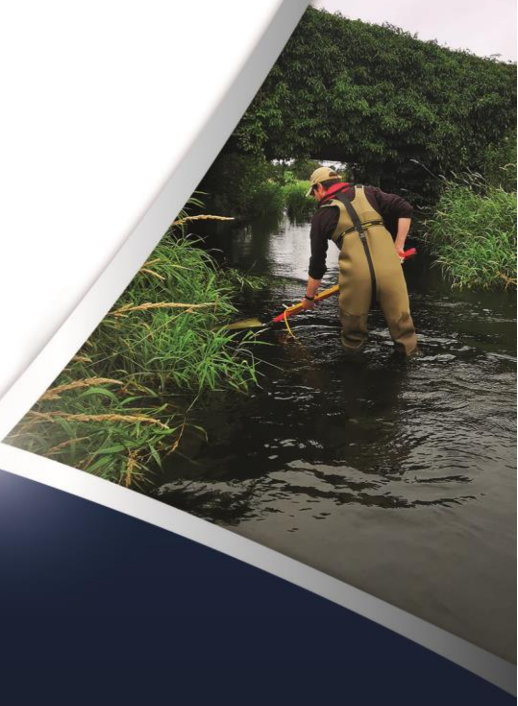
Environmental River Enhancement Programme

Annual Report 2021

IFI/2022/1-4586



Iascach Intíre Éireann
Inland Fisheries Ireland

EREP 2021 Annual Report

Inland Fisheries Ireland & the Office of Public Works

Environmental River Enhancement Programme

Iascach Intíre Éireann
Inland Fisheries Ireland

OPW
Oifig na nOibreacha Poiblí
Office of Public Works

Acknowledgments

The assistance and support of OPW staff from each of the three Arterial Drainage Maintenance Regions is gratefully appreciated, along with the support of the OPW Environment Section. The support provided by regional IFI colleagues in various River Basin Districts and within Research & Development, in respect of site surveys is also acknowledged. Overland access to waterways was kindly provided by landowners in a range of channels across the country.

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Executive Summary

A catchment-wide survey was conducted in the Kells Blackwater catchment, part of the Boyne arterial drainage scheme managed by the Office of Public Works (OPW). The river rises in county Cavan and flows in a south-easterly direction towards Navan, Co. Meath where it meets the main River Boyne. Lough Ramor, adjacent to the town of Virginia, is a significant waterbody along the course of the river. The OPW scheme within the Blackwater comprises over half the total length of channel within the entire catchment area and the majority of these channels are located in low-lying areas below the lake.

23 sites throughout the catchment were electrofished and environmental parameters gathered. This data was modelled into Ecological Quality Ratios to determine the status of fish populations at those sites. Just 22% of sites passed the minimum WFD requirement of Good status, with the majority (61%) of sites classified as Moderate and the remaining 17% as Poor. Using the River Hydromorphology Assessment Technique to categorise sites on the basis of hydromorphology and habitat parameters, 26 sites were surveyed within and outside the OPW scheme. 46% achieved the minimum WFD requirement of Good status. Another 46% were classified as Moderate and finally just 8% were Poor. In the analysis of only those sites on the OPW scheme, just 23% achieved Good status. As part of the hydromorphological investigations, longitudinal connectivity in the catchment was assessed using IFI's Barrier Assessment and Screening Tool. There were 1,193 potential barriers identified during the survey and 93% of these were assessed. Of those surveyed to date, 47 (4.6%) were surveyed as barriers to fish passage, comprising 25 bridge aprons/culverts, 17 weirs, 2 fords and 3 sluices. Longitudinal connectivity is severely impacted on the main channels within the catchment, especially the Kells Blackwater itself. There are currently at least 10 major weirs intact, and detailed passabililty assessments were completed on 8 of these structures, with the majority being impassable or high impact barriers for salmonids and lamprey. This may help to explain the poorer than expected electrofishing results observed.

Further barrier assessment and screening was completed in other OPW schemes including the Broadmeadow and Ward, as well as detailed barrier surveys on the Brosna. Of 637 potential barriers identified within the Broadmeadow and Ward catchment, just 21 (4.3%) of those surveyed to date pose problems for fish passage comprising 10 weirs and 11 bridge aprons/culverts. Detailed fish passabililty assessments were completed on the main stem of the River Brosna outlining the significant fish passage issues therein. Recommendations were made as regards priorities for mitigation.

A return visit to a long-term study site on the River Dee where Capital Works were completed in 2009 revealed issues identified with bank erosion and instream cattle access had been mitigated through fencing and bank protection measures. Hard reinforcements had re-naturalised, and succession of fringing vegetation is ongoing at the site. Overall hydromorphological conditions have improved through the measures, but recommendations for tree planting in the riparian zone lend potential for further gains. Collaborations between IFI and the OPW are highlighted in the final section of the report including visual evidence of successful maintenance strategies in the Duff scheme and an overview of recent monitoring in the River Cor (Blackwater scheme) by the IFI Catchment CARE team.

The work completed within the current cycle of the EREP over the years 2018 to 2021 shows the importance of evaluating these OPW catchments in terms of complying with the WFD status. The pressures highlighted within designated catchments provide the evidence for implementing restoration measures to directly target these areas by OPW or by the IFI projects office through Salmon Conservation funding.

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1 Introduction

The year 2021 was the penultimate in the current five-year EREP agreement between the Office of Public Works (OPW) and Inland Fisheries Ireland (IFI). It marked the second year of ongoing adaptions to the project plan due to the Covid-19 pandemic, with the priority being to keep personnel on the project in line with safe systems of work. The majority of the 2021 field season focussed on the Kells Blackwater catchment-wide survey. Data on fish and hydromorphology was collected in line with Water Framework Directive methodologies, adding to the growing dataset on these topics provided annually to OPW. Data on longitudinal connectivity – a key topic within hydromorphology – was added to, with further barrier assessment and screening taking places within various OPW catchments nationally. In addition to the Kells Blackwater surveys, assessments were completed in the Broadmeadow and Ward, as well as the Brosna schemes, in collaboration with other IFI teams within Research and Development including the National Barrier Programme and Eel Monitoring Programme. Long-term monitoring of an historical Capital Works site on the River Dee was completed. Sites in other OPW schemes were re-visited where walkovers had taken place, with the Duff example highlighted herein along with an ongoing Catchment CARE study.

Collaboration with IFI colleagues and counterparts in OPW is key to the success of the EREP. Knowledge sharing and transfer is part of the ongoing best practice among the IFI and OPW teams. Training was facilitated on the RHAT methodology by the EREP team with the OPW Environment Section and colleagues within Research and Development (R&D), with each day tailored specifically to the requirements of that group. Specific training was delivered by the EREP team and other R&D colleagues on a remote training day to OPW Arterial Drainage Maintenance staff in November of 2021.

2 Kells Blackwater Catchment-wide Survey Programme

The Kells Blackwater is one of the main watershed areas within the Boyne catchment, in the east of the country (Figure 2.1). The Boyne has significant historical and archaeological connotations. Moreover, it is an important fisheries catchment and is a designated Special Area of Conservation for Salmon and River Lamprey.

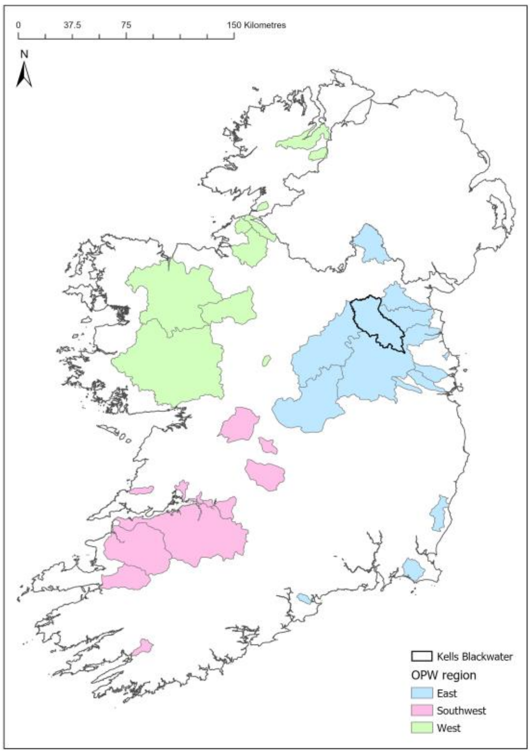


Figure 2.1 Location of the Kells Blackwater within the OPW drainage schemes.

The Blackwater comprises 726km^2 of catchment area, approximately one quarter of the entire Boyne Catchment. The river rises in the glacial drumlins around Bailieborough in county Cavan (Figure 2.2). The Moynalty river (C1/8/10) flows from Bailieborough in both south and easterly directions to the towns of Moynalty and Carlanstown. The main Blackwater channel (C1/8) flows in a south-westerly direction, and then south towards Virginia, before it enters Lough Ramor. It flows in a south-easterly direction towards Carnaross and Kells and shortly after meets with the Moynalty river (also called the Owenroe river). The Blackwater then discharges into the main River Boyne (C1) at Navan. The northern hills within the catchment are dominated by pasture, and tillage becomes more prevalent in the low-lying parts to the southeast of the catchment.

The Blackwater was dredged by the Office of Public Works as part of the Boyne arterial drainage scheme which was completed between 1969-86, generating over 48,000 hectares of benefitting land (Ryan Hanley 2014b). The OPW scheme within the Blackwater covers about 379km of channel length, over half the total length of channel within the catchment area. As can be seen in Figure 2.4 many of the upper tributaries north of Lough Ramor are unaffected by the drainage works. In the lower parts of the catchment, the effects of drainage are still evident with some of the channels deeply entrenched in bedrock (Figure 2.3).

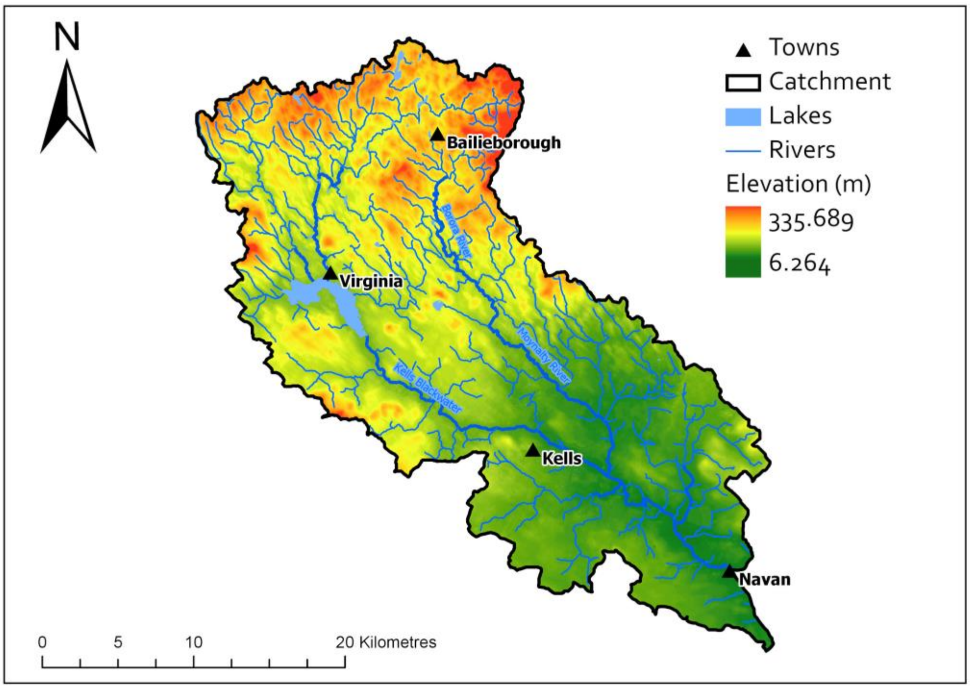


Figure 2.2 Geography of the Kells Blackwater catchment showing major tributaries, towns and elevation.

Figure 2.3 Example of an entrenched site on the Moynalty River (C1/8/10).

2.1 Fish Population Index

The Kells Blackwater catchment was surveyed between July and September 2021. A total of 23 sites were sampled to determine fish density, distribution, and population structure (Figure 2.4). Each fishing site was also assessed to identify hydromorphological pressures.

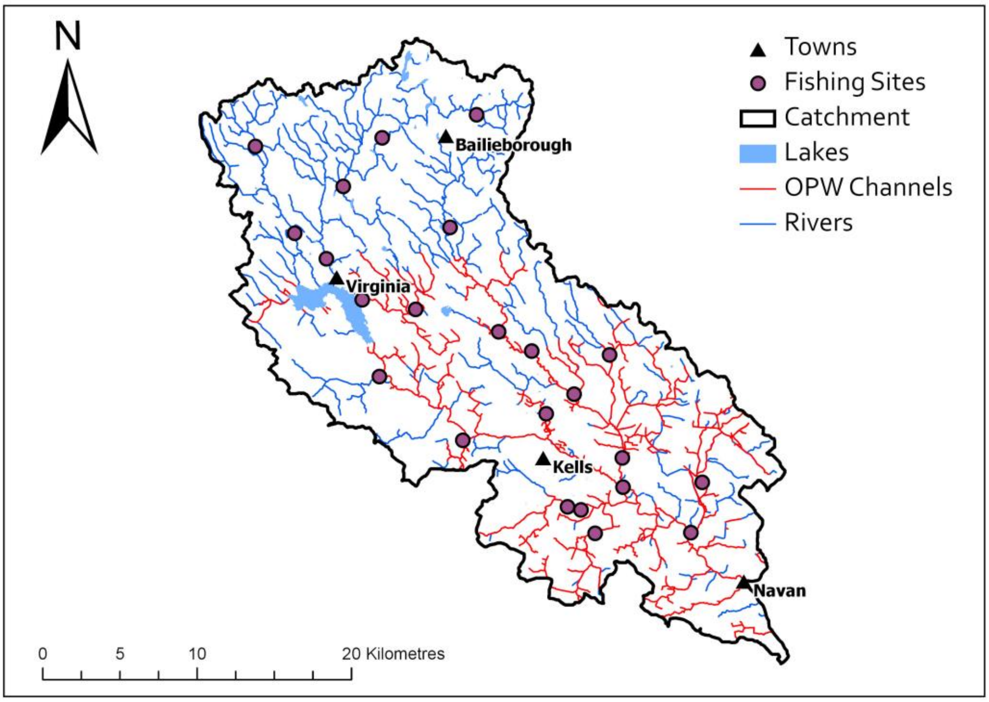


Figure 2.4 Electrofishing sites surveyed (n= 23).

All survey sites were fished using a bank-based 10-minute electrofishing method. All fishing sites averaged at 27 metres in length and 4.5 metres in wetted width. All sites fished were wadeable with depths no greater than 0.6 metres recorded. A total of 529 fish were caught, measured, and returned during the fishing survey. Brown trout was the most abundant species (n=235) following by minnow (n=105) and stoneloach (n=75) (Figure 2.5).

Trout were present at 22 of the 23 survey sites (96%). They were the most abundant species at many of the sites. The 1 site where trout was not captured was located on the Lislea River (C1/8/23). Salmon were present at 26% of the sites (n=6) and were captured in the lower end of the catchment in sites located on the Moynalty River (C1/8/10) and it's tributary (C1/8/10/12), Laurencetown (C1/8/15), Kilaconin (C1/8/17) and the Yellow River (C1/8/5) (Figure 2.6).

Crayfish and lamprey were present only at two sites. Crayfish were recorded at a site in the upper section of the Kells Blackwater and in a minor tributary (C1/8/10/12). Lamprey were present in the Laurencetown (C1/8/15) and Yellow River (C1/8/5). In stating this, it is not possible to conclude that both species were not present in any of the other channels surveyed.

The 10-minute bank-based fishing method practiced by the EREP team is not the optimal approach for capturing these rare and cryptic species, but it is the most favourable method used when targeting a multi-species population.

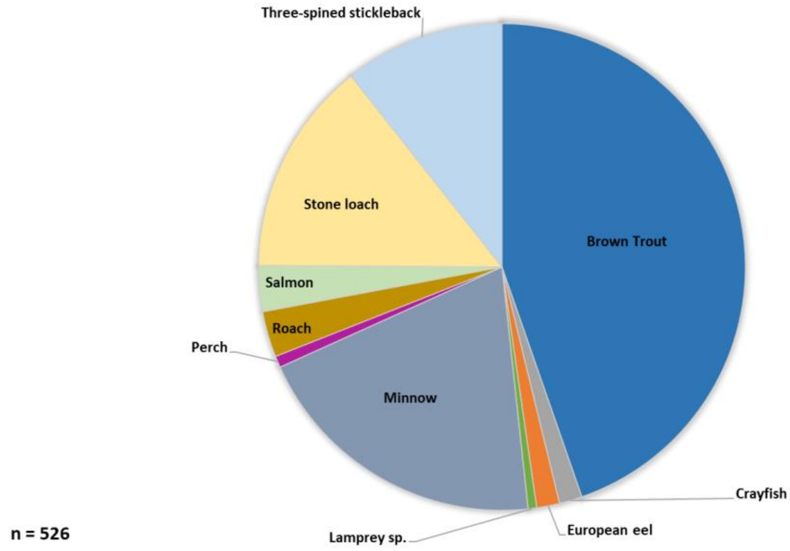


Figure 2.5 Composition of fish species captured during the electrofishing survey.

