Scottish Sanitary Survey Programme

Sanitary Survey Report
Loch Ryan
DG 191
August 2013

Cefas

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Report Distribution – Loch Ryan

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Partner Organisations

The hydrographic assessment and the shoreline survey and its associated report were undertaken by SRSL, Oban.

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Appendices

I. Executive Summary

Under (EC) Regulation 854/2004, which sets forth specific rules for the organisation of official controls on products of animal origin intended for human consumption, sanitary surveys of production areas and their associated hydrological catchments and coastal waters are required in order to establish the appropriate representative monitoring points (RMPs) for the monitoring programme.

The purpose of the sanitary survey is to demonstrate compliance with the requirements stated in Annex II (Chapter II Paragraph 6) of Regulation (EC) 854/2004. The sanitary survey results in recommendations on the location of RMPs, the frequency of sampling for microbiological monitoring, and the boundaries of the production areas deemed to be represented by the RMPs.

A sanitary survey was undertaken on the classified native oyster fishery at Loch Ryan on the basis recommended in the European Union Reference Laboratory publication: “Microbiological Monitoring of Bivalve Mollusc Harvesting Area Guide to Good Practice: Technical Application” (http://www.crlcefas.org/gpg.asp). This production area was selected for survey at this time based on a risk-based ranking of the area amongst those in Scotland that had yet to receive sanitary surveys.

The Loch Ryan production area is located in the inner part of Loch Ryan, which is situated in Dumfries and Galloway, to the south of Glasgow. Loch Ryan is the only managed native oyster (*Ostrea edulis*) fishery in Scotland, and oysters are harvested seasonally from September to the end of April, using a 1.9 m single dredge.

Loch Ryan is currently undergoing a significant sewage system upgrade to remove or UV treat the continuous discharges from community Wastewater Treatment Works (WWTW) at Cairnryan, Stranraer, Kirkcolm and Leswalt. The main sewage outfall for the majority of the population on public sewerage will be to the Irish Sea, west of the Loch. Completion of the works is due in 2013, and upon completion the principal sources of faecal contamination to the fishery will be:

- Discharges from private septic tanks to the loch
- Discharges from combined sewer overflows (CSOs) within and adjacent to the production area
- Discharge of cheese processing effluent to the loch east of Stranraer
- Diffuse and point source contamination to watercourses, particularly Bishop, Kirclachie and Sole Burns
- Diffuse contamination from a number of bird species using the loch
- Overboard discharges from boats

The majority of the loch is very shallow (<5 m) and on an ebb tide, contaminants arising from sources around the loch will tend to be carried toward the deeper channel along the eastern side of the loch from where they will be carried NW-SE on

the tide. Potential transport distances are in the order of 5-8 km. Sewage from the new outfall in the Irish Sea is highly unlikely to be transported into Loch Ryan. All discharges within the loch lie within 5-8 km of the shellfish bed. As the oysters are subtidal, contaminants associated with particulate matter sinking to the sea bed, and potentially being resuspended by ferry movements, are likely to be an important mechanism of contamination to the shellfish.

Sewage contamination from CSOs will be highly variable and risks from these sources cannot be adequately determined via the monthly monitoring programme. The majority of these discharge outwith the production area boundaries. It has been recommended, however, that the northern boundary be curtailed somewhat to exclude the remaining continuous and intermittent discharges around the port at Cairnryan.

The recommended monitoring zone and production area boundaries are presented in tabular form overleaf and graphically in Section 16, Recommendations.

II. Sampling Plan

Production Area	Loch Ryan
Site Name	Loch Ryan native oysters
SIN	DG-191-174-12
Species	Native oyster
Type of Fishery	Managed - dredged
NGR of RMP	NX0700 6690
East	207000
North	566900
Tolerance (m)	250
Depth (m)	Not applicable
Method of Sampling	Dredge
Frequency of Sampling	Monthly
Local Authority	Dumfries & Galloway
Authorised Sampler(s)	Stuart McNeil
Local Authority Liaison Officer	Kirsty McGuigan
Production Area Boundaries	The area bounded by lines drawn between NX 0417 6796 and NX 0727 6711 and between NX 0828 6200 and NX 0502 6200 and extending to MHWS

III. Report

1. General Description

Loch Ryan is a predominantly shallow, sheltered sea loch on the southwest coast of Scotland. It is situated in Dumfries and Galloway, to the south of Glasgow. The loch opens north into the Firth of Clyde and the Atlantic Ocean. The loch is approximately 13 km long from north to south and 4.8 km wide at its widest point. The depth within the loch ranges between 0 and 10 m, with much of the loch shallower than 5 m. A channel was historically dredged to 7 m to allow access for ferries to Stranraer, although the ferry terminal has recently moved to Cairnryan on the eastern shore of the loch and dredging has ceased.

The town of Stranraer is located at the head of loch. Other smaller settlements around the loch include Leswalt and Kirkcolm on the west side and Cairnryan on the east. The remaining land surrounding Loch Ryan is mainly agricultural in use.

The sanitary survey at Loch Ryan has been undertaken due to the risk-based ranking of the area amongst classified Scottish production areas that had yet to receive a survey.

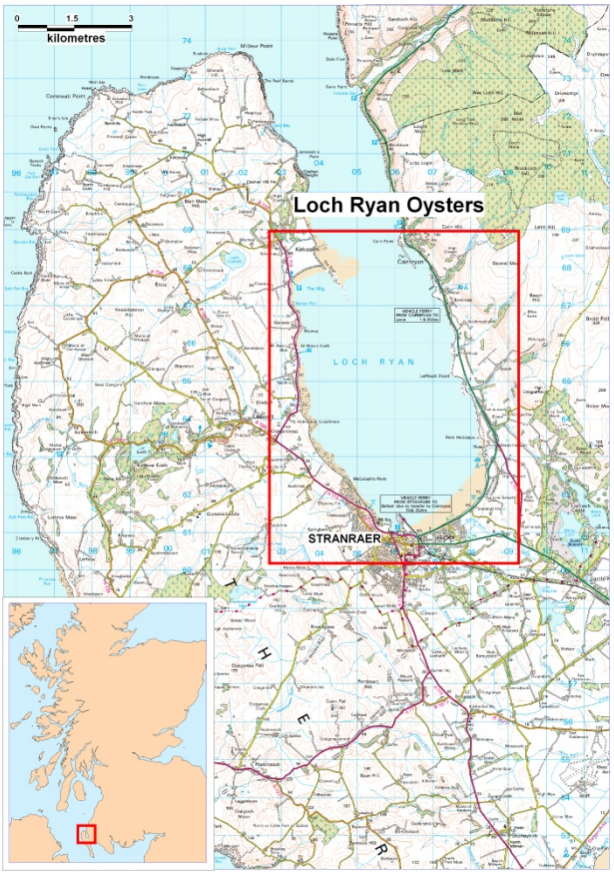

Figure 1.1 Location of Loch Ryan survey area

2. Fishery

The fishery at Loch Ryan is a large native oyster (*Ostrea edulis*) bed which covers the majority of the shallow (<5 m) basin(University Marine Biological Station Milport, 2007). Fishing occurs south of Cairnryan on both east and west shores (T. Hugh-Jones 2012, pers. comm. 20 Dec). The FSAS classification listing identifies two different sites, Leffnoll Point (DG-191-174-12) and Loch Ryan (DG-191-175-12). Boundaries for the currently classified production area are as follows: NX 0416 6796 and NX 0693 6796 extending inshore to MHWS. The current RMP is identified only to the nearest 100 metres, and is located at NX 072 652.

Loch Ryan is the only managed native oyster fishery in Scotland and the only remaining large-scale fishery exploiting wild stocks of *O. edulis* (University Marine Biological Station Milport, 2007). A survey conducted by Stena Line Limited placed abundance at a maximum of 80 oysters/m^2 with a population estimate of 60 million.(Dickson, 2009). Harvesting uses a 1.9 m single dredge with the largest five percent of the catch kept for sale. The remaining 95% are relayed in denser beds to aid future harvesting and improve fertilisation.(Hugh-Jones, 2011; Dickson, 2009). Native oysters are harvested seasonally from September to the end of April, seven days a week.

Based on conversations with local fishermen during the shoreline survey, the area close to Leffnoll Point is heavily affected by extra silt load and bilge water due to the increased ferry traffic in Cairnryan (see Section 3). This, in their opinion, is caused by Stena Line ferries moving from Stranraer to Cairnryan in November 2011, with both P&O Ferries and Stena Line now operating from the area. However, due to the movement of the Stena Terminal to its current location from Stranraer, SEPA report that there is no longer dredging of the navigation channel to the inner part of the loch, which would be expected to result in less sediment suspension over much of the bed.

A restricted sanitary survey was conducted at the Loch Ryan North razor clam production area (DG 500 866 16), in November 2010. This area was declassified in April 2012.

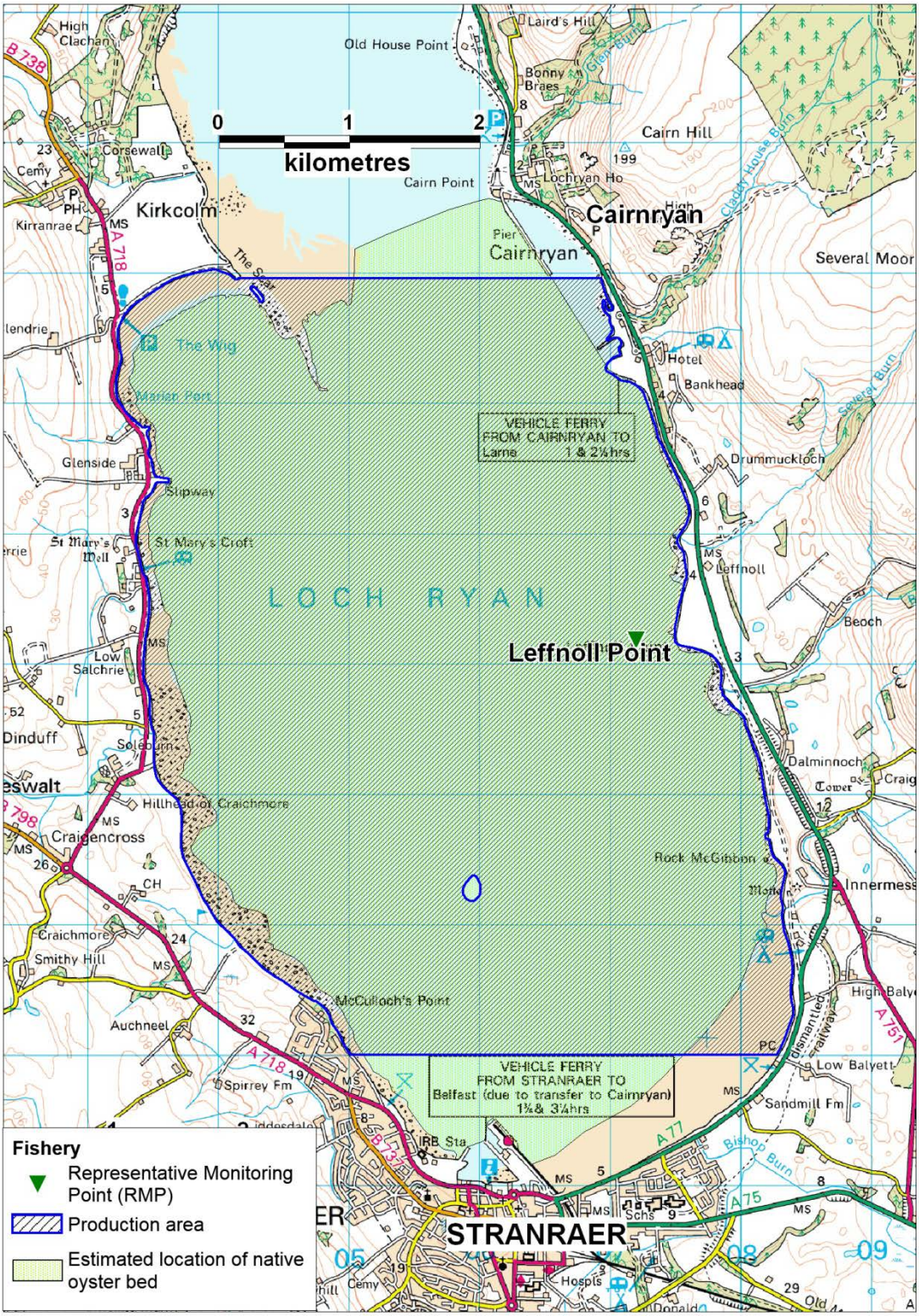

Figure 2.1 Loch Ryan Fishery

3. Human Population

Information was obtained from the General Register Office for Scotland on the population within the census output areas in the vicinity of Loch Ryan. The last census was undertaken in 2011. However, the 2011 census data was unavailable at the time of writing this report and therefore data from the 2001 census was used.

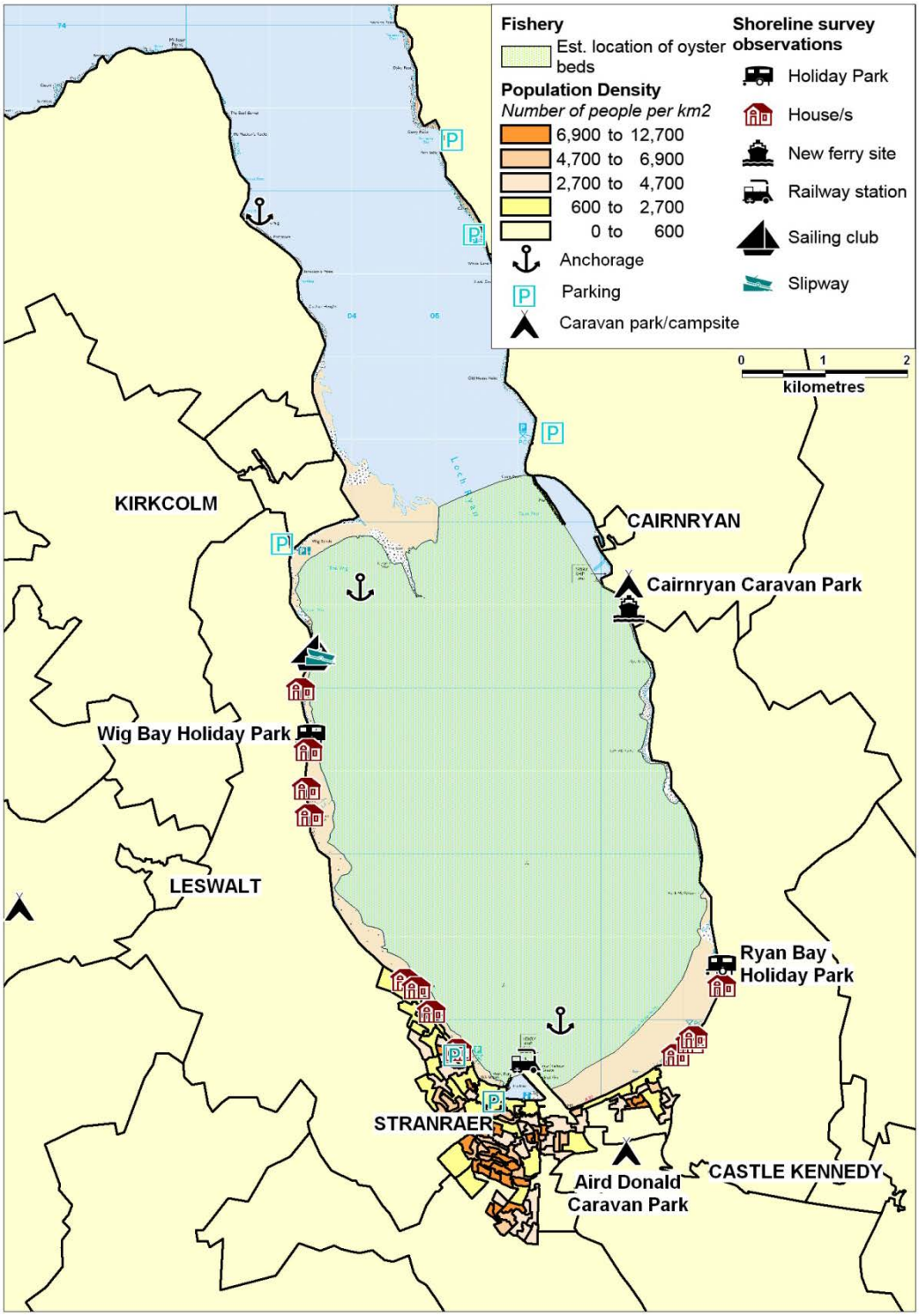

Figure 3.1 Population map of Loch Ryan

Figure 3.1 shows that population density is relatively high for the census output areas representing the town of Stranraer and very low elsewhere around the loch. Stranraer had an estimated population of 10,290 in mid-2010 (General Register Office for Scotland, 2012). The town has primary and secondary schools, a community hospital and plentiful tourist accommodation including hotels, bed & breakfasts and self-catering units. Other settlements in the vicinity of Loch Ryan include Leswalt, Kirkcolm, Cairnryan and Castle Kennedy.

The ferry terminal from Cairnryan runs services to Larne (14 sailings weekly) and Belfast (5 sailings daily). Sewage from both ferries is taken off at Larne and Belfast. Stranraer marina has visitor facilities, 53 annual berths and 9 visitor berths, plus additional moorings (Dumfries and Galloway Council, 2013). There are no pump-out facilities for onboard sewage wastes, and the harbour authority website contains no guidance on avoiding overboard discharges inside the loch. There are two anchorages within Loch Ryan, one close to Stranraer and another along the north western shoreline, near the entrance to the loch. During the shoreline survey a small slipway was observed on the north western shore of Loch Ryan next to the sailing club (see Figure 3.1). Wig Bay is a popular anchorage for visiting yachts. At the head of the loch, a pontoon was observed with approximately ten fishing boats moored along side, although no geographical reference was recorded at the time. Occupied boats or yachts may have heads that discharge directly overboard, leading to faecal contamination of the surrounding water and elevated faecal coliform levels up to 300 metres away (Sobsey *et. al.*, 2003).

There are numerous caravan and campsites in the Loch Ryan area. The Aird Donald Caravan Park on the outskirts of Stranraer has the capacity for 30 units. At the east end of the beach is the Ryan Bay Holiday Park with a licence for 200 units and during the shoreline survey it was observed that the park contained static caravans and plots for mobile caravans and tents. Ryan Bay Holiday Park has a consented discharge licence and is discussed further in section 4. Halfway along the coast between Kirkcolm and Stranraer is Wig Bay Holiday Park with a licence for 197 units. Cairnryan Caravan Park, adjacent to the ferry terminal is estimated to have in excess of 90 static pitches.

Due to the large size of Stranraer and the close proximity of Kirkcolm and Cairnryan to the production area, it is likely that faecal contamination associated with human population (sewage, urban runoff, and overboard discharges from yachts) from all three settlements will contribute to the observed E. coli results at the shellfishery.

Due to the number of caravan sites in the area, it is expected that the population in the area will increase significantly during the summer holiday months. Any overboard discharges from boats using the Stranraer anchorage could have a significant impact on water quality at the site. While any impact from fishing boats may be year-round, impact from yachting activity would be highest during the summer months around the marina at Stranraer and in Wig Bay.

4. Sewage Discharges

Information on sewage discharges to the area was sought from Scottish Water and the Scottish Environment Protection Agency (SEPA). Data requested included the name, location, type, size (in either flow or population equivalent), level of treatment, sanitary or bacteriological data, spill frequency, discharge destination (to land or to waterbody), any available dispersion or dilution modelling studies, and whether improvements were in work or planned. Scottish Water identified community septic tanks and sewage discharges for the area surrounding Loch Ryan (Table 4.1).

Table 4.1 Sewage discharges identified by Scottish Water – current system

Ref. Consent	Discharge Name	NGR	Discharge Type	Level of Treatment	Flow (m^3/d)	PE
CAR/L/1003622	Cairnryan WWTW	NX 070 679	Continuous	Septic Tank	74	183
CAR/L/1082403	Cairnryan CSO1	NX 0700 6790	Intermittent	12mm screen	-	-
CAR/L/1003622	Cairnryan CSO2	NX 0680 6820	Intermittent	12mm screen	-	-
CAR/L/1003622	Cairnryan CSO3	NX 0660 6840	Intermittent	12mm screen	-	-
CAR/L/1003617	Kirkcolm WWTW*	NX 039 688	Continuous	Septic tank	150	
CAR/L/1082402	Kirkcolm WWTW CSO	NX 039 688	Intermittent	6mm screen	-	-
WPC/W/16172	Kirkcolm Main Street, CSO	NX 0391 6873	Intermittent	-	-	-
CAR/L/1003619	Port Rodie WWTW*	NX 0580 6140	Continuous	Secondary	8524	
CAR/L/1082401	Leswalt WWTW*	NX 0210 6429	Continuous	Septic tank	-	-
CAR/L/1026411	12 McMasters Road CSO**	NX 0739 6126	Intermittent	-	-	-
CAR/L/1026411	12A Hanover Square CSO	NX 0613 6070	Intermittent	-	-	-
CAR/L/1026411	26 Mayfield Av CSO	NX 0489 6152	Intermittent	-	-	-
CAR/L/1026411	54 Sheuchan ST/Foreland Place CSO/EO	NX 0553 6148	Intermittent	6mm screen	-	-
CAR/L/1026411	AT SPS/Larg Road CSO/EO	NX 0482 6234	Intermittent	-	-	-
CAR/L/1026411	Beechmount/Cairnryan Rd CSO	NX 0675 6096	Intermittent	screened	-	-
CAR/L/1026411	Chevron/Lochview Rd CSO**	NX 0766 6135	Intermittent	-	-	-
CAR/L/1026411	Lewis Street CSO	NX 0612 6154	Intermittent	screened	-	-
CAR/L/1026411	Orchardview/Glebe ST NO1 CSO	NX 0549 6058	Intermittent	6mm screen	-	-
CAR/L/1026411	Orchardview/Glebe ST NO2 CSO	NX 0550 6058	Intermittent	-	-	-
CAR/L/1003619	Port Rodie WWTW CSO	NX 0590 6110	Intermittent	12mm screen	-	-
CAR/L/1026411	Dalrymple Street CSO	NX 0626 6065	Intermittent	screened	-	-

- Not stated * Flows to be pumped to new Loch Ryan WWTW ** To be removed CSO – combined sewage overflow, EO – emergency overflow, PE – population equivalent, SPS – sewage pumping station, ST – septic tank, WWTW – Wastewater Treatment Works

No sanitary or microbiological data was provided for these discharges. Scottish Water is currently undertaking major works to improve the sewerage network and point source sewage discharge quality around Loch Ryan in order to achieve compliance with the Urban Waste Water Treatment Directive (91/271/EEC) and the

Shellfish Waters Directive (2006/113/EC). The assets identified in Table 4.1 represent the current sewerage network as of January 2012 (the date of data provision).

Prior to commencement of recent improvements to the sewerage provision around Loch Ryan, sewage from three major public waste water treatment works (Cairnryan, Stranraer Port Rodie, and Kirkcolm) discharged primary treated sewage from a total population equivalent of over 15, 000 into Loch Ryan. A fourth WWTW, Leswalt, discharged to Sole Burn. However, data provided by SEPA and Scottish Water disagreed on the treatment level provided, with Scottish Water identifying it as a septic tank and SEPA identifying it as a secondary treatment works.

The new system being implemented aims to significantly reduce the amount of sewage entering into the loch. A new WWTW will process sewage that is currently discharged via the current WWTWs at Stranraer Port Rodie, Leswalt and Kirkcolm. A new pumping station with CSO is being built on the site of the old Port Rodie WWTW and the existing underground settlement tanks are being converted into storm storage tanks to increase storm storage capacity at Stranraer and reduce the incidence of stormwater overflows. The Leswalt and Kirkcolm WWTWs are being converted to pumping stations with CSO/EOs to an unnamed tributary of Sole Burn and to Loch Ryan, respectively. All three pumping stations will pump sewage to the new Loch Ryan WWTW at Smithy Hill (near Leswalt). Once at the works, sewage will receive secondary level treatment and final effluent will discharge into the Irish Sea through a new outfall pipe approximately 600 m offshore of Broadsea Bay at NW 9675 5969. This is shown in Figure 4.2.

A large number of CSOs at Stranraer will remain in operation. These are anticipated to discharge only infrequently (predicted spill frequency = <10/year), particularly once the new storm storage tanks at the Port Rodie pumping station are put into use. The majority of these CSOs will incorporate improved 6 mm screening prior to discharge. The discharge from Kirkcolm Main Street CSO will receive 14 mm screening. The 12 McMasters Road and Chevron/Lochview Rd CSOs are set to be phased out.

The existing Cairnryan WWTW is to be demolished and a new pumping station built in its place. The new pumping station will include greater storage capacity in order to reduce the predicted frequency of spills to 10 or fewer per year and is to have improved screening. A new WWTW is being privately developed at the Stena Ferry Terminal. This will discharge tertiary treated effluent outwith the production area boundary. Scottish Water identified that both new WWTWs were being constructed offline, and that there would be no reduction in existing treatment or any increase in spills during construction.

This will pump sewage along a new pipeline to the new Stena Ferry Terminal WWTW where it will receive tertiary treatment (UV) prior to discharge near the entrance of Loch Ryan.

Scottish Water also provided information on discharges at Glenstockadale, Castle Kennedy, Kildrochat, and Lochans, located to the south and southwest of Stranraer. These all discharge outside the catchment for Loch Ryan and therefore would not be expected to affect water quality of either the loch or the watercourses discharging to it.

SEPA provided information on a large number (260) consented discharges within a 10 km radius of Loch Ryan. A subset of 149 of these located nearest the fishery and including those discharges to water that lie within the catchment of Loch Ryan are summarised in Table 4.2.

Table 4.2 Summary of discharge consents identified by SEPA

Type	Number of consents
Associated with public sewerage network	38
Trade effluent	5
Private discharges to water	23
Private discharges to land or soakaway	75

Consented discharges associated with the public sewerage network and trade effluent are listed in Table 4.3 and these together with discharges to water are displayed in Figure 4.1.

Table 4.3 Significant sewage discharges to Loch Ryan, identified by SEPA

No	Ref	NGR*	Discharge Type	Level of Treatment	PE	Discharge to
1	CAR/L/1003617	NX 0390 6880	Continuous	Secondary	600	Loch Ryan
2	CAR/L/1003618	NX 0215 6432	Continuous	Secondary		Sole Burn
3	CAR/L/1003619	NX 0580 6140	Continuous	Primary	14999	Loch Ryan
4	CAR/L/1003622	NX 0695 6789	Continuous	Primary		Loch Ryan
5	CAR/L/1003622	NX 0700 6790	Intermittent	CSO/EO	183	Loch Ryan
6	CAR/L/1003622	NX 0680 6820	Intermittent	CSO/EO		Loch Ryan
7	CAR/L/1003622	NX 0660 6840	Intermittent	CSO/EO		Loch Ryan
8	CAR/L/1003634	NX 0390 6880	Intermittent	CSO		Loch Ryan
9	CAR/L/1003636	NX 0211 6430	Intermittent	CSO		U/T of Sole Burn
10	CAR/L/1026411	NX 0466 6237	Intermittent	CSO		Loch Ryan
11	CAR/L/1026411	NX 0476 6227	Intermittent	CSO		Loch Ryan
12	CAR/L/1026411	NX 0521 6174	Intermittent	CSO		Loch Ryan
13	CAR/L/1026411	NX 0489 6153	Intermittent	CSO		Loch Ryan
14	CAR/L/1026411	NX 0553 6148	Intermittent	CSO		Loch Ryan
15	CAR/L/1026411	NX 0605 6100	Intermittent	CSO		Loch Ryan
16	CAR/L/1026411	NX 0626 6102	Intermittent	CSO		Loch Ryan
17	CAR/L/1026411	NX 0761 6142	Intermittent	CSO		Loch Ryan

No	Ref	NGR*	Discharge Type	Level of Treatment	PE	Discharge to
18	CAR/L/1026411	NX 0765 6135	Intermittent	CSO		Bishop Burn
19	CAR/L/1026411	NX 0706 6108	Intermittent	CSO		Loch Ryan
20	CAR/L/1026411	NX 0676 6097	Intermittent	CSO		Loch Ryan
21	CAR/L/1026411	NX 0744 6112	Intermittent	CSO		Unnamed watercourse
22	CAR/L/1026411	NX 0613 6070	Intermittent	CSO		Unnamed watercourse
23	CAR/L/1026411	NX 0549 6058	Intermittent	CSO		Unnamed watercourse
24	CAR/L/1026411	NX 0550 6058	Intermittent	CSO		Unnamed watercourse
25	CAR/L/1026411	NX 0612 6054	Intermittent	CSO		Town Burn
26	CAR/L/1026411	NX 0608 6050	Intermittent	CSO		Unnamed watercourse
27	CAR/L/1026411	NX 0532 6044	Intermittent	CSO		Unnamed watercourse
28	CAR/L/1026411	NX 0614 6035	Intermittent	CSO		Unnamed watercourse
29	CAR/L/1026411	NX 0606 6032	Intermittent	CSO		Unnamed watercourse
30	CAR/L/1026411	NX 0616 6029	Intermittent	CSO		Unnamed watercourse
31	CAR/L/1026411	NX 0619 6021	Intermittent	CSO		Unnamed watercourse
32	CAR/L/1026411	NX 0627 6103	Intermittent	EO		Loch Ryan
33	CAR/L/1026411	NX 0763 6139	Intermittent	EO		Bishop Burn
34	CAR/L/1082401	NX 0211 6429	Intermittent	CSO/EO		U/T of Sole Burn
35	CAR/L/1082402	NX 0391 6873	Intermittent	CSO/EO		Loch Ryan
36	CAR/L/1082403	NX 0696 6787	Intermittent	CSO/EO		Loch Ryan
37	CAR/L/1087260	NX 0310 6870	Intermittent	CSO		Corsewall Burn
38	CAR/L/1087410	NX 0604 6936	Continuous	Tertiary	368	Loch Ryan
39	CAR/L/1000892	NX 0419 6286	TE	Potable Water Treatment		Loch Ryan
40	CAR/L/1081060	NX 0580 6975	TE	Other Effluent		Loch Ryan
41	PPC/A/1003173	NX 0750 6170	TE	Dairy/cheese processing effluent		Loch Ryan
42	CAR/S/1035132	NX 0690 6038	TE	SUDS		Black Stank
43	CAR/S/1063034	NX 0665 5956	SWO			Not stated
44	CAR/L/1003357	NX 0707 6740	Continuous	Septic tank	510	Loch Ryan

U/T – Unnamed tributary, TE – Trade effluent, SUDS – Sustainable urban drainage system, SWO – Surface water overflow

SEPA identified both public and private consents which were predominantly concentrated on the western shoreline of Loch Ryan. The SEPA consent data for the new Stena Ferry Terminal WWTW show that the tertiary treated final effluent is to be discharged to Loch Ryan between Cairn Point and Old House Point, 1.7 km NNW of the location given by Scottish Water. This was later confirmed by Scottish Water as the location of the new outfall. The resulting outfall will therefore be outwith the current boundary of the classified shellfish production area.

