Survey of the Manulla River in Belcarra





A Report to Belcarra Tidy Towns

December 2021

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Contents

Introduction

This report gives the result of a baseline survey of the Manulla River undertaken for Belcarra Tidy Towns in September and December 2021. Biological surveys of the river's macroinvertebrates and aquatic plants at four sites along the Belcarra stretch of the Manulla River were undertaken. The hydromorphological status of the river stretch is also considered. Historical information on the water quality of the river is also provided and discussed – both biological and physico-chemical results were available.

Locations

Figure 1 shows the section of the Manulla River flowing through Belcarra. The Openstreetmap.org map shows the River Walk and the two footbridges over the river upstream and downstream of Belcarra.

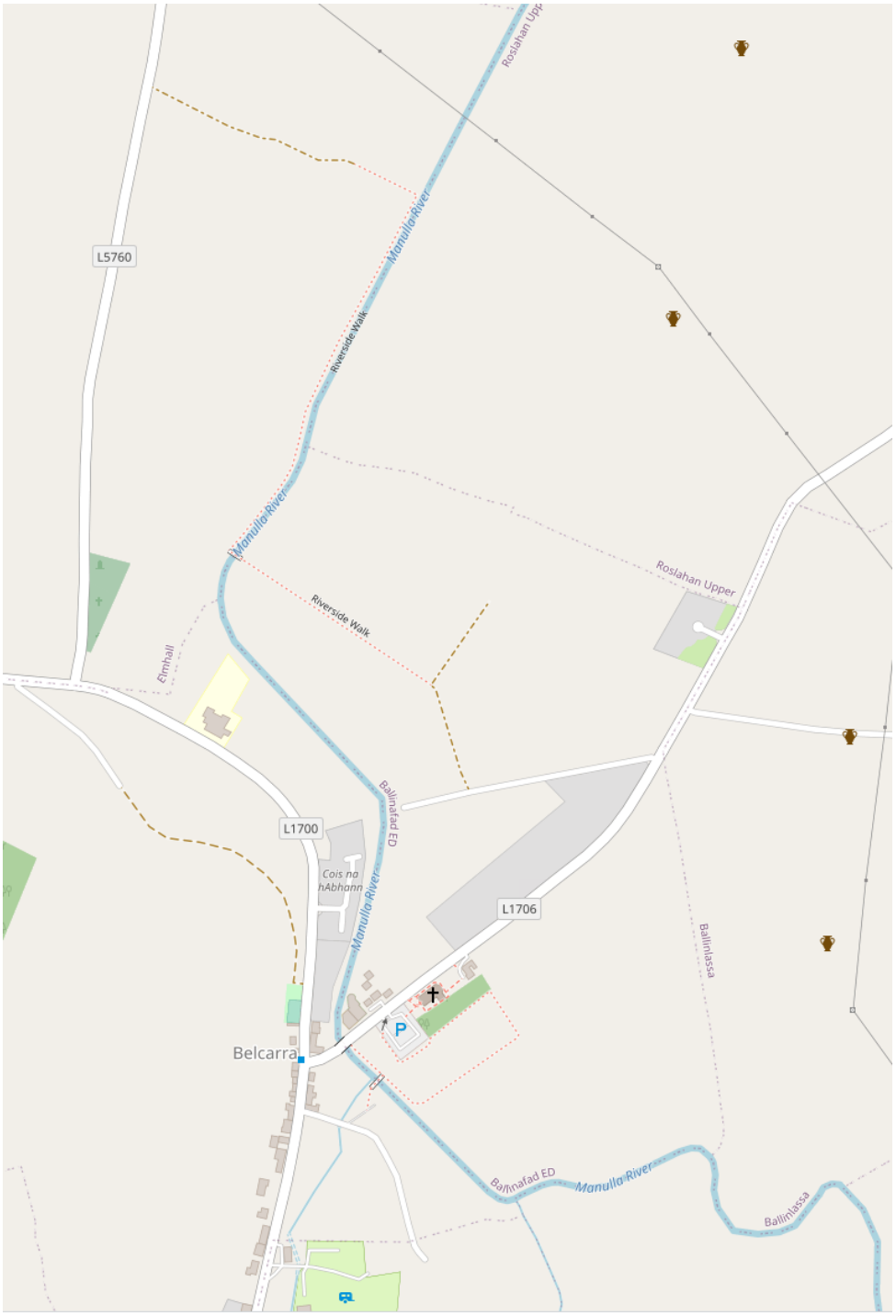

Figure 1. OpenStreetMap map of Manulla River flowing through Belcarra. © OpenStreetMap contributors.

Figure 2. Location of the Sites sampled on the Manulla River for this study. © OpenStreetMap contributors.

