Appendix 2 Aquatic Survey Reports

EIAR – Volume 3

Knockanarragh Wind Farm

SLR Project No.: 501.V00727.00008

25/01/2024

Aquatic baseline report for Knockannarragh wind farm, Co. Westmeath

Prepared by Triturus Environmental Ltd. for SLR Consulting

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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 Knockannarragh 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 project, located approximately 3km north-east of Delvin, Co. Westmeath.

Undertaken on a catchment-wide scale, the baseline surveys focused on the detection of freshwater habitats and species of high conservation value. These included surveys for white-clawed crayfish (*Austropotamobius pallipes*), freshwater pearl mussel (*Margaritifera margaritifera*) (eDNA only), macro-invertebrates (biological water quality) and fish of high conservation value, inclusive of supporting nursery and spawning habitat. The surveys also documented macrophyte and aquatic bryophyte communities including Annex I habitat associations in the vicinity of the project (**Figure 2.1**). Aquatic surveys were undertaken in July 2022.

1.2 Project description

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

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 baseline. A total of *n*=26 sites were 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). Riverine survey sites (*n*=13) were present on the Kilrush Lower Stream (EPA code: 07K27), Kilskeer River (07K26), Athboy River (07A01), Killacroy Stream (07K16), D'arcy's Crossroads Stream (07D06), Stonyford River (07S02), Cavestown & Rosmead Stream (07C57) and an unnamed drainage channel tributary of Newtown Lough (**Table 2.1**). Survey sites were also selected at Newtown Lough and 12 no. small pond sites[1] located within or adjoining the proposed site boundary (**Figure 2.1**).

The aquatic survey sites were located within the Boyne_SC_050 and Boyne_SC_070 river sub-catchments. The proposed wind farm site was not located within a European site. However, there was potential downstream hydrological connectivity between the proposed project and the adjacent River Boyne and River Blackwater SAC (002299), a site designated for numerous aquatic qualifying interests (NPWS, 2021).

Please note this aquatic report should be read in conjunction with the final Environmental Impact Assessment Report (EIAR) and NIS 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 19th to Friday 22nd July 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) (**Figure 2.1**).

Suitability for freshwater pearl mussel was assessed at each survey site with environmental DNA (eDNA) sampling undertaken for the species at *n*=4 strategically chosen riverine locations in the vicinity of the project. These water samples were also analysed for white-clawed crayfish and crayfish plague (*Aphanomyces astaci*). A composite sample as also collected from Newtown Lough and analysed for several high conservation value species. 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

[1] Of 21 no. potential ponds within or adjoining the site boundary, 12 were found to contain water at the time of survey and were thus surveyed

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 impacts
- 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 and bordering land use type

Table 2.1 Location of *n*=26 aquatic survey sites in the vicinity of Knockannarragh wind farm, Co. Westmeath (* denotes eDNA sampling)

Site no.	Watercourse	EPA code	Location	X (ITM)	Y (ITM)
Riverine sites					
A1	Drainage channel	n/a	Newtown Lough inflow	[redacted]	
A2	Kilrush Lower Stream	07K27	Newtown Lough inflow		
A3	Kilskeer River	07K26	N52 road crossing		
A4*	Athboy River	07A01	N52 road crossing		
B1	Killacroy Stream	07K16	Galboystown		
B2	Killacroy Stream	07K16	Newtown		
B3	D'arcy's Crossroads Stream	07D06	Galboystown		
B4	D'arcy's Crossroads Stream	07D06	Newtown		
B5*	D'arcy's Crossroads Stream	07D06	Snipe's Bridge		
B6	Stonyford River	07S02	Cavestown & Rosmead		
B7	Stonyford River	07S02	Cavestown & Rosmead		
B8	Cavestown & Rosmead Stream	07C57	Cavestown & Rosmead		
B9*	Stonyford River	07S02	Lisclogher Bridge		
Lacustrine sites					
L1*	Newtown Lough	07_255	Newtown	[redacted]	
P1	Pond	n/a	Newtown		
P2	Pond	n/a	Newtown		
P3	Pond	n/a	Newtown		
P4	Pond	n/a	Newtown		
P5	Pond	n/a	Newtown		
P6	Pond	n/a	Newtown		
P7	Pond	n/a	Newtown		
P8	Pond	n/a	Newtown		

Site no.	Watercourse	EPA code	Location	X (ITM)	Y (ITM)
P9	Pond	n/a	Newtown	[redacted]	
P10	Pond	n/a	Cavestown and Rosmead		
P11	Pond	n/a	Carnybrogan		
P12	Pond	n/a	Cavestown and Rosmead		

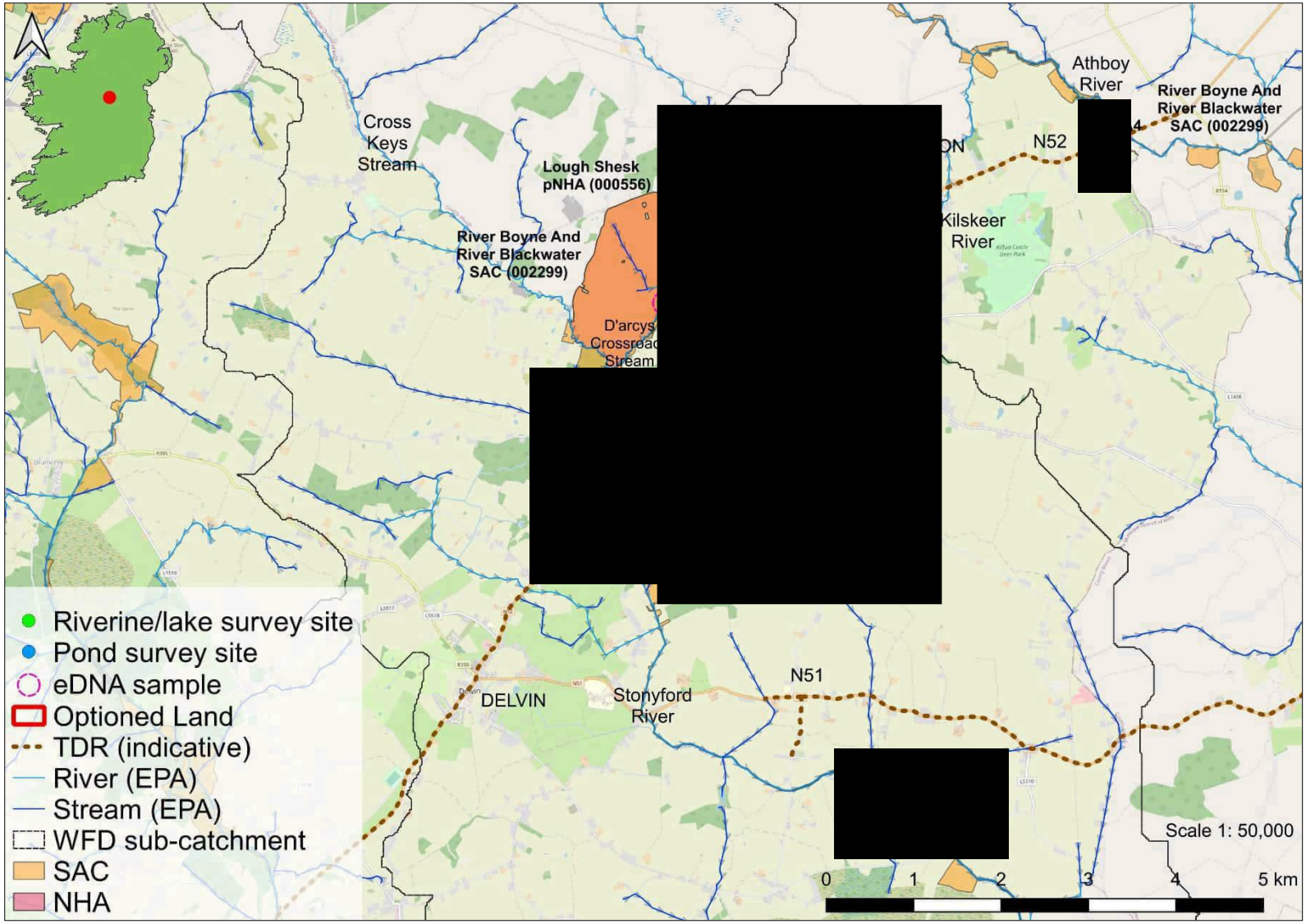

Figure 2.1 Overview of the *n*=26 aquatic survey site locations for the proposed Knockannarragh wind farm, Co. Westmeath, July 2022

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 Knockannarragh wind farm in July 2022 (**Table 2.1, Figure 2.1; Appendix A**), following notification to Inland Fisheries Ireland, under the conditions of a Department of the Environment, Climate and Communications (DECC) licence. The survey was undertaken in accordance with best practice (CFB, 2008; CEN, 2003) 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. 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 surveys were undertaken at the aquatic survey sites in July 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 transferring 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 Knockannarragh wind farm survey area was completed.

2.5 eDNA analysis (including freshwater pearl mussel)

To validate site surveys and to detect potentially cryptically low populations of freshwater pearl mussel and white-clawed crayfish within the study area, *n*=3 composite water samples were collected from the Athboy River (site A4), D'arcy's Crossroads Stream (B5) and the Stonyford River (B9) and analysed for freshwater pearl mussel eDNA (**Figure 2.1**). This would help validate the species' presence and or absence given that no data was available on the status of pearl mussel in these rivers. Samples were also analysed for white-clawed crayfish and crayfish plague. The water samples were collected on 21st July 2022, with the sites strategically chosen to maximise longitudinal (instream) coverage within the catchment (i.e. facilitating a greater likelihood of species detection). Newtown Lough (L1) was also 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 within 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.

2.6 Biological water quality (Q-sampling)

The 13 no. riverine survey sites were assessed for biological water quality through Q-sampling in July 2022 (**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

2.7 Lake & pond macro-invertebrate communities

Newtown Lough and the 12 no. wetted pond survey sites were 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/pond 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.

2.8 Macrophytes and aquatic bryophytes

Surveys of the macrophyte and aquatic bryophyte community were conducted by instream wading at each of the survey sites, with specimens collected (by hand, sweep nets or via grapnel) for on-site identification. An assessment of the aquatic vegetation community helped to identify any rare

macrophyte species (Flora Protection Order or Wyse-Jackson et al., 2016) or habitats corresponding to the 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'). Links with Annex I lake habitats were also assessed at lacustrine sites.

2.9 Otter signs

The presence of otter (*Lutra lutra*) at each aquatic survey site was determined through the recording of otter signs within 150m of each survey site. 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, crustaceans, molluscs etc.).

2.10 Amphibian (pond) surveys

All pond sites were appraised for the presence of and suitability for amphibians, namely smooth newt (*Lissotriton vulgaris*) and common frog (*Rana temporaria*). Given the surveys were undertaken in July 2022 (i.e. outside of the breeding season & optimal amphibian survey period), surveys focused on the evaluation of amphibian suitability. However, sweep netting was also undertaken to help detect any remaining smooth newt efts, common frog adults and late-metamorphosing frog tadpoles.

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. Cognisance was given towards preventing the spread or introduction of crayfish plague given the known historical distribution of white-clawed crayfish and previous outbreaks of crayfish plague 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 Knockannarragh wind farm catchment and survey area description

The proposed Knockannarragh wind farm site boundary is located in a lowland area within the townlands of Newtown, Cavestown & Rosmead and Galboystown, approximately 2km south-west of Clonmellon and 3km north-east of Delvin, Co. Westmeath (**Figure 2.1**). The proposed wind farm site is within the Eastern River Basin District and within hydrometric area 7 (Boyne). The aquatic survey sites were located within the Boyne_SC_050 and Boyne_SC_070 river sub-catchments. The proposed wind farm site is drained by the Killacroy Stream (EPA code: 07K16), D'arcy's Crossroads Stream (07D06) and the Stonyford River (07S02) (**Figure 2.1**).

The watercourses and aquatic surveys sites in the vicinity of Knockannarragh wind farm are typically small, lowland depositing channels (FW2; Fossitt, 2000) which have been historically modified as part of arterial drainage works. The watercourses in the vicinity of the proposed project flow over areas of Visean limestone and calcareous shale (Geological Survey of Ireland data). Land use practices in the wider survey area are dominated by pastures (CORINE 231) with localised areas of broad-leaved forests (311), mixed forests (313) and land principally occupied by agriculture with significant areas of natural vegetation (243).

3.2 Fisheries asset of the survey area

The Stoneyford River, a tributary of the River Boyne, is known to support Atlantic salmon (*Salmo salar*), brown trout (*Salmo trutta*) and lamprey (*Lampetra* sp.) (Triturus, 2021). Recreational brown trout fishing is popular along this river (O'Reilly, 2009). In terms of genetic stock, the Stonyford is known to be a significant contributor of brown trout to the main Boyne channel (one of the three most important spawning tributaries in the middle-Boyne catchment; Mariani & Massa-Gallucci, 2012).

The Athboy River, also a tributary of the River Boyne also known as the Trimblestown River, is known to support Atlantic salmon, brown trout, European eel (*Anguilla anguilla*), lamprey (*Lampetra* sp.), stone loach (*Barbatula barbatula*), minnow (*Phoxinus phoxinus*) and three-spined stickleback (*Gasterosteus aculeatus*) (Kelly et al., 2013, 2011: IFI data[2]). The Athboy is also a valuable recreational brown trout fishery (O'Reilly, 2009). The river was first subject to arterial drainage in 1972 and had significant reduction of the fisheries habitat and fish populations, particularly salmonids (O'Grady, 1991).

Whilst *Lampetra* sp. ammocoetes (likely brook lamprey *Lampetra planeri*) are widespread throughout the Stonyford River and Athboy River, densities have been recorded as low (O'Connor, 2006) and the species is known to suffer from the impacts of continued arterial drainage throughout the catchment (IFI, 2013).

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

[2] Inland Fisheries Ireland data available at: https://opendata-ifigis.hub.arcgis.com/datasets/IFIgis::water-framework-directive-fish-ecological-status-2008-2021

3.3 Protected aquatic species

A comprehensive desktop review of available data (NPWS, NBDC, BSBI & other data) for 10km grid squares adjoining the project (i.e. N65, N66, N67 & N75) identified a number of records for a low number of rare and or protected aquatic species within the vicinity of the proposed wind farm.

Records for otter (*Lutra lutra*) were widespread throughout the respective grid squares, with over half of records (61 no. total) historical only (i.e. pre-1992). The more contemporary records in vicinity of the project were available for the D'arcy's Crossroads Stream (survey site B5), Stonyford River (including survey site B7) and the Athboy River (**Figure 3.1**).

A low number of records for white-clawed crayfish (*Austropotamobius pallipes*) were available for the wider survey area although the majority were historical only (1971 to 1997). Contemporary records (2000-2009) in vicinity of the project were available for the Stonyford River and upper Athboy River, in addition to the downstream connecting River Boyne (**Figure 3.1**).

A moderate number of contemporary common frog (*Rana temporaria*) records (>30) were available for the N56, N66 and N75 grid squares. A low number of records for smooth newt (*Lissotriton vulgaris*) (<10) were also available. None of these amphibian records overlapped with the survey area (data not shown).

There are no records for red-listed stoneworts (Stewart & Church, 1992) in the vicinity of the study area that are considered rare or threatened from the BSBI database. The review included species that are known to occur in limestone lakes including *Chara denudata* and *Chara tormentosa*. These species are known however from other lakes in Westmeath including Loughs Owel, Ennell and Derryvarragh to the west of the study area.

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. Contemporary EPA biological monitoring data was only available for the D'arcy's Crossroads Stream, Stonyford River and Athboy River.

Please note that biological water quality analysis was undertaken as part of this study, with the results presented in the **section 4** and **Appendix B** of this report.

3.4.1 D'arcy's Crossroads Stream

There was a single contemporary EPA biological monitoring station located on the D'arcy's Crossroads Stream (07D06) in the vicinity of the proposed project. At Snipe's Bridge (stationRS07D060030, survey site B5), the river achieved **Q3-4 (moderate status)** in 2020.

The D'arcy's Crossroads Stream_010 river waterbody achieved moderate status in the 2016-2021 period and was considered 'at risk' of not achieving good ecological status (WFD Risk 3rd cycle). Channelisation (hydromorphology) and agricultural siltation are the primary threats to water quality in this waterbody (EPA, 2018a).

3.4.2 Stonyford River

There were 3 no. contemporary EPA biological monitoring stations located on the Stonyford River (07S02) downstream of the proposed project. In 2020 the river achieved **Q3-4 (moderate status)** at station RS07S020065, **Q3 (poor status)** at Stonestown Bridge (station RS07S020075) and **Q3-4 (moderate status)** at Stonyford Bridge (station RS07S020400).

In vicinity of the proposed project, the Stonyford_010 river waterbody achieved moderate status in the 2016-2021 period and was considered 'at risk' of not achieving good ecological status (WFD Risk 3rd cycle). Moving downstream, the Stonyford_020 and Stonyford_030 waterbodies achieved poor status in the 2016-2021 period and were also considered 'at risk' of not achieving good ecological status (WFD Risk 3rd cycle).

3.4.3 Athboy River

There were 4 no. contemporary EPA biological monitoring stations located on the Athboy River (07A01) in the downstream vicinity of the proposed project. At station RS07A010070 (survey site A4) the river achieved **Q4 (good status)** on 2020. However, downstream, the river fell to **Q3-4 (moderate status)** at stations RS07A010100, RS07A010300 and RS07A010400 (Tremblestown Bridge), also in 2020.

Whilst the Athboy_030 river waterbody (an area which encompassed Newtown Lough & the Kilskeer River) achieved good status in the 2016-2021 period, it was considered 'at risk' of not achieving good ecological status (WFD Risk 3rd cycle) due to wastewater discharges, channelisation (hydromorphology) and agricultural siltation (EPA, 2018b). Downstream, the Athboy_040 and Athboy_050 waterbodies were of poor and moderate status, respectively, in the 2016-2021 period and both 'at risk' of not achieving good ecological status (WFD Risk 3rd cycle). This was due to channelisation (hydromorphology) and agricultural siltation pressures (EPA, 2018b).

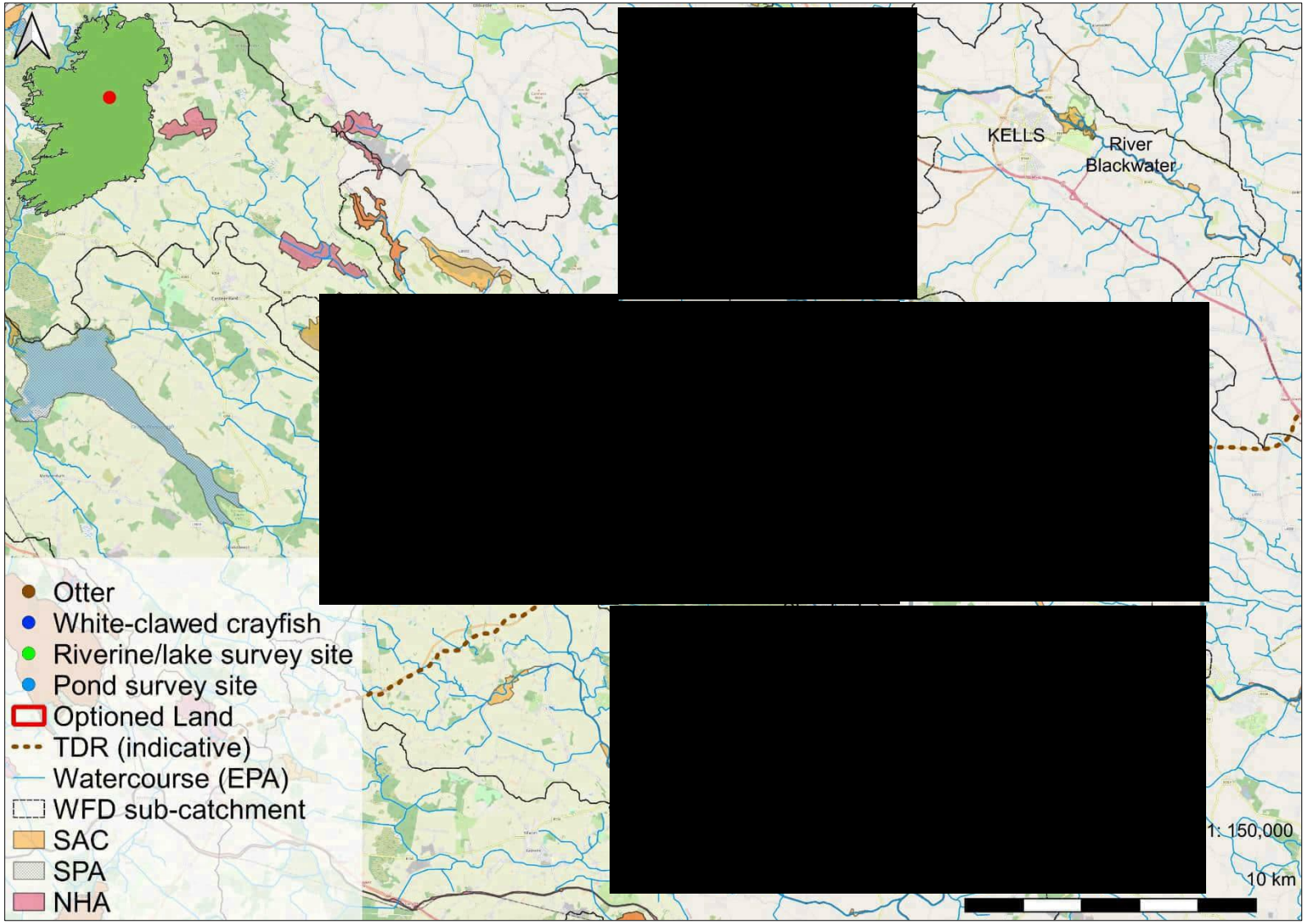

Figure 3.1 Selected protected aquatic species records in the vicinity of the proposed Knockannarragh wind farm (source: NPWS & NBDC data, 2000-2015)

4. Results of aquatic surveys

The following section summarises each of the *n*=26 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 riverine sampling site and in **Appendix B**. Habitat codes are according to Fossitt (2000). Scientific names are provided at first mention only. Sites were surveyed in July 2022. Please refer to **Appendix A** (fisheries assessment report) for more detailed fisheries results. A summary of the fish species recorded at each survey site is provided in **Table 4.2**. A summary of the aquatic species and habitats of high conservation concern recorded during the surveys is provided in **Table 4.3**. An evaluation of the aquatic ecological importance of each survey site based on these aquatic surveys is provided and summarised in **Table 4.4**.

4.1 Riverine survey site results

4.1.1 Site A1 – drainage channel, Newtown Lough inflow

Site A1 was located on a small drainage channel tributary of Newtown Lough. The drainage channel (FW4) had been extensively straightened and deepened historically and averaged 1.5-2m wide and 0.2-0.4m deep. The water was stagnant at the time of survey and numerous blockages to flow (silt dams) were present resulting in several dry areas, localised ponding of water and little or no connectivity to Newtown Lough. The substrata were comprised entirely of deep, anoxic silt of up to 0.5m in depth. Peat staining was high. The channel was heavily vegetated with abundant frogbit (*Hydrocharis morsus-ranae*), frequent bottle sedge (*Carex rostrata*) and occasional bog bean (*Menyanthes trifoliata*). No aquatic bryophytes were present. Filamentous algal mats were abundant (30% cover). Terrestrial encroachment of the narrow channel was high with frequent (Livestock-derived) slumping of banks into the channel. The site was bordered by wet grassland (GS4) and scrub (WS1) along the banktop with adjoining low-intensity pasture (GA1) and Newtown Lough (likely FL5).