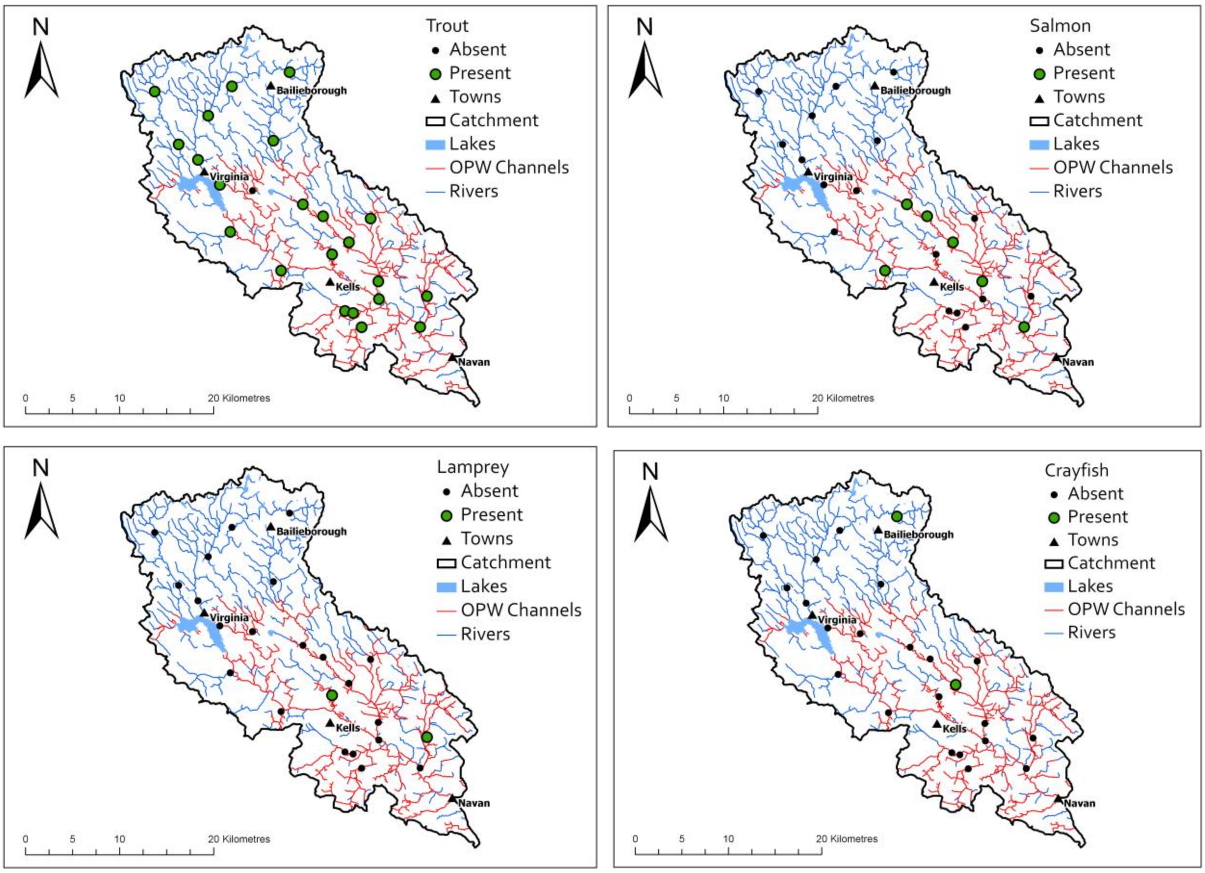


Figure 2.6 Presence/absence of trout, salmon, lamprey and crayfish.

Brown trout captured ranged from 4-32 centimetres in length (Figure 2.7). The first and largest modal peak consisted of fish measuring 4-11cm and these were classified as 0+ fish. The next modal group 12-20cm inclusive were categorised as 1+ fish and those greater than 21cm classed as 2+. Numbers of 1+ fish were relatively lower than 0+ age class but more abundant than 2+ and older fish.

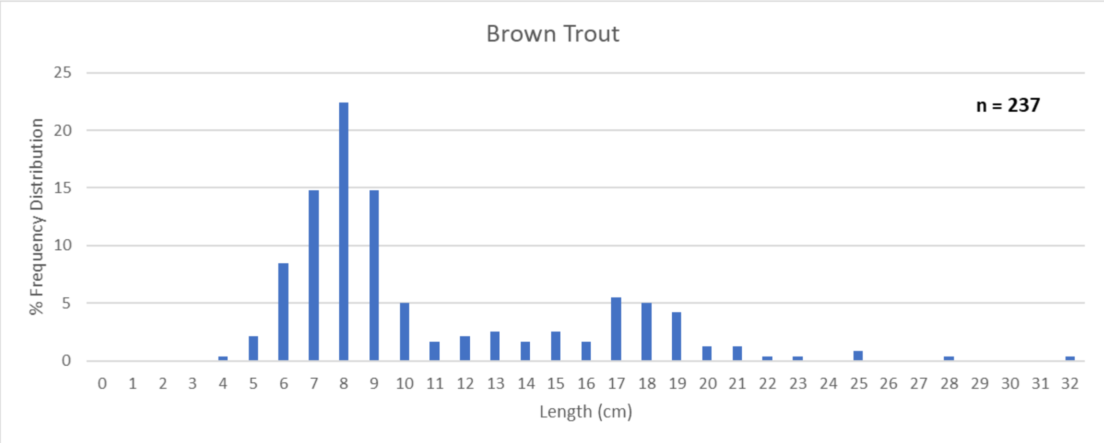


Figure 2.7 Percentage length frequency distribution of brown trout captured using the bank-based electrofishing survey.

Salmon was recorded in lower numbers (n=16) and predominantly 1+ salmon ranging from 11-15cm (Figure 2.8). Low numbers of 0+ salmon (n=3) were recorded throughout the catchment wide survey.

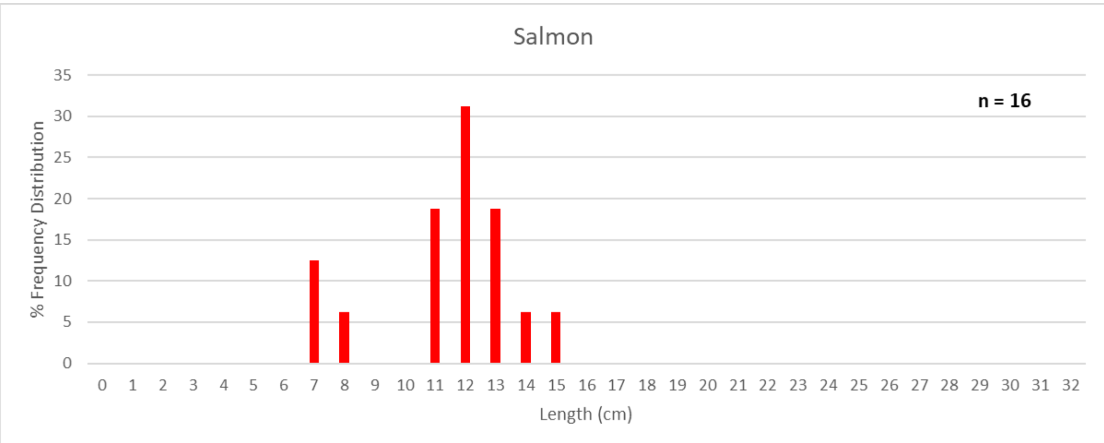


Figure 2.8 Percentage length frequency distribution of Salmon captured by bank-based electrofishing from the Kells Blackwater Catchment wide Survey in 2021.

Capturing high numbers of 0+ salmonids are an indication of recruitment within the catchment. Sites fished using the bank based 10-minute electrofishing method tend to be no greater than 0.5m deep which are optimal depths for residing and nursery areas for juvenile trout.

2.1.1 Ecological Quality Ratio (EQR)

Presence and absence of salmonids influence the EQR scores given to a water body. When calculating an EQR score for any waterbody salmonids are scored by presence and abundance of both age classes (0+ and 1+ fish). This plays a significant role in the model output. If both 0+ and 1+ salmon/trout are recorded during the fishing survey the waterbody will achieve a higher EQR score, whereas if only one age class was present the riverine system would achieve a lower EQR score. Presence of both classes of salmonids at a given site is an indication of recruitment within the riverine system.

Fish EQR scores were generated for each fishing site (n=23, Figure 2.9). 61% of sites fished were classified with a Moderate score and 17% of sites scored Poor Status. Only 22% of sites (n=5) passed the WFD requirement of a Good EQR result.

Reporting on brown trout only, 4 of the 5 sites classified with a Good EQR status had both age classes present. Of the sites scored as Moderate status 63% had both classes present with the remaining 37% have 1 class of trout present. Sites scored with a Poor score had one site including two age classes and 3 sites containing only one age class present in low abundance (<10). Salmon influences EQR scores in a similar way as brown trout presence. The EQR scoring system also accounts for the diversity of species present in a waterbody - including lamprey, crayfish, stoneloach, stickleback, minnow and others along with 0+ and 1+ salmonids.

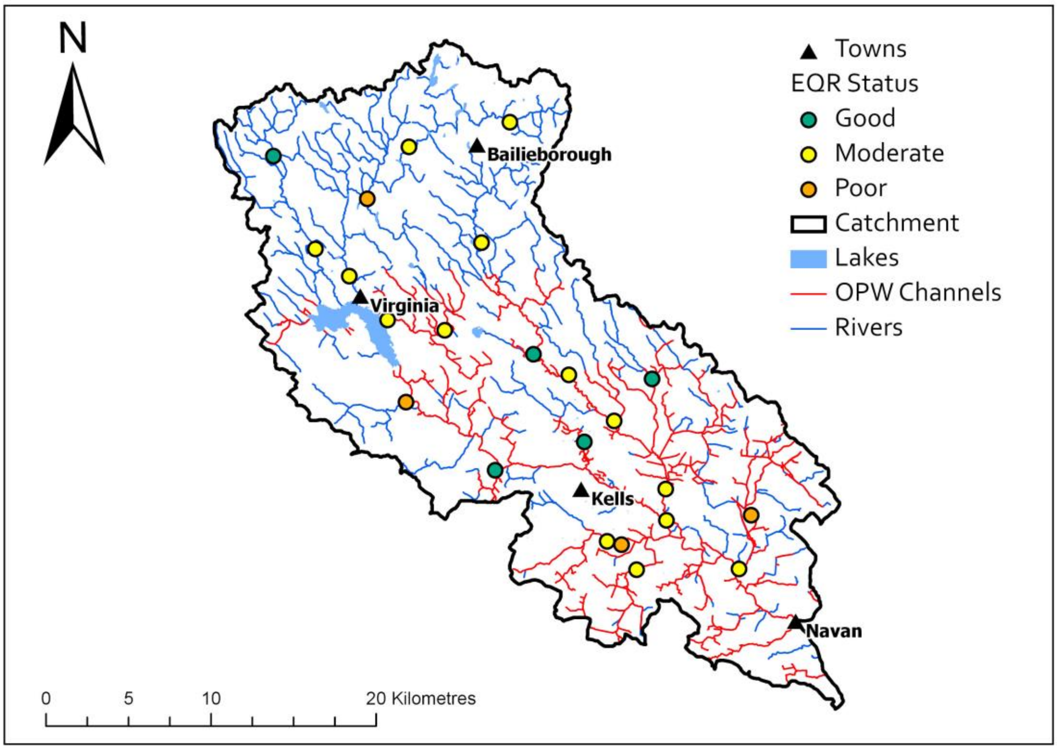


Figure 2.9 Fishing locations with EQR scores (n=23).

2.2 Further catchment context

A report published in 2021 focusing on the status of Irish Salmon stocks advised that rivers within the Boyne catchment are below conservation limits (CL) (Gargan *et al*., 2021). These rivers were advised to open on a catch and release basis on meeting the CL threshold following a catchment wide electrofishing survey recording ≥15 salmon fry per 5-minute fishing on average. This specific survey within the Boyne Catchment was undertaken by regional IFI staff. As the Kells Blackwater is a sub-catchment of the Boyne catchment some sites of interest on the main stem were fished.

Data shared with the EREP team by IFI regional staff give an insight into the productivity of the main channel. In 2020, four index sites (Figure 2.10) on the main stem were fished using a 5-minute electrofishing method to determine recruitment in areas with suitable habitat.

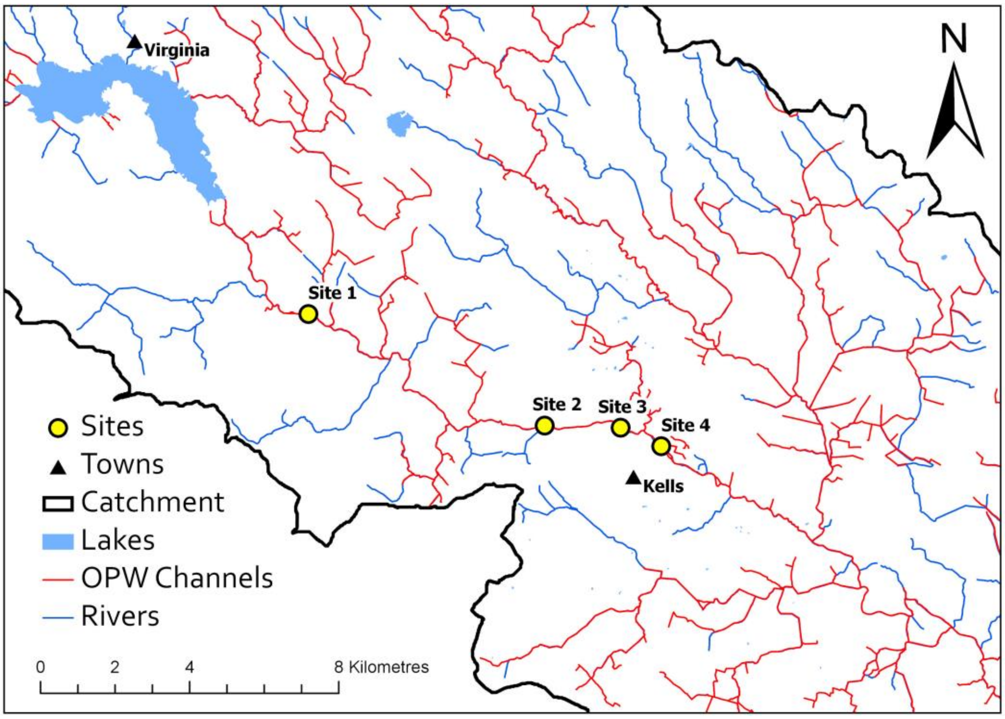


Figure 2.10 Site locations on the main Kells Blackwater fished using a 5-minute electrofishing method in 2020.

Listed in order of abundance, species composition within the 4 sites comprised salmon fry, trout fry, stoneloach, minnow, salmon parr, eel, stickleback and trout parr (Figure 2.11). For each site fished, similar age classes were captured, typically salmon and trout fry. Some salmon (n=12) and trout parr (n=4) were recorded, but in relatively low numbers. Salmon was the most abundant species at each of the 4 sites. The 5-minute electrofishing method focusses on shallows and riffles, habitat typically utilised by juveniles. Capturing these large numbers of salmon fry is an indication of recruitment and spawning in this river channel.

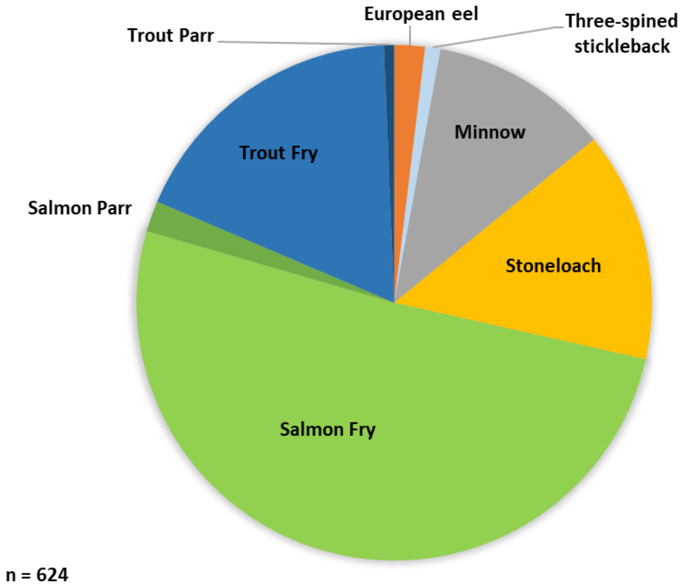


Figure 2.11 Composition of fish species captured during 5-min electrofishing on the main stem of the Kells Blackwater.

This data provides information on fish status for the main stem of the Kells Blackwater in 2020, which supplements the data reported thus far. During the 2021 survey, the main stem was not surveyed by the EREP team due to restrictions and water levels. Distribution of salmonids within the Kells Blackwater catchment is related to recruitment and movement within the main stem. Despite our results showing limited salmon numbers, these 5-minute results obtained at targeted habitat shows the distribution is more widespread than the 2021 results indicate. All the electrofishing results should be taken in the context of the CL within the Boyne, as this dataset is standardised and modelled nationally.

2.3 River Hydromorphological Assessment Technique

Hydromorphology is an important component of catchment-wide surveys in OPW catchments. The Kells Blackwater catchment was surveyed using the River Hydromorphological Assessment Technique (RHAT) methodology of Murphy and Toland (2014). The RHAT methodology records field observations at 50 metre intervals over a 500 metre walkover. The observations made using this visual assessment method are related to the continuity and morphological conditions of the stretch. Although it is a qualitative survey methodology, efforts were made to standardise the results by completing surveys at all sites with similar water levels and at the same time of the year.

In 2021, the method was implemented for the first time in IFI using a digital interface specifically developed by the EREP team. Using the web-mapping application Survey123 for ArcGIS, the RHAT survey paper interface was replicated in a digital format (Figure 2.12) with the ability to include geo-located photos of every spot observation recorded along the reach. This method of recording saves RHAT data directly to the cloud, reducing the data processing time required.

