Aquatic and Fisheries Report for proposed Derrinlough wind farm, Co. Offaly

Prepared by Triturus Environmental Ltd. for McCarthy Keville O'Sullivan

December 2019

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1. Introduction

1.1 Project background

Triturus Environmental Ltd. were appointed by McCarthy Keville O'Sullivan Ltd. (MKO) on behalf of Bord na Móna to undertake a baseline aquatic survey of watercourses in the vicinity of the proposed Derrinlough wind farm located near Cloghan, Co. Offaly.

The proposed wind farm site has indirect downstream connectivity, via several riverine watercourses, with the River Shannon Callows SAC (site code: 000216) and the Middle Shannon Callows SPA (site code: 004096). Located approx. 2.8km downstream (shortest distance, via the Grant's Island Stream), the River Shannon Callows SAC is designated for otter (*Lutra lutra*) in addition to non-aquatic habitats (NPWS, 2018a). The Middle Shannon Callows SPA (shortest distance 2.8km downstream) is designated for wetland habitat plus a range of birds including whooper swans (*Cygnus cygnus*) and the corncrake (*Crex crex*) (NPWS, 2018b), a species Red-listed under the Birds of Conservation Concern in Ireland (BoCCI; Colhoun & Cummins, 2014).

The aquatic habitats within the catchment of the proposed wind farm may provide downstream contributions to the downstream River Shannon Callows SAC, Middle Shannon Callows SPA sites and All Saints Bog SPA sites. The main purpose of the site surveys, including both desktop and walkover surveys, was to describe the existing environment in terms of its fisheries value but also for important aquatic species and habitats within the vicinity of the development. The baseline data collated would thus inform the preparation of the final Environmental Impact Assessment Report (EIAR) for the proposed development.

1.2 Project description

The aquatic baseline survey was undertaken in the context of the proposed 21 turbine, Derrinlough wind farm, located in west Co. Offaly, approximately 4.5km south of Cloghan and 10km west of Kilcormac (Figure 1.1). The wind farm site encompasses both Clongawny and Drinagh Bogs, both part of the Boora Bog group. The Boora Bog group is regulated by the Environmental Protection Agency (EPA) under IPC Licence Register No. P0500-01. Two smaller-scale wind farm developments adjoin the proposed site namely the constructed Meenwaun (4 turbine) site and the proposed Cloghan (9 turbine) site. The proposed site location for the wind farm development is provided in Figure 1.1

The proposed wind farm will have approximately 28km of internal road network. It is intended that approximately 18km of this road network will be open for public use when the wind farm becomes operational. An additional 6.5km of amenity links are proposed to provide connectivity from the internal road network to local/regional roads.

The two bogs have a total area of approximately 2,360 hectares. Combined they are approximately 6km long in a north/south direction and 9km wide in an east/west direction at their widest point. The closest settlements to the site are Cloghan which is located approximately 2km to the north and Fivealley which is located approximately 2.5km to the south. Other settlements and towns in the area

include Banagher (circa. 3km west), Ferbane (circa. 6km north) Birr (circa 7km south-west) and Shannonbridge (circa. 15km north-west).

The land use activities within the proposed development site is a mixture of ceased peat extraction, bare cutaway peat, re-vegetation of bare peat, telecommunications and wind measurement (a single anemometry mast on Clongawny Bog). There are also a number of Bord na Móna rail lines that pass through the bogs facilitating the transportation of milled peat to Derrinlough Briquette Factory which is located in the most western part of Drinagh bog. The surrounding landscape is a mixture of forestry, agricultural land and cutaway peatland. The landscape is predominately flat.

For a detailed description of the proposed wind farm development and associated infrastructure please refer to Chapters 1 & 4 of the accompanying EIAR.

1.3 Derrinlough fisheries asset

The Derrinlough study area is part of both the wider River Brosna and River Shannon catchments and features a number of major and minor riverine watercourses (see Figure 1.1 for locations). A number of lacustrine (wetland) waterbodies are also associated with areas of historical cutover bog.

The Silver River is the major watercourse in the vicinity of Derrinlough wind farm and represents an important recreational fishery, especially for the "Croneen" trout, a genetically-distinct population of brown trout indigenous to Lough Derg and its tributaries, including the River Brosna catchment. There is a run of "Croneen" trout from Lough Derg to the Silver River, particularly from mid-July to September, depending on water levels. The river also supports the protected white-clawed crayfish (*Austropotamobious pallipes*) and brook lamprey (*Lampetra planeri*) and still receives a small, irregular run of Atlantic salmon (*Salmo salar*) (Triturus, 2019). Although regularly utilised by anglers, historical drainage has made the banks throughout the Silver River catchment difficult to access (O'Reilly, 2003). In addition to trout, the Silver River (at Lumcloon Bridge near Kilcormac) is known to support European eel (*Anguilla anguilla*), gudgeon (*Gobio gobio*), minnow (*Phoxinus phoxinus*), perch (*Perca fluviatilis*), three-spined stickleback (*Gasterosteus aculeatus*), stone loach (*Barbatula barbatula*) and occasional Atlantic salmon (Kelly et al., 2015; Kelly et al., 2009).

The Little (Cloghan) River, a tributary of the Brosna River, bisects the Derrinlough wind farm site and is known to support stocks of brown trout, minnow, Lampetra sp., gudgeon, roach (*Rutilus rutilus*), stone loach and three-spined stickleback in its lower reaches (Kelly et al., 2015; Kelly et al., 2009).

1.4 Water quality in the study area

The following outlines the available water quality data for the watercourses in context of the proposed Derrinlough wind farm development. Only recent water quality (i.e. since 2002) is summarised below. No existing EPA biological monitoring data was available for the Mullaghkaraun Stream, Feeghroe River, Whigsborough Stream, Derrinlough Stream, Stonestown Stream, Madden's Derry Stream or Grants Island Stream. Please note that contemporary physio-chemical and biological water quality analysis was undertaken as part of this study, with the data presented in the results section of this report.

Little Cloghan River

The Little Cloghan River (EPA code: 25L01) is a lowland tributary of the River Brosna which rises south of Drinagh Bog at Whigsborough. Approximately half of the watercourse flows through cutover bog (PB4; Fossitt, 2000) in the vicinity of Derrinlough wind farm. There is a single recent EPA monitoring station (station code: RS25L010200) on the river, located at the R356 road crossing, approx. 4.5km downstream of survey site 6 (see Figure 1.1 below for sampling site locations). This site was assessed in 2017 as having Q4-5 (high status) water quality. Historically, another monitoring station on the Little Cloghan River (RS25L010100) at Crancreagh Bridge (N62 road crossing), approx. 1.4km downstream of site 6, achieved Q2-3 (poor status) water quality in 1999 (pre-Water Framework Directive monitoring).

Silver River

The Silver River (EPA code: 25S02) is a major lowland tributary of the River Brosna which rises in the Slieve Bloom Mountains east of Kilcormac and flows through an agricultural grassland-dominated landscape. There are a number of current EPA monitoring stations on the Silver River (EPA code: 25S02) downstream of Kilcormac. The nearest upstream monitoring point (station code: RS25S020500) is located at Wooden Bridge, approx. 5km upstream of survey site 9. This site was assessed as having Q4 (good status) water quality in 2017. Further upstream, near Kilcormac, two stations (RS25S020400 and RS25S020320) were assessed as having Q3-4 (moderate status) water quality in 2017. The nearest downstream monitoring point to survey site 9 is located at Lumcloon Bridge (station code: RS25S020700) (approx. 1.3km downstream). This site achieved Q4 (good status) in 2017.

