Site assessment

River Esk – Ruswarp

North Yorkshire

23/08/16

Undertaken by Gareth Pedley - Conservation Officer

1.0 Introduction

This report is the output of a site visit to two sites on the River Esk, undertaken by Gareth Pedley of the Wild Trout Trust (WTT). The visit was requested by Rex Parry of the River Esk Fisheries Association (REFA), to provide an independent perspective on proposed alterations to the river channel associated with the hydropower installation at Ruswarp Weir (NZ 88650 08943) in Whitby and at another large weir further upstream, near Danby (NZ 70716 08305). Also present during the Ruswarp part of the visit were Stephen Larkin and Mike Ford (Esk Energy Yorkshire Ltd.) and Pat O'Brien (Environment Agency Fisheries Technical Specialist).

Normal convention is applied with respect to bank identification, i.e. the banks are designated left bank (LB) or right bank (RB) while looking downstream. For simplicity references to upstream and downstream are often abbreviated to u/s and d/s, respectively.

2.0 Background

The North Yorkshire River Esk is a relatively small river (c.45 km long) that originates on the North Yorkshire Moors and flows in an easterly direction to discharge into the North Sea at Whitby. The river has a long history as a migratory salmonid fishery, supporting stocks of salmon (*Salmo salar*) and sea trout (*Salmo trutta*), amongst other species including a small population of grayling (*Thymallus thymallus*). In recent decades, catches of migratory fish have fallen, leading to concerns about their populations, although fish do continue to be caught by anglers each year. This led to the initiation of an Environment Agency local broodstock scheme, taking eggs from fish caught in the river and rearing them in Kielder Hatchery to be released back into the river. Controversially, major fish passage issues on the catchment were not addressed before assessing the requirement for such action.

Decreased marine survival rates currently impact upon many UK migratory fish populations and in addition, the Esk suffers from numerous barriers to fish passage along its length. These range from minimal to, potentially, high levels of impact upon fish movements u/s and d/s, for adult and juvenile fish. Ruswarp Weir, being at the head of tide, has the potential to cause significant issues if fish passage at the site is not optimised.

As shown in Figure 1, Ruswarp Weir is a c.270-metre long, 10-m wide block stone and concrete structure that spans the full width of the River Esk in a slight dog-leg that is further u/s at the RB than the LB end. Until installation of the current Larinier pass in the summer of 2012, u/s fish passage was provided by a pool traverse pass at the u/s (RB) end of the weir (in the location of the current Larinier pass) and a diagonal baulk pass approximately mid-way along its length. Passage d/s may occur via these routes, over the weir (in high flows) or via a smolt pass located at the d/s end of the weir which is operated during peak migration times (blue arrow).

