THE INFLUENCE OF ROCK RAMP FISHWAYS

ON THE HYDRAULIC CHARACTERISTICS OF WEIRS

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Abstract

A physical model of a weir and rock ramp fishway installation on the Thomson River, Victoria, was constructed to evaluate the effect of rock ramp fishway design on the rating curve of the weir. Two different designs with 1:20 slopes, one constructed with a pool between the weir and fishway crests and the other constructed fully up to the weir crest were evaluated. The pool-type and full length rock ramp fishways affected the weir rating curve by 50% and 20%, respectively. Removal of large resting rocks from the fishway surface was found to decrease the effect of the fishway on the weir rating curve by approximately 5%. The presence of a rock ramp fishway downstream of the weir crest elevated the upstream water level for a given discharge.

Introduction

Weirs are regulatory structures commonly used for flow measurement and water level control in streams. However, these structures also present a barrier to fish passage and threaten the existence of many migratory species (O'Brien 1996, Bell 1986).

Considerable research, particularly in North America (Katopodis 1981, Bell 1986) has resulted in the design of structures that allow successful passage of salmonid species for upstream migration and spawning. Australian fish are considerably different in character to salmon, tending to swim at lesser velocities

and not to jump (Mallen-Cooper 1996). Consequently, modified fishway designs have been developed for Australian streams. One such design is the rock ramp fishway, which is considered to be the most viable option for weirs with a low head drop (O'Brien 1999). Rock ramp fishways are suitable for weir heights up to about 2m. They tend to be impractical for higher weirs because of the volume and length of fishway required to reduce the water gradient sufficiently to enable fish passage.

A disadvantage of the construction of rock ramp fishways at gauging weirs is the potential of the fishway to elevate the downstream water level such that the weir crest becomes drowned. This, in turn, affects the rating curve of the weir. This issue is of major practical importance because the construction of a fishway at a small flow measurement weir will require resource-intensive, manual re-rating of the weir. This must be done over several years to obtain the rating curve for a complete range of flows.

This paper presents the results of an experimental study of the effect of several rock ramp fishway designs on the rating curve of a small gauging weir. Included in this study were such issues as rock ramp slope and the influence of resting rocks. The weir and fishway installation at Cowwarr Weir, West Gippsland, was selected as the prototype due to the presence of a standard gauging weir with a rock ramp fishway downstream.

Design and construction aspects of the model are discussed first. The results are then presented and discussed and potential for further work in this field is explained.

Experimental methodology

The gauging weir itself is compound in nature and consists of a 10 m wide central sharp-crested section inset 0.30 m below flanking "broad-crested" concrete sills.

Unlike the recommended Victorian rock ramp fishway design (O'Brien 1998), the fishway at Cowwarr does not ascend up to the weir crest but terminates at a similar height to the sharp-crest approximately 3 m downstream of the weir, thereby creating a large pool immediately downstream of the weir. Larger rocks protrude from the surface of the fishway to produce resting areas for the ascending fish. A recessed gutter has been provided in the centre of the fishway to

allow passage at low flows. Figure 1 shows a photograph of the prototype fishway installation.

Figure 1: Prototype Fishway Installation.

A fixed-bed scale model of the Cowwarr Weir fishway was constructed in the Monash University Civil Engineering Hydraulics Laboratory to a scale of 1:9. Figure 2 shows a photograph of the constructed model.

The central weir section consisted of a central knife-edge constructed from a brass plate flanked by broad crest sections constructed from marine ply.

The flow was monitored using two electromagnetic flowmeters of size 150 and 300 mm installed in parallel branches of the supply. In this way, the full range of tested flows were measured to an accuracy of ± 0.5 %. Water surface elevations were monitored using pitot-static tubes connected to stilling wells. The accuracy of water level measurement was ± 0.1 mm.

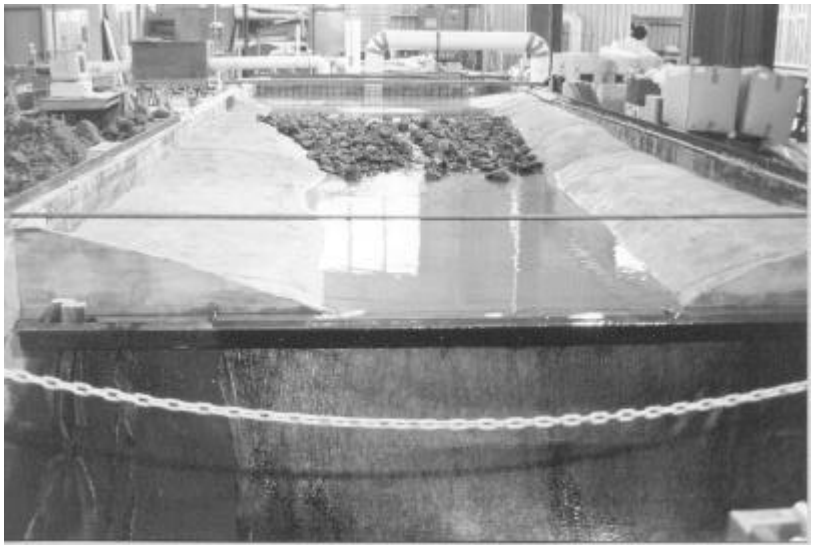

Figure 2: Model Weir and Fishway Installation.

