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Black Water of Dee fisheries and habitat study

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Summary

Black Water of Dee fisheries and habitat study

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Background

The Black Water of Dee is the largest tributary of the Kirkcudbrightshire Dee and was historically known as an important salmon and trout river. When the Galloway Hydro Scheme was constructed a large dam was built across the Black Water of Dee to create Clatteringshaws Reservoir. This dam had no fish pass included in its design and the original legally required compensation water flow in the lower Black Water of Dee was relatively low compared to present day requirements for new hydroelectric developments. One tributary of the Black Water of Dee, the Pullaugh Burn (which flows from Loch Grannoch), was dammed as part of the Galloway Hydro Scheme to divert water into Clatteringshaws Reservoir and away from the natural route of the burn which should join the river just below the Reservoir dam. Diverting this water away from the river, the setting of a low compensation water flow and water quality problems originating from the poor designed surrounding Sitka spruce plantations resulted in the loss of nearly all fish life from the Black Water of Dee downstream of the Reservoir. Following a review of the Controlled Activities Regulation (CAR) licence, Scottish Power agreed to increase the compensation water flow in the Black Water of Dee and re-establish water flow down the lower Pullaugh Burn. Since December 2012, the new and improved compensation water flows have been in operation.

This report focuses on the lower section of the Pullaugh Burn and the Black Water of Dee between Loch Ken and the dam at Clatteringshaws Reservoir. It is important to investigate how the fish populations have reacted to the increased compensation water flow. The study also examined the habitats present along these watercourses and considered whether further improvements to instream habitats, riparian habitats or water flows are required to assist in the recovery of the fish stocks.

Main findings

- Electrofishing in the Pullaugh Burn upstream of the abstraction dam found 'low' numbers of juvenile trout present. Both trout fry and trout parr were present. Although densities were low they were much improved compared to historical figures from a decade ago.
- Two sites were electrofished on the Pullaugh Burn downstream of the abstraction dam. This river channel was largely dried out and was fishless prior to the 2012 improved compensation water agreement. Trout densities at both sites were found to be 'very low' for fry but 'moderate' for parr showing that trout are successfully utilising the available habitat. The very low trout fry densities can be explained by the lack of suitable spawning substrates present downstream of the abstraction dam on the burn.
- The electrofishing found no juvenile salmon at any of the 11 sites surveyed in 2016.
- Juvenile trout (fry and/or parr) were found at all eight Black Water of Dee sites surveyed. Trout parr were absent at only one site and typically were in reasonable numbers at all other sites. Trout fry were absent from two of the sites and typically were found in densities a lot lower than would be expected in watercourses of this size.
- Recent electrofishing undertaken in 2013, 2014 and 2016 consistently shows improvements in trout densities at all Black Water of Dee sites since compensation flows have been increased. Salmon numbers have not shown a similar improvement.
- The improvements in trout numbers following the increased compensation flows suggest that the trout already present are either having a greater recruitment success from spawning due to more suitable instream flow conditions (especially marginal habitat near the bank) or spawning adults are able to access more suitable spawning habitats because the increased flows has improved their ability to migrate upstream to find the limited spawning substrates present. Improved trout densities are likely to be a result of both of these changes.
- To date, salmon have not shown any lasting improvement in numbers or distribution from the changes in compensation flows and this could be due to a lack of spawning habitat and continuing difficulties of upstream access over some instream structures, bedrock areas and waterfalls.
- North American signal crayfish were caught at the lower two electrofishing sites suggesting they are moving up from Loch Ken. The remains of a predated crayfish was found just downstream of Clatteringshaws Dam but no live crayfish were caught when electrofishing nearby.
- Scales were collected from 24 trout parr caught during the electrofishing survey. The results of the scale readings identified the breakpoint between 1+ aged and 2+ aged parr being around 160 mm. Growth rates were as expected for trout in similar waters in Galloway.
- Acidification (low pH) was found to be a concern in the Pullaugh Burn and would be expected to reduce the survival of salmon and trout eggs.
- The Black Water of Dee was found to have a relatively high pH just below Clatteringshaws Dam but when the Pullaugh Burn joins the main river its lower pH causes an overall lowering of the pH in the larger river. As the Black Water of Dee continues downstream the pH increased as more water sources join. Water quality in the Black Water of Dee was considered acceptable for fish survival throughout although there could be impacts on salmon survival where pH is at its lowest.
- Nearly 20 km of the lower Pullaugh Burn and Black Water of Dee were surveyed looking at the instream and riparian habitats present.

- Both the wetted area and suitability of instream habitats to support juvenile salmonids had improved following the increase in compensation water flows.
- Habitat suitable for parr aged salmon and trout dominated all areas surveyed.
- Very few areas suitable for salmonid spawning (especially salmon) were found in the survey. This is due to a distinct lack of smaller sized substrates in the main watercourses due to the dam structures and Clatteringshaws reservoir stopping the natural movement of substrates from further upstream.
- It is recommended that suitable smaller substrates are added to the Black Water of Dee at carefully selected locations where river morphology would, over time, create good spawning habitat for salmon and trout. It should also be explored whether the operation of the Pullaugh Burn dam structure could allow sediment movement through it at certain times.
- The habitat survey identified a number of waterfalls and rock ledges which were considered impassable to upstream migrating fish at base compensation water flows. Fish would only access over these potential barriers during flood conditions which could be impaired by the water abstraction. The release of carefully timed freshets from Clatteringshaws Dam during the autumn months could aid upstream migration of adult spawning fish especially in dry years.
- Conifers (both planted and from natural seeding) were found to be in close proximity of the watercourses along most of the surveyed sections. Many of these trees were considered as being detrimental to the water quality (loss of buffer zone width) and aquatic life (potential overshading which will reduce instream productivity).
- It is recommended that naturally seeded conifers in the riparian zone are removed and discussions undertaken with the Forestry sector regarding how to manage the planned open space (as per best practice). One area was highlighted where numerous mature conifers had fallen into the river and these trees should be removed.
- Many of the riparian zones surveyed contained few deciduous trees. It is recommended that suitable native deciduous trees species are planted to help provide dappled shade and input, over time, woody debris which is an important aquatic habitat.

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Acknowledgements

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1 INTRODUCTION

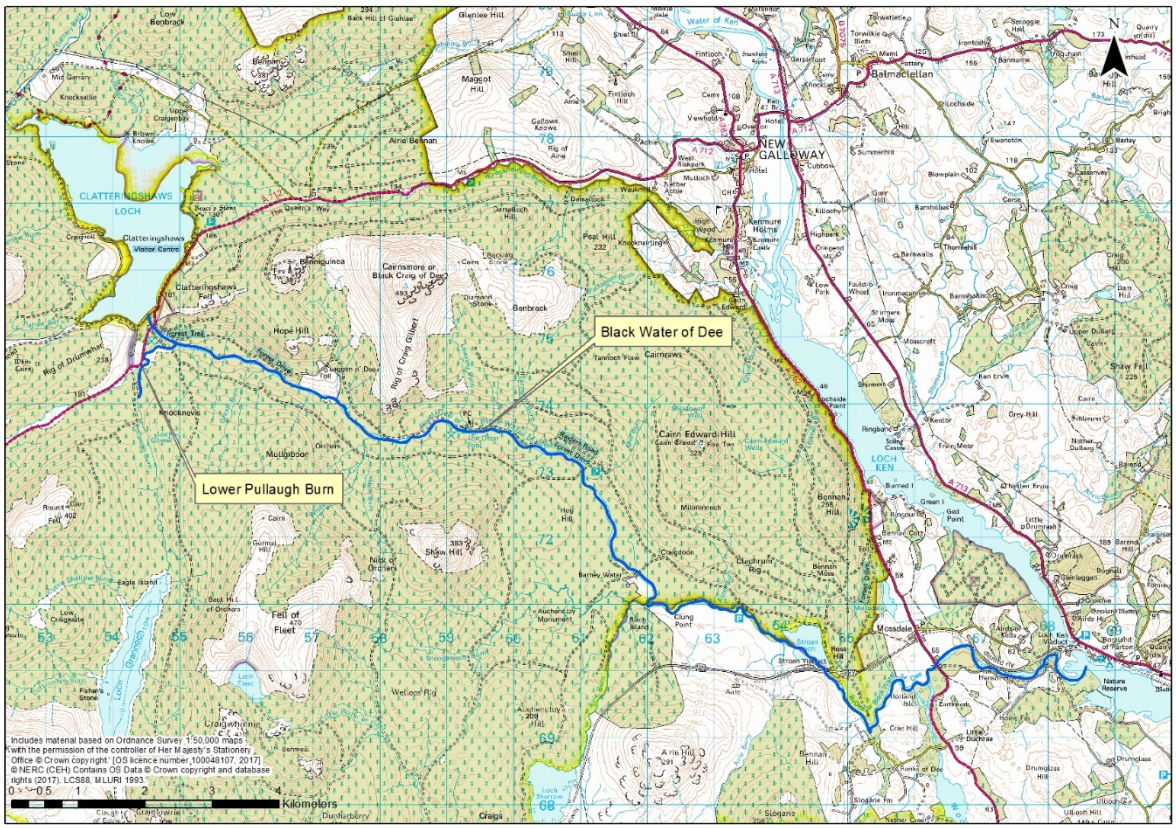
The Black Water of Dee is the largest tributary of the Kirkcudbrightshire Dee and was historically known as an important salmon and trout river. When the Galloway Hydro Scheme was constructed a large dam was built across the Black Water of Dee to create Clatteringshaws Reservoir. This dam had no fish pass included in its design and the original agreed compensation water flow in the lower Black Water of Dee was relatively low compared to present day requirements for new hydro developments. One tributary of the Black Water of Dee, called the Pullaugh Burn (which flows from Loch Grannoch), was dammed as part of the Galloway Hydro Scheme so that water would be diverted into Clatteringshaws Reservoir and away from the natural route of the burn which should join the river just below the Reservoir dam. Diverting this water away from the river, the setting of a low compensation water flow and water quality problems originating from the poorly designed surrounding Sitka spruce plantations, resulted in the loss of nearly all fish life from the Black Water of Dee downstream of the Reservoir. Galloway Fisheries Trust (GFT) electrofishing data collected annually between 1996 and 2012 found a very impoverished fish population with only a few trout and the occasional perch present.

