Advisory Visit

Upper Wyre, Abbeystead Estate

June/July 2016

Key Findings

- The Upper Wyre on the Abbeystead Estate is a curate’s egg. Topography and land management in various guises influence the whole of the upper catchment, for better *and* for worse.

- Situated in the North West of England and forming the first set of hills exposed to the prevailing winds, the area receives high rainfall. The depauperate vegetation on the high fells and steep gradient in the headwaters then combine to increase conveyance of spate flows. This exacerbates erosion throughout the estate waters, and beyond.

- However, topography and lack of management in some of the wooded valley sections, coupled with replanting of riparian areas with trees and hedges, and exclusion of livestock in limited areas, has resulted in areas of fantastic quality riparian and instream habitat, the latter full of wild fish. If the Upper Wyre could be better connected to the rest of the Wyre system, then the potential for a truly wild, migratory and resident fishery is enormous.

- The majority of the main stem Wyre and mid sections of its two major tributaries are devoid of gravels (a function of the spate flows, a lack of channel sinuosity and complexity from historical channel ‘straightening’, and Abbeystead Dam), and hence even the smallest of tributaries is important for spawning habitat. Some of these are in better health than others; some are more accessible than others.

- There is great potential for simple, low-cost, small-scale natural flood management approaches to be applied as the estate controls the very headwaters. Key will be to prevent the water from gaining momentum by ‘slowing the flow’ little and often before it reaches the steepest parts of the fells, and by instigating or maintaining as long a channel as possible (via meandering) as it reaches the flatter valley floors and / or attenuating peak flows by increasing utilisation of the floodplain.

- There is sufficient space, and the raw materials on the estate, to apply these approaches without unduly compromising the current management of the estate for shooting and farming. Indeed, the benefits are multiple, including reduced loss of land area / soil cover as well as increasing biodiversity and ecological functioning.

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1.0 Introduction

This report is the output of a series of site visits to the Abbeystead Estate which encompasses the entire Upper Wyre catchment, Lancashire, undertaken by Jon Grey of the Wild Trout Trust. The assessment was requested by Neil Kilgour, Agent for the Abbeystead Estate. Rob Foster provided a guided overview of the extent of the Estate waters, and the report was compiled from a further 3 days of assessment; a day each on the mainstem Wyre, Tarnbrook Wyre, and Marshaw Wyre (in late June / early July). These were conducted either independently by JG or accompanied by Tom Myerscough of the Wyre Rivers Trust.

Normal convention is applied with respect to bank identification, i.e. left bank (LB) or right bank (RB) whilst looking downstream. Upstream and downstream references are often abbreviated to u/s and d/s, respectively, for convenience. The Ordnance Survey National Grid Reference system is used for identifying locations.

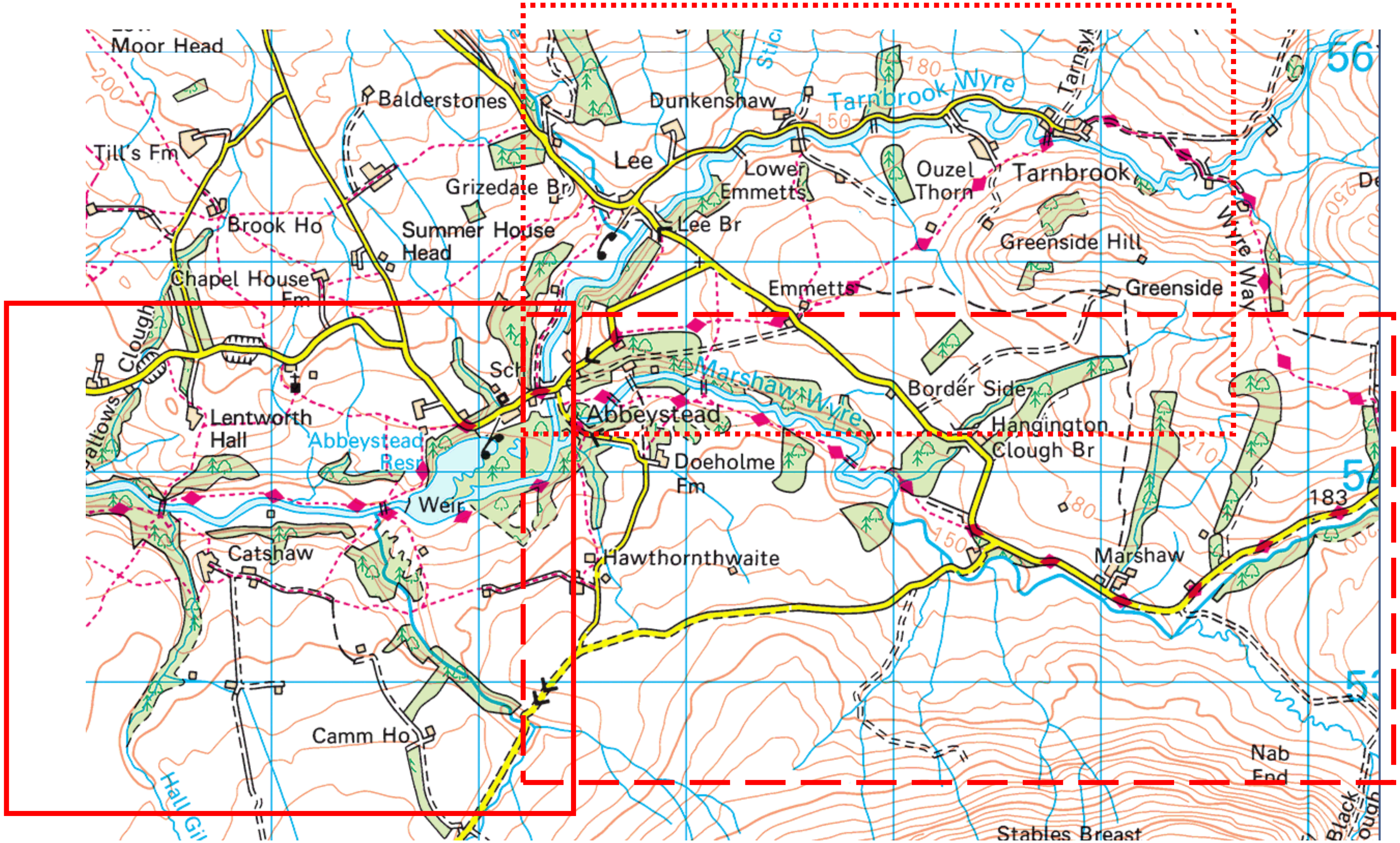
Under the Water Framework Directive (WFD), the Wyre - Upper (GB112072065821) is reported as having no artificial or heavily modified hydromorphological designations which is curious given the extent of modification to create Abbeystead Reservoir and potential historic straightening or moving of the channel to the side of valleys to create coherent tracts of agricultural land. A total of 43.9km of river or beck drain a relatively small catchment area of 59.1km^2.

Through two cycles of assessment, it has achieved *Good Ecological Status* overall. It is important to note that five ecological classes are used for WFD Water Bodies: high, good, moderate, poor, and bad. These are assessed against 'ecological status' (or 'ecological potential' in the case of heavily modified water bodies, HMWBs). The status (or potential) of a waterbody is derived through classification of several parameters: water quality, physical condition and barriers, invasive non-native species, fish, and flows and levels. The overall status is then dictated by the lowest score amongst those parameters. The river is a protected area under the Drinking Water Directive.

