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Galloway Fisheries Trust / Peatland Action annual water quality monitoring report 2023/2024 – Bladnoch Catchment

For further information on this report please contact:

Name of GFT Project Manager – K Galt
Galloway Fisheries Trust
Fisheries House
Station Industrial Estate
Newton Stewart
DG8 6ND
Telephone: 01671 403011
E-mail: kenny@gallowayfisheriestrust.org

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Summary

Annual water quality monitoring report on behalf of Peatland Action – Bladnoch catchment

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Keywords

Peat; Peatland Restoration; EXO1 Sonde; Brown trout; Atlantic salmon; River Bladnoch; Tarf Water; Water Quality, pH; acidification

Galloway Fisheries Trust (GFT) have been actively involved with encouraging and supporting peatland restoration in Southwest Scotland. GFT's main interest in this work is associated with the potential water quality benefits from peatland restoration, particularly to help address acidification problems and restore impacted fish populations. In November 2019, Peatland Action (PA) agreed to fund an annual water quality monitoring program monitoring peatland restoration sites within the Galloway region under the guidance of Emily Taylor, Galloway's local Peatland Action Peatland Officer.

The Bladnoch catchment water quality monitoring during winter 2023/2024 was essentially split into two interconnected projects. The first was a continuation of the water quality monitoring in the Dargoal Burn as part of the Tannylaggie Flow peatland restoration monitoring, which aims to record the extent of the potential for improvements in water quality resulting from peatland restoration within an acidified watercourse. Tannylaggie Flow is an area of deep basin peat in the upper Bladnoch catchment (within the Polbae Burn sub-catchment). A large percentage of the Polbae Burn sub-catchment was historically drained and converted to commercial forestry, typically dominated by Sitka spruce, covering most of the Tannylaggie Flow peatland. The Dargoal Burn flows through Tannylaggie Flow and is the destination for many of the drainage ditches within. The Dargoal Burn flows into the Polbae Burn, itself a major headwater tributary of the upper Bladnoch and forms part of the River Bladnoch SAC. As a result of historic acidic pollutants in the atmosphere, industrial scale drainage and dense conifer planting the Dargoal Burn has become one of the most acidified watercourses within Galloway and frequently experiences pH levels that are lethal to fish (regularly below pH 4 as previously shown by GFT/PA water quality monitoring). The resulting degraded water quality extends downstream for a considerable distance impacting both the Polbae Burn and the River Bladnoch, and therefore the River Bladnoch SAC. As part of the latest plan for the management of Tannylaggie Forest areas of deep peat at Tannylaggie Flow and some surrounding areas have been highlighted for peatland restoration. As the felling of mature conifer plantations is staggered some areas are still covered in mature conifer's and will not be considered for restoration until the trees are removed. However, extensive areas have been felled and are ready for peatland restoration. Restoration commenced in a section of land adjacent to the Dargoal Burn in early 2023, with just under 10% of the target areas being restored as of winter 2023/2024. Restoration techniques included stump flipping, ground smoothing and ditch blocking. Water quality was recorded from the Dargoal Burn using EX01 Sondes which collect data at 15-minute intervals. Parameters recorded include pH, Dissolved Oxygen (DO), depth, conductivity and Fluorescent Dissolved Organic Matter

(fDOM), the latter two being a representative measure of peatland erosion. Water quality monitoring to date has picked up no obvious improvement within the Dargoal Burn. However, this is to be expected at this early stage due to the time scale since restoration took place and the area restored.

The second was a catchment wide review of the electrofishing data held by GFT and a catchment scale water quality overview to record the extent of acidification within the upper catchment and the contribution of degraded peatlands. Given the sensitivity of salmon and trout to low pH during sensitive periods of development the aim of the electrofishing review was to look at the current distribution and density of trout and salmon, to see if there were any areas where fish numbers showed signs of being impacted by poor water quality and to see if there were any changes in fish numbers over time that would indicate improving or declining conditions. The water quality overview focused primarily on pH and combined constant water quality monitoring (at 15 min intervals) from chosen locations with catchment wide spot sampling, which involved collecting water samples from around the Bladnoch catchment during low pH flushes and analysing the samples in the office. Again, EX01 Sondes were used to record water quality and the parameters recorded were pH, DO, depth, conductivity and fDOM.

The electrofishing review and general water quality monitoring for the Bladnoch catchment allowed spatial variations in water quality to be mapped and provided detailed water quality data from central points in both upper catchments. The River Bladnoch has seen some recovery from historic acidification. However, recovery is slow with some areas showing little or no recovery in fish populations. As a result, native fish populations, and therefore the Bladnoch SAC, are significantly impacted where acidification persists. Where acidification persists, there is generally an association with deep peat and commercial forestry. The 2023/2024 water quality monitoring has allowed four main areas to be identified as being particularly problematic and having a significant impact on aquatic ecosystems. The first is the Polbae Burn sub-catchment within the upper Bladnoch, and Tannylaggie Flow in particular. The whole area appears particularly sensitive to acidification, and it is hoped the on-going Forestry and Land Scotland de-forestation, and peatland restoration can go a long way to addressing current water quality issues. The second is Kilquhockadale Flow which is essentially the same area of peatland (basin peat) as Tannylaggie Flow but is called Kilquhockadale Flow on the South end. It is largely afforested with commercial trees. Some of the burns flowing South from Kilquhockadale Flow are causing localised issues within the Black Burn (Bladnoch tributary). The third is Moss of the Horse Hill, an area of afforested deep peat located within Artfield Forest in the upper Tarf Water. The Tarf Water has experienced a faster recovery from acidification than the upper Bladnoch. However, acidification persists within upper Artfield Forest causing water quality issues that appear to stem from the Moss of the Horse Hill peatlands. The fourth area is Mark of Luce Moss, an afforested area of basin peat within the lower Tarf Water sub-catchment, which is causing localised water quality issues within the burns that drain it.

Main findings/recommendations

- There is no obvious recovery in water quality within the Dargoal Burn at the current stage of peatland restoration. This is not unexpected at such an early stage. As such long-term monitoring is required if the full benefits are to be recorded.

- The results from the peatland restoration monitoring, combined with the results from the Bladnoch water quality overview provides data that can be fed into FLS Tannylaggie peatland restoration plans and GFT/Crichton Carbon Centre and SEPA should meet with FLS to discuss the water quality monitoring results.

- As a result of the Bladnoch Catchment Electrofishing and Water Quality overview it has been possible to identify the name/locations of the areas of degraded peat/commercial forestry that have the biggest impact on water quality. They have been prioritised as the following:

    1. Tannylaggie Flow and surrounding deep peat – the restoration of the deep basin peat at Tannylaggie has already been identified as a priority for restoring water quality in the upper Bladnoch. However, while Tannylaggie Flow is the main source of reduced water quality the watercourses neighbouring Tannylaggie Flow are also impacted, all of which also contribute to the poor water within the Polbae Burn which extends downstream into the River Bladnoch (both part of the Bladnoch SAC). Whilst the restoration of the basin peat at Tannylaggie Flow should continue to be the priority extending the peatland restoration into any surrounding areas of deep peat where commercial trees have been felled will all help contribute to improving the water quality if possible.
    2. Whilst the Tarf Water is generally less impacted by acidification than the upper Bladnoch it does still have acidification issues. Water quality monitoring results have shown that the main source of the acidification is the Moss of the Horse Hill peatland with the resulting low pH potentially extending downstream for several km during very high flows.
    3. Due to the overall good water quality the Black Burn is likely important regarding retaining salmon populations within the upper River Bladnoch. However, the acidified Pultyan Burn is having a localised impact within the burn. The source of the poor water quality is the Kilquhockadale Flow peatland, and its restoration should also be considered a priority in regard to restoring impacted salmonid populations within the River Bladnoch.
    4. Given localised poor water quality within a cluster of burns in a section of the lower to mid Tarf Water peatland restoration options should be explored within the Mark of Luce Moss (basin peat) to help restore water quality in the largest of these burns (Lannygore Burn).

- Additional peat surveys should be carried out within the Polbae Burn catchment in the areas surrounding Tannylaggie Flow to help identify opportunities for peatland restoration.

- Given a possible link between poor water quality and degraded deep basin peat within the Bladnoch catchment there should be consideration towards a general policy of restoration of all areas of deep basin peat in areas of base-poor geology.

- The low DO levels within the Dargoal Burn highlight the need for further investigation into the impacts of degraded peatlands on oxygen levels within watercourses, particularly within areas with limited re-oxygenation capacity.

For further information on this project contact:
Name of Project Manager – K Galt
Telephone No. of Project Manager – 01671 403011

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1 INTRODUCTION

1.1 Acidification in Galloway and native fish species

The Galloway region of Southwest Scotland has been well documented in being subject to the effects of acidification. Atmospheric acid deposition from the burning of fossil fuels in areas of base-poor geology has resulted in soils exceeding their capacity to buffer against acid inputs, leading to artificially lowered pH within soils and waterbodies in these areas. Where large scale conifer plantations are present (in particular Sitka spruce) the impacts of acidification are often greater, with a number of authors finding a direct link between plantations and lowered pH (e.g. Harriman & Morrison, 1982) resulting from increased rates of wet and dry deposition of acidic pollutants. The Galloway region is one of the most afforested areas in the UK with most plantations typically consisting of Sitka spruce (*Picea sitkensis*). Much of the planting was historically carried out in the "lower-value", base-poor upland areas that are more susceptible to acidification. This has resulted in widespread artificially lowered pH levels in many upland areas within the Galloway region, with many upland lochs being reported as fishless by the late 1980's (Maitland et al., 1987).

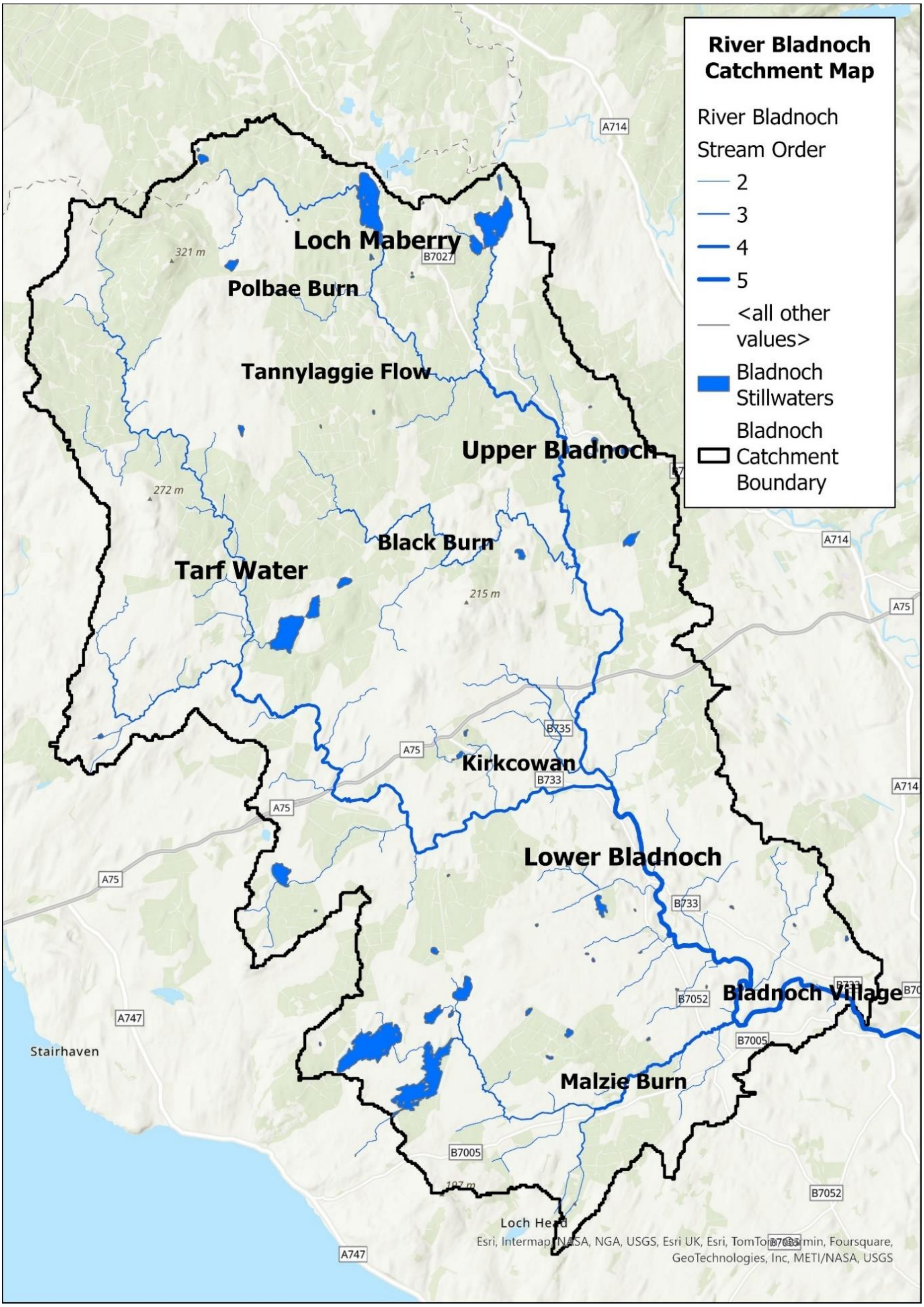
The two main native fish species within these areas are typically Brown trout (*Salmo trutta*) and Atlantic salmon (*Salmo salar*). Low pH can have significant impacts to both trout and salmon at critical stages within their lifecycle. At the time of hatching pH below 4.5 can block the action of the hatching enzyme chorionase leading to mortalities in Atlantic salmon (Waiwood & Haya, 1983). One of the main impacts of lowered pH is the association with increased levels of labile Aluminium (Driscoll, 1985), which can be toxic to trout and salmon. Mobilised Aluminium in soils can form complexes with water molecules, enabling them to bind to fish gills at low pH levels resulting in both ionoregulatory and respiratory impacts (Gensemer & Playle, 1999), whilst the physiological transformations that Atlantic salmon smolts undergo to cope with changes in salinity levels makes them particularly sensitive to Aluminium levels and has been associated with mortalities (Kroglund et al., 2008). Due to the complex interactions between pH and the environment and the subsequent impacts on fish Crisp (2000) summarises the general levels of concern of low pH for trout and salmon as being harmful at values below five and lethal at values below four. As a result of reduced pH levels within watercourses one of the major impacts within the Galloway region was the reduction, and in many cases complete loss, of Brown trout and Atlantic salmon populations. Maitland et al., in their 1987 publication *Acidification and Fish in Scottish Lochs* reported that in eleven lochs studied in the Galloway region that were known to once hold fish, six were now fishless whilst others showed impacts consistent with increased acidity. Since the late 1980's improvements in air quality, liming, forestry restructuring and changes in land use have resulted in some improvements to fish populations with recovery of trout populations in some areas. However, recovery appears slow in some areas where improvements have been made, whilst other areas still remain at pH levels that severely impact fish populations (Ferrier et al., 2001, Battarbee et al., 2011, Brown et al., 1998, Shilland et al., 2009). Electrofishing surveys carried out by Galloway Fisheries Trust (GFT) still routinely record low or absent trout and salmon numbers from some upland areas that once held either or both.

Peatlands are common within many of the acidified areas within the Galloway region, with Dumfries and Galloway holding some of the largest areas of peat within Scotland (Chapman et al., 2009). The importance of Peatlands cannot be understated. Their role as a carbon store is gaining increasing exposure in the public eye given the importance being placed upon acting on climate change. However, they also carry out several other ecological services including water purification, improving climate resilience, flood control and act as unique habitats for flora and fauna (Harenda et al., 2018). Their occurrence on waterlogged, often nutrient poor "low value" uplands has resulted in the degradation of many peat bogs within Dumfries and Galloway, primarily from draining for agriculture and forestry (Peacock et al., 2018). Draining peatlands lowers the water table and exposes the peat to aerobic decomposition, resulting in the stored carbon being released into the atmosphere (Martin-Ortega et al., 2014). In addition to the release of carbon, drained peatlands can have impacts on waterbodies with increases in the quantity of Fine Particulate Organic Matter, metal concentrations, dissolved organic carbon (DOC), water turbidity and lowered pH (Martin-Ortega et al., 2014). In areas where conifer plantations have been planted on drained peat the resulting changes can be very damaging. Drainage and loss of vegetation, combined with the increased scavenging of atmospheric acidic pollutants associated with conifers, can result in the amplification of acidification issues within watercourses beyond that experienced within degraded peatlands or conifer plantations alone. Conifer plantations planted on peat can result in an additional lowering of pH, an increase in toxic metals, an increase in ammonia, an increase in DOC and an increase in turbidity (Harrison et al., 2014; Puhr et al., 2000). Whilst there have been studies in some locations that showed no link between degraded peatlands and water quality, results from West Galloway show a much stronger link, possibly due to the limited acid neutralising capacity within the soils/bedrock, the nature of the degraded peat and/or land use. Previous Peatland Action funding water quality monitoring reports have shown clear differences in pH levels within the same deep peat unit at Cairnsmore of Fleet (Water of Fleet) based on land use and peat condition (Galloway Fisheries Trust, 2022), while similar monitoring on the Water of Luce showed acidification impacts in un-afforested deep basin peat dominated sub-catchments (Galloway Fisheries Trust, 2023).

The identification of areas where acidification impacts fish populations, and working to address, mitigate or inform land management practice, forms a large part of the work carried out by GFT. Within this the identification of areas of degraded peatlands (and areas where conifers are planted on deep peat) that are causing significant water quality issues forms a key component of this work. Where land use results in degraded peatlands that are impacting fish populations there may be the opportunity for multiparty work towards peatland restoration that fulfils several environmental and climatic goals, such as carbon storage, repopulating unique peatland flora and fauna and improved water quality with resulting benefits for fish populations. For that purpose, GFT has been working in partnership with Peatland Action (PA) and the Crichton Carbon Centre (CCC) since 2019 to monitor water quality in sections of Galloway rivers that are impacted by acidification resulting from damaged/degraded peatlands. The project aims to monitor the impacts of peatland restoration on water quality (particularly in relation to salmonids), assess water quality across upland sections of rivers where degraded peat is present and to use the information gathered to raise awareness, prioritise areas where peatland restoration will result in the biggest improvements to water quality and to provide data to feed into land management plans. The collaboration between GFT, CCC and PA is funded by NatureScot (NS) with funding being secured in the autumn of 2023 to monitor water quality within the River Bladnoch catchment over winter 2023/24 (winter being the period when rainfall is typically highest resulting in more frequent acid flushes into watercourses).

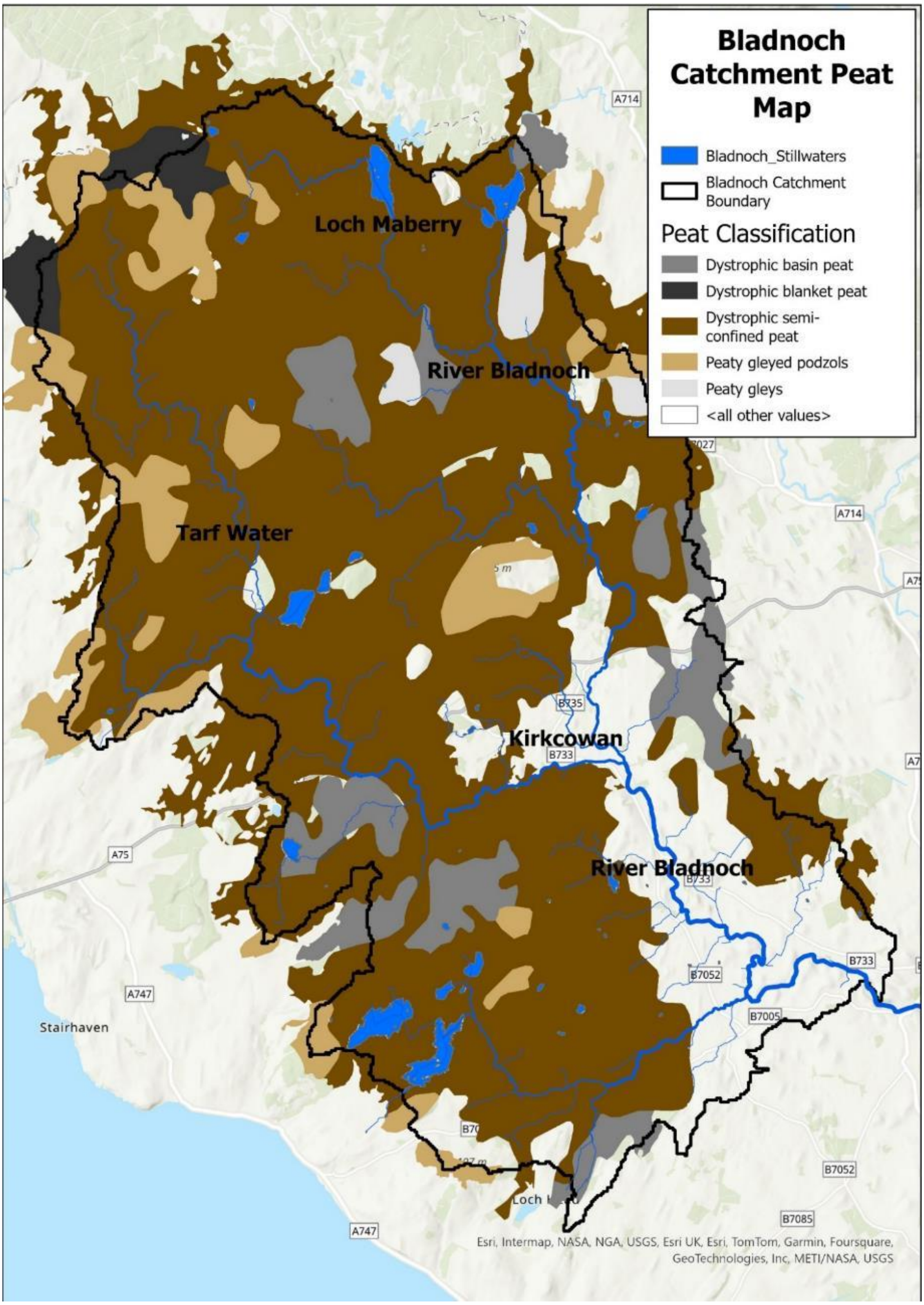
1.2 River Bladnoch catchment summary

The Bladnoch is a medium sized river located in Western Galloway. It is approximately 56 km long and has a catchment of roughly 340 km^2. The river originates from the outflow of Loch Maberry near Drumlamford at an altitude of approximately 120 m. However, Loch Maberry is fed by the Pulganny Burn which is several km long and rises at a height of roughly 150 m, with the source of the burn essentially being the source of the river. The Bladnoch flows into the Solway Firth at Wigtown Bay next to the town of Wigtown. The river runs North to South and is roughly “y” shaped. It has one major tributary, the Tarf Water, which flows into the Bladnoch due South of the village of Kirkcowan. The Bladnoch has a relatively uncrowded catchment with a low human population density. There are only three significant (but still relatively small) settlements along the length of the river, namely Kirkcowan, Bladnoch village and Wigtown. The latter two lie next to the tidal section of the river. The main stem of the river and most tributaries and larger burns are designated as a Special Area of Conservation (SAC). This is primarily because of the river's Atlantic salmon populations which, unlike most rivers in the Southwest of Scotland, still supports a population of salmon who return to the river as adults during spring.



Map 1: Catchment map for the River Bladnoch

Like many of the rivers in Southwest Scotland, much of the upper Bladnoch catchments consist of nutrient poor moorland and heathland with significant areas of deep and shallow peat present. Map 2 shows the peat map for the Bladnoch catchment.



Map 2: Catchment map for the River Bladnoch showing peat distribution and type

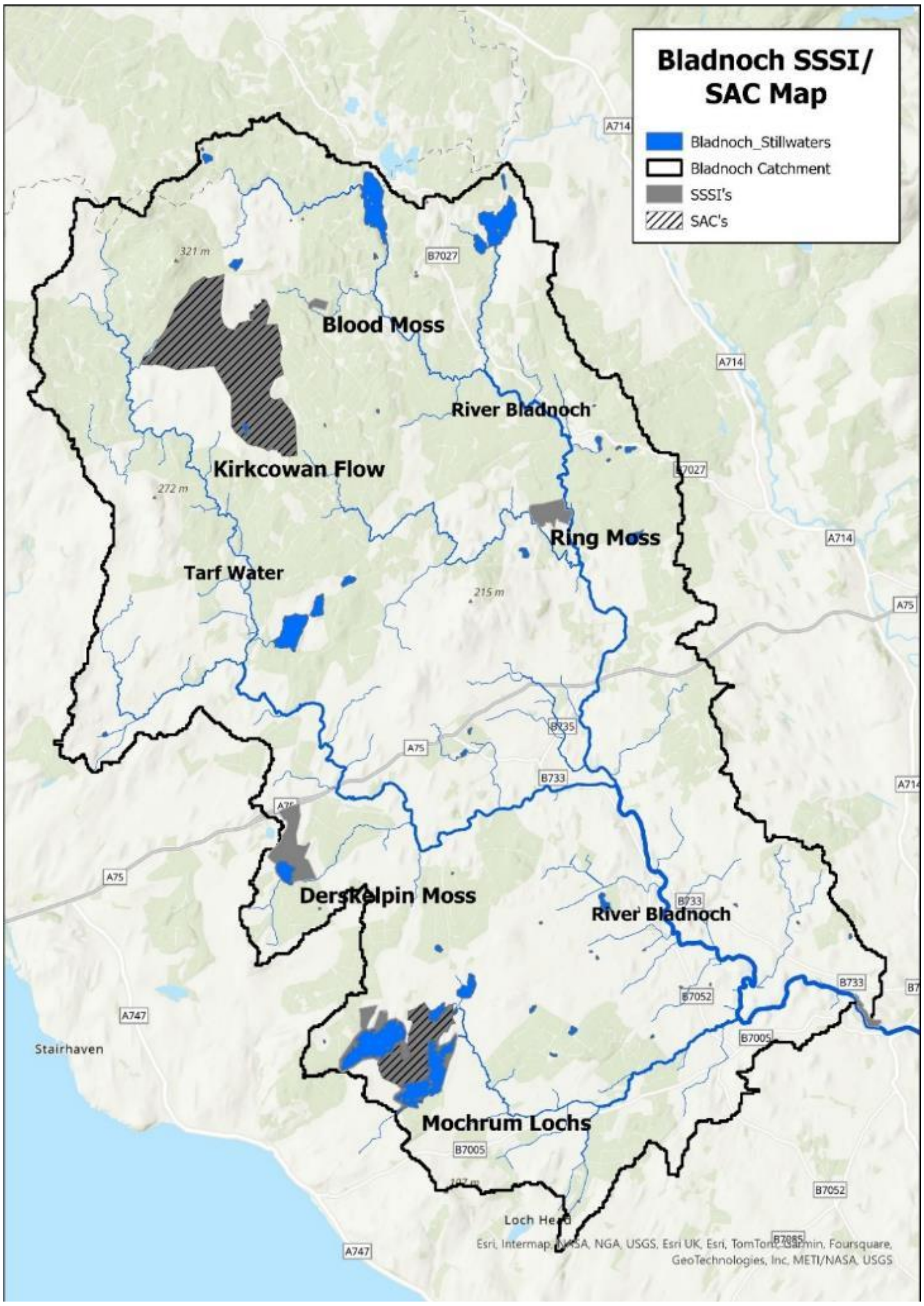
Whilst the exact locations and areas of all deep peat have not been accurately recorded within the Bladnoch catchment there are several clues that suggest deep peat is widespread. Analysis of the National Soil Map of Scotland[1] shows that peatlands make up a significant proportion of the soils in the catchment (Table 1).

Table 1: Peatland soils in the Bladnoch catchment[1]

Soil Type	*Area (Ha)*	*% of Catchment*
Dystrophic basin peat	2,272	7
Dystrophic blanket peat	272	1
Dystrophic blanket peat with peaty gleys	22	0
Dystrophic semi-confined peat with brown earths	7,903	23
Dystrophic semi-confined peat with peaty gleyed podzols with peaty gleys	3,989	12
Dystrophic semi-confined peat with peaty rankers	10,855	32

It is also interesting to note that Ordnance Survey maps highlight numerous areas that are named as Moss or Flow, old names for waterlogged peatlands. These include Tannylaggie Flow, Kilquhockadale Flow, two separate Blood Moss's, Ink Moss, Drummurrie Moss, Ring Moss, two Eldrig Moss's, Loden's Moss, Gall Moss, Moss of the Horse Hill, Mark Broom Moss, Grennan Moss, Dergoals Moss, Gracehill Moss, Burnpark Moss, Flow of Dergoals, Dirnean Moss, Barskeoch Moss, Barlae Moss, Mark of Luce Moss, Knocketie Moss, Annabaglish Moss, Mindork Moss and several areas simply named Moss. Most of these peatlands are likely degraded because of land use. Five areas have been identified nationally and been given the status of SSSI's and/or SAC's. They are Blood Moss (Polbae) SSSI, Kirkcowan Flow SSSI & SAC, Ring Moss SSSI, Derskelpin Moss SSSI and Mochrum Lochs SSSI & SAC. Map 3 shows the location and size of the SSSI's/SAC's. They represent a relatively small proportion of the deep peat present within the catchment meaning the majority of peatland is not designated for peatland habitat and associated species assemblages.

[1] Soil Survey of Scotland Staff (1981). Soil maps of Scotland at a scale of 1:250 000. Macaulay Institute for Soil Research, Aberdeen. DOI: 10.5281/zenodo.4646891'



Map 3: Bladnoch catchment map showing the locations of SSSI's/SAC's

The latest NatureScot review of the condition of the Mochrum Lochs SSSI/SAC states it is in unfavourable condition because of historic drainage and current grazing and burning regimes, whilst Kirkcowan Flow SSSI/SAC is classed as being in unfavourable and declining condition because of historic drainage, burning, current grazing and invasive species (predominantly non-native conifers). Limited ditch blocking has been carried out over a small area of Kirkcowan Flow as part of an agri-environment scheme, but the hydrological impact of this work will be limited in scale. More information can be found following the links below.

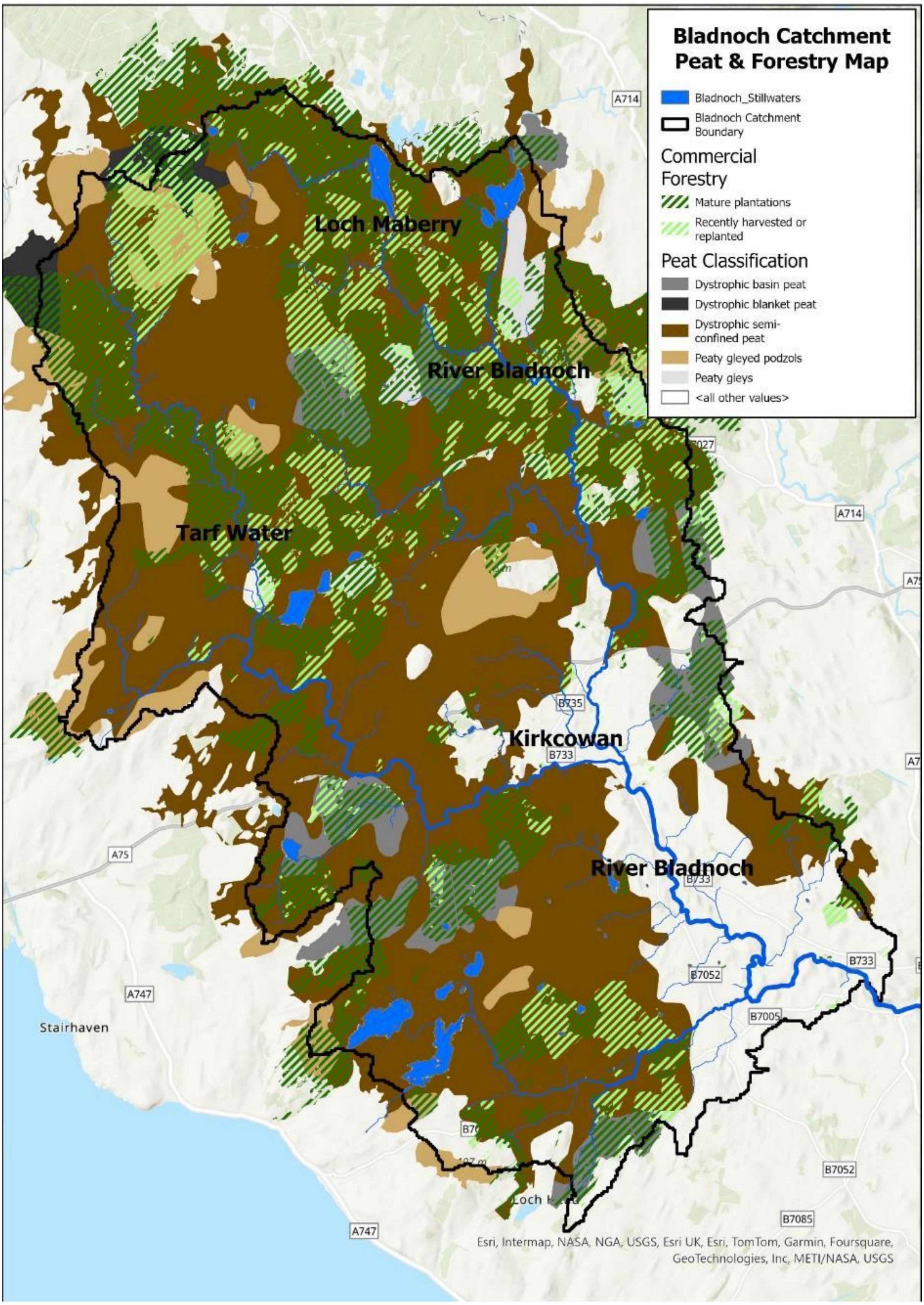
SiteLink - Mochrum Lochs SAC (nature.scot)

SiteLink - Kirkcowan Flow SAC (nature.scot)

Less information is available for the remaining SSSI's. A NatureScot report commissioned in 2018 found Derskelpin Moss to be generally in good condition except for some drainage and grazing around the outer edges of the site, whilst little information on the status of Ring Moss and Blood Moss SSSI's could not be found using an internet search.

The lower Bladnoch catchment is relatively low lying and low gradient. It is set in rural surroundings within the Machars of Galloway. Whilst the upland areas of the catchment have the greatest distribution of peat there are still extensive deposits of peat within the Machars. As with the uplands much of the peat within the Machars has been drained/damaged for the planting of commercial forestry or to promote grass growth for livestock grazing. The extent drainage is often easily observed using modern aerial photography available online.

Image 1: Applemap aerial photography showing drainage lines through peatland within the Kirkcowan Flow SSSI/SAC



Map 4: Catchment map for the River Bladnoch showing extent and distribution of afforested peatland

1.3 SEPA water hub Bladnoch catchment water quality data

Given the known water quality issues within the Bladnoch and their impacts on fish populations some information on current River Bladnoch water quality and ecological status is available through the Scottish Environment Protection Agency (SEPA) water hub (https://www.sepa.org.uk/data-visualisation/water-classification-hub/), which summarises their own monitoring data. The hub splits the Bladnoch catchment into several sub-catchments. All parameters are scored on a "High" (Blue), "Good" (Green), "Moderate" (Yellow), "Poor" (Amber) and "Bad" (Red) scoring system. Screenshots from the SEPA hub for Overall status, Overall ecology, Water quality, pH, Dissolved oxygen, Fish ecology, Macroinvertebrates (acid) and Macroinvertebrates (RICT/WHTP) are shown below.