Five consents related to trade effluent discharges to Loch Ryan. Number 40 in Table 4.3 relates to treated site drainage for construction of the new ferry terminal at Old House Point north of Cairnryan.

The Caledonian Cheese Company, situated east of Stranraer, has a consent for discharge of trade effluent from cheese processing (Number 41, Table 4.3). In 2011, the operators were fined for failure to comply with the conditions of their discharge consent. From a desk-based internet search, no further details have been found to suggest that improvements have since been made. SEPA identified in the shellfish growing water report for Loch Ryan that further action against the company was being considered (SEPA, 2010). Untreated discharge from cheese processing was listed in the SEPA Shellfish Growing Waters site action plan for targeted improvement. SEPA identified that the discharge was found to contain 5×10^6/100 ml faecal coliforms, approximately 5000 times above permissible concentrations.

The majority of private discharge consents relate to septic tanks with reported population equivalents of between 5 and 15. Most of these discharge to land or soakaway along the west side of the loch. Although there is public sewerage provision in Leswalt, there remain a significant number of private septic tanks in the area. The majority discharge to soakaway, however six discharge to Sole Burn and its tributaries, and one discharges directly to Loch Ryan.

On the east side of the loch, the most significant private discharge is from Cairnryans Caravan Park, which is served by a large septic tank with a consented PE of 510 and dry weather flow of 70.5 m^3/day (Number 44, Table 4.3). Effluent from this tank discharges to Loch Ryan south of the ferry pier at Cairnryan. Significant seasonal variation is expected in discharges from this site, with highest flows during the peak tourist season in summer.

Septic tank soakaways situated very close to the shoreline or watercourses may contribute faecal contamination particularly if poorly maintained or when ground conditions are saturated.

During the shoreline survey nineteen observations related to possible sewage or septic discharges were made. Some of these related to pipes of unknown use, but that were made of materials consistent with septic use (clay or iron). Some may relate to parts of the sewerage infrastructure that were being removed, as there was work underway in the area at the time of the survey. The observations made are listed in Table 4.4.

Table 4.4 Discharges and septic tanks observed during shoreline surveys

No.	Date	NGR	Description
1	19/02/2013	NX 0353 6644	Large clay pipe (Ø: 30 cm) next to slipway
2	19/02/2013	NX 0338 6603	Clay pipe (Ø: 25 cm) running onto shore
3	19/02/2013	NX 0347 6565	Large, broken iron outflow pipe to shore just opposite main entrance to caravan site. Water sample <100 *E. coli* cfu/ 100 ml
4	19/02/2013	NX 0413 6286	Plastic pipe joining into river. Water sample from river below end of pipe 300 *E. coli* cfu/ 100 ml
5	19/02/2013	NX 0464 6248	Plastic outfall pipe with concrete structure at top of pipe. Houses on hill beyond. Water sample 400 *E. coli* cfu/ 100 ml
6	19/02/2013	NX 0478 6238	Clay pipe (Ø: 20 cm) embedded in concrete below houses.
7	19/02/2013	NX 0496 6210	Small plastic pipe embedded in concrete on shore with houses beyond. Two more pipes along shore wall next to road/houses.
8	19/02/2013	NX 0532 6161	Concrete chamber and manhole cover
9	19/02/2013	NX 0541 6150	Large plastic pipe (Ø: 0.6 m) running under the road towards shore. Slight smell of sewage. Water sample 180000 *E. coli* cfu/ 100 ml
10	19/02/2013	NX 0544 6143	Possible pumping station next to road, several manhole covers around,slight smell of sewage. Large concrete structure runs from manholes to shore, no pipe or discharge visible.
11	20/02/2013	NX 0660 6093	Pipe flowing heavily from under railway lines.
12	20/02/2013	NX 0660 6093	Pipe flowing from under railway lines. Two manhole covers in about 5 m distance from outflow pipe with the sound of running water. Other manhole covers and drain pipes are present all along seawall.
13	20/02/2013	NX 0714 6114	Plastic outfall pipe embedded in concrete with manhole cover. Active outflow. Pipe Ø: 35 cm; estimated flow: 300 ml/s, no access, no sample taken.
14	20/02/2013	NX 0758 6634	Outflow from rusted iron pipe onto shore, runs along an adjacent broken clay pipe. Sample 100 *E. coli* cfu/ 100ml
15	20/02/2013	NX 0764 6140	Pumping station on shore. Scottish Water van parked next to it.
16	20/02/2013	NX 0807 6173	Metal pipe with no discharge running from under road with houses on shore.
17	20/02/2013	NX 0812 6179	Plastic pipe with yellowish discharge running from farmland with houses under road, no smell. Pipe Ø: 23 cm; Depth: 2 cm; Flow: 0.558 m/s; SD: 0.007. Sample 11400 *E. coli* cfu/ 100 ml.
18	20/02/2013	NX 0829 6354	Broken clay pipe with diameter of 12 cm runs onto shore, only dripping. Not sampled.
19	20/02/2013	NX 0755 6640	Clay pipe embedded in concrete. Slightly dripping, no sample taken.

Ø diameter

The majority of observations related to observed pipes and flows around the town of Stranraer. One of the observed discharges appeared to relate to two consented discharges via partial soakaway at Sandmill Farm, east of Stranraer (Number 17, Table 4.4). A sample taken on the day returned a result of 11400 *E. coli* cfu/100 ml, confirming that it had significant faecal content. Observation number 7 appeared to related to a consented private discharge to water. However, no note was made regarding whether the pipe was flowing at the time.

Discharges were also noted on the eastern and western shorelines, though where samples were taken, contamination levels were low (<100 – 400 *E. coli* cfu/100 ml).

It was not clear in some cases whether an observed flow related to an outfall, an overflow or a flow to a watercourse. If there was any doubt, the observation was included above. Therefore, not all of the observations in Table 4.4 may relate to sewage discharges.

Summary

Improvements to the public sewerage network around the loch, in particular the relocation of continuous discharges to the Irish Sea and outwith the production area, are expected to lead to significant improvements in water quality in the loch. Figure 4.2 shows the location of the main public sewage outfalls projected after completion of the current upgrade programme. Despite the provision of public sewerage in the area, there remain a significant number of private septic tank discharges. Sole Burn, on the west shore, receives septic tank effluent from a number of private dwellings though water quality in the burn will be improved markedly by the removal of the Leswalt WWTW continuous outfall. Discharges from the caravan parks and from Caledonian Cheese Company contribute significant amounts of faecal indicator bacteria to the loch. However, of these the discharge from the Cairnryans Caravan Park septic tank is likely to pose the greatest risk of contamination from human pathogens directly to the fishery.

A large number of CSOs are to remain at Stranraer and Cairnryan, as well as at Kirkcolm. No information was obtained regarding the historical frequency of CSO spills to the loch. If the provision of greater storm storage capacity at Stranraer works as planned, there will be fewer CSO spills to the loch in future. However, monthly *E. coli* monitoring is unlikely to adequately reflect risk of contamination from intermittent sources and therefore may underestimate the risk to human health particularly once the largest continuous sources are removed.

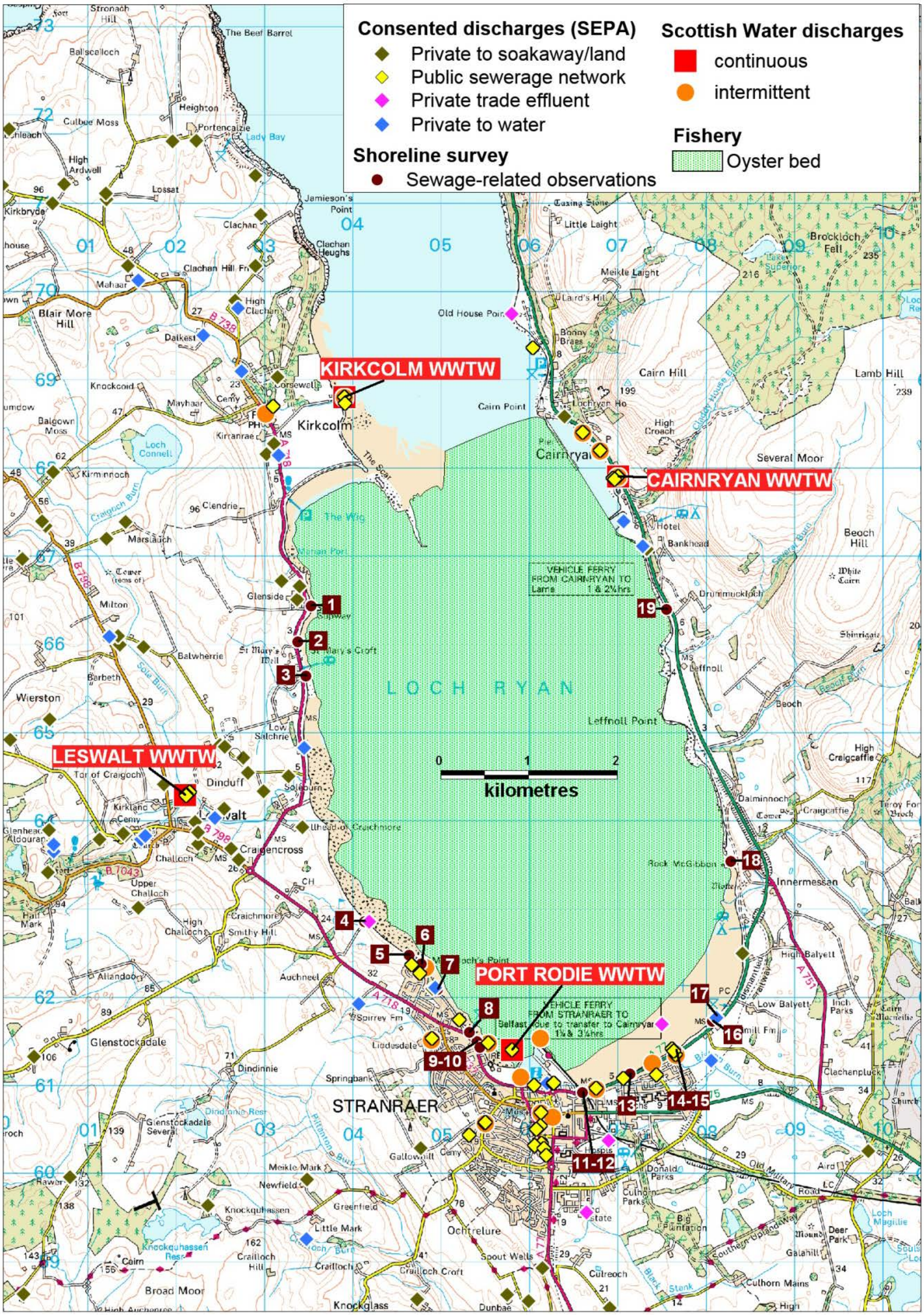

Figure 4.1 Sewage discharges around Loch Ryan

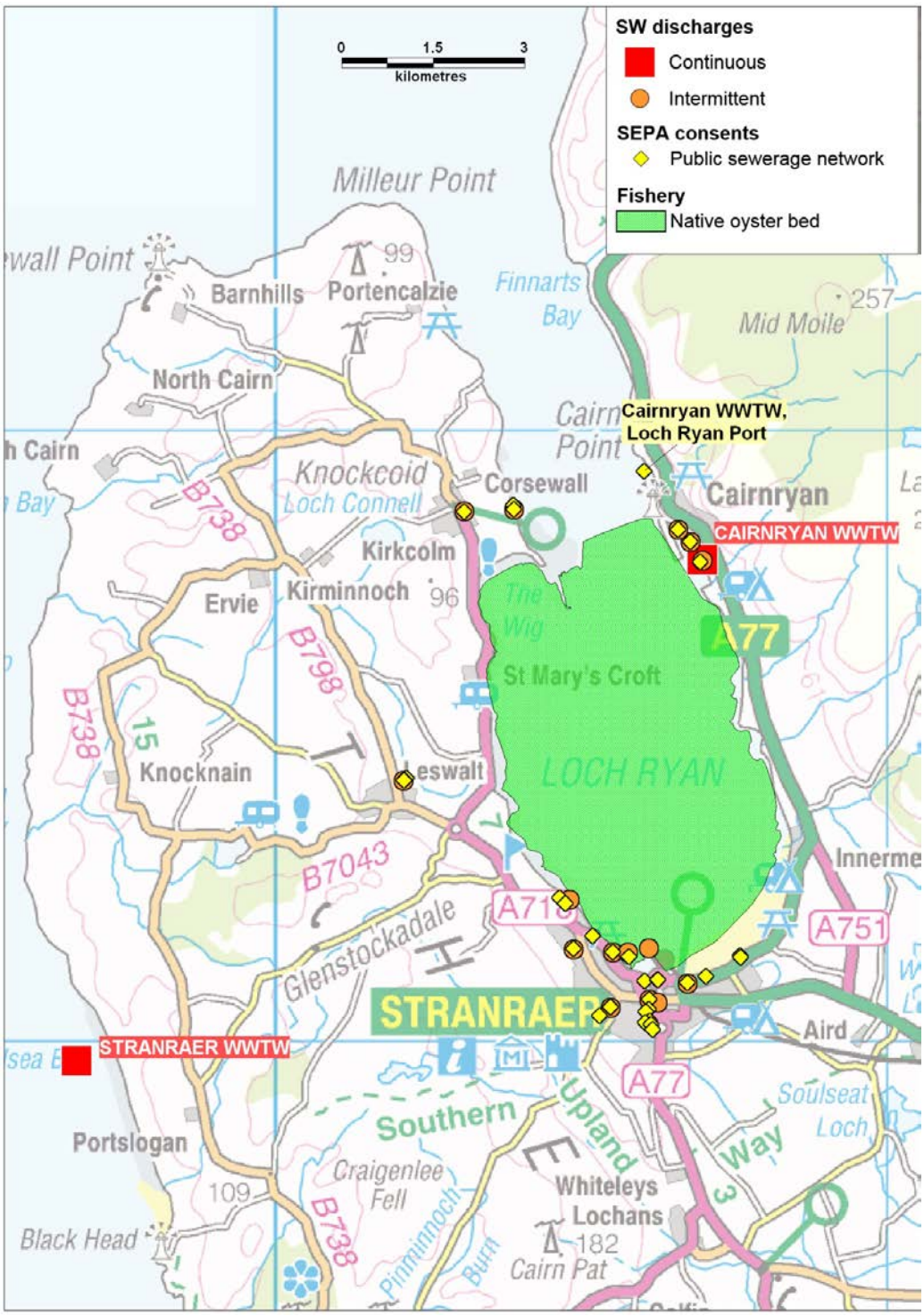

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Figure 4.2 Future public discharges only, Loch Ryan

5. Agriculture

Information on the spatial distribution of animals on land adjacent to or near the fishery can provide an indication of the potential amount of organic pollution from livestock entering the shellfish production area. Agricultural census data to parish level was requested from the Scottish Government Rural Environment, Research and Analysis Directorate (RERAD) for the Kirkcolm, Leswalt, Stranraer, Inch and Ballantree parishes. Reported livestock populations for the parish in 2012 are listed in Table 5.1. RERAD withheld data for reasons of confidentiality where the small number of holdings reporting would have made it possible to discern individual farm data. Any entries which relate to less than five holdings, or where two or fewer holdings account for 85% or more of the information, are replaced with an asterisk.

Table 5.1 Livestock numbers in agricultural parishes along the Loch Ryan coastline 2012

	Kirkcolm		**Leswalt**		**Stranraer**		**Inch**		**Ballantree**	
	56 km^2		51 km^2		0.6 km^2		126 km^2		134 km^2	
	Holdings	Numbers	Holdings	Numbers	Holdings	Numbers	Holdings	Numbers	Holdings	Numbers
Pigs	*	*	*	*	0	0	0	0	0	0
Poultry	5	110	8	48,669	0	0	*	*	*	*
Cattle	44	10,935	22	6,381	*	*	31	6,789	19	6,380
Sheep	15	4,764	12	4,416	0	0	14	18,701	15	28,535
Other horses and ponies	7	18	8	18	0	0	*	*	*	*

The agricultural parishes of Kirkcolm, Leswalt and Inch border the production area. Ballantree agricultural parish is located on the north west coastline of the loch. The Stranraer agricultural parish is located inland south of the loch and contains little or no livestock (see Table 5.1). The five agricultural parishes encompass a total land area of over 367 km^2 (shown in the inset of Figure 5.1). Because the livestock census numbers relate to such a large parish areas, it is not possible to determine the spatial distribution of the livestock in relation to the Loch Ryan area or identify how many animals are likely to impact the catchment around the fishery. Therefore the figures are of little use in assessing the potential impact of livestock contamination to the fishery; however they do give an idea of the total numbers of livestock over the broader area. The livestock numbers indicate that sheep and cattle are present in large numbers in all parishes apart from Stranraer. The SEPA Shellfish Growing Water report states that “the land to the west, south and east of Loch Ryan is fertile and used for grazing and intensive arable farming” (SEPA, 2011).

The only significant source of spatially relevant information on livestock population in the area was the shoreline survey (see Appendix 5) which only relates to the period of the site visit during the 19th and 20th February 2013 (see Table 5.1). Observations

made during the survey are dependent upon the viewpoint of the observer, therefore some animals may have been obscured by terrain. The spatial distribution of animals observed and noted during the shoreline survey is illustrated in Figure 5.1.

The shoreline survey identified that the land surrounding Loch Ryan is primarily agricultural, with some grazing land. A large farm observed on the western shoreline of Loch Ryan had approximately 14 sheep and four horses.Livestock feeders were located along the shoreline south of the farm. East of Stranraer was a second farm with approximately 70 – 100 cattle, livestock feeders and 2 horses. North of this farm were approximately 50 sheep. SEPA has been conducting individual farm inspections as part of the Galloway Coastal Diffuse Pollution project and any regulatory breaches are being addressed directly with landowners.

It is anticipated that the shellfish bed adjacent to the identified farms, in particular the area by the cattle farm, would be subject to greater faecal contamination than sections of shoreline adjoining primarily agricultural land.

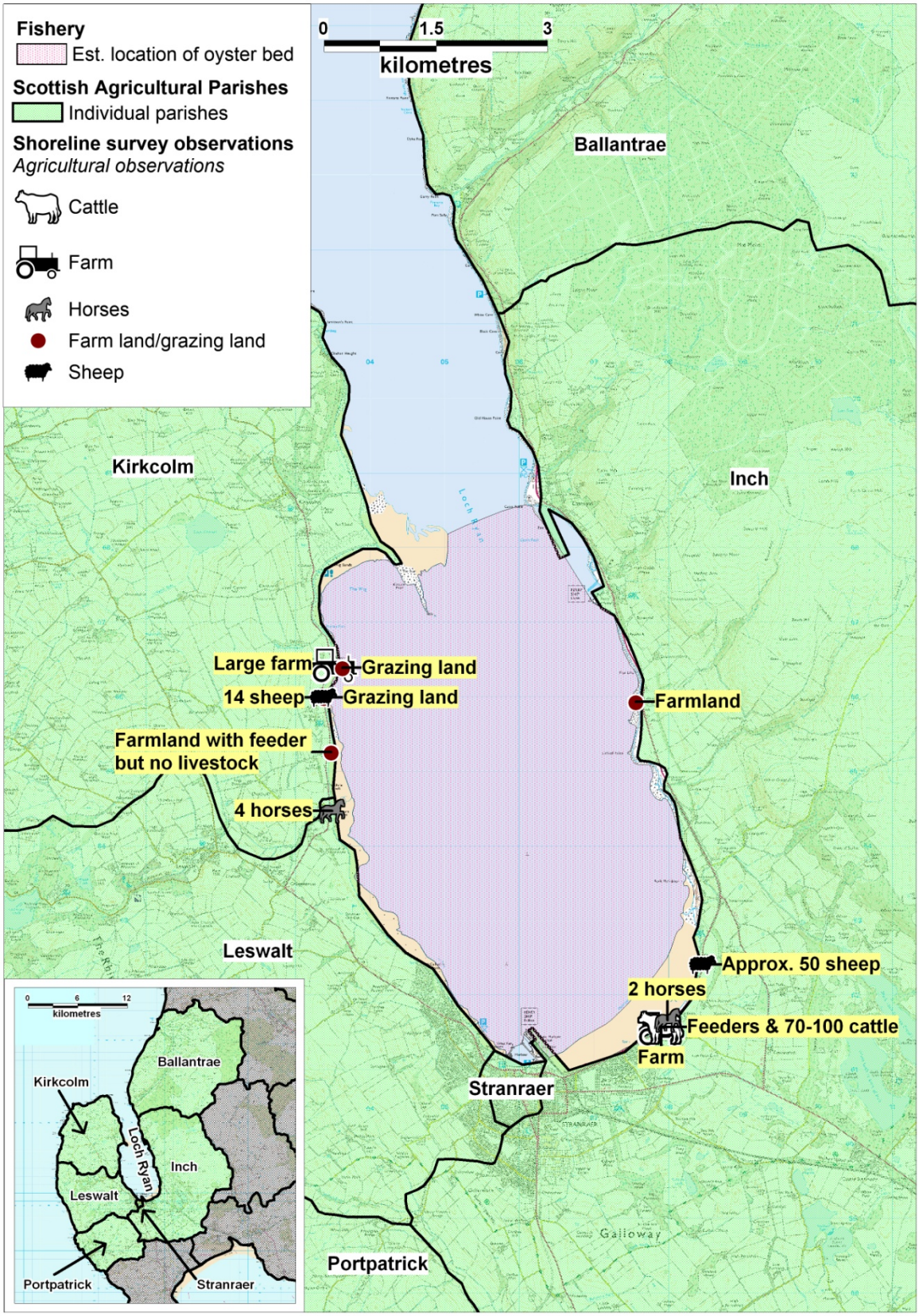


Figure 5.1 Livestock observations at survey area

6. Wildlife

Pinnipeds

The common/harbour seal (*Phoca vitulina*) and the grey seal (*Halichoerus grypus*) are commonly spotted in Loch Ryan. However there are no known colonies of either species that reside in Loch Ryan.

No firm data was available on grey seal numbers within Loch Ryan, though there are anecdotal accounts of grey seals in Loch Ryan (Stranraer & The Rhins of Galloway Community & Tourist Information Site, 2008). From August surveys undertaken between years 2007 and 2009, between 26-50 common seals were seen to the west of Loch Ryan (Special Committee on Seals, 2011).

Due to the transient nature of seals, it is likely that these animals will use Loch Ryan to forage and rest in from time to time. Faecal loadings from seals will therefore be unpredictable and limited. No seals were observed during the shoreline survey.

Cetaceans

There are many reports of harbour porpoises (*Phocoena phocoena)* and bottlenose dolphins (*Tursiops truncates)* in the open waters outside Loch Ryan. Despite the high levels of shipping traffic operating at the mouth of Loch Ryan, it is likely that from time to time, individuals from both these species will enter Loch Ryan. At the time of this report however there was no data available on numbers of these species seen in Loch Ryan and it is assumed their contamination impact will be small. No cetaceans were observed during the shoreline survey.

Birds

Seabird 2000 census data (Mitchell, et al., 2004) was queried for the area within a 5 km radius of the Loch Ryan production area and the output is summarised in Table 6.1 and displayed in Figure 6.1. This census was undertaken between 1998 and 2002 and covered the 25 species of seabird that breed regularly in Britain and Ireland.

Table 6.1 Seabird populations within a 5 km radius around Loch Ryan (Seabird 2000)

Common Name	Species	Count*	Method
Black guillemot	*Cepphus grylle*	179	Individuals on land
Razorbill	*Alca torda*	9	Individuals on land
Northern Fulmar	*Fulmarus glacialis*	285	Occupied sites
European Herring Gull	*Larus argentatus*	810	Occupied nests Occupied sites Individuals on land
Black-headed Gull	*Larus ridibundus*	64	Occupied nests
Great Black-backed Gull	*Larus marinus*	16	Occupied nests
Lesser Black-backed Gull	*Larus fuscus*	16	Occupied nests
Common Gull	*Larus canus*	4	Occupied nests
Great Cormorant	*Phalacrocorax carbo*	100	Occupied nests
European Shag	*Phalacrocorax aristotelis*	277	Individuals on land/ occupied nests
Common Tern	*Sterna hirundo*	44	Occupied nests
Sandwich Tern	*Sterna sandvicensis*	140	Occupied nests
Arctic Tern	*Sterna paradisaea*	6	Occupied nests

* Occupied nest or site counts multiplied by 2.

The majority of the birds noted in the Seabird (2000) data were found on the northeast and northwest shorelines of Loch Ryan, at the mouth of the loch. Table 6.1 lists total counts for species, but individual counts varied between 3 and 303 birds at any one time. It is expected that all species observed in this survey will utilise the surroundings areas to forage and rest. However contamination levels will be highest where the occupied nests are located.

Loch Ryan is a nationally important site for several species of wetland bird. The scaup is found mostly to the southern basin of Loch Ryan and the light-bellied brent goose (*Brenta bernicla*) distributed on the exposed mud flats and eelgrass beds to the south. Red-throated diver and Canadian geese are also common in the loch, particularly on the eastern shorelines (Stranraer & The Rhins of Galloway Community & Tourist Information Site, 2008).

Other birds that are common along Loch Ryan's shoreline include plover, dunlin and gulls. During the winter, species of wildfowl such as eider, goldeneye, scaup and wigeon can be found in high numbers. Vast flocks of twite migrate to the fields surrounding the shores of Loch Ryan, with estimates of 500+ birds in the past (Dumfries & Galloway Council, 2011). During the shoreline survey, birds were observed primarily on intertidal areas along the head and western shorelines of the loch.

Wetland birds are more prevalent in winter on the intertidal areas of the loch along the head and western shore.

Otters

Anecdotal accounts exist on Eurasian otters (*Lutra lutra*) around Loch Ryan (Natural Capital, 2013). At the time of this report, there was no population data available for otters around Loch Ryan. No otters were seen during the shoreline survey.

Deer

There is anecdotal evidence that red deer (*Cervus elaphus*) are present around Loch Ryan (Rotary Club of Stranraer, 2012). At the time of this report there was no population data available on deer around Loch Ryan. No deer were observed during the shoreline survey.

Overall

Wildlife potentially impacting Loch Ryan includes seals, deer, and various species of birds. Impacts from many of these animals on the fishery will be unpredictable, and deposition of faeces by most wildlife is likely to be widely distributed around the area. However, contamination from droppings deposited around seabird nesting sites will be most likely to affect waters near the nests, during and immediately after the summer nesting season. The most significant of the identified nesting areas with regard to the shellfishery is that located around the Scar, at the northwestern extent of the shellfish bed. Impacts from geese and other overwintering wildfowl and wading birds will be higher from approximately October to March in the area around the head of the loch and the western shore where there is larger intertidal area.

