are sparsely distributed in low numbers in the Maitai catchment. However, predicted probability of occurrence is high (82%) for this species in the North Branch. Until specific sampling is undertaken to assess the kōaro population in the North Branch (see Section 5.2), we recommend an annual transfer of 20 individuals of varying sizes (*i.e.* < 50–>150 mm) from the Maitai River Main Branch into the North Branch. Kōaro can either be trapped (*e.g.* using Gee-minnow traps) or netted as whitebait in the lower catchment, electric-fished or hand-picked of the apron / spillway to attain the numbers required. Sampling should occur between August–February each year to ensure fish of varying sizes are transferred.

5.2. Fish monitoring recommendations

5.2.1. Quantitative fish passage survey over the dam

At the time of writing this report, it is anticipated that fish passage improvements at the Maitai Dam are scheduled to be completed prior to June 2015. This would allow one year of pre-remediation monitoring and two years of post-remediation monitoring prior to the re-consenting hearing in 2017.

Ideally, monitoring would compare the proportion of fish successfully passing the spillway between pre- and post- remediation installation. This requires monitoring numbers of fish that start the ascent (at the bottom of the spillway) as well as numbers successfully passing the spillway crest.

The survey could include the installation of some form of a bucket / net at the top of the spillway that traps any fish that successfully passed the spillway. The net would need to be emptied regularly (perhaps daily, depending on fish numbers) between November 2014–March 2015. In addition, cameras with night vision would need to be installed on either side of the spillway, recording any fish beginning their ascent of the spillway.

5.2.2. Additional assessment of kōaro and eel populations in the North and South branches including their tributaries

Sampling efforts to determine kōaro and eel populations (longfin and shortfin) in the North and South Branches have mainly focussed on areas in the direct vicinity of the Maitai Dam and South Branch weir. The furthest upstream that fish have been surveyed, according to the NZFFD, is 2 km above the South Branch weir and 500 m upstream of the Maitai Dam. No fish surveys have been undertaken in any of the upper Maitai catchment, nor its tributaries. This means that current fish distribution knowledge in the upper Maitai catchment is based on localised fish surveys.

Semi-quantitative fish sampling in the upper South and North branches, including tributaries, for two summers prior to the re-consent hearing (*i.e.* 2014 / 15 and 2015 / 16) would be useful to fill in knowledge gaps. Ideally, the surveys should include a combination of night-time spotlighting (two visits per branch per summer) and electric-fishing (two visits per branch per summer) sometime between November and March during each summer.

Furthermore, the probability of occurrence (Leathwick *et al*. 2008) for shortjaw kōkopu was predicted to be medium to high in the South and North branches and their tributaries (69% and 85%, respectively) and additional sampling to see whether shortjaw kōkopu are actually found in these areas would be useful. The survey recommended to assess the kōaro and eel populations would also identify if shortjaw kōkopu are present. If shortjaw kōkopu are found to be present in the upper Maitai River catchment, consent conditions may need to be adjusted accordingly, potentially including trap and transfer for this species.

In addition, although not required for re-consenting, we recommend Council sample Maitai River main stem tributaries (such as Sharland and Groom creeks) for eel and kōaro presence. These tributaries are likely to be valuable fish juvenile recruitment sources for the upper Maitai River catchment and might need some form of specific protection.

6. REFERENCES

Allen C, Kelly D, Holmes R, Jiang W 2014. Longitudinal assessment of the health of the Maitai River: The influence of the Maitai Reservoir. Prepared for Nelson City Council. Cawthron Report No 2552.

Boubée JA, Jowett IG, Nichols S, Williams E 1999. Fish passage at culverts: a review, with possible solutions for New Zealand indigenous species. NIWA report for the Department of Conservation, New Zealand. Prepared for NIWA client report. 29 p.

Charteris SC 2007. Native fish requirements for water intakes in Canterbury. Unpublished Department of Conservation publication. Christchurch. (docdm-27440).

David B, Hamer M, Tonkin J, Bourke C 2014. Appropriate use of mussel spat ropes to facilitate passage for stream organisms. Waikato Regional Council Technical Report 2014/29.

Goodman JM, Dunn NR, Ravenscroft PJ, Allibone RM, Boubee JAT, David BO, Griffith M, Ling N, Hitchmough RA, Rolfe JR 2014. Conservation Status of New Zealand Freshwater Fish, 2013. New Zealand Threat Classification Series 7. Department of Conservation, Wellington. 12 p.