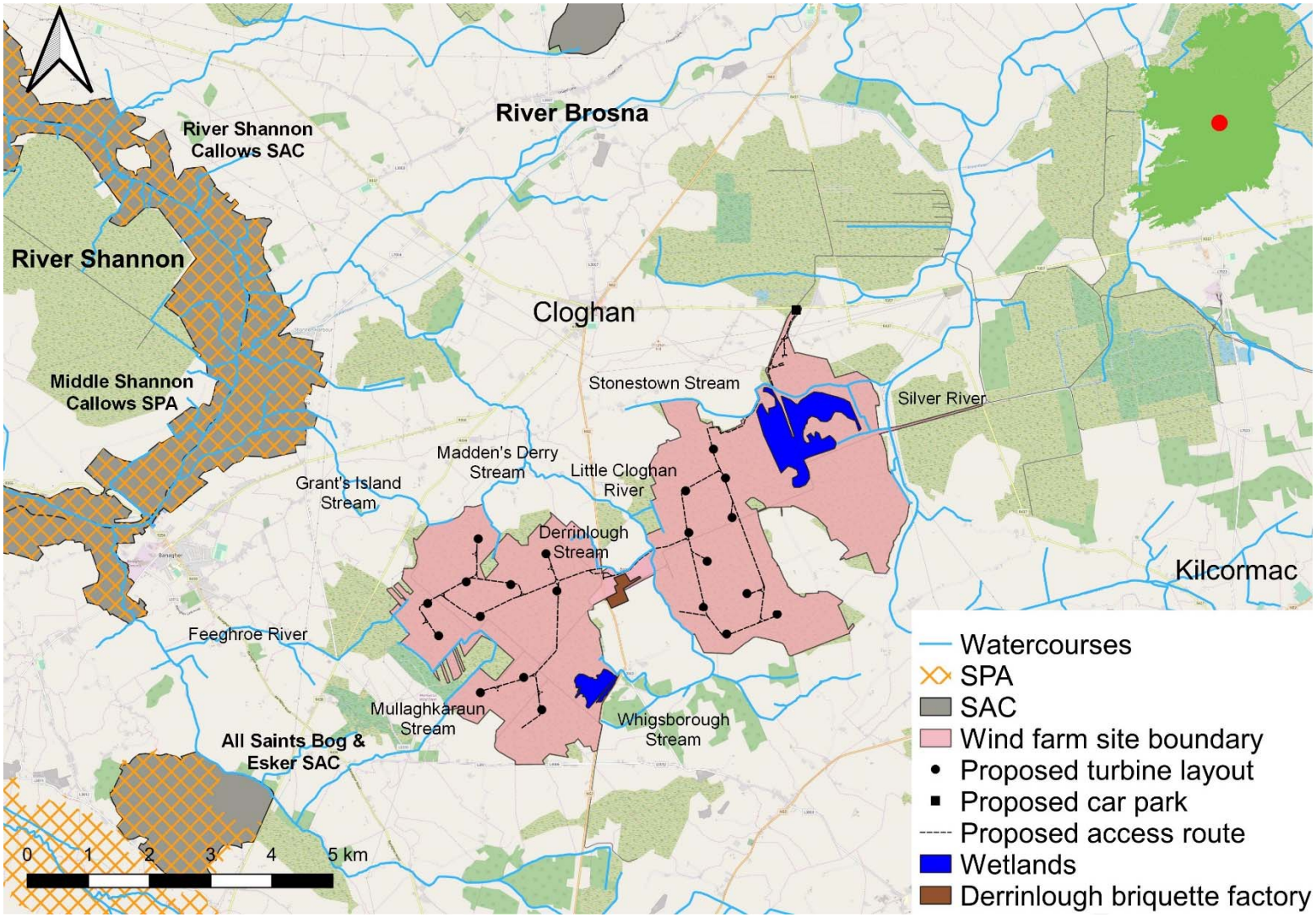

Figure 1.1 Location of the proposed Derrinlough wind farm near Cloghan, Co. Offaly.

2. Methodology

2.1 Desktop review

A desktop survey of published and unpublished material for the watercourses in the vicinity of the proposed wind farm development was undertaken in respect of fisheries and general aquatic flora and fauna. The review included data held by the National Parks and Wildlife Service (NPWS), National Biodiversity Data Centre (NBDC), Inland Fisheries Ireland (IFI) and Botanical Society of Britain & Ireland (BSBI).

2.2 Walkover surveys

Walkover surveys of the Derrinlough wind farm site were conducted on Tuesday 22nd and Wednesday 23rd October 2019. Watercourses within and adjoining the site boundary were assessed in light of proposed works, with survey effort focused on both instream and riparian habitats at each site. Surveys were focused at sites on the Feeghroe River (EPA code: 25F41), Mullaghkaraun Stream (25M48), Whigsborough Stream (25W43), Derrinlough Stream (25I29), Little Cloghan River (25L01), Silver River (25S02), Madden's Derry Stream (25M776), Stonestown Stream (25S55) and Grants Island Stream (25Y47), as well as three unnamed wetland/bog pool habitats (Table 2.1, Figure 2.1).

Aquatic habitat assessment was conducted according to the methodology given in the Environment Agency's *'River Habitat Survey in Britain and Ireland Field Survey Guidance Manual 2003*' (EA, 2003) and the Irish Heritage Council's *'A Guide to Habitats in Ireland*' (Fossitt, 2000). All sites were assessed in terms of:

- Stream width and depth and other physical characteristics.
- Substrate type, listing substrate fractions in order of dominance, i.e. large rocks, cobble, gravel, sand, mud etc.
- Flow type, listing percentage of riffle, glide and pool in the sampling area.
- In-stream vegetation, listing plant species occurring and their percentage coverage of the stream bottom at the sampling site (as applicable) and on the bankside.
- Bankside vegetation composition.

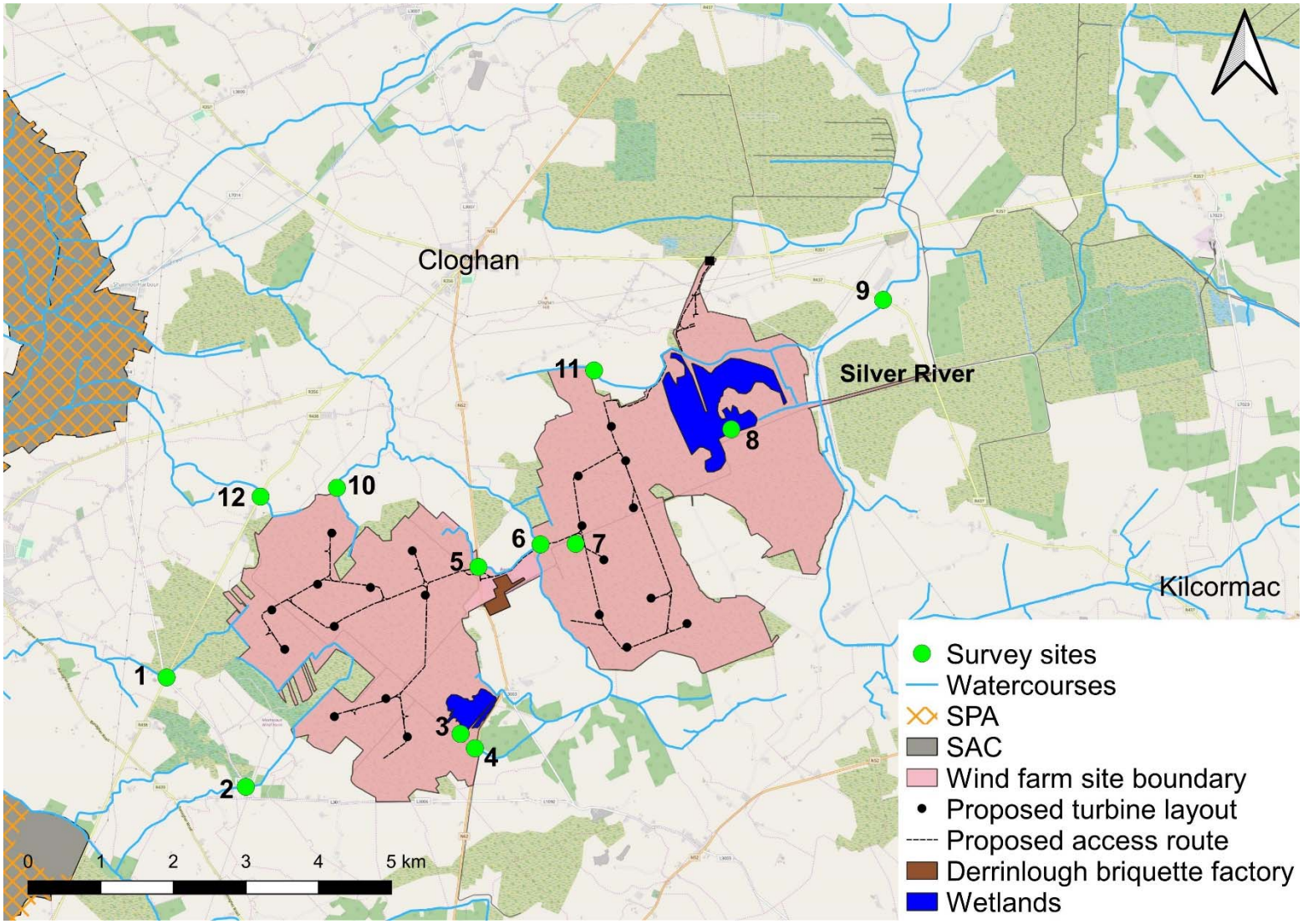

Figure 2.1 Location of aquatic survey sites visited in the vicinity of Derrinlough wind farm, October 2019.

Table 2.1 Location of aquatic survey sites. *denotes Q-sample site

Site no.	Site name	Location / townland	ITM (x)	ITM (y)
1*	Mullaghkaraun Stream	Boggaunreagh	604740	712138
2*	Feeghroe River	Five Roads Cross	603631	713628
3	Unnamed wetland	Clooneen	607678	713012
4*	Whigsborough Stream	Clooneen	607855	712651
5*	Derrinlough Stream	N62 road crossing	607930	715156
6*	Little Cloghan River	Derrinlough	608791	715461
7	Settlement pond	Derrinlough	609267	715481
8	Unnamed wetland	Stonestown	611309	716948
9*	Silver River	Millbrook Bridge	613487	718835
10	Madden's Derry Stream	R438 road crossing	604935	716121
11*	Stonestown Stream	Stonestown	609514	717862
12	Grants Island Stream	R438 road crossing	604938	716124

2.3 Fisheries habitat

An assessment of fisheries habitat at the survey sites within the vicinity of the Derrinlough wind farm site was undertaken to establish the importance of these areas as salmonid, lamprey, European eel and general fisheries habitat. The baseline appraisal considered the quality of spawning, habitat and nursery habitat at the sites. No targeted electro-fishing or netting methodologies were employed to further elucidate fish stocks of the study site during this survey.