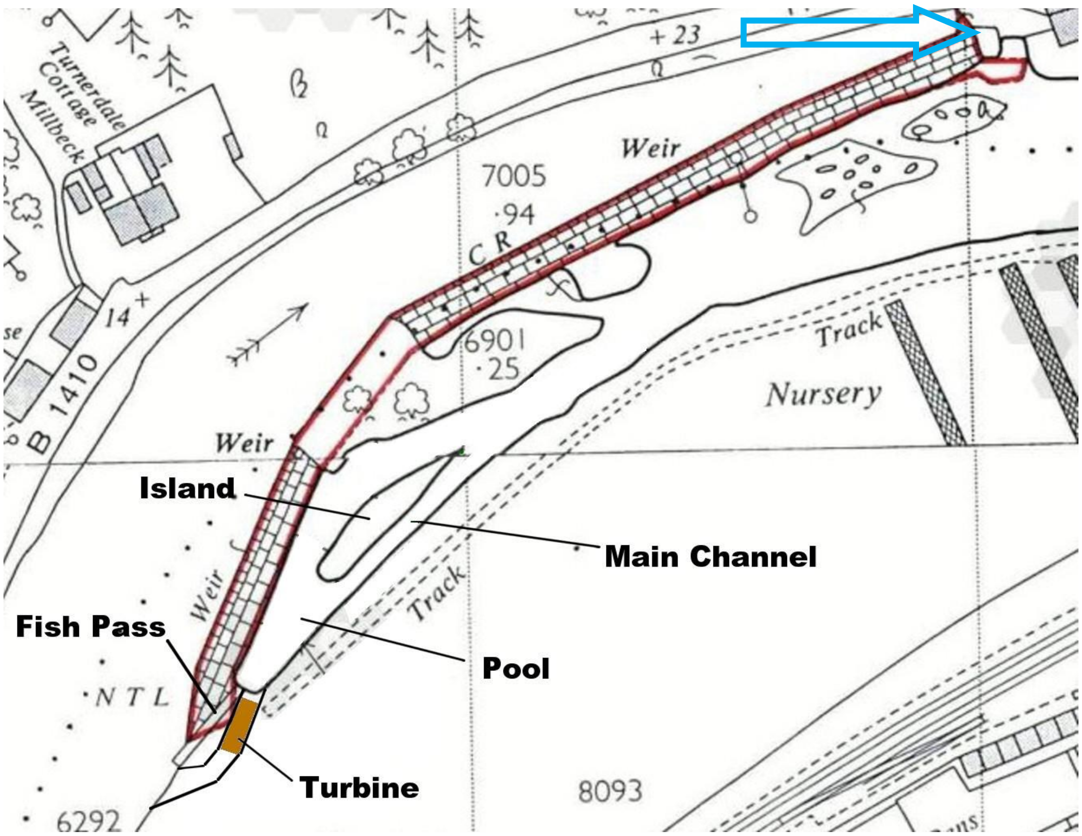

Figure 1. Ruswarp Weir location plan.

A community hydropower scheme installed at the RB end of the weir in 2012 was seen as an opportunity to generate 'green' energy and potentially improve fish passage at the weir by replacing the pool traverse pass with a bottom baffle Larinier type pass. However, the potential for such alterations to impact on fish passage at an already contentious site was recognised. Consequently, a study to monitor and report on fish passage at the site was commissioned by the Environment Agency and undertaken by the Hull International Fisheries Institute (HIFI). Data were collected in the area u/s of the weir in 2010, commencing d/s of the weir in 2011. The study therefore provides one year's data with the pool pass and one year with the Larinier pass, before three further years' study (2013-15) with the Larinier pass operating alongside the hydropower turbine (P O'Brien 2016, pers. comm., 23 August 2016).

The findings of the HIFI study are not yet published and it has yet to be determined whether the hydropower installation is negatively impacting upon fish pass efficacy or fish residency d/s (delays to migration). Once the report is published it will provide important insight to the situation.

To improve the efficiency of the hydropower generation, there is now a proposal by the operators to dredge the river bed d/s of the turbine and lower the bed and water level to increase the operating head available. This report will contain a brief assessment of the current situation at the site and identify key considerations that should be made in identifying potential impacts resulting from this action.

3.0 Assessment

3.1 Ruswarp

Ruswarp Weir is a large structure by any standards and consequently, an unavoidable issue for fish passage. Even with a fish pass, the structure can never be as naturally passable as an unaltered river channel and therefore the site requires careful management to ensure that fish passage is optimised.

On the day of the visit, river flow was only slightly above low summer level and below that which is required to provide a surplus for hydropower generation. Correspondingly, all flow was passing the weir via the Larinier and baulk passes. It was indicated that below the flow required for turbine operation the Larinier would take up to $1m^3/s$ and the baulk pass up to $0.5m^3/s$ (S Larkin 2016, pers. comm., 23 August 2016).

Downstream of the weir, a permanent, vegetated/wooded island splits the channel (Fig. 2), funnelling flows down a relatively uniform width (c.10 metres wide) channel along the RB (Fig. 3), with a more variable but apparently similarly discharging (on the day of the visit) channel down the LB side (Fig. 4).

For clarity, the channel to the LB side of the island will be referred to as the LB channel and the channel to the RB side the RB channel. Both channels appeared to be supporting juvenile salmonids (as evident by surface feeding) but the left channel generally provides greater morphological and flow diversity, a greater occurrence of pool and riffle features, and shade variability; correspondingly, providing greater general habitat quality despite adjoining the weir. The dredging proposed is to lower the bed level within the RB channel, which would therefore mean that it take a greater proportion of the flow emanating from the turbine and/or fish pass. This would consequently reduce flows in the LB channel.