Following detailed discussions between Scottish Power (who operate the Galloway Hydro Scheme), SEPA and other stake holders, a review of the Controlled Activities Regulation (CAR) licence was undertaken for the Black Water of Dee abstraction and impoundment. Scottish Power agreed to increase the water flow in the Black Water of Dee and re-established flow down the lower Pullaugh Burn. Since December 2012, the new and improved compensation water flows have been in operation; at Pullaugh Burn compensation flows have increased from zero to 0.224 m^3/sec and on the Black Water of Dee (at Hensol Weir) from 0.63 m^3/sec to 0.914 m^3/sec.

GFT undertook some monitoring work following the changes to compensation flows and found encouraging results regarding how the fish populations appeared to have responded. Brown trout parr had returned to the lower Pullaugh Burn (which was previously dry) in the summer of 2013. By the summer of 2014, a few trout fry were also caught suggesting that trout have bred successfully in the re-wetted channel.

The conifer planting around these watercourses was originally undertaken close to the water and forest drains ran straight into the watercourses. This ‘old style’ forestry is known to impact negatively on the water quality of surrounding watercourses. The combined impact of poorly buffered geology, acid rain and the scavenging of pollutants by Sitka spruce resulted in surface water acidification across much of the Galloway uplands. The Black Water of Dee catchment had suffered from acidification but appears now to be recovering as overall air quality has improved and the surrounding conifer plantations are felled and replanted to higher environmental standards which includes keeping away from watercourses, improved drainage design and silt control measures.

The report focuses on the lower section of the Pullaugh Burn and the Black Water of Dee between Loch Ken and the dam at Clatteringshaws Reservoir (see Map 1). It is important to investigate how the fish populations have reacted to the increased compensation water flow which started in 2012. The study also examined the habitats present along these watercourses and considered whether further improvements to instream habitats, riparian habitats and water flows are required to assist in the further recovery of the fish stocks.



Map 1: Surveyed length of the Black Water of Dee and Pullaugh Burn

2 AIMS

The aims of this study were as follows:

2.1 Assess the recovery of fish populations within the lower Black Water of Dee and the lower Pullaugh Burn following the addition of increased compensation water flows. The fish populations will be studied through electrofishing surveys and scale reading.

2.2 Undertake a walkover habitat survey of the watercourses described in section 2.1 to assess the suitability of instream habitats to support the recovery of the fish populations and to describe any potential barriers to fish migration which may be present. Water quality will also be examined to ensure it is acceptable for fish survival.

2.3 All the data collected from the surveys will be considered together and recommendations made regarding any further measures required to assist the recovery of fish stocks.

3 METHODOLOGY

3.1 Habitat survey

The fisheries-specific walkover habitat survey aimed to give general information on the current status of the instream and bankside habitats present within the watercourses. A walkover survey, modified from Hendry and Cragg-Hine (1997)[1], was developed and undertaken (see Table 1).

This method of habitat surveying allows for much ground to be covered, giving the maximum amount of information to be gained in the minimum of time. Walkover habitat surveys aim to provide an insight into the status and locations of sensitive spawning gravels and juvenile habitat areas within watercourses.

During surveys, information on substrate type, bank structure and obstructions to fish passage are also recorded. General comments on individual stretches of river are recorded to assist in the rapid overview of the survey area as a whole. A photographic record of the watercourses is collected during the surveys.

The watercourses were surveyed by a GFT surveyor (Anthony Brett). The predominant habitat types were recorded within specific stretches, or at specific grid referenced points, and defined as described in Table 1. The habitats described are not disparate but regarded as definable parts of a spectrum of habitats found in a watercourse. The bankside structure and surrounding land use was also described where appropriate.

Table 1: Hendry and Cragg-Hine habitat classification for walkover survey method

Habitat Type	Classification
Spawning gravel	Stable gravel up to 30 cm deep that is not compacted or contains excessive silt. Substrate size with a diameter of 0.8 to 10.2 cm.
Silted spawning habitat	Stable gravel up to 30 cm deep that is compacted or contains excessive silt. Substrate size with a diameter of 0.8 to 10.2 cm.
Fry habitat	Shallow (<0.2 m) and fast flowing water indicative of riffles and runs with a substrate dominated by gravel (16 – 64 mm) and cobbles (64 – 256 mm).
Parr habitat	Riffle – run habitat that is generally faster and deeper than fry habitat (0.2 – 0.4 m). Substrate consists of gravels (16 – 64 mm), cobbles (64 – 256 mm) and boulder (> 256 mm).
Glides	Smooth laminar flow with little surface turbulence and generally greater than 0.3 m deep.
Pools	No perceptible flow and usually greater than 1 m deep.
Flow constriction	Where physical features provide a narrowing of the channel resulting in increased velocity and depth (often combined with a localised increase in gradient and bedrock substrates).
Obstacles/Obstruction to migration	A structure or item identified as a potential obstruction to fish passage at certain water heights (e.g. impassable falls, weirs, bridge aprons, shallow braided river sections preventing upstream migration during low flows).
<u>Additional Habitat Type</u>	<u>Classification</u>
Mixed juvenile habitat *	A mix of fry and parr habitat, suited to both age classes in combination – the deeper, faster, larger substrate areas used by parr, and the shallower, slower, smaller substrate areas used by fry.

** In addition to the Hendry and Cragg-Hine 'fry habitat' and 'parr habitat' types described above, if significant amounts of fry and parr habitat are found to co-exist and be somewhat amalgamated in the same section, these*

[1] Hendry and Cragg-Hine (1997), Restoration of Riverine Salmon Habitats: A Guidance Manual. Environment Agency Fisheries Technical Manual 4, R&D Technical Report W44 http://www.apemltd.co.uk/wp-content/uploads/2016/08/Restoration-of-Riverine-Salmon-Habitats-A-Guidance-Manual.pdf

habitat classifications are combined and classified as 'mixed juvenile habitat'. Within this report where parr habitat is mentioned this will refer to habitat that has principally been identified as habitat more suited to parr than fry however will habitually contain a lower quantity of fry habitat and habitat which is suited to both fry and parr. The opposite is true for fry habitat.

Problematic bank structures such as areas of severe erosion were recorded, if present. If the reason for the problem is evident then this is highlighted, e.g. over-grazing by cattle causing trampling, erosion and a collapsing bank.

Obstructions are assessed for complete impassability at any flow or for being passable under certain flow conditions. Additional comments are also made as to the nature and permanency of the obstruction, if applicable. Photographs are taken throughout the survey and of all major obstructions.

3.2 Electrofishing surveys

To assess the fish population present within a section of river various techniques have been developed in the recent decades. The main method of determining a fish population is through electrofishing equipment.

This technique of electrofishing involves the 'stunning' of fish using an electric current which enables the operator to remove the fish from the water. Once captured, the fish recover in a holding container. They are then anaesthetised using a specific fish anaesthetic, identified to species, measured and recorded, and once recovered, returned unharmed to the area from which they were captured.

The method of fishing involves the anode operator drawing stunned fish downstream to a net held against the current by another biologist. Captured fish are then transferred to a water-filled recovery container. The fishing team works its way across the survey section and upstream, thereby fishing thoroughly all the water in the chosen survey area.

All electrofishing was undertaken to obtain quantitative information on the fish, primarily juvenile salmonid, and populations within an area of interest. Each survey site was fished through once to enable a minimum estimation of the fish population to be calculated for that section of the river. A Zippin estimation[2] of a fish population was not possible as multiple run fishings were not undertaken. The result provides an estimate of the fish population density per 100 m^2 of water.

After the electrofishing exercise has been completed, a targeted and detailed SFCC habitat survey is completed of the actual fishing site.

For this study, electrofishing was undertaken by three SFCC accredited GFT staff at all survey sites.

It is GFT policy to disinfect all relevant equipment both prior to and following work in each river catchment, to ensure that there is no transfer of disease organisms.

3.2.1 Limitations of electrofishing surveys

The SFCC method of electrofishing was primarily developed to survey juvenile salmonids in relatively shallow running water. Non-salmonid fish species may be present and caught during these surveys but their populations may not be properly determined using this method of electrofishing. Any non-salmonid fish species are therefore counted and measured but no population estimate is made.

[2] Zippin, C. (1958), The Removal Method of Population Estimation Journal of Wildlife Management, 22. Pp 82-90

Electrofishing will never capture all the fish in a survey site so densities presented in this report are a minimum estimate of the juvenile salmonid population residing within the site. The absence of fish cannot be ascertained with certainty using electrofishing techniques so a density of zero does not always guarantee these fish are altogether absent from this section of watercourse.

3.2.2 Electrofishing equipment used

The location of the electrofishing survey sites selected for this study required the use of both a bankside generator powered electrofishing equipment and a mobile backpack electrofishing kit.