Salmonids

Fisheries habitat for salmonids was assessed using the Life Cycle Unit method (Kennedy, 1984; O'Connor & Kennedy, 2002) to map riverine sites as nursery, spawning and holding water, by assigning quality scores to each type of habitat. Overall scores are calculated as the sum of individual habitat scores. Those habitats with poor quality substrata, shallow depth and a poorly defined river profile

receive a higher score. Higher scores in the Life Cycle Unit method of fisheries quantification are representative of poorer value, with lower scores being more optimal despite this appearing counter-intuitive. Life Cycle Unit scores are not calculated for lacustrine habitats.

Table 2.1 Life Cycle Unit scoring system for salmonid nursery, spawning and holding habitat value

Habitat quality	Habitat score	Overall score
Poor	4	12
Moderate	3	9-11
Good	2	6-8
Excellent	1	3-5

Lamprey species

Lamprey habitat evaluation for each riverine site was undertaken using the Lamprey Habitat Quality Index (LHQI) scoring system as devised by Macklin et al. (2018).

The LHQI broadly follows a similar rationale as the Life Cycle Unit score for salmonids. Those habitats with a lack of soft, largely organic sediment areas for ammocoete burrowing, shallow sediment depth (<10cm) or compacted sediment nature receive a higher score. Higher scores in this index are thus of poorer value (in a similar fashion to the salmonid Life Cycle Unit Index), with lower scores being more optimal. Overall scores are calculated as a simple function of the sum of individual habitat scores.

Larval lamprey habitat quality as well as the suitability of adult spawning habitat is assessed based on the information provided in Maitland (2003) and other relevant literature (e.g. Gardiner, 2003). Unlike the salmonid Life Cycle Unit index, holding habitat for adult lamprey is not assessed owing to their different migratory and life history strategies, and that surveys such as this one routinely only sample larval lamprey.

The LHQI scoring system provides additional information compared to the habitat classification based on the observations of Applegate (1950) and Slade et al. (2003), which deals specifically with larval (sea) lamprey settlement habitat. Under this scheme, habitat is classified into three different types: preferred (Type 1), acceptable (Type 2), and not acceptable for larvae (Type 3) (Slade et al. 2003). Type 1 habitat is characterized by soft substrate materials usually consisting of a mixture of sand and fine organic matter, often with some cover over the top such as detritus or twigs in areas of deposition. Type 2 habitat is characterized by substrates consisting of shifting sand with little if any organic matter and may also contain some gravel and cobble (lamprey may be present but at much lower densities than Type 1). Type 3 habitat consists of materials too hard for larvae to burrow including bedrock and

highly compacted sediment. This classification can also be broadly applied to other lamprey species ammocoetes.

Table 2.2 Lamprey Habitat Quality Index (LHQI) scoring system for lamprey spawning and settlement habitat value (Macklin et al., 2018)

Habitat quality	Habitat score	Overall score
Poor	4	8
Moderate	3	6 - 7
Good	2	3 - 5
Excellent	1	2

2.4 White-clawed crayfish

A survey for white-clawed crayfish (*Austropotamobius pallipes*) at each aquatic survey site was undertaken using a combination of sweep netting, hand-searching and mustelid spraint walkover surveys. Furthermore, a desktop review of known distributions of crayfish within the wider proposed development catchment was undertaken.

Crayfish survey (sweep netting)

Sweep netting (following Reynolds et al., 2010) was utilised at each site to detect both adult and juvenile crayfish and assess habitat quality. Sweep netting involves sampling of both in-channel macrophytes, in addition to checking typical refugia via lifting of littoral boulders (single boulder considered a single refuge) while the net is swept underneath to trap any crayfish.

Crayfish survey (riparian walkover survey)

Riparian walkover surveys were undertaken at each site to examine any spraint from mustelids (i.e. otters and mink) feeding along riparian corridors. Given that mustelids hunt large areas of river, they can detect cryptic prey present at low densities, which are not easily attainable via conventional survey methodologies (e.g. sweep netting). Riparian walkover/spraint surveys are useful for clarifying the presence or absence of crayfish at a particular site.

2.5 Biological water quality (Q-sampling)

Biological water quality was assessed through Q-sampling at each riverine site (*n*=8 samples) (Table 2.1). Macro-invertebrate samples were converted to Q-ratings as per Toner et al. (2005). The applied Q ratings followed the EPA water quality classes and Water Framework Directive status categories (Table 2.3 below). All riverine samples were taken with a standard kick sampling hand net (250mm width, 500µm mesh size) from areas of riffle/glide utilising a two-minute sample, as per ISO standards for water quality sampling (ISO 10870:2012). Large cobble was also washed at each site where present and samples were elutriated and fixed in 70% ethanol for subsequent laboratory identification. Any rare invertebrate species were identified from the NPWS Red List publications for beetles (Foster et al., 2009), mayflies (Kelly-Quinn & Regan, 2012) and other relevant taxa (i.e. Byrne et al., 2009; Nelson et al., 2011).

Table 2.3 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	Moderately polluted	Unsatisfactory
Q2, Q1-2 or Q1	Bad	Seriously polluted	Unsatisfactory

2.6 Physio-chemical water quality

Physio-chemical water quality samples were collected from each aquatic survey site (*n*=11 samples) on the 22nd-23rd October 2019. Samples were cooled and delivered to the laboratory on the same day for analysis. In order to collate a broad water quality baseline for the study area in question, a range of physio-chemical parameters for each site were laboratory-tested, namely;

- pH
- Alkalinity (mg $CaCO_3$/l)
- Conductivity @25°C (µS/cm)
- Suspended solids (mg/L)
- Molybdate Reactive Phosphorus (MRP) (mg P/l)
- Total Ammonia (mg N/l)
- Total Nitrate (mg N/l)
- Total Oxidised Nitrogen (TON) (mg N/l)
- Biochemical Oxygen Demand (BOD) (mg O_2/l)
- Chemical Oxygen Demand (COD) (mg O_2/l)
- Dissolved Organic Carbon (DOC) (mg C/l)

2.7 Biosecurity protocol

A strict biosecurity protocol including the Check-Clean-Dry approach was adhered to during all surveys for all equipment and PPE used. Disinfection of all equipment and PPE was carried out before and after use with Virkon™ was conducted to prevent the transfer of pathogens or invasive propagules between survey sites. Particular cognisance was given to the potential spread of crayfish plague (*Aphanomyces astaci*) given recent outbreaks across Ireland. Surveys were undertaken at sites in a downstream order to minimise the risk of upstream propagule mobilisation.

3. Results

3.1 Site descriptions and habitats

Site 1 – Feeghroe River

The Feeghroe River (EPA code: 25F41) at site 1 was a small 1.5-2m wide shallow stream (FW2) running alongside and underneath the R438 road at Five Roads Cross. Located approx. 1.1km downstream of the Derrinlough wind farm site, the channel had been straightened along the road historically and deepened locally downstream of the cross roads (but not upstream). The river was bordered by birch and willow-dominated scrub/woodland to the north with improved agricultural grassland (GA1) to the south. The river featured largely homogenous habitat with slow, heavily silted slow glide dominating throughout although a small area of harder substrata and accelerated flow was present in association with the main road culvert. The channel was glide dominated (90%) with smaller proportions of riffle and pool (5% by surface area of each). The average depth upstream of road crossing was 0.1-0.2m with 100% silt base and much instream detritus. Downstream of the road culvert the channel had been deepened historically and was more representative of a drainage channel, with a 100% silt (peat) base, deeper U-shaped profile and imperceptible flow rates. A small area immediately downstream of the culvert (between road culverts) featured deeper pool habitat up to 0.4m deep and medium to coarse gravels plus small cobble (partially bedded). Riparian shading was high from mature treelines of ash, sycamore and willow. There were no instream macrophytes due to shading and peat-staining, which was relatively high at time of survey. The road bridge structure had partially collapsed at time of survey and was limiting fish passage upstream (i.e. through the culvert).

Site 1 offered poor salmonid value overall with very limited spawning habitat (single location only, downstream of the main road culvert). Nursery and holding habitat was also considered as poor. Fish passage was impacted due to poorly accessible road culverts. Lamprey habitat was poor with any silt accumulations peat-derived and thus not suitable for larval settlement (too fine, humic sediment). The site offered some moderate value for European eel. White-clawed crayfish habitat was considered poor overall but some localised moderate value habitat was present immediately downstream of the road culvert and was found to support the species at low densities (via kick sampling).

