River Irk – Greater Manchester

An advisory visit carried out by the Wild Trout Trust – Feb 2015

1. Introduction

*This report is the output of a Wild Trout Trust Advisory Visit (AV) undertaken along **approximately 3km of the River Irk in Greater Manchester.***

The visit was carried out by Dr. Paul Gaskell and hosted by Jo Fraser (Groundwork North West), Mike Duddy (Salford Friendly Anglers) and Dave Barlow (Manchester City Council). The River Irk was walked from an upstream limit at NGR (National Grid Reference) SD 86762 05493 to a downstream limit at SD 83972 03627

Throughout the report, normal convention is followed with respect to bank identification i.e. banks are designated **Left Hand Bank** (**LHB**) or **Right Hand Bank** (**RHB**) whilst looking downstream.

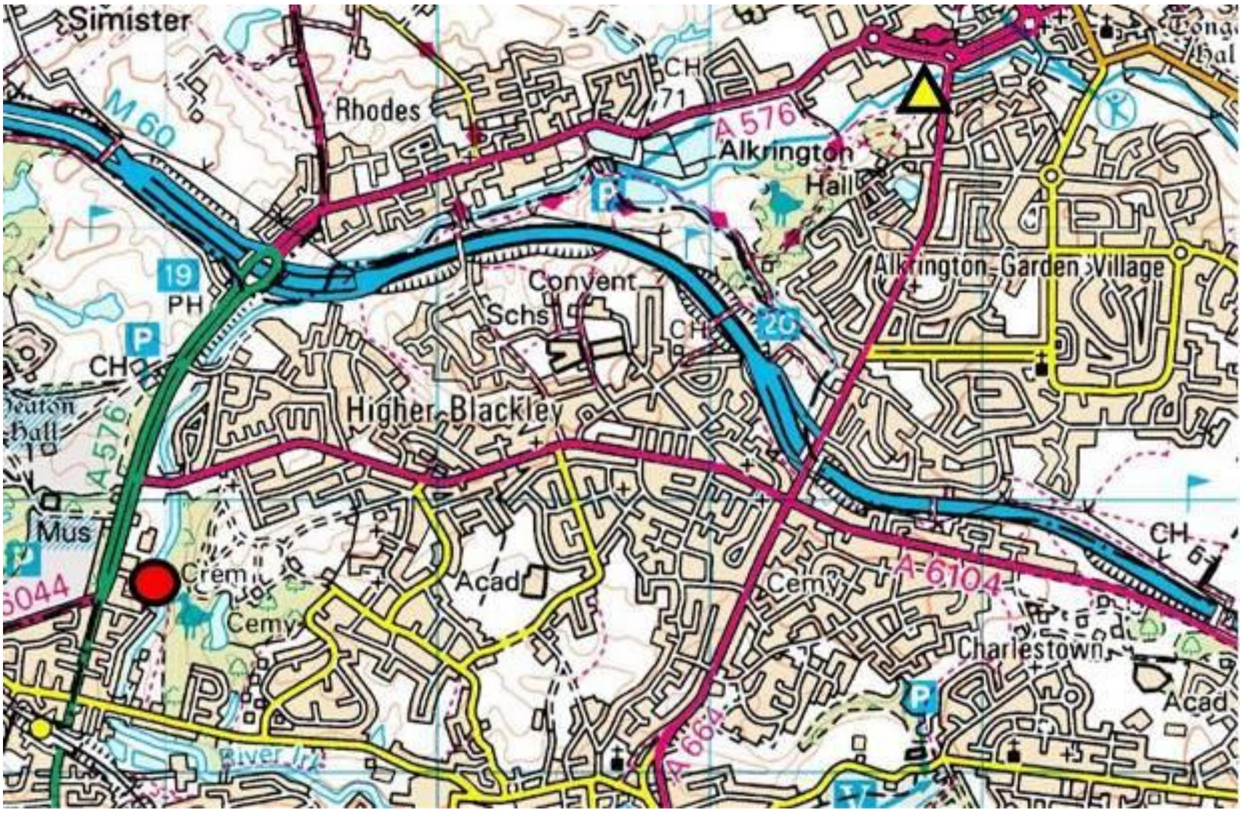

Figure 1: Map overview of the catchment including upstream (yellow triangle) and downstream (red dot) limits of inspected reaches

2. Catchment overview

The surveyed sections of watercourse are all captured within a single waterbody (GB112069061130); listed as River Irk – Wince Brook to Moston Brook. A number of the parameters are judged to be of less than "Good Potential" for this heavily modified waterbody (e.g. excerpted data given in Table 1.) – giving an overall current and projected ecological potential of "Moderate". The stand-out assessment results are those for "Phosphate" and "Invertebrate" parameters that are judged to be of "Poor" and "Bad" potential respectively; resulting in an overall biological quality of "Bad". The presence of a detergents factory (with associated, documented pollution and fish-kill incidents) is a fundamental issue for this section of the River Irk.

Table 1: Summary of current and predicted Water Framework Directive classifications for River Irk

River Irk (Wince Brook to Moston Brook)		
		View data
Waterbody ID	GB112069061130	
Waterbody Name	River Irk (Wince Brook to Moston Brook)	
Management Catchment	Irwell	
River Basin District	North West	
Typology Description	Low, Small, Calcareous	
Hydromorphological Status	Heavily Modified	
Current Ecological Quality	Moderate Potential	
Current Chemical Quality	Does Not Require Assessment	
2015 Predicted Ecological Quality	Moderate Potential	
2015 Predicted Chemical Quality	Does Not Require Assessment	
Overall Risk	At Risk	
Protected Area	Yes	
Number of Measures Listed (waterbody level only)	5	

Site details	
Waterbody Name	River Irk (Wince Brook to Moston Brook)
Waterbody ID	GB112069061130
Management Catchment	Irwell
River Basin District	North West
Current Ecological Quality	Moderate Potential

Biological Quality:	
A characteristic or property of a biological element that is specifically listed in Annex V of the Water Framework Directive for the definition of the ecological status of a water body (for example composition of invertebrates; abundance of angiosperms; age structure of fish).	
OVERALL BIOLOGICAL QUALITY	Bad
Fish	Poor
Macro-invertebrates	Bad

