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River Sheppey, Shepton Mallet, Somerset

Wild Trout Trust report on walkover surveys carried out on 13 February and 5 March 2021

Written by Theo Pike: tpike@wildtrout.org

Contents

1. Key findings

1.1. Water quantity, 'slowing the flow' and flood risk

- The River Sheppey responds rapidly to rainfall, due to the steep topography of its upper catchment, and this 'flashiness' has been exacerbated by historic urbanisation.

- Opportunities to reduce local flood risk have been identified, including repurposing former mill ponds, and deculverting other suitable stretches, to create Sustainable Drainage Solutions (SuDS) and blue-green recreation spaces. This could also help to reduce flood risk further down the catchment.

- River restoration to add sinuosity and flow diversity in urban and semi-urban areas could help to 'slow the flow' of spates on one hand, and maximise environmental benefits of low flows on the other.

1.2. Water quality and habitat improvement

- The River Sheppey's limestone water chemistry should naturally support a rich ecology. However, water quality has been variable in the recent and not-so-recent past, with serious fish kills believed to have been caused by industrial effluents (and underperforming sewage treatment works downstream of Shepton Mallet).

- Despite the pressures of urbanisation, there are good opportunities to reverse historic habitat damage – particularly around redundant weirs, and stretches of river adjacent to semi-urban pasture land.

1.3. Barriers to fish passage

- The River Sheppey is notably fragmented by barriers to fish passage dating from the early industrial era. While some of the longer culverts may be difficult to address, removing redundant weirs would represent important progress in restoring the river's ecological connectivity – and thus the sustainability of future trout populations.

1.4. Opportunities for community engagement

- River restoration could be an exciting and transformative focus for Shepton Mallet – giving local people more access to nature, and turning the urban River Sheppey from an unloved source of pollution and flood risk into a community asset and a public source of pride.

- Local residents could also take part in river-based citizen science programmes, such as riverfly monitoring and Westcountry CSI, as well as habitat enhancements and other hands-on river-based activities.

2. Introduction

This report is the output of visits undertaken by Theo Pike of the Wild Trout Trust on approximately 4 km of the River Sheppey in and around Shepton Mallet, Somerset.

These initial visits were undertaken on 13 February and 5 March 2021 to provide a baseline habitat assessment of the urban reaches of the River Sheppey as part of the TWIST (Transforming Waterways In Somerset Towns) pilot project – understanding pressures on the urban water environment, as well as investigating opportunities for physical enhancements and engaging urban dwellers with their local river. Particular attention was paid to:

- identifying opportunities to 'slow the flow' and reduce flood risk
- identifying and prioritising barriers to fish migration
- identifying opportunities to improve water quality and habitat
- identifying opportunities and locations for community engagement

At the time of the walkovers, the River Sheppey was judged to be at moderate winter flow, and water clarity was very good.

Comments in this report are based on observations on the days of the visits. Throughout the report, normal convention is followed with respect to bank identification i.e. 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.

Figure 1: A map showing the course of the River Sheppey through Shepton Mallet, Somerset

3. Catchment and location overview

The River Sheppey is a small watercourse which rises from a number of springs near Doulting, and flows west through Shepton Mallet, Croscombe, Dinder and Dulcote to join the Keward Brook at Coxley. From this point it follows a highly modified course across the Somerset Levels to join the River Brue at Westhay, and eventually the Bristol Channel at Burnham-on-Sea.

Owing to the Sheppey's reliable spring flows, it contributes an important proportion of the summer base flows of the lower Brue (Brue and Axe Local Environment Agency Plan 1997).

River	Sheppey
Waterbody Name	Sheppey
Waterbody ID	GB108052021221
Management Catchment	Somerset South and West / Brue and Axe
River Basin District	South West
Current Ecological Quality	Moderate (as at 2019)
U/S Grid Ref inspected	ST 63348 42895
D/S Grid Ref inspected	ST 60188 43977
Length of river inspected	4 km approx

Error! Reference source not found.*Table 1: Water Framework Directive (WFD) information for the River Sheppey*

Shepton Mallet is located in the upper catchment of the River Sheppey, about 1 km west of the river's source from limestone springs (including St Aldhelm's Well, an ancient 'holy well' whose flow was reputed never to run dry) below the village of Doulting.

As the Sheppey flows west across farmland towards Shepton Mallet, its headwaters exhibit 'karst' characteristics including sinkholes and resurgences (pers. comm. Calm Engineering, February 2021) which are typical of such limestone streams. Located on Jurassic and Triassic deposits of mudstone, blue lias and oolitic limestone, the upper Sheppey's underlying hydrology appears to be largely unmapped and is likely to be complicated: for example, no sinkholes or swallets on the Mendip ridge have yet been positively connected to St Aldhelm's Well.

Owing to the extended residence time of water in their underground aquifers, limestone streams like the Sheppey are typically somewhat more stable in temperature and flow regime than rain-fed systems. When combined with calcium-rich and slightly alkaline water chemistry, these conditions can promote highly productive ecosystems. However, despite their reputation for pure, rock-filtered water, limestone karst systems are particularly vulnerable to pollution via sinkholes, swallets and quarrying activities, and such contamination can sometimes be long-lasting. The capacity or conveyance of local aquifers may also be adversely affected by wider limestone quarrying in the eastern Mendip area.

The town of Shepton Mallet has developed at a point where the Sheppey valley narrows and steepens - possibly to take advantage of increased gradient for historic water-milling purposes as well as easy availability of building stone and upland pasture. One mill is listed in the Domesday survey of 1086, and the town essentially developed as a chain of mill-based settlements along the river in subsequent centuries, from Charlton and Garston Street in the east to Bowlish and Darshill in the west. By the early 18th century, Shepton Mallet had around 50 mills and factories, and the river had been highly modified to provide a power source for weaving, corn-milling, brewing and other activities. Today, the town is still noted for cider making, and a long stretch of the river remains culverted under the Showerings cider mill along Garston Street.

Flowing down its steep-sided valley, the River Sheppey responds very quickly to rainfall, and areas of Shepton Mallet (and Croscombe further downstream) on the valley floor are vulnerable to flash flooding. Very long stretches of the river through Shepton Mallet have been completely culverted, and the capacity of these culverts can sometimes be overwhelmed, with notable recent floods in October 2006 and May 2008, when some houses around Leg Square, Lower Lane and Draycott Road were submerged to a depth of 1 metre.

Although the EA implemented a flood alleviation scheme in 2010, current climate change predictions include an increased intensity of rainfall and other weather events, which may also be borne out by the pattern of events noted above. As such, it would be prudent to anticipate recurring future events of this nature, and investigate any possible deculverting, river restoration and natural flood management (NFM) measures to alleviate pressures on the town's culverts and other infrastructure. On a wider upper-catchment scale, such interventions may also help to augment low flows at other times.

In 2016, a fisheries walkover survey by Westcountry Rivers Trust (WRT) and Bristol Avon Rivers Trust (BART) characterised most of the upper River Sheppey as dominated by parr-type habitat (suitable for juvenile salmonids, post-fry stage): 20-40cm deep, fast-flowing (60-75 cm/s), surface turbulent, with gravel/cobble/boulder substrate. This assessment is unsurprising in light of the river's long history of modification for industry: channel simplification and straightening, to deliver a smooth and consistent flow of water to mills, has also steepened the gradient of the river and shortened the length of its channel.

In order to recreate habitats for all life stages of fish in the Sheppey, hydraulic roughness, complexity and connection to the river's floodplain need to be reinstated on a catchment scale. Locally, this means making the river as sinuous as possible again, including within its existing planform in areas where it cannot be 'broken out' because of buildings and other infrastructure. In turn, this may also help to 'slow the flow' and reduce flood risk at unavoidable pinch points and other vulnerable areas.

In addition to lateral (floodplain) connectivity, strong consideration should also be given to longitudinal connectivity. The Sheppey has been severely fragmented by weirs and other industrial structures (the WRT/BART survey identified 35 such structures downstream of Darshill alone) which are likely to make fish passage and/or recolonisation after pollution incidents very difficult or even impossible.

Natural recolonisation by native species is almost always preferable to reintroduction by humans (which may only serve to mask the pressures which contributed to the original decline or localised extinction). Under some circumstances, however, it is recognised that reintroduction is the only way to restore valuable populations to areas which might otherwise remain uncolonised for many years – thus also denying engagement opportunities for local people.