	Abbeystead Estate		
River	River Wyre		
Waterbody Name	Wyre - Upper	Tarnbrook Wyre	Marshaw Wyre
Waterbody ID	GB112072065821	GB112072066240	GB112072066230
Operational Catchment	Wyre and Calder	Wyre and Calder	Wyre and Calder
River Basin District	North West	North West	North West
Current Ecological Quality	Overall status of **Good** ecological status sustained through two assessment cycles from 2009 - 2015	Overall potential of **Moderate** has been sustained from 2009 - 2015	Overall status has improved from **Moderate** to **Good** ecological status from 2009 - 2015
U/S Grid Ref inspected	SD5637654123	SD6116157713	SD6126653868
D/S Grid Ref inspected	SD5385654098	SD5637654123	SD5637654123
Length of river inspected	~2500m (incl. Cam Brook)	~5000m	~6000m (incl. Black & Tail Cloughs)

Table 1. Overview of the waterbody. Information sourced from: http://environment.data.gov.uk/catchment-planning/OperationalCatchment/3552

The upper reaches of the Estate waters are split between two main tributaries which form the Wyre – Upper at their confluence just above Abbeystead Reservoir (Map 1). The Marshaw Wyre to the East comprises 12.7km of beck within a catchment of 18.1km^2 and has improved from *Moderate* to *Good Ecological Status* overall. The Tarnbrook Wyre to the West comprises 15.9km of beck, draining 28.3km^2; it is classified as HMWB (presumably on the basis of the abstraction infrastructure in the headwaters) and was consistently reported as achieving *Moderate Ecological Potential*.



Map 1. Overview map. Red rectangles are: solid – Main-stem Wyre, Map 2; dotted – Tarnbrook Wyre, Map 3; and dashed – Marshaw Wyre, Map 4.

Catchment / Fishery Overview

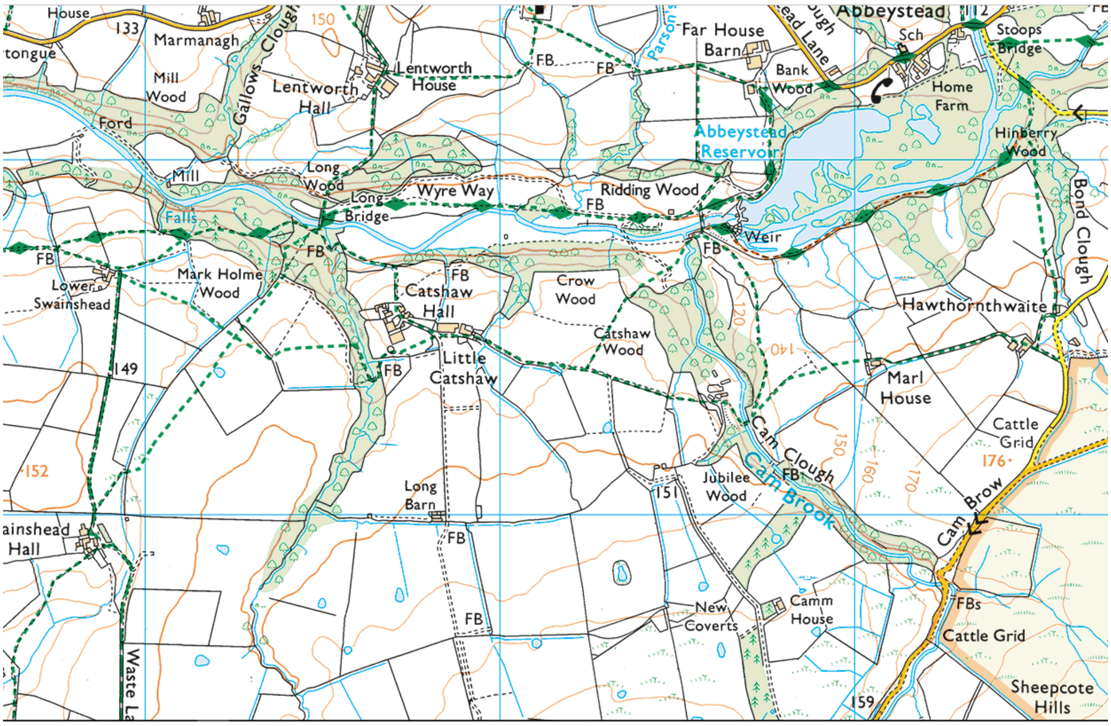
The Wyre catchment drains a small area in North West Lancashire and features a wide variety of habitats. It is bordered by the Lune catchment to the North and the Ribble Catchment to the South and East. The upper reaches of the catchment (Tarnbrook and Marshaw Wyres) are centred on the Bowland Fells where many of the headwaters arise on peat blanket mire and cascade rapidly down relatively steep gradients to the valley floors. Abbeystead Reservoir is situated just below the confluence of the two major tributaries and clearly intercepts much of the silt, gravel, and cobble transported during spate flows. The central part or Wyre Upper then takes in the Amounderness plain at the base of the fells, and the lower catchment takes in the northern Fylde Coast.

The catchment supports a wide variety of wildlife. The vast majority of the Bowland Fells are within the Forest Of Bowland Area of Outstanding Natural Beauty; those fells also host many SPAs and SSSIs, which are areas of habitat that are nationally designated, to protect the flora and fauna that is contained within them (e.g. the Conservation of Wild Birds Directive).

The estate waters are only lightly fished and no electric fishing surveys have been conducted, so there is scant information on the wild trout populations. Light stocking with triploid brown trout from Dunsop Bridge occurs on the reservoir, and these fish are noted in the main stem Wyre below the dam. There is anecdotal evidence of a few individual salmon managing to ascend the fish pass on the dam.

2.0 Habitat Assessment

2.1 Main stem Wyre



Map 2. Main stem Wyre in relation to Abbeystead Reservoir; the confluence of Tarnbrook & Marshaw Wyres can be seen within Hinberry Wood (top left). Cam Brook flows from the south and joins the main river below the dam infrastructure.

The main river was walked in an u/s direction from the ford (SD5385654098) to the dam foot, and immediately above the reservoir to the confluence of Marshaw & Tarnbrook Wyres. For ~800m where both banks are protected by mature riparian vegetation, the instream habitat is diverse and of excellent quality (Fig 1). Accordingly, many trout were seen rising, and while some of these were undoubtedly stocked fish, the majority were smaller, wild fish. Pool-riffle-glide sequences offer variability in flow and depth, augmented by numerous natural inputs of large woody material (tree-falls) which provide refugia from both predators and high flows, as well as food for the organisms at the base of the food web.

The banks are naturally steep, precipitous in some places, and the substrate is a mix of primarily boulders and large cobbles with some exposed bedrock; there is limited retention of the smaller fractions such as gravel. Indeed, this is common throughout the main river and highlights the importance of the smaller tributaries for spawning and juvenile habitat which are assessed later. A cursory examination of some of the cobbles revealed many Plecoptera (stoneflies), Ephemeroptera (mayflies) and Trichoptera (caddisflies) indicative of good water quality.

Fig 1. Upper: typical view of lower reach of the Wyre with natural pool-riffle-glide sequences and mature riparian vegetation on both banks providing good quality habitat. Lower: abundant, stabilised, large woody material helps to diversify flow and aids the slowing of flow under spate conditions.

On the RB, ~100m d/s of the footbridge (Long Bridge; SD5448853825), there were two clumps of Japanese knotweed (*Fallopia japonica*) noted (Fig 2). The presence of this invasive, non-native species (INNS) should be addressed as it outcompetes native plants but has little root structure to enhance bank stability. When it dies back completely in winter, it leaves the bank soils entirely exposed to erosion.

Fig 2. On the RB d/s of Long Bridge, a stand of Japanese knotweed has taken hold.

Habitat degrades where the natural riparian vegetation is replaced by grazing land and stock have unfettered access to the river. Without the protection of a diverse plant cover and the structural stability provided by the associated root matrix (both substantially reduced by grazing), the soils comprising the banks are easily eroded by high flows and the actions of grazing and poaching (trampling).