General Physico Chemical Quality:	
OVERALL PHYSICO CHEMICAL QUALITY	Moderate
Ammonia	Moderate
Dissolved Oxygen	High
pH	High
Phosphate	Poor

The Irk rises to the east of Royton in Greater Manchester, flowing past Chadderton and Middleton before joining the River Irwell via a culvert at Ducie Bridge in Manchester town centre. The underlying geology consists of sandstones (principally Chester Pebble beds formation, Manchester marls formation and mudstone) as well as coal measures. The bedrock formations are overlain by Till (Devensian – Diamicton) and, in the river valley, alluvium, clay, silt, sand and gravel – including glacio-fluvial deposits, Devensian sand and gravel. During the visit it was notable that the waters of the Irk carry far less peat stain than many northern spate rivers – and this is matched by the apparent relative scarcity of peat in the upper catchment.

3. Habitat assessment

The watercourse was examined for its general characteristics and broad ecological issues. In addition, the focus of this Advisory Visit was to identify whether there were obvious shortages of (or lack of access to) habitat features that would support the full lifecycle of wild trout (*Salmo trutta*). The sensitivity of trout to low oxygen levels and requirement for physical diversity in riparian and aquatic habitat and associated flora and fauna make it a good species to use as a yardstick of river quality. Figure 2 (below) illustrates the effect that a lack of specific habitat features will have on the structure of trout populations.

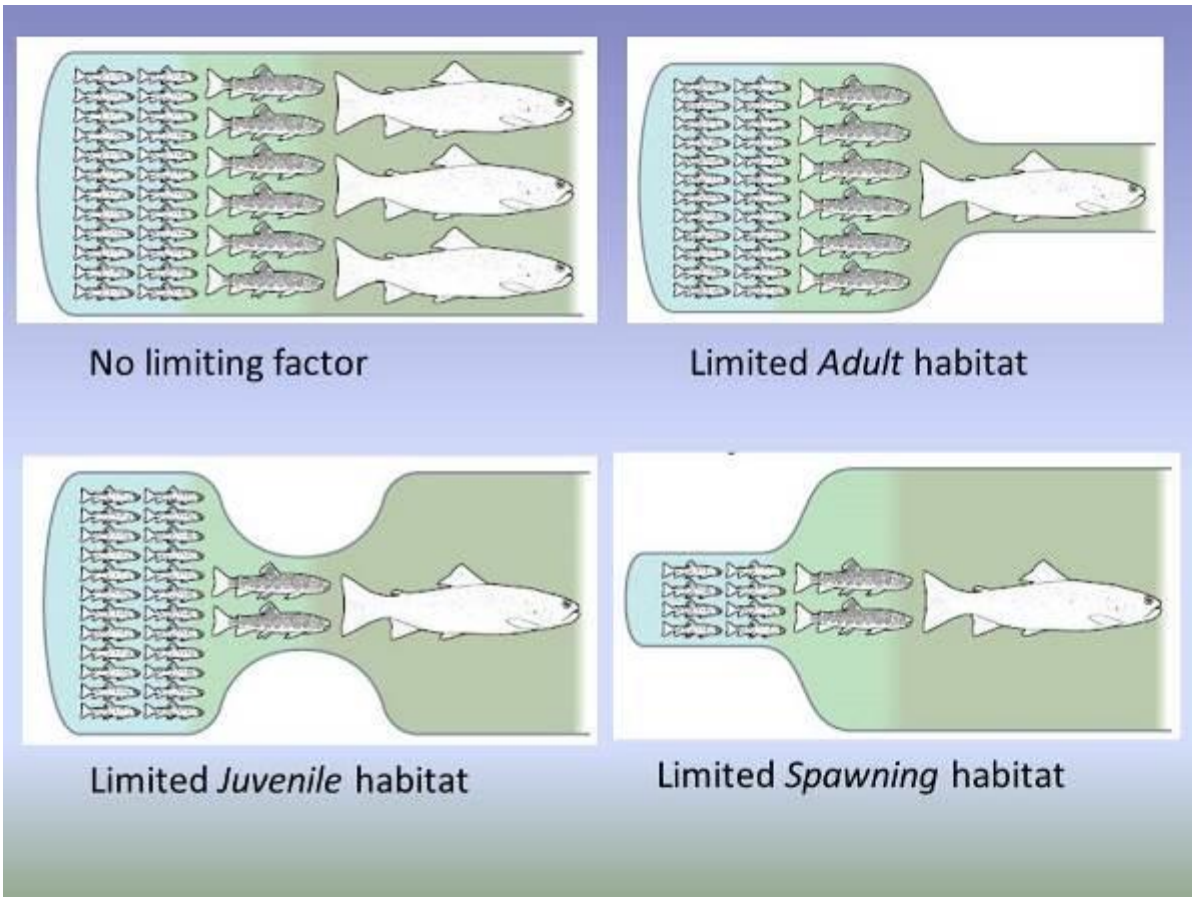

Figure 2: The knock-on impacts to fish populations caused by a lack (or degradation) of specific types of habitat at three crucial lifecycle stages; spawning, juvenile/nursery and adult. Spawning trout require loose gravel with a good flow of oxygenated water between gravel grains. Juvenile trout require shallow water (quite variable around an average of 20-cm) with plenty of dense submerged/tangled structure for protection against predators and wash-out during spates. Adult trout require deeper pool habitat (generally > 30cm depth) with nearby robust structural cover such as undercut boulders, sunken trees/tree limbs and/or low overhanging cover (ideally within 30cm of the water's surface. Strengths (i.e. excellent quality) in one or two out of the three crucial habitats may not be able to completely make up for a "weak link" in the remaining critical habitat type(s).

3.1 Reach 1

The watercourse was surveyed in two sections – firstly from the downstream limit at SD 83972 03627 up to SD 84133 04463. In this region the presence of extensive woodland, the relative lack of impounding structures and a gradient that is sufficient to encourage redistribution of cobbles and gravel provide some valuable habitat. This partially offsets some of the impacts of the channel modifications (e.g. retaining walls and straightening) that artificially set the course of the river. Constraining the river's propensity to produce natural meanders and to migrate laterally within its flood-plain reduces opportunities for structural variety to arise through natural scour and deposition.

