Sanitary Survey Report

and

Sampling Plan

for Gweedore Bay

Produced by

AQUAFACT International Services Ltd

In conjunction with

The Sea Fisheries Protection Authority

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Glossary

AFBI	Agri-Food and Biosciences Institute
ANOVA	Analysis Of Variance
APP	Average Physical Product
ASP	Amnesic Shellfish Poisoning
Bathymetry	The measurement of water depth at various places of a water body
Benthic	Of, pertaining to, or occurring at the bottom of a body of water
Biogenic	Produced by living organisms or biological processes
Bioturbation	The stirring or mixing of sediment or soil by organisms
BOD	Biochemical Oxygen Demand
BTO	British Trust for Ornithology
Bysso-pelagic drifting larval mussels	Drifting or dispersal that is aided by long byssus threads produced by young post-
Byssus Threads	Strong filaments by which mussels attach themselves to fixed surfaces
CD	Chart Datum
CEFAS	Centre for Environmental, Fisheries & Aquaculture Science
Corine landuse	is a Pan-European landuse and landcover mapping programme. It supplies spatial data on the state of the European environmental landscape and how it is changing over time. Based on the interpretation of satellite imagery, Corine landuse provides national scale maps of landcover and landcover change on a six year basis for thirty nine countries in Europe.
CSO	Central Statistics Office
CSO	Combined Sewer Overflow
DARD	Department of Agriculture and Rural Development
DED	District Electoral Divisions
Depuration	The process of purification or removal of impurities
Detrital/Detritus	Non-living, particulate, organic fragments which have been separated from the body to which they belonged
DSP	Diarrhetic Shellfish Poisoning
DWF	Dry Weather Flow
EC	European Communities
E. coli	Escherichia coli
EMS	Environmental Monitoring Stations
Epifauna	Animals living on the surface of marine or freshwater sediments

Epiflora	Plants living on the surface of marine or freshwater sediments
Fecundity	A measure of fertility or the capability to produce offspring
Fetch	The distance a wave can travel towards land without being blocked
FSA in NI	Food Standards Agency of Northern Ireland
Gamete	A reproductive cell that fuses with another gamete to produce a zygote, which develops into a new individual
Gametogenesis	The formation or production of gametes or reproductive cells
Genotype	The genetic makeup of an organism
Geometric Mean	The nth root of the product of n numbers (The average of the logarithmic values of a data set, converted back to a base 10 number).
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine environmental Pollution
GIS	Geographical Information Systems
GPS	Global Positioning System
GSM	Global System for Mobile Communication
Heterozygosity	Having two different alleles of the same gene
Hydrodynamic	Forces in or motions of liquids
Hydrography	The description and analysis of the physical conditions, boundaries, flows and related characteristics of water bodies
IID	Infectious Intestinal Disease
INAB	Irish National Accreditation Board
Interspecific Competition	Competition for resources between different species
Intraspecific competition	Competition for resources between members of the same species
Intervalvular	Between valves
I-WeBS	Irish Wetland Bird Survey
LAT	Lowest Astronomical Tide
Marpol 73/78	International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978. Marpol is short for Marine Pollution, 73 for 1973 and 78 for 1978.
Metamorphosis	The transformation from the larval to the adult form that occurs in the life cycle of many invertebrates and amphibians
MPN	Most Probable Number
MSD	Marine Sanitation Device
Multilocus	Occurring at more than one position or locus on a chromosome
NAP	Nitrates Action Programme
ND	Not Detectable

NH_4	Ammonium
NIEA	Northern Ireland Environment Agency
NISRA	Northern Ireland Statistics and Research Agency
NITB	Northern Ireland Tourist Board
Nitrification	The conversion of ammonia to nitrate
NI Water	Northern Ireland Water
NO_2	Nitrite
NO_3	Nitrate
NoV	Norovirus
NRFA	National River Flow Archive
NRL	National Reference Laboratory
OSPAR	Oslo/Paris convention (for the Protection of the Marine Environment of the North-East Atlantic)
P	Phosphorus
PAH	Polycyclic Aromatic Hydrocarbons
Pathogenic	Capable of causing disease
PCB	Polychlorionated Biphenyls
PCP	Pentachlorophenol
p.e.	Population Equivalent
Plankton/Planktonic	Pertaining to small, free-floating organisms of aquatic systems
PMFSC	Pacific States Marine Fisheries Commission
Pseudofaeces	Material rejected by suspension or deposit feeders as potential food before entering the gut
PSP	Paralytic Shellfish Poisoning
PSU	Practical Salinity Units
RAMSAR	A term adopted following an international conference, held in 1971 in Ramsar in Iran, to identify wetland sites of international importance, especially as waterfowl habitat.
Regulation (EC) 854/2004	REGULATION (EC) No 854/2004 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 29 April 2004 laying down specific rules for the organisation of official controls on products of animal origin intended for human consumption
RIB	Rigid Inflatable Boat
RMP	Representative Monitoring Point
RNA	Ribonucleic Acid
SAC	Special Area of Conservation

SFPA	Sea Fisheries Protection Authority
SMILE	Sustainable Mariculture in northern Irish Lough Ecosystems
SOA	Super Output Areas or ward
SPA	Special Protection Area
SPM	Suspended particulate Matter
SPS	Sewage Pumping Station
SS	Suspended Solids
STW	Sewage Treatment Works
Suspension feeders	Animals that feed on small particles suspended in water
TBTO	Tributyl Tin Oxide
Telemetry	The measurement and transmission of data from remote sources to receiving stations for recording and analysis
TPP	Total Physical Product
UKAS	United Kingdom Accreditation Service
UKHO	United Kingdom Hydrographic Office
Vector	A carrier, which transmits a disease from one party to another
WeBS	Wetland Bird Survey
WTP	Water Treatment Plant
WWTW	Waste Water Treatment Works

1. Introduction

Consumption of raw or lightly cooked bivalve molluscs can results 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 microorganisms may cause infectious disease 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.

The risk of contamination of bivalve molluscs with pathogen microorganisms is assessed through microbiological monitoring programmes. This assessment results in the classification of bivalve mollusc production areas, which in turn governs the level of treatment required before human consumption of the shellfish.

Under EU regulations sanitary surveys of bivalve mollusc production areas and their associated hydrological catchments and coastal waters are required in order to establish the appropriate representative monitoring points 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 219 states:

1. Before classifying a production or relaying area, the competent authorities shall carry out a sanitary survey that includes:

- an inventory of the sources of pollution of human or animal origin likely to be a source of contamination for the production area;
- 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, waste-water treatment, etc.;
- 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 1 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.

Currently the Sea Fisheries Protection Authority in conjunction with AQUAFACT International Services Ltd 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 Gweedore Bay, County Donegal. It identifies the representative monitoring points and supporting sampling plans for pacific oysters and razor clams in Gweedore Bay. It also sets out the production area boundaries in the Bay.

2. Overview of the Fishery/Production Area

2.1. Description of the Area

Gweedore Bay BMPA is located along the north western coast of Ireland. Gweedore Bay is divisible into two distinct sections; the outer is exposed to the Atlantic, while the inner is narrow and river like with a maximum width of 1.2km and is almost completely intertidal except for a narrow channel. The deeper part of the channel runs from Meenaduff Point out along the middle of the bay until it meets Inishinny Island where it splits into two channels running either side of the Island. Depths in this channel range from 0.2 to 5.3m (Admiralty Chart 1883). In the outer part a deep channel runs between Gola Island and Inishmeane Island and then between Gola Island and Inishinny Island. The depths in this channel range from 6 to 14m.

Gweedore Bay is designated as part of a Special Area of Conservation (SAC); Gweedore Bay and Islands SAC (Site Code: IE001141) (see Figure 2.1) due to the presence of a number of important habitats and species. The Fawnboy Bog/Lough Nacung SAC (Site Code: IE000140) follows into the Gweedore Bay BMPA via the Clady River at Bunbeg (see Figure 2.1).

Gweedore Bay is also designated as a Special Protection Area (SPA): West Donegal Islands SPA (IE004230) and West Donegal Coast SPA (Site Code: IE004150) (see Figure 2.1). These sites are designated due to the presence of a number of important bird species.

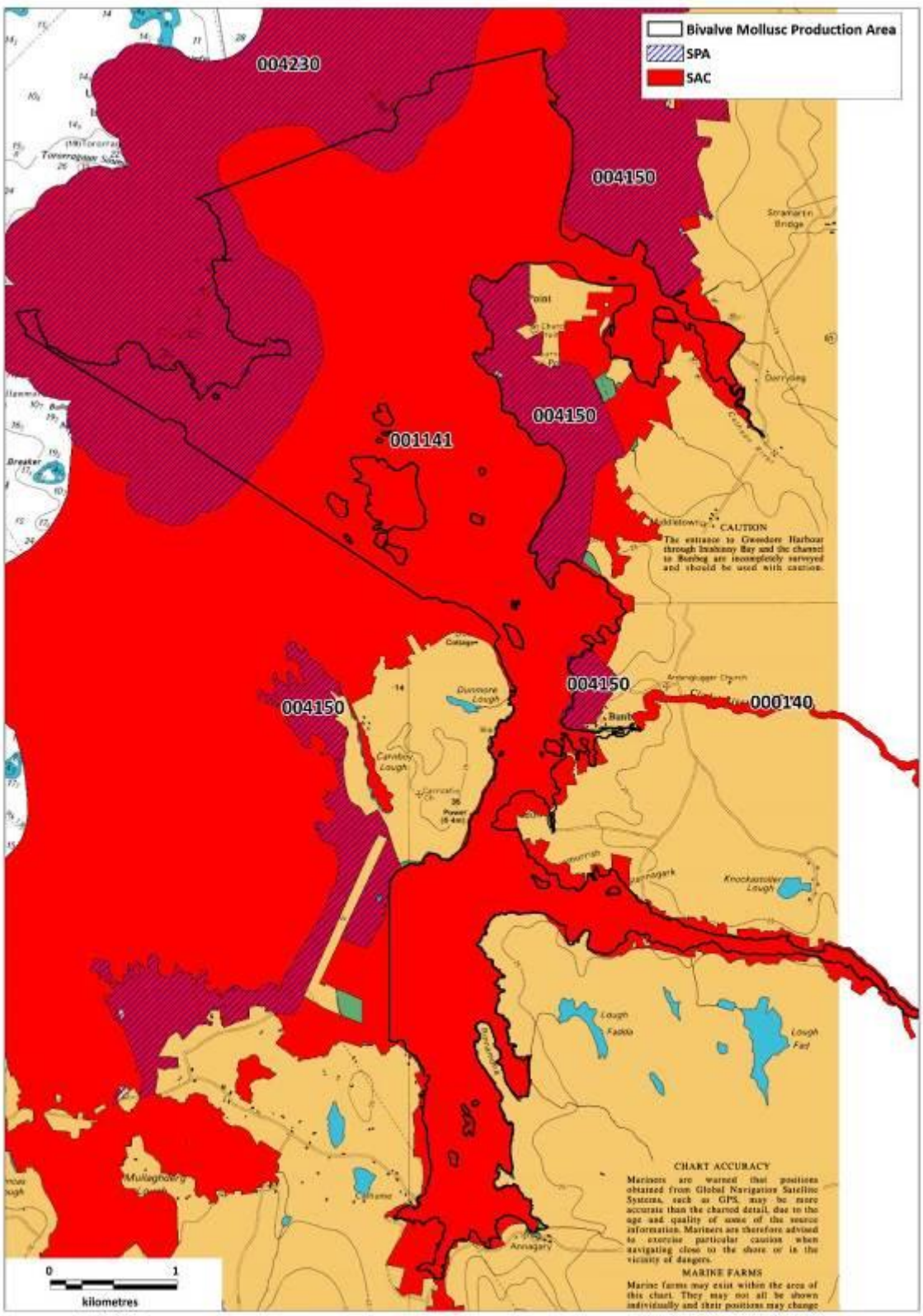

Figure 2.1: Location of Natura 2000 sites overlapping with the Gweedore Bay BMPA.

The Gweedore Bay BMCPA supports a diversity of fish species. Species present include sea trout, flounder, European eel, dogfish, dab, Pollack, ling, coalfish, ray and cod (IFI, 2019). There is virtually no inshore fishing activity in the inner parts of the production area but in particular during the summer months small

vessels would target crab and lobster around the islands in the outer production area. The port of Bunbeg which is located within the production area supports quite a few inshore fishing vessels.

Land cover within the Gweedore Bay catchment is a mixture of Peat bogs, Land principally occupied by agriculture, with significant areas of natural vegetation, Sparsely vegetated areas, Complex cultivation patterns, Beaches, dunes, sands, Moors and heathland, Water bodies, Intertidal flats, Natural grasslands, Estuaries, Discontinuous urban fabric, Transitional woodland-shrub, Coniferous forest, Pastures, Bare rocks, Airports, Industrial or commercial units, Sport and leisure facilities, Broad-leaved forest, Mineral extraction sites and Salt marshes.

The population of the catchment is approximately 6,753. There are three towns/urban centres within the catchment area. Bunbeg (1,491) has the largest population, followed by Rann na Feirste (309) and Annagary (236).

2.2. Gweedore Bay Fishery

2.2.1. Location/Extent of Growing/Harvesting Area

The shellfish designated waters in Gweedore Bay cover an area of approximately 5.73km^2 and the Bivalve Mollusc Classified Production Area (BMCPA) covers *c*. 13.49km^2. Both can be seen in Figure 2.2. Oyster cultivation occurs in Gweedore Bay.

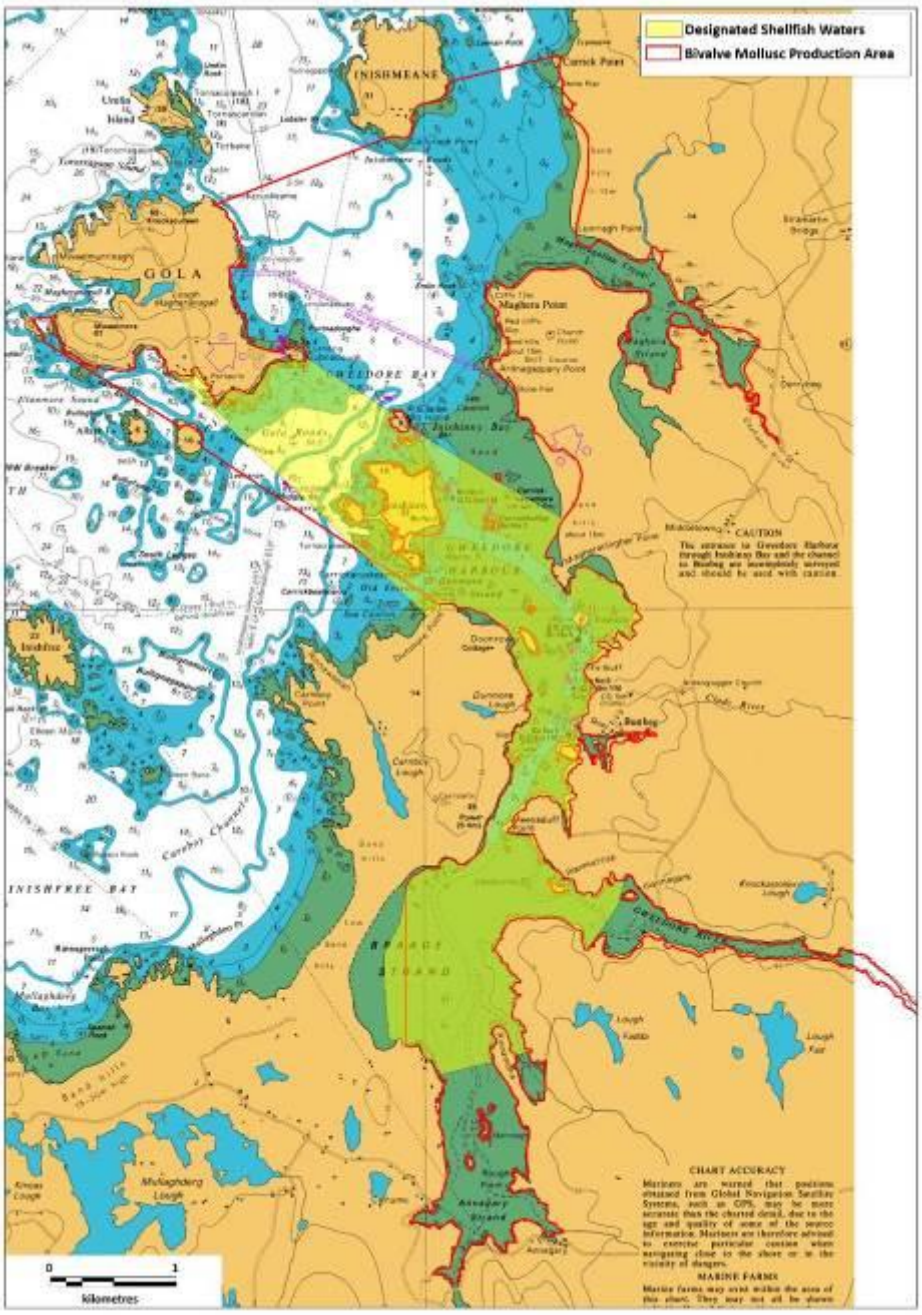

Figure 2.2: Bivalve Mollusc Classified Production Area and Designated Shellfish Waters within Gweedore Bay.

Figure 2.3 shows the current locations of licenced aquaculture sites within Gweedore Bay. All sites are

licensed for oysters and these extend from Braade Strand in the south to the channel flowing into Gweedore Harbour in the north. All sites are located in the intertidal zone. The area licenced for oyster cultivation is approximately 0.1km^2.

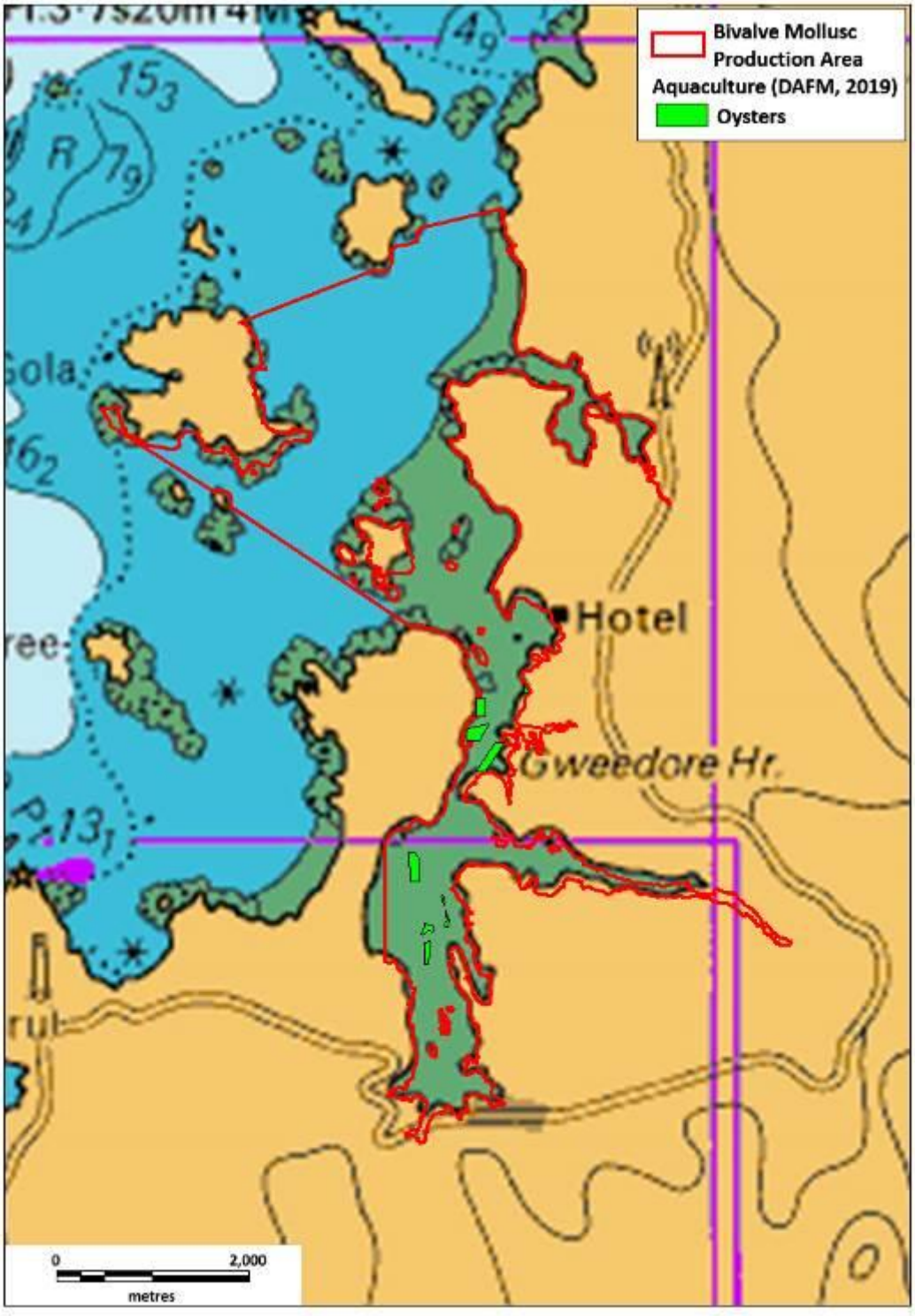

Figure 2.3: Licenced aquaculture sites within Gweedore Bay (Source: DAFM, 2019).

2.2.2. Description of Species

*2.2.2.1. Pacific Oysters (*Crassostrea gigas*)*

Distribution

Figure 2.4 shows the locations of licenced intertidal farmed Pacific oyster sites in Gweedore Bay. These farmed sites cover an area of 0.103km^2. The farms in Gweedore Bay are located on the intertidal sandflats in Braade strand and on the eastern and western shores of the channel entering Gweedore Harbour.

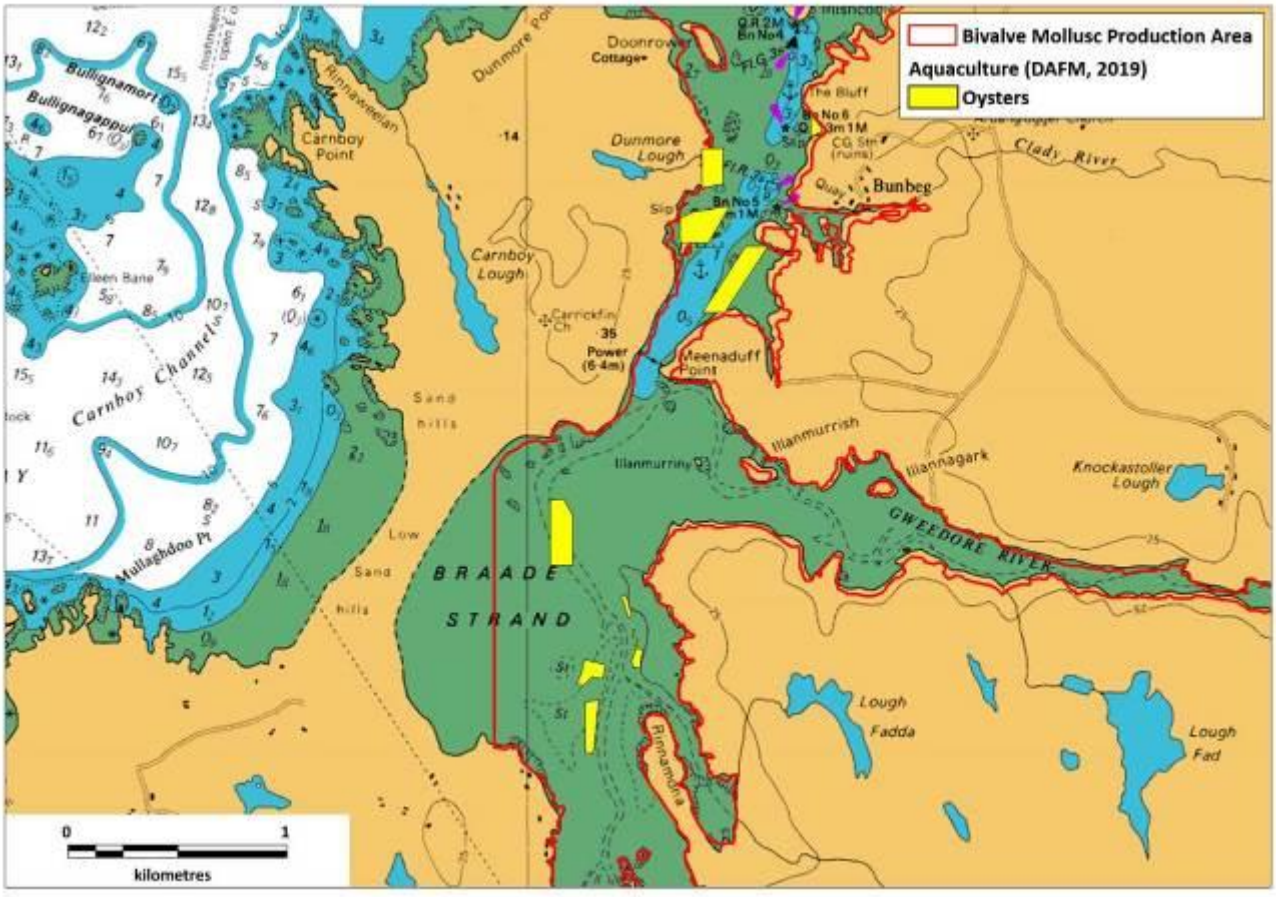

Figure 2.4: Licenced Pacific oyster harvesting sites in Gweedore Bay (Source: DAFM, 2019).

Fishery

Oyster cultivation in Gweedore Bay is intensive and uses the bag and trestle method within the intertidal zone. This method uses steel table-like structures which rise from the shore to above knee-height, arrayed in double rows and with wide gaps between the paired rows to enable access (Marine Institute, 2016a).
Seed is brought in from France to the site in spring or late summer each year. Oysters are thinned out and graded throughout the production cycle. Farms are accessed typically during low spring tides using tractors

and preparatory works are undertaken on site. The average production levels of oysters from Gweedore bay from 2016 to 2018 was 109 tonnes. Some of the pacific oysters grown in Gweedore Bay are directed towards the half grown market with maturation and finishing taking place elsewhere.

*2.2.2.2. Razor Clams (*Ensis *spp.)*

Distribution

Two different species of naturally occurring razor clams are found in the outer reaches of the Gweedore Bay production area, *Ensis arcuatus* and *Ensis siliqua*. There is currently no active fishery for these species.

Gweedore Bay was surveyed by the Marine institute for razors on 14th October 2016 aboard MFV Rosanne using a hydraulic dredge. Both species were present, with a dominance of *Ensis arcuatus* (Marine Institute, 2016b). Distribution of biomass of both species of razor clam can be seen in Figure 2.5 and 2.6.

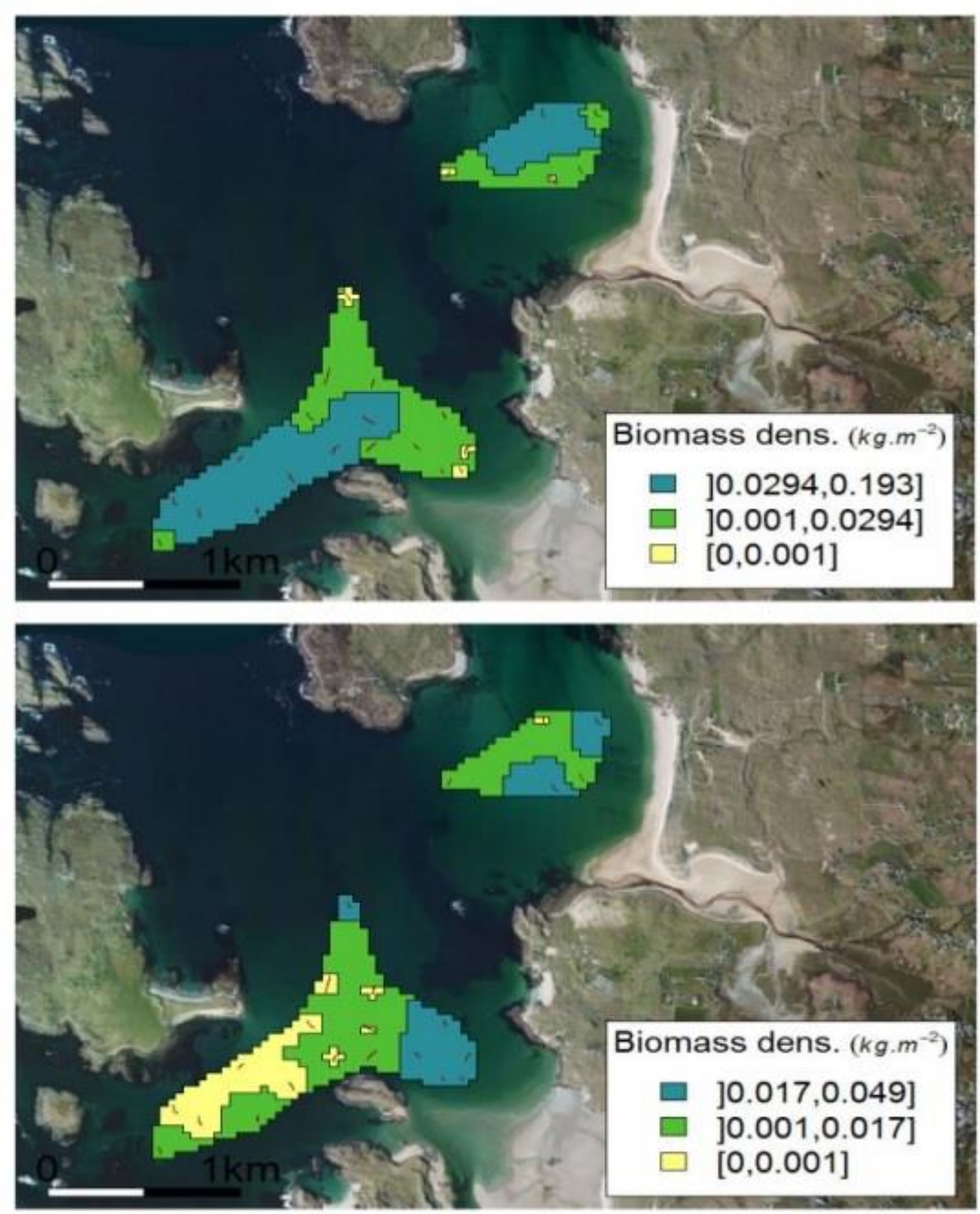

Figure 2.5: Marine institute 2016 biomass survey of Razor Clams in Gweedore bay. *Ensis arcuatus* (Top) and *E. siliqua* (Bottom) (Marine, 2016).

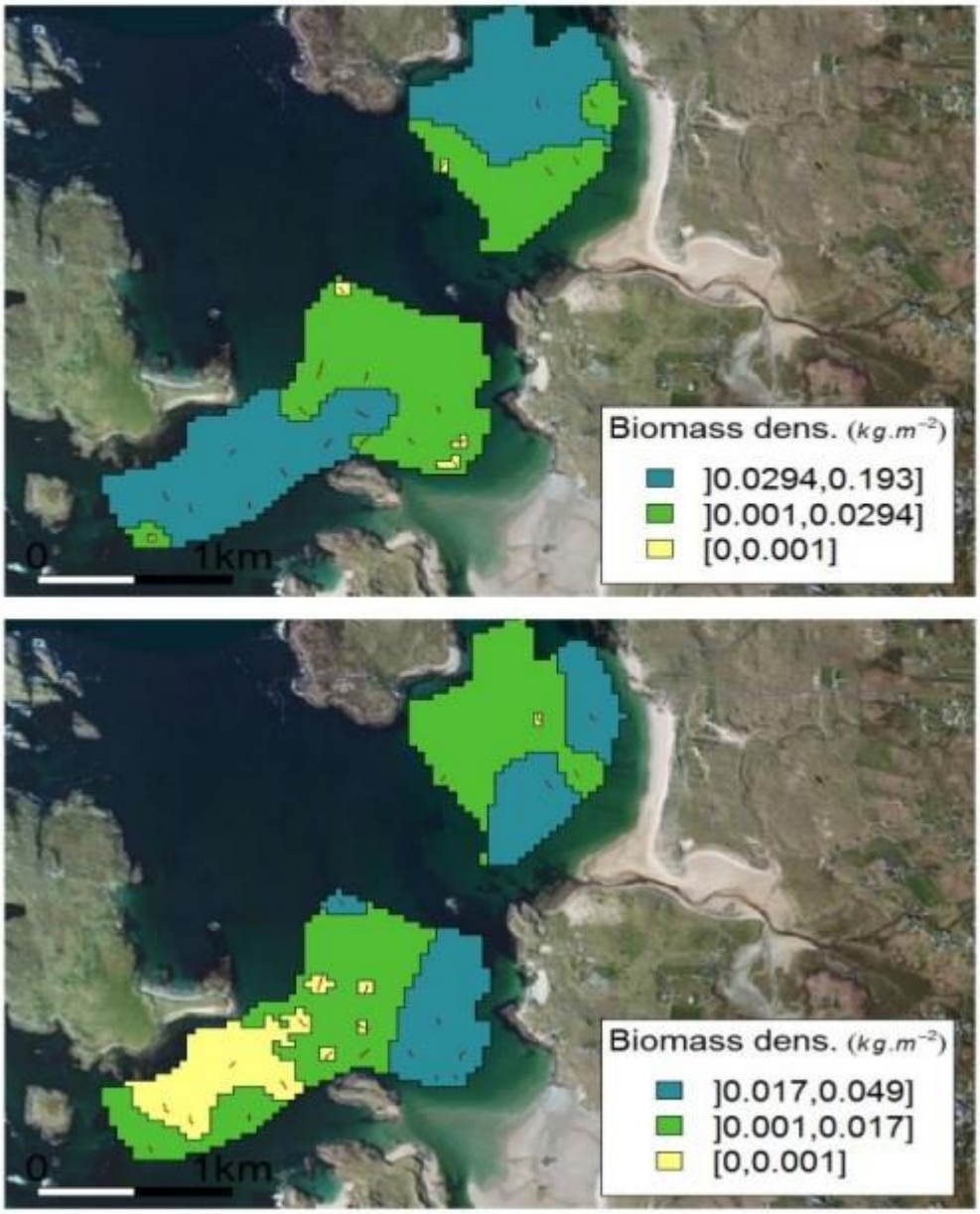

Figure 2.6: Marine Institute 2016 biomass survey extended zone (potential distribution) in Gweedore Bay (Marine, 2016).

Fishery

There is currently no fishery as the bay is as of yet not classified for razor clams. Background sampling is taking place for the area.

3. Identification of Pollution Sources

This section attempts to document all pollution sources within the Gweedore Bay catchment area.

3.1. Desktop Survey

Pollution sources were considered within the catchment area of Gweedore Bay (see Figure 3.1). The catchment area covers an area of 244km^2, approximately 4km southwest to northeast at its widest point and 4.6km northeast southwest at its longest point.

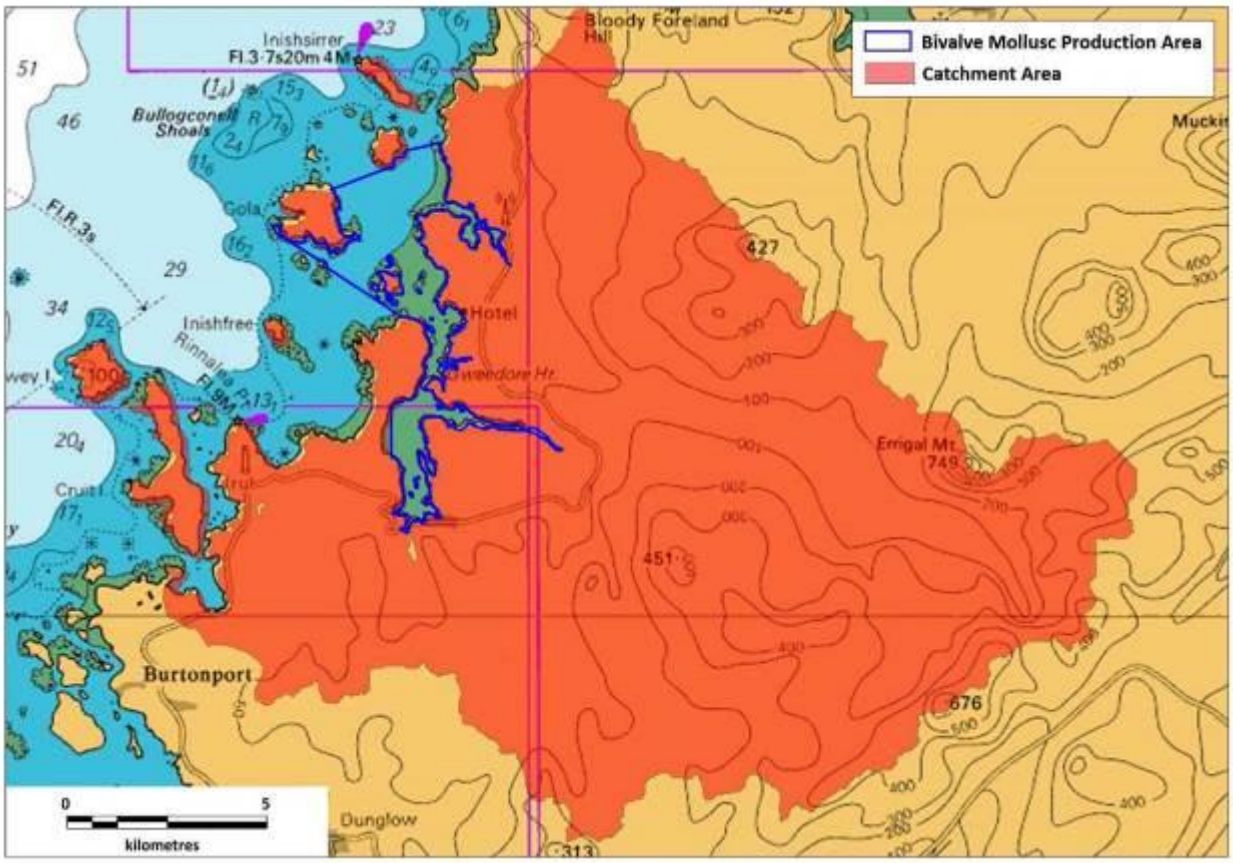

Figure 3.1: Gweedore Bay catchment area used for assessment of the pollution sources.

3.1.1. Human Population

Population census data used by the Central Statistics Office (CSO) is given in units of Electoral Divisions (ED). Figure 3.2 shows the EDs within the catchment area. The population data were obtained through the Central Statistics Office (CSO) online Small Area Population Statistics (SAPS) (CSO, 2019a) for the year 2016. Figure 3.3 shows the human population within Gweedore Bay catchment area and Table 3.1 shows these data in tabular form.

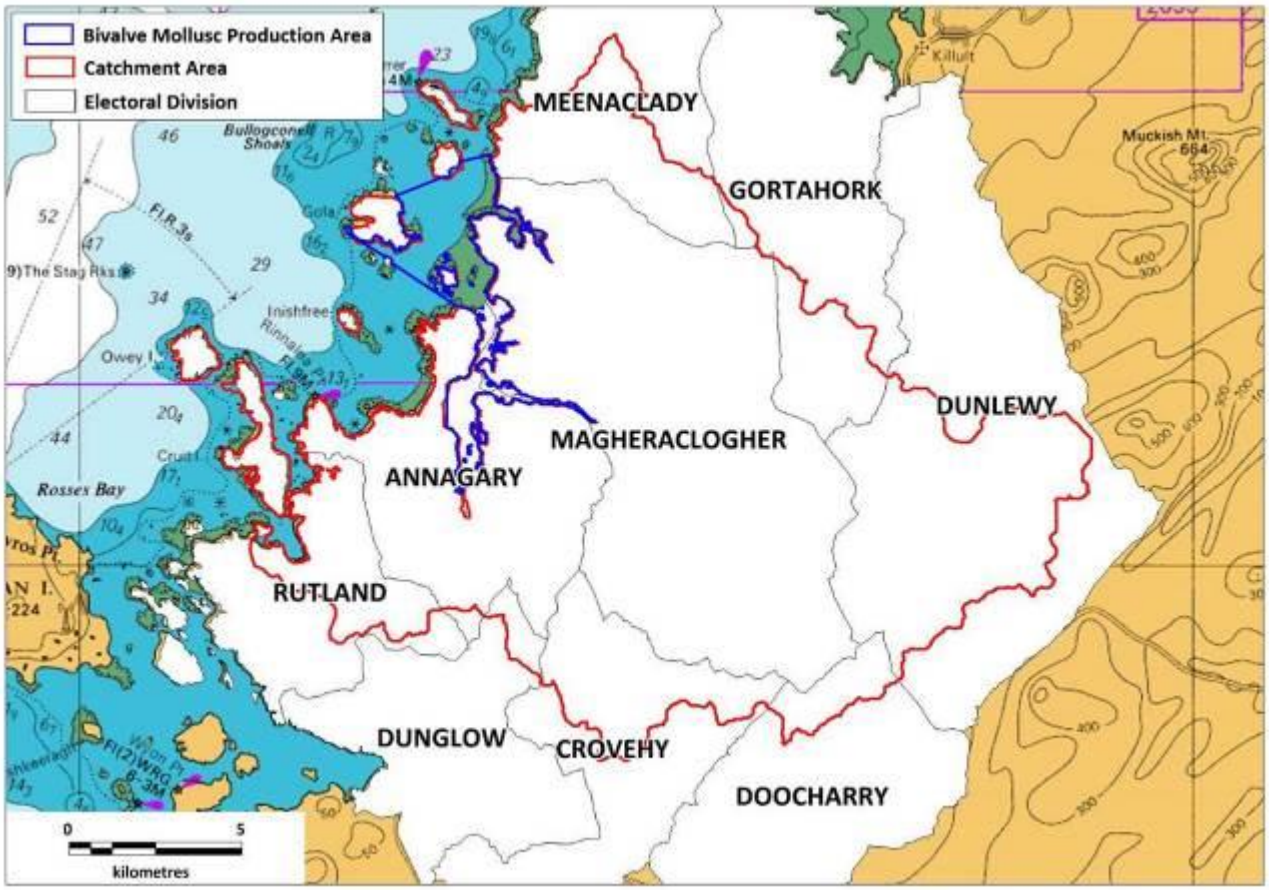

Figure 3.2: Electoral Divisions within the Gweedore Bay Catchment Area.