Plate 3.1 The Feeghroe River at site 1

Site 2 – Mullaghkaraun Stream

Site 2 on the Mullaghkaraun Stream (EPA code: 25M48) was a small 2-2.5m wide stream (FW2) located at a road crossing approx. 1km downstream of the existing Meenwaun wind farm. The channel demonstrated some local straightening but had not been deepened historically in the vicinity of a 1.5m pipe culvert. The site was relatively fast flowing with an average depth 0.2m (uniform) and up to 0.3m near the culvert (small pool). Shallow, fast glide habitat dominated (90%) with 5% pool and 5% riffle. The substrata were dominated by fine-coarse gravels which were partially bedded with 20% small cobble and occasional small boulder. The site featured moderate siltation, which was largely peat derived. The site was bordered by coniferous plantations (WD4; sitka & lodgepole pine with alder/willow border) and agricultural grassland (GA1) to south (both sides of road). Heavy tunnelling was present upstream of culvert due to mature treelines of ash and hawthorn with a dense bramble and bracken-dominated scrub understorey. A greater degree of shading was present downstream of the culvert with heavy tunnelling from willow scrub. There were no instream macrophytes or bryophytes due to high riparian shading with no bryophytes.

The Mullaghkaraun Bog Stream at site 2 offered moderate value salmonid habitat. There was limited spawning due to siltation and bedding of substrata and a lack of deeper holding habitat for adult fish. Nursery habitat was of moderate value. The lamprey habitat was poor with limited spawning and little to no suitable nursery habitat due to fast flows and harder substrata dominating (few silt accumulations). Some moderate eel value was present although the lack of deeper areas and larger boulder refugia reduced the value overall. White-clawed crayfish habitat was poor overall and none were recorded via sweep netting.

Plate 3.2 The Mullaghkaraun Stream at site 2

Site 3 – Unnamed wetland, Clooneen

Site 3 comprised an extensive area of artificial wetland (dystrophic lake habitat, FL1) located in cutaway bog (PB4) to the south-west of the Derrinlough Bord na Mona briquette factory. The c. 20ha wetland was shallow (mostly <1m) with a 100% silt (peat) base and fringed by extensive beds of bottle sedge (*Carex rostrata*) with occasional bog pondweed (*Potamogeton polygonifolius*). Small islands of bulrush (*Typha latifolia*) were present occasionally in open water. Peat-staining was high at the time of survey. The banks were dominated by exposed peat with scattered growth of ling (*Calluna vulgaris*), downy birch (*Betula pubescens*), lodgepole pine (*Pinus contorta*), gorse (*Ulex europaeus*), cotton grass (*Eriophorum angustifolium*), deergrass (*Trichophorum cespitosum*) and purple moor grass (*Molinia caerulea*).

The site provided low to moderate value habitat for both salmonids (brown trout only) and European eel and both were known locally. Three-spined stickleback were recorded via sweep netting. Intermittent drainage channels provided only intermittent surface water connectivity to downstream watercourses. There was no lamprey potential given the lacustrine habitat. No white-clawed crayfish were recorded and suitability was very low for the species.

Plate 3.3 Site 3 was an unnamed wetland at Clooneen

Site 4 – Whigsborough Stream

Site 4 on the upper Whigsborough Stream (EPA code: 25W43) was a narrow, shallow drainage channel (FW4) located in cutaway bog (PB4) to the west of the wetland at site 3. The channel provided only intermittent surface water connectivity with the wetland given to infilling and was frequently impounded. The drainage channel ran alongside a Bord na Móna railway and was stagnant throughout, being more representative of pond habitat upstream of the N62 road. The 1-2m wide channel had a 100% deep silt base composed of peat, with frequently exposed banks of peat. Some sparse vegetation of ling, gorse, downy birch, wild carrot (*Daucus carota*), common knapweed (*Centaurea nigra*) and purple moor grass was present on degraded cutover bog. Instream, bottle sedge and broad-leaved pondweed dominated the macrophyte community although cover was limited overall (20%). The depth was typically <0.1m, often less although some sections of channel featured depths to 0.5m. Sediment was often >0.5m in depth.

Site 4 provided little fisheries value although three-spined stickleback were present in moderate densities (confirmed by sweep netting). Surface water connectivity with the wetland (site 3) and downstream watercourses (i.e. Derrymullin Stream, Loughderry Stream, Little Cloghan River) was very poor. The site offered low value for migratory European eel. Salmonid and lamprey habitat was absent. No white-clawed crayfish were recorded and the site was considered unsuitable for the species.

Plate 3.4 The upper reaches of the Whigsborough Stream at site 4

Site 5 – Derrinlough Stream

Site 5 on the Derrinlough Stream (EPA code: 25I29) was located approx. 100m upstream of Derrinlough Briquette Factory at the N62 road crossing. The lowland depositing stream (FW2) stream was 1.5-2m wide and situated in a very steep V-shaped peat-based channel, which had been straightened and extensively deepened historically. Bank height exceeded 6-7m upstream of the road crossing (pipe culvert). The depth averaged 0.2-0.5m with a bed composed of heavily compacted gravels and cobbles with very heavy peat siltation. The instream profile comprised 90% glide, 5% riffle and 5% pool. Flow was slow and dominated by glide at the time of survey. The channel supported occasional branched bur-reed and very localised fool's watercress. The steep channel embankments supported riparian scrub dominated by willow, gorse, bramble and bracken. The channel bordered cutover bog with fringes of scrub.

The site offered some low-quality salmonid (brown trout only) habitat, but this was diminished due to low flow rates and heavily compacted gravels with very heavy peat siltation. The site was not considered suitable for lamprey. Three-spined stickleback were present (sweep netting). The stream offered low potential for European eel. No white-clawed crayfish were recorded although there was some low suitability given their known presence downstream (i.e. Little Cloghan River confluence).

Plate 3.5 The Derrinlough Stream at site 5, upstream of the N62 road crossing

Site 6 – Little Cloghan River

Site 6 on the Little Cloghan River (EPA code: 25L01) was located at the confluence with the Derrinlough Stream, approx. 0.4km downstream of the Derrinlough Peat Briquette Factory. The river had been straightened and deepened historically to facilitate bog drainage and sat in a 3m-wide, deep U-shaped channel. Bank heights were up to 3m in places. Downstream of the pipe culvert, the depth varied between 0.5 and 1m with a peat dominated base with some low clay fractions. Glide dominated the site (100%). Macrophyte growth was sparse although occasional common reed (*Phragmites australis*), fool's watercress and common water starwort (*Callitriche stagnalis*) grew occasionally in the margins. Water plantain (*Alisma plantago-aquatica*) was rare. Upstream of the pipe culvert was shallower (0.5m) and more heavily vegetated with dense stands of common reed instream. The river was bordered by cutover bog (PB4), improved agricultural grassland (GA1), scrub (WS1) and hawthorn hedgerows (WL1). Riparian areas comprised bramble, bracken, gorse and hawthorn hedgerows with scattered willow. The adjoining Derrinlough Stream featured shallow, fast glide and riffle over a partially bedded bed of boulder, cobble, coarse gravels and occasional clay.

Site 6 was considered of some moderate value to salmonids (brown trout only) given the presence of deeper holding habitat. Nursery and spawning conditions were poor due to siltation and slow flow rates but were superior in the adjoining Derrinlough Stream (moderate value). The site was not of value to lamprey due to high clay/ humic fractions in sediment. Both channels could be considered of moderate value for European eel, however the limited boulder and cobble would reduce the habitat potential for the species. Although no white-clawed crayfish were recorded during the survey, the species is alleged to occur at the site (Bord na Móna pers. comm.). There was some moderate crayfish potential given instream macrophyte refugia.

Plate 3.6 The Little Cloghan River at site 6, approx. 0.4km downstream of the Derrinlough Peat Briquette Factory.

Site 7 – Settlement pond, Derrinlough

Site 7 was an artificial peat settlement channel situated in cutover bog (PB4). The site was approx. 200m long, 6-8m wide and averaged 1-1.5m deep. Bank height was 3-4m. There was some indirect connectivity with the Little Cloghan River via several other settlement ponds and drains to the north of the site. There was a slow flow of water through the channel. The channel featured a peat base with high fractions of clay underneath and on marginal slopes. Boulders were frequent but were bedded in peat. Fossilised sedimentary rocks (Carboniferous limestone) were frequent to the north of the site in cutover bog and were noted as possibly being of geological heritage value. They contained fossilised bryozoans, ammonites and crinoids. The site featured exposed peat and clay banks with little riparian vegetation. Macrophyte cover was sparse although localised common reed and broad-leaved pondweed was present marginally.

The settlement pond at site 7 was considered of moderate vale for brown trout and European eel, given the connectivity with riverine watercourses downstream. The general lack of flowing water would preclude lamprey species. Three-spined stickleback were confirmed present during sweep netting. Although no white-clawed crayfish were recorded, similar settlement ponds to the north of the site (downstream) are known to support crayfish and there was some moderate suitability for the species at this site.

