Water Framework Directive Investigation

King Water

Waterbody - GB102076074080

May 2012

1.0 Introduction

This report is the output of site visits undertaken by Gareth Pedley of the Wild Trout Trust to the King Water, Cumbria on 3rd, 23rd and 25th May, 2012. Assessment of the waterbody was undertaken through spot checks carried out in the upper reaches (around RAF Spadeadam base), and walkovers conducted along the rest of the waterbody.

Comments in this report are based on site observations and discussions with Rebecca Chaffer (Eden Rivers Trust Fisheries Scientist). Information was also gathered from Andy Gowans (Environment Agency Fisheries Technical Specialist) and Keith Bell (Sampling and Collection Team – formerly Fisheries).

Normal convention is applied throughout the report with respect to bank identification, i.e. the banks are designated left hand bank (LB) or right hand bank (RB) whilst looking downstream. Location coordinates are given using the Ordnance Survey National Grid Reference system.

2.0 Catchment / Overview

The King Water is a tributary of the River Irthing, which is a lower tributary of the River Eden, lying along the north eastern fringe of the Solway Basin Natural Area.

The solid geology of the Solway Basin largely comprises sandstones and clays laid down in a desert in Triassic times, probably similar to parts of northern Africa today, with seasonal rivers depositing sands and muds. Following sea level rises at the beginning of the Jurassic period, the area was flooded, depositing bluish, fossil-rich clays which are known as the Lias and which are now found as an outlier to the west of Carlisle.

The area was glaciated with ice from the Lake District and the Galloway hills leaving extensive glacial deposits of clays and sands which have largely masked the underlying solid geology. Depositional features that have exerted an influence on the topography of the area include drumlins, elongated hummocks of boulder clay dropped from the base of ice sheets, and ribbons of sands and gravels deposited by sub-glacial streams known as eskers. (www.naturalareas.naturalengland.org.uk/Science/natural/NA_search.asp).

The sediments resulting from erosion of this geology tend to have a high proportion of sand, which influence the composition of the river bed and in-stream habitat. Boulder clays and the light soils also have a significant influence, contributing to fine sediment loading of the watercourse.

The Environment Agency (EA) have assessed the fish populations of this waterbody as being in Moderate status, meaning that electro-fishing survey results revealed lower densities of native fish populations than would be expected. Water Framework Directive (WFD) details regarding the waterbody and its status are shown in the table below.

Parameter	**Status**
OVERALL STATUS	MODERATE
Overall ecology	Moderate
Physico-Chem	High
Temperature	High
Soluble reactive phosphorus	High
pH	High
Dissolved Oxygen	High
Biological elements	Moderate
Phytobenthos	High
Macrophytes	Good
Benthic invertebrates	High
Fish	Moderate
Specific pollutants	High

Copper	High
Zinc	High
Hydromorphology	Good
Morphology	Good
Hydrology	High
Regulatory ammonium	High

3.0 Habitat Assessment

The headwaters of this waterbody (primarily King Water and Caud Beck) lie on the edge of Spadeadam Forest, where large areas adjacent to the watercourse have recently been harvested, leaving the watercourse open, lacking in-channel structure and with little shade (Picture 1). Downstream of the main forestry area the upper sections of this waterbody are subject to unrestricted sheep grazing which has also denuded the banks of trees, shrubs and herbaceous vegetation (Picture 2). This reduces habitat quality, by reducing the availability of suitable refuge and leaves the watercourses susceptible to high temperatures on warm, sunny days.

Enrichment was impacting on the watercourse, even in the upper reaches, as shown by algal growth on the river bed (Picture 2). This may be attributable to the forestry operations adjacent to the watercourse. Some areas are now being replanted with deciduous species which should help to act as a buffer strip for nutrients, but also provide beneficial shade and in time, a source of woody material to the watercourse.

In the headwaters, low flows were observed, typical of small, upland, bog-fed watercourses; when this combined with high summer water temperatures and increased algal growth through nutrient enrichment, significant diurnal fluctuations in dissolved oxygen levels can occur. These may not easily be detectable without continuous monitoring, but can put significant additional stresses on cool water species such as brown trout (*Salmo trutta*).

High algal activity can also lead to significant diurnal fluctuations in pH through the rapid removal of carbon dioxide (CO_2) from the water during photosynthesis and may also be an impact on fish stocks. However, as pH was assessed as being at a “High” status by the Environment Agency waterbody classification it would suggest that this is not a major issue. More Detailed water quality data would be required to better assess the chemical processes that may be impacting upon the waterbody.

