Scottish Sanitary Survey Project

Restricted Sanitary Survey Report

Luce Bay Razors
DG 499
November 2010

Cefas

Food Standards Agency
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Buidheann Inbhe-Bìdhe

Report Distribution – Luce Bay Razors

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1. Area Overview

Luce Bay is a broad, shallow, embayment on the south west coast of Scotland (see Figure 1.1). Luce Bay is bounded by the Rhins of Galloway peninsula on the west and the Machars peninsula on the east. The bay is 30 km wide at its entrance (from the Galloway headland – Mull of Galloway to the Machar headland – Burrow Head) and approximately 11 km wide within the inner bay. There is an extensive intertidal area and most of the bay is sheltered from wave action. Luce Bay was designated a Special Area of Conservation in 2005 due to its important dune, seashore and seabed habitats. The bay is also an active Ministry Of Defence firing range and training area.

A restricted sanitary survey at Luce Bay Razors was conducted in response to receipt of a full application to classify the north end of the loch for commercial harvest of razor clams (*Ensis* spp.).

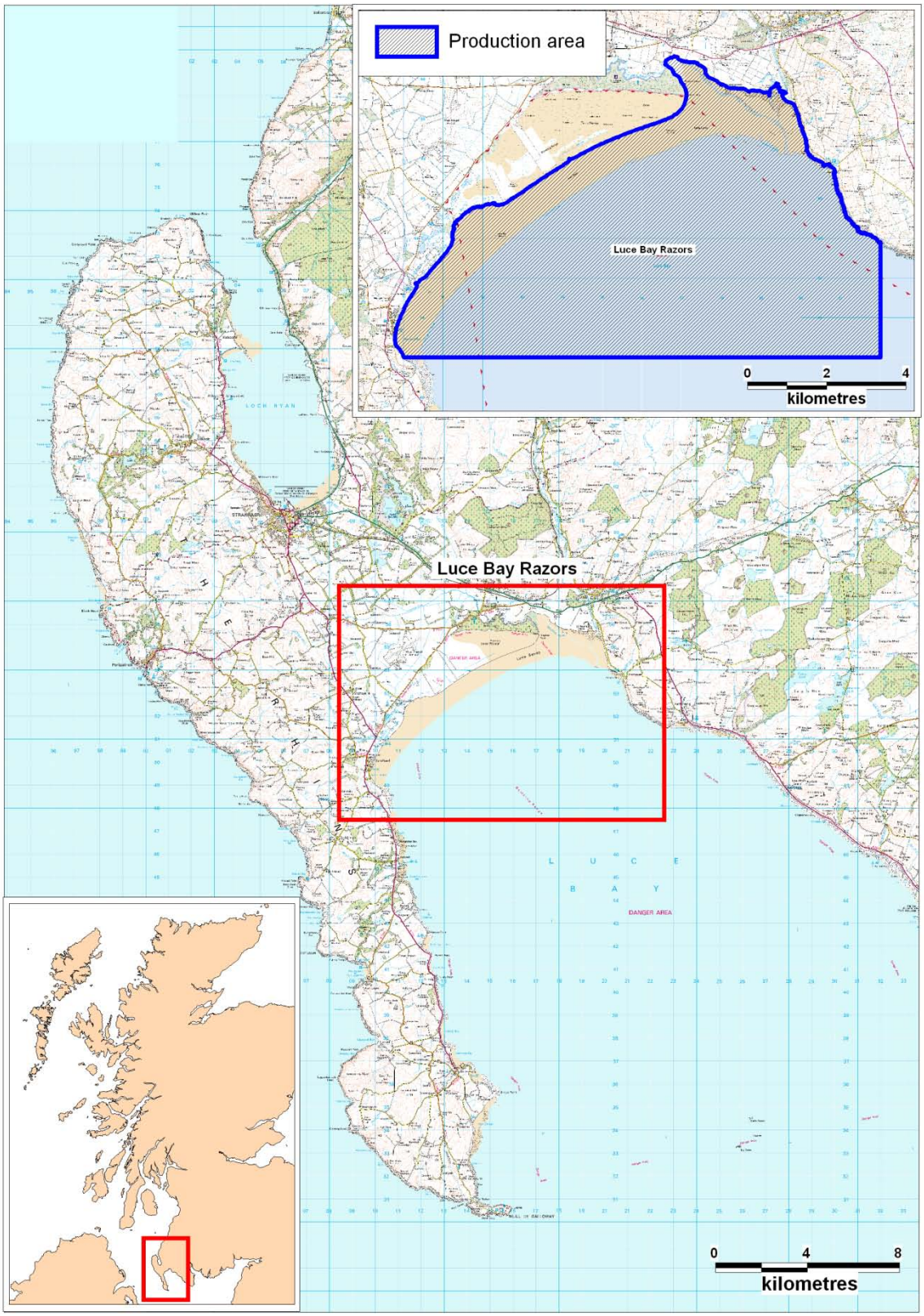

Figure 1.1 Location of Luce Bay Razors

1.1 Land Use

Land Cover 2000 data indicates that the land surrounding Luce Bay is a mixture of six main types of land cover: improved grassland, agricultural and horticulture, acid grassland, coniferous woodland, open dwarf shrub heath and bog. There are also smaller areas of calcareous grassland, littoral sediment and supra-littoral sediment. The west and north shoreline of the bay is predominantly improved grassland with patches of arable and horticultural land. The east side shoreline of the bay is more varied with areas of coniferous woodland, acid grassland, bog and neutral grassland in addition to areas of improved grassland and agricultural and horticultural land (see Figure 1.2).

Faecal coliform contributions from improved grassland have been shown to be approximately 8.3 x 10^8 cfu km^{-2} hr^{-1} (Kay et al, 2008). The contributions to the contamination if shellfish from all land cover types would be expected to increase significantly after marked rainfall events. This increase would be highest, at more than 100-fold, for improved grassland. The large areas of improved grassland adjacent to the majority of the shoreline surrounding the bay would be expected to contribute to contamination levels carried in surface runoff to the razor clam beds.

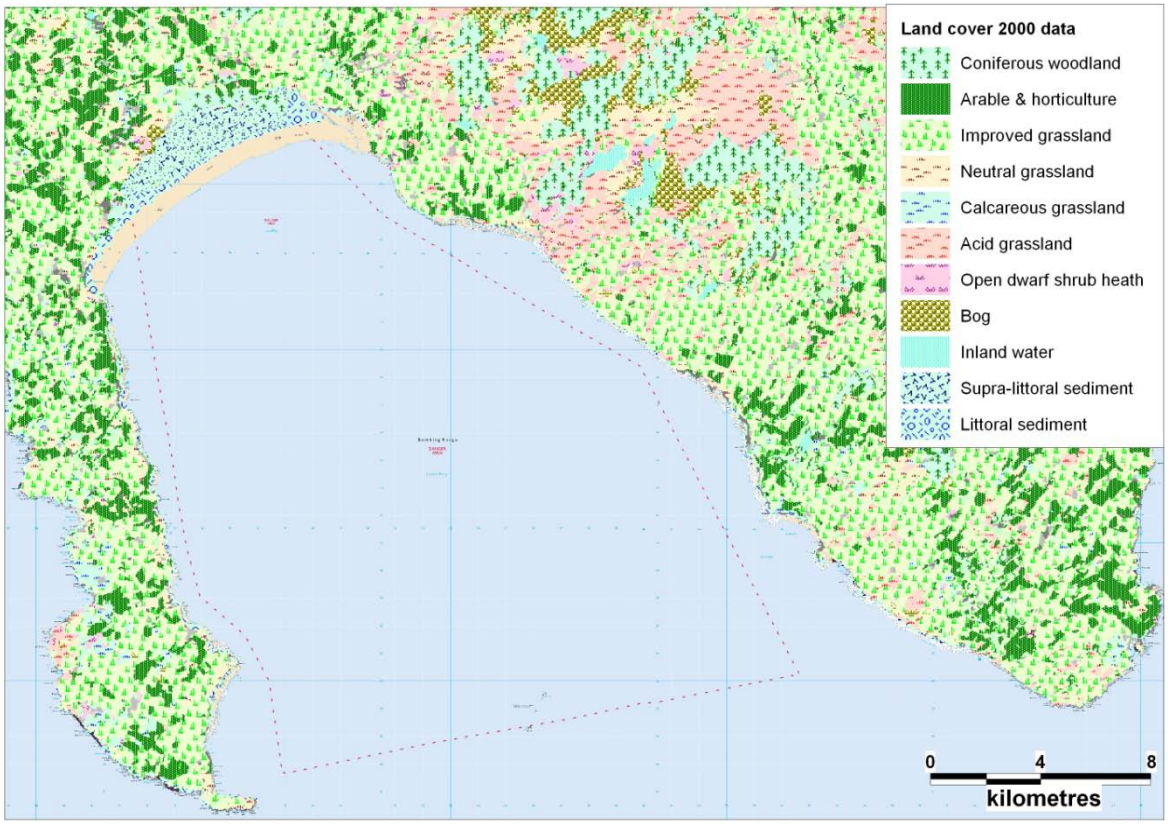

Figure 1.2 Land Cover 2000 data for Luce Bay Razors

1.2 Human Population

Human population figures from the 2001 census were obtained from the General Register Office for Scotland on the population within the census output areas in the vicinity of the Luce Bay Razors production area. Figure 1.3 shows the population density of the census output areas that are adjacent to Luce Bay.

There are five small settlements situated close to the shoreline of Luce Bay: Drummore, Sandhead, Dunragit, Glenluce and Port William. Glenluce is the largest of these with a population of 611, followed by Port William (468). The communities of Sandhead, Drummore and Dunragit have roughly 300 people each.

There are 12 caravan park/campsites on the surrounding coastline of Luce Bay. The largest is at Sandhead and is licensed for 386 units another halfway along the Rhins of Galloway peninsula is licensed for 159 units, a third on Burrow Head is licensed for 130 units and a fourth located in Glenluce is licensed for 47 units. The caravan park at Sandhead has 8 septic tanks. No information was found regarding sizes of the remaining sites.

Due to the majority of settlements being located directly on the shoreline of the Luce Bay, it is likely that sewage discharges from the settlements will contribute to the faecal contamination of the shellfish bed. Due to the large number of caravan parks/campsites, it is expected that the population in the area will increase significantly during the summer holiday months.

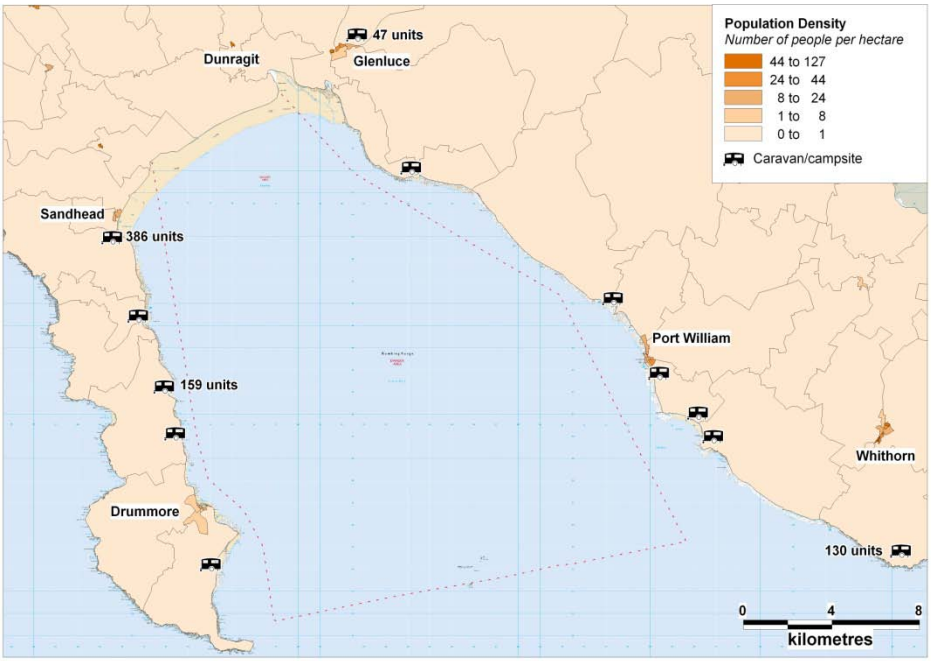

Figure 1.3 Population density of census output areas surrounding Luce Bay

2. Fishery

The fishery at Luce Bay Razors (DG 499 865 16) is comprised of a wild razor clam (*Ensis* spp.) bed. The western side of Luce Bay is currently harvested for razor clams. Natural razor beds are found in the sub tidal sandy beds and are inaccessible other than by boat. The razor clams are hand dived and harvesting is planned to take place throughout the year.

The fast track classification production area boundaries for Luce Bay Razors were identified by the Food Standards Agency (FSA) as the area bounded by lines drawn between points NX 1000 4900 to NX 2200 4900 to NX 2200 5190 extending to MHWS (see Figure 2.1). Due to the substantial number of Fast Track samples already submitted, the area has been given a provisional 'A' classification all year round. FSA Scotland had permitted for samples to be harvested from a representative monitoring zone located within the harvesting area boundary. This sampling area is defined by the points NX1160 5100, NX 1230 5050, NX 1430 5230, NX 1380 5280 and NX 1160 5100. The razor bed at Luce Bay does not lie within a designated shellfish growing water.

