Scottish Sanitary Survey Project

Restricted Sanitary Survey Report

Machrie Bay
AB 510
November 2009

Cefas

Food Standards Agency
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Buidheann Inbhe-Bìdhe

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1. Area Overview

Machrie Bay is located on the western central coastline of the Isle of Arran (see Figure 1.1).

Machrie Bay is a shallow, exposed bay located on Kilbrannan Sound. The depth of Machrie Bay increases gradually from 0 to 20 m and then increases to depths of up to 100 m in the middle of Kilbrannan Sound. A restricted sanitary survey at Machrie Bay was conducted in response to receipt of an application to classify the area for commercial harvest of razor clams (*Ensis* spp.).

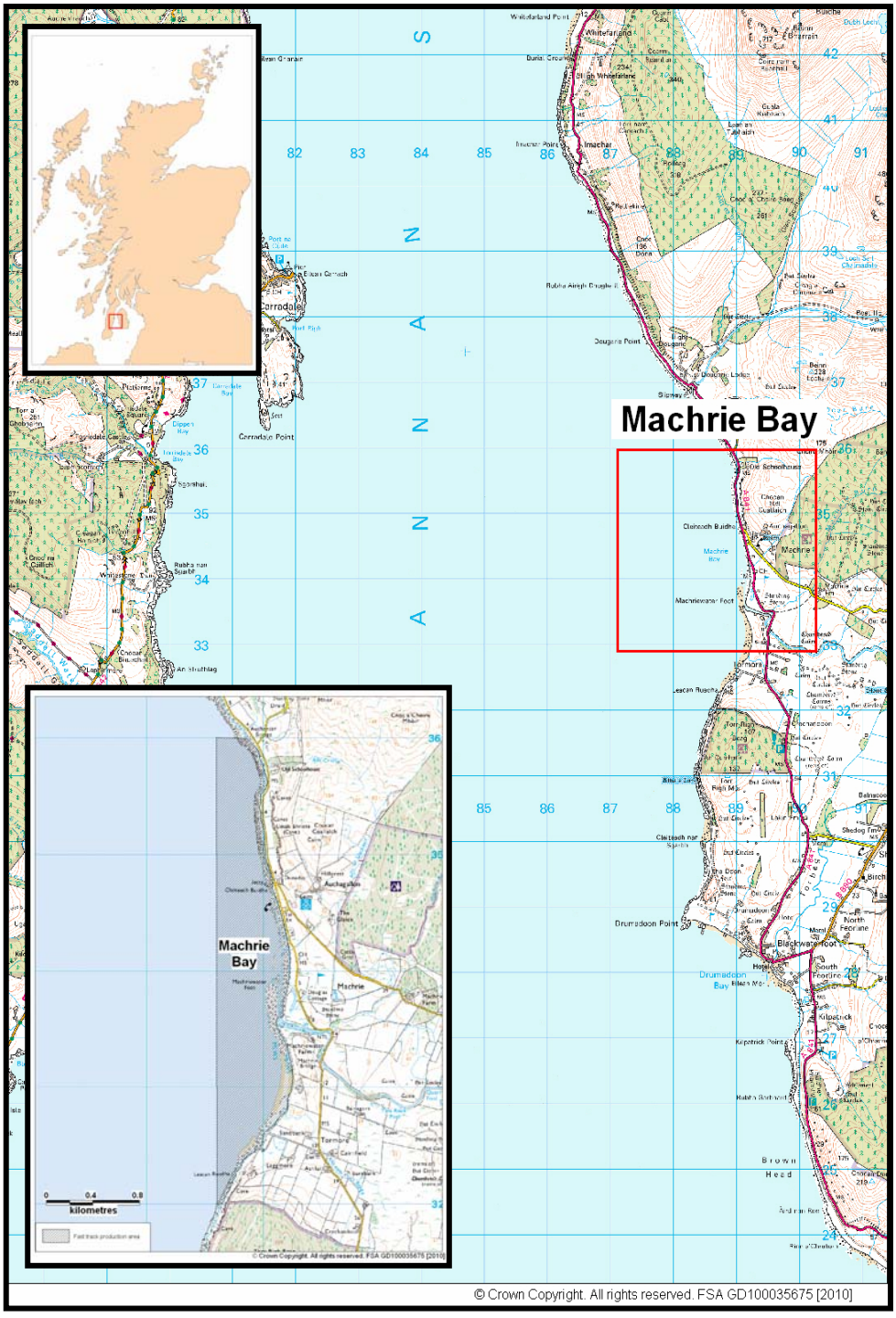

Figure 1.1 Location of Machrie Bay

1.1 Land Use

Land Cover 2000 data indicates that the land adjacent to Machrie Bay is mostly improved grassland with some small patches of open heathland and acid grassland (see Figure 1.2). There are also large areas of coniferous and broadleaf woodland slightly further inland.

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. Areas of improved grassland surrounding Machrie Bay would be expected to contribute the most to contamination levels carried in surface runoff to this side of the razor clam bed. This effect would be seen through almost all of the area.

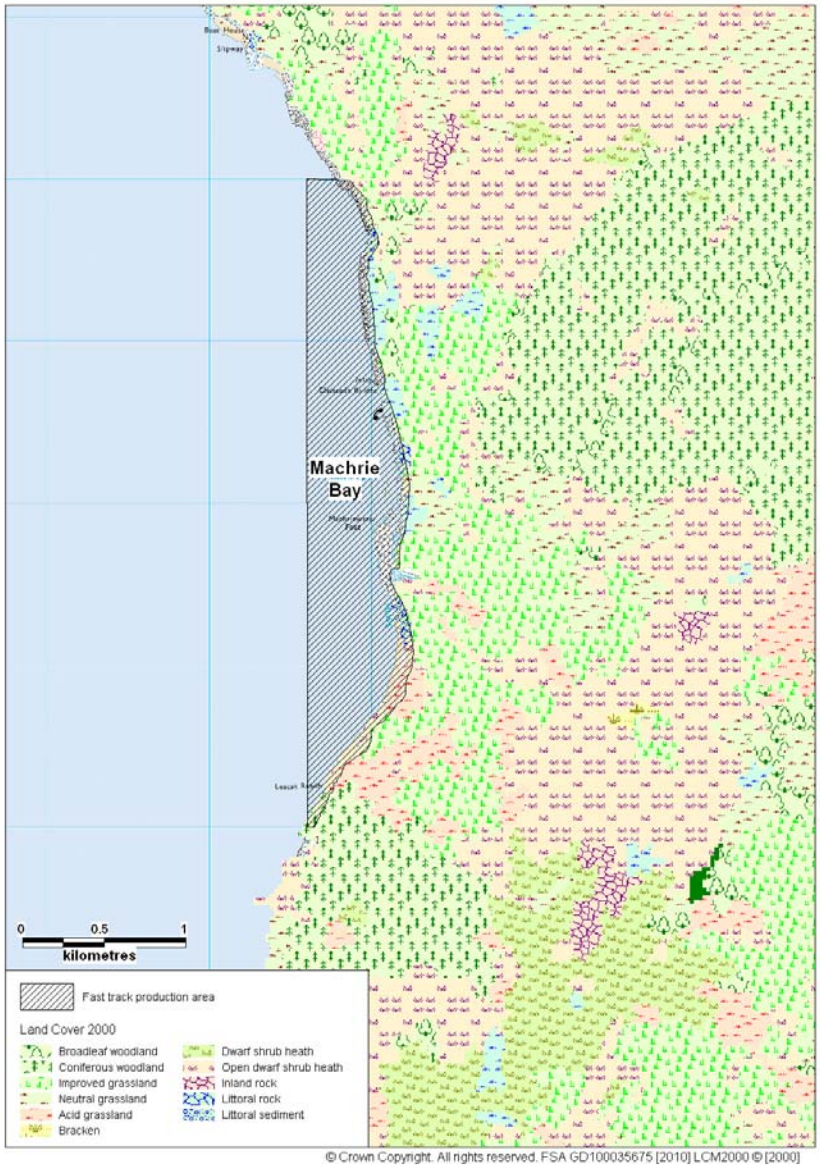

Figure 1.2 Land Cover 2000 data for Machrie Bay

1.2 Human Population

Figure 1.3 shows the census output areas in the vicinity of Machrie Bay. There is one census output area directly adjacent to Machrie Bay and another three within the surrounding area. There are a small number of tiny villages, such as Machrie, Tormore and Auchagallon but the rest of the population is located in scattered dwellings. Machrie includes a Bed & Breakfast, golf course and village hall. There are also some tourist attractions in the area. The villages will provide higher potential contributions of faecal contamination. There is likely to be a seasonal effect with increased visitors from April to September.