The battery powered E-fish backpack electrofishing kit consists of an electronic controller unit with a linked cathode of braided copper (placed instream) and a linked, mobile, single anode, consisting of a pole-mounted stainless steel ring and trigger switch.

The bankside generator apparatus which was used was powered by a 2.2 kW petrol generator (5 horse power) with a variable voltage output (200 – 400 volts) linked to an Electracatch controller unit (model WFC7 – 1a).

Smooth direct current was used in all survey sites.

3.2.3 Non-salmonid fish species

At each survey site the presence of non-salmonid fish species is noted. Population densities for these species are not calculated.

3.2.4 Site measurement

At each survey site a total site length was recorded and average wet and dry widths calculated.

The average wet width is calculated from five or more individual widths recorded at equidistant intervals from the bottom of the site (0 m) to the top. At each site a final width is noted at the absolute upper limit of the surveyed water. From these site measurements the total area fished can be calculated.

3.2.5 Bankside/instream electrofishing site habitat assessment

At each electrofishing site a detailed habitat assessment using SFCC protocol is made of the instream habitat available for older (parr (1++) aged) fish. This assessment grades the cover available to salmonids instream as none, poor, moderate, good or excellent. This grading provides an index of instream cover where diverse substrate compositions will score more favorably than areas of uniform substrate providing lower levels of cover.

In accordance with standard protocols, percentage estimates of depths, substrate type and flow type are made at each electrofishing site. Additionally, percentage estimates of the quantity of the bankside features undercut banks, draped vegetation, bare banks and marginal vegetation are made.

3.3 Age determination of juvenile trout

For this study the electrofishing survey concentrated on assessing the status of juvenile salmonid species, namely salmon (*Salmo salar*) and trout (*Salmo trutta*). In the majority of cases age determination can be made by assessment of the length of fish present. However, with older fish it is more difficult to clarify age classes. In these cases a small number of scale samples were taken from fish, in addition to taking length assessments, to verify the ages of fish.

The reading of the fish scales were undertaken by Bryce Whyte who is a recognised expert in aging fish by this technique. He worked for many years for Marine Scotland Science in Pitlochry at the Freshwater Laboratory.

3.4 Water quality testing

Ensuring that there is adequate water quality for the survival of fish is important in any planned restoration project. The water pH and water temperature of the Pullaugh Burn and Black Water of Dee within the study area was recorded using an EXO1 Sonde. The EXO 1 Multi-parameter water monitoring platform is produced by Xylem Analytics. It has the ability to monitor a number of different factors at one time. Spot sampling was undertaken at four locations on the 8th December 2016, after rainfall had occurred the previous day.

4 RESULTS

4.1 Habitat survey

The habitat survey concentrated on the lower Pullaugh Burn (from the water abstraction dam down to the Black Water of Dee confluence) and the lower Black Water of Dee (from Clatteringshaws Dam down to the Loch Ken). Most photographs are taken facing in an upstream direction.

Habitat characteristics were collected during the walkover survey and are presented below. In addition, recommendations are presented regarding possible enhancement measures to improve instream habitats and riparian habitats for fish. At each habitat characteristic or point of note a GPS reading was taken, a short description of the habitat was noted and a photograph taken of the location.

4.1.1 Pullaugh Burn

The survey commenced at the water abstraction dam on Pullaugh Burn (Figure 1, grid reference NX 254418 574123) and was carried out in a downstream direction from the dam to the confluence where it meets the Black Water of Dee (NX 254966 574881). Overall approximately 1.19 km of the Pullaugh Burn was surveyed with an average wetted channel width of 4 m. In total an area of 4,760 m^2 of water was surveyed.

The habitat survey found that the Pullaugh Burn mainly hosts parr habitat, specifically run-riffle habitat with many small waterfalls over bedrock substrate (Figures 5 and 7). Some of these falls may cause problems for ascending fish travelling up the burn (Figures 7 and 9). Although there are various small sections where mixed juvenile habitat dominates (NX 254599 574778), the majority of the habitat appeared to be most suitable for parr. The substrates present were predominately bedrock and boulders with some small areas of cobbles and gravels. It appears that the increased compensation flow has dramatically improved parr habitat on the lower Pullaugh Burn. There was very little spawning habitat found in the Pullaugh Burn. There were several stretches of the burn which held small amounts of gravel (as seen in Figure 6) and others which had adequate flows for spawning sites however contained no suitable substrate (Figure 8). No clear spawning sites for trout or salmon were found along the burn.

Numerous naturally seeded conifers and conifer plantations are present within 20 m of the watercourse. It would be beneficial to consider cutting down the natural regenerating riparian conifers and conifer plantations close to the water. Due to the scarcity of riparian deciduous trees it would be beneficial to plant some at locations along the burn where conifer felling has occurred. No concerns were found regarding bankside erosion on the Pullaugh Burn, this is possibly due to the short amount of time in which this burn has experienced increased water flows.

Recommendations to improve habitats:

Table 2: Issues faced and recommendations table

Issue faced	Recommended solution(s)
Little spawning habitat as a lack of substrate moving naturally downstream due to dam.	Consider introducing smaller substrates below the dam which in time would create spawning habitat downstream.
Excessive shading and loss of riparian vegetation due to coniferous trees within 20 m of the watercourse. Approximately 700 - 800 m of this section was affected by coniferous trees. Plantations starting at: (NX 254398 574265, NX 254414 57366,	Discuss with Forest Enterprise regarding on-going forestry management to ensure problematic trees will be removed or managed. Remove the individual naturally regenerating conifers (with volunteers or contractors).

NX 254477 574569, and NX 254966 574881).	
Lack of shade and cover as a result of low number of riparian deciduous trees.	Plant deciduous trees where suitable to increase the amount of cover available for fish.
Obstruction to migrating fish via waterfalls and bedrock areas.	Protect level of compensation flow.

Figure 1: Downstream of dam at Pullaugh Burn, start point for habitat survey (NX 254418 574123)

Figure 2: Downstream of dam, parr habitat with boulder and bedrock substrate (NX 254418 574123)

Figure 3: Example of run habitat suitable for parr, visible conifer plantations on both banks (NX 254398 574265)

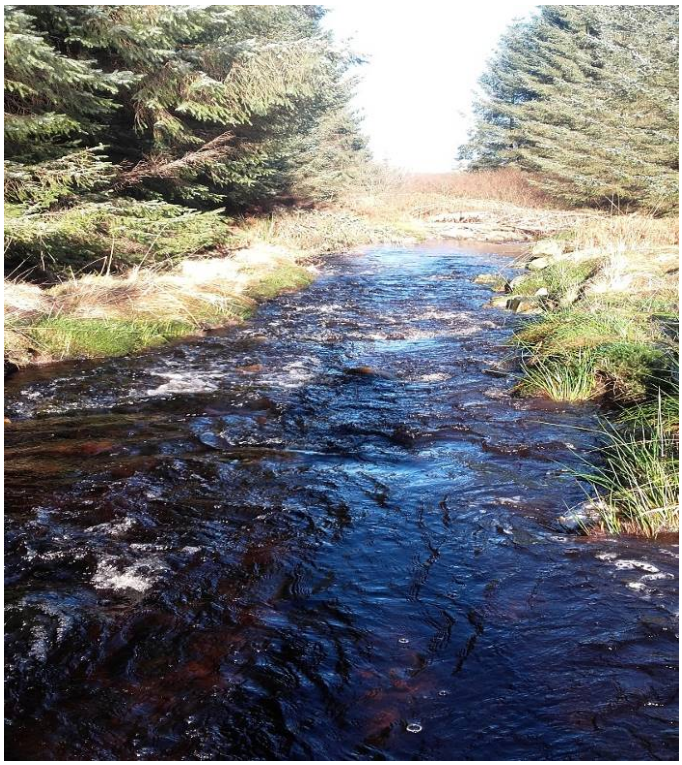


Figure 4: Example of parr habitat found throughout the survey of Pullaugh Burn, run-riffle habitat with large boulder substrate and conifer plantations on both banks

Figure 5: Small waterfalls over bedrock with visible boulder substrate

Figure 6: Mixed juvenile habitat (NX 254599 574778)

Figure 7: Example of small falls seen along Pullaugh Burn (NX 254406 574481)

Figure 8: Areas of suitable spawning flows were found, however they lacked suitable small substrate (NX 25395 574423)

Figure 9: Larger falls seen at the bottom of the Pullaugh Burn, which may be a possible obstruction to fish movement at low water levels (NX 254966 574881)

4.1.2 Clatteringshaws Dam to Nannie Walkers Wa's

This walkover survey of the Black Water of Dee commenced directly below the outflow from Clatteringshaws Dam (NX 254528 575334) (Figure 10). This stretch was surveyed in a downstream direction and ended at the area known as 'Nannie Walkers Wa's' located at NX 255688 574709. The distance surveyed was approximately 1.52 km with an average channel width of 12 m. The overall area surveyed was 18,240 m^2 of river.

The initial flows found were pool and run habitats over a bedrock substrate (Figure 11). This continued for approximately 20 m before becoming glide habitat (Figure 12). The glide habitat continued to dominate until downstream of the A702 road bridge at NX 254712 575083, and from here run habitat started to develop (Figure 14). This section of river was then dominated by riffle-run habitats which characterised this stretch and created good parr habitat throughout (Figures 16 and 17). Bedrock and boulders were the predominant substrates found with very little cobble or gravel recorded. Falls were recorded along this section which may be obstructions to migrating fish at lower flow levels (Figures 14 and 18). Very little definite salmonid spawning habitat or fry habitat was identified however some areas were recorded which contained good flows and gradient but lacked smaller substrate (NX 755495 574744). The flows observed however were good in most areas resulting from the compensation flow now released from Pullaugh Burn and Clatteringshaws Dam. This has directly led to the abundance of parr habitat.

