

# Evaluating the effectiveness of the Dights Falls fishway in the Yarra River, Melbourne Australia

Dan Borg<sup>1</sup>, Justin O'Connor<sup>2</sup> and Matthew Jones<sup>2</sup>

1 Melbourne Water, PO Box 434, Melbourne VIC 3001 Email: [dan.borg@melbournewater.com.au](mailto:dan.borg@melbournewater.com.au)

2. Arthur Rylah Institute for Environmental Research, Department of Environment and Primary Industries, PO Box 137, Heidelberg, VIC 3084 Email: [justin.o'connor@depi.vic.gov.au](mailto:justin.o'connor@depi.vic.gov.au) and [matthew.jones@depi.vic.gov.au](mailto:matthew.jones@depi.vic.gov.au)

## Key Points

- This paper presents a preliminary evaluation of the effectiveness of the Dights Falls rock ramp and vertical slot fishway in the lower Yarra River in Melbourne, Australia.
- Two years of fishway monitoring following commissioning indicate that the full suite of species and life stages of fish targeted are using the fishway; however, hydraulic conditions at the fishway entrance are delaying the movement of the majority of species of fish during higher flows.
- Fish monitoring at 20 sites in the catchment upstream of the fishway demonstrate that the fishway is passing the abundant Common Galaxias (*Galaxias maculatus*), however there has been a limited response from other migratory species in the two years following the opening of the fishway.
- We propose a number of minor modifications to the fishway to improve hydraulic conditions near the entrance and enhance fishway efficiency.

## Abstract

Barriers to fish passage, such as dams, weirs and culverts, are commonly implicated in the decline of native fish populations. These barriers act as behavioural and physical impediments to fish movement. Various intervention options are available to waterway managers to mitigate these effects. Here we report on the preliminary evaluation of a rock ramp and vertical slot fishway construction project at Dights Falls in the lower Yarra River in Melbourne, Australia in the two years following the opening of the fishway. The evaluation is based on both an assessment of the efficiency at the fishway itself, and a broader study of whether there is evidence that fish populations are benefiting from the fishway. We conclude, first, that the fishway itself is passing the full suite of species and life stages targeted, including the threatened Australian Grayling (*Prototroctes maraena*). The fishway has yet to be monitored over the full range of streamflows it was designed for, however, it appears that hydraulic conditions near the vertical slot entrance are preventing fish from passing at high flows. We make some recommendations to enhance performance of the fishway. Second, the assessment of sites upstream demonstrates that the fishway is passing the more abundant Common Galaxiid (*Galaxias maculatus*), but effectiveness is less clear for other diadromous species. There have been some significant records of other species; but overall there has been a limited response from other migratory species in the two years following opening of the fishway. The results of these studies improve our understanding of the effectiveness of fish passage interventions.

## Keywords

Fishway; fish passage; monitoring; evaluation; adaptive management; vertical slot fishway; rock ramp;

## Introduction

This paper presents an evaluation of the effectiveness of a fish passage project at Dights Falls on the lower Yarra River in Melbourne, Australia. Background to the project has previously been described in detail (Zampatti et al. 2003; Halstead-Smith et al. 2012); but in summary:

- A weir was first constructed 17km from the mouth of the Yarra River at Dights Falls in 1895 to service a flour mill adjacent to the river.

