CatchmentCARE River Restoration Works Report

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Disclaimer:

The views and opinions expressed in this report do not necessarily reflect those of the European Commission or the Special EU Programmes Body (SEUPB).

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CatchmentCARE
Community Actions for Resilient Ecosystems

Executive Summary

This report, for the SEUPB funded CatchmentCARE project, is part of WP4 *“Waterbody Actions in Catchments*’.

Habitat Restoration is a major environmental benefit to improve overall ecosystem health.
This report highlights the habitat restoration work carried out within the three River Basin Catchments by the T2 working group and their benefits to the ecosystem in the short term which will feed into long term benefits after the life of the CatchmentCARE Project.

The CatchmentCARE project has been crucial in facilitating river restoration projects aimed at enhancing the health and resilience of freshwater ecosystems across three cross-border river basins: Finn, Arney, and Blackwater. These catchments are predominantly rural and are characterised by their scenic landscapes, which are home to a range of habitats, including upland blanket bog, heath and grassland, rolling hills, lakes, and wetlands. However, these catchments have been impacted by agricultural practices, forestry practices, urbanisation, and industrial activities, resulting in water pollution and habitat degradation.

To address these issues, CatchmentCARE has adopted a collaborative approach, involving local communities, environmental organisations, and government agencies, to complete several river restoration projects. These projects aimed to improve water quality, enhance biodiversity and restore natural habitats. Prior to the works, sites were identified as requiring environmental improvement measures based on surveys undertaken in the prioritisation elements of the CatchmentCARE project. Surveys carried out included River Hydromorphology Assessment Techniques (RHATS), macroinvertebrates surveys, barriers to fish migration surveys and electrofishing surveys. Water Framework Directive Water Quality Status data were also used to characterise water bodies and these data were taken from the EPA and NIEA websites. Every site identified as a potential site for works was subject to a detailed walk over by the CatchmentCARE team to design bespoke remediation works for that site.

CatchmentCARE delivered 130 instream works across the 3 catchments. This work included the removal of two major barriers to fish migration, pinning of woody material at 28 sites, over 80 km of bank stabilisation and a huge array of other techniques at multiple sites including installation of willow weave walls, gravel cleaning, rubble mat installation, creation of meander complexes, pools and riffles.

CatchmentCARE created nearly 100 km of new riparian margins across the 3 catchments. The project also installed 100’s of gates and stile and 455 offline drinking solutions for livestock. The CatchmentCARE project is also responsible for planting well over 30,000 native broadleaved trees.

1. Introduction

River restoration projects are critical to the health and resilience of our freshwater ecosystems, and the CatchmentCARE project has played a vital role in facilitating such efforts. Through a collaborative approach that involved local communities, environmental organisations and government agencies, CatchmentCARE has successfully completed several river restoration projects aimed at improving water quality, enhancing biodiversity and restoring natural habitats. These projects have not only benefited the environment but have also provided economic and social benefits to the local communities.

Freshwater systems are under extreme pressure from anthropogenic activities both now and historically. These pressures can be categorised in these 8 groups:

Diffuse: pollutants and contaminants which enter surface and ground water through diffuse pathways such as run-off and rainfall.

Point: contamination from fixed identifiable sources such as wastewater treatment plants.

Hydrological alterations; where humans have changed the flow and patterns in hydrological regimes.

Abstraction; where humans remove water from freshwater systems for all of the various aspects of human society.

Barriers: which reduce connectivity for animals/sediment/nutrients.

Physical Alterations: alterations to the channel, riparian zones and surrounding floodplains for agriculture and urban development.

Introduced Non Native Species: lead to additional pressures such as habitat competition, habitat alterations, predation, hybridisation and competition for resources and habitats.

Climate change: leading to changes such as increased water temperature, flooding, drought and eutrophication.

These pressures are not mutually exclusive and often are happening all at once in a single system. Therefore there is no “one size fits all” solution as the sheer number of pressures on freshwater systems means that this is a multifaceted issue. Pressures cause changes in the state of freshwater systems and lead to a whole host of impacts such as biodiversity loss and reductions in water quality.

Recognizing the pressures a particular catchment is subject to will help to understand the bespoke needs of the site. Understanding pressures also underlines the need to improve water quality by restoring our water bodies to as close to their natural state as possible. Restoration refers to the re-establishment of the natural functions of the water body related to physical, chemical and biological processes and importantly the linkages between the terrestrial and aquatic ecosystems. The aim of any river restoration project should be to repair the natural processes of diversity and dynamics of aquatic ecosystems in order to ensure that the dynamics of natural ecosystem processes are operating efficiently. By restoring natural processes this ensures our waterways arerobust enough to build resilience in our systems.

The CatchmentCARE project focused on three cross border river basin catchments: Finn, Arney and the Blackwater.

The Finn Catchment is located in County Donegal, in the Northwest of Ireland. It covers an area of approximately 494 km^2 and is home to a range of habitats including upland blanket bog, heath and grassland. The catchment is predominantly rural and is characterised by its scenic landscape, with the River Finn flowing through it and forming several deep gorges and waterfalls. The Finn Catchment is an important area for angling, with the River Finn being renowned for its salmon and trout populations. However, like many catchments it has been impacted by agricultural practices, forestry practices, urbanisation and industrial activities, resulting in water pollution and habitat degradation. The River Finn is also a Special Area of Conservation (SAC) with the designation capturing almost all of the river and its tributaries. The qualifying interests of this Natura 2000 site are; oligotrophic waters containing very few minerals of sandy plains, Northern Atlantic wet heaths with *Erica tetralix*, Blanket bogs (if active bog), Transition mires and quaking bogs, Salmon (*Salmo salar*) and Otter (*Lutra lutra*).

The Arney Catchment is located in County Fermanagh, Northern Ireland and covers approximately 265 km^2. The Catchment is predominantly rural, with agriculture being the primary land use. The landscape is characterised by rolling hills, lakes and wetlands, including the Arney River, which flows through the catchment and into the River Erne. The Arney catchment is an important area for wildlife, with several designated sites of special scientific interest, including the Arney River Woodlands and the Fardrum and the Derrylester Loughs. However, the catchment has been affected by a range of environmental issues, including agricultural runoff, peatland degradation, and invasive species.

The Blackwater catchment is located southeast of Northern Ireland, covering an area of approximately 1,491 km^2. The catchment is predominantly rural, with agriculture being the primary land use. The landscape is diverse, ranging from upland peatlands and mountains to lowland rivers and wetlands. The River Blackwater, which flows through the catchment, is one of the largest rivers in Ireland and is an important area for fishing, with populations of Salmon and Trout. However, the catchment has been affected by a range of environmental issues, including agricultural runoff, habitat degradation and water pollution. The Blackwater catchment is also home to several designated sites of special scientific interest, including the Knockmealdown Mountains and the

Ballyduff Upper and Lower wetlands, which are important areas for wildlife and biodiversity conservation.

2. EVIDENCE BASED APPROACH

The three river catchments were assessed in detail prior to the implementation of river habitat restoration works undertaken by the CatchmentCARE teams under work package T1. The assessments allowed the catchment teams to select areas of concern and prioritise works. Sites were selected for river restoration works based on "water quality". For the purposes of the CatchmentCARE project "water quality" was defined using the Water Framework Directive Ecological Status of the area as a proxy.

The metrics surveyed included;

- RHATS (River Hydromorphology Assessment Techniques);
- Macroinvertebrates surveys;
- Barriers to fish migration; and
- Electrofishing surveys.

Every potential site was also walked over by the CatchmentCARE teams in order to design bespoke remediation works for the site.

RHAT is designed to be a holistic visual assessment and can be used to assess individual sites. This generates data for 8 relevant variables of habitat quality within 10 sub-sections of a 500 m length of channel. Key parameters include the flow, sediment type, channel and floodplain dimensions, topography and substratum, continuity and connectivity of a river. Anthropogenic features such as bank protection works, artificial barriers (weirs, dams) and modifications to processes are also included. RHAT makes the assumption that natural systems support ecology better than modified systems. Hence, the RHAT method classifies river hydromorphology based on a departure from naturalness. RHAT assigns a morphological classification directly related to that of the WFD: High, Good, Moderate, Poor and Bad, based on semi-qualitative and quantitative criteria.

2.1. Macroinvertebrates

As historical data collected by Loughs Agency indicated that macroinvertebrate populations were in decline in the Finn Catchment, an agreement between the partners at the initial design stage of the project was made to allow Loughs Agency to use both the 'Small Stream Risk Score' method and the 'Q-Value' as metrics that would be taken into consideration when prioritising sites for selection. These data would complement the overall Environmental Quality Ratio (EQR) value for water bodies on the Finn which was formulated using data taken during 10 minute electrofishing surveys and processed by IFI. These data were used to establish a baseline and were monitored throughout the life of the project. Macroinvertebrates were not monitored in the Arney or Blackwater catchments as their populations were not considered as much of a concern as they were in the Finn. The inclusion of macroinvertebrate surveys on the Finn was also related to Loughs Agency's investigations into Chemical Export from Land Use which was part of their T2 deliverables and it was suspected that this activity was negatively impacting upon macroinvertebrate populations in the Catchment.

Figure 1: CatchmentCARE Team conducting Macroinvertebrate survey.

Data collected on macroinvertebrate populations was in a format which could be used to calculate Q-Value scores (which are the standard Environmental Protection Agency (EPA_ scoring system) and Average Score Per Taxon (ASPT) & Biological Monitoring Working Party (BMWP) Scores (which are the standard scoring systems used in Northern Ireland). This allowed these data to be compared temporally to data collected by the LA and Environmental Protection Agency at corresponding sites in the past, facilitating observation of a longer trend in data for the use of CatchmentCARE project objectives.

2.2. Electrofishing

Electrofishing was undertaken as the standard sampling strategy. A timed, 10-minute, semi-quantitative fishing protocol was used. In shallow water locations electrofishing backpacks were used as a power source and a team of two or three persons undertook the fishing, wading in an upstream direction, one undertaking the fishing and one carrying a bucket to retain captured fish. All fish encountered during the 10-minute fishing period, including crayfish and larval lamprey, were collected and retained in a holding bucket of clean water. All fish were subsequently measured and held in a recovery bin of water from the sampling site until all data collection was completed. Fish were then returned into the sampling site on completion of the site survey. Key elements of the data collection were (a) recording of all fish species encountered i.e. the fish community composition and (b) the length range of all fish within any species (Note: Loughs Agency record length range for salmonids only).

Figure 2: Electrofishing in the Finn Catchment.

2.3. RHATs

The River Hydromorphological Assessment Technique (RHAT) is a survey developed by NIEA specifically for the Water Framework Directive (Murphy and Toland, 2012). Hydromorphology describes the physical habitat of a river constituted by the physical form (abiotic and biotic) and flow of the river. RHAT surveys were carried out at numerous locations on all three catchments and provided significant detail on the areas assessed which helped inform habitat restoration measures implemented. Key parameters assessed include the flow, sediment type, channel and floodplain dimensions, topography and substratum, continuity and connectivity of a river. Any deviations from the anticipated natural state of a river stretch or undue influence from adjacent land use attributed to human activity, where insufficient riparian protective buffers were present, informed the RHAT score.

2.4. Continuous Monitoring

The surveys completed in the pre-works monitoring stage acted as baseline information specific to each site. The pre-works surveys were then repeated after works completion and will also be conducted after the life of the CatchmentCARE project to monitor the long-term ecosystem benefits. Repeat surveys after works are completed will provide important temporal data on the efficacy of the river restoration projects.

2.5. Measures Implemented

Habitat protection and restoration measures that could be implemented during the CatchmentCARE Project were decided upon during the project design phase of the Overall Project and helped inform the deliverables of the Project.

Acceptable protection/ restoration measures were included based on the wealth of science already available that supported their effectiveness in dealing with certain issues related to river habitat and water quality protection and enhancement.

Generally, measures to be implemented were selected which aimed to replicate natural river habitats and processes that had been removed or impacted due to various modifications of the river channel and riparian zone. Inclusion of these types of measures not only help to restore the water quality of a river but help to improve the microhabitat biodiversity of the instream and riparian habitats which allows the aquatic environment to be more resilient to any potential system shocks caused by pollution events or extreme climate conditions.

A list of the measures that formed the ‘toolbox’ of measures that were to be incorporated at sites selected includes:

Barrier modification/ easement

This measure seeks to address an existing barrier to fish migration and natural river sediment/ nutrient transport by either completely removing the structure and re-naturalising the river stretch or, if the barrier can’t be removed, to modify it so that it can still perform the function for which it was installed whilst still allowing the movement of migratory fish.

Bank Protection

Bank protections are measures that are put in place to stop excessive erosion of river banks. For the CatchmentCARE Project, these measures were implemented in areas that were undergoing erosion due to measures/ activities previously carried out by human activity specifically. An emphasis was placed on ‘green’ engineering structures initially, where flow conditions would allow, followed by a mix of ‘green-grey’ and finally ‘grey’ engineering. The terms ‘green’, ‘green-grey’ and ‘grey’ refer to the type of erosion controls put in place. ‘Green’ measures are ones that use completely natural materials such as root wads, brash, willow spilling, pinned woody material etc. to create a protective layer in front of the river bank. The benefit of ‘green’ engineering is that they allow the bank to re-establish and re-build itself over time through the collection of river sediment, they promote the growth of vegetation which further strengthens the bank against any erosion and the porous nature of the structure helps absorb the stream flow energy, reducing it’s potential for erosion here and further downstream. They also provide numerous instream and riparian microhabitats for aquatic flora and fauna to exploit and are more aesthetically pleasing as they appear completely natural when fully established. ‘Grey’ engineering refers to the installation of rock armour, groynes, rip-rap or gabion walls which use rock as the primary material from protecting the river bank from erosion. The benefit of ‘grey’ engineering is that it can be installed in rivers that have very strong water flows, flows so strong that any ‘green’ engineering would not be able to survive long enough to get established and would be torn out by the rivers flow. Unfortunately, ‘grey’ engineering does not provide the same types of microhabitat niches that ‘green’ engineering measures do and the rock and cobble substances used do not help reduce the flow energy of the river water as it passes the erosion point on the bank. This results in the river water effectively being ‘bounced’ off the ‘grey’ engineering and can lead to erosion occurring on the opposite bank or further down the river stretch. ‘Grey’ engineering is also not as aesthetically pleasing as ‘green’ engineering as the installations are clearly man made. ‘Green-grey’ engineering involves using a mix of both ‘green’ and ‘grey’ engineering at a site and is useful in areas where the river water flow is too strong for ‘green’ engineering alone but isn’t so strong that a complete ‘grey’ approach is required. These installations often involve the use of a rock roll toe to eliminate structure undercutting and then this is overlain with pinned woody material or brash.

Large Woody Debris Pinning

Large woody debris generally consists of either a fallen tree or large tree branches which are pinned in strategic locations in a river channel. They are installed so as not to disrupt the flow of the river or cause an obstruction which will gather river debris. The reason for installing large woody debris is to create diversity within the channel; in both flow and habitat creation. This includes additional habitat and refugia for macroinvertebrates and fish species in the river. The wood itself is fed on my aquatic macroinvertebrates and acts as an attachment point for aquatic plants. It also provides shading during warm weather to fish species.

Gravel Cleaning

Gravel cleaning is carried out on gravels that are suitable for spawning salmonids but have been compacted by silt and are too compacted for salmonids to create their spawning redds. To carry this out either a long-armed digger equipped with a special ‘riddle’ bucket (a digger bucket with openings to release small pebbles) rakes the gravel to release the silt and loosen it or a pressurised water lance can be used where an operator sprays the gravel to release the silt.

Substrate Grading

Substrate grading is the process of removing larger stones and cobbles from a potential spawning area and leaving behind smaller more suitable spawning gravel. This is carried out using a long arm digger equipped with a ‘riddle’ bucket.

Habitat Unit Creation

Habitat unit creation refers to the installation of several features, either instream or in the riparian zone that, when combined create numerous microhabitats or water protection features. Unit design varies greatly but examples of such installations would be a meander complex, which would incorporate installation of groynes, pool-riffle-run sequences, nursery habitat and spawning habitat creation along a specified river stretch. An example for a riparian zone would be the installation of fencing to create a riparian buffer, planting of trees and shrubs in this area and installation of a vegetated sump/ swale to capture field runoff from drainage ditches.

Pool Creation

Pool creation involves excavating the river bed and placing protective boulders and cobbles within the pool and along its upstream edge to help prevent scour and the pool filling in. These are usually installed in stream areas of low depth variability and act as important refugia for aquatic species in low flow conditions. This is normally introduced after channels have been subject to arterial drainage programmes and river energy reduced so pools are no longer formed naturally.

Rubble Mats

Rubble mats involve introducing large stones and boulders to an area of a river that exhibits no or very little turbulence (i.e. a run/ glide area). The idea is to create turbulence so that the water/ air interface interacts to a greater degree and encourages mixing of oxygen into the water column. The stones and boulders also create an area of respite for fish species to rest behind when migrating upstream. Rubble mats are a natural feature of unimpacted rivers, however rivers subjected to arterial drainage are normally lacking this feature.

Fencing

Installation of fencing along a river bank allows a riparian buffer zone to be established and also eliminates access by livestock to the river. Reducing livestock access reduces the erosion of river banks caused by poaching and also eliminates the entry of faecal matter into the water. If a riparian buffer zone is created it can be planted with trees and shrubs and these protect the river from any runoff sediment, nutrients, chemicals or slurries from adjacent land, safeguarding water quality. Alternatively, these buffer strips will naturally vegetate but over a longer time period.

Offline Drinking Solutions

Offline drinking solutions are items such as solar powered pumps or pasture pumps linked to troughs so that water can be abstracted from a river for livestock. These are necessary when fencing is installed on agricultural lands as fencing eliminates access for livestock to a river to drink and so an alternative source must be provided.

Tree Planting

When a riparian buffer strip is established, trees are planted if there is an insufficient amount already present. Planting of trees along a river bank provides several benefits to the aquatic environment. Firstly, tree roots help slow runoff from adjacent land and absorb excess nutrients from any runoff and reduce the amount of sediment entering the watercourse. Trees also provide allochthonous material to a river in the form of leaf and woody debris which is used as a food source by aquatic macroinvertebrates and can also provide additional habitat (similar to large woody debris). Macroinvertebrate communities are also enhanced in the riparian zone with the presence of trees and increased numbers of terrestrial and aquatic macroinvertebrates providing a readily available food source for fish species. The increase of aquatic macroinvertebrate communities also facilitates numerous ecological functions as macroinvertebrates break down wood and leaf litter and feed on algae and microorganisms on the surface of leaves and wood, which allows this energy to be utilised further up the food chain and helps maintain a healthy ecosystem. Finally, trees provide shade for rivers and help with water temperature regulation, which is becoming increasingly important with the advance of climate change.

Many rivers can and will recover and flourish if the pressures are reduced or removed, and natural features are restored. Installation of the above described measures in areas that require them can help restore habitat diversity and natural channel dynamics and make the aquatic ecosystem as a whole more resilient.

3. HABITAT RESTORATION WORKS – FINN CATCHMENT

3.1. Approvals and Consents from Relevant Authorities

As Loughs Agency was carrying out works on the Finn Catchment, there was a need to ensure that the proper approvals and consents were obtained from the relevant authorities due to the works occurring within the Finn River Special Area of Conservation (SAC).

Initially, it was advised by Donegal County Council that planning permission would be needed for any works proposed by Loughs Agency in the area, as the works had the potential to impact upon the integrity of the SAC.

Loughs Agency went through the planning process for their initial two work packages on the Cummirk River and this involved supplying duplicate copies of the specification of works, site plans, advertising the works in the newspaper, erecting site notices and producing an Appropriate Assessment for the works. These tasks were addressed and planning permission ultimately approved for the works but it became clear that, due to the length of time it takes to obtain planning permission, this process would be overly cumbersome if other work packages carried out under T2 of the project were to be progressed and this may jeopardise the success of the CatchmentCARE Project in the Finn.

Loughs Agency initiated discussions with the Donegal County Council (DCC) Planning Department on this issue and the outcome was that the planning department were primarily concerned with the approval for works that would be granted by the National Parks and Wildlife Service (NPWS) and were not necessarily concerned with the nature of the works from a civic or public perspective. In light of this Loughs Agency and the lead partner, Donegal County Council, organised a meeting between representatives of their two organisations and representatives from the planning department and NPWS. It was decided at that meeting that the DCC planning department would forgo the need for planning permission as long as NPWS were consulted by Loughs Agency on any works that were to be carried out by providing NPWS with either an Appropriate Assessment or a Screening for Appropriate Assessment document.

Follow up discussions between Loughs Agency and NPWS revealed that Loughs Agency, as a competent authority, were not required to provide NPWS with any documentation if they produced a Screening for Appropriate Assessment that screened the works planned by Loughs Agency out from needing an Appropriate Assessment.

As all works to be carried out by Loughs Agency on the Finn were designed specifically to protect and enhance the habitat of the River Finn SAC then this would result in all works screening out.
Therefore, in order to be completely transparent and to follow best practice, Loughs Agency agreed to carry out an Appropriate Assessment of all works and include it as an Appendix to the Screening

for Appropriate Assessment Documents produced, and these documents were shared with a representative of NPWS to ensure that NPWS were happy with Loughs Agency's conclusions and mitigation measures for each work package.

As Loughs Agency also intended to carry out two barrier removal and replacement work packages in the Finn, they procured the expertise of a consulting engineer to help obtain Section 50 consents from the Office of Public Works (OPW) for those two work packages, carried out as part of T2, as well as for an additional work package on the Reelin which was unable to be carried out during the CatchmentCARE project but which Loughs Agency have committed to addressing as part of their core works. These section 50's gave Loughs Agency the permission to replace barriers to fish migration on the Rough Burn and on the Dresnagh River.

Finally, Loughs Agency, as well as the other Catchment officers on the Arney and the Blackwater, obtained signed permissions from all landowners on whom's land work was carried out. Landowner permissions were only signed by landowners once they had been provided with a Specification of the works and given a chance to comment on them. Once comments or any outstanding issues were addressed, landowners signed permissions and works packages proceeded to the tender stage.
The vast majority of the works packages carried out by the three partners were advertised on eTenders and eSourcing as they were above the €30,000 threshold. All work packages that were less than this threshold were tendered by requesting quotations from at least three suitable contractors that would be able to deliver the work package in question.

3.2. Cummirk

Improvement works along the Cummirk River were situated in the upper reaches of the Finn catchment, north of Cloghan, Co Donegal. Works involved the installation of instream soft engineering measures at two locations on the Right bank of the River Cummirk (Irish Grid Reference: 198736 E 402813 N & 198762 E 402737 N), as well as the installation of a riparian margin between the following coordinates 198637 E 402873 N and 199838 E and 401353 N (Irish Grid Reference). Land in this area is primarily improved and semi-improved grasslands, used mostly for agricultural purposes, with sheep farming most prevalent.

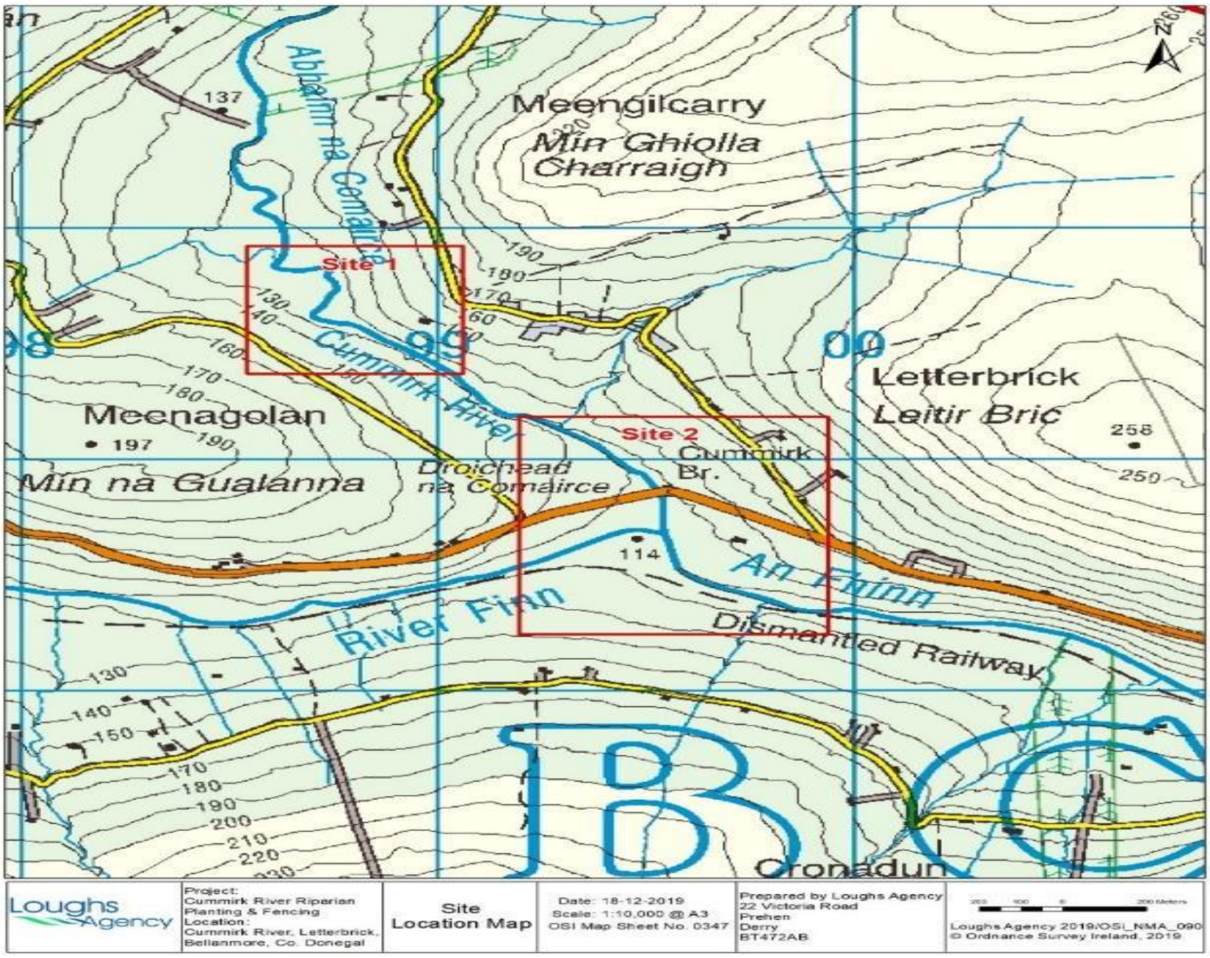

Figure 3: Location of the Cummirk River Restoration Works.

The Cummirk 010 waterbody has been identified as an ‘Area for Action’ within the second cycle River Basin Management Plan for Ireland 2018-2021. These actions will be prioritised to achieve WFD objectives and will be directed towards pressures such as agriculture, urban waste water, domestic wastewater and forestry.

The Cummirk River suffered from erosion on both banks along its length, with evidence of significant livestock poaching at numerous points along the river. The effects of erosion have had particular impact on the northern bank of the river, with formation of a deep pool and the deposition of gravel on the opposite bank causing loss of valuable land. Fencing is also inadequate and intermittent along the stretch of river, with only a small pre-existing riparian margin of ~1 m.

Figure 4: Deep pool had been created by erosion with large amounts of high and dry gravel deposits.

Two locations along the northern banks of the Cummirk River were identified as needing soft engineering measures to mitigate erosion. Coir mats and rock rolls were installed to a height of 1 m at the toe of the eroding eastern/north eastern bank face to alleviate erosion pressures and prevent undercutting.

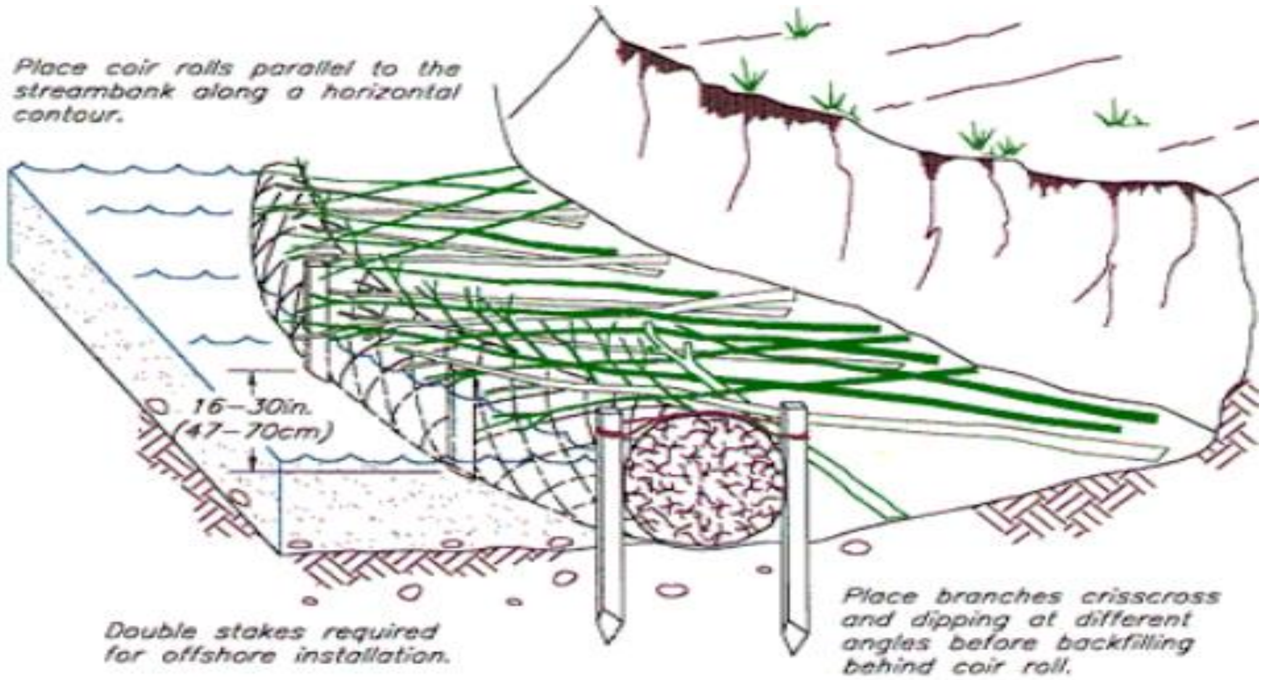

Figure 5: Schematic of soft engineering implemented with coir roll toe emplacement.