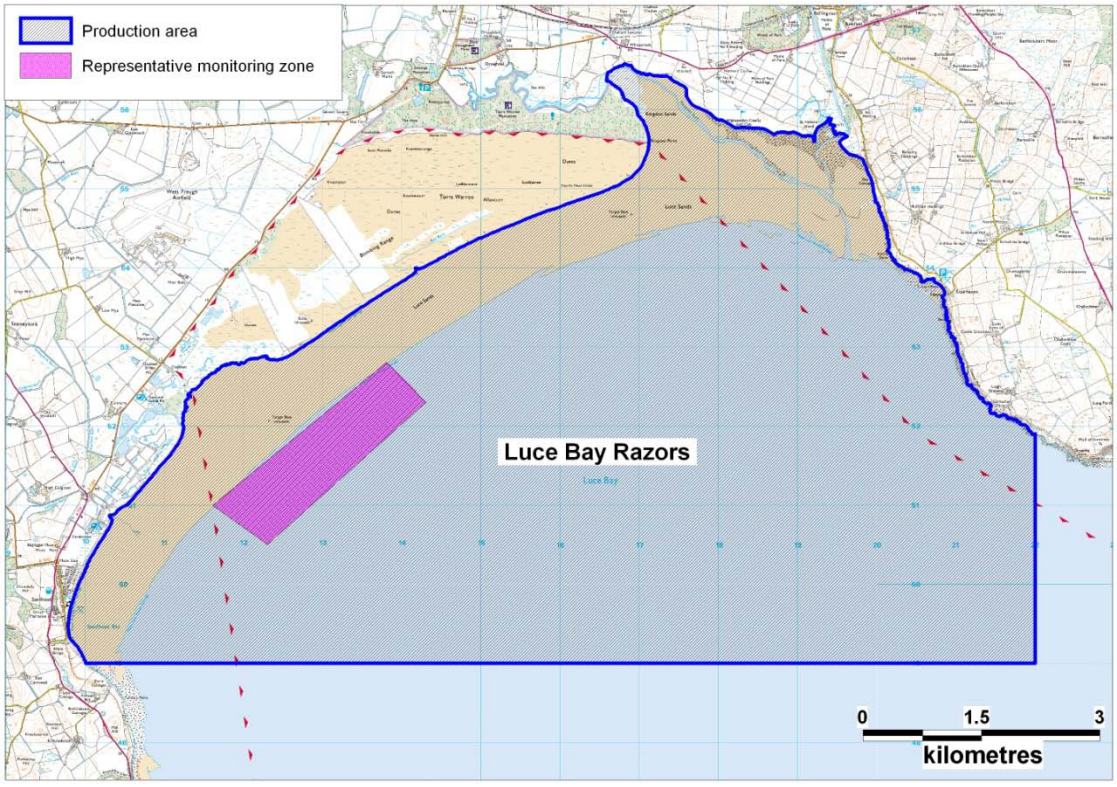

Figure 2.1 Luce Bay Razors fishery

3. Sewage Discharges

Scottish Water identified community septic tanks (ST) and other sewage infrastructure for the coastline surrounding Luce Bay. These are detailed in Table 3.1 and their locations are identified in the map in Figure 3.1. A short table of acronyms follows at the end of this section for reference.

Table 3.1 Sewage discharges identified by Scottish Water

Licence Reference	Discharge Name	NGR of Discharge	Type	Level of Treatment	Consented Flow (DWF) m3/d	Design POP
Not given	Dunragit settled CSO	NX 1550 5647	Intermittent	Primary	131	404
Not given	Dunragit CSO	NX1550 5647	Intermittent	6mm screening	131	404
CAR/L/1021183	Dunragit STW	NX 1550 5647	Continuous	Primary	131	404
CAR/L/1003488	Sandhead PS2 EO PS1 CSO/EO	NX 0990 4960	Intermittent	6mm screening	NA	380
CAR/L/1000804	Sandhead STW	NX 0980 4930	Continuous	Primary	408	380

No sanitary or microbiological data was available for these discharges.

Information on consented discharges to the Luce Bay area was sought from the Scottish Environment Protection Agency (SEPA). Information provided on public and/or commercial sewage discharges is listed in Table 3.2 below.

Table 3.2 Public discharges identified by SEPA

No.	Reference	NGR of discharge	Name	Discharge Type	Consented flow (DWF) m^3/d	Consented/ design PE	Discharges to
1	CAR/L/1003488	NX 0990 4960	Sandhead PS1	Sewage EO			Luce Bay
2	CAR/L/1003488	NX 0980 4960	Sandhead PS1	CSO			Luce Bay
3	CAR/L/1003488	NX 0989 4932	Sandhead STW	FE, primary			Luce Bay
4	CAR/L/1000804	NX 0980 4920	Sandhead PS	CSO	408	380	Cairnweil Burn
5	CAR/L/1067512 and CAR/L/1003130	NX 0893 5333	Stoneykirk WWTW	CSO, EO and FE, secondary			Caldons Burn
6	CAR/L/1003613	NX 1123 5425	Rae West Freugh STW	FE, primary			U/T of Luce Bay
7	CAR/L/1003485	NX 0678 5646	Lochans	FE, secondary			Piltanton Burn
8	CAR/L/1003485	NX 0671 5651	Lochans	CSO/SSO			Piltanton Burn
9	CAR/L/1021183	NX 1550 5647	Dunragit STW	CSO/SSO and FE, secondary	131	404	Piltanton Burn
10	CAR/L/1000572	NX 1979 5728	Glenluce, 20 Main St.	CSO			Lady Burn
11	CAR/L/1003603	NX 1932 5660	Glenluce	CSO			Luce Water
12	CAR/L/1003603	NX 1931 5671	Glenluce WWTW	FE, secondary	462	850	Luce Water
13	CAR/L/1003603	NX 1939 5660	Glenluce	SSO			Luce Water
14	CAR/L/1066026	NX 1958 5716	Sevenoaks	CSO			Lady Burn
15	CAR/L/1066082	NX 1995 5733	Balkail Caravan Park	CSO			Lady Burn

SEPA noted a septic tank at Ardwell, but that it was very small and therefore no licence details were available. Three further community discharges were identified by SEPA at Drummore, Port William and Montreith, located between 16 and 23 km south of the fishery. These discharges may contribute to background levels of faecal contamination in the upper part of the bay, however due to their distance from the fishery, they are not specifically considered here. Details of these discharges can be found listed in Appendix 4.

In addition to the public sewage works, a large number of consents for small, private sewage discharges and septic tanks were identified by SEPA. Those located within 3 km of the fishery are listed in Table 3.3 below. The majority were for septic tank discharges to soakaway systems. When properly sited and maintained, septic tanks and soakaway systems are not likely to impact water quality in the bay. However, the condition of these systems is not known and any malfunctioning systems near the shore or watercourses could contribute to faecal contamination levels in the bay.

Table 3.3 Consents for domestic discharges identified by SEPA

No.	Reference	NGR of discharge	Discharge Type	Consented/ design PE	Discharges to
1	CAR/R/1080838	NX 0987 5011	STE	7	Soakaway
2	CAR/R/1017737	NX 2126 5416	STE	10	Soakaway
3	CAR/R/1079774	NX 2083 5383	STE	5	Soakaway
4	CAR/R/1018897	NX 2090 5372	STE	7	Soakaway
5	CAR/R/1018420	NX 2089 5368	STE	6	Soakaway
6	CAR/R/1018573	NX 2089 5367	STE	6	Soakaway
7	CAR/R/1019397	NX 2089 5368	STE	6	Soakaway
8	CAR/R/1060222	NX 2248 5504	STE	5	Soakaway
9	CAR/R/1017506	NX 2074 5383	STE	5	Soakaway
10	CAR/R/1021265	NX 2087 5362	STE	5	Soakaway
11	CAR/R/1014352	NX 2070 5380	STE	5	Soakaway
12	CAR/R/1078992	NX 0928 4880	STE	5	Soakaway
13	CAR/R/1026600	NX 0842 5007	STE	5	Soakaway
14	CAR/R/1072226	NX 0971 4870	STE	15	U/T Cairnweil Burn
15	CAR/R/1078910	NX 0971 4871	STE	6	U/T Cairnweil Burn
16	CAR/R/1078934	NX 0970 4864	STE	5	Unnamed ditch
17	CAR/R/1078951	NX 1029 4873	STE	5	Luce Bay
18	CAR/R/1078852	NX 1011 4855	STE	5	Soakaway
19	CAR/R/1078994	NX 0927 4846	STE	5	Soakaway
20	CAR/R/1069854	NX 2274 5325	STE	5	Soakaway
21	CAR/R/1078928	NX 1008 4847	STE	5	Soakaway
22	CAR/R/1052150	NX 0974 5148	STE	12	Soakaway
23	CAR/R/1078923	NX 1011 4839	STE	5	Soakaway
24	CAR/R/1078922	NX 1013 4839	STE	5	Soakaway
25	CAR/R/1078924	NX 1010 4838	STE	5	Soakaway
26	CAR/R/1078989	NX 0819 4891	STE	5	Soakaway
27	CAR/R/1078975	NX 0834 4860	STE	5	Soakaway
28	CAR/R/1078983	NX 0994 4808	STE	5	Soakaway
29	CAR/R/1069846	NX 2281 5354	STE	5	Soakaway
30	CAR/R/1069807	NX 2283 5347	STE	5	Soakaway
31	CAR/R/1020334	NX 2174 5247	FE-secondary	6	U/T of Auchenmalg Bay
32	CAR/R/1078984	NX 0840 4840	STE	5	Soakaway
33	CAR/R/1078980	NX 0987 4795	STE	6	Soakaway
34	CAR/R/1078991	NX 0893 4796	STE	5	Soakaway
35	CAR/R/1078988	NX 0886 4797	STE	5	Soakaway
36	CAR/R/1016523	NX 0883 5199	STE	5	U/T of Culgroat Burn

No.	Reference	NGR of discharge	Discharge Type	Consented/ design PE	Discharges to
37	CAR/R/1075177	NX 2379 5241	STE	5	Soakaway
38	CAR/R/1075168	NX 2384 5248	STE	5	Soakaway
39	CAR/R/1071203	NX 0748 4853	STE	6	Soakaway
40	CAR/R/1078958	NX 0818 4765	STE	5	Soakaway
41	CAR/R/1051317	NX 0903 5263	STE	10	Soakaway
42	CAR/R/1079552	NX 0898 5265	STE	13	Soakaway
43	CAR/R/1078977	NX 0887 4708	STE	5	Unnamed watercourse
44	CAR/R/1078985	NX 1030 4708	STE	5	Soakaway
45	CAR/R/1013445	NX 0895 5285	STE	*	Soakaway
46	CAR/R/1050814	NX 0714 5166	STE	*	Soakaway

* data not provided

The list of private discharges in Table 3.3 is unlikely to include all septic tanks in the area, as there has not historically been a requirement to register all septic tanks in Scotland. No consent was obtained for the large caravan park/campground northeast of Sandhead (Sands of Luce Holiday Park), which is likely to have a septic tank.

During the shoreline survey, a small number of sewage related assets were observed. Sewage infrastructure recorded during the shoreline survey is listed in Table 3.3.

Table 3.4 Sewage discharge observations recorded during the shoreline survey

No.	**Date**	**NGR**	**Description**
1	30/08/2010	NX 0981 4929	Sandhead septic tank
2	30/08/2010	NX 0985 4930	Outfall pipe
3	31/08/2010	NX 1945 5678	Glenluce sewage works
4	31/08/2010	NX 1979 5545	Septic tank
5	31/08/2010	NX 1997 5508	Septic tank outfall from house
6	31/08/2010	NX 2081 5385	Stairhaven septic tank
7	31/08/2010	NX 2073 5388	13 new houses on septic tanks & public toilets on septic tank

Sewage infrastructure relating to the Sandhead and Glenluce works was observed during the shoreline survey. Observations 1 and 2 relate to the Sandhead septic tank and outfall pipe and observation 3 relates to the location of the Glenluce sewage works. The remaining observations relate to septic tanks along the northeastern shore.

Overall, the primary sources of sewage to the fishery are the discharges directly to the bay at Sandhead on the western end of the sands and those to Piltanton Burn and Luce Water at the eastern end of the sands, as well as the smaller septic tanks along the eastern shore. The soakaway systems identified near to observations 7 and 8 lie very close to the shoreline, and in one case below MHWS. These are likely to pose a risk to water quality in the near vicinity.

Acronymns

CSO	Combined Sewer Overflow
DWF	Dry Weather Flow
EO	Emergency Overflow
FE	Final Effluent

PE	Population Equivalent
ST	Septic Tank
STE	Septic Tank Effluent
U/T	Unnamed Tributary
WWPS*	Wastewater Pumping Station

* Also sometimes designated as PS, pumping station.

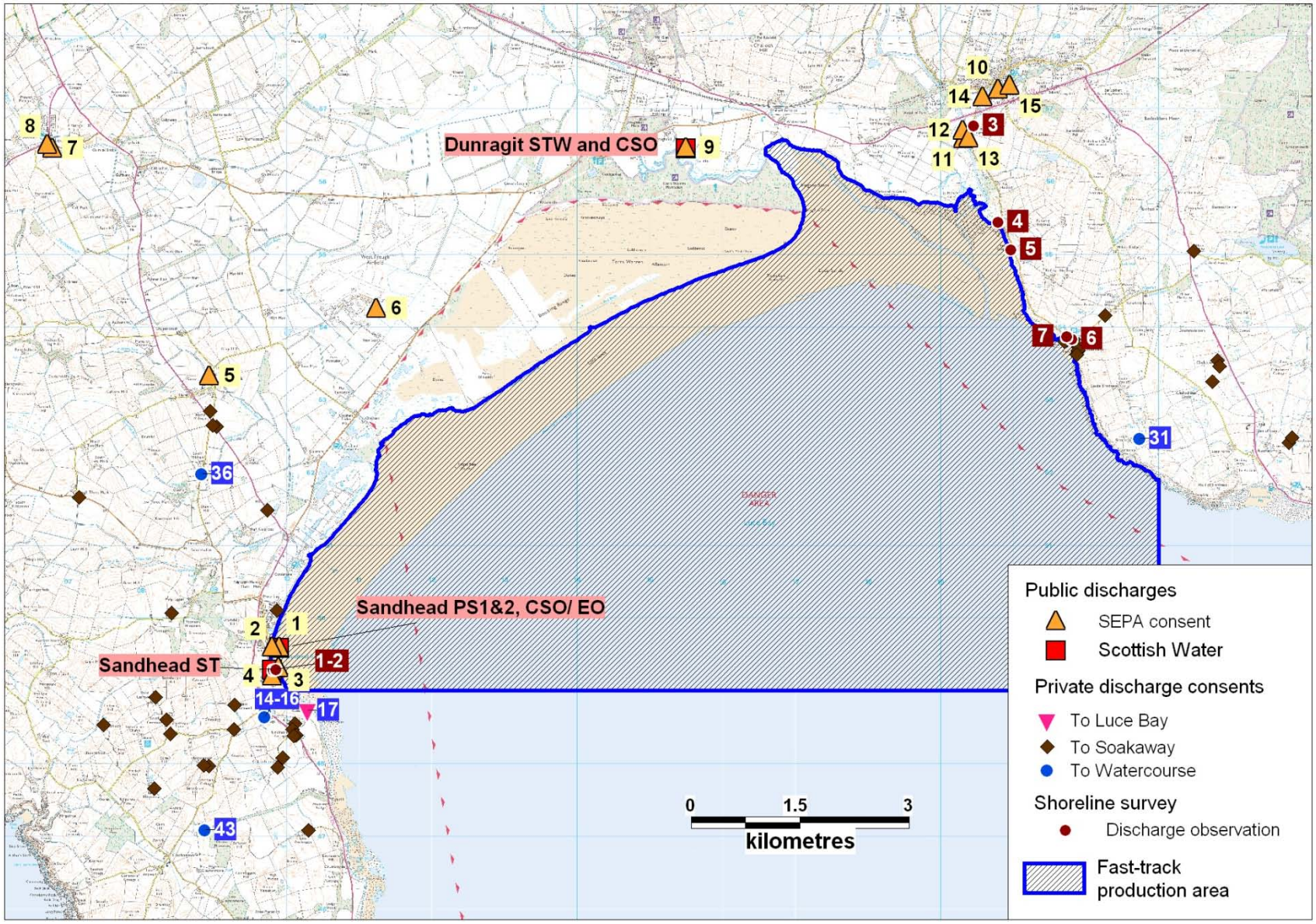

Figure 3.1 Luce Bay sewage discharges

4. Animals

4.1 Livestock

Agricultural census data to parish level was provided by the Rural Environment, Research and Analysis Directorate (RERAD) for the parishes Stoneykirk and Old Luce which are adjacent to the Luce Bay production area (see Figure 4.1). The two parishes encompass an area of 203 km^2. Reported livestock populations for the parishes in 2009 are listed in Table 4.1. 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 4.1 Livestock numbers in Stoneykirk and Old Luce - 2009