Borg et. al. – Evaluating the effectiveness of the Dights Falls Fishway

- A large proportion of the Yarra River’s fish fauna are diadromous (requiring unimpeded access to and from salt water). Consequently, the 3m high concrete weir at Dights Falls has been a significant barrier to upstream migration (and long been recognized as a major threat to fish in the Yarra River).
- In 1994, a rock-ramp style fishway was installed to improve fish passage.
- Within 10 years of the installation of the fishway, 80% of the diadromous fishes previously recorded in the lower Yarra River had been observed above Dights Falls indicating that the fishway had improved the upstream passage of fish (Zampatti et al. 2003; Ryan 2008)
- Evaluations of the effectiveness of this fishway in 2003 and in 2008 demonstrated that this fishway was passing fish but was unlikely to be operating efficiently, due to both physical and behavioural barriers associated with distraction flows, high velocities and elevation drops > 300mm (Zampatti et al. 2003). The efficiency of this rock ramp fishway has been classified as ‘very low’.
- Melbourne Water, the waterway management authority, replaced the weir and constructed a new fishway over the 2010-2012 period, with the fishway becoming operational in November 2012.
- The concept for providing fish passage past the weir is based on two connected pieces of infrastructure (Figure 1):
  - a rock ramp style fishway leading up to the weir; and,
  - a vertical slot fishway facilitating passage past the weir itself.
- The vertical slot fishway has two entrances (a low flow entrance near the weir wall and a high flow entrance a further 4m downstream); and the weir contains a 6m long and 150mm deep notch in the weir adjacent to the fishway entrances. This notch directs more flow to this location and is intended to act as an attractant flow to migrating fish.



**Figure 1: Dights Falls fishway complex: The rock ramp and vertical slot fishway (river flow direction is from right to left); and the two entrances to the vertical slot fishway and the weir notch to attract fish to the entrances**

The objective of the fishway component of the project was to pass the full suite of target native species at a range of flows; from summer baseflows of approximately 200 ML/day up to the 1 year recurrence interval flow of approximately 13,500 ML/day. This paper reports on the results of a program monitoring the effectiveness of the Dights Falls vertical

slot fishway; and is based on the first two years post fishway commissioning. Here we report on two components of the program:

1. Monitoring to determine fish passage efficiency at the fishway
2. Monitoring at sites throughout the catchment

Our intention is not to present a thorough, detailed evaluation of fishway efficiency (that the planned longer term monitoring program will allow). Rather, we report on some important early outcomes of the evaluation that pose lessons for the industry.

## **Methods**

### *Monitoring fish passage at Dights Falls*

Evaluating the efficiency of the fishway involved two components: the rock ramp leading up to the weir and the vertical slot fishway. The monitoring was designed to answer the following questions:

- Is the rock-ramp fishway passing all the species and size classes of fish?
- Is the vertical-slot fishway passing all the species and size classes of fish?

#### *Rock Ramp*

A combination of fyke-netting and backpack electrofishing was used to sample fish. Double-winged fyke nets (four mm mesh, total length 7.6m) were set simultaneously at the entrance, middle and exit of the rock ramp; with a further net occasionally set downstream of the entrance trap. Nets were set in the morning (between 9-11 am) and retrieved at the end of the day (between 2-5 pm). A Smith Root model LR20B backpack electro-fishing unit was also used to collect fish from four roughly equal zones located downstream of the entrance and at the entrance, middle and exit of the rock ramp fishway.



**Figure 2: Equipment used to sample fish. Double winged fyke net (left); and purpose built trap (right)**

#### *Vertical slot fishway*

Purpose built traps were used to sample fish using the vertical slot fishway. A set of traps (high and low flow) were constructed from stainless steel and aluminium to sample the two entrance slots (corner and middle entrance); the first baffle; and, the upstream exit of the fishway (Figure 1).

Both the rock ramp and vertical slot fishway were initially monitored over six days between 21 November and 12 December 2012 (immediately following commissioning of the fishway; as part of a pilot study). Sampling resumed in October 2013, with the sampling frequency varying from sub-weekly to monthly until April 2013. Sampling of the rock ramp reported here was much less intense (with eight days electrofishing effort and 5 days of fyke netting effort); as safe access precluded more frequent sampling during high flows. Captured fish were identified, counted and measured for length.