Due to the large number of weirs along the Sheppey, it would be beneficial to consider restoring trout populations to the upper river by translocation, when water quality and habitat are deemed to be suitable. However, this should not reduce the imperative to address fish passage issues strategically throughout the catchment, with the aim of maximising free migration for long-term resilience of all fish species.

In 2018, a catchment walkover by FWAG also identified a range of rural land management issues which are also likely to affect the River Sheppey (since rivers tend to aggregate the impacts of wider activities within their catchment). These challenges include excessive poaching around watercourses and ditches, plus runoff from farm tracks, maize cultivation, roads and blocked roadside ditches. FWAG's investigation was designed to help the Somerset Catchment Partnership to draft a work programme for a multiple-benefit project for the Sheppey catchment, and it is hoped that the particular urban focus of this WTT report will inform and support the wider strategy.

Classification Item	2013	2014	2015	2016	2019
Overall Water Body	Moderate	Moderate	Moderate	Moderate	Moderate
Ecological	Moderate	Moderate	Moderate	Moderate	Moderate
Supporting elements (Surface Water)	-	-	Moderate	Moderate	Moderate
Biological quality elements	Poor	Poor	Poor	Moderate	Moderate
Hydromorphological Supporting Elements	Supports Good	Supports Good	Supports Good	Supports Good	Supports Good
Physico-chemical quality elements	Moderate	Moderate	Moderate	Moderate	Moderate
Specific pollutants	High	High	High	High	High
Chemical	Good	Good	Good	Good	Fail
Priority substances	Good	Good	Good	Good	Good
Other Pollutants	Does not require assessment	Does not require assessment	Does not require assessment	Does not require assessment	Does not require assessment
Priority hazardous substances	Good	Good	Good	Good	Fail

Table 2: Water Framework Directive (WFD) details for the River Sheppey: for full details see https://environment.data.gov.uk/catchment-planning/WaterBody/GB108052021221

According to the Environment Agency's assessment of the River Sheppey under the Water Framework Directive (WFD: the scheme currently used to assess the Ecological Status or Ecological Potential of our surface waterbodies in Britain), the river is classified as a 'Heavily Modified Water Body' (HMWB) as a result of much historic modification for milling, transport and general urbanisation. These typical urban pressures were very much in evidence on the days of these walkover surveys.

For HMWBs like the River Sheppey, the classification of Ecological Potential (rather than Ecological Status) is applied. The Environment Agency (EA) data held for this waterbody indicate an overall classification of 'Moderate' Ecological Potential, according to the most recent assessment in 2019. Reasons for not reaching 'Good' status are listed as physical modification for industry and transport, plus ammonia and phosphates from ineffective water treatment.

Reviewing the EA's ecological data (Table 2**Error! Reference source not found.**), it is somewhat encouraging to see that the Sheppey improved from 'Poor' to 'Moderate' on biological measures between 2015 and 2016, and remained at this status in 2019. Within these measures, invertebrates have been assessed as 'High' since 2014, while fish improved from 'Poor' in 2015 to 'Moderate' in 2016 and 2019. At the same time, it is worth remembering (as discussed below) that the EA's monitoring sites are all located well downstream of the urban areas of Shepton Mallet. It is also slightly anomalous to see the river's hydromorphological elements at 'Supporting good' despite the river's status as a HMWB and the clear issues that barriers create. On the other hand, this also suggests that tried and tested habitat improvement techniques may be able to improve the situation in simplified and highly modified urban channels.

Moving on to the EA's chemical data, most chemical elements are classified either as 'Good' or 'Does not require assessment'. The exception is priority hazardous substances, including Polybrominated diphenyl ethers (PBDE) and Benzo(g-h-i)perylene (PAH: polycyclic aromatic hydrocarbons), as well as mercury and its compounds.

This is a situation which now applies to a very high proportion of the UK's rivers, following new standards applied to chemical assessments in the 2019 round of WFD classifications. Under the 'one out, all out' rule, the River Sheppey now fails the EA's tests for chemical quality (whereas it passed them before). Since the newly-measured chemicals are now considered to be chronically present in almost all of the UK's fresh waters, it is not currently known how this situation can be improved. However, since the River Sheppey's other chemical classifications are listed as 'Good' or 'Does not require assessment', this still implies considerable opportunities to enhance fish populations if historic fish passage and habitat issues can be addressed.

One of the major threats to urban rivers is the presence of sewage treatment works (STWs) which are liable to underperform or even fail catastrophically. This was grimly illustrated on the River Sheppey in August 2019, when an unknown substance overwhelmed Wessex Water's sewage treatment works downstream of Shepton Mallet, causing a pollution incident that severely damaged fish and insect populations for 9 miles (15 km) and is still under investigation. (Effluent from industrial processes in Shepton Mallet is also believed to have caused pollution incidents on the Sheppey in the past).

This constant threat from STWs means that it is vitally important to optimise habitat and water quality in the 'safe' areas of catchments upstream of STW locations – since these areas serve as vital refuges for populations of fish and other species which may be uniquely genetically adapted to the characteristics of their river, and therefore irreplaceable.

In the case of the Sheppey, this would correspond to the river upstream of Shepton Mallet STW at ST 60032 44000 (approx.) where it will also be essential to remain alert for damage from combined sewer overflows (CSOs) as mapped in Figure 2: A map of CSOs at Shepton Mallet on the River Sheppey (data from 2019)Figure 2 below, misconnections or faulty septic tanks contributing to chronic pollution.

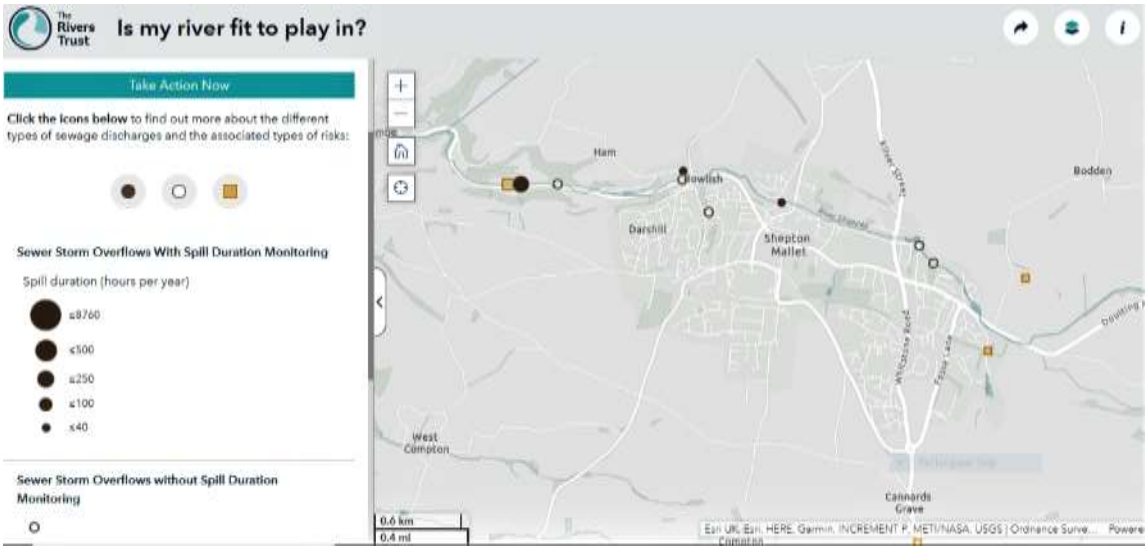

Figure 2: A map of CSOs at Shepton Mallet on the River Sheppey (data from 2019)

According to the Rivers Trust's interactive map of sewage outfalls (Figure 2 - available via https://www.theriverstrust.org/what-we-do/is-your-river-fit-to-swim-in/ - most recent data from 2019, as above) the River Sheppey in and around Shepton Mallet may be affected by 6 CSOs operated by Wessex Water:

- ST 62856 43417 (approx.): Fosse Lane pumping station: spill durations are not currently monitored
- ST 62772 43538 (approx.): Victoria Grove: spill durations are not currently monitored
- ST 61829 43830 (approx.): Cat's Ash / Cowl Street: in 2019 this CSO spilled 22 times for a total of 5 hours
- ST 61152 44047: Sunny Mount / Ham Lane: in 2019 this CSO spilled 10 times for a total of 3 hours
- ST 61152 43987 (approx.): Sunny Mount: spill durations are not currently monitored

- ST 60298 43969: Shepton Mallet STW storm tanks: spill durations are not currently monitored

The impact of the main effluent from the Shepton Mallet STW is discussed in the corresponding TWIST walkover survey report for Croscombe.