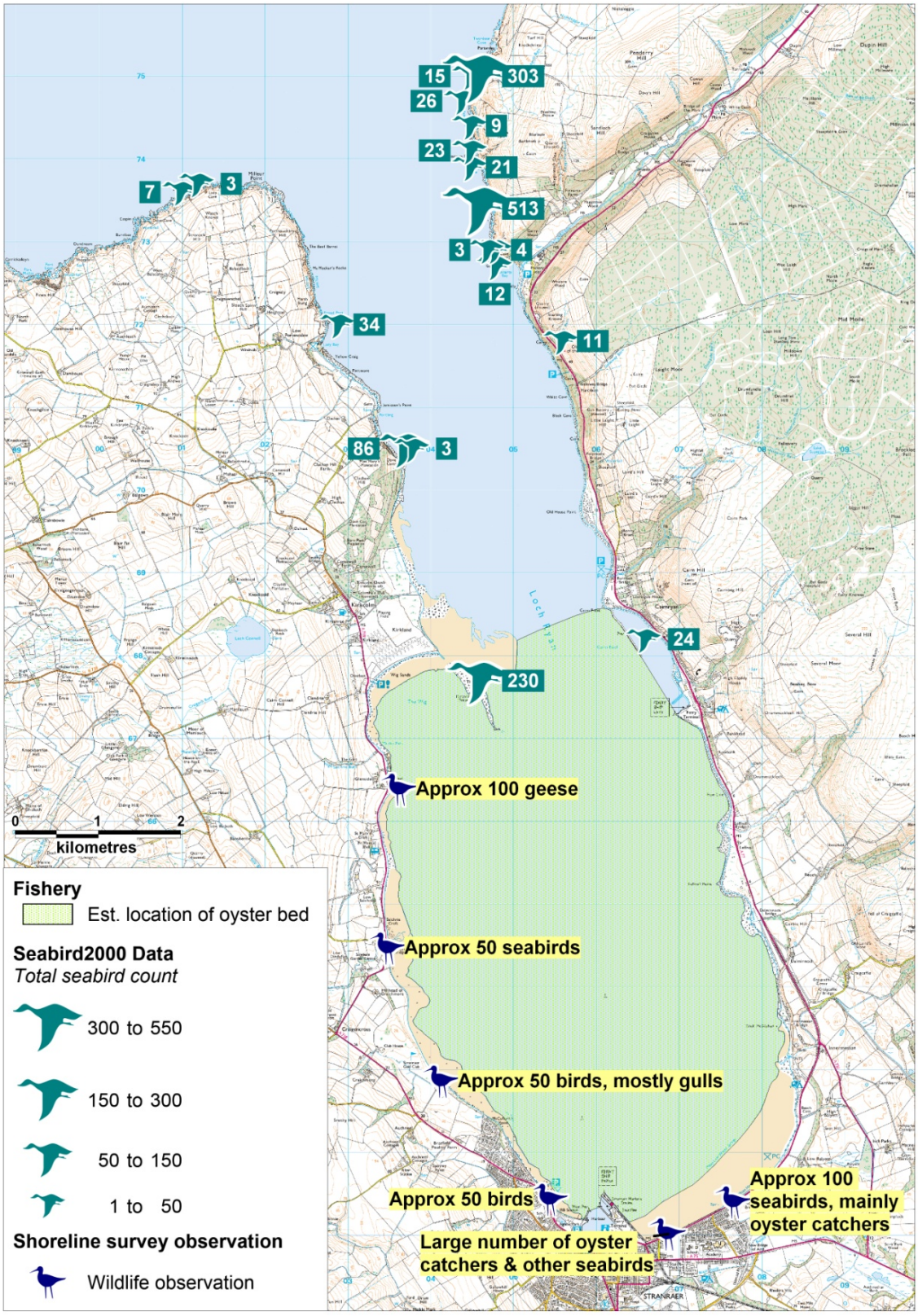


Figure 6.1 Wildlife observations around Loch Ryan

7. Land Cover

The Land Cover Map 2007 data for the area is shown in Figure 7.1 below:

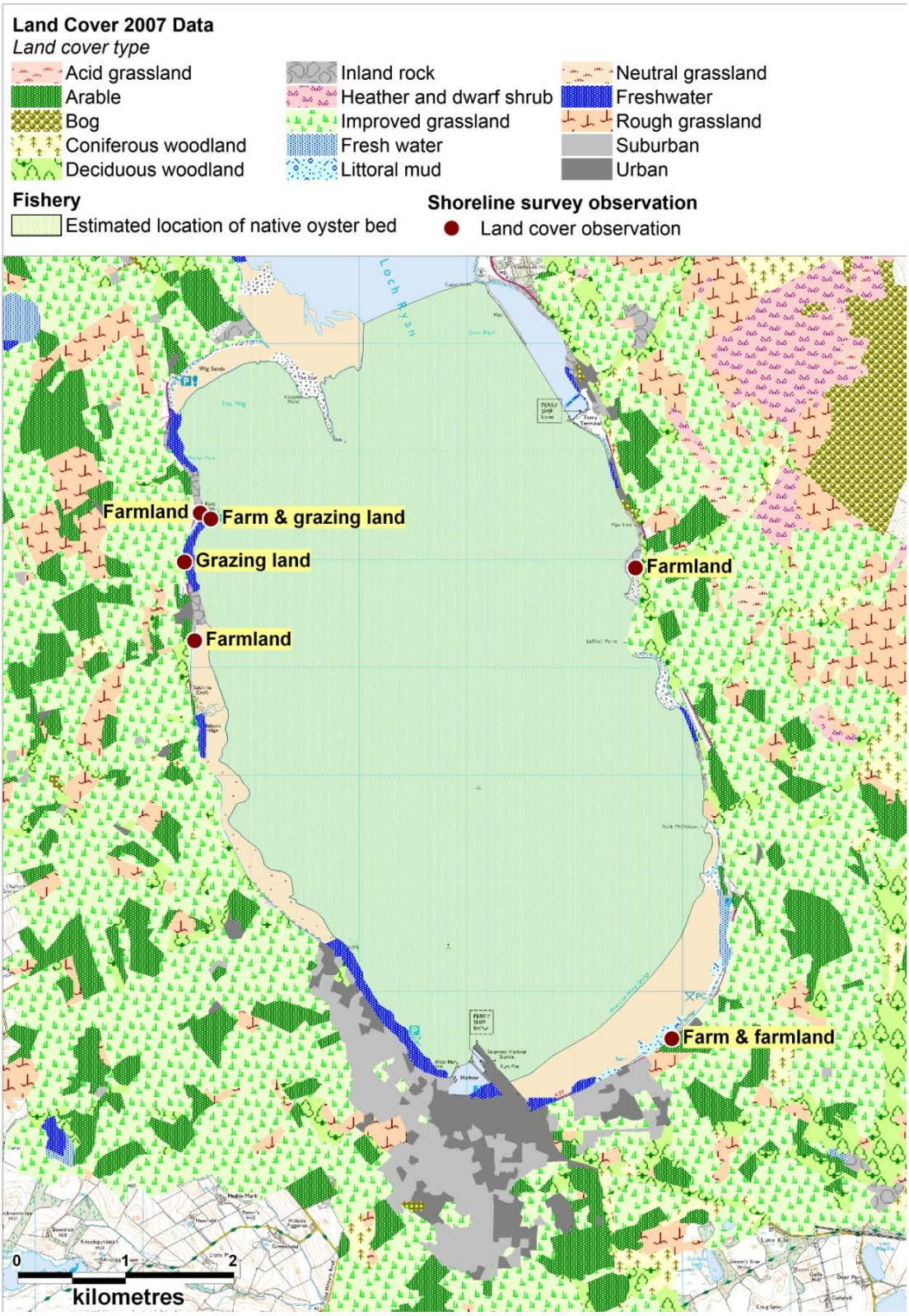


Figure 7.1 LCM2007 land cover data for Loch Ryan

Improved grassland, arable land and rough grassland are the predominant land cover types on the shoreline adjacent to Loch Ryan. Stranraer and Cairnryan are shown as a suburban and urban area. Areas of arable land are likely to receive application of slurry, sludge, and/or inorganic fertilisers. Imported sewage sludge has been applied to some fields in the Leswalt area, according to the local press (Grant, 2011).

During the shoreline survey land cover observations were recorded and these verified the Land Cover 2007 data in most cases. Areas along the shoreline that are represented as freshwater are actually intertidal areas where watercourses are present and do not reflect areas covered in freshwater.

Faecal indicator organism export coefficients for faecal coliform bacteria have been found to be approximately 1.2 – 2.8×10^9 cfu/km^2/hr for urban catchment areas, approximately 8.3×10^8 cfu/km^2/hr for areas of improved grassland and approximately 2.5×10^8 cfu/km^2/hr for rough grazing(Kay, et al., 2008a). The contributions from all land cover types would be expected to increase significantly after rainfall events, however this effect would be particularly marked from improved grassland areas (roughly 1000-fold)(Kay, et al., 2008a).

The highest potential contribution of contaminated runoff to the Loch Ryan Oysters shellfish farm is from the suburban/urban area of Stranraer and the areas of arable land and improved grassland lining the shore adjacent to the fishery as well as the catchments of watercourses discharging to the loch. Arable areas receiving slurry or sludge amendment may pose a particular risk if good practice in application is not utilised. In addition, areas utilised for rough grazing would be expected to contribute significantly to faecal contaminant loading carried in watercourses and overland flow draining the area during rainfall. Spatially, the areas most impacted will be near the head of the loch, however impacts from agricultural areas would be expected to affect the entire shoreline of the loch and may be most concentrated where watercourses discharge to the bay (see Section 8).

8. Watercourses

There are no current public river gauging stations on watercourses discharging to Loch Ryan.

The following six watercourses listed in Table 8.1 were observed during the shoreline survey and represent the largest freshwater inputs into the survey area. No precipitation fell in the two days prior to the survey, or during the two survey days (19th and 20th February 2013).

Table 8.1 Watercourse loadings to Loch Ryan

No	NGR	Description	Width (m)	Depth (m)	Flow (m^3/d)	*E. coli* (cfu/100 ml)	Loading (*E. coli* /day)
1	NX 0349 6447	Sole Burn	6.80	0.18	1798	10000	$1.8x10^{11}$
2	NX 0413 6286	unnamed burn	1.30	0.17	7466	300	$2.2x10^{10}$
3	NX 0766 6140	Bishop Burn	4.60	0.28	54529	6200	$3.4x10^{12}$
4	NX 0837 6316	Kirclachie Burn	5.20	0.25	79691	1300	$1.0x10^{12}$
5	NX 0788 6480	Beach Burn	2.00	0.20	9919	100	$9.9x10^{9}$
6	NX 0756 6593	Several Burn	1.50	0.20	5573	500	$2.8x10^{10}$

E. coli loading to Loch Ryan varied between $9.9x10^{9}$ and $3.4x10^{12}$ *E. coli*/day. During the survey, three main watercourses were found to enter Loch Ryan from the east, two from the west and one from the south at the head of Loch Ryan. At the time of the survey eleven additional areas of land drainage were noted, with the majority on the northwest shoreline (Figure 8.1).

The most significant watercourse contamination sources entering Loch Ryan were Bishop Burn and Kirclachie Burn, located on the south and southeast shorelines, respectively. These watercourses were large, with high flow rates at the time of the survey. Estimated *E. coli* loadings based on samples and measurements taken on the day of shoreline survey illustrated relatively high contamination levels ($3.4x10^{12}$ and $1.0x10^{12}$ *E. coli*/day, respectively). The area surrounding Bishop Burn includes both agricultural farmland and developed urban areas, which are both likely to contribute to overall contamination levels entering the burn. Bishop Burn receives input from Black Stank, which was identified as being affected by intensive livestock agriculture and poaching of the riverbank by livestock (SEPA, 2010). Comparatively land surrounding Kirclachie Burn is mostly agricultural, with a few associated farm houses and dwelling houses. Both burns enter Loch Ryan south of the southern extent of the estimated oyster bed and it is likely that contamination will not mix to deeper waters and contaminate the oyster bed.

Beach Burn and Several Burn enter Loch Ryan either side of Leffnoll Point, adjacent to the nominal RMP. These watercourses contained moderate levels of contamination at the time of the survey, with estimated loadings of $9.9x10^9$ and $2.8x10^{10}$ *E. coli*/day respectively. The surrounding area around both watercourses is mostly agricultural, with several associated farm houses and dwelling houses also located on the eastern shoreline. Due to their proximity to the estimated oyster bed it is likely that the contamination entering from both watercourses will impact the oyster bed.

Two watercourses were measured on the western shoreline; Sole Burn and an unnamed burn. Loadings were estimated at $1.8x10^{11}$ and $2.2x10^{10}$ *E. coli*/ day respectively. The surrounding catchment area of Sole Burn includes the small village of Leswalt as well as agricultural farmland to the northwest. The unnamed burn is located close to Stranraer golf course and surrounding fields are used for rearing livestock.

Overall, freshwater input into Loch Ryan is low. Edwards and Sharples (1986) calculated freshwater input was small, causing only a small salinity reduction level of 0.1 ppt. They estimated total runoff as 167.0 million m^3/ year.

'Churning' of water around the Cairnryan P&O ferry terminal (as observed and noted by the harvester), may act to mix freshwater with seawater and resuspend sediment. and may therefore act to increase contamination levels crossing and settling onto the oyster bed.

Spatially, the contribution of watercourses to faecal contamination at the oyster bed is likely to be highest around the southeast end of the loch, where *E. coli* loadings were highest based on spot sampling undertaken during the shoreline survey, and around the mouth of Sole Burn, where though the loading was found to be lower due a much lower flow volume, the sample *E. coli* concentration was very high (10000 cfu/100 ml).

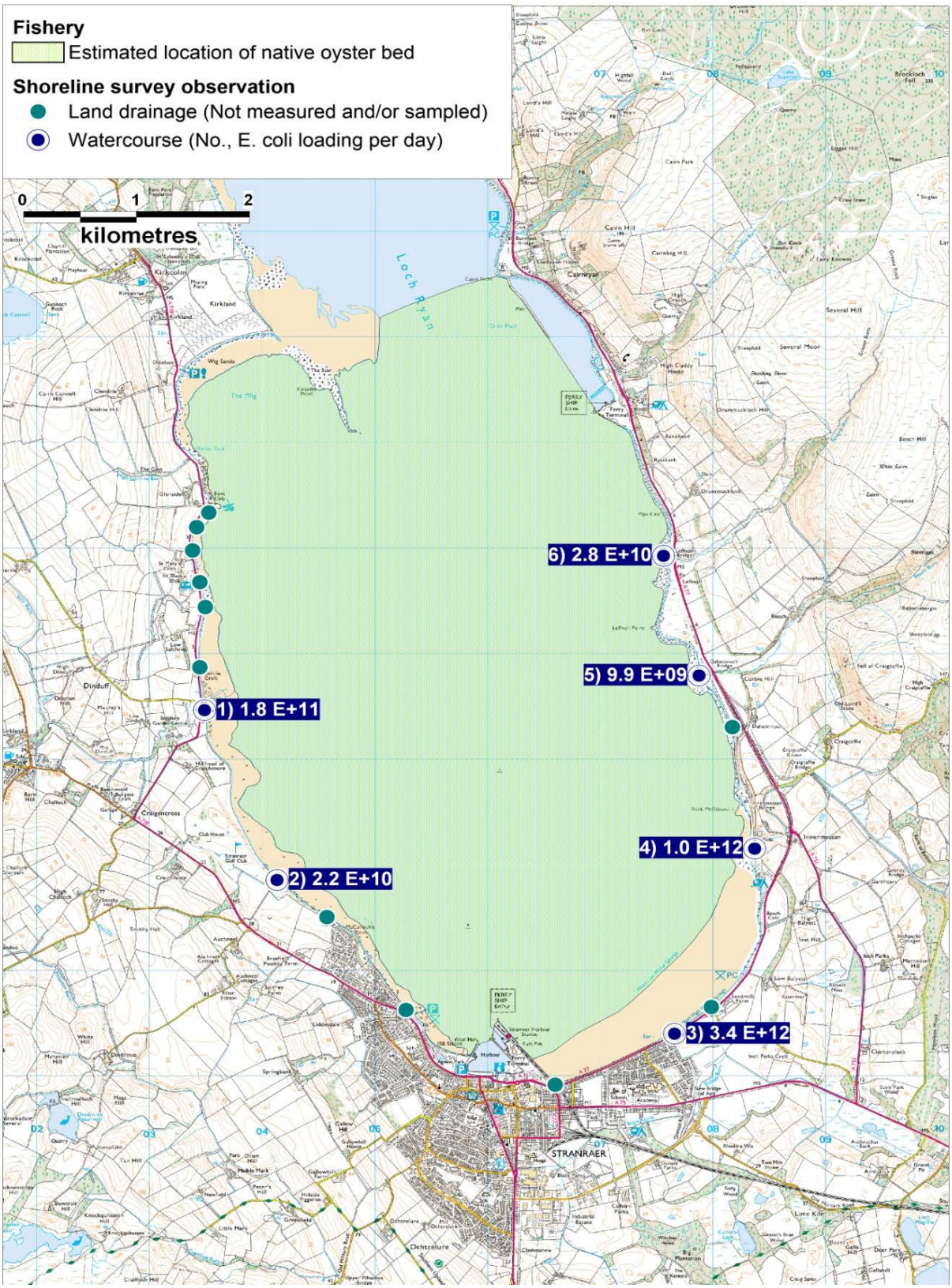


Figure 8.1 Map of watercourse loadings to Loch Ryan during the 2013 shoreline survey.

9. Meteorological Data

The nearest weather station for which rainfall data was available is located at Castle Kennedy, situated approximately 6 km to the south east of the production area. Rainfall data was available for January 2007 – August 2012. At the time of writing this report rainfall data for August 2012 onwards, had not been published. The nearest wind station is also situated in Prestwick Gannet, located 70 km north east of the production area. Conditions may differ between this station and the fisheries due to the distances between them. However, this data is still shown as it can be useful in identifying seasonal variation in wind patterns.

Data for these stations was purchased from the Meteorological Office. Unless otherwise identified, the content of this section (e.g. graphs) is based on further analysis of this data undertaken by Cefas. This section aims to describe the local rain and wind patterns in the context of the bacterial quality of shellfish at Loch Ryan.

9.1 Rainfall

High rainfall and storm events are commonly associated with increased faecal contamination of coastal waters through surface water runoff from land where livestock or other animals are present, and through sewer and waste water treatment plant overflows (e.g. Mallin et al, 2001; Lee & Morgan, 2003). The box and whisker plots in Figures 9.1 and 9.2, present a summary of the distribution of individual daily rainfall values by year and by month. The grey box represents the middle 50% of the observations, with the median at the midline. The whiskers extend to the largest or smallest observations up to 1.5 times the box height above or below the box. Individual observations falling outside the box and whiskers are represented by the symbol *.

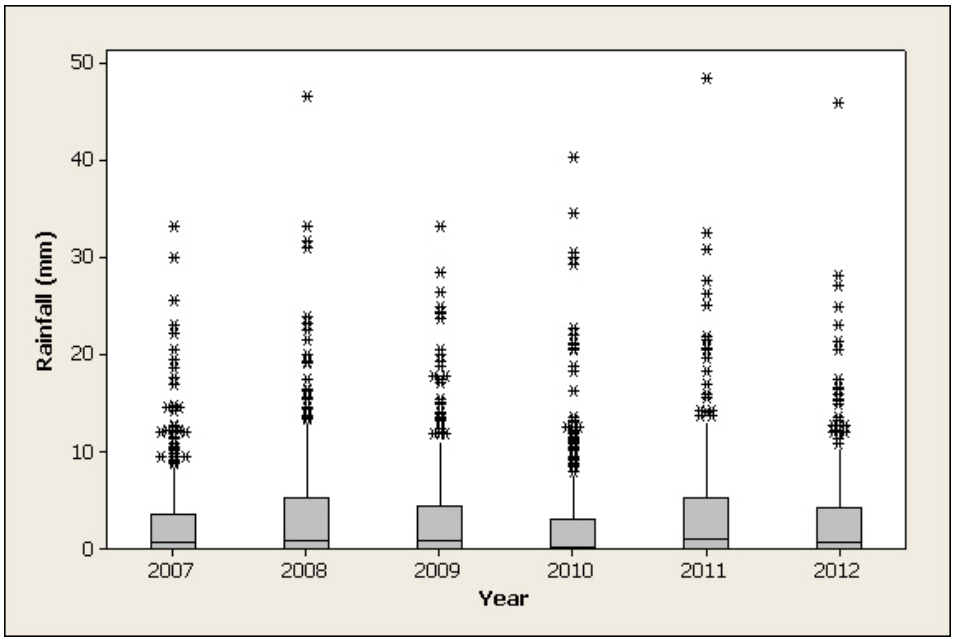


Figure 9.1 Box plot of daily rainfall values by year at Castle Kennedy (2007 – 2012)

Daily rainfall values varied from year to year, with 2010 being the driest year. The wettest year was 2011. High rainfall values of more than 30 mm/d occurred in all years but an extreme rainfall event of nearly 50 mm/d were seen in 2008, 2011 and 2012.

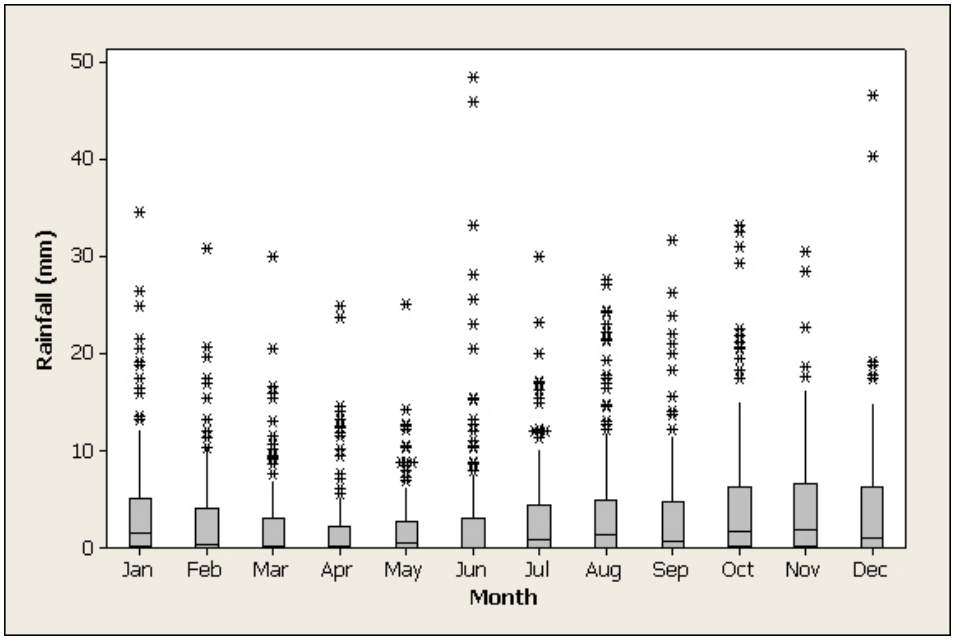


Figure 9.2 Box plot of daily rainfall values by month at Castle Kennedy (2007 – 2012)

Daily rainfall values were higher during the autumn and winter. Rainfall increased from July onward and was highest in October and November. Weather was drier from March to June. Rainfall events exceeding 30 mm/d were seen in all months apart from April and May. The extreme events of nearly 50 mm/d occurred in June and December.

For the period considered here (2007 – 2012) 54% of days received daily rainfall of less than 1 mm and 10% of days received rainfall of over 10 mm.

It is therefore expected that runoff due to rainfall will be higher during the autumn and winter months. However, extreme rainfall events leading to episodes of high runoff can occur in most months and when these occur during generally drier periods in summer and early autumn, they are likely to carry higher loadings of faecal material that has accumulated on pastures when greater numbers of livestock were present.

9.2 Wind

Wind data was collected from Prestwick Gannet and summarised in seasonal wind roses in Figure 9.3 and annually in Figure 9.4.

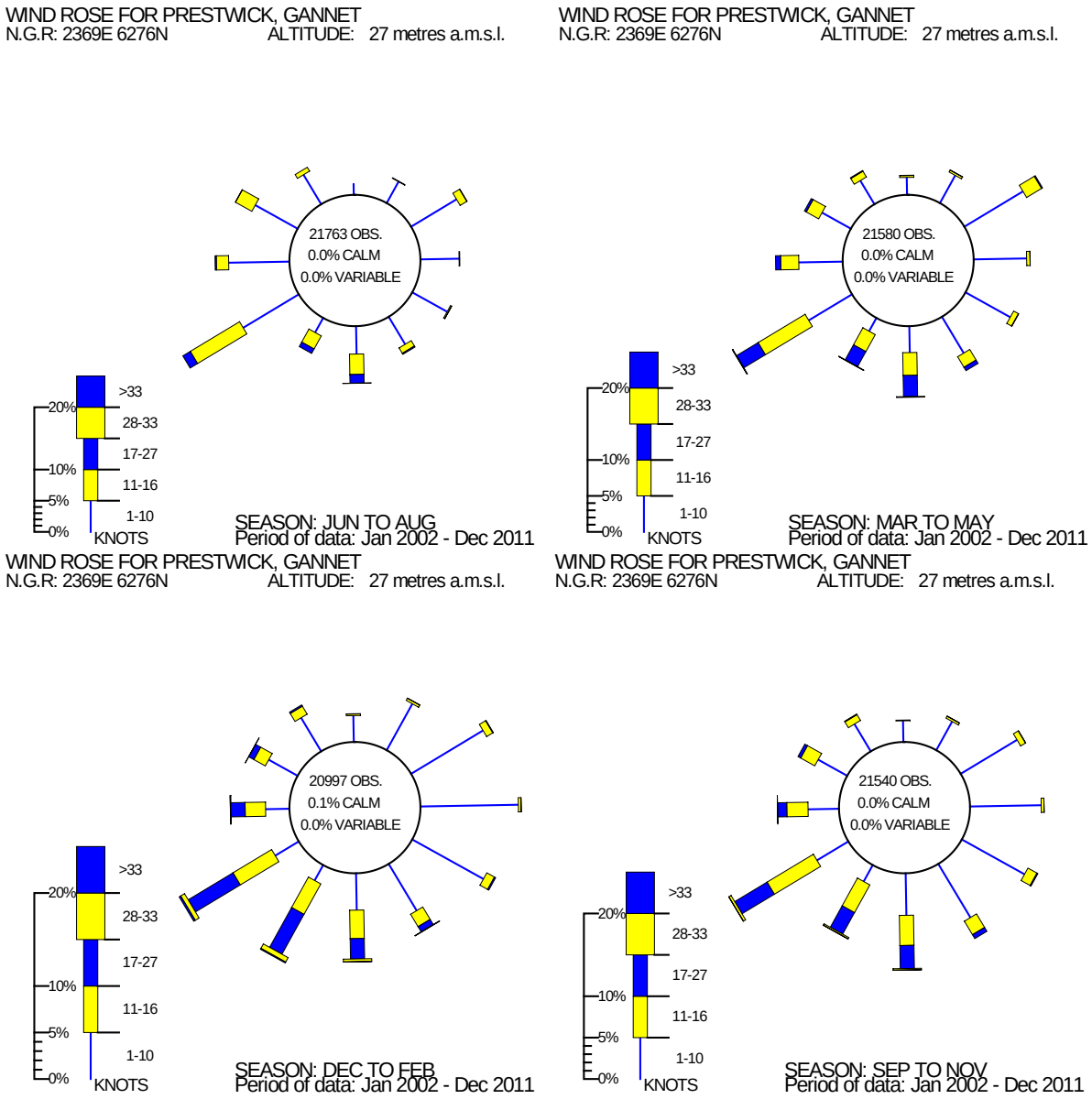


Figure 9.3 Seasonal wind roses for Prestwick Gannet

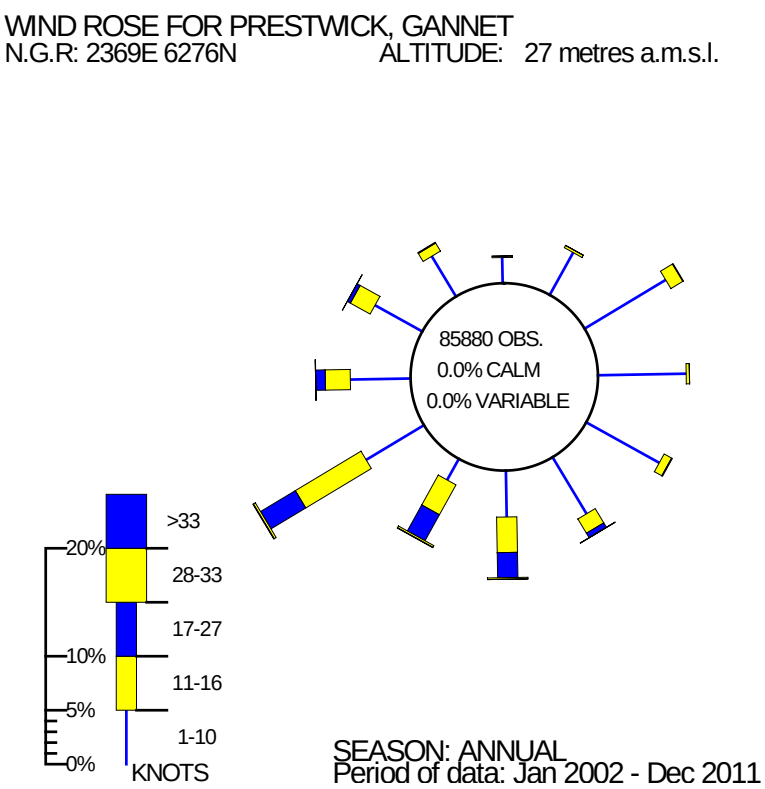


Figure 9.4 Annual wind rose for Prestwick Gannet

Overall the annual wind direction showed that wind was stronger when coming from the west than the east, and winds from the southerly direction were stronger than those from the north. There was no marked change in wind direction throughout the months; however winds were much stronger in the winter months than in the summer months.