Three-spined stickleback (*Gasterosteus aculeatus*) was the only fish species recorded via electro-fishing at site A1 (**Appendix A**). With the exception on low densities of stickleback, the site was not of fisheries value given heavy siltation pressures and poor hydromorphology. Poor connectivity with the downstream Newtown Lough (instream blockages) would likely preclude the channel's use as a nursery for coarse fish species or European eel. There was no suitability for white-clawed crayfish. No otter signs were recorded in vicinity of the survey 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 A1 was of **local importance (lower value) (Table 4.4).**

Plate 4.1 Representative image of site A1 on the Newtown Lough inflow, July 2022

4.1.2 Site A2 – Kilrush Lower Stream, Newtown

Site A2 was located on the Kilrush Lower Stream (07K27), approx. 0.2km upstream of Newtown Lough (i.e. Newtown Lough inflow). The lowland depositing stream (FW2) had been historically straightened and deepened with a deep U-shaped profile and bankfull heights of 2m. The stream was dry at the time of survey with a damp mud base in a 1.5m-wide channel, i.e. ephemeral/seasonal channel. However, immediately downstream of the survey site, a small inline pond was present, measuring approx. 2.5m wide and 15m long. The pond averaged 0.3m deep with a very deep anoxic silt base. The pond supported a diverse range of macrophytes and wetland plants. Greater bladderwort (*Utricularia australis*), water horsetail (*Equisetum fluviatile*) and water plantain (*Alisma plantago-aquatica*) were frequent with more occasional branched bur-reed (*Sparganium erectum*). Frogbit was also occasional. Water mint (*Mentha aquatica*), blue water speedwell (*Veronica anagallis-aquatica*) and lesser water parsnip (*Berula erecta*) were present along the pond margins. Common frog were evidently abundant within the pond and adjoining grassland habitats. The pond was bordered by dry meadows (GS2) and seasonally wet grassland (GS4) to the west with improved pasture (GA1) to the east.

Electro-fishing was not undertaken at site A2 (dry stream and pond) (**Appendix A**). With the exception of three-spined stickleback (recorded via sweep sampling), the pond was not of fisheries value given heavy siltation, the ephemeral nature of the flow-through stream and very poor connectivity with downstream lake habitats. There was no suitability for white-clawed crayfish. No otter signs were recorded in vicinity of the survey site.

Given the dry nature of the stream at this location, it was not possible to collect a biological water quality sample. However, a composite sweep sample was taken in the small pond. No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via sweep netting.

Given the location of the site within the River Boyne And River Blackwater SAC (002299), the aquatic ecological evaluation of site A2 was of **international importance (Table 4.4).**

Plate 4.2 Representative image of site A2 at an inline pond on the otherwise dry Kilrush Lower Stream, July 2022

4.1.3 Site A3 – Kilskeer River, Clonmellon

Site A3 was located on the Kilskeer River (07K26) at the N52 road crossing, approx. 1.2km downstream of Newtown Lough. The lowland depositing river (FW2) had been historically straightened and over-deepened, with maintenance in the recent past (spoil on banks, collapsing banks etc.). The river averaged 2.5-3m wide and 0.2-0.3m deep on average, with bankfull heights of 3-4m in a very steep trapezoidal channel. There was a near imperceptible flow at the time of survey. The profile was of very slow-flowing glide with areas of stagnant pool. The substrata comprised very heavily silted cobble and mixed gravels (none of which were exposed). Macrophyte coverage was very high (>60%), with abundant lesser water parsnip and fool's watercress (*Apium nodiflorum*), in addition to frequent common duckweed (*Lemna minor*). Ivy-leaved duckweed (*Lemna trisulca*) was present but rare. Water mint was occasional. Upstream of the bridge, the channel had been cleared and the only vegetation was filamentous algae. Aquatic bryophytes were not recorded. Riparian shading was very high, with tunnelling present downstream of the bridge, given a mature ash (*Fraxinus excelsior*), blackthorn (*Prunus spinosa*), sycamore (*Acer psuedoplatanus*) and elder (*Sambucus nigra*) treeline with a scrubby understorey of ivy (*Hedera* sp.), hogweed (*Heracleum sphondylium*) and nettle (*Urtica dioica*) along the north bank. Rough pasture (GS2) was present along the south, with a riparian zone dominated by nettle and bramble (*Rubus fruticosus* agg.) scrub (WS1).

Three-spined stickleback and ten-spined stickleback (*Pungitius pungitius*) were the only fish species recorded via electro-fishing at site A3 (**Appendix A**). With the exception of stickleback, the site was not of fisheries value given gross siltation and low seasonal flows. Poor hydromorphology resulting

from historical modifications further reduced the potential of the stream at this location. There was no potential for white-clawed crayfish or otter and neither species were recorded.

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 A3 was of **local importance (lower value) (Table 4.4).**

Plate 4.3 Representative image of site A3 on the Kilskeer River, July 2022

4.1.4 Site A4 – Athboy River, Drewstown Little

Site A4 was located on the Athboy River (07A01) at the N52 road crossing. The lowland depositing river (FW2) at this location had been straightened and deepened historically but showed some good instream recovery. Retaining walls and a rendered apron were present in the vicinity of the bridge crossing. The river averaged 3-4m wide and 0.3-0.6m deep, with locally deeper pool to 1m in vicinity of the bridge. The profile was of deep slow-flowing glide, with frequent pool and occasional riffle. The substrata were dominated by cobble and abundant boulder with frequent beds of mixed gravels. Boulder was dominant downstream of the bridge, with old sections of broken parapet also present instream. Sand and silt accumulations were present locally, along channel margins, in association with macrophyte beds and in pool slacks. Calcification was evident on instream substrata. Sedimentation was moderate overall (significant plumes underfoot). Macrophyte growth was restricted to marginal beds of lesser water parsnip and water mint, with occasional branched bur-reed present upstream of the bridge. Water crowfoot (*Ranunculus* sp.) was present but rare. Curled pondweed (*Potamogeton crispus*) and filamentous algae were present (<1%), indicating enrichment pressures. Aquatic

bryophyte coverage was high overall, being dominated by abundant *Riccardia chamedryfolia* on larger boulder and cobble (and bridge abutment). The moss *Fontinalis antipyretica* was occasional. The riparian zone supported mature ash, beech (*Fagus sylvatica*) and willow with bramble, hogweed, nettle and dog rose. The site was bordered by dry meadow habitat (GS2) and improved pasture (GA1).

Atlantic salmon (*Salmo salar*), brown trout (*Salmo trutta*), lamprey (*Lampetra* sp.) and European eel (*Anguilla anguilla*) were recorded via electro-fishing at site A4 (**Appendix A**). The site was a good all-round salmonid habitat, with combinations of good spawning, nursery and holding habitat. Whilst the quality of spawning substrata was reduced due to siltation, some good quality areas were present for both salmonids and lamprey. Abundant boulder and occasional macrophyte beds provided good refugia for juvenile salmonids, whilst good quality holding habitat was present in the vicinity of the bridge. Soft sediment areas (often sand dominated) supported low densities (4.3 per m^2) of *Lampetra* sp. ammocoetes - these were typically associated with macrophyte beds given swift flow rates. The site was of high value for European eel habitat given ample instream refugia (boulders, holes in retaining walls etc.). Suitability for white-clawed crayfish was high although only a single juvenile (13mm) was recorded (40+ refugia searched). No otter signs were not recorded in the vicinity of the site, despite high foraging suitability.

Biological water quality, based on Q-sampling, was calculated as **Q4 (good 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 location of the site within the River Boyne And River Blackwater SAC (002299), the aquatic ecological evaluation of site A2 was of **international importance (Table 4.4).** The site also supported salmonids (including Atlantic salmon), *Lampetra* sp., European eel and white-clawed crayfish, in addition to good status water quality.

Plate 4.4 Representative image of site A4 on the Athboy River, July 2022 (facing upstream towards bridge)

4.1.5 Site B1 – Killacroy Stream, Galboystown

Site B1 was located on the upper reaches of the Killacroy Stream (07K16) at a local road crossing, approx. 1km north of the site boundary. The Stoneyford River tributary had been extensively straightened and deepened historically, with bankfull heights of up to 3m in a steep trapezoidal channel. The lowland depositing stream (FW2) featured near-imperceptible flows at the time of survey and averaged <0.05m deep. The channel averaged 2-2.5m wide with a profile of slow-flowing glide (near stagnant) and stagnant pool. The substrata comprised mixed gravels and occasional cobble which were grossly silted. Silt accumulations were present locally in pools of up to 0.2m deep. Livestock poaching was evident upstream and downstream of the bridge. The site supported abundant growth of fool's watercress and watercress (*Nasturtium officinale*), covering >95% of the channel (open areas only present in heavily tunnelled sections). Common duckweed was present but rare. Aquatic bryophytes were not recorded. The stream was very heavily shaded and tunnelled locally, with dense intermittent treeline of sycamore, hawthorn, elder and bramble and nettle scrub in narrow (fenced) riparian zones. The site was bordered by improved pasture (GA1).

Three-spined stickleback and ten-spined stickleback were the only fish species recorded via electro-fishing at site B1 (**Appendix A**). With the exception of low densities of stickleback, the site was not of fisheries value given gross siltation and low seasonal flows. Poor hydromorphology resulting from historical modifications further reduced the potential of the stream at this location. There was no potential for white-clawed crayfish or otter and neither species were recorded.

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 location of the site within the River Boyne And River Blackwater SAC (002299), the aquatic ecological evaluation of site B1 was of **international importance (Table 4.4).** However, the aquatic value of the site was poor, with an absence of aquatic species or habitats of higher conservation value, in addition to poor status water quality.

Plate 4.5 Representative image of site B1 on the Killacroy Stream, July 2022

4.1.6 Site B2 – Killacroy Stream, Newtown

Site B2 was located on the Killacroy Stream (07K16) in the vicinity of a farm bridge crossing, approx. 1.5km downstream of site B1. The lowland depositing stream had been extensively deepened historically (but not straightened). The deep U-shaped channel featured bankfull heights of 1.5-2m The stream averaged a homogenous 2.5m wide and 0.5-0.6m deep. There was an imperceptible flow at the time of survey. The bed was dominated by deep silt with superficial fine gravels on top. The profile comprised stagnant glide with no riffle or pool. The site was very heavily vegetated with abundant fool's watercress occupying >95% cover. Common duckweed was frequent with iris (*Iris psuedacorus*) recorded as rare. Terrestrial encroachment was present with reed canary grass, great willowherb (*Epilobium hirsutum*) and terrestrial grasses in the channel. The riparian zone comprised open grassland (GS2) with only very intermittent hawthorn (historical bank clearance). The site was bordered by extensive meadow habitat (GS2) with patches of scrub dominated by gorse (*Ulex europaeus*).

Three-spined stickleback and ten-spined stickleback were the only fish species recorded via electro-fishing at site B2 (**Appendix A**). With the exception of low densities of stickleback, the site was not of fisheries value given gross siltation, excessive macrophyte coverage (near 100% cover) and low seasonal flows. Poor hydromorphology resulting from historical modifications further reduced the potential of the stream at this location. There was very low potential for white-clawed crayfish and none were recorded. No otter signs were recorded in vicinity of the site.

Biological water quality, based on Q-sampling, was calculated as **Q2 (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 Boyne And River Blackwater SAC (002299), the aquatic ecological evaluation of site B2 was of **international importance (Table 4.4).** However, the aquatic value of the site was poor, with an absence of aquatic species or habitats of higher conservation value, in addition to poor status water quality.

Plate 4.6 Representative image of site B2 on the Killacroy Stream, July 2022 (near complete coverage of aquatic vegetation)

4.1.7 Site B3 – D'arcy's Crossroads Stream, Galboystown

Site B3 was located on the Darcy's Crossroads Stream (07D06) at local road crossing upstream of the site boundary. The small lowland depositing stream (FW2) had been historically straightened and deepened (old embankments/spoil heaps visible) but showed some good instream recovery. The single arch bridge featured a rendered apron with a small fall on the downstream side. The stream averaged 2.5m wide and 0.2-0.3m deep with steeply sloping bankfull heights of 2m. The trapezoidal profile comprised slow-flowing shallow glide with occasional riffle and shallow pool. The substrata were dominated by mixed gravels and sands with frequent cobble and occasional small boulder. Larger boulder was more prominent downstream where the stream flowed over an increased gradient. Shallow soft sediment deposits were occasional in pool slacks and in association with macrophytes beds. Siltation was low overall but nonetheless present (e.g. livestock poaching). Some calcification was evident although compaction was typically low. Fool's watercress, lesser water parsnip and watercress were frequent. Aquatic bryophyte coverage was low although *Hygroamblystegium* sp. and *Rhynchostegium riparoides* was present on occasional larger boulder. The calcicolous liverwort *Riccardia chamedryfolia* was present but rare. Upstream of the bridge the site was bordered by rough pasture (GA1) with intermittent hawthorn and bramble-dominated scrub on the north bank. Dense willow scrub dominated downstream.

Brown trout, lamprey (*Lampetra* sp.) and three-spined stickleback were recorded via electro-fishing at site B3 (**Appendix A**). The site was considered an excellent quality salmonid nursery, supporting a

relatively high density of juvenile brown trout. The site also provided excellent quality spawning habitat for both salmonids and lamprey, despite some slight siltation and livestock pressures. Holding habitat for adult, whilst present, was limited to occasional shallow pools. Larval lamprey habitat was present but sub-optimal given the shallow, superficial/fine nature, supporting a low density of ammocoetes only (2 per m^2). European eel habitat and white-clawed crayfish habitat was poor overall given the generally shallow nature of the stream and none were recorded. A regular otter spraint site was recorded on a boulder on the downstream side of the bridge (ITM 662606, 768646).

Biological water quality, based on Q-sampling, was calculated as **Q4 (good 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 location of the site within the River Boyne And River Blackwater SAC (002299), the aquatic ecological evaluation of site B3 was of **international importance (Table 4.4).** The site also supported salmonids and *Lampetra* sp., in addition to otter.

Plate 4.7 Representative image of site B3 on the D'arcy's Crossroads Stream, July 2022

4.1.8 Site B4 – D'arcy's Crossroads Stream, Newtown

Site B4 was located on the Darcy's Crossroads Stream (07D06) approx. 0.5km upstream of Snipe's Bridge and 1km downstream of site B3. The lowland depositing river (FW2) had been deepened but not straightened historically and retained a meandering profile. However, hydromorphology was poor and the flow rates were very low at the time of survey. The river averaged a homogenous 3-4m wide and 0.5-1m deep, with localised deeper areas to 1.5m. The profile comprised very slow-flowing glide and localised pool (no riffle areas). Despite low flows, the substrata were dominated by mixed gravels with frequent cobble, with occasional small boulder. However, siltation was high throughout (livestock poaching frequent) with frequent accumulations along channel margins, in pool slacks and in association with macrophyte beds. Macrophyte coverage was extremely high, with >95% coverage.

lesser water parsnip, watercress and branched bur-reed were abundant, with frequent common duckweed and ivy-leaved duckweed more occasional. Water forget-me-not (*Myosotis scorpioides*) and water mint were present but rare. Aquatic bryophytes were absent given competitive shading by macrophytes. The narrow riparian zones supported reed canary grass, great willowherb, meadowsweet (*Filipendula ulmaria*) and occasional common valerian (*Valeriana officinalis*). The site was bordered by rough pasture (GA1) (sheep grazing).

Brown trout, lamprey (*Lampetra* sp.) and three-spined stickleback were recorded via electro-fishing at site B4 (**Appendix A**). The site was considered a poor quality salmonid habitat given observed low flows, noxious macrophyte growth and siltation pressures. However, some localised spawning habitat was present. Similarly, low flows significantly reduced the potential for lamprey although some spawning habitat was present in addition to sub-optimal ammocoete habitat (which supported a very low density of ammocoetes, 1.5 per m^2). Despite some suitability for European eel and white-clawed crayfish, none were recorded. No otter signs were recorded in the vicinity of the site (few marking opportunities present).

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 location of the site within the River Boyne And River Blackwater SAC (002299), the aquatic ecological evaluation of site B4 was of **international importance (Table 4.4).** The site also supported salmonids and *Lampetra* sp.

Plate 4.8 Representative image of site B4 on the D'arcy's Crossroads Stream, July 2022

4.1.9 Site B5 – D'arcy's Crossroads Stream, Snipe's Bridge

Site B5 was located on the Darcy's Crossroads Stream (07D06) at Snipe's Bridge, approx. 0.6km downstream of site B4. The lowland depositing river (FW2) had been historically straightened and deepened, with embankment and spoil evident. The river averaged 3m wide and 0.3-0.6m deep. The profile was of swift-flowing glide with occasional riffle and pool. Slower glide predominated upstream of the bridge, with faster habitat downstream of the two rendered aprons. The substrata were dominated by cobble and boulder with mixed gravels locally. Gravels and smaller cobble were more prominent upstream of the bridge. Upstream of the bridge the channel was open and heavily vegetated with abundant lesser water parsnip and watercress (>90% cover, despite swift flows). This was considered indicative of high nutrient levels. Filamentous algae (*Cladophora* sp.) were also present (<1%). Downstream featured high levels of riparian shading and macrophyte growth was much reduced (occasional lesser water parsnip only). Common duckweed was occasional, with water starwort (*Callitriche* sp.) and ivy-leaved duckweed (*Lemna trisulca*) being rare. In terms of aquatic bryophytes, *Hygroamblystegium* sp. was frequent on larger boulder, with more occasional *Rhynchostegium riparoides*. The riparian zone supported bramble-dominated scrub upstream of the bridge with bittersweet (*Solanum dulcamara*), great willowherb and nettle, whilst downstream was shaded heavily by a mature sycamore and ash-dominated treeline. The site was bordered by rough pasture (GA1).

Atlantic salmon, brown trout and lamprey (*Lampetra* sp.) were recorded via electro-fishing at site B5 (**Appendix A**). The site was considered a good quality salmonid nursery and spawning habitat, supporting a relatively high density of juvenile brown trout and a low density of Atlantic salmon. Siltation, partial compaction of substrata and noxious macrophyte growth reduced the quality of the salmonid habitat. Holding habitat for adults, whilst present, was limited to occasional shallow pools. Good quality lamprey spawning habitat was present but the site was largely unsuitable for ammocoete burial given a paucity of soft sediment accumulations (largely superficial only). European eel habitat was good given ample refugia but none were recorded. Despite some moderate suitability for white-clawed crayfish, none were recorded. Furthermore, crayfish were not detected via eDNA analysis at the site (**Table 4.1**). Two regular otter spraint sites were recorded at the upstream and downstream side of the dry bridge arch (ITM 662283, 767280 and 662281, 767278). Neither contained white-clawed crayfish remains.

Biological water quality, based on Q-sampling, was calculated as **Q4 (good 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 location of the site within the River Boyne And River Blackwater SAC (002299), the aquatic ecological evaluation of site B5 was of **international importance (Table 4.4).** The site also supported salmonids (including Atlantic salmon), *Lampetra* sp. and otter.

Plate 4.9 Representative image of site B5 on the D'arcy's Crossroads Stream at Snipe's Bridge, July 2022 (downstream of bridge)

4.1.10 Site B6 – Stonyford River, Cavestown and Rosmead

Site B6 was located on the Stonyford River (07S02) at a local road crossing. The lowland depositing river (FW2) had been straightened and deepened historically, with bankfull heights of 2.5m to >4m in a deep trapezoidal channel. The river was undergoing OPW maintenance at the time of survey (OPW channel no: C1/32) (**Plate 4.10**). The profile was of swift-flowing shallow glide and riffle with very occasional shallow pool. The substrata were dominated by cobble and small boulder with frequent patches of fine gravels and sand - these were moderately silted. Soft sediment accumulations were frequent though shallow, where present (often associated with macrophyte beds). In terms of macrophytes, water crowfoot (*Ranunculus* sp.) was frequent alongside frequent branched bur-reed and lesser water parsnip. Water starwort (*Callitriche* sp.) was present but rare. Broad-leaved pondweed (*Potamogeton natans*) was present downstream of the bridge in deeper glide. Aquatic bryophytes were dominated by *Hygroamblystegium* sp. with more occasional *Riccardia chamedryfolia. Fontinalis antipyretica* was present but rare on larger boulder near the bridge. The riparian zone supported a mature treeline of ash with hawthorn and ivy on the north bank (providing valuable shading), with open, improved grassland (GA1) along the south bank. The site was bordered by improved pasture (GA1), with coniferous afforestation (WD4) and scrub (WS1) upstream.

A total of 7 no. fish species were recorded via electro-fishing at site B6, namely Atlantic salmon, brown trout, lamprey (*Lampetra* sp.)., European eel, three-spined stickleback, ten-spined stickleback and stone loach (*Barbatula barbatula*) (**Appendix A**). This was the highest species diversity recorded during the survey. Site B6 was considered an excellent quality salmonid habitat, with good quality spawning habitat present (although compromised by siltation). Good quality holding habitat was present downstream of the bridge (deep, slower-flowing glide) but pools were sparse overall. The site was of most value as a nursery, with high quality refugia (cobble, boulder, macrophyte beds) present. Good

quality lamprey spawning habitat was frequent. Soft sediment accumulations were shallow where present along channel margins but nevertheless supported low densities of smaller ammocoetes. Deeper silt deposits associated with macrophyte beds supported higher (but still low) densities of ammocoetes (5.3 per m^2 overall). The site was also a good European eel habitat although the species was only recorded at very low densities. Despite good suitability for white-clawed crayfish, none were recorded. An otter spraint site was recorded under a scoured overhang under a mature ash tree (ITM 661407, 766194).

Biological water quality, based on Q-sampling, was calculated as **Q4 (good 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 location of the site within the River Boyne And River Blackwater SAC (002299), the aquatic ecological evaluation of site B6 was of **international importance (Table 4.4).** The site also supported salmonids (including Atlantic salmon), *Lampetra* sp., European eel and otter.

Plate 4.10 Representative image of site B6 on the Stonyford River, July 2022 (ongoing arterial drainage maintenance evident)

4.1.11 Site B7 – Stonyford River, Cavestown and Rosmead

Site B7 was located on the Stonyford River (07S02) at the N52 road crossing, approx. 2km downstream of site B6. The lowland depositing river (FW2) had been straightened and deepened historically in the vicinity of the bridge, with a steep trapezoidal profile and bank heights of 2.5m. The river averaged 6-8m wide and 0.3-0.5m deep. The profile comprised shallow swift-flowing glide and riffle with very localised small pool to 0.8m. The substrata were dominated by cobble with frequent coarse gravels and occasional boulder. Whilst loose, the substrata were exposed to moderate siltation (plumes underfoot) with a high coverage of filamentous algae. Soft sediment accumulations were not present (superficial deposits only). Macrophyte coverage was low given flow rates. However, lesser water

parsnip, watercress and water mint was frequent along channel margins and on instream cobble bars, with occasional curled pondweed (the latter being indicative of enrichment). Ivy-leaved duckweed was present locally. Marestail (*Hippuris vulgaris*) and water starwort (*Callitriche* sp.) were present but rare. Branched bur-reed was present upstream of the bridge (excessive coverage where channel had not been maintained). The liverwort *Pellia endiviifolia* was frequent along channel margins and on larger cobble and boulder. *Leptodictyum riparium* was occasional. The riparian zone supported an intermittent treeline of ash and hawthorn with bramble-dominated scrub, with open improved grassland along the north bank. The site was bordered by improved pasture (GA1)

Atlantic salmon, brown trout, lamprey (*Lampetra* sp.) and there-spined stickleback were recorded via electro-fishing at site B7 (**Appendix A**). The site was considered a very good salmonid habitat, with combination of good quality spawning, nursery and, locally, holding. The spawning value of the site was reduced due to siltation pressures, whilst the nursery value was compromised given excessive filamentous algal cover (reduced accessibility to refugia). Holding habitat by way of deeper pool was scarce, although deep glide underneath the bridge (to 1.4m) provided excellent quality holding habitat for adult salmonids. Additionally, undercut banks and overhanging macrophyte vegetation provided (seasonal) high quality holding habitat (most fish captured from these refugia). The presence of finer gravels provided good quality lamprey spawning habitat (but quality reduced due to siltation). However, ammocoete habitat was largely absent (superficial deposits only) and only a very low density of larvae were recorded (0.67 per m^2). European habitat was moderate to good overall but none were recorded. Though some suitability for white-clawed crayfish was present, the reduced accessibility to refugia (filamentous algae) and compacted banks (unsuitable for burrowing) reduced the value overall - none were recorded. No otter signs were recorded in vicinity of the site despite highly suitable foraging habitat.

