Appendix 6C

Aquatic Report

MWP

Aquatic Ecology and Fish Report

Ballycar Wind Farm

Ballycar Green Energy

January 2024

Contents

Tables

Figures

Plates

Appendices

Project No.	Doc. No.	Rev.	Version	Date	Prepared By	Checked By	Approved By	Status
22156	6001	B	01	20/12/2022	GH	PD	PB	DRAFT Sent for Client review
22156	6001	C	01	04/12/2023	GH	PD	PB	Revised after client review
22156	6001	C	01	19/01/2023	GH	PD/MT	PB	FINAL

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Non-Technical Summary

A suite of aquatic ecology and fish surveys were undertaken during the summers of 2021 and 2023, and February 2022 to establish the importance of watercourses potentially affected by the proposed Ballycar Wind Farm. A total of 12 sites were examined (10 in 2021, 12 in 2023) on streams draining the proposed development site. Habitat surveys were performed to assess the suitability of streams in terms of their importance to fish. Electrical fishing was carried out to assess fish populations. Biological sampling (surveying for aquatic animals) was used to measure water quality. Water samples were taken and analysed for important water quality elements. Data for these surveys were complimented with existing information to form conclusions e.g. site previously examined in the Blackwater (Clare) catchment to the north of the proposed development (referred to as Site 11).

The watercourses potentially affected by the proposed development are small streams and land drains with gradients decreasing with distance from the proposed development. Salmonid spawning and nursery areas are of variable quality across the sites surveyed. There are no suitable fish habitats within the proposed development site as all waterbodies are too small. The streams draining the site increase in value for salmonids with distance from source, due to their increasing size. The watercourses draining the proposed development site collectively support brown trout, European eel and brook lamprey. These streams are generally shallow, have migratory fish passage problems and some water quality issues.

It is concluded, with the exception of the River Shannon, that migratory lampreys (sea and river lamprey) are highly unlikely to occur in the watercourses potentially affected by the proposed development, and that salmon are not present in the Cromapun East and Ballycannan catchments. This is due to stream size, poor habitat in the lower reaches of these streams and impediments to fish passage. There appears to be no fish population in the South Ballycar or West Roo Streams that drain the eastern extent of the proposed development. This is most likely due to steep artificial inclines where these streams meet the River Shannon. Salmon, along with minnow, three spine-stickleback and stone loach occur in the Blackwater catchment north of the proposed development site.

No protected aquatic macroinvertebrates were recorded in the subject streams. The streams draining the proposed development site largely support pollution tolerant animals with a smaller proportion of pollution sensitive species. Biological water quality at the study sites varied between Q3-4 (slightly polluted) to Q4-5 (unpolluted). Biological water quality was generally satisfactory in the upper reaches of streams draining the proposed development. Some local water quality issues associated with agriculture were found to be impacting water quality however. Runoff from bare soils next to one stream draining the site was causing substrate siltation which in turn led to reduced biological diversity and reduced biological water quality.

The proposed development site is used by breeding and foraging frogs. The streams downslope of the site are important frog refugia during summer time.

Mitigation measures will be required to contain soil/sediment within construction areas. It is considered that water quality and aquatic species can be protected with appropriate mitigation.

1. Introduction

MWP have been commissioned by Ballycar Green Energy Ltd. to prepare an Environmental Impact Assessment Report (EIAR) to accompany a planning application in Co. Clare. A full description of the proposed development is outlined in Chapter 2 of the EIAR.

A suite of aquatic ecology and fish surveys were undertaken to inform this assessment and report. The study area includes the water features within the proposed development site and watercourses considered to be part of the receiving environment of the project.

This report outlines the survey methods deployed to collect field data and presents the related findings. The ecological features covered in this report are fish, macroinvertebrates, amphibians and aquatic ecology, in addition to water quality assessments.

This report is based primarily on field studies of watercourses potentially affected by the proposed development. Some information collated from desk studies has also been included in this report. The proposed grid connection route (GCR) is within the Blackwater catchment to the north of the proposed windfarm. This report contains results from a survey carried out by MWP ecologists in 2018 at a site within the Blackwater catchment, which can be regarded as a reference site going forward.

1.1 Statement of Authority

This report and the related field surveys were carried out by Gerard Hayes. Gerard is a Senior Aquatic Ecologist with over 13 years' experience in environmental consultancy. He is a member of the Chartered Institute of Ecology and Environmental Management (MCIEEM) and the Freshwater Biological Association (FBA). Gerard has a diverse ecological profile, with Phase 1 habitat, tree, mammal (including bats), fish, bird, amphibian, macroinvertebrate survey experience. He has had numerous responsibilities including report writing (EIAR, EIA, EA, AA, NIS), waste assimilation capacity assessment and ecological monitoring. His area of expertise covers infrastructure projects ranging from wind energy development, waste-water treatment, roads/bridges, water supply, flood defence and hydroelectric schemes. He is co-author and/or carried out surveys for NPWS Irish Wildlife Manual Nos. 15, 24, 26, 37, 45.

1.2 Guidance and Legislation

The assessment has regard to the following legislation:

- European Communities Environmental Objectives (Surface Waters) Regulations 2009 (S.I. 272 of 2009) and (Amendment) Regulations 2012 and 2015;
- Birds and Natural Habitats Regulations 2011 (S.I. No. 477/2011), and (Amendment) Regulations 2013 and 2015; and
- Wildlife Act 1976 as amended.
- Council Directive 78/659/EEC of 18 July 1978 on the quality of fresh waters needing protection or improvement in order to support fish life;

- S.I. No. 293/1988 - European Communities (Quality of Salmonid Waters) Regulations, 1988;
- S.I. No. 258/1998 - Local Government (Water Pollution) Act, 1977 (Water Quality Standards For Phosphorus) Regulations, 1998;
- S.I. 296 of 2009, European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations';
- S.I. No. 288/2022, European Communities Environmental Objectives (Surface Waters) (Amendment) Regulations 2022.

The European Communities Environmental Objectives (Surface Waters) Regulations 2009 (S.I. 272 of 2009) and (Amendment) Regulations 2012 and 2015 establish legally binding quality objectives for all surface waters and environmental quality standards for pollutants for purposes of implementing provisions of E.U. legislation on protection of surface waters. These regulations clarify the role of public authorities in the protection of surface waters and also concern the protection of designated habitats.

The Water Framework Directive (WFD), (2000/60/EC) is EU legislation and a major driver for achieving sustainable management of water in Ireland and across the EU. The objective of this directive is to prevent any further deterioration in status of all inland and coastal waters and to restore polluted waterbodies to at least 'Good' ecological status. 'Good ecological status' means achieving satisfactory quality water, suitable for local communities' drinking, bathing, agricultural, industrial and recreational needs, while maintaining ecosystems that can support all the species of plants, birds, fish and animals that live in these aquatic habitats.

The European Communities Birds and Natural Habitats Regulations 2011 transpose the Habitats Directive and the Birds Directive. The Habitats Directive contributes to ensuring biodiversity in the European Union by conserving natural habitats and wild fauna and flora species. It sets up the 'Natura 2000' network, the largest ecological network in the world. Natura 2000 comprises special areas of conservation designated by EU countries under this directive and special protection areas classified under the Birds Directive (Directive 2009/147/EC).

The Wildlife Act, 1976 provided a good legislative base for nature conservation. The species protection provisions, including those regulating hunting, are quite comprehensive, to the extent, for example, that they largely foresaw similar aspects of the EU Birds and Habitats Directives.

Relevant guidance published by the National Roads Authority (NRA, now TII), and applicable to assessing watercourses in Ireland were also followed, including 'Guidelines for the Crossing of Watercourses during the Construction of National Road Schemes' (NRA, 2005). IFI (2016) 'Guidelines on Protection of Fisheries during Construction Works in and Adjacent to Waters' was also consulted in relation to necessary mitigation.

Section 171 of the Fisheries (Consolidation) Act 1959 creates the offence of throwing, emptying, permitting or causing to fall onto any waters deleterious matter. Deleterious matter is defined not only as any substance that is liable to injure fish but is also liable to damage their spawning grounds or the food of any fish, or to injure fish in their value as human food, or to impair the usefulness of the bed and soil of any waters as spawning grounds, or other capacity to produce the food of fish. It is necessary to get written permission from Inland Fisheries Ireland to proceed with works in any areas where disturbance to the spawning and nursery areas of both salmonids and lampreys occur. Salmon, all lamprey species, and their habitats are further protected under the EU Habitats Directive.

Under Section 3 of the Local Government (Water Pollution) Act, 1977 (as amended by Sections 3 and 24 of the 1990 Act) it is an offence to cause or permit any polluting matter to enter waters. Suspended solids would be a key parameter here. Likewise, any visual evidence of oil/fuel in the watercourse would constitute an offence.

Relevant guidance considered as part of this assessment and report includes:

- National Roads Authority (NRA, now TII), and applicable to assessing watercourses in Ireland
- Guidelines for the Crossing of Watercourses during the Construction of National Road Schemes' (NRA, 2008).
- Guidelines on Protection of Fisheries during Construction Works in and Adjacent to Waters' IFI (2016), was also consulted in relation to necessary mitigation.
- Methods for the Water Framework Directive - Electric Fishing in Wadable Reaches' (CFB, 2008)

1.3 Consultation

Consultation was carried out with Inland Fisheries Ireland (IFI) on 17th December 2021 (see **Appendix 1B** of the EIAR). IFI's initial concerns and recommendations in relation to the proposed development relate to the protection of the aquatic resource and the associated riparian habitat, in particular, the protection of streams such as East Ballycannan, Cappateemore East and Crompaun streams that cross or bound the proposed site and which feed into the River Shannon. IFI noted that:

- The discharge of polluting or deleterious matter to any watercourse except under and in accordance with a licence may be an offense under the Fisheries Acts and/or under the Water Pollution Acts; and
- Should works be approved a finalised CEMP must be agreed with Inland Fisheries Ireland before works commence.

IFI supplied general comments relating to the existing environment which apply to all wind farm developments as outlined hereunder, as follows:

1. All watercourses that will receive drainage from the construction sites of the turbines or the access roads must be assessed in terms of aquatic biodiversity with particular emphasis on fish, the food of fish, spawning grounds and fish habitat in general.
2. The aquatic habitat and physical nature of any watercourse affected by the development must be fully described in detail. This includes areas of open water, pool riffle glide sequences, density and types of aquatic vegetation, description of riparian zones to depth of at least 10 metres on either bank etc. The extent of the surveys should be sufficiently long enough so as to be representative of the habitat contained in that watercourse. There should be a particular focus on sections upstream and downstream of any point where an impact on the watercourse is likely to arise.

It is considered that the scope of this report will satisfy the feedback, outlined above, from the IFI consultation response.

IFI comments relating to aquatic ecology mitigation are presented in **Section 4** 'Mitigation Measures'. These will be important in design and mitigation for the proposed development. Other IFI concerns and recommendations concern soils and hydrology, which are outside the scope of this report, and addressed in the relevant chapters of the EIAR (**Chapter 08 Water, Chapter 09 Land and Soils**).

2. Methodology

2.1 Scope

The study area was defined as fluvial habitats (watercourses) potentially affected by the proposed development, including within the proposed development site boundary, and those downstream, within the receiving environment. While survey locations down-gradient of the proposed development area are influenced by factors outside of the site boundary, downstream biota are nonetheless receptors with regard to potential effects of the proposed development. Therefore, baseline information at these locations is required to help inform a more complete understanding of aquatic sensitivities in the receiving environment. Indeed, the larger size of watercourses downstream of the proposed development site provide more habitat and are considered more suitable for aquatic biota than reaches inside the proposed development site boundary.

The EPA/OSI registered watercourses were the focus of the aquatic field study. This watercourse data is publicly available[1] and is the standard source of identifying significant flowing surface waters (streams and rivers). Aquatic survey locations were selected on such watercourses given that these are the most important in terms of evaluation with regard to diversity of aquatic life, and discerning water quality, in the receiving environment. It is noted that the pathways of some EPA/OSI registered streams are altered due to natural and/or anthropogenic influences and therefore do not always occur where they are indicated on mapping. Every effort has been made to map the most significant overland flow pathways within the proposed development site using the EPA waterbody dataset in combination with field surveys. Other surface water features including overland flow pathways and areas of standing water were also identified within the zone of potential influence[2], with more emphasis on establishing the presence of such features overlapped by and in close proximity to proposed infrastructure. It is important to note that preferential overland surface water pathways can be difficult to ascertain during dry periods. With the level of surveying carried out, which took place during a range of conditions of saturation, it is considered that all significant overland flows have been recorded.

2.2 Desk Study

A desktop review was carried out to collate information on fish and to identify features of aquatic ecological importance within the study area (the water features within the proposed development site and watercourses considered to be part of the receiving environment). Records of protected aquatic species in the environs of the proposed development were identified. This information was obtained by accessing the website of the National Parks & Wildlife Service (NPWS)[3] and Inland Fisheries Ireland (IFI)[4]. The database of the National Biodiversity Data

[1] https://gis.epa.ie/EPAMaps/Water

[2] As described in CIEEM (2018), the 'zone of influence' for a project is the area over which ecological features may be affected by biophysical changes as a result of the proposed project and associated activities. This is likely to extend beyond the project site, for example where there are ecological or hydrological links beyond the site boundaries.

[3] https://www.npws.ie/maps-and-data

[4] https://www.fisheriesireland.ie/

Centre (NBDC)[5] was consulted to assess the presence of aquatic faunal species and records of protected species from records of the study area. The document '*Quantification of the freshwater salmon habitat asset in Ireland*' by McGinnity *et al.* (2003) was also reviewed to classify the salmonid habitats in the study area. The watercourses names follow EPA nomenclature, and stream order is described using the classification system given in Strahler (1957) which defines stream size based on a hierarchy of tributaries (with 1st order streams being the smallest).

MWP carried out aquatic surveys in the Blackwater (Clare) catchment during August 2018. Survey results from the 2018 surveys at the R465 Bridge were used in this report as the proposed grid connection route (GCR) occurs in the Blackwater catchment. The surveys undertaken at R465 Bridge are referenced as Site 11.

2.3 Field Surveys

The field surveys comprised aquatic assessment at representative sites on watercourses in the study area as shown in Figure 1 and Table 1. These sites were selected at/near roads and/or tracks, given that these sites may require monitoring at a later stage. The following surveys were completed:

- Evaluation of aquatic habitats;
- Fish survey;
- Biotic assessment using aquatic macroinvertebrates; and
- Water sampling for analysis of physico-chemical water quality parameters.

Water quality affects the viability and quality of salmonid habitat so is useful in assessing habitats for aquatic organisms, including trout and salmon. To this end biological sampling and water quality indices, as well as macroinvertebrate functional feeding group analysis were used to evaluate watercourses at selected locations. Field work pertaining to aquatic habitats and macroinvertebrates at Site 1 – Site 10 was carried out between the 18th and 24th of June 2021. Biological sampling and water sampling for physico-chemical analysis was repeated at Site 1 – Site 10 on 21st and 22nd June 2023. Aquatic habitat surveying was undertaken at Site 12 in June 2023. Site 11 and Site 12, which are located in the Blackwater River catchment were added following an extension of the proposed development into this catchment, noting that data for Site 11 was from a survey carried out in 2018.

Survey site photographs can be seen in Plate 1 to Plate 6.

2.3.1 Aquatic Biosecurity

In cognisance of the risk of spread of non-native invasive alien species, the Inland Fisheries Ireland (IFI) document '*Biosecurity Protocol for Field Survey Work*' (IFI, 2010) was followed at all stages of field work. A strict biosecurity protocol including the Check-Clean-Dry approach was adhered to during surveys for all equipment and PPE used. All equipment (including waders etc.) was disinfected with spray bleach disinfectant after use, washed, dried out and put in storage.

[5] http://www.biodiversityireland.ie/

Table 1: Survey locations and survey types on watercourses draining the proposed Ballycar Wind Farm.

Hydrometric Area	Subbasin	River Catchment	Watercourse	River Segment Code	Stream order	Site	Coordinate		Survey			
							x	y	Habitat survey	Fish survey	Biotic assessment	Water sampling
Shannon Estuary North	Crompaun (East)_010	Crompaun (East)	Crompaun	27_755	2	Site 1	553790	663975	✓	✓	✓	✓
			Glennagross	27_431	2	Site 2	554084	663753	✓	✓	✓	✓
			Cappateemore east	27_277	1	Site 3	554792	663405	✓	✓	✓	✓
			Crompaun East	27_1129	3	Site 4	555000	662040	✓	✓	✓	✓
Lower Shannon	North Ballycannan_ 010	North Ballycannan	North Ballycannan	25_866	1	Site 5	556531	663068	✓	✓	✓	✓
			North Ballycannan	25_185	2	Site 6	556445	661639	✓	✓	✓	✓
			West Ballycannan	25_1699	2	Site 7	556084	661408	✓	✓	✓	✓
			South Ballycar	25_1694	1	Site 8	556538	664031	✓	✓	✓	✓
			South Ballycar	25_181	3	Site 9	557344	661790	✓	✓	✓	✓
			West Roo	25_1150	2	Site 10	558026	662034	✓	✓	✓	✓
	Blackwater (Clare_010)	Blackwater (Clare)	Blackwater (Clare)	25_3209	3	Site 11	559355	665585	✓	✓	✓	
			Kilnacreagh	25_3206	1	Site 12	553630	665468	✓			

Blackwater River (Site 11) surveyed in 2018 only, results based on desk study data

Biotic assessment and water sampling carried out in 2021 and 2023 for sites 1 – 10

Kilnacreagh Stream (Site 12) surveyed in 2023 only

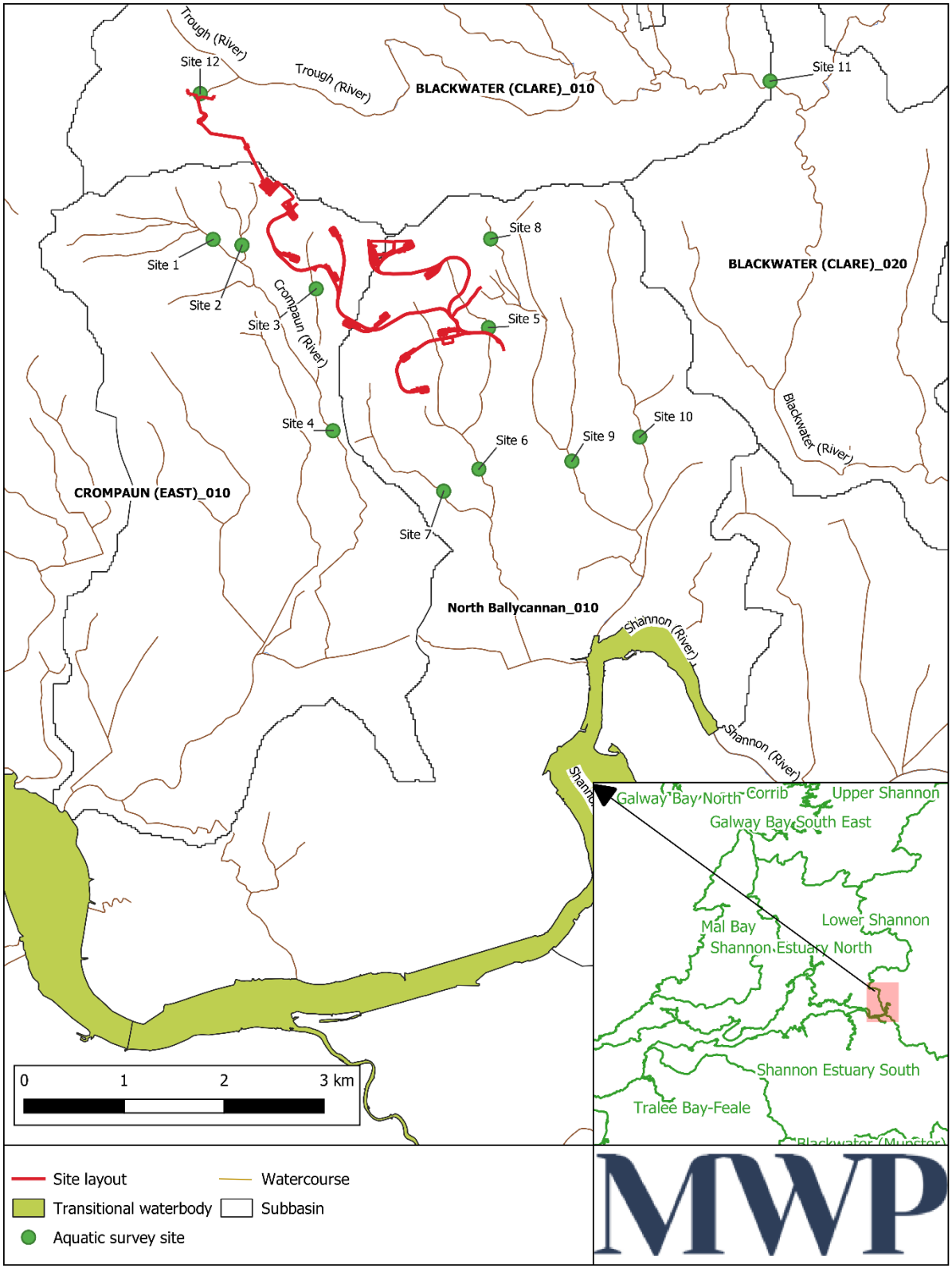


Figure 1: Watercourses and survey sites examined as part of the aquatic ecology studies for the proposed Ballycar Wind Farm.

Plate 1: Site 1 (left) on the Crompaun Stream and Site 2 (right) on its 1st order tributary the Glennagross Stream.

Plate 2: Site 3 (left) on the Cappateemore east Stream and Site 4 (right) on the Crompaun East Stream.

Plate 3: Site 5 (left) and Site 6 (right) on the North Ballycannan Stream.

Plate 4: Site 7 (left) on the West Ballycannan Stream and Site 8 (right) on the South Ballycar Stream.

Plate 5: Site 9 (left) and Site 10 (right) on the South Ballycar and West Roo Streams, respectively.

Plate 6: Site 11 on the Blackwater River (Clare) at the R465 Bridge (left). Site 12 (right) on the Kilnacreagh Steam in the vicinity of the grid connection.

2.3.1.1 Aquatic Habitats

Habitat assessment was carried out at these sites using 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). Watercourses were photographed at survey site locations and at various locations throughout the study area. Anthropogenic and livestock influences on fluvial and riparian habitats were noted along the surveyed stretches. Aquatic survey 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[6], glide[7] and pool[8] in the sampling area;
- Instream vegetation, listing plant species occurring and their percentage coverage of the stream bottom at the sampling site (as applicable) and on the bankside; and
- Estimated cover by bankside vegetation, giving percentage shade of the sampling site.

2.3.1.2 Macroinvertebrate Habitat Evaluation

Habitat has a key influence on the macroinvertebrate communities, which occur in rivers and streams. The physical habitats of survey sites were assessed in relation to macroinvertebrates using a method given by Barbour and Stribling (1991). This method assesses habitat parameters and rates each parameter as optimal, sub-optimal, marginal or poor (scores 5, 10, 15 and 20 respectively). The scores for each parameter are then added up to give an overall habitat score. Appendix 1 of this report shows how habitats are assessed using this method.

2.3.1.3 Fish Habitat Evaluation

The results of the aquatic habitat survey were used in conjunction with the document '*Ecology of the Atlantic Salmon*' (Hendry and Cragg-Hine, 2003) to assess habitat suitability for salmonids at selected representative sites. An evaluation of lamprey nursery habitat was also carried out based on the habitat requirements of juvenile lampreys as outlined in Maitland (2003). Searches for juvenile lampreys were carried out using agitation sampling where suitable nursery habitat occurred.

The results of the stream habitat surveys were used in conjunction with the leaflet '*The Evaluation of habitat for Salmon and Trout*' (DANI, 1995) to assess habitat suitability for salmonids at selected representative sites. This leaflet (Advisory leaflet No. 1) was produced by the Department of Agriculture for Northern Ireland Fisheries Division and was designed for use in the EU salmonid enhancement programme.

[6] Described in EA (2003) as shallow, fast-flowing, water with a distinctly disturbed surface over unconsolidated gravel-pebble, or cobble, substrate

[7] Laminar flow where water movement did not produce a disturbed surface

[8] Little/no observable flow

2.3.2 Macroinvertebrates

2.3.2.1 Benthic Macro-invertebrate Sampling

Semi-quantitative sampling of benthic macroinvertebrates, or aquatic insects, was undertaken at all survey sites[9] using kick-sampling (Toner *et al*., 2005). Benthic (bottom dwelling) macroinvertebrates are small stream-inhabiting creatures that are large enough to be seen with the naked eye and spend all or part of their life cycle in or on the stream bottom. Three replicate, 3-minute, multi-habitat kick samples were taken within a 50m stretch using a 1mm mesh kick net (see Plate 7). All samples of invertebrates were combined for each site and live sorted on location, fixed in ethanol and labelled for subsequent laboratory identification.

The relative abundance and numbers of macroinvertebrates was recorded on-site at each sampling location. Macroinvertebrate sampling was carried out in accordance with *ISO 5667-3:2004: Water Quality – Sampling – Part 3: Guidance on the Preservation and Handling of Water Samples* and *ISO 7828: Water Quality – Methods of biological sampling – Guidance on Hand net sampling of aquatic benthic macro-invertebrates*. Macroinvertebrates were identified using keys listed in the references section. Biological water quality assessments and Functional Feeding Group (FFG) analysis was carried out for each site using biotic indices, based on the range and abundances of macroinvertebrates recorded. Details of biotic indices and FFG are provided in Appendix 2 of this report.

Plate 7: Biological sampling including live sorting of macroinvertebrates (left) was undertaken at selected representative watercourses in the study area. Biological water quality sampling apparatus employed during the on-site investigations (right).

[9] Except for Site 12, which was too small, too overgrown and difficult to access.

Plate 8: Aquaread used to take physico-chemical readings onsite (left). Electrical fishing on the Crompaun East Stream at Site 4 (right).

2.3.2.2 Freshwater Pearl Mussel Survey

The study area is not within a catchment listed in the NPWS *Margaritifera* Sensitive Areas Map[10] but selected reaches listed in **Table 2** and illustrated in **Figure 1** were surveyed on a precautionary basis. MWP applied for and were issued a licence from NPWS to carry out freshwater pearl mussel (FPM) *Margaritifera margaritifera* survey work in the study area. The surveys were carried out between 18th and 24th June 2021 (licence No. C47/2021). The potential for FPM to occur along each watercourse draining the proposed development site was assessed with reference to the following publication: Conserving Natura 2000 Rivers Ecology Series No. 2 *'Ecology of the Freshwater Pearl Mussel*' (Skinner *et al.*, 2003). The areas surveyed were then selected on the basis of suitability (watercourse size, modifications), accessibility (incl. safety), proximity to site, and zone of influence. The Crompaun River was not selected for survey taking account of the physically degraded state on the lower reaches, the only part of the catchment with enough flow to support FPM.

Table 2: FPM survey location in the study area of the proposed Ballycar wind farm, Co. Clare.

Hydrometric Area/River Basin	Subbasin	Waterbody / Code	Segment code	Stream order	Survey stretch (ITM)		Approx. length of channel surveyed (m)
					Upstream	Downstream	
25/Lower Shannon	North Ballycannan	North Ballycannan	25_3896	3	556937, 659784	157546, 159729	500

Surveying for FPM was carried out following the NPWS guidance '*Margaritifera margaritifera'* Stage 1 and Stage 2 survey guidelines, Irish Wildlife Manuals, No. 12' (Anon, 2004). The watercourse reaches examined as subject to a presence/absence survey which involved wading in the river while viewing the substrate and looking for FPM with the aid of a bathyscope and with polarised sunglasses. Instream movements were from downstream to upstream. The survey also involved checking for the presence of dead shells, particularly in depositing areas.