The Gweedore Bay Catchment Area overlaps 9 ED's. The ED's that are partially within the catchment are Dunglow, Doocharry, Annagary, Crovehy, Dunlewy, Gortahork, Rutland, Magheraclogher and Meenaclady. Magheraclogher contains the largest population (2,750) followed by Annagary (2,196), Dunglow (1,886) and Gortahork (1608).

These 9 ED's accommodate a total population of 12,104. As most of these ED's only partially overlap the catchment area, an attempt was made to estimate the actual population within the catchment. The percentage of the ED lying within the catchment was calculated in GIS and from this value the population size was calculated e.g. if 50% of ED lies within catchment area then 50% of the total population was taken to be the population size of the area within the catchment. Using this method, the population of the catchment areas is estimated at 6,753 people. Table 3.1 shows this estimation.

There are three towns/urban centres within the catchment area. Bunbeg (1,491) has the largest population, followed by Rann na Feirste (309) and Annagary (236).

There are 8,188 households within the 9 ED's within the catchment area. Of this, 17% are vacant (1398) and a further 21% are holiday homes (1733). Of the 4,615 houses actually within the catchment (based on the % of the ED within the catchment), 16% are vacant and 23% are holiday homes. Table 3.2 shows the number of households in each ED and the proportion actually within the catchment area.

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 clear that areas with a higher population will have higher levels of sewage and wastewater entering the Gweedore Bay system. Magheraclogher and Annagry are the most populated of the electoral divisions within the catchment so it is reasonable to expect that the rivers and streams draining through these will be at greater risk of carrying contamination into the fishery. As holiday homes account for 23% of the dwellings in the catchment they are likely to cause an increase in the sewage and waste water levels during holiday periods.

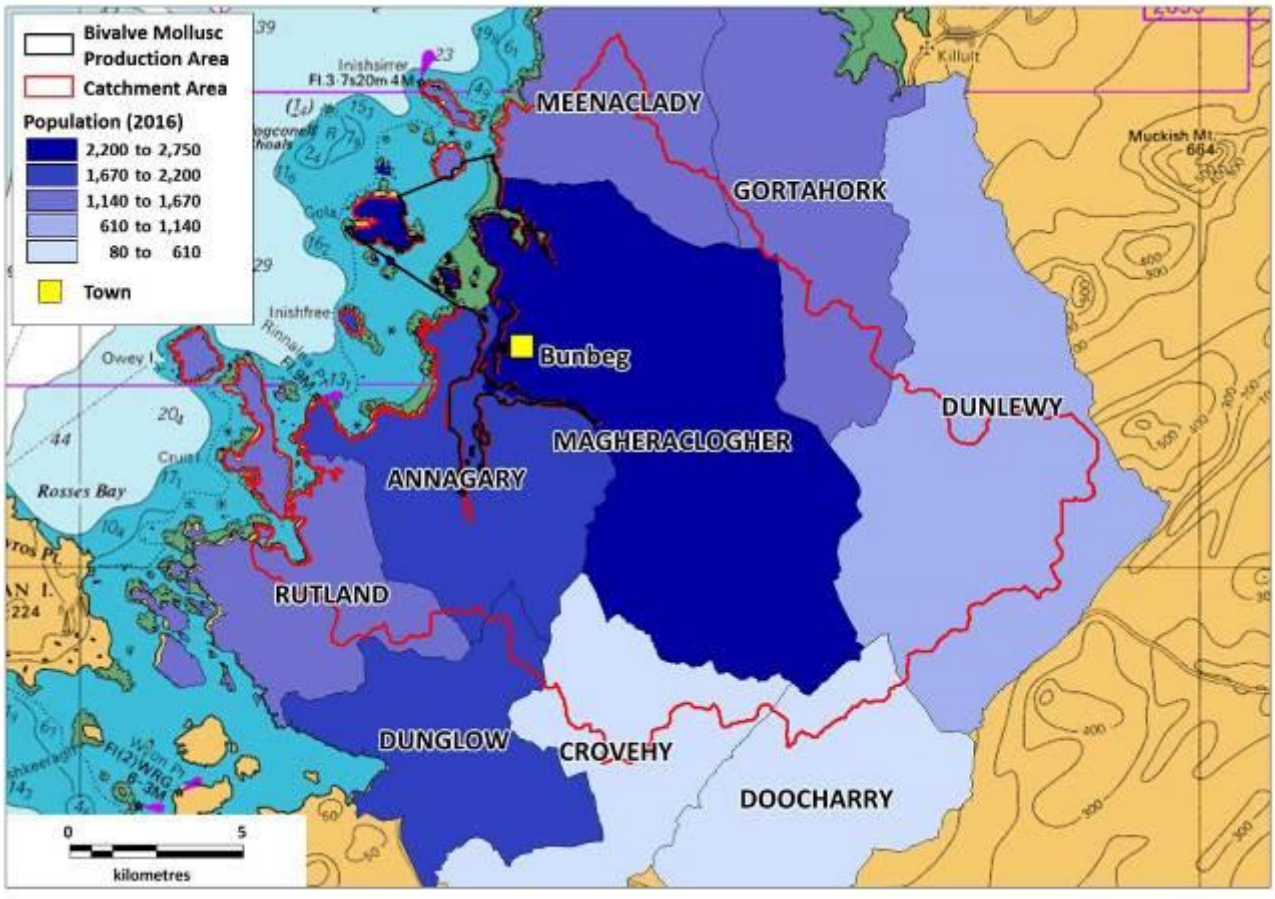

Figure 3.3: Human population within the Gweedore Bay Catchment Area (Source: CSO, 2019a).

Table 3.1: Human population within the Gweedore Bay Catchment Area (Source: CSO, 2019a).

Electoral Division	Population (2016)	% ED in Catchment	Estimated Population
Dunglow	1886	5.45	103
Doocharry	88	10.76	9
Annagary	2196	90.15	1980
Crovehy	155	40.21	62
Dunlewy	693	41.67	289
Gortahork	1608	19.53	314
Rutland	1440	49.10	707
Magheraclogher	2750	98.54	2710
Meenaclady	1288	44.94	579

Table 3.2: Households within the EDs in the Gweedore Bay Catchment Areas (Source: CSO, 2019a).

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
Dunglow	1131	792	90	226	62	43	5	12
Doocharry	62	37	18	6	7	4	2	1
Annagary	1493	886	369	205	1346	799	333	185
Crovehy	97	58	6	31	39	23	2	12
Dunlewy	453	277	93	74	189	115	39	31
Gortahork	1036	646	194	183	202	126	38	36
Rutland	1174	624	305	223	576	306	150	109
Magheraclogher	1794	1093	403	262	1768	1077	397	258
Meenaclady	948	497	255	188	426	223	115	84

* This figure includes those houses temporarily unoccupied on census night

3.1.2. Tourism

In 2017, 2.4 million tourists visited the Border Region of Ireland (Failte Ireland, 2018a). This figure was made up of 746,000 overseas tourists, 1,000,000 domestic tourists and 648,000 Northern Irish tourists. Donegal accounted for 255,000 of the overseas tourists and 376,000 of the domestic tourists (Failte Ireland, 2018b). The main tourist attractions in the area are Glenveagh National Park, Glenveagh Castle and Gardens, Mount Errigal, Owey and Gola islands, along with multiple beaches including Carrickfinn Blue Flag beach. For Ireland as a whole, in 2017 most tourists visited between July and September (31%), followed by April to June (27%), October to December (23%) and January to March (18%). There is no reason to expect this trend to be any different in the Border region.

Several operators use the natural amenities in and adjacent to Gweedore Bay as a focal point for their aqua-tourism businesses. Saoire Mara charters operate an angling and charter vessel out of Kincasslagh. There are a number of businesses that use the area for adventure sports (Selkie Sailing, Rapid Kayaking Unique Ascent, Rock agus Roam and Ionad Cois Locha).

In addition to the above there is also a number of beaches and caravan/camping sites located along the shore of Gweedore Bay and a number of piers, quays and slips which provide sea access.

Increases in population in the local area due to tourism may result in an increase in the quantity of sewage discharged within the Gweedore Bay catchment area. In addition, Papadakis *et al.* (1997) found significant correlations between the number of swimmers present on beaches and the presence of pathogenic bacteria. In 2007, Elmir *et al.* (2007) showed the role of human skin as an intermediate mechanism of pathogen transmission to the water column. There are two monitored bathing waters near the production area one is Carrickfinn Beach, which is a Blue Flag beach and the other is Portarthur Beach which has excellent water quality. Carrickfinn Beach is used for swimming, kayaking, boating, windsurfing and other land-based activities such as football, kite flying etc. Other activities which are popular at the beach include walking and watching for dolphins. Activities at Portarthur Beach include swimming, kayaking, boating, sailing, power boating, jet skiing, diving and other land based activities on the beach.

3.1.3. 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 sewerage systems (intermittent);
- septic tanks (intermittent);
- crude sewage discharges at some estuarine and coastal locations (continuous).

Treatment of sewage ranges from:

- none at all (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 - N 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 a coastal works) or a treatment to reduce the load of micro-organisms in the effluent)., typically removes 100% of BOD, 100% of suspended solids, 33% of nitrogen and 38% of phosphorus from the untreated sewage.

3.1.3.1. Water Treatment Works

There are five waste water or sewage treatment works within the Gweedore Bay catchment, four of which discharge to the groundwater (Loughanure Housing Scheme, Stranacorcragh Housing Scheme, Meenanillar Housing Scheme and Cottain Housing Scheme) and one which discharges directly into Gweedore Bay (Annagary). Figure 3.4 shows all 5 Treatment Works within the Gweedore Bay catchment area and Table 3.3 shows the coordinates and facility capacities of each works (EPA, 2019c).

3.1.3.2. Continuous Discharges

Annagary WWTP is a primary treatment facility with a design capacity of 500 PE (Population Equivalent) and is currently under capacity at 473 PE, the maximum discharge for this facility is 177 m^3/day. Loughanure Housing Scheme WWTP is a secondary treatment facility the design capacity is not available

and the current capacity is 48 PE, at the time of writing there was no data for the maximum discharge from this facility. Meenanillar Housing Scheme WWTP is a secondary treatment facility with a design capacity of 90 PE and is currently at capacity, the maximum discharge for this facility is 33.75 m^3/day. Cottain Housing Scheme WWTP is a primary treatment facility with a design capacity of 60 PE and is currently at capacity, the maximum discharge for this facility is 22.5 m^3/day. Stranacorcragh Housing Scheme WWTP is a primary treatment facility with a design capacity of 60 PE and is currently at capacity, the maximum discharge for this facility is 22.5 m^3/day. The locations of the discharges can be seen in Figure 3.5 and Table 3.4 provides details of the discharge. Strict emissions limits are set out in the discharge Licences for each facility in terms of BOD (Biological Oxygen Demand), Orthophosphate, Suspended Solids, Nitrogen and Ammonia. These emissions limits comply with the parameters of Shellfish Directive (2006/113/EC) and the Quality of Shellfish Waters Regulations 2006.

There is no geo-referenced database for septic tanks and on-site domestic waste water treatment systems. 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 (CSO, 2019a). Of the 4,834 permanent private households in the 9 EDs, 14.6% (706) were connected to a public sewer/treatment system and 80.2% (3,877) had septic tanks or other individual treatment systems. The estimate for the total number of private permanent households actually within the catchment (based on % within the catchment) is 2,674 and of this 9% (241) are on the public system while 85% (2,285) households have their own septic tanks or other individual treatment systems. Table 3.5 shows this information at the ED level and an estimation (based on % within the catchment) of the numbers actually within the catchment.

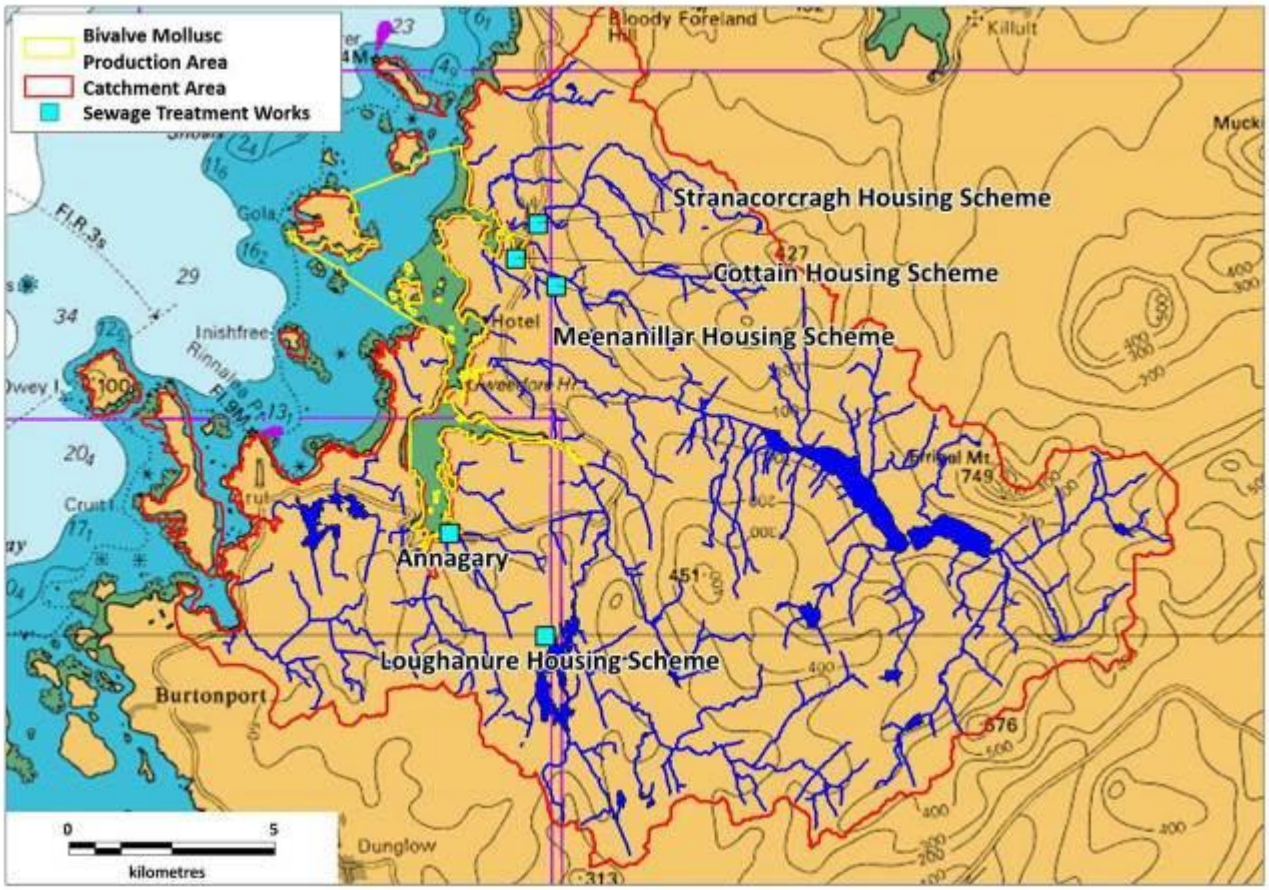

Figure 3.4: Sewage Treatment Works within the Gweedore Bay Catchment Area (Source: The EPA, 2019c).

Table 3.3: Sewage Treatment Works within the Gweedore Bay Catchment Area (Source: EPA, 2019c).

Name	Easting	Northing	Longitude	Latitude	p.e.	Designed p.e.
Annagary	179487.2	419499.9	-8.3215	55.02249	473	500
Loughanure Housing Scheme	181777.2	417014.8	-8.28553	55.00026	48	N/A
Meenanillar Housing Scheme	182077.2	425450.9	-8.28138	55.07604	90	90
Cottain Housing Scheme	181110.2	426112.9	-8.29656	55.08195	60	60
Stranacorcragh Housing Scheme	181655.2	426944.9	-8.28808	55.08945	60	60

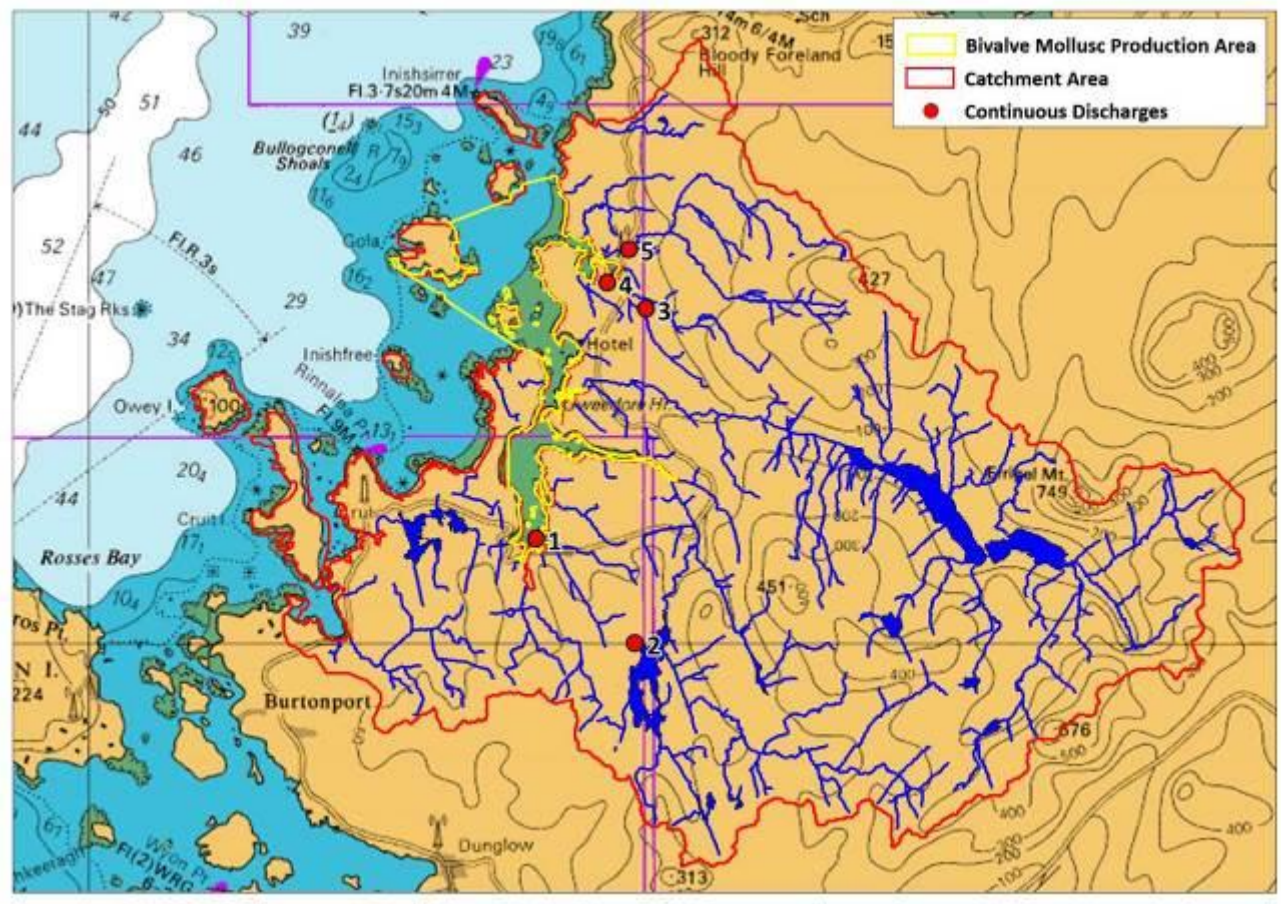

Figure 3.5: Continuous Discharges associated with the Sewage Treatment Works within the Gweedore Bay Catchment Area (Source: EPA, 2019c).

Table 3.4: Continuous Discharges within the Gweedore Bay Catchment area (Source: EPA, 2019c). Map Codes refer to Figure 3.5.

Map Code	Name	Treatment	Easting	Northing	Longitude	Latitude	Receiving Body	Max Discharge/ day (m3)	DWF/ day (m3)
1	Annagary	1 - Primary Treatment	179229	419701	-8.32557	55.02449	Gweedore Estuary	177	N/A
2	Loughanure Housing Scheme	2 - Secondary Treatment	181712	417048	-8.28658	55.00076	Groundwater	N/A	N/A
3	Meenanillar Housing Schem	2 - Secondary Treatment	182022	425470	-8.28226	55.07643	Groundwater	33.75	N/A
4	Cottain Housing Scheme	1 - Primary Treatment	181054	426128	-8.29746	55.08230	Groundwater	22.5	N/A
5	Stranacorcragh Housing Scheme	1 - Primary Treatment	181592	426971	-8.28909	55.08989	Groundwater	22.5	N/A

Table 3.5: Sewage facilities at permanent households in the catchment area (CSO, 2019a).

Electoral Division	Entire ED						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
Dunglow	779	349	370	22	37	1	42	19	20	1	2	0
Doocharry	37	18	16	0	2	1	4	2	2	0	0	0
Annagary	869	110	689	29	41	0	783	99	621	26	37	0
Crovehy	58	0	55	2	1	0	23	0	22	1	0	0
Dunlewy	276	9	251	6	10	0	115	4	105	3	4	0
Gortahork	639	89	517	11	22	0	125	17	101	2	4	0
Rutland	605	36	500	29	40	0	297	18	246	14	20	0
Magheraclogher	1079	74	884	52	65	4	1063	73	871	51	64	4
Meenaclady	492	21	432	12	26	1	221	9	194	5	12	0

3.1.3.3. Rainfall Dependent / Emergency Sewage Discharges

In addition to WWTPs having a continuous discharge pipe, they also have intermittent or rainfall-dependent discharge pipes in the form of storm water overflows. 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. Annagary WWTP is the only plant in the catchment that has a storm water overflow. The details for the intermittent discharge can be seen in Table 3.6 and its locations can be seen in Figure 3.6.

Table 3.6: Rainfall dependent discharges (storm water overflows) within the Gweedore Bay Catchment area (Source: EPA, 2019a). Map Codes refer to Figure 3.6.

Map Code	Name	Discharge Point Code	Easting	Northing	Longitude	Latitude	Receiving Body
1	Annagary	SW2	179361	419330	-8.32348	55.02117	Gweedore Estuary

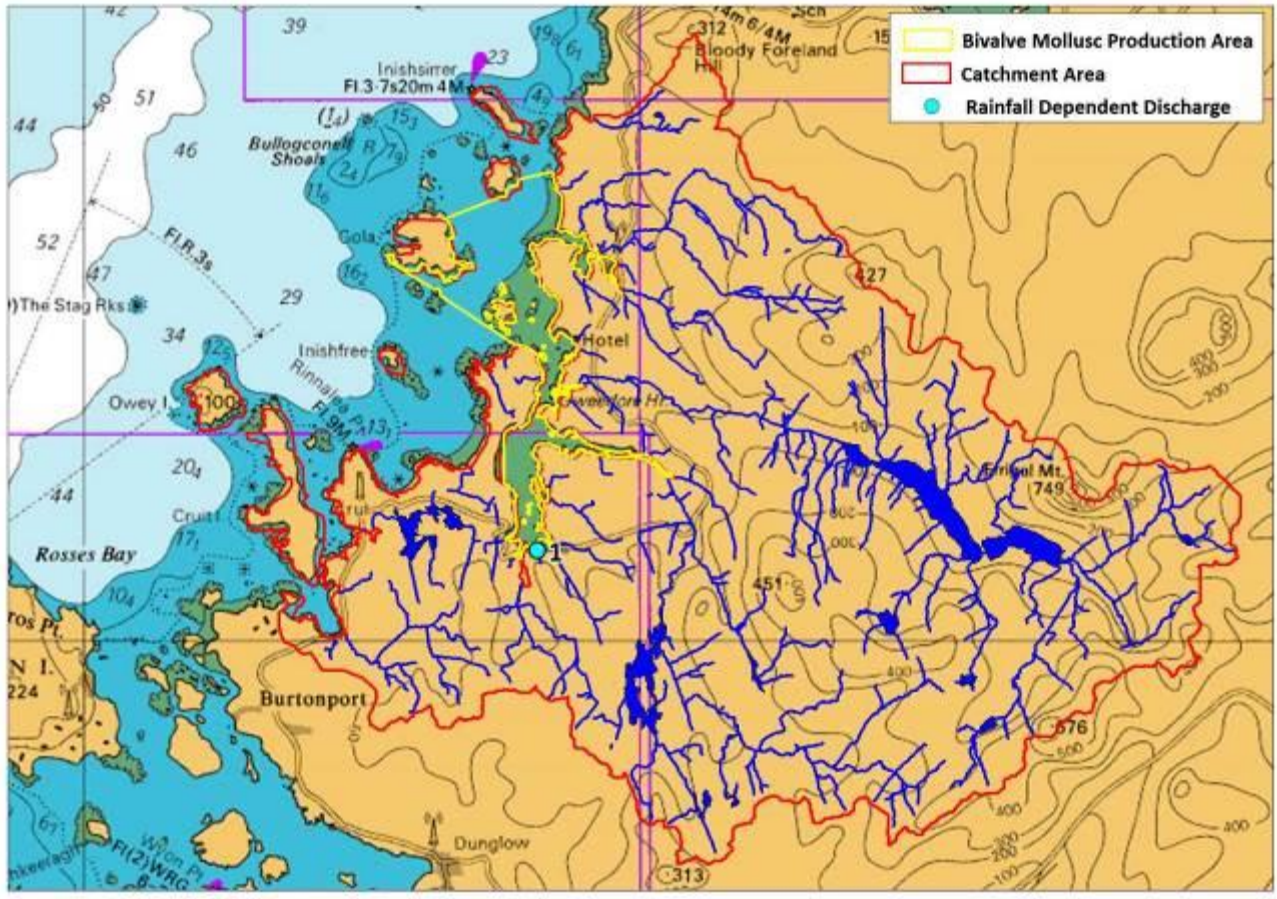

Figure 3.6: Rainfall Dependent Discharges associated with the Sewage Treatment Works within the Gweedore Bay Catchment Area (Source: EPA, 2019c).

3.1.4. Industrial Discharges

There are no IPC or IEL facilities with discharges to water within the Gweedore Bay catchment area accounted for during the desk-based assessment (EPA, 2019d).

There are 5 Section 4 licences (see Figure 3.7) for the discharge of trade effluent, with one discharging directly into the sea and the remaining four discharging to rivers within the catchment. Table 3.7 shows details of these Section 4 licences. Specifics of the discharges are unknown.

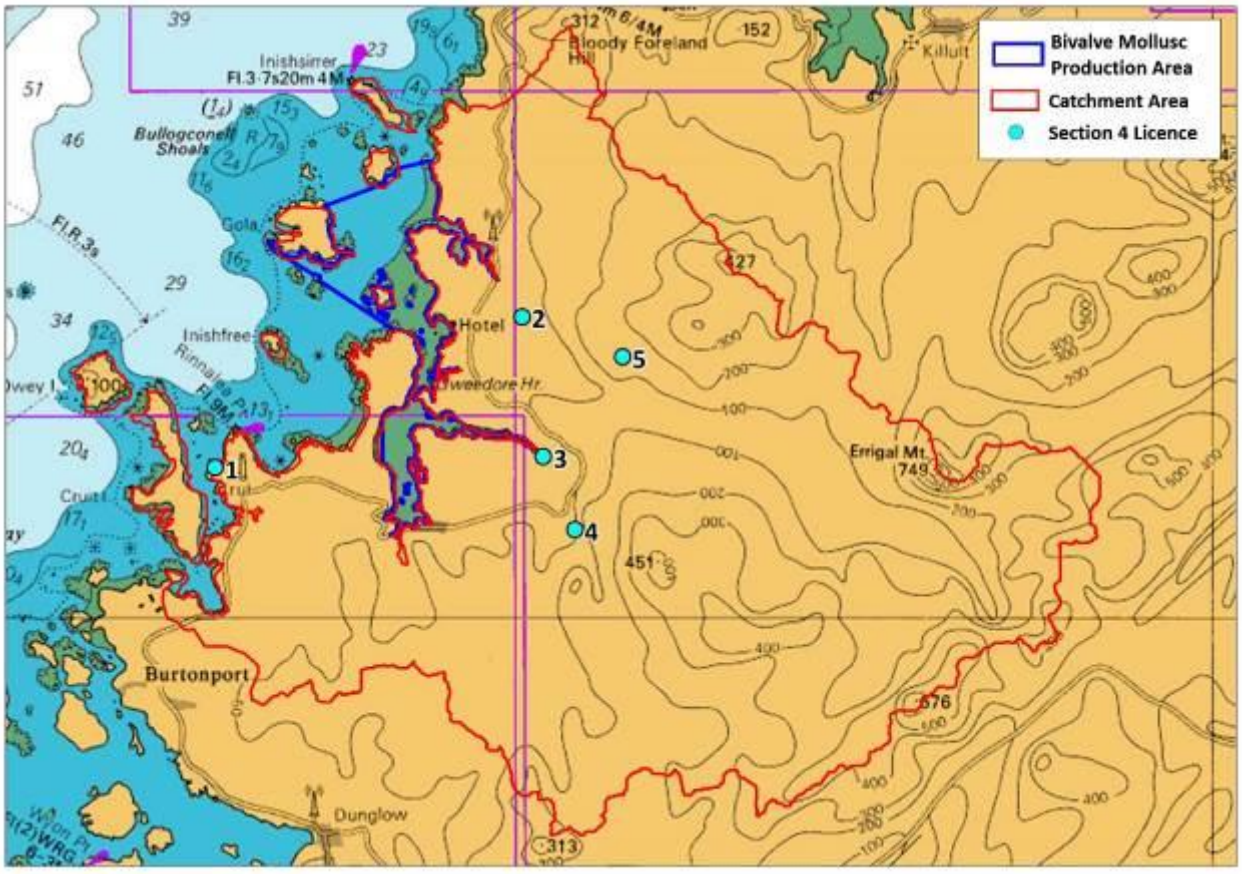

Figure 3.7: Section 4 discharges within the Gweedore Bay Catchment Area (Source: (EPA, 2019e).

Table 3.7: Details on Section 4 discharges within the Gweedore Bay Catchment Area (Source: EPA, 2019e). Map Codes refer to Figure 3.7.

Map Code	File Reference	Licence holder	Facility ad	Longitude	Latitude	Easting	Northing
1	Lwat32	Premier Fish Products Teo.	Kincasslagh, Letterkenny, Co. Donegal	55.035835	-8.4047981	174170	420990
2	Lwat35	Udaras na Gaeltachta	Derrybeg, Letterkenny, Co. Donegal	55.07069	-8.2809227	182105	424831
3	Lwat16	Electricity Supply Board	Clady Hydro Generating Station, Clady, Letterkenny, Co. Donegal	55.038351	-8.272343	182639	421229
4	Lwat58	Gillespie Readymix Company Ltd.	Crolly, Letterkenny, Co. Donegal	55.021436	-8.2596098	183446	419343
5	Lwat49	Gillespie Readymix Company Ltd.	Meenderrygamph, Derrybeg, Letterkenny, Co. Donegal	55.061461	-8.2404291	184688	423794

3.1.5. Landuse Discharges

Figure 3.8 shows the Corine landuse (EPA, 2019f) within the Gweedore Bay catchment area. Figure 4.3 shows all rivers/streams within the catchment area. Within the catchment area, land use is dominated by peat bogs (160.5km^2; 63.5%), followed by land principally occupied by agriculture, with significant areas of natural vegetation (24.9km^2; 9.8%), sparsely vegetated areas (13.1km^2; 5.2%) and complex cultivation patterns (11.8km^2; 4.7%) (see Figure 3.9). Forestry (coniferous and broad-leafed) makes up 2% of the land use in the area (0.79km^2).

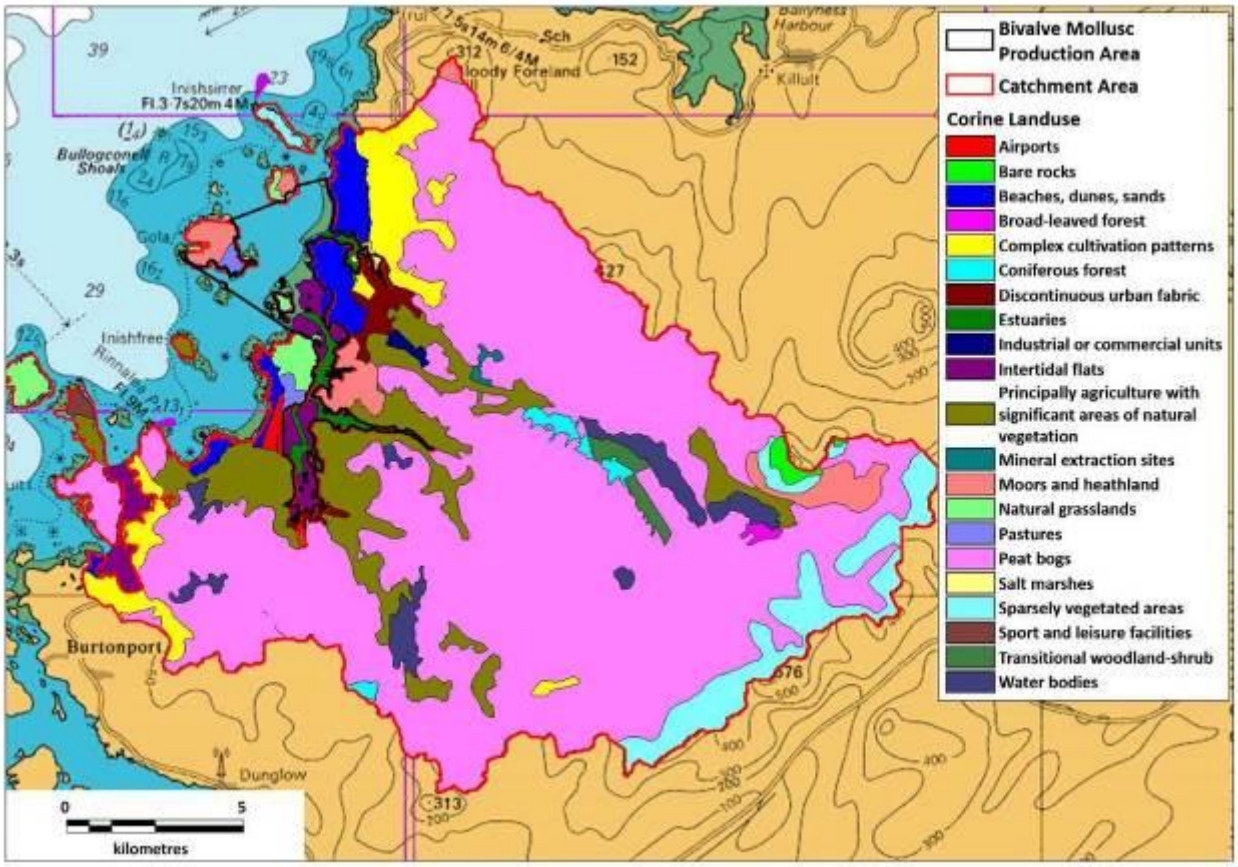

Figure 3.8: Land use within the Gweedore Bay Catchment Area (Source: EPA, 2019f).

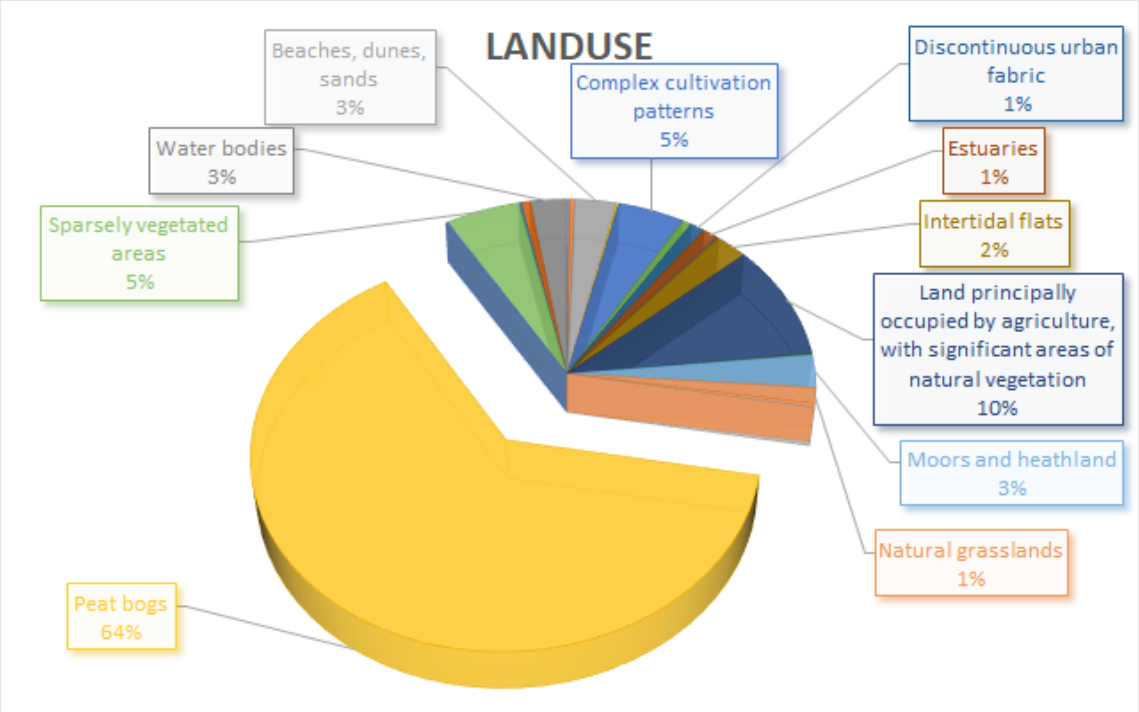

Figure 3.9: Breakdown of landuse within the Gweedore Bay Catchment Area (only landuse ≥1% is labelled).

Data from the Census of Agriculture 2010 (CSO, 2019b) can be seen in Table 3.8 below. Figures 3.10 to 3.17 show thematic maps for each category in Table 3.8. Numbers of farms within the catchment range from 20 in Doocharry to 97 in Gortahork. The total area farmed within the catchment varies from 410 ha in Doocharry to 1,815 ha in Crovehy. The average farm size ranges from 7.7 ha in Gortahork to 33 ha in Crovehy.

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 410 ha in Doocharry to 1,796 ha in Crovehy. Total crops range from 0 ha in all areas with the exception of 19 ha in Crovehy.

The total number of cattle within the catchment ranges from 3 in Doocharry to 318 in Annagary. The total number of sheep within the catchment ranges from 307 in Rutland to 5,543 in Dunlewy. The total number of horses within the catchment ranges from 0 at Doocharry and Crovehy to 43 in Magheraclogher.

The total area farmed in the entire ED's shown in Figures 4.10 to 4.17 amounts to 9,570 ha. However, as most of these ED's only partially overlap the catchment area, an attempt was made to estimate the actual area farmed within the catchment. The percentage of the ED lying within the catchment was calculated in GIS and from this value the area farmed was calculated *e.g.* if 50% of ED lies within catchment area then

50% of the area farmed was taken to be the area farmed within the catchment. Using this method, the area farmed within the catchment is estimated at 5,064 ha. This represents 53% of the area. This estimation was also used to determine the numbers of livestock within the catchment (Table 3.8). There are estimated to be 11,145 sheep, 888 cattle and 91 horses within the catchment area.

Table 3.8: Farm census data for all EDs within the Gweedore Bay Catchment Area (Source: CSO, 2019b).