This is most notable around the base of riparian trees (Fig 3) where sheep (in this case) tend to congregate, and their trampling and rubbing at exposed banks and landslips further exacerbates erosion and prevents the natural recolonisation of the exposed soils by plants. The focus of erosion around bankside trees has multiple impacts. It increases sediment ingress to the channel, reducing water and substrate quality. It increases the likelihood of tree loss to spates, further reducing the structural integrity of banks, and removing the shading, refuge, and nutrient benefits of trees. There is also a complete lack of self-set young trees to replace those lost through the processes above; this is because stock preferentially target the more nutritious shoots and saplings. Excessive erosion of both banks leads to over-widening of the river channel, and a consequent uniformity of depth and substrate composition as the flow energy is dissipated over a greater cross-section (Fig 3). The alders at SD5497553867 (Fig 3: lower panel) are particularly vulnerable as they are on the outside of the bend (RB). There is already a fence preventing access from the field to the north and little viable grazing would actually be lost by preventing access along this sliver of bank from the field to the west.

Fig 3. Upper: overly wide section of river where both banks are heavily grazed. Mid upper: sheep maintaining exposed soils around tree roots. Mid lower: typical stock erosion impacts around each tree. Lower: friable soils left exposed after sheep trampling. Note also lack of low branches to provide valuable cover and shade.

Fords have similar effects to stock poaching on both the river and the banks (Fig 4). If these are necessary, then entrance and exit points should be formalised with some kind of hard-standing or railway sleepers to prevent continual poaching (from stock) or rutting (from tyres) of soils and further fine sediment ingress from the slopes whenever it rains.

Fig 4. A fording point (SD5479053762) which causes erosional over-widening of the channel and ingress of fine sediments if the entrance/exit points are not formalised.

At the formal vehicle crossing point, there was considerable erosion evident on the LB, which had been recently rebuilt and re-profiled (Fig 5). Unfortunately, the concrete ford has been installed at an angle across the river which, at certain flow heights, will divert the flow path of the river directly at the LB and/or cause eddying turbulence (dependent upon gauge height), and hence will continue to cause erosion at that point. The actual structure of the rebuilt section of bank was not visible, but the surface re-profiling was essentially with cobbles and soil. Over the 6 weeks between first and final visit there was virtually no regrowth of plant cover on this bank and further evidence of some slippage, probably because it was not protected from stock access.

At the gauge height depicted in Fig 5, the ford is an obstruction to the free passage of fish and it impedes the free movement of bed substrate; it also impounds the river for ~80-100m u/s creating a relatively featureless section (Fig 6).

Fig 5. Formal concrete ford crossing the Wyre below the dam infrastructure. The angle it is installed will divert flows toward the LB (blue arrow) and consequently continue to cause erosion. The rebuilt section (white ellipse), as with most riverbank, requires stock exclusion to allow a diverse flora to regenerate and cover the exposed soils. Once stock are excluded, the area would benefit from willow whips or stakes driven into the toe of the bank to provide further structural stability.

Fig 6. The relatively featureless impounded section of river (immediately u/s of Fig 5).

Cam Brook enters the Wyre on the LB, ~100m d/s of the major dam infrastructure. As such, it is the furthest u/s tributary that both migratory and wild fish can access below the dam and thus, potentially has even greater importance in terms of its spawning and juvenile habitat potential; it will be considered in section 3.3. While there is a fish pass installed to ascend the 24m dam and provide access to the reservoir and the upper catchment, it appears anecdotally to be ineffective. The 'attraction flow' from the fish pass mouth is effectively lost in the plethora of flow paths from the overspill and dam gates, and the habitat is highly modified by all the infrastructure associated with the reservoir.

The short (~300-400m) section immediately u/s of the reservoir to the confluence of the tributaries effectively reflected the transition from freestone spate river to delta as the flow dissipated into the standing waterbody (Fig 7).

Fig 7. Upper: cobble and gravel bars, meandering planform and large woody material maintain natural geomorphology of the river below the confluence. Mid: pool with excellent quality gravels for spawning habitat and refugia in alder roots; note dimple ring left by rise of small trout. Lower: deeper, slower flowing water as the river forms a delta with the reservoir; note the beneficial trailing branches of the willow but the presence of Japanese knotweed (white ellipses) on the opposite bank (LB).

The surrounding terrestrial environment is fabulous, diverse wet woodland, marred only by extensive (and spreading) stands of Japanese knotweed along the banks (Fig 7 lower panel). Dense willow and alder provide ample submerged refugia via their roots and low over-hanging cover via their trailing branches. There is abundant, natural, large woody material deposited within the channel to divert flows and cause scour pools to develop, thereby diversifying the depth profile. The variance in flows effectively sorts the substrate - where flow energy decreases, so does the ability to transport bed material. This deposits rich ramps of gravels toward the tail of pools. These gravels have good through-flow of oxygenated water, and hence provide ideal habitat for spawning salmonids to create their redds (nests), as well as refugia and foraging areas for many macroinvertebrate species.

2.2 Small tributaries from mainstem Wyre (Gallows Clough; Parson's Brook & Joshua's Beck)

The tributary descending from Gallows Clough enters the Wyre on the RB near to the mill at SD5405753939. It was assessed to the first estate track crossing point, ~150m from the confluence with the Wyre. For most of that distance, it was devoid of much beneficial vegetative cover as it is exposed to stock grazing on both banks (Fig 8). As a consequence, the banks have been subject to considerable erosion over the last winter and the majority of the bed substrate comprises overly large boulders and cobbles relative to the cross sectional area and 'normal' flow observed. However, in the one deeper pool, beneath a mature tree and immediately d/s of the track culvert, there were several small trout indicating the potential of the beck for spawning and juvenile recruitment to the wider Wyre population. The double culvert pipes are perched, i.e. ~25cm above the pool surface, and the depth of water flow through the culvert was insufficient for fish passage (Fig 8 mid panel). Combined with accumulation of debris immediately u/s of the culvert pipes, these factors create a considerable barrier to fish movement both up and downstream. Single, large culverts always present a better option than multiple smaller ones and should be sunken at least one third of their depth below the bed of the watercourse to allow free movement of sediment and prevent them from becoming perched.

Fig 8. Upper: beck descending from Gallows Clough showing lack of bankside cover and over-sized substrate. Mid: pool below perched culvert pipes at the track crossing. Lower: debris and water gate immediately u/s of culvert pipes; note deposit bar of appropriately sized spawning gravels cobble and gravel bars prevented from moving d/s by debris blockage.

The joint flow of Parson's Brook and Joshua's Beck enters the Wyre on the RB at SD5509253828. Both watercourses were walked for their lowest 20m to confirm the presence of trout. However, the following focuses on the 150m between the confluence with the Wyre and the estate track ~150m u/s, where there is some intriguing man-made infrastructure installed. The culvert under the track is perched (~15cm) and so constitutes a barrier to free fish passage; the pool immediately d/s contained >10 trout. Sheep grazing and trampling has impacted upon bank integrity and the flora (Fig 9).

Fig 9. Impacts of sheep: undermining the root structure of hawthorne bushes (upper); and (lower) browsing of this small alder, effectively forcing it grow horizontally over the channel so that now it can be accessed from the opposite bank.

Himalayan balsam was present at this site and the source of such a localised infestation should be relatively easy to identify. The channel path has been modified historically; in some places, the beck has been forced to turn and in others, meanders have been by-passed (Fig 10). The wooden piling sides are being compromised at several points. Several small wooden, notched weirs have been created which have created a series of pools and gravel ramps that are certainly being used by juvenile trout and likely being used for spawning, respectively. Silt ingress however, presumably from the livestock activities, was a problem at the water level encountered.

Fig 10. Wooden pilings and weirs introduced into the small tributary.