[10] https://www.npws.ie/maps-and-data/habitat-and-species-data

The river condition and habitat features at the survey stretch were noted. The habitat was evaluated with reference to Environmental Quality Objectives (EQOs) as specified in Schedule 4 of the '*European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations'*, S.I. 296 of 2009.

Results for the survey reach were compared with the ecological quality objective set for macroalgae in the European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations, S.I. 296 of 2009 (See **Table 3**). The following evaluation ranges for population densities, siltation and filamentous algae were employed in the survey, based on the monitoring methods set out in the Freshwater Pearl Mussel Sub-basin Plans (North South 2, 2009) and employed by the NPWS during Freshwater Pearl Mussel monitoring:

Population densities:

- Abundant (>250 per 100m of channel);
- Frequent to Common (20 – 250 per 100m);
- Occasional (less than 20 per 100m); and
- Absent.

Siltation:

- no visible silt plume;
- some visible silt; and
- a lot of visible silt.

Algae

- *Rare:* just visible in the field, covers < 1 % of the riverbed;
- *Occasional*: covers 1 % to < 5 % of the riverbed;
- *Frequent*: covers 5 % to < 25 % of the riverbed;
- *Abundant*: covers 25 % to < 50 % of the riverbed*; and*
- *Dominant*: covers > 50 % of the riverbed.

Table 3: Ecological Quality Objectives for Freshwater pearl mussel habitat.

Element	Objective	Notes
Filamentous algae (Macroalgae)	Absent or Trace (<5%)	Any filamentous algae should be wispy and ephemeral and never form mats
Phytobenthos (Diatoms)	EQR 0.93	High status
Macrophytes Rooted higher plants	Absent or Trace (<5%)	Rooted macrophytes should be absent or rare within the mussel habitat
Siltation	No artificially elevated levels of siltation	No plumes of silt when substratum is disturbed

from S.I. No. 296 of 2009

2.3.3 Biological Water Quality

Benthic macroinvertebrates, or aquatic insects were used as an indicator of water quality at each sampling site, with the exception of Site 12. The Quality Rating (Q) System and other biotic indices described below were used to classify biological water quality at all aquatic survey sites (See **Table 1** and **Figure 1**). The Kilnacreagh Stream (Site 12) was unsuitable for assigning a Q-rating or any other biotic index due to its small size, marginal habitat and difficult access.

2.3.3.1 Biotic Indices

Biotic indices used to assess water quality are described here and further detail is provided in Appendix 2.

2.3.3.1.1 *Quality Rating (Q) System*

The Quality Rating (Q) System devised by Toner *et al.* (2005) was used to obtain a water quality rating, or Q-value. As per S.I. No. 258 of 1998, 'biological quality rating' means a rating of water quality for any part of a river based principally on the composition of macroinvertebrate communities/faunal groups present and their general sensitivity to organic pollution. This method categorises invertebrates into one of five groups (A-E), depending on their sensitivity to pollution. Q values range from Q1-Q5 with Q1 being of the poorest quality and Q5 representing pristine/unpolluted conditions. The Q index system is used by the Environment Protection Agency (EPA) and is currently the standard biological assessment technique used in surveying rivers in Ireland under the Water Framework Directive (WFD).

Biological quality elements are classified into five WFD ecological status classes – High, Good, Moderate, Poor, and Bad. These have been intercalibrated with the EPA Q-rating system as shown in Appendix 2. These tables also provide a description of each of the ecological status classes based on the definitions in the WFD and the typical ecological responses associated with each class.

2.3.3.1.2 *Biological Monitoring Working Party (BMWP)*

The other main biotic index used was the BMWP score. In the revised BMWP scheme (Walley and Hawkes, 1997), each family recorded in the sample is assigned a habitat specific score. This score depends on the pollution sensitivity of the invertebrate family together with the characteristics of the site where the invertebrates were found. A site is classed as one of the following depending on substrate type: riffle (>= 70% boulders and pebbles), pool (>= 70% sand and silt) or riffle/pool (the remainder). The BMWP score is the sum of the individual scores of the families recorded at each site - a family scores if present. A higher BMWP score is considered to reflect a better water quality and a score over 100 is indicative of very good water quality. Appendix 2 shows revised BMWP scores for riffled locations and the BMWP scoring system. Each site was assigned a biological status on a scale of High-Good-Moderate-Poor-Bad.

The Habitat Specific Scores are based on the following substrate compositions:

- Riffles: >= 70% boulders and pebbles;'
- Pool: >= 70% sand and silt; and
- Riffle/Pool: the remainder.

2.3.3.1.3 *Average Score Per Taxa*

Each site was allocated an Average Score Per Taxa (ASPT). A weakness of the BMWP system, in common with many other score systems, is the effect of sampling effort. A prolonged sampling period can be expected, under most circumstances, to produce a higher final score than a sample taken quickly. To overcome this inherent weakness of the BMWP system, it became common practice to calculate the ASPT. The ASPT index calculation is based on the average value of each taxa (families) sampled and is calculated by summing up the indicator values and their division by numbers of taxa (families) sampled, with the results ranging from 0 to 10. A high ASPT index

value indicates high ecological status and low values indicate bad/degraded ecological status. In general, the higher the number of taxa present, the better the biological quality of the reach, especially where the ASPT values are high (greater than 5.5).

2.3.3.1.4 *EPT Index*

Biological water quality was also assessed using the EPT (**E**phemeroptera **P**lecoptera **T**richoptera) index. The EPT index (Lenat, 1988) uses three orders of aquatic insects that are easily sorted and identified: mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera), and is commonly used as an indicator of water quality. The EPT index is calculated by summing the number of taxa represented by these 3 insect orders. The EPT Index is based on the premise that high-quality streams usually have the greatest species richness. Many aquatic insect species are intolerant of pollutants and will not be found in polluted waters. The greater the pollution, the lower the species richness expected.

2.3.4 Physico-Chemical Water Quality

Water samples were taken on 24th June 2021 and 26th June 2023. See **Table 1** and **Figure 1** for locations. Samples were taken from each site using aseptic techniques and were then stored in a cooler box. The samples were then delivered to BHP Laboratories the following morning. The following physico-chemical parameters were assessed: Ammonium, Total Ammonia, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrate, Nitrite, Orthophosphate, Suspended Solids, Total Phosphorus, Total Hardness, Total Dissolved Solids, and Total Organic Carbon (TOC). Water levels and conditions were noted at the time of the survey.

Each site was assigned a chemical status on a scale of High-Good-Moderate-Poor-Bad based on water quality standards given in Surface Water Regulations (DoEHLG, 2009), the Freshwater Fish Directive (78/659/EEC) and the Salmonid Water Regulations (1998)[11].

Table 4 gives chemical parameter thresholds for achievement of Water Framework Directive 'High' and 'Good' Status.

Table 4: Physico-chemical parameter thresholds for achievement of Water Framework Directive 'High' and 'Good' Status. From the Surface Water Regulations (SWR, 2009 and as amended)

Parameter	High Status	Good Status
BOD	≤1.3 (mean) or ≤2.2 (95%ile)	≤1.5 (mean) or ≤2.6 (95%ile)
Total Ammonia	≤0.040 (mean) or ≤0.090 (95%ile)	≤0.065 (mean) or ≤0.140 (95%ile)
Orthophosphate	≤0.025 (mean) or ≤0.045 (95%ile)	≤0.035 (mean) or ≤0.075 (95%ile)

2.3.5 Functional Feeding Group (FFG) Analysis

Functional Feeding Group (FFG) analysis was undertaken to gain further insight into the aquatic ecology of the receiving environment. FFG analysis was carried out on the macroinvertebrates recorded at each site. FFG is a

[11] http://www.irishstatutebook.ie/eli/1988/si/293/made/en/print

classification technique for stream macroinvertebrates which involves the functional analysis of invertebrate feeding, based on morpho-behavioural mechanisms of food acquisition. Several functional feeding groups of invertebrates occur in streams. These are Shredders, Collectors (or filterers), Scrapers (or grazers), and Predators. Changes in functional groups reflect changes in food sources, nutrient processing and energy flow in the river system. Human influences on a river can dramatically alter food sources and in turn affect the trophic groups. This method of analyses was used as it provides a greater insight into the ecology of a river and can detect more subtle changes in community structure than would be apparent from biotic indices.

The juvenile P/R ratio and salmonid index were calculated based on the relative abundances of macroinvertebrates. The P/R ratio is a measure of the trophic status of a system: the ratio of gross primary production to community respiration (ratio of scrapers to collectors and shredders). If P/R ratio is >1, the system is autotrophic. Heterotrophy vs autotrophy is based on a P/R threshold of > 0.75 = autotrophic (Rabenil *et al*. 2005).

The juvenile salmonid index is the ratio of behavioural drifters (filtering and gathering collectors) to accidental drifters (scrapers, shredders and predators). A predictable juvenile salmonid food supply is based on a threshold of >0.50 (Rabenil *et al*. 2005).

2.3.6 Fish

An electric fishing survey was carried out at all sites (except at Site 12 due to its small size, marginal habitat and difficult access) under authorisation from the Department of Communication, Energy and Natural Resources under Section 14 of the Fisheries Act (1980). Table 5 presents the upstream and downstream limits of the electrical fishing surveys. The purpose of this survey was to assess fish populations present at selected sites on watercourses draining the proposed development. Sites were surveyed following the methodology outlined in the CFB guidance '*Methods for the Water Framework Directive - Electric Fishing in Wadable Reaches*' (CFB, 2008).

Fishing was carried out continuously for 10 minutes at each site. Captured fish were collected into a container of river water using dip nets. On completion of the survey, fish were then anaesthetised using a solution of clove oil, identified, and measured to the nearest mm using a measuring board. Subsequent to this, the fish were allowed to recover in a container of river water and were then released alive and spread evenly over the sampling area. Quantitative/depletion electrical fishing was carried out at Site 4. The area at Site 4 was fished a total of four times (four passes). Records were taken of fish captured from each pass immediately after each pass.

Following completion of the fishing, the dimensions and physical habitat characteristics of each site were recorded, including area and flow characteristics. The electrical fishing surveys were carried out on 18th August 2021 under ideal environmental conditions, low water levels and a bright day. Any fish captured during biological sampling and electrical fishing were recorded and identified with reference to the Freshwater Biological Association's publication *'Key to British Freshwater Fish with notes on their ecology and distribution*' (Maitland, 2004) and other referenced sources.

It is noted that the North Ballycannan Stream is fed by a spring at Site 6 which was contributing significantly to its size during the survey. Electrical fishing was carried out below the influence of this spring.

Catch Per Unit Effort (CPUE) indices were derived for each site surveyed based on numbers of fish captured and time fished. Length - frequency distribution graphs were derived for all salmon and all trout captured during the surveys, and at locations where statistically significant numbers of fish were recorded.

Table 5: Downstream and upstream limits of the electrical fishing surveys undertaken on watercourses draining the proposed development.

River sub-basin	Watercourse	Site No.	Stream Order	Survey extent (ITM)				Length fished (m)	Width fished (m)	Area fished (m²)	Time fished (min)	Passes
				Downstream		Upstream						
				X	Y	X	Y					
Crompaun (East)_010	Crompaun	1	2	553790	663975	553728	664006	50	3	150	10	1
	Glennagross	2	2	554084	663753	554069	663798	45	1.5	67.5	10	1
	Cappateemore east	3	1	554792	663405	554786	663426	60	1.2	72	10	1
	Crompaun East	4	3	555000	662040	554975	662085	58	1	58	10	4
North Ballycannan_010	North Ballycannan	5	1	556531	663068	556511	663120	55	1	55	10	1
	North Ballycannan	6	2	556445	661639	556442	661656	40	0.4	16	10	1
	West Ballycannan	7	2	556084	661408	556072	661457	55	0.5	27.5	10	1
	South Ballycar	8	1	556538	664031	556533	664089	50	0.8	40	10	1
	South Ballycar	9	3	557344	661790	557329	661831	48	1.3	62.4	10	1
	West Roo	10	2	558026	662034	558038	662078	45	1.7	76.5	10	1
Blackwater (Clare)	Blackwater (Clare)	11	3	559393	665563	559338	665586	4	35	140	10	1
				559333	665588	n/a	n/a	n/a	1	1[$]	1	1

[$]*survey aimed at lampreys*

2.3.7 Amphibians

The proposed development site was surveyed for frog spawning locations on 23rd February 2022. The focus of this survey was on wetter parts of the site, namely drainage ditches and depressions holding water. The locations of any frog spawn was recorded. The number of clumps of frog spawn at each location was recorded.

3. Results

This section provides a description of the waterbodies, aquatic habitats, macroinvertebrates (incl. FPM) and fish in the study area based on the survey sites examined. Representative photos of river survey sites and aquatic biota are provided.

3.1 Description of Waterbodies

The eastern and western components of the proposed development are located in Hydrometric Area (HA) 25 (Lower Shannon) and HA 27 (Shannon Estuary North) respectively as indicated in **Figure 1**.

The eastern component of the proposed development is within the North Ballycannan_010 subbasin. This subbasin has an area of ca. 26.5 km^2. The primary watercourses in this area are, from east to west the 3rd order South Ballycar Stream (EPA code 25S75) and North Ballycannan Stream (EPA code 25N17). The South Ballycar Stream rises east of the proposed development site ca. 170 m above sea level (A.S.L) and is fed by four minor 1st order streams within 1.5 km of its source. The South Ballycar Stream flows in a southerly direction for ca. 4 km until meeting the tailrace of the Ardnacrusha hydroelectric scheme. The lower reach of the South Ballycar Stream is fed by the 1st order Glenlon North Stream (EPA code 25G89) and the 2nd order West Roo Stream (EPA code 25W38). The tailrace of the Ardnacrusha scheme is an artificial waterbody and flows only when water is passed through the turbines in the dam. The bed of the 100m reach of the South Ballycar Stream upstream of the headrace has been reinforced with stone and concrete and falls suddenly into the tailrace. Approximately 950 m southwest of this junction, the South Ballycar Stream/tailrace meets the 7th order River Shannon. This reach of the River is influenced by the tide.

The North Ballycannan Stream rises ca. 190 m A.S.L within the proposed development site. It flows in a southerly direction for ca. 4.5 km and discharges to the River Shannon. This stream is fed by the 1st order East Ballycannan Stream (EPA code 25E12) and East Cappateemore Stream (EPA code 25E13), and the 2nd order West Ballycannan Stream (25W23). These are small streams with low base flow and drain the southern and south-eastern component of the proposed development. It is noted that the North Balycannan Stream is fed by a spring at Site 6 which was contributing significantly to its size during current survey.

The western component of the proposed development is within the Crompaun (East)_010 subbasin, a coastal drainage unit. The main watercourse is the 3rd order Crompaun [East] Stream which has a channel length of ca. 10 km. It rises ca. 220 m A.S.L. and is fed within 1.5 km from source by several 1st order streams, including an un-named minor watercourse that drains the western extent of the proposed development (stream segment code 27_430). The 1st order Cappateemore East Stream which has a channel length of ca. 1.6 km also drains the proposed development and flows into the Crompaun East Stream from the north. It is noted that the Cappateemore East Stream, as mapped by the EPA is actually much smaller in size than an adjacent stream that appears to have its source near the source of the Cappateemore East Stream, as indicated in **Figure 3** and shown

in Plate 9 below. This stream that is not mapped by the EPA is classified as an 'eroding / upland river' using Fossitt (2000) criteria and is of far greater ecological importance than the EPA mapped channel.

The lower 5 km reach of the Crompaun Stream has a low gradient has been highly modified by drainage. The Crompaun East Stream discharges to the Shannon Estuary ca. 3km west of Limerick City. Embankments have been constructed along the lower reach to prevent/reduce flooding associated with the Shannon Estuary and tidal influence. The Crompaun East Stream likely has a sluice valve to prevent backflow during high tides.

The proposed GCR and substation location to the north of the proposed wind farm site occur within the Blackwater (Clare) River catchment. The nearest watercourse to the proposed substation is a 1st order unnamed tributary (EPA segment code 27_430) of the Glenagross Stream in the Crompaun River catchment. The grid connection route crosses the 1st order Kilnacreagh Stream (EPA segment code 25_3206) which flows from west to east approximately 50m to the south of the nearest proposed tower to be erected to connect to the existing overhead line. The Kilnacreagh Stream joins the 1st order Trough River (EPA code 25B06, also known as the Blackwater River) which flows in a westerly direction for ca. 5.2 km until it is fed by the 3rd order Derryvinnann River. There is an unmapped watercourse near the northern extent of the proposed development site that flows into the Kilnacreagh Stream as indicated in Figure 3 and shown in Plate 10. This watercourse corresponds to an eroding / upland river.

Plate 9: Cappateemore East Stream as mapped by the EPA (left). Watercourse less than 50m east of the Cappateemore East Stream in July 2023, not mapped by EPA (right).

The Blackwater (Clare) River drains an area between Broadford and Ardnacrusha, where gradient is generally of a south-westerly aspect. It has several tributaries from the north including the 3rd order Snaty River, the 2nd order O'Neill's Stream and the 3rd order Mountrice River. The largest tributary of the Blackwater River is the 3rd order Glenomra Wood Stream which joins the Blackwater River from the north. After the Glenomra River confluence, the Blackwater River flows south for ca. 4km as a 4th order watercourse before intersecting with the headrace of the Ardnacrusha Hydro-scheme. The headrace is classified as a canal, owing to its artificial character. The Blackwater River flows under the headrace through a culvert. At the upper (northern) end of this culvert, the Blackwater River falls steeply over a sloped concrete sill. This is considered a significant barrier to fish migration as flows are fast and would be impassable in the upstream direction for most fish species. After flowing under the headrace, the Blackwater River flows south for ca. 4.5km to meet the 7th order River Shannon at Plassey.

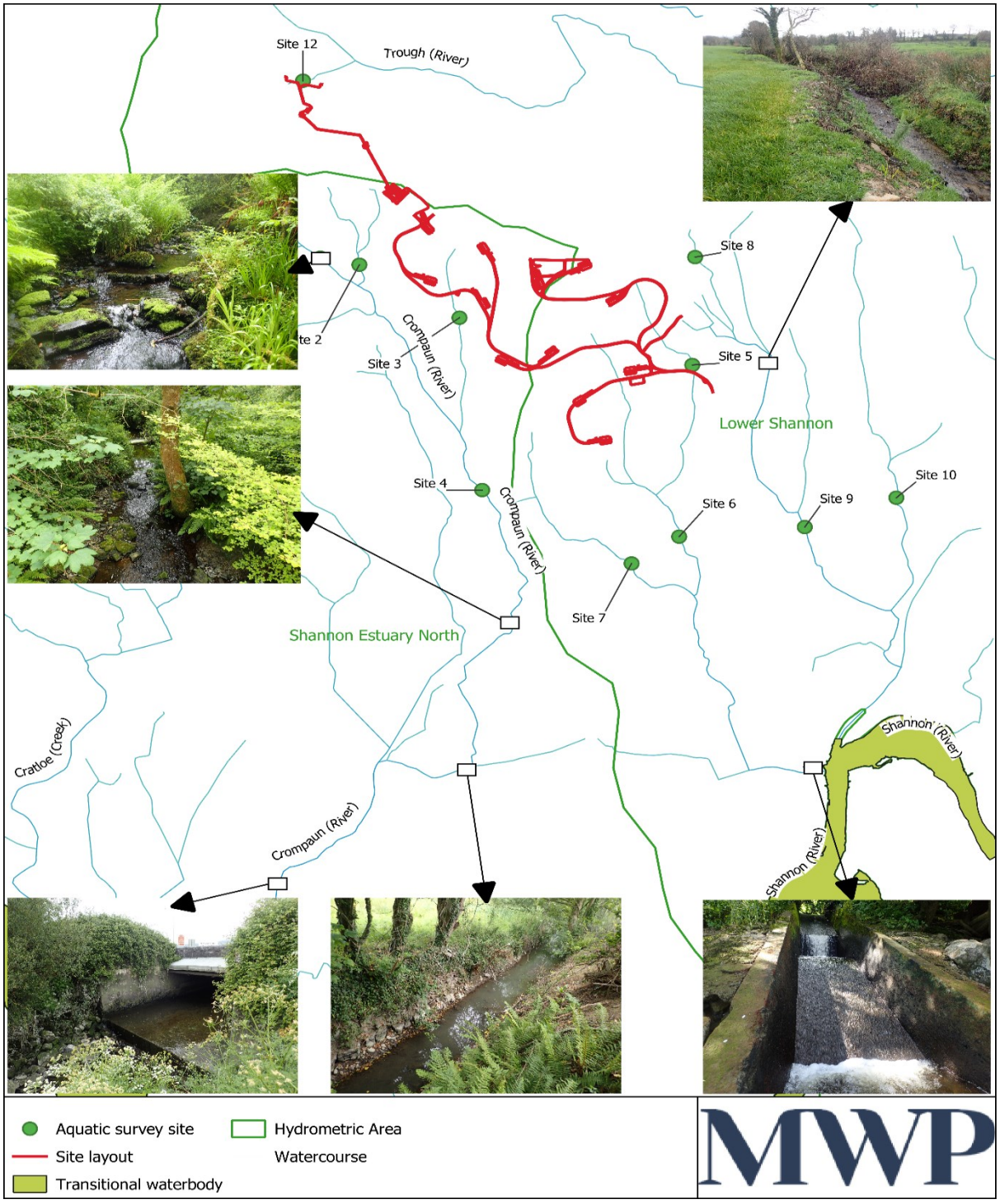


Figure 2: Survey site locations and photographs of some watercourses in the wider study area.

Plate 10: Channel to the east of T4 in July 2023, unmapped by the EPA (left). Watercourse at the northern extent of the proposed development site that feeds the Kilnacreagh Stream in July 2023, not mapped by EPA (right).

Plate 11: Aquatic sponges *Porifera* spp. in the lower reach of the North Ballycannan Stream (left). Zebra mussel in the tailrace of Ardnacrusha power station at the confluence of the South Ballycar Stream (right).

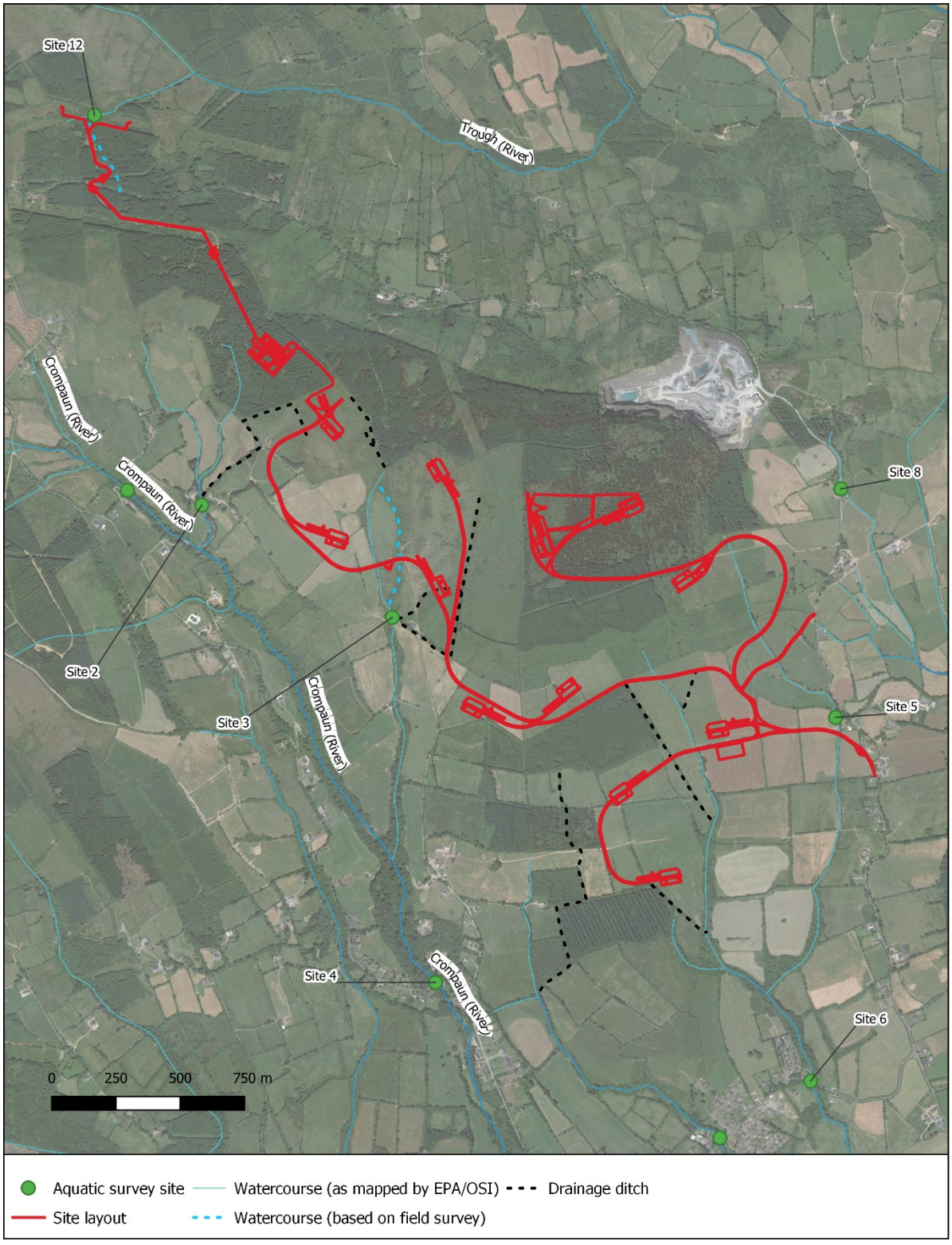


Figure 3: EPA registered watercourses and additional channels recorded during field surveys.

3.2 Aquatic Habitats

The physical attributes of watercourses draining the proposed development are the basis of the aquatic ecosystems supported therein. The habitat quality for macroinvertebrates (Section 3.4.2) and fish (Section 3.3) is a function of watercourse characteristics in the receiving riverine environment. Habitat for FPM is discussed separately in Section 3.5.1.

The watercourses within the boundary of the proposed development site and indeed the upper reaches of all watercourses draining the proposed development site are high gradient streams considered prone to drying out during prolonged dry spells, based on the water levels observed in June 2021 and 2023. These upper reaches therefore were deemed to have limited lotic[12] carrying capacity. These reaches are generally fast flowing and of a spate nature i.e. they are rainwater fed from overland flow and thus exhibit fast repsonse to rainfall. They are categorised as eroding/upland rivers with reference to Fossitt (2000). The watercourses draining the proposed development drain predominantly podzol soils over siliceous geology. The substrates were generally larger type materials like boulder and cobble. The only aquatic vegetation recorded at the aquatic survey sites were (collectively) the bryophytes *Leptodictyum riparium, Conocephalum* sp., *Chiloscyphus polyanthos* and filamentous algae. The cyanobacteria *Lyngbya* was recorded at Site 10. At lower elevations, the streams have lower gradients with generally finer particle sizes and smoother flows. The physical characteristics of survey sites are listed in Table 6.

Excessive siltation was observed at several survey sites. This is considered a result of land management practices associated with activities such as agriculture and commercial forestry. For example, cattle access to the Cappateemore East Stream was found to be adversely affecting substrate quality and water quality through excessive sedimentation. Water level and flow at Site 5 – 8 was very low during the surveys. Such flows can lead to the loss of sensitive macroinvertebrate taxa and biomass due to decreased buffering capacity i.e. rapid changes in temperature, oxygenation, etc.

[12] of organisms or habitats inhabiting or situated in rapidly moving fresh water

Plate 12: Heavy silt plume after kick sampling at Site 3 on the Cappateemore East Stream (left). Siltation and some algal growth at Site 4 on the Crompaun East Stream.

