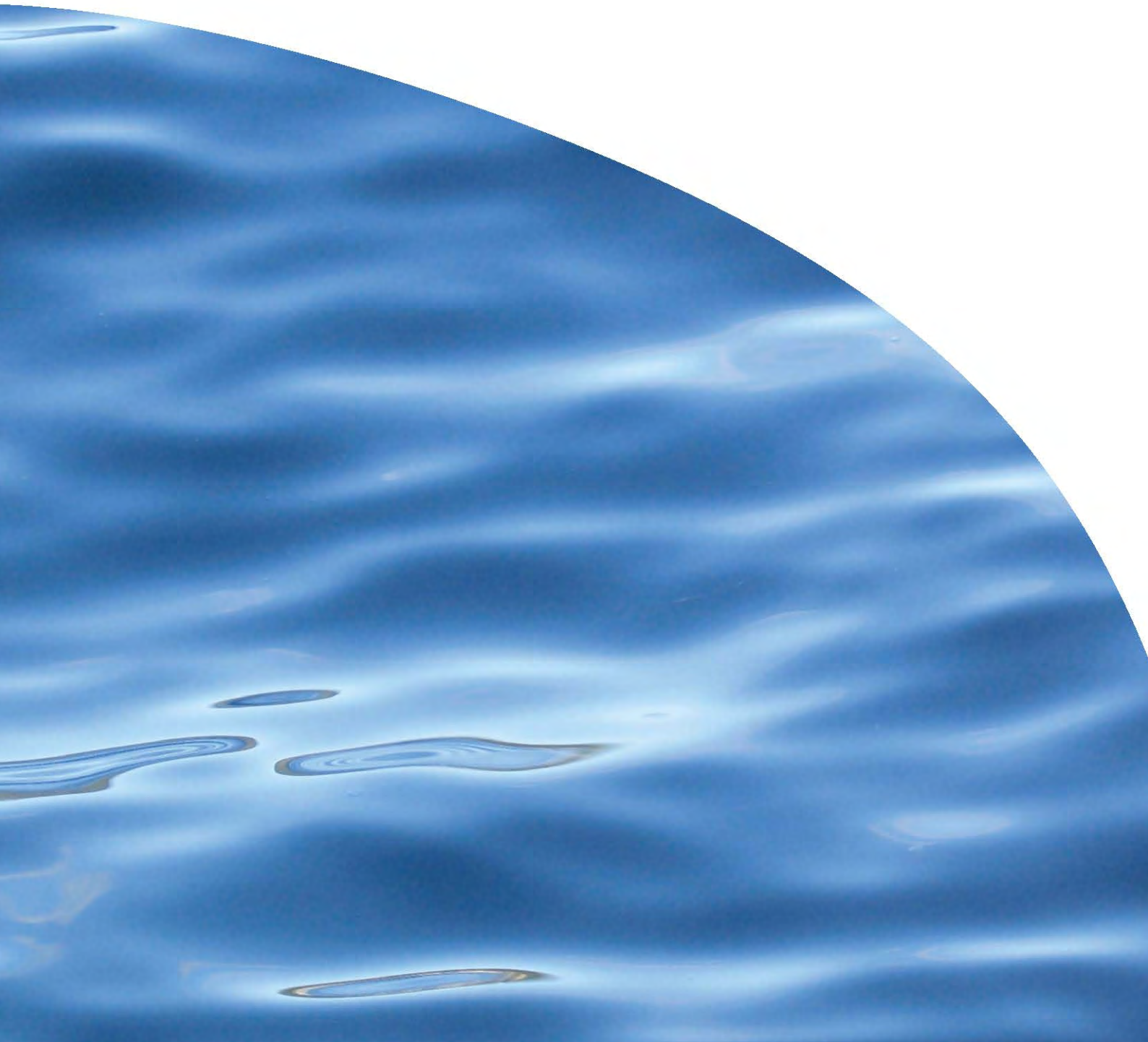
CAWTHRON INSTITUTE

REPORT NO. 2730

MAITAI SOUTH BRANCH WEIR FISH PASSAGE REMEDIATION EFFICACY MONITORING



MAITAI SOUTH BRANCH WEIR FISH PASSAGE REMEDIATION EFFICACY MONITORING

JOE HAY, MITCHELL CHANDLER, DAVID KELLY

Prepared for Nelson City Council

CAWTHRON INSTITUTE
98 Halifax Street East, Nelson 7010 | Private Bag 2, Nelson 7042 | New Zealand
Ph. +64 3 548 2319 | Fax. +64 3 546 9464
www.cawthron.org.nz

REVIEWED BY:
Rasmus Gabrielsson

APPROVED FOR RELEASE BY:
Roger Young

ISSUE DATE: 23 June 2015

RECOMMENDED CITATION: Hay J, Chandler M, Kelly D. 2015. Maitai South Branch weir fish passage remediation efficacy monitoring. Prepared for Type in client name. Cawthron Report No. 2730. 17 p.