Sampling Sites

The river Manulla was sampled at four locations (Figure 2) for the purposes of this survey. Sites 1 and 2 were approximately 10 m upstream and 10 m downstream of the River Walk footbridge some 60 m upstream of the main Manulla Bridge in Belcarra. Site 1 was open to the light and Site 2 was in a shaded stretch. Site 3 was just downstream of the Belcarra Sports Centre, 70 m downstream of Belcarra Bridge, and Site 4 was at the lower footbridge on the River Walk 700 m downstream of the main Manulla Bridge in Belcarra and 400 m downstream of the waste water treatment plant (WWTP). Additional historical biological quality information is also available for the Manulla River in the vicinity of Belcarra from the EPA for the period 1980 to 2019 at Belcarra Bridge (EPA code RS34M010200) and downstream of the WWTP at Cuilmore (RS34M010225) (Table 5). Physico-chemical data are also available for the Manulla River for the period 2016-2020 (Table 7).

Site	Location	Latitude	Longitude
Site 1	Upstream of River Walk Footbridge (open)	53.8015391	-9.2169017
Site 2	Downstream of River Walk Footbridge (shaded)	53.8016661	-9.2156778
Site 3	Downstream of Sports Centre	53.8028476	-9.2164023
Site 4	At lower River Walk Footbridge	53.8075296	-9.2186503

Sampling Methods

Standard kick sampling using a pond net with a 1 mm mesh was used to collect the invertebrate samples. Typically, a 3-minute kick sample was taken. The sampling methodology is compliant with the EPA's standard operating procedures (SOP) used in the Water Framework Directive (WFD) monitoring programme. The samples were placed on a white tray, cleaned of leaves and debris and then the species were identified and recorded on the river bank. The relative abundance of each type found was recorded. The material was returned to the river alive.

The aquatic plants were recorded visually.

The hydromorphological assessment was done using the River Hydromorphological Assessment Technique (RHAT) and scored as per the EPA's SOP.

All sites were photographed with GPS coordinates recorded and a selection of these photographs are shown below.

Results

Macroinvertebrates

Table 1 lists the macroinvertebrate types recorded at the four sites in September and December 2021 with the relative abundance of each type or taxon found. A total of 25 different taxa were recorded with 19 at Site 1. Table 2 gives the taxonomic details for the 25 different types recorded plus common names. Some of the insect common names are angler's names for the adult flying insects as opposed to the nymphs or larvae.

Of note is the occurrence of white-clawed crayfish (*Austropotamobius pallipes*) at three of the sites. The occurrence of both dragonfly (Anisoptera) and damselfly (Zygoptera) nymphs at the upstream Site 1 is also of interest and these species certainly add a bit of colour and interest to the river when the damselflies emerge as delicate, colourful adults – shimmering with green, metallic blue or red colours depending on the species. The large powerful dragonfly adults hunt other insects – flying on a regular beat up and down the river in search of prey. The National Biodiversity Centre has a constant call out for citizen scientists / volunteer recorders to identify and record these species.

The European white-clawed crayfish is a protected species in Ireland because of its threatened status across Europe. Crayfish are typically found in hard water, mineral-rich rivers such as the Manulla River but they have disappeared from many Irish rivers in recent years due to the spread of crayfish plague. It is believed that this fungal disease (*Aphanomyces astaci*) has been introduced by North American crayfish species imported into Ireland. The American species are relatively immune, but it is highly lethal to the native European species *A. pallipes*.

In terms of water quality, the dominance of the flattened mayfly nymph, *Heptagenia,* indicates good water quality. The occurrence of the stonefly species *Brachyptera risi* is also a good sign. Both were found at all four sites sampled. This is particularly so as the river is quite slow-flowing and deep as it flows through Belcarra – flattened mayfly nymphs and stoneflies are normally more associated with fast, riffled stretches with a lot of cobble and stones on the river bed.

The shrimp *Gammarus* was found at all sites, and this is to be expected as it is perhaps the most common freshwater invertebrate to be found in Irish rivers and lakes. Its relative *Crangonyx* was also found in relatively high numbers. This invasive species was first recorded in Ireland in 1975 and is believed to have been introduced via tanks containing ornamental aquatic plants. It is now widespread across Ireland. It was first recorded by the EPA in the Manulla River in 2011 downstream of the Belcarra WWTP at Cuilmore.

Table 1. List of macroinvertebrates recorded in the Belcarra section of the River Manulla. The relative abundance of each type is Few, Common, Numerous, Dominant in order of increasing numbers.