Grainger N, Collier KJ, Hitchmough R, Harding JS, Smith B, Sutherland D 2013. Conservation Status of New Zealand freshwater invertebrates, 2013. New Zealand Threat Classification Series 8. Department of Conservation. Wellington. 28 p.

Holmes R 2009. Maitai River South Branch Consent Compliance (2008-2009). Prepared for Nelson City Council. Cawthron Report No. 1659. 31p.

Holmes R 2010. The Potential for Metal Contamination in the Maitai River. Prepared for Nelson City Council. Cawthron Report No. 1850. 11 p.

Holmes R 2012. Maitai River South Branch Consent Compliance (2011-2012). Cawthron Report No. 2250. 28 p. plus appendices.

Joy MK, David B, Lake MD 2013. New Zealand Freshwater Fish Sampling Protocols. Part 1. Wadeable Rivers & Streams. The Ecology Group - Institute of Natural Resources. Massey University. Palmerston North.

Kelly D, Shearer KA 2013. Maitai Reservoir and North Branch Habitat Survey 2013. Prepared for Nelson City Council. Cawthron Report No. 2359. 49 p. plus appendices.

Leathwick JR, Julian K, Elith J, Rowe DK 2008. Predicting the distributions of freshwater fish species for all New Zealand's rivers and streams. Prepared for Department of Conservation under the Terrestrial and Freshwater Biodiversity Information System (TFBIS) programme. NIWA Client Report: HAM2008-005. 56 p.

Mitchell CP 1989. Swimming performances of some native freshwater fishes. N Z J Mar Freshwater Res 23: 181-187.

NZFFD; National Institute of Water & Atmospheric Research (NIWA) New Zealand Freshwater Fish Database, http://www.niwa.co.nz/our-services/databases/freshwater-fish-database, accessed on 15/08/2014.

Olsen D 2010. Maitai River South Branch Consent Compliance (2009-2010). Prepared for Nelson City Council. Cawthron Report No 1846. 41p.

Olsen DA, Tremblay L, Clapcott J & Holmes R. 2011. Water temperature criteria or aquatic biota. Prepared for Auckland Council, Environment Waikato and Hawkes Bay Regional Council. Cawthron Report No. 2024. 80p. plus appendices.

Payne D 2007. Maitai Dam drought storage study for 2055. Opus consulting Report 3AW513.00. 19 p.

Richardson J, Boubee JAT, West DW 1994. Thermal tolerance and preference of some native New Zealand freshwater fish. Cawthron Report No. 4. 399-407 p.

Rowe D, Kusabs I 2007. Taonga and mahinga kai of the Te Arawa lakes: a review of current knowledge - Kōaro. NIWA client report HAM2007-022. 33p.

