WILD TROUT TRUST

River Bradford, Haddon Estate

12/05/2021

River	Bradford
Waterbody Name	Bradford Catchment (trib of Lathkill)
Waterbody ID	**GB104028053450**
Management Catchment	Derwent Derbyshire
River Basin District	Humber
Current Ecological Quality	Moderate
U/S Grid Ref inspected	SK1995163335
D/S Grid Ref inspected	SK2194364472
Length of river inspected	3km

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1. Summary

- Multiple small dams have detrimental impacts on rivers via impoundment and drowning of habitat; preventing fish passage; and disrupting natural sediment transport.
- Complete dam removal gives the most potential for river habitat restoration and benefit for aquatic wildlife. Stakeholder engagement and interpretation would form an important element of any such project.
- Where dam removal is not possible, leaving the sluices open to allow a free-flowing river would be the next best option.
- If dams and water impoundments are retained (sluices closed) it may be possible to install fish passage improvements but this is probably not cost-effective.
- Fish passage improvements at any retained smaller impoundments (e.g. swimming pool weir) are recommended. Smaller weirs should be removed or notched wherever possible.
- For weirs carrying service pipes, using a pre-barrage (with a notch) makes it possible to drown-out the obstruction while improving fish passage.
- The introduction of large woody material and – potentially – locally-appropriate gravel would also help to improve the quality of habitat for wild trout and a variety of aquatic species.
- Maintaining ungrazed/unmown buffer strips of vegetation adjacent to the channel would reverse some of the habitat simplification currently evident.
- Measuring some basic chemical properties and temperature of the spring-water feeding the Bradford may aid the interpretation of how trout use different sections of the river (portable probes are available for this purpose).

2. Introduction

The Wild Trout Trust were invited by the Haddon Estate to give advice on the Bradford Catchment from above its confluence with the Lathkill up to its source – a distance of around 3 km.

Normal convention is applied throughout this report with respect to bank identification, i.e. the banks are designated left bank (LB) or right bank (RB) whilst looking downstream. The Ordnance Survey National Grid Reference system is used to identify specific locations.

3. Background

The Bradford is a rich, limestone stream in Derbyshire and forms part of the Haddon Estate. Historically impacted by multiple weirs – and the creation of stillwater "dams" (small on-line lakes), the channel of the Bradford has been extensively engineered. This may not be immediately apparent to the general public – given the picturesque rural setting in Bradford Dale. Considerable numbers of walkers use the Dale with footpaths running alongside the Bradford for much of its length. There is also a specifically-allocated public swimming area, created for local people by means of a weir, which is firmly embedded in local traditions. Consequently, there is as much public as private interest in the River Bradford and Bradford Dale.

The Wild Trout Trust were asked to provide an assessment of existing habitat quality and identify opportunities to improve conditions for river corridor species – including brown trout native to this catchment.

4. Habitat Assessment

The advice on habitat management concentrates mainly from the source springs (SK1995163335) down as far as Mawstone Lane (SK2131363994) – though the fenced off section down as far as the confluence with the Lathkill (SK2194364472) was also observed. The recipient is, in the first instance, particularly interested in options relating to the reach above Mawstone Lane.

Observations are listed, sequentially in an upstream to downstream direction starting at the source of the Bradford – which is identified as a spring entering the Rowlow Brook (Figs.1 and 2). Springs from limestone aquifers that feed surface watercourses tend to be associated with crystal clear water and highly productive, diverse rivers. The mineral content supports diverse food webs – aided by particulate filtration and temperature buffering provided by percolation through underlying limestone. That being said, at the specific locations that springs enter surface watercourses, there can be local de-oxygenation and maybe elevated levels of potentially toxic metals (depending on the exact nature of the underlying geology). For this reason, a good understanding of the

Bradford would benefit from even basic investigation of the spring-water properties where possible.

Figure 1: The formalised outflow of the underground spring marking the source of the Bradford.

Figure 2: The outflow from the spring into the Rowlow Brook (an ephemeral stream) - to form the Bradford.

Because the spring is physically separated from the river (rather than issuing into the bed of the river), it would be possible to sample its physico-chemical properties. Basic measurements such as temperature, dissolved oxygen, pH and electrical conductivity (a measure of dissolved salts/ions – and so related to the mineral content) are possible to monitor with appropriate, portable probes (e.g. HI-98194 Multiparameter Waterproof Meter (hannainstruments.co.uk)).

Similarly, those same parameters would be possible to measure at points within the river channel by way of comparison.