	Site 1	Site 2	Site 3	Site 4		
Taxon	**29/09/2021**	**29/09/2021**	**29/09/2021**	**20/12/2021**		**Count**
Anisoptera	Few					1
Ancylus	Few		Few	Few		3
Asellus aquaticus	Common	Few	Few	Common		4
Austropotamobius pallipes	Few	Few	Few			3
Baetis rhodani			Dominant	Numerous		2
Brachyptera risi	Common	Few	Few	Few		4
Chironomidae	Common	Few	Few	Common		4
Cloeon dipterum	Few			Few		2
Crangonyx	Dominant	Common	Few	Common		4
Daphnia	Few					1
Dicranota				Few		1
Dytiscidae	Few					1
Elmis aenea	Few	Few	Few			3
Gammarus	Numerous	Numerous	Common	Numerous		4
Gerridae			Few			1
Heptagenia	Common	Dominant	Numerous	Dominant		4
Hydropsyche			Common			1
Lumbriculidae				Few		1
Notonecta glauca	Few					1
Polycentropus	Common	Common	Few	Few		4
Potamopyrgus antipodarum	Few	Few	Few	Common		4
Sialis	Few					1
Simuliidae	Few	Few	Few	Common		4
Tubificidae				Few		1
Zygoptera	Few					1
Number of Taxa	**19**	**11**	**15**	**14**		**25**

Table 2. Taxonomic listing for macroinvertebrates recorded in the Manulla River showing Order, Family and taxon name at the level of identification.

Order	Family	Common Name	Taxon
Coleoptera	Dytiscidae	Diving Beetle	Dytiscidae
Coleoptera	Elmidae	Leaf Beetle	*Elmis aenea*
Crustacea	Asellidae	Hog Louse or Water Louse	*Asellus*
Crustacea	Astacidae	*White clawed crayfish*	*Austropotamobius pallipes*
Crustacea	Crangonycitidae	*Shrimp*	*Crangonyx*
Crustacea	Daphniidae	*Water Flea*	*Daphnia*
Crustacea	Gammaridae	*Freshwater shrimp*	*Gammarus*
Diptera	Chironomidae	Non-biting midge	Chironomidae
Diptera	Pedicidae	Crane Fly	*Dicranota*
Diptera	Simuliidae	Blackfly	Simuliidae
Ephemeroptera	Baetidae	Large Dark Olive	*Baetis rhodani*
Ephemeroptera	Baetidae	Pond or Lake Olive	*Cloeon*
Ephemeroptera	Heptageniidae	Yellow Dun	*Heptagenia*
Gastropoda	Ancylidae	*Freshwater Limpet*	*Ancylus fluviatilis*
Gastropoda	Hydrobiidae	*New Zealand Mud Snail*	*Potamopyrgus antipodarum*
Hemiptera Heteroptera	Notonectidae	*Common Backswimmer*	*Notonecta*
Heteroptera	Gerridae	*Pond Skater*	*Gerris*
Megaloptera	Sialidae	*Alderfly*	*Sialis*
Odonata	n/a	Dragongfly	Anisoptera
Odonata	n/a	Damselfly	Zygoptera
Oligochaeta	Lumbriculidae	Freshwater Worm	Lumbriculidae
Oligochaeta	Tubificidae	Sludge Worm	Tubificidae
Plecoptera	Taeniopterygidae	Stonefly (February Red)	*Brachyptera risi*
Trichoptera	Hydropsychidae	Welshman's Button (Caddisfly)	*Hydropsyche*
Trichoptera	Polycentropidae	*Sedge (Caddisfly)*	*Polycentropus*

Table 3. Aquatic plants recorded in the Manulla River.

Common Name	**Taxon**	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Blanket Weed (green algae)	*Cladophora*		Too Shaded	**X**	
A "blue-green" alga (Cyanobacteria)	*Phormidium*			**X**	
Moss	*Fissidens*				**X**
Moss	*Fontinalis antipyretica*	X			**X**
Moss	*Platyhipnidium riparioides*	**X**		**X**	
Canary Reed Grass	*Phalaris arundinacea*	**X**			
Common Club Rush	*Schoenoplectus (Scirpus) lacustris*	**X**		**X**	
Branched Bur-Reed	*Sparganium erectum*	X		**X**	**X**
Water Plantain	*Alisma plantago-aquatica*			**X**	
Fool's Watercress	*Apium nodiflorum*	**X**		**X**	**x**
Lesser Water-Parsnip	*Berula erecta*	**X**			
Water-Starwort	*Callitriche sp.*			**X**	
Canadian Pondweed	*Elodea canadensis*	***X***			
Water Mint	*Mentha aquatica*			**X**	
Water Forget-Me-Not	*Myosotis sp.*			**X**	
Water Milfoil	*Myriophyllum alterniflorum*	X		**X**	
Water Cress	*Nasturtium officinale*			**X**	
Water Lily	*Nuphar lutea*	**X**			
Floating Pondweed	*Potamogeton natans*	**X**			
Arrow Head	*Saggitaria*			**X**	

Aquatic Plants

Table 3 lists the plants and algae recorded during the survey. These combined a mix of algae, mosses and higher plants, grasses and flowering plants. All species recorded are typical of hard water rivers such as the Manulla. The only concern is the occurrence of Blanket Weed, *Cladophora* and the blue-green mat forming algae, *Phormidium*, at Site 3. These species typically indicate nutrient enrichment. The fact that these algae were not recorded at the Site 4 downstream of the Belcarra Waste Water Treatment Plant discharge is, however, a good indication that the plant is operating efficiently.