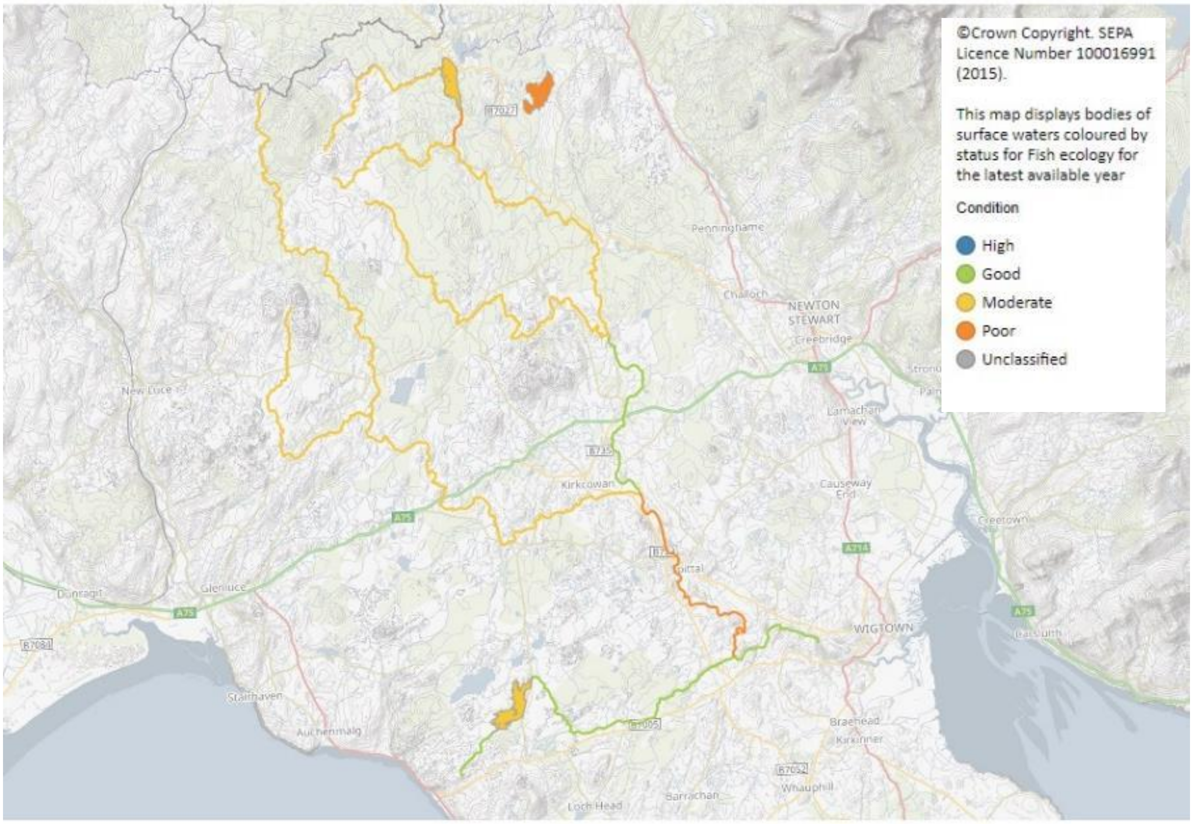


Figure 1: SEPA water hub River Bladnoch classification: Overall Status

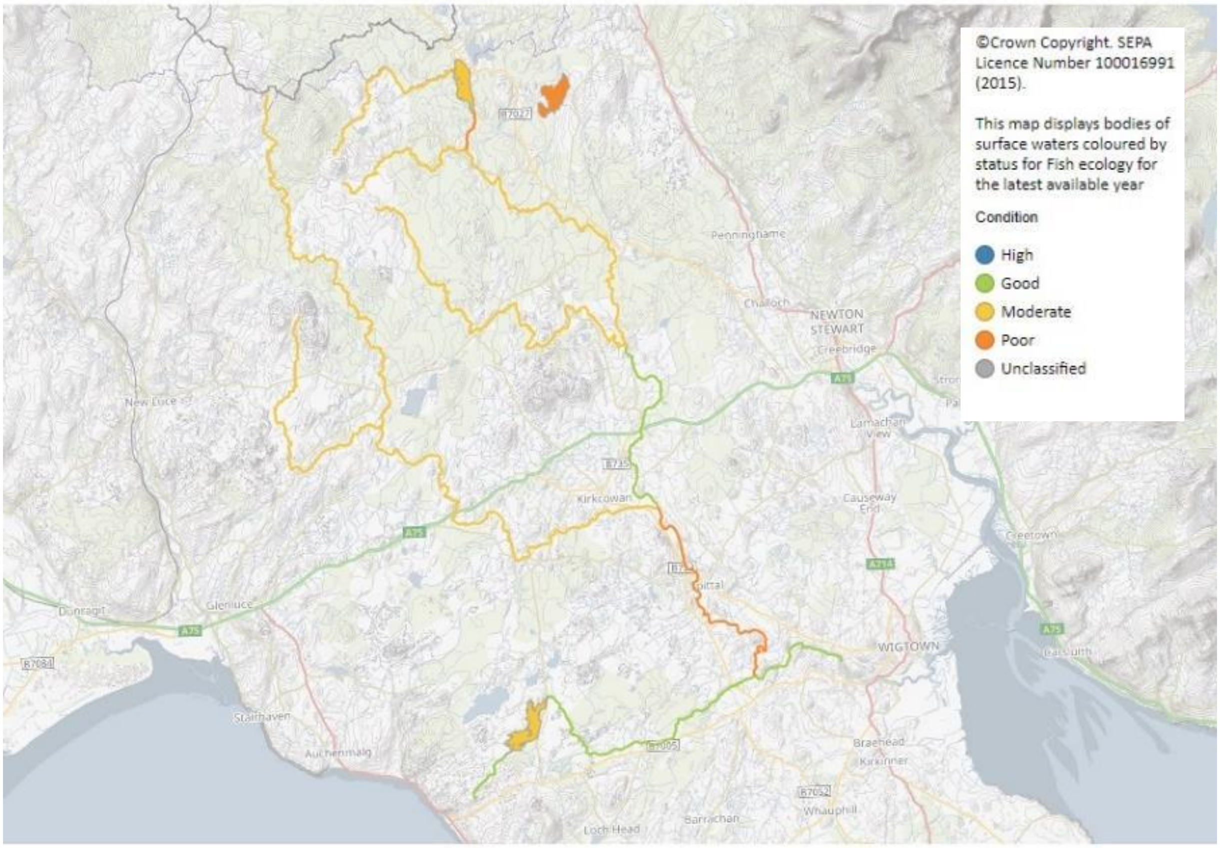


Figure 2: SEPA water hub River Bladnoch classification: Overall Ecology

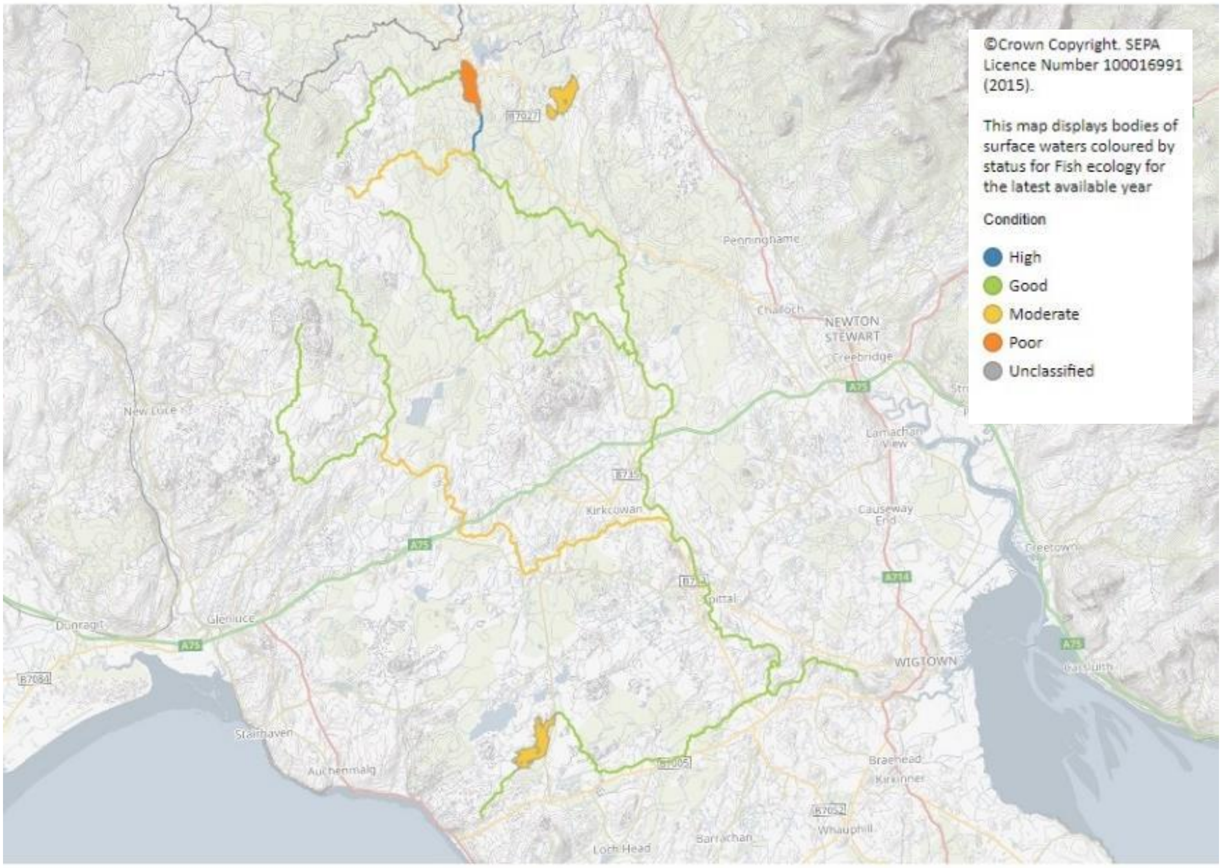


Figure 3: SEPA water hub River Bladnoch classification: Water Quality

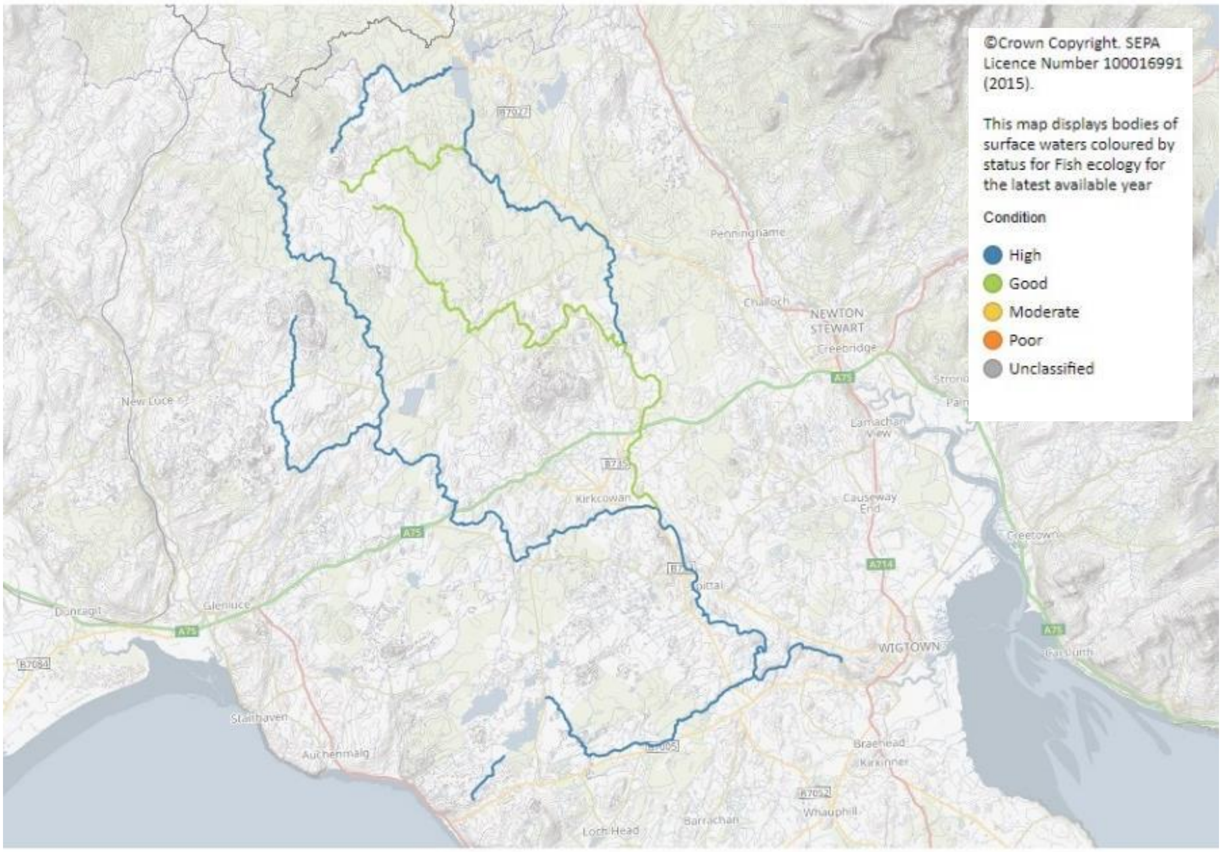


Figure 4: SEPA water hub River Bladnoch classification: pH

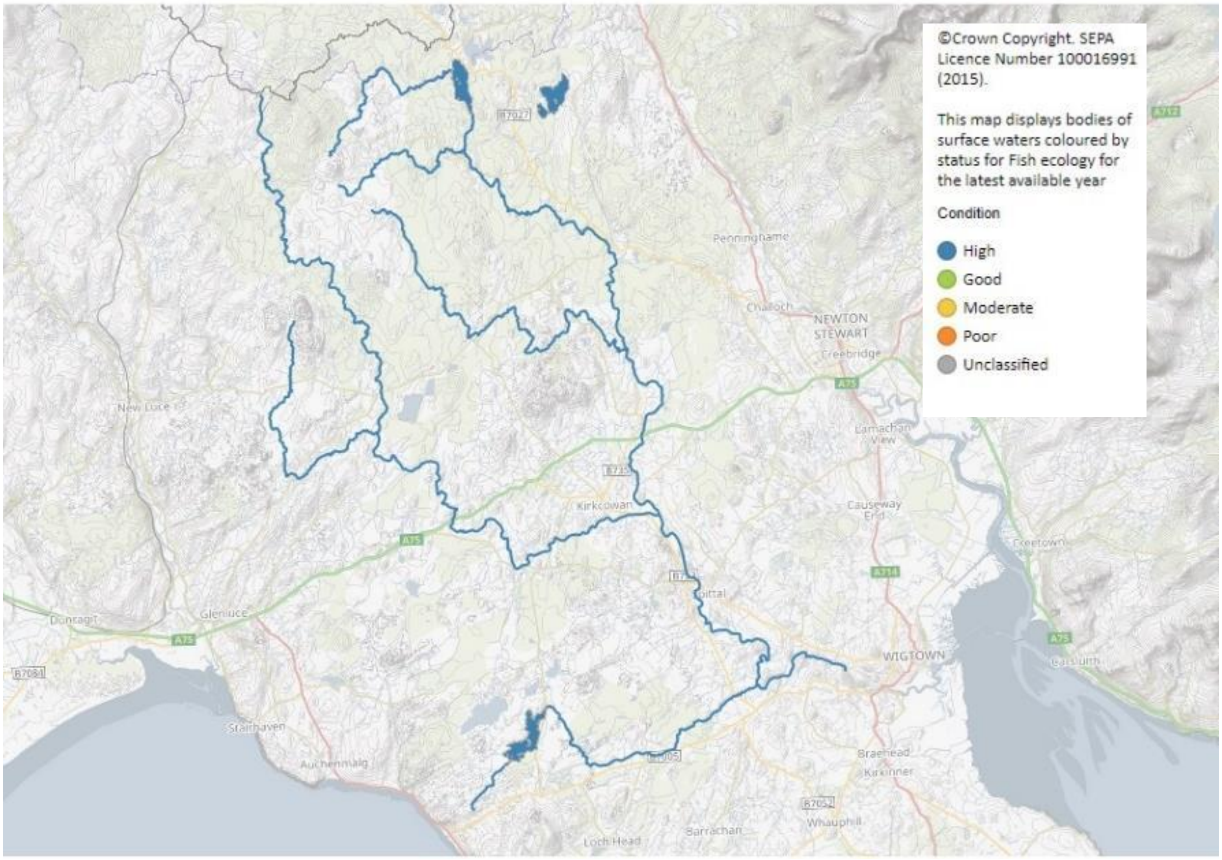


Figure 5: SEPA water hub River Bladnoch classification: Dissolved Oxygen

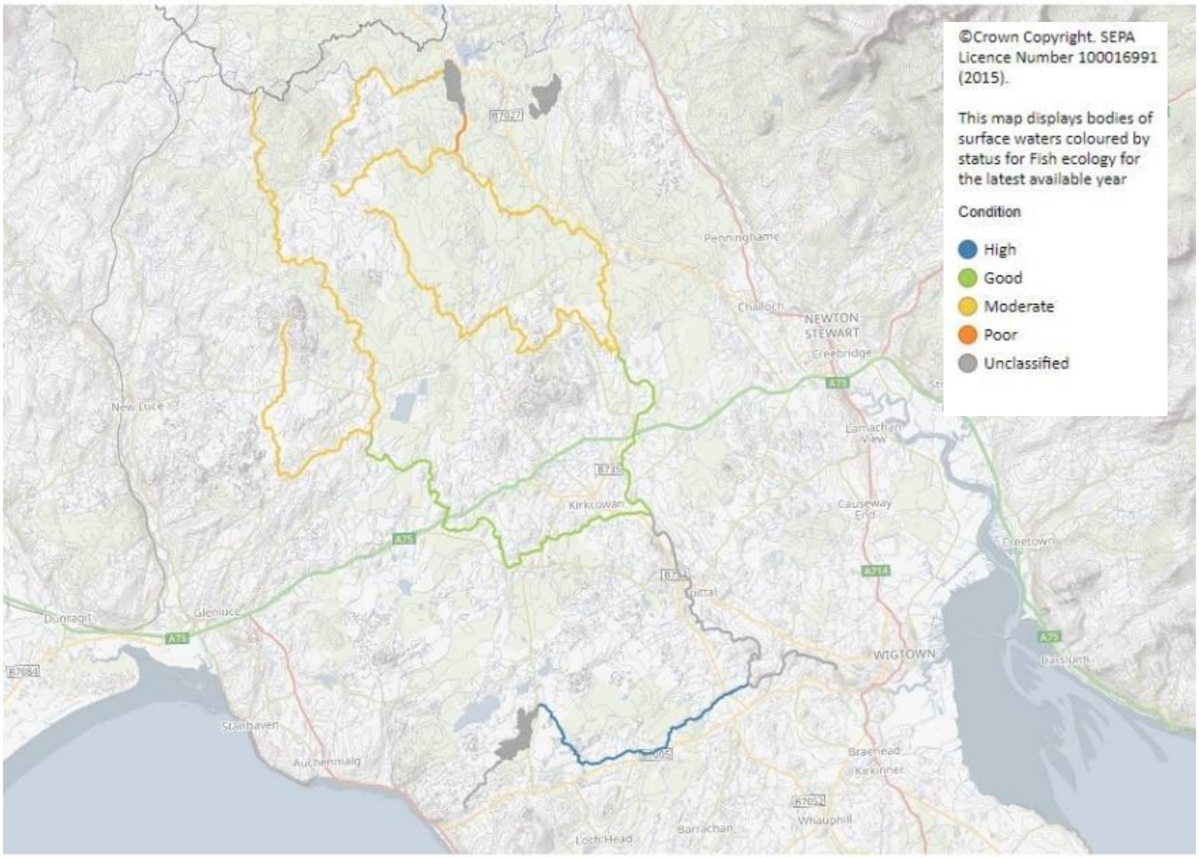


Figure 6: SEPA water hub River Bladnoch classification: Fish Ecology

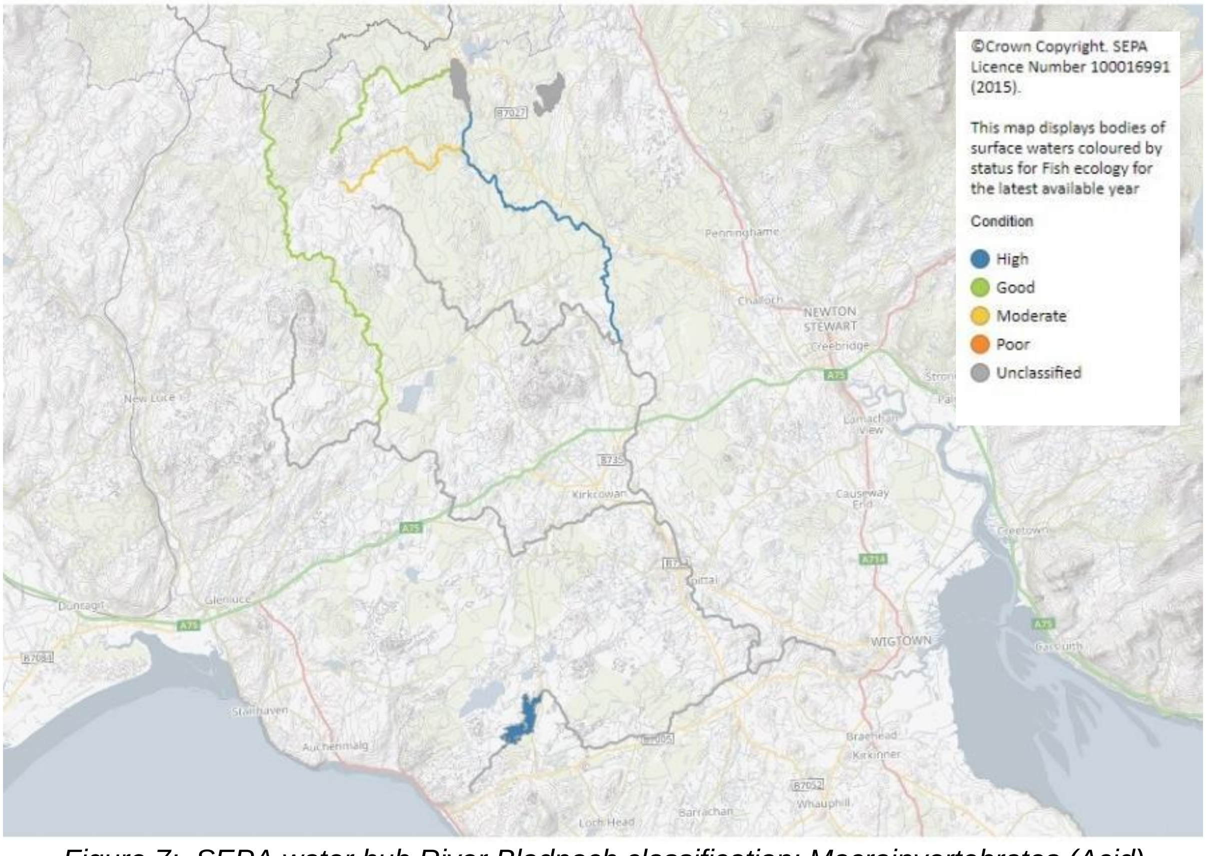


Figure 7: SEPA water hub River Bladnoch classification: Macroinvertebrates (Acid)

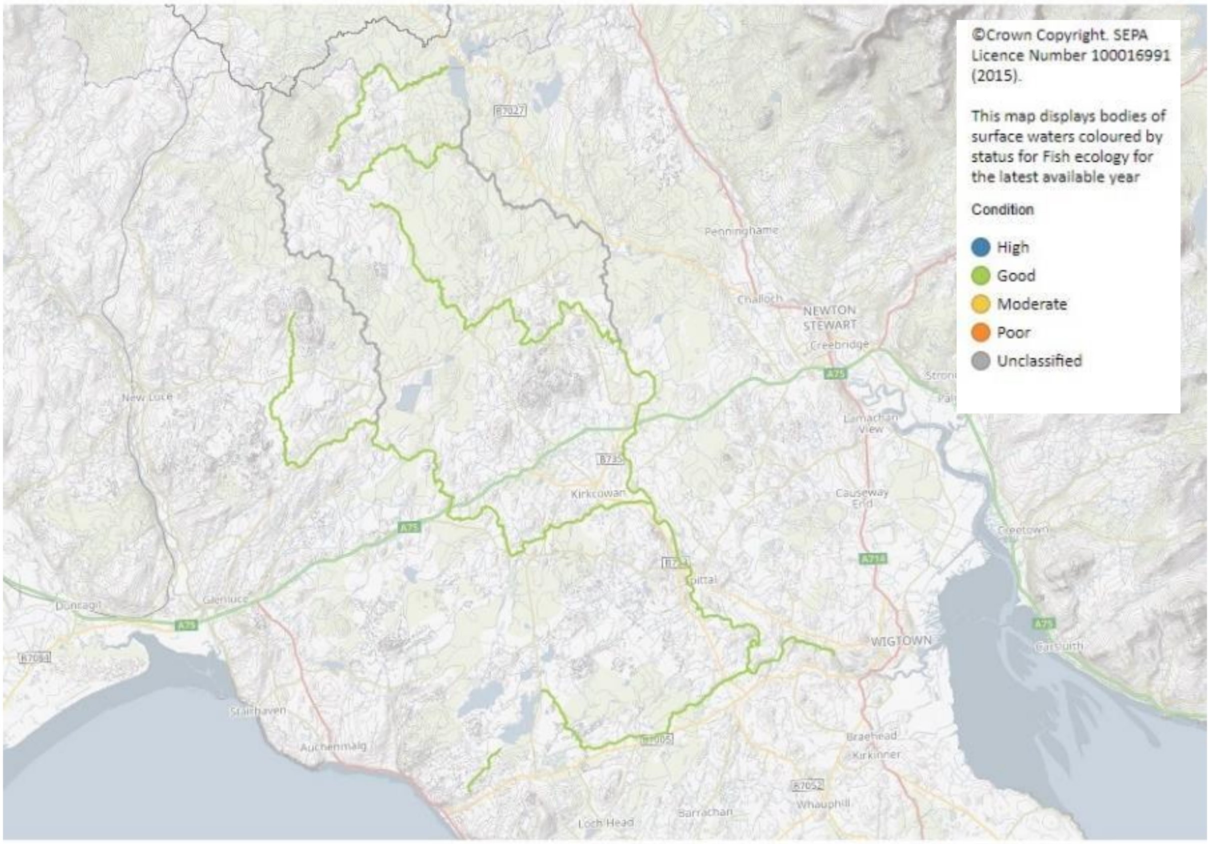


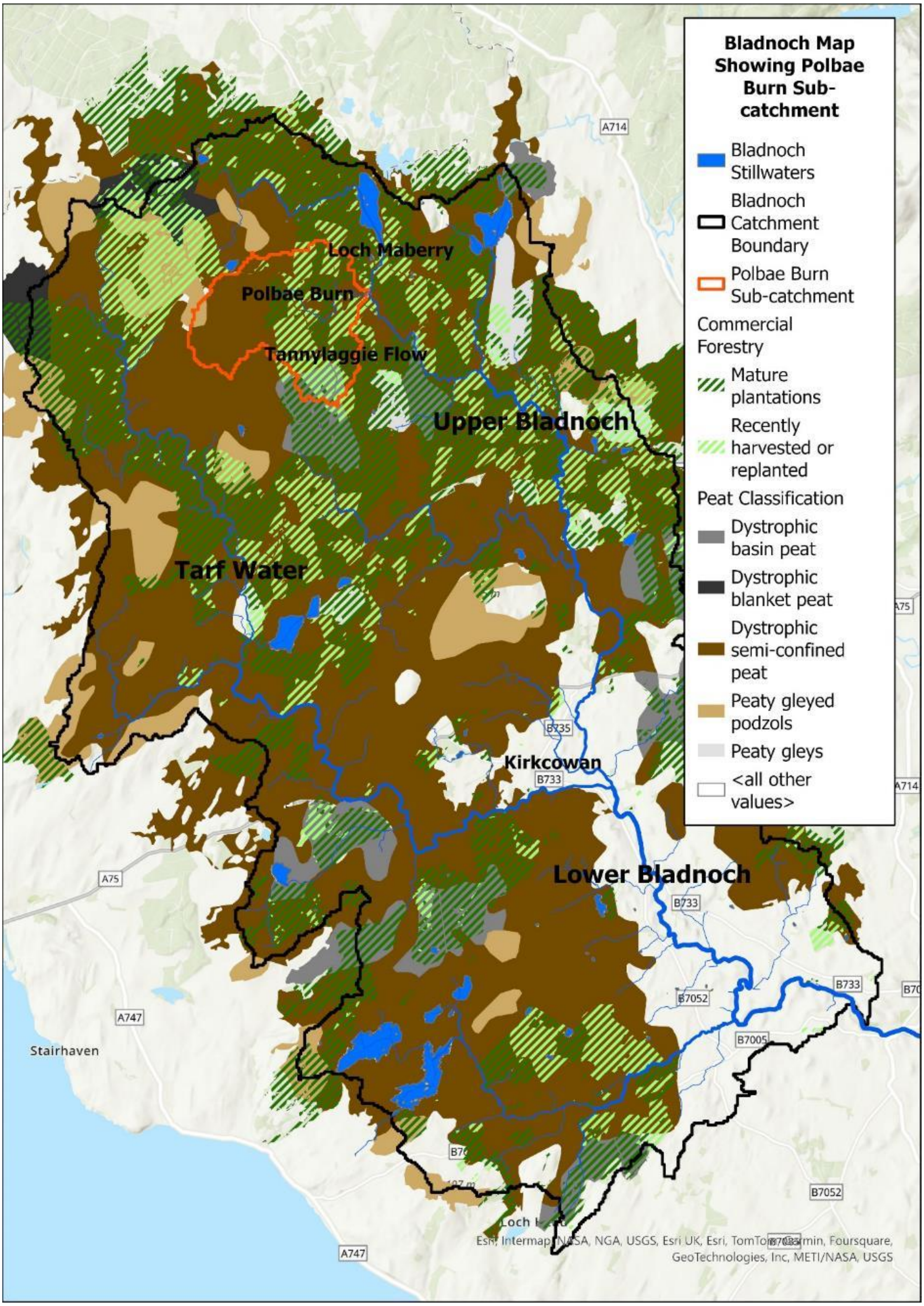
Figure 8: SEPA water hub River Bladnoch classification: Macroinvertebrates (RICT/WHTP)

As can be seen from the SEPA classifications, the results for some parameters vary between maps, and often vary from the results shown later in this report. This may be because of limited SEPA sampling within a section of river or from results from a small number of locations being considered representative of a much larger area with localised impacts being missed as a result. The results generally show the river system to be in “poor” to “good” status for water quality and aquatic life.

1.4 GFT Peatland Action Bladnoch catchment water quality monitoring

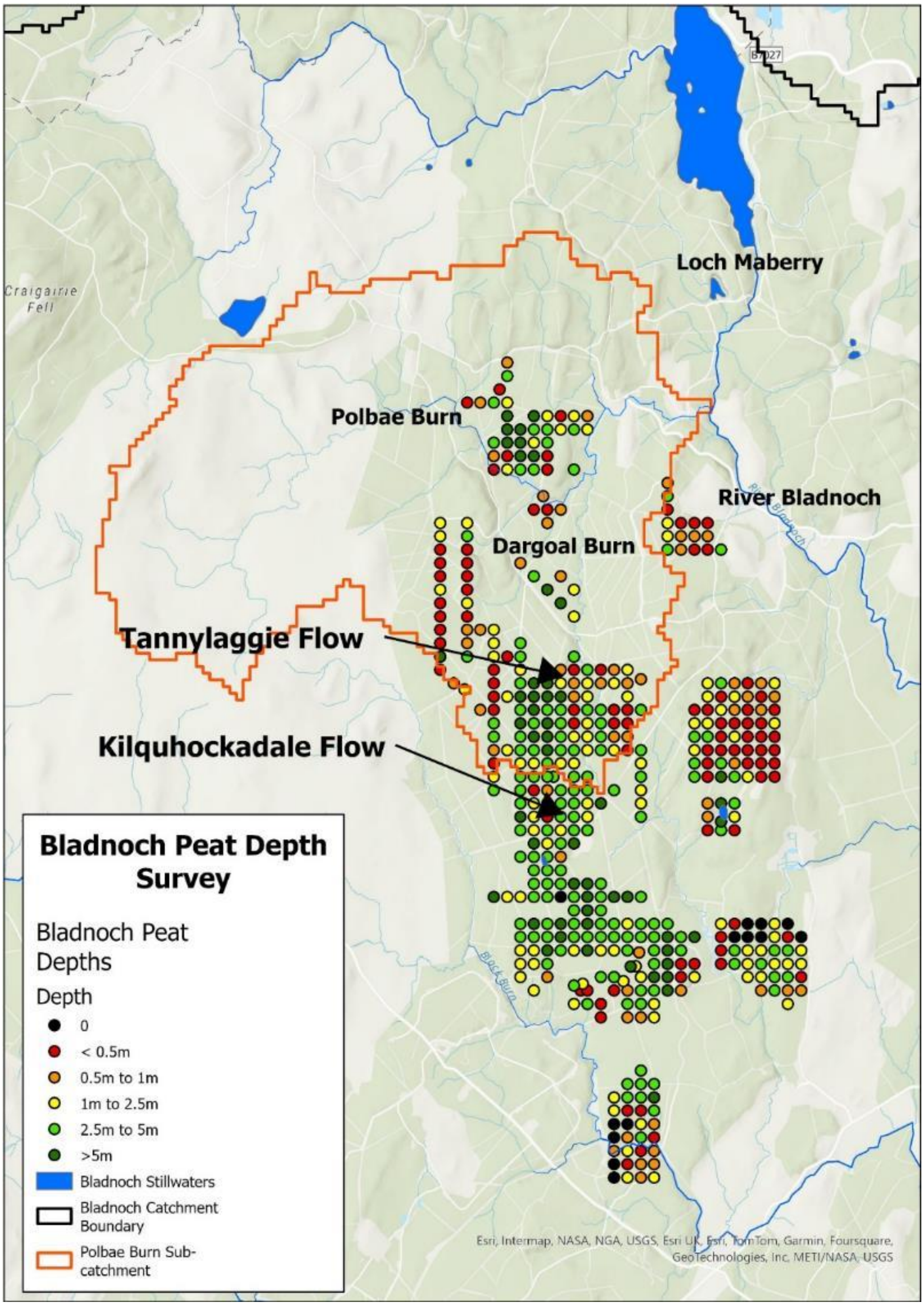
GFT/PA water quality monitoring carried out during winter 2023/2024 centred on the River Bladnoch, to tie in with on-going peatland restoration work in the upper Bladnoch being undertaken by Forestry and Land Scotland at Tannylaggie Flow (Tannylaggie land management plan - Forestry and Land Scotland). The water quality monitoring was essentially split into three interconnected projects.

The first was a continuation of the Tannylaggie peatland restoration water quality monitoring on the Dargoal Burn, which aims to record the extent of the potential for improvements in water quality resulting from peatland restoration in an acidified watercourse. Tannylaggie Flow is an area of deep basin peat in the upper Bladnoch catchment. It lies within the Polbae Burn sub-catchment near waterside as shown on Map 5.

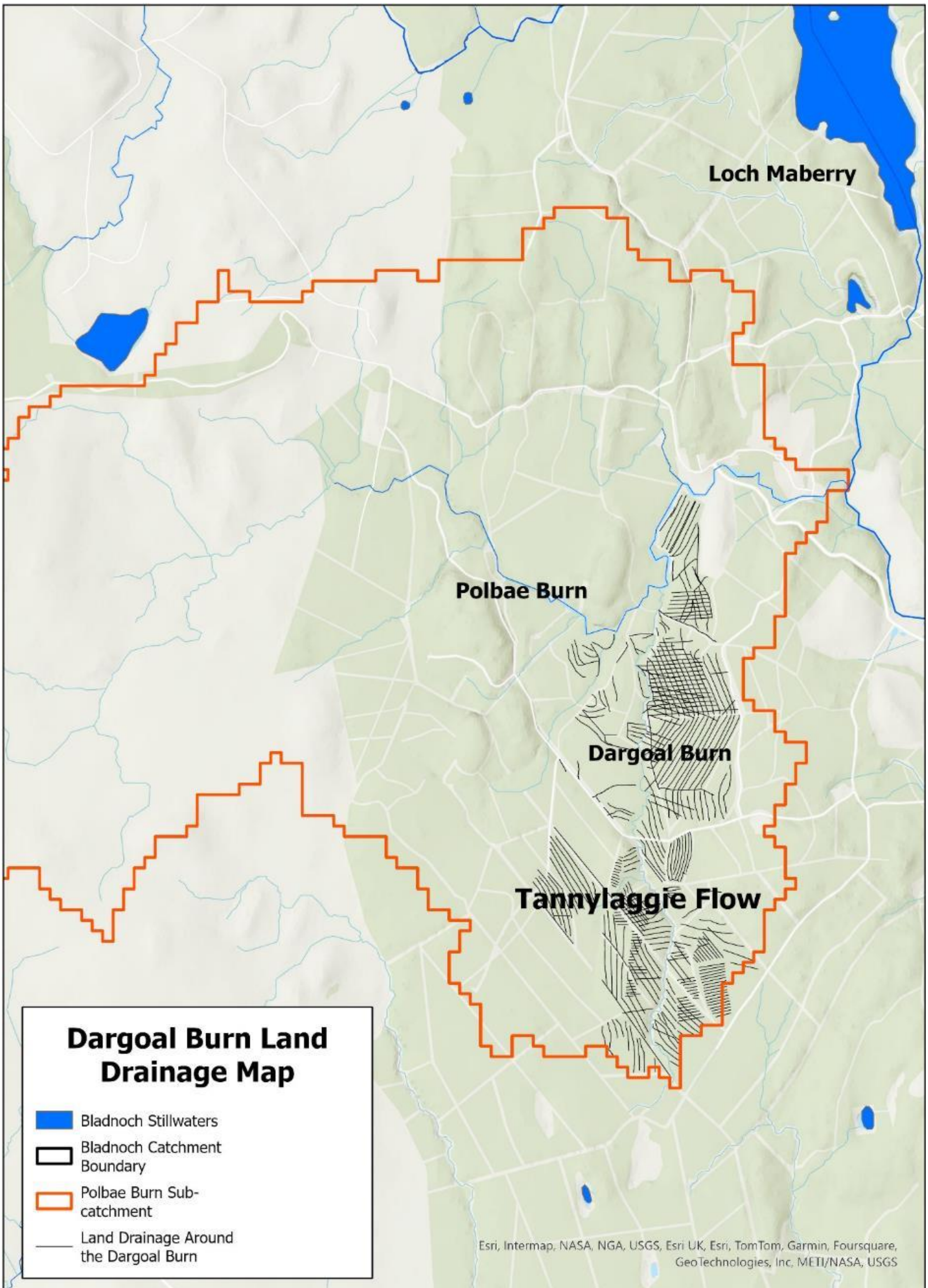


Map 5: Catchment map for the River Bladnoch showing the location of the Polbae Burn sub-catchment

A large percentage (well over half) of the Polbae Burn sub-catchment was purchased by the UK government post Second World War and converted to commercial forestry, typically dominated by Sitka spruce. This area covers almost the entirety of the Tannylaggie Flow peatland. To allow for the growth of commercial trees the land was extensively drained to prep the land for planting. The combination of drainage and planting caused considerable damage to the peatland. Map 6 shows peat depths recorded by GFT in and around Tannylaggie Flow whilst Map 7 shows a sub-section of the drainage channels along the Dargoal Burn as mapped by the Crichton Carbon Centre to give an indication of the extent and intensity of artificial drainage.