ED Name	County	No. Farms	Area Farmed (ha)	Avg. Farm Size (ha)	Total Crops (ha)	Total Grass & Rough Grazing (ha)*	Cattle	Sheep	Horses
Dunglow	DONEGAL	44	771	17.5	0	771	136	439	3
Doocharry	DONEGAL	20	410	20.5	0	410	3	1114	0
Annagary	DONEGAL	63	1321	21.0	0	1320	318	685	17
Crovehy	DONEGAL	55	1815	33.0	19	1796	282	2981	0
Dunlewy	DONEGAL	86	1198	13.9	0	1198	302	5543	19
Gortahork	DONEGAL	97	751	7.7	0	751	307	3513	41
Rutland	DONEGAL	39	915	23.5	0	915	149	307	29
Magheraclogher	DONEGAL	91	1657	18.2	0	1656	194	5361	43
Meenaclady	DONEGAL	47	732	15.6	0	732	67	1680	6
Total		**542**	**9570**		**19**	**9549**	**1758**	**21623**	**158**
Total in Catchment[#]		**268**	**5064**		**8**	**5054**	**888**	**11145**	**91**

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

[#] Estimate of total farmland and livestock was calculated using the percentage of each ED lying within the catchment using GIS.

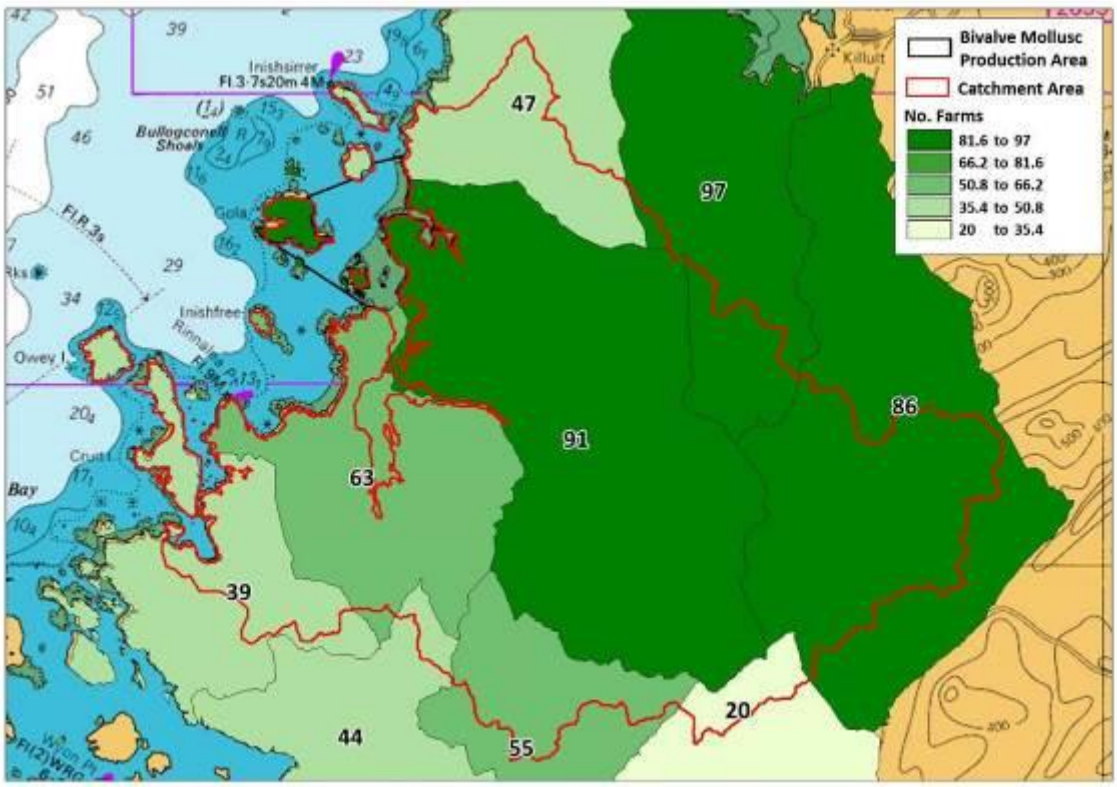

Figure 3.10: Number of farms within the Gweedore Bay Catchment Area (Source: CSO, 2019b).

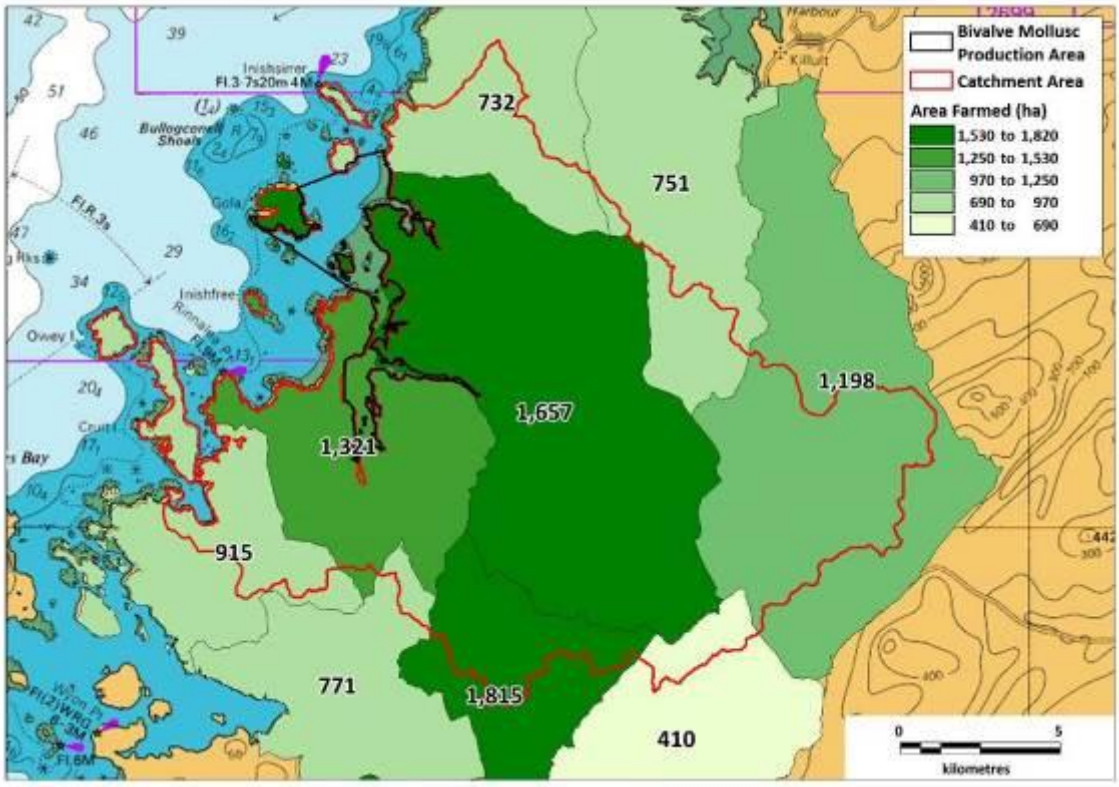

Figure 3.11: Area farmed (ha) within the Gweedore Bay Catchment Area (Source: CSO, 2019b).

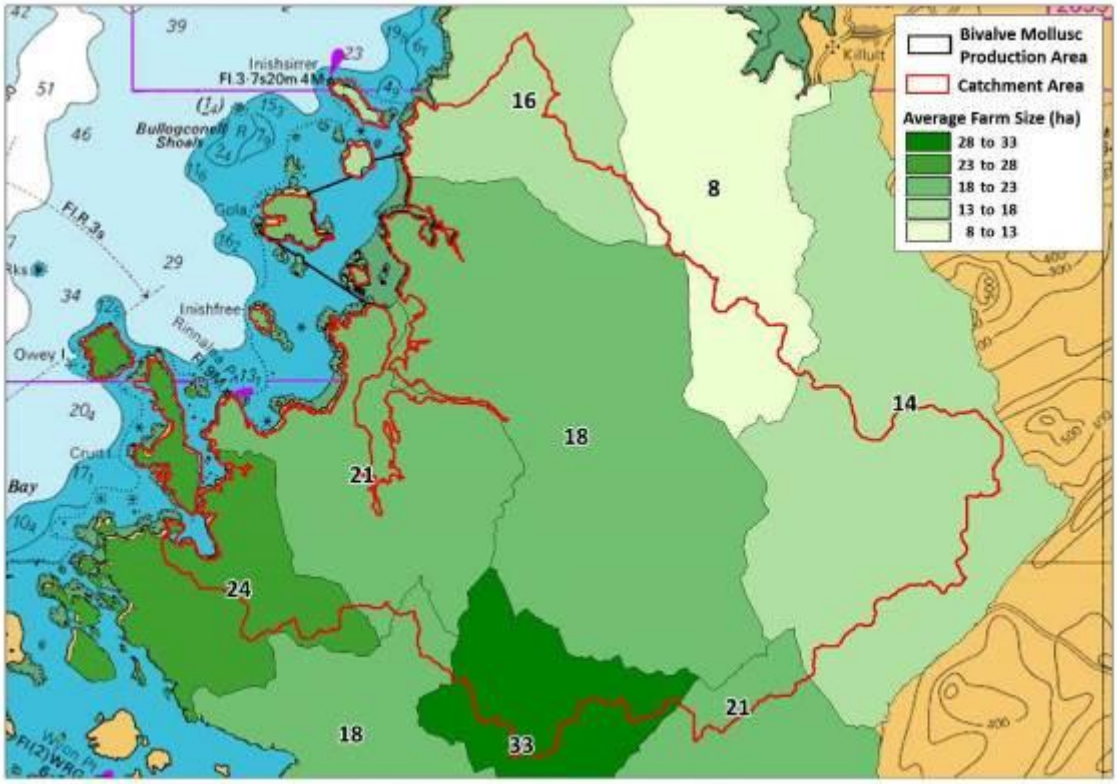

Figure 3.12: Average farm size (ha) within the Gweedore Bay Catchment Area (Source: CSO, 2019b).

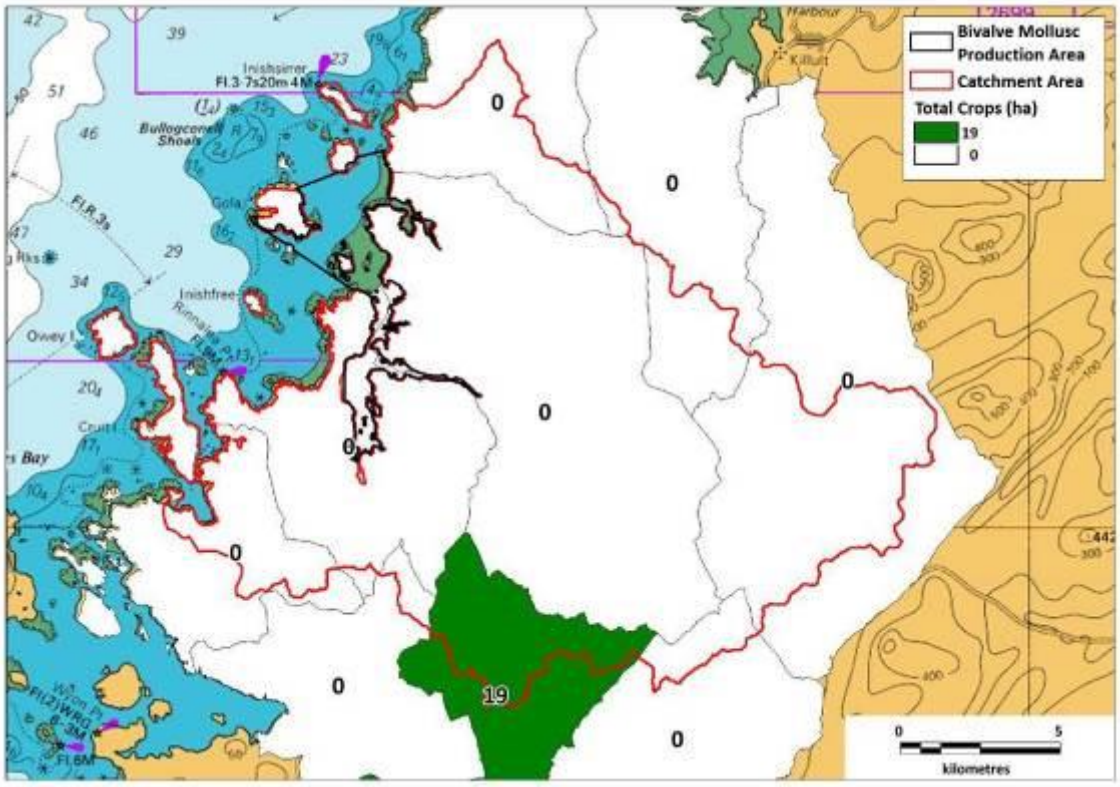

Figure 3.13: Total crops within the Gweedore Catchment Area (Source: CSO, 2019b).

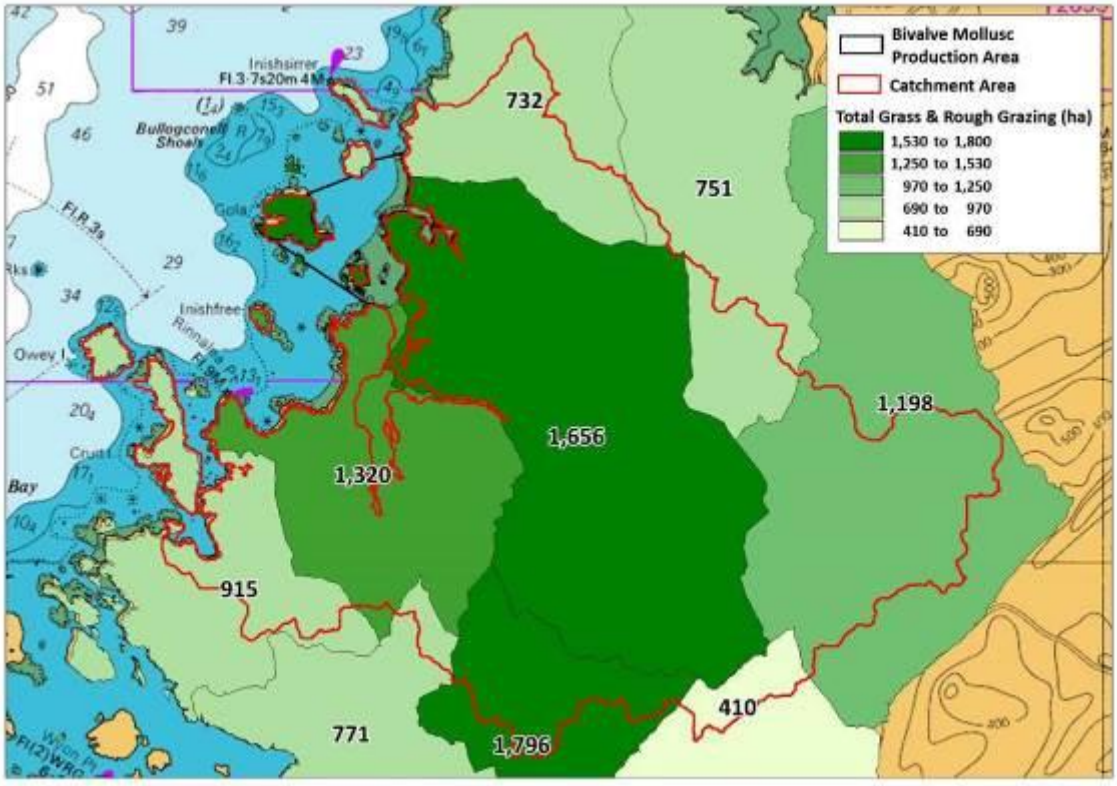

Figure 3.14: Total grass and rough grazing within the Gweedore Bay Catchment Area (Source: CSO, 2019b).

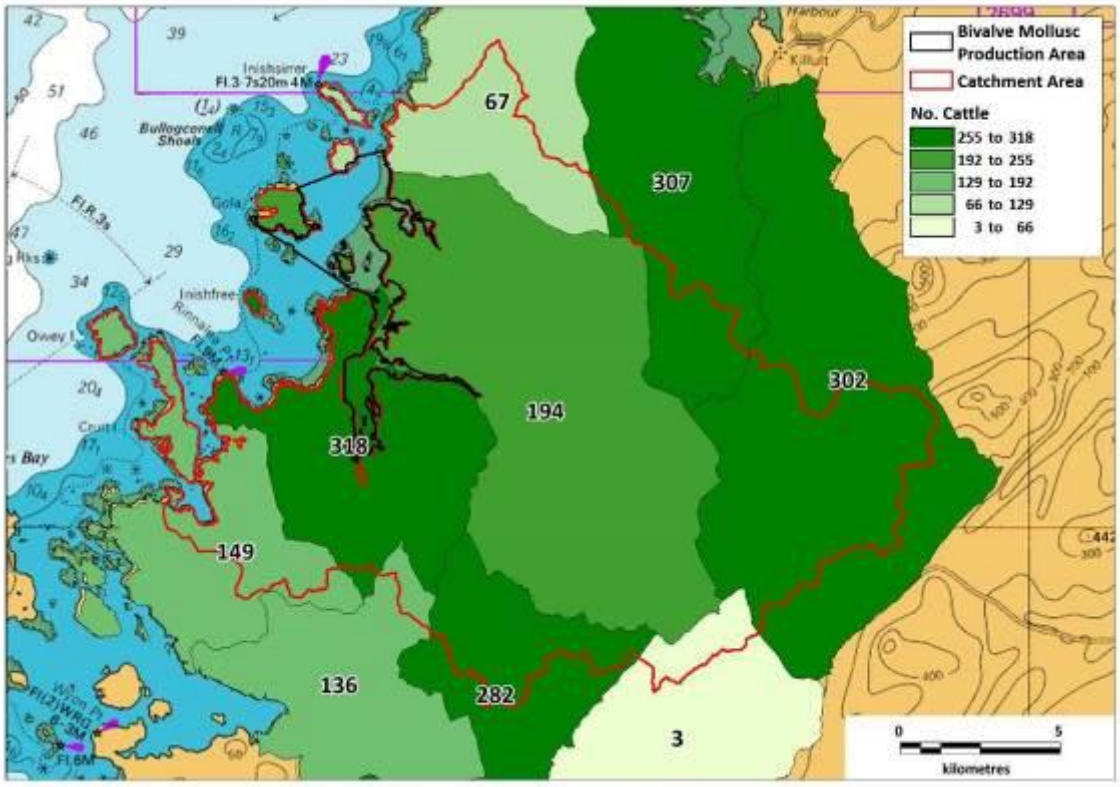

Figure 3.15: Cattle within the Gweedore Bay Catchment Area (Source: CSO, 2019b).

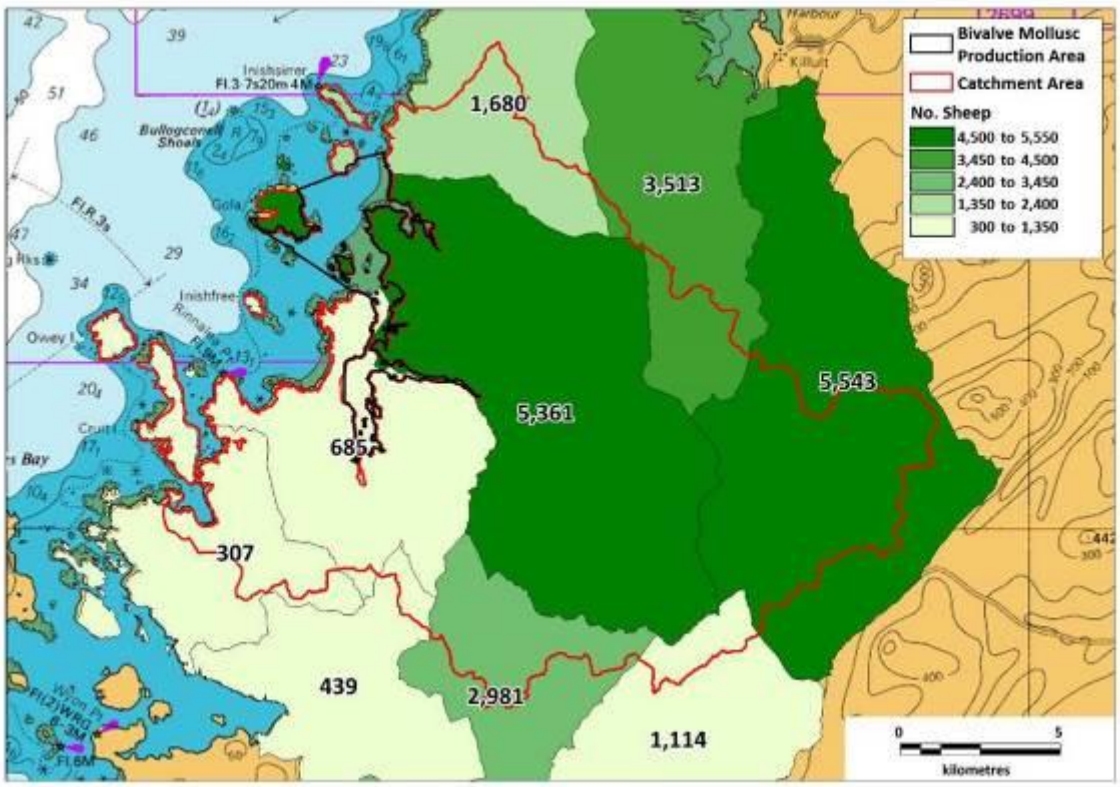

Figure 3.16: Sheep within the Gweedore Bay Catchment Area (Source: CSO, 2019b).

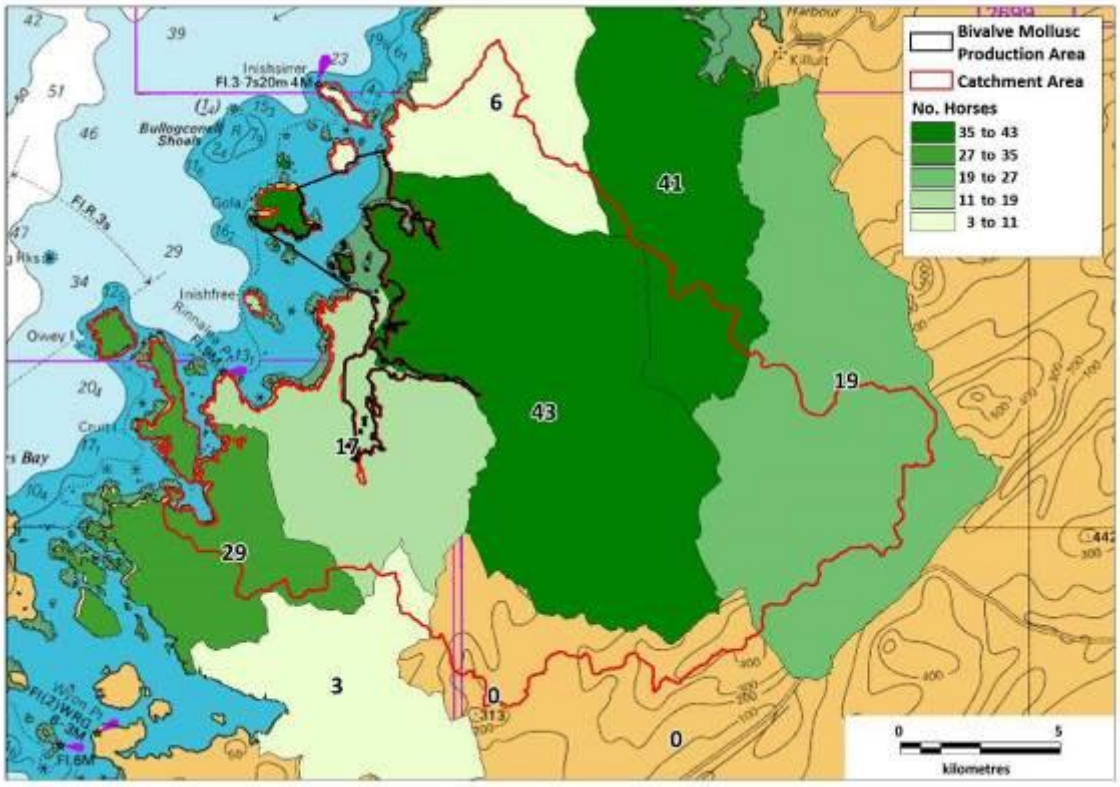

Figure 3.17: Horses within the Gweedore Bay Catchment Area (Source: CSO, 2019b).

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 3.9 shows the potential daily loading of *E. coli* from livestock (compared to humans and birds). It can be seen that sheep rank the worst, followed by pigs, cows, birds, humans and poultry.

Table 3.9: 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 large majority of livestock in the area are sheep. Cattle are also present but in lower numbers. 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 northern eastern extent of the catchment which is more mountainous. While the cattle are present in relatively low numbers throughout the catchment. 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.

3.1.6. Other Pollution Sources

3.1.6.1. Shipping

Figure 3.18 shows all boat facilities and activities in Gweedore Bay. Table 3.10 details these facilities. There are no commercial ports in Gweedore Bay.

Gola ferry service operates from Bunbeg Harbour to Gola Island from June to September. There is also a ferry that operates intermittently from Bunbeg to Tory Island. There are several piers and slipways located along the shorelines of Gweedore Bay and Islands. Bunbeg harbour at the mouth of the Clady River supports a number of inshore fishing vessels and recreational craft. Very few if any of these boats would be occupied overnight.

While data on sewage discharge levels from boating activities in the area are not available, it is highly

unlikely that any discharges from the relatively small number of vessels in the area would have any negative impacts on water quality.

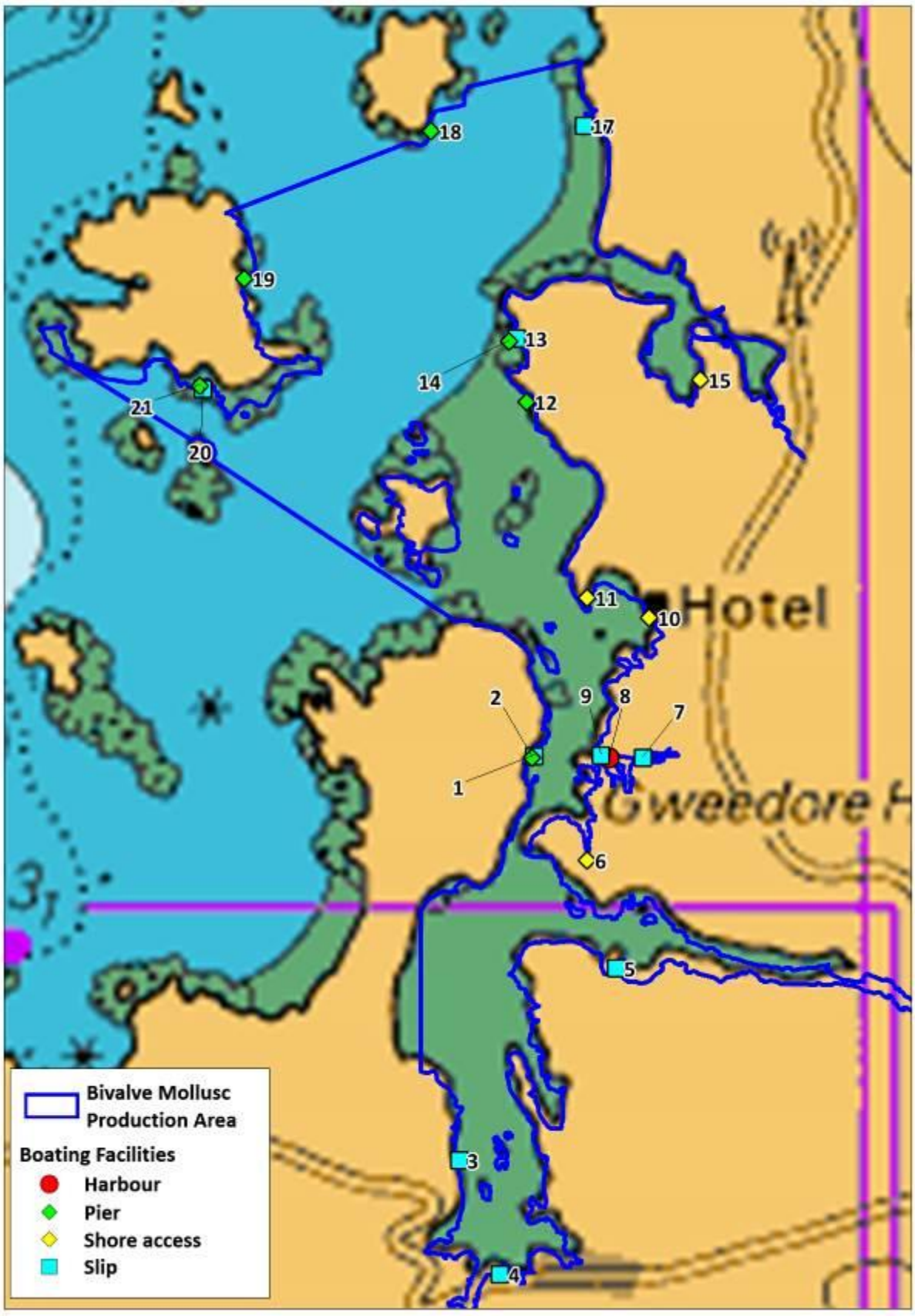

Figure 3.18: Location of all boating facilities and activities in Gweedore Bay.

Table 3.10: Boating facilities in the Gweedore Bay. Map Code refers to Figure 3.18.

Map Code	Feature	Use (if known)
1	Slip	Aquaculture, Pleasure craft, Fishing, Aqua tourism
2	Pier	Aquaculture, Pleasure craft, Fishing, Aqua tourism
3	Slip	Private Slip
4	Slip	Pleasure craft, Fishing, Aqua tourism
5	Slip	
6	Shore Access	Aquaculture
7	Slip	Bunbeg Harbour
8	Harbour	Bunbeg Harbour
9	Slip	Bunbeg Harbour
10	Shore access	
11	Shore access	
12	Pier	Pleasure craft, Fishing, Aqua tourism
13	Slip	Pleasure craft, Fishing, Aqua tourism
14	Pier	Pleasure craft, Fishing, Aqua tourism
15	Shore access	
16	Pier	Pleasure craft, Fishing, Aqua tourism
17	Slip	Pleasure craft, Fishing, Aqua tourism
18	Pier	Pleasure craft, Fishing, Aqua tourism
19	Pier	Pleasure craft, Fishing, Aqua tourism
20	Slip	Pleasure craft, Fishing, Aqua tourism
21	Pier	Pleasure craft, Fishing, Aqua tourism

3.1.6.2. Birds

It is important to document the bird populations in the Gweedore 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).

Gweedore Bay is designated as a Special Protection Area (SPA): West Donegal Islands SPA (IE004230) and West Donegal Coast SPA (Site Code: IE004150). West Donegal Islands SPA of special conservation interest for the following species: Shag *Phalacrocorax aristotelis* (40 pairs on Gola Island in 1999 and 30 pairs on Inishsirrer in 2000), Barnacle Goose *Branta leucopsis* (272 individuals - four survey mean between 1993 and 2003), Corncrake *Crex crex* (13 pairs - five year mean peak between 2003 and 2007, based on records of calling males), Common Gull *Larus canus* (20 pairs on Gola Island in 1999 and 55 pairs on Inishsirrer and Inishmeane in 2000) and Herring Gull *Larus argentatus* (65 pairs on Gola Island in 1999 and 25 pairs on Inishsirrer in 2000) (NPWS, 2015b)

West Donegal Coast SPA is of special conservation interest for the following species: Chough *Pyrrhocorax pyrrhocorax* (40 breeding pairs were recorded from the site in the 1992 survey and 58 in the 2002/03 survey), Peregrine *Falco peregrinus* (6 pairs in 2002), Fulmar *Fulmarus glacialis* (1,879 pairs), Cormorant *Phalacrocorax carbo* (71 pairs in 1999 and 2006), Shag *P. aristotelis* (86 pairs), Herring Gull *Larus argentatus* (229 pairs), Kittiwake *Rissa tridactyla* (1,037 pairs) and Razorbill *Alca torda* (322 pairs) (NPWS, 2011).

Bird numbers in the area increase during the winter months when the wintering waterfowl arrive. However, it is highly likely that these levels are low when compared with land-based discharges.

3.2. Shoreline Survey Report

A shoreline survey was carried out by the Sea Fishery Protection Authority between February and June 2019. Figure 3.19 shows the GPS (Global Positioning System) and photography sites accounted for during the 9 survey days.

The aim of the survey was to confirm the location of the bivalve mollusc fishery and to confirm the presence of the sources of contamination already identified during the desktop study and to also identify any additional potential sources of contamination. 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.

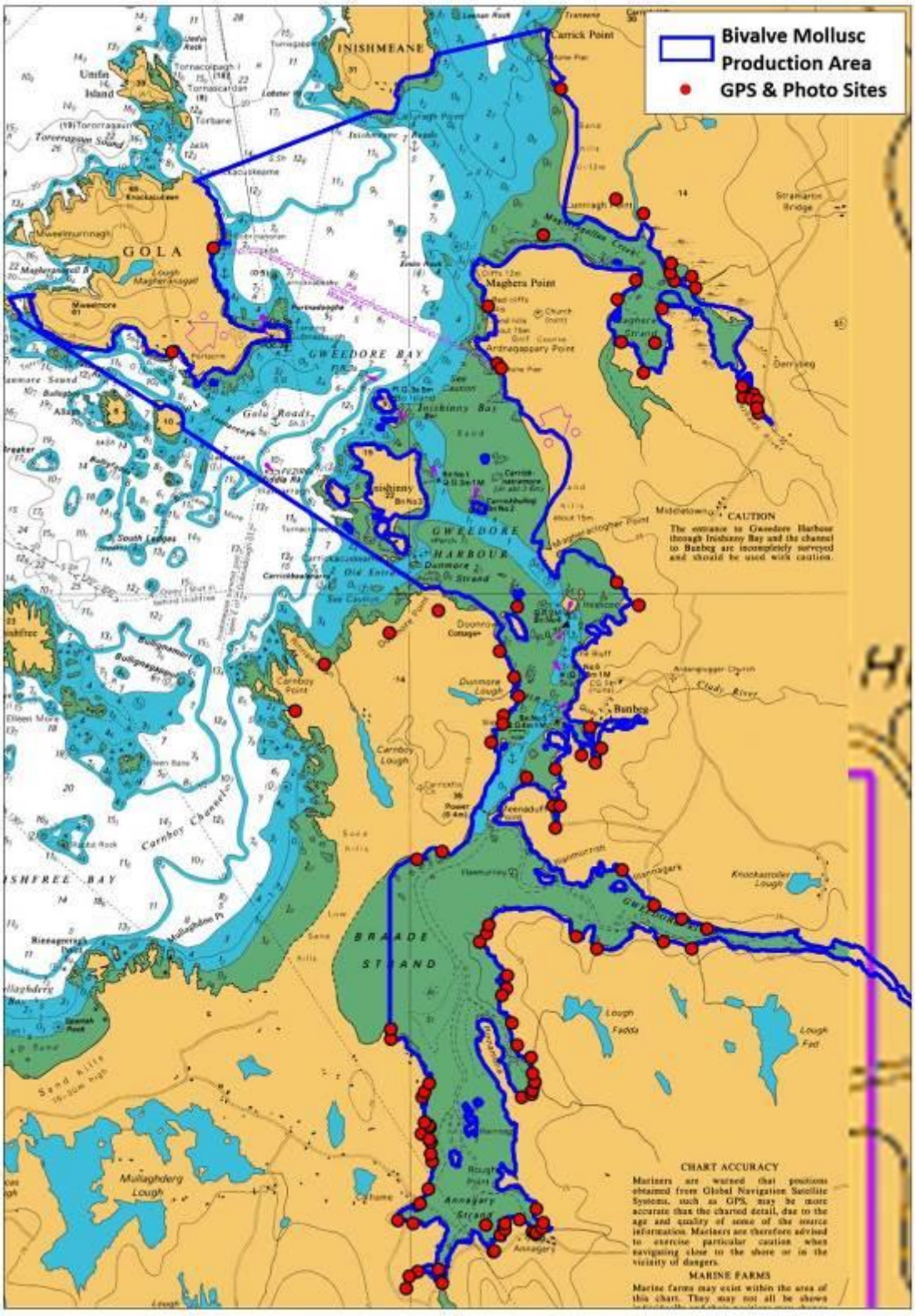

Figure 3.19: Locations of GPS and Photograph Sites.

Figure 3.20 shows the locations of all features observed during the shoreline survey. In total 110 features

were identified, of which 21 rivers/streams were identified, 55 drains/ pipes, 8 piers, 4 Septic tanks, 2 slips, 2 oyster farms, a manhole , Annagary WWTP and a caravan park. Figures 3.21 to 3.41 show aerial imagery of the location of the features and Appendix 1 shows images of most of these features. Table 3.11 details all features identified and the numbering used is cross-referenced to Figures 3.21 to 3.41 and Appendix 1.

Table 3.11: Features identified during the shoreline survey. Refer to Figures 3.21 – 3.41 for locations and Appendix 1 for photographs.