The substrate in the upper King Water and tributaries was generally coarse, comprising predominantly cobble and boulders (Picture 1 & 2). There were sufficient areas of finer, 10-40mm gravels suitable for successful trout spawning, but generally less than in comparable catchments. The juvenile habitat would be greatly improved, however, by the presence of more riparian cover.

Picture 1. The result of recent felling operations can be seen in the background.

Picture 2. Open Channel, with little riparian vegetation, typical of the upper King Water and tributaries. Higher than expected algal growth was observed on the bed.

The other major impact on the fish populations of the upper King Water is the presence of a two significant structures, on the Middle Shield Beck (Picture 3) and King Water (Pictures 4). Both of these are associated with the access road to the RAF Spadeadam base and form significant barriers to fish movement, particularly trout. Their size means that by the time flows are sufficient to reduce the head difference and make them passable, water velocities are likely to be towards the upper limit of trout swimming capability.

The barriers are likely to be less of an issue for salmon, due to their greater size and swimming ability and this could in part explain the much higher densities of salmon (*Salmo salar*) than trout above the barrier on the King Water. In addition, the more open nature of the watercourse may be less of an issue to salmon, which tend to rely more heavily upon in-channel cobble and boulder structure for habitat than trout, for which aerial cover is of greater importance.

Immediately downstream of the barrier on the King Water (Picture 4) was the confluence of the Middle Shield Beck. A natural obstruction on the latter Beck prevents its utilisation as a spawning tributary by fish that cannot ascend the weir on the King Water, as may ordinarily occur.

Picture 3. Culvert providing access to Spadeadam base that exacerbates fish passage issues over a significant natural obstruction (NY6170170343). No fish were observed above this point on the Middle Shield Beck.

Picture 4. Weir on the King Water, presumably to protect the upstream Spadeadam access bridge/culvert (NY6180470173). This is a significant barrier to all species, but particularly so for trout and smaller species. While at site a minnow was seen unsuccessfully trying to ascend the structure demonstrating the issue posed for juvenile fish and smaller species.

Immediately downstream of the weir, the King Water descends into a relatively steep narrow section, where the substrate is again cobble and boulder, providing little spawning substrate for trout, or other species that fail to pass the weir.

Picture 5. Coarse cobble and boulder substrate, with little opportunity for trout spawning, immediately downstream of Spadeadam access road.

Further downstream the valley opens slightly and the land use reverts to sheep grazing. Here, beneficial riparian shrubs and vegetation are again absent due to grazing and habitat quality is reduced for trout. From this point downstream, bedrock becomes a significant component of the bed material, with boulders making up the other significant portion (Picture 6). This appears to be a natural consequence of the steep gradient and relatively narrow river valley producing flows that transport finer material further down the system; although, there may be a sediment trapping influence from the weir structure upstream. This area provides lower than optimal spawning opportunities for trout, although small pockets of suitable gravel were present in sheltered areas behind boulders (Picture 7).

In this area, another significant tributary (Trout Beck) enters the King Water, which would potentially provide good spawning and juvenile habitat but an impassable natural waterfall prevents access a short distance upstream from the confluence (Picture 8). Inaccessible tributaries that would ordinarily provide spawning and juvenile habitat must also be taken into account when predicting the densities of trout and salmon expected on the King Water.

Picture 6. Confluence of the King Water and Trout Beck. Around this point the bed is dominated by bed rock and boulders. This section was walked on 03 May and high algal growth was already apparent.

Picture 7. One of the few pockets of gravel available to provide trout spawning substrate. By the nature of these aggregations, being in the lea of boulders and out of the flow they are likely to be sub optimal for egg incubation.

Picture 8. Impassable waterfall on the Middle Shield Beck, which prevents its use as a spawning tributary (NY6062570285).

Further downstream trout habitat quality increases significantly as riparian trees become more prevalent, increasing the level of shading. Shading and in-channel structure increases to a beneficial level. Alder (*Alnus glutinosa*) and ash (*Fraxinus excelsior*) trees provide high quality canopy cover above, and root structure below the water surface. There is also a more readily available supply of woody debris (WD), which becomes a regular feature (Picture 9).

