NRA South West 83

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Environmental Protection Report

INVESTIGATION INTO THE INTERMITTENT FAILURE OF WEMBURY BEACH TO COMPLY WITH EC BATHING WATER

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Author: C Martin
Investigations Officer

NRA
National Rivers Authority
South West Region

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Summary

Bathing waters at Wembury in South Devon have failed the mandatory standards for Faecal Coliforms in 1986, 1987, 1988 and 1990, and for Total Coliforms in 1990.

Analysis of routine monitoring data reveals an inverse relationship between salinity and bacterial numbers in bathing water samples. This indicates that Wembury Stream is a significant factor in bathing water failure. In addition all of the mandatory (I) value failures, and more than half of all guide (G) value failures, have coincided with either substantial rainfall, and/or within 3 hours of low water. Rainfall however, seems to be more significant than tidal state in predisposing to failure.

Two bacteriological surveys were undertaken; one which coincided with the passage of a depression, and one during a dry weather period. The results were used to assess the influence of rainfall on bacterial numbers in the Wembury Stream, and subsequently in the bathing water.

Significant increases in bacterial levels occurred in the Wembury Stream as a result of rainfall. Factors identified as contributing to the poor bacterial quality were; diffuse and point source agricultural inputs, and a foul sewer wrongly connected to a surface water sewer.

When bacterial levels in the stream are high, risk of bathing water failure is increased, particularly if sampling is undertaken within three hours of low water. This is because of the shape of the beach. Near the low water mark, the stream tends to be channelled through a narrow gap between rock outcrops. This has the effect of reducing mixing with the sea such that samples will contain a high proportion of stream water.

Wembury sewage treatment works is unlikely to cause exceedance of the EC mandatory bacteriological standards at Wembury Beach. Operation of the pumping station emergency overflow however, could have considerable impact on the bathing waters because of its proximity to the beach.

Introduction

Bathing waters at Wembury in South Devon have been sampled for the EC Bathing Water Directive since 1986. Samples have failed the mandatory standard for Faecal Coliforms (2000/100ml) once in each of the years 1986, 1987, 1988 and 1990. The mandatory level for Total Coliforms (10,000/100ml) has been exceeded only once, in 1990.

The beach at Wembury is situated some 1.5 km to the west of the Yealm Estuary. It consists of a small area of shingle and coarse sand, bounded on either side by wave-cut rock platforms, and is backed by raised beach material. Wembury Stream rises 2 to 3 km to the north near Staddiscombe and drains an area of some 5 to 6 km^2 before flowing across the beach. Sewage from the village is pumped to Wembury sewage treatment works (STW) (SX512487) from a pumping station near to public toilets above the beach (SX517485). Effluent from the sewage works discharges via a small stream to the west of the beach. This stream emerges above Mean High Water Springs from a pipe at SX510484, some 400 metres from the bathing water, and flows across the foreshore into the sea. An emergency overflow from the pumping station discharges to the Wembury Stream some 20m upstream of the beach (see Figs.1 and 1A).

Analysis Of Historical Data

Despite individual sample failures, the bathing water at Wembury can be considered generally to be of reasonable quality. Median values from all samples between 1986 and 1990 are 64/100ml for Total Coliforms and 40/100ml for E.coli.

The data were analysed with particular reference to the stream and factors (such as rainfall and tidal state) which may affect its interaction with the bathing water. This analysis reveals that all of the mandatory (I) value failures, and more than half of all guide (G) value failures, have coincided with either significant rainfall (>5mm), within 3 hours of low water, or both.

Rainfall seems to be the more significant factor than tidal state in predisposing to failure. Out of a total of 84 sampling occasions only 8 have coincided with rainfall of 5mm or more. These same eight occasions have however, accounted for four of the five I value failures (see Figs. 2 and 3). This correlation between EC failure and rainfall, and the inverse relationship between salinity and bacterial numbers; were both indicative of influence from the Wembury Stream.

In light of the above findings a bacteriological survey was planned to coincide with a significant rainfall event following a relatively dry period. In addition it was also decided to visit the catchment during a dry weather period in order to quantify the relative inputs from individual tributaries to the Wembury stream.

Rainfall Event Survey

During February the general weather situation was monitored for a suitable frontal system (ie. one with significant rainfall) which would cross the region in a reasonably predictable way, so that a survey could be carried out both before and after its arrival at Wembury. Information from Plymouth Meteorological Office (Mount Batten, 5km north west of Wembury) on the 19th February indicated that such a frontal system was expected to affect the South West Peninsula on the 22nd. Hydrometric staff and the laboratory were advised accordingly. Data from Plymouth Meteorological Office indicates that the only rainfall in February preceding the survey was as follows; 12th 3.4mm, 14th 9.5mm, 15th 1.9mm, 20th 7.2mm and 21st 7.4mm.

By 07.00 on the 22nd February rainfall had appeared on radar, to the west of Cornwall and was tracking north-easterly. Plymouth Meteorological office predicted that it would reach the Wembury area at approximately 11.00.

Flows were measured in the stream at 08.00 and 08.48 adjacent to the pumping station emergency overflow. A stage height logger was also installed at this site so that a continuous flow record could be calculated.

Microbiological Sampling sites:

1. Wembury Stream at the gauging site.
2. Wembury Beach from the EC monitoring point.
3. Tributary on left bank 150m from the beach (two occasions only).

Microbiological samples were taken at 30 minute intervals from 08.20 until 17.50.

The weather remained showery until about 11.00 when continuous moderate rainfall started; this increased to heavy rainfall between 12.00 and 15.00, then reduced to moderate until about 17.30hrs when it became light and showery. Wind direction throughout was 205°(T) and the speed increased throughout the day from 14 knots at 08.00 to 25 knots by 18.00.
The pumping station emergency overflow (PSEO) adjacent to the gauging site did not operate during the course of the survey.

High water (Devonport) was at 10.27 and low water at 17.02.

Dry Weather Background Survey

This was undertaken on 26th July 1991 and consisted of a series of samples taken from all significant tributaries (see Fig.1) at hourly intervals for 5 hours from 07.00.

RESULTS

Rainfall Event Survey 22.02.1991

Fig.4 shows the hydrograph derived from the logged stage heights and measured flows for the duration of the survey.
Bacteriological and salinity results are presented in Table 1 and are represented graphically in Figs.5, 6 and 7.

Rainfall (from the Mount Batten gauging station) on 22.02.91 was 18mm.

Dry Weather Survey 26.07.1991

Results from the dry weather sampling, are given in Fig.8.

Discussion

The desired objective of monitoring both stream and beach immediately prior to, and during a significant rainfall event, was achieved.

The hydrograph (Fig.4) shows that the stream responded to changes in the observed rainfall within approximately one hour, highlighting the "flashy" nature of this catchment. Peak flow measured at 16.00 (0.201m^3/sec) was approximately three times greater than those (0.07m^3/sec) from the morning's gauging, and over four times base flow gauging (0.046m^3/sec) which was undertaken on 13.02.91.

Bacteriological results for the stream show a three to four fold increase during the course of the wet weather survey. The maximum value for total coliforms (>110,000/100ml) occurred at 11.50 although there was no parallel increase in E.coli. This coincided with a marked increase in flow following the onset of heavier rainfall. It is possible that this exceptionally high value was caused by the washing away of trash dams because of increased flow. The resultant mobilisation of organically rich material eg.rotting vegetation, could have released large numbers of coliforms into the stream.

Various factors may cause elevated bacterial numbers in rivers during rainfall and subsequent increased flows. These include general run-off from fields and roads etc., hydraulic loading on farm containment systems, the operation of storm sewer overflows, flushing of bank margins due to increased river levels, and re-suspension of sediment bound organisms from the stream bed. Evidence from the dry weather survey indicates that run-off, bank flushing and sediment re-suspension are probably significant factors for this particular stream. Approximately 50 percent of the catchment area is pasture; the rest comprising roughly equal amounts of arable land and urban development, with small pockets of woodland. Much of the pasture is steep, and animals have direct access at many points along the stream. The large quantity of hoof-prints and faeces, both in the watercourse and on the margins at these sites, indicate that cattle spend a significant amount of time there. Storm events will obviously wash contamination from the pasture and stream margins as well as mobilising sediment associated bacteria.

Bacterial levels found during the wet weather survey might well have been even higher had it not been preceded by rainfall on the 20th and 21st. It is probably this initial flush of rain, following a dry spell, which causes the greatest bacterial contamination.

Results from the beach show a dramatic increase during the last three hours of the survey. All samples taken after 15.00 for E.coli, and after 15.30 for Total coliforms failed the mandatory levels for these parameters. Increase in bacterial numbers in the bathing water samples can be accounted for by the increased proportion of fresh (stream) water in them as evidenced by a concurrent decrease in salinity. Fig.5 shows the relationship between salinity (and therefore percentage freshwater) and tidal height for the duration of the survey.