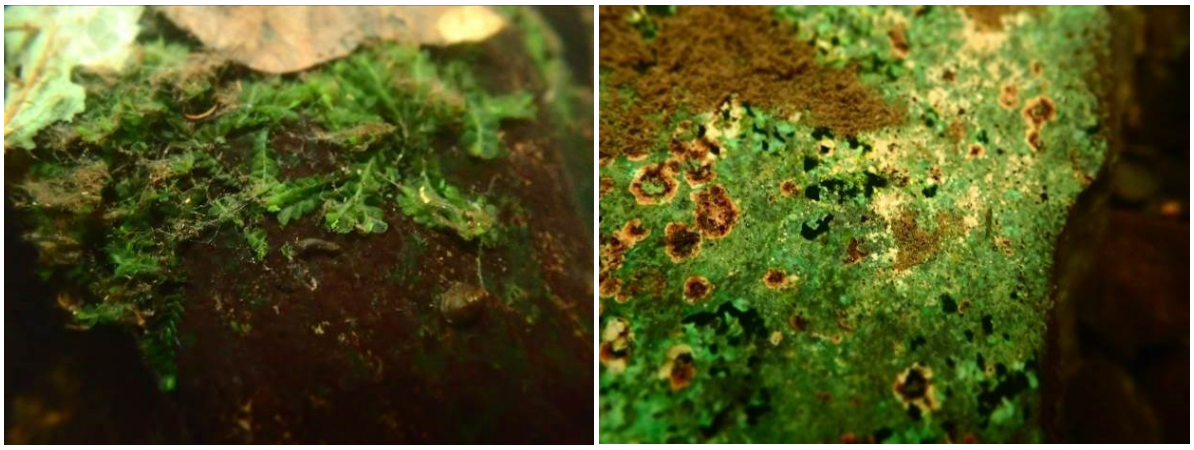


Plate 13: *Chiloscyphus polyanthos* (left) and *Lyngbya* sp. (right).

Table 6: Physical characteristics of the aquatic study sites

Site	1	2	3	4	5	6	7	8	9	10	11	12
Wetted width (m)	1.5	1	1.2	3	0.5	0.8	1	0.4	1.3	1.7	4	0.3
Mean depth (cm)	5	5	3	10	2	3	4	2	5	5	20	<5
Max depth (cm)	40	30	10	60	15	5	15	4	20	35	80	5
Bedrock	5	0	5	0	0	0	0	0	20	10	0	0
Boulder (%)	15	55	25	60	5	5	30	0	20	20	5	5
Cobble (%)	20	20	30	25	15	55	30	50	25	35	50	35
Gravel (%)	40	20	30	10	70	25	20	30	20	30	30	45
Sand (%)	20	5	10	5	10	5	15	5	15	5	10	10
Silt (%)	0	0	0	0	0	10	5	15	5	0	5	5
Overlying silt (%)	30	10	50	55	20	30	60	75	30	50	40	10
Plume	M	M	H	H	M	H	H	H	M	M	H	H
Riffle (%)	55	70	60	45	35	30	25	35	25	50	30	25
Glide (%)	10	5	15	20	0	10	5	5	25	20	40	25
Pool (%)	35	25	25	35	65	60	75	60	50	30	30	50
Algal cover (%)	2	0	0	10	0	55	0	0	0	<1	45	0
Instream vegetation (%)	5	0	5	10*	0	0	0	0	0	0	5	0
Shade (%)	95	90	80	55	85	30	95	75	85	50	70	100
Bank cover (%)	60	100	50	95	100	25	45	100	90	95	75	75

[1] **H**eavy, **M**oderate, **S**light, **N**one

*instream vegetation of bryophytes

3.3 Fish

An account of the fluvial habitats on watercourses draining the proposed development site (PDS) with respect to fish is provided for each site below, but firstly, a general description of fish habitats in the study area is given.

3.3.1 Existing Information

The study area is located in the 10km grid square R56. The distribution and range of protected fish in the 10km grid square containing the proposed development (R56) are illustrated in **Table 7.** This is based on Article 17 (2013 – 2018) Assessments in NPWS (2019) and includes the three lamprey species.

In McGinnity *et al.* (2003), which classifies Irish rivers in terms of salmonid habitats, all watercourses >1st order in the:

- Crompaun East_010 subbasin are indicated as 'Producers of sea trout only'; and
- North Ballycannan_010 subbasin are indicated as 'Not considered a significant producer of Salmonids'.

The River Shannon to the south is classified as a transitional water called 'Limerick Dock' (SH_060_0900). This is a 'Meso or Polyhaline, Strongly Mesotidal, Sheltered' type waterbody. Dace (*Leuciscus leuciscus*) is a non-native species that occurs in the lower reaches of the River Shannon. This species occurs in R56 – part of the River Shannon occurring within this 10 km grid square.

Table 7: Distribution and range of aquatic Annex II listed habitats and species in the 10km grid square R56 containing the study area

	Code	Current distribution	Current range	Likely reason for distribution in the 10km grid square R56
Floating river vegetation	3260	Yes	Yes	The extent of this habitat has not been mapped and the area is based on the distribution of rivers. There are no particularly important watercourses draining the PDS with respect to 3260
Sea lamprey	1095	No	No	n/a
River lamprey	1099	Yes	Yes	Part of the River Shannon, which supports this species occurs within R56
Brook lamprey	1096	No	Yes	n/a
Atlantic salmon	1106	Yes	Yes	Part of the River Shannon, which supports this species occurs within R56
White-clawed crayfish	1092	No	Yes	Part of the River Shannon, which supports this species occurs within R56

Brown trout are the most widespread fish in Ireland and are found in practically every river, stream and lake in the country. Brown trout are not specifically listed for protection by EU directives. In Ireland, brown trout fisheries are regulated by national legislation and bye laws governing closed seasons, angling methods, size limits, bag limits, etc. Angling clubs may also have their own regulations. Sea trout are the migratory form of Brown trout. Sea trout > 40cm fork-length are classified as salmon in terms of legislation and are covered under salmon regulations; commercial and rod harvest of salmon is permitted where stocks are in surplus (exceeding a system-specific Conservation Limit) and the fisheries are very strictly controlled[13].

3.3.2 Overview of Fish Habitats

It is considered that the importance of streams draining the proposed development site generally increase with distance downstream. This is a universal concept related to stream size and water quantities, especially in parts of catchments near watershed boundaries. There are no watercourses of value to fish within the proposed development site. This is due to their small size and propensity to drying out during periods of drought.

The proposed development site is located in three subbasins (Crompaun East_010, North Ballycannan_010, Blackwater (Clare)_010). The fact that these subbasins are small drainage areas, somewhat of coastal context,

[13] https://www.fisheriesireland.ie/fish-species/brown-trout.html

and where the largest watercourses are 3rd order limits their carrying capacity for fish. The south Ballycar and West Roo Streams in the eastern part of the North Ballycannan_010 subbasin do not appear to support any fish.

The watercourses in the Crompaun (east)_010 and Ballycannan_010 are considered unsuitable for salmon due to their small size. Based on the habitats and electrical fishing survey results, it is concluded that salmon do not occur in the watercourses draining the proposed development site, with the exception of the Blackwater (Clare) River. The Blackwater (Clare) is suitable for salmon is as it is sufficiently large and connected to the River Shannon without barriers to migration.

The other watercourses draining the proposed development site all feature some type of impediment to fish movement, either in the form of steep inclines in the case of those in the Ballycannan subbasin or barrages associated with tidal sluices in the Crompaun. Figure 4 gives the designation of rivers as salmonid habitats in the study area. The 1st order streams draining the proposed development are deemed too small to be of importance to trout. Indeed, 1st order watercourses are not shown in McGinnity et al. (2003). For example, trout were detected at Site 1 on a 2nd order reach Crompaun Stream but not on its 1st order tributary the Glennagross Stream at Site 2. The Glennagross Stream features a perched culvert <200m upstream of the Crompaun Stream. This culvert likely blocks the upstream passage of trout, limiting their penetration into the middle reaches of this stream. Recent works has damaged the Kilmoculla Stream, a tributary of the South Ballycar Stream. Runoff from denuded banks and adjacent lands has resulted in excessive instream silt. Instream works has left this stream in uniform shape with reduced physical diversity. Furthermore, a blockage in this stream, probably fencing, has accumulated a considerable amount of silt which has created a small falls which represents a potential fish migration barrier.

The higher gradient reaches of watercourses draining the site are considered suitable for the early life stages of salmonids. Such reaches do not occur within the development boundary due to their small size however. The lower reaches of the watercourses draining the site are more suitable for adult fish, with some deeper pools but these reaches were found to be impacted by siltation and are suboptimal for spawning due to their low gradient and/or degraded morphological character (drained).

Overall, the streams draining the south facing slopes of the site, which includes all turbine infrastructure, are suboptimal trout habitats, poor in terms of lampreys and highly unlikely to support migratory fish populations. The Blackwater catchment to the north is important for salmon and possibly lampreys downstream of its intersection with the Ardnacrusha headrace.

Within the streams surveyed, a small proportion of the fluvial habitat was classified as suitable for salmonid spawning. Such habitats are the transitional areas between pool and riffle where flow accelerates and depth decrease over gravel beds, due to a marked change in hydraulic head over the gravel. The gravel substrates at the end of pools provide spawning areas. It is noted by Crisp (2000) that small trout may spawn in quite small gravel patches between large stones. Such features are deemed important to spawning trout in the mid reaches of streams draining the proposed development site. The small size of the watercourses near the proposed development are unsuitable for holding larger salmonids: the small/shallow pools are not considered sufficiently large for large trout througout the year.

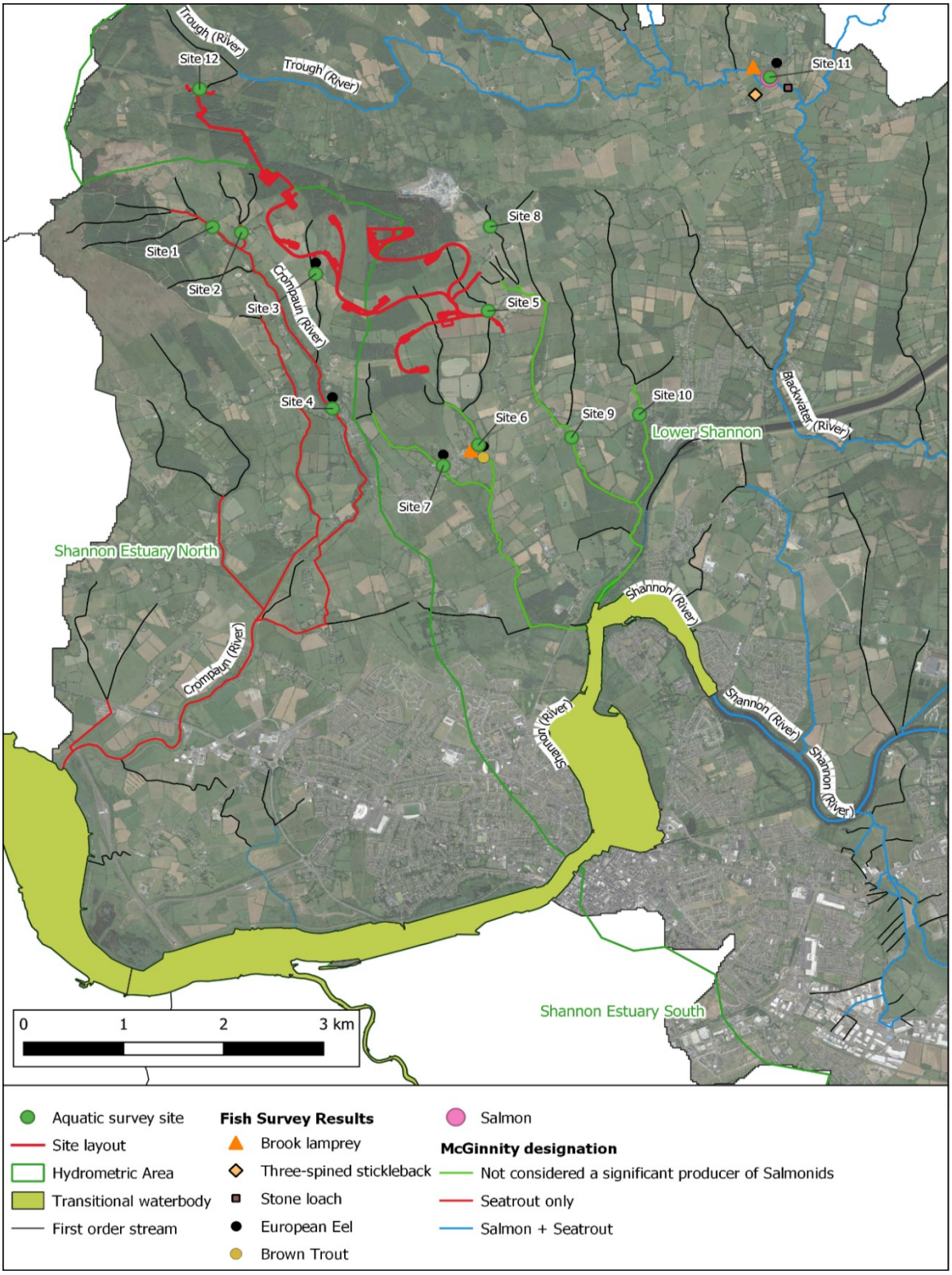


Figure 4: Designation of rivers as salmonid habitats in the study area (based on McGinnity *et al.* 2003) and electrical fishing survey results.

Table 8 gives the habitat rating of the watercourses examined with reference to salmonid habitats.

Table 8: Habitat rating at the sites examined on watercourses potentially affected by the proposed development

Site	Watercourse	Spawning		Nursery		Holding	
		Habitat grade*	fluvial cover$ (≈%)	Habitat grade*	fluvial cover$ (≈%)	Habitat grade*	fluvial cover$ (≈%)
1	Crompaun	2	10	2	50	3	5
2	Glennagross	3	15	2	60	4	5
3	Cappateemore east	3-4	5	2	60	4	5
4	Crompaun East	2-3	10	2-3	80	4	5
5	North Ballycannan	3-4	5	1	10	4	25
6	North Ballycannan	3-4	10	3	80	4	10
7	West Ballycannan	3-4	10	3	50	4	10
8	South Ballycar	4	5	3-4	60	4	5
9	South Ballycar	2	10	2	50	3	20
10	West Roo	2	10	1-2	60	3	15
11	Blackwater	1	10	1-2	60	2-3	25
12	Kilnacreagh	4	5	4	10	4	5

Following DCAL's advisory leaflet '*The Evaluation of habitat for Salmon and Trout*'

**Grade 1 is optimal habitat and habitat quality reduces with increases in Grade (Grade 4 = poor)*

$ *Fluvial cover relates to river substrate under water and available to fish*

The abundance of riffle (broken water), instream rocks, irregularities in the stream bed and overhanging banks and dappled shade, or combinations thereof, generally provide good salmonid nursery habitat in the subject watercourses. There are some obvious water quality problems associated with siltation and enrichment which reduce the quality of salmonid spawning and nursery habitat, however.

Based on the assemblages of instream macroinvertebrate life, good juvenile salmonid food supply was recorded at all survey locations except for Sites 5, 6 and 8. Salmonids, especially at early life stage require good water quality, and generally unsatisfactory water quality conditions at the survey sites means suboptimal water quality conditions for salmonids. Unsatisfactory water quality at Site 4 – Site 7 (Q3-4, See **Section 3.6**) is considered to limit reproductive success (decreasing oxygen supply to ova buried in gravels) and early life stage opportunities for trout. A study by Kelly *et al.* (2007) established that there is a relationship between fish-community composition and Q-values – the abundance of 1+ and older salmon was significantly different between moderate (Q3–4) and good-quality (Q4) sites.

Rocks in the watercourses draining the site are considered important refuges for European eel *Anguilla anguilla.* The European eel is subject to European Council Regulation 1100/2007 '*Establishing measures for the recovery of the stock of European eel*'. Recruitment of glass eels is 5% of the pre-1980's levels[14]. European eel is listed as 'Critically endangered' and is now 'Red Listed' according to '*Red List No. 5: Amphibians, Reptiles & Freshwater Fish*' (King *et al*., 2011).

[14] https://www.fisheriesireland.ie/fish-species/eel.html

Lamprey likely occur in low densities in low gradient reaches of the rivers assessed, where flows are sufficiently slow to allow accumulation of fine substrates. Any lamprey, if/where they occur within the freshwater receiving environment of the development are considered brook lamprey *Lampetra planeri*. Indeed, brook lamprey *Lampetra planeri*. was detected at only one location during surveying (Site 6 on the North Ballycannan Stream). Brook lampreys have similar spawning habitat requirements to small trout, so the spawning ratings in Table 8 can apply. There is adequate lamprey spawning habitat in the watercourses draining the proposed development, particularly for brook lamprey (smaller lamprey species). There is a general lack of sand/silt deposits on the higher gradient reaches closer to the site, a requirement for lamprey larvae (also known as ammocoetes).

The hydromorphology of the Blackwater River as it flows under the Ardnacrusha headrace is such that migratory lampreys (sea and river lampreys) are highly unlikely to occur above this point, as this part of the river featured a steep artificial incline. According to Reinhardt *et al. (*2009), lampreys are poor swimmers and cannot jump or climb. A perched bridge foundation on the lower reach of the Crompaun River at the R445 is also a likely barrier for migratory lampreys.

Plate 14: Suitable juvenile salmonid habitat on the Crompaun River at Site 1 (left) and on the North Ballycannan Stream downstream of a spring feed (right).

Plate 15: Poor salmonid habitat on the lower Crompaun River on a reach that was drained (left). Crompaun River at Site 4 features a series of steps impassable for upstream movement of lampreys (right).

Plate 16: Examples of silted conditions on the channels draining to the south of the site: Site 4 (left) and Site 7 (right).

Plate 17: The intersection of the Blackwater River and the headrace of Ardnacrusha Hydro-scheme (left). Upper end of the culvert for the Blackwater River under the headrace of Ardnacrusha Hydro-scheme (right).

3.3.3 Fish Habitats at Survey Sites

3.3.3.1 Site 1

This reach of the Crompaun Stream was a good nursery area for salmonids with good numbers recorded during electro-fishing. The spawning value was good as pockets of course and medium gravels existed between boulders providing ample spawning opportunities. The holding value was fair given the presence of sporadic but shallow pools. The high energy of the reach would not make the channel suitable for juvenile lampreys due to lack of fine

sediment accumulations. Some bank slippage was contributing soil to this reach while the extent of conifer leaves (needles) reduced habitat quality somewhat.

3.3.3.2 Site 2

The salmonid nursery value of the reach of the Glennagross Stream was very good given the presence of boulder and cobble refugia, glide and riffle sequences. Potential salmonid spawning value was regarded as moderate. These areas were more extensive in the slack areas of slower moving pool. The presence of a perched culvert <200 m upstream of the Crompaun reduces the available trout habitat in this stream, though no fish were recorded in the surveyed section which was downstream of the culvert. The erosive nature of this reach of stream makes it unsuitable for lampreys.

3.3.3.3 Site 3

The nursery value of this reach of the Cappateemore east Stream was poor given its small size, levels of siltation, the latter feature attributed to cattle access and associated soil erosion. This reach had no lamprey nursery value given higher gradient and spate nature of channel.

3.3.3.4 Site 4

This reach on the Crompaun East Stream provided good nursery areas for trout, exemplified by the fair numbers of trout captured during electrical fishing. The channel could nonetheless be considered a moderate to good nursery given riffle, glide and pool areas, and ample flows. A high proportion of concrete rubble in this reach provides good refuge for young trout. The spawning value was fair due to the roughness of the channel, dominated by larger substrates, the only ample spawning areas of small pockets of coarse and medium gravels occurring between boulders. Holding areas were considered suboptimal for brown trout but not suitable for lamprey. The bridge foundation featured a series of artificial falls and pools deemed impassable for upstream movement of lampreys.

3.3.3.5 Site 5

The fish habitat value of this reach on the North Ballycannan Stream was poor due to its small size and almost dried out state. It was deemed poor as a salmonid nursery and spawning area given the physical conditions. This observation was confirmed as no fish were captured. This reach had no lamprey value.

3.3.3.6 Site 6

The reach of the North Ballycannan Stream surveyed during electrical fishing (downstream of spring feed) was a moderate-good spawning and nursery area for salmonids with fair numbers of trout recorded during electro-fishing. Salmonid habitat was regarded as poor upstream of the influence of a spring due to critically low water levels at the time of the survey. The holding value was deemed poor given the lack of pool habitat. Conditions for lamprey ammocoete were moderate due to the presence of silt pockets between rocks and a brook lamprey was recorded.

3.3.3.7 Site 7

The fish habitat value of this reach on the West Ballycannan Stream was marginal-poor due to small size and degraded morphological condition, excessive shade and siltation. Much of substrate comprised artificial items including concrete blocks. Wire netting was also recorded, obstructing flow and possibly fish. It was deemed poor as a salmonid nursery and spawning area given the physical conditions. This observation was confirmed as no trout were captured, though an eel was recorded. This reach had limited lamprey value.

3.3.3.8 Site 8

The fish habitat value of this reach on the South Ballycar Stream was marginal-poor due to small size and degraded morphological condition, excessive shade and culverted reaches (piped under roads). It was deemed poor as a salmonid nursery and spawning area given the physical conditions. This observation was confirmed as no fish were captured. This reach had no lamprey value.

3.3.3.9 Site 9 and Site 10

These reaches of the South Ballycar Stream (Site 9) and West Roo Stream (Site 10) had good physical diversity and a good flow of water. They were deemed optimal-good as a salmonid nursery and spawning areas given the proportions of rock cobble gravel substrates but no fish were captured. These reaches had little/no lamprey value. These watercourses have severed links with the River Shannon and drop sharply into the Ardnacrusha tailrace which is a factor that could explain the apparent absence of fish in these channels.

3.3.3.10 Site 11

The fish habitat value of this reach on the Blackwater (Clare) River was optimal for the early life stages of salmonids due to its relatively large size and diverse morphology. Both trout and salmon were recorded here. Holding was deemed moderate for trout but marginal for adult salmon. This reach had some accumulations of deposited sand/silt of nursery value to lamprey ammocoetes.

3.3.3.11 Site 12

The fish habitat value of this reach on the Kilnacreagh Stream was unsuitable for the early life stages of salmonids due to its small size, excessive shade and minimal flow. Though this stream could not be easily accessed and could not be viewed in significant detail, it is considered that it would not be large enough to hold trout. This stream is not an important watercourse for fish.

3.3.4 Fish Survey Results

Brown trout and European eel were recorded during the electrofishing survey of watercourses draining the proposed Ballycar Wind Farm site in June 2021. Electrofishing was not carried out as part of the 2023 surveys. It is considered that the electrofishing surveys carried out in 2021 provide an accurate representation of the watercourses. Atlantic salmon, stone loach *Barbatula barbatula* and minnow *Phoxinus phoxinus* were previously recorded in the Blackwater River in September 2018, noting that the Blackwater catchment drains an area north of the proposed development site. Table 9 gives length and descriptive statistics for all fish species captured. Table 10 gives Catch Per Unit Effort (CPUE) indices for trout and European eel. All electrical fishing data is presented in Appendix 5 in this report. Photographs of selected fish captured/seen during the survey are presented below.

Table 9: Length descriptive statistics for fish captured during the 2021 electrofishing survey of watercourses draining the proposed Ballycar Wind Farm

Subbasin	Watercourse	Site	Stream order	Fish Species	Scientific Name	N	Length (cm)			St. Dev.
							Mean	Min	Max	
Crompaun (East)_010	Crompaun	Site 1	2	Brown trout	*Salmo trutta*	30	6.9	3.9	14	3.07
	Glennagross	Site 2	2	-	-	-	-	-	-	-
	Cappateemore east	Site 3	1	European eel	*Anguilla anguilla*	1	15	15	15	-
	Crompaun East	Site 4	3	Brown trout	*Salmo trutta*	130	6.68	4.5	21	2.17
				European eel	*Anguilla anguilla*	4	15.05	8.2	22.5	7.15
North Ballycannan_ 010	North Ballycannan	Site 5	1	-	-	-	-	-	-	-
	North Ballycannan	Site 6	2	Brown trout	*Salmo trutta*	25	10.87	6.7	21	4.22
	West Ballycannan	Site 7	2	European eel	*Anguilla anguilla*	1	20	20	20	-
	South Ballycar	Site 8	1	-	-	-	-	-	-	-
	South Ballycar	Site 9	3	-	-	-	-	-	-	-
	West Roo	Site 10	2	-	-	-	-	-	-	-
Blackwater (Clare_010)	Blackwater (Clare)	Site 11	3	Brown trout	*Salmo trutta*	19	14.7	7	16.5	4.9
				Salmon	*Salmo salar*	7	10.8	6.6	13.1	2.7
				stone loach	*Barbatula barbatula*	5	7.2	6.2	8.5	1
				Three-spined stickleback	*Gasterosteus aculeatus*	5	2.6	2.1	3	0.3
				minnow	*Phoxinus phoxinus*	2	2.6	2	3.2	0.8
				Brook Lamprey	*Lampetra planeri*	17	3.7	3.1	4.3	0.6

Brown trout were recorded at Site 1 (n = 30), Site 4 (n = 130), Site 6 (n = 25) and Site 11 (n = 19). A total of 159 brown trout were captured in the North Ballycannan and Cromapun East subbasins. These trout ranged in length (fork length) from 3.9cm to 21cm with an average length of 7.3cm. The only fish recorded at Site 3 and Site 7 was European eel; however European eel and brook lamprey were detected at Site 6. There is only a small proportion of suitable habitat for juvenile lamprey in the streams draining the proposed development site. It is considered that any lampreys in the subject watercourses occur in low densities and are brook lampreys.

Fish were not encountered at Site 9 or Site 10. The likely reason for this is due to fish passage problems and / or past pollution events. Frog *Rana temporaria* was found while electrical fishing at Site 7 and Site 10. The watercourses in the study area downstream of the proposed development site contain plentiful rocks which provide good suitable habitat for trout and eel.

Table 10 presents the length - frequency distribution (LFD) for trout captured during the surveys.

It can be seen from LFDs that the age structure is generally dominated by fish in younger cohorts (age groups). The LFD for all trout at Site 1 clearly illustrates two cohorts. It appears that four cohorts were captured at Site 4. Separation of various trout age groups at Site 6 is uncertain, but it appears that at least four cohorts were captured. The smaller watercourses are important for younger class fish. The trend observed are attributed to stream size, with the larger watercourses able to support a greater array of fish cohorts. Figure 7 shows the depletion line for trout at Site 4 (see Table 11 also). Based on the depletion, the population estimate for the reach surveyed was 133 trout.

Table 10: Catch Per Unit Effort (CPUE) indices for salmonids and eels captured during the electrofishing surveys of watercourses draining the proposed Ballycar Wind Farm.