Above and in front of the coir matting, pinned woody material was installed using onsite felled tree material, packed brushwood fascine and brash material (weathered Christmas trees). Brash and brushwood fascine material was densely packed to deflect the rivers flow, and the weaving of live willow cuttings onto the face of the soft engineering measures ensured its binding to the bank face soil, preventing further erosion.

Figure 6: Live Willow weave wall with brash material packed behind.

Stands of trees adjacent to the works were removed, with root structures of felled trees left in place to help bind bankside sediment. Areas of pinned woody material have now successfully naturalised into the existing environment, providing food and refugia for fish and macroinvertebrates.

“High and dry” gravel (under normal flow conditions) adjacent to the soft engineering was also regraded to provide appropriate spawning habitats for salmonids, in the hopes of increasing survivability of salmonids in the locality.

To amend the previously inadequately narrow riparian margin, a 5m wide fenced margin was implemented along an 1,849 m stretch of the northern river banks, planted with a mixture of native broadleaf trees. In order to provide access to the riparian margin, 19 unigates and 13 stiles were also installed.

Figure 7: Cummirk Restoration works in 2022. Banks have successfully naturalised and gravel is available for spawning habitat.

3.3. Elatagh

The Elatagh River is surrounded by majorly unimproved grassland, with some improved grassland and silage present. The land is used primarily for agriculture, with particular emphasis on grazing.
Riparian and instream works were carried out along the Elatagh River between the coordinates 54.875056N -7.975384W (Irish Grid: 201629 E 403019 N) & 54.889283N -7.962506W (Irish Grid: 202455 E 404603 N).

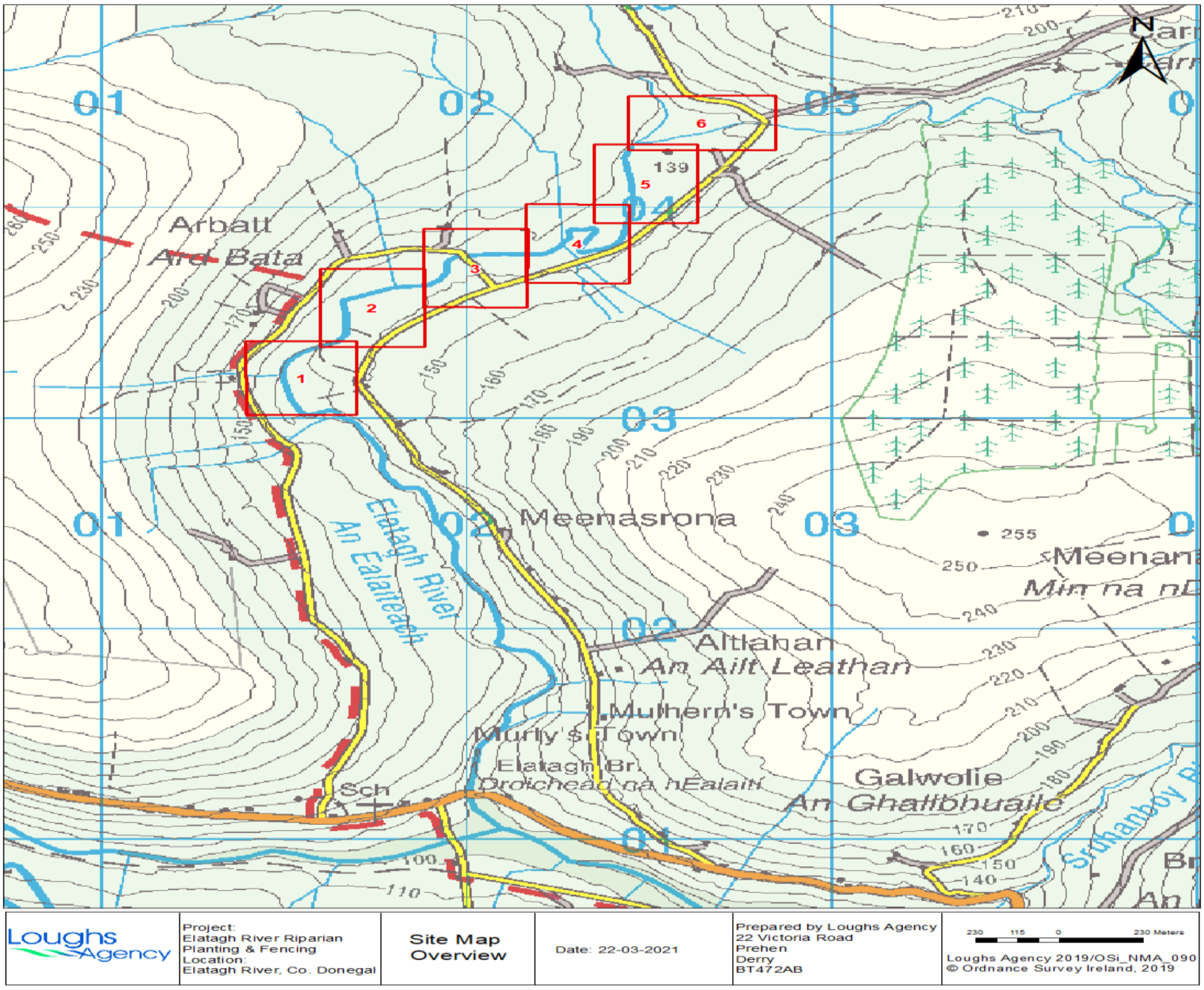

Figure 8: Location of the Elatagh River Restoration Works.

The Elatagh 001 waterbody has been identified as an 'Area for Action' within the second cycle River Basin Management Plan for Ireland 2018-2021. These actions will be prioritised to achieve WFD objectives and will be directed towards pressures such as agriculture, urban waste water, domestic wastewater and forestry.

Areas along the Elatagh River have an inadequately fenced riparian margin, allowing direct livestock access into the river and subsequent poaching of river banks and riverbeds. Areas of banks have also been subject to erosion and collapse as a result of natural instream processes.

Figure 9: Evidence of poaching from livestock into the river.

Small, poorly planted riparian margins fail to provide sufficient surface area for absorption/degradation of agricultural, waste water, domestic and forestry chemical export, and vegetation uniformity has also resulted in reduced habitat diversity along the length of the Elatagh. Several areas also had significant stands of overhanging trees which effectively blocked all sunlight from the river.

Figure 10: Banks had been fenced off in areas and had lacked appropriate riparian margins.

Within the river channel there was an absence of habitat variability, with a lack of pool-riffle-glide sequences and channel straightening at two locations Significant amounts of “high and dry” gravel otherwise suitable for salmonid spawning was also compacted with silt.

Figure 11: High and Dry gravel within the river which is unsuitable for spawning habitat.

The Loughs Agency, as a partner of the CatchmentCARE Project, proposed to carry out stream bank improvement works and instream improvement works along both banks of the Elatagh River in the Finn River Catchment, Co. Donegal.

Riparian improvement works

Riparian works along the Elatagh involved the installation of 3,360 m of fencing to create a riparian margin of varying distances from the river bank (2-20 m), with 28 single wooden unigates and 24 stiles for ease of access to the riparian margin. Approximately half of the area targeted had existing fencing, although much of this was in poor repair and was therefore replaced. In lieu of direct livestock access to the river, 22 x 80 gallon twin reservoir plastic drinking troughs connected to solar powered pump systems were provided to landowners as an offline drinking water source for livestock.

Figure 12: Riparian fencing installed along the Elatagh.

Discussion with the Curlew Conservation Program highlighted their ongoing work to protect a breeding pair of curlew in the locality. Therefore, the Loughs Agency adopted planting clutches of native grasses and shrubs (including Deergrass, Common Cottongrass, Hare's-tail Cottongrass, Bog-bean, Ling Heather and several Sedge species), as well as a 145 m^2 area of emergent and submergent wetland plants as opposed to native broadleaf trees, which could be used as roosts for corvids to predate on young curlew.

Instream improvement works

Instream improvement measures involved the pinning of woody material, artificial pool creation, installation of rubble mats, gravel regrading and creation of artificial meander complexes.

As several areas of the Elatagh exhibited habitat uniformity, artificial meander complexes were introduced at two locations using limestone deflectors to address impacts of historical channel straightening. The installation of rubble mats at 11 locations helped recreate the naturally occurring riffle habitat, providing shelter for fish as well as small scale turbulent mixing of water to increase oxygen levels. Installation of artificial pools in tandem with the strategically placed stones helped to replicate the pool/riffle sequence seen in healthy rivers, providing variability and heterogeneity in the river bed.

Figure 13: Artificial Meanders complexes installed

Figure 14: Rubble Mats installed within the Elatagh River.

Pinning of woody material at six locations was required to protect the river banks from erosion, while also providing aquatic refugia for fish and a source of food and habitation for macroinvertebrates.

Figure 15: Area of Pinned woody Material installed with the Elatagh Restoration Works.

Regrading and local redistribution of “high and dry” gravel deposits increased available spawning habitat for salmonids, suitable even in low flow conditions. Additionally, several areas where gravel was compacted by sediment were regraded and cleaned of excess sediment to better allow its use by salmonids.

Gravel was regraded in such a way that the integrity of the river bank was not compromised or exposed to elevated levels of erosion. Gravel regrading has since supported increased redd counts along the Elatagh river.

A follow-up site visit identified the advancement of an area of natural erosion along a meander within the habitat improvement works. In order to protect the areas of gravel regrading adjacent to the meander, additional green engineering measures were implemented. These included reprofiling of the undercut and eroded bank, with installation of coir matting and rock rolls at the toes of areas uniquely vulnerable to heavy erosive forces.

Figure 16: Additional Works implemented on the Elatagh included bank reprofiling of eroded and undercut banks.

3.4. Dresnagh

The Dresnagh River is located near Castlefinn, Co. Donegal, surrounded by primarily improved agricultural land along the stretch of river, with some urban housing developments present upstream.

The area of the River Dresnagh in which the works took place was not historically surveyed by the Loughs Agency for salmonid redds, although suitable spawning, nursery and holding habitats do exist along its length. Livestock poaching and dense, overhanging tree canopy likely impact the habitat quality in supporting salmonid spawning, as reflected by moderate fish EQR scores.

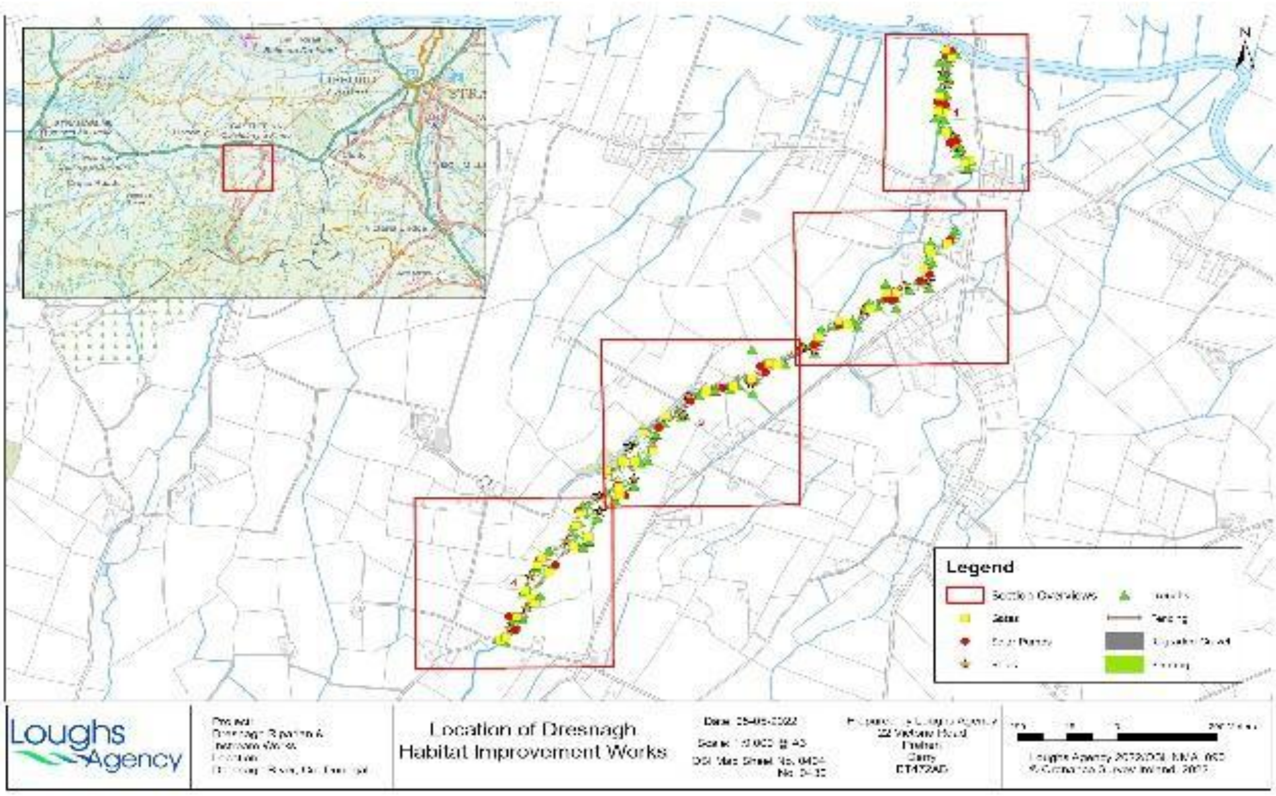

Figure 17: Overall Location of the Dresnagh Restoration Works.

The Dresnagh_001 waterbody has been identified as an ‘Area for Action’ within the second cycle River Basin Management Plan for Ireland 2018-2021. These actions will be prioritised to achieve WFD objectives and will be directed towards pressures such as agriculture, urban waste water, domestic wastewater and forestry.

The Dresnagh River at this section suffers from erosion on both sides along its length. The site had no or very little riparian margin, with fencing at approximately 0.5 m from the water’s edge on both sides throughout areas of agricultural land. At several points along the river, dense, overgrowing tree canopy hindered light penetration to the river’s surface.

Site walkovers undertaken by CatchmentCARE in the prioritisation elements of the project highlighted evidence of livestock poaching the river at numerous points, leading to increased sedimentation from bank erosion. Introduction of elevated levels of sediment into the channel was particularly evident toward the Dresnagh river’s confluence with the main stem of the Finn River, where significant build-up of silt had severely reduced the connectivity of the tributary to the main river.

Figure 18: Bank erosion on the Dresnagh from livestock poaching.

Some fencing was observed intentionally positioned so as to facilitate direct livestock access to the river for drinking water. This is likely due to the high quality of the land, which is used primarily for dairy cattle. The river itself has been straightened and deepened at several locations and these areas lack appropriate habitat diversity for fish. The proximity of agricultural land, poaching and natural debris dams were issues that impacted the RHAT Score.

A small arched bridge with missing keystones was also identified. If this bridge was left in a state of disrepair there was a risk of it collapsing into the river and forming a complete barrier to upstream fish migration. Additionally, there was a risk of the river forming secondary channels during flood conditions if the bridge were to collapse.

Figure 19: Bridge at risk of collapsing into river, causing a potential barrier to fish migration.

Riparian improvement works

A combination of new and replacement fencing, posts, splitters and strainers were installed along both banks of the Dresnagh river to a total length of 5,144 m. The majority of fencing was sheep wire.

Figure 20: Fencing along the banks of the Dresnagh River.

An 806 m length of fencing required the addition of two lines of horizontal barbed wire to the existing fence, with replacement of some older posts.

Figure 21: fencing erected along the recreational walkway of the Dresnagh River.

Along a 530 m stretch through a recreational walk, replacement posts were creosote treated to meet the aesthetic of the area.

Figure 22: area of land cleared and levelled for recreational walkway for the Community around the Dresnagh River.

The area of land cleared for a recreational walkway will help the local community connect with the river. A total of 626 m of fencing comprising two strands of high tensile electrified fence fitted with appropriate batteries fitted with solar powered recharging units was installed. In order to allow access to the riparian margins 35 unigates, one single wooden gate, two double wooden gates, four 14 ft galvanised steel gates and 19 stiles were also installed.

Along the entire river reach areas of dense canopy were also cut to increase light penetration to the river.

To provide increased light penetration to the river's surface, overgrown tree canopy was trimmed over a 2,152 m stretch of the works.

Figure 23: one of the areas of implemented bush trimming to increase light penetration.

In lieu of direct livestock access to the river, 24 low spec and 4 high spec solar powered pumps with associated screens, filters, pipes and 73 x 80 gallon twin reservoir drinking troughs were installed for landowners.

Figure 24: Solar powered pump and trough installed within the Dresnagh River Restoration works in lieu of preventing livestock access to the river.

Instream improvement works

To improve connectivity to the main River, excessive silt as a result of bank erosion was removed from the confluence of the Dresnagh River with the main stem of the River Finn.

A small arched bridge with missing keystones threatened to collapse and form a complete barrier to upstream fish migration and would have forced the river to form secondary channels during flood conditions. Removal of this potential barrier was carried out and it was replaced with a clear span structure, strong enough to support tractor and trailer access while preserving the natural river bed below.

Figure 25: Clear span bridge replaced the potential barrier for landowner to access both fields on either side of river.

3.5. Finn 003

Riparian work along the Finn 003 stretch involved the planting of native broadleaf trees for a riparian margin and installation of ~3.5 km of fencing, along with associated installation of 1800 mm unigates and stiles for ease of access to the riparian margin and river. Installation of water troughs for livestock using solar powered water pump systems will provide a source of drinking water in lieu of access to the river by livestock.

The instream works involved the pinning of woody material and regrading of high and dry gravel and bush trimming at several locations along the length of the river stretch. These works were conducted between the coordinates 54.792441N, -7.682007W (Irish Grid Ref: 220502E 393869N) & 54.797551W, -7.637504W (Irish Grid Ref: 223361E 394451N).
The Finn catchment is an area of high biodiversity and conservation value and is protected by a number of National and International designations.

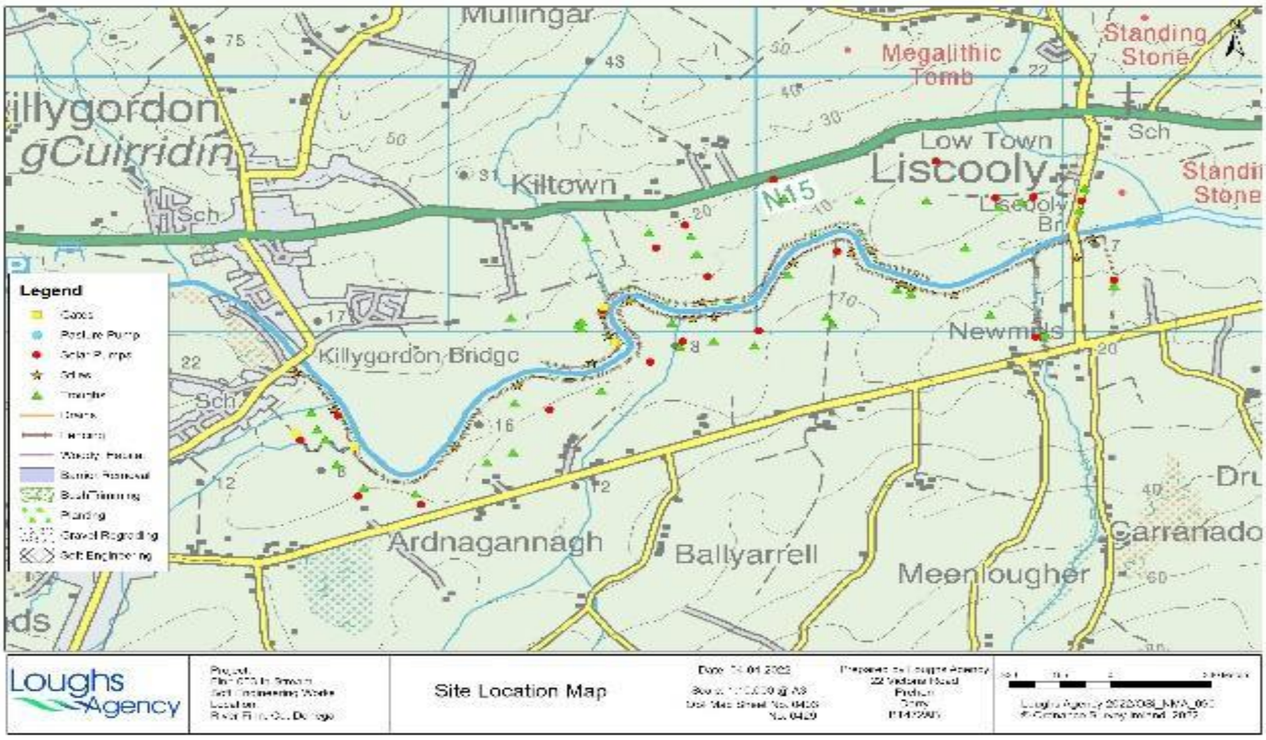

Figure 26: Overall location of the Finn 003 River Restoration Works.

The stretch of river identified for works lacked a consistent riparian margin, with an absence of appropriate fencing and riparian margin between agricultural land and the River Finn. Domestic waste water, agricultural and forestry pressures within the Finn catchment mean that a riparian margin with appropriate surface area is essential for the absorption and degradation of chemical export run-off.

Figure 27: example of the inconsistent riparian margins, lack of fencing in areas allowing livestock to encroach the banks of the River Finn.

Pre-existing riparian margins were inconsistent in width, varying from 1–14 m from the river bank. However, less than half of these margins were planted with trees. The pre-existing margins were mostly colonised by a mixture of grasses and scrub.

Figure 28: lack of riparian margin between agricultural use and the River Finn.

Along with a lack of broadleaf native trees present in the riparian margin, significant clusters of invasive species are present along the entire length of the works area, including Himalayan balsam and Japanese knotweed.

Issues were further compounded by the fact that the stretch of land running along the Finn 003 was owned by several landowners, adding an element of logistical difficulty in achieving landowner contact and buy-in. The cost of instream and riparian works was also dependent on the level of landowner buy-in and therefore length of the area targeted, which includes installation of fencing, stiles, unigates, water troughs and a footbridge in significant disrepair for farmers involved.

Figure 29: Footbridge degraded over time due to usage and weather.

The main stem of the River Finn is subject to strong currents, which has resulted in heavily eroded river banks and loss of land along the Finn 003 stretch. In combination with this, low lying river banks mean that many areas are at high risk of flooding.

Figure 30: example of land loss landowners along the Finn 003 stretch were experiencing.

Therefore, in approaching instream works to mitigate bank erosion at this site, Loughs Agency were acutely aware of the need to ensure that bank woody material was pinned securely in order to provide long term resilience. Additionally, two areas along the stretch of instream works exhibited significant “high and dry” gravel sandbanks, made unavailable as fish spawning habitat due to natural deposition processes within the river.

Riparian improvement works

In total 6,564 m of fencing, including 18 stiles, two 12ft galvanised sheep gates and one kissing gate for ease of access, posts, splitters and strainers was installed along the Finn 003 works, with removal of old fencing and provision made for disposal or return of old fencing to landowners if desired.

Figure 31: Fencing installed along the Finn 003 stretch.

A total of 5,663 trees composed of Alder, Willow, Silver Birch and Rowan were planted to fortify the riparian zone, with sessile oak trees planted sparsely throughout the stretch. Placement of trees was decided upon in consultation with the local angling club who were eager to ensure that riparian margins did not interfere with angling activity. A small degraded stream crossing frequently used by both anglers and landowners was also replaced with a new structure. In addition to native broadleaf trees, a 240 m^2 area with hedgerows consisting mainly of black thorn was planted along the works.

Upon fencing of the riparian margin, direct livestock access to the river was no longer possible. In lieu of this, 7 lower spec solar powered pumps and associated screens, filters and pipes capable of pumping water 10 m vertically and 30 m horizontally, and 14 higher spec solar powered pumps capable of pumping 1,200 L of water per hour to higher elevations and over longer distances were installed at various locations throughout the works. As a result of the works, 39 80-gallon twin reservoir drinking troughs filled by the solar powered pump systems now provide offline drinking water for livestock. In addition, 60 m of perforated twin wall pipe was installed and covered with appropriately sized stones for efficient land drainage at one location.

Figure 32: solar powered pump installed for livestock welfare.

Riparian improvements along the Finn 003 stretch also involved the repair of low lying and eroded river banks. A 221 m^2 area of artificial embankment (berm) was repaired on the south bank of the river between the coordinates 54.789145N -7.679260W and 54.788275N -7.677887W.

Figure 33: bank build up implemented along the Finn 003 stretch.

This was achieved by adding a mixture of gravel and clay to strengthen the existing berm, raising it to a height of 1.5m above the level of the adjacent field. Material added was compressed to ensure it was not easily washed away by heavy rain and was seeded with grass to add stability. ~200 tonnes of soil and gravel mix and ~200 tonnes of soil were used for this bank stabilisation.

Instream improvement works

Several instream measures were also employed to improve microhabitat biodiversity and bolster moderate populations of fish and macroinvertebrates within the river environment. All instream works were carried out on days of low flow, with sediment screens deployed downstream of any works.

Woody material was pinned at six locations along the stretch of river, with tree trunks and tree limbs sourced from established trees within the work area, in agreement with the landowner. Material was pinned using posts and anchors, with the amount and placement of material designed specific to the site, so as not to block the main river flow or collect significant debris.

Figure 34: pinned woody material implemented at 6 locations of the Finn 003 stretch.

Two areas within the instream improvement works exhibited collections of “high and dry” gravel beds which would be otherwise suitable for salmonid spawning. Gravel was therefore regraded so that it lay below the water surface even on days of low flow, making it available to salmonids. Gravel in the areas immediately surrounding the once “high and dry” gravel deposits were also regraded, with a section of the gravel left to protect the existing bank from future erosion.

Figure 35: area of high and dry gravel was regraded into the river to create spawning habitat for salmonids.

3.6. Finn 001

The Loughs Agency, as a partner of the CatchmentCARE Project, proposed to carry out stream bank improvement works along the northern bank of the 001 Stretch of the Finn River in the Finn River Catchment, Co. Donegal, between the co-ordinates 54.862285, -8.038209 (Irish Grid Reference: 197596E, 401597N) and 54.859479, -8.024965 (Irish Grid Reference: 198446E 401285N).

The site land cover is primarily natural upland vegetation, less than half of which is covered with unimproved or improved grassland.

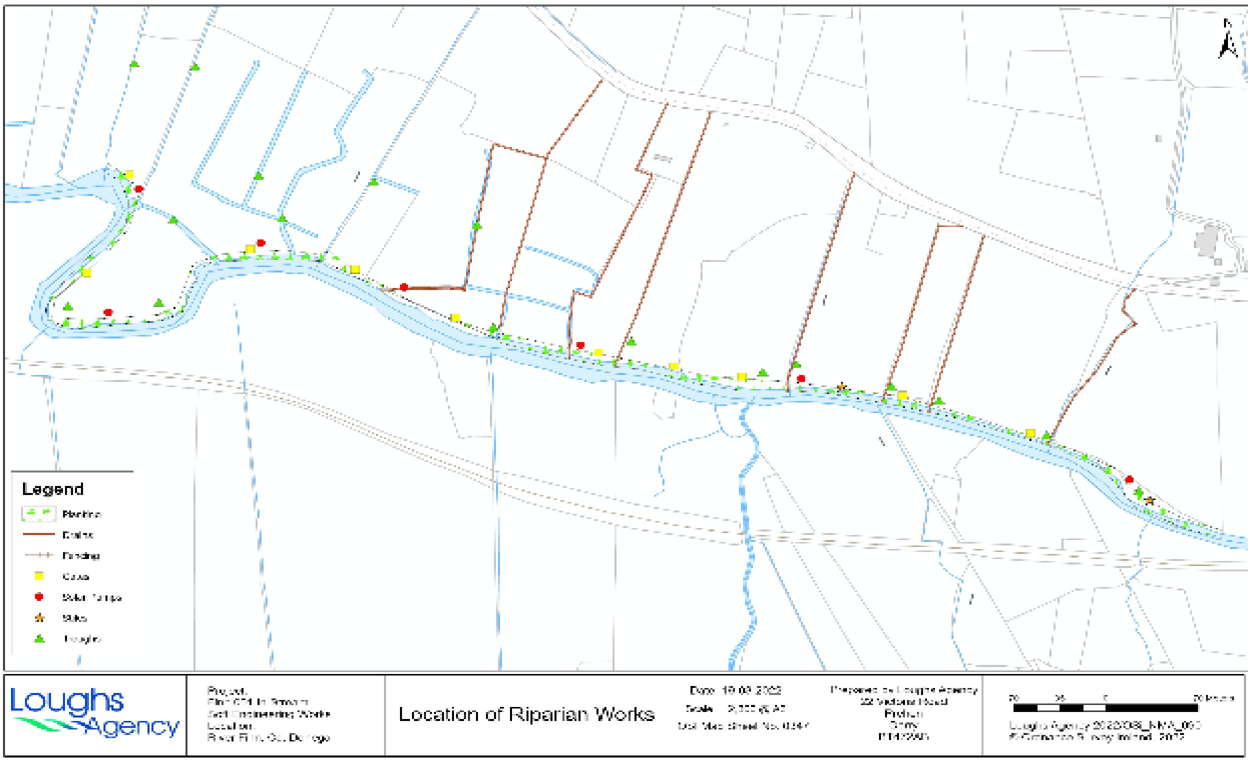

Figure 36: Location of Riparian Restoration works on the Finn 001 stretch of the River Finn.