Wind is an important factor in the spread of contamination as it has the ability to drive surface water at about 3% of the wind speed(Brown, 1991) so a gale force wind (34 knots or 17.2 m/s) would drive a surface water current of about 1 knot or 0.5 m/s. Therefore strong winds can significantly alter the pattern of surface currents. Strong winds also have the potential to affect tide height depending on wind direction and local hydrodynamics of the site. A strong wind combined with a spring tide may result in higher than usual tides, which will carry any accumulated faecal matter at and above the normal high water mark into the production area.

10. Classification Information

The area has been classified for native oyster production since prior to 2001. The classification history since April 2006 is listed in Table 10.1.

Loch Ryan has had A/B classification for the past five years. Since 2008, the area has consistently been class A in January and February, with the remaining months largely class B. March was historically class B but for the past two years has been awarded A classification.

Table 10.1 Loch Ryan, (native oyster) classification history

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
				B	B	B	B	B	B	B	B	B
2007	B	B	B	B	B	B	B	B	B	B	B	B
2008	A	A	B	B	B	B	B	B	B	B	B	B
2009	A	A	B	B	B	B	B	B	B	B	B	B
2010	A	A	B	B	B	B	B	B	B	B	B	B
2011	A	A	B	A	B	B	B	B	B	B	B	B
2012	A	A	A	B	B	B	B	B	B	B	B	B
2013	A	A	A									

The Loch Ryan North razor clam production area (DG 500 866 16), which lies adjacent immediately to the north, was classified in November 2010 and declassified in April 2012.

11. Historical *E. coli* Data

11.1 Validation of historical data

Results for all samples assigned against the Loch Ryan production area for the period 01/01/2007 to the 28/02/2013 were extracted from the FSAS database and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data. The data was extracted from the database on 28/02/2013. All *E. coli* results were reported as most probable number (MPN) per 100g of shellfish flesh and intravalvular fluid. Due to the small number of samples associated with the Leffnoll Point site, for the purposes of statistical analysis results from both the Leffnoll Point and Loch Ryan sites have been collated.

Nine samples were recorded in the database as 'rejected' and were deleted. Forty-four samples were collected and delivered to the laboratory within the 48 hr limit, and all box temperatures were <8^{o}C. Six samples had an *E. coli* level of <20, so were assigned nominal values of 10 *E. coli* MPN/100 g for the purposes of graphical representation and statistical analysis.

11.2 Overall geographical pattern of results

Sample locations for the Loch Ryan site all plot at the RMP (NX 072 652). This location was only reported to the nearest 100 m. Locations of results taken at the Leffnoll Point site were only verified for two samples, the locations of which were reported to the nearest 10 m. The locations of all samples for which geographic location was reported are shown in Figure 11.1. No analysis of geographic variation in results was possible as the large majority of results were reported against the nominal RMP.

Figure 11.1 Locations of native oyster sampling at Loch Ryan

11.3 Summary of microbiological results

The validated historical monitoring results since 2007 are summarised below in Table 11.1.

Table11.1 Summary of historical sampling and results.

Sampling summary		
Production area	Loch Ryan	
Site	Leffnoll Point	Loch Ryan
Species	Native oyster	
SIN	DG-191-174-12	DG-191-175-12
Location	Various & unverified	Various
Total no. of samples	9	42
No. 2007	-	3
No. 2008	-	7
No. 2009	-	9
No. 2010	-	10
No. 2011	-	10
No. 2012	7	3
No. 2013	2	-
Results summary		
Minimum	<20	
Maximum	1300	
Median	155	
Geometric mean	125	
90 percentile	490	
95 percentile	790	
No. exceeding 230 MPN/100g	19 (45%)	
No. exceeding 1000 MPN/100g	1 (2%)	
No. exceeding 4600 MPN/100g	0	
No. exceeding 18000 MPN/100g	0	

The sampling rate across years varied at both sites, with the majority of samples attributed to DG-191-175-12. Nearly half (45%) of samples had a result exceeding 230 *E. coli* MPN/ 100 g, with the highest result at 1300 *E. coli* MPN/ 100 g. The results for the two sites were combined for further analyses.

11.4 Overall temporal pattern of results

A scatterplot of combined native oyster *E. coli* results for Loch Ryan and Leffnoll Point sites are plotted against date in Figure 11.2. The dataset is fitted with a lowess trend line. Lowess trendlines allow for locally weighted regression scatter plot smoothing. At each point in the dataset an estimated value is fitted to a subset of the data, using weighted least squares. The approach gives more weight to points near to the x-value where the estimate is being made and less weight to points further away. In terms of the monitoring data, this means that any point on the lowess line is

influenced more by the data close to it (in time) and less by the data further away. The trend line helps to highlight any apparent underlying trends or cycles.

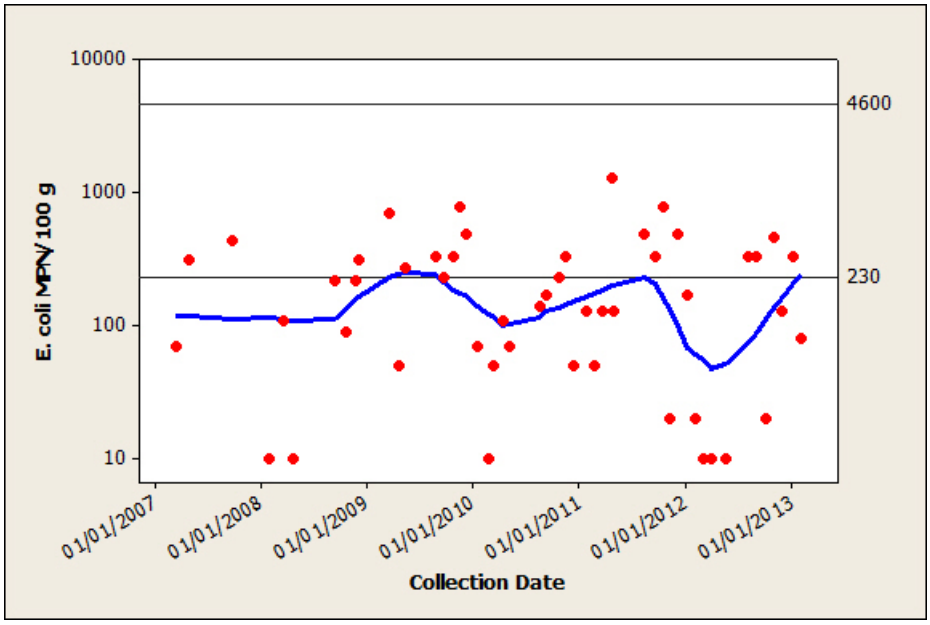


Figure 11.2 Scatterplot of shellfish *E. coli* results by date with lowess line

Overall the level of contamination in native oysters at Loch Ryan varied with time, but with no distinctly evident annual or seasonal patterns. As shown by the lowess line there are two periods where *E. coli* levels dip in 2010 and 2012. These dips are caused by the majority of results recorded <230 *E. coli* MPN/ 100 g. Two peaks in contamination levels are also shown in 2009 and 2011. During these periods there was an increase in results >230 *E. coli* MPN/ 100 g and an absence of very low results.

11.5 Seasonal pattern of results

Season dictates not only weather patterns and water temperature, but livestock numbers and movements, presence of wild animals and patterns in human distribution. All of these can affect levels of microbial contamination, causing seasonal patterns in results. Figure 11.3 presents native oyster *E. coli* results by month, overlaid with a lowess line to highlight trends.

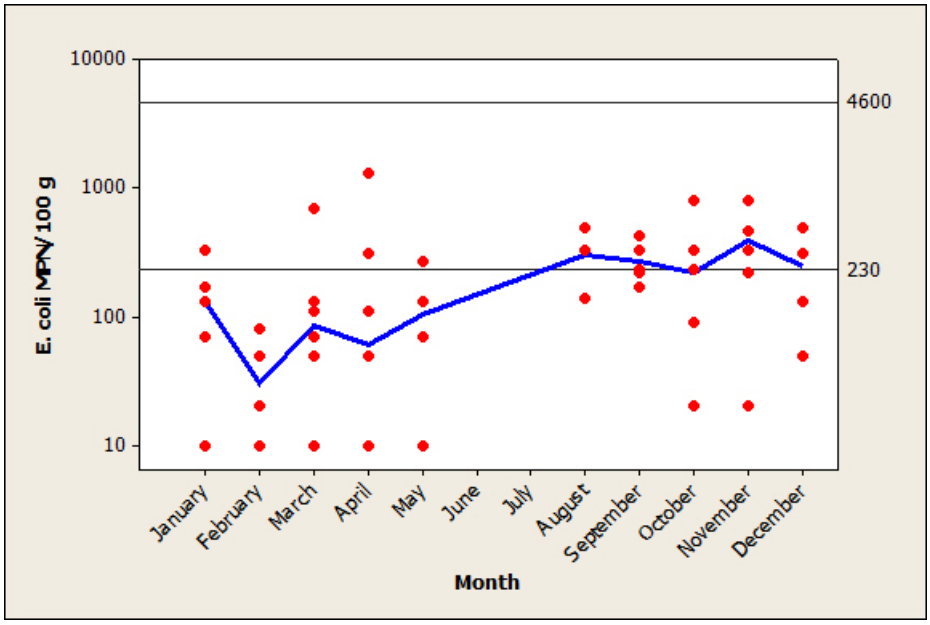


Figure 11.3 Scatterplot of shellfish *E. coli* results by month with lowess line

The trend line shows a step increase in contamination levels between May and August. However, no results were reported in June and July and therefore contamination levels during these months cannot be inferred from the figure. All of the results obtained in February were <100 *E. coli* MPN/100 g. No results <100 *E. coli* MPN/100 g occurred in August or September.

For statistical evaluation, seasons were split into spring (March-May), summer (June-August), autumn (September-November) and winter (December-February). Figure 11.4 presents a boxplot of native oyster *E. coli* results by season.

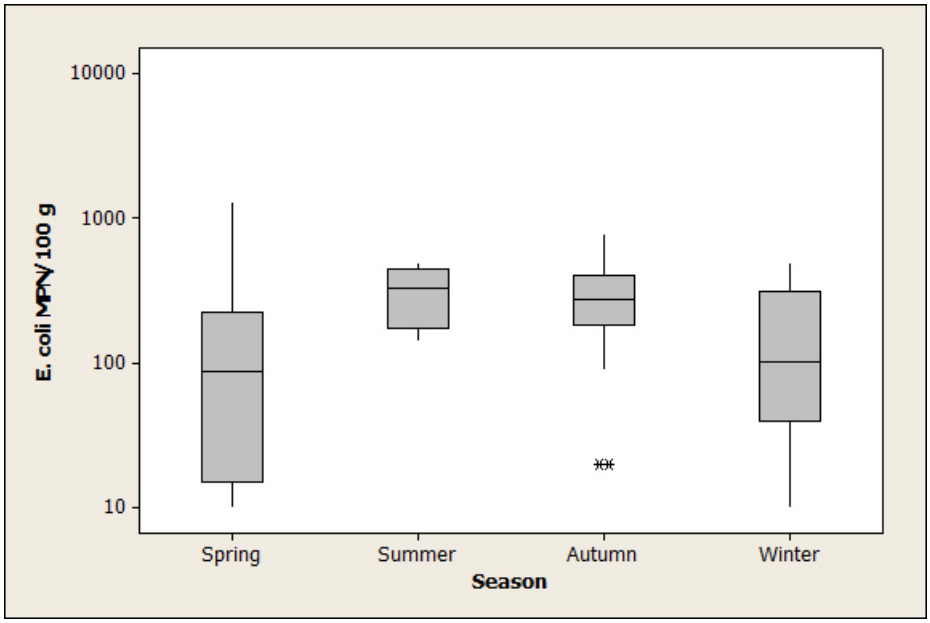


Figure 11.4 Boxplot of shellfish *E. coli* results by season

Summer results include three results from August only (due to the lack of sampling in June and July) , and therefore should not be taken as representative of

contamination levels in the summer months. No significant difference was found between results by season (one-way ANOVA, p = 0.060, Appendix 4).

11.6 Analysis of results against environmental factors

Environmental factors such as rainfall, tides, wind, sunshine and temperature can all influence the flux of faecal contamination into growing waters (Mallin, et al., 2001; Lee & Morgan, 2003). The effects of these influences can be complex and difficult to interpret. This section aims to investigate and describe the influence of these factors individually (where appropriate environmental data is available) on the sample results using basic statistical techniques.

11.6.1 Analysis of results by recent rainfall

The nearest weather station with available rainfall data was at Castle Kennedy, approximately 6.3 km southeast of the production area. Rainfall data was purchased from the Meteorological Office for the period of 01/01/2007 – 31/08/2012 (total daily rainfall in mm). Data was extracted from this for native oyster between 01/01/2009 – 31/08/2012 and data was missing for three of these days. The six samples taken after 31/08/2012 were not included as rainfall data was not available.

Two-day rainfall

Figure 11.5 presents a scatterplot of native oyster *E. coli* results against total rainfall recorded on the two days prior to sampling.

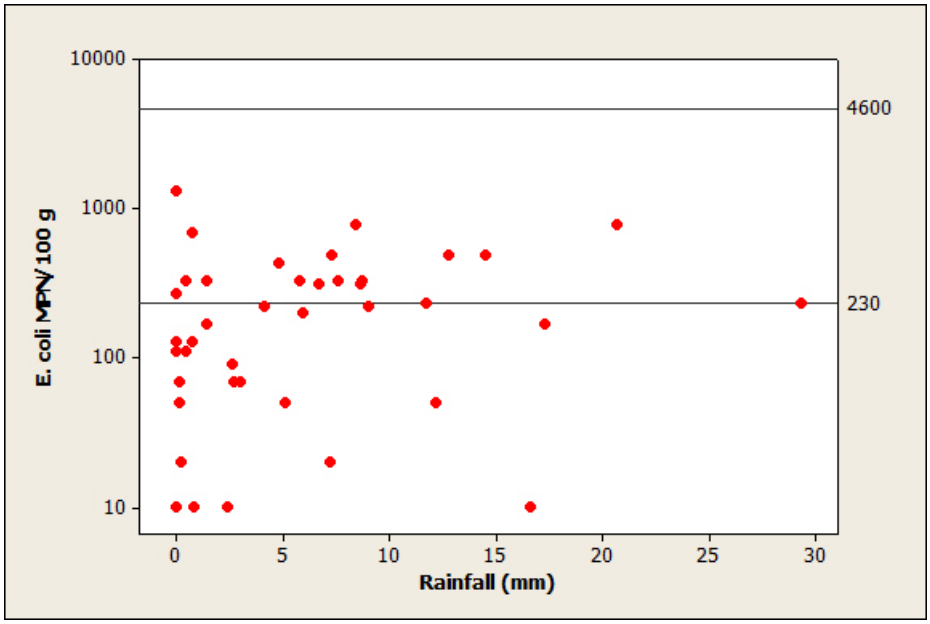


Figure 11.5 Scatterplot of shellfish *E. coli* results against 2-day rainfall

A significant correlation was found between the native oyster results and previous two-day rainfall (Spearman's rank correlation r = 0.350, p = 0.023). This appears to

be largely due to a decrease in the number of low results with increasing rainfall levels. The highest result overall occurred during dry weather.

Seven-day rainfall

The effects of heavy rainfall may take differing amounts of time to be reflected in shellfish sample results in different systems, the relationship between rainfall in the previous seven days and sample results was investigated in an identical manner to the above. Figure 11.6 presents a scatterplot of native oyster *E. coli* results against total rainfall recorded for the seven days prior to sampling.

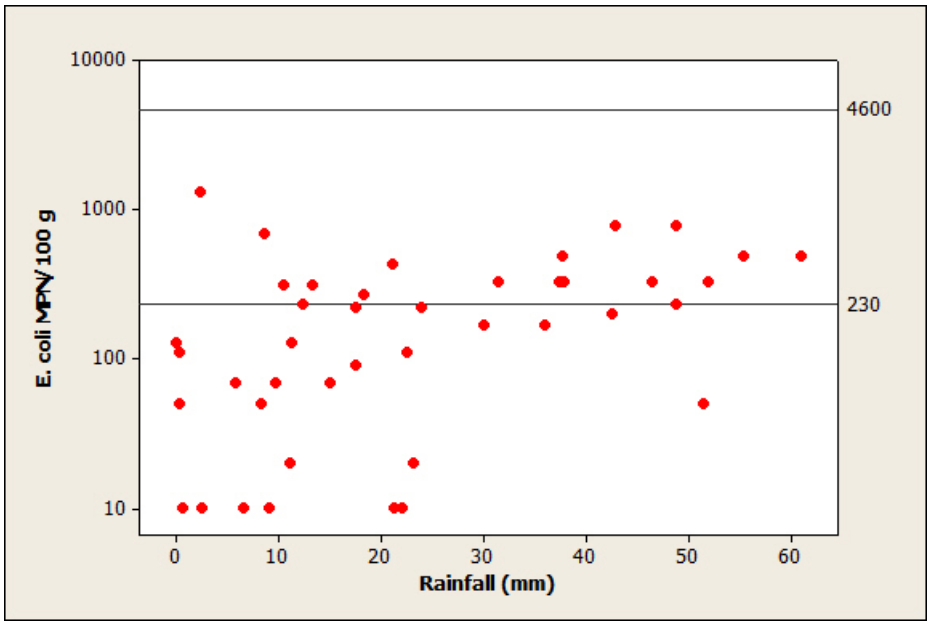


Figure 11.6 Scatterplot of shellfish *E. coli* results against 7-day rainfall

A significant correlation was found between the native oyster results and the previous seven-day rainfall (Spearman's rank correlation r = 0.482, p = 0.001). Again, this appears to be largely due to a decrease in the number of low results with increasing rainfall levels. Analysis of results by tidal cycle

11.6.2 Analysis of results by tidal cycle

Spring/neap tidal cycle

Spring tides are large tides that occur fortnightly and are influenced by the state of the lunar cycle. They reach above the mean high water mark and therefore increase circulation and particle transport distances from potential contamination sources on the shoreline. The largest spring tides occur approximately two days after the full moon, shown at about 45^{o}, then decreases to the smallest neap tides at about 225^{o}, before increasing back to spring tides. Figure 11.7 presents a polar plot showing native oyster *E. coli* results against the lunar cycle**.** It should be noted local meteorological conditions (e.g. wind strength and direction) can also influence tide height, but are not taken into account in this section.

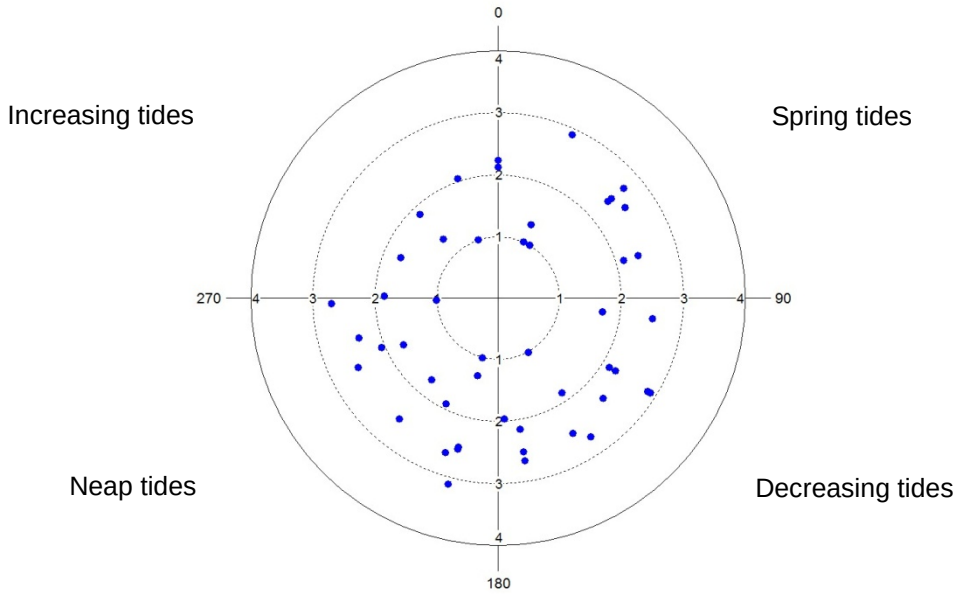


Figure 11.7 Polar plots of shellfish Log_{10} *E. coli* results on the spring/neap tidal cycle

A significant correlation was found between native oyster log_{10} *E. coli* results and the spring/neap tidal cycle (circular-linear correlation r = 0.34, p = 0.004). Lower *E. coli* results were generally seen with increasing tides, but not spring or neap tides.

High/low tidal cycle

Tidal state (high/low tide) changes the direction and strength of water flow around production areas. Depending on the locations of contamination sources, tidal state may cause marked changes in water quality in the vicinity of the farms. Figure 11.8 presents a polar plot showing native oyster *E. coli* results against lunar tidal cycle, where high water is shown at 0^o and low water at 180^o.

High and low water data from Stranraer was extracted from POLTIPS-3 in February 2013. This site was the closest to the production area and it is assumed that tidal flow will be very similar between sites.

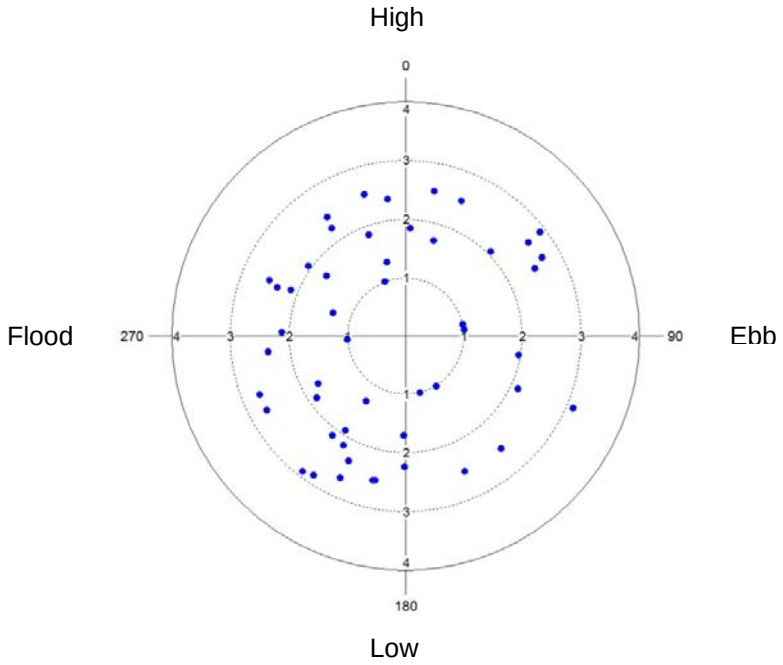


Figure 11.8 Polar plots of shellfish log_{10} *E. coli* results on the high/low tidal cycle

No significant correlation was found between native oyster log_{10} *E. coli* results and the high/low tidal cycle (circular-linear correlation r = 0.061, p = 0.84).

11.6.3 Analysis of results by water temperature

Water temperature can affect survival time of bacteria in seawater (Burkhardt, et al., 2000). It can also affect the feeding and elimination rates in shellfish and therefore may be an important predictor of *E. coli* levels in shellfish flesh. Water temperature is closely related to season, therefore any correlation between temperatures and *E. coli* levels in shellfish flesh may therefore not be directly attributable to temperature, but to the other factors e.g. seasonal differences in livestock grazing patterns. Only eight of the 51 samples had an associated water temperature reading, therefore it was not appropriate to undertake further analysis of results by water temperature.

11.6.4 Analysis of results by salinity

Salinity will give a direct measure of freshwater influence and hence freshwater borne contamination at a site. Figure 11.9 presents native oyster *E. coli* results against salinity, where salinity was recorded for 39 of the 51 samples. Jittering of sampling points was conducted at X axis: 0.200 and Y axis 0.001 to allow for the majority of data points to be displayed in Figure 11.9.

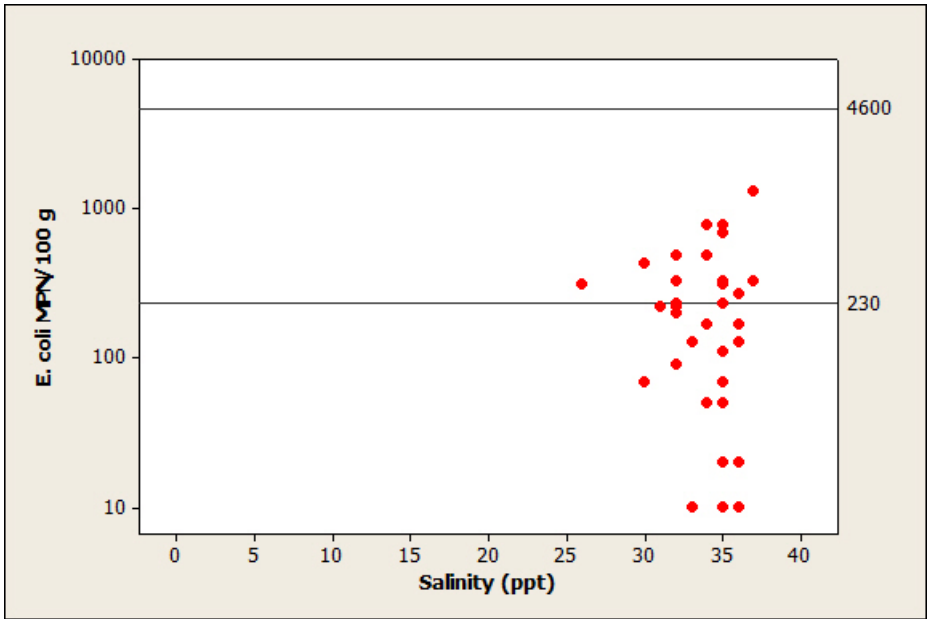


Figure 11.9 Scatterplot of shellfish *E. coli* results against salinity

No statistically significant correlation was found between native oyster *E. coli* results and salinity (Spearman's rank correlation r = -0.179, p = 0.275). Reported salinities were tightly clustered around 35 ppt.

11.7 Evaluation of results over 230 *E. coli* MPN/100g

Table 11.2 shows historic combined *E. coli* results >230 *E. coli* MPN/100 g for Loch Ryan and Leffnoll Point.

Table 11.2 Historic *E. coli* sampling results >230 *E. coli* MPN/100 g

Collection date	*E. coli* (MPN/ 100g)	Location	2 day rainfall (mm)	7 day rainfall (mm)	Water Temp (°C)	Salinity (ppt)	Tidal state (high/low)	Tidal state (spring/neap)
23/04/2007	310	Loch Ryan	8.6	13.3	-	26	High	Ebb
19/09/2007	430	Loch Ryan	4.8	21.1	-	30	High	Neap
11/12/2007	310	Loch Ryan	0.5	46.3	-	30	Low	High
16/03/2009	700	Loch Ryan	0.7	8.6	-	35	Ebb	Neap
11/05/2009	270	Loch Ryan	0	18.3	-	36	High	Increasing
24/08/2009	330	Loch Ryan	1.4	46.5	-	37	Ebb	Increasing
26/10/2009	330	Loch Ryan	8.7	31.5	-	35	Low	Increasing
17/11/2009	790	Loch Ryan	8.4	42.9	-	34	High	Spring
08/12/2009	490	Loch Ryan	12.8	61	-	32	Ebb	Neap
15/11/2010	330	Loch Ryan	0.4	52	-	32	Low	Spring
26/04/2011	1300	Loch Ryan	0	2.3	-	37	Low	Decreasing
15/08/2011	490	Loch Ryan	7.3	55.4	-	34	High	Neap
19/09/2011	330	Loch Ryan	7.6	37.8	-	32	Ebb	Neap
17/10/2011	790	Loch Ryan	20.7	48.8	-	35	Ebb	Neap
06/12/2011	490	Loch Ryan	14.5	37.7	-	32	Low	Increasing
06/08/2012	330	Leffnoll Point	5.8	37.4	18	-	Ebb	Decreasing

Collection date	*E. coli* (MPN/ 100g)	Location	2 day rainfall (mm)	7 day rainfall (mm)	Water Temp (^{o}C)	Salinity (ppt)	Tidal state (high/low)	Tidal state (spring/neap)
03/09/2012	330	Leffnoll Point	-	-	15	-	High	Neap
05/11/2012	460	Leffnoll Point	-	-	8	-	Ebb	Neap
07/01/2013	330	Leffnoll Point	-	-	12	-	Low	Decreasing

Elevated *E. coli* sample results reported at Loch Ryan varied between 270 and 1300 *E. coli* MPN/100 g. The majority of samples were taken at Loch Ryan's RMP, with only two of the samples taken for Leffnoll Point with verified national grid references. The highest numbers of elevated results were taken in 2009, compared to only one sample in 2010. No elevated results were recorded from 2008. The majority of elevated results occurred from August to December.

