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Environmental Protection Report

INVESTIGATIONS INTO THE CONTRIBUTION OF MALBOROUGH STW TO THE NON–COMPLIANCE OF SALCOMBE SOUTH SANDS WITH THE EC BATHING WATERS DIRECTIVE

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INVESTIGATIONS INTO THE CONTRIBUTION OF MALBOROUGH STW TO THE NON-COMPLIANCE OF SALCOMBE SOUTH SANDS WITH THE EC BATHING WATERS DIRECTIVE.

TECHNICAL REPORT NO. TWU/92/10

SUMMARY

The E.C. identified bathing waters of Salcombe South Sands beach have failed to meet mandatory European Quality Standards for faecal coliforms in recent years. Potential sources of such bacteria in the area are numerous and include the main Salcombe sewage outfall, several other crude sewage outfalls and Combe Stream. Effluent from Malborough Sewage Treatment Works (STW) is discharged into Combe Stream approximately 2 km upstream of South Sands beach.

In the light of planned improvements to the sewerage and sewage disposal systems of the Kingsbridge estuary and surrounding area under South West Water Services Ltd's (SWWSL) capital improvements programme, NRA South West has investigated the impact of Malborough STW on the bacterial quality of South Sands bathing waters.

Three separate investigations were carried out by the NRA's Tidal Waters Investigations Unit during the winter months of 1991/92. SWWSL are also known to have carried out their own investigations during the summer of 1990.

It was established that freshwater derived from Combe Stream influenced bacterial concentrations across the full width of South Sands beach within 2 hours of meeting the sea. It was also determined that effluent from Malborough STW reached the bathing water within 4 hours of discharge under winter flow conditions.

Malborough STW was shown to be the dominating source of faecal coliform bacteria to Combe Stream under winter flow and population conditions, although data provided by SWWSL indicates that the relative influence of the STW may be reduced during summer months. Sources other than Malborough STW were also seen to influence faecal coliform concentrations in Combe Stream. The duck pond just upstream of South Sands beach appeared to provide a consistent faecal coliform input throughout both winter and summer months, while the toilet storage tank situated in the caravan park a little further upstream is suspected of providing a more significant faecal coliform source during summer months.

Sources of faecal coliform bacteria other than those entering Combe Stream also appear to influence bacterial concentrations in the bathing waters of South Sands, particularly on the flood tide. Such sources may have a greater impact during summer months due to a large seasonal increase in population although this cannot be confirmed by data collected to date. The nearest of these sources is South Sands crude sewage outfall. The poor design and physical condition of this outfall are a clear threat to the bacterial water quality of the adjacent bathing water.

It is concluded that the quality of Malborough STW effluent requires improvement if the good quality of South Sands bathing water is to be assured.

The following recommendations are made:

- Malborough STW should be included in SWWSL's proposed Salcombe Sewerage Improvements Scheme.
- Occasional inspections of the state of repair of the crude sewage outfalls close to North and South Sands beaches should be made.
- The water quality of Combe Stream should continue to be monitored after planned improvements have been completed to ensure that no major sources of contamination persist.
- Approaches should be made to the owners of the caravan park at South Sands regarding the connection of their toilets to the public sewerage system.

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1. INTRODUCTION

The E.C. identified bathing waters of Salcombe South Sands beach (ECB0330), which lie on the south western edge of the Kingsbridge estuary, failed to meet the European Commission mandatory standard for faecal coliforms (95% compliance per bathing season at 2000 faecal coliforms per 100ml) in 1986 and 1988, whilst the mandatory numerical limit was exceeded once in 1990. Although no failures to meet the equivalent standard for total coliforms have been recorded (95% compliance per season at 10000 total coliforms per 100ml), the numerical limit was exceeded once in each of 1986 and 1988.

There are a number of sources of faecal coliform bacteria in the vicinity of South Sands beach. These include the main Salcombe sewage outfall 1 km up-estuary of South Sands, the two crude sewage outfalls at North Sands and South Sands, and the effluent from Malborough STW that is discharged to Combe Stream approximately 2 km upstream of South Sands. Combe Stream runs into the Kingsbridge estuary directly across South Sands beach. A general map of the lower Kingsbridge estuary is shown in FIG [1].

The lower reaches of the Kingsbridge estuary have already been identified as having poor bacterial water quality as a result of inadequate/ ineffective, sewage disposal. The Salcombe Sewerage Improvement Scheme, part of SWWSL's capital programme, has thus been proposed to facilitate an improvement in general water quality, and more particularly to ensure, as far as is possible, the compliance of all relevant bathing waters - South Sands included - with the required bacterial Environmental Quality Standards (EQS's).

Early negotiations surrounding the preferred scheme option to be pursued by SWWSL left the fate of the effluent from Malborough STW unclear. As a result of this, and the fact that preliminary examination of the routine beach data for South Sands displays high levels of faecal coliforms in Combe Stream as it flows across the beach, the Tidal Waters Officer of NRA South West requested that the Tidal Waters Investigations Unit (TWIU) undertook to determine whether or not Malborough STW was contributing to the bacterial EQS failure of South Sands beach. In this way NRA South West could establish its requirement for the inclusion/exclusion of Malborough STW in/from the Salcombe Sewerage Improvement Scheme.

2. FIELDWORK

2.1 PROGRAMMING

In order to meet the objective of the investigation, as set out in the final paragraph of the introduction, the fieldwork was split into two distinct parts:

(a) An investigation to examine the extent of influence of Combe Stream (ECBR0330) on bacterial levels in the bathing waters off South Sands beach (ECB0330).

(b) A further investigation to ascertain the relative contribution of Malborough STW to bacterial levels in Combe Stream as it flows onto South Sands beach.

The work in connection with (a) above was carried out on Wednesday 11-12-91. The predicted tidal conditions for the day were;

	TIME (GMT)	ELEVATION
HW	08.20	4.9 m
LW	14.40	1.6 m
HW	20.40	4.6 m

In connection with (b) above, intensive sampling of Combe Stream took place on Thursday 6-2-92. A subsequent detailed examination of the lower part of the Combe Stream catchment was carried out on Monday 16-3-92.

2.2 METHODS

2.2.1 INVESTIGATION (a)

Since the investigation was to focus on the bacterial contribution of a freshwater source to the saline waters of the Kingsbridge estuary, it was decided to base the survey around the use of a conservative bacterial tracer (B.globigii spores) in conjunction with accurate salinity determinations to examine the distribution of freshwater from Combe Stream across South Sands beach. The application of such a method to South Sands was considered particularly appropriate due to the fact that the Kingsbridge estuary has no major freshwater inputs upstream of South Sands (Wimpol 1990).

Combe Stream was subjected to a continuous injection of the tracer, just upstream of South Sands beach, over a full tidal cycle - 12.5 hours commencing at high water (HW). The injection was achieved by means of a small peristaltic pump draining a 25 l graduated canister containing B.globigii spores at a concentration of 5.5 x 10^9 per ml.

An hourly sampling programme was devised to provide data on both B.globigii and bacterial levels (total coliforms, faecal coliforms and faecal streptococci) at six beach sites along the waters edge, including the ECB sampling line, and at one site in Combe Stream. FIG [2] provides a schematic representation of the positions of these sampling points.

A further aspect of the survey work was designed to identify whether or not effluent from the main Salcombe sewage outfall, 1 km up-estuary, impacted directly on South Sands beach. Hourly dye releases were made on the ebb tide from a point some 100 m downstream of the main Salcombe effluent boil. On each occasion 500 ml of fluorescein, at a concentration of 300 g/l, was poured over the side of a small inflatable vessel. A photographic record of the progress of each dye patch was obtained from a raised vantage point on Splatcove Point. A single similar dye release was also made on the early flood tide from the vicinity of the South Sands crude sewage outfall.

A summary of the sites relevant to all aspects of the fieldwork undertaken on 11-12-91 is given in FIG [3]. Samples were delivered to the NRA's Manley House laboratory at three times during the survey, thus enabling all bacteriological analysis to be carried out within six hours of sample collection.

2.2.2 INVESTIGATION (b)

Combe Stream catchment was examined using 1:10000 Ordnance Survey maps in order to define a series of sampling points that were both accessible and that would provide data representative of all the potential bacterial inputs to the stream. The positions of the resulting six sampling points visited on 6-2-92, together with other details of the catchment, are shown in FIG [4].

A sampling protocol was devised in order to provide the maximum possible information from only limited analytical effort. The following summarizes the above protocol and details the determinands utilized:

SITE 5:	West Portlemouth -	Hourly samples for faecal coliforms and faecal streptococci.
SITE 4:	D/S Malborough STW -	Half-hourly samples for faecal coliforms and faecal streptococci, bulked into hourly composite samples for analysis. A spot injection of <u>B.Globigii</u> spores (10 l at 5.5 x 10^6 spores per ml) was also carried out at 11.00.
SITE 3:	U/S Plympton -	Half-hourly samples for faecal coliforms and faecal streptococci, bulked into hourly composite samples for analysis.
SITE 2:	D/S Combe -	As SITE 3, but with the addition of half-hourly samples for <u>B.Globigii</u> (after 11.00).
SITE 1:	D/S Southern Mill -	As SITE 2 above.
SOUTH SANDS BEACH -		Again, as SITE 2.

The above programme was commenced at 07.00 and ran for a further 11 hours to 18.00. In this way the sampling programme covered the period during which the majority of diurnal variations in sewer flow occur. As with the previous TWIU investigation on Wednesday 11-12-91, samples were delivered to the NRA's Manley House laboratory at three times during the survey thus ensuring that all bacteriological analyses were carried out within six hours of sample collection.

In the light of results from the 6-2-92 investigation a further detailed examination of the lower Combe catchment (between SITE 1 and South Sands beach) was carried out on Monday 16-3-92. Seven bacteriological samples were collected from the sites detailed in FIG [5] and returned to the Manley House laboratory for analysis within six hours.

South West Water Services Ltd. (SWWSL) are also known to have carried out limited bacteriological sampling from Combe Stream on several dates prior to NRA investigations (10-8-90, 15-8-90 and 17-8-90). The methodology employed in all cases is unknown, as are the times to analysis of the resulting samples. However, for the sake of completeness the data are included and discussed in Section 4.5 below.

3. RESULTS

The historical monitoring data for Salcombe South Sands beach (ECB0330) and Combe Stream (ECBR0330) are given in TABLE [1].

A summary of the field data collected on 11-12-91 together with the results of the relevant sample analyses are given in TABLE [2]. TABLE [2] also contains information derived from the collected data in order to aid interpretation, namely freshwater fractions and bacterial ratios that are discussed below. Information relating to the various dye releases carried out on 11-12-91 is not specifically tabulated, but is used as supporting information in the discussion.

A summary of the analytical results obtained from the investigation of 6-2-92 is given in TABLE [3]. TABLE [4] contains the data from the same date that has been shifted in time to take account of the "time of travel" of effluent from Malborough STW to the various downstream sampling sites.

TABLE [5] contains the analytical results obtained from those samples collected during the detailed investigation of the lower Combe catchment on 16-3-92, while TABLE [6] contains the data derived from the 1990 SWWSL work referred to above.

4. DISCUSSION

4.1 NRA ROUTINE BEACH AND STREAM DATA

The NRA routine beach and stream sampling data provided in TABLE [1] demonstrate several significant points. Firstly, bacterial levels in Combe Stream are consistently high - faecal coliform results in excess of 2000 per 100 ml have been recorded in 91% of the routine samples taken (n=81), while total coliform results exceed 10000 per 100 ml 79% of the time (n=81). The fact that the routine stream sampling point lies less than 50m from the E.C. Bathing Water sampling line makes such results cause for concern.

On the occasion that TWIU staff visited South Sands, Combe Stream flowed into the sea along the southern edge of the beach, thus maximizing the distance between the stream and the E.C. Bathing Water line. However, it is likely that the course of the stream will alter over time due to differences in prevailing weather and sea conditions, thus the possibility exists for Combe Stream to run right across the E.C.B. sampling line.

The routine beach data have also been examined graphically - FIGS [6] to [9] inclusive show variations in faecal coliform concentrations with key variables. FIG [6] shows some evidence of a trend of increasing faecal coliform levels with decreasing "adjusted salinity"[1] in samples that exceed the guideline EC value for faecal coliforms of 100 per 100 ml. This implies that a freshwater source of faecal coliforms is significant on some occasions, although not all the EQS failures observed can be associated with reduced salinity.

FIGS [7] and [8] show the variations in faecal coliform levels in Combe Stream and the bathing waters of South Sands with respect to rainfall on the day of sampling. Faecal coliform concentrations in Combe Stream remain relatively constant with increasing rainfall (FIG [7]), thus implying that no dilution of faecal coliforms occurs as stream flows increase. Consequently, the loading of faecal coliforms from Combe Stream to the adjacent bathing water will increase with increasing rainfall. As a result of the above, faecal coliform concentrations in the bathing waters of South Sands might be expected to show some positive correlation with rainfall. However, the bathing water data set plotted in FIG [8] shows no such correlation.

FIG [9] shows variations in faecal coliform concentrations with respect to the tide. All six historical EQS failures have occurred in the seven hours between HW and HW-6, i.e. mainly on the ebb tide. A previous study of the Kingsbridge estuary (Wimpol 1990) identified strongest ebb flows towards the western edge of the estuary, closer to South Sands beach. This could therefore imply that bacteria derived from the main Salcombe sewage outfall potentially have a larger impact on South Sands beach on the ebb

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[1] Historical salinity data obtained in the field suffer some inaccuracies - see TWIU Technical Note no. TWIU 91/010. A correction has thus been applied to provide more representative values, hence "adjusted salinity".

rather than the flood tide, thus the main Salcombe outfall could be partially responsible for historical EQS failures. However, qualitative dye releases carried out by the TWIU suggested that effluent from the main outfall discussed above is flushed from the estuary within 1 hour of discharge on intermediate range ebb tides. No dye released in the vicinity of the main outfall during NRA fieldwork was observed to impact directly on South Sands beach.

FIG [10] demonstrates the relationship between faecal coliform concentrations observed historically on South Sands and those that would have been expected if all faecal coliforms in the bathing waters had been derived from Combe Stream only. The "expected" levels have been calculated in the following way:

$$\text{Freshwater fraction of bathing water} \times \text{Faecal coliforms in Combe stream} = \text{"Expected" faecal coliforms in the bathing water}$$

Since the salinity data used to derive values for freshwater (FW) fraction are considered somewhat unreliable, as discussed above, the relationship shown in FIG [10] must be treated with some caution. However, there is some evidence of positive correlation between "actual" and "expected" faecal coliform concentrations.

Considering in turn each of the three points shown in FIG [10] which exceed the EC mandatory limit for faecal coliforms and for which corresponding stream bacterial data are available, it appears that on two out of three occasions Combe Stream is the most likely cause of non-compliance. On both 27-9-88 and 29-8-90 levels of faecal coliforms in Combe Stream were so high - 227000 and 436000 per 100 ml respectively with corresponding salinities of 34.35 and 33.52 - that the levels observed in the bathing water could more than be accounted for by dilution of stream water across the beach. Thus Combe Stream would appear to be a significant source of faecal coliforms to the bathing waters of South Sands on some occasions.

4.2 TWIU DATA, 11-12-91 INVESTIGATION

The data collected by the TWIU on 11-12-91, shown in TABLE [2], demonstrate that throughout the survey period levels of faecal coliforms in Combe Stream, as it flowed onto South Sands beach, were consistently greater than 2000 per 100 ml. On one occasion (early morning) nearly 90000 faecal coliforms per 100 ml were present. However, this value is considerably lower than those sometimes observed in historical samples- values in excess of 500000 faecal coliforms per 100 ml have been recorded. During the 12.5 hour survey period, the EC mandatory limit for faecal coliforms was exceeded four times in samples collected from the bathing water - although none of the "failed" samples were collected on the official ECB sampling line. However, the freezing conditions and overcast skies throughout the survey period will have resulted in low bacterial mortality.

The high levels of B.globigii spores recorded in Combe Stream from the second sampling run onwards (HW+1 etc), indicate that the injection of the tracer spores was successful. The very small number of spores (20 per 100 ml) present in the stream prior to the commencement of injection is not considered significant. FIG [11] shows the relationship between the levels of B.Globigii in Combe Stream and those "expected" in the bathing waters of South sands from the salinity data collected. "Expected" levels were derived in a similar way to the "expected" faecal coliform levels used in FIG [10]. The strong positive correlation observed demonstrates that the tracer was behaving in a conservative manner.

FIG [12] shows the change in faecal coliform concentrations with respect to salinity. A trend of increasing numbers of faecal coliforms with decreasing salinity (i.e. increased influence of Combe Stream) is clearly evident. A decrease in salinity of 10 p.s.u. (35 to 25 p.s.u.) results in a minimum 6 fold increase in faecal coliforms (Log 2.4 to Log 3.2).

FIG [13] shows another "actual" versus "expected" relationship, this time for faecal coliforms observed during the 12 hour TWIU survey of 11-12-92. The correlation between faecal coliform concentrations in Combe Stream and those to be "expected" in the associated bathing waters is poorer than might have been expected from the evidence provided up to now. However, in FIG [13], no account has been taken of the background levels of faecal coliforms expected to be present in seawater, i.e. it has been assumed that no faecal coliforms were present in the waters off South Sands other than those derived from Combe Stream. Despite the above assumption being flawed, in two out of the four samples exhibiting faecal coliform concentrations in excess of the EC mandatory limit, dilution of freshwater from Combe Stream combined with bacterial mortality account for the values observed.

Having established the significance of faecal coliform inputs from Combe Stream, FIGS [14] to [26] inclusive examine the distribution of faecal coliforms, the B.globigii tracer and salinity across the face of South Sands beach throughout the tidal cycle.

