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Environmental Impact Assessment Report

Cummeennabuddoge Wind Farm

Technical Appendix 8-3: Aquatic and Fish Surveys

Cummeennabuddoge Wind (DAC)

September 2024

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1 Introduction

1.1 Terms of Reference

A range of aquatic ecological surveys were undertaken by Malachy Walsh & Partners (MWP) Ireland in August- September 2021 at the at the Proposed Development Site, known as Cummeenabuddoge Wind Farm.

The following aquatic surveys were undertaken:

- Aquatic Habitat Assessment
- Fish and Macroinvertebrate Habitat Evaluation
- Electrofishing
- Benthic Macroinvertebrate Sampling
- Freshwater Pearl Mussel *Margaritifiera margaritifiera* Survey
- Biological Water Quality monitoring (using benthic macroinvertebrates, or aquatic insects were used as an indicator of water quality)
- Physico-Chemical Water Quality monitoring

The Proposed Development Site is centred on Irish Transverse Mercator (ITM) coordinate system (W 19846 83148) and occupies an area of approximately 986ha, (shown bounded by the red line on Figure 1-1a).

The Proposed Development lies within existing commercial forestry, located on land at Clydaghroe and Cummeenabuddoge, Clonkeen, almost entirely within County Kerry, although a proportion of the grid connection cabling and works along the turbine delivery route is proposed within County Cork. The settlements of Millstreet and Ballyvourney are approximately 11km to the northwest and 6km to the south of the Proposed Development respectively.

The study area includes the water features within the site and watercourses considered to be part of the receiving environment of the project.

The term Site (as above) is different to 'survey sites' which relate to discrete survey locations.

This TA supports Chapter 8 of the EIAR and as such, does not comprise an assessment of results, but information only.

1.2 Objectives

The principal objectives of this report are:

- To describe the methodology and report on the results of surveys described above.
- To describe the baseline ecological status in relation for fish and aquatic Important Ecological features (IEFs) within the Site and study area.

2 Methodology

2.1 Field Surveys

The field surveys were undertaken by Malachy Walsh & Partners (MWP)(Ireland and comprised an evaluation of aquatic habitats, fish assessments, biotic assessment using aquatic macroinvertebrates, and water sampling for analysis of physico-chemical water quality parameters. A Freshwater Pearl Mussel (FPM) survey was carried out on selected watercourses. Representative accessible locations on watercourses draining the Proposed Development Site were surveyed (Figure 8-6). A total of ten sites were surveyed. These sites were selected at/near roads and/or tracks, given that these sites may require monitoring.

Water quality affects the viability and quality of salmonid habitat so is useful in assessing habitats for aquatic organisms, including trout, *Salmo trutta* and salmon, *Salmo salar*. 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 electrical fishing was carried out on 17th, 18th, 19th, and 23rd August 2021. Freshwater pearl mussel surveying was undertaken on 1st and 2nd September and 13th, 14th, and 15th September 2021.

Sampling for macroinvertebrates was carried out on the 8th, 11th, and 12th September 2021. Water samples were taken on the 15th September. Water quality samples covering four seasons (winter, spring, summer, and Autumn) during 2021/21 have also been undertaken to inform Chapter 11: Hydrology, Water Quality and Flood Risk Chapter and were also considered.

Table 1: Aquatic ecology and fish survey locations on watercourses draining the Site (Figure 8.6)

Subbasin	Tributary - Sub-tributary /EPA Code	Site	Stream order	EPA River Segment code	Location (ITM)		Survey			
					X	X	Fish habitat	Fish survey	Biological	Physico-chemical
Flesk (Kerry)_010	River Clydagh tributary	1	1	22_3	522175	584273	✓	✓	✓	✓
	River Clydagh / 22F02	2	2	22_1863	522064	584323	✓	✓	✓	
	Mullaghanish River tributary	3	2	22_1826	520902	583830	✓	✓	✓	
	Mullaghanish River / 24M42	4	2	22_900	520845	583728	✓	✓	✓	✓
	River Clydagh tributary	5	2	22_1551	519641	583575	✓	✓	✓	
	River Clydaghroe	6	2	22_984	519430	583409	✓		✓	
Flesk (Kerry)_020	River Clydagh tributary	7	2	22_233	518291	583464	✓	✓	✓	
	River Clydagh tributary	8	2	22_233	518352	583432	✓	✓	✓	
	River Clydagh tributary	9	2	22_230	517770	583268	✓	✓	✓	
	River Clydagh	10	3	22_231	517590	583368	✓	✓	✓	

2.2 Aquatic Habitats

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

Habitat assessment was carried out at these locations 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, glide and pool 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
- Estimated cover by bankside vegetation, giving percentage shade of the sampling site.

2.2.1 Macro-invertebrate Habitat Evaluation

Habitat has a key influence on the macroinvertebrate communities, which occur in rivers and streams. The physical habitats of study 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** shows how habitats are assessed using this method.

2.2.2 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.

2.3 Macro-invertebrates

2.3.1 Benthic Macro-invertebrate Sampling

Semi-quantitative sampling of benthic macroinvertebrates, or aquatic insects, was undertaken at all river sites 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 (Plate 1). 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 site. 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**.

Plate 1: Biological water sampling apparatus employed during the on-site investigations (left). Electrical fishing at site 9 (right).

Plate 2: Site 1 on a 1st order tributary of the River Flesk (left). Site 2 on the River Flesk upstream of the Proposed Development (right)

Plate 3: Site 3 on a tributary of the Mullaghanish Stream (left). Site 4 on the Mullaghanish Stream (right)

Plate 4: Site 5 (left) – habitat altered by commercial forestry. Site 6 (right) on 2nd order tributary of the River Flesk – seminatural / pristine riparian conditions

Plate 5: Site 7 (left) on stream segmented 22_233. Site 8 (right) on stream segmented 22_233

Plate 6: Site 9 (left) and site 10 (right)

2.3.2 Freshwater Pearl Mussel Survey

Malachy Walsh and Partners (MWP) applied for and were issued a licence (No. C47/2021) from NPWS to carry out freshwater pearl mussel (FPM) survey work in the study area. Surveying was undertaken on 1st and 2nd September and 13th, 14th, and 15th September 2021. At these times, water levels were low, sunshine dominated, and underwater visibility was suitable for FPM detection.

The Flesk catchment is within a catchment listed in the NPWS *Margaritifera* Sensitive Areas Map and is the only such catchment potentially impacted by the Proposed Development. This catchment is identified as a 'Catchment of other extant populations'. The river reaches listed in Table 1 and illustrated in Figure 8-6 were surveyed. The areas surveyed were selected on the basis of accessibility (incl. safety), proximity to site, watercourse size and coverage within the receiving environment.

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 were 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 checked for the presence of dead shells, particularly in depositing areas. Transect surveys were carried out, with the location of each recorded by GPS. Searches for FPM were also carried out when walking between transect locations when access and water depth allowed.

Table 2: Watercourses reaches on the River Flesk surveyed for FPM during 2021.

Survey reach code	Location / townland	Survey stretch (ITM)				No. of transects	Approx. length of channel surveyed (km)
		Start (downstream)		Finish (upstream)			
		X	Y	X	Y		
R1	Environs of Brewsterfield Bridge / Gortahoosh, Oldforge, Brewsterfield	503156	587775	504567	587210	13	1
R2	Reach downstream of Carries Bridge / Drominaharee, Islandmore	507263	585194	508075	583742	21	1.8
R3	Reach downstream of Poulgorm Bridge / Dromavrauka, Foiladuane, Inch	507976	582062	509314	581815	25	1.8
R4	Derrynafinnia, Glashacormick	513739	583648	513739	514698	17	1.2
R5	Clydaghroe, Cummeennabuddoge, Knocknagowan	518982	583770	520387	584501	39	2.5

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

Element	Objective	Notes
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*

The river condition and habitat features at each survey stretch were noted. The potential for FPM to occur along each stretch 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 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 each 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. The following evaluation ranges for population densities, siltation and filamentous algae were employed in the current 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)
- Absent

Siltation:

- no visible silt plume
- some visible silt
- 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
- Dominant: covers > 50 % of the riverbed

2.4 Biological Water Quality

Benthic macroinvertebrates, or aquatic insects were used as an indicator of water quality at each sampling site. 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).

2.4.1 Biotic Indices

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

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 and have been intercalibrated with the EPA Q-rating system as shown in **Appendix 1.** 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.

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
- Riffle/Pool: the remainder

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 circumstance, 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 is calculated by summing up the indicator values and their division by numbers of taxa (families) sampled and ranges from 0 to 10. A high ASPT index values indicates thus 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).

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.

2.5 Physico-Chemical Water Quality

Water samples were taken at Site 1 and Site 4 on 15th October 2021. Samples were taken using aseptic techniques and were then stored in a cooler box. The samples were then delivered to Southern Scientific Laboratories the same day. 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.

Both sites were 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) gives chemical parameter thresholds for achievement of Water Framework Directive 'High' and 'Good' Status.

Table 4: On-site physico-chemical readings were obtained for Dissolved Oxygen, Temperature, Conductivity, Turbidity and Total Dissolved Solids using calibrated portable meters.

Parameter	High Status	Good Status
BOD	≤1.3 (mean(1)) or ≤2.2 (95%ile)	≤1.5 (mean(1)) 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)

2.6 Functional Feeding Groups (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 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).

2.7 Fish

An electric fishing survey was carried out at site 1 to site 10 (Figure 8-7) in the River Finn catchment 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). A 'Smith Root' portable electrical fishing unit was used during the assessment. Electric fishing focussed on sites in the Finn catchment as all most infrastructure is in this area (i.e., all proposed turbines).

Fishing was carried out continuously for 10 minutes at each site with the exception of site 10. 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 the released alive and spread evenly over the sampling area. Quantitative/depletion electrical fishing was carried out at site 10. This area was fished a total of four times (five passes). Records were taken of fish captured from each pass immediately after each pass.

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

Tributary - Sub-tributary / EPA Code	site	Upstream co-ordinate (ITM)		Downstream co-ordinate (ITM)		Length fished (m)	Area fished (m2)
		X	Y	X	Y		
River Clydagh tributary	1	522175	584273	522130	584296	70	105
River Clydagh / 22F02	2	522064	584323	522061	584284	45	180
Mullaghanish River tributary	3	520902	583830	520862	583848	55	132
Mullaghanish River / 24M42	4	520845	583728	520841	583768	46	96.6
River Clydagh tributary	5	519641	583575	519616	583584	60	60

River Clydaghroe / 22C46	6	519430	583409	519459	583459	65	65
River Clydagh tributary	7	518291	583464	518253	583484	40	48
River Clydagh tributary	8	518352	583432	518302	583452	37	55.5
River Clydagh tributary	9	517770	583268	517733	583290	38	45.6
River Clydagh / 22F02	10	517590	583368	517554	583392	50	300

Following completion of the fishing, the dimensions and physical habitat characteristics of each site were recorded, including area and flow characteristics. The surveys were carried out 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.