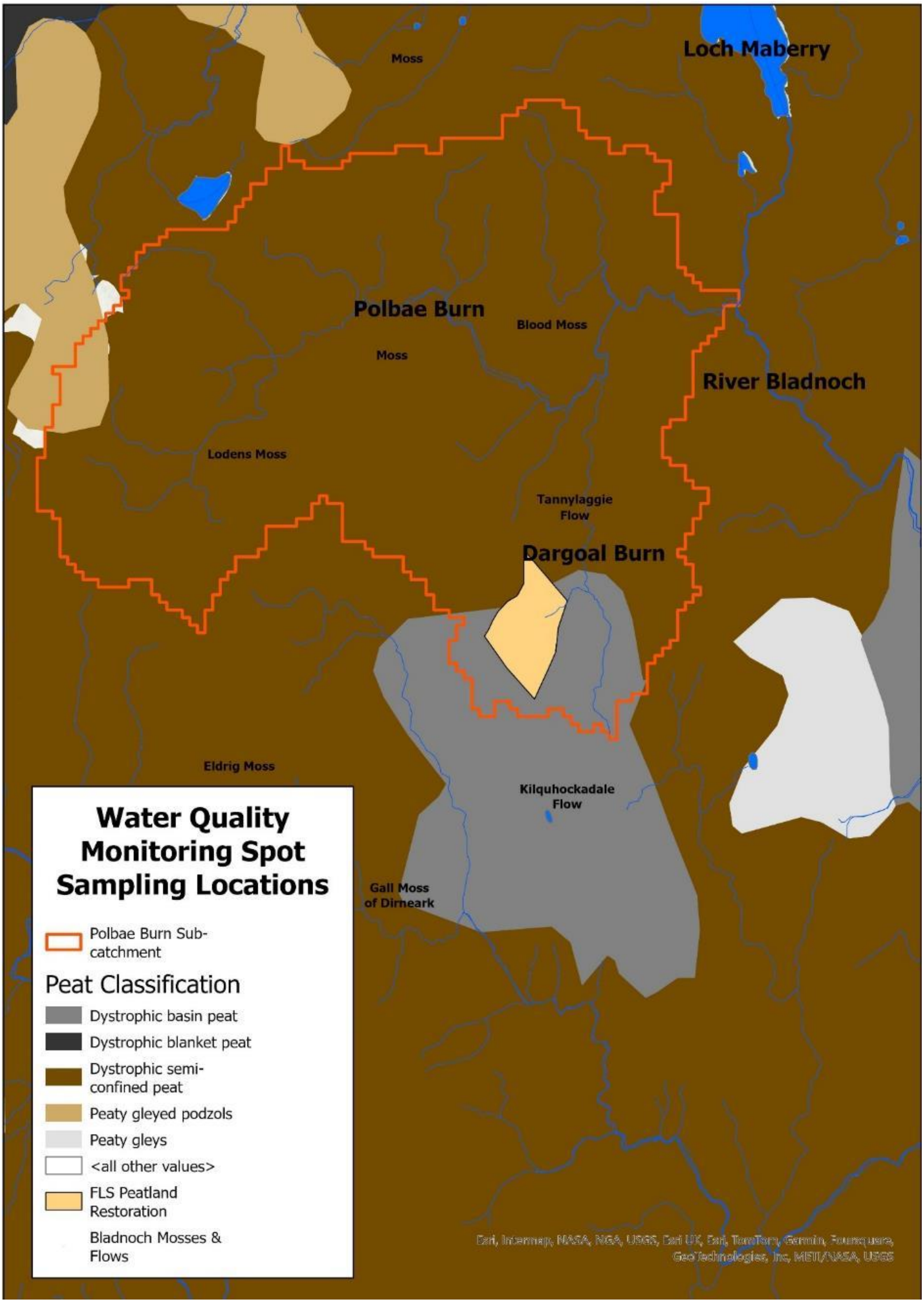


Map 6: Peat depths recorded around Tannylaggie and Kilquhockadale Flow (deep peat is classed as peat at a depth of 0.5m or over)



Map 7: Some of the forestry drainage network around the Dargoal Burn as mapped by the Crichton Carbon Centre

The Dargoal Burn flows through Tannylaggie Flow and is the destination for many of the drainage ditches within. Given the extent of the drainage and the size of the burn it is unclear just how natural it is in its current form. The Dargoal Burn flows into the Polbae Burn, itself a major headwater tributary of the upper Bladnoch and part of the River Bladnoch SAC. As a result of historic acidic pollutants in the atmosphere, industrial scale drainage and dense conifer planting the Dargoal Burn has become one of the most acidified watercourses within Galloway and frequently experiences pH levels that are lethal to fish (regularly below pH 4 as previously shown by GFT/PA water quality monitoring). As a result of low pH levels within the Dargoal Burn, and in the general area surrounding the upper Polbae Burn, water quality (low pH) is impacted in the middle and lower Polbae Burn, with impacts persisting well downstream into the River Bladnoch. As a result, the acidification in the Dargoal Burn and greater Polbae Burn sub-catchment is impacting the River Bladnoch SAC. The commercial forestry within the Dargoal Burn and greater Polbae Burn sub-catchment is primarily owned/managed by Forestry and Land Scotland, the government agency responsible for state owned forestry. As part of the latest plan for the management of Tannylaggie Forest (the name for the large section of commercial forestry surrounding the section of the upper Bladnoch catchment containing the Dargoal and Polbae Burns) areas of deep peat at Tannylaggie Flow and some surrounding areas have been highlighted for peatland restoration. As the felling of mature conifer plantations is staggered some areas are still covered in mature conifer’s and will not be considered for restoration until the trees are removed. However, other areas have been felled and are ready for peatland restoration. After a delay resulting from FLS being unable to find a contractor to carry out the work peatland restoration commenced in a section of land adjacent to the Dargoal Burn in early 2023. Restoration techniques included stump flipping, ground smoothing and ditch blocking. Map 8 shows an estimation of the area that has been restored to date. As a result of the restoration only beginning in early 2023 water quality monitoring to date has been pre-restoration data collection, with monitoring over winter 2023/2024 recording data during the early stages of restoration.



Map 8: Approximate area of FLS peatland restoration at Tannylaggie Flow

The FLS Tannylaggie Forest Land Management Plan 2016 – 2026 is available from the link below.

https://forestryandland.gov.scot/images/corporate/design-plans/galloway/tannylaggie-land-management-plan-2016-26.pdf

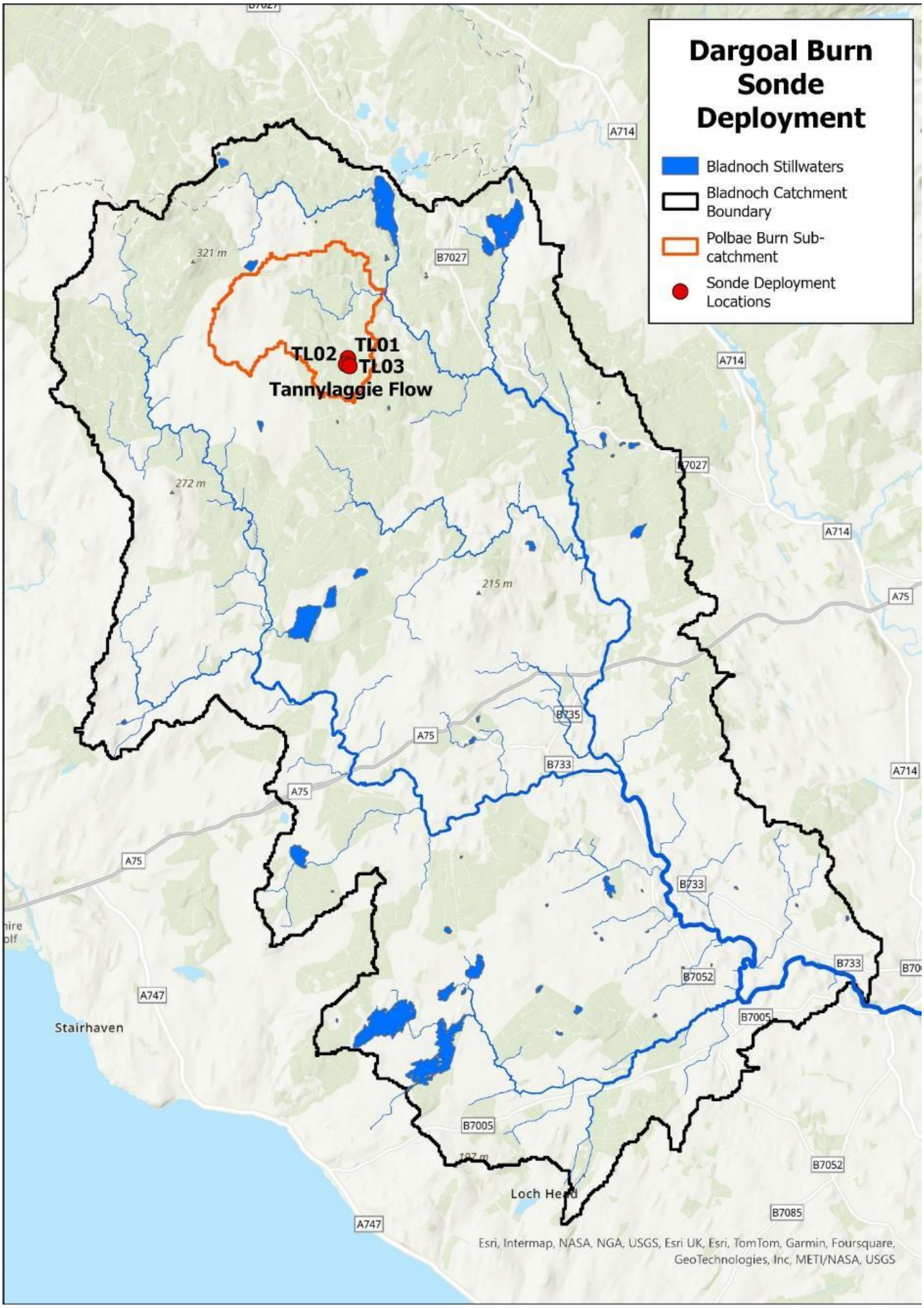
The second part of the 2023/2024 water quality monitoring was a catchment wide review of River Bladnoch electrofishing data held by GFT to assess the current impacts of water quality on fish populations across the Bladnoch catchment and to ascertain long term trends. Given the sensitivity of salmon and trout to low pH during some periods of development the aim of the review was to look at the current distribution and density of trout and salmon, to see if there were any areas where fish numbers showed signs of being impacted by poor water quality and to see if there were any changes in fish numbers over time that would indicate improving or declining conditions. GFT has been carrying out electrofishing surveys to record juvenile salmonid densities in the Bladnoch river system since the late 1990's and has amassed a significant amount of data from over 200 separate survey sites. However, sampling was undertaken for a wide variety of reasons and in a wide variety of locations so the amount of long-term data from individual sampling sites is limited.

The third part of the winter 2023/2024 monitoring was to collect a general record of catchment wide water quality across the Bladnoch river system. The aim was to look at variation in water quality (primarily pH) across both upper catchments and some lowland sites where basin peat is present, and to highlight areas of poorer water quality for further gathering of information. It is hoped that once the areas with the poorest water quality have been identified more data can be collected and that this can be directly linked to the current land use land use and/or the current state of any peatlands present.

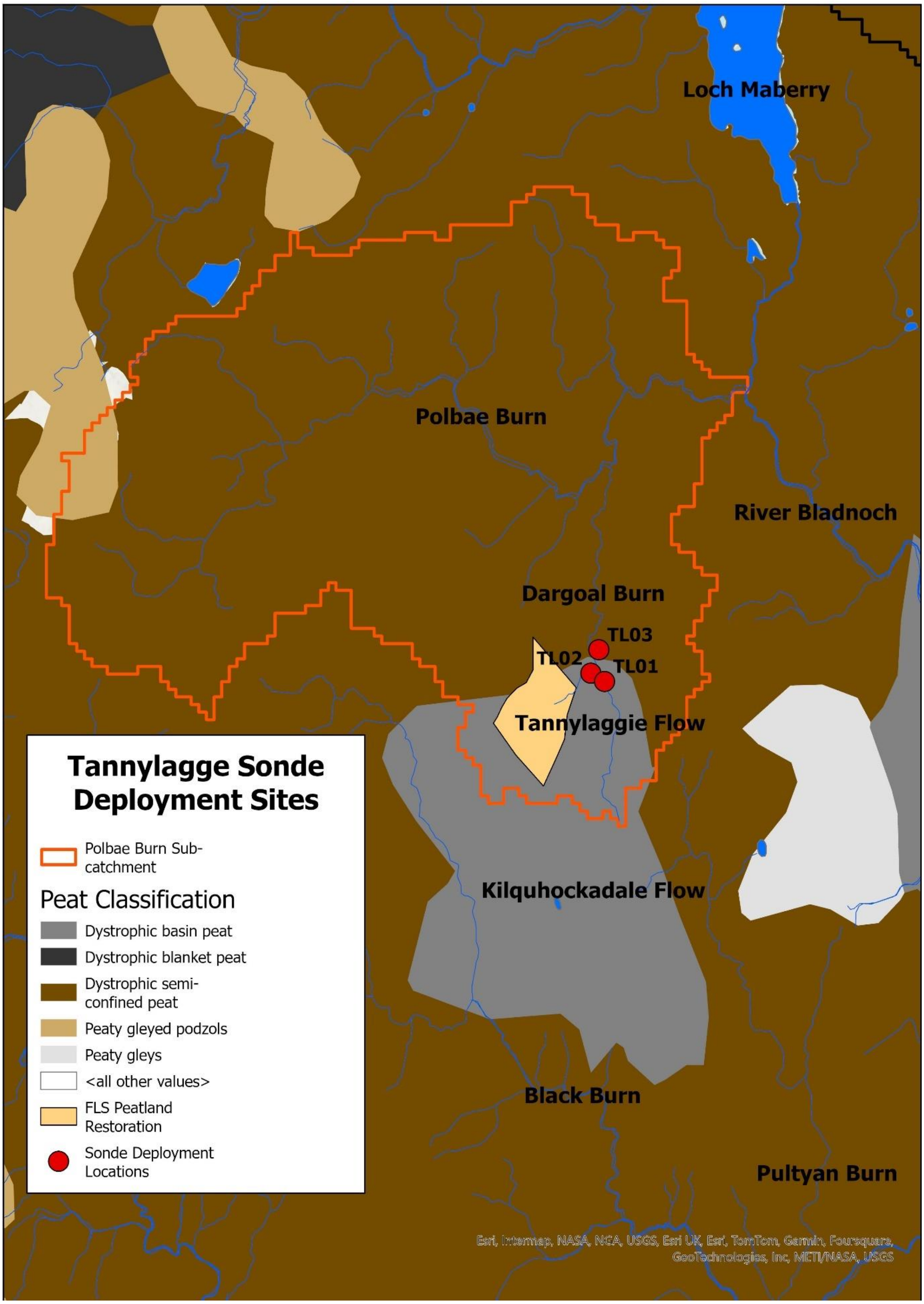
2 METHOD

2.1 Tannylaggie peatland restoration water quality data collection

Tannylaggie peatland pre-restoration recording began in winter 2019/2020, with additional pre-restoration data being collected during winter 2020/2021 and winter 2021/2022. No monitoring took place during winter 2022/2023 as the upper Water of Luce was monitored instead because of the possibility of peatland restoration taking place. Tree felling within the Tannylaggie Flow restoration area was well underway by the time the pre-restoration monitoring began, although there has been significant regeneration of Sitka since the felling took place (author, personal observation). The monitoring sites in the Dargoal Burn centre around a small tributary/large drain within Tannylaggie Flow into which several forestry ditches drain. Sites are located above the tributary (TL01), within the tributary itself (TL02) and below the tributary (TL03). The peatland restoration carried out to date lies upstream of this tributary, but it is unclear just how much of the area drains into it. The sites were chosen to show the overall condition of the Dargoal Burn, localised variations coming from the tributary and to show if the water from the tributary is having any significant impact on water quality within the Dargoal Burn. Map 9 shows the locations of the sample sites within the greater Bladnoch catchment whilst Map 10 shows the sites at a local level. The monitoring site above the tributary (TL01) has proven problematic during monitoring and readings were thought to have been impacted by periodic exposure to air during low flows. As a result, and due to only two water quality monitoring sondes being available at the time, this site was not monitored during winter 2020/2021. It was redeployed during winter 2021/2022 with the sonde placed in deeper water. However, the issues persisted revealing that water stagnating at the monitoring site was the factor impacting results. The site was moved upstream approximately 10 m into an area of swifter flow during winter 2023/2024 which appeared to solve the issue. As such, the only reliable data for this site is from winter 2023/2024 and all other data from this site has been disregarded.



Map 9: Tannylaggie peatland restoration water quality monitoring Sonde deployment sites within the greater Bladnoch catchment



Map 10: Tannylaggie peatland restoration water quality monitoring Sonde deployment sites within the Polbae Burn sub-catchment

With the first phases of peatland restoration works underway during Spring and Summer 2023 data was collected from all three sites during January/February 2024 (but with the TL01 sonde moved upstream approximately 10 m). As with all previous GFT water quality monitoring data was collected using EXO1 Sondes. All three sondes were deployed on 20/01/2024 and were taken out on 21/02/2024, essentially giving one month of comparable data. After being taken to the GFT office for re-calibration a Sonde was re-deployed in site TL03 from 21/02/2024 to 24/03/2024. The sonde was redeployed at this site to give a longer period of data collection from the Dargoal Burn. Site TL03 was chosen because the largest volume of pre-restoration data is available from this monitoring site.

EXO1 Sondes recorded water quality parameters at 15-minute intervals after deployment. At each site pH, Dissolved Organic Matter (DOM), Dissolved Oxygen (DO), conductivity, and depth were recorded. Of the sensors available from the manufacturer each parameter was chosen for the following reason:

- pH – acidification of upland waterbodies on base-poor geology is a significant problem within the Galloway region. Several scientific papers have linked degraded peat with increased acidification in watercourses.
- Dissolved Organic Matter – as extensive drainage is often the primary cause of damage to Peatlands and as the drainage results in the peat eroding around the drains and entering watercourses DOM represents a direct measure of the levels of suspended solids within watercourses.
- Dissolved Oxygen – as peat is partly decomposed organic matter decomposition is likely to continue (but at a faster oxidised rate) when it enters rivers/burns through bacterial action. The increase in bacteria associated with increased volumes of organic matter increases Biological Oxygen Demand and can lead to reduced oxygen levels within watercourses.
- Conductivity – the ease at which an electric current can pass through water is directly related to the level of particulate matter in the watercourse. As such conductivity represents another method of recording the volume of suspended solids resulting from Peatland erosion.
- Depth – to give an indication of flow so it can be used to assess impacts of changes in flow/rainfall.

SEPA record flow data at their River Bladnoch gauging station at Lower Malzie in the lower river. The data was requested with the intent of using it instead of the depth data due to it being a more accurate indication of flow. However, the location of the gauging station is much further downstream within a much larger channel and there was a large lag between changes in the depth readings and the associated change in flow at the SEPA gauging station.

Sondes were calibrated before being deployed. The Sondes were held in place submerged within monitoring sites using frames constructed out of drainpipe and supported by wooden stobs as shown in Picture 1.

Picture 1: GFT frame designed for the support of EXO1 Sondes

The Sondes are located within the lower, submerged sections of pipe, which are perforated to allow water to pass through.

The parameters measured, the calibration interval (one month) and the method of deployment are standard for all GFT PA funded continual water quality monitoring.

2.2 River Bladnoch electrofishing data review

GFT has been carrying out electrofishing surveys to assess juvenile salmonid populations on the River Bladnoch since the late 1990's, with sites having been visited on and off between 1997 and 2023. Bladnoch electrofishing sites have been chosen and/or visited for several purposes. These include general monitoring of fish populations, assessing spatial distribution, directly monitoring habitat works, consultancy work and investigative work (e.g. investigating the impacts of barriers or acidification on fish populations). The period within which each site was visited, and the number of times each site has been repeated, varies greatly between electrofishing sites. As the purpose of this electrofishing review is to look at the areas impacted, or potentially impacted, by acidification, the review focuses on sites within areas of base-poor geology. However, all main stem Bladnoch/Tarf sites have also been included regardless of geology to see how far downstream populations are potentially impacted by poor water quality.

The electrofishing sampling methodology adopted the electrofishing sites included within the review is one to three run area delineated sampling following the Scottish Fisheries Co-ordination Centre (SFCC) methodology (Scottish Fisheries Co-ordination Centre, 2021). This gives quantitative or semi-quantitative results based on the number of runs completed and gives, at the very least, a minimum estimate of fish density per 100 m^2 for each site. This allows, at the very least, for the first run fish density to be compared between sites, with electrofishing efficiency likely to be relatively similar between different sites. Due to the practical limitations of electrofishing the fish habitat sampled is typically shallow riffle and run habitat which is normally dominated by juvenile salmon and trout, with salmon and trout being both the target species and typically the main native fish species present within watercourses. Sites are normally visited during July, August, or September, and to a lesser extent October. This is when fry (juveniles in the first year of their life) have grown big enough to be influenced by the electrofishing process and to be identified. If/when repeated sites are typically visited as close as possible to the original date the survey was conducted (weather dependent). In all cases the results are given as a minimum density per 100 m^2 based on a single electrofishing run. Whilst this does not give the actual density and underrepresents the fish numbers present, it does allow a comparison between equal sampling effort between all sites regardless of the numbers of runs completed. The results given in this report are for the fry (0-year-old "young-of-the-year") stage of salmon and trout. Fry are chosen as their movements from the areas in which they were spawned are more limited than older life stages (Hesthagen, 1988) and therefore give the most accurate indication of whether the eggs of salmon and trout can develop and hatch (the stage most susceptible to the impacts of acidification). As such, fry give the best indication of any potential impacts on fish populations caused by acidification. Where electrofishing sites have been visited on six or more occasions the individual results for these sites are shown individually to show long term trends in numbers. Only a relatively small number of sites have enough data to show the long-term trends for individual sites. Therefore, to allow some sort of comparison that can be used to assess whether there have been changes in trout and salmon numbers over time, the results have been assigned into three roughly equal time periods – 1997 to 2005; 2006 to 2014 and 2015 to 2023. Where a site has had more than one visit during a given period the results have been averaged. It should also be noted that salmon and trout tend to segregate at spawning time with salmon spawning in larger, wider channels (rivers) and trout in smaller, narrower channels (burns). The exact channel width at which salmon spawning changes to trout spawning varies from location to location (and can overlap) but, for the most part, shallow riffles and runs within burns under 2 - 3 m average width should be dominated by trout fry (with salmon fry often absent), with larger channels dominated by salmon fry. This has been considered within the data analysis with salmon fry results shown for larger channels, trout fry results shown for burns and both shown where salmon and trout fry overlap. To aid with data analysis a scoring/rating system for salmon and trout fry densities was developed by Godfrey (2006) using data collected from 1,638 Scottish electrofishing survey sites covering the period 1997 to 2002. From this, regional figures were created to allow more accurate local 'density ranges' with the Solway region scorings/ratings shown in Table 2. Colour coding has been added to help visualize results shown on maps.

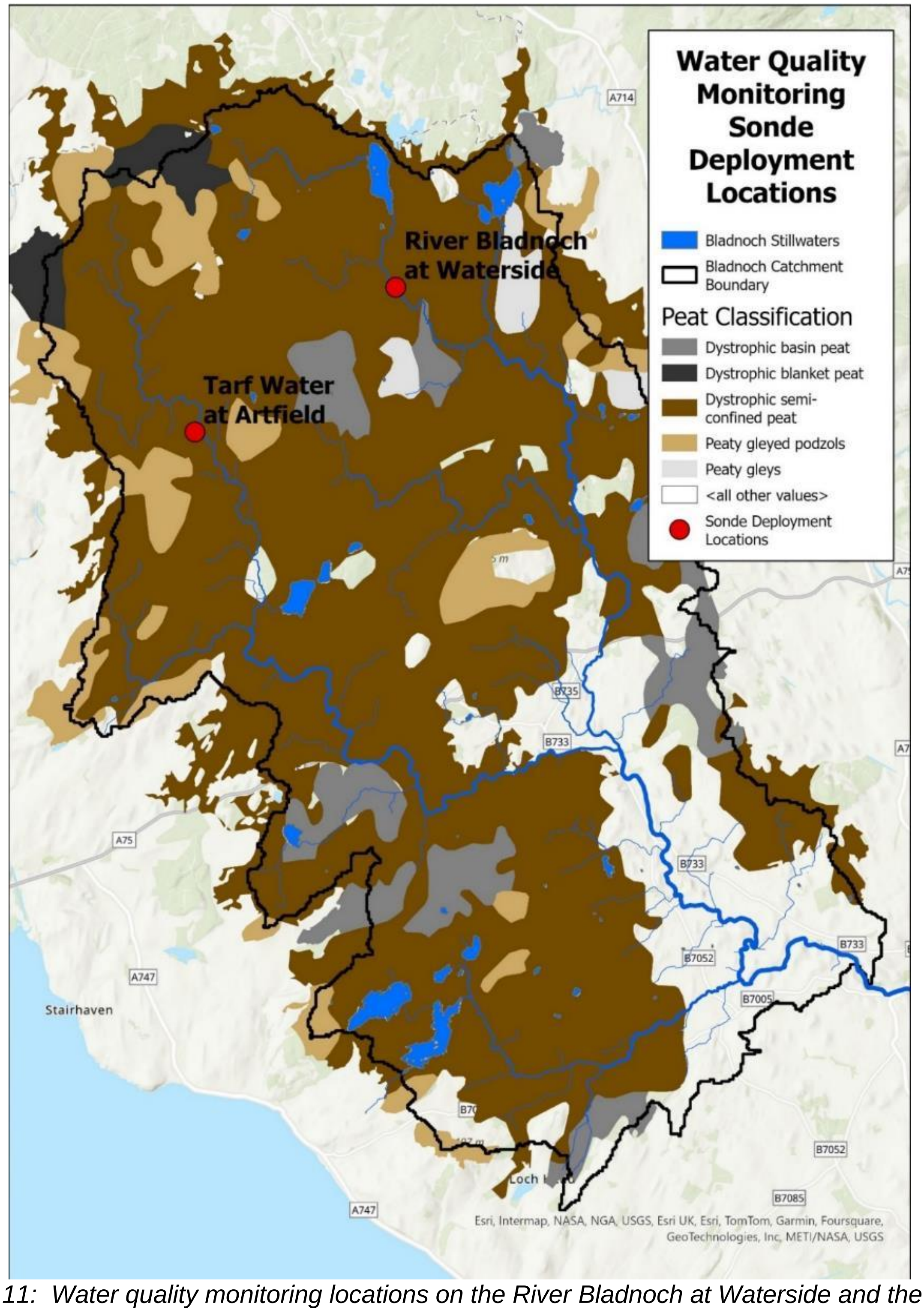
Table 2: Minimum density per 100 m^2 ranges for juvenile trout and salmon fry based on one-run electrofishing events, calculated on densities > 0 over 291 sites in the Solway Statistical Region

Fry Density Rating	Salmon Fry Density Range	Trout Fry Density Range
Absent	0	0
Very Low	0.01 to 5.20	0.01 to 4.13
Low	5.21 to 12.67	4.14 to 12.08
Moderate	12.68 to 25.27	12.09 to 26.62
High	25.28 to 46.52	26.63 to 56.48
Very High	46.53 +	56.49 +

2.3 River Bladnoch water quality overview

To gain an overview of water quality across the River Bladnoch catchment EXO1 Sondes were deployed at central locations on the upper Bladnoch (Grid Ref: 228948 572216) and Tarf

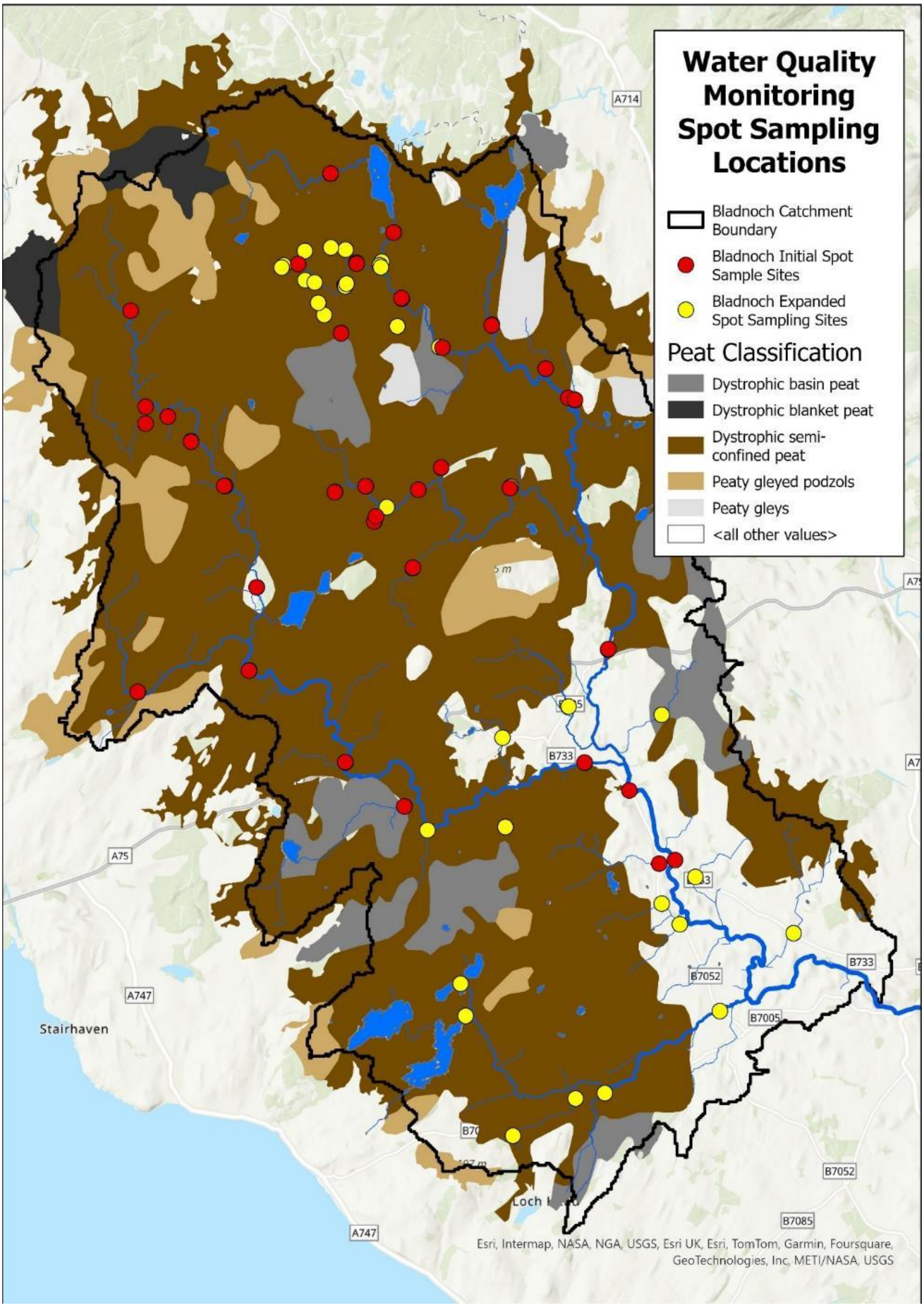
Water (Grid Ref: 223870 568483). The upper Bladnoch sonde was deployed between 29/02/2024 and 20/03/2024, with the Tarf Sonde being deployed between 04/03/2024 and 20/03/2024. The locations chosen were at Waterside (Bladnoch) and within Artfield Forest (Tarf) and are shown in Map 11. Sites were chosen within salmon spawning grounds towards the lower end of sections of river thought to be impacted by acidification, in the hope that the data would give a general overview of the variations in water quality within each location. The water quality parameters recorded are the same as those for the Tannylaggie peatland restoration monitoring, for the same reasons.



Map 11: Water quality monitoring locations on the River Bladnoch at Waterside and the Tarf Water within Artfield Forest

In addition to the deployment of the EXO1 Sondes spot sampling was carried out across the Bladnoch catchment. Spot sampling involves collecting water samples from chosen locations within watercourses after periods of high flows to catch pH at, or near, its lowest levels. Once collected water samples are taken back to the GFT office and water quality parameters are recorded using an EXO1 Sonde retained within the office. The same parameters are recorded as with the sondes that are deployed in the field. Spot sampling sites were spread across the whole catchment to assist in gaining a water quality overview for the river system. Whilst sondes deployed in the field provide detailed information on trends in water quality their cost limits the number of locations from which data can be collected at any one time. Although only one reading is collected from a single point in time, spot sampling allows data to be collected from many sites in a relatively short period of time allowing any spatial relationships to be investigated and allowing areas to be highlighted for more detailed investigation.

Map 12 shows the spot sampling sites within the Bladnoch catchment. Sites were chosen to give the maximum coverage possible within the time available. Based on initial results the sampling was extended to cover the lower catchment then to concentrate additional sampling around the Polbae Burn/Tannylaggie Flow area. Spot sampling was carried out on 26/01/2024, 01/02/2024, 22/02/2024, 14/03/2024, 17/03/2024 and 21/03/2024. Most sampling took place after (variable) periods of rainfall, however the sampling carried out on 06/03/2024 was conducted at relatively low flows to give an indication of how persistent/variable pH levels are within watercourses. GFT made best attempts to catch river levels at peak flows after significant floods but there was inevitably some variation in flood size during recording. Some landowners required three working days' notice to access their land. This resulted in surveys having to be arranged a minimum of three working days in advance based on weather forecasts. As a result of this combined with the exact timing of flood peaks (e.g. the middle of the night) some smaller floods were sampled, and it was not always possible to catch the flow peak.



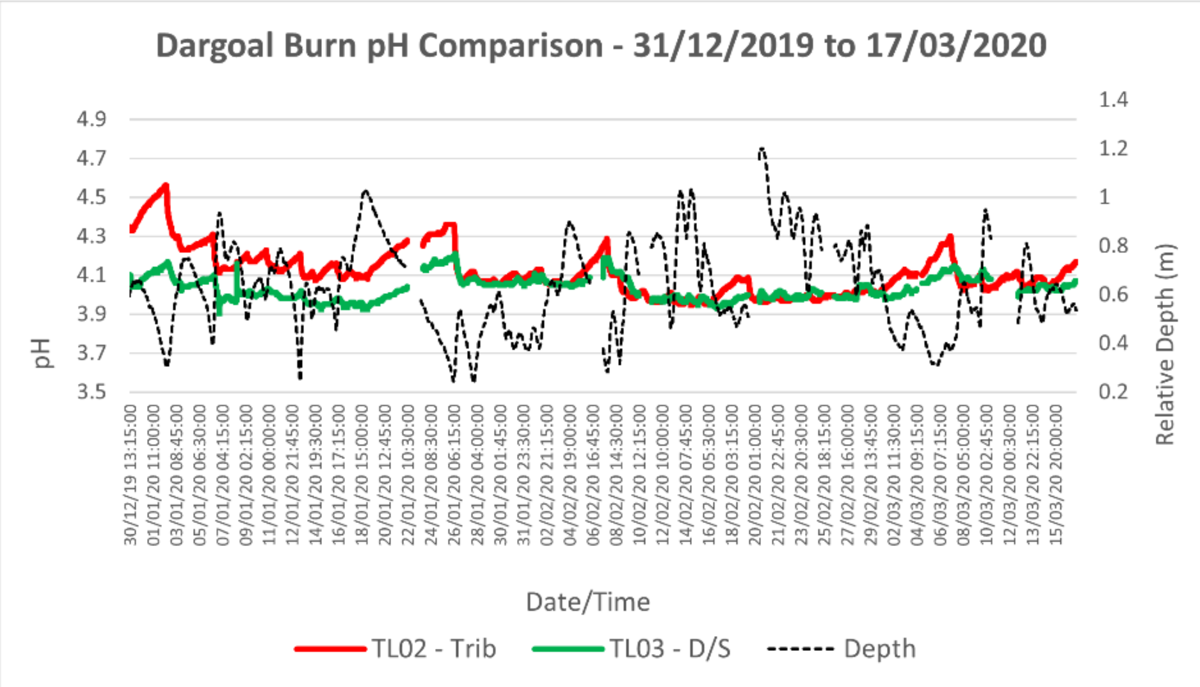
Map 12: Initial and expanded network of spot sampling sites within the Bladnoch catchment

3 RESULTS

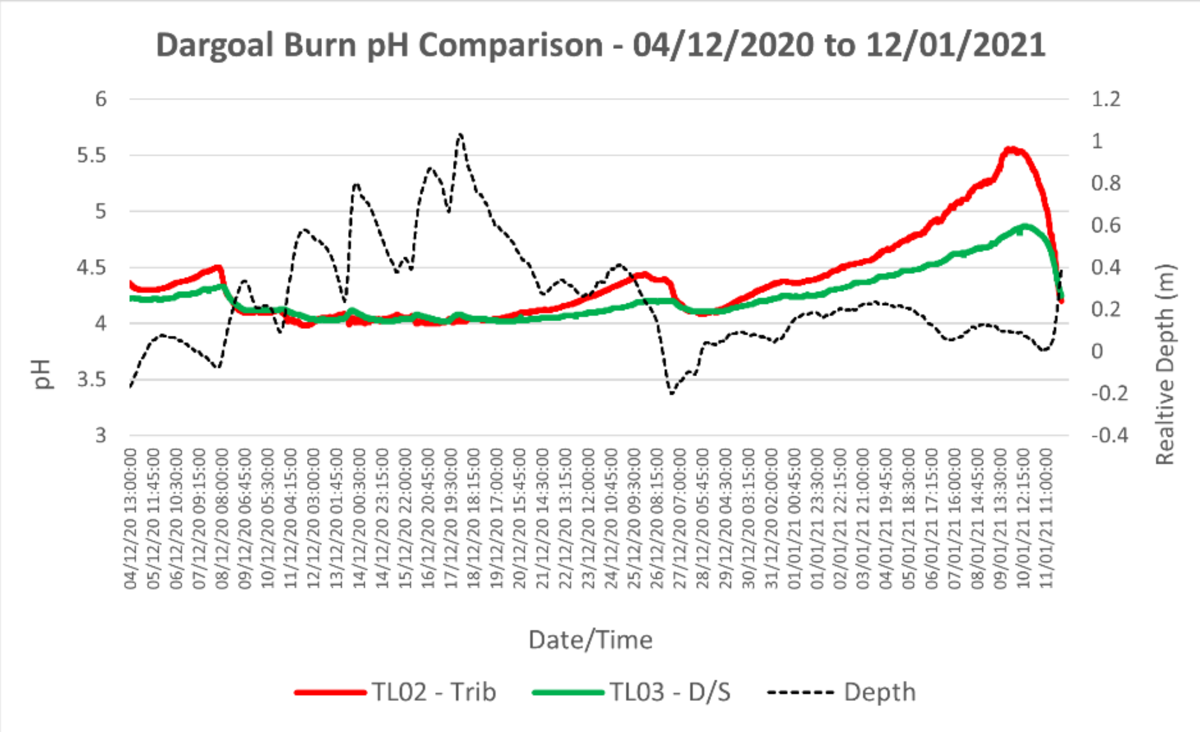
3.1 Tannylaggie peatland restoration water quality data collection

The water quality monitoring results from the Dargoal Burn during winters 2019/2020, 2020/2021, 2021/2022 and 2023/2024 are shown below in Graphs 1 to 12. The results for pH, fDOM and Dissolved Oxygen are shown. Conductivity was also recorded but fDOM is thought to be a better indication of suspended peat resulting from peatland erosion. The averages from each period are also listed in Tables 2 to 4. The data from site TL01 (upstream) for 2019/2020, 2020/2021 and 2021/2022 has, for the most part, been left out of the results due to the issues described earlier in the report. However, the pH results from winter 2020/2021 have been included to highlight the issues experienced with the data.

