Sanitary Survey Report and Sampling Plan for Inver Bay, Co. Donegal

Produced by

AQUAFACT - APEM Group

In conjunction with

The Sea Fisheries Protection Authority (SFPA)

October 2023

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Statement of use:

Under EU Regulation 2019/627 which lays down uniform practical arrangements for the performance of official controls on products of animal origin intended for human consumption, a sanitary survey relevant to bivalve mollusc production in Inver Bay was undertaken in 2023. This report provides an appropriate hygiene classification zoning and monitoring plan based on the best available information
with detailed supporting evidence. AQUAFACT undertook the desktop component of the work on behalf of the SFPA.

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Revisions

Revision No.	Date	Comment
1	05/07/23	Interim report for SFPA review
2	30/08/23	Draft final report for SFPA review
3	27/10/23	Final report

Document and QA Approval - Aquafact

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Consultation - SFPA

Consultee	Date of Consultation	Date of Response
Peter McGroary (Interim)	05/07/23	17/07/23
SFPA (Final draft)	30/08/23	21/09/2023
Approved (Final)	24/11/2023	27/11/2023

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Glossary, Acronyms, and Abbreviations

ADCP	Acoustic doppler current profiler
BMPA	Bivalve Mollusc Production Area
Cefas	Centre for Environment, Fisheries and Aquaculture Science
cfu	Colony forming unit (scientific estimate of microbial cells)
CRS	Coordinated reference system
CSO	Central Statistics Office
CSO	Combined Sewer Overflow
DAFM	Department of Agriculture, Food and the Marine
Depuration	The process of purification or removal of impurities
DSW	Designated Shellfish Waters
DWF	Dry weather flow
E. coli	*Escherichia coli*
ED	Electoral Division
EPA	Environmental Protection Agency
EU	European Union
GIS	Geographical Information Systems
GPS	Global Positioning System
Industry	Relates to shellfish producers, BIM and any relevant shellfish production stakeholders
ING	Irish National Grid
kn	Knots (kilometres per hour [km/h] is equal to 0.54 knots
MPN	Most Probable Number (technique used for estimating bacterial populations)
NBDC	National Biodiversity Data Centre
PE	Population Equivalent
Pollution	Encompasses *E. coli* contamination only for the purposes of this sanitary survey report.
PSU	Practical Salinity Units
RMP	Representative Monitoring Point
SAC	Special Area of Conservation
SFPA	Sea Fisheries Protection Authority
SI	Statutory Instrument
SPA	Special Protection Area
WGS84	World Geodetic System 1984 – datum featuring coordinates that change with time
WWTP	Wastewater Treatment Plant

1. Executive Summary

Under Regulation (EU) 2017/625 and its subsequent Implementing Regulation (EU) 2019/627, there is a requirement for competent authorities intending to classify bivalve production and relaying areas to undertake a sanitary survey. The purpose of a sanitary survey is to determine the extent to which potential sources of pollution may impact a production area and ultimately inform the sampling plan for the National Microbiological Sampling Programme, as operated by the Sea Fisheries Protection Authority (SFPA); the results of which determine the annual classification for Bivalve Mollusc Production Areas (BMPAs). In the context of this sanitary survey report, pollution encompasses *E. coli* contamination only. In accordance with the European Union Reference Laboratory (EURL) Guide to Good Practice on the microbiological monitoring of bivalve mollusc harvesting areas, a re-evaluation of pollution sources and the sampling plan (primary sanitary survey) should be undertaken if a time trigger (six years or more since the last survey) or a change in the environment has occurred. In 2015, the shellfish production area in Inver Bay entered a period of dormancy, leading to its declassification in 2017. The shellfish industry in Inver Bay submitted a request to reopen the production area to harvest mussels. Consequently, a sanitary survey must be undertaken. This report identifies the sources and types of faecal, *i.e.*, *E. coli*, contamination discharging into Inver Bay and assesses whether or not these sources are likely to affect the microbiological concentration in the production area.

Inver Bay is approximately 19 km^2 in area, U-shaped, south-westerly facing, and located in the outer northern part of Donegal Bay, Co. Donegal. The seabed of Inver Bay is mainly flat, with a depositional area composed predominantly of muddy, fine sand throughout the bay which is typical of relatively low current regimes (AQUAFACT, 2023a). Areas of coarser sediment, including medium and coarse sand, are located on the northern and southern shores. Additionally, there are patches of live maërl beds and exposed bedrock (AQUAFACT, 2021). The blue mussel (*Mytilus edulis*) is the primary shellfish species currently licensed for production in Inver Bay.

Once the production area has been classified, the sampling plan recommends a minimum of 15 individual mussels of market size (minimum length of 4 cm) be collected (Cefas[1]; European Commission[2]). Sampling will need to be monthly and year-round as harvesting can take place throughout the year. However, the sampling frequency will also be influenced by seasonal and other variability in microbiological levels in the production area.

The boundary of the BMPA has undergone revisions since its establishment in 2012. While the amended boundary maintains the outlines as defined by the Designated Shellfish Waters (DSW), it also incorporates the licensed shellfish site T12/428A situated at Doorin Point. Moreover, it excludes areas vulnerable to *E. coli*

contamination, such as the emergency overflow area associated with the Dunkineely Wastewater Treatment Plant (WWTP), which is expected to have a high bacteriological load when in operation. The amended BMPA also excludes the upper estuarine section of the Eany River, where no licensed shellfish production sites are currently established.

This report endeavours to document and quantify all known sources of pollution entering Inver Bay. The investigation concluded that the primary sources of pollution in Inver Bay are the Eany River waterbody and the emergency overflow associated with Dunkineely WWTP, when in operation. While the river waterbodies within Inver Bay's contributing catchment generally maintain a Good to High Water Framework Directive (WFD) status, and the coastal waterbody of Inver Bay is classified as having High status (EPA Catchments, 2016), there are concerns regarding potential pollution. The Eany River waterbody is expected to channel diffuse agricultural pollutants, along with domestic and urban wastewater contamination, into the production area, thus potentially becoming the main driver for contamination levels in the production area, particularly during periods of high rainfall (EPA Catchments, 2019). However, it should be noted that the bacteriological sampling undertaken as part of this study did not corroborate this assumption (**section 9.2.2**). Furthermore, there may be seasonal differences in contamination levels. For example, increased numbers of lambs within the contributing catchment are expected during the spring/summer seasons. Additionally, Met Éireann rainfall data show higher volumes of rainfall from October to February; both of the aforementioned may result lead to increased *E. coli* levels.

In this report, one Representative Monitoring Point (RMP) has been designated for Inver Bay, and it is located at the licensed site T12/538A (**Figure 6-1**). Inner Inver Bay is thought to be more susceptible to elevated levels of *E. coli* pollution, given the greater number of potential sources and pathways of contamination compared to the outer bay area. This RMP location for monitoring *E.* coli levels in blue mussel was strategically chosen based on a range of hydrodynamic and spatial features that include areas of similar depth, tidal currents, suspended sediment levels, and freshwater influence. Currently, this is the only RMP in the bay, and it is to be sampled fortnightly until the bay receives a classification.

2. Introduction

Consumption of raw or lightly cooked bivalve molluscs can result in illness due to the presence of micro-organisms, many of which are derived from faecal contamination of the marine environment. Shellfish contaminated with pathogenic micro-organisms may cause infectious diseases in humans, and such outbreaks are more likely to occur close to our coasts where production areas are impacted by sources of human and animal faecal contamination; referred to as pollution for the purposes of this report. The risk of contamination of bivalve molluscs with pathogenic microorganisms is assessed through a microbiological monitoring programme. This assessment results in the classification of bivalve mollusc production areas, which in turn governs the statutory level of treatment required for the shellfish before human consumption.

Under European Union (EU) regulations, sanitary surveys of bivalve mollusc production areas and their associated hydrological catchments and coastal waters are required to establish the appropriate representative monitoring points (RMPs) for these monitoring programmes. Specifically, under regulation (EU) 2017/625 and its subsequent implementing regulation (EU) 2019/627, there is a requirement to carry out a sanitary survey before classifying any shellfish production or relaying area. Article 56 of Implementing Regulation 627 of 2019 states:

1. before classifying a production or relaying area, the competent authorities shall carry out a sanitary survey that includes:
    a. an inventory of the sources of pollution of human or animal origin likely to be a source of contamination for the production area.
    b. an examination of the quantities of organic pollutants released during the different periods of the year, according to the seasonal variations of human and animal populations in the catchment area, rainfall readings, wastewater treatment, *etc*.
    c. determination of the characteristics of the circulation of pollutants by virtue of current patterns, bathymetry and the tidal cycle in the production area.
2. the competent authorities shall carry out a sanitary survey fulfilling the requirements set out in paragraph one in all classified production and relaying areas, unless carried out previously.
3. the competent authorities may be assisted by other official bodies or food business operators under conditions established by the competent authorities in relation to the performance of this survey.

In addition, Article 57 of the same regulation requires competent authorities to establish a monitoring programme for live bivalve mollusc production areas that is based on an examination of the sanitary survey described above. Currently, the Sea Fisheries Protection Authority (SFPA), in conjunction with AQUAFACT - APEM Group (AQUAFACT) are conducting sanitary surveys for new bivalve mollusc production areas and for

those existing classified production areas which were previously not surveyed. This report contains the documents relevant to the sanitary survey of the bivalve mollusc production area at Inver Bay, County Donegal. It identifies the representative monitoring point and supporting sampling plan for mussels in Inver Bay. It also sets out the production area boundaries in the bay.

3. Overview of the Fishery/Production Area

3.1. Description of the Area

Inver Bay is located along the north-western coast of Ireland (**Figure 3-1**). It is a U-shaped, south-westerly facing bay located approximately 6.5 km east of Killybegs in the outer, northern part of Donegal Bay, Co. Donegal. The bay is approximately 7 km in length and a 3.5 km in width, giving an overall area of *c.* 19 km^2. Inver Bay is exposed with relatively low current speeds (0.06-0.22 ms^{-1}). The seabed of Inver Bay is mainly flat with a depositional area composed predominantly of muddy, fine sand throughout the bay which is typical of relatively low current regimes (AQUAFACT, 2023a). Areas of coarser sediment, including medium and coarse sand, are located on the northern and southern shores. Additionally, there are patches of live maërl beds and exposed bedrock (NPWS, 2015).

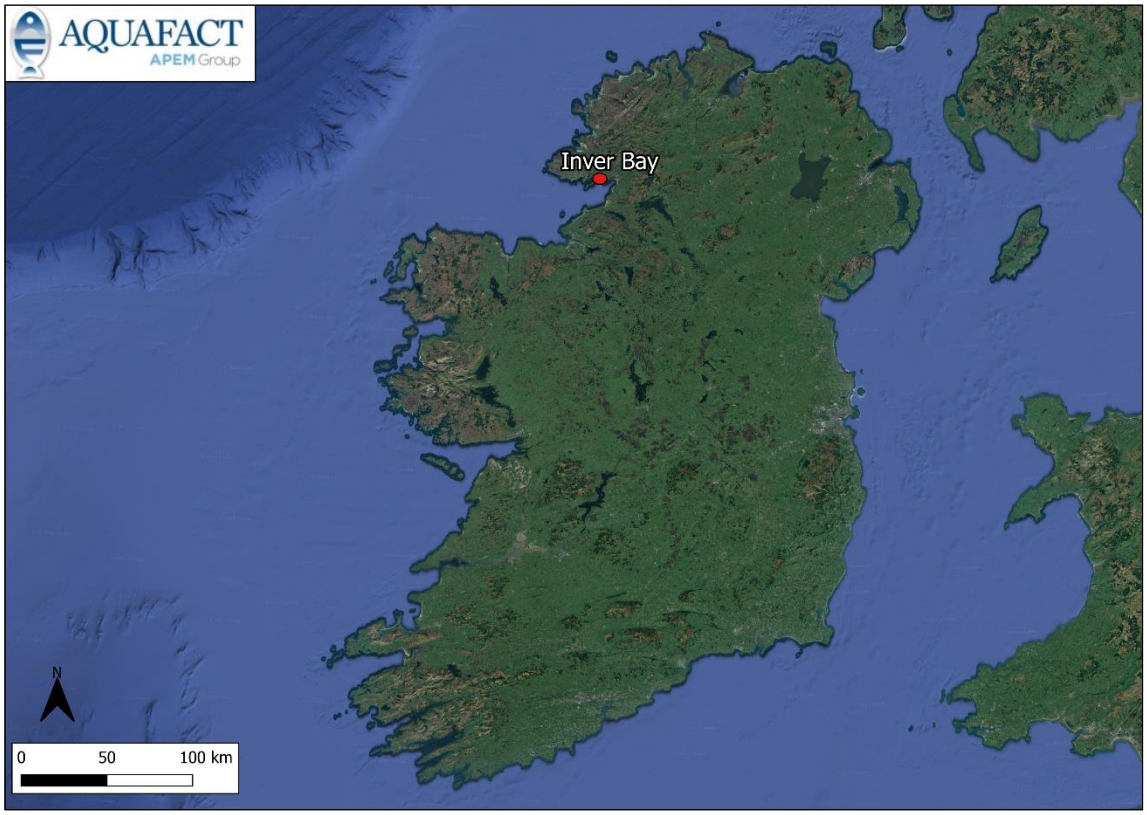


Figure 3-1: Location of Inver Bay, Co. Donegal.

Two sub-catchments within the Donegal Bay North Water Framework Directive (WFD) catchment contribute to Inver Bay, mainly the Eany [water] sub-catchment and to a lesser extent the Stragar sub-catchment. It is necessary to note that the WFD catchments and sub-catchments were established for hydrological purposes and not bacteriological, which is what is required for this sanitary survey. The Inver Bay contributing catchment has been determined accordingly by amending the boundaries of the WFD sub-catchments for the purposes of this sanitary survey report only. AQUAFACT has determined a boundary line based on the

river waterbodies within these sub-catchments that flow into Inver Bay and simultaneously the Designated Shellfish Waters within this bay (see **Figure 3-2** for sub-catchments and boundary line). According to Article 2(10) of Directive 2000/60/EC a "body of surface water means a discrete and significant element of surface water such as a lake, a reservoir, a stream, river or canal, part of a stream, river or canal, a transitional water or a stretch of coastal water." As rivers are defined under the same directive as mainly being on the surface, a river waterbody can therefore be described based on the definition of a "body of surface water". The area within this boundary line will be hereafter referred to as Inver Bay contributing catchment/the contributing catchment. Inver Bay contributing catchment covers an area of *c.* 170 km^2. The catchment is dominated by the River Eany and associated river waterbodies and sub-basins, which together drain over half of the contributing catchment.

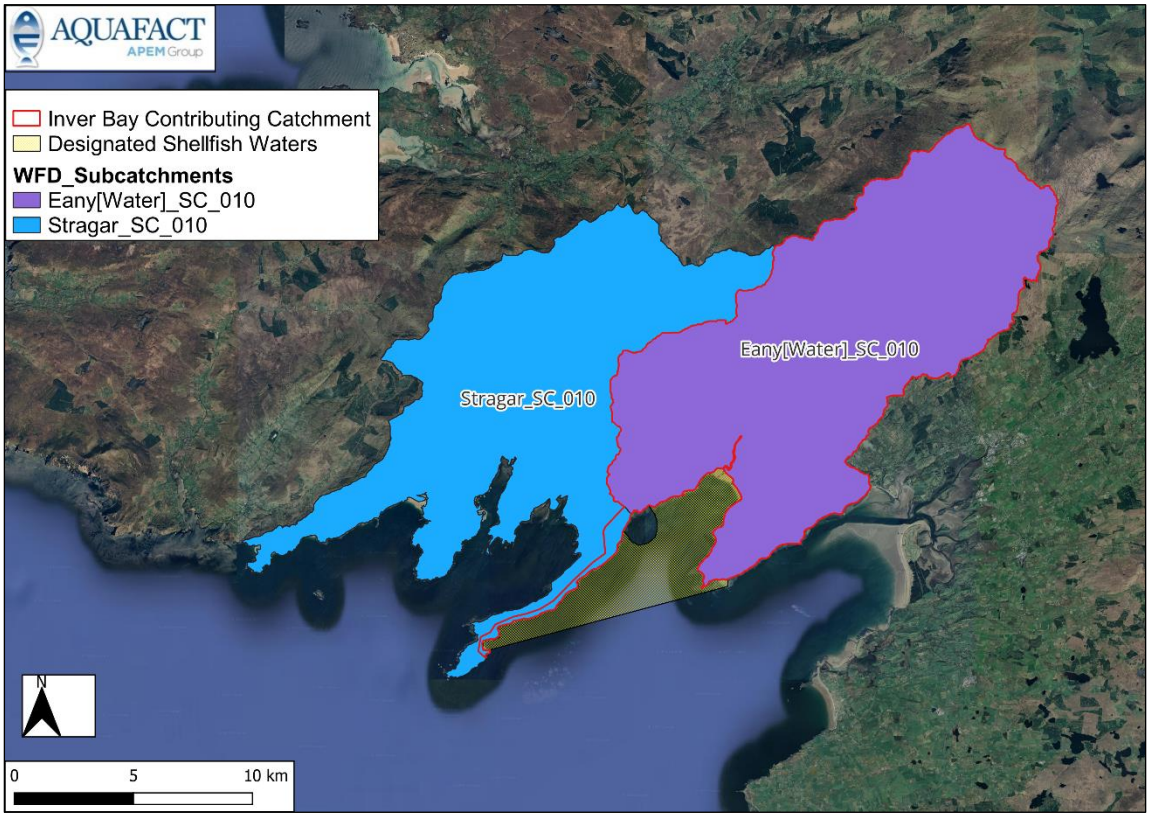


Figure 3-2: Water Framework Directive (WFD) sub-catchments that contribute to Inver Bay designated shellfish waters with specific areas of the sub-catchments that contribute to Inver Bay outlined in red.

The land surrounding Inver Bay features many drumlins and ribbed moraines. The moraines are primarily composed of limestone bedrock from the Lower Carboniferous era (McClure *et al.*, 2019). As limestone is highly permeable, it is expected to enable surface and groundwater runoff to drain into the bay. Spits and shingle barriers link the drumlins in Donegal Bay, providing shelter from the open sea to salt marshes. Grassy dunes precede these spits and sandy beaches. Low tide exposes sandy and muddy flats in inner Inver Bay

(McClure *et al.*, 2019). The area encompassed by Donegal and Inver Bays is also known as the north-western part of the 'Drumlin Belt'.

Inver Bay overlaps with Donegal Bay (Murvagh) Special Area of Conservation (SAC) and St. John's Point SAC and is close to Durnesh Lough SAC. These sites are designated for the presence of some important Annex I/II habitats and species[3]. Donegal Bay Special Protection Area (SPA) is the only SPA located in the immediate vicinity of Inver Bay.

The Corine land cover within the Inver Bay contributing catchment is largely made up of peat bogs (40%) with a mixture of pastures, land principally occupied by agriculture and significant areas of natural vegetation, coniferous forests, transitional woodland/shrub, moors and heathland, and natural grasslands. A small percentage of land cover in Inver Bay consists of sparsely vegetated areas, discontinuous urban fabric, broad-leaved forest, mixed forest, beaches, dunes, sands, intertidal flats, water bodies and, sea and ocean (**Figure 7-8**).

3.2. Inver Shellfish Fisheries

3.2.1. Location/Extent of Growing/Harvesting Area

Inver Bay covers an area of approximately 19 km^2 and is currently a WFD designated shellfish water (DSW) but not a classified Bivalve Mollusc Production Area (BMPA). **Figure 3-3** shows the current locations of licensed aquaculture sites within Inver Bay. Site T12/538A (shown in orange) is licensed for blue mussel (*Mytilus edulis*), Pacific oyster (*Crassostrea gigas*), stony sea urchin (*Paracentrotus lividus*), Manila clam (*Ruditapes philippinarum*) and brown seaweeds with a total area of *c*. 0.1455 km^2. Site T12/535A (shown in aqua blue) is licensed for brown seaweeds, Pacific oyster, Manila clam and stony sea urchin with a total area of *c.* 0.1331 km^2. Sites T12/381A-D (shown in green) are four sites licensed for blue mussel with a total area of *c.* 0.068 km^2, 0.0715 km^2, 0.1117 km^2 and 0.1177 km^2, respectively. Site T12/428A (shown in purple) is licensed for stony sea urchin. The remaining six sites (shown in pink) are licensed for finfish, namely Atlantic salmon.

While blue mussels are not currently produced in Inver Bay, Industry wishes to initiate the harvest of this species. As outlined above licences exist for other shellfish species in the area, but these were not in active production at the time of compiling this report.

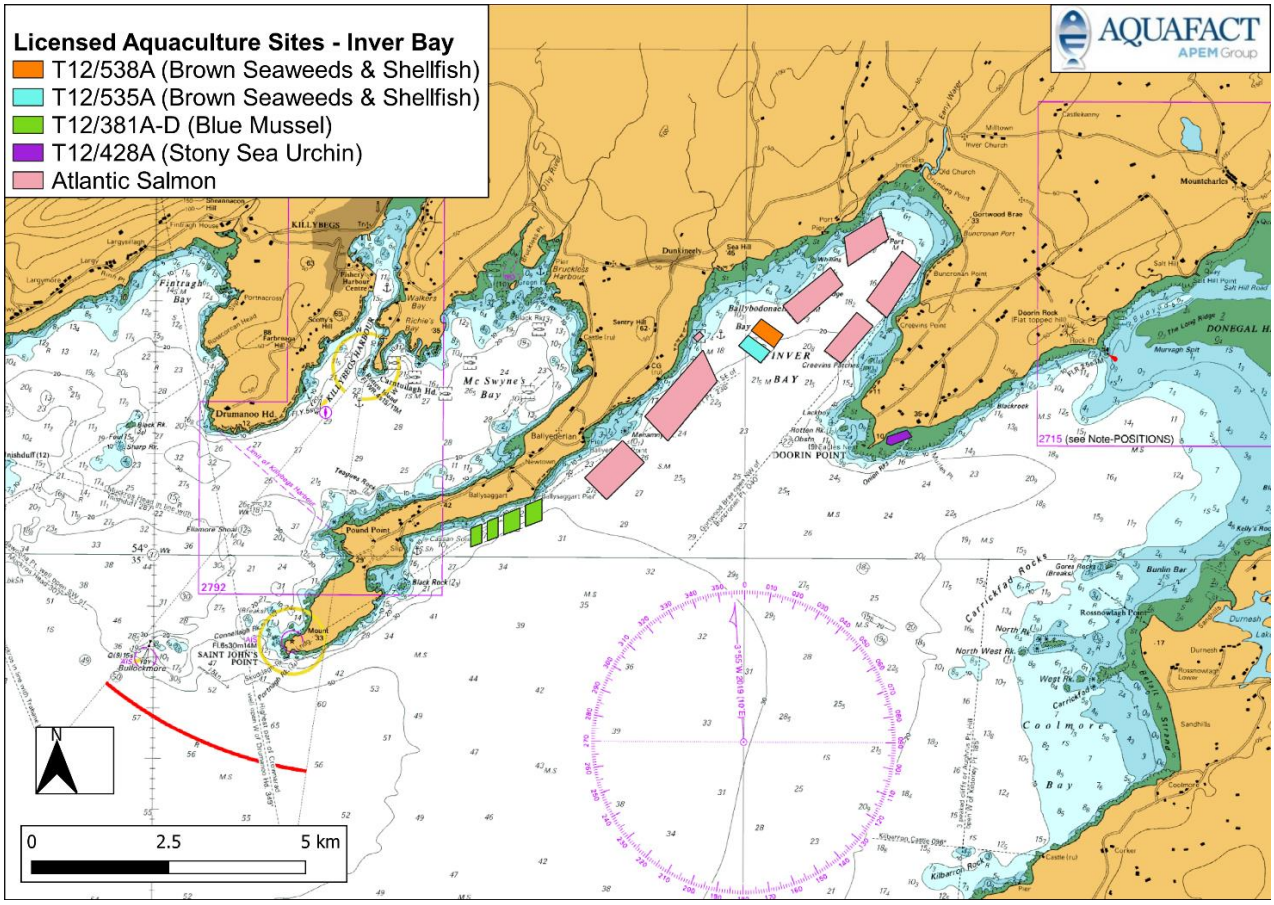


Figure 3-3: Licensed aquaculture sites within Inver Bay (source: Ireland's Marine Atlas[4]).

3.2.2. Description of Bivalve Species

3.2.2.1. Mussels (Mytilus edulis)

Distribution

Figure 3-4 shows the locations of the licensed mussel sites in Inver Bay which combined cover an area of 0.51 km^2.

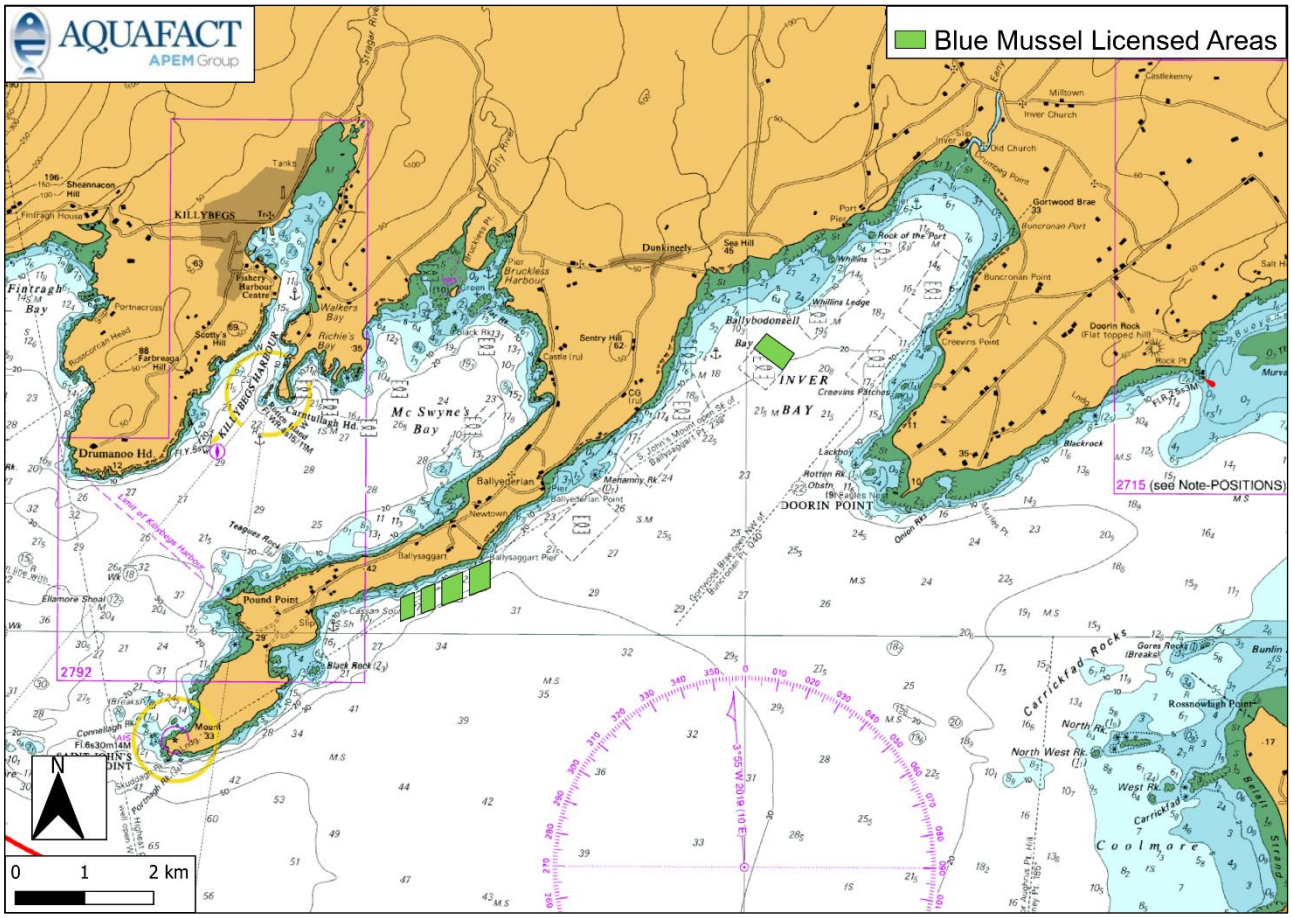


Figure 3-4: Blue mussel licensed areas in Inver Bay (source: DAFM[5]).

Fishery

There is currently no active commercial blue mussel production in Inver Bay. Traditionally, a hand-picked mussel fishery existed within Inver Bay where mussels were harvested from rocky intertidal areas along the shore. The main areas for this activity were from Fanaghan's to Ballybodonnell on the northwestern shore of the bay and to a lesser extent the Creevin area on the southern shore. These mussels naturally recruited to the shore and no cultivation was involved. The fishery operated all year round, and the mussels were taken ashore by hand before cleaning and grading. They would have been depurated before going for onward sale. Due to a decline in the stock, this fishery has ceased and currently no hand gathering for sale takes place.

Mussels have also been harvested previously in Inver Bay from licensed aquaculture sites. The existing farm (T12/381A) is located on the open seaward end of the previously classified area adjacent to the shoreline at Ballysaggart, St. John's Point (**Figure 3-3**; green sites). Mussels were grown here with longlines using natural spatfall collected on the droppers. In recent years this farm has ceased production, but it will likely recommence in the future. As a result of the cessation of harvesting activities in Inver Bay the classification went dormant before lapsing in 2014.

A new producer has been licensed in the bay and is intending to commence the production of mussels in the near future. This site (T12/535A) is located a mile off the shore at Ballybodonnell (**Figure 3-4**; aqua blue). Mussels here will be grown using longlines and will rely primarily on natural spatfall to populate the lines. Occasionally, seed stock may be taken from external sources. It is intended that harvesting of commercially sized mussels will take place throughout the year. The T12/535A site is also licensed for the cultivation of both Pacific oysters and manilla clams. Although there is currently no shellfish stocked on site, this may change in the future. Should producers wish to initiate operations for these additional shellfish species, they are required to contact the SFPA, and a further sanitary survey may be required. There are currently no closed seasons or other fishery management measures in place for the mussel fishery in Inver Bay.

4. Overall Assessment of Potential Pollution Sources Influencing Shellfish Contamination

This section endeavours to summarise the potential pollution sources impacting Inver Bay and the associated DSW; in the context of this report, pollution refers to *E. coli* contamination only. For that reason, details on the local human population, boating activities and sewage discharges are provided. Agricultural operations, as potential contamination sources, the contributions of rivers and streams, and how contaminants move throughout the bay based on currents, tidal data, and the bathymetry of Inver Bay are also discussed. Additional potential pollution sources including changes in tourism numbers and activities, yearly variations in agricultural practices, and seasonal precipitation are detailed. Notably, this section incorporates a detailed inventory of pollution sources observed during the shoreline survey, complemented by a discussion on the bacteriological sampling results acquired concurrently. Details of SPAs and SACs in the vicinity of the bay are also provided.

4.1. Human Population

Inver Bay contributing catchment has a population of 3,952 people with no towns or large urban areas. The population of the contributing catchment is just below the average density for rural Ireland with 23.2 people per km^2 compared to 27 people per km^2 nationally in rural areas (CSO, 2016a), and is low in comparison to the population density of the State (73 people per km^2) (CSO, 2022). The 2016 census recorded 2,083 households in the catchment, of which 16% are vacant, and 11% are holiday homes.