Subbasin	Watercourse	Site	Stream order	Area fished (m^2)	Time fished (mins)	Brown trout			European Eel		
						N	CPUE		N	CPUE	
							Fish/m^2	Fish/min		Fish/m^2	Fish/min
Crompaun (East)_010	Crompaun	Site 1	2	150.0	10	30	0.2	3	0	0	0
	Glennagross	Site 2	2	67.5	10	0	0	0	0	0	0
	Cappateemore east	Site 3	1	72.0	10	0	0	0	1	0.01	0.1
	Crompaun East	Site 4	3	58.0	n/a	130	2.24	n/a	4	0.07	n/a
North Ballycannan_ 010	North Ballycannan	Site 5	1	55.0	10	0	0	0	0	0	0
	North Ballycannan	Site 6	2	16.0	10	25	1.56	2.5	0	0	0
	West Ballycannan	Site 7	2	27.5	10	0	0	0	1	0.04	0.1
	South Ballycar	Site 8	1	40.0	10	0	0	0	0	0	0
	South Ballycar	Site 9	3	62.4	10	0	0	0	0	0	0
	West Roo	Site 10	2	76.5	10	0	0	0	0	0	0
Blackwater (Clare_010)	Blackwater (Clare)	Site 11	3	140	10	19	0.14	1.9	0	0	0

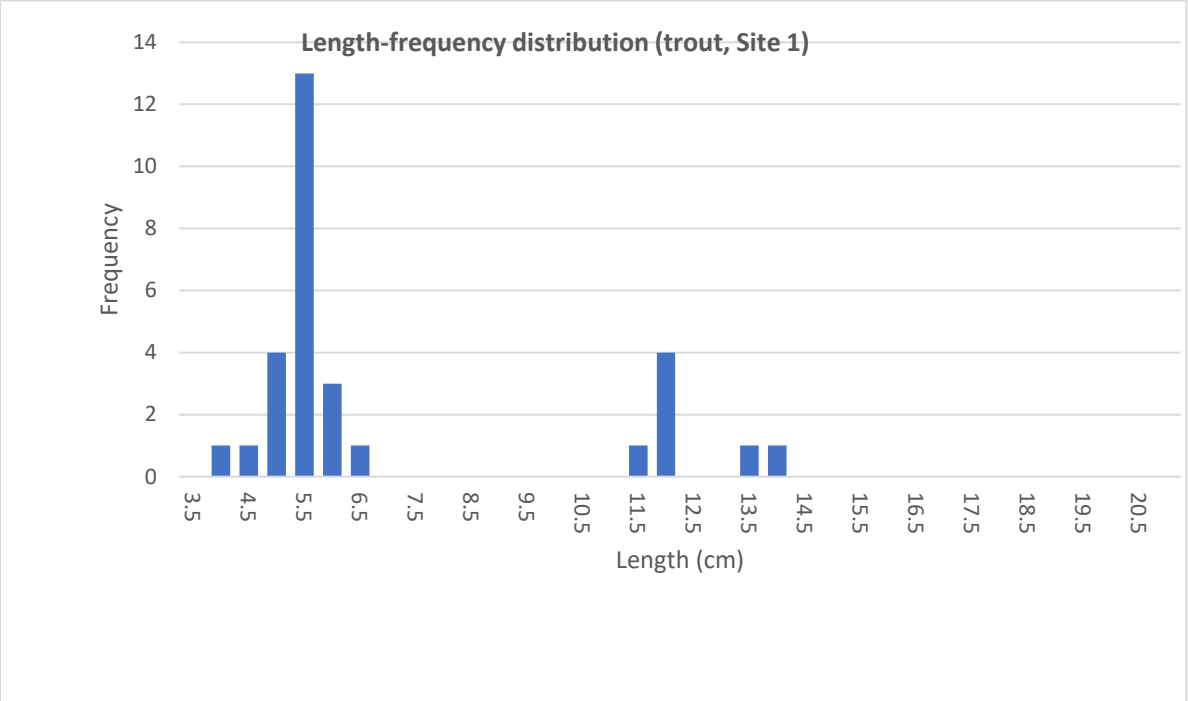


Figure 5: Length frequency distribution for trout at Site 1

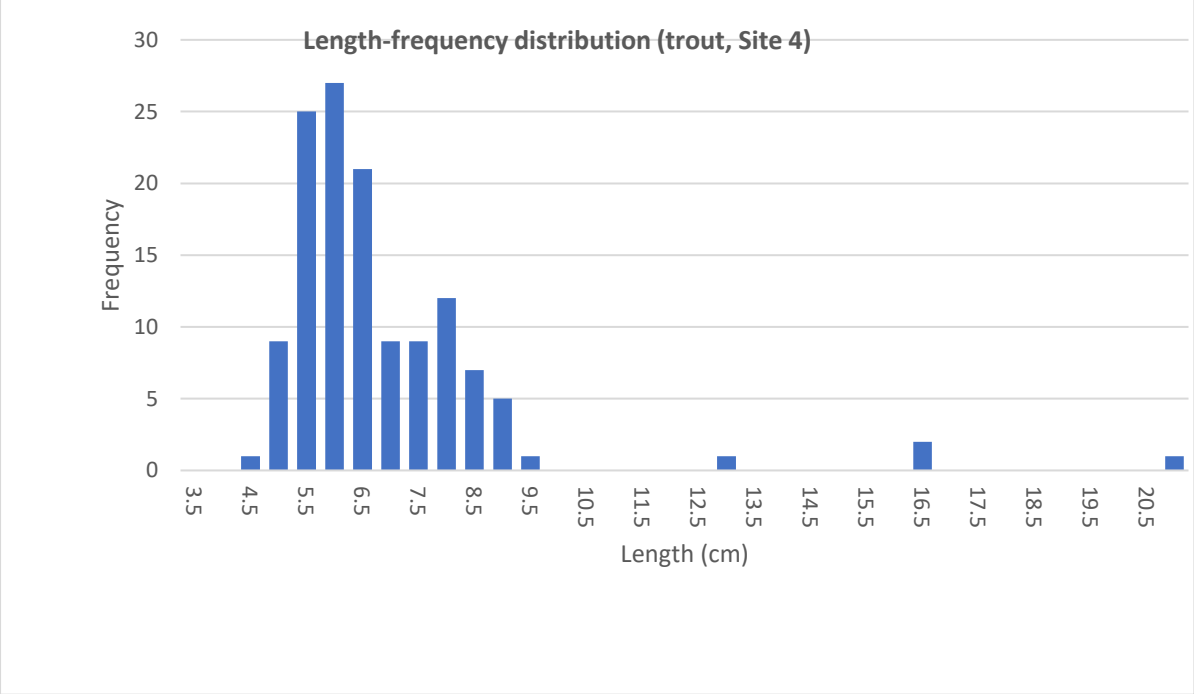


Figure 6: Length frequency distribution for trout at Site 4

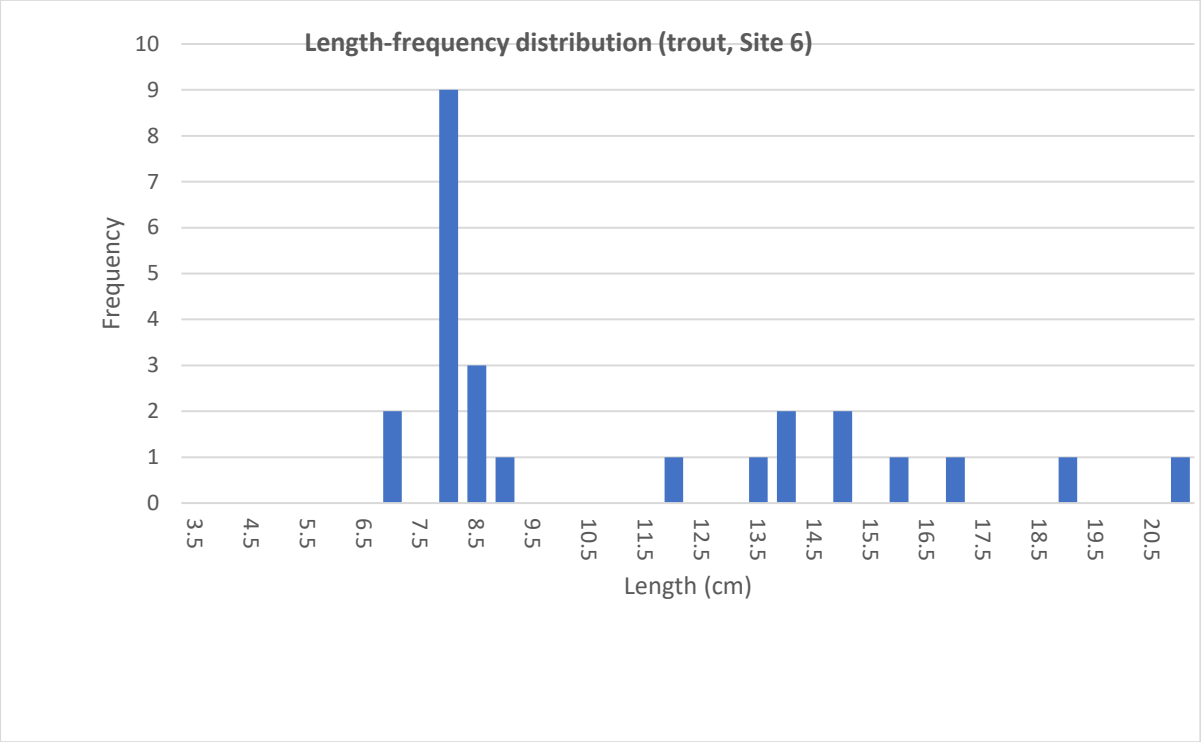


Figure 7: Length frequency distribution for trout at Site 6

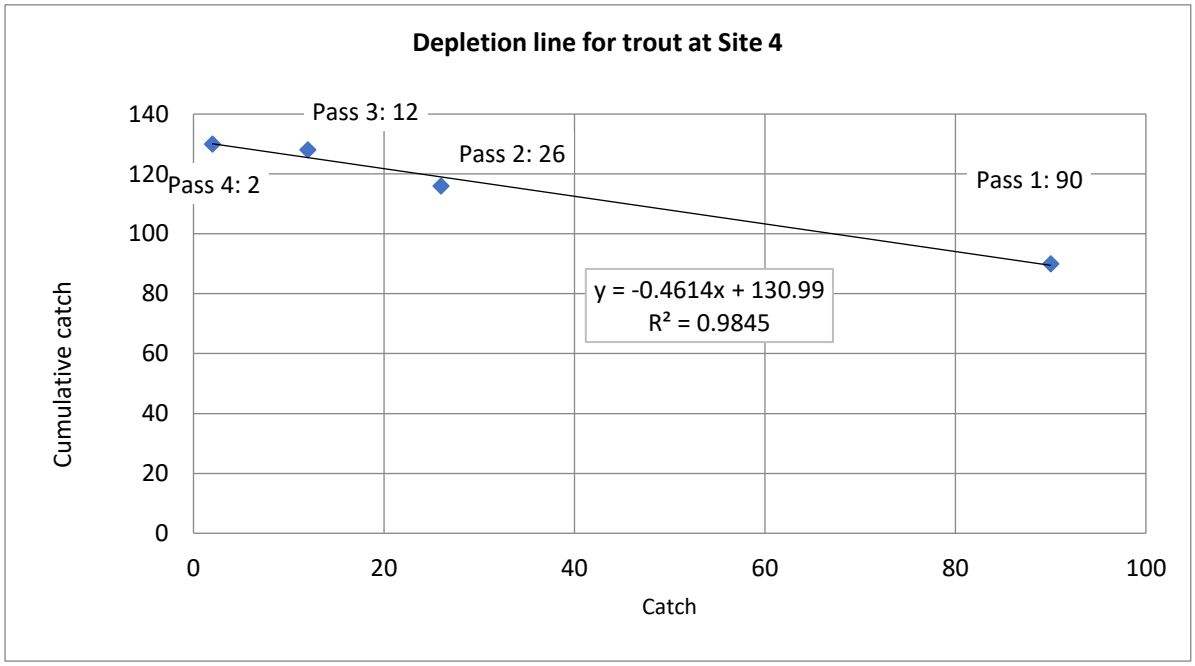


Figure 8: Depletion line for trout at Site 4

Table 11: Minimum density estimations (fish m^{-2}) for trout Site 4 on the Crompaun East Stream

Species	Equation	R^2	Population estimate	Minimum density (fish/m^2)
Brown trout	y = -0.4614x + 130.99	0.9845	133	2.26

Plate 18: European eel at Site 7 (left) and brown trout (right) at Site 6 captured during electrical fishing.

Plate 19: Salmon and Trout from Site 11 (left). Brook lamprey recorded at Site 6.

An area of 1m^2 was surveyed for lampreys in the Blackwater River at Site 11. A total of 16 Brook / River Lampreys were recorded in the Blackwater River. This included one brook lamprey transformer.

3.4 Macroinvertebrates

This section provides information on aquatic macro-invertebrates other than freshwater pearl mussel (FPM). FPM is discussed in Section 3.5 below.

3.4.1 Existing Information

The proposed development and the watercourses examined during the current assessment occur in the 10km grid square R56. National Biodiversity Data Centre (NBDC) records indicate the presence of numerous groups of aquatic insects in this area. Water beetles (Coeloptera) previously recorded include *Agabus (Gaurodytes) bipustulatus, Ilybius fuliginosus, Elmis aenea, Dytiscidae, Hydrobius fuscipes, Stictotarsus duodecimpustulatus* and *Hydroporus* spp. Aquatic Molluscan records in the study area were minimal with just one species: *Ancylus fluviatilis*. Dragonflies known to occur comprise *Aeshna grandis* and *Pyrrhosoma nymphula*. The habitats of these Odonates are slow flowing waterbodies and lakes. Mayflies known to occur comprise *Baetis rhodani* and *Serratella ignita*.

3.4.2 Macroinvertebrate Habitats

The physical habitat suitability assessment of the survey sites for macroinvertebrate production is provided in Table 12. Based on the physical attributes of the surveyed sites and assessment criteria, the sites are generally rated between marginal and suboptimal. This rating was applied to sites mainly due to the domination of substrates by one size class (rock/cobble), owing to their high gradient, suboptimal habitat complexity, coupled with mainly marginal pool quality (<1m deep), bank stability (eroding in some instances) and canopy conditions (excessive shade). Habitats of this classification can limit taxa richness as there are fewer ecological niches available e.g., high gradient streams more suitable for macroinvertebrates with morphology evolved for fast flows such as Heptagenid mayflies.

Table 12: Physical habitat assessment of the survey sites regards suitability for macroinvertebrate production (adapted from Barbour and Stribling, 1991).

Site	Watercourse	Bottom substrate	Habitat complexity	Pool quality	Bank stability	Bank protection	Canopy	Score	Overall Assessment*
1	Crompaun	20	15	10	20	20	15	100	suboptimal
2	Glennagross	10	5	5	5	5	10	40	poor
3	Cappateemore east	20	20	10	15	15	15	95	suboptimal
4	Crompaun East	15	5	5	15	10	10	60	marginal
5	North Ballycannan	10	5	5	15	15	10	60	marginal
6	North Ballycannan	10	5	5	10	10	10	50	marginal
7	West Ballycannan	15	5	5	15	15	10	65	marginal
8	South Ballycar	20	15	10	20	15	15	95	suboptimal
9	South Ballycar	20	15	10	20	20	20	105	suboptimal/optimal
10	West Roo	20	15	10	20	20	15	100	suboptimal
11	Blackwater (Clare)	20	15	15	20	15	15	100	suboptimal
12	Kilnacreagh	10	10	0	5	4	5	35	marginal

** scale: poor (0-5); marginal (6–10); suboptimal (11-15); optimal (16-20)*

Habitat suitability also depends on water quality, and impacted conditions (e.g. below 'good' status) will also result in fewer taxa. The synergistic effect of river morphological character (including physical habitat) and stressors (e.g. silt) along with other water quality influences (e.g. nutrient loading) could explain the variation in faunal results at the study sites.

3.4.3 Macroinvertebrate Diversity and Abundance

The results of the macroinvertebrate surveys are presented in **Appendix 3**, where a species list of macroinvertebrates recorded at each survey location during 2021 and 2023 has been provided. The bulk of macroinvertebrates recorded belong to pollution sensitivity group C (pollution tolerant), as per Toner *et al,* (2005). Some of the macroinvertebrates recorded in the study area are shown below.

Mayfly (Ephemeropteran) larvae of pollution tolerant (Group C) *Baetis rhodani* were among the most widespread and abundant macroinvertebrate and abundance ranged from 'common'[15] to 'numerous' where encountered. Larvae of Group B *Baetis muticus* was less common. Pollution sensitive (Group A) mayfly larvae were limited to *Ecdyonurus* sp., which were sparse throughout the study area and *Rhithrogena semicolorata* (moderate distribution, few-common). Larvae of less sensitive stonefly *Leuctra* sp. and pollution sensitive *Chloroperla* sp. were generally limited throughout the study area and occurred at <50% of sites. The Trichopterans were a well

[15] *Few (<5%), Common (6-20%), Numerous (21-50%), Dominant (51-74%), Excessive (>75%)*

represented group with three cased (Group B) taxa and four caseless (Group C) taxa recorded. Cased caddisfly larvae of Limnephelidae and caseless caddisfly larvae of *Hydropsyche* sp., trumpet-net caddisflies (Polycentopodidae), Finger-net caddisflies (Philopomatidae) and *Rhyacophila* sp. were well distributed within the surveyed sites but generally scarce.

Dipteran larvae accounted for a significant proportion of the macroinvertebrate community at the survey sites. The most abundant true fly larvae were pollution tolerant Simulidae (common-numerous) and *Chironomous* sp. (few - common). The crustacean *Gammarus duebeni* was probably the most widespread and abundant macroinvertebrate across the study area, with *Asellus aquaticus* present only at Site 3.

The macroinvertebrates recorded at Site 11 on the Blackwater River were different to those taxa recorded at Site 1 – 10. At site 11 there were pollution sensitive large pale stonefly *Perla bipunctata, Dinocras cephalotes,* and two species of brown stoneflies (Nemouridae), the cased caddis *Athripsodes* sp., the whirligig beetle *Gyrinus substriatus*, *Brychius elevatus* and *Hydraena sp.* as well as the wandering snail *Radix balthica.* The size of the Blackwater River at this location in combination with good water quality accounts for the increased diversity at this location.

Plate 20: Larvae of the caseless Hydropsychidae, Polycentropodidae and Philopotamidae caddisflies (left). Larvae of cased Glossosomatidae (right).

Plate 21: Larva of the Ephemeroptera / mayfly *Ecdyonurus* sp. and *Rhithrogena semicolorata* recorded at Site 2 on the Cromapun River (left) and Baetidae (right).

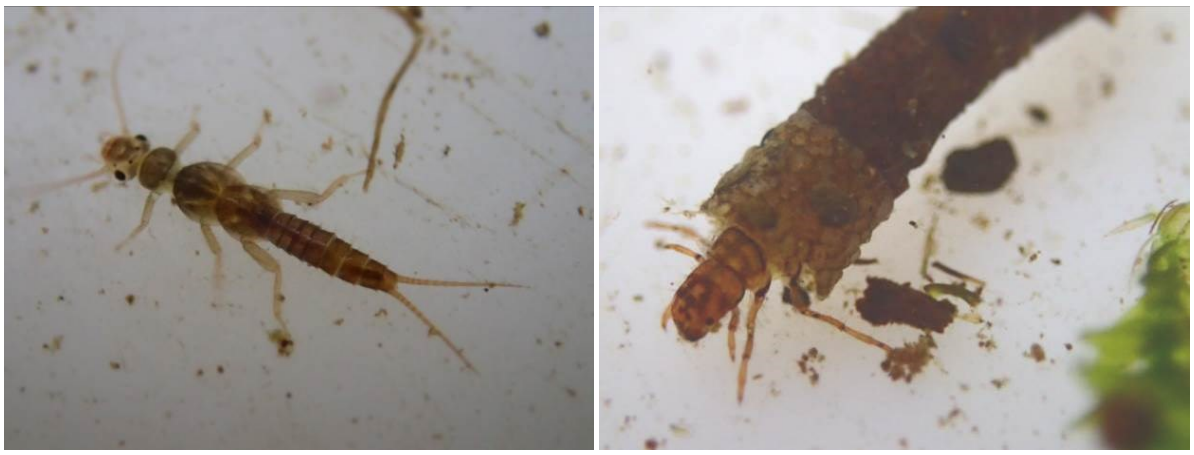


Plate 22: Stonefly larvae of *Chloroperla* sp. (left). Larvae of the cased caddisfly *Odontocerum albicorne* (right).

3.5 Freshwater Pearl Mussel (*Margaritifera margaritifera*)

3.5.1 Freshwater Pearl Mussel Habitat and Ecology

The FPM life cycle involves an adult stage, living as a filter feeder, a juvenile stage living interstitially in sediment, and a larval (glochidial) stage living attached to the gills of trout or salmon. All life stages therefore need consideration, as does the viability of the host species of fish.

'Ecological status' is an expression of the quality of the structure and functioning of aquatic ecosystems associated with surface waters, classified in accordance with the normative definitions of ecological status described in the WFD. 'Ecological Quality Ratio' (EQR) is an expression of the relationship between the values of the biological parameters observed for a given body of surface water and the values for those parameters in the reference conditions applicable to that body. The ratio is expressed as a numerical value between zero and one, with high ecological status represented by values close to one and bad ecological status by values close to zero. For intercalibration of river ecological classification systems across the European Union as required by the Water Framework Directive (WFD), Ireland has used the Q-rating system[16]. For example, the EQR for macroinvertebrates is given as ≥0.85 to meet the high status/good status boundary in the Surface Water Regulations (SWR) (2009). The Freshwater Pearl Mussel Objectives (S.I. No. 296/2009) requirement for an EQR ≥0.90 relates to 'high status' watercourses i.e. Q4-5 and Q5, as per the EPA Q-rating system. Regarding the ecological quality objectives for FPM habitat, the watercourses within and adjacent to the proposed development site channel generally fail on criteria for macroinvertebrates, macroalgae and siltation (DoEHLG, 2009).

It is noted in Moorkens *et al.* (1992) that alteration in a river's flow regime, such as that caused by drainage for forestry or agriculture, may result in summer flows being insufficient to support FPM. The lower reaches of watercourses in the Crompaun and Ballycannan subbasins have been drained/modified where they occur on the floodplain, a pressure on FPM as noted in Moorkens (1999). Also, the middle to upper reaches of channels in these catchments are considered to have insufficient base flows to sustain FPM. The only watercourse considered sufficiently large to support FPM was the North Ballycannan River and the Blackwater River. Table 13 presents the findings of the FPM survey in terms of habitat quality and survey extents.

The FPM is a large, long-lived, bivalve mollusc found in clean, fast-flowing rivers and has a complex and unusual life cycle. It produces very tiny young that burrow into river gravels to prevent being washed to sea. The species requires very clean and well oxygenated rivers. In recent decades, when experts began searching for the young, they discovered that most Irish populations have not recruited since the 1970s or 80s. Riverbeds had become clogged with silt, algae and rooted-plants so that the young mussels can no longer survive. In some rivers, pollution is sufficiently severe that adult mussels are also dying. Mussels mature between seven and fifteen years of age, and have a prolonged fertile period lasting into old age. The species produces glochidial larvae that use a temporary salmonid host, typically Atlantic salmon and sea trout in Ireland, but also brown trout. Juvenile mussels occupy interstitial habitats in the riverbed for five years or more (NPWS, 2019).

Table 13: Findings of the surveys carried out on the North Ballycannan River.

Segment code		25_3896
Stream order		3
Approx. length of channel surveyed (m)		500
Environmental Quality Objectives (EQO)[17]	Filamentous algae	Rare
	Macrophytes	Rare
	Siltation	A lot of visible silt
FPM population		Absent

[16] See Table A2.1 in Appendix 2 for more EQR values and intercalibration information.

[17] EQO = Ecological Quality Objectives for FPM habitat.

Notes	The entire length of the channel was examined. The reach downstream is deemed too sluggish and silted for FPM. This reach does not pass on the EQO's for silt. The degree of shade was a likely factor in the amount of algae recorded: heavy shade reduces algal growth.

In a pearl mussel river, the effects of pollution can range from loss of the salmonid fish which are essential to the mussel's life cycle, to long term stress and death of adult and young mussels from oxygen deprivation, to immediate death of the entire mussel population from toxic poisoning (Moorkens, 1999). Freshwater pearl mussels are flagship, indicator, keystone and umbrella[18] species (Geist, 2005). The pearl mussel is a key indicator species of river ecosystem quality i.e., protecting the pearl mussel has a positive impact on the entire river ecosystem. Adults are more tolerant of a wider range of in-river conditions than juveniles (Hastie *et al.,* 2000 in Skinner *et al.,* 2003).

This species is under increasing pressure from a number of sources and are continuing to decline and are classified as Endangered on the IUCN Red List of Endangered Species. They are also listed under Annex II of the EU Habitats Directive.

3.5.2 Existing Information

The proposed development is not located in a freshwater pearl mussel (*Margaritifera margaritifera*) catchment sensitive area in mapping produced by NPWS[19]. Drainage from the proposed development site is to the Crompaun, North Ballycannan and Blackwater (Clare) Rivers, none of which have previous FPM records (See Figure 9).

Using criteria in Anon (2004), the North Ballycannan River and the Blackwater River are classified as '*moderate priority rivers'* i.e. rivers with no prior records but with either igneous or sandstone bedrock underlying *at least one third of their* length; rivers flowing from lakes. The study area is mainly underlain by 'Devonian Old Red Sandstones', 'Silurian Metasediments and Volcanics', 'Dinantian (early) Sandstones, Shales and Limestones' and 'Dinantian Pure Bedded Limestones'.

3.5.3 Survey Results

During the 2018 survey of the Blackwater (Clare) River, FPM were not recorded along the reach surveyed. FPM were not detected during the surveys carried out on the North Ballycannan River in 2021. No live FPM or evidence of FPM in the form of shells were recorded during the field investigations. The stretches examined were deemed representative of these rivers and a variety of microhabitats were surveyed (e.g., clean substrates in riffle, glide and pool under partial and full shade). In general, the sedimentation levels recorded were generally indicative of

[18] Protecting the pearl mussel has a positive impact on the entire river ecosystem. The most important features of an effective umbrella species are a large range size and complex habitat requirements (Caro, 2010).

[19] https://www.npws.ie/maps-and-data/habitat-and-species-data

artificially induced siltation and these conditions are considered unfavourable in terms of the species' habitat. Findings of the surveys carried out on the North Ballcannan catchment are presented in **Table 13**.

The modified character of the lower reach of the North Ballycannan River, being drained, almost certainly precludes FPM presence. Water quality is another factor that negatively influences FPM habitat. Reduced macroinvertebrate diversity owing to degraded water quality at upstream locations (see Section 4.6) is a limiting factor for FPM presence. A foul discharge to the surveyed reach of the North Ballycannan River was also noted.

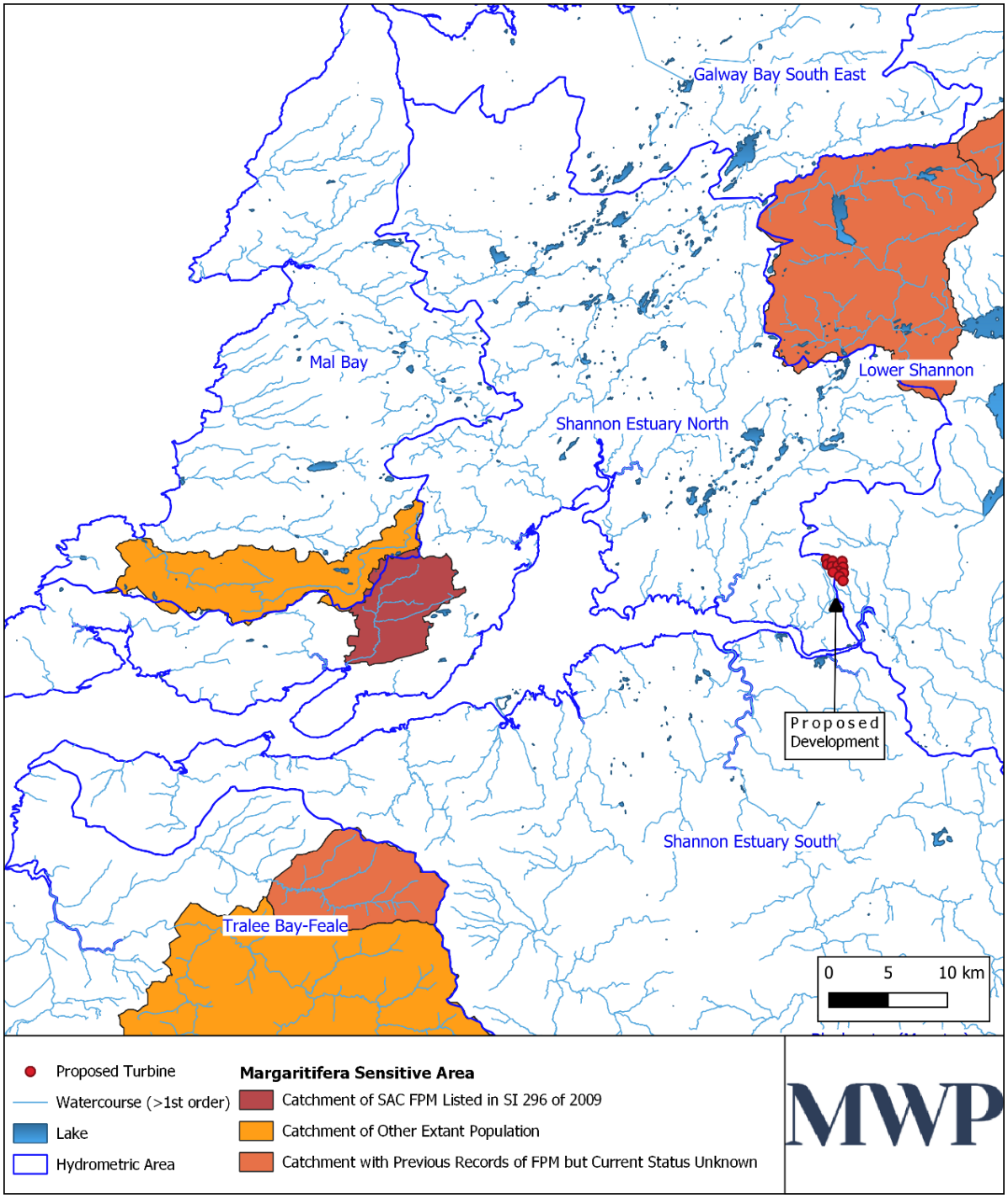


Figure 9: Proposed development location in the context of NPWS mapped *Margaritifera* sensitive areas

The 2009 Irish Red list of non-marine molluscs identified the following as major threats to FPM: reduction in water quality; increases in siltation and physical interference with habitat (Byrne *et al.* 2009). These threats decrease macroinvertebrate and fish habitat quality in general and were noted at several locations as outlined above.