The Finn_001 waterbody has been identified as an ‘Area for Action’ within the second cycle River Basin Management Plan for Ireland 2018-2021. These actions will be prioritised to achieve WFD objectives and will be directed towards pressures such as agriculture, urban waste water, domestic wastewater and forestry.

The riparian margin along the Finn 001 stretch, where present, is inadequate at 1 m or less, with inadequate or no fencing on both sides of the river. A lack of native deciduous trees present also means livestock can directly access the river, causing poaching on both banks.

Figure 37: Along the Finn 001 Stretch there was a severe lack of riparian margins and fencing.

RHAT scores for this site were also impacted by both riparian margin uniformity and lack of variability in the river bed and stream flow.

Riparian improvement works

The Loughs Agency, as a partner of the CatchmentCARE Project, proposed to carry out stream bank improvement works along the northern bank of the 001 Stretch of the Finn River in the Finn River Catchment, Co. Donegal, Riparian improvement works commenced in January 2023. Works were conducted between the co-ordinates 54.862285, -8.038209 (Irish Grid Reference: 197596E, 401597N) and 54.859479, -8.024965 (Irish Grid Reference: 198446E 401285N).

A total of 1,200 m of fencing, including posts, splitters and strainers where appropriate was installed, creating a riparian margin along the Finn 001 stretch at distances varying from 2–5 m from the river bank. As approximately half of the targeted area had existing fencing, fencing works included installation of new fencing, as well replacement of old fencing no longer fit for purpose.

Old fencing posts and wire were offered to the landowner for salvage before fencing was disposed of using pre-stipulated disposal provisions.

Figure 38: Fencing installed along the Finn 001 stretch to prevent livestock poaching.

Two stiles, nine single wooden unigates and one 12 ft sheep gate located on the south east side of the work area were installed along with the fencing for ease of access to the riparian margin. Nine drains with a combined length of 1,703m were excavated, with installation of a 6 m length of 375 mm perforated twinwall drainage pipe where each drain passes below fencing.

A mix of 900 native broadleaf trees composed of 25% Alder, 25% Willow, 25% Silver Birch and 25% Rowan were planted within the riparian margin created between the fencing and water's edge. As fencing eliminated direct livestock access to the river, 17 80 gallon twin reservoir drinking troughs filled by seven solar powered pumps with associated screens, filters and pipes were installed to supply offline drinking water to livestock.

Figure 39: Planting of 900 native broadleaf trees along the Finn 001 stretch to provide adequate riparian margins and improve ecosystem diversity.

3.7. Rough Burn

The Rough Burn located in Corraine, Co. Donegal is surrounded by a mix of improved and semi-improved grassland, the majority of which is used for agricultural practice (primarily sheep farming). A series of riparian works were completed at Rough Burn, including ~1.73 km of riparian fencing, bush trimming of overhanging canopy, planting of native trees and installation of water trough and solar powered pumps as a source of offline drinking water for livestock.

Instream improvement works consisted of the removal of a barrier to fish migration and the installation of a clear span bridge.

Works were conducted primarily along both banks of the Rough Burn. The works on the Rough Burn took place between these coordinates: 209285 E 396046 N & 208721 E 395275 N (Irish Grid

Reference). The works along the River Finn took place between these coordinates: 209041 E 396206 N & 209541 E 396015 N (Irish Grid Reference).

A concrete pipe culvert overlain with crushed boulder and rubble used for agricultural purposes posed a potential barrier to fish migration. The weight of overlying rock was gradually crushing the pipe culvert and would have eventually collapsed and blocked the river entirely. The pipe culvert itself was 1 m in diameter; a fraction of the river's natural 7 m width, meaning the river could not flow freely during times of high flow. This led to the creation of secondary channels around the existing barrier structure into the adjacent field, with silt build-up accumulating upstream of the barrier and compacting spawning gravel.

Figure 40: downstream view of the Rough Burn Barrier to fish migration.

Figure 41: upstream view of the Rough Burn Barrier to fish migration.

Another issue this site faced was intermittent/poor fencing along its length with small or non-existent riparian margins in areas. Site walkovers undertaken by CatchmentCARE in the prioritisation element of the project highlighted evidence of livestock entering the river at numerous points and significant poaching of the stream banks.

Figure 42: example of the poor fencing along the Rough burn

Riparian improvement works

In total 700 trees composed of a mix of 25% Alder, 25% Willow, 25% Silver Birch & 25% Rowan were planted to form a riparian margins along the stretch of the Rough Burn works, with 1,730 m of fencing, including posts, and strainers where appropriate, installed at varying distances of 3–20 m from the bank of the river to prevent livestock poaching.

Figure 43: planting of the 700 native broadleaf trees along the Rough Burn Riparian margins.

As fencing eliminated direct livestock access to the river, installation of 14 x 80 gallon twin reservoir drinking troughs filled on demand by 5 solar powered pumps provided an offline source of drinking water. 10 unigates, 9 stiles and 12 ft gates (below the confluence of the rough burn with main River Finn) were also installed for access to the riparian margin.

Figure 44: one of the 9 stiles installed along the Rough Burn restoration works for landowner and angler access.

Bush trimming of overhanging canopy was also required at several locations along the main stream to allow for increased sunlight penetration to the river's surface.

Figure 45: area of brush trimming implemented to increase light penetration into the Rough Burn.

Instream improvement works

Instream improvement works involved the removal of the pipe culvert and overlain crushed boulder which acted as a potential barrier to fish migration. This structure was replaced with a more suitable clear span bridge, allowing landowner access with machinery and livestock, while preventing the river from cutting secondary channels into the river banks.

Figure 46: Clear span bridge replaced the prior crossing which was a barrier to fish migration.

Gravel cleaning upstream of the barrier addressed issues related to increased silt levels. Gravel compacted with silt was removed using a metal spike and water pump with a high pressure lance as gravel had become compacted with silt, moving from upstream to downstream to avoid removing sediment from the same area more than once.

3.8. Upper Reelin

The Reelan Habitat Improvement works involved the installation of approximately 5.1 km of riparian fencing and planting of native trees to create riparian margins along the river bank. There was one area of instream works for gravel regrading to increase spawning habitat for salmonids.

Solar powered pumps and troughs were also installed for livestock with the addition of stiles and gates for landowner and angler access. The land in this area is a mix of semi improved grassland and rough pasture and is used for agricultural practice with sheep farming most prevalent.
These works were carried out between the coordinates 54.787068N, -8.093669W (Irish Grid Ref: 1940024 393228) & 54.797566N, -8.052367W (Irish Grid Ref: 196681 394394).

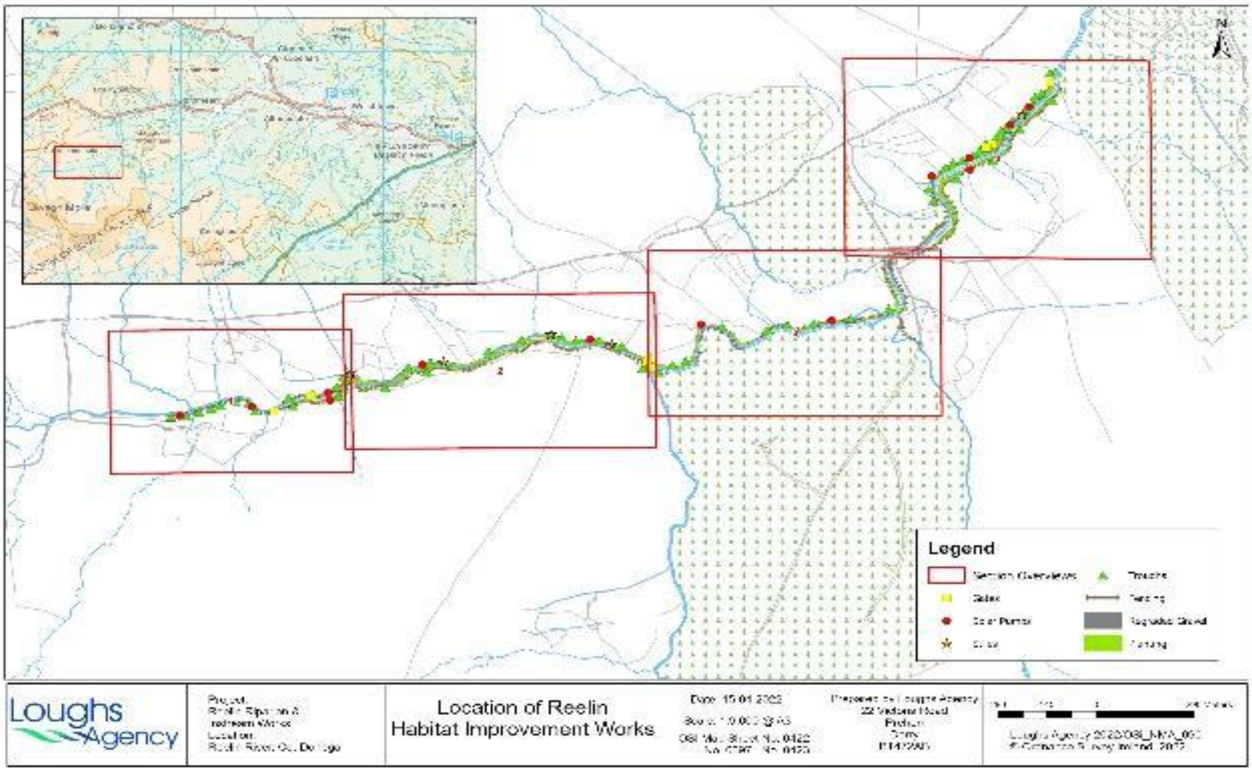

Figure 47: Overall location of Reelan River Restoration works.

The Upper Reelan_002 waterbody has been identified as an 'Area for Action' within the second cycle River Basin Management Plan for Ireland 2018-2021. These actions will be prioritised to achieve WFD objectives and will be directed towards pressures such as agriculture, urban waste water, domestic wastewater and forestry.

This site had a mixture of natural upland vegetation, unimproved grassland and conifer plantations present along the stretch. While riparian margins between conifer plantation and river range from 10 –25 m, RHAT scores were primarily impacted by the presence of conifer plantation as adjacent land use and the lack of native, broadleaf woody habitat, as well as the barrier to fish migration.
Areas of the Reelan River lacked a riparian margin, with intermittent or no fencing along the stretch of works. In particular, improved grassland on the southern bank of the river had a very small riparian margin which could be optimised to the benefit of aquatic macroinvertebrates if enlarged and planted with native deciduous trees.

Figure 48: highlighting the lack of riparian margins along the Reelan River.

Instream there were several areas of "high and dry" gravel which needed to be made available for salmonid spawning, as well as areas of bank erosion and collapse which required pinning of wood. These soft engineering measures were also beneficial in providing food and refugia to macroinvertebrate and fish communities.

Figure 49: large area of high and dry gravel unreachable for spawning salmonids.

Riparian improvement works

Riparian improvement works along the River Reelan comprised of 5,110 m of both new and replacement fencing, along with planting of 7,613 native trees composed of 25% Alder, 25% Willow, 25% Silver Birch & 25% Rowan to create a 5 m riparian margin in areas which previously lacked an adequate riparian margin. Posts, splitters and strainers were installed continuously along the length of fencing for stability, particularly during times of high flow and flood conditions, along with five stiles and 8 unigates for access to the riparian margin.

Figure 50: fencing implemented along the Reelan River.

As fencing eliminated direct livestock access to the river for drinking water, landowners were provided with 12 solar power pasture pumps (11 low spec, one high spec) and associated screens, filters and pipes to fill a total of 56 x 80 gallon twin reservoir drinking troughs.

Figure 51: Solar powered pump and trough installed for livestock welfare.

Instream improvement works

One area exhibiting significant "high and dry" gravel was regraded with the use of a riddle bucket to grade the gravel across the river bed, increasing available habitat suitable for salmonid spawning.

Figure 52: a large bank of high and dry gravel had been regraded into the river to provide spawning habitat for salmonids.

3.9. Pre and Post Works Surveys

Habitat restoration plays a vital role in preserving and enhancing biodiversity, promoting ecological balance, and supporting the overall health of our ecosystems. To ensure the effectiveness of habitat restoration efforts, pre- and post-work monitoring is crucial. These monitoring practices involve systematically assessing and evaluating the condition of an area before and after restoration activities take place. By collecting data on key indicators such as species diversity, vegetation composition, and habitat structure, pre- and post-work monitoring allows us to gauge the success of restoration projects and make informed decisions for ongoing management. Through the analysis of these monitoring results, valuable insights can be gained, informing future restoration strategies and contributing to the conservation of our natural habitats.

Long term monitoring and assessment of river restoration projects is required in order to provide rigorous post project assessment and evaluation. The assessment methodology needs to allow examination of the impacts on appropriate temporal scales in order to account for the various life history traits of the organisms in the system. There is a need to continuously assess the integrity of the works as well and account for any maintenance issues which may cause secondary negative impacts. Continuous assessment also allows for critique of the effectiveness of techniques used over time – which will streamline the process and inform decision making in the future. Essentially this allows qualitative and quantitative assessment of long term performance. There is also a need to be aware of new and emerging threats and pressures which may not have been accounted for in the original assessment of the site. There is a need to be able to account for how the restoration works are behaving against any new pressures to the system and act accordingly.

To assess metrics of success following implemented water quality improvement measures, a number of focused surveys were carried out within the Finn catchment. The metrics surveyed were comparable to the pre works survey to ensure an evaluation of efficacy could be made between pre and post conditions:

- Fish (via electrofishing)
- Hydromorphology (via RHAT surveys)
- Macroinvertebrate (Via kick sampling and stone pick sampling).

Fish EQR

Table 1, Classification Categories for Fish EQR and RHAT Surveys.

High
Good
Moderate
Poor
Bad

Table 2, Survey Results for Fish EQRs from 2019 to 2022 for all sites.

Fish EQR				
Site Name	**2019**	**2020**	**2021**	**2022**
Cummirk	Moderate	Moderate	Good	N/A
Elatagh	Moderate	Moderate	Good	Poor
Dresnagh	Good	Poor	N/A	N/A
Finn 001	Moderate	Good	Good	Moderate
Finn 003	Moderate	N/A	Moderate	Poor
Rough Burn	Good	Moderate	Good	Moderate

Reelan	Moderate	Good	Good	Moderate

The results presented in Table 2, show that some sites have shown consistent "GOOD" or "MODERATE" ecological quality over the years, while others have fluctuated or shown POOR ecological quality in some years. For example, the site Cummirk has consistently shown MODERATE to GOOD ecological quality from 2019 to 2021, while the site Elatagh has shown MODERATE to GOOD ecological quality in most years except for 2022 when it was categorised as poor.

The Dresnagh site has shown good ecological quality in 2019, POOR ecological quality in 2020, and no data for 2021 and 2022, indicating fluctuations in the ecological quality of this site over time. Similarly, the site Finn 003 has no data for 2020 and POOR ecological quality in 2022, indicating a decline in ecological quality over time.

Overall, the results presented provide an insight into the ecological quality of various sites based on Fish EQR assessments. However, it is important to consider other factors that may affect the overall health of the ecosystem and to monitor changes in ecological quality over time to ensure the sustainability of these ecosystems.

River Habitat Assessment Techniques (RHATS)

Table 3, Survey Results for River Habitat Assessment Techniques between 2019 and 2022.

RHATS				
Site Name	**2019**	**2020**	**2021**	**2022**
Cummirk	N/A	N/A	N/A	N/A
Elatagh	N/A	N/A	N/A	Good
Dresnagh	N/A	N/A	Moderate	Moderate
Finn 001	N/A	N/A	Moderate	N/A
Finn 003	N/A	N/A	High	Moderate
Rough Burn	N/A	N/A	Moderate	Good
Reelan	N/A	N/A	High	N/A

Table 3 shows that there is no data available for the Elatagh in 2019, 2020 and 2021, but in 2022 it was categorised as having GOOD quality habitat available for fish.

The Dresnagh has no data for 2019 and 2020, but it was categorised as having MODERATE quality habitat in 2021 and 2022.

Finn 001 has no data for 2019 and 2020, but it was categorised as having MODERATE quality habitat in 2021. No data was available for 2022.

Finn 003 has no data for 2019 and 2020, but it was categorised as having HIGH quality habitat in 2021 and MODERATE quality habitat in 2022.
The Rough Burn has no data for 2019 and 2020, but it was categorised as having MODERATE quality habitat in 2021 and GOOD quality habitat in 2022.

The Upper Reelan has no data for 2019 and 2020, but it was categorised as having HIGH quality habitat in 2021. No data was available for 2022.

Macroinvertebrates

Table 4, Classification Categories for Small Stream Risk Scores and Q-Values.

Not At Risk
Probably not At Risk
May be at Risk
At Risk

Table 5, Survey Results for Small Stream Risk Scores (Spring) from 2019 to 2022.

Small Stream Risk Scores Spring				
Site Name	**2019**	**2020**	**2021**	**2022**
Cummirk	N/A	N/A	May be at Risk	At Risk
Elatagh	N/A	N/A	May be at Risk	At Risk
Dresnagh	N/A	N/A	N/A	N/A
Finn 001	N/A	N/A	May be at Risk	At Risk
Finn 003	N/A	N/A	May be at Risk	N/A
Rough Burn	N/A	N/A	May be at Risk	May be at Risk
Reelan	N/A	N/A	May bet at Risk	May be at Risk

Table 6, Q Values (Spring) for all sites from 2019 to 2022.

Q Values Spring				
Site Name	**2019**	**2020**	**2021**	**2022**
Cummirk	N/A	N/A	Probably Not at Risk	N/A
Elatagh	N/A	M/A	Probably Not at Risk	N/A
Dresnagh	N/A	N/A	N/A	N/A
Finn 001	N/A	N/A	Probably Not at Risk	N/A
Finn 003	N/A	N/A	At Risk	N/A

Rough Burn	N/A	N/A	Probably Not at Risk	N/A
Reelan	N/A	N/A	At Risk	N/A

Table 7, Small Stream Risk Scores (Autumn) from 2019 to 2022.

Small Stream Risk Scores Autumn				
Site Name	**2019**	**2020**	**2021**	**2022**
Cummirk	At Risk	N/A	At Risk	Probably Not at Risk
Elatagh	Probably Not at Risk	N/A	At Risk	May be At Risk
Dresnagh	Probably Not at Risk	N/A	At Risk	At Risk
Finn 001	N/A	N/A	At Risk	N/A
Finn 003	Probably Not at Risk	N/A	At Risk	May be At Risk
Rough Burn	Probably Not at Risk	N/A	At Risk	At Risk
Reelan	May be at Risk	N/A	At Risk	May be at Risk

Table 8, Q Value Scores (autumn) from 2019 to 2022 for all sites.

Q Values Autumn				
Site Name	**2019**	**2020**	**2021**	**2022**
Cummirk	Probably Not at Risk	N/A	Probably Not at Risk	At Risk
Elatagh	N/A	N/A	Probably Not at Risk	Probably Not at Risk
Dresnagh	Probably Not at Risk	N/A	At Risk	May be at Risk
Finn 001	N/A	N/A	Probably Not at Risk	N/A
Finn 003	Probably Not at Risk	N/A	At Risk	At Risk
Rough Burn	Probably Not at Risk	N/A	At Risk	At Risk
Reelan	At Risk	N/A	At Risk	N/A

The SSRS and Q Values for all sites between 2019 and 2022 highlighted that there was no immediate benefit to macroinvertebrate populations following the implementation of the river restoration works. However, macroinvertebrate scores are expected to improve for these sites in future post work monitoring.

4. HABITAT RESTORATION WORKS – ARNEY CATCHMENT

4.1. Arney Phase One

The site of the CatchmentCARE works is located at the Arney Bridge, close to Arney Village, Co. Fermanagh. The surrounding land is predominantly improved grassland and used for agricultural practice with cattle farming being the most prevalent form.

The Arney River connects Lough MacNean to the River Erne by flowing East. The Arney waterbody has been given a Moderate Status in accordance to the Water Framework Directive. The assessment by Northern Ireland Environment Agency has identified fish status and river morphology as failing elements in this waterbody.

Arterial drainage has altered the Arney River from its natural state by deepening the river channel. This has resulted in the river channel having unnaturally steep banks and channel form.
Site walkovers were used to identify evidence of livestock entering the river at multiple locations which has caused erosion of the banks and input of excess sediment into the river. Large areas of the bank top support a simple vegetation structure such as a monoculture of grass, instead of a healthy riparian zone. The river alterations, cattle ingress and excess input of silt has resulted in a reduction of diverse habitat in the river channel, which is having a knock on effect to the overall water quality rating.

Figure 53: Location of the Arney Site

Measures to reduce the pressures on the river and allow it to naturally recover include; fencing along the river and providing alternative drinking sources for livestock. With the aims to:

- Stop cattle from entering the river and allow the river to return to its natural form and processes
- Stabilize the banks that have been degraded by the cattle
- Improve the riparian vegetation to increase biodiversity, be a source of nutrients into the river and provide cover and shade for fish species

Figure 54: Cattle poaching site due to no riparian fencing or buffer zone.

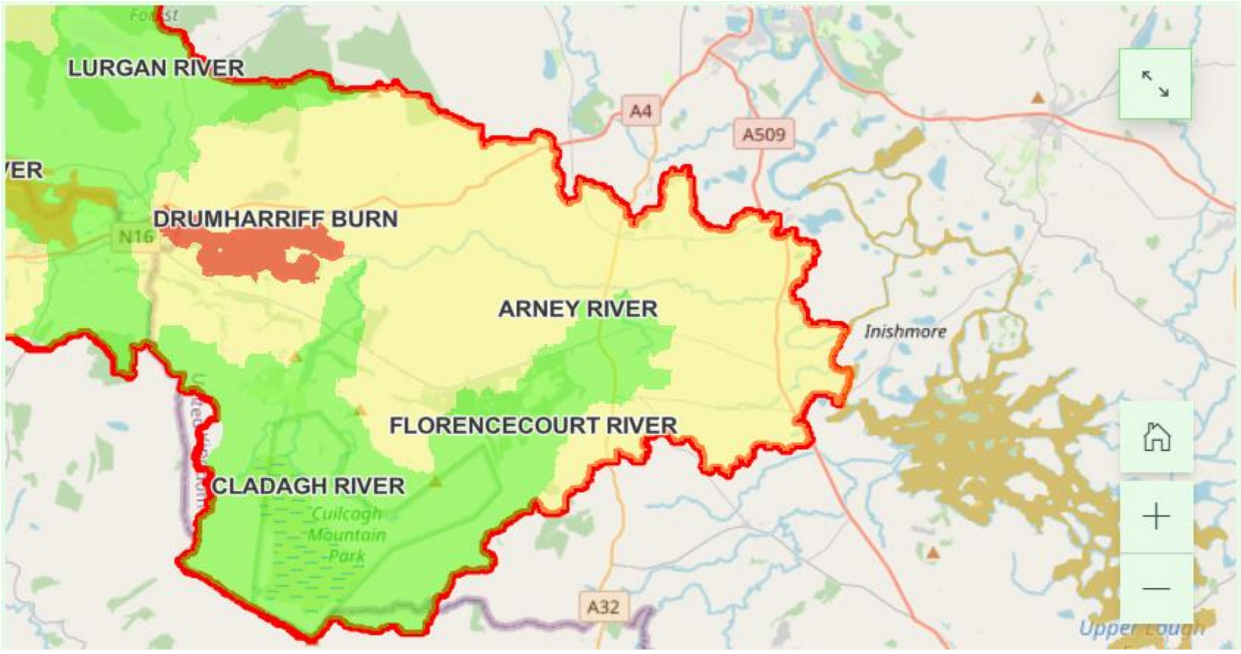

Figure 55: Arney Water Quality Data. Green Indicates Good, Yellow is Moderate and Red is Poor water quality.

Figure 56: Cattle Poaching with large amounts of sediments with bank toe reinforcement.

Figure 57: Area poached by cattle.

Figure 58: Lack of Riparian buffer zone and diversity of vegetation.

Figure 59: Location of the Arney Works.

Installed measures:

- A total of 4,000 m of fencing has been installed along a river stretch of 2.7 km. Fencing consists of both sheep proof and stock proof which is comprised of 5 rows of barbed wire.

Figure 60: an example of the fencing installed along the Arney River.

- 8 galvanised field gates have been installed for access to the river. The gates provide access to retrieve livestock (welfare gate), to allow any potential river maintenance by DfI Rivers and as a recreational access for canoes, anglers etc.
- 3 stiles have been installed for angler and recreational access to river.
- 28 livestock drinkers have been installed as alternative drinker sources for livestock. Drinking troughs are placed away from the river to reduce soil erosion close to the channel.

Figure 61: Livestock Trough with hard core to reduce soil erosion.

- 500 tree saplings have been planted along the river corridor. The planting consists of 60 cm saplings composed of Oak, Alder, Guelder Rose, Spindle, Hazel, Crab Apple, Scots Pine, Rowan, Holly. 1 kg of wildflower sew mix was sewed along banks of river to encourage pollinator species.

Figure 62: Planting of native broadleaf saplings along riparian zone.

Figure 63: One Year after Fencing, cattle access to the river is now restricted, reducing pressure on the banks.

Figure 64: Two years after fencing has been installed. Riparian vegetation growth in the buffer zone is now evident, helping to stabilise the river bank and reduce excess sediment input.

Figure 65: Location of the Arney River Site.

4.2. Arney Phase Two

The phase 2 work site is located at the outfall of Lower Lough MacNean, Co. Fermanagh. The land in this area is predominantly improved grassland used for agricultural practice with cattle farming being the most common.

The pressures on this stretch of the catchment include:

- Agricultural pressures such as cattle ingress to river channels
- Cattle poaching of river banks
- Silt input from field drains
- Channelization of river
- Lack of riparian vegetation and fencing leading to exposed banks

The Arney has been given a Moderate status under the Water Framework Directive. The WFD assessment by Northern Ireland Environment Agency has identified fish status and river morphology as failing elements in the Arney River.