The Environment Agency carries out monitoring of fish, invertebrates, macrophytes and diatoms on rivers in England and Wales: these results are available in 'explorer' format at:

https://environment.data.gov.uk/ecology-fish/

The monitoring points for the River Sheppey are all located a considerable distance downstream of the urban areas of Shepton Mallet: macroinvertebrates at ST 57599 44455 (Dinder), macrophytes at ST 56014 44820 (Dulcote) and fish at ST 53616 44062 (Woodford). However, some details are provided below for wider catchment reference.

Macroinvertebrates

The EA's most recent survey of macroinvertebrates, in September 2018, shows a good count of freshwater shrimp (c250), indicating good chemical water quality. Among other species, pollution-sensitive blue-winged olives were also found (c20).

Fish

The EA's most recent fish survey, in June 2018, showed the presence of brown trout (9), bullhead (54), European eel (9), and three-spined stickleback (2). Trout were found in a range of year classes, from 57 – 272 mm, such as one might hope to encounter in a productive limestone stream.

These data provide a snapshot of the River Sheppey at that time: however, it should be remembered that the river has been subjected to significant pollution events for at least 20 years (River Sheppey fisheries survey, WRT/BART 2016) and then suffered a major fish kill in August 2019. Unfortunately, no trout were seen in the course of these walkovers in Shepton Mallet and Croscombe: it is likely that that low flows and/or previous pollution incidents have extirpated trout from the upper River Sheppey, and impassable weirs and other structures have subsequently prevented them from recolonising from downstream reaches.

Bullheads are also an indicator of clean water and high-quality habitat, with tolerances very similar to trout. European eel are now regarded as a threatened species, so their appearance in sizes from 120 – 330mm is a positive sign (again, dated from 2018).

Despite all these caveats, it would be reasonable to suggest that a range of fish species (including trout) should thrive in the upper reaches of the River Sheppey around Shepton Mallet if water quality, quantity, fish passage and habitat issues were successfully addressed.

4. Habitat assessment

Figure 3: A redundant weir impounding c 120 m of the River Sheppey at Charlton

About 1 km downstream of its source at Doulting, the River Sheppey enters the urban areas of Shepton Mallet in the grounds of the Charlton House hotel. Here its straightened course flows over a number of ornamental cascades parallel to the southern edge of the A361 Charlton Road, and enters a canal-like lake. This is impounded by a larger weir (as shown in Figure 3 above) which is considered to be impassable to fish of all species.

As discussed in *Appendix 3: Weirs and their impacts*, structures like this weir interrupt the river's longitudinal connectivity and strangle its natural sediment transport processes, causing fine silt to drop out of suspension, and creating a uniform and degraded habitat. In the case of this lake, the main flow appears to follow the RB, with higher levels of sedimentation on the LB, some of which has become partially consolidated by a reed bed. Although the reed bed does offer some habitat benefits, the rest of the lake is dark, swampy, and ecologically and visually unappealing. Despite some tree shade, water quality in this large, shallow impoundment may also be affected by solar thermal heating, particularly in the summer months, leading in turn to elevated temperatures and reduced dissolved oxygen further down the river – a factor which will also apply to other impoundments further downstream.

On the LB between the weir and the road bridge, a constant flow of water was noted from a rough hole in the rock revetment at a point just above water level. Very close inspection was not possible, but since this outflow is not visibly formalised with a pipe or headwall, it may be an early indication that the river's flow is starting to bypass the weir within the revetment, raising the possibility of sudden structural failure.

Even if this risk can be ruled out, it would be highly beneficial to restore fish passage and natural river processes throughout this area by removing the weir and re-meandering the river through the current footprint of the lake (and indeed upstream). Together with a natural, 'shaggy' riparian fringe including attractive native plants like purple loosestrife and meadowsweet, this would offer real aesthetic improvements for visitors to the hotel, as well as huge ecological benefits for many species of birds, fish and insects.

Figure 4: Shallow, impassable flow through the narrow bridge culvert under the A361 Charlton Road (Photo: Somerset Rivers: www.somersetrivers.uk)

The River Sheppey flows under the A361 road bridge through a small arched culvert, which could not be easily accessed for closer inspection. However, a photograph found on the Somerset Rivers website (www.somersetrivers.uk) suggests that it is likely to be impassable for fish in most flows, due to the step up to shallow, high velocity water over a smooth concrete bed (as shown in Figure 4 above).

Pre-barraging the bridge to drown out the step and the fast, shallow flow within the culvert, perhaps with a small rock ramp or an oak board easement, would allow fish to pass more freely into future restored stretches of river upstream.

Figure 5: Looking downstream from the A361 Charlton Road bridge

After passing under the A361 road bridge, the River Sheppey flows in a long curve around what appears to be a stormwater retention basin before flowing into a former mill pond on the site of the old Charlton brewery, now converted into a private office park and industrial estate. (It is thought that the retention basin captures water from the largely culverted Frog Lane stream, where opportunities have been identified for deculverting and NFM measures – pers. comm. Calm Engineering, Feb 2021).

Downstream from the road bridge, the river appears to become progressively more incised and disconnected from its floodplain – although, as shown in Figure 5 above, there is also a recognisable pool and riffle sequence at its upstream end. Adding one or two pieces of Large Woody Material (LWM) at the tail of each pool would help to 'sort' the substrate, creating well-scoured areas of fine gravel favoured by trout for spawning. Extra LWM in the pools would also increase hydrological roughness and habitat complexity for all life stages of fish.

The retaining bund of the stormwater basin (ie the LB of the river) appears to be closely mown, and it would be far better to manage both banks with a lighter touch, promoting beneficial 'shaggy' trailing vegetation at the river's margins. This is particularly valuable for juvenile fish, which may otherwise struggle to swim against strong currents and evade predators.

The same recommendation for light touch management also applies to the inner banks of the basin, where wildlife habitat value would certainly be increased by establishing a soft fringe of reeds and other marginal plants.

Figure 6: A mill pond adjacent to Martin's Lane

At ST 63099 43179 (approx.) the River Sheppey flows into an online mill pond - impounded by an impassable stepped weir at its downstream end - with mainly hard vertical edges and limited wildlife value as shown in Figure 6 above.

This is a typical post-industrial area which has now been converted to retail, offices, roads and car parks, where rain falling on hard, impermeable surfaces quickly produces high volumes of urban runoff, increasing the risk of flash flooding from overland flow in the immediate area, and fluvial flooding further downstream.

Converting this redundant mill pond into a permanent blue-green 'pocket park', with one or more sinuous river channels winding through it at low flows, would boost local biodiversity and add aesthetic and recreational value for local people. At times of heavy rain and runoff, suitable outflow controls could allow the area to function as a temporary wetland and Sustainable Drainage Scheme (SuDS), 'slowing the flow', improving water quality and reducing flood risk locally and further downstream.

To optimise habitat gains, an important part of the functionality of this concept would be to minimise the throttle on the downstream end, so that the SuDS fills only on the highest flows. Too much of a throttle could result in excessive deposition of fine sediment, leading to maintenance and habitat issues, particularly if subsequent flushing of that sediment occurs (including algal blooms downstream in following years). As part of this project, full fish passage through this area should also be restored.

Figure 7: The river is fast, straight and shallow as it flows towards the Charlton Viaduct

As the River Sheppey leaves the mill pond, it flows into a culvert under Martin's Lane, the former Charlton Brewery buildings and part of Brewery Lane, and only reappears approximately 180m downstream at ST 62960 43363.

From this point, it runs along the end of private gardens towards the Charlton Viaduct (as shown in Figure 7 above). On the river's RB, the green space seems to be lightly managed as rough grazing land, with bramble thickets partly cleared (perhaps by local residents) and stacked into insect habitats. However, despite being lightly managed, with good 'shaggy edges' the river in this area is effectively one long gravel and cobble riffle, which may provide some spawning opportunities for trout, but is rather too uniformly fast, straightened and shallow to offer good habitat for the different life stages of many species.