Map Code	Observation	Comments	Longitude	Latitude	Easting	Northing
1	Natural drain	Draining very rough grazing land	55.05863	-8.34792	177815	423530
2	Stream on beach	Draining very rough grazing land	55.06188	-8.34442	178041	423890
3	Small stream	Draining sand dune grazed land	55.06410	-8.33655	178544	424135
4	Caravan Park	Small caravan park	55.06563	-8.33052	178931	424303
5	Stream	Stream running onto sand flats adjacent oyster farm	55.06590	-8.32102	179538	424330
6	Field drain	Field drain	55.06280	-8.32310	179403	423986
7	Septic tank	Small house septic - outflow not visible	55.06097	-8.32133	179515	423781
8	Oyster farm	Start of farm - oyster trestles	55.05963	-8.32080	179549	423633
9	Septic tank	Small house septic - outflow not visible	55.05832	-8.32270	179426	423487
10	Small pier	Small, a few boats moored here.	55.05772	-8.32282	179419	423420
11	Field drain	Draining onto sand flats adjacent oyster trestles	55.05645	-8.32417	179332	423279
12	Two pipes	No discharge, possibly septic related	55.04882	-8.33010	178949	422431
13	Field drain	Very low flow	55.04828	-8.33322	178749	422373
14	Drain	Steady flow across machair	55.03647	-8.33639	178540	421059
15	Field drain	Steady flow, field drain	55.03577	-8.33641	178538	420981
16	Field drain	Field drain, flowing.	55.03269	-8.33175	178835	420636
17	Field drain	Field drain, flowing.	55.03209	-8.33236	178795	420570
18	Field drain	Field drain, flowing.	55.03173	-8.33256	178782	420530
19	Field drain	Field drain, flowing.	55.02997	-8.33228	178799	420334
20	Field drain	Field drain, flowing.	55.02997	-8.33228	178799	420334
21	Piped drain	Drainage pipes from garden by 2	55.02972	-8.33173	178834	420305
22	Slip way	No boats located or visible.	55.02962	-8.33172	178835	420294
23	Field drain	Field drain, flowing.	55.02913	-8.33272	178771	420240
24	Field drain	Field drain, flowing.	55.02875	-8.33175	178833	420198

Map Code	Observation	Comments	Longitude	Latitude	Easting	Northing
25	Slip way – old	Unused.	55.02855	-8.33155	178845	420175
26	Field drain	Field drain, flowing.	55.02776	-8.33163	178840	420087
27	Field drain	Field drain, flowing.	55.02723	-8.33141	178853	420028
28	Field drain	Field drain, flowing.	55.02529	-8.33186	178824	419813
29	Septic tank	Broken - unsure if operational	55.02430	-8.33287	178759	419703
30	Stream	Stream coming through saltmarsh, small inlet.	55.02313	-8.33558	178584	419574
31	Field drain	Adjacent main road to airport	55.02290	-8.33377	178700	419547
32	Birds	Birds - seagulls 60 +	55.01973	-8.33065	178898	419194
33	Field drain	Flowing through saltmarsh	55.01957	-8.33322	178734	419176
34	Three pipes - discharge	Three pipes, odour. Grey colour, possible sewage	55.01922	-8.33423	178669	419137
35	Large stream	Large stream, good flow of water.	55.01840	-8.33462	178644	419046
36	Lagoon discharge	Tidal flow from lagoon	55.01875	-8.33022	178925	419084
37	Birds	Brent geese 25 +	55.02278	-8.32493	179265	419531
38	Stream	Stream, good flow	55.02093	-8.32403	179322	419325
39	Pipe	Pipe, small bore no flow	55.02098	-8.32390	179331	419331
40	Concrete pipe	Virtually no flow	55.02210	-8.32318	179377	419455
41	Annagary WWTP Septic plant	Annagry Plant	55.02250	-8.32257	179417	419499
42	WWTP Manhole	Manhole cover- no discharge	55.02290	-8.32260	179415	419544
43	Pipe	Pipe -small bore, no flow	55.02317	-8.32080	179530	419573
44	Pipe	Pipe -small bore, no flow	55.02230	-8.31925	179629	419476
45	Small river	Small river - good flow	55.02215	-8.31890	179651	419459
46	WWTP Pump chamber	Infrastructure	55.02223	-8.31875	179661	419468
47	Stream	Stream - good flow, piped under road	55.02257	-8.31812	179701	419505
48	Drain	Drain - coming off road	55.02293	-8.31795	179712	419546
49	Stream	Stream	55.02393	-8.31875	179661	419658

Map Code	Observation	Comments	Longitude	Latitude	Easting	Northing
50	Drain	Stone built drain	55.03170	-8.32053	179551	420523
51	Field drain	Field drain	55.03190	-8.31932	179629	420545
52	Field drain	Field drain	55.03215	-8.31927	179633	420573
53	Small river	Small river - good flow	55.03270	-8.31895	179653	420634
54	Drain	Stone built drain	55.03277	-8.31898	179651	420641
55	Field drain	Field drain	55.03333	-8.31922	179636	420704
56	Stream	Stream	55.03448	-8.31942	179624	420832
57	Drain	Field drain	55.03532	-8.32103	179521	420926
58	Drain/stream	Drain flowing from field -	55.03685	-8.32173	179477	421096
59	Drain	Drain through small redbud	55.03880	-8.32297	179399	421314
60	Drain - Stream	Drain/stream - good flow	55.03927	-8.32233	179440	421366
61	Drain	Drain - rubbish, some enrichment	55.04020	-8.32228	179444	421470
62	Drain	Field drain	55.04250	-8.32558	179234	421727
63	Drain	Field drain	55.04313	-8.32475	179288	421797
64	Drain	Field drain	55.04370	-8.32445	179307	421860
65	Tidal Ponds Outflow	Outflow from rectangular pond- saltwater only likely	55.04288	-8.31393	179979	421766
66	Drain	Drain	55.04203	-8.31142	180139	421671
67	Drain	Drain	55.04252	-8.30328	180660	421722
68	Stream	Stream	55.04203	-8.29985	180879	421667
69	Drain	Field drain coming off hill	55.04340	-8.29800	180998	421819
70	Drain	Field drain	55.04410	-8.30112	180799	421898
71	Drain	Drain entering alongside slipway	55.04508	-8.30445	180586	422008
72	Stream	Stream, good flow, coming off hill	55.04750	-8.30832	180340	422278
73	Oyster farms	Mostly smaller size oysters in bags and trestles	55.05398	-8.31992	179602	423003
74	Pier	Very small pier, no boats evident	55.05200	-8.31665	179810	422782

Map Code	Observation	Comments	Longitude	Latitude	Easting	Northing
75	Drainage pipe	Steady flow, some enrichment	55.05047	-8.31637	179827	422611
76	Stone drain	Drain, most likely field drain	55.05203	-8.31585	179861	422785
77	Drain	Field drain	55.05455	-8.31637	179829	423065
78	Drain	Drain, most likely field drain	55.05550	-8.31325	180029	423170
79	Stream	Steady flow	55.05497	-8.31155	180137	423110
80	Drain	Field drain	55.05602	-8.31083	180184	423227
81	Pier with boats	Bunbeg pier with quite a few permanently moored boats	55.05750	-8.31223	180095	423393
82	Small stream	Stream and drain flowing through salt marsh	55.06595	-8.30618	180486	424332
83	Drain	Drain flowing through dunes onto beach	55.06755	-8.30892	180312	424511
84	Possibly septic	No visible outflow	55.08253	-8.32288	179427	426183
85	Small Pier	No vessels moored or in use at time	55.08285	-8.32335	179398	426218
86	Small Pier	No vessels moored or in use at time	55.08682	-8.32445	179329	426660
87	Birds	Geese, Brent 25 +	55.09178	-8.31773	179761	427211
88	Sheep on foreshore	Approx. 30 sheep grazing on foreshore and strand	55.08862	-8.30653	180474	426855
89	Pipe field drain	Low flow, possibly field drain.	55.08728	-8.30873	180333	426707
90	Drains	Drains running off saltmarsh-adjacent football ground	55.08432	-8.30827	180362	426377
91	Channel	Channel running from small lagoons in saltmarsh	55.08217	-8.30557	180533	426137
92	Sheep on foreshore	20 odd sheep	55.08427	-8.30417	180623	426370
93	Birds	Geese 25 +	55.08667	-8.30340	180673	426637
94	Sheep	Sheep 10+	55.08120	-8.29365	181294	426026
95	Drain	Drain - iron oxide. Houses at head of drains.	55.08047	-8.29357	181299	425944
96	Drain	Drain	55.08033	-8.29258	181361	425929
97	Channel-river	Slow flow channel - small stream or river upstream	55.07932	-8.29163	181421	425816
98	Small river	Small river - good flow	55.07970	-8.29187	181407	425859
99	Septic tank	Septic tank immediately adjacent river	55.08025	-8.29180	181411	425920

Map Code	Observation	Comments	Longitude	Latitude	Easting	Northing
100	Field drain	Small field drain entering river channel.	55.08068	-8.29225	181383	425968
101	River	River, good flow	55.08810	-8.29925	180939	426796
102	Drains	Drains, grey coloured	55.08892	-8.29977	180907	426887
103	Sheep	Sheep on foreshore 20 +	55.08858	-8.30188	180771	426850
104	Animal manure	Large amount of sheep manure on shore adjacent shore	55.08910	-8.30233	180743	426908
105	Sheep	Sheep 100 +, grazing foreshore and saltmarsh	55.08978	-8.30227	180747	426984
106	Stream	Stream through sand dunes	55.09327	-8.30557	180538	427373
107	Cattle	20 + cattle	55.09427	-8.30893	180324	427485
108	Pier	Small pier, no boats	55.10197	-8.31557	179904	428344
109	Pier	Small pier, frequented by small ferry. No overnight boats	55.00151	-8.35780	177202	427129
110	Pier	Small pier, no boats.	55.00139	-8.36289	176873	426323

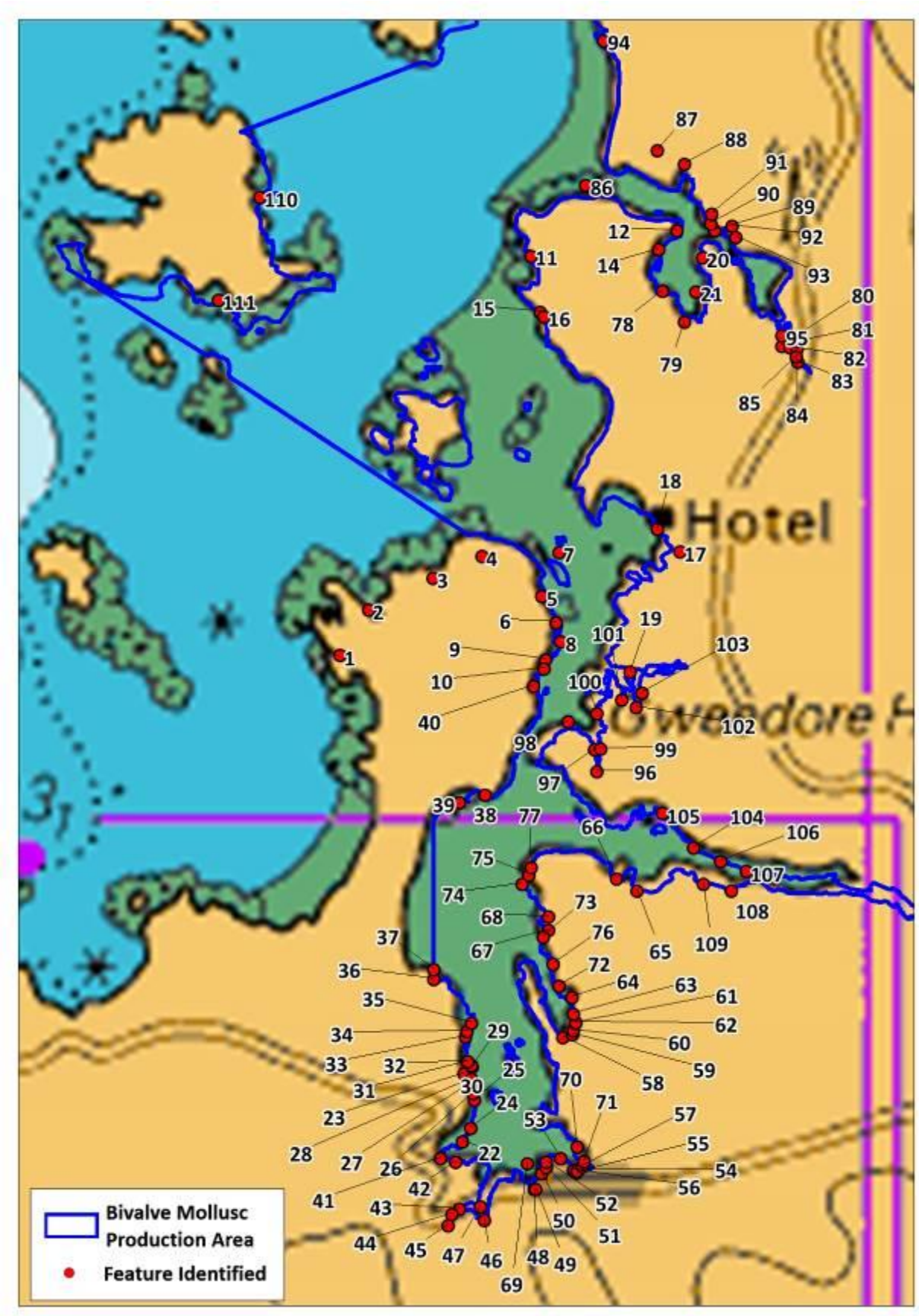

Figure 3.20: All features (numbering cross-reference to Table 3.11) identified during the shoreline survey.

Figure 3.21: Features 1-4 (numbering cross-reference to Table 3.11) identified during the shoreline survey.

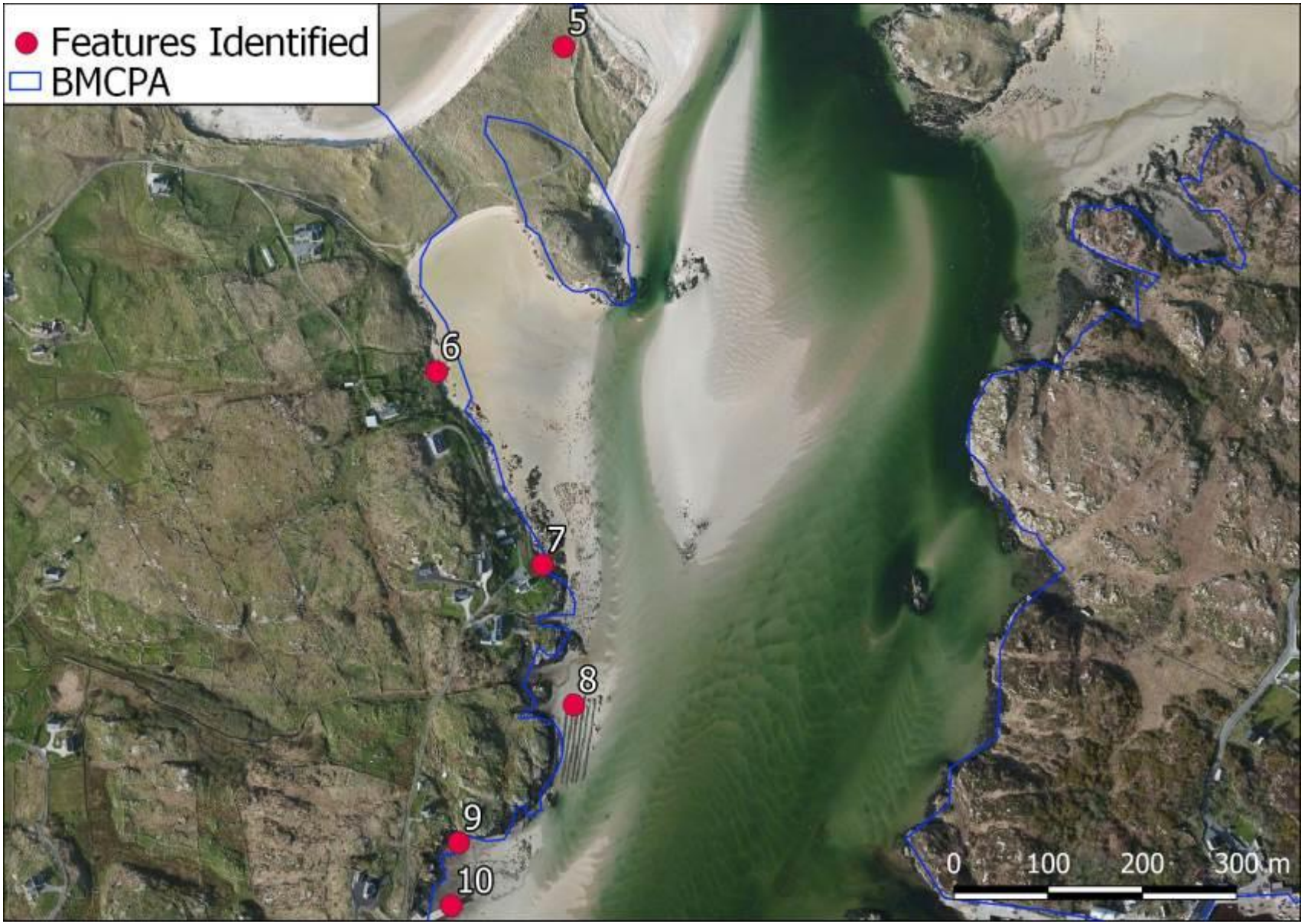

Figure 3.22: Features 5-10 (numbering cross-reference to Table 3.11) identified during the shoreline survey.

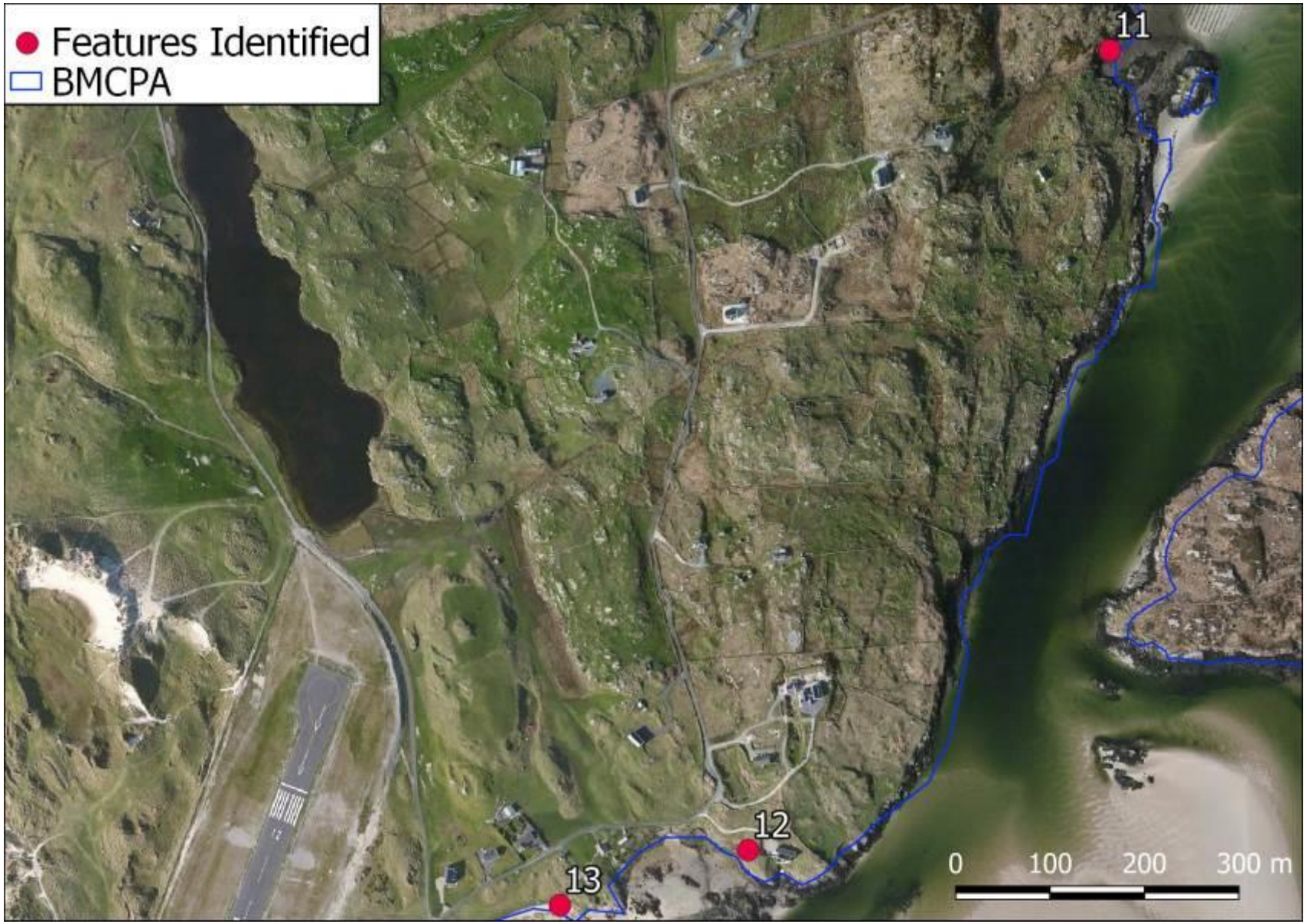

Figure 3.23: Features 11-13 (numbering cross-reference to Table 3.11) identified during the shoreline survey.

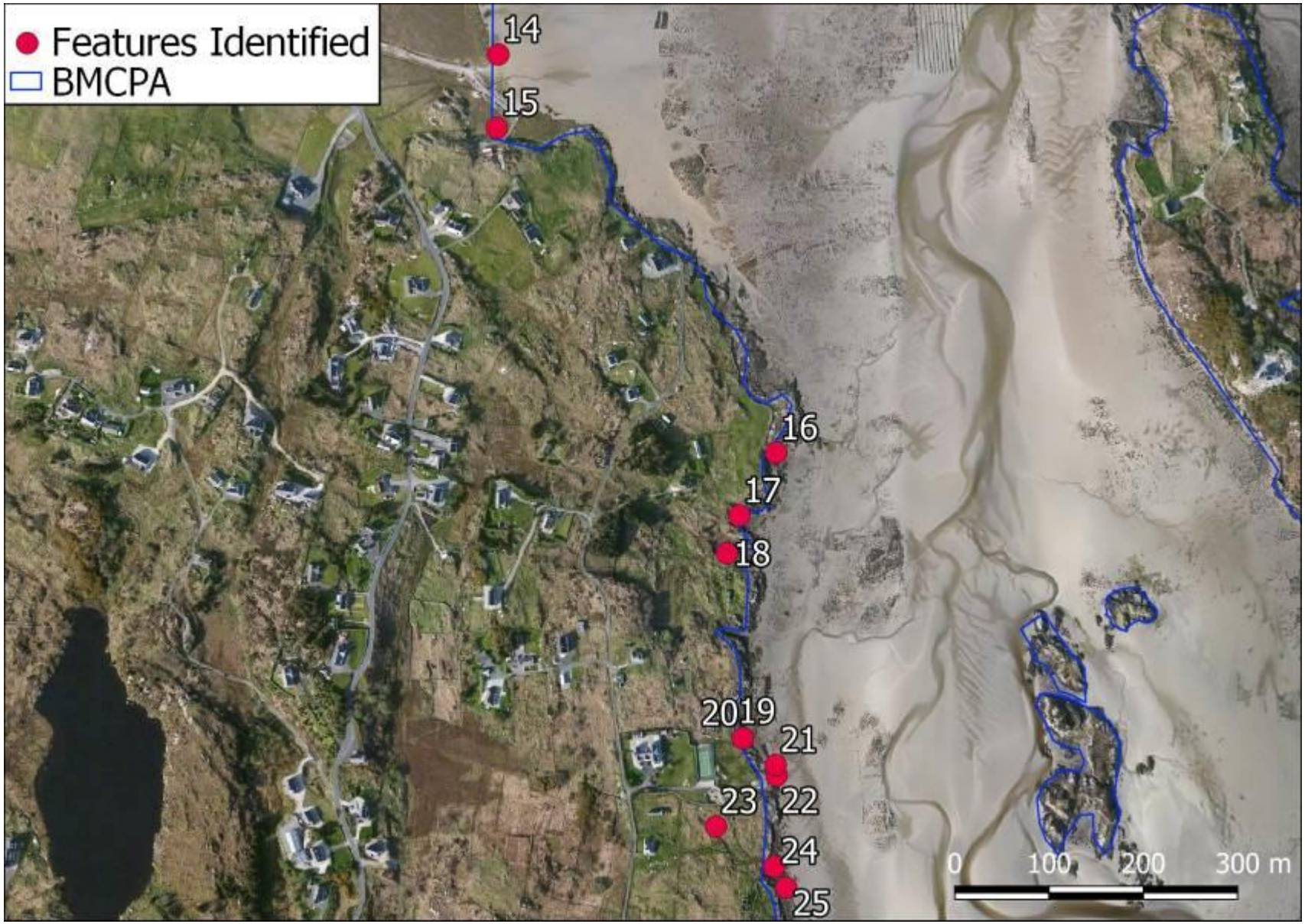

Figure 3.24: Features 14-25 (numbering cross-reference to Table 3.11) identified during the shoreline survey.

Figure 3.25: Features 26-31 (numbering cross-reference to Table 3.11) identified during the shoreline survey.

Figure 3.26: Features 32-36 (numbering cross-reference to Table 3.11) identified during the shoreline survey.

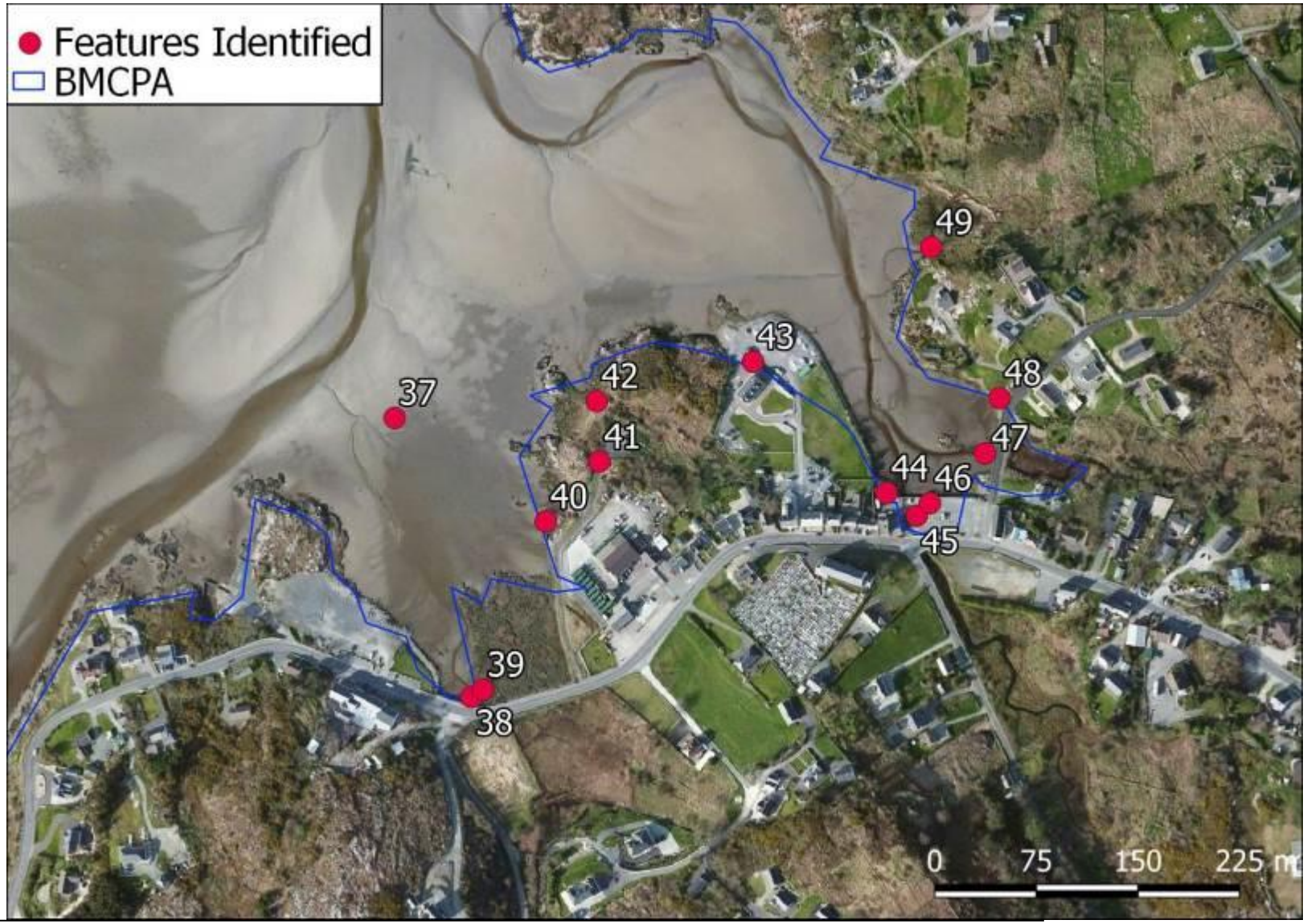

Figure 3.27: Features 37-49 (numbering cross-reference to Table 3.11) identified during the shoreline survey.

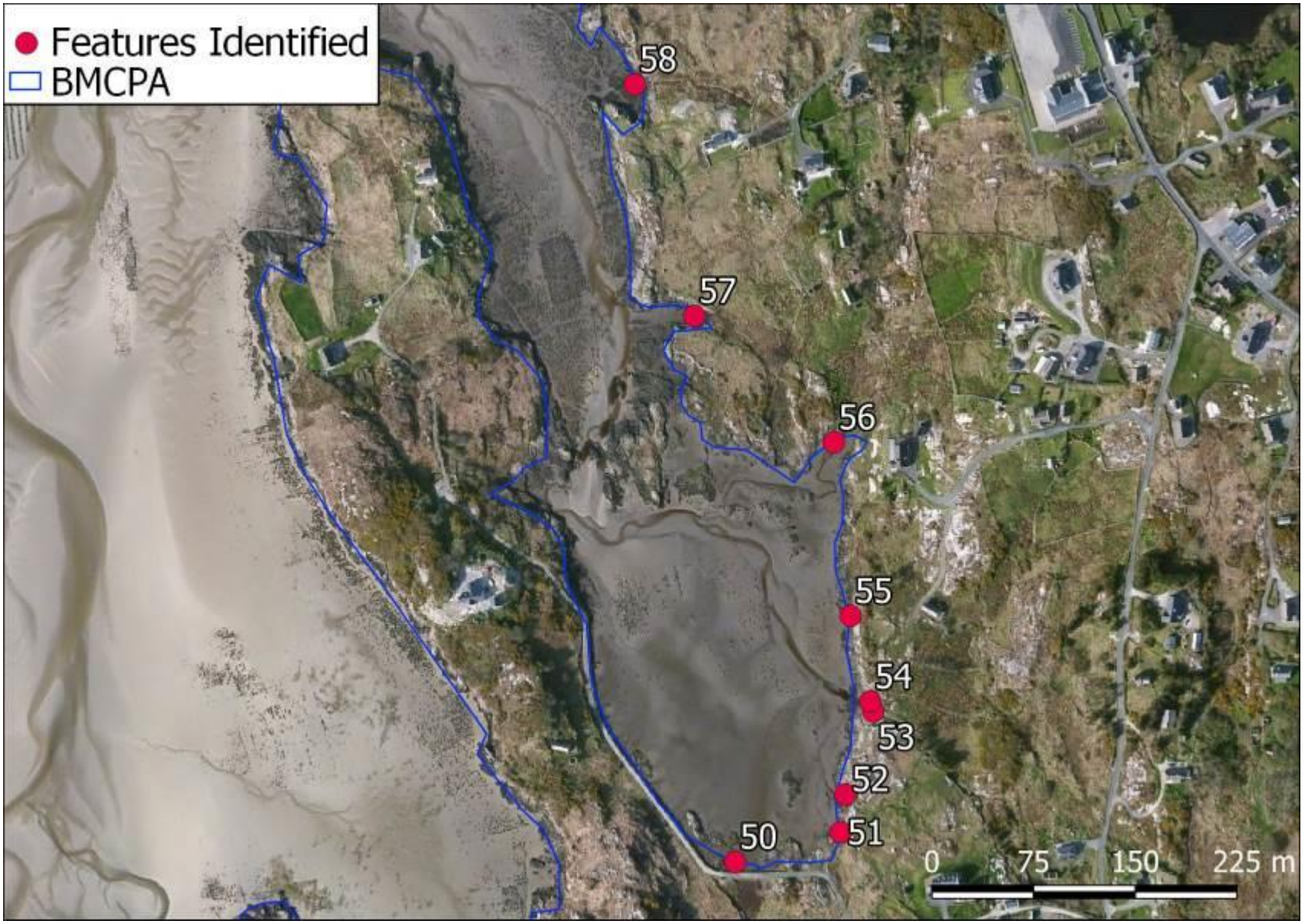

Figure 3.28: Features 50-58 (numbering cross-reference to Table 3.11) identified during the shoreline survey.

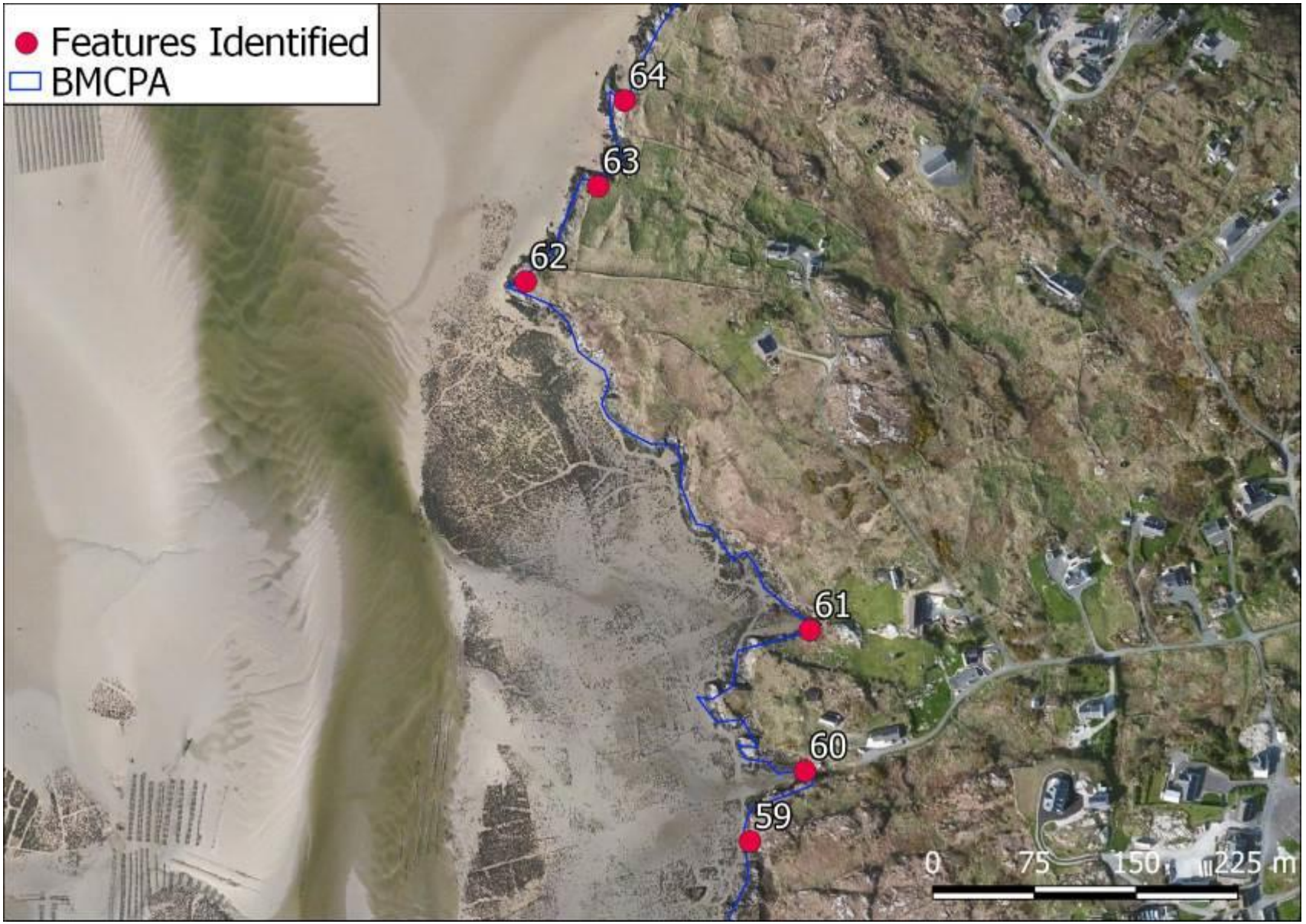

Figure 3.29: Features 59-64 (numbering cross-reference to Table 3.11) identified during the shoreline survey.

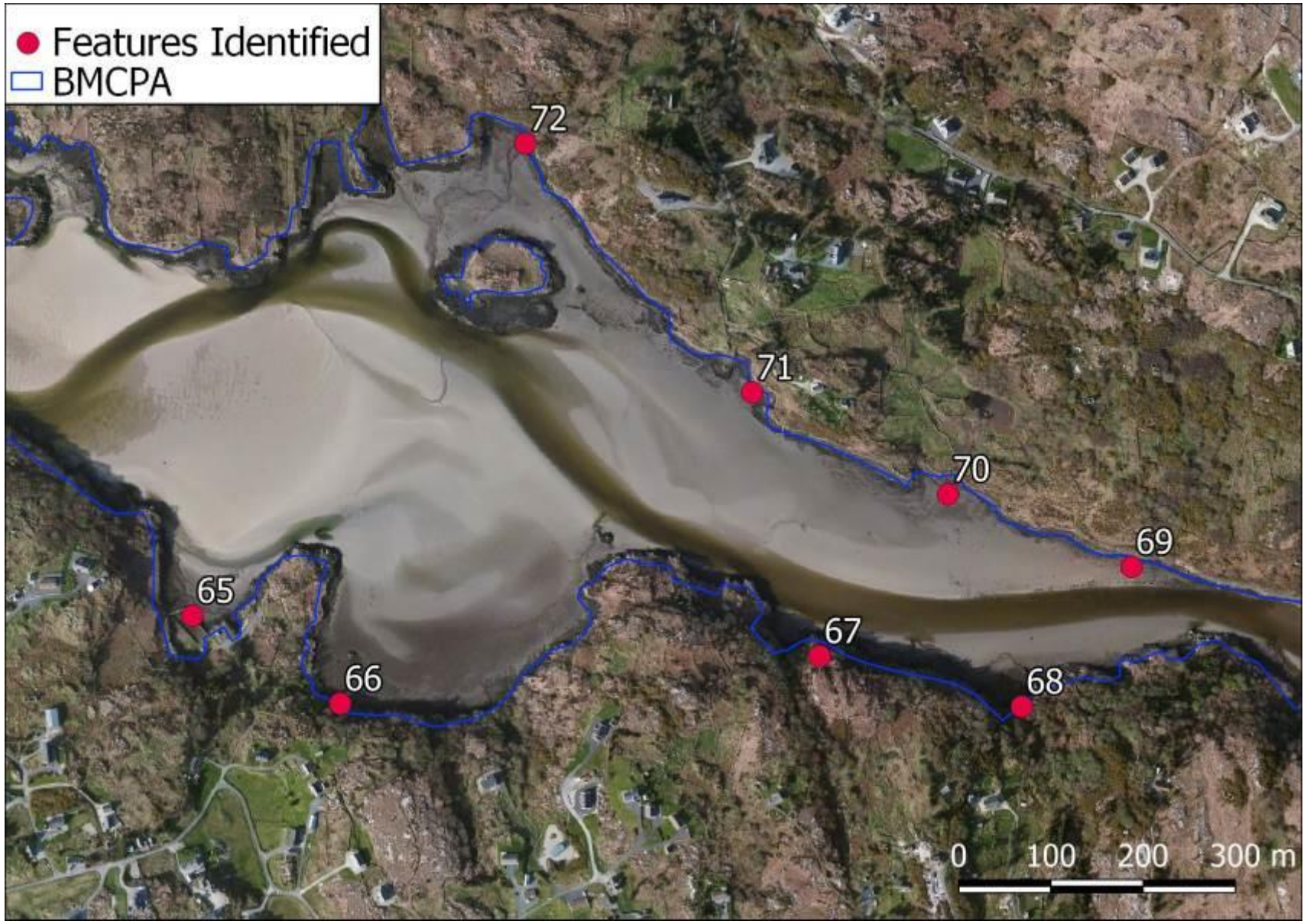

Figure 3.30: Features 65-72 (numbering cross-reference to Table 3.11) identified during the shoreline survey.

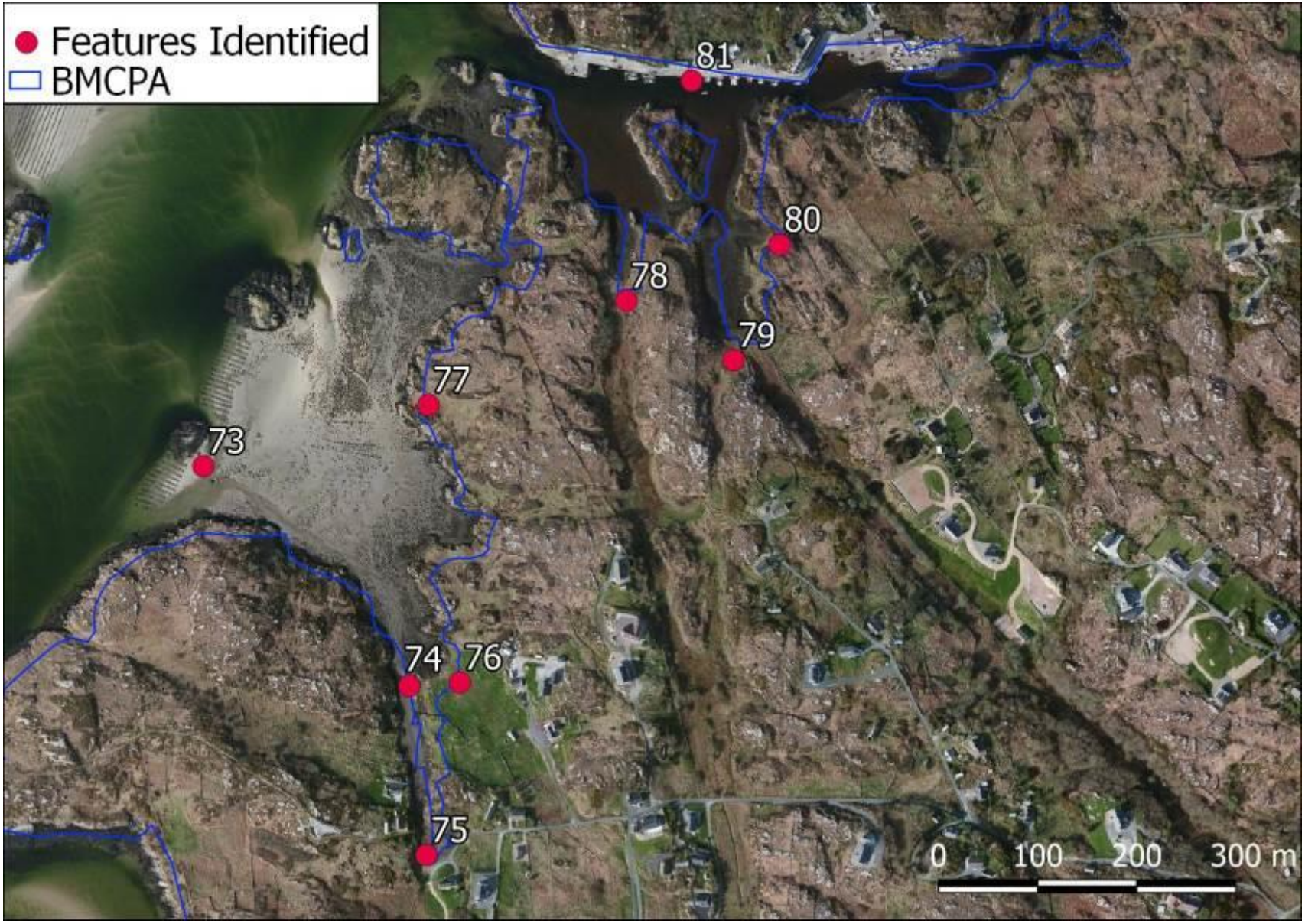

Figure 3.31: Features 73-81 (numbering cross-reference to Table 3.11) identified during the shoreline survey.

Figure 3.32: Features 82-83 (numbering cross-reference to Table 3.11) identified during the shoreline survey.

Figure 3.33: Features 84-86 (numbering cross-reference to Table 3.11) identified during the shoreline survey.

Figure 3.34: Features 87 (numbering cross-reference to Table 3.11) identified during the shoreline survey.

Figure 3.35: Features 88-90 (numbering cross-reference to Table 3.11) identified during the shoreline survey.