FIG [14] represents the distribution of faecal coliforms across South Sands at HW, prior to the injection of the B.Globigii tracer to Combe Stream. A significant peak in faecal coliform concentrations is evident at the point of minimum salinity where Combe Stream meets the sea. FIG [15] demonstrates that at HW+1, approximately 45 minutes after the commencement of the B.Globigii injection, high levels of B.Globigii are present across one third of the beach. Since Combe Stream entered the sea on the southern extremity of South Sands beach, the above shows that freshwater derived from the stream is mixed across the face of the beach rapidly. As FIG [16] shows, by HW+2, less than two hours after the initial injection of the tracer, water originating in Combe Stream has spread right across the beach. The "response time" of South Sands beach to the influence of Combe Stream is therefore less than two hours. It is also evident from FIGS [14] to [26] that the B.Globigii distribution correlates well with the faecal coliform distribution throughout the tidal cycle. This confirms that faecal coliform concentrations in Combe Stream directly influence faecal coliform concentrations in the saline waters across the entire beach.

The single flood tide dye release carried out by the TWIU in the vicinity of the South Sands crude outfall (see FIG [3]) indicated that some effluent travelled in a northwesterly direction towards the beaches of North and South Sands. This outfall would thus appear to have a more substantial impact on the bathing water quality off South Sands on the flood rather than the ebb tide, contradicting to some extent the comments made in the discussion of NRA routine data. However no EC bacterial limit exceedances have historically been observed on the flood tide, suggesting that the direct impact of effluent from South Sands crude outfall on South Sands beach is relatively small. This confirms the importance of Combe stream as a source of faecal coliforms to the bathing water.

Finally, several points not directly related to the data collected are worthy of note. Firstly, the South Sands crude sewage outfall, which runs directly across the southern extreme of South Sands beach, together with connections into the outfall are in a very poor state of repair (see attached photographs in APPENDIX [1]). Due to the time of year of the survey (December), and the small population of the area as a result, no flow was evident down the pipe. However, in mid summer, when a considerable flow is inevitable, crude sewage will leak directly on to South Sands beach.

A second point connected with the above concerns crude sewage overflowing from drains only metres upstream of the beach. A conversation with a local Hotelier during the TWIU survey confirmed that on occasions the South Sands crude outfall becomes blocked. As a result of back-pressure, crude sewage spills from man-holes into a car park situated next to Combe Stream only 10 m upstream of South sands beach. Evidence of such incidents is confirmed in various reports on the NRA Pollution Incidents Logging System (PILS), although none coincide with routine beach samples. However, both the design and physical state of the South sands crude outfall appear to be unsatisfactory and as such, the outfall must be considered a potential cause of bacterial non-compliance in the bathing waters off South Sands.

4.3 TWIU DATA, 6-2-92 INVESTIGATION

The data collected by TWIU staff on 6-2-92, shown in TABLE [3], indicate once again that faecal coliform concentrations in Combe Stream as it flows across South Sands beach are consistently greater than 2000 per 100 ml. The mean faecal coliform concentration on this occasion was 4383 per 100ml (n=12).

FIG [27] examines changes in faecal coliform concentrations with time for all six of the NRA sampling sites in Combe Stream on the above date. It is immediately evident that the effluent from Malborough STW, which is discharged to Combe Stream approximately 2.2 km upstream of South Sands beach (just upstream of SITE 4), is by far the largest source of faecal coliforms in the stream catchment. No major bacterial inputs are apparent from the catchment above the STW (SITE 5), while faecal coliform concentrations downstream of the works are for the most part consistent with those that might reasonably be expected from natural bacterial decay. On the one occasion (midday) when faecal coliform concentrations appear to increase with distance downstream - potentially indicating a major bacterial source other than the STW - it is also evident that the input from Malborough STW was reduced almost to zero. The apparent increase in faecal coliform concentrations downstream is thus likely to be due to those downstream samples picking up faecal coliform bacteria discharged from the STW several hours prior to the reduction in effluent flows around midday.

The data presented in FIG [27] also show a minor, but consistent, input of faecal coliforms to Combe Stream between SITE 1 and the beach. Concentrations of faecal coliforms recorded in Combe Stream as it flowed across the beach were equal to or exceeded those concentrations recorded in the stream at SITE 1 on every occasion other than at 12.00. Increases of up to 3800 faecal coliforms per 100 ml were observed between the above sampling points. The mean concentration of faecal coliforms at SITE 1 was 3200 per 100 ml (n=12) compared to a mean of 4383 per 100 ml in the stream on the beach. It was for this reason that the lower part of Combe Stream catchment was subjected to further investigation on 16-3-92.

In addition to the bacterial data in TABLE [3], B.globigii spore results are also presented following a spot injection of the spores at SITE 4 at 11.00. These data, plotted in FIG [28], clearly demonstrate that the "time of travel" of effluent from Malborough STW to South Sands beach is of the order of 4 hrs. The "times of travel" of effluent from the STW to SITES 2 and 1 are approximately 2 and 3 hours respectively (the single anomalous result of 300 spores per 100 ml at the beach site at 11.00 is known to have been caused by cross contamination by the sampler).

Knowing "times of travel" of effluent from the STW to various sites downstream it is possible to estimate the rate of bacterial decay in Combe Stream on the day of sampling. FIG [29] shows bacterial concentrations plotted on a logarithmic scale versus distance upstream. Such distances can now be directly equated to time using the "times of travel" derived above. By convention, the rate of decay of a bacterial population is described by its T_{90}, i.e. the time taken for numbers to be reduced by 90%. On a logarithmic scale T_{90} may be defined as the time taken for a Log 1 reduction in numbers to occur. Excluding the data from samples collected at 10.00, FIG [29] displays a linear reduction in faecal coliform concentrations between SITE 4 and SITE 1 that approximates well to a Log 1 reduction in numbers (values fall from about Log 4.7 per 100 ml to Log 3.7 per 100 ml over this distance). The "time of travel" of effluent between SITES 4 and 1 thus represent a reasonable estimate of T_{90} - 3 hours in this case.

However, a T_{90} value of 3 hours for Combe Stream is considered very small for a freshwater environment, especially on a day when air temperatures were low (<10°C) and complete cloud cover was observed. It thus seems likely that some form of active removal of faecal coliforms from South sands stream was occurring in addition to natural die-off. Such processes are as yet unquantifiable, but include predation by other micro-organisms such as Rotifers together with adsorption of faecal coliforms onto suspended solids. It is difficult to extrapolate when such processes are so poorly quantified, but should the rate of such removal processes be significantly reduced, faecal coliform concentrations in the lower part of Combe stream would increase substantially. A doubling in the apparent T_{90} time on 6-2-92 from 3 to 6 hours would have resulted in faecal coliform concentrations approaching 16000 per 100 ml in Combe Stream on South Sands beach rather than the 5000 per 100 ml observed.

In order to take account of the "time of travel" of effluent downstream from Malborough STW, the data presented in TABLE [4] has been shifted by an appropriate amount in time according to the B.Globigii results presented in TABLE [3]. The resulting "time-shifted" faecal coliform results are plotted against distance upstream in FIG [30] for SITES 4 to South Sands beach. A small faecal coliform input between SITE 1 and the beach, as identified in FIG [27], is again apparent. A further possible faecal coliform input between SITES 3 and 2 is also evident at 11.00 and 12.00. This may be the result of low flows from the STW as discussed above or it may indicate a "real" faecal coliform input from the tributary entering Combe Stream just downstream of Combe itself.

FIG [31] shows the ratio of faecal coliforms to faecal Streptococci observed on 6-2-92 at SITE 4 just downstream of Malborough STW and on South Sands beach. While no firm conclusions can be drawn from the intersite variations observed - due to the differential die-off rates experienced by faecal coliforms and faecal Streptococci during their passage down the stream - the faecal coliform/faecal streptococci ratio remains greater than or equal to 2:1 at all times. This discounts the possibility of the presence of large amounts of animal faeces for which the equivalent ratio is considered to be less than or equal to 0.8:1. It therefore appears unlikely that any major agricultural inputs are impacting on bacterial levels in Combe Stream during winter months, although during the summer cattle are known to be kept in fields immediately adjacent to the stream.

4.4 TWIU DATA, 16-3-92 INVESTIGATION OF THE LOWER COMBE CATCHMENT

The data previously presented in FIG [27] indicate a small but persistent faecal coliform input to Combe Stream between the car park at the lower end of the catchment and South Sands beach. The data presented in TABLE [5] and in FIG [32] represent the bacterial results derived from a single set of spot samples taken on 16-3-92 in order to further investigate the source of this input.

Immediately evident from FIG [32] is the fact that the duck pond contains elevated concentrations of faecal coliforms with respect to Combe Stream. Since the water from the pond runs back into Combe Stream at two points at a rate approximating to 25% of the total stream flow (mostly over a weir at SITE F and a small amount through a sluice gate at SITE D) it appears that the duck pond provides the continuous source of faecal coliforms to Combe stream that was observed during the investigation of 6-2-92. Large quantities of duck faeces were evident around the perimeter of the pond on all occasions that TWIU staff visited the area.

FIG [32] also indicates that the tributary flowing into Combe Stream just downstream of Southern Mill does, at least on some occasions, contribute to the faecal coliform loading of the stream. This conclusion is drawn from the rise in faecal coliform concentrations observed on 16-3-92 between SITES A and B, after noting that no flow was evident from the toilet storage tank discharge within the caravan park. During summer months it is likely that the above storage tank discharge will provide another source of faecal coliforms to Combe Stream since SWWSL have confirmed that at present it is not connected to the public sewerage system.

FIG [32] also shows that faecal coliform concentrations upstream of Southern Mill were relatively low at 11.27 on 16-3-92 - only 2400 faecal coliforms per 100 ml were present. This indicates one of two things; either the flow from Malborough STW was low at that time of day or greater bacterial reduction was occurring upstream of this site. In either case, the impact of effluent from Malborough STW on bacterial levels on South Sands beach on 16-3-92 was less than during the previous investigation of 6-2-92.

4.5 SWWSL DATA

The data listed in TABLE [6] represent the results of three sets of spot samples obtained by SWWSL staff from South Sands stream and beach during August 1990. As such it represents the only non-routine data provided in this report representative of summer flow and population conditions. Although this is useful in some respects it makes direct comparison with data collected by NRA staff during winter months difficult.

A further problem with the data listed in TABLE [6] is the large number of "greater than" results presented, particularly for the site immediately downstream of Malborough STW. It is thus impossible to compare the loading from the STW under summer conditions with that observed by TWIU staff during the winter.

Despite the above problems, it is evident from the SWWSL data that faecal coliform concentrations at Combe bridge (NRA SITE 2) are of the same order of magnitude as those observed during all three NRA investigations. The SWWSL site described simply as "South Sands Stream" is assumed to lie within Combe Stream as it flows on to South Sands beach - if this is the case, once again faecal coliform concentrations exceed 2000 per 100 ml on every occasion. Despite this, faecal coliform concentrations in the bathing waters off South Sands remained below the EC mandatory limit at all times. However, it is not known where in relation to the mouth of the stream such samples were taken, neither were the salinity of the samples measured.

The other major point evident from the SWWSL data concerns the presence of a consistent source of faecal coliforms to Combe Stream between Combe bridge and the beach - increases of up to an order of magnitude in faecal coliform concentrations are evident from the data. While it is probable that the faecal coliform input from the duck pond discussed earlier is partially responsible for the above, the magnitude of the above input suggests that a further faecal coliform source is contributing. The most likely explanation for the above is that during the summer months the caravan park discussed earlier is populated, and as result the toilet storage tank regularly discharges to Combe Stream. Once again agricultural sources are not thought to be responsible due to the relatively high faecal coliform/faecal streptococci ratio observed (>4:1).

5. CONCLUSIONS

(1) Combe Stream is a major source of faecal coliforms to the bathing waters of South Sands beach under both winter and summer flow conditions. Since the four samples from the bathing water that exceeded the EC mandatory limit for faecal coliforms during the NRA investigation of 11-12-91 exhibited reduced salinity (suggesting a freshwater source) and flows down the adjacent crude outfalls were minimal, Combe Stream must be considered a potential cause of bacterial non-compliance at South Sands. Under summer flow conditions the relative importance of Combe Stream compared to other bacterial sources may be reduced.

(2) During NRA investigations Combe Stream ran across South Sands beach at the maximum possible distance from the ECB sampling line. However, it is likely that the course of the stream will alter over time, thus the stream could have a greater influence on faecal coliform concentrations at the E.C. Bathing Water sampling line at some point in the future.

(3) Sources of bacteria other than Combe Stream, although not identified specifically, have some influence over faecal coliform concentrations in the bathing waters off South Sands beach. Such an influence is more evident on the flood than the ebb tide.

(4) Under summer flow and population conditions, South Sands crude sewage outfall is also a potential cause of EC mandatory limit exceedance for faecal coliforms in the bathing waters of South Sands. The risk of limit exceedance in this case may currently arise more directly from the poor design and maintenance of the outfall than from any direct impact of the effluent from the designed point of discharge.

(5) Under winter flow and meteorological conditions Malborough STW is the dominant source of faecal coliforms to Combe Stream. Despite this the combined effects of bacterial die-off, predation and the travel time of effluent from the STW to the beach (c.4 hours) result in residual faecal coliform concentrations of the order only of 10^3 per 100 ml. However, the T_{90} associated with such concentrations arriving at the beach is small (c.3 hours), thus only a small reductions in bacterial decay can result in significantly greater residual faecal coliform concentrations.

(6) Water derived from Combe Stream influences faecal coliform concentrations across South Sands beach within 2 hours of entering the sea. Effluent from Malborough STW thus influences the whole of South Sands bathing water within 6 hours of discharge. This period is likely to be substantially reduced under storm conditions when effluent will travel downstream more rapidly.

(7) Sources of faecal coliforms to Combe Stream other than Malborough STW are important at times, particularly under summer population conditions. The duck pond just upstream of South sands beach appears to provide a consistent input of faecal coliforms to Combe Stream all year round, while the unconsented toilet storage tank discharge

situated in the caravan park further upstream may provide a more substantial source of faecal coliforms during summer months.

(8) Agricultural bacterial inputs were not identified as significant during NRA investigations.

6. RECOMMENDATIONS

(1) Once planned improvements to the public sewerage system have been completed, the water quality of Combe stream should be monitored and further investigations into potential sources of contamination carried out under summer population conditions should routine bathing water quality monitoring show this to be necessary.

ACTION: NRA Tidal Waters Officer.

(2) Occasional inspections of the state of repair of the crude sewage outfalls in the vicinity of South Sands beach should be undertaken-particularly for South Sands crude outfall itself. This is considered necessary as an interim measure to avoid potential bacterial non-compliance prior to the implementation of SWWSL's capital improvement scheme.

ACTION: NRA Pollution Controller.

(3) Malborough STW should be included in SWWSL's proposed Salcombe Sewerage Improvement Scheme to remove the dominant bacterial loading to Combe stream. Careful consideration should also be given to the retention of storm flows at Malborough STW bearing in mind that under storm conditions effluent may impact on South Sands bathing waters within only 2 to 3 hours of discharge.

ACTION: NRA Tidal Waters Officer, NRA Quality Regulation Officer.

(4) Approaches should be made to the owners of the caravan park regarding the connection of their toilets to the main sewerage system. This is particularly relevant in the light of planned improvements to be made by SWWSL in the area.

ACTION: NRA Pollution Controller.

7. REFERENCES

(1) BABBEDGE, N.: 1991: Routine Beach Sampling Salinity Data. TWIU Technical Note no. 91/010.

(2) WIMPOL Ltd.: 1990: Environmental Survey of the Kingsbridge Estuary and Thurlestone Coastal Region. Volume I.

8. TABLES

TABLE [1]: Sampling History For SALCOMBE SOUTH SANDS BEACH (ECB0330) & COMBE STREAM (ECBR0330)