Figure 2. Larinier pass (foreground left) discharging flow that is then split down either side of the island (centre background). The hydropower installation (right of shot) was not in operation (or discharging) at the low flows observed. The proposed dredging would lower the RB channel (right of shot) and send a greater portion of flows down that channel.

Figure 3. Looking d/s at the RB channel. Relatively over capacity and poor general habitat. Also note the hard bank revetment/toe and associated significant undercutting of the bank (red ellipse).

Figure 4. Looking u/s at the LB channel. Although abutting the weir, this channel generally supports greater habitat and flow diversity, with a pool and riffle sequence, low overhanging and trailing cover and in-channel woody material. Correspondingly, this channel appeared to be supporting more juvenile salmonids, as observed by surface feeding activity.

Fish passage here is complex owing to the two potential approach routes (either side of the island) to the main Larinier pass (and hydropower turbine when operating). While the baulk pass is less likely to be utilised in lower flows, it creates an attraction at all flows which, combined with the discharge flow of the LB channel, is likely to draw fish towards the middle of the weir in preference to the RB channel in low flows (Fig. 5 & 6). The access route to the RB channel (at the d/s end of the island) is also shallower over a greater area than the LB channel, providing less attractive flow and poorer passability than the LB channel at low flows. Fish unable to ascend a weir will also instinctively follow that weir to its upstream extent, making the LB channel a vital migration at both high and low flows (in addition to being important habitat in its own right). This is why fish passes are ideally located in the u/s corner of a weir and why free passage along the toe of a weir must be maintained.

There is a long-held misconception that fish will only move during high flows but becomes a self-fulfilling prophecy if structures are only passable by fish at high flows. In reality, fish will move whenever they need to, if unimpeded, which will be at a range of times throughout the year and on a range of flows (and at a wide range of fish sizes!). This is particularly true of sea trout which often move in very low water conditions. For these reasons, it is vital to ensure that all un-natural/man-made structures are made as passable as they can be, at as wide a range of flows as possible.

At higher flows, when the turbine is discharging, more water will flow down both channels, with possibly slightly more flowing down the RB channel, owing to the turbine's orientation. Observation d/s of the island when the turbine is discharging would be beneficial in ascertaining the associated impact upon attraction flows; however, the LB channel is likely to be an important route for fish migration at all flows, especially at higher flows when water overtopping the weir increases attraction to the LB channel.

Figure 5. Looking u/s at the two possible approach routes around the island, from the d/s end. The longer, shallow access route to the RB channel (blue arrow) and the narrower, deeper access route to the LB channel (red arrow), via the deeper area of the d/s river channel. Note the additional attraction to the LB channel provided by the baulk pass (black arrow).

There could be an argument for closing the baulk pass completely and optimising passability at the Larinier pass. This could consolidate some of the attraction flows, but not once the weir is overtopping and attraction increases along the weir toe and LB channel. There is also the consideration that the efficacy of the Larinier has not been established and the baulk pass may remain an important migration route at higher flows. Passage via the Larinier pass may also be delayed by attraction to the hydropower turbine discharge, whereas fish that find the baulk pass, and are capable of ascending it (of sufficient size and power) may not experience such delays.