2.3 Cam Brook

Cam Brook enters the Wyre on the LB, immediately above the Lune-Wyre transfer infrastructure. Short sections were assessed: the lowest 100m, ~100m near to the pheasant pens within Catshaw Wood, ~100m above and below the road at Cam Brow, and several 20m sections ascending Catshaw Fell.

Like the majority of the headwaters feeding into the Wyre, the Cam Brook descends steeply from the surrounding fells. The riparian vegetation near to the headwaters is a low-lying, scrubby mixture of heather, bilberry, rushes and grasses; there are no trees (Fig 11). There is much evidence of substantial flooding, even high up the Catshaw Clough; large boulders and flayed strips of vegetation are to be found where the brook has over-topped its banks. The majority of smaller cobbles and gravels have been washed out because there is no structure to retain them; large woody material would perform this function if it could be stabilised in such an already exposed system. This section, and those in other similar tributaries, are candidate locations for leaky dam construction and willow introduction, to potentially slow the flow – see Recommendations.

Sheep tend to use the land-slips and eroded overhangs of vegetation for shelter and hence exacerbate the erosion further. Demonstrating their incredible resilience, small trout were observed ~500m u/s of Cam Brow but they were few and far between. As the gradient flattens out toward the valley floor, there are large deposits of smaller cobbles. These are particularly obvious above man-made obstructions such as the culvert comprising 5 separate pipes which allows for the track up Catshaw Greave from the Cam Brow road (at SD5581752071; Fig 12). All the pipes are perched with insufficient depth of flow and hence constitute a barrier to fish passage.

Cam Brook is forced parallel to the Cam Brow road for ~800m but still manages to retain some marginally meandering planform. More appropriate pipe culverting is found at SD5625252808 as Cam Brook passes under the road (Fig 12 mid). There is a sufficient depth of water throughout each culvert; indeed, there is some cobble substrate within it creating a more natural ‘bed’. The pool depicted in Fig 12 lower panel, located ~10m d/s of the road culvert contained >10 trout.

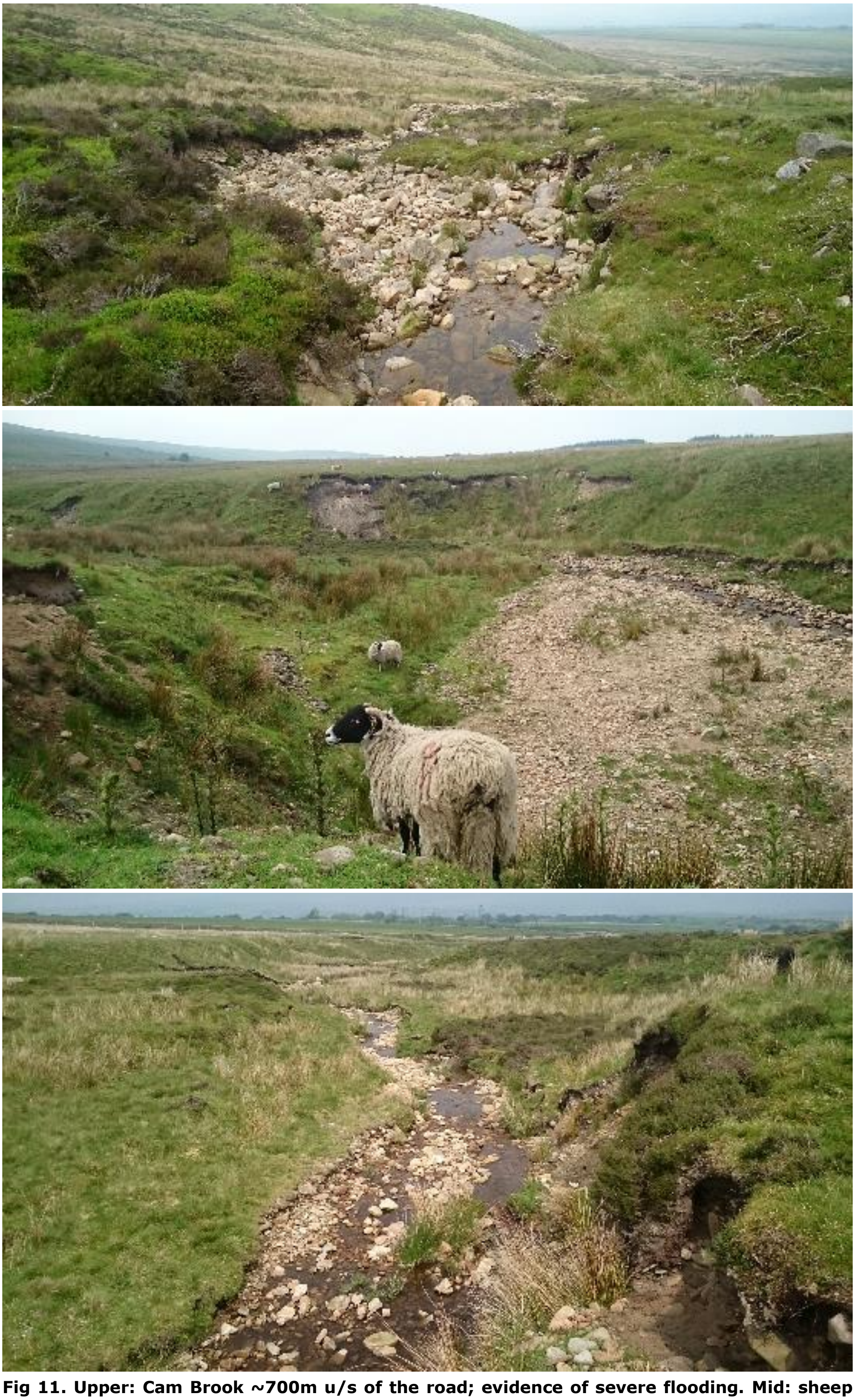


Fig 11. Upper: Cam Brook ~700m u/s of the road; evidence of severe flooding. Mid: sheep using the scours and landslips. Lower: a few trout were observed here, despite the exposed nature of the environment.

Fig 12. Upper: perched culvert pipes at the lower end of Catshaw Greave; note the interruption of sediment transport and cobble deposits u/s. Mid: more appropriate culverting with at least some water depth maintained throughout, under the road at Cam Brow. Lower: pool at the watergate immediately d/s of the road culvert containing >10 trout.

Cam Brook proceeds to flow through a relatively narrow wooded valley (from Fig 12 lower panel). It was next accessed at the pheasant pens in Catshaw Wood. That steep, yet surprisingly wet woodland is essentially unmanaged and, as a consequence of the topography and lack of interference, the brook comprises excellent habitat for salmonids (Fig 13).

Fig 13. Examples of excellent quality juvenile salmonid habitat induced by woody material, naturally introduced and retained in channel, which also retained ramps of finer gravels for spawning.