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 location of the site within the River Boyne And River Blackwater SAC (002299), the aquatic ecological evaluation of site B7 was of **international importance (Table 4.4).** The site also supported salmonids (including Atlantic salmon) and *Lampetra* sp.

Plate 4.12 Representative image of site B7 on the Stonyford River, July 2022

4.1.12 Site B8 – Cavestown and Rosmead Stream, Cavestown and Rosmead

Site B8 was located on the Cavestown & Rosmead Stream (07C57), approx. 250m upstream of the Stonyford River confluence. The diminutive lowland depositing stream (FW2) had been extensively straightened and deepened (historical embankments present), with a deep U-shaped channel and bankfull heights of 2m. The stream averaged 1.5m wide and <0.1m deep and suffered from low summer flows at the time of survey. The profile was of very slow-flowing glide with near stagnant pool (no riffles). The substrata comprised fine mixed gravels and small cobble but these were very heavily silted. Livestock poaching was evident. Given low flows and the shallow nature of the stream, macrophyte vegetation was excessive with abundant watercress and frequent water starwort (*Callitriche* sp.). Common duckweed was also frequent. Encroachment from terrestrial grasses (*Agrostis* sp.) was also present. The channel was lined on the north bank by an intermittent hawthorn, blackthorn and ash treeline, with rough pasture on the south bank. The site was bordered by pasture (GA1) and bracken scrub (HD1).

Three-spined stickleback and ten-spined stickleback were the only fish species recorded via electro-fishing at site B8 (**Appendix A**). With the exception of low densities of stickleback, the site was not of fisheries value given gross siltation and low seasonal flows. Poor hydromorphology resulting from historical modifications further reduced the potential of the stream at this location. Fisheries value improved (marginally) further downstream near the Stonyford River confluence (even then, only at higher flows). There was no potential for white-clawed crayfish. No otter signs were recorded in vicinity of the survey site.

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 absence of aquatic species or habitats of higher conservation value, in addition to poor status water quality, the aquatic ecological evaluation of site B8 was of **local importance (lower value) (Table 4.4).**

Plate 4.12 Representative image of site B8 on the Cavestown and Rosmead Stream, July 2022

4.1.13 Site B9 – Stonyford River, Lisclogher Bridge

Site B9 was located on the Stonyford River (07S02) at Lisclogher Bridge, approx. 6.5km downstream from site B7. The lowland depositing river (FW2) had been extensively straightened and deepened in vicinity of the bridge, with retaining walls, a rendered apron and poor hydromorphology. Deep glide predominated with localised pool (1.6m) and no riffle areas. The river averaged 7-8m wide and >1m deep in a deep U-shaped channel with quickly shelving marginal slopes. The substrata were dominated by soft sediment accumulations (often sand-dominated), with localised areas of cobble and boulder (mostly along channel margins). Upstream of the bridge small beds of finer gravels and coarse sands were present amongst macrophyte beds. These were exposed to moderate (locally heavy) siltation. Livestock poaching was frequent along the east bank. Calcification of the hard substrata was also evident. The depositional habitat was heavily vegetated with abundant branched bur-reed (*Sparganium emersum*) in addition to frequent water crowfoot (*Ranunculus* sp.) and fool's watercress. Common duckweed and watercress were occasional along the channel margins. Water starwort (*Callitriche* sp.), curled pondweed (*Potamogeton crispus*) and variable-leaved pondweed (*Potamogeton gramineus*) were rare overall. Given siltation and calcification pressures, aquatic bryophyte coverage was low with only very occasional *Rhynchostegium riparioides*. Filamentous algae were present on instream substrata, indicating enrichment. Whilst the west bank featured a mature treeline dominated by horse chestnut (*Aesculus hippocastanum*) and beech woodland block (WD1) (providing valuable thermal refugia). The east bank was open and grazed improved grassland (GA1).

Atlantic salmon, brown trout, lamprey (*Lampetra* sp.), minnow (*Phoxinus phoxinus*) and three-spined stickleback were recorded via electro-fishing at site B9 (**Appendix A**). The site was of high value for salmonids, supporting a healthy population of mixed-cohort brown trout. A single Atlantic salmon parr was also recorded. The predominance of adult trout reflected the value of the site as a holding habitat for adult salmonids (deep glide and pool). However, some moderate quality salmonid and lamprey spawning habitat was present upstream of the bridge (but compromised by siltation). The site provided moderate quality salmonid nursery habitat with abundant instream macrophyte refugia. Abundant soft sediment beds provided only moderate suitability for larval lamprey with a low density of *Lampetra* sp. ammocoetes recorded (2 per m^2). Despite some good suitability, no European eel or white-clawed crayfish were recorded. Environmental DNA analysis did not detect white-clayed crayfish (**Table 4.1**). Despite high foraging suitability, no otter signs were recorded in vicinity of the site although marking opportunities were rare.

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 location of the site within the River Boyne And River Blackwater SAC (002299), the aquatic ecological evaluation of site B9 was of **international importance (Table 4.4).** The site also supported salmonids (including Atlantic salmon), *Lampetra* sp. and otter.

Plate 4.13 Representative image of site B9 on the Stonyford River at Lisclogher Bridge, July 2022

4.2 Lacustrine survey site results

4.2.1 Site L1 – Newtown Lough, Newtown

Site L1 was located at Newtown Lough, immediately north-east of the proposed site boundary. The 5.2ha lowland, alkaline lake featured steeply shelving margins which averaged >1.5m deep with a deep silt bed supporting abundant stonewort (*Chara* spp.) including *Chara globularis* and *Chara hispida*. Characteristic of lakes lying over limestone, the lake was fringed by well-developed rich fen (PF1), transition mire (PF3), marsh (GM1) and tall reed swamp (FS1) habitat dominated by great pond sedge (*Cladium marsicus*) and common reed (*Phragmites australis*), with frequent scattered stands of common clubrush (*Schoenoplectus lacustris*) (fringes up to 10m thick). The paludal areas supported a high diversity of herbaceous/fen vegetation, with abundant water mint and bog bean (*Menyanthes trifoliata*), frequent water forget-me-not (*Myosotis scorpioides*), common duckweed, watercress, marsh pennywort (*Hydrocotyle vulgaris*) and occasional frogbit (*Hydrocharis morsus-ranae*), brooklime, greater spearwort (*Ranunculus lingua*), marsh bedstraw (*Galium palustre*) and branched bur-reed. Beds of *Chara* spp. and yellow water lily (*Nuphar lutea*) were abundant along lake margins. Scattered (stunted) grey willow and downy birch (*Betula pubescens*) were also present in wetter paludal areas. These areas graded into marsh/fen habitat supporting abundant meadowsweet, vetch (*Vicia* spp.), marsh cinquefoil (*Comarum palustre*), marsh pennywort, marsh willowherb (*Epilobium palustre*), American willowherb (*Epilobium ciliatium*), marsh lousewort (*Pedicularis plaustris*), purple loosestrife (*Lyrthrum salicaria*), quaking grass (*Briza media*), common spotted orchid (*Dactylorhiza fuchsii*) and rushes (e.g. *Juncus articulates*). The lake was bordered by wet willow woodland (WN6) with downy birch. Low-intensity pasture (GA1) as present to the west, east and south.

A fisheries appraisal was undertaken at Newtown Lough (i.e. no netting or electro-fishing survey was completed). The lake was evidently of high suitability for a range of coarse fish such as pike (*Esox lucius*), perch (*Perca fluviatilis*), European eel and cyprinid species including rudd (*Scardinius erythropthalmus*) (the latter were observed shoaling in lake margins). European eel were detected via eDNA analysis (see section 4.4 below). The lake and fringing habitats also provided highly suitable habitat for white-clawed crayfish and smooth newt, respectively. However, neither were detected via eDNA analysis (**Table 4.1**). Whilst no signs were recorded, the lake also had high suitability as an otter foraging habitat.

No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via sweep sampling.

Given the location of Newtown Lough within the River Boyne And River Blackwater SAC (002299), the aquatic ecological evaluation of site B2 was of **international importance (Table 4.4).** The lake also forms part of the Lough Shesk pNHA (000556).

Plate 4.14 Representative image of site L1 at Newtown Lough, July 2022

4.2.2 Site P1 – pond, Newtown

Site P1 was an artificial mature quarry pond (FL8) that had a loose figure of eight-shaped basin 0.06 hectares in size with steep sided 2-3m high banks and complex margins (i.e. frequent points and bays). The pond basin typically had steep sided margins given its use a historical quarry pit. The north-western margins provided cattle drinking access. This area was heavily eroded with a gentler sloping margin. The pond varied from 0.6m to 1.3m in depth. The water had localised moderate turbidity because of silt escapement from poaching but nonetheless supported a good diversity of macrophytes. This included frequent floating broad-leaved pondweed and emergent water horsetail. The pond also supported localised bulrush (*Typha latifolia*) in the margins with occasional small pondweed (*Potamogeton berchtoldii*) and common water crowfoot (*Ranunculus aquatilis*). The south western corner supported clearer water with abundant hedgehog stonewort (*Chara aculeolata*). In the pond margins meadowsweet, clustered dock (*Rumex conglomeratus*) and lesser pond sedge (*Carex acutiformis*) were present with scattered gorse and willow (*Salix* spp.). The pond was bordered by mixed broad-leaved woodland (WD1), scrub (WS1) and improved pasture (GA1).

It is unlikely that the pond supported any fish apart from three-spined stickleback, although none were observed. There was suitability for European eel. Common frog (*Rana temporaria*) were present in the invertebrate sweep samples but no smooth newt (*Lissotriton vulgaris*) eft were recorded despite high suitability for the species. Despite habitat suitability no white-clawed crayfish were recorded and, given the artificial nature of the pond, the species would likely not have established. No otter signs were recorded in vicinity of the site.

No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via sweep netting.

Given the presence of common frog, in addition to a well-developed macrophyte community and good habitat quality for European eel, the aquatic ecological evaluation of site P1 was of **local importance (higher value) (Table 4.4).**

Plate 4.15 Representative image of site P1, July 2022

Plate 4.16 Common frog recorded at site P1, July 2022

4.2.3 Site P2 – pond, Newtown

Site P2 was a large pond and wetland basin situated south-west of the active quarry. The 0.6ha pond was broadly oval shaped with very gently sloping banks at grade with the adjoining improved grassland. The eastern side of the basin was accessible to cattle but the majority of the pond perimeter was fenced. The pond was 0.2-0.5m deep with a deep silt base. The water had high turbidity and supported abundant emergent vegetation. In the open water basin (that took up c. 30% of the overall wetland area) was abundant bottle sedge (*Carex rostrata*) and lesser pond sedge. The pond also supported locally frequent branched bur-reed in the margins with occasional water forget-me-not and small patches of common clubrush. The reeded littorals also supported occasional gypsywort (*Lycopus*

europaeus), redshank (*Persicaria maculosa*), marsh bedstraw (*Galium palustre*), clustered dock, creeping buttercup (*Ranunculus repens*) and soft rush (*Juncus effusus*). The open water supported locally abundant broad-leaved pondweed only with no other floating or submerged macrophyte species present due to the very high turbidity of the water. The pond was bordered by improved pasture (GA1).

With the exception of some low suitability for three-spined stickleback, site P2 was not of fisheries value given its small, shallow and isolated basin. There was some moderate suitability for common frog and smooth newt albeit the species were not recorded during sweep netting. No white-clawed crayfish or otter signs were recorded and the site had limited suitability for either species.

No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded via sweep netting.

Given the suitability for amphibians, in addition to a moderate diversity of macrophyte species and the large size of the pond basin, the aquatic ecological evaluation of site P3 was of **local importance (higher value) (Table 4.4).**

Plate 4.17 Representative image of site P2, July 2022

4.2.4 Site P3 – pond, Newtown

Site P3 was a small circular pond and wetland basin c.0.1 hectares in size immediately east of the active quarry. The small pond with had gently sloping banks at grade with the adjoining improved grassland and had very shallow water of 0.05-0.1m deep with exposed mud in the margins and a deep silt base. The pond was fenced-off from livestock (cattle) apart from localised drinking access. The water had a high turbidity and supported only broad-leaved pondweed in the small body of open water in the centre of the pond. The site was considered eutrophic given visible algal blooms and high abundance of common duckweed. The margins adjoining the exposed muddy paludal areas supported occasional branched bur-reed, gypsywort, celery leaved buttercup (*Ranunculus sceleratus*), hairy

bittercress (*Cardamine hirsuta*), American willowherb (*Epilobium ciliatum*) and soft rush. The pond was bordered by improved pasture (GA1).

The pond had no suitability for fish (including European eel) due to its very shallow depth and heavy enrichment. There was very limited suitability for smooth newt due to the very shallow nature of the pond, high turbidity and limited macrophytes and the species was not recorded during sweep netting. No white-clawed crayfish or otter signs were recorded and the site had limited suitability for either species.

No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded during sweep netting.

Given the absence of aquatic species or habitats of higher conservation value, the aquatic ecological evaluation of site P3 was of **local importance (lower value) (Table 4.4).**

Plate 4.18 Representative image of site P3, July 2022

4.2.5 Site P4 – pond, Newtown

Site P4 was a small circular pond and wetland basin situated to the south-east of the active quarry. The 0.08ha pond featured very gently sloping banks at grade with the adjoining improved grassland. The pond basin was not fenced-off to cattle and the banks were very heavily eroded with no marginal emergent vegetation present. The pond had very shallow water between 0.05 and 0.2m deep with exposed mud in the margins and a deep silt base. The high turbidity of the site limited macrophyte growth with only localised broad-leaved pondweed and floating sweet grass (*Glyceria fluitans*) present. The site was considered eutrophic given visible algal blooms. The site was bordered by heavily improved pasture (GA1).

The pond had no suitability for fish (including European eel) due to its very shallow depth and heavy enrichment. There was some suitability for common frog but not for smooth newt given the very limited macrophytes and high turbidity. No white-clawed crayfish or otter signs were recorded and the site had limited suitability for either species.

No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded during sweep netting.

Given the absence of aquatic species or habitats of higher conservation value, the aquatic ecological evaluation of site P4 was of **local importance (lower value) (Table 4.4).**

Plate 4.19 Representative image of site P4, July 2022

4.2.6 Site P5 – pond, Newtown

Site P5 was a small teardrop-shaped pond of 0.075ha with very gently sloping banks at grade with the adjoining improved grassland. The pond was not fenced-off to cattle and the banks were heavily poached. The pond basin was very shallow and averaged 0.1m with deeper areas to 0.3m locally. The pond basin was hyper-eutrophic with a deep green coloration caused by algal blooms. Due to very high turbidity, macrophytes were limited to water-purslane (*Lythrum portula*) that surrounded the pond littoral in disjunct patches, in addition to floating sweet grass. The pond had no reeded margins and was bordered exclusively by heavily improved pasture (GA1).

The pond had no suitability for fish given the observed limited depths and enrichment. There was some suitability for common frog but poor suitability for smooth newt given the absence of any pondweeds or submerged aquatic vegetation, in addition to the shallow depth and heavy enrichment of site (algal blooms visible). No white-clawed crayfish or otter signs were recorded and the site had no suitability for either species.

No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded during sweep netting.

Given the absence of aquatic species or habitats of higher conservation value, the aquatic ecological evaluation of site P5 was of **local importance (lower value) (Table 4.4).**

Plate 4.20 Representative image of site P5, July 2022

4.2.7 Site P6 – pond, Newtown

Site P6 was a small circular pond situated south of the quarry. The 0.04ha pond featured very gently sloping banks at grade with the adjoining improved grassland. The pond was not fenced-off to cattle and the banks were heavily poached. The shallow pond averaged 0.2-0.4m deep with a bed comprised of very deep, soft silt. The high turbidity of the site limited submerged macrophyte growth with abundant emergent broad-leaved pondweed and common duckweed. The site was considered eutrophic given visible algal blooms in addition to abundant duckweed. The site was bordered by heavily improved pasture (GA1).

The pond had no suitability for fish given the observed limited depths and enrichment. There was some suitability for common frog but poor suitability for smooth newt given the paucity of submerged aquatic vegetation, in addition to the shallow depth and heavy enrichment of site (algal blooms visible). No white-clawed crayfish or otter signs were recorded and the site had no suitability for either species.

No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded during sweep netting.

Given the absence of aquatic species or habitats of higher conservation value, the aquatic ecological evaluation of site P6 was of **local importance (lower value) (Table 4.4).**

Plate 4.21 Representative image of site P6, July 2022

4.2.8 Site P7 – pond, Newtown

Site P7 was a small circular pond and wetland basin situated southwest of the quarry. The pond was 0.12ha in size with very gently sloping banks at grade with the adjoining improved grassland (GA1). The pond was not fenced-off to cattle but, surprisingly, the banks were not heavily poached. The pond ranged from 0.5m to 1.1m and the bed was comprised of mixed gravels and soft silt. The water had low turbidity and supported very dense growth of broad-leaved pondweed that covered the entire basin (>95% surface cover). The site was considered mesotrophic to eutrophic based on visual observations albeit of lower trophy than nearby sites P3 and P4. The site was bordered by heavily improved pasture (GA1).

The pond had good suitability for European eel given adequate depths and prey resources. There was high suitability for smooth newt and good densities of newt (*n*=38) were recorded in the 15-minute sweep of the 135m perimeter, applying a commonly used CPUE density estimate. Despite some low suitability, no white-clawed crayfish or otter were recorded.

No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded during sweep netting.

Given the presence of smooth newt, the aquatic ecological evaluation of site P7 was of **local importance (higher value) (Table 4.4).**

Plate 4.22 Representative image of site P7, July 2022

Plate 4.23 Smooth newt 'efts' recorded at site P7, July 2022

4.2.9 Site P8 – pond, Newtown

Site P8 was a small circular pond and wetland basin located south-east of the quarry. The small pond was 0.07ha in size with very gently sloping banks at grade with the adjoining improved grassland. The pond was not fenced-off to cattle and the banks were very heavily eroded with no marginal emergent vegetation. The shallow pond averaged 0.1-0.2m with exposed mud in the margins and a deep silt base. The high turbidity of the site limited submerged macrophyte growth with only localised broad-leaved pondweed and floating sweet grass. Least duckweed (*Lemna minuta*) was abundant and the pond basin was considered eutrophic given visible algal blooms. The pond was bordered by heavily improved pasture (GA1) with little to no riparian vegetation.

The pond had no suitability for fish given the observed limited depths and heavy enrichment. There was some suitability for common frog but poor suitability for smooth newt given the paucity of

submerged aquatic vegetation, in addition to the shallow depth and heavy enrichment of site (algal blooms visible). No white-clawed crayfish or otter signs were recorded and the site had no suitability for either species.

No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded during sweep netting.

Given the absence of aquatic species or habitats of higher conservation value, the aquatic ecological evaluation of site P8 was of **local importance (lower value) (Table 4.4).**

Plate 4.24 Representative image of site P8, July 2022

4.2.10 Site P9 – pond, Newtown

Site P9 was a small oval shaped pond situated south of the quarry in the corner of a field of improved grassland (GA1). The small 0.05ha pond featured very gently sloping banks which graded into more steeply sloping adjoining pasture. The pond varied between 0.1m and 0.5m deep and the bed comprised mixed superficial gravels in very deep soft silt. The pond was fenced-off to cattle with exception of one access drinking point where soil erosion was visible on the north side of the basin. The water had very high turbidity and had a deep green colour given dense algae blooms indicating a hyper eutrophic state. The pond was bordered by scattered hawthorn hedgerows and supported no marginal vegetation apart from improved pasture vegetation.

With the exception of three-spined stickleback (none recorded), the pond had no suitability for fish given its evidently eutrophic state and absence of macrophyte plants. There was poor suitability for smooth newt given the hyper eutrophic state and also given the absence of macrophyte vegetation. Common frogs may use the pond for spawning given their non-punctilious breeding habitat choices and the proximity of the pond to hedgerows which would act as winter hibernacula. No white-clawed crayfish or otter signs were recorded and the site had no suitability for either species.

No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded during sweep netting.

Given the absence of aquatic species or habitats of higher conservation value, the aquatic ecological evaluation of site P9 was of **local importance (lower value) (Table 4.4).**

Plate 4.25 Representative image of site P9, July 2022

4.2.11 Site P10 – pond, Cavestown & Rosmead

Site P10 was a small circular pond of 0.045ha in size with very gently sloping banks at grade with the adjoining improved grassland (GA1). The pond basin was very shallow and averaged 0.1m with exposed mud. Open water was largely restricted to the centre of the basin. The pond was not fenced-off to cattle and the banks were poached. Nonetheless, the pond supported some emergent macrophytes in the littorals. Water purslane was abundant with occasional broad-leaved pondweed. Small patches of branched bur-reed and floating sweetgrass were also present in the margins, alongside abundant soft rush and gypsywort. The site was bordered by heavily improved pasture (GA1).

The pond had no suitability for fish given its limited depths and enrichment. There was some suitability for common frog given their non-punctilious breeding habitat choices. However, smooth newt habitat suitability was poor given the very shallow depth, evident enrichment and limited macrophyte cover. No white-clawed crayfish or otter signs were recorded and the site had no suitability for either species.

No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded during sweep netting.

Given the absence of aquatic species or habitats of higher conservation value, the aquatic ecological evaluation of site P10 was of **local importance (lower value) (Table 4.4).**

Plate 4.26 Representative image of site P10, July 2022

4.2.12 Site P11 – pond, Carnybrogan

Site P11 was a small circular pond that was considered seasonal given that only very small remnant pools of water were present at the time of survey. The normal wetted basin size was calculated at 0.04ha. The pond was very shallow being 0.05m deep with very gently sloping banks at grade with the adjoining improved grassland. The seasonal pond basin featured exposed mud with shallow pools of water only. The pond was not fenced-off to cattle and the banks were heavily poached. The pools of water formed between abundant beds of water purslane (50% cover). Small patches of branched bur-reed were also present. The pond was bordered by heavily improved pasture (GA1).

The pond had no suitability for fish given its limited depths and enrichment. There was some suitability for frog but poor suitability for smooth newt given the absence of any pondweeds or submerged aquatic vegetation in addition to the shallow depth and heavy enrichment of the pond basin (algal blooms visible). No white-clawed crayfish or otter signs were recorded and the site had no suitability for either species.

No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded during sweep sampling.

Given the absence of aquatic species or habitats of higher conservation value, the aquatic ecological evaluation of site P11 was of **local importance (lower value) (Table 4.4).**

Plate 4.27 Representative image of site P11, July 2022

4.2.13 Site P12 – pond, Cavestown & Rosmead

Site P12 was a very small circular pond (<0.001ha) situated in an improved grassland (GA1) field hollow. The pond had steep banks and had very limited water restricted to small shallow pools. The pond basin was not fenced-off to cattle but given the steep banks access was poor. The pond supported a monodominant stand of lesser pond sedge with an absence of macrophytes given the very limited standing water. The pond was bordered by heavily improved pasture (GA1) on all sides with a narrow uncut dry grassy border (GS2) comprising silverweed (*Potentilla anserina*), Yorkshire fog (*Holcus lanatus*), perennial rye grass (*Lolium perenne*), cocksfoot (*Dactylis glomerata*), thistles (*Cirsium* spp.) and hedge woundwort (*Stachys sylvatica*).