Over time the Arney River has been altered through arterial drainage, which involves deepening the river channel and results in unnaturally steep banks and channel form. Evidence of livestock

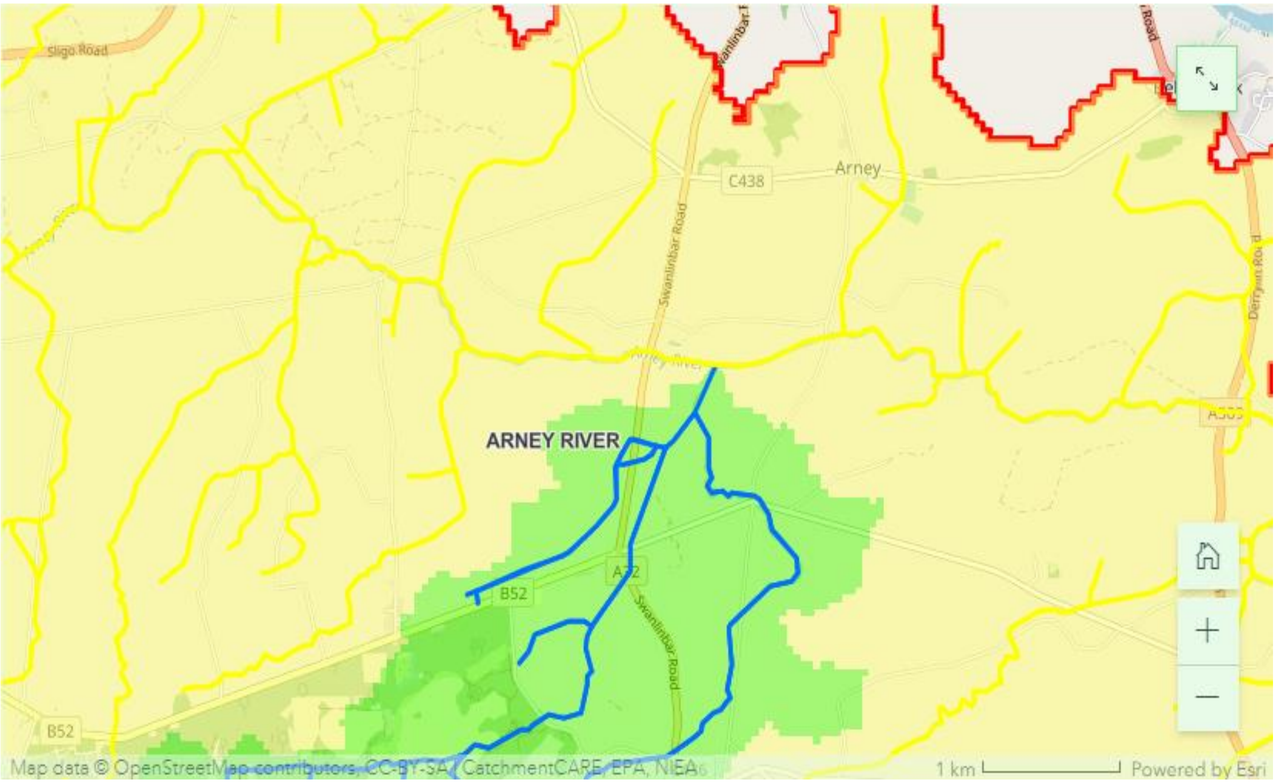

Figure 66: Arney River Quality Data. Green indicates Good status, Yellow indicates Moderate

Figure 67: Cattle poaching area with large inputs od sediment, lack of riparian buffer and lack of diversity of riparian vegetation.

entering the river at numerous locations was found in the early site walkovers. Cattle ingress causes further erosion of the banks and leads to the input of excess sediment into the river. This was paired with large sections of the bank top being covered by simple vegetation structures, particularly monocultures of grass. This indicates an unhealthy riparian zone, as a healthy one can be identified by a diversity of vegetation types and ages.

The river alteration, cattle ingress and excess input of silt has resulted in a reduction of the habitat diversity within the river channel.

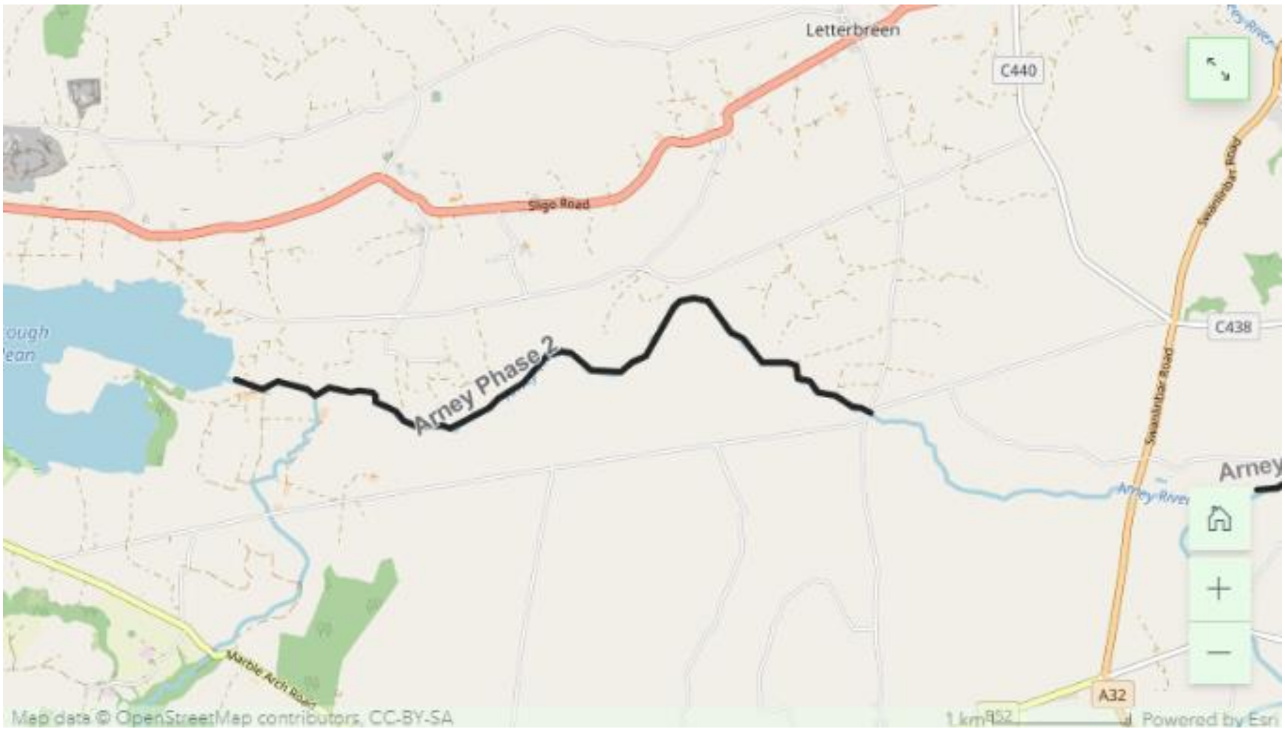

Figure 68: Arney Phase 2 location of works.

Simple measures can be put in place to reduce the pressures on rivers and allow them to naturally recover, this includes fencing along the river and providing alternative drinking sources for livestock. Installing fencing can reduce and remove multiple pressures. Passive restoration is a method that concentrates on stopping harmful land management practices within a catchment and then allowing the ecosystem to heal naturally. Many rivers can and will recover and flourish if the pressures are reduced or removed, which can restore habitat diversity and natural channel dynamics.

Preventing access by grazing animals is a low cost method that can provide significant improvements in riparian vegetation, bank stability and overall river health and channel morphology. Fencing that completely excludes livestock prevents the introduction of additional nutrients and pathogens and allows the native vegetation to rebuild the riparian buffer, without the pressures of grazing. The natural recovery of the river and its channel can be assisted via the planning and reintroduction of native flora.

The aims are to:

- Prevent cattle access to the river and allow the river to return to its natural form
- Stabilize banks that were degraded by the cattle

- Improve riparian vegetation along the bank. The increased vegetation will increase biodiversity, be a source of nutrients into the river and provide cover for fish species

This project included 16 different landowners that allowed the above measures to be implemented on their land that bordered the river.

Details of installed measures:

- A total of 7,500 m of fencing has been installed along a river stretch of 5.4 km. Fencing consists of both sheep proof and stock proof which is comprised of 5 rows of barbed wire.
- 27 galvanised field gates have been installed for access to the river. The gates provide access to retrieve livestock (welfare gate), to allow any potential river maintenance by DfI Rivers and as a recreational access for canoes, anglers etc.
- 8 stiles have been installed for angler and recreational access to river.
- A discrete patch of invasive Japanese knotweed (*Fallopia japonica*) was identified in the area and were targeted with two applications of herbicide to prevent regrowth.

- 31 livestock drinkers have been installed as alternative drinker sources for livestock, including 3 pasture pumps and 4 solar pumps. Drinking troughs are placed away from the river to reduce soil erosion close to the channel.

Figure 69: Pasture Pump providing alternative water source for livestock.

Figure 70: Installation of fencing before and after works.

Figure 71: solar pump alternative water source for livestock.

Figure 72: Before and after Riparian planting.

- 500 tree saplings have been planted along the river corridor. The planting consists of 60 cm saplings composed of Oak, Alder, Guelder Rose, Spindle, Hazel, Crab Apple, Scots Pine, Rowan, Holly.

4.3. Arney Phase Three

Figure 73: Location of the Arney Site

The work site for Arney Phase 3 is located at the confluence to the River Erne, Co. Fermanagh.

The land surrounding the works is predominantly improved grassland used for agricultural practice with cattle farming being the most common.

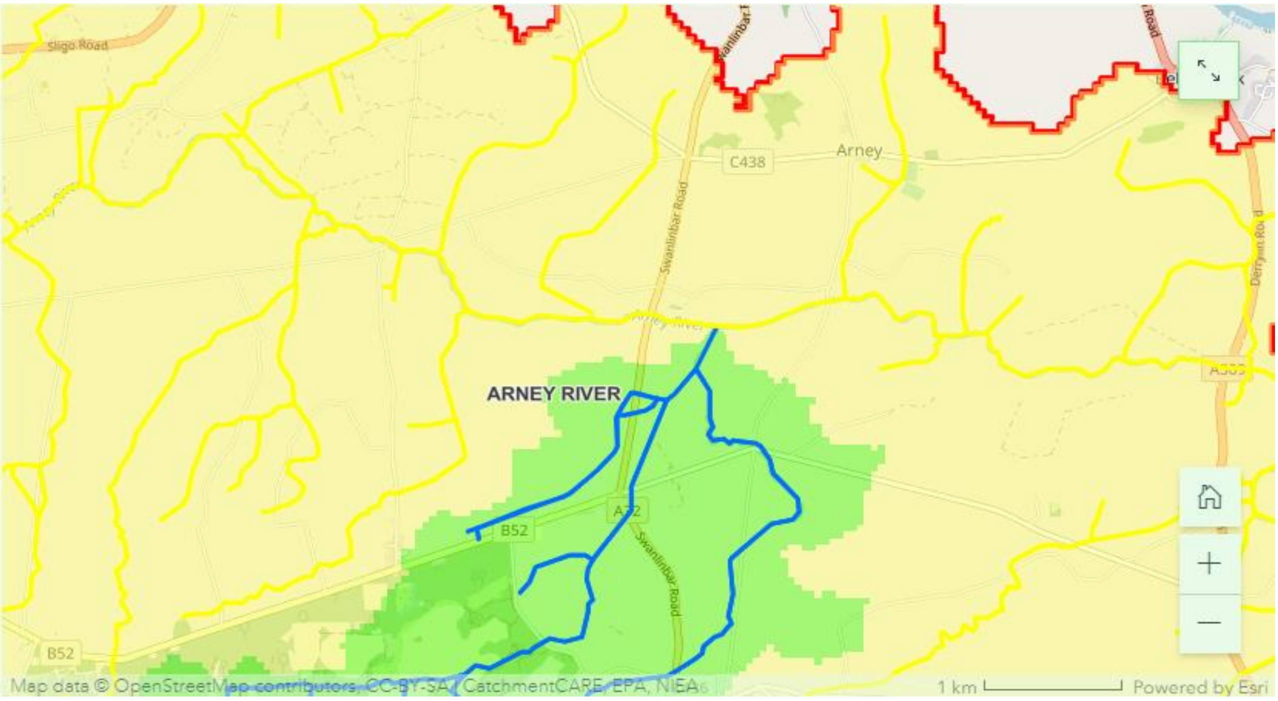

Figure 74: Arney River Quality, Green indicates Good Water quality status and Yellow Indicates Moderate Water Quality Status

The different pressures in this area include:

- Agricultural pressures
- Cattle ingress to river channels
- Cattle poaching of river banks
- Silt input from field drains
- Channelization of river
- Lack of riparian vegetation and fencing leading to exposed banks

Figure 75: Location of Arney Phase 3 Works.

The Arney River flows East, connecting Lower Lough MacNean to the River Erne. Under the Water Framework Directive the Arney River is currently rated moderate, after an assessment by Northern Ireland Environment Agency. The assessment identified that fish status and river morphology as failing elements in the waterbody.

Over time the Arney has been altered from its natural state through arterial drainage. These practices have deepened the channel and resulted in unnaturally steep banks. Evidence of livestock ingress into the river was identified at numerous locations during initial site walkovers. This cattle ingress has caused erosion of the banks and the input of excess sediment into the river. These pressures have led to a reduction in diversity of the river habitats and had been detrimental to the overall water quality as reflected in the WFD rating.

Figure 76: Cattle poaching area with large inputs of sediment, lack of riparian buffer and lack of diversity of riparian vegetation.

A healthy riparian zone consists of a diversity in vegetation types and ages, however, for large sections of the bank top simple vegetation structure, particularly monoculture of grass, is found.

Simple measures can be put in place to reduce the pressures on rivers and allow them to naturally recover, this includes fencing along the river and providing alternative drinking sources for livestock. Installing fencing can reduce and remove multiple pressures. Passive restoration is a method that concentrates on stopping harmful land management practices within a catchment and then allowing the ecosystem to heal naturally. Many rivers can and will recover and flourish if the pressures are reduced or removed, which can restore habitat diversity and natural channel dynamics.

Figure 78: fencing installed to encourage vegetation growth on the banks.

Preventing access by grazing animals is a low cost method that can provide significant improvements in riparian vegetation, bank stability and overall river health and channel morphology. Fencing that completely excludes livestock prevents the introduction of additional nutrients and pathogens and allows the native vegetation rebuild the riparian buffer, without the pressures of grazing. The natural recovery of the river and its channel can be assisted via the planning and reintroduction of native flora.

The aims are to:

- Prevent cattle access to the river and allow the river to return to its natural form
- Stabilize banks that were degraded by the cattle

- Improve riparian vegetation along the bank. The increased vegetation will increase biodiversity, be a source of nutrients into the river and provide cover for fish species.

All measures and works were agreed with 8 landowners along this stretch of the river.

Details of installed measures:

- A total of 3,000 m of fencing has been installed along a river stretch of 2 km. Fencing consists of both sheep proof and stock proof which is comprised of 5 rows of barbed wire.
- 20 galvanised field gates have been installed for access to the river. The gates provide access to retrieve livestock (welfare gate), to allow any potential river maintenance by DfI Rivers and as a recreational access for canoes, anglers etc
- 3 stiles have been installed for recreational access to river
- 19 livestock drinkers (136 L premium water troughs) have been installed as alternative drinker sources for livestock, and one pasture pump. Large water networks also contain valves (boundary boxes) as water conservation measures. Drinking troughs are placed away from the river to reduce soil erosion close to the channel. Hard core bases are provided at each livestock drinking trough to ensure stability of trough and reduced soil erosion.

Figure 79: Livestock access point fenced to prevent ingress to the river.

Figure 80: Livestock drinker with hard core installed away from the river to reduce soil exposure and to provide an alternative drinking solution for cattle.

4.4. Roo River

The Roo_010 waterbody has been identified as a Priority Area for Action within River Basin Management Plan 2018-2021. Actions will be prioritised to achieve WFD objectives and will be directed towards pressures such as agriculture, urban waste water, domestic wastewater and forestry.

Figure 81: Location of the Roo Site

Issues on Site

The Roo river flows into Upper Lough Macnean in a northerly direction. The Roo_010 waterbody is in Poor status under the Water Framework Directive. The water quality status has deteriorated from Good to Moderate to Poor over the last 12 years.

A section at the lower end of the Roo river has been historically altered (deepened) for construction of the railway line. The majority of the channels upstream have not been significantly altered. However, land practices are impacting the channel.

Agriculture practices and impacts have been identified as a pressure on this watercourse. Site walkovers have identified evidence of livestock entering the river at numerous locations causing further erosion of banks and input of excess sediment into the river. Diverse riparian vegetation has been removed from sections of the channels in recent years resulting in a lack of sufficient riparian cover.

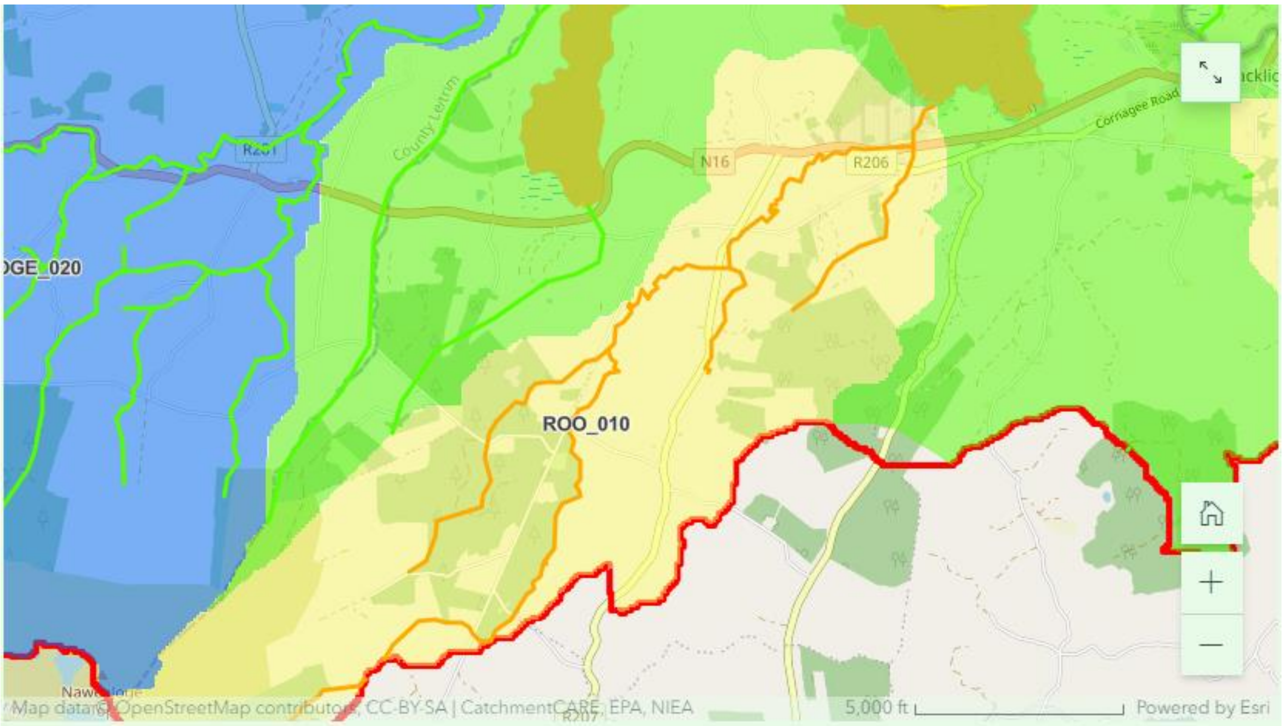

Figure 82: Roo River Water Quality data. Green Indicates Good, Yellow is Moderate and Red is Poor water quality.

Figure 83. Livestock access points.

Figure 84. Natural channel morphology (left) and altered over-deepened channel with steep banks (right) 200 m downstream.

There are several measures to reduce the agricultural pressures on the river. Measures include fencing along the river and providing alternative drinking sources for livestock.

The aims are to:

- stop cattle from entering the river and allow the river to recover.
- stabilise banks that were degraded by the cattle.
- improve riparian vegetation along the bank. Vegetation will increase biodiversity, be a source of nutrients into the river and provide cover for fish species.

A total of 5.5 km of fencing has been installed along a river stretch of 3.9 km. 32 livestock drinkers have been installed as alternative drinker sources for livestock. Solar pumps, nose pumps and rainwater harvesting systems have been installed as an alternative sources of water for livestock.

Figure 85. Before. Lack of riparian vegetation and livestock ingress to channel.

Figure 86. After Year 1.

Figure 87. Before. Livestock ingress to channel.

Figure 88. After. Year 1

Figure 89. Before. Livestock ingress to channel, excess sediment input.

Figure 90. After. Year 1

Figure 91. Before. Lack of fencing

Figure 92. After year 1.

Figure 93. Installation of rainwater harvesting system.

4.5. Pre and Post-works Surveys

Arney

During the Scoping Phase of the CatchmentCARE project, a range of sites were surveyed throughout the Arney Catchment. The results of these surveys highlighted where to undertake works. To assess the impact of the works, a focused evaluation of treatment sites was carried out. In the case of the main channel of the Arney, three phases of works were carried out. The whole channel was evaluated as works aimed to positively impact the entire channel and waterbody.

To evaluate Arney Phase 1, Arney Phase 2 and Arney Phase 3 collectively, a number of surveying sites were identified to assess physical impact and biological response of works. Seven sites spread evenly along the main channel were sampled pre and post works. Sampling included electrofishing (6 sites), RHAT (3 sites of 500 m lengths), aerial imagery (2 sites of 700 m), instream physical survey (2 sites) and temperature (7 sites post-works). Changes to vegetation type and habitat form between pre works and year of installation will be the same as the works for these sites are passive and will take time to have an effect on the ecosystem.

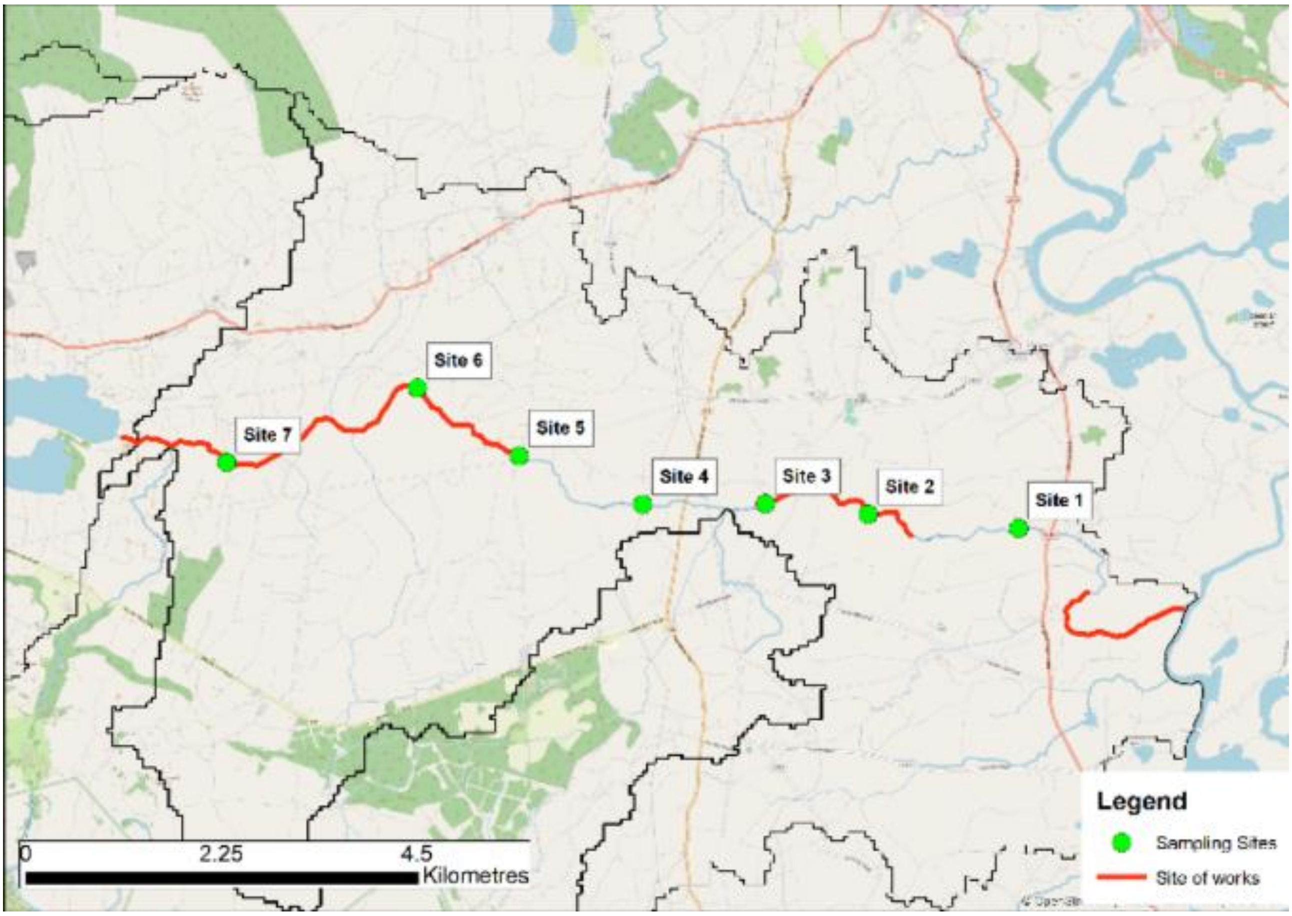

Figure 94: Electrofishing sites for before and after assessment of the Arney River.

To assess metrics of success following implemented water quality improvement measures, a number of focused surveys were carried out on Arney River waterbody. The metrics surveyed were:

- Fish (via electrofishing)
- Hydromorphology (via RHAT surveys)
- Riparian vegetation (via drone surveys)
- Instream physical (via differential GPS)
- Water temperature (via loggers)

Fish

The Before-After (BA) approach was used in the Arney River. Fish EQR (Ecological Quality Ratio) scores were modelled for each site (n=6) electro-fished in 2022 as well as those previously fished in

2021 (Figure 94). The EQR scores of sites sampled in 2021 (pre-works) and 2022 (post-works) are shown in Table . The change in EQR scores from 2021 to 2022 were compared and displayed in Figure 94. The EQRs have increased in four out of the six sites surveyed; 2 sites did not have measures implemented. While fishing, there were noticeably more species diversity in 2022. This may indicate an increase in habitat types created within river channel as a result of natural river processes taking place.

Table 9, EQR Results for before and after assessments of Arney River.

Works	Site	2021	2022
No	Site 1	0.01375	0.01404
Yes	Site 2	0.02792	0.119846
Yes	Site 3	0.059054	0.291518
No	Site 4	0.142568	0.015074
Yes	Site 5	0.103472	0.119734
Yes	Site 6	No Data	No Data
Yes	Site 7	0.013716	0.138838

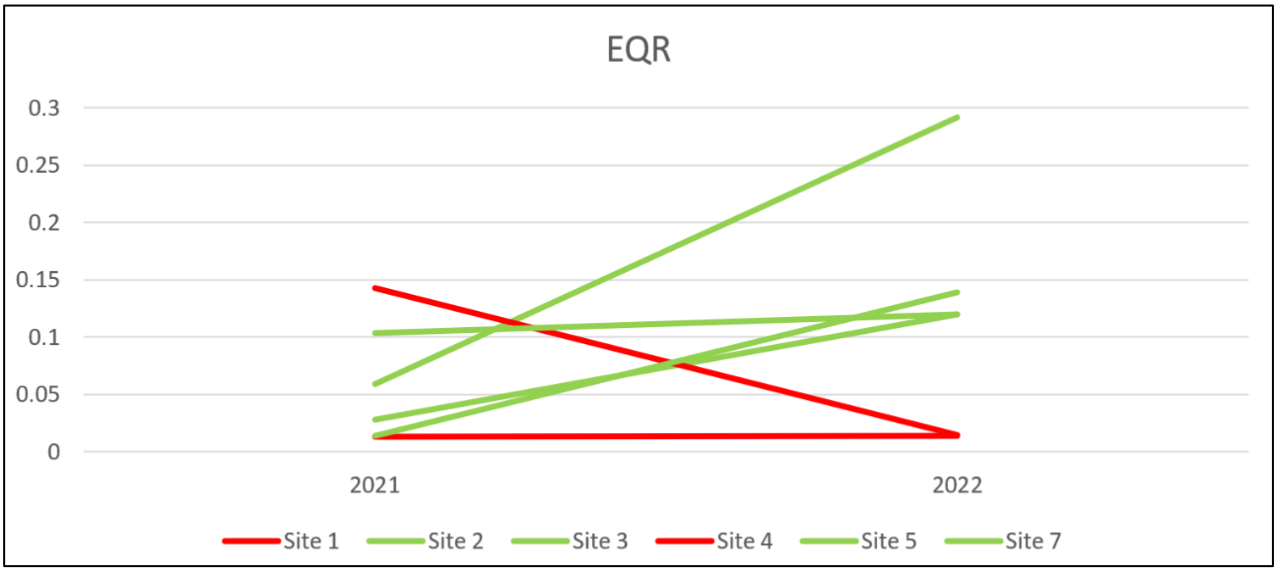

Figure 95: EQR Results for before and after assessments of the Arney River in 2021 and 2022. Green represents sites where works have taken place and red represents sites where works have not taken place.

Hydromorphology

Hydromorphology was assessed using a before -after (BA) approach. Eight attribute scores were collected for each RHAT survey. The difference in attribute scores before and after works were examined for Site 3, Site 5a and Site 7.

Table 10, RHAT Attribute scores for Site 3 2018 and 2022.

Site 3 Main channel (Works site) (AR_41)			
Year	2018	2022	
RHAT Attributes	**Score**	**Score**	**Change**
Channel Form and Flow Types	3	3	=
Channel Vegetation	2	4	↑
Substrate Condition	3	4	↑
Barriers to Continuity	4	4	=
Bank Structure & Stability	2	2.5	↑
Bank Vegetation	2	3	↑
Riparian Land Use	2	2	=
Floodplain Connectivity	1	1	=
∑ Attribute Score	**19**	**23.5**	
WFD Class	**Moderate**	**Good**	

Table 11, RHAT Attribute scores for site 5a 2018 and 2022.