The likelihood of FPM occurring in the North Ballycannan River and Blackwater (Clare) River is deemed very low considering the habitats present. According to Moorkens (1999), FPM may be affected by impacts occurring at considerable distances upstream from their populations and taking into account its conservation status, the presence of FPM in the Zone of Influence (ZOI) of the proposed development is considered highly unlikely however.

Plate 23: Stretch of the North Ballycannan River surveyed for FPM (left). Foul discharge to a lower reach of the North Ballycannan River (right).

3.6 Water Quality

3.6.1 Existing information

3.6.1.1 Biological Water Quality

The EPA carries out biological monitoring at stations at various locations along the Crompaun and Blackwater (Clare) Rivers which drain the proposed development site. The most recent EPA biological water quality results at the closest EPA biological monitoring stations can been seen in Figure 10 and Table 14, these stations are downstream of the development site.

Table 14: Summary of most recent EPA biological water quality ratings for the rivers draining the proposed development

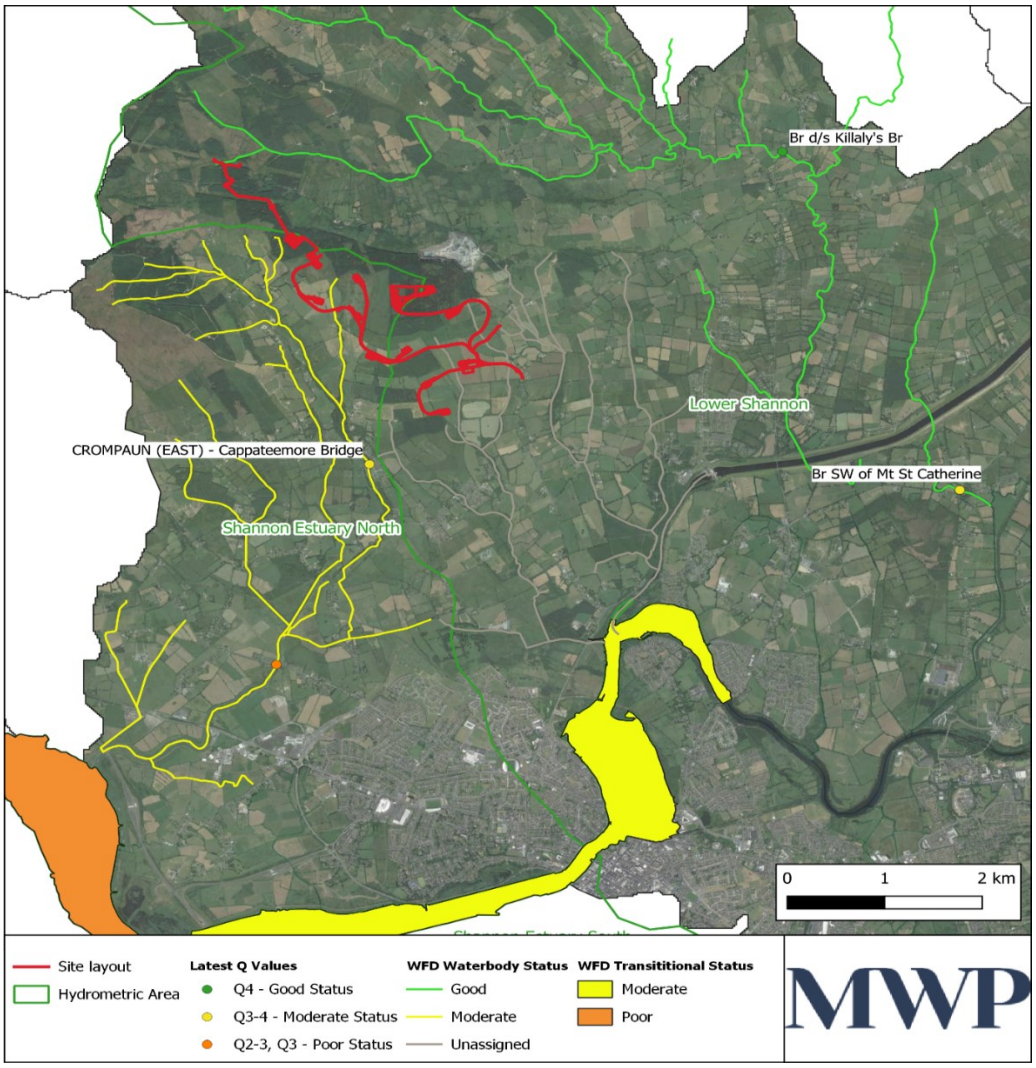
River	EPA station code	Location	2002	2005	2006	2007	2009	2011	2012	2013	2014	2016	2017	2018	2019	2021	2022
Crompaun East	RS27C090300	Cappatemore Bridge		4-5							4	3-4			3-4		3-4

	RS27C090600	Meelick Bridge	4	4	3-4	3-4	3		3		3			
Black water (Clare)	RS25B060120	Br d/s Killaly's Br	4-5	4-5	4-5	4-5	4*	4-5	4	4	4			

The Q-rating scheme mainly reflects the effects of organic pollution (i.e., de-oxygenation and eutrophication) but where a toxic effect is apparent or suspected the suffix '0' is added to the biotic index.

The following are the EPA assessments[20] for the watercourses draining the proposed development, based on surveys in 2019:

- Cromapun East: Moderate ecological conditions were again recorded at the upstream site (0300) while poor ecological conditions were again indicated at the lower site (0600); and
- Blackwater (Clare): Good ecological condition was again recorded in 2019 at Station 0120.



[20] http://www.epa.ie/QValue/webusers/PDFS/HA24.pdf?Submit=Get+Results

Figure 10: WFD waterbody status 2013-2018 and the most recent EPA biological water quality ratings at monitoring stations on watercourses draining the proposed development.

3.6.1.2 Physico-chemical water quality parameters

Nutrient enrichment (excessive inputs of phosphorus and nitrogen) is the main cause of water pollution in Ireland. The Environmental Quality Standards (EQS) for individual chemical parameters, define the threshold for achieving 'Good' chemical status. The compliance of river and lake monitoring stations against the physico-chemical EQSs, in particular ortho-phosphate, but also nitrate and ammonia, is usually complimentary to biological assessments at the same monitoring point. Nutrient concentrations are available for the North Ballycannan Stream as part of WFD surface water monitoring (see Table 15). The station monitored is ca. 160m upstream of the River Shannon. Taking results form 2020 and 2021 to date, Total oxidised nitrogen (TON) concentrations were below detection limits and the threshold for TON (0.91 mg/l) was not exceeded. The average orthophosphate result was 0.19 mg/L so there was not compliance with the EQS of 0.035 mg/l (mean) or ≤0.075 mg/l (95%ile). Ammonia concentrations were <. 0.012 mg/l on 15 occasions, and the mean of the remainder of readings was 0.028 mg/l, so the EQS for ammonia (0.065mg/l) was not exceeded.

Table 15: Mean values of selected physico-chemical water quality parameter results for site in the WFD surveillance sites in the North Ballycannan catchment during 2020 and 2021. (Values in parentheses represent the number of samples taken).

Parameter	Unit	North Ballycannan_010 IE_SH_25N170970
Ammonia	mg/L	<.028 (22)
Nitrate	mg/L	0.91 (22)
Ortho-Phosphate (as P -unspecified)	mg/L	0.19 (13)
Total Oxidised Nitrogen	mg/L	0.91 (22

The effects of increased drainage on water quality, such as land drainage of peatland, are multiple. Too many nutrients, especially phosphorus, can result in excessive plant and algae growth which severely impacts the normal functioning of aquatic environments. This results in changes in the natural biological communities and an undesirable disturbance to the overall ecology. According to the national characterisation programme undertaken for the second cycle of Water Framework Directive river basin management planning:

- Diffuse agriculture (notably pasture) and septic tanks are the likely significant pressures for the AT RISK river water bodies in the Owenogarney_SC_020 subcatchment, of which the Crompaun East subbasin is part of[21]. Furthermore, hydro-morphological impacts, such as embankment and channelisation, are present throughout and may impinge on habitat conditions and therefore, biology status; and

[21] https://catchments.ie/wp-content/files/subcatchmentassessments/27_12%20Owenogarney_SC_020%20Subcatchment%20Assessment%20WFD%20Cycle%202.pdf

- The significant issue is likely to be sediment from agriculture and/or forestry in the Shannon [Lower]_SC_100 subcatchment[22], which contains the North Ballycannan and Blackwater River subbasins within the study area.

Forested areas planted on peat soils and forestry activities, such as clearfelling and replanting, have contributed to significant impacts of siltation and excess nutrients in surface water bodies resulting in algal growth (EPA, 2018). Domestic wastewater has been identified as a significant pressure. This is due to concentrations of domestic waste-water systems in areas of high susceptibility to phosphate transport via near surface pathways, leading to elevated nutrients (EPA, 2018).

3.6.2 Survey Results

3.6.2.1 Biological Water Quality

The watercourses provide water of a quality adequate to support some pollution sensitive mayfly and stonefly larvae as well as trout. Q-ratings, EPT and BMWP indices derived from the diversity and relative abundance of the macroinvertebrates at the study sites from sampling undertaken in 2021 by MWP are given in **Table 16.**

Table 16: Biological water quality results from 2021 sampling and interpretations at study sites on watercourses potentially affected by the proposed Ballycar Wind Farm.

Site	Watercourse	Q-rating	Quality Status	Corresponding WFD Status	BMWP Score	BMWP Category	BMWP Interpretation	ASPT	EPT
1	Crompaun	3-4	Slightly polluted	Moderate	96.7	Good	Clean but slightly impacted	7.4	8
2	Glennagross	4-5	Unpolluted	High	105	Very good	Unpolluted, unimpacted	8.1	10
3	Cappateemore east	4	Unpolluted	Good	91.8	Good	Clean but slightly impacted	6.6	8
4	Crompaun East	3-4	Slightly polluted	Moderate	94.2	Good	Clean but slightly impacted	6.7	7
5	North Ballycannan	3	Moderately Polluted	Poor	9.2	Very poor	Heavily polluted	4.6	0
6	North Ballycannan	3	Moderately Polluted	Poor	46.8	Moderate	Moderately impacted	5.9	3
7	West Ballycannan	3	Moderately Polluted	Poor	69.4	Moderate	Moderately impacted	6.3	4
8	South Ballycar	3	Moderately Polluted	Poor	78.5	Good	Clean but slightly impacted	6.5	6
9	South Ballycar	4-5	Unpolluted	High	133	Very good	Unpolluted, unimpacted	7.4	11

[22] https://catchments.ie/wp-content/files/subcatchmentassessments/25D_3%20Shannon[Lower]_SC_100%20Subcatchment%20Assessment%20WFD%20Cycle%202.pdf

10	West Roo	4	Unpolluted	Good	124.6	Very good	Unpolluted, unimpacted	6.9	10
11*	Blackwater	4-5	Unpolluted	High	149.1	Very good	Unpolluted, unimpacted	6.8	11

Q-ratings for the 2023 sampling are presented in Table 17. There was no change to the ecological status of Site 1, 3, 4, 5, 7 and 8. From 2021, there was a decline in biological water quality at Site 2 on the Glenagross Stream (Q3-4 to Q3), at Site 9 on the South Ballycar Stream (Q4-5 to Q3-4) and at Site 10 on the West Roo Stream (Q4 to Q3-4). This was linked to a reduction in the relative abundance of Group A pollution sensitive taxa at these locations. Excessive siltation is thought to have contributed to these declines. There was an improvement in biological water quality at Site 6 on the North Ballycannan Stream (Q3 to Q4).

Table 17: Biological water quality results from 2023 sampling at sites on watercourses potentially affected by the proposed Ballycar Wind Farm.

Site	Watercourse	Q-rating	Quality Status	Corresponding WFD Status
1	Crompaun	3-4	Slightly polluted	Moderate
2	Glennagross	4	Unpolluted	Good
3	Cappateemore east	4	Unpolluted	Good
4	Crompaun East	3-4	Slightly polluted	Moderate
5	North Ballycannan	3	Moderately Polluted	Poor
6	North Ballycannan	3	Moderately Polluted	Poor
7	West Ballycannan	3	Moderately Polluted	Poor
8	South Ballycar	3	Moderately Polluted	Poor
9	South Ballycar	3-4	Slightly polluted	Moderate
10	West Roo	3-4	Slightly polluted	Moderate

Plate 24: Excessive silt (left) and algal growth (right) in the Cappateemore East Stream at Site 3.

3.6.2.2 Physico-chemical Water Quality

Results of the on-site physico-chemical measurements at survey sites in 2021 are presented in Table 18. Physico-chemical laboratory analysis results for 2021 and 2023 are presented in Table 19 and Table 20, respectively. Appendix 4 contains copies of the laboratory test reports. The results are discussed by parameter below.

Table 18: Physico-chemical water quality results from on-site measurements taken on 24th June 2021.

Parameter	Site									
	1	2	3	4	5	6	7	8	9	10
Dissolved Oxygen (%)	82.1	78.6	77.4	100.9	43.7	64.6	56.4	37.9	76.4	82.1
Dissolved Oxygen (ppm)	8.85	8.38	8.28	11.23	4.62	6.49	6.05	4.01	8.29	8.86
Time	9.47	13.23	12.20	15.08	15.54	16.33	14.23	15.23	10.54	11.20
Conductivity (µS/cm)	269	321	291	334	302	495	399	558	444	470
Temp (°C)	10.8	12.05	11.1	11.25	12.58	16.2	12.48	12.4	12.63	13.15
pH	6.77	7.43	7.34	7.35	7.42	7.32	7.42	7.25	7.36	7.56
Turbidity (NTU - 1st)	1.35	1.8	7.32	0.81	1.02	0.99	3.17	9.16	2.05	1.31
Turbidity (NTU - 2nd)	2.22	1.53	7.09	0.94	0.82	0.86	3.82	9.07	1.36	1.06
Turbidity (NTU - 3rd)	1.04	1.5	7.28	0.95	0.85	0.71	3.56	8.62	1.48	0.71
Turbidity (NTU - average)	1.54	1.61	7.23	0.90	0.90	0.85	3.52	8.95	1.63	1.03

Table 19: Physico-chemical water quality results from laboratory analysis (samples taken on 24th June 2021).

Parameter	Unit	Site									
		1	2	3	4	5	6	7	8	9	10
B.O.D.	mg/L	2.3	1	0.7	0.4	0.6	0.5	0.9	0.3	0.2	<0.1
Total Ammonia	mg/L N	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Dissolved Solids	mg/L	128	216	122	192	148	280	200	336	224	242
Total Hardness	mg/L $CaCO_3$	82	123	75	111	75	191	147	201	129	149
Total Organic Carbon	mg/L	4.2	<2	2.8	2	3	3.1	6	3.3	4.6	5.2
Total Phosphorus (as P)	mg/L P	<0.1	0.1	0.13	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Suspended Solids	mg/L	<5	<5	<10	<10	<10	<10	<10	<10	<10	<10
Nitrate (as NO_3)	mg/L NO_3	1.5	5.6	3.9	2.3	1.3	2.3	0.57	3.3	2	2.9
Nitrite (as NO_2)	mg/L NO_2	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ortho-Phosphate (as P)	mg/L P	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2

Table 20: Physico-chemical water quality results from laboratory analysis (samples taken on 26th June 2023).

Parameter	Unit	Site									
		1	2	3	4	5	6	7	8	9	10
Conductivity	µS/cm	66	62	61	66	15	62	63	62	64	74
B.O.D.	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Suspended Solids	mg/L	<4	<4	<4	<4	<4	<4	6	<4	<4	<4
Total Ammonia	mg/L N	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nitrate (as NO_3)	mg/L NO_3	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Nitrite (as NO_2)	mg/L NO_2	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Ortho-Phosphate (as P)	mg/L P	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Hardness	mg/L $CaCO_3$	16	16	16	17	29	16	16	16	18	22
Chemical Oxygen Demand (COD)	mg/l	<10	<10	10	<10	<10	11	<10	13	13	12
Total Phosphorus (as P)	mg/L P	0.08	0.06	0.07	0.04	0.08	0.06	0.06	0.04	0.05	0.06
Total Organic Carbon (TOC)	mg/L	4.6	4.9	5.3	5.4	5	6	6	5.9	6.8	8.4
Total Dissolved Solids	mg/L	47	35	34	37	54	35	35	35	36	42

3.6.2.2.1 *Total Ammonia/Ammonium*

Ammonia occurs naturally in rivers arising from the microbiological decomposition of nitrogenous compounds in organic matter. Fish and other aquatic organisms also excrete ammonia (EPA, 2001). Total Ammonia concentrations were <0.1 mg/l in water samples taken at all sites. In relation to the 'Quality of Salmonid Waters Regulations 1988' this parameter has an EQS of ≤1mg/L NH_4, subject to conforming to the standard for non-ionized ammonia. The mandatory value for Ammonium in the 'Freshwater Fish Directive (78/659 EEC) is <0.1 mg/L NH_4^+. To determine the water quality of salmonid waters, this parameter should be measured by using 95% of the results collected over a 12-month period for it to be considered an appropriate reading (Flynn, 1988).

Ammonia is naturally present in unpolluted waters in small amounts usually <0.02mg/L as N. Animal slurry, domestic sewage and industrial processes can all contribute to ammonia levels in water bodies. Ammonia may also be discharged directly into water bodies by some industrial processes or as a component of domestic sewage or animal slurry. The decay of organic waste is another factor leading to the addition of ammonia in waters (EPA, 2001).

3.6.2.2.2 *Oxygen, dissolved*

The prime requirements for Dissolved Oxygen (DO) arise in connection with fish life and it is generally true that if water quality is suitable for fish it will also meet the criteria for most if not all other beneficial uses and be of good ecological status, as required by the Water Framework Directive (EPA, 2001). Water samples tested in 2021 had DO concentrations ranging from 37.9% (4.01 mg/L) at Site 8 to 100.9% (11.23 mg/L) at Site 4. In relation to the 'Quality of Salmonid Waters Regulations (SWR) 1988' this parameter has an EQS >6 mg/L and ≤9 mg/L. Therefore,

the DO concentration (oxygenation conditions) at Site 5 (43.7%) and Site 8 were below the minimum stipulated in the SWR, while Site 4 exceeded the maximum in 2021. An excess of DO is not a problem in itself but it indicates that the daytime conditions may be mirrored by an equally large undersaturation of oxygen at night-time when photosynthesis ceases and plant respiration takes over, and oxygen is consumed (EPA, 2001).

According to EPA (2001), salmonid fish will begin to be affected as DO levels drop to around 50% saturation, and in many instances of fish kills the mortality is directly due to asphyxiation as the DO levels fall significantly because of organic pollution. The effects of eutrophication are closely related to the DO regime in both rivers and lakes. Where there are dense growths of phytoplankton, photosynthesis will take place during the extended daylight periods of summertime, resulting in the production of oxygen which may lead to water DO levels far in excess of 100% saturation.

3.6.2.2.3 *Biochemical Oxygen Demand (BOD)*

BOD serves as an indicator of the presence of organic matter in a watercourse (eutrophication) and is a useful measure of water quality. BOD results were within the range <0.1 mg/l (Site 10) to 2.3 mg/l (Site 1). The results at all locations coincided with WFD high status with respect to this parameter with the exception of Site 1 in the 2021 round of sampling. At Site 1, the result corresponded with WFD 'good status' (95% ile) and within the range for WFD good status. The results at all locations adhered to the 'Freshwater Fish Directive (78/659/EEC)' guidance of 3mg/L O2 for salmonid waters, the recommended tolerance of 5mg/L O_2 in the SWR.

3.6.2.2.4 *Orthophosphate/Total Phosphorus*

Orthophosphate is the most readily available form of the nutrient Phosphorous for plant uptake during photosynthesis and is generally considered to be the limiting nutrient for plant growth in freshwater. The results for orthophosphate across all sites was <0.02 mg/l in both 2021 and 2023 sampling. The orthophosphate levels for the surveyed sites met the 'high' quality status requirements (mean value). Phosphorus occurs naturally in water bodies from geological sources. Elevated levels of this chemical can have a detrimental effect on aquatic life. The main cause for elevated levels is from agricultural runoff from land and farmyards which can contain organic and artificial fertilisers and other effluents (EPA, 2001).

In the Freshwater Fish Directive [78/659/EEC], a Total Phosphorus concentration of 0.2mg/l for salmonids is regarded as indicative in order to reduce eutrophication. The total phosphorus result for each site was <0.02mg/l, so are below the 0.2mg/l target.

3.6.2.2.5 *Nitrate/Nitrite*

There are no environmental quality standards for nitrate but average nitrate concentration values less than 4 mg/l NO_3 (0.9 mg/l N) and less than 8 mg/l NO_3 (1.8 mg/l N) are considered by the EPA to be indicative of high and good quality respectively (EPA, 2017). The results for all sites were below 4 mg/l NO_3 which means these sites are considered to be of good quality, in accordance with EPA (2001) guidance. The concentration of nitrite was <0.02 mg/L, which is below the SWR threshold of 0.05 mg/L in both 2021 and 2023 sampling.

3.6.2.2.6 *Suspended Solids/Total Dissolved Solids/Total Hardness*

Results from all sites for suspended solids was <10 mg/L which is much less than the mandatory value of ≤25mg/L stated in the 'Salmonid Water Regulations (1988)'. Total dissolved solids (TDS) were between 122 mg/L (Site 3)

and 336 mg/l (Site 8). There are no specified parametric limits for TDS but the result at Site 8 was considered elevated.

Total Hardness values of 75 mg/L (Site 3 and Site 5) to 201 mg/L (Site 8) $CaCO_3$ were recorded. Water that has a hardness less than 61 mg/L is considered soft; 61-120 mg/L, moderately hard; 121-180 mg/L, hard; and more than 180 mg/L, very hard (Heath, 1983). Water in the study area is classified mostly moderately hard but very hard in parts of the north Ballycannan catchment (Site 6 and Site 8 >180 mg/L). Harder water can reduce the effect of toxicity of some metals including zinc, copper and lead (EPA, 2019).

3.6.2.2.7 *Total Organic Carbon (TOC)*

Most of the organic carbon in water is made up of humic substances as well as partially degraded plant and animal materials. Organic carbon is resistant to microbial degradation (EPA, 2019). TOC values varied from <2 mg/L at Site 2 to 8.4 mg/l at Site 10. This parameter has no limit target specified in legislation.

3.7 Macroinvertebrate Functional Feeding Group Analysis

Table 21 shows the functional feeding group characteristics of the aquatic study sites. Sites 5, 6 and 8 were considered unsuitable for juvenile salmonids with respect to the macroinvertebrate community structure. These sites had an unpredictable juvenile salmonid index due to the low relative abundance of drifters e.g. mayfly larvae. The remainder of sites had a predictable juvenile salmonid index.

The lack of macroinvertebrates that feed on diatomaceous particles and peritphython (scrapers) from all locations indicate impoverished primary instream production. All survey sites had a P/R ratio of less than 0.5, well below the threshold of 0.75 (>0.75 = autotrophic). This signifies that the watercourses in the study area require an external supply of organic matter (allochthonous organic matter) for biological sustenance i.e., energy sources for aquatic ecosystems in the study area are derived from outside the watercourses.

The absence of the feeding groups scrapers and collectors at Site 5, is suggestive of an unbalanced/unstable ecosystem. In general, the relative abundance of scrapers was low. This could be attributed to excessive substrate siltation which limits light reaching hard substrata, the medium for many phytobenthos (diatoms). All watercourses in the study area drain soils overlaying siliceous geology, where low nutrient soils are predominant. The naturally low nutrient concentrations of surface waters in the study area, coupled in some instances with heavy shade means that benthic life and therefore higher aquatic organisms are highly dependent on terrestrial energy sources for survival. For example, leaf litter and aerial insects are likely important food sources for macroinvertebrates and fish, respectively.

Table 21: Functional Feeding Group characteristics of the study sites

	Site									
	1	2	3	4	5	6	7	8	9	10
Filtering collector	72	38	44	40	0	2	18	15	41	34
Gathering collector	33.5	30.5	30	60.5	0	4	17	3	50.5	105.5
Scraper	50.5	56.5	20	49.5	0	4	21	8	34.5	65.5
Predator		6	5	13	12	7	4	8	10	10
Shredder	63	29	27	35	110	98	26	39	58	28
Total	219	160	126	198	122	115	86	73	194	243
P/R ratio[1]	0.30	0.58	0.20	0.37	0	0.04	0.34	0.14	0.23	0.39
Heterotrophic (H) vs Autotrophic (A)	H	H	H	H	H	H	H	H	H	H
Juvenile salmonid index	0.93	0.75	1.42	1.03	0	0.06	0.69	0.33	0.89	1.35
Predictable (P) vs Unpredictable (U) [2]	P	P	P	P	U	U	P	U	P	P

[1]*Heterotrophy vs autotrophy based on a P/R threshold of > 0.75 = autotrophic*

[2]*Predictable juvenile salmonid food supply based on a threshold of >0.50*

3.8 Amphibians

The proposed development site has habitats suitable for all life stages of frog. The wet grassland and limited peat habitat are considered important for froglets and adult feeding. Some wetter parts of the site are suitable spawning areas and likely used by hibernating frogs but such habitats are sparse (See **Figure 11**). Two such areas were identified during the February 2022 survey, as listed in **Table 22**. Several adult frog carcasses were recorded near these spawning sites during the survey. In June 2021, adult frogs were recorded during electrical fishing in watercourses at Site 7 and Site 10. These sites are located downstream of the proposed development. Frog will sometimes use streams during summer-time when flows are low. Also, frogs are likely to occur in the streams within the proposed development site.