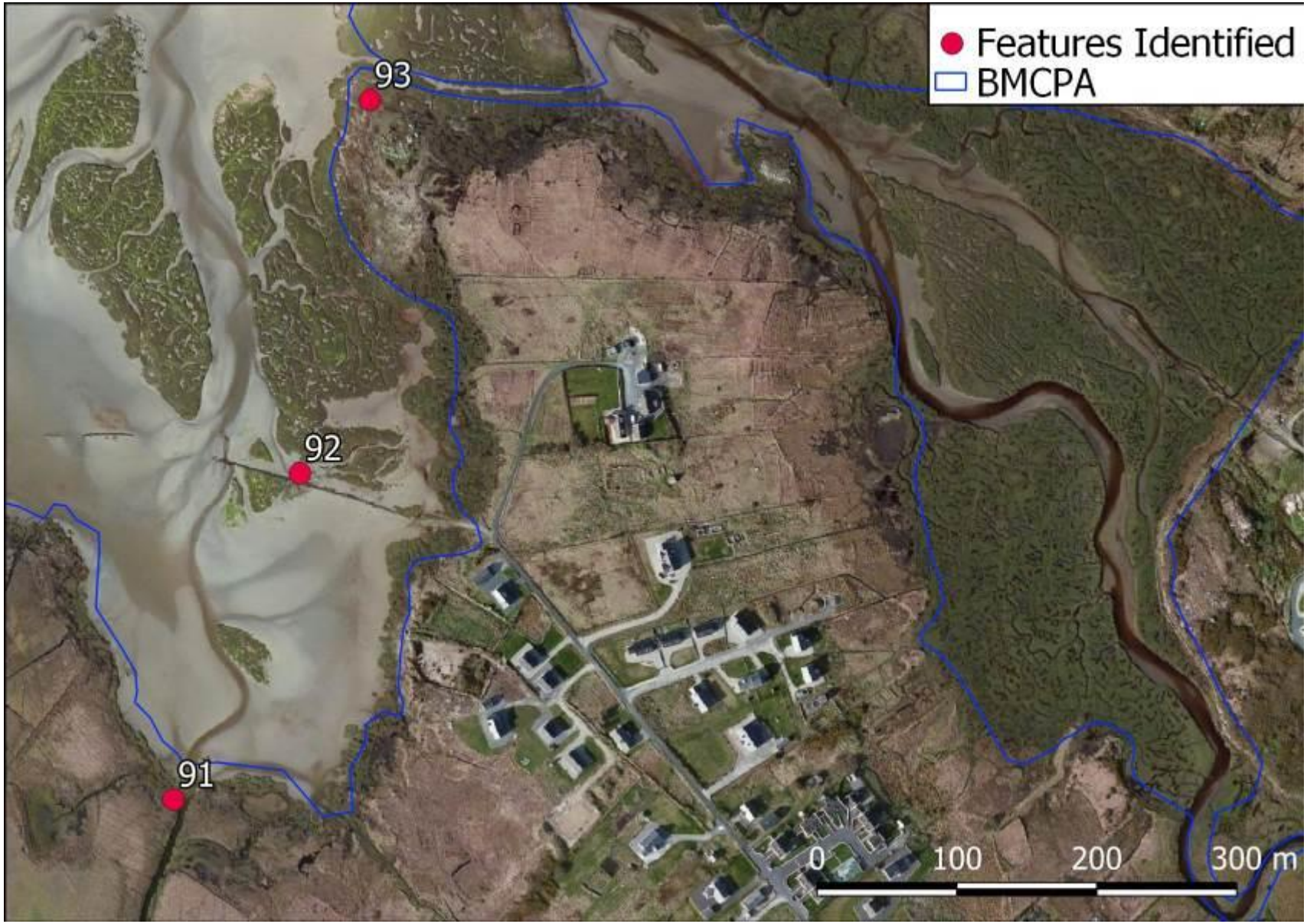

Figure 3.36: Features 91-93 (numbering cross-reference to Table 3.11) identified during the shoreline survey.

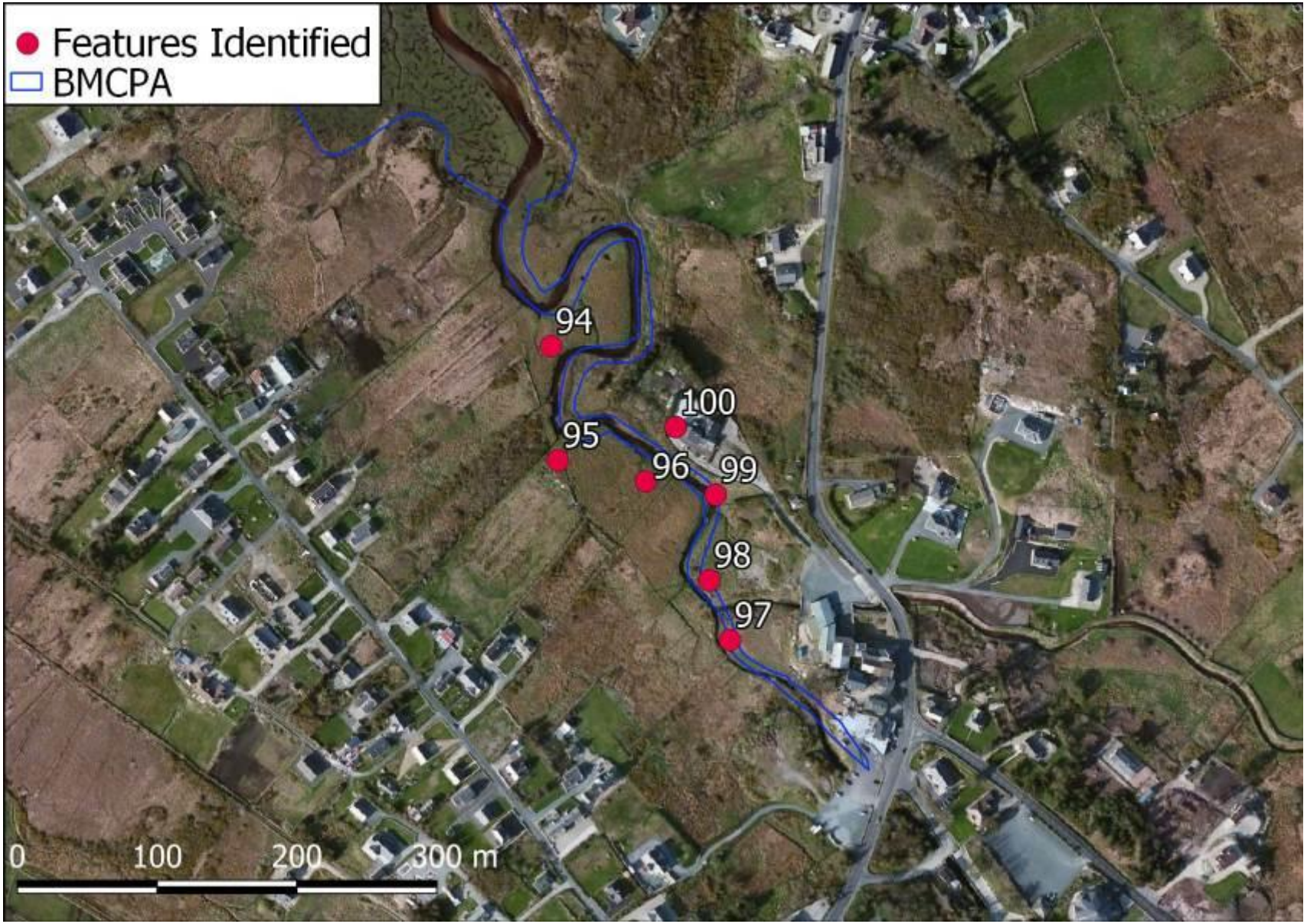

Figure 3.37: Features 94-100 (numbering cross-reference to Table 3.11) identified during the shoreline survey.

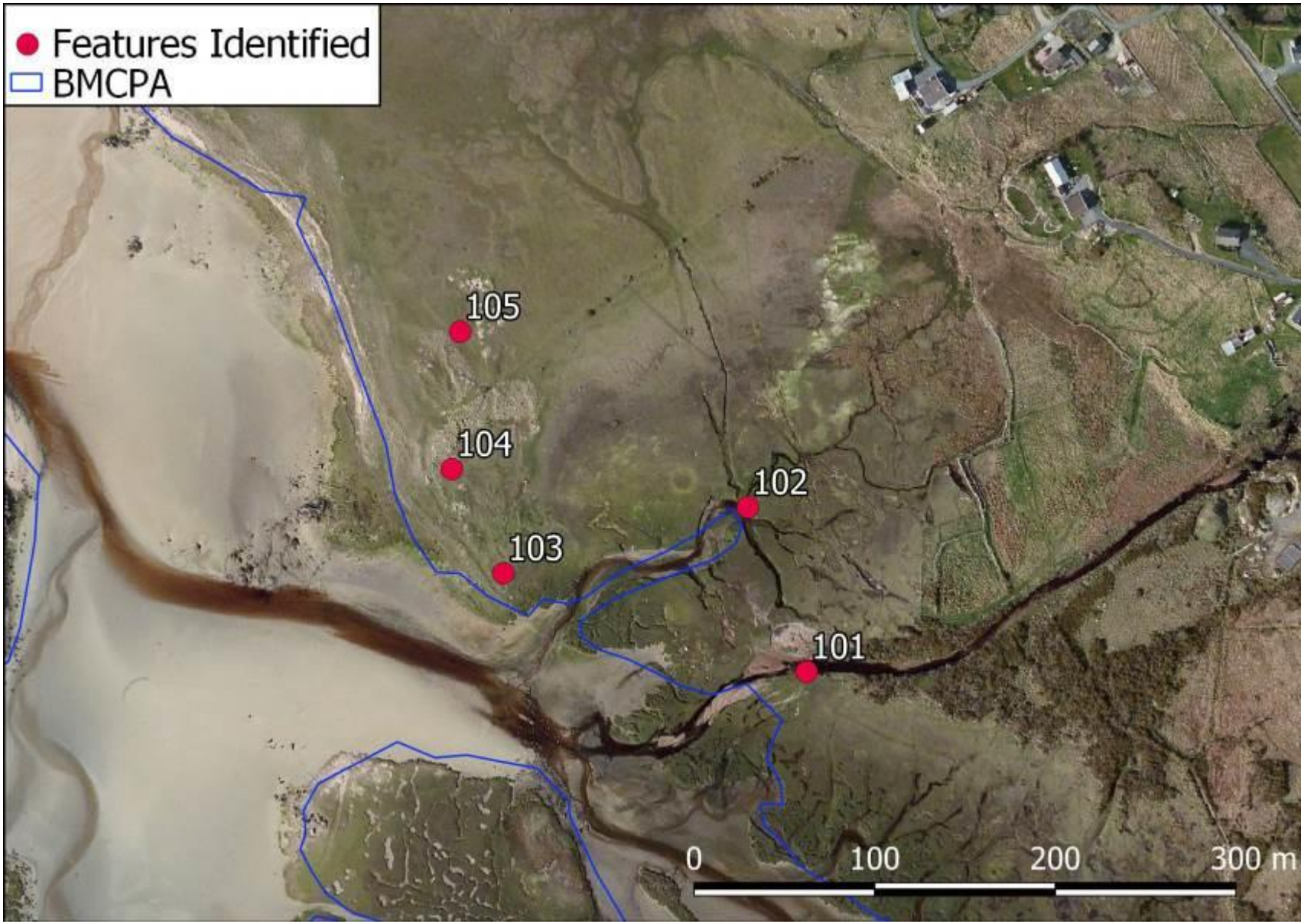

Figure 3.38: Features 101-105 (numbering cross-reference to Table 3.11) identified during the shoreline survey.

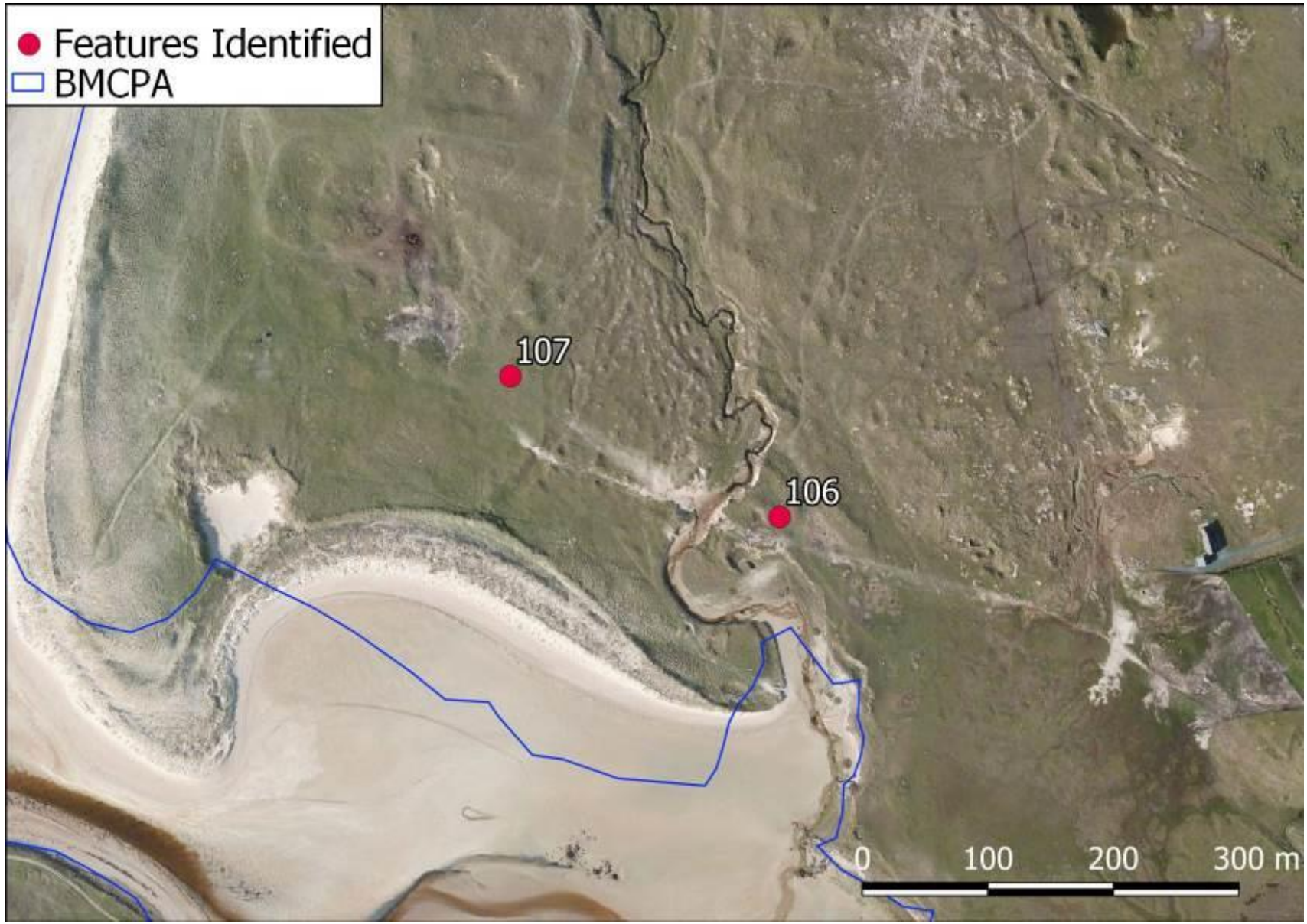

Figure 3.39: Features 106-107 (numbering cross-reference to Table 3.11) identified during the shoreline survey.

Figure 3.40: Features 108 (numbering cross-reference to Table 3.11) identified during the shoreline survey.

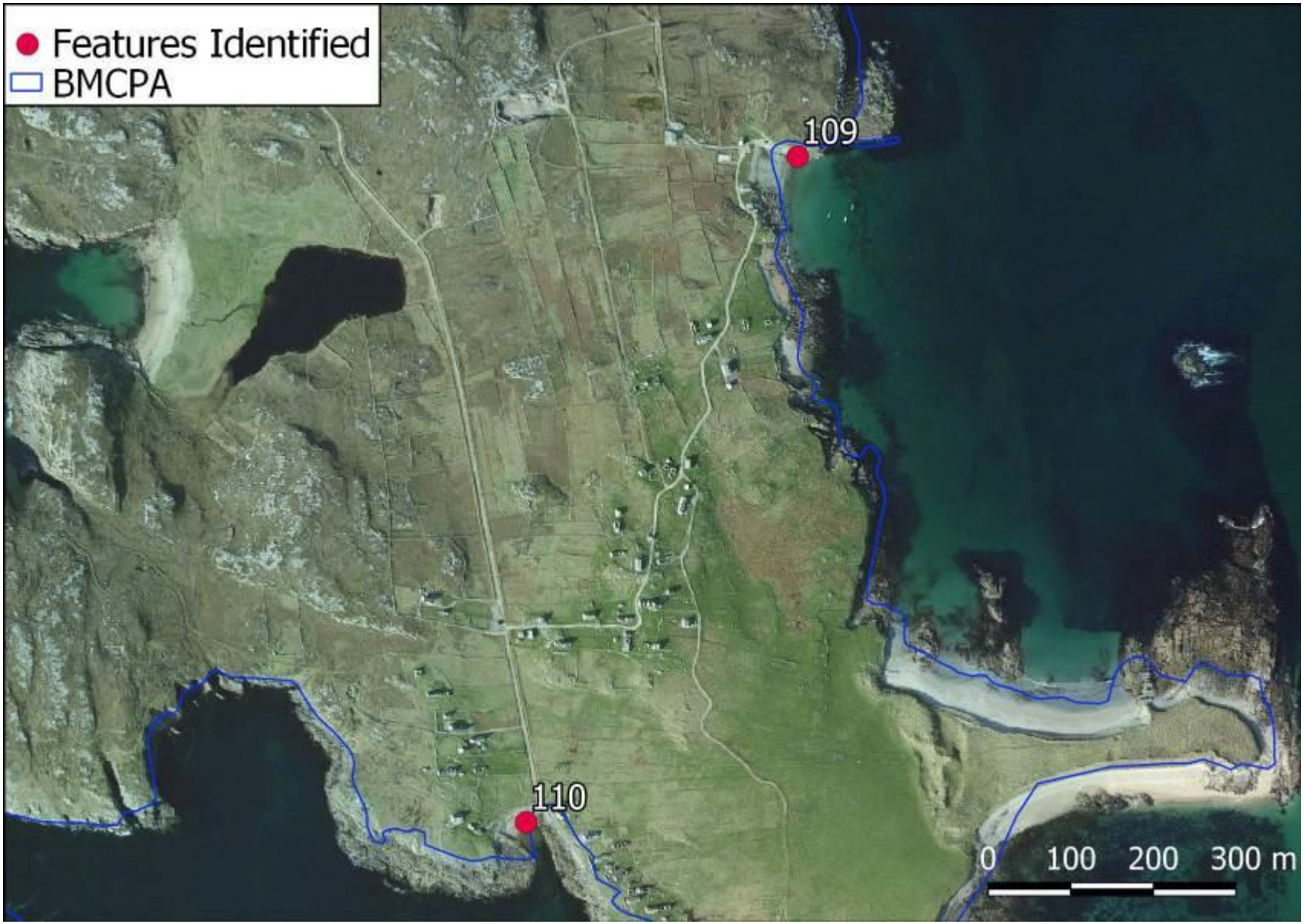

Figure 3.41: Features 109-110 (numbering cross-reference to Table 3.11) identified during the shoreline survey.

3.3. Locations of Sources

Figure 3.42 shows all watercourses discharging into Gweedore Bay and Table 3.12 provides cross-referenced details for this map. Figure 3.43 and 3.44 show all discharges in the Gweedore Bay catchment area and Tables 3.13 provides cross-referenced details for the WwTP, drain and pipe discharges and Section 4 discharges.

Figure 3.42: Location of all watercourses discharging into Gweedore Bay.

Table 3.12: Cross-referenced table for Figure 3.42 Watercourses.

Map I.D	River Name
1	Unnamed
2	Meenderryowan
3	Unnamed
4	Unnamed
5	Loughanure
6	Mín Doire Na Slua
7	Mín Na Leice
8	Rann Na Feirste
9	Muíne Dubh
10	Gweedore
11	Unnamed
12	Dobhar
13	Doir Na Mainséar
14	Knockastoller
15	Dunbeg
16	Clady
17	Unnamed
18	Unnamed
19	Unnamed
20	Unnamed
21	Catheen
22	Srath conach
23	Stranacorcragh
24	Owencronahulla
25	Unnamed
26	Unnamed

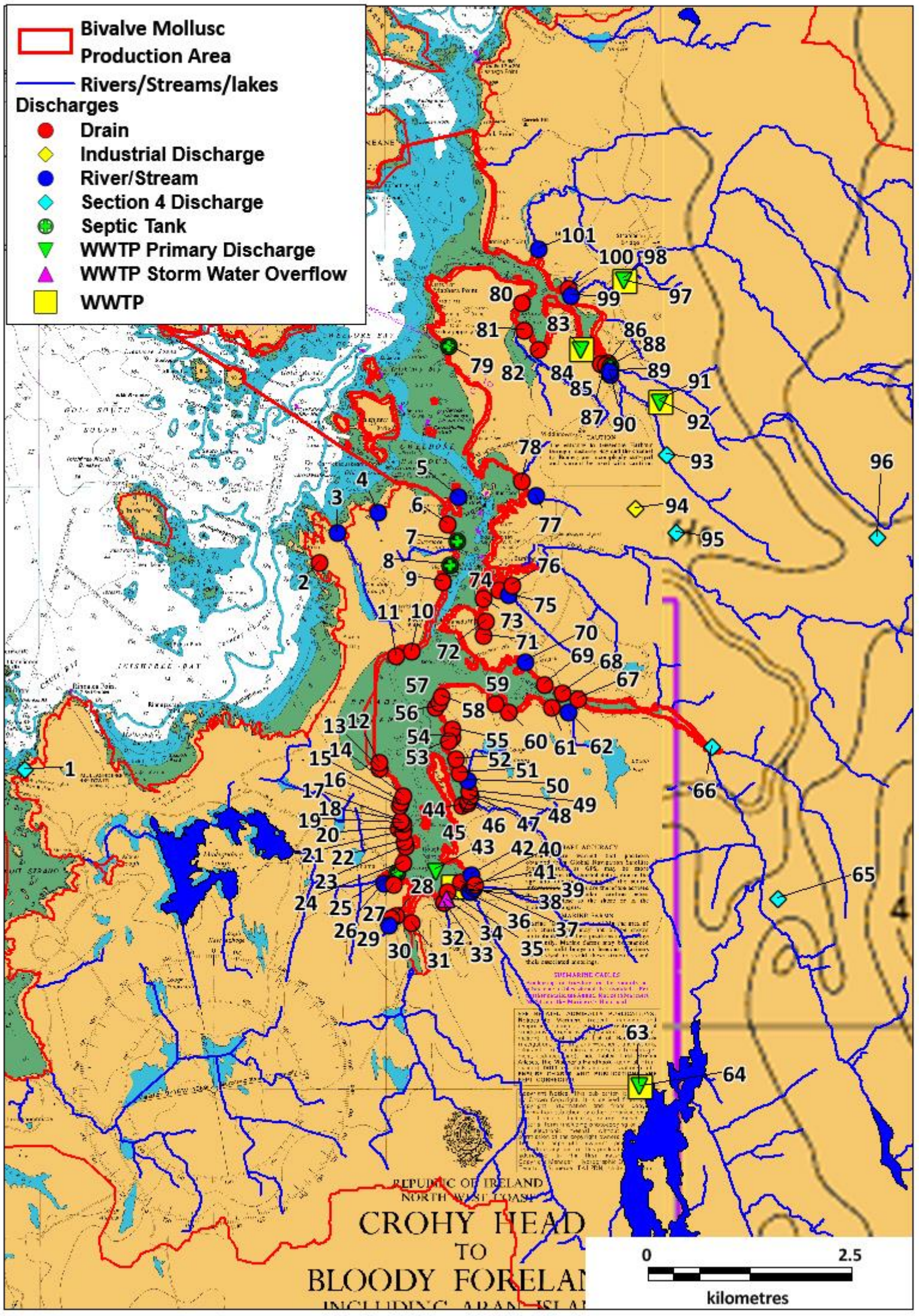

Figure 3.43: Locations of all discharges within the Gweedore Bay Catchment Area.

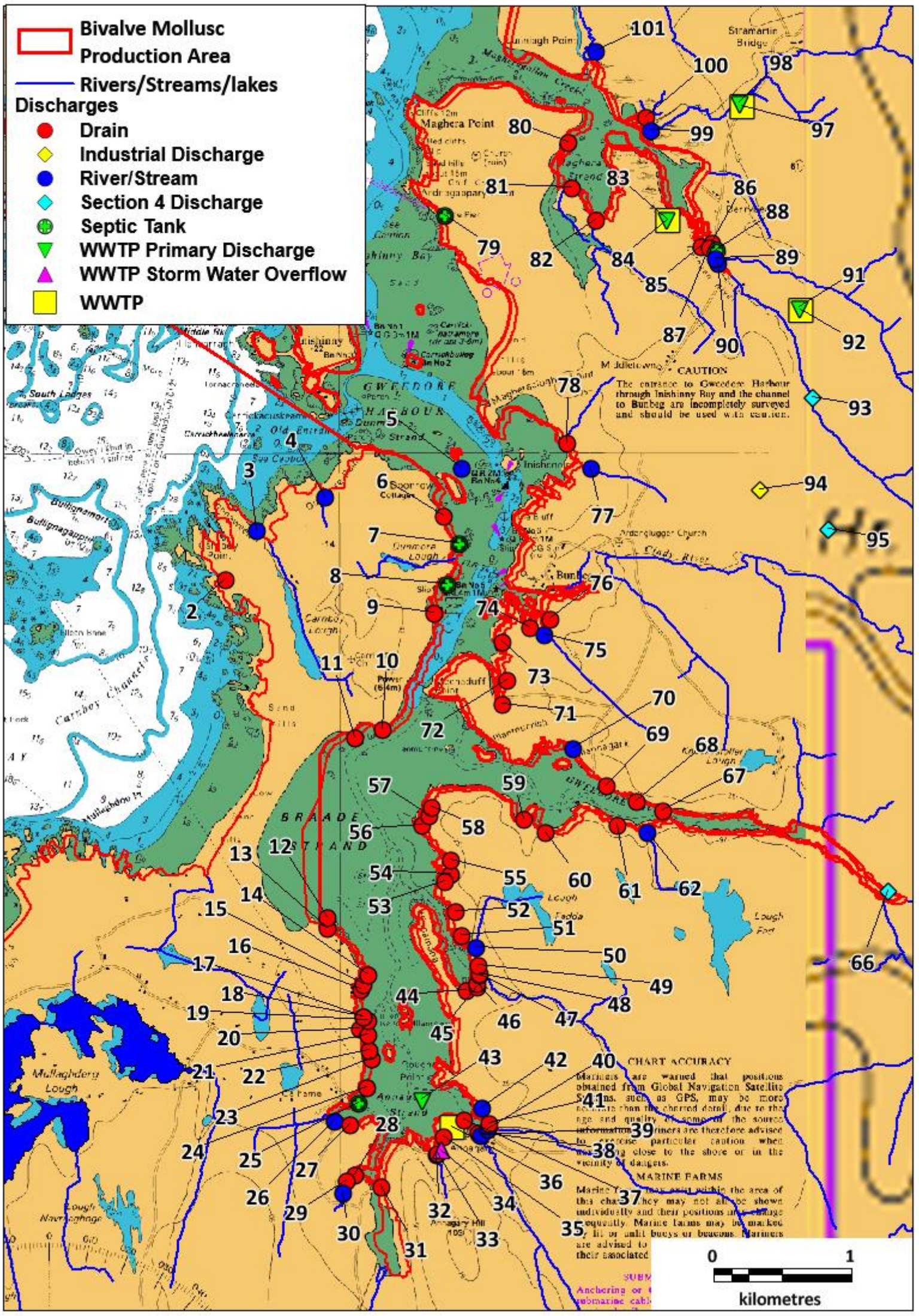

Figure 3.44: Location of discharges in Gweedore Bay.

Table 3.13: Cross-referenced table for Figure 3.43 & 3.44 Discharges.

Map ID	Discharge	Description	Comments	Latitude	Longitude	Easting	Northing
1	Premier Fish Products Teo.	Section 4 discharge		55.035437	-8.403974	174220.2	420968.9
2	Natural drain	Shore Survey	Draining very rough grazing land	55.058423	-8.347163	177865.4	423508.4
3	Stream on beach	Shore Survey	Draining very rough grazing land	55.061673	-8.343663	178090.8	423869.1
4	Small stream	Shore Survey	Draining sand dune grazed land	55.063890	-8.335796	178594.7	424113.5
5	Stream	Shore Survey	Stream running onto sand flats adjacent oyster farm	55.065690	-8.320263	179588.1	424309.2
6	Field drain	Shore Survey	Field drain	55.062590	-8.322346	179453.4	423964.7
7	Septic tank	Shore Survey	Small house septic - outflow not visible	55.060757	-8.320579	179565.4	423760.1
8	Septic tank	Shore Survey	Small house septic - outflow not visible	55.058107	-8.321946	179476.7	423465.5
9	Field drain	Shore Survey	Draining onto sand flats adjacent oyster trestles	55.056240	-8.323413	179382.0	423258.1
10	Two pipes	Shore Survey	No discharge, possibly septic related	55.048607	-8.329346	178998.8	422410.1
11	Field drain	Shore Survey	Very low flow	55.048073	-8.332463	178799.3	422351.6
12	Drain	Shore Survey	Steady flow across machair	55.036260	-8.335636	178590.1	421037.4
13	Field drain	Shore Survey	Steady flow, field drain	55.035560	-8.335656	178588.5	420959.5
14	Field drain	Shore Survey	Field drain, flowing.	55.032480	-8.330996	178884.8	420615.2
15	Field drain	Shore Survey	Field drain, flowing.	55.031880	-8.331606	178845.5	420548.6
16	Field drain	Shore Survey	Field drain, flowing.	55.031520	-8.331806	178832.5	420508.6
17	Field drain	Shore Survey	Field drain, flowing.	55.029760	-8.331526	178849.5	420312.6
18	Field drain	Shore Survey	Field drain, flowing.	55.029760	-8.331526	178849.5	420312.6
19	Piped drain	Shore Survey	Drainage pipes from garden by 2	55.029507	-8.330979	178884.3	420284.2
20	Field drain	Shore Survey	Field drain, flowing.	55.028920	-8.331966	178820.9	420219.2
21	Field drain	Shore Survey	Field drain, flowing.	55.028540	-8.330996	178882.7	420176.6
22	Field drain	Shore Survey	Field drain, flowing.	55.027550	-8.330876	178889.9	420066.3
23	Field drain	Shore Survey	Field drain, flowing.	55.027020	-8.330656	178903.7	420007.3

24	Field drain	Shore Survey	Field drain, flowing.	55.025080	-8.331106	178873.9	419791.4
25	Septic tank	Shore Survey	Broken - unsure if operational	55.024090	-8.332113	178808.9	419681.5
26	Stream	Shore Survey	Stream coming through saltmarsh, small inlet.	55.022923	-8.334829	178634.6	419552.4
27	Field drain	Shore Survey	Adjacent main road to airport	55.022690	-8.333013	178750.7	419525.9
28	Field drain	Shore Survey	Flowing through saltmarsh	55.019357	-8.332463	178784.0	419154.7
29	Three pipes - discharge	Shore Survey	Three pipes, odour. Grey colour.	55.019007	-8.333479	178718.9	419116.0
30	Large stream	Shore Survey	Large stream, good flow of water.	55.018190	-8.333863	178693.9	419025.2
31	Lagoon discharge	Shore Survey	Tidal flow from lagoon	55.018540	-8.329463	178975.5	419062.8
32	Stream	Shore Survey	Stream, good flow	55.020723	-8.323279	179372.2	419304.0
33	Pipe	Shore Survey	Pipe, small bore no flow	55.020773	-8.323146	179380.8	419309.5
34	Annagary	WWTP Storm Water Overflow		55.020960	-8.322726	179407.7	419330.2
35	Concrete pipe	Shore Survey	Virtually no flow	55.021890	-8.322429	179427.2	419433.7
36	Annagary	WWTP		55.022487	-8.321495	179487.2	419499.9
37	Pipe	Shore Survey	Pipe -small bore, no flow	55.022957	-8.320046	179580.2	419551.8
38	Pipe	Shore Survey	Pipe -small bore, no flow	55.022090	-8.318496	179678.8	419454.8
39	Small river	Shore Survey	Small river - good flow	55.021940	-8.318146	179701.2	419438.0
40	Stream	Shore Survey	Stream - good flow, piped under road	55.022357	-8.317363	179751.5	419484.2
41	Drain	Shore Survey	Drain - coming off road	55.022723	-8.317196	179762.3	419524.9
42	Stream	Shore Survey	Stream	55.023723	-8.317996	179711.7	419636.4
43	Annagary	WWTP Primary Discharge		55.024280	-8.324816	179275.7	419700.5
44	Drain	Shore Survey	Stone built drain	55.031490	-8.319779	179601.6	420501.6
45	Field drain	Shore Survey	Field drain	55.031690	-8.318563	179679.4	420523.6
46	Field drain	Shore Survey	Field drain	55.031940	-8.318513	179682.8	420551.4
47	Small river	Shore Survey	Small river - good flow	55.032490	-8.318196	179703.3	420612.5
48	Drain	Shore Survey	Stone built drain	55.032557	-8.318229	179701.2	420620.0

49	Field drain	Shore Survey	Field drain	55.033123	-8.318463	179686.6	420683.1
50	Stream	Shore Survey	Stream	55.034273	-8.318663	179674.4	420811.2
51	Drain	Shore Survey	Field drain	55.035107	-8.320279	179571.5	420904.5
52	Drain/stream	Shore Survey	Drain flowing from field -	55.036640	-8.320979	179527.5	421075.4
53	Drain	Shore Survey	Drain through small reed bed	55.038590	-8.322213	179449.6	421292.8
54	Drain - Stream	Shore Survey	Drain/stream - good flow	55.039057	-8.321579	179490.3	421344.6
55	Drain	Shore Survey	Drain - rubbish, some enrichment	55.039990	-8.321529	179494.0	421448.5
56	Drain	Shore Survey	Field drain	55.042290	-8.324829	179284.2	421705.5
57	Drain	Shore Survey	Field drain	55.042923	-8.323996	179337.8	421775.7
58	Drain	Shore Survey	Field drain	55.043490	-8.323696	179357.3	421838.7
59	Tidal Ponds Outflow	Shore Survey	Outflow from rectangular pond- saltwater only likely	55.042673	-8.313179	180029.2	421744.7
60	Drain	Shore Survey	Drain	55.041823	-8.310663	180189.6	421649.4
61	Drain	Shore Survey	Drain	55.042307	-8.302529	180709.9	421701.0
62	Stream	Shore Survey	Stream	55.041823	-8.299096	180929.1	421646.1
63	Loughanure Housing Scheme	WWTP Primary Discharge		55.000550	-8.285827	181758.6	417047.7
64	Loughanure Housing Scheme	WWTP		55.000255	-8.285534	181777.2	417014.8
65	Gillespie Readymix Company Ltd.	Section 4 discharge		55.021038	-8.258807	183496.2	419321.8
66	Electricity Supply Board	Section 4 discharge		55.037951	-8.271538	182689.2	421207.9
67	Drain	Shore Survey	Field drain coming off hill	55.043190	-8.297246	181048.0	421797.8
68	Drain	Shore Survey	Field drain	55.043890	-8.300363	180849.1	421876.6
69	Drain	Shore Survey	Drain entering alongside slipway	55.044873	-8.303696	180636.5	421987.0
70	Stream	Shore Survey	Stream, good flow, coming off hill	55.047290	-8.307563	180390.5	422257.1
71	Drainage pipe	Shore Survey	Steady flow, some enrichment	55.050257	-8.315613	179877.4	422589.7
72	Stone drain	Shore Survey	Drain, most likely field drain	55.051823	-8.315096	179911.3	422763.9
73	Drain	Shore Survey	Field drain	55.054340	-8.315613	179879.5	423044.3

74	Drain	Shore Survey	Drain, most likely field drain	55.055290	-8.312496	180079.2	423149.2
75	Stream	Shore Survey	Steady flow	55.054757	-8.310796	180187.5	423089.3
76	Drain	Shore Survey	Field drain	55.055807	-8.310079	180233.9	423206.0
77	Small stream	Shore Survey	Stream and drain flowing through salt marsh	55.065740	-8.305429	180535.9	424310.6
78	Drain	Shore Survey	Drain flowing through dunes onto beach	55.067340	-8.308163	180362.0	424489.4
79	Possibly septic	Shore Survey	No visible outflow	55.082323	-8.322129	179477.4	426161.5
80	Pipe field drain	Shore Survey	Low flow, possibly field drain.	55.087073	-8.307979	180383.5	426686.3
81	Drains	Shore Survey	Drains running off saltmarsh-adjacent football ground	55.084107	-8.307513	180411.7	426355.9
82	Channel	Shore Survey	Channel running from small lagoons in saltmarsh	55.081957	-8.304813	180583.1	426115.8
83	Cottain Housing Scheme	WWTP Primary Discharge		55.082090	-8.296706	181101.0	426128.4
84	Cottain Housing Scheme	WWTP		55.081952	-8.296559	181110.2	426112.9
85	Drain	Shore Survey	Drain - iron oxide. Houses at head of drains.	55.080257	-8.292813	181348.7	425923.3
86	Field drain	Shore Survey	Small field drain entering river channel.	55.080473	-8.291496	181432.9	425947.0
87	Drain	Shore Survey	Drain	55.080123	-8.291829	181411.5	425908.1
88	Septic tank	Shore Survey	Septic tank immediately adjacent river	55.080040	-8.291046	181461.5	425898.6
89	Small river	Shore Survey	Small river - good flow	55.079490	-8.291113	181457.0	425837.4
90	Channel-river	Shore Survey	Slow flow channel - small stream or river upstream	55.079107	-8.290879	181471.7	425794.7
91	Meenanillar Housing Scheme	WWTP Primary Discharge		55.076220	-8.281506	182069.1	425470.9
92	Meenanillar Housing Scheme	WWTP		55.076041	-8.281377	182077.2	425450.9
93	Udaras na Gaeltachta	Section 4 discharge		55.070286	-8.280115	182155.2	424809.9
94	Euroflex Teoranta	IPC		55.064250	-8.286123	181768.7	424139.5
95	Earrai Pacala Idirnaisiunta Teoranta	IEL		55.061649	-8.278318	182266.2	423847.9
96	Gillespie Readymix Company Ltd.	Section 4 discharge		55.061058	-8.239628	184738.3	423772.9

97	Stranacorcragh Housing Scheme	WWTP		55.089445	-8.288080	181655.2	426944.9
98	Stranacorcragh Housing Scheme	WWTP Primary Discharge		55.089680	-8.288336	181639.0	426971.1
99	River	Shore Survey	River, good flow	55.087890	-8.298496	180989.4	426774.6
100	Drains	Shore Survey	Drains, grey coloured	55.088707	-8.299013	180956.8	426865.7
101	Stream	Shore Survey	Stream through sand dunes	55.093057	-8.304813	180588.5	427351.6

4. Hydrography/Hydrodynamics

4.1. Simple/Complex Models

No models exist for Gweedore Bay. However, the information that follows will allow for an understanding of the hydrographic conditions in the area.

4.2. Depth

The Gweedore shellfish area is divisible into two distinct sections, the outer is exposed to the Atlantic, while the inner is narrow and river like with a maximum width of 1.2km and is almost completely intertidal except for a narrow channel. The deeper part of the channel runs from Meenaduff Point out along the middle of the bay until it meets Inishinny Island where it splits into two channels running either side of the Island. Depths in this channel range from 0.2 to 5.3m (Admiralty Chart 1883). In the outer part a deep channel runs between Gola Island and Inishmeane Island and then between Gola Island and Inishinny Island. The depths in this channel range from 6 to 14m. Figure 4.1 shows water depth in the area.