Figure 3: Facing upriver at downstream limit - modified channel is reclaiming a degree of natural physical diversity thanks to steep longitudinal bed-slope and associated redistribution of riverbed material

It is notable in this section that the woodland is providing highly valuable supplies of leaf litter that form the major source of nutrition for food webs within upland river systems. However, this channel has been artificially "smoothed" by the presence of extensive retaining walls, absence of in-channel woody debris and a lack of submerged, complex cover. Consequently, the retention of those leaf-litter nutrients within this reach will be poorer than it would be in a naturally roughened channel.

Increasing in-channel structure would also assist in the retention of gravel substrate, which at present is likely to be washed straight through the uniform walled sections. Gravels that are of a size that would enable trout to attempt to spawn (i.e. approximately 20-50 mm in diameter) were observed (e.g. Fig. 3). However, these gravel deposits also suffered from extensive infiltration of finer sediment that occupied the gaps between gravel particles. Without loose deposits of gravel that have clear gaps between gravel grains (interstices), it is not possible to maintain a sufficient flow of oxygenated water to support good survival of eggs laid in gravel beds.

Localised scour of the riverbed helps to "sort" gravel particles from finer substrate by washing away silt and redistributing the sorted gravel locally. Consequently, another beneficial impact of retaining and stabilising pieces of woody debris is an increased potential for successful trout-spawning through increased retention and sorting of the substrate.

Figure 4: Gravels of potentially suitable size-ranges for trout spawning (SD 83951 03646). However, extensive infiltration of sand and silt between gravel grains currently limits potential egg survival

The vital role of an appropriate (natural) rate of bank erosion is illustrated by small sections where the stone-work at the toe of the bank (i.e. where the riverbank joins the riverbed) has failed. In those instances (e.g. Fig. 5) the inputs of valuable spawning gravel substrate – as well as finer particles – can clearly be seen. The key is to have a deep and complex root-structure within the river banks so that the rate of erosion is slow enough to provide beneficial effects without causing additional problems. The use of woodland trees to manage erosion can, and should, be combined with routing/re-routing of access paths so as to minimise damage or failure of formal paths whilst providing maximal habitat benefits.

A program of light, rotational coppicing will allow the river corridor to remain sufficiently visible from paths that benefit from being sited among a matrix of below-ground root systems. It will also promote vital low, bushy cover that is generally lacking in these sections of river. Added benefits of this more varied canopy height and age include greater terrestrial habitat diversity as well as a

more varied light/shade regime for the woodland understory and river-channel alike.
Furthermore, the coppice re-growth can subsequently easily be hinged or laid (as in hedge-laying) into the margins of the river. Again, providing a vital shelter to assist the over-winter survival of juvenile and adult fish. This latter need is not well catered for in the visited reaches of the Irk.

Figure 5: Small area of bank-toe stonework failure at SD83925 03659 (Left) leading to vital inputs of spawning gravel (Right). Watercourses with stone retaining walls have their supplies of spawning gravel choked off at source. They often also tend to suffer the additional impact from weirs that intercept any gravels that have managed to find their way into the system.

Deliberate management practices are also actively minimising the formation of low and submerged marginal cover (Fig. 6)

Figure 6: Trailing branches that would previously have provided vital over-wintering habitat that have been cut back at SD83925 03675 (usually in an attempt to minimise perceived flood risk). If left trailing within the channel, those branches would also have assisted in gravel retention

A number of similar examples to those depicted in Fig. 6 were noted throughout the visit and such works are often carried out on the assumption that they will reduce flood risk. Commonly, the effect is far more closely related to perception of flood risk than any gains in reducing the frequency and magnitude of flooding events. In many cases, trying to maximise conveyance of flood waters at all points along the course of a river will actually increase the frequency and magnitude of flooding downstream:
(e.g. http://geology.gsapubs.org/content/29/10/875.short).

Extensive channelization using stonework to define the dimensions and (straightened) course of a river can have the same effect. It also greatly reduces the physical variety of habitat and associated ecological niches within a watercourse (Fig. 7).

Figure 7: The trailing and low-overhanging vegetation in this section at SD83934 03675 provides at least some (much-needed) cover. However, overall the straightened, stone-walled channel only retains a very small proportion of the structural diversity that would be present in a more natural channel

The Irk in these reaches benefits from a longitudinal bed slope and channel dimensions that, together, are sufficient to redistribute riverbed material. As a result, there are examples of regeneration or retention of some structural diversity (e.g. Fig. 8).

Although the channel does not conform to a naturally meandering planform, some variation in patterns of erosion and deposition have given rise to a series of linear glides and pools. The head of the riffle and tail of the pool shown in Figure 8 are an example of this. It was not clear whether the substrate at the shallow tail of the much deeper pool contained gravels that would be suitable for spawning trout. Some of the more visible areas appeared to be dominated by larger (cobble) particles that may only provide viable spawning opportunities for uncommonly large trout. This is likely to be due to the straightening, smoothing and confinement of the channel causing finer material to be washed out of the reach.

If it is possible for fish to dig "redds" (gravel nests) at the location pictured in Fig. 8, the riverbed would certainly benefit from localised bed-scour to "sort" the coarse from the fine particles. This would produce at least localised deposits of loose, silt and sand-free spawning substrate (see section 4 "Recommendations" for additional guidance).

Figure 8: A linear pool (upper right of frame) giving way to a ramp of substrate that produces the head of the riffle pictured in the centre and lower-left of frame at SD83959 03742.

The great value of removing impounding structures – combined with the replacement of stone bank-toes by natural vegetation and erosional/depositional features – is clearly evident in Figs. 9 and 10. A huge increase in the variety of flow depths and velocities across the width of the channel is matched by the formation of cobble bars, scour pools and glide sections. The removal of the weir has allowed the bend in the river to develop much greater structural diversity than would be possible in an impounded reach. Recent weir-removal projects like this on the Irk are having beneficial impacts throughout previously impounded reaches and the adjacent reaches above and below removed structures.