1. INTRODUCTION

Nelson City Council (NCC) has recently undertaken remediation work to improve fish passage over the water intake weir on the South Branch of the Maitai River (Figure 1). This remediation work was based on recommendations made by Doehring and Hay (2014), in a report commissioned by NCC to assess fish passage at the Maitai Dam and the Maitai South Branch weir, prior to re-consenting of the Maitai Water Supply Scheme in 2017.

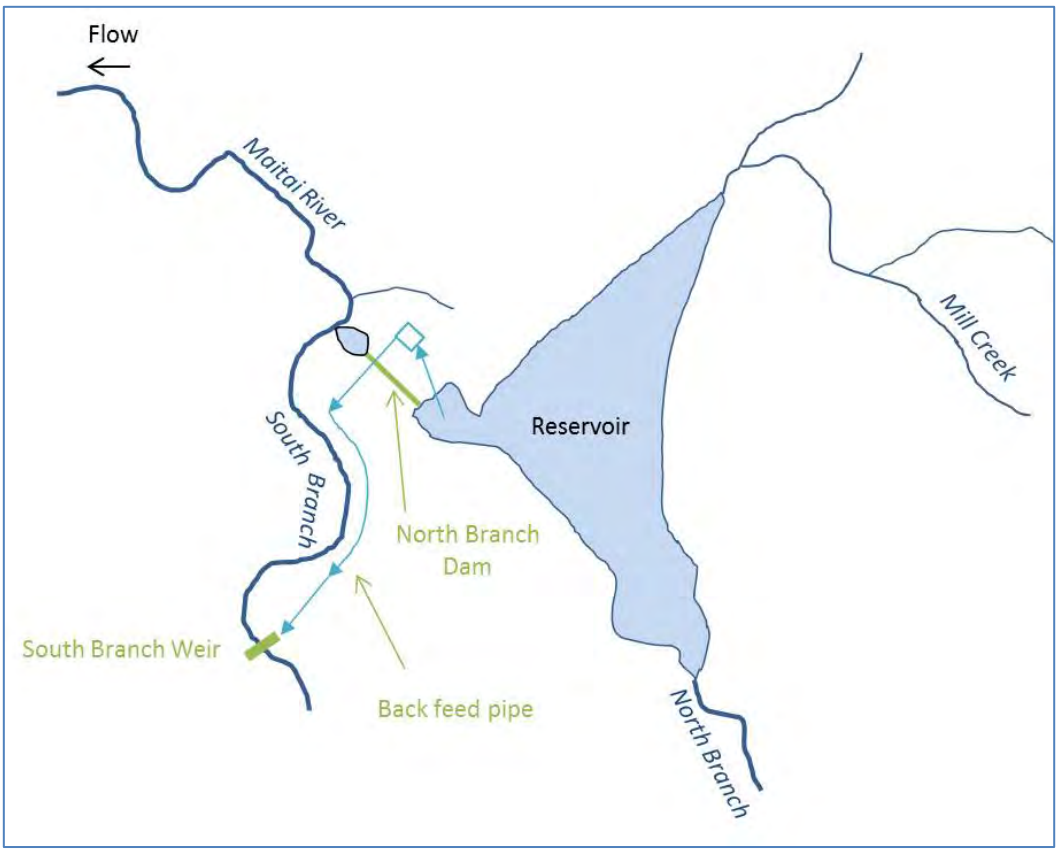


Figure 1. Schematic diagram of the Maitai Water Supply Scheme showing the locations of the Maitai Dam, the South Branch weir and the back-feed pipe in relation to the reservoir (not to scale).

Doehring and Hay (2014) also made recommendations for improving fish passage over the Maitai Dam spillway. Most of those recommendations have also recently been completed. However, this work was not completed in time for the summer (2014/15) upstream elver migration season. Hence, an assessment of the efficacy of these changes cannot yet be made.

This report includes:

- A summary of the remediation work undertaken at both the South Branch weir and Maitai Dam spillway.
- Discussion of the results of fish monitoring work undertaken during summer 2014/15 around the South Branch weir (and limited observations at the Maitai Dam spillway).
- Recommendations for further work.

Field monitoring undertaken as part of this investigation was funded through a Project Maitai summer student scholarship[1], sponsored by NCC.

2. SOUTH BRANCH WEIR

2.1. Fish passage remediation work

2.1.1. Remediation recommended

Doehring and Hay (2014) identified the following key fish passage issues at the South Branch weir:

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 was likely to be difficult for native fish species to pass.

To address these issues the following fish passage remediation actions were recommended:

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.

