# Preliminary scoping of low cost fish passage easements

## River Loxley, South Yorkshire

## September 2012

# Loxley weirs: low cost fish passage easement scoping

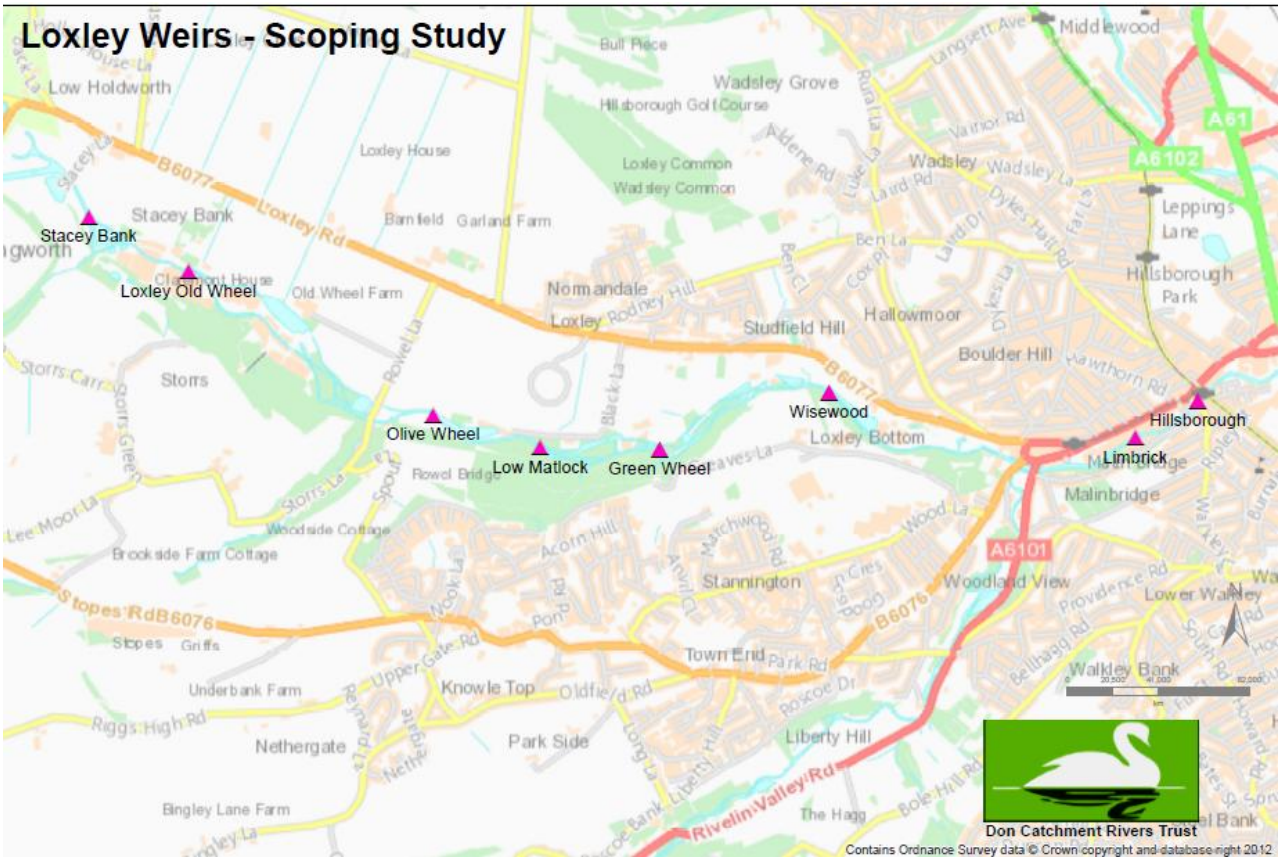



**Figure 1: Position of named weirs along the Loxley**

## Introduction

This report is based on a site visit and discussions between Paul Gaskell (Wild Trout Trust) and Chris Firth MBE and Karen Eynon (Don Catchment Rivers Trust) on the 2nd of August 2012. Its purpose is to propose cost effective means of connecting salmonid spawning habitat within the River Loxley to fish populations within the main river Don (including migratory salmon and trout). Where possible the works should be made feasible to be carried out, at least in part, by supervised volunteers. In addition, the archaeological value of structures should be acknowledged and accounted for when meeting the legal requirements for fish passage under the European Water Framework Directive (WFD). The River Loxley itself comprises three waterbodies under the WFD river basin management plan; GB104027057390 (River Loxley from Source to Strines Dyke), GB104027057370 (River Loxley from Strines Dyke to River Rivelin) and GB104027057350 (River Loxley from River Rivelin to River Don). The remainder of the document appraises each weir featured in Fig. 1 and offers potential easement options.