Figure 9: Lack of impoundment and more natural bank profiles - great habitat SD83996 03805

Figure 10: Valuable diverse riverbed features in un-impounded reach at SD 84041 03895

A rare example of a fallen tree that was, at the time of the visit, allowed to remain within the channel (Fig. 11) is providing excellent habitat benefits in the reach just upstream of the small tributary confluence with the main river at SD 84040 03970.

Figure 11: Valuable structural diversity provided by fallen tree trunk. The tree is still well attached at the bank-side end. If there were concerns about its ongoing stability - it would be far better to only remove the uppermost section of the trunk and, if necessary, to provide additional anchoring. This would retain a useful proportion of the benefits it is currently providing to river corridor wildlife in general and the prospects for self-sustaining trout populations specifically

Overall, pending suitable water quality, the prospects for wild trout populations in the section between SD 83972 03627 and SD 84133 04463 are relatively good. Particular benefits from the removal of impounding structures are plainly evident and there are relatively simple additional measures that could help to tackle the generally low proportion of suitable spawning habitat within this reach. Similarly, additional opportunities for improved survival of juvenile fish and overwinter survival of all fish are available (see section 4 "Recommendations" for further detail).

3.2 Reach 2

There is a substantially different character in the section walked during the afternoon of the visit. In contrast to the morning survey, the afternoon assessment was carried out from an upstream to downstream direction. The upstream limit for this section (and, consequently the visit as a whole) was SD 86762 05493 and the downstream limit was SD 84494 04717.

Modifications - both of the river channel and surrounding land – are much more prominent by comparison to Reach 1. The uppermost reaches visited during the current survey are dominated by the extensive Robert McBride Detergents Ltd. site that backs on to the RHB. In 2009, the company was found to be responsible for a pollution event that affected at least 3 miles of the River Irk (http://www.manchestereveningnews.co.uk/news/greater-manchester-news/firm-fined-over-river-pollution-893476). The RHB that runs along one part of the perimeter of the site consists of the vertical wall that is topped by the hard-standing of the yard within the fenced complex (Fig. 12).

Figure 12: Right hand bank formed by the edge of the McBride's detergent facility at SD86699 05488

The lack of impoundment in this reach is a significant boon - although the straightened nature of the channel is coupled with a general lack of submerged and marginal cover. The variation in micro habitat types that is lost through channel simplification are illustrated quite well at the artificial bend at the downstream limit of the McBride's complex (Fig. 13). Here, at SD 86617 05447 the simple change in direction introduces additional hydrological “roughness” that allows for more varied patterns of deposition and erosion of substrate. Consequently, a larger variety of available microhabitats are retained in that highly localised example of a deviation from the (artificial) norm.

Figure 13: Not the most visually appealing example - but a clear demonstration that a bend (even when artificial) has introduced sufficient variety in the flow characteristics to promote point-bar deposition and lateral scour-pool formation. Unfortunately, these artificial bends tend to occur at a much lower frequency than those that emerge spontaneously during the natural development of a river channel

The weir at SD 86557 05424 presents a significant barrier to fish movement due to the shallow/powerful flow over its sloping face (Fig. 14). Often this type of structure is not perceived as being difficult/impossible to pass by fish because they are not a vertical wall. However, appearances are often deceptive since when flows are high enough to encourage upstream migration, the uniformly rapid flow often exceeds the maximum burst speed that many fish are capable of. Similarly, the distance between the bottom and top of the sloping face is too far for many/most fish to jump (even if the pool at the foot of the weir were to be deep enough to allow fish to generate a substantial leap).

What is often overlooked is that the impoundment upstream of the weir acts as another kind of barrier in (at least) two further ways. Firstly, the slowed pace in the impounded section (Fig. 15) often confuses fish that are migrating downstream. For instance, juvenile fish drifting downstream to find unoccupied territories in which to mature – which would include those juvenile fish attempting to migrate to sea. Secondly, the slowing of the water and simplification of the habitat (coupled with the delay in downstream movement past the obstruction) also dramatically increases the mortality due to predation of fish trapped on the upstream side.

Furthermore, weirs (as mentioned previously) intercept and store riverbed materials that are vital for the supply and creation of intermittently-mobile habitat features such as gravel and cobble bars. This constrains opportunities for diverse biological communities to form and persist – as well as limiting opportunities for individual species of interest, such as trout, to complete their lifecycle.

Figure 14: Although not the worst example of a barrier - this weir will be passable to a much lower proportion of fish than might be apparent at first glance. Particularly when the consequences of delayed downstream migration are also taken into account

Figure 15: Impounding effect of weir pictured in Fig. 14. Riverbed material interception, lack of diverse flows and depths are impacting biological quality in this reach

These impacts of impounding structures are, consequently, highly relevant to the series of ornamental "stepped pools" produced by weirs spanning between SD 86464 05331 and SD86300 05317. This series of five weirs (Figs. 16 – 18) were presumably built as a landscape feature (and/or a means of limiting riverbed incision in a straightened channel) for the Georgian Manor house "Alkrington Hall West" that overlooks this section of the river Irk.

Figure 16: Upstream end of series of low weirs (SD 86464 05331)

Figure 17: Ornamental weir at SD 86414 05327 showing propensity for bank erosion (both banks – directly downstream of the weir) when barriers are placed across the stream at 90 degrees to the flow.

Figure 18: Ornamental weir at SD 86352 05327 - the wooden "toe boarding" and ornamental stonework that form the river banks here are extremely poor in ecological terms

As shown in Figure 18, there are impacts on the ecology of this section in addition to those caused by the weirs. The smooth-walled channel created by a combination of stonework and wooden shuttering (toe boarding) prevent the development of habitat that would support a richer biological community.

Downstream of the ornamental weirs there are examples of both failed willow spiling (e.g. Fig. 19), more wooden toe-boarding (Fig. 20) and also concrete bank revetment work (Fig. 21).

Figure 19: Willow spiling that has been washed out and dog access point erosion. The spiling may have been installed too high above the water. A stepped terrace or sloping design would have had a much greater chance of succeeding – as would the use of back-filling. Both measures would help to keep the live willow in contact with growing substrate.