Plate 3.7 Unnamed settlement pond at site 7

Site 8 – Unnamed wetland complex, Stonestown

Site 8 was an artificial wetland complex (dystrophic lake FL1 habitat) situated in cutover bog (PB4) to the eastern extent of the Derrinlough bog site. The wetlands covered approx. 150ha in area and were shallow, invariably <1m deep. The base was composed of 100% peat-derived sediment and peat-staining was high throughout. Connectivity with the Silver River to the east was poor and largely via seepage or intermittent peat drainage channels. The wetland supported extensive marginal beds of bottle sedge with occasional stands of bulrush and common clubrush (*Schoenoplectus lacustris*) in open water, indicating occasional calcareous influences. Bog bean (*Menyanthes trifoliata*) was also present in marginal areas. Riparian areas supported typically low-lying wetland community composed primarily of purple moor grass, deer grass, downy birch and willow shrubs.

Despite limited connectivity with flowing watercourses, the wetland offered moderate value for brown trout (observed during site visit). Three-spined stickleback were present in good numbers. European eel value was moderate to good. The lack of flowing water precluded lamprey species. No white-clawed crayfish were recorded and the wetland was considered to offer low suitability given high siltation levels.

Plate 3.8 The unnamed wetland complex at site 8

Site 9 – Silver River, Millbrook Bridge

The Silver River (EPA code: 25S02) at site 9 was a lowland depositing watercourse (FW2) with a semi-natural profile (i.e. broken glide habitat) despite evident historical deepening and straightening. The channel had bank heights of 3-5m and was 7-8m wide. The water depth was 1.0-1.2m deep on average although deeper pools were present locally upstream of the bridge. The channel instream profile comprised 100% fast flowing deep glide. The river bed comprised bedded boulder and cobble (heavily compacted) with evident clay deposits. Some localised medium and finer gravels existed between cobble habitat. Sediment accumulations were restricted to marginal extremities – these were shallow and compacted where present. Instream macrophytes comprised bog pondweed with ivy leaved duckweed (*Lemna trisulca*) present locally in the river margins. Common clubrush was present in very localised patches (i.e. rare). The embankments (riparian areas) supported frequent grey willow, alder, sycamore and hawthorn. The bordering land use was heavily improved pasture.

The site offered good quality nursery habitat for salmonids in swift flowing glide, but the spawning value was diminished due to compacted substrata (dominated by boulder and cobble). The holding value was good due to deep glides. European eel habitat was good due to widespread boulder habitat although this too was somewhat reduced because of bedding. Lamprey spawning habitat was present given small lenses of finer gravels between cobble but soft substrata was very localised and evidently compacted given high clay fractions. No white-clawed crayfish were recorded during the site visit but are known from the river. Suitability was moderate given the typically fast flows.

Plate 3.9 Site 9 on the Silver River at Millbrook Bridge

Site 10 – Madden's Derry Stream

Site 10 on the Madden's Derry Stream (EPA code: 25M76) was located approx. 50m downstream of the wind farm boundary in an area of agricultural grassland (GA1). The 2-2.5m wide channel represented a drainage ditch (FW4) and had been historically straightened and deepened in the vicinity of the survey site, with near-vertical V-shaped banks (2-3m bank height). The stream was heavily silted throughout with an imperceptible flow at the time of survey – the channel was stagnant and featured pool habitat only. The average depth was <0.2m with a 100% silt base. Some harder substrata were present underfoot but bedded in >0.2m of soft sediment. There was excessive instream vegetation from both terrestrial (rank grasses, bramble etc.) with macrophyte species such as watercress (*Rorippa nasturtium-aquaticum*) and fool's watercress present in more open areas of channel. Blockages to flow (and fish passage) were frequent throughout. Cover of common duckweed (*Lemna minor*) was extremely high in more open areas (>90%). Riparian shading was very high (>80%) throughout much of the site with the channel flanked by dense hawthorn hedgerow (WL1) (north bank) and dense bramble-dominated scrub elsewhere. Livestock poaching (cattle) was evident at several more accessible points downstream of the survey site.

There was no salmonid potential at this site although habitat did improve considerably further down the watercourse (near the Little Cloghan River confluence >1km downstream). Lamprey habitat was not present given the absence of spawning substrata and the lack of flow which removed potential for nursery habitat. Some low potential existed for migratory European eel but the channel was considered unlikely to support resident eel. Three-spined stickleback were present in high densities at the time of survey. No white-clawed crayfish were recorded.

Plate 3.10 The Madden's Derry Stream at site 10

Site 11 – Stonestown Stream

Site 11 on the Stonestown Stream (EPA code: 25S55) was located at the northern extent of Derrinlough Bog, approx. 3.8km upstream of the Little Cloghan River confluence. The lowland depositing river (FW2) had been heavily modified historically (straightened and deepened throughout) and sat in a deep U-shaped channel. The river featured bank heights of 2-3m and was 4-6m wide. Depths typically exceeded 1m and were uniform (typical of dredged channels). The site was composed of 100% deep glide with an imperceptible flow. The river bed comprised 100% silt and clay substrata. Macrophyte cover was heavy (70% cover) with common reed (dominant) and abundant unbranched bur-reed (*Sparganium emersum*). Common duckweed was occasional. The embankments were heavily scrubbed with grey willow, bramble, bracken, gorse and occasional dog rose. The water clarity was good at the time of survey with low levels of suspended sediment.

Site 11 offered some low-quality brown trout and European eel holding habitat, but was diminished due to low flow rates and silt base. The site was not considered of any value as a nursery or for spawning. Lamprey habitat was poor given the imperceptible flow. White-clawed crayfish were not recorded during sweep netting and overall the site offered low potential for the species.

Plate 3.11 The Stonestown Stream at site 11

Site 12 – Grants Island Stream

Site 12 on the Grants Island Stream (EPA code: 25Y47) was located along the wind farm boundary in a small area of beech-dominated mixed broadleaved woodland with sycamore, holly, hazel and sitka spruce (WD1). The site was adjoined by agricultural grassland on all sides (GA1). The stream was representative of a drainage channel (FW4) and was dry at the time of sampling with only small rainwater pools present and no flow. The channel had been straightened and deepened historically in the vicinity of the road crossing, with bankful heights of 2-3m in a steep V-shaped channel. The stream had a 100% mud base and appeared to only carry water during high rainfall or flood events (i.e. largely seasonal channel). There were no instream macrophytes or bryophytes present.

The site had no fisheries potential or habitat present at the time of survey. Given surface water connectivity with Derrinlough Bog there may be some limited (seasonal) potential for migrating European eel during higher water periods.

Plate 3.12 The Grants Island Stream at site 12 (dry at the time of survey)

3.2 Fisheries habitat

Salmonids

Salmonid habitat ranged from poor to moderate value across the majority of survey sites (Table 3.2). Only site 9 (Silver River) offered good salmonid habitat according to life Cycle Unit scores, owing to the presence of some good quality spawning substrata and deeper holding habitat for adults in the vicinity of Millbrook Bridge. Sites 4, 5 and 10 offered poor quality habitat overall. Sites 3 and 8 were lacustrine habitats but nevertheless provided some moderate nursery value for brown trout, as did site 7 (settlement pond with outflow). Site 12 was dry at the time of survey and did not support fish.

Table 3.2 Life Cycle Unit scores for sites surveyed in the vicinity of the proposed Derrinlough wind farm

Site	Salmonid habitat value	Spawning	Nursery	Pool (holding)	Total Score
1	Moderate	3	3	3	**9**
2	Moderate	3	3	3	**9**
3	Moderate	4	3	4	**11**
4	Poor	4	4	4	**12**
5	Poor	4	4	4	**12**
6	Moderate	4	3	2	**9**
7	Moderate	3	3	3	**9**
8	Moderate	3	4	3	**10**
9	Good	2	3	2	**7**
10	Poor	4	4	4	**12**
11	Moderate	4	4	3	**11**
12	n/a – site dry at time of survey				

Lamprey

Lamprey habitat was poor across the majority of survey sites, with poor spawning and poor nursery habitat present throughout all but one site. Site 9 on the Silver River at Millbrook Bridge offered moderate quality spawning and nursery habitat. Sites 3 and 8, being lacustrine habitats with no flow, were not considered suitable for lamprey. Site 7, although more representative of a lacustrine habitat (i.e. settlement pond), featured some flowing water at the outflow but this offered poor quality lamprey habitat. Site 12 was dry at the time of survey and was not capable of supporting fish.

Table 3.3 Lamprey Habitat Quality Index (LHQI) scores for riverine sites surveyed in the vicinity of the proposed Derrinlough wind farm

Site	Lamprey habitat value	Spawning	Nursery	Total Score	Habitat type present
1	Poor	4	4	**8**	Type 2
2	Poor	4	4	**8**	Type 2
3	n/a – lacustrine habitat				
4	Poor	4	4	**8**	Type 2
5	Poor	4	4	**8**	Type 2
6	Poor	4	4	**8**	Type 2
7	Poor	4	4	**8**	Type 2
8	n/a – lacustrine habitat				
9	Moderate	3	3	**6**	Type 2
10	Poor	4	4	**8**	Type 2
11	Poor	4	4	**8**	Type 2
12	n/a – site dry at time of survey				

European eel

European eel habitat was moderate across most survey sites. The larger riverine sites such as site 6 and 9 offered the best eel habitat overall in terms of foraging, refugia and downstream connectivity with larger watercourses, i.e. River Shannon catchment. Wetland habitats at sites 3 and 8, as well as the settlement pond at site 7, also offered good overall eel habitat although downstream connectivity issues were evident. Whilst site 12 was dry at the time of survey and was not capable of supporting fish, the channel offered some low potential for migrating eel during higher flow periods given downstream connectivity with the River Shannon catchment.