## Initial appraisal of weirs identified in Figure 1

### *Hillsborough weir*

Figure 2: Hillsborough weir at Hillsborough corner

A large, stepped weir and an impassable barrier to fish under virtually all flow conditions. Possibly the simplest easement option here would be a “diagonal baulk” constructed using a reinforcing bar (rebar) frame to support a concrete “fin” (Figs. 3 and 4). This would be a relatively simple way of moulding the underside of the baulk to the stepped face of the weir.

Figure 3: Concrete diagonal baulk (right) cast over rebar frame (left) courtesy of the Wye and Usk Foundation

**Figure 4: Concrete baulk under normal flow courtesy of the Wye and Usk Foundation**

A much more novel approach (that would be within the abilities of volunteer groups) could be to use a diagonal baulk made from wooden sleepers bolted to the face of the weir. This approach would, however, necessitate the improvisation of measures to adequately seal the gaps between the underside of the sleepers and the stepped face of the weir. One potentially novel way of achieving this could be to use heavy duty Polyvinylchloride (PVC) sheeting that is available on rolls (e.g. http://www.pvc-strip-doors.co.uk/product.php?id=60 and pictured in Fig. 5). Verification that the material is adequately stable in sunlight would, of course, need to be carried out and balanced with likely maintenance requirements.

**Figure 5: Clear, heavy duty PVC roll (4-mm thick). Using black or clear material would minimize visual impact of this method.**

Cut sections of PVC could be screwed onto the upstream face of the wooden baulk and also to the vertical and horizontal faces of each weir step by means of drilled recesses and rawl plugs. Washers

would be used between the screw heads and the PVC sheet to provide sufficient surface area for secure fixing without risk of tearing. A more conventional installation of wooden sleepers to produce a diagonal baulk on a smooth-faced weir is shown below (Fig. 6) and gives an impression of how this type of construction would appear in practice. Interpretive signage to outline the function of the easement, weir's construction technique and the consequent easement design would be valuable additions to the surrounding street environment. However, it must be appreciated that the experimental nature of this recommendation (compared to a cast concrete option) implies a more extensive ongoing monitoring and maintenance requirement than a cast concrete option. A skilled carpenter may, of course, be able to shape the underside of each sleeper so as to adequately conform to the stepped surface (and the seal need not be actually watertight). Alternatively, see Wisewood weir for another potential solution.

**Figure 6: Wooden sleeper diagonal baulk easement – here the face of the weir is sufficiently uniform as to hold up a sufficient depth of water for fish to swim up without requiring additional sealant measures. Sleepers are attached by means of expansion bolts fitted into drilled recesses in the face of the stone-work. Courtesy of Wye and Usk Foundation.**

## *Limbrick weir*

**Figure 7: Limbrick weir**

Another very substantial barrier – and one noted for potential flood risk implications to the surrounding developments. As with the majority of the weirs on the Loxley, this shares the same construction technique as the even larger Hillsborough weir. The height of the weir and the steep-sided nature of the valley combine to produce an extensive impounded reach upstream of the weir. Consequently, the upstream habitat is degraded by being made much more uniform over a very substantial reach. Access to view the weir is also restricted to the grounds of private accommodation (photography in Fig. 7 requires resident's permission for access). The combination of these factors of barrier-effect, upstream habitat degradation, flood risk and lack of public access make this a potential candidate for gradual (step-wise) removal. This process would, in combination with archaeological experts, enable an in-depth study and recording of the internal construction techniques of the weir - and could form a valuable dossier of written and pictorial records. The similarity in construction technique to more publicly accessible weirs on the Loxley would enable selected text and pictorial illustrations generated by this recording process to be used in interpretive displays at comparable sites (as well as local museum exhibitions). Keeping a record of the removal process would also allow the impact on the river habitat to be documented and included in displays associated with the history of the area. This would provide a unique opportunity to document the change from a pre-industrial era landscape to the impoundment of water to harness power for industry. Consequently a much greater variety of important local history can be brought to life when compared to simple weir retention (where multiple other examples exist on the same river).