It should be noted that such equipment needs to be calibrated using commercially-available standard solutions if readings are to be accurate. For the Haddon Estate, basic physicochemical sampling could well be instructive in terms of the potential trout egg survival and breeding success (as well as simple habitat preference for adult fish). Walking downstream from the source, the first "dam" (*colloquial name for on-line ponds created by weirs*) encountered is shown in Fig.3. As the furthest upstream of five ponds, this is known as dam #5 by the Haddon Estate.

Figure 3: The dam furthest upstream on the Bradford - showing the condition with the sluice raised (and hence the "pond" is drained).

While locally contentious, raising the sluice-gate (bypassing the overflow channel; Fig. 4) at the downstream end of the dam shows the potential for river-channels to re-form in the absence of impoundment. Allied to this, there are successional processes of flora/fauna re-colonising what was previously the pond-bed; reclaiming it as a vegetated flood-plain. Given sufficient time, the initially-dominant flora (thriving on the nutrient-rich sediments) will diversify as those nutrients become sequestered in longer-living plant tissues and create more complex competitive interactions. Already, as observed on the walkover, there are a variety of insects and birds benefiting from the re-vegetation of exposed substrate.

With a much greater diversity in flow depth and pace over the wetted cross-section, there is also opportunity for increased diversity in aquatic fauna – particularly invertebrates. However, structural diversity of the stream substrate throughout Bradford Dale is limited due to the multiple impoundments (weirs) and the rigidly engineered channel planform. Those two actions intercept gravels and cobbles travelling downstream and limit gravel/cobble inputs that would otherwise be derived from periodic bank erosion (now protected by engineered banks).

Figure 4: Cobbled overflow channel at the downstream end of the dam #5. Currently dry since the sluice gate bypasses this structure.

For instance, cobble material deposited downstream of the sluice shows the potential for ramps of spawning gravel to form – but has insufficient depth of suitable particle-sizes (Fig. 5).

Figure 5: A shallow fan of gravel and cobble below the raised sluice draining dam #5.

Additionally, there is little opportunity for localised bed-scour to sort (or grade) those substrate particles into deposits according to particle-size. The grading of substrate deposits is a key function of large woody material in river channels (e.g. Fig.6).

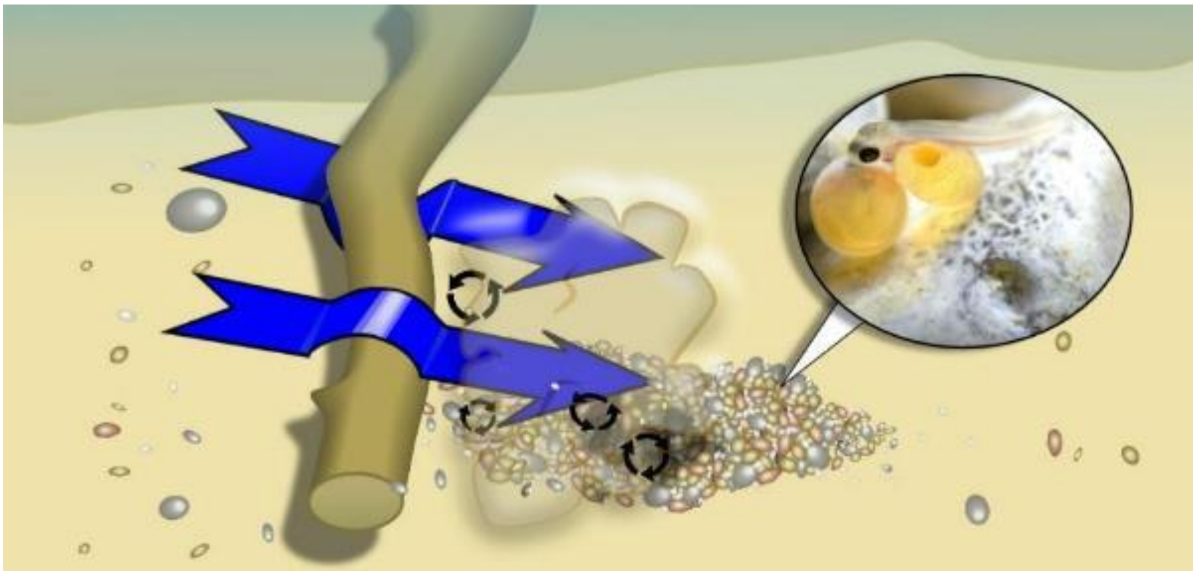

Figure 6: A fallen tree limb is focusing the flows (both under and over the limb as indicated by the blue arrows) on a small area of riverbed that results in silt being mobilised from between gravel grains. A small mound of gravel is deposited just downstream of the hollow scoured by focused flows. In these silt-free gaps between the grains of gravel it is possible for sufficient oxygen-rich water to flow over developing trout eggs, and newly-hatched "alevins" to keep them alive within the gravel mound (inset) until emerging in spring.