Reduction in salinity towards low water results from the local topography. As can be seen from Fig.1A the beach is very narrow near to the low water mark. The effect of this narrowing is to channel and retain the stream between the rock platforms. This results in reduced mixing with the sea, and was apparent on site during the survey when the increased turbidity of the stream water acted as a visual tracer. Mixing of stream and sea water was severely restricted around low water by a combination of this channelling, and backing up due to the strong south-westerly wind. Analysis of routine data between 1987 and 1990[1] also demonstrates that there is a tendency towards lower salinity around low water (Fig.9). There does not however, seem to be a correlation between low salinity and high bacterial numbers in these data. This probably reflects the variable but generally low levels of bacteria in the stream; such that it is only at times of substantial rainfall and associated poor bacterial quality in the stream that lowered salinity can cause the bathing water to fail EC Directive standards.

From the intensive survey results it is possible to predict theoretical bacterial levels in the sea at a given time. The percentage of fresh water (derived from salinity results) in the bathing water sample is multiplied by the concentration of bacteria in the associated stream sample. This has been done for both total coliforms and E.coli, and plotted against actual bacterial levels in the bathing water samples (see Figs 10 and 11). There is reasonably close agreement between actual and predicted values although the latter are generally higher than the former. This is as expected since the calculation for the predicted values assumes no mortality (although it also

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[1] Because there is currently some doubt regarding the accuracy of the reported salinity results (see TWIU Technical Note 91/10), the data used for Fig.9 have been corrected.

assumes no background contamination in the sea water).

At sampling site E, high in the catchment, "sewage fungus" was observed and subsequently traced upstream to a chronically polluted tributary of the Wembury Stream. The bed of this small stream was completely covered with a white/grey growth and the water smelled of silage/slurry. Pollution control staff at Bodmin were informed and R.Torr (PI) attended within an hour or so. He visited Spirewell Farm where this stream rises, and found that due to poor operational practice, a lagoon which received both silage liquor and slurry, was leaking into the stream. It appeared to have been doing so for some considerable time (years) and would have been much worse during periods of heavy or prolonged rainfall. Remedial action was suggested to the farmer and a written warning was issued by Pollution Section. The farmer is currently receiving advice from ADAS on his waste management system.

There was also evidence that the small tributary which joins Wembury Stream at the footbridge 250 metres from the beach adds a significant contribution to the overall bacterial loading. For E.coli this comprised approximately 16% of the total loading for the wet weather survey, and 20% for the dry. In addition, for the dry weather survey, the E.coli values for this tributary were initially very high; 54,000/100ml at 07.00 falling to 7000/100ml by 11.00 with correspondingly high faecal coliform/faecal streptococci ratios (98 to 19 respectively). These results, which suggest sewage contamination, prompted further investigation of the tributary.

Approximately 50 metres from source, the tributary changes direction and runs parallel to Church Road, Wembury. At this point, which is 70 metres from the junction of Cliff Road a 50cm concrete pipe discharges to the tributary. The concrete apron below the pipe was covered with sewage fungus, faecal solids and toilet paper. The discharge, estimated to be 0.25 l/sec, had a bacterial count of 150,000 total coliforms, 68,000 E.coli and 2000 faecal streptococci per 100ml. It appears to cause a substantial increase in bacterial levels in the tributary; although the discharge was only one fiftieth of the flow in the tributary, it contributed over ten times the microbiological loading! Bacterial numbers in the tributary increased from 200 total coliforms and 130 E.coli per 100ml immediately above the discharge, to 23,000 and 3,700 at the confluence with Wembury Stream.

South West Water Services Ltd. (SWWSL) were informed of our findings and confirmed that this discharge was from a surface water sewer which runs parallel to the foul sewer beneath Church Road. Surface water sewers should only convey water from roof drainage, surface water, and road drains. Following investigation of the sewerage system, SWWSL have discovered the source of the problem. It appears that the foul sewer from a property in Hawthorn Park Road was wrongly connected to the surface water sewer when the property was built, approximately 20 years ago. The owner has been informed of the mis-connection and is undertaking remedial action.

Apart from this survey there are no data available on the bacterial water quality during the months November to April. It is likely that as a result of greater rainfall during these months, water quality in the Wembury Stream will be worse, and EC mandatory values are more likely to be exceeded in the bathing waters. Wembury Beach regularly attracts surfers and surf canoeists, particularly in the sort of weather conditions which prevailed on the wet weather survey. There was at least one, and up to a maximum of six surfers in the water at any given time between 08.00 and 12.30.

The relative loadings from the sewage treatment works (estimated at 5.8×10^6 E.coli/sec) compared to those from the stream (2.7×10^6 E.coli/sec for dry weather, and 1.5×10^7 E.coli/sec for the rainfall event survey), coupled with its distance from the bathing water, make it unlikely to be a cause of failure.

Operation of the emergency overflow however could have considerable impact on the bathing waters because of its proximity to the beach.

Conclusions

1. Findings from both the rainfall survey and from analysis of historical data, lead to the conclusion that Wembury Beach is at risk of failing the EC mandatory bacterial standards when there is significant rainfall.

2. Both diffuse and point source agricultural inputs have been identified as factors affecting the bacterial quality of the Wembury Stream.

3. Operation of the surface water sewer discharge in Church Road has contributed significant bacterial loadings to Wembury Stream, probably for the last 20 years, as a result of the mis-connection in Hawthorn Park Road.

4. When bacterial levels in the stream are high, risk of failure is probably greater when sampling is undertaken within three hours of low water as a result of the beach topography.

5. Surfers and other water contact sports enthusiasts are likely to encounter poor bathing water quality during the winter months.

6. Wembury sewage treatment works is unlikely to cause exceedance of the EC mandatory bacteriological standards at Wembury Beach.

7. Operation of the Pumping Station Emergency Overflow which discharges to the Wembury Stream is likely to have a significant effect on bacterial quality in the bathing waters.

Recommendations & Actions

1. The farm campaign should be extended/repeated/implemented throughout the Wembury catchment in order to resolve point source discharges which affect the bacterial quality of the stream, and ultimately the bathing waters.

   Action: Pollution Officer (West)

2. The surface water sewer discharge in Church Road, Wembury should be periodically inspected and sampled in order to ensure that the problem does not re-occur

   Action: Pollution Officer (West)

3. Wembury Beach should be included in any future routine winter monitoring programme for surf beaches.

   Action: Tidal Waters' Scientist

4. The consent for the Pumping Station Emergency Overflow should be reviewed with regard to storage such that it complies with current policy.

