Delivering River Restoration: Recipes for Success

13th Annual Network Conference

Restoring Europe’s Rivers

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Byron’s Pool nature-like fish pass, highlighting the need for a ‘hands on’ approach

Project funded by

Cambridgeshire Horizons
Environment Agency
Cambridge City Council

Ellis Selway MIEEM
Bodhi Ecology
Anthropogenic in-channel structures
The problem- a complete barrier!
The solution - bypass channel
Small side weir- flow control and maintenance

Profile of existing river bank

8.4 m AOD

7.7 m AOD

7.4 m AOD

3NR Treated Timber Stoplogs Placed
True Nominal 2500 x 100 x 200

Alcove for fish monitoring device
Including pipe duct of 25mm Ø

A393 Mesh

250 Thick Gabion Mattress

75 Mln Blinding Concrete C10

Geotextile
Terram 1500 or similar

Excavation at Intake to weir structure

Section D-D
Scale A
Construction starts-at last!
Problem- No hard bed level
Construction modifications

Solution - Import additional gravel
Operational modifications

Problem - Excessive water velocity
Operational Modifications
Solution- turreted stop log and additional riffle
Operational Modifications

Solution - Perturbation boulders
Did it work?

Free passage—connecting isolated and fragmented aquatic systems

Creating valuable habitats—lost on our regulated rivers
Thank you
A CASE STUDY ON THE DESIGN, CONSTRUCTION AND EFFECTIVENESS OF A NEW NATURE-LIKE FISH PASS AT BYRON’S POOL ON THE RIVER CAM, HIGHLIGHTING THE NEED FOR A 'HANDS ON' APPROACH

ELLIS J. SELWAY

Ecologist – Bodhi Ecology
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Abstract

Riverine fish depend highly upon the physical characteristics of their habitat, utilising different niches during their life cycle for growth, survival and reproduction. Anthropogenic in-channel structures such as weirs can impede these movements, contributing to the decline of fish populations. Fortunately, as a result of legislative and climate change targets, the restoration of riverine habitats has gained momentum in recent years and fish passes of varying design, including ecologically minded nature-like passes, are widely accepted as a method of helping to restore connectivity. Despite this there only a few nature-like fish passes in the UK and limited information available on their effectiveness.

An ambitious project, spanning 5 years from concept to construction, the Byron’s Pool nature-like fish pass was installed on the River Cam to bypass a fixed crest weir and sluice representing a complete barrier to fish migration. Specialist contractors were appointed to engineer the design and construct the pass, with construction carried out between 16th December 2010 and 30th March 2011. Several modifications to the design, needed to make the pass fully operational, were carried out both during construction and immediately after the opening of the pass. These included the import of additional gravels, retention of a turreted stop log and installation of additional rocks and boulders.

The effectiveness of the pass was measured using a combination of visual surveys, electrofishing and use of remote video cameras. Environmental conditions were also measured to indicate if these were within the range of physical and biological parameters required by fish.

The pass has proven to be effective and valuable lessons have been learned about the importance of a 'hands on' approach, using manual alterations and adaptations to enhance an otherwise formulaic process.

Keywords: Anthropogenic in-channel structures; Complete barrier; Migration; Fish pass; Effectiveness; Electrofishing; Remote video cameras.
I devised and led this project whilst employed by Cambridge City Council. Conceived back in 2006 as management of the adjoining nature reserve was considered, it was the proximity of proposed housing in area of significant urban growth which provided the financial and ecological opportunity, in 2008, to turn this concept into a reality. Primarily funded through Housing Growth Funding secured by Cambridgeshire Horizons from the Department of Communities and Local Government, the project was also part funded by the Environment Agency, after a near 50% cut in HGF funding following Central Government cuts and unforeseen costs experienced during construction!

This presentation explains how a ‘hands on’ approach was needed to resolve problems which arose during construction and initial operation of the pass. It also includes a summary of the findings of my MSc research project which included an assessment of its effectiveness within the first 3 months of operation.

Byron’s Pool is situated 3km SW of Cambridge on the River Cam (a heavily modified water body) of poor ecological status* within the Cam and Ely Ouse catchment (2009 WFD classification of Upper Cam waterbody*).