Table 22: Frog spawning / hibernation habitat at the proposed development site

Site code	Habitat	Coordinate (ITM)		Number of clumps
		X	Y	
A	Old drainage ditch / flush	554448	664241	25
B	Drainage ditch	554700	664202	14

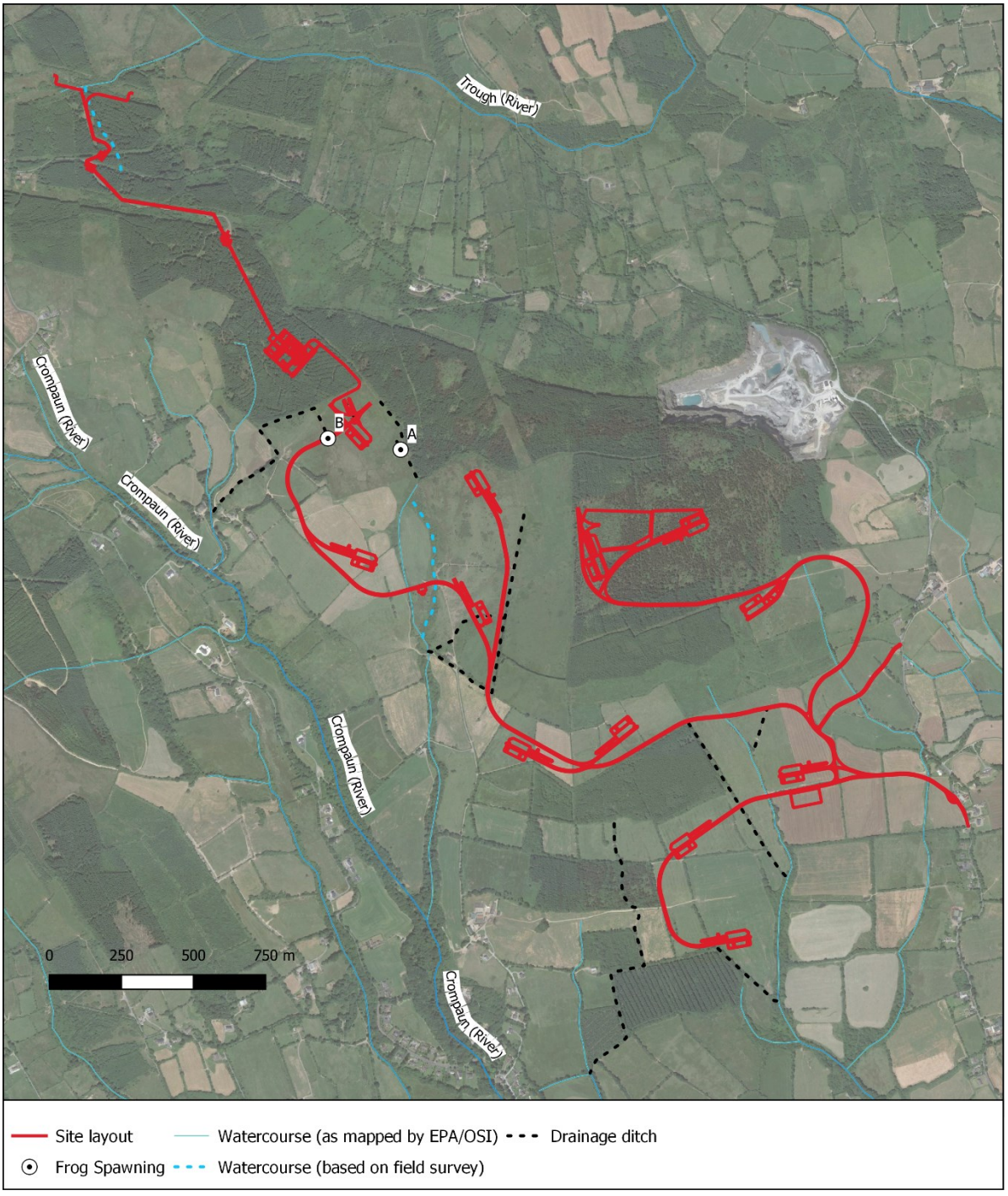


Figure 11: Frog spawning / hibernation habitat at the proposed development site

Plate 25: Frog recorded at Site 10 (left). Frog spawn in an old drainage ditch/flush within the proposed development site (right).

Plate 26: Drainage ditch at frog spawn site B (left) and nearby frog carcass (right) within the proposed development site.

Plate 27: Drainage ditch to the north of T1 (left) and froglet found in an adjacent grassland habitat (right).

4. Mitigation Measures

It is imperative that any development do not cause further deterioration to surface water quality or inhibits restoration of surface waters to at least WFD 'good status' in the catchments affected. A conclusion of the Davis *et al.* (2018) study was that improving river ecological quality requires improved management of sediment inputs.

Incorrect practices in land use, and improper management during construction projects can lead to excessive runoff of silt, nutrients and organic matter in times of heavy rainfall. A Surface Water Management Plan (SWMP) has therefore been produced for the proposed development (Appendix 2B of the EIAR). This outlines methods for protecting water quality. The SWMP will be distributed and discussed with all parties involved in construction (including any sub-contractors) to protect aquatic conservation interests within the study area. The SWMP sets out measures to avoid siltation, erosion, surface water run-off and accidental pollution events which all have the potential to adversely affect water quality within the proposed development site during the construction phase. Any new development at watercourse crossings (upgrading/new tracks) will consider fish passage. Any works involving stream crossings will maintain or improve faunal connectivity upstream and downstream of works. The proposed development will be constructed with regard to the following guidelines:

- '*Guidelines for the Crossing of Watercourses during the Construction of National Road Schemes'* (NRA, 2008);
- '*River Crossings and Migratory Fish: Design Guidance'* (Scottish Executive, 2000);
- '*Guidelines on Protection of Fisheries during Construction Works in and Adjacent to Waters'* (IFI, 2016);
- '*Control of water pollution from construction sites – Guidance for consultants and contractors*' (Masters-Williams *et al*. 2001); and
- '*Control of water pollution from linear construction projects*' (Murnane *et al.* 2006).

Silt control will be a primary focus for the Contractor(s) during construction stage. Robust mitigation, including silt ponds will be required mitigation adjacent to access tracks and swales at the proposed development site as these are considered an effective method of retaining silt (see Plate 28). The design of these features will be in accordance with best practice, oversized and retained where suitable post construction as per the Biodiversity Enhancement Management Plan (Appendix 6E of the EIAR for more details) that accompanies the application.

Plate 28: Examples of typical silt ponds that will form part of construction mitigation and be retained during operation stage.

IFI supplied general comments relating to mitigation which apply to all wind farm developments as outlined below. This feedback is deemed invaluable, and have been incorporated into the design of the proposed development to ensure they will be implemented:

- Changes to river morphology should be avoided.
- Attention should be paid to drainage during both the construction phase and the operational phase. This includes waters being pumped from foundations or other excavations. It is particularly important during the construction phase that sufficient retention time is available in any settlement pond to ensure no deleterious matter is discharged to waters. We strongly recommend that settlement ponds are maintained, where appropriate, during the operational phase to allow for the adequate settlement of suspended solids and sediments and prevent any deleterious matter from discharging. In constructing and designing silt traps particular attention should be paid to rainfall levels and intensity. The silt traps should be designed to minimise the movement of silt during intense precipitation events where the trap may become hydraulically overloaded. It is essential that they are located with good access to facilitate monitoring sampling and maintenance. A license to discharge to waters may be required from the local authority.
- Consideration must be given to the disposal of waste materials such that they will not give rise to discharges to waters. In terms of risk, the placing of soils on watercourse-adjacent ground should not be permitted unless the area has been the subject of a risk assessment. Furthermore, drainage from disturbed and stockpiled soils will have to be considered in advance. It may be necessary to carry out soil stockpiling operations in confined areas only and to ensure vegetation/covering of the soils to prevent wash-out.
- The use of sedimentary rocks, such as shale, in road construction should be avoided. This type of material has poor tensile strength and is liable to be crushed by heavy vehicles thereby releasing fine sediment materials into the drainage system which are difficult to precipitate and may give rise to water pollution. We recommend that specialist expertise should advise on the type of material required for road construction bearing in mind the pressures that will arise during the construction phase and the necessity to avoid pollution due to fines washing out into the roadside drainage.
- In relation to watercourse crossings for the road or grid connection please be advised that IFI will require to be consulted well in advance in relation to all watercourse crossings or the use of any temporary diversions. We strongly recommend that these crossings should be kept to a minimum. We will also require that any instream structures or bridge crossings are approved by the IFI. In designing crossings, the length, slope and width of any instream structure will be important. Clear span bridges are the preferred option for all crossings especially in upland areas.
- Any instream works or other works which may impact directly on a watercourse should only be carried out during the open season which is from 1st July to 30th of September in each year (so as to avoid impacting on the aquatic habitat during the spawning season.) It would be important that appropriate scheduling of works is allowed for.
- The EIAR should indicate proposals to monitor the impact on watercourses within the site. In the event that environmental damage to the aquatic habitat and associated riparian zone is caused, the EIAR should indicate the steps that may be taken to rectify any damage to the aquatic habitat including liaison with the appropriate authorities.

- In relation to wind farm structures and infrastructure it is important that a sufficient bank side riparian zone is maintained to absorb and attenuate overland flows.

5. Conclusions

The watercourses potentially affected by the proposed development are small streams with gradients deceasing with distance from the proposed development. These streams are generally shallow, have migratory fish passage problems, and some water quality issues. It is considered that water quality and aquatic species can be protected with appropriate mitigation.

5.1 Fish

Salmonid spawning and nursery areas are of variable quality across the sites surveyed. There are no suitable fish habitats within the proposed development site as all waterbodies are too small. The streams draining the site increase in value for salmonids with distance from source, due to their greater fluvial area and presence of larger pools with associated increasing size. Indeed, salmonid juveniles and smolts have similar general requirements to those of sexually mature fish, and as they grow, the juveniles of both species of *Salmo* tend to move into deeper water (Crisp, 2000). This was exemplified by the current results where more cohorts of trout were detected where streams were larger, downstream from the proposed development site.

The downstream reaches of the watercourses draining the proposed development site collectively support brown trout, European eel and brook lamprey. It is concluded that migratory lampreys (sea and river lamprey) are highly unlikely to occur in the watercourses potentially affected by the proposed development, and that salmon are not present in the Crompaun or North Ballycannan catchments. This is due to stream size, poor habitat in the lower reaches of these streams and impediments to fish passage. Habitat for juvenile lampreys is unsuitable along high gradient reaches close to the proposed development site but improves in their lower reaches where gradient is low. There appears to be no fish populations in the South Ballycar or West Roo Streams that drain the eastern extent of the proposed development. This is most likely due to steep artificial inclines where these streams meet the River Shannon. Salmon, along with minnow, three spine-stickleback and stone loach occur in the Blackwater catchment north of the proposed development site.

The existing poor water quality, and high concentrations of silt reduces the salmonid habitat value in the North Ballycannan catchment and the lower reaches of the Crompaun catchment. As pointed out by Crisp (2000), inert suspended solids can have a variety of effects upon salmonid fishes. They may have indirect effects through reduction of light input and, when they settle out in slower flows, they may occlude gravel interstices and reduce the amount of hiding places for small fish and/or their invertebrate prey. More directly, they may abrade or clog delicate membranes (e.g., fish gills) and they may cause skin irritation and abrasions, which may facilitate various secondary infections (Crisp, 2000).

5.2 Macroinvertebrates and Water Quality

With regard to habitat for aquatic macroinvertebrates, the streams draining the proposed development site were rated marginal-suboptimal. The macroinvertebrates recorded are common and most were pollution tolerant. Macroinvertebrates communities across the study area showed reduced diversity. This is considered associated with the fluvial condition/habitat suitability of the subject streams, some which are physically degraded due to anthropogenic activities (agriculture, stream crossings). Denuded areas due to agricultural practices are the key issues in this regard (See Plate 29).

In 2021, biological water quality was satisfactory (Good-High status) in the upper reaches of streams in the Crompaun and North Ballycannan subbasins, with the exception of the upper reach of the North Ballycannan Stream (Site 6) which was moderately impacted. Biological water quality varied between Q3-4 to Q4-5. Substrate siltation could explain the reduced biological diversity and subsequent biological water quality recorded in the study area. In a detailed study carried out by Davis *et al.* (2018), sediment, phosphorus and nitrogen were manipulated simultaneously. Davis *et al.* (2018) concluded that sediment was the most pervasive stressor particularly at high cover levels. Problems in watercourses arise from smothering of coarse patches of sediment with fine particles that ingress into the coarse sediment and deplete oxygen levels by reducing through-flow within the sediment (Walsh *et al.,* 2012)[23]. The negative impacts of high and persistent sediment loads affect invertebrate assemblages and abundances, with Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa exhibiting the greatest negative response to increased sediment[24].

A decline in biological water quality from 2021 to 2023 was recorded at three locations and attributed in part to substrate siltation. An improvement in biological water quality was observed at Site 6 on the North Ballycannan Stream. It is noted that water levels in 2023 were higher than in 2021, with critically low flow in the North Ballycannan Stream in 2021. It is considered that when flows in streams in the study area drop below 95%ile (flow equalled or exceeded 95% of the time), that habitats for aquatic macroinvertebrates is reduced in both extent and quality, and this could account for the change in ecological status in the North Ballycannan Stream. It is clear that streams of the size draining the proposed development are sensitive to changes in flow and nutrient loading, and that this is related to their small size and low assimilation capacity.

Plate 29: Denuded area adjacent to the North Ballycannan Stream (left). Instream disturbance (right) within the corridor of the North Ballycannan Stream (right).

[23] https://www.epa.ie/pubs/reports/water/rivers/EPA_River_Sediment_Studies.pdf

[24] https://www.salmon-trout.org/wp-content/uploads/2017/09/STC-The-impact-of-excess-fine-sediment-on-invertebrates-and-fish-in-riverine-systems.pdf

Plate 30: Recent works has damaged the Kilmoculla Stream, a tributary of the South Ballycar Stream: excessive instream silt and uniform shape (left); fish migration barrier (right).

Suspended solids levels in water samples taken during 2021 were all below 25mg/l (no evidence of harm from concentrations < 25mg/l) but samples were taken after a dry period with little overland flows. It is clear that land management and associated activities were having an adverse effect on water quality in the streams within the proposed development site. Based on the results of the current surveys, it is concluded that the main water quality problems in the study are consistent with those documented by the EPA i.e. agricultural and domestic wate-water.

It is concluded that FPM are highly unlikely to occur in the ZOI of the proposed development, acknowledging that the study area in not in a FPM sensitive area.

5.3 Amphibians

The proposed development site is used by breeding and foraging frogs. The streams within and downslope of the site are important frog refugia during summer time.

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APPENDIX 1

MACROINVERTEBRATE PHYSICAL HABITAT SUITABILITY

Table A1.1: Physical habitat assessment of streams for their suitability for macroinvertebrate production (adapted from Barbour and Stribling, 1991).

	Optimal	Suboptimal	Marginal	Poor
Score	20	15	10	5
Bottom substrate	More than 60% of bottom is gravel, cobble, and boulders. Even mix of substratum size classes.	30-60% of bottom is cobble or boulder substrata. Substrate may be dominated by one size class.	10-30% of substrata consists of large materials. Silt or sand accounts for 70-90% of bottom.	Substrate dominated by silt and sand. Gravel, cobble and larger substrate sizes <10%.
Habitat complexity	A variety of types and sizes of material form a diverse habitat.	Structural types or sizes of material are less than optimum but adequate cover still provided.	Habitat dominated by only one or two structural components. Amount of cover is limited.	Monotonous habitat with little diversity. Silt and sand dominate and reduce habitat diversity and complexity.
Pool quality	25% of the pools are as wide or wider than the mean stream width and area >1m deep.	<5% of the pools are >1m deep and wider than the mean stream width.	<1% of the pools are >1m deep and wider than the mean stream width. Pools present may be very deep or very shallow. Variety of pools or quality is fair.	Majority of pools are small and shallow. Pools may be absent.
Bank stability	Little evidence of past bank failure and little potential for future mass wasting into channel.	Infrequent or very small slides. Low future potential of slides.	Mass wasting moderate in frequency and size. Raw spots eroded during high floods.	Frequent or large slides. Banks unstable and contributing sediment to the stream.
Bank protection	Over 80% of streambank surfaces are covered by vegetation, boulders, bedrock, or other stable materials.	50-80% of the streambanks covered with vegetation, cobble, or larger material.	25-50% of the streambank is covered by vegetation.	<25% of the streambank is covered by vegetation or stable materials.
Canopy	Vegetation of various heights provides a mix of shade and filtering light to water surface.	Discontinuous vegetation provides areas of shade alternating with areas of full exposure. Or filtering shade occurs <6h/day.	Shading is complete and dense. Or filtering shade occurs <3h/day.	Water surface is exposed to full sun nearly all day long.

APPENDIX 2

BIOTIC INDICES

Table A2.1: Intercalibration of EPA Q-rating system with Water Framework Directive status based on macroinvertebrates.

Q Value*	WFD Status	WFD Intercalibration Common Metric Value[25]	Pollution Status	Condition**	Ecological description
Q5, Q4-5	High	0.92	Unpolluted	Satisfactory	No or only minor difference from reference condition. Normal community structure, sensitive species present. Ecological processes functioning normally.
Q4	Good	0.853	Unpolluted	Satisfactory	Slight difference from reference condition. Slight change in community structure. Fewer sensitive species present but increase in species richness and productivity. Ecological processes functioning normally.
Q3-4	Moderate	0.764	Slightly polluted	Unsatisfactory	Moderate difference from reference condition. Moderate change in community structure and loss of some niche species. Some ecological processes altered. Reduced resilience and ability to absorb external shocks.
Q3, Q2-3	Poor	0.627	Moderately polluted	Unsatisfactory	Major difference from reference condition. Significant change in community structure. Significant loss of niche species. Food chains and biogeochemical pathways significantly altered. Limited ability to absorb external shocks
Q2, Q1-2, Q1	Bad	0.42	Seriously polluted	Unsatisfactory	Severe difference from reference condition. Severe change in community structure. Severe loss of niche species and ecological functioning. Food chains collapse and biogeochemical pathways breakdown. Water body incapable of supporting most aquatic life.

** These Values are based primarily on the relative proportions of pollution sensitive to tolerant macroinvertebrates (the young stages of insects primarily but also snails, worms, shrimps etc.) resident at a river site.*

*** "Condition" refers to the likelihood of interference with beneficial or potential beneficial uses.*

[25]From:https://www.epa.ie/pubs/reports/water/other/wfd/EPA_water_WFD_monitoring_programme_main_report.pdf

Table A2.2: BMWP Scores, categories, and interpretation.

BMWP score	Category	Interpretation
0-10	Very poor	Heavily polluted
11-40	Poor	Polluted or impacted
41-70	Moderate	Moderately impacted
71-100	Good	Clean but slightly impacted
>100	Very good	Unpolluted, unimpacted

Table A2.3: Revised BMWP scoring system

Name	Family	Original BMWP Score	Revised BMWP Score	Habitat Specific Scores		
				Riffles	Riffle/Pools	Pools
Flatworms	Planariidae	5	4.2	4.5	4.1	3.7
	Dendrocoelidae	5	3.1	2.3	4.1	3.1
Snails	Neritidae	6	7.5	6.7	8.1	9.3
	Viviparidae	6	6.3	2.1	4.7	7.1
	Valvatidae	3	2.8	2.5	2.5	3.2
	Hydrobiidae	3	3.9	4.1	3.9	3.7
	Lymnaeidae	3	3	3.2	3.1	2.8
	Physidae	3	1.8	0.9	1.5	2.8
	Planorbidae	3	2.9	2.6	2.9	3.1
Limpets and	Ancylidae	6	5.6	5.5	5.5	6.2
Mussels	Unionidae	6	5.2	4.7	4.8	5.5
	Sphaeriidae	3	3.6	3.7	3.7	3.4
Worms	Oligochaeta	1	3.5	3.9	3.2	2.5
Leeches	Piscicolidae	4	5	4.5	5.4	5.2
	Glossiphoniidae	3	3.1	3	3.3	2.9
	Hirudididae	3	0	0.3	-0.3	
	Erpobdellidae	3	2.8	2.8	2.8	2.6
Crustaceans	Asellidae	3	2.1	1.5	2.4	2.7
	Corophiidae	6	6.1	5.4	5.1	6.5
	Gammaridae	6	4.5	4.7	4.3	4.3
	Astacidae	8	9	8.8	9	11.2
Mayflies	Siphlonuridae	10	11	11		
	Baetidae	4	5.3	5.5	4.8	5.1
	Heptageniidae	10	9.8	9.7	10.7	13
	Leptophlebiidae	10	8.9	8.7	8.9	9.9
	Ephemerellidae	10	7.7	7.6	8.1	9.3
	Potamanthidae	10	7.6	7.6		
	Ephemeridae	10	9.3	9	9.2	11
	Caenidae	7	7.1	7.2	7.3	6.4
Stoneflies	Taeniopterygidae	10	10.8	10.7	12.1	
	Nemouridae	7	9.1	9.2	8.5	8.8
	Leuctridae	10	9.9	9.8	10.4	11.2
	Capniidae	10	10	10.1		
	Perlodidae	10	10.7	10.8	10.7	10.9

Name	Family	Original BMWP Score	Revised BMWP Score	Habitat Specific Scores		
				Riffles	Riffle/Pools	Pools
	Perlidae	10	12.5	12.5	12.2	
	Chloroperlidae	10	12.4	12.5	12.1	
Damselflies	Platycnemidae	6	5.1	3.6	5.4	5.7
	Coenagriidae	6	3.5	2.6	3.3	3.8
	Lestidae	8	5.4			5.4
	Calopterygidae	8	6.4	6	6.1	7.6
Dragonflies	Gomphidae	8				
	Cordulegasteridae	8	8.6	9.5	6.5	7.6
	Aeshnidae	8	6.1	7	6.9	5.7
	Corduliidae	8				
	Libellulidae	8	5			5
Bugs	Mesoveliidae *	5	4.7	4.9	4	5.1
	Hydrometridae	5	5.3	5	6.2	4.9
	Gerridae	5	4.7	4.5	5	4.7
	Nepidae	5	4.3	4.1	4.2	4.5
	Naucoridae	5	4.3			4.3
	Aphelocheiridae	10	8.9	8.4	9.5	11.7
	Notonectidae	5	3.8	1.8	3.4	4.4
	Pleidae	5	3.9			3.9
	Corixidae	5	3.7	3.6	3.5	3.9
Beetles	Haliplidae	5	4	3.7	4.2	4.3
	Hygrobiidae	5	2.6	5.6	-0.8	2.6
	Dytiscidae	5	4.8	5.2	4.3	4.2
	Gyrinidae	5	7.8	8.1	7.4	6.8
	Hydrophilidae	5	5.1	5.5	4.5	3.9
	Clambidae	5				
	Scirtidae	5	6.5	6.9	6.2	5.8
	Dryopidae	5	6.5	6.5		
	Elmidae	5	6.4	6.5	6.1	6.5
	Chrysomelidae *	5	4.2	4.9	1.1	4.1
	Curculionidae *	5	4	4.7	3.1	2.9
Alderflies	Sialidae	4	4.5	4.7	4.7	4.3
Caddisflies	Rhyacophilidae	7	8.3	8.2	8.6	9.6
	Philopotamidae	8	10.6	10.7	9.8	
	Polycentropidae	7	8.6	8.6	8.4	8.7
	Psychomyiidae	8	6.9	6.4	7.4	8
	Hydropsychidae	5	6.6	6.6	6.5	7.2
	Hydroptilidae	6	6.7	6.7	6.8	6.5
	Phryganeidae	10	7	6.6	5.4	8
	Limnephilidae	7	6.9	7.1	6.5	6.6
	Molannidae	10	8.9	7.8	8.1	10
	Beraeidae	10	9	8.3	7.8	10
	Odontoceridae	10	10.9	10.8	11.4	11.7
	Leptoceridae	10	7.8	7.8	7.7	8.1
	Goeridae	10	9.9	9.8	9.6	12.4
	Lepidostomatidae	10	10.4	10.3	10.7	11.6
	Brachycentridae	10	9.4	9.3	9.7	11

Name	Family	Original BMWP Score	Revised BMWP Score	Habitat Specific Scores		
				Riffles	Riffle/Pools	Pools
	Sericostomatidae	10	9.2	9.1	9.3	10.3
True flies	Tipulidae	5	5.5	5.6	5	5.1
	Chironomidae	2	3.7	4.1	3.4	2.8
	Simuliidae	5	5.8	5.9	5.1	5.5

APPENDIX 3

MACROINVERTEBRATE SPECIES LISTS

Table A3.1: Macroinvertebrate species lists for biological sampling carried out in 2021

	Pollution sensitivity group	Functional feeding group	Site									
			1	2	3	4	5	6	7	8	9	10
MAYFLIES (Uniramia, Ephemeroptera)												
Baetidae												
Baetis rhodani	C	Scraper & gathering collector	34	16	25	56		8	24	6	20	78
Baetis muticus	B	Scraper & gathering collector		12	9	10					25	25
Heptagenidae												
Rhithrogena semicolorata	A	Scraper & gathering collector		19	6	15					24	25
Ecdyonurus sp.	A	Scraper & gathering collector	3	14								3
Serratellidae	C	Gathering collector	7		10	20			5		15	40
STONEFLIES (Order Plecoptera)												
Perlodid stoneflies (Perlodidae)												
Isoperla grammatica	A	Shredder		2	13							
Needleflies (Leuctridae)												
Leuctra sp.	B	Shredder			4	12			3		5	4
Little yellows and little greens (Chloroperlidae)												
Chloroperla sp.	A	Shredder	5	6							4	3
CASED CADDIS FLIES (Tricoptera)												
Limnephilidae	B	Shredder	9	3	2	6		6	18	6	4	
Primitive caddisflies (Sericostomatidae)												
Sericostoma personatum	B	Shredder								7	2	1

	Pollution sensitivity group	Functional feeding group	Site									
			1	2	3	4	5	6	7	8	9	10
Glossosomatidae	B	Scraper	30	24		4						
Odontoceridae												
Odontocerum albicorne	B	Gathering collector	1								1	
CASELESS CADDIS FLIES (Trichoptera)												
Green sedges (Rhyacophilidae)												
Rhyacophila sp.	C	Predator		4	2	4					1	3
Trumpet-net caddisflies (Polycentropodidae)												
Polycentropus sp	C	Filtering collector	1	2	1			2		4	3	2
Grey flags (Hydropsychidae)												
Hydropsyche sp.	C	Filtering collector		4						3		2
Finger-net caddisflies (Philopomatidae)												
Philopotamus sp.	C	Filtering collector		6						1	3	3
CRUSTACEANS (Crustacea)												
Isopods, Asellidae												
Asellus aquaticus	D	Shredder			3							1
Amphipods (Amphipoda, Gammaridae)												
Gammarus sp.	C	Shredder	47	16		14	110	90	4	24	40	16
TRUE FLIES (Diptera)												
Craneflies (Tipulidae)												
Dicranota sp	C	Shredder	2	2	5	3		2	1	2	3	3
Family Chironomidae			2						2		3	2
Chironomous sp.	C	Filtering collector	4		12	25			10	7		10
Rheotanytarsus	C	Filtering collector										
Empididae												

	Pollution sensitivity group	Functional feeding group	Site									
			1	2	3	4	5	6	7	8	9	10
Clinocera sp.	C	Filtering collector			1							
Dixidae (meniscus midge larvae)	C	Filtering collector										
Simulidae	C	Filtering collector	65	26	30	15			6		32	15
BEETLES (Coleoptera)												
Dytiscidae	C	Predator				1						
Helodidae	C	Predator						1		2		
Riffle Beetle (Elmidae)	C	Predator										
Limnius volckmari	C	Predator									6	5
Elmis aenea	C	Predator				6		5		3		
Hydraenidae	C	Predator		2		2			2			
SNAILS (Mollusca, Gastropoda)												
Family Hydrobiidae												
Potamopyrgus antipodarium	C	Scraper		2		1				5		
Family Ancylidae												
Ancylus fluviatilis	C	Scraper	2			4			9			
BUGS (Hemiptera)												
Water skaters (Gerridae)												
Gerris sp.	C	Predator					12					
Broad shouldered water skaters												
Microvelia sp.	C	Predator			3				2	3	2	1
Velia sp.	C	Predator									1	
LEECHES (Hirudinae)												
Glossiphonidae												
Glossiphonia complanata	D	Predator						1				