Site 1

Site 1. Upstream of the River Walk footbridge

Site 1. Dragonfly nymph with the shrimp *Gammarus*

Site 1. Looking upstream from Site 1

Site 1. Small Crayfish and large Dragonfly nymph

Site 1. *Notonecta* – the backswimmer

Site 1. Substratum

Site 1 Macroinvertebrates

Site 1 had the most diverse range of macroinvertebrates with 19 different taxa recorded. There was a good number of crayfish, plus the presence of both dragonfly and damsel fly nymphs and a healthy number of the sensitive mayfly *Heptagenia* and one stonefly species, *Brachyptera risi,* all indicating good conditions here. The river is deep and slow flowing here with a mix of bare (albeit quite silty) substratum and aquatic plants along the margins, providing several habitat types leading to a high diversity of types. The crustaceans *Gammarus* and *Crangonyx* were the most common types followed by another crustacean*, Asellus aquaticus*, the stonefly, *Brachyptera risi*, a mayfly, *Heptagenia*, an uncased caddis, *Polycentropus*, chironomids (non biting midges) were all common. Smaller numbers of crayfish damselfly (Zygoptera) and dragonfly (Anisoptera) nymphs were recorded with low numbers also of the pond olive mayfly, *Cloeon dipterum*, the alderfly *Sialis,* blackfly larvae, Simuliidae, some beetles belonging to the families Dytiscidae and Elmidae were recorded and two snail species – the limpet-like *Ancylus* and the mud snail *Potamopyrgus* were present in small numbers too. The final type was the water flea *Daphnia* which strictly would not be counted as a macroinvertebrate due to its small size and planktonic nature – it would normally be associated with lakes but can be found in slow-flowing waters such as the Manulla.

Site 1 Aquatic Plants

Some 11 different plant species were recorded at site 1. Two moss species: *Fontinalis antipyretica, Platyhipnidium riparioides*, three "grass" species: *Phalaris arundinacea, Schoenoplectus (Scirpus) lacustris, Sparganium erectum*, and six species of flowering plant: *Apium nodiflorum, Berula erecta, Elodea canadensis, Myriophyllum alterniflorum, Nuphar lutea and Potamogeton natans*. This is quite a diverse mix, and all are fairly common aquatic plants. The Canadian pondweed, *Elodea canadensis,* is an invasive species but it has naturalised widely in Irish rivers and lakes and is not seen as a threat.

Site 2

	
Site 2. Viewed from the footbridge	A merging stream flowing down the right-hand bank at Site 2. The main channel river bed is lowered artificially.

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Site 2 is shaded by trees and the footbridge	Both banks are tree-lined with denser shade on the left side where sampled.

Site 2 Macroinvertebrates

Site 2 is a shaded site and has a lower diversity of macroinvertebrates with 11 types recorded – essentially a subset of those found at Site 1 including crayfish, the mayfly *Heptagenia* and the stonefly *Brachyptera* but lacking the damselflies and dragonflies. The difference is most likely due to the lack of vegetation and this location, due to the dense shade at the sample point.

Site 2 Aquatic Plants

No plants were recorded at this shaded site. The site is shaded by sycamore trees.

Site 3

	
Site 3. Looking upstream	Site 3. Looking downstream

	
Some of the aquatic plants at Site 3	The green alga known as blanket weed, *Cladophora,* was noted at Site 3, bubbling to the surface in this photo.

Site 3 Macroinvertebrates

Site 3 is a faster flowing site than the others. It lacks the damselfly and dragonfly nymphs which are more likely to occur in slower flowing waters. Crayfish were present and the flattened mayfly, *Heptagenia*, and the stonefly, *Brachyptera risi*, were also once again present (Table 2) indicating good conditions at this point. The presence of the pond skater, *Gerris*, here indicates that there were some slow-flowing sections sampled, perhaps behind the concrete steps leading into the river at this site. *Gerris* are surface dwellers, skating across the water using the surface tension to stay on top. They are predatory insects – feeding on, e.g., terrestrial insects that fall onto the water.