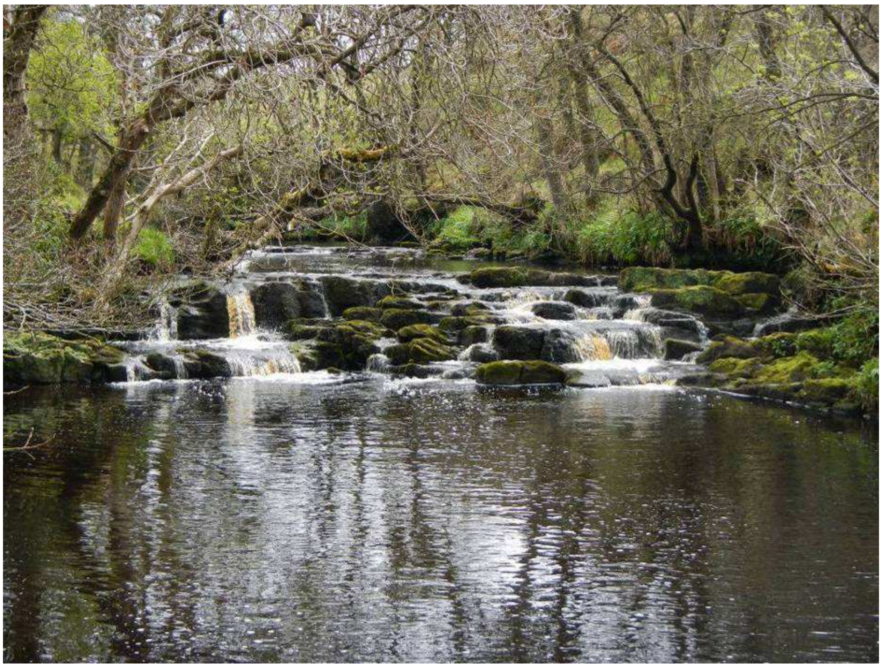
The channel remains heavily influenced by bedrock, with many small chutes and natural falls, most of which are a minimal issue to fish passage. However, the large outcrop over which the High Stead Ash access track crosses forms a significant natural obstruction and behavioural barrier (Picture 10). Another, further downstream, also poses an obstruction to fish movement (Picture 11).

Also within this area is Jamie's Hill Sike, which would be another potential spawning tributary but has no access due to a natural barrier near its confluence with the King Water (NY6031868765).

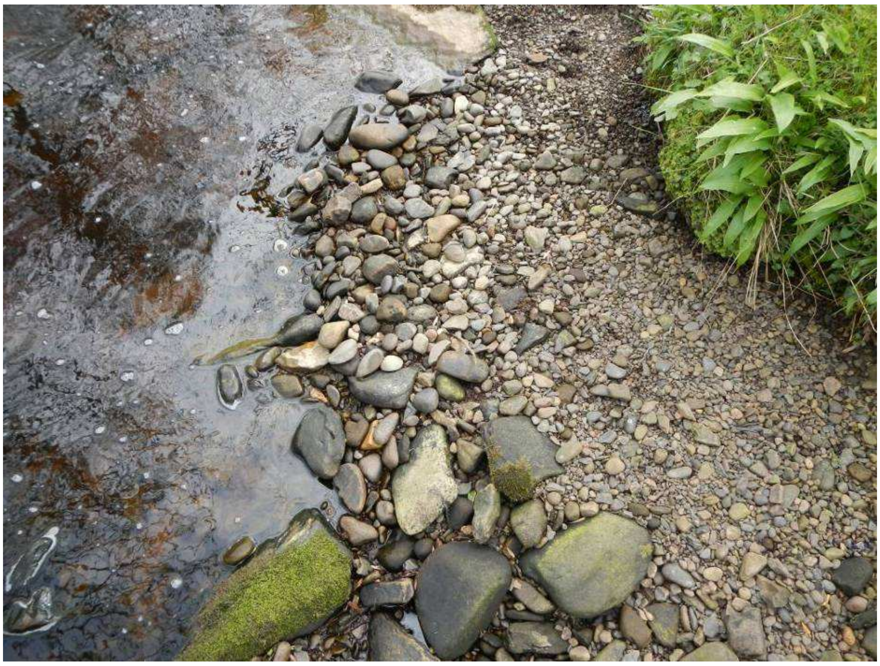
There is a continued lack of spawning gravel throughout this section, which only appears to accumulate in the river margins out of the main flow is likely a result of the naturally constrained channel and relatively steep gradient. The potential impact of forestry drainage increasing the flashiness of spates and low summer flows may also play a part. Where gravel does deposit, it is generally away from the required cleaning flows and in some cases exposed by low flows, so provides little benefit for spawning (Picture 12).