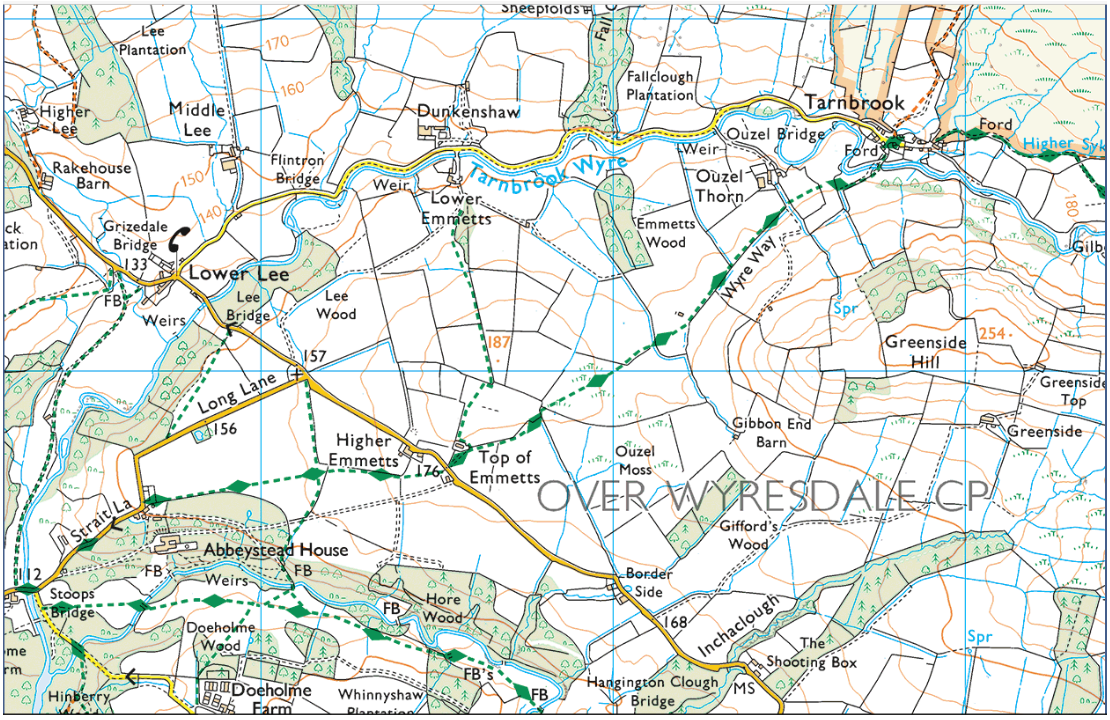
There are many fallen trees and pieces of large woody material which diversify the flow path, creating deeper pools and sorting and retaining gravels of an appropriate size for spawning redds. That wood also functions as natural flood management, impeding spate flows. Many salmonids were observed here.

As Cam Brook leaves Catshaw Wood, the LB is open to livestock access, and it appears that some grazing has occurred on the RB as well. Certainly the understory is dominated by grasses rather than the diversity of plants found within the wood u/s. There was evidence of considerable, exacerbated erosion on the outside of bends and the footings of the footpath bridge (just above the confluence with the Wyre) are now being challenged.

Cam Brook discharges into the Wyre immediately u/s of the concrete Lune-Wyre Transfer infrastructure which spans the entire channel of the Wyre (Fig 14). As such, it will be important to maintain as much natural riparian cover and ensure that access to the brook is of sufficient depth to encourage use during spawning.

Fig 14. Looking d/s between the Lune-Wyre Transfer ducts. The Wyre flows past toward the RB; the Cam Brook enters from the LB (bottom left of shot) and the deposition arc ramp of gravel can be clearly seen. Access and attraction flow are limited at this water level, especially as the bed of the Wyre between the ducts is a concrete slab.

2.4 Tarnbrook Wyre



Map 3. The lower sections of the Tarnbrook Wyre, from Tarnbrook to the confluence.

The very upper tributaries of the Tarnbrook Wyre were accessed at SD6116457658, the confluence from Hare Syke and Brown Syke. Natural waterfalls exclude salmonids from this part of the catchment. However, it was interesting to note a difference in quality between the two becks. Hare Syke was notably cleaner in terms of fine sediments, and a cursory inspection of the macroinvertebrate community revealed a more diverse and abundant assemblage compared to that emanating from Brown Syke. Peat erosion from Brown Syke is clearly an issue.

At Pea Carr Barn (SD5980955643), the Tarnbrook Wyre already shows signs of flashy, spate flows (Fig 15), with the substrate dominated by large boulders and very little retention of fine gravels. The riparian vegetation is restricted to closely grazed grasses, *Juncus* rushes and some bracken.

Fig 15. The Tarnbrook Wyre at Pea Carr Barn.

From here, the gradient of the valley lessens considerably, and the brook flows through a mixture of improved grassland, and natural and managed woodland until the confluence with the Marshaw Wyre. For approximately 1.5km of this section, the path of the brook is tightly associated with (and in some instances constrained by) the road from Lower Lee to Tarnbrook. Historically, the brook appears to have been diverted around the uppermost farm, based upon the placement of old stone wall embankments and tree-lines. Perhaps as part of the diversion, a considerable amount of farm rubbish has been buried and turfed over (Fig 16). The brook is now eroding into the hidden midden and distributing its contents d/s. While removal of all the material is the ideal, the scale (unknown) and location (directly receiving the brunt of current flow) suggests a more pragmatic approach to encourage the brook to return to its former course using protection of the RB might be worth exploring.

Fig 16. Erosion into the 'midden' at the Tarnbrook farm exposing some relatively modern rubbish which is being liberally distributed downstream. Photo: Tom Myerscough

While it is natural for the brook to meander and cause some erosion on the outside of developing bends, there are some notable areas where the erosion rate is excessive and exacerbated by grazing and trampling by livestock, such as at SD5846555655 (Fig 17). The addition of rock boulders to alleviate the erosion may provide a limited solution at that very local point but simply deflects the flow energy elsewhere, typically around the edges of the boulders causing even greater erosion to either side. It also fails to address the underlying issue(s), manifesting as the rate of conveyance of water to that point from the upper catchment and livestock grazing of the banks.

The footings of the bridge at Ouzel Thorn Farm are a substantial barrier to fish passage. The footings are perched during low flows and the relatively smooth surface acts like a flume at higher flows. Several smaller tributaries enter from both banks between Tarnbrook and Lower Lee, and those that flow from the north, particularly through wooded valleys are likely to be used for spawning. The RB is heavily modified in places where it abuts the road; the LB is in better condition wherever stock are excluded. For the majority of the distance from Tarnbrook to Lower Lee, the brook is heavily shaded and 'tunnelled', primarily by mature alder trees. While this is natural,

Fig 17. Upper: the river has braided and cut an entirely new channel (foreground) which loops back into the main channel (blue arrow). Mid: Excessive erosion on the grazed LB is cutting behind an established tree. Lower: boulders have been tipped in to try and alleviate the erosion; note the tipping of waste in the background (white ellipse).

it has led to a sparse understory and relatively thin groundcover on the banks.It may be beneficial in specific locations to undertake coppicing to encourage new, low growth of a greater diversity of plants.

Downstream from Lee Bridge (itself a barrier to free passage: flume effect), the R. Grizedale enters from the RB, and the brook wends for ~1km to the estate office. Spate flow from the Grizedale has clearly deposited a considerable amount of boulder substrate at the confluence, as well as contributing to erosion on the LB of the Tarnbrook Wyre d/s which would otherwise be protected by riparian trees (Fig 18).

Fig 18. Upper: the Tarnbrook Wyre (flowing from top left to right) is joined by the R Grizedale (bottom left). Considerable deposition of large boulders has occurred. Lower: immediately d/s on the Tarnbrook Wyre LB there is considerable erosion caused by spate flow from the Grizedale (confluence, bottom left).

Below the influence of the Grizedale, the RB is almost entirely devoid of natural vegetation except for scrubby gorse on old gravel bars; it is mostly pasture with some mature native and newly planted ornamental trees. The LB initially comprises mature, native woodland with good quality habitat and overhanging cover, but then gives way to a similar landscape as that on the RB. There is some natural braiding of the channel. Bank erosion on the outside of one particular bend (near to the low barn at the boundary between the two main fields; Fig 19) will eventually compromise the track. This requires protection from grazing and trampling and since there are several wooden tree protectors already *in situ* here, a post & rail fence would not look untoward.

Fig 19. Upper: looking d/s at erosion exacerbated by livestock. Lower: looking back u/s to demonstrate proximity of track and presence of wooden protectors around ornamental trees.