Like most rivers in the UK a number of anthropogenic structures are present which prevent or restrict free passage for fish and invertebrates. This results in a loss of longitudinal connectivity with often degraded and fragmented habitats remaining.

The Cam has been historically controlled at this location since the Domesday Survey with the current fixed crest weir and radial sluice gate constructed in 1949 to control discharge downstream and to retain upstream water levels for recreational and conservation.

The considerable head difference, broad width and dry weir crest represent a complete barrier to fish migration as defined by SNIFER criteria. (Coarse-resolution rapid assessment) (Kemp et al, 2008). Upstream migration physically impossible and are beyond the leaping abilities of both Salmonid (Bell 1986, cited in Salla et al. 2005; Larinier et al. 2002; Kemp et al. 2008), and Non-salmonoid species (Winter and Van
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So what was the solution...

A nature-like fish pass (bypass channel), was my preferred solution, offering free passage whilst restoring and enhancing key features identified in Byron’s Pool Local Nature Reserve which included the restoration of four adjoining ponds managed for amphibians. It gave the best overall ecological gain.

In 2008 a topographic survey was conducted and a specialist contractor employed to engineer the design. This was based on the fish pass design principles set out by FAO/DVWK (2002)

KEY FEATURES:
A bypass channel 110m in length and containing a series of pools and ripples formed by excavating silt (to hard bed level) from along the route of an existing heavily silted drainage channel, with a new channel dug to connect the pass to the main river.

Ripples formed using lengths of felled timber (along the proposed route) set into the bank to protrude into the channel to retain imported gravel and deflect flow, creating variable flow conditions.

A gradient of 0.1%, with a head loss across the consecutive pools of <0.10m, (c.10m long x 2m wide x <0.7m deep) creating areas of rest where water velocity is <0.5m/s, whilst the series of ripples (c.10m x 2m wide x <0.4m deep) offering an attractant water velocity of <1.4m/s to a maximum of 2m/s.

Entrance to the pass would ideally be located close to the main current found at the sluice where fish are likely to congregate but due to site constraints is to be located as close to the main obstacle within Byron’s Pool nature reserve. Therefore pass entrance with 2% gradient (formed using wire gabion baskets for erosion control) to produce attractant current of 0.8m/s to 2m/s and generate jet in to main weir pool.
A small concrete side-weir installed to allow flow control and for maintenance operations. The exit was designed so that water velocity should not exceed 2m/s with no head difference.

Additional feature
A new inlet pipe with gravel chamber and valve installed into and between the ponds to facilitate the adjustment of water levels but to restrict entry of fish.

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2.35m wide with angular stones set into the apron to provide fish refuge (areas of slack water). It also included alcoves for the installation of remote cameras to monitor fish movements. Use of stop logs to temporarily stop flow during maintenance works.

Following local consultation, the pass was finally given consent by the Environment Agency (L09/C/105) and planning permission (S/1272/10) by the Local Planning Authority in late 2010 (SCDC 2011).

Specialist contractors were appointed following an open tender process and construction of the pass began on the 16th December 2010 with an estimate 6 week build.

Problem- During excavation of the channel the hard bed level identified in the topographic survey was not found. This meant that the channel could not be formed as designed and that if constructed as is, the channel morphology and heterogeneity of flow characteristics would be lost the moment the pass became operational!

A solution was needed...
Solution- To form the channel to the dimensions as designed an additional mixed fill of claybound rejects, ranging from 20-100mm, and graded gravel 10-20mm was imported. This material was also used to infill areas which had become unstable during the removal of silts from the main channel. This provided the opportunity for shallow gravel margins alongside the main channel diversifying the habitat.

I also placed woody debris and individual angular gabion stones (up to 200mm) randomly in the channel to provide suitable refuge for fish such as Bullhead *Cottus gobio*. Further piles of gravel and gabion stones were left on the bank so that I could tweak the riffles once operational.

With these problems during construction overcome the pass was eventually opened on the 30th March 2011.

*However the next problem arose*...