Rainfall over the previous two and seven days to sampling appears varied between 0.0-20.7 mm for the two days and 2.3-61.0 mm for the seven days. The result with the highest *E. coli* level had the lowest two- and seven-day rainfall levels recorded. Temperature was only recorded for the four Leffnoll Point samples, and varied from 8 and 18^{o}C. Salinity was recorded for most of the results and ranged between 32 and 37 ppt. Elevated results occurred during all tidal states.

11.8 Summary and conclusions

The highest results were predominantly seen between August and October, with results in February all recorded as <100 *E. coli* MPN/100 g. No statistically significant difference was seen between seasons. A significant difference was found between results and two-day rainfall and between seven-day rainfall, with higher results associated with higher levels of rainfall. Statistical analysis of correlation between water temperature and results was not possible due to insufficient samples. No significance was found between salinity and *E. coli*. A statistically significant correlation was found between results and tidal state (spring/neap), with lowest results taken on increasing tides. No significant correlation was found between results and high/low tidal state. A spatial assessment of the sampling data could not be undertaken due to the majority of samples being identified at the nominal RMP.

12. Designated Shellfish Growing Waters Data

The Loch Ryan designated Shellfish Waters comprises the waters lying south of a line from Milleur Point to Finnarts Point, extending to MHWS. The area was designated in 1999 and has been monitored by SEPA since then. Under the Shellfish Waters Directive (European Communities, 2006), designated waters must be monitored quarterly for faecal coliforms in the shellfish flesh and intervalvular fluid, as well as for a variety of chemical parameters. SEPA is responsible for ensuring that this monitoring is undertaken, and have used common mussels for this purpose. Sampling for faecal coliforms in mussels was undertaken at the Loch Ryan, Soleburn monitoring point (NX 0360 6450).

The relative positions of the Shellfish Growing Waters (SGW) boundary, the Loch Ryan production area, RMP and the SGW monitoring point are shown in Figure 12.1. SEPA ceased quarterly faecal coliform monitoring in early 2007, and since then has used FSAS *E. coli* data to assess compliance. The last faecal coliform result provided from Soleburn mussel sampling point, from 15/01/2007, gave a result of 11000 *E. coli* (MPN/ 100g). The result suggests that mussels in the area of Sole Burn can be subject to substantial faecal contamination.

The area failed to comply with Guideline standards for faecal coliforms (≤300 faecal coliforms/100 ml flesh and intravalvular fluid) in most years up to 2010, though it passed in 2008 and in 2010. Shellfish hygiene monitoring results from 2011-2012 showed failure to meet the guideline standard in those years, as well.

The SGW site report for Loch Ryan (last updated 14/06/2011) identified that diffuse pollution from agriculture, abundant bird populations and urban surface water runoff as well as point source discharges from a cheese processing facility and the sewerage network all contributed to faecal contamination levels found in the loch.

Shellfish growing waters are currently under review by SEPA and Scottish Government, and the boundaries of the Loch Ryan SGW may be amended as part of that process. SEPA aim to have a Parliamentary Order in force by December 2013, outlining the new designations, in time for the repeal of the Shellfish Waters Directive.

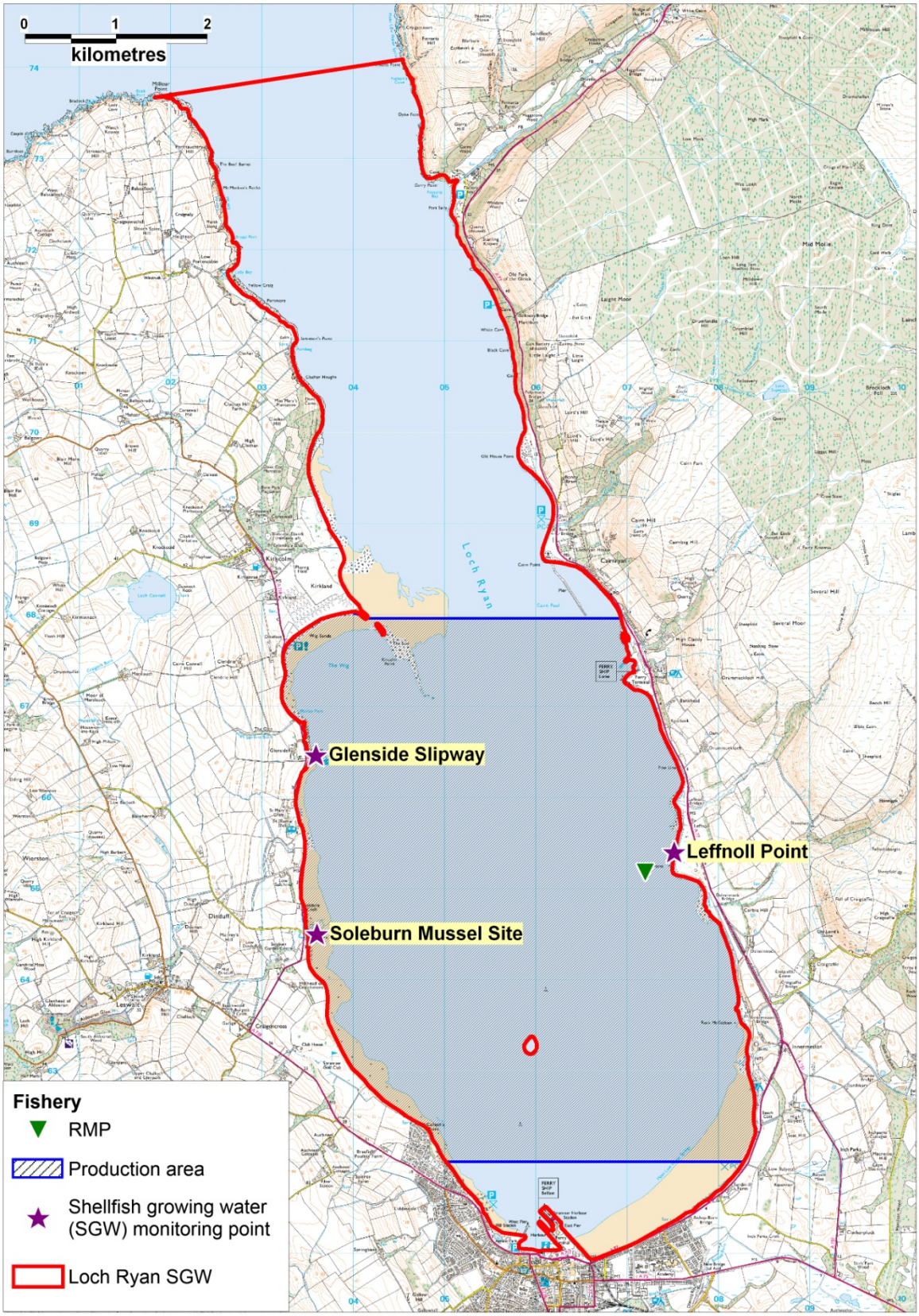


Figure 12.1 Designated shellfish growing water – Loch Ryan

13. Bathymetry and Hydrodynamics

13.1 Introduction

13.1.1 The Study Area

Loch Ryan is situated in the south west of Scotland. It is a large but shallow natural harbour angled on a north-south axis with its northern mouth adjacent to the Firth of Clyde. It is the most southerly situated Scottish sea loch. The environment creates a sheltered and calm location and the loch is used as the main shipping route between Scotland and Northern Ireland principally operating from Cairnryan situated on the eastern shore of the loch. From the west, Loch Ryan is bounded by the hammerhead peninsula of the Rhins of Galloway. To its eastern boundary is the Scottish landmass consisting of Galloway and South Ayrshire. Stranraer lies at the head of Loch Ryan and is the principle town in the area. The mouth of the loch is located between Milleur Point and Finnarts Point. A number of small rivers discharge into the Loch. The study area is shown in Figure 13.1 and the assessment area is contained within the yellow line.

Coordinates for the middle of Loch Ryan:
54° 56.6’ N 005° 2.03’ W
NX 05777 65307

Figure 13.1 Extent of hydrographic study area

13.2 Bathymetry and Hydrodynamics

13.2.1 Bathymetry

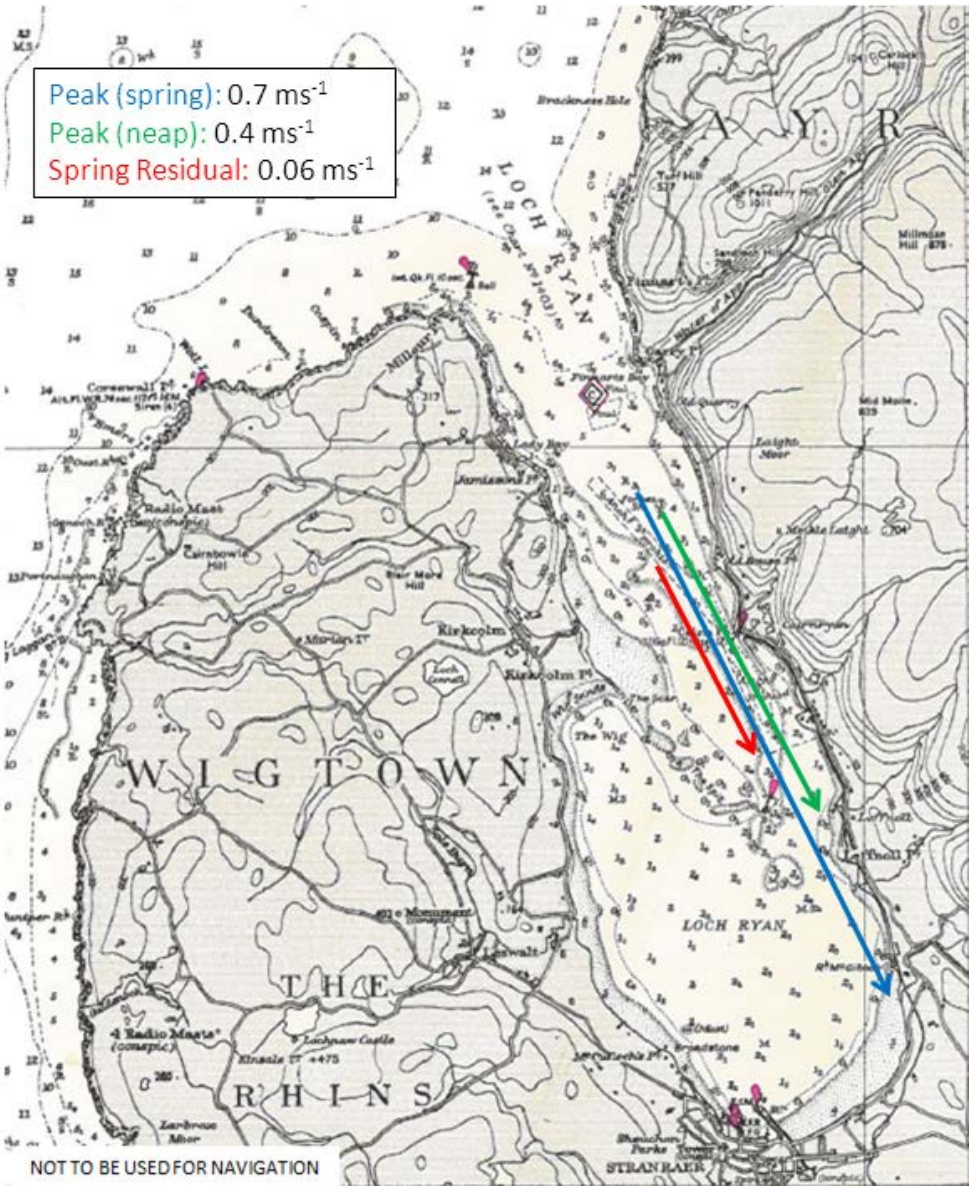


Figure 13.2 Admiralty chart (1403) extract for Loch Ryan. Note that the length of the flow arrows approximately equate with the transport distance during the flood phases of the tide where the peak flow occurs.

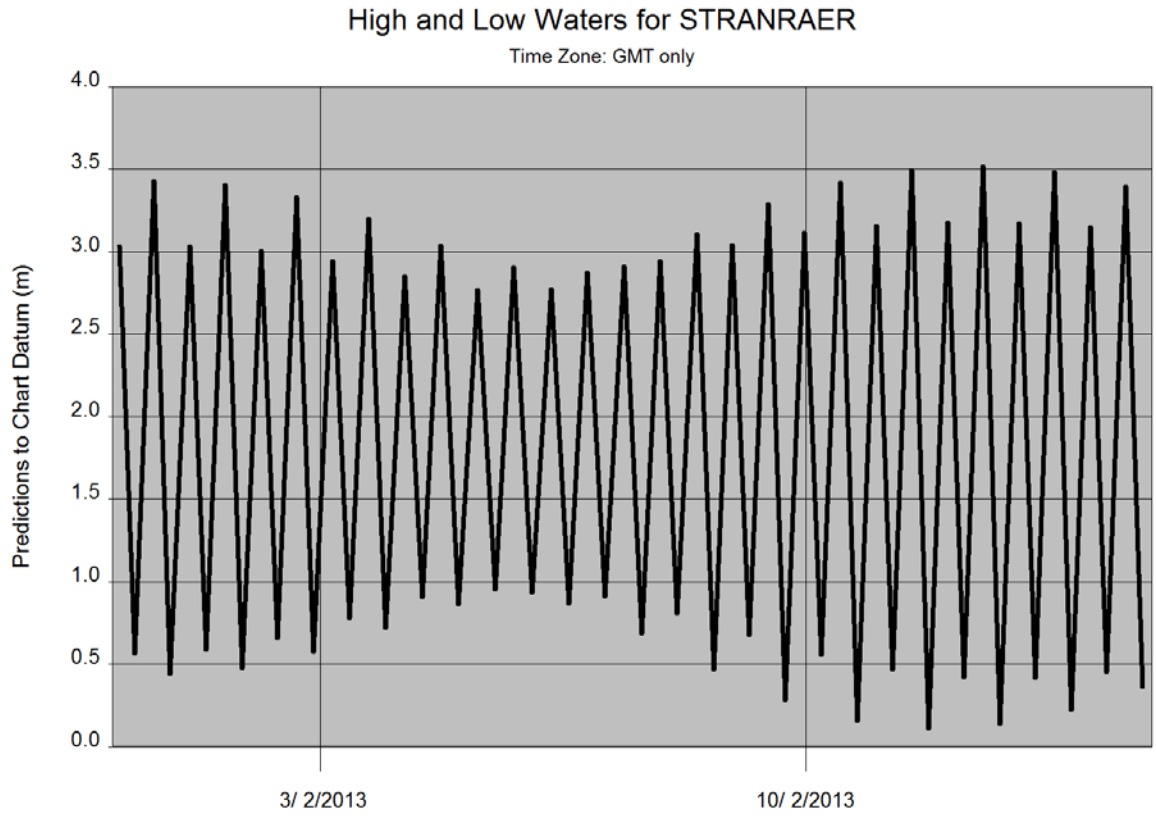
Figure 13.2 shows the bathymetry of Loch Ryan. The maximum depth is 16 m near the entrance although much of the loch is < 5 m. It has a single basin and one sill which is 3450 m in length with a charted depth of 7 m. The loch has a total length of 13.4 km with a maximum width of 4.8 km and a minimum width of 1.5 km. The average width is approximately 3 km with an estimated mean low water depth of 4.7 m (Edwards & Sharples, 1986). Therefore the estimated low water volume is approximately 1.9×10^8 m^3. The loch is generally deeper to the north and north east where it is steep sided with depths increasing to around 8 – 12 m within 50 – 150 m

from the shore. Elsewhere the gradients from the shore to inner reaches of the loch are more gradual. To the south of the loch there is a large estuary area which consists of a muddy intertidal zone of around 700 km in width. Continuing northwards to Kirkcolm, the western coast of Loch Ryan is composed of sheltered sand and gravel beaches.

13.2.2 Tides

Loch Ryan has a typical semi-diurnal tidal characteristic. Data on tidal information is given from charted information. The nearest location for tidal predictions is Stranraer [http://easytide.ukho.gov.uk].

Standard tidal data for Loch Ryan are given below (from Admiralty Surveys) and the spring/neap cycle of tidal height around the time of the planned survey (early February 2013) is shown in figure 13.3:



Reproduced from Poltips3 [www.pol.ac.uk/appl/poltips3]

Figure 13.3 Two week tidal curve for Loch Ryan.

Tidal Heights at Stranraer:
Mean High Water Springs = 2.8 m
Mean Low Water Springs = 0.06 m
Mean High Water Neaps = 2.3 m
Mean Low Water Neaps = 0.4 m
Tidal Ranges:
Mean Spring Range = 2.74 m
Mean Neap Range = 1.9 m

This gives a tidal volume of water during each tidal cycle of approximately:
Springs: 1.1×10^8 m^3
Neaps: 7.6×10^7 m^3

13.2.3 Tidal Streams and currents

There are no accessible current meter records available from SEPA, British Oceanographic Data Centre (BODC) or records collected by SAMS. There is a tidal diamond in the north of the area between Lady Bay and Finnarts Bay. There is also another diamond in the main channel to the west of Cairnryan. It is from this later diamond that the following statements on streams are derived although given the prevalence of spits, banks and channels, the flow characteristics of Loch Ryan will be rather variable throughout the loch. In addition, it should be remembered that data at tidal diamonds may only be relatively crude indications of flow characteristics derived from short current records (e.g. Bell & Carlin, 1998).

The flow is aligned along the axis of the loch approximately $300^o/145^o$. The flood tide flows generally southeast (SE) and the ebb flows northwest (NW) with maximum rates of 1.3 knots (0.7 ms^{-1}) at springs and 0.8 knots (0.4 ms^{-1}) at neaps, shown in Figure 13.2. There will be variations to these values across the assessment area in the vicinity of spits and banks. The tidal flow is typically rectilinear (back and forth) rather than elliptical suggesting it is strongly constrained by the bathymetry.

In Loch Ryan, off Cairnryan, the cumulative transport that might be expected during each phase of the tide is approximately 8 km (springs) and 5 km (neaps).

A residual flow in Loch Ryan has been estimated using the tidal diamond data. The tidal diamond provides a drift rate and direction for each hour of the tide. By summing the vectors for both spring flow and neap flow it is possible to calculate the residual flow, or net flow, over a tidal cycle. At neaps the residual flow is 1.5 km to the SE, at springs the residual flow amounts to a displacement of 2.4 km to the SE over the tidal cycle giving residual current speeds of approximately 0.03 m/s and 0.06 m/s respectively. The transport over a tidal cycle of the spring residual is shown on Figure 13.2. The residual demonstrates a strong asymmetry between inflow and outflow which may be related to the presence of a shallow spit to the west which would tend to intensify the inflow in the channel at periods of low water.

Dispersion is an important property of a water body with respect to redistribution of contaminants over time. There are no measurements or published data relating to dispersion in Loch Ryan. However, given the occurrence of banks and spits in the loch it is anticipated that there would be rather active eddies increasing dispersion rates in this site.

Loch Ryan is open to swell waves which have their origin in the North Atlantic and the North Channel between Northern Ireland and Scotland. These swell waves are generally from the direction of 340^{o} and they are most prevalent on the eastern and western coastlines of the northern part of the loch. They can have a period of around 12 to 15 seconds and are often enhanced by the addition of shorter waves created in the Firth of Clyde and the North Channel. South-easterly winds create some localised waves that generally have a period of around 4 to 5 seconds (Bell, et al., 2000)

13.2.4 River/Freshwater Inflow

There are several rivers surrounding Loch Ryan which may or may not flow depending on the season and weather. The Water of App flows in from Finnart Bay to the north east of the area. Next to this, there is the smaller Galloway Burn and further south is Glen Burn which flows into the loch from Cairn Point. Four more rivers are situated on the east of the site, Claddy House Burn, Several Burn, Beach Burn and Kirclachie Burn. Bishop Burn is the most southerly river. On the west side, Soleburn, Loch Connell and several other unnamed rivers also flow into the loch. The annual precipitation in the area is approximately 1100 mm and the annual freshwater runoff is estimated as 167 Mm^3yr^{-1} (Edwards & Sharples, 1986). The ratio of freshwater flow to tidal flow ratio in Loch Ryan is low at approximately 1:330 and therefore the input of freshwater has rather little influence over the salinity of the loch which is generally around 33 psu (SEPA, 2011), though this will likely have considerable seasonal variability.

13.2.5 Meteorology

The meteorological section for this area indicates that the prevailing winds and the strongest winds are found in the SW quadrant. Loch Ryan is sheltered from prevailing south westerly winds due to the natural north facing aspect. However, there may be some intensification in surface flow during periods of strongest winds from the south. Northerly winds are shown to be rather uncommon.

13.2.6 Model Assessment

The exchange characteristics of Loch Ryan were assessed using a layered box model approach. The model represents the Loch as a box made up of three layers and was formulated according to the method of Gillibrand et al (2012). The box layers are forced with surface wind stress, estimates of fresh water discharge, surface heat flux parameters and, at the open coastal boundary, profiles of

temperature and salinity are prescribed from climatology compiled by the UK Hydrographic Office. This sets the model with climatological boundary conditions to represent an 'average' year. The model was tuned and validated for Lochs Creran and Etive though a full validation for Loch Ryan has not been done due to lack of seasonal data.

The box model quantifies the primary exchange mechanisms. The key outputs from the model with respect to this hydrographic assessment are a series of annual mean values that describe the relative importance of the estuarine (gravity) exchange, tidal exchange, exchange between the layers and the flushing time, which is the inverse of the exchange rate. These values are given in Table 13.1

Table 13.1 Summary of annual mean parameter values from the box modelling exercise.

Parameter	Value
Tidal Volume Flux (m3 s-1)	458
Estuarine Circulation Volume Flux (m3 s-1)	49
Wind Driven Entrainment between upper and lower layer (m3 s-1)	1.4
Tidal and Density driven entrainment between upper and lower layers (m3 s-1)	1.3
Median Flushing Time (days)	4.4
95%-ile Flushing Time (days)	7.1

The ratio of tidal volume flux to estuarine circulation volume flux is 9.4. Values greater than 2 indicate a system that is strongly tidal in its exchange characteristics (Gillibrand, et al., 2012).

13.3 Hydrographic Assessment

13.3.1 Surface flow

The site and the meteorological data indicate that there is likely to be a rather steady freshwater discharge into the surface waters of the loch, though the absolute value of discharge would be seasonally varying. The distribution of fresh water sources is spread around the perimeter of the loch, rather than concentrated at its head. Therefore, it is unlikely that a well-developed estuarine flow would be established. Rather there would be generally weak surface flows of rather uncertain strength and direction.

In the deeper channels of the loch, there is a dominant tidal flow and so it is likely that this will be the greater influence on surface flows, rather than estuarine circulation. Further, the tidal discharges are concentrated in the channel to the east and this is where much of the surface flow would also be concentrated. Cumulative transport on each phase of the tide is estimated to be between 5 – 8 km.

It is likely that any surface contaminant would be transported primarily along the axis of the loch but with the potential for some dispersion as the flow encounters shallows and spits.

The dominance of the south west winds, although sheltered, will likely enhance any surface flows during periods of strong wind.

13.3.2 Exchange Properties

The key aspect of the model output in terms of the exchange is that the tidal volume flux dominates the estuarine (or gravitational) volume flux by a factor of 9.4. This means that exchange of waters in Loch Ryan is principally a tidally driven process. Hence there is likely to be rather little seasonal variation in the flushing time of the Loch. The model predicts that 95% of the time the flushing time will be 7.1 days or less.

It is expected that Loch Ryan would be a moderately-well flushed system throughout most of the year with surface contaminants being effectively dispersed in the residual flow.

There are no data available from current meters for Loch Ryan and there is a paucity of any measured hydrographic data. However, there is sufficient ancillary data derived from interpolated data sets to set up the layered box model with the caveat that it is not validated. Therefore the confidence level of this assessment is LOW.

14. Shoreline Survey Overview

The shoreline survey was conducted on the 19th and 20th February 2013. No precipitation fell in the 48 hours prior to survey, or on the two survey days. On the first day of sampling temperatures ranged between -2 to 6°C, with clear skies and a calm sea state. The second day was cloudy with 30-40 km/hr winds in an S/SE direction. Air temperature was 4°C and the sea state turned from fairly calm to choppy during early afternoon.

The fishery is comprised of one native oyster bed (*Ostrea edulis*) which is fished at two distinct locations: Leffnoll Point on the east side of the loch and the Loch Ryan site roughly across from this area on the west side of the loch. Fishing is seasonal from September to the end of April for seven days a week.

Public sewerage systems have recently been upgraded to re-direct sewage from the densely populated areas around Loch Ryan into a new facility at Leswalt, which will discharge outside of Loch Ryan. At present there continues to be a large number of CSOs that will discharge to Loch Ryan. These are predominantly located in the town of Stranraer. There are also many privately owned septic tanks on the land surrounding Loch Ryan.

Three major settlements are situated around Loch Ryan. Stranraer lies south, at the head of the loch, approximately 1 km from the southern boundary of the estimated oyster bed. Two smaller settlements; Cairnryan and Kirkcolm, are located east and north-west respectively. Dwelling houses and several farms are also dotted between these settlements. Hotels, B&Bs, guest houses and cafés/restaurants were all noted in the three settlements, plus two caravan/camping sites were also observed; Ryan Bay Holiday Park located near the head of the loch and Wig Bay Holiday Park is located on the west. These are all likely to have a peak season during the summer months, which will also lead to an increase in faecal loadings. Through discussions held with a member of staff at Ryan Bay Holiday Park it was revealed that the holiday parks' septic tank discharges to the large watercourse (Kirclachie Burn) that runs adjacent to the park.

Loch Ryan also contains three main piers and one smaller slipway. The Stena (P&O) ferry terminal is used for boats going to and from Ireland. The old Stena line ferry terminal at the head of the loch is no longer in use, and the ferry now operated from the new site to the north-eastern shore at Cairnryan. Works are still on-going. A pontoon is also located at the head of the loch and contains fishing boats. Approximately 10 fishing boats including a dredger were noted in operation on the first day of the survey. The Loch Ryan Sailing Club is located on the north-west shoreline. No boats were moored on the water at the time of the survey, although approximately 6 sailing yachts were on land next to the club house.

Land surrounding Loch Ryan is largely agricultural. Farmland did not seem to be concentrated to any one side of the loch and was seen on all sides of the loch. Little livestock was observed during the shoreline survey, but included cattle, sheep and horses. A large group of 50-100 cattle were however seen on the southern shoreline at the head of the loch, close to a feeder on a farm.

Birds were the only wildlife observed during the shoreline survey and were seen on the shore on all sides of the loch as well as on the surrounding farmland. Birds included oyster catchers, geese and seagulls. Crows were also seen both on the shore and on the surrounding farmland. A particularly dense collection of seabirds including oyster catchers were observed close to the farm on the southern shoreline, east of the town of Stranraer.

Freshwater samples taken from the six watercourses sampled had varying levels of contamination between 10000 and <100 *E. coli* cfu/100 ml. A further nine freshwater samples were taken from suspected contaminated discharges. Contamination from these inputs varied hugely from <100 to 180000 *E. coli* cfu/100 ml. Seawater samples were also taken at areas expected to have high levels of contamination and levels varied hugely between 8-600 *E. coli* cfu/100 ml. Two native oyster samples were taken; one close to Leffnoll Point and one to the southwest of the estimated oyster bed. *E. coli* levels returned results of 230 and 50 *E. coli* MPN/100 g respectively. A summary map showing the most significant findings from the shoreline survey is presented in Figure 14.1.