Picture 9. Good quality in-channel habitat provided by root structure, WD and canopy shading.

Picture 10. Bedrock outcrop preventing optimal utilisation of available habitat u/s (NY5986168610).



Picture 11. Medium sized natural rock outcrop (>1.25m) that will inhibit upstream migration of trout and smaller species (NY5869368056).



Picture 12. Grading of bed material, typical of the King Water, with boulders in the main flow, cobbles towards the river margin and gravel only retained in the very edges; in this case becoming exposed by lower flows. This may be a naturally occurring issue due to gradient and geology, but may also be exacerbated by upland land management and drainage around the headwaters. This lack of suitable sized and located spawning substrate creates a significant limiting factor for trout spawning.

Approximately 0.5 km upstream of Kingbridge Ford, the river valley character starts to change, becoming wider and reducing in gradient. The land use in this area also changes, with the level of grazing increasing, and riparian and in-channel cover decreasing. It is from around this point that the first major issues with erosion were encountered (Picture 13). This appeared to have been a result of a land slip on the RB pushing the flow over into the LB, but the grazing of the banks within the buffer fencing in the background will be exacerbating the issue.

Picture 13. The first significant area of bank erosion observed.

Kingbridge Ford bridge footings pose another issue to upstream fish passage, particularly for trout and smaller species. It may be that there is some form of natural barrier underneath, as is often the case with bridge locations, but the situation is certainly exacerbated by the concrete work and bridge footings. Improvements to fish passage have been attempted here, as seen by the dilapidated fish passage structure (Picture 14). This was never of a suitable standard and certainly no longer provides a significant improvement. A replacement fish pass/easement structure is required at this location.

Picture 14. Dilapidated fish pass at Kingbridge Ford (NY5775267462).

Downstream of Kingbridge Ford the quality of habitat was also closely linked to the presence or absence of buffer fencing, with fenced areas supporting a much healthier array of trees, cover and greater bank stability. This was true of the tributaries, which due to the change in valley gradient became more accessible than those upstream. However, two of the tributaries with significant spawning potential were compromised by overgrazing and sedimentation. If the sedimentation issues on both the Mill Beck and Stone Beck could be reduced through buffer fencing to reduce livestock access, the habitat they provide could be more efficiently used for trout and salmon spawning (Pictures 14 & 16). Access over a barrier on the Stone Beck would also need to be addressed for improvements on that tributary to be fully realised (Picture 17).

Picture 15. The Mill Beck, which provides significant potential as a trout spawning tributary if the stock access and sedimentation issues can be addressed (NY5726667160).

Picture 16. The Stone Beck also has potential as a spawning tributary but suffering from livestock access, dredging and a barrier to fish passage created by the B6318 road crossing (Picture 17).

Picture 17. Obstruction on Stone Beck, created by the B6318 road crossing (NY5694767393).

A short distance downstream on the King Water was another significant barrier restricting fish access up the river. The issue is a road ford crossing that is now significantly perched above the river bed, impassable to most species in most flows (Picture 18).

Picture 18. Perched road ford to West Hall, posing a serious obstacle for all species (NY5667667438).

The fields downstream of the West Hall Ford on both the RB and LB suffer erosion issues associated with cattle access and grazing, particularly around NY5653867462. This forms another significant nutrient and sediment input to the river. Major erosion issues are also occurring a short distance further downstream (Pictures 19 & 20), which greatly exacerbate sedimentation of the King Water.

These land slips are in part natural, due to the steep banks and light friable soils, but have potentially been exacerbated by past land drainage activity, leading to saturated areas towards the top of the banks that are susceptible to slumping. Past grazing and gravel extraction may have also played a part, and although the gravel extraction is greatly reduced and stock is now excluded, the legacy of this management remains and the banks will be difficult to stabilise.

Tree planting at the top of the bank may provide a little benefit, but the main issue currently is the fact that the river is now undercutting the bank toe, which greatly reduces the opportunity for slumped materials to stabilise through vegetation.