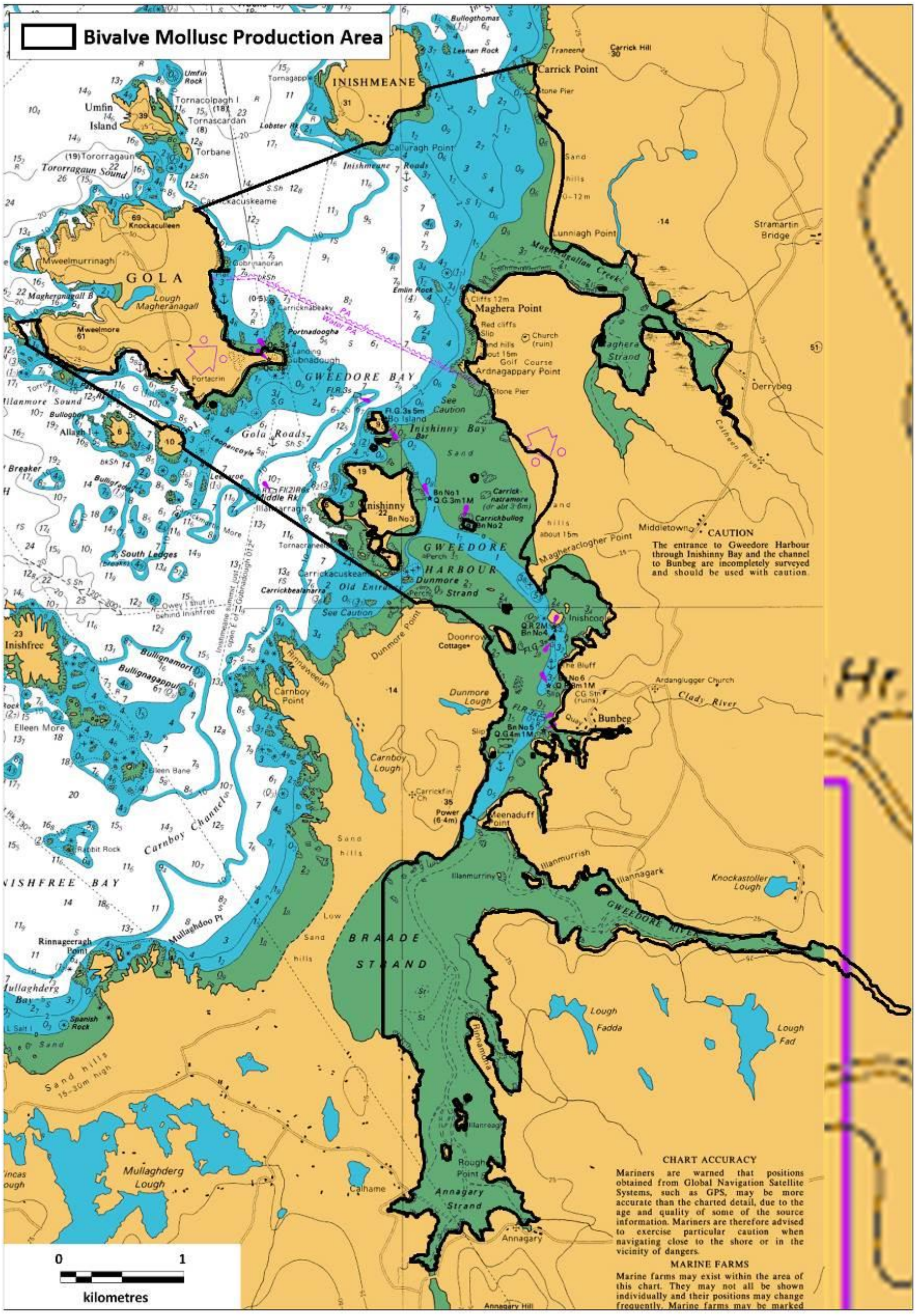

Figure 4.1: Depths in Gweedore Bay (Source: Admiralty Chart 1883).

4.3. Tides & Currents

Predicted spring and neap tidal ranges in Gweedore Bay are in the region of 3.3 and 1.4m respectively (Admiralty Chart 1883). The characteristic tidal levels for Gweedore Bay can be seen in Table 4.1. These are taken from the Admiralty Chart 1883. Levels are presented in metres Chart Datum, which is approximately equal to Lowest Astronomical Tide (LAT). On a flooding tide the majority of water movement is likely to be north and south of Gola Island moving southeast towards the inner bay converging on the eastern side of Inishinny Island where it will then flow south into the inner part of the bay. On an ebbing tide the water moves north out of the inner bay until it meets Inishinny Island where it splits into the two channels. One channel goes to the south of the island in a westerly direction and the other channel goes northerly and then northwesterly after it passes the island. The currents within the inner bay are likely to run parallel to the main channel. The highest currents during both flood and ebb tides will likely occur as the water is forced through the narrow passage between Inishinny Island and Dunmore Point.

Table 4.1: Gweedore Bay tidal characteristics (Source: Admiralty Chart No. 1883).

Admiralty Chart 2800 Levels (m CD)	MHWS	MHWN	MLWN	MLWS
Gweedore Bay	3.8	2.9	1.5	0.5

4.4. Wind and Waves

Wind data from 2014 to 2018 from the Finner station (Met Eireann, 2019a) (Co. Donegal, located approximately 62km south of Gweedore Bay) are displayed in Table 4.2 below and wind roses for each year can be seen in Figure 4.2 below. In 2014, 19.8% of the wind came from the west, while 16.8% came from the south and 16.5% from the east. The strongest winds came from the west (44kn). In 2015, 21.6% of the wind came from the west, 18.4% from the southwest and 18% from the south. The strongest winds (39kn) came from the west. In 2016, 19.4% of the wind came from the east, 19% came from the west and 17.3% came from the south. The strongest winds (38kn) came from the southwest. In 2017, 24.2% of the winds came from the west, with 17.1% coming from the south and 16.6% coming from the southwest. The strongest winds (39kn) came from the northwest. In 2018, 20.3% of the wind came from the west, 16.6% came from the southwest, 16.5% came from the southeast and 16.4% came from the south. The strongest winds (37kn) came from the west. It can be seen from the 2014-2018 wind rose diagram that the prevailing wind direction is southwest.

Table 4.3 shows the seasonal averages from 2014 to 2018. 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 5 years indicate that winds are typically strongest in the winter months (12.6kn), followed by spring (10.2kn) and autumn (10kn), with 9.1kn in summer.

Table 4.2: Wind speed and direction data for Finner from 2014-2018 (Source: Met Eireann, 2019a).

	2014		2015		2016		2017		2018	
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	11.7	195	16.4	251	12.5	188	10.9	209	14.5	213
February	14.0	213	10.9	216	12.1	207	12.2	185	11.1	218
March	11.3	208	13.8	222	10.2	198	10.8	177	9.8	144
April	9.8	183	9.0	224	10.2	195	10.8	255	9.8	168
May	8.9	202	13.0	235	8.6	188	8.1	205	8.2	194
June	7.3	203	10.3	249	8.0	219	10.2	227	7.8	236
July	8.6	235	9.4	223	9.5	254	8.9	227	7.3	236
August	10.9	243	8.7	239	10.2	212	9.5	247	9.6	261
September	6.3	206	8.8	220	9.7	198	10.5	240	10.8	270
October	11.0	181	8.2	184	8.0	153	12.3	232	11.5	234
November	8.0	183	14.1	234	8.8	184	10.8	265	10.9	165
December	14.8	237	14.1	190	11.1	183	11.3	249	11.0	214

Degrees Direction Key: 0°/360° = N; 23° = NNE; 45° = NE; 68° = ENE; 90° = N; 113° = ESE; 135° = SE; 158° = SSE; 180° = S; 203° = SSW; 225° = SW; 248° = WSW; 270° = W; 293° = WNW; 315° = NW; 338° = NNW

Table 4.3: Seasonal averages (knots) for Finner wind data (Source: Met Eireann, 2019a).

Season	2014	2015	2016	2017	2018	5 Year Average
Winter	13.5	13.8	11.9	11.5	12.2	12.6
Spring	10.0	11.9	9.7	9.9	9.3	10.2
Summer	9.0	9.5	9.2	9.5	8.2	9.1
Autumn	8.5	10.4	8.8	11.2	11.1	10.0

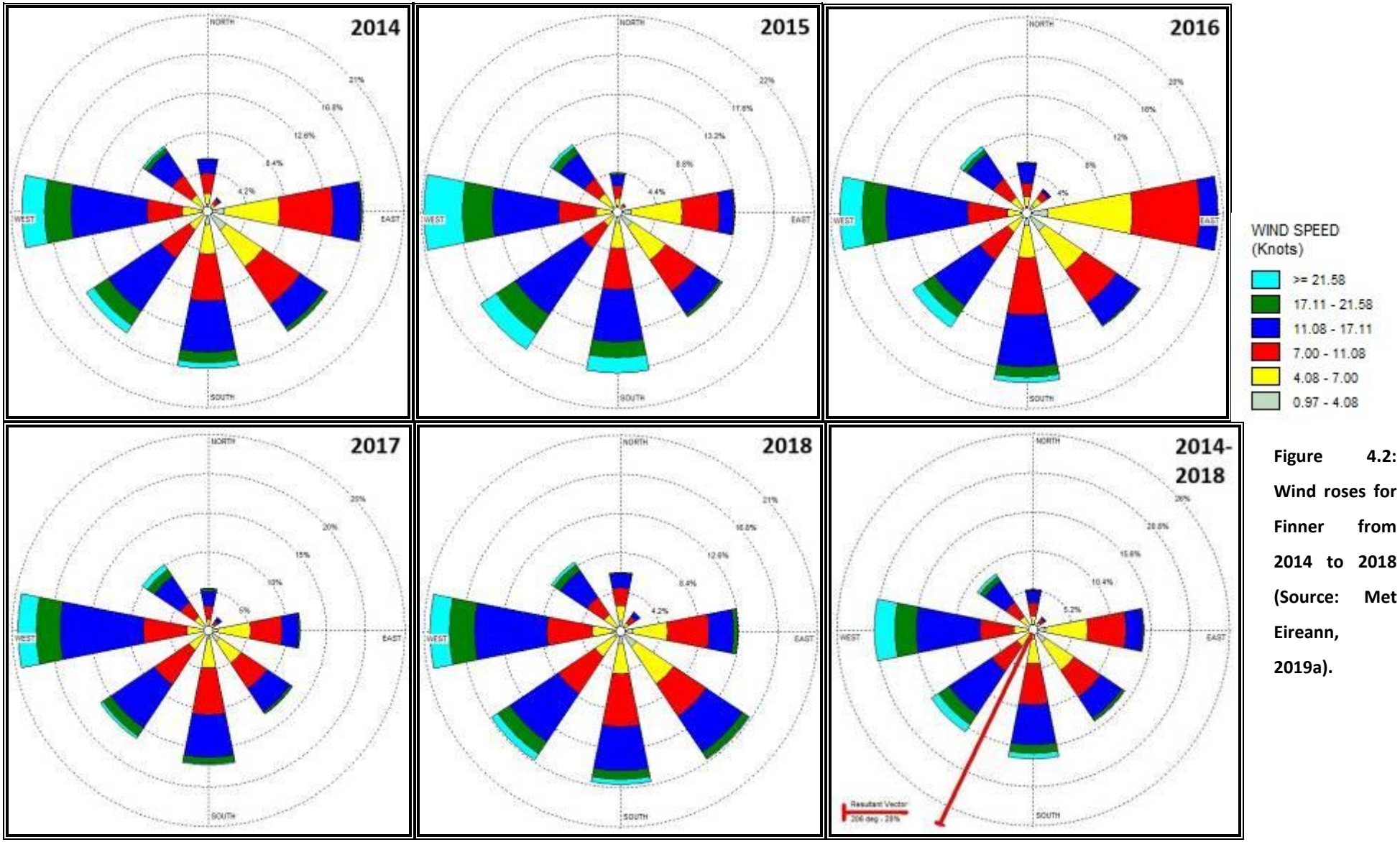

Figure 4.2: Wind roses for Finner from 2014 to 2018 (Source: Met Eireann, 2019a).

Wind conditions affect the hydrodynamic conditions in Gweedore 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 southwesterly 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 and
- the fetch.

4.5. River Discharges

Gweedore Bay drains a catchment of 244km^2, 38% of this flows through the Clady River. The Clady River is approximately 7km long and flows from Lough Nacung into the Bunbeg harbour. The Gweedore River drains a further 23% of the catchment, it is approximately 4km long and flows from Lough Anure into the eastern side of the bay. The mean flow of the Gweedore River as it leaves Lough Anure is 1.8 m^3/s (EPA, 2019a). The southerly extent of the bay south of Braade strand drains 8% of the catchment through a series of small unnamed rivers. Two rivers the Owencronahulla and the Catheen flow into Magheragallan Creek which is a small bay just north of Gweedore bay; 13% of the catchment is drained by these two rivers. The remaining 18% of the catchment drains through a series of small unnanmed rivers along the shoreline.

Due to the Coriolis effect and given the prevailing wind direction (southwesterly), on an ebbing tide, freshwater entering Gweedore Bay along its eastern side will hug this eastern shore and be washed out of the bay.

Lough Nacung is a small lake of 2.1km^2 and is partially fed by small streams which flow directly into the lake. It is also fed by a smaller lake to the east Dunlewy Lough which is 1.1km^2. Lough Anure is a lake on the Gweedore River and has an area of 1.3km^2. Figure 4.3 shows the Gweedore Bay catchment and rivers and lakes.

The current (2010-2015) WFD status of Gweedore Bay and its associated freshwater sources can be seen in Figure 4.4. Of the river and lake systems flowing directly into the Gweedore Bay BMCPA, the Gweedore, Clady and Owencronahulla Rivers are of Good status while the Catheen River is of Poor status. The remaining small streams flowing directly into Gweedore bay are unnamed and have not been assigned a status. Both Lough Nacung and Dunlewy Lough have not been assigned a status. Lough Anure is of Good status while Lough Keel is of Moderate status. The remaining small lakes in the catchment have not been assigned a

status. The coastal and transitional water bodies of Gweedore Bay have not been assigned a status but the Northwestern Atlantic Seaboard coastal waterbody to the west has been assigned a High status.

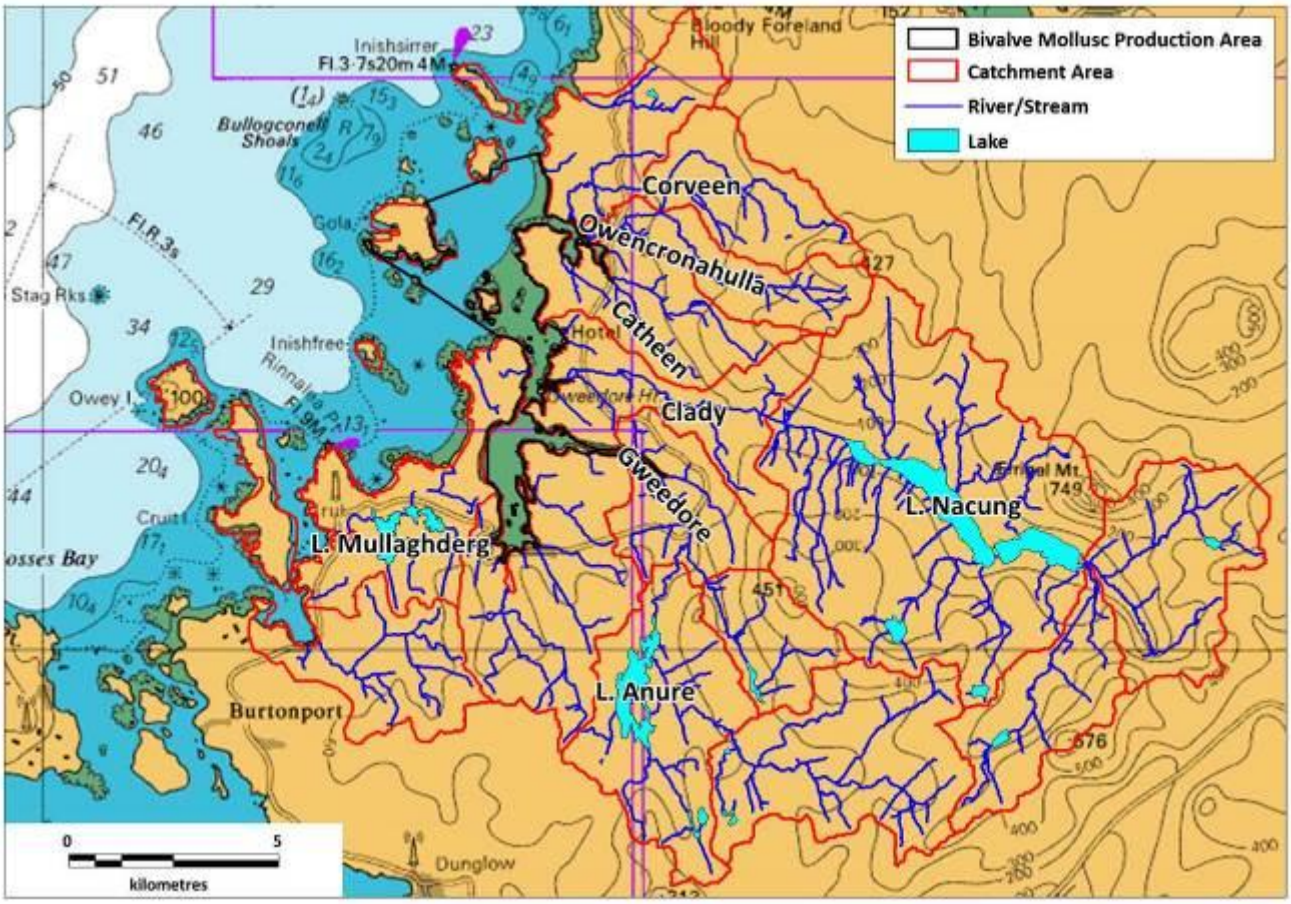

Figure 4.3: Rivers, streams and lakes in the catchment area (Source: EPA, 2019b).

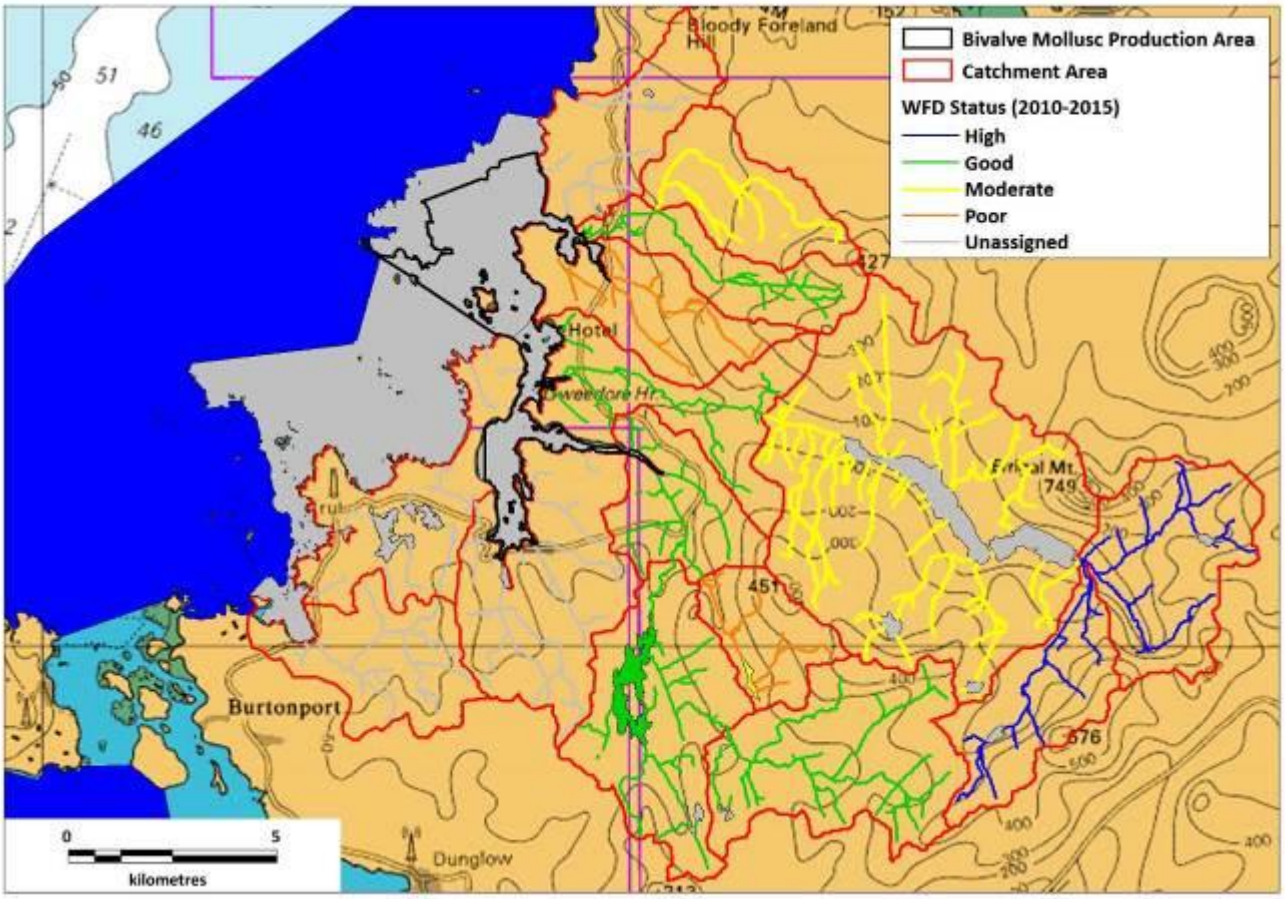

Figure 4.4: WFD Status of the coastal, transitional, lake and river waterbodies in the catchment area (Source EPA, 2019b).

4.6. Rainfall Data

4.6.1. Amount & Time of Year

Figure 4.5 shows the average monthly rainfall data for Ireland (Met Eireann, 2019b) from 1981 to 2010. The wettest months in the Gweedore Bay region over this 30-year period were October to January with the driest months from April to July. Table 4.4 shows the 30-year average monthly rainfall at the Malin Head station which is located c. 68km east of the Gweedore Bay production area (Figure 4.6 shows the location of the Malin Head station). During the period 1981 to 2010, average rainfall at Belmullet was lowest in May (56.9mm) and highest in October (118.4mm). The greatest daily total ranged from a low of 26.3 in April to a high of 60mm in October. Table 4.5 shows the seasonal averages at Malin Head from 1981 to 2010. Lowest average rainfall over the 30 year period was in spring (68.6mm) with the highest average rainfall experienced in winter (112mm).

Table 4.4: Monthly average rainfall at Malin Head from 1981 to 2010 (Source: Met Eireann, 2019b).

Average Rainfall (mm)	Month	Greatest Daily Total (mm)
117.4	January	32.6
84.8	February	34.3
85.9	March	31.4
63.1	April	26.3
56.9	May	35
69.1	June	26.7
76.8	July	38.7
93.2	August	49.9
91.8	September	48.6
118.4	October	60
104.5	November	31.6
114.2	December	39.6
1076	Year	60

Table 4.5: Average seasonal rainfall values (mm) from 1981-2010 at Malin Head (Source: Met Eireann, 2019b).

Season	Average
Spring	68.6
Summer	79.7
Autumn	104.9
Winter	112

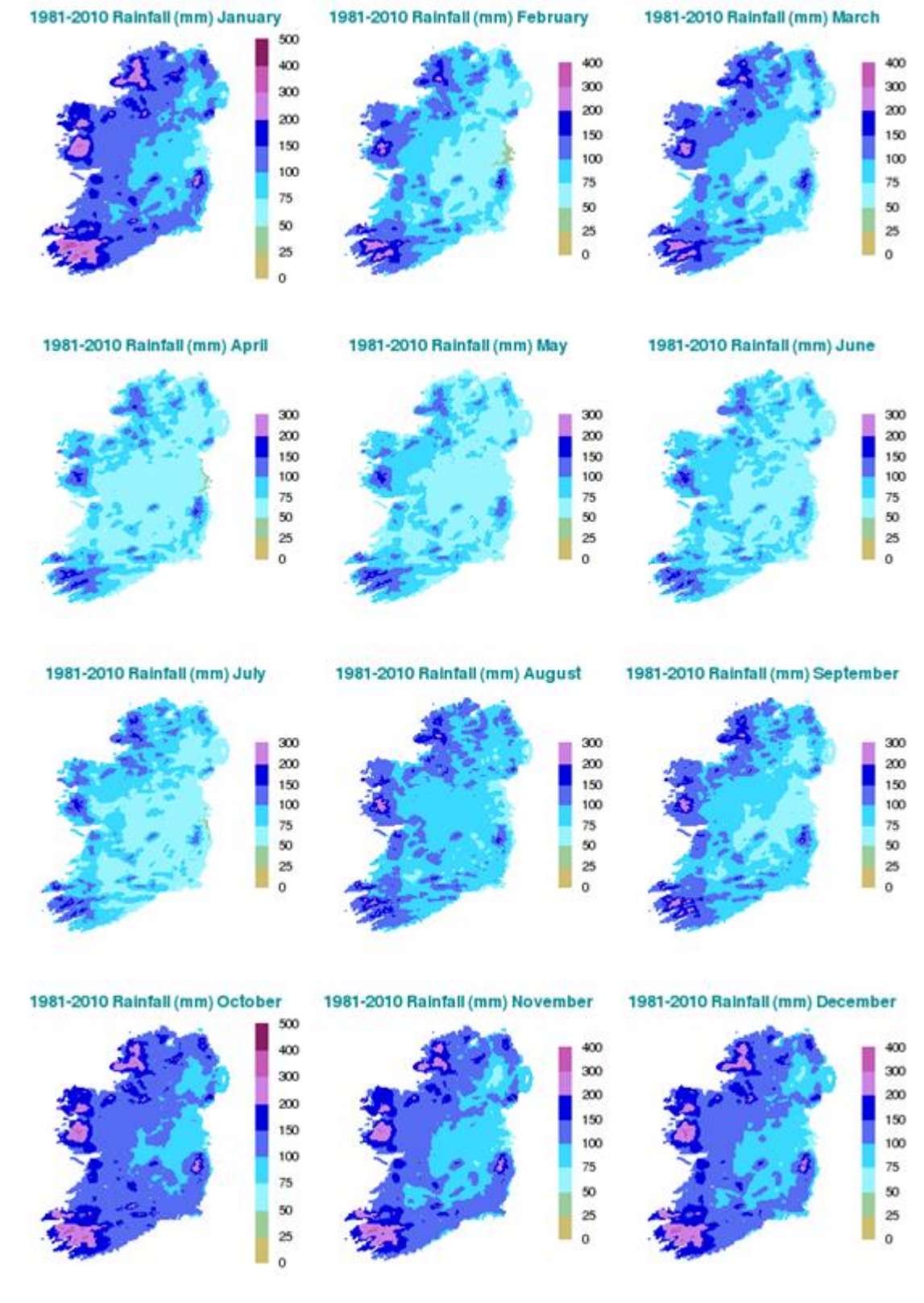

Figure 4.5 Average monthly rainfall (mm) data from 1981 to 2010 for Ireland (Source: Met Eireann, 2019c).

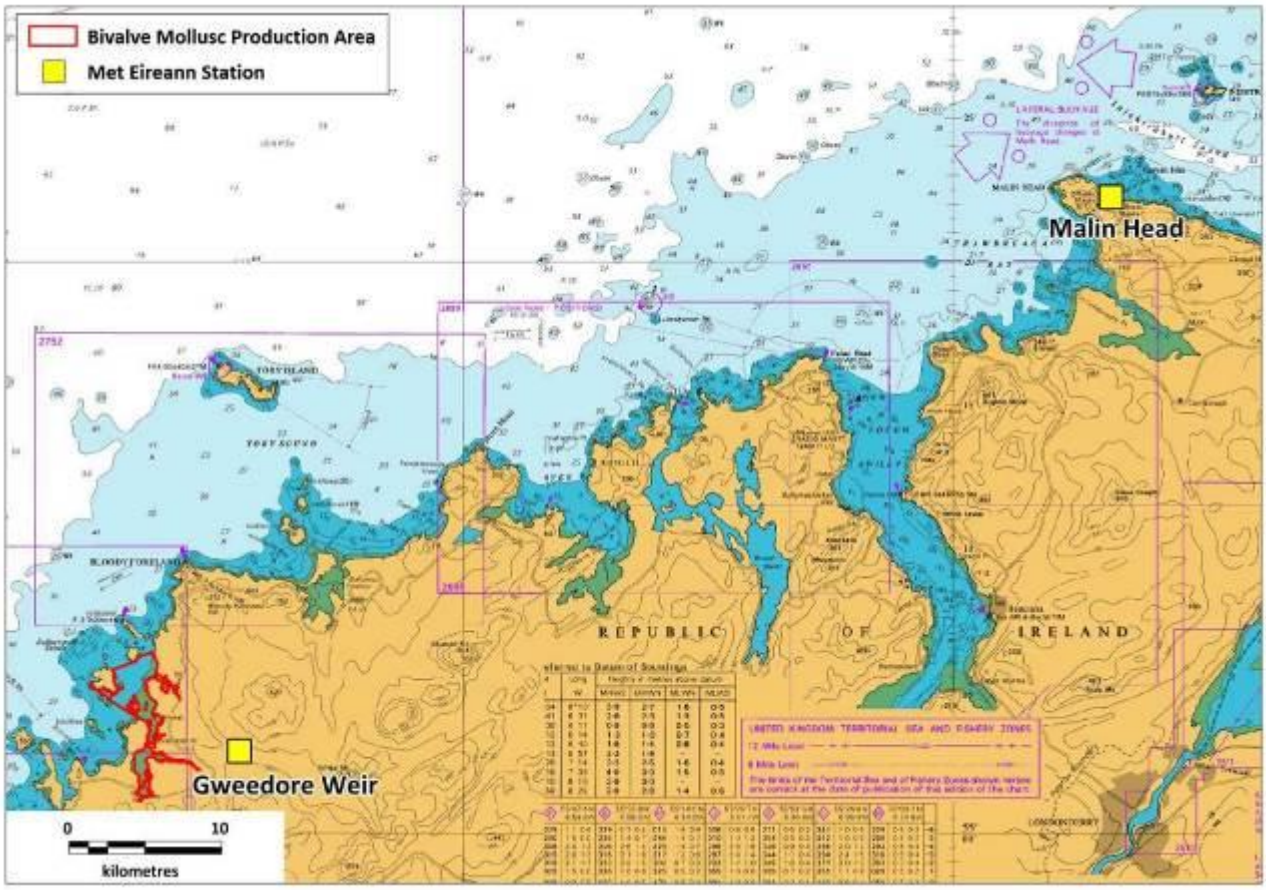

Figure 4.6: Location of Met Eireann weather stations in relation to the Gweedore Bay production area.

Table 4.6 shows total monthly rainfall at the Gweedore Weir Met Eireann station (see Figure 4.6), located to the east of Gweedore Bay production area from 2014 to 2018 (Met Eireann, 2019d).

Gweedore Weir weather station is located at Gweedore town to the south of the Clady River to the east of Gweedore Bay. Maximum monthly rainfall was in January 2018 (317.5mm) and the lowest monthly rainfall was April 2014 (30.4mm). The 5-year average monthly rainfall ranged from a low of 71.9mm in April to a high of 204.1mm in January. Annual averages ranged from 84.8mm in 2018 to 115.1mm in 2015.

Table 4.7 shows the total seasonal rainfall at Gweedore Weir from 2014-2018 (Met Eireann, 2019d The following seasonal fluctuations were observed from 2014-2018: In 2014, spring was the driest season and winter was the wettest, in 2015 summer was the driest and winter was the wettest. In 2016, spring was the driest and winter was the wettest, in 2017 spring was the driest and autumn was the wettest and in 2018 spring was the driest and winter was the wettest. Over the five years, spring 2018 was the driest season and winter 2014 was the wettest season.

Table 4.6: Total monthly rainfall (mm) data at Gweedore Weir Co. Donegal, from 2014 to 2018 (Source: Met Eireann, 2019d).

Year	2014	2015	2016	2017	2018	Monthly 5-yr Average
Jan	219.9	210.6	199.1	73.3	317.5	204.1
Feb	296	116	170.2	148	115.1	169.1
Mar	99	181.3	101.4	153.9	71.6	121.4
Apr	30.4	104.3	79.1	53.4	92.4	71.9
May	109.5	173.4	76.2	59.9	59.8	95.8
Jun	52.2	72.5	88.3	112.8	52.7	75.7
Jul	125.2	171.3	135.2	170.8	97.6	140
Aug	147.8	138.6	122.1	123.1	178.7	142.1
Sep	32.4	54.9	132.3	176.3	119.3	103
Oct	208.2	81.5	35	172.7	206.9	140.9
Nov	188.7	298.7	161.2	184.7	144.3	195.5
Dec	242.6	249.9	96.1	176.4	131.4	179.3
Annual Average	99.2	115.1	88.3	88.0	84.8	

Table 4.7: Total seasonal rainfall (mm) at Gweedore Weir Co. Donegal, from 2014-2018 (Source: Met Eireann, 2019d).

Station	Season/Year	2014	2015	2016	2017	2018
Gweedore Weir	Spring	238.9	459	256.7	267.2	223.8
	Summer	325.2	382.4	345.6	406.7	329
	Autumn	429.3	435.1	328.5	533.7	470.5
	Winter	758.5	576.5	465.4	397.7	564

4.6.2. Frequency of Significant Rainfalls

Figure 4.7 shows the average monthly rainfall at Malin Head from 1981-2010 and Figure 4.8 shows the 5 year monthly average rainfall at Gweedore Weir weather station. Over the 30-year period from 1981 to 2010, October was the wettest month followed closely by January and then December. Over this period, October followed by August and then September had the greatest daily rainfall. Over the past 5 years at Gweedore Weir, January has been the wettest month followed closely by November, with December the next wettest. April and June were the driest months followed by May.

For the 5-year 2014-2018 period, average greatest daily rainfall at Gweedore Weir was 22.9mm, with a maximum of 56.5mm. Over the same period, the number of wet days (rainfall >1mm) a month averaged at 19 with the maximum number of 29 days/month.

Met Eireann has developed a depth duration frequency model for the estimation of point rainfall frequencies (Fitzgerald, 2007; Met Eireann, 2019e). For a 1 in 100 year return period, 34.4 mm of rain would be expected over 1 hour and 90.9mm over 24 hours. Whiles these would be extreme uncommon events, the model predicts that once a year 10.1mm would fall in 1 hour and 34.2mm over a 24 hour period.

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 waste water 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 November to February period. However, as can be seen in Table 4.4, extreme 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.

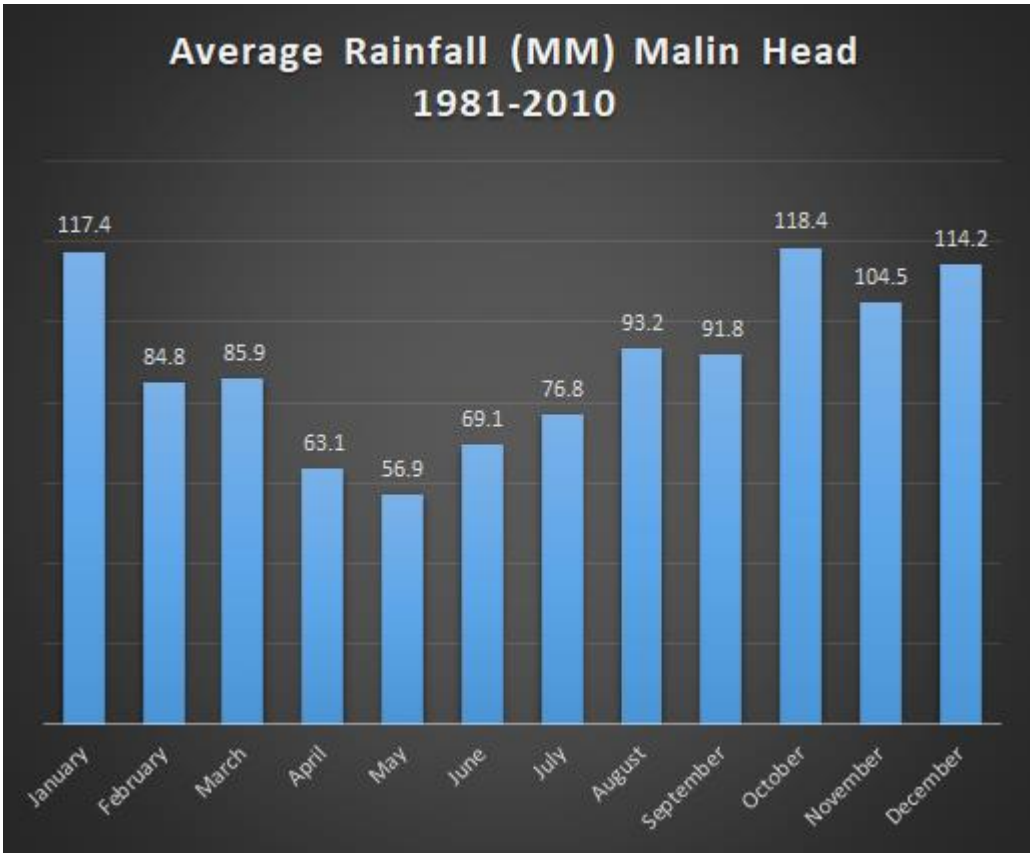

Figure 4.7: Average monthly rainfall (mm) at Malin Head from 1981-2010 (Source: Met Eireann, 2019b).

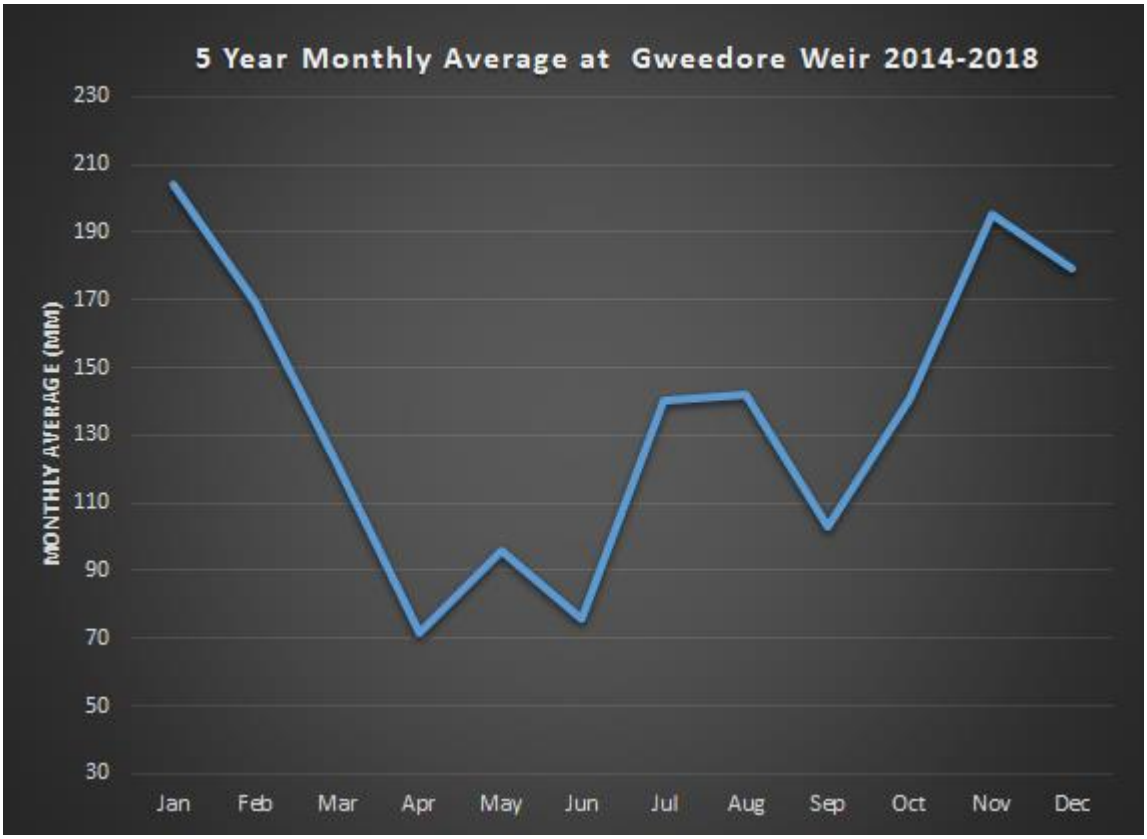

Figure 4.8: 5 year monthly average rainfall (mm) at Gweedore Weir weather station from 2014-2018 (Source: Met Eireann, 2019d).

4.7. Salinity

Gweedore Bay production area salinity is effected by the stage of the tide and the flow rates of the Clady and Gweedore Rivers, along with a handful of other smaller rivers. The inner part of Gweedore Bay, inside Dunmore Point and Maghersclogher Point is classified as a transitional water body and so is likely to have a varied salinity. There is a Shellfish waters (SWD) station location in the inner part of Gweedore Bay (See Figure 3:10). Salinities at this station ranged from 31.34 to 33.22PSU in 2015 (Marine Institute, 2019).The outer part of the bay is classified as a Coastal Water Body (CWB); although no data are available for this area, it is likely that it will have a higher more stable salinity due to its connectivity with the open ocean.

4.8. Turbidity

The turbidity of Gweedore Bay is likely to vary significantly depending on the tide, levels of freshwater input and weather conditions. Turbidity is measured at the Gweedore Bay (SWD) water sampling station (See Figure 3.9) and levels at this site can ranged from 0 to 1NTU in 2015 (Marine Institute, 2019). However, only two results were available for this station. There are no available turbidity data for the outer Bay; however, due to its connectivity with the open ocean turbidity is likely to be low.

4.9. Residence Times

Residence time can be defined as the average amount of time that a molecule of water spends in a particular system. Residence times are important because of the way they govern productivity rates as well as the vulnerability to water quality degradation. In a report by the Marine Institute (2016), it is stated that the residence time for Gweedore Bay is short, *i.e.* 1 day.

4.10. Discussion

The majority of the inner bay is made up of intertidal sandflats, while the outer bay is deeper with depths of 6 to 14m and is more exposed to the Atlantic. The channel in the inner bay runs from Meenaduff Point out along the middle of the bay until it meets Inishinny Island where it splits into two channels running either side of the Island. Depths in this channel range from 0.2 to 5.3m Gweedore Bay has a short residence which indicates a relatively high exchange rate of water within the bay which will aid in the removal of contamination entering the area. The main direction of water flow is to the North West during an ebbing tide and south easterly on a flooding tide. Freshwater input from the Clady and Gweedore Rivers are the main source of salinity variation with salinity ranging from 31.34 to 33.22PSU in the inner part of the bay.