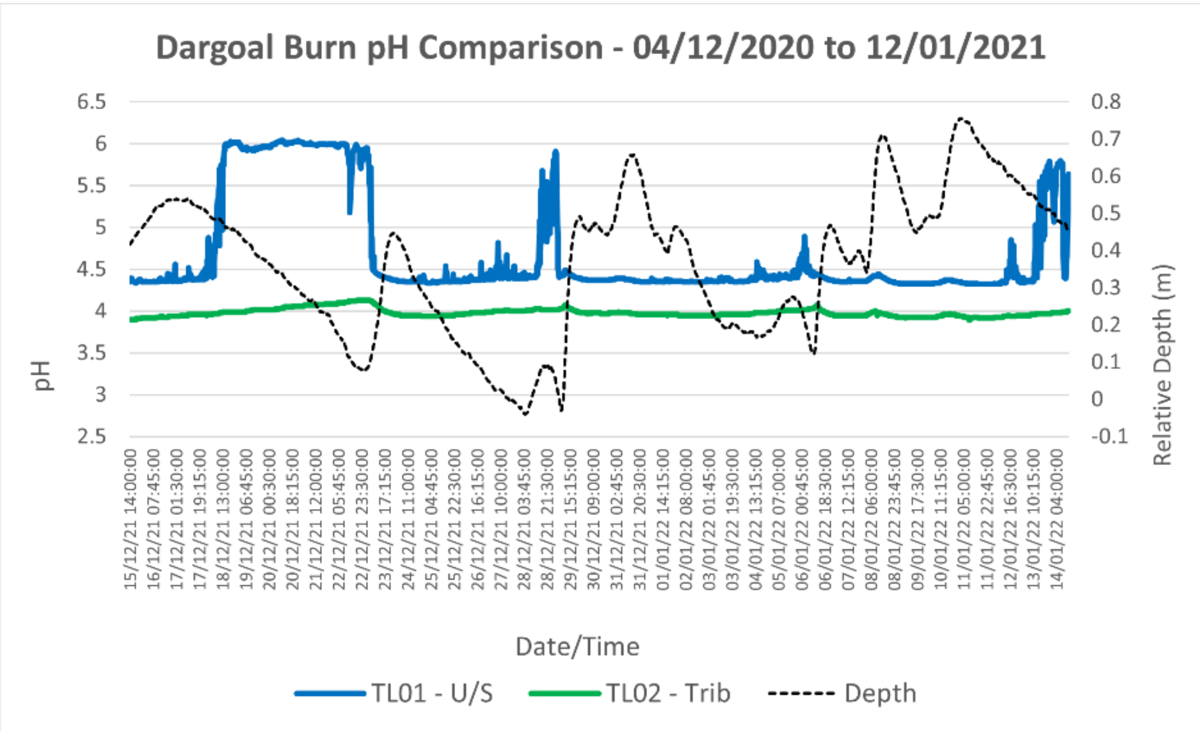
As FLS peatland restoration at Tannylaggie will be ongoing over the next few years the data prior to 2023 should be considered "pre-restoration" data whilst the winter 2023/2024 data should be considered as "during restoration" data. Even though the first stage of restoration has been completed a significant area of additional restoration is still in planning.



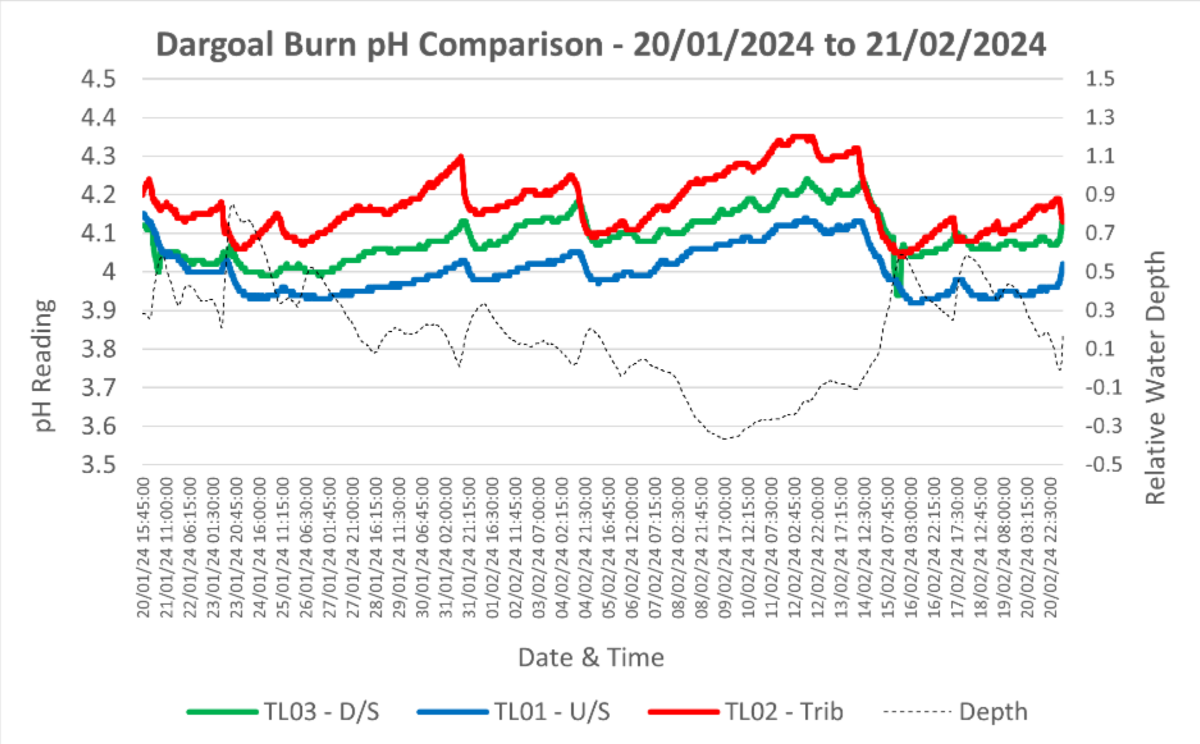
Graph1: Comparison between pH and relative water depth (m) at TL02 (tributary) and TL03 (downstream) on the Dargoal Burn during winter 2019/2020



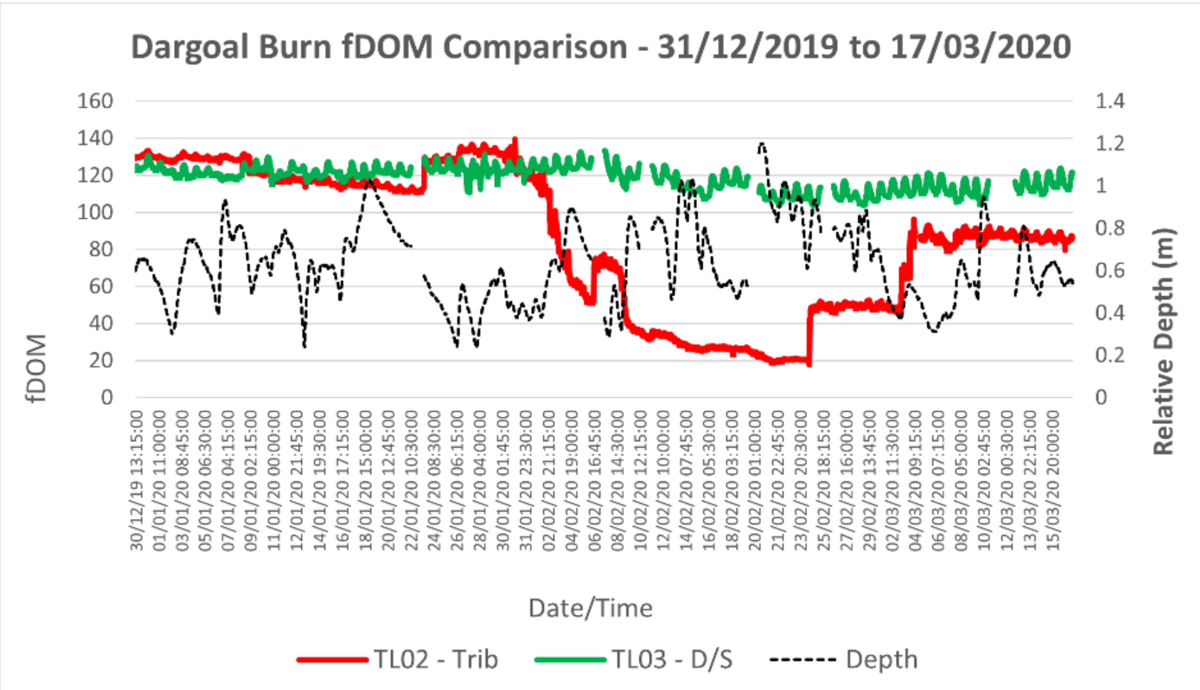
Graph 2: Comparison between pH and relative water depth (m) at TL02 (tributary) and TL03 (downstream) on the Dargoal Burn during winter 2020/2021



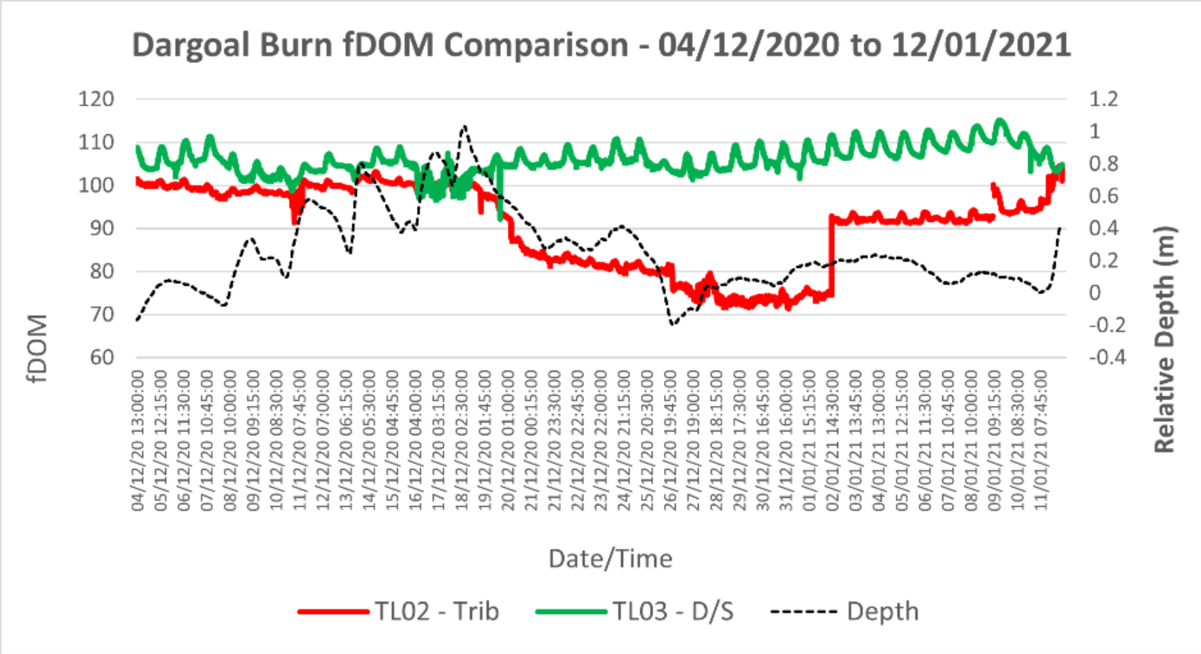
Graph 3: Comparison between pH and relative water depth (m) at TL01 (upstream) and TL03 (downstream) on the Dargoal Burn during winter 2021/2022



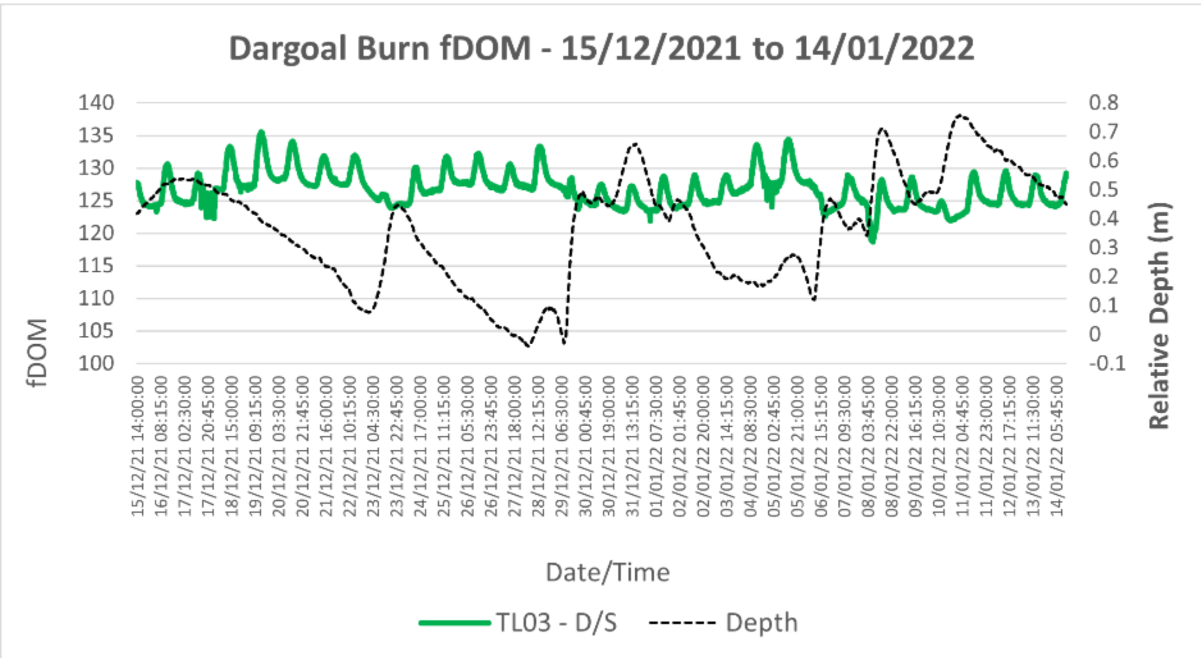
Graph 4: Comparison between pH and relative water depth (m) at TL01 (upstream), TL02 (tributary) and TL03 (downstream) on the Dargoal Burn during winter 2023/2024



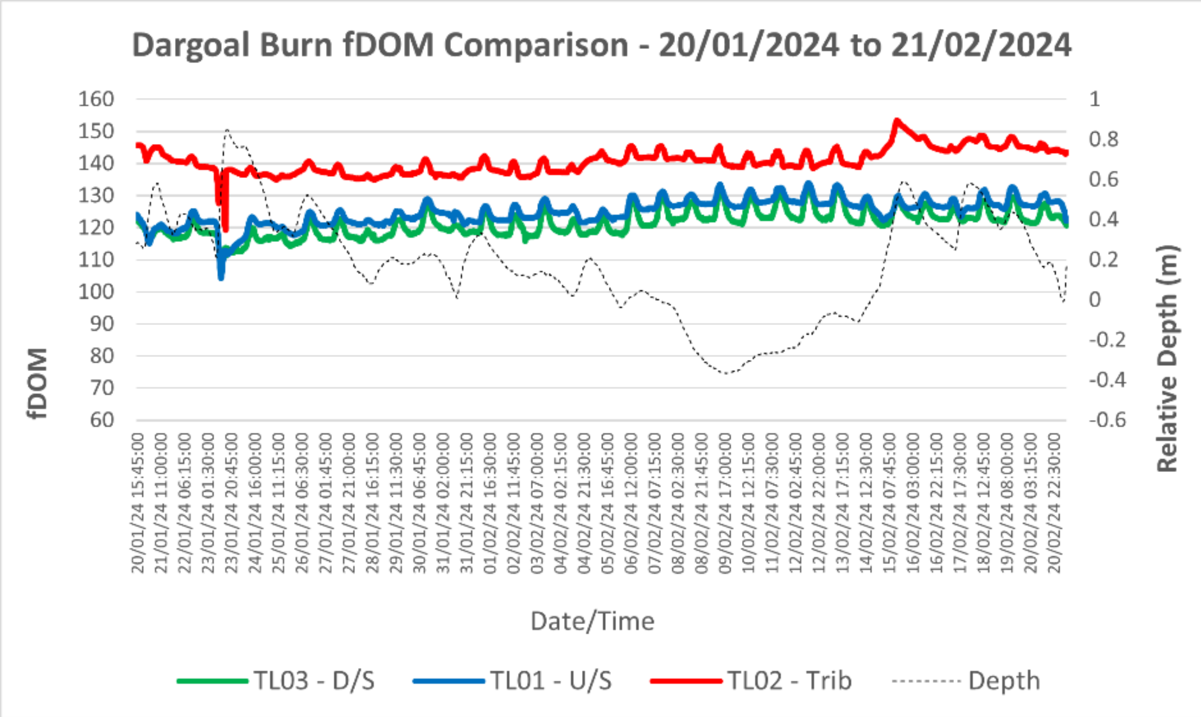
Graph 5: Comparison between fDOM and relative water depth (m) at TL02 (tributary) and TL03 (downstream) on the Dargoal Burn during winter 2019/2020



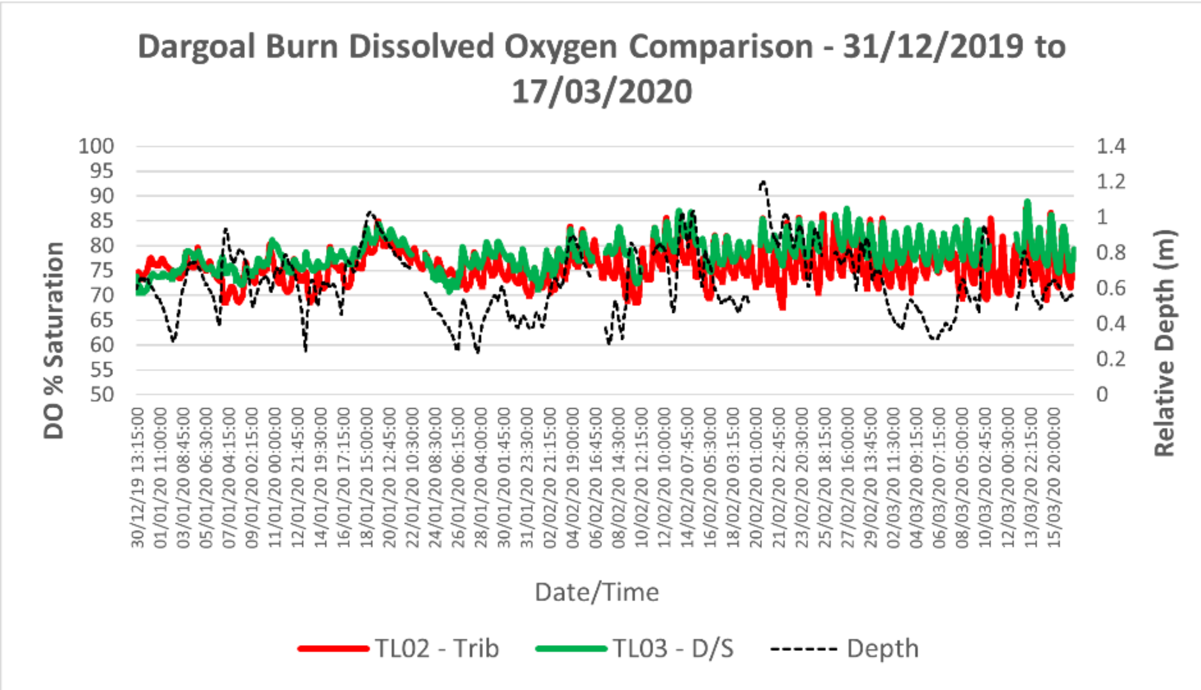
Graph 6: Comparison between fDOM and relative water depth (m) at TL02 (tributary) and TL03 (downstream) on the Dargoal Burn during winter 2020/2021



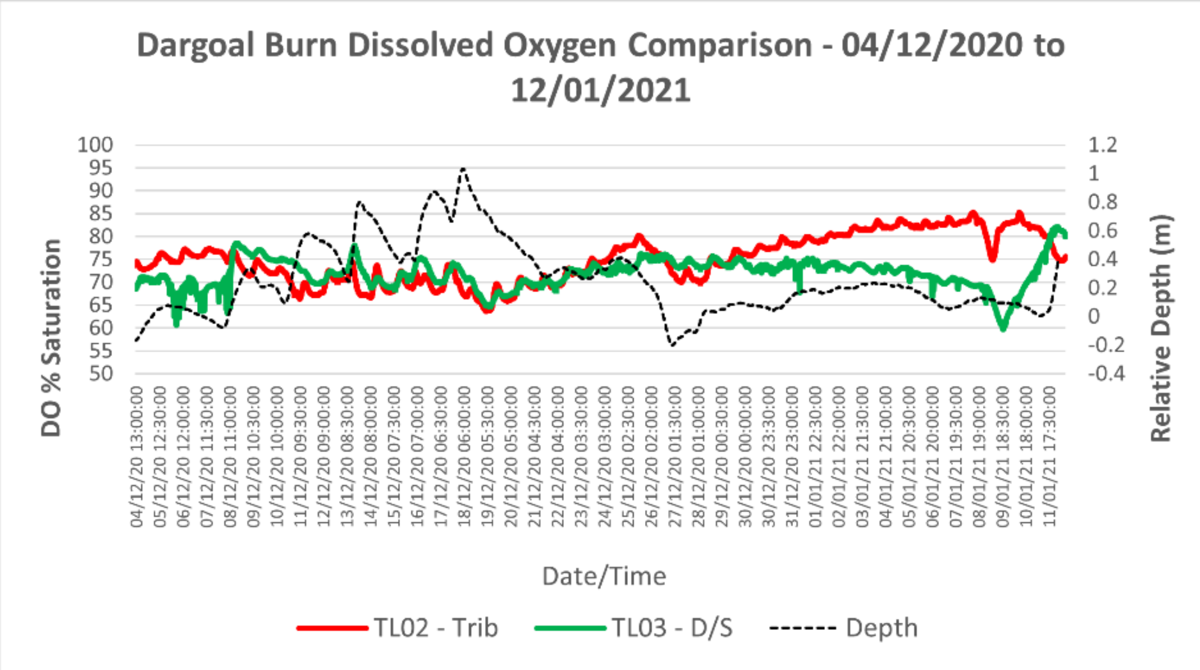
Graph 7: Comparison between fDOM and relative water depth (m) at TL03 (downstream) on the Dargoal Burn during winter 2021/2022



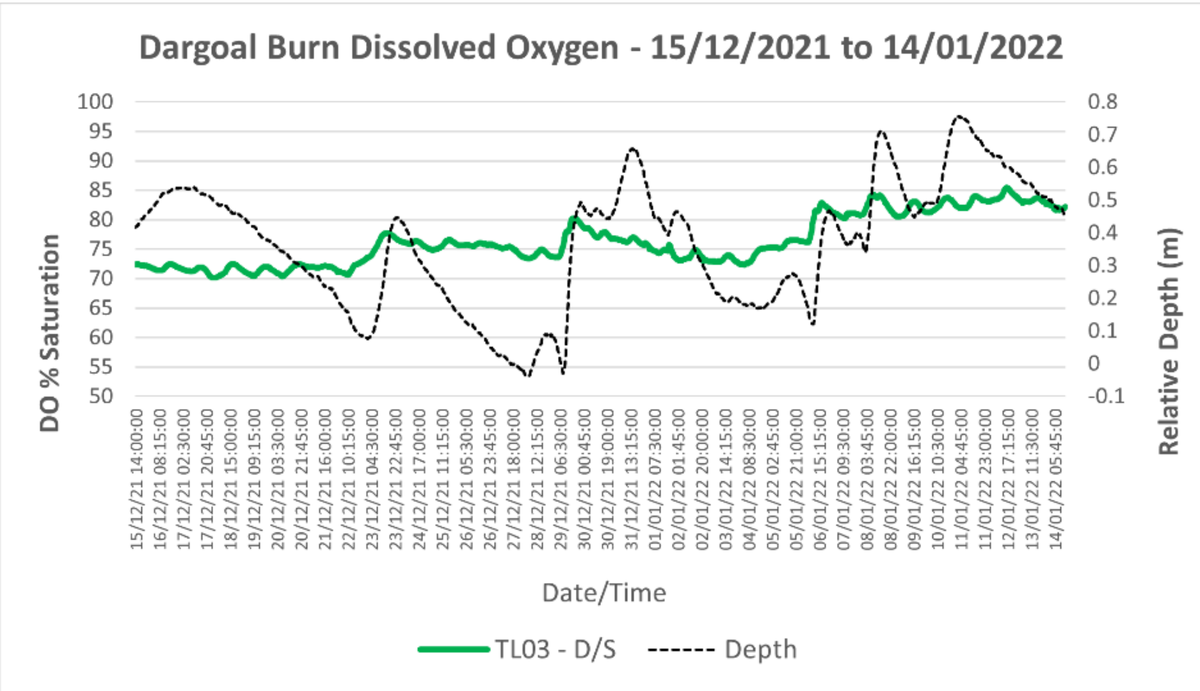
Graph 8: Comparison between fDOM and relative water depth (m) at TL01 (upstream), TL02 (tributary) and TL03 (downstream) on the Dargoal Burn during winter 2023/2024



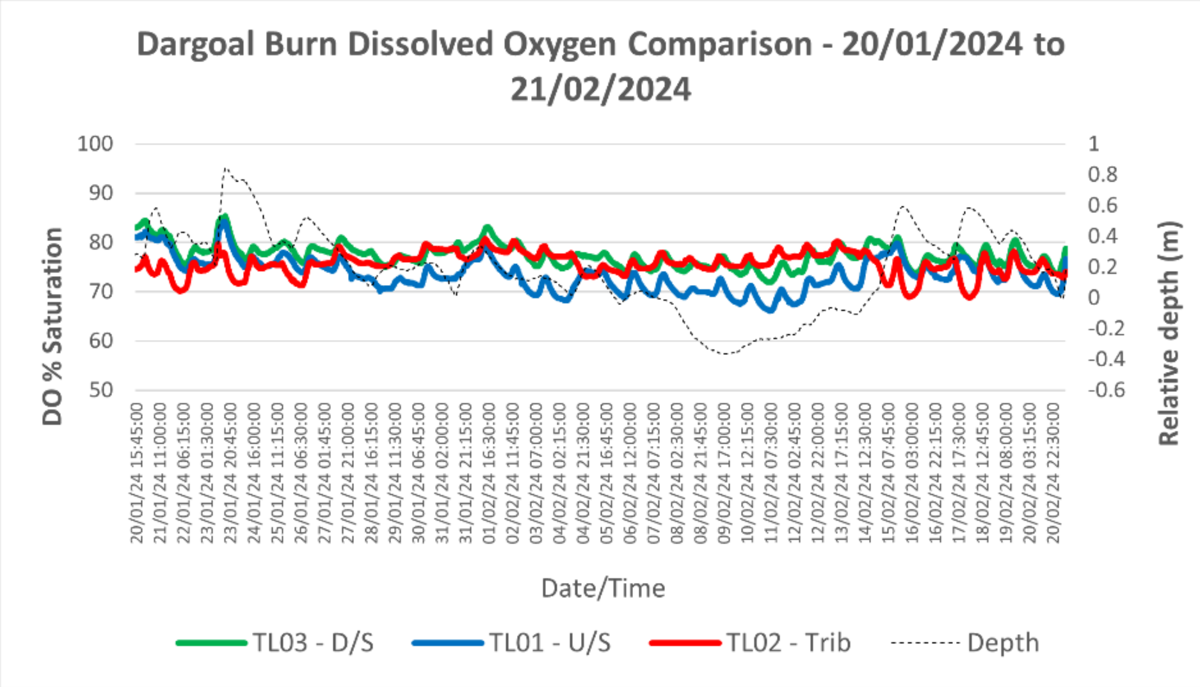
Graph 9: Comparison between Dissolved Oxygen and relative water depth (m) at TL02 (tributary) and TL03 (downstream) on the Dargoal Burn during winter 2019/2020



Graph 10: Comparison between Dissolved Oxygen and relative water depth (m) at TL02 (tributary) and TL03 (downstream) on the Dargoal Burn during winter 2020/2021



Graph 11: Comparison between Dissolved Oxygen and relative water depth (m) at TL03 (downstream) on the Dargoal Burn during winter 2021/2022



Graph 12: Comparison between Dissolved Oxygen and relative water depth (m) at TL01 (upstream), TL02 (tributary) and TL03 (downstream) on the Dargoal Burn during winter 2023/2024

Table 3: Dargoal Burn pH averages for each monitoring period

Site	*Winter 2019/2020*	*Winter 2020/2021*	*Winter 2021/2022*	*Winter 2023/2024*
TL01	-	-	-	*4.00*
TL02	*4.11*	*4.37*	-	*4.17*
TL03	*4.03*	*4.24*	*3.98*	*4.09*

Table 4: Dargoal Burn fDOM averages for each monitoring period

Site	*Winter 2019/2020*	*Winter 2020/2021*	*Winter 2021/2022*	*Winter 2023/2024*
TL01	-	-	-	*124.9*
TL02	*86.1*	*90.54*	-	*140.7*
TL03	*118.6*	*106.2*	*126.28*	*121.4*

Table 5: Dargoal Burn Dissolved Oxygen (% saturation) averages for each monitoring period

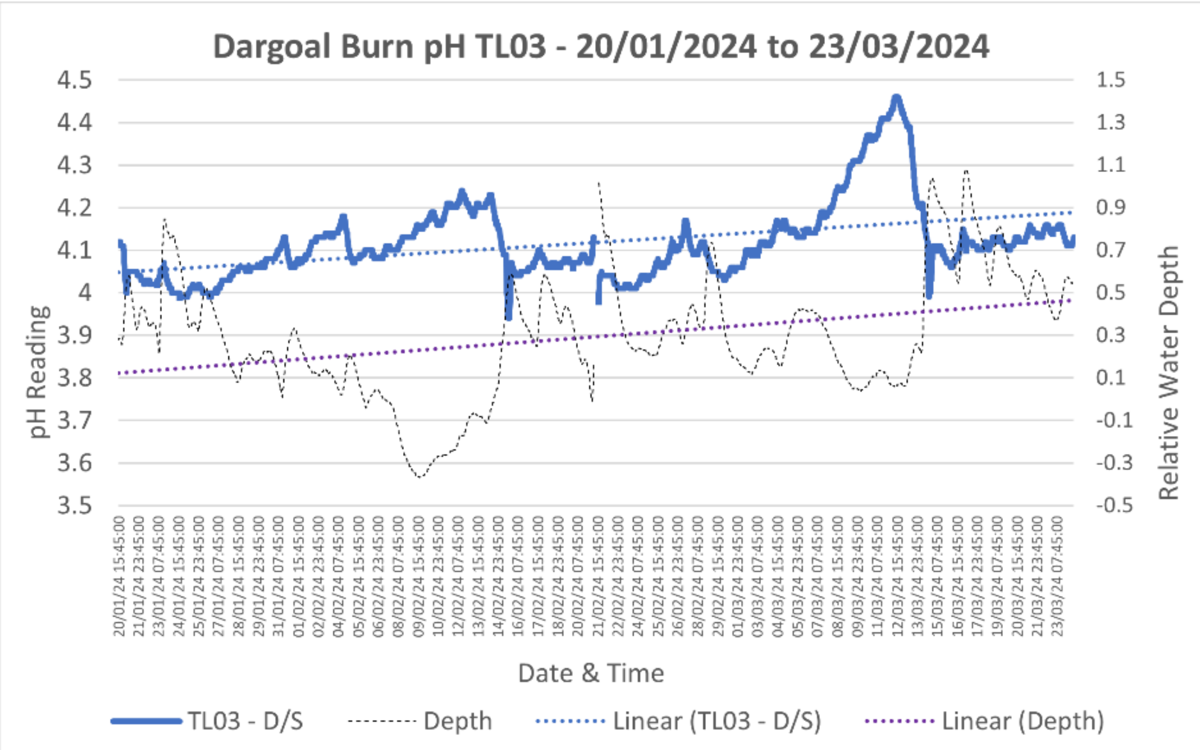
Site	*Winter 2019/2020*	*Winter 2020/2021*	*Winter 2021/2022*	*Winter 2023/2024*
TL01	-	-	-	*73.5*
TL02	*75.8*	*75.1*	-	*75.7*
TL03	*78.4*	*71.9*	*76.4*	*77.4*

A consistent pattern appears evident within the data. Whilst acidified, the pH in the Dargoal tributary TL02 is typically less acidic than the pH in the Dargoal Burn. This appears to have a slight diluting effect with the site above the tributary (TL01) being slightly more acidic that the downstream site (TL03). Despite peatland restoration being underway at the current point in data collection the pH averages show no obvious sign of change with flow levels being the most likely driver of the relatively small variations seen between years.

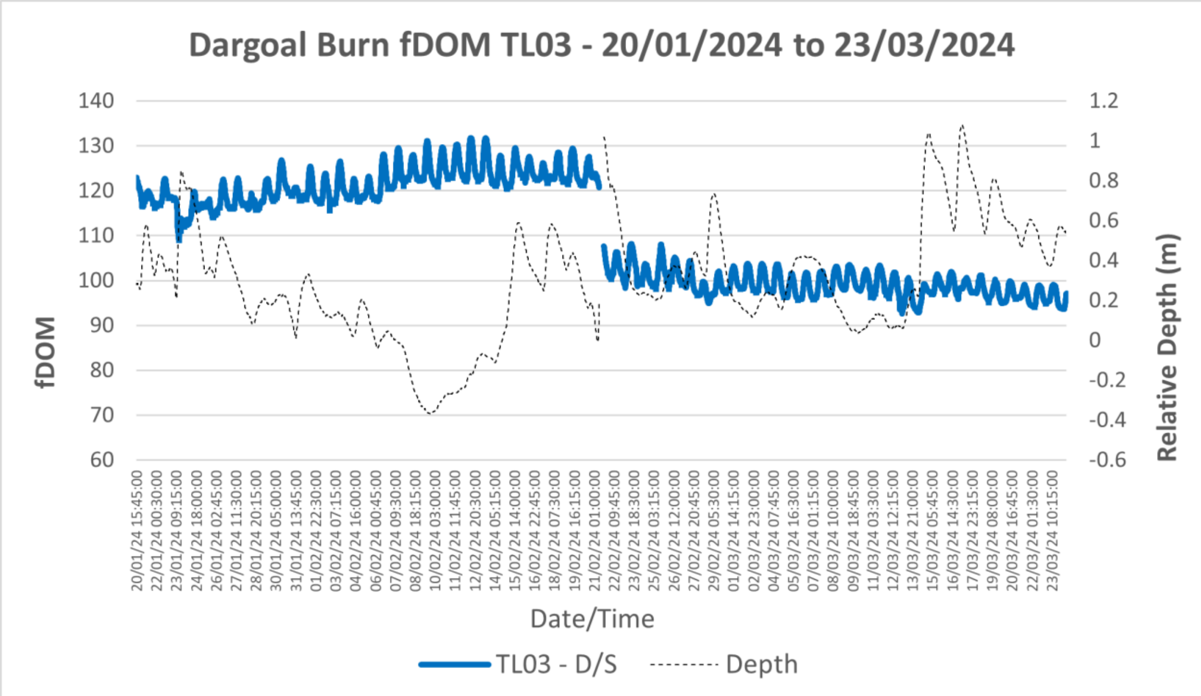
In contrast to the pH results the fDOM results show more variability between winters. It should also be noted that there are periods of recorded data from TL02 (tributary) during winter 2019/2020 and 2020/2021 where the results suddenly drop in a manner that is inconsistent with the other sites and years, suggesting a possible issue with the sensor at these points. As such the fDOM averages for 2019/2020 and 2021/2022 should be taken with a "pinch of salt". Looking at the Graphs, when considering the periods of reliable recording the fDOM results from 2024 show no large-scale changes between years, except in the case of site TL02 (tributary) which records higher levels in 2024. This may be because of disturbance from the recently restored section of peatland. If this is the case, then levels should improve as the peatland settles, repairs and the vegetation re-establishes.

As has been described in previous reports the relatively low Dissolved Oxygen levels in the Dargoal Burn remain a cause for concern for aquatic life, with the 2024 results continuing the trend of low levels being recorded.

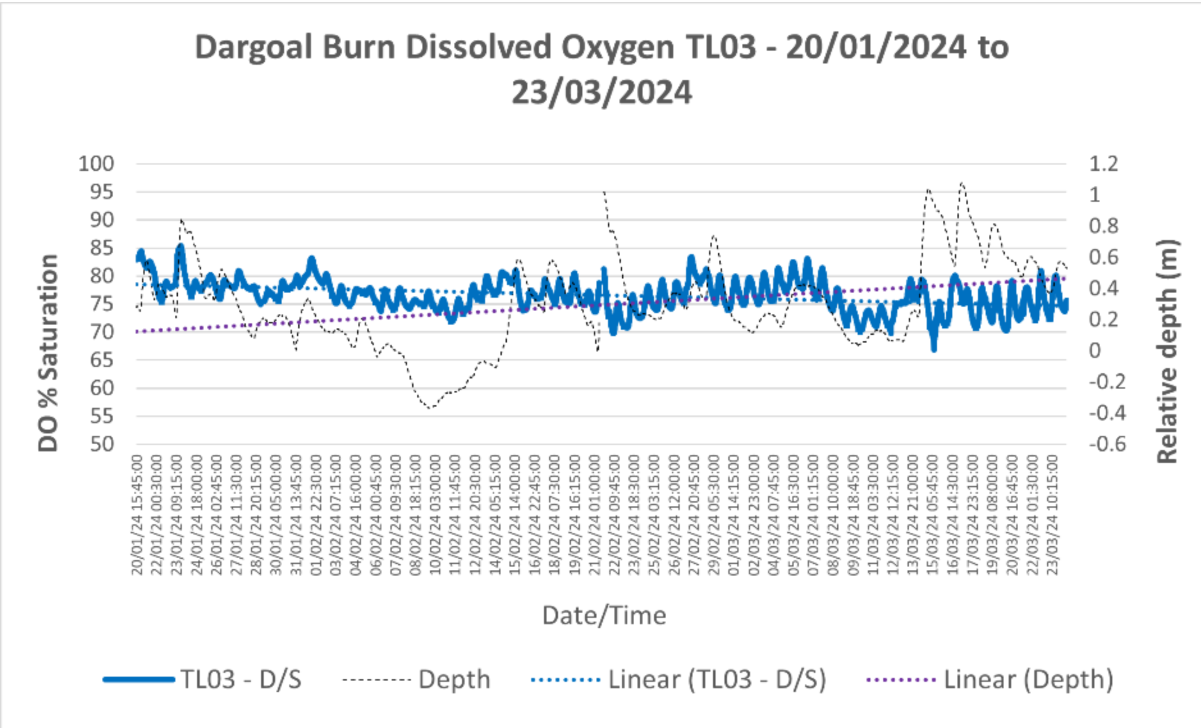
The results from the extended monitoring from site TL03 in early 2024 are shown in Graphs 13 to 15.