Figure 20: Failed spiling in combination with old toe-boarding at SD 86216 05297. Planting onto the deposited sediments is likely to rectify the problem fairly quickly

Figure 21: Old toe-boarding on LHB at SD86175 05252. The RHB provides some cover via the riparian woodland – however the stone wall and straightened nature mean that this section would still be characterised as a straight chute of very uniform habitat. The over-narrowed status of the channle is also why it is persistently eating into the bank that supports the footpath. The river is "trying" to regain its inherent, natural channel dimensions – so pulling back sections of the opposite bank would release this pressure.

Figure 22: Cast concrete "studded" bank revetment on the LHB (photo taken facing downstream) at SD 86090 05230. The proximity of the footpath and the existence of spiling/toe boarding and concrete revetments indicate the sensitivity of the footpath to the potential impacts of bank-erosion.

A substantial weir at SD 85892 05151 is a complete barrier to upstream migration and also significantly degrading the upstream reach (Fig. 23).

Figure 23: Large impassable weir at SD85892 05151 and associated upstream impoundment

When small opportunities arise for the river to escape the confines of the artificial channel boundaries – highly valuable habitat is produced (Fig. 24). This shows a potential route to increasing the biological value of this channel through localised removal of reinforcing structures to promote lateral movement of the channel into areas that are not sensitive from an infrastructure perspective (i.e. footpath/transport link etc.). For Reach 2, there is frequently dense woodland and plenty of space along the RHB to allow a series of opportunistic channel realignments. This would produce higher quality habitat. In turn, it would also reduce the pressure acting upon sensitive banks that are currently eroding – and whose hard revetments will accelerate (rather than retard) erosion rates once they begin to break up. This breakdown of hard revetments is already taking place and the inappropriate use of spiling to reduce this effect has, in fact, exacerbated the issue slightly.

Figure 24: Small bay produced by the failure (or removal) of stonework at the toe of the RHB (photo taken looking upstream). Consolidating this benefit by installing low, submerged structural cover – or planting willow whips on the toe/margins of the LHB directly opposite this bay would offer both structural and ecological benefits

A far better way to both protect the sensitive banks and simultaneously improve biological status of the channel would be to identify suitable locations that the non-sensitive bank (in erosion terms) could be pulled back. This could be coupled with the secure installation of low marginal structures that would consolidate the opposite (sensitive) banks and direct flows into the channel capacity created. In effect this would achieve a degree of re-meandered flow whilst reducing the need for ongoing hard bank revetment repairs to sensitive banks (see section 4 "Recommendations").

In well-wooded areas where the channel runs between (older) vertical stone walls and the flow is not impacted by impoundment, there is some natural regeneration of relatively good habitat. This is particularly evident wherever the channel engineers set a slightly meandering path for the river (Fig. 25). This has allowed a degree of recovery of microhabitat variety through geomorphological (erosion and deposition) processes – albeit within the confines set by the position of the retaining walls.

Figure 25: A degree of variation in cross-sectional depth and flow-velocity profiles is evident in some (generally older) engineered channel sections e.g. photo here at SD 85643 05223.

Again there would be benefits having areas with submerged, complex cover in the otherwise fairly blank margins. Similarly, opportunities to remove sections of retaining wall (e.g. on the bank opposite to footpath) should be explored where possible.

At the points where the channel is artificially narrowed to the greatest degree between high vertical walls – considerable shear velocities will be generated during spate flows. For instance, the bridge arch at SD 85575 05258 carries coarse woody debris at an impressive height above normal flow levels (Fig. 26).

Figure 26: Debris strand-line on the red ironwork on the underside of the footbridge at SD 85575 05258

This structure is likely to set the hydraulic limit for the section upstream of this point. Consequently, there is plenty of scope for introduction of materials into the channel (with or without re-profiling the banks opposite such introductions) whilst having no negative impacts on the risk of damaging flood occurrence.

In comparison to "softer" brash bank-toe stabilisation techniques, when water works behind "hard" stonework revetment – the rate of bank erosion is usually much faster (Fig. 27). This is because the hard, angular surfaces deflect and "bounce" fast spate flows instead of slowing and diffusing them. In addition, the angular faces are prone to producing strongly eddying currents that are highly erosive. Where brash revetments can be suitably keyed into the bank (or where suitable anchor points for tree kickers exist) – the propensity for erosion is, counter-intuitively, often much less. Furthermore, the dissipation of flows that more complex structures create can often actually increase deposition of substrate in that area.

Figure 27: Failing stonework revetment - this is accelerating the erosion potential into the narrow footpath (note also dead Japanese knotweed canes on RHB)

A very few examples of the benefits that stable large woody debris (LWD) can provide to river ecology were noted in this reach. The two most significant are pictured in Figure 28. In both cases the localised riverbed scour and deflection of the current had produced isolated examples of extremely valuable habitat.

Opportunities to securely anchor similar structures throughout the reach would bring valuable benefits. Logs that deflect flow in this way typically make negligible difference to "out of bank" flood events upstream of them when modelled. Their streamlined nature also means that they have much lower propensity to accumulate trash than their initial appearance might suggest.


Figure 28: Naturally arising LWD generating much-needed habitat diversity around SD 85298 05082 (note the lack of blockage/accumulation of significant additional debris and also dead Japanese knotweed canes)

The sections of Reach 2 closest to the downstream limit take on a significantly more modern, heavily-modified character. This is possibly associated with the construction of the adjacent motorway. Straight channels with significant impoundments and a trapezoidal cross section become more dominant (e.g. Fig. 31). At the same time, deeper root systems begin to be replaced by shallow-rooted turf along the LHB.

Figure 29: An absolutely impassable weir (and associated significant upstream impoundment) that consists not only of a high vertical face, but also a very shallow stone apron that fish would find impossible to cross to reach the foot of the vertical wall at SD 84977 04963

The most valuable habitat tends to occur directly downstream of such weirs – where all of the energy of the water that has been stored up via the upstream impoundment is discharged and produces scour-pool habitat. However, those restricted areas of better habitat (e.g. Fig. 30) arise at the expense of all similar scour-pool habitat within the impounded reach and, consequently, the overall habit6at would be of significantly higher quality without the presence of weirs..