4.2. Boating

Eight piers/slipways were noted during the desktop survey, however the shoreline survey validated only four of these. Five small boats and approximately seven open style fishing boats were observed at the four piers/slipways identified in the shoreline survey (**Table 7.11**), and an additional boat was noted at a fish farm site (**Figure 7-18**; map ID 29). While data on sewage discharge levels from boating activities in Inver Bay are not currently available, it is anticipated that, due to the small size, lack of overnight berthing vessels and the low vessel numbers, impacts to water quality by boating activities at the shellfish production sites will be highly unlikely.

4.3. Sewage Discharges

Sewage from the majority of households (78%) in the contributing catchment is treated by means of their own septic tanks or other individual treatment systems. Although there is a high percentage of households on private treatment systems, the overall population density is low within the Inver Bay contributing catchment compared to that of the rest of Ireland (CSO, 2022), and the settlement pattern is well dispersed

throughout the contributing catchment with no large towns. However, without definitive data on the locations of these septic tanks it is challenging to use these data in the selection of the specific RMP location.

There are four wastewater treatment plants (WWTP) in the catchment with four associated continuous discharges which, based on available data, are all operating within their design capacity. There are no rainfall-dependant sewage discharges associated with these WWTPs; however, an emergency overflow associated with Dunkineely WWTP discharges directly into the Bunlacky River waterbody and subsequently into Inver Bay. Only one industrial facility is present, a Section 4 discharge with no emissions to water; therefore, it will have no impact on faecal contamination in Inver Bay.

The shoreline survey revealed a number of human inputs via more than 14 drains/pipes (**Table 7.11**) and one culvert (**Figure 7-18**, map ID 19). The latter had a good flow of water at the time of the survey, with a lot of *Enteromorpha*/*Ulva* algae and moss observed. The water that passed through the culvert appeared to originate from mixed scrubland and a residential area.

4.4. Agriculture Sources

Agricultural land (pastures 18.3% and land principally occupied by agriculture 16.5%) accounts for 34.8% of the Inver Bay contributing catchment. It is notable though that the pastureland and better grazing areas are predominantly located in proximity to the licensed sites and overlap with multiple rivers and discharges entering Inver Bay. This was confirmed during the shoreline survey.

According to the Census of Agricultural 2020 (CSO, 2023), there are 5,517 cattle in the Electoral Divisions (EDs) that overlap with the contributing catchment, with the highest number of cattle occurring in Tantallon (1,376). The density of cattle in the catchment is low at 0.24 cattle/ha of farmland, which is less than the average national stocking density which ranges from 0.4 livestock units/ha of farmland to 1 livestock unit/ha depending on the age and type of bovine animal (DAFM[6]). There are 49,152 sheep in the catchment, with the highest number of sheep occurring in An Ghrafaidh (13,378). The stocking density for sheep in the catchment (*c.* 2.11 sheep/ha of farmland) is more than twice that of the national average for ewes in 2016 of 1 ewe/ha (Keady and Hanrahan, 2016[7]). This high number of sheep is consistent with the 2021 census of sheep which reports that Donegal had the greatest sheep population in Ireland (DAFM[8]).

Due to the numbers of animals quoted above, it is expected that sheep are one of the principal pollution sources in the production area particularly after periods of elevated rainfall when surface water runoff may bring more faecal contamination into the bay; it is of note that the ED of An Ghrafaidh is located the furthest away geographically from the Inver Bay DSW boundary. Four sheep were noted on the shore during the shoreline survey (**Figure 7-18**, map ID 2).

Water sampling during the shoreline survey showed evidence of faecal contamination in all four of the samples taken. Currently, there are no guideline values for *E. coli* in DSW, however, the water samples are not considered to have high *E. coli* levels (**Table 9.5**). It is suspected that diffuse agricultural inputs may be responsible for this faecal contamination.

4.5. Rivers and Streams

Inver Bay drains a catchment of *c.* 170 km^2 and is dominated by the Eany, Eanybeg and Eanymore river sub-basins, which combined drain 67.75% of the catchment (24.82%, 23.48% and 19.45%, respectively) (**Figure 8-3**). Though the majority of the Mountcharles_010 river sub-basin drains into the Donegal Bay (Erne) WFD coastal waterbody, it has been assessed as part of the Inver Bay contributing catchment due to the water circulation patterns in this area.

The current (2016-2021) WFD status for the Bunlacky River waterbody and both the Eanybeg River waterbodies is High. The remaining river waterbodies within the contributing catchment are of Good status. Inver Bay coastal waterbody (CWB) is of High status (EPA Catchments, 2016).

The Eany River waterbody enters Inver Bay at the head of the estuary at Inver Harbour, *c.* 4 km from the mussel growing area (**Figure 8-4**). It is thought that this river waterbody will bring diffuse agricultural, domestic, and urban wastewater contamination into the production area (EPA Catchments, 2019). Due to its size, the high percentage of the catchment area that this river waterbody drains and proximity to the designated shellfish waters, the Eany River waterbody will likely be the main driver of contamination levels within the production area, particularly during periods of high rainfall as the Eany River waterbody is a spate river (Inland Fisheries Ireland, 2016). While other river waterbodies, namely the Eanymore and Eanybeg River waterbodies, drain a similar relative percentage of the contributing catchment into Inver Bay, their distance from the DSW subjects them to a dilution factor and so these river waterbodies are not considered the main drivers of contamination levels within the production area. River waterbodies are defined by the EPA and are the units being used in this report to determine how the Inver Bay contributing catchment is drained rather than considering individual rivers and streams. However, it should be noted that while the Eanymore and Eanybeg River waterbodies are separately designated waterbodies to the Eany River waterbody, they are upper tributaries of the Eany River and so enter the production area through the Eany River. Other river waterbodies of note are Drumnakilly, Bunlacky and Bogside, due to their proximity to the mussel growing area and because they discharge directly into the DSW.

Salinity values range from 32 psu at the surface to 33.7 psu at 15 m depth in Inver Bay (Cronin *et al*., 2004). This variation between surface salinity values and those taken at depth is to be expected and indicates the

freshwater influence of the rivers, streams, and field drains in the vicinity does not dominate the hydrodynamics of Inver Bay, in particular the designated shellfish waters.

It was noted during the shoreline survey that there were seven streams/rivers draining into the production area (**Figure 8-4**), with three of these inputs being close to the licensed sites and having the potential for more localised impacts. The SFPA collected two water samples in the locality of the production area (stations 3 and 4, **Figure 9-1**) both of which showed evidence of faecal contamination (**section 9.2.2**); station 3 corresponds to the Bunlacky River which discharges immediately adjacent to the licensed area. Currently, there are no guideline values for *E. coli* in DSW, however, the water samples are not considered to have high *E. coli* levels (**Table 9.5**, **Figure 9-1**). There were in excess of 14 field drains/pipes and one culvert identified during the shoreline survey and collectively these have the potential, particularly after heavy rain, to add to faecal contamination levels entering the production area.

4.6. Movement of Contaminants

Inver Bay is a U-shaped bay, with its substrate composed mostly of fine sands and mud throughout with coarser sands and rock closer to the shore, and there is a deep channel running the length of the bay. The bay is almost completely subtidal, apart from the inner bay and along the shoreline which is intertidal. Depths in inner Inver Bay range from 0 to 10 m and increase south-westwards along the peninsula from 22-40 m. Due to the depth and breadth of the bay, tidal velocities are slack and prevailing winds dominate the circulation pattern (AQUAFACT, 2023b[27]).

Acoustic doppler current profiler (ADCP) measurements were taken to measure water current flow in April-May 2016 at two stations in Inver Bay (AQUAFACT, 2023b). These showed average water flow velocity magnitudes of 0.07, 0.06 and 0.07 m/s for near-bed, mid-column and near surface layers, respectively, at station A (southeast Inver Bay) and 0.03, 0.05 and 0.06 m/s at station B (inner Inver Bay) (AQUAFACT, 2023b[9]). Computed tidal velocities at the surface on a flooding tide showed highest velocities along the southwestern side of Inver Bay, greatly dissipating upon reaching the mussel production area and flowing around the production area in an anti-clockwise pattern. Beside the south-eastern side of the bay, along the Mountcharles river sub-basin, all river waterbodies draining into the bay here will, on a flooding tide, be pushed north-eastwards towards Donegal Harbour and will not likely enter Inver Bay and the shellfish production area. Computed tidal velocities at the surface of an ebbing tide showed the highest velocities along the south-easterly side of inner Inver Bay, and the flow is predominantly linear in a south-westerly direction (AQUAFACT, 2023b[27]). However, this linearity is expected to be disrupted by the prevailing south-westerly wind (see **Figure 8-2**) which combined with an ebbing tide will likely lead to eddies. Surface tidal velocities on a flooding tide are expected to be exacerbated by the prevailing south-westerly wind.

The desktop survey identified that one of the primary sources of contamination in the contributing catchment is from sheep farming. This faecal contamination through diffuse agricultural run-off is washed into rivers, streams, and drains during high levels of rainfall. As the Eany, Eanybeg, and Eanymore River sub-basins combined drain 67.75% of the contributing catchment, the confluence of these three river sub-basins is likely to be one of the main sources of contamination in the bay. As such, contamination entering the bay through the River Eany at the head of the estuary (**Figure 7-28,** map ID 9) will follow the main channel of Inver Bay on the ebbing tide and so flow directly past the production area. Due to the subtidal nature of the production area, such contamination will be dispersed on the ebbing tide, and, when the prevailing wind is strong enough, surface water will be forced in a north-easterly direction away from the production areas.

The highest recorded *E. coli* result from the shoreline survey water sampling was taken next to a stream, near a field drain discharging to the northeast of the mussel production area (**Figure 9-1**). However, considering the above mentioned computed tidal velocities and directions, this discharge is not likely to interact with the production area. Additionally, this stream is not located near a WWTP, and no sheep were noted in the area during the shoreline survey, and as this stream is small the discharge will be diluted into the bay relatively quickly reducing any potential impact on the production area.

4.7. Wildlife

Inver Bay catchment overlaps slightly with Lough Nillan Bog SPA (<0.5%). It borders Donegal Bay SPA, adjacent to which is Durnesh Lough SPA and there is a large diversity of bird species found in these areas. Although no specific bird counts are available for Inver Bay, it can be assumed that a proportion of these birds visit the actual production area (Roycroft *et al.*, 2007). The number of birds visiting the site is likely to increase in winter due to the arrival of over wintering water birds. The bird species for which these three SPAs are designated are listed in **section 7.1.6.2**; see also **footnote 3**. The bird species for which Lough Nillan Bog and Durnesh Lough SPAs are designated for are unlikely to visit the shellfish production area as the habitat type is not particularly conducive to the presence of these birds. Gulls and cormorants which are supported by Donegal Bay SPA are the only bird species likely to perch on the floating mussel longlines. The potential use of the longlines by gulls and cormorants suggests they may defaecate while present in the area which would add to the *E. coli* levels in the surrounding water.

Both harbour (*Phoca vitulina*) and grey seals (*Halichoerus grypus*) have been recorded within Inver Bay. Twenty individual harbour seals were sighted at St. John's Point in 2011, with multiple further sightings in adjacent bays (National Biodiversity Data Centre [NBDC], 2022a). A number of seal breeding, resting, and moulting sites are located in Donegal Bay (Murvagh) SAC, which borders the south-eastern boundary of the Inver Bay catchment area[10]. Only individuals or small groups of grey seals have been recorded within the

catchment area and no haul-out sites are listed[26]. Other aquatic mammals that may occur in Inver Bay include otter (*Lutra lutra*), bottlenose dolphin (*Tursiops truncatus*) and common porpoise (*Phocoena phocoena*).

The bird and marine mammal populations that visit the site may contribute to the background bacteriological levels within the bay, but their impacts will be largely diffuse and so will have little bearing on the actual locations of the RMP itself.

4.8. Seasonality

In 2019, 768,000 overseas tourists, 1,189,000 domestic tourists, and 597,000 Northern Irish tourists visited the Border Region of Ireland (Fáilte Ireland, 2019). Of the domestic tourists a total of 445,000 visited Co. Donegal. Out of 30 participating tourist attractions, the main attractions in the area in 2019 were Glenveagh Castle and Grounds, Sliabh Liag Cliffs and Grianán of Aileach (Fáilte Ireland, 2022b).

There are four attractions located inside the catchment area: Raneely Promontory Fort, Salthill Gardens, Bonnyglen Falls, and St. John's Point Beach. As these tourist attractions do not appear in the top ten tourist attractions for Co. Donegal, it is thought that only a small proportion of the tourists for the county are likely to visit the area (Discover Ireland[11]). The number of holiday homes accounts for 11% of the permanent households in the catchment. For Ireland as a whole, in 2019 most tourists visited between June and August (32%), followed by October to December (22%), January to March (19%) and 9% in each of April, May and September. There is no reason to expect this trend to be any different in the Northwest region. As tourism numbers in the area are presumed to be relatively low based on the lack of popularity of the tourist attractions in the vicinity, it is unlikely that there will be a seasonal impact on the shellfish area from tourism.

In terms of agriculture, the number of sheep would be expected to be higher in spring/summer when lambs are present. But also at that time of the year there may also be more extensive grazing in the hills and thus bacterial impacts would be more widely spread. In Co. Donegal the spreading of slurry is permitted between February 1st and October 15th. Statutory Instrument (S.I.) No. 113/2022[21] sets out guidelines relating to the environmental conditions that should be avoided when spreading slurry or fertiliser. Particular guidelines are also in place for slurry spreading near watercourses, with recommended buffer strip distances provided, *e.g.,* 20 m from lakes and main river channels.[22] Much of the land in the contributing catchment is agricultural, with pastureland and better grazing areas being located close to the shoreline, so there is a potential risk associated with contamination resulting from slurry spreading if the guidelines are not adhered to.

In the contributing catchment there may also be an increase in wading bird and wildfowl numbers during autumn/winter due to migrating species. However, it is difficult to identify the level of impact due to limited

information on numbers and behaviour of bird species in the area. Furthermore, as these species will forage along the shoreline, their faeces will be deposited there and will not impact the production sites.

Analysis of rainfall data for the Inver Bay area has shown that October to February are the months with higher rainfall. During this period of time, faecal contamination may enter the bay in run-off from the land. The highest bacterial loading from the land is expected to occur in August and September as faecal biomass may accumulate over the dryer period of April to July. As significant rainfall events can occur throughout the year it is not just during the winter months that a risk of increased contamination is present.

4.9. Shoreline Survey

Inventory of Pollution Sources

Twenty-nine potential pollution sources were identified in total by the shoreline survey, of which there were seven rivers/streams, more than 14 drains/pipes, one culvert, four piers, three fish farm locations, and at one location sheep were seen on the shore. Where these sheep were recorded, four individuals were observed on the shore (**Figure 7-29**, map ID 4). Evidence of *Enteromorpha*/*Ulva* and possible enrichment was noted at the sites of three drains, two rivers, four streams, and one culvert. All of these discharges, except one drain and one river (see **Figure 7-29**, map ID 1 and 2, respectively) input directly into the DSW.

Bacteriological Sampling Results

Water sampling was undertaken out as part of the shoreline survey with four water samples taken from two rivers and two streams. Currently, there are no guideline values for *E. coli* in DSW. The highest *E. coli* levels were measured at Station 2 (stream; **Figure 9-1**), for comparison, however, this is not considered a high level of *E. coli*. Levels of *E. coli* measured at Stations 3 and 4 were lower than at Station 2 (Bunlacky River and stream, respectively; **Figure 9-1**). Station 1 at the mouth of the Eany River had the lowest *E. coli* levels at the time of the survey, even though this river waterbody drains 67.75% of the catchment, and so would be presumed to be the main potential source of bacterial contamination due to run-off from the land.

Of the discharges noted during the shoreline survey, only six out of 21 were man-made discharges or pipes. As such the impact due to human activities is likely to be relatively low, however as no water samples were taken from these discharge points, a definitive evaluation cannot be made at this time. There are four WWTPs within the Inver Bay contributing catchment, none of which discharge directly into the bay, but discharge into rivers which subsequently flow into Inver Bay. No commercial facilities discharge into the bay. There is one Section 4 discharge (EPA, 2022b), a quarry, within the contributing catchment of Inver Bay, however as the quarry has no emissions to water it will not contribute to faecal contamination in the bay.

5. Recommended Amendments

The 2012 Inver Bay BMPA boundary (**Figure 5-1**) formed the basis for assessing the amended production area boundary (**Figure 5-2**). The 2012 production area boundary has been broadly amended to align with the DSW boundary. Primarily, the amended production area includes the licensed shellfish site (T12/428A) at Doorin Point. The amended boundary excludes the potential discharge area from the Dunkineely WWTP emergency overflow, as this would be likely to have a high bacteriological load when in operation. The amended boundary also excludes the upper estuarine section of the Eany River as there are no licensed shellfish production sites located there.

The Dunkineely WWTP emergency overflow discharges into the Inver Bay shellfish production area (**Figure 7-5**). However, this discharge only comes into operation during periods of excessively high levels of rainfall when the WWTP cannot cope with the volume of freshwater being delivered to it. Such events can happen at any time of the year (see **section 8.6.2**). As freshwater is discharged, it is less dense than seawater by about 3%. Given this, once it reaches the sea, it will sit on top of the denser, higher salinity, seawater. During flooding tides, this freshwater can be pushed in a north-easterly direction and stay close to the shore (*c*. 100 m) while on ebbing tides and due to the Coriolis effect, it will flow in a south-westerly direction and stay close to the shore. Once the excessively high rainfall conditions abate, the emergency overflow plume from the WWTP will become mixed with seawater and normal salinity conditions will return.

The nearest licensed shellfish site is *c*. 1 km southeast of the emergency discharge location and, given the above description of how the emergency overflow plume flows on both flooding and ebbing tides, it is not physically possible for sufficient volumes of this discharge to affect water quality at the production site. For this reason, it is recommended that the south-easterly boundary of the production area is amended, by placing it 100 m away from the licensed shellfish site, compared to that of the designated shellfish waters boundary. It should be noted that extreme levels of rainfall may occur, though infrequent, and in these instances combined with a strong north-westerly wind, the discharge from the emergency overflow could flow out over the shellfish production site leading to high levels of *E. coli* accumulating in the shellfish flesh.

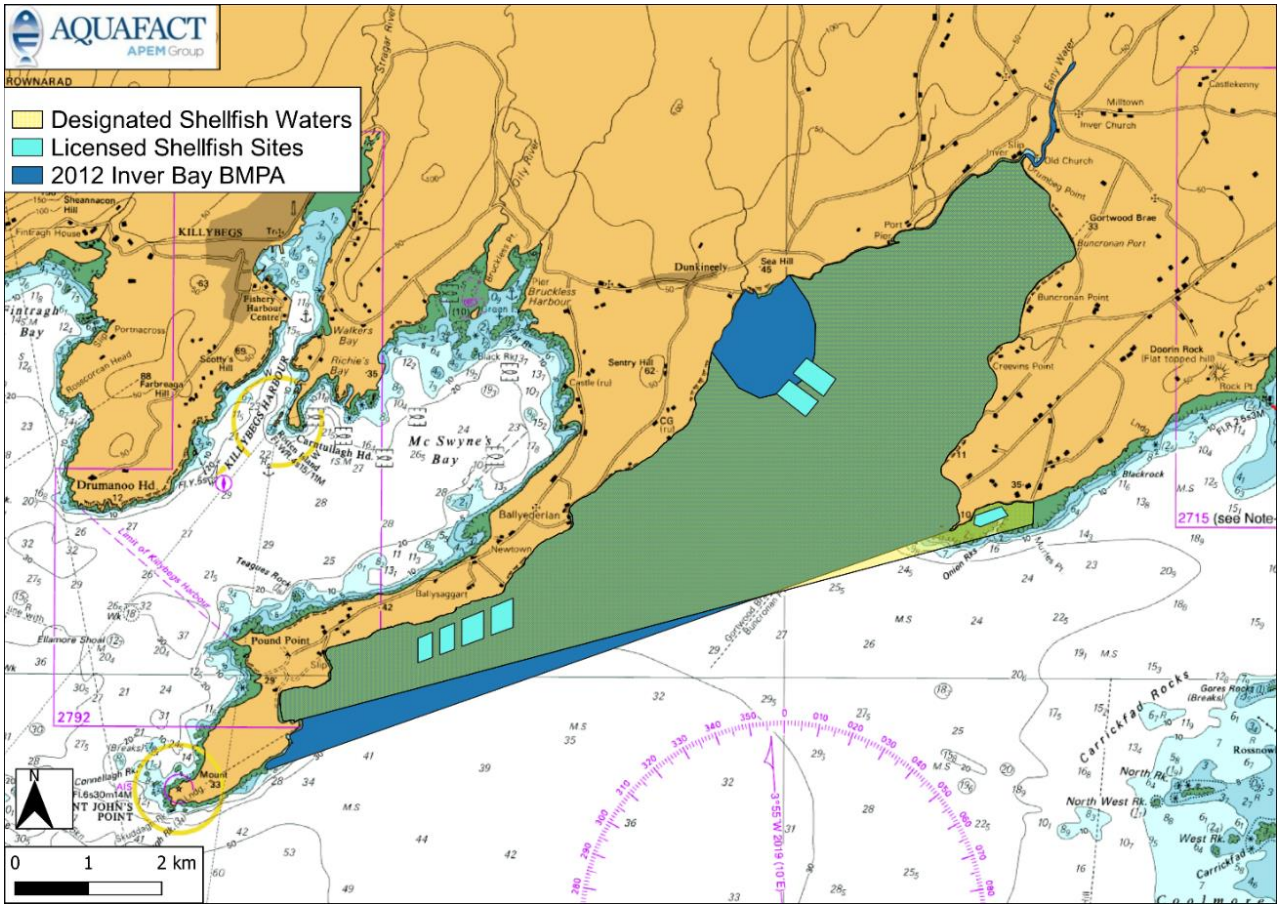


Figure 5-1: Inver Bay 2012 Bivalve Mollusc Production Area and licensed shellfish sites.

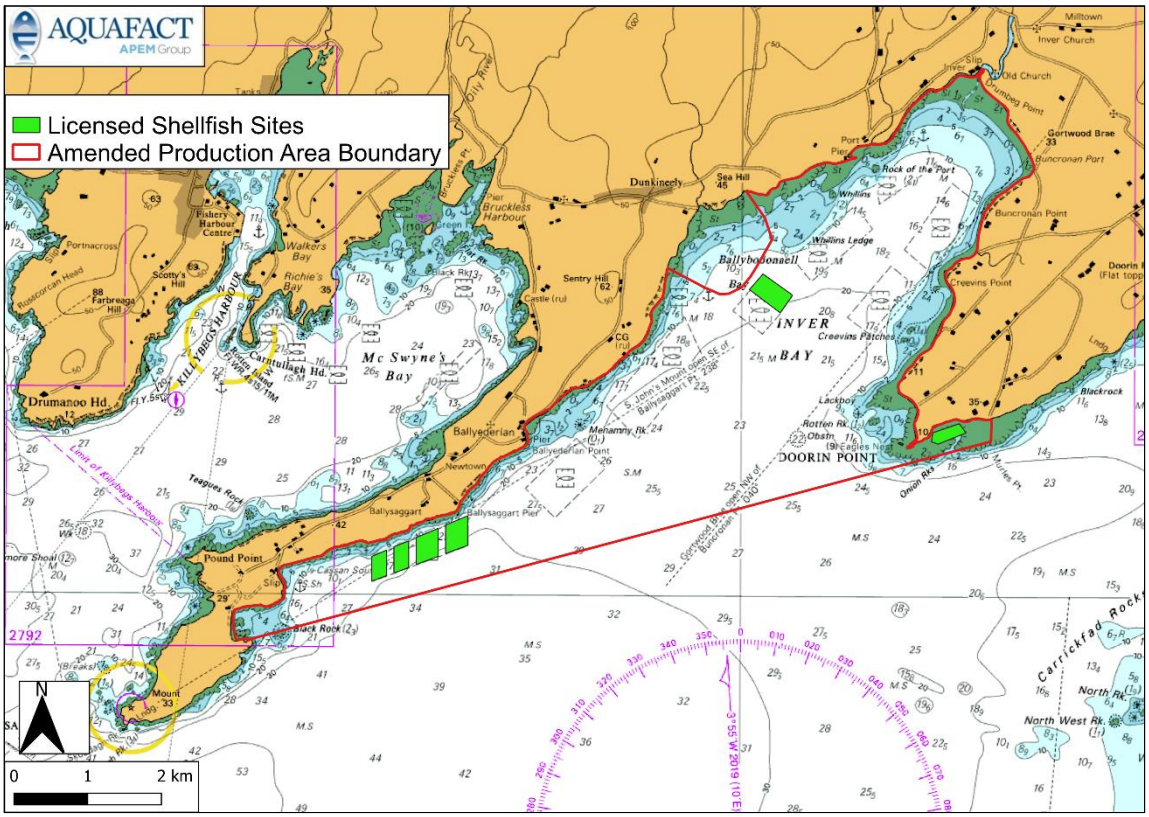


Figure 5-2: Inver Bay amended production area boundary and current licensed shellfish sites.

Table 5.1: Coordinates of the amended production area.

Corner	Latitude	Longitude	Easting	Northing
N	54.647687	-8.282721	581752.641	877758.595
N	54.647287	-8.282791	581747.944	877714.095
NW	54.632699	-8.332525	578530.31	876104.564
NW	54.623230	-8.348873	577469.563	875055.82
SW	54.577915	-8.435101	571869.717	870043.548
SE	54.604972	-8.280731	581862.086	873004.065

6. Representative Monitoring Points (RMP) and Sampling Plan

6.1. RMP for Mussels (*Mytilus edulis*)

It is recommended that the location of RMP 1 for blue mussels is situated on the north-western side of the bay on licensed site T12/538A (**Figure 6-1**, **Table 6.1**).

This RMP will adequately capture contamination emanating from the Dunkineely WWTP emergency overflow which discharges into Inver Bay via the Bunlacky River waterbody, and the Eany River, the principal river entering the production area, draining 67.75% of the contributing catchment. The shoreline survey sampling revealed moderate levels of faecal contamination from the Bunlacky River and a stream flowing into the bay adjacent to the RMP, although currently there is no guideline value for *E. coli* in DSW. Water samples taken from discharges at Stations 3 and 4 during the shoreline survey, corresponding to the Bunlacky River and a stream, detected *E. coli* at low levels. Nevertheless, the RMP is located accordingly so as to detect *E. coli* from these potential sources as a precautionary approach, should the bacterial levels increase. Similarly, the cumulative waters from most of the other streams/rivers and drains/pipes identified during the shoreline and desktop surveys will be carried over the RMP on the ebbing tide and due to the hydrodynamics of the bay.

The RMP has been located so as to reflect the effect of any contamination from the abovementioned discharges. Accordingly, samples should be taken at the RMP within the top one m of water as freshwater discharges are the primary *E. coli* source in Inver Bay, and as freshwater is less dense than seawater it tends to sit on top of saltwater until mixing occurs. The RMP has been located at the edge of the main channel to also reflect any contamination emanating on the downstream flow.

6.2. Microbiological Sampling Plan

A minimum of 15 individual blue mussels of market size (minimum 4 cm shellfish length) are required to be sampled monthly[12;2]. Flesh samples should be taken within the top one m of the water column and as close to the surface as possible, in order to obtain a representative sample of the *E. coli* levels in the bay. Flesh samples should be taken within a maximum distance of 100 m from the abovementioned RMP[12]. Upon establishment of the classified production area for blue mussels and considering that harvesting can potentially take place year-round, monthly sampling will be required throughout the entire year. The SFPA is the competent authority responsible for implementing this sampling plan.

Table 6.1: Coordinates of the Representative Monitoring Point (RMP). Note: the coordinate reference system is Irish National Grid (ING).

RMP	Site Code	Species	Longitude	Latitude	Easting	Northing
RMP 1	DL-IB-IB	*Mytilus edulis*	-8.33170	54.62066	178621.040	374767.966

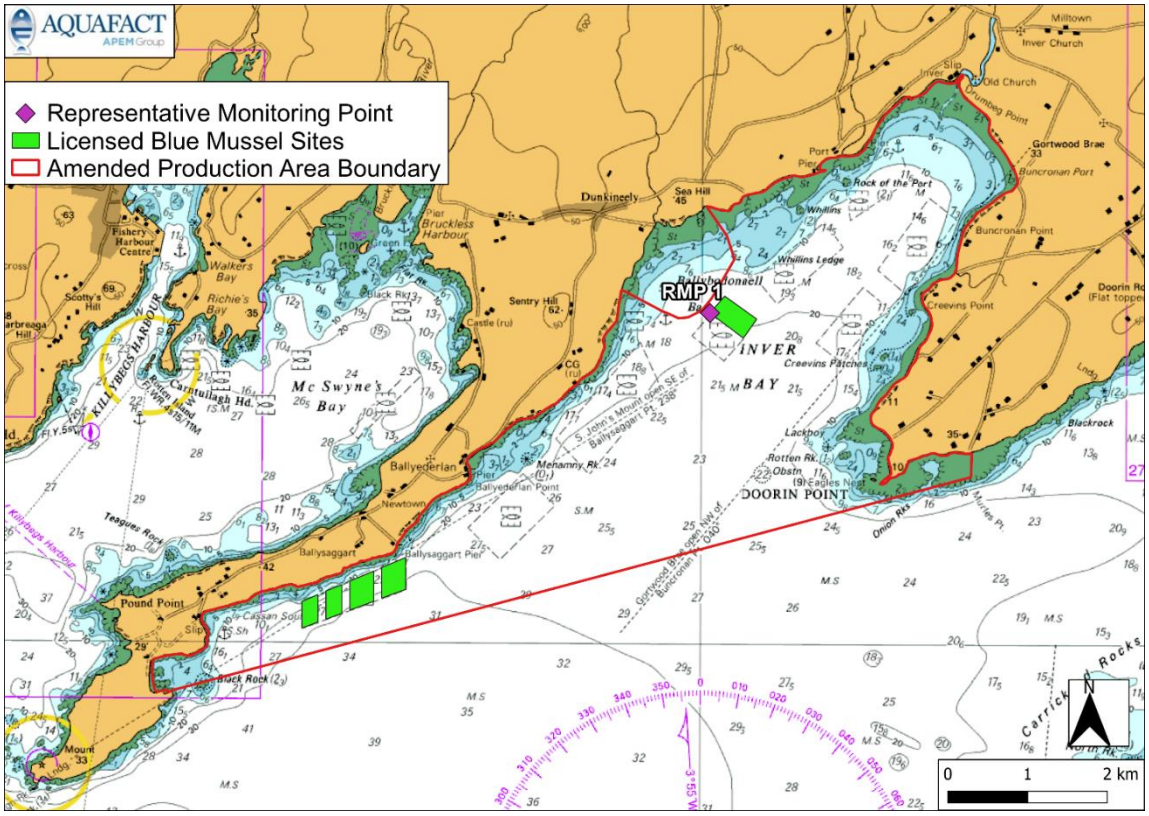


Figure 6-1: Amended production area boundary with proposed representative monitoring point (RMP) for mussels in Inver Bay.