	Pollution sensitivity group	Functional feeding group	Site									
			1	2	3	4	5	6	7	8	9	10
Erpobdellidae					1						1	
Erpobdella sp	D	Predator										
Aquatic earthworm (Lumbriculidae)	D	Predator										1
Total			212	160	127	198	122	115	86	73	195	243

Table A3.2: Macroinvertebrate species lists for biological sampling carried out in 2023

	Pollution sensitivity group	Functional feeding group	Site									
			1	2	3	4	5	6	7	8	9	10
MAYFLIES (Uniramia, Ephemeroptera)												
Baetidae												
Baetis rhodani	C	Scraper & gathering collector	C	C	C	C		F	C	F	C	N
Baetis muticus	B	Scraper & gathering collector	F	F	F	F			C		C	C
Heptagenidae												
Rhithrogena semicolorata	A	Scraper & gathering collector	F	F		F					C	F
Ecdyonurus sp.	A	Scraper & gathering collector		C				C			F	F
Serratellidae	C	Gathering collector	F			F			F		F	F
STONEFLIES (Order Plecoptera)												
Perlodid stoneflies (Perlodidae)												
Isoperla grammatica	A	Shredder			F							
Needleflies (Leuctridae)												
Leuctra sp.	B	Shredder			F	F			C		C	C
Little yellows and little greens (Chloroperlidae)												

	Pollution sensitivity group	Functional feeding group	Site									
			1	2	3	4	5	6	7	8	9	10
Chloroperla sp.	A	Shredder	F								F	
CASED CADDIS FLIES (Tricoptera)												
Limnephilidae	B	Shredder	C	C		F		C	F	C	F	F
Limnephilus			F									
Primitive caddisflies (Sericostomatidae)												
Sericostoma personatum	B	Shredder					F			7		
Glossosomatidae	B	Scraper	C	C		F						C
Odontoceridae			F									
Odontocerum albicorne	B	Gathering collector	F	C		F						
CASELESS CADDIS FLIES (Trichoptera)												
Green sedges (Rhyacophilidae)												
Rhyacophila sp.	C	Predator	C	F		F		F			F	F
Trumpet-net caddisflies (Polycentropodidae)												
Polycentropus sp	C	Filtering collector	F	C		F	F	F	F	C		F
Grey flags (Hydropsychidae)												
Hydropsyche sp.	C	Filtering collector	F	F						C		F
Finger-net caddisflies (Philopomatidae)												
Philopotamus sp.	C	Filtering collector	F	F	F					C		F
CRUSTACEANS (Crustacea)												
Isopods, Asellidae												
Asellus aquaticus	D	Shredder							F		F	F
Amphipods (Amphipoda, Gammaridae)												
Gammarus sp.	C	Shredder	C	C	C	C	D	C	C	N	C	C
TRUE FLIES (Diptera)												

	Pollution sensitivity group	Functional feeding group	Site									
			1	2	3	4	5	6	7	8	9	10
Craneflies (Tipulidae)												
Dicranota sp	C	Shredder	F	F	F	F		C	F	F	F	F
Family Chironomidae			F						F		F	
Chironomous sp.	C	Filtering collector			F	F		C				F
Rheotanytarsus	C	Filtering collector						F				
Empididae												
Clinocera sp.	C	Filtering collector									F	
Dixidae (meniscus midge larvae)	C	Filtering collector				F						
Simulidae	C	Filtering collector	C	C	D	C						C
BEETLES (Coleoptera)												
Dytiscidae	C	Predator				F						
Dytiscus sp.									F			
Gyrinidae	C	Predator									F	
Riffle Beetle (Elmidae)	C	Predator										
Limnius volckmari	C	Predator										F
Elmis aenea	C	Predator								F		F
Haliplidae						F						
SNAILS (Mollusca, Gastropoda)												
Family Hydrobiidae												
Potamopyrgus antipodarium	C	Scraper					C					
Family Ancylidae												
Ancylus fluviatilis	C	Scraper	2							F		
BUGS (Hemiptera)												
Water skaters (Gerridae)												

	Pollution sensitivity group	Functional feeding group	Site									
			1	2	3	4	5	6	7	8	9	10
Gerris sp.	C	Predator					F					
Broad shouldered water skaters												
Microvelia sp.	C	Predator	F									f
Velia sp.	C	Predator		F			C		F			
LEECHES (Hirudinae)												
Glossiphonidae												
Glossiphonia complanata	D	Predator						F				
Erpobdellidae											F	
Erpobdella sp	D	Predator			F	F						F
Aquatic earthworm (Lumbriculidae)	D	Predator		F								F
Flatworms (Platyhelminthes)			F	F								
Water mites (Hydrachnidae)								C				

APPENDIX 4

LABORATORY TEST REPORTS

TEST REPORT NO: 201579 .1

Client: Malachy Walsh & Partners
Reen Point
Blennerville
Tralee
Co. Kerry

BHP Ref. No: 21/06/3891
Quote Ref: QC005494
Order No: N/A
Sales Order: 109723
Date Received: 24/06/2021
Date Sampled: 24/06/2021
Date Completed: 08/07/2021
Sample Type: Surface Water

FTAO: Gerard Hayes
Site: Ballycar
BHP Ref: On Demand_Surface Water
Client Ref: Site 1

Testing
Analysing
Consulting

BHP Laboratories
New Road
Thomondgate
Limerick
Tel: +353 61 455399
Fax: +353 61 455261
EMail:dervlapurcell@bhp.ie

Test		Units	Results	Customer Limits	Date Analysed	Method
B.O.D.	Acc.	mg/L	2.3		01/07/2021	BHP AC 005
Total Ammonia (as N)	Acc.	mg/L	<0.1		01/07/2021	BHP AC 095
Total Dissolved Solids		mg/L	128		25/06/2021	BHP AC 011
Total Hardness (as $CaCO_3$)		mg/L	82		25/06/2021	BHP AC 095
Total Organic Carbon		mg/L	4.2		28/06/2021	BHP AC 153
Total Phosphorus as P		mg/L	<0.1		08/07/2021	BHP AC 142
Total Suspended Solids	Acc.	mg/L	<5		25/06/2021	BHP AC 012
Nitrate (as NO_3)	Acc.	mg/L	1.5		25/06/2021	BHP AC 019
Nitrite (as NO_2)	Acc.	mg/L	<0.05		24/06/2021	BHP AC 019
OrthoPhosphate (as PO_4)	Acc.	mg/L	<0.2		24/06/2021	BHP AC 019

Authorised by: Dervla Purcell
Laboratory Manager

Date Authorised: 08/07/2021

Additional Information:(Opinions, where stated, are not covered by accreditation)
Acc.: INAB Accredited
ND: None detected in volume analysed
^ Potable water matrix
***** Subcontracted to an approved accredited laboratory
****** This sample has been analysed outside recommended stability times. It is therefore possible that the results provided may be compromised.

~ : Sample Condition : ACCEPTABLE

TEST REPORT NO: 201579 .2

Client: Malachy Walsh & Partners
Reen Point
Blennerville
Tralee
Co. Kerry

BHP Ref. No: 21/06/3892
Quote Ref: QC005494
Order No: N/A
Sales Order: 109723
Date Received: 24/06/2021
Date Sampled: 24/06/2021
Date Completed: 08/07/2021
Sample Type: Surface Water

FTAO: Gerard Hayes
Site: Ballycar
BHP Ref: On Demand_Surface Water
Client Ref: Site 2

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Analysing
Consulting

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New Road
Thomondgate
Limerick
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Fax: +353 61 455261
EMail:dervlapurcell@bhp.ie

Test		Units	Results	Customer Limits	Date Analysed	Method
B.O.D.	Acc.	mg/L	1.0		01/07/2021	BHP AC 005
Total Ammonia (as N)	Acc.	mg/L	<0.1		01/07/2021	BHP AC 095
Total Dissolved Solids		mg/L	216		25/06/2021	BHP AC 011
Total Hardness (as $CaCO_3$)		mg/L	123		25/06/2021	BHP AC 095
Total Organic Carbon		mg/L	<2		28/06/2021	BHP AC 153
Total Phosphorus as P		mg/L	<0.1		08/07/2021	BHP AC 142
Total Suspended Solids	Acc.	mg/L	<5		25/06/2021	BHP AC 012
Nitrate (as NO_3)	Acc.	mg/L	5.6		25/06/2021	BHP AC 019
Nitrite (as NO_2)	Acc.	mg/L	<0.05		24/06/2021	BHP AC 019
OrthoPhosphate (as PO_4)	Acc.	mg/L	<0.2		24/06/2021	BHP AC 019

Authorised by: Dervla Purcell
Laboratory Manager

Date Authorised: 08/07/2021

Additional Information:(Opinions, where stated, are not covered by accreditation)
Acc.: INAB Accredited
ND: None detected in volume analysed
^ Potable water matrix
***** Subcontracted to an approved accredited laboratory
****** This sample has been analysed outside recommended stability times. It is therefore possible that the results provided may be compromised.

~ : Sample Condition : ACCEPTABLE

TEST REPORT NO: 201579 .3

Client: Malachy Walsh & Partners
Reen Point
Blennerville
Tralee
Co. Kerry

BHP Ref. No: 21/06/3893
Quote Ref: QC005494
Order No: N/A
Sales Order: 109723
Date Received: 24/06/2021
Date Sampled: 24/06/2021
Date Completed: 08/07/2021
Sample Type: Surface Water

FTAO: Gerard Hayes
Site: Ballycar
BHP Ref: On Demand_Surface Water
Client Ref: Site 3

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Limerick
Tel: +353 61 455399
Fax: +353 61 455261
EMail:dervlapurcell@bhp.ie

Test		Units	Results	Customer Limits	Date Analysed	Method
B.O.D.	Acc.	mg/L	0.7		01/07/2021	BHP AC 005
Total Ammonia (as N)	Acc.	mg/L	<0.1		01/07/2021	BHP AC 095
Total Dissolved Solids		mg/L	122		25/06/2021	BHP AC 011
Total Hardness (as $CaCO_3$)		mg/L	75		25/06/2021	BHP AC 095
Total Organic Carbon		mg/L	2.8		28/06/2021	BHP AC 153
Total Phosphorus as P		mg/L	0.13		08/07/2021	BHP AC 142
Total Suspended Solids	Acc.	mg/L	<10		25/06/2021	BHP AC 012
Nitrate (as NO_3)	Acc.	mg/L	3.9		25/06/2021	BHP AC 019
Nitrite (as NO_2)	Acc.	mg/L	<0.05		24/06/2021	BHP AC 019
OrthoPhosphate (as PO_4)	Acc.	mg/L	<0.2		24/06/2021	BHP AC 019

Authorised by: Dervla Purcell
Laboratory Manager

Date Authorised: 08/07/2021

Additional Information:(Opinions, where stated, are not covered by accreditation)
Acc.: INAB Accredited
ND: None detected in volume analysed
^ Potable water matrix
***** Subcontracted to an approved accredited laboratory
****** This sample has been analysed outside recommended stability times. It is therefore possible that the results provided may be compromised.

~ : Sample Condition : ACCEPTABLE

TEST REPORT NO: 201579 .4

Client: Malachy Walsh & Partners
Reen Point
Blennerville
Tralee
Co. Kerry

BHP Ref. No: 21/06/3894
Quote Ref: QC005494
Order No: N/A
Sales Order: 109723
Date Received: 24/06/2021
Date Sampled: 24/06/2021
Date Completed: 08/07/2021
Sample Type: Surface Water

FTAO: Gerard Hayes
Site: Ballycar
BHP Ref: On Demand_Surface Water
Client Ref: Site 4

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Analysing
Consulting

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New Road
Thomondgate
Limerick
Tel: +353 61 455399
Fax: +353 61 455261
EMail:dervlapurcell@bhp.ie

Test		Units	Results	Customer Limits	Date Analysed	Method
B.O.D.	Acc.	mg/L	0.4		01/07/2021	BHP AC 005
Total Ammonia (as N)	Acc.	mg/L	<0.1		01/07/2021	BHP AC 095
Total Dissolved Solids		mg/L	192		25/06/2021	BHP AC 011
Total Hardness (as $CaCO_3$)		mg/L	111		25/06/2021	BHP AC 095
Total Organic Carbon		mg/L	2.0		28/06/2021	BHP AC 153
Total Phosphorus as P		mg/L	<0.1		08/07/2021	BHP AC 142
Total Suspended Solids	Acc.	mg/L	<10		28/06/2021	BHP AC 012
Nitrate (as NO_3)	Acc.	mg/L	2.3		25/06/2021	BHP AC 019
Nitrite (as NO_2)	Acc.	mg/L	<0.05		24/06/2021	BHP AC 019
OrthoPhosphate (as PO_4)	Acc.	mg/L	<0.2		24/06/2021	BHP AC 019

Authorised by: Dervla Purcell
Laboratory Manager

Date Authorised: 08/07/2021

Additional Information:(Opinions, where stated, are not covered by accreditation)
Acc.: INAB Accredited
ND: None detected in volume analysed
^ Potable water matrix
* Subcontracted to an approved accredited laboratory
** This sample has been analysed outside recommended stability times. It is therefore possible that the results provided may be compromised.

~ : Sample Condition : ACCEPTABLE

TEST REPORT NO: 201579 .5

Client: Malachy Walsh & Partners
Reen Point
Blennerville
Tralee
Co. Kerry

BHP Ref. No: 21/06/3895
Quote Ref: QC005494
Order No: N/A
Sales Order: 109723
Date Received: 24/06/2021
Date Sampled: 24/06/2021
Date Completed: 08/07/2021
Sample Type: Surface Water

FTAO: Gerard Hayes
Site: Ballycar
BHP Ref: On Demand_Surface Water
Client Ref: Site 5

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Consulting

BHP Laboratories
New Road
Thomondgate
Limerick
Tel: +353 61 455399
Fax: +353 61 455261
EMail:dervlapurcell@bhp.ie

Test		Units	Results	Customer Limits	Date Analysed	Method
B.O.D.	Acc.	mg/L	0.6		01/07/2021	BHP AC 005
Total Ammonia (as N)	Acc.	mg/L	<0.1		01/07/2021	BHP AC 095
Total Dissolved Solids		mg/L	148		25/06/2021	BHP AC 011
Total Hardness (as $CaCO_3$)		mg/L	75		25/06/2021	BHP AC 095
Total Organic Carbon		mg/L	3.0		28/06/2021	BHP AC 153
Total Phosphorus as P		mg/L	<0.1		08/07/2021	BHP AC 142
Total Suspended Solids	Acc.	mg/L	<10		28/06/2021	BHP AC 012
Nitrate (as NO_3)	Acc.	mg/L	1.3		25/06/2021	BHP AC 019
Nitrite (as NO_2)	Acc.	mg/L	<0.05		24/06/2021	BHP AC 019
OrthoPhosphate (as PO_4)	Acc.	mg/L	<0.2		24/06/2021	BHP AC 019

Authorised by: Dervla Purcell
Laboratory Manager

Date Authorised: 08/07/2021

Additional Information:(Opinions, where stated, are not covered by accreditation)
Acc.: INAB Accredited
ND: None detected in volume analysed
^ Potable water matrix
***** Subcontracted to an approved accredited laboratory
****** This sample has been analysed outside recommended stability times. It is therefore possible that the results provided may be compromised.

~ : Sample Condition : ACCEPTABLE

TEST REPORT NO: 201579 .6

Client: Malachy Walsh & Partners
Reen Point
Blennerville
Tralee
Co. Kerry

BHP Ref. No: 21/06/3896
Quote Ref: QC005494
Order No: N/A
Sales Order: 109723
Date Received: 24/06/2021
Date Sampled: 24/06/2021
Date Completed: 08/07/2021
Sample Type: Surface Water

FTAO: Gerard Hayes
Site: Ballycar
BHP Ref: On Demand_Surface Water
Client Ref: Site 6

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Analysing
Consulting

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Fax: +353 61 455261
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Test		Units	Results	Customer Limits	Date Analysed	Method
B.O.D.	Acc.	mg/L	0.5		01/07/2021	BHP AC 005
Total Ammonia (as N)	Acc.	mg/L	<0.1		01/07/2021	BHP AC 095
Total Dissolved Solids		mg/L	280		25/06/2021	BHP AC 011
Total Hardness (as $CaCO_3$)		mg/L	191		25/06/2021	BHP AC 095
Total Organic Carbon		mg/L	3.1		28/06/2021	BHP AC 153
Total Phosphorus as P		mg/L	<0.1		08/07/2021	BHP AC 142
Total Suspended Solids	Acc.	mg/L	<10		28/06/2021	BHP AC 012
Nitrate (as NO_3)	Acc.	mg/L	2.3		25/06/2021	BHP AC 019
Nitrite (as NO_2)	Acc.	mg/L	<0.05		24/06/2021	BHP AC 019
OrthoPhosphate (as PO_4)	Acc.	mg/L	<0.2		24/06/2021	BHP AC 019

Authorised by: Dervla Purcell
Laboratory Manager

Date Authorised: 08/07/2021

Additional Information:(Opinions, where stated, are not covered by accreditation)
Acc.: INAB Accredited
ND: None detected in volume analysed
^ Potable water matrix
* Subcontracted to an approved accredited laboratory
** This sample has been analysed outside recommended stability times. It is therefore possible that the results provided may be compromised.

~ : Sample Condition : ACCEPTABLE

TEST REPORT NO: 201579 .7

Client: Malachy Walsh & Partners
Reen Point
Blennerville
Tralee
Co. Kerry

BHP Ref. No: 21/06/3897
Quote Ref: QC005494
Order No: N/A
Sales Order: 109723
Date Received: 24/06/2021
Date Sampled: 24/06/2021
Date Completed: 08/07/2021
Sample Type: Surface Water

FTAO: Gerard Hayes
Site: Ballycar
BHP Ref: On Demand_Surface Water
Client Ref: Site 7

Testing
Analysing
Consulting

BHP Laboratories
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Thomondgate
Limerick
Tel: +353 61 455399
Fax: +353 61 455261
EMail:dervlapurcell@bhp.ie

Test		Units	Results	Customer Limits	Date Analysed	Method
B.O.D.	Acc.	mg/L	0.9		01/07/2021	BHP AC 005
Total Ammonia (as N)	Acc.	mg/L	<0.1		01/07/2021	BHP AC 095
Total Dissolved Solids		mg/L	200		25/06/2021	BHP AC 011
Total Hardness (as $CaCO_3$)		mg/L	147		25/06/2021	BHP AC 095
Total Organic Carbon		mg/L	6.0		28/06/2021	BHP AC 153
Total Phosphorus as P		mg/L	<0.1		08/07/2021	BHP AC 142
Total Suspended Solids	Acc.	mg/L	<10		28/06/2021	BHP AC 012
Nitrate (as NO_3)	Acc.	mg/L	0.57		25/06/2021	BHP AC 019
Nitrite (as NO_2)	Acc.	mg/L	<0.05		24/06/2021	BHP AC 019
OrthoPhosphate (as PO_4)	Acc.	mg/L	<0.2		24/06/2021	BHP AC 019

Authorised by: Dervla Purcell
Laboratory Manager

Date Authorised: 08/07/2021

Additional Information:(Opinions, where stated, are not covered by accreditation)
Acc.: INAB Accredited
ND: None detected in volume analysed
^ Potable water matrix
***** Subcontracted to an approved accredited laboratory
****** This sample has been analysed outside recommended stability times. It is therefore possible that the results provided may be compromised.

~ : Sample Condition : ACCEPTABLE

TEST REPORT NO: 201579 .8

Client: Malachy Walsh & Partners
Reen Point
Blennerville
Tralee
Co. Kerry

BHP Ref. No: 21/06/3898
Quote Ref: QC005494
Order No: N/A
Sales Order: 109723
Date Received: 24/06/2021
Date Sampled: 24/06/2021
Date Completed: 08/07/2021
Sample Type: Surface Water

FTAO: Gerard Hayes
Site: Ballycar
BHP Ref: On Demand_Surface Water
Client Ref: Site 8

Testing
Analysing
Consulting

BHP Laboratories
New Road
Thomondgate
Limerick
Tel: +353 61 455399
Fax: +353 61 455261
EMail:dervlapurcell@bhp.ie

Test		Units	Results	Customer Limits	Date Analysed	Method
B.O.D.	Acc.	mg/L	0.3		01/07/2021	BHP AC 005
Total Ammonia (as N)	Acc.	mg/L	<0.1		01/07/2021	BHP AC 095
Total Dissolved Solids		mg/L	336		25/06/2021	BHP AC 011
Total Hardness (as $CaCO_3$)		mg/L	201		25/06/2021	BHP AC 095
Total Organic Carbon		mg/L	3.3		28/06/2021	BHP AC 153
Total Phosphorus as P		mg/L	<0.1		08/07/2021	BHP AC 142
Total Suspended Solids	Acc.	mg/L	<10		28/06/2021	BHP AC 012
Nitrate (as NO_3)	Acc.	mg/L	3.3		24/06/2021	BHP AC 019
Nitrite (as NO_2)	Acc.	mg/L	<0.05		24/06/2021	BHP AC 019
OrthoPhosphate (as PO_4)	Acc.	mg/L	<0.2		24/06/2021	BHP AC 019

Authorised by: Dervla Purcell
Laboratory Manager

Date Authorised: 08/07/2021

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ND: None detected in volume analysed
^ Potable water matrix
* Subcontracted to an approved accredited laboratory
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~ : Sample Condition : ACCEPTABLE

TEST REPORT NO: 201579 .9

Client: Malachy Walsh & Partners
Reen Point
Blennerville
Tralee
Co. Kerry

BHP Ref. No: 21/06/3899
Quote Ref: QC005494
Order No: N/A
Sales Order: 109723
Date Received: 24/06/2021
Date Sampled: 24/06/2021
Date Completed: 08/07/2021
Sample Type: Surface Water

FTAO: Gerard Hayes
Site: Ballycar
BHP Ref: On Demand_Surface Water
Client Ref: Site 9

Testing
Analysing
Consulting

BHP Laboratories
New Road
Thomondgate
Limerick
Tel: +353 61 455399
Fax: +353 61 455261
EMail:dervlapurcell@bhp.ie

Test		Units	Results	Customer Limits	Date Analysed	Method
B.O.D.	Acc.	mg/L	0.2		01/07/2021	BHP AC 005
Total Ammonia (as N)	Acc.	mg/L	<0.1		01/07/2021	BHP AC 095
Total Dissolved Solids		mg/L	224		25/06/2021	BHP AC 011
Total Hardness (as $CaCO_3$)		mg/L	129		25/06/2021	BHP AC 095
Total Organic Carbon		mg/L	4.6		28/06/2021	BHP AC 153
Total Phosphorus as P		mg/L	<0.1		08/07/2021	BHP AC 142
Total Suspended Solids	Acc.	mg/L	<10		28/06/2021	BHP AC 012
Nitrate (as NO_3)	Acc.	mg/L	2.0		24/06/2021	BHP AC 019
Nitrite (as NO_2)	Acc.	mg/L	<0.05		24/06/2021	BHP AC 019
OrthoPhosphate (as PO_4)	Acc.	mg/L	<0.2		24/06/2021	BHP AC 019

Authorised by: Dervla Purcell
Laboratory Manager

Date Authorised: 08/07/2021

Additional Information:(Opinions, where stated, are not covered by accreditation)
Acc.: INAB Accredited
ND: None detected in volume analysed
^ Potable water matrix
* Subcontracted to an approved accredited laboratory
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~ : Sample Condition : ACCEPTABLE

TEST REPORT NO: 201579 .10

Client: Malachy Walsh & Partners
Reen Point
Blennerville
Tralee
Co. Kerry

BHP Ref. No: 21/06/3900
Quote Ref: QC005494
Order No: N/A
Sales Order: 109723
Date Received: 24/06/2021
Date Sampled: 24/06/2021
Date Completed: 08/07/2021
Sample Type: Surface Water

FTAO: Gerard Hayes
Site: Ballycar
BHP Ref: On Demand_Surface Water
Client Ref: Site 10

Testing
Analysing
Consulting

BHP Laboratories
New Road
Thomondgate
Limerick
Tel: +353 61 455399
Fax: +353 61 455261
EMail:dervlapurcell@bhp.ie

Test		Units	Results	Customer Limits	Date Analysed	Method
B.O.D.	Acc.	mg/L	<0.1		01/07/2021	BHP AC 005
Total Ammonia (as N)	Acc.	mg/L	<0.1		01/07/2021	BHP AC 095
Total Dissolved Solids		mg/L	242		25/06/2021	BHP AC 011
Total Hardness (as $CaCO_3$)		mg/L	149		25/06/2021	BHP AC 095
Total Organic Carbon		mg/L	5.2		28/06/2021	BHP AC 153
Total Phosphorus as P		mg/L	<0.1		08/07/2021	BHP AC 142
Total Suspended Solids	Acc.	mg/L	<10		28/06/2021	BHP AC 012
Nitrate (as NO_3)	Acc.	mg/L	2.9		24/06/2021	BHP AC 019
Nitrite (as NO_2)	Acc.	mg/L	<0.05		24/06/2021	BHP AC 019
OrthoPhosphate (as PO_4)	Acc.	mg/L	<0.2		24/06/2021	BHP AC 019

Authorised by: Dervla Purcell
Laboratory Manager

Date Authorised: 08/07/2021

Additional Information:(Opinions, where stated, are not covered by accreditation)
Acc.: INAB Accredited
ND: None detected in volume analysed
^ Potable water matrix
* Subcontracted to an approved accredited laboratory
** This sample has been analysed outside recommended stability times. It is therefore possible that the results provided may be compromised.

~ : Sample Condition : ACCEPTABLE

Certificate of Analysis

Customer:	M. Walsh & Partners	**Project:**	Surface Water Analysis
Address:	Reen Point Blennerville Tralee Co Kerry	**Site**	
		Date Received:	22/06/2023
		Condition of Sample:	Satisfactory
Report to:	Gerard Hayes	**Date Analysed:**	22/06/2023 - 04/07/2023
Customer PO	22156	**Issue Date:**	06/07/2023
Quote No.	Q23-00418	**BATCH NUMBER:**	**23-29768**

Sadhbh O Brien

Sadhbh O Brien
Chemistry Team Lead

Index to symbols used & Notes

*	Analysis is not INAB/UKAS accredited
**	Adapted from Standard Methods for the Examination of Water and Wastewater.
***	Customer specific limits
(F)	Analysis carried out at our Farranfore Laboratory.
(D)	Analysis carried out at our Dunrine Laboratory.
LOQ	Parameter Limit of Quantification
Note 6	Subcontracted Parameter.

Notes

- **The results relate only to the items tested.**
- **Opinions and interpretations expressed herein are outside the scope of INAB accreditation.**
- **The analysis report shall not be reproduced except in full without written approval of the laboratory.**
- **Sampling is outside the scope of the laboratory activities.**

Notes for Drinking Water samples

Note A	The water should not be aggressive
Note B	Compliance must be ensured with the conditions that [NO3]/50 + [NO2]/3 =1
Note C	Acceptable to customers and no abnormal change
Note D	In the case of surface water treatment, a parametric value not exceeding 1 NTU in the water ex treatment works must be strived for
Note F	Fluoridated supplies 0.8 mg/L; Natural supplies 1.5 mg/L.