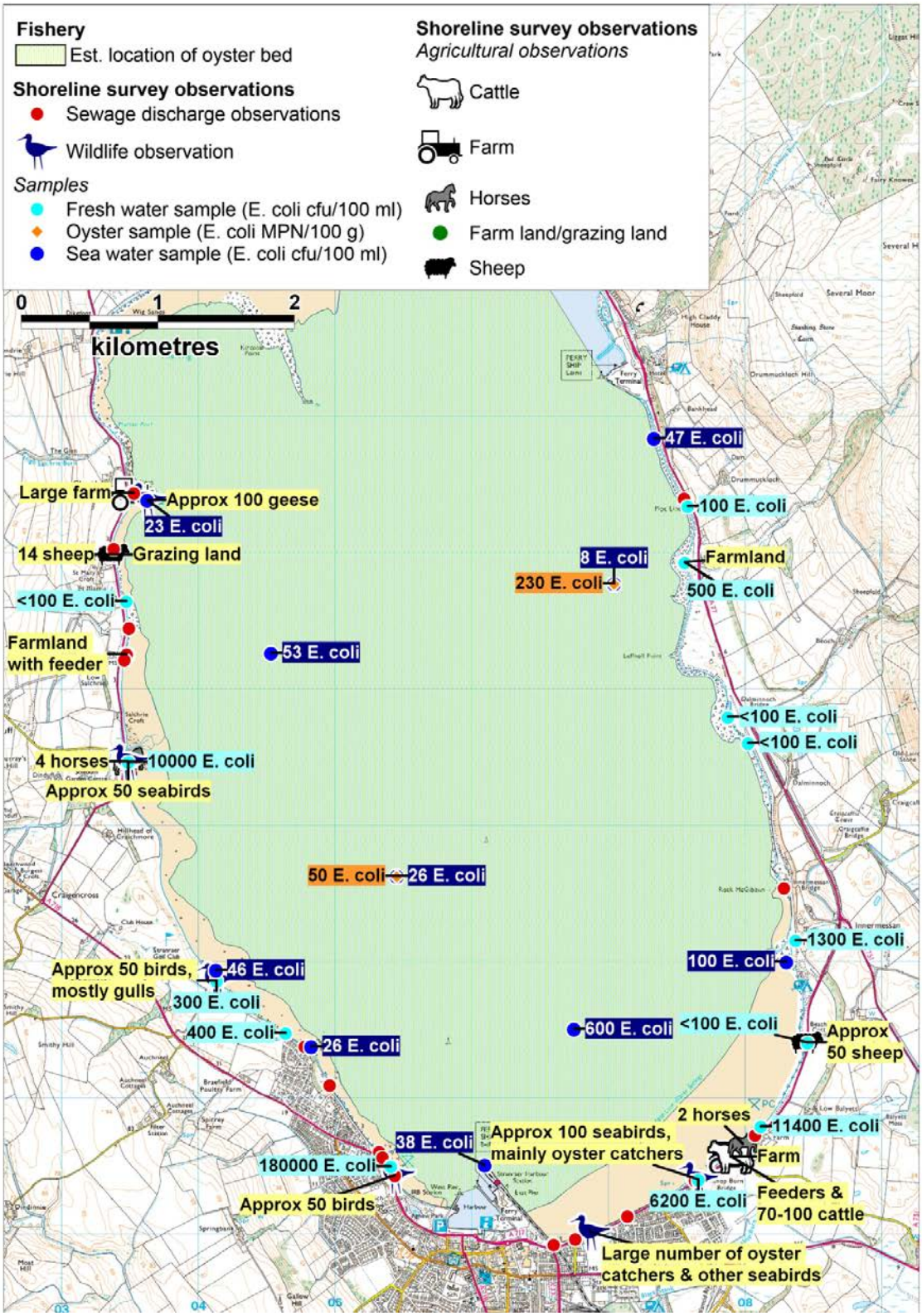


Figure 14.1 Summary of shoreline survey findings for Loch Ryan

15. Overall Assessment

Human sewage impacts

Loch Ryan has significant human population residing on its shores and also draws large numbers of visitors. The town of Stranraer and villages of Cairnryan, Kirkcolm and Leswalt have all had community wastewater provision, though in the past these have been independent works offering relatively low levels to treatment to effluent discharging into the loch. Work on a new sewerage scheme, due to be completed in 2013, combines sewage treatment for a significant proportion of the population into two facilities: one secondary treatment works at Leswalt serving Stranraer, Leswalt and Kirkcolm and discharging to the west, outside Loch Ryan and a tertiary treatment works at the Cairnryan ferry terminal serving the village and the terminal. A large number of CSOs will remain, the majority of which are situated at Stranraer and Cairnryan. A larger storm water storage facility is being built at Stranraer and it is expected that the increased capacity for holding storm flow will dramatically reduce the frequency of CSO overflows to well under 10 per year.

The CSOs at Cairnryan lie closest to the RMP and the most heavily stocked and harvested part of the oyster bed, and therefore may be more likely to contribute to faecal contamination in shellfish harvested from this area. The main outfall for the treatment works is due to be relocated to the north, just outside the production area boundary (To be confirmed with Scottish Water). As this will in future also receive tertiary treatment, it is expected to significantly reduce the impact of human sewage contamination to the most heavily utilised part of the fishery. Although tertiary treatment systems dramatically reduce bacterial concentrations in sewage, many types are less effective at removing viruses and in all cases the effectivity of treatment depends on how well the entire works is maintained.

Despite the area being served by public sewerage, a considerable number of private septic tank discharges remain in the area. The most significant of these is the large tank serving the Cairnryans Caravan Park, near the ferry terminal at Cairnryan. The septic tank has a PE of 500, and serves approximately 90 static caravans as well as park offices and facilities. This will be the largest continuous discharge to the production area after the changes to the public sewerage network have been completed. This is likely to impact the east side of the fishery near the ferry terminal. Several private discharges to Sole Burn will remain after Leswalt WWTW has been converted to a pumping station, therefore the burn will still carry some faecal contamination from sewage to the west side of the fishery.

There is significant tourist accommodation in the area, and therefore there is likely to be higher demand on the sewerage network during peak tourist periods including July-August, Easter, Christmas and school holidays. Overboard discharges of sewage waste from boats would be expected to have significant localised impacts, particularly around established moorings and some seasonality in this risk is

expected as, although fishing boats are present year round yachting activity is greater in summer months. The risk would be highest at the head of the loch and at The Wig, where visiting yachts are likely to congregate.

Operation of any of the CSOs is likely to have an impact on the oyster bed, particularly those arising from Cairnryan. Due to the large number of CSOs it is unlikely that a monthly monitoring scheme will adequately control for risks associated with intermittent discharge of screened sewage effluent.

Agricultural impacts

Outside of Stranraer, the land is used predominantly for arable agriculture and livestock grazing. Farmland was observed during the shoreline survey along the west side of the loch north of Leswalt and along the east side of the loch from east of Stranraer to just north of Lefnoll Point. Cheese production is undertaken near Stranraer and the effluent discharged to the loch. Effluent from this source has been found to contain very high concentrations of faecal bacteria, and based on the reported discharge location would affect water quality at the head of the loch most acutely.

Cattle, sheep and horses were observed around the southeastern shore of the loch, though they are likely to be present in other areas within the catchment area of the loch. Highest contribution of faecal contamination from this source is likely to be carried via watercourses around much of the loch and where livestock were seen close to shore near the head of the loch.

Anecdotal evidence of sewage sludge application to farm land around Leswalt was found in the local press, and this would be most likely to have an impact on water quality along the west side of the loch if the sludge were to be applied immediately prior to wet weather.

Wildlife impacts

The impact from wildlife sources of faecal contamination is likely to be largest from birds, particularly gulls and other shore birds that feed on the intertidal areas of the loch as well as any geese feeding on agricultural land. Highest impacts are likely around the western side of the production area from the head of the loch to The Scar. Seabirds are more prevalent in the outer loch, however significant numbers of gulls and terns nest at or near The Scar and therefore impacts from nest areas would be highest at the northwest end of the production area.

There is likely to be significant seasonal variation in the numbers and types of birds present with shorebirds and waterfowl predominating in winter and seabirds in summer. Gulls are likely to be present year round. Seals may be found throughout the Firth of Clyde, however no direct evidence was found of their presence in Loch Ryan.

Seasonal variation

No statistically significant variation in *E. coli* results was seen by season. The dataset, however, was skewed due to a lack of reported results during the months of June and July. Lowest results occurred from February through May and results greater than 230 *E. coli* MPN/100 g were found in all months sampled except February. Seasonal variation in the human population due to the large number of campsites around the area is likely to lead to increases in the amount of sewage effluent from these camps during periods of peak occupation. The presence of anchored yachts at the Wig and near Stranraer is most likely to occur during the summer months.

Rivers and streams

There is relatively little freshwater flow into Loch Ryan, though the three largest watercourses observed during the shoreline survey (Sole Burn, Bishop Burn and Kirclachie Burn) were found to carry high loadings of faecal contamination. Sole Burn drains a mixed catchment that includes the village of Leswalt and surrounding farm area and receives effluent from both private septic tanks and the CSO at Leswalt pumping station (previously Leswalt WWTW). Bishop Burn drains a mixed urban and rural catchment, receiving CSO effluent before discharging to Loch Ryan just east of Stranraer. Kirclachie Burn drains a largely rural catchment that includes Black Loch and discharges adjacent to a campground along the eastern side of the loch approximately 2 km NE of Bishop Burn. The largest observed loadings were to the east of the loch, with a significant additional loading carried to the west side near Leswalt.

Movement of contaminants

The loch is shallow, with tidal flows likely to be concentrated toward deeper channels along the east side of the loch. Surface contamination is predicted to be transported primarily along this channel, and effectively dispersed. Contamination arising from the western side of the loch is likely to be transported toward the channel before following the main axis of flow on the outgoing tide. Cumulative transport during each phase of the tide is predicted to be between 5 and 8 km. Any contamination arising from agricultural or human sources at the head of the loch would tend to be carried toward the channel on the eastern side of the loch and across the main bed area.

Temporal and geographical patterns of sampling results

The majority of samples were attributed to the RMP or were unverified, therefore it was not possible to undertaken a meaningful geographic analysis of historical monitoring results. Two oyster samples were obtained during the shoreline survey, one from north of the RMP and another toward the southeastern end of the loch.

These showed low levels of faecal contamination though a higher result was obtained from the sample taken from north of Leffnoll Point.

Over time, the levels of contamination found in native oysters in the loch have been variable, with a sharp decrease in *E. coli* results observed during early 2012 coinciding with a run of results below the limit of detection of the test (<20 *E. coli* MPN/100 g).

A statistically significant correlation was found between shellfish *E. coli* results and rainfall in the 2 and 7 days prior to sampling. This was primarily due to a decrease in the number of low results with higher rainfall. The highest result for the analysis period (1300 *E. coli* MPN/100 g) occurred during dry weather, which suggests that while rainfall dependent sources may be important in the loch, rainfall alone is not an adequate predictor of high results. A significant correlation was found between shellfish *E. coli* results and the spring/neap tidal cycle, with lower results generally seen on increasing tides but not on spring or neap tides. The reason for this is not clear.

Conclusions

Overall, Loch Ryan is subject to significant faecal contamination arising from both diffuse and point sources. Although there is public sewerage provision around the loch, there appear to be large numbers of properties remaining on private septic tanks. The majority of these discharge to soakaway, however a some discharge directly to the loch or to watercourses within the catchment for the loch. The main continuous sewage discharges will soon be diverted to a new outfall to the sea west of the loch and the sewage from Cairnryan will pass through the new UV treatment works at the ferry terminal and discharge to the loch north of the production area boundary. However, there will remain a large number of CSOs, though the frequency of spills is predicted to be less than 10 per year.

Despite improvements to the public sewerage system, there will remain significant private septic tank discharges both to the loch and to its catchment. The largest of these are located along the head of the loch and along Sole Burn, which discharges to the west side of the loch.

Diffuse contamination of watercourses and the loch itself is also significant. Streams discharging to the head of the loch in particular were found to carry substantial estimated *E. coli* loadings. The significant correlation found between shellfish *E. coli* results and rainfall suggest that rainfall dependent sources, such as diffuse runoff and the operation of CSOs, are important drivers of contamination levels at this fishery. Predicted transport of contaminants is likely to be toward the deeper channel along the east side of the loch and then NW-SE along the axis of the loch. Highest impacts from identified sources are likely to be near shore at the northeastern end of the fishery, where sewage discharged from the holiday park will

remain after the public sewerage network is upgraded, along the head of the loch where trade and intermittent sewage discharges and surface water runoff from the town of Stranraer will still be present, and around the mouth of Sole Burn, on the west shore of the loch where high levels of faecal contamination were found in the burn.

Poor recording of actual sampling locations in the past has made it difficult to examine any spatial variation in results across the fishery, and it is recommended that accurate data be gathered during sampling in order to support future analysis.

Overall Risk Table

Risk	
Sewage discharges from private and public sewerage works	Moderate
Rainfall-dependent diffuse sources	High
Wildlife sources	Moderate
Overboard discharges from yachts	Moderate
Seasonal variability	Moderate

16. Recommendations

Production area

It is recommended that the production area boundaries be curtailed somewhat to exclude the pier and ferry terminal. Although there are a number of smaller point sources extant along the east and west shores of the loch that would ideally be excluded from the production area, it is not practical to so without excessively restraining the existing fishery. Therefore, the recommended production area is herefore the area bounded by lines drawn between NX 0417 6796 and NX 0727 6711 and between NX 0828 6200 and NX 0502 6200 and extending to MHWS.

RMP

It is recommended that the RMP be retained along the east side of the loch, where contaminants are likely to be carried via tidal movement. The nearest remaining continuous discharges, at the Cairnryan holiday park and the new WWTW at the ferry terminal, are most likely to impact the northeast end of the production area, and therefore it is recommended that the RMP be relocated to NX 0700 6690, which lies near to the these sources.

Tolerance

As this is a dredged fishery, a sampling tolerance of 250 metres is recommended. The sampling location should be recorded as the mid-point of the dredge, to the nearest 10 m, using a GPS unit.

Frequency

The fishery is currently classified seasonally and there is likely to be seasonal variation in faecal input to the loch and therefore sampling frequency should remain at monthly.

Depth of sampling

Sampling depth is not applicable as the fishery is sub tidal.

A map showing the recommended boundaries, RMP and tolerance area is shown in Figure 16.1.

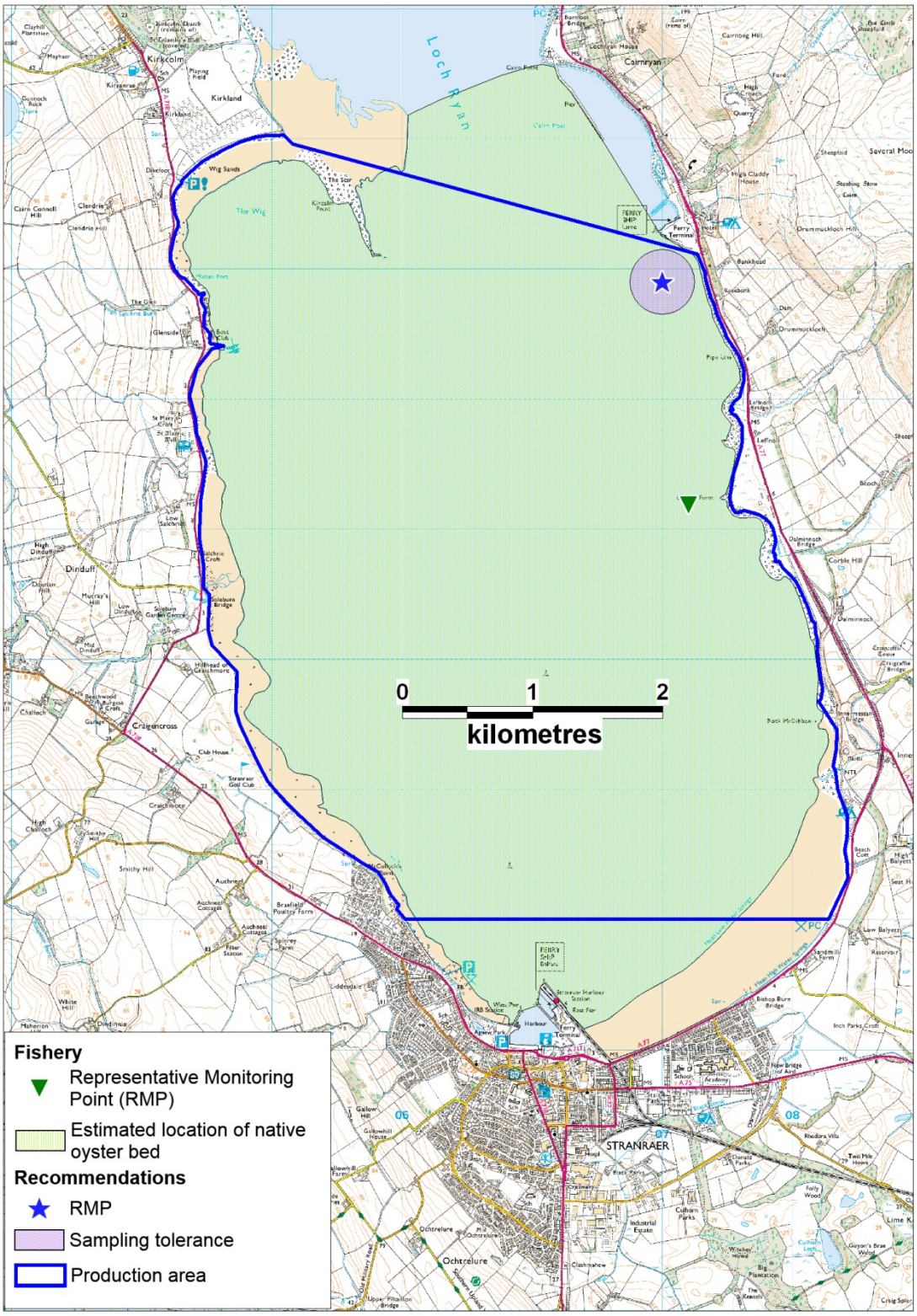


Figure 16.1 Map of recommendations at Loch Ryan

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18. List of Figures and Tables

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2. **Tables of Typical Faecal Bacteria Concentrations**
3. **Statistical Data**
4. **Hydrographic Section Glossary**
5. **Shoreline Survey Report**
6. **Reported sewage discharges**

1. General Information on Wildlife Impacts

Pinnipeds

Two species of pinniped (seals, sea lions, walruses) are commonly found around the coasts of Scotland: These are the European harbour, or common, seal (*Phoca vitulina vitulina*) and the grey seal (*Halichoerus grypus*). Both species can be found along the west coast of Scotland.

Common seal surveys are conducted every 5 years and an estimate of minimum numbers is available through Scottish Natural Heritage.

According to the Scottish Executive, in 2001 there were approximately 119,000 grey seals in Scottish waters, the majority of which were found in breeding colonies in Orkney and the Outer Hebrides.

Adult Grey seals weigh 150-220 kg and adult common seals 50-170 kg. They are estimated to consume between 4 and 8% of their body weight per day in fish, squid, molluscs and crustaceans. No estimates of the volume of seal faeces passed per day were available, though it is reasonable to assume that what is ingested and not assimilated in the gut must also pass. Assuming 6% of a median body weight for harbour seals of 110kg, that would equate to 6.6kg consumed per day and probably very nearly that defecated.

The concentration of *E. coli* and other faecal indicator bacteria contained in seal faeces has been reported as being similar to that found in raw sewage, with counts showing up to 1.21×10^4 CFU (colony forming units) *E. coli* per gram dry weight of faeces (Lisle *et al* 2004).

Both bacterial and viral pathogens affecting humans and livestock have been found in wild and captive seals. *Salmonella* and *Campylobacter* spp., some of which were antibiotic-resistant, were isolated from juvenile Northern elephant seals (*Mirounga angustirostris*) with *Salmonella* found in 36.9% of animals stranded on the California coast (Stoddard, et al., 2005) *Salmonella* and *Campylobacter* are both enteric pathogens that can cause acute illness in humans and it is postulated that the elephant seals were picking up resistant bacteria from exposure to human sewage waste.

One of the *Salmonella* species isolated from the elephant seals, *Salmonella typhimurium*, is carried by a number of animal species and has been isolated from cattle, pigs, sheep, poultry, ducks, geese and game birds in England and Wales. Serovar DT104, also associated with a wide variety of animal species, can cause severe disease in humans and is multi-drug resistant (Poppe, et al., 1998)

Cetaceans

As mammals, whales and dolphins would be expected to have resident populations of *E. coli* and other faecal indicator bacteria in the gut. Little is known about the concentration of indicator bacteria in whale or dolphin faeces, in large part because the animals are widely dispersed and sample collection difficult.

A variety of cetacean species are routinely observed around the west coast of Scotland. Where possible, information regarding recent sightings or surveys is gathered for the production area. As whales and dolphins are broadly free ranging, this is not usually possible to such fine detail. Most survey data is supplied by the Hebridean Whale and Dolphin Trust or the Shetland Sea Mammal Group and applies to very broad areas of the coastal seas.

It is reasonable to expect that whales would not routinely affect shellfisheries located in shallow coastal areas. It is more likely that dolphins and harbour porpoises would be found in or near fisheries due to their smaller physical size and the larger numbers of sightings near the coast.

Birds

Seabird populations were surveyed all over Britain as part of the SeaBird 2000 census. These counts are investigated using GIS to give the numbers observed within a 5 km radius of the production area. This gives a rough idea of how many birds may be present either on nests or feeding near the shellfish farm or bed.

Further information is gathered where available related to shorebird surveys at local bird reserves when present. Surveys of overwintering geese are queried to see whether significant populations may be resident in the area for part of the year. In many areas, at least some geese may be present year round. The most common species of goose observed during shoreline surveys has been the Greylag goose. Geese can be found grazing on grassy areas adjacent to the shoreline during the day and leave substantial faecal deposits. Geese and ducks can deposit large amounts of faeces in the water, on docks and on the shoreline.

A study conducted on both gulls and geese in the northeast United States found that Canada geese (*Branta canadiensis*) contributed approximately 1.28×10^5 faecal coliforms (FC) per faecal deposit and ring-billed gulls (*Larus delawarensis*) approximately 1.77×10^8 FC per faecal deposit to a local reservoir (Alderisio & DeLuca, 1999). An earlier study found that geese averaged from 5.23 to 18.79 defecations per hour while feeding, though it did not specify how many hours per day they typically (Gauthier & Bedard, 1986)

Waterfowl can be a significant source of pathogens as well as indicator organisms. Gulls frequently feed in human waste bins and it is likely that they carry some human pathogens.

Deer

Deer are present throughout much of Scotland in significant numbers. The Deer Commission of Scotland (DCS) conducts counts and undertakes culls of deer in areas that have large deer populations.

Four species of deer are routinely recorded in Scotland, with Red deer (*Cervus elaphus*) being the most numerous, followed by Roe deer (*Capreolus capreolus*), Sika deer (*Cervus nippon*) and Fallow deer (*Dama dama*).

Accurate counts of populations are not available, though estimates of the total populations are >200,000 Roe deer, >350,000 Red deer, < 8,000 Fallow deer and an unknown number of Sika deer. Where Sika deer and Red deer populations overlap, the two species interbreed further complicating counts.

Deer will be present particularly in wooded areas where the habitat is best suited for them. Deer, like cattle and other ruminants, shed *E. coli*, *Salmonella* and other potentially pathogenic bacteria via their faeces.

Other

The European Otter (*Lutra lutra*) is present around Scotland with some areas hosting populations of international significance. Coastal otters tend to be more active during the day, feeding on bottom-dwelling fish and crustaceans among the seaweed found on rocky inshore areas. An otter will occupy a home range extending along 4-5km of coastline, though these ranges may sometimes overlap (Scottish National Heritage, n.d.). Otters primarily forage within the 10 m depth contour and feed on a variety of fish, crustaceans and shellfish (Paul Harvey, Shetland Sea Mammal Group, personal communication).

Otters leave faeces (also known as spraint) along the shoreline or along treams, which may be washed into the water during periods of rain.

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2. Tables of Typical Faecal Bacteria Concentrations

Summary of faecal coliform concentrations (cfu $100ml^{-1}$) for different treatment levels and individual types of sewage-related effluents under different flow conditions: geometric means (GMs), 95% confidence intervals (CIs), and results of t-tests comparing base- and high-flow GMs for each group and type.

Indicator organism	Base-flow conditions				High-flow conditions			
Treatment levels and specific types: Faecal coliforms	n^c	Geometric mean	Lower 95% CI	Upper 95% CI	n^c	Geometric mean	Lower 95% CI	Upper 95% CI
Untreated	252	$1.7 \times 10^{7*}$ (+)	1.4×10^{7}	2.0×10^{7}	282	$2.8 \times 10^{6*}$ (-)	2.3×10^{6}	3.2×10^{6}
Crude sewage discharges	252	$1.7 \times 10^{7*}$ (+)	1.4×10^{7}	2.0×10^{7}	79	$3.5 \times 10^{6*}$ (-)	2.6×10^{6}	4.7×10^{6}
Storm sewage overflows					203	2.5×10^{6}	2.0×10^{6}	2.9×10^{6}
Primary	127	$1.0 \times 10^{7*}$ (+)	8.4×10^{6}	1.3×10^{7}	14	4.6×10^{6} (-)	2.1×10^{6}	1.0×10^{7}
Primary settled sewage	60	1.8×10^{7}	1.4×10^{7}	2.1×10^{7}	8	5.7×10^{6}		
Stored settled sewage	25	5.6×10^{6}	3.2×10^{6}	9.7×10^{6}	1	8.0×10^{5}		
Settled septic tank	42	7.2×10^{6}	4.4×10^{6}	1.1×10^{7}	5	4.8×10^{6}		
Secondary	864	$3.3 \times 10^{5*}$ (-)	2.9×10^{5}	3.7×10^{5}	184	$5.0 \times 10^{5*}$ (+)	3.7×10^{5}	6.8×10^{5}
Trickling filter	477	4.3×10^{5}	3.6×10^{5}	5.0×10^{5}	76	5.5×10^{5}	3.8×10^{5}	8.0×10^{5}
Activated sludge	261	$2.8 \times 10^{5*}$ (-)	2.2×10^{5}	3.5×10^{5}	93	$5.1 \times 10^{5*}$ (+)	3.1×10^{5}	8.5×10^{5}
Oxidation ditch	35	2.0×10^{5}	1.1×10^{5}	3.7×10^{5}	5	5.6×10^{5}		
Trickling/sand filter	11	2.1×10^{5}	9.0×10^{4}	6.0×10^{5}	8	1.3×10^{5}		
Rotating biological contactor	80	1.6×10^{5}	1.1×10^{5}	2.3×10^{5}	2	6.7×10^{5}		
Tertiary	179	1.3×10^{3}	7.5×10^{2}	2.2×10^{3}	8	9.1×10^{2}		
Reed bed/grass plot	71	1.3×10^{4}	5.4×10^{3}	3.4×10^{4}	2	1.5×10^{4}		
Ultraviolet disinfection	108	2.8×10^{2}	1.7×10^{2}	4.4×10^{2}	6	3.6×10^{2}		

Source: (Kay, et al., 2008)

Table 3 – Geometric mean (GM) and 95% confidence intervals (CIs) of the GM faecal indicator organism (FIO) concentrations (cfu 100ml$_{-1}$) under base- and high-flow conditions at the 205 sampling points and for various subsets, and results of paired t-tests to establish whether there are significant elevations at high flow compared with base flow

FIO	*n*	Base Flow			High Flow		
Subcatchment land use		Geometric mean	Lower 95% CI	Upper 95% CI	Geometric mean[a]	Lower 95% CI	Upper 95% CI
Total coliforms							
All subcatchments	205	5.8×10^{3}	4.5×10^{3}	7.4×10^{3}	7.3×10^{4}**	5.9×10^{4}	9.1×10^{4}
Degree of urbanisation							
Urban	20	3.0×10^{4}	1.4×10^{4}	6.4×10^{4}	3.2×10^{5}**	1.7×10^{5}	5.9×10^{5}
Semi-urban	60	1.6×10^{4}	1.1×10^{4}	2.2×10^{4}	1.4×10^{5}**	1.0×10^{5}	2.0×10^{5}
Rural	125	2.8×10^{3}	2.1×10^{3}	3.7×10^{3}	4.2×10^{4}**	3.2×10^{4}	5.4×10^{4}
Rural subcatchments with different dominant land uses							
≥75% Imp pasture	15	6.6×10^{3}	3.7×10^{3}	1.2×10^{4}	1.3×10^{5}**	1.0×10^{5}	1.7×10^{5}
≥75% Rough Grazing	13	1.0×10^{3}	4.8×10^{2}	2.1×10^{3}	1.8×10^{4}**	1.1×10^{4}	3.1×10^{4}
≥75% Woodland	6	5.8×10^{2}	2.2×10^{2}	1.5×10^{3}	6.3×10^{3}*	4.0×10^{3}	9.9×10^{3}
Faecal coliform							
All subcatchments	205	1.8×10^{3}	1.4×10^{3}	2.3×10^{3}	2.8×10^{4}**	2.2×10^{4}	3.4×10^{4}
Degree of urbanisation							
Urban	20	9.7×10^{3}	4.6×10^{3}	2.0×10^{4}	1.0×10^{5}**	5.3×10^{4}	2.0×10^{5}
Semi-urban	60	4.4×10^{3}	3.2×10^{3}	6.1×10^{3}	4.5×10^{4}**	3.2×10^{4}	6.3×10^{4}
Rural	125	8.7×10^{2}	6.3×10^{2}	1.2×10^{3}	1.8×10^{4}**	1.3×10^{4}	2.3×10^{4}
Rural subcatchments with different dominant land uses							
≥75% Imp pasture	15	1.9×10^{3}	1.1×10^{3}	3.2×10^{3}	5.7×10^{4}**	4.1×10^{4}	7.9×10^{4}
≥75% Rough Grazing	13	3.6×10^{2}	1.6×10^{2}	7.8×10^{2}	8.6×10^{3}**	5.0×10^{3}	1.5×10^{4}
≥75% Woodland	6	3.7×10	1.2×10	1.2×10^{2}	1.5×10^{3}**	6.3×10^{2}	3.4×10^{3}
Enterococci							
All subcatchments	205	2.7×10^{2}	2.2×10^{2}	3.3×10^{2}	5.5×10^{3}**	4.4×10^{3}	6.8×10^{3}
Degree of urbanisation							
Urban	20	1.4×10^{3}	9.1×10^{2}	2.1×10^{3}	2.1×10^{4}**	1.3×10^{4}	3.3×10^{4}
Semi-urban	60	5.5×10^{2}	4.1×10^{2}	7.3×10^{2}	1.0×10^{4}**	7.6×10^{3}	1.4×10^{4}
Rural	125	1.5×10^{2}	1.1×10^{2}	1.9×10^{2}	3.3×10^{3}**	2.4×10^{3}	4.3×10^{3}
Rural subcatchments with different dominant land uses							
≥75% Imp. pasture	15	2.2×10^{2}	1.4×10^{2}	3.5×10^{2}	1.0×10^{4}**	7.9×10^{3}	1.4×10^{4}
≥75% Rough Grazing	13	4.7×10	1.7×10	1.3×10^{2}	1.2×10^{3}**	5.8×10^{2}	2.7×10^{3}
≥75% Woodland	6	1.6×10	7.4	3.5×10	1.7×10^{2}**	5.5×10	5.2×10^{2}
[a] Significant elevations in concentrations at high flow are indicated: **po0.001, *po0.05.							
[b] Degree of urbanisation categorised according to percentage built-up land: 'Urban' (X10.0%), 'Semi-urban' (2.5–9.9%) and 'Rural' (o2.5%).							