Date	Time (local)	HW (local)	wrt HW	Sal.	Adj. Sal.	Beach Bacteria Data						Combe Stream Bacti Data						*****Rainfall (mm/day)***** Kingsbridge (RF365789)			Hours of Sunshine	Cloud Cover	Wind Dir.	Wind Dir. Octal	Wind spd (BS)
						T.coli	E.coli	F.Strep	Log (TC)	Log (EC)	Log (FS)	T.coli	E.coli	F.Strep	Log (TC)	Log (EC)	Log (FS)	Day-2	Day-1	Day					
13/05/86	9.33	9.09	0	30.93	30.88	540	280		2.7324	2.4472								0.0	0.2	0.0	9.3	7	225	6	3
03/06/86	9.00	3.28	6	34.33	34.35	530	172		2.7243	2.2355								0.0	0.0	0.1	2.5	8	315	8	4
10/06/86	9.00	8.29	1	33.60	34.10	2200	960		3.3424	2.9823								0.0	22.9	2.3	9.5	3	315	8	4
24/06/86	9.13	8.44	0	28.52	29.50	> 30000	14000		4.4771	4.1461								0.0	12.7	0.4	0.2	8	135	4	2
08/07/86	8.50	7.40	1	33.92	34.34	1650	550		3.2175	2.7404								0.0	0.0	0.0	5.4	6	270	7	3
22/07/86	8.40	7.44	1	33.60	34.18	770	530		2.8865	2.7243								0.0	0.0	0.0	7.1	6	315	8	0
05/08/86	9.10	6.41	2	32.79	33.12	7800	3400		3.8921	3.5315								4.4	2.9	0.3	5.1	5	45	2	0
19/08/86	8.30	6.41	2	33.76	34.34	590	177		2.7709	2.248								2.8	10.9	0.0	6.0	1	45	2	1
02/09/86	8.35	5.33	3	28.13	27.82	2650	850		3.4232	2.9294								0.0	0.1	3.1	6.2	8	315	8	4
16/09/86	9.25	5.37	4	26.85	26.74	4500	3000		3.6532	3.4771								6.3	10.2	0.0	4.0	7	315	8	4
30/09/86	9.10	3.58	5	33.68	33.70	2600	560		3.415	2.7482								0.0	0.0	0.6	0.4	8	45	2	4
14/10/86	9.20	4.23	5	35.22	34.43	1610	420		3.2068	2.6232								0.0	0.0	0.1	0.0	8			1
19/05/87	9.20	11.25	-2	29.48	29.85	890	440	15	2.9494	2.6435	1.1761	8900	4600		3.9494	3.6628		1.2	0.0	0.0		1			4
02/06/87	9.05	10.01	-1	31.65	32.12	1470	650	31	3.1673	2.8129	1.4914	28000	10500		4.4472	4.0212		0.0	1.8	13.7		8	180	5	3
16/06/87	8.30	10.35	-2	33.76	33.78	700	310	26	2.8451	2.4914	1.415	21000	6100		4.3222	3.7853		0.0	1.7	1.2		7			2
30/06/87	9.35	9.15	0	33.84	33.94	340	168	32	2.5315	2.2253	1.5051	31000	9600		4.4914	3.9823		1.7	0.0	0.0		4	225	6	4
15/07/87	14.25	10.02	4	33.52	34.33	4800	1910	240	3.6812	3.281	2.3802	65000	25700		4.8129	4.4099		3.6	3.6	6.7		8	225	6	6
21/07/87	9.15	15.14	-6	33.35	34.41	690	550	42	2.8388	2.7404	1.6232	12000	4300		4.0792	3.6335		2.8	0.6	0.0		8	315	8	0
04/08/87	10.00	12.37	-3	32.87	33.67	190	108	17	2.2788	2.0334	1.2304	23000	5600		4.3617	3.7482		2.7	0.0	0.0		1	180	5	2
18/08/87	9.30	13.07	-4	34.00	34.66	510	220	15	2.7076	2.3424	1.1761	18000	8900		4.2553	3.9494		0.0	0.0	0.9		5	225	6	4
01/09/87	8.45	10.47	-2	33.35	34.25	1410	570	41	3.1492	2.7559	1.6128	38000	3900		4.5798	3.5911		0.0	1.6	0.0		8			0
15/09/87	9.00	11.08	-2	32.38	33.17	1050	890	74	3.0212	2.9494	1.8692	6000	4300		3.7782	3.6335		0.5	0.6	1.3		6			0
29/09/87	8.55	9.46	-1	33.03	33.75	510	320	53	2.7076	2.5051	1.7243	5200	3700		3.716	3.5682		0.0	0.0	0.0		2	135	4	2
13/10/87	9.10	9.55	-1	33.92	35.00	670	350	34	2.8261	2.5441	1.5315	13700	8500		4.1367	3.9294		2.6	0.7	1.2		1	225	6	6
06/05/88	14.00	9.34	4	27.01	27.60	124	32	3	2.0934	1.5051	0.4771	15000	3200		4.1761	3.5051		0.0	0.0	0.0		1	45	2	2
26/05/88	11.50	14.32	-3	32.95	33.12	150	81	>300	2.1761	1.9085		11000	3500	>3000	4.0414	3.5441		3.2	7.9	0.0	7.4	7	135	4	1
08/06/88	14.20	13.15	1	30.85	30.60	350	108	7	2.5441	2.0334	0.8451	20000	2300	260	4.301	3.3617	2.415	4.1	1.4	0.0	2.2	6	135	4	2
12/06/88	10.40	4.56	6	28.92	30.13	230	67	3	2.3617	1.8261	0.4771	7600	1630	80	3.8808	3.2122	1.9031	0.0	0.0	0.0	7.7	2	225	6	4
21/06/88	11.50	10.45	1	34.49	34.43	170	70	7	2.2304	1.8451	0.8451	26000	7200	260	4.415	3.8573	2.415	0.0	0.0	0.0	6.5	7	315	8	1
10/07/88	8.45	12.41	-4	33.35	34.82	1560	860	63	3.1931	2.9345	1.7993	21000	4600	2100	4.3222	3.6628	3.3222	0.0	3.8	10.4	0.0	8	135	4	2
12/07/88	14.30	17.58	-3	34.00	34.42	390	158	32	2.5911	2.1987	1.5051	18000	3300	360	4.2553	3.5185	2.5563	10.4	0.0	0.0		6	135	4	3
27/07/88	11.45	17.36	-6	31.98	32.00	3500	1440	290	3.5441	3.1584	2.4624	77000	10900	740	4.8865	4.0374	2.8692	0.0	0.0	17.9	11.2	2	45	2	3
03/08/88	10.45	10.36	0	30.77	30.79	1200	450	23	3.0792	2.6532	1.3617	17000	4500	330	4.2304	3.6532	2.5185	0.0	0.0	0.0	11.2	2	270	7	2
07/08/88	14.50	14.11	1	32.22	33.56	770	360	46	2.8865	2.5563	1.6628	52000	9600	890	4.716	3.9823	2.9494	0.0	0.0	0.0	11.2	1	45	2	2
16/08/88	12.35	8.56	4	33.11	33.28	280	96	25	2.4472	1.9823	1.3979	28000	2250	680	4.4472	3.3522	2.8325	2.0	0.0	0.0	12.0	2	135	4	1
22/08/88	12.00	12.47	-1	32.87	33.20	410	116	23	2.6128	2.0645	1.3617	24000	7900	1350	4.3802	3.8976	3.1303	0.0	0.0	1.0	2.6	8	225	6	1
04/09/88	9.15	12.28	-3	31.98	32.84	600	150	30	2.7782	2.1761	1.4771	4800	1910	340	3.6812	3.281	2.5315	2.0	0.0	1.2	10.3	7	135	4	2
05/09/88	10.30	13.42	-3	34.33	34.76	260	105	20	2.415	2.0212	1.301	4500	2900	570	3.6532	3.4624	2.7559	0.0	1.2	0.0	6.8	4	315	8	3
09/09/88	12.10	18.11	-6	35.22	35.00	380	320	24	2.5798	2.5051	1.3802	27000	4600	1340	4.4314	3.6628	3.1271	0.0	0.0	0.0	11.4	1	270	7	3
14/09/88	11.55	8.29	3	32.71	32.28	1090	530	83	3.0374	2.7243	1.9191	10900	5600	780	4.0374	3.7482	2.8921	0.0	0.2	0.0	9.6	3	45	2	3
27/09/88	14.00	20.12	-6	34.65	34.35	4700	2100	>300	3.6721	3.3222		>300000	227000	35500		5.356	4.5502	1.8	14.1	16.8	0.9	8	225	6	3
10/10/88	12.15	6.35	6	34.82	34.76	10600	5700	242	4.0253	3.7559	2.3838	33000	7300	580	4.5185	3.8633	2.7634	39.9	1.7	1.5	7.3	3	225	6	2
13/10/88	8.35	8.03	1	34.49	34.51	360	220	34	2.5563	2.3424	1.5315							26.2	0.1	0.1	4.5	2	270	7	1
20/10/88	11.05	13.46	-3	32.30	33.49	1010	300	31	3.0043	2.4771	1.4914							1.0	0.0	0.0	7.0	1	0	1	4

TABLE [1]: Sampling History For SALCOMBE SOUTH SANDS BEACH (ECB0330) & COMBE STREAM (ECBR0330)

Date	Time (local)	HW (local)	wrt HW	Sal.	Adj. Sal.	Beach Bacteria Data						Combe Stream Bacti Data						*****Rainfall (mm/day)***** Kingsbridge (RF365789)			Hours of Sunshine	Cloud Cover	Wind Dir.	Wind Dir. Octal	Wind spd (BS)
						T.coli	E.coli	F.Strep	Log (TC)	Log (EC)	Log (FS)	T.coli	E.coli	F.Strep	Log (TC)	Log (EC)	Log (FS)	Day-2	Day-1	Day					
05/05/89	12.35	19.03	-6	25.12	25.37	6200	1570	>300	3.7924	3.1959		47000	13800	>300	4.6721	4.1399		0.0	0.0	0.0	12.4	1	270	7	4
11/05/89	14.00	11.01	3	30.05	30.07	1650	860	400	3.2175	2.9345	2.6021	16000	5700	980	4.2041	3.7559	2.9912	0.0	0.0	4.0	3.5	4	315	8	4
19/05/89	11.00	5.50	5	26.38	29.96	1500	480	108	3.1761	2.6812	2.0334	164000	4900	900	5.2148	3.6902	2.9542	0.0	0.0	0.0	13.7	1			5
30/05/89	13.15	14.24	-1	29.89	30.77	900	340	400	2.9542	2.5315	2.6021	32000	7300	360	4.5051	3.8633	2.5563	0.0	0.0	0.0	0.0	8	135	4	1
05/06/89	11.35	7.58	4	34.57	35.00	10	8	2	1	0.9031	0.301	44000	23000	1490	4.6435	4.3617	3.1732	1.3	1.9	0.5	3.1	7	270	7	4
14/06/89	9.55	14.38	-5	33.19	32.09	450	370	58	2.6532	2.5682	1.7634	33000	10900	790	4.5185	4.0374	2.8976	4.9	0.0	0.0	13.7	4			0
22/06/89	12.45	8.57	4	30.61	31.06	1270	1260	103	3.1038	3.1004	2.0128	61000	43000	3300	4.7853	4.6335	3.5185	0.0	0.0	0.0	14.1	1	90	3	3
30/06/89	10.00	16.13	-6	34.25	34.76	40	21	3	1.6021	1.3222	0.4771	14000	7100	650	4.1461	3.8513	2.8129	1.6	0.0	1.7	7.7	6	45	2	2
10/07/89	10.10	11.00	-1	30.45	30.90	3800	740	139	3.5798	2.8692	2.143	27000	8700	6200	4.4314	3.9395	3.7924	0.0	0.8	0.0	9.1	1	90	3	2
16/07/89	13.15	17.10	-4	33.19	34.25	92	104	13	1.9638	2.017	1.1139	6200	390	570	3.7924	2.5911	2.7559	0.0	0.0	0.0	15.1	1	90	3	1
24/07/89	9.50	10.34	-1	33.76	34.10	210	79	30	2.3222	1.8976	1.4771	25000	7200	1330	4.3979	3.8573	3.1239	0.0	0.0	0.0	13.6	1	45	2	2
01/08/89	12.05	10.21	2	30.33	34.59	140	41	23	2.1461	1.6128	1.3617	234000	17700	4700	5.3692	4.248	3.6721	0.0	0.6	0.0	13.7	2	0	1	3
16/08/89	9.50	6.21	3	31.50	35.00	410	240	10	2.6128	2.3802	1	65000	58000	5700	4.8129	4.7634	3.7559	14.8	0.0	0.0	10.5	5	225	6	3
24/08/89	11.05	11.55	-1	30.47	34.66	56	48	7	1.7482	1.6812	0.8451	20000	9700	1660	4.301	3.9868	3.2201	0.8	0.0	0.0	10.7	1	225	6	1
01/09/89	12.50	7.43	5	30.69	34.10	370	120	19	2.5682	2.0792	1.2788	18400	5300	700	4.2648	3.7243	2.8451	0.0	0.0	0.0	6.0	7	180	5	2
07/09/89	12.45	10.04	3	29.75	32.45	104	69	28	2.017	1.8388	1.4472	11700	6600	640	4.0682	3.8195	2.8062	0.0	0.0	0.0	6.0	1			1
15/09/89	9.35	6.44	3	29.24	35.00	430	210	61	2.6335	2.3222	1.7853	23600	6800	5000	4.3729	3.8325	3.699	1.6	34.3	3.7	6.0	8	225	6	1
21/09/89	11.20	10.42	1	27.71	32.84	1600	510	60	3.2041	2.7076	1.7782	7000	2400	1270	3.8451	3.3802	3.1038	0.0	0.0	0.3	6.0	3	225	6	1
04/10/89	9.35	8.46	1	26.06	29.93	1700	710	230	3.2304	2.8513	2.3617	5400	1760	830	3.7324	3.2455	2.9191	0.0	0.0	1.2	8.0	6	135	4	4
04/10/89	9.25	8.46	1									32000	4300		4.5051	3.6335		0.0	0.0	1.2					
12/10/89	8.55	4.18	5	29.67	34.41	480	170	48	2.6812	2.2304	1.6812	10900	6800	1880	4.0374	3.8325	3.2742	0.0	0.1	0.0	5.5	4	315	8	1
04/05/90	10.15	14.55	-5	28.00	34.11	190	60	5	2.2788	1.7782	0.699	11000	3200	1930	4.0414	3.5051	3.2856	0.0	0.0	0.0	13.5	1	90	3	4
14/05/90	11.15	9.17	2	25.05	29.91	2200	1000	48	3.3424	3	1.6812	45000	9200	400	4.6532	3.9638	2.6021	0.0	0.0	0.0	3.6	7	90	3	3
23/05/90	12.45	18.03	-5	26.27	32.00	41	58	30	1.6128	1.7634	1.4771	8800	3320	450	3.9445	3.5211	2.6532	0.0	0.0	0.0	13.9	3	90	3	2
30/05/90	12.57	11.03	2	24.91	29.10	3900	1890	66	3.5911	3.2765	1.8195	69000	19200	840	4.8388	4.2833	2.9243	0.0	12.6	4.1	0.0	8	90	3	3
02/06/90	13.15	13.50	-1	25.41	30.20	1230	940	53	3.0899	2.9731	1.7243	11600	2700	530	4.0645	3.4314	2.7243	0.0	0.4	1.4	1.8	4	315	8	4
11/06/90	10.15	8.39	2	29.31	34.66	110	41	8	2.0414	1.6128	0.9031	3300	1600	360	3.5185	3.2041	2.5563	0.0	0.0	0.1	1.9	8	315	8	1
20/06/90	12.45	16.23	-4	28.66	34.40	620	110	28	2.7924	2.0414	1.4472	108000	8600	810	5.0334	3.9345	2.9085	1.1	2.8	5.0	9.2	5	225	6	3
29/06/90	10.20	11.12	-1	31.09	33.61	620	430	112	2.7924	2.6335	2.0492	5200	1420	430	3.716	3.1523	2.6335	0.0	0.0	3.0	0.9	7	135	4	4
08/07/90	10.15	7.09	3	29.24	35.00	46	22	2	1.6628	1.3424	0.301	41000	4800	1600	4.6128	3.6812	3.2041	5.2	1.1	0.0	8.5	8	225	6	4
17/07/90	10.15	13.23	-3	27.93	34.03	290	98	46	2.4624	1.9912	1.6628	39000	15200	3200	4.5911	4.1818	3.5051	0.0	0.0	0.0	13.8	1	90	3	1
23/07/90	13.15	7.46	5	25.99	31.42	920	520	50	2.9638	2.716	1.699	38000	8200	1650	4.5798	3.9138	3.2175	0.0	0.0	0.0	12.3	2	90	3	4
26/07/90	13.30	9.39	4	25.63	31.22	240	72	49	2.3802	1.8573	1.6902	22000	3700	660	4.3424	3.5682	2.8195	0.0	0.0	4.4	10.9	2	135	4	4
04/08/90	10.25	5.06	5	25.63	32.28	490	310	53	2.6902	2.4914	1.7243	48000	38000	3480	4.6812	4.5798	3.5416	0.0	0.0	0.0	13.7	1			0
13/08/90	10.50	10.48	0	26.63	33.72	340	240	38	2.5315	2.3802	1.5798	12800	6200	940	4.1072	3.7924	2.9731	0.0	0.0	0.5	3.3	4			0
22/08/90	12.35	8.07	4	27.35	35.00	41	31	4	1.6128	1.4914	0.6021	16800	9400	928	4.2253	3.9731	2.9675	0.0	0.0	0.0	3.0	8	270	7	1
29/08/90	12.50	11.55	1	25.99	33.52	6300	3300	>300	3.7993	3.5185		>300000	436000	>3000		5.6395		0.3	0.0	10.7	3.1	8	45	2	3
03/09/90	13.25	18.06	-5	27.50	34.73	480	250	16	2.6812	2.3979	1.2041	17800	8600	560	4.2504	3.9345	2.7482	0.0	0.0	0.0	6.1	7	180	5	4
10/09/90	10.30	10.01	0	27.50	34.28	910	263	132	2.959	2.42	2.1206	49000	11500	460	4.6902	4.0607	2.6628	0.0	0.0	0.0	10.9	1	90	3	2
19/09/90	10.15	7.05	3	27.71	34.94	440	90	205	2.6435	1.9542	2.3118	4800	1600	1210	3.6812	3.2041	3.0828	0.0	2.4	0.0	7.7	4	270	7	4
28/09/90	10.55	12.32	-2	26.42	33.98	230	280	52	2.3617	2.4472	1.716	2300	1700	392	3.3617	3.2304	2.5933	0.0	0.0	0.6	8.7	2	135	4	1

TABLE (1): Sampling History For SALCOMBE SOUTH SANDS BEACH (ECB0330) & COMBE STREAM (ECBR0330)