   Action: Quality Regulation Officer

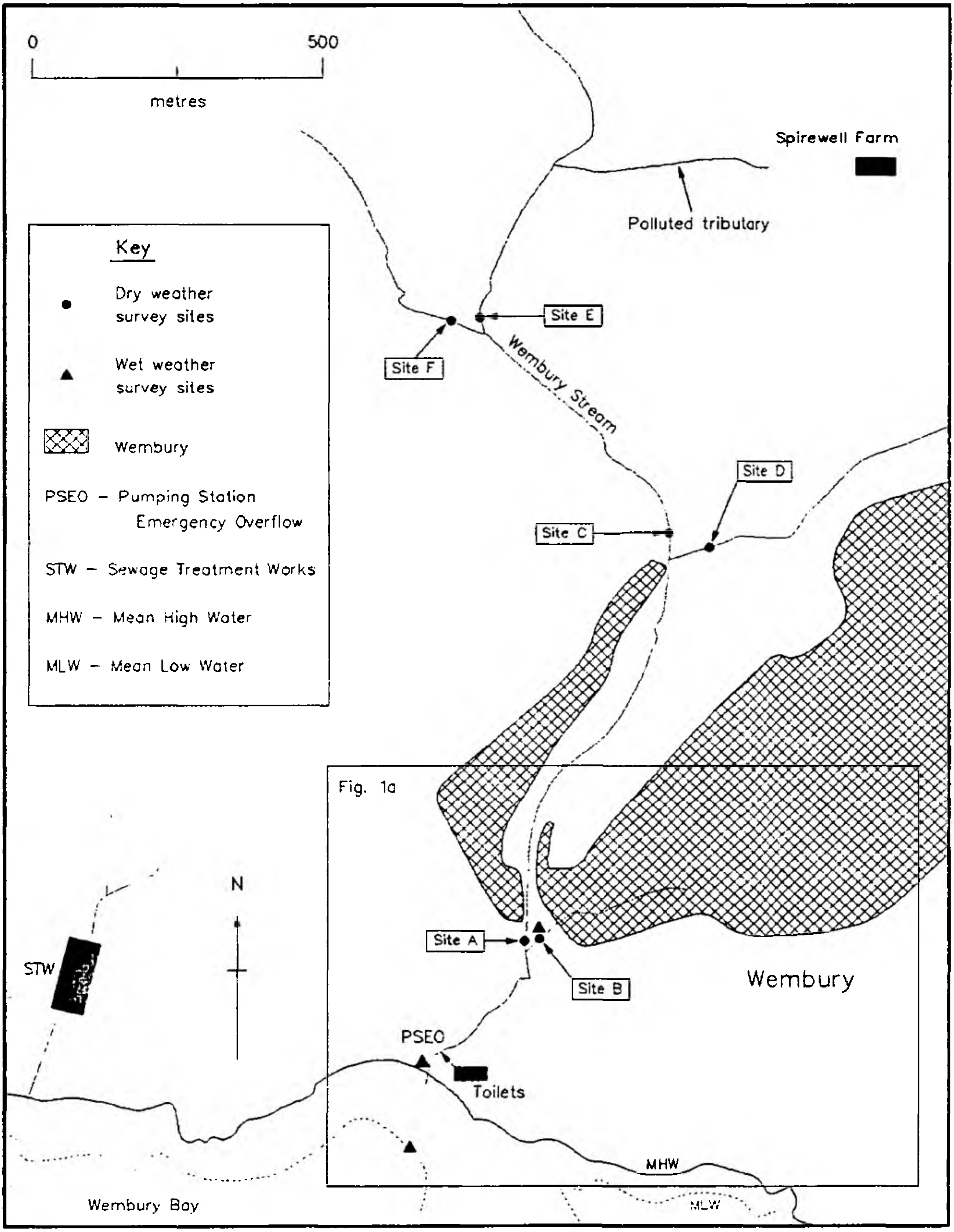

Fig. 1: Wembury Stream Catchment

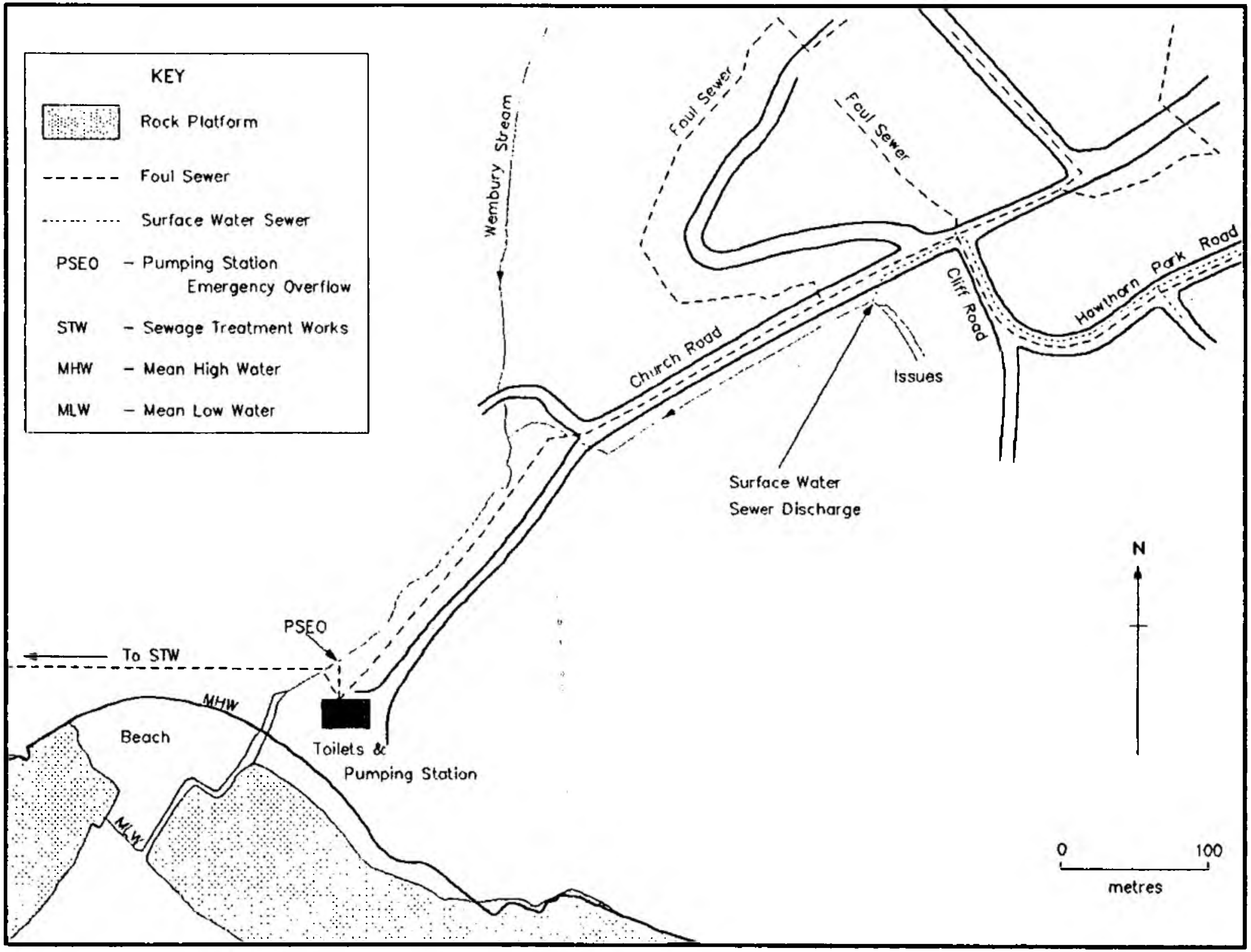

Fig. 1a: Detail of Wembury Sewerage (inset from Fig. 1)