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.

2.8 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. All equipment (including waders etc.) was disinfected with spray bleach disinfectant after use, washed, dried out and put in storage.

2.9 Survey Limitations

Electrical fishing efficiency was reduced at some locations due overhanging banks (site 1 and site 3), and entrapment of small fish between boulders at site 1 and site 10. Water at some locations (site 7, 8 and 9) was turbid which impacted visibility, but efficiency was not significantly affected as these streams were small and shallow, thus facilitating capture of fish by placement of dip nets across the full width of these channels.

3 Results

This section provides a description of the aquatic habitats, macroinvertebrates (incl. FPM) and fish in the study area, based on the 10 survey sites examined.

3.1 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 3.1.1) and fish (Section 3.1.2) is a function of watercourse characteristics in the receiving riverine environment. Habitat for FPM is discussed separately in Section 3.3. The physical characteristics of survey sites are listed in Table 7. The watercourses feeding the River Flesk within the boundary of the Proposed Development are high gradient streams. Their lotic[1] carrying capacity is limited by characteristics including small size, riparian conditions (e.g., overshading) and / or fragmentation of fluvial habitat.

All surface drainage from the Proposed Development is to the north to the upper reaches of the 3rd order River Flesk. The watercourses in the study area are fast flowing and of a spate nature i.e., they are rainwater fed from overland flow and thus exhibit fast response to rainfall. They are medium-high gradient watercourses categorised as 'eroding/upland rivers' with reference to Fossitt (2000). They drain lands over siliceous geology where the overburden is mostly peat, so are naturally nutrient poor.

The stream substrates comprise mainly of cobble and gravel with little to no silt deposits, except for some peat. Boulder was the main component of the streambeds of the surveyed sites, typical of high gradient reaches. The subject watercourses are generally characterised by riffle-glide-pool sequences. They are generally shallow with a mean summer depth of 10cm-20cm. Significant substrate siltation caused by peat was observed at site 1 and site 8. Evidence of enrichment in the form of filamentous algae was also recorded at these locations. There was an extensive bloom of the bacteria *Leptothrix ochracea* on the benthos at site 5. The bed of this stream was considered excessively blanketed and all interstitial spaces between substrates were occupied by the colony. Less colonisation was recorded at site 4. The excessive bloom at site 4 was considered to reduce the habitat available to benthic macroinvertebrates. This bacterium is dependent in high iron concentrations in water. Drainage of peat soils, penetration into subsoils and associated leaching of nutrients could be attributed to the degree of this organism at site 4.

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

Table 6: Physical characteristics of the aquatic survey sites

Site No.	1	2	3	4	5	6	8	7	9	10
Wetted width (m)	1.5	4.0	2.4	2.1	1.0	1.0	1.2	1.5	1.2	6.0
Mean depth (cm)	15	20	15	25	10	10	15	15	15	20
Maximum depth (cm)	45	55	50	45	50	40	55	60	40	60
Bedrock (%)	0	0	65	0	5	0	0	5	0	0
Boulder (%)	10	5	10	45	55	35	45	60	35	35
Cobble (%)	40	60	15	30	30	35	30	30	35	40
Gravel (%)	43	30	8	20	10	25	20	0	20	20
Sand (%)	5	5	2	5	0	5	5	5	10	5
Silt (%)	2	0	0	0	0	0	0	0	0	0
Siltation (clean/slight/ moderate / heavy/not visible)	Slight	Slight	Slight	Slight	Moderate	Slight	Moderate	Moderate	Slight	Slight
Plume (heavy/moderate/ slight/none)	Moderate	Slight	Slight	Slight	Heavy	None	Slight	Slight	Slight	Slight
Riffle (%)	50	50	80	55	55	65	80	90	50	90
Pool (%)	10	15	5	25	10	15	10	10	30	5
Glide (%)	40	35	15	20	35	20	10	0	20	5
Shade (%)	5	0	85	100	95	10	40	20	5	0
Bank height (m)	0.6	0.4	2.0	1.0	0.8	0.6	0.5	40.0	0.5	40.0
Bank slope (degrees)	90	45	60	90	90	90	90	80	90	45
Bank vegetation cover (%)	75	40	95	20	60	90	80	90	95	90
Bank erosion (mild/moderate/ severe)	Mild	Moderate	Moderate	Severe	Severe	Mild	Moderate	Mild	Mild	Mild
Colour (none/slight/ moderate /high)	Slight	None	None	Slight	Moderate	None	Slight	Slight	Moderate	Moderate
Reason for colour (general/humic/ other)	Humic	Humic	Humic	Humic	Humic and Iron	n/a	Humic	Humic	Humic	Humic
Water clarity (v. clear/clear/ slightly turbid/turbid/ highly turbid)	Clear	Clear	Clear	Clear	Slightly turbid	Clear	Turbid	Turbid	Turbid	Slightly turbid
Algal cover (%)	5	2	5	0	2	2	0	0	5	5
Plant cover* (%)	0	1	10	0	0	10	25	25	5	5

*Plant cover dominated by bryophytes

The aquatic plant community was dominated by the bryophytes *Fontinalis* sp. and *Chiloscyphus polyanthus*. These plants are deemed important in providing ecological niches for a variety of macroinvertebrates, which in turn feed fish and higher organisms. *Callitriche* sp. was also recorded in the River Flesk at Site 2. Primary instream production can be expected a significant building block of the ecosystem in watercourses exposed to light. Shade along the streams at site 3, 4 and 5 was excessive as there was insufficient setback of commercial forestry. Channels affected in this way had reduced floral diversity both at instream and riparian level. They are likely to be less productive in terms of plant and animal life.

Drainage associated with afforestation and commercial forestry activity in the catchments may be affecting the flow regime of the receiving watercourses. For example, low flows during the summer could have been exacerbated by drainage of peat habitats, where potential water reserves in peat are released faster than natural processes by lowering the local water table. The development of large areas of commercial forestry can also limit precipitation reaching the soil and therefore reduce surface water flow. At the time of the current surveys, clear-felling of Sitka spruce *Picea sitchensis* was ongoing in the study area. Soil and nutrient loss to headwater streams and other vectors of overland water (rills, drains, roadside channels) is inevitable during clear-felling in upland areas like the Proposed Development Site when trees are planted to the verge of streams, as was seen to be the case. Clear-felling along riparian zones that have an impoverished ground flora due to excessive shading results in poor / no buffering, easily damaged and extensive soil loss (eroded soils) following heavy rainfall. Clearfelling of commercial in the study area is considered a potential water quality pressure in terms of peat loss due to denuded soils and nutrient loss due to decomposition of brash. The large areas of Sitka spruce forestry that were being felled and other areas had been felled in the previous months are likely an ongoing source of peat silt and phosphate until such areas have revegetated and stabilised. Indeed, substrate conditions at site 1, located downslope of an area being felled and the time of the current surveys, was found to be impacted by peat silt and there was evidence of enrichment in the form of filamentous algae.

Some obvious barriers to upstream moving fauna were recorded at the study sites. On stream segment 22_233 between site 7 and site 8, a track has been constructed over the bed of the stream and there is a drop of ca. 1.2m immediately below the track. There is a perched pipe at Site 6. These artificial features are barriers to continuity and likely obstruct upstream fish migration. There is a waterfall on the 2nd order reach of the Mullaghanish Stream downstream of site 3 and site 4. This is a natural feature with a deep plunge pool.

Plate 7: Silted Substrate and evidence of enrichment (algal growth) at site 1(left). *Callitriche sp*. And *Fontinalis sp.* At site 2 in the River Flesk with relatively clean conditions (right).

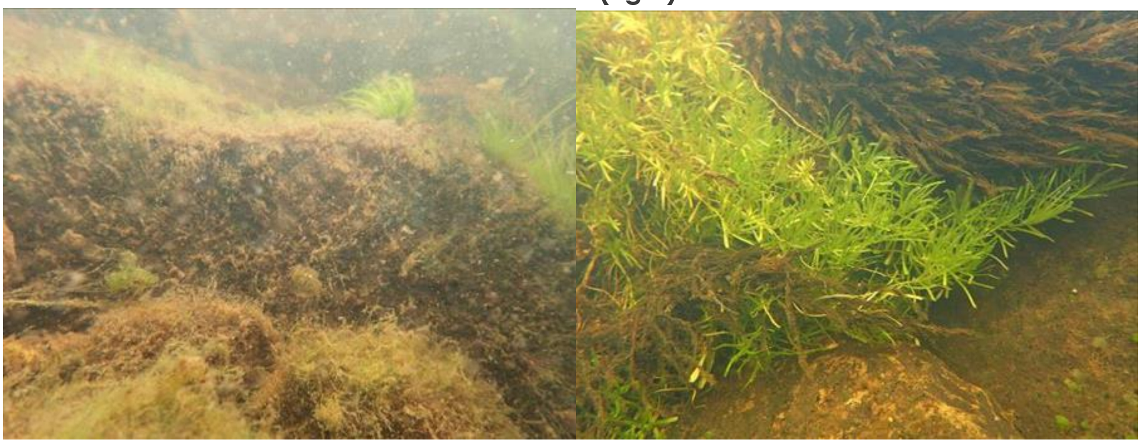

Plate 8: Site 5 where levels of Leptothrix ochracea were deemed excessive.

Plate 9: A perched pipe under a track at site 6(left) and a track between site 7 and site 8 on stream segment 22_233 are barriers to continuity

Plate 10: Waterfall on the 2nd order reach of the Mullaghanish Stream downstream of site 3 and site 4. View of typical substrate at site 3.

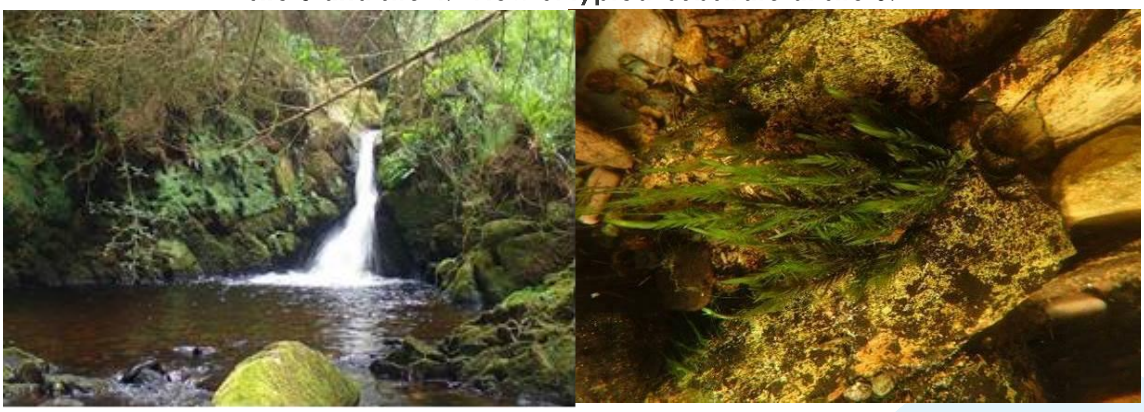

Plate 11: Mullaghanish Stream confluence with stream 22_1826 downstream of site 3 and Site 4 (left). Substratum siltation an enrichment at site 8 (right). Planting too close to watercourses brings about multiple water quality problems.