2.5 R. Grizedale

Only the lower 200m of the Grizedale were examined. On the first visit, it was virtually dry, a series of stagnating pools which were poorly linked through over-sized boulder substrate; on the second, it was flowing well. This is clearly a function of the archaic abstraction regime imposed upon it. Like many of the other brooks and becks draining the steeper cloughs, the substrate size (and lack of retention of smaller particles) indicates a very flashy hydrograph which places un-natural erosional stress on the banks, especially where these are also grazed by livestock (Fig 20).

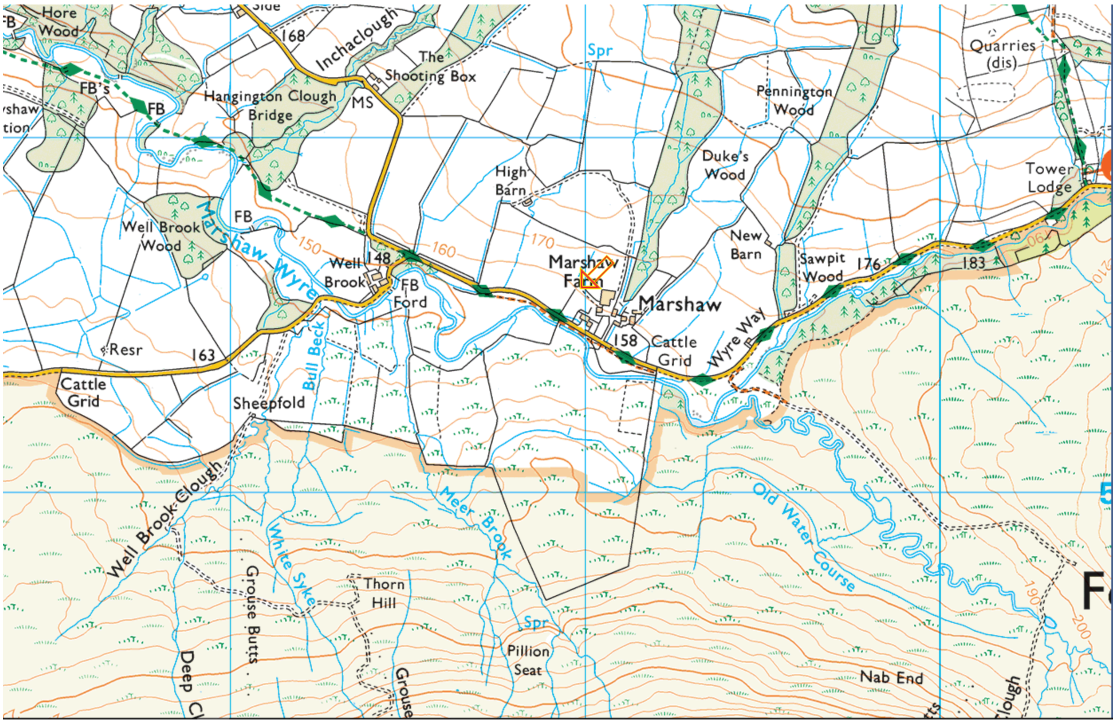
Fig 20. Upper: the Grizedale under low flow ('full-take' abstracted) during the first visit; and Lower: erosion particularly on the grazed banks. Note the lack of species diversity growing along the bank top (due to grazing) and the associated lack of root structure within the bank.

A series of mature hawthorn trees are in grave danger of being lost in the near future as the bank is eroded slowly from beneath by the river, and from above by the trampling and grazing from sheep. One lamb was trapped in the run beneath the horizontal roots in Fig 21.

Observations of the Grizedale valley from the road, and from Google Earth, reveal that it is subject to the same issues as the Tarnbrook Wyre but appears overly influenced by the water abstraction.

Fig 21. Horizontal roots protecting these mature hawthorns from erosion by the river, but sheep grazing and trampling of these roots will eventually weaken them and a large area of bank and all the fine soil associated with it will be swept into the Tarnbrook Wyre and eventually to the reservoir.

2.6 Marshaw Wyre



Map 4. The lower sections of the Marshaw Wyre, from Tower Lodge to Abbeystead House. The meandering path of the unnamed beck from Black & Tail Cloughs flows from the south east (lower right).

Various sections of the Marshaw Wyre were assessed on different days but for consistency the report will proceed from the uppermost site (SD6126653868) in a d/s direction. At this point it encounters and then runs parallel to the Trough Road (on the RB), and the surrounding land changes from open heather moorland to a sparse mixture of native coniferous and deciduous trees. Small trout were observed as far up as the estate track bridge (Fig 22). Already, the channel form and substrate suggests extremes of flow are experienced; it is wide with relatively large substrate and little evidence of particle size sorting except on the inside of sharper bends. The banks are heavily cropped by sheep (in some places degraded by picnickers) and numerous mature trees on the outside of bends are being undermined by erosion (Fig 22).

Fig 22. The Marshaw Wyre exhibiting an already overly wide channel and evidence of high spate flows leading to an over-supply of cobble substrate. Note the undermining of mature trees and closely grazed understory.

The RB is reinforced with concrete and boulder riprap wherever it encounters the road. There is a steep slope set back from the LB which is bisected by numerous small gullies, and the large swathes of *Juncus* hint at the wetness of this slope. Indeed, there is plenty of evidence of land slips which have accounted for the loss of several mature trees. While several areas have been fenced off and replanted, which should be commended, it only highlights the fact that the sheep grazing everywhere else is preventing the natural regeneration of self-set trees, especially on those slopes. The value of tree root structure in preventing land slips on such slopes cannot be underestimated; various small willow species would be ideal for that location. Where trees have slipped or fallen into the river, they should be secured and left if possible to perform a valuable function in diversifying the channel structure and 'slowing the flow' (Fig 23).

Fig 23. Fantastic tree fall (large woody material) in the channel. The beneficial functions of these trees should be retained whenever and wherever possible; by creating more bank resistance, large woody material produces bed scour rather than bank scour.

At the track to Black Clough (assessed in section 3.7), the LB u/s of the estate bridge has been reprofiled using cobbles from the deposit bars (Fig 24). Unless sheep are excluded from this area, it is unlikely that any vegetation will develop to consolidate the bank and provide better resilience to future spate flows. Fig 24 also highlights an issue which is apparent from the start of the assessment to SD5787054125 (~2.5km d/s); because the channel width accommodates such high spate flows (made even wider through grazing associated erosion), at 'normal' levels, the water is far from the vegetated banks (except at bends) and hence there is no low cover for fish and it is of rather uniform depth. Thus, while small salmonids can make use of the relatively shallow water and shelter afforded by boulders, larger individuals will not tolerate such exposure. There is also the physical aspect of an almost complete lack of shading / cooling of the water.

Fig 24. Extremely exposed channel above the Black Clough track bridge. The LB has been re-profiled using deposited material.

Immediately below the confluence with the Black Clough tributary, the Marshaw Wyre sweeps around a broad right hand bend and the combined spate flow of the two watercourses at that point seems to have worsened the erosion on the grazed LB (Fig 25). There are several bends from here to Well Brook where poor vegetative structure on the bank has allowed severe slippage to occur. The banks comprise former alluvial deposits which are now being cut back into, a natural process but operating at an excessive rate caused by accelerated conveyance from the moors and grazing pressure. Fascines, low, staked bundles of material aligned to the contours would help to reduce further erosion – see Recommendations.

Fig 25. Excessive bank erosion. Upper: immediately d/s with the confluence of Black Clough on the LB. Mid: landslips on the bend d/s of the confluence. Lower: further slippage not far u/s from Well Brook. Large areas like these would benefit from installation of fascines.

Opposite Marshaw Farm, there was evidence of vehicle access to the beck bed, and use of gravels to shore up eroded bank faces (Fig 26).