It would be vital to undertake the lowering and removal process in a very gradual manner. Between each removal (and archaeological recording) step, the upstream river-bed must be given time to re-grade. This process initiates on the upstream side of the structure itself as a "nibble" point in the stream bed. Erosion of the river bed then works back upstream until a new, stable longitudinal gradient is established (Fig.8). The risk of removing a large structure in just one step is likely to induce a much more unpredictable range of erosive effects that would be likely to also include extensive river bank (rather than river bed) erosion. Doing it more gradually allows river-banks to colonise with stabilising vegetation as well as introducing much smaller erosive forces.

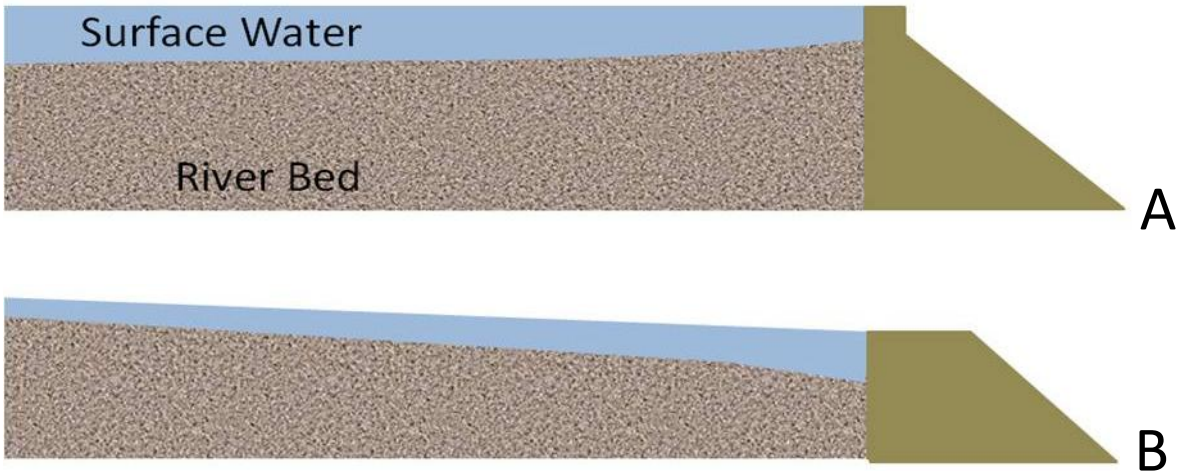



**Figure 8: Longitudinal bed slope re-grading with weir-lowering from full height (A) to stepwise lowered conditions (e.g. B)**

## *Wisewood*

Figure 9: Wisewood weir

Here there is a good opportunity for a volunteer-installed easement that follows a “vertical slot” type design. Parallel sleepers that are attached (via expansion bolts) to a pair of the existing stone columns that run down the face of the weir (i.e. perpendicular to the lip) will act as retaining side-walls. Sleepers can then be bolted onto horizontal steps in the weir so as to produce increased pool depth over the stonework. These lateral sleepers should butt up to one side-wall and have a small (~30-cm) gap between the end of the sleeper and the opposite side wall. The arrangement of these gaps should be alternated so as to avoid a straight cascade of water from the top lip to the bottom of the weir. This also provides resting pool opportunities for fish ascending the easement (Fig. 10).

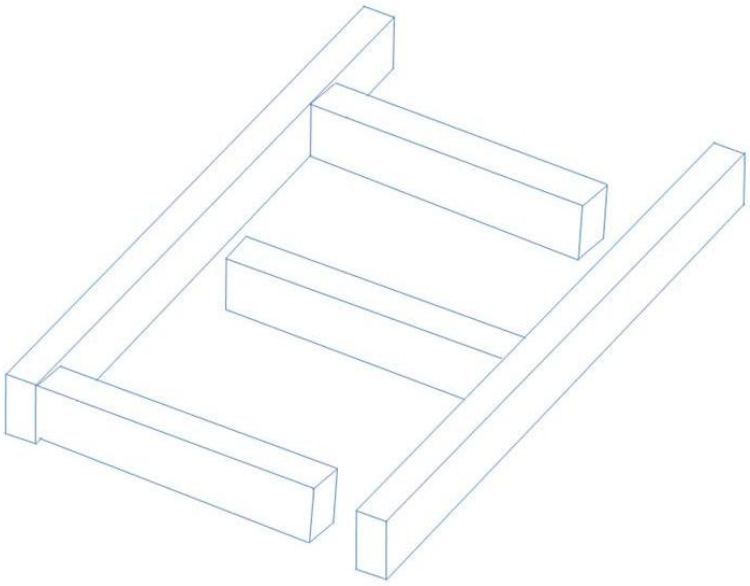


Figure 10: Bolted sleepers forming a vertical slot type easement

## *Green Wheel*

Figure 11: Green wheel weir

Partial removal (and use of the arising stone to form a rock-ramp structure) is likely to be the best ecological outcome for this structure. However, if there are legal archaeological constraints or issues arising from the mixed riparian and structural ownership of Green Wheel, this may not be viable. In that instance, a diagonal baulk as illustrated in Figs. 3 and 6 could be a beneficial compromise.