Figure 30: Better habitat than that upstream of the weir - but this is generated at the expense of that degraded habitat within the impounded reach

Figure 31: A typical representation of much of the lower sections visited in Reach 2 - shallow root systems on the LHB, long impounded reaches and very uniform channel cross-sections (photo at SD 84874 04911)

The naturally-occurring tree-kickers (see section 4 "Recommendations" and Fig. 32) will be absolutely vital to the overwintering prospects of any adult trout that find their way into this section (probably via downstream drift over several weirs). Although many such structures have been cut or pruned back during maintenance works, some still persist and these are extremely valuable habitat features. It will be worth identifying and influencing the party/parties carrying out such maintenance towards current best practice measures.

Figure 32: Submerged (left) and low, overhanging (right) marginal cover generated by naturally-occurring tree-kickers. Much of the willow stand growing on the far bank should be hinged into the margins to bolster this rare and small example of submerged cover

Figure 33: Another weir - this one at SD 84759 04877

Figure 34: Grassed LHB, long impounded reach (wooded opposite bank) and artificially uniform channel defined by stonework – typical of the lower visited sections of Reach 2. Again, here are extensive opportunities for willow-laying to produce vital submerged cover.

The downstream limit of the habitat assessed in Reach 2 is a useful example of the defining characteristic of the Irk below the unimpounded reaches around SD 85233 05057 down to the weir (Fig. 35) that marks the downstream limit of Reach 2 at SD 84494 04717

Figure 35: Impassable weir (left) and resultant impoundment (right) at SD 84494 04717

4. Recommendations

4.1 Retaining and expanding on existing high-quality features

As an overarching guiding principle towards effective river restoration – an ideal first step is to tackle the channel modifications by removal of retaining walls and impounding structures. As the channel naturally rebalances its dimensions and bed-slope, it is then possible (and far more beneficial) to add habitat-enhancing tweaks that will maximise the benefits made possible by those large-scale measures. A degree of trust is involved when taking this approach since the most challenging and radical measures are enacted first – followed by a transitional period that may initially see poorer fish populations and habitat.

The first rule of ensuring the biological quality and healthy fish populations in our rivers is maintained is to recognise and avoid destroying valuable features. To this end, the program of maintenance works on the Irk should be revisited to reflect best practice balancing of flood risk (and the difference between perceived and actual risk) with ecological potential considerations (including "no deterioration" clauses) under the Water Framework Directive. Patches of trailing and submerged branches in the margins of rivers are absolutely crucial opportunities to promote overwinter survival of juvenile and adult fish. Such opportunities are in relatively short supply for much of the River Irk surveyed during this visit.

There would be significant value in examining opportunities to actively (and securely) introduce this type of cover – either in the form of "Tree Kickers" (explained here: https://vimeo.com/72720550) or as "log and brash" style bank-toe revetments (Fig. 36) – or even via root wad revetments. These latter two approaches could be used to stabilise banks that are sensitive to erosion due to their proximity to footpaths (for example) – whilst simultaneously generating cover for juvenile fish.

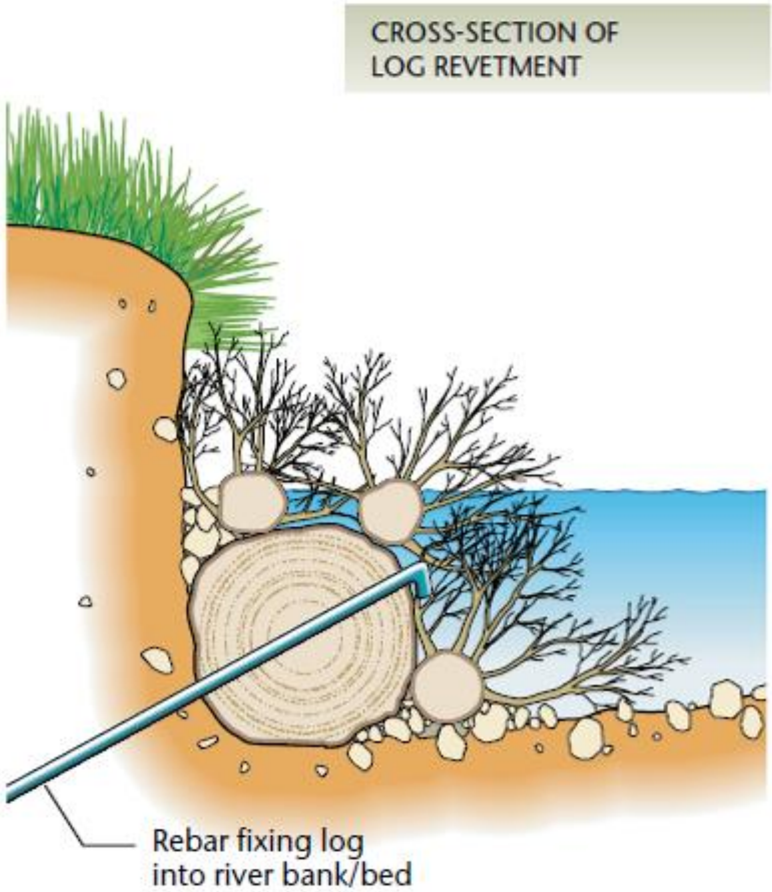

Figure 36: Log and brash style bank-toe revetment (and creation of in-stream cover). Brash is nailed to the outside of the logs pinned to the toe of the eroding bank

With all potential techniques for brashy revetments there are measures that maximise stability (and consequently control erosion of sensitive banks). The plan view (Fig. 37) shows an example of the considerations for alignment of installed logs when using that technique. By way of comparison, where "D-shaped" marginal berms are constructed using logs to define their outline, it is imperative that the bank-side edge of the material used to back-fill behind the logs is always highest (relative to the low points that project into the river channel). This ensures that flood waters do not cut behind the installed berms. Berms may also be an option as a means of reintroducing a degree of more natural meandering flow – and the associated retention of a greater variety of particle sizes within deposited substrate.