3.3 White-clawed crayfish

White-clawed crayfish were recorded from a single site during the survey; sweep netting resulted in the capture of a single crayfish at site 1 on the Feeghroe Stream (immediately below the R468 road culvert). Despite some moderate to good suitability for the species at certain sites (e.g. sites 6, 7, 9), no live crayfish were recorded from any other site via sweep netting or hand searching. However, crayfish are known locally (Bord na Móna pers. comm.) from site 6 (Little Cloghan River) and the connected settlement pond at site 7, both in the vicinity of the Derrinlough briquette factory. Walkover surveys failed to identify remains of crayfish in mustelid spraint.

3.4 Biological water quality (Q-sampling)

Q-samples were collected and analysed from *n*=8 riverine sites in the vicinity of the proposed Derrinlough wind farm. A total of *n*=42 species across *n*=32 families were recorded in the kick samples (sample compositions summarised in Table 3.5A and 3.5B below).

Following the methodology of Toner et al. (2005), the Environmental Protection Agency (EPA) group invertebrates into classes whereby pollution intolerant species are denoted class A, and species with greater pollution tolerance fall into successive classes (B through E, respectively). As such, the presence or absence of these groups and their relative abundance facilitates an assessment of biological river health. Good status (Q4) unpolluted water quality is achieved according to the EPA if at least one Group A taxon is present in, at least, fair numbers (5-10% total sample composition). Group B taxa may be common or absent and *Baetis rhodani* (large dark olive mayfly) is often dominant. Other Group C taxa are never excessive and group D / E taxa are present in small numbers or absent (Toner et. al., 2005). Our results are discussed in this context in order to interpret potential changes in the macroinvertebrate community composition.

Of the eight sampling sites, only site 9 on the Silver River attained target good status **Q4** water quality as required under the Water Framework Directive (2000/60/EC). The presence of clean water indicative EPA Class A Ephemeridae mayflies and class B caddisflies (Seracostomatidae and Limnephilidae) was indicative of better water quality.

The majority of the remaining sites had either **Q2-3** or **Q3** water (i.e. Poor Status). These includes sites 1, 2, 4, 5, 6 and 11. These sites were for the most part highly modified streams with fine peat-derived sediment deposits. The taxonomic compositions of these samples typically were dominated by more pollution tolerant EPA Class C and D invertebrates. The samples comprised a mixture of caseless caddis, coleopterans and dipterans with pollution indicator species such as freshwater hoglouse *Asellus aquaticus* often being numerically abundant.

The lowest biological Q rating of **Q2** (Bad Status) was recorded at site 10 (Madden's Dairy Stream), albeit a tentative Q was applied given the very limited flow recorded within the stream. The samples only had three taxa present, two of which are pollution indicators, namely the gastropod snail species *Radix balthica* and *Asellus aquaticus* (EPA class D).

No rare macroinvertebrate species were recorded from the *n*=8 samples collected in the vicinity of Derrinlough wind farm (summarised below & cross referenced against national red lists; Tables 3.5A

and 3.5B). In summary, of the *n*=8 survey sites, only site 9 (Silver River) achieved good status **Q4** water quality as required under the Water Framework Directive (2000/60/EC). This is implemented by the recently amended European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2019 (S.I. No. 77 of 2019) that specify a minimum target EQR of 0.75 or equivalent **Q4** for all rivers. The Q-Ratings for each watercourse can be summarised in Table 3.4 and Figure 3.1 below.

Table 3.4 Q-ratings for aquatic survey sites in the vicinity of Derrinlough wind farm, October 2019

Site	Watercourse	Q-rating	WFD status
1	Mullaghkaraun Stream	**Q2-3**	Poor Status
2	Feeghroe Stream	**Q3**	Poor Status
4	Whigsborough Stream	**Q3**	Poor Status
5	Derrinlough Stream	**Q3**	Poor Status
6	Little Cloghan River	**Q2-3**	Poor Status
9	Silver River	**Q4**	Good Status
10	Madden's Derry Stream	**Q2**	Bad Status
11	Stonestown Stream	**Q3**	Poor Status

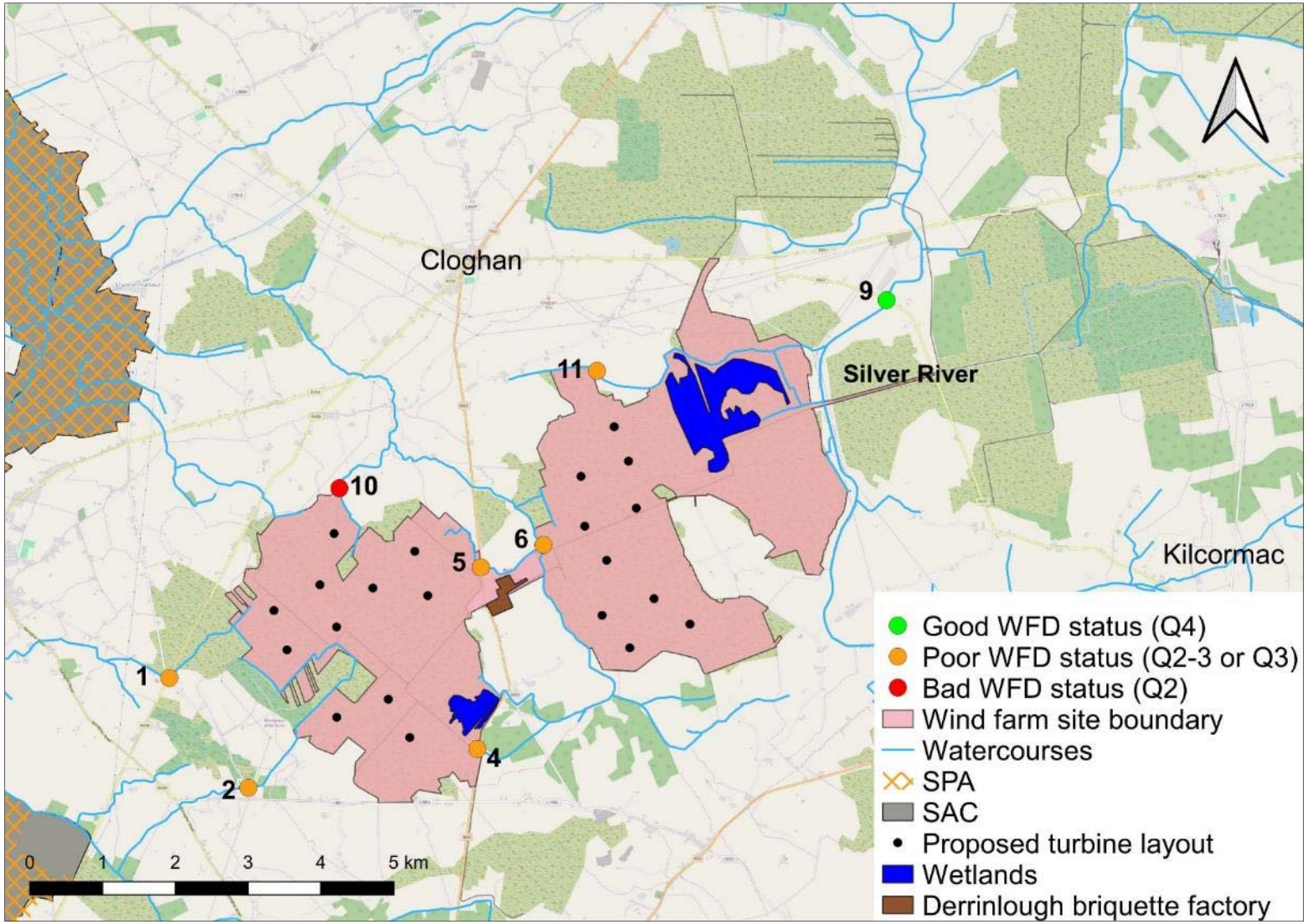

Figure 3.1 Water quality of Q-sampling sites visited in the vicinity of Derrinlough wind farm, October 2019.