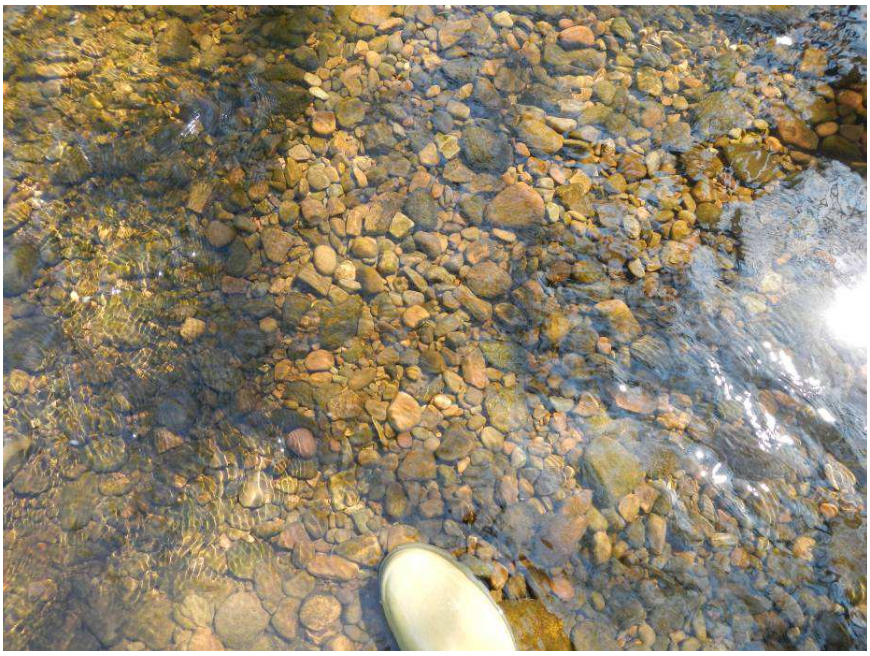
Picture 19. Serious erosion and land slippage that is leading to high sediment loading of the watercourse downstream. In this example the issue is likely to be exacerbated by the historic ridge and furrow land management of the field above concentrating drainage to certain areas.

Picture 20. More typical erosion on smaller banks. still hard to stabilise due to the soil type.

Despite serious erosion issues, high quality trout habitat (particularly for adults) was available, most notably in the areas where livestock are excluded. Due to the sediment and nutrient issues, algae were still very notable and gravels contained high levels of fine sediment (Picture 21).

Picture 21. Algae in the foreground, but high quality adult trout habitat in background.

In the more heavily shaded sections, particularly where flows facilitated a healthy level of gravel sorting, the issues with algae and siltation were greatly reduced. This, coupled with the generally lower gradient of the bottom third of this waterbody and less constrained channel, allows the deposition of suitable trout spawning substrate (Picture 22).



Picture 22. The bottom third of the waterbody was the only section to have regular aggregations of suitable trout spawning substrate.

Livestock access to the river bank is a continuing issue at locations throughout the bottom third of the waterbody, where poaching and overgrazing of the banks is leading to increased erosion. If livestock access is restricted it is very probable that the banks will naturally re-grade and re-vegetate. This process has already started in pictures 23 and 24, but is likely to be reversed when stock are given access to the bank.

Picture 23. Naturally re-grading bank that is likely to consolidate, providing stock access is prevented (NY5396165712).

Picture 24. Unmaintained fence allowing livestock to the riverbank. Poaching damage on the RB is likely to prevent natural bank stabilisation (NY5299464686).

Only one point-source pollution was identified during the walkover and this was towards the bottom of the waterbody. This discharge was considered to be a serious impact on the lower end of the waterbody and water bodies downstream, as shown in picture 25. The discharge appeared to contain high organic content.

Picture 25. Pollution occurring at a flap valve on the lower King Water (NY5256663976).

4.0 Conclusions/summary

The walkover investigations conducted on the King Water have identified a series of issues that are undoubtedly impacting on the resident trout and salmon stocks, but also areas of high quality adult trout habitat.

There are a series of significant barriers, both natural and man-made with poor passability at several locations throughout the waterbody, restricting access to large areas of habitat on the main stem of the King Water and tributaries. This is a particular problem, considering issue when considered in the context that the physical character of much of the middle section of the waterbody is not conducive to the accumulation of salmonid spawning substrate due to the gradient and constrained river valley. The availability of suitable spawning substrate is further restricted by significant sedimentation issues on the King Water and several tributaries that would ordinarily provide spawning and juvenile habitat.

There is also a notable issue with nutrients, which may be a combination effect of the forestry and logging operations in the upper catchment, and land use in the middle and lower, primarily through un-restricted stock access increasing direct nutrient input and bank erosion. It is advised that the discharges from waste water treatment works and along the waterbody are also investigated, as these may also be contributing to the nutrient issues.