Strong consideration should be given to re-meandering the channel, with a very much more sinuous course, into the green space on the RB - thus reducing the channel's gradient, reconnecting the river with the floodplain (perhaps also creating seasonal wetlands) and 'slowing the flow' of water into more intensively urbanised areas downstream. Increasing the amount of LWM to the channel would improve hydraulic roughness and force natural processes of localised scour and deposition, creating habitat niches for many more species.

With landowner permission, easy access to the river at this point could make it a suitable location for riverfly monitoring by members of the local community. It should also be noted that Wessex Water's Fosse Lane pumping station is consented to discharge a little further downstream at ST 62856 43417 (approx.). The duration of any such discharges is not currently monitored, and it would be useful to gain better understanding of these incidents (potentially also including kick sampling up and down stream of the outfall). It is important to monitor CSOs and ensure that they only discharge during or shortly after excessive rainfall, when the sewage treatment network is unavoidably overloaded (and, importantly, the excess water in the watercourse can dilute the effluent). Any discharges outside of those times are likely to be illegal and constitute pollution events.

Figure 8: Looking upstream into the short stretch of open channel at Kilver Court, with a valuable vegetated depositional area forming on the inside of the bend

At Kilver Court Gardens, the River Sheppey is dammed into a very large ornamental lake. While the landscape and cultural value of this lake is recognised, it would certainly be better for the river's ecology and natural processes to reduce the size of such an impoundment as much as possible, with extensive river restoration throughout this area for all the reasons described above (and in Appendix 3: Weirs and their impacts). It is also worrying to note that the unmonitored Victoria Grove STW is currently licensed to discharge more or less directly into this lake at ST 62772 43538 (approx.).

At present, the river emerges from a culvert at the western end of the lake, and flows through a narrow open channel for about 50m alongside a car park before disappearing into another long (c 700 m) culvert under the A37 and Showerings cider mill along Garston Road. Throughout this area, wide expanses of impermeable car parks and roofs are likely to increase urban runoff into vulnerable pinch points downstream, and it would be useful to investigate options for Sustainable Drainage Solutions (SuDS) including permeable paving and green swales (perhaps located at the bottom of the slope, between the car park and the A37).

In the longer term, strong consideration should be given to breaking out the culvert and establishing a soft, sloping natural margin on the LB – a measure which could also increase flood storage in this area and reduce flood risk downstream, as well as providing community access to the river. In the meantime, a few depositional areas have accumulated silt and vegetation on the inside of bends (as shown on the RB in Figure 8 above): these valuable softer areas should be retained and even formalised with brush bundles along the toe, before incorporation into the more ambitious project. Small flow deflectors could help to promote localised scour and deposition, creating pockets of habitat in what is mainly a single fast riffle. Supplementary planting of attractive native streamside species such as purple loosestrife, hemp agrimony and water forget-me-not would also help to change perceptions and draw attention to the river as a positive local asset, instead of an overlooked and under-appreciated space.

Figure 9: One of three short open culverts in the green space at the western end of Garston Street, which could be broken out as a pocket park for flood storage and social amenity

After flowing through an extremely long culvert from ST 62623 43573 to ST 62234 43678 (approx.) under Showerings cider mill, the River Sheppey briefly re-emerges into three very short stretches of open channel in a green space at the factory's western end (one example of these open channels is shown in Figure 9 above). It then disappears into another lengthy culvert underneath Garston Street and Lower Lane. These constraints clearly contribute hugely to flood risk in this part of the town. Whilst it may not be immediately possible to deculvert the river where it now flows under the cider mill and residential properties (although one ambitious option could include running a new channel through the detached gardens and parking areas between the south side of the road and the north side of the factory), the area of green space around the short open culverts may offer some exciting river enhancement potential with multiple flood risk management, place-making and other community benefits.

For example, in Sheffield, a similarly culverted stretch of the Porter Brook has been successfully 'daylighted', converting a problem culvert into a much-loved pocket park for local people. In times of heavy rainfall, the new Matilda Street pocket park serves as a SuDS – alleviating flooding in a highly urbanised downstream area which is cognate in many ways to the centre of Shepton Mallet. This pocket park has also contributed to urban regeneration goals, radically transforming and providing public access to nature in an area where the benefits of the natural environment were previously hidden from local view.

More information about the Porter Brook's pocket park, and its wide range of benefits, can be found on the following link:

https://www.wildtrout.org/wttblog/buried-stream-project-wins-national-prize

Figure 10: Looking downstream from the high footbridge over the River Sheppey and Lower Lane, with an unsightly transformer station on the RB, and the site of a potential pocket park on the LB

Between ST 62195 43712 to ST 62031 43763 (approx.) the River Sheppey is totally culverted again, this time under Garston Street, Leg Square and Lower Lane, where it finally re-emerges into a residential area (as seen on the front cover of this report).

From here, it flows for about 150 m in another open channel (as seen in Figure 10 above) down to a third long culvert. For about 120 m, in this highly-modified, hard-sided channel, the river bed appears to be a mixture of unsorted gravel and cobbles, before becoming paved with concrete upstream of the third culvert. Once again, some depositional areas on the inside edges of bends appeared to have accumulated sediment (as shown in Figure 10 above), and a few valuable emergent plants have become established: these areas should be retained, and perhaps formalised with brush bundles and protective flow deflectors at their upstream ends.

This was once a was "a highly industrialised suburb and a mixture of clothiers' houses, weavers' cottages, mills, osier beds and watercourses" (Somerset Extensive Urban Survey - Shepton Mallet Archaeological Assessment, 2003), and there are potentially spectacular views from a footbridge high above the river at ST 62012 43774 (shown above looking downstream, and on the front cover of this report looking upstream). However, the central view of the river is hostile to say the least. Some bushes like buddleia and dogwood seem to have been planted for wildlife and possibly landscape value at the top of high vertical flood walls, but the channel is predominantly hardened and ugly, and access is difficult or impossible.

This area also appears to hold huge potential for regeneration linked to river restoration, perhaps including breaking out an area of the LB as a small pocket park and flood storage area (as discussed above) – a project which could also be linked to relocation / redevelopment of the extensive and unsightly transformer station on the RB. (In view of climate change, relocating important electrical infrastructure away from the floor of a flood-prone urban valley should surely be a strategic priority).

Figure 11: Active geomorphology in the channel beyond Draycott Road

The Sheppey's third very long urban culvert extends from ST 61932 43815 to ST 61644 43939 (approx.) under Longbridge, Cowl Street and Draycott Road, also taking in a CSO outfall, before the river finally reappears to public view at ST 61606 43975, the western end of Draycott Road.

From here, it follows the southern boundary of a large area of fenced pasture, with grazing animals like horses and llamas much in evidence. Access to the river was not possible, but from the public footpath across the fields it could be seen that the RB of the river is dominated by high blockstone revetments, some of these recently reconstructed with gabion wire baskets. Channel morphology at the upstream end of this stretch looks reasonably active, perhaps even including mid-channel gravel bars and braiding. Further downstream, the channel appears straighter, shallower and more uniform.

The potential impacts of horse culture on streams and rivers (including runoff, bank poaching, soil compaction and over-grazing) are not as widely recognised as those from other farming activities. From an ecological point of view, as well as to ensure compliance with Defra's Farming Rules for Water, it would beneficial to engage with the relevant land managers to install pasture pumps for watering livestock, while fencing animals out of the river with stockproof fencing.

Ideally this fencing would be set 5 - 10m back from the bank top, in order to allow a wide, ungrazed marginal fringe of native plants to develop, with strong root structures to prevent excessive bank erosion in high flows. Meanwhile, the river should also be encouraged to develop a more sinuous course within its current planform, perhaps with flow deflectors or marginal berms created by redistributing existing bed material.

A more ambitious vision for this this area could include meandering the river further out into the fields, with a much more sinuous course. Increasing the overall length of the channel, and reconnecting it with its floodplain, could help to 'slow the flow' and reduce flood risk at pinch points (such as bridges and undersized culverts) further downstream, as well as boosting aquifer recharge and maintaining flows during dryer periods.

