# SEEKING BETTER FISHWAYS: THE PUMP FISHWAY PROGRAM

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## 1 ABSTRACT

The construction of barriers to riverine connectivity has profoundly affected freshwater fishes. Fish migrations that are essential for species' biodiversity, productivity and viability are impeded globally by millions of constructed barriers. Mitigation of barrier effects commonly involves installation of fishways to aid the passage of migrating fish but, when judged by ecologically based criteria, fishway performance to date often falls far short of ideal. Further, because of the generally high costs of installing fishways, they are fitted at relatively very few barriers. The Pump Fishway program addresses the need for better-performing, lower-cost fishways suitable for mitigating fish-passage problems at a broad range of barrier types and sizes.

## 2 INTRODUCTION

Water-resource developments often conflict with aquatic conservation. In particular, dams, weirs, barrages, road crossings and other barriers fragment riverine habitats and obstruct migrations that are essential for sustaining freshwater fish [1], thus threatening aquatic biodiversity, fisheries and food security. Millions of such barriers impede fish passage in rivers and streams globally [2], but many of the fishways that have been built to mitigate their effects fail to meet desirable performance standards and are often prohibitively costly [3, 4]. Although fishway performance assessments have previously been based on movements of individuals from favoured species, ecologically based measures assess the passage of whole populations and communities [4, 5].

Barriers cause declining biodiversity and production of freshwater fish internationally and in Australia [4]. Better, less-costly fishway designs are urgently needed to help in reversing the loss of riverine connectivity, rehabilitating fish communities and restoring fisheries [6, 7]. Our research program responds to this need.

## 3 OBJECTIVES OF THE PUMP FISHWAY PROGRAM

People working in fish passage use fishways to move fish past riverine barriers; aquaculturists, on the other hand, commonly use pumps to move fish around safely in fish farms [8]. Marrying these techniques from fish passage and aquaculture presents an exciting prospect in fishway development, and inter-disciplinary research at UNSW Australia has begun to develop and test a novel pump fishway concept that combines the two technologies. The objectives are to transform the performance of upstream fishways, cut fishway costs and optimize all four critical stages of the fish-passage process. These stages are: attracting migrating fish to find the fishway location; encouraging them to enter the fishway; ensuring the fishes' effective passage to the upstream exit; and providing them with safe refuge beyond the exit [2, 4, 9].

## 4 PUMP FISHWAY DESIGN CONCEPT

The basic design concept is to use existing fishways knowledge to attract fish into the structure and to raise them above tailwater; thence to enclose them in a chamber that can be pressurized to achieve upstream passage; and to exploit the hydraulic head of the reservoir to provide all of the system's flow and energy needs. The design involves using a circular fishway section based on the Deelder open-lock design [10] (Figs 1, 2) to provide slight elevation (~0.4m) above tailwater. At this point, fish are held in a trap area before being gravitated through a transfer gate and into water at tailwater level in a transfer chamber. Following this, the chamber is pressurized with reservoir water. This flow carries fish up a rising exit pipe to the reservoir (Figs 1, 2).

The original Deelder open lock effectively passes a wide range of fish species and sizes at low-elevation barriers [10]. It adapts the design of a navigation lock, having two chambers separated by an internal weir, with gates upstream and downstream controlling water flow. Outflows attract upstream-migrating fish into the lower chamber. The downstream gate closes to raise water level above the internal weir and continued flow attracts fish into the upper chamber. The upstream gate then opens fully and fish continue their migration in the river upstream.

In the pump fishway concept, a downstream collection area is added to the original open-lock design, and the internal weir leads fish into to an overfall trap area. This trap is periodically emptied through a slide gate leading into the centrally located transfer chamber, which is then pressurized by a flow piped from the reservoir, carrying fish into an exit pipe and up to near-reservoir level. Fish are finally delivered over the crest and into refuge habitat in the reservoir, using either a small auxiliary pump or other device (Fig. 2).