The pond had no suitability for fish given the observed limited depths. There was very limited suitability for smooth newt and common frog given the very limited surface water in the pond basin. It may be possible in wetter years that the pond is used by frogs. No white-clawed crayfish or otter signs were recorded and the site had no suitability for either species.

No macro-invertebrate species of conservation value greater than 'least concern', according to national red lists, were recorded during sweep sampling.

Given the absence of aquatic species or habitats of higher conservation value, the aquatic ecological evaluation of site P12 was of **local importance (lower value) (Table 4.4).**

Plate 4.28 Representative image of site P12, July 2022

4.3 White-clawed crayfish survey

A single juvenile white-clawed crayfish (13mm carapace length) was recorded via hand searching and sweep netting of instream refugia at site A4 on the Athboy River (**Plate 4.29**). White-clawed crayfish eDNA was also detected from site A4 (see section 4.4 below).

White-clawed crayfish were not recorded from any other sites during the survey and no crayfish remains were identified in otter spraint sites recorded at 3 no. riverine sites.

Plate 4.29 Juvenile white-clawed crayfish recorded from site A4 on the Athboy River, July 2022

4.4 eDNA analysis

White-clawed eDNA was detected at site A4 on the Athboy River (12 positive qPCR replicates out of 12, respectively) (**Table 4.1; Appendix C**). However, no crayfish eDNA was detected in composite water samples collected from sites on the D'arcy's Crossroads Stream (site B5) and the Stonyford River (site B9) (0 positive qPCR replicates out of 12, respectively) (**Table 4.1; Appendix C**). These results were considered as evidence of the species' absence at and or upstream of the sampling locations (see Discussion).

Site B5 on the D'arcy's Crossroads Stream and site B9 Stonyford River tested positive for crayfish plague (*Aphanomyces astaci*) (1 positive qPCR replicates out of 12, at each site) (**Table 4.1**). Both sites tested negative for white-clawed crayfish presence and it remains unknown whether plague has eradicated local populations (none recorded during site surveys).

European eel were detected at Newtown Lough (site L1) (7 positive qPCR replicates out of 12, respectively) (**Table 4.1**). However, no white-clawed crayfish, crayfish plague or smooth newt eDNA was detected from the lake site.

No freshwater pearl mussel eDNA was detected in the 3 no. riverine samples (0 positive qPCR replicates out of 12, respectively) (**Table 4.1; Appendix C**). These results were considered as evidence of the species' absence within the survey area, in keeping with the known distribution (absence) of the species in the wider survey area.

4.5 Otter signs

A total of 4 no. otter signs were recorded across 13 no. riverine and 13 no. lacustrine survey sites during the course of aquatic surveys undertaken in July 2022.

A regular otter spraint site was recorded on the D'arcy's Crossroads Stream at site B3 (ITM 662606, 768646). Two regular otter spraint sites were also recorded on this watercourse at site B5 (ITM 662283, 767280 and 662281, 767278). An otter spraint site was recorded on the Stonyford River at site B6 (ITM 661407, 766194).

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

4.6 Invasive aquatic species

Environmental DNA analysis detected the non-native pathogen crayfish plague (*Aphanomyces astaci*) in the D'arcy's Crossroads Stream (B5) and Stonyford River (B9) (**Table 4.1**). With the exception of crayfish plague, no other aquatic invasive species were recorded during the July 2022 surveys.

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

Site	Watercourse	Freshwater pearl mussel	White-clawed crayfish	Crayfish plague	European eel	Smooth newt
A4	Athboy River	Negative (0/12)	**Positive (12/12)**	Negative (0/12)	n/a	n/a
L1	Newtown Lough	n/a	Negative (0/12)	Negative (0/12)	**Positive (7/12)**	Negative (0/12)
B5	D'arcy's Crossroads Stream	Negative (0/12)	Negative (0/12)	**Positive (1/12)**	n/a	n/a
B9	Stonyford River	Negative (0/12)	Negative (0/12)	**Positive (1/12)**	n/a	n/a

4.7 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 12 no. wetted riverine sites in July 2022 (**Appendix B**).

A total of 4 no. sites on the Athboy River (site A4), D'arcy's Crossroads Stream (B3 & B5) and the Stonyford River (B6) achieved **Q4 (good status)** water quality and thus met the 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**). This was given the presence of one group A taxa (in this case the mayfly *Ecdyonurus dispar*) in fair numbers (5% of total abundance) (**Appendix B**).

A total of 3 no. sites on D'arcy's Crossroads Stream (B4), Stonyford River (B7) and the Cavestown and Rosmead Stream (B8) achieved **Q3-4 (moderate status)** water quality (**Figure 4.1**). This was given the low numbers (<5%) of group A species; low to moderate abundances of group B species such as the mayfly *Alainites muticus* and stonefly *Leuctra hippopus,* and a dominance of group C species such as the mayflies *Baetis rhodani* and *Seratella ignita*, the riffle beetle *Elmis aenea* and freshwater shrimp (*Gammarus duebeni*) (**Appendix B**).

Sites A1 on an unnamed drainage channel, A3 on the Kilrush Lower Stream, B1 on the Killacroy Stream and B9 on the Stonyford River achieved **Q2-3** (A3 & B1) **or Q3 (poor status)** (A1 & B9) based on an absence of group A species; low numbers or absence of group B species and a dominance of group C species, particularly *Gammarus duebeni* (**Appendix B**). Sites A3 and B1 supported higher proportions of group D and E taxa and thus were reduced to **Q2-3 (poor status).**

It should be noted that the ratings for sites A1, A3, B1, B2, B4 and B8 were tentative due to low summer flows and or a lack of suitable riffle areas for sampling (Toner et al., 2005).

Sites A2 on the Kilrush Lower Stream was dry at the time of survey (July 2022) and thus no biological water quality sample could be collected.

4.8 Pond & lake macro-invertebrates

No rare or protected macro-invertebrate species (according to national red lists) were recorded in the sweep samples taken from 13 no. wetted pond and lake sites in July 2022 (**Appendix B**). The pond samples were typically dominated by dipteran and hemipteran species such as biting midge larvae (non-*Chironomus* spp.) and water boatmen (Corixidae), respectively. The mayfly *Cloeon dipterum* was present in approximately half of the wetted ponds.

Newtown Lough (site L1), an alkaline lake, was dominated by molluscan species (e.g. Sphaeriidae) and freshwater hoglouse (*Asellus aquaticus*) with low numbers of damselflies (*Aeshna* sp. & *Coenagrion* sp.). The lake also supported larvae of the dragonfly species, four-spotted chaser (*Libellula quadrimaculata*) (**Appendix B**).

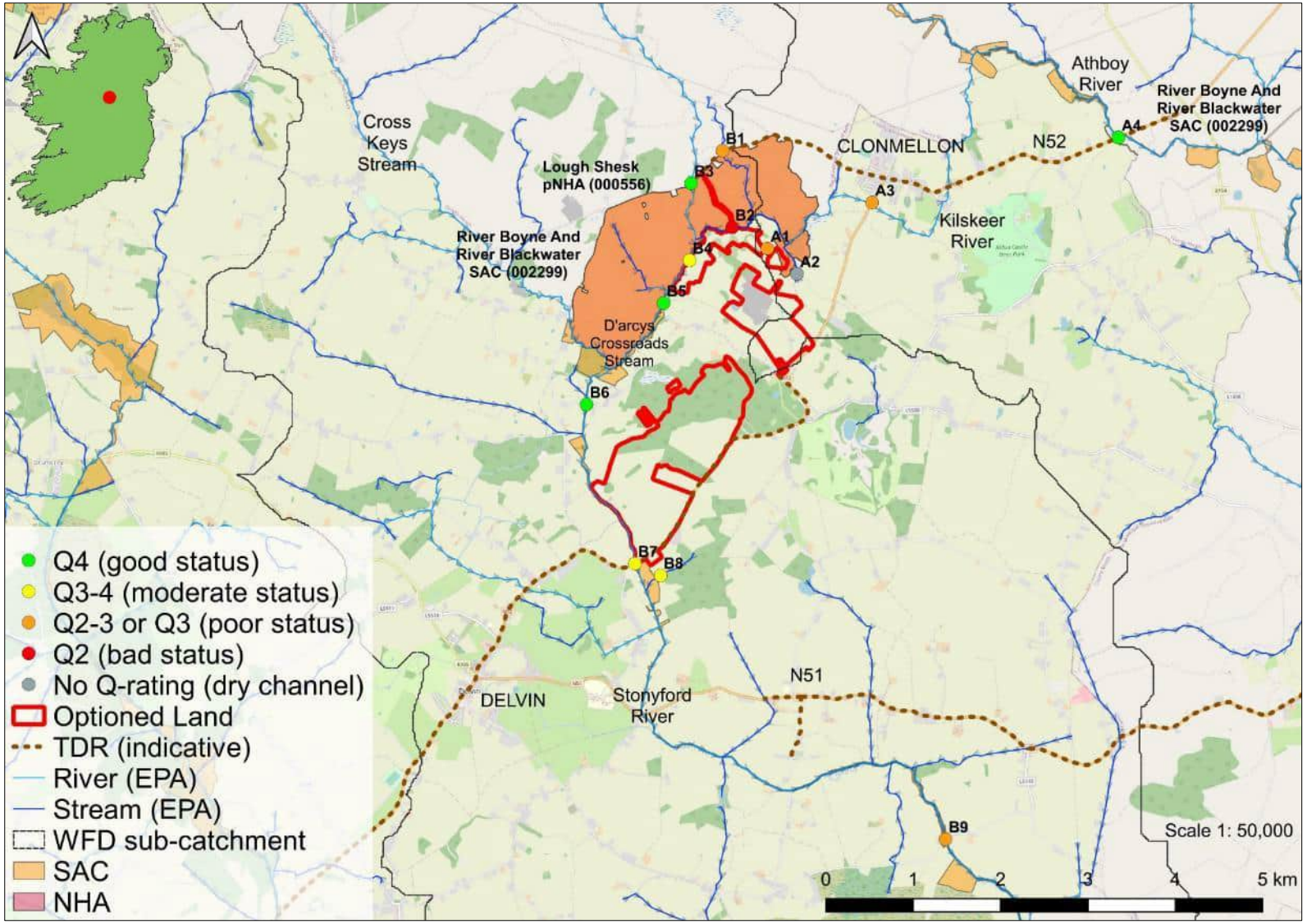

Figure 4.1 Overview of the riverine biological water quality status in the vicinity of the proposed Knockannarragh wind farm project, July 2022

4.9 Macrophytes and aquatic bryophytes

No rare or protected macrophytes or aquatic bryophytes were recorded at the 13 no. riverine or 13 no. lacustrine sites in July 2022. Similarly, no examples of Annex I aquatic vegetation habitats were recorded during the surveys.

4.10 Aquatic ecological evaluation

An aquatic ecological evaluation of each survey site was based on the results of desktop review (i.e., presence of species of high conservation value), fisheries assessments and habitat assessments, the presence of protected or rare invertebrates (e.g. white-clawed crayfish), environmental DNA 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**).

A total of 11 no. sites in the vicinity of the proposed Knockannarragh wind farm project were evaluated as **international importance** given their location within the River Boyne And River Blackwater SAC (002299). These sites were located on the Kilrush Lower Stream (A2), Athboy River (A4), Killacroy Stream (B1 & B2), D'arcy's Crossroads Stream (B3, B4 & B5), Stonyford River (B6, B7 & B9) and Newtown Lough (L1).

Pond sites P1, P2 and P7 were evaluated as **local importance (higher value)** due to the presence of amphibians and or good quality amphibian habitat (**Table 4.4**).

The remaining 12 no. sites on an unnamed drainage channel (A1), Kilskeer River (A3), Cavestown & Rosmead Stream (B8) and pond sites P3, P4, P5, P6, P8, P9, P10, P11 & P12 were evaluated as **local importance (lower value)** in terms of their aquatic ecology given an absence of aquatic species or habitats of high conservation value and or less than Q4 (good status) water quality (**Table 4.4**).

Table 4.2 Summary of fish species of higher conservation value and relative abundances (low, medium, high & very high) recorded via **electro-fishing** per riverine survey site in the vicinity of the proposed Knockannarragh wind farm, July 2022

Site	Watercourse	Relative abundance				
		Atlantic salmon	Brown trout	*Lampetra* sp.	European eel	Other species
A1	Drainage channel					Three-spined stickleback
A2	Kilrush Lower Stream	No fish recorded (dry channel)				
A3	Kilskeer River					Three-spined stickleback, ten-spined stickleback
A4	Athboy River	Low	High	Medium	Low	
B1	Killacroy Stream					Three-spined stickleback, ten-spined stickleback
B2	Killacroy Stream					Three-spined stickleback, ten-spined stickleback
B3	D'arcy's Crossroads Stream		Very high	Low		Three-spined stickleback
B4	D'arcy's Crossroads Stream		Low	Low		Three-spined stickleback
B5	D'arcy's Crossroads Stream	Low	High	Low		
B6	Stonyford River	Low	High	Medium	Low	Three-spined stickleback, ten-spined stickleback, stone loach
B7	Stonyford River	Medium	High	Low		Three-spined stickleback
B8	Cavestown & Rosmead Stream					Three-spined stickleback, ten-spined stickleback
B9	Stonyford River	Low	High	Medium		Three-spined stickleback, minnow

Conservation value: Atlantic salmon (*Salmo salar*), 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 Inland Fisheries Acts 1959 to 2017, brown trout and coarse fish species have no legal protection in Ireland.

Table 4.3 Summary of aquatic species (**excluding fish**) & habitats of higher conservation value recorded in the vicinity of the proposed Knockannarragh wind farm, July 2022

Site	Watercourse	White-clawed crayfish	Freshwater pearl mussel (eDNA)	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
Riverine survey sites								
A1	Drainage channel	None recorded		No signs	Not present	None recorded	None recorded	None recorded
A2	Kilrush Lower Stream	None recorded		No signs	Not present	None recorded	None recorded	None recorded
A3	Kilskeer River	None recorded		No signs	Not present	None recorded	None recorded	None recorded
A4	Athboy River	**Single juvenile recorded; positive eDNA result at site**	Negative eDNA result at site, no records in catchment	No signs	Not present	None recorded	None recorded	None recorded
B1	Killacroy Stream	None recorded		No signs	Not present	None recorded	None recorded	None recorded
B2	Killacroy Stream	None recorded		No signs	Not present	None recorded	None recorded	None recorded
B3	D'arcy's Crossroads Stream	None recorded		**Regular spraint site**	Not present	None recorded	None recorded	None recorded
B4	D'arcy's Crossroads Stream	None recorded		No signs	Not present	None recorded	None recorded	None recorded
B5	D'arcy's Crossroads Stream	None recorded; negative eDNA result at site	Negative eDNA result at site, no records in catchment	**2 no. regular spraint sites**	Not present	None recorded	None recorded	None recorded
B6	Stonyford River	None recorded		**Spraint site**	Not present	None recorded	None recorded	None recorded
B7	Stonyford River	None recorded		No signs	Not present	None recorded	None recorded	None recorded
B8	Cavestown & Rosmead Stream	None recorded		No signs	Not present	None recorded	None recorded	None recorded
B9	Stonyford River	None recorded; negative eDNA result at site	Negative eDNA result at site, no records in catchment	No signs	Not present	None recorded	None recorded	None recorded

Site	Watercourse	White-clawed crayfish	Freshwater pearl mussel (eDNA)	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
Lacustrine survey sites								
L1	Newtown Lough	None recorded		No signs	Not present	None recorded	None recorded	None recorded
P1	Pond	None recorded		No signs	Not present	None recorded	None recorded	**Common frog recorded**
P2	Pond	None recorded		No signs	Not present	None recorded	None recorded	None recorded
P3	Pond	None recorded		No signs	Not present	None recorded	None recorded	None recorded
P4	Pond	None recorded		No signs	Not present	None recorded	None recorded	None recorded
P5	Pond	None recorded		No signs	Not present	None recorded	None recorded	None recorded
P6	Pond	None recorded		No signs	Not present	None recorded	None recorded	None recorded
P7	Pond	None recorded		No signs	Not present	None recorded	None recorded	**Smooth newt efts recorded**
P8	Pond	None recorded		No signs	Not present	None recorded	None recorded	None recorded
P9	Pond	None recorded		No signs	Not present	None recorded	None recorded	None recorded
P10	Pond	None recorded		No signs	Not present	None recorded	None recorded	None recorded
P11	Pond	None recorded		No signs	Not present	None recorded	None recorded	None recorded
P12	Pond	None recorded		No signs	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. Smooth newt (*Lissotriton vulgaris*) and common frog (*Rana temporaria*) are protected under the Irish Wildlife Acts 1976-2021.

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

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

Site no.	Watercourse	EPA code	Evaluation of importance	Rationale summary
Riverine survey sites				
A1	Drainage channel	n/a	Local importance (lower value)	Shallow, heavily modified, heavily silted stagnant drainage channel with poor connectivity to Newtown Lough; three-spined stickleback recorded via electro-fishing & of poor fisheries value; **Q3** (poor status) water quality (tentative rating); no aquatic species or habitats of high conservation value
A2	Kilrush Lower Stream	07K27	**International importance**	Site located within the **River Boyne And River Blackwater SAC** (002299); ephemeral lowland depositing stream that was dry at the time of survey with a heavily-vegetated inline pond of high value for amphibians (common frog abundant)
A3	Kilskeer River	07K26	Local importance (lower value)	Historically straightened & over-deepened lowland depositing stream with near imperceptible flows & gross siltation; three-spined and ten-spined stickleback recorded via electro-fishing; **Q2-3** (poor status) water quality (tentative); no aquatic species or habitats of high conservation value
A4	Athboy River	07A01	**International importance**	Site located within the **River Boyne And River Blackwater SAC** (002299); semi-natural swift-flowing calcareous lowland river of high fisheries & aquatic value; Atlantic salmon, brown trout, *Lampetra* sp. & European eel recorded via electro-fishing; white-clawed crayfish recorded via hand searching & eDNA; **Q4** (good status) water quality
B1	Killacroy Stream	07K16	**International importance**	Site located within the **River Boyne And River Blackwater SAC** (002299); however, very heavily modified, heavily silted lowland stream with poor flows & poor aquatic value; three-spined and ten-spined stickleback recorded via electro-fishing; **Q2-3** (poor status) water quality (tentative); no aquatic species or habitats of high conservation value
B2	Killacroy Stream	07K16	**International importance**	Site located within the **River Boyne And River Blackwater SAC** (002299); however, very heavily modified, very heavily silted lowland stream with no flows & poor aquatic value; three-spined and ten-spined stickleback recorded via electro-fishing; **Q2** (bad status) water quality (tentative); no aquatic species or habitats of high conservation value
B3	D'arcy's Crossroads Stream	07D06	**International importance**	Site located within the **River Boyne And River Blackwater SAC** (002299); semi-natural swift-flowing lowland stream of high value as a salmonid nursery; brown trout, *Lampetra* sp. & three-spined stickleback recorded via electro-fishing; **Q4** (good status) water quality; regular otter spraint site recorded
B4	D'arcy's Crossroads Stream	07D06	**International importance**	Site located within the **River Boyne And River Blackwater SAC** (002299); heavily modified, heavily silted lowland stream with low summer flows; brown trout,

Site no.	Watercourse	EPA code	Evaluation of importance	Rationale summary
				Lampetra sp. & three-spined stickleback recorded via electro-fishing; **Q3-4** (moderate status) water quality
B5	D'arcy's Crossroads Stream	07D06	**International importance**	Site located within the **River Boyne And River Blackwater SAC** (002299); heavily modified lowland stream with low summer flows but some localised semi-natural areas; Atlantic salmon, brown trout & *Lampetra* sp. recorded via electro-fishing; **Q4** (moderate status) water quality; two regular otter spraint sites recorded
B6	Stonyford River	07S02	**International importance**	Site located within the **River Boyne And River Blackwater SAC** (002299); historically straightened & deepened swift-flowing lowland river with localised semi-natural areas, undergoing OPW maintenance at time of survey; Atlantic salmon, brown trout, *Lampetra* sp., European eel, three-spined stickleback, ten-spined stickleback & stone loach recorded via electro-fishing; **Q4** (good status) water quality; otter spraint site recorded
B7	Stonyford River	07S02	**International importance**	Site located within the **River Boyne And River Blackwater SAC** (002299); historically straightened & deepened swift-flowing lowland river of high salmonid value; Atlantic salmon, brown trout, *Lampetra* sp. & three-spined stickleback recorded via electro-fishing; **Q3-4** (moderate status) water quality
B8	Cavestown & Rosmead Stream	07C57	Local importance (lower value)	Narrow, shallow, heavily modified lowland stream with poor summer flows; three-spined and ten-spined stickleback recorded via electro-fishing; **Q3-4** (moderate status) water quality (tentative); no aquatic species or habitats of high conservation value
B9*	Stonyford River	07S02	**International importance**	Site located within the **River Boyne And River Blackwater SAC** (002299); historically straightened & deepened lowland depositing river of high salmonid value (despite several impacts); Atlantic salmon, brown trout, *Lampetra* sp. minnow & three-spined stickleback recorded via electro-fishing; **Q3** (poor status) water quality
Lacustrine survey sites				
L1*	Newtown Lough	07_255	**International importance**	Site located within the **River Boyne And River Blackwater SAC** (002299); natural 5ha alkaline lake of high aquatic value; high suitability for a range of coarse fish species, European eel detected via eDNA; high suitability for otter; Annex I terrestrial/fringing habitats likely present
P1	Pond	n/a	**Local importance (higher value)**	Small, shallow mature quarry pond with well-developed macrophyte community of high value for amphibians; **common frog** recorded; some suitability for European eel
P2	Pond	n/a	**Local importance (higher value)**	Large 0.6ha shallow, heavily vegetated pond of high suitability for amphibians, no fisheries value

Site no.	Watercourse	EPA code	Evaluation of importance	Rationale summary
P3	Pond	n/a	Local importance (lower value)	Small 0.1ha, very shallow, heavily silted eutrophic pond of low value for amphibians, no fisheries value; no aquatic species or habitats of high conservation value
P4	Pond	n/a	Local importance (lower value)	Small 0.08ha, very shallow, heavily silted, turbid eutrophic pond of low value for amphibians, no fisheries value; no aquatic species or habitats of high conservation value
P5	Pond	n/a	Local importance (lower value)	Small 0.075ha, very shallow, heavily silted, eutrophic pond of low value for amphibians, no fisheries value; no aquatic species or habitats of high conservation value
P6	Pond	n/a	Local importance (lower value)	Small 0.04ha, very shallow, heavily silted, turbid eutrophic pond of low value for amphibians, no fisheries value; no aquatic species or habitats of high conservation value
P7	Pond	n/a	**Local importance (higher value)**	Small 0.12ha heavily vegetated, clear water pond of 0.5-1m depth with high value for amphibians and some suitability for European eel; **smooth newt efts** recorded via sweep netting
P8	Pond	n/a	Local importance (lower value)	Small 0.07ha, shallow, heavily silted, turbid eutrophic pond of low value for amphibians, no fisheries value; no aquatic species or habitats of high conservation value
P9	Pond	n/a	Local importance (lower value)	Small 0.05ha highly eutrophic pond with high turbidity and absence of aquatic vegetation; of low value for amphibians and unsuitable for fish; no aquatic species or habitats of high conservation value
P10	Pond	n/a	Local importance (lower value)	Small 0.045ha, very shallow, heavily silted, turbid eutrophic pond of low value for amphibians, no fisheries value; no aquatic species or habitats of high conservation value
P11	Pond	n/a	Local importance (lower value)	Small 0.04ha, very shallow, heavily silted, turbid eutrophic pond of low value for amphibians, no fisheries value; pond possibly seasonal (evident shrinkage); no aquatic species or habitats of high conservation value
P12	Pond	n/a	Local importance (lower value)	Very small <0.001ha pond with localised pools of standing water only (semi-dry) & high levels of terrestrial vegetation encroachment; of low value for amphibians, no fisheries value; no aquatic species or habitats of high conservation value

Conservation value: Atlantic salmon (*Salmo salar*), *Lampetra* spp. and otter (*Lutra lutra*) are all listed under Annex II of the Habitats Directive [92/42/EEC]. Furthermore, Atlantic salmon, *Lampetra* spp. are also listed under Annex V of the Habitats Directive [92/42/EEC] while otter are also listed on under Annex IV of the Habitats Directive [92/42/EEC]. 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 Inland Fisheries Acts 1959 to 2017, brown trout and coarse fish species have no legal protection in Ireland. Smooth newt (*Lissotriton vulgaris*) and common frog (*Rana temporaria*) are protected under the Irish Wildlife Acts 1976-2021.