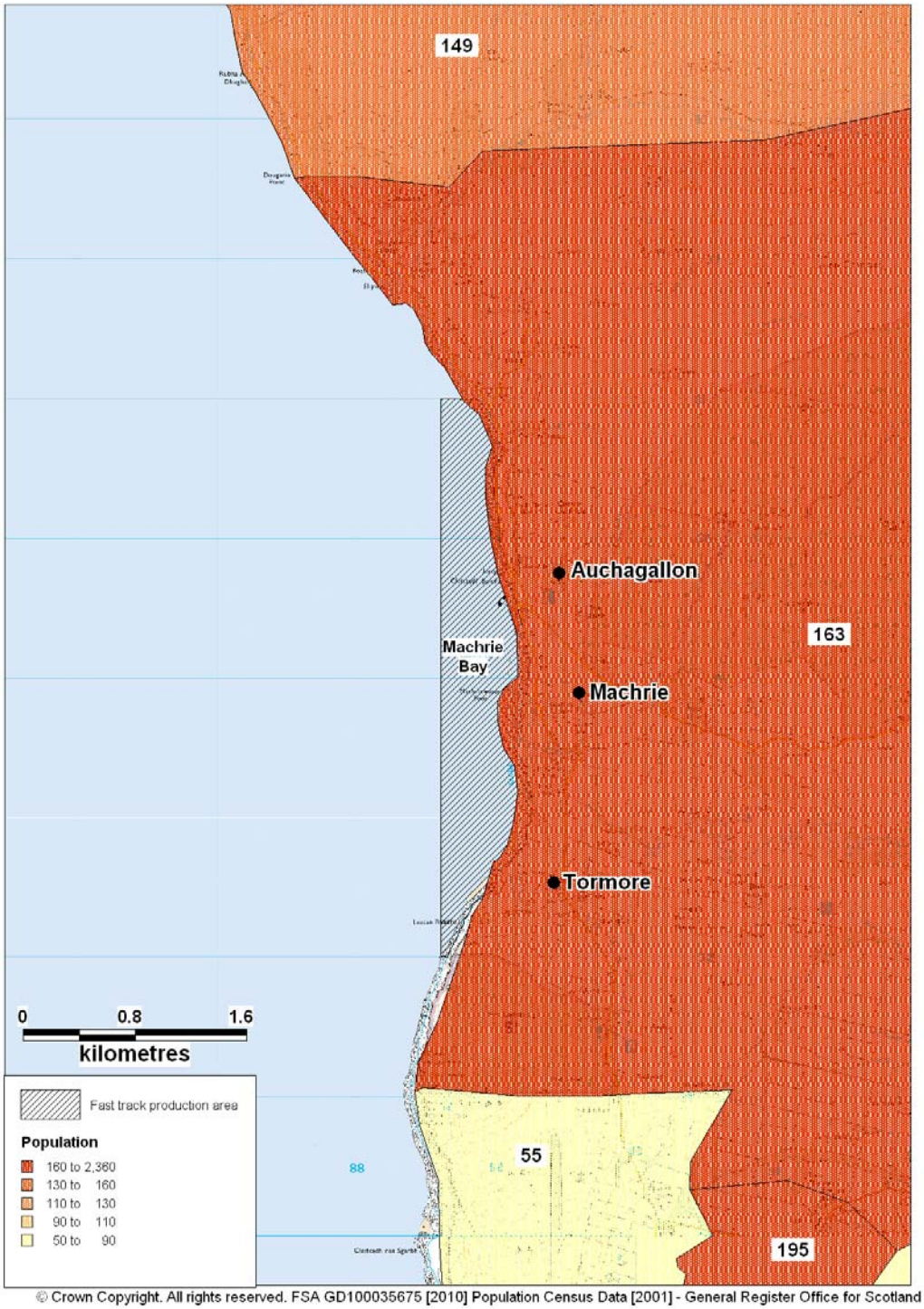

Figure 1.3 Human population surrounding Machrie Bay

2. Fishery

The fishery at Machrie Bay (AB 510 929 16) is comprised of a wild razor clam (*Ensis* spp.) bed.

During 2009, the area was subject to applications for both fast track and full classifications for razor clams. The potential fast track classification production area boundaries, as identified by the Food Standards Agency on 12th June 2009, are given as the area bounded by lines drawn between NR 8890 3600 to NR 8860 3600 and between NR 8860 3600 to NR 8860 3200 extending to MHWS. At the time of drafting this report (February 2010), no samples had been submitted in support of the fast track application and so no classification had been issued.

There is currently no RMP assigned to this area. The razor bed at Machrie Bay does not lie within a designated shellfish water.

From information given by the harvester in support of the classification applications, the razor clam bed lies within the fast track production area boundaries, over the area identified in Figure 2.1. Harvesting of razor clams is planned to take place throughout the year. The razor clams will be hand dived.

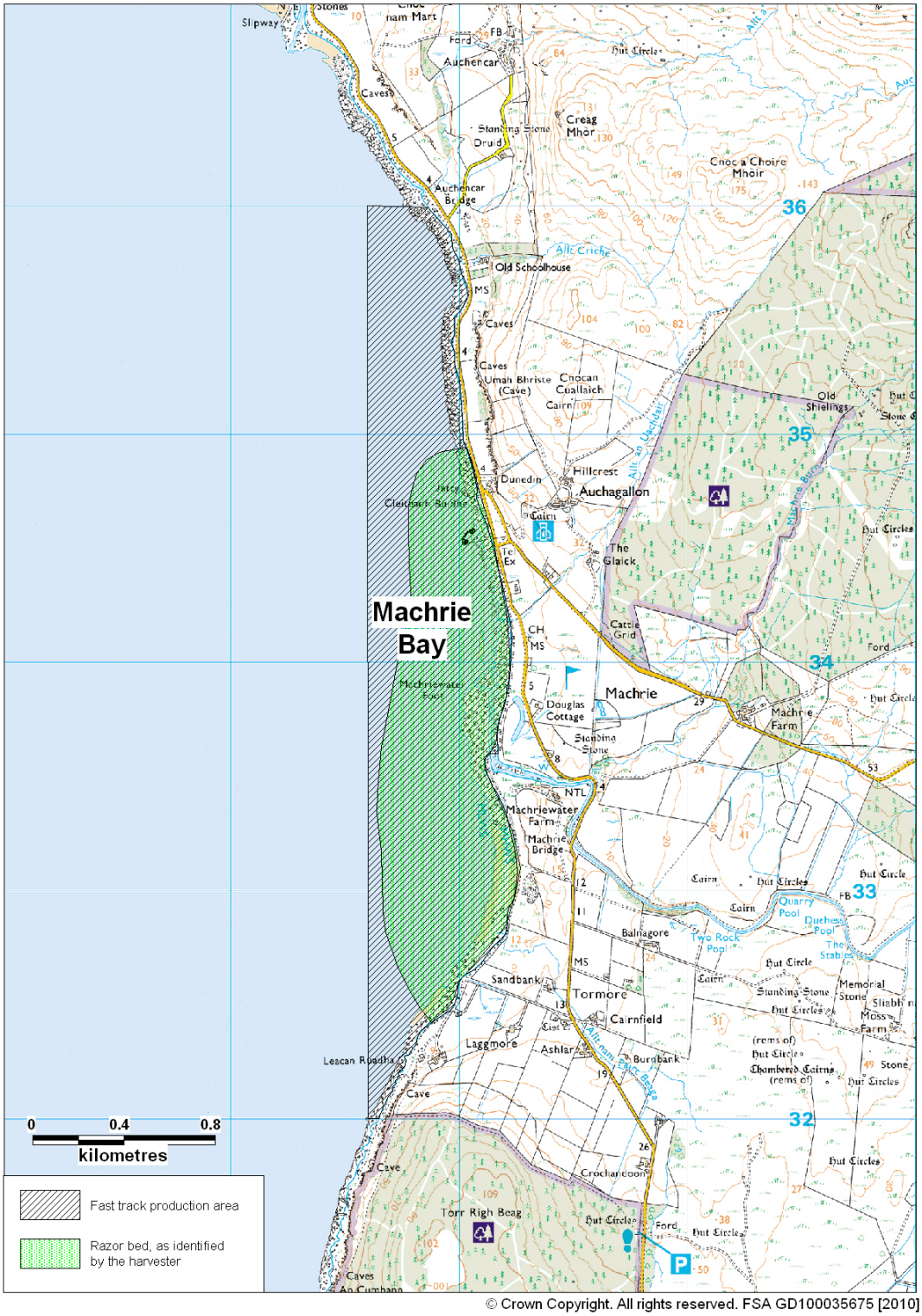

Figure 2.1 Machrie Bay fishery

3. Sewage Discharges

A number of discharge consents were provided by SEPA for the area on the eastern side of Kilbrannan Sound adjacent to Machrie Bay. These are listed in Table 3.1 and mapped in Figure 3.1. It is assumed that discharges on the western side of Kilbrannan Sound will not impact on the microbiological quality of shellfish in Machrie Bay.

Table 3.1 SEPA discharge consents

Consent No.	NGR of discharge	Discharge type	Discharges to	PE	Discharge Vol m^3 per day
CAR/R/1017247	NR 9017 2941	Continuous	Land via soakaway	18	-
CAR/R/1016023	NR 89428 28505	Continuous	Land	5	-
CAR/R/1014354	NR 89606 28221	Continuous	Blackwater	12	-
CAR/R/1073512	NR 89546 28236	Continuous	Land via soakaway	5	-
CD 11669	NR 8952 2794	Continuous	Drumadoon Bay	-	47
CAR/R/1042287	NR 9001027980	Continuous	Land via soakaway	8	-
CAR/L/1018265	NR 8970 2680	Continuous	Kilbrannan Sound	-	64
CAR/R/1030363	NR 89824 28227	Continuous	Land via soakaway	7	-

No sanitary or microbiological data were available for these discharges. A consent for a septic tank discharge approximately 7 km to the north of the production area has been omitted on the basis that it will not be of significance to the present assessment.

No community sewage discharges were identified for Scottish Water for the eastern side of Kilbrannan Sound in the vicinity of Machrie Bay.

A golf club house septic tank and possible outfall pipes were also observed during the shoreline survey and these are listed in Table 3.2. Their locations have been included in the mapped discharges in Figure 3.1. Further details can be found in the shoreline survey report in the appendix.

Table 3.2 Observations of potential sewage discharges

No.	Date	NGR	Description of potential sewage discharge
1	10/11/2009	NR 88800 32296	Several houses and septic tanks close by
2	10/11/2009	NR 88973 32487	Septic tank outfall
3	10/11/2009	NR 88946 32545	Three houses is distance, possible septic tank outfalls
4	10/11/2009	NR 89226 33973	Possible outfall pipe for golf course on beach
5	10/11/2009	NR 89267 33997	Two inspection covers on golf course, unsure if drainage/sewerage
6	10/11/2009	NR 89297 34125	Golf club house septic tanks
7	10/11/2009	NR 89239 34070	Possible outfall pipe for golf club septic tanks

Several outfall pipes and septic tanks were observed directly adjacent to Machrie Bay during the shoreline survey. There were no SEPA discharge consents or Scottish Water discharges registered in the same area; within a 4.3 km radius from the fishery. Approximately 5 km south of Machrie Bay there are eight registered SEPA discharge consents which may affect the fishery depending on tidal flow patterns. The impacts from sewage discharges are likely to be greatest in the immediate vicinity of the discharges observed

during the shoreline survey. These were all located in the southern half of the fast track production area.

Figure 3.1 Sewage discharges at Machrie Bay

4. Animals

4.1 Livestock

The only significant source of information concerning livestock numbers in the area surrounding Machrie Bay was available from the shoreline survey. The shoreline survey relates to the time of the site visits on the 10th November 2009.

During the shoreline survey livestock were observed roaming widely along the coastline adjacent to Machrie Bay. North of Machrie there were four large flocks of sheep (approx 195 in total) north and south of Auchagallon (see Figure 4.1). Close to Machrie Water approx 72 sheep and 12 cattle were observed. South of Machrie Water near Laggmore approx 12 cattle and 95 sheep in total were also observed.

All livestock numbers are approximations and it should be noted that the livestock was roaming on the day of the shoreline survey.

Livestock numbers in the area 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.

4.2 Wildlife

Seabirds such as gulls will always be present on and around Machrie Bay but, in the absence of defined nesting or roosting sites, their distribution is likely to be even over time. However, during the shoreline survey approximately 70 sea birds, including gulls were observed on rocks on the north side of Machrie water at low tide (see Figure 4.1). This may represent an area at higher risk of contamination from this source.

No other wildlife was observed at the time of the shoreline survey. However, it is possible that other animals including seals, otters and other seabirds may be present in the area. The distribution and numbers of these species was not investigated.