Parish:	Stoneykirk		Old Luce	
Total area (sq km):	77.77		125.5	
Year:	2009			
	Holdings	*Numbers*	*Holdings*	*Numbers*
Pigs	*	*	*	*
Poultry	8	228	6	99
Cattle	49	14071	42	14180
Sheep	7	23	28	228
Horses and ponies	14	38	9	39

* Data withheld for reasons of confidentiality

Livestock numbers on the surrounding land as a whole are likely to be at their highest during the summer months when calves and lambs are present. During the warmer months, livestock may access streams to drink and cool off more frequently, leading to higher levels of faecal contamination in freshwater streams and the shellfish bed itself. During the shoreline survey approximately 30-40 cattle were observed grazing on the eastern shoreline of Luce Bay, in a field just behind the shoreline. A pair of horses with riders was also observed at the north eastern end of the beach.

Although not specifically investigated for this area, livestock are commonly housed in barns during the winter months, leading to an increase in slurry production and higher runoff from hard standing areas. SEPA identified that large quantities of slurry were traditionally applied to land in June, after the first silage cut of the year. Large dairy holdings were reported to be present in the Piltanton Burn catchment, which is a candidate NVZ (nitrate vulnerable zone). Much of this catchment lies within Inch and Leswalt agricultural parishes, for which census data was not obtained. Dairy cattle are often bred in rotation to allow for year-round milk production, therefore there is likely to be less seasonal variation in the number of animals present. Slurry application in June is likely to lead to a significant increase in faecal loading to watercourses should it occur under rainy conditions, and direct deposition of faeces onto grazed areas will lead to an increase in faecal loadings to streams carrying runoff from these areas.

4.2 Wildlife

At the time of the shoreline survey various animal tracks including those from deer, stoat/mink and wading birds were observed along the central shoreline of the bay. Although numbers were not recorded swans and gulls were observed on the north east shoreline of the bay.

Luce Bay and Sands Special Area of Conservation was designated in 2005 and is identified as having important feeding and roosting areas for winter wildfowl and waders. Seals and seabirds were noted in the outer bay and the outer Mull of Galloway, which forms the western shore of the bay. Marine mammals, such as seals and dolphins, are reported to occur in the waters outside Luce Bay though no specific information was available regarding their presence within the razor clam production area identified at the head of the bay. SEPA identified that basking sharks were regularly observed in the bay, however sharks and other fish species are not known to be sources of *E. coli* or faecal pathogens of human importance.

It is possible that other animals including otters may be present in the area, however the distribution and numbers of these species was not investigated. Given the subtidal nature of the fishery, and its location near head of the loch, it is unlikely to be significantly impacted by faecal contamination from marine mammal or seabird sources. Gulls and other birds located at the head of the loch may contribute to background levels of contamination found in seawater at the head of the loch, and this impact may vary with season as some species of birds are more likely to be present in large numbers in winter.

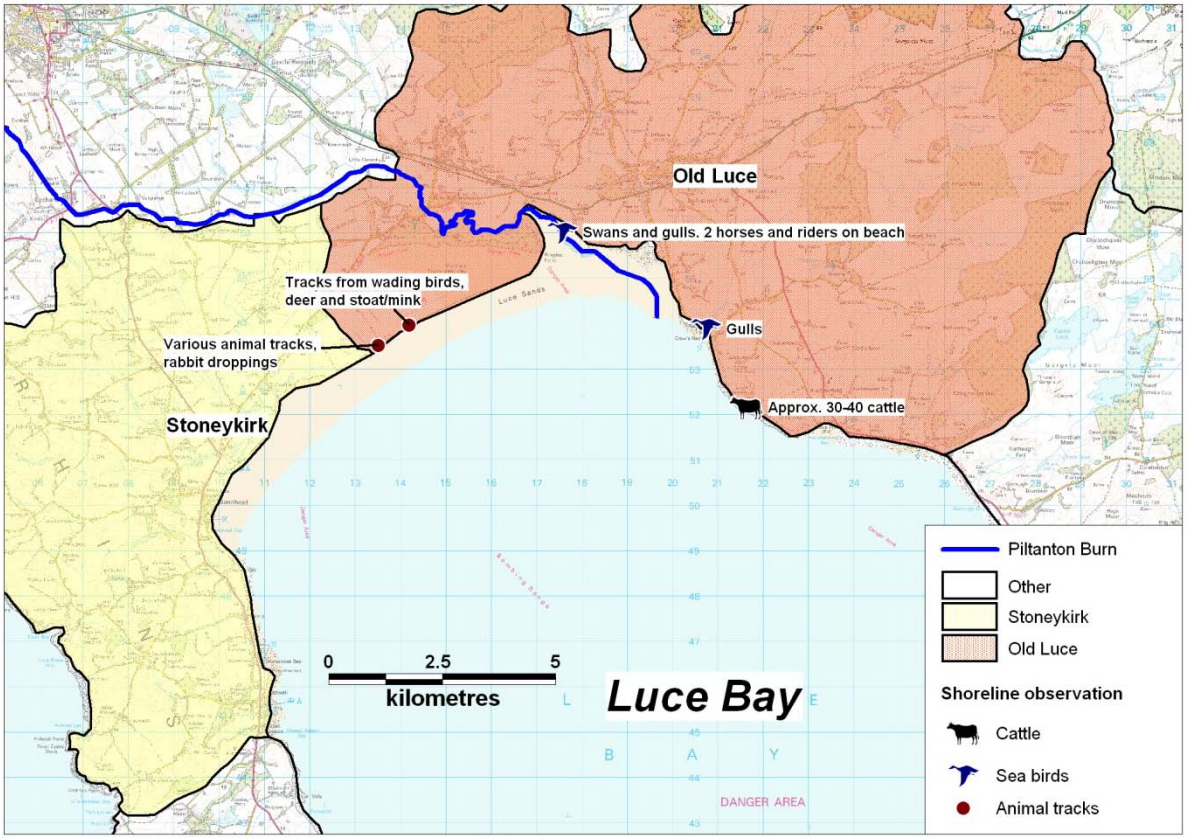

Figure 4.1 Agricultural parish boundaries and animals observed at Luce Bay

5. Rainfall

There are two weather stations close to Luce Bay. The closest is West Freugh located approximately 2.7 km north of Luce Bay and the second is Castle Kennedy located approximately 7.5 km north of Luce Bay. Daily rainfall values were purchased from the UK Meteorological Office for the period 1/1/2005 to 31/12/2009 inclusive for the Castle Kennedy weather station. Although closer to the fishery, the data for West Freugh was not complete and so the data from Castle Kennedy was used for the rainfall analysis. Unless otherwise identified, the content of this section (e.g. graphs) is based on further analysis of this data undertaken by Cefas.

5.1 Rainfall at Castle Kennedy

High rainfall and storm events are commonly associated with increased faecal contamination of coastal waters through surface water run-off 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 influence of rainfall on microbiological quality will depend on factors such as local geology, topography, land use and sewerage infrastructure. Figures 5.1 and 5.2 present box and whisker plots summarising 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 marked as a line within the box. 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 '*'.

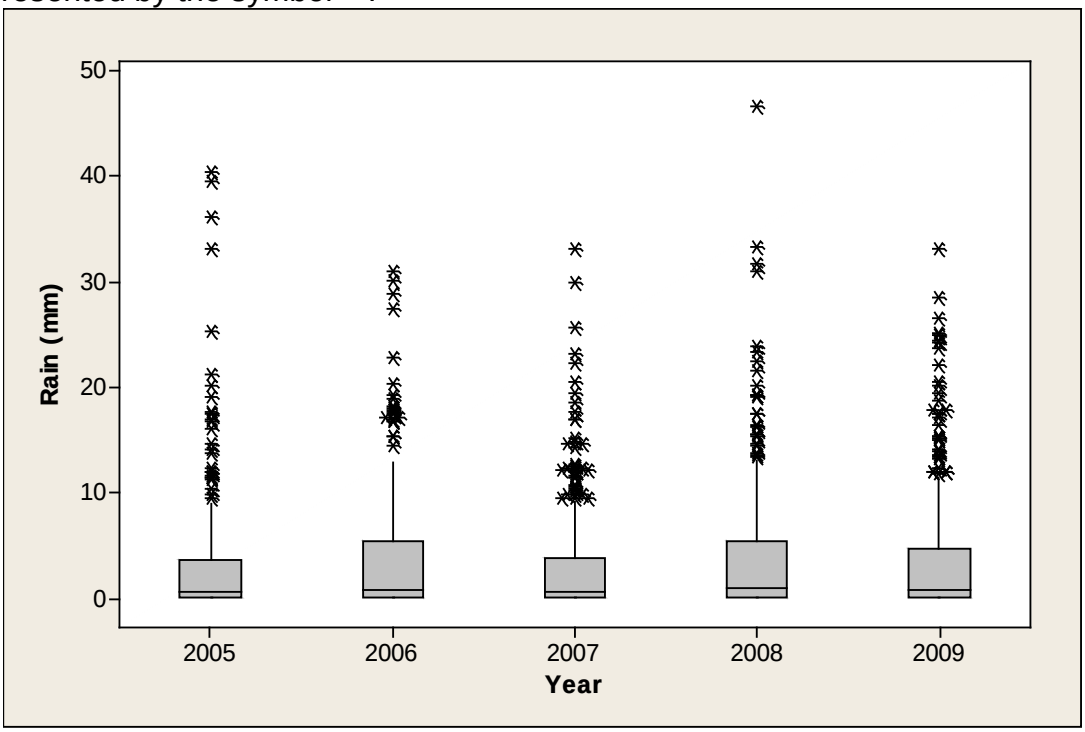

Figure 5.1 Box plot of daily rainfall values by year at Castle Kennedy, 2005-2009

Figure 5.1 shows that 2005 and 2007 were generally drier than 2006, 2008 and 2009.

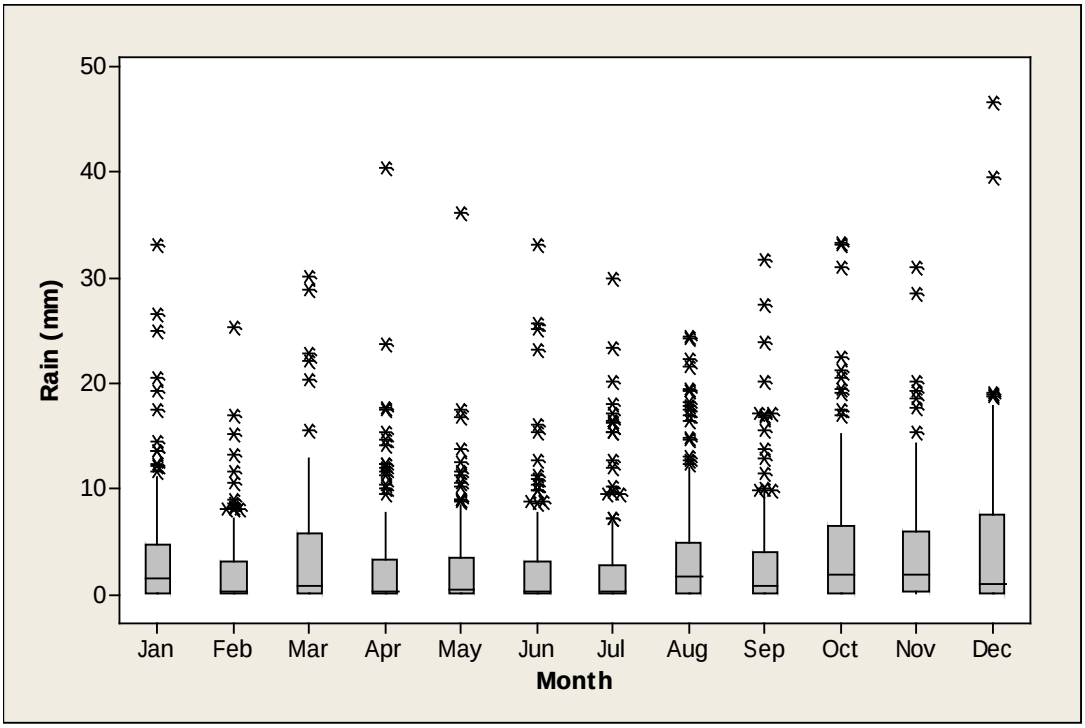

Figure 5.2 Box plot of daily rainfall values by month at Castle Kennedy, 2005-2009

Figure 5.2 indicates that the wettest months were October to January and March. February and April to July were the driest months. Days with rainfall greater than 25 mm occurred during all months apart from February. For the period considered here (2005-2009), 52% of days experienced rainfall less than 1 mm, and 9% of days experienced rainfall of 10 mm or more.