For each test, the upstream water level was measured for a number of increasing pre-selected flow rates. Longitudinal flow profiles, both with and without the fishway in place, were measured across the weir crest to examine the effect of the fishway on the nappe and the corresponding effect on the rating curve.

Results and Discussion

Cowwarr Weir Pool Type Rock Ramp Fishway

The water surface level in the upstream weir pool relative to the knife edge was recorded for each of the test flow rates with the Cowwarr model fishway in place. These results were plotted, as shown in Figure 3, as a height-discharge relationship and compared to the theoretically derived relationship for the weir alone.

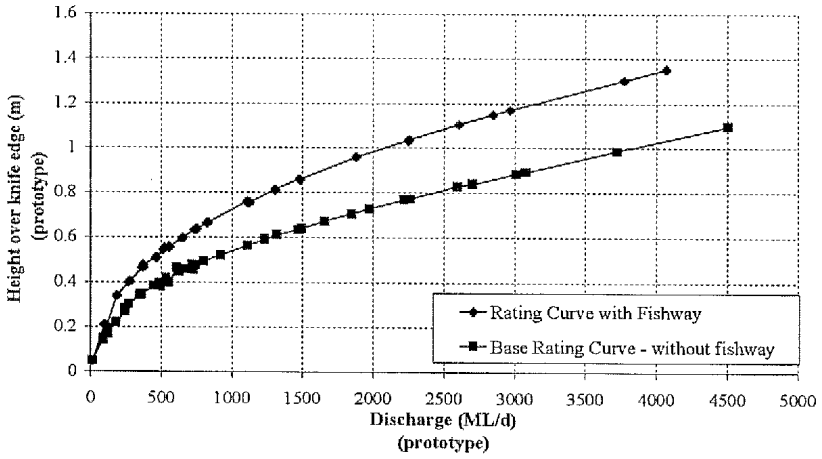

Figure 3: Rating Curve for Cowwarr Weir Fishway

It is evident that the presence of the fishway downstream of the weir crest increases the water surface elevation for a given discharge by between 25 and 30 %. This increase was due to the presence of submerged flow over the weir crest. As the fishway did not extend back to the weir crest, a pool equal in height to the fishway crest formed between the weir and fishway crests, thereby submerging the weir crest.

The experimental rating curve with the weir in place was then plotted against a theoretically determined submerged rating curve. The result, plotted in Figure 4, shows excellent agreement.

Effect of Resting Rock Location

Initially, larger resting rocks were placed along a central S-shaped low flow gutter from the weir crest to the downstream end of the fishway, as shown in Figure 2. The longitudinal spacing between the rocks was approximately 0.30 m. Subsequent trials with the 1:20 and 1:10 sloped fishways investigated the effect of the removal and relocation of the resting rocks on the rating curve of the weir.

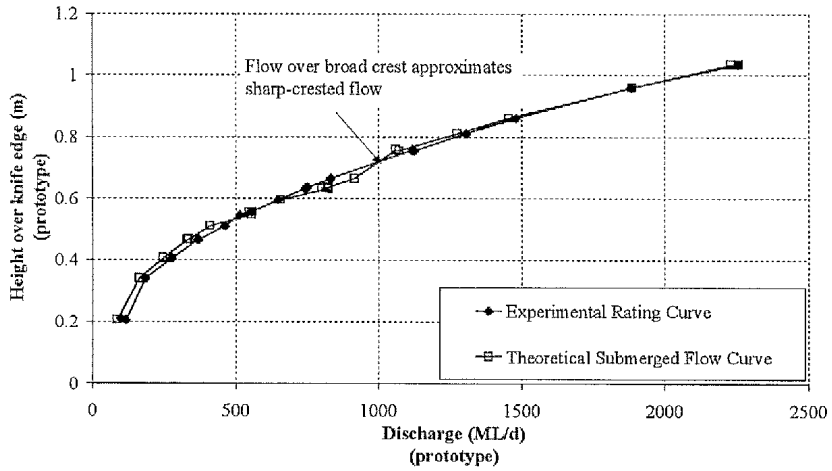

Figure 4: Experimental and Theoretical Submerged Flow Curves for Cowarr *Model Fishway*

It was observed that the removal of the larger protruding resting rocks from the fishway surface had a small but significant effect on the weir/fishway rating curve, as shown in Figure 5 for the 1:20 sloped full length rock ramp fishway. Similar discrepancies between the fishway and base rating curves were observed for the 1:10 sloped fishway. In both cases an increase in discharge of approximately 4% for a given water surface elevation relative to the weir crest was observed following removal of the resting rocks. It is possible that removal of the resting rocks from the fishway may have increased the nappe pressure, thereby increasing the discharge for a given height.