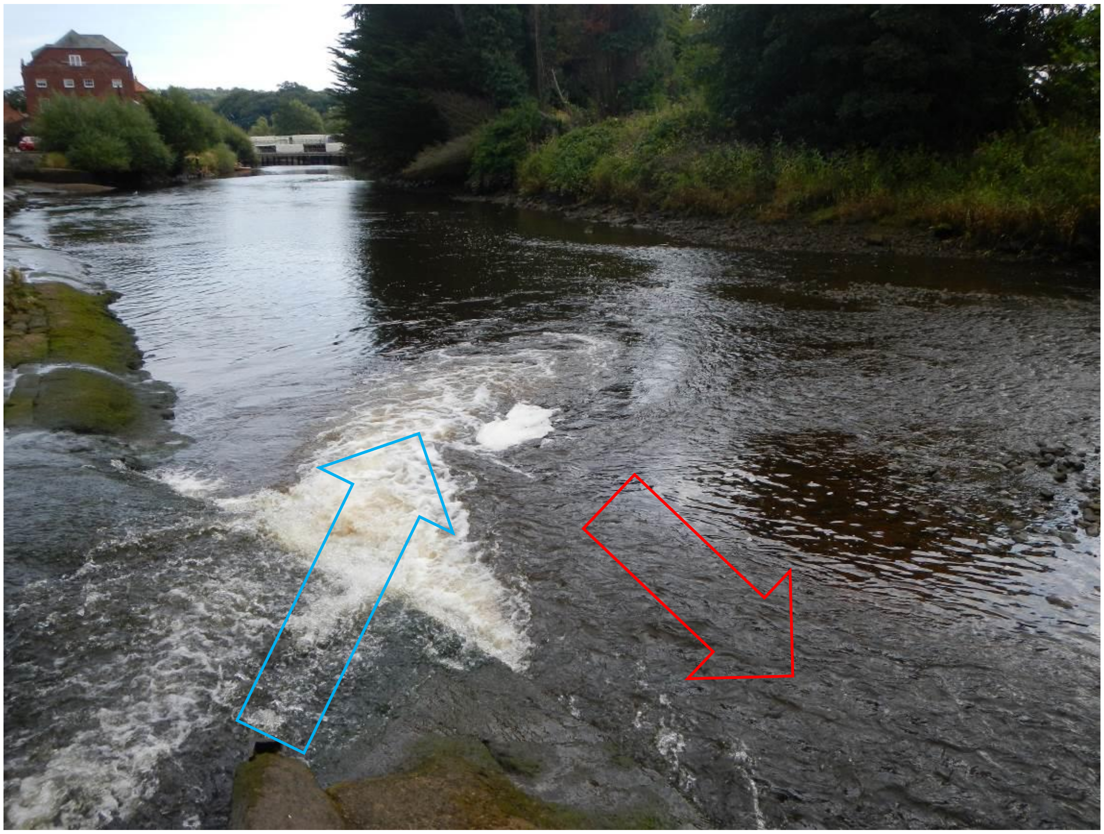

Figure 6. Looking d/s at the discharge from the baulk pass (blue arrow), creating a major attraction towards the baulk and, when the baulk is not passable, to the LB channel (red arrow). Note the wider, shallower, less attractive approach to the RB channel (far right of shot).

Having already considered the approach to the pass, the other factors that need to be considered include the weir pool at the pass; the hydropower discharge; and the location and design of the pass (Fig. 7).

Fish are usually instinctively drawn to the most significant flow (combination of volume and velocity), which will be the fish pass at lower flows. At higher flows, the most significant discharge will become the hydropower, which can be up to four times that of the Larinier pass but should never exceed 1m/s in an attempt to limit its attraction (S Larkin 2016, pers. comm., 23 August 2016). However, fish will still be drawn to the discharge and, owing to the deeper channel already present d/s of the turbine, will likely lie there while resting or if unable to locate the pass. Attraction flows are difficult to manage and fish attraction to the main flow (wherever it is) is something that is hard to overcome. This is one of the many reasons why few passes achieve anywhere near 100% passability.

To optimise efficiency, it is expected that the pass should have been designed to the existing conditions at the weir, and this is an important consideration. Larinier pass efficiency is governed by several factors, particularly the length of each flight (maximum 12000 mm for migratory salmonids, less for smaller fish), the gradient (maximum 15% - <u>ideally 10-15%</u>), baffle height (100-200 mm – 100mm for smaller fish), width (which is dictated by the set baffle dimensions in multiples of 600 mm), and the level of the pass discharge. Specifications taken from the EA Fish Pass Manual - www.gov.uk/government/uploads/system/uploads/attachment_data/file/298053/geho0910btbp-e-e.pdf).

The Ruswarp pass has 100 mm baffles (suitable for small and large fish) and lies within the other guideline parameters, although being at the upper limit for both length (10917 mm + 500 mm to exit the u/s end of the channel) and gradient (15%). This restricts the scope for alterations to any of the parameters.