5. Shellfish and Water Sampling

5.1. Historical Data

5.1.1. Shellfish Water Quality

The Marine Institute carry out quarterly water quality monitoring as part of the Shellfish Waters Directive in Gweedore Bay. All sampling is confined to the oyster aquaculture area. The EPA carry out monitoring under the Water Framework Directive. However, *E. coli* is not routinely measured under these programmes.

5.1.2. Shellfish Flesh Quality

In accordance with Regulation (EU) 2017/625 and the subsequent implementing regulation (EU) 2017/627 the Sea Fishery Protection Authority 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 Sea Fisheries Protection Authority currently sample shellfish flesh at one location in the Gweedore Bay production area for classification purposes. Figure 5.1 shows this location of this sampling site Table 5.1 shows the coordinates.

Table 5.1: Coordinates of sampling sites within the Gweedore Bay Production Area.

Sample Code	Species	Latitude	Longitude
DL-GE-GE-PO	Pacific Oysters	55.0544	-8.3186

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. Table 5.2 summarises this system.

Table 5.3 shows the current and historical (back to 2014) classifications within Gweedore Bay. For the 2018-2019 period, Gweedore Bay is classified as B for Oysters. There is no classification available for Razors as they are currently being trialled.

Table 5.2: Classification system for shellfish harvesting areas.

Classification			Permitted Levels	Outcome
	A	<230	Not exceeding 230 E. coli per 100 g flesh and intravalvular liquid in 80% of the samples in the review period	May go direct for human consumption if end product standard met.
	B	<4600	not exceeding 4600 E. coli per 100 g flesh and intravalvular liquid in 90% of the 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 per 100 g of flesh and intravalvular liquid	Must be subject to relaying for a period of at least 2 months or cooked by an approved method.
	Above 46,000 *E.coli*/100g flesh			Prohibited. Harvesting not permitted

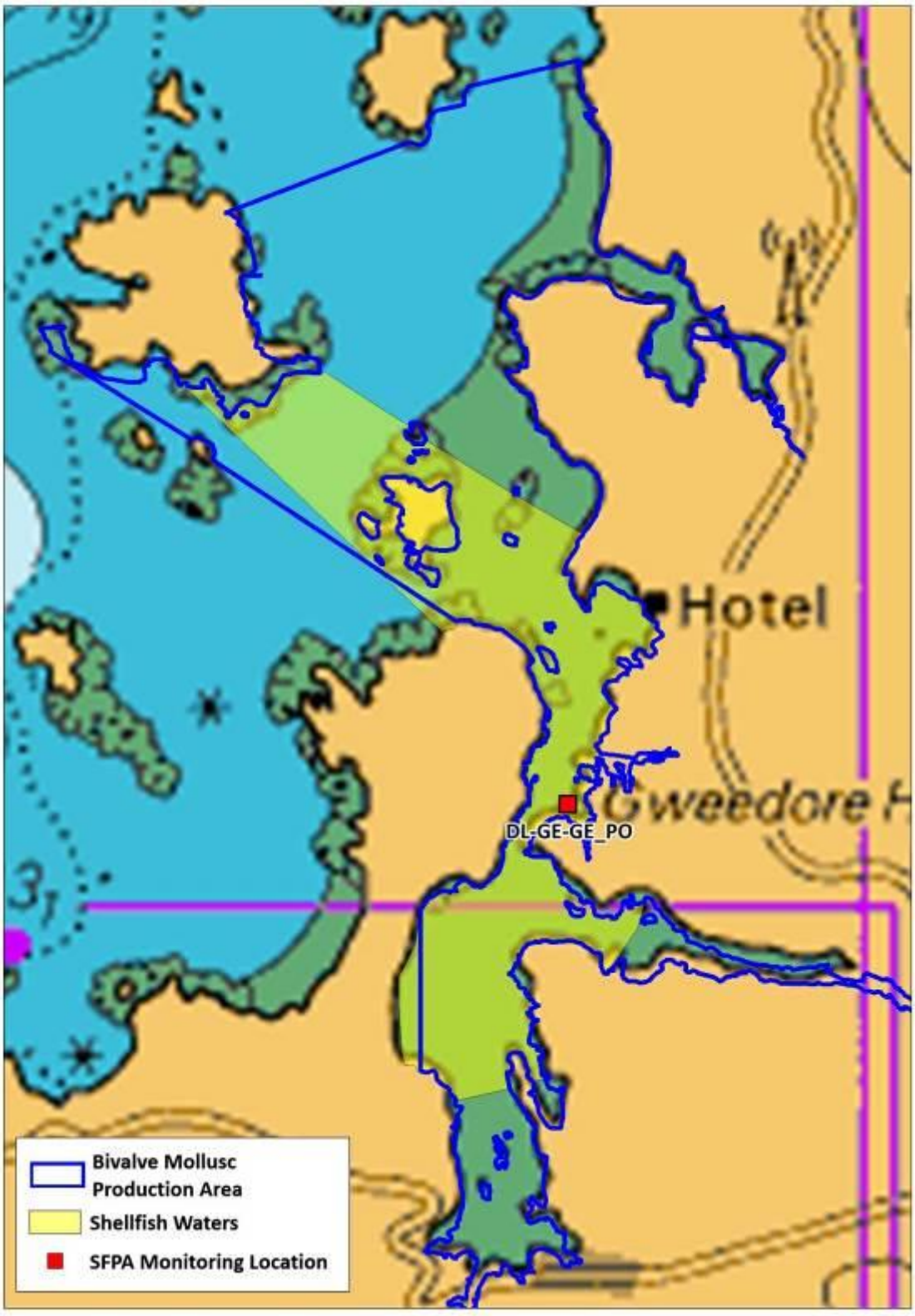

Figure 5.1: Location of SFPA shellfish monitoring point for classification purposes.

Table 5.3: Current and historical classification of shellfish beds in Gweedore Bay (2014 – 2019).

Boundaries	Bed Name	Species	Classification					
			2014	2015	2016	2017	2018	2019
Carrick Point to Carrickacuskeame and Torglass Island to Dunmore Point	All Beds	Oysters	B	B	B	B	B	B

Tables 5.4 and 5.5 list the *E. coli* results for oysters and Razor clams from Gweedore Bay from 2014 to 2019 (where available). Figures 5.2 and5.3 show these data in graphical form.

As shown in Table 5.3 above, Gweedore Bay has had a **B** classification for Oysters from 2014 to 2019. Razor clams have not been classified. The monthly classification trends for oysters can be seen in Table 5.4 and Figure 5.2. The monthly classification trends for Razor clams can be seen in Table 5.5 and Figure 5.3.

Table 5.6 shows the summary statistics for the *E. coli* historical data from the shellfish monitoring site from 2014 to 2019. Table 5.7 shows the variations of the annual geometric means of *E. coli*. Figure 5.4 shows the trend in geometric mean from 2014 to 2019 for Pacific Oysters and Razor clams in Gweedore Bay. The geometric mean for oysters ranged from 64 MPN/100ml in 2016 to 185 MPN/100ml in 2017. The geometric mean for Razors clams ranged from 27 MPN/100ml in 2017 to 18 MPN/100ml in 2018.

There was no significant differences in *E. coli* levels based on season for oysters (one-way ANOVA, p = 0.1454, Appendix 2)

Table 5.4: *E. coli* results from Gweedore Bay oysters from 2014 to 2019 (Source: SFPA)

Date	MPN *E. coli* /100g	Category	Date	MPN *E. coli* /100g	Category
16-Jan-14	20	A	17-Jan-17	700	B
18-Feb-14	70	A	22-Feb-17	490	B
27-Mar-14	490	B	13-Mar-17	110	A
15-Apr-14	20	A	25-Apr-17	230	A
28-May-14	110	A	8-May-17	20	A
30-Jun-14	20	A	27-Jun-17	18	A
14-Jul-14	110	A	24-Jul-17	170	A
25-Aug-14	230	A	23-Aug-17	5400	C
25-Sep-14	78	A	31-Aug-17	78	A
30-Oct-14	170	A	19-Sep-17	490	B
12-Nov-14	490	B	12-Oct-17	45	A
8-Dec-14	170	A	20-Nov-17	330	B
20-Jan-15	45	A	17-Jan-18	20	A
25-Feb-15	20	A	21-Feb-18	230	A
19-Mar-15	78	A	27-Mar-18	78	A
16-Apr-15	45	A	17-Apr-18	20	A
18-May-15	18	A	15-May-18	330	B
16-Jun-15	78	A	27-Jun-18	78	A
14-Jul-15	3500	B	10-Jul-18	78	A
24-Aug-15	2400	B	22-Aug-18	330	B
28-Sep-15	40	A	11-Sep-18	68	A
30-Oct-15	20	A	9-Oct-18	330	B
23-Nov-15	110	A	7-Nov-18	330	B
27-Jan-16	20	A	12-Dec-18	20	A
25-Feb-16	130	A	8-Jan-19	130	A
21-Mar-16	110	A	21-Feb-19	490	B
27-Apr-16	20	A	19-Mar-19	230	A
10-May-16	45	A	25-Apr-19	45	A
20-Jun-16	110	A	20-May-19	130	A
21-Jul-16	68	A	29-Jul-19	330	B
24-Aug-16	78	A	19-Aug-19	78	A
28-Sep-16	130	A	12-Sep-19	490	B
14-Oct-16	130	A	30-Oct-19	45	A
13-Nov-16	45	A	14-Nov-19	20	A
7-Dec-16	45	A	05-Dec-19	18	A

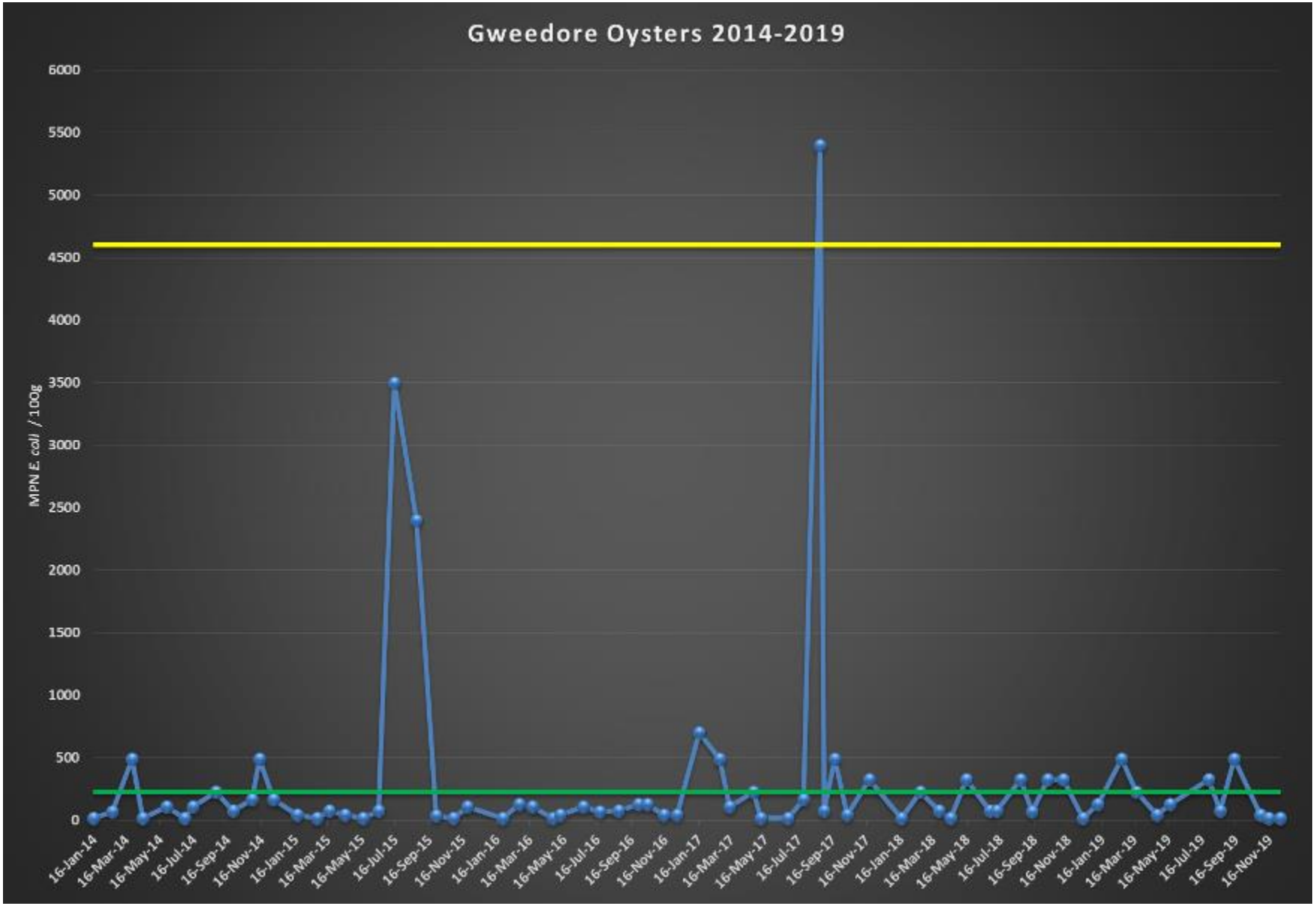

Figure 5.2: *E. coli* levels from oysters at Gweedore Bay from 2014 to 2019 (Source: SFPA).

Table 5.5: *E. coli* results from Gweedore Bay Razor clams from 2017 to January 2018 (Source: SFPA).

Date	MPN *E. coli* /100g	Category
28-Apr-17	18	A
28-May-17	18	A
28-Jul-17	45	A
13-Aug-17	20	A
4-Sep-17	18	A
6-Nov-17	68	A
3-Oct-18	18	A

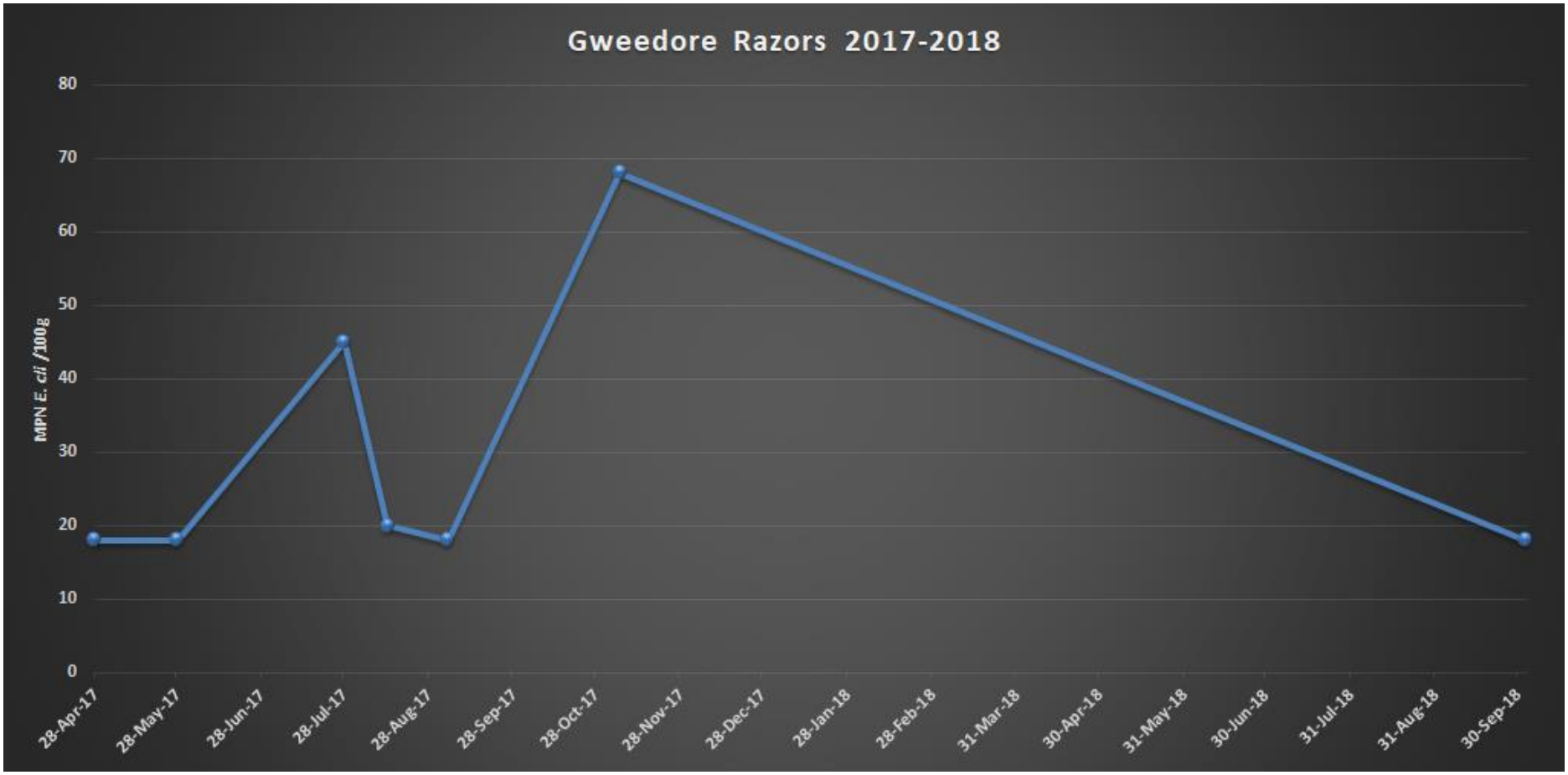

Figure 5.3: *E. coli* levels from Razor clams at Gweedore Bay from 2017 to 2018 (Source: SFPA).

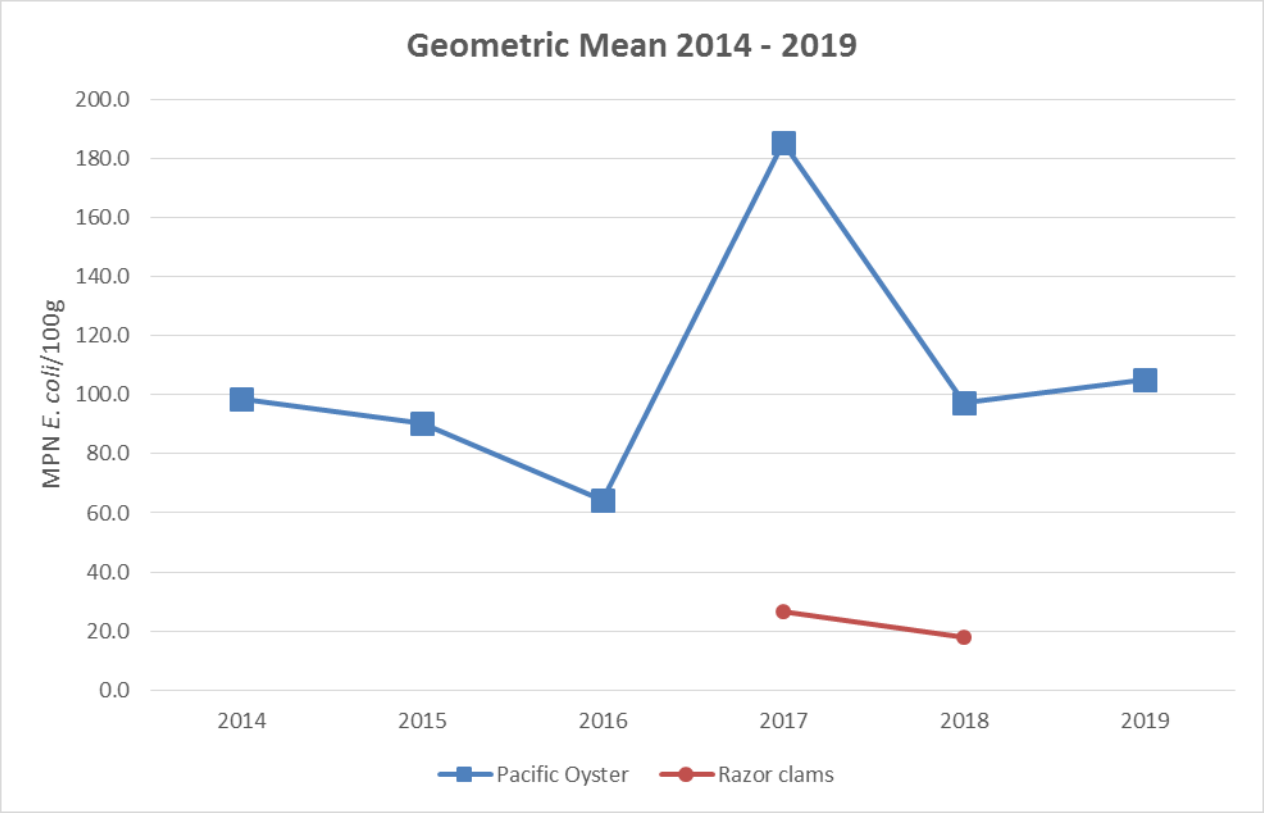

Figure 5.4: Trend in geometric mean of *E. coli* levels from 2014 to 2019 for Pacific Oysters and Razor clams in Gweedore Bay.

Table 5.6: Summary statistics of historical *E. coli* data monitored from shellfish beds in Gweedore Bay.

Code	Species	Date of 1st Sample	Date last Sample	Minimum *E. coli* (MPN/100g)	Maximum *E. coli* (MPN/100g)	Median *E. coli* (MPN/100g)	Geometric Mean *E. coli* (MPN/100g)
DL-GE-GE	Pacific Oyster	16/01/2014	05/12/2019	18	5400	78	102
DL-GE-GE	Razor Clams	28/04/2017	03/10/2018	18	68	18	25

Table 5.7: Variation of annual geometric means of *E. coli* (MPN/100g) from shellfish beds monitored in Gweedore Bay.

Code	Species	2014	2015	2016	2017	2018	2019
DL-GE-GE	Pacific Oyster	99	90	64	185	97	105
DL-GE-GE	Razor Clams	N/A	N/A	N/A	27	18	N/A

In addition to *E. coli* monitoring carried out by Sea Fisheries Protection Authority, the Marine Institute (MI) conduct monthly monitoring for the presence of toxin producing phytoplankton in shellfish waters, including *Alexandrium spp* and *Dinophysis spp.* and for marine biotoxins (including DSP, PSP and ASP) in shellfish flesh. The MI also monitor shellfish flesh for chemical contaminants e.g. heavy metals, organochlorides, polychlorinated biphenyls (PCB), polycyclic aromatic hydrocarbons (PAH), pentachlorophenol (PCP) and Tributyl Tin Oxide (TBTO).

Over the period 2014 to 2018, there have been no biotoxin related closures.

5.1.3. Norovirus (NoV)

The Gweedore Bay production area has to date not been subject to any norovirus sampling programme or baseline studies of norovirus levels. It is expected that during the winter months that norovirus may be present in the production area due to the waste water inputs from the various treatment plants and on-site septic tanks also.

5.2. Current Data

5.2.1. Sampling Sites & Methodology

Eighteen water sampling sites were sampled within the Gweedore Bay BMCPA between May 2019 and August 2019. The locations of these sites can be seen in Figure 5.5 and Table 5.8 shows the station coordinates.

Ten stations were sampled on the 2nd May 2019 (Stations 1 - 10) and there was 4.8mm of rain in the previous 48hrs. Four stations were sampled on the 10th June 2019 (Stations 11-14). There was 2 mm of rain in the previous 48hrs. Four stations were sampled on the 29th August 2019 (Stations 15-18). There was 24.5 mm of rain in the previous 48hrs. Of the 18 water samples collected, 13 were taken from the inner bay (Stations 1-12, 18) and 5 were from the outer bay (Station 13-17).

In addition, a bacteriological survey for shellfish flesh was carried out over a three month period (Feb-April 2020). Four locations were sampled which were located within pacific oyster harvesting areas. This survey was carried out to aid in the selection of the most appropriate RMP location for oysters. The locations of these sites can be seen in Figure 5.5 and Table 5.9 shows the station coordinates.

All stations were sampled on the 25th February, 10th of March and 8th of April 2020. Rainfall for the previous 48 hours was 30.8mm on the 25th of February, 14.8mm on the 10th of March and 1mm on the 8th of April.

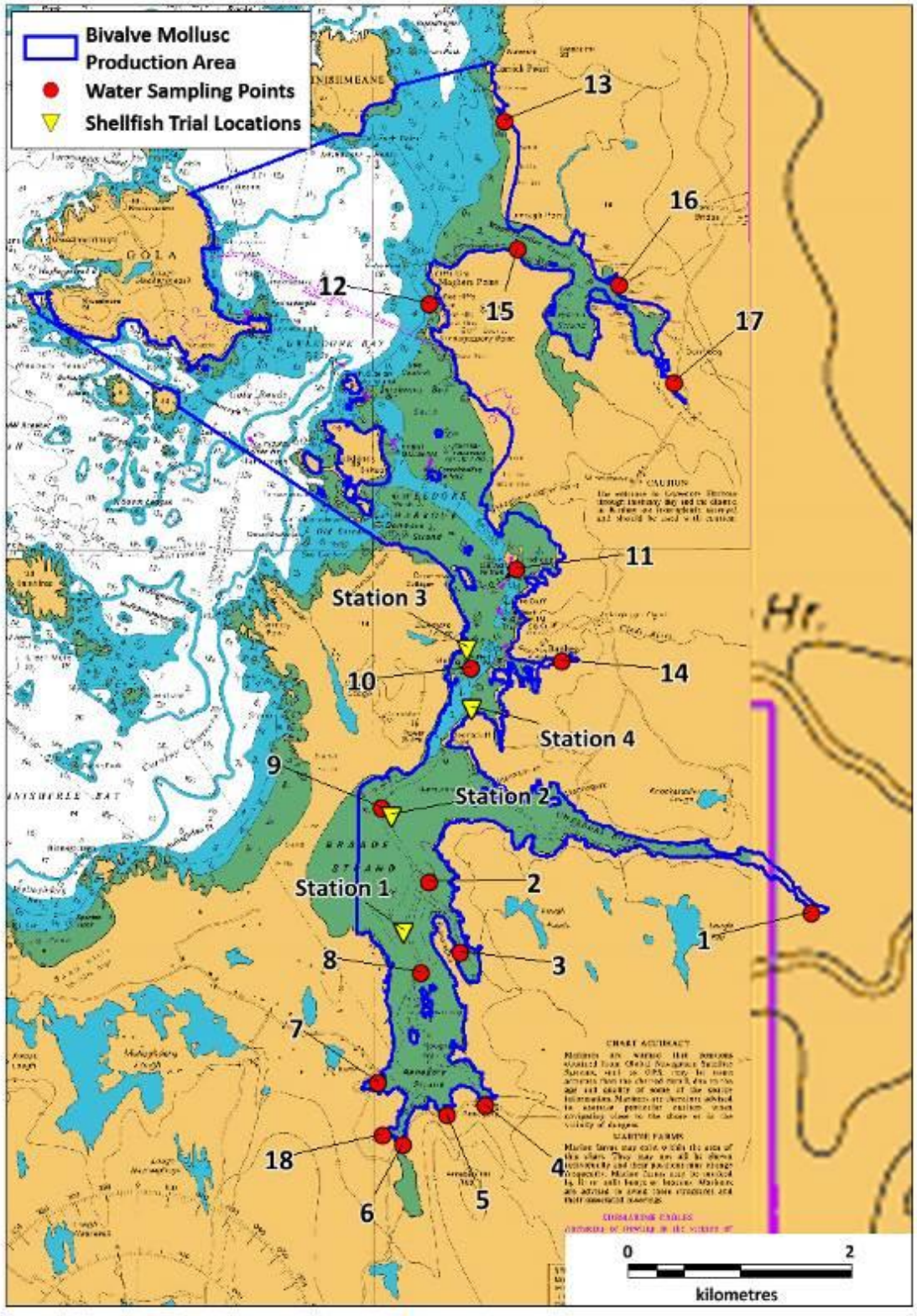

Figure 5.5: Water and shellfish sampling sites

Table 5.8: Water sample coordinates with date of sampling.

Station	Feature	Latitude	Longitude	Easting	Northing	Sampling Date
1	Lagoon from Lough Moorlagh	55.01861	-8.33017	182615	421135	02/05/2019
2	Two drains near hotel	55.02099	-8.32396	179175	421431	02/05/2019
3	Small river in Annagary	55.02177	-8.31862	179450	420795	02/05/2019
4	Bridge near lagoon	55.02363	-8.33366	179669	419417	02/05/2019
5	Seawater, oysters nearest Crolly	55.03252	-8.32754	179327	419331	02/05/2019
6	Seawater	55.03414	-8.32214	178928	419068	02/05/2019
7	Seawater near oysters	55.03984	-8.32648	178708	419628	02/05/2019
8	Crolly River	55.03732	-8.27266	179104	420616	02/05/2019
9	Seawater, near oysters	55.04587	-8.33313	178753	422104	02/05/2019
10	Seawater, near oysters	55.05721	-8.3205	179566	423363	02/05/2019
11	At mouth of Clady River in Bunbeg Harbour	55.05769	-8.30767	179982	424245	10/06/2019
12	Near Inishcoo Island	55.06515	-8.31406	179216	426636	10/06/2019
13	Seawater near Maghermallon	55.0866	-8.32623	179900	428289	10/06/2019
14	Seawater northern part of area	55.10147	-8.31563	180387	423413	10/06/2019
15	Channel Mouth	55.09113	-8.31381	180013.3	427139.3	29/08/2019
16	Small river	55.08816	-8.29945	180928.5	426805.2	29/08/2019
17	Small river	55.08025	-8.29179	181413.9	425922.3	29/08/2019
18	Combined stream/drains outflow	55.01941	-8.33295	178752.7	419160.9	29/08/2019

All water samples were collected in sterile plastic water bottles. These samples were stored in a cool box until delivery to AQUALAB in Killybegs, Co. Donegal (within 24hrs of collection). AQUALAB is INAB accredited and the *E. coli* analysis was carried out on the water samples by membrane filtration. Appendix 1 contains the result certificates from the lab.

Table 5.9: Shellfish trial sampling coordinates.

	Latitude	Longitude	Easting	Northing
Station 1	55.03593	-8.32992	178955.4	420998.9
Station 2	55.04532	-8.33167	178848.5	422044.8
Station 3	55.05885	-8.32093	179542.0	423547.9
Station 4	55.05393	-8.32033	179577.8	423000.0

5.2.2. Microbial Analysis Results

Table 5.10 shows the water sample analysis results and Figure 5.6 gives a visual representation of the

results. Highest *E. coli* levels were recorded from the Catheen river which flows into the Magheragullan Creek in the north east of the bay (Station 17; 5,000 cfu/100ml), followed by the Owencronahulla River which flows into the same creek (Station 16; 4,600 cfu/100ml). The next two highest *E. coli* results were recorded at Stations 18 (2,200 cfu/100ml) and 15 (1,700 cfu/100ml). Station 15 is located at the mouth of Magheragullan Creek, while station 18 is located in the very inner part of Gweedore Bay near Annagary. These four samples were all taken on 29/08/19 after a period of significant rainfall. Levels appear to be high close to all river inputs (see Figure 5.6) and decrease with distance from these inputs. The station from the mouth of the Clady River had a value of 85 cfu/100ml (Station 11). The lowest *E. coli* levels came from the stations in the outer bay (Station 13 & 14, >1 cfu/100ml and Station 12, 5 cfu/100ml)

Table 5.10: Water *E. coli* results for Gweedore Bay.

Station No.	*E. coli* (cfu/ 100ml)
1	445
2	230
3	595
4	250
5	110
6	95
7	15
8	160
9	15
10	10
11	85
12	5
13	> 1
14	> 1
15	1,700
16	4,600
17	5,000
18	2,200

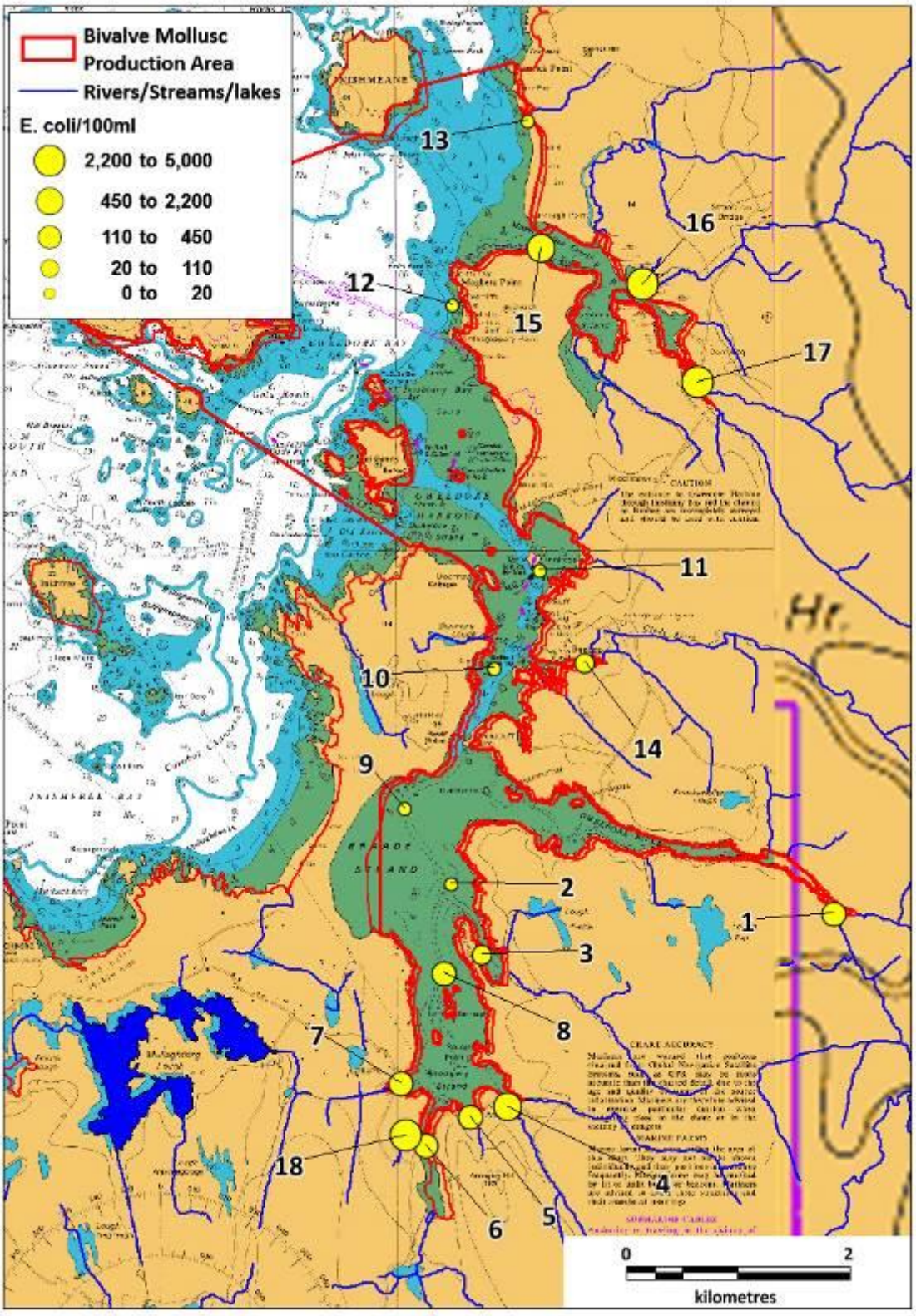

Figure 5.6: Location and magnitude of *E. coli* results from the shore survey.

Table 5.11 shows the results of the three month shellfish monitoring survey and Figure 5.7 gives a graphical representation of the data. Results ranged from <18 MPN/100g in March at station 4 to 330 MPN/100g in April at station 1. Station 1 had the highest *E. coli* levels on all three sampling occasions. There was no obvious relationship between rainfall and *E. coli* concentrations. Taking the average for each station over the three months *E. coli* reduces towards the mouth of the bay.

Table 5.11: Shellfish flesh *E. coli* results (MPN/100g) for Gweedore Harbour.

Date /Location	Station 1	Station 2	Station 3	Station 4
25th February 20	230	110	45	78
10th March 20	110	68	20	<18
8th April 20	330	68	20	78
Average	223	82	28	58

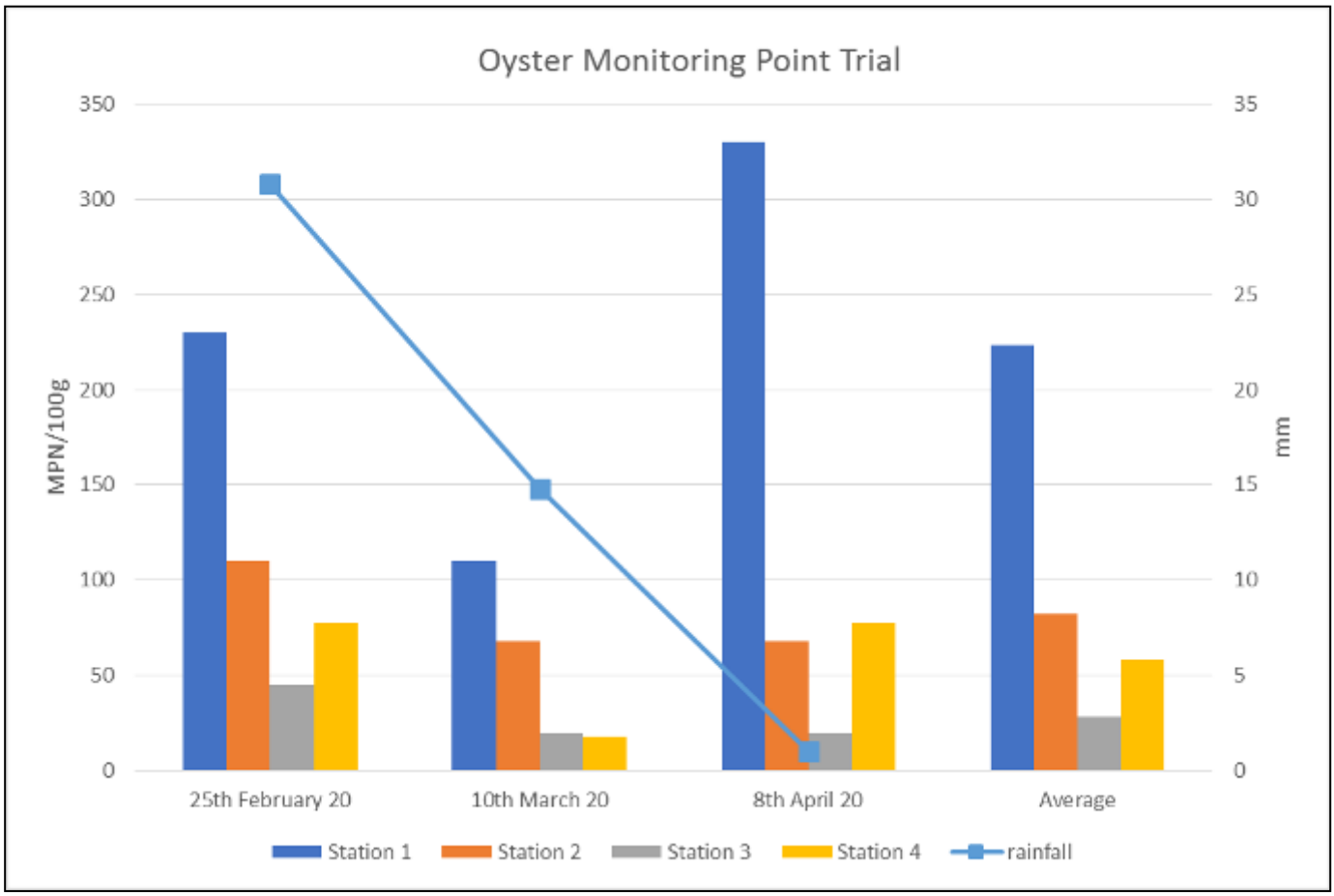

Figure 5.7: Shellfish flesh *E. coli* results for Gweedore Bay with previous 48 hour rainfall levels.

6. Overall Assessment of the Effect of Contamination on Shellfish

6.1. Human sewage/Human population

There are three main conurbations within the catchment area with Bunbeg (1,491) having the largest population, followed by Rann na Feirste (309) and Annagary (236). It is estimated that 2,875 houses are permanently occupied in the catchment. It is clear that areas with a higher population will have higher levels of sewage and wastewater entering the Gweedore Bay system. Therefore, the highest levels of sewage and waste would be expected to enter through the Clady and Gweedore Rivers which together drain 62% of the catchment. Magheraclogher is the most populated ED and is also drained by these two rivers. As holiday homes account for 23% of the dwellings in the catchment, they may cause an increase in the sewage and waste water levels during holiday periods.