Plate 12: Commercial forestry on land upslope of site 1 was being clear-felled during August 2021 (left). Tributary of the River Flesk upslope of site 1 (right).

Plate 13: Clear-felled conifer forestry near the River Flesk at site 10. A pond adjacent to the River Flesk can act as an area of attenuation for water with elevated suspended solids

3.1.1 Macro-invertebrate Habitats

The physical habitat suitability assessment of the survey sites for macroinvertebrate production is provided in Section 3.1.2. 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 all the 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 (heavily shaded). 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. 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 and other water quality influences (e.g., nutrient loading) could explain the variation in results at the study sites.

Table 7: Physical habitat assessment of the survey sites regards suitability for macroinvertebrate production (adapted from Barbour and Stribling, 1991)

site	Bottom substrate	Habitat complexity	Pool quality	Bank stability	Bank protection	Canopy	Score	Average score	Overall Assessment
1	15	15	5	15	10	10	70	11.7	Marginal
2	20	15	20	15	5	5	80	13.3	Suboptimal
3	15	15	15	15	20	10	90	15.0	Suboptimal
4	15	15	10	5	5	10	60	10.0	Marginal
5	5	5	5	15	15	10	55	9.2	Marginal
6	20	15	10	20	20	15	100	16.7	Suboptimal
7	20	20	10	20	20	20	110	18.3	Suboptimal / Optimal
8	20	20	10	10	20	10	90	15.0	Suboptimal
9	15	20	5	20	20	15	95	15.8	Suboptimal
10	20	15	20	20	20	10	105	17.5	Suboptimal / Optimal

3.1.2 Fish Habitats

It is considered that the importance of the small streams draining the Proposed Development generally increases with distance downstream until their gradient eases, or merge with other streams to become larger watercourses. This is a universal concept related to stream size and water quantities in parts of catchments near watershed boundaries. It is particularly relevant to the subject streams as some feature barriers to upstream migration.

Within the streams surveyed, a relatively 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. Based on the physical character of the sites surveyed, the watercourses draining the site are considered optimal for the early life stages of salmonids and suitable for spawning adult salmonids. 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 may be of more importance to spawning trout in the tributaries of the River Flesk (1st and 2nd order streams) draining the Proposed Development.

The abundance of riffle (broken water), instream rocks, irregularities in the stream bed, 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 however which reduce the quality of salmonid spawning and nursery habitat, however. The small size of the watercourses near the Proposed Development are unsuitable for holding large salmonids: the small/shallow pools are not considered sufficiently large for large trout and adult salmon througout the year.

Based on the assemblages of instream macroinvertebrate life, generally good juvenile salmonid food supply exists in the headwaters of the streams draining the Site (Section 3.5). Salmonids, especially at early life stage require good water quality. Unsatisfactory water quality conditions at site 4 and site 5 are considered to limit reproductive success (decreasing oxygen supply to ova buried in gravels) and early life stage opportunities for salmon and 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. Table 8 gives the habitat rating of the watercourses examined with reference to salmonid habitats.

Table 8: Salmonid habitat rating at the aquatic survey sites.

	Spawning		Nursery		Holding	
Site	Habitat grade[2]	fluvial cover[2,3] (≈%)	Habitat grade[5]	fluvial cover[6] (≈%)	Habitat grade[5]	fluvial cover[6] (≈%)
1	3	10	2	50	4	5
2	2	5	1	70	1/2	5
3	4	5	2	30	3/4	10
4	3	5	2/3	60	4	5
5	4	<5	4	10	4	5
6	2/3	10	1/2	75	4	5
7	4	<5	1	90	4	10
8	4	<5	1	80	4	<5
9	2/3	10	2	50	4	5
10	2	5	1	85	2	5

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

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

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

Plate 14: Salmonid spawning habitat at the tail of a pool (site 2, left) and optimal nursery habitat site 10, right) in the River Flesk

Lampreys have similar habitat requirements for spawning to small trout. There is adequate lamprey spawning habitat in the watercourses draining the Proposed Development, particularly for smaller lamprey species (brook lamprey *L. planeri*), but there is a general lack of sand/silt deposits, a requirement for lamprey larvae. A search for juvenile lamprey was undertaken in a sandy deposit in the River Flesk ca. 1.5km downstream of site 10. This was deemed the most suitable refuge encountered for juvenile lampreys during the current surveys. Lampreys were not recorded in this area however during agitation sampling. Lamprey likely occur in the river downstream of Poulgorm Bridge where gradient eases and flows are sufficiently slow to allow accumulation of fine substrates. Any lamprey (if they occur) in the River Flesk upstream of Poulgorm Bridge are considered brook lamprey. This assertion takes account of the poor swimming ability of lampreys (Reinhardt *et al.* 2009) and high river gradients.

site 1

The channel was a good nursery area for salmonids with brown trout *Salmo trutta* recorded during electro-fishing. Potential salmonid spawning value was assessed as moderate/poor and good/optimal with reference to nursery. The holding value was poor given the lack of pool habitat. The high energy of the area would not make the channel suitable for juvenile lampreys (larvae, also known as ammocoetes) due to lack of fine sediment.

site 2

The salmonid nursery value of the River Flesk at site 2 was optimal given the presence of boulder and cobble refugia, glide and riffle sequences. The spawning value was good as pockets of course and medium gravels existed between boulders providing ample spawning opportunities. These areas were more extensive in the slack areas of slower moving pools. The holding value was also good locally for trout but would also support larger salmonids in winter should conditions for downstream fish passage be suitable. This reach had no lamprey value given higher gradient and spate nature of channel.

site 3

The nursery value of this stream was very good given the presence of bedrock, boulder, and cobble refugia with some bryophyte cover. The spawning value was poor due to the lack of degree of bedrock. This reach had no lamprey nursery value given higher gradient and spate nature of channel.

site 4

This reach provided moderate spawning areas for trout, but salmonid habitat was diminished by adjoining afforested areas of mature Sitka spruce. The channel could nonetheless be considered a moderate to good nursery given riffle, glide and pool areas, and ample flows, but a deposited iron residue clogged the substratum somewhat. Indeed, only small numbers of trout were captured during electrical fishing. Holding areas were considered suboptimal for brown trout but not suitable for other larger salmonid species (i.e., sea trout or Atlantic salmon or lamprey.

site 5

The fish habitat value of this reach was reduced both by the size of the stream (narrow and shallow), adjoining peat soils and coniferous plantation. It was rated unsuitable/poor as a salmonid nursery and spawning area given the presence of limited spawning areas, small size of channel, excessive bloom of iron bacterium, peat soils and bordering land uses. This observation was confirmed during electrical fishing, with no fish captured. This reach had no lamprey value given the unsuitable gradient and likely spate nature of channel.

site 6

The spawning value at this site on the Clydaghroe Stream was good/moderate as pockets of coarse and medium gravels occurred in areas of pool-glide, providing ample spawning conditions. The fish habitat value of this reach was diminished both by the size of the stream (narrow and shallow), peat base and adjoining coniferous plantations. This value of this reach was deemed optimal as a salmonid nursery, but poor for holding adult fish due to its small size.

sites 7 and 8

Site 7 and site 8 were located upstream and downstream of a track crossing the stream, in that order. The channel was considered a good nursery area for salmonids. Spawning habitat was regarded as poor. Brown trout and salmon were recorded during electro-fishing at site 8 but only brown trout at site 7. The track therefore represents a barrier to migrating salmonids. The holding value was deemed poor given the absence of deeper glide and pool habitat. The number of fish at this site was deemed high despite the substratum siltation. The high energy of the area would not make the channel suitable for lamprey.

site 9

This site was characterised by long shallow pools connected by short riffles. Nursery and potential salmonid spawning habitat were deemed moderate and good respectively, the latter based on the presence of pockets of coarse =medium gravels between boulders. This stream supported a healthy population of small trout but is considered too small for salmon. The erosive nature of this stream makes it unsuitable for lampreys.

site 10

This reach of the River Flesk had good substratum heterogeneity and was deemed an optimal nursery area. Salmonid spawning potential along this reach was regarded as moderate, owing largely to too high a gradient. Pool quality was poor in terms of holding adult fish. This reach supported a brown trout (adults and juvenile) and salmon (juvenile) population. This reach did not have suitable lamprey nursery habitat, thereby precluding the presence of this group.

3.2 Macro-invertebrate 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 has been provided. The bulk of macroinvertebrates recorded belong to pollution sensitivity group C across the survey sites (pollution tolerant) as per Toner *et al,* (2005). Some of the most commonly recorded macroinvertebrates in the study area are shown below. The greatest diversity of macroinvertebrates was recorded at Site 10 on the River Flesk where 18 taxa were recorded. Only four families were found at Site 5. Family diversity is shown in Table 9.

Table 9 Family diversity at the aquatic survey sites.

site	1	2	3	4	5	6	7/8	9	10
Family richness	14	14	14	10	4	15	15	15	18

Pollution tolerant mayfly larvae of *Baetis rhodani* were the most abundant macroinvertebrate at the survey sites. The only other Ephemeropterans (mayflies) recorded were larval pollution sensitive 'Group A' *Ecdyonurus* sp. and *Rhithrogena semicolorata*. Group A mayfly larvae were recorded at most locations, but not at sites 4, 5 and 9.

Order Plecoptera (stoneflies) had varied distribution and five taxa were recorded across the study area. Larvae of pollution sensitive *Protonemura* sp. were the most widespread and abundant stonefly and were generally 'few' throughout the study area. This species was recorded at all locations except for site 5. Pollution sensitive larvae of the *Chloroperla* sp., *Isoperla* sp., *Perla bipunctata* and less sensitive *Leuctra* sp. had scattered occurrence and abundance ranged from 'single' to 'common' where encountered.

The Trichopterans were well a represented group with three each of cased (Group B) and caseless (Group C) families recorded. Cased caddisfly larvae in families *Limnephilidae, Sericostomatidae* and *Goeridae* were scarce where they occurred. Larvae of *Goeridae* was the most frequently recorded, found at all sites except site 4 and 5. Caseless caddisfly larvae of *Polycentropus* sp. and *Rhyacophila* sp. were well distributed within the study area and generally scarce (few), but neither was found at site 5. *Hydropsyche* sp had patchy distribution within the surveyed sites and generally scarce, this species having an association with bryophytes.