Observation and brief inspection on the day of the visit identified the pass discharge to already be very close in height to the d/s water level; something that may have already been exacerbated by previous channel dredging undertaken during the hydropower turbine installation (M Ford 2016, pers. comm., 23 August 2016). Unlike pool traverse passes designed to allow fish to jump between deep pools of water, Larinier passes assist fish by baffling flows to create lower-velocity water, within which it is easier to ascend an obstacle. If Larinier passes become perched, their efficacy is greatly diminished as fish cannot easily or safely jump into shallow turbulent water over hard angular metal baffles. To function properly, the d/s entrance of a Larinier pass must therefore discharge below the d/s water level, with several sets of baffles submerged in the d/s pool, even at the lowest river flows (this also assist fish attraction to the pass).

These are major considerations in light of a proposal to lower the d/s bed and water level further and alter the conditions from those for which the current pass was designed. While it is understood that a 50% gradient (1 in 2) rip rap (150 - 300 dia. pieces) ramp exists immediately d/s of the pass, the steepness and absence of wing-walls mean it cannot mitigate lowering of the d/s water level as it only serves to assist attraction flows and guiding of fish towards the pass (which was its intended purpose).

Another potential issue is that reducing the impounding effect of the pool into which hydropower turbine discharges will reduce the flow dissipation currently provided by the pool and could result in an increase to discharge velocities above the required 1m/s. Therefore, increasing turbine output may be in direct conflict with the vital goal of minimising attraction to the turbine discharge.

The exact implications of any alteration to the bed level would have to be assessed from site plans and the as-built drawings of the Larinier pass and hydropower installation, along with more detailed site inspection. All assessment should take into account a range of river flows and d/s water levels.

In addition to salmonid passage at the Larinier pass, it is also important to consider the requirement of passage by other species, particularly sea, river and brook lamprey (*Petromyzon marinus*, *Lampetra fluviatilis* and *Lampetra planeri*, respectively) and the European eel (*Anguilla anguilla*) which is in significant decline across its native range. While the weir face may provide some roughness and structure up which some eels may ascend (still less than ideal), the concrete ridge along the weir crest greatly reduces its overall passability (Fig. 8). If, as it appears, the ridge raised the weir height, improvements to fish passage would have been required under the Salmon and Freshwater Fisheries Act 1975 for that aspect alone.

It is understood that an eel pass was installed on the weir (P O'Brien 2016, pers. comm., 23 August) but was removed due to a suspected negative impact upon salmonid passage. Options to optimise passage for all species at this site should be made a priority (including eels and lamprey), in line with the Eels (England and Wales) Regulations 2009.

Figure 7. The d/s end of the fish pass, the level of which already appeared very close to the d/s water level. Ideally, a Larinier pass should terminate well below the d/s water level to allow fish to enter the plume within the water column of the pool.

Figure 8. The size of the weir structure and concrete ridge along its crest also render it a significant obstacle to eel migration.

A further major consideration before dredging the channel d/s of the pass is the potential unintended consequences of lowering the bed and removing sediment from an already incised channel with unstable banks (Fig. 9). Dredging will leave the banks further perched above the bed and reduce the supply of sediment downstream. When this is coupled with the increased flow volume and energy down that RB channel (as is the purpose of the dredging) acting upon the already perched, undercut banks (banks that support the access track only a couple of metres from the bank top), the potential for further detrimental bank erosion issues is high.

Past attempts to stabilise the bank toe with block stone have provided some stability there but, as with any installation of hard, immovable structures within a channel, has simply deflected flows and accelerated adjacent bank erosion. The bank stability is also reduced by over-shading from a line of Leyland cypress trees. While the trees provide some bank stability from their roots it is much less than most native deciduous species and their over-shading of the bank prevents establishment of the herbaceous vegetation that would ordinarily protect and stabilises the topsoil.

Figure 9. Significantly undercut, perched RB of the RB channel. Dredging this channel to lower the bed level will not only increase the flow and erosive forces acting upon the bank but also increase the height by which the banks are perched, encouraging even greater undercutting and tree loss and further reducing bank stability.