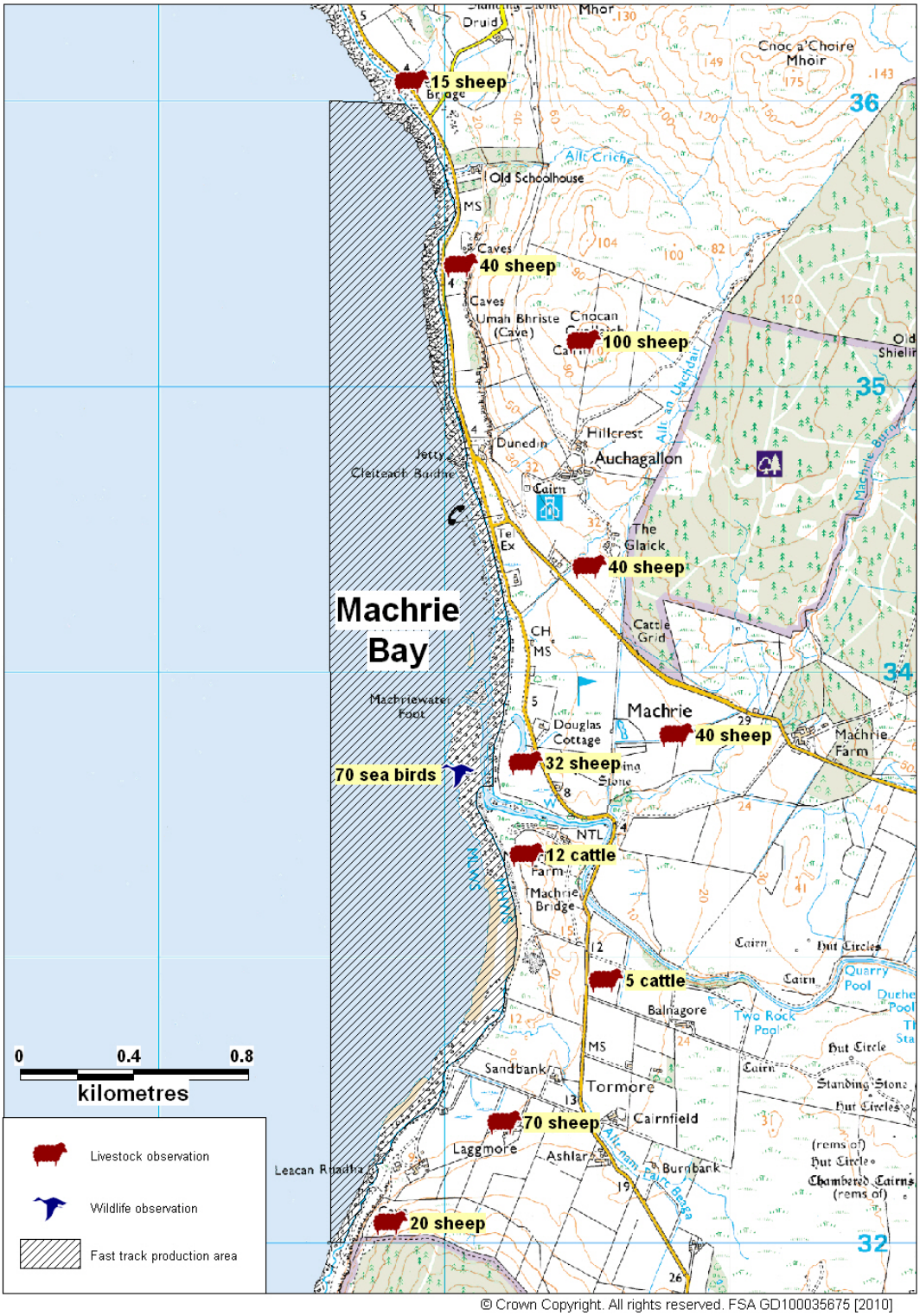

Figure 4.1 Livestock and wildlife present at Machrie Bay during the shoreline survey

5. Rainfall

The nearest weather station is located at Arran Dougarie Lodge, approximately 1 km north of Machrie Bay. Daily rainfall values were purchased from the Meteorological Office for the period 1/1/2003 to 31/12/2008 inclusive for the Arran Dougarie Lodge weather station. For this period of 2192 days, total daily rainfall was not recorded for 206 days, including the entire month of October 2006. Due to the close proximity of the weather station to Machrie Bay, rainfall recorded here is likely to be very similar to that experienced in the bay and the surrounding land.

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 wastewater treatment plant overflows (Mallin et al. 2001, Lee and Morgan 2003).

The influence of rainfall on microbiological quality will depend on factors such as local geology, topography, land use and sewerage infrastructure.

5.1 Rainfall at Arran Dougarie Lodge

Due to the missing data it is not appropriate to present total rainfall at Arran Dougarie Lodge by year or month. Instead, Figures 5.1 and 5.2 summarise the pattern of rainfall recorded at Arran Dougarie Lodge. The box and whisker plots present the distribution of individual daily rainfall values (observations) by year (Figure 5.1) or by month (Figure 5.2). The grey box represents the middle 50% of the observations, with the median represented by the line. 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 *.

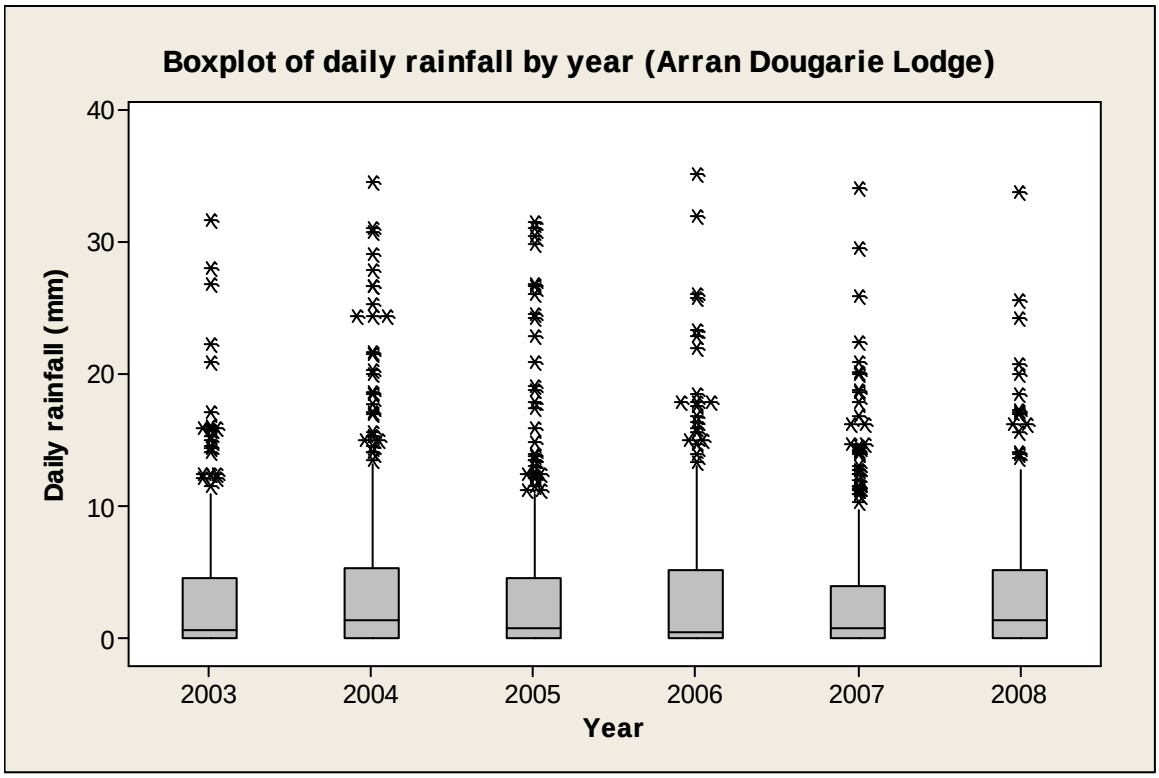

Figure 5.1 Boxplot of daily rainfall at Arran Dougarie Lodge by year

The median daily rainfall in 2004 and 2008 was somewhat higher than in the other years. Other than this, the general pattern was similar over the years 2003 to 2008 inclusive.

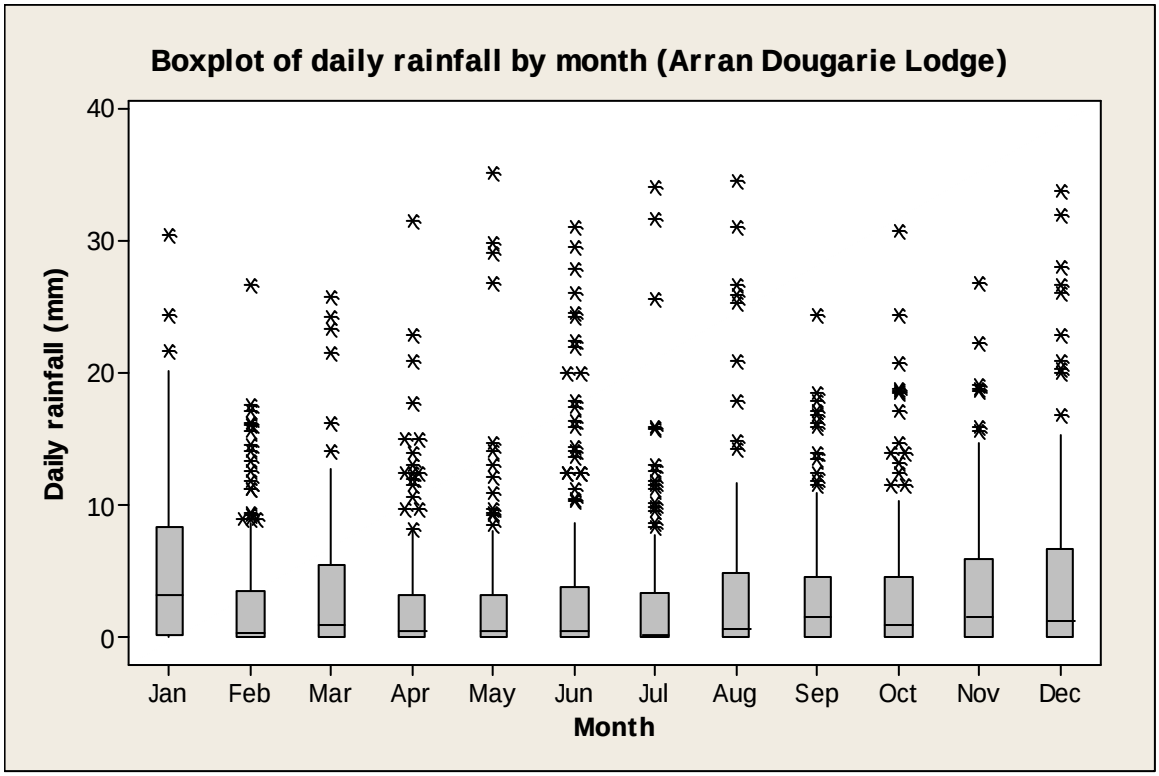

Figure 5.2 Boxplot of daily rainfall values at Arran Dougarie Lodge by month

The wettest months were December and January. For the period considered here (2003 – 2008), 35% of days for which records were available experienced no rainfall while 52% of days experienced rainfall of 1mm or less. Though median rainfall was less than 10 mm per day, the maximum recorded daily rainfall was greater than 30 mm and such events were seen in most months. The highest daily rainfall recorded here fell in May, one of the driest months.