## *Low Matlock*

Figure 12: Low Matlock weir

The sloping face of Low Matlock weir could be tackled using a vertical slot arrangement as illustrated in Fig. 10. However, the vertical drop over the lintel at the downstream edge of the weir is problematic for getting fish up into the easement structure. This would be aided by cutting a slot down to the riverbed level through the lintel. HOWEVER – THIS WOULD REQUIRE CONSULTATION WITH A STRUCTURAL ENGINEER TO DETERMINE IMPLICATIONS FOR ONGOING STABILITY AND/OR ASSOCIATED STRUCTURES AND SERVICES. As an alternative, a wooden beam could be bolted to the vertical face of the downstream lintel and a slot cut into this (rather than the stonework itself). Subsequent alignment of the lowest slot in the wooden beam structure with the slot cut into the stonework/added beam would allow fish to enter the easement. A solid plume of water could be produced as it exits the lowest slot in the wooden beam structure via the installation of an "adherent nape" (Fig. 13). A cheap construction of this could be to cut and sand a curved surface into section of wooden beam (and could be incorporated as part of any beam added to the face of the lintel). Whichever option is adopted, a sufficient length of beam should be retained either side of this curved face to act as retaining side-walls. This "retaining" function is provided by the welded-side plates in the (metal) illustrated example (Fig. 13).

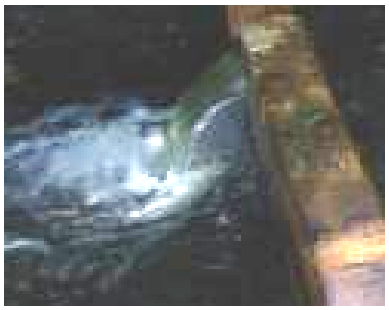
A  B 

**Figure 13: A solid plume of water (B) that is much easier for fish to swim up than frothy white water with lots of entrained air can be produced by installing an adherent nape (A). This is an example of a welded metal nape. The same shape (with retaining side walls) can be produced by cutting a section out of a wooden beam and sanding to smoothness**

## *Olive Wheel*

**Figure 14: Olive Wheel weir**

Again, a diagonal baulk constructed in a modular fashion using wooden sleepers (as per Fig. 6) could be successful here. As with all suggested options for all other weirs, it may be necessary to cut a small slot in the upstream lip of the weir in order to ensure that water flows down the full length of the baulk and that fish can exit the top of the easement freely.

## *Loxley Old Wheel*

Figure 15: Loxley Old Wheel weir

Loxley old wheel is another weir that would be amenable to a simple vertical slot easement constructed from wooden sleepers bolted in place to form a structure such as that illustrated in Fig. 10. The materials and work on this weir may be an appropriate subject for a funding application to the current riparian developer (Bovis).

## *Stacey Bank*

Figure 16: Stacey Bank weir

Stacey Bank weir offers the challenge of a broad, shallow and level apron at the foot of the weir (which is too shallow for fish to swim on – and provides no opportunity for generating a vertical leap up the subsequent weir face). There is a vertical lintel to negotiate before reaching that apron and then the actual face of the weir itself is impassable in its own right. However some good depth in the pool below the lintel assists fish in attempting to pass the first part of this barrier. It may be possible to combine several of the previous approaches to ease fish passage and retain an affordable pricing. Specifically, the lower lintel would benefit from a slot or adherent nape. A single vertical slot "pool" could be formed from timber sleepers bolted onto the flat surface of the (level) apron. This could then lead into a vertical slot easement consisting of the required number of offset baffles. A possible arrangement is illustrated in Fig. 17.