Figure 12: Two weirs at Forum Lane in Bowlish

At the downstream end of the grazing fields, the River Sheppey reaches Bowlish, a former milling hamlet which is now a suburb of Shepton Mallet. Although several large clothiers' houses still survive, the mill pond was filled in and built over in the late 19th century.

Consequently, long stretches of the river in this area are now channelised (and possibly culverted) through domestic gardens and other private land, and cannot easily be assessed. Experience suggests that river channels in residential areas like these have often been simplified and hardened, and ornamental lawns may be mowed right down to the water's edge, leaving little marginal vegetation as habitat for birds and fish. Runoff from roofs and paved areas is likely, and misconnections are possible. There are also 2 CSOs in this area whose effects could be assessed by local people through riverfly monitoring.

As in all urban and semi-urban areas, it would be beneficial to engage with local residents to highlight these potential issues and communicate the benefits of 'river-friendly gardening': solving misconnections, and promoting use of water butts, rain gardens, and permeable paving, as well as softening banks and improving in-channel habitat along individual lengths of stream. This could include replacing any hard, vertical banks with sloping edges fringed with 1 – 2 metres of softly trailing waterside plants, to increase biodiversity and habitat for birds, fish and insects.

From the public highway at the eastern end of Forum Lane, two weirs can be seen (as shown in Figure 12 above) with a sewer pipe also crossing the channel between them. The crest of the upper weir is reinforced with blockstone paving, which extends for about 10 m upstream. Both weirs now appear to be redundant, but are likely to be obstructions to fish passage in many flows, and should be removed.

Figure 13: Shallow, impassable flow down Ham Mill weir

Near Ham Mill at ST 61038 43960, the River Sheppey finally becomes visible again as it cascades through an old sluice gate and down a long, angled blockstone weir (as shown in Figure 13 above) which is considered impassable to fish at all flows.

At the foot of this weir, the river drops into a culvert under the A371 Wells Road, and apparently flows west under the road for c 50 m, before reappearing very briefly at the corner of the old mill building, and finally crossing under the road.

In addition to fish passage issues caused by the weir, the straight high-level leat which once provided a steady flow of water to the mill is probably also now a flood risk issue for residential properties in this area. As such, the best combined solution for flood risk management, sediment transport and fish passage improvements alike would be removing the weir completely. If this is not possible for any reason, other options for enhancing fish passage should certainly be investigated.

Figure 14: The River Sheppey downstream of Ham Mill

After passing under the A371 Wells Road, the River Sheppey enters a hard-sided channel in an area of woodland, with a corrugated iron building in the distance which was once the pump-house for the Anglo-Bavarian Brewery in Shepton Mallet.

High flows through the bridge culvert have scoured a relatively deep pool on its downstream side, with deposits of finer gravel at the tail of the pool (although the supply of this gravel is likely to be limited by Ham Mill weir upstream).

Adding LWM to this stretch of constrained, stone-walled channel would help to accelerate natural processes of scour and deposition – including 'sorting' and desilting the cobble and gravel substrate, thus providing better spawning conditions for fish. Some of this LWM could be locally won through selective tree thinning or skylighting, letting more light into the channel and helping beneficial macrophytes such as water crowfoot to become established. Such beds of water crowfoot would increase localised scour and deposition, and provide excellent habitat for many insect and fish species.

As shown in Figure 14 above, a convenient flight of steps provides unusually easy access to the river at this point: with landowner permission, it could be a suitable location for riverfly monitoring by members of the local community.

Figure 15: A more open, naturalistic stretch of river, with abundant water crowfoot

Beyond the old pumphouse buildings, the River Sheppey appears to have been historically straightened, perhaps in order to regulate flow into the former Darshill Mill pond.

With fewer trees on the LB, more light is able to penetrate to the river, and abundant stands of water crowfoot are present (as shown in Figure 15 above). This valuable macrophyte provides important habitat and flow complexity, but the straightened river would still benefit from additional roughness and sinuosity, which could be generated by introducing more LWM to the channel.

In this area of naturalistic soft banks (rarely seen in the course of this survey), it was unfortunate to note clear signs of infestation by invasive American signal crayfish, whose distinctive half-moon burrows undermine banks and dump large quantities of silt into affected rivers. At present there is no known method of eradicating signal crayfish, but they can be discouraged from burrowing into vertical banks by regrading to a very shallow batter and re-lining with cobbles. This makes the margins undesirable for crayfish, without restricting a vegetated fringe from redeveloping - an approach which could usefully be implemented here.

Figure 16: The River Sheppey in the renaturalised Darshill Mill pond

After flowing under the A371 Wells Road again, the River Sheppey emerges into the old mill pond of what was once Darshill Lower Silk Mill. This pond has been very successfully renaturalised as an area of wet woodland: the river runs close beside the road, while the rest of the former impoundment is braided with channels supplied by the nearby Orledge spring. The whole area is now owned and maintained by the Darshill and Bowlish Conservation Society (D&BSC).

As the river emerges from under the A371 Wells Road, abundant gravels could be seen, but the straightened channel is steep and torrential, and would benefit from LWM to diversify flow patterns and increase sinuosity. D&BSC's website suggests that the millpond area may have become more and more shaded over time, causing the loss of some species of riparian plants: future tree management to reduce overshading could also provide arisings for in-river LWM projects.

In terms of ecological benefit, other day-to-day management of this wet woodland should be as light-touch as possible, including leaving 'shaggy edges' along the river and stream braids in order to provide rough, complex cover for fish and invertebrates, and not removing any trees which fall into the river. It could also be very useful to monitor the health of the river in this area with riverfly and other citizen science monitoring activities.

Figure 17: The complex weir structure at Darshill Mill: lower flows are presently channelled down the steep chute on the right hand side of this photo

At Darshill Mill (ST 60731 43886) the River Sheppey pours down into a culvert through a system of sluices and overflow channels (on the right hand side of Figure 17 above). Due to the height and complexity of this structure, it is considered to be impassable to fish in all conditions of flow. Due to the pinch point that it creates, it is also very likely to be adding to flood risk in the immediate area.

Taken together, the stretches of river up- and downstream from this barrier seem likely to provide some of the best possibilities for re-introducing trout to the upper Sheppey – so restoring fish passage through this area should be investigated as a priority.

For flood risk management and ecological purposes, the best option would undoubtedly be to remove this structure completely, and re-grade the river channel accordingly. If this proves impossible for any reason, options to enhance fish passage could include a technical fish pass or a bypass channel, which might need to traverse at least one private garden beside the A371 Wells Road.

Figure 18: The culvert pool at the Darshill Mill access bridge

At the downstream end of the Darshill Mill complex, now converted into private properties, the River Sheppey flows under a modern box culvert bridge.

The pool below the bridge (as shown in Figure 18 above) offers good deep water habitat for adult trout: however the flow within the box culvert is shallow, fast and laminar, and is likely to represent a barrier to fish.

Options to improve fish passage through this structure could include chiselling a notch in the downstream sill of the box culvert, and fixing low-cost baffles to the flat concrete footings in order to add depth and turbulence, and create a ‘thalweg’ of passable flow.

Figure 19: Steep but getting more complex: the River Sheppey approaching Darshill Middle Mill

On its approach to the former Darshill Middle Mill (which still features one of only two teazel-drying 'handle houses' remaining in the UK) the River Sheppey flows though a strip of woodland alongside the A371.

Although still fairly straight and steep, the channel seems hydromorphologically active, with the beginnings of mid-channel bars (as shown in Figure 19 above) and even braids where the flow from a small tributary joins from the RB. In this area, it would be beneficial to hinge a few small trees into the edges of the channel to promote localised scour, deposition and sorting of the gravel and cobble substrate, as well as providing low, complex cover for fish.

Figure 20: Approaching the Shepton Mallet STW, the river channel would benefit from added LWM for diversity and hydraulic roughness

For the remainder of its course down to the Shepton Mallet STW, the River Sheppey is straight, uniform and channelled closely alongside the A371 Wells Road.

Both banks are largely armoured with rock revetments, and it would be beneficial to break these out wherever possible, to restore connectivity between the river and its floodplain during higher flows. As part of this project, rocks from the RB armouring could be repositioned against the LB roadside wall to increase sinuosity. Available trees should also be hinged or otherwise introduced into the channel to 'slow the flow' down what is essentially a roadside flume, rushing water downstream into Croscombe and other vulnerable areas.