Conifer plantations and naturally seeded conifers were abundant along this section (Figures 17, 18 and 19). At grid reference (NX 254994 574899) windblown conifers were also found lying across the river (Figure 20) and these should be removed. Bankside erosion was not observed along this section of river.

Recommendations to improve habitats:

Table 3: Issues faced and recommendations table

Issue faced	Recommended solution(s)
Little spawning habitat due to a lack of substrate moving naturally downstream due to Clatteringshaws Dam.	Consider introducing smaller substrates below the dam which in time would create spawning habitat downstream.
Excessive shading and loss of riparian vegetation due to coniferous trees within 20 m of the watercourse. This entire stretch was affected negatively by conifers.	Discuss with Forest Enterprise regarding on-going forestry management to ensure problematic trees will be removed or managed. Remove the individual naturally regenerating conifers (with volunteers or contractors).
Lack of shade and cover as a result of low number of riparian deciduous trees.	Plant deciduous trees where suitable to increase the amount of cover available for fish.
Obstruction to migrating fish via waterfalls and bedrock areas.	Protect level of compensation flow.
Windblown conifers lying across the river at NX 254994 574899.	Remove fallen trees.

Figure 10: The Black Water of Dee at Clatteringshaws Dam facing downstream (NX 254528 575334)

Figure 11: Pool/fall habitat below Clatteringshaws Dam

Figure 12: Glide habitat found downstream of Clatteringshaws Dam (NX 254583 575249)

Figure 13: Directly under road bridge downstream of Clatteringshaws dam, glide habitat predominant

Figure 14: Directly downstream of road bridge at NX 254635 575176, obstruction of upstream migration due to bedrock falls

Figure 15: Run habitat beginning to develop, bedrock and boulder substrate visible (NX 254712 575083)

Figure 16: Example of run habitat seen throughout this section with large substrate

Figure 17: Conifer plantations can be seen close to the bank, a common occurrence along this stretch of river

Figure 18: Difficult falls for ascending fish at (NX 255369 574769) with conifer plantations in the background

Figure 19: Area of glide found at the bottom of this stretch of river with conifer plantation and naturally regenerated conifers visible (NX 255688 574709)

Figure 20: Windblown conifers lying across the Black Water of Dee (NX 254994 574899)

Figure 21: Good potential site for juvenile habitat however no small substrate was present, and flows are good (NX 255495 574744)

4.1.3 Nannie Walkers Wa's to Holly Island

This section commenced at NX 255917 574654 on the Black Water of Dee and was surveyed in a downstream direction until Holly island was reached at NX 258205 573432. The overall length of this section was recorded as 3 km with an average wetted channel width of 10 m. Therefore the estimated total area of river surveyed in this section was 30,000 m^2.

This section of the Black Water of Dee was again dominated by parr habitat, mainly consisting of run-riffle habitats with large substrate (Figures 22, 23, 25 and 26). Small waterfall sections were also recorded along the surveyed section (Figures 23, 28 and 29). The most abundant substrates recorded were boulder and bedrock with a few areas containing small amounts of cobbles and gravels. The smaller substrate was very limited in area and was spread out throughout the section surveyed (Figure 24). The source of the smaller sized substrate was the various smaller tributaries. The areas of gravels were the first, i.e. most upstream, to be recorded during the survey of the Black Water of Dee.

Very little habitat suitable for spawning by salmonids was recorded within this section of river. Although some areas appeared to have suitable flows for spawning purposes (Figure 27), there was an overall lack of gravels and small substrates limiting its suitability. This area close to Holly Island (NX 258205 573432) consisted mainly of falls and pool habitat (Figures 29 and 30) with bedrock recorded as the predominant substrate. Some of these falls may cause an obstruction to migrating fish during usual compensation water flows in dry weather. The lack of water depth immediately below these bedrock falls make passage through them difficult for fish during lower flows. It was found that the recent increased flow of compensation water has created an abundance of parr habitat along this section of the Black Water of Dee.

Conifer plantations were a concern throughout this section of river. For almost the entire length of this section conifer were within 20 m of the right bankside. The left bankside however contained several open treeless areas (grid ref NX 256834 574244, NX 257407 574005, NX 257065 574138) which may be suitable for riparian deciduous tree planting in order to create shading and cover for fish. Natural seeding of conifers was seen to be quite prevalent throughout this section (for example at NX 256118 574605) and should be addressed in the future via the recommendations made below in Table 4.

Recommendations to improve habitats:

Table 4: Issues faced and recommendations table

Issue faced	Recommended solution(s)
Little spawning habitat present due to a lack of substrate moving naturally downstream at Clatteringshaws Dam.	Consider introducing smaller substrates below the dam which in time would create spawning habitat downstream.
Excessive shading and loss of riparian vegetation due to coniferous trees within 20 m of the watercourse. This entire 3 km stretch was negatively affected by coniferous trees.	Discuss with Forest Enterprise regarding on-going forestry management to ensure problematic trees will be removed or managed. Remove the individual naturally regenerating conifers (with volunteers or contractors).
Lack of shade and cover as a result of low number of riparian deciduous trees.	Plant deciduous trees where suitable to increase the amount of cover available for fish.
Obstruction to migrating fish via waterfalls and bedrock areas.	Protect level of compensation flow.

Figure 22: Example of run habitat with large substrate, conifer plantation also visible on the right bankside (NX 255917 574654)

Figure 23: Bedrock falls at (NX 256118 574605) which make migrating upstream difficult for fish

Figure 24: Gravel sections observed at (NX 256336 574486), these may be very important areas as suitable spawning substrate was seen to be lacking overall

Figure 25: Example of the parr habitat with large substrate and conifer plantations that were found to be predominant features throughout this section (NX 256497 574414)

Figure 26: Parr habitat with conifer plantation and naturally re-generating conifer on the right bank (NX 257065 574138)

Figure 27: Example of flows and gradient suitable for fry or spawning habitat but with a distinct lack of small substrate present (NX 257801 573563)

Figure 28: Waterfall with large substrate found at (NX 257065 574138) which may be problematic to migrating fish under usual flows

Figure 29: Bedrock substrate with stepped falls, this may be an issue for migrating fish. Also note the conifer plantation seen close to the bankside (NX 258205 573432)

Figure 30: Bedrock area with small falls which may be an obstruction to fish migration (NX 258205 573432)

4.1.4 Holly Island to Ford

This section commenced at NX 258258 573432 and was undertaken in a downstream direction until ending at the Ford found at NX 261059 573012. The total length of the section surveyed was 3.08 km with an average channel width of 12 m. Therefore 36,960 m^2 of river was surveyed here.

This section of the Black Water of Dee contained a range of habitat types. Although parr habitat is predominant over the entirety of this section, a combination of parr habitat, mixed juvenile habitat, glide and bedrock falls were recorded. Also along with the boulder and bedrock substrates that have been predominant in the sections upstream, there were areas where cobbles are predominant within this stretch.

At the beginning of this section parr habitat was recorded with run-riffle habitat, large substrates of boulder and bedrock with some natural regeneration of conifers on the right bankside (Figure 31). Downstream there was a small area with suitable fry habitat and spawning habitat, however this area consisted of a mostly bedrock substrate (Figure 32). Therefore, although there were suitable water depths, gradient and flows the overall lack of small substrate still limited its usefulness as fry and spawning habitat (Figure 32). Run-riffle parr habitat continued downstream after this (Figures 33 and 34) with conifer plantations and natural regeneration of conifers featuring heavily in the riparian areas. Glide habitat was then predominant (Figure 35) prior to reaching the 'Otter Pool' (Figures 36 and 37). The 'Otter Pool' section of this stretch consisted mainly of bedrock substrate with many falls and shallow run-riffle flows which are causing an obstruction to migrating fish during usual water flows (Figure 36). Specifically the bedrock falls found at the grid reference NX 259491 573583 appeared to be impassable to migrating fish at base flow (Figure 37). Adequate water flows are required in order to ensure fish migration can occur unimpeded so spawning fish can access habitat upstream.

Downstream of the 'Otter Pool', the habitat returns again to run-riffle parr habitat (Figure 39) with several inflowing burns adding some gravel and other small substrates (Figure 38). These substrate rich burns would be expected to play an important role in the Black Water of Dee's salmonid reproduction, especially trout. They appear to be the most suitable spawning sites within this section of the river and are providing small amounts of gravel to the river itself. A predominantly cobble rich parr habitat was seen at NX 260300 573364 (Figure 40). This was the first section observed throughout this entire survey which contained cobble as the dominant substrate. This may be a direct result of the nearby burn (NX 260323 573374) which was found to contain a considerable amount of smaller substrate (Figure 41). Downstream from here, dense conifer plantation was present on both banks with riffle-run habitat (Figure 42) before reaching a waterfall with a bedrock substrate at NX 260604 573268 (Figure 43). At the water flows present on the day of the survey it was considered that fish would have difficulty accessing over the falls.

The next section of this stretch mainly consisted of mixed habitat with cobble and boulder substrate with a conifer plantation along the left bank (Figure 44). This area may have potential as fry habitat due to the suitable flows and gradient however it is again lacking in smaller substrates (Figure 45). Finally the end point of this survey section was at the ford at NX 261059 573012. This area contained mixed habitat with cobble and boulder substrate, better suited to parr (Figure 46).