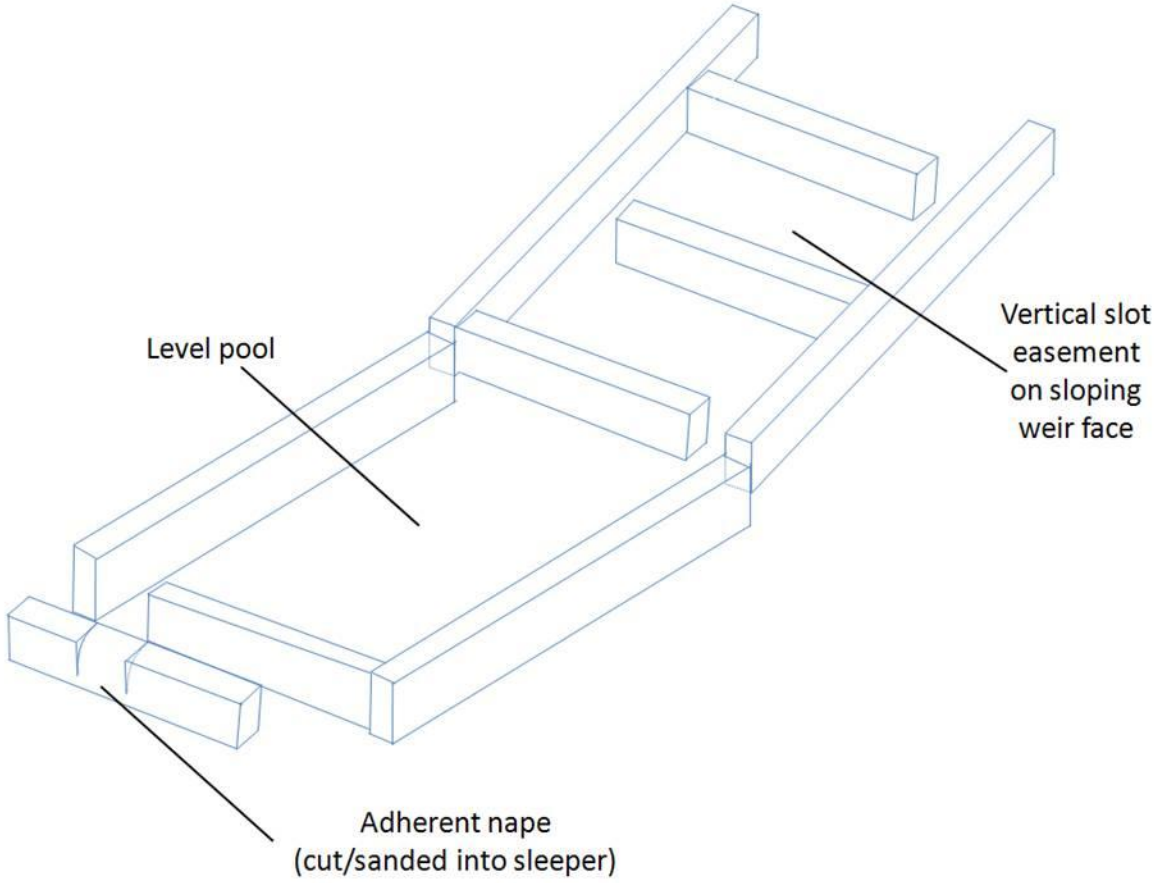



**Figure 17: Possible arrangement of bolted sleepers to afford eased passage up vertical lintel, level apron and sloping weir face**

The value of attempting this easement lies in the gravel beds (Fig.18) that are present at the upstream limit of this section of the river (formed by a reservoir dam wall). Future collaboration with the operators of the reservoir could enable flow regimes to be implemented that would both stimulate spawning migration and provide localized remobilization and deposition of loose spawning gravels.

**Figure 18: Potential spawning substrate at the foot of the reservoir dam wall. Secure installations of large and coarse woody debris would greatly enhance the value of spawning and juvenile habitat in this reach.**

## Guiding principles that should be applied to recommended easements

In order to achieve the best possible outcomes using the basic suggestions offered in the previous section, there are a series of reference principles that should also be applied. These are given below and there is a wealth of much more detailed technical information on considerations for fish passage available from the Environment Agency (http://publications.environment-agency.gov.uk/PDF/GEHO0910BTBP-E-E.pdf )

### Ensure adequate depth of water at both entrance and exit to easements

This can be achieved by cutting small slots in the upper and lower lips of the weir at the entrance and exit points to the easement. The siting of a slot at the upper lip of the weir can also be used to ensure that the full extent of the easement is adequately supplied with water. Where structural restrictions make cutting slots impractical, the addition of a (low) baton to the upper lip (with a gap that is aligned with the upstream exit of the easement) can be used to generate the effect of a slot on the upper weir lip. The previously mentioned (i.e. Low Matlock weir) addition of slotted beams to the lower lip can, of course, be used at the downstream edge of the barrier.