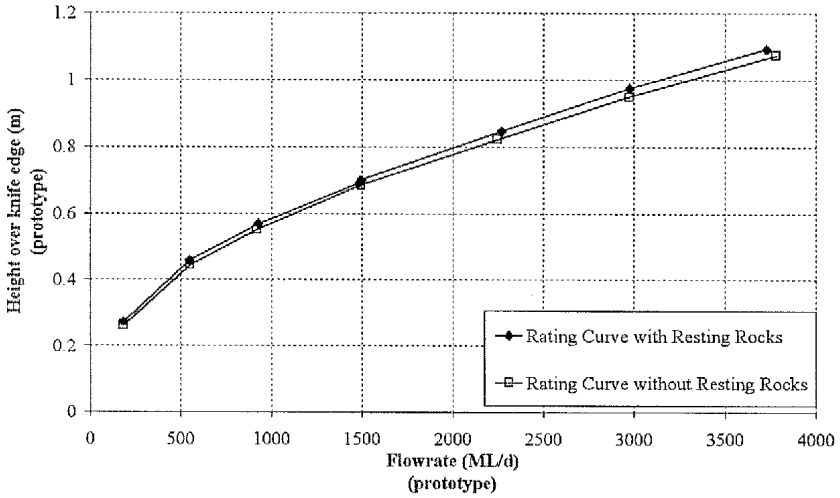

Figure 5: Effect of Resting Rocks in 1:20 sloped fishway on Cowwarr Weir Rating Curve

Comparison Between Full Length and Pool-Type Fishways

Both of the fishways investigated (pool-type fishway and full-length fishway) were shown to have a significant effect on the rating curve of the weir. A comparison of the effect of the two 1:20 sloped fishway designs is shown in Figure 6. The mechanism affecting flow over the weir crest is different for both fishway types, resulting in the observed differences in their effect on the weir rating curve.

The full length fishway affected the weir rating curve through interference with the nappe. The pool-type fishway, on the other hand, affected the weir rating curve through the creation of submerged flow over the weir crest.

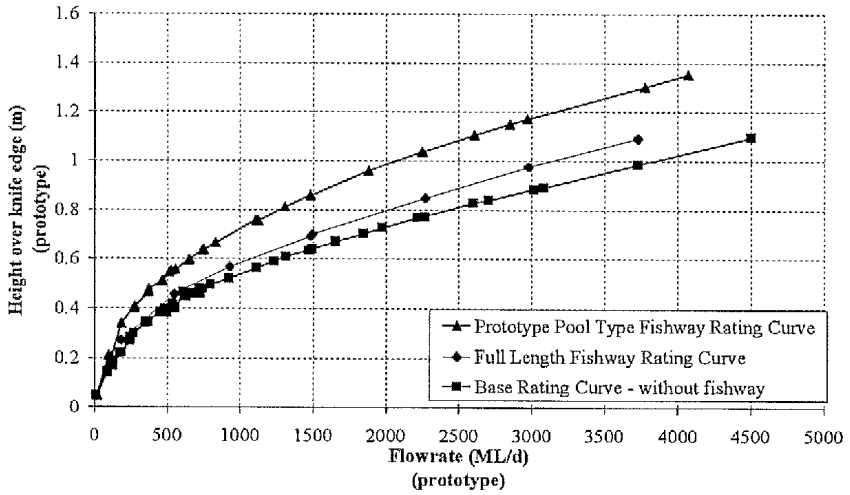

Figure 6: Effect of Two Fishway Designs on Weir Rating Curve

Conclusions and Recommendations

On the basis of this study, the following conclusions are drawn:

1. Construction of a rock ramp fishway downstream of a sharp-crested weir has a significant effect on the rating curve of the weir. It is therefore vital that this effect be considered, by physical model or other means, if a rock ramp fishway is to be constructed at an existing discharge measurement weir. Further investigations are necessary to determine the effect on the rating curves of other types of weir.

2. The pool-type fishway and full-length fishway affected the rating curve of the weir differently. A decrease of 50% in the discharge for a given water surface elevation was observed for the pool-type fishway compared to a decrease of only 20% for the full-length fishway. The full length fishway design is therefore recommended for construction at existing weir sites, especially if flooding is a concern.

3. The presence of resting rocks on the surface of the fishway reduces the discharge for a given water surface elevation. It is therefore recom-

mended that the number of large surface rocks, especially near the weir crest, be restricted to the minimum necessary to allow passage of all target fish species. Further work is required to identify the migratory preferences of Australian fish.

References

Bell, M. C. 1986. Fisheries Handbook of Engineering Requirements and Biological Criteria. US Army Corps of Engineers.

Katopodis, C. 1981. Considerations in the Design of Fishways for Freshwater Species. 5th Canadian Hydrotechnical Conference. Fredricton: N.B.

Mallen-Cooper, M. 1996. Fishways and Freshwater Fish Migration in South-Eastern Australia. Sydney: University of Technology.

O'Brien, T. (1996). Design Considerations for Coastal Waterways, Report on Rock Fishways. Melbourne: Marine and Freshwater Resources Institute.

O'Brien, T. 1998. Fish Passage on Small Instream Structures. Melbourne: Marine and Freshwater Resources Institute.

O'Brien, T. et al. 1999. Providing Fish Passage at Small Instream Structures. Water 99 Joint Congress, Brisbane: Institution of Engineers Australia.

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