Graph 13: pH readings against relative depth for Site TL03 (downstream) during winter 2023/2024



Graph 14: fDOM readings against relative depth for Site TL03 (downstream) during winter 2023/2024

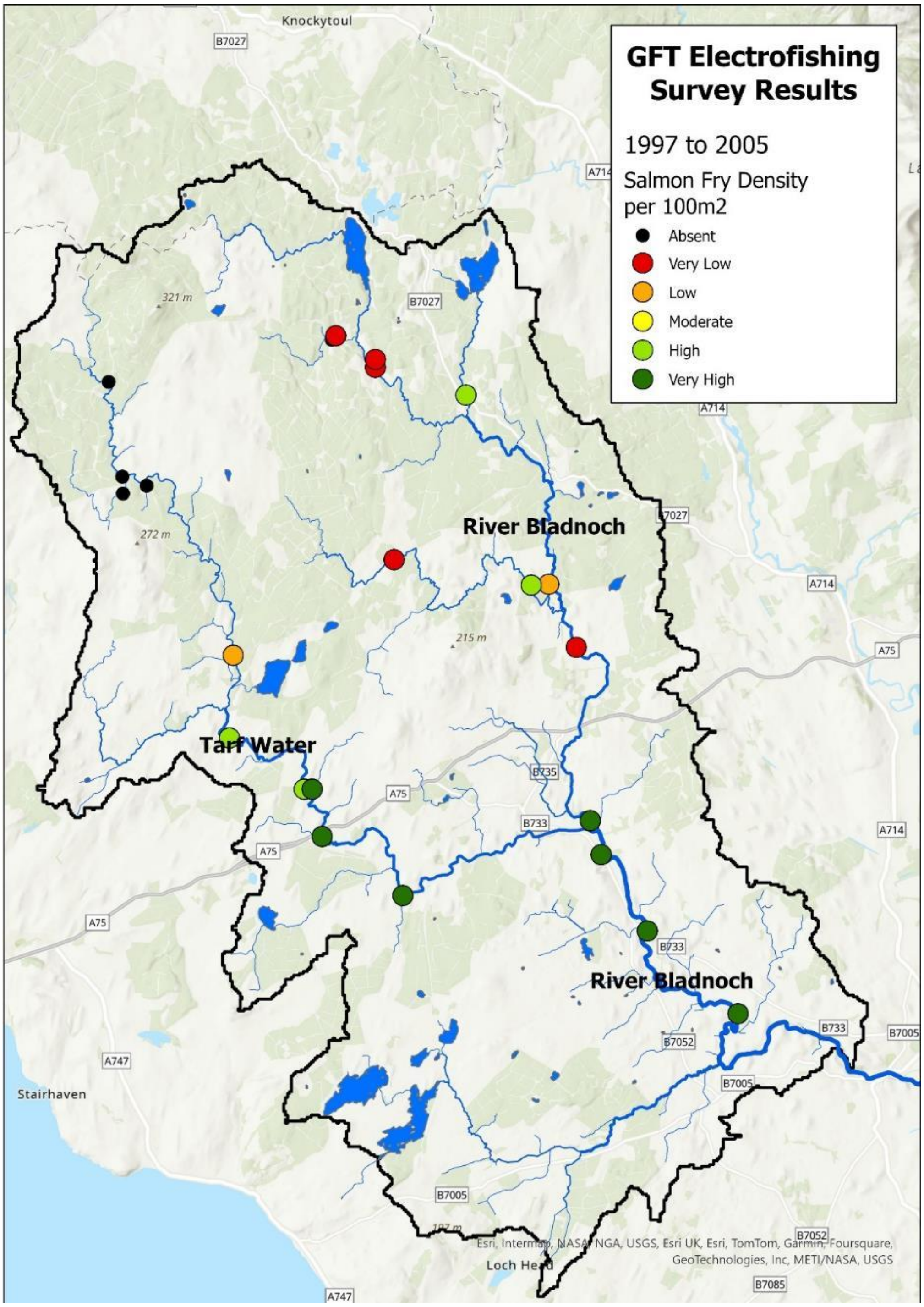


Graph 15: DO readings against relative depth for Site TL03 (downstream) during winter 2023/2024

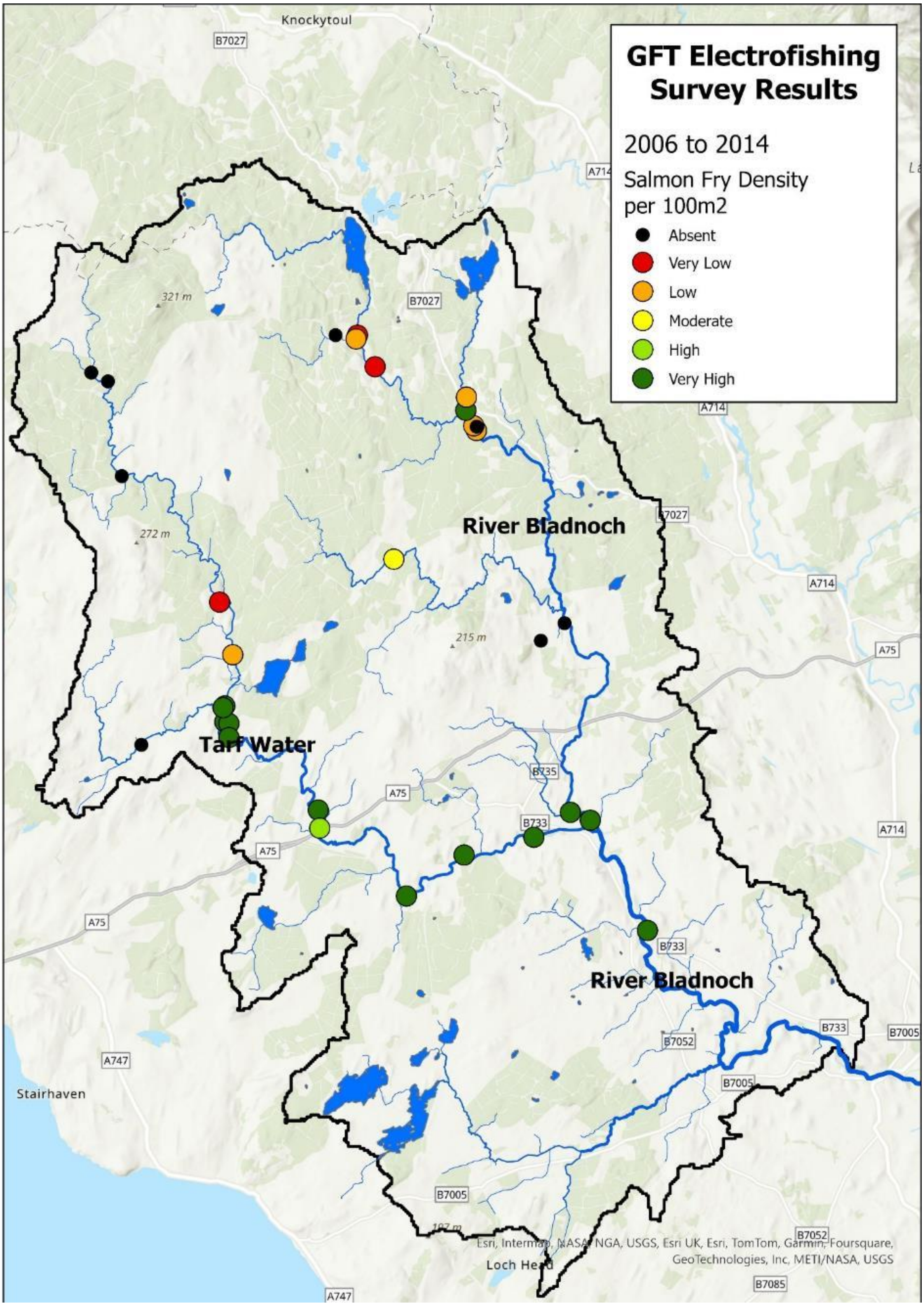
The linear trendlines for Graph 13 (pH) show overall increases in rainfall during the recording period and an overall decrease in acidity, despite there being a clear relationship between higher flows and increased acidity. This may indicate a reduction in acidity associated with increased biological activity within the watercourse as winter moves into spring. Unfortunately, trend lines could not be fitted to Graph 14 (fDOM) as there is a clear drop in the readings on the 21st February. This is the date when the sonde was taken out, re-calibrated and redeployed and, as such, most likely represents an issue with the calibration. As the readings before calibration are very similar to the results from TL01 and TL02 this indicates that the readings prior to re-calibration are the more accurate/reliable ones. The extended DO level recording in Graph 15 is consistent with those recorded previously but does show a slight trend towards decreasing DO saturation with increased flow.

3.2 River Bladnoch electrofishing data review

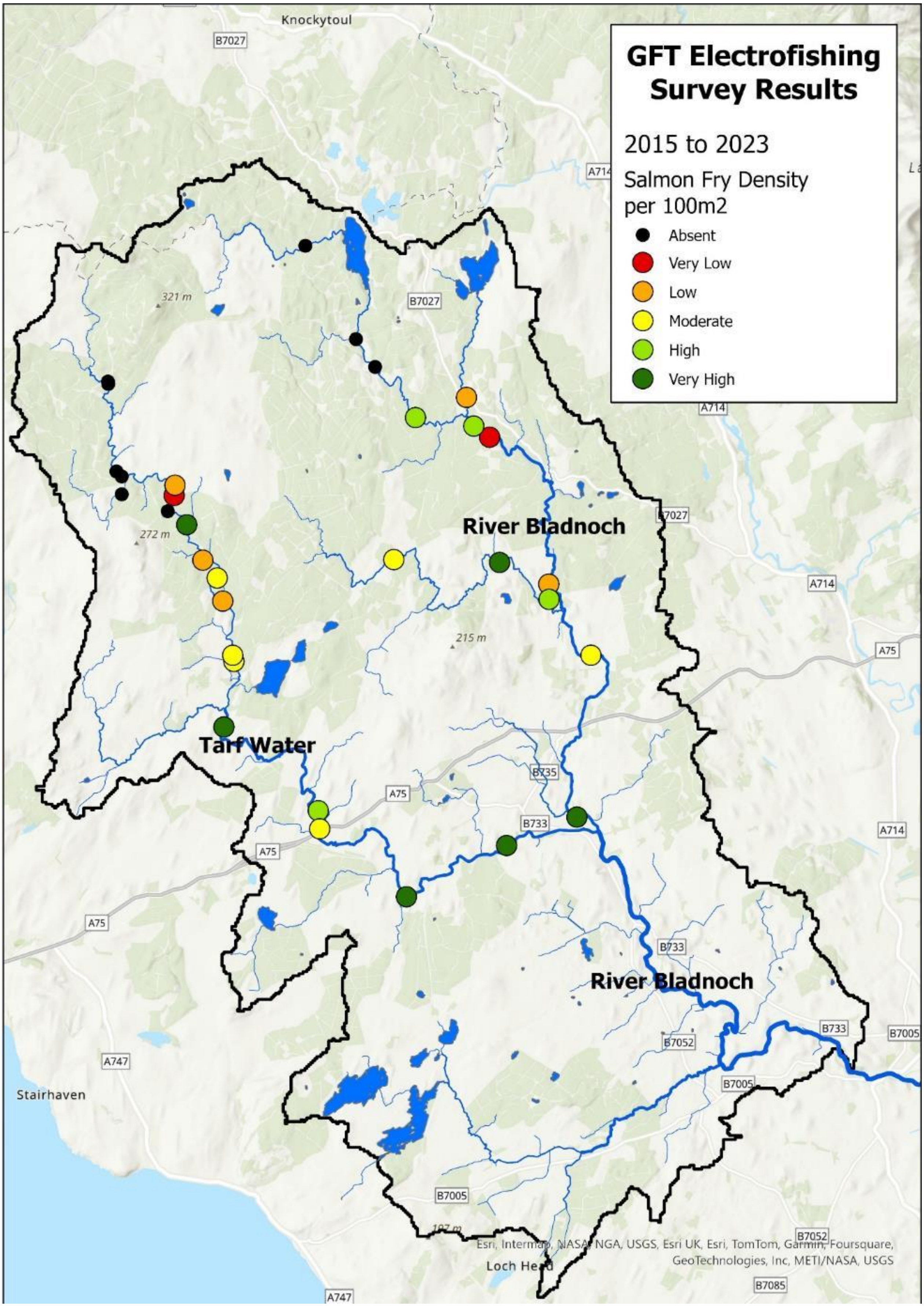
The salmon fry electrofishing results for the River Bladnoch from the 1997 – 2005, 2006 – 2014 and 2015 - 2023 time periods are shown on Maps 13 to 15. Within the maps the electrofishing results have been displayed using the colour coding described in Section 2.2.



Map 13: Bladnoch salmon fry electrofishing results from 1997 – 2005

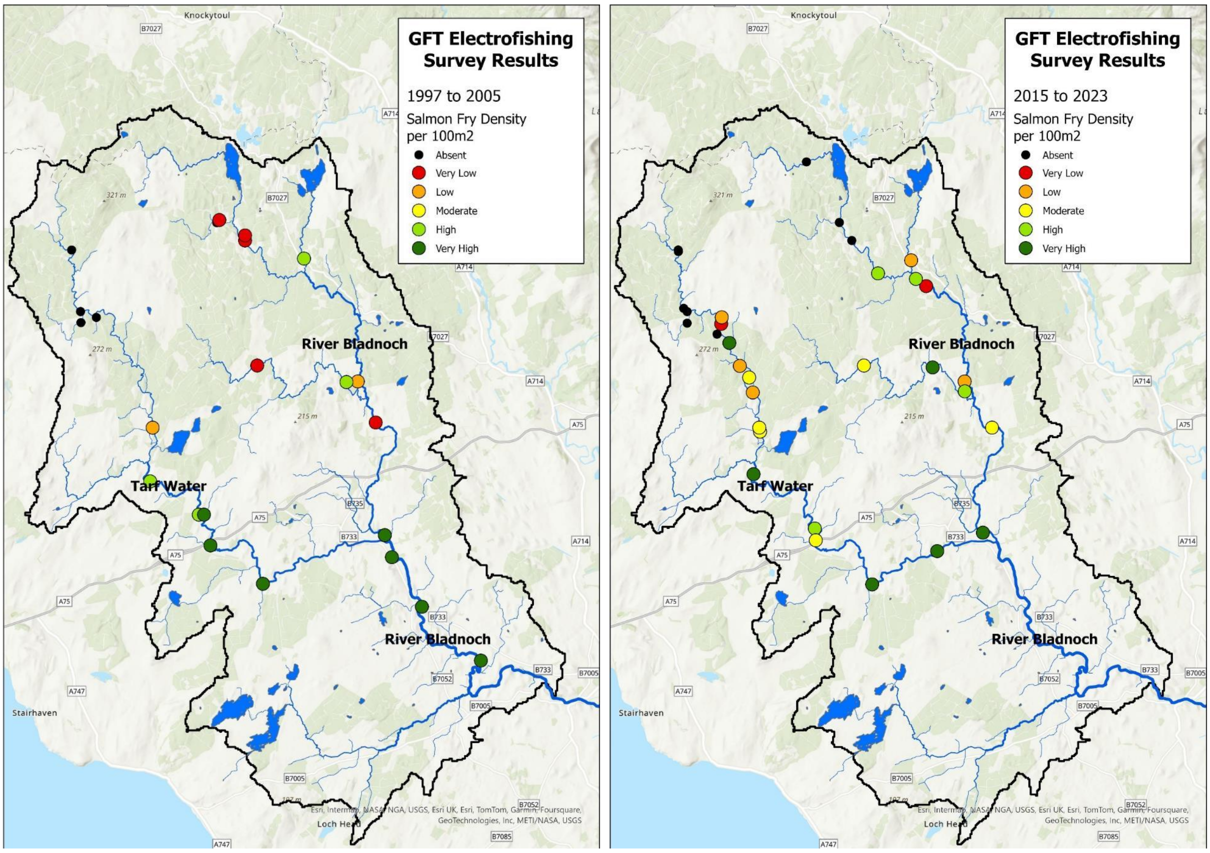


Map 14: Bladnoch salmon fry electrofishing results from 2006 – 2014



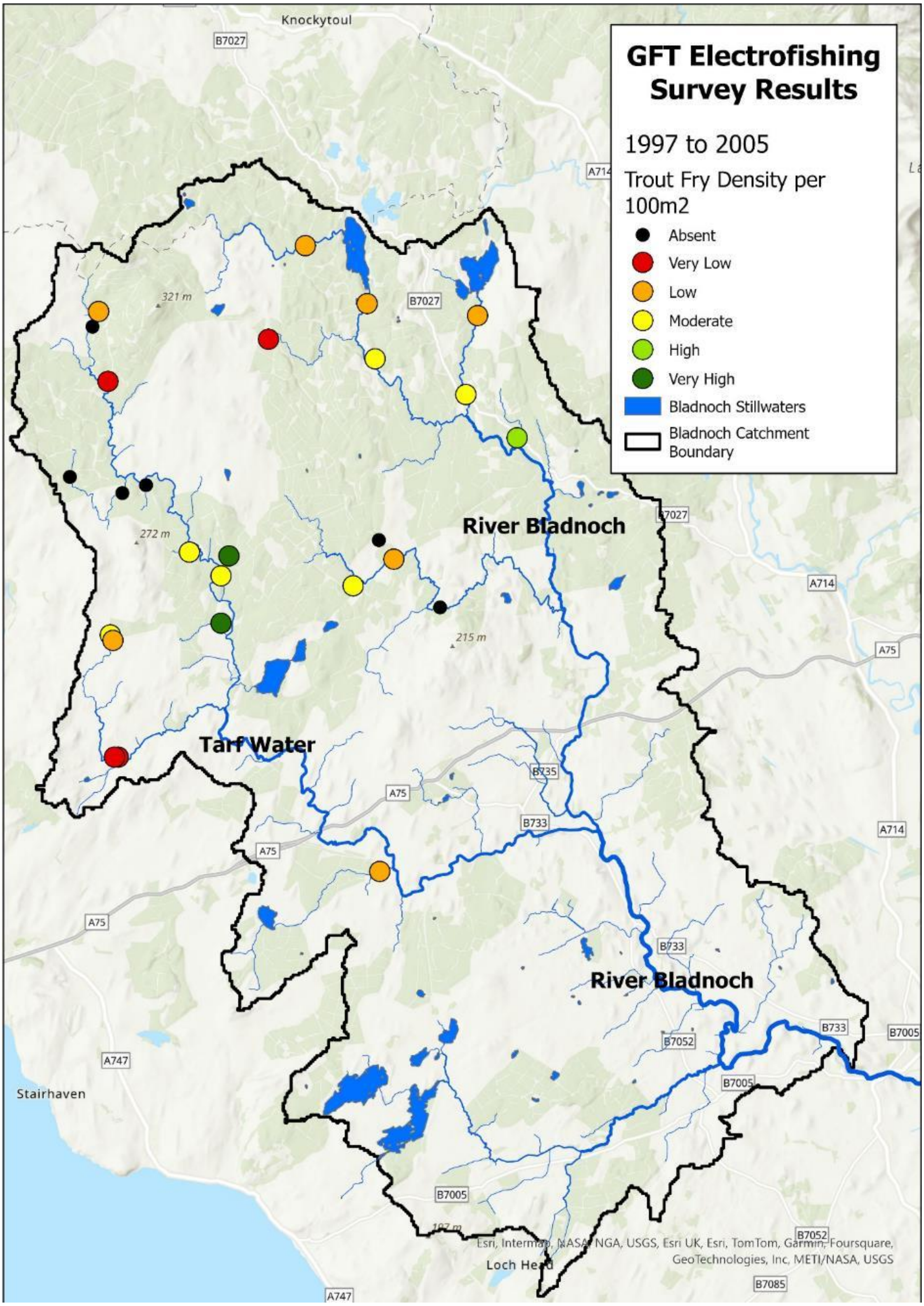
Map 15: Bladnoch salmon fry electrofishing results from 2015 – 2023

Due to the difference in the location and number of sites between each period it is difficult to draw anything statistically conclusive from the salmon fry results. However, while there does not appear to be any noticeable difference between the 1997 - 2005 and the 2006 - 2014 periods there does appear to be an improvement in juvenile salmon numbers within the 2015 - 2023 period. The improvements seen in the 2015 - 2023 results are concentrated around the mid to upper Tarf Water and mid to upper Bladnoch. This would fall in line with some recovery from acidification, as has been seen in other Galloway rivers. There is also some indication from the results that there may be some minor recovery from acidification in the mid Bladnoch, although a lack of data from the two earlier recording periods makes it very difficult to draw any strong conclusions. The continued poor results at the very top of the Bladnoch and Tarf indicate that factors are still impacting fish salmon populations in these areas and water quality issues are still on-going. This trend of limited slow recovery from acidification has also been noted in other Galloway rivers. It should also be noted that the recovery in the Tarf appears to expand further upstream than in the Bladnoch, in relation to the relative sizes of each watercourse.

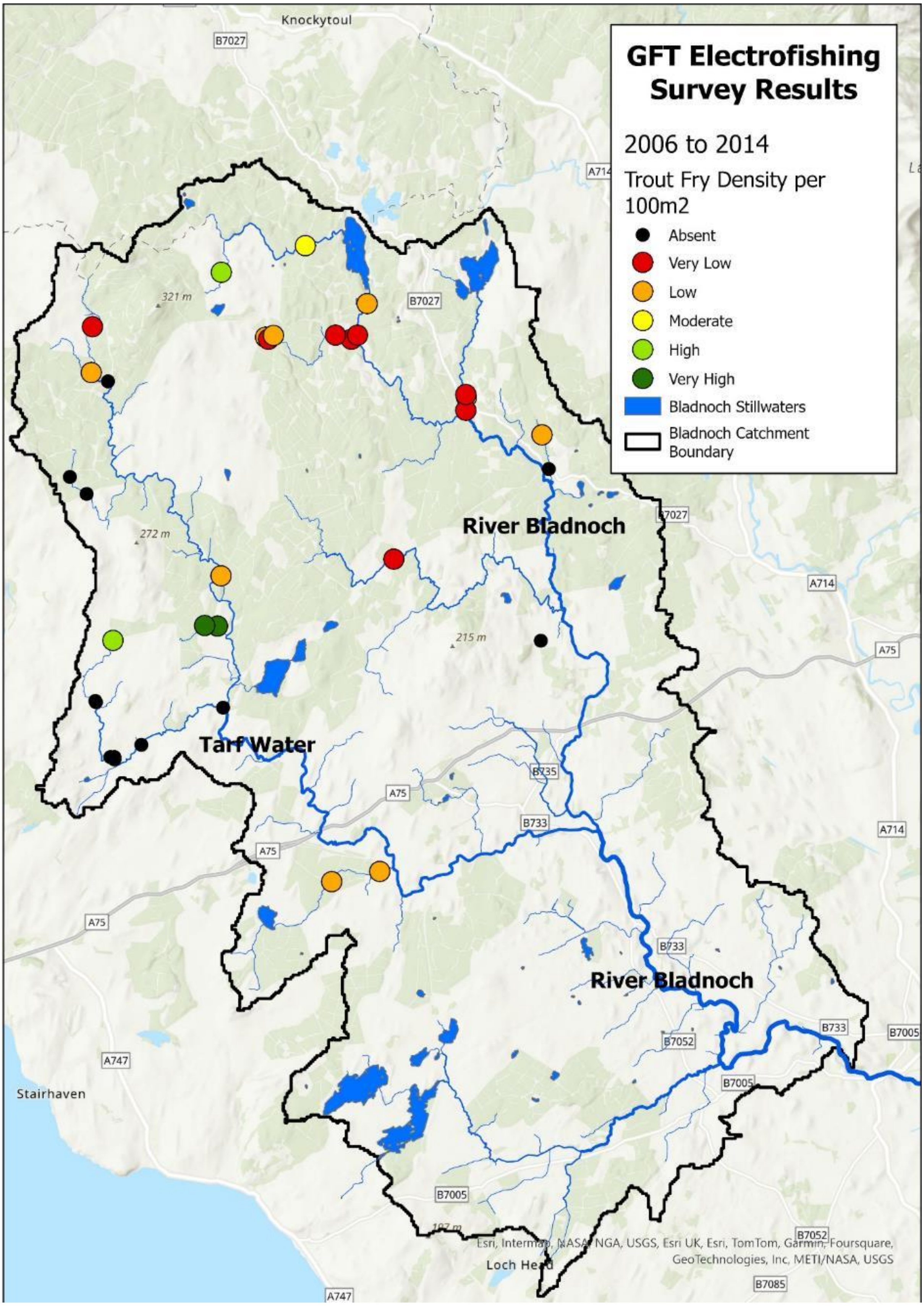


Comparison between Map 13 and Map 15 comparing salmon fry distribution and abundance between the earliest recording period (1997 – 2005, left) and latest (2015 – 2023, right)

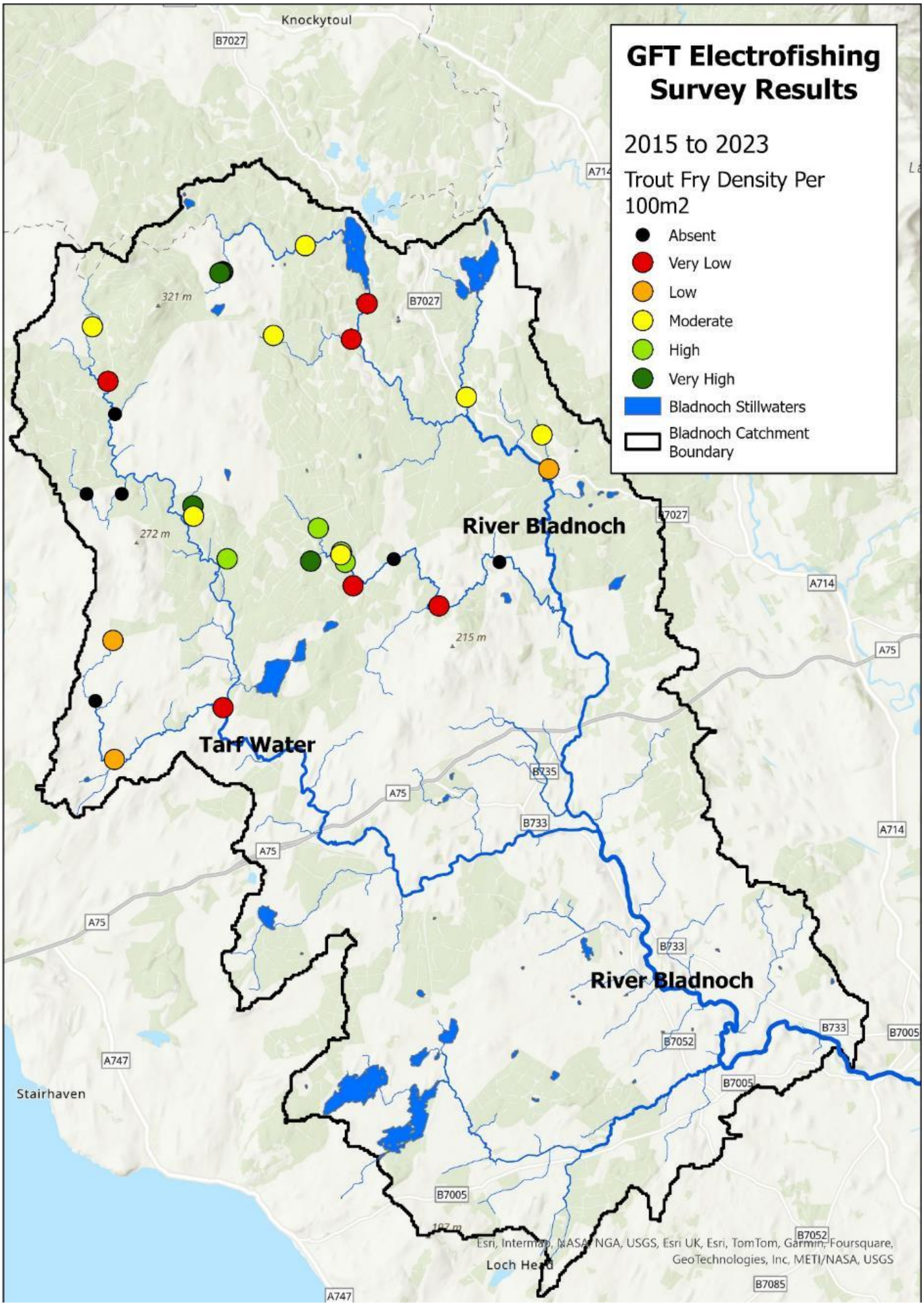
As with the salmon fry electrofishing results the trout fry results for the River Bladnoch from the 1997 - 2005, 2006 - 2014 and 2015 - 2023 time periods are shown on Maps 16 to 18. Again, within the maps the electrofishing results have been displayed using the colour coding described in Section 2.2.



Map 16: Bladnoch trout fry electrofishing results from 1997 – 2005



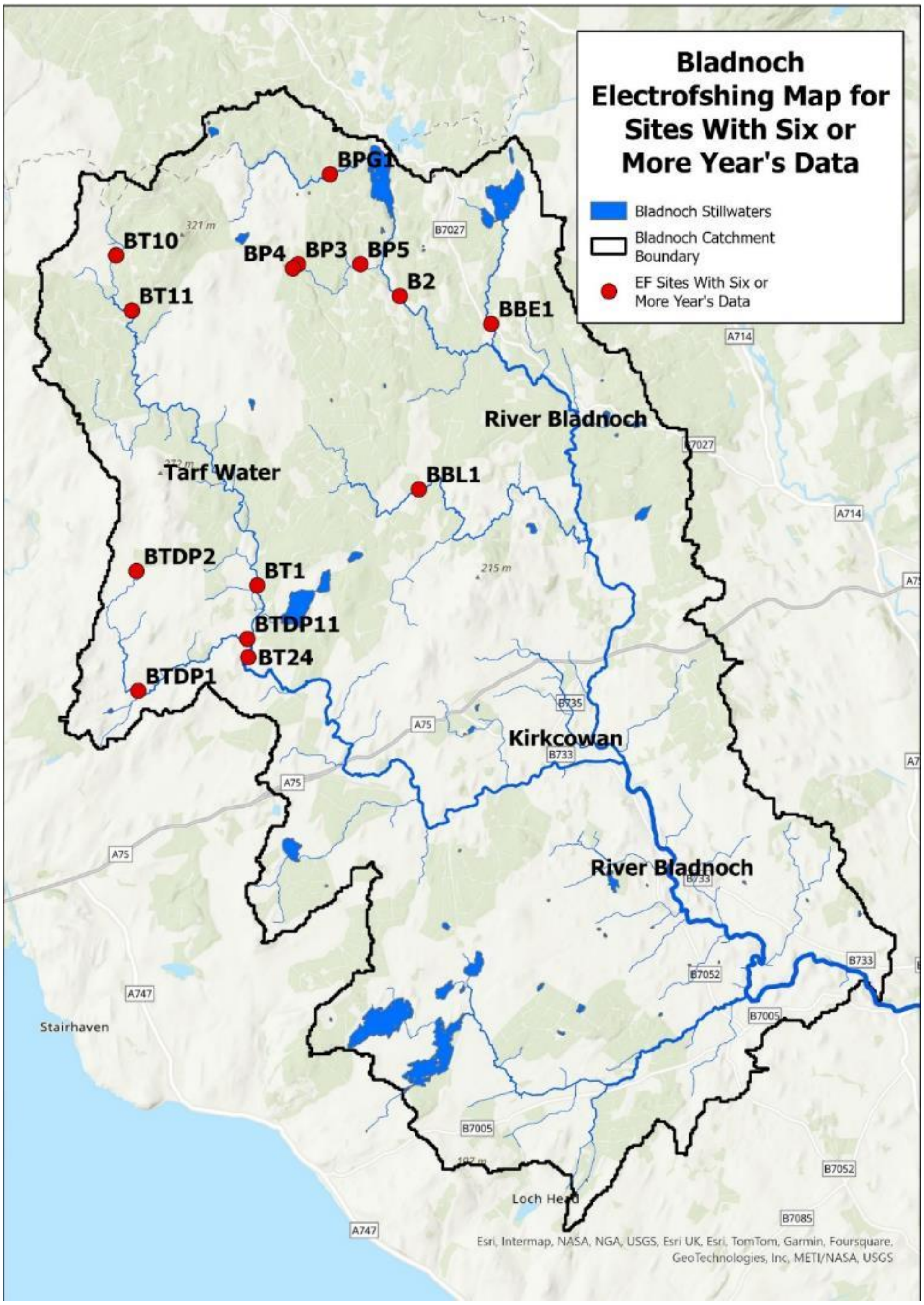
Map 17: Bladnoch trout fry electrofishing results from 2006 – 2014



Map 18: Bladnoch trout fry electrofishing results from 2015 – 2023

Any trends present within the trout fry results are much more subtle and less obvious than with the salmon fry results. The results may show some improvement in numbers at the very top of the Bladnoch (Pulganny Burn) and at the very top of the Tarf Water, representing some slow recovery from acidification, but it is difficult to say for sure. This may indicate that additional factors other than just acidification may be equally impacting trout numbers in the Bladnoch catchment.

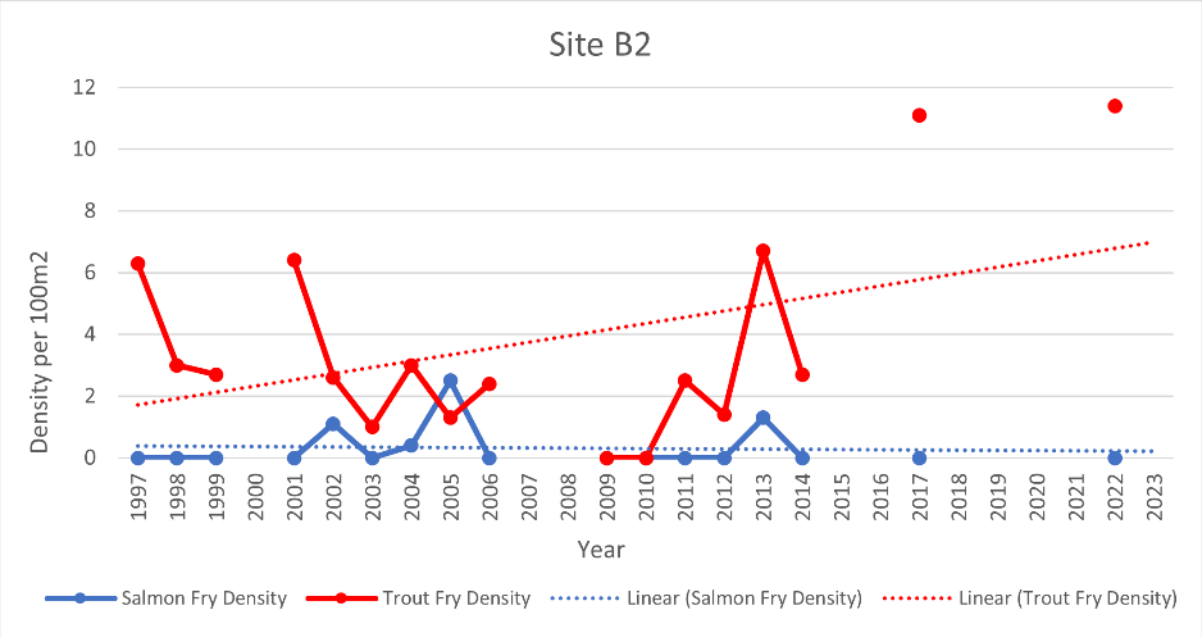
Within the electrofishing results there are several sites that have been visited repeatedly since electrofishing began. Sites with six or more years of data have been analysed. Juvenile trout or salmon results (or both) are shown depending on which should be/is the dominant spawning species within the areas surveyed. Map 19 shows the location of the sample sites, Table 5 gives the site information, and the results are displayed on Graphs 16 to 29.