[1] Survey work was primarily undertaken by Mitchell Chandler, studying toward a BSc at Otago University. He was assisted in the field by Cawthron staff and other summer students.

2. Fish passage at the weir intake could be improved for climbing species by providing a smooth wetted margin along the true left side, using cobbles set in a concrete matrix.

3. Six retrofits to the existing step-pool salmonid fish pass to improve fish passage for non-jumping fish species were recommended:

    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 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 on the 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.

2.1.2. Remediation undertaken

On 2 December 2014 all of the remediation works recommended under points 2 and 3 of the list above were carried out (Figure 2 and Figure 4).

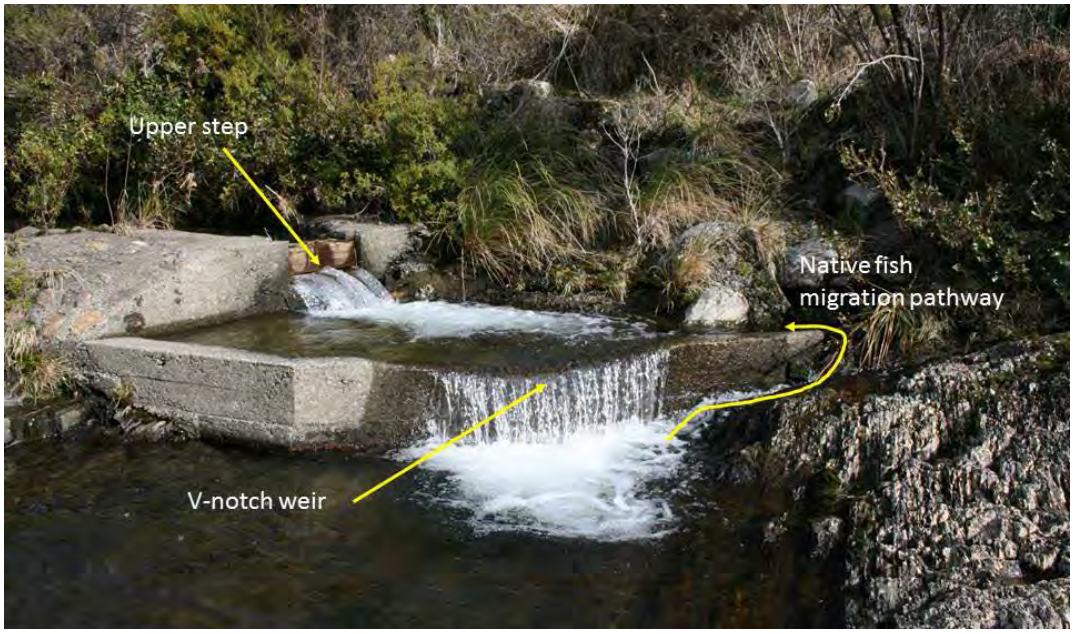


Figure 2. Step-pool fish pass on true left of the Maitai South Branch weir, prior to remediation work.

Figure 3. Step-pool fish pass on true left of the Maitai South Branch weir, following remediation work. Numbered arrows indicate remediation undertaken, with numbers referring to the points outlined under heading 3 of the recommended remediation actions in section 2.1.1, above. Note: river flow in this image is substantially lower than in Figure 2.

Figure 4. The water intake screen in the Maitai South Branch weir, showing the smooth wetted margin constructed with epoxy cement as part of the remediation works (highlighted within the white oval). Insert shows the screen prior to remediation.

No action has currently been undertaken to address the issue of the back-feed attractant flow.

2.2. Fish passage monitoring

2.2.1. Methods

Spotlight surveys

During January 2015 three spotlight surveys were carried out (on the nights of 15, 22, and 27 of January) in order to assess the distribution of fish in the vicinity of the weir (110 m upstream and downstream, respectively).

Spotlighting is a rapid survey method generally used to target small areas of interest for nocturnally active fish. It is most effective in shallow pools and run habitats where a calm water surface allows for good visibility into the water. The sampling methodology used was based on that outlined in New Zealand Freshwater Fish Sampling Protocols (Joy et al, 2014). Reaches were surveyed in an upstream direction, in 10 m subsections.

Observations were also made of fish attempting to pass the weir during these spotlight surveys.

Infrared Video Surveillance

In addition, video surveillance was used to monitor two alternative routes over the weir:

1. The step-pool fish pass on the true left of the river (for one night 28 January 2015).

2. The ramp on the true left of the intake screen (over two nights, 4-5 February 2015).

The video camera was fitted with an infrared lens and an infrared light source and was set up to monitor the top section of each fish pass. The camera was set to record at one frame per minute.