These interventions to add 'roughness' will also help to create pockets of habitat for many species of birds, fish and insects, in the river's final stretch before it is joined by effluent from the STW.

It should also be noted that a CSO from the Shepton Mallet STW is located about halfway down this reach: this is not currently monitored by Wessex Water, so studying its impact on the river with riverfly monitoring and other citizen science projects would be interesting.

Figure 21: A weir just upstream of the entrance to Shepton Mallet STW

Adjacent to Shepton Mallet STW, the River Sheppey flows over a two-stage weir (as shown in Figure 21 above), under the present flat concrete access bridge, and through a short brick culvert (probably the original access bridge to the mill which once stood on this site).

The weir is considered to be impassable to all fish, and complete removal is recommended, re-grading the channel accordingly through this reach.

Flow in the culvert under the bridges is likely to represent a barrier to fish passage, being very shallow, fast and laminar, so this issue should also be addressed as part of the weir removal project.

5. Recommended projects and improvements

5.1. Citizen science: riverfly monitoring

Riverfly monitoring is a tried and tested methodology which enables local volunteers to support the statutory agencies by checking the health of their neighbourhood river. Such citizen science activities also have a track record of enhancing community cohesion and sense of place – all of which will be particularly important as Somerset emerges from Covid-19.

Subject to landowner permission, easy-access potential locations for riverfly monitoring, and other citizen science projects like Westcountry CSI, have been identified at the following locations on the upper River Sheppey in and around Shepton Mallet:

- ST 62960 43363 (approx.): near Brewery Lane, Charlton
- ST 60956 43909 (approx.): downstream of Ham Mill
- ST 60842 43893 (approx.): Darshill Mill pond area

Additional CSO-related locations to monitor could include:

- ST 62856 43417 (approx.): Fosse Lane pumping station
- ST 62772 43538 (approx.): Victoria Grove
- ST 61152 44047: Sunny Mount / Ham Lane
- ST 61152 43987 (approx.): Sunny Mount
- ST 60298 43969: Shepton Mallet STW storm water tanks

5.2. Habitat improvements

The ecological health and habitat value of the upper River Sheppey could be enhanced with some or all of the following habitat and fish passage improvements.

Flow deflectors

Figure 22: A flow deflector log pinned at an angle, using rebar stakes, partially across the stream (split chestnut stakes can also be used). In order to create scour in the centre of the channel, the log is angled upstream. At lower flows, the stream width is reduced, keeping the gravels clean and helping to move mobile sediment downstream. Higher flows can run over the top with little impediment.

Hinged trees

Figure 23: To reduce overshading and increase habitat, bankside trees can be hinged into the edge of a river so that they can continue to grow (depending on species) and provide low-level cover for fish, insects and birds. For extra security, the branches can be staked, or the trunk can be cabled back to the stump.

Weir removal and regrading

Figure 24: Before and after: an impounded and ecologically impoverished stretch of river (left) can be renaturalised by removing the weir, and then re-grading and re-meandering the channel through the site (right). Connectivity, sinuosity and natural processes have all been restored to this stretch of the River Wandle in Carshalton, south London.

Rock ramp

Figure 25: A rock ramp is an effective fish passage solution when a culvert cannot be modified with baffles or other easements, and a step up into it may need to be 'drowned out'. This example uses a series of erratic perturbation boulders to baffle the flow and ease fish passage.

Soft vegetated margins

Figure 26: Millais's 'Ophelia' was painted from life on the banks of the Hogsmill chalkstream, and is widely regarded as a portrait of a perfect, diverse assemblage of native riparian plant species.

6. Making it happen

The creation of any structures within 'Main Rivers' or within 8m of the channel boundary (which may be the top of the flood-plain in some cases) normally requires a formal Environmental Permit from the Environment Agency. This enables the EA to assess possible flood risk, and also any possible ecological impacts. Many watercourses perceived to be lower flood risk are not designated as 'Main River', in which case they are classed as 'Ordinary Watercourse' and the body responsible for issuing consent will be the Local Authority. In any case, contacting the EA early and informally discussing any proposed works is recommended as a means of efficiently processing an application.

The WTT website library has a wide range of free materials in video and PDF format on habitat management and improvement:

http://www.wildtrout.org/content/index

A focused Trout in the Town Urban River Toolkit is available at:

https://www.wildtrout.org/content/trout-town

There is also the possibility that the WTT could help via a Practical Visit (PV). PV's typically comprise a 1-3 day visit where WTT Conservation Officers will complete a demonstration plot on the site to be restored.

This enables recipients to obtain on the ground training regarding the appropriate use of conservation techniques and materials, including Health & Safety, equipment and requirements. This will then give projects the strongest possible start leading to successful completion of aims and objectives.

Recipients will be expected to cover travel and accommodation (if required) expenses of the WTT attendees.

There is currently a big demand for practical assistance and the WTT has to prioritise exactly where it can deploy its limited resources. The Trust is always available to provide free advice and help to organisations and landowners through guidance and linking them up with others that have had experience in improving river habitat.

7. Acknowledgement

The Wild Trout Trust would like to thank the Environment Agency for funding this walkover survey.

8. Disclaimer

This report is produced for guidance; 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 guidance made in this report.

9. Appendix 1: Summary tables of recommendations

Location	Photo (If required)	Priority (1-3)	Grid reference	Proposed action
Charlton House hotel grounds		1	**ST 63178 43023**	Fish passage and habitat: remove weirs and re-meander to allow fish passage and restore natural processes
Charlton bridge culvert		1	**ST 63170 43038**	Fish passage: restore fish passage with rock ramp or oak board easement
Channel beside flood attenuation basin		1	**ST 63179 43070 (approx.)**	Habitat: introduce LWM deflectors or tree kickers to create more sinuous flow, increasing channel roughness and habitat pockets

Flood attenuation basin (SuDS)		1	**ST 63142 43105**	Habitat: more relaxed management regime to allow soft marginal fringe to develop
Mill pond beside office park		2	**ST 63085 43221**	Flood risk and habitat: 'slow the flow' and reduce flood risk by repurposing former mill pond as urban SuDS and blue-green pocket park
Channel towards Charlton Viaduct		1	**ST 62952 43372 to ST 62790 43512 (approx.)**	Habitat and community engagement: re-meander straightened channel into green space; establish riverfly monitoring (possibly linked to CSO location)
Kilver Court car park channel		1 - 3	**ST 62647 43578**	Habitat, community engagement and flood risk: break out culvert on LB; in the meantime, retain/formalise/supplement riparian plants in depositional areas within channel; investigate SuDS to reduce runoff from car park, roofs etc

Green space at west end of Showerings cider mill		3	**ST 62220 43717**	Flood risk, habitat and community engagement: investigate options for breaking out culverts to create flood alleviation area and pocket park
Lower Lane		1 - 3	**ST 62031 43764 to ST 61939 43813 (approx.)**	Flood risk, habitat and community engagement: retain / formalise / supplement vegetated depositional areas; investigate breaking out riverside pocket park for community access; relocate / redevelop transformer substation
Grazing fields west of Draycott Road		1	**ST 61597 43997 to ST 61364 44060**	Habitat and flood risk: fence livestock out of river and provide pasture pump drinkers; establish marginal buffer; add LWM for sinuosity; more ambitiously, re-meander river into pasture land
Weirs at Pike Lane, Bowlish		2	**ST 61351 44048**	Fish passage, habitat and community engagement: remove weirs and investigate others; engage with residents to soften banks and promote river-friendly gardening.