Date	Time (local)	HW (local)	wrt HW	Sal.	Adj. Sal.	Beach Bacteria Data T.coli	E.coli	F.Strep	Log (TC)	Log (EC)	Log (FS)	Combe Stream Bacti Data T.coli	E.coli	F.Strep	Log (TC)	Log (EC)	Log (FS)	*****Rainfall (mm/day)***** Kingsbridge (RF365789) Day-2	Day-1	Day	Hours of Sunshine	Cloud Cover	Wind Dir.	Wind Dir. Octal	Wind spd (BS)
07/05/91	13.40	12.05	2	32.70	32.70	30	10	<10	1.4771	1		6900	2700	540	3.8388	3.4314	2.7324	31.4	0.0	0.0	3.0	6	0	1	2
14/05/91	13.50	18.18	-4	25.60	25.60	130	40	<10	2.1139	1.6021		7200	4100	2400	3.8573	3.6128	3.3802				9.0	2	90	3	4
23/05/91	13.45	14.45	-1	34.00	34.00	100	20	10	2	1.301	1	21000	4500	760	4.3222	3.6532	2.8808	0.0	0.0	0.0	7.9	7			0
02/06/91	10.45	8.26	2	33.70	33.70	110	50	<10	2.0414	1.699		37000	4600	410	4.5682	3.6628	2.6128	0.0	0.0	0.1	8.3	6	0	1	1
06/06/91	10.40	12.30	-2	33.70	33.70	200	40	10	2.301	1.6021	1	49000	5200	1200	4.6902	3.716	3.0792	2.8	9.5	5.4	5.8	4	225	6	2
11/06/91	11.20	5.35	6	34.20	34.20	1800	1800	300	3.2553	3.2553	2.4771	26000	2900	820	4.415	3.4624	2.9138	1.6	0.0	17.9	5.8	8	180	5	3
18/06/91	13.30	11.09	2	34.70	34.70	250	60	30	2.3979	1.7782	1.4771	18000	4900	540	4.2553	3.6902	2.7324	0.8	0.0	0.0	4.7	7	45	2	3
27/06/91	12.55	6.54	6	34.40	34.40	900	290	20	2.9542	2.4624	1.301	31000	12000	1000	4.4914	4.0792	3	4.6	11.0	0.0		6	225	6	3
04/07/91	10.35	10.54	0	26.50	26.50	1300	690	50	3.1139	2.8388	1.699	11000	8300	470	4.0414	3.9191	2.6721	0.5	0.0	0.0	10.3	7	90	3	4
13/07/91	10.20	8.02	2	34.40	34.40	600	330	50	2.7782	2.5185	1.699	52000	25000	2800	4.716	4.3979	3.4472	3.5	8.0	2.8		8	225	6	2
22/07/91	10.20	15.10	-5	32.90	32.90	1800	180	60	3.2553	2.2553	1.7782	100000	52000	2600	5	4.716	3.415	0.0	0.0	1.7		5	135	4	2
29/07/91	12.55	8.34	4	26.00	26.00	1400	770	210	3.1461	2.8865	2.3222	29000	6500	900	4.4624	3.8129	2.9542	0.0	0.0	2.8		6	135	4	3
02/08/91	13.10	10.25	3	34.90	34.90	10	10	<10	1	1		28000	10000	1900	4.4472	4	3.2788	0.3	0.0	1.6		6	270	7	1
07/08/91	10.40	16.24	-6	34.50	34.50	690	350	50	2.8388	2.5441	1.699	109000	11400	1900	5.0374	4.0569	3.2788	4.8	0.0	0.0		8	0	1	1
14/08/91	11.55	9.30	2	34.30	34.30	400	140	20	2.6021	2.1461	1.301	29000	11600	780	4.4624	4.0645	2.8921	0.0	0.1	0.0	0.1	6	270	7	2
23/08/91				35.00	35.00	4400	910	180	3.6435	2.959	2.2553	320000	101000	55000	5.5051	5.0043	4.7404	0.0	17.4	0.5	4.7	8	45	2	4
02/09/91	10.30	11.37	-1	34.50	34.50	340	110	50	2.5315	2.0414	1.699	14000	8000	2500	4.1461	3.9031	3.3979	0.0	3.6		3.0	8			0
11/09/91	13.30	14.35	-1	34.60	34.60	400	200	20	2.6021	2.301	1.301	40000	19000	4300	4.6021	4.2788	3.6335				0.2	7	135	4	2
18/09/91	13.15	13.46	-1	34.60	34.60	40	10	<10	1.6021	1		12000	3800	2200	4.0792	3.5798	3.3424					2	225	6	2
27/09/91	12.55	8.54	4	34.90	34.90	60	20	100	1.7782	1.301	2	16000	2800	1300	4.2041	3.4472	3.1139					3	225	6	2

TABLE [2]: SALCOMBE SOUTH SANDS: GLOBIGII & BACTERIAL INVESTIGATION

Date: 11th December 1991 HW: 08.20 & 20.40 hours

Run Time	Time wrt HW	Site	Site Description	Sampling Time	Distance from S. edge	T Coli	E Coli	F Streps	Glob /100ml
8.20	HW	3	South edge of beach	8.21	5	1800	550	180	<10
		6	South mid salinity	8.30	28	31000	31000	170	<10
		4	Minimum salinity	8.28	37	12000	12000	90	10
		5	North mid salinity	8.35	44	1800	1800	100	<10
		2	E.C.B. line	8.25	80	1300	1200	50	<10
		1	North edge of beach	8.20	115	730	340	30	<10
		7	Combe stream	8.32		89000	89000	290	20
9.20	HW + 1	3	South edge of beach	9.33	5	2400	1900	80	570000
		6	South mid salinity	9.25	28	2200	700	70	780000
		4	Minimum salinity	9.21	37	2000	1500	140	720000
		5	North mid salinity	9.30	44	2200	900	90	350000
		2	E.C.B. line	9.24	80	880	500	60	90
		1	North edge of beach	9.20	115	1300	500	90	<10
		7	Combe stream	9.35		4100	2300	280	2370000
10.20	HW + 2	3	South edge of beach	10.21	5	2400	1300	150	720000
		6	South mid salinity	10.25	15	1900	800	70	560000
		4	Minimum salinity	10.28	20	2100	800	20	69000
		5	North mid salinity	10.30	37	2900	1300	30	180000
		2	E.C.B. line	10.24	80	2900	1200	50	240000
		1	North edge of beach	10.20	145	2000	600	60	150000
		7	Combe stream	10.35		4600	3300	360	3040000
11.20	HW + 3	3	South edge of beach	11.25	5	1100	390	30	81000
		6	20m from South edge	11.26	20	2100	810	80	530000
		4	40m from South edge	11.21	40	2300	700	30	290000
		5	60m from South edge	11.23	60	2100	900	40	300000
		2	E.C.B. line	11.24	80	1700	1000	20	370000
		1	North edge of beach	11.20	145	1200	900	30	78000
		7	Combe stream	11.30		11000	3000	180	6880000
12.20	HW + 4	3	South edge of beach	12.25	5	1300	340	40	290000
		6	20m from South edge	12.23	20	2400	770	70	460000
		4	40m from South edge	12.21	40	1800	700	60	710000
		5	60m from South edge	12.28	60	1300	720	60	320000
		2	E.C.B. line	12.24	80	2000	510	70	360000
		1	North edge of beach	12.20	145	800	400	40	22000
		7	Combe stream	12.31		5000	4900	490	910000
13.20	HW + 5	3	South edge of beach	13.26	5	7300	1700	340	920000
		6	20m from South edge	13.27	20	1500	460	20	320000
		4	40m from South edge	13.21	40	1400	490	70	410000
		5	60m from South edge	13.27	60	4200	640	160	680000
		2	E.C.B. line	13.22	80	3300	520	80	300000
		1	North edge of beach	13.20	145	550	300	10	49000
		7	Combe stream	13.30		39000	7400	620	3060000

WEATHER: Freezing, dry and overcast.

Salinity (Lab)	Salinity (in situ)	F Water Fraction	Stream E.coli x FW fraction	Log actual E.Coli	Log expect E.Coli	Log Glob	Stream Glob x FW fraction	Log expected Glob
28.10	30.40	0.186	16510	2.7404	4.2178			
23.50	28.00	0.319	28377	4.4914	4.4530			
25.60	29.00	0.258	22959	4.0792	4.3610			
29.60	30.80	0.142	12641	3.2553	4.1018			
31.90	32.00	0.075	6707	3.0792	3.8265			
33.60	34.00	0.026	2322	2.5315	3.3658			
0.25				4.9494				
27.30	28.60	0.209	480	3.2788	2.6812	5.7559	494609	5.6943
24.40	29.80	0.293	673	2.8451	2.8282	5.8921	693826	5.8413
24.80	29.10	0.281	647	3.1761	2.8107	5.8573	666348	5.8237
28.80	30.40	0.165	380	2.9542	2.5798	5.5441	391565	5.5928
32.20	32.50	0.067	153	2.6990	2.1856	1.9542		
33.60	34.10	0.026	60	2.6990	1.7782	0		
0.24				3.3617		6.3747		
24.40	26.00	0.293	966	3.1139	2.9850	5.8573	889971	5.9494
29.10	29.80	0.157	517	2.9031	2.7131	5.7482	475826	5.6774
33.10	33.80	0.041	134	2.9031	2.1268	4.8388	123362	5.0912
32.50	33.00	0.058	191	3.1139	2.2817	5.2563	176232	5.2461
29.60	30.00	0.142	469	3.0792	2.6709	5.3802	431768	5.6353
32.00	32.50	0.072	239	2.7782	2.3786	5.1761	220290	5.3430
0.27				3.5185		6.4829		
33.30	33.20	0.035	104	2.5911	2.0185	4.9085	239304	5.3790
27.90	31.20	0.191	574	2.9085	2.7588	5.7243	1316174	6.1193
30.50	32.00	0.116	348	2.8451	2.5414	5.4624	797681	5.9018
30.40	31.00	0.119	357	2.9542	2.5521	5.4771	817623	5.9126
30.40	31.00	0.119	357	3.0000	2.5521	5.5682	817623	5.9126
31.80	32.50	0.078	235	2.9542	2.3707	4.8921	538435	5.7311
0.24				3.4771		6.8376		
33.00	32.10	0.043	213	2.5315	2.3285	5.4624	39565	4.5973
28.80	31.00	0.165	810	2.8865	2.9083	5.6628	150348	5.1771
28.20	31.50	0.183	895	2.8451	2.9517	5.8513	166174	5.2206
30.10	31.00	0.128	625	2.8573	2.7958	5.5051	116058	5.0647
30.70	31.20	0.110	540	2.7076	2.7322	5.5563	100232	5.0010
33.40	34.10	0.032	156	2.6021	2.1938	4.3424	29014	4.4626
0.25				3.6902		5.9590		
26.60	29.70	0.229	1694	3.2304	3.2290	5.9638	700696	5.8455
30.80	31.80	0.107	794	2.6628	2.8996	5.5051	328174	5.5161
30.10	31.30	0.128	944	2.6902	2.9749	5.6128	390261	5.5914
29.80	30.50	0.136	1008	2.8062	3.0035	5.8325	416870	5.6200
31.00	31.00	0.101	751	2.7160	2.8755	5.4771	310435	5.4920
33.80	34.40	0.020	150	2.4771	2.1765	4.6902	62087	4.7930
0.27				3.8692		6.4857		

TABLE (2): SALCOMBE SOUTH SANDS: GLOBIGII & BACTERIAL INVESTIGATION

Date: 11th December 1991 HW: 08.20 & 20.40 hours WEATHER: Freezing,

Run Time	Time wrt HW	Site	Site Description	Sampling Time	Distance from S. edge	T Coli	E Coli	F Streps	Glob /100ml	Salinity (Lab)	Salinity (in situ)	F Water Fractio
14.20	HW + 6	3	South edge of beach	14.26	5	2900	1400	200	600000	29.00	31.20	0.159
		6	20m from South edge	14.22	20	3900	740	150	510000	29.00	30.20	0.159
		4	40m from South edge	14.21	40	4500	2000	150	680000	27.50	31.00	0.203
		5	60m from South edge	14.27	60	4500	630	100	340000	30.30	30.00	0.122
		2	E.C.B. line	14.22	80	2900	1500	140	520000	28.70	29.00	0.168
		1	North edge of beach	14.20	145	2300	590	50	270000	31.90	32.00	0.075
		7	Combe stream	14.30		24000	5200	760	2810000	0.26		
15.20	-5hr 20	3	South edge of beach	15.26	5	2900	1400	180	940000	26.60	27.80	0.229
		6	20m from South edge	15.25	20	3300	1300	370	1530000	23.90	28.70	0.307
		4	40m from South edge	15.21	40	3300	1700	210	1260000	26.40	29.00	0.235
		5	60m from South edge	15.24	60	3000	1500	190	1050000	26.70	25.00	0.226
		2	E.C.B. line	15.22	80	2600	870	310	780000	28.60	28.00	0.171
		1	North edge of beach	15.20	145	1600	530	80	98000	32.50	33.00	0.058
		7	Combe stream	15.30		21000	7000	720	2530000	0.26		
16.20	-4hr 20	3	South edge of beach	16.20	5	1400	600	100	330000	32.30	33.80	0.064
		6	20m from South edge	16.23	20	1400	700	150	340000	30.50	30.10	0.116
		4	40m from South edge	16.20	40	2900	980	130	420000	30.00	30.80	0.130
		5	60m from South edge	16.25	60	2500	800	210	500000	29.30	31.00	0.151
		2	E.C.B. line	16.22	80	3600	790	120	310000	30.60	31.00	0.113
		1	North edge of beach	16.21	145	6000	3900	600	107000	32.30	33.60	0.064
		7	Combe stream	16.26		15000	5400	540	3480000	0.25		
17.20	-3hr 20	3	South edge of beach	17.23	5	2900	1700	280	640000	28.80	31.00	0.165
		6	20m from South edge	17.25	20	1800	870	140	196000	32.20	33.90	0.067
		4	40m from South edge	17.22	40	1400	640	130	36000	33.10	34.00	0.041
		5	60m from South edge	17.24	60	1700	770	170	340000	31.60	31.60	0.084
		2	E.C.B. line	17.21	80	1800	740	80	170000	32.30	32.40	0.064
		1	North edge of beach	17.20	145	2600	900	260	31000	34.20	34.60	0.009
		7	Combe stream	17.26		11000	5100	600	2860000	0.25		
18.20	-2hr 20	3	South edge of beach	18.24	5	1900	600	120	176000	32.30	30.90	0.064
		6	20m from South edge	18.22	20	900	770	150	220000	31.30	32.00	0.093
		4	40m from South edge	18.20	40	1000	690	150	160000	32.50	31.10	0.058
		5	60m from South edge	18.21	60	1300	540	150	151000	32.70	33.20	0.052
		2	E.C.B. line	18.23	80	1100	550	110	230000	33.40	36.00	0.032
		1	North edge of beach	18.25	145	3100	1100	360	88000	33.50	34.00	0.029
		7	Combe stream	18.27		6300	3000	450	2560000	0.25		
19.20	-1hr 20	3	South edge of beach	19.22	5	810	810	280	680000	26.70	27.90	0.226
		6	20m from South edge	19.25	20	620	430	90	63000	33.80	34.20	0.020
		4	40m from South edge	19.23	40	1300	1300	160	330000	31.00	33.85	0.101
		5	60m from South edge	19.24	60	2100	720	130	400000	30.30	31.00	0.122
		2	E.C.B. line	19.21	80	1600	700	160	194000	32.20	32.30	0.067
		1	North edge of beach	19.20	145	2900	2500	520	153000	32.10	32.80	0.070
		7	Combe stream	19.26		6400	4200	50	2640000	0.25		
20.20	-0hr 20	3	South edge of beach	20.22	5	1700	730	220	470000	29.00	29.40	0.159

dry and overcast.

Stream E.coli x FW fraction	Log actual E.Coli	Log expect E.Coli	Log Glob	Stream Glob x FW fraction	Log expected Glob
829	3.1461	2.9185	5.7782	447971	5.6512
829	2.8692	2.9185	5.7076	447971	5.6512
1055	3.3010	3.0233	5.8325	570145	5.7560
633	2.7993	2.8014	5.5315	342087	5.5341
874	3.1761	2.9416	5.7160	472406	5.6743
392	2.7709	2.5932	5.4314	211768	5.3259
	3.7160		6.4487		
1603	3.1461	3.2049	5.9731	579333	5.7629
2151	3.1139	3.3326	6.1847	777333	5.8906
1643	3.2304	3.2158	6.1004	594000	5.7738
1583	3.1761	3.1994	6.0212	572000	5.7574
1197	2.9395	3.0781	5.8921	432667	5.6362
406	2.7243	2.6083	4.9912	146667	5.1663
	3.8451		6.4031		
344	2.7782	2.5370	5.5185	221913	5.3462
626	2.8451	2.7966	5.5315	403478	5.6058
704	2.9912	2.8478	5.6232	453913	5.6570
814	2.9031	2.9106	5.6990	524522	5.7198
610	2.8976	2.7856	5.4914	393391	5.5948
344	3.5911	2.5370	5.0294	221913	5.3462
	3.7324		6.5416		
843	3.2304	2.9256	5.8062	472522	5.6744
340	2.9395	2.5315	5.2923	190667	5.2803
207	2.8062	2.3159	4.5563	116058	5.0647
429	2.8865	2.6321	5.5315	240406	5.3809
325	2.8692	2.5122	5.2304	182377	5.2610
44	2.9542	1.6469	4.4914	24870	4.3957
	3.7076		6.4564		
191	2.7782	2.2817	5.2455	163246	5.2128
278	2.8865	2.4445	5.3424	237449	5.3756
174	2.8388	2.2403	5.2041	148406	5.1715
157	2.7324	2.1946	5.1790	133565	5.1257
96	2.7404	1.9807	5.3617	81623	4.9118
87	3.0414	1.9393	4.9445	74203	4.8704
	3.4771		6.4082		
950	2.9085	2.9775	5.8325	596870	5.7759
85	2.6335	1.9305	4.7993	53565	4.7289
426	3.1139	2.6295	5.5185	267826	5.4279
511	2.8573	2.7087	5.6021	321391	5.5070
280	2.8451	2.4472	5.2878	176000	5.2455
292	3.3979	2.4656	5.1847	183652	5.2640
	3.6232		6.4216		
542	2.8633	2.7340	5.6721	385797	5.5864

TABLE [2]: SALCOMBE SOUTH SANDS: GLOBIGII & BACTERIAL INVESTIGATION

Date: 11th December 1991 HW: 08.20 & 20.40 hours WEATHER: Freezing, dry and overcast.