Juvenile habitat was of a reasonable quality throughout the watercourse, although there was a significant lack of marginal and aerial cover in the headwaters around RAF Spadeadam. The character of the area there also appeared to leave the watercourses susceptible to low flows. The boulder and cobble habitat of the upper middle section provides an abundance of suitable habitat for 0 and 1+ trout and salmon, providing there is sufficient spawning and recruitment locally.

Along with juvenile habitat, the middle and lower reaches also provide a wide range of high quality trout habitat, as demonstrated by numerous adult trout observed, up to c. 0.85kg, particularly in the area downstream of Kingbridge Ford to the River Irthing. Large numbers of grayling were also observed in the lower 0.5km of the waterbody.

5.0 Recommendations

The following steps should be undertaken in order to progress a restoration project for this waterbody:

- Undertake removal of all major weirs and man-made obstructions or installation of species appropriate easements. These are larger scale projects, potentially requiring large scale rock ramp-type, or more technical fish passes, but could potentially be tackled through partnership working with Eden Rivers Trust (ERT).

Description	**Picture**	**NGR**
Ford on King Water Nr West Hall	18	NY5667667438
Dilapidated fish pass at Kingbridge Ford	14	NY5775267462
Weir at access track to RAF Spadeadam on King Water	4	NY6180470173
Bridge footings on Stone Beck	17	NY5694767393

- Install easements at the minor barriers around RAF Spadeadam and adjacent forestry area. These barriers are all small scale but easements would improve fry and juvenile utilisation of the available habitat. The work could easily be tackled with a partnership project between the EA and ERT.

Description	Picture	NGR
Ford at edge of Spadeadam	26 (Appendix 1)	NY6266172211
Concrete pipe culvert on Spadeadam	27 (Appendix 1)	NY6200670948
Corrugated pipe culvert on land leased by GL Noble Denton	28 (Appendix 2)	NY6093572517
Concrete pipe culvert on Spadeadam	29 (Appendix 2)	NY6042672819

- Investigate the opportunity for reducing sediment input and increasing marginal cover

  There are multiple locations within this waterbody where sedimentation issues could be addressed through buffer fencing to exclude livestock from the riparian zone.

Impact	Description	Picture	NGR	Action
Low	Erosion through stock access on RB	30 (Appendix 3)	NY5992268654	Buffer fencing
Medium	Erosion LB	13	NY5803467779	Increase size of buffer strip and prevent future grazing within strip
Medium	High grazing pressure resulting in a lack of riparian vegetation RB	31 (Appendix 3)	NY5747467247	Install buffer fence
High	Serious siltation of Mill Beck which is a valuable spawning tributary (LB & RB)	15	NY5726667160	Install buffer fencing
High	Serious siltation of Stone Beck which is a valuable spawning tributary (LB & RB)	16	NY5694767393	Install buffer fencing
Medium	Damage to banks through livestock leading to increased erosion (LB and RB)	32 (Appendix 4)	NY5671467363	Install buffer fencing
Medium	Suspected grazing issues, although the	33	NY5535266774	Install buffer fencing and

	field appears to be in silage during the walkover	(Appendix 4)		allow buffer between mowing and banks
Medium	Erosion on LB that could easily be prevented by stock exclusion	23	NY5396165712	Install buffer fencing
Medium	Erosion to LB that is likely to e reduced through reduced grazing pressure	34 (Appendix 5)	NY5385665548	Install buffer fencing
Medium	Unrestricted stock access to both LB and RB leading to serious siltation	24	NY5299464686	Install buffer fencing

In addition, there are several locations, particularly around NY5612167147 and NY5576667104 (Pictures 19 and 20) where a detailed geomorphological survey would be beneficial to fully understand the pressures and measures to address them.

While undertaking the walkover discussion with the landowner Richard Ritson, of Swaites Farm, which encompasses much of the land around the affected are area, indicated that he may be willing to try brash toe protection on some of the lower banks. This treatment may retain enough of the slumped material and protect the bank long enough for it to consolidate and naturally re-grade and form the basis of an experimental project.

- Investigation of pollution source at should be undertaken at NY5256663976.

6.0 Acknowledgement

The Wild Trout Trust would like to thank the Environment Agency for the support which made this visit possible.

Appendix 1

Picture 26 (NY6266172211)

Picture 27 (NY6200670948)

Appendix 2

Picture 28 (NY6093572517)

Picture 29 (NY6042672819)

Appendix 3

Picture 30 (NY5992268654)

Picture 31 (NY5747467247)

Appendix 4

Picture 32 (NY5671467363)

Picture 33 (NY5535266774)

Appendix 5

Picture 34 (NY5385665548)