### Monitoring at sites throughout the catchment

A "before fishway commissioning" vs "after fishway commissioning" study design was adopted. A network of 24 sites was sampled for fish with a Smith-Root model LR20B backpack electrofishing unit. Four of these sites were located in tributaries of the Yarra River downstream of the fishway to use as a comparison, with the remainder of the sites in the Yarra River above Dights Falls or a tributary (Figure 3). A five year monitoring design has been developed. Here we report on the first two years of this program following fishway construction and our evaluation is based on:

1. Length-frequency distribution of Common Galaxias (*Galaxias maculatus*); and,
2. Species diversity of diadromous fish.

Sites were sampled in early Autumn once before the fishway was commissioned (in 2012); and twice following fishway commissioning (2013 and 2014).



Figure 3: Monitoring sites (red dots) in the Yarra Catchment (location of Dights Falls is marked with a red arrow)

## Results

### Monitoring fish passage at Dights Falls

#### 2012 Pilot Study

A total of 13 fish species were collected from the vertical slot fishway during the pilot study (Table 1). Eight of these fish species are considered diadromous. The catch was dominated by Common Galaxias, with 4146 individuals trapped. It is notable that the fishway was being used by Tupong (*Pseudaphritis urvillii*) as there are only limited records of Tupong upstream of the weir (two records in Victorian Biodiversity Atlas, DEPI 2014 ) and Australian Grayling (*Prototroctes maraena*) a species of national conservation significance.

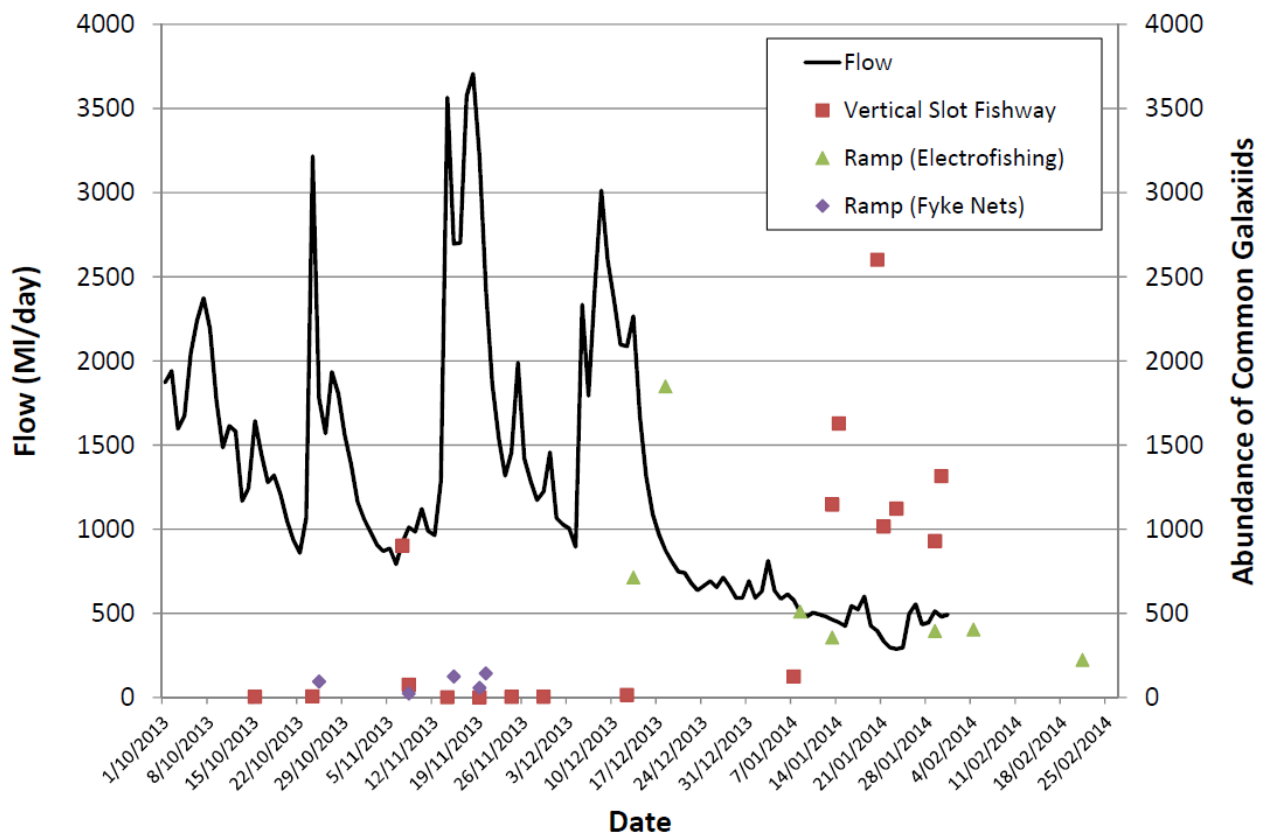
**Table 1: Fish species (common names), abundance and location of capture within the vertical slot fishway during the 2012 pilot study and in both the vertical slot fishway and rock ramp – caught using fyke nets and backpack electrofishing - during 2013-14. Note there is substantially different sampling effort and detectability between rock ramp gear types and the vertical slot fishway traps.**