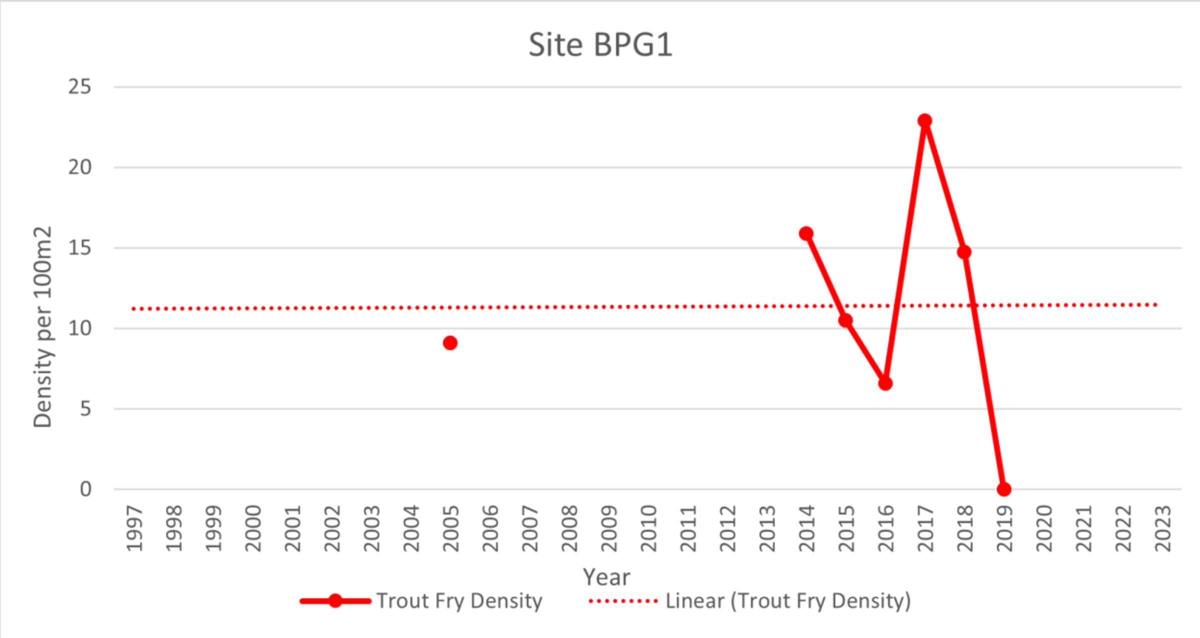
Map 19: Locations of electrofishing sites with six or more years of electrofishing data

Table 6: Location details for electrofishing sites with five or more years of electrofishing data

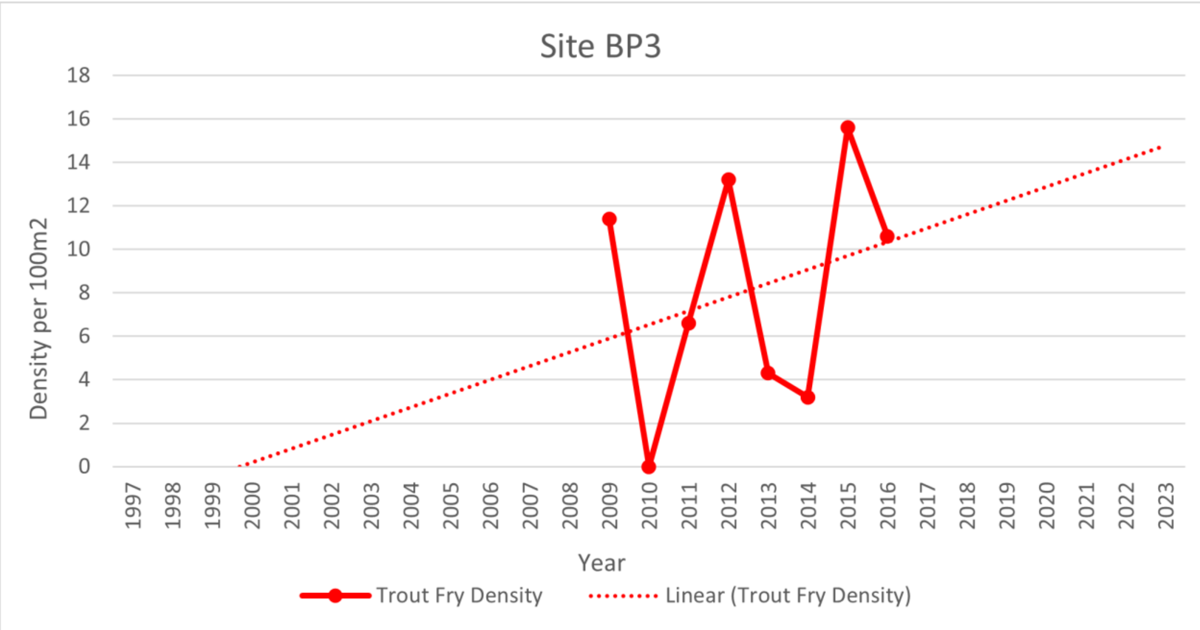
Site Code	Easting	Northing	Channel Order 1	Channel Order 2	Channel Order 3
B2	229100	572100	*River Bladnoch*		
BPG1	227340	575169	*River Bladnoch*	*Pulganny Burn*	
BP3	226531	572898	*River Bladnoch*	*Polbae Burn*	
BP4	226400	572800	*River Bladnoch*	*Polbae Burn*	
BP5	228100	572900	*River Bladnoch*	*Polbae Burn*	
BBE1	231400	571400	*River Bladnoch*	*Beoch Burn*	
BBL1	229575	567224	*River Bladnoch*	*Black Burn*	
BT1	225500	564800	*River Bladnoch*	*Tarf Water*	
BT10	221944	573120	*River Bladnoch*	*Tarf Water*	
BT11	222340	571732	*River Bladnoch*	*Tarf Water*	
BT24	225274	562982	*River Bladnoch*	*Tarf Water*	
BTDP1	222503	562139	*River Bladnoch*	*Tarf Water*	*Drumphail Burn*
BTDP2	222461	565160	*River Bladnoch*	*Tarf Water*	*Drumphail Burn*
BTDP11	225255	563451	*River Bladnoch*	*Tarf Water*	*Drumphail Burn*



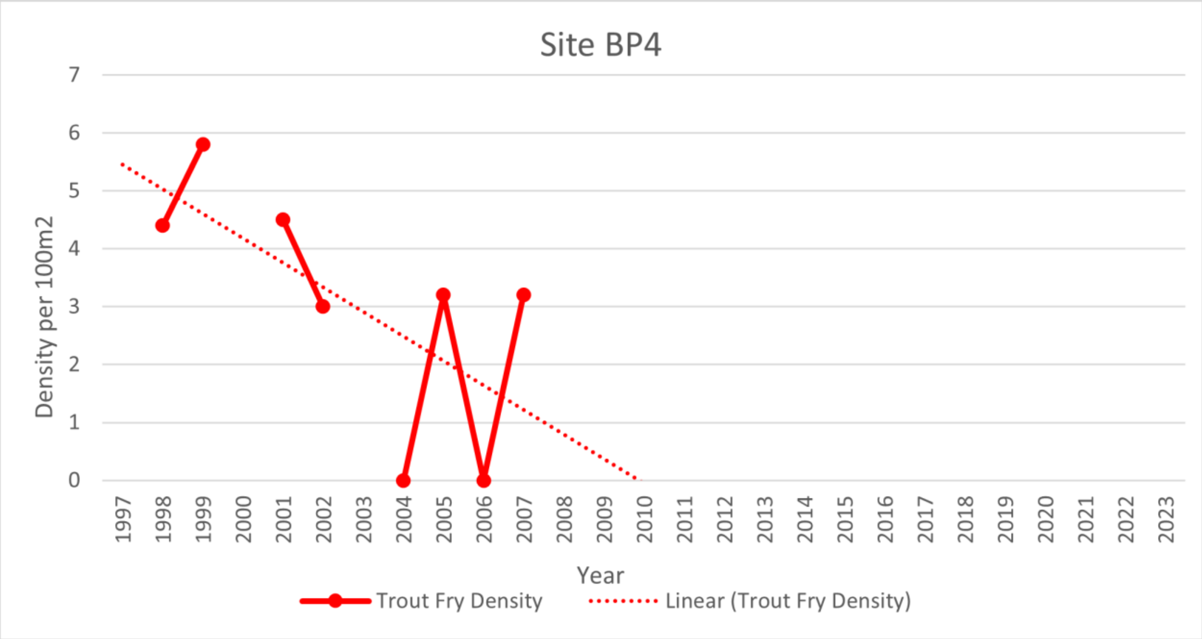
Graph 16: Single run salmon and trout fry densities for electrofishing site B2



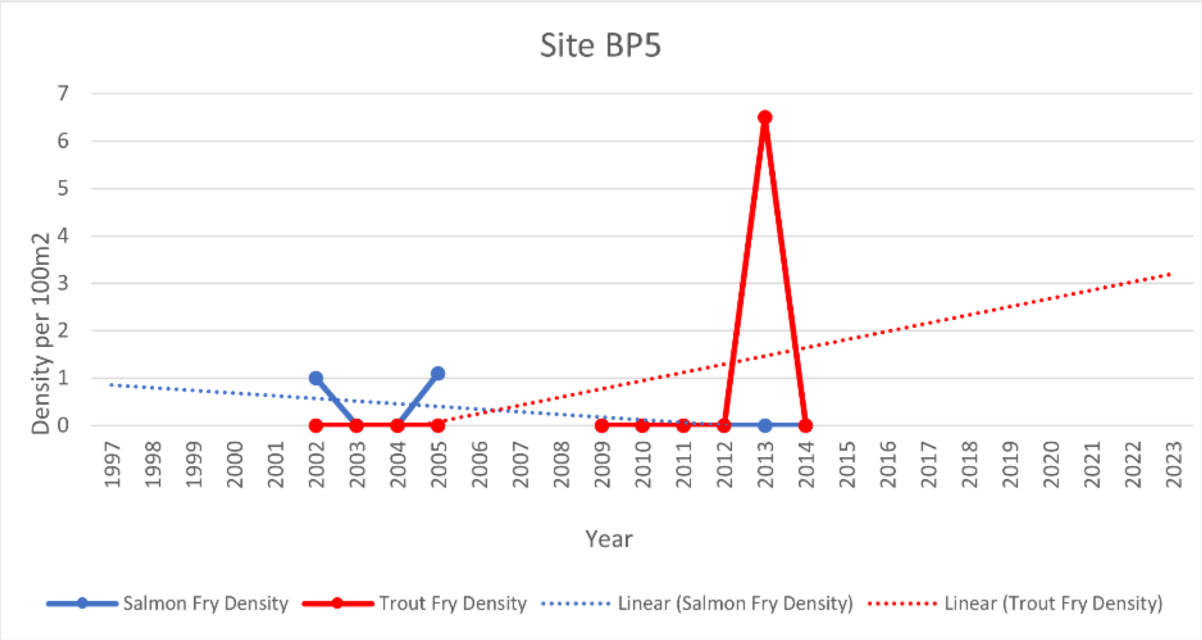
Graph 17: Single run trout fry densities for electrofishing site BPG1



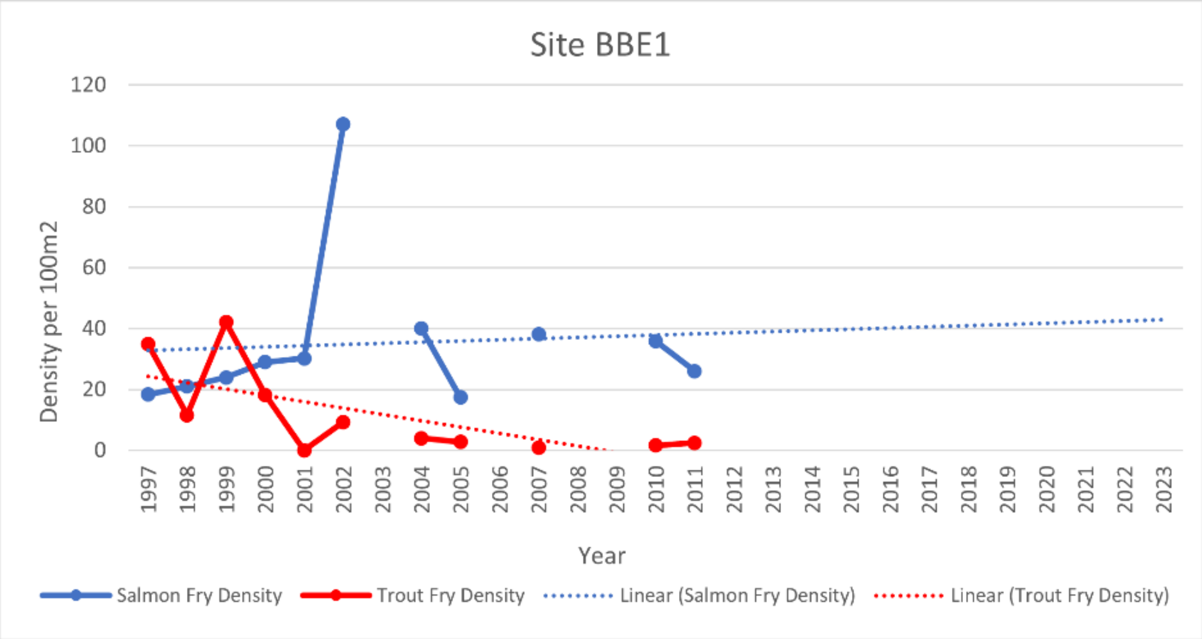
Graph 18: Single run trout fry densities for electrofishing site BP3



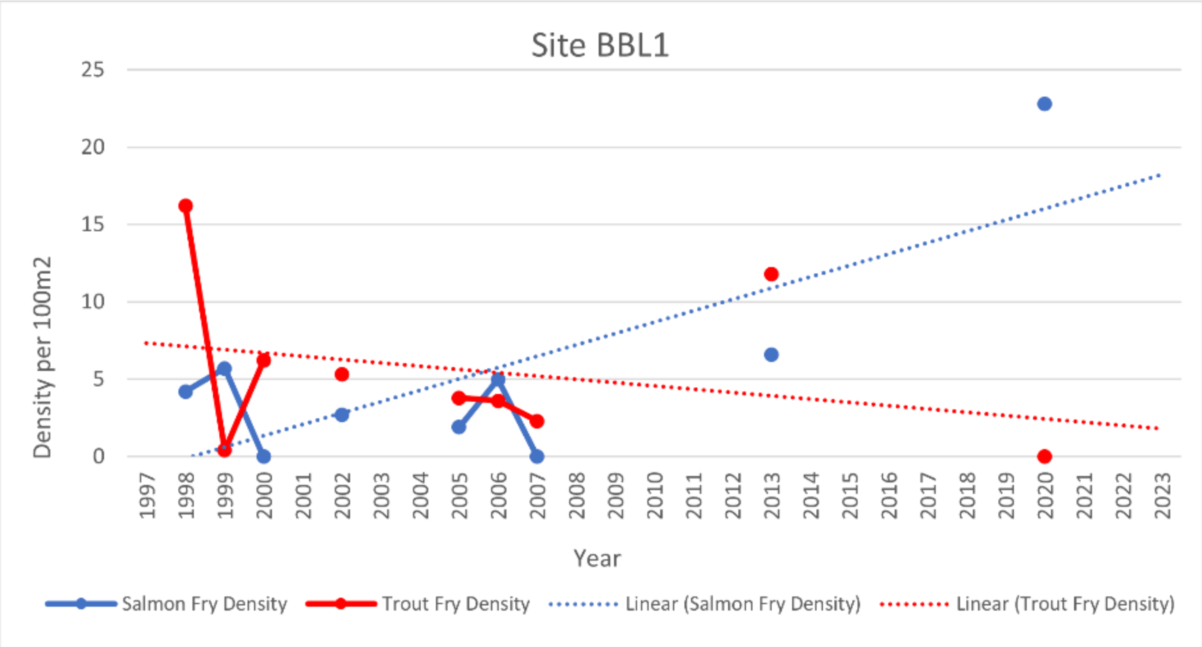
Graph 19: Single run trout fry densities for electrofishing site BP4



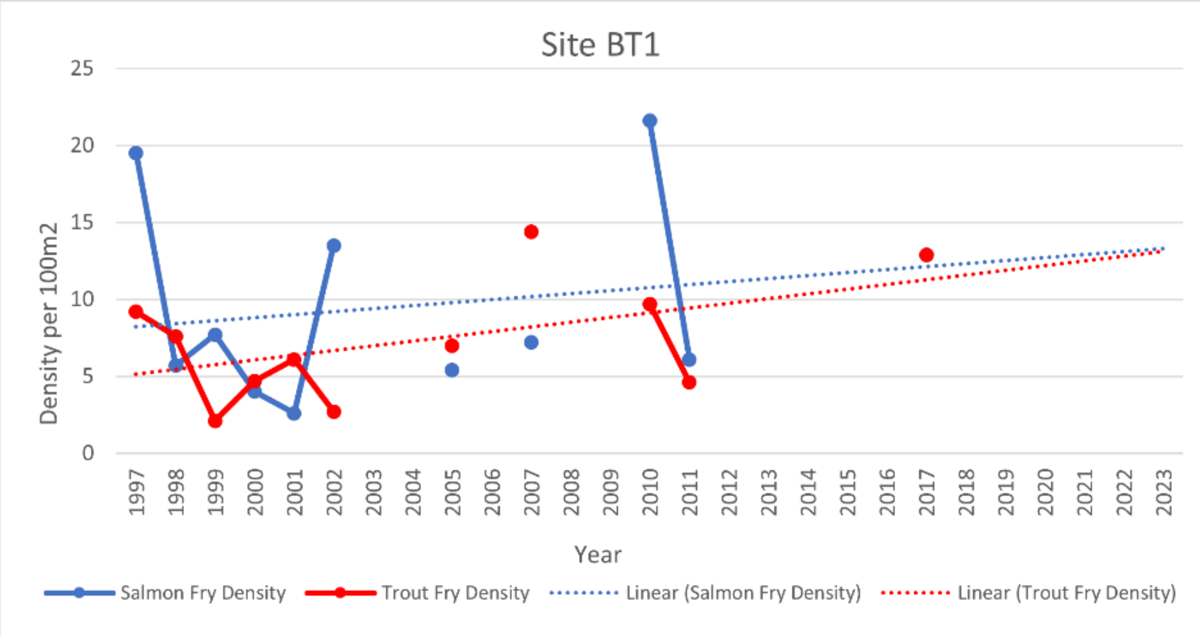
Graph 20: Single run salmon and trout fry densities for electrofishing site BP5



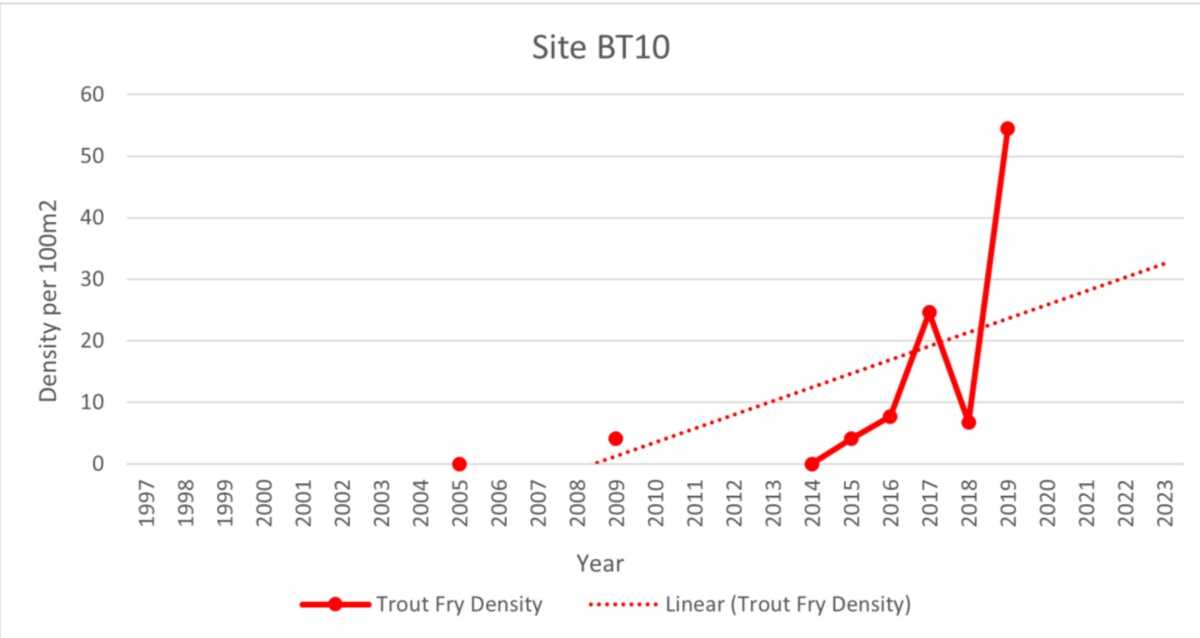
Graph 21: Single run salmon and trout fry densities for electrofishing site BBE1



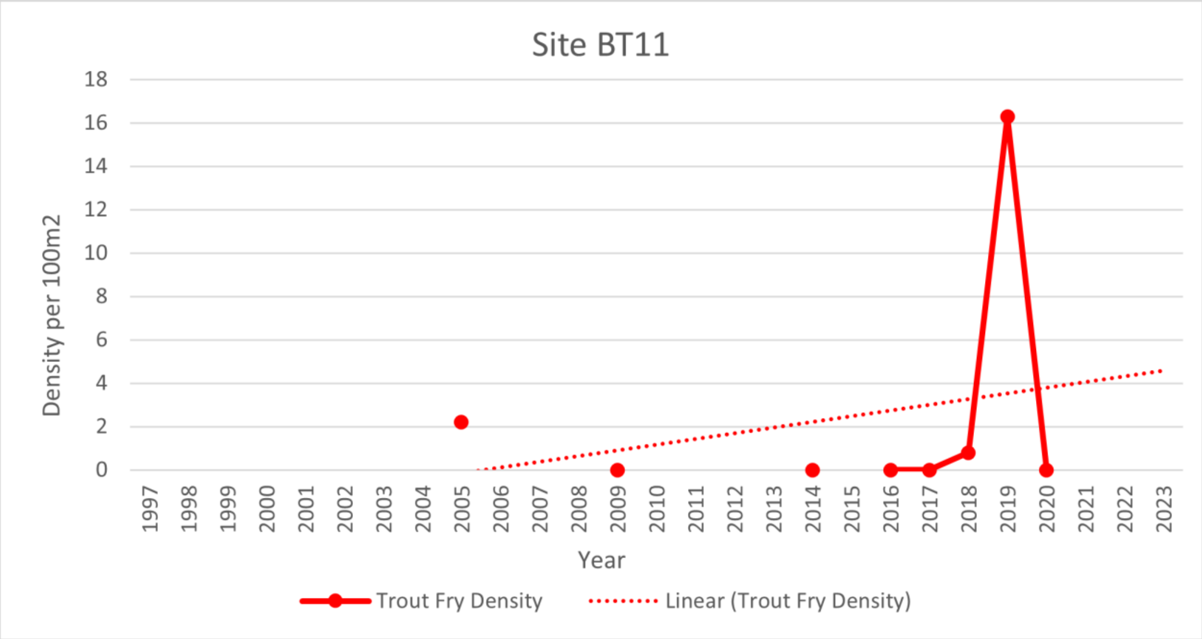
Graph 22: Single run salmon and trout fry densities for electrofishing site BBL1



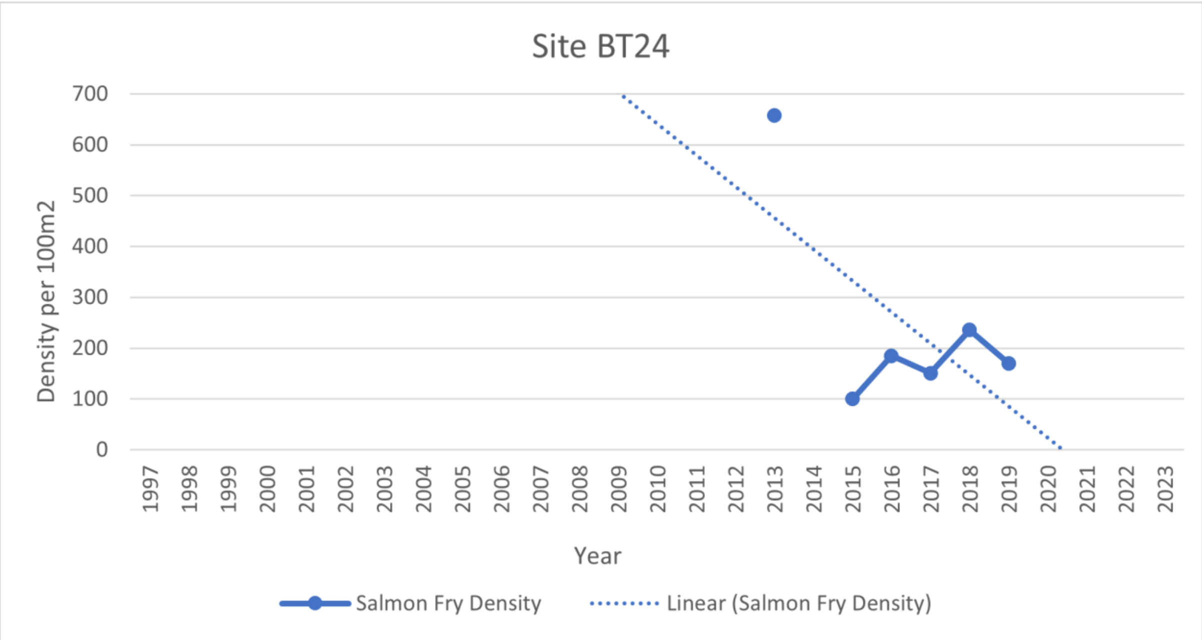
Graph 23: Single run salmon and trout fry densities for electrofishing site BT1



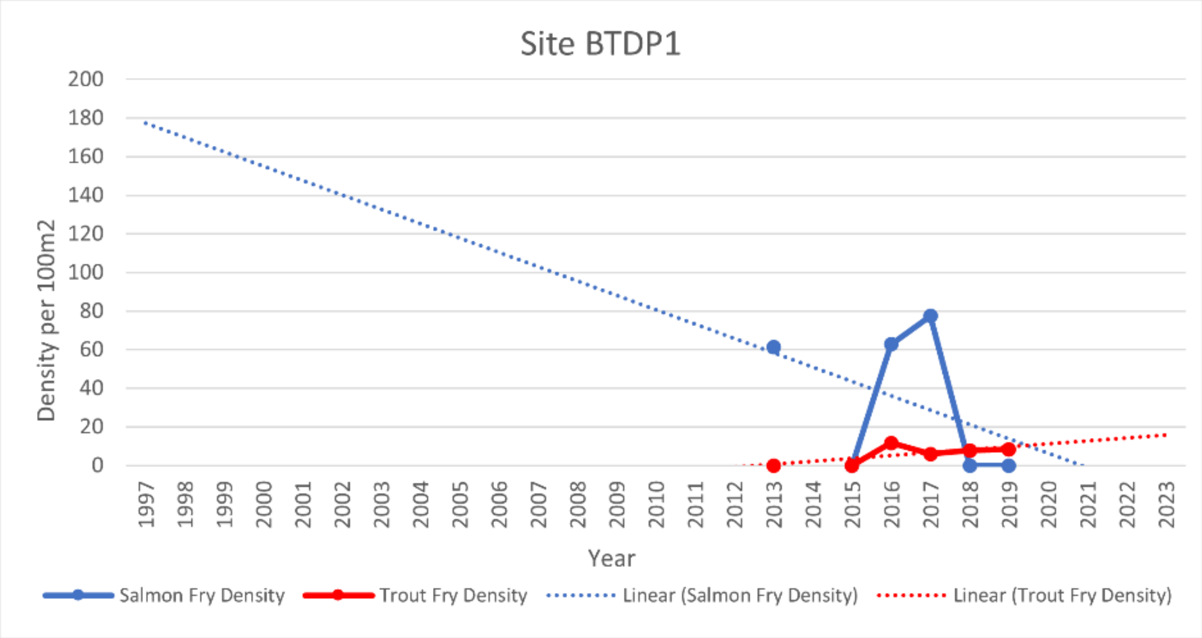
Graph 24: Single run trout fry densities for electrofishing site BT10



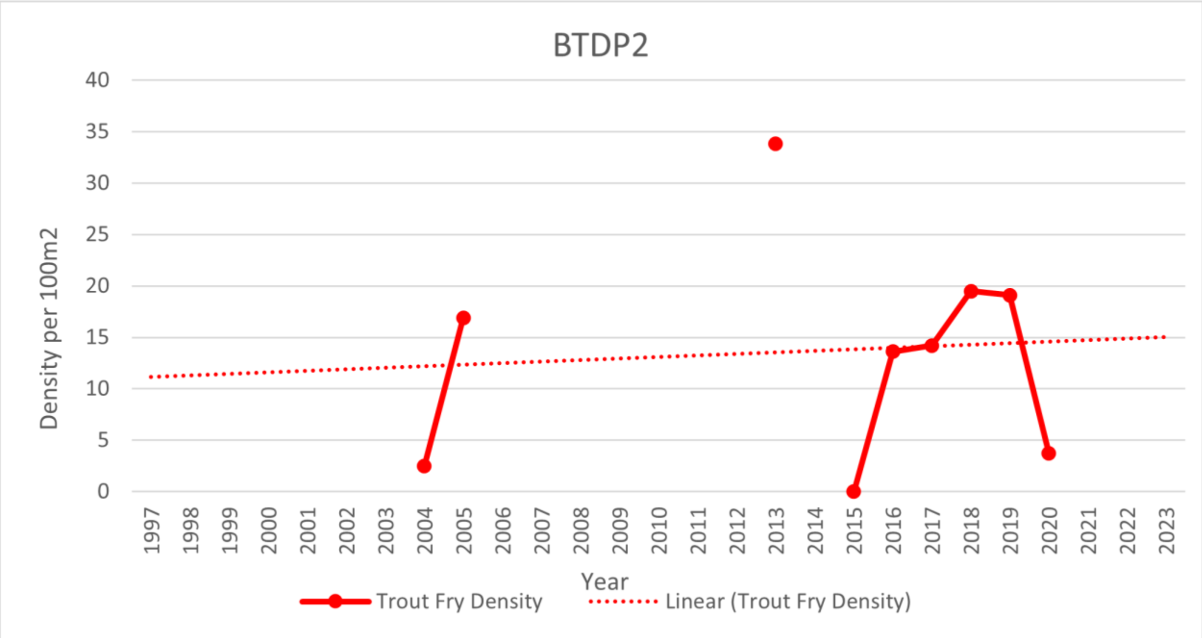
Graph 25: Single run trout fry densities for electrofishing site BT11



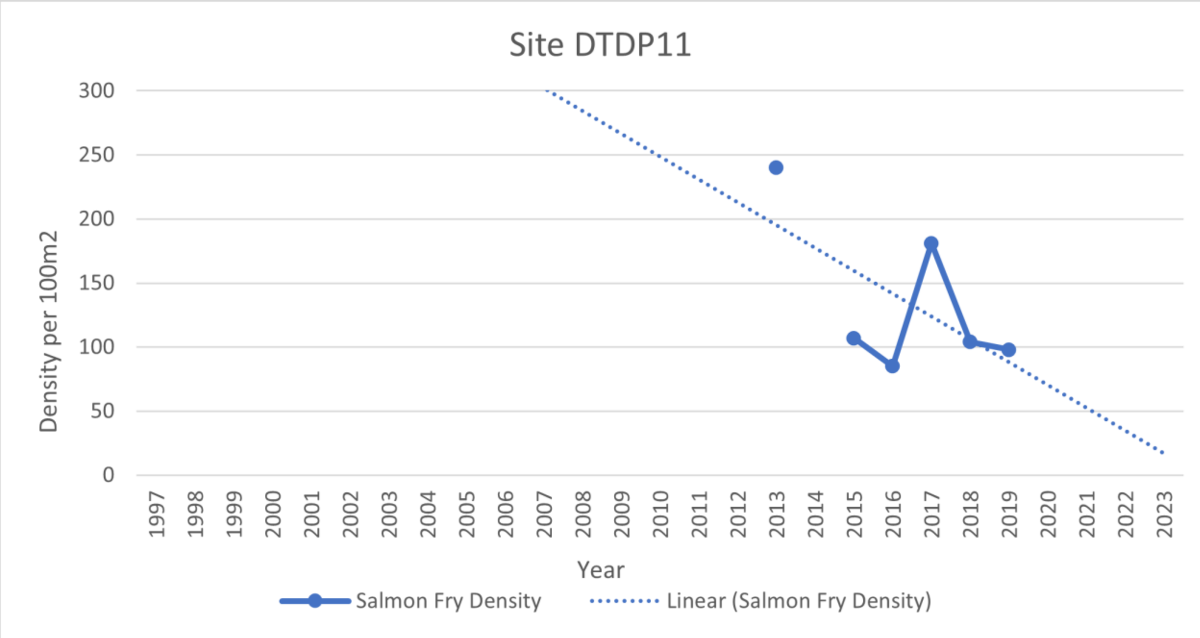
Graph 26: Single run salmon fry densities for electrofishing site BT24



Graph 27: Single run salmon and trout fry densities for electrofishing site BTDP1



Graph 28: Single run trout fry densities for electrofishing site BTDP2



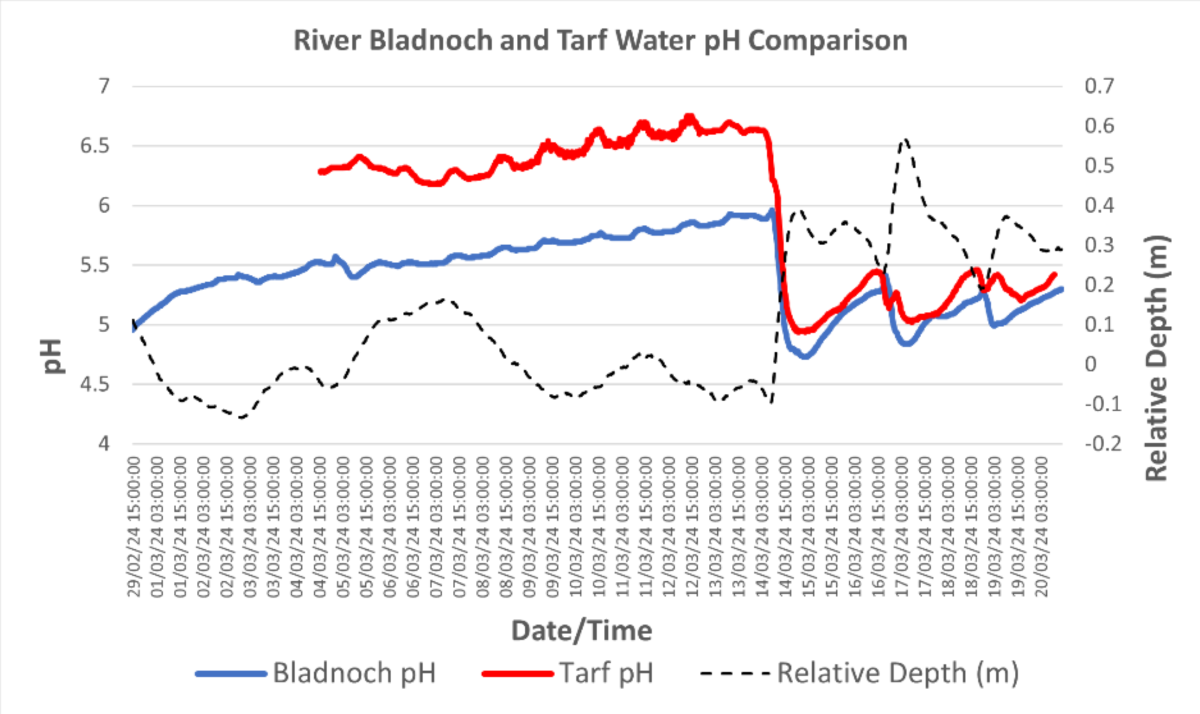
Graph 29: Single run salmon fry densities for electrofishing site BTDP11

It should be noted that the period over which each individual site was sampled varies. The trends over time for each site also clearly vary. Starting from top to bottom and from Bladnoch to Tarf, the sites at the top of the Polbae (BP3, BP4) and Pulganny (BPG1) Burns show no overall trend in trout numbers (the burns are too small for salmon spawning and the Pulganny Burn is above an impassable waterfall) with the adjacent Polbae Burn upper sites showing opposing trends and the Pulganny Burn showing no overall trend. The trout fry densities are relatively low indicating on-going water quality issues or issues with adult habitat or survival. The lower Polbae site (BP5) shows very low densities for both salmon and trout fry, also likely indicating on-going water quality issues that are causing large scale mortalities in salmonid eggs. This is most likely having a knock-on impact on the River Bladnoch downstream of the Polbae confluence as very low salmon and trout fry abundances are recorded from site B2. Although low there are some signs of improvements in trout fry density from B2 possibly indicating some improvements in water quality and backing up the previous results, but not at a level that is having any large-scale impact. The results from the Beoch Burn show moderate numbers of salmon fry and an overall improving trend, possibly signalling that water quality is improving and only having a minor impact on salmon fry survival. Trout fry numbers show the opposite trend, but this may simply be a result of the trout being pushed further upstream at spawning time because of salmon spawning, or due to changes in instream habitat. The Black Burn site (BBL1) shows similar trends to the Beoch Burn but with lower densities of salmon and trout fry. Combined salmon and trout fry numbers are possibly high enough at these two sites to suggest acidification is much less of an issue within these watercourses.

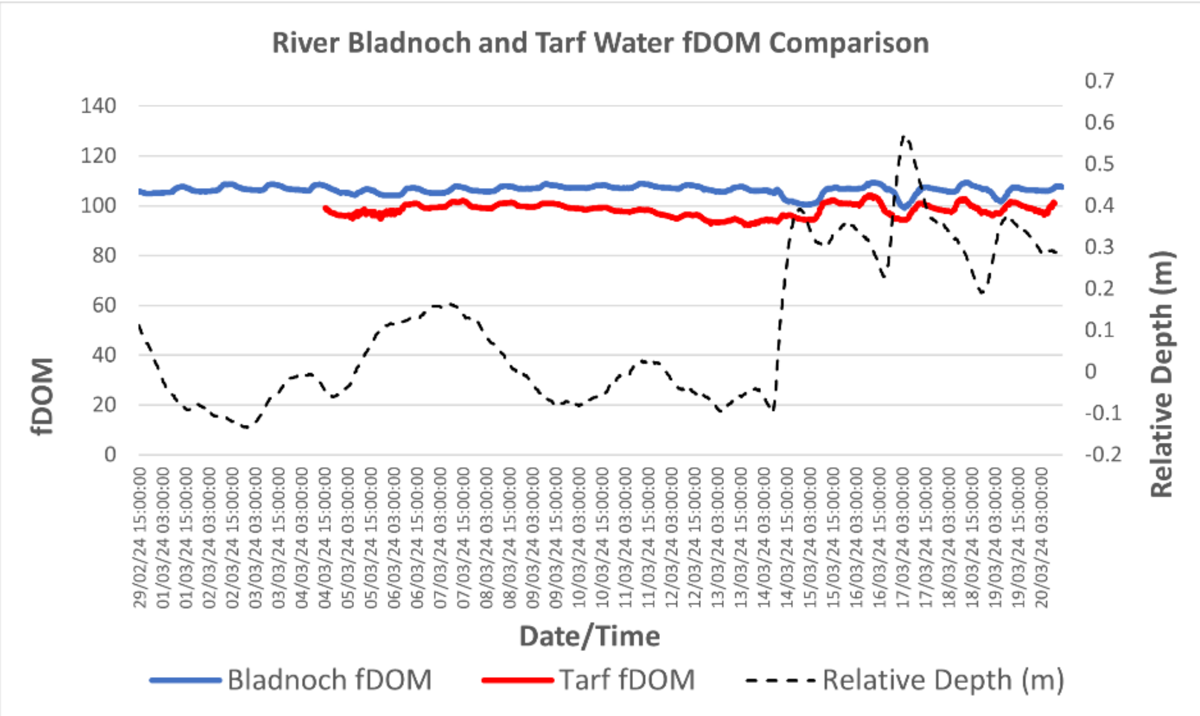
The uppermost Tarf sites (BT10 and BT11) both show overall increases in trout fry densities with BT10 densities in later years reaching the levels probably expected from a watercourse with no water quality issues. This most likely represents improving water quality and backs up the results seen in the previous maps. This is echoed in site BT1 further down the main stem of the Tarf, which appears to show recovering densities of both salmon and trout fry. In contrast, salmon fry densities on the Tarf a short distance downstream (BT24) show a declining trend. However, it should be noted that densities are very high at all times and that the exceptionally high result in 2013 may be influencing the overall trend. As the BT24 densities are so much higher than the BT1 densities it may indicate a positive impact of water quality from the Drumphail Burn, which flows into the Tarf between these two sites. This is backed up by the fry densities from the Drumphail Burn sites (BTDP1, BTDP2, BTDP11) which, despite varying overall trends, consistently show moderate to high fry densities.