This video footage was used to quantify fish moving through the fish passes and estimate climbing speeds over the passes. To count fish using the passes, footage was replayed at twice normal play back speed — to help make detection of movement easier and to reduce total play back time and therefore reduce observer fatigue. The observer used a push button counter to record fish seen passing through the field of view. Each night of footage was watched three times, in random order, to give an average count for each night.

For a subset of nine observed elvers, the time signature on the first and last frames in which they were visible in the camera field of view was noted. These data, along with a measurement of the height of the pass covered by the field of view, were used to calculate an approximate average climbing speed.

2.2.2. Results and discussion

Spotlight surveys

Four fish species were recorded in the immediate vicinity of the South Branch weir during spotlighting observations undertaken in January 2015 (Table 1). Of these, two species (redfin and upland bully) were recorded downstream of the weir only, while the other two were recorded at significantly lower abundance upstream of the weir than downstream (Poisson ANOVA with Chi test, brown trout $P < 0.001$, longfin eel $P = 0.037$). These data suggest that the weir remains an impediment to upstream fish passage (although it does not represent a total block).

The numbers of longfin eels observed above and below the weir on the last survey occasion were more similar than on the previous two occasions (Table 1). Although this may simply be an artefact of sampling, it could be interpreted as suggesting that

longfin eels were passing upstream over the weir, supporting the observations discussed below.

Table 1. Fish observed during spotlight surveys in January 2015, in the vicinity (110 m upstream and downstream, respectively) of the Maitai South Branch water intake weir.

	Date	15/01/2015	22/01/2015	27/01/2015
	Maitai South Branch flow (m^3/s)	0.249	0.227	0.197
	Species	**Total Count**	**Total Count**	**Total Count**
Below weir	longfin eel (*Anguilla dieffenbachia)*	19	9	14
	brown trout (*Salmo trutta)*	42	24	33
	upland bully (*Gobiomorphus breviceps)*	1	0	1
	redfin Bully (*Gobiomorphus huttoni)*	1	0	1
Above weir	longfin eel	10	2	13
	brown trout	9	8	13

In addition to the eels recorded in Table 1, elvers (small juvenile eels) were observed attempting to climb over the weir during each of the three spotlight surveys. The vast majority of these were observed attempting to climb over wet rocks in the splash zone of the back-feed discharge and around the pipe end, with more than 100 elvers observed in this area during each of the first two surveys. These elvers appeared unable to pass over the weir in this area, due to the lack of a continuous wetted route on this side of the river.

By contrast, lower numbers of elvers were observed attempting to climb over the weir via the other two routes, where remediation work had been done. However, some successful passage was observed, especially via the wetted splash zone adjacent to the intake screen in the middle of the weir. Elvers were observed attempting to climb this route (Figure 5) on each of the three surveys (counts of 3, 6, 7, respectively), with individuals being observed successfully passing upstream on the second and third surveys.

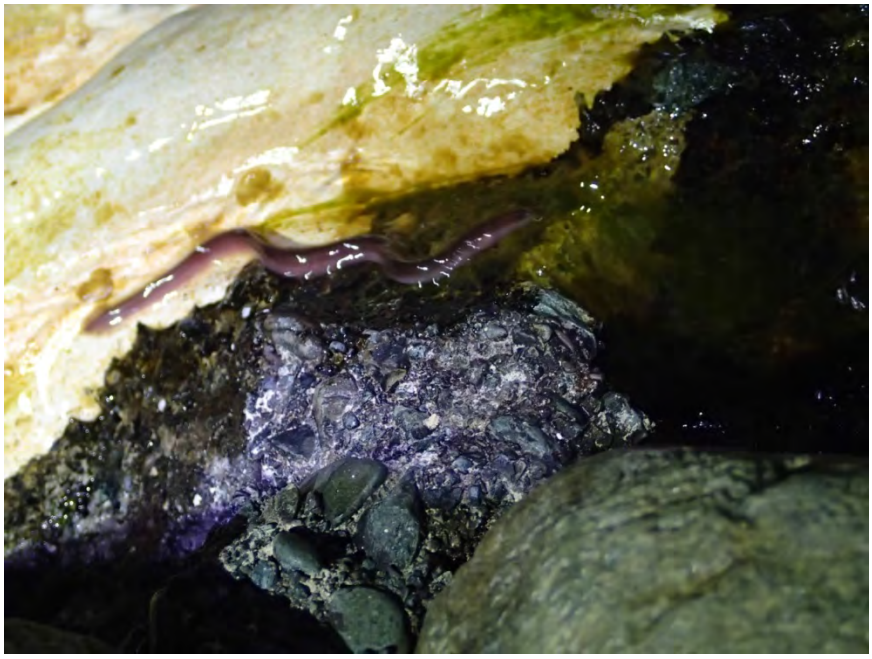


Figure 5. Elver attempting to climb the wetted edge constructed on the true left of the intake screen at the Maitai South Branch weir.