	2012-13		2013-14		2013-14		Rock Ramp	
	Vertical slot fishway		Abundance	%	Rock Ramp (Fyke nets)		(Electrofishing)	
	Abundance	%	Abundance	%	Abundance	%	Abundance	%
Australian Smelt	-	-	80	0.71%	6	1.35%	82	1.60%
Climbing Galaxias	3	0.07%	7	0.06%	6	1.35%	-	-
Common Galaxias	4146	96.11%	10897	96.35%	420	94.38%	4818	93.95%
Spotted Galaxias	23	0.53%	49	0.43%	3	0.67%	2	0.04%
Flat-headed Gudgeon	31	0.72%	7	0.06%	-	-	57	1.11%
Pouched Lamprey	1	0.02%	-	-	-	-	-	-
Short-headed Lamprey	37	0.86%	-	-	-	-	-	-
Tupong	38	0.88%	30	0.27%	-	-	1	0.02%
Australian Grayling	16	0.37%	14	0.12%	-	-	-	-
Short-finned Eel	5	0.12%	2	0.02%	8	1.80%	38	0.74%
Macquarie Perch	3	0.07%	1	0.01%	-	-	1	0.02%
Carp	1	0.02%	-	-	2	0.45%	4	0.08%
Redfin	7	0.16%	2	0.02%	-	-	-	-
Roach	3	0.07%	1	0.01%	-	-	-	-
Tamar River Goby	-	-	-	-	-	-	2	0.04%
Yellow Finned Goby	-	-	220	1.95%	-	-	114	2.22%
<b>Total</b>	<b>4314</b>	-	<b>11310</b>	-	<b>445</b>	-	<b>5128</b>	-

#### 2013-2014 Assessment

A total of 14 species of fish were caught in the 2013-14 study period (Australian Smelt, *Retropinna semoni*, Tamar River Goby, *Afurcagobius tamarensis*, and the introduced Yellow Fin Goby, *Acanthogobius flavimanus* were not caught in the 2012-13 study period). Again, Common Galaxias dominated the catch in both the rock ramp and the vertical slot fishway (for example, of the 10,897 individuals trapped in the vertical slot fishway, 96.3% were Common Galaxias).

There is a strong relationship between numbers of Common Galaxias trapped and streamflow. Few individuals were caught at streamflows greater than around 1000 ML/day (Figure 4); despite the expectation that this species would be migrating upstream during this period (based on reported migratory periods, for example, see Koehn and O'Connor 1990; Ryan 2008) and the catch of this species in fyke nets during the same high-flow period.



**Figure 4: River flow compared with abundance of Common Galaxias (*Galaxias maculatus*) caught in the vertical slot fishway**

#### *Monitoring at Sites throughout the catchment*

Results from sites within the catchment provide some evidence that the fishway is working for Common Galaxias, however, the monitoring suggests a very limited response for other diadromous species two years following fishway commissioning.