Run Time	Time wrt HW	Site	Site Description	Sampling Time	Distance from S. edge	T Coli	E Coli	F Streps	Glob /100ml	Salinity (Lab)	Salinity (in situ)	F Water Fraction	Stream E.coli x FW fraction	Log actual E.Coli	Log expect E.Coli	Log Glob	Stream Glob x FW fraction	Log expected Glob
		6	20m from South edge	20.25	20	2300	780	170	330000	28.90	28.25	0.162	552	2.8921	2.7418	5.5185	392812	5.5942
		4	40m from South edge	20.23	40	1000	520	130	70000	33.50	33.95	0.029	99	2.7160	1.9937	4.8451	70145	4.8460
		5	60m from South edge	20.24	60	800	630	160	210000	32.60	32.60	0.055	187	2.7993	2.2724	5.3222	133275	5.1247
		2	E.C.B. line	20.21	80	1900	630	150	170000	31.90	32.30	0.075	256	2.7993	2.4086	5.2304	182377	5.2610
		1	North edge of beach	20.20	145	2500	1600	560	180000	32.10	33.00	0.070	237	3.2041	2.3739	5.2553	168348	5.2262
		7	Combe stream	20.26		6500	3400	520	2420000	0.26				3.5315		6.3838		

TABLE [3]: SALCOMBE SOUTH SANDS: COMBE STREAM INVESTIGATION 6-2-92

SITE	BEACH	1	2	3	4	5
DIST. U/S (km)	0	0.4	1.3	1.9	2.1	2.4
TIME	E.coli					
7.00	3600	2600	7000	5400	26000	800
8.00	3700	2300	2900	26000	53000	190
9.00	3500	1300	2100	39000	47000	480
10.00	3900	100	250	50000	75000	2400
11.00	5000	2400	8700	44000	61000	11000
12.00	2300	4300	13000	6100	2500	3400
13.00	6300	5600	10000	7100	29000	700
14.00	5100	4800	12000	39000	78000	2400
15.00	6200	5500	14000	34000	44000	1000
16.00	6200	4400	5500	20000	68000	250
17.00	4100	2400	12000	33000	45000	1200
18.00	2700	2700	16000	34000	59000	700
TIME	F.strep					
7.00	250	200	490	600	2300	80
8.00	380	220	210	2200	5800	3400
9.00	320	110	350	3200	4600	2600
10.00	190	100	330	9000	6000	1200
11.00	220	310	1600	14000	13000	1200
12.00	490	380	1600	18000	480	810
13.00	580	650	2500	1100	7100	320
14.00	650	1400	3500	15000	31000	440
15.00	1300	800	3300	2500	2700	130
16.00	630	490	2100	3000	4400	130
17.00	700	600	3000	2500	4300	14000
18.00	1400	700	1800	4300	8000	8100
TIME	B.Globigii					
7.00						
8.00						
9.00						
10.00	0	0	0			
11.00	300	0	0			
12.00	0	20	0			
13.00	0	0	> 100000			
14.00	40	41000	> 100000			
15.00	89000	> 100000	> 100000			
16.00	> 100000	> 100000	> 100000			
17.00	> 100000	> 100000	> 100000			
18.00	> 100000	> 100000	> 100000			

BEACH	1	2	3	4	5
0	0.4	1.3	1.9	2.1	2.4
Log E.coli					
3.5563	3.415	3.8451	3.7324	4.415	2.9031
3.5682	3.3617	3.4624	4.415	4.7243	2.2788
3.5441	3.1139	3.3222	4.5911	4.6721	2.6812
3.5911	2	2.3979	4.699	4.8751	3.3802
3.699	3.3802	3.9395	4.6435	4.7853	4.0414
3.3617	3.6335	4.1139	3.7853	3.3979	3.5315
3.7993	3.7482	4	3.8513	4.4624	2.8451
3.7076	3.6812	4.0792	4.5911	4.8921	3.3802
3.7924	3.7404	4.1461	4.5315	4.6435	3
3.7924	3.6435	3.7404	4.301	4.8325	2.3979
3.6128	3.3802	4.0792	4.5185	4.6532	3.0792
3.4314	3.4314	4.2041	4.5315	4.7709	2.8451
Log F.strep					
2.3979	2.301	2.6902	2.7782	3.3617	1.9031
2.5798	2.3424	2.3222	3.3424	3.7634	3.5315
2.5051	2.0414	2.5441	3.5051	3.6628	3.415
2.2788	2	2.5185	3.9542	3.7782	3.0792
2.3424	2.4914	3.2041	4.1461	4.1139	3.0792
2.6902	2.5798	3.2041	4.2553	2.6812	2.9085
2.7634	2.8129	3.3979	3.0414	3.8513	2.5051
2.8129	3.1461	3.5441	4.1761	4.4914	2.6435
3.1139	2.9031	3.5185	3.3979	3.4314	2.1139
2.7993	2.6902	3.3222	3.4771	3.6435	2.1139
2.8451	2.7782	3.4771	3.3979	3.6335	4.1461
3.1461	2.8451	3.2553	3.6335	3.9031	3.9085
E.coli/F.strep ratio					
14.40	13.00	14.29	9.00	11.30	10.00
9.74	10.45	13.81	11.82	9.14	0.06
10.94	11.82	6.00	12.19	10.22	0.18
20.53	1.00	0.76	5.56	12.50	2.00
22.73	7.74	5.44	3.14	4.69	9.17
4.69	11.32	8.13	0.34	5.21	4.20
10.86	8.62	4.00	6.45	4.08	2.19
7.85	3.43	3.43	2.60	2.52	5.45
4.77	6.88	4.24	13.60	16.30	7.69
9.84	8.98	2.62	6.67	15.45	1.92
5.86	4.00	4.00	13.20	10.47	0.09
1.93	3.86	8.89	7.91	7.38	0.09

TABLE [4]: SALCOMBE SOUTH SANDS: COMBE STREAM INVESTIGATION 6-2-92 TIME CORRECTED DATA

SITE	BEACH	1	2	3	4
DIST. U/S (km)	0	0.4	1.3	1.9	2.1
TIME CORRECTION APPLIED	+4 HRS	+3 HRS	+2 HRS	+1 HR	+0 HRS
TIME OF DISCHARGE	E.coli				
3.00	3600				
4.00	3700	2600			
5.00	3500	2300	7000		
6.00	3900	1300	2900	5400	
7.00	5000	100	2100	26000	26000
8.00	2300	2400	250	39000	53000
9.00	6300	4300	8700	50000	47000
10.00	5100	5600	13000	44000	75000
11.00	6200	4800	10000	6100	61000
12.00	6200	5500	12000	7100	2500
13.00	4100	4400	14000	39000	29000
14.00	2700	2400	5500	34000	78000
15.00		2700	12000	20000	44000
16.00			16000	33000	68000
17.00				34000	45000
18.00					59000

SITE	BEACH	1	2	3	4
DIST. U/S (km)	0	0.4	1.3	1.9	2.1
TIME CORRECTION APPLIED	+4 HRS	+3 HRS	+2 HRS	+1 HR	+0 HRS
TIME OF DISCHARGE	Log E.coli				
3.00	3.5563				
4.00	3.5682	3.4150			
5.00	3.5441	3.3617	3.8451		
6.00	3.5911	3.1139	3.4624	3.7324	
7.00	3.6990	2.0000	3.3222	4.4150	4.4150
8.00	3.3617	3.3802	2.3979	4.5911	4.7243
9.00	3.7993	3.6335	3.9395	4.6990	4.6721
10.00	3.7076	3.7482	4.1139	4.6435	4.8751
11.00	3.7924	3.6812	4.0000	3.7853	4.7853
12.00	3.7924	3.7404	4.0792	3.8513	3.3979
13.00	3.6128	3.6435	4.1461	4.5911	4.4624
14.00	3.4314	3.3802	3.7404	4.5315	4.8921
15.00		3.4314	4.0792	4.3010	4.6435
16.00			4.2041	4.5185	4.8325
17.00				4.5315	4.6532
18.00					4.7709

TABLE [6]: S.W.W.S.L. DATA - SUMMER 1990

SITE DATE OF SAMPLING	S.SANDS BEACH	S.SANDS STREAM	COMBE BRIDGE	D/S S.T.W.	U/S S.T.W.
			E.coli / 100 ml		
10-8-90	142	7300	1400	>30000	1520
15-8-90	1160	9600	4100	>30000	4500
17-8-90	31	18400	3900	>30000	1560
			F.strep / 100 ml		
10-8-90	142	1510	368	>300	320
15-8-90	>300	1550	>300	>300	>300
17-8-90	19	2780	>300	>300	>300
			T.coli / 100 ml		
10-8-90	260	5200	7200	>30000	11000
15-8-90	2800	16000	11600	>30000	7300
17-8-90	44	24000	10400	>30000	4700

TABLE [5]: NRA INVESTIGATION OF LOWER COMBE CATCHMENT 16-3-92

SAMPLING SITE	SITE DESCRIPTION	SAMPLING TIME	Bacteria / 100 ml		
			T.coli	E.coli	F.strep
A	D/S OF SOUTHERN MILL	11.27	5100	2400	210
B	D/S OF CARAVAN PARK	11.35	21000	4200	110
C	SMALL TRIBUTARY	11.40	110	110	20
D	SLUICE GATE FROM POND	11.15	12000	4000	170
E	NEXT TO CAR PARK	11.00	6300	1700	20
F	POND WEIR	10.55	13000	4800	160
G	SOUTH SANDS BEACH	11.10	7900	3000	90

9. FIGURES

FIG [1]: BACTERIAL SOURCES TO SOUTH SANDS BEACH

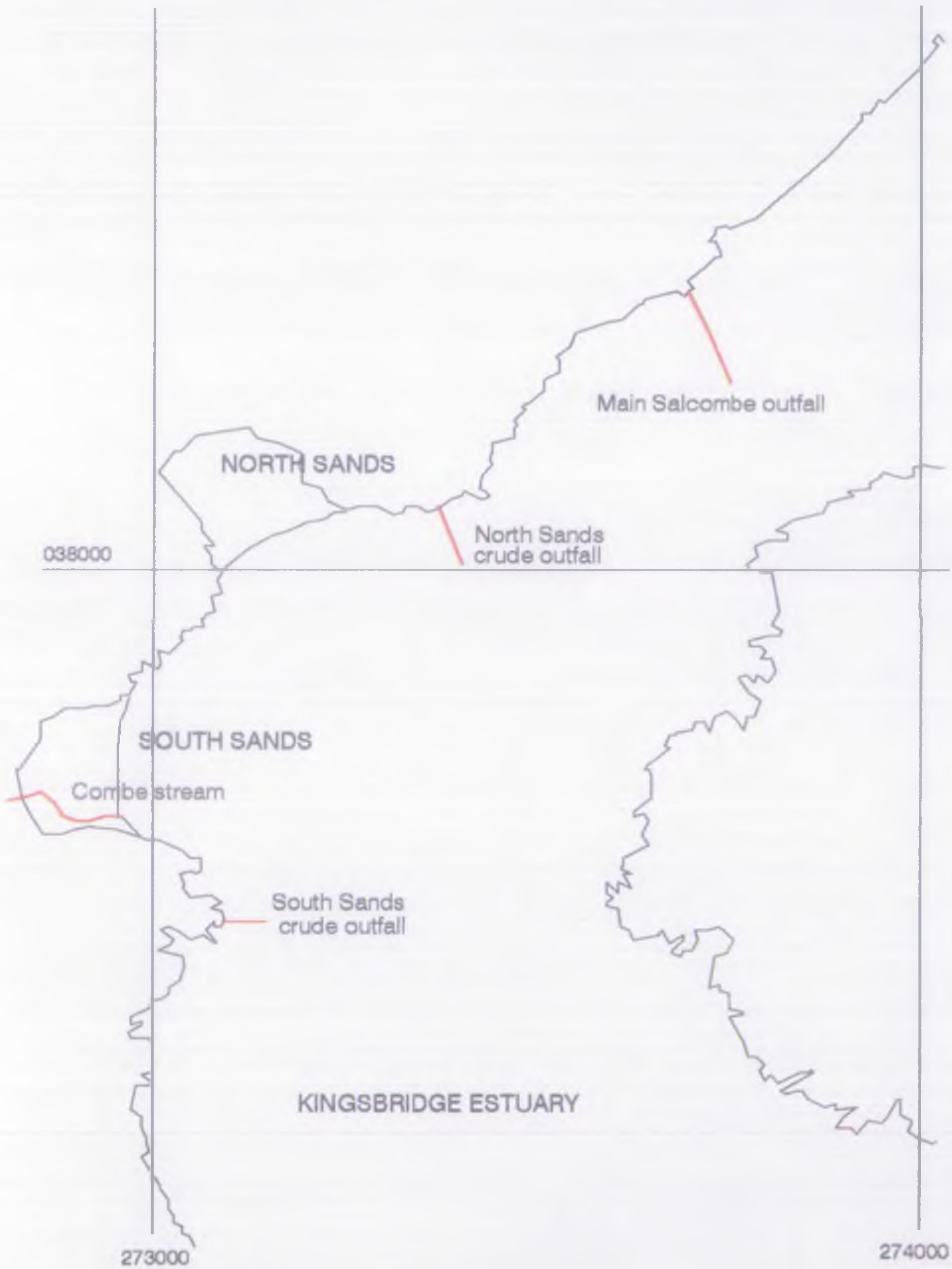
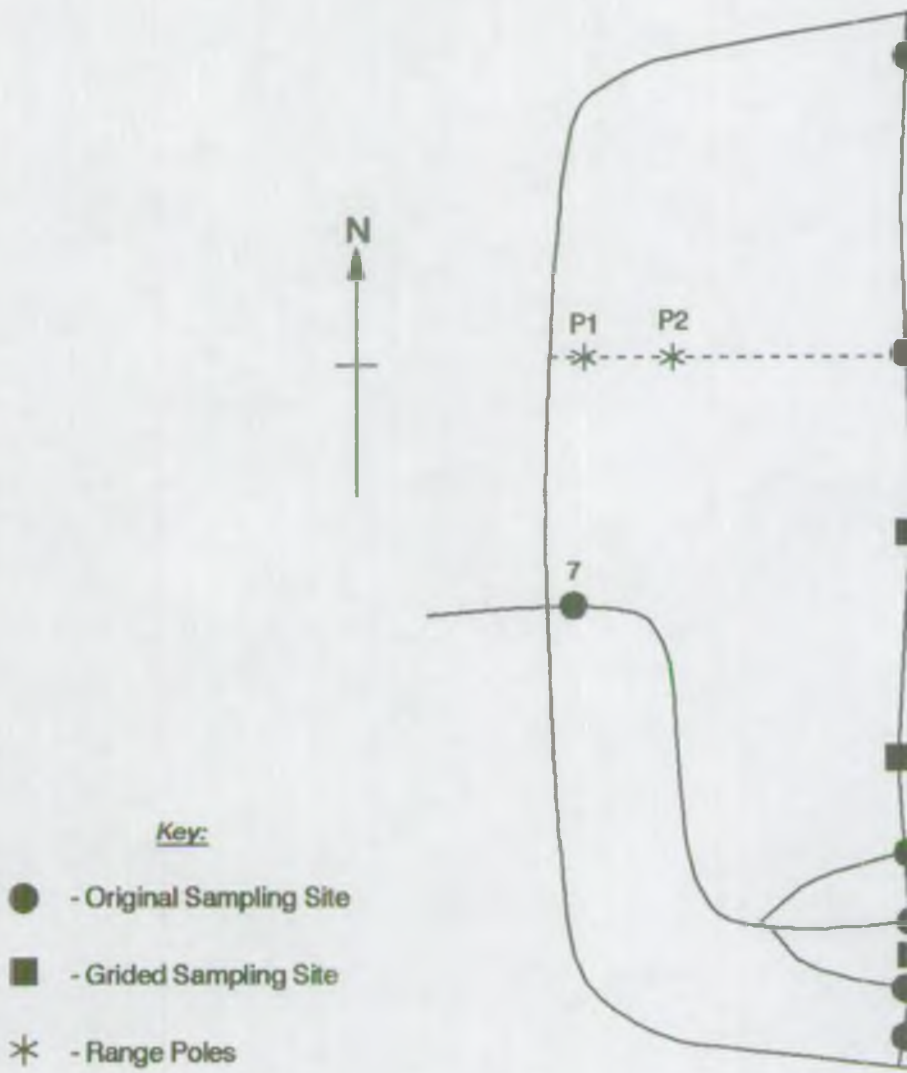


Fig [2]: Salcombe South Sands -



Schematic Sampling Sites:

FIG [3]: SITES RELEVANT TO TWIU FIELDWORK AT SOUTH SANDS BEACH

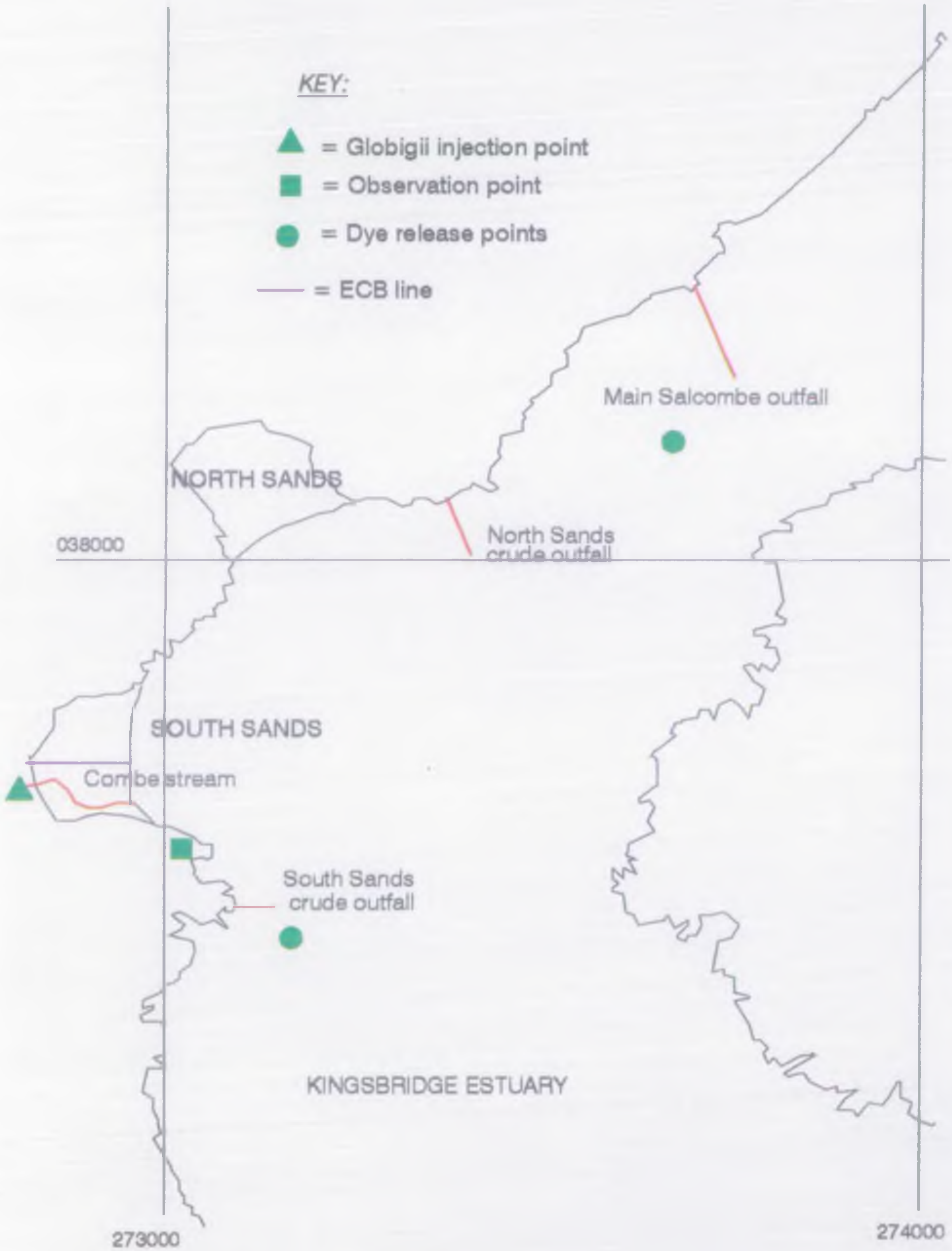


Fig [4]: Combe Stream Catchment

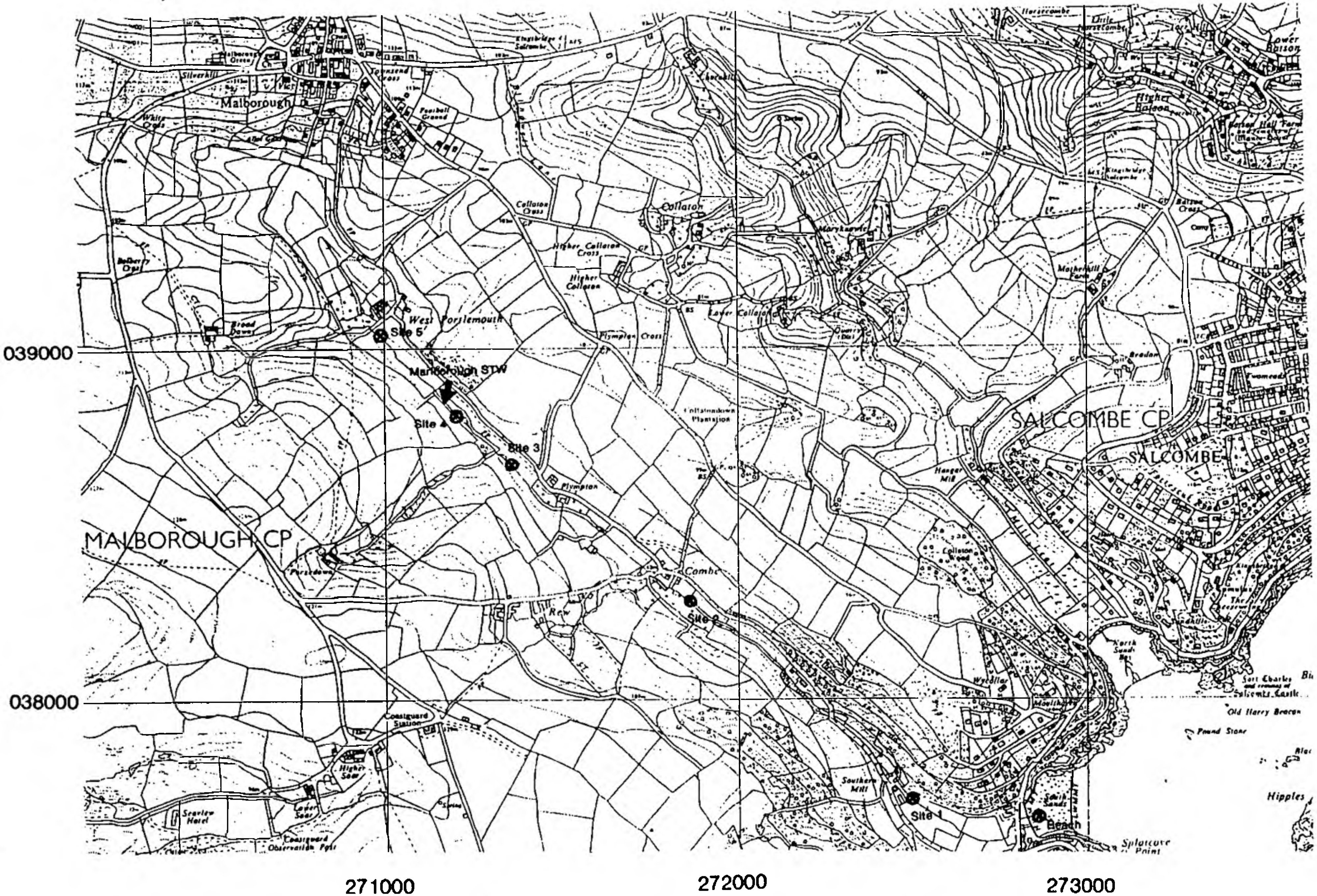
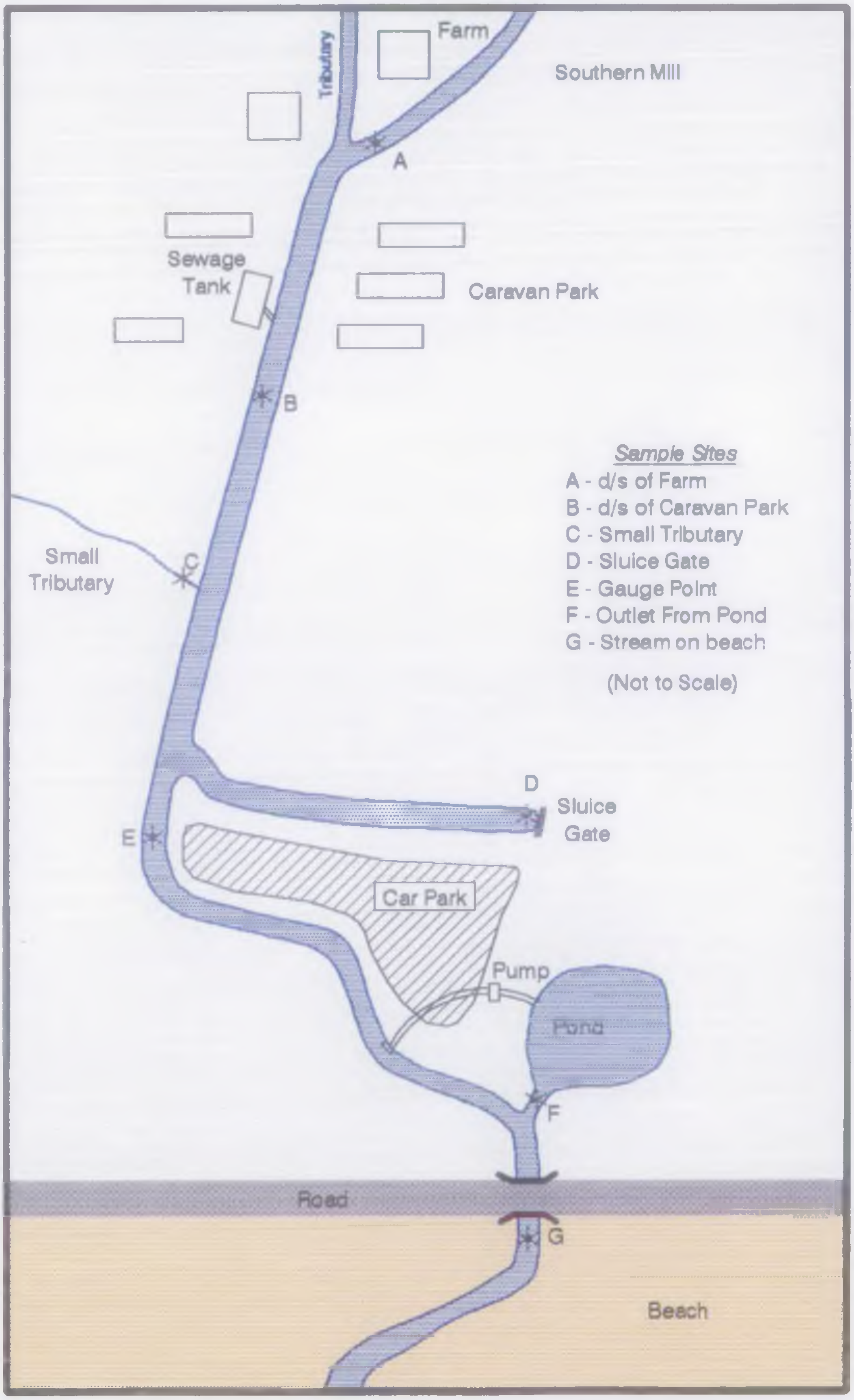


Fig [5]: Combe Stream, Salcombe: Lower Catchment



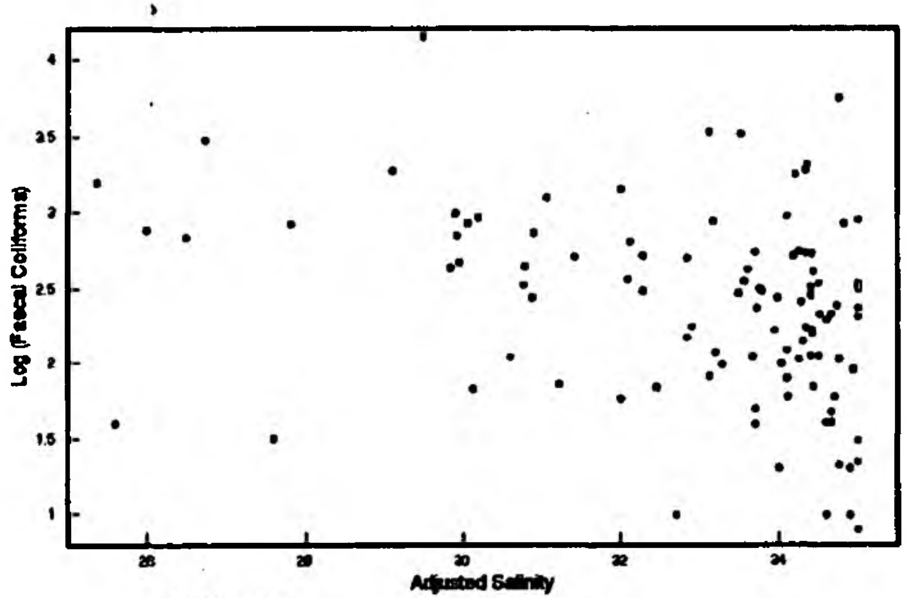


Fig [6]: Log Faecal Coliforms v Salinity

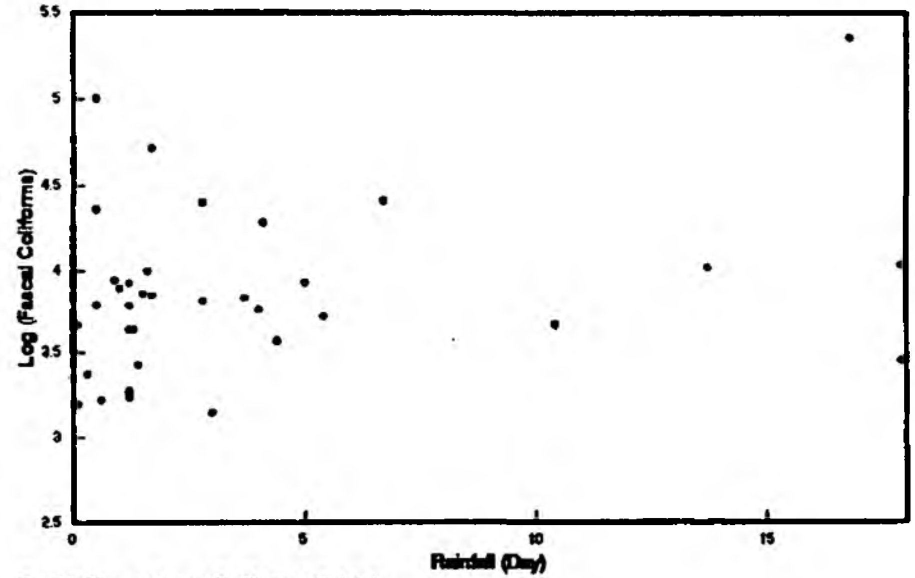


Fig [7]: Stream Faecal Coliforms v Rainfall

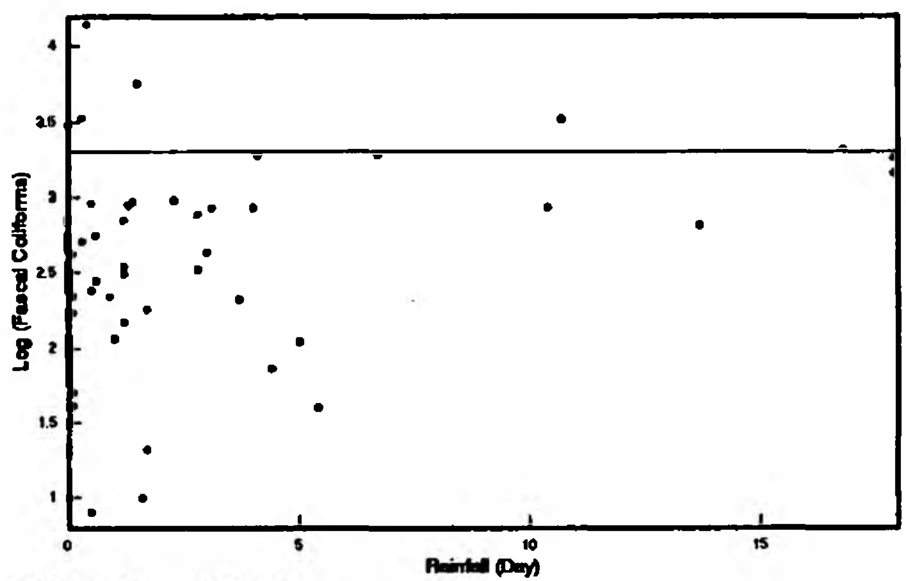


Fig [8]: Beach Faecal Coliforms v Rainfall (Day)