Site 3 Aquatic Plants

Site 3 had a very diverse range of plants with a total of 13 different types recorded. Obviously, a diverse range of different plants is an indication of a healthy ecosystem. The only negative aspect was the presence of two species of algae – *Cladophora,* the so-called blanket weed, was noted bubbling to the surface albeit not overly-abundant. *Cladophora* is generally seen as an indicator of enriched conditions, and it may be that there is a local sourced of nutrient input. The presence of the mat-forming blue-green algae *Phormidium* is also seen as a negative indication although again in small quantities. The general picture is positive regarding the plant community here.

Site 4

Site 4. Looking upstream

Site 4. Looking downstream

Site 4. Just upstream of the lower River Walk Bridge.

Site 4 has large stands of the Branched Bur-Reed, *Sparganium erectum*

Site 4 Macroinvertebrates

Site 4 had 14 different macroinvertebrate types – all being a subset of the species found at Site 1. This is quite a deep site and sampling was more difficult than at the upper sites – essentially the sample was taken from the bank rather than from in the river. This may have resulted in a less efficient sampling effort and, for example, the failure to record crayfish here – crayfish can avoid nets in slower flowing water. The dominant type was the flattened mayfly, *Heptagenia*, and the stonefly, *Brachyptera* was also present once again. The presence of these two is seen as an indication of good water quality here.

Site 4 Aquatic Plants

As noted above this is quite a deep-water site but it has a range of submerged, floating and emergent plants – nine different types were recorded. The floating pond weed, *Potamogeton natans*, which has oval floating leaves and is normally found in slow flowing waters was recorded here along with emergent Common Club Rush, Schoenoplectus (Scirpus) lacustris, and the Branched Bur-Reed, *Sparganium erectum* with lesser amounts of the Water Plantain, *Alisma plantago-aquatica* which still had flowering/seed heads emerging above the water in late September. At the margins, Canary Reed Grass, *Phalaris arundinacea* was noted and Fool's Watercress, *Apium nodiflorum*, another emergent type was present. The Mare's Tail, *Hippuris vulgaris*, was noted as a submerged species.

The floating pond weed *Potamogeton natans*

Hydromorphology

Table 4. RHAT River Hydromorphology Assessment Technique Field Sheet.

River Name: **Manulla** GPS Coordinates: 53.8015421,-9.2168407 (Start Point)

Site Code: **From Upper River Walk Footbridge in Belcarra to Lower Footbridge 700 m d/s Belcarra Bridge**

Survey Distance U/S (m): 100 m

Survey Distance D/S (m): 800 m

Date: **29 September 2021**

Type		Comments
1.Channel form and flow types	1 / 4	The Manulla River has been subjected to arterial drainage as part of the Moy drainage programme 1960-1971. The riverbed has been lowered significantly and the channel has been straightened.
2. Channel vegetation	3 / 4	The vegetation is generally typical of limestone rivers such as the Manulla. Some stretches, however, are quite shaded due to overhanging trees and devoid of plants – such as Site 2.
3. Substrate condition	2 / 4	The substratum is quite silty with more fine sediment that expected for the river type
4. Barriers to continuity	3 / 4	The channel has been drained to allow for quick runoff of water. There are some minor weirs, but they should not pose a blockage to fish passage.
5. Bank structure & stability L+R	1.5 / 1.5 4	The banks are stable but are not natural due to the extensive deepening and blasting of the channel during the drainage programme.
6. Bank vegetation L+R	1 / 1 4	The Bank vegetation is largely comprised of grasses, brambles, Canary Reed Grass, and a selection of trees including alder, ash and sycamore. With Ash Dieback disease many of the bankside trees will die off in coming years. The town centre section has quite dense sycamore cover causing excessive shading.
7. Riparian land cover L+R	0.5 / 0.5 4	The stretch running through Belcarra is predominantly flanked by urban landcover. There are some improved grasslands adjoining the river downstream of the town but there are also industrial units and a school in the immediate riparian zone. The residual spoil heaps from the drainage programme are also very evident albeit mostly vegetated.
8. Floodplain connectivity L+R	0 / 0 4	The drainage programme has completely disconnected the river from its floodplain. The floodplain and original channel can be seen on the historic OSI maps. Inflowing tributaries are also disconnected generally joining the main channel as a small waterfall that is unlikely to allow fish passage into the tributaries.
Total	15/32	
Hydromorph Score*	0.46875	
WFD class **	Moderate	

* Hydromorph score = $\frac{\Sigma \text{ Assessment score}}{\text{Maximum score}}$