The length-frequency distributions of Common Galaxias indicate passage of Young-Of-Year or 0+ age class of fish in 2013 and 2014 (Figure 5). A large proportion of individuals caught at each of the sites in Merri Creek, Mullum-Mullum Creek, Diamond Creek and Warrandyte sites were less than 80mm length (falling into the 'young-of-year' age-size class). The life history strategy of this species has a larval phase in marine waters followed by an upstream migration of juveniles into freshwater in Spring-Summer. These fish that are less than 80mm length could only have come from downstream of the fishway suggesting that these fish have successfully negotiated the rock ramp and vertical slot fishway. Further, fish less than 120mm are considered to be less than two years of age (Amtstaetter et al. 2014). Most common galaxiids caught in 2014 are less than 120mm; and must have moved through the fishway.

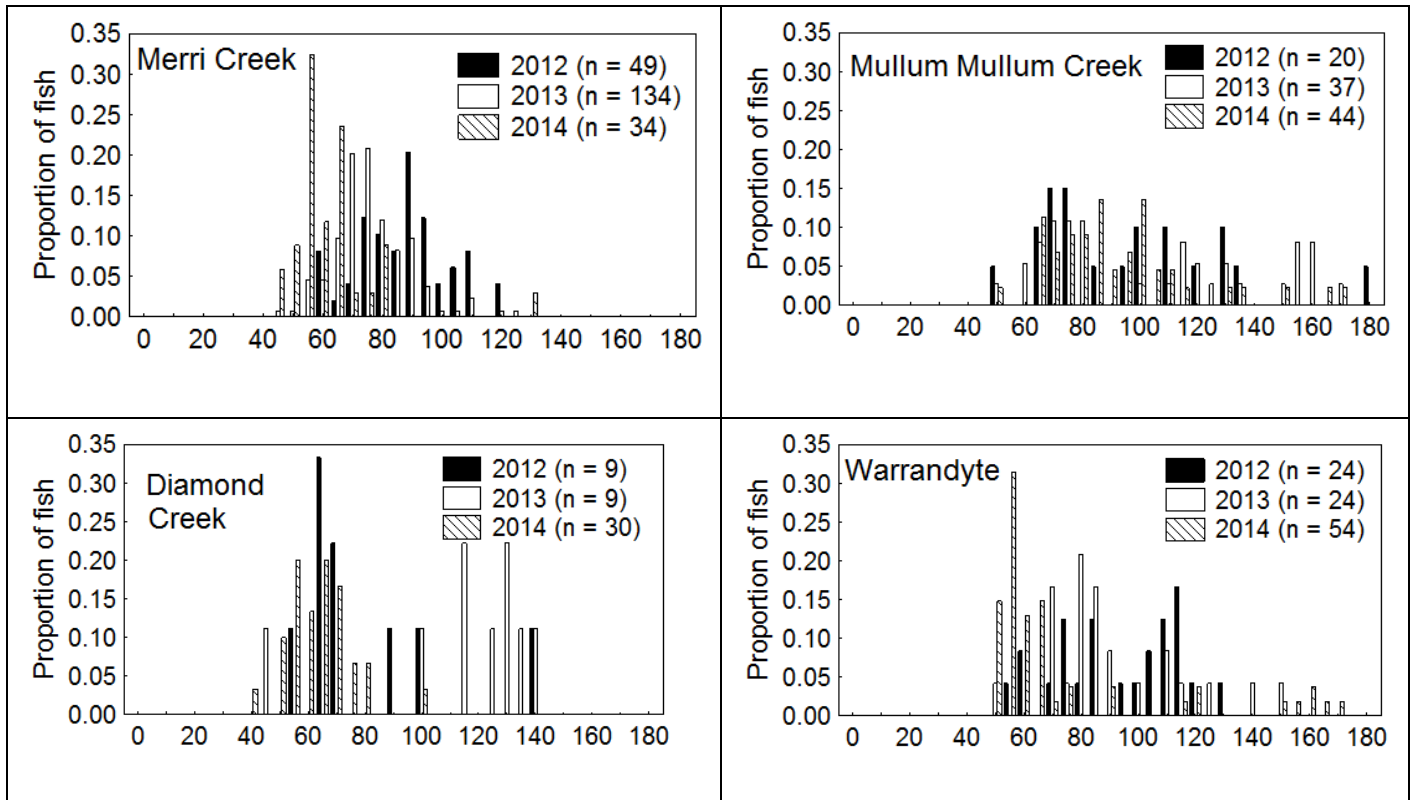


Figure 5: Length-Frequency histograms for Common Galaxias (*Galaxias maculatus*) at Merri Creek, Mullum-Mullum Creek, Diamond Creek and Warrandyte sites

Second, collections of other species provide little indication of any substantial changes in diadromous species richness at sites upstream of the Dights Falls fishway (compared to the diversity of species recorded using the fishway). In addition to successful passage of Common Galaxias, the results show:

- Large numbers of Short-Finned Eel (*Anguilla australis*) at most sites sampled (with between 1 and 30 individuals captured at each site). However, this species was widespread prior to the fishway commissioning and can be considered a poor indicator of fishway effectiveness.
- Occasional records of other diadromous species. A single Spotted Galaxias (*Galaxias truttaceus*) was caught in each of 2013 and 2014 surveys; three Short Headed Lamprey (*Mordacia mordax*) were caught in Merri Creek (but limited inferences can be drawn from these catches);
- Notable records of three Tupong (*Pseudaphritis urvillii*) upstream of Dights falls in Merri Creek. As noted earlier, there are only limited records of Tupong upstream of the weir despite considerable survey effort. These Tupong were greater than 170mm in fork length, indicating that they were greater than four years of age and unlikely to have migrated through the fishway as young-of-year upstream migrants (Amtstaetter et al. 2014).