Source: (Kay, et al., 2008a)

Comparison of faecal indicator concentrations (average numbers/g wet weight) excreted in the faeces of warm-blooded animals

Animal	Faecal coliforms (FC) number	Excretion (g/day)	FC Load (numbers/ day)
Chicken	1,300,000	182	2.3 x 108
Cow	230,000	23,600	5.4 x 109
Duck	33,000,000	336	1.1 x 1010
Horse	12,600	20,000	2.5 x 108
Pig	3,300,000	2,700	8.9 x 108
Sheep	16,000,000	1,130	1.8 x 1010
Turkey	290,000	448	1.3 x 108
Human	13,000,000	150	1.9 x 109

Source: (Gauthier & Bedard, 1986)

3. Statistical Data

One-way ANOVA: LogEC versus season

Source DF SS MS F P
season 3 1.769 0.590 1.89 0.148
Error 37 11.551 0.312
Total 40 13.320
S = 0.5587 R-Sq = 13.28% R-Sq(adj) = 6.25%
Individual 95% CIs For Mean Based on Pooled StDev
Level N Mean StDev +---------+---------+---------+---------
1 12 1.9086 0.6924 (-------*-------)
2 4 2.4683 0.2295 (-------------*-------------)
3 12 2.3407 0.5244 (--------*-------)
4 13 2.0081 0.5077 (-------*-------)
+---------+---------+---------+---------
1.60 2.00 2.40 2.80
Pooled StDev = 0.5587
Grouping Information Using Tukey Method
season N Mean Grouping
2 4 2.4683 A
3 12 2.3407 A
4 13 2.0081 A
12 1.9086 A

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of season

Individual confidence level = 98.93%

season = 1 subtracted from:

season Lower Center Upper ---------+---------+---------+---------+
2 -0.3070 0.5598 1.4266 (-----------*-----------)
3 -0.1808 0.4321 1.0450 (--------*--------)
4 -0.5015 0.0995 0.7006 (-------*--------)
---------+---------+---------+---------+
-0.70 0.00 0.70 1.40

season = 2 subtracted from:

season Lower Center Upper ---------+---------+---------+---------+
3 -0.9945 -0.1277 0.7391 (-----------*-----------)
4 -1.3186 -0.4602 0.3982 (-----------*-----------)
---------+---------+---------+---------+
-0.70 0.00 0.70 1.40

season = 3 subtracted from:
season Lower Center Upper ---------+---------+---------+---------+
4 -0.9336 -0.3326 0.2685 (-------*--------)
---------+---------+---------+---------+
-0.70 0.00 0.70 1.40

4. Hydrographic Assessment Glossary

The following technical terms may appear in the hydrographic assessment.

Bathymetry. The underwater topography given as depths relative to some fixed reference level e.g. mean sea level.

Hydrography. Study of the movement of water in navigable waters e.g. along coasts, rivers, lochs, estuaries.

MHW. Mean High Water, The highest level that tides reach on average.

MHWN. Mean High Water Neep, The highest level that tides reach on average during neep tides.

MHWS. Mean High Water Spring, The highest level that tides reach on average during spring tides

MLW. Mean Low Water, The lowest level that tides reach on average.

MLWN. Mean Low Water Neep, The lowest level that tides reach on average during neep tides.

MLWS. Mean Low Water Spring, The lowest level that tides reach on average during spring tides.

Tidal period. The dominant tide around the UK is the twice daily one generated by the moon. It has a period of 12.42 hours. For near shore so-called rectilinear tidal currents then roughly speaking water will flow one way for 6.2 hours then back the other way for 6.2 hours.

Tidal range. The difference in height between low and high water. Will change over a month.

Tidal excursion. The distance travelled by a particle over one half of a tidal cycle (roughly~6.2 hours). Over the other half of the tidal cycle the particle will move in the opposite direction leading to a small net movement related to the tidal residual. The excursion will be largest at spring tides.

Tidal residual. For the purposes of these documents it is taken to be the tidal current averaged over a complete tidal cycle. Very roughly it gives an idea of the general speed and direction of travel due to tides for a particle over a period of several days.

Tidal prism. The volume of water brought into an estuary or sea loch during half a tidal cycle. Equal to the difference in estuary/sea loch volume at high and low water.

Spring/Neap Tides. Spring tides occur during or just after new moon and full moon when the tide-generating force of the sun acts in the same direction as that of the moon, reinforcing it. The tidal range is greatest and tidal currents strongest during spring tides.

Neep tides occur during the first or last quarter of the moon when the tide-generating forces of the sun and moon oppose each other. The tidal range is smallest and tidal currents are weakest during neep tides.

Tidal diamonds. The tidal velocities measured and printed on admiralty charts at specific locations are called tidal diamonds.

Wind driven shear/surface layer. The top metre or so of the surface that generally moves in the rough direction of the wind typically at a speed that is a few percent (~3%) of the wind speed.

Return flow. A surface flow at the surface may be accompanied by a compensating flow in the opposite direction at the bed.

Stratification. The splitting of the water into two layers of different density with the less dense layer on top of the denser one. Due to either temperature or salinity differences or a combination of both.

5. Shoreline Survey Report

Production area:	Loch Ryan	
Site name:	Leffnoll Point	
	Loch Ryan	
SIN:	Leffnoll Point -	DG-191-174-12
	Loch Ryan-	DG-191-175-12
Species:	Native Oysters	
Harvester:	Tristan Hugh-Jones	
Local Authority:	Dumfries and Galloway	
Status:	Existing area	
Date Surveyed:	19-20 February 2013	
Surveyed by:	Eilidh Cole, Andrea Veszelovszki	
Existing RMP:	Loch Ryan NX 0720 6520	
Area Surveyed:	Loch Ryan shoreline and native oyster beds in the production area, with access by boat provided by Tristan Hugh-Jones (skippered and crewed by Robert Lamont and John Mills).	

Weather

No precipitation 48 hours prior to survey.

Tuesday 19th February 2013 - Calm, cold and frosty morning with mist. Sunny later but with persisting mist. Slight breeze and clear skies. Temperatures ranged between ~ -2 to 6 °C during the day. Sea state: 0-1, calm.

Wednesday 20th February 2013 - No precipitation overnight. A cold morning with wind and 100% cloud cover, wind speed 30-40 km/hr, S/SE direction. Temperature approximately 4 °C throughout the day. Sea state turning from fairly calm to choppy during early afternoon.

Fishery

The fishery is comprised of two native oyster beds (*Ostrea edulis*) at two locations: Leffnoll Point on the east side of the loch and the Loch Ryan site roughly across from this area on the west side of the loch.

Active fishing is on-going on a seasonal basis from September to the end of April for seven days a week.

Based on conversations with the local fishermen, the oyster bed close to Leffnoll Point is heavily affected by extra silt load, bilge water and possibly untreated sewage released by ferries due to the increased ferry traffic in Cairnryan. This, in their opinion, is caused by Stena Line ferries moving from Stranraer to Cairnryan in November 2011, with both P&O Ferries and Stena Line now operating from the area.

Sewage Sources

The land at the head of the loch is heavily populated and the town of Stranraer is located about 1 km south of the southern boundary of the production area. Two smaller settlements, Cairnryan and Kirkcolm are located at the eastern and north-western shorelines respectively. Other dwellings are located at random in between these three settlements, with at least three farms noted during the survey (nature unknown due to the distance from the shore, but cattle numbers and farming activity recorded on table 1 where noted).

Ryan Bay Holiday Park is located near the head of the loch. Through discussions held with a member of staff, it was revealed that the holiday parks' septic tank discharges to the large watercourse that runs adjacent to the park.

On the western shore near the Wig Bay Holiday Park, works on the road surface and the disruption of ground and pipes in the area suggest that new sewerage works have recently been undertaken. There was no indication to confirm whether this work is any way was related to the sewage upgrade work at Leswalt.

Seasonal Population

Three settlements are located around Loch Ryan. Cairnryan is on the eastern shore, the town of Stranraer at the head of the loch and Kirkcolm on the western shore. Of these, Stranraer is the largest and most densely populated. There are a few hotels, several guest houses and B&Bs in Stranraer and there are also a few guest houses in each village, as well as two caravan/campsites in the area.

One relatively large caravan and camping park, Ryan Bay Holiday Park, was located near the head of Loch Ryan. This park contained static caravans for hire and had spaces for mobile caravans as well as camp sites for tents. Guests appeared to be staying even though it was early on in the season. Wig Bay Holiday Park caravan site was located on the western shore of Loch Ryan however, it was set back from the shore and so details of caravans, etc. could not be seen clearly.

These areas are all likely to experience an increase in population due to tourism during the summer months.

Boats/Shipping

A small slipway was located on the north western shore of Loch Ryan at the sailing club. At the time of survey, no boats were moored on the water

although approximately 6 sailing yachts were out of the water on land next to the club house. There are three main piers in the area surrounding Loch Ryan. The old Stena line ferry terminal is located at the head of the loch next to the train station but is no longer in use. Access to this area was restricted. Stena line has now moved to the eastern shore at Cairnryan where the P&O ferry terminal is also located, however, access to this area was also restricted as works are still on-going. There is also a pontoon at the head of the loch where fishing boats are located. Approximately 10 fishing boats including a dredger were noted in operation on the first day of the survey.

Farming and Livestock

The land surrounding Loch Ryan is largely agricultural and the locations of farms seen during the survey are noted in Table 1. Farmland did not seem to be concentrated to any one side of the loch and several fields of farm animals including cows, horses and sheep were seen at various locations around the loch.

Land Use

The land surrounding Loch Ryan is largely agricultural and any land not in use for campsites appeared to be used for grazing livestock such as cows, sheep and horses rather than for growing crops. No areas of woodland or forestry were seen during the survey.

Two ferry companies operate out of Loch Ryan; P&O and Stena line, which both have large ferry terminals and provide ferry links to Ireland.

Land Cover

Inland from the shore, the land surrounding Loch Ryan is mainly open with gently rolling shallow hills. There is no forestry or woodland in the area. There did not appear to be any rough heath or grassland and the land further back from the shore was predominantly split into fields for grazing livestock.

Watercourses

There are numerous watercourses of different sizes discharging into Loch Ryan within the production area with the largest being Bishop Burn, Sole burn and Several Burn. Other unnamed and smaller watercourses/streams also discharge into the production area. Numerous discharges from pipes were also noted during the course of the survey and sampled as appropriate.

Wildlife/Birds

Several species of seabirds and a seal were noted during the survey the details of which can be found in Table 1. Oyster catchers in particular were seen feasting on cockles on the eastern shore near the head of Loch Ryan. Other species observed included geese and seagulls. Crows were also seen both on the shore and on the surrounding farmland.

Shoreline Survey Maps

Figure 1. Loch Ryan waypoints (please note that waypoints 56 and 56A and 58 and 58A correspond to the same location therefore marked as one on the map).

Figure 2. Loch Ryan samples.

Table 1. Shoreline Observations

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
1	19/02/2013	10:46	NX 03527 66440	203528	566440	Fig 3		Start of survey at the Loch Ryan Sailing club. Large farm - most likely active - behind the sailing club on the other side of the road. Large clay pipe next to slipway. Pipe Ø: 30 cm, no sample taken.
2	19/02/2013	10:51	NX 03625 66386	203626	566386		LRSW5	End of slipway, seawater sample taken. Behind the road there are approximately 100 geese on hills. The surrounding land is used as farm/grazing land. A seal was spotted at the end of slipway.
3	19/02/2013	10:58	NX 03521 66344	203522	566344	Fig 4		Small burn runs onto shore on the south side of slipway. Width: 48 cm; Depth: 9 cm; Flow: 0.030 m/s; SD: 0.01. No sample taken.
4	19/02/2013	11:06	NX 03415 66205	203416	566206			Burn runs through culvert under the road. Pipe Ø: 25 cm; Depth: 11 cm; Flow: 0.097 m/s; SD:0.019
5	19/02/2013	11:11	NX 03378 66033	203379	566033			Clay pipe running onto shore. Pipe Ø: 25 cm; Depth: 4 cm; Flow: 0.9 m/s; SD: 0.192
6	19/02/2013	11:15	NX 03378 65986	203379	565987			Beginning of shore wall next to/under road. Several land drainage pipes through wall with little or no outflow. One large half blocked clay pipe with small dribble - not measured or sampled. Beyond the road there are two houses with grazing fields with 14 sheep. The houses are right next to the north end of Wig Bay Holiday Park caravan site.
7	19/02/2013	11:23	NX 03444 65687	203445	565687			South end of shore wall. Along the wall there are about 20-30 land drains at regular intervals and five were observed to be active with some drainage at time of survey.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
8	19/02/2013	11:25	NX 03472 65646	203473	565647	Fig 5	LRFW1	Large metal outflow pipe running to shore, just opposite of the main entrance to the caravan site. The pipe is broken with small outflow.
9	19/02/2013	11:33	NX 03491 65449	203492	565450	Fig 6		Southern end of caravan site with a larger burn running from fields beyond through culvert/concrete pipe under the road. (photo was taken later) On the road surface and around the area there are signs that sewerage work was completed recently. Pipe Ø: 1 m; Depth: 23 cm; Flow: 0.260 m/s; SD: 0.017
10	19/02/2013	11:40	NX 03474 65258	203474	565258	Fig 7		Possibly disused sewerage pipe runs down to shore. (photo was taken later) Pipe Ø: 15 cm with no outflow. Large house on shore surrounded by farmland with feeder close to road but no livestock were present at the time. At the upper end of pipe freshly dug ditch and flattened area with manhole covers and newly resurfaced road. Possibly newly developed sewerage works.
11	19/02/2013	11:45	NX 03456 65217	203457	565217	Fig 8		Right next to waypoint no. 10 concrete structure, most likely associated with sewage works.
12	19/02/2013	11:52	NX 03445 64878	203445	564879			Start of other shore wall with land drainage pipes with only very small outflow.
13	19/02/2013	11:54	NX 03451 64787	203452	564787			End of shore wall with a house beyond the road.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
14	19/02/2013	12:09	NX 03487 64467	203487	564468	Fig 9	LRFW2	Bridge over Sole Burn. Farmhouse on both sides of burn beyond the road. Two horses closer to shore and a further two up the hill. Width of burn at bridge: 6.8 m, other measurements were done further down on shore due to lack of access by bridge. Depth 1: 15 cm; Flow: 0.103 m/s; SD: 0.008 Depth 2: 20 cm; Flow: 0.408 m/s; SD: 0.026 The burn breaks up to smaller streams on shore. There are about 50 seabirds on shore. End of first leg of survey at 12:25.
15	19/02/2013	13:53	NX 04132 62859	204132	562860	Fig 10	LRFW3	Second leg of survey. River running from fields and road to shore. A plastic pipe joins into river on shore. Sample was taken lower down on shore beyond the end of plastic pipe. Width: 1.3 m; Depth: 17 cm; Flow: 0.391 m/s, SD: 0.009 Approximately 50 birds on shore, mostly gulls.
16	19/02/2013	14:02	NX 04127 62938	204128	562939		LRSW6	Seawater sample taken from along the shore near where river meets the sea.
17	19/02/2013	14:12	NX 04572 62513	204572	562514			Freshwater stream running from fields onto shore. No sample taken. Width: 40 cm; Depth: 5-10 cm; Flow: 0.181 m/s; SD: 0.006
18	19/02/2013	14:16	NX 04637 62476	204638	562476	Fig 11	LRFW4	Plastic pipe outflow with concrete structure at top of pipe. Houses on hill beyond. Width: 24 cm; Depth: 3 cm; Flow: 0.49 m/s; SD: 0.006
19	19/02/2013	14:25	NX 04778 62379	204779	562379			Clay pipe embedded in concrete flowing from fields above onto shore. Houses beyond shore. Pipe Ø: 20 cm; Estimated flow: 100 ml/s. No sample taken.
20	19/02/2013	14:29	NX 04824 62378	204825	562378		LRSW7	Seawater sample.
21	19/02/2013	14:39	NX 04961 62095	204961	562095	Fig 12		Small plastic pipe embedded in concrete on shore with houses beyond. Two more pipes along shore wall next to road/houses.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
22	19/02/2013	14:49	NX 05273 61634	205273	561634	Fig 13		Burn running under road through storm drain that is just being replaced at time of survey. The burn runs down from hill beyond road and between houses.
23	19/02/2013	14:52	NX 05321 61607	205322	561608	Fig 14		Old metal pipe on shore - disused, no flow with metal cover over concrete structure.
24	19/02/2013	14:54	NX 05346 61565	205347	561565	Fig 15		Other pipe replacement work along shore in town.
25	19/02/2013	14:56	NX 05408 61499	205409	561500	Fig 16, 17	LRFW5	Large plastic pipe running under the road towards shore. Slight smell of sewage. Pipe Ø: 0.6 m; Depth: 2 cm; Flow: 0.013 m/s; SD: 0.003
26	19/02/2013	15:04	NX 05437 61431	205438	561432	Fig 18, 19		Suspected Green pumping station along the shore next to road with several manhole covers around it with a slight smell of sewage. Trickling of water can be heard. Large concrete structure runs from manholes to shore, no pipe or discharge visible. Approximately 50 birds on shore.
27	19/02/2013	15:14	NX 05831 61140	205832	561140			End of survey day at the Harbour Office in Stranraer.
28	20/02/2013	8:51	NX 05826 61038	205827	561039			Start of second survey day at Harbour Office.
29	20/02/2013	8:57	NX 06041 60993	206042	560994	Fig 20		No access to shore along the Stena line offices. Building works are on-going and all access is blocked.
30	20/02/2013	9:15	NX 06096 61509	206096	561510		LRSW8	Seawater sample taken at the end of pier next to railway station.
31	20/02/2013	9:55	NX 06599 60930	206599	560930	Fig 21		Pipe flowing heavily from under railway lines. No access, no sample taken. Red-orange algae growing on surfaces where water from pipes flows.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
32	20/02/2013	9:56	NX 06599 60925	206600	560926			Orange and green algae growing on rocks at another pipe flowing from under railway lines. No sample taken. Pipe Ø: 15 cm, clean looking water discharges from it. Land seepage also evident. Two manhole covers in about 5 metres distance from outflow pipe with the sound of running water. Other manhole covers and land drain pipes are present all along seawall.
33	20/02/2013	10:02	NX 06756 60966	206757	560966	Fig 22		Two other manhole cover with outflow pipe in lower section of seawall. Pipe with metal lid, no outflow.
34	20/02/2013	10:06	NX 06866 61014	206867	561015	Fig 23		Huge amount of small cockles on shore with huge number of oyster catchers and other seabirds feasting on them.
35	20/02/2013	10:11	NX 07139 61135	207139	561135	Fig 23		Plastic outflow pipe embedded in concrete with manhole cover further away. Active outflow. Pipe Ø: 35 cm; estimated flow: 300 ml/s, no access, no sample taken.
36	20/02/2013	10:22	NX 07660 61402	207660	561402	Fig 24	LRFW6	River runs under road onto shore. Width: 4.6 m Depth 1: 35 cm, Flow: 0.649 m/s; SD: 0.010 Depth 2: 20 cm; Flow: 0.330 m/s; SD: 0.017 Approximately 100 seabirds, mainly oyster catchers on shore. Further two pipes run into river, not certain whether they are still in use.
37	20/02/2013	10:28	NX 07635 61395	207635	561396	Fig 25		Possible pumping station on shore with three manhole covers. Scottish Water van parked next to it for a short duration.
38	20/02/2013	10:39	NX 07899 61569	207900	561569			Farm beyond the main road with large field extending to the houses at the edge of town with about 70-100 cattle with feeders.
39	20/02/2013	10:44	NX 07985 61661	207985	561661	Fig 26		Temporary burn - not flowing - coming from farm behind. Two horses in field.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
40	20/02/2013	10:47	NX 08073 61727	208074	561728	Fig 27		Metal pipe with no discharge running from under road with houses on shore.
41	20/02/2013	10:49	NX 08116 61791	208117	561792	Fig 28	LRFW7	Plastic pipe with yellowish discharge running from farmland with houses, under road, no smell. Pipe Ø: 23 cm; Depth: 2 cm; Flow: 0.558 m/s; SD: 0.007
42	20/02/2013	11:02	NX 08458 62407	208458	562407		LRFW8	River runs under road onto shore. Sheep in field with house next to it beyond road, approx. 50 animals. Width: 2.5 m; Depth: 10 cm; Flow: 0.206 m/s; SD: 0.011
43	20/02/2013	11:16	NX 08445 62669	208445	562670			Beginning of Ryan Bay Holiday Park (caravan park).
44	20/02/2013	11:41	NX 08303 63000	208303	563001		LRSW9	Seawater sample taken by caravan site.
45	20/02/2013	11:46	NX 08371 63157	208371	563158	Fig 29	LRFW9	River at northern edge of caravan site. Fields next to river outside caravan site. Width: 5.2 m Depth 1: 35 cm; Flow: 1.133 m/s; SD: 0.042 Depth 2: 15 cm; Flow: 0.286 m/s; SD: 0.036
46	20/02/2013	11:56	NX 08286 63544	208286	563544			Broken clay pipe with diameter of 12 cm runs onto shore, only dripping. Not sampled.
47	20/02/2013	12:09	NX 08170 64313	208171	564313			Plastic pipe with outflow, possibly land drain from under road. Pipe Ø: 24 cm; Depth: 3 cm; Flow: 0.508 m/s; SD: 0.046. No sample taken.
48	20/02/2013	12:16	NX 08024 64605	208024	564605	Fig 30	LRFW10	Broken plastic pipe runs onto shore from under road with discharge. Pipe Ø: 35 cm; estimated flow: 25 ml/s
49	20/02/2013	12:23	NX 07876 64796	207877	564797		LRFW11	River running onto shore. Width: 2 m; Depth: 20 cm; Flow: 0.287 m/s; SD: 0.054
50	20/02/2013	12:44	NX 07560 65931	207560	565932		LRFW12	River runs onto shore. Farmland on hill beyond road. Width: 1.5 m; Depth: 20 cm; Flow: 0.215 m/s; SD: 0.021

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
51	20/02/2013	12:57	NX 07582 66342	207582	566343	Fig 31	LRFW13	Two pipes run onto shore from under road. Pipe 1. Broken, old clay pipe with Ø: 60 cm; half-blocked with some discharge. Pipe 2. Rusted metal pipe from further up shore; diameter of 45 cm. Measurements were taken further down on shore. Width: 50 cm; Depth: 12 cm; Flow: 0.471 m/s; SD: 0.034 Latter seems to be flowing into the first broken pipe
52	20/02/2013	13:05	NX 07554 66402	207554	566402			Clay pipe embedded in concrete. Slightly dripping, no sample taken.
53	20/02/2013	13:18	NX 07334 66840	207334	566840		LRSW10	Seawater sample.
54	20/02/2013	13:21	NX 07338 66933	207339	566934	Fig 32		End of survey at new P&O building site just south of terminal.
55	19/02/2013	07:29	NX 06748 62506	206749	562506		LRSW1	Boat work in loch. Location one. First attempt to dredge, no shellfish found, seawater sample taken. Approx. 10 fishing boats at pontoon including a dredger in operation within Stranraer Harbour.
56	19/02/2013	08:00	NX 07042 65775	207042	565776		LRSW2	Boat work in loch. Location two. Seawater sample taken.
56A	19/02/2013	08:00	NX 07042 65775	207042	565776	Fig 33	LRSF1	Boat work in loch. Location two. Shellfish samples taken.
57	19/02/2013	08:53	NX 04532 65266	204533	565266		LRSW3	Boat work in loch. Location third, no shellfish found, seawater sample taken.
58	19/02/2013	09:14	NX 05452 63629	205452	563629		LRSW4	Boat work in loch. Location four. Seawater sample taken.
58A	19/02/2013	09:14	NX 05452 63629	205452	563629		LRSF2	Boat work in loch. Location four, shellfish samples taken.

Photographs referenced in the table can be found attached as Figures 3 – 33.

Sampling

Water samples were collected at sites marked on the map shown in Figure 2. Samples were transferred to either Biotherm 10 or Biotherm 25 boxes with ice packs and shipped to Glasgow Scientific Services (GSS) for *E. coli* analysis. All samples were shipped on the day of collection and all of them were received and analysed the following day. The sample temperatures on arrival to the laboratory ranged between 1.8 ˚C and 4.2 ˚C.

Seawater samples were tested for salinity by GSS and the results reported in mg Chloride per litre. These results have been converted to parts per thousand (ppt) using the following formula:

$$\text{Salinity (ppt)} = 0.0018066 \text{ X } Cl^{-} \text{ (mg/L)}$$

In Loch Ryan oyster samples were collected by dredging from a boat kindly provided by the harvester.

Table 2. Water Sample Results

No.	Date	Sample	Grid Ref	Type	E. coli (cfu/100 ml)	Salinity (ppt)
1	19/02/2013	LRFW1	NX 03472 65646	Fresh Water	<100	
2	19/02/2013	LRFW2	NX 03487 64467	Fresh Water	10000	
3	19/02/2013	LRFW3	NX 04132 62859	Fresh Water	300	
4	19/02/2013	LRFW4	NX 04637 62476	Fresh Water	400	
5	19/02/2013	LRFW5	NX 05408 61499	Fresh Water	180000	
6	19/02/2013	LRSW1	NX 06748 62506	Sea Water	600	33.42
7	19/02/2013	LRSW2	NX 07042 65775	Sea Water	8	33.60
8	19/02/2013	LRSW3	NX 04532 65266	Sea Water	53	33.06
9	19/02/2013	LRSW4	NX 05452 63629	Sea Water	26	32.70
10	19/02/2013	LRSW5	NX 03625 66386	Sea Water	23	33.06
11	19/02/2013	LRSW6	NX 04127 62938	Sea Water	46	33.42
12	19/02/2013	LRSW7	NX 04824 62378	Sea Water	26	33.06
13	20/02/2013	LRFW6	NX 07660 61402	Fresh Water	6200	
14	20/02/2013	LRFW7	NX 08116 61791	Fresh Water	11400	
15	20/02/2013	LRFW8	NX 08458 62407	Fresh Water	<100	
16	20/02/2013	LRFW9	NX 08371 63157	Fresh Water	1300	
17	20/02/2013	LRFW10	NX 08024 64605	Fresh Water	<100	
18	20/02/2013	LRFW11	NX 07876 64796	Fresh Water	<100	
19	20/02/2013	LRFW12	NX 07560 65931	Fresh Water	500	
20	20/02/2013	LRFW13	NX 07582 66342	Fresh Water	100	
21	20/02/2013	LRSW8	NX 06096 61509	Sea Water	38	33.78
22	20/02/2013	LRSW9	NX 08303 63000	Sea Water	100	32.16
23	20/02/2013	LRSW10	NX 07334 66840	Sea Water	47	32.70

Table 3. Shellfish Sample Results

No.	Date	Sample	Grid Ref	Type	E. coli (MPN/100 g)
1	19/02/2013	LRSF1	NX 07042 65775	Oysters	230
2	19/02/2013	LRSF2	NX 05452 63629	Oysters	50

Photographs

Figure 3. Large clay discharge pipe at Loch Ryan Sailing Club. Waypoint 1.