Recommendations to improve habitats:

Table 5: Issues faced and recommendations table

Issue faced	Recommended solution(s)
Little spawning habitat due to a lack of substrate moving naturally downstream of Clatteringshaws Dam.	Consider introducing smaller substrates just below the dam which in time would create spawning habitat downstream.
Excessive shading and loss of riparian vegetation due to coniferous trees within 20 m of the watercourse. At least 2.5 km of this stretch was affected by coniferous plantations and naturally seeded conifers.	Discuss with Forest Enterprise regarding on-going forestry management to ensure problematic trees will be removed or managed. Remove the individual naturally regenerating conifers (with volunteers or contractors).
Lack of shade and cover as a result of low number of riparian deciduous trees.	Plant deciduous trees where suitable to increase the amount of cover available for fish.

Obstruction to migrating fish via waterfalls and bedrock areas (specifically at otter pool section).	Protect level of compensation flow and release targeted freshets.

Figure 31: Start of survey, large substrate with run-riffle parr habitat. Naturally re-generating conifers seen on right bank (NX 258258 573432)

Figure 32: Great flows, gradient and depths for fry habitat and spawning habitat but flowing over bedrock substrate (NX 258381 573451)

Figure 33: Parr habitat with large substrate, riffle-runs and conifer plantations on both banksides (NX 258565 573494), some deciduous trees can also be seen

Figure 34: Parr habitat with boulder and cobble substrate, both conifer plantations and naturally regenerating conifers can be seen here (NX 259018 573715)

Figure 35: Glide habitat found at NX 259360 573571 stretching down to the 'Otter Pool' area

Figure 36: Bedrock falls section found at the 'Otter Pool' area (NX 259441 573576). This will be an obstruction to migrating fish at usual flows as water was very shallow over the bedrock outcrops

Figure 37: Obstruction to fish migration found at the Otter pool, these bedrock falls appear to be impassable in base flow (NX 259491 573583)

Figure 38: Example of gravel filled burns which flow into the river, these should be important areas for trout spawning (NX 259702 573645)

Figure 39: Return to parr habitat downstream of 'Otter Pool' area, large substrate with natural regeneration of conifers on right bank (NX 259825 573587)

Figure 40: Parr habitat found with a cobble and boulder substrate (NX 260300 573364)

Figure 41: Another example of gravel filled burns which flow into the river which may be important areas of trout spawning and gravel addition into the main river (NX 260323 573374)

Figure 42: Riffle-run area enclosed by conifer plantations on both banks at (NX 260427 573317)

Figure 43: Difficult falls for fish access found at (NX 260604 573268), falls are quite steep with a bedrock substrate

Figure 44: Mixed habitat of run-riffle with boulder and cobble substrate. Conifer plantation on the left bank, right bank may be suitable to future deciduous planting (NX 260738 573261)

Figure 45: Example of run-riffle habitat found at (NX 260779 573256) which seems to have potential for being fry habitat however contains very little small substrate

Figure 46: End point at 'ford', mixed habitat with cobble and boulder substrate at (NX 261059 573012)

4.1.5 Ford to Stroan Loch

This walkover survey commenced at NX 261239 572731 and was undertaken in a downstream direction until Stroan Loch was reached (Figure 62). The total length of the section surveyed was 4.99 km with and average wetted channel width of approximately 20 m. Therefore the total estimated area of river surveyed was 99,800 m^2 in this section.

This section of the Black Water of Dee was quite variable in nature with several different types of habitat and substrate recorded prior to reaching Stroan Loch. The section hosted a mixture of parr, fry and glide habitats with a range of substrates including boulders, cobbles, pebbles and gravels. Initially parr habitat and boulder substrate were predominant downstream of the Ford along with a

conifer plantation on the left bankside and some naturally regenerating conifers on the right bank (Figure 47). However downstream a section of mixed habitat was recorded at NX 261109 572788. On the day of the survey here the water flows and substrates present provided suitable fry habitat (Figure 48). Downstream parr habitat was once again the dominant habitat type recorded (Figure 49). Boulder and cobbles were recorded as the predominant substrates and conifers were also noted a being prevalent along the left bankside. The right bankside was an open treeless area possibly suitable for riparian deciduous planting (Figure 49). An area of glide was reached downstream from here with an open treeless section on the left bank suitable for riparian deciduous planting (Figure 50).

A section of potential spawning habitat and fry habitat was present 40 m downstream of the glide area seen in Figure 50. The predominant substrate found was generally smaller than previously seen within the river with cobbles being present in large amounts (Figures 51, 52 and 53). Gravels were found here in their highest abundance recorded so far throughout this habitat survey. The shallow flowing riffles and smaller substrates present appeared to create the most suitable spawning site discovered to date along the Black Water of Dee (NX 261476 572219). The estimated area of spawning habitat was 400 m^2 approximately. A conifer plantation was very close on the right bank here.

Downstream there was a section of mixed habitat with predominantly cobble substrate, with boulders and gravels present in smaller amounts (Figure 54). Conifer plantations were found to be within 20 m of both banks (NX 261535 572083). Glide habitat subsequently dominated downstream (Figure 55). At NX 261477 571899 several windblown conifers were found lying across the river (Figure 56), these trees should be removed from the riverbed. It was noted that the river widened considerably along this stretch (Figure 57) prior to reaching Barney Bridge at NX 261870 571460 (Figure 58). Barney Bridge was mainly parr habitat with boulder and bedrock substrate along with deep run-riffle above the bridge (Figure 58). Bedrock run-riffle was found to be predominant downstream of the bridge. The river then becomes dominated by glide habitat for approximately 3 km until reaching Stroan Loch (Figures 59 and 61). Conifer plantations were found along both banks at various areas throughout this 3 km stretch with some conifers windblown into the river at NX 262429 570552 (Figure 60). The river widens considerably to approximately 30 m within this stretch before flowing into Stroan Loch (Figure 62).

No obstructions to fish migration were recorded within this section of the Black Water of Dee. Planting riparian deciduous trees would be beneficial at various areas along this section where there is a lack of shade and cover for fish. Suitable areas are found at the grid references NX 261372 572528, NX 261534 571763 and NX 262036 571346.

Recommendations to improve habitats:

Table 6: Issues faced and recommendations table

Issue faced	Recommended solution(s)
Excessive shading and loss of riparian vegetation due to coniferous trees within 20 m of the watercourse. 3 - 4 km of this section was negatively affected by coniferous trees.	Discuss with Forest Enterprise regarding on-going forestry management to ensure problematic trees will be removed or managed. Remove the individual naturally regenerating conifers (with volunteers or contractors).
Lack of shade and cover as a result of low number of riparian deciduous trees.	Plant deciduous trees where suitable to increase the amount of cover available for fish.

Figure 47: Parr habitat found directly below the ford with boulder substrate, conifer plantation on the left bank and natural regeneration of conifers on the right bank (NX 261093 572933)

Figure 48: Good mixed habitat section with fry habitat nearby, conifer plantation can also be seen in the background (NX 261109 572788)

Figure 49: Example of the parr habitat found within this section with boulder and cobble substrate and naturally regenerating conifers. Suitable area on the right bank for deciduous tree planting (NX 261168 572774)

Figure 50: Glide habitat found at NX 261372 572528, conifer plantation is clearly seen on the right bank within 20 m of the bankside

Figure 51: Shallow flows over cobble and gravel substrate at (NX 261476 572219), suitable spawning site and fry habitat. Conifer plantation can be seen close to right bank in background

Figure 52: Shallow flows over cobble and gravel substrate at (NX 261476 572219), suitable spawning site and fry habitat

Figure 53: Shallow flows over cobble and gravel substrate at (NX 261476 572219), suitable spawning site and fry habitat

Figure 54: Mixed habitat section with conifer plantations recorded on both banks (NX 261535 572083)

Figure 55: A return to glide habitat with a conifer plantation visible on the right bank (NX 261535 572083)

Figure 56: Example of fallen conifers at NX 261477 571899, this should be addressed

Figure 57: River widens considerably with glide habitat (NX 261534 571763)

Figure 58: Picture of the upstream view from Barney bridge, parr habitat was found to dominate this area with a mix of deciduous and coniferous trees on both banks (NX 261870 571460)

Figure 59: Glide habitat found downstream of Barney Bridge at NX 262036 571346

Figure 60: Windblown conifers found lying in the river at NX 262429 570552

Figure 61: Deep glide section at 'Bodens island', conifer plantation on the left bank (NX 263485 570907)

Figure 62: Stroan Loch

4.1.6 Stroan Loch to Hensol Bridge

The banks of Stroan Loch were not surveyed and the walkover survey commenced at NX 264701 569972 and undertaken in a downstream direction until Hensol Bridge at NX 266364 570073. The total length of the section surveyed was 2.83 km with an average channel width of approximately 12 m. Therefore a total area of 33,960 m^2 was surveyed within this section of the Black Water of Dee.

Overall predominantly contained parr habitat with various falls and glide sections recorded throughout the walkover. Bedrock and boulder substrates were prevalent throughout with this stretch which was generally lacking in small substrates.

At the beginning of this section run-riffle and glide habitats were found downstream of the bridge at NX 264701 569972 (Figures 63 and 64). Numerous deciduous trees were present on the banks with bedrock and boulder the dominant substrate. An area of bedrock falls was recorded immediately downstream at NX 264769 569885, this section of falls may be an obstruction to fish migrating upstream, under normal flows, to Stroan Loch (Figures 65 and 66). Naturally regenerating conifers were also found (Figures 64 and 66). Downstream there was a return to parr habitat with boulder substrate and a mix of run-riffle with some glide habitat (Figures 67, 68 and 69). Deciduous trees became quite abundant at this section and can be clearly seen in Figures 67, 68, 69 and 70.