- Large numbers of introduced fish; including Carp (*Cyprinus carpio*), Mosquito fish (*Gambusia holbrooki*), Roach (*Rutilus rutilus*), Oriental Weatherloach (*Misgurnus anguillicaudatus*) and Goldfish (*Carassius auratus*)

## Discussion and Conclusions

An efficient fishway passes the full suite of target fish species with minimal delays at the full range of streamflows over which the fishway should operate. A thorough evaluation of the efficiency of the Dights Falls fishway at this stage of our monitoring program is limited due to:

- The short time frame following fishway commissioning (November 2012 to present);
- The limited fishway operating range over which we have monitored (up to flows of around 3500 ML/day);
- Safe access when sampling the rock ramp and the different effectiveness of fish sampling equipment used in the rock ramp (compared to the vertical slot fishway).

It is both scientifically and technically difficult to estimate fishway efficiency; and we are not yet in a position estimate this for the fishway or to make reasonable comparisons with previous efforts to estimate fishway effectiveness (e.g. Zampatti et al. 2003). Given these limitations, what can we then conclude about the efficiency of the Dights Falls fishway at this early stage of evaluation? First, the fishway is passing the full suite of fish using the rock ramp and vertical slot fishway. Notably, the fishway is successfully passing the nationally listed Australian Grayling (in addition to all other anticipated species). Second, it does appear that the efficiency of the fishway is compromised at flows greater than approximately 1000 ML/day. Very few fish were trapped in the fishway at these flows despite observations that fish were present throughout the rock ramp fishway at those flows. We believe that this is most likely due to hydraulic conditions near the entrances to the vertical slot fishway which are delaying fish from reaching and finding the fishway entrance (see the turbulence, upwelling and cavitation associated with the weir attraction notch in Figure 1, and note the lack of slow flow velocity refuges). We haven't measured turbulence near the fishway entrances, but this most certainly exceed the specifications that the cells in the vertical slot fishway were designed for. This is further corroborated by visual observations of accumulations of fish downstream of the entrance to the vertical slot fishway where these refuges do exist (Figure 6).