It is likely that amount of rainfall dependent faecal contamination entering the production area will be higher on average during the autumn and winter months. However, high rainfall events can occur at any time of the year. These may result in a contaminated 'first flush' of pasture runoff which may be particularly acute during the summer when livestock numbers are likely to be highest and preceding dry periods may result in a build-up of faecal matter on pastures. Additionally, as identified in Section 4, slurry is traditionally applied after silage is cut in June which could lead to high levels of faecal contamination in runoff should heavy rain occur soon after application.

6. River Flow

There are two river gauging stations in the vicinity of Luce Bay. Both of these were on watercourses that were identified as discharging into the eastern corner of the bay and thus potentially relevant to the Luce Bay assessment (see Figure 6.1). The location of both of watercourses was recorded during the shoreline survey. Piltanton Burn was sampled and measurements of size and flow were recorded. The Water of Luce was sampled and measurements of size but not flow were recorded (see Table 6.1). The river gauging station on the Water of Luce (NX 180 599) has a catchment area of 171 km^2, a mean flow of 6.09 m^3s^{-1} and a 90% quartile of 16.376 m^3s^{-1}. The river gauging station at Piltanton Burn (NX 107 564) has a catchment area of 34.2 km^2, a mean flow of 0.72 m^3s^{-1} and a 90% quartile of 1.827 m^3s^{-1}. Flows (m^3 per day) and loadings (*E. coli* per day) for both watercourses have been calculated using the river gauging station mean flow data and the dimensions taken during the shoreline survey (see Table 6.1).

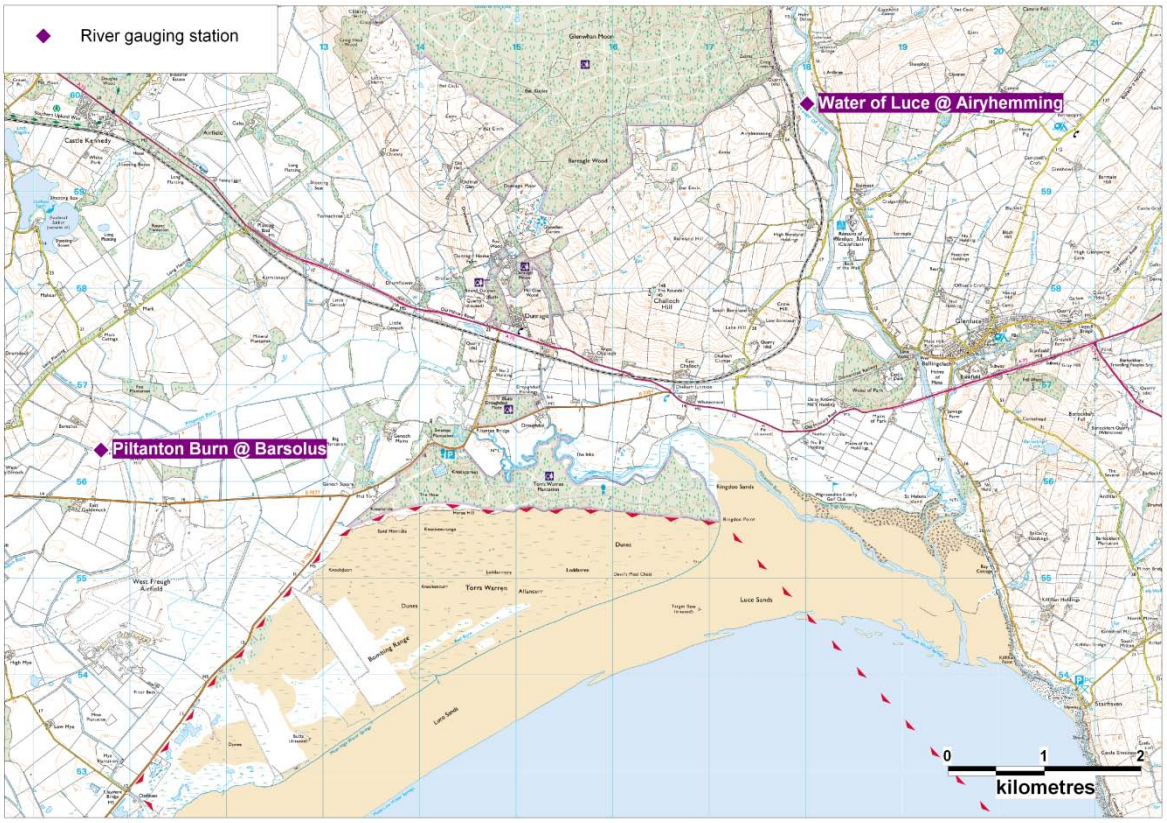

Figure 6.1 River gauging stations at Luce Bay

The watercourses listed in Table 6.1 were recorded and sampled and measured where possible, during the shoreline survey. The locations are shown on the map presented in Figure 6.1. Where the bacterial loading is labelled on the map, the scientific notation is written in digital format, as this is the only format recognised by the mapping software. So, where normal scientific notation for 1000 is 1 x 10^3, in digital format it is written as 1E+3.

Table 6.1 River/stream loadings and *E. coli* results for Luce Bay

No	Sample number	Grid Ref	Description	Width (m)	Depth (m)	Flow (m/s)	Flow in m^3/day	River gauging station mean flow m^3/day[1]	*E.coli* (cfu/ 100ml)	Loading (*E.coli* per day)	Loading (E. coli per day) using river gauging station mean flow m^3/day
1	LB001	NX1418353982	Red Burn	1.20	0.40	*	NA	NA	<10	NA	NA
2	LB002	NX1351253532	Stream	1.40	0.60	*	NA	NA	30	NA	NA
3	LB003	NX 11229 51980	Culmore Burn	3.10	0.34	*	NA	NA	70	NA	NA
4	LB004	NX10321 50738	Sandmill Burn	1.05	0.50	0.15	6804	NA	>10000	6.8×10^{11}	NA
5	LB007	NX10307 48796	Cairnwell Burn	1.10	0.50	0.024	1141	NA	300	3.4×10^{9}	NA
6	LB009	NX 17561 56008	Piltanton Burn	26	0.20	0.90	404000[2]	323000[2]	320	1.3×10^{12}	1.0×10^{12}
7	LB010	NX19476 55616	Water of Luce	9.4	0.24	*	NA	119000[2]	180	NA	2.1×10^{12}
8	LB011	NX20733 53878	Stream	3.6	0.14	0.118	5138	NA	250	1.3×10^{10}	NA

*Flow not measured
[1] Flow calculated using dimensions recorded during shoreline survey
[2]To three significant figures

Only the north end of the bay was surveyed, so not all streams were sampled, measured and/or recorded. The weather was dry during the survey period. The largest watercourse flowing into the northern end of the bay recorded during the shoreline survey was the Piltanton Burn.

The stream with the greatest calculated loading, (using measurements taken from the shoreline survey), of 6.8 x 10^{11} *E. coli* per day, was the Piltanton Burn located in the eastern corner of the bay. The data collected at the Piltanton Burn was similar to the data provided by the river gauging station, with a 0.3 difference in the calculated *E. coli* loading per day. Although the flow was not measured at the Water of Luce, an *E. coli* loading per day of 2.1 x 10^{12} was calculated using the river gauging station flow data and the shoreline survey measurements. This indicates that the *E. coli* loading per day is potentially greater at the Water of Luce compared to Piltanton Burn and would therefore have a greater impact on the shellfish bed. Both of these watercourses receive sewage effluent from upstream villages.

In general, loadings of streams would be expected to increase significantly following moderate to heavy rainfall and thus any effects on the microbiological quality of the razors would also increase. There is also the possibility for direct run-off from the surrounding land after rainfall. All of the streams recorded during the shoreline survey, especially the Water of Luce and Piltanton Burn would be potential pathways for contamination from animal faeces to enter the bay.

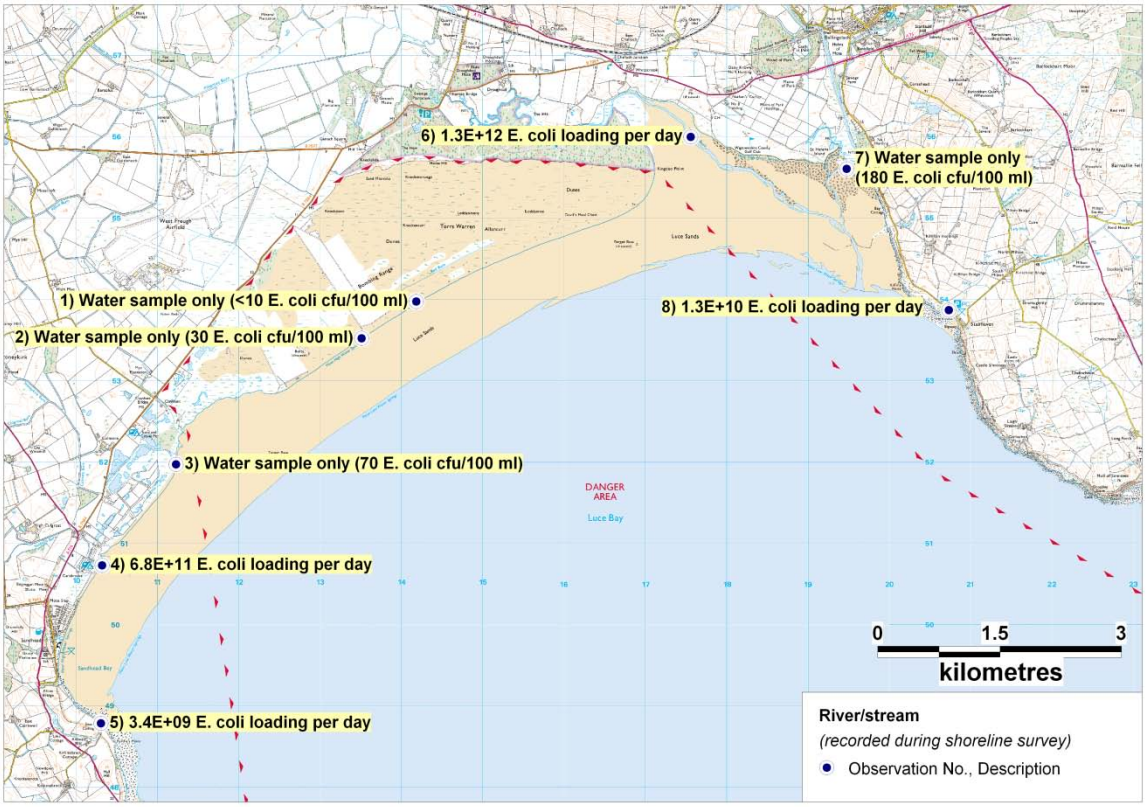

Figure 6.2 River/stream loadings and *E. coli* results at Luce Bay

7. Historical *E. coli* Monitoring Data

7.1 Validation

The *E. coli* results of all the razor samples taken from Luce Bay from mid 2008 up to October 2010 were extracted from the database and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data. No samples were rejected on the basis of sampling date discrepancies.

All *E. coli* results are reported in most probable number per 100 g of shellfish flesh and intravalvular fluid.

7.2 Summary of sampling and results by species/monitoring point

A summary of the number of samples and the *E. coli* results is presented in Table 7.1.

Table 7.1 Summary of historical results from Luce Bay 1, Luce Bay 2, Luce Bay 3, Luce Bay 4 and Luce Bay Razors

Sampling Summary					
Production area[1]	Luce Bay 1	Luce Bay 2	Luce Bay 3	Luce Bay 4	Luce Bay Razors
Site	Terally Point	Luce Sands	Luce Bay 3	Site 4	Luce Sands Razors
Species	Razor fish	Razor fish	Razor fish	Razor fish	Razor fish
SIN	DG 428 833 16	DG 429 834 16	DG 449 853 16	DG 483 808 16	DG 499 865 16
NGR	various	various	various	NX 165 535	various
Total no of samples	9	9	2	2	8
n 2008	9	9	0	0	0
n 2009	0	0	2	2	2
n 2010	0	0	0	0	6
Results Summary					
Minimum	<20	<20	40	80	<20
Maximum	5400	2400	70	170	80
Median	40	40	55	125	15
Geometric mean	79	51	52	117	24

[1] The production areas listed refer to entries in the SHS database and not classified areas. Apart from the samples where the site was given as Luce Bay 1 (Terally Point), all of the sampling locations were located towards MLWS in the inner bay. The sampling locations for Luce Bay 2, Luce Bay 3 and Luce Bay Razors showed some overlap.

7.3 Temporal pattern of results

Figure 7.1 presents a scatter plot of the individual log *E. coli* results against date for all razor clam samples taken from Luce Bay for all sites.