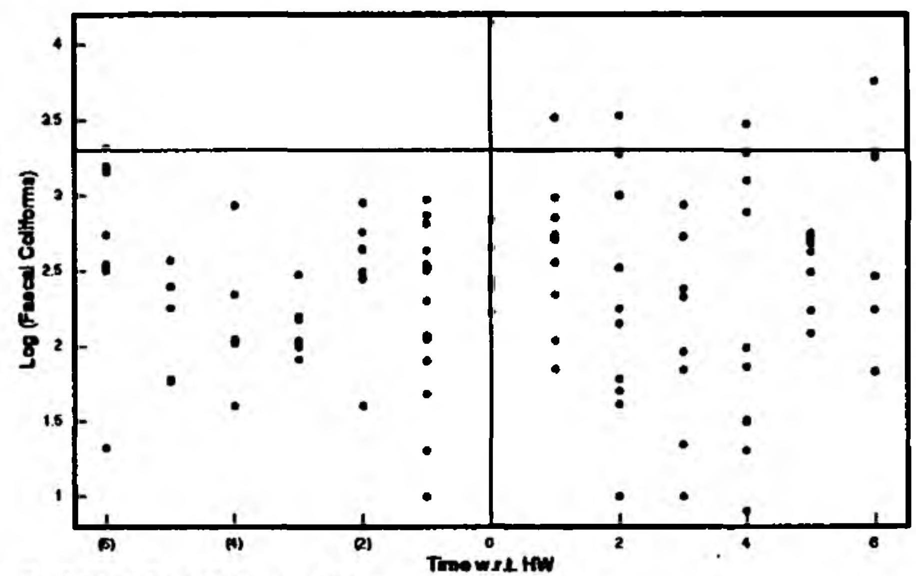


Fig [9]: Beach Faecal Coliforms v Tide

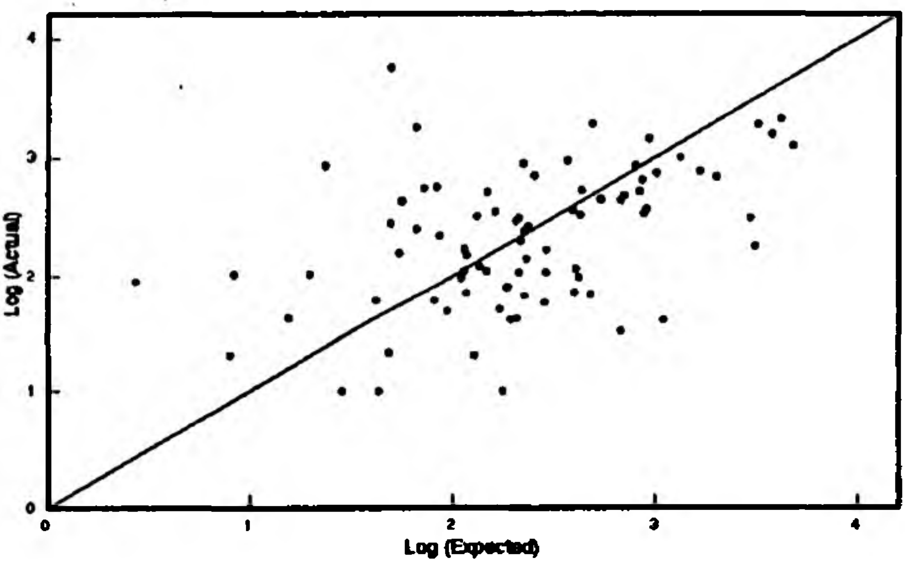


Fig [10]: Historical Faecal Coliforms
Actual v Expected Levels

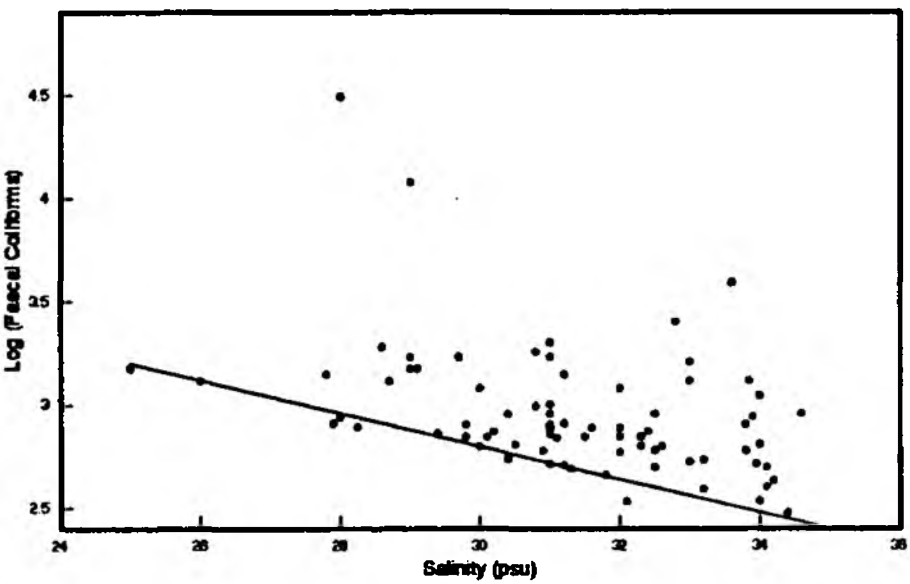


Fig [12]: Log Faecal Coliforms v Salinity

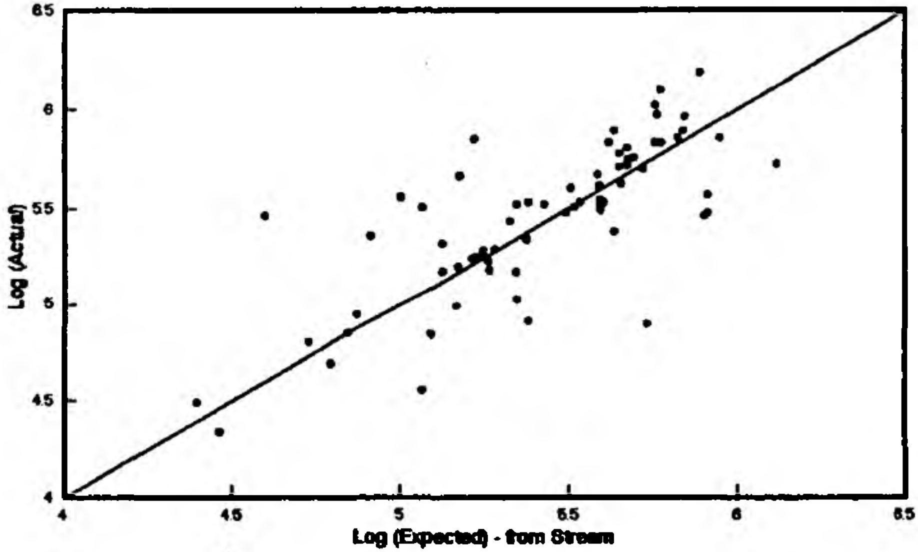


Fig [11]: Beach B.Globigii
Actual v Expected Levels

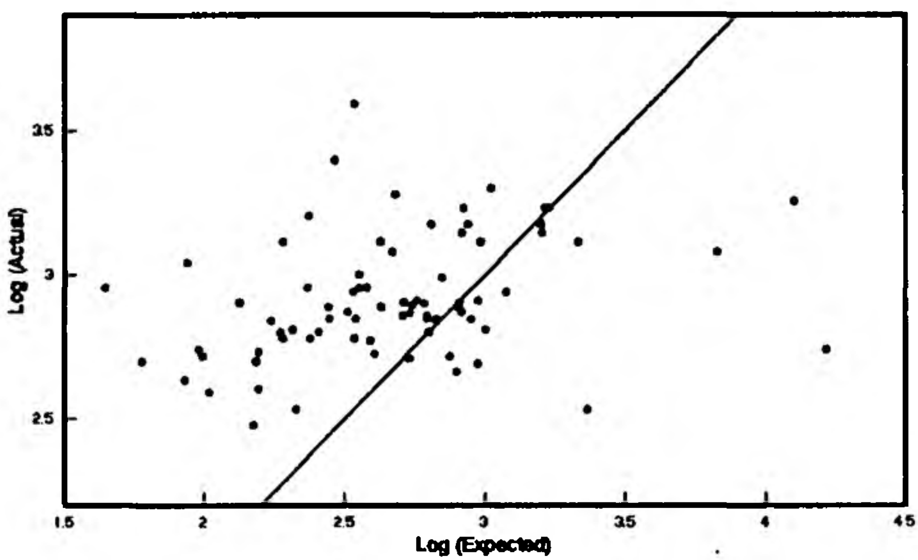


Fig [13]: Beach Faecal Coliforms
Actual v Expected Levels

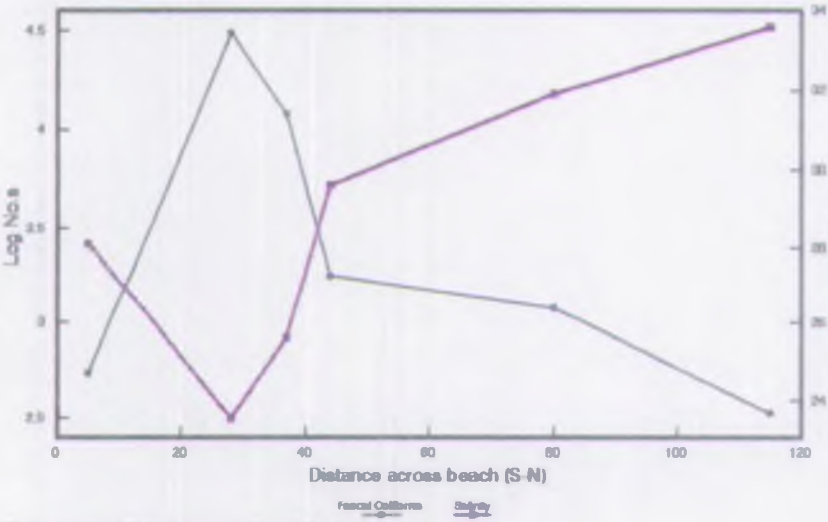


Fig [14]: Globigii & Faecal Coliform Distribution
HW

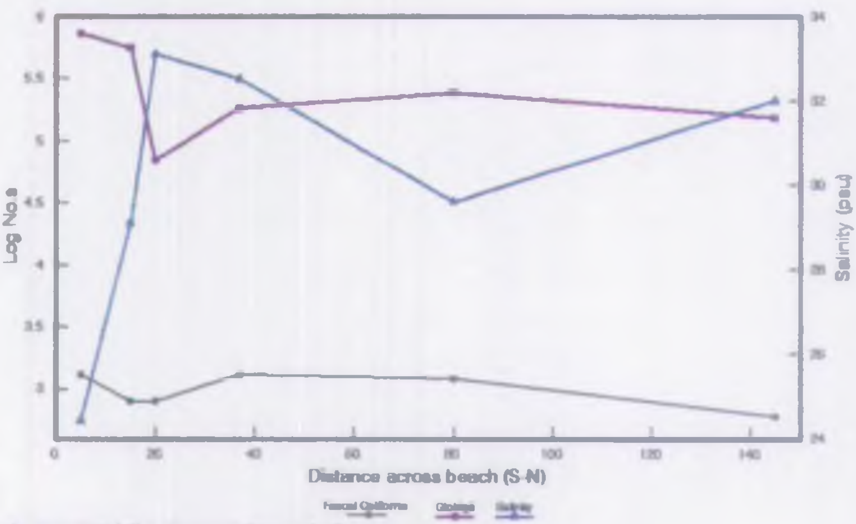


Fig [16]: Globigii & Faecal Coliform Distribution
HW +2

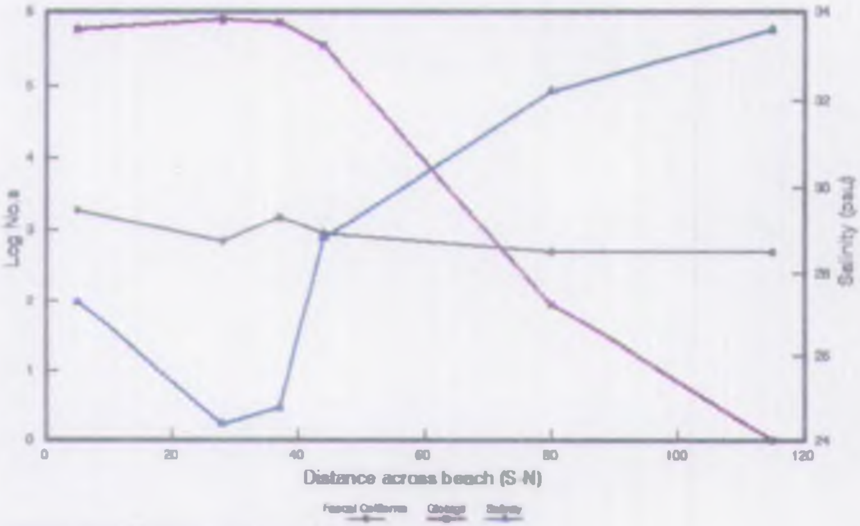


Fig [15]: Globigii & Faecal Coliform Distibution
HW + 1

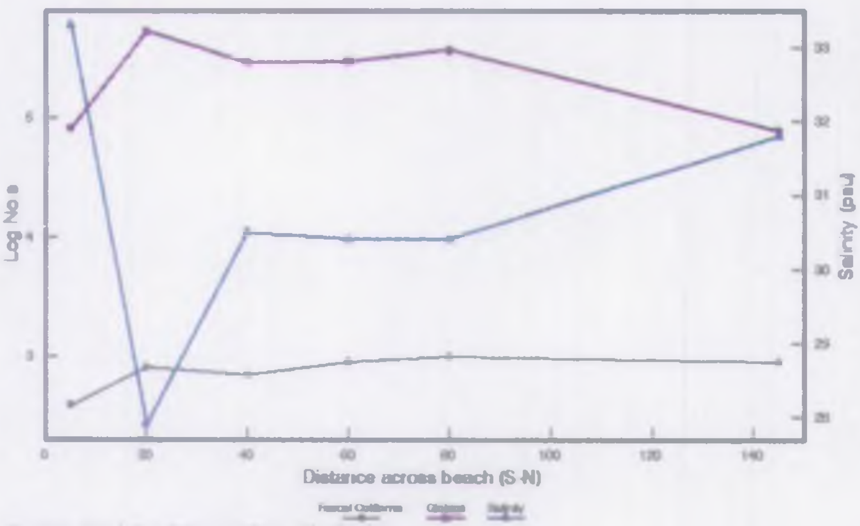


Fig [17]: Globigii & Faecal Coliform Distribution
HW + 3

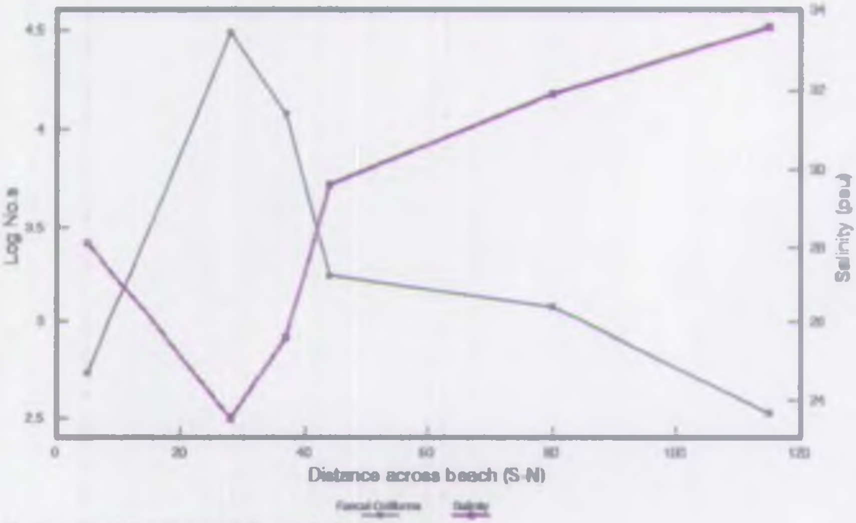


Fig [14]: Globigii & Faecal Coliform Distribution
HW

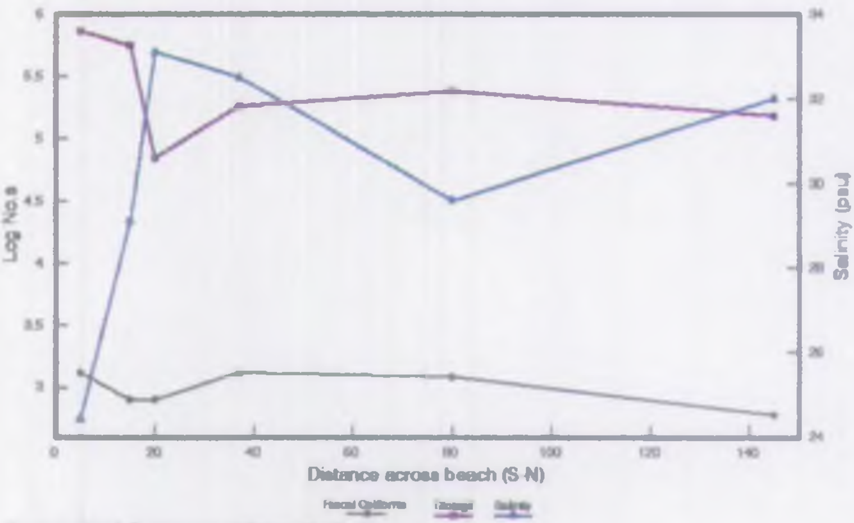


Fig [16]: Globigii & Faecal Coliform Distribution
HW+2

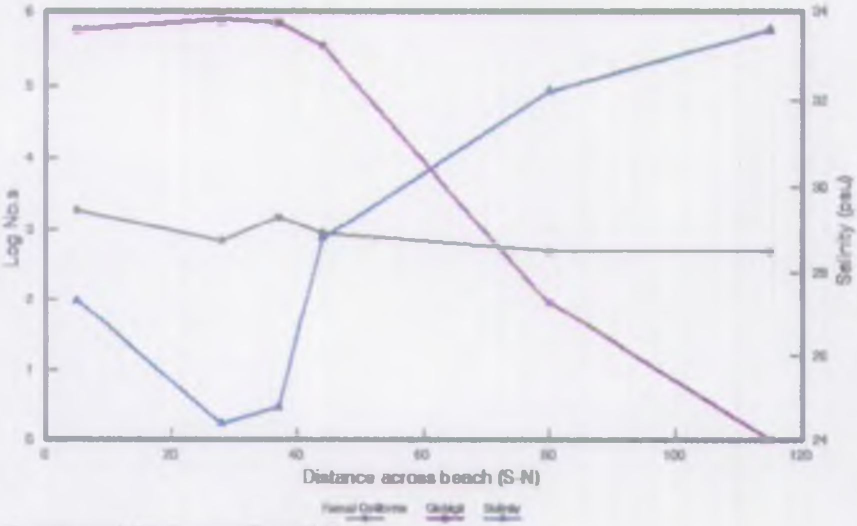


Fig [15]: Globigii & Faecal Coliform Distribution
HW+1

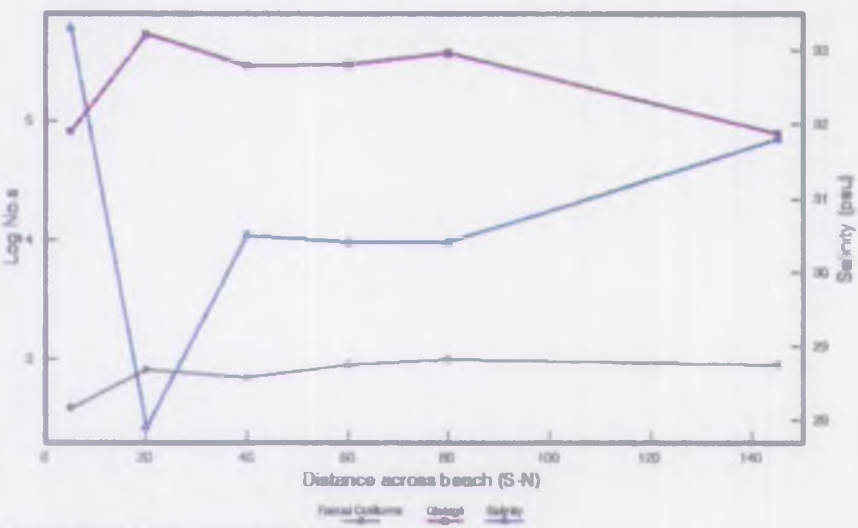


Fig [17]: Globigii & Faecal Coliform Distribution