5. Discussion

5.1 Most valuable areas for aquatic ecology

The majority of riverine survey sites (10 no.) in the vicinity of the proposed Knockannarragh wind farm project were evaluated as **international importance** by virtue of their location within the River Boyne and River Blackwater SAC (002299). These sites were located on the Kilrush Lower Stream (A2), Athboy River (A4), Killacroy Stream (B1 & B2), D'arcy's Crossroads Stream (B3, B4 & B5) and the Stonyford River (B6, B7 & B9). It should be noted that several of these sites (e.g. A2, B1, B2, B8) were of low aquatic value despite being situated within the European site due to historical modification, siltation and or eutrophication pressures. Newtown Lough (L1) was also evaluated as **international importance** given its location within the River Boyne And River Blackwater SAC (002299). The lake was of very high aquatic value, with high suitability for otter and a range of fish species including Red-listed European eel inclusive of supporting native stonewort communities.

Pond sites P1, P2 and P7 were evaluated as **local importance (higher value)** due to the presence of good quality amphibian habitat, common frog (P1) and smooth newt efts (P7) (**Table 4.4**). The remaining 12 no. sites including both riverine and pond sites (A1, A3, B8, P3, P4, P5, P6, P8, P9, P10, P11 & P12) were evaluated as **local importance (lower value)** in terms of their aquatic ecology given an absence of aquatic species or habitats of high conservation and of higher quality supporting habitat (**Table 4.4**).

5.1.1 Fish species of high conservation value

Salmonids were present at 7 no sites in total, with Atlantic salmon present at five of these on the Athboy River (A4), D'arcy's Crossroads Stream (B5 & B6) and the Stonyford River (B7 & B9). With the exception of site B7 (medium density population), salmon were recorded at lower densities (**Appendix A**). These watercourses can be considered the most important salmonid habitats in the survey area. Sites B3 on the D'arcy's Crossroads Stream and B6 on the Stonyford River were particularly high value salmonid nurseries.

Lamprey ammocoetes (*Lampetra* sp.) were widespread in the vicinity of the proposed project, being recorded from a total of 7 no. sites on the Athboy River (A4), D'arcy's Crossroads Stream (B5 & B6) and the Stonyford River (B7 & B9) **Table 4.2; Appendix A**). These sites supported both salmonids and lamprey increasing their overall fisheries value. Ammocoetes were present in low to medium densities in the study area (≤5.3 per m^2) and this was reflective of the more limited larval settlement habitat inclusive of sub-optimal larval habitat quality. Low summer flows and siltation pressures reduced the spawning habitat quality and also the oxygenation of bottom sediments which would influence recruitment success and ammocoetes densities (**Appendix A**).

European eel were only recorded in low densities from sites A4 on the Athboy River and B6 on the Stonyford River (**Table 4.2; Appendix A**). European eel are Red-listed in Ireland (King et al., 2011) and are classed as 'critically endangered' on a global scale (Pike et al., 2020). As eel occurrence decreases significantly with increasing distance from the sea (Degerman et al., 2019), the paucity of eel observed in the Boyne_SC_050 and Boyne_SC_070 river sub-catchments can be partly explained by the distance between the survey area and marine habitats (Chadwick et al., 2007) (>80km nearest instream

distance). The absence of eel from many sites also reflects the considerable hydromorphological pressures in the survey area which have reduced the overall quality of eel habitat (**Appendix A**). Straightening, deepening and the removal of bed substrata and channel heterogeneity inclusive of regular pool formation limits eel refugia and increases predation risk.

5.1.2 Otter

Despite widespread suitability, otter signs (spraint sites) were only recorded at a total of 3 no. sites on the D'arcy's Crossroads Stream (site B3 & B5) and the Stonyford River (B6). This paucity of signs was considered to mainly reflect the influence of historical drainage on the surveyed watercourses which has reduced habitat heterogeneity and resulted in steep(er) banks with poor marking opportunities for otter. Sign marking is routinely associated with prominent features such as large instream boulders, marginal gravel shoals, tree root systems, grassy hummocks and holts, as well as at typical key foraging sites such as pools (Brazier & Macklin, 2020; Macklin et al., 2019; Almeida et al. 2012). Should such suitable deposition features be scarce or unavailable in a given habitat (i.e. removed via arterial drainage), otter signs may be sporadic or even absent entirely despite utilisation of a watercourse. Furthermore, otter distribution is more strongly correlated with river increase in river width (i.e. larger rivers have higher densities of otter sign marking inferring higher utilisation). The majority of the rivers in the catchment were smaller lower order channels which typically are of lower value for foraging otter especially when subject to drainage pressures (i.e. hydromorphological impacts).

No otter signs were identified in vicinity of the 12 no. pond survey sites. This was unsurprising given that most ponds were unsuitable for fish, the key prey resource of otter (Krawczyk et al., 2016). However given otter's highly opportunistic diets (Kloskowski et al., 2013) and proclivity to forage for amphibians during the early spring there may be some seasonal foraging opportunities in those areas nearer to riverine watercourses.

No breeding (holt) or couch (resting) areas were identified in the vicinity of the survey sites in July 2022.

5.1.3 Amphibians (pond sites)

Whilst the majority of the 12 no. pond sites were of lower suitability or unsuitable for smooth newt, efts (juveniles) were recorded at site P7 via sweep netting. High densities of newt (*n*=38) were recorded in the 15-minute sweep of the 135m perimeter. Whilst the surrounding terrestrial habitats were of poor quality (improved pasture), site P7 was of greater depth (exceeding 1m), less enriched and supported a greater diversity of submerged and emergent vegetation for egg attachment (Beebee, 1985) in comparison to other ponds. Despite high suitability, no smooth newt eDNA was detected at Newtown Lough (**Table 4.1**).

There was more frequent suitability for common frog at the pond survey sites given the species' less specific breeding habitat preferences (Reid et al., 2013). Frogs were recorded at site P1 with some suitability at most pond sites. However, clear correlations have been shown between agricultural intensification and the occurrence and genetic integrity of both smooth newt and common frog, primarily due to a loss of supporting terrestrial habitats (Mulkeen et al., 2017; Beebee, 2005; Johansson et al., 2005). Thus, the survey area typically provided sub-optimal amphibian habitats given

agricultural land practices. Smooth newt and common frog are protected under the Irish Wildlife Acts 1976-2021.

5.1.4 White-clawed crayfish & crayfish plague

White-clawed crayfish were recorded via both hand searching (single juvenile) and eDNA analysis at site A4 on the Athboy River (12 positive qPCR replicates out of 12, respectively) (**Table 4.1**). White-clawed crayfish were not recorded from any other sites during the survey and no crayfish remains were identified in otter spraint sites recorded at 3 no. riverine sites.

The failure to detect crayfish eDNA at sites on the Stonyford River (B9) was at odds with the known distribution of the species in the watercourse (**Figure 3.1**). 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 lower summer flows and high amounts of instream vegetation present on the Stonyford River at the time of survey may have limited the flow of eDNA and thus influenced detection rates of crayfish (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 eDNA detection probability (Sint et al., 2022). The absence of an eDNA signature at site B9, coupled with the failure to record live crayfish elsewhere on the river (surveys & eDNA) and an absence of crayfish remains in otter spraint, would suggest a cryptically low abundance or even absence of the species from the river. Likewise, it would appear that white-clawed crayfish are present at cryptically low densities or absent from the D'arcy's Crossroads Stream.

Crayfish plague was detected in both the D'arcy's Crossroads Stream (site B5) and the Stonyford River (B9) but not the Athboy River (A4) (**Table 4.1**). This may explain the results of our eDNA and traditional surveys on these watercourses. Crayfish plague is listed at one of the world's 100 worst invasive species (GISD, 2022; Lowe et al., 2000) and is becoming highly prevalent across Ireland. *Aphanomyces astaci* is considered an obligate crayfish parasite not capable of surviving for a long period outside a crayfish host (Strand et al., 2011; Söderhall & Cerenius, 1999). The pathogen was confirmed in the wider Boyne catchment in the late 1980s (Reynolds, 1988), although no contemporary outbreaks have been recorded in the catchment under the national crayfish plague surveillance programme (Swords et al., 2021, 2020; White et al., 2019). The detection of crayfish plague in the D'arcy's Crossroads Stream and the Stonyford River is likely to jeopardise any remaining crayfish populations within the vicinity of the proposed project.

5.1.5 Macro-invertebrates & biological water quality

No rare or protected macro-invertebrate species (according to national red lists) were recorded in the biological water quality samples taken from 12 no. wetted riverine or 13 no. lacustrine sites in July 2022 (**Appendix B**). Hydromorphological pressures and more intensive bordering land use practices are considered to have created conditions inimical for the establishment of rarer invertebrate species. However, despite evident catchment pressures, a total of 4 no. sites on the Athboy River (site A4), D'arcy's Crossroads Stream (B3 & B5) and the Stonyford River (B6) achieved **Q4 (good status)** water quality and thus met the target good status (≥Q4) requirements of the European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2019 and the Water Framework Directive

(2000/60/EC) (**Appendix B**). The remaining 8 no. sites achieved **Q3-4 (moderate status)** (B4, B7 & B8) or **Q2-3** (A3 & B1) **or Q3 (poor status)** (A1 & B9).

Whilst the larger survey watercourses supported improved conditions, the biological water quality of the survey area was evidently impacted via eutrophication, siltation and or historical modifications (hydromorphology). Low summer flows and associated lower water volumes further reduced the water quality within the survey area in July 2022. Channelisation (hydromorphology) as previously mentioned and agricultural derived siltation and enrichment are the primary threats to water quality within the survey area (EPA, 2018a, 2018b) and this was observed during the site surveys.

5.2 Aquatic ecology summary

The watercourses in the vicinity of the proposed Knockannarragh wind farm were typically lowland depositing channels which had been historically (and often extensively) straightened and deepened, impacting their hydromorphology and exacerbating agricultural pressures such as eutrophication and siltation, as well as low summer flows. The majority of riverine sites (11 no.) in the vicinity of the proposed project were evaluated as **international importance** by virtue of their location within the River Boyne And River Blackwater SAC (002299) but these were not always of inherently high aquatic value (e.g. sites A2, B1, B2, B4). The majority of pond sites were evaluated as **local importance (lower value).** The ponds were evidently impacted by cattle poaching, overgrazing, enrichment and siltation with poor connectivity to adjoining high quality habitat that would buffer the deleterious effects of adjoining land use practices.

Salmonids and *Lampetra* sp. were relatively widespread within the survey area (albeit in low densities), with European eel showing a much more restricted distribution. Atlantic salmon were recorded from the Athboy River (A4), D'arcy's Crossroads Stream (B5) and Stonyford River (B9). White-clawed crayfish were only recorded from the Athboy River (via both hand searching & eDNA), with crayfish plague detected (eDNA) on the D'arcy's Crossroads Stream and Stonyford River. A low number of otter signs were recorded in vicinity of the project (no holts or couches). Smooth newt were recorded from site P7, with suitability low elsewhere. Most pond sites surveyed had some suitability for common frog (recorded at site P2 only). No rare or protected macro-invertebrates, macrophytes or aquatic bryophytes were recorded and no examples of Annex I aquatic habitats were present. Aside from crayfish plague detected at the D'arcy's Crossroads Stream (B5) and Stonyford River (B9), no aquatic invasive species were recorded. Biological water quality was less than satisfactory (<Q4) at all sites with the exception of 4 no. sites on the Athboy River (site A4), D'arcy's Crossroads Stream (B3 & B5) and the Stonyford River (B6). Broadly speaking, these rivers, alongside Newtown Lough, were the highest value watercourses within vicinity of the project.

6. References

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7. Appendix A – fisheries assessment report

Please see accompanying fisheries assessment report

8. Appendix B – Q-sample (biological water quality) and pond macro-invertebrate results

Table 8.1 Macro-invertebrate Q-sampling results for riverine sites A1, A2, A4, A5, A6, A7, A9, A10, A11 & A12, July 2022

Group	Family	Species	A1	A3	A4	B1	B2	B3	B4	B5	B6	B7	B8	B9	EPA class
Ephemeroptera	Heptageniidae	*Ecdyonurus dispar*			14			19	1	12	10	5			A
Ephemeroptera	Heptageniidae	*Ecdyonurus insignis*			3										A
Ephemeroptera	Heptageniidae	*Rhithrogena semicolorata*						3		4	4				A
Plecoptera	Nemouridae	*Nemoura cinerea*											1		A
Plecoptera	Perlodidae	*Isoperla grammatica*										2			A
Ephemeroptera	Baetidae	*Cloeon dipterum*													B
Ephemeroptera	Baetidae	*Alainites muticus*							1	4	1	43			B
Ephemeroptera	Baetidae	*Centroptilum luteolum*												3	B
Ephemeroptera	Leptophlebiidae	*Paraleptophlebia cincta*							1						B
Plecoptera	Leuctridae	*Leuctra hippopus*						6		3		21			B
Trichoptera	Leptoceridae	*Athripsodes* sp.										1			B
Trichoptera	Limnephilidae	*Drusus annulatus*						1			1	2			B
Trichoptera	Limnephilidae	*Limnephilus lunatus*		2		6	3	1	2	1			5		B
Trichoptera	Limnephilidae	*Potamophylax cingulatus*						1			1			1	B
Trichoptera	Hydroptilidae	*Ithytrichia* sp.												1	B
Trichoptera	Sericostomatidae	*Sericostoma personatum*			4			17			4	11			B
Trichoptera	Glossosomatidae	*Agapetus fuscipes*						24		4	1				B
Trichoptera	Goeridae	*Silo pallipes*						3			2				B
Odonata	Aeshnidae	*Aeshna* sp.					1								B
Odonata	Coenagrionidae	*Coenagrion* sp.	5												B
Odonata	Calopterygidae	*Calopteryx splendens*												6	B
Ephemeroptera	Baetidae	*Baetis rhodani*			2			111	21	56	84	116	29	15	C
Ephemeroptera	Ephemerellidae	*Serratella ignita*			25	1		27	12	25	51	40			C
Trichoptera	Hydropsychidae	*Hydropsyche instabilis*						1				1		13	C
Trichoptera	Polycentropodidae	*Plectrocnemia conspersa*											1		C

Group	Family	Species	A1	A3	A4	B1	B2	B3	B4	B5	B6	B7	B8	B9	EPA class
Trichoptera	Polycentropodidae	*Polycentropus kingi*			2							5		2	C
Trichoptera	Rhyacophilidae	*Rhyacophila dorsalis*			1			3		2	1				C
Crustacea	Gammaridae	*Gammarus duebeni*	6	1	91	84		46	122	2	95	87	17	35	C
Gastropoda	Bithnyiidae	*Bithynia tentaculata*		1											C
Gastropoda	Lymnaeidae	*Galba truncatula*					9	8							C
Gastropoda	Lymnaeidae	*Lymnaea stagnalis*	2		2										C
Gastropoda	Planorbidae	*Planorbis planorbis*	4	2	5										C
Gastropoda	Planorbidae	*Bathyomphalus contortus*							1						C
Gastropoda	Planorbidae	*Ancylus fluviatilis*								5					C
Gastropoda	Tateidae	*Potamopyrgus antipodarum*			101										C
Coleoptera	Dytiscidae	*Colymbetes fuscus*													C
Coleoptera	Dytiscidae	*Ilybius ater*					1								C
Coleoptera	Dytiscidae	*Hydroporus planus*													C
Coleoptera	Dytiscidae	Dytiscidae larva		3					1				2	1	C
Coleoptera	Dytiscidae	*Dytiscus marginalis*		1									2		C
Coleoptera	Dytiscidae	*Agabus paludosus*					3	1							C
Coleoptera	Dytiscidae	*Hydroporus tessellatus*					1								C
Coleoptera	Dytiscidae	*Ilybius fuliginosus*											1		C
Coleoptera	Elmidae	*Elmis aenea*		25	27			4	13	42	38	28	31	1	C
Coleoptera	Gyrinidae	*Gyrinus substriatus*		6									4		C
Coleoptera	Halipliidae	*Haliplus ruficollis group*													C
Coleoptera	Halipliidae	*Brychius elevatus*						3	1	2	14	2			C
Coleoptera	Hydrophilidae	*Helophorus grandis*		1											C
Coleoptera	Hydrophilidae	*Helophorus brevipalpis*		1		6				1			2		C
Coleoptera	Hydrophilidae	*Anacaena globulus*					2								C
Diptera	Chironomidae	non-*Chironomus* spp.		1		4	7	7		11		2			C
Diptera	Culicidae	sp. indet.		3									1		C

Group	Family	Species	A1	A3	A4	B1	B2	B3	B4	B5	B6	B7	B8	B9	EPA class
Diptera	Pediciidae	*Dicranota* sp.						3				1			C
Diptera	Ptychopteridae	sp. indet.				1									C
Diptera	Simuliidae	sp. indet.			26			89	1	36	159	41			C
Diptera	Thaumaleidae	sp. indet.											1	1	C
Hemiptera	Corixidae	Corixidae nymph													C
Hemiptera	Corixidae	*Hesperocorixa sahlbergi*	3												C
Hemiptera	Corixidae	*Siagara* sp.													C
Hemiptera	Gerridae	Gerridae nymph	2												C
Hemiptera	Notonectidae	Notonecta nymph													C
Hemiptera	Notonectidae	*Notonecta marmorea viridis*	6												C
Arachnida	Hydrachnidiae	sp. indet.	6	11		17						2	6		C
Hirudinidae	Piscicolidae	*Piscicola* sp.											1	1	C
Tricladida	Planariidae	sp. indet.		10			20	10		6		10			C
Crustacea	Asellidae	*Asellus aquaticus*	12	43		23	308		2	13	2		152	15	D
Gastropoda	Lymnaeidae	*Ampullacaena balthica*		3	12	2			3				1	11	D
Gastropoda	Physidae	*Physa fontinalis*		4		4			12						D
Hirudinidae	Glossiphoniidae	sp. indet.				1	2			1	1				D
Annelidae	Naididae (Tubificidae)	*sp. indet.*		1											E
Diptera	Chironomidae	*Chironomus* spp.				32	2						16	2	E
Annelidae	Oligochaeta	sp. indet.					2	2				2			n/a
Annelidae	Nematomorpha	sp. indet.													n/a
Abundance			**46**	**119**	**315**	**181**	**361**	**390**	**194**	**230**	**469**	**422**	**273**	**108**	
Q-rating			Q3*	Q2-3*	Q4	Q3*	Q2*	Q4	Q3-4*	Q4	Q4	Q3-4	Q3-4*	Q3	
WFD status			Poor	Poor	Good	Poor	Bad	Good	Mod	Good	Good	Mod	Mod	Poor	

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

Table 8.2 Macro-invertebrate sweep sampling results for pond and lake sites, July 2022

Group	Family	Species	P1	P3	P4	P5	P7	P9	P11	P13	P15	P16	P20a	L1	A2
Ephemeroptera	Baetidae	*Cloeon dipterum*	10	12			2	2	5		20	2		1	
Ephemeroptera	Caenidae	*Caenis luctuosa*												7	
Trichoptera	Leptoceridae	*Mystacides longicornis*	1												
Trichoptera	Limnephilidae	*Limnephilus lunatus*	10										1		2
Trichoptera	Limnephilidae	*Limnephilus nigriceps*												5	
Trichoptera	Limnephilidae	*Limnephilus marmoratus*	4												
Trichoptera	Hydroptilidae	*Ithytrichia* sp.													1
Trichoptera	Polycentropodidae	*Holocentropus picicornis*		4				1							
Trichoptera	Cased caddis pupa	sp. indet.	2												
Odonata	Aeshnidae	*Aeshna* sp.												3	
Odonata	Coenagrionidae	*Coenagrion* sp.	24	1		1			4		4			4	11
Odonata	Calopterygidae	*Calopteryx splendens*													3
Odonata	Libellulidae	*Libellula quadrimaculata*	6											2	
Coleoptera	Dytiscidae	*Acilius canaliculatus*						1							
Coleoptera	Dytiscidae	Dytiscidae larva	1	1	1	1	1		1	5		4			2
Coleoptera	Dytiscidae	*Colymbetes fuscus*													2
Coleoptera	Dytiscidae	*Dytiscus marginalis*				1									4
Coleoptera	Dytiscidae	*Hydaticus seminiger*										1			1
Coleoptera	Dytiscidae	*Hydroporus tessellatus*	9										8		
Coleoptera	Dytiscidae	*Hydroporus planus*													1
Coleoptera	Dytiscidae	*Hygrotus inaequalis*											1		
Coleoptera	Dytiscidae	*Ilybius ater*	1										1		8
Coleoptera	Dytiscidae	*Ilybius quadriguttatus*				2		1					1		
Coleoptera	Dytiscidae	*Rhantus exsoletus*	1												11
Coleoptera	Haliplidae	*Haliplus flavicollis*												2	3

Group	Family	Species	P1	P3	P4	P5	P7	P9	P11	P13	P15	P16	P20a	L1	A2
Coleoptera	Halipliidae	*Haliplus ruficollis group*			1										1
Coleoptera	Hydrophilidae	*Helophorus brevipalpis*	2	1		5			2						
Coleoptera	Hydrophilidae	*Hydrobius fuscipes*		1											
Coleoptera	Noteridae	*Noterus clavicornis*		1		2					1				
Diptera	Ceratopogonidae	sp. indet.	1												
Diptera	Chaoboridae	Chaoboridae pupa		2				1							
Diptera	Chironomidae	non-*Chironomus* spp.		3	5	1		1	4	7		20		4	
Diptera	Culicidae	sp. indet.		2					1			1		1	1
Hemiptera	Corixidae	*Corixa punctata*	1	1	6	3	11			6	6	5			
Hemiptera	Corixidae	Corixidae nymph	3	2	12	4	1		6	12	2	9			2
Hemiptera	Corixidae	*Hesperocorixa sahlbergi*													2
Hemiptera	Corixidae	*Siagara* sp.		8					7	9	4	10			
Hemiptera	Gerridae	Gerridae nymph	3			1									1
Hemiptera	Gerridae	*Gerris* sp.	1			1									
Hemiptera	Hydrometridae	*Hydrometra stagnorum*	1												
Hemiptera	Notonectidae	*Notonecta marmorea viridis*				3	6	3			3				21
Hemiptera	Notonectidae	Notonecta nymph	1		1	4				2	4	1			2
Hirudinidae	Glossiphoniidae	sp. indet.		2	3	5	1	5	16	2	39	5			
Arachnida	Hydrachnidiae	sp. indet.	1	1										11	
Crustacea	Asellidae	*Asellus aquaticus*												30	1
Megaloptera	Sialidae	*Sialis lutaria*		17						2				3	
Gastropoda	Bithnyiidae	*Bithynia tentaculata*												7	
Gastropoda	Lymnaeidae	*Ampullacaena balthica*	30			1		16						4	1
Gastropoda	Lymnaeidae	*Lymnaea stagnalis*													10
Gastropoda	Planorbidae	*Planorbis planorbis*													27
Gastropoda	Planorbidae	*Hippentis complanatus*										2			
Gastropoda	Sphaeriidae	Sphaeriidae		3	1			5		6				44	