Customer Sample Ref:	23960 Site 1	**Customer Sample Code:**	
Project:	Surface Water Analysis	**Sampled By:**	Catriona Fox
Our Reference:	94932 (23-29768)	**Sample Matrix:**	Surface Water
Date Sampled:	22/06/2023	**Time Sampled:**	:

Method:		Parameter:	Units	LOQ	Result
		Chemical Analysis: (F)			
SCP 052		Conductivity	µS/cm @ 20 ℃	*15*	66
SCP 015		Biological Oxygen Demand (BOD)	mg/L	*1.0*	< 1.0
SCP 010		Suspended Solids	mg/L	*2*	< 4
SCP 027A		Total Ammonia	mg/L N	*0.02*	< 0.02
SCP 027G		Nitrate	mg/L N	*0.25*	< 0.25
SCP 027F		Nitrite	mg/L N	*0.005*	< 0.005
SCP 027C		Orthophosphate	mg/L P	*0.01*	0.02
SCP 027I		Total Hardness	mg/L CaCO3	*5*	16
SCP 016		Chemical Oxygen Demand (COD)	mg/L	*10*	< 10
SCP 044		Total Phosphorus	mg/L P	*0.04*	0.08
SCP 065B		Total Organic Carbon (TOC)	mg/L	*0.5*	4.6
**2510 B	*	Total Dissolved Solids (TDS)	mg/L	*5*	47

Customer Sample Ref:	23960 Site 2	**Customer Sample Code:**	
Project:	Surface Water Analysis	**Sampled By:**	Catriona Fox
Our Reference:	94933 (23-29768)	**Sample Matrix:**	Surface Water
Date Sampled:	22/06/2023	**Time Sampled:**	:

Method:		Parameter:	Units	LOQ	Result
		Chemical Analysis: (F)			
SCP 052		Conductivity	µS/cm @ 20 ℃	*15*	62
SCP 015		Biological Oxygen Demand (BOD)	mg/L	*1.0*	< 1.0
SCP 010		Suspended Solids	mg/L	*2*	< 4
SCP 027A		Total Ammonia	mg/L N	*0.02*	< 0.02
SCP 027G		Nitrate	mg/L N	*0.25*	< 0.25
SCP 027F		Nitrite	mg/L N	*0.005*	< 0.005
SCP 027C		Orthophosphate	mg/L P	*0.01*	< 0.01
SCP 027I		Total Hardness	mg/L CaCO3	*5*	16
SCP 016		Chemical Oxygen Demand (COD)	mg/L	*10*	< 10
SCP 044		Total Phosphorus	mg/L P	*0.04*	0.06
SCP 065B		Total Organic Carbon (TOC)	mg/L	*0.5*	4.9
**2510 B	*	Total Dissolved Solids (TDS)	mg/L	*5*	35

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directors: K. Murphy, M. Murphy & C. Murphy
registered in ireland no 323196 | vat reg no IE 6343196 M

Customer Sample Ref:	23960 Site 3	**Customer Sample Code:**	
Project:	Surface Water Analysis	**Sampled By:**	Catriona Fox
Our Reference:	94934 (23-29768)	**Sample Matrix:**	Surface Water
Date Sampled:	22/06/2023	**Time Sampled:**	:

Method:		Parameter:	Units	LOQ	Result
		Chemical Analysis: (F)			
SCP 052		Conductivity	µS/cm @ 20 ℃	*15*	61
SCP 015		Biological Oxygen Demand (BOD)	mg/L	*1.0*	< 1.0
SCP 010		Suspended Solids	mg/L	*2*	< 4
SCP 027A		Total Ammonia	mg/L N	*0.02*	< 0.02
SCP 027G		Nitrate	mg/L N	*0.25*	< 0.25
SCP 027F		Nitrite	mg/L N	*0.005*	< 0.005
SCP 027C		Orthophosphate	mg/L P	*0.01*	< 0.01
SCP 027I		Total Hardness	mg/L CaCO3	*5*	16
SCP 016		Chemical Oxygen Demand (COD)	mg/L	*10*	10
SCP 044		Total Phosphorus	mg/L P	*0.04*	0.07
SCP 065B		Total Organic Carbon (TOC)	mg/L	*0.5*	5.3
**2510 B	*	Total Dissolved Solids (TDS)	mg/L	*5*	34

Customer Sample Ref:	23960 Site 4	**Customer Sample Code:**	
Project:	Surface Water Analysis	**Sampled By:**	Catriona Fox
Our Reference:	94935 (23-29768)	**Sample Matrix:**	Surface Water
Date Sampled:	22/06/2023	**Time Sampled:**	:

Method:		Parameter:	Units	LOQ	Result
		Chemical Analysis: (F)			
SCP 052		Conductivity	µS/cm @ 20 ℃	*15*	66
SCP 015		Biological Oxygen Demand (BOD)	mg/L	*1.0*	< 1.0
SCP 010		Suspended Solids	mg/L	*2*	< 4
SCP 027A		Total Ammonia	mg/L N	*0.02*	< 0.02
SCP 027G		Nitrate	mg/L N	*0.25*	< 0.25
SCP 027F		Nitrite	mg/L N	*0.005*	< 0.005
SCP 027C		Orthophosphate	mg/L P	*0.01*	< 0.01
SCP 027I		Total Hardness	mg/L CaCO3	*5*	17
SCP 016		Chemical Oxygen Demand (COD)	mg/L	*10*	< 10
SCP 044		Total Phosphorus	mg/L P	*0.04*	0.04
SCP 065B		Total Organic Carbon (TOC)	mg/L	*0.5*	5.4
**2510 B	*	Total Dissolved Solids (TDS)	mg/L	*5*	37

Customer Sample Ref:	23960 Site 5	**Customer Sample Code:**	
Project:	Surface Water Analysis	**Sampled By:**	Catriona Fox
Our Reference:	94936 (23-29768)	**Sample Matrix:**	Surface Water
Date Sampled:	22/06/2023	**Time Sampled:**	:

Method:		Parameter:	Units	LOQ	Result
		Chemical Analysis: (F)			
SCP 052		Conductivity	µS/cm @ 20 ℃	*15*	97
SCP 015		Biological Oxygen Demand (BOD)	mg/L	*1.0*	< 1.0
SCP 010		Suspended Solids	mg/L	*2*	< 4
SCP 027A		Total Ammonia	mg/L N	*0.02*	< 0.02
SCP 027G		Nitrate	mg/L N	*0.25*	< 0.25
SCP 027F		Nitrite	mg/L N	*0.005*	< 0.005
SCP 027C		Orthophosphate	mg/L P	*0.01*	< 0.01
SCP 027I		Total Hardness	mg/L CaCO3	*5*	29
SCP 016		Chemical Oxygen Demand (COD)	mg/L	*10*	< 10
SCP 044		Total Phosphorus	mg/L P	*0.04*	0.08
SCP 065B		Total Organic Carbon (TOC)	mg/L	*0.5*	5.0
**2510 B	*	Total Dissolved Solids (TDS)	mg/L	*5*	54

Customer Sample Ref:	23960 Site 6	**Customer Sample Code:**	
Project:	Surface Water Analysis	**Sampled By:**	Catriona Fox
Our Reference:	94937 (23-29768)	**Sample Matrix:**	Surface Water
Date Sampled:	22/06/2023	**Time Sampled:**	:

Method:		Parameter:	Units	LOQ	Result
		Chemical Analysis: (F)			
SCP 052		Conductivity	µS/cm @ 20 ℃	*15*	62
SCP 015		Biological Oxygen Demand (BOD)	mg/L	*1.0*	< 1.0
SCP 010		Suspended Solids	mg/L	*2*	< 4
SCP 027A		Total Ammonia	mg/L N	*0.02*	< 0.02
SCP 027G		Nitrate	mg/L N	*0.25*	< 0.25
SCP 027F		Nitrite	mg/L N	*0.005*	< 0.005
SCP 027C		Orthophosphate	mg/L P	*0.01*	< 0.01
SCP 027I		Total Hardness	mg/L CaCO3	*5*	16
SCP 016		Chemical Oxygen Demand (COD)	mg/L	*10*	11
SCP 044		Total Phosphorus	mg/L P	*0.04*	0.06
SCP 065B		Total Organic Carbon (TOC)	mg/L	*0.5*	6.0
**2510 B	*	Total Dissolved Solids (TDS)	mg/L	*5*	35

Customer Sample Ref:	23960 Site 7	**Customer Sample Code:**	
Project:	Surface Water Analysis	**Sampled By:**	Catriona Fox
Our Reference:	94938 (23-29768)	**Sample Matrix:**	Surface Water
Date Sampled:	22/06/2023	**Time Sampled:**	:

Method:		Parameter:	Units	LOQ	Result
		Chemical Analysis: (F)			
SCP 052		Conductivity	µS/cm @ 20 ℃	*15*	63
SCP 015		Biological Oxygen Demand (BOD)	mg/L	*1.0*	< 1.0
SCP 010		Suspended Solids	mg/L	*2*	6
SCP 027A		Total Ammonia	mg/L N	*0.02*	< 0.02
SCP 027G		Nitrate	mg/L N	*0.25*	< 0.25
SCP 027F		Nitrite	mg/L N	*0.005*	< 0.005
SCP 027C		Orthophosphate	mg/L P	*0.01*	< 0.01
SCP 027I		Total Hardness	mg/L CaCO3	*5*	16
SCP 016		Chemical Oxygen Demand (COD)	mg/L	*10*	13
SCP 044		Total Phosphorus	mg/L P	*0.04*	0.04
SCP 065B		Total Organic Carbon (TOC)	mg/L	*0.5*	5.9
**2510 B	*	Total Dissolved Solids (TDS)	mg/L	*5*	35

Customer Sample Ref:	23960 Site 8	**Customer Sample Code:**	
Project:	Surface Water Analysis	**Sampled By:**	Catriona Fox
Our Reference:	94939 (23-29768)	**Sample Matrix:**	Surface Water
Date Sampled:	22/06/2023	**Time Sampled:**	:

Method:		Parameter:	Units	LOQ	Result
		Chemical Analysis: (F)			
SCP 052		Conductivity	µS/cm @ 20 ℃	*15*	64
SCP 015		Biological Oxygen Demand (BOD)	mg/L	*1.0*	< 1.0
SCP 010		Suspended Solids	mg/L	*2*	< 4
SCP 027A		Total Ammonia	mg/L N	*0.02*	< 0.02
SCP 027G		Nitrate	mg/L N	*0.25*	< 0.25
SCP 027F		Nitrite	mg/L N	*0.005*	< 0.005
SCP 027C		Orthophosphate	mg/L P	*0.01*	< 0.01
SCP 027I		Total Hardness	mg/L CaCO3	*5*	18
SCP 016		Chemical Oxygen Demand (COD)	mg/L	*10*	13
SCP 044		Total Phosphorus	mg/L P	*0.04*	0.05
SCP 065B		Total Organic Carbon (TOC)	mg/L	*0.5*	6.8
**2510 B	*	Total Dissolved Solids (TDS)	mg/L	*5*	36

Customer Sample Ref:	23960 Site 9	**Customer Sample Code:**	
Project:	Surface Water Analysis	**Sampled By:**	Catriona Fox
Our Reference:	94940 (23-29768)	**Sample Matrix:**	Surface Water
Date Sampled:	22/06/2023	**Time Sampled:**	:

Method:		Parameter:	Units	LOQ	Result
		Chemical Analysis: (F)			
SCP 052		Conductivity	µS/cm @ 20 ℃	*15*	74
SCP 015		Biological Oxygen Demand (BOD)	mg/L	*1.0*	< 1.0
SCP 010		Suspended Solids	mg/L	*2*	< 4
SCP 027A		Total Ammonia	mg/L N	*0.02*	< 0.02
SCP 027G		Nitrate	mg/L N	*0.25*	< 0.25
SCP 027F		Nitrite	mg/L N	*0.005*	< 0.005
SCP 027C		Orthophosphate	mg/L P	*0.01*	< 0.01
SCP 027I		Total Hardness	mg/L CaCO3	*5*	22
SCP 016		Chemical Oxygen Demand (COD)	mg/L	*10*	12
SCP 044		Total Phosphorus	mg/L P	*0.04*	0.06
SCP 065B		Total Organic Carbon (TOC)	mg/L	*0.5*	8.4
**2510 B	*	Total Dissolved Solids (TDS)	mg/L	*5*	42

Customer Sample Ref:	23960 Site 10	**Customer Sample Code:**	
Project:	Surface Water Analysis	**Sampled By:**	Catriona Fox
Our Reference:	94941 (23-29768)	**Sample Matrix:**	Surface Water
Date Sampled:	22/06/2023	**Time Sampled:**	:

Method:		Parameter:	Units	LOQ	Result
		Chemical Analysis: (F)			
SCP 052		Conductivity	µS/cm @ 20 ℃	*15*	96
SCP 015		Biological Oxygen Demand (BOD)	mg/L	*1.0*	< 1.0
SCP 010		Suspended Solids	mg/L	*2*	< 4
SCP 027A		Total Ammonia	mg/L N	*0.02*	< 0.02
SCP 027G		Nitrate	mg/L N	*0.25*	< 0.25
SCP 027F		Nitrite	mg/L N	*0.005*	< 0.005
SCP 027C		Orthophosphate	mg/L P	*0.01*	< 0.01
SCP 027I		Total Hardness	mg/L CaCO3	*5*	25
SCP 016		Chemical Oxygen Demand (COD)	mg/L	*10*	16
SCP 044		Total Phosphorus	mg/L P	*0.04*	0.06
SCP 065B		Total Organic Carbon (TOC)	mg/L	*0.5*	7.2
**2510 B	*	Total Dissolved Solids (TDS)	mg/L	*5*	54

Customer Sample Ref:	23960 Site 11	**Customer Sample Code:**	
Project:	Surface Water Analysis	**Sampled By:**	Catriona Fox
Our Reference:	94942 (23-29768)	**Sample Matrix:**	Surface Water
Date Sampled:	22/06/2023	**Time Sampled:**	:

Method:		Parameter:	Units	LOQ	Result
		Chemical Analysis: (F)			
SCP 052		Conductivity	µS/cm @ 20 ℃	*15*	860
SCP 015		Biological Oxygen Demand (BOD)	mg/L	*1.0*	< 1.0
SCP 010		Suspended Solids	mg/L	*2*	< 4
SCP 027A		Total Ammonia	mg/L N	*0.02*	< 0.02
SCP 027G		Nitrate	mg/L N	*0.25*	1.96
SCP 027F		Nitrite	mg/L N	*0.005*	0.027
SCP 027C		Orthophosphate	mg/L P	*0.01*	0.62
SCP 027I		Total Hardness	mg/L CaCO3	*5*	102
SCP 016		Chemical Oxygen Demand (COD)	mg/L	*10*	10
SCP 044		Total Phosphorus	mg/L P	*0.04*	0.66
SCP 065B		Total Organic Carbon (TOC)	mg/L	*0.5*	8.0
**2510 B	*	Total Dissolved Solids (TDS)	mg/L	*5*	486

Customer Sample Ref:	23960 Site 12	**Customer Sample Code:**	
Project:	Surface Water Analysis	**Sampled By:**	Catriona Fox
Our Reference:	94943 (23-29768)	**Sample Matrix:**	Surface Water
Date Sampled:	22/06/2023	**Time Sampled:**	:

Method:		Parameter:	Units	LOQ	Result
		Chemical Analysis: (F)			
SCP 052		Conductivity	µS/cm @ 20 ℃	*15*	232
SCP 015		Biological Oxygen Demand (BOD)	mg/L	*1.0*	2.7
SCP 010		Suspended Solids	mg/L	*2*	< 4
SCP 027A		Total Ammonia	mg/L N	*0.02*	< 0.02
SCP 027G		Nitrate	mg/L N	*0.25*	< 0.25
SCP 027F		Nitrite	mg/L N	*0.005*	< 0.005
SCP 027C		Orthophosphate	mg/L P	*0.01*	< 0.01
SCP 027I		Total Hardness	mg/L CaCO3	*5*	102
SCP 016		Chemical Oxygen Demand (COD)	mg/L	*10*	< 10
SCP 044		Total Phosphorus	mg/L P	*0.04*	< 0.04
SCP 065B		Total Organic Carbon (TOC)	mg/L	*0.5*	5.8
**2510 B	*	Total Dissolved Solids (TDS)	mg/L	*5*	134

Customer Sample Ref:	23960 Site 13	**Customer Sample Code:**	
Project:	Surface Water Analysis	**Sampled By:**	Catriona Fox
Our Reference:	94944 (23-29768)	**Sample Matrix:**	Surface Water
Date Sampled:	22/06/2023	**Time Sampled:**	:

Method:		Parameter:	Units	LOQ	Result
		Chemical Analysis: (F)			
SCP 052		Conductivity	µS/cm @ 20 ℃	*15*	397
SCP 015		Biological Oxygen Demand (BOD)	mg/L	*1.0*	1.5
SCP 010		Suspended Solids	mg/L	*2*	< 4
SCP 027A		Total Ammonia	mg/L N	*0.02*	< 0.02
SCP 027G		Nitrate	mg/L N	*0.25*	< 0.25
SCP 027F		Nitrite	mg/L N	*0.005*	< 0.005
SCP 027C		Orthophosphate	mg/L P	*0.01*	< 0.01
SCP 027I		Total Hardness	mg/L CaCO3	*5*	210
SCP 016		Chemical Oxygen Demand (COD)	mg/L	*10*	< 10
SCP 044		Total Phosphorus	mg/L P	*0.04*	< 0.04
SCP 065B		Total Organic Carbon (TOC)	mg/L	*0.5*	4.0
**2510 B	*	Total Dissolved Solids (TDS)	mg/L	*5*	224

Customer Sample Ref:	23960 Site 14	**Customer Sample Code:**	
Project:	Surface Water Analysis	**Sampled By:**	Catriona Fox
Our Reference:	94945 (23-29768)	**Sample Matrix:**	Surface Water
Date Sampled:	22/06/2023	**Time Sampled:**	:

Method:		Parameter:	Units	LOQ	Result
		Chemical Analysis: (F)			
SCP 052		Conductivity	µS/cm @ 20 ℃	*15*	393
SCP 015		Biological Oxygen Demand (BOD)	mg/L	*1.0*	< 1.0
SCP 010		Suspended Solids	mg/L	*2*	< 4
SCP 027A		Total Ammonia	mg/L N	*0.02*	< 0.02
SCP 027G		Nitrate	mg/L N	*0.25*	0.27
SCP 027F		Nitrite	mg/L N	*0.005*	< 0.005
SCP 027C		Orthophosphate	mg/L P	*0.01*	< 0.01
SCP 027I		Total Hardness	mg/L CaCO3	*5*	213
SCP 016		Chemical Oxygen Demand (COD)	mg/L	*10*	< 10
SCP 044		Total Phosphorus	mg/L P	*0.04*	< 0.04
SCP 065B		Total Organic Carbon (TOC)	mg/L	*0.5*	4.4
**2510 B	*	Total Dissolved Solids (TDS)	mg/L	*5*	221

APPENDIX 5

ELECTRICAL FISHING DATA

Table A5.1: Results of the electrical fishing surveys undertaken on watercourses draining the proposed development during 2021.

Site	Species	Length cm	Pass	Length fished (m)	Width fished (m	Time fished (min)
1	trout	11.3	1	50	3	10
1	trout	14	1	50	3	10
1	trout	13.3	1	50	3	10
1	trout	12	1	50	3	10
1	trout	11.7	1	50	3	10
1	trout	11.8	1	50	3	10
1	trout	11.8	1	50	3	10
1	trout	5.8	1	50	3	10
1	trout	6.2	1	50	3	10
1	trout	4.4	1	50	3	10
1	trout	5.4	1	50	3	10
1	trout	5.3	1	50	3	10
1	trout	5.2	1	50	3	10
1	trout	5.3	1	50	3	10
1	trout	5.4	1	50	3	10
1	trout	5.3	1	50	3	10
1	trout	5.3	1	50	3	10
1	trout	5.3	1	50	3	10
1	trout	5.5	1	50	3	10
1	trout	5.5	1	50	3	10
1	trout	5.6	1	50	3	10
1	trout	5	1	50	3	10
1	trout	5.8	1	50	3	10
1	trout	5.5	1	50	3	10
1	trout	5.3	1	50	3	10
1	trout	5	1	50	3	10
1	trout	5.2	1	50	3	10
1	trout	4.9	1	50	3	10
1	trout	5	1	50	3	10
1	trout	3.9	1	50	3	10
2	No Fish		1	45	1.5	10
3	eel	15	1	60	1.2	10
4	trout	21	1	58	1	n/a
4	trout	12.9	1	58	1	n/a
4	trout	6	1	58	1	n/a
4	trout	8	1	58	1	n/a
4	trout	5	1	58	1	n/a
4	trout	5.6	1	58	1	n/a
4	trout	8.4	1	58	1	n/a
4	trout	7.2	1	58	1	n/a
4	trout	5.4	1	58	1	n/a
4	trout	7.7	1	58	1	n/a
4	trout	4.8	1	58	1	n/a
4	trout	4.9	1	58	1	n/a
4	trout	5.4	1	58	1	n/a
4	trout	8.5	1	58	1	n/a
4	trout	5.9	1	58	1	n/a
4	trout	5.8	1	58	1	n/a
4	trout	5.4	1	58	1	n/a

Site	Species	Length cm	Pass	Length fished (m)	Width fished (m	Time fished (min)
4	trout	4.8	1	58	1	n/a
4	trout	7.9	1	58	1	n/a
4	trout	6.2	1	58	1	n/a
4	trout	6.5	1	58	1	n/a
4	trout	8.4	1	58	1	n/a
4	trout	4.9	1	58	1	n/a
4	trout	5	1	58	1	n/a
4	trout	9.4	1	58	1	n/a
4	trout	7.8	1	58	1	n/a
4	trout	4.6	1	58	1	n/a
4	trout	5.3	1	58	1	n/a
4	trout	5.5	1	58	1	n/a
4	trout	8.6	1	58	1	n/a
4	trout	5.2	1	58	1	n/a
4	trout	6.4	1	58	1	n/a
4	trout	6.8	1	58	1	n/a
4	trout	7.9	1	58	1	n/a
4	trout	5.4	1	58	1	n/a
4	trout	5.9	1	58	1	n/a
4	trout	5.9	1	58	1	n/a
4	trout	6.5	1	58	1	n/a
4	trout	5.4	1	58	1	n/a
4	trout	8.8	1	58	1	n/a
4	trout	5.9	1	58	1	n/a
4	trout	6.4	1	58	1	n/a
4	trout	7.9	1	58	1	n/a
4	trout	5.5	1	58	1	n/a
4	trout	5.9	1	58	1	n/a
4	trout	6.3	1	58	1	n/a
4	trout	5.9	1	58	1	n/a
4	trout	7.8	1	58	1	n/a
4	trout	6.8	1	58	1	n/a
4	trout	7.7	1	58	1	n/a
4	trout	8.6	1	58	1	n/a
4	trout	16.5	1	58	1	n/a
4	trout	7.3	1	58	1	n/a
4	trout	5.9	1	58	1	n/a
4	trout	6.3	1	58	1	n/a
4	trout	5.6	1	58	1	n/a
4	trout	6.4	1	58	1	n/a
4	trout	5.7	1	58	1	n/a
4	trout	7.7	1	58	1	n/a
4	trout	6.5	1	58	1	n/a
4	trout	5.4	1	58	1	n/a
4	trout	6.5	1	58	1	n/a
4	trout	6.7	1	58	1	n/a
4	trout	6.6	1	58	1	n/a
4	trout	7.4	1	58	1	n/a
4	trout	8.3	1	58	1	n/a
4	trout	6.9	1	58	1	n/a
4	trout	5.8	1	58	1	n/a
4	trout	7.5	1	58	1	n/a
4	trout	6.6	1	58	1	n/a

Site	Species	Length cm	Pass	Length fished (m)	Width fished (m	Time fished (min)
4	trout	7.4	1	58	1	n/a
4	trout	8.8	1	58	1	n/a
4	trout	5.3	1	58	1	n/a
4	trout	6.1	1	58	1	n/a
4	trout	5.2	1	58	1	n/a
4	trout	7.2	1	58	1	n/a
4	trout	5.3	1	58	1	n/a
4	trout	4.7	1	58	1	n/a
4	trout	5.6	1	58	1	n/a
4	trout	5.6	1	58	1	n/a
4	trout	5.4	1	58	1	n/a
4	trout	7.9	1	58	1	n/a
4	trout	4.7	1	58	1	n/a
4	trout	6.1	1	58	1	n/a
4	trout	6.3	1	58	1	n/a
4	trout	5.6	1	58	1	n/a
4	trout	5.3	1	58	1	n/a
4	trout	4.5	1	58	1	n/a
4	trout	5.4	1	58	1	n/a
4	trout	5.5	1	58	1	n/a
4	eel	9.7	1	58	1	n/a
4	eel	8.2	1	58	1	n/a
4	eel	22.5	1	58	1	n/a
4	eel	19.8	2	58	1	n/a
4	trout	7.8	2	58	1	n/a
4	trout	7.2	2	58	1	n/a
4	trout	6.2	2	58	1	n/a
4	trout	5.8	2	58	1	n/a
4	trout	5.2	2	58	1	n/a
4	trout	6.4	2	58	1	n/a
4	trout	8.5	2	58	1	n/a
4	trout	8.8	2	58	1	n/a
4	trout	6	2	58	1	n/a
4	trout	6.2	2	58	1	n/a
4	trout	5.8	2	58	1	n/a
4	trout	5.6	2	58	1	n/a
4	trout	8.1	2	58	1	n/a
4	trout	6.1	2	58	1	n/a
4	trout	7.3	2	58	1	n/a
4	trout	6.6	2	58	1	n/a
4	trout	5.9	2	58	1	n/a
4	trout	6	2	58	1	n/a
4	trout	6.3	2	58	1	n/a
4	trout	5.5	2	58	1	n/a
4	trout	6.5	2	58	1	n/a
4	trout	6.6	2	58	1	n/a
4	trout	7.2	2	58	1	n/a
4	trout	6.6	2	58	1	n/a
4	trout	6.1	2	58	1	n/a
4	trout	7.6	2	58	1	n/a
4	trout	16.5	3	58	1	n/a
4	trout	8.5	3	58	1	n/a
4	trout	5.3	3	58	1	n/a

Site	Species	Length cm	Pass	Length fished (m)	Width fished (m	Time fished (min)
4	trout	5.6	3	58	1	n/a
4	trout	5.4	3	58	1	n/a
4	trout	5.6	3	58	1	n/a
4	trout	5.6	3	58	1	n/a
4	trout	5.2	3	58	1	n/a
4	trout	5.6	3	58	1	n/a
4	trout	6.1	3	58	1	n/a
4	trout	5.1	3	58	1	n/a
4	trout	5.3	3	58	1	n/a
4	trout	5.5	4	58	1	n/a
4	trout	5.6	4	58	1	n/a
5	No Fish		1	55	1	10
6	trout	17	1	40	0.4	10
6	trout	14.8	1	40	0.4	10
6	trout	21	1	40	0.4	10
6	trout	15	1	40	0.4	10
6	trout	8.2	1	40	0.4	10
6	trout	8.1	1	40	0.4	10
6	trout	8	1	40	0.4	10
6	trout	7.6	1	40	0.4	10
6	trout	7.6	1	40	0.4	10
6	trout	8	1	40	0.4	10
6	trout	7.8	1	40	0.4	10
6	trout	8	1	40	0.4	10
6	trout	8.2	1	40	0.4	10
6	trout	7.9	1	40	0.4	10
6	trout	7.8	1	40	0.4	10
6	trout	6.7	1	40	0.4	10
6	trout	7.6	1	40	0.4	10
6	trout	6.8	1	40	0.4	10
6	trout	8.6	1	40	0.4	10
6	trout	13.4	1	40	0.4	10
6	trout	11.8	1	40	0.4	10
6	trout	13.7	1	40	0.4	10
6	trout	15.7	1	40	0.4	10
6	trout	18.8	1	40	0.4	10
6	trout	13.6	1	40	0.4	10
6	brook lamprey	13.5	1	40	0.4	10
6	eel	35	1	40	0.4	10
7	eel	20	1	55	0.5	10
8	no fish		1	50	0.8	10
9	no fish		1	48	1.3	10
10	no fish		1	45	1.7	10