Parr habitat continued downstream with a mix of run-riffle and glide being recorded. Mixed habitat was recorded at NX 265401 569310 with run-riffle flows and boulder and cobble substrate (Figure 70). A section of bedrock and boulder falls was then recorded at NX 265577 569596. These falls did not appear to cause a definite obstruction to fish moving upstream, however they occurred in a series of steps (seen in Figure 71) which may make migration difficult for fish. Once again riparian deciduous trees were plentiful on the right-hand bank (Figure 71), the left bank was found to be relatively treeless and could be a suitable location for deciduous planting. A glide section located downstream had treeless banks on both sides (Figure 72).

Parr habitat continued to dominate downstream with smaller sections of mixed habitat also found at several locations (see Figure 73). A large natural falls was located at NX 265996 569811, which appeared to be an obstruction to fish migration at low and medium flows (Figures 74 and 75). Its boulder and bedrock substrate along with its steep gradient will be difficult to migrate through (Figure 74). Below these falls there was an area of run-riffle with cobble and boulder substrate with the potential to be suitable fry habitat. There was however a lack of small substrate recorded here so it will be better suited to parr (Figure 76). Riparian deciduous trees were plentiful on the right bankside.

Downstream of Hensol Bridge consisted mainly of cobble and boulder dominant run-riffle areas which would provide good mixed habitat if smaller substrate was present (Figure 77). Hensol Bridge was reached at NX 266364 570073, glide habitat was recorded upstream of the weir (Figure 78). This weir appears to alter the natural flow regime of the river and therefore its impact should be investigated as even small barriers like this can have significant impacts on many aspects of river ecology. An abundance of deciduous trees can be seen on the right bank in Figure 78 which was seen to be a common feature of this overall section.

Recommendations to improve habitat:

Table 7: Issues faced and recommendations table

Issue faced	Recommended solution(s)
Little spawning habitat as a lack of substrate moving naturally downstream due to Clatteringshaws Dam.	Consider introducing smaller substrates just below the dam which in time would create spawning habitat downstream.
Excessive shading and loss of riparian vegetation due to coniferous trees within 20 m of the watercourse. Approximately 1 km of this stretch was negatively affected by coniferous trees.	Discuss with Forest Enterprise regarding on-going forestry management to ensure problematic trees will be removed or managed. Remove the individual naturally regenerating conifers (with volunteers or contractors).
Lack of shade and cover as a result of low number of riparian deciduous trees.	Plant deciduous trees where suitable to increase the amount of cover available for fish.

Obstruction to migrating fish via waterfalls and bedrock areas.	Protect level of compensation flow. Hensol Weir itself should be investigated in order to determine what affect it may have on the river ecology.

Figure 63: Start of survey at the bottom of Stroan Loch (NX 264701 569972)

Figure 64: Parr habitat area with boulder substrate and riparian deciduous trees and naturally regenerating conifers (NX 264701 569972)

Figure 65: Falls section with bedrock and boulder substrate, this may cause an obstruction to fish migration under normal compensation flows (NX 264769 569885)

Figure 66: Another view of the falls section from Figure 65, some naturally regenerating conifers are visible along with the bedrock substrate (NX 264769 569885)

Figure 67: Glide section with some run habitat found at NX 264769 569885, both riparian deciduous trees and conifers can be seen here. The right bank may be suitable for further riparian deciduous planting

Figure 68: Parr habitat with boulder substrate and riparian deciduous trees on the left bank, the right bank was relatively treeless and may be a suitable site for future planting (NX 264881 569764)

Figure 69: Glide section at NX 265039 569468, riparian deciduous trees were numerous along this section

Figure 70: Mixed habitat with cobble and boulder substrate, riparian deciduous trees were abundant on the right bank (NX 265401 569310)

Figure 71: Small bedrock falls at NX 265577 569596, the stepped nature of these falls may make upstream migration difficult in normal flows

Figure 72: Glide section with a treeless left bank (NX 265628 569718)

Figure 73: Area of mixed habitat with boulder and cobble substrate, treeless banks were found here indicating that it may be a suitable site for planting deciduous trees (NX 265796 569853)

Figure 74: Steep bedrock falls at NX 265996 569811, these appear to cause a possible obstruction to migrating fish under normal compensation flows

Figure 75: Steep falls from Figure 74, an abundance of riparian deciduous trees can be seen here (NX 265996 569811)

Figure 76: Run-riffle habitat with cobble and some boulder substrate, deciduous trees were abundant on the right bank with the left bank found to be treeless. This site has the potential to be good fry habitat if smaller substrate were more abundant (NX 266163 569826)

Figure 77: Run-riffle habitat with cobble and boulder substrate, this site has potential to be good fry habitat if smaller substrate were present (NX 266181 569942)

Figure 78: Hensol Weir located at NX 266364 570073, glide habitat was recorded upstream. The impact of this weir on fish migration and sediment transport should be investigated

4.1.7 Hensol Bridge to Loch Ken

This final section commenced at NX 266364 570073 and was undertaken in a downstream direction until Loch Ken was reached. The total length of this section surveyed was 2.97 km with an average channel width of approximately 12 m. Therefore a total area of 35,640 m^2 was surveyed within this lower section of the Black Water of Dee. Overall this section consisted mainly of glide habitat with some small areas of run-riffle parr habitat (Figure 79), mixed habitat (Figure 81) and bedrock falls (Figures 82 and 84).

Downstream from Hensol weir initially was run-riffle parr habitat with boulder substrate and lots of riparian deciduous cover along both banks (Figure 79). This developed into glide habitat (Figure

80) and continued until a mixed habitat area was found at NX 266723 570375 (Figure 81). The substrate was predominantly cobble with boulder, pebbles and gravels found in smaller amounts. There were numerous deciduous trees on the right bank which provide excellent shade and cover during the summer months (Figure 81).

A small bedrock falls was found just downstream of Figure 81 (Figure 82), it was not considered an obstruction to migrating fish at the current compensation flow. Glide habitat resumed downstream from here (Figure 83) with numerous deciduous trees on both banks. Another set of bedrock falls were found at grid reference NX 268043 570171, these were found to be more difficult to pass at the current base flow and may difficult to migrating fish under the baseline flows (Figure 84). The habitat returned to deep glide downstream from here (Figure 86) and continued until reaching Loch Ken.

No conifer plantations or many seeded conifers were recorded within this section. Riparian deciduous trees were found to be abundant and would provide good cover and shade for fish. No sites were recorded as potential spawning habitats with glide habitat and large substrates common.

Recommendations to improve habitat:

Table 8: Issues faced and recommendations table

Issue faced	Recommended solution(s)
Little spawning habitat due to a lack of substrate moving naturally downstream due to Clatteringshaws Dam.	Consider introducing smaller substrates just below the dam which in time would create spawning habitat downstream.
Obstruction to migrating fish via waterfalls and bedrock areas.	Protect level of compensation flow.

Figure 79: Parr habitat found just downstream of Hensol Bridge at NX 266364 570073. Riparian deciduous trees were abundant on both banks

Figure 80: Deep glide habitat found at NX 266471 570179

Figure 81: Mixed juvenile habitat area at (NX 266723 570375). Cobble, boulder, pebble and gravel substrates were all found here

Figure 82: Small bedrock and boulder falls found just downstream of Figure 81

Figure 83: Area of deep glide found at (NX 267956 570076). Numerous deciduous trees were present on both banks

Figure 84: Bedrock falls found at NX 268043 570171.

Figure 85: Small falls with bedrock and boulder substrate. Deciduous trees were numerous on both banks (NX 268061 570199)

Figure 86: Deep glide that was found at the bottom of the Black Water of Dee (NX 268187 570121) which continued until it reached Loch Ken

4.2 Electrofishing surveys

The results of the electrofishing survey are outlined in this section and presented in detail in Appendix 1, which provides information on the population densities of juvenile salmonids at each survey sit. Site code, watercourse, site location, O.S. Grid reference, survey date, non-salmonid species and area fished (m^2) are also shown in Appendix 1.

With regard to the juvenile salmonid age classes, these are separated into two categories, which are defined in Table 9. No categories are provided for juvenile salmon as none were found during the 2016 electrofishing survey.

Table 9: Salmonid age classifications referred to in this report

Trout Fry (0+):	refers to young fish less than one year old resulting from spawning at the end of 2015
Trout Parr (1+ and older, (1++)):	refers to young fish of greater than one year and greater than two years old (where present) from spawning in 2014 or previously. Trout of up to three or four years old are also included in this category

Along with classifying salmonids into age brackets within the electrofishing results, juvenile salmonid numbers recorded have also been classified into several 'density' categories. A classification scheme for densities of salmonids was previously generated by the SFCC using data collected from 1,638 Scottish electrofishing survey sites covering the period 1997 to 2002 (SFCC, 2006[3]). From this, regional figures were created to allow more accurate local 'density ranges'. The categories referred to in this report are based on quintile ranges for one-run electrofishing events in the Solway region (Solway Salmon Fishery Statistical Region) allowing densities of salmonids observed to be put into regional contexts.