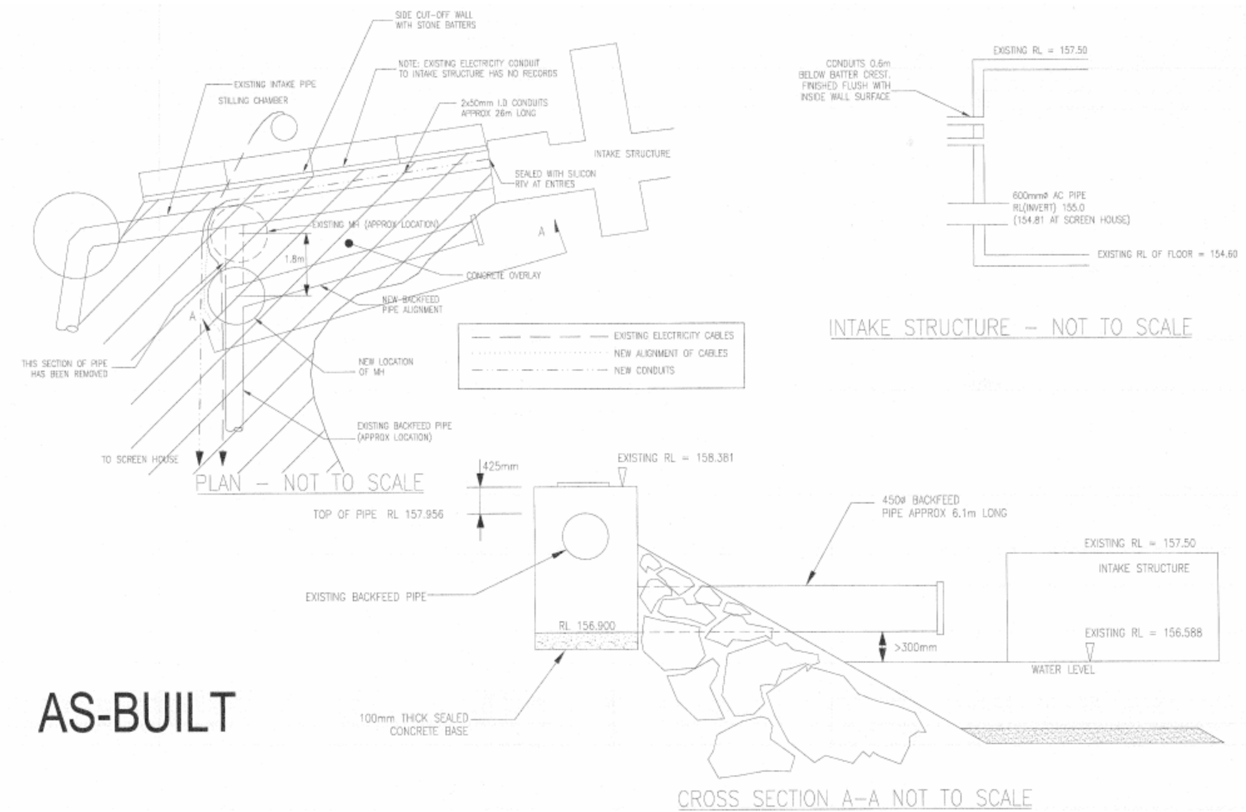
Stancliff AG, Boubee JAT, Mitchell CP 1989. Cross-channel movement of small migratory fish and shrimps in the Waikato River near Huntly thermal power station. Prepared for Electricorp. New Zealand Freshwater Fisheries Report 107: 30 p.

Taylor MJ 1988. Features of freshwater fish habitat in South Westland, and the effect of forestry practices. Fisheries Environmental Report 97. New Zealand Ministry of Agriculture and Fisheries.

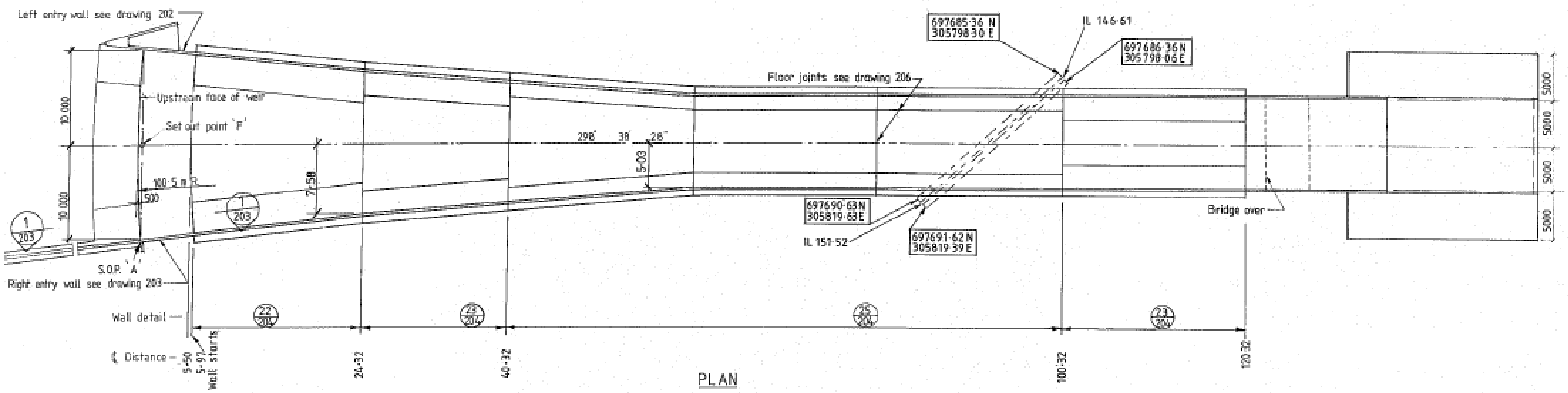
Young RG, Clark K 2006. Native fish distribution in the Nelson City Council Area. A report for the Nelson City Council. 11 p.