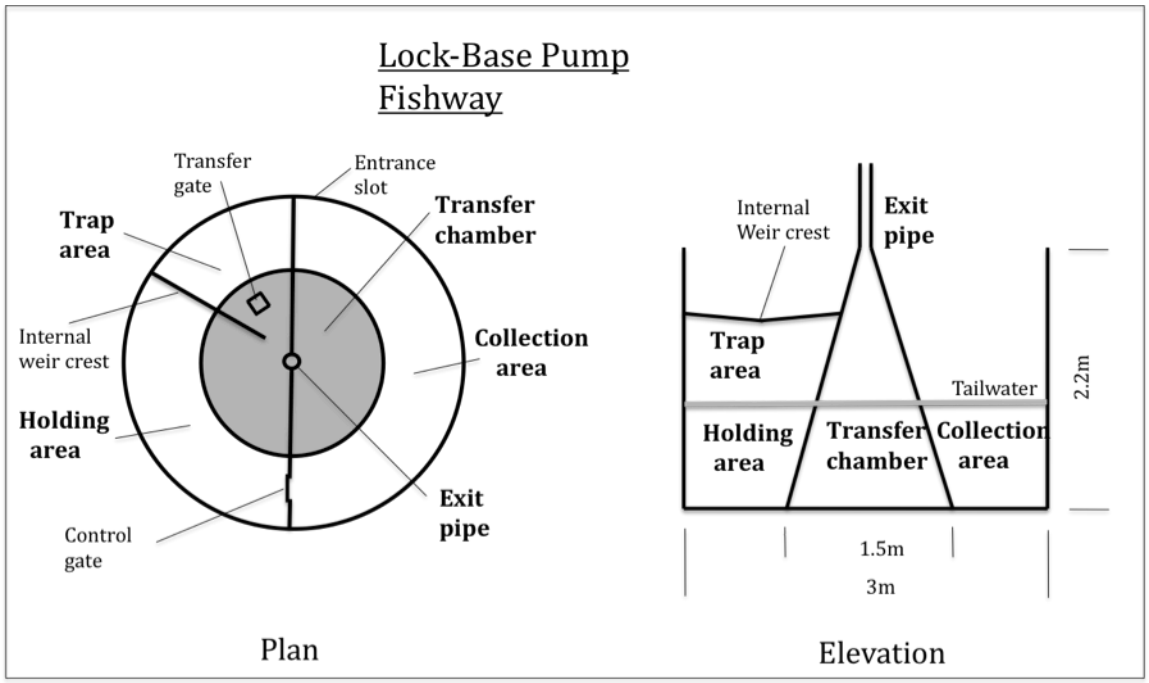


**Figure 1.** Plan and elevation of the Pump Fishway concept based on the Deelder open-lock design. Dimensions are approximate.