Periods of increased rainfall are generally associated with higher levels of contaminated surface water runoff. Marked changes in the level of rainfall may also cause significant wash off of accumulated material.

Faecal contaminants from other sources may be independent of rainfall and so episodes of contamination may occur outside identified periods of higher rainfall, for example when livestock are present on the shoreline.

6. River Flow

There is no river gauging station in the vicinity of Machrie Bay. A total of seven significant fresh water inputs were observed discharging into the bay. Only four of these streams were of a measurable size and had a measurable flow. The Machrie Water was too large to measure size and flow safely. These streams represented the largest freshwater inputs to the area and are listed in Table 6.1 and mapped in Figure 6.1.

Table 6.1 Stream/river flow and loadings – Machrie Bay

No.	Grid Ref	Description	Width (m)	Depth (m)	Measured Flow (m/s)	Flow in m^3/day	*E. coli* (cfu/ 100 ml)	Loading (*E. coli* per day)
1	NR 88753 32154	Small stream	*	*	*	*	100	Not determined
2	NR 89034 32609	Small stream	*	*	*	*	1100	Not determined
3	NR 89214 32802	Allt nam Pairc Beaga Water	1.58	0.23	0.826	25900	400	1.0×10^{11}
4	NR 89232 33513	Machrie Water	§	§	§	§	<100	Not determined
5	NR 89265 34188	Allt an Uachdair Water	0.55	0.10	2.066	9820	1800	1.8×10^{11}
6	NR 89036 35750	Allt Criche	1	0.03	1.271	3290	<100	$<3.3 \times 10^{9}$
7	NR 88885 36065	Small stream	2.5	0.22	0.504	24000	100	2.4×10^{10}

* Stream too small to measure
§ River too large to measure safely

Calculated loadings are based on the flows and dimensions recorded during the shoreline survey and do not necessarily reflect those that would apply under different conditions.

The major *E. coli* loadings from freshwater sources are located at the north, in the middle and towards the south of the fast track production area. It would be expected that the microbiological quality of the razors in the near vicinity of these sources would be affected.

Although the sample taken from Machrie Water at the time of the shoreline survey gave an *E. coli* result less than the limit of detection of the method, the large flow (unmeasured due to safety reasons) means that this watercourse could still contribute a significant loading to the immediate area where it enters the sound.

The shoreline survey was undertaken under dry conditions and it would be expected that the loadings associated with these sources would increase under rainfall conditions.

Where the bacterial loading is labelled as 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 this case it would be written as 1E+3.

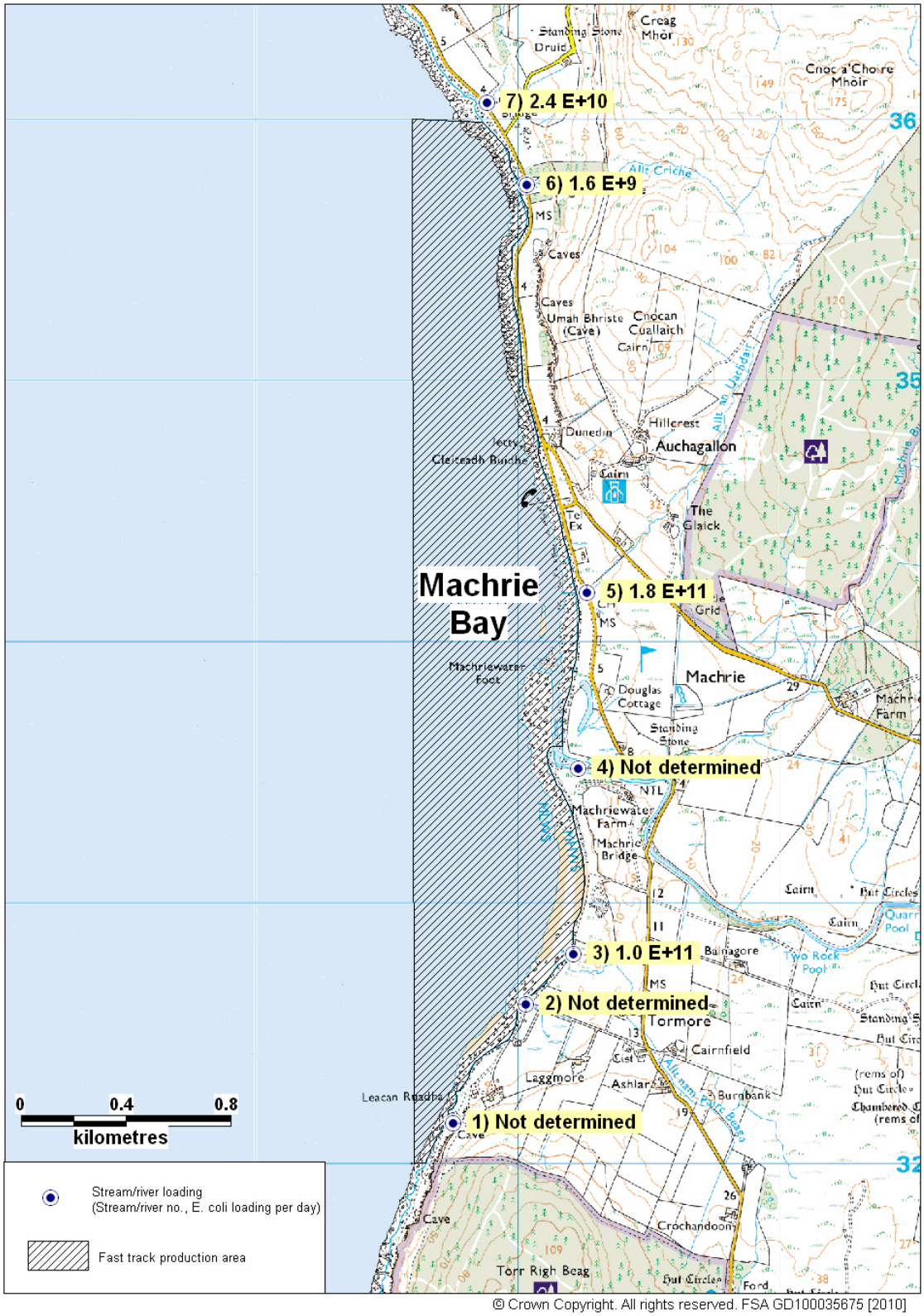

Figure 6.1. Location of stream/river flows and loadings at Machrie Bay

7. Historical *E. coli* Monitoring Data

There is no historical *E. coli* monitoring data available for Machrie Bay.

8. Bathymetry and Hydrodynamics

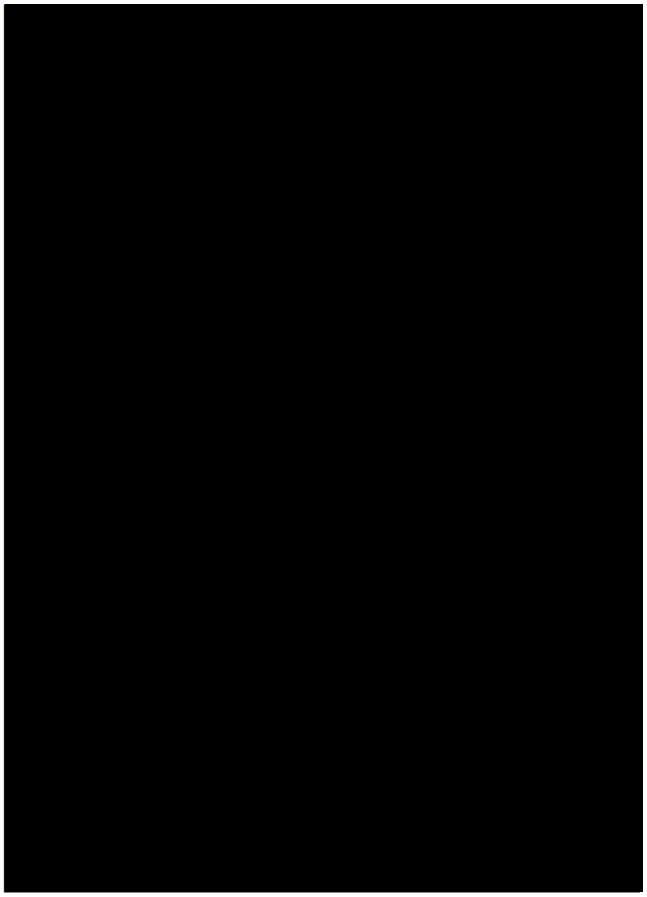

Figure 8.1 Machrie Bay bathymetry chart

Figure 8.2 Machrie Bay OS map

The depth of the bay increases with distance from the shoreline (see Figure 8.1). The depth of Machrie Bay increases gradually from 0 to 20 m: the depth then increases markedly up to 100 m in the middle of Kilbrannan Sound.

8.1 Tidal curve and description

The two tidal curves below are for the port of Carradale, the nearest secondary port– they have been output from UKHO TotalTide. The first is for seven days beginning 00.00 GMT on 10th November 2009. The second is for seven days beginning 00.00 GMT on 24th November 2009. Together they show the predicted tidal heights over high/low water for a full neap/spring tidal cycle.