Only two elvers were observed attempting to climb the modified step-pool fish pass on the true left of the river. These elvers were both observed during the first spotlight survey. One was observed beginning to climb at the very bottom of the lower step, while the other was climbing the vertical face of the wooden water level regulator board that forms the top of the upper step of the pass. The low rates of use of this fish pass are almost certainly due to the lack of attractant flow to draw fish to this route. The fish pass conducts a negligible flow compared with discharge from either the back-feed or over the intake screen (as recognised in the recommendations of Doehring and Hay 2014).

By contrast the wetted splash zone adjacent to the intake screen in the middle of the weir has a substantially larger attractant flow, while the back-feed discharge appears to be the dominant attractant flow across the weir ─ although this is likely to vary with the rate of discharge from the back-feed. During January and February the back-feed discharge ranged between 0 - 314 L/s, median 156 L/s. During this same period the median flow at the Maitai Forks recorder was 269 L/s, suggesting that the back-feed discharge contributed close to 60% of the median flow over this period. The disparity in numbers of elvers observed attempting to climb the weir by each of these three routes serves to illustrate the critical importance of attractant flow to successful fish passage design.

No other species were observed attempting to climb the weir by any route during these surveys.

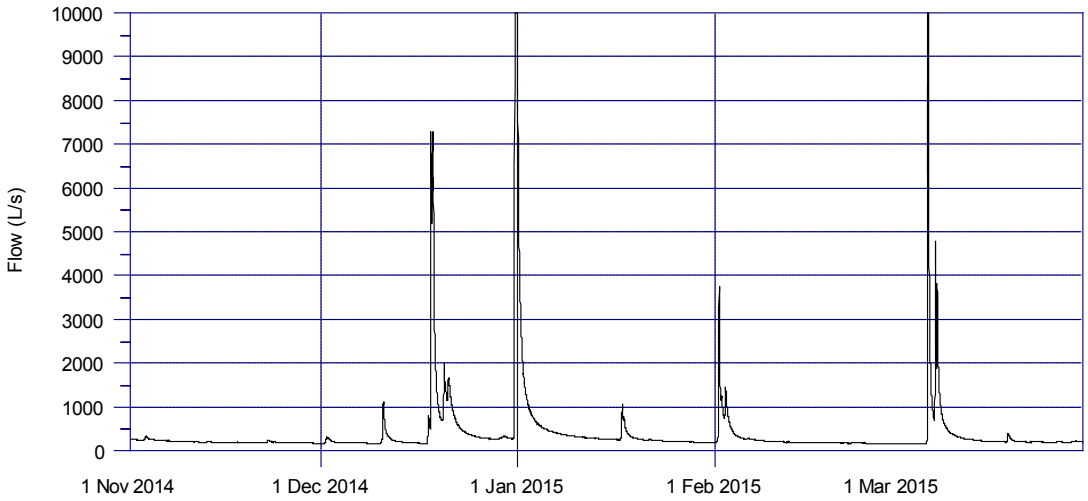


Figure 6. Hydrograph showing flow in the Maitai South Branch upstream of the water supply weir during the summer of 2014/15.

The spotlight surveys were conducted during relatively low flows only (range 0.197 – 0.249 m^3/s, *c.f.* 7- day mean annual low flow 0.161 m^3/s in the South Branch above the weir). This reflected the fact that flow was reasonably low and stable through most of the period covered by the surveys (i.e. mid-January to early February) (Figure 6). These consistently low flows may have influenced the number and variety of fish attempting to migrate upstream during this period. Elevated flow events can act as a trigger for migration in many species (Jellyman 2012, Hay and Kitson 2013), with increased flow either stimulating or enabling fish movement. Also the very low flows may have influenced use of the step-pool weir. At higher flow this pass would conduct more flow, which may attract more migrants to it. However, it is still likely to represent a comparatively minor proportion of the total flow discharging downstream of the weir and so would not be expected to attract a large proportion of upstream migrants.

No kōaro were observed in the vicinity of the South Branch weir during the January spotlight surveys. However, kōaro were observed during spotlight surveys in the same area during the previous summer (2013/14), both upstream and downstream of the weir, including two juvenile kōaro seen attempting to climb the step-pool fish pass on the true left of the weir (Doehring and Hay 2014). Like elvers, juvenile kōaro are adept climbers. Subsequent spotlighting and electric fishing surveys (conducted on behalf of NCC during April 2015) further up the South Branch and in Wrey Creek (a tributary of the South Branch upstream of the reservoir) also show that kōaro must be passing the weir, albeit in relatively low numbers.