However, that localised grading process can only operate to a significant degree where the flow can't simply "escape" or disperse around obstructions. In channels with wide, shallow cross-sections (as in the engineered channel shown in Fig. 5), such dispersal around fallen tree-limbs would prevent focused bed-scour and limit the potential for substrate grading. Just downstream (Fig.7), the straightened channel is much narrower – to the point where focused bed-scour could be generated.

Figure 7: Narrowed, straightened channel connecting dams #5 and #4.

As throughout the Bradford, the impact of old bridge footings (e.g. Fig.7) or low weirs could be mitigated by notching or removal down to bed level. As well as reducing the potential for those structures to impede upstream and downstream fish passage, this also reduces the interception of important bed-substrate.

Just below the undershot wall/boundary structure (background in Figs. 7 and 8), there is some potential spawning habitat (Fig. 8).

Figure 8: Gravels in the 20-50mm particle diameter range could potentially support some trout spawning. There is scope for improvement of this habitat for that purpose.

The existence of downstream substrate transport from dam #5 (and flowing riverine habitat within the boundaries of that "dam") show the potential benefits of keeping sluices permanently raised. A significant increase in the amount of in-stream cover would result from allowing/encouraging trees to encroach into the channel and ultimately fall over (being anchored if additional stability is required). That process would also increase gravel retention and sorting processes to create more favourable spawning conditions.

Creation of cover is central to spawning success – since the threat of predation (as well as *actual* predation) both greatly reduce the actual utilisation of available gravel beds. Cover and bed scour could both be kick-started via the deliberate introduction of stable, large woody material in this section.

The contrasting situation of sluice gates remaining closed can be seen in the typical, impounded habitat evident in dam #4 during the visit (Figs. 9 and 10). Although creating deeper water (and consequently the potential to hold adult trout), the uniform habitat, interception of bed material, restriction of up/down-stream fish movement and relative lack of cover are all limiting its value to wild trout populations.

Figure 9: Central section of dam #4 facing upstream.

Figure 10: Dam #4 facing downstream.

As part of various possible future scenarios, the overspill at the downstream end of dam #4 may be a potential site of a fish passage easement (Fig. 11). However, installation of fish easements and/or formal fish passes do not contribute to habitat quality. Instead, they may at least allow some fish to bypass the most degraded habitat (which is at least better than a complete barrier). At the other end of the scale would be genuine reconnection of geomorphological process throughout the Bradford (via removal of weirs and reconnection to floodplains). That would create the greatest biodiversity gain in terms of both native species richness and the resilience of those populations – while also being likely to encounter a variety of strong opinions from local residents and the 20K to 30K annual visitors to the Dale’s footpaths.

That being said, maintaining the raised sluice gate in the dam upstream shows the potential for natural recovery.

Figure 11: Overspill (in action) at the downstream end of dam #4 – there is potential for a baulk or other improvised baffle easement to be constructed on the sloping face.

Directly below the overspill (Fig.12) it should be possible to augment the existing substrate with additional spawning gravel (to offset impacts resulting from past channel engineering).

Figure 12: Depending on the options adopted by the Estate, seeding this area with locally-appropriate gravel could provide some mitigation for interruptions to the natural supply.

Figure 12 also shows the presence of more cross-sectional variation in depth and flow velocity – along with low overhanging cover. There is also a mixture of dappled light, shade and full sunlight – with patches of in-channel weed growth responding to that variable light regime. This is creating many more microhabitat niches for a variety of species. Allowing any natural deadfall of large wood to remain in the channel – or deliberately introducing some – would further enhance the diversity of this habitat.

Below this section the habitat within dam #3 (in its impounded state) is shown in Fig. 13:

Figure 13: Some overhanging and emergent tree cover coupled with deep water and uniform silty bed in dam #3.

Again, while one or two adult trout were spotted, the ideal situation (ecologically-speaking) would be the removal or bypassing of the weir. The resultant connectivity for both bed-material-transport and free fish passage – coupled with the ability of the river to create pool, riffle, glide habitat of its own – would be of great benefit to fish and other aquatic populations.