Dipteran larvae accounted for a significant proportion of the macroinvertebrate community in the survey sites. The most common true fly larvae were pollution tolerant *Simulidae* and green chironomids (few - numerous). Other true fly larvae recorded as ‘few’ were *Dicranota sp*., *Tipula sp.,* and T*haumaleidae*. Beetles in two different families were recorded: Elmidae and Hydraenidae, ‘Group C’. Beetle abundance was found to be low (few). The only mollusc species recorded was the river limpet *Ancylus fluviatilis* and *Potamopyrgus antipodarum* which were present at site 3, 6 and 7/8 (few - common). The crustacean *Gammarus deubeni* was the sole member of Order Crustacea recorded during the current study and appeared at five sites (few - common).

Plate 15: Larva of the mayfly *Ecdyonurus* sp. and *Rhithrogena semicolorata (left)*. The most common macroinvertebrate encountered was mayfly larvae of *Baetis rhodani (right)*.

Plate 16: Pollution sensitive mayfly larvae of *Ecdyonurus* sp. and caseless caddisfly larvae of *Rhyacophila* sp. recorded during the current survey (left). The molluscs *Ancylus fluviatiles (right)*.


Plate 17: Larvae of the caseless caddisfly (Polycentropodidae) was restricted to the uppermost sites in the study area

3.3 Freshwater Pearl Mussel

3.3.1 Freshwater Pearl Mussel Habitat

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. Adults are more tolerant of a wider range of in-river conditions than juveniles (Hastie *et al.,* 2000 in Skinner *et al.,* 2003).

'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[4]. 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 (2009) requirement for an EQR ≥0.90 relates to 'high status' watercourses i.e., Q4-5 & 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 macroalgae and siltation (DoEHLG, 2009). Biological water quality ratings based on macroinvertebrates indicate that the water quality in the River Flesk is of adequate in terms of supporting FPM.

[4] See Appendix 1, **Table A2.1** for more EQR values and intercalibration information

Using criteria in Anon (2004), the upper River Flesk is classified as a moderate priority river 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 upper reaches of the River Flesk are underlain by 'Devonian Old Red Sandstones'. The only watercourse in the study area that could possibly support FPM is the River Flesk. The tributaries of the River Flesk that drain the Proposed Development Site, as well as the River Flesk in its upper reaches are all above an elevation of 200 m. Such areas are indicated in Anon (2004) as not being likely to support FPM.

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 morphology of the river reaches downstream of Poulgorm Bridge, where FPM is most likely to occur has likely been altered by excessive erosion, cattle access, and invasive plants. These are known pressures on FPM (Moorkens, 1999) Table 10 presents the findings of the survey in terms of habitat quality and survey extent.

Table 10: habitat quality and survey extent in relation to FPM.

.Survey reach code	No. of transects	Approx. length of channel surveyed (km)	Environmental Quality Objectives (EQO)5			FPM population	Notes
			Filamentous algae	Macrophytes	Siltation		
R1	13	1	Frequent	Frequent	A lot of visible silt	Occasional	Low energy / low gradient Stable substrates and generally good FPM habitat. Part of lower section of river impacted by instream river works, where large boulders appeared to have been moved to the bank and sides of channel. Only a single FPM recorded.
R2	21	1.8	Frequent	Occasional	A lot of visible silt	Absent	Low energy / low gradient Substrates mostly of gravels and finer particles. No / minimal shade. Extensive blooms of L. ochracea in backwaters. Extensive bank erosion, slippage. Riparian and instream degradation by cattle. Frequent stands of Japanese knotweed along channel.
R3	25	1.8	Frequent	Rare	A lot of visible silt	Absent	Lower extent Low energy / low gradient Finer substrates Soil loss from banks to river exacerbated by cattle access and frequent Japanese knotweed

[5] EQO = Ecological Quality Objectives for FPM habitat

.Survey reach code	No. of transects	Approx. length of channel surveyed (km)	Environmental Quality Objectives (EQO)5			FPM population	Notes
			Filamentous algae	Macrophytes	Siltation		
							Little/no shade Upper extent Moderate energy, moderate gradient Coarse substrates and more suitable habitat. Dappled shade
R4	17	1.2	Frequent	Absent	Some visible silt	Absent	Moderate energy, moderate gradient Coarse substrates dominate Dappled shade
R5	39	2.5	Occasional	Absent	Some visible silt	Absent	Moderate energy, moderate gradient Coarse substrates dominate with unstable substrates in places Little/no shade

3.3.2 Survey Results

A single FPM was recorded during the current survey. This mussel was found near the right bank of the river at survey reach R2 upstream of the N22 Bridge. It is considered that the FPM population in the River Flesk has seriously declined and faces extinction. The reaches at R1 and R3 were previously surveyed by Gerard Hayes in January 2013 and the FPM population at this time was marginally better.

FPM were not detected during the surveys carried out at all other surveyed reaches on the River Flesk. In general, macroalgal coverage within the survey reaches was frequent, and these conditions are considered unfavourable in terms of the species' habitat. Likewise, the sedimentation levels recorded were generally indicative of artificially induced siltation. Representative photos of FPM survey reaches can be seen below in order from downstream to upstream.

No evidence of FPM in the form of shells were recorded during the field investigations, despite extensive searches on deposits at the leeward side of bends. The stretches examined were deemed representative of the rivers and a variety of microhabitats were surveyed (e.g., clean substrates in riffle, glide and pool under partial and full shade). Approximately 8.3km of the River Flesk was surveyed (115 transects), which represents a significant proportion of this watercourse, the primary river receptor for the Proposed Development.

The main channel of the River Flesk has been badly affected by riparian habitat degradation and instream disturbance, with major implications for FPM. Any physical effects on a river likely have direct and indirect negative effects on FPM (injury, mortality and stress), and a permanent impact on supporting habitats. Substrates were considered highly mobile in some areas, especially at R2 and the lower extent of R3, thereby rendering substrate conditions unsuitable for FPM. Japanese knotweed *Reynoutria japonica* has colonised much of the riverbank at R2 and R3 with implications for bank stability as well as soil loss to the river. These impacts also affect the habitats and therefore abundance of FPM host fish.

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. An entire survey of the and River Flesk (the only suitable habitats in the receiving environment within a FPM sensitive area) was not undertaken as this would be beyond the scope of this assessment. The likelihood of FPM occurring in the either the River Flesk upstream of Poulgorm Bridge (reach R3) is deemed very low considering the habitats present.

The presence of FPM in the Zone of Influence (ZOI) of the Proposed Development is therefore considered unlikely. The river reaches surveyed were considered to have overlapped with the ZOI of the Proposed Development regarding FPM. It is considered likely that the current FPM record from the River Flesk is beyond the ZOI of the Proposed Development, taking account of hydrological separation in excess of 17km (from site 10), dilution provided by other watercourses flowing into the River Flesk and recovery from pollution which takes place in rivers with distance downstream from sources. Given the apparent low numbers of FPM, it is highly unlikely this species would be affected by the Proposed Development. According to Moorkens (1999) however, this species may be affected by impacts occurring at considerable distances upstream from their populations, and taking into account its conservation status, impacts on this species cannot be ruled out.

Plate 18: Cattle access and severe poaching at R2 (left). Upper extent of R2 (right).

Plate 19: River Flesk at reach R4 (LEFT) where evidence of high energy flows were recorded. Algal growth and siltation in slow flowing habitat at R4 (right).

3.4 Water Quality

3.4.1 Biological Water Quality

The watercourses provide water of a quality adequate to support some of pollution sensitive mayfly and stonefly larvae, as well as salmonids, but water quality is largely compromised in the study area. Q-ratings and EPT indices derived from the diversity and relative abundance of the macroinvertebrates at the study sites are given in **Table 11.**

Based on macrcoinvertebrate assemblages, at least good ecological conditions were recorded at all locations with the exception of sites 4 and 5. Sites 1, 7, 8 and 9 were rated Q4, corresponding to Water Framework Directive (WFD) ‘good status’. Sites 2, 3, 6 and 10 were rated Q4-5, corresponding to WFD ‘high status’. Biological water quality at site 5 was rated 'Moderately polluted (Q3)', equivalent to WFD 'Poor status' due the absence of pollution sensitive taxa. Site 4 was rated Q3-4, corresponding to WFD ‘moderate status’.

Based on BMWP scores, biological water quality ratings ranged from ‘poor’ at site 5 to ‘very good’ at site 6 -10 at the western extent of the study area. ASPT scores ranged from 7.3 to 8.9. These values are indicative of good water quality, where a value of > 5.5 is deemed to signify this.

The EPT (Ephemeroptera, Plecoptera, Trichoptera) index of water quality varied between 1 (site 5) to 11 (site 10). Based on the EPT index therefore, macroinvertebrate richness is highly variable. Overall, this is suggestive of an unstable aquatic ecosystem some of the smaller streams in the study area.

The effects of increased drainage on water quality, such as drainage of peatland for forestry are multiple. For example, iron-oxidizing bacteria have direct and indirect effects on river ecosystems. Iron precipitates on both biological and other surfaces indirectly affects organisms by disturbing the normal metabolism and osmoregulation and by changing the structure and quality of benthic habitats and food resources. The combined direct and indirect effects of iron contamination decrease the species diversity and abundance of periphyton (organisms attached to submerged surfaces), benthic invertebrate and fish (Vuori, 1995).

Too many nutrients, especially phosphorus, can result in excessive plant and algae growth which severely impacts the normal functioning of aquatic environment. This results in changes in the natural biological communities and an undesirable disturbance to the overall ecology (EPA, 2018).

Table 11: Biological water quality results and interpretations at study sites on watercourses potentially affected by the Proposed Development

Site	Watercourse	Q-rating	Quality Status	Corresponding WFD Status	BMWP Score	BMWP Category	BMWP Interpretation	ASPT	EPT
1	River Clydagh tributary	4	Unpolluted	Good	87.8	Good	Clean but slightly impacted	7.3	7
2	River Clydagh / 22F02	4-5	Unpolluted	High	94.9	Good	Clean but slightly impacted	7.9	10
3	Mullaghanish River tributary	4-5	Unpolluted	High	91.3	Good	Clean but slightly impacted	7.6	8
4	Mullaghanish River / 24M42	3-4	Slightly polluted	Moderate	84.3	Good	Clean but slightly impacted	8.4	7
5	River Clydagh tributary	3	Moderately Polluted	Poor	29.2	Poor	Polluted or impacted	7.3	1
6	River Clydaghroe	4-5	Unpolluted	High	106.8	Very good	Unpolluted, Unimpacted	7.6	8
7/8	River Clydagh tributary	4	Unpolluted	Good	107.3	Very good	Unpolluted, Unimpacted	7.7	8
9	River Clydagh tributary	4	Unpolluted	Good	106.5	Very good	Unpolluted, Unimpacted	8.9	9
10	River Clydagh	4-5	Unpolluted	High	128.7	Very good	Unpolluted, Unimpacted	8.0	11

3.4.2 Physico-chemical Water Quality

Results of the on-site physico-chemical measurements at sites 1 and 3 are presented in **Table 12.** Laboratory physico-chemical results for site 1 and site 3 are presented in **Table 13**. The results for the onsite results are discussed briefly. The laboratory results are discussed in more detail below.