Ham Mill weir		2	**ST 61039 43960**	Flood risk, fish passage and habitat: investigate options for removal or other fish passage enhancement
Channel downstream from Ham Mill		1	**ST 60956 43909 (approx.)**	Habitat and community engagement: selective skylighting to let more light into channel and generate arisings to add LWM; possible easy-access site for riverfly monitoring
Channel downstream from old Anglo-Bavarian Brewery pump-house		1	**ST 60890 43887**	Habitat and INNS: regrade banks to a shallow batter, and line with cobbles to 'design out' invasive non-native American signal crayfish
Former Darshill Mill pond		1	**ST 60787 43899**	Habitat and community engagement: implement light-touch management including 'shaggy edges' for biodiversity; hinge trees into channel for hydromorphological and biodiversity benefits; possible easy-access site for riverfly monitoring

Darshill Mill weir complex		1	**ST 60728 43887**	Flood risk, fish passage and habitat: investigate options for removal of weir or other fish passage enhancement
Darshill Mill access bridge footings		2	**ST 60579 43918**	Fish passage: chisel notch into downstream sill and add low cost baffles for depth and turbulence over flat concrete footings
Channel approaching Darshill Middle Mill		1	**ST 60480 43903 (approx.)**	Habitat: hinge trees into channel for hydromorphological and biodiversity benefits
Channel between Darshill Middle Mill and STW		1	**ST 53882 44935**	Flood risk and habitat: break out retaining walls to reconnect river to floodplain and 'slow the flow'; reposition rocks from RB against LB roadside wall to add sinuosity, and hinge trees into channel ; also monitor stormwater tanks CSO at ST 60298 43969

Weir adjacent to Shepton Mallet STW, plus culvert just downstream		1	**ST 60066 43968**	Fish passage and habitat: remove weir and regrade river through this stretch; also address fish passage through culvert under bridges just downstream

10. Appendix 2: Trout habitat

Due to their need for clean, well-oxygenated water, structurally-varied habitat, and free movement between different types of habitat at different life stages, the UK's native wild brown trout makes an ideal indicator species for healthy rivers. These characteristics mean that a simple and effective assessment for river health can be based around the life cycle requirements of brown trout.

As a result, identifying and noting the presence or absence of habitat features required for trout to complete their full life cycle is a very practical way to assess overall habitat quality (Figure 27). By identifying the gaps (i.e. where crucial habitat is lacking: Figure 28 to Figure 30), it is often possible to design actions to solve those habitat bottlenecks.

To put all this into context, there are three main habitat types required for wild trout to complete each of their three key life cycle stages. This creates a demand for varied habitat, which is vital for supporting a wide diversity of other species too.

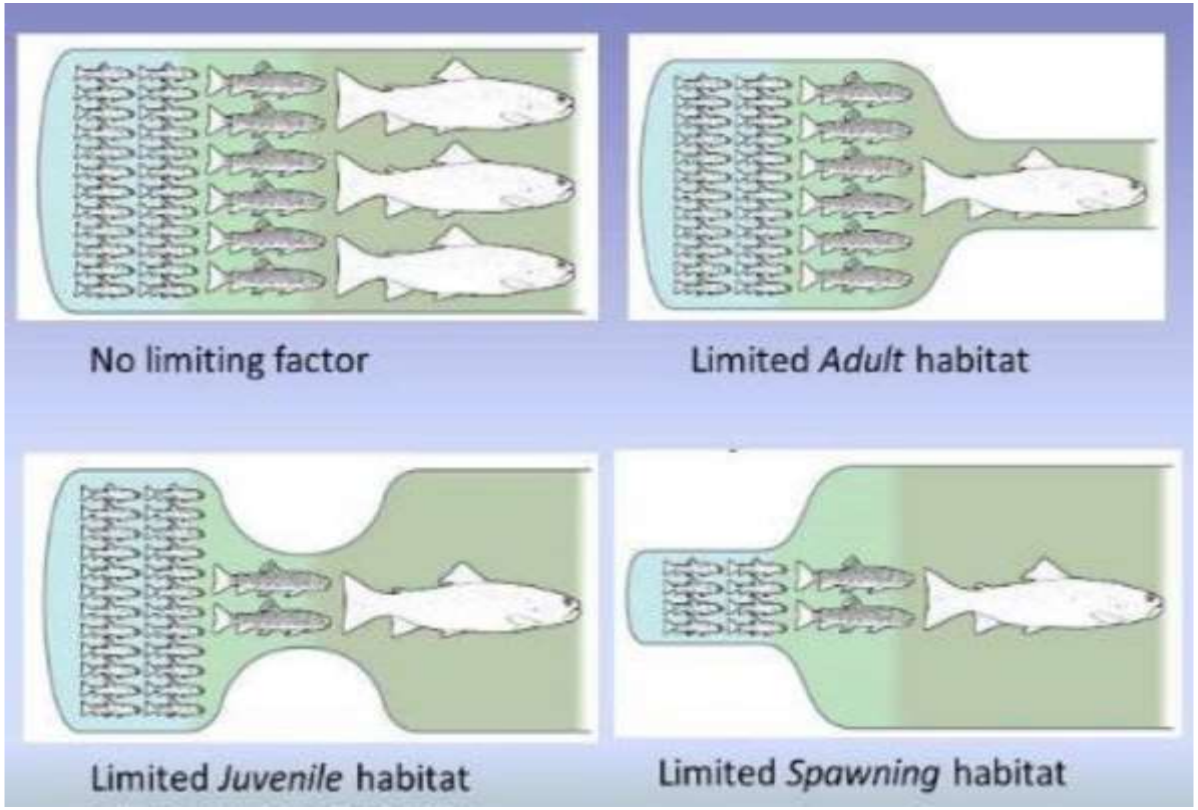

Figure 27: The impacts on trout populations lacking adequate habitat for key life cycle stages. Spawning trout require loose gravel with a good flow-through of oxygenated water. Juvenile trout need shallow water with plenty of diverse structure for protection against predators and wash-out during spates. Adult trout need deeper pools (usually > 30cm depth) with nearby structural cover such as undercut boulders, sunken trees/tree limbs and/or low overhanging cover (ideally trailing on, or at least within 30cm of, the water's surface). Excellent quality in one or two out of the three crucial habitats may not mitigate a 'weak link' in the remaining critical habitat.

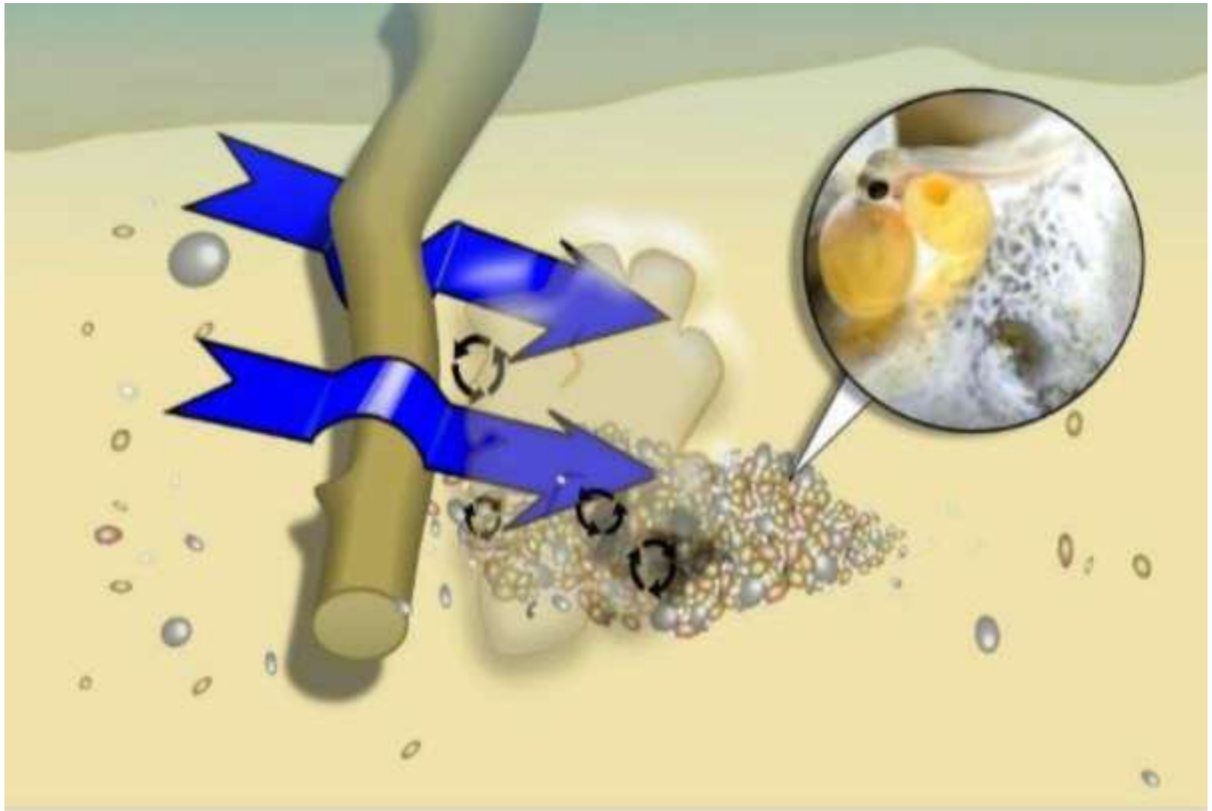

Figure 28: Successful trout spawning requires relatively silt-free gravels. Here, the action of a fallen tree limb is focusing the flows (both under and over the limb as indicated by the blue arrows) on a small area of riverbed that results in silt being washed out from between gravel grains. A small mound of gravel is deposited just below the hollow scoured out by focused flows: this mound will be selected by trout to dig a 'redd' for spawning. In the silt-free gaps between the grains of gravel it is possible for sufficient oxygen-rich water to flow over the developing eggs and newly-hatched 'alevins' to keep them alive as they hide within the gravel mound (inset) until emerging in spring.