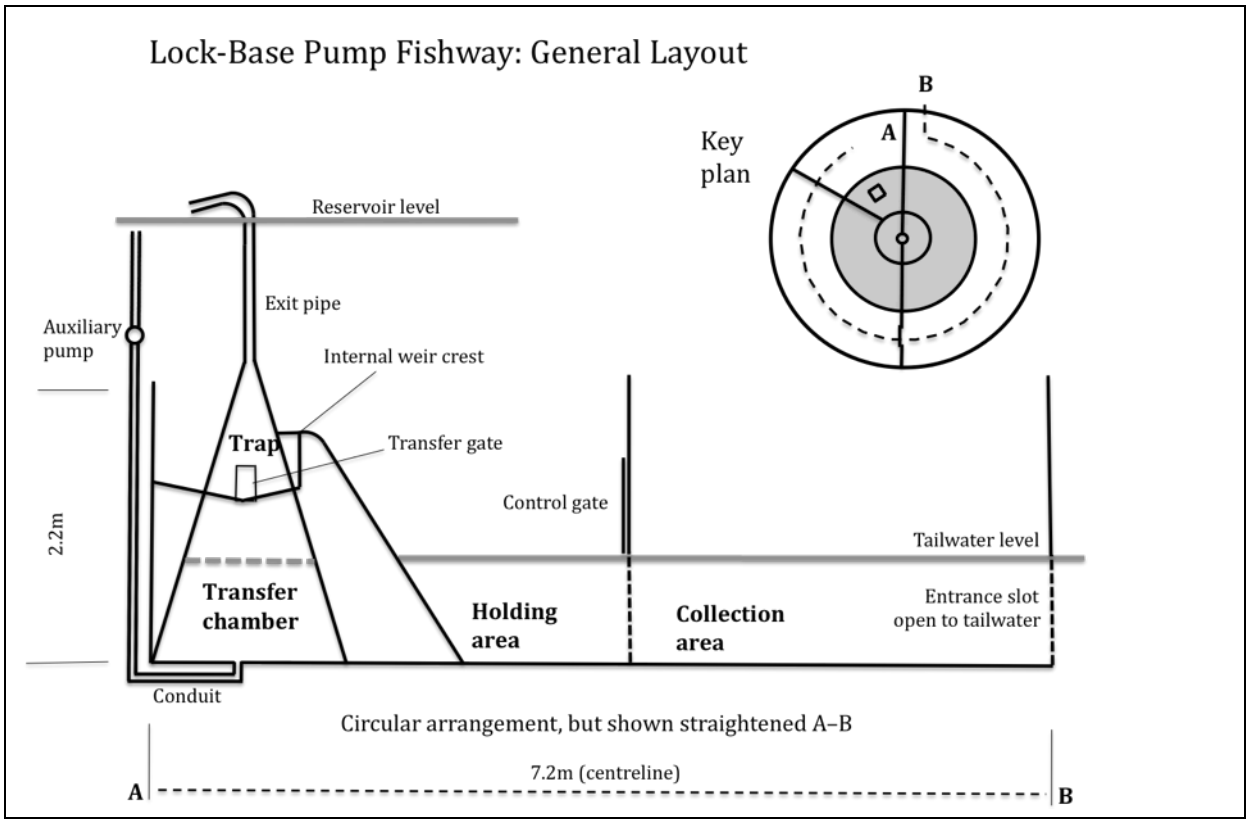


**Figure 2.** General layout of the Pump Fishway, with the circular arrangement (see Key Plan) shown straightened,. The auxiliary pump shown may be unnecessary. Dimensions are approximate.

## 5 BENEFITS OF THE PUMP FISHWAY CONCEPT

The pump fishway concept offers many potential benefits: effective upstream passage for migratory fish communities; lightweight, modular construction with few moving parts (three valves, two gates, turbine, auxiliary pump); applicability to diverse sites and barriers >2m high; energy-independence; and continuous operation with brief transfer cycles. Being lightweight and self-contained, it has potential for deployment as a floating structure with adjustable positioning, able to be removed for flood protection, and less constrained by changing tailwater levels. Large savings on capital and operating costs are predicted.

## 6 CONCLUSION

The application of pumping in aquaculture fish-relocation systems is well understood [8], and extensive data are available on key design requirements for effective fishway performance over a wide range of fish species and sizes [6, 7, 9, 11, 12, 13]. The UNSW research program will combine these two areas of knowledge in the Pump Fishway research and development program. The design's characteristics suggest it may be expected to serve the four essential requirements for effective fishway performance: attraction, entry, passage and refuge of diverse fish communities. Potential advantages include versatility, adaptability, effectiveness and low costs. PhD projects in hydraulics, control systems and fish behaviour will be based at the UNSW Water Research Laboratory. We are now seeking to establish proof of concept through scale-model trials with small fish, together with preliminary hydraulic studies, while exploring potential program partnerships.

## 7 REFERENCES

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