3.2 Key considerations

- Pass Design – when the pass was designed the existing conditions at the weir and in the pool downstream were taken into account. Altering those conditions could detrimentally impact upon the efficacy of the pass. This is particularly pertinent if lowering of the bed (and water level) increases the height the pass sits above the d/s water level.

- Any changes that significantly alter the conditions within the pass, the pool d/s or the hydropower discharge should require formal approval from the EA's fish pass panel.

- The LB channel is likely to be the primary approach route to the fish pass in certain flows. Altering the flow down that route could reduce its passability and attraction flow. An option to consolidate fish passage to the one route (e.g. via the Larinier pass by closing the baulk) could overcome some of the attraction flow issues but would not negate the requirement for free passage up the LB channel and could lead to other unintended issues. This is especially pertinent when the efficacy of the Larinier pass is not fully understood and delays to fish migrations within the pool d/s are suspected. Owing to the complexities of fish passage, any action with the potential to create an impact upon the operation the fish pass should require approval by the EA fish pass panel.

- All weirs create an impact upon the flows, geomorphology and ecology of a river. Any action that further inhibits or delays the free movement of fish up or downstream at the weir must be avoided.

- Lowering the bed d/s of the fish pass and turbine is likely to reduce the pool depth (although subsequent scour/deepening could occur) and this would reduce the holding water and, potentially, sanctuary that is provided for fish delayed in ascending the weir.

- The LB channel currently provides reasonable quality juvenile trout habitat in its own right. Reducing the flow to this channel would create an impact upon the habitat quality and the ecology it supports.

- Removing substrate from the channel d/s of the turbine will render the banks even more perched and potentially subject to major erosion issues. This could jeopardise the access track if bank slumping occurred.

- European eels are in major decline and their passage at the site should also be considered of high importance and optimised, as per the Eel Regulations 2009.

4.0 Danby Weir

The second site visited was much further u/s at Danby, to provide an opinion on the potential impact of a large mill weir. While it appeared that the structure is no longer in use for milling, the large diagonal weir across the river remains (Fig. 10).

Figure 10. Danby Weir.

At the time of the visit, the vast majority of the river flow appeared to be passing over the crest of the weir with a little discharging via the sluice; neither route was passable to fish. The dimensions of the structure (>2m high) and c.100% slope (1 in 1) make it impassable to salmonids in low and medium flows and very poorly passable to most fish at all other flows. Especially in light of the poorly performing fish stocks on the Esk system, fish passage at such a major obstruction should be considered a top priority. Improving fish passage there could increase access to a large area of the catchment, including the upper river and its tributaries, which are likely to include some of the prime salmonid spawning and juvenile areas.

The EA are looking into improving fish passage at the site and it is on their fish pass prioritisation list (P O'Brien 2016, pers. comm., 23 August) to be addressed; this should be a major goal in the management and improvement of the River Esk. As with the Ruswarp site, eel passage as well as salmonid passage must be considered.

Figure 11. The height and steep c.100% slope makes Danby Weir a major barrier to fish passage severely inhibiting utilisation of spawning and juvenile habitat in the upper river.

Ideally, weirs should always be removed once they have ceased to perform their intended purpose, to remove the major impact they create upon a river. However, some structures continue to provide amenity and historical value and other options may have to be explored. The site does provide two locations (sluice or wheel housing) in which fish passes could be relatively easily installed, although, unfortunately, they are not in the optimal, u/s corner of the weir. Sympathetically removing the weir structure (or a significant portion of the weir) would be by far the best outcome for the ecology and geomorphology (often overlooked) of the river, and for fish passage. Consideration would also have to be given to the likelihood of subsequent natural bank and bed regrading u/s and reinstatement of any abstractions dependent upon the u/s water level.

5.0 Acknowledgement

The WTT would like to thank the Environment Agency for supporting the advisory and practical visit programme in England, through a partnership funded using rod licence income.

6.0 Disclaimer

This report is produced for guidance only. No liability or responsibility for any loss or damage can be accepted by the Wild Trout Trust as a result of any other person, company or organisation acting, or refraining from acting, upon comments made in this report.