### Minimise the presence of entrained air (white water) within the easement

For easements utilizing beams perpendicular to the direction of water flow (i.e. vertical slot easements), it is advantageous to round the top surface of all perpendicular beams to a smooth curve. This will smooth the water flow overtopping the beams that separate each chamber within the easement. Entrained air dramatically reduces the swimming ability of fish – and consequently compromises their ability to negotiate installed easements and barriers.

## Consider pre-barrages

Although especially valuable for weirs that have vertical lintels and shallow, level aprons at their downstream edge; the ability to "drown out" the lowest section of a weir is highly effective in ensuring fish can enter the subsequent easement structures. Pre-barrages are essentially pools constructed below the downstream lip of a weir that locally raise the downstream water level. They can be constructed using imported stone as well as timber pinned to the stream bed. Vertical slots should, of course, be incorporated in the transverse walls of the barrage. An example incorporating a double pre-barrage is pictured below (Fig. 19).

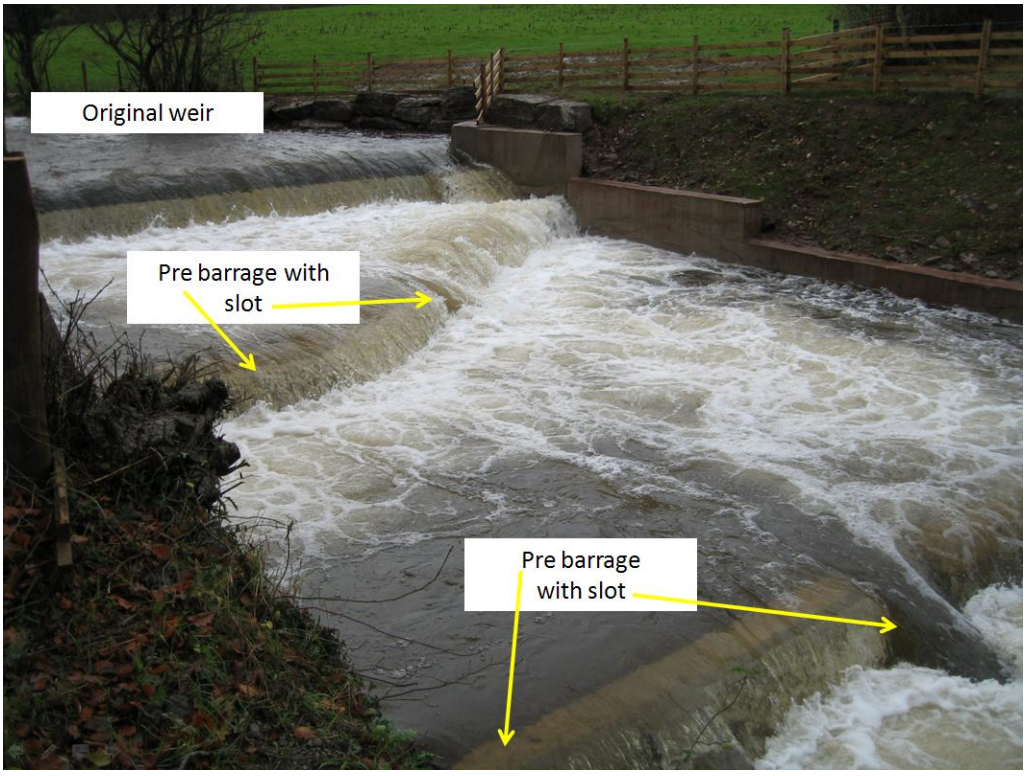



**Figure 19: Example of two large pre-barrages below a vertical weir. Courtesy of Wye and Usk Foundation.**

## Produce visualizations to aid consultation process

Investment of some time and resources into producing helpful visual representations of proposed easement designs will be invaluable to subsequent consultation and application processes. This will be especially useful for accommodating local aesthetic concerns (e.g. adding a matching pair of diagonal baulks at opposite sides of Hillsborough weir may be more visually acceptable to the public than a single baulk).

## Plan for long term liability and maintenance of structures

Each of the recommended structures will need to be looked after following installation. There is a likely additional advantage of incorporating local volunteers – since participation in installation is likely to engender a stronger sense of ownership when compared to externally-contracted installations. The Don

Catchment Rivers Trust is ideally placed to initiate such volunteer-group participation in both installation and maintenance.

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