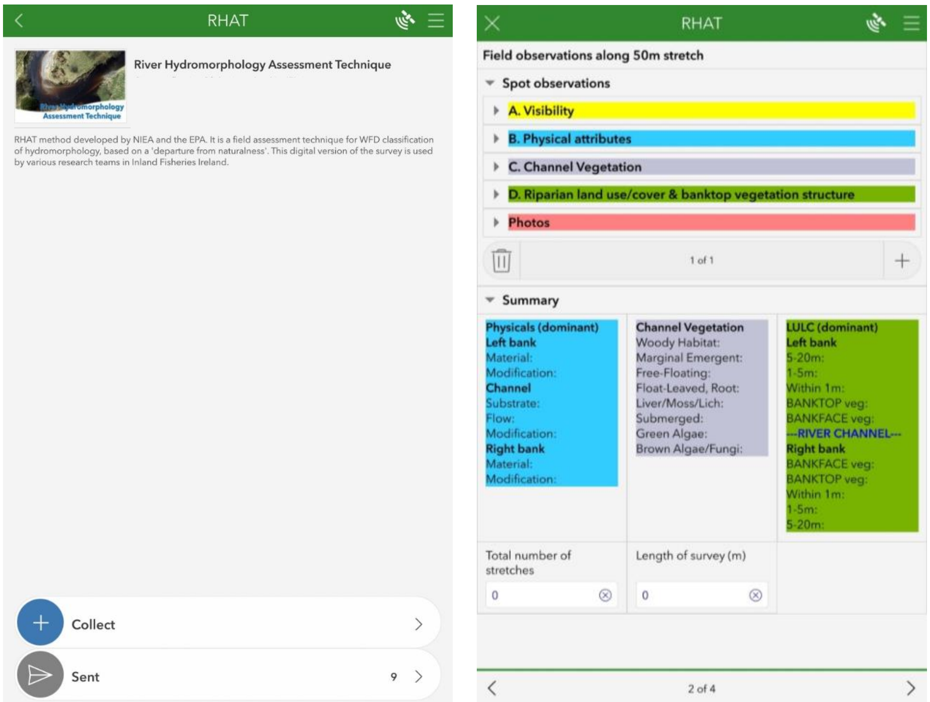


Figure 2.12 RHAT form interface on Survey123.

2.3.1 Results

In total, 26 sites were surveyed using the RHAT methodology in the Kells Blackwater (Figure 2.13). 20 of these sites were located on OPW channels, with just 6 sites located on channels outside the scheme. The map shows the WFD classes derived from summary scores using the RHAT methodology. When considering all sites, 46% (n=12) achieved the minimum WFD requirement of Good status. The remaining sites were classified as Moderate (46%, n=12) and Poor (8%, n=2). In the analysis of those sites on the OPW scheme, just 23% (n=6) achieved Good status. All of the Moderate and Poor sites within the entire catchment area were on OPW scheme channels.

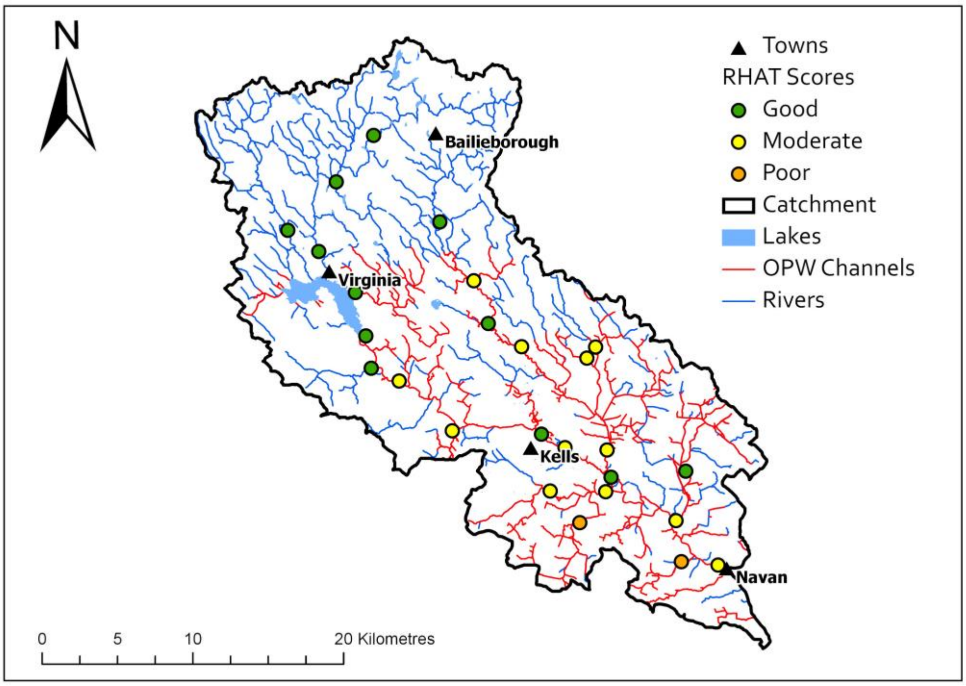


Figure 2.13 RHAT scores for sites surveyed in the Kells Blackwater (n=26).

When all the RHAT scores are averaged, it can be seen that they range from 1.48-2.73 (Figure 2.14). Of the averaged attributes, riparian land use and floodplain connectivity scored lower, along with substrate condition. Barriers to continuity and bank structure and stability on average score higher within the catchment. A cursory comparison to previous RHAT results in OPW catchments (Fleming *et al.,* 2020, 2021) indicates a similar trend in lowest average scores.

The data can be sub-divided into OPW and non-OPW channels (Figure 2.15). Average scores for substrate condition as well as bank vegetation are slightly higher for OPW channels. The other 6 attributes score lower in OPW channels, particularly floodplain connectivity; channel form and flow; as well as bank structure and stability. The latter two components can be affected by river management activities such as arterial drainage maintenance. There may be scope to improve these attributes by effectively using the measures outlined in the OPW guidance booklet (Brew and Gilligan, 2019).

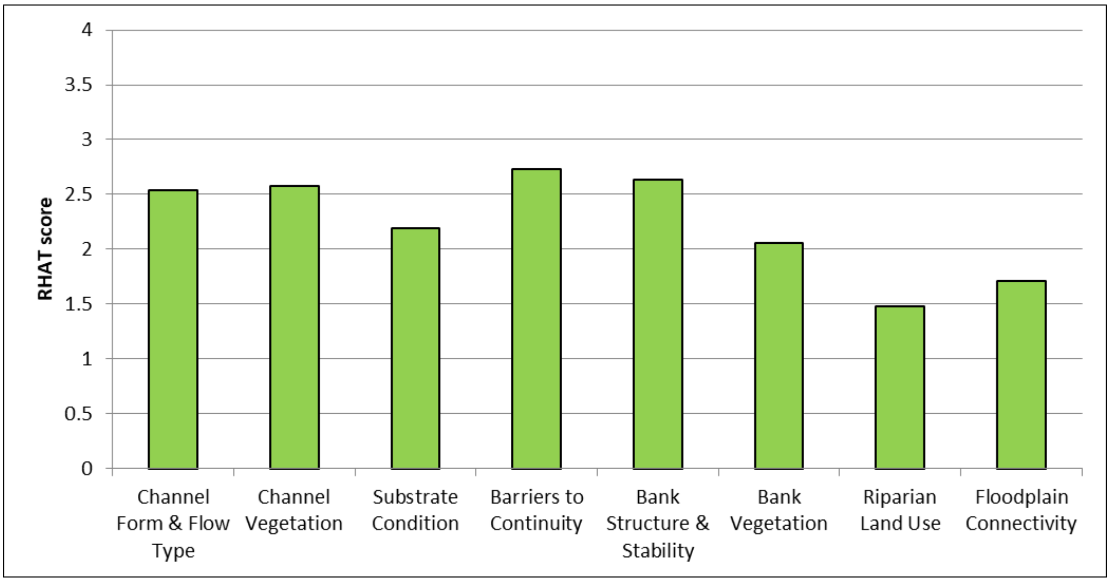


Figure 2.14 Mean RHAT scores for all sites in the Kells Blackwater (n=26).

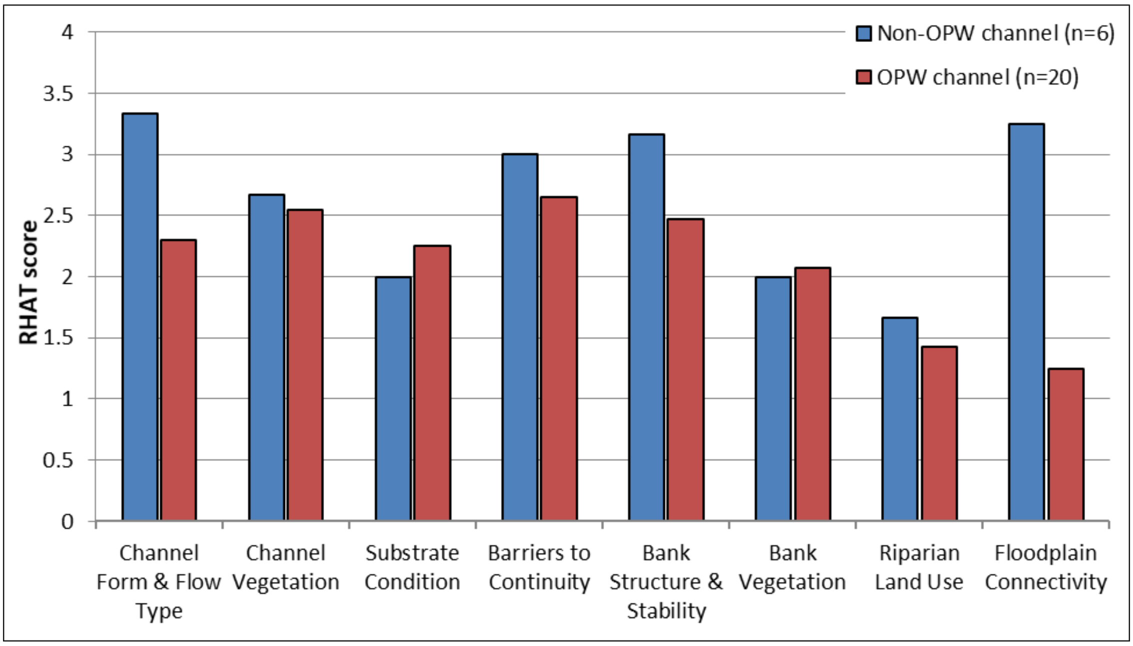


Figure 2.15 Mean RHAT scores for non-OPW (n=6) and OPW (n=20) sites.

2.3.2 Case studies

What follows below are some examples of sites scored using the RHAT in OPW scheme channels within the Kells Blackwater.

The first example is a site on a small tributary (C1/8/5) off the main Blackwater channel, upstream of the Boyne confluence (Figure 2.16). On the day of the survey, it was classed as Moderate. Good channel form and flows were present, with berm development and soft engineered banks in places along with some diversity in marginal instream vegetation. However this was negated by a high level of algal growth due to nutrient input, poaching by cattle de-stabilising the banks, excessive silt in the channel and minimal vegetation in the riparian corridor.

Figure 2.16 Example of soft engineering (left) and poaching (right) on channel C1/8/5 (Moderate status).

Upstream of this site, the channel changes to a modified and straightened tributary. Another site was surveyed with RHAT and was classified as Good status (Figure 2.17, left). Although straightened, it has been enhanced for fisheries through the implementation of artificial deflectors, creating good diversity in form and flow within confined banks. The instream vegetation and substrate were both diverse and favourable habitat. Despite agricultural practices occurring to the bank top, there was limited cattle access to the channel resulting in good bank stability. Overall it was a marginal Good status stream.

The next site is on another straightened tributary (C1/8/1) discharging into the main Blackwater (Figure 2.17, right). The site has been extensively over-deepened, resulting in minimal variation in channel velocities and depths. The substrate is good in places for the river type but there is excessive silt on it. The banks are now re-naturalising, and simple native vegetation is in succession. There is no floodplain connectivity due to the re-sectioning. Overall the site was classified as Poor.

Figure 2.17 Artificial deflectors (left) creating good flows in a straightened part of the river channel C1/8/5 (Good status). Picture shows excessive silt on substrate (right), extensive over-deepening of the channel and simple native bank vegetation colonising the banks in channel C1/8/1 (Poor status).

Another site which displayed issues with hydromorphology was on a larger tributary within the scheme (C1/8/9) which fared Poor. The banks have been excessively over-deepened at this location resulting in a lack of connectivity between the channel and floodplain. There was poaching at various points along the reach, and the scale of these cattle drinkers was quite extensive (Figure 2.18). The flows in this channel were not perceptible, and the substrate not visible due to the high levels of turbidity in the water. Overall, there was a good range of riparian cover, although this is not immediately visible in the photos below.

Figure 2.18 Cattle poaching and high turbidity within the channel C1/8/9 (Poor status).

On the main stem of the Barora River (C1/8/10), just upstream of the Moynalty confluence, the site was surveyed and yielded an overall Good result despite the extensive over-deepening and over-widening (Figure 2.19). The historic re-sectioning has renaturalised along the bank profiles and the site has good riparian habitat and cover. There was diversity in velocities and depths, with a variety of instream vegetation and woody habitat present. The substrate is also free from siltation and favourable for fish. This is supported by the electrofishing results at the site, with a wide variety of species recorded, of various age classes.

Figure 2.19 Riffle habitat and riparian cover, instream vegetation on channel C1/8/10 (Good status).

2.4 Barrier Screening and Assessment

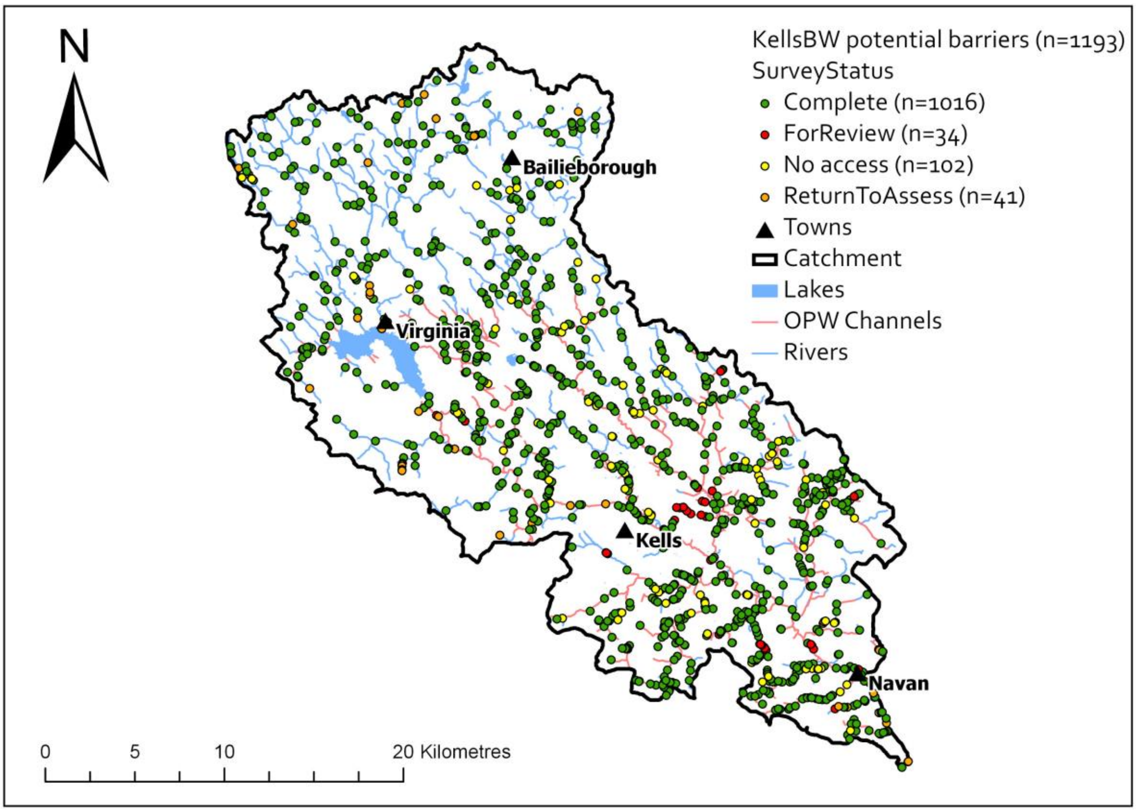
2.4.1 I-BAST surveys

Initial barrier assessments were completed in parts of the Kells Blackwater catchment in 2017-18. The IFI assessment for barrier surveying was used as part of various work packages of the EPA-funded ReConnect project, and surveys carried out in the Moynalty sub-catchment area are relevant to this discussion (Atkinson *et al.*, 2020). While working in the area in 2020, IFI colleagues in the Eel Monitoring Programme had expanded the geographical spread throughout the Kells Blackwater catchment doing preliminary barrier assessments using the revamped Barrier Assessment and Screening Tool (i-BAST) developed by IFI's National Barrier Programme. Moreover, sections of the catchment were subsequently assessed by ERBD staff using the i-BAST methodology.

These efforts were built upon by the EREP team during the 2021 field season, with numerous barriers identified by the previous two IFI teams needing surveying by a two-person team. The aim of the 2021 survey was to compete the entire catchment area, which has a considerable density of potential barriers. There were 1,193 potential barriers in total identified during the survey. To date, 1,016 were visited and assessed, with 102 further structures not able to be assessed due to issues of access or safety. In total, just 75 remain to be visited and assessed within the catchment (Figure 2.20). A total of 47 potential barriers to fish passage are identified and measured in the Kells Blackwater catchment (Table 2.1, Figure 2.20).

Table 2.1 Barriers identified and assessed in the Kells Blackwater survey

Structure type	Number
Culvert / bridge apron	25
Weir	17
Ford	2
Sluice	3
Total	**47**



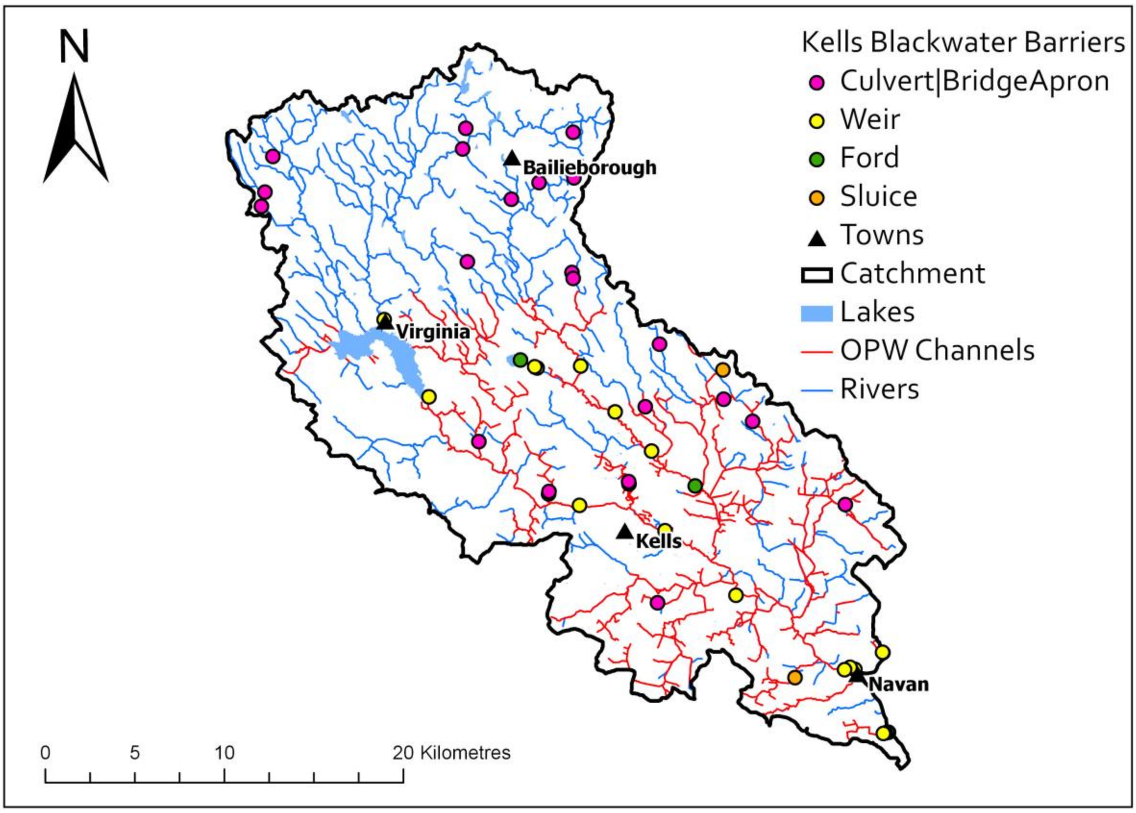


Figure 2.20 Distribution of all potential barriers within the Kells Blackwater (top, n=1193). Barriers assessed and surveyed to date (bottom, n=47).

Out of the total of 1,016 visited and assessed, approximately 4.6% (n=47) barriers to fish migration were identified. Given that 75 potential structures remain, this proportion may change and indeed is likely to increase. As many as 40 of the remaining 75 structures are likely to be barriers. These structures were visually assessed remotely or in the field by one person and need to be visited and measured by a two-person team. Within the currently assessed cohort of 47 barriers, 13 coincide with the OPW structures database. These include bridge aprons/culverts (n=9), weirs (n=2) and sluices (n=2). Using the recently published OPW guidance for fish passage on small barriers (OPW, 2021), it may be possible to mitigate these types of structures in future. Examples of some of the smaller barriers identified on OPW channels are included below (Figure 2.21).

Figure 2.21 Small gauging weir (top left, C1/8/10); two-eye bridge with drop (top right, C1/8/15); culvert with apron and drop (bottom left, C1/8/16); perched culvert (bottom right, C1/8/19).

2.4.2 SNIFFER surveys

Larger barriers or those structures proposed for mitigation are surveyed by IFI staff trained in the WFD111 methodology developed by SNIFFER (Scotland and Northern Ireland Forum for Environmental Research, 2010). Surveyors assess each structure, dividing it into transects with similar hydraulic properties. Depending on the type of transect, various measurements of same are taken including hydraulic head height and dimensions. Flow is measured across each transect at the inlet, mid-point and outlet. Each transect is assessed for fish passability for a range of target species, and subsequently the structure is assigned an overall passability ranking. The National Barrier Programme aimed to complete SNIFFER surveys on all large structures in the Boyne catchment, including those presented here on the Kells Blackwater (Figure 2.22).

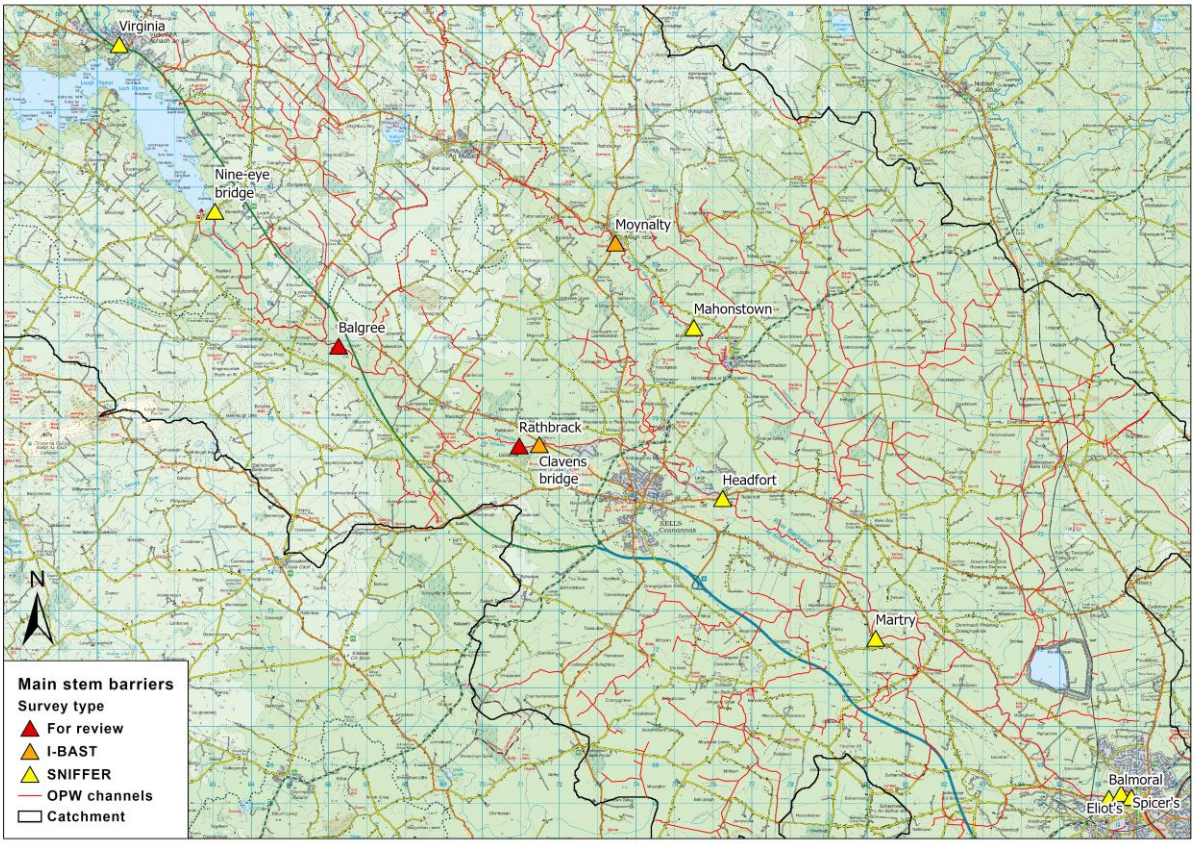


Figure 2.22 Large barriers on the main Blackwater and Moynalty channels.

Navan was a prominent trading and industrial centre in the late eighteenth century. Mills with weirs alongside to power them are a prominent feature of the lower Blackwater landscape. Three weirs are still intact within the first kilometre up from the Boyne confluence. Many more exist on the main channel of the Blackwater up to Lough Ramor and beyond, as well as on the Moynalty River. The weirs which are still in existence today pose problems for longitudinal connectivity of the river channel, as well as for fish migration. Anadromous fish species are particularly affected as they attempt to move upstream to spawn, completing their life cycle.

Lower Blackwater surveys

Elliot's Saw Mill weir is the first on the Blackwater, just 400 metres upstream of the Boyne confluence. It has 4 transversals comprising 1 stepped section, 2 slopes and 1 vertical drop (Figure 2.23). It is marked on the first Ordnance Survey (OS) 6 inch maps so pre-dates 1835. It has almost 1.2 metre of an hydraulic head differential with the river channel. The steep slope along with the shallow water depth over the face of the weir and the lip at the crest of the structure are the main issues. On the day of the survey, it was deemed a High Impact Partial Barrier for adult salmon and trout, and a Complete Barrier to most of the species considered in the survey (lamprey, cyprinids and juvenile salmonids). It was No Barrier to juvenile eels due to the presence of a climbing substrate on the weir surface.

The Spicers Mill (or Blackwater Mill) weir is in a state of disrepair (Figure 2.23). The mill building accompanying the weir dates from 1783 (Navan & District Historical Society, 2022). There are two sloped transversals which contain the majority of the discharge and the rest of the weir crest is dry. These are breaches within the original structure. The vertical hydraulic head height is 0.72 metres. This presents the main challenge for upstream migrants, along with the high levels of turbulence and a standing wave at the base of the weir. It is a Complete Barrier to lamprey, cyprinids, juvenile salmonids, a High Impact Partial Barrier to trout and Low Impact Partial Barrier to adult salmon. Again, the presence of climbing substrate would likely enable eel passage over the weir.

Approximately 400 metres upstream is the Balmoral weir (Figure 2.23), alongside Millbrook, also present on the OS 6 inch maps indicating it pre-dates 1835. There were 3 transversals on the weir face – 2 slopes and a stepped fish pass. The height of the weir is significant – standing at 2.1 metres. On the slopes there were very high velocities and shallow water depths making them impassable. The height of the steps in the fish pass, along with high turbulence and lack of resting locations make it an extremely challenging structure for any upstream migrants to tackle. On the day of the survey it was deemed a Complete Barrier to all species considered in the survey including salmonids. The only species which may make passage is eel – again due to the age of the structure, good climbing substrate has developed on the weir face.

Martry weir is another structure located 7 kilometres upstream on the main channel of the Blackwater (Figure 2.23). A weir existed here since at least 1835 according to the OS maps. However it used to be positioned somewhat obliquely along the channel, whereas the current weir is completely perpendicular to flow. It was surveyed using the WFD111 methodology

(SNIFFER, 2010) in 2015. At the time of the survey the hydraulic head was 0.96m and there were two transversals – the vertical drop and a central fish pass. The height of the weir is the main issue for upstream fish passage. The additional lip on the crest of the structure compounds that problem. On the day of the survey it was a High Impact Partial Barrier for adult salmon and trout, and a Complete Barrier to all other species, save for eels.

Figure 2.23 The four lowest weirs on the Blackwater: Eliot's Saw Mill (top left); Spicer's Mill (top right); Balmoral weir (bottom left); and Martry weir (bottom right).

Going in an upstream direction, these four structures on the main stem of the Blackwater are challenging for fish passage before the channel bifurcates into the Moynalty 3km upstream from the Martry weir. From this point onwards, there are at least 4 more problematic structures on the main stem of the Blackwater, and 2 on the Moynalty.

Upper Blackwater surveys

3.5km upstream of the confluence on the main Blackwater channel is Headfort weir (Figure 2.24). It is positioned obliquely within the channel with a sluice gate on the main structure and a sluice channel separated from the structure by an island. On the OS 6 inch map it is marked as an eel weir indicating the history of eel fishing on the Blackwater prior to 1835. Many more of these eel weirs existed (or still do) between this location and Lough Ramor. Four transversals were recorded during the barrier survey – 3 sloping faces and a fish pass. The weir height is just over 1 metre which given the shallow water depth on the face, is a challenging height for upstream passage. Moreover there is a lip on the crest of the weir further impeding passage. The fish pass is sloped with a high angle, making this transversal a difficult option. The weir was deemed a High Impact Partial Barrier for adult and juvenile salmon, trout, cyprinids, and lamprey. It was considered a Low Impact Partial Barrier for juvenile eel.

Figure 2.24 Headfort weir with a sloping face and central sloped fish pass (left) and abstraction weir at Clavens bridge (right).

5.5km upstream form Headfort weir is an abstraction weir at Clavens bridge (Figure 2.24). It is present on the last edition of the 6 inch map so therefore was in place by 1910. This is a simple vertical weir with an hydraulic head of approximately 0.9 metres. It is not yet assessed by IFI staff with the WFD111 method, but was surveyed using the I-BAST methodology in 2021. 200 metres upstream is another potential barrier at Rathbrook which has yet to be visited and assessed. There are another two potential barriers to be visited and assessed upstream of where the N3 crosses the main stem.

Following these structures upstream of Kells, many more eel weirs and mills are marked along the course of the channel on the historic OS maps, which are now defunct. The only other structure impeding passage upstream towards Lough Ramor is the nine-eye bridge at Stramatt (Figure 2.25). The bridge itself has a sloped apron at the outfall of the lake. Immediately downstream there is a gauging weir with a sloped face and drop onto an apron. The step height along with the standing wave at the outfall, and high velocities present challenges to fish passage. The structure was considered a Complete Barrier to cyprinids and adult lamprey, and a High Impact Partial Barrier to juvenile and adult salmon along with adult trout. It was not a barrier to juvenile eel.

Figure 2.25 The nine-eye bridge at Stramatt with gauging weir downstream (left). Note Lough Ramor in the background. Virginia weir (right). Note the person in the left of frame for scale, demonstrating the extreme hydraulic head height.

Just 1 kilometre upstream from Lough Ramor is Virginia weir (Figure 2.25). This is the last of the major structures impeding passage on the main Blackwater channel and has been in place since at least 1835. It is a very significant structure with a hydraulic head height of 2.65 metres, which presents a major obstacle for any upstream migrants. Not surprisingly this weir was deemed a Complete Barrier to all of the species considered in the survey, save for eels. Again due to the presence of a climbing substrate on the weir surface, it was not deemed a barrier to juvenile eels, although they are unlikely to be present so far upstream in the catchment.

Moynalty surveys

The Moynalty (also called Owenroe river) is the main tributary of the Blackwater. It is visible from RHAT surveys that this channel was more affected by arterial drainage (see Figure 2.3). Indeed there is even a drop at the confluence with the Blackwater at Bloomsbury which would be unusual with a natural channel form (Figure 2.26). The section from the confluence up as far as Carlanstown was initially part of the Drainage District, with initial drainage works dated to 1884 (Figure 2.26). The Moynalty has changed its course in parts of the lower reaches, and elsewhere has been straightened artificially. Some of the old course can be easily seen in the landscape using satellite imagery and historical maps.

Figure 2.26 Confluence of the Moynalty (facing opposite) and Kells Blackwater rivers during flood (left); inscription on a bridge over the Moynalty river (right).

There are two large barriers on the main Moynalty channel. The first is at Mahonstown, 8.9 km from the confluence with the Kells Blackwater (Figure 2.27). It was marked as an eel weir on the OS 6 inch maps but was likely modified during the course of the arterial drainage scheme. It is a stepped weir with a vertical hydraulic head height of 1.13m. Debris accumulates on the structure due to its shape and presence of a lip on the crest. The height of the drop is an issue, especially for non-salmonids. It was deemed a High Impact Partial Barrier for all of the species migrating upstream in the survey (adult salmon and trout, cyprinids, lamprey, juvenile salmon) and a Low Impact Partial Barrier for juvenile eel. The weir at Moynalty (Figure 2.27) is a stepped weir with denil fish pass. Using the I-BAST methodology, barrier height was estimated to be 1.7m, and it was deemed to be problematic for all fish species, except for eel.

Figure 2.27 The stepped weirs at Mahonstown (left) and Moynalty (right).

Conclusion

The above details 7 structures surveyed on the Kells Blackwater main channel using the WFD111 methodology (SNIFFER, 2010) and 1 using the i_BAST methodology, with 3 more potential barriers remaining to be assessed. On the Moynalty tributary, there is currently one structure measured using i-BAST at Moynalty village and one measured using the WFD111 method at Mahonstown. The passability assessments for all 4 structures on the lower Blackwater are summarised in Figure 2.28. From here, anadromous fish could migrate up the Kells Blackwater or the Moynalty tributary. Although not all structures have yet been assessed in these locations, the data shows both directions have more passage problems (Figure 2.28). All of the structures represent significant issues in relation to passage of salmonids and lamprey.

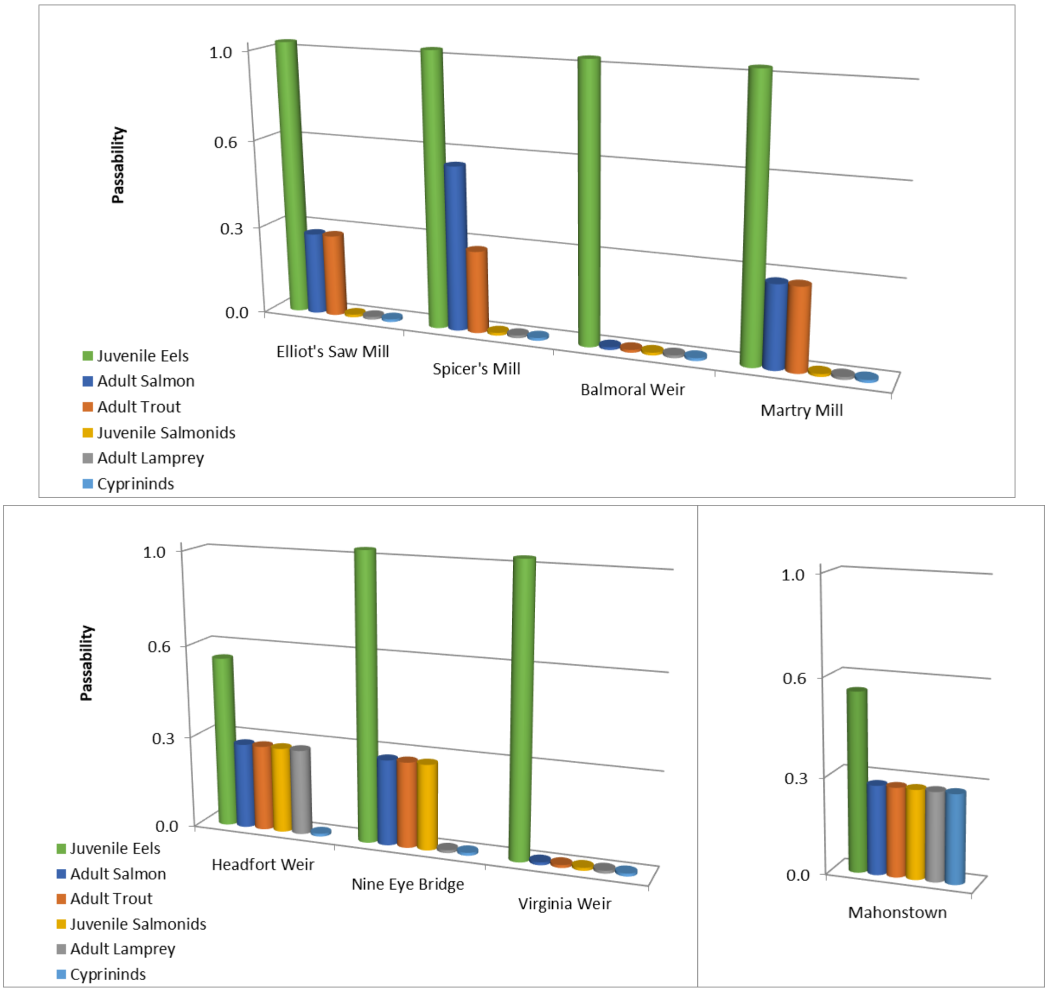


Figure 2.28 Passability assessment for 4 weirs on the lower Blackwater (top), 3 on the upper Blackwater (bottom left) and 1 on the Moynalty (bottom right). The 0-1 scale is as follows: 0 – Complete Barrier; 0.3 – Partial High Impact Barrier; 0.6 Partial Low Impact Barrier; 1 – Passable Barrier.

2.5 Catchment context

2.5.1 Water quality

Water quality data can be accessed on the Environmental Protection Agency site (EPA, 2022a). For the Kells Blackwater, it was assessed in 2020, just one year prior to our catchment-wide survey. In line with other WFD metrics, Good status is the target for water quality. 28 sites were assessed for water quality, with 28% (n=8) passing this minimum requirement. 36% (n=10) were classed as Moderate and 36% (n=10) as Poor (Figure 2.29), resulting in 72% of monitored sites failing to achieve required standards. Salmonids thrive in Q3 and above sites (Kelly *et al.,* 2007), meaning ideally water quality should be at least Moderate. Salmon are less tolerant than trout, so it would be expected that there may be higher numbers in Q4/Q5 channels. Looking at the electrofishing results (Figure 2.6), there are more sites with salmon present on the Moynalty main channel, despite the water quality here being Moderate and Poor. Salmon were recorded at six sites in the overall catchment and four of them had Moderate water quality and the remaining two sites were classed with a Poor status. It is likely that other pressures, such as the presence of large impassable barriers on the main stem of the Kells Blackwater are impeding salmon migration and subsequent recruitment.

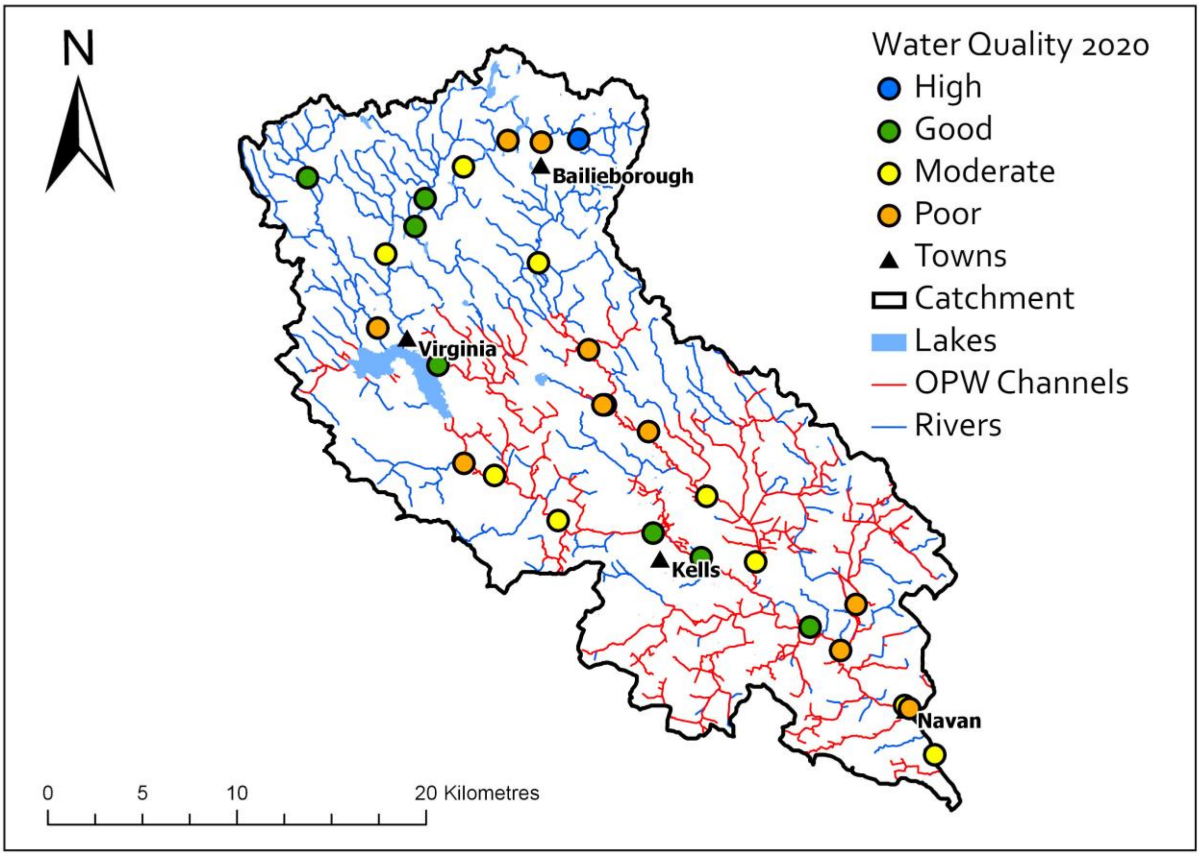


Figure 2.29 Water quality assessed in 2020 (data: EPA, 2022a).

2.5.2 Pressures

There are five subcatchment units delineated in the Kells Blackwater using the EPA WFD water regions (Figure 2.30). Their main characteristics are summarised per subcatchment in Table 2.2 using data freely available online (EPA 2022b, 2022c). Pasture is the dominant land use throughout all the subcatchments within the Kells Blackwater, with more arable land use in the southern part of the catchment near Navan. Given this intensive land use, agriculture is a significant pressure on surface waters within the catchment, in line with the national outlook (EPA, 2020). Hydromorphology is a pressure in 4 of the 5 subcatchment areas and is significant in 3 of those.

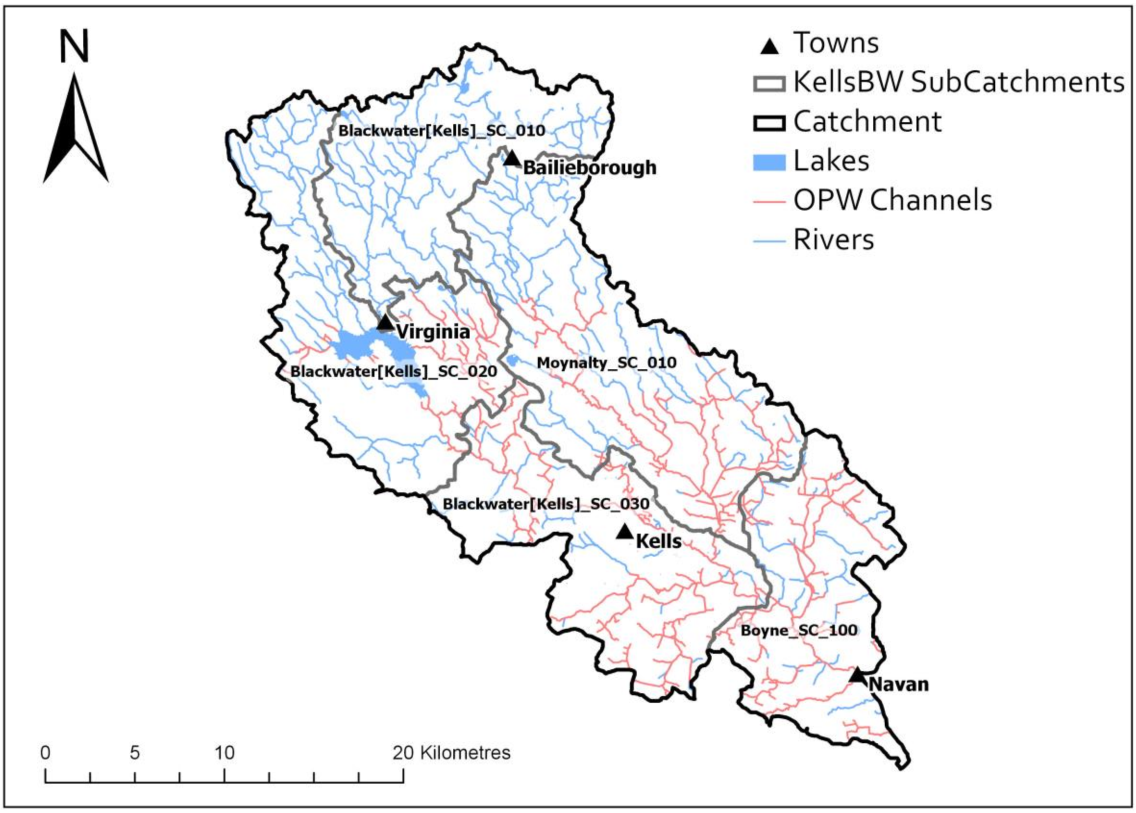


Figure 2.30 Subcatchments within the Kells Blackwater.

Two of the RHAT survey sites in Blackwater (Kells)_SC_20 occurred on channels where hydromorphology is listed as a significant pressure, corresponding with OPW drainage scheme channels. One of these sites scored Good in our assessment and one Moderate. At the Moderate location upstream of Carnaross (C1/8), bank structure and stability; bank vegetation; riparian land use and floodplain connectivity all scored lowly.

On the channels where Hydromorphology is a significant pressure in Blackwater (Kells)_SC_30 the RHAT results are Moderate (n=3) and Poor (n=1) and all of these sites are in the OPW scheme (two sites on C1/8/9; one site on C1/8/9/4 and one on C1/8/17). Channel form and flow; substrate condition; riparian land use and floodplain connectivity were the main attributes with low scores.

Table 2.2 Land use and pressures per subcatchment within the Kells Blackwater

Subcatchment	Urban area	Land use (*main)	Pressures (*significant)	At risk water body (total number)
Blackwater (Kells)_SC_010	Bailieborough	***Pasture** Peat Forestry Woodland Quarry Urban fabric	***Agriculture** ***Anthropogenic pressures** ***Domestic waste water** Industry ***Invasive species** ***Urban waste water**	3 river (8) 3 lakes (3)
Blackwater (Kells)_SC_020	Virginia	***Pasture** Arable Peat Forestry	**Agriculture** **Anthropogenic pressures** **Domestic waste water** **Hydromorphology** Industry **Invasive species** **Urban waste water**	3 rivers (5) 2 lakes (2)
Blackwater (Kells)_SC_030	Kells	***Pasture** Arable Natural vegetation Urban fabric	Agriculture Anthropogenic pressures Extractive Industry ***Hydromorphology** Industry Urban waste water	4 rivers (4)
Moynalty_SC_010	Moynalty	***Pasture** Arable Natural vegetation Forestry	***Agriculture** ***Anthropogenic pressures** ***Hydromorphology** ***Industry** ***Urban waste water**	6 rivers (9)
Boyne_SC_100	Navan	***Arable** ***Pasture** Urban fabric Mining	***Agriculture** Hydromorphology Urban waste water	5 rivers (7)

Just two RHAT sites where hydromorphology was listed as a significant pressure in the Moynalty_SC_010 subcatchment overlap with the OPW scheme and both are Moderate status. Riparian land use and floodplain connectivity score lowly for both locations (C1/8/10 upstream of main confluence and on C1/8/10 north of Mullagh). One site has relatively lower scores for channel form and flow; bank structure and stability and bank vegetation. Both sites have lower substrate condition scores, with excessive fines impacting the result.

2.6 Conclusion

As regards the WFD metrics within the Kells Blackwater catchment, our results show that 22% (n=5) of sites are of Good status for fish, and 46% (n=12) for hydromorphology. With some surveys still remaining to be completed, the current barrier density is 4.6% (n=47). These results can be put into context when compared with other recent catchment-wide surveys completed by the EREP team: Inny 2017/18; Deel 2019 and the Glyde 2020.

The ecological quality ratio scores for the Kells Blackwater are not as favourable as expected given some of the good quality habitat observed in the catchment. Just 22% of sites passed the minimum WFD class of Good, with no sites being classified as High status for fish (Table 2.3). The significant pressures outlined herein, specifically agriculture, are pervasive throughout the catchment. Moreover, in the upper parts there are many significant waste water pressures, from both domestic and urban settings.

The Kells Blackwater has more positive results overall in terms of hydromorphology scores, compared to previous catchment-wide survey efforts (Table 2.3). The same RHAT attributes scored lower, on average – riparian land cover; flood plain connectivity; substrate condition. 46% (n=12) achieved the minimum WFD requirement of Good status whereas when only OPW channels are considered that number reduces to 23% (n=6), with the remained being classed as Moderate and Poor. No sites surveyed were classified as Bad.

Table 2.3 EQR and RHATs broken down by proportion per WFD category for the Inny, Deel, Glyde and Kells Blackwater.

	EQR				RHAT			
WFD Score	Inny (n=77)	Deel (n=47)	Glyde (n=25)	Kells BW (n=23)	Inny (n=51)	Deel (n=26)	Glyde (n=19)	Kells BW (n=26)
High			16%				5%	
Good		13%	48%	22%	4%	19%	16%	46%
Moderate	28%	53%	32%	61%	39%	50%	63%	46%
Poor	71%	34%	4%	17%	54%	27%	16%	8%
Bad					4%	4%		

Overall, barrier density is lower than other catchments currently (Table 2.4) – the total survey is not yet complete. However, longitudinal connectivity is severely impacted on the main channels within the catchment, especially the Kells Blackwater itself. Previously heavily used for industry along with eel fishing, historical maps show there were once even more weirs on the main channels than there are today. There are currently at least 10 major barriers intact, and the majority are impassable or high impact barriers for salmonids and lamprey. This may help to explain the poorer than expected electrofishing results observed.

Table 2.4 Barrier surveys in the Inny, Deel, Glyde and Kells Blackwater (*some surveys outstanding not included in any of these figures)

Structure Status	Inny	Deel*	Glyde	Kells Blackwater*
Barrier	155	68	40	47
No barrier	1399	443	580	969
Total surveyed	1553	511	620	1018
Barrier %	**10%**	**13.3%**	**6.4%**	**4.6%**

3 National Barrier Screening and Assessment

3.1 Broadmeadow and Ward catchment

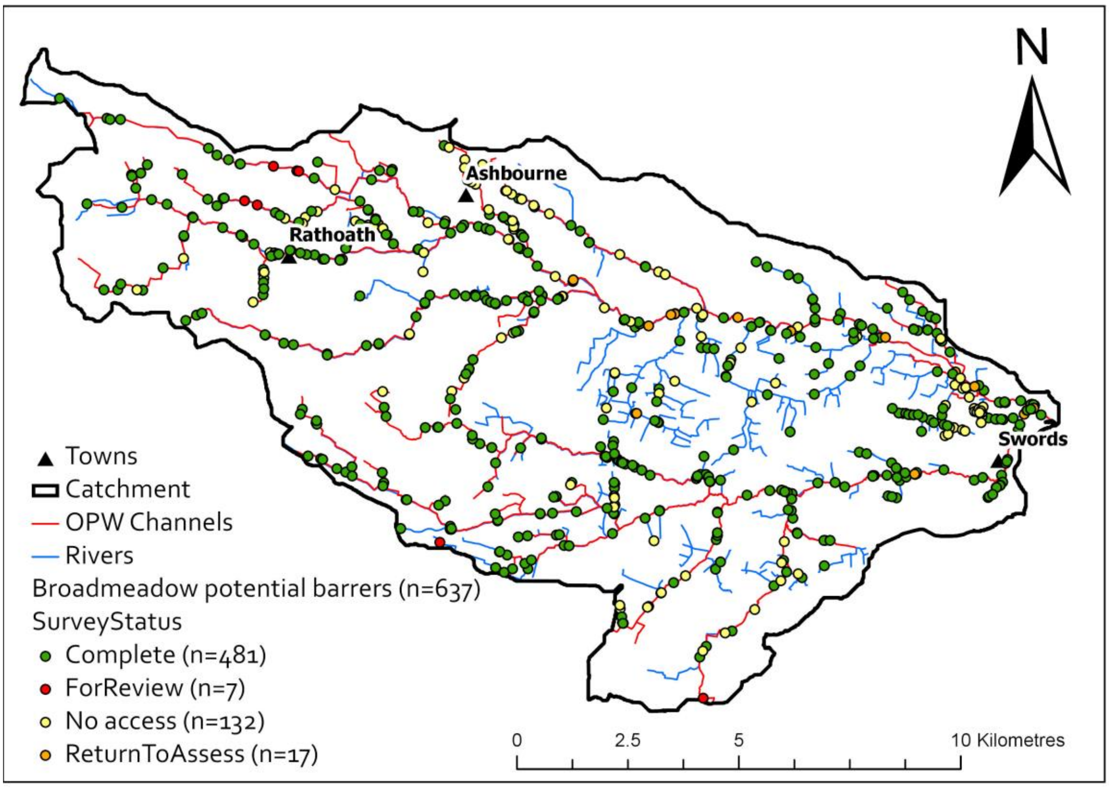
The Broadmeadow and Ward scheme is located in the east of the country. This scheme is one of the minor schemes drained by the Office of Public Works between 1961-64, benefitting just under 3,000 hectares of land (Ryan Hanley 2014b). The Broadmeadow and Ward rivers meet in Swords and discharge into the Malahide estuary. There are numerous large urban centres within the 167km^2 area of the catchment, including Dunshaughlin, Ratoath, Ashbourne and Swords. Various land uses exist in the catchment in addition to the urban fabric, including pasture, arable land, mixed agriculture and industrial areas.

The Broadmeadow and Ward scheme was chosen for a barrier assessment survey during 2021 in collaboration with the National Barrier Programme and the Eel Monitoring Programme. The area was subdivided between each of the three teams, and the catchment was surveyed using IFI's Barrier Assessment and Screening Tool (i-BAST) at low to moderate water levels suitable for the survey.

There were 637 potential barriers identified within the Broadmeadow and Ward catchment (Figure 3.1). Structures can prove difficult to access in urbanised areas, and indeed 132 were visited but deemed not accessible. 481 structures were visited and assessed with just 21 measured (Table 3.1), giving a relatively low proportion of barriers within the catchment, approximately 4.3%. However, of the remaining locations to visit (n=24), at least 13 may also pose problems for fish passage, therefore the overall proportion of barriers in the catchment is likely to increase when the full survey is complete. Examples of problematic structures recorded are shown in Figure 3.2. These examples are all listed on the register as OPW structures.

Table 3.1 Barriers identified and assessed in the Broadmeadow and Ward survey

Structure type	Number
Culvert / bridge apron	11
Weir	10
Other	0
Natural – rock/bedrock	0
Total	**21**



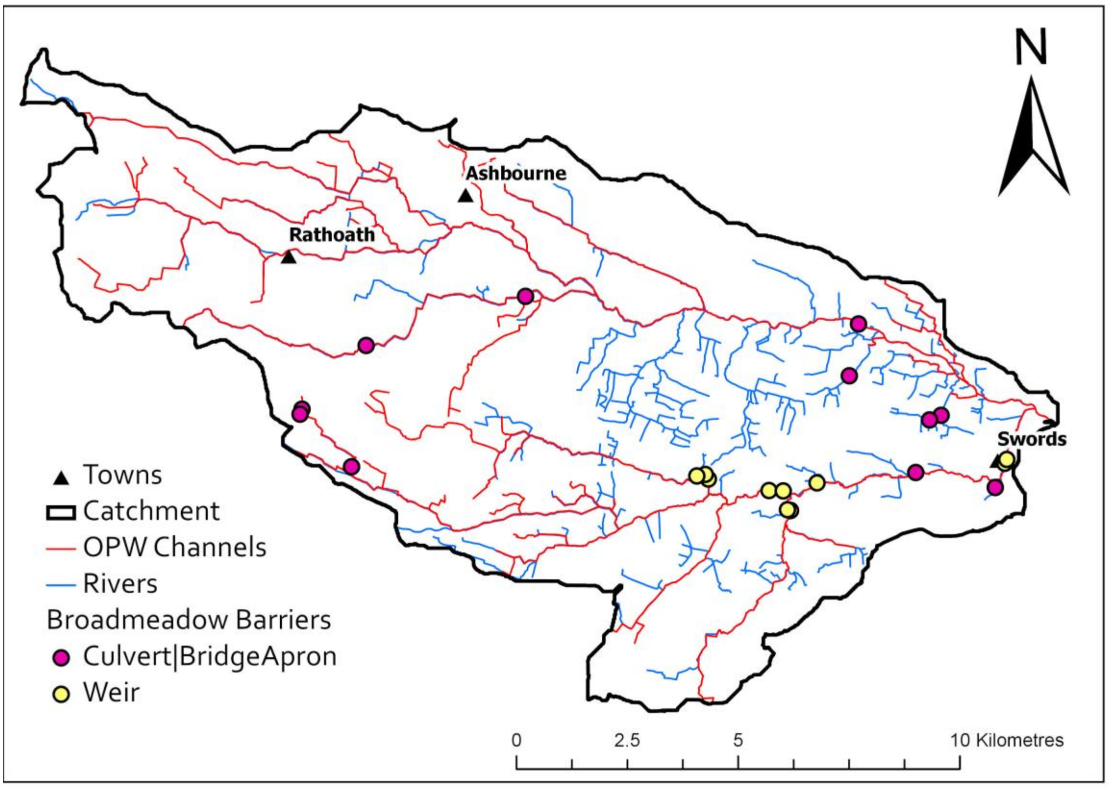


Figure 3.1 Distribution of all potential barriers within the Broadmeadow and Ward Catchment (top, n=637). Barriers assessed and surveyed to date (bottom, n=21).

Figure 3.2 Examples of barriers on the Broadmeadow & Ward scheme. Bridge apron with drop, and perched culvert (top, C1/6). Two perched culverts (bottom, C2/10).

3.2 Brosna main channel

The Brosna scheme is located in the midlands. This scheme is one of the major schemes drained by the Office of Public Works between 1948-55, benefitting 34,883 hectares of land (Ryan Hanley 2014b). The River Brosna is approximately 79 km in length, draining an area of 1,248km² and is part larger Shannon River Basin, flowing through the Counties Westmeath and Offaly. Discharging from Lough Owel in a south-south-westerly direction it flows through Mullingar, into Lough Ennell. From Lough Ennell, the river flows to Kilbeggan, then southwest through Clara, Ballycumber and Pullough. East of Ferbane it is joined by the Silver River. From Ferbane it heads to Shannon Harbour, north of Banagher, where it joins the Shannon. The Brosna from Lough Ennell to its outflow in Shannon Harbour now has 6 significant weirs rated as an issue for fish passage (Figure 3.3). The river has a long history of industrial use and associated modifications including construction of weirs and sluices, as well as diversion channels. When the Brosna catchment was subjected to a major OPW arterial drainage scheme, modifications were also made to the instream structures (weirs/sluices), with similarly constructed sluices, winches and concrete structures still evident in many of the 6 main stem barriers on the river Brosna.

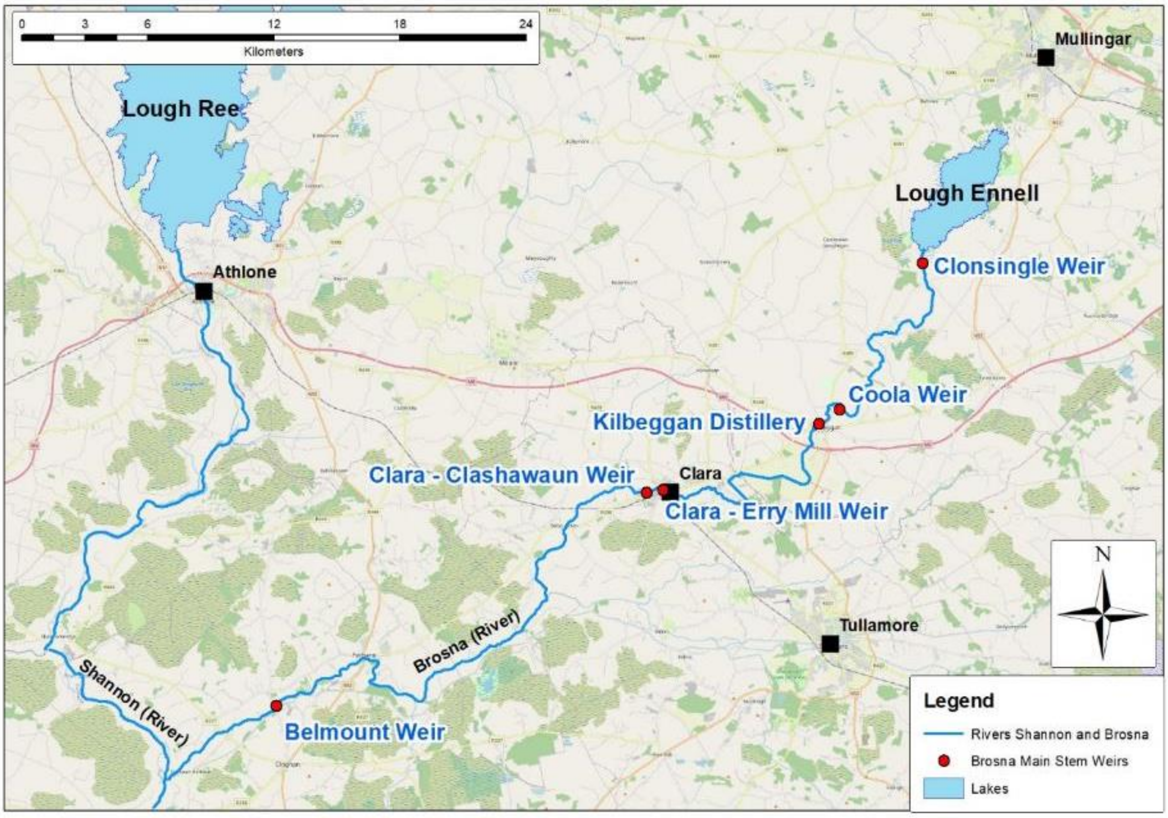


Figure 3.3 Location of the 6 main stem barriers on the River Brosna

Detailed passabillity assessments were completed on these 6 structures by IFI's National Barrier Programme during 2021. These are detailed in the report Coghlan *et al.* (2022) and demonstrate the significant fish passage issues in the Brosna. The presence of these artificial barriers in the Brosna has contributed to the fragmentation of brown trout populations and hinders upstream migration of annex species including Atlantic salmon and European eel. Furthermore, recommendations are made as regards to priorities for a large-scale barrier mitigation programme in a catchment context. Smaller-scale recommendations are also outlined which would help to address some of the issues observed with these barriers in the short term.

4 Long-term monitoring: capital works on the River Dee

4.1 Introduction

The Dee is located in the east of the country and is part of the OPW Glyde & Dee scheme. This scheme was originally drained by the Office of Public Works between 1950-57, generating over 10,000 hectares of benefitting land between the two river catchments (Ryan Hanley 2014b). The vast majority of channels within the 392km^2 catchment area of the Dee have been drained. Like the Glyde, land use consists of predominantly pasture in the hummocky uplands west of Ardee, with arable land in the lowlands to the east. The Dee meets the Glyde at Annagassan and thereafter drains into the Irish Sea. Approximately 20km upstream from confluence of the two channels is Hem Bridge, on the main River Dee (C2(1)). The Dee study site is located downstream of Hem Bridge (Figure 4.1).

Figure 4.1 Location of the Dee Survey Site.

The River Dee was chosen as part of the Capital Works scheme in 2009. The channel was heavily poached by livestock, which grazed and trampled the left-hand bank (LHB) causing it to become unstable and susceptible to extensive erosion. The Capital Works carried out in 2009 involved rock armour, christmas tree work, fencing, creation of pools and the construction of a low-grade vortex weir. Christmas tree work entails the strategic positioning of old trees along the bank to prevent erosion, a soft engineering alternative approach to traditional rock armour. Overall, a large amount of works were carried out at this degraded site.

4.2 Methodology

Pre-surveying of the site in 2008 consisted of levelling (longitudinal profiles and cross-sections), vegetation and physical habitat surveys.

Post-monitoring of the site was completed in 2010, 2012 and again in 2021. The aim of revisiting this site was to determine naturalisation of these works and their success or otherwise. Initial inspection on a walkover show that the banks have naturalised and are colonised with vegetation which aids bank stability. The vortex weir has naturalised with vegetation settling on the margins of the structure where flows tend to be slower. The gravel shallows located downstream of the structure are still evident becoming partially exposed during lower flows and creating a riffle in higher flows.

Post-monitoring surveys conducted in 2021 include:

a) Longitudinal profiles of the riverbed generated from levelling surveys

b) Representative cross-sections

c) Vegetation assessment using 10x 1m^2 randomised quadrats

d) Habitat surveys using the RHAT

4.3 Results

4.3.1 Levelling surveys

A longitudinal profile of the site was generated for 2008 pre-works (Figure 4.2). This shows the riverbed and its characteristics before and after the completion of capital works activities by the OPW. The green line (2008) shows a uniform channel bed typical of a deep glide, supporting little to no variance in depths or flows. The blue dashed line shows the water surface level recorded in 2009 giving a visual indication of water depths. Repeating the levelling surveys of the channel longitudinal sections post-works indicate changes made to the riverbed. Alterations to the channel bed are evident when comparing the 2008 (green line) profile to the 2009 (orange line).

Two significant pools were excavated at T20 and T40 located directly upstream and downstream of the vortex weir constructed at T30 (T meaning transect and x metres upstream from the bottom of the site). Gravels were also positioned downstream of T20, at T5, as part of the capital works programme to create a shallow riffle.

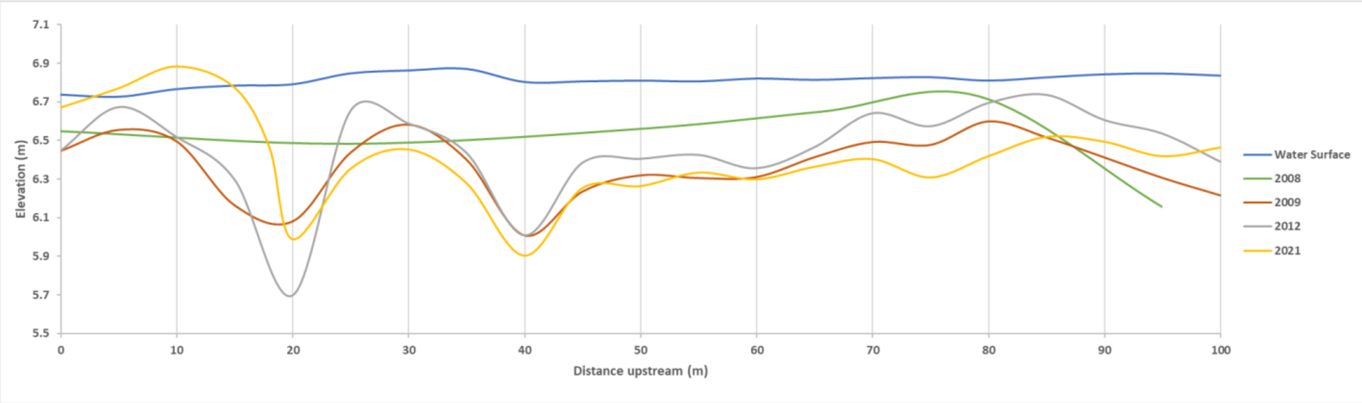


Figure 4.2 Longitudinal Profile of Dee Survey site pre- and post-works completed in 2009.

This levelling survey was carried out again in 2012 (grey line) which indicated the new channel form remained intact 4 years post-works. The pool downstream of the vortex weir deepened by approximately 0.4m perhaps due to scouring caused immediately below the structure in heavier flows. Repeating this longitudinal profile in 2021, 13 years post-works, this pool has filled to the level it was excavated to in 2008. As substrate and sediment moved within the riverine system it is expected that pools will retain some material over time. Also, as part of the vortex weir works smaller gravels were used as part of the construction process filling spaces between larger boulders, and it is likely that these have shifted over time and washed downstream into the pool.

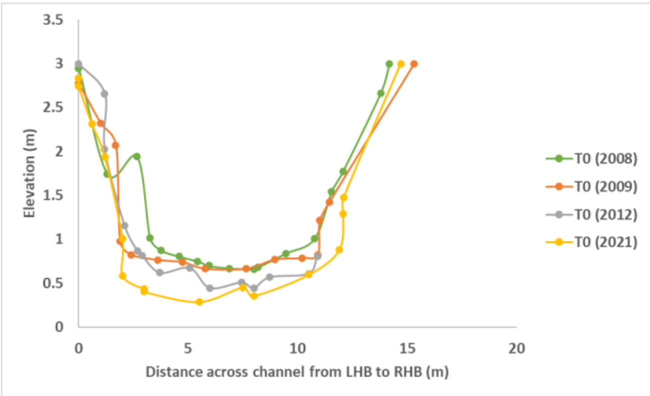
Repeating the levelling surveys of channel longitudinal sections post-works indicates the nature and impact of the initial works between 2008 and 2021. Overall, the works remain intact, adding a variety of depths to a section of channel which originally pre-works was a uniform glide. Within its modified cross-section, the channel has adjusted post-works to being more dynamic with associated diversity in flows and depths. This positive impact of Capital Works has been previously observed in the likes of the Enfield Blackwater, for example (Fleming *et al.*, 2020).

4.3.2 Cross sections

Cross sections were taken at selected locations throughout the site. The discussion will focus on four cross sections, which were located at T0, T14 T20 and T92.

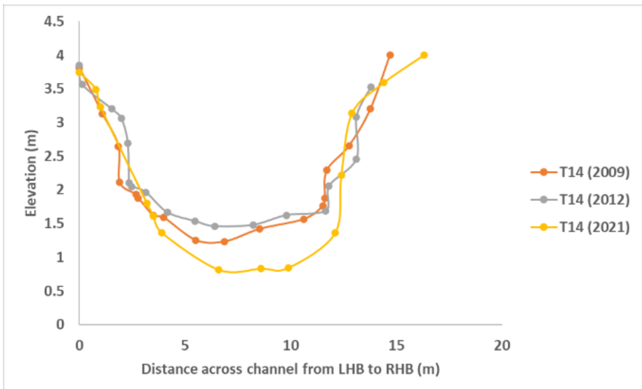
T0, T14 and T20 cross sections were all located downstream of the low-grade vortex weir constructed at T30 in 2009 (Figure 4.3).

Figure 4.3 Photograph taken on the left-hand bank looking from T0 upstream to T30 (left, 2009 and right, 2022) where the vortex weir was constructed.



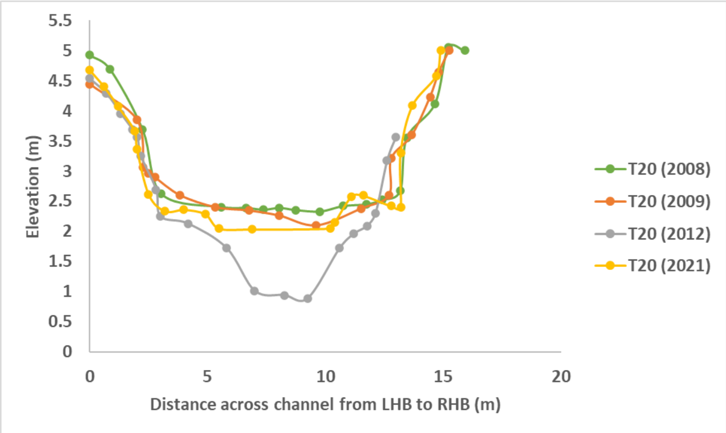
T0 shows little difference in the cross-section profile throughout all the survey years (Figure 4.4). The LHB was re-profiled slightly during the works in 2008 and is evident here.

Figure 4.4 Cross section located at T0.



T14 cross section was first recorded in 2009 post-works. Works completed downstream of the structure were minimal. The profile shows the channel bed is deeper in 2021 compared with 2012 (Figure 4.5) This is possibly due to natural moving of substrate and erosion within the river channel.

Figure 4.5 Cross section located at T14.



T20 was located directly downstream of the vortex weir. This cross section shows a pool formation downstream of the structure (Figure 4.6). The scoured pool in 2012 is distinctively evident from the longitudinal profile shown previously in Figure 4.2.

Figure 4.6 Cross section located at T20.

T92 was the only cross section located upstream of the vortex weir. The section of channel upstream of the structure was characterised as a deep uniform glide for all years of the surveying works. The cross-sectional profile of the channel shows changes in channel width between 2009 and 2021 (Figure 4.7). Works carried out in 2009 consisted of various methods to stabilise the riverbanks which included rock armour and strategic positioning of Christmas trees along the bank. During recovery, the channel has narrowed as the banks stabilise and vegetation colonises (Figure 4.8).

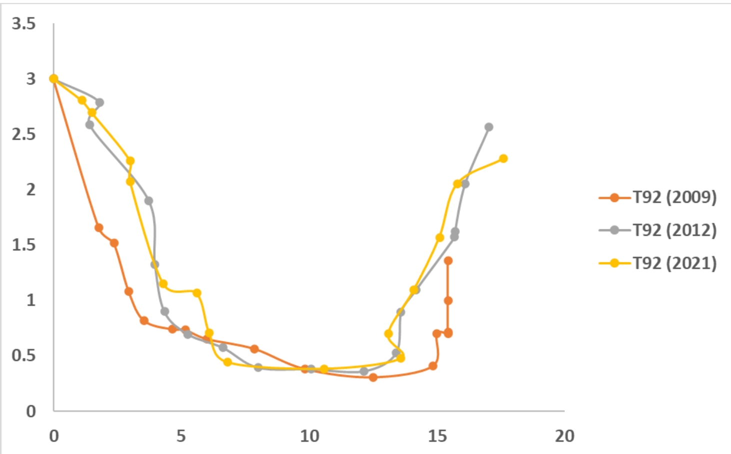


Figure 4.7 Cross section located at T92.

Figure 4.8 Photo taken in the channel in 2009 (left). Photo taken from left bank top of the same stretch of channel in 2021 (right). Both images are facing upstream.

4.3.3 Vegetation surveys

A vegetation survey was carried out pre- and post-works to determine vegetation composition before any alterations, and to identify changes in vegetation as recovery occurred following instream works. Vegetation was recorded using twenty 1m^2 quadrats positioned randomly throughout the site. Ten random quadrats were used instream to record aquatic vegetation and ten others within the channel margins to record fringing vegetation.

Vegetation was classified into morphological groups which covered all species present. There were five classes which entailed – NV (No vegetation/Open Water); PS/LS (Submerged); LE (Linear Emergent); BLBE (Broad Leaf Branched Emergent); and ML (Marginal Linear/ Fringing). The abundance of each of these groups was recorded using the Domin-Krajina scale, then converted to percentage cover for all quadrats.

Instream vegetation was not impacted by the instream works completed and instream cover remains similar for all years monitoring post-works (Figure 4.9). Even though the capital works improved flows and depth diversity within the channel, they caused limited changes to instream vegetation as pre-works conditions were already favourable for the river vegetation that is present in the channel.

Submerged vegetation was the most abundant type present all years of the survey. The presence of in-stream vegetation patches reduces velocities within vegetated patches and increase flows in adjacent non-vegetated areas. Water levels are altered in vegetated areas compared to unvegetated areas (Verschoren *et al.*, 2016). Instream vegetation in turn increases the diversity of habitats and resources, therefore influencing habitat choice, survival and growth of migrating fish (Diehl and Kornijow, 1998).

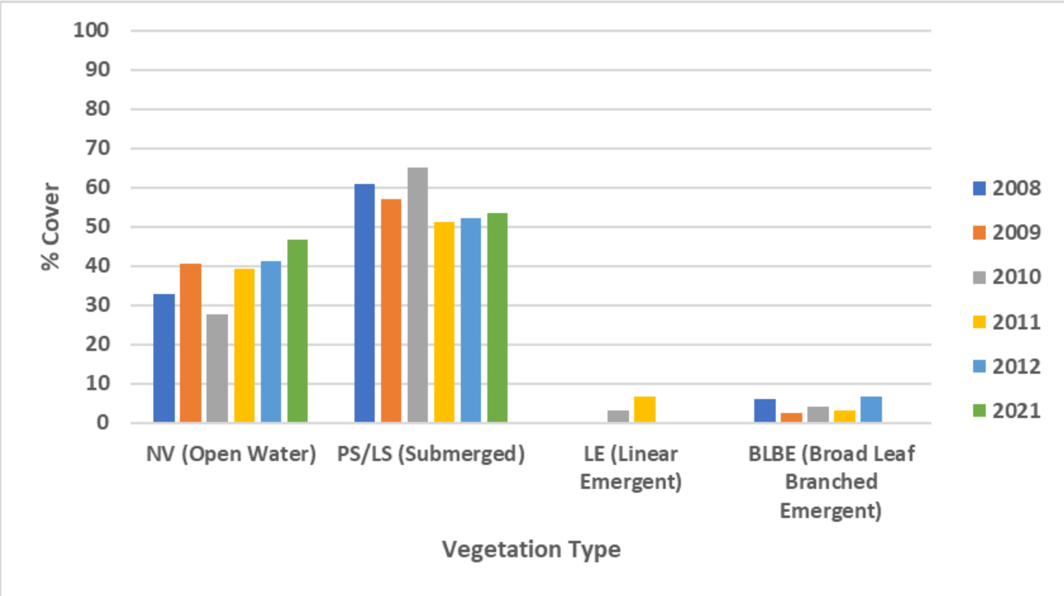


Figure 4.9 Percentage cover of instream vegetation before and after capital works were completed on the Dee River in 2009.

Marginal/fringing vegetation was not recorded pre-works as there was limited amounts present along the channel banks due to extensive cattle poaching. Marginal vegetation colonised the newly re-profiled banks 1 year post-works as cattle had been omitted due to the erection of extensive fencing. Marginal vegetation has been surveyed since 2010. Examining Figure 4.10 it has thrived since then, colonising the banks which assists in bank stability.

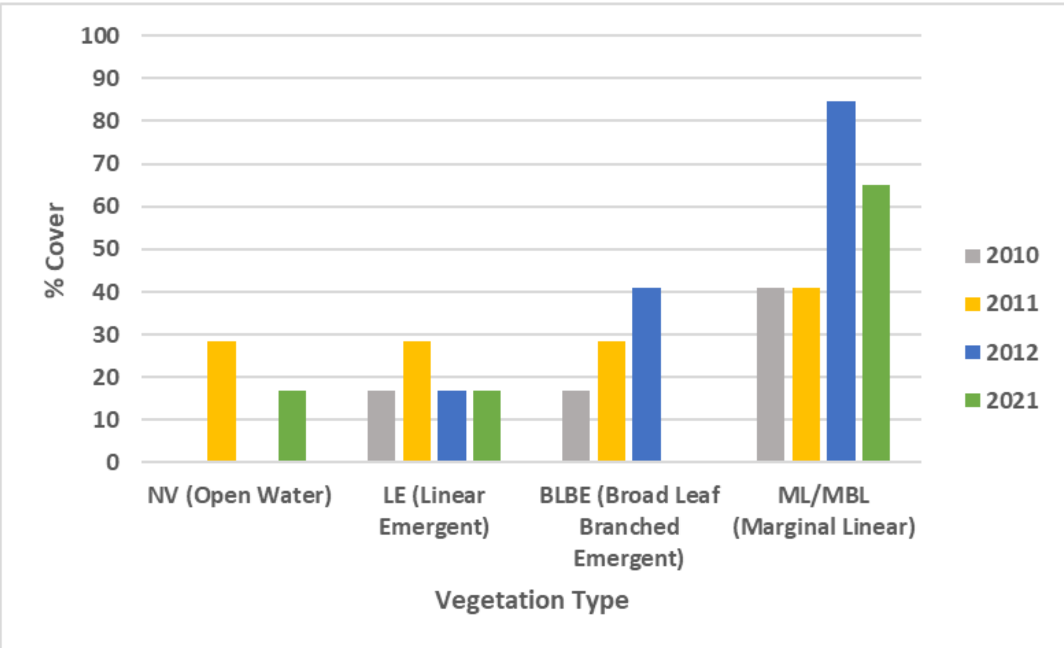


Figure 4.10 Percentage Cover of marginal vegetation following the erection of fencing during capital works completed on the Dee River in 2009.

4.3.4 RHAT surveys

RHAT Surveys (also discussed in Section 2.3) assessing instream habitat along with other physical elements of the channel and riparian zone were completed at the site of works in 2021. RHAT's scores were generated for earlier years (2008 and 2010) were based on photographic evidence. In completing each RHAT survey, eight attributes are visually assessed and scored. Six of the right attributes didn't change score pre- and post- works, so only those two which did (bank structure and stability; bank vegetation) are presented here.

The RHAT survey completed in 2008 post-works classified the site as having Poor hydromorphological status overall. The bank vegetation attribute had the lowest score for both banks with a 0 score for the LHB and 0.5 for the RHB (Figure 4.11). Bank vegetation improved after the implementation of the Capital Works, scoring 1 for both banks in 2010 and 2021. The slight improvement in scores post-works led to a Moderate hydromorphology status. Fencing the left bank as part of the capital works omitted cattle access, allowing vegetation growth to take hold. The highest score that can be given to each bank is a 2 and in this case bank vegetation scored no higher than a 1 as trees were absent from the banks. Planting trees along the newly fenced banks in 2009 would have improved this score greatly for 2021.

Bank structure and stability scores remained the same for the RHB for all years, whereas the LHB scored 0.5 pre- and post-works. This score improved to a 1 in 2021 as the hard reinforcement had renaturalised over the intervening 11-year period.

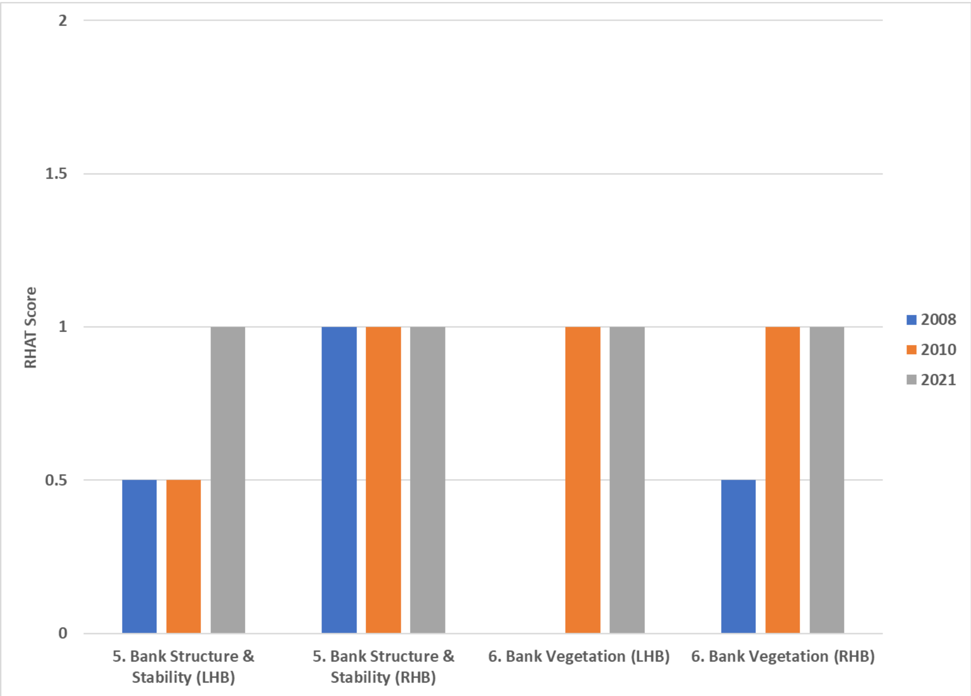


Figure 4.11 RHAT Scores for survey site pre- and post- capital works.

4.4 Conclusion

Overall, the extensive Capital Works at this site have proved successful in improving plant species diversity on the margins, maintaining the existing instream plant diversity, and stabilising the previously eroding banks. This survey also shows that the naturalisation of artificial interventions can improve various channel attributes. When these structures naturalise and become incorporated into the riverine system, they can lead to improved RHAT scores over time.

Compared to 2008 this site has improved significantly with respect to marginal plants, providing diverse habitat for a variety of species to utilise. Improved bank vegetation growth and thriving instream vegetation supports a range of aquatic and terrestrial fauna. Fish surveys were completed at this site pre- (2008) and post- (2010) works and reported on in 2011. Post-works, the site showed a considerable increase in salmon and trout numbers (IFI, 2011). The changes in channel habitat due to the works undertaken in 2009 had increased the river's carrying capacity for all life stages of trout and salmon. The site was not electrofished since 2010. Physical characteristics of the channel have improved over the survey years as depths remain diverse, marginal and bank vegetation colonised and instream aquatic vegetation trends remain like that observed in 2010. With this is mind, it is possible to state that this stretch of channel should have the capability to continue to support these large numbers of salmonids which pass through the system each year.

When considering the overall hydromorphological status the site was initially very limited and was ranked as Poor in 2008, with an overall score of 12.5, due to the issues with bank stability and bank vegetation. In 2010, the site was classified as Moderate status with a score of 14. This score improved further between 2010 and 2021 to 14.5, maintaining its Moderate status. The other RHAT attributes remained the same for all years of the survey. Due to the intervention of Capital Works, the RHAT score changed slightly to improve classification from Poor to Moderate, yet this doesn't pass the WFD requirement of Good status for hydromorphology. The incorporation of tree planting into plans like this would improve the score further, perhaps something to consider when planning future enhancement works.

5 Inter-agency collaboration

5.1 Ballaghnatrillick River walkover: Duff Scheme

The Ballaghnatrillick River (C1/8) is located south of Bundoran, Co. Donegal (Figure 5.1) and is a major tributary of the Duff River. Drainage works were completed on this scheme between 1963-65. A walkover of this site pre-maintenance was undertaken in July 2020 with attendees from local OPW Offices and EREP team members. A post-maintenance walkover was carried out in 2021.

During the initial walkover in 2020 advice was given on the implementation and best practice of the 10 Steps to Environmentally Friendly Maintenance (Brew and Gilligan, 2019). Within the 2km of channel walked 19 work sites were identified (Figure 5.1) with removal of blockages that hindered flood conveyance was the main area of focus. They were also advised to leave many sections untouched where no maintenance was required.

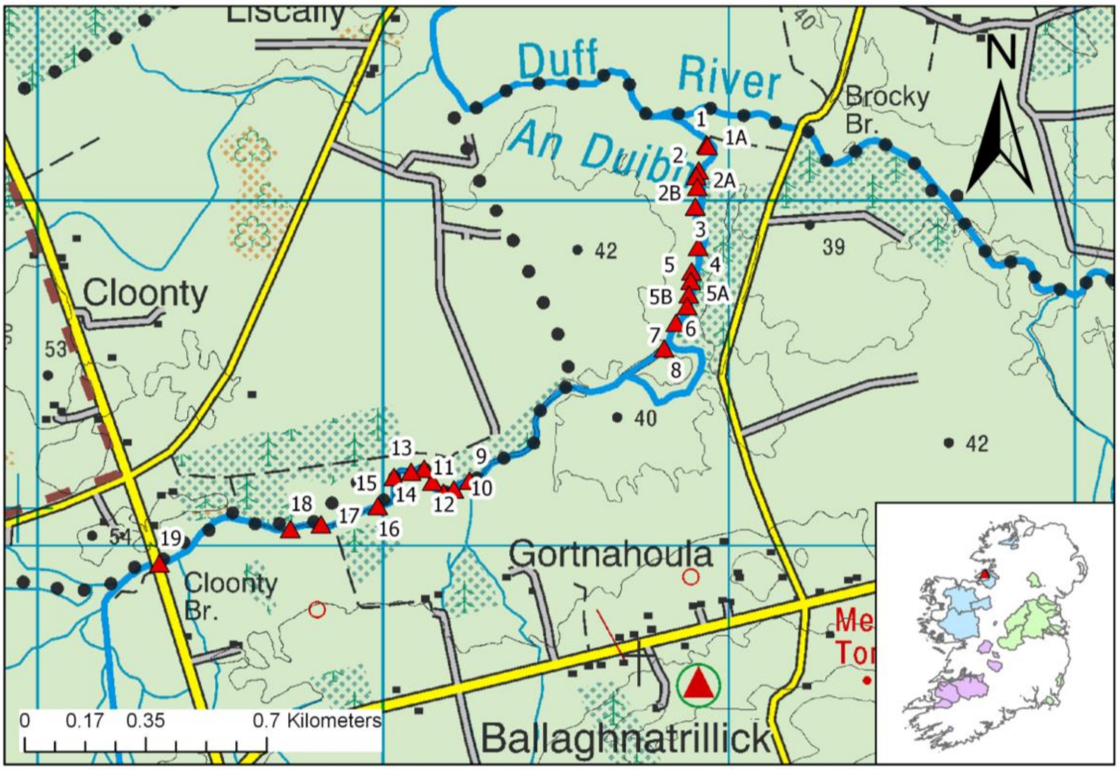


Figure 5.1 Map showing work site locations identified during a walkover undertaken in July 2020 on channel C1/8.

During the follow up walkover in 2021, identified work sites from 2020 were photographed post works to show the extent of works undertaken. Blockage / tree removal from the instream sections of the river was recommended if currently impeding on flood conveyance, and if items had the potential to impact flows before the next maintenance cycle. In Figure 5.2, it can be seen that low impact methods were used to remove this obstruction from the left-hand bank (LHB). This tree stump remains intact and continues to stabilise the bank. Similar work at a larger scale is evident in Figure 5.3 below.

Figure 5.2 Example of an obstruction removed from the channel (left, 2020 & right, 2021).

Figure 5.3 Example of effective but not destructive debris dam removal (top, 2020 & bottom, 2021).

In Figure 5.4, further blockage removal is evident from the before and after shots. A small blockage was removed from the LHB as well as the juvenile tree located in the centre of the channel. The overhanging draping tree located on the RHB was also removed in a sensitive manner. It was agreed that this tree would be removed as it posed a potential threat to catching moving material during elevated flows and over time creating a blockage.

Figure 5.4 Example of the removal of minor and potential blockages (left, 2020 & right, 2021).

Areas that required no work were advised to be left untouched during maintenance in 2020. This advice was taken on board by the local OPW staff. In Figure 5.5, it is evident that no works were completed at this site as advised. A discussion was had about the possibility of removing the trees located on the face of the RHB at the bend of the river. The EREP team indicated that these trees should stay as they are stabilising the banks and preventing further erosion at this location.

Figure 5.5 Example of a site where guidance was given to leave this section untouched (left, 2020 & right 2021).

Guidance was given to retain this the log photographed in Figure 5.6, as it added diversity to in flow form to the channel in lower water levels. This log was embedded into the bank over time and posed no threat of moving downstream and creating a blockage, which would be deemed an issue by OPW.

Figure 5.6 Logs retained in the channel (left, 2020 & right, 2021).

Overall, the walkover deemed a success. Advice shared between attendees on the 2020 walkover was taken on board and all works were carried out in an environmentally friendly manner. It is hoped that when similar scenarios are identified on other channels with the same level of work required that the OPW staff will apply the same approach as applied here. During the walkover other typical situations drivers might come across were discussed and recommendations on how to approach these scenarios during maintenance works were reviewed. All in all, knowledge was shared between all attendees from IFI and OPW. The EREP team feel that these walkovers are important in sharing knowledge between teams from each organisation. For success to come from these walkovers, OPW drivers must understand the rationale for selected works and be comfortable to apply similar strategies elsewhere. The EREP team are readily contactable if unusual scenarios arise during maintenance and advice needed on how to tackle the situation. An online training day for OPW Staff – engineers and foreman – conducted in 2021 re-iterated the importance of applying the 10 Steps to Environmentally Friendly Maintenance when carrying out any works on a river network. Information obtained from the training day should be shared with those working on site and application of the steps monitored on an ongoing basis.

5.2 Catchment CARE update: River Cor case study

5.2.1 Introduction

A section of the Cor River (C1/1) was programmed for routine maintenance by OPW in 2019. The Cor River is located in the Blackwater catchment (Figure 5.7) and hence a synergy with the Catchment CARE project was explored. The section of channel scheduled for maintenance was located on the 'Clontibret Stream_030' waterbody which was in Poor WFD status. The section of channel scheduled for maintenance was 2.4 km in length. The Cor River has been historically straightened leading to a significant loss of sinuosity.

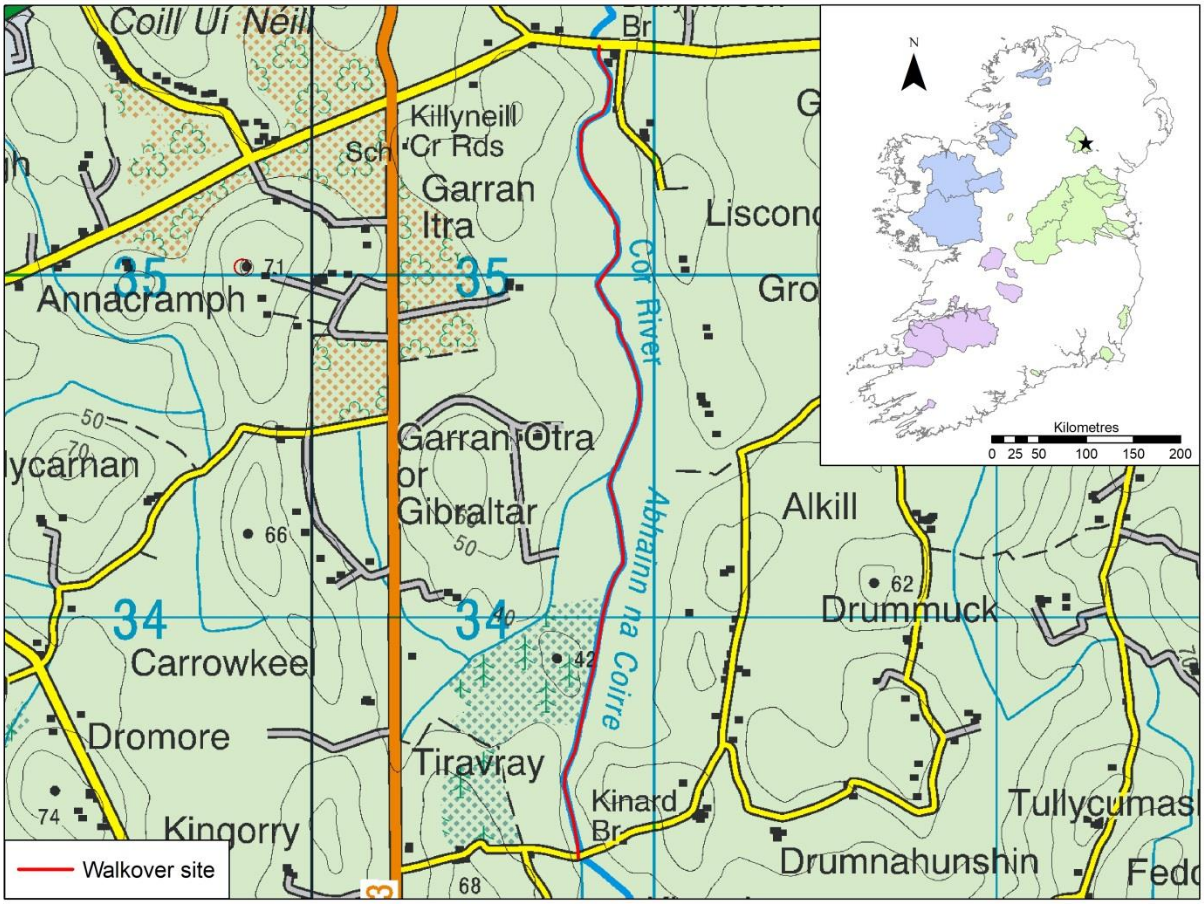


Figure 5.7 The Cor River is located in the OPW East region (inset). The red line indicates the stretch of river assessed during the walkover.

Scoping surveys were initially carried out by Catchment CARE personnel. A walkover was completed in May 2019 between the Catchment CARE and EREP teams, along with OPW. The entire stretch was walked, and along the route discussions were had around the recommend works to undertake at various locations. A programme of measures was agreed between all, and photos and GPS locations taken on site.

The instream measures proposed included bank protection using soft engineering methods; berm-topping and re-profiling the channel bed, all in line with OPW ten steps to environmentally friendly maintenance (Brew and Gilligan, 2019). The inclusion of soft engineering methods within this scope was a value-added measure. These instream works were implemented by the OPW foreman and drivers. A return visit later in 2019 revealed progress in these areas (Fleming *et al.*, 2020).

The OPW measures were considered as contributing to enhancing the hydromorphology of the Cor channel. Hydromorphology is one of the metrics within the Water Framework Directive and improvements in this area could potentially assist in improving overall ecological quality of the channel. To further enhance the river corridor, the erection of fencing along both banks was recommended, which was predicted to provide total livestock exclusion from the channel and would have required the provision of off-line drinking troughs for livestock. Catchment CARE had planned to take the lead in this aspect of the project. However, following a shift in priorities, it was not possible within IFI's remit of the project at the time.

5.2.2 Monitoring Method

The Before-After Control-Impact (BACI) is a commonly used methodology in ecology studies. The BACI approach includes time and impact factors, with 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. "Before" can be baseline for both sites, or just a comparatively unimpacted situation, and a "control" can refer to a site either fully or partially sheltered from the impact. Samples were taken at control site and impacted sites before and after works (Figure 5.8).

The samples taken included:

a) Fish EQR (Ecological Quality Ratio) scores were modelled for each site (n=10) electrofished in 2021 as well as those previously fished in 2019. The EQR scores of sites sampled in 2019 (pre-works) and 2021 (post-works)
b) Eight attribute scores were collected for each RHAT survey (n=2), one at the control site and one at the impacted site. The differences in attribute scores between control pre, control post, impact pre- and impact post- were examined.
c) Photos: images were compared between pre- and post-treatment. Observing visual difference is very intuitive and conveys metrics of success to the general public (Figure 5.10 ,Figure 5.11 & Figure 5.12).

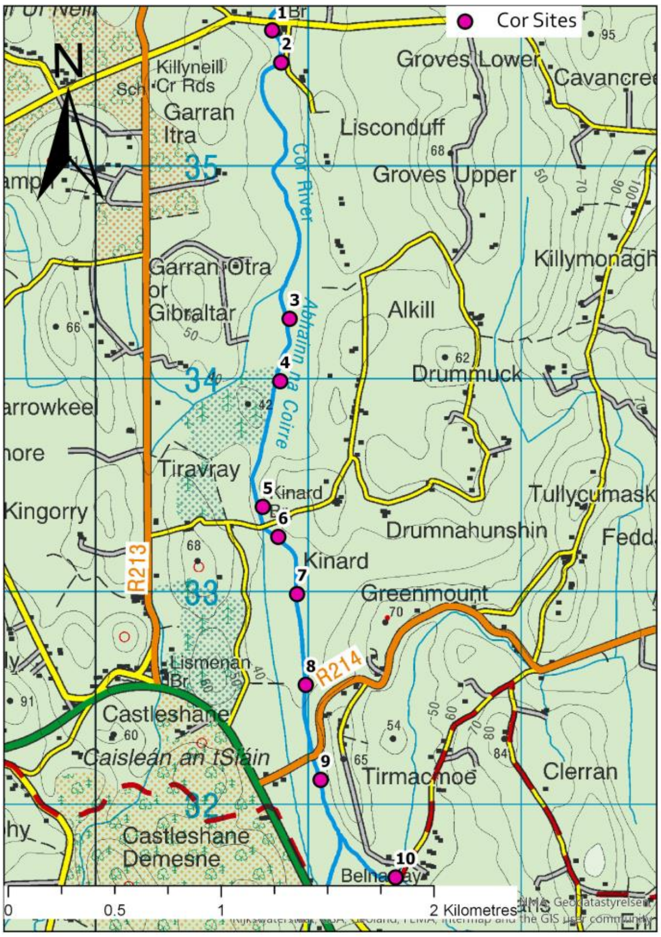


Figure 5.8 Location of monitoring impact and control sample sites on the Cor River. Locations 1-5 are Impact sites and 6-10 are Control sites.

5.2.3 Results

EQRs (Ecological Quality Ratios) range from 0 to 1 that relate to the five WFD classes: High, Good, Moderate, Poor and Bad. EQRs are calculated using FCS2 which is a tool for classifying the ecological status of fish in Irish rivers that satisfies the criteria required by the WFD. The FCS2 models uses a suitable statistical distribution to relate models the number of fish caught on a survey to the abundance and prevalence of the species there, as well as the survey area and a parameter that describes the shape of the statistical distribution. A classification is then provided based on an Ecological Quality Ratio (EQR), which is calculated by comparing observed fish catches with the fish catch that would be expected under reference conditions.

The EQR results show improvement from Poor to Moderate at one Impact site and two Control sites (Table 5.1). In addition, there is an improvement from Moderate to Good in two Control sites. The nature of electrofishing and the observed results should be interpreted with caution. Overall, there were low numbers of fish caught (Figure 5.9) and the numbers increased in both the control and impact sites over the survey years.

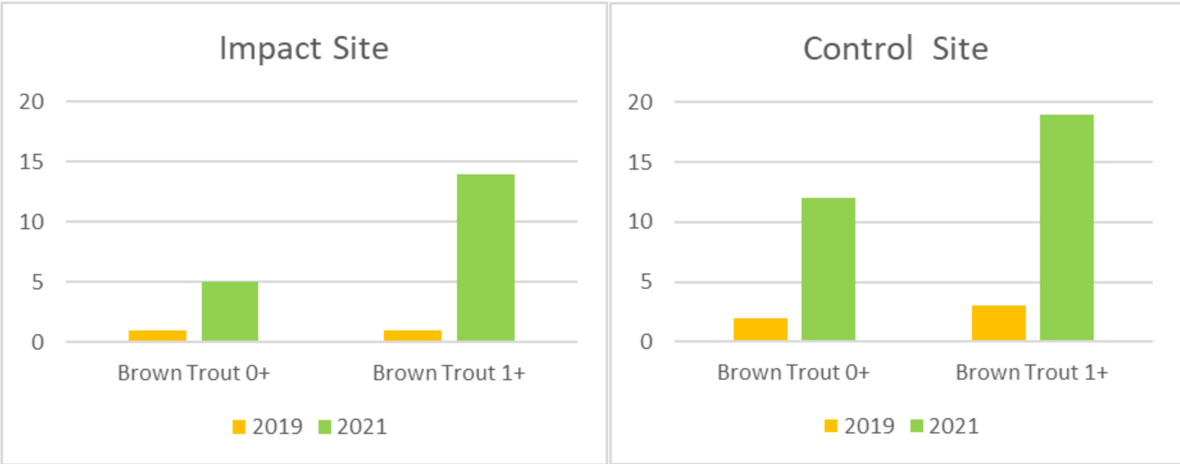


Figure 5.9 Abundance of 0+ and 1+ brown trout caught at the Control and Impact sites, pre- and post-works.

Table 5.1 EQRs for the impact and control sites pre- and post- works

	Before		**After**	
	Site ID	All Species EQR	Site ID	All Species EQR
Impact	1	0.240	1	0.530
	2	0.339	2	0.218
	3	0.062	3	0.143
	4	0.078	4	0.079
	5	0.154	5	0.470
Control	6	0.265	6	0.379
	7	0.045	7	0.301
	8	0.062	8	0.195
	9	0.238	9	0.783
	10	0.233	10	0.736

The results of the RHAT surveys (Table 5.2) at the Control and Impact sites show no difference in the Control site. It scored 14.5 which translates to a Moderate status both before and after the works. The Impact site shows a difference in two attributes: channel form and flow; and bank structure and stability. This increased the overall score by 1.5, still keeping it within its Moderate status, showing improvement even for a drained channel. More gains could potentially be made in improving the RHAT score.

Table 5.2 RHAT scores for the Impact and Control sites, pre- and post-works.

	Impact site		Control site	
RHAT Attribute	**2019**	**2021**	**2019**	**2021**
Channel Form & Flow Types	0	1	1	1
Channel Vegetation	2	2	3	3
Substrate Condition	3	3	3	3
Barriers to Continuity	3	3	2	2
Bank Structure & Stability	2	2.5	1	1
Bank Vegetation	3	3	2.5	2.5
Riparian Land Use	1	1	1	1
Floodplain Connectivity	0	0	1	1
∑ Attribute Scores	13	14.5	14.5	14.5
WFD Class	Moderate	Moderate	Moderate	Moderate

Photographic evidence shows the instream works on the Cor remain intact two years after implementation (Figure 5.10Figure 5.10 Figure 5.11, Figure 5.12).

Figure 5.10 Left photo was taken post-works in 2019, and right photo was taken during a follow up walkover in 2021. It is evident that the pool and riffle remained intact.

Figure 5.11 Left photo was taken pre-works showing a unform glide and the photo on the right taken post-works. Changes in flows are evident following the introduction of paired deflectors which were created using the material from within the channel.

Figure 5.12 Left photo was taken post works of a berm topped during the works and the follow up photo on the right was taken in 2021.

5.2.4 Conclusion

Electrofished sites demonstrated change in classification in both the Control and Impact sites. Overall there were low numbers of fish caught in the pre-works survey. As the graphic outlining brown trout numbers shows, there were increases in numbers of both age classes at both sites. These results are positive, and more surveys would need to be completed at these sites to confidently confirm long-term changes to the fish population here.

The results for both fish and hydromorphology show modest improvements in status. The Impact site improved in overall score but remained within the same RHAT classification band.

The classification bands for the method are wide, and as such there would need to be improvement across a number of attributes to demonstrate significant change.

6 Conclusion/ summary

The current cycle of the Environmental River Enhancement Programme has focussed on WFD-compatible outcomes. This standardisation of metrics within the programme has allowed the collection of data on hydromorphology, barriers and fish at a catchment-wide scale. The work completed over the years 2018 to 2021 shows the importance of evaluating these OPW catchments in terms of complying with the WFD status. The pressures highlighted within designated catchments provide the evidence for implementing restoration measures to directly target these areas by the OPW or by the IFI projects office through Salmon Conservation funding.

Barriers interfering with longitudinal connectivity within rivers continues to remain a key priority for EREP and the OPW. The barrier data collected under EREP feeds into IFI's National Barrier Programme, including the catchment-wide efforts on the Kells Blackwater and Broadmeadow & Ward scheme. The detailed surveys on the Brosna completed by the NBP outline recommendations for a remediation programme. EREP continues to return to historical sites where Capital Works were implemented to assess the efficacy of the implemented measures.

In 2022, the focus will shift to the OPW west region, with a catchment-wide survey of the Lung, part of the upper Shannon river basin. This catchment has a large geographical spread with a dense network of potential barriers to longitudinal connectivity. It has never been surveyed for hydromorphology and was last electrofished at a catchment scale by the EREP in 2011. It will be the final year within the current cycle of the EREP which has completed surveys across all OPW regions, generating valuable datasets for both IFI and the OPW.

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