The overspill at the downstream end of dam #3 is a steep drop (Fig.14). This would create a different challenge for the creation of fish passage easements or formal fish pass structures. With sufficient material and the ability to transport it to site, it would be possible to build out a rock ramp (with retaining side-walls to contain the flow). Doing this should make some upstream and downstream migration more feasible for strongly-swimming species. Again, though, this solution leaves the impacts of impounded flows in place – which also include a greater vulnerability to avian predation.

Obviously, in the absence of an impoundment there would be free passage for all species in both up and downstream directions (regardless of swimming ability). That passage is also enabled at all flow levels; rather than being constrained to particular “sweet spot” conditions that usually apply to fish passes and easement structures.

Figure 14: Overspill at the downstream end of dam #3.

At dam #2 there are efforts being made to maintain a permanently low level by lifting the controlling sluice (Figs. 15, 16 and 17). This section is immediately adjoining the overspill shown in Fig.14).

Figure 15: Significant benefits to habitat from lifting the sluice of dam #2 the encroachment of vegetation and recovery of some meandering planform add to the benefits of varied flow velocity and depth that emerge when impoundment is removed.

Figure 16: Further downstream in the perimeter of dam #2.

Figure 17: The dam wall for dam #2 – showing the former level of impoundment when the sluice was closed.

Throughout that flowing section of watercourse within the perimeter of dam #2, the introduction of large woody material would be of great benefit. As well as natural cover, structural diversity would be generated via localised scour and deposition.

As would be expected, the free-flowing watercourse of dam #2 is a very marked contrast to the uniform habitat found in dam #1 which is maintained at full capacity (Fig. 18). Again, all the previous comments on the impacts of holding flowing water back and the interruption of bed-material transport, habitat simplification (risking over-exploitation by avian predators) and prevention of free movement between good quality habitat apply here.

Figure 18: Dam #1 impounded reach with simplified/silty habitat.

The overspill at the downstream end of dam #1 (Fig. 19) may be amendable to low-tech easement installation – though implicitly that carries no habitat benefits.

Figure 19: It may be possible to facilitate some upstream migration by installing batons to produce a series of resting pools and baffled flow on the face of the weir (arranged so that access to each resting pool is as easy as possible for fish ascending the structure).

The free-flowing channel below dam #1 (Figs. 20 and 21) would benefit from the introduction of "lay-down" style woody material cover (by avoiding removal when trees fall in naturally and/or kick-starting with some targeted felling).

Figure 20: Riparian cover is generally quite high above the water - and relatively sparse. Laying down some riparian trees into the channel at a variety of angles to the flow would improve this situation.

Figure 21: Examples of low, overhanging cover such as this are relatively rare within the free-flowing reach below dam #1.

Another spring input (Fig. 22) was photographed from SK2068963945 and this may provide another opportunity for comparative water physicochemical sampling of upstream, downstream and spring-water conditions.

Figure 22: Spring issuing into the River Bradford mid/left of frame.

The reach below the spring runs into the public swimming area – though upstream of that impoundment is free-flowing and contains potential spawning substrate (Fig. 23).

Figure 23: Unimpounded flow and potential spawning gravels. A cessation of grazing would benefit riparian habitat.

The RB of this reach has more vegetation cover – although an apparent recent change in land-use may mean that neither bank is grazed in future. Maintaining an unmown/ungrazed buffer along the LB would be of great benefit to aquatic and terrestrial communities. For instance, such cover would increase the likelihood of fish attempting to use available spawning substrate (and avoid predation in the process).

The low barriers (Fig. 24) within this reach would be relatively easy to notch and this would provide great connectivity and geomorphological benefits.

Figure 24: Notching these low barriers would be surprisingly beneficial.

The next barrier downstream (Fig. 25) appears to contain a service pipe that -if live – would obviously make removal, bypass or notching extremely problematic. Constructing a "pre-barrage" a few metres downstream (with a notch to allow fish passage) would effectively drown-out this barrier.

Figure 25: Apparent service pipe buried beneath a smooth, sloping weir-face.

The designated swimming area (Figs. 26 and 27) is formed by a substantial weir (Fig. 28) which – because of the degree of public use – would face strong resistance to removal.

Figure 26: Swimming area sign (indicative of local attachment to this amenity).

Figure 27: The shallow head of the swimming area - dropping off into deeper more impounded water.