Conductivity at both locations were low, as would be expected in watercourses draining peaty soils in a terrain where the solid geology is siliceous. Dissolved Oxygen concentrations were slightly lower than the optimal of around 100%. pH at site 1 and site 3 was 7.3 and 7.89 respectively, readings typical of upland streams draining peatland. Further sampling points were undertaken during hydrological surveys and Chapter 12 Hydrology, Water Quality and Flood Risk should be consulted for this information.

Table 12 Results of the on-site physico-chemical measurements

Parameter and Unit	site 1	site 3
Conductivity (µS/cm)	75.5	78.6
Temperature (°C)	11.2	11.7
Dissolved Oxygen (%)	93.2	87.5
Dissolved Oxygen (p.p.m.)	10.27	9.8
Total Dissolved Solids (mg/l)	53.7	41.7
Turbidity (NTU)	3.56	1.43
Turbidity (NTU)	3.82	1.3
Turbidity (NTU)	3.96	1.29
Turbidity (NTU) average	3.78	1.34
pH	7.3	7.89

Table 13 Laboratory physico-chemical results

Parameter and Unit	Site 1	Site 3
Biological Oxygen Demand (BOD) (mg/L)	< 1.0	< 1.0
Suspended Solids (mg/L)	< 4	< 4
Total Ammonia (mg/L N)	< 0.02	< 0.02
Nitrate (mg/L N)	< 0.25	< 0.25
Nitrite (mg/L N)	< 0.005	< 0.005
Orthophosphate (mg/L P)	0.03	< 0 .01
Total Hardness (mg/L CaCO3)	17	12
Total Phosphorus (mg/L P)	0.04	< 0.04
Total Organic Carbon (TOC) (mg/L)	6.1	5.0

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). 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).

Total Ammonia concentrations at site 1 and site 3 were <0.02 mg/l. 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 (EC, 1988). Both sites meet this objective based on the sample taken, however this parameter should be measured for its quality of salmonid waters by using 95% of the results collected over a 12-month period for it to be considered an appropriate reading (EC, 1988). The result in the table above is single reading only in this regard.

The results for Ammonium was <0.129 for every site is well below the mandatory values of the 'Freshwater Fish Directive (78/659 EEC) of <1mg/L NH_4^+.

Biological 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 at Site 1 and Site 3 were <1 mg/l, consistent with WFD high status with respect to this parameter. These results are within the recommended tolerance of 5mg/L O_2 for salmonid species which are vital for FPM establishment. The results also achieve adherence to the 'Freshwater Fish Directive (78/659/EEC)' guidance of 3mg/L O_2 for salmonid waters.

Orthophosphate/Total Phosphorus

This chemical parameter does occur naturally in water bodies from geological sources. Orthophosphate is the most readily available form of the nutrient Phosphorous for plant uptake for uptake during photosynthesis and is generally considered to be the limiting nutrient for plant growth in freshwater. Elevated levels of this chemical can have a detrimental effect on aquatic life. The result for orthophosphate for site 1 and site 3 was <0.03 mg/l and < 0.01 mg/l, in that order. The orthophosphate levels for the surveyed sites met the 'good' quality status requirements for the mean value stipulated in the SWR (2009) though the results for the sites was from a single reading. 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). The concentration of this parameter at Site 1 was deemed elevated and the likely cause was considered related to clear-felling of commercial forestry upslope.

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 (Planning, 1990). The total phosphorus concentration for site 1 and site 3 was 0.04 mg/l and <0.04 mg.

Nitrate/Nitrite

There are no environmental quality standards for nitrate but average nitrate concentration values less than 4 mg/l NO_3 (0.9mg/l N) and less than 8 mg/l NO_3 (1.8mg/l N) are considered by the EPA to be indicative of high and good quality respectively (EPA, 2017). The results for all sites were < 0.25 mg/l which means these sites are considered to be of good quality, in accordance with EPA (2001) guidance.

Suspended Solids/Total Dissolved Solids/Total Hardness

Both sites had suspended solids levels of <4 mg/L which is much less than the mandatory value of ≤25mg/L which is stated in the 'Salmonid Water Regulations (1988)' EPA, 2001).

Total dissolved solids (TDS) were 53.7 mg/l at Site 1 and 41.7 mg/l at Site 3. There are no specified parametric limits for TDS but these results would not be considered elevated.

Total Hardness values of 17 mg/L and 12 mg/L $CaCO_3$ were obtained for Site 1 and Site 3 respectively. According to the EPA's classification table for water hardness (EPA, 2019), water in the study area is classified as soft. Harder water can reduce the effect of toxicity of some metals including zinc, copper, and lead (EPA, 2019).

Total Organic Carbon (TOC)

The majority of 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 were 6.1 mg/L at site 1 and 5 mg/l at site 3. This parameter has no limit target specified in Irish legislation.

3.5 Functional Feeding Group Analysis

Table 14 shows the functional feeding group characteristics of the aquatic study sites. All study sites except for site 7 were considered suitable to the rearing of juvenile salmonids with respect to macroinvertebrates, as all had a predictable juvenile salmonid index. It is noted however that water quality conditions at site 5 would be unsuitable for juvenile salmonids. 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).

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. All watercourses in the study area drain soils overlaying schist geology, where nutrient peaty soils are predominant. The naturally low nutrient concentrations of surface waters in the study area, coupled in some instances with their peaty nature mean that benthic life and therefore higher 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 14: Functional Feeding Group characteristics of the study sites

Functional Feeding Group	Site								
	1	2	3	4	5	6	7	9	10
Filtering collector	69	63	53	51	26	37	23	56	63
Gathering collector	7	34	10	0	0	21	2	0	12
Scraper	50	59	48	13	0	50	38	8	48
Predator	13	3	11	9	0	8	11	5	6
Shredder	23	19	19	14	3	18	37	5	42
Totals	162	178	141	87	29	134	111	74	171
Indices and Interpretations									
P/R[6] ratio	0.51	0.51	0.59	0.2	0	0.66	0.61	0.13	0.41
Heterotrophic (H) vs Autotrophic (A)	H	H	H	H	H	H	H	H	H
Juvenile salmonid index	0.88	1.20	0.81	1.42	8.67	0.76	0.29	3.11	0.78
Predictable (P) vs Unpredictable (U)[7]	P	P	P	P	P	P	U	P	P

3.6 Fish

Atlantic salmon and brown trout were the only species recorded during the survey of watercourses draining the Proposed Development. Table 15 gives length descriptive statistics for all fish species captured. Table 16 gives Catch Per Unit Effort (CPUE) indices for the salmonids captured. All electrical fishing data is presented in **Appendix 4**. Figure 8.7 illustrates fish records at the aquatic survey sites.

Salmonids were recorded at all survey locations with the exception of site 5, where no fish were recorded. Water quality was an issue with the stream at site 5 and the most likely reason for the absence of fish here. Brown trout were the most widespread species, occurring at all but site 5. Salmon were recorded at both sites on the River Flesk (site 2 and site 10) as well as at site 8. This is related to habitat suitability. Salmon can be expected to occur in the lower reaches of the Clydaghroe, Mullaghanish streams which drain the Proposed Development. It is noted that site 7 than site 8 were located upstream and downstream of a track crossing the stream, respectively. Far fewer trout were recorded upstream (N=2) than downstream (N=1). In addition, salmon (N=3) were recorded downstream but not upstream. Trout of smaller adult proportion are able to penetrate further into the headwaters of the upper flesk and its tributaries and take advantage of spawning and nursery areas in 1st and 2nd order streams such as the Clydaghroe, Mulaghnaish and the streams at site 1, 3, 7 and 9, avoiding competition with salmon in these areas. The salmonids in the subject watercourses were mostly juvenile fish, highlighting the importance of these channels for the early life stages of trout and salmon.

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

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

A total of 150 trout were captured and ranged in length from 4.2 cm to 20 cm. These fish had a mean length of 10.6 cm. A total of 55 salmon were captured and ranged in length from 5.1 cm to 11.8 cm. These fish had a mean length of 10.1 cm.

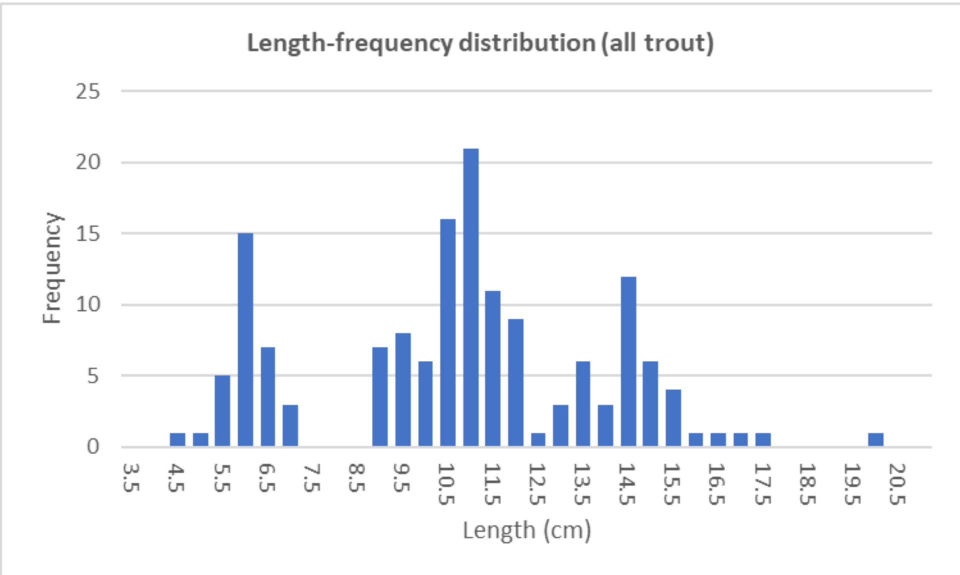
Plate 20: Salmon at site 2. Trout (above) and salmon (below) at site 8

Plate 21: Brown Trout)left) and Salmon (right) captured at site 10.