6.3. General Sampling Method

All collection and transport of shellfish samples for *E. coli* testing under the sampling plan identified as part of the Inver Bay Sanitary Survey should adhere to the Code of Practice for the Microbiological Monitoring of Bivalve Mollusc Production Areas[12]. The sampling procedure and guidance notes are found in Appendix 9.2 of that document.

7. Appendix 1: Identification of Pollution Sources

This section documents all pollution sources identified during the desktop and shoreline surveys within the Inver Bay catchment area; in the context of this report, pollution encompasses *E. coli* contamination only.

7.1. Desktop Survey

Pollution sources were considered within the contributing catchment of Inver Bay (**Figure 7-1**). The contributing catchment covers an area of approximately 170 km^2, *c.* 15 km east-west at its widest point and *c.* 13 km north-south at its longest point.

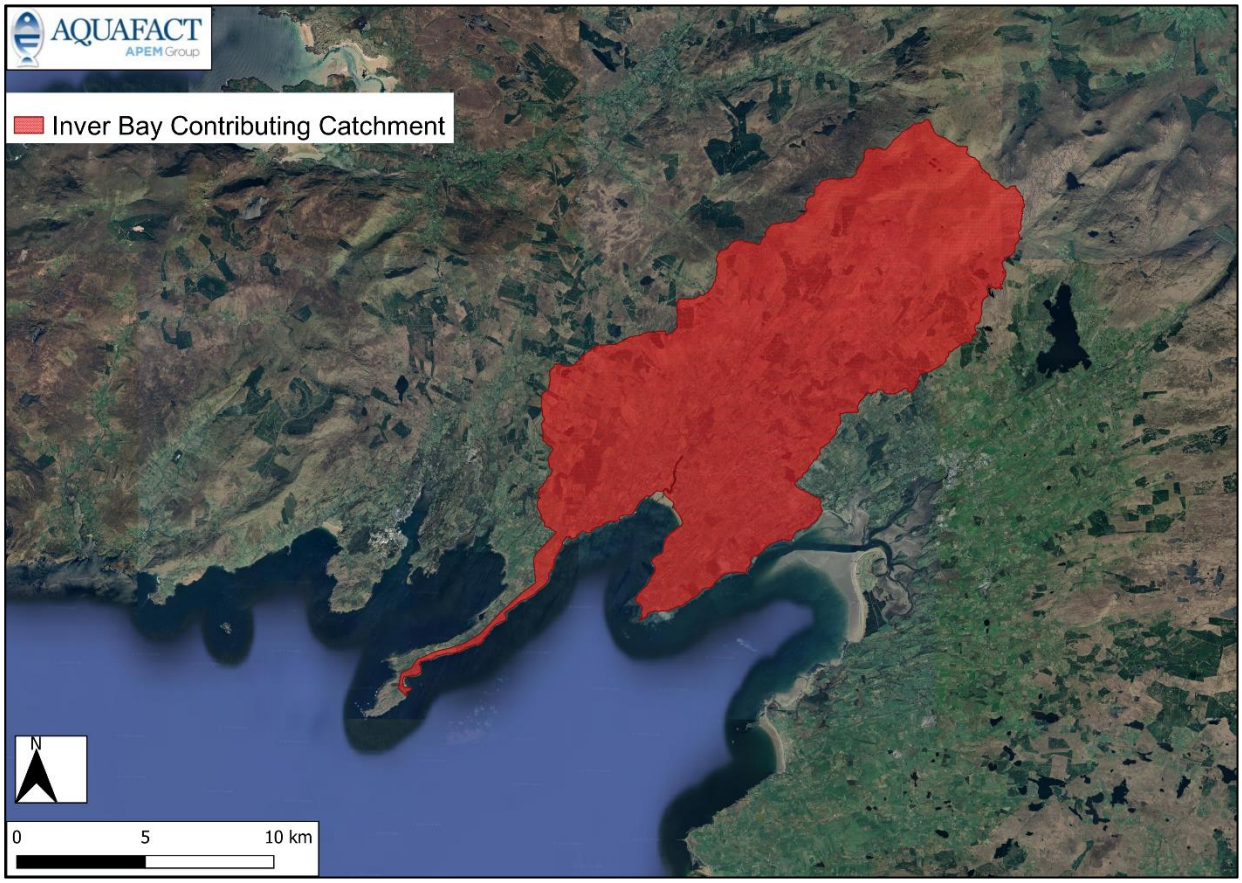


Figure 7-1: Inver Bay contributing catchment area used for assessment of potential pollution sources.

7.1.1. Human Population

Population census data provided by the Central Statistics Office (CSO) is given in units of Eds; **Figure 7-2** shows the EDs within the contributing catchment. The population data were obtained through the CSO online Small Area Population Statistics (SAPS)[13] for the year 2016. **Figure 7-3** shows the human population within Inver Bay contributing catchment and **Table 7.1** shows these data in tabular form.

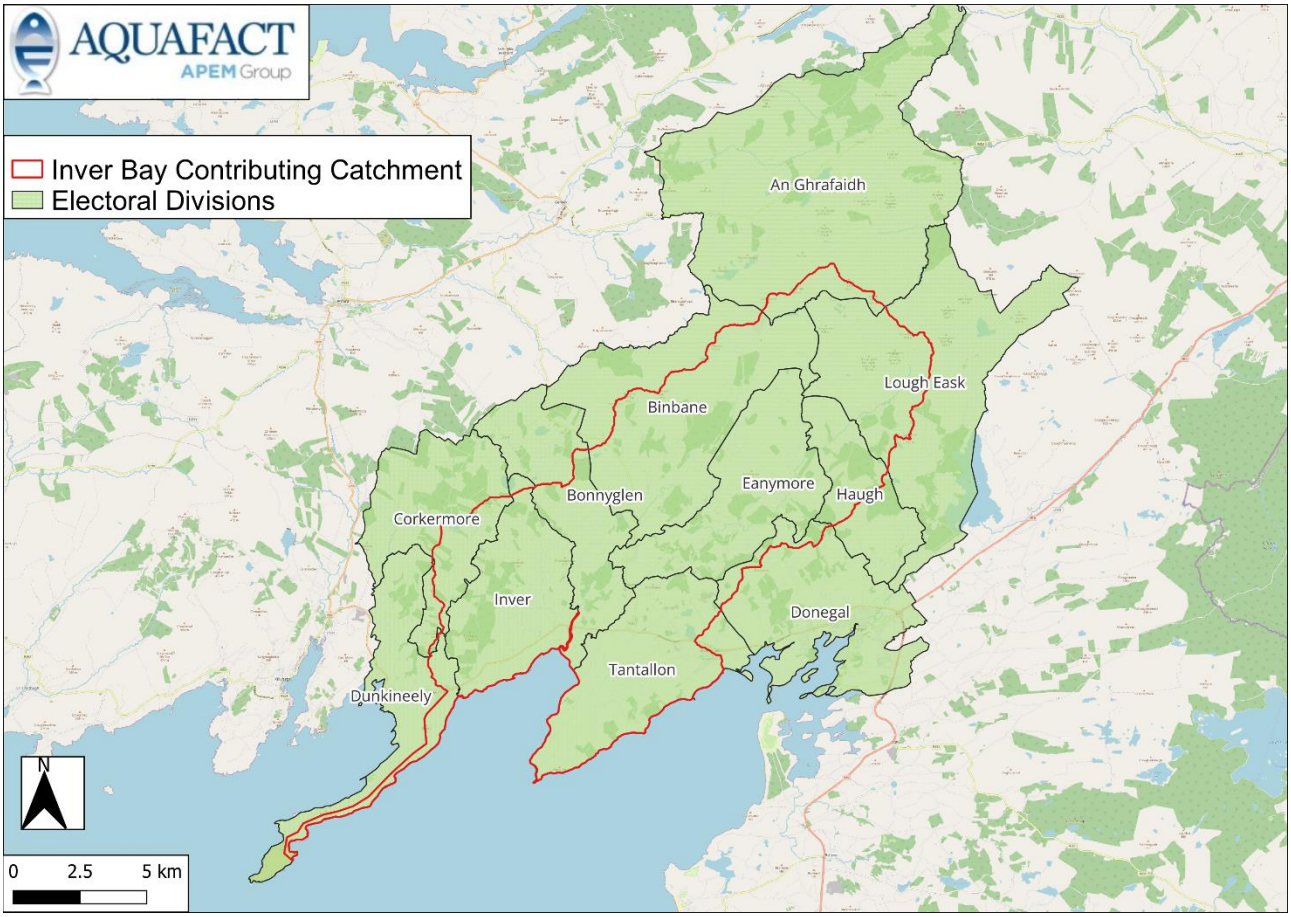


Figure 7-2: Electoral Divisions within the Inver Bay contributing catchment area.

The Inver Bay contributing catchment overlaps 11 EDs (all partially, except for Eanymore with which there is total overlap). The EDs that are partially within the catchment are An Ghrafaidh, An Bhinn Bhán (Binbane), Bonnyglen, Corkermore, Donegal, Dunkineely, Haugh, Inver, Loch Iascaigh (Lough Eask) and Tantallon.

The entirety of the 11 EDs accommodate a total population of 9,378[13]. As Eanymore is the only ED that completely overlaps with the contributing catchment, an attempt was made to estimate the actual population within the catchment for the remaining 10 EDs. The geographical area of the remaining 10 EDs overlapping with the catchment was calculated using QGIS software and then converted to a percentage of the overall area (km^2) of the ED using Microsoft Excel. From this value the population size in each ED was calculated *e.g.*, if 50% of the ED lies within the contributing catchment then 50% of that total population was taken to be the population size of the area within the contributing catchment. Using this method, the population of the contributing catchment is estimated at 3,952 people. Tantallon contains the largest population within the contributing catchment (1,492), followed by Inver (737) and Eanymore (517); **Table 7.1** shows this estimation. There are no towns/urban centres within the contributing catchment.

There are 4,851 households within the 11 EDs that intersect with the contributing catchment. Of this, 16% are vacant (794) and a further 9% are holiday homes (449). Of the 2,083 houses within the contributing catchment (based on the % of the ED within the contributing catchment), 16% are vacant and 11% are holiday homes. **Table 7.2** shows the number of households in each ED and the proportion within the contributing catchment.

Human population in given areas is obtainable from census data; however, relating this information to the level of microbial contamination in coastal waters is difficult and is constrained by the geographic boundaries used. Nonetheless, it is plausible that areas with a higher population will have higher levels of sewage and wastewater entering the Inver Bay system. Therefore, the highest levels of sewage and waste are expected to enter from the Tantallon ED. As holiday homes only account for 9% of the dwellings in the contributing catchment they are unlikely to cause a significant increase in the sewage and wastewater levels relative to the permanent population.

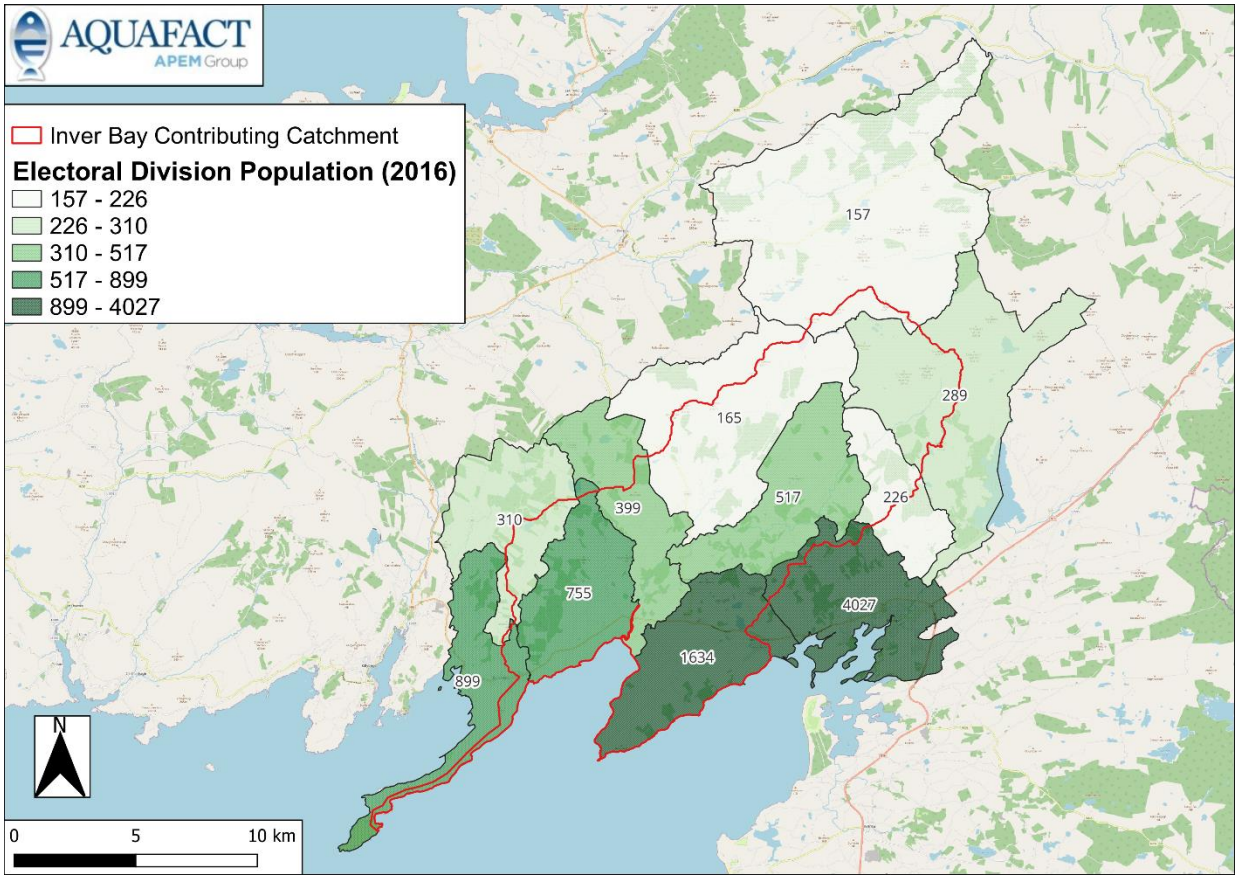


Figure 7-3: Electoral division (ED) population distribution (2016) within the Inver Bay contributing catchment (source: CSO[13]).

Table 7.1: Calculated human population within the Inver Bay contributing catchment (source: CSO[13]).

Electoral Division	Population (2016)	% ED in Catchment	Estimated Population
An Ghrafaidh	157	4.29	7
An Bhinn Bhán (Binbane)	165	70.17	116
Bonnyglen	399	58.84	235
Corkermore	310	24.38	76
Donegal	4,027	9.05	365
Dunkineely	899	20.74	186
Eanymore	517	100%	517
Haugh	226	53.44	121
Inver	755	97.64	737
Loch Iascaigh (Lough Eask)	289	35.07	101
Tantallon	1,634	91.33	1,492

Table 7.2: Households within the Electoral Divisions in the Inver Bay contributing catchment (source: CSO[13]).

Electoral Division	Total Households	No. Occupied*	Unoccupied holiday homes	Vacant houses	Total Households in Catchment	No. Occupied in Catchment	Unoccupied holiday homes in Catchment	Vacant houses in Catchment
An Ghrafaidh	119	66	12	41	5	3	1	2
An Bhinn Bhán (Binbane)	104	72	15	17	73	51	11	12
Bonnyglen	205	158	19	28	121	93	11	16
Corkermore	154	110	20	24	38	27	5	6
Donegal	1,991	1,599	90	302	180	145	8	27
Dunkineely	544	355	97	92	113	74	20	19
Eanymore	288	214	39	35	288	214	39	35
Haugh	90	74	1	15	48	40	1	8
Inver	417	285	53	79	407	278	52	77
Loch Iascaigh (Lough Eask)	84	57	15	12	29	20	5	4
Tantallon	855	618	88	149	781	564	80	136

* This figure includes those houses temporarily unoccupied on census night.

7.1.2. Tourism

In 2019, more than 2.5m tourists visited the Border Region of Ireland[14]. This figure was made up of 768,000 overseas tourists, 1,189,000 domestic tourists and 597,000 Northern Irish tourists. Of the domestic tourists a total of 445,000 visited Co. Donegal, with 1,363,000 staying on average three nights[15]. Out of 30 participating tourist attractions, the main tourist attractions in Co. Donegal in 2019 were Glenveagh Castle and Grounds, Sliabh Liag Cliffs and Grianán of Aileach[16].

There are approximately four tourist attractions located within the contributing catchment: Raneely Promontory Fort, Salthill Gardens, Bonnyglen Falls, and St. John's Point Beach. For Ireland as a whole in 2019, most tourists visited between June and August (32%), followed by October to December (22%), January to March (19%), and 9% in each of April, May, and September. There is no reason to expect this trend to be any different in the Northwest region.

Charter boats for whale and dolphin spotting operate out of Inver Bay. There are no Green or Blue Flag beaches within Inver Bay, but eight slips were identified in the desktop survey. Papadakis *et al.* (1997) found significant correlations between the number of swimmers present on beaches and the presence of pathogenic bacteria in Greece. In 2007, Elmir *et al.* (2007) showed the role of human skin as an intermediate mechanism of pathogen transmission to the water column. However, as there are no monitored beaches or bathing water locations within the bay the numbers of swimmers are likely to be low, and so will not impact on the bacteriological quality of the bay[17].

7.1.3. Sewage Discharges

Sewage effluent can vary in nature depending on the degree to which the sewage has been treated. Discharges of sewage effluent can arise from a number of different sources and be continuous or intermittent in nature:

- treated effluent from urban sewage treatment plants (continuous)
- storm discharges from urban sewage treatment plants (intermittent)
- effluent from 'package' sewage treatment plants serving small populations (continuous)
- combined sewer and emergency overflows from sewage systems (intermittent)
- septic tanks (intermittent)
- crude sewage discharges at some estuarine and coastal locations (continuous)

Treatment of sewage ranges from:

- none (crude sewage)
- preliminary (screening and/or maceration to remove/disguise solid matter)

- primary (settling to remove suspended solids as sewage sludge). Typically removes 40% of BOD (Biochemical Oxygen Demand), 60% of suspended solids; 17% of nitrogen and 20% of phosphorus from the untreated sewage.
- secondary (settling and biological treatment to reduce the organic matter content). Typically removes 95% of BOD, 95% of suspended solids, 29% of nitrogen and 35% of phosphorus from the untreated sewage. Nutrient removal steps can be incorporated into secondary treatment which can reduce ammonia - nitrogen down to 5 mg/l and phosphorus to 2mg/l.
- tertiary (settling, biological treatment and an effluent polishing step which may involve a reed bed (unlikely for coastal works) or a treatment to reduce the load of microorganisms in the effluent). Typically removes 100% of BOD, 100% of suspended solids, 33% of nitrogen and 38% of phosphorus from the untreated sewage.

7.1.3.1. Water Treatment Works

There are four wastewater or sewage treatment works within the Inver Bay contributing catchment, all with a population equivalent (PE) size of less than 500[18]. The Letterbarra housing scheme WWTP discharges directly into the Eany Water_010 river waterbody and the Letterbarra No. 2 housing scheme WWTP discharges into the Inver-Banagher Hill groundwater waterbody. The Frosses housing scheme WWTP discharges into the Eany Water_020 river waterbody, while the Frosses No. 2 housing scheme WWTP discharges into the Frosses groundwater waterbody. **Figure 7-4** shows these four WWTPs within the Inver Bay contributing catchment and **Table 7.3** shows the coordinates and facility capacities of each works[18]. Those households in the contributing catchment not facilitated by one of these four WWTP are treated by means of private treatment systems or group septic tanks, and some households have no means of treatment according to the CSO[13]. Dunkineely WWTP lies outside of the Inver Bay contributing catchment and discharges into McSwyne's Bay, however it is noted here as its associated emergency overflow discharges into Inver Bay via the Bunlacky River (**Figure 7-4**, **Figure 7-5**).

7.1.3.2. Continuous Discharges

The four WWTPs within the Inver Bay contributing catchment are all secondary treatment facilities, with data on maximum discharge and design capacity PE only available for Frosses housing scheme WWTP. Letterbarra housing scheme WWTP has an agglomeration of 15 PE, Letterbarra No. 2 housing scheme WWTP has an agglomeration of 30 PE, Frosses housing scheme WWTP has a design capacity of 70 PE and is currently under capacity at 60 PE, and Frosses No. 2 housing scheme WWTP has an agglomeration of 18 PE. Frosses housing scheme WWTP has a maximum discharge rate of 26.25 m^3/day and a dry weather flow (DWF) rate of 0.0003 m^3/sec[19]. The Dunkineely WWTP is a primary treatment facility with a design capacity of 470 PE, it is currently

operating under capacity at 416 PE. The locations of the discharges can be seen in **Figure 7-5**, and **Table 7.3** and **Table 7.4** provide details of these discharges. Strict emissions limits are set out in the discharge licences for each facility in terms of BOD, orthophosphate, suspended solids, nitrogen, and ammonia.

There is no geo-referenced database for septic tanks or on-site domestic wastewater treatment systems available. In order to estimate the numbers of these domestic sewage facilities within the catchment, information on the number of permanent private households and their sewage facilities was sourced from the 2016 census[13]. Of the 3,472 permanent private households in the 11 EDs, 36.5% (1,266) were connected to a public sewer/treatment system and 59% (2,054) had septic tanks or other individual treatment systems. A further 4.3% (148) had another treatment system or it was not stated, and <1% (4) had no sewage facility. The estimate for the total number of private permanent households actually within the contributing catchment (based on % within the contributing catchment) is 1,465 and of this 19% (274) are on the public system while 78% (1,146) of households have their own septic tanks or other individual treatment systems. Almost 3% (42) of households have another treatment system or it was not stated, and <1% (3) have no sewage facility. **Table 7.5** shows this information at the ED level and an estimation (based on % within the contributing catchment) of the numbers within the contributing catchment.

Table 7.3: Sewage treatment works within the Inver Bay contributing catchment (source: EPA[18]) and Dunkineely sewage treatment works. Note: coordinate reference system (CRS) for longitude/latitude is WGS84 and CRS for easting/northing is Irish National Grid (ING).

Name	PE	Designed PE	Latitude	Longitude	Easting	Northing
Letterbarra housing scheme	15	Null	54.69087	-7.81584	188172	382548
Letterbarra No. 2 housing scheme	30	Null	55.00047	-7.71372	181727	417036
Frosses housing scheme	60	70	54.66713	-7.76023	184577	379916
Frosses No. 2 housing scheme	18	null	54.66916	-7.7606	184602	380142
Dunkineely	416	470	54.62510	-7.619852	175494	375278

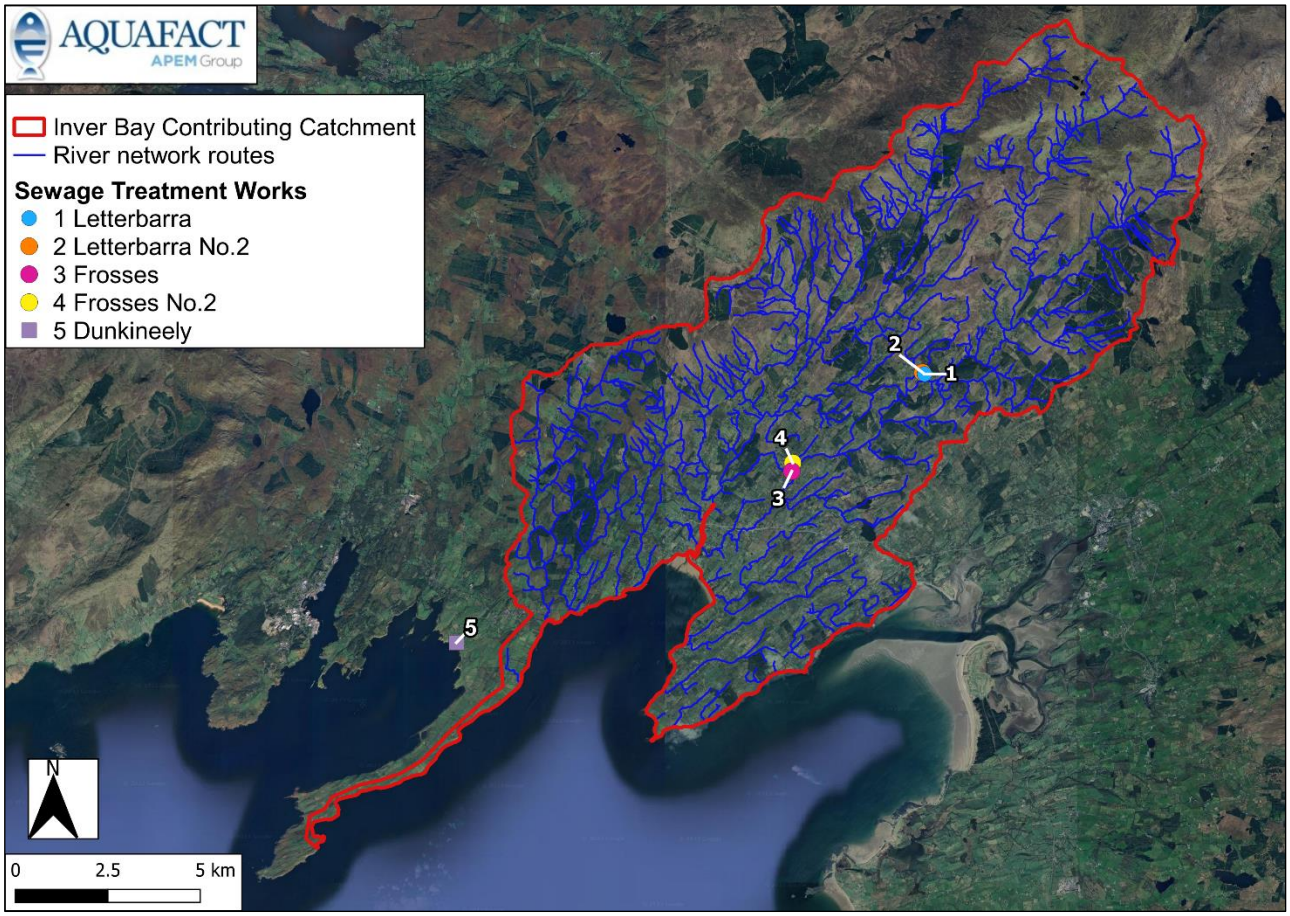


Figure 7-4: Inver Bay contributing catchment, river network routes and sewage treatment works; Dunkineely sewage treatment works lies outside of the contributing catchment (source: EPA[18,19]).

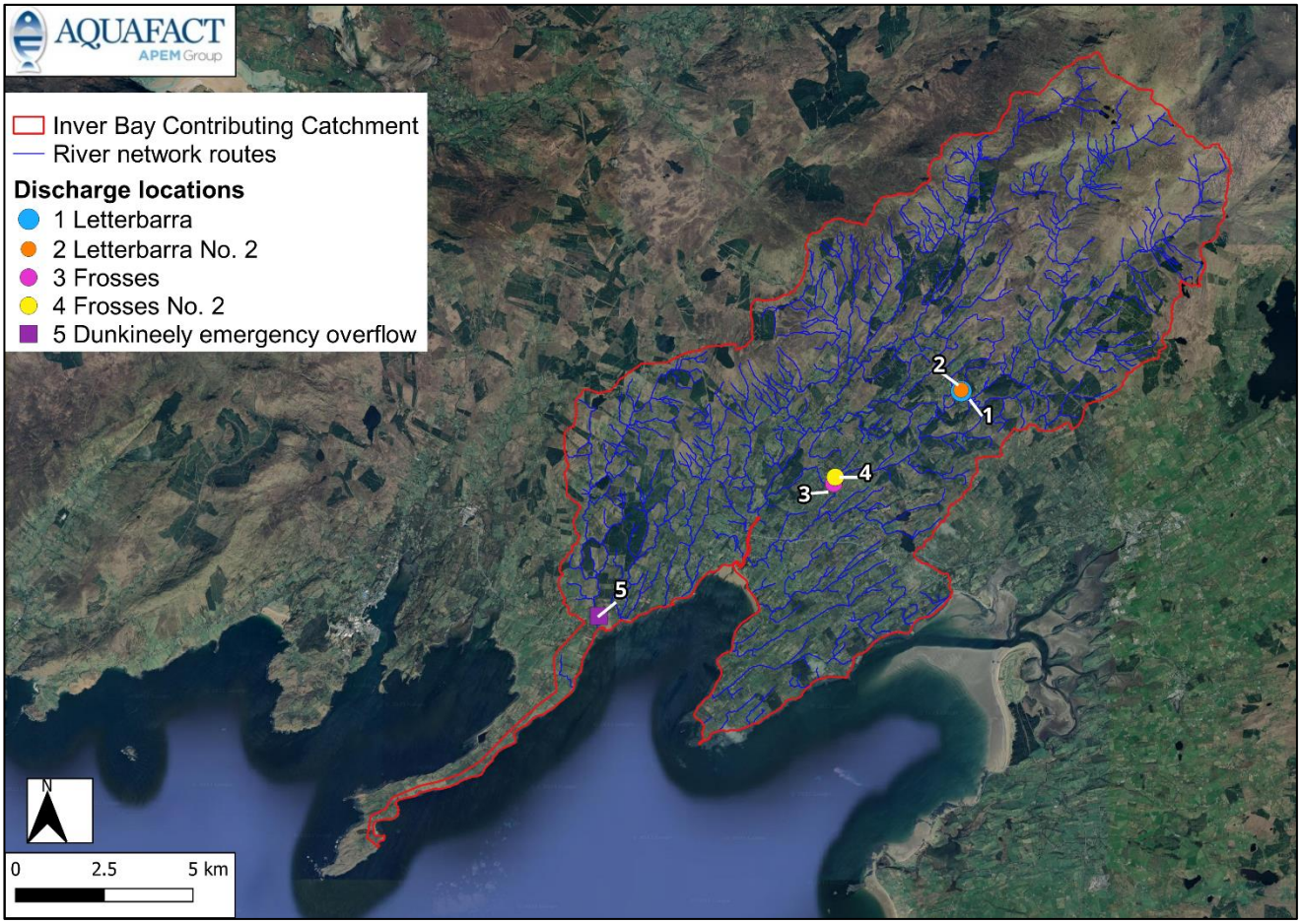


Figure 7-5: Continuous and rainfall dependent discharges associated with the sewage treatment works within Inver Bay contributing catchment (source: EPA[18,19]).

Table 7.4: Continuous discharges within the Inver Bay contributing catchment (source: EPA[18]). Note: coordinate reference system (CRS) for longitude/latitude is WGS84 and CRS for easting/northing is Irish National Grid (ING). Map codes refer to Figure 7-5.

Map code	Name	Treatment	Latitude	Longitude	Easting	Northing	Receiving Body	Max discharge/ day (m^3)	DWF/day (m^3)
1	Letterbarra housing scheme	2 - Secondary Treatment	54.69099193	-7.815726877	188165	382562	Eany Water_010	N/A	N/A
2	Letterbarra No. 2 housing scheme	2 - Secondary Treatment	55.00057457	-7.713480639	181712	417048	Inver-Banagher Hill	N/A	N/A
3	Frosses housing scheme	2 - Secondary Treatment	54.66755695	-7.760117107	184570	379964	Eany Water_020	26.25 m^3	0.0003 m^3
4	Frosses No. 2 housing scheme	2 - Secondary Treatment	54.66913025	-7.760758804	184612	380139	Frosses	N/A	N/A
5	Dunkineely	1 – Primary Treatment	54.62474199	-7.619081398	175444	375238	McSwyne's Bay	N/A	N/A

Table 7.5: Sewage facilities at permanent households in the contributing catchment (CSO[13]).