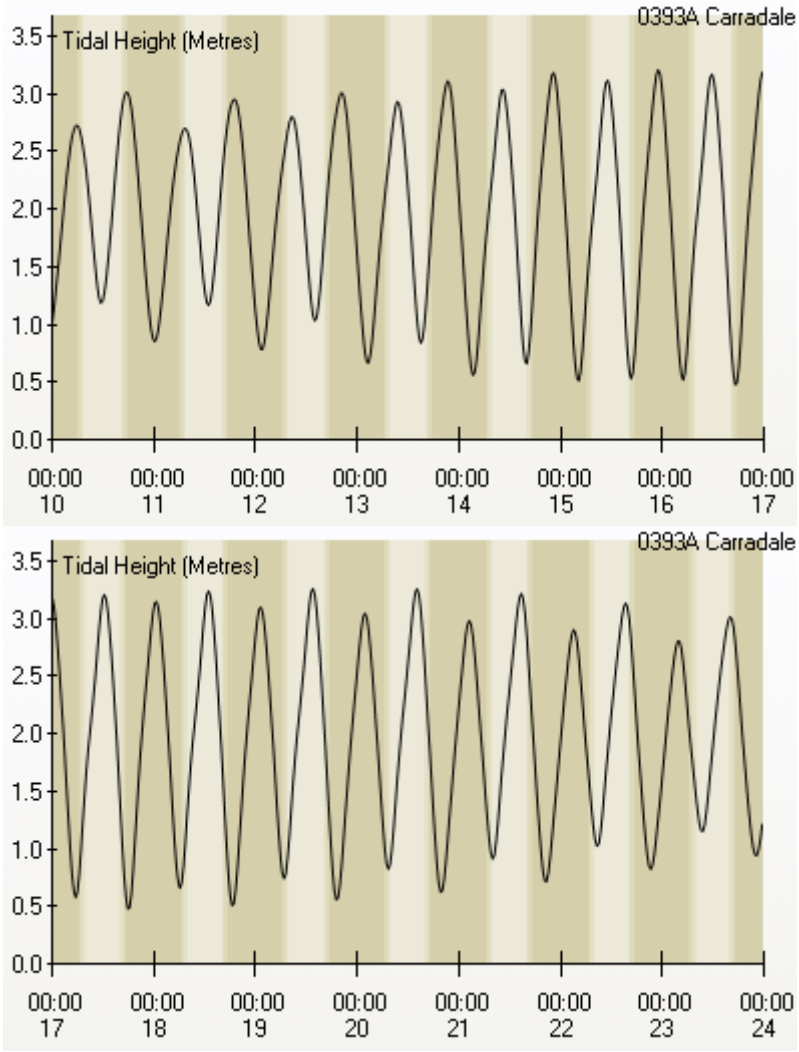

Figure 8.3 Tidal curves for Carradale

The following is the UKHO summary description for Carradale:

The tide type is Semi-Diurnal.

MHWS	3.1 m
MHWN	2.6 m
MLWN	1.1 m
MLWS	0.4 m

Predicted heights are in metres above chart datum. The tidal range at spring tide is therefore approximately 2.7 m and at neap tide 1.5 m.

8.2 Currents

The Admiralty Tidal Stream Atlas for Firth of Clyde and Approaches (UKHO 1992) indicates that the peak tidal stream within Kilbrannan Sound is approximately 0.2 (neap) to 0.3 knots (spring) in a northerly direction on the rising tide and 0.3 (neap)

to 0.4 knots (spring) in a southerly direction on a falling tide. The relationship between knots and metres per second is that the latter is approximately half the former (i.e. 0.2 knots is about 0.1 m/s). The tidal streams may be modified by strong winds, especially at the surface.

As in many areas, the change from rising to falling and vice versa does not exactly coincide in time with change in direction of the tidal streams.

8.3 Conclusions

Contamination arising from sources tend to follow the coast, to the north on the rising tide and to the south on the falling tide. This may be modified by winds and westerly winds will constrain any contamination close to shore. Apart from the latter effect, the relatively rapid increase in depth means that, in the absence of large community sewage outfalls, significant dilution of contamination would be expected to be seen past the 10 m depth contour (50 to 100 m from shore).

9. Shoreline Survey Overview

A restricted shoreline survey of the Machrie Bay shoreline was undertaken by staff from North Ayrshire Council on the 10th November 2009.

Sub surface sea water samples were taken from several points along the Machrie Bay coastline and also from within the shellfish bed area. Results ranged from 8 to 50 *E. coli* cfu/100 ml. The highest result of 50 *E. coli* cfu/100 ml was taken from the centre of the bay.

Fresh water samples were taken all along the coastline of Machrie Bay at any streams or burns flowing at the time of the shoreline survey. Results ranged from <100 to 1800 *E. coli* cfu/100 ml. Allt an Uachdair Water is located at the centre of Machrie Bay and had the highest result of 1800 *E. coli* cfu/100 ml.

Livestock were scattered along most of the coastline of Machrie Bay, although the majority of livestock seemed to be concentrated into three main areas. There were large flocks of sheep (approx 140 in total) north and south of Auchagallon. Close to Machrie Water approx 72 sheep and 12 cattle were observed. Further south near Laggmore approx 90 sheep in total were also observed. Approximately 70 sea birds were seen on rocks near the mouth of Machrie Water.

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

In summary, identified sources of potentially significant contamination are:

- Contaminated freshwater streams in the area
- Sewage outfall pipes discharging into the area
- Livestock grazing on the shoreline
- Sea birds close to shore

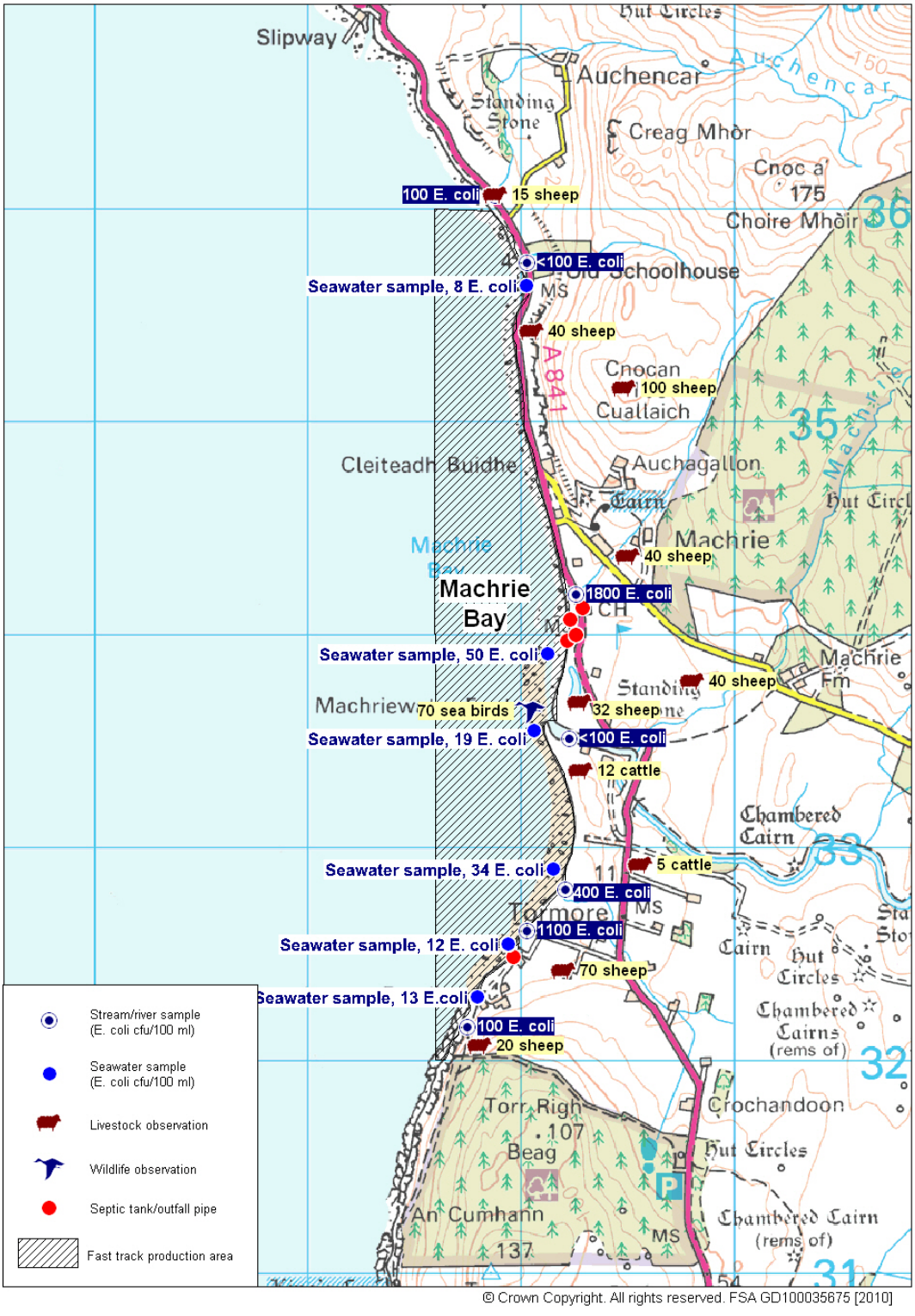

Figure 9.1 Summary of shoreline observations

10. Overall Assessment

Fishery

The shellfish bed is located within Machrie Bay. The harvester has indicated that the razor clam bed lies within the fast track production area boundaries. The razors will be hand dived and harvesting is planned to take place throughout the year.

Human sewage inputs

There are no large settlements within the catchment of Machrie Bay. There are some small villages in the area with the rest of the population in scattered dwellings. Several septic tanks and outfall pipes were observed within the area, connected to several houses and the golf course club house. These feel into two groups, one midway down the fast track production area and one towards the southern end.

Approximately 5 km south of Machrie Bay there are eight registered SEPA discharge consents which may affect the fishery depending on tidal flow patterns. It is unlikely that a single discharge more than 7 km to the north of the fishery, or discharges on the western side of Kilbrannan Sound, will affect the microbiological quality of the razors at Machrie Bay.

Overall, risk of contamination is therefore more likely to occur from the discharges located south of the fishery where contamination levels are therefore expected to be higher towards the southern end of the Bay.

Agricultural inputs

During the shoreline survey livestock were observed roaming widely along the coastline adjacent to Machrie Bay (see Figure 4.1). North of Machrie there were four large flocks of sheep (approx 195 in total) north and south of Auchagallon. Close to Machrie Water approx 72 sheep and 12 cattle were observed. South of Machrie Water near Laggmore approx 12 cattle and 95 sheep in total were also observed. All livestock were observed within 500 m of the shoreline and due to the large numbers, agricultural sources are considered to be a significant source of contamination to the shellfish bed.

Wildlife inputs

During the shoreline survey, in total approximately 70 seabirds including gulls were observed were observed on some rocks on the north side of Machrie water at low tide.

Rivers and streams

A total of seven significant fresh water inputs were observed discharging into the Machrie Bay area at the time of the shoreline survey. The streams were spread along the entire length of the bay. The largest fresh water input to the

bay, is Machrie Water, however this was considered too dangerous to measure at the time of the shoreline survey. It was possible to calculate daily *E. coli* loadings for four of the streams. The stream (Allt an Uachdair Water) with the largest *E. coli* loading of 1.8×10^{11} was located at the centre of the bay and shellfish bed. The stream with the second largest *E. coli* loading of 1.0×10^{11} was located towards the southern end of the shellfish bed. The remaining two streams with *E. coli* loadings of 1.6×10^{9} and 2.4×10^{10} were located towards the northern end of the shellfish bed. Overall it is expected that the freshwater inputs into Machrie Bay will have an effect on the bacterial contamination of shellfish, especially where the *E. coli* loadings are higher at the centre and south end of the bay.