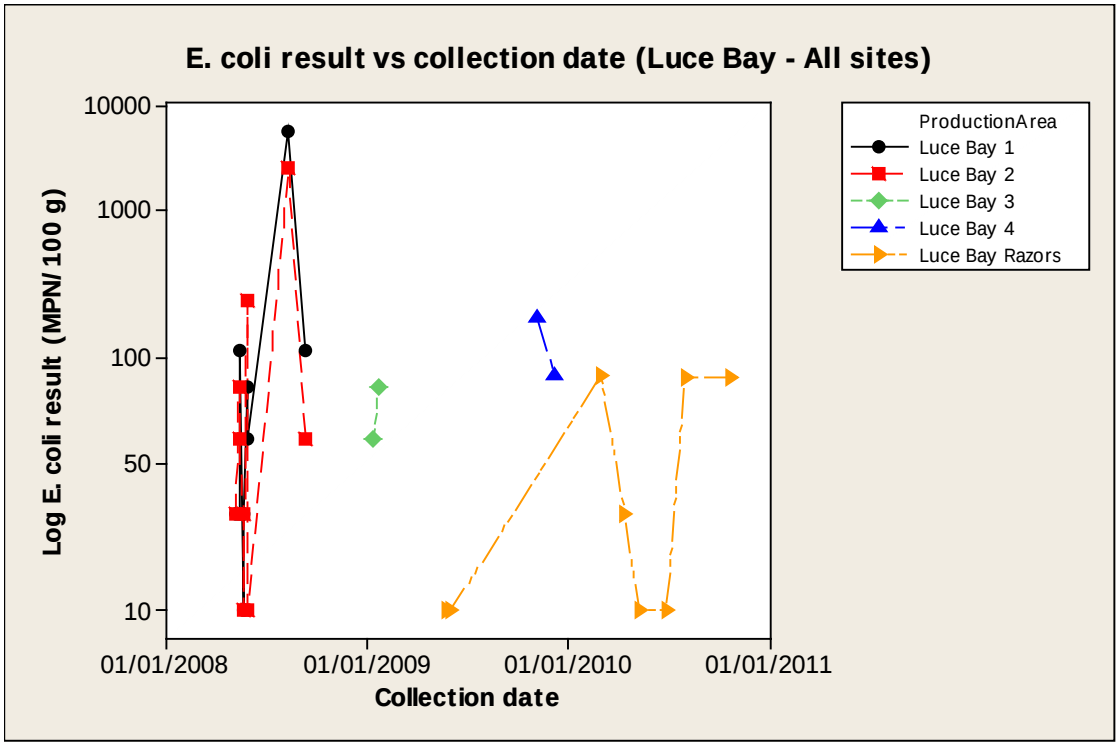

Figure 7.1 Scatter plot of *E. coli* result (MPN/100 g) for razor clams vs. collection date

Overall, there does not appear to be a consistent seasonal trend in results. Interpretation is complicated by the small data sets at several different sites.

7.4 Geographical pattern of results

Figure 7.2 shows a thematic map with the *E. coli* results plotted at the sampling locations of razor clams at Luce Bay. The samples shown at the far south western end of Luce Bay at Terally Point fall outside the production area, indicating that the shellfish bed extends outside of the current production area boundaries. The highest result (5,400 *E. coli* MPN/100 g) was seen at Terally Point. The second highest result (2,400 *E. coli* MPN/100 g) was seen at Luce Bay 2, located towards the centre of the inner bay immediately below mean low water springs. All other results were <230 *E. coli* MPN/100 g. No general spatial tendency is apparent in the data.

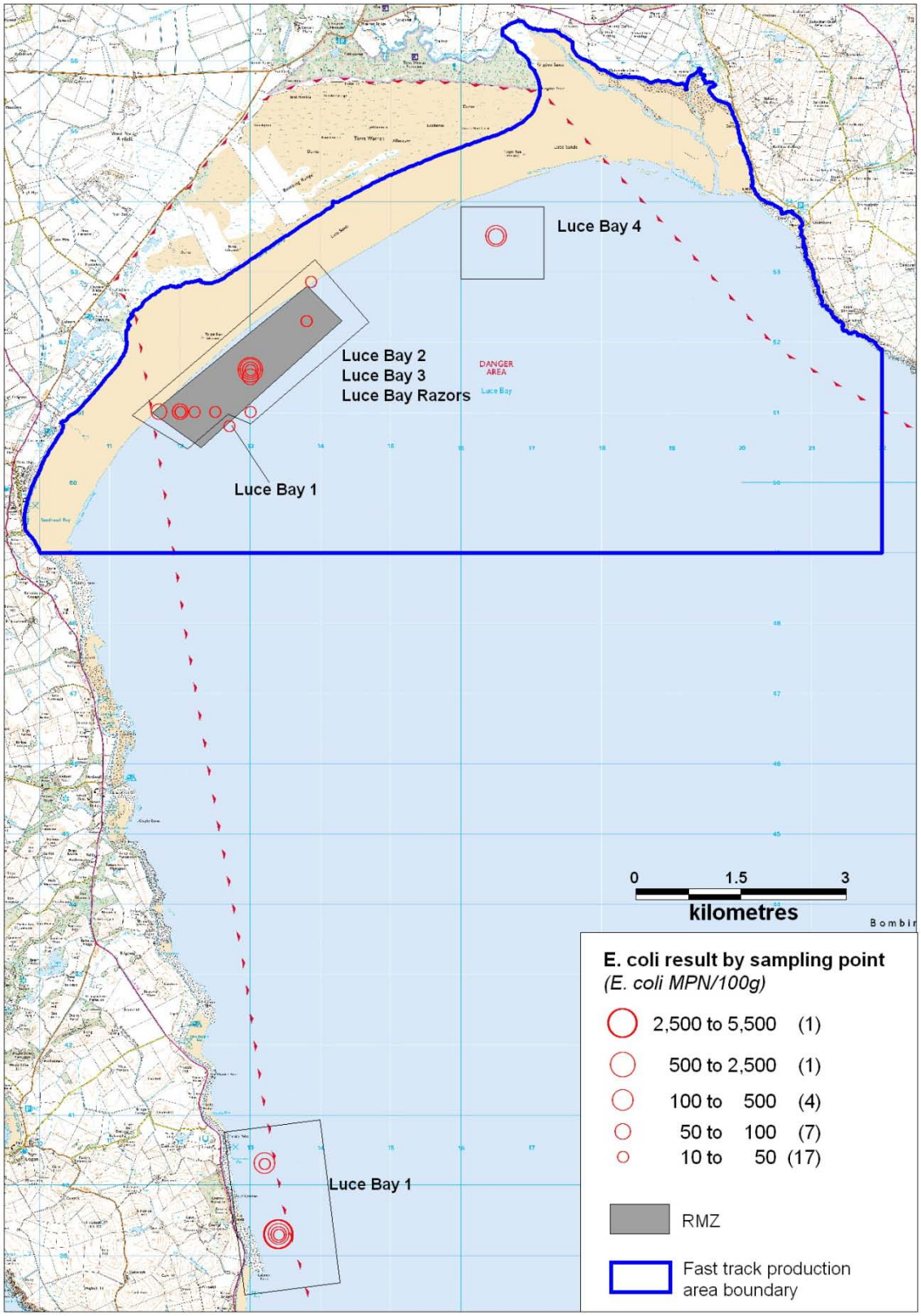

Figure 7.2 *E. coli* result (MPN/100 g) by sampling location for razor clams at Luce Bay

8. Bathymetry and Hydrodynamics

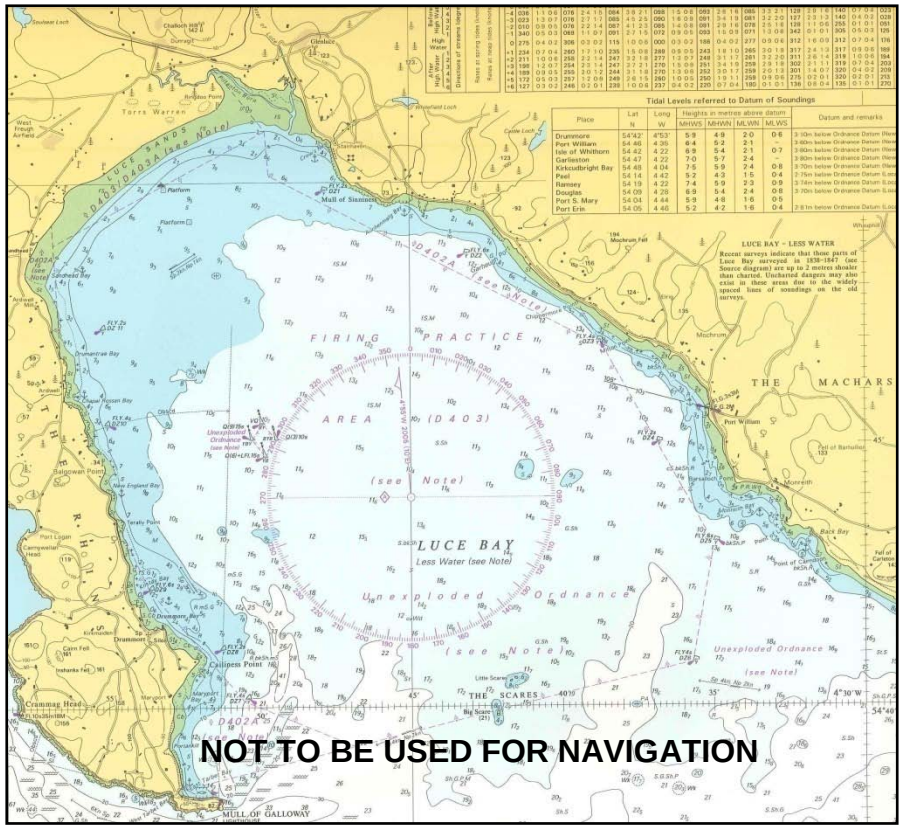

Figure 8.1 Luce Bay Admiralty chart

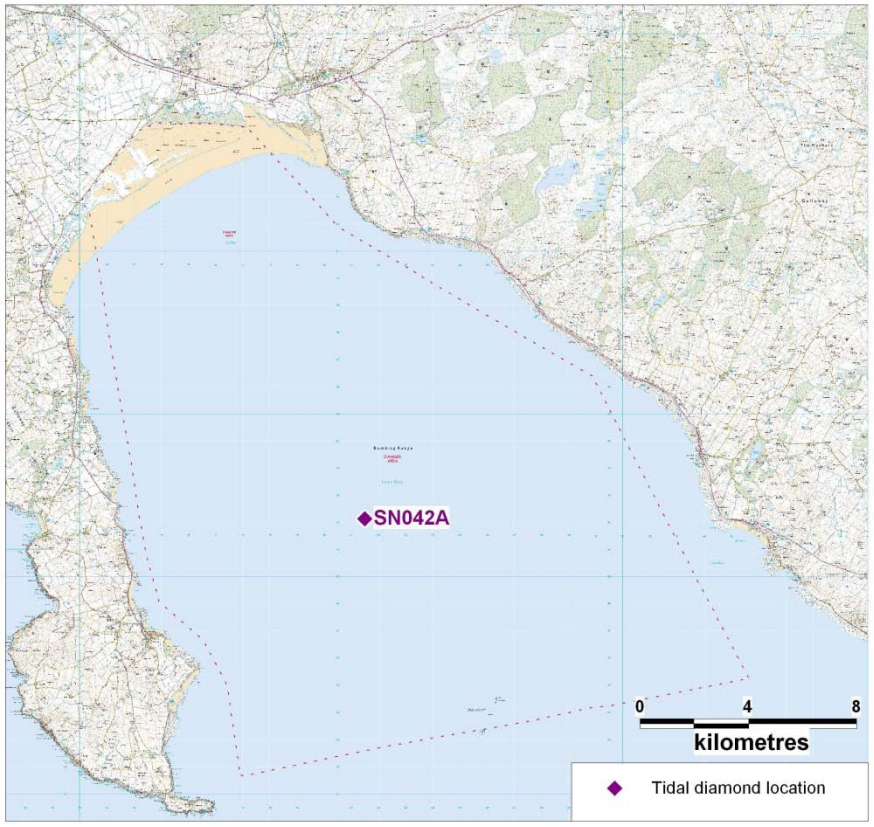

Figure 8.2 Ordnance Survey map of Luce Bay

The Admiralty chart in Figure 8.1 shows there is a drying area situated along the immediate shoreline of the bay, including Luce Sands. Depths in the northern part of the bay adjacent to Luce Sands are generally shallow (<10 m), and towards the centre of the bay the depth increases to 20 m. Past The Scares at the opening of Luce Bay, depths reach up to 30 m. Figure 8.2 shows the Ordnance Survey map of Luce Bay, with the tidal diamond plotted on.

The two tidal curves in Figure 8.3 are for the port of Luce Bay (Offshore Platform), the secondary non-harmonic port located in central Luce Bay. These have been output from UKHO TotalTide. The first is for seven days beginning 00.00 GMT on 20th August 2010. The second is for seven days beginning 00.00 GMT on 27th August 2010. Together they show the predicted tidal heights over high/low water for the full neap/spring tidal cycle during which the shoreline survey was undertaken.

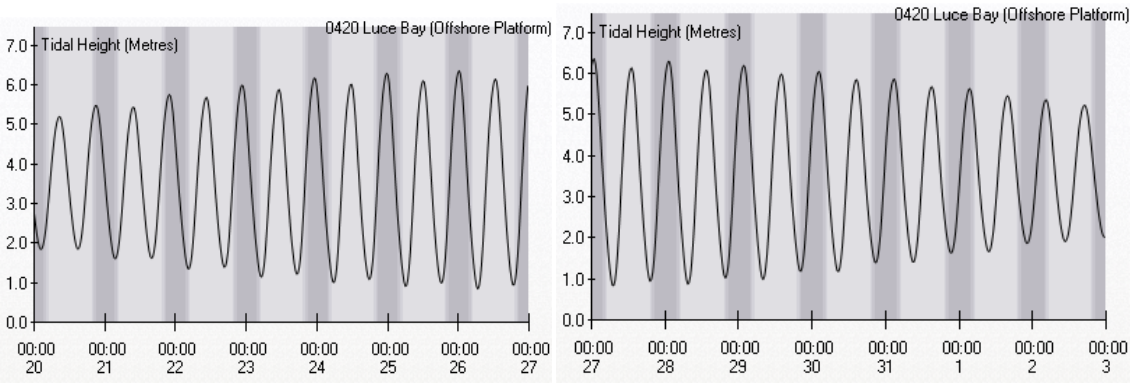

Figure 8.3 Tidal curves for Luce Bay (Offshore Platform)

The following is the UKHO summary description for Luce Bay (Offshore Platform):

The tide type is Semi-Diurnal.

MHWS	6.5 m
MHWN	5.3 m
MLWN	1.9 m
MLWS	0.6 m

Predicted heights are in metres above chart datum. The tidal range at spring tide is therefore approximately 5.9 m and at neap tide 3.4 m. The tidal range in the area is therefore moderate.

8.1 Currents

Tidal stream information available was from TotalTide for the tidal diamond SN042A located in Luce Bay (see Figure 8.2). The tidal diamond information is given below in Tables 8.1. The associated spring tidal streams are shown in Figure 8.4 (flood tide) and Figure 8.5 (ebb tide).