Electoral Division	Entire ED						Contributing Catchment %					
	Permanent Private Household	Public Sewage Scheme	Individual Septic Tank	Other individual treatment	Other /Not Stated	No sewage facility	Permanent Private Households	Public Sewage Scheme	Individual Septic Tank	Other individual treatment	Other /Not Stated	No sewage facility
An Ghrafaidh	61	0	57	1	2	1	3	0	2	0	0	0
An Bhinn Bhán (Binbane)	70	1	63	5	1	0	49	1	44	4	1	0
Bonnyglen	147	3	127	9	8	0	86	2	75	5	5	0
Corkermore	109	0	96	9	4	0	27	0	23	2	1	0
Donegal	1521	945	457	26	93	0	138	86	41	2	8	0
Dunkineely	343	150	169	12	12	0	71	31	35	2	2	0
Eanymore	212	23	169	12	8	0	212	23	169	12	8	0
Haugh	73	0	67	4	2	0	39	0	36	2	1	0
Inver	277	12	248	14	3	0	270	12	242	14	3	0
Loch Iascaigh (Lough Eask)	56	0	51	3	2	0	20	0	18	1	1	0
Tantallon	603	132	421	34	13	3	551	121	384	31	12	3

7.1.3.3. Rainfall Dependent/Emergency Sewage Discharges

There are no rainfall dependant sewage discharges such as storm water overflows associated with the four WWTPs within the contributing catchment. However, the Dunkineely WWTP, located in the adjacent McSwyne's Bay, has an emergency overflow which discharges into the Bunlacky River waterbody, relatively close to the coastline. As such, the DSW boundary (**Figure 3-2**) is configured to omit the waters in the immediate locality of this discharge. During storm flows in excess of a predetermined flow rate, the excess will bypass the works and flow directly to the outfall via the storm overflow discharge pipes. The details for this intermittent discharge can be seen in **Table 7.6** and its location can be seen in **Figure 7-5**. As detailed in **Table 7.3**, the Dunkineely WWTP is currently operating below capacity.

Table 7.6: Rainfall dependent discharge (emergency overflow) within the Inver Bay contributing catchment (source: EPA[19]). Note: coordinate reference system (CRS) for longitude/latitude is WGS84 and CRS for easting/northing is Irish National Grid (ING). Map code refers to Figure 7-5.

Map code	Name	Discharge point code	Latitude	Longitude	Easting	Northing	Receiving Body
5	Dunkineely	SW-3	54.63371491	-7.657834673	177952	376224	Bunlacky_010

7.1.4. Industrial Discharges

There are no industrial facilities within the contributing catchment that have emissions to water[18]. There is one Section 4 discharge in the contributing catchment, namely Drimkeelan Sandstone Quarry Ltd. located in Drimkeelan, Mountcharles, Co. Donegal, however this discharge has no emissions to water (**Figure 7-6**; **Table 7.7**) [18].

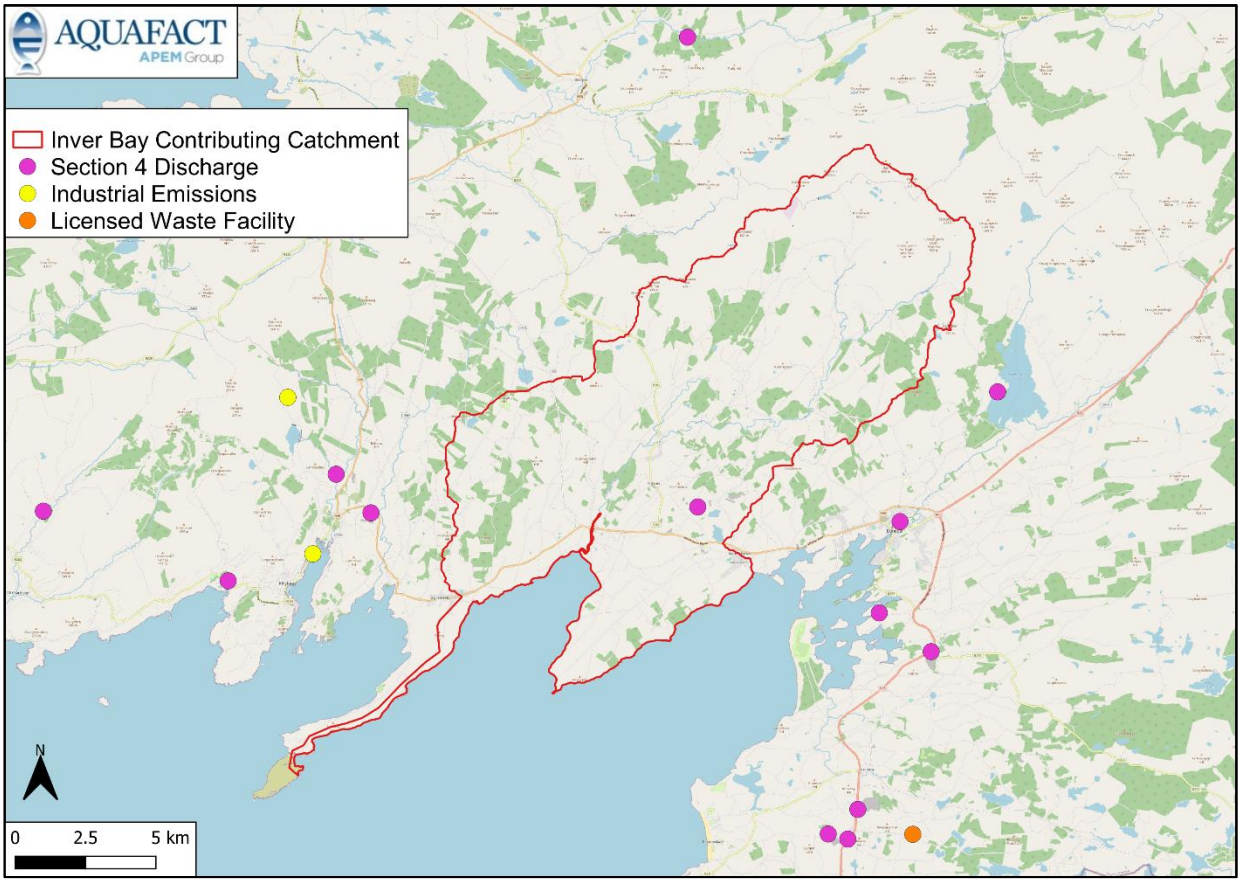


Figure 7-6: Location of industrial discharges in the Inver Bay contributing catchment[18,20].

Table 7.7: Details of the Section 4 discharge within the Inver Bay contributing catchment (EPA[18]; Donegal County Council, 2019). Note: coordinate reference system (CRS) for longitude/latitude is WGS84 and CRS for easting/northing is Irish National Grid (ING). Map code 1 refers to Figure 7-6.

Map Code	File Reference	Licence holder	Type	Discharge (m^3/day)	Longitude	Latitude	Easting	Northing
1	Lwat59	Drimkeelan Sandstone Quarry Ltd.	Quarry	135	-8.21904	54.65904	185976	379365

7.1.5. Land Use Discharges

Figure 7-7 shows the Corine land use[20] within the Inver Bay contributing catchment. **Figure 8-4** shows all river waterbodies within the contributing area. The land use within the contributing catchment is dominated by peat bogs (68.8 km^2, 40.4%), pastures (31.2 km^2, 18.3%), land principally occupied by agriculture (28.2 km^2, 16.5%), coniferous forest (12.2 km^2; 7.2%), transitional woodland/shrub (10.1 km^2; 5.9%), natural grasslands (7.2 km^2, 4.2%), moors and heathland (6.3 km^2, 3.7%), followed by sparsely vegetated areas, discontinuous urban fabric, broad-leaved forest, mixed forest, beaches, dunes, sands, intertidal flats, water bodies, and sea and ocean (**Figure 7-8**).

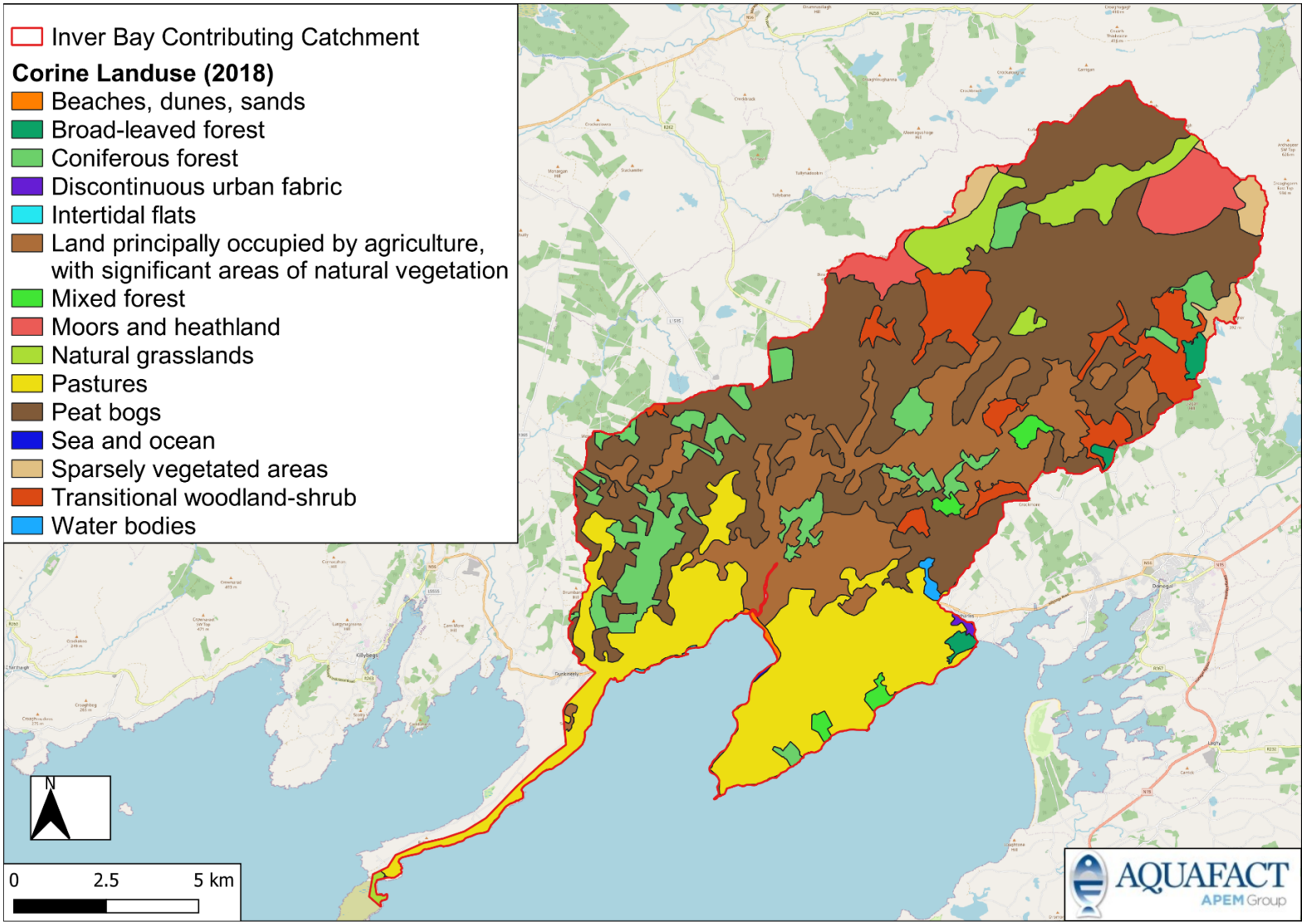


Figure 7-7: Land use within the Inver Bay contributing catchment (source: EPA[20]).

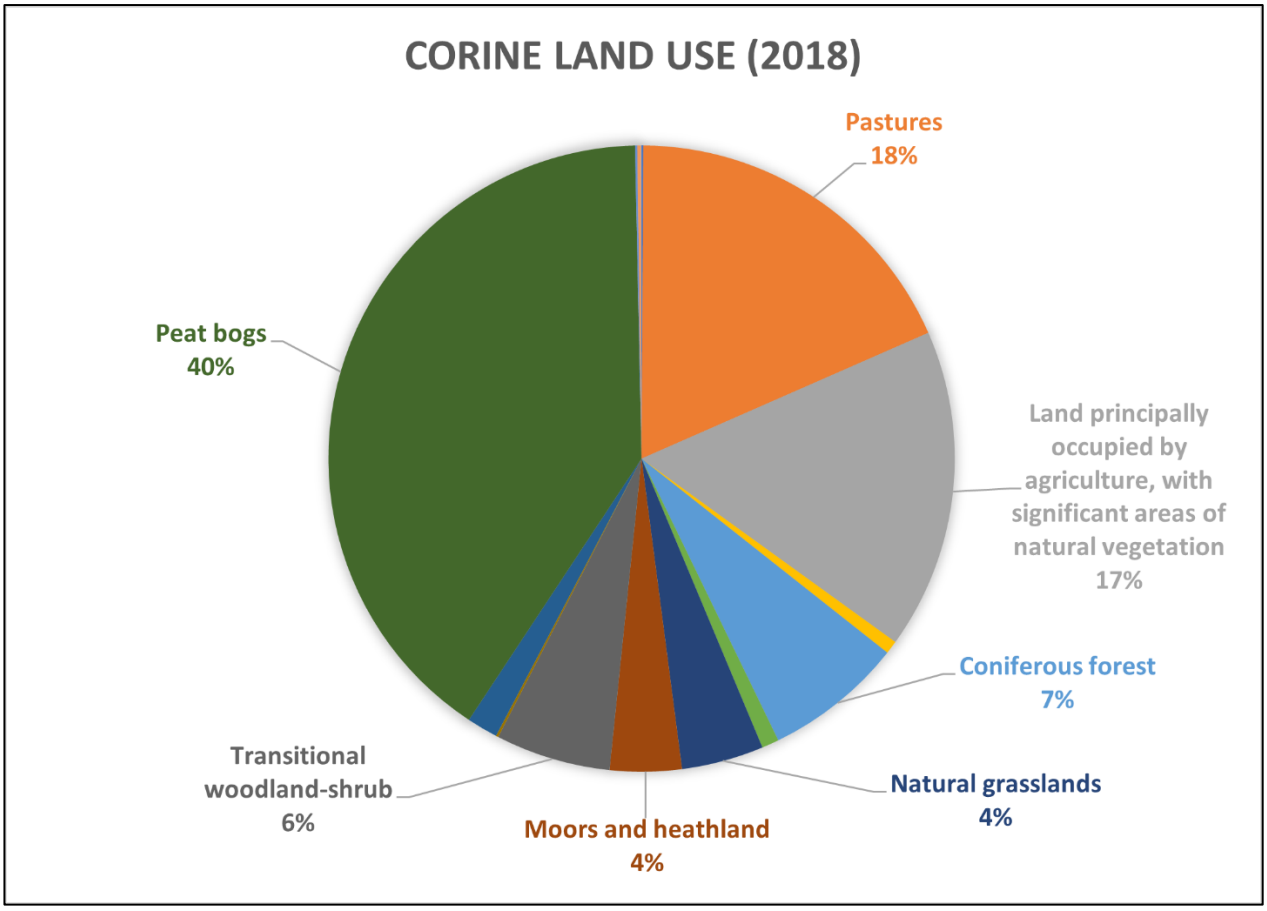


Figure 7-8: Breakdown of Corine land use (2018) within the Inver Bay contributing catchment (percentages have been rounded up and only land use ≥4% are labelled).

Data from the Census of Agriculture 2020[13] can be seen in **Table 7.8** below. **Figure 7-10** to **Figure 7-16** show thematic maps for each category in **Table 7.8**. The number of farms within the EDs in the contributing catchment ranges from 41 in Haugh to 102 in An Ghrafaidh. The total area farmed varies from 998.2 ha in Haugh to 6,488.7 ha in An Ghrafaidh. The total area farmed in the entire EDs shown in **Figure 7-10** to **Figure 7-16** amounts to 23,248.2 ha. However, as most of these EDs only partially overlap the contributing catchment, an attempt was made to estimate the actual area farmed within the contributing catchment. The percentage of the ED lying within the contributing catchment was calculated in QGIS and from this value the area farmed was calculated *e.g.,* if 50% of ED lies within contributing area, then 50% of the area farmed was taken to be the area farmed within the contributing catchment. Using this method, the total area farmed within the contributing catchment is estimated at 9,740.2 ha. This represents 41.9% of the area.

Total grass and rough grazing (combination of total pasture, total silage, total hay, and rough grazing) accounted for almost all of the area farmed, ranging from 995.5 ha in Haugh to 6,485.5 ha in An Ghrafaidh. There was no record of crops growing within any of the EDs.

The total number of cattle within the EDs ranges from 194 in Bonnyglen to 1,376 in Tantallon. The total number of sheep within the EDs ranges from 1,669 in Dunkineely to 13,378 in An Ghrafaidh. There were no horses or dairy cows recorded within the EDs, however the total number of other cows ranges from 78 in Loch Iascaigh (Lough Eask) to 551 in Tantallon.

Statutory Instrument (S.I.) No. 113/2022[21] sets out regulations on the application of slurry and organic fertilisers, notably the method by which it is spread, the amount, the environmental conditions, and required distance from water courses. Low emission slurry spreading equipment is recommended. At the time of writing, data available on slurry spreading from Donegal County Council stipulated spreading can occur between February 1st and October 15th each year[22]. It is noteworthy that limestone bedrock occurs in the Inver Bay contributing catchment due to its highly permeability which provides a pathway for pollutants and land run-off, *e.g.*, slurry, to enter groundwater. The Geological Survey of Ireland groundwater data viewer[23] shows that patches of high to extreme groundwater vulnerability areas occur within the catchment, predominantly on the north to north-western boundary (**Figure 7-9**). These areas of high to extreme vulnerability primarily coincide with peat bogs, but also overlap with pastures and agricultural land. In such areas S.I. No. 113/2022 states that "soiled water"[24] cannot be spread on land if the quantity exceeds 25,000 L/hectare in a 42-day period or at an irrigation rate > 3 mm/hr on land of thickness < 1 m. While the levels of slurry and soiled water spreading were not readily available for the Inver Bay contributing catchment at the time of writing, that 34.8% of the land is comprised of pastures and agricultural land gives an indication of the potential levels of spreading in the vicinity and potential discharge levels to groundwater and, subsequently, the DSW in the bay.

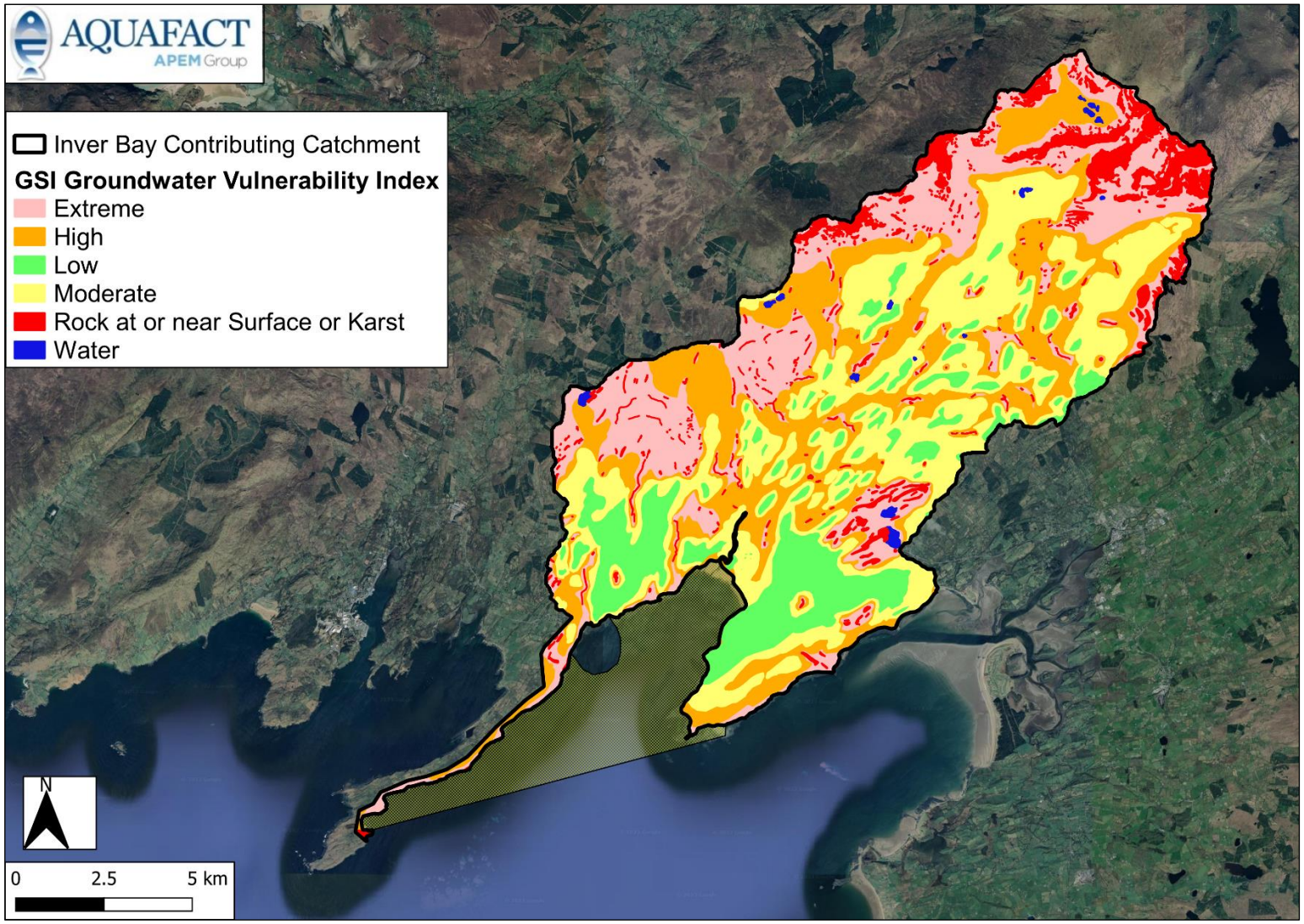


Figure 7-9: GSI Groundwater vulnerability within the Inver Bay contributing catchment. Contains Irish Public Sector Data (Geological Survey Ireland) licensed under a Creative Commons Attribution 4.0 International (CC BY 4.0) licence[23].

Table 7.8: Farm census data for all EDs within the Inver Bay Catchment Area (source: CSO[13]).

ED Name	No. Farms	Area Farmed (ha)	Avg. Farm Size (ha)	Total Grass & Rough Grazing (ha)*	Cattle	Sheep	Non-dairy cows
An Ghrafaidh	102	6488.7	63.6	6485.5	215	13378	85
An Bhinn Bhán (Binbane)	72	2976.5	41.3	2976.4	205	7394	91
Bonnyglen	48	1415	29.5	1404.8	194	2728	88
Corkermore	46	1419.3	30.9	1418.9	407	3642	191
Donegal	76	1678.5	22.1	1675.4	1010	2765	413
Dunkineely	49	1193.1	24.3	1190.7	579	1669	206
Eanymore	74	1521	20.6	1520.9	379	3378	168
Haugh	41	998.2	24.3	995.5	325	3069	113
Inver	66	1249.7	18.9	1246.4	584	2556	237
Loch Iascaigh (Lough Eask)	44	2512.4	57.1	2512.4	243	5995	78
Tantallon	100	1795.8	18	1766	1376	2578	551

* Total Grass and Rough Grazing was taken to be the sum of Total Pasture, Total Silage, Total Hay, and Rough Grazing.

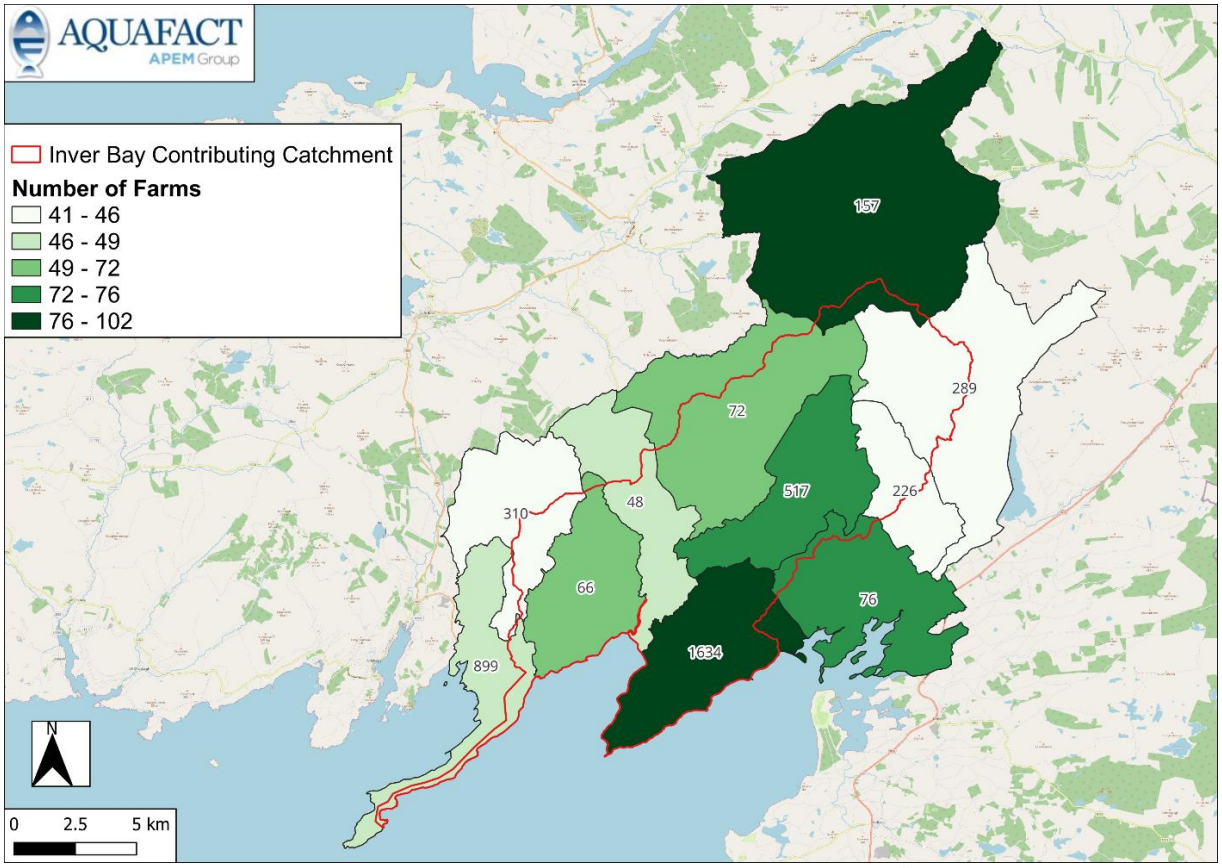


Figure 7-10: Number of farms within the Inver Bay Catchment Area (source: CSO[13]).

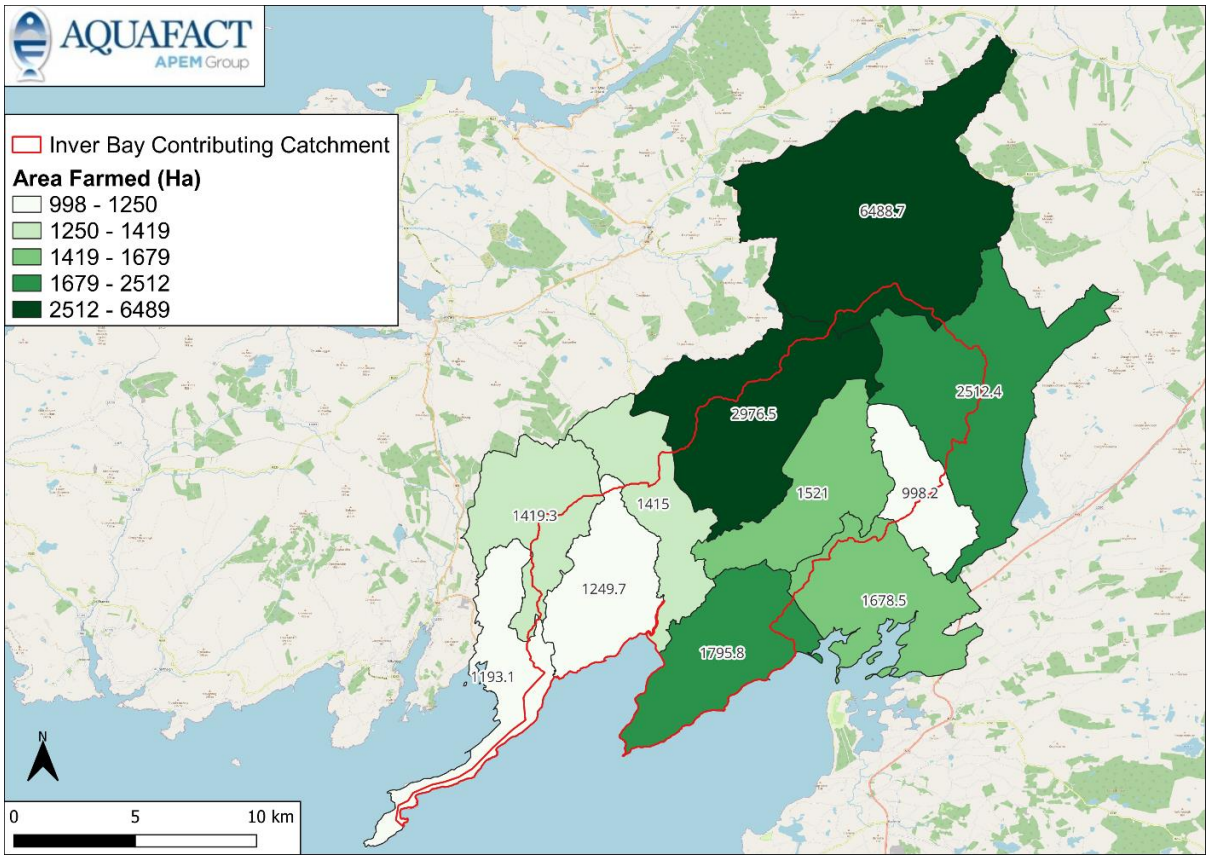


Figure 7-11: Area farmed (Ha) within the Inver Bay contributing catchment area (source: CSO[13]).