Problem- When the temporary dam and stop logs were removed the flow was highly turbulent swamping the riffles and producing a flow beyond the designed parameters. This was in part due to downstream water levels on the main river being c.200mm lower than average due to exceptionally low rainfall between March and May, the driest 3 month period on record (since 1910), resulted in river flows on the Cam being 42% of the Long Term Average (Environment Agency 2011b).

Initial solution- To avoid the washing out of gravel from the constructed riffles I put one of the stop logs back in to reduce the flow entering the pass, however this created a head difference of c.300mm between the exit pool and the upstream water level. A couple of days later after the channel was operational, Minnows *Phoxinus phoxinus* were observed failing to leap over the obstacle.

*A further solution was needed*...
Solution- I cut three sections (450mm wide by 100mm deep) out of the retained stop log to try and resolve this. The head difference was reduced by c.100mm however the flow through the turretted log was still too high for Minnows to be able to negotiate the structure.

I needed to raise the downstream water level and the solution was to effectively dam-hold back the water by installing an additional riffle downstream of the exit pool using 200-300mm angular granite rocks. This worked with the head difference eliminated and within minutes several Minnows were observed successfully exiting the pass. The pass worked at last!

Problem- I was concerned about the impact the low water levels on the main river and how this might affect the ability of a range of fish to negotiate into the pass. The water level at the pass entrance were very shallow (<100mm) and the water velocity was potentially too high-exceeding the maximum swimming performance (Armstrong et al.2010) of some of the fish species found in the Cam. It also could potentially restrict access for larger fish.

*I felt a further tweak was needed...*

Solution- With assistance I placed a combination of gabion rocks and larger 300-450mm perturbation boulders (Heimerl & Wurster 2006) in to the entrance of the pass and the first riffle to baffle the flow, producing areas of slack water for fish to rest in whilst ascending into the pass.

Flow velocity was later measured at a maximum of 1.2m/s, 10cm below water level (water depth c.25cm), well within the recommended maximum velocity parameters of 2m/s for passage of fish (FAO/DVWK 2002).

*So with the modifications made did it work...?*
Yes but only after these modifications were made. Even operational at historic low flow on the main river the combination of surveys conducted in first 3 months of operation proved that the pass was effective both in terms of the presence of fish within the channel (utilising the habitat) and passage of fish able to migrate upstream beyond the physical barrier.

- visual surveys- minnows negotiating pass/ spawning activity (Minnows, Gudgeon and Chub)
- Remote camera- (small sample out of hours of footage) showed 244 fish observed successfully existing the pass, 88% of all fish did so at night.
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Key messages:

- Would it of worked without a hands on approach, NO
- Even with an engineered design, problems may arise during construction and operation whereby physical alterations maybe needed.
- As a project manager you need to be able to find solutions.
- In this project this approach made the difference between it being a failure and a success.
Extracts from my MSc study* in relation to:

- specific question asked at conference in relating to Eel passage
- Limitations of, and recommendations for, monitoring
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Eel passage

Measured exit water velocity
The water velocity through the slots in the stop log (the fish pass exit) were measured at 1.2m/s. Although these are within acceptable ranges for coarse fish, the water velocity through the stop log slots may exclude passage of elvers (juvenile Eels), as observations by McLeave (1980 cited in Larinier et al. 2002) found that their ability to pass a laminar flow was very limited and that they could only cover a distance of 30cm at a water velocity of 0.5m/s. However, the cumulative impact of barriers to migration further downstream and the relative position of he pass within the catchment mean that the number of elvers reaching Byron’s Pool is low (0-1 Ind./100m2) (DEFRA 2010).

The monitoring carried out as part of this study has highlighted the need for some minor modifications to allow free passage for elvers and the need for long-term maintenance of the pass to prevent woody debris (flotsam) potentially blocking the channel.

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Passes of this type can contribute to the holistic approach needed to restore the ecological status of our rivers. They provide not only free passage beyond physical structures helping to join isolated and fragmented aquatic systems, but also create valuable habitats, many of which have been lost on our regulated rivers.

RRC Conference 2012
Ellis Selway’s presentation-supplementary notes
Cited References:


Additional References of use


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