Figure 29: Larger cobbles and submerged ‘brashy’ cover and/or exposed fronds of tree roots provide vital cover from predation and spate flows for tiny juvenile fish in shallower water (<30cm deep). Trailing, overhanging vegetation also provides a similar function, and has many benefits for invertebrate populations (some of which will provide a ready food supply for the juvenile fish).

Figure 30: The availability of deeper water bolt holes (>30cm), low overhanging cover and/or larger submerged structures such as boulders, fallen trees, large root-wads etc. close to a good food supply (e.g. below a riffle in this case) are all strong components of adult trout habitat requirements.

11. Appendix 3: Weirs and their impacts

Urban rivers usually exhibit a typical mixture of challenges, including weirs, hard/revetted banks, culverts, impoundments, and straightened/modified channels.

Among these modifications, weirs are perhaps the most damaging. Many of these are likely to have been constructed to provide a head of water for milling purposes: more recently, others may have been installed with the aim of 'keeping more water in the river' – in reality, an intervention which always does more harm than good.

Weirs tend to create extended stretches of slowly-moving water, where sediment carried in suspension drops out of the water column uniformly across the stream bed, and habitat quality and diversity are severely degraded (Figure 31). Such conditions can sometimes temporarily provide sufficient deep water habitat for small numbers of adult trout and other species (until the deep water inevitably fills with sediment) but are generally unsuitable for many beneficial invertebrates, and gravel spawning fish, fry and juveniles.

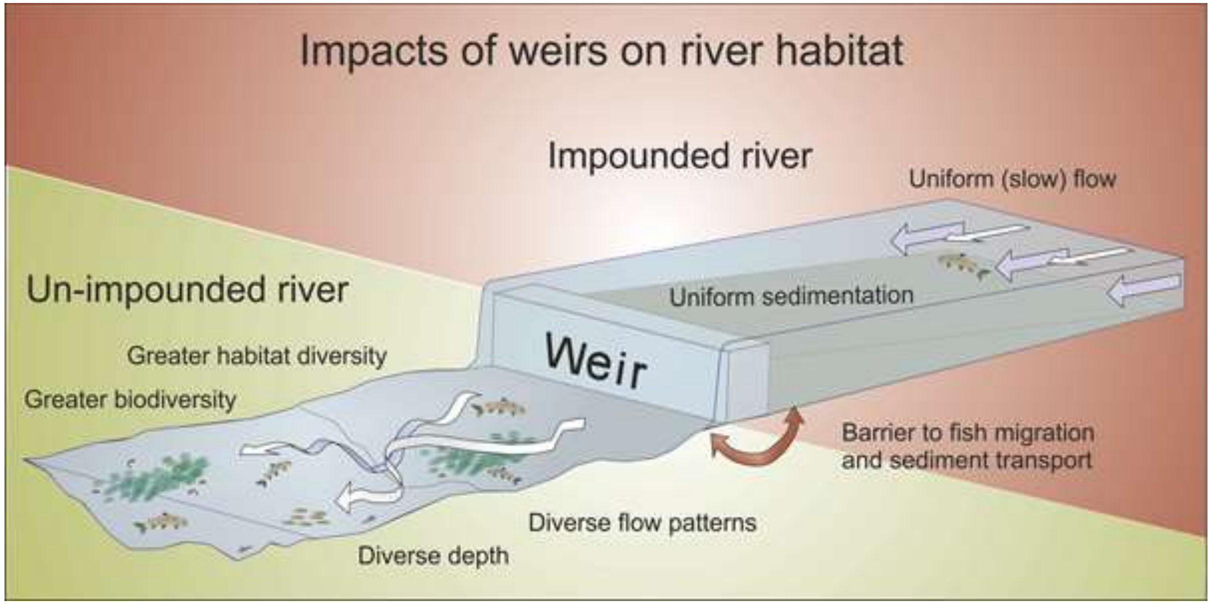

Figure 31: An illustration showing the impacts of weirs on habitat quality

Weirs of all sizes are often significant obstacles – or even complete barriers – to fish passage, preventing many species from moving up and down rivers freely to fulfil the different stages of their life cycles. Weirs also interrupt the natural transport of river sediment (Figure 32). This can cause the river downstream to become depleted of coarse sediment, and increase rates of bed and bank erosion as a result of the interrupted supply of suitable gravel and cobbles from upstream.

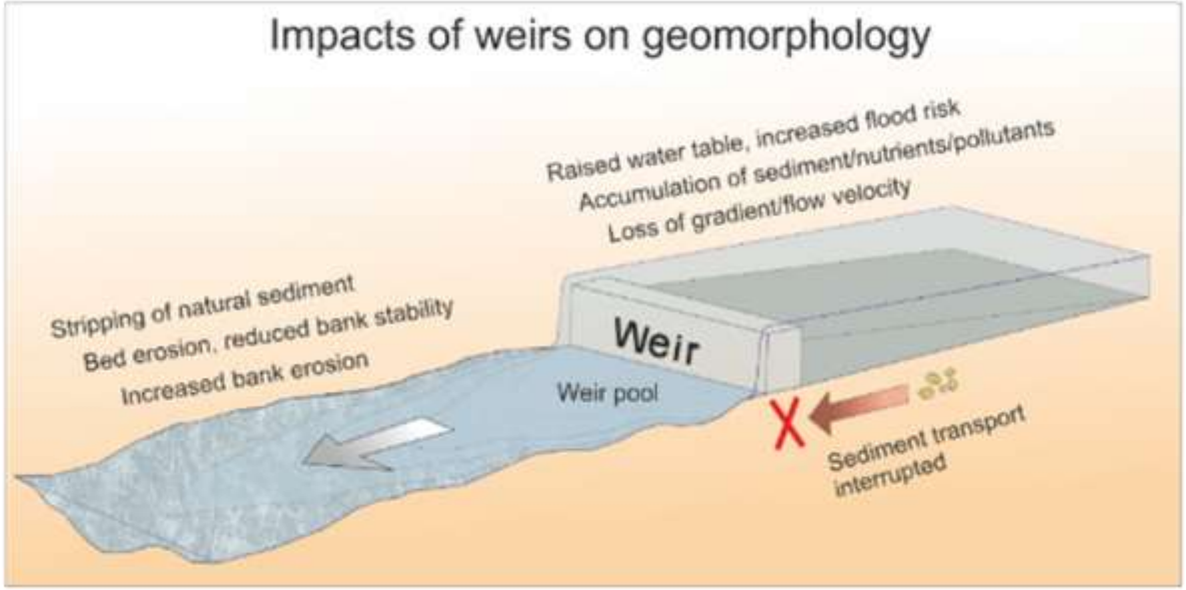

Figure 32: An illustration showing the impacts of weirs on river geomorphology

Weirs and other modifications also produce cumulative effects in terms of their impact. More information about weirs, and the benefits of removing them, can be found on the following links:

https://www.wildtrout.org/content/weirs-culverts-and-barriers

http://urbantrout.blogspot.com/2018/02/why-presume-to-remove-weirs-with-river.html

https://www.americanrivers.org/threats-solutions/restoring-damaged-rivers/how-dams-damage-rivers