Group	Family	Species	P1	P3	P4	P5	P7	P9	P11	P13	P15	P16	P20a	L1	A2
Diptera	Chironomidae	*Chironomus* spp.	1	5	8					2	1	2		7	24
Annelidae	Naididae (Tubificidae)	sp. indet.													5
Annelidae	Nematomorpha	sp. indet.													4
Abundance			**114**	**68**	**38**	**35**	**23**	**36**	**52**	**53**	**86**	**63**	**12**	**136**	**152**

9. Appendix C – eDNA analysis lab report

SureScreen Scientifics

Folio No: E15284
Report No: 1
Client: Triturus Environmental Ltd
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: 19/08/2022
Date results reported: 01/09/2022
Matters affecting result: None

TARGET SPECIES: Crayfish plague *(Aphanomyces astaci)*

Lab ID	Site Name	OS Reference	SIC	DC	IC	Result	Positive Replicates
FK193	A4 Athboy River	-	Pass	Pass	Pass	Negative	0/12
FK301	L1 Newton Lough	-	Pass	Pass	Pass	Negative	0/12
FK905	B9 - Stonyford River, Knockannaragh WF	-	Pass	Pass	Pass	Positive	1/12
FK596	B5 D'arcy's Crossroads Stream	-	Pass	Pass	Pass	Positive	1/12

Forensic Scientists and Consultant Engineers
SureScreen Scientifics Division Ltd, Morley Retreat, Church Lane, Morley, Derbyshire, DE7 6DE, UK
Tel: +44 (0)1332 292003 Email: scientifics@surescreen.com
Company Registration No. 08950940

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

Lab ID	Site Name	OS Reference	SIC	DC	IC	Result	Positive Replicates
FK193	A4 Athboy River	-	Pass	Pass	Pass	Positive	12/12
FK301	L1 Newton Lough	-	Pass	Pass	Pass	Negative	0/12
FK905	B9 - Stonyford River, Knockannaragh WF	-	Pass	Pass	Pass	Negative	0/12
FK596	B5 D'arcy's Crossroads Stream	-	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
FK193	A4 Athboy River	-	Pass	Pass	Pass	Negative	0/12
FK301	L1 Newton Lough	-	Pass	Pass	Pass	Negative	0/12
FK905	B9 - Stonyford River, Knockannaragh WF	-	Pass	Pass	Pass	Negative	0/12
FK596	B5 D'arcy's Crossroads Stream	-	Pass	Pass	Pass	Negative	0/12

Forensic Scientists and Consultant Engineers
SureScreen Scientifics Division Ltd, Morley Retreat, Church Lane, Morley, Derbyshire, DE7 6DE, UK
Tel: +44 (0)1332 292003 Email: scientifics@surescreen.com
Company Registration No. 08950940

SureScreen Scientifics

TARGET SPECIES: European eel *(Anguilla anguilla)*

Lab ID	Site Name	OS Reference	SIC	DC	IC	Result	Positive Replicates
FK301	L1 Newton Lough	-	Pass	Pass	Pass	Positive	7/12

TARGET SPECIES: Smooth Newt *(Lissotriton vulgaris)*

Lab ID	Site Name	OS Reference	SIC	DC	IC	Result	Positive Replicates
FK301	L1 Newton Lough	-	Pass	Pass	Pass	Negative	0/12

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SureScreen Scientifics Division Ltd, Morley Retreat, Church Lane, Morley, Derbyshire, DE7 6DE, UK
Tel: +44 (0)1332 292003 Email: scientifics@surescreen.com
Company Registration No. 08950940

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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SureScreen Scientifics Division Ltd, Morley Retreat, Church Lane, Morley, Derbyshire, DE7 6DE, UK
Tel: +44 (0)1332 292003 Email: scientifics@surescreen.com
Company Registration No. 08950940

SureScreen Scientifics

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.

Forensic Scientists and Consultant Engineers
SureScreen Scientifics Division Ltd, Morley Retreat, Church Lane, Morley, Derbyshire, DE7 6DE, UK
Tel: +44 (0)1332 292003 Email: scientifics@surescreen.com
Company Registration No. 08950940

Triturus Environmental Ltd.

42 Norwood Court,

Rochestown,

Co. Cork,

T12 ECF3.

Fisheries assessment for Knockannarragh wind farm, Co. Westmeath

Prepared by Triturus Environmental Ltd. for SLR Consulting

February 2023

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Table of contents

1. Introduction

1.1 Background

Triturus Environmental Ltd. were commissioned by SLR to undertake a baseline fisheries assessment of watercourses in the vicinity of the proposed Knockannarragh wind farm, located approximately 3km north-east of Delvin, Co. Westmeath (**Figure 2.1**).

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 13 no. 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 (*Lampetra* sp.) and European eel (*Anguilla anguilla*). Other species of lower conservation value were also recorded. A fisheries appraisal of 13 no. lacustrine sites (including Newtown Lough) was also undertaken. The presence and or absence of fish populations and or associated supporting habitat would help 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 Knockannarragh wind farm. Permission was granted on the 12th July 2022 and the survey was undertaken on Tuesday 19th to Friday 22nd July 2022.

1.2 Fisheries asset of the survey area

The Stoneyford River, a tributary of the River Boyne, is known to support Atlantic salmon (*Salmo salar*), brown trout (*Salmo trutta*) and lamprey (*Lampetra* sp.) (Triturus, 2021). Recreational brown trout fishing is popular along this river (O'Reilly, 2009). In terms of genetic stock, the Stonyford is known to be a significant contributor of brown trout to the main Boyne channel (one of the three most important spawning tributaries in the middle-Boyne catchment; Mariani & Massa-Gallucci, 2012).

The Athboy River, also a tributary of the River Boyne also known as the Trimblestown River, is known to support Atlantic salmon, brown trout, European eel (*Anguilla anguilla*), lamprey (*Lampetra* sp.), stone loach (*Barbatula barbatula*), minnow (*Phoxinus phoxinus*) and three-spined stickleback (*Gasterosteus aculeatus*) (Kelly et al., 2013, 2011: IFI data[1]). The Athboy is also a valuable recreational brown trout fishery (O'Reilly, 2009). The river was first subject to arterial drainage in 1972 and had significant reduction of the fisheries habitat and fish populations, particularly salmonids (O'Grady, 1991).

Whilst *Lampetra* sp. ammocoetes (likely brook lamprey *Lampetra planeri*) are widespread throughout the Stonyford River and Athboy River, densities have been recorded as low (O'Connor, 2006) and the species is known to suffer from the impacts of continued arterial drainage throughout the catchment (IFI, 2013). Fisheries data for the other watercourses surveyed was not available at the time of survey.

[1] Inland Fisheries Ireland data 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 riverine watercourses in the vicinity of the proposed Knockannarragh wind farm on Tuesday 19th to Friday 22nd July 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).

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. 50-100m 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 to high conductivity waters of the sites (draining limestone) a voltage of 200-250v, frequency of 35-40Hz 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 riverine site was also undertaken to evaluate the wider contribution to salmonid and lamprey spawning and general fisheries habitat. An appraisal of the fisheries value of 13 no. lacustrine sites was also undertaken. 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. Cognisance was given towards preventing the spread or introduction of crayfish plague given the known historical distribution of white-clawed crayfish and previous outbreaks of crayfish plague in the wider survey area (i.e. Boyne catchment). 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 fisheries assessment and appraisal survey sites in the vicinity of Knockannarragh wind farm, Co. Westmeath (* indicates fisheries appraisal only)

Site no.	Watercourse	EPA code	Location	X (ITM)	Y (ITM)
Riverine sites					
A1	Drainage channel	n/a	Newtown Lough inflow	[redacted]	
A2	Kilrush Lower Stream	07K27	Newtown Lough inflow		
A3	Kilskeer River	07K26	N52 road crossing		
A4	Athboy River	07A01	N52 road crossing		
B1	Killacroy Stream	07K16	Galboystown		
B2	Killacroy Stream	07K16	Newtown		
B3	D'arcy's Crossroads Stream	07D06	Galboystown		
B4	D'arcy's Crossroads Stream	07D06	Newtown		
B5	D'arcy's Crossroads Stream	07D06	Snipe's Bridge		
B6	Stonyford River	07S02	Cavestown & Rosmead		
B7	Stonyford River	07S02	Cavestown & Rosmead		
B8	Cavestown & Rosmead Stream	07C57	Cavestown & Rosmead		
B9	Stonyford River	07S02	Lisclogher Bridge		
Lacustrine sites					
L1*	Newtown Lough	07_255	Newtown		
P1*	Pond	n/a	Newtown		
P2*	Pond	n/a	Newtown		
P3*	Pond	n/a	Newtown		
P4*	Pond	n/a	Newtown		
P5*	Pond	n/a	Newtown		
P6*	Pond	n/a	Newtown		
P7*	Pond	n/a	Newtown		
P8*	Pond	n/a	Newtown		
P9*	Pond	n/a	Newtown		
P10*	Pond	n/a	Cavestown and Rosmead		
P11*	Pond	n/a	Carnybrogan		
P12*	Pond	n/a	Cavestown and Rosmead		

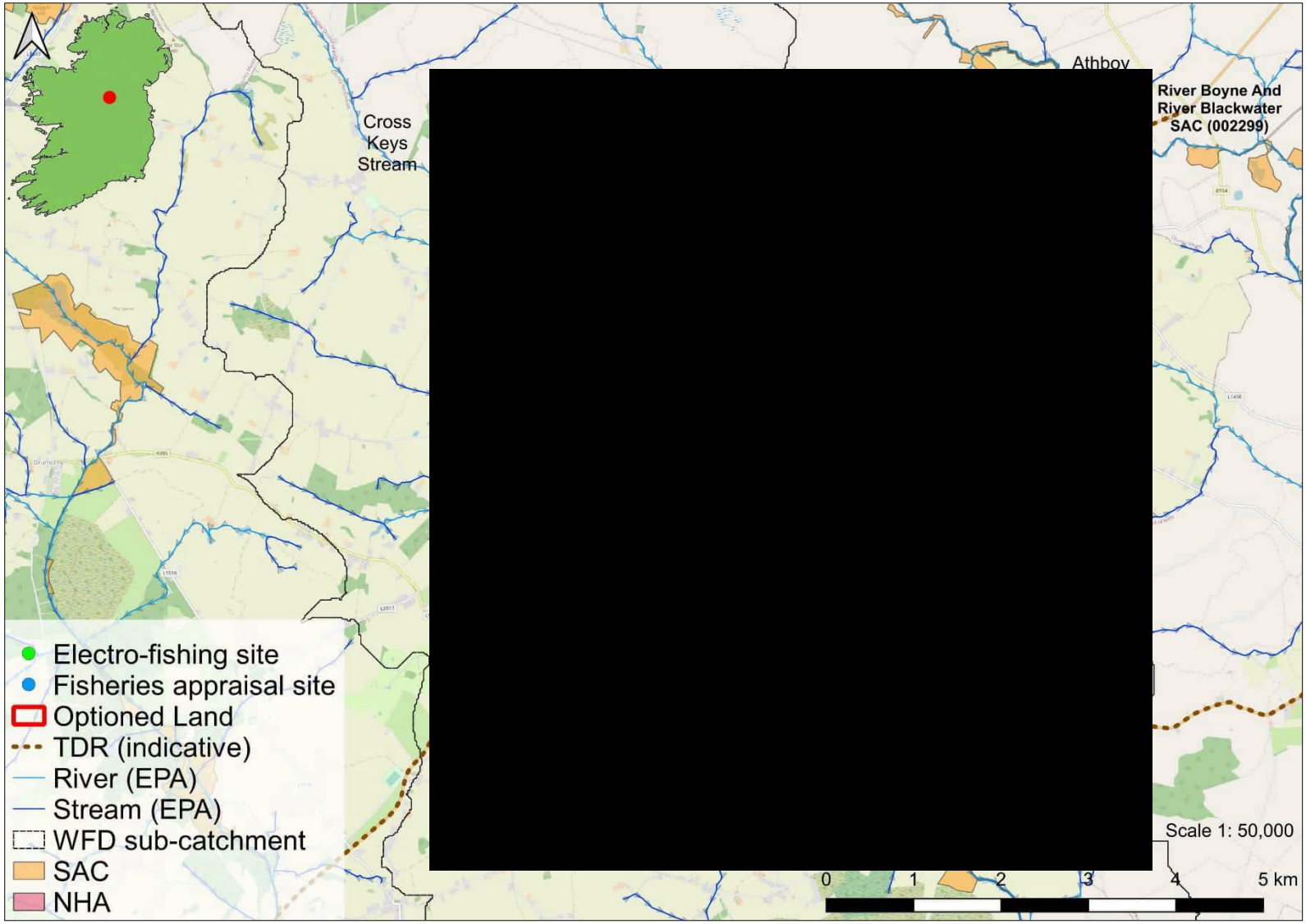

Figure 2.1 Overview of the *n*=26 electro-fishing & fisheries appraisal survey sites in vicinity of the proposed Knockannarragh wind farm, Co. Westmeath

3. Results

A catchment-wide electro-fishing survey of 13 no. riverine sites in the vicinity of the proposed Knockannarragh wind farm was conducted on Tuesday 19th to Friday 22nd July 2022 following notification to Inland Fisheries Ireland. Fisheries appraisals of 13 no. lacustrine sites were also undertaken. 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, lamprey and other species. Scientific names are provided at first mention only.

3.1 Fisheries assessment & appraisal

3.1.1 Site A1 – drainage channel, Newtown Lough inflow

Three-spined stickleback (*Gasterosteus aculeatus*) (*n*=20) was the only fish species recorded via electro-fishing at site A1 on a drainage channel tributary of Newtown Lough (**Figure 3.1**). With the exception on low densities of stickleback, the heavily modified site was not of fisheries value given heavy siltation pressures and poor hydromorphology. Poor connectivity with the downstream Newtown Lough (instream blockages) would likely preclude the channel's use as a nursery for coarse fish species or European eel.

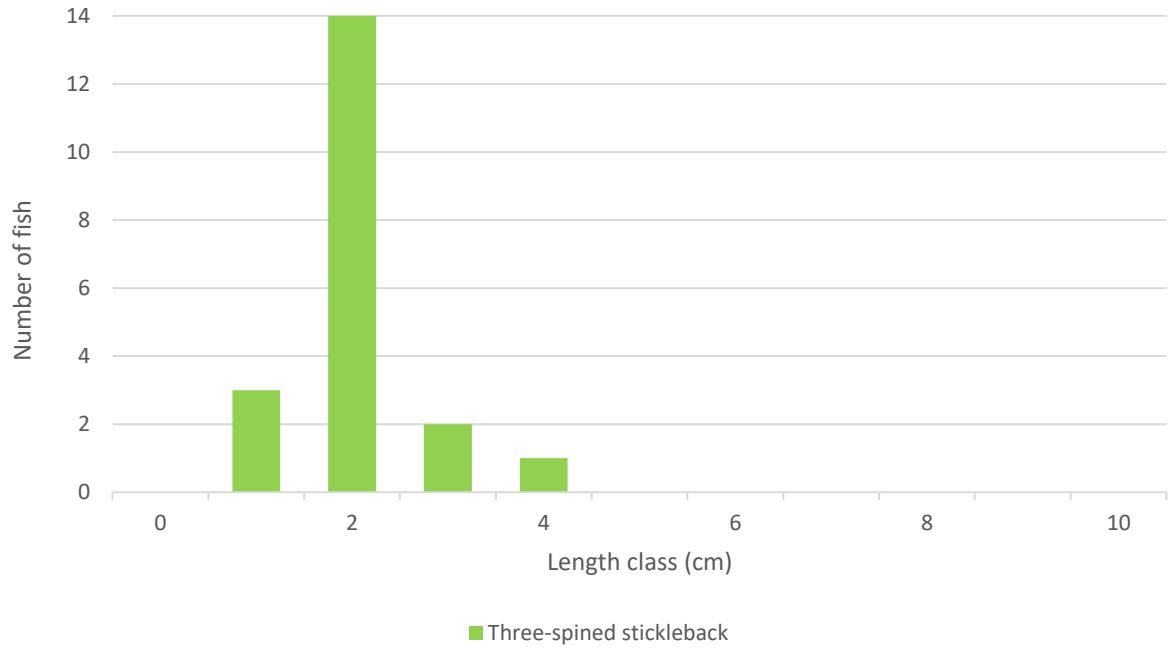

Figure 3.1 Length frequency distribution recorded via electro-fishing at site A1 on a drainage channel tributary of Newtown Lough, July 2022

Plate 3.1 Representative image of site A1 on the Newtown Lough inflow, July 2022

3.1.2 Site A2 – Kilrush Lower Stream, Newtown

Electro-fishing was not undertaken at site A2 on the Kilrush Lower Stream given the stream was dry at the time of survey (apart from a small inline pond). With the exception of three-spined stickleback (recorded via sweep sampling), the pond was not of fisheries value given heavy siltation, the ephemeral nature of the flow-through stream and very poor connectivity with downstream lake habitats.

Plate 3.2 Representative image of site A2 on the Kilrush Lower Stream, July 2022 (dry channel)

3.1.3 Site A3 – Kilskeer River, Clonmellon

Three-spined stickleback (*n*=28) and ten-spined stickleback (*Pungitius pungitius*) (*n*=5) were the only fish species recorded via electro-fishing at site A3 on the Kilskeer River (**Figure 3.2**). With the exception of stickleback, the site was not of fisheries value given gross siltation and low seasonal flows. Poor hydromorphology resulting from historical modifications further reduced the potential of the stream at this location.

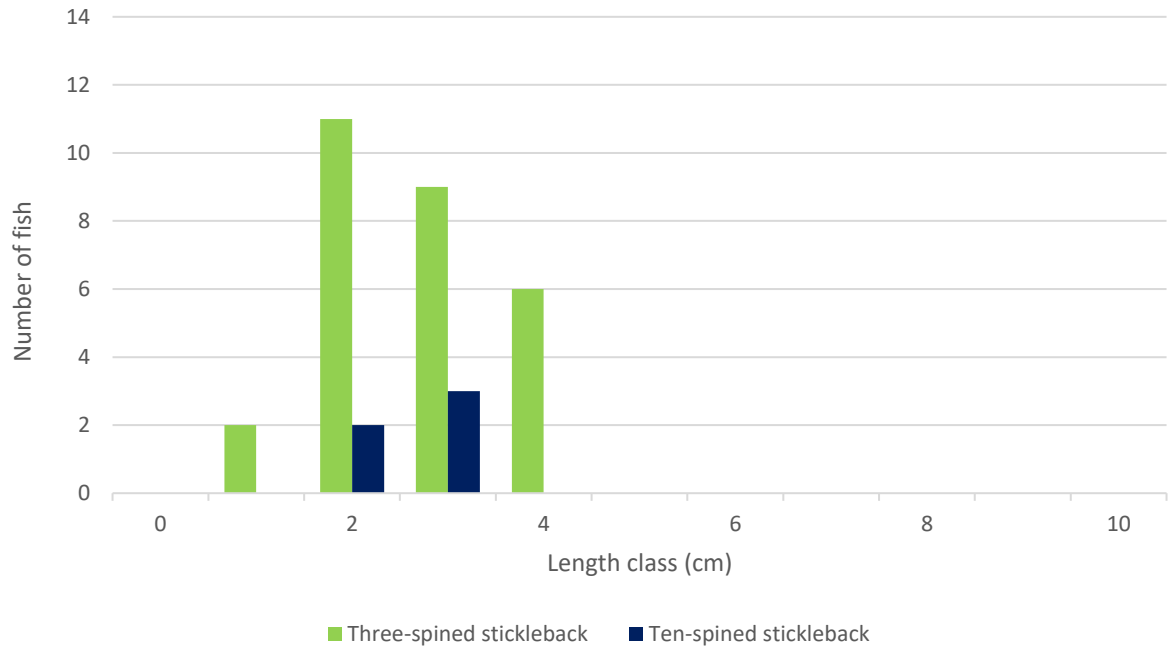

Figure 3.2 Length frequency distribution recorded via electro-fishing at site A3 on the Kilskeer River July 2022

Plate 3.3 Ten-spined stickleback recorded at site A3 on the Kilskeer River, July 2022

3.1.4 Site A4 – Athboy River, Drewstown Little

Atlantic salmon (*Salmo salar*) (*n*=1), brown trout (*Salmo trutta*) (*n*=41), lamprey (*Lampetra* sp.) (*n*=13) and European eel (*Anguilla anguilla*) (*n*=2) were recorded via electro-fishing at site A4 on the Athboy River (**Figure 3.3**).

The semi-natural site was a good all-round salmonid habitat, with combinations of good spawning, nursery and holding habitat. Whilst the quality of spawning substrata was reduced due to siltation, some good quality areas were present for both salmonids and lamprey. Abundant boulder and occasional macrophyte beds provided good refugia for juvenile salmonids, whilst good quality holding habitat was present in the vicinity of the bridge. Soft sediment areas (often sand dominated) supported low densities (4.3 per m^2) of *Lampetra* sp. ammocoetes - these were typically associated with macrophyte beds given swift flow rates. The site was of high value for European eel habitat given ample instream refugia (boulders, holes in retaining walls etc.) although only a ow density of adults was recorded.

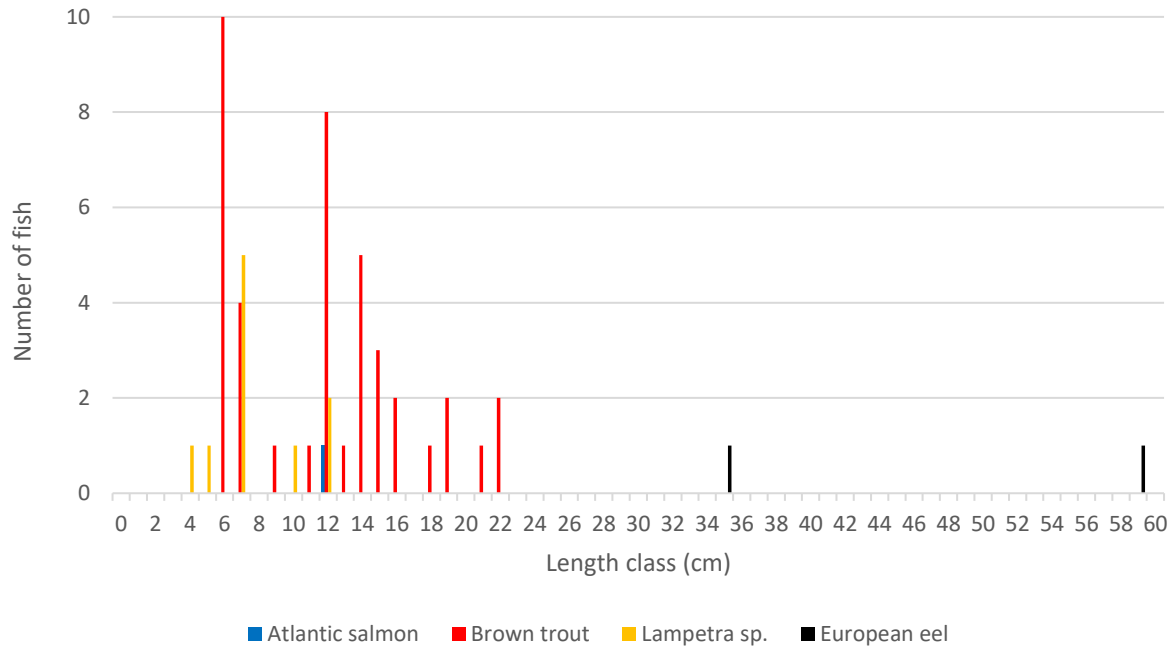

Figure 3.3 Length frequency distribution recorded via electro-fishing at site A4 on the Athboy River July 2022

Plate 3.4 Adult European eel recorded at site A4 on the Athboy River, July 2022

3.1.5 Site B1 – Killacroy Stream, Galboystown

Three-spined stickleback (*n*=7) and ten-spined stickleback (*n*=3) were the only fish species recorded via electro-fishing at site B1 on the upper reaches of the Killacroy Stream (**Figure 3.4**). With the exception of low densities of stickleback, the heavily modified site was not of fisheries value given gross siltation and low seasonal flows. Poor hydromorphology resulting from historical modifications further reduced the potential of the stream at this location.