Table 3.5A Macro-invertebrate Q-sample compositions for sites 1, 2, 4 and 5 sampled in the vicinity of Derrinlough wind farm, October 2019

Group	Family	Species	Site 1	Site 2	Site 4	Site 5	EPA Class
Emphemeroptera	Baetidae	*Baetis rhodani*	None	4	None	None	C
Trichoptera (cased)	Limnephilidae	*Limnephilus* sp.	None	None	None	2	B
	Seracostomatidae	*Seracostoma personatum*	None	3	None	None	B
	Glossosomatidae	*Agapetus fuscipes*	None	None	None	7	B
Trichoptera (uncased)	Hydropyshcidae	*Hydropsyche angustipennis*	None	2	None	None	C
Odonata	Coenagrionidae	*Ischnura elegans*	None	None	2	None	C
Hemiptera	Notonectidae	*Notonecta glauca*	None	None	1	None	C
Hemiptera	Corixinae	n/d	None	None	2	None	C
Coleoptera	Dyistcidae	*Dytiscus marginalis*	None	None	1	None	C
Coleoptera	Haliplidae	*Haliplus confinus*	None	None	2	None	C
Coleoptera	Elmidae	*Limnius volckmari*	None	3	None	5	C
Coleoptera	Elmidae	*Elmis aenea*	2	2	None	None	C
Mollusca	Lymnaeidae	*Radix balthica*	None	None	9	None	D
	Hydrobiidae	*Potamopyrgus antipodarum*	None	None	None	5	C
Crustacea	Asellidae	*Asellus aquaticus*	15	12	None	1	D
Crustacea	Gammaridae	*Gammarus duebenii*	11	17	None	6	C
Crustacea	Astacidae	*Austropotamobious pallipes*	1	None	None	None	C
Diptera	Tipulidae	*Dicranota* sp.	None	None	None	2	C
Diptera	Chironomidae	*Chironomini tribe*	1	None	None	None	C
Diptera	Chironomidae	*Chironomus* sp.	9	None	None	None	D
Diptera	Simuliidae	*Simulium* sp.	6	None	None	None	C
Hirudinea	Glossiphonidae	*Glossiphonia complanata*	None	1	None	None	D
Notes			**Small stream**	**Small stream**	**Tentative Q (canalised bog drain)**	**Small stream**	
Q Rating			**Q2-3 (moderately polluted)**	**Q3 (Moderately Polluted)**	**Q3 (Moderately Polluted)**	**Q3 (Moderately Polluted)**	
Equivalent WFD Status			**Poor Status**	**Poor Status**	**Poor Status**	**Poor Status**	

Table 3.5B Macro-invertebrate Q-sample compositions for sites 6, 9, 19 and 11 sampled in the vicinity of Derrinlough wind farm, October 2019

Group	Family	Species	Site 6	Site 9	Site 10	Site 11	EPA Class
Emphemeroptera	Ephemeridae	*Ephemera danica*	None	5	None	None	A
Trichoptera (cased)	Limnephilidae	*Limnephilus flavicornis*	None	2	None	None	B
	Leptoceridae	*Anthripsodes* sp.	None	None	None	5	B
	Seracostomatidae	*Seracostoma personatum*	None	8	None	None	B
Trichoptera (uncased)	Hydropyshcidae	*Hydropsyche angustipennis*	2	3	None	None	C
Trichoptera (uncased)	Polycentropodidae	*Polycentropus flavomaculatus*	None	1	None	None	C
Odonata	Coenagrionidae	*Ischnura elegans*	None	None	None	6	C
Coleoptera	Dyistcidae	*Dytiscus marginalis*	None	None	None	1	C
Coleoptera	Haliplidae	*Haliplus* sp.	1	None	None	None	C
Coleoptera	Elmidae	*Elmis aenea*	None	3	None	None	C
Mollusca	Lymnaeidae	*Radix balthica*	None	None	None	3	D
	Lymnaeidae	*Lymnaea stagnalis*	None	None	6	5	C
	Valvatidae	*Valvata piscinalis*	None	1	None	None	C
	Valvatidae	*Valvata cristata*	None	None	None	2	C
	Valvatidae	*Anisus leucostoma*	None	None	3	None	C
	Sphaeriidae	*Pisdium subtruncatum*	None	None	None	2	C
	Sphaeriidae	*Pisidium personatum*	1	None	None	None	C
	Hydrobiidae	*Potamopyrgus antipodarum*	None	1	None	None	C
Crustacea	Asellidae	*Asellus aquaticus*	93	2	26	24	D
Diptera	Chironomidae	*Chironomus* sp.	None	4	None	12	D
Diptera	Simuliidae	*Simulium* sp.	None	6	None	None	C
Chelicerata	Hydrachnidae	*Not identifiable*	None	None	None	5	C
Oligochaeta	Lumbricidae	*Eiseniella tetraeda*	None	1	None	None	N/A
Oligochaeta	Tubificidae	*Tubifex* sp.	93	None	None	None	D
Notes			**Small stream**	**Silver River**	**Tentative Q (stream with limited flow)**	**Tentative Q (canalised peat drain)**	
Q Rating			**Q2-3 (moderately polluted)**	**Q4 (unpolluted)**	**Q2 (Seriously polluted)**	**Q3 (Moderately Polluted)**	
Equivalent WFD Status			**Poor Status**	**Good Status**	**Bad Status**	**Poor Status**	

3.5 Physio-chemical water quality

Table 3.6 below provides a summary of physio-chemical results collected at the same locations as the biological water quality monitoring (*n*=8 sites). The results are discussed below relative to target thresholds in the legislation.

The pH and alkalinity were relatively consistent across all samples, with high alkalinity of ≥169 mg $CaCO_3$/l in all samples (Table 3.6) reflecting local calcareous geological influences (GSI, 2019). Levels of Molybdate Reactive Phosphorus (MRP) (the amount of phosphorus bioavailable for plant uptake) were low across all sample sites, i.e. all ≤0.012mg P/l) (Table 3.6). The Surface Water Regulations (S.I. 77 of 2019) sets a target of ≤0.025 mg P/l for high status rivers. Thus, all samples conformed to high status based on MRP levels.

The recorded suspended solids levels were low across the survey sites with levels recorded at <25mg/l with the exception of site 4 where levels were recorded at 39.3mg/l (see Table 3.6 below).

Levels of Total Oxidised Nitrogen (TON) (nitrate + nitrite in combination) were varied across the samples, ranging from 0.069 to 3.205mg N/l (Table 3.6). The European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2019 (S.I. 77 of 2019) sets no specific boundary conditions for nitrate. However, EPA assessment of high-quality water sources has set boundary conditions of 0.8 mg/l NO_3-N (nitrate as nitrogen) for high quality waters and 1.8 mg/l NO_3-N for good quality waters. Thus, only site 4 (Whigsborough Stream) met the high-quality threshold. Sites 1 and 5 met good quality standards (0.806, 0.850mg N/l). Sites 2, 6, 9, 10 and 11 failed to meet good quality standards, with all TON levels exceeding 2.246mg N/l. Such levels indicate enrichment (eutrophication).

Nitrite is an intermediate in the oxidation of ammonia to nitrate and concentrations of nitrite in unpolluted waters should be low (<0.05mg N/l) according to the EPA but also in salmonid bearing watercourses. Levels of nitrite were low across all of the *n*=8 physiochemical sampling sites. Levels of total ammonia however, exceeded limits set for healthy waters (good status ≤0.065 mg N/l) under the European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2019 (S.I. 77 of 2019) at the majority of sites (i.e. sites 1, 2, 4, 5, 6, and 11, all ≥ 0.069mg N/l). Total ammonia levels at sites 1, 2 and 5 were particularly high (all ≥0.352mg N/l) (Table 3.6). Of the *n*=8 physiochemical sampling sites only two sites (i.e. sites 9 and 10) corresponded to 'high status' given significantly lower levels of total ammonia levels at ≤0.034mg N/l. The un-ionised fraction of ammonia (NH_3) is known to be toxic to freshwater fish and elevations e.g. >0.1mg/l indicate contamination from effluent and or agricultural sources. The European Communities (Quality of Salmonid Waters) Regulations 1988 (S.I. 293 of 1988) specifies a limit for unionised ammonia of 0.02 mg/l NH_3. Thus, all sites met un-ionised ammonia targets (all sites ≤0.016mg mg/l NH_3).

Biochemical Oxygen Demand (BOD), the amount of oxygen consumed by microorganisms in breaking down the organic matter, for all sites was ≤2.4 mg/l O_2 (Table 3.6). Therefore, all sampling sites fell within acceptable limits for clean river water (i.e. ≤2.6 mg/l O_2 95th percentile) as set out under the

under the European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2019 (S.I. 77 of 2019).

Levels of dissolved organic carbon (DOC) were varied across sampling sites (8.2 – 34.7mg C/l). Sites 1, 4, 5, and 10 showed higher DOC levels (≥58.9 mg C/l) and this likely reflects the greater levels of humic substances present, originating from cutover bog habitats.

Table 3.6 Physio-chemical water quality results, October 2019. No samples were taken for lacustrine sites 3, 7 or 8. Site 12 was dry at the time of survey[1].