Wembury Beach and Stream Investigations

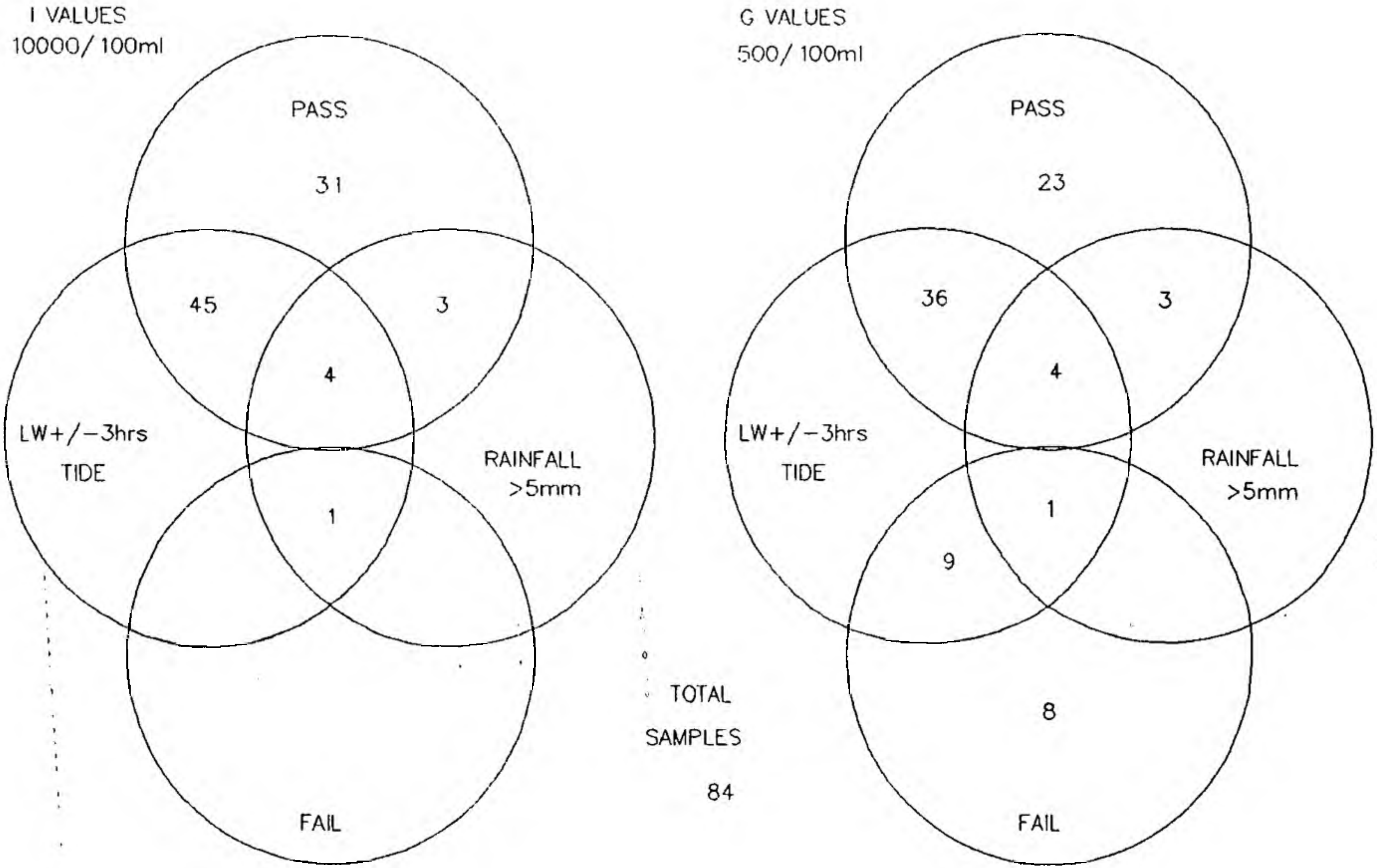

Fig. 2: Wembury Beach Routine Sampling: Total Coliform Results 1986 to 1990

Wembury Beach and Stream Investigations

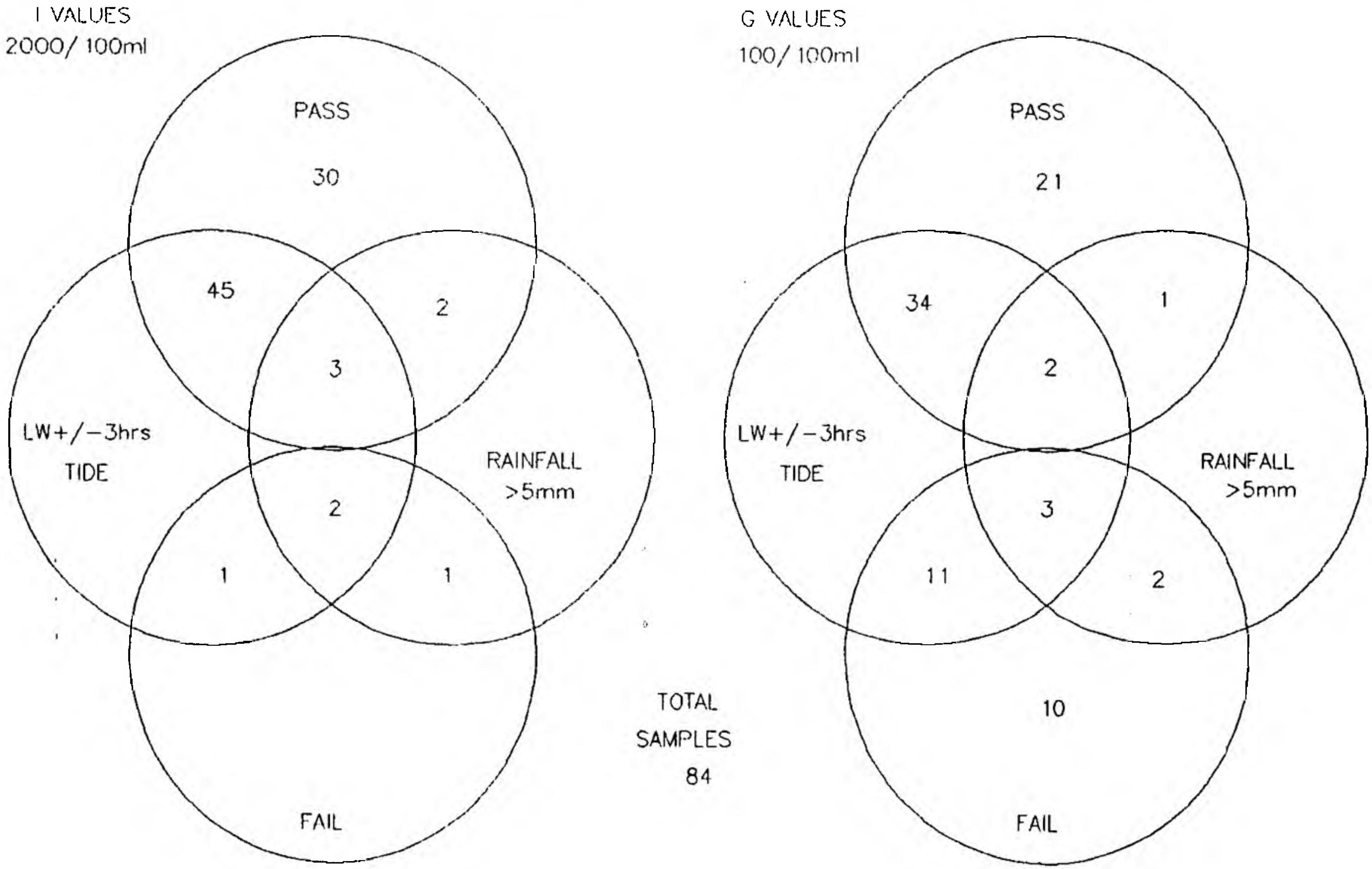

Fig. 3: Wembury Beach Routine Sampling: E.coli Results 1986 to 1990