Figure 4. Small burn running onto shore at southern edge of slipway. Waypoint 3.

Figure 5. Large metal outflow pipe at the entrance to caravan site. Waypoint 8.

Figure 6. Large burn runs through concrete pipe from under road at the southern end of caravan site. Waypoint 9

Figure 7. Manhole cover is freshly flattened area along the shore. Waypoint 10.

Figure 8. Concrete structure most likely associated with sewage work. Waypoint 11.

Figure 9. Sole Burn with bridge. Waypoint 14.

Figure 10. River/burn running onto shore with a joining outflow pipe. Waypoint 15.

Figure 11. Plastic outflow pipe running onto shore with houses above. Waypoint 18.

Figure 12. Small pipe with outflow in seawall along the shore in town. Waypoint 21.

Figure 13. Storm drain replacement work. Waypoint 22.

Figure 14. Old metal pipe in concrete with manhole cover. Waypoint 23.

Figure 15. Pipe replacement work. Waypoint 24.

Figure 16. Discharge from large pipe. Waypoint 25.

Figure 17. Large plastic pipe with discharge runs onto shore. Both photos belong to Waypoint 25.

Figure 18. Pumping station with pipe running into sea. Waypoint 26.

Figure 19. Manhole covers at pumping station. Waypoint 26.

Figure 20. Closed access to shore around Stena Line office in Stranraer. Waypoint 29.

Figure 21. Outflows from under railway line. Waypoint 31.

Figure 22. Manhole covers in seawall in Stranraer. Waypoint 33.

Figure 23. Large amount of cockles and outflow pipe at waypoint 35. Waypoint 34, 35.

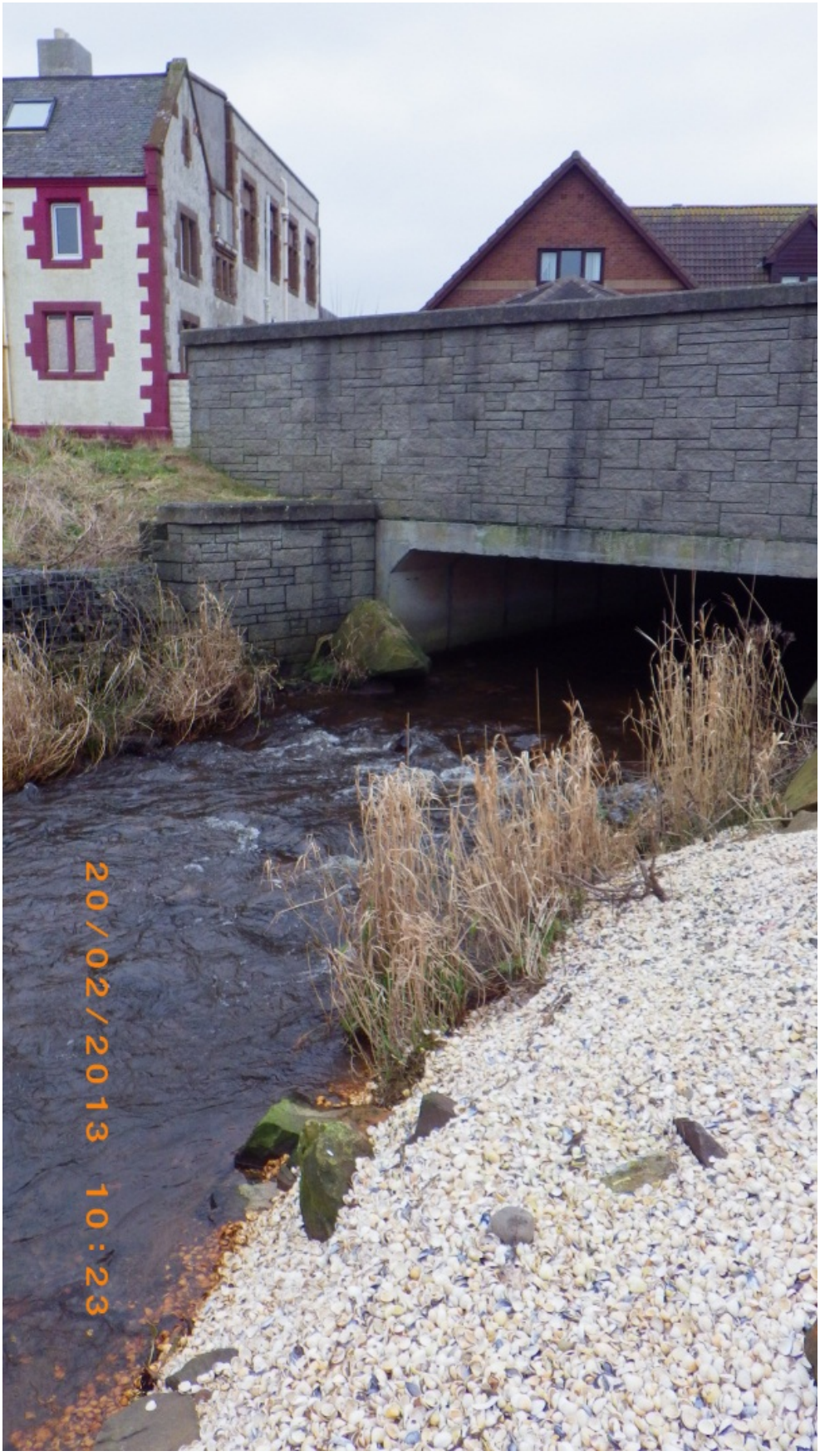

Figure 24. River runs under road onto shore. Waypoint 36.

Figure 25. Pumping station on shore with manhole covers. Waypoint 37.

Figure 26. Burn – currently not flowing from under road onto shore. Waypoint 39.

Figure 27. Metal pipe on shore with no discharge. Waypoint 40.

Figure 28. Plastic pipe with yellowish discharge runs onto shore. Waypoint 41.

Figure 29. River at northern edge of caravan park. Waypoint 45.

Figure 30. Broken plastic pipe runs onto shore from under the road. Waypoint 48.

Figure 31. Outflow from one pipe runs into the other one. Waypoint. 51.

Figure 32. End of survey route at south end of P&O ferry terminal just outside of Cairnryan. Waypoint 54.

Figure 33. Dredge sample close to Leffnoll Point (Location 2). Waypoint 56A.

6. SEPA Sewage Discharges

Ref No.	NGR	Discharge Type	Level of Treatment	Flow (m^3/d)	PE	Discharges to
CAR/L/1003357	NX 07067 67398	Continuous	Septic Tank	70.5	510	Loch Ryan
CAR/L/1003485	NX 06711 56513	Intermittent	CSO	1	280	Piltanton Burn
CAR/L/1003485	NX 06711 56513	Intermittent	CSO			Piltanton Burn
CAR/L/1003485	NX 06778 56455	Intermittent	Secondary			Piltanton Burn
CAR/L/1003605	NX 10796 59367	Intermittent	CSO	1	310	U/T of Soulseat
CAR/L/1003605	NX 10793 59331	Intermittent	CSO			U/T of Soulseat
CAR/L/1003605	NX 10793 59334	Intermittent	Secondary			U/T of Soulseat
CAR/L/1003617	NX 03900 68800	Intermittent	Secondary		600	Loch Ryan
CAR/L/1003618	NX 02151 64324	Intermittent	Secondary	1	0	Sole Burn
CAR/L/1003619	NX 05800 61400	Continuous	Septic Tank	1	14999	Loch Ryan
CAR/L/1003622	NX 07000 67900	Intermittent	CSO		183	Loch Ryan
CAR/L/1003622	NX 06800 68200	Intermittent	CSO			Loch Ryan
CAR/L/1003622	NX 06600 68400	Intermittent	CSO			Loch Ryan
CAR/L/1003622	NX 07000 67900	Intermittent	EO			Loch Ryan
CAR/L/1003622	NX 06800 68200	Intermittent	EO			Loch Ryan
CAR/L/1003622	NX 06600 68400	Intermittent	EO			Loch Ryan
CAR/L/1003622	NX 06946 67885	Continuous	Septic Tank			Loch Ryan
CAR/L/1003634	NX 03900 68800	Intermittent	CSO			Loch Ryan
CAR/L/1003636	NX 02111 64298	Intermittent	CSO			U/T of Sole Burn
CAR/L/1026411	NX 04662 62365	Intermittent	CSO			Loch Ryan
CAR/L/1026411	NX 04760 62270	Intermittent	CSO			Loch Ryan
CAR/L/1026411	NX 05205 61743	Intermittent	CSO			Loch Ryan
CAR/L/1026411	NX 04893 61533	Intermittent	CSO			Loch Ryan
CAR/L/1026411	NX 05530 61480	Intermittent	CSO			Loch Ryan
CAR/L/1026411	NX 06049 61004	Intermittent	CSO			Loch Ryan
CAR/L/1026411	NX 06264 61024	Intermittent	CSO			Loch Ryan
CAR/L/1026411	NX 07612 61417	Intermittent	CSO			Loch Ryan
CAR/L/1026411	NX 07654 61347	Intermittent	CSO			Bishop Burn
CAR/L/1026411	NX 07060 61081	Intermittent	CSO			Loch Ryan
CAR/L/1026411	NX 06756 60969	Intermittent	CSO			Loch Ryan
CAR/L/1026411	NX 07435 61121	Intermittent	CSO			Un/Wc
CAR/L/1026411	NX 06131 60696	Intermittent	CSO			Un/Wc
CAR/L/1026411	NX 05491 60577	Intermittent	CSO			Un/Wc
CAR/L/1026411	NX 05497 60580	Intermittent	CSO			Un/Wc
CAR/L/1026411	NX 06120 60540	Intermittent	CSO			Town Burn
CAR/L/1026411	NX 06075 60502	Intermittent	CSO			Un/Wc
CAR/L/1026411	NX 05315 60436	Intermittent	CSO			Un/Wc
CAR/L/1026411	NX 06139 60348	Intermittent	CSO			Un/Wc
CAR/L/1026411	NX 06059 60319	Intermittent	CSO			Un/Wc
CAR/L/1026411	NX 06159 60289	Intermittent	CSO			Un/Wc
CAR/L/1026411	NX 06190 60209	Intermittent	CSO			Un/Wc
CAR/L/1026411	NX 04775 62284	Intermittent	EO			Loch Ryan
CAR/L/1026411	NX 04760 62270	Intermittent	EO			Loch Ryan
CAR/L/1026411	NX 05530 61480	Intermittent	EO			Loch Ryan
CAR/L/1026411	NX 06272 61025	Intermittent	EO			Loch Ryan
CAR/L/1026411	NX 07630 61388	Intermittent	EO			Bishop Burn
CAR/L/1081060	NX 05803 69746	Unknown	Other Effluent			Loch Ryan
CAR/L/1082401	NX 02109 64288	Intermittent	CSO			U/T of Sole Burn

Ref No.	NGR	Discharge Type	Level of Treatment	Flow (m^3/d)	PE	Discharges to
CAR/L/1082401	NX 02109 64288	Intermittent	EO			U/T of Sole Burn
CAR/L/1082402	NX 03910 68730	Intermittent	CSO			Loch Ryan
CAR/L/1082402	NX 03910 68730	Intermittent	EO			Loch Ryan
CAR/L/1082403	NX 06960 67870	Intermittent	CSO			Loch Ryan
CAR/L/1082403	NX 06960 67870	Intermittent	EO			Loch Ryan
CAR/L/1087260	NX 03097 68695	Intermittent	CSO			Corsewall Burn
CAR/L/1087410	NX 06040 69358	Continuous	Tertiary		368	Loch Ryan
CAR/R/1009265	NW 98842 63402	Continuous	Septic Tank		5	Mill Isle Burn
CAR/R/1009295	NX 02360 59644	Continuous	Septic Tank		5	Soakaway
CAR/R/1009296	NX 02360 59644	Continuous	Septic Tank		5	Soakaway
CAR/R/1009684	NX 01340 72520	Continuous	Septic Tank		6	Soakaway
CAR/R/1009819	NX 04937 62109	Continuous	Septic Tank		8	Loch Ryan
CAR/R/1011703	NW 99883 59474	Continuous	Septic Tank		5	Knock and Maize Burn
CAR/R/1011794	NW 97120 69410	Continuous	Septic Tank		10	Soakaway
CAR/R/1013675	NX 00063 61119	Continuous	Untreated		5	Green Burn
CAR/R/1013950	NW 98698 59314	Continuous	Septic Tank		5	Un/Wc
CAR/R/1014237	NX 07329 67080	Continuous	Septic Tank		5	Soakaway
CAR/R/1014406	NX 07287 67113	Continuous	Septic Tank		6	Loch Ryan
CAR/R/1015161	NX 00616 63730	Continuous	Secondary		14	Un/Wc
CAR/R/1015313	NW 98190 69510	Continuous	Septic Tank		5	Soakaway
CAR/R/1016382	NW 97200 69660	Continuous	Septic Tank		15	Soakaway
CAR/R/1016516	NW 99314 65340	Continuous	Septic Tank		5	U/T of Glengyre
CAR/R/1016695	NW 99650 60680	Continuous	Septic Tank		5	Soakaway
CAR/R/1017264	NX 11338 60089	Continuous	Septic Tank		5	Land
CAR/R/1017375	NX 08259 56252	Continuous	Septic Tank		5	Soakaway
CAR/R/1017385	NX 00390 61330	Continuous	Septic Tank		14	Land
CAR/R/1017800	NX 13380 70990	Continuous	Septic Tank		5	Soakaway
CAR/R/1018125	NX 01210 67200	Continuous	Septic Tank		5	Soakaway
CAR/R/1018183	NX 03477 59264	Continuous	Septic Tank		8	Partial soakaway to Crailloch Burn
CAR/R/1018330	NX 03517 57648	Continuous	Septic Tank		5	Un/Wc
CAR/R/1018687	NX 01630 65970	Continuous	Septic Tank		5	Soakaway
CAR/R/1018760	NX 08416 62499	Continuous	Untreated		5	Soakaway
CAR/R/1019069	NX 01245 66088	Continuous	Septic Tank		5	U/T of Sole Burn
CAR/R/1019613	NX 02501 64863	Continuous	Septic Tank		5	Soakaway
CAR/R/1019718	NX 00257 66972	Continuous	Septic Tank		15	Soakaway
CAR/R/1020004	NX 11026 59715	Continuous	Septic Tank		50	Soakaway
CAR/R/1021307	NX 04339 59747	Continuous	Septic Tank		6	Piltanton Burn
CAR/R/1021903	NX 01340 66100	Continuous	Septic Tank		5	Soakaway
CAR/R/1021981	NW 98590 71870	Continuous	Septic Tank		5	Soakaway
CAR/R/1022029	NX 02707 63562	Continuous	Septic Tank		10	Soakaway
CAR/R/1022357	NX 05750 58630	Continuous	Septic Tank		8	Soakaway
CAR/R/1022362	NX 05750 58630	Continuous	Septic Tank		10	Soakaway
CAR/R/1025508	NW 98224 68599	Continuous	Septic Tank		10	Soakaway
CAR/R/1026443	NX 08020 56350	Continuous	Septic Tank		5	Soakaway
CAR/R/1027232	NW 98201 68187	Continuous	Septic Tank		15	Soakaway
CAR/R/1027665	NW 98786 63225	Continuous	Septic Tank		5	Mill Isle Burn
CAR/R/1027954	NX 02442 64035	Continuous	Septic Tank		5	Sole Burn
CAR/R/1030980	NX 00570 65150	Continuous	Septic Tank		5	Soakaway

Ref No.	NGR	Discharge Type	Level of Treatment	Flow (m^3/d)	PE	Discharges to
CAR/R/1031932	NX 00730 71220	Continuous	Septic Tank		6	Soakaway
CAR/R/1031933	NX 00600 71000	Continuous	Septic Tank		10	Soakaway
CAR/R/1033944	NX 08120 61770	Continuous	Septic Tank		29	Soakaway and Loch Ryan
CAR/R/1033948	NX 08120 61770	Continuous	Septic Tank		29	Soakaway and Loch Ryan
CAR/R/1033949	NX 08060 61282	Continuous	Septic Tank		29	Soakaway and Loch Ryan
CAR/R/1033978	NX 07229 56454	Continuous	Septic Tank		5	Soakaway and Piltantin Burn
CAR/R/1034289	NX 04747 58591	Continuous	Septic Tank		5	Soakaway
CAR/R/1034290	NX 04732 58576	Continuous	Septic Tank		5	Soakaway
CAR/R/1034510	NX 01212 71049	Continuous	Septic Tank		5	Soakaway
CAR/R/1034511	NX 01207 71113	Continuous	Septic Tank		8	Soakaway
CAR/R/1034874	NW 97490 65450	Continuous	Septic Tank		5	Soakaway
CAR/R/1035413	NX 09836 60263	Continuous	Septic Tank		5	Soakaway
CAR/R/1043220	NX 01602 63791	Continuous	Septic Tank		11	U/T of Sole Burn
CAR/R/1049606	NX 06396 68584	Continuous	Septic Tank		10	Land
CAR/R/1050227	NX 08275 75296	Continuous	Septic Tank		5	Duplin Burn
CAR/R/1050228	NX 07527 74590	Continuous	Septic Tank		6	U/T to Water of App.
CAR/R/1050229	NX 07355 74669	Continuous	Septic Tank		6	Water of App
CAR/R/1050230	NX 06741 74200	Continuous	Septic Tank		5	Lissies Burn
CAR/R/1050231	NX 05595 73430	Continuous	Septic Tank		5	Altygunach Burn
CAR/R/1050232	NX 05460 73353	Continuous	Septic Tank		5	Un/Wc
CAR/R/1050233	NX 05170 72750	Continuous	Septic Tank		5	Soakaway
CAR/R/1050234	NX 07840 75114	Continuous	Septic Tank		5	Water of App
CAR/R/1051271	NX 01429 63836	Continuous	Septic Tank		5	Soakaway
CAR/R/1051391	NX 01392 63862	Continuous	Septic Tank		5	Soakaway
CAR/R/1051760	NX 03370 66510	Continuous	Septic Tank		5	Soakaway
CAR/R/1051761	NX 04770 60294	Continuous	Septic Tank		5	Soakaway
CAR/R/1052027	NX 02216 63987	Continuous	Septic Tank		45	Soakaway
CAR/R/1052059	NX 02544 64139	Continuous	Septic Tank		5	Soakaway
CAR/R/1052125	NX 03481 59935	Continuous	Septic Tank		5	Soakaway
CAR/R/1052317	NX 06634 56590	Continuous	Septic Tank		5	Duchra Burn
CAR/R/1052506	NX 00798 59963	Continuous	Septic Tank		5	Soakaway
CAR/R/1052873	NX 01399 63860	Continuous	Septic Tank		6	Soakaway
CAR/R/1053272	NW 96980 66060	Continuous	Septic Tank		10	Soakaway
CAR/R/1053557	NX 06618 56573	Continuous	Septic Tank		5	Duchra Burn
CAR/R/1053612	NX 03608 57600	Continuous	Septic Tank		8	Soakaway
CAR/R/1054162	NX 05835 55770	Continuous	Septic Tank		5	Soakaway
CAR/R/1054295	NW 98187 70509	Continuous	Septic Tank		6	Soakaway
CAR/R/1054483	NX 03196 66722	Continuous	Septic Tank		5	Soakaway
CAR/R/1054507	NX 01430 67390	Continuous	Septic Tank		5	Soakaway
CAR/R/1054520	NX 01360 66000	Continuous	Septic Tank		5	Soakaway
CAR/R/1054529	NX 03400 66660	Continuous	Septic Tank		5	Soakaway
CAR/R/1055256	NW 98386 60991	Continuous	Septic Tank		14	Un/Wc
CAR/R/1055558	NX 07742 57491	Continuous	Septic Tank		5	Un/Wc
CAR/R/1056103	NX 05285 55872	Continuous	Septic Tank		5	Soakaway
CAR/R/1057518	NX 06450 58060	Continuous	Septic Tank		6	Soakaway

Ref No.	NGR	Discharge Type	Level of Treatment	Flow (m^3/d)	PE	Discharges to
CAR/R/1057610	NX 12590 71980	Continuous	Septic Tank		5	Soakaway
CAR/R/1063382	NX 02230 71900	Continuous	Septic Tank		6	Soakaway
CAR/R/1066549	NX 05990 58560	Continuous	Septic Tank		5	Soakaway
CAR/R/1068033	NX 13369 69524	Continuous	Septic Tank		10	Penwhirn Burn
CAR/R/1068037	NX 01958 71704	Continuous	Septic Tank		5	Soakaway
CAR/R/1068147	NX 02226 71711	Continuous	Septic Tank		5	Soakaway
CAR/R/1068603	NX 02310 69504	Continuous	Septic Tank		7	Corsewall Burn
CAR/R/1068605	NX 01569 70127	Continuous	Septic Tank		7	Corsewall Burn
CAR/R/1068608	NX 01445 70289	Continuous	Septic Tank		5	Balloch a Rody
CAR/R/1068611	NX 02900 70290	Continuous	Septic Tank		6	Soakaway
CAR/R/1068615	NX 02670 69900	Continuous	Septic Tank		5	Soakaway
CAR/R/1068621	NX 02956 70872	Continuous	Septic Tank		5	Soakaway
CAR/R/1068626	NX 02741 69095	Continuous	Septic Tank		10	Corsewall Burn
CAR/R/1068636	NX 01454 70293	Continuous	Septic Tank		10	Balloch a Rody
CAR/R/1068645	NX 03151 69030	Continuous	Septic Tank		14	Soakaway
CAR/R/1069764	NX 08222 56293	Continuous	Septic Tank		5	Soakaway
CAR/R/1069767	NX 00560 63900	Continuous	Septic Tank		12	Soakaway
CAR/R/1069799	NX 01134 63794	Continuous	Septic Tank		6	Soakaway
CAR/R/1069856	NX 03110 68274	Continuous	Septic Tank		5	Soakaway
CAR/R/1069923	NX 00616 63657	Continuous	Septic Tank		5	Un/Wc
CAR/R/1070743	NX 01858 64416	Continuous	Septic Tank		5	Soakaway
CAR/R/1070824	NW 99493 59820	Continuous	Septic Tank		5	Soakaway
CAR/R/1070826	NW 99720 59523	Continuous	Septic Tank		5	Soakaway
CAR/R/1071426	NX 02900 71320	Continuous	Secondary		6	Soakaway
CAR/R/1071541	NX 01189 56950	Continuous	Septic Tank		5	Soakaway
CAR/R/1071747	NW 97250 65931	Continuous	Septic Tank		5	Un/Wc
CAR/R/1071786	NW 97200 65750	Continuous	Septic Tank		5	Un/Wc
CAR/R/1071797	NX 06605 56513	Continuous	Septic Tank		5	Duchra Burn
CAR/R/1071819	NW 97250 65867	Continuous	Septic Tank		7	Un/Wc
CAR/R/1071961	NX 01570 63020	Continuous	Septic Tank		5	Soakaway
CAR/R/1072037	NX 06628 56515	Continuous	Septic Tank		5	Duchra Burn
CAR/R/1072084	NX 05140 55990	Continuous	Septic Tank		5	Soakaway
CAR/R/1072092	NX 00270 57540	Continuous	Septic Tank		5	Soakaway
CAR/R/1072097	NX 05140 55980	Continuous	Septic Tank		5	Soakaway
CAR/R/1072120	NX 05620 55910	Continuous	Septic Tank		5	Soakaway
CAR/R/1072128	NX 05635 55916	Continuous	Septic Tank		5	Soakaway
CAR/R/1072164	NX 06147 58933	Continuous	Septic Tank		5	Soakaway
CAR/R/1072185	NX 04070 61928	Continuous	Septic Tank		5	Un/Wc
CAR/R/1072213	NX 04788 58713	Continuous	Septic Tank		5	U/T of Piltanton Burn
CAR/R/1072222	NX 00118 64919	Continuous	Septic Tank		5	Soakaway
CAR/R/1072476	NW 99725 65632	Continuous	Septic Tank		5	Soakaway
CAR/R/1073011	NX 03024 68159	Continuous	Septic Tank		5	Soakaway
CAR/R/1073745	NX 00610 67957	Continuous	Septic Tank		15	Soakaway
CAR/R/1073831	NX 08130 56268	Continuous	Septic Tank		5	Soakaway
CAR/R/1073906	NW 97896 66658	Continuous	Septic Tank		6	Soakaway
CAR/R/1073918	NW 97897 66634	Continuous	Septic Tank		5	Soakaway
CAR/R/1074319	NX 02250 63870	Continuous	Septic Tank		10	Soakaway
CAR/R/1074625	NX 02620 63690	Continuous	Septic Tank		7	Soakaway

Ref No.	NGR	Discharge Type	Level of Treatment	Flow (m^3/d)	PE	Discharges to
CAR/R/1074971	NX 01651 63829	Continuous	Septic Tank		7	U/T of Sole Burn
CAR/R/1074994	NX 02750 64690	Continuous	Septic Tank		6	Soakaway
CAR/R/1075606	NX 03276 64508	Continuous	Septic Tank		5	Soakaway
CAR/R/1075609	NX 02990 64340	Continuous	Septic Tank		5	Soakaway
CAR/R/1075611	NX 02810 64550	Continuous	Septic Tank		5	Soakaway
CAR/R/1075902	NX 05163 55989	Continuous	Septic Tank		5	Soakaway
CAR/R/1076493	NX 00110 71840	Continuous	Septic Tank		50	Soakaway
CAR/R/1078575	NW 99450 57940	Continuous	Septic Tank		5	Soakaway
CAR/R/1080097	NX 00030 71203	Continuous	Septic Tank		5	Soakaway
CAR/R/1081521	NX 00651 59060	Continuous	Secondary		5	U/T of Craigslave Burn
CAR/R/1084070	NW 97170 65360	Continuous	Septic Tank		5	High Mark Burn
CAR/R/1085405	NX 06910 58480	Continuous	Septic Tank		5	Soakaway
CAR/R/1085838	NX 00460 72200	Continuous	Septic Tank		10	Soakaway
CAR/R/1085928	NW 98760 70170	Continuous	Septic Tank		6	Soakaway
CAR/R/1086532	NX 00550 63420	Continuous	Septic Tank		5	Soakaway
CAR/R/1086898	NX 04900 62100	Continuous	Septic Tank		6	Soakaway
CAR/R/1087481	NX 00520 67345	Continuous	Septic Tank		5	Soakaway
CAR/R/1087750	NX 03450 64830	Continuous	Secondary		5	Loch Ryan
CAR/R/1087931	NX 02552 64843	Continuous	Septic Tank		6	Soakaway
CAR/R/1088666	NW 99480 65150	Continuous	Septic Tank		5	Soakaway
CAR/R/1090126	NX 03430 63930	Continuous	Septic Tank		15	Soakaway
CAR/R/1092694	NX 09963 58727	Continuous	Septic Tank		15	Soulseat Loch
CAR/R/1094230	NW 97453 59937	Continuous	Septic Tank		5	Soakaway
CAR/R/1094491	NX 03158 68148	Continuous	Secondary		5	U/T of Loch Ryan
CAR/R/1094692	NX 02760 64720	Continuous	Septic Tank		5	Soakaway
CAR/R/1094693	NX 02660 64750	Continuous	Septic Tank		5	Soakaway
CAR/R/1096705	NX 02699 69811	Continuous	Secondary		6	U/T of Corsewall Burn
CAR/R/1097357	NW 98240 61560	Continuous	Septic Tank		5	Soakaway
CAR/R/1098567	NW 97100 68850	Continuous	Septic Tank		5	Soakaway
CAR/R/1098831	NX 02250 63740	Continuous	Septic Tank		5	Soakaway
CAR/R/1098933	NW 98550 59750	Continuous	Septic Tank		6	Soakaway
CAR/R/1102269	NX 00480 67400	Continuous	Septic Tank		5	Soakaway
CAR/R/1102549	NW 98890 71530	Continuous	Septic Tank		6	Soakaway
CAR/R/1104721	NW 99170 68480	Continuous	Septic Tank		5	Soakaway
CAR/R/1105875	NX 00270 58640	Continuous	Septic Tank		5	Soakaway
CAR/S/1015115	NX 11260 59420	Continuous	Septic Tank		53	Soakaway
CAR/S/1035132	NX 06895 60378	Intermittent	Surface Water (Other) Commercial, Ind & Other			Black Stank Burn
CAR/S/1063034	NX 06648 59564	Continuous	Surface Water (SW) Commercial, Ind & Other			Land
CAR/S/1094806	NX 06202 61030	Intermittent	Other Effluent	1200	500	Loch Ryan
PPC/A/1003173	NX 07500 61700	Continuous	TE			Loch Ryan

Ref No.	NGR	Discharge Type	Level of Treatment	Flow (m^3/d)	PE	Discharges to
CAR/L/1000856	NX 13202 69581	Continuous	Other Effluent Potable Water Treatment and Supply	1		Penwhirn Burn
CAR/L/1000892	NX 04185 62860	Continuous	Other Effluent Potable Water Treatment and Supply	1		Loch Ryan