Parameter	Site 1	Site 2	Site 4	Site 5	Site 6	Site 9	Site 10	Site 11
pH	7.48	7.40	7.63	7.37	7.72	7.90	7.49	7.72
Alkalinity (mg $CaCO_3$/l)	183	252	169	182	293	280	273	326
Suspended solids (mg/l)	0.8	2.0	**39.3**	0.6	1.8	2.6	6.2	0.2
MRP (mg P/l)	0.005	0.002	0.011	0.007	0.004	0.012	0.007	0.004
Total Oxidised Nitrogen (mg N/l)	0.806	**2.402**	0.069	0.850	**2.722**	**3.008**	**2.246**	**3.205**
Nitrite (mg N/l)	0.010	0.032	<0.001	0.033	0.025	0.010	0.019	0.033
Total Ammonia (mg N/l)	**0.356**	**0.374**	**0.102**	**0.352**	**0.082**	0.032	0.032	0.069
BOD (mg O_2/l)	0.004	0.004	0.002	0.004	0.002	0.001	<0.001	0.016
COD (mg O_2/l)	2.1	2.2	1.8	2.4	1.4	1.0	2.0	0.6
DOC (mg C/l)	**71.3**	45.4	**118.9**	**58.9**	37.7	24.9	**72.9**	12.9

[1] Results highlighted in bold indicate elevations

4. Discussion

4.1 Most and least valuable sites

Salmonids

Salmonid habitat was poor to moderate across the majority of survey sites based on combinations of nursery, spawning and adult holding habitat (i.e. Life Cycle Unit scores; Table 3.2 results). This largely reflected the peat-based nature and heavily silted substrata of many sites (e.g. sites 1, 2, 5, 10, 11), which significantly reduced or removed the availability of clean, unbedded gravel/cobble spawning habitat required for healthy salmonid populations. Peat-based catchments such as Derrinlough are less productive than other those flowing over other geologies (O'Grady, 2006), with reduced primary productivity, reduced macro-invertebrate communities, and, generally speaking, lower fish biomass (Richardson, 1993).

Channels with higher proportions of fine sediment (such as peat) can also impact spawning and intragravel development of salmonid eggs (Louhi et al., 2011; Greig et al., 2007), further limiting local populations. Such conditions were prevalent at sites 1, 2, 5, 10 and 11 which were however, highly degraded from historical drainage works. Silted and compacted gravels can no longer function as salmonid spawning areas and it has been shown that eggs laid in clean gravels which have subsequently been silted over by peat have failed to hatch (Crisp 1993, 2000). Siltation of watercourses from peat-derived sediment in the vicinity of the proposed wind farm site primarily relates to historical drainage works.

Site 9 on the Silver River at Millbrook Bridge, the largest watercourse within the study area, offered the best salmonid habitat overall, with both good quality spawning and (adult) holding habitat present but localised in the vicinity of the bridge. The (Kilcormac) Silver River is locally recognised as a recreational brown trout fishery and receives small runs of Croneen trout (genetically-distinct migratory form from Lough Derg) and Atlantic salmon via the Brosna River.

Although offering limited (poor) spawning opportunities, the wetlands located at sites 3 and 8, as well as the settlement pond at site 7, provided some moderate brown trout habitat in terms of nursery and feeding. Trout are known locally from all three sites (Bord na Móna, pers. comm.).

Lamprey species

Overall, lamprey potential (primarily for brook lamprey *Lampetra planerii* given the location of the Derrinlough sites) was low across the riverine sites surveyed (Table 3.3). No sites were considered to offer moderate or good lamprey spawning or nursery habitat (i.e. all poor, according to LHQI scores). Primarily this was due to limited (or absent) clean, unbedded gravel substrata and the predominance of humic, flocculent sediment. *Lampetra* species such as brook lamprey not only require good fractions of clean, fine gravels for spawning but also soft, organic-rich sediment for larval settlement, be it mud, sand, silt, clay or a matrix of all types, ≥5cm in depth (Maitland, 2003). Invariably such areas are composed of organic-rich fines with a high level of non-humic detritus. Such conditions were not present across the Derrinlough survey sites. Site 9, on the Silver River at Millbrook Bridge, featured

more in the way of cleaner hard substrata (including some coarse gravels) required for lamprey spawning but these were bedded given high flow rates and were considered sub-optimal. However, *Lampetra* sp. (likely brook lamprey, given access difficulties for river lamprey) are known from the Silver River both upstream and downstream of this site (Kelly et al., 2009, 2015).

The survey sites were dominated by peat-derived sediments. Typically, heavily silted peat-dominated channels, such as those found in the vicinity of Derrinlough wind farm, do not provide optimal conditions for lamprey spawning or settlement, with the species generally favouring sites with well-sorted soft substrata and clean, uncompacted gravels (Goodwin et al., 2008; Aronsuu & Virkkala, 2014).

European eel

European eel habitat was moderate across most survey sites, with the quality typically reduced given limited deeper holding water and limited refugia such as macrophyte beds and boulders. Diurnal refugia are vital to European eel such as deep pools, large macrophyte beds, boulders, large cobble and in-stream structure like submerged tree roots and stumps (Degerman et al., 2019; Laffaille et al., 2003). The larger riverine sites such as site 6 (Little Cloghan River) and 9 (Silver River) offered the best eel habitat overall in terms of foraging, boulder/macrophyte refugia and downstream connectivity with larger watercourses, i.e. River Shannon catchment.

The wetland habitats located at sites 3 and 8, as well as the settlement pond at site 7, also offered good overall eel habitat although downstream connectivity issues were evident (e.g. impounded peat drainage channels, partially-blocked culverts etc.). These sites provided ample refugia and prey resources for eel (e.g. three-spined stickleback, amphibians, macro-invertebrates).

Whilst site 12 was dry at the time of survey and was not capable of supporting fish, the channel offered some low potential for migrating eel during higher flow periods given downstream connectivity with the River Shannon catchment. More so than other fish species, even perceptibly sub-optimal foraging and nursery sites may act as valuable migratory pathways for European eel to and from the wider Brosna and Shannon catchments, particularly in the higher-flow periods typically persistent during the adult eel migration season (i.e. October onwards). Thus, anywhere that is capable of facilitating passage for this Annex II, critically endangered species (Jacoby & Gollock, 2014), should be considered of value.

White-clawed crayfish

A single white-clawed crayfish was recorded from site 1 on the Feeghroe Stream during the survey. This watercourse has indirect downstream connectivity (approx. 5.7km, via the Rapemills River) with the River Shannon. Despite some moderate to good suitability for the species at certain sites (e.g. sites 6, 7, 9), no live crayfish were recorded from any other site via sweep netting or hand searching. However, crayfish are known locally from site 6 (Little Cloghan River) and the connected settlement pond at site 7 (Bord na Móna pers. comm.), both in the vicinity of the Derrinlough briquette factory. Walkover surveys failed to identify remains of crayfish in mustelid spraint in the vicinity of any survey sites.

White-clawed crayfish typically require hard, mineral rich waters flowing over (high calcium) calcareous substrates, preferably with alkalinity levels of >100mg $CaCO_3$ (Lucey & MacGarrigle, 1987; Holdich, 2003; Gallagher et al., 2006). Consequentially, crayfish distribution follows many of Ireland's carboniferous limestone belts and occurs mostly throughout the limestone-rich midlands. Whilst the Derrinlough wind farm site drains Clongawny and Drinagh Bogs, these areas are underlain by carboniferous limestone and mudstones (Waulsortian limestones, GSI, 2019). Alkalinity levels are appreciably high across the riverine sampling sites (≥169 mg $CaCO_3$/l, Table 3.7) and are therefore, physiochemically capable of supporting white-clawed crayfish. Aside from site 1 on the Feeghroe Stream, sites 6 (Little Cloghan River) and 7 (settlement pond) are known locally to support crayfish despite a lack of records during the current survey.

Siltation is known to negatively impact respiratory function of crayfish (Rosewarne et al., 2014) and the high levels of peat-derived, flocculent sediments in the majority of survey sites (e.g. site 2, 5, 10, 11) have resulted in sub-optimal crayfish habitat, despite some suitable physiochemical and physical habitat parameters.

Water quality

Water quality was measured both physiochemically (i.e. surface water samples tested by a laboratory) and biologically (i.e. Q samples).

The biological water quality was recorded as good status **Q4** as required under the Water Framework Directive (2000/60/EC) at site 9 but at none of the other sites Q-sampling sites (i.e. sites 1, 2, 4, 5, 6, 10 & 11). These sites had biological water quality recorded between **Q2** and **Q3** (i.e. either bad or poor status). The channelised nature of many of the watercourses and high quantities of peat is considered to be the main reason for the poorer recorded biological water quality.

The physiochemical samples recorded at the same *n*=8 sites recorded elevations in Total Oxidised Nitrogen (TON), Total Ammonia and Dissolved Organic Carbon (DOC). Sites 2, 6, 9, 10 and 11 failed to meet good quality standards, with all TON levels exceeding 2.246mg N/l, thus not meeting the 1.8mg/l threshold for good status water. Total ammonia (sum of ammonia and ammonium) levels at sites 1, 2 and 5 were considered high with all sites recording levels of ammonia at ≥0.352mg N/l) (Table 3.7 results). Sites 1, 4, 5, and 10 had elevated DOC levels (≥58.9 mg C/l). These elevations likely reflect the greater levels of humic substances present, originating from adjacent cutover bog habitats. Overall, the observed localised elevations in ammoniacal substances and DOC would not be considered unusual for watercourses emanating from extensive peat cutover.

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Triturus Environmental Ltd.,

42 Norwood Court,

Rochestown,

Co. Cork.