Wembury Beach and Stream Investigations

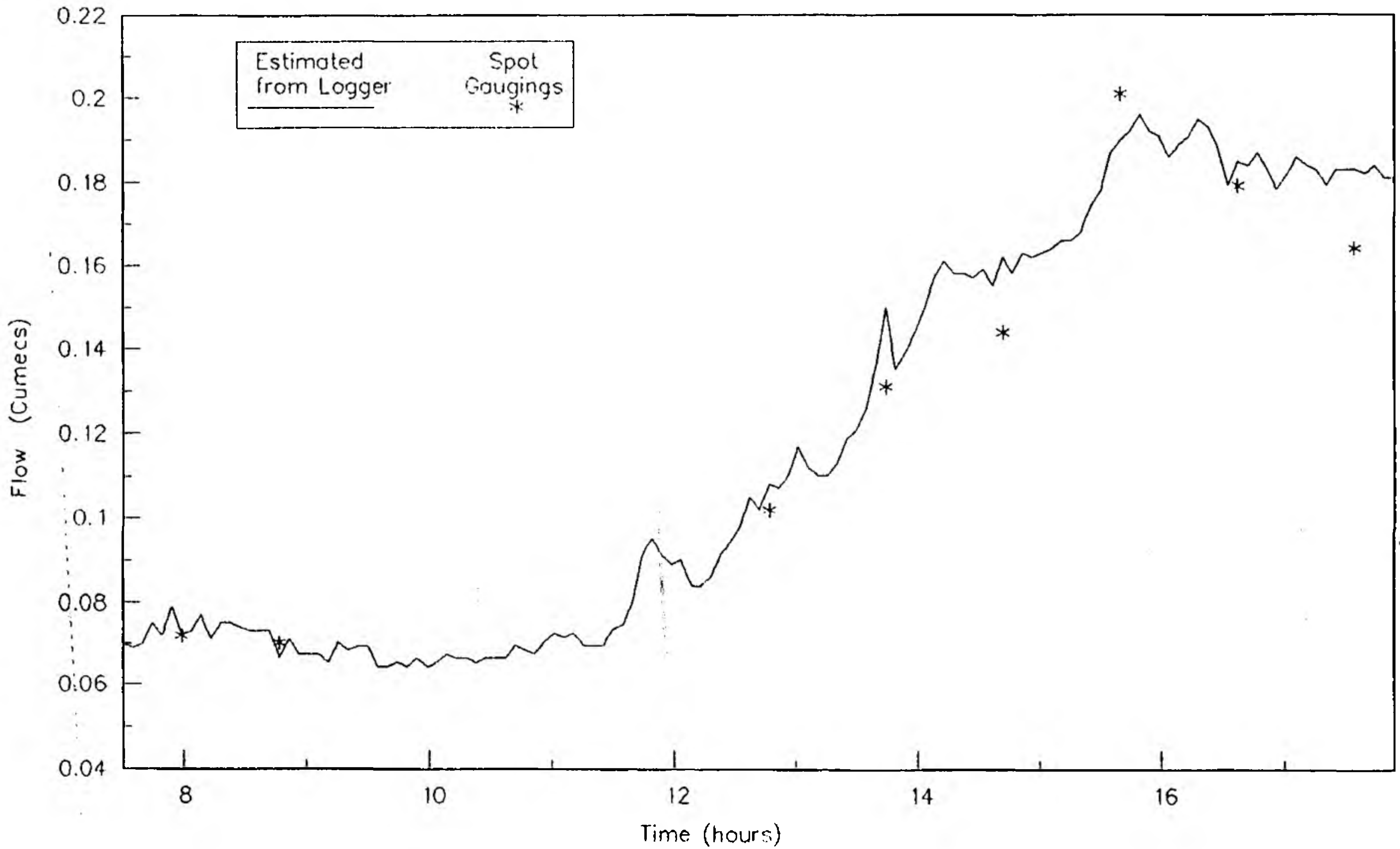

Fig. 4: Wembury Sream Flows (Estimated & Measured) 22.02.91

Wembury Beach and Stream Investigations

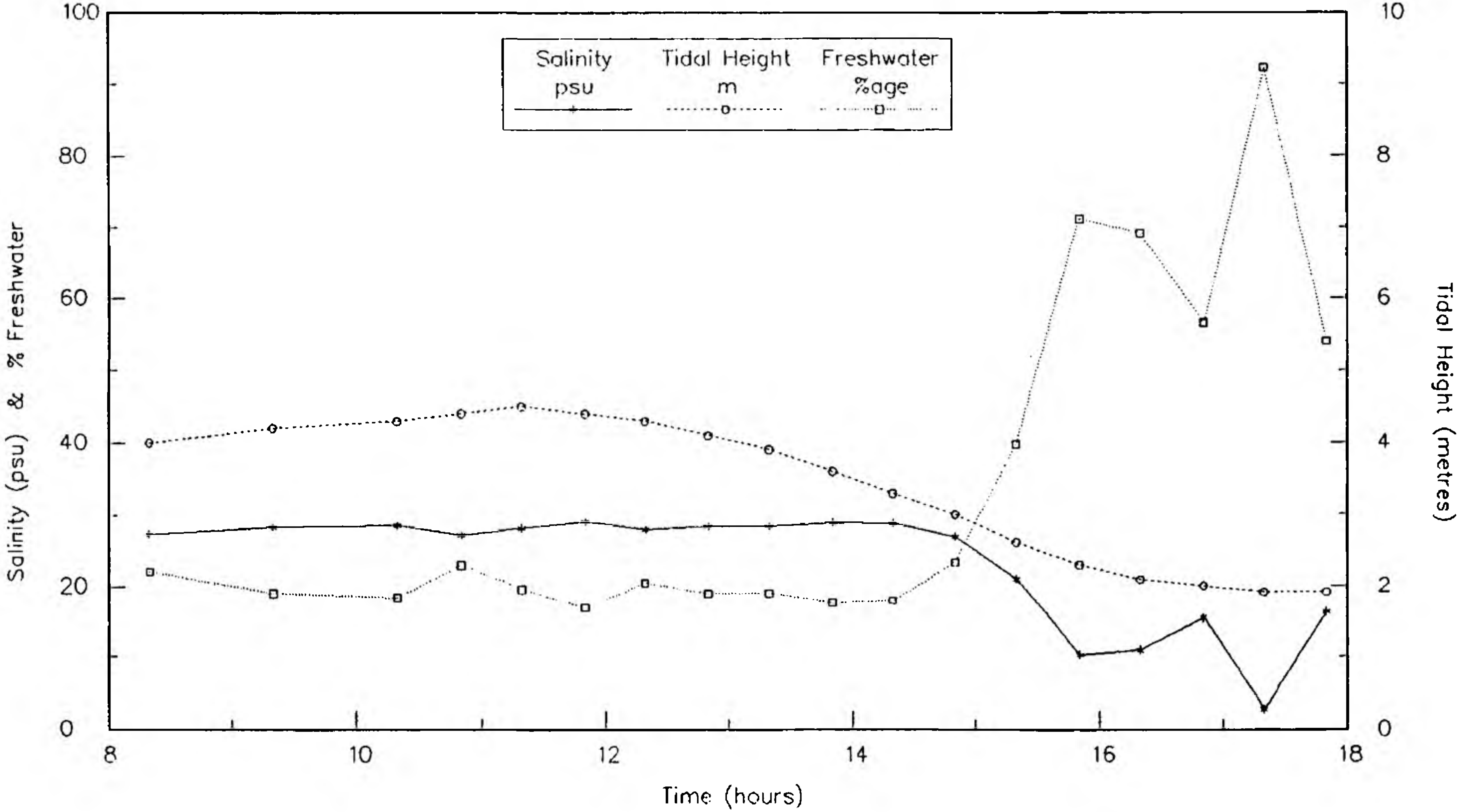

Fig. 5: Correlation between Tidal State & Salinity in Bathing Water Samples: 22.02.91