3.3 River Bladnoch water quality overview

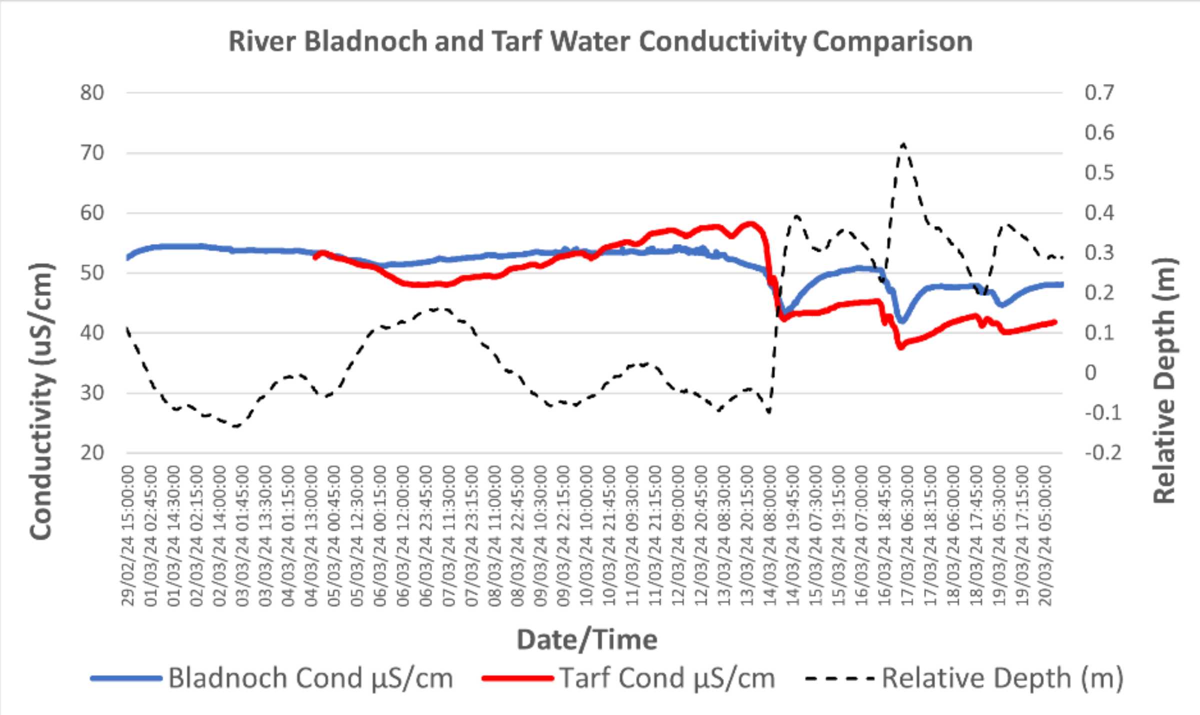
The Bladnoch (at Waterside) Sonde was deployed on 29/02/2023 whilst the Tarf Water (at Artfield) Sonde was deployed on 04/03/2024. Both were retrieved on 20/03/2024. During deployment there were several rises in water levels to provide data on how pH water quality varies with flow levels, with the rises in levels generally being greater later in the recording period. The water quality monitoring data can be seen in Graphs 30 to 33.



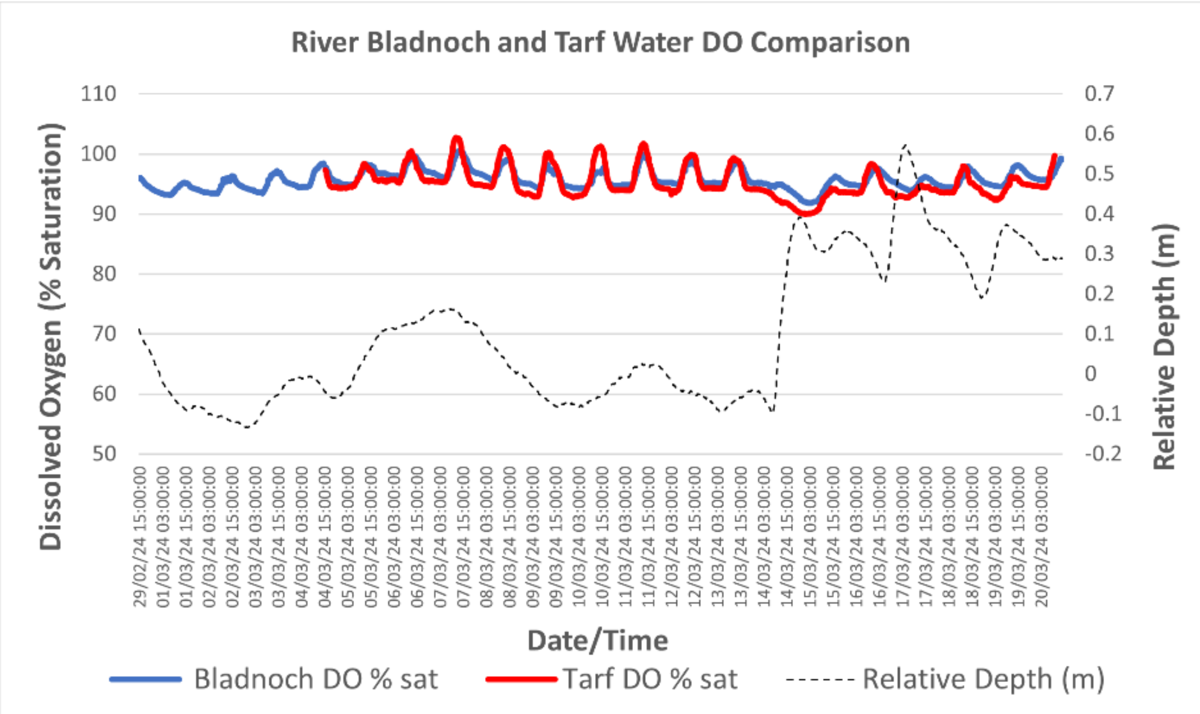
Graph 30: pH comparison between the upper Bladnoch and upper Tarf Water



Graph 31: fDOM comparison between the upper Bladnoch and upper Tarf Water



Graph 32: Conductivity comparison between the upper Bladnoch and upper Tarf Water

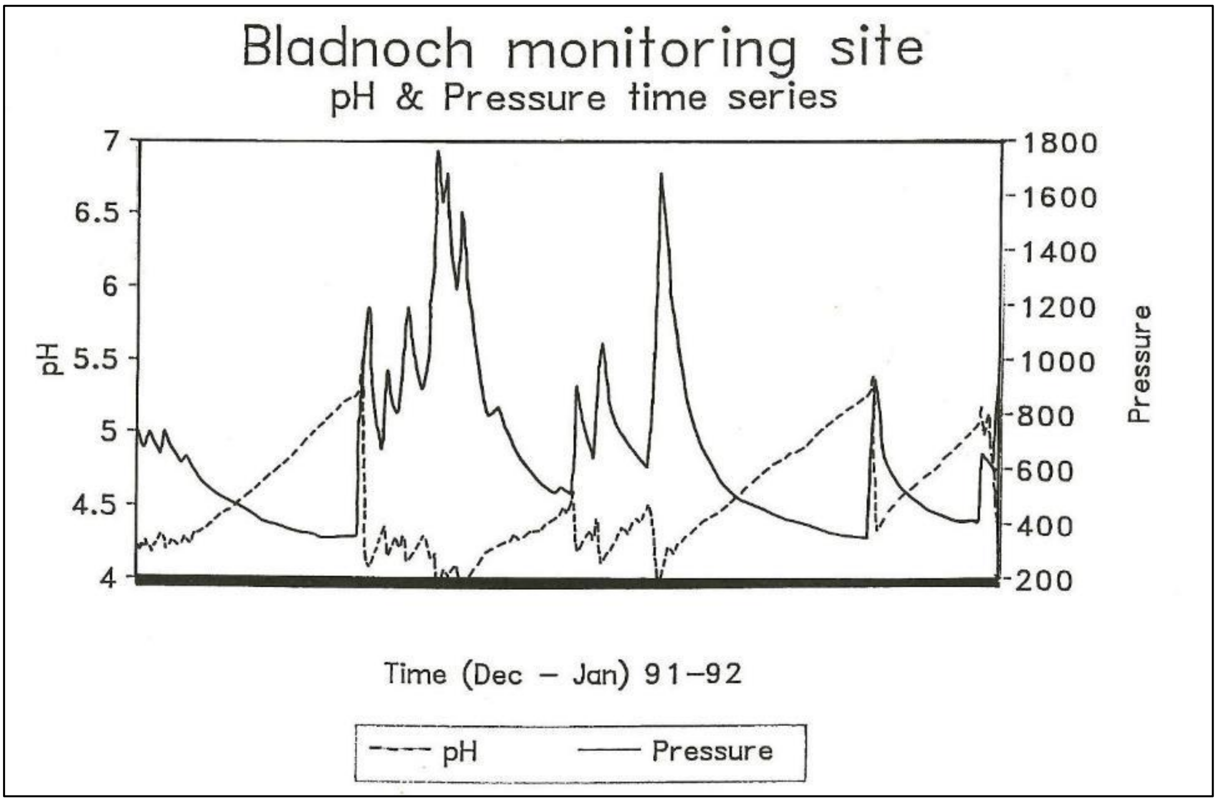


Graph 33: Dissolved Oxygen comparison between the upper Bladnoch and upper Tarf Water

The overall variation in pH levels with flow levels for the sites of the Bladnoch and Tarf are very similar, but with the Bladnoch site clearly being more acidic. The Bladnoch also regularly gets below pH 5 (the level below which is thought to be damaging to salmonids) during periods of heavy rain/high flows whilst the Tarf only briefly got below pH 5 (and only just) during the time it was recording, although it is possible that longer periods of low pH are experienced during higher flows or wetter periods. This backs up the results from the electrofishing review which indicate that whilst recovery from historic acidification is slow, the Tarf is recovering slightly quicker than the Bladnoch. This is supported by the results from the fDOM recording with the Bladnoch site recording higher levels of DOM, potentially indicating higher levels of eroded peat within the Bladnoch upstream of the monitoring site and supporting the hypothesis that degraded peat, particularly when planted with conifers, can impact recovery from acidification. In contrast to the DOM results the conductivity results show obvious differences between the two watercourses, with considerable variation between being seen. However, conductivity is a back-up to DOM which is a much more reliable indicator of peat erosion, with conductivity potentially being influenced by other suspended particulate matter.

The DO results indicate relatively high oxygen saturation in both watercourses. Dissolved oxygen is generally highest in winter due to increased turbulence from higher flows, lower temperatures and decreased biological activity. Whilst excessive peat erosion can potentially reduce DO levels in rivers due to aerobic bacteria breaking down the organic material, reduced levels are likely only noticeable in heavily impacted areas or where there is less potential for re-oxygenation (e.g. slower, deeper sections of river).

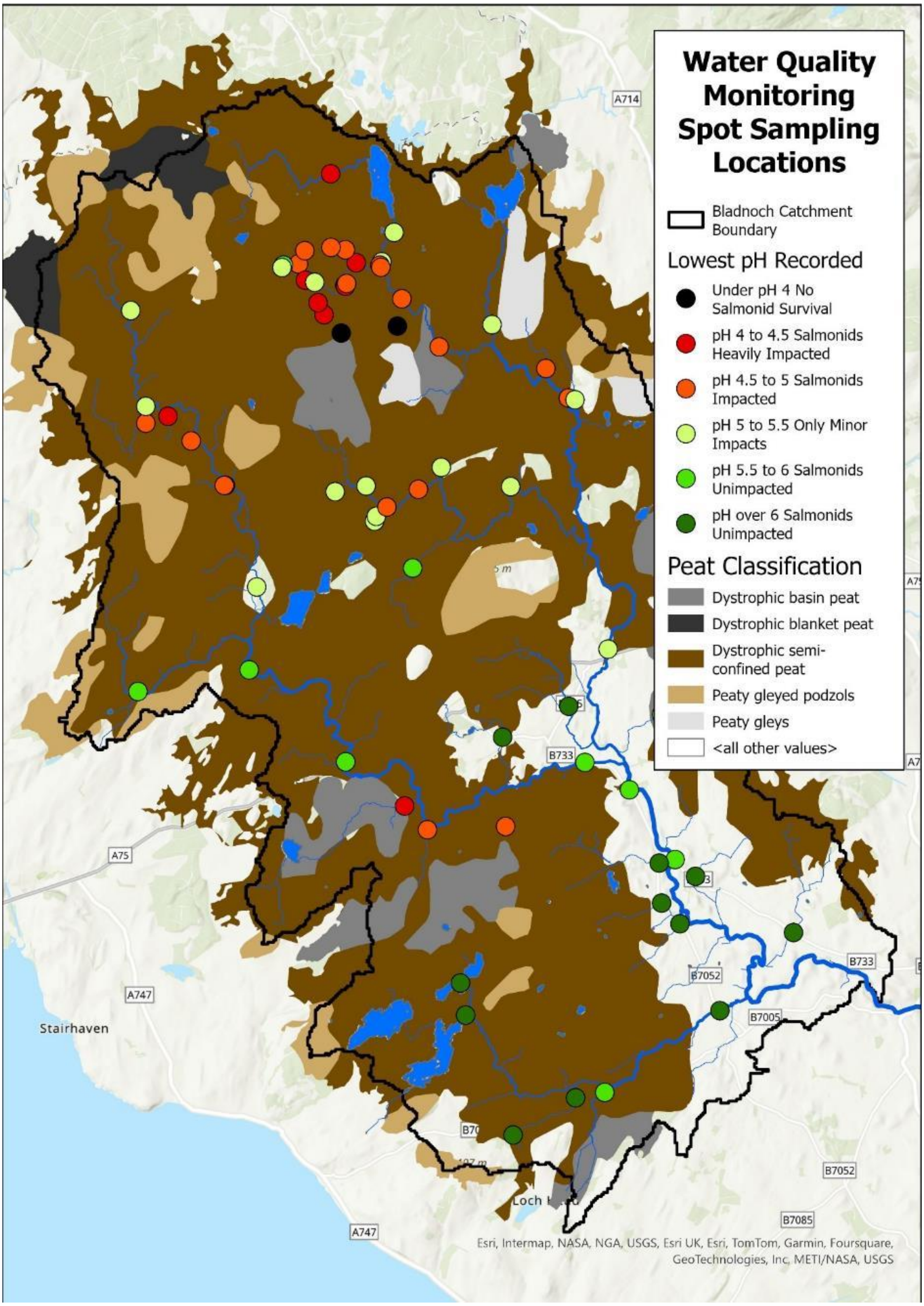
In addition to the pH data recorded on the Bladnoch some additional historic data is available from the Galloway Fisheries Trust Annual Report from 1991 to 1992. As with the 2024 monitoring the data comes from the River Bladnoch at Waterside, and although no exact location is given the two sites should be close enough for comparison. Unfortunately, the raw data is unavailable and as a result we have had to use a copy of the graph from the report. The graph uses pressure as a substitute for water flows. The results are show in Graph 34.



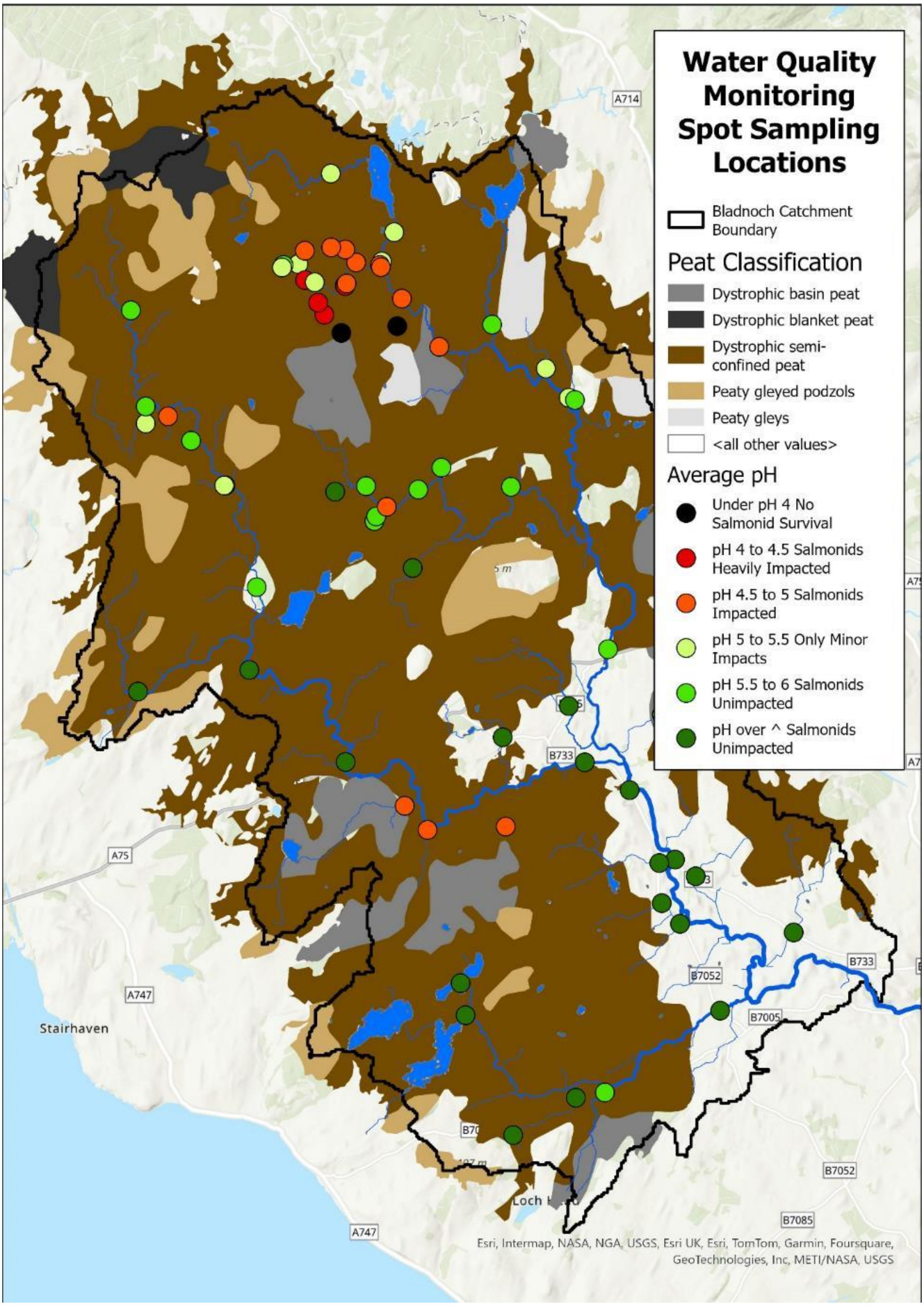
Graph 34: pH levels from the River Bladnoch at Waterside during December 1991 and January 1992

As we are unable to analyse the raw data and have no direct flow data for comparing variation in flows between the two data sets, we have had to rely on a simple visual comparison. However, we can clearly see that the lower pH limit from the 1991/1992 data is clearly lower that from the 2024 data set. This lends more evidence towards the conclusion that even though the upper Bladnoch is still heavily acidified there have been slight improvements over time.

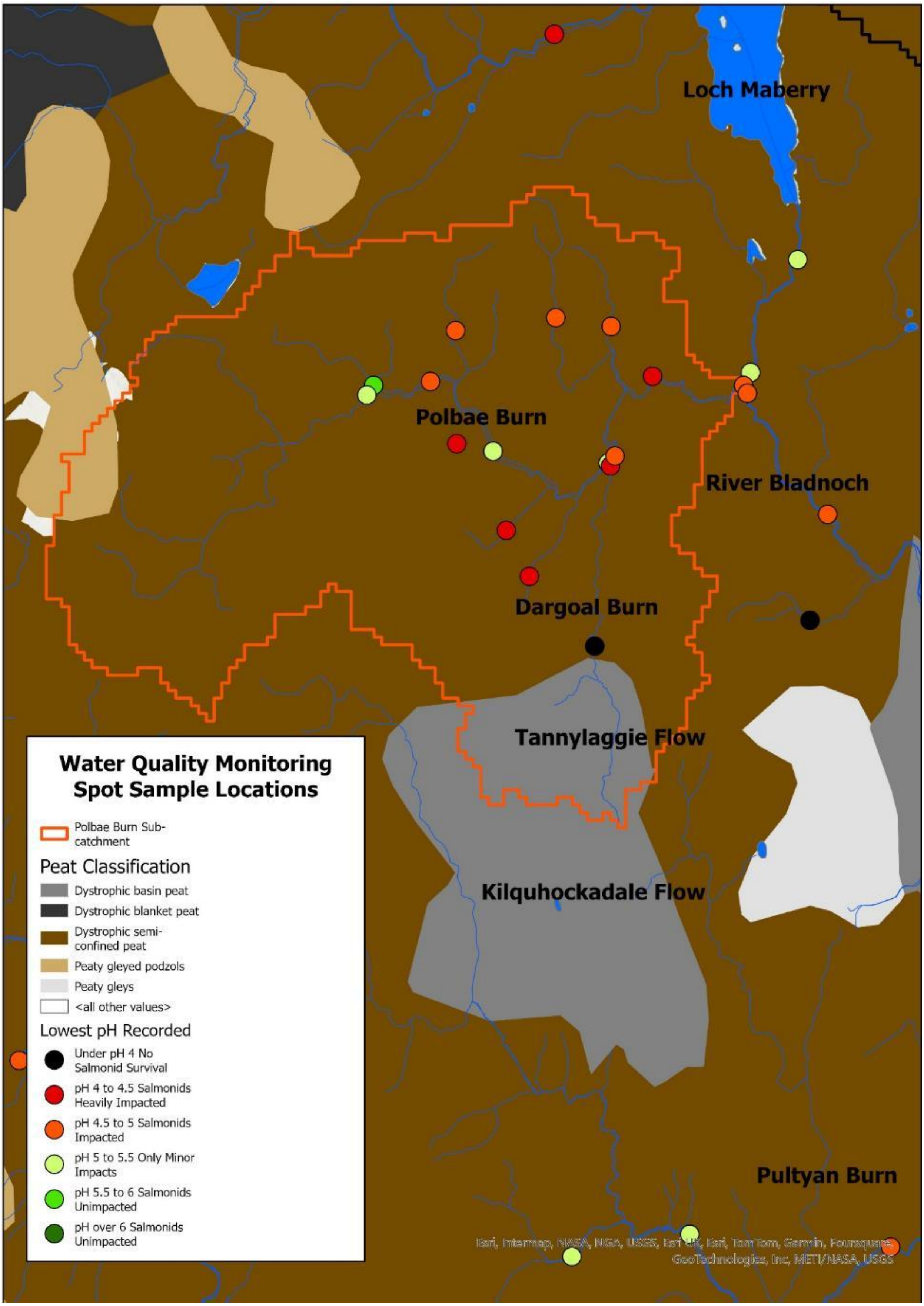
In addition to the Sonde data spot samples were taken to show special variation in pH across the upper Bladnoch catchments on 26/01/2024, 01/02/2024, 22/02/2024, 14/03/2024 and 21/03/2024. Sampling at Tannylaggie was extended to include several new sites on 21/03/2024 to look in more detail following consistently low pH results. In addition, following on from early results which showed low pH results from the Lannygore Burn in the lower catchment the spot sampling was extended to include the lower river catchment, with sampling carried out on the 17/03/2024. Spot sampling results from each individual sampling day are shown in Appendix 1. However, to ease interpretation the results have been combined and are summarised in Maps 20 to 23. Within the maps the results are displayed using a rudimentary "traffic light" scoring system based on salmonid pH tolerance. This is to help visualise how salmonid populations are impacted across the whole catchment. In maps 20, 22 and 23 the results are shown for the lowest pH recorded to help show which sites are most acidic. Persistence of low pH can also be a major factor in relation to impacts on fish populations. As sampling was carried out over a variation in flow levels the average pH for each site has been shown on Map 21 to give a basic measure of pH persistence.



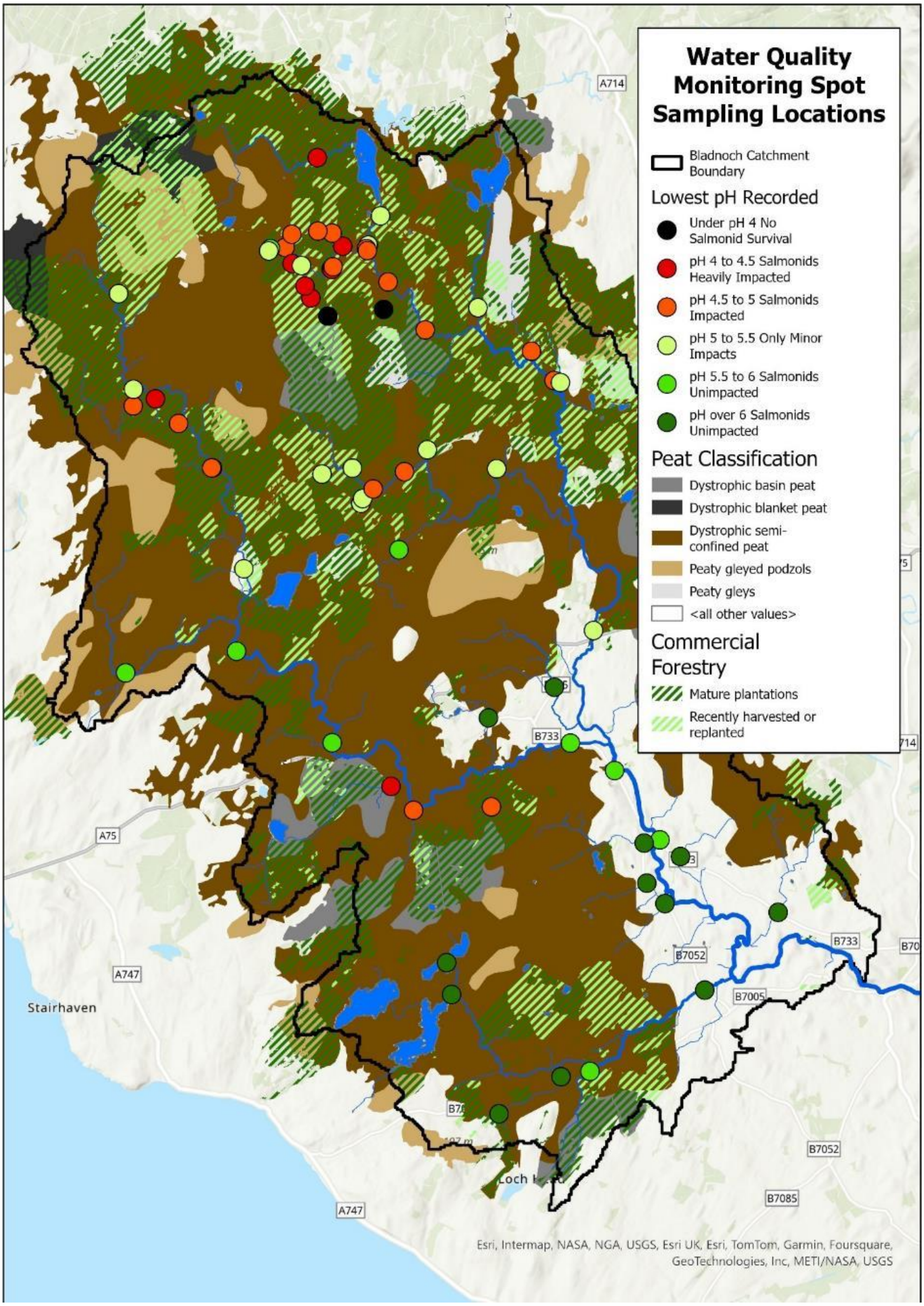
Map 20: Lowest pH recorded from each sampling site during all spot sampling events



Map 21: Average pH recorded from each sampling site during all spot sampling events



Map 22: Lowest pH recorded during focused additional sampling from the Polbae Burn sub-catchment



Map 23: Lowest pH recorded from each sampling site during all spot sampling events in comparison to peat classification and commercial forestry cover

The spot sampling results from the Bladnoch clearly show considerable variation across the catchment. However, low pH is being experienced in a significant proportion of the catchment at a level that is heavily impacting salmonid populations. Whilst winter 2023/2024 was particularly wet (as referenced earlier) with the potential to impact results, some low pH results were recorded on multiple occasions (as shown in the individual spot sampling results in the Appendix). In addition, previous Bladnoch spot sample data collected during 2020 from serveral of the sampled sites produced similar results (Galloway Fisheries Trust, 2020). This would suggest that the results recorded during 2023/2024 are not uncommon during winters. The results, to an extent, back up the electrofishing results with the upper Bladnoch being more heavily impacted by acidification than the Tarf, although some localised impacts are still evident in the Tarf. The focused sampling around the Polbae Burn also gives a clear example of how acidification can impact watercourses, with low pH levels being recorded despite sampling having taken place after only a moderate flood (Map 25, Appendix 1). Water quality at the source of the burn is at levels which are unlikely to impact salmonids. However, as the burn flows downstream numerous acidified watercourses flow into the burn causing a considerable change in pH. This is most notable above and below the confluence of the Dargoal Burn. It should also be noted the impact the low pH in the lower Polbae Burn has on the River Bladnoch, with the resulting acidification potentially impacting the river for several km downstream with the inflow of the Black Burn most likely having a beneficial impact on water quality.

4 DISCUSSION

4.1 Tannylaggie peatland restoration water quality data collection

The results from the water quality monitoring suggest that, to date, if the FLS peatland restoration at Tannylaggie is having any impact it is not yet obvious enough to detect. This is not unexpected as the full restoration is incomplete, with only a modest section within the area of degraded peatland likely responsible for the poor water quality having been completed. In addition, it will also take time for the current restored section to fully restore and for peatland vegetation to establish. As winter 2023/2024 is the first period of sustained high flows following the initial stage of restoration it is possible that the restoration disturbance may cause an initial period of increased peat run-off before things settle and improve. This is backed up by the relative increase in fDOM levels recorded within the Dargoal Burn tributary (TL02). The small differences in pH levels recorded between years are most likely because of variations in flow between years, for example winter 2023/2024 was particularly wet with many periods of high flow (https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/weather/learn-about/uk-past-events/summaries/seasonal-assessment---dec23jan24.pdf) and it may be that this contributes to a lower average pH for this particular winter, which has to be taken into account within the overall trends. It may be possible to tease out any differences between years by taking flow levels or rainfall into account. Whilst any available flow/rainfall data will be sought out going forward any statistical analysis that can tease out subtle differences may be beyond the abilities of the current project. As such, it would be necessary to bring in additional resources going forward to ensure the results can be sufficiently analysed to draw firm conclusions. However, this would be most beneficial when a significant amount of post-restoration data has been collected.

Comparing the 2024 Dargoal Burn Sonde data with 2024 spot sampling data appears to indicate that while the whole Dargoal Burn system is heavily acidified from top to bottom, pH does get slightly less acidic as it flows downstream. Going by the peat map the most likely source of the more acidic pH is the area of basin peat that covers the upper half of the burn. The previous GFT/PA Water Quality Monitoring report from the River Luce catchment (Galloway Fisheries Trust, 2023) recorded a similar relationship between blanket peat and semi-confined peat within the Luce catchment. However, like with the Luce, the conclusions are based on relatively small amount of data and the relationship requires further investigation. If correct this would indicate that while both damaged basin and semi-confined peat can contribute to chronic acidification damaged basin peat may have greater potential to impact freshwater ecosystems. Basin peat could therefore be particularly important to target for restoration and management to improve water quality in the Bladnoch catchment, particularly as there is an estimated 2,272 Ha across the catchment.

A significant point of note is the continued low Dissolved Oxygen (DO) levels recorded within the Dargoal Burn. Current levels are likely to have a significant impact of aquatic life and when combined with the pH results paint a bleak picture. The impact on the Polbae Burn of the reduced DO levels should be considered and monitored going forward.

Although not recorded or measured within this document it was evident from site visits during data recording that conifer regeneration with Tannylaggie Flow, and within the greater Tannylaggie Forest, is a major problem with some areas surrounding the Dargoal Burn appearing to have a higher Sitka density than would be planted commercially. Given the relationship between peatlands, commercial forestry and water quality this would indicate that the regen, if allowed to mature at the densities observed in some locations, has the potential to reduce water quality and potentially counteract the benefits gained though the on-going peatland restoration.

4.2 River Bladnoch electrofishing data review and water quality overview

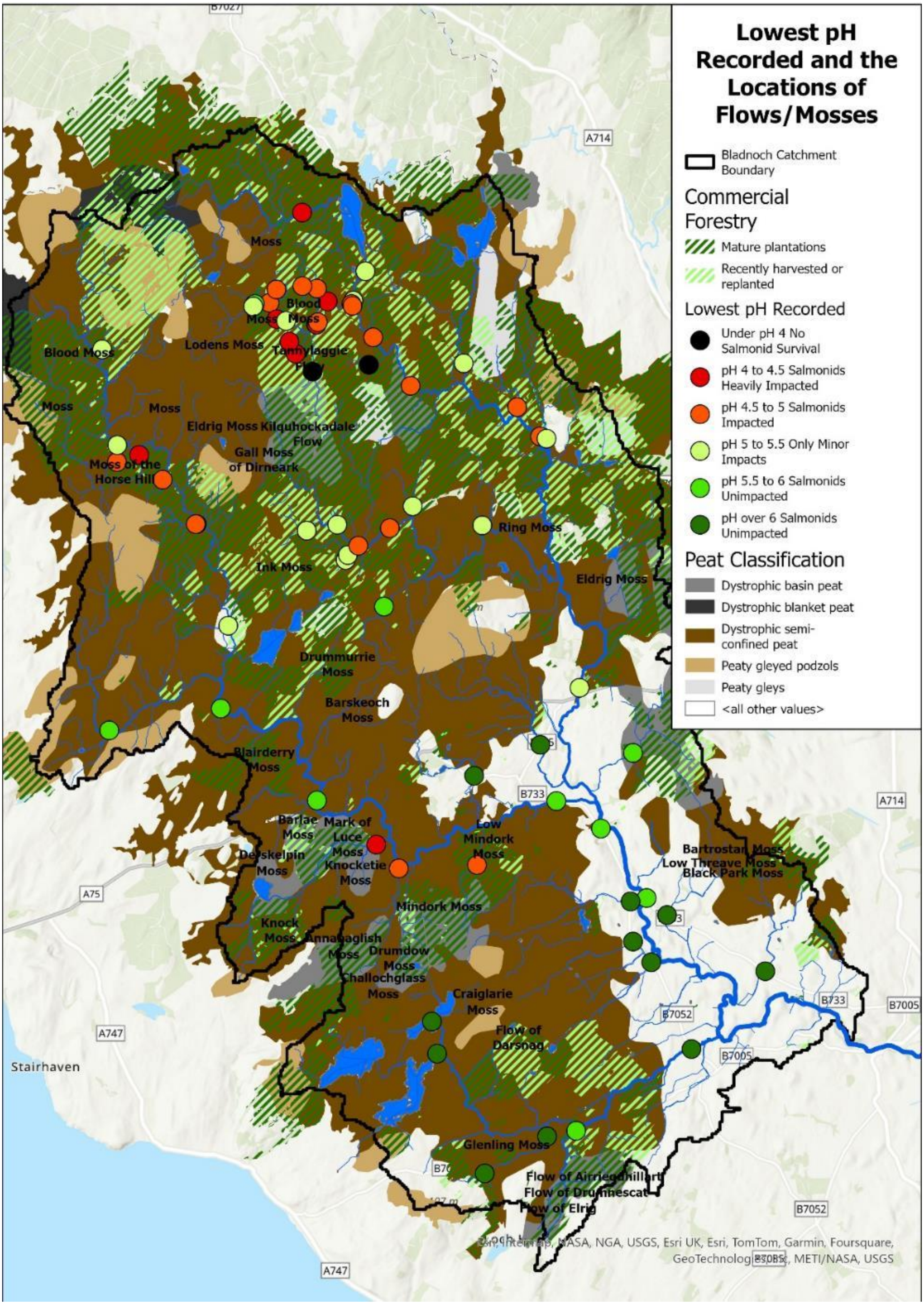
The GFT electrofishing and water quality overview results show there has been some recovery from historic acidification caused by atmospheric pollution. However, recovery is clearly slow and, in some cases, clearly slowed or even prevented by current land use and the degraded condition of peatland areas. There is a stark contrast in combined fish and water quality results between the lower and upper reaches of the Bladnoch catchment. While lower fish densities and lower pH should be expected naturally from upland areas due to lower productivity and lower acid neutralising capacity (related to natural variation in geology and soils), moderate to high fish densities resulting from good water quality would still be expected and would have been present historically (some local anglers still remember abundant fish populations in these areas – personal comment, author). The low densities, and complete lack of salmonids in some areas, are undoubtedly because of artificially low pH levels. By combining the electrofishing results and the water quality results we gain a better picture of current salmonid distribution within the Bladnoch catchment, the impacts that reduced water quality (primarily pH) is having on fish populations and the likely causes. The most heavily impacted section of the catchment is clearly the upper Bladnoch with the reduced water quality source stemming from Tannylaggie area, specifically around the Polbae Burn sub-catchment. The Dargoal Burn has the poorest water quality (lowest pH, low DO) with results indicating that the degraded basin deep peat within the burn headwaters (Map 20) is having the biggest impact on water quality. However, watercourses and artificial drains within the greater area around much of the Polbae Burn return water sampling results that are almost as low. Given the links between forestry and degraded peatlands in the amplification of acidification, and the relatively good pH results from the Polbae Burn above the commercial forestry, there can be no doubt that current land use (commercial forestry) and the associated degraded peatland are the cause of the poor water quality. The detailed results from the Tannylaggie peatland restoration monitoring and the surrounding water spot sampling results show the true extent of the poor water quality. In addition, the results show that the impacts of the poor water quality extend downstream for some considerable distance with associated negative impacts on salmonid populations. The electrofishing results indicate that the negative impacts on Atlantic salmon spawning potentially extend downstream to the River Bladnoch's confluence with the Black Burn, a distance covering approximately 15 km of river. As the Bladnoch is a SAC for Atlantic salmon this represents an impact on a significant proportion of the salmon population in the system and, as such, within the SAC. While the on-going peatland restoration at Tannylaggie should go some way to addressing the water quality issues the extended spot sampling results indicate that any deep peat within the surrounding area should be considered as "sensitive" regarding impacts on water quality and aquatic ecosystems and should be considered as a priority within the environmental responsibilities of Forestry and Land Scotland (the main landowner/manager) and surrounding landowners. It would be recommended that peatland restoration plans carefully consider the hydrology and target sub catchments, particular comprising basin peats, showing the worst markers for water quality and fish populations.