**WFD Class – > 0.8 = high – >0.6 – 0.8 = good >0.4 – 0.6 = moderate – >0.2 - 0.4 = poor – < 0.2 = bad.

Table 4 is a completed field sheet for the River Hydromorphology Assessment Technique (RHAT) as used by the EPA and Northern Ireland Environment Agency. The river was drained as part of the Moy drainage scheme in the 1960s and presumably is subject to regular 'maintenance' dredging as per the 1945 Drainage Act. Steep canyon-like sides are evident over much of the reach. Tributary streams are perched well above the water level of the main channel and where they are flowing, they can be seen streaming down the limestone banks. The small stream entering the Manulla at the River Walk footbridge just upstream of the main road bridge in Belcarra is interesting in that it is dry for most of the year. It is likely that this is due to the lowering of the water table due to the drainage programme. The area is a karst limestone region as evidenced by two swallow-holes are mapped on the Geological Survey of Ireland website (GSI.IE) in the townland of Knockbaun just to the west of Belcarra. The significant lowering of the river bed is likely to have lowered the catchment's water table. The inflowing streams appear to be disconnected in the sense of allowing fish passage from the main channel into the side streams.

The main hydromorphological threat at this stage is the repeat 'maintenance' drainage that may be undertaken by the Office of Public Works (OPW). When such maintenance occurs the flora and fauna of the river are dumped onto the river bank with the sediment being removed. Schemes to reduce the amount of silt getting into rivers can reduce the need for this type of 'maintenance'. As noted above the river bed is quite silted, indicating that upstream agricultural practices (most likely) are generating significant silt loads.

Inland Fisheries Ireland have undertaken some schemes to re-establish the original riffle/glide/pool sequence typically found in undisturbed 'natural' rivers. These schemes have been very successful in improving fish habitat and improving fish populations, particularly in the Moy and Corrib catchments. They have been carried out in conjunction with the engineering staff of OPW and typically involve taking the spoil heaps from the original drainage and placing this material judiciously back into the channel. These schemes have recreated a more natural channel by, for example, creating sinuous thalwegs – a deeper central channel that retains a depth of water and faster flow velocity even in very low flows that allows fish to avoid high temperatures in summer. Similarly, the reintroduction of pools into drained rivers can increase the capacity of a river to hold larger more mature fish. Inland Fisheries Ireland have published a training manual aimed specifically at the enhancement of previously drained rivers (O'Grady, 2006).

Water Quality

Historical Biological Quality

Table 5 shows historical water quality assessments of the Manulla beginning in 1980 based on the EPA's Quality Rating (or Q-Value) methodology. Appendix 1 provides an interpretative guide to the Q-Values shown in the table. In recent years a major decline in water quality was noted at the first station on the Manulla at Ballinafad Bridge from Good status in 2013 to Poor status in 2016. The stretch from Belcarra Bridge to Manulla Bridge was rated as Moderate status in 2019 (Q3-4). The present survey, however, suggests that water quality has improved since 2019 to Good status, particularly as evidence by the macroinvertebrate communities described above. The EPA will re-survey the Manulla in 2022 under the Water Framework Directive ecological monitoring programme.

Table 5. Historical water quality information for the Manulla River 1980 to 2019 – based on the EPA's macroinvertebrate surveys.

MANULLA **34M01**

Date Surveyed (last survey year only): 09/07/19, 15/07/19

Biological Quality Rating (Q Values)

Station Code	1980	1984	1989	1993	1995	1998	2001	2005	2007	2011	2013	2015	2016	2019
RS34M010100	5	4-5	4-5	4	4	4-5	4-5	4	4	4	4		3	3
RS34M010150	5	4-5	4	4										
RS34M010200		4	5	4-5	4	4-5	4-5	4-5						3-4
RS34M010225								4	4	4		4	4	
RS34M010300	5	3-4	4-5	3-4	4	4	4	4	3-4	3-4		3-4	3	3-4
RS34M010400	5	3-4	3-4	4										
RS34M010500	5	3-4	4	3-4	3	4	4	3-4	3-4	3-4		4	3-4	4

Most Recent Assessment:

The serious decline in the quality in the upper Manulla at Ballinafad Bridge (0100) has not improved on the situation in 2016 and the reach continues to be poor in quality. The lowland reach at the bridge at Ballycarra was reassessed and was also unsatisfactory with a drop in quality since the last survey at this station in 2005. Condition of the slow flowing 'potamon' reaches at Manulla Bridge has improved but remains unsatisfactory. Quality in the clacifying reach at the lowermost station just upstream of the Castlebar River (0500) has also improved to satisfactory, although there was also clear indications of nutrient enrichment there.