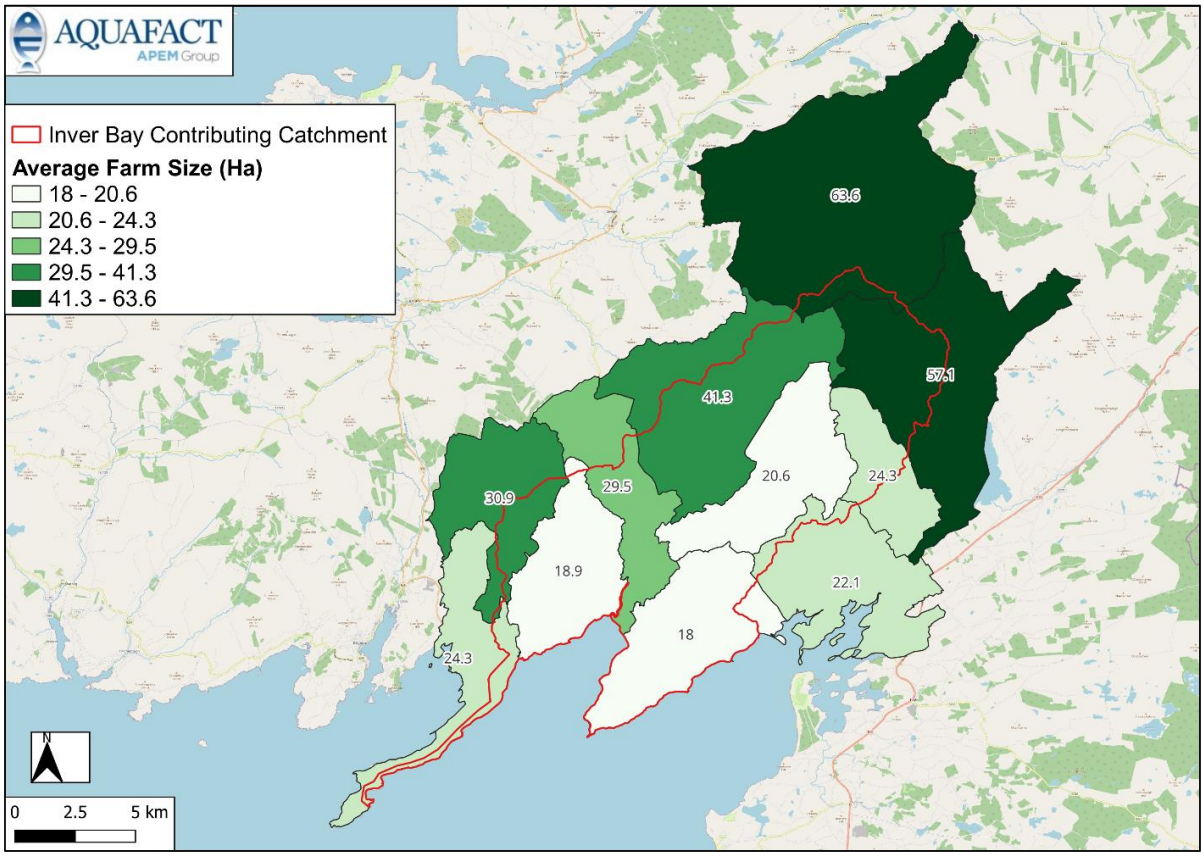


Figure 7-12: Average farm size (ha) within the Inver Bay contributing catchment area (source: CSO[13]).

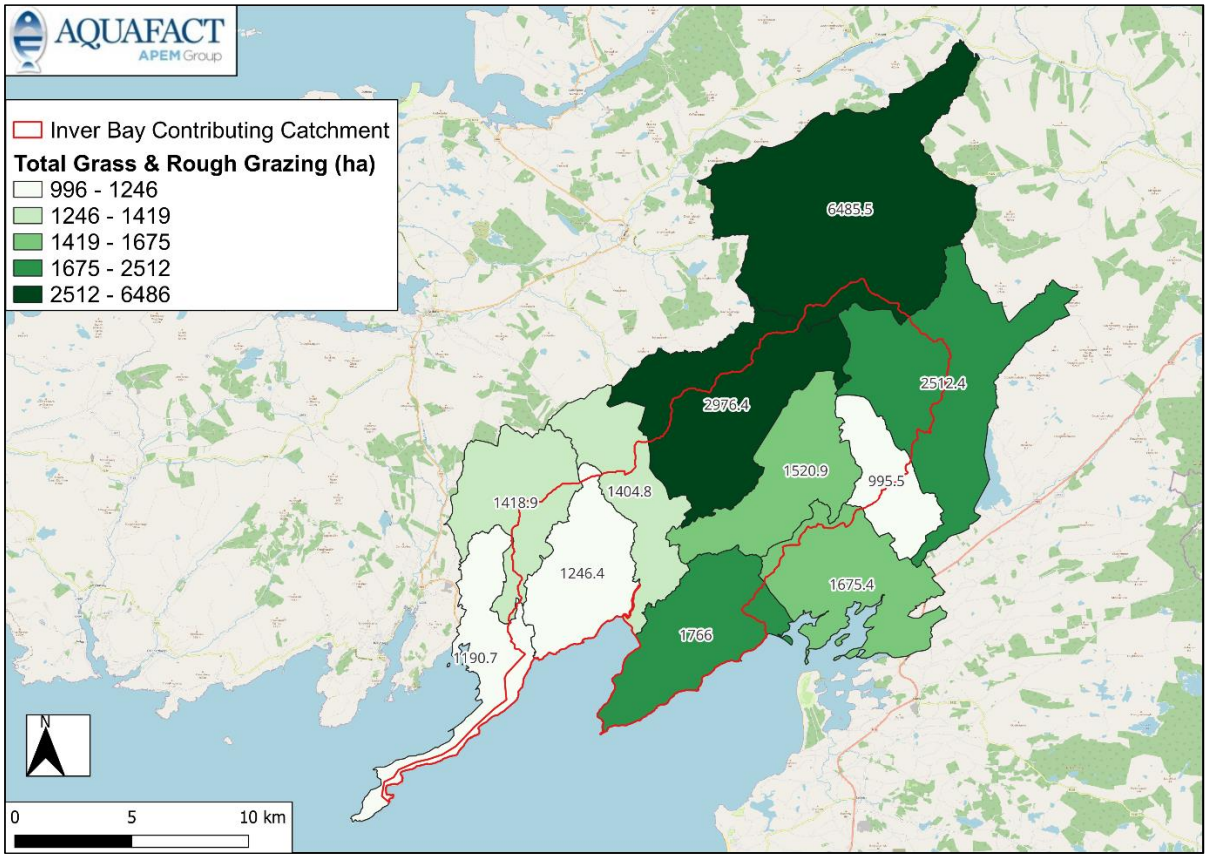


Figure 7-13: Total grass and rough grazing area (ha) within the Inver Bay contributing catchment area (source: CSO[13]).

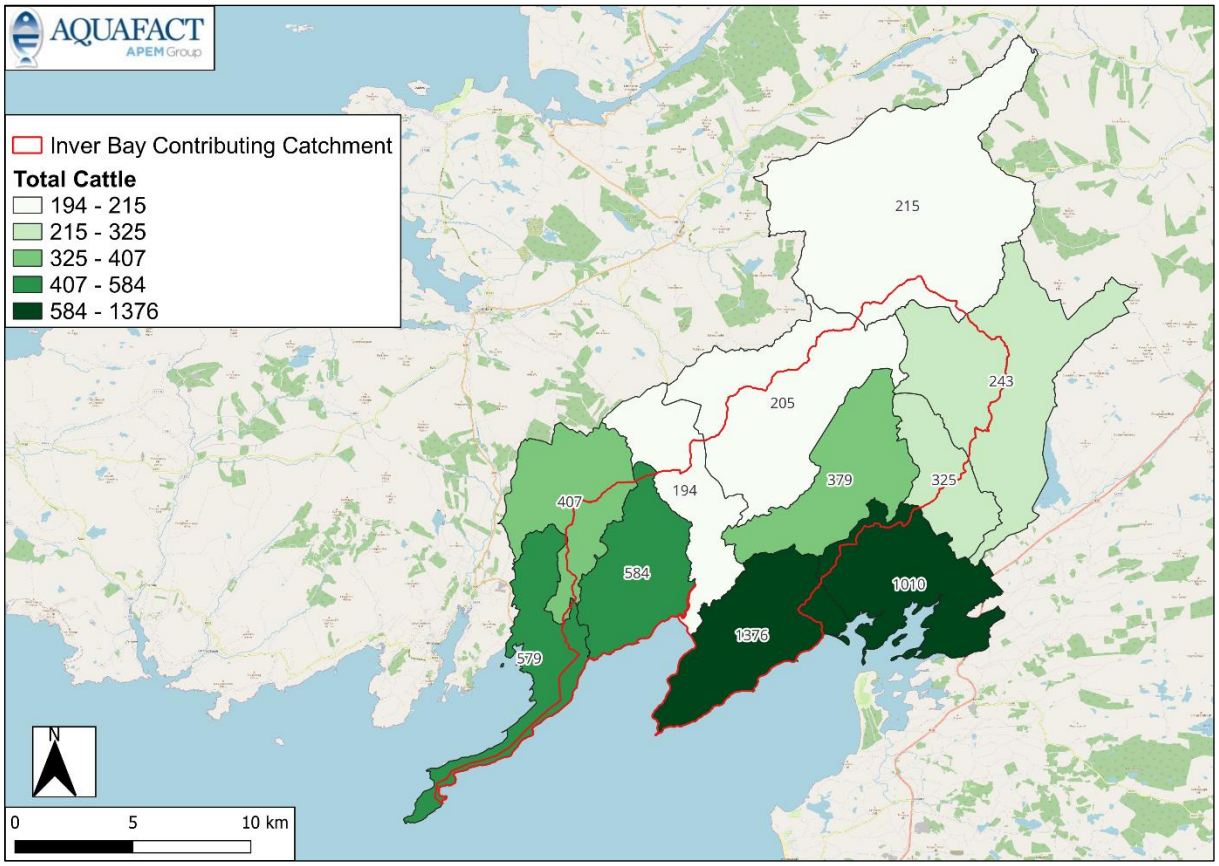


Figure 7-14: Cattle within the Inver Bay contributing catchment area (source: CSO[13]).

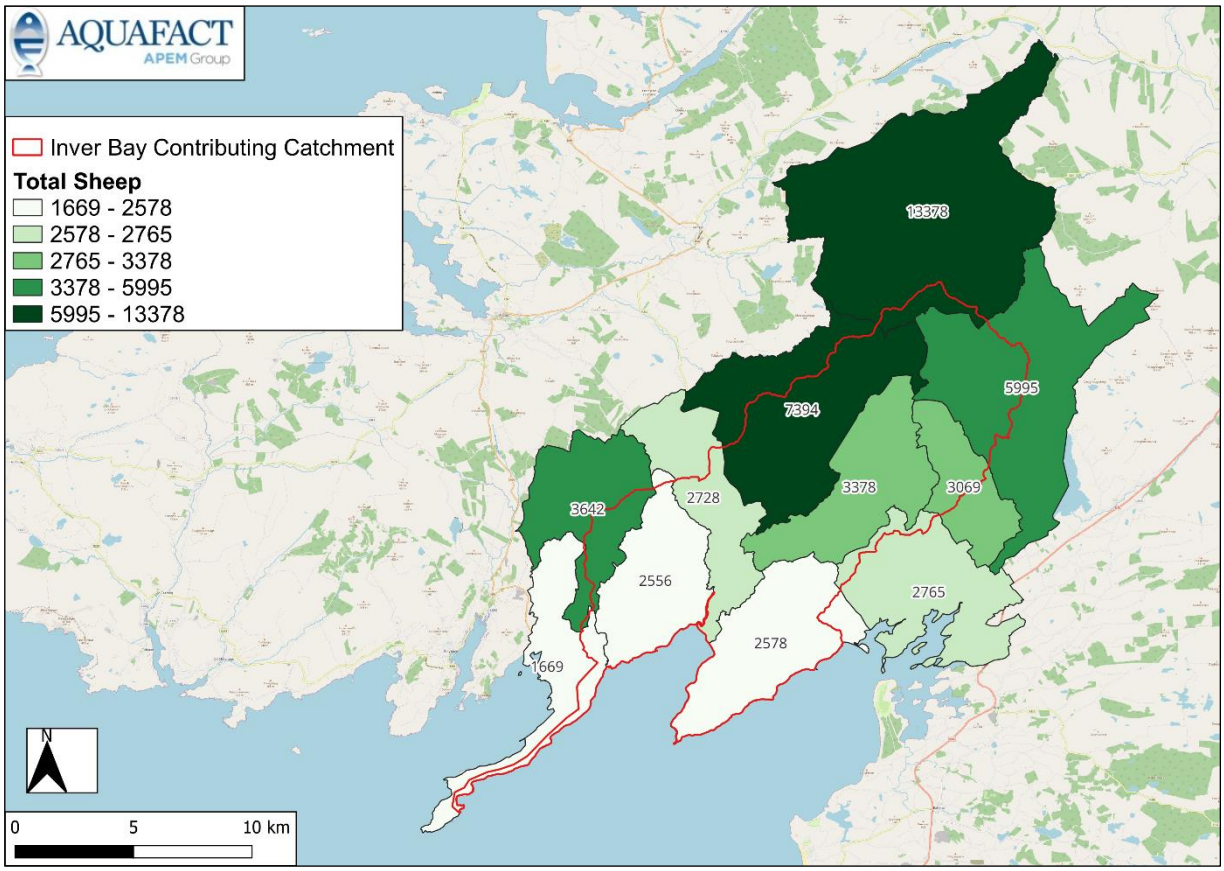


Figure 7-15: Sheep within the Inver Bay contributing catchment area (source: CSO[13]).

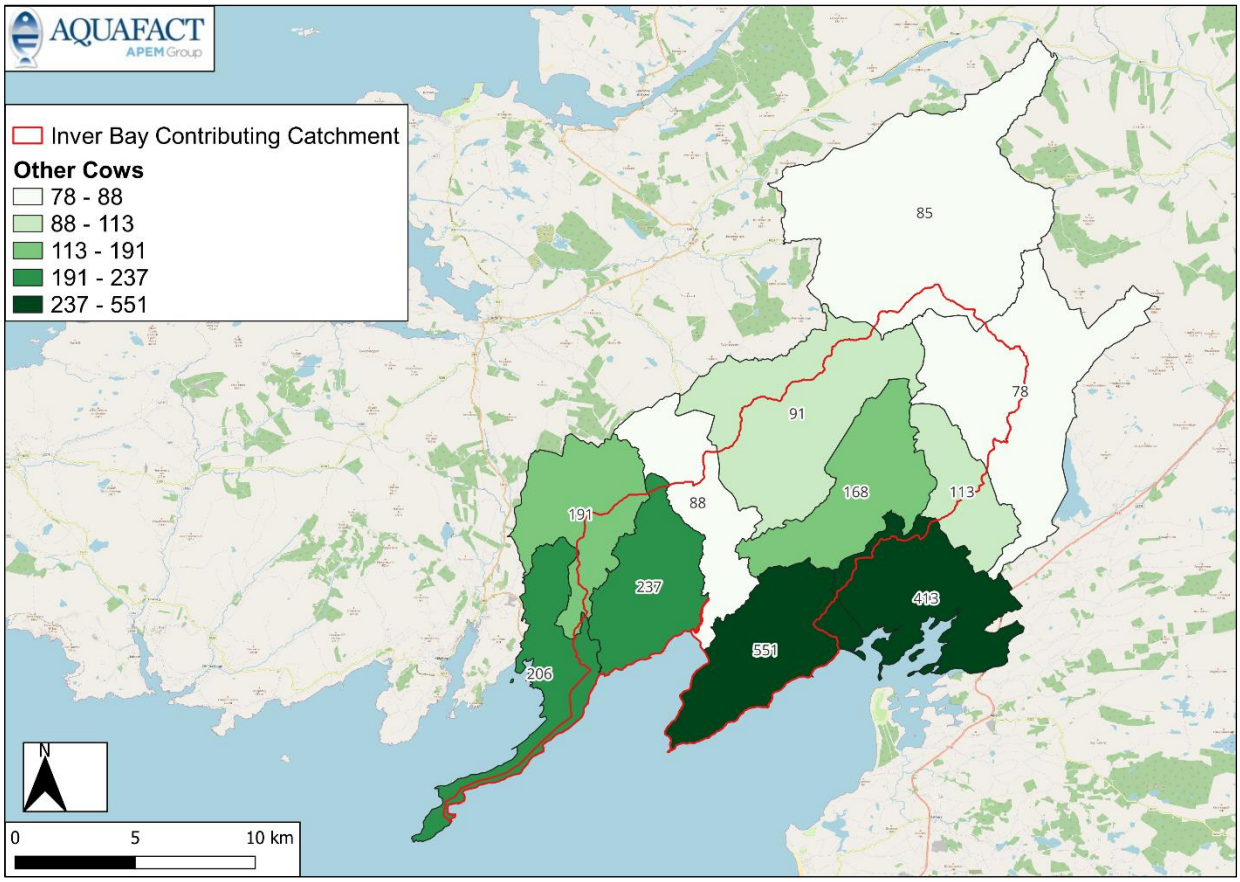


Figure 7-16: Other cows within the Inver Bay contributing catchment area (source: CSO[13]).

A number of studies have reported a strong association between intensive livestock farming areas and faecal indicator concentrations of microorganisms in streams and coastal waters due to run-off from manure, especially during high flow conditions, both from point and non-point sources of contamination (*e.g.,* Crowther *et al.,* 2002). **Table 7.9** shows the potential daily loading of *E. coli* from livestock (compared to humans and birds). It can be seen that sheep rank the worst based on the average number of *E. coli* per gram of faecal production, followed by pigs, cows, birds, humans, and poultry.

Table 7.9: Potential daily loading of *E. coli* (Jones & White, 1984).

Source	Faecal Production (g/day)	Average Number (*E. coli*/g)	Daily Load (*E. coli*)	Rank
Man	150	13×10^6	1.9×10^9	5
Cow	23600	0.23×10^6	5.4×10^9	3
Sheep	1130	16×10^6	18.1×10^9	1
Chicken	182	1.3×10^6	0.24×10^9	6
Pig	2700	3.3×10^6	8.9×10^9	2
Gull	15.3	131.2×10^6	2×10^9	4

The largest majority of livestock in the area are sheep (49,152). Cattle are also present but in lower numbers (5,517). The majority of agricultural land use in the area is total grass and rough grazing. Sheep are present in relatively large numbers throughout with the highest numbers in the northeast in An Ghrafaidh ED, while the highest numbers of cattle are present more south-easterly in Tantallon although still in small numbers by comparison. Sheep numbers would be expected to increase in spring following the birth of lambs and decrease in the autumn as they are sent to market. Therefore, larger quantities of livestock droppings will be deposited during this period, though it may not impact the fishery until washed into the sea during and/or after periods of rainfall unless deposited directly on the shoreline.

7.1.6. Other Pollution Sources

7.1.6.1. Shipping

Operational waste from vessels, if not properly managed, can end up in the sea where the potential for contamination or pollution occurs. Wastes generated or landed in ports and harbours can be broadly divided into a) operational and domestic waste from ships and boats, b) waste from commercial cargo activities and c) wastes generated from maintenance activities and associated maritime industry activities.

Marpol Annex IV defines sewage as “drainage from medical premises, toilets, urinals, spaces containing live animals and other waste waters when mixed with sewage waste streams”. Although adopted in 1973, the Annex did not come into effect internationally until September 2003, with subsequent amendments entered into force in August 2005. Annex IV requires ships to be equipped with either a sewage treatment plant, a sewage comminuting and disinfecting system or a sewage holding tank. Within 3 miles of shore, Annex IV requires that sewage discharges be treated by a certified Marine Sanitation Device (MSD) prior to discharge into the ocean. Sewage discharges made between 3 and 12 miles off shore must be treated by no less than maceration and chlorination and sewage discharged greater than 12 miles from shore are unrestricted. Annex IV also established certain sewage reception facility standards and responsibilities for ports and contracting parties.

Ship sewage originates from water-borne human waste, wastewaters generated in preparing food, washing dishes, laundries, showers, toilets, and medical facilities. However, as waste enters the marine environment from many sources, it makes the identification of specific impacts from ship/boat waste very difficult. It is widely recognised that the majority of pollution entering the marine environment comes from land-based sources and atmospheric inputs from land-based industrial activities, with only an estimated 12% originating from shipping activities (GESAMP [Joint Group of Experts on the Scientific Aspects of Marine environmental Pollution], 1990).

Figure 7-17 shows all boat facilities and activities, namely slipways, piers and ports within the Inver Bay contributing catchment; **Table 7.10** details these facilities. Inver Port is the only commercial port in Inver Bay (**Figure 7-17**, map ID 8); there are no ferries operating in the bay (Donegal County Council[22]). There were eight slipways/piers noted from the desktop survey within Inver Bay: The Docks beside St. John's Point, Cassan Sound, Ballysaggart Pier, Ballyederland, Port Pier, Buncronan Port, and two unlabelled slipways/piers. Buncronan Port and Unnamed Slip/Pier B are located along the southeastern shoreline, the remainder are located along the western shoreline. However, the shoreline survey only verified four of these piers/slipways in Inver Bay, namely Ballyederland, Port Pier, Inver Port, and unnamed slipway/pier (**Figure 7-17**; map ID 5, 6, 8, and 10, respectively). These four piers/slipways correspond to map ID 1, 17, 10, and 13, respectively, in **Figure 7-18** .

The piers/slipways noted during both the desktop and shoreline surveys are small piers/slipways used commercially by inshore fishing boats and also by vessels engaged in the salmon farming industry. Additionally, at the most south-westerly point within the catchment there is a fishing location (**Figure 7-17**, map ID 1), Heelin Port, at St. John's Point Beach (Angling Ireland[25]). Boat activity in the bay is expected to be low and mostly made up of small fishing craft and fish farm service boats.

While data on sewage discharge levels from boating activities in the area were not available at the time of writing, it is unlikely that pollution occurs; the disposal of sewage at sea governed by S.I. No. 492/2012 ensures this. Therefore, it is highly unlikely that any vessels in the area would have any negative impacts on the water quality.

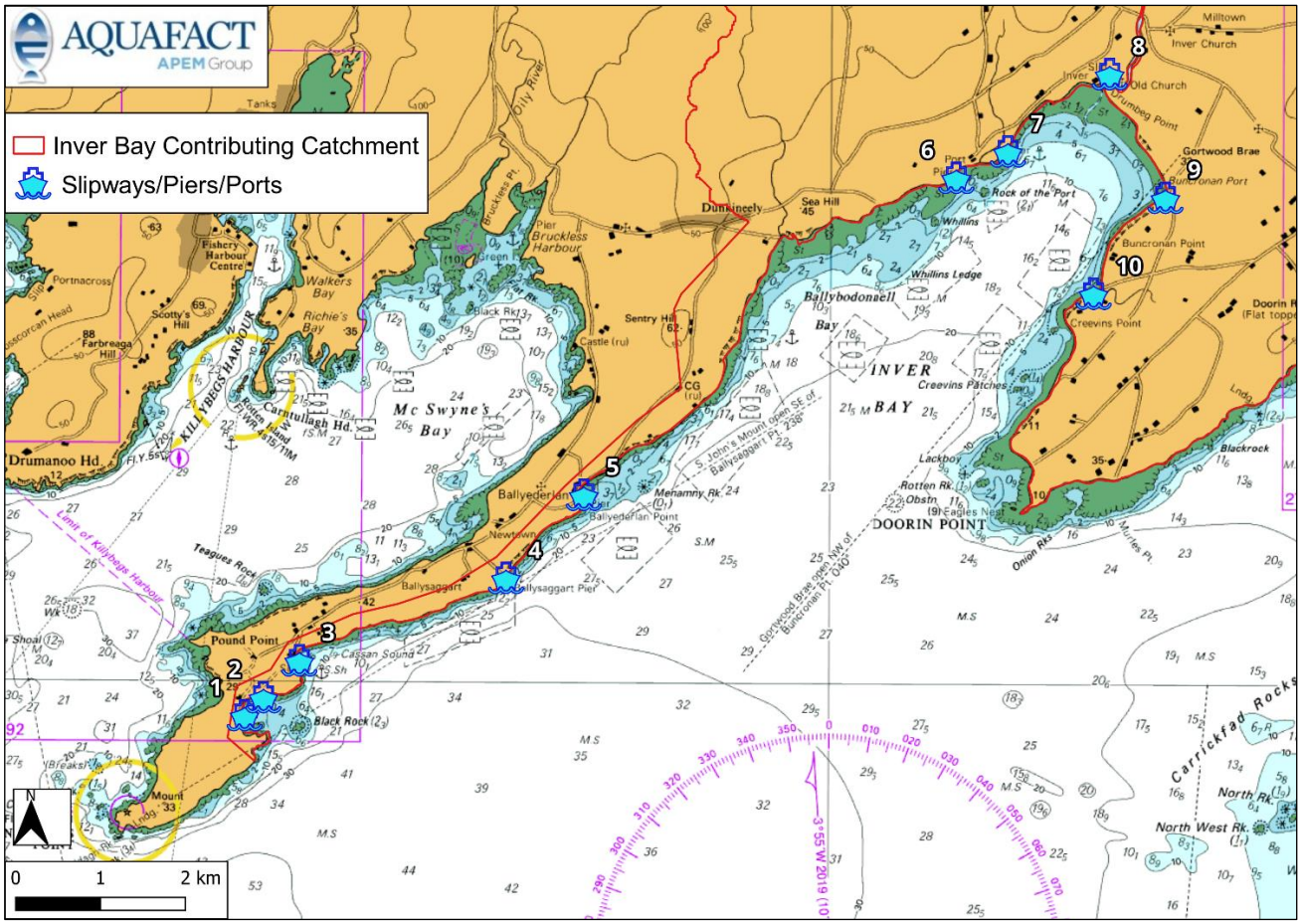


Figure 7-17: Location of all slipways, piers and ports that allow for boating facilities and activities within the Inver Bay contributing catchment.

Table 7.10: Boating facilities within the Inver Bay contributing catchment (source: Donegal County Council[22]). Map codes refer to Figure 7-17.

Map Code	Feature	Name
1	Fishing point	St. John's Point/Heelin Port
2	Slip/Pier	The Docks
3	Slip/Pier	Cassan Sound
4	Slip/Pier	Ballysaggart
5	Slip/Pier	Ballyederlan
6	Slip/Pier	Port Pier
7	Slip/Pier	Unnamed Slip/Pier A
8	Port	Inver Port
9	Slip/Pier	Buncronan Port
10	Slip/Pier	Unnamed Slip/Pier B

7.1.6.2. Wildlife

Birds

It is important to document the bird populations in the Inver Bay area as bird faeces are rich in faecal bacteria (Oshira & Fujioka, 1995) and have been shown to be a source of faecal contamination in the marine environment (Jones *et al.,* 1978; Standridge *et al.,* 1979; Levesque *et al.,* 1993, Alderisio & DeLuca 1999, Levesque *et al.,* 2000, Ishii *et al.,* 2007).

There is minimal overlap between Lough Nillan Bog SPA and the northern boundary of Inver Bay contributing catchment (<0.5%). Donegal Bay SPA borders the southern boundary of the contributing catchment, while Durnesh Lough SPA is located adjacent to Donegal Bay SPA.

Lough Nillan Bog SPA is located south of Glenties, Co. Donegal. The site is comprised of blanket bog, wet heath, lakes, rivers and streams, with varying topography. The site is an SPA under the EU Birds Directive, of special conservation interest for the following species: Greenland White-fronted Goose, Merlin, Golden Plover and Dunlin. There have been 16 nesting pairs of Golden Plover recorded at the site (in 2002) and 53 visits by the Greenland White-fronted Goose (in 1999/2000)[3].

Donegal Bay SPA is a large marine-dominated site, extending from Doorin Point, Co. Donegal approximately 15 km to Tullaghan Point, Co. Leitrim. The site is an SPA under the E.U. Birds Directive, of special conservation interest for the following species: Great Northern Diver (138), Light-bellied Brent Goose (207), Common Scoter (860) and Sanderling (68). The E.U. Birds Directive pays particular attention to wetlands, and as these form part of this SPA, the site and its associated waterbirds are of special conservation interest for Wetland and Waterbirds. A number of other bird species associated with the estuarine and shoreline habitats at the site include Cormorant (29), Shelduck (24), Wigeon (224), Mallard (100), Long-tailed Duck (14), Red-breasted Merganser (38), Oystercatcher (581), Ringed Plover (99), Golden Plover (103), Lapwing (122), Dunlin (269), Bar-tailed Godwit (49), Curlew (359), Redshank (93), Greenshank (12) and Turnstone (53). In autumn and winter Black-headed Gull (239) and Common Gull (297) occur regularly. This site also supports populations of Black-throated Diver (11) and Red-throated Diver (21). Oceanic species such as Gannet, Fulmar, Manx, Sooty, Great and Cory's Shearwater, Storm Petrel also occur in the bay. Note that all figures are mean peak counts for four of the five winters between 1995/96 and 1999/2000[3].

Durnesh Lough SPA is situated to the east of Rossnowlagh on the southern side of Donegal Bay, *c.* 10 km north of Ballyshannon in Co. Donegal. It is a large sedimentary lagoon which is separated from the sea by a barrier composed partly of drumlins and partly of high sand dunes, with the remains of a

cobble barrier occurring in places. The site is an SPA under the E.U. Birds Directive, of special conservation interest for the following species: Whooper Swan and Greenland White-fronted Goose. The site is an important wintering and staging area for Whooper Swan (140 – 5-year mean peak from 1995/96-1999/2000) and internationally important numbers have been recorded at the site; 400 being the highest number in 1966. Durnesh Lough SPA is a regular feeding site for Greenland White-fronted Goose (86 – 4-year mean peak from 2003/04-2008/09). Other bird species that have been recorded at the site are Wigeon (56), Teal (19), Pochard (97), Tufted Duck (43), Goldeneye (42), Scaup (18) and Coot (15) – all figures are mean peaks for 4 of the 5 winters between 1995/96 and 1999/2000[3].

Aquatic mammals

Harbour seal (*Phoca vitulina)* habitat occurs directly adjacent to the Inver Bay contributing catchment, along the south-eastern boundary, as part of Donegal Bay (Murvagh) SAC. A number of breeding, moulting, and resting sites for harbour seals are located here too[10]. Harbour seals have been recorded within Inver Bay; 20 individuals were sighted at St. John's Point in 2011. A number of sightings have also been recorded in the adjacent McSwyne's and Donegal Bays[26]. Grey seals (*Halichoerus grypus*) have been recorded within Inver Bay and surrounding waters, however, only individuals or small groups have been recorded and no haul-out sites are listed[26].

Numerous records of otter (*Lutra lutra*) droppings and a few sightings of individuals have been logged on the NBDC database, with a count in 1980 of 19 droppings being the largest[26]. Multiple pods of bottlenose dolphin (*Tursiops truncatus*) have been sighted in Inver Bay and its surrounding waters; the largest pod recorded within Inver Bay was comprised of 20 individuals[26]. Up to 10 individuals of common porpoise (*Phocoena phocoena*) have been recorded in one sighting in Inver Bay[26]. The aforementioned aquatic mammals have a national distribution on all Irish coastlines.

No estimates of the volumes of seal faeces are available although it is reasonable to assume that what is ingested and not assimilated in the gut must pass. The concentration of *E. coli* and other faecal indicator bacteria contained in seal faeces has been reported as being similar to that found in raw sewage, with counts showing up to 1.21 x 104 cfu *E. coli* per gram dry weight of faeces (Lisle *et al.,* 2004). *Salmonella* and *Campylobacter* spp. have also been found in wild seals (Stoddard *et al.,* 2005).