The size and design of this weir suggests that a formal fish pass may be merited as a compromise in this situation. The great value of a well-executed fish pass at this location is that, with the previously-mentioned efforts to improve connectivity upstream, the potential exists to reconnect around 3km of river habitat. As well as possibly increasing fish numbers – the degree of resilience of those populations would be significantly improved by the ability for immigration and emigration throughout Bradford Dale. It would also increase the opportunities for gene-flow, preventing in-breeding within the currently segregated smaller breeding populations. The more restrictions there are on such gene-flow; the greater the chances of harmful, non-adaptive genetic shifts occurring purely by chance. In other words, the smaller a breeding population is, the greater the chances of a random genetic change which could lead to extinction.

Figure 28: The weir that forms the swimming pool.

Low-key notching of stone (Fig. 29) and informal boulder (Fig. 30) weirs just below the swimming pool weir would help to complete that 3km of connected habitat.

Figure 29: A low stone weir just downstream of the swimming pool weir – the small existing notch needs to be enlarged to enable free fish passage.

Figure 30: Boulder weir - amenable to simple block removal.

Finally, either side of a small footbridge at Mawston lane, two very small barriers (Fig. 31) should be notched in order to ensure connectivity.

Figure 31: Small stone barriers can have a surprising (negative) impact on free fish movement. In these cases, notching is recommended.

5. Recommendations

If all relevant, legal permissions were to be obtained (including those beyond the remit of the landowner); then there are several options that could be pursued in an effort to improve and protect the ecology of the River Bradford.

- The first, and most ecologically beneficial, would be the removal of the dams from the system and restoring the river to its proper floodplain
- The next best option would be to remove the impounding effects of the structures controlling water flow in the five dams. Probably the simplest way to achieve this would be to maintain (and if necessary construct) open sluices between each dam:
    - Appropriate checks would need to be made to ensure that the open sluices themselves did not represent a barrier to free passage.
    - A significant amount of public consultation (and interpretive material) would also be required in order to broker either of these arrangements.
- In the event that the presence of impounded dams were deemed essential features of the landscape – a far more costly solution would be to attempt to create nature-like bypass channels to each dam; while diverting sufficient flow to maintain ponded water. Significant complexities and costs into the millions of pounds should be expected in that instance. In reality there may well be insufficient room to create such a bypass channel while still retaining public access and the dams.
- Thirdly, a combined approach of agreeing a number of dam(s) to be maintained as impounded – versus free-flowing – with fish-easement structures installed on active overspills. Advice on potential designs and materials for such easements can be subject to a separate project-proposal.
    - The ecological value of this solution is strongly limited by the continued existence of degraded habitat within the dams and the absence of natural sediment transport.
    - Similar limits on ecological value stem from the inevitable fact that fish pass structures function at far less than 100% efficiency for movement both up and downstream.
- In any/all instances above, there are opportunities (cited in the report) for:
    - Increasing the amount of large woody material in and around the stream.
    - Potential seeding of some areas with locally-appropriate spawning substrate.
    - Creation of unmown/ungrazed buffer strips in what are currently open-field settings.
    - Notching or removal of all low barriers.
    - Installation of a formal, technical fish-pass on the weir at the downstream end of the public swimming area.

- Physicochemical testing of spring water and main-river water may also inform on the prospects for successful breeding and/or habitation by subsequent year-classes of fish.

6. Further information

The WTT may be able to offer further assistance such as:

- WTT Practical Visit
    - Where recipients require assistance to carry out improvements highlighted in an advisory report, there is the possibility of WTT staff conducting a practical visit. This would consist of 1-3 days' work, with a WTT Conservation Officer(s) teaming up with interested parties to demonstrate habitat enhancement methods (e.g. tree kickers and willow laying etc.).
- WTT presentation/Q&A session
    - Where recipients are unsure about the issues raised in the AV report, it is possible that your local conservation officer may be able to attend a meeting to explain the concepts in more detail.

In these examples, the recipient would be asked to contribute to the reasonable travel and subsistence costs of the WTT Officer. The WTT website library has a wide range of free materials in video and PDF format on habitat management and improvement:

www.wildtrout.org/content/wtt-publications

We have also produced a 70-minute DVD called 'Rivers: Working for Wild Trout' which graphically illustrates the challenges of managing river habitat for wild trout, with examples of good and poor habitat and practical demonstrations of habitat improvement. Additional sections of film cover key topics in greater depth, such as woody debris, enhancing fish populations and managing invasive species. The DVD is available to buy for £10.00 from our website shop www.wildtrout.org/shop/products/rivers-working-for-wild-trout-dvd or by calling the WTT office on 02392 570985.

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