Station Details

Station Code	Station Location	WFD Waterbody Code	Easting	Northing	Local Authority
RS34M010100	Ballinafad Bridge	IE_WE_34M010100	123075	281168	Mayo County Council
RS34M010150	Bridge near Bridgemount	IE_WE_34M010225	121309	282306	Mayo County Council
RS34M010200	Bridge at Ballycarra	IE_WE_34M010225	119965	284278	Mayo County Council
RS34M010225	At Cuillare d/s Belcarra WWTP	IE_WE_34M010225	120025	284573	Mayo County Council
RS34M010300	Manulla Bridge	IE_WE_34M010300	121300	288600	Mayo County Council
RS34M010400	Br NE Gneeve	IE_WE_34M010500	122315	291142	Mayo County Council
RS34M010500	Bridge u/s Castlebar River	IE_WE_34M010500	121937	293360	Mayo County Council

Physico-Chemical Results

Field measurements of dissolved oxygen, temperature, conductivity and pH were made during the 2021 survey. In September the slightly elevated dissolved oxygen noted at Site 1 at the end of September indicated that the aquatic plants were still actively photosynthesising at that time. Cold water can hold more dissolved oxygen than warm water – for a given temperature the ideal natural level where there is good interchange between the atmosphere and water is 100% saturation. The dissolved oxygen environmental quality standards in Irish law require dissolved oxygen values to be maintained between 80% and 120% saturation. Above or below these thresholds indicates problems due to eutrophication (if > 120% saturation) or organic pollution (if < 80% saturation).

Table 6. Some field physico-chemical measurements made during the surveys.

	Dissolved Oxygen % Saturation	Dissolved Oxygen mg/l	Temperature °C	Conductivity µS/cm	pH
Site 1: 29 Sep 2021	103.7	10.67	13.9	595	7.94
Site 4: 20 Dec 2019	91.9	10.97	7.6	649	7.43

The conductivities of 595 and 649 µS/cm are to be expected for a river with hard mineral water. The pH measurements also fall within the typical ranges for the river as evidenced by Table 7 which gives the minimum, mean and maximum concentrations or measurements for a range of physico-chemical parameters measured as part of the WFD National River Monitoring Programme over the period 2016 to 2020. The Station codes used in this table are the same as those in Table 5. Key parameters such as *ortho*-Phosphate indicate good conditions lying well within the WFD environmental quality standards as set out in, e.g., Statutory Instrument S.I. 272 of, 2009. The main item of concern is the occasional high Biochemical Oxygen Demand (BOD) with values of 3.7, 3.8 and 7.3 all occurring on two dates in 2016. These may possibly be related to the decline in ecological condition noted in 2016 (Table 5).

Table 7. Water chemistry results for Manulla River 2016-2020 (Source EPA).

	ortho-Phosphate (as P) mg/l				Temperature °C			
	n=	Min	Mean	Max	n=	Min	Mean	Max
RS34M010100	24	0.005	0.012	0.025	24	5.3	11.6	20.6
RS34M010200	24	0.005	0.012	0.025	24	6.3	11.3	17.9
RS34M010225	15	0.005	0.015	0.026	15	6.2	11.1	18.2
RS34M010300	24	0.005	0.012	0.022	24	5.8	11.5	21.3
RS34M010400	15	0.005	0.011	0.022	15	5.9	11.4	20.2
RS34M010500	45	0.005	0.012	0.033	45	5.6	11.3	19.4
	Nitrate (as N) mg/l				Total Oxidised Nitrogen (as N) mg/l			
	n=	Min	Mean	Max	n=	Min	Mean	Max
RS34M010100	24	0.100	0.447	1.200	24	0.100	0.449	1.200
RS34M010200	24	0.100	0.640	1.500	24	0.100	0.641	1.500
RS34M010225	15	0.100	0.540	1.200	15	0.100	0.541	1.200
RS34M010300	24	0.100	0.587	1.500	24	0.100	0.587	1.500
RS34M010400	15	0.100	0.511	1.100	15	0.100	0.511	1.100
RS34M010500	45	0.100	0.699	4.200	45	0.100	0.702	4.200
	pH				Total Hardness (as CaCO3) mg/l			
	n=	Min	Mean	Max	n=	Min	Mean	Max
RS34M010100	24	7.40	7.69	8.10	24	173.0	256.1	317.0
RS34M010200	24	7.40	7.69	8.00	24	218.0	292.0	354.0
RS34M010225	15	7.50	7.73	8.10	15	228.0	304.6	348.0
RS34M010300	24	7.60	7.81	8.10	24	222.0	301.7	384.0
RS34M010400	15	7.60	7.87	8.10	15	232.0	300.6	342.0
RS34M010500	45	7.70	7.97	8.40	45	220.0	294.0	345.0
	Ammonia-Total (as N) mg/l				BOD - 5 days (Total) mg/l			
	n=	Min	Mean	Max	n=	Min	Mean	Max
RS34M010100	24	0.010	0.022	0.055	23	0.50	1.37	3.80
RS34M010200	24	0.010	0.013	0.027	23	0.50	0.69	1.70
RS34M010225	15	0.010	0.032	0.079	14	0.50	1.10	7.30
RS34M010300	24	0.010	0.020	0.068	23	0.50	0.97	3.70
RS34M010400	15	0.010	0.015	0.031	14	0.50	0.82	2.00
RS34M010500	45	0.010	0.013	0.028	44	0.50	0.65	2.10
	Nitrite (as N) µg/l				Nitrite (as N) mg/l			
	n=	Min	Mean	Max	n=	Min	Mean	Max
RS34M010100	19	2.00	2.64	9.72	5	0.002	0.002	0.004
RS34M010200	19	2.00	2.16	5.04	5	0.002	0.002	0.002
RS34M010225	10	2.00	3.21	11.40	5	0.002	0.004	0.014
RS34M010300	19	2.00	2.87	9.26	5	0.002	0.002	0.002
RS34M010400	10	2.00	2.21	4.05	5	0.002	0.002	0.002
RS34M010500	33	2.00	2.13	4.19	12	0.002	0.002	0.005