Table 8.1 Tidal diamond for station SN042A

Time	Direction	Spring rate (m/s)	Neap Rate (m/s)
-06h	135°	0.15	0.10
-05h	062°	0.26	0.15
-04h	043°	0.46	0.26
-03h	031°	0.62	0.36
-02h	019°	0.62	0.36
-01h	001°	0.36	0.21
HW	309°	0.21	0.11
+01h	250°	0.31	0.15
+02h	220°	0.41	0.26
+03h	204°	0.57	0.31
+04h	195°	0.57	0.31
+05h	184°	0.41	0.26
+06h	153°	0.21	0.10

The direction of the currents in the centre of the bay changes continually in a clockwise manner over the course of a tidal cycle. It is likely that, in addition to the general trend of water entering and leaving the bay over the cycle, currents will flow clockwise around the bay on the flood tide and anticlockwise on the ebb tide. At the peak current of approximately 0.6 m/s the maximum distance that contamination could be transported over a single flood or ebb tide would be over 8 km, ignoring dilution and diffusion.

8.2 Conclusions

There will be two effects of water movement in the transport of contaminates in relation to the fishery. On the ebbing tide, contamination from local sources will be taken across the drying area towards the bay. In addition, on the ebb tide, contaminants will be swept around the bay in an anticlockwise direction. On the flood tide, the flow will be in the opposite direction. Given the relatively shallow depths, dilution will be limited at any one point but both significant dilution and dispersion will occur under the distances (>10 km) across the fishery. Winds from the south or southeast may tend to entrain contamination arising from Piltanton Burn and Luce River at the head of the bay, potentially allowing it to persist over the shellfish bed for longer periods, thereby increasing exposure times.

Figure 8.4 Spring flood tide at Luce Bay

Figure 8.5 Spring ebb tide at Luce Bay

9. Shoreline Survey Overview

A restricted shoreline survey of the shoreline surrounding the Luce Bay Razors production area was undertaken by staff from Dumfries and Galloway Council and Cefas on the 30th and 31st August 2010.

On the north eastern coast of Luce Bay were the Glenluce sewage works, two private septic tanks, a septic tank outfall plus public toilets and 13 new houses that were connected to septic tanks. On the north western coast of Luce Bay there was a septic tank and outfall pipe.

Livestock were only observed in one location during the shoreline survey. Approximately 30-40 cattle were grazing on the eastern shoreline in a field behind the shoreline.

Various animal tracks including those from deer, stoat/mink and wading birds were observed along the central shoreline of the bay. Although numbers were not recorded, swans and gulls were observed on the north east shoreline. A pair of horse and horse riders were also observed at the north eastern end of the beach.

A total of nine sub-surface sea water samples were taken within the Luce Bay production area boundaries. Seven of these returned results of <10 *E. coli* cfu/100 ml. A sample taken on the western shoreline returned a result of 20 *E. coli* cfu/100 ml. A sample taken on the western shoreline close to an outfall pipe had a very high result of >10000 *E. coli* cfu/100 ml. Salinities recorded during the shoreline survey ranged from 34.9 to 36.2 ppt, apart from the sample taken close to the outfall pipe, this yielded a result of 30.3 ppt.

Freshwater samples were taken at most of the streams draining into the survey area, discharge measurements were taken were possible. The streams were of varying size and drained areas of arable and grazing land. Streams contained varying levels of contamination (<10 to >10000 *E. coli* cfu/100 ml). The stream with the highest *E. coli* result (>10000 *E. coli* cfu/100 ml) was located on the north-west side of the bay.

Razor clam samples were collected and provided by the harvester from three locations within the production area. The two samples taken at the east side of the bay both gave results of 130 *E. coli* MPN/100 g and the sample taken from the west side of the bay gave a result of 140 *E. coli* MPN/100 g.

A map is provided in Figure 9.1 that shows the relative locations of the most significant findings of the shoreline survey.

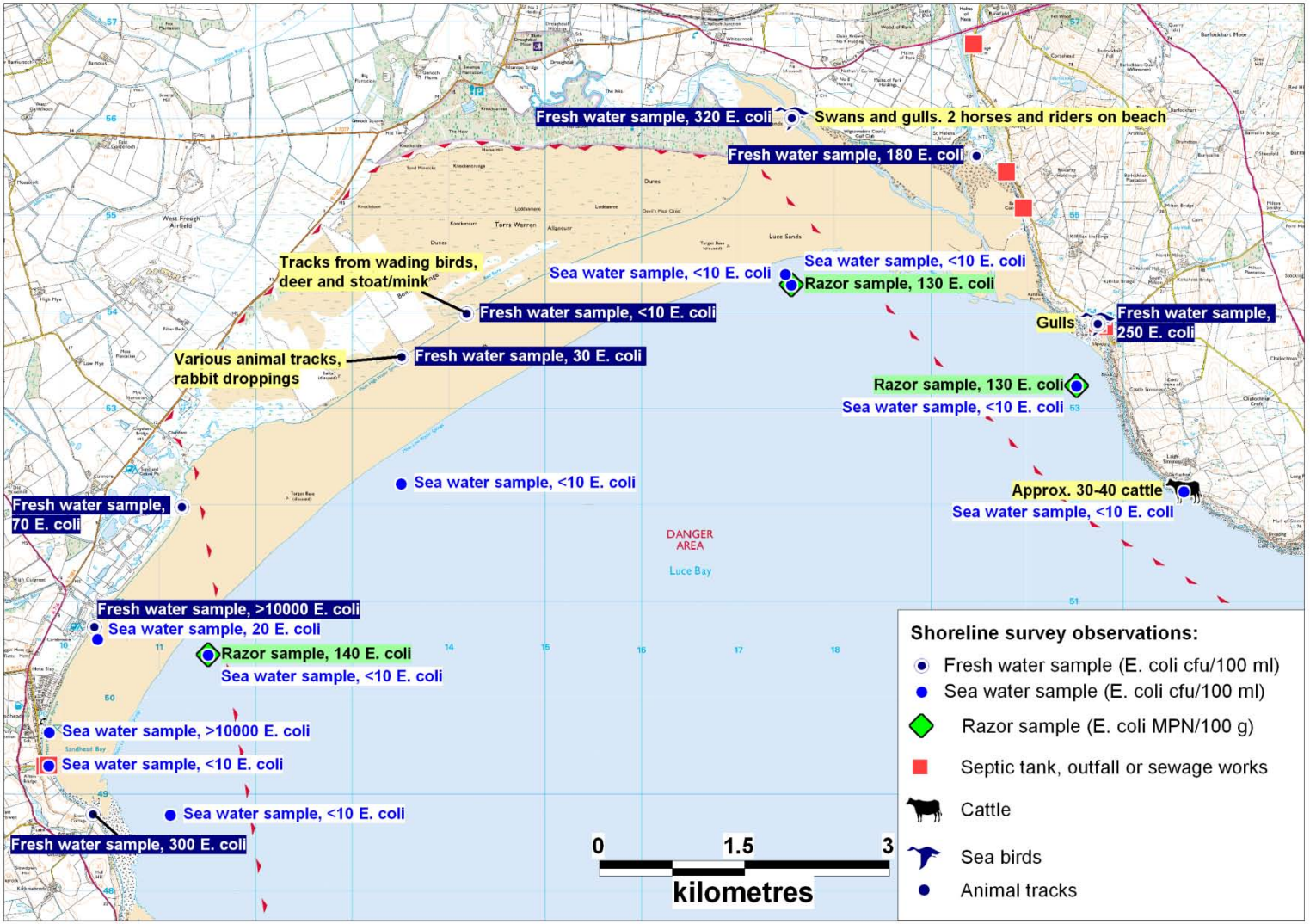

Figure 9.1 Summary of shoreline observations

10. Overall Assessment

Fishery
Natural razor clam beds are found in the sub-tidal sands of Luce Bay and are inaccessible other than by boat. The razor clams are hand-dived and harvesting may take place at any time of year. A representative monitoring zone was established by FSAS on the west side of the harvesting area, near to shore, based on fast track monitoring results.

Human sewage inputs
Human sewage is likely to directly impact the razor clam bed. The effects are likely to be concentrated at either end of Luce Sands. On the west side of the fishery is the settlement of Sandhead which has three public septic tanks and further smaller sewage discharges directly to Luce Bay as well as numerous septic tanks that discharge to land via soakaway systems. The Rae West Freugh and Stoneykirk sewage discharges reach the bay via smaller watercourses discharging to the bay along the western half of the sands. Dunragit STW discharges to Piltanton Burn which joins the bay to the east of Luce Sands. On the eastern shore the sewage works at Glenluce discharge to Luce Water.

In addition to the identified sewage discharges, there are 12 caravan parks/campsites scattered along the coast surrounding the bay and so it is expected that the population in the area will increase significantly during the summer holiday months. Although no discharge consent was obtained for the caravan park and campground east of Sandhead (Sands of Luce Holiday Park), a water sample taken from Sandmill Burn, which passes through the park was found to contain >10000 E. coli per 100 ml. This indicates that there is potentially a septic tank onsite discharging to the burn. This would impact the western side of the production area.

Luce Bay is an active bombing range, therefore boating activity, and hence the potential for overboard discharges, is limited.

Agricultural inputs
Agricultural census data indicated large numbers of cattle in the two parishes immediately adjacent to the fishery but the data did not allow assessment of spatial distribution. Approximately 30-40 cattle were observed on the eastern shoreline of the production area during the shoreline survey, and SEPA reported large dairy holdings within the Piltanton Burn, and that animals had access to the burn. Contamination arising from agricultural sources are principally likely to impact on the water quality within the bay via watercourses (see below).

Wildlife inputs
As this survey was restricted in scope, limited information was sought on wildlife presence in the area. A rudimentary search showed little information available regarding specific wildlife populations in the area. Some evidence of animals and birds was seen during the shoreline survey. The impact on water quality will be small relative to others sources: any that does occur will tend to be higher nearer the coast.

Rivers and streams
The locations of eight watercourses were recorded in the part of the shoreline of Luce Bay that was covered during the shoreline survey. The three having the greatest calculated loadings were Piltanton Burn and the Water of Luce, both entering the north side of the bay, and a stream towards the western end of Luce Sands. A stream at the eastern end of Luce Sands had a moderately high calculated loading.

Rainfall
Rainfall data for Castle Kennedy (the nearest rainfall station with a complete data set) shows that the wettest months were between October to January and March. However, high rainfall events occur during most months and the greatest impact on water quality may occur when such events follow a dry period. The impact of rainfall events is likely to be most acute nearest where the streams enter the shellfish bed.

Analysis of results
Historical *E. coli* monitoring results were available for Luce Bay from 2008 to present. There were too few results to determine whether there was a seasonal pattern to the data. There did not appear to be a spatial trend in the results.

During the shoreline survey razor clam samples were collected from three points within the bay. The two samples taken at the east side of the bay both had results of 130 *E. coli* MPN/100 g and the sample taken from the west side of the bay had a result of 140 *E. coli* MPN/100 g.

Sea water samples were taken from nine points within the production area boundaries. Seven of the samples returned results of <10 *E. coli* cfu/100 ml. A sample taken on the western shoreline returned a result of 20 *E. coli* cfu/100 ml. Another sample taken on the western shoreline, close to an outfall pipe, had a high result of >10000 *E. coli* cfu/100 ml.

It should be noted that the shoreline survey shellfish samples were collected a few days after the freshwater and seawater samples that showed high results. It therefore cannot be assumed that the two sets of results relate to the same conditions.

Movement of contaminants

On the ebbing tide, contamination arising from the sewage discharge and two watercourses at the north end of the bay will be taken across the drying area into the bay. Contamination from all sources will tend to be taken around the bay in an anticlockwise direction. On the flooding tide, contamination arising form all sources will be taken round the bay in a clockwise direction.

Overall conclusions

There are significant sources of faecal contamination from sewage inputs and watercourses at the centre and at both the western and eastern ends of Luce Sands. The effects of central and western inputs are expected to predominate and the area immediately offshore between these locations would tend to be affected by both as the tidal currents change.

11. Recommendations

Production area

It is recommended that the area is kept as that defined for the fast track classification, i.e. “The area bounded by lines drawn between points NX 1000 4900 to NX 2200 4900 to NX 2200 5190 extending to MHWS”.

All recent samples have been taken within these boundaries and the current assessment has focussed on this area.

RMZ

Monitoring should be undertaken on the north-west side of the bay to reflect the two areas where the principles sources of contamination lie (north and west). An RMZ is recommended to reflect the diverse sources of contamination and the difficulty of sources suffiicent razors from a small location on an ongoing basis. The reccemened RMZ is defined by the following points.

NX13005200 NX13505160 NX15005260 NX14555320

This RMZ also covers the razor clam sampling locations within the fast track production area that had yielded the highest *E. coli* results.

Frequency

It is recommended that sampling within the new RMZ be undertaken on a monthly basis and the frequency reviewed on the basis of a year’s worth of results.

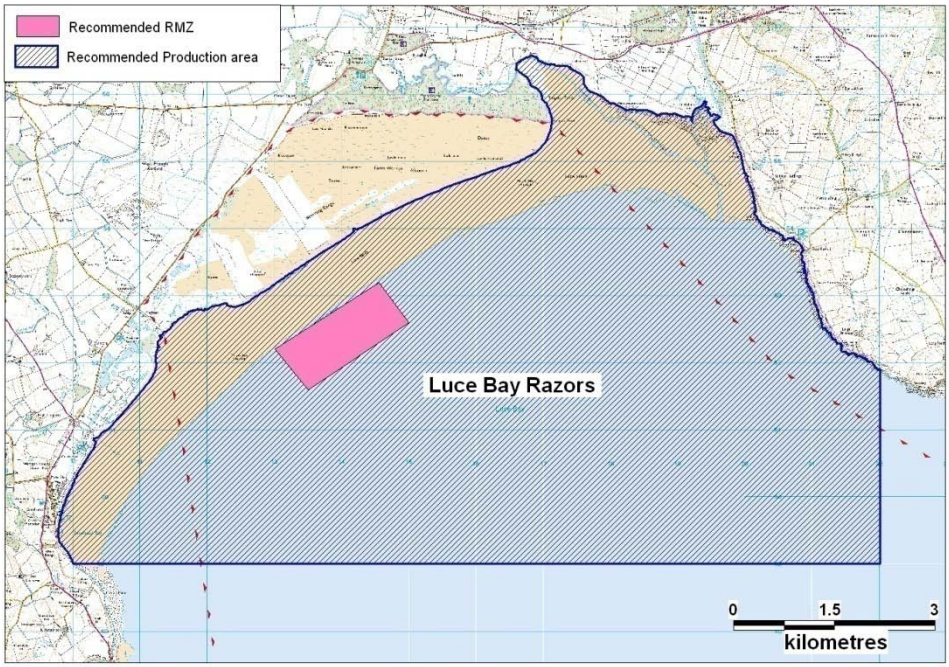

Figure 11.1 Recommendations for Luce Bay Razors

12. References

Kay, D, Crowther, J., Stapleton, C.M., Wyer, M.D., Fewtrell, L., Anthony, S.G., Bradford, M., Edwards, A., Francis, C.A., Hopkins, M. Kay, C., McDonald, A.T., Watkins, J., Wilkinson, J. (2008). Faecal indicator organism concentrations and catchment export coefficients in the UK. *Water Research* 42, 2649-2661.

Lee, R.J., Morgan, O.C. (2003). Environmental factors influencing the microbial contamination of commercially harvested shellfish. *Water Science and Technology* 47, 65-70.

Mallin, M.A., Ensign, S.H., McIver, M.R., Shank, G.C., Fowler, P.K. (2001). Demographic, landscape, and meteorological factors controlling the microbial pollution of coastal waters. Hydrobiologia 460, 185-193.

13. List of Figures and Tables

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Appendices

1. Summary Sampling Plan
2. Comparative Table of Boundaries and RMPs
3. Restricted Shoreline Survey Report
4. Additional discharge consents

Sampling Plan for Luce Bay Razors

PRODUCTION AREA	Luce Bay Razors
SITE NAME	Luce Sands
SIN	DG 49986516
SPECIES	Razor clams (*Ensis* spp)
TYPE OF FISHERY	Wild
RMZ	Area defined by: NX13005200 NX13505160 NX15005260 NX14555320
DEPTH (M)	NA
METHOD OF SAMPLING	Hand dived
FREQUENCY OF SAMPLING	Monthly
LOCAL AUTHORITY	Dumfries & Galloway Council
AUTHORISED SAMPLER(S)	Kirsty McGuigan, Matthew Murdoch
LOCAL AUTHORITY LIAISON OFFICER	Kirsty McGuigan

Comparative Table of Boundaries and RMPs – Luce Bay Razors

PRODUCTION AREA	Luce Bay Razors
SPECIES	Razor clams (*Ensis* spp)
SIN	DG 49986516
EXISTING BOUNDARY	The area bounded by lines drawn between points NX 1000 4900 to NX 2200 4900 to NX 2200 5190 extending to MHWS
EXISTING SAMPLING AREA (RMZ)	Area defined by the points NX1160 5100, NX 1230 5050, NX 1430 5230, NX 1380 5280 and NX 1160 5100
RECOMMENDED BOUNDARY	The area bounded by lines drawn between points NX 1000 4900 to NX 2200 4900 to NX 2200 5190 extending to MHWS
RECOMMENDED RMP	Area defined by the points NX 1300 5200, NX 1350 5160, NX 1500 5260, NX 1455 5320
COMMENTS	Recommended boundary stays the same as the fast track production area boundary. The location and size of the recommended RMZ is different to that previously defined.

Shoreline Survey Report

Production area:	Luce Bay Razors
Site name:	Luce Sands Razors (DG 499 865 16)
Species:	Razor clams
Harvester:	John Mitchell Kevin Miller
Local Authority:	Dumfries & Galloway Council
Status:	New application
Date Surveyed:	30th & 31st August 2010, 3rd September (Razor sampling)
Surveyed by:	M Murdoch (Dumfries & Galloway Council), K McGuigan (Dumfries & Galloway Council)
Observers:	L Paton (Dumfries & Galloway Council) and J Howie (FSA Scotland) 30 August only Michelle Price-Hayward (Cefas) 30 and 31 August
Existing RMP:	N/A
Area Surveyed:	See Figure 1.

Weather observations

30th August: Dry and sunny with SE winds, up to 6 knots. Seas were calm throughout the survey period.

31st August: Dry and sunny with SW winds, averaging 3 knots. Seas were calm throughout the survey period.

Site Observations

Fishery

The western side of Luce Bay, is currently fished for razor clams (*Ensis* sp). Natural razor beds are found in the sub tidal sandy beds which are inaccessible by boat. The razors are harvested all year round.

Sewage/Faecal Sources

On the western side of Luce Bay there is one small village, Sandhead. There is a caravan site (open 11 months of the year, closed in February) at Sandhead which has 8 septic tanks. An additional septic tank and outfall pipe were also observed in this area.

On the north eastern side of Luce Bay are the villages of Dunragit, Glenluce and Stairhaven. There is a caravan site at Glenluce, which is open all year round. The sewage from the caravan site discharges to Glenluce sewage works. Three additional septic tanks were observed in the area.

Livestock

No livestock were observed in the areas surveyed.

Seasonal Population
There are two caravan sites on the shoreline surrounding the fishery, so a seasonal fluctuation in human population in the area is likely. The caravan site at Sandhead on the west coast of Luce Bay, is licensed to hold 368 units, for 11 months of the year and is closed in February. The caravan site has 8 septic tanks. The caravan site at Glenluce on the north-east coast of Luce Bay is licensed to hold 47 units and is open all year round.

Boats/Shipping
One fishing boat was observed in the bay on the second day of the survey.

Land Use
The land use surrounding the production area is primarily agricultural with a mix of arable and grazing land. A large area of land on the west side of the bay is used by the Ministry of Defence as a bombing range. Slurry spreading is carried out on the arable farms, at various times of the year.

Wildlife/Birds
On the western coast of the loch, gulls, cormorants, gannets, ducks, geese, sanderlings, plover, and other birds were observed. Evidence of deer tracks, stoat or mink tracks and rabbits were also found on the shoreline. There were numerous shells evident on the beach, including mussel, razor, cockles and some oysters.

On the north-east coast, swans and seagulls were observed. Numerous shells were found on the shoreline including mussel, clams, scallop, oyster and some razors.

General observations
Recorded observations apply to the date of survey only. Animal numbers were recorded on the day from the observer's point of view. This does not necessarily equate to total numbers present as natural features may obscure individuals and small groups of animals from view.

Dimensions and flows of watercourses are estimated at the most convenient point of access and not necessarily at the point at which the watercourses enter the loch.

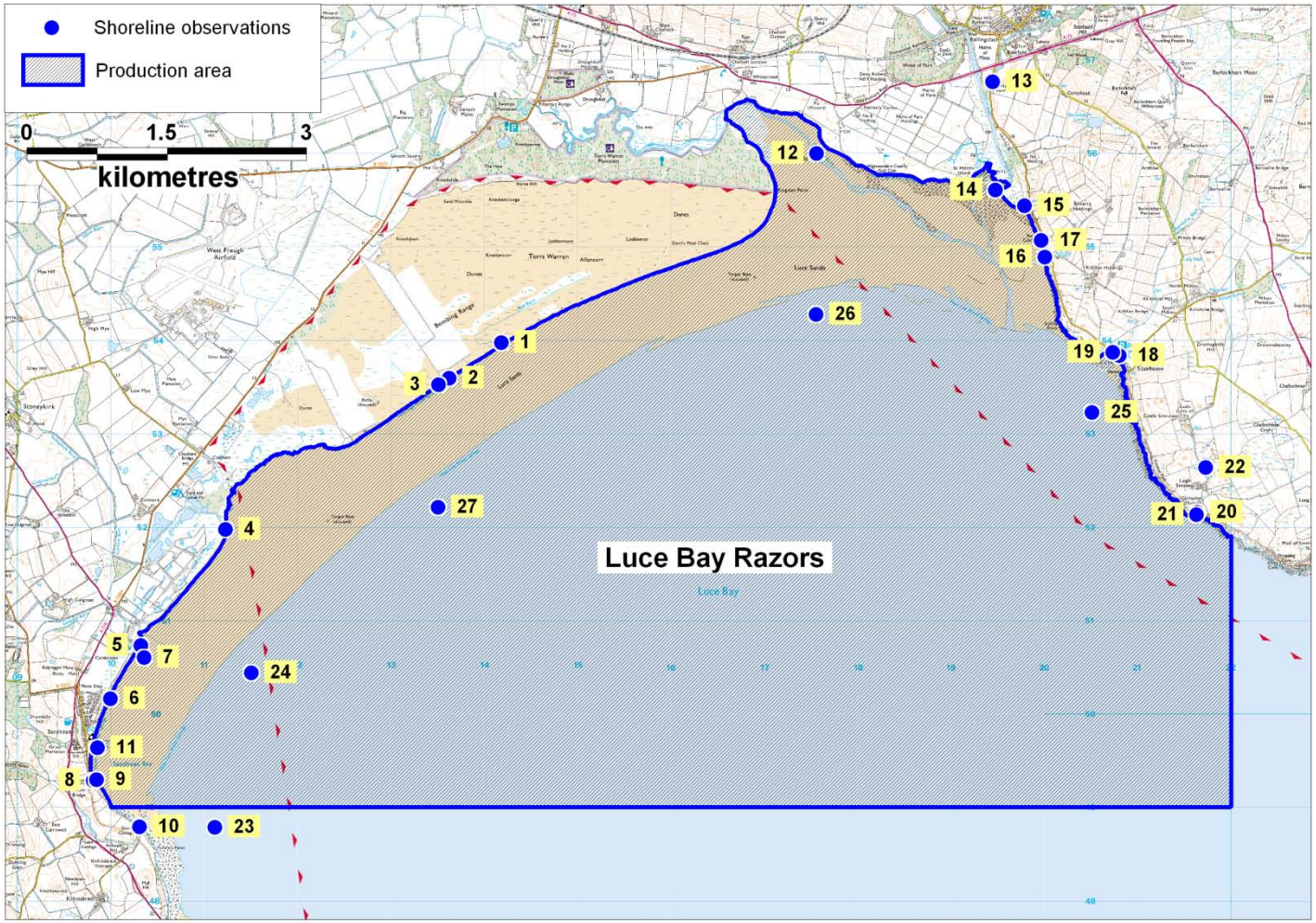

Figure 1. Shoreline observations

Table 1 Shoreline Observations

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
1	30/08/2010	09:41	NX 14183 53982	214183	553982	Figure 4	FW LB001	Stream, Fresh water sample 1 (LB001) Depth 0.04 m, width 1.2m, flow measured with flow meter later found to be faulty. Tracks from wading birds, deer and stoat/mink, razor, clam & whelk shells.
2	30/08/2010	10:14	NX 13623 53601	213623	553601	Figure 5		Evidence of a stream but not flowing at time of survey
3	30/08/2010	10:22	NX 13512 53532	213512	553532	Figure 6	FW LB002	Stream, Fresh water sample 2 (LB002) Depth 0.06 m at channel 0.02 m at edges. Width 1.4m, no flow recorded due to meter problems. Various animal tracks, rabbit droppings, temp 15^{0}C. Wind speed 3.4 knots.
4	30/08/2010	10:57	NX 11229 51980	211229	551980	Figure 7	FW LB003	Stream, Fresh water sample 3 (LB003). Depth 0.28 – 0.40 m, width 3.10 m, no flow recorded due to meter problems. Wind 5 ½ - 6 knots, temp 13 ½ ^{0}C. Dog walkers on beach.
5	30/08/2010	11:42	NX 10321 50738	210321	550738	Figure 8	FW LB004	Stream, Fresh water sample 4 (LB004). Depth 0.05 m, width 1.05m, average flow 0.15m/s (using pooh stick method).
6	30/08/2010	13:10	NX 09993 50168	209993	550168	Figure 9		New culvert – outlet boarded up.
7	30/08/2010	13:32	NX 10355 50610	210355	550610	Figure 10	SW LB005	Sea water sample 5 (LB005) Salinity 32 ppt.
8	30/08/2010	14:13	NX 09810 49293	209810	549293	Figure 11		Sandhead Septic Tank
9	30/08/2010	14:19	NX 09846 49301	209846	549301	Figure 12	SW LB006	Sea water sample 6 (LB006) Outlet pipe. Seawater sample salinity 30 ppt
10	30/08/2010	14:40	NX 10307 48796	210307	548796	Figure 13	FW LB007	Stream, Fresh water sample 7 (LB007) Width 1.1m, depth 0.05 m, average flow 0.024m/s (using pooh stick method)
11	31/08/2010	09:15	NX09853 49644	209853	549644	Figure 14,15 & 16	SW LB008	Sewage outlet, sea water sample 8 (SW LB008) Salinity 10 ppt, temp 12° C, Wind East 1.5 knots
12	31/08/2010	10:07	NX 17561 56008	217561	556008	Figure 17	FW LB009	Piltanton Burn fresh water sample 9 (LB009): Width 26 m, depth 0.20 m, average flow 0.90m/s (using pooh stick method). Shrimp, flounders in abundance. Swans and seagulls observed. 2 horses and riders on beach. Agricultural land and 18 hole golf course also adjacent to survey area.
13	31/08/2010	10:44	NX 19447 56775	219447	556775	Figure 18		Glenluce Sewage Works.
14	31/08/2010	11:15	NX 19476 55616	219476	555616	Figure 19	FW LB010	Luce River fresh water sample 10 (LB010): Width 9.4 m, depth 0.24-0.25 m,7.99m/s (using pooh stick method). Temp 15^{0}C, wind speed 3 knots. Flounder in river. Large numbers of mussel shells and clams, scallop and oyster shells.
15	31/08/2010	11:39	NX 19788 55449	219788	555449			Septic tank.
16	31/08/2010	12:13	NX 20006 54898	220006	554898			Spring – no flow measure.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
17	31/08/2010	12:23	NX 19965 55075	219965	555075			Septic tank outfall from house.
18	31/08/2010	13:13	NX 20805 53846	220805	553846	Figure 20		Stairhaven septic tank.
19	31/08/2010	13:17	NX 20733 53878	220733	553878	Figure 21	FW LB011	Stream at Stairhaven. Fresh water sample 11 (LB011): width 3.6 m, depth range 0.10-0.19 m, flow 0.118m/s (using pooh stick method). 13 new houses on septic tanks. Many people on beach, fishing boat in bay, gulls, public toilets on septic tank. Small spring on beach emerging from the retaining wall - Stairhaven.
20	31/08/2010	14:18	NX 21641 52167	221641	552167			Spring/burn outlet – dry (at Laigh Sinniness)
21	31/08/2010	14:22	NX 21629 52141	221629	552141	Figure 22	SW LB012	Sea water sample 12 (LB012). Laigh Sinniness Farm, very rocky bay. Agricultural land surrounding it, 30-40 cattle in fields above bay.
22	31/08/2010	14:39	NX 21730 52644	221730	552644			The mill pond – it had been cleared out the previous week. The overflow from the pond usually feeds the stream at NX 21641 52168.
23*	02/09/2010		NX 11111 48792	211111	548792		SW LB014	Seawater Sample. LB014.
24*	02/09/2010		NX 11502 50447	211502	550447		Razor LB015, SW LB016	Razor LB015 & Seawater LB016
25*	02/09/2010		NX 20514 53235	220514	553235		Razor LB019, SW LB017	Razor LB019 & Seawater LB017
26*	02/09/2010		NX 17556 54283	217556	554283		Razor LB20, SW LB018	Razor LB020 & Seawater LB018
27*	02/09/2010		NX 13506 52221	213506	552221		SW LB021	Seawater LB021
28*	02/09/2010		NX 22431 69128	222431	569128		SW LB022	Seawater LB022

Photos referenced in the table can be found attached as Figures 4 - 22

* Observations 24-29 were made by the harvester, who collected shellfish and water samples from these points.