Wembury Beach and Stream Investigations

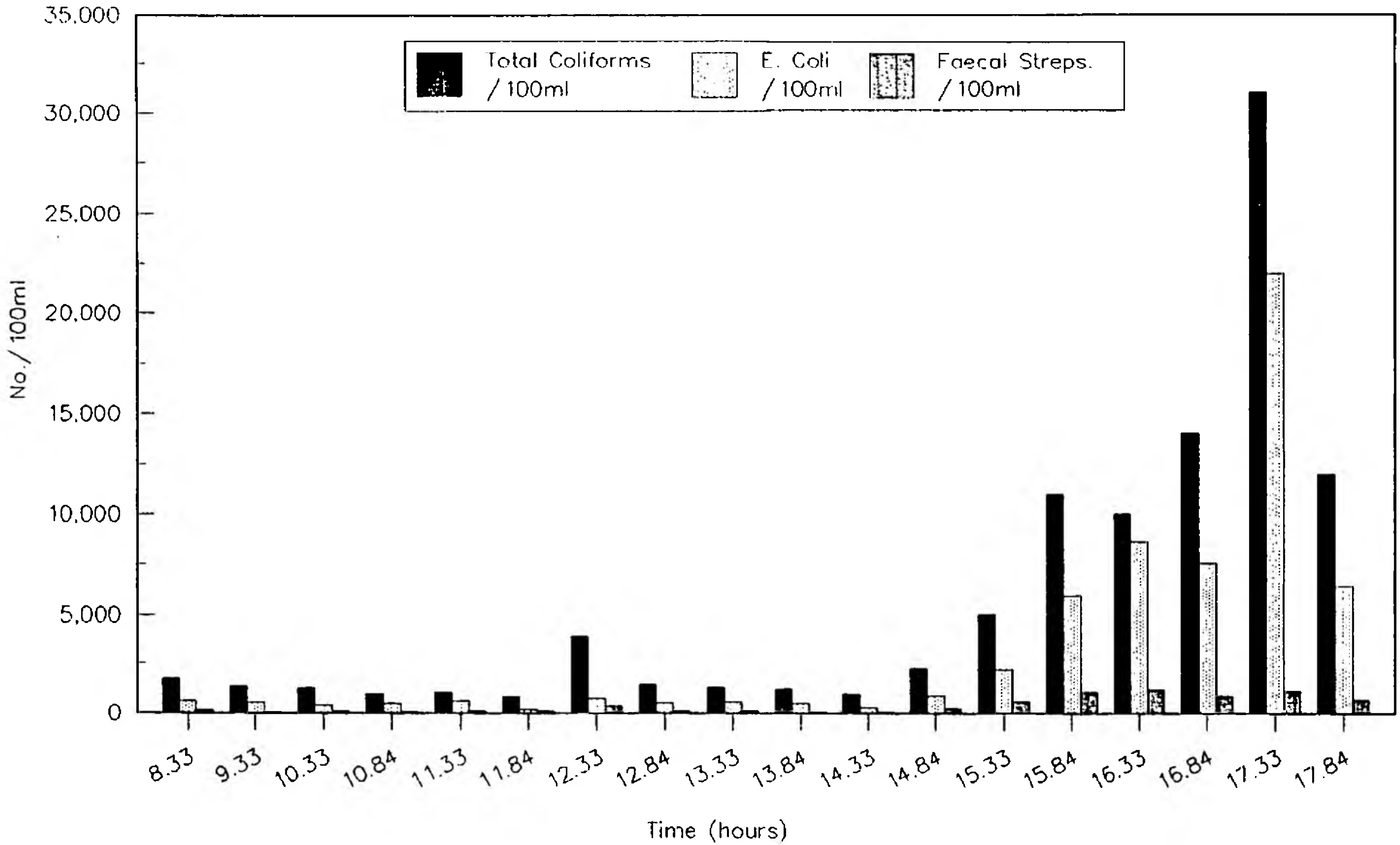

Fig. 6: Wembury Bathing Water Bacteriological Results for 22.02.91

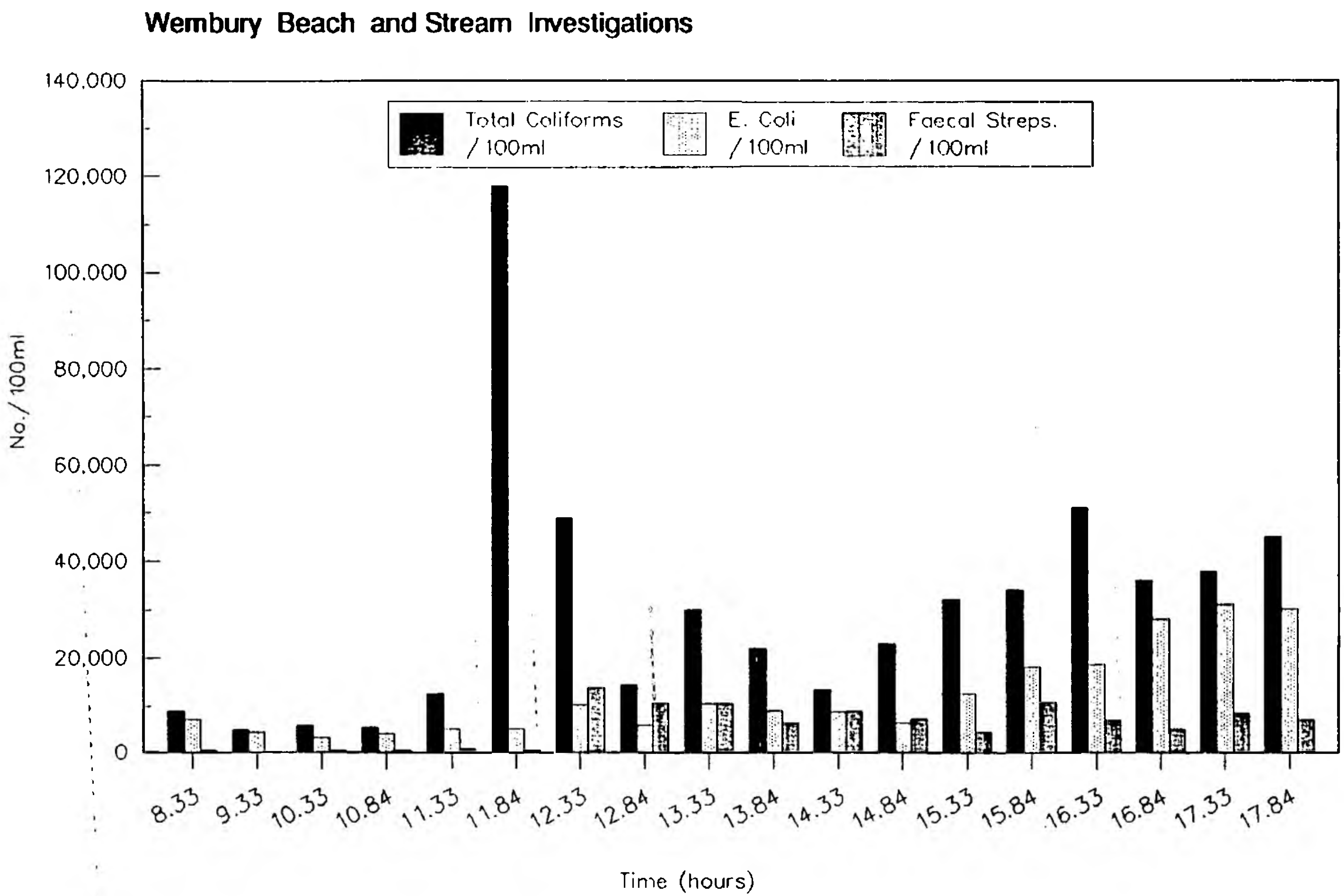

Fig. 7: Wembury Stream Bacteriological Results for 22.02.91

Wembury Beach and Stream Investigations

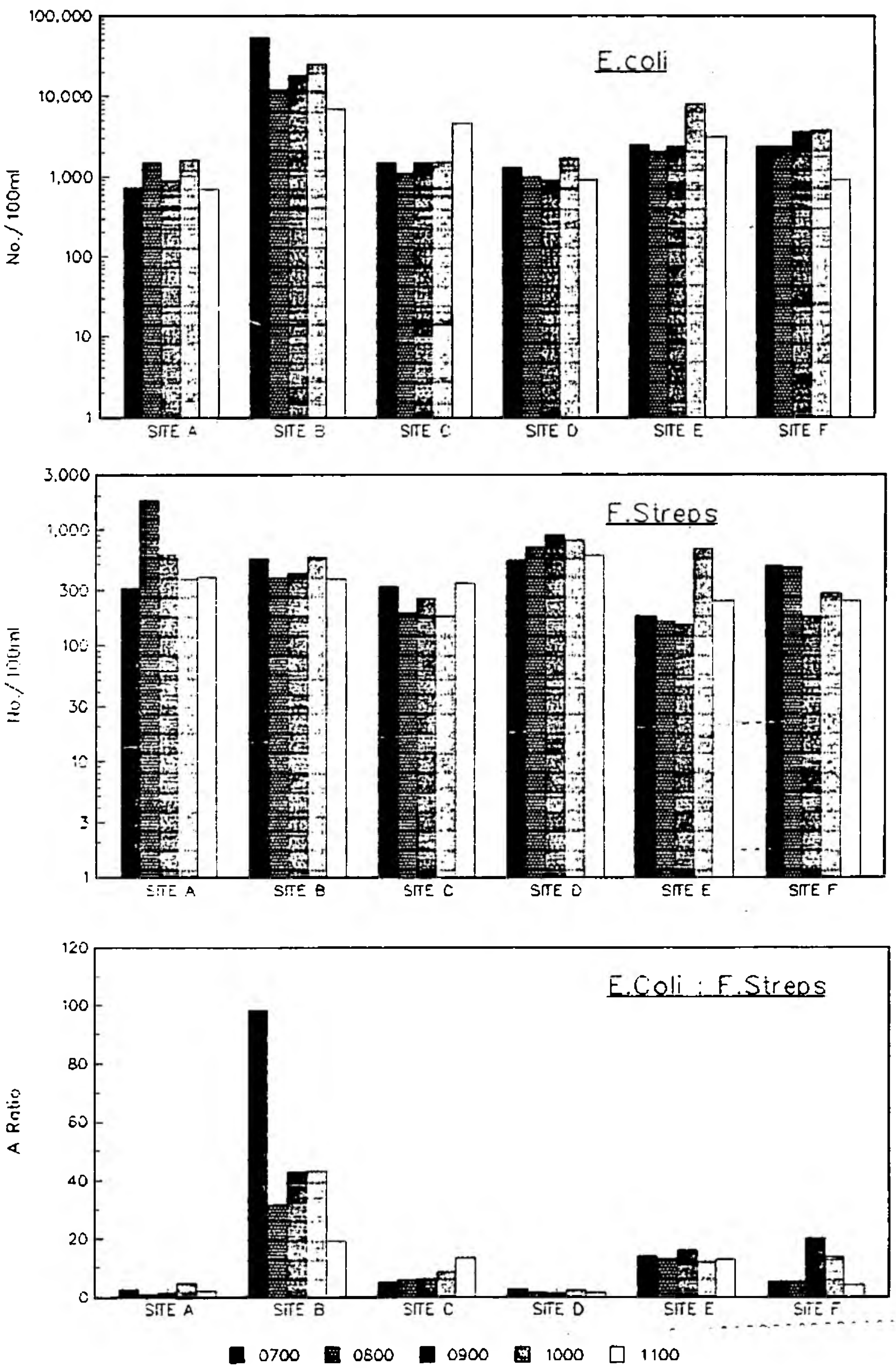

Fig. 5: Wembury Stream Dry Weather Survey 26.07.91

Wembury Beach and Stream Investigations

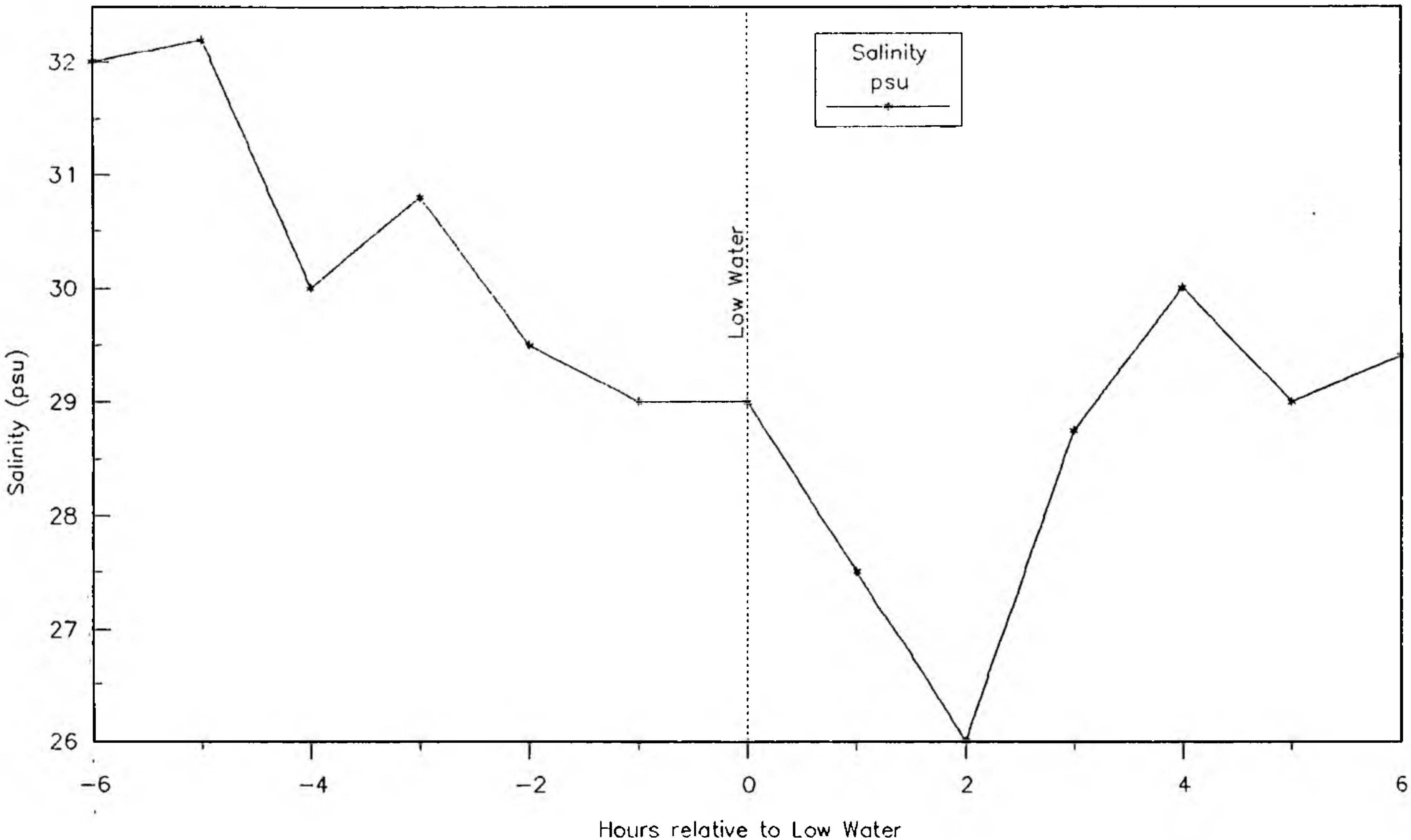

Fig. 9: Salinity of Routine Bathing Water Samples Related to Low Water 1987 – 1990