Other Observations

When sampling at Site 4 a brook lamprey, *Lampetra planeri,* was caught in the pond net used for the macroinvertebrates. This is a protected species under European and Irish law. This means that the Manulla has four protected species – the white-clawed crayfish, *Austropotamobius pallipes*, the brook lamprey, *Lampetra planeri*, and in addition the Manulla River is designated as a salmonid river for Atlantic salmon, *Salmo salar*, as part of the larger Moy catchment. Finally, while sampling Site 4, and otter, *Lutra lutra*, was observed in the river – also a protected species.

A grey wagtail, *Motacilla cinerea,* a river specialist, was also recorded at the waste water treatment plant and appeared to be feeding from the oxidation tank.

The Belcarra waste water treatment plant appears to be functioning well – it is a secondary treatment plant and it was built in 2001. It does not have phosphorus removal. The most recent Annual Environmental Report (AER) published on the EPA website for the calendar year of 2019 shows it to be compliant with its licence conditions as set by the EPA. It is located on the right bank of the river some 300 m downstream of Belcarra Bridge and 400 m upstream of Site 4.

Figure 3. Belcarra waste water treatment plant is between Site 3 and Site 4.

Conclusions and Discussion

The survey has provided a baseline set of observations covering the macroinvertebrates, aquatic plants and hydromorphological condition of the Manulla River as it flows through Belcarra. The river appears to be in good ecological condition with a diverse flora and fauna including the protected, white-clawed crayfish in good numbers and some pollution-sensitive mayfly and stonefly nymphs.

There are issues with excessive shading in the immediate Belcarra vicinity. Removal of some of the trees there should improve the river's condition with the return of some aquatic vegetation.

The fact that the river was subjected to arterial drainage has undoubtedly reduced its capacity to hold good salmonid populations. The type of river enhancement programmes undertaken by Inland Fisheries Ireland and referenced in the text above may worth considering – but such programmes do require significant expertise.

Ash dieback is a highly destructive disease of ash trees, and it has progressed rapidly across Ireland in recent years, particularly in limestone regions where ash trees are more common. There are a significant number of ash trees along the banks of the Manulla River in the Belcarra region. It is to be expected that these will all die over the next number of years. Consideration should be given to planting replacement trees to maintain a suitable degree of shade for the river.

References

O'Grady, M. F. (2006) 'Channels and Challenges. Enhancing Salmonid Rivers.', *Irish Freshwater Fisheries Ecology & Management Series: Number 4*, 4, p. 148. Available at: https://www.fisheriesireland.ie/sites/default/files/migrated/docman/Channels %26 challenges-enhancing salmonid rivers 72secure.pdf.

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Appendix 1.

Table 8. Guide to the interpretation of Q-Values used in the EPA Biological Survey of Rivers.

Environmental Protection Agency

EPA RIVER QUALITY SURVEYS: BIOLOGICAL

Biotic indices ("Q Values") reflect average water quality at any location as follows:

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

* 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. The intermediate values (Q1-2, 2-3, 3-4 etc.) denote transitional conditions. The scheme mainly reflects the effects of organic pollution (i.e. de-oxygenation and eutrophication) but where a toxic effect is apparent or suspected the suffix '0' is added to the biotic index (e.g. Q1/0, 2/0 or 3/0). An asterisk after the Q value (e.g. Q3*) indicates something worthy of special attention, typically heavy siltation of the substratum.

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

Also presented is a description of the exact location surveyed with relevant OS Grid Reference, WFD river water body code and relevant Local Authority.