This is a futile exercise as the unconsolidated, poor growing medium will simply slump back into the channel under the next spate, especially as livestock can trample it and prevent colonisation of plants. Whilst we did not make a direct observation of the activity, we were alerted by the discolouration of the river ~1.5km d/s and traced it to this source.

Fig 26. Very recent evidence of vehicles in the beck and use of unconsolidated gravels to shore up eroded banks.

Downstream of Well Brook, after passing under the road via four reasonable sized culverts that contained natural substrate (and were passable to fish even at low flow, Fig 27), the Marshaw Wyre wends through pasture that appears to be under less grazing pressure. The riparian vegetation was 'shaggier' and more diverse as compared to u/s sections but, importantly, the grazing activities of livestock, even at low density are still preventing any regeneration with self-set trees. As a consequence, there was a tendency for lack of beneficial cover from riparian trees unless the steepness of the bank, or truly wooded sections were encountered (Fig 28). The lowest 1km section immediately past Abbeystead House was not seen; only at the confluence with the Tarnbrook Wyre near to the estate office, where it was once again in good condition because of abundant woody material in channel and natural vegetation on the banks.

Of note, at the confluence with Bull Beck, silty deposits were evident. These were traced u/s along the beck until it departed from the Cam Brow road, seemingly suggesting an erosional problem u/s in either White Syke or Deep Clough (or both).

Fig 27. Adequate culverting under the road at Well Brook. Trout were observed swimming freely from the pool into the culvert pipes, and there were no passage issues at the u/s end.

Fig 28. Upper: low intensity pasture / meadow below Well Brook but note the lack of self-set tree saplings / tree regeneration. Lower: where woodland replaced pasture, the quality of riparian and instream habitat improved.

2.7 Black Clough & Tail Clough

The largest tributary joining the Marshaw Wyre descends rapidly from Marshaw Fell via Black and Tail Cloughs into such a low gradient valley that it is already meandering considerably u/s of the confluence. The Black Clough arm of the tributary contained abundant trout for ~300m until the gradient became so steep that natural waterfalls presumably prevented passage. The Tail Clough arm appeared devoid of trout within 10m. There were clear differences in water and habitat quality; the substrate was relatively clean and with abundant invertebrate life in the former, while there were peaty deposits smothering the stones in the latter.

Fig 29. The confluence of small becks from Tail Clough (left) and Black Clough (right) and the difference in substrate quality evident in each

Immediately d/s of that confluence, a culverted track bridge to Black Clough introduced some challenges to fish passage (Fig 30), then from that point down to the Marshaw Wyre, the channel meandered and braided seemingly naturally (Fig 31). The scrubby nature of the heather on the undercut banks means that there is reasonable cover for small trout, but it could be improved with some low tree cover. The meander path substantially increases the distance travelled by the water, slowing the flow from the source to the confluence with the Marshaw Wyre and encouraging peak flows to spill out onto the floodplain, performing a natural flood management function; this should be maintained, actively encouraged in other sections, and added too with the planting of some low-growing goat willow and installation of some leaky dams.

Fig 30. The culverted track bridge at the bottom of Black Clough is partially blocked at the u/s side and requires monitoring for maintenance of fish passage

Fig 31. In the valley bottom, the tributary starts to braid (upper panel) and meander (lower panels) which will increase conveyance time to the Marshaw Wyre considerably.

3.0 Recommendations

The character of the Upper Wyre is governed strongly by the natural topography of the catchment and land management practices, both historic and ongoing. Water falling on the fells is transported rapidly to the valley floors and into the mainstem Wyre. The channel forms of every watercourse bear evidence to extremely high spate flows and rapid conveyance leading to excessive erosion on those sections of bank inadequately protected or to eddying scour at the outflows of culvert pipes leaving them 'perched' (further accentuated by the interruption to sediment transport). Sections which butt up against bedrock, or flow through mature woodland are much more resilient and provide excellent quality habitat, both instream and on the riparian strip.

3.1 **Slowing the flow**

The most beneficial action across the whole estate will be to 'slow the flow', i.e. reduce the conveyance speed during and following rainfall events. Valuable land is being lost at a considerable rate so there are benefits to both land practice and habitat quality. *The estate is in an 'enviable' position in this respect by having control of how the whole of the upper catchment is managed*. There are several approaches using natural flood management that could be employed, especially as there is the space and the majority of raw materials available on site already. Little and often is key for reducing conveyance across the upper catchment.

3.1.1 High fells

It is appreciated that the land is managed as a working estate, that vehicular access is required to certain points, and that some drainage is necessary for the tracks to be maintained. However, it is easier to slow the flow at the top of the system before it gathers momentum on the steep fell sides. If heather burning is practised, then a buffer zone of at least 5m should be left unburnt along watercourses to maintain the best possible riparian root structure and above-ground roughness to slow overland flow. Installation of 'leaky dams' in series will greatly reduce the conveyance of water from the fell tops and prevent too much momentum building up in the first instance. The principle behind leaky dams is to mimic natural log jams found in wooded sections and there are plenty of good examples across the estate waters further d/s. Thus, at low flows, the water just passes under or through the material, but at higher flows, each dam in series creates resistance to the flow. Leaky dams should not trap sediments *per se* and hence should not require too much maintenance, especially as there is little riparian vegetative material (e.g. tree branches etc) to block the interstices of the dam. Leaky dams can either be constructed in a log-jam style, tree limbs or trunks interlocked and secured into position by tethering / posts, or by interweaving substantial brash through braced posts on either side of the low-flow channel, essentially leaving a gap in the middle; see leaky bunds, section 4.2 in the final report available at: https://northyorkmoorsnationalpark.wordpress.com/tag/sinnington/

Fascines are long bunds of brashy, twiggy material that are semi-buried and staked in lines along contours in areas subject to high overland flow, or on exposed slippage sites. They trap material over time, essentially becoming a series of terraces that slowly consolidate and help to protect eroded areas as well as slow the flow to the nearest watercourse. They have been used to good effect in areas of similar topography (and rainfall) such as on Hebden Water (see: http://www.treesponsibility.com/wp-content/uploads/2013/09/Understanding-the-Hebden-Water-Catchment-LOW-RES.pdf).

Leaky dams should ideally be used in conjunction with some judicious planting of hardy, low-growing scrub like willow, individual trees of which were noted in some isolated locations at altitude. The dense shoots of willow will introduce resistance to water flow during spates and the roots will introduce physical resistance to erosion on the bank soils. As the majority of gills and sykes are gullied even at the tops of the fells, they are: (a) not so useful for shooting / grazing interests; (b) better protected from the elements for tree establishment; and (c) potentially easier to prevent livestock / deer gaining access. Willow is ideal as it will tolerate the saturated soils, and can be introduced as whips or stakes cut from established trees elsewhere on the estate. To maintain, dense low growth, some occasional coppicing may be required.

Some specific becks noted earlier in the report had substantially higher peat / silt deposits smothering the bed, and demonstrably poorer invertebrate life and salmonid use. These should be targeted to identify particular problem areas and address using the naturally sensitive methods outlined above.

3.1.2 Lower fells

There is little that can be done in some of the steepest gradient gills, sykes and cloughs. If the water can be slowed sufficiently at the top of the fells (see above), then it may be possible to install some simple log jams on the more accessible stretches (for machinery), especially where bedrock or very large boulders can be used to anchor / wedge limbs or trunks across the becks.

As the gradient reduces though, a combination of leaky dams (in series as before) and more planting of willow and perhaps alder in any of the boggier areas where the becks clearly overspill would be beneficial, especially to encourage meandering of the channel and hence increase the distance the water has to travel. The valley bottom receiving water from Marshaw Fell via Black & Tail Cloughs is a very good example (Fig 31). Spate flow overtops the beck banks and runs straight across the meanders, thereby short-circuiting the beck path. Planting of willow within all the *Juncus* rushes on and within the meander bends will increase resistivity to flow on the floodplain. Again these already boggy areas are of limited use for grazing, and diversifying the bank vegetation benefits both aquatic and terrestrial life.