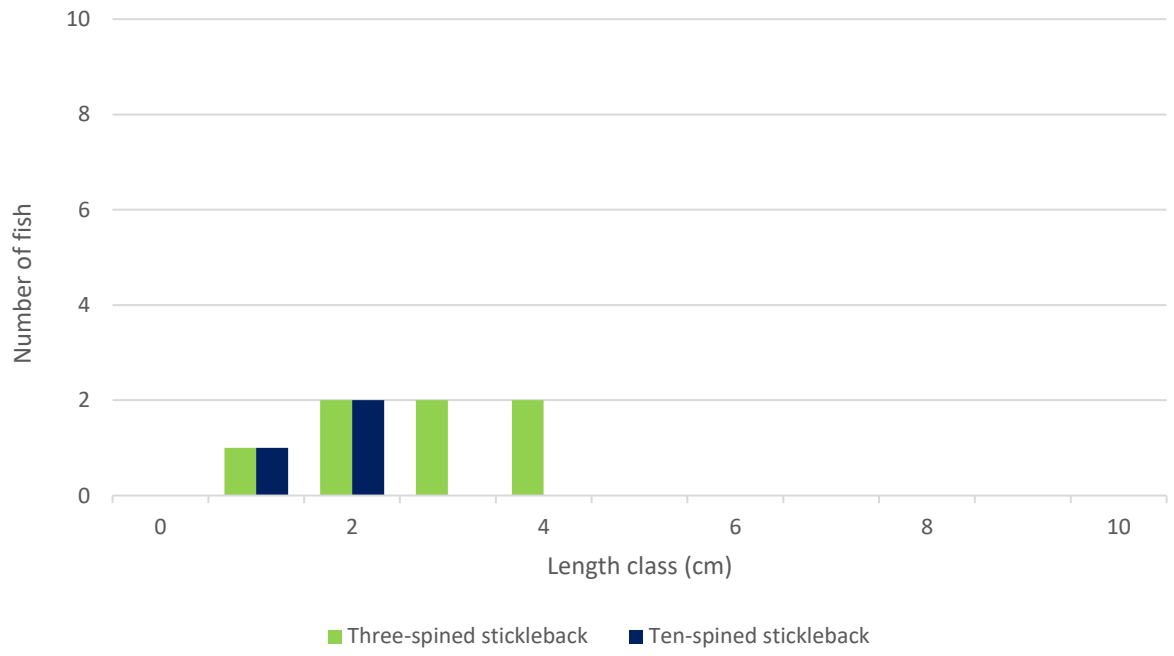

Figure 3.4 Length frequency distribution recorded via electro-fishing at site B1, July 2022

Plate 3.5 Representative image of site B1 on the Killacroy Stream, July 2022

3.1.6 Site B2 – Killacroy Stream, Newtown

Three-spined stickleback and ten-spined stickleback were the only fish species recorded via electro-fishing at site B2 on the Killacroy Stream (**Appendix A**). With the exception of low densities of stickleback, the site was not of fisheries value given gross siltation, excessive macrophyte coverage (near 100% cover) and low seasonal flows. Poor hydromorphology resulting from historical modifications further reduced the potential of the stream at this location.

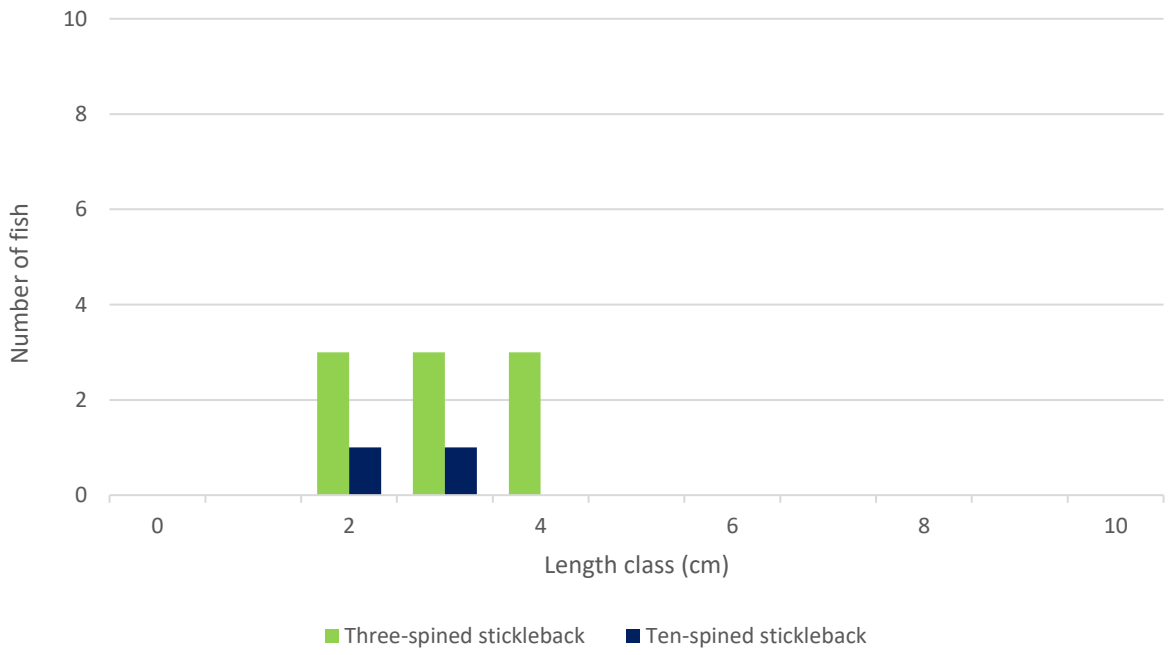

Figure 3.5 Length frequency distribution recorded via electro-fishing at site B2, July 2022

Plate 3.6 Representative image of site B2 on the Killacroy Stream, July 2022

3.1.7 Site B3 – D'arcy's Crossroads Stream, Galboystown

Brown trout (*n*=66), lamprey (*Lampetra* sp.) (*n*=4) and three-spined stickleback (*n*=3) were recorded via electro-fishing at site B3 on the D'arcy's Crossroads Stream (**Figure 3.6**).

The site was considered an excellent quality salmonid nursery, supporting a relatively high density of juvenile brown trout. The site also provided excellent quality spawning habitat for both salmonids and lamprey, despite some slight siltation and livestock pressures. Holding habitat for adult, whilst present, was limited to occasional shallow pools. Larval lamprey habitat was present but sub-optimal given the shallow, superficial/fine nature, supporting a low density of ammocoetes only (2 per m^2). European eel habitat was poor overall given the generally shallow nature of the stream and none were recorded.

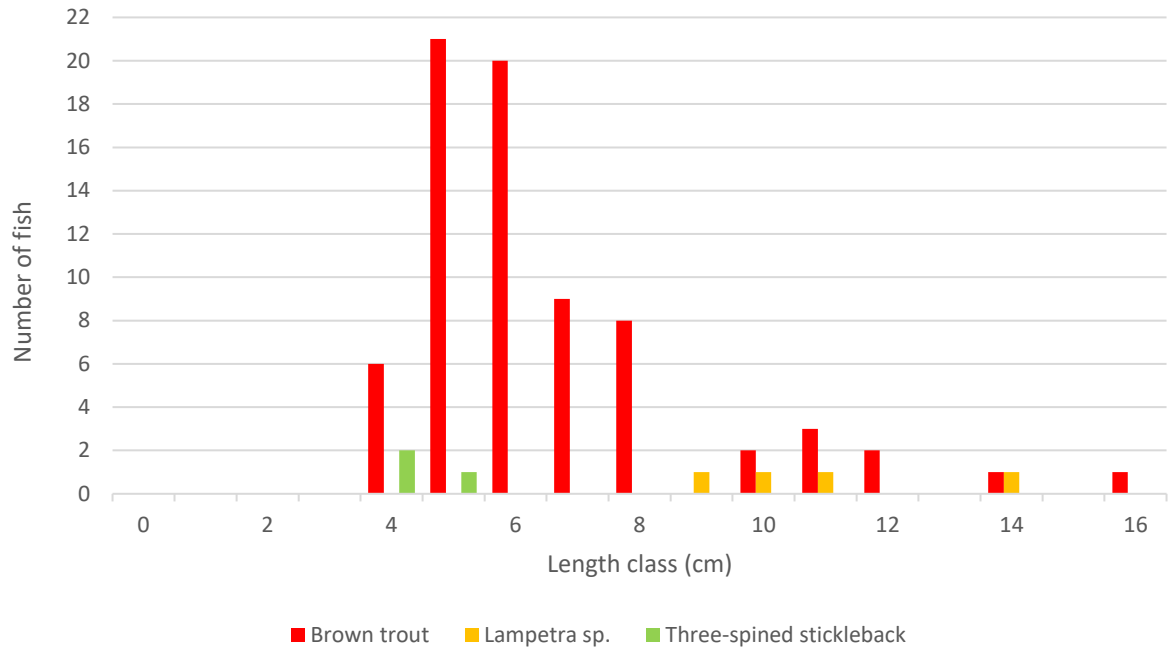

Figure 3.6 Length frequency distribution recorded via electro-fishing at site B3 on the D'arcy's Crossroads Stream, July 2022

Plate 3.7 Mixed cohort brown trout recorded at site B3 on the D'arcy's Crossroads Stream, July 2022

3.1.8 Site B4 – D'arcy's Crossroads Stream, Newtown

Brown trout (*n*=4), lamprey (*Lampetra* sp.) (*n*=3) and three-spined stickleback (*n*=26) were recorded via electro-fishing at site B4 (**Figure 3.7**).

The site was considered a poor quality salmonid habitat given observed low flows, noxious macrophyte growth and siltation pressures. However, some localised spawning habitat was present.

Similarly, low flows significantly reduced the potential for lamprey although some spawning habitat was present in addition to sub-optimal ammocoete habitat (which supported a very low density of ammocoetes, 1.5 per m^2). Despite some suitability for European eel, none were recorded.

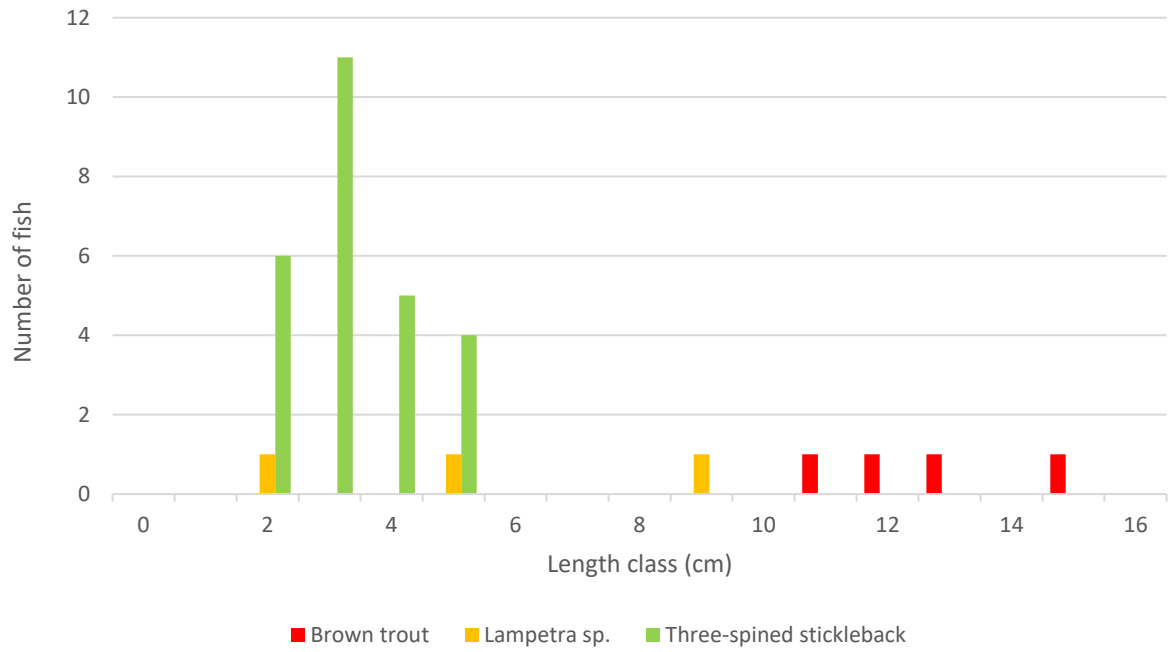

Figure 3.7 Length frequency distribution recorded via electro-fishing at site B4 on the D'arcy's Crossroads Stream, July 2022

Plate 3.8 Juvenile *Lampetra* sp. recorded at site B4 on the D'arcy's Crossroads Stream, July 2022

3.1.9 Site B5 – D'arcy's Crossroads Stream, Snipe's Bridge

Atlantic salmon (*n*=1), brown trout (*n*=36) and lamprey (*Lampetra* sp.) (*n*=1) were recorded via electro-fishing at site B5 on the D'arcy's Crossroads Stream (**Figure 3.8**).

The semi-natural site was considered a good quality salmonid nursery and spawning habitat, supporting a relatively high density of juvenile brown trout and a low density of Atlantic salmon. Siltation, partial compaction of substrata and noxious macrophyte growth (upstream of the bridge) reduced the quality of the salmonid habitat. Holding habitat for adults, whilst present, was limited to occasional shallow pools. Good quality lamprey spawning habitat was present but the site was largely unsuitable for ammocoete burial given a paucity of soft sediment accumulations (largely superficial only). European eel habitat was good given ample refugia but none were recorded.

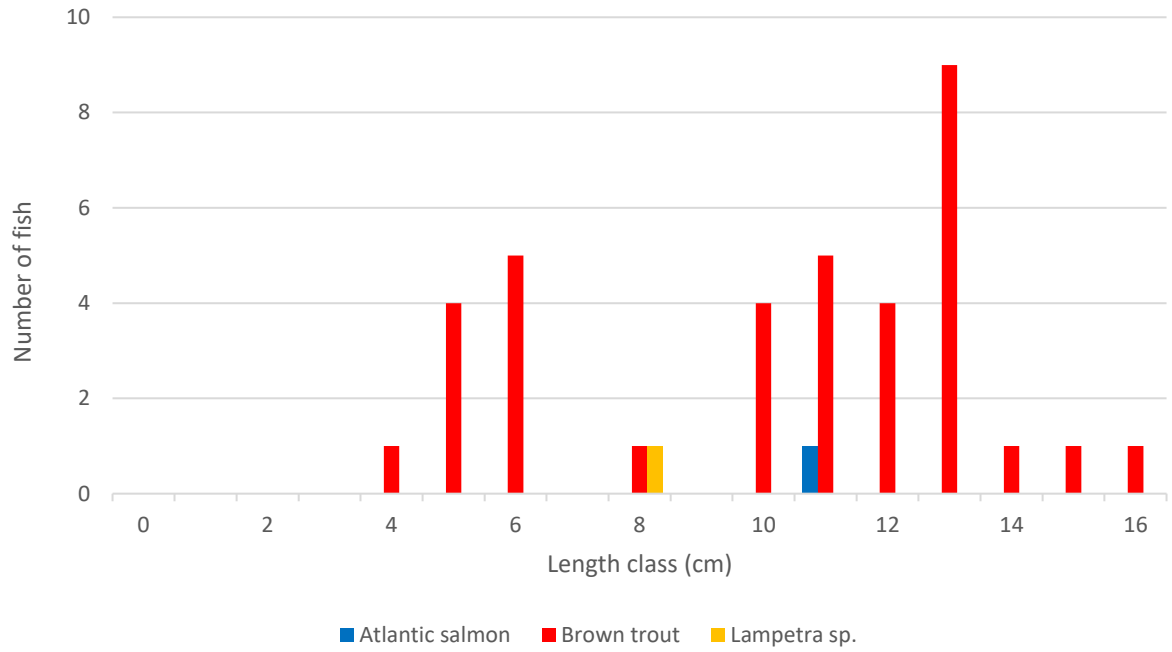

Figure 3.8 Length frequency distribution recorded via electro-fishing at site B5 on the D'arcy's Crossroads Stream, July 2022

Plate 3.9 Juvenile Atlantic salmon (top) and brown trout (bottom) recorded at site B5 on the D'arcy's Crossroads Stream at Snipe's Bridge, July 2022

3.1.10 Site B6 – Stonyford River, Cavestown and Rosmead

A total of 7 no. fish species were recorded via electro-fishing at site B6 on the Stonyford River, namely Atlantic salmon (*n*=8), brown trout (*n*=45), lamprey (*Lampetra* sp.) (*n*=8), European eel (*n*=1), three-spined stickleback (*n*=1), ten-spined stickleback (*n*=1) and stone loach (*Barbatula barbatula*) (*n*=13) (**Figure 3.9**). This was the highest species diversity recorded during the survey.

Site B6 was considered an excellent quality salmonid habitat, with good quality spawning habitat present (although compromised by siltation). Good quality holding habitat was present downstream of the bridge (deep, slower-flowing glide) but pools were sparse overall. The site was of most value as a nursery, with high quality refugia (cobble, boulder, macrophyte beds) present. Good quality lamprey spawning habitat was frequent. Soft sediment accumulations were shallow where present along channel margins but nevertheless supported low densities of smaller ammocoetes. Deeper silt deposits associated with macrophyte beds supported higher (but still low) densities of ammocoetes (5.3 per m^2 overall). The site was also a good European eel habitat although the species was only recorded at very low densities.

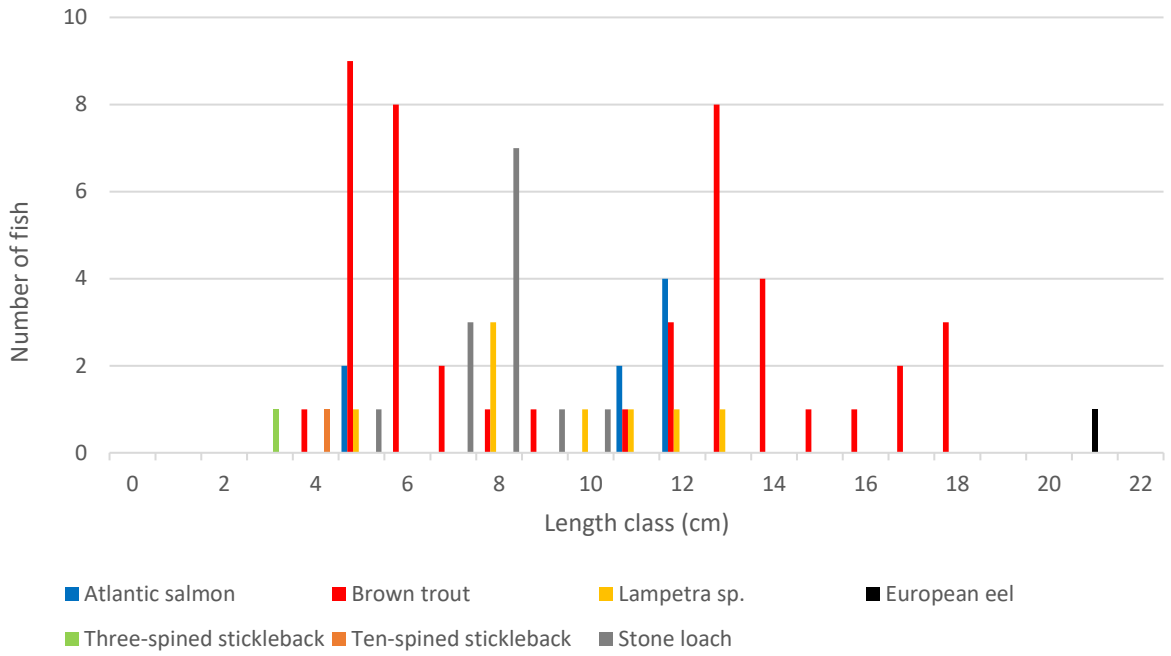

Figure 3.9 Length frequency distribution recorded via electro-fishing at site B6 on the D'arcy's Crossroads Stream, July 2022

Plate 3.10 *Lampetra* sp. ammocoetes recorded at site B6 on the Stonyford River, July 2022

3.1.11 Site B7 – Stonyford River, Cavestown and Rosmead

Atlantic salmon (*n*=13), brown trout (*n*=44), lamprey (*Lampetra* sp.) (*n*=1) and there-spined stickleback (*n*=1) were recorded via electro-fishing at site B7 on the Stonyford River (**Figure 3.10**).

The site was considered a very good salmonid habitat, with combination of good quality spawning, nursery and, locally, holding. The spawning value of the site was reduced due to siltation pressures, whilst the nursery value was compromised given excessive filamentous algal cover (reduced accessibility to refugia). Holding habitat by way of deeper pool was scarce, although deep glide underneath the bridge (to 1.4m) provided excellent quality holding habitat for adult salmonids. Additionally, undercut banks and overhanging macrophyte vegetation provided (seasonal) high quality holding habitat (most fish captured from these refugia). The presence of finer gravels provided good quality lamprey spawning habitat (but quality reduced due to siltation). However, ammocoete habitat was largely absent (superficial deposits only) and only a single larva was recorded (0.67 per m^2). European habitat was moderate to good overall but none were recorded.