The juvenile salmonid density classification scheme (SFCC, 2006) is based solely on data from surveyed sites containing fish in 1997 to 2002 and refers to regional conditions at that time; it must

[3] Godfrey, J. D. (2006), Site Condition Monitoring of Atlantic Salmon SACs: Report by the SFCC to Scottish Natural Heritage, Contract F02AC608 http://www.gov.scot/resource/doc/295194/0096508.pdf

only be used as a very relative guide and not be used to draw conclusions. The figures for juvenile trout also included (some surveyed populations of trout which were isolated but sea trout contributing to stock in some areas too). Table 10 shows these quintile ranges for the Solway region.

Table 10: Quintile ranges for juvenile salmonids (per 100 m^2 of water) based on one-run electrofishing events, calculated on densities >0 over 291 sites in the Solway Statistical Region

	Salmon 0+	Salmon 1++	Trout 0+	Trout 1++
Minimum (Very Low)	0.22	0.38	0.38	0.35
20th Percentile (Low)	5.21	2.86	4.14	2.27
40th Percentile (Moderate)	12.68	5.87	12.09	4.71
60th Percentile (High)	25.28	9.12	26.63	8.25
80th Percentile (Very High)	46.53	15.03	56.49	16.28

Electrofishing and habitat information for all electrofishing survey sites surveyed is discussed in Section 4.2.2.

4.2.1 Electrofishing results (see Appendix 1 for tabulated results)

- Site BWD1: Grid reference: 254841 574988

Salmon fry and parr were absent at this site. Trout fry were absent and trout parr, in low density (4.17 per 100 m^2 of water). No non-salmonid species were recorded.

- Site PB1 (Pullaugh Burn): Grid reference: 254399 573931

Salmon fry and parr were absent. Trout fry were present in a low density (7.68 per 100 m^2 of water) alongside a low density (3.07 per 100 m^2 of water) of trout parr. No non-salmonid fish species were recorded.

- Site PB2 (Pullaugh Burn): Grid reference: 254404 574193

Salmon fry and parr were absent at this site. Trout fry were in very low densities (1.33 per 100 m^2 of water) but trout parr were found in moderate densities (5.33 per 100 m^2 of water). No non-salmonid fish species were recorded.

- Site PB3 (Pullaugh Burn): Grid reference: 254890 574804

Salmon fry and parr were absent at this site. Trout fry were recorded in a very low density (2.33 per 100 m^2 of water), whereas trout parr were found to be moderate (6.99 per 100 m^2 of water). No non-salmonid species were recorded.

- Site BWD2: Grid reference: 256536 574368

Salmon fry and parr were absent at this site. Trout fry were present at a low density (9.78 per 100 m^2 of water) and trout parr were recorded in a low density (3.26 per 100 m^2 of water). No non-salmonid species were recorded.

- Site BWD3: Grid reference: 258509 573491

Salmon fry and parr were absent at this site. Trout fry were found at a low density (4.83 per 100 m^2 of water) and trout parr were present in a low density (2.9 per 100 m^2 of water). No non-salmonid species were recorded.

- Site BWD4: Grid reference: 261059 573004

Salmon fry and parr were absent at this site. Trout fry were found at a very low density (3.22 per 100 m^2 of water) and so were trout parr (2.42 per 100 m^2 of water). No non-salmonid species were recorded.

- Site BWD5 Grid reference: 261877 571443

Salmon fry and parr were absent at this site. Trout fry were found at a low density (9.17 per 100 m^2 of water) and trout parr densities were at moderate levels (7.34 per 100 m^2 of water).

- Site BWD6 Grid reference: 264887 569744

Salmon fry, salmon parr and trout fry were absent at this site. Trout parr were found at a low density (3.43 per 100 m^2 of water). No non-salmonid species were recorded.

- Site BWD7 Grid reference: 265371 569192

Salmon fry and parr were absent at this site. Trout fry were found in only very low densities (2.92 per 100 m^2 of water) and trout parr in low densities (2.92 per 100 m^2 of water). A single large NAS Crayfish was also caught in site.

- Site BWD8 Grid reference: 266077 569843

Salmon fry, salmon parr and trout parr were absent at this site. Trout fry were only found in very low densities (2.18 per 100 m^2 of water). Within the site a total of 9 NAS Crayfish were also caught. A few minnows were also present in site.

4.3 Age determination of juvenile trout

The results from the scale reading are outlined in this section and are presented in detail in Appendix 2 which provides information on each fish giving its length, age, date of sampling and site code.

Scales from 24 trout were collected. Only trout over one year old were sampled i.e. parr.

A clear break point in length was identified between trout aged just over a year (1+) which will have originated from spawning in 2014 and trout aged just over two years (2+) which will have originated from spawning in 2013.

Sixteen trout were aged as 1+ which ranged from 105 mm to 156 mm. Eight trout were aged as 2+ which ranged in length from 167 mm up to 198 mm.

4.4 Water quality testing

The results from the water quality testing are outlined in this section and are presented in detail in Appendix 3, which provides information on the grid reference, pH and water temperature at four sites (three on the Black Water of Dee and one on the Pullaugh Burn).

The most upstream site on the Black Water of Dee was just downstream of the Clatteringshaws Dam (site 1). The recorded pH was 6.41 (the highest figure of the sites sampled) and water temperature was 5.68 ºC. This water temperature was the lowest figure recorded from the four sites and presumably is due to the dam compensation flow coming from deep water in the reservoir.

The Pullaugh Burn (site 2) originates from Loch Grannoch which is known to suffer from acidification. The pH of the burn was 5.03 (the most acidified of the four sites sampled) and a water temperature of 7.65 ºC (the warmest of the four sites surveyed).

The next site (moving downstream) was site 3 on the Black Water of Dee near Holly Island. Here the pH was 5.4 and the water temperature 7.42 ºC.

The most downstream site on the Black Water of Dee was site 4, near Boddon's Island upstream of Loch Stroan. Here the pH had increased again (compared to site 3) and 5.98 and the water temperature 7.22 ºC.

5 DISCUSSION

5.1 Habitat survey

The habitat survey was undertaken over approximately 1.19 km of the lower Pullaugh Burn (downstream of the abstraction dam) and 18.4 km of the Black Water of Dee (between Clatteringshaws Reservoir and Loch Ken). All of the areas surveyed were downstream of Galloway Hydro Scheme dams. Neither of these dams contained fish passes.

The surveys were undertaken during periods of dry weather when water flows in the Black Water of Dee and lower Pullaugh Burn were slightly above agreed compensation flows (as recorded at Pullaugh Burn abstraction dam and Hensol Weir on the Black Water of Dee).

The survey highlighted that instream habitats were heavily dominated by habitat conditions suited for parr (salmon and trout aged at least a year old). The increased compensation water flow now present has improved the suitability of instream habitats for fish by increasing the velocity of flows and the overall wetted habitat. In particular the lower Pullaugh Burn was rewetted between the abstraction dam and the Black Water of Dee. This 1190 m of the burn now provides suitable habitat for parr aged salmonids and reconnects the burn back to the river allowing upstream fish migration to the dam again.

The habitat survey found that although suitable gradients, water flows and river morphology were present to form salmonid spawning beds this was not occurring due to a lack of suitable smaller sized substrates present within the river system. Since the Clatteringshaws Dam was built the natural downstream movement of substrates will have been stopped from the river upstream due to them becoming deposited in the reservoir even though smaller substrates could potentially travel through the valve in the dam. Over time, as the smaller substrates below the dam continue to be washed downstream but not replenished, the spawning habitats will be lost. The survey found some limited input of smaller substrates from various inflowing side tributaries but only on a small scale. The severe shortage of suitable spawning habitats and fry habitat will be limiting both salmon and trout populations in the lower Pullaugh Burn and surveyed section of the Black Water of Dee. It is recommended that suitable smaller sized substrate is added into the waters surveyed to replace the lost material which used to travel downstream from where the dam is now located.

The water flows present during the survey (which were above the minimum compensation flow requirements) resulted in various potential fish barriers in the river being impassable for upstream salmonid migration usually due to insufficient water depths, particularly at the Otter Pool which water flows were very shallow over bed rock ledges. During increased flows after rainfall the river should be higher and thus these potential fish barriers more accessible for fish although the water abstraction undertaken by the Galloway Hydro Scheme will curb many of the small and medium floods. These findings suggest that the present compensation flows should be treated as minimum flows required in the river and consideration should be given to the release of carefully timed freshets (increased flows) in the autumn to aid upstream migration of salmon and trout.

With regard to the riparian corridor of the surveyed sections there was a concern with the proximity of the bankside conifers. Conifers were present close to the water along most of the surveyed areas. These were a mix of plantations (various ages) and natural regeneration and are a lot closer to the edge of the water than stipulated in the Forest and Water Guidelines. It is important to have an adequate buffer zone on river banks otherwise overshading will occur which reduces instream productivity, reduces food availability for fish and erosion may occur. Water quality can also deteriorate if adequate open space and riparian zones are not present with both siltation and acidification a concern.

It is important that management of the conifers in the riparian zone takes place, particularly Sitka spruce, to adhere to best practice and legal requirements. This will require the removal of conifers.

Where mature conifers are present and will be retained for at least another three years then high coppicing of the lower branches can help to address overshading and increase buffer zones.

The survey identified an area downstream of Clatteringshaws Dam where numerous conifer trees had blown over and into the river. These windblown trees should be removed as the high number of them have the potential to cause problems of blocking fish access, causing erosion, damage to downstream bridges, etc.

The survey also identified that only low numbers of riparian deciduous trees were present along most of the area looked at. It is recommended that native deciduous trees are planted along the river banks to improve habitats, increase instream productivity, input woody debris, increase food availability for fish and help to address concerns regarding future rises in water temperatures.