HW+3

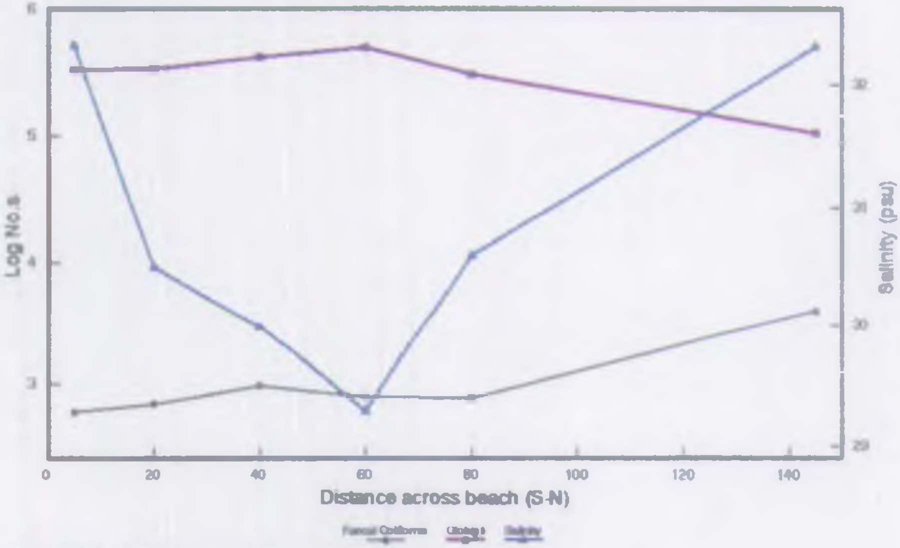


Fig [22]: Globigii & Faecal Coliform Distribution
HW-4:20

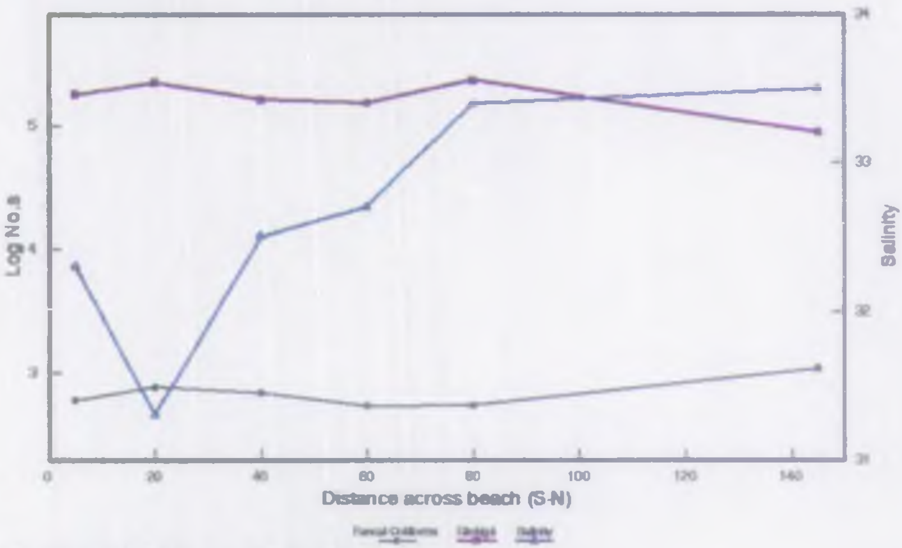


Fig [24]: Globigii & Faecal Coliform Distribution
HW-2:20

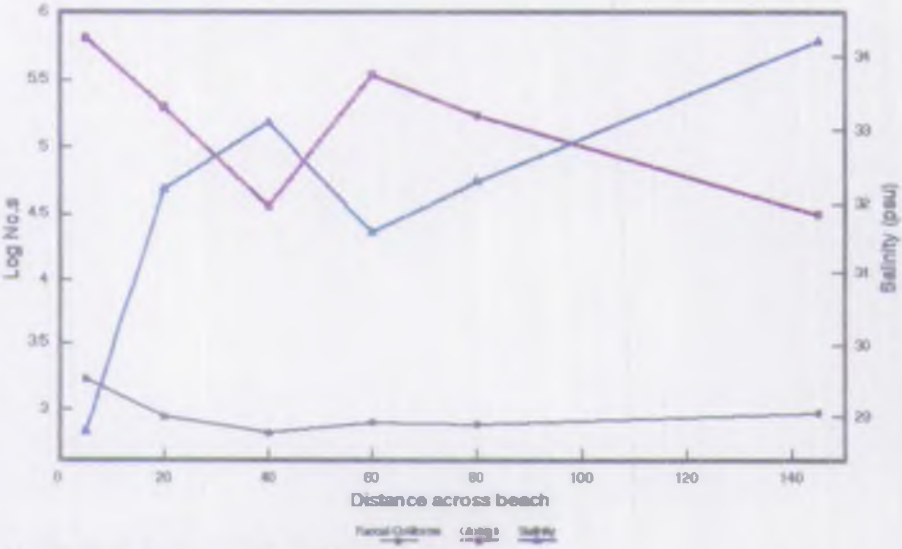


Fig [23]: Globigii & Faecal Coliform Distribution
HW-3:20

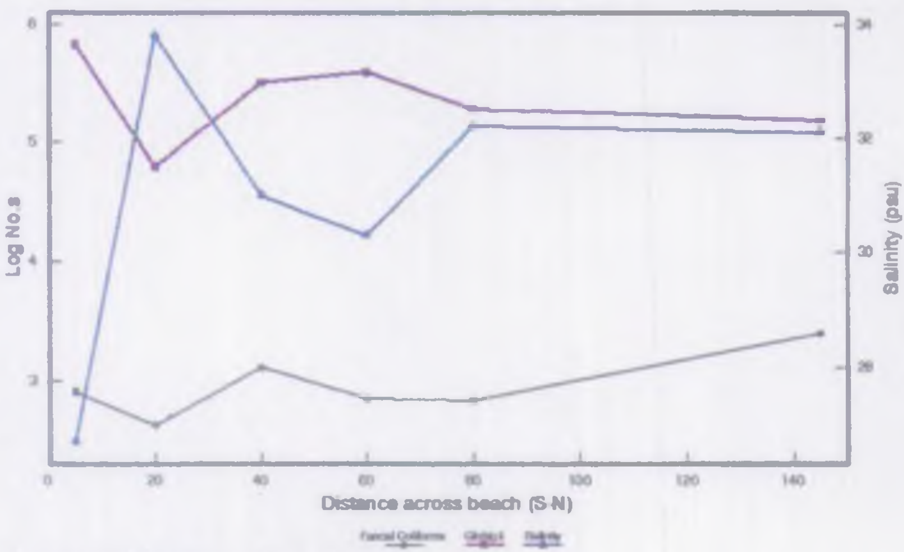


Fig [25]: Globigii & Faecal Coliform Distribution
HW-1:20

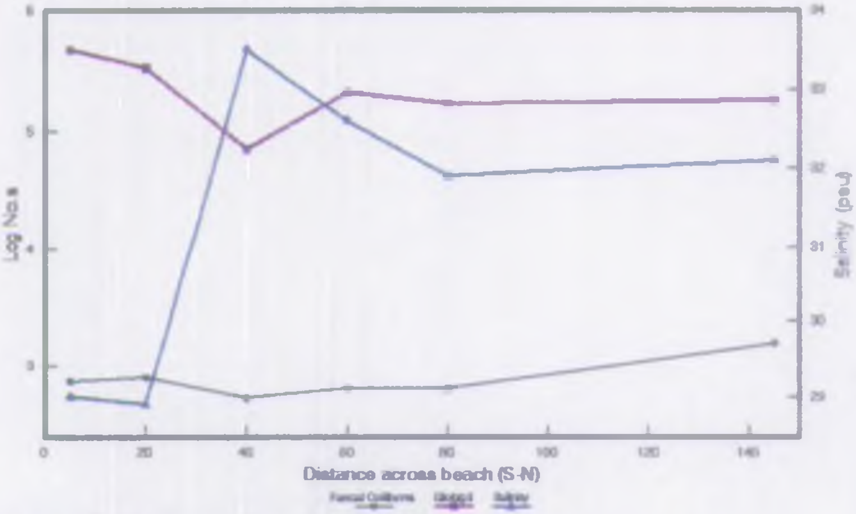


Fig [26]: Globigii & Faecal Coliform Distribution
HW-0:20

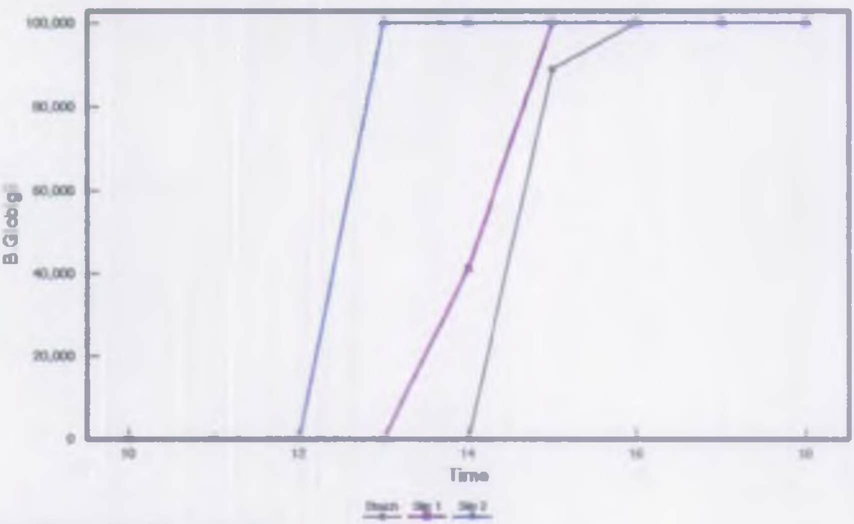


Fig [28]: Combe Stream 6-2-92
B.Globigii v Time

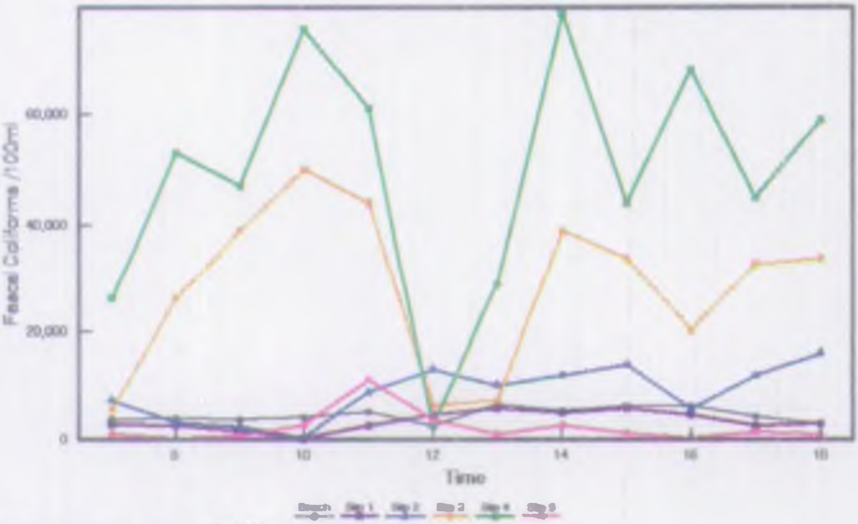


Fig [27]: Combe Stream 6-2-92
Faecal Coliforms v Time

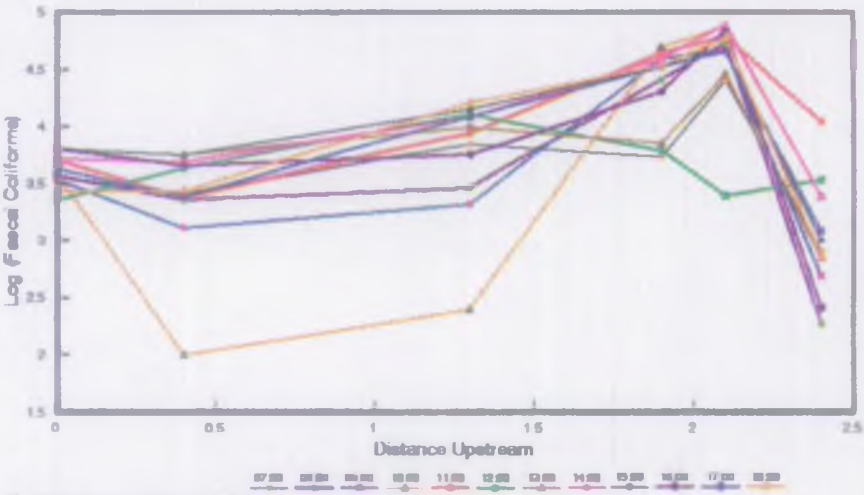


Fig [29]: Combe Stream 6-2-92
Log Faecal coliforms v Distance Upstream
(07:00 to 18:00)

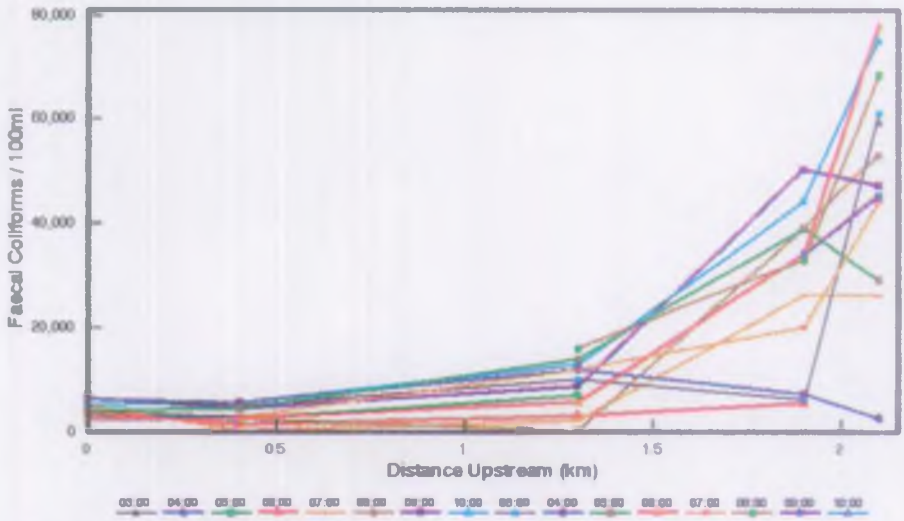


Fig [30]: Combe Stream 6-2-92
Time Shifted Faecal Coliforms v Distance Upstream

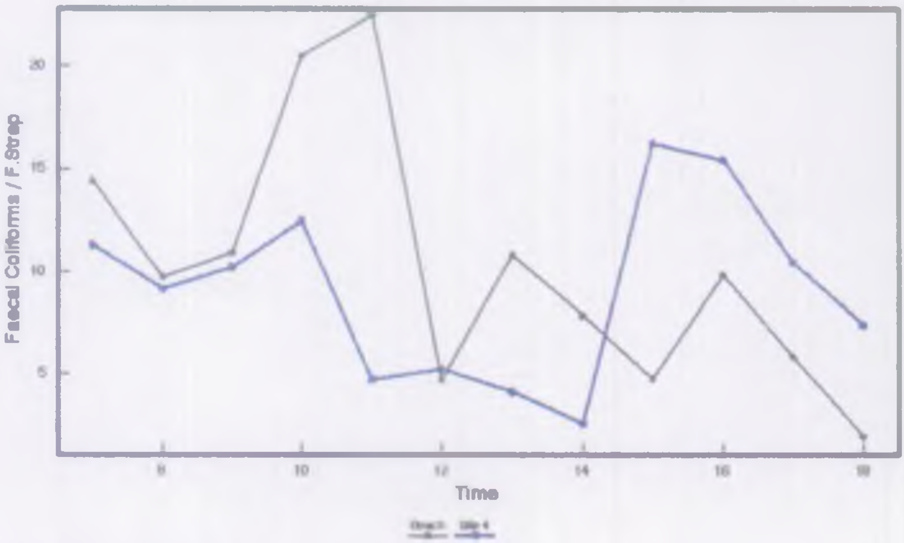
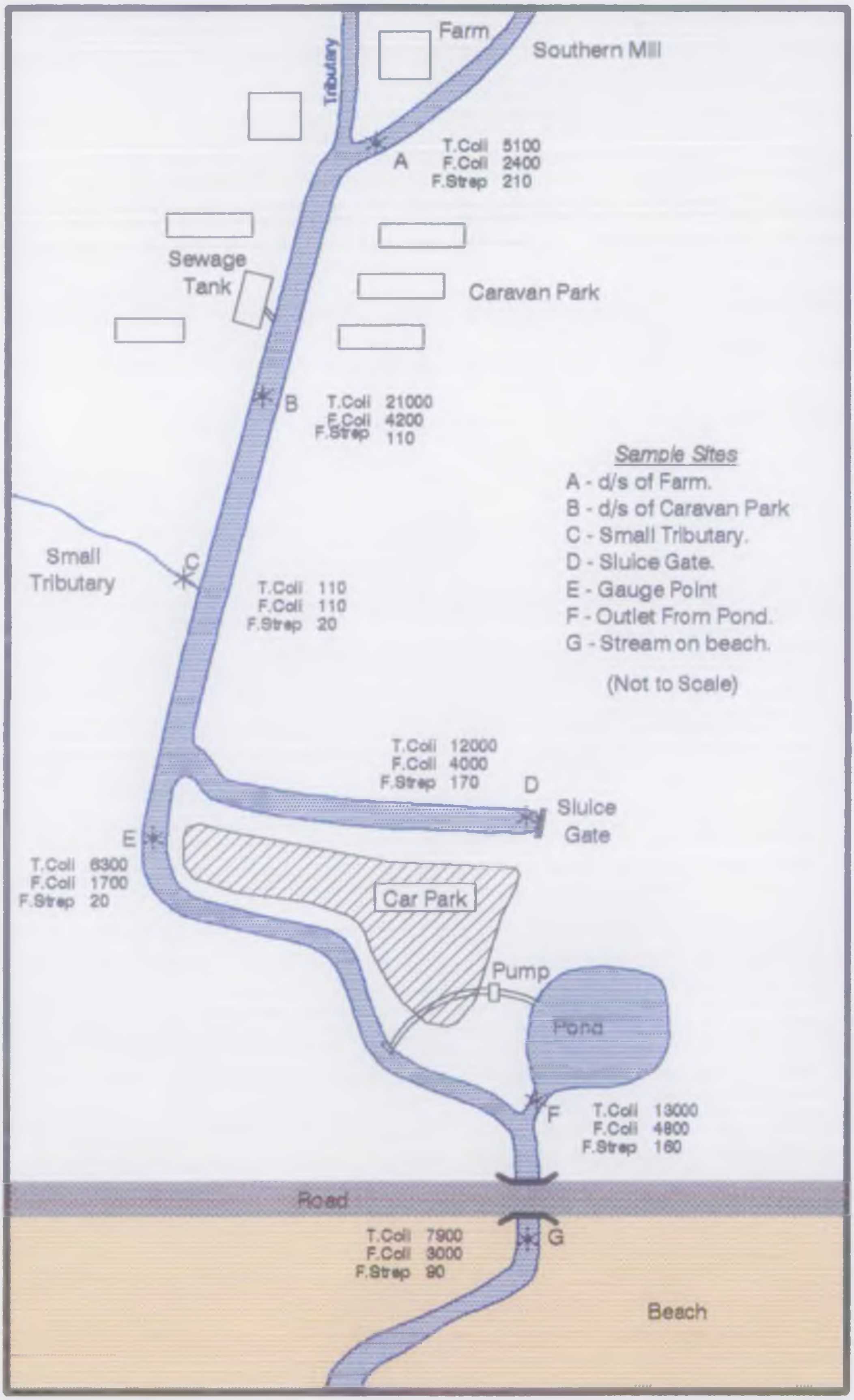


Fig [31]: Combe Stream 6-2-92
Faecal Coliforms / F.Strep Ratio

Fig [32]: Combe Stream, Salcombe: Lower Catchment



10. APPENDIX 1

VIEWS OF SOUTH SANDS CRUDE OUTFALL

EVIDENCE OF LEAKAGE: SOUTH SANDS CRUDE OUTFALL