**Figure 6: A school of Common Galaxias immediately downstream of the vertical slot fishway entrance**

We believe that the efficiency of the fishway can be improved through minor modification to these entrance hydraulic conditions. This should be relatively straightforward and involve rearranging rock near the vertical slot fishway entrance. The type of rock rearrangement we call for should be a routine requirement in the operation and maintenance of rock chute fishways; with the failure to do this routine maintenance cited as a reason for the poor performance of many fishways across Victoria (O'Brien et al 2010). We also recommend reducing the width of the weir notch to reduce the attractant flow.

Finally, is there any evidence of effectiveness at sites in the catchment? Whilst it might be too early to draw strong inferences about overall effectiveness of the fishway; we can say that most of the Common Galaxias caught in tributaries upstream of the fishway are less than two years old and must have moved through the fishway. This is a strong indicator of effectiveness, given the large number of Common Galaxias trapped in the fishway complex. As for the other species trapped moving through the fishway that we haven't caught upstream, it is too early to tell if this is because of the study design, the limited period of monitoring post-fishway commissioning; the sensitivity of these species to other threats (such as urbanization or habitat modification – as outlined in Danger and Walsh 2008) or a combination of these factors. Continuing the monitoring program will address some of these questions but other threats may limit any response.

In summary, the lessons from this monitoring and evaluation program so far are:

- The fishway is passing the full suite of species and size-classes targeted, but there is some evidence that passage is prevented or delayed at higher flows.

## **7ASM Full Paper**

### *Borg et. al. – Evaluating the effectiveness of the Dights Falls Fishway*

- These efficiency issues are most likely related to hydraulic conditions near the vertical slot fishway entrance; and are the result of the existing rock arrangement and the flow attractant notch in the weir wall. Improvements can be achieved with minor modifications that can be considered routine maintenance.
- Sites upstream of the fishway show some evidence of effectiveness; but the lack of measureable response could be due to a number of factors (some unrelated to the fishway's efficiency).

Further monitoring will increase our confidence about fishway effectiveness.

## **Acknowledgments**

Frank Amtstaetter at the Arthur Rylah Institute of Environmental Research developed the study design; led the program monitoring the response at tributaries in the catchment and made important contributions to our understanding of fishway effectiveness.

## **References**

- Amtstaetter, F., J. O'Connor and L. Dodd (2014). Effects of a new fishway at Dights Falls on diadromous fishes in tributaries of the Yarra River: year 3 sampling results, Report by the Arthur Rylah Institute for Environmental Research for Melbourne Water.
- Danger, A. and C. J. Walsh (2008). Management options for conserving and restoring fauna and other ecological values of urban streams in the Melbourne Water region, Report to Melbourne Water by the Department of Resource Management and Geography, the University of Melbourne.
- Halstead-Smith, J., T. Myatt and C. Zarosinski (2012). The Dights Falls weir and fishway replacement project: managing in-stream construction during floods. Proceedings of the 6th Australian Stream Management Conference Managing for Extremes, 6-8 February, Canberra, Australia, Published by the River Basin Management Society.
- Koehn, J. D. and W. G. O'Connor (1990). Biological Information for Management of Native Freshwater Fish in Victoria, Department of Conservation and Environment, Freshwater Fish Management Branch, Arthur Rylah Institute for Environmental Research.
- Ryan, T. (2008). A seasonal assessment of fish below Dights Falls, Report by Streamline Research for Melbourne Water.
- Zampatti, B., W. M. Koster and D. Crook (2003). Assessment of the rock-ramp fishway at Dights falls, Lower Yarra River, Melbourne. Report by the Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment.