Cush Wind Farm

Environmental Impact Assessment Report

Annex 5.4: Baseline Aquatic Ecology & Fisheries Survey Reports

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Aquatic baseline report for Cush wind farm, Co. Offaly

Prepared by Triturus Environmental Ltd. for SLR Consulting

November 2022

Please cite as:

Triturus (2022). Aquatic baseline report for Cush wind farm, Co. Offaly. Report prepared by Triturus Environmental Ltd. for SLR Consulting. November 2022.

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1. Introduction

1.1 Background

Triturus Environmental Ltd. were commissioned by SLR Consulting to conduct baseline aquatic surveys to inform EIAR preparation for the proposed Cush wind farm project. The following report provides a baseline assessment of the aquatic ecology including fisheries and biological water quality, as well as protected aquatic species and habitats in the vicinity of the proposed Cush wind farm, located approx. 5km north of Birr, Co. Offaly.

Undertaken on a catchment-wide scale, the baseline surveys focused on aquatic habitats in relation to fisheries potential (including both salmonid and lamprey habitat), white-clawed crayfish (*Austropotamobious pallipes*), freshwater pearl mussel (*Margaritifera margaritifera*) (eDNA only), macro-invertebrates (biological water quality), macrophytes and aquatic bryophytes, aquatic invasive species, and species of conservation value which may use the watercourses in the vicinity of the proposed project (**Figure 2.1**). Aquatic surveys were undertaken in August 2022.

1.2 Project description

A full description of the proposed project is provided in the accompanying Environmental Impact Assessment Report (EIAR).

2. Methodology

2.1 Selection of watercourses for assessment

All freshwater watercourses which could be affected directly or indirectly by the proposed wind farm project were considered as part of the current assessment. A total of *n*=25 riverine sites, *n*=1 canal site and *n*=1 lake site was selected for detailed aquatic assessment (see **Table 2.1, Figure 2.1** below). The nomenclature for the watercourses surveyed is as per the Environmental Protection Agency (EPA). Aquatic survey sites were present on the Woodfield River (EPA code: 25W29), Little Brosna River (25L02), Rapemills River (25R01), Eglish Stream (25E18), West Galros Stream (25W44), Mullaghakaraun Bog Stream (25M48), Milltown Stream (25M79), Feeghroe River (25F41), Whigsborough Stream (25W43), Grant's Island River (25Y47), Bullock Island Stream (25I23), Park River (25P28), Little [Cloghan] River (25L01), River Brosna (25B09), Blackwater River (25B27) and Silver River (25S02), in addition to the Grand Canal and an unnamed quarry lake (**Table 2.1**).

The *n*=27 aquatic survey sites were located within the Shannon[Lower]_SC_060, Shannon[Lower]_SC_040, Shannon[Lower]_SC_030, Brosna_SC_070 and Brosna_SC_080 river sub-catchments. The proposed wind farm site was not located within a European site. However, grid connection route (GCR) option C crossed 3 no. watercourses within the River Shannon Callows SAC (000216) and Middle Shannon Callows SPA (004096). There was also potential downstream hydrological connectivity between the proposed project and River Little Brosna Callows SPA (004086) and Dovegrove Callows SPA (004137).

Please note this aquatic report should be read in conjunction with the final Environmental Impact Assessment Report (EIAR) prepared for the proposed project. More specific aquatic methodology is outlined below and in the appendices of this report.

2.2 Aquatic site surveys

Aquatic surveys of the watercourses within the vicinity of the proposed wind farm project were conducted on Tuesday 23rd to Thursday 25th August 2022. Survey effort focused on both instream and riparian habitats at each aquatic sampling location (**Figure 2.1**). Surveys at each of these sites included a fisheries assessment (electro-fishing and or fisheries habitat appraisal), white-clawed crayfish survey, macrophyte and aquatic bryophyte survey and (where suitable) biological water quality sampling (Q-sampling) or macro-invertebrate sweep sampling. (**Figure 2.1**).

Suitability for freshwater pearl mussel (*Margaritifera margaritifera*) was assessed at each survey site with environmental DNA (eDNA) sampling undertaken for the species at *n*=2 strategically chosen riverine locations within the vicinity of the project. These water samples were also analysed for white-clawed crayfish (*Austropotamobius pallipes*) and crayfish plague (*Aphanomyces astaci*). Furthermore, a composite water sample was also analysed for white-clawed crayfish, crayfish plague, European eel (*Anguilla anguilla*) and smooth newt (*Lissotriton vulgaris*) eDNA at a single quarry lake site adjoining the proposed site boundary. A composite water sample from the proposed GCR crossing of the Grand Canal was analysed for white-clawed crayfish, crayfish plague and invasive quagga mussel (*Dreissena bugensis rostriformis*). This holistic approach informed the overall aquatic ecological evaluation of

each site in context of the proposed project and ensured that any habitats and species of high conservation value would be detected to best inform mitigation for the wind farm project.

In addition to the ecological characteristics of the site, a broad aquatic and riparian habitat assessment was conducted utilising elements of the methodology given in the Environment Agency's 'River Habitat Survey in Britain and Ireland Field Survey Guidance Manual 2003' (EA, 2003) and the Irish Heritage Council's 'A Guide to Habitats in Ireland' (Fossitt, 2000). This broad characterisation helped define the watercourses' conformity or departure from naturalness. All sites were assessed in terms of:

- Physical watercourse/waterbody characteristics (i.e. width, depth etc.) including associated evidence of historical drainage
- Substrate type, listing substrate fractions in order of dominance (i.e. bedrock, boulder, cobble, gravel, sand, silt etc.)
- Flow type by proportion of riffle, glide and pool in the sampling area
- An appraisal of the macrophyte and aquatic bryophyte community at each site
- Riparian vegetation composition

2.3 Fish stock assessment (electro-fishing)

A single anode Smith-Root LR24 backpack (12V DC input; 300V, 100W DC output) was used to electro-fish sites on watercourses in the vicinity of the proposed Cush wind farm in August 2022, following notification to Inland Fisheries Ireland, under the conditions of a Department of the Environment, Climate and Communications (DECC) licence. Electro-fishing was undertaken at all riverine survey sites containing water or where prohibitive depths meant electro-fishing was not viable. Sites A1 (Woodfield River), B2 (Eglish Stream) and B11 (Milltown Stream) were dry at the time of survey, whilst sites B5 (West Galros Stream), B6 (West Galros Stream) and D4 (Grand Canal) were found to not be suitable for electro-fishing due to prohibitive depths. In a similar fashion the quarry lake site (L1) was not suitable for electrofishing. Therefore, a total of *n*=20 sites were surveyed via electro-fishing (**Table 2.1, Figure 2.1; Appendix A**). The survey was undertaken in accordance with best practice (CEN, 2003; CFB, 2008) and Section 14 licencing requirements.

Furthermore, a fisheries habitat appraisal of the aquatic survey sites (**Figure 2.1**) was undertaken to establish their importance for salmonid, lamprey, European eel and other fish species. This was also undertaken at sites where electro-fishing was not feasible due to prohibitive depths (i.e. D4, Grand Canal & L1, Quarry Lake). The baseline assessment also considered the quality of spawning, nursery and holding habitat for salmonids and lamprey within the vicinity of the survey sites. For detailed survey methodology, please refer to accompanying fisheries assessment report in **Appendix A.**

2.4 White-clawed crayfish survey

White-clawed crayfish (*Austropotamobius pallipes*) surveys were undertaken at the aquatic survey sites in August 2022 under a National Parks and Wildlife (NPWS) open licence (no. C31/2022), as prescribed by Sections 9, 23 and 34 of the Wildlife Act (1976-2021), to capture and release crayfish to their site of capture, under condition no. 6 of the licence. As per Inland Fisheries Ireland recommendations, the crayfish sampling started at the uppermost site(s) of the wind farm

catchment/sub-catchments in the survey area to minimise the risk of transfer invasive propagules (including crayfish plague) in an upstream direction.

Hand-searching of instream refugia and sweep netting was undertaken according to Reynolds et al. (2010). An appraisal of white-clawed crayfish habitat at each site was conducted based on physical channel attributes, water chemistry and incidental records in mustelid spraint. Additionally, a desktop review of crayfish records within the wider Cush wind farm survey area was completed.

Table 2.1 Location of n=27 aquatic survey sites in the vicinity of Cush wind farm, Co. Offaly (* indicates eDNA sampling)

Site no.	Watercourse	EPA code	Location	X (ITM)	Y (ITM)
A1	Woodfield River	25W29	Banagher Road R439 crossing	605395	708239
A2	Woodfield River	25W29	Clondallow	605352	707970
A3*	Little Brosna River	25L02	Derrinasallow Bridge	603240	707953
L1*	Quarry lake	n/a	Eglish	608806	709567
B1	Rapemills River	25R01	Eglish	608544	709346
B2	Eglish Stream	25E18	Eglish	608194	709857
B3	Rapemills River	25R01	Boolinarig Bridge	607478	709372
B4	Rapemills River	25R01	Cush	606559	709867
B5	West Galros Stream	25W44	Eglish	608047	710214
B6	West Galros Stream	25W44	N62 road crossing	607627	710485
B7	West Galros Stream	25W44	Cush	606664	710294
B8*	Rapemills River	25R01	Banagher Road R439 crossing	604773	710211
B9	Mullaghakaraun Bog Stream	25M48	Ballyneena	603822	711896
B10	Rapemills River	25R01	All Saints Bridge	602588	711394
B11	Milltown Stream	25M79	Ballyneena	603454	712240
B12	Feeghroe River	25F41	Five Roads Cross	603610	713632
B13	Rapemills River	25R01	Lusmagh Bridge	600120	714650
C1	Whigsborough Stream	25W43	Clooneen	608877	713034
D1	Grants Island River	25Y47	L7014 road crossing	603109	717415
D2	Bullock Island Stream	25I23	L7014 road crossing	603118	717707
D3	Park River	25P28	L7014 road crossing	603143	718403
D4*	Grand Canal	n/a	Griffith Bridge, Shannon Harbour	603604	719282
D5	Little [Cloghan] River	25L01	L7014 road crossing	604150	719834
D6	River Brosna	25B09	Moystown Bridge	604710	720913
D7	Blackwater River	25B27	Blackwater Bridge, R357	601538	723464
E1	Silver River	25S02	Wooden Bridge	612676	714360
E2	Silver River	25S02	Millbrook Bridge	613497	718834

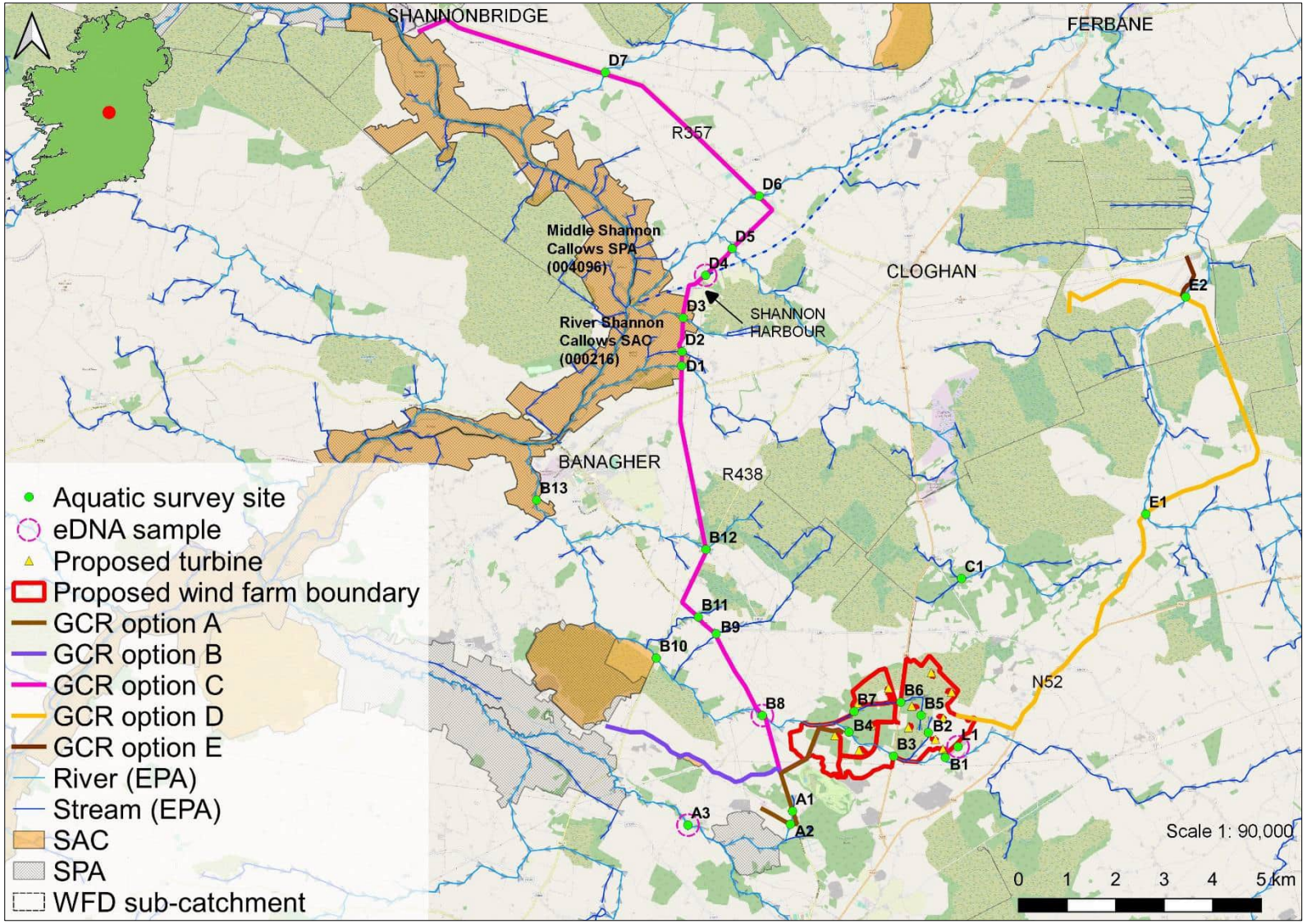

Figure 2.1 Overview of the *n*=27 aquatic survey site locations for Cush wind farm, Co. Offaly

2.5 Freshwater pearl mussel survey (eDNA only)

There are no known freshwater pearl mussel (*Margaritifera margaritifera*) records in the Shannon[Lower]_SC_060, Shannon[Lower]_SC_040, Shannon[Lower]_SC_030, Brosna_SC_070 or Brosna_SC_080 river sub-catchments. This was based on an extensive literature review and also examination of NPWS sensitive species data. However, following to the precautionary principle and to account for any lacunae in data for the species, environmental DNA (eDNA) samples were collected from the Little Brosna River and Rapemills River and analysed for freshwater pearl mussel eDNA to confirm the species' absence within vicinity of the proposed wind farm site. Please refer to section 2.6 (eDNA analysis) below for further detail.

2.6 eDNA analysis

To validate site surveys and to detect potentially cryptically-low populations of sensitive aquatic receptors within the study area, *n*=3 composite water samples were collected from the Little Brosna River (site A3) and Rapemills River (B8) and analysed for freshwater pearl mussel, white-clawed crayfish and crayfish plague environmental DNA (eDNA) (**Figure 2.1**). The water samples were collected on 25th August 2022, with the sites strategically chosen to maximise longitudinal (instream) coverage within the catchment (i.e. facilitating a greater likelihood of species detection). A composite water sample was also collected from the Grand Canal at Shannon Harbour (D4) and analysed for white-clawed crayfish, crayfish plague and invasive quagga mussel[1]. Further, a composite water sample from the small quarry lake at site L1 was analysed for white-clawed crayfish, crayfish plague, European eel (*Anguilla anguilla*) and smooth newt (*Lissotriton vulgaris*).

In accordance with best practice, a composite (500ml) water sample was collected from the sampling point, maximising the geographic spread at the site (20 x 25ml samples at each site), thus increasing the chance of detecting the target species' DNA. The composite sample was filtered on site using a sterile proprietary eDNA sampling kit. The fixed sample was stored at room temperature and sent to the laboratory for analysis with 48 hours of collection. A total of *n*=12 qPCR replicates were analysed for the site. Given the high sensitivity of eDNA analysis, a single positive qPCR replicate is considered as proof of the species' presence (termed qPCR No Threshold, or qPCR NT). Whilst an eDNA approach is not currently quantitative, the detection of the target species' DNA indicates the presence of the species at and or upstream of the sampling point. Please refer to **Appendix C** for full eDNA laboratory analysis methodology.

[1] recently discovered in the Shannon system, in Loughs Ree and Derg and the interconnecting River Shannon (Baars & Minchin, 2021)

2.7 Otter signs

The presence of otter (*Lutra lutra*) within 150m of each aquatic survey site was determined through the recording of otter signs. Notes on the age and location (ITM coordinates) were made for each otter sign recorded, in addition to the quantity and visible constituents of spraint (i.e. remains of fish, molluscs etc.).

2.8 Biological water quality (Q-sampling)

A total of 22. no riverine survey sites were assessed for biological water quality through Q-sampling in August 2022 (sites A1, B2 & B11 were dry at the time of survey**; Figure 2.1).** All samples were taken with a standard kick sampling hand net (250mm width, 500µm mesh size) from areas of riffle/glide utilising a 2-minute kick sample, as per Environmental Protection Authority (EPA) methodology (Feeley et al., 2020). Large cobble was also washed at each site for 1-minute (where present) to collect attached macro-invertebrates (as per Feeley et al., 2020). Samples were elutriated and fixed in 70% ethanol for subsequent laboratory identification. Samples were converted to Q-ratings as per Toner et al. (2005) and assigned to WFD status classes. Any rare invertebrate species were identified from the NPWS Red List publications for beetles (Foster et al., 2009), mayflies (Kelly-Quinn & Regan, 2012), stoneflies (Feeley et al., 2020) and other relevant taxa (i.e. Byrne et al., 2009; Nelson et al., 2011).

Table 2.2 Reference categories for EPA Q-ratings (Q1 to Q5)

Q Value	WFD status	Pollution status	Condition
Q5 or Q4-5	High status	Unpolluted	Satisfactory
Q4	Good status	Unpolluted	Satisfactory
Q3-4	Moderate status	Slightly polluted	Unsatisfactory
Q3 or Q2-3	Poor status	Moderately polluted	Unsatisfactory
Q2, Q1-2 or Q1	Bad status	Seriously polluted	Unsatisfactory

2.9 Lake & Canal macro-invertebrate communities

The lake survey site (L1) and the Grand Canal (D4) was sampled for macro-invertebrates via sweep netting. A standard pond net (250mm width, mesh size 500µm) was used to sweep macrophytes to capture macro-invertebrates. The net was also moved along the lake bed to collect epibenthic and epiphytic invertebrates from the substratum (as per Cheal et al., 1993). A 3-minute sampling period was employed. To ensure appropriate habitat coverage, the sampling period was also divided amongst the range of meso-habitats present at the survey sites to get a representative sample for sub-habitats.

2.10 Macrophytes and aquatic bryophytes

Surveys of the macrophyte and aquatic bryophyte community were conducted by instream wading at *n*=25 riverine, *n*=1 canal and *n*=1 lake survey sites, with specimens collected (by hand or via grapnel) for on-site identification. An assessment of the aquatic vegetation community helped to identify any rare macrophyte species or habitats corresponding to Annex I habitats, e.g. 'Water courses of plain to

montane levels, with submerged or floating vegetation of the *Ranunculion fluitantis* and *Callitricho-Batrachion* (low water level during summer) or aquatic mosses [3260]' (more commonly referred to as 'floating river vegetation').

2.11 Aquatic ecological evaluation

The evaluation of aquatic ecological receptors contained within this report uses the geographic scale and criteria defined in the 'Guidelines for Assessment of Ecological Impacts of National Road Schemes' (NRA, 2009).

2.12 Biosecurity

A strict biosecurity protocol following IFI (2010) and the Check-Clean-Dry approach was adhered to during surveys for all equipment and PPE used. Disinfection of all equipment and PPE before and after use with Virkon™ was conducted to prevent the transfer of pathogens or invasive propagules between survey sites. Surveys were undertaken at sites in a downstream order to minimise the risk of upstream propagule mobilisation. Particular cognisance was given towards preventing the spread or introduction of crayfish plague (*Aphanomyces astaci*) given the known distribution of white-clawed crayfish (*Austropotamobius pallipes*) in the wider survey area. Furthermore, staff did not undertake any work in a known crayfish plague catchment for a period of <72hrs in advance of the survey. Where feasible, equipment was also thoroughly dried (through UV exposure) between survey areas. Any aquatic invasive species or pathogens recorded within or adjoining the survey areas were geo-referenced. All Triturus staff are certified in 'Good fieldwork practice: slowing the spread of invasive non-native species' by the University of Leeds.

3. Receiving environment

3.1 Cush wind farm catchment and survey area description

The proposed Cush wind farm is located in a lowland area within the townlands of Cush, Conspark, Garbally, Pollaghoole, Ballyslavin, Boolinarig Big, Galros West, Galros East and Eglish, approximately 5km north of Birr, Co. Offaly (**Figure 2.1**). The proposed wind farm site is within the Shannon River Basin District and within hydrometric area 25 (Lower Shannon).

The aquatic survey sites were located within the Shannon[Lower]_SC_060, Shannon[Lower]_SC_040, Shannon[Lower]_SC_030 and Brosna_SC_080 river sub-catchments (**Figure 2.1**). The proposed wind farm site is drained by the Rapemills River (25R01), Eglish Stream (25E18), West Galros Stream (25W44), with numerous other watercourses crossed by the proposed GCR alignments.

The watercourses and aquatic surveys sites in the vicinity of Cush wind farm are typically small, lowland depositing channels which have been historically modified for land drainage purposes (FW2; Fossitt, 2000). Predominantly, the watercourses flow over areas of Tournaisian limestone and Visean limestone & calcareous shale (Geological Survey of Ireland data). Land use practices in the wider survey area comprise mixed forests (CORINE 313), agricultural areas (CORINE 242), land principally occupied by agriculture with significant areas of natural vegetation (CORINE 243), peat bogs (CORINE 412) and pastures (CORINE 231).

3.2 Fisheries asset of the survey area

The Little Brosna River is known to support Atlantic salmon (*Salmo salar*), brown trout (*Salmo trutta*), European eel, lamprey (*Lampetra* sp.), minnow (*Phoxinus phoxinus*) and stone loach (*Barbatula barbatula*) (Kelly et al., 2010, 2015).

The Silver [Kilcormac] River (crossed by proposed GCR) is known to support brown trout, European eel, gudgeon (*Gobio gobio*), minnow, perch (*Perca fluviatilis*), three-spined stickleback (*Gasterosteus aculeatus*), stone loach and (occasional) Atlantic salmon (Kelly et al., 2010, 2015). Both the Little Brosna and Silver Rivers also support spawning 'Croneen', a genetically distinct migratory population of potadromous brown trout indigenous to Lough Derg (Igoe et al., 2003).

The Little [Cloghan] River, a tributary of the Brosna River, is known to support stocks of brown trout, minnow, *Lampetra* sp., gudgeon, roach (*Rutilus rutilus*), stone loach and three-spined stickleback (*Gasterosteus aculeatus*) (Kelly et al., 2010, 2015; IFI 2020 data[2]).

The Grand Canal is known to support a range of coarse fish species, including perch, pike (*Esox lucius*), bream (*Abramis brama*), roach, rudd (*Scardinius erythropthalmus*) and their respective hybrids, European eel, tench (*Tinca tinca*) and highly localised common carp (*Cyprinus carpio*) and brown trout (IFI data; McLoone, 2011; Tierney et al., 1999; pers. obs.). *Lampetra* sp. lamprey have also been recorded at a low number of locations, e.g. 11th lock, ROD, 2016; 7th lock, Caffrey et al., 2006; 5th lock, MKO, 2019).

[2] Inland Fisheries Ireland data for Water Framework Directive Fish Ecological Status 2008-2021. Available at https://opendata-ifigis.hub.arcgis.com/datasets/IFIgis::water-framework-directive-fish-ecological-status-2008-2021/

Fisheries data for the other watercourses within the survey area was not available at the time of survey.

3.3 Protected aquatic species

A comprehensive desktop review of available data (NPWS, NBDC & BSBI data) for 10km grid squares containing and adjoining the project (i.e. M91, M92, N00, N01, N02, N11 & N12) identified records for a low number of rare and or protected aquatic species within the vicinity of the proposed wind farm.

A low number of records for Annex II white-clawed crayfish (*Austropotamobius pallipes*) were available for the Little Brosna River, River Brosna, Silver River and Blackwater [Shannonbridge] River (**Figure 3.1**). The Feeghroe River is also known to support white-clawed crayfish (Triturus, 2019). The Grand Canal supports white-clawed crayfish throughout much of its length (NBDC & NPWS data; Swords et al., 2020). No white-clawed crayfish records were available for the 10km grid square N01 (containing the northern extent of the proposed site boundary).

Records for Annex II otter (*Lutra lutra*) were widespread within the respective grid squares. However, most records were historical only (c.1980). More contemporary records (2000 onwards) were available for the Rapemills River, Silver River, Little [Cloghan] River and Blackwater [Shannonbridge] River (**Figure 3.1**).

A high number of records (>50) for the Flora Protection Order species opposite-leaved pondweed (*Groenlandia densa*) were available for back channels of the River Shannon in the vicinity of Meelick near Eyecourt, Co. Galway (grid square M91, data not shown). These records ranged from 1991 to 2021.

A low number of records for the near threatened (Wyse-Jackson et al., 2016) macrophyte tubular water-dropwort (*Oenanthe fistulosa*) were available for the River Shannon callows both north and west of Shannon Harbour and downstream of Friar's Island (NPWS & NBDC data). The species occupies a limited Irish distribution and is found in of damp, often seasonally inundated wetland habitats (Stroh, 2015).

Common frog (*Rana temporaria*) records were widespread in the M91, M92, N00, N01, N02, N11 & N12 grid squares, although none overlapped with the proposed wind farm site (data not shown). A low number of contemporary records for smooth newt (*Lissotriton vulgaris*) were available but these also did not overlap with the proposed project.

3.4 EPA water quality data (existing data)

The following outlines the available water quality data for the watercourses in context of the proposed wind farm project. Only recent water quality is summarised below. There was no contemporary EPA biological monitoring data available for numerous surveyed watercourses, namely the Woodfield River (25W29), Eglish Stream (25E18), West Galros Stream (25W44), Mullaghakaraun Bog Stream (25M48), Milltown Stream (25M79), Feeghroe River (25F41), Whigsborough Stream (25W43), Grant's Island River (25Y47), Bullock Island Stream (25I23) or Park River (25P28).

Please note that biological water quality analysis (Q-sampling) was undertaken as part of this survey, with the results presented in the **section 4** and **Appendix A** of this report.

3.4.1 Little Brosna River

Two contemporary EPA biological monitoring stations were located on the Little Brosna River (25L02). The river achieved **Q3-4 (moderate status)** at Riverstown Bridge near Birr (station RS25L020700) in 2021 (i.e. upstream of proposed project). The river achieved **Q4 (good status)** at station RS25L021000, 2.4km downstream of survey site A3, in 2017.

The middle reaches of Little Brosna River (Little Brosna_060 river waterbody) achieved good status in the 2013-2018 period and was not considered at risk of achieving target good status water quality. However, the upper reaches (Little Brosna_060) and the lower reaches (Incherky_010) both achieved moderate status in the 2013-2018 period. The Little Brosna_060 river waterbody was considered 'at risk' of not achieving good status water quality, primarily due to eutrophication (agriculture) and hydromorphology (EPA, 2019a). The river waterbodies risk of the Incherky_010 was under review at the time of survey.

3.4.2 Rapemills River

A single contemporary EPA biological monitoring station was located on the Rapemills River (25R01). The river achieved **Q3-4 (moderate status)** at survey site B8 (station RS25R010300) in 2017.

The Rapemills River (Rapemills_010 and Rapemills _020 river waterbody) achieved **moderate status** in the 2013-2018 period with both considered 'at risk' of not achieving target good status water quality, primarily due to eutrophication (agriculture) and hydromorphology (EPA, 2019b).

3.4.3 Little [Cloghan] River

Two contemporary EPA biological monitoring stations were located on the Little Brosna River (25L02). The river achieved **Q4-5 (high status)** at station RS25L010200 and RS25L010400 (survey site D5) in 2017.

The upper reaches of Little [Cloghan] River (Little (Cloghan)_010 and Little (Cloghan)_020 river waterbody) achieved poor status in the 2013-2018 period, with the Little (Cloghan)_020 'at risk' of achieving target good status water quality, primarily due to forestry and peat extraction pressures (EPA, 2022). However, the lower reaches (Little (Cloghan)_030) achieved good status in the 2013-2018 period and was not at risk of failing to achieve good status.

3.4.4 Silver River

A number of contemporary EPA biological monitoring stations were located on the Silver River. The river achieved **Q3-4 (moderate status)** at station RS25S020400 (upstream of the project) in 2017 but **Q4 (good status)** at station RS25S020500 (survey site E1) and station RS25S020700 (1.3km downstream of E2).

The upper reaches of Silver River (Silver (Kilcormac)_020 & Silver (Kilcormac)_030 river waterbodies) achieved moderate status in the 2013-2018 period, with both 'at risk' of not achieving target good status water quality. The Silver (Kilcormac)_040 river waterbody achieved good status in the 2013-2018 period and was not at risk of failing to achieve target good status water quality. Moving

downstream, the Silver (Kilcormac)_040 river waterbody achieved moderate status in the 2013-2018 period and was at risk of not achieving target good status water quality. The lower reaches of the Silver River (Brosna_120 river waterbody) achieved good status in the 2013-2018 period with a river waterbodies risk of 'not at risk'.

3.4.5 River Brosna

A number of contemporary EPA biological monitoring stations were located on the lower reaches of the River Brosna. The river achieved **Q3-4 (moderate status)** at station RS25B091000 (upstream of the project) in 2017 but **Q4 (good status)** at station RS25B091100 (survey site D6) in 2021.

The lower reaches of River Brosna (Brosna_130 & Brosna_140 river waterbodies) achieved moderate status in the 2013-2018 period, with both 'at risk' of not achieving target good status water quality.

3.4.6 Blackwater [Shannonbridge] River

Two contemporary EPA biological monitoring stations were located on the Blackwater River (25B27). The river achieved **Q2-3 (poor status)** at station RS25B270110 (upstream of the project) and **Q3-4 (moderate status)** at Blackwater Bridge (station RS25B270200, survey site and RS25L010400 (survey site D7) in 2021

The Blackwater River (Blackwater (Shannonbridge)_010 and Blackwater (Shannonbridge)_020 river waterbodies) achieved **good status** in the 2013-2018 period and were 'under review' and 'not at risk' of achieving good water quality, respectively. The lowermost reaches (Shannon (Lower)_010 river waterbody) were unassigned in terms of water quality and under review at the time of survey.

3.4.7 Grand Canal

The Grand Canal in the vicinity of the project (survey site D4) achieved **good status** in the 2013-2018 period (Grand Canal Main Line (Lower Shannon) waterbody) and were considered 'not at risk' of achieving good status water quality.

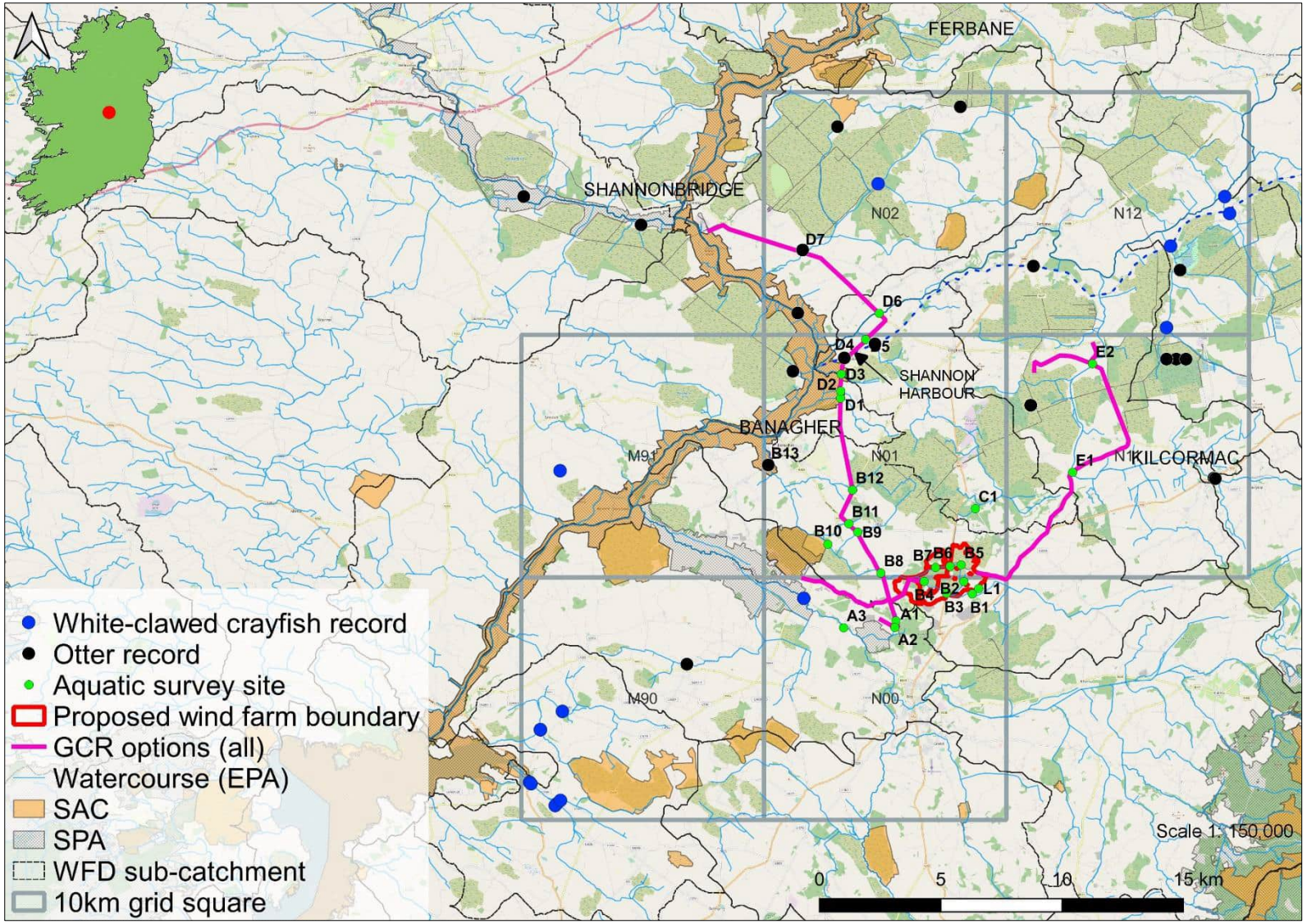

Figure 3.1 Distribution of white-clawed crayfish and otter records in the vicinity of the proposed Cush wind farm (NPWS & NBDC data, 2000 onwards)

4. Results of aquatic surveys

The following section summarises each of the *n*=25 survey sites in terms of aquatic habitats, physical characteristics and overall value for fish, white-clawed crayfish and macrophyte/aquatic bryophyte communities. Biological water quality (Q-sample) results are also summarised for each (wetted) riverine sampling site (*n*=20) and in **Appendix A**. Habitat codes are according to Fossitt (2000). Scientific names are provided at first mention only. Sites were surveyed in August 2022. Please refer to **Appendix A** (fisheries assessment report) for more detailed fisheries results. An evaluation of the aquatic ecological importance of each survey site based on these aquatic surveys is provided and summarised in **Table 4.1**.

4.1 Aquatic survey site results

4.1.1 Site A1 – Woodfield River, R439 road crossing

Site A1 was located on the uppermost reaches of the Woodfield River (25W29) at the R439 road and proposed GCR crossing. The river at this location was 100% dry at the time of survey, with a damp mud base indicative of its ephemeral nature. The shallow U-shaped channel (1.5m bankfull heights) had been historically straightened and deepened with a bed comprised exclusively of deep mud/peat. The channel passed under the R438 via a pipe culvert and was straightened through an agricultural field downstream of the road. The river channel was very heavily tunnelled by dense scrub vegetation supporting blackthorn (*Prunus spinosa*), spindle (*Euonymus europaeus*), elder (Sambucus nigra) and hazel (*Corylus avellana*) with abundant bramble (*Rubus fruticosus* agg.). The site was bordered by scrubby mixed broad-leaved woodland (WD1) and (often wet) improved agricultural grassland (GA1).

Site A1 was not of fisheries value given its dry, ephemeral nature and absence of aquatic habitats. No otter signs were recorded in the vicinity of the site.

Given the dry nature of the site, it was not possible to collected a biological water quality sample at the time of survey.

Given the absence of aquatic habitats in the ephemeral channel, the aquatic ecological evaluation of site A1 was of **local importance (lower value) (Table 4.4).**

Plate 4.1 Representative image of site A1 on the upper reaches of the Woodfield River, August 2022 (dry, ephemeral channel)

4.1.2 Site A2 – Woodfield River, Clondallow

Site A2 was located on the upper reaches of the Woodfield River at a local road crossing, approx. 0.3km downstream of site A1. The river passed under the local road via a twin-bore pipe culvert with a 0.75m fall on the downstream side. The small river (FW2) suffered from very low seasonal water levels at the time of survey, with localised pool of water (0.2m deep) located immediately below to road culvert (i.e. no flow). Upstream of the culvert, the river represented a drainage channel, being 1-1.5m wide and semi-dry in a straightened and deepened heavily silted channel dominated by common reed (*Phragmites australis*). Downstream, the channel averaged 2m wide in a deep, historically modified trapezoidal channel with a mud base. Given the semi-dry, ephemeral nature, no macrophytes or aquatic bryophytes were recorded. The channel was heavily tunnelled by scrub/hedgerow vegetation supporting abundant blackthorn and ivy (Hedera sp.) with elder, hawthorn (*Crataegus monoygna*), dog rose (*Rosa canina*) and bramble. The site was bordered by improved agricultural grassland (GA1).

With the exception of ten-spined stickleback (*Pungitius pungitius*), site A2 was not of fisheries value given its semi-dry, evidently ephemeral nature. A low density of fish were recorded from a shallow, isolated stagnant ($1m^2$) pool immediately below the road culvert. The species is highly tolerant of low oxygen conditions and is often found in very shallow channels exposed to seasonal flow pressures (Lewis et al., 1972). No otter signs were recorded in the vicinity of the site.

Biological water quality, based on Q-sampling, was calculated as **Q3 (poor status)** (**Appendix B**). However, it should be noted that this is a tentative rating given poor flows and lack of suitable riffle areas for sampling (as per Toner et al., 2005). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the absence of aquatic species or habitats of higher conservation value, in addition to poor status water quality, the aquatic ecological evaluation of site A2 was of **local importance (lower value)** (**Table 4.4**).

Plate 4.2 Representative image of site A2 on the upper reaches of the Woodfield River, August 2022

4.1.3 Site A3 – Little Brosna River, Derrinasallow Bridge

Site A3 was located on the Little Brosna River (25L02) at Derrinasallow Bridge, approx. 2.8km downstream of site A2. The large high energy river (FW1 with some depositing characteristics) retained a high degree of naturalness in the vicinity of the bridge, despite some local bank and hydromorphological modifications as part of a derelict mill. The river averaged 12-14m wide and 0.3-0.7m deep. Fast-flowing glide predominated with frequent small pool (to 1.2m) associated with large boulders. The substrata were dominated by cobble and boulder which were compacted due to high flow rates and significant calcification (with abundant cyanobacterial crusts). Small patches of fine and medium interstitial gravels were frequent. Soft sediment deposits were sparse and shallow/flocculent where present. Given the calcified bed, aquatic vegetation was sparse. However, water crowfoot (*Ranunculus* sp.) and variable-leaved pondweed (*Potamogeton gramineus*) were both occasional (small stands). Lesser water parsnip (*Berula erecta*) was present in both emergent and submerged forms but rare overall. Branched bur reed (*Sparganium erectum*), water starwort (*Callitriche* sp.), blue water speedwell (*Veronica anagallis-aquatica*), ivy-leaved duckweed (*Lemna trisulca*) and common duckweed (*Lemna minor*) were present but also rare. Aquatic bryophyte coverage was high with abundant *Leptodictyum riparium* and more occasional submerged *Fissidens crassipes*. *Fontinalis antipyretica* was present but rare. The calcicolous liverwort *Pellia endiviifolia* was frequent, particularly in the vicinity of the bridge. *Marchantia polymorpha* was present but rare. Given low coverage of indicator species, the aquatic vegetation community did not represent Annex I habitat 'Water courses of plain to montane levels, with submerged or floating vegetation of *Ranunculion fluitantis* and *Callitricho-Batrachion* or aquatic mosses [3260]'. The shaded boulder zone under the

bridge supported freshwater sponge (*Porifera* sp.). The riparian zone supported mature treelines of ash (*Fraxinus excelsior*), sycamore (*Acer pseudoplatanus*), hazel and willow (*Salix* spp.) with reed canary grass (*Phalaris arundinacea*), hedge bindweed (*Calystegia sepium*) and pendulous sedge (*Carex pendulata*), with localised water mint (*Mentha aquatica*) and bittersweet (*Solanum dulcamara*). The site was bordered by mixed broad-leaved woodland (WD1), amenity grassland (GA2) and improved grassland (GA1).

Site A3 was of high value for salmonids, with a mixed-cohort population of brown trout (*Salmo trutta*) and a low density of Atlantic salmon (*Salmo salar*) parr recorded via electro-fishing (**Appendix A**). European eel (*Anguilla anguilla*), stone loach (*Barbatula barbatula*) and minnow (*Phoxinus phoxinus*) were also recorded. The site was of most value as a habitat for adult trout, with frequent deeper pool and glide present in addition to naturally scoured banks and occasional overhanging willow. Given high flow rates and compaction/calcification of the bed (which reduced the number of accessible refugia), the site provided sub-optimal nursery conditions, being better suited to Atlantic salmon than trout. The site provided some good spawning habitat for both salmonids and lamprey although suitable substrata were highly localised. Larval lamprey habitat was not present. European eel habitat was moderate overall given a general paucity of accessible instream refugia. Despite some suitability for white-clawed crayfish (*Austropotamobius pallipes*), none were recorded via hand-searching and suitability was sub-optimal given a paucity of accessible instream refugia. However, eDNA sampling at the site detected crayfish (**Table 4.1**) and crayfish remains were identified in old otter spraint on a marginal boulder upstream of the bridge (ITM 603243, 707933). Suitability for otter was high.

Biological water quality, based on Q-sampling, was calculated as **Q3-4 (moderate status)** (**Appendix B**). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the presence of salmonids (including Atlantic salmon), in addition to otter utilisation and detection of white-clawed crayfish, the aquatic ecological evaluation of site A3 was of **local importance (higher value) (Table 4.4).**

Plate 4.3 Representative image of site A3 on the Little Brosna River, August 2022 (facing upstream to bridge)

4.1.4 Site L1 – unnamed quarry lake, Eglish

Site L1 was located at an unnamed lake to the north-west of an active quarry ([redacted]). The small quarry lake covered a surface area of 1.2ha, although the northern end of the lake was being back-filled at the time of survey. The substrata was dominated by hard substrata with flocculent soft sediment deposits in the margins. The lake shelved very steeply in the rocky, compacted margins to an unknown depth. As a result, macrophyte growth was sparse, being limited to narrow fringes of bulrush (*Typha latifolia*), mostly along the western bank, and very occasional broad-leaved pondweed (*Potamogeton natans*). Lesser spearwort (*Ranunculus flammula*) and jointed rush (*Juncus articulatus*) were occasional along the littoral zones. Filamentous algal mats were frequent in the lake margins, indicating enrichment. Calcification of submerged substrata was evident, indicating highly alkaline conditions. Furthermore, the narrow outflowing stream (which adjoined the Rapemills River at site B1) was heavily calcified, averaging 2m wide and <0.2m deep with a compacted cobble bed. The eastern shoreline of the lake supported recolonising bare ground habitat (ED3) and supported typical species such as coltsfoot (*Tussilago farfara*), weld (*Reseda luteola*), wild marjoram (*Origanum vulgare*), yellow wort (*Blackstonia perfoliata*), wild carrot (*Daucus carota*) and purple loosestrife (*Lythrum salicaria*) with scattered shrubby willow (*Salix* sp.). The west bank supported a narrow treeline of mature willow, elder and dense bramble scrub.

Site L1 was of low fisheries value given poor connectivity with downstream habitats, evident enrichment and high turbidity. However, three-spined stickleback (*Gasterosteus aculeatus*) were observed during the site visit. Environmental DNA sampling indicated the absence of European eel, white-clawed crayfish, crayfish plague and smooth newt (*Lissotriton vulgaris*) (**Table 4.1**). Despite some suitability for otter, no signs were recorded around the lake's perimeter.

The lake site was not suitable for biological water quality assessment via Q-sampling. However, a composite sweep sample was taken to gain a representation of the macro-invertebrate community. No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded (**Appendix B**).

Given the absence of habitats or species of high conservation value, the aquatic ecological evaluation of site L1 was of **local importance (lower value)** (**Table 4.4**).

Plate 4.4 Representative image of the quarry lake at site L1, August 2022 (taken from southern shoreline)

4.1.5 Site B1 – Rapemills River, Eglish

Site B1 was located on the upper reaches of the Rapemills River (25R01) near [redacted] at the confluence with the site L1 lake outflow. The lowland depositing watercourse (FW2) had been historically straightened and deepened but retained some good semi-natural characteristics and showed some good instream recovery. The river flowed in a deep U-shaped channel with bankfull heights of 1-2m. The river averaged 2.5m wide and 0.2-0.3m deep. The profile comprised swift-flowing glide with occasional shallow pool (maximum depth 0.6m). Riffle habitat was limited. The substrata were dominated by fine and medium gravels with abundant soft sediment accumulations in association with macrophyte beds and pool slacks. Sand was also present in slower-flowing areas. Cobble was present but rare and exposed to moderate calcification (with cyanobacterial crusts). Boulder was almost entirely absent. The site was heavily vegetated with abundant fool's watercress (Apium nodiflorum) and watercress (*Nasturtium officinale*) and frequent branched bur-reed (*Sparganium erectum*) and heterophyllus lesser water parsnip (*Berula erecta*). Ivy-leaved duckweed (*Lemna trisulca*) and localised stands of iris (*Iris psuedacorus*) were also present occasionally instream. Water mint was present along the channel margins. Aquatic bryophytes were limited to occasional *Fontinalis antipyretica* and the calcicolous liverwort *Pellia endiviifolia*. The moss *Leptodictyum*

riparium was also present on larger substrata. The mature riparian zone supported abundant reed canary grass, great willowherb (*Epilobium hirsutum*), iris, hedge bindweed and bramble with scattered ash, spindle, blackthorn and hawthorn. Livestock poaching and grazing was present along the south bank near the bridge. The site was bordered by intensive agricultural pasture (GA1) and mixed woodland (WD1) with abundant hazel.

Brown trout, lamprey (*Lampetra* sp.) and three-spined stickleback were recorded via electro-fishing at site B1 (**Appendix A**). The site was of high value to salmonids, supporting a moderate density of mixed-cohort brown trout. The population was dominated by adult fish. Fine gravel spawning habitat for both salmonids and lamprey, whilst widespread, was compromised by moderate siltation. The site provided good quality salmonid nursery and holding habitat. The site was a high value lamprey habitat, with excellent quality nursery habitat by way of abundant soft sediment deposits. These supported high densities of c.20 per m^2. Despite high suitability for European eel (abundant instream refugia), none were recorded. Suitability for white-clawed crayfish was high given clay banks for burrowing and abundant macrophytes. However, none were recorded via hand searching. Two regular otter spraint sites (ITM 608547, 709348 and 608550, 709346) were recorded on a clay ledge underneath the bridge. These contained abundant crayfish remains.

Biological water quality, based on Q-sampling, was calculated as **Q3-4 (moderate status)** (**Appendix B**). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the presence of salmonids and Annex II lamprey (*Lampetra* sp.) and utilisation by otter, the aquatic ecological evaluation of site B1 was of **local importance (higher value)** (**Table 4.4**).

Plate 4.5 Representative image of site B1 on the upper reaches of the Rapemills River, August 2022 (taken from quarry access road bridge)

4.1.6 Site B2 – Eglish Stream, Eglish

Site B2 was located on the upper reaches of the Eglish Stream (25E18), approx. 0.7km upstream of the Rapemills River confluence. The channel had been extensively straightened and deepened was dry at the time of survey. The stream represented a 1m-wide peat drainage channel with a dry mud (peat) base with steep trapezoidal banks. These were heavily scrubbed by bramble, bracken (*Pteridium aquilinum*) and willow, with high levels of terrestrial encroachment in the channel indicating an ephemeral nature. The site was bordered by scrubby woodland (WN7) dominated by willow and downy birch (*Betula pubescens*) to the west and intensive pasture (GA1) and arable crops (BC1) to the east.

Site B2 was not of fisheries value given its dry, ephemeral nature and absence of aquatic habitats. No otter signs were recorded in the vicinity of the site.

Given the dry nature of the site, it was not possible to collected a biological water quality sample at the time of survey.

Given the absence of aquatic habitats in the ephemeral channel, the aquatic ecological evaluation of site B2 was of **local importance (lower value) (Table 4.4).**

Plate 4.6 Representative image of site B2 on the Eglish Stream, August 2022 (dry channel)

4.1.7 Site B3 – Rapemills River, Boolinarig Bridge

Site B3 was located on the Rapemills River at Boolinarig Bridge (N62 road crossing). The lowland depositing river (FW2) had been historically straightened and deepened in vicinity of the road crossing (cobbled bridge apron). The river averaged 3-4m wide and 0.5-1m deep, with locally deeper pool to 1.6m downstream of the bridge apron. The deep U-shaped channel featured bankfull heights of 2m and steeply sloping margins. The profile was dominated by deep slow-flowing glide with riffle habitat

confined to the installed cobbles at the bridge. The substrata were dominated by organic-rich silt underlain by compacted cobble, gravels and clay. Installed angular cobbles and occasional boulder were present in vicinity of the bridge, with boulder rare elsewhere. Mixed exposed gravels were very occasional along channel margins. Siltation was high overall given the predominance of deep depositional glide habitat, with frequent deep deposits (some up to 0.5m deep). Given high shading, macrophyte growth was sparse However, heterophyllus fool's watercress was occasional, with infrequent branched bur-reed. Ivy-leaved duckweed was also occasional, with rare common duckweed. Aquatic bryophyte coverage was low overall although the boulder/cobble area downstream of the bridge supported the liverwort *Pellia endiviifolia* (submerged form) and the moss species *Rhynchostegium riparioides* and *Leptodictyum riparium*. Filamentous algal cover (primarily *Vaucheria* sp.) was high (20%), indicating significant enrichment. The river at this location was heavily shaded by mature ash-dominated treelines with frequent grey willow and bramble-dominated understories. The site was bordered by improved agricultural grassland (GA1).

Brown trout and lamprey (*Lampetra* sp.) were the only two fish species recorded via electro-fishing at site B3 (**Appendix A**). Despite evident hydromorphological modifications, site B3 was of good value for salmonids, supporting a moderate density of mixed-cohort brown trout. Spawning habitat for salmonids and lamprey was present but highly localised in the vicinity of the bridge and exposed to moderate to high siltation pressures. The installed cobbles on the bridge apron provided some good quality nursery habitat for juvenile trout (habitat which is rare within the Rapemills River; pers. obs.). Holding habitat was of excellent quality given the predominance of deep glide and pool, with frequent undercut/scoured banks and floating macrophyte vegetation. Despite an abundance of soft sediment accumulations, lamprey nursery habitat was considered of moderate quality only given low flow rates and the generally flocculent nature of the silt. However, a low density of ammocoetes was recorded via targeted electro-fishing. European eel habitat was good given ample refugia although none were recorded. The site provided some good suitability for white-clawed crayfish although none were recorded via sweep netting and hand-searching. However, crayfish remains were identified in otter spraint under the road bridge on marginal boulders (ITM 607476, 709372).

Biological water quality, based on Q-sampling, was calculated as **Q3-4 (moderate status)** (**Appendix B**). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the presence of salmonids and Annex II *Lampetra* sp., in addition to utilisation by otter, the aquatic ecological evaluation of site B3 was of **local importance (higher value)** (**Table 4.4**).

Plate 4.7 Representative image of site B3 on the Rapemills River, August 2022 (facing downstream from bridge)

4.1.8 Site B4 – Rapemills River, Cush

Site B4 was located on the Rapemills River, approx. 1.1km downstream of site B3 (Boolinarig Bridge). The lowland depositing river (FW2) had been extensively historically straightened and deepened throughout, with resulting poor hydromorphology, poor connectivity and poor instream recovery. The river averaged a homogenous 3-4m wide and 0.5-1m deep, with locally deeper glide and pool to 2m. The clay-dominated banks were up to 2m high throughout. The profile was dominated by very slow-flowing depositional glide throughout and this had resulted in a bed comprised almost entirely of deep silt (often >0.5m deep). Widespread livestock poaching also contributed to the silt loads. Hard substrata were almost entirely absent for long sections upstream and downstream of the survey site. Sand accumulations (with a high silt component) were occasional near faster flowing areas. Gravels, where present, were heavily bedded in silt. The river was also very heavily vegetated with >95% cover of macrophytes including frequent branched bur-reed, fool's watercress and water mint, with occasional watercress. Blue water speedwell, ivy-leaved duckweed, common duckweed and water starwort (*Callitriche* sp.) were all occasional. Stands of iris and floating sweet grass (*Glyceria fluitans*) were occasional both instream and along channel margins. Filamentous algae were frequent (*Cladophora* sp.), indicative of the high nutrient conditions. The narrow riparian zones (historically cleared) supported a typical low-diversity nitrophilous community dominated by reed canary grass with occasional meadowsweet (*Filipendula ulmaria*), great willowherb and scattered grey willow. The site was bordered by improved agricultural grassland (GA1) with coniferous afforestation present to the north (WD3).

Brown trout, lamprey (*Lampetra* sp.) and three-spined stickleback were recorded via electro-fishing at site B4 (**Appendix A**). The site was a poor salmonid habitat given gross siltation and very poor hydromorphology, supporting a very low density of adult brown trout only (no juveniles). Salmonid

spawning habitat was not present given siltation pressures, with nursery habitat also of poor quality. The site had some value as a holding habitat given the predominance of deep glide with frequent scoured banks and overhanging vegetation (providing valuable thermal refugia in the near absence of riparian trees). Whilst the site featured abundant soft sediment, few areas were considered optimal for lamprey ammocoetes given poor flows/hydromorphology, However, a low density of ammocoetes were recorded from localised faster-flowing areas (typically associated with instream debris). Despite some low suitability for European eel and white-clawed crayfish, none were recorded. No otter signs were recorded in vicinity of the site (poor marking opportunities).

Biological water quality, based on Q-sampling, was calculated as **Q3 (poor status)** (**Appendix B**). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the presence of salmonids and Annex II *Lampetra* sp., the aquatic ecological evaluation of site B4 was of **local importance (higher value)** (**Table 4.4**).

Plate 4.8 Representative image of site B4 on the Rapemills River, August 2022

4.1.9 Site B5 – West Galros Stream, Eglish

Site B5 was located on the upper reaches of the West Galros Stream (25W44). The stream had been extensively straightened and over-deepened historically (peat drainage) and represented a canal habitat throughout with no observable flow. The heavily modified U-shaped channel featured bankfull heights of 2-2.5m and averaged 5-6m wide and 1.5-1.8m deep. The bed comprised exclusively clay-dominated silt, with very steeply-sloping clay banks. Clay agglomerations (from bank slumping) were frequent instream. Macrophyte cover was low within the channel given historical excavations. However, the canalised channel was fringed by narrow stands of common reed with very occasional water mint and common duckweed. Greater bladderwort (*Utricularia vulgaris* agg.) was present but

rare. The liverwort *Pellia endiviifolia* was frequent on the sloping clay banks. The riparian zone supported abundant herbaceous vegetation including bramble, purple loosestrife, meadowsweet, hedge bindweed, common knapweed (*Centaurea nigra*), bracken and common reed. To the west the channel was lined by very dense (impenetrable) scrubby woodland of downy birch and grey willow. Coniferous afforestation was present upstream. Cutover bog (PB4), with two mature peat settlement ponds, bordered the site to the north.

Electro-fishing was not undertaken at site B5 given prohibitive depths of >1.5m and a deep silt base. With the exception of three-spined stickleback, site B5 was of poor fisheries value given poor hydromorphology, low flows and heavy siltation. However, whilst salmonid spawning and nursery habitat was absent, the site had some low value as a holding habitat for adult trout given the high average depth. Suitability for European eel was high. Whilst no white-clawed crayfish were recorded by sweep netting, burrows in the soft clay banks were evident and frequent throughout the site. Furthermore, the remains of an adult crayfish was identified on the sloping clay banks (possible otter prey remains, see Plate 4.10). In light of the crayfish prey resource, otter suitability was good although no otter signs were recorded in the vicinity of the site (no marking opportunities).

Biological water quality, based on Q-sampling, was calculated as **Q3 (poor status)** (**Appendix B**). However, it should be noted that this is a tentative rating given poor flows and lack of suitable riffle areas for sampling (as per Toner et al., 2005). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the presence of Annex II white-clawed crayfish, in addition to suitability for Red-listed European eel and Annex II otter, the aquatic ecological evaluation of site B5 was of **local importance (higher value)** (**Table 4.4**).

Plate 4.9 Representative image of site B5 on the upper reaches of the West Galros Stream, August 2022

Plate 4.10 Remains of an adult white-clawed crayfish on the sloping clays banks of site B5

4.1.10 Site B6 – West Galros Stream, N62 road crossing

Site B6 was located on the West Galros Stream at the N62 road crossing, approx. 0.5km downstream of site B5. The stream had been extensively straightened and over-deepened historically and represented a canal habitat upstream of the road culvert. Downstream, given a slight gradient, the stream featured slight flow (as opposed to imperceptible flow upstream). The heavily modified U-shaped channel featured bankfull heights of 1.5-2m and averaged 5-6m wide and 1.5-2m deep. The bed comprised exclusively clay-dominated silt, with steeply-sloping clay banks. Clay agglomerations (from bank slumping) were frequent instream. Some localised sand and peat (silt) accumulations were present downstream (alongside abundant fly tipping and instream trash). Macrophyte cover was low within the channel given historical excavations. However, the canalised channel was fringed by narrow stands of common reed with frequent broad-leaved pondweed. Water starwort (*Callitriche* sp.) was present but rare. The liverwort *Pellia endiviifolia* was frequent on the sloping clay banks. The channel was bordered by herbaceous vegetation supporting purple loosestrife, meadowsweet, hedge bindweed, common reed and rank grasses, with scattered bracken scrub (HD1). Blackthorn and grey willow were scattered along the channel. The site was bordered by an immature plantation (WS2) of sycamore on the south bank with scrub on the north. Cutover bog (PB4) was present upstream.

Electro-fishing was not undertaken at site B6 given prohibitive depths of >1.5-2m. With the exception of three-spined stickleback, site B5 was of poor fisheries value given poor hydromorphology, low flows and heavy siltation. However, whilst salmonid spawning and nursery habitat was absent, the site had some low value as a holding habitat for adult trout given the high average depth. Suitability for European eel was high. Whilst no white-clawed crayfish were recorded by sweep netting, burrows in the soft clay banks were evident and frequent throughout the site (as per upstream site B5). In light of this prey resource, otter suitability was good although no signs were recorded in the vicinity of the site (poor marking opportunities).

Biological water quality, based on Q-sampling, was calculated as **Q3 (poor status)** (**Appendix B**). However, it should be noted that this is a tentative rating given poor flows and lack of suitable riffle areas for sampling (as per Toner et al., 2005). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the suitability for Annex II white-clawed crayfish, Annex II otter and Red-listed European eel, the aquatic ecological evaluation of site B6 was of **local importance (higher value)** (**Table 4.4**).

Plate 4.11 Representative image of site B6 on the West Galros Stream, August 2022 (facing upstream from road crossing)

4.1.11 Site B7 – West Galros Stream, Cush

Site B7 was located on the West Galros Stream approx. 0.6km downstream of B6 and 0.8km upstream of the Rapemills River confluence. The lowland depositing stream (FW2) represented a drainage channel and had been extensively historically straightened and deepened throughout, with resulting poor hydromorphology, poor connectivity and poor instream recovery. The stream had a trapezoidal shape and averaged a homogenous 2.5m wide and 0.6-0.8m deep with approx. 2m bankfull heights. Flows were imperceptible at the time of survey. The substrata consisted of a 0.2m deep layer of peat-derived silt on top of a compacted clay / gravel bed. The site supported a very high coverage of macrophytes dominated by common reed with rare water mint, water starwort (*Callitriche* sp.) and common duckweed. Shading was high. The liverwort *Pellia endiviifolia* was occasional on the steeply-sloping banks. The riparian zone supported scattered willow, great willowherb, hedge bindweed and wild angelica (*Angelica sylvestris*). The stream was bordered by improved grassland (GA1), cutover bog (PB4) and coniferous afforestation (WD3).

Three-spined stickleback was the only species recorded via electro-fishing at site B7 (**Appendix A**). With the exception of low densities of three-spined stickleback, the site was not of fisheries value given poor hydromorphology, low flows and heavy siltation, in addition to poor connectivity with downstream habitats. No white-clawed crayfish were recorded by sweep netting and suitability was poor (much improved upstream). No otter signs were recorded in the vicinity of the site.

Biological water quality, based on Q-sampling, was calculated as **Q3 (poor status)** (**Appendix B**). However, it should be noted that this is a tentative rating given poor flows and lack of suitable riffle areas for sampling (as per Toner et al., 2005). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the absence of aquatic species or habitats of higher conservation value, in addition to poor status water quality, the aquatic ecological evaluation of site B7 was of **local importance (lower value)** (**Table 4.4**).

Plate 4.12 Representative image of site B7 on the West Galros Stream, August 2022

4.1.12 Site B8 – Rapemills River, R439 road crossing

Site B8 was located on the Rapemills River at the R439 road and proposed GCR crossing, approx. 2km downstream of site B4 and at the confluence with a small unmapped stream. With the exception of some local bank modifications in vicinity of the pipe culvert and along the roadside, the river had not been modified and retained a largely natural profile. The upland eroding watercourse (FW1) averaged 4m wide and 0.3-0.6m deep. Downstream of the road crossing, the profile of the high energy site was dominated by swift glide with occasional small pool and localised riffle. The substrata were dominated by boulder and cobble, with only localised interstitial mixed gravels. These were compacted due to high flows and also heavily calcified (with cyanobacterial crusts). With the exception of the road culvert area, soft sediment deposits were not present and siltation was low overall (in stark contrast

to upstream sites). Livestock poaching was present downstream of the survey site. Due to high flows and high shading, macrophyte growth was sparse and limited to occasional fool's watercress, water mint and lesser water parsnip (including the submerged form of the latter). However, the site featured a high coverage of aquatic bryophytes (70%) with abundant *Leptodictyum riparium* and *Pellia endiviifolia*. *Rhynchostegium riparioides* was present but rare overall. The site was shaded on the west bank by a narrow mature treeline of sycamore, ash, elder and hawthorn. Upstream of the culvert, the channel was heavily scrubbed (also with mature trees). The site was bordered by the R498 road and improved agricultural grassland (GA1).

Brown trout was the only species recorded via electro-fishing at site B8 (**Appendix A**). The site was of high value for salmonids, supporting a moderate density of mixed-cohort brown trout. The site was considered a good quality salmonid nursery although the value was reduced given the paucity of accessible instream refugia due to calcification of the bed. Spawning habitat was largely absent given compaction and calcification of the substrata. Some excellent quality holding habitat was present in deeper shaded pool and glide areas, many of which were adjoined by scoured banks and tree root systems. These areas also provided good refugia for European eel although none were recorded via electro-fishing. Suitability for lamprey was low due to the high energy nature of the site and more flocculent nature of any soft sediment deposits. The site provided some suitability for white-clawed crayfish although the poor accessibility of many cobble and boulder refugia reduced the value considerably. Environmental DNA sampling at the site did not detect white-clawed crayfish but did detect crayfish plague (**Table 4.1**). Despite good suitability, no otter signs were recorded in the vicinity of the site.

Biological water quality, based on Q-sampling, was calculated as **Q3 (poor status)** (**Appendix A**). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the presence of salmonids, in addition to high otter suitability, the aquatic ecological evaluation of site B8 was of **local importance (higher value) (Table 4.4).**

Plate 4.13 Representative image of site B8 on the Rapemills River, August 2022 (facing downstream from road culvert)

4.1.13 Site B9 –Mullaghakaraun Bog Stream, Ballyneena

Site B9 was located on the Mullaghakaraun Bog Stream (25M48) at the R439 road and proposed GCR crossing, approx. 1.3km upstream of the Rapemills River confluence. The small upland eroding stream (FW1) had been historically straightened in the vicinity of the bridge but not elsewhere. The stream suffered from low seasonal flows at the time of survey and flowed over a slight gradient in a shallow U-shaped channel (1m bank heights). The stream averaged 2-2.5m wide and 0.1-0.15m deep, with only very localised deeper areas (maximum of 0.3m). The profile was of very slow-flowing glide with occasional near-stagnant pool. Given low water levels, glide habitat had become riffle-like near the bridge (box culvert). The substrata were dominated by angular cobble and boulder in the vicinity of the bridge although deep soft sediment deposits were abundant elsewhere. These areas had a very high content of leaf litter and woody debris. Mixed gravels were present downstream of the bridge but highly localised and heavily silted. Siltation was high (exacerbated by low seasonal flows) with low levels of calcification also present. Given high shading upstream of the bridge, macrophytes and aquatic bryophytes were absent. However, downstream of the bridge (and a livestock access point), fool's watercress and branched bur-reed was occasional. The stream was heavily shaded by mature sycamore and hazel dominated treelines upstream of the bridge, with abundant bramble and ivy scrub. Downstream, due to historical clearance, the narrow riparian zones supported herbaceous vegetation and bramble scrub. The site was bordered by improved pasture (GA1).

Lamprey (*Lampetra* sp.) and ten-spined stickleback were the only to fish species recorded via electro-fishing at site B9 (**Appendix A**). The site was of poor value for salmonids (none recorded) given evident siltation and hydromorphological pressures (i.e. poor seasonal flows, forestry upstream etc.). Despite some low suitability as a brown trout nursery and holding habitat, none were recorded via electro-fishing. Likewise, no European eel were recorded despite some low suitability. The site was of

moderate value for *Lampetra* sp., with a low density (4.6 per m^2) of ammocoetes recorded from deep organic-rich soft sediment upstream of the bridge. However, the site was considered sub-optimal for the species given low seasonal flows and a lack of spawning gravels (siltation). Site B9 supported juvenile white-clawed crayfish (hatchlings) which were recorded at low densities in angular cobble and boulder nursery habitat. No otter signs were recorded in the vicinity of the site.

Biological water quality, based on Q-sampling, was calculated as **Q3 (poor status)** (**Appendix B**). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the presence of Annex II *Lampetra* sp. and Annex II white-clawed crayfish, the aquatic ecological evaluation of site B9 was of **local importance (higher value)** (**Table 4.4**).

Plate 4.14 Representative image of site B9 on the Mullaghakaraun Bog Stream, August 2022 (upstream of road crossing)

4.1.14 Site B10 – Rapemills River, All Saints Bridge

Site B10 was located on the Rapemills River at All Saints Bridge (R468 road crossing). As per upstream, the lowland depositing river (FW2) had been historically straightened and deepened throughout. The canalised channel averaged 6-7m wide and >1.2m deep, with shallower areas in the vicinity of the bridge only (0.7m). Deep, very slow-flowing glide predominated with deeper areas representing pool habitat. Riffles were absent. The site was very heavily silted, with deep deposits on the bed of up to 0.2m deep. Harder substrata were limited to localised mixed gravels and very occasional boulder and cobble on the rendered bridge apron. These were heavily silted and also calcified. The site was heavily vegetated with abundant branched-bur-reed with frequent lesser water parsnip and ivy-leaved duckweed. Water starwort (*Callitriche* sp.), fool's watercress and water mint were present occasionally. The liverwort species *Pellia endiviifolia* and *Riccardia chamedryfolia* were present locally.

Filamentous algae coverage was high (>30%) indicating significant enrichment. The riparian zones supported abundant common reed, hedge bindweed, cleavers (*Galium aparine*) and nettle (*Urtica dioica*) with scattered hawthorn, grey willow and osier (*Salix viminalis*). The site was bordered by improved grassland (GA1) and cutover bog (PB4).

Brown trout, European eel, three-spined stickleback and minnow were recorded via electro-fishing at site B10 (**Appendix A**). The site was of moderate value for salmonids only given hydromorphological and gross siltation pressures. The site supported a very low density of adult brown trout, with no juveniles recorded. Spawning habitat was almost entirely absent and sub-optimal where present given calcification and siltation of the bed. The site was not of value as a salmonid nursery (i.e. more suited to coarse fish). European eel habitat was of good quality given abundant instream refugia. However, only a single large adult eel (62.4cm TL) was recorded via electro-fishing. Despite abundant soft sediment deposits, no lamprey ammocoetes were recorded. This was considered reflective of low flows at the (depositional) site. Despite some good suitability, no white-clawed crayfish were recorded. Otter suitability was high although no signs were recorded in the vicinity of the bridge (few marking opportunities).

Biological water quality, based on Q-sampling, was calculated as **Q3-4 (moderate status)** (**Appendix B**). However, it should be noted that this is a tentative rating given poor flows and lack of suitable riffle areas for sampling (as per Toner et al., 2005). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the presence of salmonids and Red-listed European eel, in addition to high otter suitability, the aquatic ecological evaluation of site B10 was of **local importance (higher value) (Table 4.4).**

Plate 4.15 Representative image of site B10 on the Rapemills River at All Saints Bridge, August 2022 (taken from bridge, facing upstream)

4.1.15 Site B11 – Milltown Stream, Ballyneena

Site B11 was located on the upper reaches of the Milltown Stream (25E18) at the R439 road and proposed GCR crossing, approx. 1.5km upstream of the Rapemills River confluence. The channel had been locally straightened and deepened and was dry at the time of survey. The deep U-shaped channel averaged 3m wide with bankfull heights of up to 2m. The bed featured damp mud with frequent scattered cobble and boulder with localised mixed gravels. The presence of dried-out cased caddis species (Glossosomatidae and Sericostomatidae) within the channel, in addition to bank scouring, was indicative of an ephemeral/seasonal watercourse. The site was bordered by mature linear mixed broad-leaved woodland (WD1) supporting ash, hazel, hawthorn, and sycamore with adjoining improved pasture (GA1).

Site B11 was not of fisheries value at the time of survey given its dry, ephemeral nature and absence of aquatic habitats. However, there was some low physical habitat suitability for salmonids and European eel under higher flow periods and such species may migrate from the downstream-connecting Rapemills River. No otter signs were recorded in the vicinity of the site.

Given the dry nature of the site, it was not possible to collected a biological water quality sample at the time of survey.

Given the absence of aquatic habitats in the ephemeral channel, the aquatic ecological evaluation of site B11 was of **local importance (lower value) (Table 4.4).**

Plate 4.16 Representative image of site B11 on the Milltown Stream, August 2022 (downstream of road culvert)

4.1.16 Site B12 – Feeghroe River, Five Roads Cross

Site B12 was located on the Feeghroe River (25F41) at Five Roads Cross on the R438, a proposed GCR crossing. The river had been historically straightened and deepened and also recently realigned (2021) with the installation of an upgraded precast box culvert under the R438 road (Plate 4.17). The lowland depositing river (FW2) suffered from low flows at the time of survey and averaged 2-2.5m wide and 0.2-0.4m deep. The rendered culvert apron was 0.6m deep. The profile was of very slow-flowing glide (near imperceptible flow) with steep, unstable (slumping) banks up to 2m in height. The river was heavily silted throughout (given that it drained cutover bog upstream) with peat-dominated silt deposits of up to 0.3m deep on the bed. Whilst mixed gravels and cobbles were present historically between the R438 and Shannon Harbour road (Triturus, 2019), these had been excavated during culvert installation and hard substrata were no longer present. The heavily-silted channel supported sparse growth of macrophytes although some lesser pondweed (*Potamogeton pusillus*) was present in addition to very occasional branched bur-reed and water starwort (*Callitriche* sp.). Aquatic bryophytes were absent. The modified riparian zones supported grey willow and blackthorn with bramble scrub. The site was bordered by local roads with scrub (WS1) and improved pasture (GA1), with cutover bog (PB4) present upstream.

Brown trout, three-spined stickleback and ten-spined stickleback were recorded via electro-fishing at site B12 (**Appendix A**). The site was of moderate value only for salmonids given gross siltation (from peat escapement), poor hydromorphology and poor seasonal flows. However, the site supported a small population of adult brown trout, with the box culvert providing some suitable holding habitat. Spawning substrata were absent from the site (present in 2019) and nursery habitat was very poor. Suitability for European eel was also poor (none recorded). Poor flows and peat-dominated substrata precluded the presence of lamprey. Despite gross siltation and poor suitability, white-clawed crayfish were present, with a low density of juveniles recorded via hand-searching of silt and woody debris refugia (no other refugia present). No otter signs were recorded in the vicinity of the bridge and suitability was poor.

Biological water quality, based on Q-sampling, was calculated as **Q3 (poor status)** (**Appendix B**). However, it should be noted that this is a tentative rating given poor flows and lack of suitable riffle areas for sampling (as per Toner et al., 2005). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the presence of salmonids and Annex II white-clawed crayfish, the aquatic ecological evaluation of site B12 was of **local importance (higher value)** (**Table 4.4**).

Plate 4.17 Representative image of site B12 on the Feeghroe River at Five Roads Cross, August 2022 (facing upstream to upgraded box culvert)

4.1.17 Site B13 – Rapemills River, Lusmagh Bridge

Site B13 was located on the lower reaches of the Rapemills River at Lusmagh Bridge, approx. 4.4km downstream of site B7 and 1.2km upstream of the River Shannon confluence. The lowland depositing river (FW2) had been straightened, deepened and realigned historically and flowed in an open channel with low-lying banks (up to 2m high). The river averaged a homogenous 6-8m wide and >1.5m deep. Shallower water (ranging from 0.2-0.5m) was present in the vicinity of the bridge. The substrata comprised of cobble and boulder with occasional coarse gravels that were heavily silted. Elsewhere, in deeper, more depositing habitat, the bed was dominated by silt with occasional boulder. Siltation was high overall. Calcification of hard substrata was also evident. Given the site characteristics, macrophyte growth was diverse and profuse with frequent unbranched bur-reed (*Sparganium emersum*), lesser water parsnip and water starwort (*Callitriche* sp.). Common clubrush (*Schoenoplectus lacustris*), blue water speedwell, fool's watercress, water mint and invasive Canadian pondweed (*Elodea canadensis*) were all occasional. Beds of yellow lily (*Nuphar lutea*) were present in deeper glide upstream and downstream of the bridge. Amphibious bistort (*Persicaria amphibia*) and water plantain (*Alisma plantago-aquatica*) were present but rare. The margins supported abundant reed canary grass with occasional iris and water forget-me-not (*Myosotis scorpioides*) with great yellow cress (*Rorippa amphibia*) being rare. Aquatic bryophyte coverage was low overall although the harder substrata in vicinity of the bridge supported *Leptodictyum riparium* and rare *Fontinalis antipyretica*. Filamentous algae and floc[3] were abundant, indicating significant enrichment. The banks were typically open and grazed with occasional patches of bramble scrub with scattered hawthorn.

[3] floc is defined as an aggregation of (mostly dead) organic material, mainly from algae and diatoms, but also with potential origins from decaying macrophytes and associated decomposers (bacteria and fungi). The floc can form a layer at the surface of the substrate, or infiltrate the substrate, generally where there is insufficient flow to keep the material in suspension (Moorkens & Killeen, 2020)

The site was bordered by agricultural grassland (GA1), with frequent livestock poaching. A total of *n*=6 species were recorded via electro-fishing at site B13, namely brown trout, European eel, minnow, three-spined stickleback, stone loach and pike (*Esox lucius*) (**Appendix A**). This was the highest fish species diversity recorded during the survey. The site was of moderate value to salmonids, supporting a low density of primarily adult brown trout. The predominant deeper glide habitat provided some good holding habitat for large trout (e.g. overhanging aquatic vegetation). Some limited nursery habitat was present in the vicinity of the bridge but this was reduced in value given significant siltation pressures. Spawning habitat for salmonids and lamprey was also confined to the bridge area and also impacted by siltation and filamentous algae. Despite abundant soft sediment, no larval lamprey were recorded. The site was of most value for coarse fish habitat given the predominance of heavily vegetated, depositional glide and pool. European eel habitat was good overall given abundant instream refugia (mostly macrophyte beds), although only a low density were recorded via electro-fishing. Despite some suitability for white-clawed crayfish, none were recorded from boulder and cobble refugia via hand searching. No otter signs were recorded in vicinity of the bridge.

Biological water quality, based on Q-sampling, was calculated as **Q3 (poor status)** (**Appendix B**). However, it should be noted that this is a tentative rating given a lack of suitable riffle areas for sampling (as per Toner et al., 2005). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the location of the site within the River Shannon Callows SAC (000216) and Middle Shannon Callows SPA (004096), the aquatic ecological evaluation of site B13 was of **international importance** (**Table 4.4**). The site also supported salmonids and Red-listed European eel.

Plate 4.18 Representative image of site B13 on the lower reaches of the Rapemills River at Lusmagh Bridge, August 2022 (facing downstream from bridge)

4.1.18 Site C1 – Whigsborough Stream, Clooneen

Site C1 was located on the Whigsborough Stream (25W43) at a local road crossing approx. 1.7km north-east of the proposed site boundary. The small stream had been historically straightened and deepened with resulting poor hydromorphology. The stream represented a peat drainage channel and averaged 1-1.5m wide and <0.1m deep with no flows at the time of survey (stagnant pools only). The substrata comprised exclusively deep peat-derived silt, with deposits up to 1m in depth. Peat blockages to flow were frequent instream resulting in intermittent fluvial connectivity. Given very high shading, macrophytes were limited to occasional water mint, fool's watercress and common duckweed in more open areas of channel. Aquatic bryophytes were not recorded. Terrestrial encroachment of the channel was high with abundant reed canary grass, great willowherb and bramble along channel margins. The site was located in an area of heavily-scrubbed, wet mixed broad-leaved woodland supporting abundant sycamore with ash, hawthorn, alder, hazel, elder and grey willow. Coniferous plantations (WD3) were present upstream.

No fish species were recorded via electro-fishing at site C1 (**Appendix A**). The site was not of fisheries value given gross siltation, poor hydromorphology and low flows, in addition to poor connectivity with downstream habitats (frequent peat blockages instream). No white-clawed crayfish were recorded by sweep netting and there was no suitability. No otter signs were recorded in the vicinity of the site.

Biological water quality, based on Q-sampling, was calculated as **Q2-3 (poor status)** (**Appendix B**). However, it should be noted that this is a tentative rating given poor flows and lack of suitable riffle

areas for sampling (as per Toner et al., 2005). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the absence of aquatic species or habitats of higher conservation value, in addition to poor status water quality, the aquatic ecological evaluation of site C1 was of **local importance (lower value)** (**Table 4.4**).

Plate 4.19 Representative image of site C1 on the Whigsborough Stream, August 2022

4.1.19 Site D1 – Grant's Island River, L7014 road crossing

Site D1 was located on the Grant's Island River (25W43) at a local road and proposed GCR crossing approx. 0.8km upstream of the confluence with a River Shannon backwater (i.e. Bullock Island). The small channel had been historically straightened and deepened with resulting poor hydromorphology and evidently intermittent flows. The river represented a peat drainage channel and averaged <1.5m wide and <0.1m deep with no flows at the time of survey (stagnant pools only). The substrata comprised exclusively deep peat-derived silt, with deposits up to 0.5m in depth. Peat and large woody debris blockages to flow were frequent instream resulting in intermittent fluvial connectivity with the River Shannon. Given very high shading, macrophytes were limited to occasional water mint in more open areas of channel. Aquatic bryophytes were not recorded. The site was located in an area of dense (often impenetrable) wet willow-dominated woodland, with abundant osier, grey willow and bramble scrub. The site was bordered by improved (often wet) pasture (GA1).

No fish species were recorded via electro-fishing at site D1 (**Appendix A**). The site was not of fisheries value given gross siltation, poor hydromorphology and low flows, in addition to poor connectivity with downstream habitats (frequent blockages instream). No white-clawed crayfish were recorded by sweep netting and there was no suitability. No otter signs were recorded in the vicinity of the site.

Biological water quality, based on Q-sampling, was calculated as **Q1 (bad status)** (**Appendix B**). However, it should be noted that this is a tentative rating given poor flows and lack of suitable riffle areas for sampling (as per Toner et al., 2005). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the location of the site within the River Shannon Callows SAC (000216) and Middle Shannon Callows SPA (004096), the aquatic ecological evaluation of site D1 was of **international importance** (**Table 4.4**). However, the site supported poor quality aquatic habitats and bad status water quality.

Plate 4.20 Representative image of site D1 on the Grant's Island River, August 2022

4.1.20 Site D2 –Bullock Island Stream, L7014 road crossing

Site D2 was located on the Bullock Island Stream (25I23) at a local road and proposed GCR crossing, approx. 0.7km upstream of the confluence with a River Shannon backwater (i.e. Bullock Island). The stream had been extensively straightened and deepened historically and represented a drainage channel that was dry at the time of survey. However, the damp mud base supporting planorbid snails and the presence of macrophyte species such as common duckweed, indicated the channel held water in the recent past, i.e. an ephemeral channel which can dry out seasonally. The 1.5m wide U-shaped channel supported occasional stands of iris, lesser water parsnip, water mint and fool's watercress instream. The nationally uncommon greater water parsnip (*Sium latifolium*) was also recorded downstream of the road crossing (ITM 603093, 717714). The channel was heavily shaded by a mature treeline of grey willow and osier, with abundant bramble, nettle, ivy and dog rose scrub. The site was bordered by improved grassland (GA1).

Site D2 was not of fisheries value at the time of survey given its dry, ephemeral nature and absence of aquatic habitats. However, given evidence that it supports water seasonally, the channel may be of some low value as a coarse fish and European eel habitat during (winter) higher water periods. No otter signs were recorded in the vicinity of the site.

Given the dry nature of the site, it was not possible to collected a biological water quality sample at the time of survey.

Given the location of the site within the River Shannon Callows SAC (000216) and Middle Shannon Callows SPA (004096), the aquatic ecological evaluation of site D2 was of **international importance** (**Table 4.4**). However, aquatic habitats were absent in the ephemeral channel at the time of survey and the site was not of any aquatic value.

Plate 4.21 Representative image of site D2 on the Bullock Island Stream, August 2022 (dry channel)

4.1.21 Site D3 – Park River, L7014 road crossing

Site D3 was located on the Park River (25P28) at a local road and proposed GCR crossing, approx. 0.7km upstream of the confluence with a River Shannon backwater. The stream had been extensively straightened and deepened historically and represented a drainage channel that was dry at the time of survey. However, the damp mud base and presence of macrophyte species indicated an ephemeral channel which can dry out seasonally. The 2-3m wide U-shaped channel supported abundant wetland herbaceous vegetation including frequent bulrush, water mint, water horsetail (*Equisetum fluviatile*) and occasional lesser water parsnip and water forget-me-not. The riparian areas supported abundant reed sweet grass (*Glyceria maxima*). Terrestrial encroachment was high with frequent grey willow, great willowherb, iris, marsh woundwort (*Stachys palustris*), wild angelica and meadowsweet within the channel. The site was bordered by wet improved grassland (GA1).

Site D3 was not of fisheries value at the time of survey given its dry, ephemeral nature and absence of aquatic habitats. However, given evidence that it supports water seasonally, the channel may be of some low value as a coarse fish and European eel habitat in its lower reaches during (winter) higher water periods. No otter signs were recorded in the vicinity of the site.

Given the dry nature of the site, it was not possible to collected a biological water quality sample at the time of survey.

Given the location of the site within the River Shannon Callows SAC (000216) and Middle Shannon Callows SPA (004096), the aquatic ecological evaluation of site D3 was of **international importance** (**Table 4.1**). However, aquatic habitats were absent in the ephemeral channel at the time of survey and the site was not of any aquatic value.

Plate 4.22 Representative image of site D3 on the Park River, August 2022 (dry, ephemeral channel)

4.1.22 Site D4 – Grand Canal, Griffith Bridge

Site D4 was located on the Grand Canal at Griffith Bridge near Shannon Harbour at a local road and proposed GCR crossing, approx. 1km from the River Brosna/Shannon confluence. The canal (FW3) averaged 14-18m wide and >2m deep. In the vicinity of the bridge the canal banks had been modified with retaining (quay) walls on either bank (i.e. a harbour). However, a more natural bank form was present eastwards of the bridge. The substrata were dominated by silt and clay with occasional boulder and cobble. Typical of the canal, the site supported a diverse range of macrophytes including frequent spiked water-milfoil (*Myriophyllum spicatum*) and arrowhead (*Sagittaria sagittifolia*). Beds of yellow lily, whorled water-milfoil (*M. verticillatum*), shining pondweed (*Potamogeton lucens*), broad-leaved pondweed, water starwort (*Callitriche* sp.), mare's-tail (*Hippuris vulgaris*) and the non-native invasive Nuttall's pondweed (*Elodea nuttallii*) were all occasional. Greater bladderwort (*Utricularia vulgaris* agg.) and the nationally scarce rigid hornwort (*Ceratophyllum demersum*) were present but rare. Shallower littoral areas supported water plantain and bottle sedge (*Carex rostrata*) with riparian fringes dominated by reed sweet grass, common reed and common clubrush. The moss *Fontinalis antipyretica* was abundant on quay walls, with occasional *Platyhypnidium riparioides*. Filamentous algal mats were present along the channel margins. The narrow riparian zones were

dominated by amenity grassland (GA2) and towpaths (BL3) although strips of dry meadows habitat (GS2) supporting herbaceous vegetation were present. The site was bordered by buildings (BL3), improved pasture (GA1) and scattered treelines of sycamore, ash and willow species.

Electro-fishing was not undertaken at site C4 given prohibitive depths of >1.5-2m. Site D4 was of high value to European eel and a range of coarse fish species. The site was of highest value as a coarse fish spawning and nursery habitat given an abundance of macrophytes. The site was not considered of value to salmonids given poor connectivity with the River Shannon and River Brosna (i.e. upstream of 36th lock). Suitability for white-clawed crayfish was high and eDNA analysis detected the species at the site (see section 4.3). However, crayfish plague eDNA was also detected in the sample. Despite some good foraging and commuting suitability, no otter signs were recorded in vicinity of the bridge.

The canal site was not suitable for biological water quality assessment via Q-sampling. However, a composite sweep sample was taken to gain a representation of the macro-invertebrate community. No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded (**Appendix B**). The invasive zebra mussel (*Dreissena polymorpha*) was locally abundant at the site, with a low abundance of the non-native amphipod *Chelicorophium curvispinum*.

Given the location of the site within the Grand Canal pNHA (002104), the aquatic ecological evaluation of site D4 was of **national importance** (**Table 4.1**). The site was of high value for Red-listed European eel and coarse fish and also supported Annex II white-clawed crayfish (detected via eDNA analysis).

Plate 4.23 Representative image of site D4 on the Grand Canal at Griffith Bridge, August 2022 (facing westwards from bride)

4.1.23 Site D5 – Little River, L7014 road crossing

Site D5 was located on the Little [Cloghan] River (25L01) at the L7014 road and proposed GCR crossing, approx. 0.5km upstream of the River Brosna confluence. The lowland depositing watercourse (FW2) had been extensively straightened and over-deepened in the vicinity of the road crossing, with a deep trapezoidal bank and 3m bankfull heights. The river averaged 2-2.5m wide and 0.2-0.4m deep. The water width reduced to <1.5m downstream of the bridge in a heavily vegetated channel of up to 3m wide. The profile comprised slow-flowing glide with frequent small pool. Riffle was confined to a short section upstream of the bridge (resulting from instream debris). The substrata were dominated by mixed gravels and cobble with frequent boulder. However, these were heavily silted and soft sediment deposits were abundant throughout, particularly in deeper depositional glide downstream of the road crossing. Sediment accumulations were humic in nature and featured a high proportion of leaf litter and woody debris. Upstream of the bridge, macrophyte growth was limited to marginal stands of fool's watercress with occasional water mint. Downstream, the river was more heavily vegetated with abundant branched bur-reed and reed sweet grass instream, in addition to abundant water mint and frequent fool's watercress. Water forget-me-not was occasional. Common duckweed was present but confined to pool areas. Aquatic bryophytes were limited to occasional *Pellia* sp. The steeply-sloping banks supported abundant herbaceous vegetation comprising hedge bindweed, nettle, hogweed (*Heracleum sphondylium*), great willowherb and purple loosestrife with scattered sycamore and willow. Dense hawthorn, blackthorn and willow hedgerows (WL1) lined the channel upstream, providing a greater degree of shading compared with downstream. The site was bordered by improved agricultural grassland (GA1) and private residential areas.

A total of *n*=6 species were recorded via electro-fishing at site D5, namely brown trout, lamprey (*Lampetra* sp.), European eel, minnow, stone loach and roach (*Rutilus rutilus*) (**Appendix A**). This was the highest fish species diversity recorded during the survey. Site D5 was of moderate value to salmonids only given significant siltation pressures and poor hydromorphology resulting from historical arterial drainage. However, the site supported a low density of adult brown trout. Spawning habitat for both salmonids and lamprey was present but highly localised and significantly impacted by siltation. Occasional deeper pool and deeper glide habitat provided some good holding opportunities for adult trout. The site was a poor quality salmonid nursery, as reflected in the absence of juveniles recorded during electro-fishing. In contrast, the site was of high value as a lamprey nursery, with high densities of larvae recorded from abundant soft sediment areas (average >10 per m^2). European eel habitat was moderate overall, with a low density present. The site was of greater value as a coarse fish habitat and supported roach, stone loach and minnow. Despite some low suitability for white-clawed crayfish, none were recorded. No otter signs were recorded in the vicinity of the bridge. However, a non-native mink (*Neovison vison*) spraint site was recorded on a marginal boulder upstream of the bridge.

Biological water quality, based on Q-sampling, was calculated as **Q3 (poor status)** (**Appendix B**). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the presence of salmonids, Annex II *Lampetra* sp. and Red-listed European eel, the aquatic ecological evaluation of site B12 was of **local importance (higher value)** (**Table 4.4**).

Plate 4.24 Representative image of site D5 on the Little River, August 2022 (facing downstream towards bridge)

4.1.24 Site D6 – River Brosna, Moystown Bridge

Site D6 was located on the River Brosna (25B09) at Moystown Bridge at the R357 road and proposed GCR crossing, approx. 4km upstream from the River Shannon confluence. With the exception of some local bank modifications (e.g. boulder revetment) in the vicinity of the bridge, the large lowland depositing watercourse (FW2) was natural in profile. The river averaged 20-25m wide and 0.5-0.8m deep, with frequent small pool to 1.4m in association with natural boulder and bedrock. The profile comprised swift-glide and pool with riffle present downstream of the rendered bridge apron. The substrata of the undulating, high-energy site were dominated by calcareous bedrock and cobble with frequent large boulder. However, these were heavily calcified and compacted. Localised patches of fine and medium gravels with some sands were present in pool slacks but these were rare. Soft sediment deposits were frequent along treelined margins (sand dominated). Siltation was low overall given high flow rates. Macrophyte growth was largely restricted to channel margins, with occasional small stands of heterophyllous common clubrush instream. The margins supported abundant reed canary grass with occasional branched bur-reed and common clubrush in addition to water mint, lesser water parsnip and water forget-me-not. Great yellow cress was also occasional. The site was dominated by aquatic bryophytes with very high coverage of *Rhynchostegium riparoides* and frequent *Fontinalis antipyretica.* The mosses *Leptodictyum riparium* and *Fissidens crassipes* were present but rare overall. The liverwort species *Pellia endiviifolia* and *Riccardia chamedryfolia* were locally frequent along channel margins. The river was lined by mature treelines dominated by grey willow, with frequent ash and sycamore. The site was bordered by improved pasture (GA1).

Electro-fishing was not undertaken at site D6 given the large width, prohibitive depths and high flow rates. However, the site was of high value for salmonids being most suited to adults given a predominance of deeper glide and pool. Overhanging willow-dominated treelines provided valuable shading and cover. Whilst some spawning substrata was present for both salmonids and lamprey, this was highly localised (rare overall). Salmonid nursery habitat was superficially good although closer inspection of instream substrata revealed a paucity of accessible refugia due to substrate compaction and calcification. Furthermore, macrophyte refugia cover was low. The high-energy site was largely unsuitable as a lamprey nursery habitat (high flow rates), though some sub-optimal habitat was present away from main flow channels. The site was of relatively poor value for European eel given a paucity of instream refugia. However, the River Brosna is known to support European eel in addition Atlantic salmon, brown trout, lamprey (*Lampetra* sp.), minnow and stone loach (Kelly et al., 2010, 2015). Two gudgeon (*Gobio gobio*) were recorded during kick sampling. Suitability for white-clawed crayfish was moderate, at best, given a paucity of instream refugia. None were recorded via hand-searching. A single otter spraint site was recorded on a marginal boulder underneath the eastern arch of the bridge (ITM 604731, 720911, no crayfish remains identified).

Biological water quality, based on Q-sampling, was calculated as **Q3-4 (moderate status)** (**Appendix B**). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the suitability for salmonids, Red-listed European eel, Annex II *Lampetra* sp. and utilisation by Annex II otter, the aquatic ecological evaluation of site D6 was of **local importance (higher value) (Table 4.4).**

Plate 4.25 Representative image of site D6 on the River Brosna at Moystown Bridge, August 2022 (facing downstream from bridge)

4.1.25 Site D7 – Blackwater River, Blackwater Bridge

Site D7 was located on the lower reaches of the Blackwater River (25B27) at Blackwater Bridge (R357), a proposed GCR crossing approx. 2km upstream from the River Shannon confluence. The lowland depositing river (FW2) had been extensively straightened and deepened in the vicinity of the bridge. The site featured a trapezoidal channel with steep excavated banks of up to 2.5m. The river suffered from very low flows at the time of survey and averaged a homogenous 6-7m and 0.1-0.3m deep (in a channel of up to 10m wide). The profile was of very slow flowing glide, with small pools created by occasional large woody debris (i.e. fallen trees and debris dams). The river at this location suffered from gross siltation, with deep peat-dominated deposits of up 0.3m deep on the bed. Peat agglomerations were frequent instream. Boulder was present locally but heavily bedded in silt (except on the rendered bridge apron). Given gross siltation and high riparian shading, macrophyte growth was sparse with only very localised yellow lily and variable-leaved pondweed. Scattered fool's watercress, water plantain and water forget-me-not grew along the muddy paludal. Instream bryophytes were absent with abundant *Conocephalum conicum* and *Pellia* sp. on muddy banks. The riparian zones supported mature narrow treelines of ash and hawthorn with occasional sycamore. The site was bordered by improved agricultural grassland (GA1) with cutover bog (PB4) upstream.

A total of *n*=4 fish species were recorded via electro-fishing at site D7, namely brown trout, lamprey (*Lampetra* sp.), minnow and stone loach (**Appendix A**). The site was of very poor value for salmonids given poor hydromorphology and gross siltation. However, a single adult brown trout was recorded via electro-fishing alongside a very low density of stone loach and minnow. The site was of very high value for *Lampetra* sp., with abundant soft sediment habitat and high densities of ammocoetes (>15 per m^2). Lamprey spawning habitat was almost entirely absent in the vicinity of the bridge (superficial gravels at one location only near a debris dam), indicating superior spawning habitat was present upstream. Despite some suitability for European eel, none were recorded. The site had poor suitability for white-clawed crayfish given very high levels of siltation and none were recorded via sweep sampling of hand-searching of instream refugia. However, fresh crayfish remains were identified in otter spraint recorded near the bridge (ITM 601536, 723473). A second otter spraint site (ITM 601536, 723479) was recorded on the bridge ledge (west bank). A third, regular spraint site, containing abundant crayfish remains, with prints, was recorded on a marginal muddy ledge and willow trunk (ITM 601529, 723448). Crayfish burrows were also identified in soft loamy banks.

Biological water quality, based on Q-sampling, was calculated as **Q3-4 (moderate status)** (**Appendix B**). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the presence of salmonids and Annex II *Lampetra* sp., utilisation by Annex II otter and likely presence of Annex II white-clawed crayfish, the aquatic ecological evaluation of site D7 was of **local importance (higher value) (Table 4.4).**

Plate 4.26 Representative image of site D7 on the Blackwater River at Blackwater Bridge, August 2022 (downstream of bridge)

4.1.26 Site E1 – Silver River, Wooden Bridge

Site E1 was located on the Silver River (25S02) at Wooden Bridge, a proposed GCR crossing. The lowland depositing watercourse (FW2) had been extensively straightened and deepened historically, with a deep trapezoidal channel and bankfull heights of up to 5-6m in vicinity of the bridge. However, some good instream recovery was evident. The river averaged 12m wide and 0.3-0.5m deep near the bridge in shallower glide habitat, although upstream and downstream areas were dominated by deeper, depositional glide and pool to 2.5m in depth. In vicinity of the bridge the bed comprised mixed gravels and cobble with frequent sand accumulations and occasional boulder. However, these were heavily silted. Elsewhere, in deeper glide and pool, silt dominated the bed. Siltation was moderate to high overall. The bridge apron was rendered and supported marginal silt beds. The site featured a relatively high cover of macrophytes with frequent stands of common clubrush, unbranched bur-reed and variable-leaved pondweed. Water mint, fool's watercress and blue water speedwell were occasional. Aquatic bryophyte coverage was low with only very occasional *Leptodictyum riparium* and *Riccardia chamedryfolia*. Freshwater sponge (*Porifera* sp.) was occasional on larger boulder and cobble. Filamentous algae and floc cover was high, indicating significant enrichment. The steep banks supported abundant hedge bindweed with iris, water figwort (*Scrophularia umbrosa*), nettle, thistles (*Cirsium* spp.), bramble and scattered grey willow and osier. The site was bordered by improved grassland (GA1).

A total of *n*=5 fish species were recorded via electro-fishing at site E1, namely brown trout, lamprey (*Lampetra* sp.), minnow, three-spined stickleback and stone loach (**Appendix A**). Despite significant siltation pressures, site E1 was of good value to salmonids, supporting a moderate density of primarily adult trout. The site was of most value as an adult trout habitat given an abundance of deep glide with high instream cover. The site was of moderate value as a nursery given compaction of instream

refugia. Whilst mixed gravels and small cobble present downstream of the bridge provided some localised spawning habitat for salmonids and lamprey, the value was reduced given siltation pressures. Despite frequent sand and silt accumulations, the site supported only a low density of lamprey ammocoetes (<1 per m^2). Whilst no European eel were recorded, the site provided some good suitability (e.g. deep, macrophyte-rich glide). The site also provided good suitability for white-clawed crayfish but none were recorded via hand-searching. No otter signs were recorded in the vicinity of the site.

Biological water quality, based on Q-sampling, was calculated as **Q3-4 (moderate status)** (**Appendix B**). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the presence of salmonids and Annex II *Lampetra* sp., the aquatic ecological evaluation of site E1 was of **local importance (higher value) (Table 4.4).**

Plate 4.27 Representative image of site E1 on the Silver River at Wooden Bridge, August 2022 (facing downstream from bridge)

4.1.27 Site E2 – Silver River, Millbrook Bridge

Site E2 was located on the Silver River at Millbrook Bridge, a proposed GCR crossing approx. 5km downstream of site E1. The lowland depositing watercourse (FW2) had been extensively straightened and deepened historically, with a deep trapezoidal channel and steep bankfull heights of up to 5-6m in vicinity of the bridge. The river averaged 10m wide and 0.5-0.8m deep near the bridge in shallower glide habitat, although upstream and downstream areas featured deeper glide and pool to >2m. In the vicinity of the bridge the bed comprised abundant cobble and frequent boulder with interstitial mixed gravels (including on the bridge apron). Areas of finer gravels were present but sparse. Soft sediment accumulations were occasional along the steeply-sloping margins upstream of the bridge

and also in association with frequent instream macrophyte beds. Siltation was moderate to high overall with locally high calcification. The site featured a relatively high cover of macrophytes with frequent stands of heterophyllus common clubrush and variable-leaved pondweed. Unbranched bur-reed was present but rare. Fool's watercress and water mint were very occasional along the rocky margins. The duckweed species *Lemna trisulca* and *L. minor* were present but rare. Aquatic bryophyte coverage was high with abundant *Chiloscyphus polyanthos* and frequent *Fissidens crassipes*. The mosses *Fontinalis antipyretica* and *Leptodictyum riparium* were present but localised. *Riccardia chamedryfolia* was also localised. Freshwater sponge (*Porifera* sp.) was very occasional on larger boulder and cobble. Filamentous algae and floc cover was low to moderate. The steep banks supported dense hedgerows and treelines of sycamore, alder, blackthorn and willow with dense bramble-dominated scrub. The site was bordered by improved grassland (GA1).

A total of *n*=4 fish species were recorded via electro-fishing at site E2, namely Atlantic salmon, brown trout, lamprey (*Lampetra* sp.) and stone loach (**Appendix A**). Site E2 was of good value for salmonids, supporting a moderate density of primarily adult brown trout. A single Atlantic salmon parr was also captured. The site was of highest value as an adult holding habitat given the predominance of deeper glide and pool with frequent macrophyte beds. These areas also provided some good quality nursery although densities of juveniles were low given the reduced spawning capacity of the site due to bedding, siltation and calcification pressures. Nevertheless, some good quality spawning habitat was present locally for both salmonids and lamprey. Good quality larval lamprey habitat was also present locally although these areas supported only low densities of ammocoetes (<4 per m^2). Despite some good suitability for both European eel and white-clawed crayfish, none were recorded, likely reflecting the relative paucity of accessible boulder and cobble refugia. No otter signs were recorded in vicinity of the site. However, non-native mink spraint was recorded c.5m upstream of the bridge on a marginal mound (west bank).

Biological water quality, based on Q-sampling, was calculated as **Q3 (poor status)** (**Appendix A**). No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via Q-sampling.

Given the presence of salmonids (including Atlantic salmon) and Annex II *Lampetra* sp., the aquatic ecological evaluation of site E2 was of **local importance (higher value) (Table 4.4).**

Plate 4.28 Representative image of site E2 on the Silver River at Millbrook Bridge, August 2022 (facing upstream from bridge)

4.2 White-clawed crayfish

Live white-clawed crayfish were recorded from sites on the Mullaghakaraun Bog Stream (B9) and Feeghroe River (B12). Both sites supported low densities of juveniles only.

Crayfish remains were identified in otter spraint at sites on the Little Brosna River (site A3), Rapemills River (B1 & B3) and Blackwater River (D7). The remains on an adult crayfish (possibly preyed upon by otter) were also recorded at site B5 on the West Galros Stream, in addition to widespread crayfish burrows in sloping clay banks. Crayfish burrows were also visibly widespread at site B6 on the West Galros Stream.

Environmental DNA analysis detected white-clawed crayfish in the Little Brosna River (site A3) and Grand Canal (site D4) (see below section 4.3).

4.3 eDNA analysis

Composite water samples collected from the from the Little Brosna River (site A3) and Rapemills River (B8) returned a negative result for freshwater pearl mussel eDNA, i.e. freshwater pearl mussel eDNA not present or was present below the limit of detection in a series of 12 qPCR replicates (0 positive replicates out of 12, respectively) (**Table 4.1** above; **Appendix D**). These results were considered as evidence of the species' absence at and or upstream of the sampling locations and support the absence of records for the species within the wider survey area.

Both the Little Brosna River (Site A3) and Grand Canal (D4) tested positive for white-clawed crayfish eDNA (7 and 2 positive qPCR replicates out of 12, respectively) (**Table 4.1**; **Appendix C).** However, no crayfish eDNA was detected in the quarry lake at site L1 or the Rapemills River (site B8), i.e. eDNA not

present or was present below the limit of detection in a series of 12 qPCR replicates**.** This was despite crayfish remains being recorded in otter spraint at two sites on the Rapemills River during August 2022 (sites B1 & B3).

Crayfish plague eDNA was detected in the Little Brosna River (12 positive qPCR replicates out of 12), Rapemills River (1 positive qPCR replicates out of 12) and Grand Canal (1 positive qPCR replicates out of 12) (**Table 4.1**; **Appendix C).** These results were considered as evidence of the species' presence at and or upstream of the sampling locations. Crayfish plague eDNA was not detected in quarry site L1 (0 positive qPCR replicates out of 12).

The quarry lake (site L1) sample tested negative for European eel and smooth newt eDNA (0 positive qPCR replicates out of 12) (**Table 4.1**). These results were considered as evidence of the species' absence within the lake.

The Grand Canal sample (site D4) tested negative for invasive quagga mussel (*Dreissena rostriformis bugensis*) eDNA (0 positive qPCR replicates out of 12) (**Table 4.1**).

4.4 Otter signs

Despite some good suitability at numerous survey locations, otter signs were only recorded at a total of *n*=5 sites during the course of aquatic surveys undertaken in August 2022.

Regular otter spraint sites were recorded at sites on the Rapemills River (B1 & B3), River Brosna (D6) and Blackwater River (D7). An old otter spraint site (not regularly used) was also recorded on the Little Brosna River at site A3. With the exception of site D6 on the River Brosna, all spraint sites recorded contained identifiable white-clawed crayfish remains. Fresh otter prints were recorded on littoral mud alongside regular spraint sites at site D7 on the Blackwater River.

No breeding (holts) or resting (couch) areas were identified in the 150m vicinity of the survey sites in August 2022.

4.5 Invasive aquatic species

Zebra mussel (*Dreissena polymorpha*) was recorded in high abundances at site D4 on the Grand Canal in August 2022. This invasive bivalve is well-established in the Shannon catchment, having proliferated in the mid to late 1990's (Minchin et al., 2002). Zebra mussel is both considered a high-risk impact species in Ireland (O' Flynn et al., 2014) and is subject to restrictions under Regulations 49 and 50 of the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations 2011-2021 (S.I. 477/2011).

The non-native (potentially invasive) amphipod species Caspian mud shrimp (*Chelicorophium curvispinum*) was also recorded, in low numbers, at site D4 on the Grand Canal. The species is commonly found associated with the druses[4] of the zebra mussel and has been known in the Shannon system since 2003 (Lucey et al., 2004).

[4] Druses are aggregates of live mussels

The New Zealand mud snail (*Potamopyrgus antipodarum*) was the most widespread non-native invertebrate recorded in the study being recorded at sites A2, B1, B3, B4, B5, B6, B7, B8, B10, B12, D6, D7, E1 and E2. The species is thought to have been introduced to Ireland in the early 19th century and has a ubiquitous distribution nationally (Anderson, 2016). The species can dominate molluscan communities and reduce the growth rates of native molluscs while also resulting in weight loss to fish species that consume it in abundance, given it survives passage through the digestive tract (CABI, 2020 & references therein).

Environmental DNA analysis (site D4 only) and macro-invertebrate sampling did not detect quagga mussel (*Dreissena bugensis rostriformis*), an invasive bivalve mollusc recently discovered in the Shannon system, in the vicinity of Loughs Ree and Derg (Baars & Minchin, 2021). However, eDNA analysis did detect the non-native pathogen crayfish plague (*Aphanomyces astaci*) in the Little Brosna River, Rapemills River and Grand Canal (**Table 4.1**; see section 4.3 above).

Roach (*Rutilus rutilus*) is a medium impact invasive fish species in Ireland (O'Flynn et al., 2014) also listed on the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations 2011-2021 (S.I. 477/2011) and was recorded via electro-fishing at site D5 on the Little [Cloghan} River.

The invasive macrophyte Nuttall's pondweed (*Elodea nuttallii*) was recorded at site D4 on the Grand Canal. The closely related Canadian pondweed (*Elodea canadensis*) was recorded at site B13 on the lower Rapemills River. Both species are very widespread in Ireland and are listed on the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations 2011-2021 (S.I. 477/2011). Both are considered a high-risk invasive species in Ireland (O' Flynn et al., 2014).

Spraint of the invasive mink (*Neovison vison*) was recorded at sites D5 (Little River) and E2 (Silver River).

Table 4.1 eDNA results in the vicinity of the proposed Cush wind farm, Co. Offaly (positive qPCR replicates out of 12 in parentheses)

Sample	Watercourse	Freshwater pearl mussel	White-clawed crayfish	Crayfish plague	European eel	Quagga mussel	Smooth newt
FK628	Little Brosna River (site A3)	Negative (0/12)	**Positive (7/12)**	**Positive (12/12)**	n/a	n/a	n/a
FK604	Rapemills River (site B8)	Negative (0/12)	Negative (0/12)	**Positive (1/12)**	n/a	n/a	n/a
FK597	Grand Canal (site D4)	n/a	**Positive (2/12)**	**Positive (1/12)**	n/a	Negative (0/12)	n/a
FK620	Quarry lake (L1)	n/a	Negative (0/12)	Negative (0/12)	Negative (0/12)	n/a	Negative (0/12)

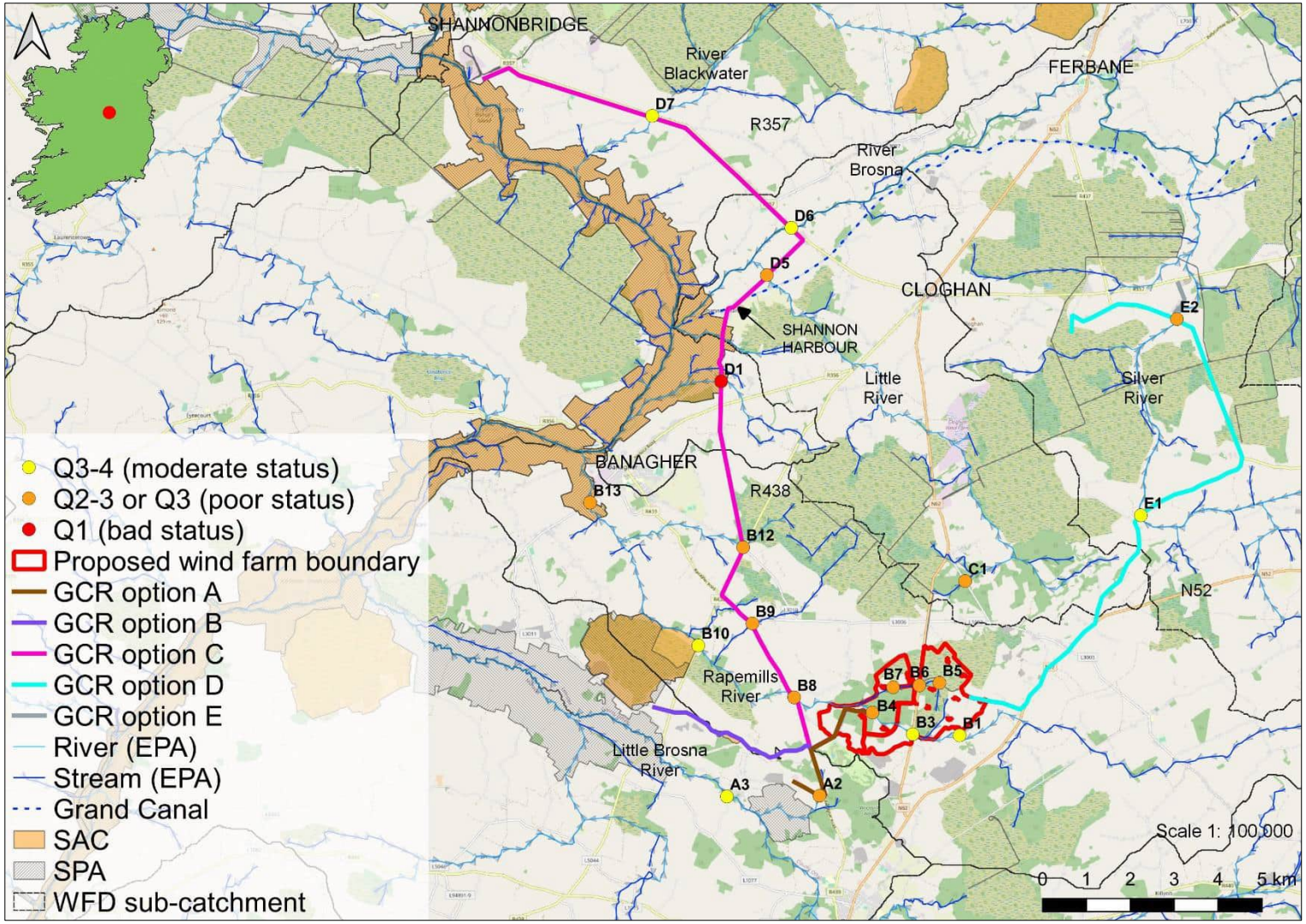

Figure 4.1 Overview of the biological water quality status in the vicinity of the proposed Cush wind farm project, Co. Offaly, August 202

4.6 Biological water quality (macro-invertebrates)

No rare or protected macro-invertebrate species (according to national red lists) were recorded in the biological water quality samples taken from *n*=20 riverine sites in August 2022 (**Appendix A**).

None of the survey sites achieved target good status (≥Q4) requirements of the European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2019 and the Water Framework Directive (2000/60/EC) (**Figure 4.1** above).

Sites on the Little Brosna River (A3), Rapemills River (B1, B3 & B10), River Brosna (D6), Blackwater River (D7) and Silver River (E1) achieved **Q3-4 (moderate status)** water quality. This was given the low numbers (<5%) of group A species, such as the mayfly *Ecdyonurus dispar*, low numbers of group B species such as the mayfly *Alainites muticus* and Limnephilid cased caddis, and a dominance of group C species such as the mayflies *Baetis rhodani* and *Serratella ignita*, New Zealand mud snail (*Potamopyrgus antipodarum*), freshwater shrimp (*Gammarus duebeni*) and blackfly (Simuliidae) larvae. Site B10 on the Rapemills River was the only site to support the group A mayfly *Ephemera danica* (**Appendix B**).

With the exception of site D1 (see below), all other sites achieved **Q3 (poor status)** (i.e. sites A2, B4, B5, B6, B7, B8, B9, B12, B13, C1, D5 & E2). This rating was based on an absence of group A species, low numbers of group B species (such as the caddis *Halesus radiatus* and *Potamophylax cingulatus* and the damselfly *Calopteryx splendens*), and a dominance of group C species, particularly the freshwater shrimp *Gammarus duebeni* and the non-native snail *Potamopyrgus antipodarum*. Group D species, chiefly *Asellus aquaticus*, were also common at most of these sites.

Site D1 on Grant's Island River achieved **Q1 (bad status)** given the macro-invertebrate community comprised exclusively group E Chironomid and Tubificid species (**Appendix B**). However, it should be noted that due to poor flows and or an absence of suitable riffle areas for sampling, the Q-ratings for this site, in addition to sites B10 (moderate status) and sites A2, B5, B6, B12, B13, C1 (poor status), are tentative.

4.7 Lake and canal macro-invertebrates

No rare or protected macro-invertebrate species were recorded in the sweep samples taken from the quarry lake at site L1 or Grand Canal at site D4 (**Appendix B**).

The quarry lake supported a low diversity of low-abundance species, with the sample dominated by the lake olive mayfly (*Cloeon simile*) and *Coenagrion* sp. damselfly. The lake also supported several beetle species, water mites (Hydrachnidiae), water boatmen (Corixidae), pond skaters (Gerridae), non-biting midge larvae (*Chironomus* spp.), wandering snail (*Ampullaceana balthica*) and the aquatic larvae of a terrestrial moth (Pyralidae).

The Grand Canal at site D4 (Griffith Bridge) supported a low diversity of typically lentic species including *Coenagrion* sp. damselfly, the caseless caddis *Plectrocnemia conspersa*, Chironomid larvae, water mites (Hydrachnidiae), hoglouse (*Asellus aquaticus*) and a low diversity of common molluscan species (**Appendix B**).

4.8 Macrophytes and aquatic bryophytes

No rare or protected macrophytes or aquatic bryophytes were recorded at the *n*=27 survey sites. Similarly, no examples of the Annex I habitat 'Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation or aquatic mosses [3260]' (aka floating river vegetation) was recorded during the surveys.

4.9 Aquatic ecological evaluation

An aquatic ecological evaluation of each survey site was based on the results of desktop review (i.e., presence of fish of conservation value), fisheries habitat assessments, the presence of protected or rare invertebrates (e.g. white-clawed crayfish, freshwater pearl mussel), environmental DAN analysis, the presence of rare macrophytes and aquatic bryophytes and or associated representations of Annex I habitats. Furthermore, biological water quality status also informed the aquatic evaluation (**Table 4.4** below).

Sites B13 (Rapemills River), D1 (Grant's Island River), D2 (Bullock Island Stream) and D3 (Park River) were evaluated as **international importance** given their location within the River Shannon Callows SAC (000216) and Middle Shannon Callows SPA (004096).

Site D4 on the Grand Canal was evaluated as **national importance** given the location of the site within the Grand Canal pNHA (002104).

The majority of the remaining aquatic survey sites were evaluated as **local importance (higher value)**. The higher value sites were present on the Little Brosna River (A3), Rapemills River (B1, B3, B4, B8, B10 & B13), West Galros Stream (B5 & B6), Mullaghakaraun Bog Stream (B9), Feeghroe River (B12), Little River (D5), River Brosna (D6), River Blackwater (D7) and Silver River (E1 & E2) (**Table 4.4**). This evaluation was due to the presence of salmonids, Annex II *Lampetra* sp. and or other aquatic species of high conservation value, such as Annex II white-clawed crayfish or Annex II otter.

Sites on the Woodfield River (A2), West Galros Stream (B7), Whigsborough Stream (C1) and the quarry lake at site L1 were evaluated as **local importance (lower value)** in terms of their aquatic ecology given an absence of species or habitats of high conservation value. Sites on the Woodfield River (A1), Eglish Stream (B2) and Milltown Stream (B11) were also evaluated as **local importance (lower value)** in terms of their aquatic ecology given an absence of aquatic habitats at the time of survey (i.e. dry, ephemeral channels).

Table 4.2 Summary of fish species of higher conservation value recorded via electro-fishing per survey site in the vicinity of the proposed Cush wind farm, August 2022

Site	Watercourse	Atlantic salmon	*Lampetra* sp.	Brown trout	European eel	Other species
A1	Woodfield River	No fish recorded – dry channel				
A2	Woodfield River					Ten-spined stickleback
A3	Little Brosna River	✓		✓	✓	Stone loach, minnow
L1	Quarry lake	No electro-fishing undertaken (negative eDNA result for European eel)				

Site	Watercourse	Atlantic salmon	*Lampetra* sp.	Brown trout	European eel	Other species
B1	Rapemills River		✓	✓		Three-spined stickleback
B2	Eglish Stream	No fish recorded – dry channel				
B3	Rapemills River		✓	✓		
B4	Rapemills River		✓	✓		Three-spined stickleback
B5	West Galros Stream	No electro-fishing undertaken (prohibitive depths)				
B6	West Galros Stream	No electro-fishing undertaken (prohibitive depths)				
B7	West Galros Stream					Three-spined stickleback
B8	Rapemills River			✓		
B9	Mullaghakaraun Bog Stream		✓			Ten-spined stickleback
B10	Rapemills River			✓	✓	Ten-spined stickleback, minnow
B11	Milltown Stream	No fish recorded – dry channel				
B12	Feeghroe River			✓		Three-spined stickleback, ten-spined stickleback
B13	Rapemills River			✓	✓	Pike, minnow, stone loach, three-spined stickleback
C1	Whigsborough Stream	No fish recorded				
D1	Grants Island River	No fish recorded				
D2	Bullock Island Stream	No fish recorded – dry channel				
D3	Park River	No fish recorded – dry channel				
D4	Grand Canal	No electro-fishing undertaken (prohibitive depths)				
D5	Little [Cloghan] River		✓	✓	✓	Roach, minnow, stone loach
D6	River Brosna	No electro-fishing undertaken (prohibitive depth, width & flow)				
D7	Blackwater River		✓	✓		Minnow, stone loach
E1	Silver River		✓	✓		Minnow, stone loach, three-spined stickleback
E2	Silver River	✓	✓	✓		Stone loach

*** Conservation value:** Atlantic salmon (*Salmo salar*), sea lamprey (*Petromyzon marinus*), brook lamprey (L*ampetra planeri*) and river lamprey (*Lampetra fluviatilis*) are listed under Annex II of the Habitats Directive [92/42/EEC]. Atlantic salmon and river lamprey are also listed under Annex V of the Habitats Directive [92/42/EEC]. European eel are 'critically endangered' according to most recent ICUN red list (Pike et al., 2020) and listed as 'critically engendered' in Ireland (King et al., 2011). With the exception of the Fisheries Acts 1959 to 2019, brown trout and coarse fish species have no legal protection in Ireland.

Table 4.3 Summary of aquatic species (excluding fish) and habitats of higher conservation value recorded in the vicinity of the proposed Cush wind farm, August 2022 (occurrence in **bold** for clarity)

Site	Watercourse	White-clawed crayfish	Freshwater pearl mussel	Otter signs[4]	Annex I aquatic habitats	Rare or protected macrophytes/ aquatic bryophytes	Rare or protected macro-invertebrates	Other species/habitats of high conservation value
A1	Woodfield River	None recorded		None recorded	Not present	None recorded	None recorded	None recorded
A2	Woodfield River	None recorded		None recorded	Not present	None recorded	None recorded	None recorded
A3	Little Brosna River	**Positive eDNA result at site; remains in otter spraint**	Negative eDNA result at site, no records in catchment	None recorded	Not present	None recorded	None recorded	None recorded
L1	Quarry lake	None recorded; negative eDNA result at site		None recorded	Not present	None recorded	None recorded	None recorded
B1	Rapemills River	**Remains in otter spraint**		**Regular spraint site**	Not present	None recorded	None recorded	None recorded
B2	Eglish Stream	None recorded		None recorded	Not present	None recorded	None recorded	None recorded
B3	Rapemills River	**Remains in otter spraint**		**Regular spraint site**	Not present	None recorded	None recorded	None recorded
B4	Rapemills River	None recorded		None recorded	Not present	None recorded	None recorded	None recorded
B5	West Galros Stream	**Remains found on bank**		None recorded	Not present	None recorded	None recorded	None recorded
B6	West Galros Stream	None recorded; negative eDNA result at site		None recorded	Not present	None recorded	None recorded	None recorded
B7	West Galros Stream	None recorded		None recorded	Not present	None recorded	None recorded	None recorded
B8	Rapemills River	None recorded; negative eDNA result at site	Negative eDNA result at site, no records in catchment	None recorded	Not present	None recorded	None recorded	None recorded
B9	Mullaghakaraun Bog Stream	**Juveniles present**		None recorded	Not present	None recorded	None recorded	None recorded
B10	Rapemills River	None recorded		None recorded	Not present	None recorded	None recorded	None recorded

Site	Watercourse	White-clawed crayfish	Freshwater pearl mussel	Otter signs[4]	Annex I aquatic habitats	Rare or protected macrophytes/ aquatic bryophytes	Rare or protected macro-invertebrates	Other species/habitats of high conservation value
B11	Milltown Stream	None recorded		None recorded	Not present	None recorded	None recorded	None recorded
B12	Feeghroe River	**Juveniles present**		None recorded	Not present	None recorded	None recorded	None recorded
B13	Rapemills River	None recorded		None recorded	Not present	None recorded	None recorded	None recorded
C1	Whigsborough Stream	None recorded		None recorded	Not present	None recorded	None recorded	None recorded
D1	Grants Island River	None recorded		None recorded	Not present	None recorded	None recorded	None recorded
D2	Bullock Island Stream	None recorded		None recorded	Not present	None recorded	None recorded	None recorded
D3	Park River	None recorded		None recorded	Not present	None recorded	None recorded	None recorded
D4	Grand Canal	None recorded; **positive eDNA result at site**		None recorded	Not present	None recorded	None recorded	None recorded
D5	Little [Cloghan] River	None recorded		None recorded	Not present	None recorded	None recorded	None recorded
D6	River Brosna	None recorded		**Regular spraint site**	Not present	None recorded	None recorded	None recorded
D7	Blackwater River	**Remains in otter spraint**		**Regular spraint site**	Not present	None recorded	None recorded	None recorded
E1	Silver River	None recorded		None recorded	Not present	None recorded	None recorded	None recorded
E2	Silver River	None recorded		None recorded	Not present	None recorded	None recorded	None recorded

*** Conservation value:** White-clawed crayfish (*Austropotamobius pallipes*), freshwater pearl mussel (*Margaritifera margaritifera*) and Eurasian otter (*Lutra lutra*) are listed under Annex II and Annex V of the Directive on the Conservation of Natural Habitats of Wild Fauna and Flora (92/43/EEC) ('EU Habitats Directive'). and all are protected under the Irish Wildlife Acts 1976-2021. White-clawed crayfish (Füreder et al., 2010) and freshwater pearl mussel (Moorkens et al., 2017) are also both listed as 'Endangered' according to the IUCN Red List. The European Union (Invasive Alien Species) (Freshwater Crayfish) Regulations 2018 (SI 354/2018) affords further protection to native white-clawed crayfish by prohibiting the introduction and spread of five no. invasive 'Union concern' crayfish species listed under EU Regulation 1143/2014. Common frog (*Rana temporaria*) and smooth newt (*Lissotriton vulgaris*) are protected under the Irish Wildlife Acts 1976-2021. Common frog are also afforded protection under Annex V of the Habitats Directive [92/42/EEC].

[4] Otter signs within 150m of the survey site

Table 4.4 Aquatic ecological evaluation summary of the Cush wind farm survey sites according to NRA (2009) criteria

Site no.	Watercourse	EPA code	Evaluation of importance	Rationale summary
A1	Woodfield River	25W29	Local importance (lower value)	Upper reaches of modified ephemeral channel with no fisheries & aquatic value (dry at time of survey); no electro-fishing or biological water quality sample possible; no aquatic species or habitats of high conservation value
A2	Woodfield River	25W29	Local importance (lower value)	Upper reaches of modified ephemeral channel with intermittent flows, poor fisheries & poor aquatic value (semi-dry at time of survey); ten-spined stickleback recorded via electro-fishing; no otter suitability; Q3 (poor status) water quality (tentative rating); no aquatic species or habitats of high conservation value
A3	Little Brosna River	25L02	**Local importance (higher value)**	Large high-energy calcareous river with high fisheries value; Atlantic salmon, brown trout, European eel, stone loach & minnow recorded via electro-fishing; good quality salmonid spawning & holding habitat but moderate quality nursery; poor quality lamprey habitat, moderate quality European eel; sub-optimal for white-clawed crayfish given high rates of calcification & compaction, none recorded but detected via eDNA at site; high otter suitability with old spraint site present; Q3-4 (moderate status) water quality
L1	Quarry lake	n/a	Local importance (lower value)	Small 1.2ha quarry lake with high average depth and poor fisheries value; three-spined stickleback observed during survey; eDNA did not detect brown trout, European eel, white-clawed crayfish or smooth newt; some otter suitability but no signs recorded; no aquatic species or habitats of high conservation value
B1	Rapemills River	25R01	**Local importance (higher value)**	Upper reaches of semi-natural lowland watercourse of high salmonid & lamprey value; brown trout, *Lampetra* sp. & three-spined stickleback recorded via electro-fishing; good quality salmonid nursery & holding habitat but reduced by siltation pressures; excellent quality lamprey nursery with some good quality spawning; high suitability for European eel & white-clawed crayfish but none recorded; two regular otter spraint sites contained abundant crayfish remains; Q3-4 (moderate status) water quality
B2	Eglish Stream	25E18	Local importance (lower value)	Heavily modified ephemeral channel with no fisheries & aquatic value (dry at time of survey); no electro-fishing or biological water quality sample possible; no aquatic species or habitats of high conservation value
B3	Rapemills River	25R01	**Local importance (higher value)**	Historically modified, heavily silted lowland watercourse of good value to salmonids & moderate value to lamprey; brown trout & low density of *Lampetra* sp. recorded via electro-fishing; high suitability for European eel & white-clawed crayfish but none recorded; two regular otter spraint sites contained abundant crayfish remains; Q3-4 (moderate status) water quality
B4	Rapemills River	25R01	**Local importance (higher value)**	Heavily modified, heavily vegetated & heavily silted lowland depositing river of poor value to salmonids; brown trout, *Lampetra* sp. & three-spined stickleback recorded via electro-fishing; poor quality salmonid habitat but of some low value as a

Site no.	Watercourse	EPA code	Evaluation of importance	Rationale summary
				lamprey nursery; low suitability for European eel & white-clawed crayfish but none recorded; some otter suitability but no signs recorded; Q3 (poor status) water quality
B5	West Galros Stream	25W44	**Local importance (higher value)**	Heavily modified & heavily silted lowland depositing river with poor hydromorphology & of poor value to salmonids; electro-fishing not undertaken (prohibitive depths); some low value as a holding habitat for salmonids, moderate European eel suitability; remains of white-clawed crayfish recorded, frequent crayfish burrows identified; some otter suitability but no signs recorded; Q3 (poor status) water quality (tentative rating)
B6	West Galros Stream	25W44	**Local importance (higher value)**	Heavily modified & heavily silted lowland depositing river with poor hydromorphology of poor value to salmonids; electro-fishing not undertaken (prohibitive depths); some low value as a holding habitat for salmonids, moderate European eel suitability; frequent white-clawed crayfish burrows identified; some otter suitability but no signs recorded; Q3 (poor status) water quality (tentative rating)
B7	West Galros Stream	25W44	Local importance (lower value)	Heavily modified & heavily silted lowland depositing river with poor hydromorphology of poor fisheries value; only three-spined stickleback recorded via electro-fishing; low suitability for white-clawed crayfish & otter (none recorded); Q3 (poor status) water quality (tentative rating)
B8	Rapemills River	25R01	**Local importance (higher value)**	Semi-natural, high-energy calcareous river of high value to salmonids; only brown trout recorded via electro-fishing; excellent quality salmonid holding & moderate quality nursery habitat with poor spawning opportunities (due to calcification of bed); good suitability for European eel & poor suitability for lamprey (none recorded); some suitability for white-clawed crayfish but none recorded via survey or eDNA analysis; high otter suitability but no signs recorded; Q3 (poor status) water quality
B9	Mullaghakaraun Bog Stream	25M48	**Local importance (higher value)**	Heavily silted, semi-natural upland eroding stream with low seasonal flows; only *Lampetra* sp. & ten-spined stickleback recorded via electro-fishing; some value as lamprey nursery (low density present) but poor quality spawning habitat; some suitability for salmonids & European eel but none recorded; white-clawed crayfish present in low densities (juveniles only); Q3 (poor status) water quality
B10	Rapemills River	25R01	**Local importance (higher value)**	Heavily modified, heavily vegetated & heavily silted lowland depositing river of moderate value to salmonids; brown trout, European eel & three-spined stickleback recorded via electro-fishing; poor quality salmonid habitat (holding only) but good quality European eel habitat; abundant soft sediment for larval lamprey but none recorded (likely due to poor flows); good suitability for white-clawed crayfish & otter but none recorded; Q3 (poor status) water quality

Site no.	Watercourse	EPA code	Evaluation of importance	Rationale summary
B11	Milltown Stream	25M79	Local importance (lower value)	Ephemeral (seasonal) modified channel with no aquatic value at the time of survey (dry channel); no electro-fishing or biological water quality sample possible; no aquatic species or habitats of high conservation value
B12	Feeghroe River	25F41	**Local importance (higher value)**	Heavily modified & heavily silted lowland depositing river of moderate value to salmonids (holding habitat only); brown trout, three-spined and ten-spined stickleback recorded via electro-fishing; poor suitability for European eel (none recorded); no suitability for lamprey given poor flows; white-clawed crayfish present in low densities (juveniles only); Q3 (poor status) water quality (tentative rating)
B13	Rapemills River	25R01	**International importance**	Located within the River Shannon Callows SAC (000216) and Middle Shannon Callows SPA (004096); heavily vegetated lower reaches of modified lowland depositing river of moderate value to salmonids & high value to coarse fish; brown trout, European eel, minnow, three-spined stickleback, stone loach & pike recorded via electro-fishing; good quality salmonid holding habitat but poor nursery & spawning; good quality European eel habitat; poor lamprey suitability (none recorded); good suitability for white-clawed crayfish & otter but none recorded; Q3 (poor status) water quality (tentative rating)
C1	Whigsborough Stream	25W43	Local importance (lower value)	Heavily modified, heavily silted channel with very poor hydromorphology & connectivity; not of fisheries value, no fish recorded via electro-fishing; Q2-3 (poor status) water quality (tentative rating); no aquatic species or habitats of high conservation value
D1	Grants Island River	25Y47	**International importance**	Located within the River Shannon Callows SAC (000216) and Middle Shannon Callows SPA (004096); heavily modified & silted channel with no flow and poor quality aquatic habitats; no fish recorded via electro-fishing; Q1 (bad status) biological water quality (tentative rating); no aquatic species or habitats of high conservation value
D2	Bullock Island Stream	25I23	**International importance**	Located within the River Shannon Callows SAC (000216) and Middle Shannon Callows SPA (004096); ephemeral (seasonal) modified channel with no aquatic value at the time of survey (dry channel); no electro-fishing or biological water quality sample possible; no aquatic species or habitats of high conservation value
D3	Park River	25P28	**International importance**	Located within the River Shannon Callows SAC (000216) and Middle Shannon Callows SPA (004096); ephemeral (seasonal) modified channel with no aquatic value at the time of survey (dry channel); no electro-fishing or biological water quality sample possible; no aquatic species or habitats of high conservation value
D4	Grand Canal	n/a	**National importance**	Located within Grand Canal pNHA (002104); also of high value as an aquatic ecological corridor; high value for European eel and coarse fish species; known to support foraging/commuting otter (NPWS/NBDC data); invasive zebra mussel abundant; crayfish plague also recorded via eDNA

Site no.	Watercourse	EPA code	Evaluation of importance	Rationale summary
D5	Little [Cloghan] River	25L01	**Local importance (higher value)**	Heavily modified & heavily silted lowland depositing river of moderate value to salmonids but high value for lamprey; brown trout, *Lampetra* sp., European eel, minnow, stone loach & roach recorded via electro-fishing; good quality salmonid holding habitat but poor nursery & spawning; poor quality lamprey spawning but excellent value nursery; moderate quality European eel habitat; despite suitability, no white-clawed crayfish or otter recorded; Q3 (poor status) water quality
D6	River Brosna	25B09	**Local importance (higher value)**	Large 20-25m-wide high-energy lowland river of high value to salmonids; electro-fishing not undertaken (prohibitive depths & flows); river known to support Atlantic salmon, brown trout, European eel, *Lampetra* sp., minnow & stone loach; excellent quality salmonid holding habitat but poor spawning & nursery; site of low suitability for lamprey, European eel & white-clawed crayfish; otter spraint site recorded
D7	Blackwater River	25B27	**Local importance (higher value)**	Heavily modified, very heavily silted lowland river with low seasonal flows & high value as lamprey nursery; brown trout, *Lampetra* sp., minnow & stone loach recorded via electro-fishing; poor fisheries value due to gross siltation but high densities of *Lampetra* sp. ammocoetes recorded; white-clawed crayfish not recorded but abundant (fresh) crayfish remains in numerous otter spraint sites; Q3-4 (moderate status) water quality
E1	Silver River	25S02	**Local importance (higher value)**	Straightened & deepened lowland river with good instream recovery of good value for salmonids; brown trout, *Lampetra* sp., minnow, three-spined stickleback & stone loach recorded via electro-fishing; high value as salmonid holding habitat but moderate quality nursery & spawning; sub-optimal lamprey nursery with low density of ammocoetes present; good suitability for European eel, white-clawed crayfish & otter but none recorded; Q3-4 (moderate status) water quality
E2	Silver River	25S02	**Local importance (higher value)**	Straightened & deepened lowland river with good instream recovery of good value for salmonids; Atlantic salmon, brown trout, *Lampetra* sp. & stone loach recorded via electro-fishing; high value as salmonid holding habitat with good quality nursery & spawning; good quality lamprey nursery with low density of ammocoetes present; good suitability for European eel, white-clawed crayfish & otter but none recorded; Q3 (poor status) water quality

Conservation value: Atlantic salmon (*Salmo salar*), sea lamprey (*Petromyzon marinus*), brook lamprey (L*ampetra planeri*), river lamprey (*Lampetra fluviatilis*), white-clawed crayfish (*Austropotamobius pallipes*) and otter (*Lutra lutra*) are listed under Annex II of the Habitats Directive [92/42/EEC]. Atlantic salmon, river lamprey, freshwater pearl mussel, white-clawed crayfish and otter are also listed under Annex V of the Habitats Directive [92/42/EEC]. Freshwater pearl mussel and otters (along with their breeding and resting places) are also protected under provisions of the Irish Wildlife Acts 1976 to 2021. European eel are 'critically endangered' according to most recent ICUN red list (Pike et al., 2020) and listed as 'critically engendered' in Ireland (King et al., 2011). With the exception of the Fisheries Acts 1959 to 2019, brown trout and coarse fish species have no legal protection in Ireland.

5. Discussion

5.1 Most valuable areas for aquatic ecology

Sites B13 (Rapemills River), D1 (Grant's Island River), D2 (Bullock Island Stream) and D3 (Park River) were evaluated as **international importance** given their location within the River Shannon Callows SAC (000216) and Middle Shannon Callows SPA (004096). However, sites D1, D2 and D3 were ephemeral channels and did not support aquatic habitats at the time of survey (August 2022) but may act as ecological corridors for species movement. The lower reaches of the Rapemills River at site B13 supported salmonids and Red-listed European eel.

Site D4 on the Grand Canal was evaluated as **national importance** given the location of the site within the Grand Canal pNHA (002104). The heavily vegetated site was of high value for a range of coarse fish species, Red-listed European eel and foraging/commuting Annex II otter, with the presence of Annex II white-clawed crayfish detected via eDNA analysis (see 5.2 below). The Grand Canal is also an important ecological corridor for a range of aquatic species.

None of the remaining 22 no. aquatic survey sites were evaluated as greater than **local importance (higher value)**. The higher value sites were present on the Little Brosna River (A3), Rapemills River (B1, B3, B4, B8, B10 & B13), West Galros Stream (B5 & B6), Mullaghakaraun Bog Stream (B9), Feeghroe River (B12), Little River (D5), River Brosna (D6), River Blackwater (D7) and Silver River (E1 & E2) (**Table 4.4**). This evaluation was due to the presence of salmonids, Annex II *Lampetra* sp. and or other aquatic species of high conservation value, such as Annex II white-clawed crayfish or Annex II otter.

Salmonids were recorded from a total of 11 no. sites via electro-fishing (**Table 4.2; Appendix A**). However, these populations comprised brown trout only, with the exception of sites A3 on the Little Brosna River and E2 on the Silver River which also supported Atlantic salmon. This restricted distribution of Atlantic salmon in the vicinity of the proposed project is unsurprising given widespread historical modifications in the Shannon [Lower]_SC_060, Shannon [Lower]_SC_040, Shannon [Lower]_SC_030 and Brosna_SC_080 river sub-catchments (which have evidently reduced the quality of salmonid habitat), in addition to significant downstream barriers on the River Shannon (i.e. hydro-electric dams).

Lamprey ammocoetes (*Lampetra* sp., likely *L. planeri* given known catchment barriers) were recorded from a total of 8 no. sites on the Rapemills River (B1, B3 & B4), Mullaghakaraun Bog Stream (B9), Little River (D5) and the Silver River (E1 & E2) (**Table 4.2; Appendix A**). Moderate densities of ammocoetes were recorded at sites B1 (20 per m^2), D5 (13.2 per m^2) and D7 (11 per m^2), where optimal soft sediment habitat was abundant. Suitability was typically poor in the survey area as a result of historical modifications to hydromorphology which have resulted in often poor quality lamprey habitats. This was especially so with reference to spawning habitats which were heavily silted or even absent at many of the survey sites.

Whilst live Annex II white-clawed crayfish were only recorded from sites B9 on the Mullaghakaraun Bog Stream and B12 on the Feeghroe River (both juveniles only), crayfish remains were identified in otter spraint at sites on the Little Brosna River (site A3), Rapemills River (B1, B3) and Blackwater River (D7), with a predated adult crayfish also recorded on the West Galros Stream at site B5 (**Table 4.3**). These findings, in addition to the detection of white-clawed crayfish eDNA (see 5.2 below), indicate a

wider distribution of cryptic populations within the vicinity of the proposed wind farm. In light of ongoing national outbreaks of crayfish plague (*Aphanomyces astaci*) and resulting declines in the species (Swords, 2021), these sites are therefore of even greater importance in terms of white-clawed crayfish conservation.

Despite widespread foraging and commuting suitability, otter signs were only recorded at sites B1 & B3 on the Rapemills River, D6 on the River Brosna and D7 on the Blackwater River. This paucity of signs may reflect the low number of observed marking opportunities (Sittenthaler et al., 2020) and or local otter population demographics. These sites supported regular sprainting locations, all of which contained abundant crayfish remains. The correlation between crayfish distribution and otter utilisation (foraging) of watercourses has been repeatedly observed across many Irish river catchments, particularly where fish abundances are below average (pers. obs.). No breeding (holts) or resting (couch) areas were identified in the vicinity of the survey sites in August 2022.

No rare or protected macro-invertebrate species (according to national red lists) were recorded in the biological water quality samples taken from *n*=20 riverine sites in August 2022 (**Appendix A**). None of the survey sites achieved target good status (≥Q4) water quality requirements of the European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2019 and the Water Framework Directive (2000/60/EC) (**Figure 4.1** above). Siltation (peat extraction pressures), eutrophication and alterations to hydromorphology are known to be the major pressures within the survey area (EPA, 2019a, 2019b, 2022) and this was supported by observations made during the aquatic surveys.

No examples of the Annex I habitats were recorded during the aquatic surveys undertaken in August 2022.

5.2 eDNA analysis

White-clawed crayfish eDNA was detected in both the Little Brosna River (Site A3) and Grand Canal (D4) samples (7 and 2 positive qPCR replicates out of 12, respectively) but not in the Rapemills River sample from site B8 (**Table 4.1**; **Appendix C).** This was in spite of the identification of abundant crayfish remains in otter spraints at two survey sites (B1 & B3) located on the river >3km upstream of this point. Whilst highly sensitive and often detectable over long distances instream (including in crayfish; Chucholl et al., 2021), the detection of environmental DNA from an upstream (riverine) population depends on downstream transport of genetic material. The low seasonal flows present on the Rapemills River at the time of survey, in addition to poor hydromorphology and heavy vegetation cover, may have limited the flow of eDNA and thus influenced detection rates (i.e. DNA may have temporarily settled out of suspension; Buxton et al., 2018). The patchy distribution and often low abundances of white-clawed crayfish in a given river system may also strongly influence detection probability (Sint et al., 2022). This result highlights the importance of a multifaceted approach to crayfish surveying, i.e. a combination of crayfish surveys, inspection of otter spraint and eDNA.

No freshwater pearl mussel eDNA was detected in the Little Brosna River or Rapemills River samples collected in August 2022, in keeping with the known distribution of these species in the survey area. Whilst known from the Shannon catchment (Baars & Minchin, 2021), no quagga mussel eDNA was detected from site D4 on the Grand Canal at Shannon Harbour. However, eDNA analysis did detect the non-native pathogen crayfish plague (*Aphanomyces astaci*) in the Little Brosna River, Rapemills

River and Grand Canal samples (**Table 4.1**). Crayfish plague is listed at one of the world's 100 worst invasive species (GISD, 2022; Lowe et al., 2000) and is becoming widespread in the River Shannon catchment (pers. obs.).

5.3 Aquatic ecology summary

In summary, the majority of watercourses in the vicinity of the proposed Cush wind farm were of at least **local importance (higher value)** in terms of their aquatic ecology. However, historical drainage pressures (hydromorphology) and or siltation (primarily from peat escapement) have significantly reduced the quality of aquatic habitats on most watercourses in the vicinity of the proposed project.

Typically, larger watercourses with higher flow rates, greater water volumes and better connectivity, such as the Little Brosna River, River Brosna and Silver River, are better able to buffer against water quality impacts and these watercourses supported the better quality aquatic habitats and water dependant species of high conservation value, This included salmonids, *Lampetra* sp., otter and white-clawed crayfish populations.

None of the 20 no. sites sampled achieved target good status (≥Q4) biological water quality requirements of the European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2019 and the Water Framework Directive (2000/60/EC) (i.e. all sites **≤Q3-4 (moderate status)**. Primarily, this was considered to reflect the widespread hydromorphological pressures within the respective catchments adjoining the proposed project.

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7. Appendix A – fisheries assessment report

Please see accompanying fisheries assessment report

8. Appendix B – Q-sample results (biological water quality) & sweep samples

Table 8.1 Macro-invertebrate Q-sampling results for sites A2, A3, B1 & B3-B10, August 2022 (* species marked with an Asterix are invasive)

Group	Family	Species	A2	A3	B1	B3	B4	B5	B6	B7	B8	B9	B10	EPA class
Ephemeroptera	Ephemeridae	*Ephemera danica*											1	A
Ephemeroptera	Heptageniidae	*Ecdyonurus dispar*		1	1									A
Ephemeroptera	Heptageniidae	*Heptagenia sulphurea*		3										A
Ephemeroptera	Heptageniidae	*Rhithrogena semicolorata*				1								A
Ephemeroptera	Baetidae	*Alainites muticus*		2							5	1		B
Plecoptera	Leuctridae	*Leuctra hippopus*				1							1	B
Trichoptera	Glossosomatidae	*Agapetus fuscipes*										8		B
Trichoptera	Lepidostomatidae	*Lepidostoma hirtum*			8									B
Trichoptera	Limnephilidae	*Halesus radiatus*							1	5	1	8		B
Trichoptera	Limnephilidae	*Limnephilus lunatus*					7						6	B
Trichoptera	Limnephilidae	*Potamophylax cingulatus*		10							5	1		B
Trichoptera	Limnephilidae	sp. indet.			1								1	B
Trichoptera	Odontoceridae	*Odontocerum albicorne*				5								B
Trichoptera	Phryganeidae	*Agrypnia varia*						12	9	4			2	B
Trichoptera	Sericostomatidae	*Sericostoma personatum*			6	22							4	B
Odonata	Calopterygidae	*Calopteryx splendens*					1			8			1	B
Odonata	Coenagrionidae	*Coenagrion sp.*							4					B
Ephemeroptera	Ephemerellidae	*Serratella ignita*		13	26	2	2				3	4		C
Ephemeroptera	Baetidae	*Baetis rhodani*		29	33	4	37				15	8	9	C
Trichoptera	Hydropsychidae	*Hydropsyche instabilis*			2	27								C
Trichoptera	Philopotamidae	*Wormaldia occipitalis*										3		C
Trichoptera	Polycentropodidae	*Holocentropus dubius*										1		C
Trichoptera	Polycentropodidae	*Polycentropus kingi*									1			C
Trichoptera	Rhyacophilidae	*Rhyacophila dorsalis*		6		1					1			C
Mollusca	Lymnaeidae	*Stagnicola fuscus*					1	9	1					C

Group	Family	Species	A2	A3	B1	B3	B4	B5	B6	B7	B8	B9	B10	EPA class
Mollusca	Planorbidae	*Ancylus fluviatilis*			3	6								C
Mollusca	Tateidae	***Potamopyrgus antipodarum***	4		22	124	1	57	2	88	21		4	C
Crustacea	Gammaridae	*Gammarus duebeni*		11	25	25	11	22		23	13	11	12	C
Coleoptera	Dytiscidae	Dytiscidae larva						1				2		C
Coleoptera	Dytiscidae	*Ilybius fuliginosus*						1						C
Coleoptera	Dytiscidae	*Oreodytes sanmarkii*						1						C
Coleoptera	Elmidae	*Elmis aenea*		15	6	32	2				24	8	4	C
Coleoptera	Elmidae	*Limnius volckmari*				3								C
Coleoptera	Gyrinidae	*Gyrinus substriatus*						21	8					C
Coleoptera	Haliplidae	*Brychius elevatus*				2					1			C
Coleoptera	Haliplidae	*Haliplus ruficollis group*						1						C
Coleoptera	Hydraenidae	*Limnebius truncatellus*					1							C
Coleoptera	Hydrophilidae	*Hydrobius fuscipes*					1							C
Coleoptera	Hydrophilidae	*Laccobius bipunctatus*			1									C
Diptera	Chironomidae	*non-Chironomus* spp.	8	4			1	1		2			11	C
Diptera	Culicidae	sp. indet.				1							1	C
Diptera	Dixidae	sp. indet.			1		2							C
Diptera	Pediciidae	*Dicranota* sp.				1						1	1	C
Diptera	Simuliidae	sp. indet.		58	18	12	13				17			C
Hemiptera	Corixidae	Corixid nymph							1					C
Hemiptera	Corixidae	*Hesperocorixa linnaei*							19					C
Hemiptera	Corixidae	*Hesperocorixa sahlbergi*						1						C
Hemiptera	Gerridae	*Gerris* sp.	12					15	1				8	C
Hemiptera	Gerridae	*Gerridae nymph*	1											C
Arachnida	Hydrachnidiae	sp. indet.		2		1	7					1	7	C
Mollusca	Lymnaeidae	*Ampullacaena balthica*						10						D
Mollusca	Lymnaeidae	*Lymnaea stagnalis*					8	4						D

Group	Family	Species	A2	A3	B1	B3	B4	B5	B6	B7	B8	B9	B10	EPA class
Mollusca	Sphaeriidae	sp. indet.				1								D
Megaloptera	Sialidae	*Sialis lutaria*						2		4				D
Crustacea	Asellidae	*Asellus aquaticus*			1	13	8	18	10	3		3	33	D
Hirudinidae	Glossiphoniidae	sp. indet.			1	1							3	D
Diptera	Chironomidae	*Chironomus* spp.	3			4	5						2	E
Annelidae	Oligochaeta	sp. indet.		4	1		1							n/a
Abundance			**28**	**158**	**156**	**289**	**109**	**176**	**56**	**137**	**107**	**60**	**111**	
Q-rating			*Q3	Q3-4	Q3-4	Q3-4	Q3	*Q3	*Q3	Q3	Q3	Q3	*Q3-4	
WFD status			Poor	Mod	Mod	Mod	Poor	Poor	Poor	Poor	Poor	Poor	Mod	

* tentative Q-rating due to poor flows and or absence of suitable riffle areas for sampling (Toner et al., 2005)

Table 8.2 Macro-invertebrate Q-sampling results for sites B12, B13, C1, D1, D5, D6, D7, E1 & E2, August 2022 (* species marked with an Asterix are invasive)

Group	Family	Species	B12	B13	C1	D1	D5	D6	D7	E1	E2	EPA class
Ephemeroptera	Heptageniidae	*Ecdyonurus dispar*						2	3	3		A
Ephemeroptera	Heptageniidae	*Heptagenia sulphurea*							1			A
Ephemeroptera	Baetidae	*Alainites muticus*					1		3	6		B
Ephemeroptera	Baetidae	*Cloeon dipterum*	3									B
Plecoptera	Leuctridae	*Leuctra hippopus*					1	2		3		B
Trichoptera	Glossosomatidae	*Agapetus fuscipes*								5	23	B
Trichoptera	Limnephilidae	*Halesus radiatus*		17								B
Trichoptera	Limnephilidae	*Potamophylax cingulatus*					4	6		3	1	B
Trichoptera	Limnephilidae	sp. indet.									1	B
Trichoptera	Sericostomatidae	*Sericostoma personatum*							4		1	B
Odonata	Calopterygidae	*Calopteryx splendens*	6	1			1				2	B
Odonata	Coenagrionidae	*Coenagrion sp.*										B

Group	Family	Species	B12	B13	C1	D1	D5	D6	D7	E1	E2	EPA class
Hemiptera	Aphelochiridae	*Aphelocheirus aestivalis*					6	19	7			B
Ephemeroptera	Ephemerellidae	*Serratella ignita*		1			5	15		9	22	C
Ephemeroptera	Baetidae	*Baetis rhodani*		4			3	36	21	26	23	C
Trichoptera	Hydropsychidae	*Hydropsyche instabilis*					3					C
Trichoptera	Hydropsychidae	*Hydropsyche siltalai*							1	1		C
Trichoptera	Polycentropodidae	*Plectrocnemia conspersa*										C
Trichoptera	Polycentropodidae	*Polycentropus kingi*					1					C
Mollusca	Bithnyiidae	*Bithynia tentaculata*		1								C
Mollusca	Lymnaeidae	*Stagnicola fuscus*		9								C
Mollusca	Neritidae	*Theodoxus fluviatilis*		4						3	2	C
Mollusca	Planorbidae	*Ancylus fluviatilis*						4	2	4	4	C
Mollusca	Planorbidae	*Gyraulus albus*					1					C
Mollusca	Tateidae	*Potamopyrgus antipodarum*	38					1	12	1	18	C
Crustacea	Gammaridae	*Gammarus duebeni*	18	3			22	31	61	33	53	C
Crustacea	Corophiidae	***Chelicorophium curvispinum***										C
Coleoptera	Dytiscidae	Dytiscidae larva		1	2							C
Coleoptera	Dytiscidae	*Ilybius fuliginosus*	4									C
Coleoptera	Elmidae	*Elmis aenea*					3			11	20	C
Coleoptera	Elmidae	*Esolus parallelepipedus*								1		C
Coleoptera	Elmidae	*Limnius volckmari*					1	2		5		C
Coleoptera	Halipliidae	*Brychius elevatus*					2			1	3	C
Coleoptera	Halipliidae	*Haliplus ruficollis group*		1								C
Diptera	Chironomidae	*non-Chironomus* spp.	1							3		C
Diptera	Culicidae	sp. indet.	1									C
Diptera	Pediciidae	*Dicranota* sp.									1	C
Diptera	Simuliidae	sp. indet.							1	55	37	C
Hemiptera	Corixidae	Corixidae nymph	11	3								C

Group	Family	Species	B12	B13	C1	D1	D5	D6	D7	E1	E2	EPA class
Hemiptera	Corixidae	*Siagara* sp.	8	42								C
Hemiptera	Gerridae	*Gerris* sp.	3	2	16		1		8			C
Hemiptera	Gerridae	*Gerridae nymph*	2		2		1			1		C
Hemiptera	Veliidae	*Veliidae nymph*		1								C
Platyhelminthes	Planariidae	*Polycelis* sp.							7			C
Arachnida	Hydrachnidiae	sp. indet.		13							1	C
Mollusca	Lymnaeidae	*Ampullacaena balthica*		2								D
Mollusca	Lymnaeidae	*Lymnaea stagnalis*		6								D
Mollusca	Physidae	*Physa fontinalis*		2								D
Mollusca	Sphaeriidae	sp. indet.						6				D
Crustacea	Asellidae	*Asellus aquaticus*	15	41	14		13		3		12	D
Hirudinidae	Glossiphoniidae	sp. indet.	1									D
Diptera	Chironomidae	*Chironomus* spp.			7	12	1	1	1	1		E
Annelidae	Tubificidae	sp. indet.			5	18						E
Annelidae	Oligochaeta	sp. indet.			1			2				n/a
Abundance			**111**	**154**	**47**	**30**	**70**	**127**	**135**	**175**	**224**	
Q-rating			*Q3	*Q3	*Q2-3	*Q1	Q3	Q3-4	Q3-4	Q3-4	Q3	
WFD status			Poor	Poor	Poor	Bad	Poor	Mod	Mod	Mod	Poor	

* tentative Q-rating due to poor flows and or absence of suitable riffle areas for sampling (Toner et al., 2005)

Table 8.3 Macro-invertebrate community recorded at site L1 (quarry lake) & Grand Canal (D4), August 2022 (* species marked with an Asterix are invasive)

Group	Family	Species	L1	D4
Ephemeroptera	Baetidae	*Cloeon simile*	12	
Trichoptera	Polycentropodidae	*Plectrocnemia conspersa*		3
Odonata	Coenagrionidae	*Coenagrion sp.*	8	4
Crustacea	Corophiidae	***Chelicorophium curvispinum****		1
Crustacea	Asellidae	*Asellus aquaticus*		26
Arachnida	Hydrachnidiae	sp. indet.	4	11
Coleoptera	Dytiscidae	*Oreodytes sanmarkii*	1	
Coleoptera	Halipliidae	*Haliplus ruficollis group*	2	
Coleoptera	Halipliidae	*Haliplus linneatocollis*	2	
Coleoptera	Hydrophilidae	*Laccobius minutus*	1	
Hemiptera	Corixidae	Corixidae nymph	1	
Hemiptera	Gerridae	Gerridae nymph	5	
Mollusca	Physidae	*Physa fontanalis*		1
Mollusca	Bithnyiidae	*Bithynia tentaculata*		2
Mollusca	Lymnaeidae	*Ampullacaena balthica*	1	
Mollusca	Dreissenidae	***Dreissena polymorpha****		8
Diptera	Chironomidae	*Chironomus spp.*	2	4
Diptera	Chironomidae	*Non-Chironomus spp.*		32
Diptera	Culicidae	sp. indet.		1
Lepidoptera	Pyralidae	sp. indet.	1	
Oligochaeta	Lumbriculidae	sp. indet		1
Taxon Richness n			**12**	**12**

9. Appendix C – eDNA analysis lab report

SureScreen Scientifics

Folio No: E15388
Report No: 1
Client: Triturus Environmental Limited
Contact: Bill Brazier

TECHNICAL REPORT

ANALYSIS OF ENVIRONMENTAL DNA IN WATER FOR AQUATIC SPECIES DETECTION

SUMMARY

When aquatic organisms inhabit a waterbody such as a pond, lake or river they continuously release small amounts of their DNA into the environment. By collecting and analysing water samples, we can detect these small traces of environmental DNA (eDNA) to confirm the presence or absence of the target species within the waterbody.

RESULTS

Date sample received in laboratory: 12/09/2022
Date results reported: 21/09/2022
Matters affecting result: None

TARGET SPECIES: Crayfish plague *(Aphanomyces astaci)*

Lab ID	Site Name	OS Reference	SIC	DC	IC	Result	Positive Replicates
FK597	D4 – Grand Canal Cush Wind Farm	-	Pass	Pass	Pass	Positive	1/12
Fk604	B8 – Rapemills River Cush Wind Farm	ITM 604773, 710211	Pass	Pass	Pass	Positive	1/12
Fk620	L1 – Quarry Lake Cush Wind Farm	ITM 608806, 709567	Pass	Pass	Pass	Negative	0/12
FK628	A3 – Little Brosna River Cush Wind Farm	ITM 603240, 707953	Pass	Pass	Pass	Positive	12/12

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Company Registration No. 08950940

SureScreen Scientifics

TARGET SPECIES: European eel *(Anguilla anguilla)*

Lab ID	Site Name	OS Reference	SIC	DC	IC	Result	Positive Replicates
FK620	L1 – Quarry Lake Cush Wind Farm	ITM 608806, 709567	Pass	Pass	Pass	Negative	0/12

TARGET SPECIES: Freshwater pearl mussel *(Margaritifera margaritifera)*

Lab ID	Site Name	OS Reference	SIC	DC	IC	Result	Positive Replicates
FK604	B8 – Rapemills River Cush Wind Farm	ITM 604773, 710211	Pass	Pass	Pass	Negative	0/12
FK628	A3 – Little Brosna River Cush Wind Farm	ITM 603240, 707953	Pass	Pass	Pass	Negative	0/12

TARGET SPECIES: Quagga mussel *(Dreissena bugensis)*

Lab ID	Site Name	OS Reference	SIC	DC	IC	Result	Positive Replicates
FK597	D4 – Grand Canal Cush Wind Farm	-	Pass	Pass	Pass	Negative	0/12

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TARGET SPECIES: Smooth Newt *(Lissotriton vulgaris)*

Lab ID	Site Name	OS Reference	SIC	DC	IC	Result	Positive Replicates
FK620	L1 – Quarry Lake Cush Wind Farm	ITM 608806, 709567	Pass	Pass	Pass	Negative	0/12

TARGET SPECIES: White-clawed crayfish *(Austropotamobius pallipes)*

Lab ID	Site Name	OS Reference	SIC	DC	IC	Result	Positive Replicates
FK597	D4 – Grand Canal Cush Wind Farm	-	Pass	Pass	Pass	Positive	2/12
Fk604	B8 – Rapemills River Cush Wind Farm	ITM 604773, 710211	Pass	Pass	Pass	Negative	0/12
Fk620	L1 – Quarry Lake Cush Wind Farm	ITM 608806, 709567	Pass	Pass	Pass	Negative	0/12
FK628	A3 – Little Brosna River Cush Wind Farm	ITM 603240, 707953	Pass	Pass	Pass	Positive	7/12

If you have any questions regarding results, please contact us: ForensicEcology@surescreen.com

Reported by: **Jennifer Higginbottom** Approved by: **Gabriela Danickova**

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SureScreen Scientifics

METHODOLOGY

The samples detailed above have been analysed for the presence of target species eDNA following scientifically published eDNA assays and protocols which have been thoroughly tested, developed and verified for use by SureScreen Scientifics.

The analysis is conducted in two phases. The sample first goes through an extraction process where the filter is incubated in order to obtain any DNA within the sample. The extracted sample is then tested via real time PCR (also called q-PCR) for each of the selected target species. This process uses species-specific molecular markers (known as primers) to amplify a select part of the DNA, allowing it to be detected and measured in 'real time' as the analytical process develops. qPCR combines amplification and detection of target DNA into a single step. With qPCR, fluorescent dyes specific to the target sequence are used to label targeted PCR products during thermal cycling. The accumulation of fluorescent signals during this reaction is measured for fast and objective data analysis. The primers used in this process are specific to a part of mitochondrial DNA only found in each individual species. Separate primers are used for each of the species, ensuring no DNA from any other species present in the water is amplified.

If target species DNA is present, the DNA is amplified up to a detectable level, resulting in positive species detection. If target species DNA is not present then amplification does not occur, and a negative result is recorded.

Analysis of eDNA requires scrupulous attention to detail to prevent risk of contamination. True positive controls, negative controls and spiked synthetic DNA are included in every analysis and these have to be correct before any result is declared and reported. Stages of the DNA analysis are also conducted in different buildings at our premises for added security.

SureScreen Scientifics Ltd is ISO9001 accredited and participate in Natural England's proficiency testing scheme for GCN eDNA testing. We also carry out regular inter-laboratory checks on accuracy of results as part of our quality control procedures.

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INTERPRETATION OF RESULTS

SIC: **Sample Integrity Check** [Pass/Fail]
When samples are received in the laboratory, they are inspected for any tube leakage, suitability of sample (not too much mud or weed etc.) and absence of any factors that could potentially lead to inconclusive results.

DC: **Degradation Check** [Pass/Fail]
Analysis of the spiked DNA marker to see if there has been degradation of the kit or sample, between the date it was made to the date of analysis. Degradation of the spiked DNA marker may indicate a risk of false negative results.

IC: **Inhibition Check** [Pass/Fail]
The presence of inhibitors within a sample are assessed using a DNA marker. If inhibition is detected, samples are purified and re-analysed. Inhibitors cannot always be removed, if the inhibition check fails, the sample should be re-collected.

Result: **Presence of eDNA** [Positive/Negative/Inconclusive]

Positive: DNA was identified within the sample, indicative of species presence within the sampling location at the time the sample was taken or within the recent past at the sampling location.

Positive Replicates: Number of positive qPCR replicates out of a series of 12. If one or more of these are found to be positive the pond is declared positive for species presence. It may be assumed that small fractions of positive analyses suggest low level presence, but this cannot currently be used for population studies. Even a score as low as 1/12 is declared positive. 0/12 indicates negative species presence.

Negative: eDNA was not detected or is below the threshold detection level and the test result should be considered as evidence of species absence, however, does not exclude the potential for species presence below the limit of detection.

Inconclusive: Controls indicate inhibition or degradation of the sample, resulting in the inability to provide conclusive evidence for species presence or absence.

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Fisheries assessment of Cush wind farm, Co. Offaly

Prepared by Triturus Environmental Ltd. for SLR Consulting

November 2022

Please cite as:

Triturus (2022). Fisheries assessment of Cush wind farm, Co. Offaly. Report prepared by Triturus Environmental Ltd. for SLR Consulting. November 2022.

Table of contents

1. Introduction

1.1 Background

Triturus Environmental Ltd. were commissioned by Inis Environmental Consultants Ltd. to undertake a baseline fisheries assessment of numerous watercourses in the vicinity of the proposed Cush wind farm, located approx. 5km north of Birr, Co. Offaly.

The survey was undertaken to establish baseline fisheries data used in the preparation of the EIAR for the proposed project. In order to gain an accurate overview of the existing and potential fisheries value of the riverine watercourses within the vicinity of the proposed project, a catchment-wide electro-fishing survey across *n*=25 riverine sites was undertaken (**Table 2.1; Figure 2.1**). Electro-fishing helped to identify the importance of the watercourses as nurseries and habitats for salmonids, lamprey and European eel (*Anguilla anguilla*), as well as other species, and helped to further inform impact assessment and any subsequent mitigation for the project.

Triturus Environmental Ltd. made an application under Section 14 of the Fisheries (Consolidation) Act, 1959 as substituted by Section 4 of the Fisheries (Amendment) Act, 1962, to undertake a catchment-wide electro-fishing survey in the vicinity of the proposed Cush wind farm. Permission was granted on Monday 27th June 2022 and the survey was undertaken on Tuesday 23rd to Thursday 25th August 2022.

1.2 Fisheries asset of the survey area

The survey sites were located within the Shannon[Lower]_SC_060, Shannon[Lower]_SC_040, Shannon[Lower]_SC_030, Brosna_SC_070 and Brosna_SC_080 river sub-catchments. The proposed wind farm was not located within a European site. Fisheries survey sites were present on the Woodfield River (EPA code: 25W29), Little Brosna River (25L02), Rapemills River (25R01), Eglish Stream (25E18), West Galros Stream (25W44), Mullaghakaraun Bog Stream (25M48), Milltown Stream (25M79), Feeghroe River (25F41), Whigsborough Stream (25W43), Grant's Island River (25Y47), Bullock Island Stream (25I23), Park River (25P28), Little [Cloghan] River (25L01), River Brosna (25B09), Blackwater River (25B27) and Silver River (25S02) (**Table 2.1**).

The Little Brosna River is known to support Atlantic salmon (*Salmo salar*), brown trout (*Salmo trutta*), European eel, lamprey (*Lampetra* sp.), minnow (*Phoxinus phoxinus*) and stone loach (*Barbatula barbatula*) (Kelly et al., 2010, 2015).

The Silver [Kilcormac] River (crossed by proposed GCR) is known to support brown trout, European eel, gudgeon (*Gobio gobio*), minnow, perch (*Perca fluviatilis*), three-spined stickleback (*Gasterosteus aculeatus*), stone loach and (occasional) Atlantic salmon (Kelly et al., 2010, 2015). Both the Little Brosna and Silver Rivers also support spawning 'croneen', a genetically-distinct migratory population of potadromous brown trout indigenous to Lough Derg (Igoe et al., 2003).

The Little [Cloghan] River, a tributary of the Brosna River, is known to support stocks of brown trout, minnow, *Lampetra* sp., gudgeon, roach (*Rutilus rutilus*), stone loach and three-spined stickleback (*Gasterosteus aculeatus*) (Kelly et al., 2010, 2015; IFI, 2020 data[1]).

Fisheries data for the other watercourses within the survey area was not available at the time of survey.

[1] Inland Fisheries Ireland data for Water Framework Directive Fish Ecological Status 2008-2021. Available at https://opendata-ifigis.hub.arcgis.com/datasets/IFIgis::water-framework-directive-fish-ecological-status-2008-2021/

2. Methodology

2.1 Fish stock assessment (electro-fishing)

A single anode Smith-Root LR24 backpack (12V DC input; 300V, 100W DC output) was used to electro-fish sites on watercourses in the vicinity of the proposed Cush wind farm on the 23rd to 25th August 2022 following notification to Inland Fisheries Ireland and under the conditions of a Department of the Environment, Climate and Communications (DECC) licence. Both river and holding tank water temperature was monitored continually throughout the survey to ensure temperatures of 20°C were not exceeded, thus minimising stress to the captured fish due to low dissolved oxygen levels. A portable battery-powered aerator was also used to further reduce stress to any captured fish contained in the holding tank.

Salmonids, European eel and other captured fish species were transferred to a holding container with oxygenated fresh river water following capture. To reduce fish stress levels, anaesthesia was not applied to captured fish. All fish were measured to the nearest millimetre and released in-situ following a suitable recovery period.

As three primary species groups were targeted during the survey, i.e., salmonids, lamprey, and eel, the electro-fishing settings were tailored for each species. By undertaking electro-fishing using the rapid electro-fishing technique (see methodology below), the broad characterisation of the fish community at each sampling reach could be determined as a longer representative length of channel can be surveyed. Electro-fishing methodology followed accepted European standards (CEN, 2003) and adhered to best practice (e.g., CFB, 2008).

The catchment-wide electro-fishing (CWEF) survey was undertaken across *n*=25 riverine sites (see **Table 2.1, Figure 2.1**).

2.1.1 Salmonids and European eel

For salmonid species and European eel, as well as all other incidental species, electro-fishing was carried out in an upstream direction for a 10-minute CPUE, an increasingly common standard approach for wadable streams (Matson et al., 2018). A total of approx. 40-100m channel length was surveyed at each site, where feasible, in order to gain a better representation of fish stock assemblages. At certain, more minor watercourse sites or sites with limited access, it was more feasible to undertake electro-fishing for a 5-minute CPUE. Discrepancies in fishing effort (CPUE) between sites are accounted for in the subsequent results section (**Table 3.1**).

Relative conductivity of the water at each site was checked in-situ with a conductivity meter and the electro-fishing backpack was energised with the appropriate voltage and frequency to provide enough draw to attract salmonids and European eel to the anode without harm. For the moderate conductivity waters of the sites (most draining calcareous geologies) a voltage of 200-230v, frequency of 35-45Hz and pulse duration of 3.5-4ms was utilised to draw fish to the anode without causing physical damage.

2.1.2 Lamprey

Electro-fishing for lamprey ammocoetes was conducted using targeted box quadrat-based electro-fishing (as per Harvey & Cowx, 2003) in objectively suitable areas of sand/silt, where encountered. As lamprey take longer to emerge from silts and require a more persistent approach, they were targeted at a lower frequency (30Hz) burst DC pulse setting which also allowed detection of European eel in sediment, if present. Settings for lamprey followed those recommended and used by Harvey & Cowx (2003), APEM (2004) and Niven & McAuley (2013). Using this approach, the anode was placed under the water's surface, approx. 10-15cm above the sediment, to prevent immobilising lamprey ammocoetes within the sediment. The anode was energised with 100V of pulsed DC for 15-20 seconds and then turned off for approximately five seconds to allow ammocoetes to emerge from their burrows. The anode was switched on and off in this way for approximately two minutes. Immobilised ammocoetes were collected by a second operator using a fine-mesh hand net as they emerged.

Lamprey species were identified to species level, where possible, with the assistance of a hand lens, through external pigmentation patterns and trunk myomere counts as described by Potter & Osborne (1975) and Gardiner (2003).

2.2 Fisheries habitat

A broad appraisal / overview of the upstream and downstream habitat at each site was also undertaken to evaluate the wider contribution to salmonid and lamprey spawning and general fisheries habitat. River habitat surveys and fisheries assessments were also carried out utilising elements of the approaches in the River Habitat Survey Methodology (EA, 2003) and Fishery Assessment Methodology (O'Grady, 2006) to broadly characterise the riverine sites (i.e., channel profiles, substrata etc.).

2.3 Biosecurity

A strict biosecurity protocol following IFI (2010) and the Check-Clean-Dry approach was adhered to during surveys for all equipment and PPE used. Disinfection of all equipment and PPE before and after use with Virkon™ was conducted to prevent the transfer of pathogens or invasive propagules between survey sites. Surveys were undertaken at sites in a downstream order to minimise the risk of upstream propagule mobilisation. Particular cognisance was given towards preventing the spread or introduction of crayfish plague (*Aphanomyces astaci*) given the known distribution of white-clawed crayfish (*Austropotamobius pallipes*) in the wider survey area. Furthermore, staff did not undertake any work in a known crayfish plague catchment for a period of <72hrs in advance of the survey. Where feasible, equipment was also thoroughly dried (through UV exposure) between survey areas. Any aquatic invasive species or pathogens recorded within or adjoining the survey areas were geo-referenced. All Triturus staff are certified in 'Good fieldwork practice: slowing the spread of invasive non-native species' by the University of Leeds.

Table 2.1 Location of *n*=25 electro-fishing survey sites in the vicinity of Cush wind farm, Co. Offaly

Site no.	Watercourse	EPA code	Location	X (ITM)	Y (ITM)
A1	Woodfield River	25W29	Banagher Road R439 crossing	605395	708239
A2	Woodfield River	25W29	Clondallow	605352	707970
A3	Little Brosna River	25L02	Derrinasallow Bridge	603240	707953
B1	Rapemills River	25R01	Eglish	608544	709346
B2	Eglish Stream	25E18	Eglish	608194	709857
B3	Rapemills River	25R01	Boolinarig Bridge	607478	709372
B4	Rapemills River	25R01	Cush	606559	709867
B5	West Galros Stream	25W44	Eglish	608047	710214
B6	West Galros Stream	25W44	N62 road crossing	607627	710485
B7	West Galros Stream	25W44	Cush	606664	710294
B8	Rapemills River	25R01	Banagher Road R439 crossing	604773	710211
B9	Mullaghakaraun Bog Stream	25M48	Ballyneena	603822	711896
B10	Rapemills River	25R01	All Saints Bridge	602588	711394
B11	Milltown Stream	25M79	Ballyneena	603454	712240
B12	Feeghroe River	25F41	Five Roads Cross	603610	713632
B13	Rapemills River	25R01	Lusmagh Bridge	600120	714650
C1	Whigsborough Stream	25W43	Clooneen	608877	713034
D1	Grants Island River	25Y47	L7014 road crossing	603109	717415
D2	Bullock Island Stream	25I23	L7014 road crossing	603118	717707
D3	Park River	25P28	L7014 road crossing	603143	718403
D5	Little [Cloghan] River	25L01	L7014 road crossing	604150	719834
D6	River Brosna	25B09	Moystown Bridge	604710	720913
D7	Blackwater River	25B27	Blackwater Bridge, R357	601538	723464
E1	Silver River	25S02	Wooden Bridge	612676	714360
E2	Silver River	25S02	Millbrook Bridge	613497	718834

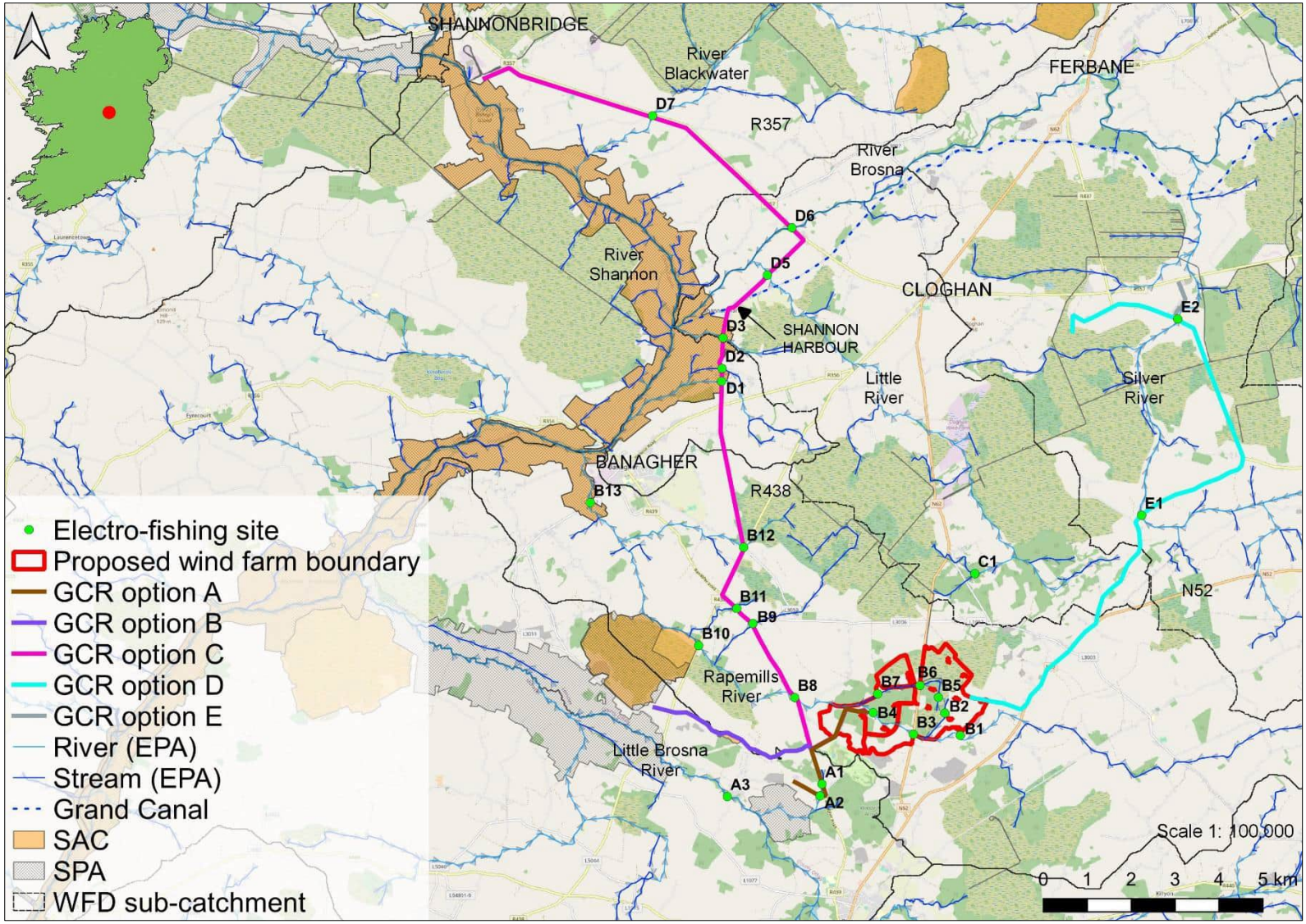

Figure 2.1 Overview of the *n*=25 electro-fishing survey site locations for Cush wind farm, Co. Offaly

3. Results

A catchment-wide electro-fishing survey of *n*=25 riverine sites in the vicinity of the proposed Cush wind farm was conducted on the 23rd to 25th August 2022 following notification to Inland Fisheries Ireland. The results of the survey are discussed below in terms of fish population structure, population size and the suitability and value of the surveyed areas as nursery and spawning habitat for salmonids, European eel and lamprey species. Scientific names are provided at first mention only.

3.1 Fish stock assessment (electro-fishing)

3.1.1 Site A1 – Woodfield River, R439 road crossing

Site A1 was not of fisheries value given its dry, ephemeral nature and absence of aquatic habitats at the time of survey. It was not possible to undertake electro-fishing at this site.

Plate 3.1 Representative image of site A1 on the upper reaches of the Woodfield River, August 2022 (dry, ephemeral channel)

3.1.2 Site A2 – Woodfield River, Clondallow

Ten-spined stickleback (*Pungitius pungitius*) was the only fish species recorded via electro-fishing at site A2 (**Figure 3.1**).

With the exception of this species, the site was not of fisheries value given its semi-dry, evidently ephemeral nature. A low density of fish (*n*=4) were recorded from a shallow, isolated stagnant (1m^2) pool immediately below the road culvert.

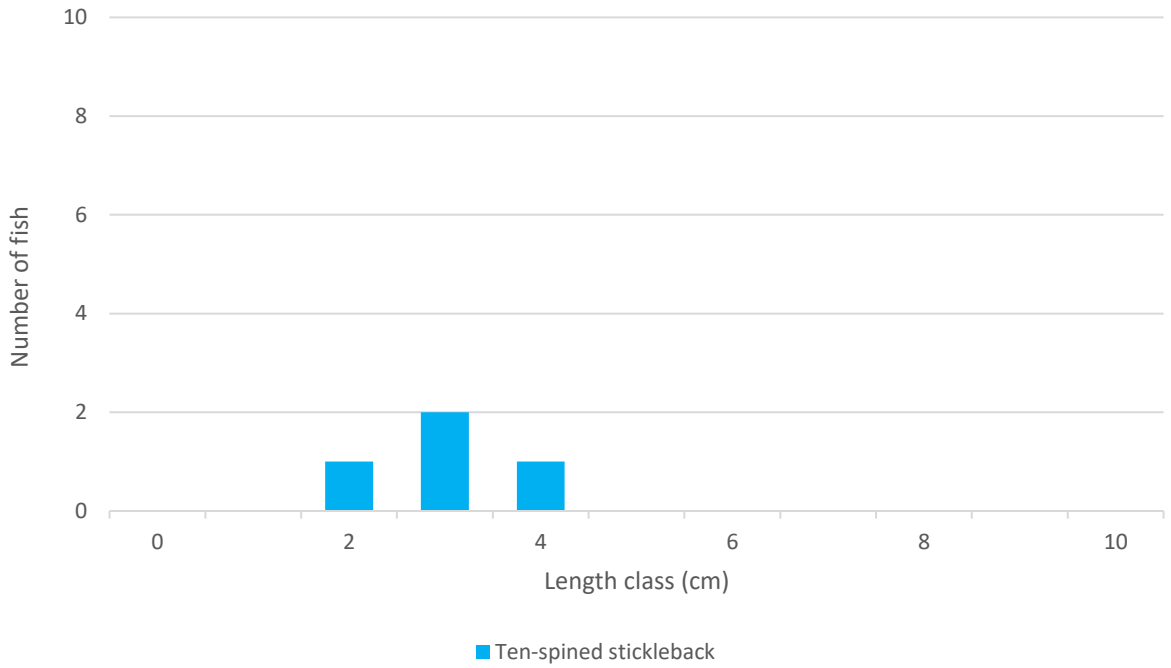

Figure 3.1 Length frequency distribution of fish recorded at site A2 on the Woodfield River, August 2022

Plate 3.2 Ten-spined stickleback recorded at site A2 on the Woodfield River, August 2022

3.1.3 Site A3 – Little Brosna River, Derrinasallow Bridge

Atlantic salmon (*Salmo salar*), brown trout (*Salmo trutta*), European eel (*Anguilla anguilla*), stone loach (*Barbatula barbatula*) and minnow (*Phoxinus phoxinus*) were recorded via electro-fishing at site A3 (**Figure 3.2**).

The site was of high value for salmonids, with a mixed-cohort population of brown trout (*n*=17) and a low density of Atlantic salmon parr (*n*=5) recorded. The site was of most value as a habitat for adult trout, with frequent deeper pool and glide present in addition to naturally scoured banks and occasional overhanging willow. Given high flow rates and compaction/calcification of the bed (which reduced the number of accessible refugia), the site provided sub-optimal nursery conditions, being better suited to Atlantic salmon than trout. The site provided some good spawning habitat for both salmonids and lamprey although suitable substrata were highly localised. Larval lamprey habitat was not present. European eel habitat was moderate overall given a general paucity of accessible instream refugia and a single adult was recorded.

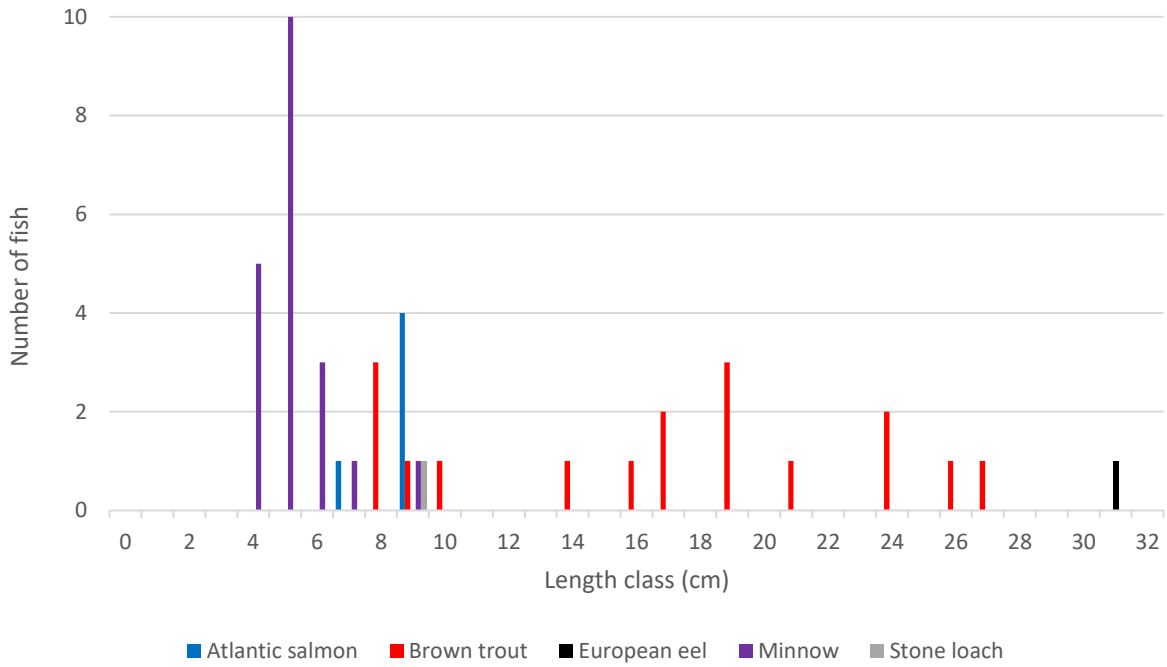

Figure 3.2 Length frequency distribution of fish recorded at site A3 on the Little Brosna River, August 2022

Plate 3.3 Juvenile Atlantic salmon (top) and brown trout (bottom) recorded at site A3 on the Little Brosna River, August 2022

3.1.4 Site B1 – Rapemills River, Eglish

Brown trout, lamprey (*Lampetra* sp.) and three-spined stickleback were recorded via electro-fishing at site B1 (**Figure 3.3**).

The site was of high value to salmonids, supporting a moderate density of mixed-cohort brown trout (*n*=45). The population was dominated by adult fish. Fine gravel spawning habitat for both salmonids and lamprey, whilst widespread, was compromised by moderate siltation. The site provided good quality salmonid nursery and holding habitat. The site was a high value lamprey habitat, with excellent quality nursery habitat by way of abundant soft sediment deposits of 5-10cm deep. These supported high densities of ammocoetes (20 per m^2), the highest recorded during the survey. Despite high suitability for European eel (abundant instream refugia), none were recorded.

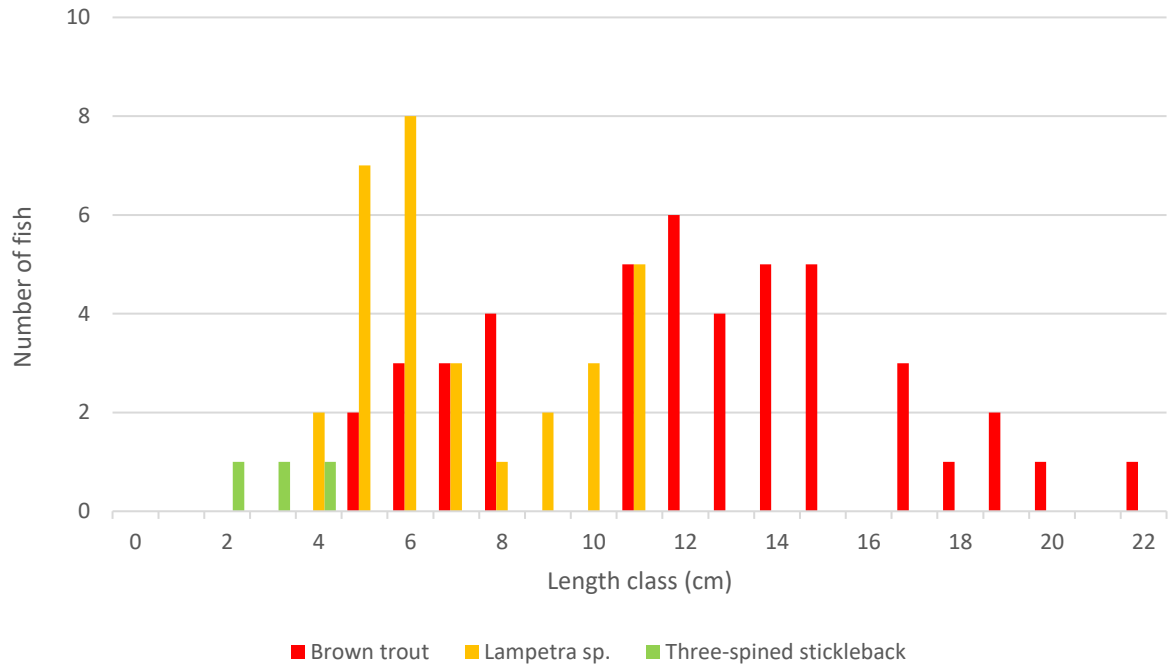

Figure 3.3 Length frequency distribution of fish recorded at site B1 on the Rapemills River, August 2022

Plate 3.4 Mixed-cohort *Lampetra* sp. ammocoetes recorded at site B1 on the Rapemills River, August 2022

3.1.5 Site B2 – Eglish Stream, Eglish

Site B2 was not of fisheries value given its dry, ephemeral nature and absence of aquatic habitats at the time of survey. It was not possible to undertake electro-fishing at this site.

Plate 3.5 Representative image of site B2 on the Eglish Stream, August 2022 (dry channel)

3.1.6 Site B3 – Rapemills River, Boolinarig Bridge

Brown trout and lamprey (*Lampetra* sp.) were the only two fish species recorded via electro-fishing at site B3 (**Figure 3.4**).

Despite evident hydromorphological modifications, site B3 was of good value for salmonids, supporting a moderate density of mixed-cohort brown trout (*n*=44). Spawning habitat for salmonids and lamprey was present but highly localised in the vicinity of the bridge and exposed to moderate to high siltation pressures. The installed cobbles on the bridge apron provided some good quality nursery habitat for juvenile trout (habitat which is rare within the Rapemills River; pers. obs.). Holding habitat was of excellent quality given the predominance of deep glide and pool, with frequent undercut/scoured banks and floating macrophyte vegetation. Despite an abundance of soft sediment accumulations, lamprey nursery habitat was considered of moderate quality only given low flow rates and the generally flocculent nature of the silt. However, a low density of ammocoetes (2 per m^2) was recorded via targeted electro-fishing. European eel habitat was good given ample refugia although none were recorded.

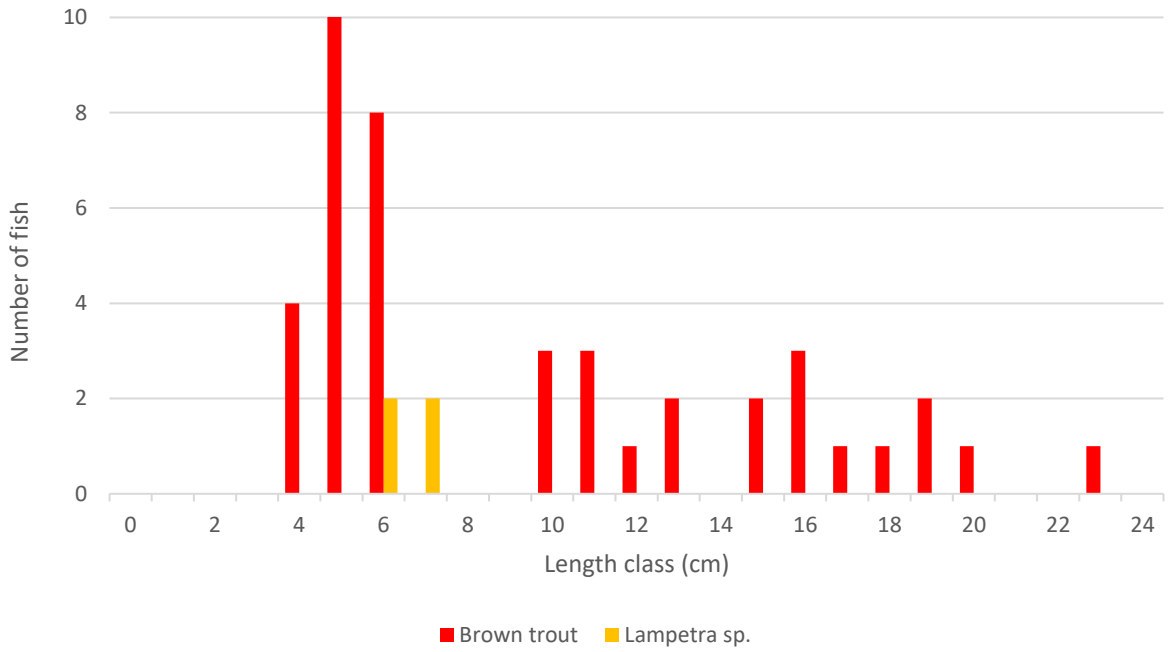

Figure 3.4 Length frequency distribution recorded via electro-fishing at site B3 on the Rapemills River, August 2022

Plate 3.6 Mixed-cohort brown trout recorded at site B3 on the Rapemills River, August 2022

3.1.7 Site B4 – Rapemills River, Cush

Brown trout, lamprey (*Lampetra* sp.) and three-spined stickleback were recorded via electro-fishing at site B4 (**Figure 3.5**).

The site was a poor salmonid habitat given gross siltation and very poor hydromorphology, supporting a very low density of adult brown trout only (no juveniles). Salmonid spawning habitat was not present given siltation pressures, with nursery habitat also of poor quality. The site had some value as a holding habitat given the predominance of deep glide with frequent scoured banks and overhanging vegetation (providing valuable thermal refugia in the near absence of riparian trees). Whilst the site featured abundant soft sediment, few areas were considered optimal for lamprey ammocoetes given poor flows/hydromorphology, However, a low density of ammocoetes (2 per m^2) were recorded from localised faster-flowing areas (typically associated with instream debris). Despite some low suitability for European eel, none were recorded.

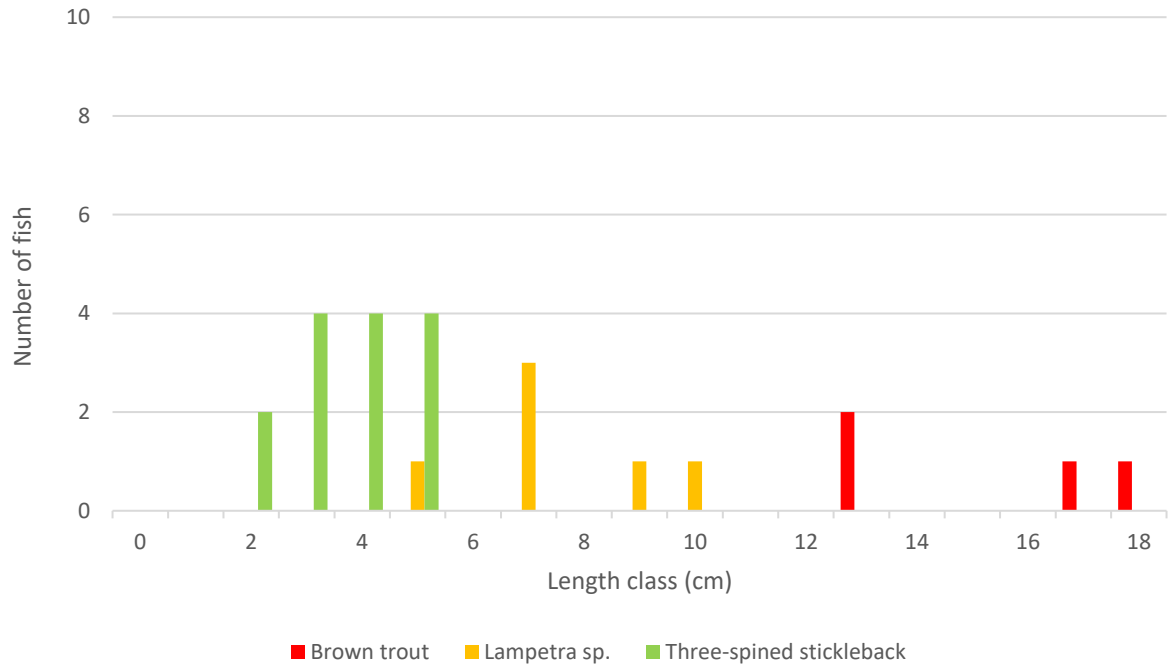

Figure 3.5 Length frequency distribution recorded via electro-fishing at site B4 on the Rapemills River, August 2022

Plate 3.7 Three-spined stickleback recorded at site B4 on the Rapemills River, August 2022

3.1.8 Site B5 – West Galros Stream, Eglish

Electro-fishing was not undertaken at site B5 given prohibitive depths of >1.5m and a deep silt base. With the exception of three-spined stickleback (Observed during the survey), site B5 was of poor fisheries value given poor hydromorphology, low flows and heavy siltation. However, whilst salmonid spawning and nursery habitat was absent, the site had some low value as a holding habitat for adult brown trout given the high average depth. Suitability for European eel was high.

3.1.9 Site B6 – West Galros Stream, Eglish

Electro-fishing was not undertaken at site B6 given prohibitive depths of >1.5-2m. With the exception of three-spined stickleback, site B5 was of poor fisheries value given poor hydromorphology, low flows and heavy siltation. However, whilst salmonid spawning and nursery habitat was absent, the site had some low value as a holding habitat for adult trout given the high average depth. Suitability for European eel was high.

Plate 3.8 Representative image of site B5 on the upper reaches of the West Galros Stream, August 2022

Plate 3.9 Representative image of site B6 on the West Galros Stream, August 2022 (facing upstream from road crossing)

3.1.10 Site B7 – West Galros Stream, Cush

Three-spined stickleback was the only species recorded via electro-fishing at site B7 (**Figure 3.6**).

With the exception of low densities of three-spined stickleback (*n*=23), the site was not of fisheries value given poor hydromorphology, low flows and heavy siltation, in addition to poor connectivity with downstream habitats.

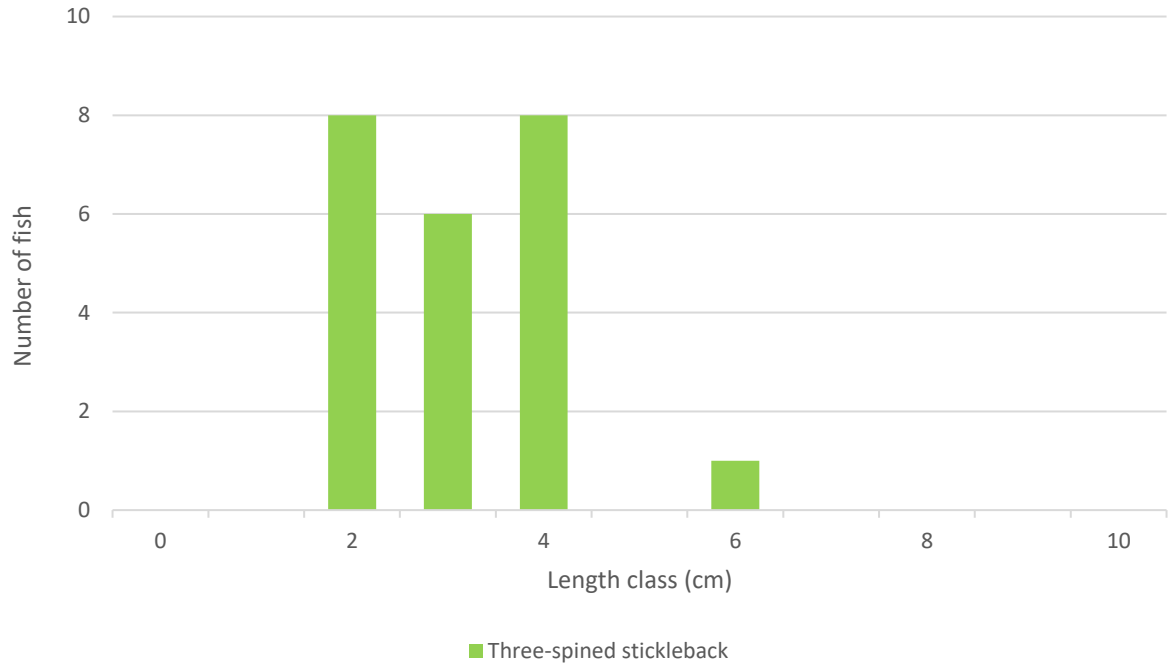

Figure 3.6 Length frequency distribution recorded via electro-fishing at site B7 on the West Galros Stream, August 2022

Plate 3.10 Representative image of site B7 on the West Galros Stream, August 2022

3.1.11 Site B8 – Rapemills River, R439 road crossing

Brown trout was the only species recorded via electro-fishing at site B8 (**Figure 3.7**).

The site was of high value for salmonids, supporting a moderate density of mixed-cohort brown trout (*n*=42). The site was considered a good quality salmonid nursery although the value was reduced given the paucity of accessible instream refugia due to calcification of the bed. Spawning habitat was largely absent given compaction and calcification of the substrata. Some excellent quality holding habitat was present in deeper shaded pool and glide areas, many of which were adjoined by scoured banks and tree root systems. These areas also provided good refugia for European eel although none were recorded. Suitability for lamprey was low due to the high energy nature of the site and more flocculent nature of any soft sediment deposits.

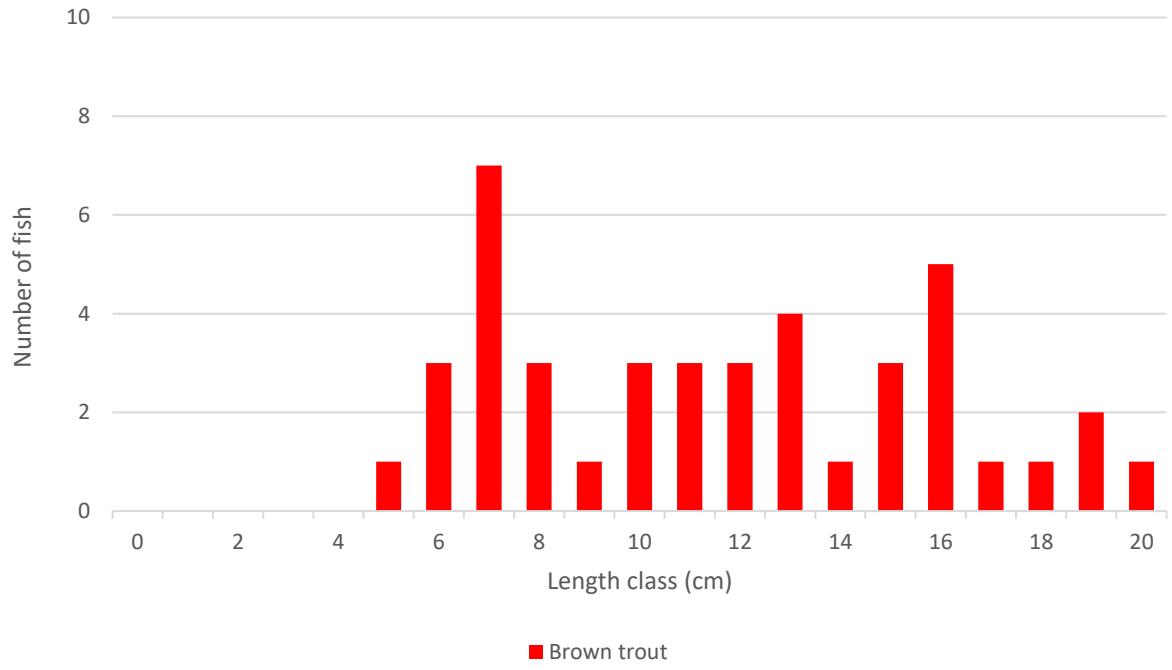

Figure 3.7 Length frequency distribution recorded via electro-fishing at site B8 on the Rapemills River, August 2022

Plate 3.11 Small adult brown trout recorded at site B8 on the Rapemills River, August 2022

3.1.12 Site B9 – Mullaghakaraun Bog Stream, Ballyneena

Lamprey (*Lampetra* sp.) and ten-spined stickleback were the only to fish species recorded via electro-fishing at site B9 (**Figure 3.8**).

The site was of poor value for salmonids (none recorded) given evident siltation and hydromorphological pressures (i.e. poor seasonal flows, forestry upstream etc.). Despite some low suitability as a brown trout nursery and holding habitat, none were recorded via electro-fishing. Likewise, no European eel were recorded despite some low suitability. The site was of moderate value for *Lampetra* sp., with a low density (4.6 per m^2) of ammocoetes recorded from deep organic-rich soft sediment upstream of the bridge. However, the site was considered sub-optimal for the species given low seasonal flows and a lack of spawning gravels (siltation).

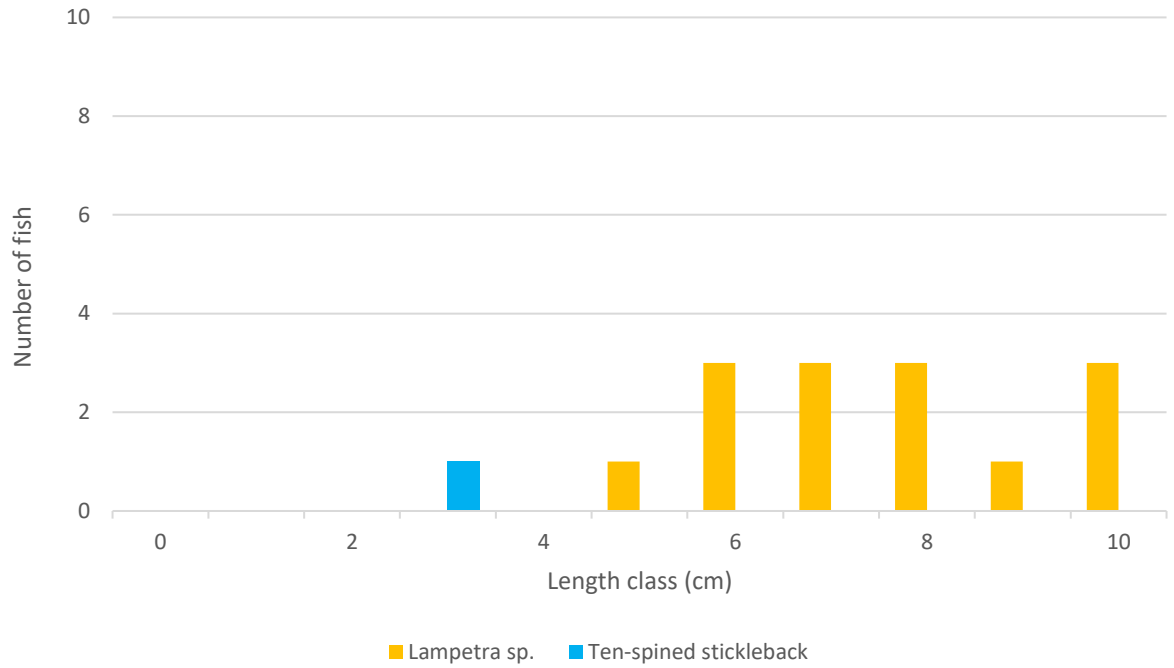

Figure 3.8 Length frequency distribution recorded via electro-fishing at site B9 on the Mullaghakaraun Bog Stream, August 2022

Plate 3.12 Mixed-cohort Lampetra sp. ammocoetes recorded at site B9 on the Mullaghakaraun Bog Stream, August 2022

3.1.13 Site B10 – Rapemills River, All Saints Bridge

Brown trout, European eel, three-spined stickleback and minnow were recorded via electro-fishing at site B10 (**Figure 3.9**).

The site was of moderate value for salmonids only given hydromorphological and gross siltation pressures. The site supported a very low density of adult brown trout (*n*=3), with no juveniles recorded. Spawning habitat was almost entirely absent and sub-optimal where present given calcification and siltation of the bed. The site was not of value as a salmonid nursery (i.e. more suited to coarse fish). European eel habitat was of good quality given abundant instream refugia. However, only a single large adult eel (62.4cm TL) was recorded via electro-fishing. Despite abundant soft sediment deposits, no lamprey ammocoetes were recorded. This was considered reflective of low flows at the (depositional) site.

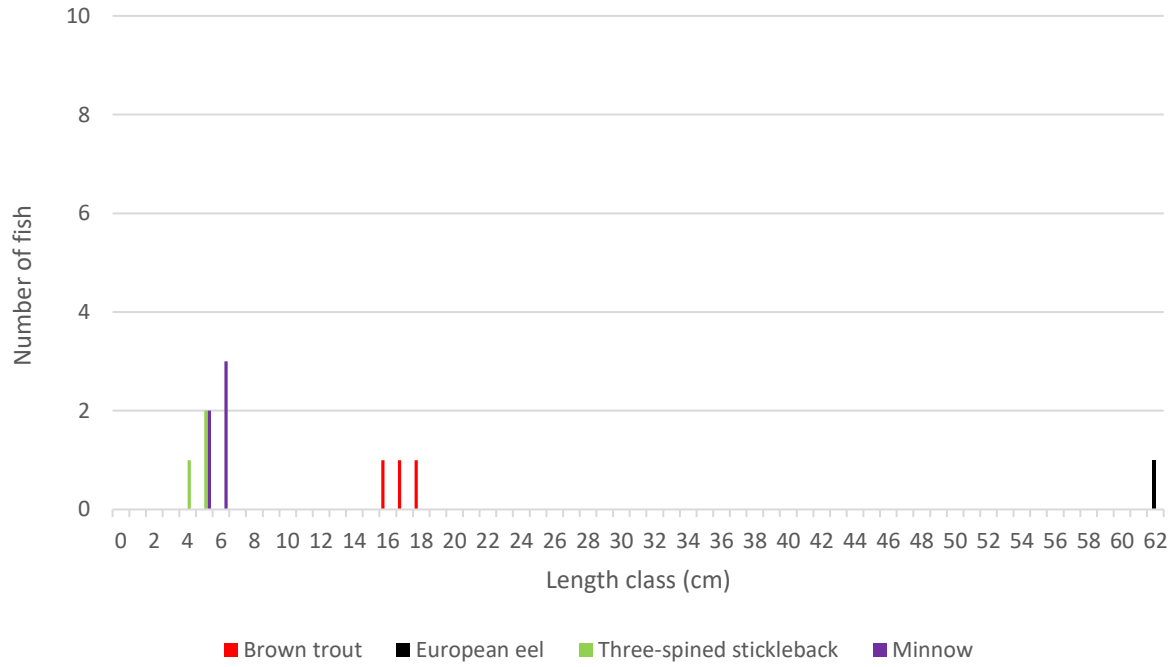

Figure 3.9 Length frequency distribution recorded via electro-fishing at site B10 on the Rapemills River, August 2022

Plate 3.13 Large adult European eel recorded at site B10 on the Rapemills River, August 2022

3.1.14 Site B11 – Milltown Stream, Ballyneena

Site B11 was not of fisheries value at the time of survey given its dry, ephemeral nature and absence of aquatic habitats. However, there was some low physical habitat suitability for salmonids and European eel under higher flow periods and such species may migrate from the downstream-connecting Rapemills River. It was not possible to undertake electro-fishing at this site.

Plate 3.14 Representative image of site B11 on the Milltown Stream, August 2022

3.1.15 Site B12 – Feeghroe River, Five Roads Cross

Brown trout (*n*=8), three-spined stickleback (*n*=18) and ten-spined stickleback (*n*=3) were recorded via electro-fishing at site B12 (**Figure 3.10**).

The site was of moderate value only for salmonids given gross siltation (from peat escapement), poor hydromorphology and poor seasonal flows. However, the site supported a small population of adult brown trout, with the box culvert providing some suitable holding habitat. Spawning substrata were absent from the site (present in 2019; Triturus, 2019) and nursery habitat was very poor. Suitability for European eel was also poor (none recorded). Poor flows and peat-dominated substrata precluded the presence of lamprey.

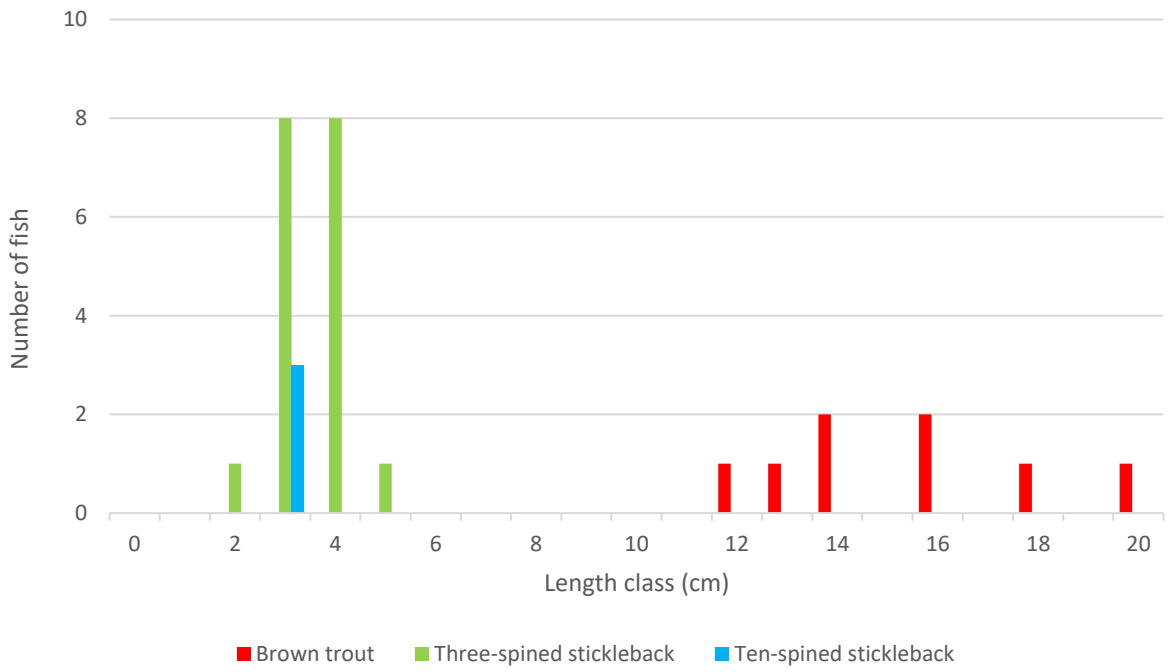

Figure 3.10 Length frequency distribution recorded via electro-fishing at site B12 on the Feeghroe River, August 2022

Plate 3.15 Small adult brown trout recorded at site B12 on the Feeghroe River, August 2022

3.1.16 Site B13 – Rapemills River, Lusmagh Bridge

A total of *n*=6 species were recorded via electro-fishing at site B13, namely brown trout (*n*=5), European eel (*n*=2), minnow (*n*=39), three-spined stickleback (*n*=23), stone loach (*n*=5) and pike (*Esox lucius*) (*n*=1) (**Figure 3.11**). This was the highest fish species diversity recorded during the survey.

The site was of moderate value to salmonids, supporting a low density of primarily adult brown trout. The predominant deeper glide habitat provided some good holding habitat for large trout (e.g. overhanging aquatic vegetation). Some limited nursery habitat was present in the vicinity of the bridge but this was reduced in value given significant siltation pressures. Spawning habitat for salmonids and lamprey was also confined to the bridge area and also impacted by siltation and filamentous algae. Despite abundant soft sediment, no larval lamprey were recorded. The site was of most value for coarse fish habitat given the predominance of heavily vegetated, depositional glide and pool. European eel habitat was good overall given abundant instream refugia (mostly macrophyte beds), although only a low density were recorded.

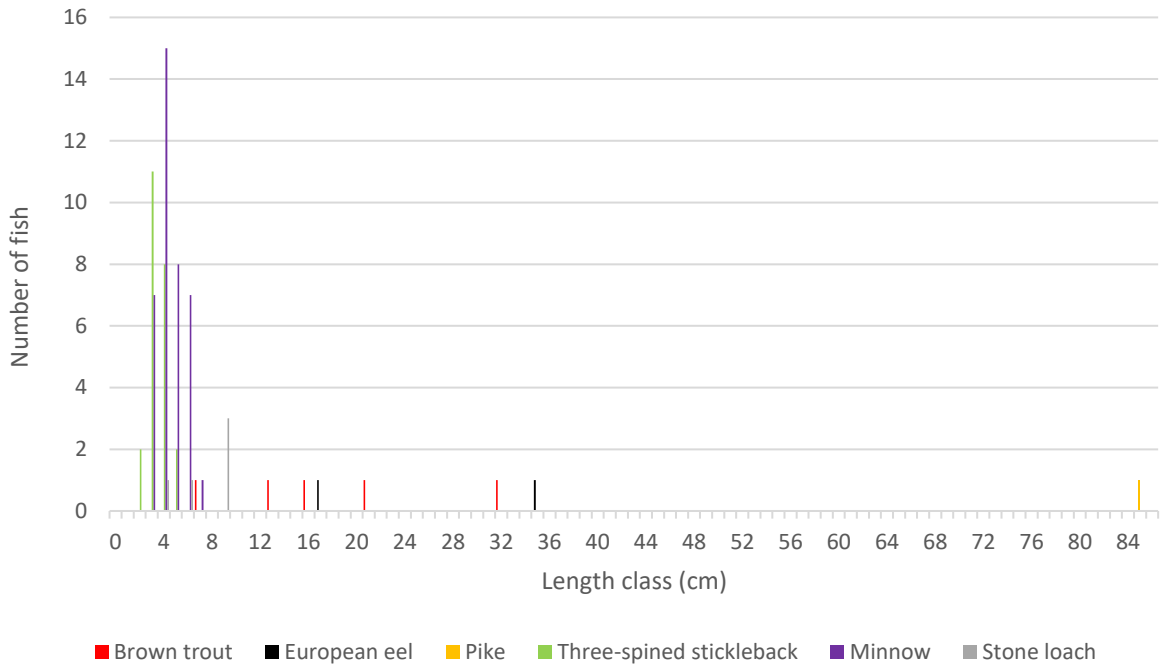

Figure 3.11 Length frequency distribution recorded via electro-fishing at site B13 on the Rapemills River, August 2022

Plate 3.16 Adult pike (85cm FL) recorded via electro-fishing at site B13 on the Rapemills River

3.1.17 Site C1 – Whigsborough Stream, Clooneen

No fish species were recorded via electro-fishing at site C1. The site was not of fisheries value given gross siltation, poor hydromorphology and low flows, in addition to poor connectivity with downstream habitats (frequent peat blockages instream).

Plate 3.17 Representative image of site C1 on the Whigsborough Stream, August 2022

3.1.18 Site D1 – Grant's Island River, L7014 road crossing

No fish species were recorded via electro-fishing at site D1. The site was not of fisheries value given gross siltation, poor hydromorphology and low flows, in addition to poor connectivity with downstream habitats (frequent blockages instream).

Plate 3.18 Representative image of site D1 on the Grant's Island River, August 2022

3.1.19 Site D2 – Bullock Island Stream, L7014 road crossing

Site D2 was not of fisheries value at the time of survey given its dry, ephemeral nature and absence of aquatic habitats. However, given evidence that it supports water seasonally, the channel may be of some low value as a coarse fish and European eel habitat during (winter) higher water periods. It was not possible to undertake electro-fishing at this site.

Plate 3.19 Representative image of site D2 on the Bullock Island Stream, August 2022 (dry channel)

3.1.20 Site D3 – Park River, L7014 road crossing

Site D3 was not of fisheries value at the time of survey given its dry, ephemeral nature and absence of aquatic habitats. However, given evidence that it supports water seasonally, the channel may be of some low value as a coarse fish and European eel habitat in its lower reaches during (winter) higher water periods. It was not possible to undertake electro-fishing at this site.

Plate 3.20 Representative image of site D3 on the Park River, August 2022 (dry, ephemeral channel)

3.1.21 Site D5 - Little River, L7014 road crossing

A total of *n*=6 species were recorded via electro-fishing at site B13, namely brown trout (n=5), lamprey (*Lampetra* sp.) (*n*=33), European eel (*n*=1), minnow (*n*=27), stone loach (*n*=4) and roach (*Rutilus rutilus*) (*n*=1) (**Figure 3.12**). This was the highest fish species diversity recorded during the survey.

Site D5 was of moderate value to salmonids only given significant siltation pressures and poor hydromorphology resulting from historical arterial drainage. However, the site supported a low density of adult brown trout. Spawning habitat for both salmonids and lamprey was present but highly localised and significantly impacted by siltation. Occasional deeper pool and deeper glide habitat provided some good holding opportunities for adult trout. The site was a poor quality salmonid nursery, as reflected in the absence of juveniles recorded during electro-fishing. In contrast, the site was of high value as a lamprey nursery, with moderate densities of larvae recorded from abundant soft sediment areas (13.2 per m^2). European eel habitat was moderate overall, with a low density present. The site was of greater value as a coarse fish habitat.

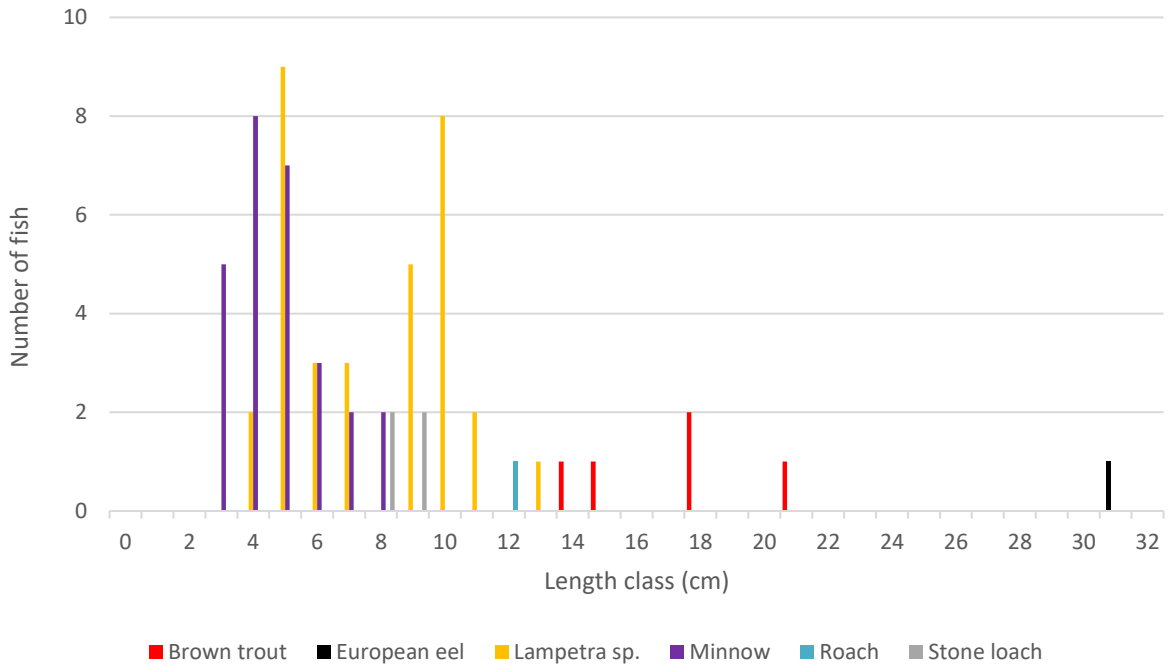

Figure 3.12 Length frequency distribution recorded via electro-fishing at site D5 on the Little River, August 2022

Plate 3.21 Juvenile roach and *Lampetra* sp. ammocoetes recorded at site D5 on the Little River, August 2022

3.1.22 Site D6 - River Brosna, Moystown Bridge

Electro-fishing was not undertaken at site D6 given the large width, prohibitive depths and high flow rates. However, the site was of high value for salmonids being most suited to adults given a predominance of deeper glide and pool. Overhanging willow-dominated treelines provided valuable shading and cover. Whilst some spawning substrata was present for both salmonids and lamprey, this was highly localised (rare overall). Salmonid nursery habitat was superficially good although closer inspection of instream substrata revealed a paucity of accessible refugia due to substrate compaction and calcification. Furthermore, macrophyte refugia cover was low. The high-energy site was largely unsuitable as a lamprey nursery habitat (high flow rates), though some sub-optimal habitat was present away from main flow channels. The site was of relatively poor value for European eel given a paucity of instream refugia. However, the River Brosna is known to support European eel in addition Atlantic salmon, brown trout, lamprey (*Lampetra* sp.), minnow and stone loach (Kelly et al., 2010, 2015). Two gudgeon (*Gobio gobio*) were recorded during kick sampling.

Plate 3.22 Two gudgeon recorded via kick sampling at site D6 on the Little River, August 2022

3.1.23 Site D7 - Blackwater River, Blackwater Bridge

A total of *n*=4 fish species were recorded via electro-fishing at site D7, namely brown trout (*n*=1), lamprey (*Lampetra* sp.) (*n*=54), minnow (*n*=3) and stone loach (*n*=4) (**Figure 3.13**).

The site was of very poor value for salmonids given poor hydromorphology and gross siltation. However, a single adult brown trout was recorded via electro-fishing alongside a very low density of stone loach and minnow. The site was of very high value for *Lampetra* sp., with abundant soft sediment habitat and moderate densities of ammocoetes (11 per m^2). Lamprey spawning habitat was almost entirely absent in the vicinity of the bridge (superficial gravels at one location only near a debris

dam), indicating superior spawning habitat was present upstream. Despite some suitability for European eel, none were recorded.

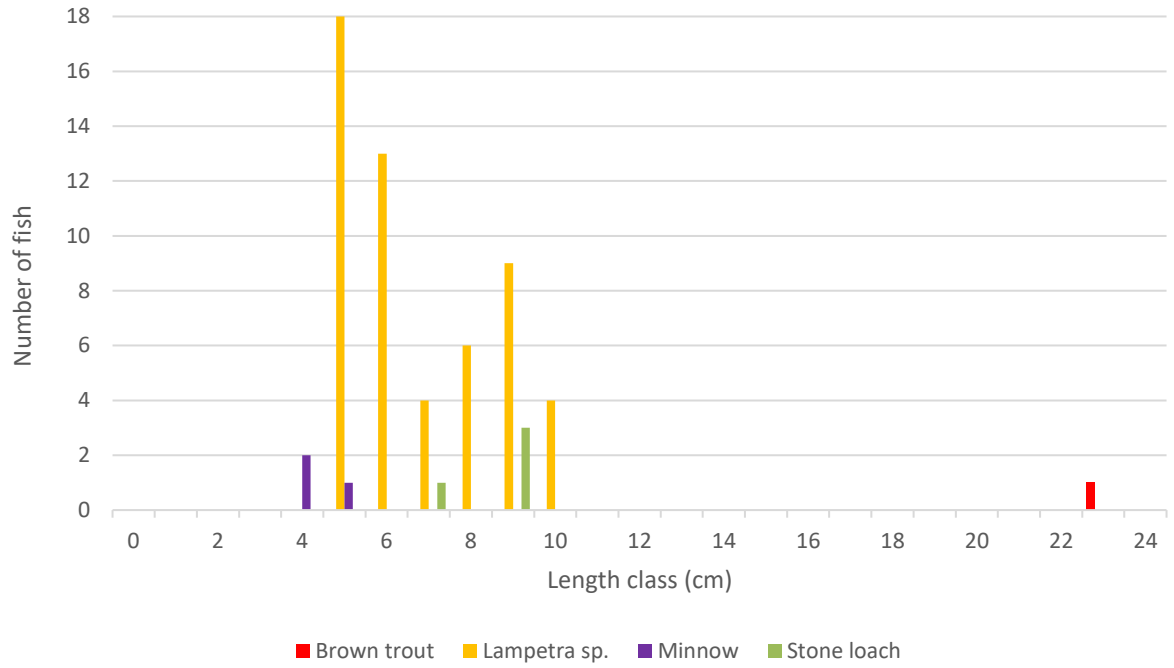

Figure 3.13 Length frequency distribution recorded via electro-fishing at site D5 on the Little River, August 2022

Plate 3.23 Mixed-cohort *Lampetra* sp. ammocoetes recorded at site D7 on the Blackwater River, August 2022

3.1.24 Site E1 - Silver River, Wooden Bridge

A total of *n*=5 fish species were recorded via electro-fishing at site E1, namely brown trout (*n*=14), lamprey (*Lampetra* sp.) (*n*=1), minnow (*n*=21), three-spined stickleback (*n*=1) and stone loach (*n*=9) (**Figure 3.14**).

Despite significant siltation pressures, site E1 was of good value to salmonids, supporting a moderate density of primarily adult trout. The site was of most value as an adult trout habitat given an abundance of deep glide with high instream cover. The site was of moderate value as a nursery given compaction of instream refugia. Whilst mixed gravels and small cobble present downstream of the bridge provided some localised spawning habitat for salmonids and lamprey, the value was reduced given siltation pressures. Despite frequent sand and silt accumulations, the site supported only a low density of lamprey ammocoetes (0.5 per m^2). Whilst no European eel were recorded, the site provided some good suitability (e.g. deep, macrophyte-rich glide).

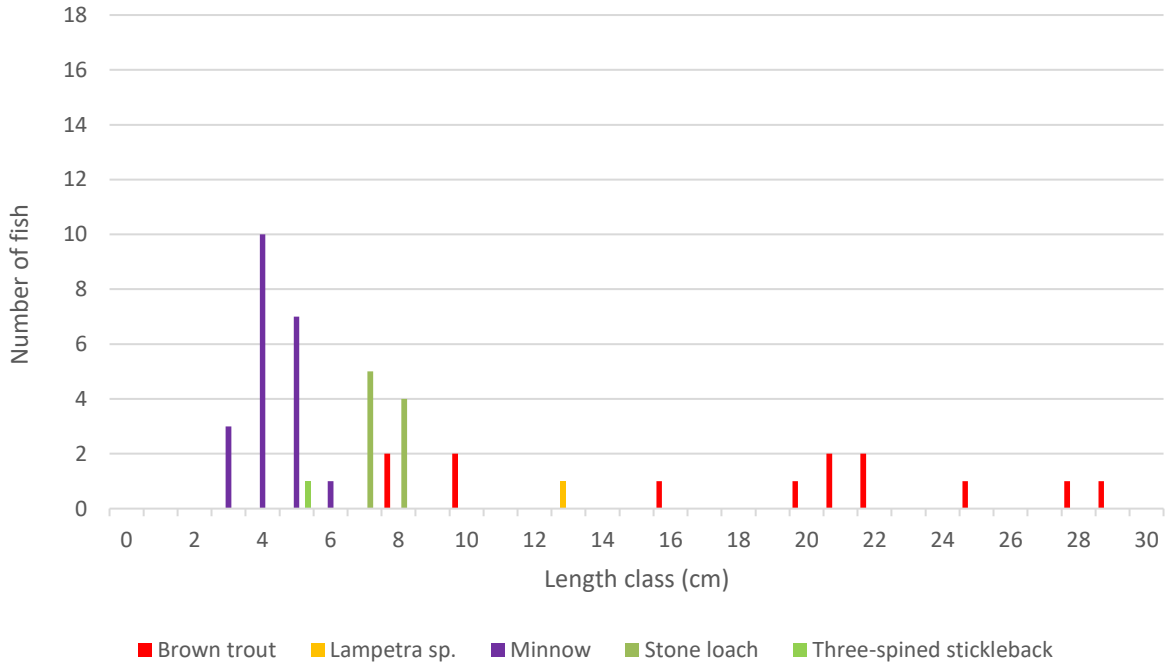

Figure 3.14 Length frequency distribution recorded via electro-fishing at site E1 on the Silver River, August 2022

Plate 3.24 Large adult brown trout recorded at site E1 on the Silver River, August 2022

3.1.25 Site E2 - Silver River, Millbrook Bridge

A total of *n*=4 fish species were recorded via electro-fishing at site E2, namely Atlantic salmon (*n*=1), brown trout (*n*=34), lamprey (*Lampetra* sp.) (*n*=1) and stone loach (*n*=7) (**Figure 3.15**).

Site E2 was of good value for salmonids, supporting a moderate density of primarily adult brown trout. A single Atlantic salmon parr was also captured. The site was of highest value as an adult holding habitat given the predominance of deeper glide and pool with frequent macrophyte beds. These areas also provided some good quality nursery although densities of juveniles were low given the reduced spawning capacity of the site due to bedding, siltation and calcification pressures. Nevertheless, some good quality spawning habitat was present locally for both salmonids and lamprey. Good quality larval lamprey habitat was also present locally although these areas supported only low densities of ammocoetes (3.5 per m^2). Despite some good suitability for European eel, none were recorded, likely reflecting the relative paucity of accessible boulder and cobble refugia

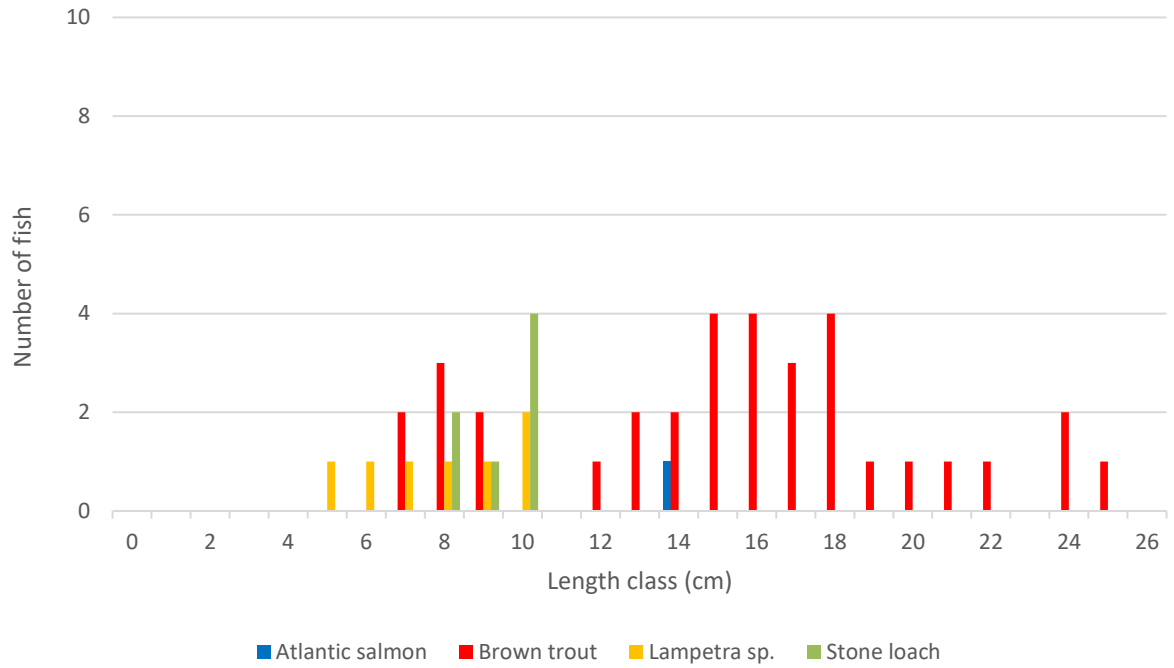

Figure 3.15 Length frequency distribution recorded via electro-fishing at site E2 on the Silver River, August 2022

Plate 3.25 Atlantic salmon parr (14.2cm FL) recorded at site E2 on the Silver River, August 2022

Table 3.1 Fish species densities per m^2 recorded at sites in the vicinity of the proposed Cush wind farm via electro-fishing in August 2022 (values in bold represent the highest densities recorded for each species, respectively)

Site	Watercourse	CPUE (elapsed time)	Approx. area fished (m^2)	Atlantic salmon	Brown trout	Lampetra sp.	European eel	Three-spined stickleback	Ten-spined stickleback	Minnow	Stone loach	Pike	Roach
A1	Woodfield River	Dry channel		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
A2	Woodfield River	5	10	0.000	0.000	0.000	0.000	0.000	**0.400**	0.000	0.000	0.000	0.000
A3	Little Brosna River	10	240	**0.021**	0.071	0.000	0.004	0.000	0.000	0.079	0.004	0.000	0.000
B1	Rapemills River	10	87.5	0.000	**0.514**	**20 per m^2**	0.000	0.034	0.000	0.000	0.000	0.000	0.000
B2	Eglish Stream	Dry channel		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
B3	Rapemills River	10	135	0.000	0.326	2 per m^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B4	Rapemills River	5	75	0.000	0.053	2 per m^2	0.000	0.187	0.000	0.000	0.000	0.000	0.000
B5	West Galros Stream	Too deep for electro-fishing		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
B6	West Galros Stream	Too deep for electro-fishing		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
B7	West Galros Stream	5	50	0.000	0.000	0.000	0.000	**0.460**	0.000	0.000	0.000	0.000	0.000
B8	Rapemills River	10	140	0.000	0.300	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B9	Mullaghakaraun Bog Stream	5	112.5	0.000	0.000	4.6 per m^2	0.000	0.000	0.009	0.000	0.000	0.000	0.000
B10	Rapemills River	10	80	0.000	0.038	0.000	**0.013**	0.038	0.000	0.063	0.000	0.000	0.000
B11	Milltown Stream	Dry channel		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B12	Feeghroe River	5	80	0.000	0.100	0.000	0.000	0.225	0.038	0.000	0.000	0.000	0.000
B13	Rapemills River	10	180	0.000	0.028	0.000	0.011	0.128	0.000	0.217	0.028	**0.006**	0.000

Site	Watercourse	CPUE (elapsed time)	Approx. area fished (m^2)	Atlantic salmon	Brown trout	Lampetra sp.	European eel	Three-spined stickleback	Ten-spined stickleback	Minnow	Stone loach	Pike	Roach
C1	Whigsborough Stream	5	5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
D1	Grants Island River	Dry channel		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
D2	Bullock Island Stream	Dry channel		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
D3	Park River	Dry channel		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
D5	Little [Cloghan] River	10	110	0.000	0.045	13.2 per m^2	0.009	0.000	0.000	**0.245**	0.036	0.000	**0.009**
D6	River Brosna	Too deep for electro-fishing		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
D7	Blackwater River	10	300	0.000	0.000	11 per m^2	0.000	0.000	0.000	0.010	0.013	0.000	0.000
E1	Silver River	10	240	0.000	0.058	0.5 per m^2	0.000	0.004	0.000	0.088	**0.038**	0.000	0.000
E2	Silver River	10	250	0.004	0.136	3.5 per m^2	0.000	0.000	0.000	0.000	0.028	0.000	0.000

Table 3.2 Summary of fish species of higher conservation value recorded via electro-fishing per survey site in the vicinity of the proposed Cush wind farm, August 2022

Site	Watercourse	Atlantic salmon	*Lampetra* sp.	Brown trout	European eel	Other species
A1	Woodfield River	No fish recorded – dry channel				
A2	Woodfield River					Ten-spined stickleback
A3	Little Brosna River	✓		✓	✓	Stone loach, minnow
B1	Rapemills River		✓	✓		Three-spined stickleback
B2	Eglish Stream	No fish recorded – dry channel				
B3	Rapemills River		✓	✓		
B4	Rapemills River		✓	✓		Three-spined stickleback
B5	West Galros Stream	No electro-fishing undertaken (prohibitive depths)				
B6	West Galros Stream	No electro-fishing undertaken (prohibitive depths)				
B7	West Galros Stream					Three-spined stickleback
B8	Rapemills River			✓		
B9	Mullaghakaraun Bog Stream		✓			Ten-spined stickleback
B10	Rapemills River			✓	✓	Ten-spined stickleback, minnow
B11	Milltown Stream	No fish recorded – dry channel				
B12	Feeghroe River			✓		Three-spined stickleback, ten-spined stickleback
B13	Rapemills River			✓	✓	Pike, minnow, stone loach, three-spined stickleback
C1	Whigsborough Stream	No fish recorded				
D1	Grants Island River	No fish recorded				
D2	Bullock Island Stream	No fish recorded – dry channel				
D3	Park River	No fish recorded – dry channel				
D5	Little [Cloghan] River		✓	✓	✓	Roach, minnow, stone loach
D6	River Brosna	No electro-fishing undertaken (prohibitive depth, width & flow)				
D7	Blackwater River		✓	✓		Minnow, stone loach
E1	Silver River		✓	✓		Minnow, stone loach, three-spined stickleback
E2	Silver River	✓	✓	✓		Stone loach

*** Conservation value:** Atlantic salmon (*Salmo salar*), sea lamprey (*Petromyzon marinus*), brook lamprey (L*ampetra planeri*) and river lamprey (*Lampetra fluviatilis*) are listed under Annex II of the Habitats Directive [92/42/EEC]. Atlantic salmon and river lamprey are also listed under Annex V of the Habitats Directive [92/42/EEC]. European eel are 'critically endangered' according to most recent ICUN red list (Pike et al., 2020) and listed as 'critically engendered' in Ireland (King et al., 2011). With the exception of the Fisheries Acts 1959 to 2019, brown trout and coarse fish species have no legal protection in Ireland.

4. Discussion

The surveyed watercourses in the vicinity of the proposed Cush wind farm were typically small, heavily silted lowland depositing channels that had been historically modified, resulting in often poor hydromorphology. Most sites supported a low diversity of fish species and generally low abundances of fish. Sites B13 on the lower reaches of the Rapemills River and site D5 on Little River supported a total of *n*=6 species, respectively, the highest diversity recorded during the survey. Sites A1 (Woodfield River), B2 (Eglish River), D1 (Grant's Island River), Bullock Island Stream (D2) and the Park River (D3) were ephemeral channels that were dry at the time of survey and, therefore, did not support fish.

Salmonids were recorded from a total of 11 no. sites, namely sites on the Little Brosna River (site A3), Rapemills River (B1, B3, B4, B8 & B13), Feeghroe River (B12), Little River (D5) and the Silver River (E1 & E2) (**Table 3.1, 3.2**). However, these populations comprised brown trout only, with the exception of sites A3 on the Little Brosna River and E2 on the Silver River which also supported low numbers of Atlantic salmon parr. This restricted distribution of Atlantic salmon in the vicinity of the proposed project is unsurprising given widespread historical modifications in the Shannon [Lower]_SC_060, Shannon [Lower]_SC_040, Shannon [Lower]_SC_030 and Brosna_SC_080 river sub-catchments (which have evidently reduced the quality of salmonid habitat), in addition to significant downstream barriers on the River Shannon (i.e. hydro-electric dams). Other pressures within the wider survey area, such as hydromorphological modifications, eutrophication and, in particular, siltation, also reduced the quality of salmonid habitat in many watercourses in the vicinity of the proposed wind farm.

Diffuse siltation is one of the greatest threats to salmonid populations, particularly in agricultural catchments such as that of the proposed Cush wind farm. Sediment not only blocks interstitial spaces in substrata and limits oxygen supply to salmonid eggs (required for healthy embryonic project and successful hatching) but can also smother substrata, thus reducing available spawning habitat and impact macro-invertebrate communities on which salmonids feed (Kelly-Quinn et al., 2020; Davis et al., 2018; Conroy et al., 2016; Cocchiglia et al., 2012; Louhi et al., 2008, 2011; Walling et al., 2003; Soulsby et al., 2001). Sedimentation of salmonid habitat is a particular problem in Irish rivers flowing through agricultural and afforested catchments (Evans et al., 2006).

Lamprey ammocoetes (*Lampetra* sp., likely *L. planeri* given known catchment barriers) were recorded from a total of 8 no. sites on the Rapemills River (B1, B3 & B4), Mullaghakaraun Bog Stream (B9), Little River (D5) and the Silver River (E1 & E2) (**Table 3.1, 3.2**). Higher densities of ammocoetes were recorded at sites B1 (20 per m^2), D5 (13.2 per m^2) and D7 (11 per m^2). These sites featured the deposition of fine, organic-rich sediment ≥5cm in depth; areas considered optimal for larval *Lampetra* spp. (Aronsuu & Virkkala, 2014; Goodwin et al., 2008; Gardiner, 2003). However, suitability was typically poor elsewhere in the survey area as a result of historical modifications to hydromorphology which have resulted in often poor quality lamprey habitats. This was especially so with reference to spawning habitats which were heavily silted or even absent at many of the survey sites. *Lampetra* sp. generally fine, clean gravels required for spawning (Dawson et al., 2015; Rooney et al., 2013; Lasne et al., 2010). Larval lamprey distribution and settlement is passive and entirely regulated by local, dynamic hydrographical (flow) regimes (Kelly & King,, 2001; Potter, 1980; Hardisty & Potter 1971). Thus, a paucity of suitable spawning sites (i.e. sources of larvae) can often counteract the presence of even widespread ammocoete burial habitat (i.e. soft sediment) and limit the success of local

populations. This was exemplified at surveys sites on the lower Rapemills River, where mean densities of 0-≤2 larvae per m^2 were recorded.

On both a global and Irish scale, the European eel is listed as 'critically endangered' (Pike et al., 2020; King et al., 2011). European eel were only recorded from sites on the Little Brosna River (A3), Rapemills River (B10, B13) and Little River (D5), and were present in low numbers only. As outlined above, the distribution of eel in the Shannon catchment is significantly impacted by instream barriers.

In summary, the best overall fisheries habitat was present on the larger watercourses surveyed, including the Little Brosna River, River Brosna and Silver River and less-modified reaches of smaller channels, such as the upper reaches of the Rapemills River. These areas featured greater levels of instream recovery from historical modifications (straightening, deepening etc.), lower rates of siltation and greater habitat heterogeneity, resulting in improved fisheries habitat for salmonids, lamprey, European eel and other fish species.

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