Wembury Beach and Stream Investigations

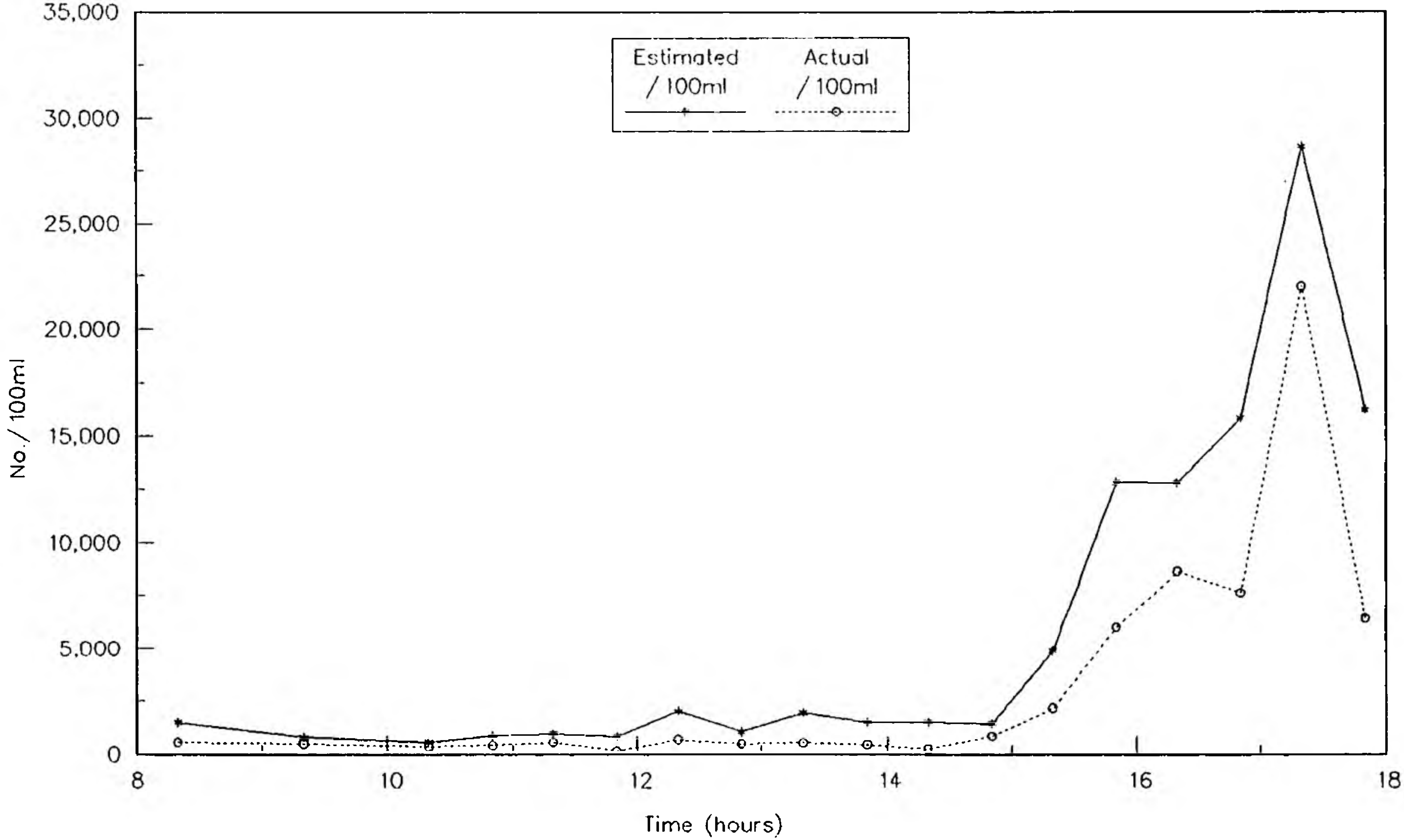

Fig. 10: Wembury Bathing Water E.Coli Values (Estimated & Actual) for 22.02.91

Wembury Beach and Stream Investigations

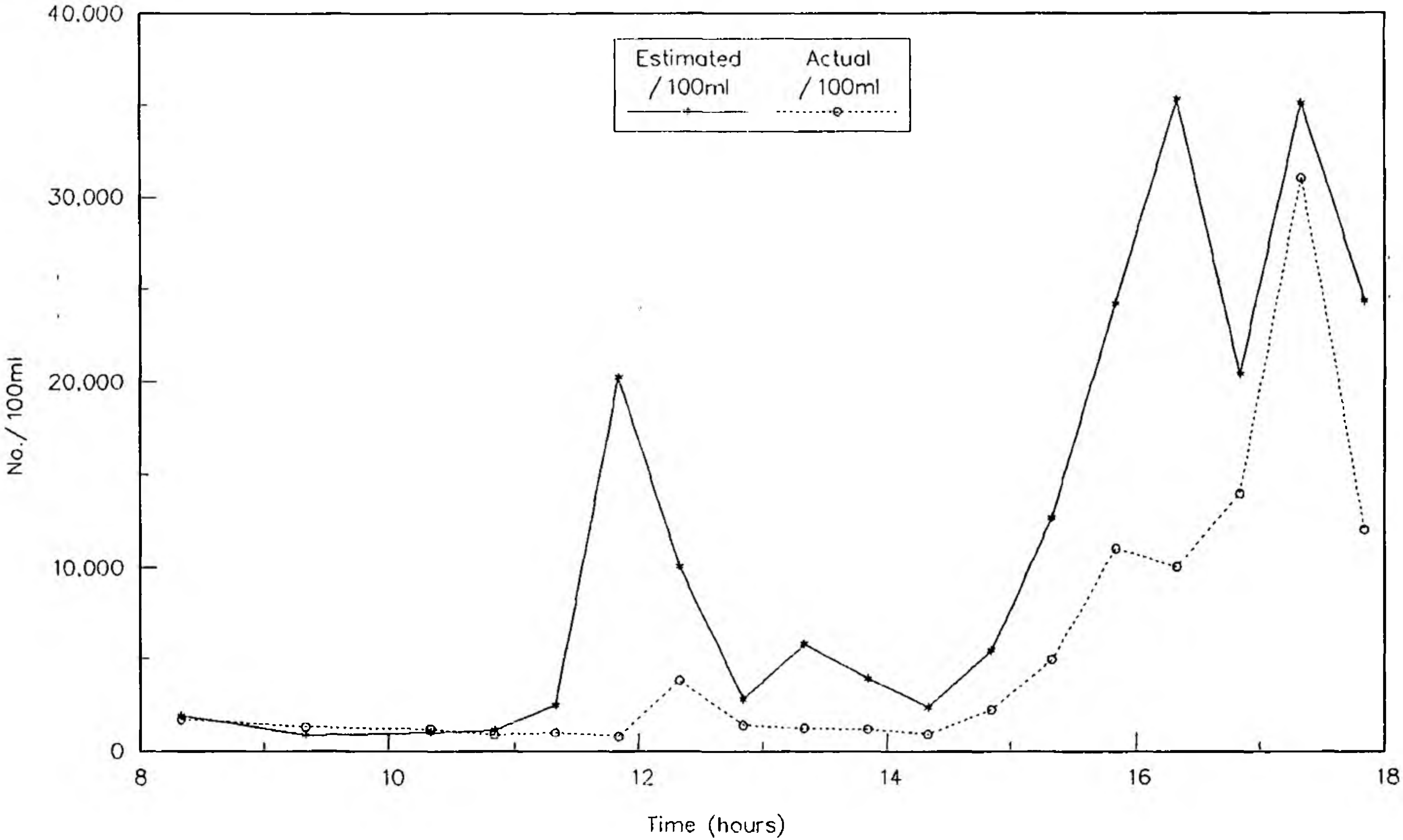

Fig. 11: Wembury Bathing Water Total Colifcm Values (Estimated & Actual) 22.02.92

Wembury Beach and Stream Investigations

Bacteriological Survey - 22.02.91

Time (local)	Total Coli (No./ 100ml)	E.Coli (No./ 100ml)	F.Streps (No./ 100ml)	Salinity (psu)
8.20	1700	560	100	27.3
9.20	1300	496	30	28.3
10.20	1200	368	70	28.5
10.50	900	432	50	27.0
11.20	1000	568	80	28.1
11.50	800	170	60	29.0
12.20	3800	700	320	27.8
12.50	1400	500	90	28.3
13.20	1240	550	90	28.3
13.50	1180	460	50	28.8
14.20	900	260	40	28.7
14.50	2200	840	210	26.8
15.20	4900	2150	540	21.1
15.50	11000	5900	980	10.1
16.20	10000	8600	1140	10.8
16.50	14000	7600	820	15.2
17.20	31000	22000	1060	2.7
17.50	12000	6300	620	16.1