Whilst much less impacted than the upper Bladnoch there is still a significant localised water quality impact within the upper Tarf Water. As shown in Map 20 this reduced water quality stems from the upper reaches of Artfield Forest with impacts extending downstream for several km during periods of very high flow. Water quality within a large section of the Tarf upstream of this point appears relatively good but has yet to see widespread recovery in salmon numbers as acidification impacts slowly ease. It may be that the water quality within the section of the Tarf is potentially acting to block upstream re-colonisation of salmon as water quality within the headwaters improves. As the area is largely covered in commercial forestry and likely has extensive areas of deep peat peatland targeted felling/cropping and peatland restoration has the potential to have significant benefits regarding salmon populations, aquatic ecosystems in general and the Bladnoch SAC, with results potentially extending far beyond the area of restoration alone.

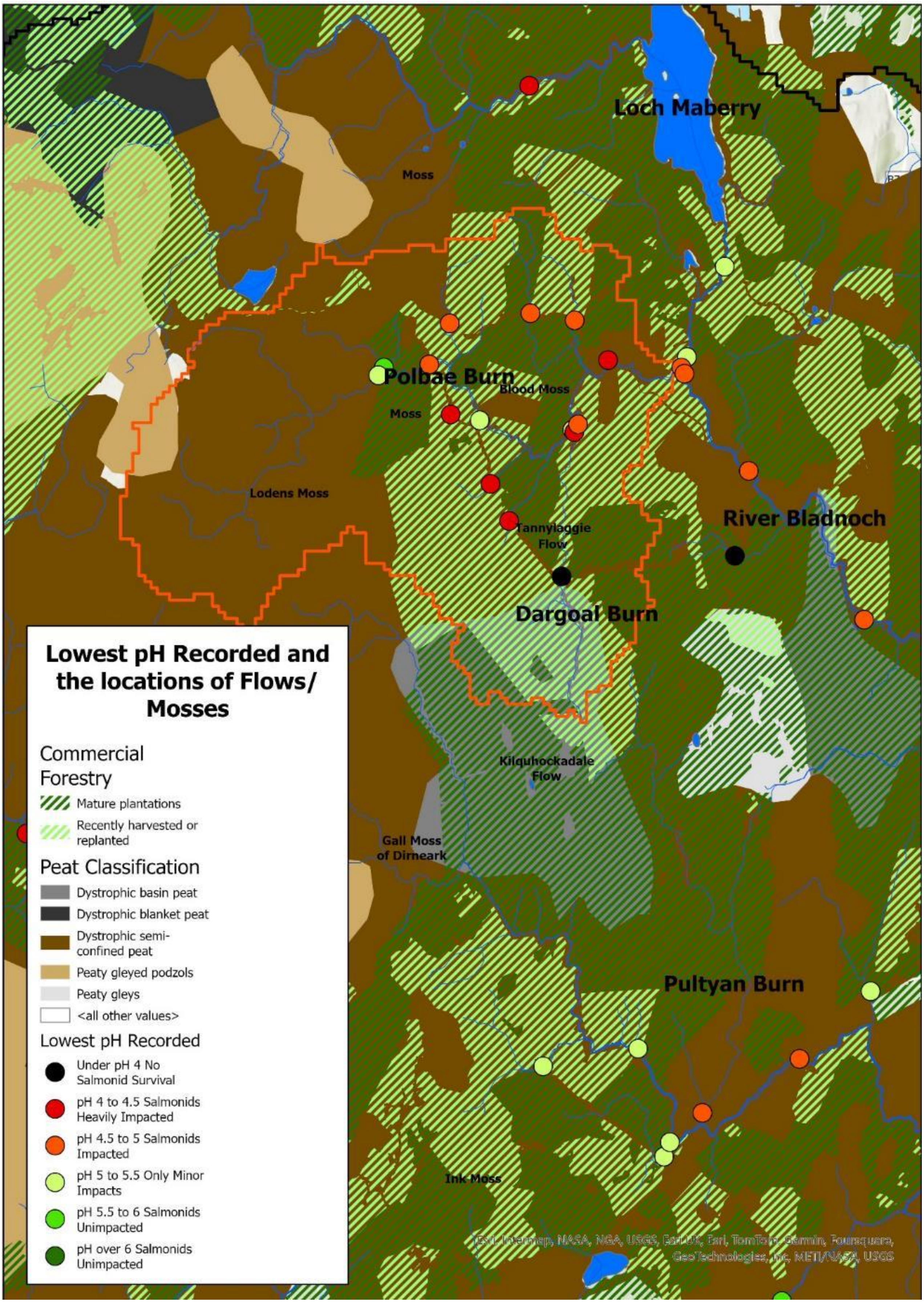
As briefly mentioned in the Tannylaggie water quality monitoring the worst of the acidification in the area appears to stem from an area of basin peat that covers the ride between the top of the Dargoal Burn and the Pultyan Burn (which flows in the opposite direction into the Black Burn). This section of basin peat appears to form the Tannylaggie Flow peatland on the Dargoal Burn side and Kilquhockadale Flow Peatland on the Pultyan Burn side and has been heavily afforested in the past (with much of the forestry remaining). Like the Dargoal Burn, the Pultyan Burn is also acidified with low pH levels being recorded (4.59 in moderate flow levels). The spot sampling map clearly shows a localised impact on the Black Burn downstream of the point at which the Pultyan Burn flows in. This shows the impact this area of degraded/afforested peat is having on water quality and highlights its importance for restoration. In contrast to the Polbae Burn, the Pultyan Burn potentially appears to be the only significant burn within the Black Burn catchment to drain Kilquhockadale Flow with water quality generally being good within the Black Burn, except for the localised impacts from the Pultyan Burn.

As acidification impacts were known in the upper Bladnoch catchment initial water sampling concentrated on these upland areas. As a result of low pH results from the lowland Lannygore Burn spot sampling was extended to the lower catchment during later sampling. The results showed pH levels across much of the lower catchment to be good, but a group of low pH readings were recorded from the area around the Lannygore Burn. In each case the burns sampled flowed from areas of basin peat that had been planted with commercial conifer plantations. As each burn is relatively small the low pH was not significantly impacting the Tarf Water below where the burns flow in due to the dilution factor (and by default the SAC). However, each individual burn is acidified (and as such represents a localised issue) with salmonid populations (in this case probably trout) likely to be heavily impacted. Unfortunately, limited fish data is available for each watercourse to show the true impacts. OS maps show several named "mosses" within these sections of basin peat indicating their historic recognition as peat bogs. The largest area of planted moss within the largest, and most heavily impacted burn (Lannygore Burn), is Mark of Luce Moss, although commercial forestry on Knock Moss, Annabaglish Moss and Mindork Moss will also be contributing to acidification within the burn, but to a lesser degree.

The Ordinance Survey Maps for the Bladnoch catchment contain multiple references to locations of peatlands that will have historically been recognised/given names (identified as Mosses or Flows). As such it has been possible to map their locations and, given the findings above, locate and name the degraded peatlands that are having the biggest impact on water quality. The locations are shown on Map 24. Whilst Map 25 is the same map but centred on the Polbae Burn sub-catchment. Whilst the names likely represent areas of deep peat within the catchment there are probably other areas of deep peat that were not named and are therefore not named/recognised in the maps.



Map 24: Bladnoch catchment map showing lowest recorded pH levels, the locations of Flows and Mosses, peat type and commercial forestry



Map 25: Polbae Burn sub-catchment showing lowest recorded pH levels, the locations of Flows and Mosses, peat type and commercial forestry

The peat classification layer within all maps shown was prepared by NatureScot from a consolidated spatial dataset of 'carbon rich soil, deep peat and priority peatlands habitat' in Scotland derived from existing James Hutton Institute soil and vegetation data. Whilst peat depth data may have been included where available it is likely to be largely based on predictions based on available geo-spatial data. As such there is likely to be some error within the boundaries shown regarding the exact range of different peat classifications, but the general locations should be correct even if the exact boundaries are not.

As can be seen from the maps it is (mostly) possible to name and locate the main areas of degraded peatland that are referred to within this discussion section and that are having the largest negative impact on water quality/aquatic ecosystems. They are Tannylaggie Flow (Dargoal Burn), Kilquhockadale Flow and potentially a section of basin peat due east of Kilquhochadale Flow (Pultayan Burn/Black Burn), Moss of the Horse Hill (Artfield Forest), Mark of Luce Moss, Lannygore Burn). All these peatlands are currently within areas covered by commercial forestry and to the best of our knowledge Tannylaggie Flow is the only area where peatland restoration is planned or is on-going. In addition to Tannylaggie Flow there is an area of peatland within the Polbae Burn sub-catchment to the Northwest of Tannylaggie Flow referred to simply as "Moss". Given the greater Polbae Burn sub-catchment water quality results it is likely that it is contributing to degraded water quality within the catchment (but to a lesser degree than Tannylaggie Flow). Any additional peatland restoration that can be carried out within the Polbae Burn sub-catchment is likely to provide significant environmental gains if additional areas like this that can be identified and discussions regarding peatland restoration can take place. Additional peat depth surveys within the general area would be of benefit in identifying deep peat locally and for taking forward discussions.

Taking the results from the water quality catchment overview as a whole and comparing them to peat type and land use allows a general pattern to be seen within the results. Whilst there are some exceptions, and as touched on already, in general the worst water quality results come from areas identified as "basin peat" that have been used for commercial forestry. As such it is the advice of this report that there should be a policy of peatland restoration in all areas of basin peat planted on base-poor geology within the Bladnoch catchment.

One final point of note is that given the Dissolved Oxygen results from the Dargoal Burn recorded as part of the Tannylaggie Peatland Restoration monitoring there is clearly a need to better understand the relationship between DO levels and degraded peatlands. This is especially so in areas of slow moving, deep water of which the Bladnoch has many. Therefore, summer monitoring of DO levels within the Bladnoch should be carried out in future.

4.3 River Bladnoch catchment management recommendations

- There are no obvious improvements in water quality within the Dargoal Burn at this early stage of the Tannylaggie Flow peatland restoration. This is not unexpected at this early stage. As such long-term monitoring is likely required at Tannylaggie Flow/the Dargoal Burn if the full benefits are to be recorded. Future monitoring should also consider further investigation into the impacts of the reduced DO levels recorded within the burn.

- Additional data analysis carried out by experienced water chemistry specialists will aid data interpretation once the peatland restoration has been completed. This is necessary to draw firm conclusions and further support long term peatland restoration and management in the catchment.

- The results from the peatland restoration monitoring, combined with the results from the Bladnoch water quality overview provides data that can be fed into FLS Tannylaggie peatland restoration plans (e.g. the prioritisation of restoring basin peat and the water quality issues in the surrounding area) and GFT/CCC should meet with FLS to discuss the water quality monitoring results and the latest Tannylaggie peatland restoration plans.

- Although not measured/recorded in this report conifer regeneration is a big issue within Tannylaggie forest and has the potential to impact water quality or even counteract some of the potential benefits of peatland restoration. This should be considered in future monitoring and land management plans.

- As a result of the Bladnoch Catchment Electrofishing and Water Quality overview it has been possible to identify the name/locations of the areas of degraded peat/commercial forestry that are having the biggest impact on water quality/freshwater ecology. They have been prioritised as the following:

    1. **Tannylaggie Flow and surrounding deep peat –** the restoration of the deep basin peat at Tannylaggie has already been identified as a priority for restoring water quality in the upper Bladnoch. However, while Tannylaggie Flow is the main source of reduced water quality the watercourses neighbouring Tannylaggie Flow are also impacted, all of which also contribute to the poor water within the Polbae Burn which extends downstream into the River Bladnoch (both part of the Bladnoch SAC). Whilst the restoration of the basin peat at Tannylaggie Flow should continue to be the priority extending the peatland restoration into any surrounding areas of deep peat where commercial trees have been felled will all help contribute to improving the water quality if possible.
    2. Whilst the Tarf Water is generally less impacted by acidification than the upper Bladnoch but it does have localised acidification issues at high flows. Water quality monitoring results have shown that the main source of the acidification is the **Moss of the Horse Hill** peatland with the resulting low pH potentially extending downstream for several km during very high flows. Aerial imagery shows this peatland to be covered in commercial forestry and GFT/PA should consult with the forestry managers, their client and CCC to discuss the possibilities for peatland restoration.
    3. Due to the overall good water quality the Black Burn is likely important regarding retaining salmon populations within the upper River Bladnoch. However, the acidified Pultyan Burn is having a localised impact within the Black Burn. The source of the poor water quality is the **Kilquhockadale Flow** peatland, and its restoration should also be considered a priority in regard to restoring impacted salmonid populations within the River Bladnoch.
    4. Given localised poor water quality within a cluster of burns in a section of the lower to mid Tarf Water peatland restoration options should be explored within the **Mark of Luce Moss** (basin peat) to help restore water quality in the largest of these burns (Lannygore Burn).

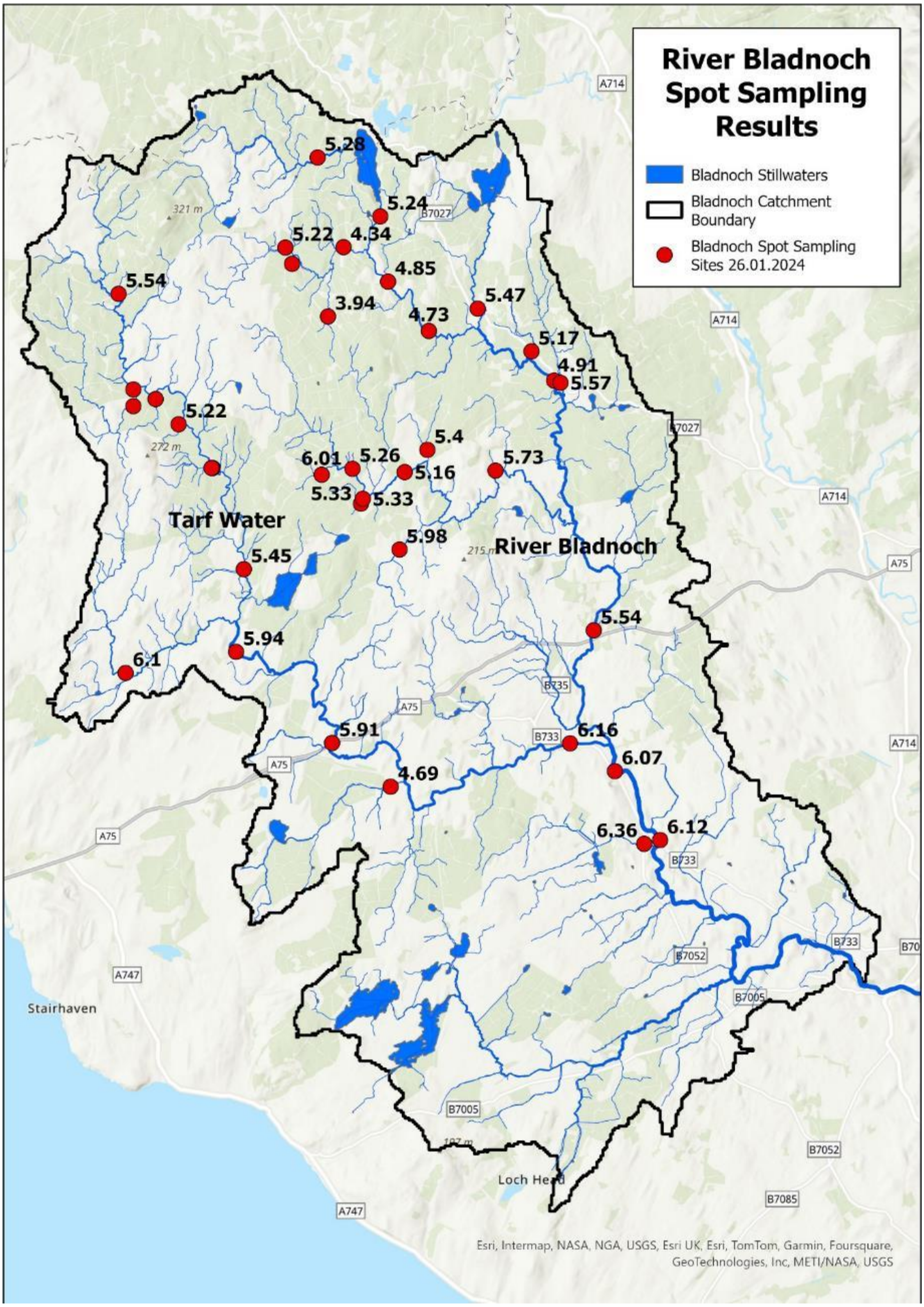
- Additional peatland condition and depth surveys should be carried out within the Polbae Burn catchment in the areas surrounding Tannylaggie Flow to help identify opportunities for peatland restoration.

- Given the possible link between poor water quality and degraded, afforested basin peat within the Bladnoch catchment consideration should be given towards a general policy towards the restoration of all areas of deep basin peat in areas of base-poor geology. As the link between deep peat in general and acidification is more conclusive (than for basin peat alone) this should possibly be considered as a minimum level of peatland restoration to work towards. It is therefore suggested that detailed hydrological, peatland condition, depth and extent be surveys be carried out as a priority on all basin peats in the catchment.

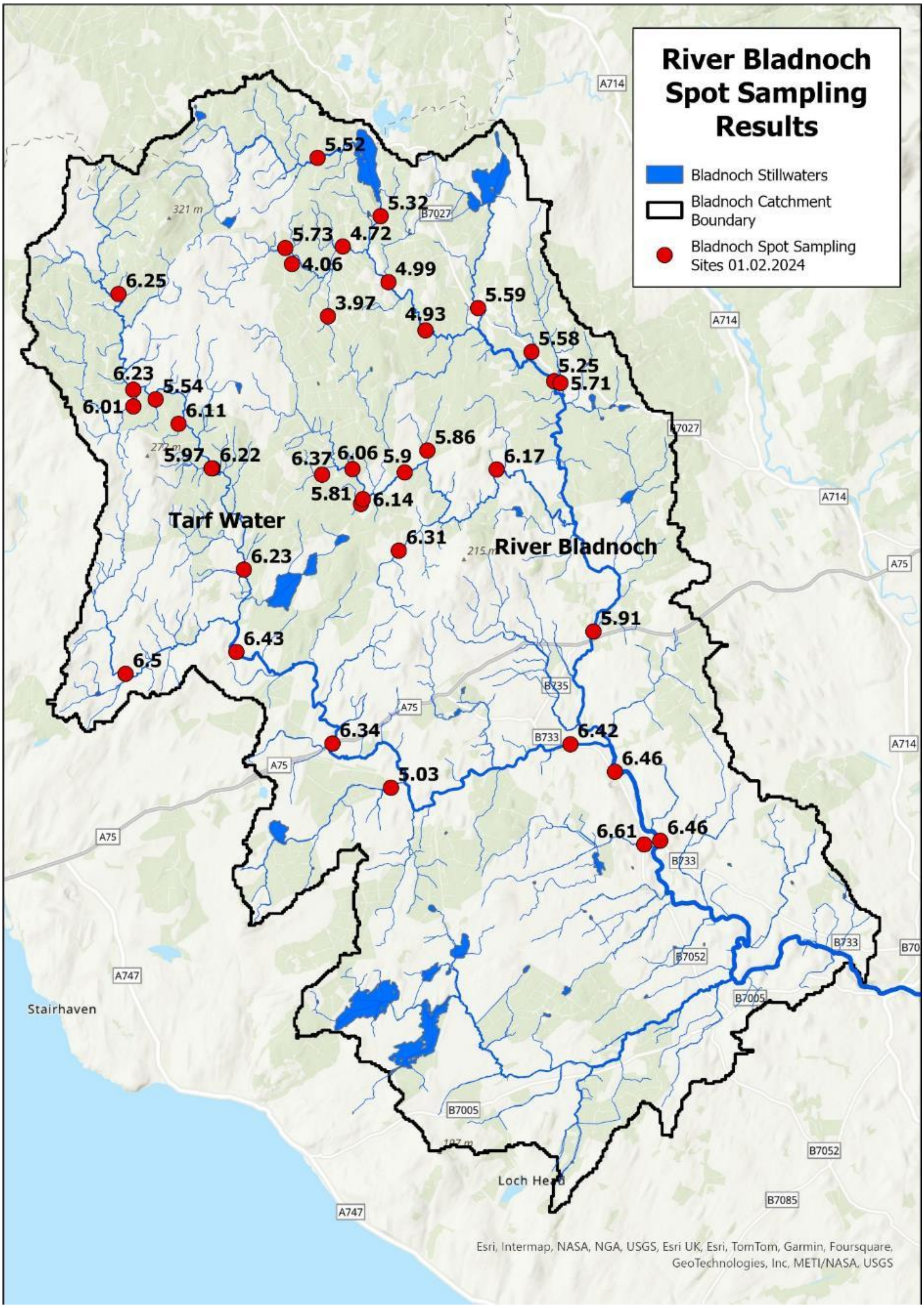
- The low DO levels within the Dargoal Burn highlight the need for further investigation into the impacts of degraded peatlands on oxygen levels within watercourses, particularly within areas with limited re-oxygenation capacity. Summer recording of DO levels should be carried out towards the downstream end of areas of slow, deep water near degraded peatlands to see if there are reduced oxygen levels within these areas and whether they are impacting any areas of salmon habitat immediately downstream.

5 APPENDIX

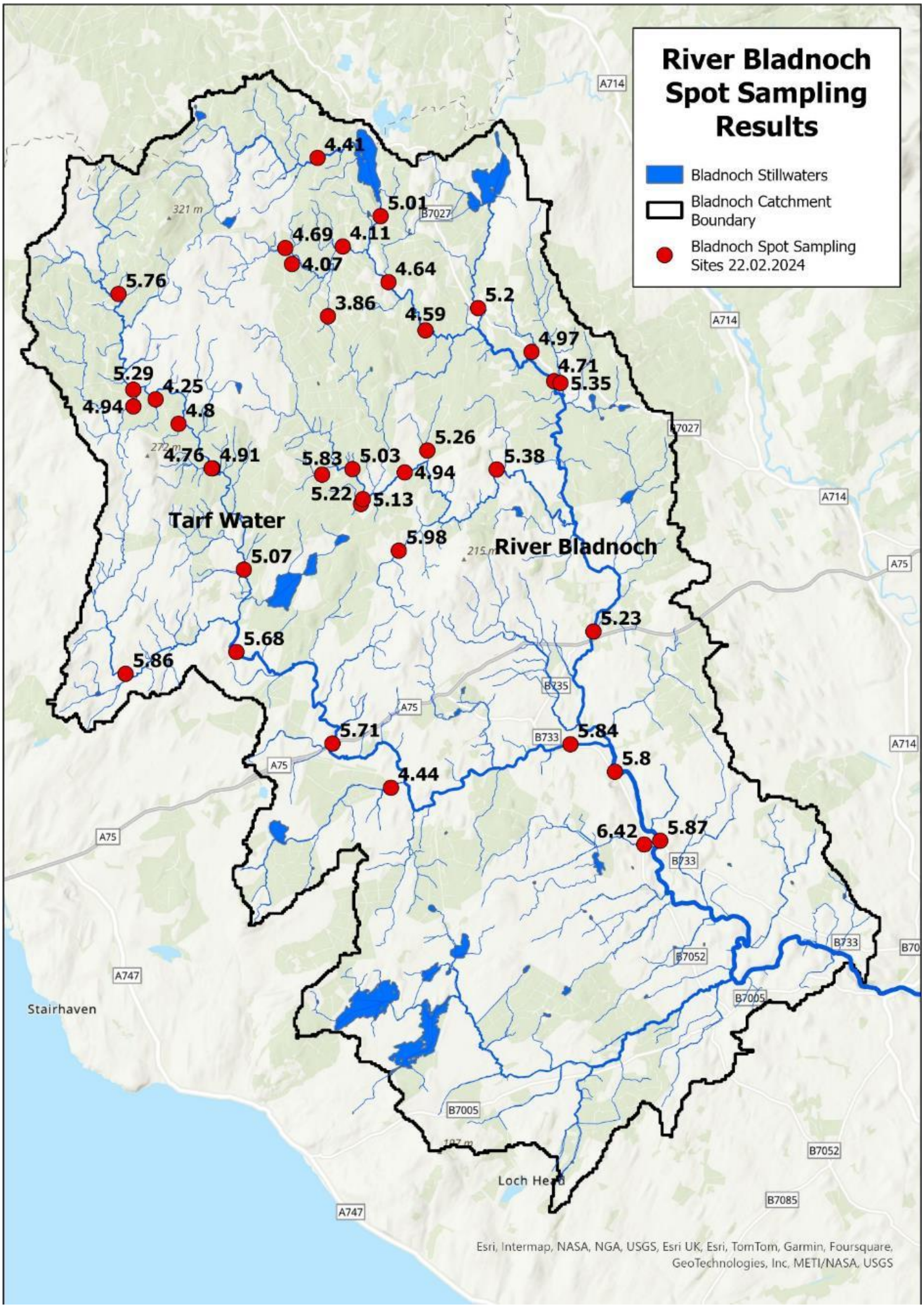
Results from individual water quality monitoring spot sampling days.



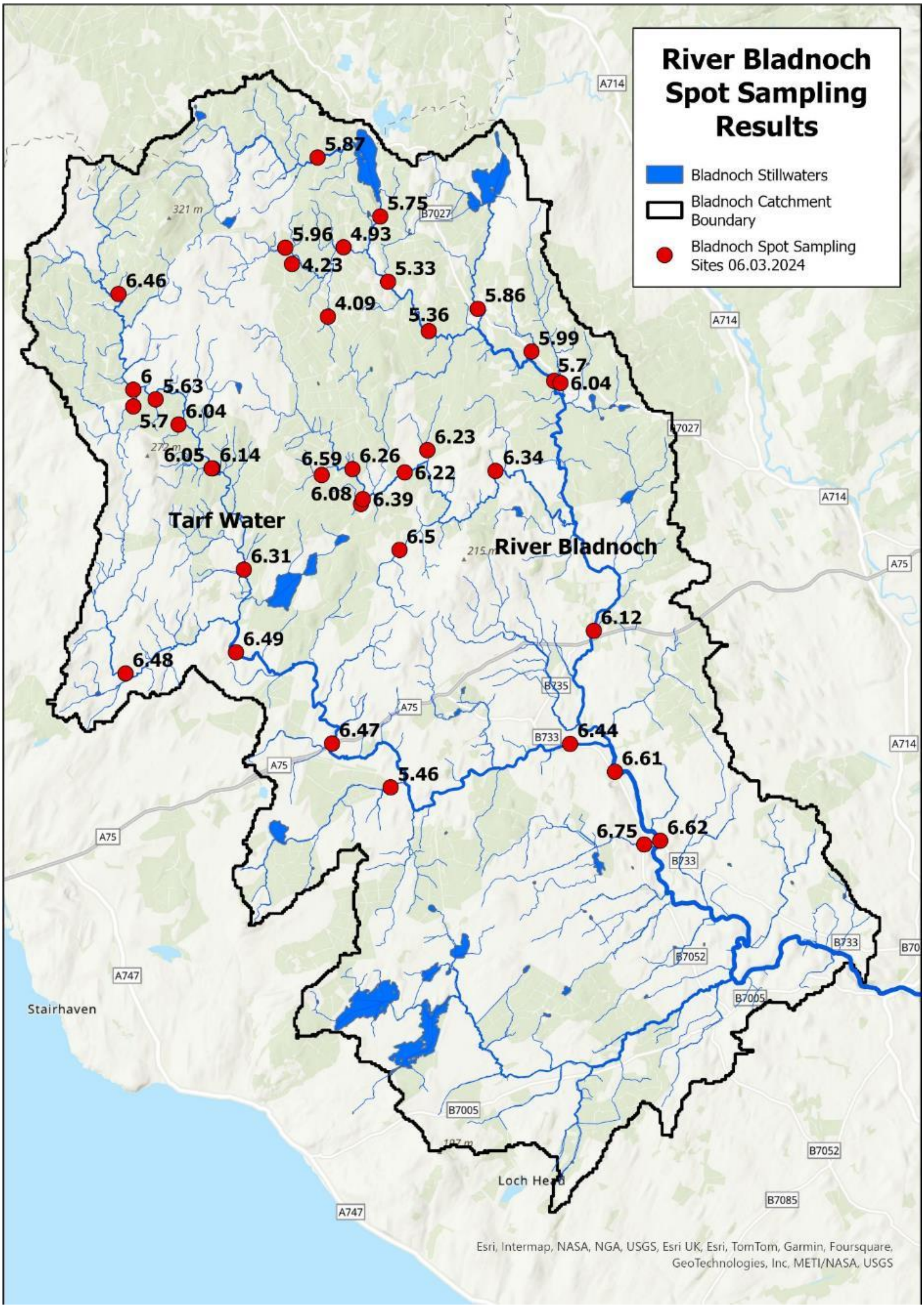
Map 26: The pH levels recorded during spot sampling on 26/01/2024



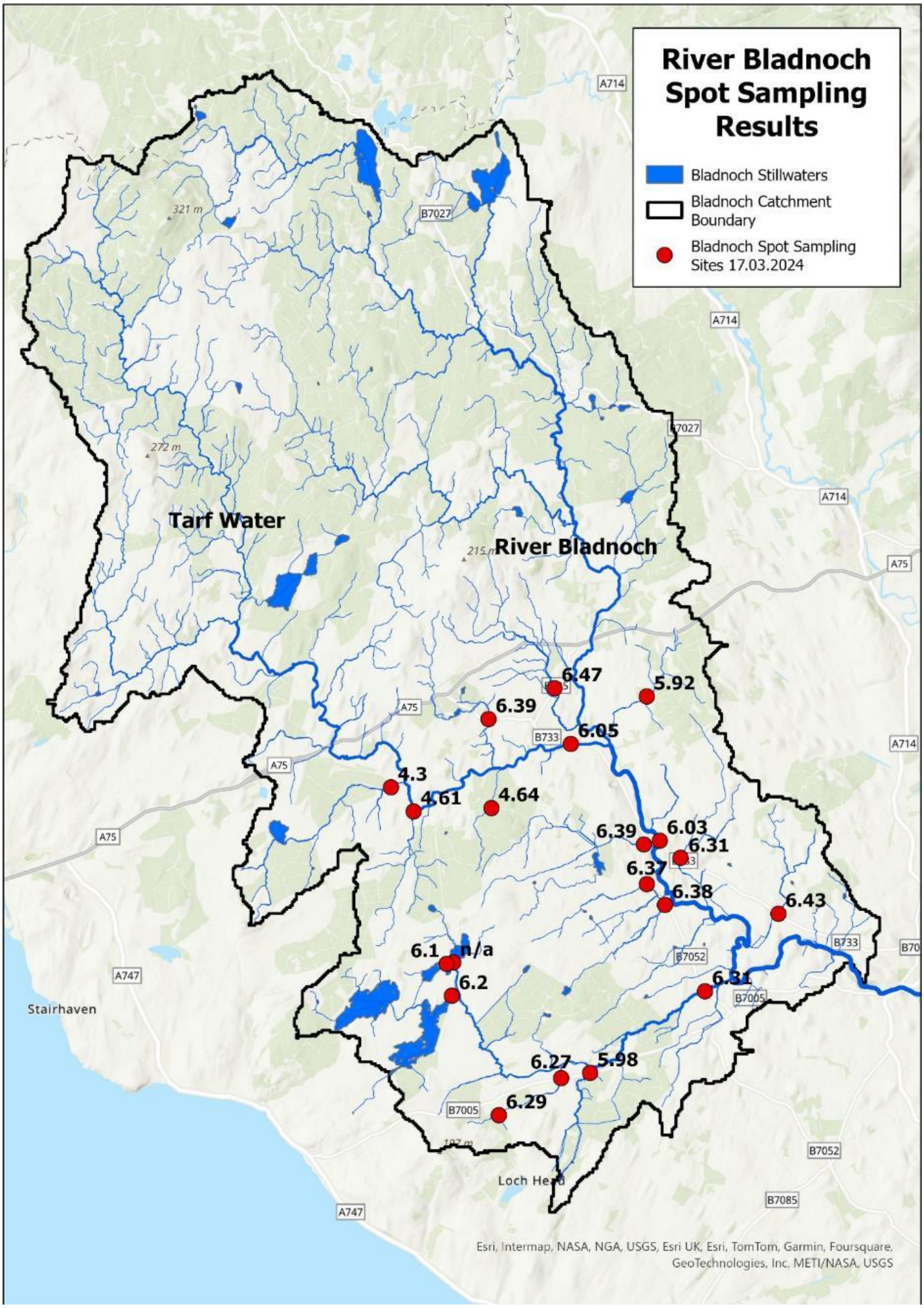
Map 27: The pH levels recorded during spot sampling on 01/02/2024



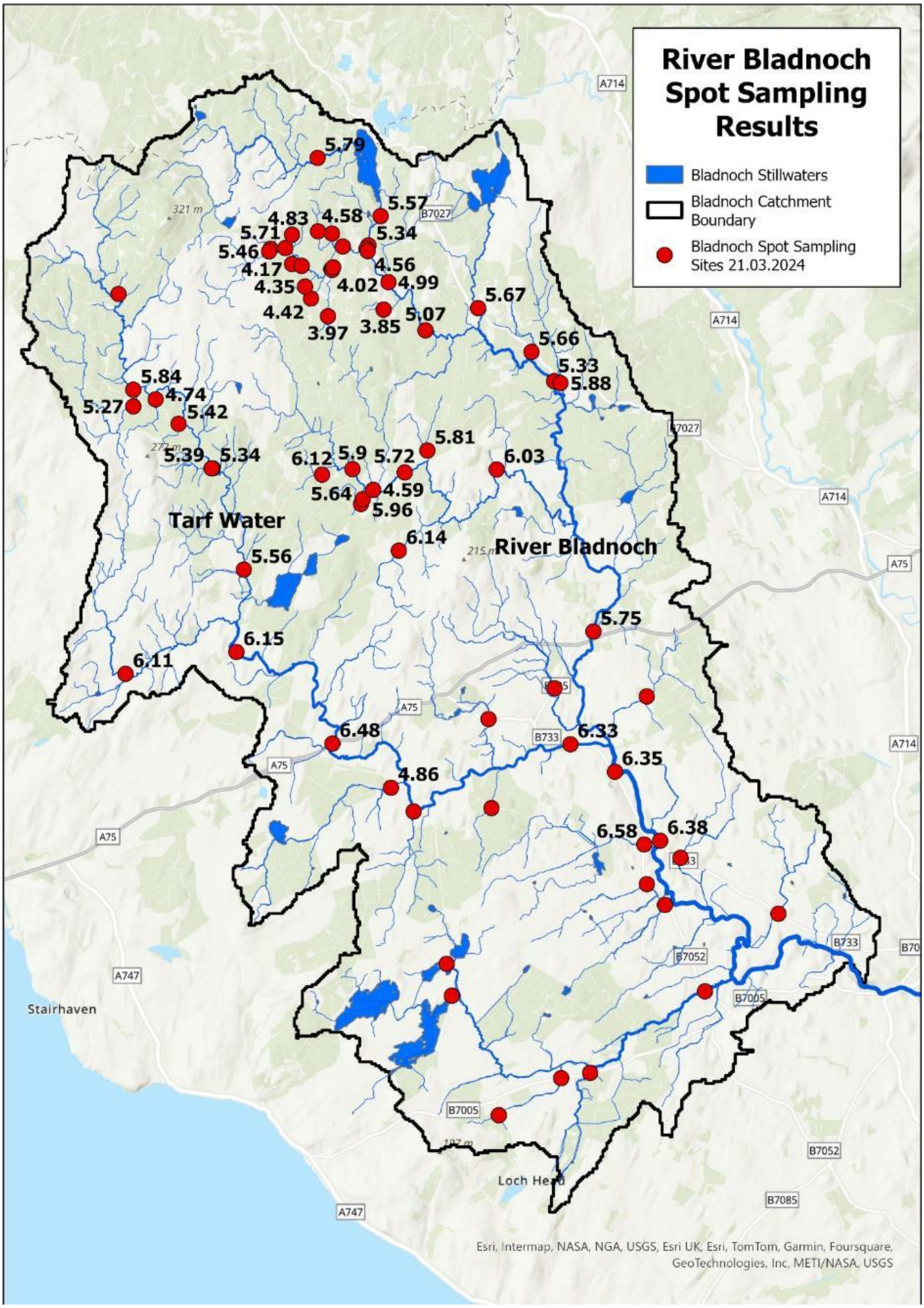
Map 28: The pH levels recorded during spot sampling on 22/02/2024



Map 29: The pH levels recorded during spot sampling on 06/03/2024



Map 30: The pH levels recorded during spot sampling on 17/03/2024



Map 31: The pH levels recorded during spot sampling on 21/03/2024

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