Chart 1 and Chart 2 present the length - frequency distribution (LFD) for trout and salmon captured during the entire survey of watercourses in the upper River Flesk catchment. It can be seen from LFDs that the age structure is generally dominated by fish in younger cohorts (age groups) for both the salmon and trout population. The LFD for all salmon clearly illustrates two cohorts for salmon (0+ and 1+) and three cohorts for trout (0+ and 1+, 2+). The 0+ cohort for trout ranged from ca. 4.2 cm to 7cm long, the 1+ cohort ranged from ca. 9 cm long to 12.5cm long and the 3+ cohort from 12.5 cm to 17.5 cm. There is not a clear distinction between 1+ and 2+ cohorts given individual variation in growth rates. Taking account of the size ranges in the watercourses studied, it is clear that the River Flesk is the most important water feature in the study area, supporting the greatest array of fish sizes. This is due to its large size and good water quality. The greatest CPUE for trout was recorded at site 9, where electrical fishing efficiency was high, water quality good, riparian land in a semi-natural state and no migration obstacles between the survey site and the River Flesk.

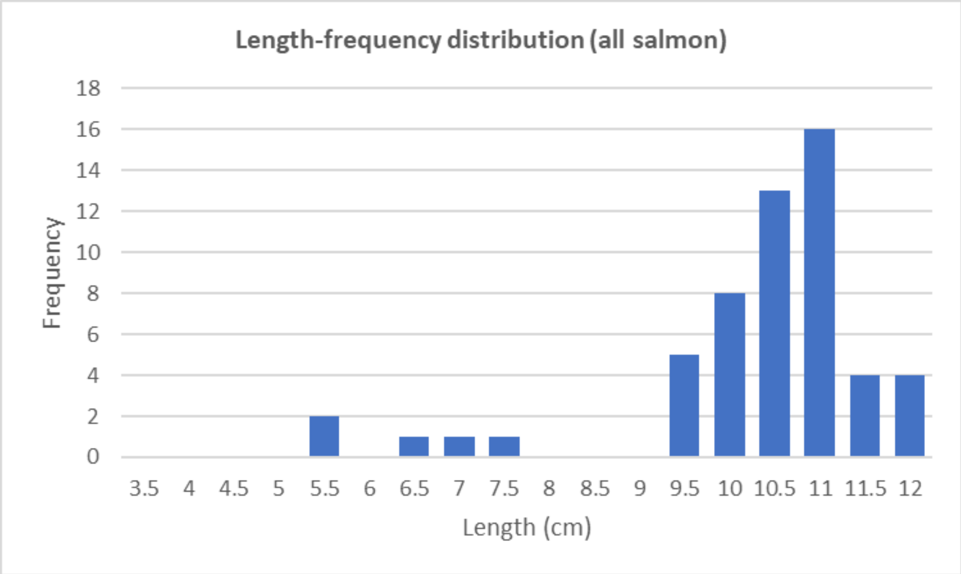
Depletion lines for the numbers of trout and salmon captured during the quantitative electrical fishing investigations on the River Flesk at Site 10 are provided in Chart 3 and Chart 4, respectively. The population estimates for trout and salmon, based on these graphs, are 0.26 trout / m^2 and 0.18 salmon / m^2.

Chart 1: Length – frequency distribution (LFD) for all trout



Source: <Insert Source text here>

Chart 2: Length - frequency distribution (LFD) for all salmon



Source: <Insert Source text here>

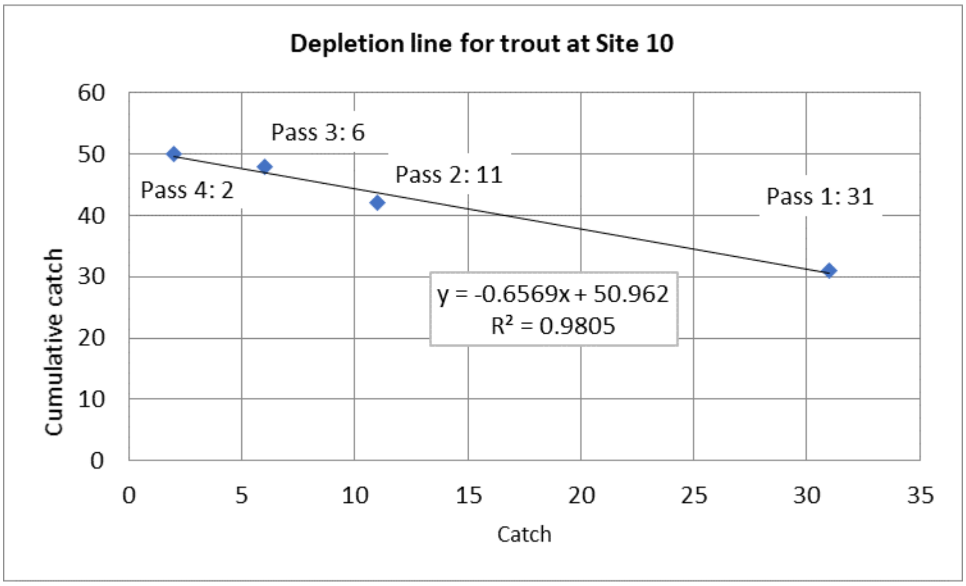
Table 15: Length descriptive statistics for fish species captured during the 2019 electrofishing survey of watercourses draining the Proposed Development.

site	Species	N	Mean	Min	Max	St. dev.
1	Trout	11	10.8	6.3	14.5	1.9
2	Trout	33	11.6	4.2	20	3.5
2	Salmon	3	6.7	6.3	7.1	0.4
3	Trout	11	11.0	8.8	14.2	1.7
4	Trout	6	8.3	5.1	11	2.4
5	No fish	0				
6	Trout	2	14.8	14.4	15.2	0.6
7	Trout	2	5.8	5.6	6	0.3
8	Trout	16	10.2	5.6	14.6	2.7
8	Salmon	3	10.5	9.6	16	0.8
9	Trout	19	7.6	4.8	13.3	2.5
10	Trout	50	11.3	5.2	17.5	2.8
10	Salmon	49	10.3	5.5	11.8	1.2

Table 16: Catch Per Unit Effort (CPUE) indices for salmonids captured during the 2019 electrofishing surveys of watercourses draining the Proposed Development.

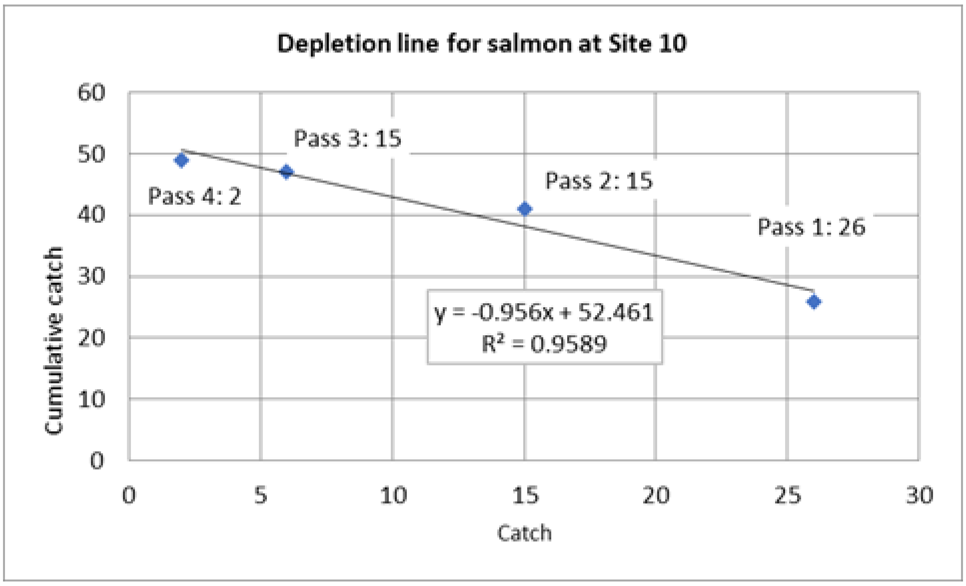
site	N	Area fished (m2)	Time fished (minutes)	Brown trout			Salmon		
				N	CPUE		N	CPUE	
					fish/m2	fish/min		fish/m2	fish/min
1	11	105	10	11	0.105	1.1	0	0	1.1
2	33	180	10	33	0.183	3.3	3	0.017	3.3
3	11	132	10	11	0.083	1.1	0	0	1.1
4	6	96.6	10	6	0.062	0.6	0	0	0.6
5	2	60	10	0	0.033	0.2	0	0	0.2
6	2	65	10	2	0.031	0.2	0	0	0.2
7	16	48	10	2	0.333	1.6	0	0	1.6
8	19	55.5	10	16	0.342	1.9	3	0.055	1.9
9	50	45.6	10	19	1.096	5	0	0	5
10	49	300	n/a	50	0.163	n/a	49	0.163	n/a

Chart 3: Depletion lines, Leslie-Davies method, for the numbers of trout captured during the quantitative electrical fishing investigation on the River Flesk at Site 10.



Source: <Insert Source text here>

Chart 4: Depletion lines, Leslie-Davies method, for the numbers of trout captured during the quantitative electrical fishing investigation on the River Flesk at Site 10.



Source: <Insert Source text here>

Table 17: Minimum density estimations (fish m-2) for trout and salmon at site 10 on the River Flesk

Species	Equation	R2	Population estimate	Minimum density (fish/m2)
Brown troutre	y = -0.6569x + 50.962	0.9805	55	0.26
Salmon	y = -0.956x + 52.461	0.9589	78	0.18

4 References

Anonymous (2004) *Margaritifera margaritifera*: Stage 1 and Stage 2 survey guidelines. Irish Wildlife Manuals No. 12. National Parks and Wildlife Service, Dublin.

Bauer, G. (1988). Threats to the freshwater pearl mussel *Margaritifera margaritffera* L. in central Europe. Biological Conservation, 45, 239–253.

Byrne, A., Moorkens, E.A., Anderson, R., Killeen, I.J. & Regan, E.C. (2009) Ireland Red List No. 2 – Non-Marine Molluscs. National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government, Dublin, Ireland.

Crisp TJ (2000). Trout and Salmon. Ecology, Conservation and Rehabilitation. Blackwell Science, Oxford. 212pp.

Davis, S. J., Ó hUallacháin, D., Mellander, P., Kelly, A., Matthaei, C. D., Piggott, J. J. and Kelly-Quinn, M. (2018) Multiple-stressor effects of sediment, phosphorus and nitrogen on stream macroinvertebrate communities. Science of the Total Environment 637–638 (2018) 577–587.

Department of Agriculture for Northern Ireland (1995) Advisory Leaflet No. 1 'The Evaluation of habitat for Salmon and Trout' Department of Agriculture for Northern Ireland Fisheries Division. EU Salmonid Enhancement Programme.

Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs (2017) Margaritifera Sensitive Areas Map. NPWS GIS files relevant to the distribution of freshwater pearl mussel (*Margaritifera margaritifera*) and Nore freshwater pearl mussel (*Margaritifera durrovensis*) in Ireland.

DoEHLG (2009) The European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009. S.I. No. 296 of 2009.

EA (2003) River Habitat Survey in Britain and Ireland: Field Survey Guidance Manual. River Habitat Survey Manual: 2003 version, Environment Agency, 136 pp

EPA (2013) Integrated Water Quality Report 2012 Monaghan & Louth. EPA Regional Inspectorate Monaghan, The Glen, Monaghan.

EPA (2017). Developing Sediment Remediation Goals at Superfund Sites Based on Pore Water for the Protection of Benthic Organisms from Direct Toxicity to Non-ionic Organic Contaminants. EPA/600/R 15/289.

EPA (2001) Parameters of Water Quality – Interpretation and Standards. Environmental Protection Agency, Ireland.

European Communities (Quality of Salmonid Waters) Regulations, 1988.

European Communities Environmental Objectives (Surface waters) Regulations. Statutory Instrument No. 272 of 2009.

EPA (2001) Parameters of Water Quality – Interpretation and Standards. Environmental Protection Agency, Ireland.

Elliott, J. M., Humpesch, U. H. & Macan, T.T. (1988) Larvae of the British Ephemeroptera – a key with ecological notes. Freshwater Biological Association, Scientific Publication No. 49.

European Communities (Quality of Salmonid Waters) Regulations, 1988.

Feeley, H.B., Baars, J-R., Kelly-Quinn, M. & Nelson, B. (2020) Ireland Red List No. 13: Stoneflies (Plecoptera). National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht, Dublin, Ireland.

Foster, G. N., Nelson, B. H. & O Connor, Á. (2009) Ireland Red List No. 1 – Water beetles. National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin, Ireland.

Gledhill, T., D.W. Sutcliffe & W.D. Williams (1993) British Freshwater Crustacea Malacostraca: a Key with Ecological Notes 1993, 176pp.

Hastie LC, Boon PJ & Young MR (2000). Physical microhabitat requirements of freshwater pearl mussel *Margaritifera margaritifera* (L.). *Hydrobiologia* 429 59–71.

Hendry K & Cragg-Hine D (2003). Ecology of the Atlantic Salmon. Conserving Natura 2000 Rivers Ecology Series No. 7. English Nature, Peterborough.

IFI (2016) Guidelines on Protection of Fisheries during Construction Works in and Adjacent to Waters. Inland Fisheries Ireland, 3044 Lake Drive, Citywest Business Campus Co. Dublin. IFI/2016/1-4298.

IFI (2010) IFI Biosecurity Protocol for Field Survey Work. Inland Fisheries Ireland. , 3044 Lake Drive, Citywest Business Campus Co. Dublin

Kelly-Quinn, M. & Regan, E.C. (2012) Ireland Red List No. 7: Mayflies (Ephemeroptera). National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland.

Lenat, D.R. (1988) Water quality assessment using a qualitative collection method for benthic macroinvertebrates. J.N. Am. Benthological Soc. 7: 222-233.

Macan T.T. (1994) A Key to the British Fresh- and Brackish-Water Gastropods, with Notes on their Ecology Fourth edition, 1977 (reprinted 1994), 46pp.

Maitland, P. S. & Campbell, R. N. (1992) Freshwater Fishes of the British Isles. Harper Collins Publishers. Somerset, UK.

Maitland PS (2003) Ecology of the River, Brook and Sea Lamprey. Conserving Natura 2000 Rivers Ecology Series No. 5. English Nature, Peterborough.

Maitland, P. (2004) Key to British Freshwater Fish with notes on their ecology and distribution. Freshwater Biological Association Scientific Publication No. 62. Freshwater Biological Association, Amblreside.

Masters-Williams, H., Heap, A., Kitts, H., Greenshaw, L., davis, S., Fisher, P., Hendrie, M., Owens, D. (2001) Control of water pollution from construction sites. Guidance for consultants and contractors. DETR/CIRIA. London.

Murnane, E., Heap, A., Swain A. (2006) Control of water pollution from linear construction projects. Technical guidance (C648). 234pp. CIRIA, UK.

NRA (2005) Guidelines for the Crossing of Watercourses during the Construction of National Road Schemes. National Roads Authority.

Rabenil, C.F., Doisy, K.E. and Zweig, L.D. (2005) Stream invertebrate community functional responses to deposited sediment Journal of Aquatic Sciences. 67(4):395-402.

Reinhardt, U.G., Binder, T., and McDonald, D.G. (2009) Ability of adult sea lamprey to climb inclined surfaces. In: Biology, Management and Conservation of lampreys in

North America (Eds: Brown, L.R., Chase, S.D., Mesa, M.G., Beamish, R.J., and Moyle P.B.). American Fisheries Society Symposium, 27: p71-115. Bethesda, Maryland.

Savage A.A. (1989) Adults of the British Aquatic Hemiptera Heteroptera: a Key with Ecological Notes1989, 173pp.

Scottish Executive (2000) River Crossings and Migratory Fish: Design Guidance. A Consultation Paper. April 2000. Available at

http://www.gov.scot/Topics/marine/science/Publications/publicationslatest/rivercrossings

S.I. No. 293/1988 — European Communities (Quality of Salmonid Waters) Regulations.

Skinner, A., Young, M. and Hastie, L. (2003) Ecology of the Freshwater Pearl Mussel. Conserving Natura 2000 Rivers Ecology Series No. 2 English Nature, Peterborough.

Toner, P., Bowman, K., Clabby, K., Lucey, J., McGarrigle, M, Concannon, C., Clenaghan, C., Cunningham, P., Delaney, J., O'Boyle, S., MaCarthaigh, M., Craig, M., and Quinn, R. (2005) Water Quality in Ireland 2001-2003. Environmental Protection Agency, Wexford.

Walsh, N., Neill, M., and Lucey, J (2012) River sediment studies in relation to juvenile pearl mussels and salmonids. Aquatic Environment, Office of Environmental Assessment Environmental Protection Agency, Seville Lodge, Callan Road, Kilkenny, Ireland.

Wallace, I.D., B. Wallace & G.N. Philipson (2003) Keys to the Case-bearing Caddis Larvae of Britain.

Appendix 1 Macroinvertebrate Physical Habitat Suitability

Table A2.1: Physical habitat assessment of streams for their suitability for macroinvertebrate production (adapted from Barbour and Stribling, 1991).

Score	Optimal 20	Suboptimal 15	Marginal 10	Poor 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 A2.2 Intercalibration of EPA Q-rating system with Water Framework Directive status based on macroinvertebrate

Q Value*	WFD Status	WFD Intercalibration Common Metric Value[8]	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.*

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

Table A2.3 Q-value for use in eroding (i.e., riffle-glide) river stretches

EPA Biological Assessment of Water Quality in Rivers and Streams*

Biotic Indices (Q Values) and typical associated macroinvertebrate community structure

WFD Status Groups	Families	High Q5	High Q4-5	Good Q4	Moderate Q3-4	Poor Q3	Poor Q2-3	Bad Q2	Bad Q1-2	Bad Q1
Group A Plecoptera Ephemeroptera Lamellibranchiata	All except Leuctridae Heptageniidae Siphlonuridae *Ephemera danica* *Ameletus inopinatus* *Margaritifera margaritifera*	**At least 3 taxa well represented i.e., common to dominant.** Expect 5 or more Group A taxa outside of June – Sept period	**At least 2 taxa well represented i.e., common to dominant.** Expect >2 Group A taxa outside of June-Sept period	**At least 1 taxon in reasonable numbers**	**At least 1 taxon Few - Common**	**Absent**	**Absent**	**Absent**	**Absent**	**Absent**
Group B Plecoptera Ephemeroptera Trichoptera Odonata Hemiptera	Leuctridae Baetidae (excl *B. rhodani* agg.) Leptophlebidae All Cased Trichoptera Odonata Aphelocheiridae	**Few to Numerous**	**Few to Numerous**	**Few to Numerous**	**Few/Absent to Numerous**	**Few/Absent**	**Absent**	**Absent**	**Absent**	**Absent**
Group C Ephemeroptera	*Baetis rhodani/Baetis atlanticus*	Few to Dominant	Few to Dominant	Numerous to Dominant	Numerous to Excessive	Numerous to Excessive	Few to Common	Absent	Absent	Absent
  Trichoptera Hemiptera Coleoptera Hydracarina Diptera	Ephemerellidae Caenidae All Uncased Trichoptera All excl Aphelocheridae All All All (excl. *Chironomus* & *Eristalis*)	**Few to Numerous** Group C taxa can represent over 70% of total abundance with good diversity and no single taxa dominant	**Few to Numerous** Group C taxa can represent over 70% of total abundance with good diversity and no single taxa dominant	**Common to Numerous (Never Excessive)**	**Common to Excessive (usually Dominant or Excessive as a group)** Diversity can be reduced with a few taxa dominant	**Dominant to Excessive** Diversity reduced with a few taxa dominant	**Few to Common** Diversity reduced with a few taxa	**Absent**	**Absent**	**Absent**
	Simuliidae	Few	Few to common	Few to Numerous	Common to Dominant/Excessive	Common to Excessive	Few to Common	Absent	Absent	Absent
Crustacea	All (excl. Asellidae & *Crangonyx* spp.)									
	Gammarus c.f. duebeni	Few to common	Few to common	Common to Dominant	Common to Excessive	Common to Excessive	Few to Common	Absent	Absent	Absent
Gastropoda Lamellibranchiata Hirudinea Platyhelminthes Oligochaeta	All (excl. *Radix peregra, Physella*) *Anodonta* sp. *Piscicola* sp. All Lumbriculidae, Lumbricidae	**Ephemeroptera, Trichoptera may be well represented Others few or absent.**	**Ephemeroptera, Trichoptera may be well represented Others few or absent.**							
Group D Crustacea Megaloptera Gastropoda Lamellibranchiata Hirudinea Oligochaeta	Asellidae, *Crangonyx* Sialidae *Radix peregra, Physella* *Sphaeriidae*, All excl. *Piscicola* Naididae, Enchytraeidae	**Few or Absent**	**Few or Absent**	**Few or Absent**	**Few/Absent to Common**	**Few/Absent to Common**	**Dominant to Excessive**	**Dominant to Excessive**	**Few to common**	**Few or Absent**
Group E Oligochaeta Diptera	Tubificidae, Chironomus, Eristalis spp.	**Few or Absent**	**Few or Absent**	**Few or Absent**	**Few or Absent**	**Few or Absent**	**Few to Common**	**Few/Absent to Common**	**Common to Numerous**	**Dominant**

* This scheme is not intended for assessment of conditions in stagnant waters or where substratum is mud, bedrock or sand. It should be borne in mind that faunal composition is affected by such factors as ground water input, calcification, drainage, canalisation, culverting, marked shading and seasonal factors. Note: **The occurrence/abundance of groups in above table refers to some but not necessarily all the constituents of the group. Single specimens may be ignored.**

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

Table A2.4: 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 A2.5: 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
	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
	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: Macroinvertebrates recorded during biological sampling on watercourses draining the Proposed Development during October 2021.