Infrared Video Surveillance

Video footage reinforced the spotlighting observations of relative intensity of use of the two alternative fish passage routes (true left step-pool pass versus ramp adjacent to intake screen) by elvers. Only a single elver was observed passing the step-pool fish pass on the true left bank. This elver climbed the vertical face of the wooden water level regulator board, forming the top step of that pass, rather than the lower gradient rock ramp constructed as part of the remediation works.

By contrast, approximately 30 elvers per night (average count 28 and 32 on the two nights, respectively) were observed to pass over the weir via the ramp on the true left of the intake screen.

The subset of nine elvers for which climbing speed was calculated moved through the camera field of view (approximately 0.4 m) in an average of 9.56 minutes (range 5 -18 minutes). Thus, their average climbing speed was approximately 0.04 metres per minute (or 2.5 m per hour), although there was considerable variation in individual climbing speeds (range 4.8 to 1.3 metres per hour).

2.2.3. Further recommendations to manage back-feed discharge attractant flow

The propensity of the back-feed discharge to attract upstream migrating fish into a migratory dead end was recognised by Doehring and Hay (2014) (as discussed in section 2.1.1). This remains a key issue for fish passage at the South Branch weir. This contention is supported by the large numbers of elvers observed attempting to climb the wet rocks in the splash zone around the back-feed, as well as on the back-feed pipe itself. Doehring and Hay (2014) suggested two possibilities to alleviating this issue:

1. moving the discharge point close to the fish pass entrances, or

2. by reducing the frequency and duration of discharge.

Another option that would help to address this problem, at least for strong climbing migrants (e.g. kōaro and eel elvers), would be to connect the splash zone from the back-feed to the water above the weir, with a continuous wetted surface or channel. This idea has been discussed on site with Alex Miller (NCC Investigator/Contracts Supervisor) and he expressed support for the concept. Two alternative approaches to achieve this were discussed (Figure 7).

Figure 7. Two options for connecting the back-feed splash zone below the Maitai South Branch weir with the water upstream on the true right of the river. Option 1: Cut new flow path, approximately following blue line. Option 2: Pump water to approximately position of oval, and let water spill back both directions from this point, approximately following white lines.

With respect to fish passage, the ideal situation would still be to move the back-feed discharge point close to the entrance of the step-pool fish pass on the true left bank (or construct something similar, such as a rock ramp pass, close to the existing back-feed discharge point on the true right). This would help attract upstream migrating fish to the fish pass and would have potential benefits for weaker climbers than elvers and kōaro, since the step-pool pass provides a lower gradient passage alternative. However, the options depicted in Figure 7 offer a lower cost mitigation possibility for strong climbing migrants. It is possible that under higher flows the true left step-pool passage may offer more effective passage for poorer climbing species than observed in this study. It is recommended that some additional surveillance work be conducted under a wider range of flows.

3. MAITAI DAM SPILLWAY

3.1. Fish passage remediation work

3.1.1. Remediation recommended

To improve fish passage over the dam Doehring and Hay (2014) recommended:

- Construction of concrete bevel inserts along either side of the apron / spillway. These were intended to provide a sloping wetted splash zone that climbing fish species can adhere to (using surface tension) to rest on and to climb.

- 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 were also recommended for the apron below the flip bucket lip.

- Installation of a pump to deliver water from the reservoir to the spillway crest, at times that the reservoir water level is too low for spilling to occur, to ensure continuous flow down the spillway during summer migration periods. Cool water from mid-lower levels of the reservoir could be used to reduce the possibility of thermal stress for fish attempting to climb the spillway.

- Plugging the drainage outlets in the flip bucket with bungs to maintain the pool that usually forms in this bucket when spilling occurs.

3.1.2. Remediation undertaken

Figure 8 illustrates the fish passage remediation work undertaken on the Maitai Dam spillway. All of the recommendations from Doehring and Hay (2014) were implemented, with the exception of the concrete bevel inserts along either side of the apron / spillway.

Figure 8. Fish passage remediation works undertaken in late March 2015 on the Maitai Dam spillway: a) pump delivering water to the spillway crest (reservoir water level >1 m below the crest), b) paired spat ropes fixed along the true right edge of the spillway from above the crest to the spillway and continuous flow provided by pump in previous image, c) close up of paired spat ropes where the spillway enters the flip-bucket, d) synthetic turf lined ramp at downstream end of flip-bucket, e) paired spat rope continues below flip-bucket ramp into plunge pool below spillway.

3.2. Fish passage observation

As mentioned previously, the fish passage remediation work undertaken on the Maitai Dam spillway, was not completed in time for this summer migration season. Hence, no formal fish passage monitoring was undertaken at the spillway over this summer. The spillway was dry for much of the 2014/2015 summer, effectively precluding fish passage for long periods (Figure 9). However information on when the spillway was spilling was not available in real-time and spotlight surveys in the vicinity did not coincide with spilling.