Rainfall

Rainfall patterns at Arran Dougarie Lodge (the nearest rainfall station) show that seasonal variation in rainfall levels occurs and the wettest months were December and January. An increase in rainfall may be expected to wash a flush of bacteria from the surrounding land into the production area. The impact of rainfall events is likely to be most acute nearest where the streams enter the bay.

Analysis of results

There was no historical *E. coli* monitoring data available for Machrie Bay.

Bad weather conditions resulted in no razor clam samples being obtained during the shoreline survey or the following months.

Sub surface sea water samples were taken from several points along the Machrie Bay coastline and also from within the shellfish bed area. Results ranged from 8 to 50 *E. coli* cfu/100 ml. The highest result of 50 *E. coli* cfu/100 ml was taken from the centre of the bay.

Movement of contaminants

It is expected that tidal stream effects will predominate and that contamination will tend to be taken along the coast from each source. This general trend may be modified by strong winds.

Overall conclusions

Although there are a number of sources of contamination along the coast adjacent to the fast track production area, there is a concentration towards the centre of it. These include four potential septic tanks outfalls, Allt nam Pairc Beaga Water (and potentially Machrie Water, depending on the actual *E. coli* loading), farm animals and sea birds. The central part of the fishery will also be affected by sources to the north and south of it, on the ebbing and flooding tide respectively.

11. Recommendations

The recommendations are summarised in Figure 11.1.

Production area

It is recommended that the production area be defined as :

The area bounded by lines drawn between NR 8898 3550 to NR 8861 3550 and between NR 8861 3550 to NR 8861 3196 extending to MHWS.

This is based on the original fast track production area but with the northern boundary constrained to omit some potential sources of pollution north of the fishery and the southern boundary redefined so as to meet mean high water springs. The recommended area covers the entire fishery as identified by the harvester.

RMP

It is recommended that the RMP be placed at NR 8890 3385 to reflect the sources of contamination immmediately towards the centre of the area and the influence of those to the north and south.

The recommended tolerance is 100 m – this recognises the potential difficulty of gathering sufficient razors close to the identified point while constraining the sampling to that area identified as of higher risk. It also takes into account the size of the fishery and the location and nature of the potential sources of contamination. Given that the razors will be gathered from the seabed, it is not appropriate to specify depth of sampling.

As there is no routine *E. coli* data available for this area, it is recommended that monthly sampling be undertaken for at least one year and then the variability reviewed ot determine whether the frequency can be reduced.

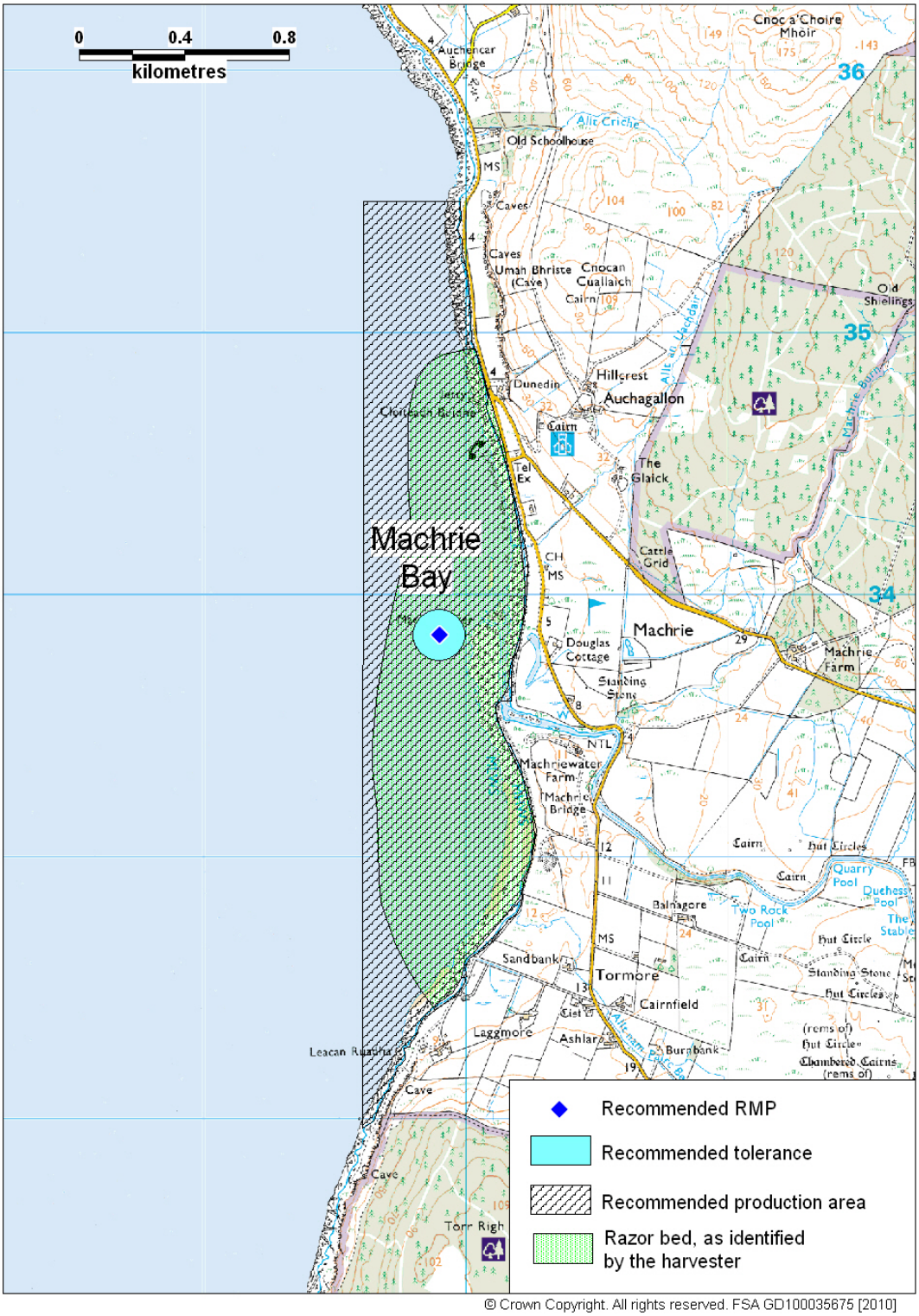

Figure 11.1 Recommendations for Machrie Bay

12. References

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Appendices

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2. **Comparative Table of Boundaries and RMPs**
3. **Shoreline Survey Report**

Sampling Plan for Machrie Bay

PRODUC-TION AREA	SITE NAME	SIN	SPECIES	TYPE OF FISHERY	NGR OF RMP	EAST	NORTH	TOLE R-ANCE (M)	DEPTH (M)	METHOD OF SAMPLING	FREQ OF SAMPLING	LOCAL AUTHORITY	AUTHORISED SAMPLER(S)	LOCAL AUTHORITY LIAISON OFFICER
Machrie Bay	Machrie Bay Razors	AB 510	Razors	Wild harvest	NR 8890 3385	188900	633850	100	NA	Hand	Monthly	Argyll and Bute Council	Christine McLachlan William MacQuarrie Ewan McDougall Donald Campbell	Christine McLachlan

Comparative Table of Boundaries and RMPs – Machrie Bay

Production Area	Species	SIN	Existing Boundary	Existing RMP	New Boundary	New RMP	Comments
Machrie Bay	Machrie Bay Razors	AB 510 929 16	The area bounded by lines drawn between NR 8890 3600 to NR 8860 3600 and between NR 8860 3600 to NR 8860 3200 extending to MHWS[1]	N/A	**The area bounded by lines drawn between NR 8898 3550 to NR 8861 3550 and between NR 8861 3550 to NR 8861 3196 extending to MHWS.**	**NR 8890 3385**	Constrained northern boundary. Minor adjustment to southern boundary. Newly defined RMP.

[1]Proposed fast track production area – not classified to date as no samples submitted

Shoreline Survey Report

Machrie Bay
AB 510

Restricted Sanitary Survey

Scottish Sanitary Survey Project

Shoreline Survey Report

Production area:	Machrie Bay	
Site name:	Machrie Bay Razors	
Species:	Razor clams (*Ensis* spp.)	
Harvester:	Andrew Charlwood	
Local Authority:	North Ayrshire Council	
Status:	New site	
Date Surveyed:	10th November 2009	
Surveyed by:	Andrew Miller	North Ayrshire Council
	William Murray	North Ayrshire Council
Existing RMP:	NA	
Area Surveyed:	See Figure 1.	

Weather observations

Tuesday 10th November: Dry, sunny, cold

Site Observations

Fishery

The Machrie Bay site is harvested for Razor clams (*Ensis* spp.). The razor clams are hand dived within the fast track production area boundaries identified in Figure 1. The harvesters plan to harvest the razors all year round.

Sewage/Faecal Sources

The area surveyed has several scattered dwellings around the bay. There is a golf course with a club house near Douglas Cottage, north of Machrie Water. The golf club house had septic tanks and several inspection covers and outfall pipes. Additional septic tanks and three possible outfall pipes were observed near houses near Laggmore.

Seasonal Population

No hotels or B&BS were observed during the shoreline survey. There is a popular golf course with a club house near Douglas Cottage, north of Machrie Water that is likely to be busy in the summer months.

Boats/Shipping

At the time of the shoreline survey two fishing boats were located at the southern end of the site, far out to sea.

Land Use

There is improved grassland on the shoreline surrounding Machrie Bay and on the upper slopes of Cnocan Cullaich Hill (NR 893 352).

Livestock

There are cattle and sheep scattered along most of the coastline of Machrie Bay, although the majority of livestock tends to be concentrated in three main areas. There were large flocks of sheep (approx 140 in total) north and south of Auchagallon. Close to Machrie Water approx 72 sheep and 12 cattle were observed. Further south near Laggmore approx 90 sheep in total were also observed.

Wildlife/Birds

During the shoreline survey approximately 70 sea birds were observed on the rocks at low tide close to the mouth of the Machrie Water.

Observations can be found in Table 1.