Taxa/Species	Pollution Sensitivity Group	Functional Feeding Group	site								
			1	2	3	4	5	6	7, 8	9	10
MAYFLIES (Uniramia, Ephemeroptera)											
Baetidae											
Large dark olive Baetis rhodani	C	Scraper & gathering collector	86	42	26	22		38	30	2	64
Family Heptagenidae											
Autumn dun Ecdyonurus sp.	A	Scraper & gathering collector	10	48	16			36	4		20
Rhithrogena semicolorata	A	Scraper & gathering collector		20	4			4			2
STONEFLIES (Order Plecoptera)											
Chloroperlidae											
Chloroperla sp.	A	Shredder				2				1	
Perlodid stoneflies (Perlodidae)											
Common yellow sally Isoperla sp.	A	Shredder		1		1		2	2	1	4
Brown stoneflies (Nemouridae)											
Protonemura sp.	A	Shredder	12	8	7	2		9	5	2	12
Golden stoneflies (Perlidae)											
Perla bipunctata	A	Shredder									5
Needleflies (Leuctridae)											
Leuctra sp.	B	Shredder	5	3						1	
CASED CADDIS FLIES (Tricoptera)											
Northern caddisflies (Limnephilidae)	B	Shredder				2			6		2
Sericostomatidae											
Black caperer Sericostoma personatum	B	Shredder			1						
Family Goeridae	B	Scraper	2	4	7			4	7	6	5
CASELESS CADDIS FLIES (Trichoptera)											
Grey flags (Hydropsychidae)											
Hydropsyche sp.	C	Filtering collector		2					3	5	6
Green sedges (Rhyacophilidae)											
The sandfly Rhyacophila sp.	C	Predator	10	3	5	7		4	2	2	2
Trumpet-net caddisflies (Polycentropodidae)											
Polycentropus sp.	C	Filtering collector	3	3	1	2	4	3		2	2

TRUE FLIES (Diptera)											
Blackfly (Simulidae)											
Simulium sp.	C	Filtering collector	10	18	39	38	7	15	5	30	7
Craneflies (Tipulidae)	C										
Tipula sp.	C	Shredder							1		
Dicranota sp.	C	Shredder	6		5	7	3	2	5		5
Family Chironomidae											
Green chironomid	C	Filtering collector	4	19			15			14	16
Solitary midges (Thaumaleidae)	C	Filtering collector	9							4	
BEETLES (Coleoptera)											
Diving beetles (Dytiscidae)	C										
Hydroporinae	C	Predator							1		
Riffle Beetle (Elmidae)											
Elmis aenea	C	Predator	3		6			2	5		4
Limnius volckmari	C	Predator							2	2	
Minute moss beetles (Hydraenidae)											
Hydraena sp.	C	Predator							1	1	
Marsh beetle (Scirtidae)	C	Predator				2		2			
SNAILS (Mollusca, Gastropoda)											
Family Ancylidae											
River limpet Ancylus fluviatilis	C	Scraper			18			5	13		
CRUSTACEANS (Crustacea)											
Amphipods (Gammaridae)											
Freshwater shrimp Gammarus duebeni	C	Shredder		7	6			5	18		14
WORMS (Oligochaeta)											
Lumbriculidae	D	Gathering collector						1			1

Appendix 4 Fish Survey results

Table A5.1: Fish survey results

site	Species	Length cm	Pass
1	Brown trout	14.5	1
1	Brown trout	11.8	1
1	Brown trout	11.0	1
1	Brown trout	11.2	1
1	Brown trout	10.9	1
1	Brown trout	10.8	1
1	Brown trout	11.7	1
1	Brown trout	9.7	1
1	Brown trout	10.1	1
1	Brown trout	10.3	1
1	Brown trout	6.3	1
2	Brown trout	14.5	1
2	Brown trout	12.8	1
2	Brown trout	14.3	1
2	Brown trout	20.0	1
2	Brown trout	14.3	1
2	Brown trout	14.5	1
2	Brown trout	10.8	1
2	Brown trout	14.6	1
2	Brown trout	16.5	1
2	Brown trout	16.7	1
2	Brown trout	10.1	1
2	Brown trout	7.0	1
2	Brown trout	10.7	1
2	Brown trout	11.5	1
2	Brown trout	15.2	1
2	Brown trout	12.8	1
2	Brown trout	15.2	1
2	Brown trout	14.9	1
2	Brown trout	10.7	1
2	Brown trout	5.8	1
2	Brown trout	13.3	1
2	Brown trout	9.6	1
2	Brown trout	10.3	1
2	Brown trout	9.2	1
2	Brown trout	11.4	1
2	Brown trout	10.4	1
2	Brown trout	9.9	1
2	Brown trout	8.6	1
2	Brown trout	4.2	1
2	Brown trout	5.7	1
2	Brown trout	8.9	1

site	Species	Length cm	Pass
2	Brown trout	9.0	1
2	Brown trout	9.2	1
2	Salmon	7.1	1
2	Salmon	6.7	1
2	Salmon	6.3	1
3	Brown trout	14.2	1
3	Brown trout	10.1	1
3	Brown trout	9.0	1
3	Brown trout	10.9	1
3	Brown trout	11.5	1
3	Brown trout	11.1	1
3	Brown trout	10.5	1
3	Brown trout	13.7	1
3	Brown trout	10.8	1
3	Brown trout	8.8	1
3	Brown trout	10.1	1
4	Brown trout	11.0	1
4	Brown trout	9.4	1
4	Brown trout	9.5	1
4	Brown trout	5.4	1
4	Brown trout	9.4	1
4	Brown trout	5.1	1
5	no fish		1
6	Brown trout	14.4	1
6	Brown trout	15.2	1
7	Brown trout	5.6	1
7	Brown trout	6.0	1
8	Brown trout	6.9	1
8	Brown trout	11.6	1
8	Salmon	11.0	1
8	Brown trout	11.0	1
8	Salmon	9.6	1
8	Brown trout	11.6	1
8	Brown trout	11.4	1
8	Salmon	11.0	1
8	Brown trout	13.3	1
8	Brown trout	14.6	1
8	Brown trout	9.6	1
8	Brown trout	11.3	1
8	Brown trout	13.3	1
8	Brown trout	10.8	1
8	Brown trout	9.5	1
8	Brown trout	10.3	1
8	Brown trout	6.3	1
8	Brown trout	5.6	1
8	Brown trout	6.0	1

site	Species	Length cm	Pass
9	Brown trout	13.3	1
9	Brown trout	8.9	1
9	Brown trout	11.6	1
9	Brown trout	9.2	1
9	Brown trout	9.6	1
9	Brown trout	10.6	1
9	Brown trout	5.9	1
9	Brown trout	5.9	1
9	Brown trout	6.2	1
9	Brown trout	6.0	1
9	Brown trout	5.7	1
9	Brown trout	6.0	1
9	Brown trout	6.4	1
9	Brown trout	4.8	1
9	Brown trout	5.2	1
9	Brown trout	5.5	1
9	Brown trout	6.0	1
9	Brown trout	10.8	1
9	Brown trout	6.0	1
10	Brown trout	14.0	1
10	Brown trout	10.2	1
10	Salmon	10.4	1
10	Salmon	10.3	1
10	Brown trout	14.7	1
10	Brown trout	14.1	1
10	Brown trout	16.0	1
10	Salmon	10.8	1
10	Brown trout	14.3	1
10	Brown trout	11.0	1
10	Salmon	9.6	1
10	Brown trout	12.0	1
10	Brown trout	13.0	1
10	Brown trout	14.1	1
10	Brown trout	14.8	1
10	Brown trout	17.5	1
10	Brown trout	10.8	1
10	Brown trout	10.7	1
10	Brown trout	14.3	1
10	Brown trout	11.0	1
10	Salmon	11.2	1
10	Salmon	10.8	1
10	Salmon	10.3	1
10	Salmon	10.4	1
10	Salmon	9.7	1
10	Brown trout	10.8	1
10	Salmon	11.8	1

site	Species	Length cm	Pass
10	Brown trout	12.4	1
10	Brown trout	10.4	1
10	Brown trout	14.7	1
10	Brown trout	11.8	1
10	Brown trout	6.7	1
10	Salmon	11.8	1
10	Brown trout	11.4	1
10	Salmon	11.8	1
10	Salmon	11.2	1
10	Salmon	11.0	1
10	Salmon	10.2	1
10	Salmon	10.0	1
10	Brown trout	10.5	1
10	Brown trout	5.8	1
10	Salmon	11.2	1
10	Salmon	10.7	1
10	Salmon	9.8	1
10	Salmon	10.9	1
10	Salmon	11.0	1
10	Salmon	10.8	1
10	Salmon	11.0	1
10	Salmon	10.0	1
10	Salmon	10.0	1
10	Brown trout	10.5	1
10	Brown trout	11.8	1
10	Brown trout	11.0	1
10	Brown trout	9.8	1
10	Brown trout	9.4	1
10	Brown trout	10.3	1
10	Brown trout	6.3	1
10	Salmon	5.1	1
10	Brown trout	11.7	2
10	Brown trout	5.9	2
10	Brown trout	14.3	2
10	Brown trout	11.4	2
10	Salmon	10.8	2
10	Salmon	9.2	2
10	Salmon	9.9	2
10	Salmon	10.1	2
10	Salmon	10.8	2
10	Salmon	10.3	2
10	Salmon	9.3	2
10	Salmon	10.5	2
10	Salmon	9.5	2
10	Brown trout	11.4	2
10	Brown trout	13.3	2

site	Species	Length cm	Pass
10	Brown trout	13.7	2
10	Brown trout	10.3	2
10	Salmon	10.3	2
10	Brown trout	15.5	2
10	Brown trout	13.4	2
10	Salmon	10.7	2
10	Salmon	11.1	2
10	Salmon	11.6	2
10	Salmon	9.2	2
10	Salmon	10.6	2
10	Brown trout	11.0	3
10	Brown trout	11.0	3
10	Brown trout	11.1	3
10	Brown trout	8.8	3
10	Brown trout	6.2	3
10	Brown trout	5.2	3
10	Salmon	10.3	3
10	Salmon	10.3	3
10	Salmon	10.4	3
10	Salmon	11.0	3
10	Salmon	10.8	3
10	Salmon	9.1	3
10	Salmon	5.5	4
10	Brown trout	10.3	4
10	Brown trout	6.3	4
10	Salmon	10.3	4