3.1.3 The lower watercourses (the Wyres, Cam Brook)

Wooded sections of the lower gradient watercourses are generally in reasonable condition, primarily through 'beneficial neglect' – allowing for the natural shaping of the channel (for example, natural tree falls introducing flow diversion and scour and performing natural flood management function), and development of diverse, native, shady riparian cover. Neglect should not be seen as a bad thing as wildlife tends to benefit from it! All of the watercourses d/s will benefit from actions taken to slow the flow from u/s.

The only site that would benefit from some coppicing of existing mature trees is the Tarnbrook Wyre between Tarnbrook and Lower Lee. The channel is heavily incised and hence steep-banked, and the mature canopy is effectively tunnelling the watercourse, excluding light and preventing development of an understory. The banks are almost bare in places and hence susceptible to erosion from spate flows despite being well protected from livestock. A strategic rotational coppicing of some of the more mature trees which have bare banks underneath will generate low regrowth at their bases and allow light for new self-set trees to develop. Diversifying the age of the canopy also benefits wildlife. Brash from all coppicing activities can be used elsewhere for bank protection.

Planting is recommended wherever there has been loss of former tree cover and where there is a lack of low cover and structure along the river margins to break up long expanses of exposed bank. It would be beneficial to include a range of native deciduous species but willow is by far the easiest to transplant and manipulate. *Note that adequate fencing or some means of stock exclusion is vital to protect such measures, as without it, any planting is likely to be browsed by livestock*.

Planting tips - The quickest and easiest way of planting willow is by pushing short sections of willow whip or sections of stake into the ground, using locally sourced material. This can be undertaken at any time of the year, but will have the greatest success if undertaken within the dormant season, shortly before spring growth begins (ideally late Jan-March). Whips should be planted into soft, wet earth/sediment so that there is a greater length within the ground than out of it, *and at a low angle,* to minimise the distance that water has to be transported up the stem; 30-40cm of whip protruding from the ground is sufficient, providing that it receives light past the other bankside vegetation. Live willow stakes can be hammered deep into the bank and may provide greater structural stability under spate conditions. Further advice and support could be sought from The Woodland Trust. See their guidance for 'Keeping rivers cool': http://www.woodlandtrust.org.uk/publications/2016/02/keeping-rivers-cool/

Further information & case studies on slowing the flow from similar environments (Pickering & Sinnington):

http://www.forestry.gov.uk/fr/infd-7yml5r

https://northyorkmoorsnationalpark.wordpress.com/tag/sinnington/

3.2 **Livestock & fencing**

The second most beneficial action across the estate will be to limit livestock access directly to the water's edge. Riparian habitats will function better to slow the flow and be of higher quality to a wide range of wildlife. As noted throughout the report, unfettered livestock access impacts heavily upon bank habitat quality, diversity, stability (loss of land), as well as water quality and community diversity via trampling, grazing, browsing and defecating at focal points such as gateways or feeding troughs placed too close to a waterway.

Existing fencing should be maintained in a state fit-for-purpose. To maximise the benefits of tree planting (above) or bank reparations already undertaken (e.g. Fig 5), it will be necessary to exclude livestock. Key sites to consider are: any that can be set aside for planting to slow the flow; banks that have already succumbed or are susceptible to further land slip; around established vegetation that is in immediate danger of succumbing to further erosion from stock trampling; and along the lower reaches of some of the small spawning tributaries. Examples of all of these are noted earlier in the report.

3.3 **Fish passage issues**

The elephant on the estate is the Abbeystead Dam. As it no longer performs the function it was designed for, in an ideal world, it should be removed as it impedes sediment transport and thereby starves the lower river of gravels and traps fine sediments creating a hot spot of greenhouse gas generation, notably methane, and obviously impedes fish passage in both directions. It is understood that the estate is looking into upgrading the fish pass which is not fit-for-purpose as it stands. The potential spawning area opened up for resident, as well as migratory salmonids is enormous, and would benefit fisheries along the whole length of the Wyre, and probably neighbouring catchments too via straying spawners.

Numerous small weirs and perched culverts were noted either during visits or from maps. While salmonids were present above almost all of them, it does not mean they are passable, and resilience is reduced by fragmenting populations and inhibiting juvenile distribution (both u/s and d/s). Many of the perching issues are caused by excessive spate flow (conveyance) scouring around the exits of hard culvert pipes, associated with an interruption of sediment conveyance that prevents replenishment of the eroded material. If it is necessary to use pipes, they should be of an appropriate bore (as large as possible) and ideally buried to a depth of 1/3 diameter, and of very shallow gradient to allow the retention of a natural substrate throughout. If they require replacing in the near future, then a clear-span (single aperture) option is always preferable; while potentially more expensive initially, they do not tend to block with debris and hence require less ongoing monitoring / maintenance.

Many of the older bridges had aprons of concrete or stone which introduce fluming flow that the majority of fish cannot navigate, even at burst speeds. Installation of low cost baffles to increase depth and provide refugia during transit, or increasing the depth of the pool immediately d/s to drown out the apron can be effective in easing fish passage.

3.4 **Tributaries and spawning habitat**

There was scant evidence of suitable spawning habitat in the main stem Wyre, nor indeed on the mid sections of the Tarnbrook and Marshaw arms; the majority of their lengths comprised gravels, cobbles and boulders in an unsorted matrix. Hence, to maximise the potential of the wild fish populations, maintaining the quality of spawning habitat in the smaller tributaries is of paramount importance. Small tributaries contribute disproportionate benefits to main river systems (partly because their length contributes enormously to the total of the whole network) and because the ratio of marginal habitat to open water is greater.

NB: It is equally important to ensure good access from the mainstem into the tributaries for the ascending adult fish, as well as dispersal of any juveniles, and making sure there is plenty of complex habitat on the edges for the fry and parr to evade predation.

Interventions already mentioned will all improve spawning potential: slowing the flow, planting of low cover, reduction of fine sediment ingress from livestock and land slippage.

3.5 **Pollution**

Diffuse pollution sources from silt and soil ingress were the most apparent across the estate. These may be addressed 'internally' i.e. between the estate and tenants, or immediately reported via the Environment Agency hotline (**0800 80 70 60**).

3.6 **Invasive species**

Himalayan balsam and Japanese knotweed were observed at specific sites and should be relatively easy to eradicate as the estate controls the entire upper catchment. All estate workers should be encouraged to follow simple biosecurity protocols to ensure they are not transporting propagules.

Tom Myerscough has produced detailed information on controlling invasive plants in the Wyre RT publications. WRT are trained and equipped to inoculate Japanese knotweed right up to the water's edge.

4.0 Making it Happen

The WTT may be able to offer further assistance:

- WTT Project Proposal
  - Further to this report, the WTT can devise a more detailed project proposal report. This would usually detail the next steps to take and highlight specific areas for work, with the report forming part of a flood defence consent application.
- WTT Practical Visit
  - Where recipients are in need of assistance to carry out the kind of improvements highlighted in an advisory visit report, there is the possibility of WTT staff conducting a practical visit. This would consist of 1-3 days' work, with a WTT Conservation Officer teaming up with interested parties to demonstrate the habitat enhancement methods described above. The recipient would be asked to contribute only to reasonable travel and subsistence costs of the WTT Officer. This service is in high demand and so may not always be possible.
- WTT Fundraising advice
  - Help and advice on how to raise funds for habitat improvement work can be found on the WTT website - www.wildtrout.org/content/project-funding

The WTT officer responsible for fundraising advice is Denise Ashton: dashton@wildtrout.org

In addition, 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

5.0 Acknowledgement

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6.0 Disclaimer

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