Figure 1. Shoreline Observations

Table 1. Shoreline Observations

No.	Date	Time	NGR	East	North	Associated photograph	Description
1	10/11/2009	09:27	NR 89287 33357	189287	633357	Figure 4	12 cattle in field just south of Machrie Water
2	10/11/2009	09:42	NR 88811 32066	188811	632066		20 sheep in field near shore, 10 in field 10 just across fence in forest
3	10/11/2009	09:42	NR 89208 32418	189208	632418	Figure 5	Approx. 70 sheep in fields around Laggmore
4	10/11/2009	10:00	NR 88688 32011	188688	632011	Figures 6 & 7	Small water fall at start of survey site. Fishing boats in Clyde near site
5	10/11/2009	10:07	NR 88709 32089	188709	632089		Photograph looking south of survey site
6	10/11/2009	10:10	NR 88732 32129	188732	632129		Photograph looking north from south end of survey site
7	10/11/2009	10:15	NR 88753 32154	188753	632154		One of two small flows in area, too small to take flow reading, not marked on map. Water sample 1 (fresh water)
8	10/11/2009	10:23	NR 88791 32253	188791	632253		Concrete slab does not look like a septic tank
9	10/11/2009	10:28	NR 8886 3226	188860	632260	Figure 8	Sewage fungus bacteria on beach at cottage and farm
10	10/11/2009	10:36	NR 88800 32296	188800	632296		Several house and septic tanks nearby. Water sample 2 (seawater) Salinity 30 ppt.
11	10/11/2009	10:49	NR 88838 32375	188838	632375		Significant flow of water through rocks on beach no main body of flow, close to water sample 2 (seawater)
12	10/11/2009	10:54	NR 88898 32409	188898	632409		Field ditch running into pond near, beach no flow onto beach apparent
13	10/11/2009	10:58	NR 88934 32433	188934	632433		Flow through rocks on beach from a small field drain
14	10/11/2009	11:01	NR 88973 32487	188973	632487		Septic Tank outfall
15	10/11/2009	11:10	NR 88946 32545	188946	632545	Figure 9	Three houses in distance, possible septic tank outfalls. Water sample 3 (seawater) Salinity 31 ppt. Photograph looking south showing houses near shore. Flows of water through rocks on beach.
16	10/11/2009	11:21	NR 89034 32609	189034	632609		Marked sampling point 4 very over grown, stream too over grown to get flow reading. Water sample 4 (fresh water).
17	10/11/2009	11:31	NR 89080 32646	189080	632646		Unmarked field drain, W 0.15, D 0.10, F 0.493
18	10/11/2009	11:41	NR 89090 32653	189090	632653		Another unmarked field drain, small flow, orange iron oxide bacteria present
19	10/11/2009	11:45	NR 89169 32742	189169	632742		Scenic picture Machrie bay looking north
20	10/11/2009	11:49	NR 89214 32802	189214	632802	Figure 10	Water sample 5 (fresh water). Allt nam Pairc Beaga water, W 1.58, D 0.23, F 0.826

No.	Date	Time	NGR	East	North	Associated photograph	Description
21	10/11/2009	12:07	NR 89158 32898	189158	632898		Water sample 6 (seawater) Salinity 26 ppt.
22	10/11/2009	12:07	NR 89566 32916	189566	632916		5 cattle in field behind sampling site for water sample 6 (seawater)
23	10/11/2009	12:10	NR 89172 32939	189172	632939		Salinity just north of water sample 6 (seawater) site is still low - 26ppt.
24	10/11/2009	12:11	NR 89195 33010	189195	633010		Sandbar at low tide holding the fresh water in near the shore
25	10/11/2009	12:21	NR 89213 33098	189213	633098		Scenic photographs looking north.
26	10/11/2009	12:21	NR 89048 33637	189048	633637	Figure 11	Approx. 70 sea birds on rocks on the north side of Machrie water at low tide
27	10/11/2009	12:28	NR 89489 35155	189489	635155	Figure 12	House and approx. 100 sheep on hills on the Northern part of site at Hill Cnocan Cullaich
28	10/11/2009	12:41	NR 89232 33513	189232	633513	Figure 13	Machrie water, too deep and too wide to measure and take a flow reading. Water sample 7 (fresh water).
29	10/11/2009	12:52	NR 89284 33678	189284	633678		Spring on beach fed from pond in field with 32 sheep, comes out next to Machrie water. Large rock pool on beach at low tide.
30	10/11/2009	12:59	NR 89058 33821	189058	633821		Large rock pool on beach at low tide North of Machrie water, this is the route of the river marked on the map, Machrie now flows straight out to sea.
31	10/11/2009	13:09	NR 89064 33547	189064	633547	Figure 14	Water sample 8 (seawater) taken here as River Machrie flows straight out to sea and not north as marked on the map (i.e. at low tide)
32	10/11/2009	13:15	NR 89070 33636	189070	633636		Salinity Test
33	10/11/2009	13:17	NR 89050 33746	189050	633746		Salinity Test
34	10/11/2009	13:22	NR 89131 33907	189131	633907		Marked seawater sampling site near Douglas Cottage (water sample 9 - sea water), The River Machrie flow at low tide has changed from that marked on the map.
35	10/11/2009	13:22	NR 89811 33776	189811	633776		Approx. 40 sheep in field behind Douglas Cottage and golf course
36	10/11/2009	13:22	NR 89226 33973	189226	633973	Figure 15	Pipe on beach, suspect drainage pipe for golf course, flow too small to measure. Water sample 10 (freshwater). Green for golf course on land behind.
37	10/11/2009	13:35	NR 89267 33997	189267	633997	Figure 16	Two man holes covers on golf course, suspect not drainage/sewerage, no outfall to beach
38	10/11/2009	NA	NR 89297 34125	189297	634125	Figures 17 & 18	Club house septic tanks, piped into a small stream which we suspect flows to underground to Allt an Uachdair water, as many a 6 to 11 other houses in catchment area for the same river

No.	Date	Time	NGR	East	North	Associated photograph	Description
39	10/11/2009	13:57	NR 89265 34188	189265	634188	Figure 19	Allt an Uachdair water, water sample 11 (fresh water) W 0.55, D 0.10, F 2.066. Estimated 11 houses in catchment area of Allt an Uachdair burn in background up hill.
40	10/11/2009	13:57	NR 89508 34364	189508	634364		Approx. 40 sheep in field behind the houses
41	10/11/2009	14:06	NR 89239 34070	189239	634070	Figures 20 & 21	Probably a drainage pipe for the golf course, but slight possibility that it is the septic tank discharge for the clubhouse, water sample 12 (fresh water) taken. Picture of shoreline looking north Ullt an Uachdair in foreground.
42	10/11/2009	14:14	NR 89210 34343	189210	634343		Pond on other side of road to beach, no flow to beach
43	10/11/2009	14:24	NR 89082 34824	189082	634824	Figure 22	32 cm diameter pipe under road from a small stream, W 0.13, D 0.01, F 1.586
44	10/11/2009	14:30	NR 89082 34802	189082	634802		20cm diameter under road to beach at Dunedin House, W 0.2, D 0.1, F 0.11
45	10/11/2009	14:30	NR 89056 35421	189056	635421		Approx. 40 sheep in field other side of road
46	10/11/2009	14:49	NR 89028 35641	189028	635641		Water sample 13 (seawater)
47	10/11/2009	14:59	NR 89036 35750	189036	635750	Figure 23	Culverted stream at Old Schoolhouse, water sample 14 (fresh water) W 0.01, D 0.03, F 1.271
48	10/11/2009	15:11	NR 88885 36065	188885	636065	Figure 24	Auchencar Bridge, approx. 15 sheep in field next to bridge. Water sample 15 (fresh water) W 2.5, D 0.22, F 0.504

Photos referenced in the table can be found attached as Figures 4 – 24.

Sampling

Water samples were collected at sites marked on the map. Bacteriology results follow in Table 2.

Bad weather conditions resulted in no razor clam samples being obtained during the shoreline survey or the following months.

Seawater samples were tested for salinity using a hand held refractometer. These readings are recorded in Table 1 as salinity in parts per thousand (ppt).

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

Table 2. Water Sample Results

No.	Date	Sample	Grid Ref	Type	*E. coli* (cfu/100ml)	Salinity (g/L)
1	10/11/2009	MBW01	NR 88753 32154	Fresh Water	100	-
2	10/11/2009	MBW02	NR 88800 32296	Sea Water	13	33.1
3	10/11/2009	MBW03	NR 88946 32545	Sea Water	12	31.4
4	10/11/2009	MBW04	NR 89034 32609	Fresh Water	1100	-
5	10/11/2009	MBW05	NR 89214 32802	Fresh Water	400	-
6	10/11/2009	MBW06	NR 89158 32898	Sea Water	34	23.6
7	10/11/2009	MBW07	NR 89232 33513	Fresh Water	<100	-
8	10/11/2009	MBW08	NR 89064 33547	Sea Water	19	19.1
9	10/11/2009	MBW09	NR 89131 33907	Sea Water	50	27.8
10	10/11/2009	MBW10	NR 89226 33973	Fresh Water	<100	-
11	10/11/2009	MBW11	NR 89265 34188	Fresh Water	1800	-
12	10/11/2009	MBW12	NR 89239 34070	Fresh Water	100	-
13	10/11/2009	MBW13	NR 89028 35641	Sea Water	8	25.1
14	10/11/2009	MBW14	NR 89036 35750	Fresh Water	<100	-
15	10/11/2009	MBW15	NR 88885 36065	Fresh Water	100	-