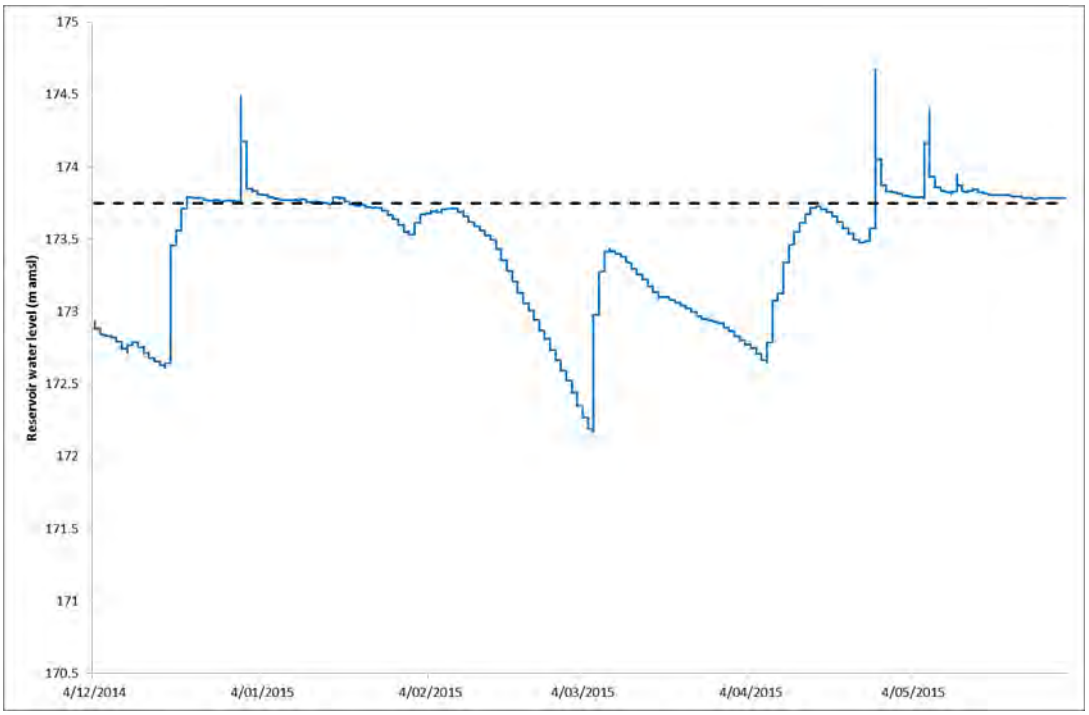


Figure 9. Time series of variation in the Maitai reservoir water level during summer 2014/15, with the dashed horizontal line indicating the level of the spillway crest (i.e. the level above which water would begin to flow down the spillway).

Nevertheless, a casual spotlight observation at the base of the spillway on the night of 15 January 2015 found 17 elvers attempting to climb the true right of the spillway immediately above the plunge pool. The spillway and flip-bucket were dry at this time, with the dam having stopped spilling early in the morning of that day. However, these

elvers were attempting to climb a trickle of water issuing from one of the flip bucket drains (visible in the top right of Figure 8). This trickle of flow almost certainly represented a migratory dead-end.

The efficacy of the remediation work remains to be seen through monitoring during the migration season next summer. The continuous wetted surface ought to make a considerable difference to passage opportunity for elvers and kōaro compared to the current situation where the spillway can be dry for extended periods.

As discussed by Doehring and Hay (2014) monitoring would , ideally, compare the proportion of fish successfully passing the spillway between pre and post-remediation installation. Formal pre-remediation installation monitoring was not carried out this summer, but since the spillway was dry for most of the summer migration season the opportunity for fish passage was effectively close to nil. Efficacy monitoring of passage success next summer (2015/16) requires observing numbers of fish that start the ascent (at the bottom of the spillway) as well as numbers successfully passing the spillway crest, to provide an estimate of the proportion successfully passing upstream (see Doehring and Hay 2014).

Given the climbing speeds calculated for the South Branch weir (section 2.2.2), passage times over the spillway could be excessively long to allow more than a few individuals to pass. The total length of the spillway is approximately 151 m (Doehring and Hay 2014). Therefore, passage times could be in the range of 31.5 - 116 hours (based on climbing speeds at the weir of 1.3 – 4.8 m per hour), which translates to 4 - 15 days. It is likely that attrition rates will be high with a climb of this magnitude. Notwithstanding this point, elvers were found most of the way up the spillway (at least as far as immediately below the short steep section at the crest) during spotlight surveys conducted in the summer 2013/14, prior to the remediation work (Doehring and Hay 2014). This illustrates the tenacity of these strong migrants. Additional resting habitat provided by the spat ropes could potentially assist in this multi-day migration. It is fortunate that the true right of the spillway remains shaded by the side walls even during summer, reducing the potential thermal stress on elvers that may be caught out on the spillway during the day.