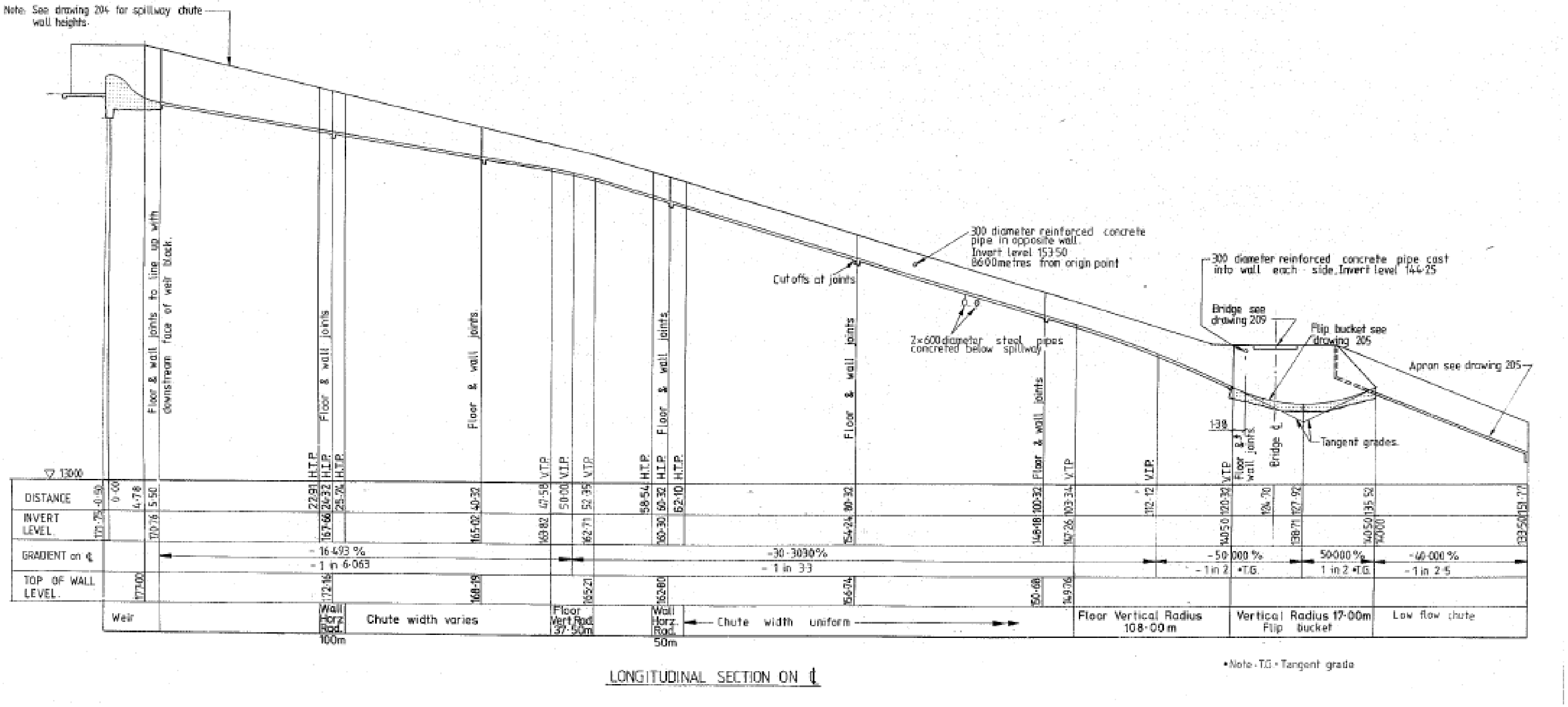
7. APPENDICES

Appendix 1. Technical details of the Maitai River South Branch back feed.



Appendix 2. Technical details of the Maitai Dam spillway (Source: Nelson City Council, 1987).





LONGITUDINAL SECTION ON ℄

Appendix 3. Technical details of the Maitai Dam flip bucket and apron (Source: Nelson City Council, 1987).

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