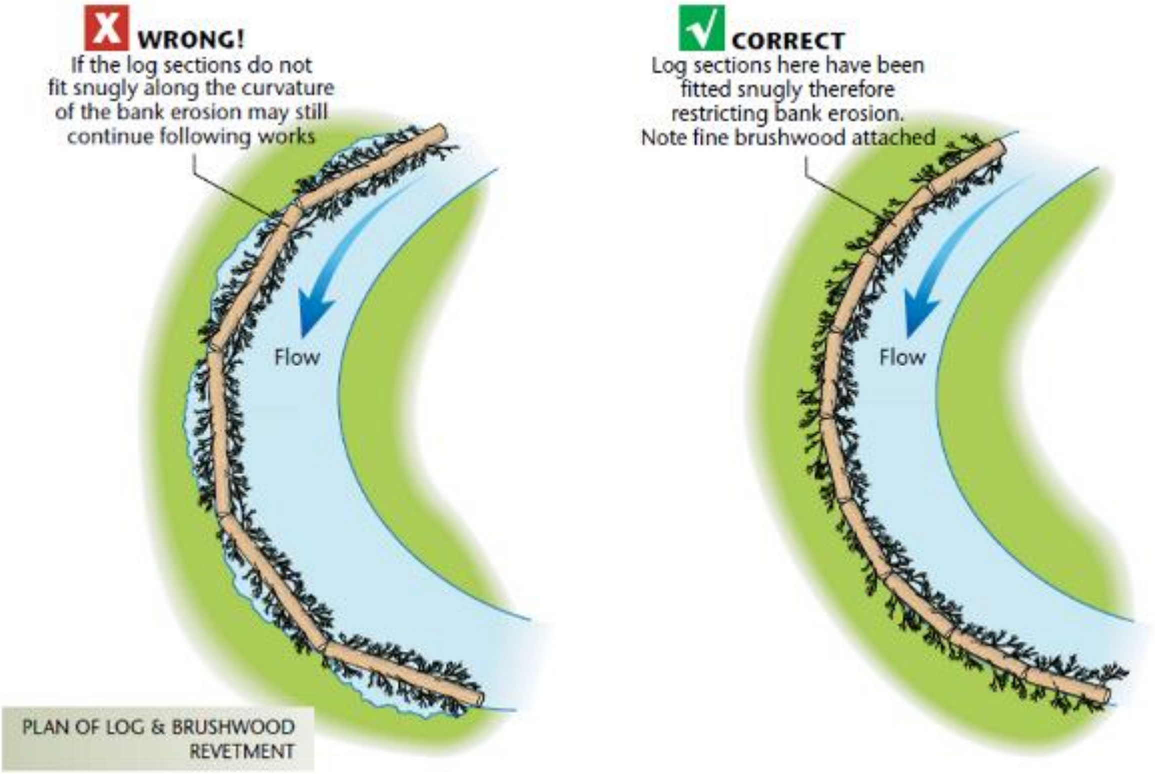

Figure 37: Examples of one kind of log and brash revetments designed to control bank erosion as well as generate juvenile habitat. Alternative measures exist and the specific reaches on the Irk would benefit from a series of bespoke project proposals

Figure 38 shows an example of an excellent alternative technique that will achieve similar aims – but would also generate probably a larger amount of habitat; whilst being extremely stable (i.e. it is likely to resist the impacts of bank erosion for the longest period of time). Tree root wads are often available as a by-product of forestry maintenance activities and their cut trunk length can be specified so that they are of the most useful dimensions for the works in question. Cutting a point into the main stem helps when driving them into the riverbank for fixing in place.

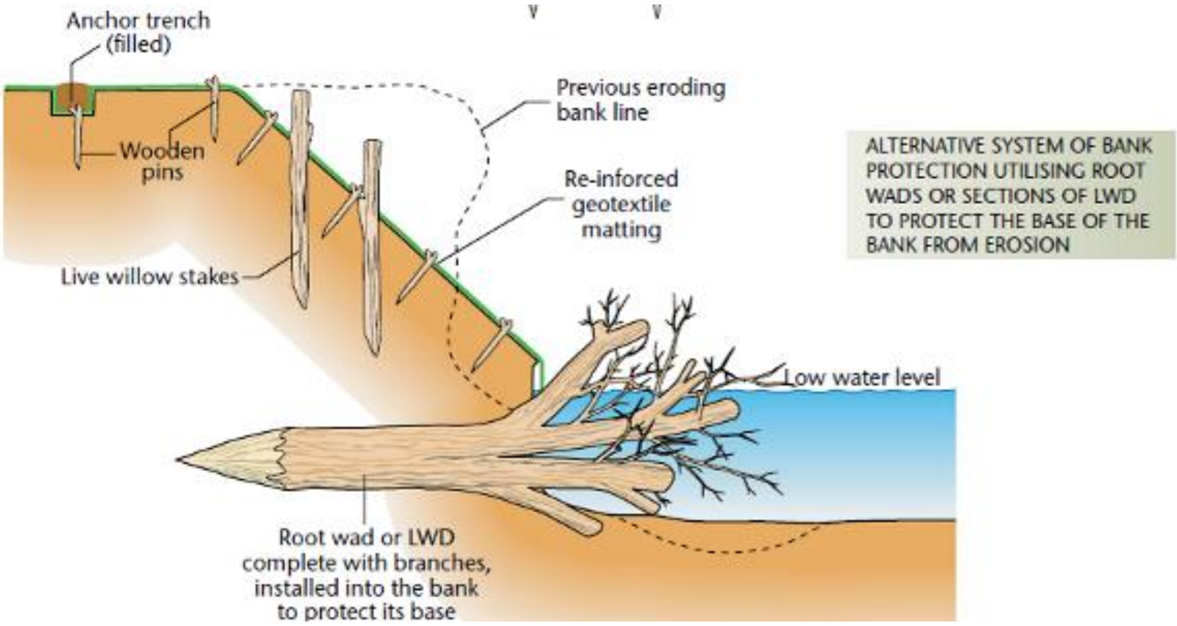

Figure 38: Root wad revetment technique

4.2 Tackle impoundments and capitalise on energised flow

In line with previous weir-removal efforts, both the large and small impounding structures within the visited reaches should be modified to reduce (if not eliminate) their impounding effects. Only when all options to fully remove a structure have been exhausted should second best alternatives be considered. Among those second-best options, notching and partial removal can be used as a means of minimising any risk of unwanted erosion of sensitive banks (i.e. those associated with highway infrastructure and footpaths). Notching of weirs that have long, shallow aprons (which are barriers in their own right) can be combined with construction of "pre-barrages" that raise the downstream water level via a series of smaller steps (Fig. 39). Maintaining a smooth plume of water flowing out of each "slot" is imperative to the success of such easements. Where white water is visible, it indicates entrained air that prevents a fish from being able to swim effectively (fins work in water, but not in air!).