Sampling

Water and shellfish samples were collected at sites marked in the maps in figures 2 and 3.

Razor samples were collected from three points within Luce Bay.

Bacteriology results follow in Tables 2 and 3.

Samples of seawater were tested for salinity by the laboratory using a salinity meter under controlled conditions. These results are shown in Table 2, given in units of grams salt per litre of water. This is the same as parts per thousand (ppt).

Table 2 Water sample results

No.	Date	Sample	Grid Ref	Type	*E. coli* (cfu/100ml)	Salinity (g/L)
1	30/08/2010	LB001	NX 14183 53982	Fresh water	<10	
2	30/08/2010	LB002	NX 13512 53532	Fresh water	30	
3	30/08/2010	LB003	NX 11229 51980	Fresh water	70	
4	30/08/2010	LB004	NX 10321 50738	Fresh water	>10000	
5	30/08/2010	LB005	NX 10355 50610	Sea water	20	35.4
6	30/08/2010	LB006	NX 09846 49301	Sea water	<10	35.8
7	30/08/2010	LB007	NX 10307 48796	Fresh water	300	
8	31/08/2010	LB008	NX 09853 49644	Sea water	>10000	30.3
9	31/08/2010	LB009	NX 17561 56008	Fresh water	320	
10	31/08/2010	LB010	NX 19476 55616	Fresh water	180	
11	31/08/2010	LB011	NX 20733 53878	Fresh water	250	
12	31/08/2010	LB012	NX 21629 52141	Sea water	<10	36.2
13	02/09/2010	LB014	NX 11111 48792	Sea water	<10	35.2
14	02/09/2010	LB016	NX 11502 50447	Sea water	<10	35.6
15	02/09/2010	LB017	NX 20514 53235	Sea water	10	34.9
16	02/09/2010	LB018	NX 17556 54283	Sea water	<10	35.2
17	02/09/2010	LB021	NX 13506 52221	Sea water	<10	35.1
18	02/09/2010	LB022	NX 22431 69128	Sea water	<10	35.4

Table 3 Shellfish sample results

No.	Date	Sample	Grid Ref	Sample Type	*E. coli* (MPN/100g)
1	02/09/2010	LB015	NX 1150250447	Razors	140
2	02/09/2010	LB019	NX 2051453235	Razors	130
3	02/09/2010	LB020	NX 1755654283	Razors	130

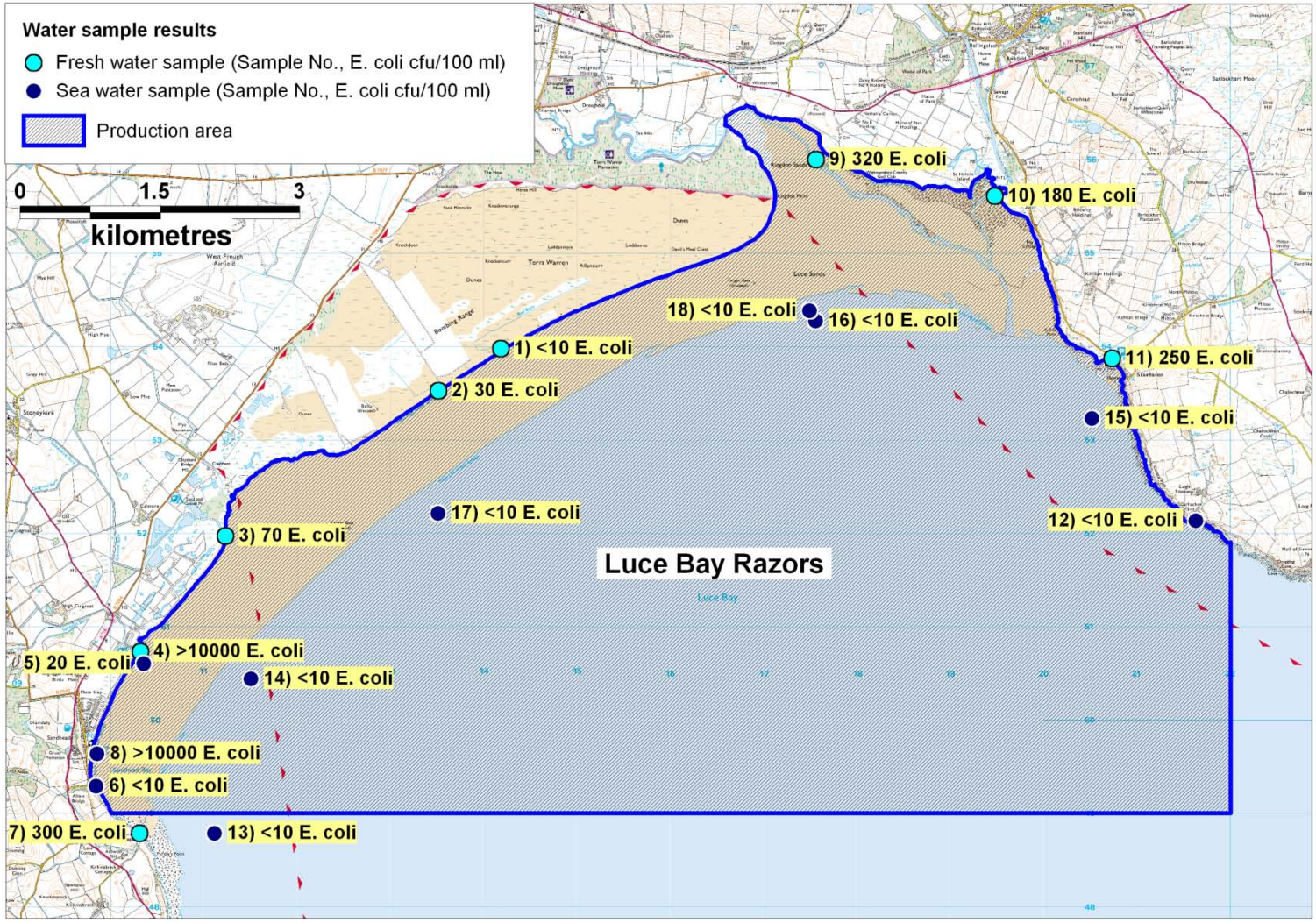

Figure 3. Water sample results

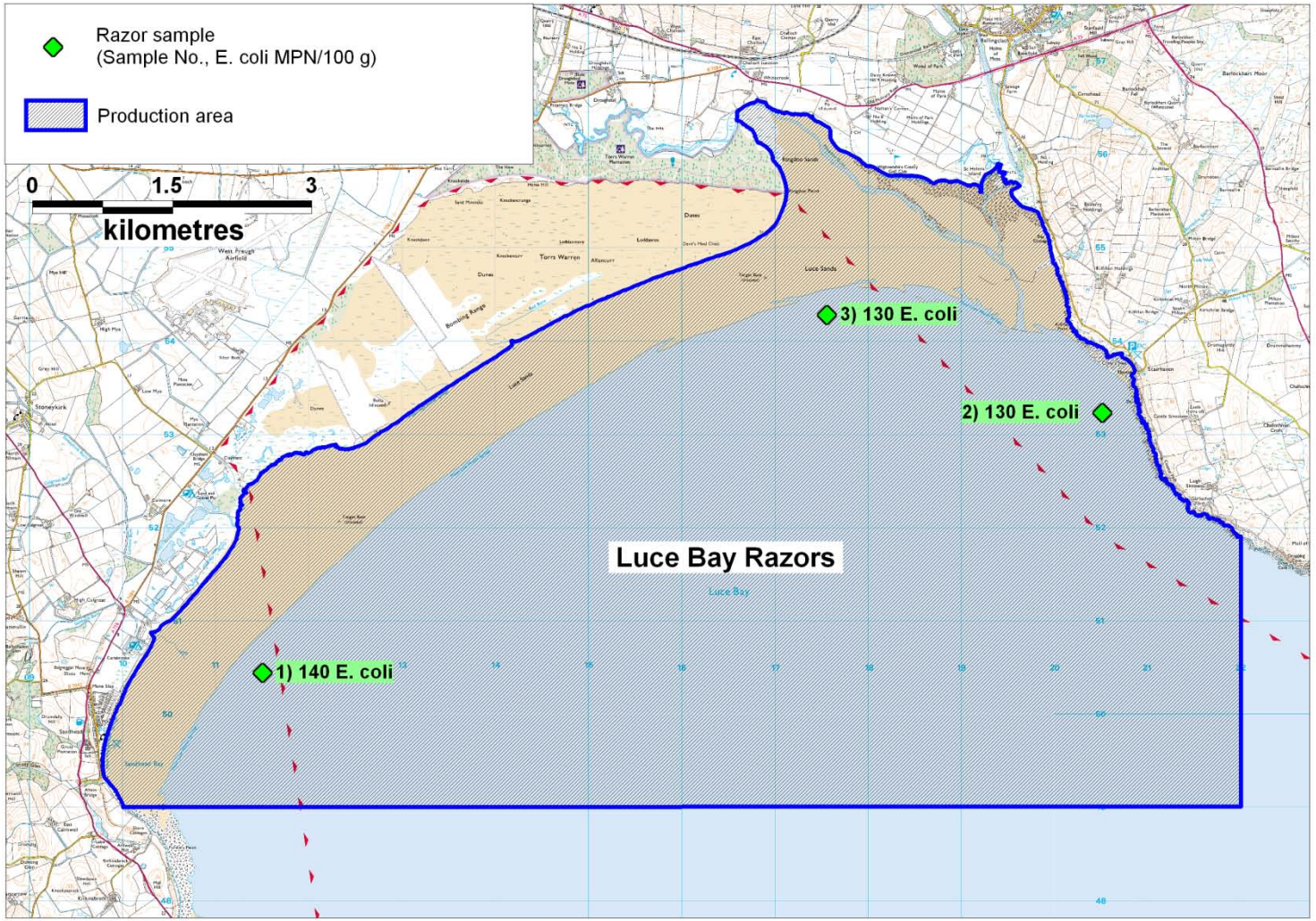

Figure 4 Shellfish sample results

Photographs

Figure 4. Stream, location of water sample LB001

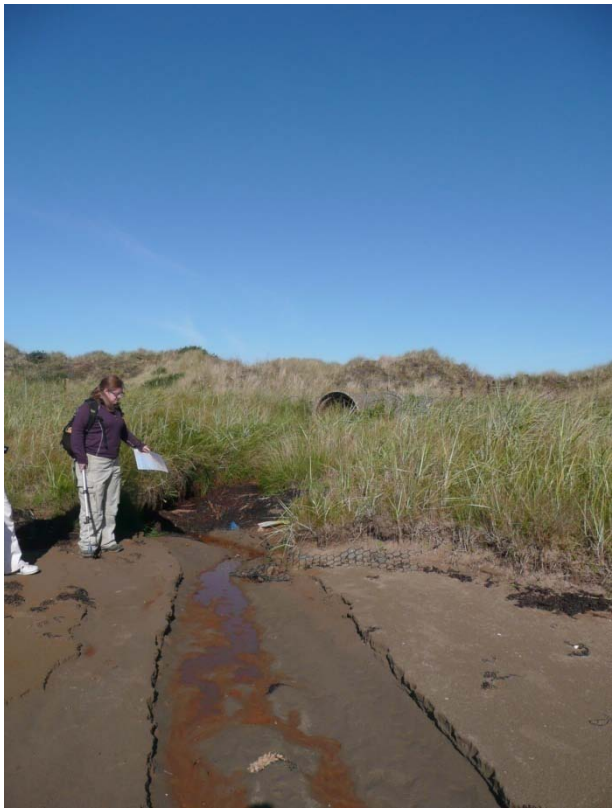

Figure 5. Stream, no flow

Figure 6. Stream, location of water sample LB002

Figure 7 Stream, location of water sample LB003

Figure 8. Stream, location of water sample LB004

Figure 9. New culvert – boarded up

Figure 10. Location of sea water sample LB005

Figure 11. Sandhead septic tank

Figure 12. Location of sea water sample LB006

Figure 13. Stream, location of water sample LB007

Figure 14. Outfall pipe

Figure 15. Link in outfall pipe, shown in Figure 14

Figure 16. End of outfall pipe shown in figures 15 & 16, location of sea water sample LB008

Figure 17. Piltanton Burn, location of water sample LB009

Figure 18. Glenluce sewage works

Figure 19. Luce River, location of water sample LB010

Figure 20. Stairhaven septic tank

Figure 21. Stream, location of water sample LB011

Figure 22. Agricultural land surrounding Laigh Sinniness

Additional discharge consents

Reference	NGR of discharge	Name	Discharge Type	Consented flow (DWF) m^3/d	Consented/ design PE	Discharges to
CAR/L/1003680	NX 1397 3686	Drummore STW	CSO and FE, primary	53	290	Luce Bay
CAR/L/1003625	NX 3363 4316	Port William STW	CSO and FE, primary	265	1023	Luce Bay
CAR/L/1003612	NX 3595 4084	Monreith STW	CSO and FE, primary	56	234	Luce Bay