Site 5a tributary (Works site) (AR_32)			
Year	2018	2022	
RHAT Attributes	**Score**	**Score**	**Change**
Channel Form and Flow Types	2	2	=
Channel Vegetation	2	3	↑
Substrate Condition	2	2	=
Barriers to Continuity	1	1	=
Bank Structure & Stability	1.5	2	↑
Bank Vegetation	1.5	2.5	↑
Riparian Land Use	2	2	=
Floodplain Connectivity	3	3	=
∑ Attribute Score	**15**	**17.5**	
WFD Class	**Moderate**	**Moderate**	

Results for Site 3 are shown in Table 10, RHAT Attribute scores for Site 3 2018 and 2022. Attributes that increased were ‘Channel Vegetation’, ‘Substrate Condition’, ‘Bank structure & Stability’ and ‘Bank Vegetation’. An improved range of vegetation was recorded instream and marginally with reeds recorded in 2022 which had been absent in 2018. Bank Vegetation improved with native vegetation growth and range of vegetation types recorded. An improved range of substrate was recorded in 2022, mainly due to noticeable reduction in excess silt. Bank structure & Stability improved due to a reduction of poaching and banks were stabilised due to vegetation growth.

Results for Site 5a are shown in Table 11, RHAT Attribute scores for site 5a 2018 and 2022.. Attributes that increased were ‘Channel Vegetation’, ‘Bank structure & Stability’ and ‘Bank Vegetation’. An improvement was recorded in the range of Channel Vegetation, specifically macrophytes growing marginally due to a reduction of cattle poaching. Bank Vegetation improved with a range of native vegetation growing due to the fenced buffer area. Consequently, Bank structure & stability improved due to reduced poaching and stabilisation of banks with vegetation growth.

Results for Site 7 are shown in Table 12, RHAT Attribute scores for Site 7 in 2018 and 2022. Attributes that increased were ‘Channel Vegetation’, ‘Substrate Condition’, ‘Bank structure & Stability’ and ‘Bank Vegetation’. Channel Vegetation, which was not visible in 2018, now has a range of instream and marginal vegetation expected for this river. Bank vegetation now has a range of canopy layers and native vegetation. Substrate Condition is now in a range expected for this type of river. Bank structure & Stability improved due to less cattle poaching and stabilising of banks.

Table 12, RHAT Attribute scores for Site 7 in 2018 and 2022.

Site 7 Main channel (Works site) (AR_36)			
Year	2018	2022	
RHAT Attributes	**Score**	**Score**	**Change**
Channel Form and Flow Types	3	3	=
Channel Vegetation	2	4	↑
Substrate Condition	2	4	↑
Barriers to Continuity	4	4	=
Bank Structure & Stability	2	3	↑
Bank Vegetation	2.5	3	↑
Riparian Land Use	1	1	=
Floodplain Connectivity	2	2	=
∑ Attribute Score	**18.5**	**24**	
WFD Class	**Moderate**	**Good**	

Riparian Vegetation

Riparian vegetation can be found on the riverbank and its presence improves the health of the river by providing bank stability and restoring natural channel dynamics. To monitor the riparian vegetation growth as a result of installed measures (i.e. fencing to remove pressure from cattle access), drone surveys were carried out at three sites in the Arney catchment (Figure 96). Surveys took place in 2020, 2021 soon after installation of measures and 2022, after measures have started to take effect. A flight plan around the sample site was created and a large number of overlapping aerial photographs were captured. The data from this survey was used to create orthomosaics (Figure 97 & Figure 98) and Digital Surface Models (DSM) of the channel, floodplain, and riparian zone (Figure 99, Figure 100 & Figure 101). The DSM can also be used to monitor canopy cover including vegetation height. Figure 100 and Figure 101 show an increase in tall herb vegetation in the riparian zone as a result of fencing. A big change was seen in 2 years from deteriorated bank condition to healthy riparian zone. In the coming years, it is expected to see a more varied increase in vegetation types such as shrub and broadleaf. An orthomosaic and DSM can monitor further change in cattle poaching areas.

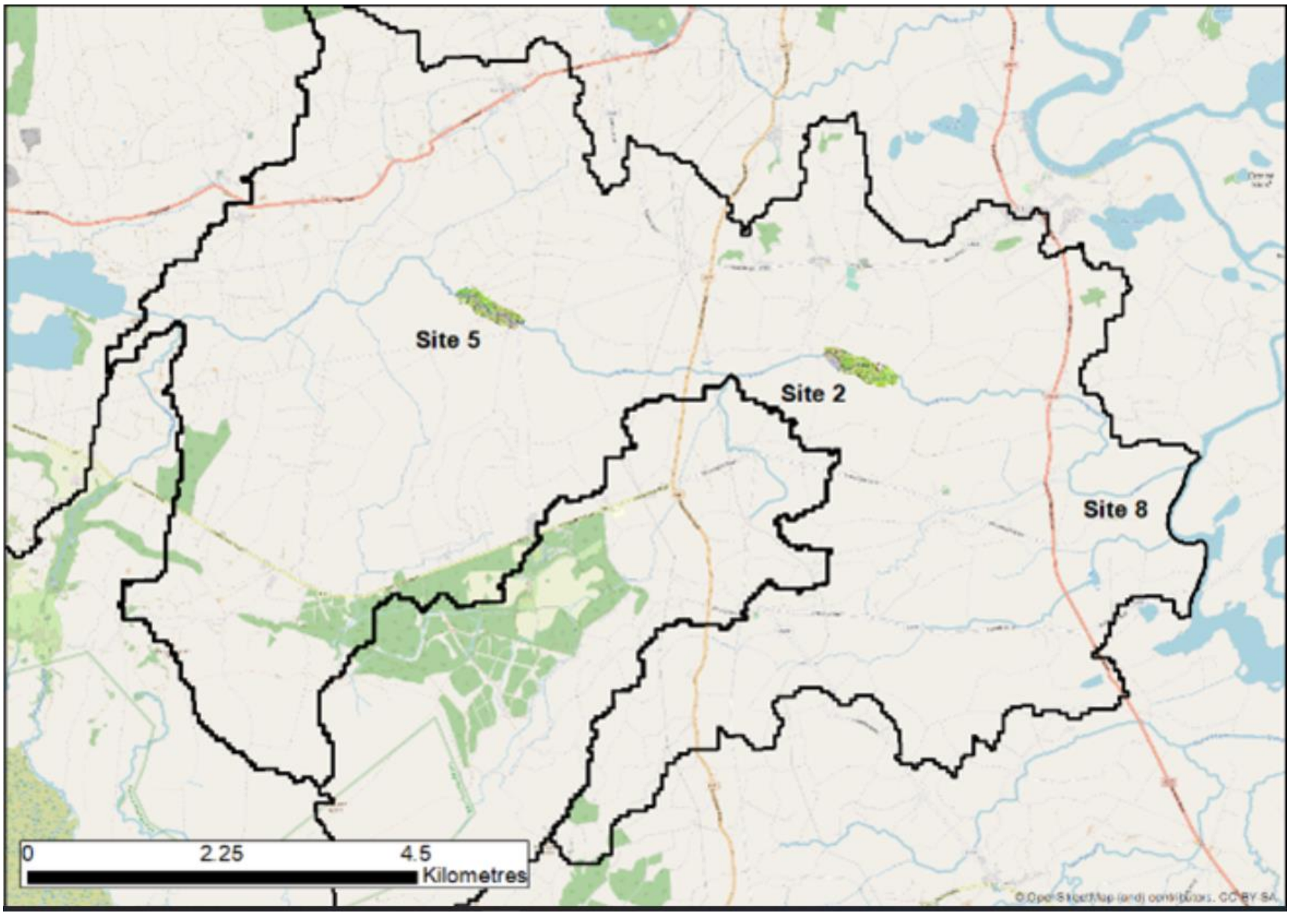

Figure 96, Location of sample sites for drone surveys.

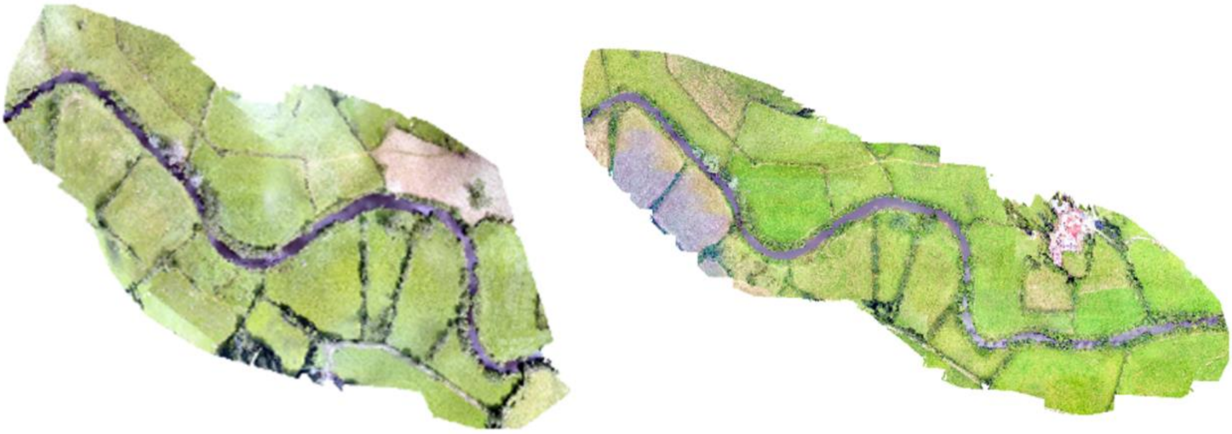

Figure 97, Orthomosaic of Site 2 in 2020 (left) and 2022 (right).

Figure 98: Orthomosaic of Site 5 in 2021(left) and 2022 (right).

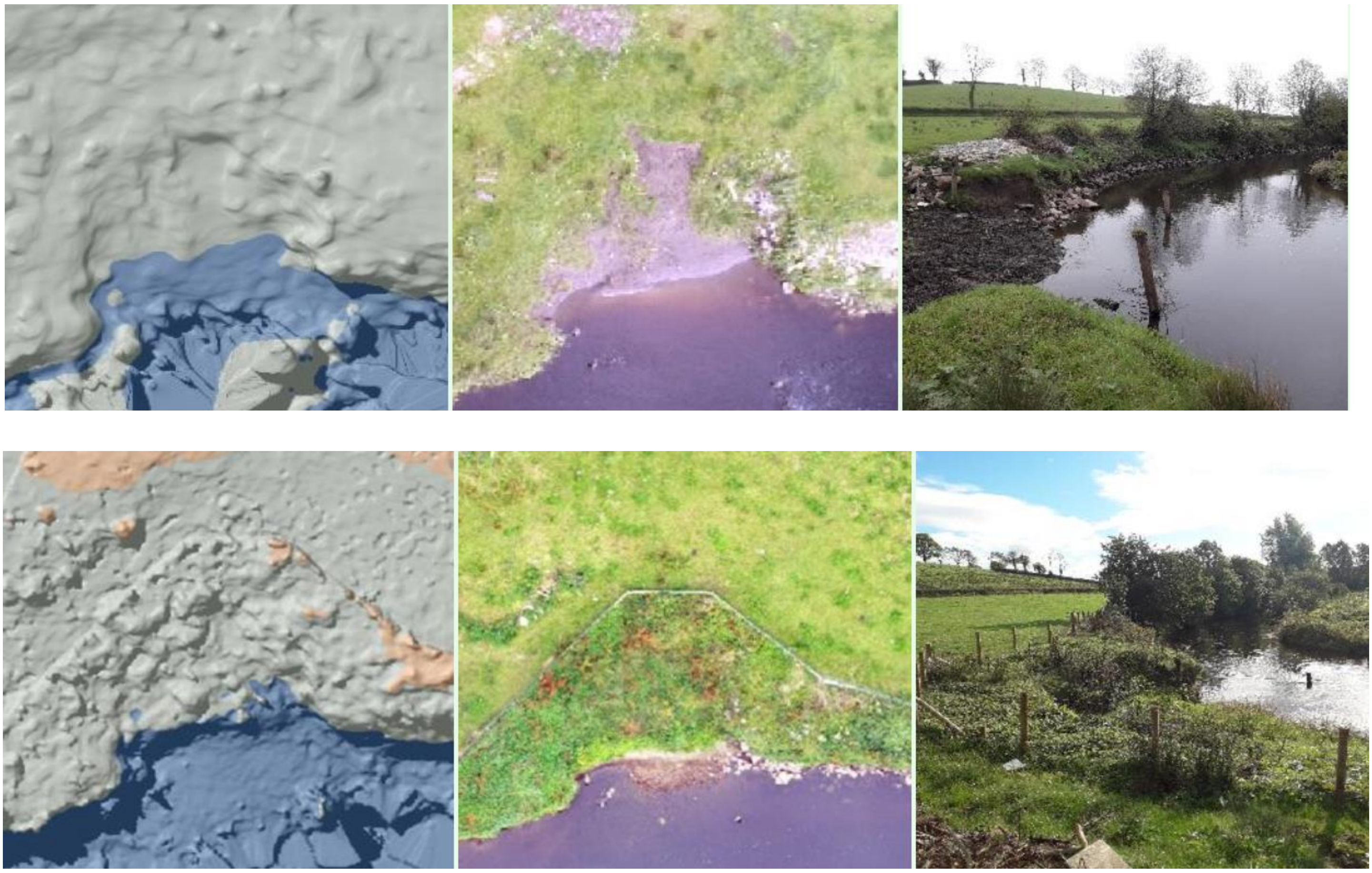

Figure 99: Digital surface model of site 2 in 2020 (top) and 2021 (bottom)

Figure 100: Digital Surface model of Site 2 in 2020 and 2022.

The bank condition and morphology were also monitored (Figure 101). In 2020 we can see this bank is slumping and the farmer was worried about erosion. In 2022, the vegetation is well established as livestock is no longer grazing this area. Willow has self-seeded this area and is starting to stabilize the banks with they're roots.

Instream Physical

A 30 m section of river channel at Site 2 was sampled using a differential GPS (Real Time Kinetic GPS). This records xyz points with latitude, longitude and elevation. With these, we can create a 3D model of the river section. We recorded multiple points across nine cross sections and then an array of points longitudinally throughout the channel.

Figure 103 is a 3D model created using the xyz points in 2021. We sampled again in 2022 and did not see any notable change in morphology but predict to see a change in a few more years. While recording xyz points we also recorded attributes such as substrate type at each point.

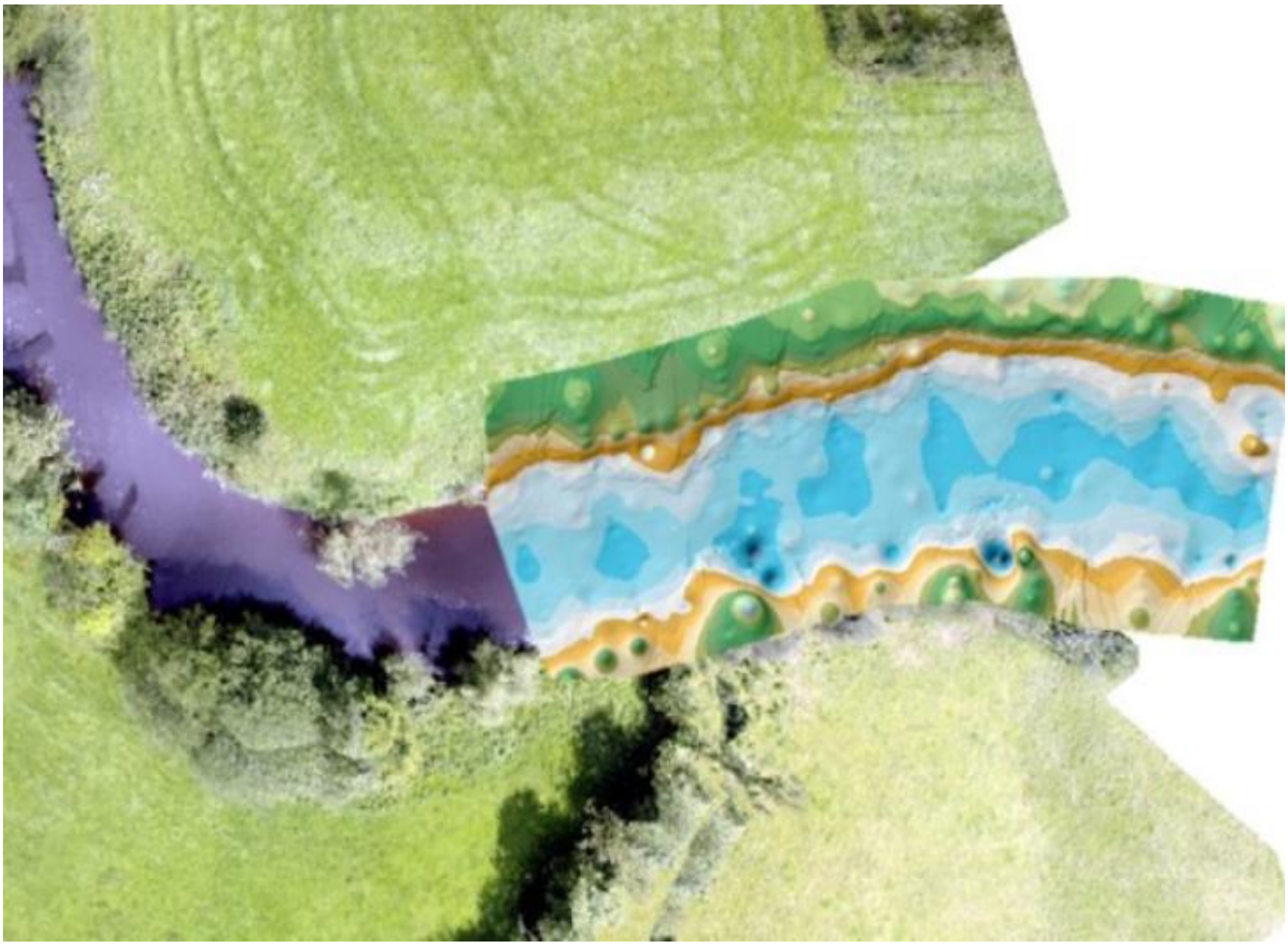

Figure 101: Instream morphology of Site 2 in 2021.

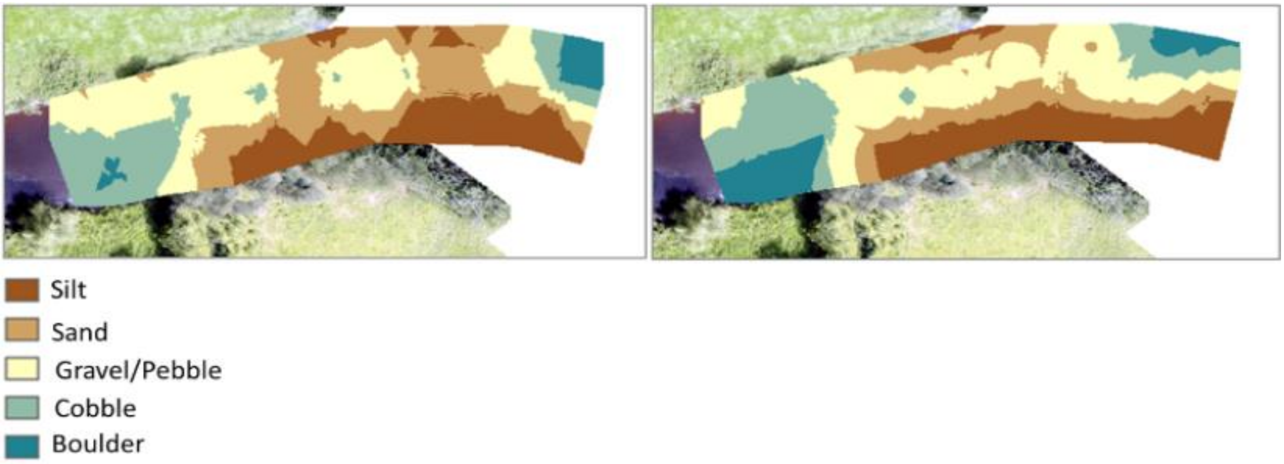

Figure 102: Substrate of silt of site 2 in 2021 (left) and 2022 (right).

Figure 102 shows substrate distribution throughout the section of the channel in 2021 and 2022. Note how it has changed in one year.

There was a cattle poaching area on the right bank (southern bank). Cattle were walking in the river and as a result there was excess fine sediment across channel. In 2022, the poaching area has been fenced. Fine sediment is being pushed to the river margins exposing more gravel pebble in river channel. A reduction of excess fine sediment within the channel should have a positive effect on water quality.

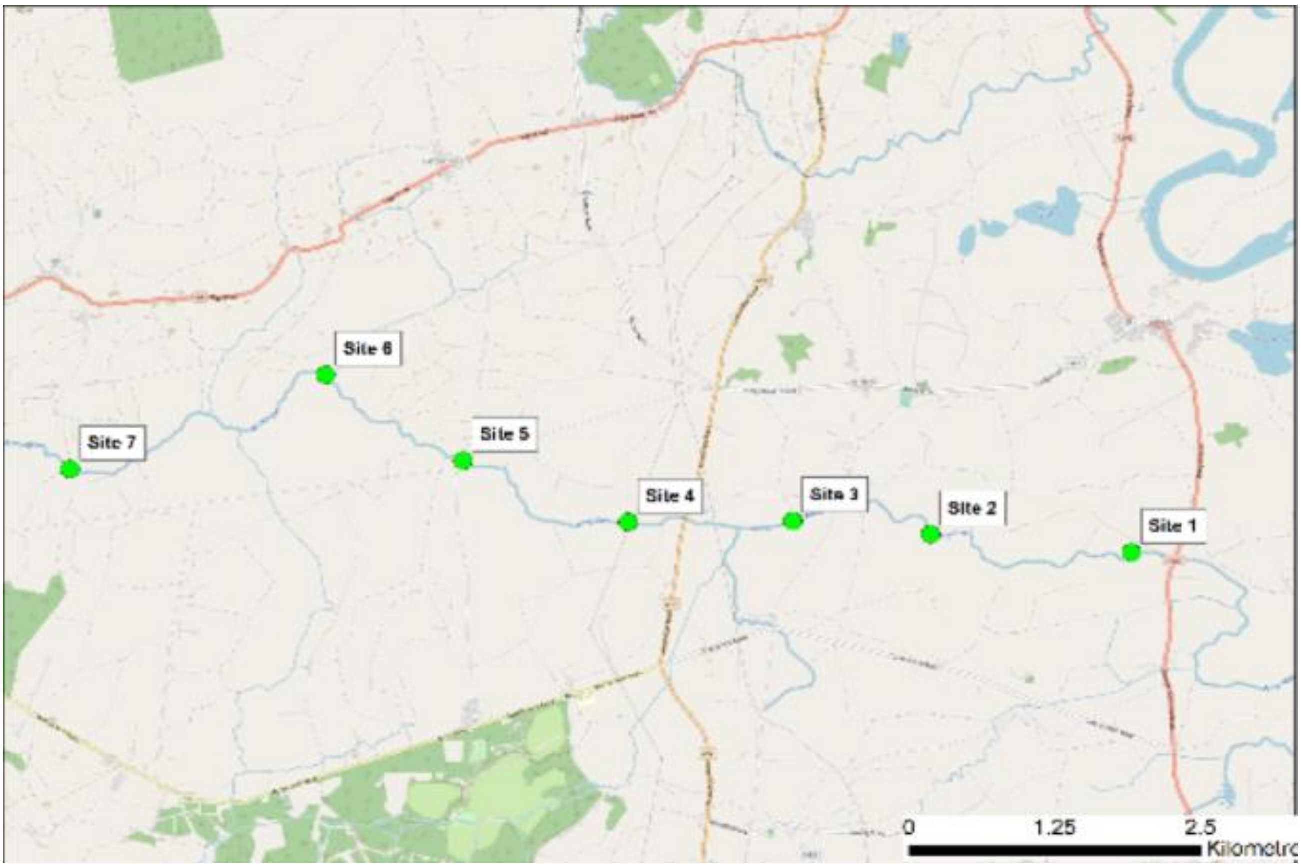

Figure 103: Location of sampling sites where temperatures loggers were deployed.

Temperature

Increased water temperatures will affect river fauna. Various heat sources can affect river temperatures however channel morphology and riparian vegetation cover can provide protection from extreme temperatures. To monitor the water temperature in the Arney River, Hobo temperature loggers were deployed at six sites in 2021 and 2022 (Figure 104). Loggers were set to record temperature every 15 minutes for the summer period (June - August) of each year. Brown trout are a typical native fish species that are sensitive to extreme temperature fluctuations therefore temperatures thresholds are included on the figures for this species. The Upper Thermal Threshold characterizes distribution limits, the Upper Growth Limit indicates the temperature that impedes growth, the Incipient Lethal Temperature is the temperature that 50 % will die with prolonged exposure (7 days) and the Lethal Temperature is one which brown trout cannot tolerate for short periods (10 mins).

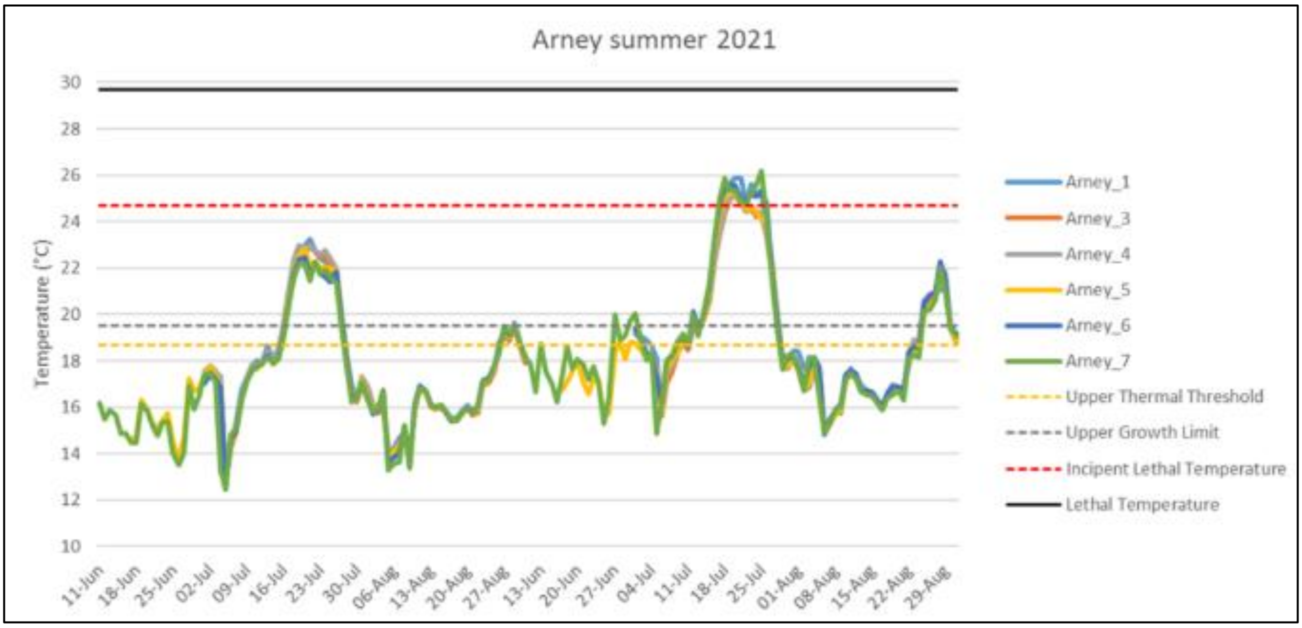

Figure 104: summer 2021 temperatures recorded in the Arney River and Brown Trout Temperature thresholds.

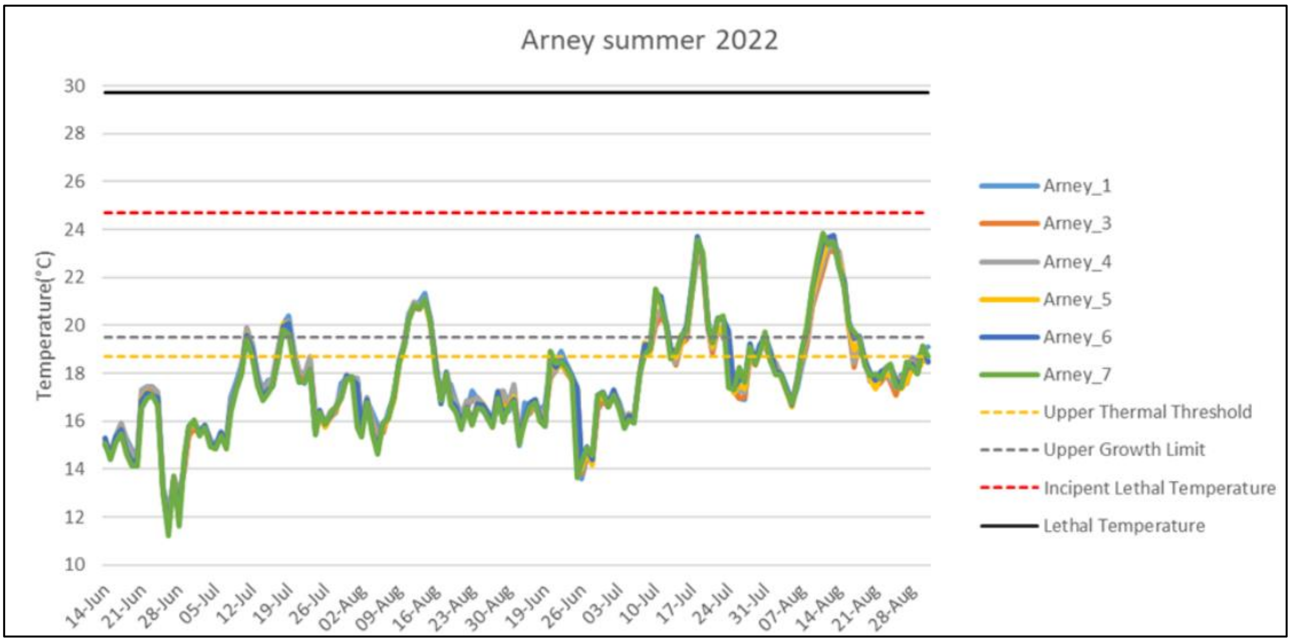

Figure 105, Summer 2022 temperatures recorded in the Arney River and Brown trout temperature thresholds.