All aquatic mammals that occur within the Inver Bay contributing catchment area are likely to contribute to background levels of faecal contamination within the area particularly during the haul-out periods.

7.2. Shoreline Survey

7.2.1. Shoreline Survey Report

A shoreline survey was carried out by the Sea Fisheries Protection Authority. **Figure 7-18** shows the GPS (Global Positioning System) locations of 29 sites which were photographed over three survey days between July and October 2022. All of the Inver Bay shoreline was walked where practical.

The aim of this shoreline survey was to identify/confirm and mark all discharges, pollution sources, waterways, and marinas along the shoreline. GPS coordinates were recorded for all features and marked on a map. In addition, all features were photographed digitally (where possible). Notes were made on the numbers and types of farm animals obvious from the shoreline and on wild fowl/populations of wild animals with an estimation of their numbers.

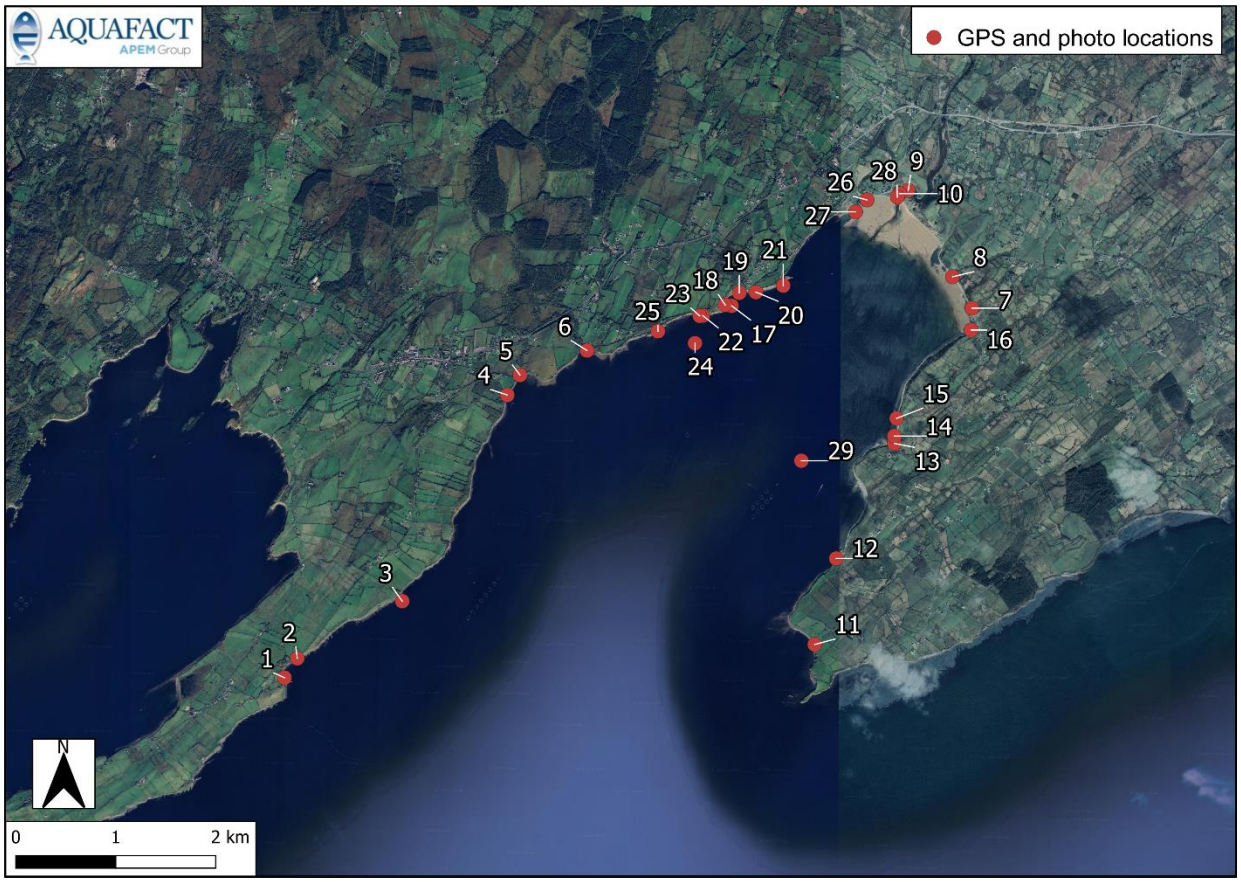


Figure 7-18: Locations of GPS and photograph sites from the shoreline survey (numbering cross-referenced to Table 7.11).

Figure 7-18 shows the locations of all features observed during the shoreline survey. In total 29 features were identified (see **Appendix 4**: Shoreline Survey Images), of which seven rivers/streams were identified, in excess of 14 drains/pipes, one culvert, four piers, one location with four sheep and three locations with fish

farms. **Figure 7-19** to **Figure 7-27** show aerial imagery of the location of these features. **Table 7.11** details all features identified, and the numbering used is cross-referenced to **Figure 7-19** to **Figure 7-27**.

Table 7.11: Features identified during the shoreline survey. Latitude and longitude values are in coordinate reference system (CRS) WGS84, easting and northing values are in CRS Irish Transverse Mercator (https://www.fieldenmaps.info/cconv/cconv_ie.html). Refer to Figure 7-19 to Figure 7-27 for locations and Appendix 4 for photographs.

Map ID	Observation	Comments	Latitude	Longitude	Easting	Northing
1	Pier	Ballyederland pier. Two small punts. No other boats.	54.60338	-8.37851	575543.7	872856.5
2	Sheep	Four sheep on the shore.	54.60513	-8.37654	575672.0	873050.6
3	Fish farm	12 cage salmon farm.	54.61031	-8.36035	576721.0	873621.6
4	Drain	Field drain, *Enteromorpha* algae evident on rocks below.	54.62887	-8.34423	577772.5	875682.1
5	River	Bunlacky River. Small river. Abundance of *Enteromorpha* algae at mouth of river.	54.63067	-8.34229	577898.7	875881.8
6	Stream	*Enteromorpha* algae. Good flow.	54.6329	-8.33193	578568.8	876126.8
7	Stream	Light flow, coming through rough grazing ground. *Enteromorpha* algae evident on shore.	54.63685	-8.27234	582418.0	876549.8
8	Drain	Field drain. Light flow of water, through rough grazing ground.	54.63966	-8.27536	582224.2	876863.3
9	River	River Eany, good flow. Drains mixed catchment.	54.6474	-8.28228	581781.0	877726.5
10	Pier	Small pier. Three small boats moored alongside.	54.64711	-8.2836	581695.6	877694.6
11	Drain	Field drain. No flow, dry. Flowing along rough grazing field boundary.	54.60659	-8.29648	580845.3	873188.3
12	Stream	Low flow, flowing through rough grazing fields. *Enteromorpha* algae evident on shore.	54.61432	-8.2932	581060.8	874047.7
13	Pier	Slipway, used by salmon farm operators. No boats present.	54.62468	-8.28428	581641.7	875198.4
14	Stream	Low flow. Coming through mixed rough fields/scrubland. *Enteromorpha* algae evident where stream hits the shore.	54.62534	-8.28428	581642.0	875271.9
15	Drain	Large bore pipe with flap, likely field drain. Trickle of a flow, some green algae noted.	54.62693	-8.28393	581665.3	875448.7

16	Drain	Likely field drain. Low flow. Some algae noted at mouth on shore.	54.63488	-8.27245	582410.0	876330.6
17	Pier	Pier. Six/seven open style fishing boats.	54.63697	-8.30956	580015.1	876573.1
18	Pipes	Pipes x 2. No flow. Likely surface from road/pier above	54.63704	-8.31055	579951.3	876581.2
19	Culvert	Culvert, good flow of water. Lot of *Enteromorpha* algae and moss. Flowing through mixed scrub/residential area.	54.63814	-8.30838	580091.9	876703.0
20	Stream	Good flow of water. Clear. Flowing through mixed scrub/rough grazing.	54.63821	-8.30581	580257.8	876710.1
21	Pipes	Pipes x numerous. Surface water from hard surface above associated with pier and commercial buildings.	54.6388	-8.30158	580531.2	876774.6
22	Drain	Field drain, good flow. Flowing though area of rough pasture.	54.63608	-8.31402	579726.8	876475.4
23	Drain	Field drain, medium flow. Flowing though area of rough pasture.	54.63606	-8.3145	579695.8	876473.3
24	Fish Farm	Salmon farm.	54.6336	-8.31521	579648.7	876199.7
25	Drain	Field drain coming off cliff/hill face. Steady flow. Coming through area of rough grazing.	54.63466	-8.32096	579278.0	876319.3
26	Pipes	Grated pipes. Steady flow. A lot of green moss and algae visible at mouth of water outlet. Flowing through residential and rough grazing.	54.64653	-8.28866	581368.8	877631.4
27	Pipes	Numerous. Not flowing. Surface water run off pipes from hard road surface behind.	54.64546	-8.29042	581254.7	877512.8
28	Pipe	Large bore grey pipe. No flow.	54.6468	-8.28396	581672.3	877660.2
29	Fish Farm	Salmon farm. Boat also.	54.62309	-8.29866	580712.3	875025.3

Figure 7-19: Features 1-3 identified during the shoreline survey (numbering cross-reference to Table 7.11).

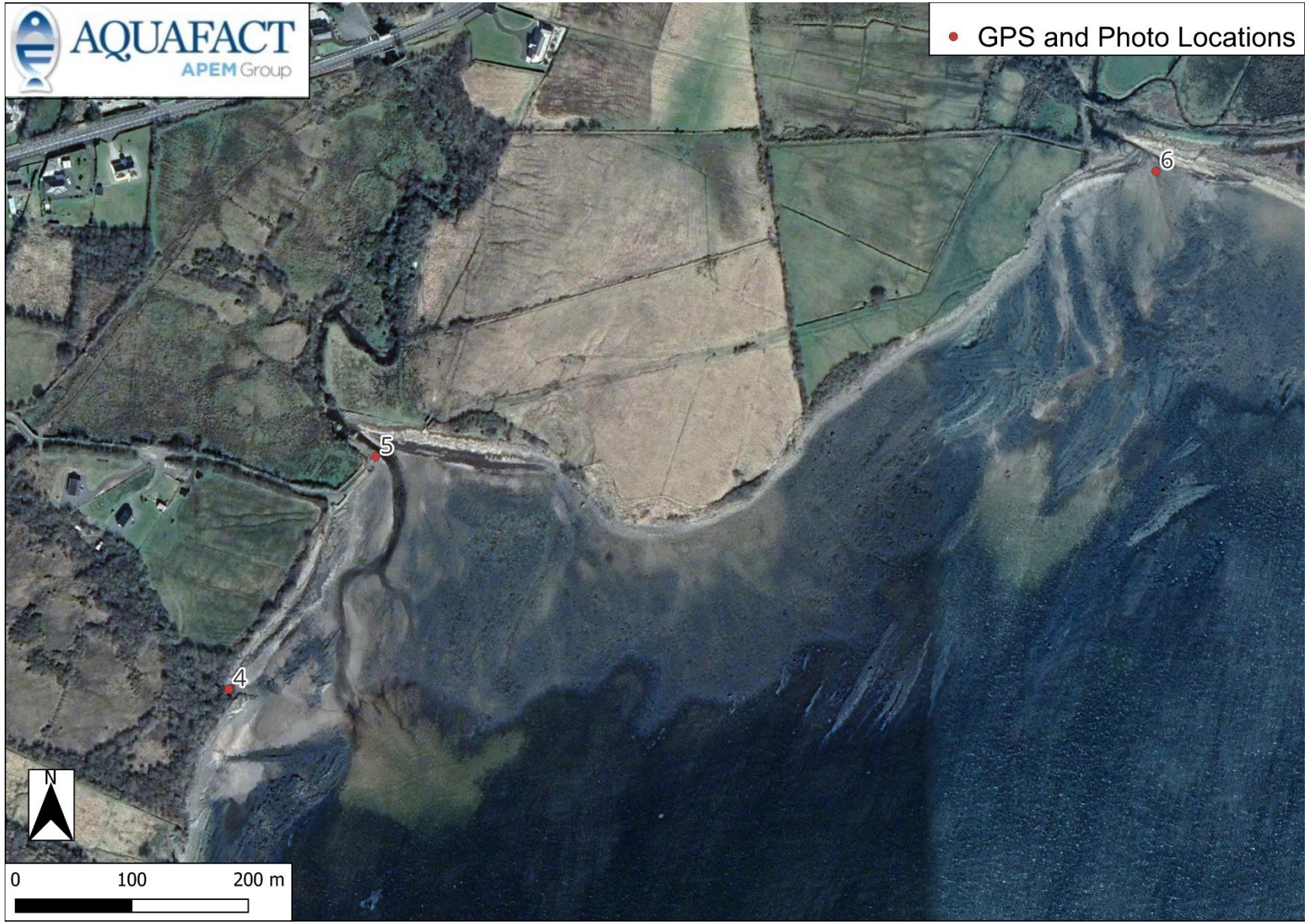


Figure 7-20: Features 4-6 identified during the shoreline survey (numbering cross-reference to Table 7.11).

Figure 7-21: Features 7-8 and 16 identified during the shoreline survey (numbering cross-reference to Table 7.11).

Figure 7-22: Features 9-10 and 26-28 identified during the shoreline survey (numbering cross-reference to Table 7.11).

Figure 7-23: Features 11-12 identified during the shoreline survey (numbering cross-reference to Table 7.11).

Figure 7-24: Features 13-15 identified during the shoreline survey (numbering cross-reference to Table 7.11).

Figure 7-25: Features 17-21 identified during the shoreline survey (numbering cross-reference to Table 7.11).

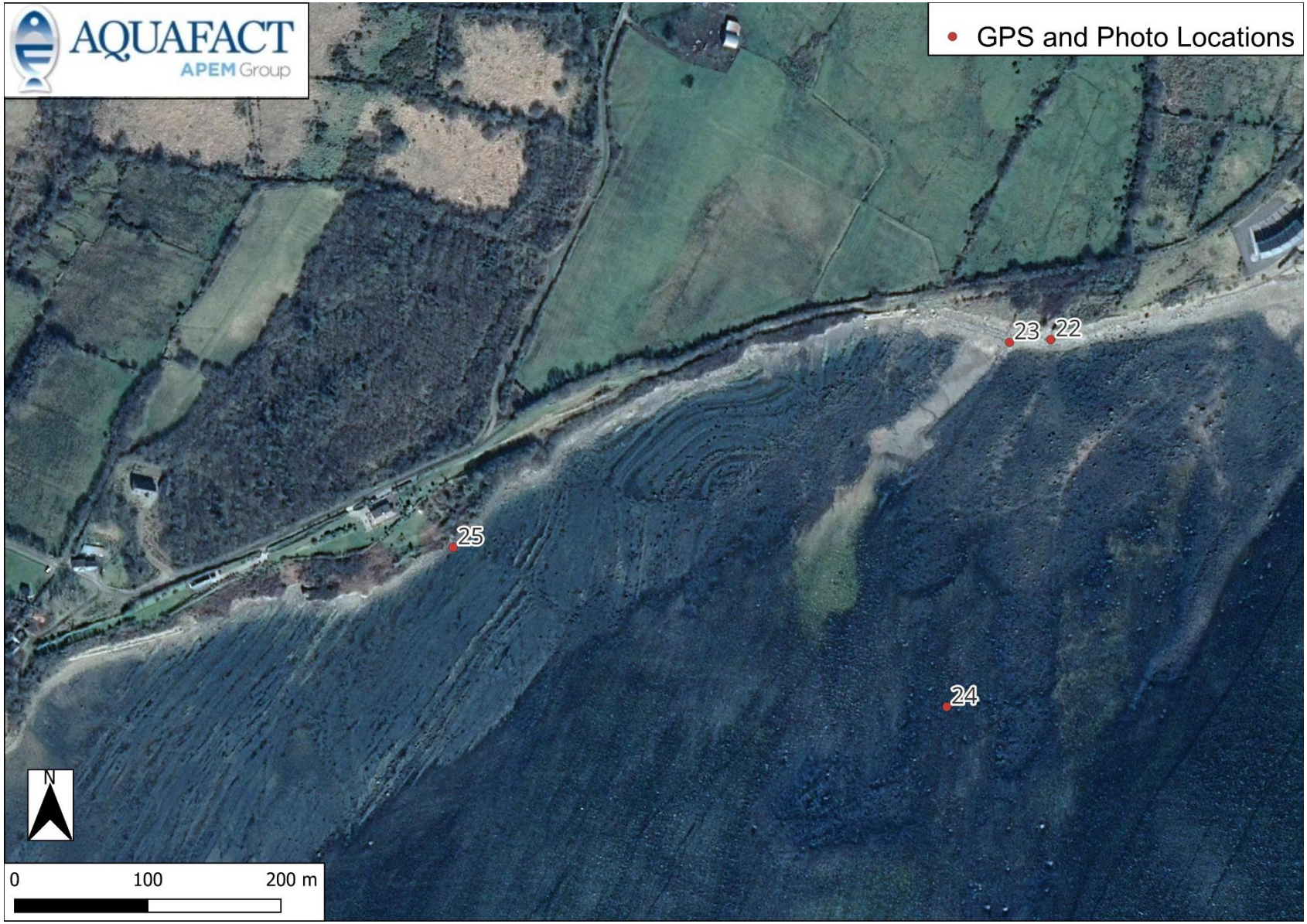


Figure 7-26: Features 22-25 identified during the shoreline survey (numbering cross-reference to Table 7.11).

Figure 7-27: Feature 29 identified during the shoreline survey (numbering cross-reference to Table 7.11).

7.2.2. Locations of Sources

Figure 7-28 shows all rivers/streams that discharge into Inver Bay and **Table 7.12** provides cross-referenced details for this map. **Figure 7-29** shows all discharges in the Inver Bay contributing catchment and **Table 7.13** provides cross-referenced details for industrial discharges, drains, pipes, rivers, and stream discharges.

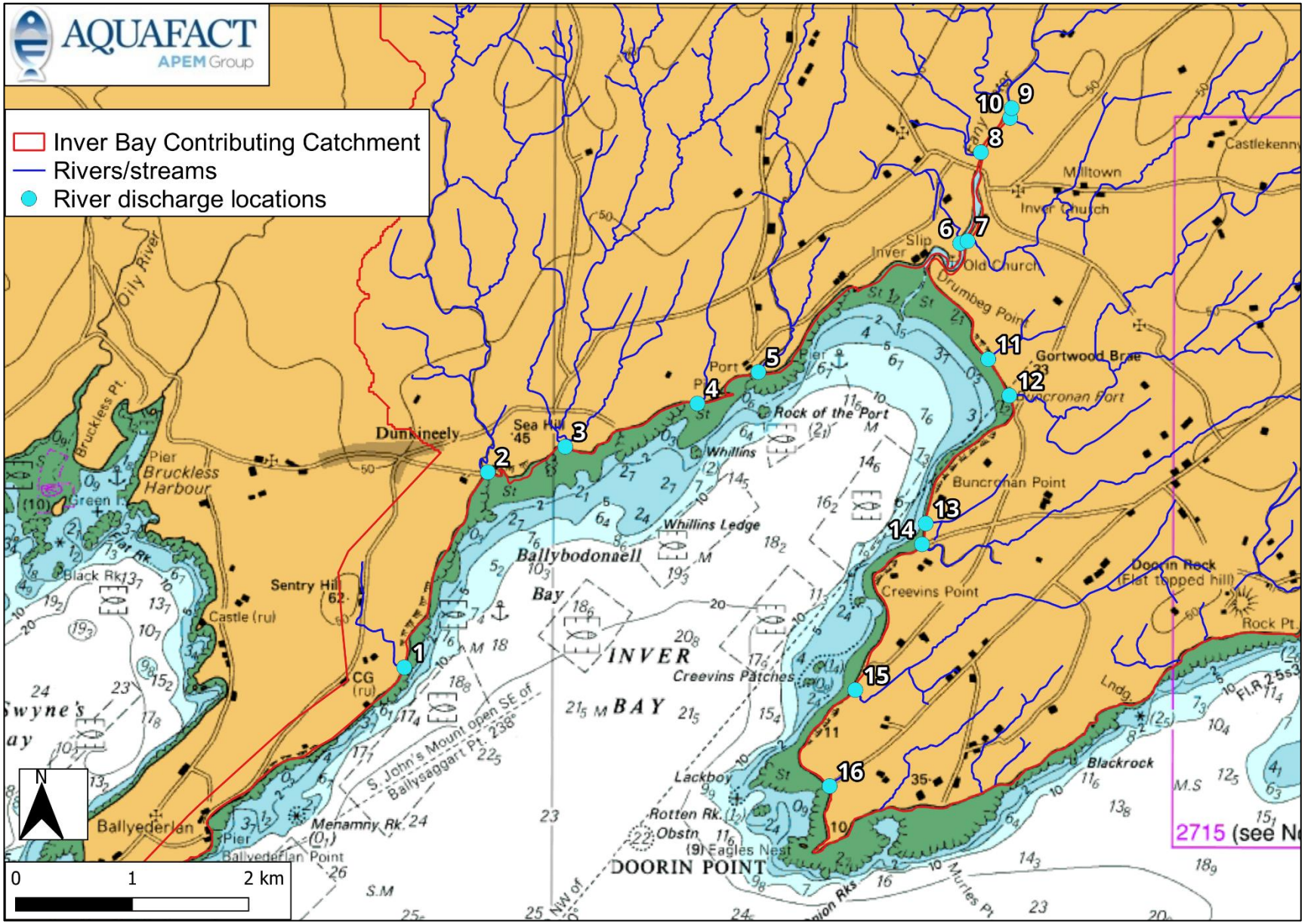


Figure 7-28: Locations of all river/stream discharge points into Inver Bay.

Table 7.12: Cross-referenced table for Figure 7-28 river/stream discharge points.

Map ID	River/stream
1	Rahan_Near
2	Bunlacky
3	Meenacharbet
4	Drumnakilly
5	Port 37
6	Ardaghy_Glebe
7	Unnamed
8	Keeloges 37
9	Eany (Water)
10	Cranny_Lower
11	Unnamed
12	Gortaward
13	Buncronan
14	Mountcharles
15	Rock 37
16	Raneely

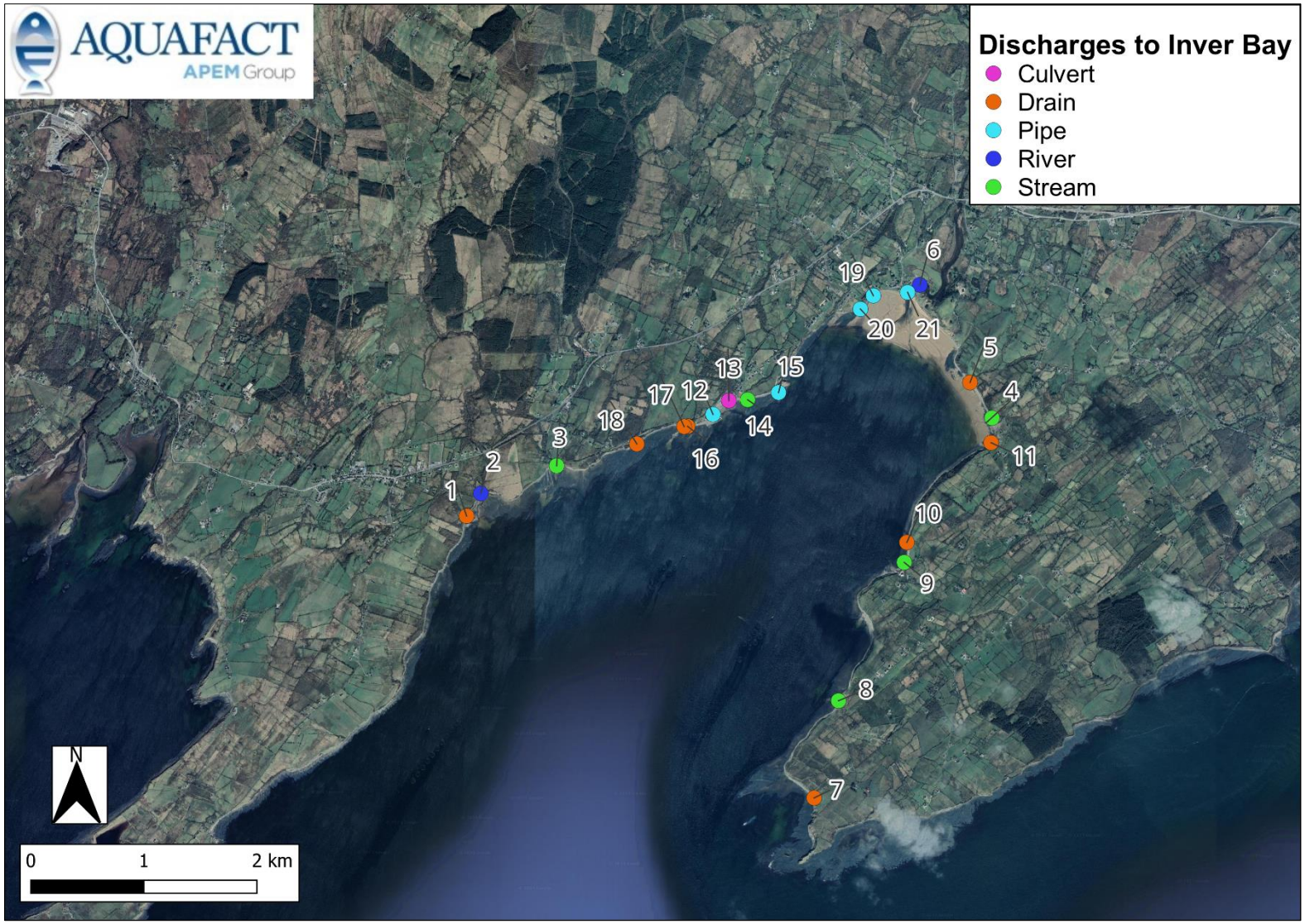


Figure 7-29: Locations of all discharges into the Inver Bay contributing catchment.

Table 7.13: Cross-referenced table for Figure 7-29 discharges. Latitude and longitude values are in coordinate reference system (CRS) WGS84, easting and northing values are in CRS Irish Transverse Mercator (https://www.fieldenmaps.info/cconv/cconv_ie.html).

Map ID	Discharge	Description	Latitude	Longitude	Easting	Northing
1	Drain	Field drain, *Enteromorpha* algae evident on rocks below.	54.62887	-8.34423	577772.5	875682.1
2	River	Bunlacky River. Small river. Abundance of *Enteromorpha* algae at mouth of river.	54.63067	-8.34229	577898.7	875881.8
3	Stream	*Enteromorpha* (green alga). Good flow.	54.6329	-8.33193	578568.8	876126.8
4	Stream	Light flow, coming through rough grazing ground. *Enteromorpha* algae evident on shore.	54.63685	-8.27234	582418.0	876549.8
5	Drain	Field drain. Light flow of water, through rough grazing ground.	54.63966	-8.27536	582224.2	876863.3
6	River	River Eany, good flow. Drains mixed catchment.	54.6474	-8.28228	581781.0	877726.5
7	Drain	Field drain. No flow, dry. Flowing along rough grazing field boundary.	54.60659	-8.29648	580845.3	873188.3
8	Stream	Low flow, flowing through rough grazing fields. *Enteromorpha* algae evident on shore.	54.61432	-8.2932	581060.8	874047.7
9	Stream	Low flow. Coming through mixed rough fields/scrubland. *Enteromorpha* algae evident where stream hits the shore.	54.62534	-8.28428	581642.0	875271.9
10	Drain	Large bore pipe with flap, likely field drain. Trickle of a flow, some green algae noted.	54.62693	-8.28393	581665.3	875448.7
11	Drain	Likely field drain. Low flow. Some algae noted at mouth on shore.	54.63488	-8.27245	582410.0	876330.6
12	Pipes	Pipes x 2. No flow. Likely surface from road/pier above	54.63704	-8.31055	579951.3	876581.2
13	Culvert	Culvert, good flow of water. Lot of *Enteromorpha* algae and moss. Flowing through mixed scrub/residential area.	54.63814	-8.30838	580091.9	876703.0
14	Stream	Good flow of water. Clear. Flowing through mixed scrub/rough grazing.	54.63821	-8.30581	580257.8	876710.1
15	Pipes	Pipes x numerous. Surface water from hard surface above associated with pier and commercial buildings.	54.6388	-8.30158	580531.2	876774.6
16	Drain	Field drain, good flow. Flowing though area of rough pasture.	54.63608	-8.31402	579726.8	876475.4
17	Drain	Field drain, medium flow. Flowing though area of rough pasture.	54.63606	-8.3145	579695.8	876473.3

Map ID	Discharge	Description	Latitude	Longitude	Easting	Northing
18	Drain	Field drain coming off cliff/hill face. Steady flow. Coming through area of rough grazing.	54.63466	-8.32096	579278.0	876319.3
19	Pipes	Grated pipes. Steady flow. A lot of green moss and algae visible at mouth of water outlet. Flowing through residential and rough grazing.	54.64653	-8.28866	581368.8	877631.4
20	Pipes	Numerous. Not flowing. Surface water run off pipes from hard road surface behind.	54.64546	-8.29042	581254.7	877512.8
21	Pipe	Large bore grey pipe. No flow.	54.6468	-8.28396	581672.3	877660.2

8. Appendix 2: Hydrography/Hydrodynamics

8.1. Simple/Complex Models

The environmental conditions of Inver Bay are summarised in chapter two of a report by Cronin *et al.* (2004). Current meters were deployed by AQUAFACT as part of that report and in 2004 a hydrodynamic model of the bay was produced by Kirk, McClure, and Morton. An additional hydrodynamic model of Inver Bay was developed by AQUAFACT in 2023 (AQUAFACT, 2023b[27]), in which tidal velocities at the surface layer on a flooding and ebbing tide were computed. The results of both hydrodynamic models have been used to describe the hydrodynamics of Inver Bay below.

8.2. Depth

Inver bay is predominantly subtidal apart from the inner bay which is intertidal. Depths in the bay range from 0 to 10 m in inner Inver Bay and increase south-westwards along the peninsula from 22-40 m deep. **Figure 8-1** shows water depth in the area.