Figure 39: Pre-barrages (shown dry here) constructed to ease passage over a weir on the Sussex Ouse system constructed as part of a partner project between WTT and Ouse and Adur Rivers Trust

In a similar fashion to the appearance of the pre-barrage design in Figure 39 - alternating slots cut into each of the low ornamental weirs running in front of Alkrington Hall West (see Figs. 16-18) will promote easier passage of fish. If the size of the slots are sufficient, it will also reduce the impounding effect of each structure. Furthermore, if courses of stone could be removed from each weir for part of the channel width - so that the long edge of each weir tapers down towards the slot; then each weir would act as a valuable flow deflector.

In spate flows these would generate valuable variation in riverbed profile and the stone arising from modifications could be scattered throughout the downstream channel to produce additional cover and flow-variation. The advantage to that is that there is a net zero impact on channel capacity – which removes the need to perform extensive risk modelling. It also recycles on-site materials and reduces the need to transport and import material on to site.

In reaches that are currently un-impounded – as well as in reaches with flows energized by removal or notching of weirs – the river's energy should be harnessed to promote formation of varied habitat. Many of the visited sections would be suitable for installations of tree kickers (as per previous video), but also secure root wad installation – this time with the base of the root wad angled more upstream into the current compared to revetment applications. This would generate excellent scour pool habitat as well as providing the required submerged and overhead cover to maximise the value of each pool.

It would also be desirable to introduce stable LWD (achieved via a combination of hinging of live trees, cabling tree crowns to anchor points where necessary and use of steel reinforcing bar ("rebar") pins that mimic the actions of the rare existing debris (e.g. Fig. 28).

4.3 Identify opportunities to pull back areas of retaining wall

Where banks are well wooded the root matrix of mature trees is far more resistant to erosion than areas of grass and other shallow rooted plants. There are many areas on the Irk where there is sufficient woodland riverbank to enable removal of bank-toe hard revetments and retaining walls. Even if performed only on one bank (for instance if there are sensitivities to erosion on the opposite bank) this will reintroduce a hugely valuable degree of meandering planform – as well as rejuvenate small inputs of substrate material.

This effect could be further capitalised upon (both in terms of ecological gains, but also for protection of footpaths) by promoting marginal berm deposition. This could be achieved, for instance, by using correctly-located tree kickers (possibly combined with planting whips of suitable tree species) to accumulate sediment during spate flows.

4.4 Tackle litter and invasive plant species and raise profile against intermittent pollution

The areas closest to the access points from surrounding urban development conspicuously suffer from littering issues. This is extremely detrimental to the perceived quality of the watercourse, which similarly reduces public expectations for the river corridor. The perceived lack of value places the watercourse at greater risk from recurrences of intermittent water quality problems (whether from combined sewer outfalls or avoidable accidental releases from industrial plants). Active litter removal and associated local media coverage are important ways to change attitudes.

Coupling that with a program to control (via hand-pulling of Himalayan balsam and stem injection of Japanese knotweed) invasive plant species will significantly increase the chances of regenerating a much more attractive understory flora. It may even be advisable, in combination with light rotational coppicing that will benefit all of the riparian woodland, to source and sow seed for appropriate species of native, river-corridor plants. This can be effective both biologically and sociologically (e.g. http://urbantrout.blogspot.co.uk/2014/07/volunteer-action-on-urban-river.html).

4.5 Establish light rotational coppicing to encourage staggered age-structure in riparian tree canopy

As indicated above, undertaking a light rotational coppicing regime will help to promote a varied and attractive understory. Aiming for an approximate 50:50 balance of dappled light and shade is a useful benchmark. In addition, the low, bushy regrowth of bankside trees may automatically generate useful cover for fish. In the event that an additional helping hand is required, the young regrowth can be easily trained such that it projects over and into the margins of the watercourse.

In addition, the larger woody materials arising from coppicing activity will provide excellent raw material for in-stream installations such as tree kickers and pinned logs. Again, this will limit the need to import materials onto site wherever possible.

4.6 Recommended action list

Each of the recommended actions above will require site-specific proposals prior to enacting (whether they are carried out as a phased series or as one large project). Consequently, there will be at least one – and possibly several – separate project proposal documents required to support the specific actions on the ground.

For ease of reference, the main objectives derived from the site visit are listed below:

- Retain naturally-occurring LWD
- Reduce/discontinue vegetation cutting for perceived flood risk management
- Create opportunities for meandering flow by pulling back sections of retaining wall(s) where there is space for the river
- Emphasise meanders with installed structures that promote the development of low, sloping point bars (via deposition of sediment)
- Install secure LWD (including root wads where available) in un-impounded reaches to generate varied bed scour/deposition
- Use soft revetment techniques to protect vulnerable banks and create juvenile fish habitat
- Remove weirs where possible – and notch those that must be retained
- Couple notching with pre-barrages where required

- Convert low, ornamental weirs into tapered flow-deflectors and incorporate slots that promote fish passage at all flow levels
- Control litter and invasive plant species – use associated publicity to maintain pressure on pollution risk
- Consider sowing native herbaceous understory plant seed (if natural recovery is poor following removal of dense stands of invasive plants)
- Use light rotational coppicing to improve variation in light reaching woodland floor, generate raw materials for habitat works and produce opportunities to create marginal cover (as well as a potential means for re-routing footpaths away from the bank-top of the river)

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