Notice in Figure 105 how all sites have similar temperature regimes. This differs from the Roo River where temperature profiles varied at the monitoring sites. The Arney has a larger mean depth, leading to the more constant temperatures. However, quite high temperatures are being reached which is affecting freshwater biota. Currently we are unable to tell if the reduced spikes in 2022 are results of our works, the sites will need monitored for a few more years to gather evidence to provide accurate conclusions.

Roo

To assess metrics of success following implemented water quality improvement measures, a number of focused surveys were carried out on Roo_010 waterbody. The metrics surveyed were

- Fish (via electrofishing)
- Hydromorphology (via RHAT surveys)
- Riparian vegetation (via drone surveys)
- Instream physical (via differential GPS)
- Water temperature (via loggers)

Fish

The Before-After Control-Impact (BACI) is a commonly used methodology in ecology studies. The BACI approach includes a control site and a comparably impacted site, both represented by data before and after the impact. The BACI approach makes it possible to account for any natural or pre-existing differences between the sites and can therefore estimate the effect of an impact variable between the control and the impacted site. In this case, the chosen control site was located upstream of the impact site. This ensured that there were similar conditions to the impact site.

Samples were taken at the control site and treatment (impact) site before and after restoration works (Figure 1).

Fish EQR (Ecological Quality Ratio) scores were modelled for each site (n=10) electro-fished in 2022 as well as those previously fished in 2020 and 2021. The EQR scores of sites sampled in 2020, 2021 (Pre-works) and 2022 (post-works) are shown in Table 1. The change in EQR scores from 2020 to 2022 at the impact site were compared and displayed in Figure 107.

The EQRs have increased in four out of the five sites surveyed. While fishing, there were noticeably more brown trout of varied age class caught in 2022. This may indicate an increase in habitat types created within river channel as a result of natural river processes taking place. Control sites had no obvious trend with some EQR values increasing and some decreasing.

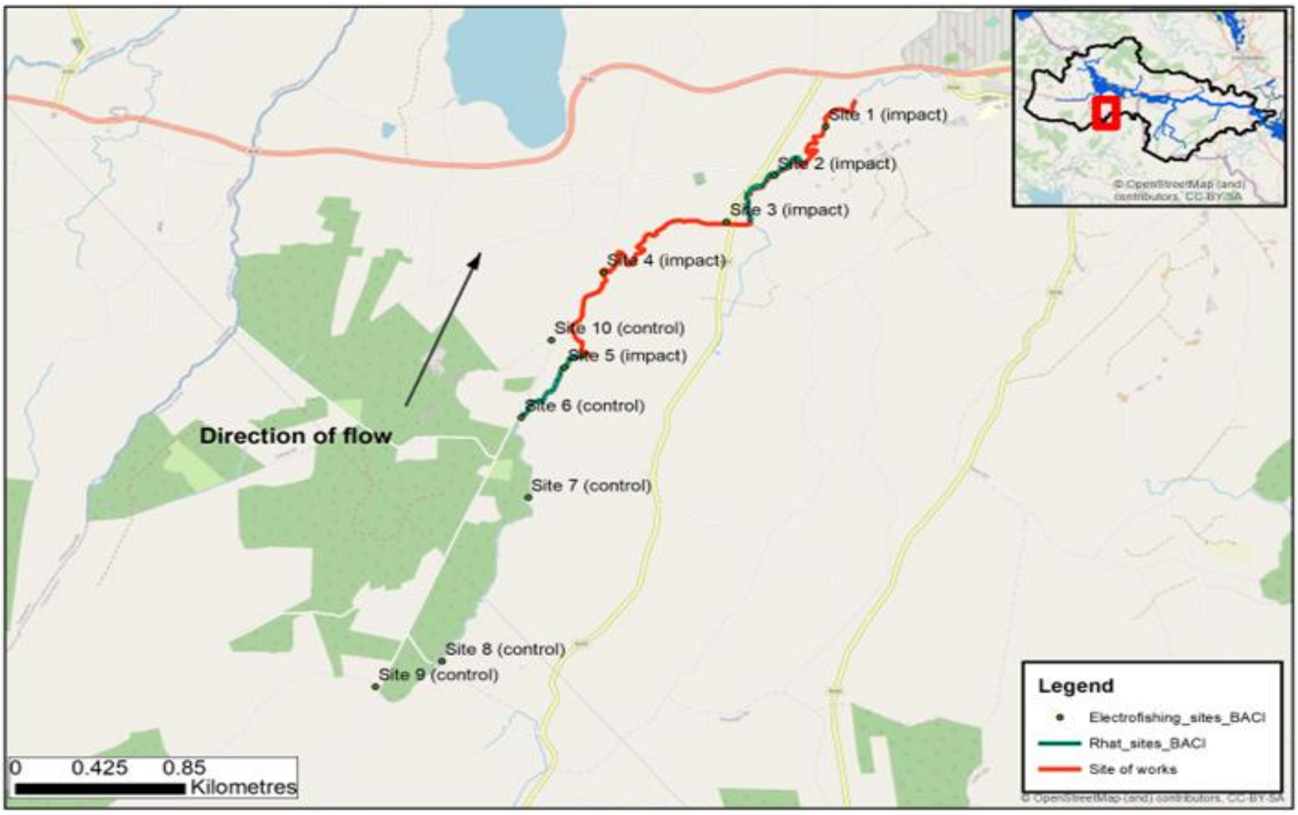

Figure 106. Electro-fishing and RHAT sites for BACI assessment of Roo River.

Table 1. EQR results for BACI assessment of Roo River. Green indicates good status, yellow indicates moderate status and orange indicates poor status.

Site type	Site no.	2020	2021	2022
Impact	**Site 1**	**0.480708**	**0.430104**	**0.762994**
Impact	**Site 2**	**0.235604**	**0.4028**	**0.611398**
Impact	**Site 3**	**0.52499**	**0.323228**	**0.249204**
Impact	**Site 4**	**0.549712**	**0.409076**	**0.780746**

Impact	Site 5	0.7547	0.21771	0.772422
Control	Site 6	0.232388	0.195514	0.27564
Control	Site 7	0.336076	0.515624	0.044948
Control	Site 8	0.185646	0.639044	0.303222
Control	Site 9	0.40801	0.063596	0.128536
Control	Site 10	0.516336	0.19244	0.366894

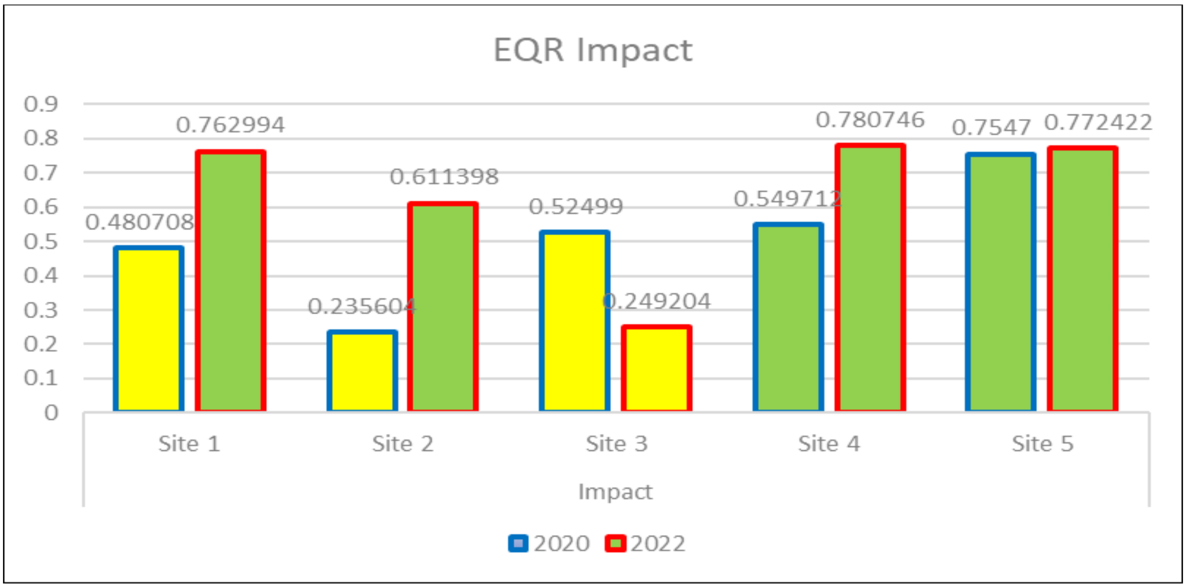

Figure 107. Histogram of EQR values at Impact sites Pre-works (2020) and Post-works (2022).

Hydromorphology

Hydromorphology was also assessed using a BACI approach. Eight attribute scores were collected for each RHAT survey. The difference in attribute score between control pre, control post, treatment pre and treatment post were examined. RHAT survey results show an increase in score from 2020 to 2022 in the impact site (Table 2). However, there was no increase in score at the control site (Table 3). Attributes that increased were 'Channel Vegetation' and 'Channel Form and Flow Types', due to increase diversity in flow types as a result of measures and allowing natural river process to take place. 'Bank structure & Stability' and 'Bank Vegetation' also increased due to livestock exclusion measures and increased vegetation growth (Figure 108-Figure 110).

Table 2. RHAT attribute scores for impact site for 2020 and 2022

Impact (Works site)			
Year	**2020**	**2022**	
RHAT Attributes	**Score**	**Score**	**Change**
Channel Form and Flow Types	3	3	=
Channel Vegetation	3	4	↑

Substrate Condition	**3**	**4**	**↑**
Barriers to Continuity	**3**	**3**	**=**
Bank Structure & Stability	**2**	**3**	**↑**
Bank Vegetation	**2**	**4**	**↑**
Riparian Land Use	**2**	**2**	**=**
Floodplain Connectivity	**3**	**3**	**=**
∑ Attribute Score	**21**	**26**	
WFD Class	**Good**	**High**	

Table 3. RHAT attribute scores for control site for 2020 and 2022

Control (No Works)			
Year	**2020**	**2022**	
RHAT Attributes	**Score**	**Score**	**Change**
Channel Form and Flow Types	**4**	**4**	**=**
Channel Vegetation	**4**	**4**	**=**
Substrate Condition	**3**	**3**	**=**
Barriers to Continuity	**4**	**4**	**=**
Bank Structure & Stability	**3.5**	**3.5**	**=**
Bank Vegetation	**3**	**3**	**=**
Riparian Land Use	**2**	**2**	**=**
Floodplain Connectivity	**4**	**4**	**=**
∑ Attribute Score	**27.5**	**27.5**	
WFD Class	**High**	**High**	

Figure 108. Bank vegetation before and after measures.

Figure 109. Substrate condition before and after measures.

Figure 110. Bank structure & Stability during installation of measures and after measures have taken effect.

Riparian Vegetation

Riparian vegetation can be found on the riverbank and its presence improves the health of the river by providing bank stability and restoring natural channel dynamics. To monitor the riparian vegetation growth as a result of installed measures (i.e. fencing to remove pressure from cattle access), drone surveys were carried out at three sites (Figure 111). Surveys took place in 2021, soon after installation of measures and 2022, after measures have started to take effect. A flight plan around the sample site was created and a large number of overlapping aerial photographs were captured. The data from this survey was used to create an orthomosaic and Digital Surface Model (DSM) of the channel, floodplain, and riparian zone (Figure 112 and Figure 113). The DSM can also be used to monitor canopy cover including vegetation height (Figure 114). Figure 114 shows an increase in tall herb vegetation in the riparian zone as a result of fencing. In the coming years, it is expected to see a more varied increase in vegetation types such as shrub and broadleaf.

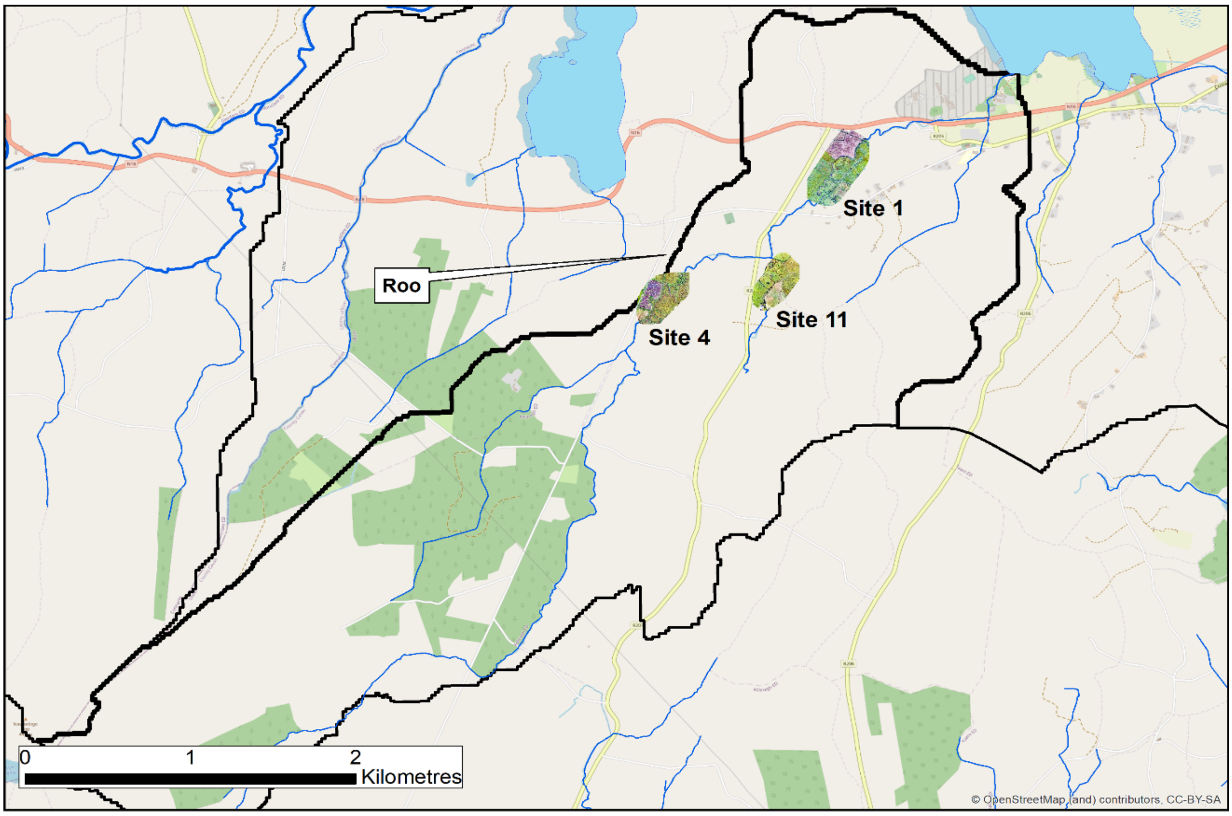

Figure 111. Location of sample sites for drone surveys.

Figure 112. Orthomosaic of site 4 in 2021 (left) & 2022 (right).

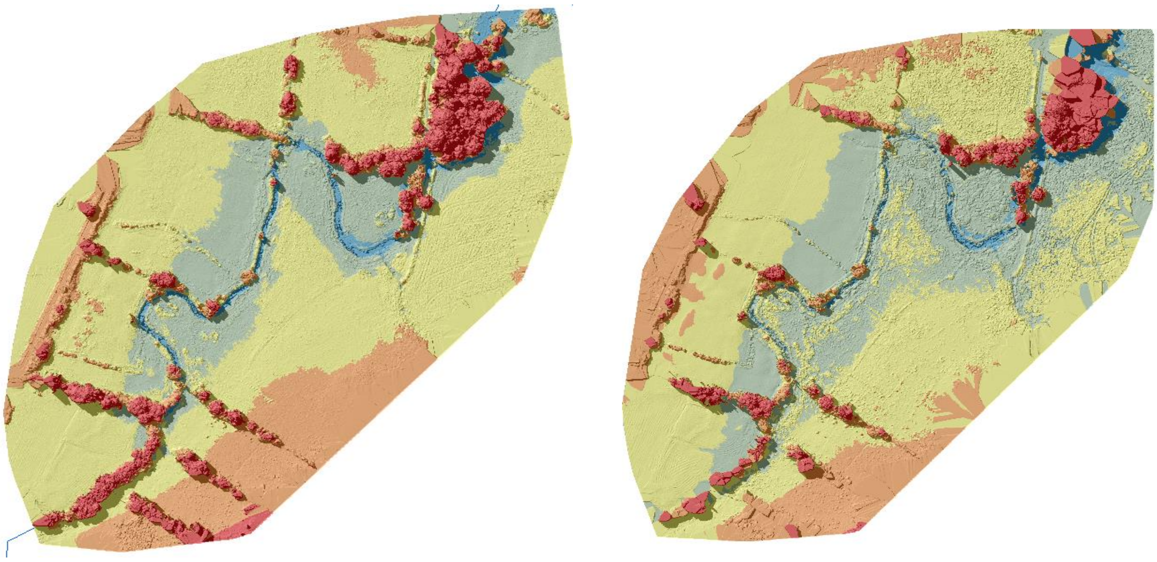

Figure 113. Digital surface model of site 4 in 2021(left) and 2022 (right).

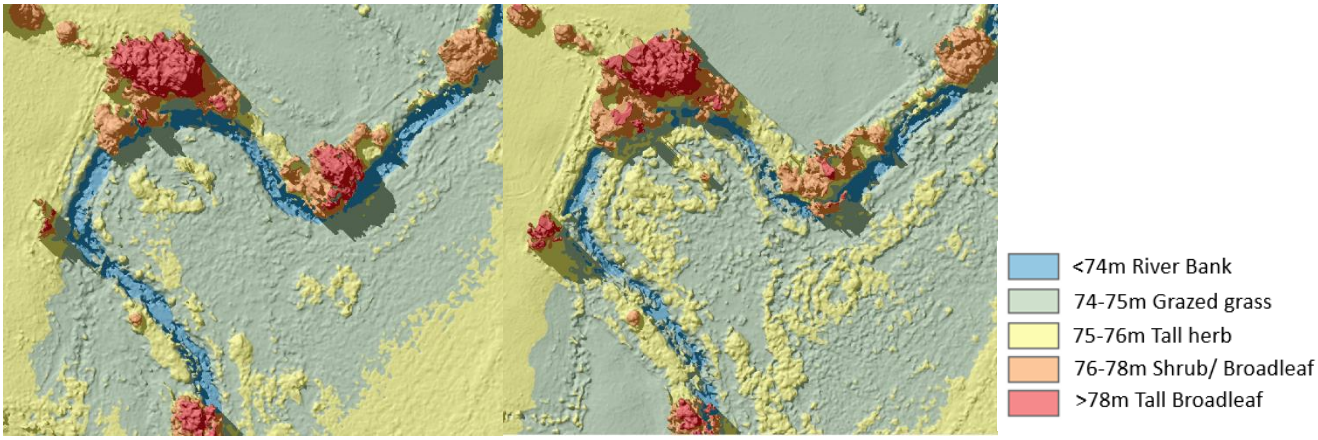

Figure 114. 50m grid square Digital surface models of site 4 in 2021 (left) and 2022 (right).

Instream Physical

We sampled a 30 m section of river channel at site 5 using a differential GPS (Real Time Kinetic GPS). This records xyz points with latitude, longitude and elevation. With these we can create a 3D model of the river section. We recorded multiple points across nine cross sections and then an array of points longitudinally through the channel (Figure 115 left). Figure 115 (right) is a 3D model created using the xyz points in 2021. We sampled again in 2022 and did not see any notable change in morphology, but predict to see a change in a few more years. While recording xyz points we also recorded attributes such as substrate type at each point. Figure 116 shows substrate distribution throughout the section of the channel in 2021 and 2022. Note how it has changed in one year. The river is flowing from south to north in this diagram. In 2021, there was cattle access point at the upstream part of the survey site. All the excess fine sediment such as silt upstream has moved and the substrate distribution has been altered. A reduction of excess fine sediment within the channel should have a positive effect on water quality.

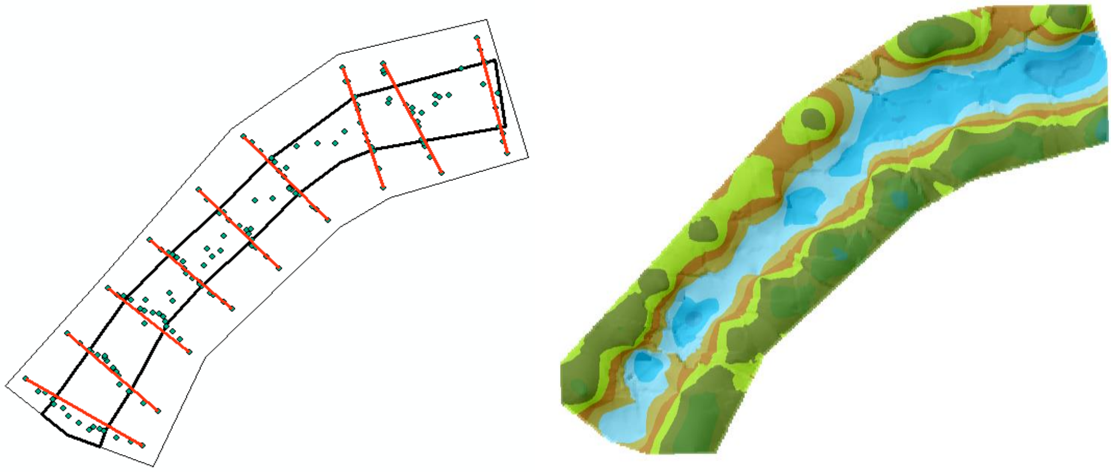

Figure 115. Sampling method schematic (left) and 3D model (right) of site 5

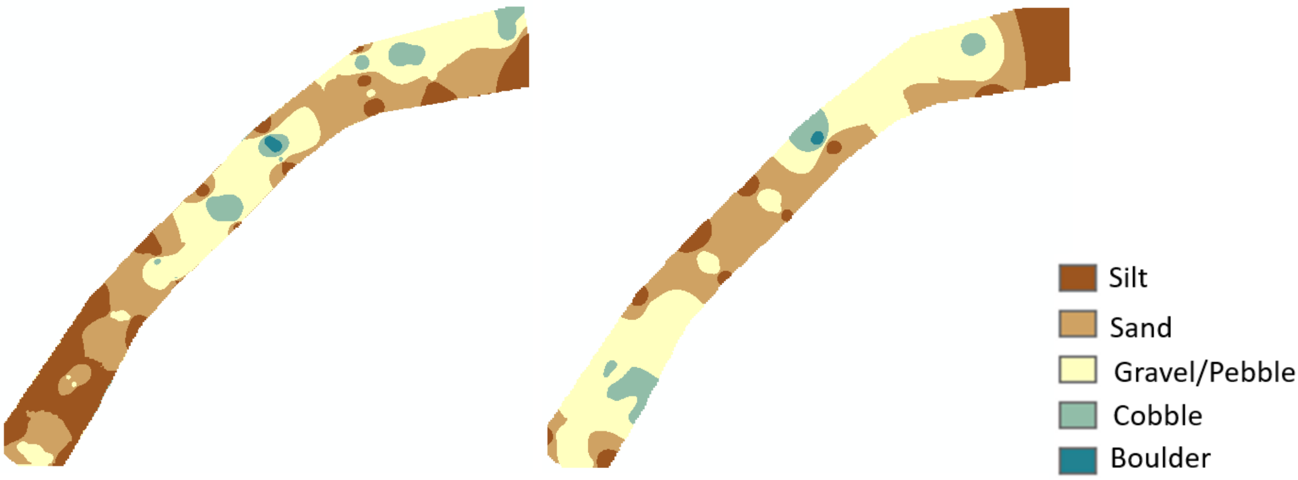

Figure 116. Diagram of substrate distribution in 2021 (left) and 2022 (right) of site 5.

Temperature

Increased water temperatures will affect river fauna. Various heat sources can affect river temperatures however channel morphology and riparian vegetation cover can provide protection from extreme temperatures. To monitor the water temperature in the Roo River, Hobo temperature loggers were deployed at six sites in 2021 and 2022. Loggers were set to record temperature every 15 minutes for the summer period (June-August) of each year. Figure 118 and Figure 119 show the temperatures recorded throughout summer 2021 and 2022. Brown trout are a typical native fish species that are sensitive to extreme temperature fluctuations therefore temperatures thresholds are included on the figures for this species. The Upper Thermal Threshold characterises distribution limits, the Upper Growth Limit indicates the temperature that impedes growth, the Incipient Lethal Temperature is the temperature that 50 % will die with prolonged exposure (7 days) and the Lethal Temperature is one which brown trout cannot tolerate for short periods (10 mins).

Site 4 has reduced riparian cover, shown with DSM in Figure 112-Figure 114. The spikes in high temperature is likely due to the reduced riparian cover and shallower mean depth of river in this section. The stream where Site 11 is located rises from Barran spring and joins the main Roo channel. It also has been subject to tree removal in the past and has reduced riparian cover. The lower temperatures are a result of the cold spring water feeding the stream. Overall, varying temperature records throughout the waterbody indicate a patchy riparian cover where higher temperatures are as a result of areas with reduced riparian cover. It is predicted to see a reduction in temperature spikes with more vegetation growth, making it more habitable for biota.

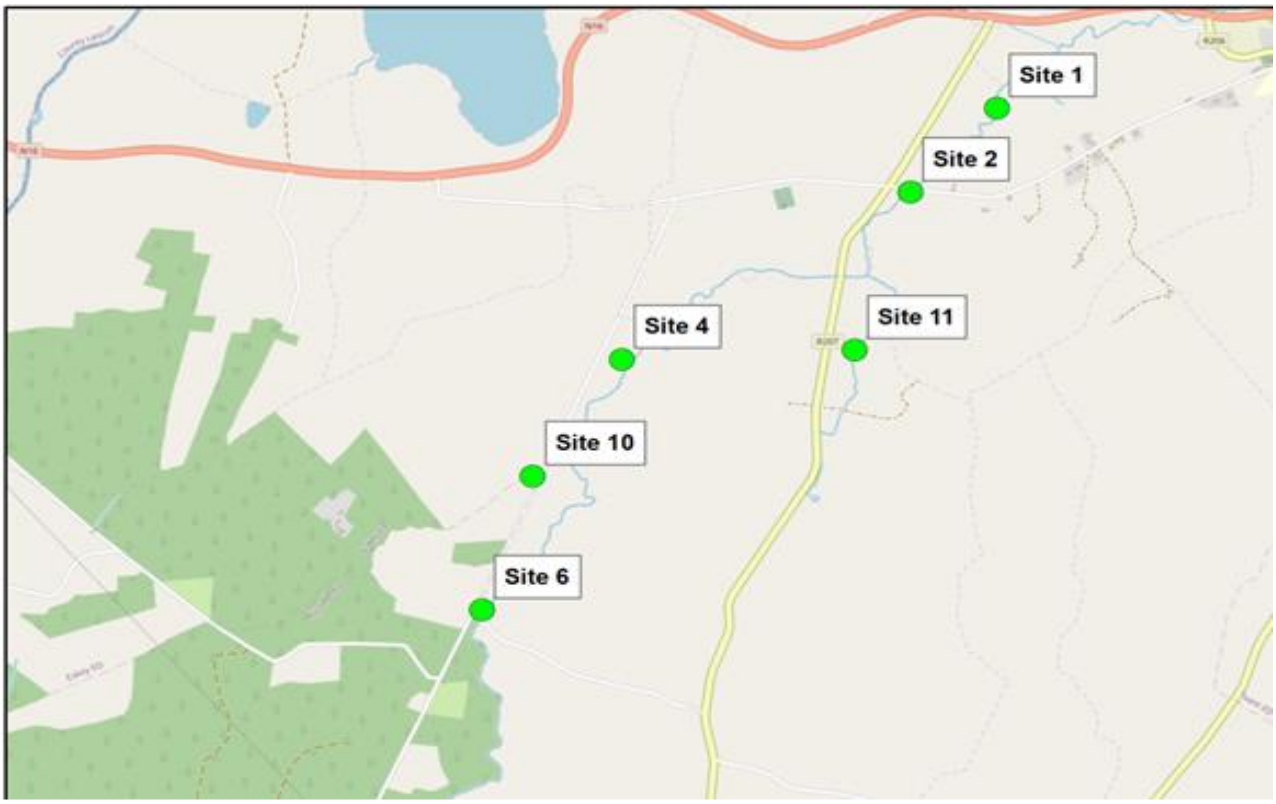

Figure 117.Temperature logger deployment sites in the Roo River during 2021 and 2022.