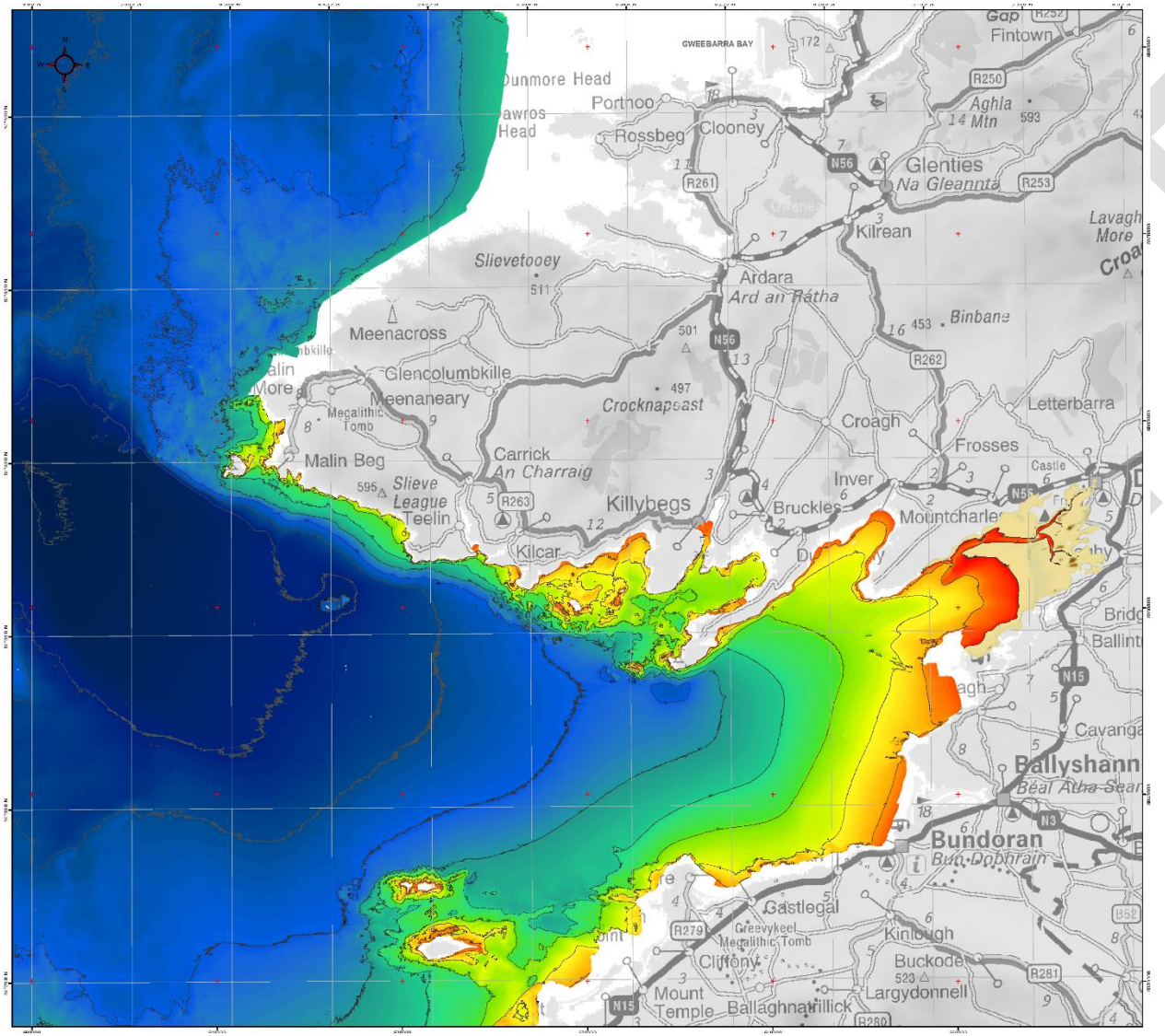


Figure 8-1: Inver Bay bathymetry (contains Irish public sector data (Geological Survey Ireland & Marine Institute) licensed under a Creative Commons Attribution 4.0 International (CC BY 4.0) licence).

8.3. Tides and Currents

The mean spring tidal range in Inver Bay is 3.4 m and 1.7 m on a neap tide. ADCP measurements taken by AQUAFACT in the southeast of Inver Bay (station A[9]) returned an average velocity magnitude of 0.07 m/s near the surface, and maximum velocity near the surface was 0.22 m/s. Wind generated currents were found to drive the current flow (AQUAFACT, 2023b). ADCP measurements taken at a second site, in what could be deemed inner Inver Bay (station B[9]), show the variation in current movements across Inver Bay. An average velocity of 0.06 m/s near the surface was recorded, and maximum velocity at the same sample location was 0.19 m/s (AQUAFACT, 2023b). Again, wind force was influencing the currents. Overall, Inver Bay has a weak current regime that is strongly influenced by wind generated currents.

8.4. Wind and Waves

Wind data from 2018 to 2022 from Finner Met Éireann station, Co. Donegal (Met Éireann[28]) are displayed in **Table 8.2** below and wind roses for each corresponding year can be seen in **Figure 8-2**.

In 2018, *c.* 34% of the wind came from the southeast, *c.* 32% came from the southwest, and *c.* 18% came from the west-northwest. The strongest winds came from the west-northwest. In 2019, *c.* 29.8% of the winds came from the southeast, with *c.* 26% coming from the southwest and *c.* 22% coming from the west-northwest. The strongest winds came from the west-northwest. In 2020, *c.* 31.9% of the wind came from the southwest, *c.* 24.5% came from the southeast, and *c.* 21.6% came from the west-northwest. The strongest winds came from the southwest. In 2021, 31.2% of the wind came from the southwest, 30.2% came from the southeast, and 23.7% came from the west-northwest. The strongest winds came from the west-northwest. In 2022, 30.2% of the wind came from the southwest, 27.8% came from the southeast, and 24.8% came from the west-northwest. The strongest winds came from the west-northwest. It can be seen from the 2018-2022 wind rose diagram that the prevailing wind direction is from the southwest.

Table 8.2 shows the seasonal wind averages from 2018 to 2022. Seasons were selected by grouping the results from the following periods: spring (March-May), summer (June-August), autumn (September-November), and winter (December-February). Seasonal averages over the past five years indicate that winds are typically strongest in the winter months (12.4 kn), followed by autumn (10.2 kn), and spring (9.8 kn), with 8.7 kn in summer.

Table 8.1: Seasonal average wind speed (knots) for Finner, Co. Donegal wind data (source: Met Éireann, 2023a).

Season	2018	2019	2020	2021	2022	5 Year Average
Winter	12.3	11.1	14.4	10.7	13.5	12.4
Spring	9.3	10.8	10.0	9.3	9.6	9.8
Summer	8.2	9.4	9.4	7.7	8.9	8.7
Autumn	11.1	9.2	10.7	9.8	10.1	10.2

Table 8.2: Wind speed and direction data for Finner, Co. Donegal from 2018-2022 (source: Met Éireann[28]).

	2018		2019		2020		2021		2022	
Month	**Mean Speed (knots)**	**Max 10-min Mean Direction (°)**	**Mean Speed (knots)**	**Max 10-min Mean Direction (°)**	**Mean Speed (knots)**	**Max 10-min Mean Direction (°)**	**Mean Speed (knots)**	**Max 10-min Mean Direction (°)**	**Mean Speed (knots)**	**Max 10-min Mean Direction (°)**
January	14.5	213	10.3	252	13.1	230	8.5	200	11.5	243
February	11.1	218	12	198	17.6	240	12.4	166	17.4	258
March	9.8	144	13.6	235	11.7	196	11.1	214	8.9	185
April	9.8	168	10.4	154	8.6	181	8	201	9.3	207
May	8.2	194	8.4	222	9.8	188	8.7	226	10.8	225
June	7.8	236	9.2	202	10	228	8.1	236	9.7	226
July	7.3	236	8.8	236	10.2	234	6.9	242	9.2	250
August	9.6	261	10	224	7.9	178	8	216	7.9	221
September	10.8	270	9.9	237	9.6	199	7.7	190	8.4	232
October	11.5	234	9.7	187	11.7	219	10	234	11.1	201
November	10.9	165	7.9	115	10.7	224	11.6	268	11	203
December	11	214	12.5	219	11.2	224	11.6	205	-	-

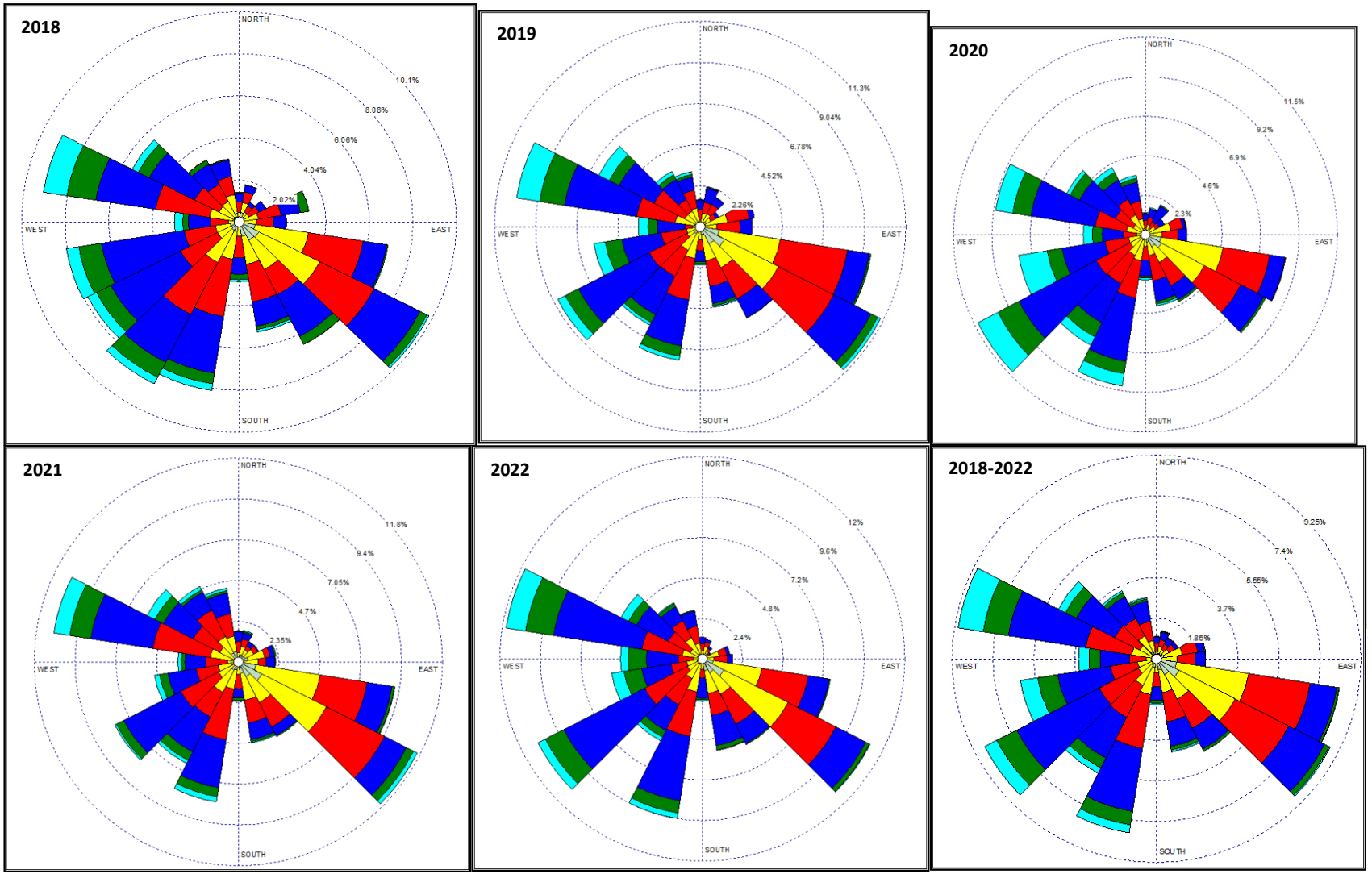


Figure 8-2: Wind roses for Finner, Co. Donegal from 2018 to 2022 (source: Met Éireann[28]).

Wind conditions affect the hydrodynamic conditions in Inver Bay by generating wind-induced currents and waves. Of these phenomena, wind-induced waves are an important factor in the process of sediment resuspension and transport. Wind waves are produced by the local prevailing wind. They travel in the direction of the prevailing wind, *i.e.,* a south-westerly wind will produce northeasterly moving waves. The height of wind waves depends on:

- the strength of the wind.
- the time the wind has been blowing.
- the fetch.

8.5. River Discharges

There are 10 WFD river sub-basins which drain into Inver Bay and one (Bogside_010) which partially drains into Inver Bay, totalling an area of 184.06 km^2; within these river sub-basins are 11 corresponding river waterbodies (see **Figure 8-3** for river sub-basins and **Figure 8-4** for river waterbodies). As this value incorporates river sub-basins which discharge outside of Inver Bay, an approximation of the area which drains into Inver Bay only was made using QGIS 3.28.2 to avoid an over-estimation of the area, returning a value of *c.* 170.37 km^2. The contributing catchment is dominated by the WFD sub-catchment Eany [Water]_SC_010 which can be broken down into the following river sub-basins: Eany Water_010 and _020 in combination drain 24.82% of the catchment, the Eanybeg Water_010 and _020 combined drain 23.48% of the catchment, and the Eanymore Water_010 and _020 combined drain 19.45% of the catchment. The remaining four river sub-basins within the Eany sub-catchment drain < 9% each. The Bogside_010 river sub-basin, the only sub-basin which lies outside of the Eany sub-catchment, falls within the Stragar_SC_010 sub-catchment and drains 1.7% of the Inver Bay contributing catchment. At the time of writing this report, there were no available data on the mean and maximum flow rates of the Eany River which primarily comprises the Eany river sub-basins.

The 2013-2018 WFD status of Inver Bay and its associated freshwater sources can be seen in **Figure 8-5**[20]. Of the river systems flowing directly into Inver Bay, both Eanybeg waterbodies were of High status, Mountcharles was Moderate, Drumnakilly was Unassigned, and the remainder were of Good status. The ecological status of these river waterbodies is available for the current (2016-2021) period; however, the corresponding mapping data was not available at the time of writing, therefore only the WFD status for 2013-2018 is reflected in **Figure 8-5**. For the 2016-2021 period, the Bunlacky river waterbody and both the Eanybeg river waterbodies were of High status. The remaining river waterbodies were of Good status. Inver Bay coastal waterbody (CWB) was of High status for both the 2013-2018 and the 2016-2021 monitoring periods[29].

Note that in **Figure 8-3** to **Figure 8-5** other river sub-basins and river waterbodies exist outside of the contributing catchment but have not been included in this map in order to focus on those most relevant *i.e.*, those within the contributing catchment.

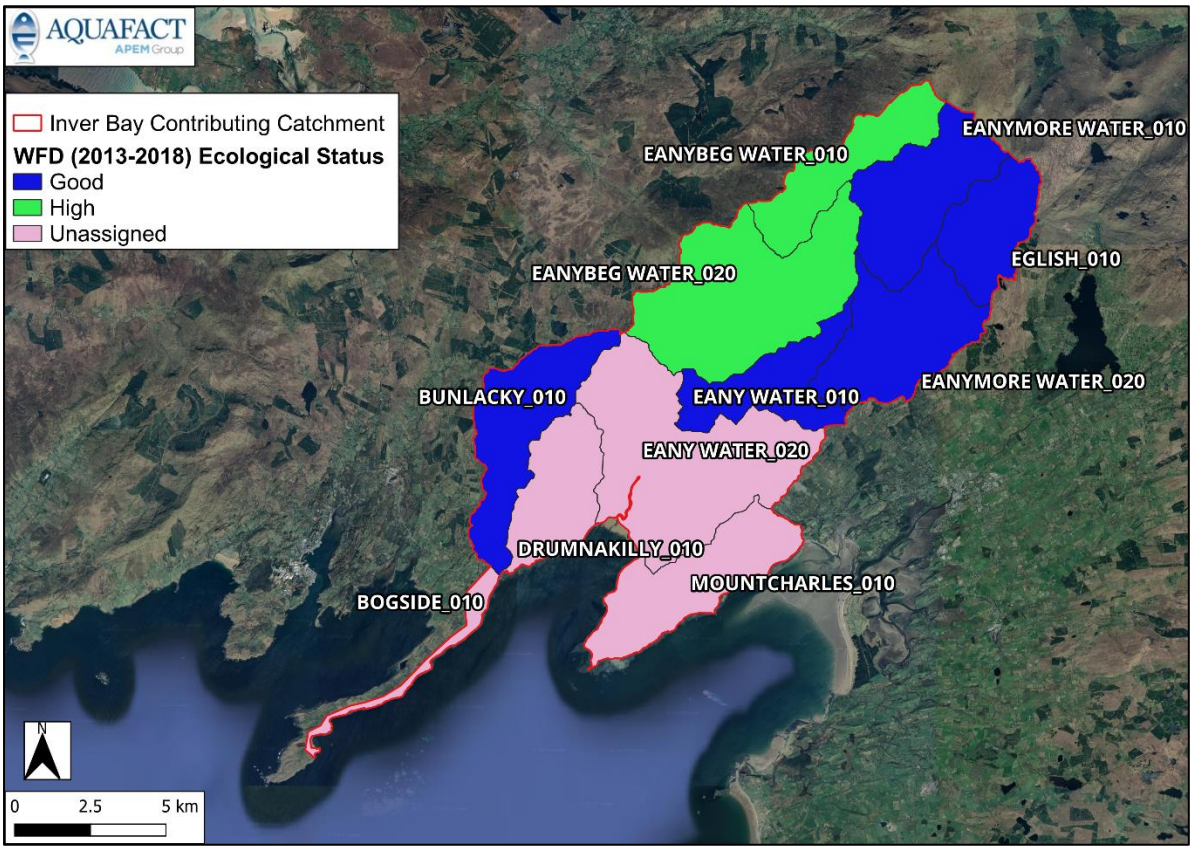


Figure 8-3: Water Framework Directive (WFD) 2013-2018 ecological status of river sub-basins within the Inver Bay contributing catchment (source: EPA[18]).

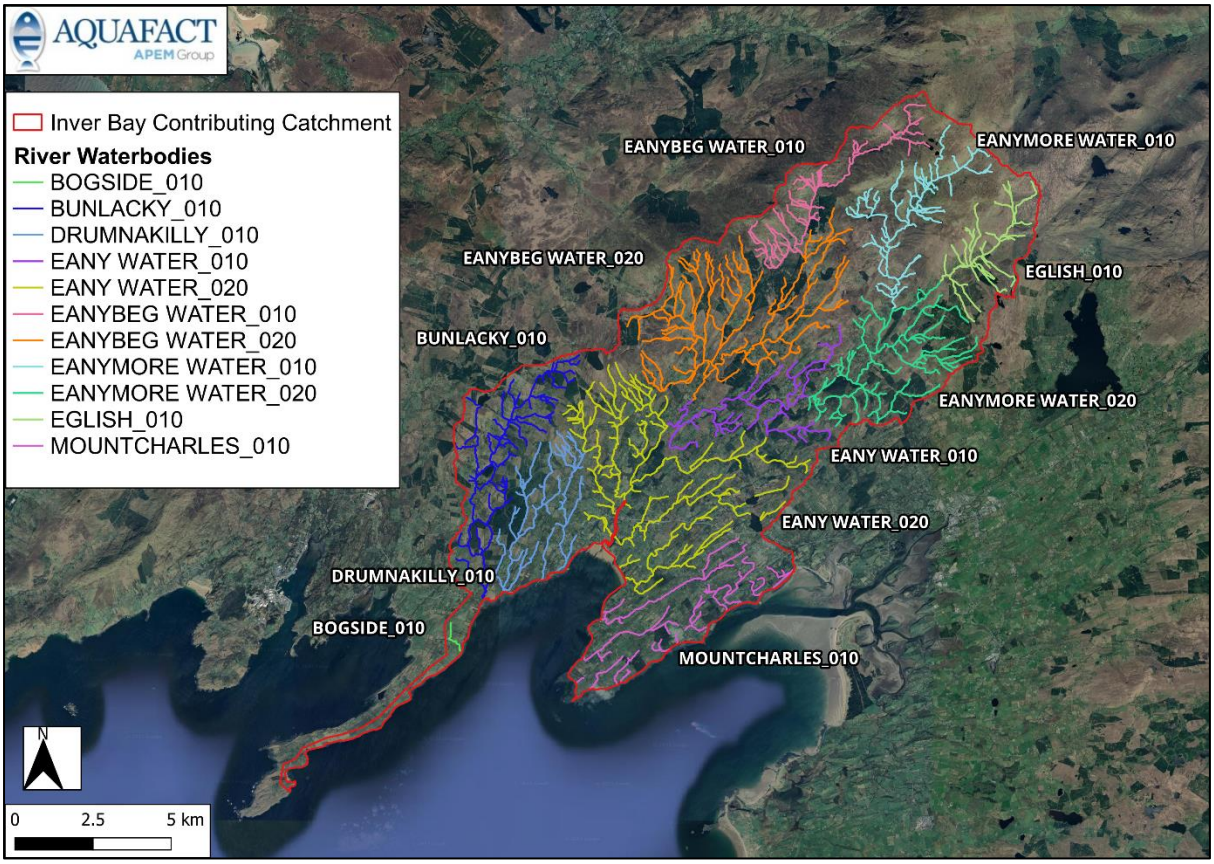


Figure 8-4: River waterbodies in the Inver Bay contributing catchment (source: EPA Catchments[29]).

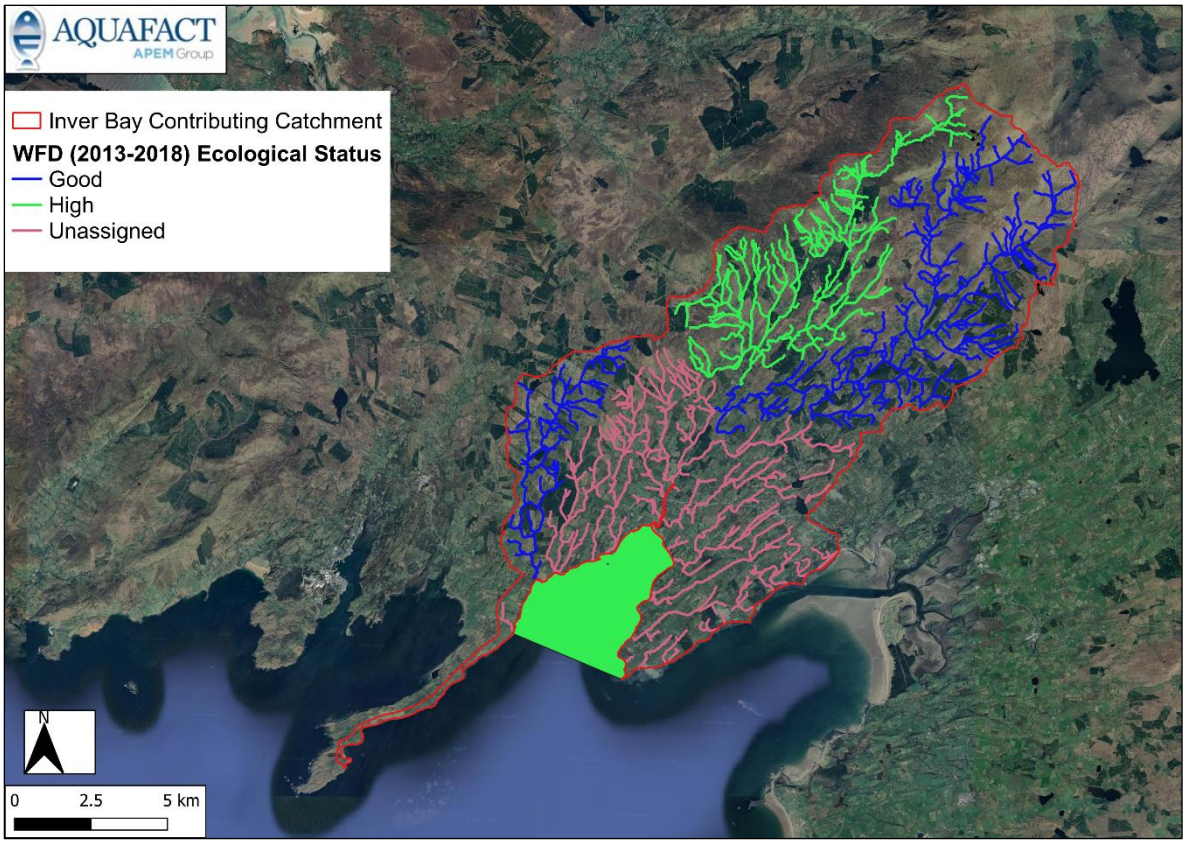


Figure 8-5: Water Framework Directive (WFD) 2013-2018 ecological status of the coastal and river waterbodies in the Inver Bay catchment area (source: EPA[18]).

8.6. Rainfall Data

8.6.1. Amount and Time of Year

In this section, data from the Bruckless Met Éireann station, situated *c.* 5 km northwest of Inver Bay, is used to investigate long term rainfall patterns, *i.e.*, 30-year period, and rainfall patterns over a recent 5-year period, *i.e.*, 2017-2021. Bruckless weather station is located in the small village of Bruckless, near Dunkineely, Co. Donegal. **Figure 8-6** shows the average monthly rainfall data for Ireland (Met Éireann[28]) from 1991 to 2021. The wettest months overall during this period were October-January. The wettest months in the Inver Bay region over this same 30-year period were October to January with the driest months from April to June. Table 8.3 shows the 30-year average monthly rainfall at the Bruckless Met Éireann station (**Figure 8-7**). During the period 1991 to 2021, average rainfall at Bruckless was lowest in April (81.5 mm) and highest in December (172.8 mm). The greatest daily total ranged from a low of 15.5 mm in April to a high of 27.9 mm in October; note that data on greatest daily total rainfall (mm) was missing for some years. **Table 8.4** shows the seasonal averages at Bruckless from 1991 to 2021. Lowest average rainfall over the 30-year period was in spring (96.4 mm) with the highest average rainfall experienced in winter (154.0 mm).

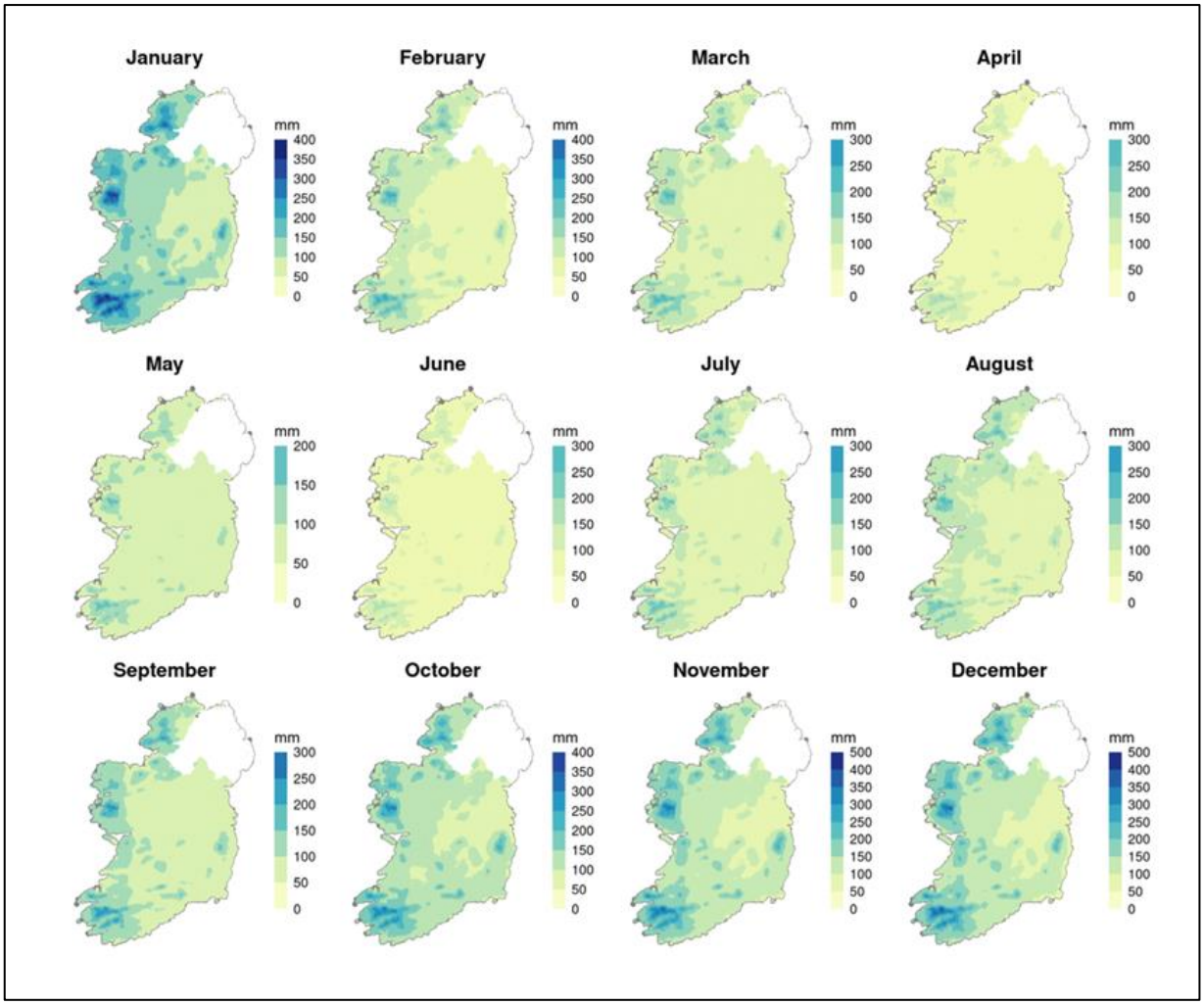


Figure 8-6: Average monthly rainfall (mm) data from 1991 to 2021 for Ireland (source: Met Éireann[28]).

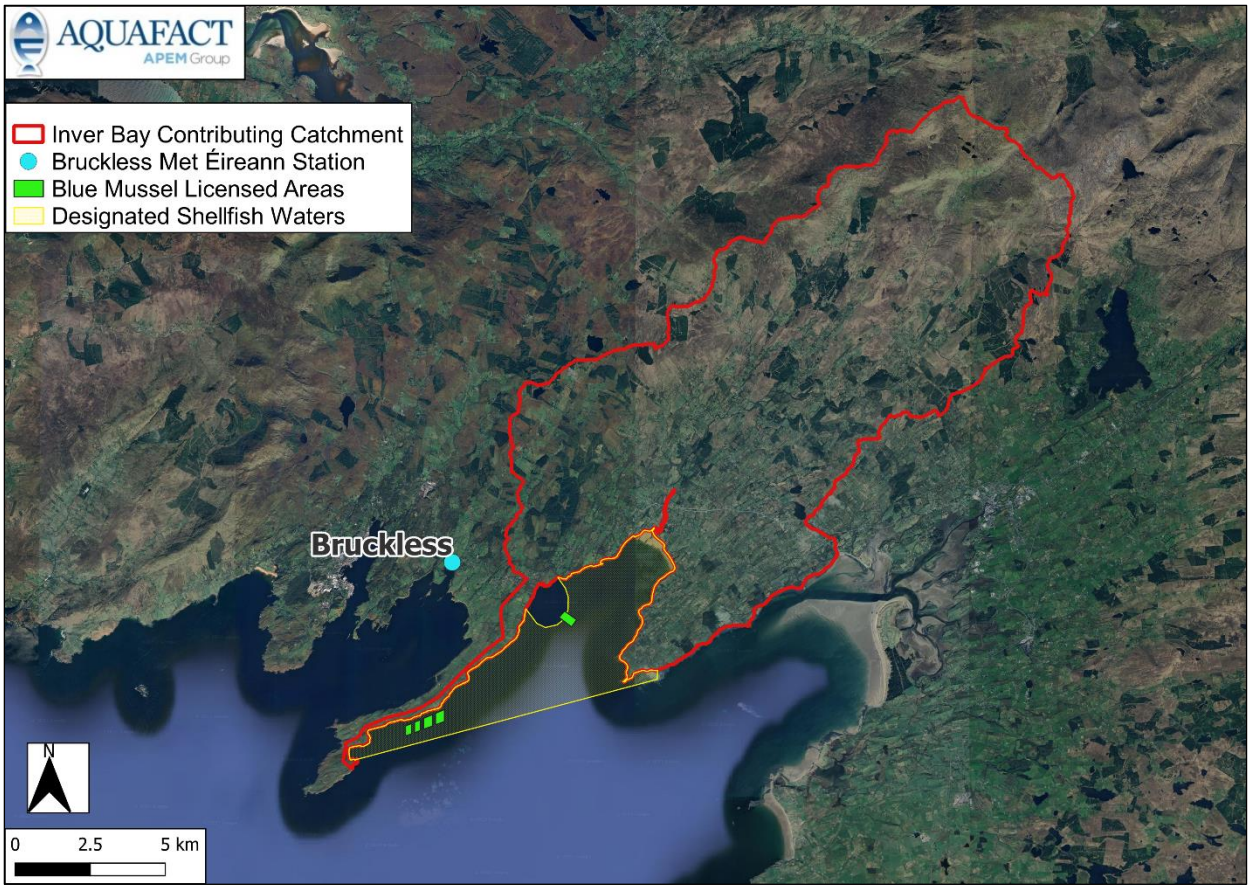


Figure 8-7: Location of Bruckless Met Éireann weather station in relation to the Inver Bay production area.