Figure 2. Water sample results

Photographs

Figure 4. Cattle in field just south of Machrie Water

Figure 5. Sheep in fields around Laggmore

Figure 6. Small waterfall at start of survey site

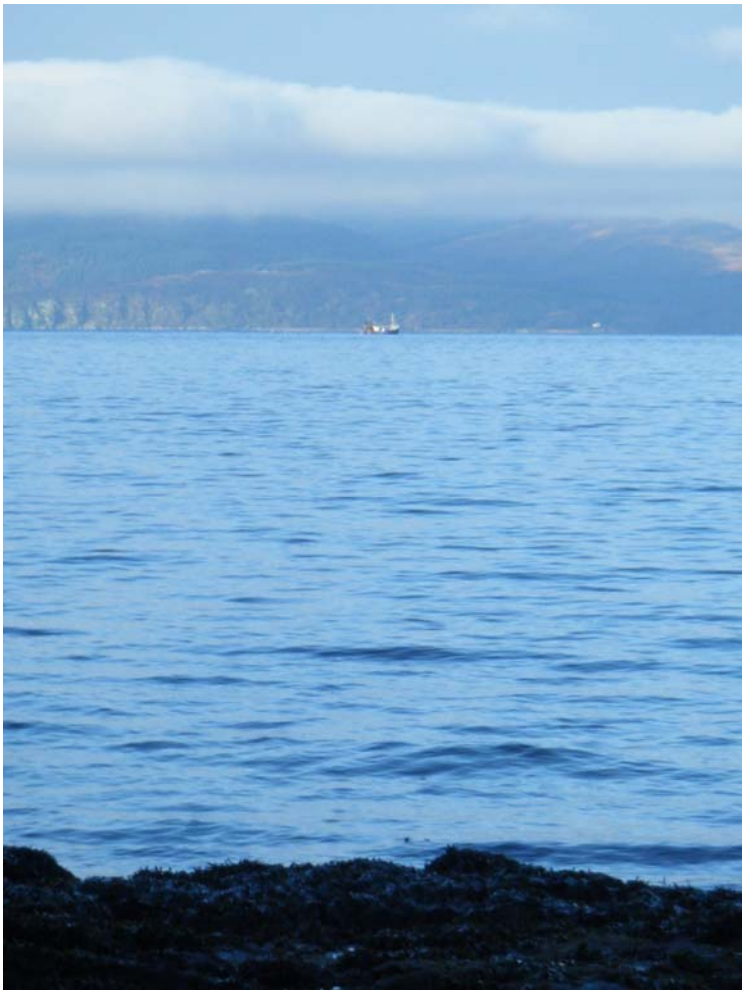

Figure 7. Fishing boats in Clyde near the site

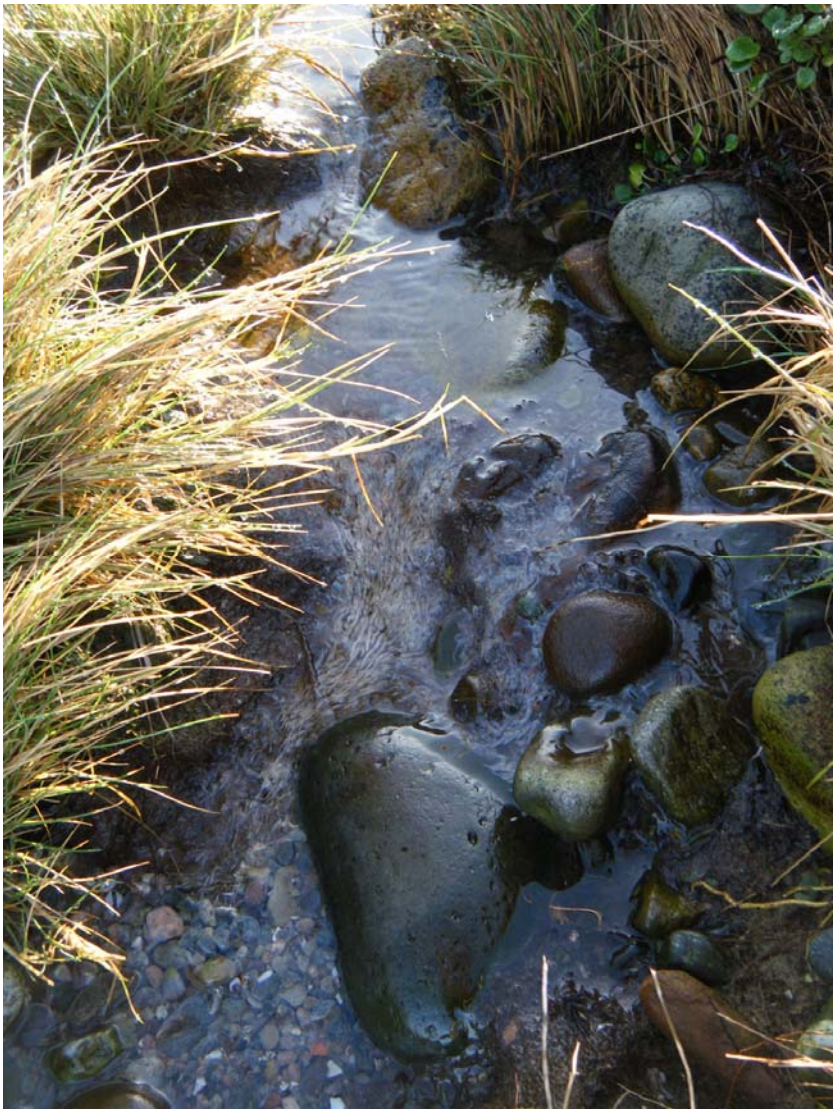

Figure 8. Sewage fungus bacteria on beach

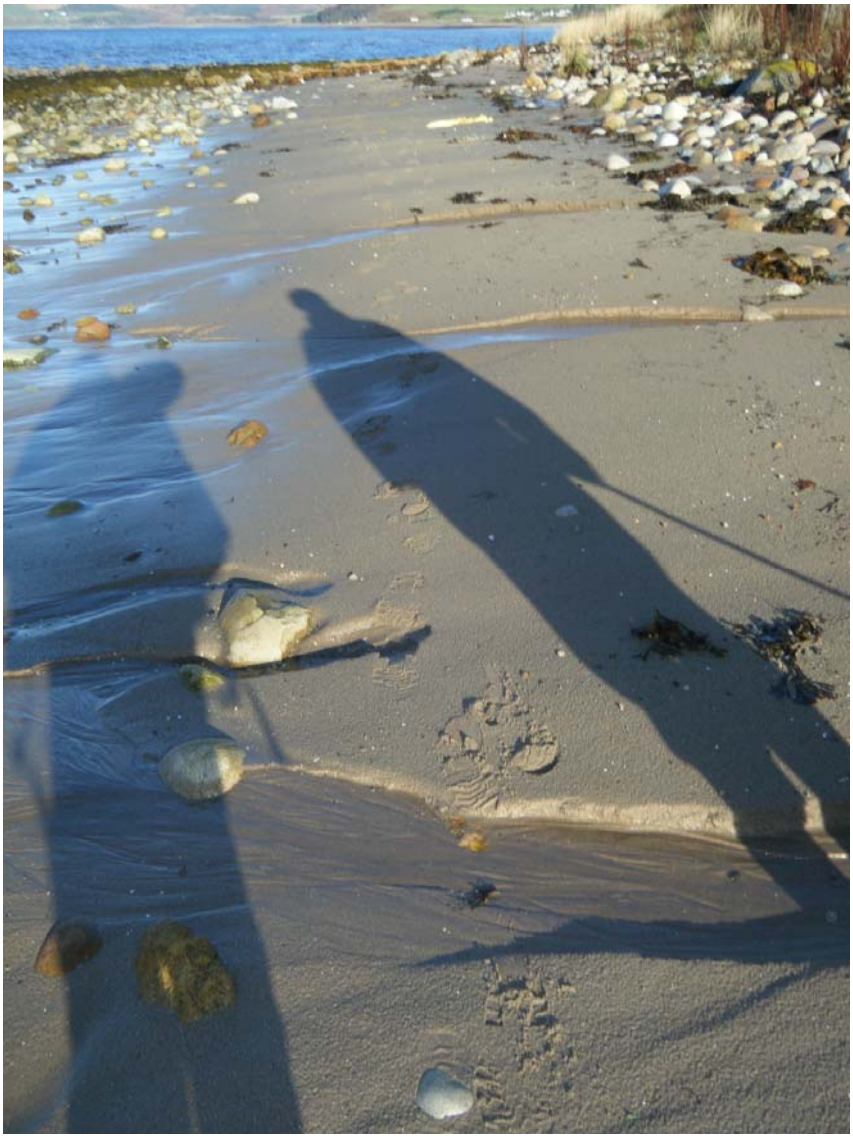

Figure 9. Flows through rocks on beach

Figure 10. Allt nam Pairc Beaga water sample 5

Figure 11. Seabirds on rocks north side of Machrie Water

Figure 12. Houses and lots of sheep on hills at North part of site

Figure 13. Machrie River

Figure 14. Seawater sample 8 taken at mouth of Machrie Water

Figure 15. Concrete drainage pipe leading onto beach, possibly from golf course

Figure 16. Two inspection covers on golf course

Figure 17. Septic tank for golf course clubhouse

Figure 18. Septic tank outfall for clubhouse leading into small stream

Figure 19. Allt an Uachdair water sample 11

Figure 20. Concrete pipe, might be drainage for golf course

Figure 21. Scenic photo looking north Allt an Uachdair

Figure 22. 32cm diameter pipe

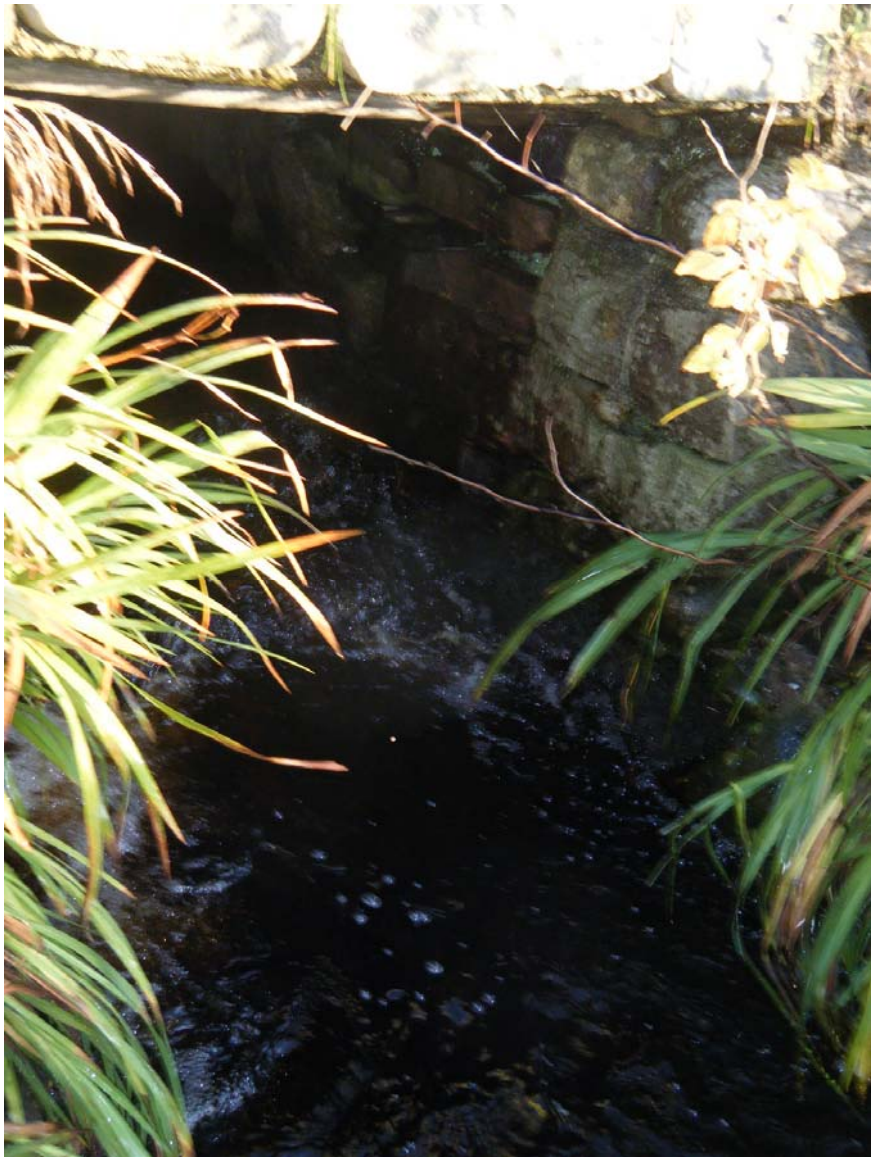

Figure 23. Culverted stream at school house water sample 14

Figure 24. Auchencar Bridge