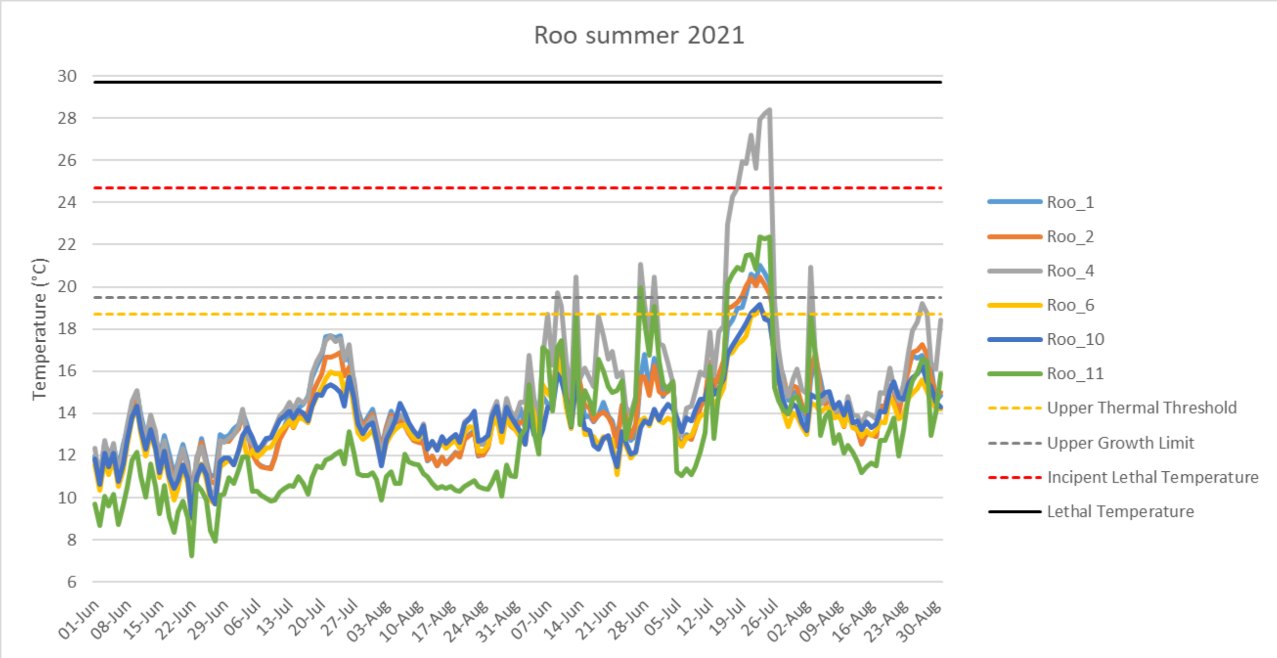

Figure 118. Summer 2021 temperatures recorded in the Roo River and Brown Trout temperature thresholds.

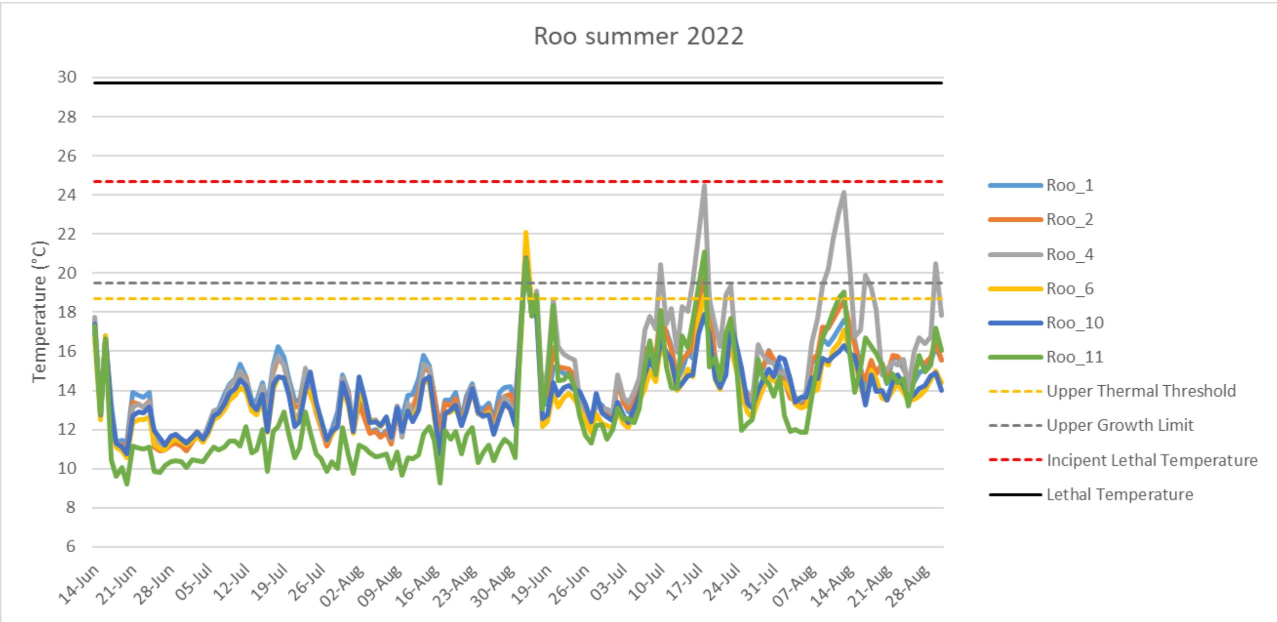

Figure 119. Summer 2021 temperatures recorded in the Roo River and Brown Trout temperature thresholds.

5. HABITAT RESTORATION WORKS – BLACKWATER CATCHMENT

5.1. Upper Blackwater Phase One

The Upper Blackwater River works involved installation of fencing, gates, stiles and livestock drinkers, bank stabilisation, and the planting of native tree species. A barrier was also removed and replaced with a bottomless bridge. Instream works were also carried out in partnership with DAERA Inland Fisheries along a 4.5 km stretch of the Blackwater River from the road bridge of the Fintona road to the old mill on the Mill road, Clogher.

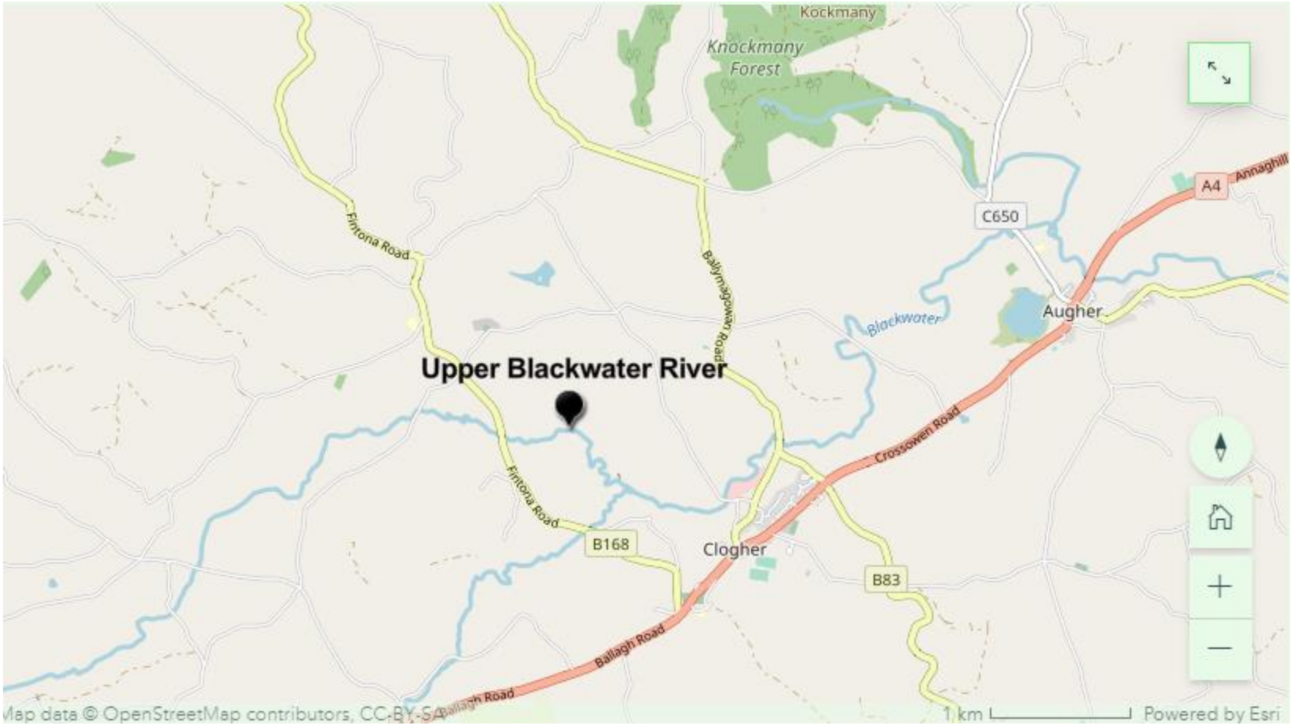

Figure 120: Upper Blackwater River Location

The main pressures on water quality at this site were primarily agriculture. These included run off from local fields due to excessive fertiliser loading, poaching of river banks due to livestock having direct access to the watercourse, siltation of riverbed caused by bank erosion and lack of riparian habitat and tree cover or from spread of invasive species (Himalayan Balsam was the only invasive species present).

As on most of the Blackwater system, the instream pressures on this stretch of the river were a legacy of the arterial drainage of the Blackwater system in the 1980’s and 1990’s. This has led to a highly modified channelized river which was prone to silting due to lack of flow diversity.

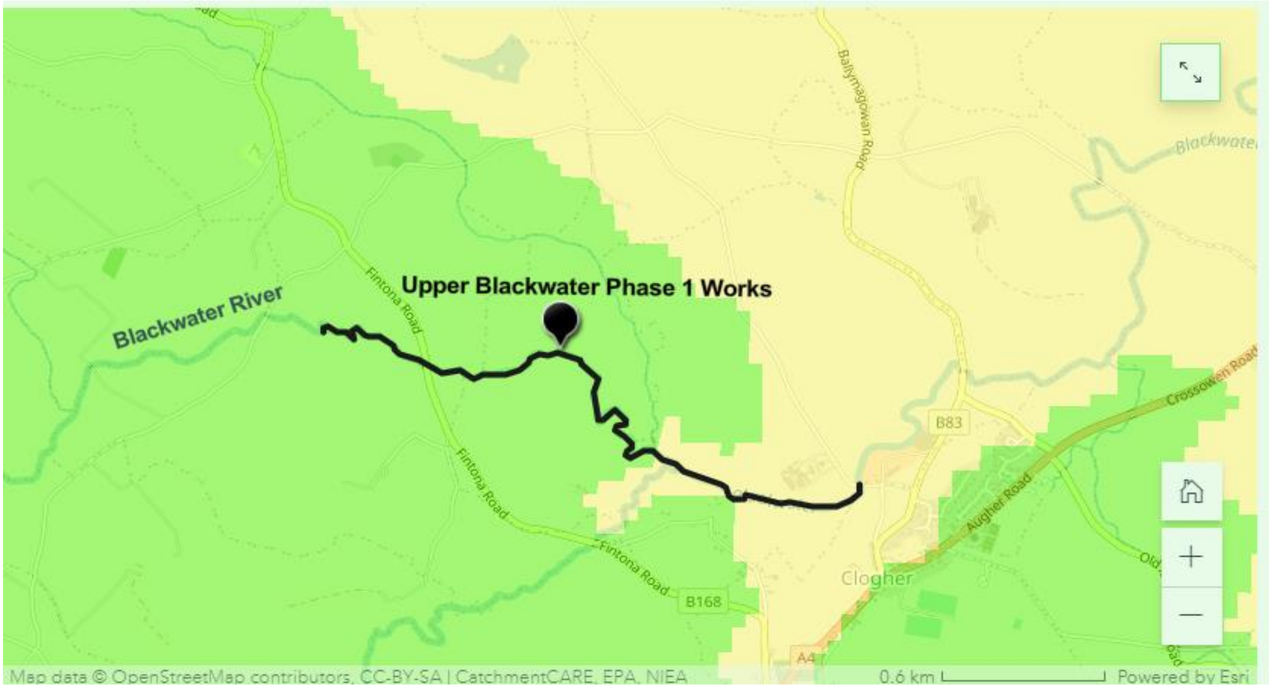

Figure 121: Location of Phase One

A wide range of remediation works were completed on this stretch of the Blackwater River, all aimed at addressing the issues on site. Works included the following –

- Installation of livestock fencing (4 rows of barbed wire) over 4.6 km of riverbank.
- Installation of 10 stiles for access to the river for anglers, landowners and other stakeholders such as NIEA staff to facilitate water testing.
- Installation of 19 livestock drinkers and associated pipework to provide water for cattle and sheep over 1.7 km of farmland.
- Removal of 37 trees (Dead Alders) and overhanging branches in the watercourse over 4.6 km.
- Planting of 500 native tree saplings (2-5 years old). A mix of native hardwood species was planted (Whitethorn, Crab Apple, Downey Birch, Silver Birch, Scots Pine, Spindle, Oak, Blackthorn Cherry, Rowan, Guelder Rose, Hazel, Sycamore, and Horse Chestnut).
- Tree protectors and stakes were included.
- Installation of solar drinking system, supplying 8 drinkers.
- Installation of 2 bottomless bridges at sites along the river. One was as a replacement for a barrier on the river, the other was to allow access for livestock to fields.
- A range of deep water revetment measures were introduced along 4.5 km of river at 3 sites – these included ‘toe revetment’ using cobbled stone, ‘log walls’ and ‘coir matting’.
- In partnership with DEARA Inland Fisheries a range of habitat improvement works were introduced over 3.2 km. These included ‘flow deflectors’, ‘rubble mats’ and ‘plumb stones’.

Figure 122: fencing installed to prevent livestock from accessing the river.

5.2. Upper Blackwater Phase Two

The Upper Blackwater River water quality improvements Phase Two works involved installation of fencing, gates, stiles and livestock drinkers, bank stabilisation, and the planting of native tree species. Instream works were also carried out along a 4 km stretch of the Ballymagowan Bridge to the Corrick Bridge close to the town of Clogher.

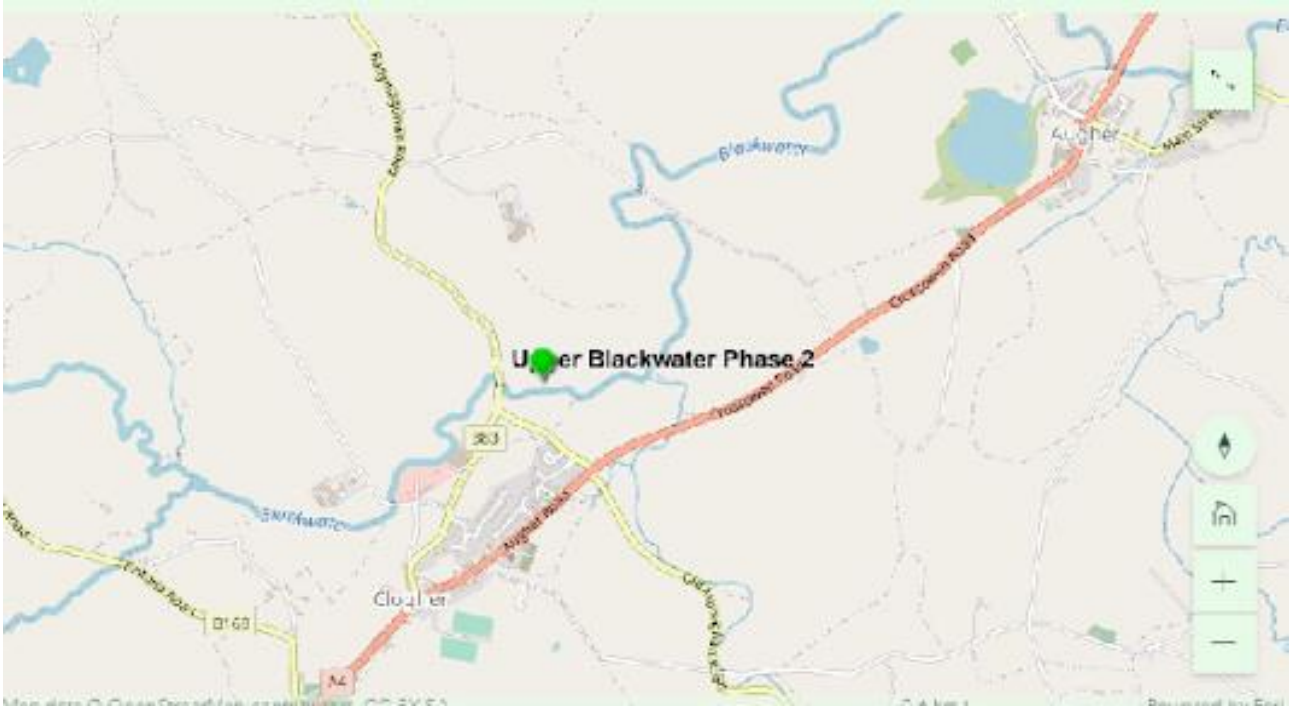

Figure 123: Location of Works

The main pressures on water quality at this site were primarily agriculture. These included run off from local fields due to excessive fertiliser loading, poaching of river banks due to livestock having direct access to the watercourse, siltation of riverbed caused by bank erosion and lack of riparian habitat and tree cover or from spread of invasive species (Himalayan Balsam was the only invasive species present).

As on most of the Blackwater system, the instream pressures on this stretch of the river were a legacy of the arterial drainage of the Blackwater system in the 1980's and 1990's. This has led to a highly modified channelized river which was prone to silting due to lack of flow diversity.
A wide range of remediation works were completed on this stretch of the Blackwater River, all aimed at addressing the issues on site. Works included the following –

- Installation of livestock fencing (4 row of barbed wire) over 4.6 km of riverbank.

Figure 124: Fencing Installed

- Installation of 10 stiles for access to the river for anglers, landowners and other stakeholders such as NIEA staff to facilitate water testing.
- Installation of 19 livestock drinkers and associated pipework to provide water for cattle and sheep over 1.7 km of farmland.
- Removal of 37 trees (Dead Alders) and overhanging branches in the watercourse over 4.6km.
- Planting of 500 native tree saplings (2-5 years old). A mix of native hardwood species was planted (Whitethorn, Crab Apple, Downey Birch, Silver Birch, Scots Pine, Spindle, Oak, Blackthorn Cherry, Rowan, Guelder Rose, Hazel, Sycamore, and Horse Chestnut). Tree protectors and stakes were included.
- Installation of solar drinking system, supplying 8 drinkers.
- Installation of 2 bottomless bridges at sites along the river. One was as a replacement for a barrier on the river, the other was to allow access for livestock to fields.
- A range of deep water revetment measures were introduced along 4.5km of river at 3 sites – these included ‘toe revetment’ using cobbled stone, ‘log walls’ and ‘coir matting’.

Figure 125: Coir Matting Installed

- In partnership with DEARA Inland Fisheries a range of habitat improvement works were introduced over 3.2 km. These included ‘flow deflectors’, ‘rubble mats’ and ‘plumb stones’.

5.3. Upper Blackwater Phase Three

Works involved installation of fencing, stiles and livestock drinkers, bank stabilisation, and the planting of native tree species. Instream works were also carried out along a 2.2 km stretch of the Blackwater River in the townland of ‘lungs’.

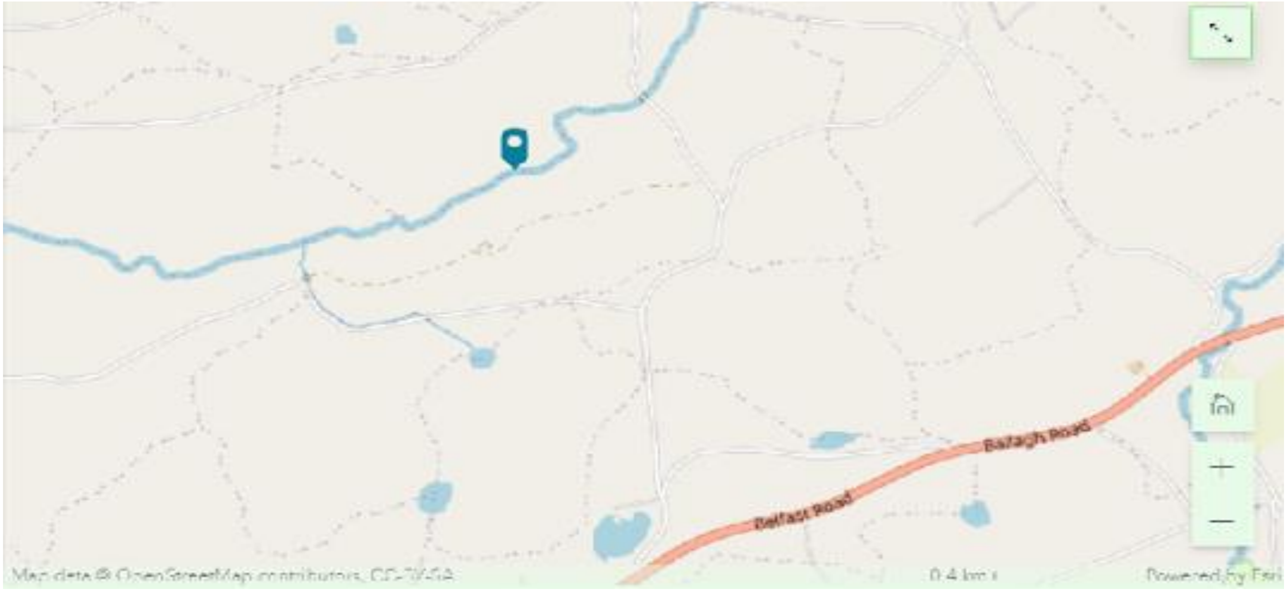

Figure 126: Location of Works

The main pressures on water quality at this site were primarily agriculture. These included run off from local fields due to excessive fertiliser loading, poaching of river banks due to livestock having direct access to the watercourse, siltation of riverbed caused by bank erosion and lack of riparian habitat and tree cover or from spread of invasive species (Himalayan Balsam was the only invasive species present).

As on most of the Blackwater system, the instream pressures on this stretch of the river are a legacy of the arterial drainage of the Blackwater system in the 1980’s and 1990’s. This has led to a highly modified channelized river which was prone to silting due to lack of flow diversity.
A wide range of remediation works were completed on this stretch of the Blackwater River, all aimed at addressing the issues on site. Works included the following –

- Installation of livestock fencing (5 rows of barbed wire) over 2.2 km of riverbank.

Figure 127: Fencing Installed

- Installation of 5 stiles for access to the river for anglers, landowners and other stakeholders such as NIEA staff to facilitate water testing.
- Installation of 4 livestock drinkers and associated pipework to provide water for cattle and sheep over 2.2 km of farmland.
- Removal of 30 trees (Dead Alders) and overhanging branches in the watercourse over 4.6km
- Planting of 1500 native tree saplings (2-5 years old). A mix of native hardwood species was planted (Whitethorn, Crab Apple, Downey Birch, Silver Birch, Scots Pine, Spindle, Oak, Blackthorn Cherry, Rowan, Guelder Rose, Hazel, Sycamore, and Horse Chestnut). Tree protectors and stakes were included.
- A range of deep water revetment measures were introduced along 2.2 km of river at 3 sites – these included 'toe revetment' using cobbled stone, 'log walls' and 'coir matting'.
- In partnership with DEARA Inland Fisheries a range of habitat improvement works were introduced over 3.2 km. These included 'flow deflectors', 'rubble mats' and 'plumb stones'.

5.4. Upper Blackwater Farmers Group

The Upper Blackwater Farmers Group Water Quality Improvements works involved installation of fencing, livestock drinkers and the planting of native tree species. The works took place over 1.2 km in the Townland of Ratory outside Clogher in Co. Tyrone.

Figure 128: Location of Works

The main pressures on water quality in this river were primarily agricultural and domestic. Agricultural pressures included runoff from adjacent fields due to excessive fertiliser loading, poaching of river banks due to livestock having direct access to the watercourse, siltation of riverbed caused by bank erosion and lack of riparian habitat and tree cover or spread of invasive species (Giant Hogweed and Himalayan Balsam were the two predominant species here).

As on most of the Blackwater system, the instream pressures on this stretch of the river were a legacy of the arterial drainage of the Blackwater system in the 1980's and 1990's. This has led to a highly modified channelized river which was prone to silting due to lack of flow diversity.
A wide range of remediation works were completed on this stretch of the Blackwater River, all aimed at addressing the issues on site. Works included the following –

- Installation of livestock fencing (4 rows of barbed wire) over 430 metres of riverbank.
- Installation of 2 stiles for access to the river for anglers, landowners and other stakeholders such as NIEA staff to facilitate water testing.
- Installation of Two 4 gallon livestock drinkers (concrete) and 9 x 45 gallon livestock drinkers (Plastic) plus 880 m 0f 25 mm pipe work (buried 400 mm).

Figure 129: Cattle drinkers installed as part of the remediation works

- Planting of 800 native tree saplings (2-5 year old). A mix of native hardwood species was planted (Whitethorn, Crab Apple, Downey Birch, Silver Birch, Scots Pine, Spindle, Oak, Blackthorn Cherry, Rowan, Guelder Rose, Hazel, Sycamore, Horse Chestnut). Tree protectors and stakes were included.

5.5. Ballygawley Phase One

The Ballygawley River water quality improvements (Phase 1) works involved installation of fencing, gates, stiles and livestock drinkers, bank stabilisation, planting of native tree species and instream works in partnership with DAERA Inland Fisheries along a 3.1 km stretch of the Ballygawley River, from the confluence of the Ballygawley river with the Blackwater river to Stockdales Bridge (Lisdoart).

Figure 130: Location of works

The main pressures on water quality in this river were primarily agricultural and domestic. Agricultural pressures include runoff from adjacent fields due to excessive fertiliser loading, poaching of river banks due to livestock having direct access to the watercourse, siltation of riverbed caused by bank erosion and lack of riparian habitat and tree cover or spread of invasive species (Giant Hogweed and Himalayan Balsam were the two predominant species here). Domestic pressures on the system came almost exclusively from household sewage tanks. If not maintained or emptied regularly, domestic waste could leach into the water either overland or piped directly into the river.

Instream pressures on this stretch of the river were a legacy of the arterial drainage of the Blackwater system in the 1980's and 1990's. This has led to a highly modified channelized river which was prone to silting due to lack of flow diversity.

A wide range of remediation works were completed on this stretch of the Ballygawley River, all aimed at addressing the issues as outlined in the pressures section. Works included the following –

- Installation of sheep proof fencing 3 row of barbed wire plus woven sheep wire) along 230 m of riverbank.
- Installation of livestock fencing (4 row of barbed wire) over 4.6 km of riverbank
- Installation of 12 stiles for access to river for anglers, landowners and other stakeholders such as NIEA staff to facilitate water testing
- Installation of 21 livestock drinkers and associated pipework to provide water for cattle and sheep over 2.2 km of farmland

- Installation of 6 galvanised steel gates to allow access to individual fields
- Removal of 51 trees (Dead Alders) and overhanging branches in the watercourse over 3.2 km
- Planting of 1,500 native tree saplings (2-5 year old). A mix of native hardwood species was planted (Whitethorn, Crab Apple, Downey Birch, Silver Birch, Scots Pine, Spindle, Oak, Blackthorn Cherry, Rowan, Guelder Rose, Hazel, Sycamore, and Horse Chestnut). Tree protectors and stakes were included.

Figure 131: Trees planted

- A range of deep water revetment measures were introduced along 3.2 km of river at 14 sites – these included ‘toe revetment’ using cobbled stone, ‘log walls’ and ‘coir matting’
- In partnership with DEARA Inland Fisheries a range of habitat improvement works were introduced over 3.2 km. These included ‘flow deflectors’, ‘rubble mats’ and ‘plumb stones’.

5.6. Ballygawley Phase Two

The Ballygawley River water quality improvements (Phase 2) works involved installation of fencing, gates, stiles and livestock drinkers, bank stabilisation, planting of native tree species along a 4 km stretch of the Ballygawley River, from the confluence of the Ballygawley river.