Table 8.3: Monthly average rainfall at Bruckless, Co. Donegal from 1991 to 2021 (source: Met Éireann[28]).

Average Rainfall (mm)	Month	Greatest Daily Total (mm)
159.9	January	23.7*
129.3	February	25.1*
116.4	March	20.3*
81.5	April	15.5*
91.1	May	19.8*
91.6	June	21.0*
125.8	July	24.2
123.3	August	22.9
122.6	September	21.1
158.9	October	27.9
164.4	November	25.2
172.8	December	25.6
1537.7	Year	272.2

*Data was missing for some years

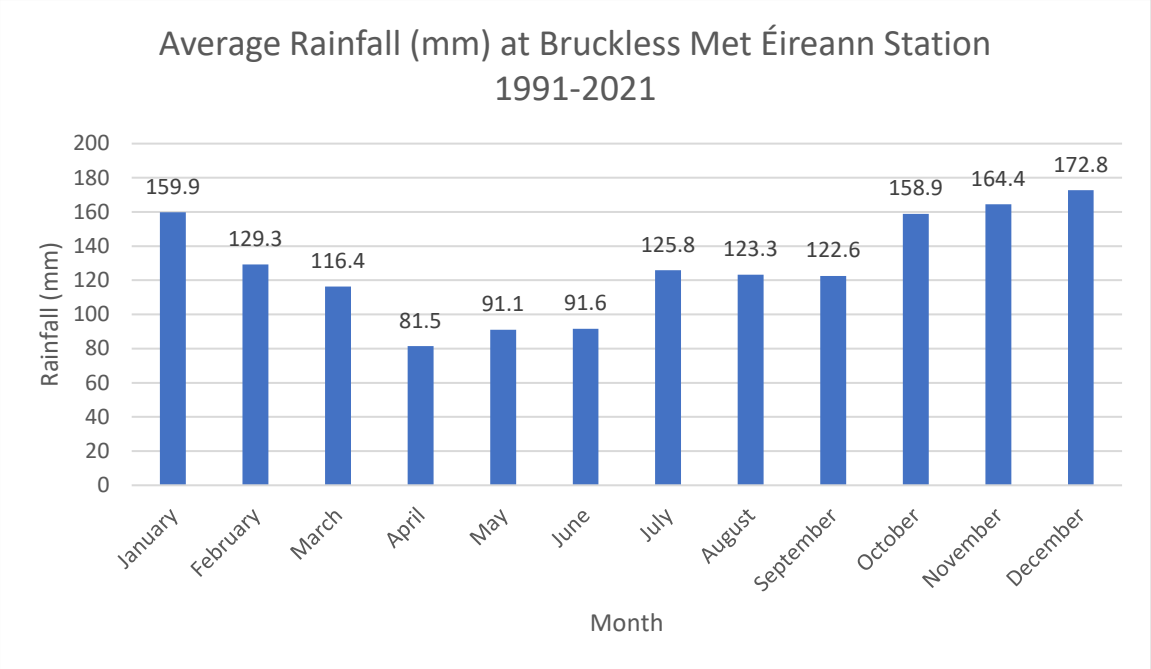


Figure 8-8: Average monthly rainfall (mm) at Bruckless Met Éireann Station from 1991 to 2021 (source: Met Éireann[28]).

Table 8.4: Average seasonal rainfall values (mm) from 1991-2021 at Bruckless, Co. Donegal (source: Met Éireann[28]).

Season	Average (mm)
Spring	96.4
Summer	113.6
Autumn	148.6
Winter	154.0

Table 8.5 shows total monthly rainfall at the Bruckless Met Éireann station (see **Figure 8-7**), from 2017 to 2021 (Met Éireann[28]). Maximum monthly rainfall was in October 2021 (262.1 mm) and the lowest monthly rainfall was April 2020 (20.5 mm). The 5-year average monthly rainfall ranged from a low of 49.0 mm in April to a high of 196.1 mm in October. Annual averages ranged from 131.0 mm in 2021 to 154.3 mm in 2020.

Table 8.6 shows the total seasonal rainfall at Bruckless from 2017-2021[28]. The following seasonal fluctuations were observed: in 2017, summer was the driest season and autumn was the wettest, in 2018 spring was the driest and winter was the wettest. In 2019, spring was the driest and autumn was the wettest. In 2020, summer was the driest and winter was the wettest, and in 2021 summer was the driest and autumn was the wettest. Over the five years, summer 2020 was the driest season and autumn 2017 was the wettest season.

Table 8.5: Total monthly rainfall (mm) data at Bruckless, Co. Donegal, from 2017 to 2021 (source: Met Éireann[28]).

Year	2017	2018	2019	2020	2021	Monthly 5-yr Average
Jan	123	251.3	117.1	103.5	192.6	157.5
Feb	105.8	127.8	109	261.3	60.5	132.9
Mar	182.9	54.2	241.7	95.3	134.7	141.8
Apr	34.8	64	64.2	20.5	61.5	49.0
May	87.4	67.2	104.4	46.2	92.2	79.5
Jun	101.1	60.2	81.2	216.3	55.6	102.9
Jul	158.3	72.2	117.9	208.7	99.6	131.3
Aug	-	176.3	247.1	115	130.8	167.3*
Sep	207.7	106.9	164	133.8	127.4	148.0
Oct	180.7	135.9	148.6	253	262.1	196.1
Nov	204.5	119.2	116.7	205.5	138.9	157.0
Dec	177.1	134.2	171.4	192.6	216.4	178.3
Annual Average	142.1**	114.1	140.3	154.3	131.0	

*Calculated as monthly 4-year average as data point for August 2017 missing.

**Average calculated across 11 months as data point for August missing.

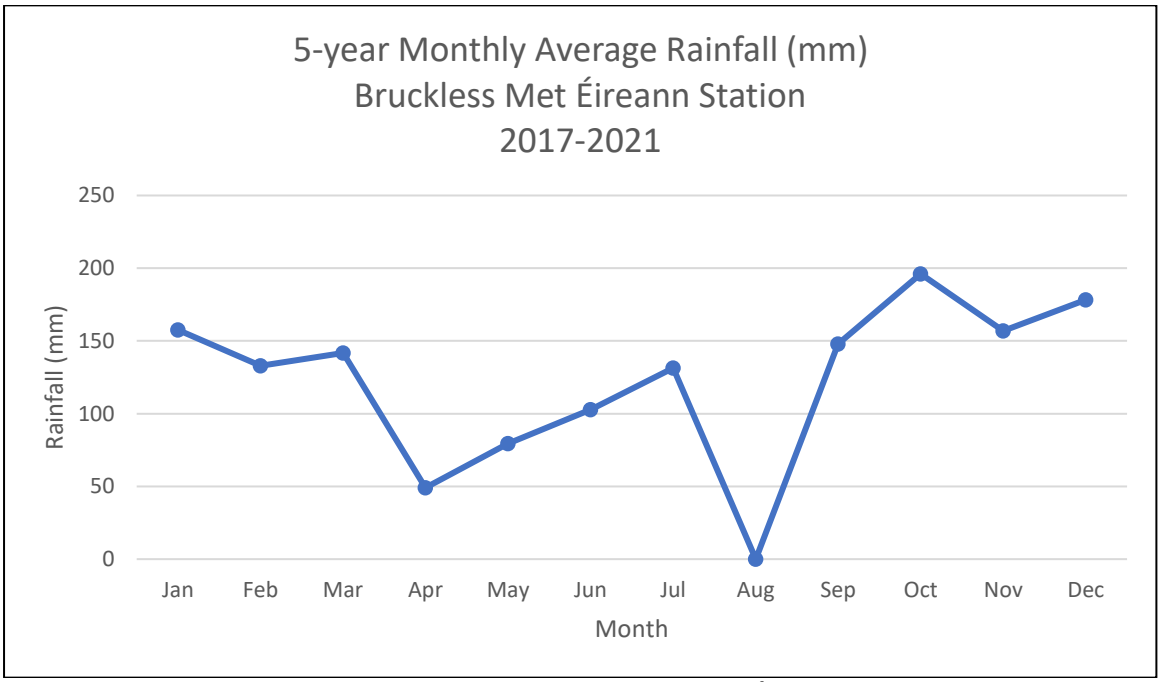


Figure 8-9: 5-year monthly average rainfall (mm) at Bruckless Met Éireann Station from 2017 to 2021 (source: Met Éireann[28]).

Table 8.6: Total seasonal rainfall (mm) at Bruckless, Co. Donegal, from 2017 to 2021 (source: Met Éireann[28]).

Station	Season/Year	2017	2018	2019	2020	2021
Bruckless	Spring	101.7	61.8	120.1	178.7	96.1
	Summer	129.7	102.9	136.8	54.0	95.3
	Autumn	197.6	120.7	148.7	180.0	176.1
	Winter	117.8	185.4	143.1	197.4	148.6

8.6.2. Frequency of Significant Rainfalls

Met Éireann has developed a depth duration frequency model for the estimation of point rainfall frequencies (Fitzgerald, 2007; Met Éireann[28]). For a one in 100-year return period, 40.4 mm of rain would be expected over a one-hour period and 107.0 mm over 24 hours. While these would be extremely uncommon events, the model predicts that once a year 11.5 mm of rain would fall in one hour and 38.8 mm over a 24-hour period. Data from Bruckless Met Éireann station show that there have been 23 24-hour periods within which more than 38.88 mm of rain fell over the 30-year period 1991-2021. For this same period, October had the greatest daily rainfall with 27.9 mm. Over the 5-year period 2017-2021, data from Bruckless Met Éireann station show that there have been eight 24-hour periods within which more than 38.88 mm of rain fell[28]. A significant rainfall is considered to be ≥ 120 mm of rain within a 24-hour time period (Tony Cawley, Hydroenvironmental Ltd., *pers. comm*).

Increased faecal contamination of coastal waters is typically associated with high rainfall and storm events through surface water run-off from livestock or other animals present and through sewer and wastewater treatment plant overflows (Mallin *et al.*, 2001; Lee & Morgan, 2003). It is therefore expected that run-off due to rainfall will be higher during the October to February period. However, as can be seen in the rainfall data in **Table 8.7**, heavy rainfall events leading to episodes of high run-off can occur in most months of the year and it is therefore not just the winter months that are at risk of increased contamination. When these occur during generally drier periods in spring and summer months, they are likely to carry higher loadings of faecal material which has accumulated on pastures where greater numbers of livestock are present.

Table 8.7: Rainfall events > 38.88 mm within a 24-hour period, recorded at the Bruckless Met Éireann station[28].

Date	Rainfall (mm)	Date	Rainfall (mm)
20-Dec-91	42.2	29-Feb-16	44
17-Feb-96	45.5	04-Oct-17	48.5
05-Dec-97	41.7	13-Mar-19	40.9
31-Oct-99	57	30-Aug-19	42.3
08-Aug-00	42	03-Oct-19	48.6
17-May-02	46.4	28-Jun-20	49.6

Date	Rainfall (mm)	Date	Rainfall (mm)
13-Jun-02	40.7	04-Jul-21	47.1
07-Nov-02	42	08-Oct-21	44
24-Oct-09	40.1	07-Dec-21	47.2
08-Feb-12	65.5		
07-Jun-12	39.1		
28-Oct-12	55.4		
14-Nov-15	59		
05-Dec-15	40.3		

8.7. Salinity

Cronin *et al*. (2004) include data collected by the R.V. Celtic Voyager research cruise in 2001 on the salinity of Inver Bay. Salinity values ranged from 32 psu at the surface to 33.7 psu at 15 m.

8.8. Turbidity

At the time of writing, no turbidity data were available.

8.9. Flushing Time

Flushing time can be defined as the time it takes to replace a certain water mass in a coastal system. Flushing times are important because of how they explain water exchange and how this governs productivity rates as well as the vulnerability to water quality degradation. The currents within Inver Bay are dominated by the prevailing wind and tidal cycle, the relatively deep bathymetry of the bay does not greatly influence the currents. The average flushing time in Inver Bay is 4.1 days (*c.* 8 tidal cycles) on mean neap tides and 1.6 days (3 tidal cycles) on mean spring tides. This is based on a bay area of *c.* 19 km^2 and a volume at mean sea level of 314 million m^3 (AQUAFACT, 2023b).

8.10. Discussion

Inver Bay is a U-shaped bay, with the seabed composed mostly of fine sands and mud. The bay is completely subtidal apart from inner Inver Bay, which is intertidal. Depths in the bay range from 0 to 10 m in the inner bay to 22-40 m deep. Currents flow in a northeast to south-westerly direction, and the prevailing wind comes from the southeast. Mean current velocities in the bay vary from 0.07 m/s along the southeastern part of the bay (AQUAFACT, 2023b; station A[9]) to 0.06 m/s at inner Inver Bay (AQUAFACT, 2023b; station B[9]). The Eany River waterbody is a spate river and so if contamination is present in the surrounding land, it will quickly make its way into the bay during high rainfall events (Inland Fisheries Ireland[30]). The salinity does not vary too greatly, with values of 32 psu at the surface compared to 33.7 psu at 15 m. The narrow range in salinity

indicates that the hydrodynamics do not strongly influence the water movement in the bay. The residence time in the bay is expected to be long due the majority of the bay being subtidal.

9. Appendix 3: Shellfish and Water Sampling

9.1. Historical Data

9.1.1. Shellfish Flesh Quality

In accordance with Regulation (EU) 2017/625 and the subsequent implementing regulation (EU) 2017/627 the SFPA is required to classify bivalve mollusc production areas and to fix the boundaries thereof. The process involves regular sampling of shellfish from each area to be classified in order to establish levels of microbiological contamination which subsequently determines which classification should be awarded for that particular area.

The regulations stipulate that the competent authority must monitor the levels of *E. coli* within the harvesting area and that according to the sample results, must classify the area as being one of three categories: **A**, **B** or **C**. An **A** classification allows for the product to be placed directly on the market, whereas a **B** or **C** classification requires the product to go through a process of depuration, heat treatment or relaying before it can be placed on the market. **Table 9.1** summarises this system.

Table 9.1: Classification system for shellfish harvesting areas.

Classification			Permitted Levels	Outcome
	A	<230	Not exceeding 230 *E. coli* 100 g flesh/liquid in 80% of samples. Not exceeding 700 *E. coli* 100 g in remaining 20% of samples.	May go direct for human consumption if end product standard met.
	B	<4600	Not exceeding 4,600 *E. coli* 100 g flesh/liquid in 90% of samples. Not exceeding 46,000 *E. coli* 100 g in remaining 10% of samples.	Must be subject to purification, relaying in Class A area (to meet Category A requirements) or cooked by an approved method.
	C	<46000	Not exceeding 46,000 *E. coli* 100 g flesh in all samples.	Must be subject to relaying for a period of at least 2 months or cooked by an approved method.
	Above 46,000 *E. coli* per 100 g flesh/liquid.			Prohibited. Harvesting not permitted

Table 9.2 lists the *E. coli* results for mussels in Inver Bay from May 2004 to May 2014. **Table 9.3** shows the historical classification of shellfish beds in Inver Bay (2008-2017). The classification status has varied in Inver Bay from 2008 to date. In 2008, Inver Bay had an **A** classification for mussels, however the production site went dormant in 2009 due to a lack of sample availability. The production site was subsequently

downgraded to a **B** classification and reactivated in 2011-2014. As no sample was provided in 2015 or 2016 the site went dormant again and was subsequently declassified in 2017 as no samples were provided from May 2014 to May 2017. In 2012 and 2013, additional samples were taken from sample point B1, located in the adjacent production site/area McSwyne's Bay (Bruckless); these results are marked with an asterisk in **Table 9.2**.

Table 9.2: Historical *E. coli* results from Inver Bay mussels from May 2004 to May 2014 (source: SFPA); colour coded per Table 9.1.

Sampling Date	MPN *E. coli* /100g	Category	Sampling Date	MPN *E. coli* /100g	Category
31-May-04	30	A	31-Jan-10	20	A
29-Jun-04	36	A	10-Feb-10	**490**	B
13-Jul-04	30	A	19-Feb-10	130	A
24-Aug-04	**1500**	B	18-Apr-10	80	A
9-Sep-04	30	A	31-May-10	20	A
27-Oct-04	150	A	25-Nov-10	170	A
26-Nov-04	36	A	19-Sep-11	**1300**	B
29-Nov-04	30	A	27-Oct-11	130	A
29-Nov-04	36	A	27-Nov-11	170	A
27-Jan-05	30	A	12-Dec-11	**1100**	B
4-Feb-05	30	A	11-Apr-12	**330**	B
10-Mar-05	30	A	22-May-12	**330**	A
20-Apr-05	30	A	30-May-12	20*	A
13-May-05	30	A	8-Jun-12	130*	A
10-Jun-05	30	A	12-Jun-12	**490**	B
29-Jul-05	20	A	15-Jun-12	20	A
29-Aug-05	20	A	11-Jul-12	230	A
23-Sep-05	20	A	18-Jul-12	20	A
26-Oct-05	20	A	20-Aug-12	20	A
30-Nov-05	20	A	21-Aug-12	**330***	B
9-Dec-05	20	A	18-Sep-12	**9200**	C
19-Jan-06	20	A	27-Sep-12	20	A
9-Feb-06	20	A	23-Oct-12	**490**	B
10-Mar-06	20	A	26-Nov-12	130	A
20-Apr-06	20	A	6-Dec-12	**330**	B
26-Apr-06	90	A	12-Dec-12	80*	A
18-May-06	**1300**	B	22-Jan-13	20*	A
13-Jun-06	20	A	25-Jan-13	80	A

Sampling Date	MPN *E. coli* /100g	Category	Sampling Date	MPN *E. coli* /100g	Category
11-Jul-06	**9100**	C	15-Feb-13	20*	A
19-Jul-06	40	A	27-Feb-13	170	A
9-Aug-06	70	A	21-Mar-13	20*	A
26-Sep-06	220	A	26-Mar-13	140	A
7-Nov-06	70	A	8-Apr-13	50	A
27-Nov-06	20	A	29-Apr-13	20*	A
13-Dec-06	110	A	22-May-13	20*	A
18-Dec-06	220	A	27-Jun-13	130	A
19-Jan-07	20	A	9-Jul-13	**330**	B
9-Feb-07	20	A	25-Jul-13	20	A
21-Mar-07	20	A	29-Aug-13	330	B
18-Apr-07	20	A	20-Sep-13	50*	A
25-May-07	40	A	30-Sep-13	**2400**	B
27-Jun-07	20	A	7-Oct-13	**330***	B
24-Jul-07	20	A	24-Oct-13	230	A
10-Aug-07	20	A	11-Nov-13	50	A
13-Sep-07	20	A	2-Dec-13	230*	A
25-Oct-07	20	A	9-Jan-14	20	A
22-Nov-07	20	A	19-Mar-14	20	A
23-May-08	20	A	30-Apr-14	20	A
27-Jun-08	220	A	14-May-14	20	A
22-Jul-08	110	A			
18-Aug-08	90	A			
28-Oct-08	110	A			
18-Nov-08	110	A			
23-Sep-09	20	A			

*Samples taken from production site/area McSwyne's Bay (Bruckless), sample point B1 for additional monitoring of Inver Bay.

Values in bold and highlighted yellow are particularly high levels of *E. coli*. Values in bold and red font are extremely high levels of *E. coli*.

Table 9.3: Historical classification of shellfish beds in Inver Bay (2008-2017) (source: SFPA).

Boundaries	Bed Name	Species	Classification				
			2008	2009-2010	2011-2014	2015-2016	2017
Inver Bay	All beds	Mussels	A	-	B	-	*declassified

* Inver Bay was declassified in 2017 as no samples were taken from May 2014 to May 2017.

9.1.2. Norovirus (NoV)

The Inver Bay production area has to date not been subject to any norovirus sampling programme or baseline studies of norovirus levels. Therefore, there are no available data to indicate the presence or levels of norovirus contamination of shellfish in Inver Bay.

9.2. Current Data

9.2.1. Sampling Sites and Methodology

Four water samples were taken within Inver Bay. The locations of these sites can be seen in **Figure 9-1** and **Table 9.4** shows the station coordinates.

Table 9.4: Water sample coordinates with date of sampling.

Station	Feature	Latitude	Longitude	Sampling Date
1	Eany River	54.64703	8.283664	22/11/2022
2	Stream	54.62566	8.284077	22/11/2022
3	Bunlacky River	54.630647	8.342095	22/11/2022
4	Stream	54.633054	8.32069	22/11/2022

All water samples were collected in sterile plastic water bottles. These samples were stored in a cool box until delivery to the lab for analysis (within 24 hours of collection).

9.2.2. Bacteriological Analysis Results

Table 9.5 shows the water sample analysis results and **Figure 9-1** shows the magnitude of the *E. coli* results. Station 1 was located at the mouth of the Eany River, adjacent to discharge no. 21 in **Figure 7-29**. The Station 2 sample was taken nearby a low flowing stream with evidence of *Enteromorpha* algae where the stream met the shore (**Figure 7-29**; map ID 9). Station 3 was located at the mouth of the Bunlacky River, which had an abundance of *Enteromorpha* algae at the river mouth and was adjacent to discharge no. 2 in **Figure 7-29**. Station 4 was located next to a stream, nearby a field drain with steady flow (**Figure 7-29**; map ID 18). Guidelines on acceptable levels of *E. coli* in DSW have not yet been established, however, the water sample results (**Table 9.5**) are not considered to have high *E. coli* levels.

Table 9.5: Water *E. coli* results for Inver Bay.

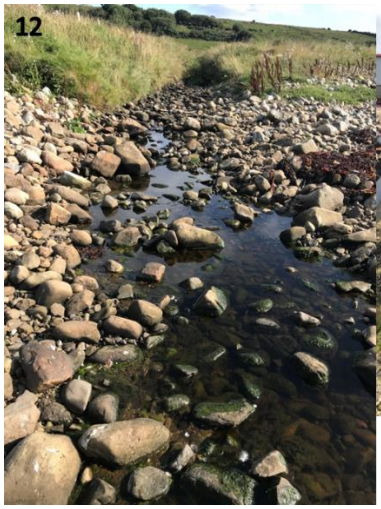
Station No.	*E. coli* (cfu/100 ml)	Latitude	Longitude
1	95	54.64703	8.283664
2	290	54.62566	8.284077
3	115	54.630647	8.342095
4	195	54.633054	8.32069

Figure 9-1: Location and magnitude of E. coli results from water samples taken during the shoreline survey (numbering cross-referenced to Table 9.5).

9.2.3. Shellfish Flesh Quality Sampling

The SFPA currently does not sample shellfish flesh in Inver Bay and no Bivalve Mollusc Production Area exists.

10. Appendix 4: Shoreline Survey Images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11. Appendix 5: Blue Mussel Monitoring Information

Inver Bay Production Area

Site Name: Inver Bay

Site Identifier: DL-IB-IB

Monitoring Point Coordinates **Latitude:** 54.62066 **Longitude:** -8.33170

Species: *Mytilus edulis*

Sample Depth: Samples should be taken within the first one m of surface water.

Sample Frequency: Monthly

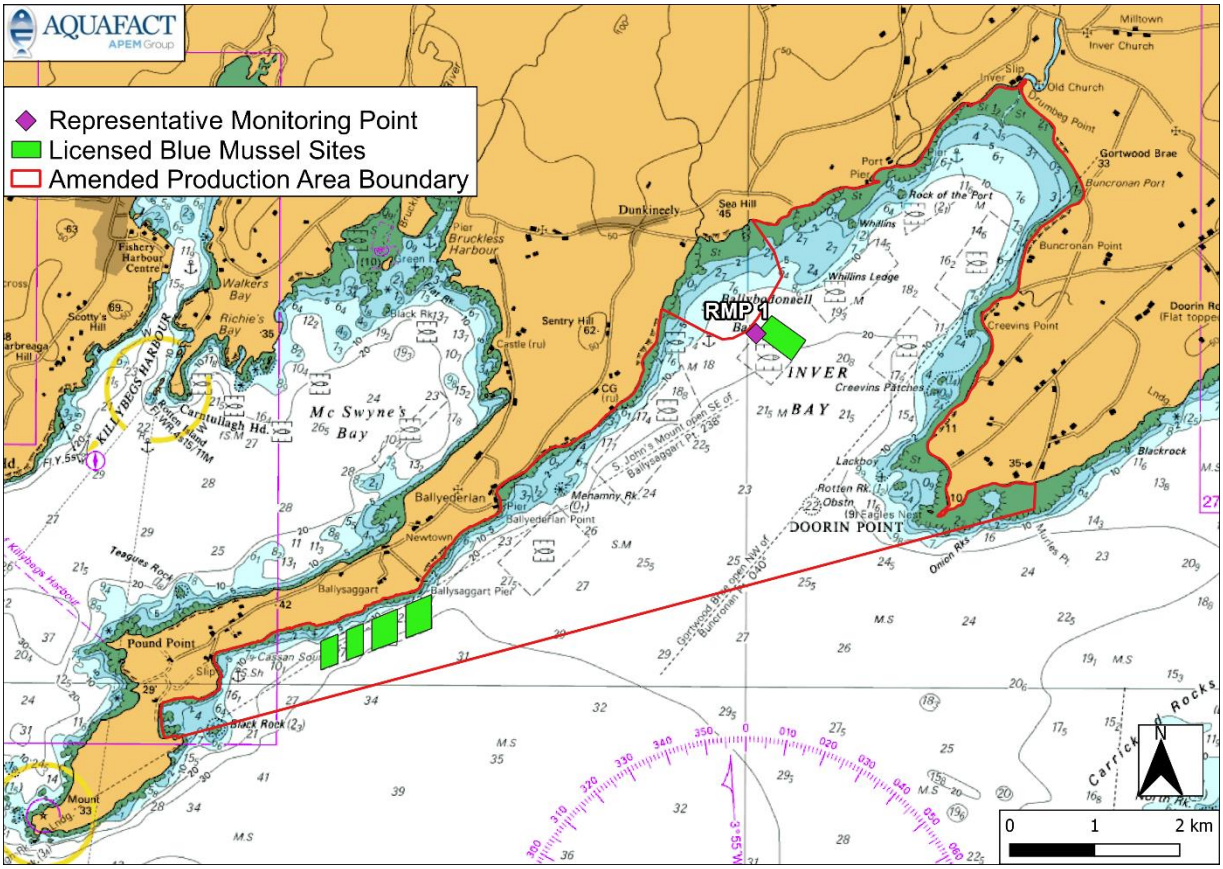
Responsible Authority: Sea Fisheries Protection Authority

Authorised Samplers: SFPA Port Office Killybegs

Maximum Allowed Distance from Sampling Point: The sample must be taken from within 100 m of the sampling point.

Sampling Size: Minimum 15 market sized animals

Sampling Method: Taken from rope at point.



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[3] See the following NPWS website for conservation features of SACs and SPAs, and their corresponding conservation objectives and site synopses: https://www.npws.ie/protected-sites

[4] Ireland's Marine Atlas: http://atlas.marine.ie/#?c=54.6230:-8.4073:12

[5] https://dafm-maps.marine.ie/aquaculture-viewer/

[6] DAFM Press Release: https://www.gov.ie/en/press-release/9cec1-farmers-individual-stocking-rates-for-new-cap-schemes-now-available-on-agfoodie/

[7] See Teagasc publications for The Sheep Industry – its recent evolution: https://www.teagasc.ie/publications/?page=3&yearReleased=2016&topic=animals%3Esheep
[8] See gov.ie webpage for National Sheep and Goat Census Report 2021: https://www.gov.ie/en/collection/3afc7-national-sheep-and-goat-census-report-2021/
[9] station coordinates for the ADCP measurements can be provided upon request.
[10] See the following NPWS website for site-specific conservation objective shapefiles: https://www.npws.ie/maps-and-data/habitat-and-species-data
[11] The 10 best things to do in Donegal: https://www.discoverireland.ie/
[12] See publications tab for SFPA code of practice: https://www.sfpa.ie/
[13] See statistics tab on CSO website for census of population 2016 & 2022; see census interactive map for small area population statistics & agricultural data: https://www.cso.ie/en/
[14] See Fáilte Ireland website for Key Tourism Facts 2019: https://www.failteireland.ie/FailteIreland/media/WebsiteStructure/Documents/3_Research_Insights/4_Visitor_Insights/KeyTourismFacts_2019.pdf?ext=.pdf
[15] https://www.failteireland.ie/FailteIreland/media/WebsiteStructure/Documents/Publications/Domestic-Trips-and-Revenue-by-County-2019-and-2021.pdf?ext=.pdf
[16] https://www.failteireland.ie/Research-Insights/Activities/visitor-numbers-to-attractions-dashboard.aspx
[17] https://www.beaches.ie/wp-content/uploads/2022/05/Map-of-identified-bathing-waters-with-classification-2021.pdf
[18] EPA Maps: https://gis.epa.ie/EPAMaps/
[19] See licensing and permitting page on https://www.epa.ie/
[20] EPA Geoportal: https://gis.epa.ie/
[21] https://www.irishstatutebook.ie/eli/statutory.html
[22]See services tab and environment for pollution control data, and road service for pier and harbour data: https://www.donegalcoco.ie/
[23] Groundwater vulnerability data viewer: https://dcenr.maps.arcgis.com/apps/webappviewer/index.html?id=7e8a202301594687ab14629a10b748ef
[24] See S.I. No. 113/2022 Part 1 *Interpretation* 4. (2) for definition of "soiled water"
[25] https://fishinginireland.info/
[26] National Biodiversity Data Centre: https://maps.biodiversityireland.ie/Species
[27] Figures displaying computed tidal velocities at the surface layer on a flooding and ebbing tide available upon request.
[28] See climate tab for current and historical data: https://www.met.ie/
[29] See the following website for WFD status of waterbodies in Ireland: https://www.catchments.ie/
[30] See publications on Inland Fisheries Ireland: https://www.fisheriesireland.ie/