Of the five waste water or sewage treatment works within the Gweedore Bay catchment, four of them discharge to groundwater (Loughanure Housing Scheme, Stranacorcragh Housing Scheme, Meenanillar Housing Scheme and Cottain Housing Scheme) and one discharges directly into Gweedore Bay (Annagary). All of these have the potential of casing contamination to cultured shellfish in Gweedore Bay. The fact that all WwTPs are near or at capacity is of concern as any increase in human population that results in the requirement of additional treatment will put any of these plants under pressure and may result in untreated sewage being released to Gweedore Bay and thereby affecting cultured and wild shellfish.

The Annagary WwTP is a primary treatment facility with a design capacity of 500 and is currently slightly under capacity at 473 PE; the maximum discharge for this facility is 177 m3/day. The Annagary system in terms of population equivalent and maximum daily discharge is greater than the four other systems combined. There is also a storm water over flow associated with this WwTP and this can deliver untreated sewage to the southern section of Gweedore Bay giving rise to contamination of shellfish in this part of the bay.

Strict emissions limits are set out in the discharge licences for each facility in terms of BOD, Orthophosphate, Suspended Solids, Nitrogen and Ammonia. These emissions limits comply with the parameters of Shellfish Directive (2006/113/EC) and the Quality of Shellfish Waters Regulations 2006.

Septic tanks, if not properly operating have the potential to cause faecal contamination of marine waters and thereby impact on both cultured and wild shellfish. It is noted that ca 85% of houses are not on the main sewer system and are therefore considered to have septic tanks. This is a very high percentage of households not connected to the main sewer system and it is expected that run off, particularly from those houses adjacent the shoreline, are adding to contamination levels within Gweedore Bay. This is further compounded by the inadequate percolation throughout the catchment. The Gweedore Bay Pollution Reduction Programme (Department of Environment, Heritage & Local Government, 2009) also identified on site waste water treatment systems as a key pressure on the designated shellfish waters.

Due to the disperse nature of the housing in the catchment accurately predicting the movement of contaminants originating via on site waste water treatment plants is extremely difficult. As a diffuse source of contamination actually locating an RMP on the basis of the information is equally problematic. Four private on-site waste water treatment systems were noted during the shoreline survey including one which appeared to be discharging to the Cathleen River. The three others were noted in the Dunmore and Annagary Strand area.

Irish Water are currently progressing a demonstration project as the first phase of a new Gweedore Sewerage scheme. This will include constructing a pressure sewer pipe network and installing pods at 40 properties. The collected wastewater will then be treated at the existing Údaras na Gaeltachta wastewater treatment plant at Annagary. There are plans then to expand this network and to upgrade the treatment plant also.

6.2. Agriculture

In terms of land use, agriculture and specifically livestock is the most likely source of bacterial impact on water quality in Gweedore Bay. 14.8% (5,063 ha.) of the catchment is used for agricultural purposes. This arises from faecal contamination arising from the stock and being initially washed into streams and rivers which then find their way to the sea. Generally pasture land is scarce and the agricultural land type most common is that of rough grazing.

The total number of livestock in the area is 5,904. Of this figure, by far the greatest number is attributed to sheep, with a total of 5,543 in Dunlewy. Off all the species farmed, sheep score highest in terms of the numbers of E.coli they produce followed by cattle. Numbers of other animals farmed are relatively low in the catchment.

The highest numbers of sheep in the catchment are in the Dunlewy and Magheraclogher areas with a total of just under 11,000. Rivers and streams, including the Clady, Gweedore, Cathleen and Owencronahulla, that flow through these areas eventually enter the sea in the northern half of Gweedore Bay. There is therefore the potential for faecal contamination from sheep in these area to impact on farmed and wild shell fish in this section of Gweedore Bay.

During the shoreline survey sheep were noted grazing the foreshore at Dunmore and Maghera Strands and actually crossing the inter-tidal sand flats. Large amounts of animal manure were also noted on the foreshore at in the Lunniagh area. No shellfish beds are located in the immediate vicinity of these locations.

The distribution and amounts of organic fertilisers applied to land in the catchment is uncertain but due to the limited areas of pasture land it could be expected to be low to moderate. The primary mechanism for mobilisation of faecal matter deposited on the land in this matter is via land runoff and will be highly rainfall dependent. A large number of field drains were noted during the shoreline survey and it is likely that much of any agricultural run-off will enter the production area through these.

6.3. Rivers and Streams

Gweedore Bay drains a catchment of 244km2 and 38% of this flows through the Clady River. The Gweedore River drains a further 23% of the catchment. The mean flow as the Gweedore River as it leaves Lough Anure is 1.8 m3/s (EPA, 2019a). The southerly extent of the bay south of Braade Strand drains 8% of the catchment through a series of small unnamed rivers. Two rivers, the Owencronahulla and the Catheen, flow into Magheragallan Creek which is a small bay just north of Gweedore bay and 13% of the catchment is drained by these two rivers. The remaining 18% of the catchment drains through a series of small unnamed rivers along the shoreline.

The current (2010-2015) WFD status of Gweedore Bay and its associated freshwater sources are presented in Figure 4.4 above. Although not directly related to shellfish production suitability, the status of these inputs to the bay do indicate the potential for impacts on shellfish production. In summary, of the rivers that flow directly into the Gweedore Bay BMCPA, the Gweedore, Clady and Owencronahulla Rivers are of Good status and this suggests that shellfish production and harvesting of wild shellfish in these areas may well be suitable. The Catheen River is rated as of being of Poor status. (It was at this location that the SFPA shoreline survey recorded a possible old WwTP). The Catheen

River flows into the eastern end of the Magheragallon Creek where there is no shellfish production at present.

The remaining small streams that flow into Gweedore bay have not been assigned a status. With regard to lakes, neither Lough Nacung nor Dunlewy Lough have not been assigned a status. Lough Anure is of Good status while Lough Keel is of Moderate status. The remaining small lakes in the catchment have not been assigned a status. The coastal and transitional water bodies of Gweedore Bay have not been assigned a status but the Northwestern Atlantic Seaboard coastal waterbody to the west has been assigned a High status.

The results of E.coli analyses on water samples collect during the SFPA shore line survey showed that the highest E. coli levels were recorded from the Catheen River (Station 17; 5,000 cfu/100ml), followed by the Owencronahulla River in the same area (Station 16; 4,600 cfu/100ml). The next two highest E. coli results were recorded at Stations 18 (2,200 cfu/100ml) and 15 (1,700 cfu/100ml). Station 15 is located at the mouth of Magheragallan Creek, while station 18 is located in the very inner part of Gweedore Bay near Annagary. These four samples were all taken on 29/08/19 after a period of significant rainfall.

6.4. Movement of Contaminants

The majority of Gweedore Bay is made up of intertidal sandflats that are exposed at low water. A channel runs from south to north and extends from Annagary in the south out to the open sea east of Gowla Island. Half way along this channel on the eastern shore, there is an east – west running channel that brings water from the Gweedore River to the sea and just to the north of this and to the south of Bunbeg, the Clady River opens to the sea. On the flood tide water levels rise, flood streams travelling up the main channel, splitting as it branches where the first the Clady and then the Gweedore Rivers enter. As the channels fills further, water will spread from the channels over the adjacent sand flats and mudflats. After high water, the water levels will drop and the process will be repeated in reverse. Sources of contamination will therefore primarily impact up and down tide of their locations along the shore to which they discharge. These impacts will lessen with distance travelled, as they become progressively more diluted.

To the north of the production area, the Magheragallon Creek brings water from the Catheen and Owencronahulla Rivers to the sea. There are however, no harvested shellfish beds directly within Magheragallon Creek. It was noted during water sampling carried out as part of the shoreline survey that

quite high faecal contamination was evident in the rivers entering the creek and this contamination was still evident at the mouth of the creek where it enters the open sea. This discharging water will be greatly diluted when meeting the open ocean and contamination levels will fall considerably. There still is though a likelihood that that it may impact upon the wild razor clam beds in the immediate locality of its outflow.

No modelling studies have been carried out for Gweedore Bay. Nonetheless, due to the fact that most of the bay is shallow and the morphology is mostly linear, it is the tidal forcing that transports any contaminants that are brought to the sea via the rivers. The ebb tide flows in a northerly direction along the main channel with tidal flows in the southern half of the bay being lower in velocity due to the fact that much of that area of the bay is very shallow. It is expected that the ebbing tide and freshwater from the two main rivers will carry faecal contamination northwards and therefore towards the shellfish beds located in the northern part of the channel. However, due to the Coriolis effect and given the prevailing wind direction (southwesterly), on an ebbing tide, freshwater entering Gweedore Bay along its eastern side will hug this eastern shore and be washed out of the bay. It is worth noting here that there is only 1 licenced site on the eastern section of the bay. On the flooding tide there is though potential for contamination from both these channels to impact the shellfish beds to the south of where they meet the main channel, both at the beds at Magheralosk and at the northern end of Braade Strand.

Potential contamination originating in the southern end of the bay will move north towards and across the shellfish beds on the ebbing tide particularly at the Braade Strand location. The five water sources sampled that empty into the southern section of Gweedore all showed evidence of faecal contamination with one downstream of a suspected sewage related discharge recording a result of 2,200 cfu's per 100 ml. A seawater sample taken downstream of this ebbing channel demonstrated evidence of this faecal contamination being carried towards the oyster beds. At the low tide period these sources impact will likely be greater as the there is less opportunity for dilution due to the decreasing water levels remaining within inter-tidal drainage channel.

With regard to residence time for Gweedore Bay, a report by the Marine Institute (2016) states that the residence time in the bay is short, i.e. 1 day. This indicates that Gweedore Bay will be totally refreshed on each tidal cycle and with regard to the razor shells that are located in the outer, open water parts of Gweedore Bay, it is considered that by the time water from inner parts of the bay reach these outer areas, dilution and decay will have been so great as to make the likelihood of any contamination impacting these beds extremely low.

The predominant wind direction in the production area is from the south west. Surface flows would be enhanced/retarded by winds blowing out or into the harbour particularly from this dominating south-westerly direction. This will also lead to an increase in the dispersion of surface contaminants. Such actions though are tempered by many variables of tidal state, size, wind speed and other environmental factors.

6.5. Shipping

With regard to shipping as being a possible source of contamination, there are no commercial ports in Gweedore Bay. Bunbeg is the most actively used port in the production area but only supports 20 to 20 small coastal vessels. The number of vessels with on-board toilets would be lower again. The ferry to Gola that operates here and from the pier at Magheragallon is a small vessel also.

While data on sewage discharge levels from boating activities in the area are not available, it is highly unlikely that any discharges from the relatively small number of vessels in the area would have any negative impacts on water quality.

6.6. Industrial Discharges

With regard to industrial discharges, there are no IPC or IEL facilities with discharges to water within the Gweedore Bay catchment area recorded by the desk-based assessment (EPA, 2019d). There are 5 Section 4 licences for the discharge of trade effluent, with one discharging directly into the sea while the remaining four discharge to rivers within the catchment. Of these, 1 is a fish processing unit, 2 are Readymix plants, 1 is from an Udaras facility and the 5th is from an ESB power plant.

Of these the Udaras facility may have the potential to impact the outer production area due to its discharging mixed trade and domestic to the Cathleen River, water samples from this river mouth showed high levels of faecal contamination. The two cement discharges are both to the Gweedore River but are unlikely to impact contamination levels. Details of the nature of the ESB power station discharge were not available at the time of the writing of this report. The fish processing discharge is to the open sea, a distance from the production area and will have no impact on contamination levels.

6.7. Wildlife

Since bird faeces are rich in 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), their presence in the bay needs to be considered as a source of contamination. It should be noted however, that bird faeces tend to more fluid that solid and once dropped into the sea, they will tend to dilute and disperse in the water column rather than fall to the sea bed.

The bay is designated as a Special Protection Area (SPA): West Donegal Islands SPA (IE004230) and West Donegal Coast SPA (Site Code: IE004150). For the West Donegal Islands SPA, the species of conservation interest are Shag Phalacrocorax aristotelis, Barnacle Goose Branta leucopsis, Corncrake Crex crex, Common Gull Larus canus and Herring Gull Larus argentatus (NPWS, 2015b). Of these, the Corncrake is a terrestrial species and is therefore not of concern. Barnacle Geese migrate to Ireland in late September and return to their breeding grounds in late March. This species mainly forages on grassland and are considered therefore to be of low concern in contributing a significant microbial load to Gweedore Bay. Shag and the two gull species are marine species and their faeces will contribute some level of bacterial loading to Gweedore Bay. However, given the short residence time (ca 1 day) of the bay, low levels of turbidity, the physical characteristics of bird faeces and high salinities, it is considered that the impact of faeces from these species on water quality is low.

For the West Donegal Coast SPA, the species of conservation interest are Chough Pyrrhocorax pyrrhocorax, Peregrine Falco peregrinus, Fulmar Fulmarus glacialis, Cormorant Phalacrocorax carbo, Shag P. aristotelis, Herring Gull Larus argentatus, Kittiwake Rissa tridactyla and Razorbill Alca torda (NPWS, 2011). As both Chough and Peregrine forage mainly on land and are not colonial species, they are therefore considered to be of low concern in contributing a significant microbial load to Gweedore Bay. The other six species are all marine in distribution and form breeding colonies during the late spring early autumn period. Outside that period, they disperse into small groups. Outside of the breeding period, Fulmar leave the coastal zone to forage in the open ocean. It is during the breeding period therefore that bird faeces will contribute the higher levels of bacterial loading to Gweedore Bay. However, given the short residence time (ca 1 day) of the bay, low levels of turbidity, the physical characteristics of bird faeces and high salinities, it is considered that the impact of faeces from these species on water quality is low.

Bird numbers in the area increase during the winter months when the wintering waterfowl arrive. However, it is highly likely that these levels are low when compared with land-based discharges. Assemblages of birds were noted during the shoreline survey at a number of locations at low tide

particularly in the south of the production area close to Annagary. These birds may impact background contamination levels in this area.

It is considered most likely that marine mammals such as seals, dolphins and porpoises use the outer and deeper parts of Gweedore Bay as a feeding resource and that seals may use the uninhabited islands as haul out sites. Nonetheless, NPWS does not list the area as being of particular importance. Because of this, the contribution of a bacterial load from marine mammals is considered to be low.

6.8. Seasonality

Tourism infrastructure in the immediate vicinity of the production area is centred around Derrybeg, Bunbeg and Annagary and there is a notable rise in population levels during the busy tourism months of July, August and September. Numbers of holiday homes in the catchment are relatively high at 25%, a reflection of the areas popularity with tourists. It is expected that during the summer months that contamination levels may rise as a result of this influx of people into the catchment.

In terms of agriculture, numbers of sheep higher in spring/summer when lambs are present but at this time of the year there will also be more extensive grazing in the hills and thus impacts would be more widely spread.

There is also a distinct seasonal flux in numbers of wintering wildfowl during the autumn/winter period. Impacts from these birds will be most apparent where they feed nearby the shellfish beds adjoining the main channel but will otherwise add to background contamination levels.

The analysis of rainfall data shows a clear seasonal trend between the drier summer months and the wetter autumn/winter; however, as can be seen from the data, extreme 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. Peak concentrations of faecal indicator bacteria in watercourses arising from agricultural sources are likely to arise when heavy rain follows a significant dry period.

Analysis of the historical microbiological data for oysters showed no clear seasonal trends in terms of higher results.

6.9. Shoreline survey

The SFPA carried out a shoreline survey of Gweedore Bay on a number of days in 2019. Over 100 sources of potential contamination were identified during the survey with the overwhelming majority being agricultural field drains. Much of the surrounding catchment is rural and this is reflected in the abundance of the aforementioned field drains and the lower number of infrastructural discharges. Clusters of field drains were noted in particular around the Ranafast area.

Farm animals were encountered on a number of occasions during the survey both on the foreshore and adjoining lands. In the Maghera Strand area sheep were seen grazing and walking upon the foreshore and the actual sand flats, at this location one single observation was of over 100 animals in the foreshore area. A large amount of dispersed animal manure was also noted here during the survey. Cattle (approx. 20 +) were also noted in this area.

In terms of physical infrastructure only one municipal waste water treatment plant was noted during the survey and this was at Annagary. Whilst the plant was observed during the survey the discharge pipe was not clearly identified but is described as discharging onto Annagary Strand to the south of the oyster farm licenses. The associated pumping station was also noted at the car park in the village.

A number of septic tank systems were observed during the survey. Two were noted close to the oyster licence at Doonrower. An older system, possibly defunct was noted north east of the R259 road bridge whilst another possible on site waste water treatment system was noted adjacent the Catheen River. Another possible system was noted at Magheragallon.

A total of 7 pipe outflows were observed in the Annagary village area. Four at the time were not flowing but three pipe outflows clustered together were noted draining into a saltmarsh channel located between Calhame and Annagary West. These were flowing at the time and were grey coloured and had a sewage type odour. A water sample taken downstream of here gave a result of 2200 ecoli (cfu/100ml) clearly indicating faecal contamination.

A very small caravan park (circa 12 units) was also observed at Dunmore.

In terms of shipping and related infrastructure the pier at Bunbeg was noted during the survey as supporting the largest number of vessels. These though were noted to be mainly small boats with no

onboard waste facilities. The small pier and slipway opposite Bunbeg at Carrickfin also held a handful of small open boats. A summer ferry operates to Gola Island during the summer months and this was vessel was observed departing from the pier at Magheragallon. Quite a number of pier/slipways were observed during the survey but the majority were found not to be in use at the time of survey.

A number of freshwater inputs were noted during the survey. The two largest freshwater bodies were the Clady and the Gweedore River which enter the bay from the east. Two smaller rivers were encountered entering the Maghera Strand area. A large number of streams, 14 in total, were located at various points around the bay.

A total of 18 water samples were taken as part of the shoreline survey. These included both freshwater inputs and seawater. Seven seawater samples were taken and most showed low levels of contamination. Those from the outer Gweedore Bay area showed virtually no faecal contamination. A sample taken from the channel south of Annagary showed a result of 110 ecoli (cfu/100ml) but the highest result was recorded at the channel exiting the Maghera Strand bay area. At 1700 ecoli (cfu/100ml) this was the highest seawater sample result for the whole survey. Levels of ecoli contamination to the freshwater inputs varied considerably with medium to high counts in the small rivers entering the Maghera Strand area and again in the south of the main Gweedore Bay waters around the village of Annagary.

Wild animal observations were limited to seabirds, primarily gulls and to a lesser extent geese. Over 60 gulls were observed north of the outflow from Lough Moorlough whilst a mixed group of geese and gulls (approx. 25 +) were encountered on the main channel edge north west of Annagary village. Other bird groups were observed in the Maghera Strand area. None of the wild bird observations were made in the vicinity of the oyster growing areas.

7. Amendments

The boundaries of the current production area have been amended to exclude the port area of Bunbeg and the area adjacent Annagary where the outfall and storm water of the associated waste water treatment plant are located.

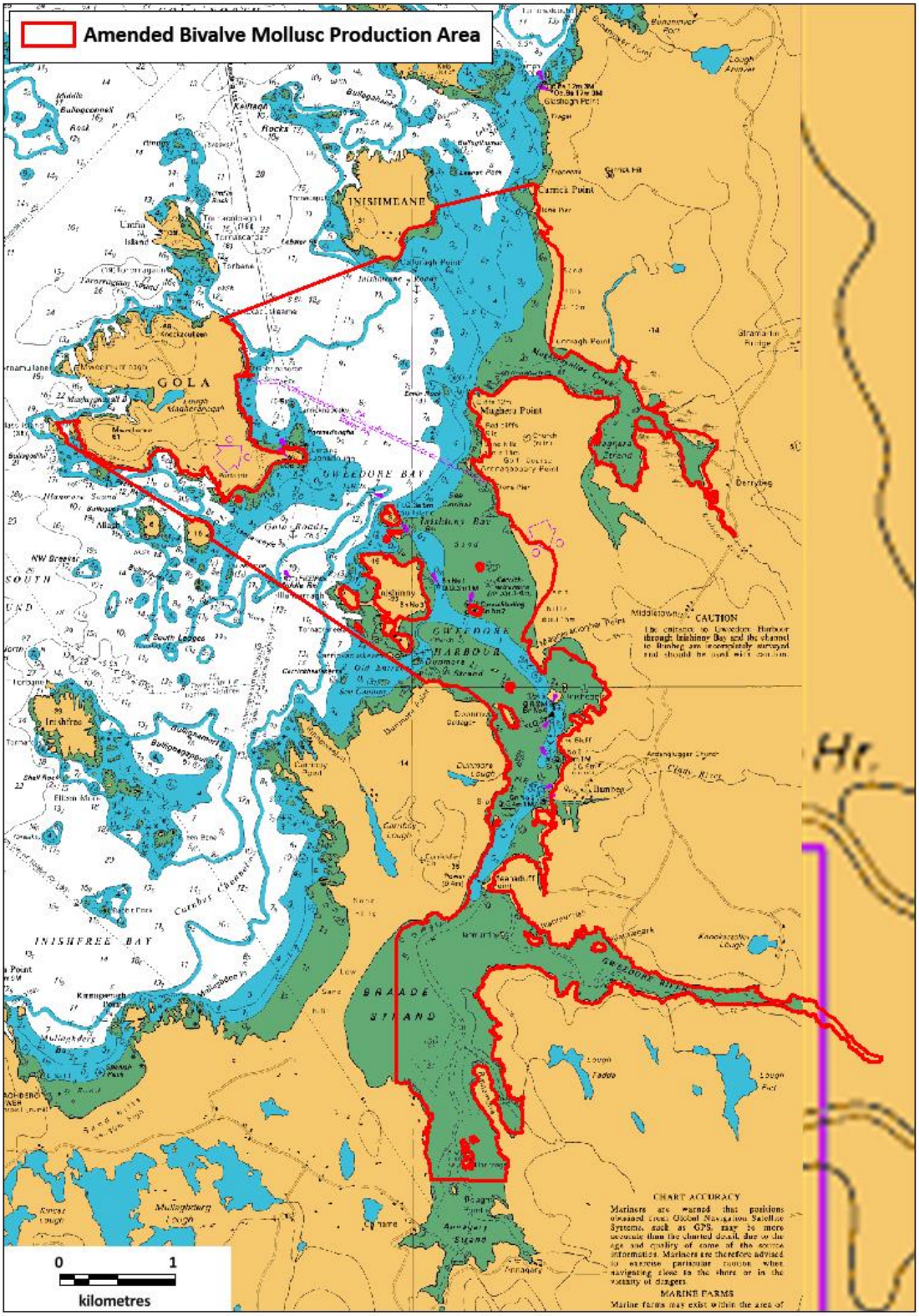

Figure 7.1: Amended Gweedore Bay Bivalve Mollusc Production Area.

8. RMP and Sampling Plan

8.1. Pacific Oysters (Crassostrea gigas)

As can be seen on Figure 2.4 above, there are 10 licensed areas for Pacific Oysters *(Crassostrea gigas*) in Gweedore. The farms in Gweedore Bay are located on the intertidal mudflats in Braade strand and on the eastern and western shores of the channel entering Gweedore Harbour. The original RMP was located in the harvest area north of Meenaduff Point on the eastern side of the Bay. However, water sampling carrier out by the SFPA during the shoreline survey identified higher *E. coli* levels in the inner bay towards Annagary Strand. Based on this a bacteriological survey of shellfish flesh was carried out at four oyster harvesting beds to aid in the selection of the RMP. The survey was completed over three months and on all three occasions the highest E. coli levels were recorded in the bed closest to Annagary Point. Therefore, the RMP is to be located in this bed as it is most likely to give the Highest *E. coli* levels for oyster harvesting areas in the bay.

10 individuals of market size (minimum shell length 8 cms) should be collected for bacteriological analysis. As harvesting takes place throughout the year, sampling needs to be on a monthly basis.

Figure 8.1 shows the location of this sampling site Table 8.1 shows the coordinates.

8.2. Razor Clams *(Ensis spp)*

In relation to the RMP for Ensis sp (Razor Clams), it is recommended that this is located in the northern section of where this shellfish species is present within the northern part of the bay (Figure 2.5). The reason for this is that it is adjacent to Magheragallen Creek where water samples collected by the SFPA returned the highest levels of *E. coli* of all 18 water samples collected throughout Gweedore Bay. On an ebbing tide, outflowing water from the creek may possibly therefore be filtered by this shellfish and compromise its bacteriological status.

Figure 8.2 shows the location of this sampling site Table 8.1 shows the coordinates.

Table 8.1: Coordinates of the RMP within the Gweedore Bay Production Area.

Sample Code	Species	Latitude	Longitude
DL-GE-GE	Pacific Oysters	55.03593	-8.32992
DL-GE-GE	Razor Clams	55.095908	-8.324204

8.3. Species Specific RMP map

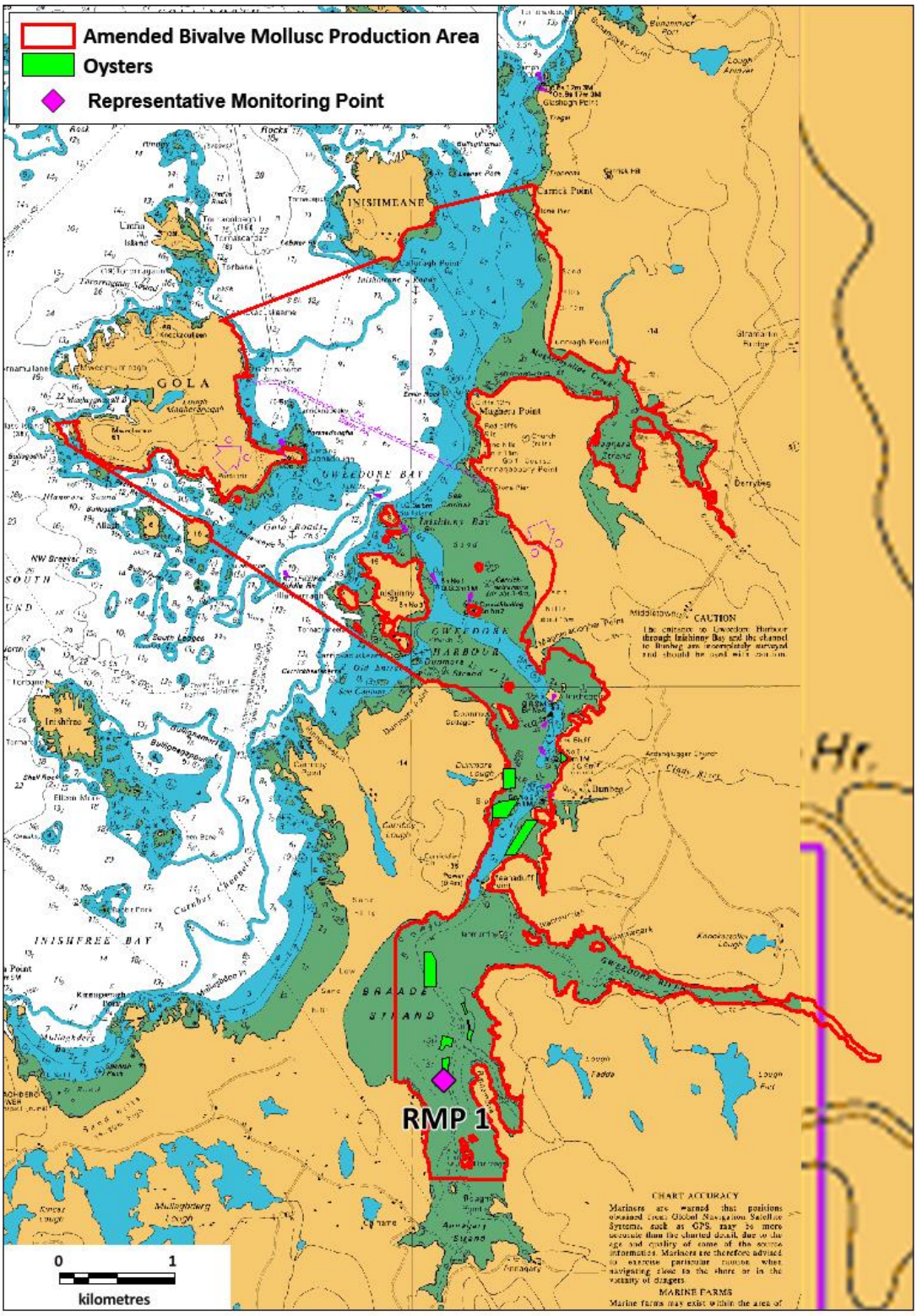

Figure 8.1: Location of the Oyster RMP within Gweedore Bay.

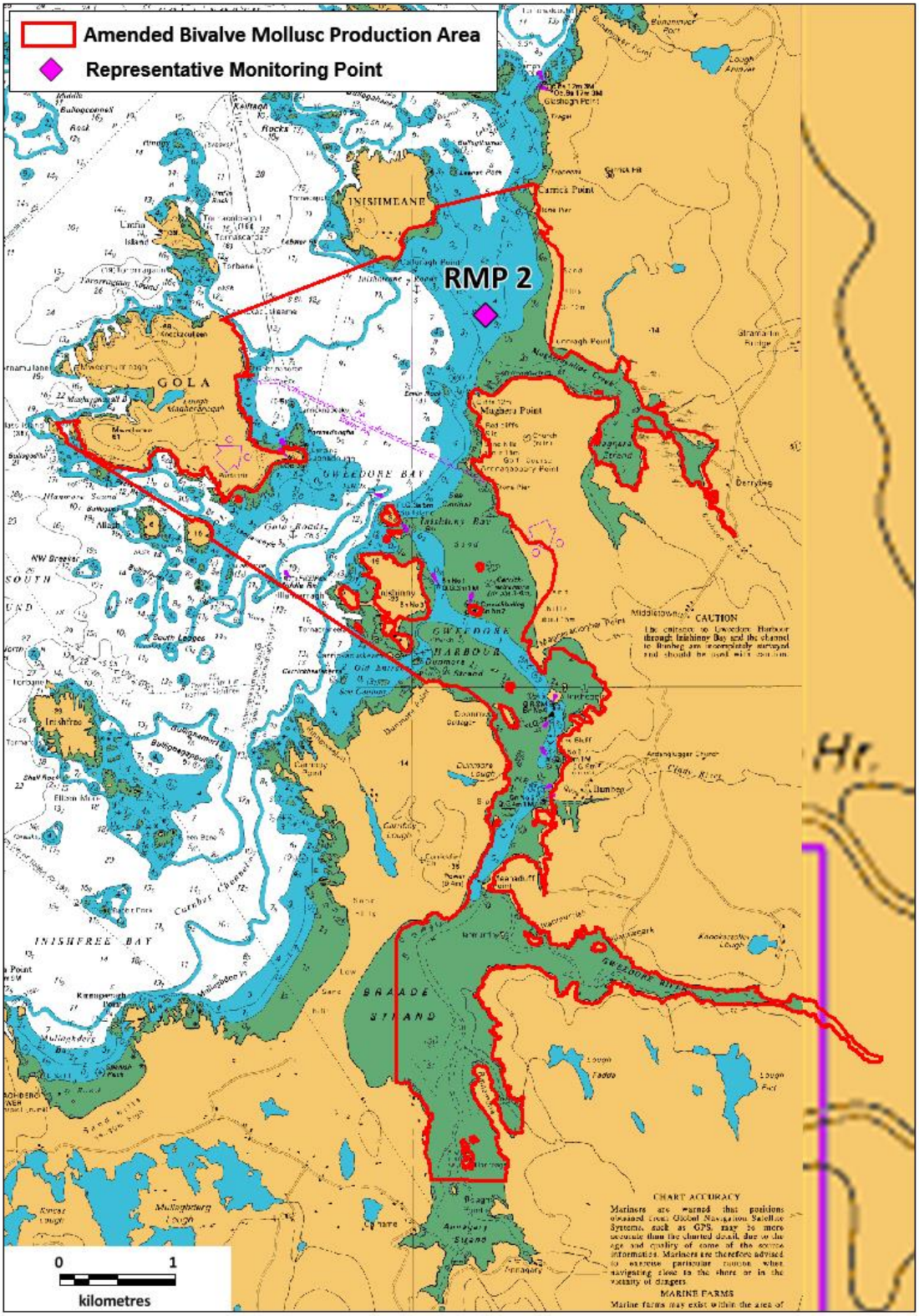

Figure 8.2: Location of the razor clam RMP within Gweedore Bay.

8.4. General Sampling Method

All collection and transport of shellfish samples for *E.coli* testing under the Sampling Plan identified as part of the Gweedore Bay Sanitary Survey should follow the Sea Fisheries Protection Authority's own Code of Practice for the Microbiological Monitoring of Bivalve Mollusc Production Areas (SFPA, 2017). The guidance notes are found at Appendix 9.2 of that document.

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Appendix 1

Shoreline Survey Images


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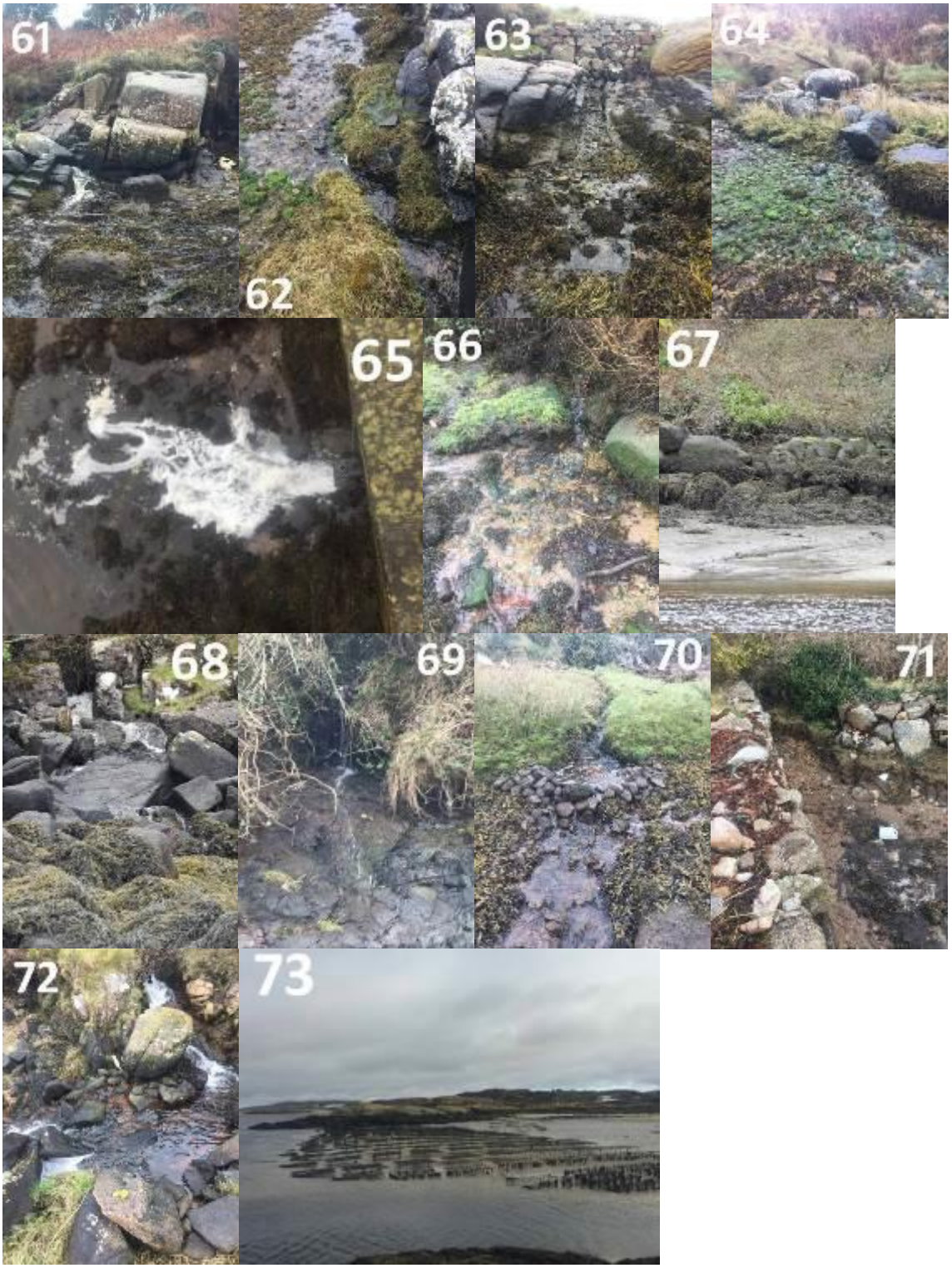
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Appendix 2

Statistical Analysis

One way ANOVA: Log *E. coli* vs Season (Oyster Flesh results 2014-2019)

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Summer	17	38.31193	2.253643	0.499175
Autumn	18	37.12756	2.062642	0.217824
winter	16	30.12566	1.882853	0.315439
spring	18	33.54253	1.863474	0.200973

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.701621	3	0.567207	1.858482	0.145382	2.745915
Within Groups	19.83794	65	0.305199			
Total	21.53956	68				

Appendix 3

Species Specific Sampling Plan

Gweedore

Bivalve Mollusc Classified Production Area

Pacific Oyster Sampling Plan Information

Site Name: Gweedore Bay

Site Identifier: DL-GE-GE

Monitoring Point Coordinates

Latitude: 55.03593 **Longitude:** -8.32992

Species: *Crassostrea gigas.*

Sample Depth: Surface **Sample Frequency:** Monthly

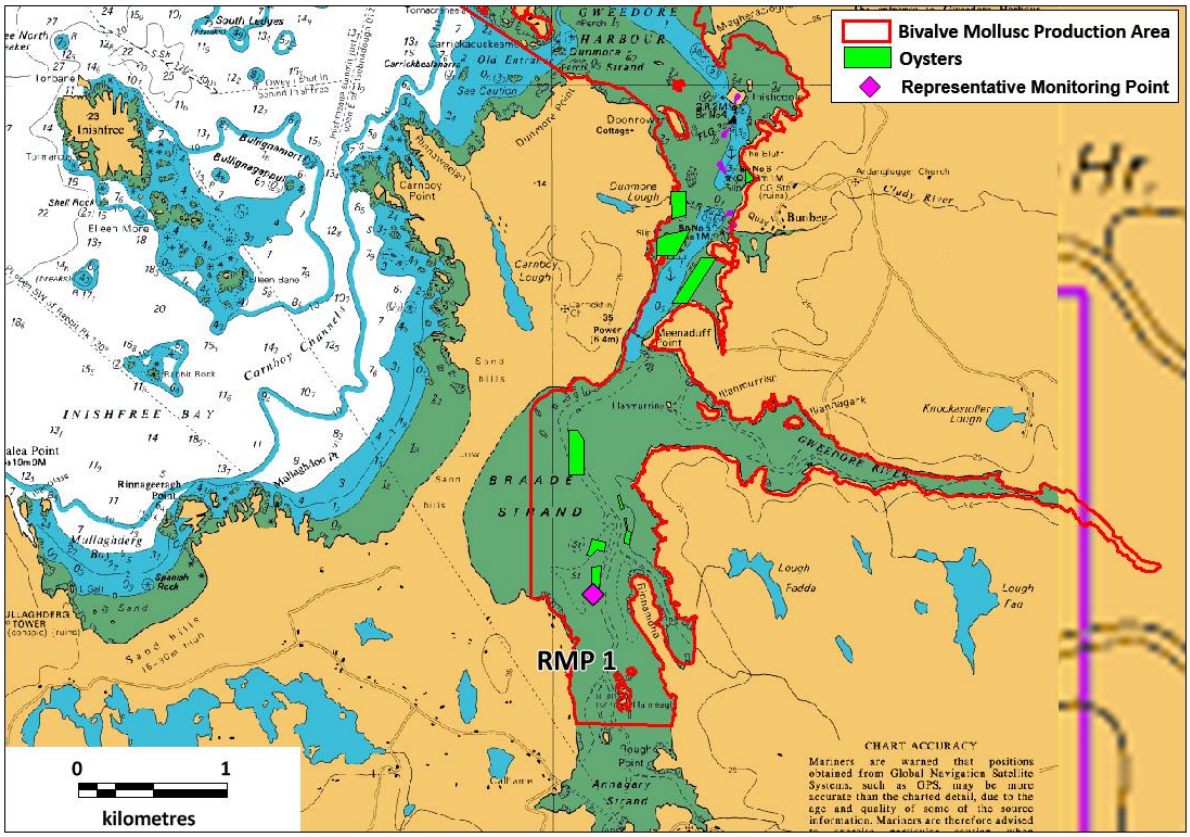
Responsible Authority: Sea Fisheries Protection Authority

Authorised Samplers: SFPA Killybegs office

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

Sampling Size: Minimum 10 market sized animals

Sampling Method: Taken from oyster trestles at point



Gweedore

Bivalve Mollusc Classified Production Area

Razor Clam Sampling Plan Information

Site Name: Gweedore

Site Identifier: DL-GE-GE

Monitoring Point Coordinates

Latitude: 55.095908 **Longitude:** -8.324204

Species: *Ensis spp.*

Sample Depth: N/A **Sample Frequency:** Monthly

Responsible Authority: Sea Fisheries Protection Authority

Authorised Samplers: SFPA Port Killybegs office

Maximum Allowed Distance from Sampling Point: The sample must be taken from within 250 metres of the sampling point.

Sampling Size: Minimum 10 market sized animals

Sampling Method: Taken from Dredge at point