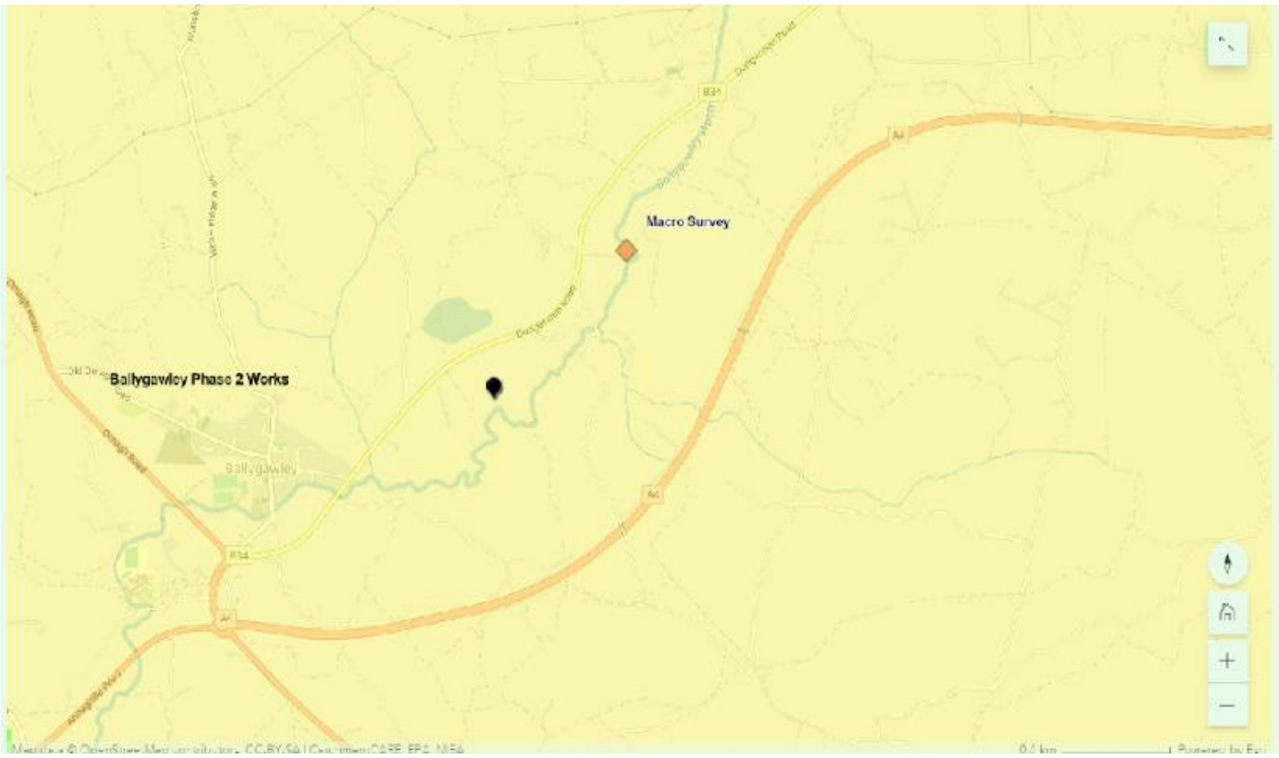

Figure 132: Location of works

The main pressures on water quality in this river were primarily agricultural and domestic. Agricultural pressures include runoff from adjacent fields due to excessive fertiliser loading, poaching of river banks due to livestock having direct access to the watercourse, siltation of riverbed caused by bank erosion and lack of riparian habitat and tree cover or spread of invasive species (Giant Hogweed and Himalayan Balsam were the two predominant species here). Domestic pressures on the system came almost exclusively from household sewage tanks. If not maintained or emptied regularly, domestic waste can leach into the water either overland or piped directly into the river.

Instream pressures on this stretch of the river were a legacy of the arterial drainage of the Blackwater system in the 1980's and 1990's. This has led to a highly modified channelised river which was prone to silting due to lack of flow diversity.

A wide range of remediation works were completed on this stretch of the Ballygawley River, all aimed at addressing the issues as outlined in the pressures section. Works included the following:

- Installation of livestock fencing (4 row of barbed wire) over 4 km of riverbank
- Installation of 1 river crossing (including x4 gates and hangers and posts)
- Installation of 22 stiles for access to river for anglers, landowners and other stakeholders such as NIEA staff to facilitate water testing
- Installation of 20 livestock drinkers and associated pipework to provide water for cattle and sheep over 2.8 km of farmland.
- Removal of 64 trees (Dead Alders) and overhanging branches in the watercourse over 4 km
- Planting of 1,700 native tree saplings (2-5 years old). A mix of native hardwood species was planted (Whitethorn, Crab Apple, Downey Birch, Silver Birch, Scots Pine, Spindle, Oak, Blackthorn Cherry, Rowan, Guelder Rose, Hazel, Sycamore, Horse Chestnut). Tree protectors and stakes were included
- A range of deep water revetment measures were introduced along 1 km of river at 21 sites – these included 'toe revetment' using cobbled stone, 'log walls' and 'coir matting'.

Figure 133: River crossing installed

- A range of habitat improvement instream works were introduced over 4 km. These included 'flow deflectors' and 'rubble mats'.

5.7. Ballygawley Farmers Group

Ballygawley Farmers Group Water Quality Improvements works involved installation of fencing, livestock drinkers and the planting of native tree species. The works took place over 4.1 km in the Townland of Golan outside Ballygawley in Co. Tyrone.

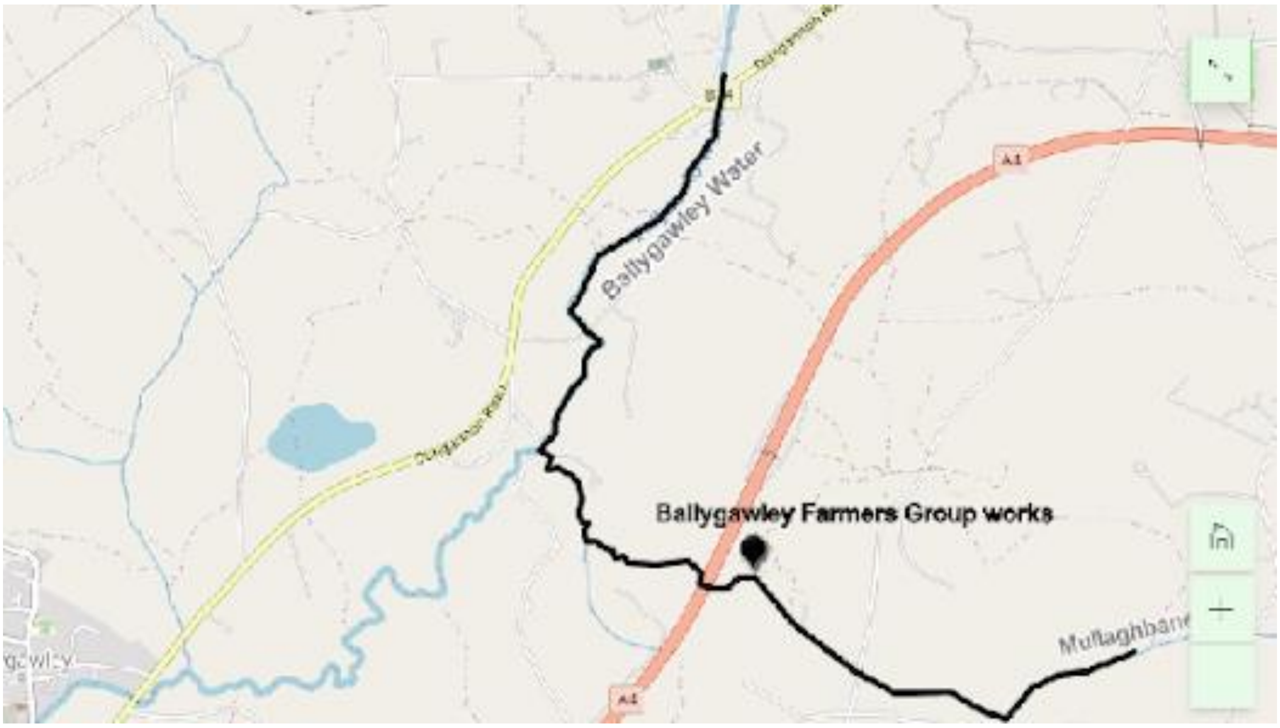

Figure 134: Location of works

The main pressures on water quality at this site were primarily agriculture. These include run off from local fields due to excessive fertiliser loading, poaching of river banks due to livestock having direct access to the watercourse, siltation of riverbed caused by bank erosion and lack of riparian habitat and tree cover. As on most of the Blackwater system, the instream pressures on this stretch of the river were a legacy of the arterial drainage of the Blackwater system in the 1980's and 1990's. This has led to a highly modified channelized river which was prone to silting due to lack of flow diversity.

A wide range of remediation works were completed on this stretch of the Ballygawley River, all aimed at addressing the issues on site. Works included the following:

- Installation of livestock fencing sheep proof fencing (3 rows of barbed wire and sheep proof wire) over 4 km of river bank.

Figure 135: Fencing installed

- Installation of 26 livestock drinkers
- Planting of 4,000 native tree saplings (2-5 years old). A mix of native hardwood species was planted (Whitethorn, Crab Apple, Downey Birch, Silver Birch, Scots Pine, Spindle, Oak, Blackthorn Cherry, Rowan, Guelder Rose, Hazel, Sycamore, and Horse Chestnut). Tree protectors and stakes were included.

Figure 136: Riparian margin implemented

5.8. Beattie's Stream

The Upper Blackwater River works involved installation of fencing, gates, stiles and livestock drinkers, bank stabilisation, and the planting of native tree species. A barrier was also removed and replaced with a bottomless bridge. Instream works were also carried out in partnership with DAERA Inland Fisheries along a 4.5 km stretch of the Blackwater river from the road bridge of the Fintona road to the old mill on the Mill road, Clogher.

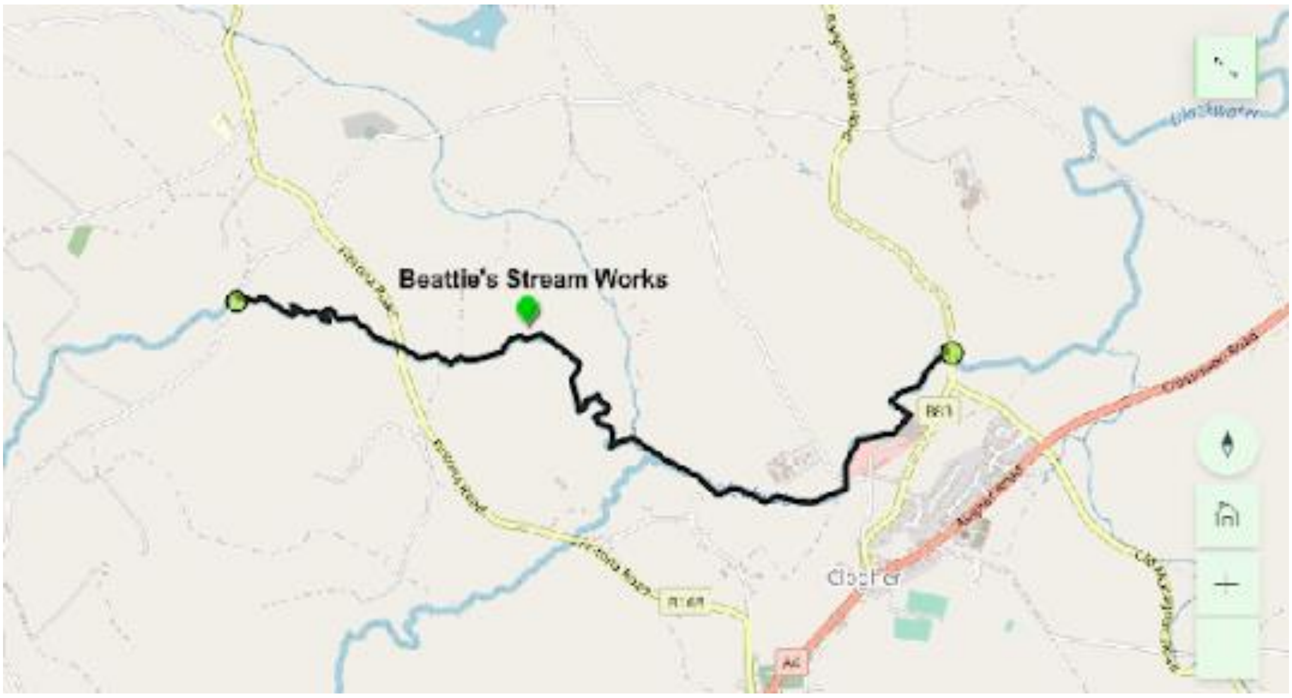

Figure 137: Location of works

The main pressures on water quality at this site were primarily agriculture. These include run off from local fields due to excessive fertiliser loading, poaching of river banks due to livestock having direct access to the watercourse, siltation of riverbed caused by bank erosion and lack of riparian habitat and tree cover or from spread of invasive species (Himalayan Balsam was the only invasive species present). As on most of the Blackwater system, the instream pressures on this stretch of the river were a legacy of the arterial drainage of the Blackwater system in the 1980's and 1990's. This has led to a highly modified channelised river which was prone to silting due to lack of flow diversity.

Figure 138: Lack of riparian margin along stretch

A wide range of remediation works were completed on this stretch of the Blackwater River, all aimed at addressing the issues on the sites. Works included the following –

- Installation of livestock fencing (4 row of barbed wire) over 2.1 km of riverbank
- Installation of 3 stiles for access to river for anglers, landowners and other stakeholders such as NIEA staff to facilitate water testing
- Installation of 3 livestock drinkers and associated pipework to provide water for cattle and sheep over 2.1 km of farmland.

Figure 139: Cattle drinkers installed

- Planting of 300 native tree saplings (2-5 year old). A mix of native hardwood species was planted (Whitethorn, Crab Apple, Downey Birch, Silver Birch, Scots Pine, Spindle, Oak, Blackthorn Cherry, Rowan, Guelder Rose, Hazel, Sycamore, and Horse Chestnut). Tree protectors and stakes were included.

5.9. River Blackwater at Favour Royal

The River Blackwater at Favour Royal Water Quality Improvements works involved installation of electric fencing, steel gates, stiles and the planting of native tree species. The works took place over 2 km on the Blackwater River at Favour Royal, Co. Tyrone.

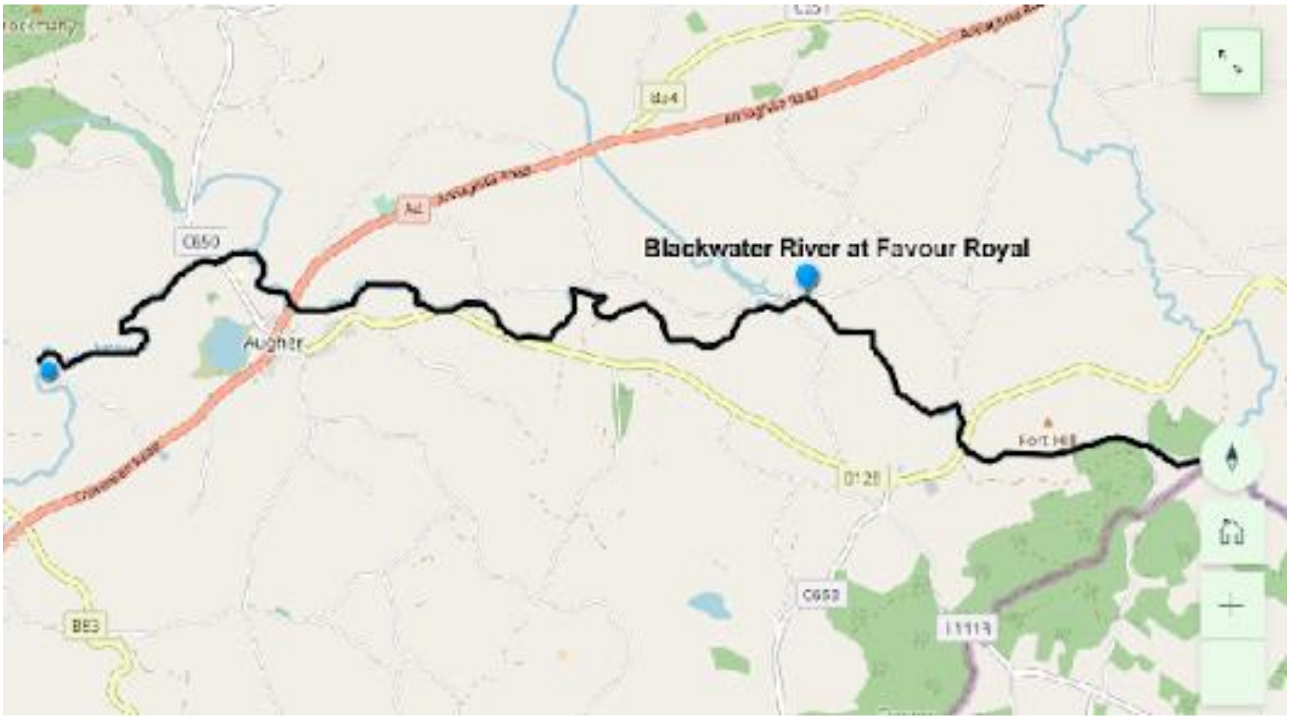

Figure 140: Location of works

The main pressures on water quality at this site were primarily agriculture. These include run off from local fields due to excessive fertiliser loading, poaching of river banks due to livestock having direct access to the watercourse, siltation of riverbed caused by bank erosion and lack of riparian habitat and tree cover or from spread of invasive species (Himalayan Balsam was the only invasive species present).

As on most of the Blackwater system, the instream pressures on this stretch of the river were a legacy of the arterial drainage of the Blackwater system in the 1980’s and 1990’s. This has led to a highly modified channelised river which is prone to silting due to lack of flow diversity.

Figure 141: Lack of fencing allowing cattle to poach banks

A wide range of remediation works was completed on this stretch of the Blackwater River, all aimed at addressing the issues of the site. Works included the following:

- Installation of 12 stiles
- Installation of 2* 14 ft long steel gates
- Installation of livestock electric fencing (2 row of high tension) over 2 km of riverbank
- Planting of x 950 native samplings (Whitethorn, Crab Apple, Downey Birch, Silver Birch, Scots Pine, Spindle, Oak, Blackthorn Cherry, Rowan, Guelder Rose, Hazel, Sycamore, and Horse Chestnut).

Figure 142: Planting and fence implemented

The scheme was funded through Phases 1 of the Community Incentive Scheme. This scheme had been designed to support community engagement, knowledge transfer and capacity building at a local level throughout the three catchments involved. This scheme was designed to support communities to take innovative approaches to looking after and caring for their local river systems including associated lakes through funded project work.

5.10. Callan River

The Callan River Works - Water Quality Improvements involved installation of fencing, stiles and livestock drinkers, bank stabilisation, and the planting of native tree species.
Instream works were also carried out along a 2.7 km stretch of the Callan river from the Milford road bridge to the Killyleagh road bridge in Armagh.

The main pressures on water quality at this site were primarily agriculture. These included run off from local fields due to excessive fertiliser loading, poaching of river banks due to livestock having direct access to the watercourse, siltation of riverbed caused by bank erosion and lack of riparian habitat and tree cover or from spread of invasive species (Himalayan Balsam was the only invasive species present).

As on most of the Blackwater system, the instream pressures on this stretch of the river were a legacy of the arterial drainage of the Blackwater system in the 1980’s and 1990’s. This has led to a highly modified channelized river which is prone to silting due to lack of flow diversity.

Figure 143: eroded river bank caused by cattle poaching

Figure 144: Silage bales stored at waters edge leaching in to watercourse

A wide range of remediation works was completed on this stretch of the Blackwater River, all aimed at addressing the issues at the site. Works included the following:

- Installation of livestock fencing (5 rows of barbed wire) over 2.7 km of riverbank.

Figure 145: Fencing installed to prevent livestock access to river

- Installation of 10 stiles for access to river for anglers, landowners and other stakeholders such as NIEA staff to facilitate water testing
- Planting of 1,500 native tree saplings (2-5 year old). A mix of native hardwood species was planted (Whitethorn, Crab Apple, Downey Birch, Silver Birch, Scots Pine, Spindle, Oak, Blackthorn Cherry, Rowan, Guelder Rose, Hazel, Sycamore, Horse Chestnut). Tree protectors and stakes were included.
- Supply and installation of livestock drinkers x8
- A range of deep water revetment measures were introduced along 430m of river – these included ‘toe revetment’ using cobbled stone, ‘log walls’ and ‘coir matting’

Figure 146: Log wall implemented

- Habitat improvement works were introduced over 2.7 km. These included 'flow deflectors', 'rubble mats' and 'repair to an existing weir'

5.11. Lower Tynan River

Works involved installation of fencing, stiles and livestock drinkers, bank stabilisation, and the planting of native tree species were also carried out along a 1.8 km stretch of the Tynan River outside Caledon, Co.Tyrone.

The main pressures on water quality at this site were primarily agriculture. These included run off from local fields due to excessive fertiliser loading, poaching of river banks due to livestock having direct access to the watercourse, siltation of riverbed caused by bank erosion and lack of riparian habitat and tree cover or from spread of invasive species (Himalayan Balsam was the only invasive species present).

As on most of the Blackwater system, the instream pressures on this stretch of the river were a legacy of the arterial drainage of the Blackwater system in the 1980's and 1990's. This has led to a highly modified channelized river which is prone to silting due to lack of flow diversity.
A wide range of remediation works were completed on this stretch of the Tynan River, all aimed at addressing the issues at each site. Works included the following –

- Installation of livestock fencing (5 rows of barbed wire) over 1.8 km of riverbank.

Figure 147: Fencing to prevent cattle poaching on banks

- Installation of 8 stiles for access to the river for anglers, landowners and other stakeholders such as NIEA staff to facilitate water testing.
- Installation of 5 livestock drinkers and associated pipework to provide water for cattle and sheep over 1.8 km of farmland.
- Installation of 450 m of river bank revetment works.

5.12. Mountain Water Phase One

The Mountain Water Phase 1 Water Quality Improvements works involved installation of fencing, bank stabilisation, livestock drinkers and the planting of native tree species. The works took place over 3.1 km on the Mountain Water, downstream of Emyvale, Co. Monaghan.

Figure 148: Location of banks

The main pressures on water quality at this site were primarily agriculture. These include run off from local fields due to excessive fertiliser loading, poaching of river banks due to livestock having direct access to the watercourse, siltation of riverbed caused by bank erosion and lack of riparian habitat and tree cover or from spread of invasive species (Himalayan Balsam was the only invasive species present).

There were also issues with the localised use of pesticides and herbicides on the land. This led to a build-up of chemicals in local drinking water sources.

A wide range of remediation works were completed on this stretch of the Mountain Water, aimed at addressing the issues as outlined in the pressures section. Works included the following:

- Installation of livestock fencing (4 row of barbed wire) over 2 km of riverbank
- Installation of livestock fencing (2 row of electric fence) over 1.2 km of riverbank.

Figure 149: Electric fencing installed

- Installation of 4 livestock drinkers
- Installation of 120 m of deep-water revetment
- Planting of 1600 native trees

5.13. Mountain Water Phase Two

The Mountain Water Phase 2 Water Quality Improvements works involved installation of fencing, livestock drinkers and the planting of native tree species. The works took place over 1.9 km on the Mountain Water, close to Emyvale, Co. Monaghan.

Figure 150: Phase two location of works

The main pressures on water quality at this site were primarily agriculture. These included run off from local fields due to excessive fertiliser loading, poaching of river banks due to livestock having direct access to the watercourse, siltation of riverbed caused by bank erosion and lack of riparian habitat and tree cover or from spread of invasive species (Himalayan Balsam was the only invasive species present). There were also issues with the localised use of pesticides and herbicides on the land. This led to a build-up of chemicals in local drinking water sources.

A wide range of remediation works were completed on this stretch of the Ballygawley River, aimed at addressing the issues as outlined in the pressures section. Works included the following:

- Installation of livestock fencing (4 row of barbed wire) over 1.8 km of riverbank
- Installation of 2 x 4 gallon livestock drinkers (concrete)

Figure 151: Weed wiping of rushes

As part of the works in this area, CatchmentCARE also funded a local farmer's project through Phases 1 & 2 of the Community Incentive Scheme (CIS). The two projects worked with 80 local farmers in the border region (north and south) aimed to remove / control rushes at selected farms in a way that will help prevent MCPA leaching into local watercourses. An extensive training programme for local farmers was included as well as the development of targeted and detailed farm nutrient management plans for those taking part in the project.

5.14. Emyvale Weir Options Report

During the prioritisation workpackage Emyvale Weir was identified as a barrier to fish migration (Figure x). The weir at Emyvale (Emyvale Weir hereafter) is currently directing a significant proportion of the Mountain Water River to Emy Lough. The diverted water (Emy Lough Channel hereafter) does not return to the Mountain Water river but rather flows directly into the Ulster Blackwater river at Figanny/Ballynahone. This diversion creates a significant impact on hydromorphological conditions in the Mountain Water River downstream of Emyvale as there are insufficient water volumes to sustain natural environmental flow regimes. Environmental flow describes the quantity, quality and timing of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems (Arthington, 2012).

CatchmentCare appointed CDM Smith Ireland Ltd (CDM Smith) to undertake a
hydraulic assessment of current flow arrangements at the Emyvale Weir on the Mountain Water

River in the village of Emyvale in County Monaghan. The report outlines the different options that are available to reduce the impact of the weir on the Mountain Water River. It is hoped that this report will allow other agencies to progress with barrier mitigation at this site in the future. This report is available on request from Inland Fisheries Ireland.

Figure 152. Emyvale weir.

6. PROJECT LEGACY

All restoration projects completed under the CatchmentCARE Project in the Finn, Arney and Blackwater Catchments have a built in legacy element. The sites will continue to be monitored using macroinvertebrate surveys and electrofishing so that any changes in the river fauna can be detected over time. There is a need to be mindful of seasonal changes and natural fluctuations in the rivers which can only be accurately ascertained with continuous monitoring. Many of the mitigations put in place by the CatchmentCARE Project could take years to really meet their full potential in terms of improving water quality. Legacy sampling regimes will help give a clearer understanding of how works undertaken by CatchmentCARE impact the rivers in the long term.

Feature	Number Installed within the Three Cross Border Catchments.
Riparian Margin Creation	**98.9km**
Bank Stabilisation Creation	**80.8km**

Sites Demonstrating Best Practice Techniques to River Restoration	**22**
Instream Habitat Improvement Sites	**130**
Barriers to Fish Migration Removed	**3**
Pinned Woody Material Sites	**28**
Offline Drinking Solutions	**455**

7. CONCLUSION

The CatchmentCARE Project's Habitat Restoration deliverables outlined in T2 of the Project were all successfully delivered and, in most cases, the amount of expected deliverables was exceeded. The table below gives details on what the target of the Project was for each deliverable and also what was delivered in the three catchments.

Table 4: Table showing targets for deliverables and what was carried out

River Restoration Works in Figures		
	CatchmentCARE Target	**Delivered**
Bank Stabilisation	10km	80.8km
Riparian Buffer Zone	10km	98.9km
Number of Sites Demonstrating Best Practice Techniques	3	22
Number of Offline Drinking Solutions Installed for Livestock	500	455
Number of Instream Works Implemented	30	130
Number of Barriers to Fish Migration Removed	No Defined Target	2
Number of Pinned Woody Material Sites	10 sites	28

Although the target of 500 offline drinkers was not reached, it should be noted that the deliverable specifically stated "up to 500 offline drinking solutions" should be installed so the 500 target was not concrete but merely a goal to aspire to.

Loughs Agency, IFI & ABC used the measures proscribed in the CatchmentCARE "toolbox" of habitat protection and restoration techniques to implement the most suitable measures at each site targeted. The techniques in this toolbox were selected at the beginning of the project and selections were based on the latest scientific knowledge and evidence of the efficacy of these techniques in protecting and enhancing river environments and water quality.

Several of the measures implemented allowed early successes to be observed during the lifetime of the project however the full benefits of the works will not be evident for several more years as the riparian zones created will need to become fully established and the instream measures will need time to take effect and be colonised by aquatic flora and fauna.

Ongoing monitoring of the impact of the habitat protection/ restoration measures will be vital to determining the overall success of the measures installed and will need to be carried out for perhaps another decade.

Although the works carried out are a great achievement and will help the targeted areas maintain or improve their ecosystem and water quality health, vigilance in these catchments must still be maintained to ensure that any new threats that emerge are dealt with so that the work carried out is not impacted. Additionally, more works will likely be needed in several areas of the catchment that are hydrologically connected to the work areas, as impacts outside of the work areas can also have a negative impact on the areas targeted.

In short, ongoing management and protection of the Finn, Arney and Blackwater Catchments is necessary and will be into the future as long as there is the threat of potential impacts from human activities adjacent to the waterbodies in question.

The CatchmentCARE Project, and the lessons learned during the Project, are already proving valuable with several government agencies taking lessons from what was achieved and how it was achieved. CatchmentCARE Project Officers have readily shared information and insights from the project by participating on forums such as the Water Framework Directive Forum and have hosted multiple site visits from members of various environmental Government Organisations on fact finding missions.

Loughs Agency have also opted to adopt the procedures learned from the CatchmentCARE Project in to how they carry out their core habitat restoration and protection activities and will be using these going forward.

There is also interest in continuing the work of the CatchmentCARE Project by again applying for additional funding from SEUPB when it becomes available to deliver a Project with similar habitat restoration aspects in other areas that need attention.

Overall, the habitat restoration and protection measures delivered in the three catchments targeted by CatchmentCARE will go a long way to protecting the aquatic environment in these areas although continued monitoring and additional works will be necessary to safeguard and enhance the works carried out.

Lessons learned from the Project will also prove extremely useful to the partners that took part of the works as well as to outside agencies which seek to carry out similar works. These lessons will also be crucial for when another project on the scale of CatchmentCARE is attempted as it will provide a template and jumping off point for any project of that nature.