5.2 Electrofishing surveys

Electrofishing surveys were completed at three sites on the Pullaugh Burn and eight sites on the Black Water of Dee.

The Pullaugh Burn was surveyed upstream of the water abstraction dam (Site PB1). Low densities of trout fry and parr were recorded. This site has been regularly surveyed in the past as part of the Acid Monitoring Network when it was unusual to find any trout at this site.

Disappointingly no juvenile salmon were found at any of the Black Water of Dee electrofishing sites even though instream habitats are suitable to support them especially since the compensation flows were increased. The lack of salmon can be explained by the lack of suitable spawning substrate and possible problems migrating upstream if insufficient water flow was present over the potential barriers identified in the habitat survey. Historical GFT electrofishing did find a low wild salmon population present at site 8 in 2013. Apart from this record, GFT electrofishing surveys have only found a single juvenile wild salmon present in the Black Water of Dee since starting electrofishing in 1996.

Trout data was more encouraging. Although the densities found ranged from 'very low' to 'moderate' they were present at all of the sites surveyed. Trout aged 0+, 1+ and 2+ were found at most sites. Only one site did not contain trout parr. Trout fry densities were lower than expected. Trout densities were lower than the habitat could support which is likely to be due to limited spawning and fry habitat due to a lack of smaller spawning substrates.

An examination of historical electrofishing data for Black Water of Dee (between Loch Ken and Clatteringshaws Dam) showed that the first electrofishing survey in 1996 which surveyed five sites reported no trout fry in any of them. Two of these sites contained no trout parr either and only single trout at two of the other sites. The trout parr densities found now are considerably higher than those found during the 1996 surveys and trout fry are now present in the river.

Electrofishing in 2004 found similar results to the 1996 survey with only the occasional trout recorded at the various sites which were surveyed. A site near the A712 was fish less.

Low numbers of trout continued to be recorded in 2012 when a survey close to site BWD4 finding only three trout in over 150 m^2 water electrofished which gave a density of 1.8 total trout per 100 m^2 of water.

Electrofishing in 2013 and 2014, which was after the compensation water flow had increased, found improving densities of juvenile trout (particularly trout fry) at all of the sites surveyed similar to the 2016 results. The trout reacted very quickly to the increased flows suggesting that the trout already present are either having a greater recruitment success from spawning due to more suitable instream flow conditions (especially marginal habitat near the bank) or spawning adults are able to

access more suitable spawning habitats because the increased flows has improved their ability to migrate upstream to find the limited spawning substrates present. Improved trout densities are likely to be a result of both of these changes. To date, salmon have not shown any lasting improvement in numbers or distribution from the changes in compensation flows and this could be due to a lack of spawning habitat and continuing difficulties for upstream access.

Few non-salmonid fish species were caught during the electrofishing survey, only minnows at the lowest site. Disappointedly North American signal crayfish were caught at the lower two electrofishing sites suggesting they are moving up from Loch Ken. Only a few individuals were seen. The remains of a crayfish was found just downstream of Clatteringshaws Dam which had been left by a predator but no live crayfish were caught when electrofishing was undertaken nearby.

5.3 Age determination of juvenile trout

The scale reading identified the breakpoint for trout between 1+ aged parr and 2+ aged parr being around 160 mm. No trout older than two years (2+) were caught in this survey probably due to older and larger trout residing in deeper water than could be surveyed with the equipment used. Growth rates were consistent with those found typically in trout populations across Galloway in similar waters and were not found to vary significantly between the survey sites. This suggests food availability for trout was similar and adequate in all of the sites electrofished.

5.4 Water quality testing

Ensuring that there is adequate water quality for the survival of fish is important. Acidification is known to have been an issue in parts of the upper Black Water of Dee catchment historically with trout populations being impacted in Loch Grannoch and Loch Dee, although both of these waters have recovered in recent years. It was important to look at the pH of the water, particularly during flood events when pH is at its lowest, to ensure it could support breeding populations of salmon and trout. These fish species are known to be particularly sensitive to low pH and the water chemistry conditions it creates.

In literature it is widely reported that if pH levels fall below pH 5 consistently then salmonid populations will find it difficult to reproduce successfully.

The spot sampling undertaken (after a rainfall event) found a surprising high pH figure just below Clatteringshaws Dam of 6.41 (site 1). The pH would be expected to be more stable here due to the influence of the reservoir leveling out the variability typically found in running water. The next sampling point on the Black Water of Dee (site 3) was near Holly Island. Here the pH had dropped to 5.4 which will be the direct influence of the inflowing Pullaugh Burn which water sampling found was acidic with a pH of 5.03. As the Black Water of Dee continues to flow downstream this acid water continues to be diluted with water entering from other sources as the pH was found to rise to 5.98.

These pH recordings suggest that salmonids should be able to breed successfully in most of the main river length looked at in this survey, although the Pullaugh Burn does push down pH recordings where it enters the main river which may be problematic for salmon. The Pullaugh Burn was found to be right on the cusp of having a pH which would impact on fish breeding success. Electrofishing finds low numbers of trout fry in the burn so some successful spawning must be occurring but it is considered too acidified for salmon survival.

When water is released as compensation flow from Clatteringshaws Dam it will rise the pH of the Black Water of Dee downstream resulting in more favorable conditions for fish survival.

Although variations in water temperatures are less of an overall concern than acidification, it was decided that it would be beneficial to investigate briefly whether Clatteringshaws Dam was having a significant impact on river temperatures. Water temperatures strongly influence fish behavior

particularly at spawning time and the development and hatching of eggs. Of the four sites checked the site just below the dam had the lowest water temperature at 5.68 ºC, presumably due to the compensation flow coming from the bottom of the reservoir. The Pullaugh Burn (site 2) had a water temperature of 7.65 ºC which was the warmest of the four sites surveyed and will have helped to raise the temperature downstream. The downstream sites (sites 3 and 4) on the Black Water of Dee had increased water temperatures again to 7.42 ºC and 7.22 ºC, compared to just below the dam. It is not considered that the dam is affecting water temperatures over much of the Black Water of Dee and is thus not a concern.

APPENDIX 1: RESULTS FROM THE ELECTROFISHING SURVEY, 2016

Site Code	Watercourse	Site Location	Grid Ref	Survey Date	Presence Of Other Species	Area Fished (m^2)	Density per 100 m^2 *			
							Salmon Fry (0+)	Salmon Parr (1+ and older)	Trout Fry (0+)	Trout Parr (1+ and older)
BWD1	Black Water of Dee	Downstream of A712 road bridge	254841 574988	29/08	None	96	0	0	0	4.17
PB1	Pullaugh Burn	Upstream of abstraction dam	254399 573931	29/08	None	65.1	0	0	7.68	3.07
PB2	Pullaugh Burn	Downstream of abstraction dam	254404 574193	29/08	None	75	0	0	1.33	5.33
PB3	Pullaugh Burn	Downstream of forestry road bridge	254890 574804	29/08	None	42.9	0	0	2.33	6.99
BWD2	Black Water of Dee	Beside circular walkway	256536 574368	01/09	None	92	0	0	9.78	3.26
BWD3	Black Water of Dee	Near Holly Island	258509 573491	01/09	None	207	0	0	4.83	2.9
BWD4	Black Water of Dee	At old ford	261059 573004	02/09	None	124.1	0	0	3.22	2.42
BWD5	Black Water of Dee	Downstream of bridge near Barney Water	261877 571443	24/10	None	109	0	0	9.17	7.34
BWD6	Black Water of Dee	Downstream of Stroan Loch	264887 569744	24/10	None	145.9	0	0	0	3.43
BWD7	Black Water of Dee	At the end of forestry track	265371 569192	24/10	AS Crayfish	102.9	0	0	2.92	2.92
BWD8	Black Water of Dee	Tail of pool, upstream of Hensol weir	266077 569843	24/10	AS Crayfish, Minnow	275	0	0	2.18	0

* The numbers presented are a minimum estimate of fish density per 100 m^2 of water surface.

APPENDIX 2: BROWN TROUT AGES DETERMINED BY SCALE READING

Fish length	Fish age	Date sampled	Electrofishing site
105	1+	24/10/16	BWD5
117	1+	24/10/16	BWD5
120	1+	02/09/16	BWD4
123	1+	01/09/16	BWD3
128	1+	24/10/16	BWD7
136	1+	24/10/16	BWD5
136	1+	29/08/16	PB3
139	1+	24/10/16	BWD6
140	1+	01/09/16	BWD3
142	1+	29/08/16	PB2
145	1+	01/09/16	BWD2
150	1+	24/10/16	BWD7
152	1+	24/10/16	BWD5
153	1+	24/10/16	BWD5
155	1+	24/10/16	BWD6
156	1+	29/08/16	PB1
167	2+	02/09/16	BWD4
172	2+	29/08/16	BWD3
174	2+	29/08/16	PB2
176	2+	29/08/16	PB3
179	2+	01/09/16	BWD2
182	2+	24/10/16	BWD6
193	2+	29/08/16	PB3
198	2+	02/09/16	BWD4

APPENDIX 3: WATER QUALITY DATA (SAMPLED ON 8/12/16)

Sample site	Grid reference	pH	Water temperature (ºC)
1. Black Water of Dee (downstream of Clatteringshaws Dam)	254610 575200	6.41	5.68
2. Pullaugh Burn (downstream of abstraction dam)	254404 574193	5.03	7.65
3. Black Water of Dee (upstream Loch Stroan near Holly Island)	258509 573491	5.40	7.42
4. Black Water of Dee (upstream Loch Stroan near Boddon's Island)	263500 570845	5.98	7.22