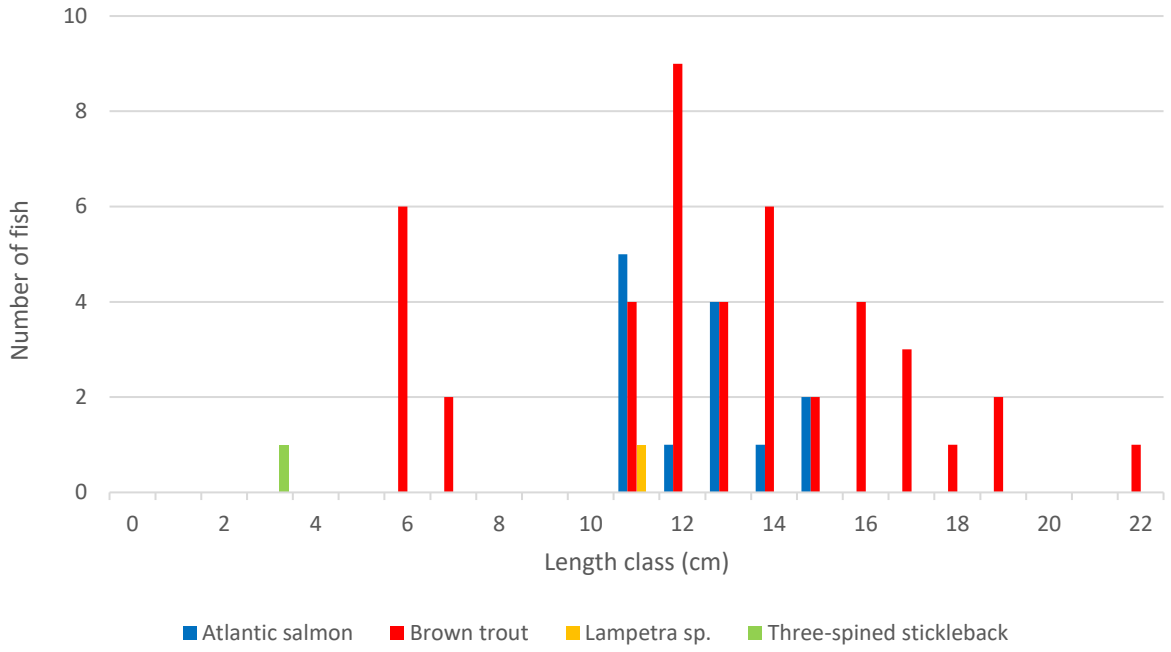

Figure 3.10 Length frequency distribution recorded via electro-fishing at site B2, July 2022

Plate 3.11 Atlantic salmon parr (top) and adult brown trout (bottom) recorded at site B7 on the Stonyford River, July 2022

3.1.12 Site B8 – Cavestown and Rosmead Stream, Cavestown and Rosmead

Three-spined stickleback and ten-spined stickleback were the only fish species recorded via electro-fishing at site B8 on the Cavestown and Rosmead Stream (**Figure 3.11**).

With the exception of low densities of stickleback, the diminutive, heavily modified site was not of fisheries value given gross siltation and low seasonal flows. Poor hydromorphology resulting from historical modifications further reduced the potential of the stream at this location. Fisheries value improved (marginally) further downstream near the Stonyford River confluence (even then, only at higher flows).

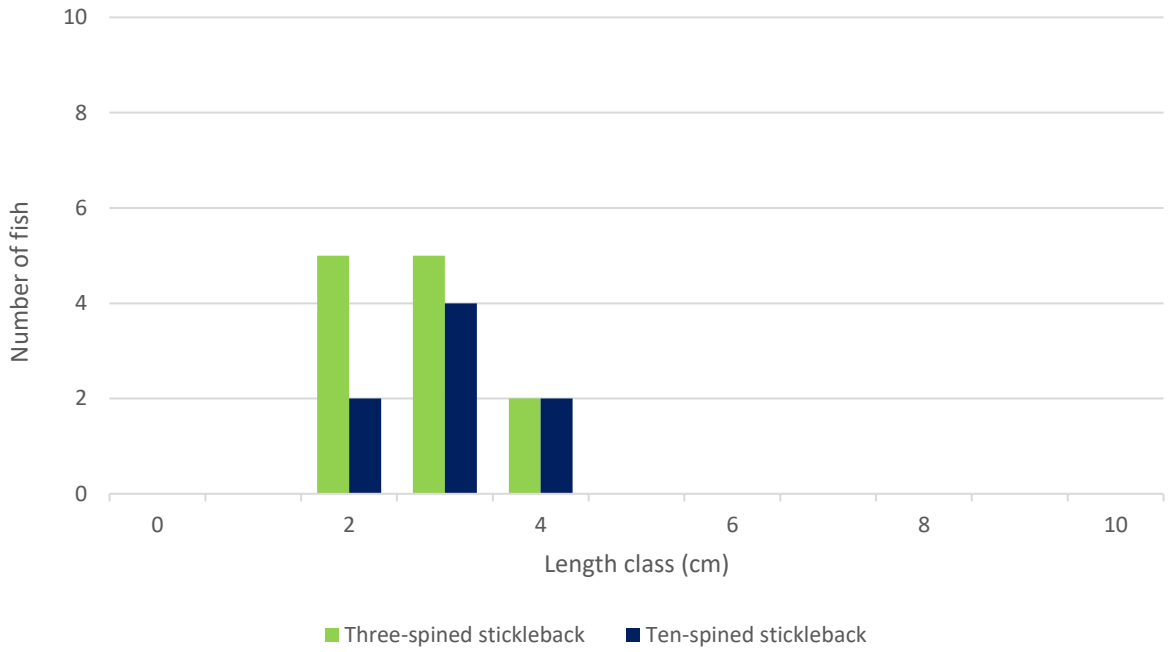

Figure 3.11 Length frequency distribution recorded via electro-fishing at site B8 on the Cavestown and Rosmead Stream, July 2022

Plate 3.12 Representative image of site B8 on the Cavestown and Rosmead Stream, July 2022

3.1.13 Site B9 – Stonyford River, Lisclogher Bridge

Atlantic salmon (*n*=1), brown trout (*n*=42), lamprey (*Lampetra* sp.) (*n*=8), minnow (*Phoxinus phoxinus*) (*n*=11) and three-spined stickleback (*n*=7) were recorded via electro-fishing at site B9 on the Stonyford River (**Figure 3.12**).

The site was of high value for salmonids, supporting a healthy population of mixed-cohort brown trout. A single Atlantic salmon parr was also recorded (sub-optimal habitat). The predominance of adult trout reflected the value of the site as a holding habitat for adult salmonids (deep glide and pool). However, some moderate quality salmonid and lamprey spawning habitat was present upstream of the bridge (but compromised by siltation). The site provided moderate quality salmonid nursery habitat with abundant instream macrophyte refugia. Abundant soft sediment beds provided only moderate suitability for larval lamprey with a low density of *Lampetra* sp. ammocoetes recorded (2 per m^2). Despite some good suitability, no European eel were recorded.

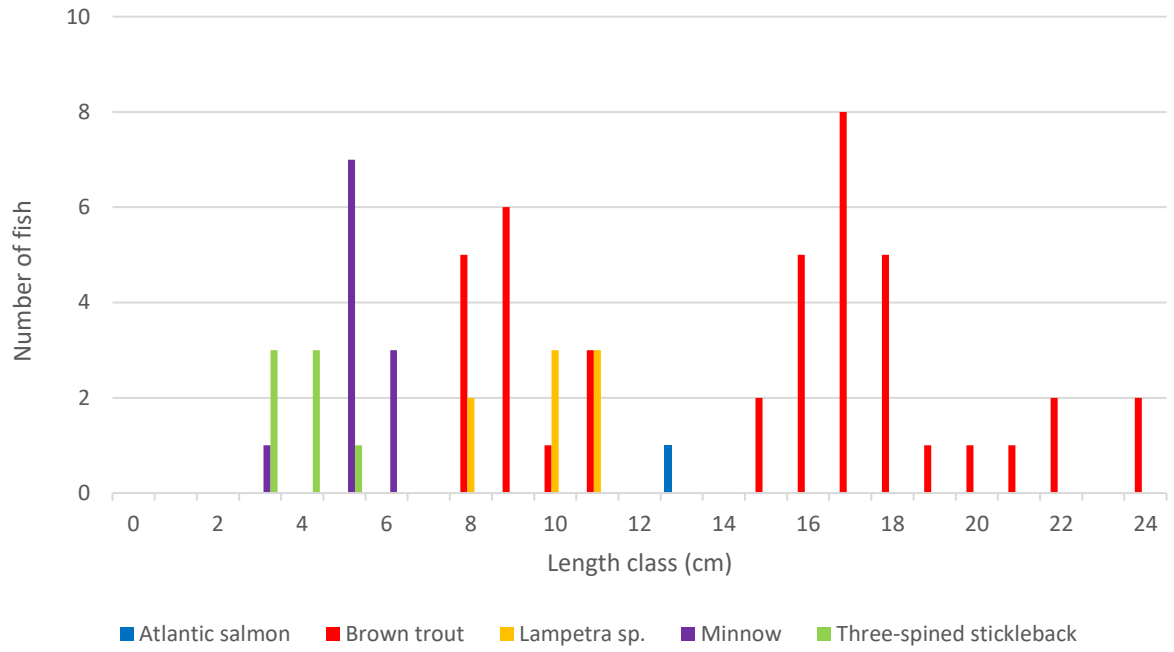

Figure 3.12 Length frequency distribution recorded via electro-fishing at site B9 on the Stonyford River, July 2022

Plate 3.13 Adult brown trout recorded at site B9 on the Stonyford River at Lisclogher Bridge, July 2022

3.2 Lacustrine survey site results

3.2.1 Site L1 – Newtown Lough, Newtown

Newtown Lough, a 5.2ha lowland, alkaline lake, was evidently of high suitability for a range of coarse fish such as pike (*Esox lucius*), perch (*Perca fluviatilis*), European eel and cyprinid species including rudd (*Scardinius erythropthalmus*) (the latter were observed shoaling in lake margins). Coarse fish spawning and nursery habitat was abundant. European eel were detected via eDNA analysis (see accompanying baseline report).

Plate 3.14 Representative image of site L1 at Newtown Lough, July 2022

3.2.2 Site P1 – pond, Newtown

It is unlikely that site P1, a mature artificial quarry pond, supported any fish apart from three-spined stickleback, although none were observed or captured via sweep netting. There was suitability for European eel given the well-developed macrophyte community and varying depths of the pond.

Plate 3.15 Representative image of site P1, July 2022

3.2.3 Site P2 – pond, Newtown

With the exception of some low suitability for three-spined stickleback (none recorded via sweep netting), site P2 was not of fisheries value given its small, shallow and isolated basin.

Plate 3.17 Representative image of site P2, July 2022

3.2.4 Site P3 – pond, Newtown

Site P3 had no suitability for fish (including European eel) due to its very shallow depth (<0.1m) and heavy enrichment.

Plate 3.18 Representative image of site P3, July 2022

3.2.5 Site P4 – pond, Newtown

Site P4 had no suitability for fish (including European eel) due to its very shallow depth (<0.2m) and heavy enrichment.

Plate 3.19 Representative image of site P4, July 2022

3.2.6 Site P5 – pond, Newtown

Site P5 pond had no suitability for fish given the observed limited depths and heavy enrichment.

Plate 3.20 Representative image of site P5, July 2022

3.2.7 Site P6 – pond, Newtown

Site P6 had no suitability for fish given the observed limited depths (typically <0.2m) and enrichment.

Plate 3.21 Representative image of site P6, July 2022

3.2.8 Site P7 – pond, Newtown

Site P7 had good suitability for European eel given adequate depths (exceeding 1m), abundant macrophyte refugia and prey resources. There was also high suitability for three-spined stickleback albeit none were recorded via sweep netting.

Plate 3.22 Representative image of site P7, July 2022

3.2.9 Site P8 – pond, Newtown

Site P8 had no suitability for fish given the observed limited depths (<0.2m) and heavy enrichment.

Plate 3.24 Representative image of site P8, July 2022

3.2.10 Site P9 – pond, Newtown

With the exception of three-spined stickleback (none recorded), site P9 had no suitability for fish given its evidently eutrophic state and absence of macrophyte plants.

Plate 3.25 Representative image of site P9, July 2022

3.2.11 Site P10 – pond, Cavestown & Rosmead

Site P10 had no suitability for fish given its limited depths (<0.1m) and enrichment.

Plate 3.26 Representative image of site P10, July 2022

3.2.12 Site P11 – pond, Carnybrogan

Site P11 had no suitability for fish given its limited depths (0.05m) and enrichment.

Plate 4.27 Representative image of site P11, July 2022

3.2.13 Site P12 – pond, Cavestown & Rosmead

Site P12 had no suitability for fish given the observed limited depths and semi-dry nature of the pond basin.

Plate 3.28 Representative image of site P12, July 2022

Table 3.1 Fish species densities per m^2 recorded at sites in the vicinity of the proposed Knockannarragh wind farm via electro-fishing in July 2022 (values in **bold** represent the highest densities recorded for each species, respectively; * = no. ammocoetes per m^2 of targeted habitat)

Site	Watercourse	CPUE (elapsed time)	Approx. area fished (m^2)	Atlantic salmon	Brown trout	*Lampetra* sp.	European eel	Three-spined stickleback	Ten-spined stickleback	Stone loach	Minnow
A1	Drainage channel	5	22.5	0.000	0.000	0.000	0.000	**0.889**	0.000	0.000	0.000
A2	Kilrush Lower Stream	n/a – dry channel		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
A3	Kilskeer River	10	112.5	0.000	0.000	0.000	0.000	0.249	0.044	0.000	0.000
A4	Athboy River	10	120	0.008	0.342	4.3*	**0.017**	0.000	0.000	0.000	0.000
B1	Killacroy Stream	10	125	0.000	0.000	0.000	0.000	0.056	0.024	0.000	0.000
B2	Killacroy Stream	5	50	0.000	0.000	0.000	0.000	0.180	0.040	0.000	0.000
B3	D'arcy's Crossroads Stream	10	87.5	0.000	**0.754**	2*	0.000	0.034	0.000	0.000	0.000
B4	D'arcy's Crossroads Stream	10	120	0.000	0.033	1.5*	0.000	0.217	0.000	0.000	0.000
B5	D'arcy's Crossroads Stream	10	180	0.006	0.200	0.5*	0.000	0.000	0.000	0.000	0.000
B6	Stonyford River	10	135	**0.059**	0.333	**5.3***	0.007	0.007	0.007	**0.096**	0.000
B7	Stonyford River	10	245	0.053	0.180	0.67*	0.000	0.004	0.000	0.000	0.000
B8	Cavestown & Rosmead Stream	5	52.5	0.000	0.000	0.000	0.000	0.229	**0.152**	0.000	0.000
B9	Stonyford River	10	280	0.004	0.150	2.0*	0.000	0.025	0.000	0.000	**0.039**

Table 3.2 Summary of fish species of higher conservation value and relative abundances (low, medium, high & very high) recorded via **electro-fishing** per riverine survey site in the vicinity of the proposed Knockannarragh wind farm, July 2022

Site	Watercourse	Relative abundance				
		Atlantic salmon	Brown trout	*Lampetra* sp.	European eel	Other species
A1	Drainage channel					Three-spined stickleback
A2	Kilrush Lower Stream	No fish recorded (dry channel)				
A3	Kilskeer River					Three-spined stickleback, ten-spined stickleback
A4	Athboy River	Low	High	Medium	Low	
B1	Killacroy Stream					Three-spined stickleback, ten-spined stickleback
B2	Killacroy Stream					Three-spined stickleback, ten-spined stickleback
B3	D'arcy's Crossroads Stream		Very high	Low		Three-spined stickleback
B4	D'arcy's Crossroads Stream		Low	Low		Three-spined stickleback
B5	D'arcy's Crossroads Stream	Low	High	Low		
B6	Stonyford River	Low	High	Medium	Low	Three-spined stickleback, ten-spined stickleback, stone loach
B7	Stonyford River	Medium	High	Low		Three-spined stickleback
B8	Cavestown & Rosmead Stream					Three-spined stickleback, ten-spined stickleback
B9	Stonyford River	Low	High	Medium		Three-spined stickleback, minnow

Conservation value: Atlantic salmon (*Salmo salar*), 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 Inland Fisheries Acts 1959 to 2017, brown trout and coarse fish species have no legal protection in Ireland.

4. Discussion

The watercourses in the vicinity of the proposed Knockannarragh wind farm were typically lowland depositing channels which had been historically (and often extensively) straightened and deepened, impacting their hydromorphology and exacerbating pressures such as eutrophication and siltation as well as low summer flows. Historical straightening and deepening of watercourses removes habitat and hydromorphological heterogeneity, encourages sediment deposition and invariably results in an irreparable reduction in fisheries potential, particularly for salmonids but also other species such as European eel (O'Grady et al., 2017; O'Grady, 2006). Diffuse siltation is one of the greatest threats to salmonid populations, particularly in agricultural catchments such as that of the proposed development. Sediment not only blocks interstitial spaces in substrata (colmation) and limits oxygen supply to salmonid eggs (required for healthy embryonic development & 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 catchments (Evans et al., 2006), such as that containing the proposed project.

Nevertheless, fish were recorded from all but one riverine survey site (A2, dry at the time of survey) with a total of ten fish species were recorded during the survey, namely Atlantic salmon, brown trout, *Lampetra* sp., European eel, stone loach, minnow, three-spined stickleback and ten-spined stickleback. Whilst fisheries appraisals were undertaken at 12 no. pond sites, suitability for fish was typically not present with exception of Ponds P1 and P7 given the small sizes of the ponds, shallow depths, fluctuating water levels, significant eutrophication and their isolated/landlocked nature. Ponds P1 and P7 had suitability for European eel given depths of 1m or greater and abundant macrophyte vegetation. Newtown Lough, the largest lacustrine habitat in the survey area was of very high value for a range of coarse fish species and also supported European eel (detected via eDNA analysis – see accompanying baseline report).

Salmonids were present at 7 no sites in total, with Atlantic salmon present at five of these on the Athboy River (A4), D'arcy's Crossroads Stream (B5 & B6) and the Stonyford River (B7 & B9). Despite evident pressures (e.g. hydromorphology, siltation), these watercourses can be considered the most important salmonid habitats in the survey area. The Stonyford is known to be a significant contributor of brown trout to the main Boyne channel (Mariani & Massa-Gallucci, 2012). Sites B3 on the D'arcy's Crossroads Stream and B6 on the Stonyford River were particularly high value salmonid nurseries. With the exception of site B7 (medium density), salmon were recorded at low densities (**Table 3.1**). There was limited or no suitability for salmonids in the Kilskeer River, Killacroy Stream or Cavestown and Rosmead Stream due to poor flows and siltation pressures.

Lamprey ammocoetes (*Lampetra* sp.) were widespread in the vicinity of the proposed project, being recorded from a total of 7 no. sites on the Athboy River (A4), D'arcy's Crossroads Stream (B5 & B6) and the Stonyford River (B7 & B9) (**Table 3.1, 3.2**). These sites supported both salmonids and lamprey. However, ammocoetes were present in low to medium densities (≤5.3 per m^2) and this was reflective of the typically limited and sub-optimal larval habitat present in addition to low summer flows. These results were also in keeping with the observations of O'Connor (2006). *Lampetra* spp. require fine gravels required for spawning (Dawson et al., 2015; Rooney et al., 2013; Lasne et al., 2010) and the

deposition of fine, organic-rich sediment ≥5cm in depth generally (Aronsuu & Virkkala, 2014; Goodwin et al., 2008; Gardiner, 2003). Such characteristics were highly localised within the wider survey area due to historical drainage pressures (hydromorphology) and siltation issues. Furthermore, low summer flows contributed to a reduction in the quality of habitat for larval (nursery) and adult lamprey (spawning), respectively. Larval lamprey dispersal and settlement is passive and entirely regulated by local, dynamic hydrographical (flow) regimes (Kelly & King, 2001; Malmqvist, 1983; Potter, 1980; Hardisty & Potter 1971) and distribution is often sporadic in watercourses which suffer from low summer flows and poor fluvial connectivity (such as several in the vicinity of the proposed project).

Despite widespread suitability, European eel were only recorded in low densities from sites A4 on the Athboy River and B6 on the Stonyford River (**Table 3.1, 3.2**). European eel are Red-listed in Ireland (King et al., 2011) and are classed as 'critically endangered' on a global scale (Pike et al., 2020). As eel occurrence decreases significantly with increasing distance from the sea (Degerman et al., 2019), the paucity of eel observed in the Boyne_SC_050 and Boyne_SC_070 river sub-catchments can be partly explained by the distance between the survey area and marine habitats (Chadwick et al., 2007) (>80km nearest instream distance). The absence of eel from many sites also reflects the considerable hydromorphological pressures in the survey area which have reduced the overall quality of eel habitat through a reduction in habitat heterogeneity and instream refugia required by the species (Laffaille et al., 2003).

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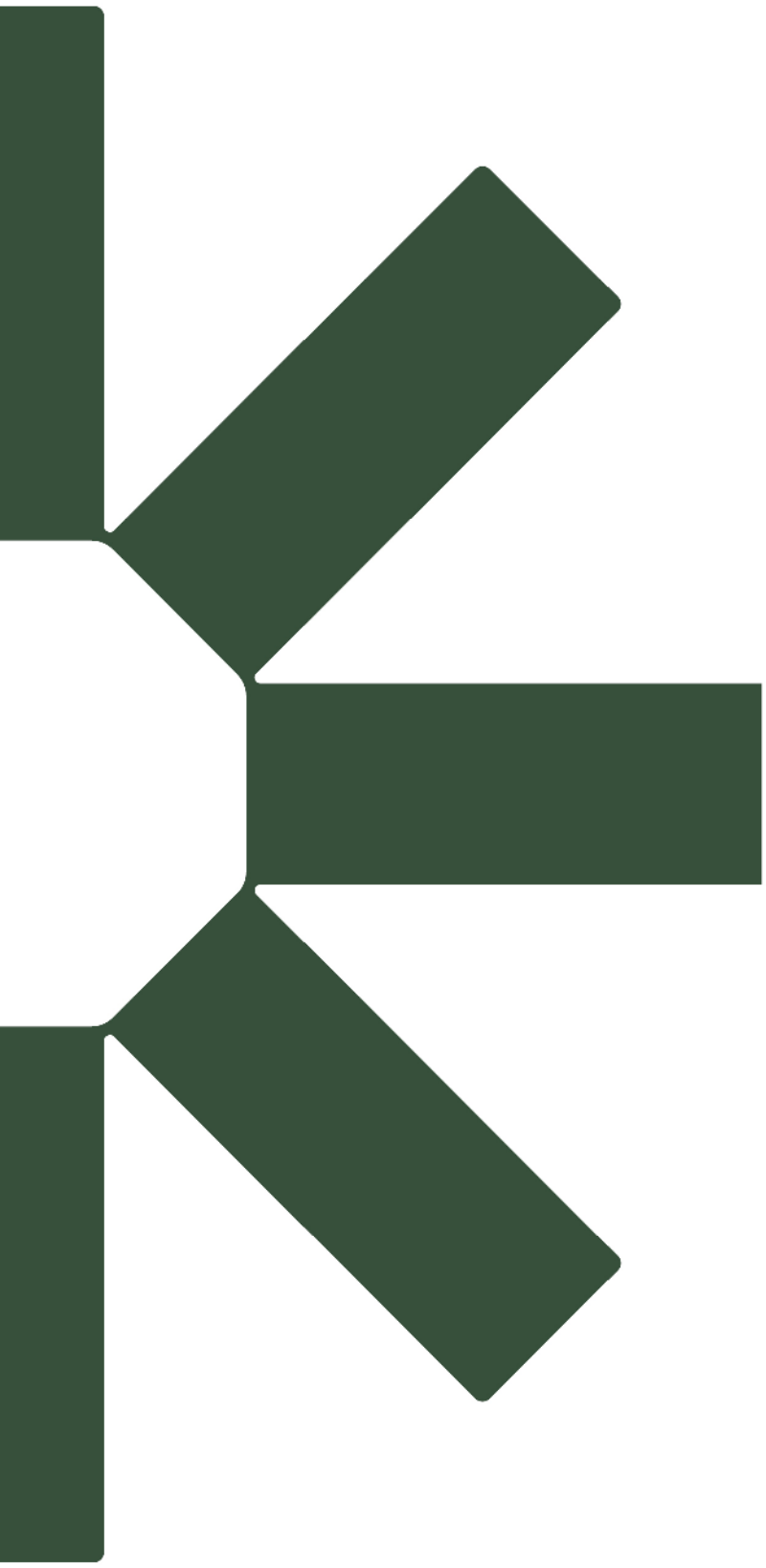
Triturus Environmental Ltd.

42 Norwood Court,

Rochestown,

Co. Cork,

T12 ECF3.



Making Sustainability Happen