Given the apparent degree of difficulty for elvers of scaling the spillway, it would be prudent to continue with existing trap and transfer operations to augment fish numbers passing the dam. As recommended by Doehring and Hay (2014), the trap and transfer operation should be extended to include kōaro as well as elvers, and the methods of capturing fish for transfer should be extended to include electric-fishing as well as trapping/netting.

Two minor improvements/alterations to the existing spillway remediation works are recommended at this stage, to be undertaken over winter (i.e. prior to the next migration season):

1. The ramp providing access to the spillway flip-bucket should have the upper end slightly dished into the flip-bucket lip (Figure 10), so that water flowing out of the flip-bucket preferentially flows down this ramp, during periods of low flow. Currently, water spills around the ramp (Figure 10), potentially making it difficult for climbing migrants to find their way onto the ramp.

2. Consideration should be given to the source water quality of water pumped to the spillway crest, during periods when the dam is not spilling naturally. Doehring and Hay (2014) suggested that this water could be sourced from the cooler lower levels of the reservoir, to minimise thermal stress for migrant species in the flip-bucket and climbing the dam. However, during a site visit on 30 March 2015, when the pump was operating, quite a strong smell of hydrogen sulphide was evident above the spillway and there was also some evidence of brown staining on the spillway in association with the water discharging from the pump. It is possible the water chemistry of anoxic bottom waters of the reservoir during periods of thermal stratification may present a chemical barrier to migrant fish, if this water is used to provide the pumped flow to the spillway.

Figure 10. Top of the ramp fitted during March 2015 to help provide easier access for climbing migrant fish to the downstream edge of the flip-bucket on the spillway of the Maitai Dam. The white arrow shows where it is recommended that this ramp be dished into the flip-bucket lip to ensure preferential flow down this ramp during periods of low flow.

4. SUMMARY AND RECOMMENDATIONS

Monitoring data suggests that the South Branch weir remains an impediment to upstream fish passage, despite the remediation work undertaken. While eel elvers and kōaro clearly are passing the weir, it appears that numbers are relatively low. It is likely that the relatively low flow range experienced in the Maitai River over the 2015 summer monitoring period may have influenced this result, and further monitoring covering a broader flow range would be informative.

The key outstanding issue is the attractant flow from the back-feed discharge leading migrants away from the potential fish passes. The ideal approach to address this would be to move the discharge closer to the fish passage entrance, or move the fish pass entrance close to the discharge (i.e. build a new pass on the true right). Alternatively, reducing the rate and frequency of discharge from the back-feed may allow more fish to be attracted to the other passage options. An inexpensive alternative work-around solution for climbing species would be to provide a simple continuous wetted route to connect the back-feed splash zone to the water upstream of the weir.

The efficacy of recent fish passage remediation work undertaken on the Maitai Dam spillway remains to be seen, since it was completed after the summer migration season. While the remediation measures ought to improve the situation for migrant elvers and kōaro attempting to climb the spillway, it is likely to remain a very demanding task due to the length of the spillway. On the basis of climbing speeds observed during monitoring at the South Branch weir, climbing the ~150 m long spillway could take in the order of 4-15 days. Consequently, attrition rates are likely to be high and continuing trap and transfer operations to augment fish numbers passing the dam would be prudent.

Efficacy monitoring of passage success next summer (2015/16) requires observing numbers of fish that start the ascent (at the bottom of the spillway) as well as numbers successfully passing the spillway crest, to provide an estimate of the proportion successfully passing upstream (as discussed by Doehring and Hay 2014). Prior to the summer migration season:

- Consideration should be given to changing the source of water pumped to the spillway crest (to facilitate fish passage when the spillway is not overtopping), to avoid poor water quality potentially acting as an additional barrier to fish passage.

- The ramp installed to provide fish access to the flip-bucket should be dished into flip-bucket lip to provide preferential flow down the ramp during periods of low flow.

REFERENCES

Doehring K, Hay J 2014. Fish passage assessment of the Maitai River North Branch Dam and South Branch weir. Prepared for Nelson City Council. Cawthron Report No. 2601. 38 p. plus appendices.

Hay J, Kitson J 2013. Flow Harvesting: A Review of Policy and Potential Effects. Prepared for Environment Southland. Cawthron Report No. 2408. 41 p. plus appendix.

Jellyman DJ 2012. Section 42A Report evidence presented to the Hearing panel presiding over the Proposed Hurunui and Waiau River Regional Plan And Proposed Plan Change 3 to the Canterbury Natural Resources Regional Plan: Effects of mid-range flow changes on fish migration.