Table 1: Wembury Bathing Water Results

Time (local)	Total Coli (No./ 100ml)	E.Coli (No./ 100ml)	F.Streps (No./ 100ml)
8.20	8600	6700	290
9.20	4500	4100	230
10.20	5500	3100	410
10.50	5000	3800	380
11.20	12500	4900	700
11.50	118000	4900	470
12.20	49000	9800	13700
12.50	14500	5500	10000
13.20	30000	10100	10000
13.50	22000	8600	6100
14.20	13000	8400	8600
14.50	23000	6100	6900
15.20	32000	12100	4000
15.50	34000	18000	10200
16.20	51000	18500	6500
16.50	36000	28000	4700
17.20	38000	31000	7900
17.50	45000	30000	6600

Table 2: Wembury Stream Results

Wembury Beach and Stream Investigations

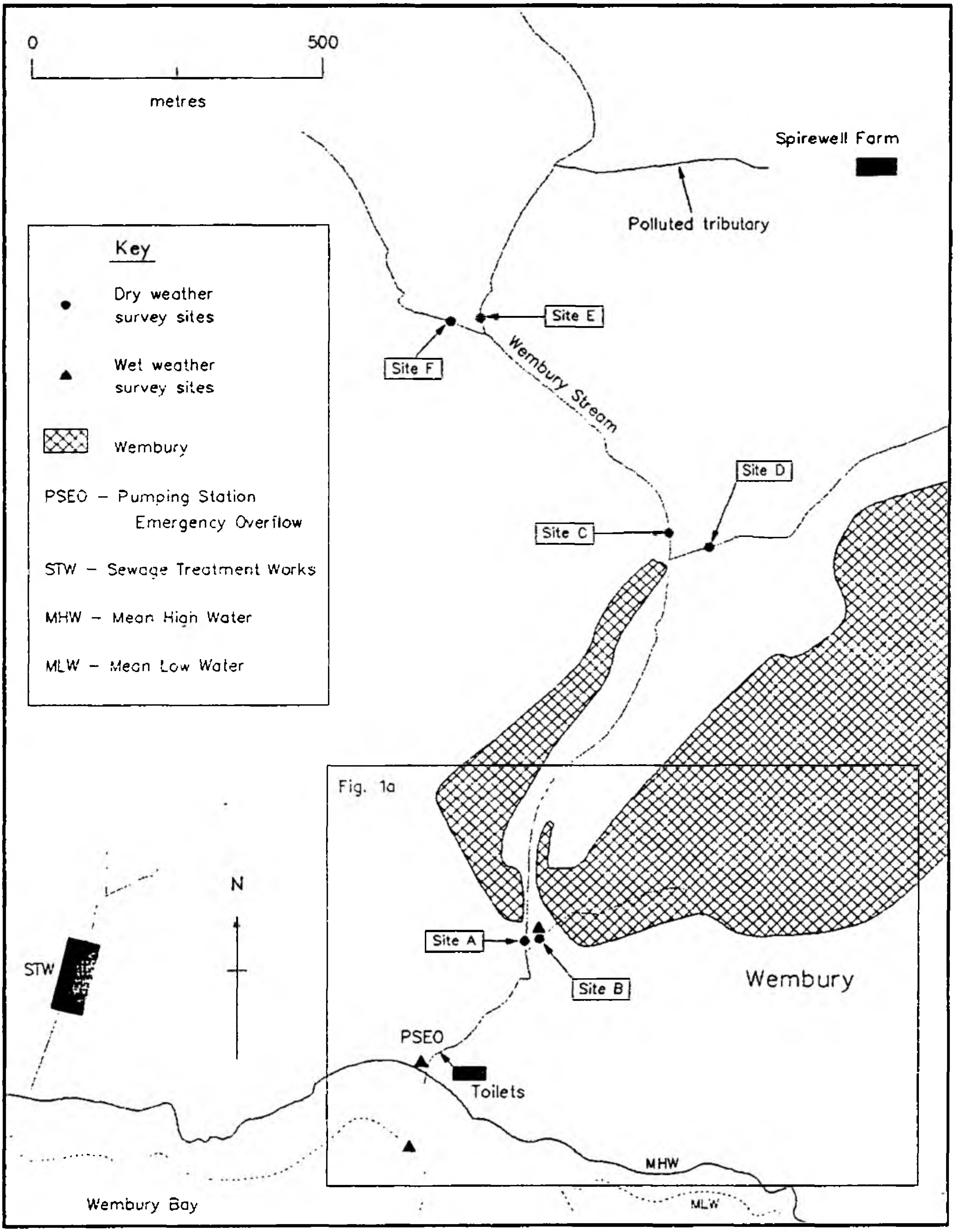

Fig. 1: Wembury Stream Catchment

Wembury Beach and Stream Investigations

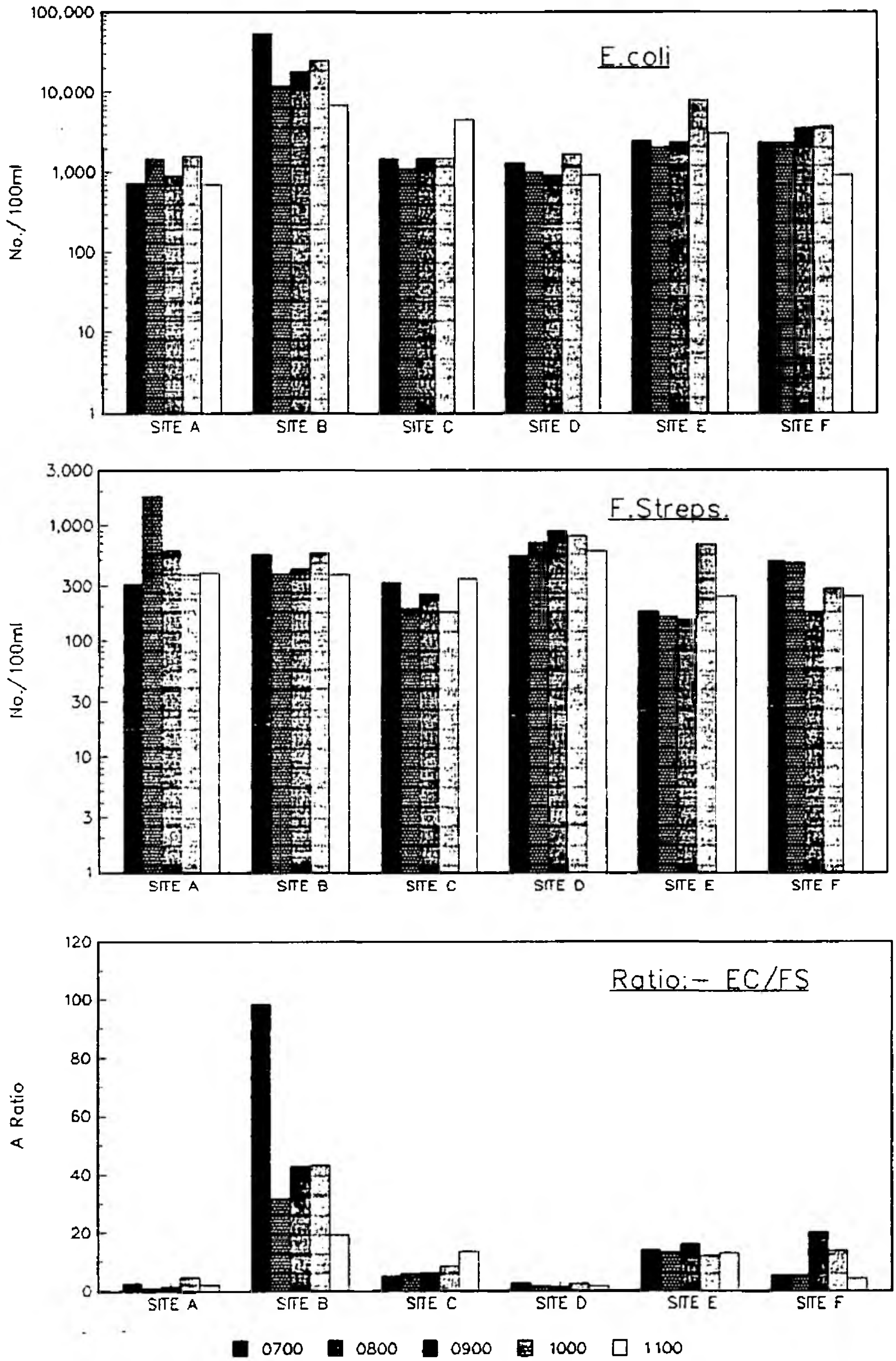

Fig. 8: Wembury Stream Dry Weather Survey 26.07.91

Wembury Beach and Stream Investigations

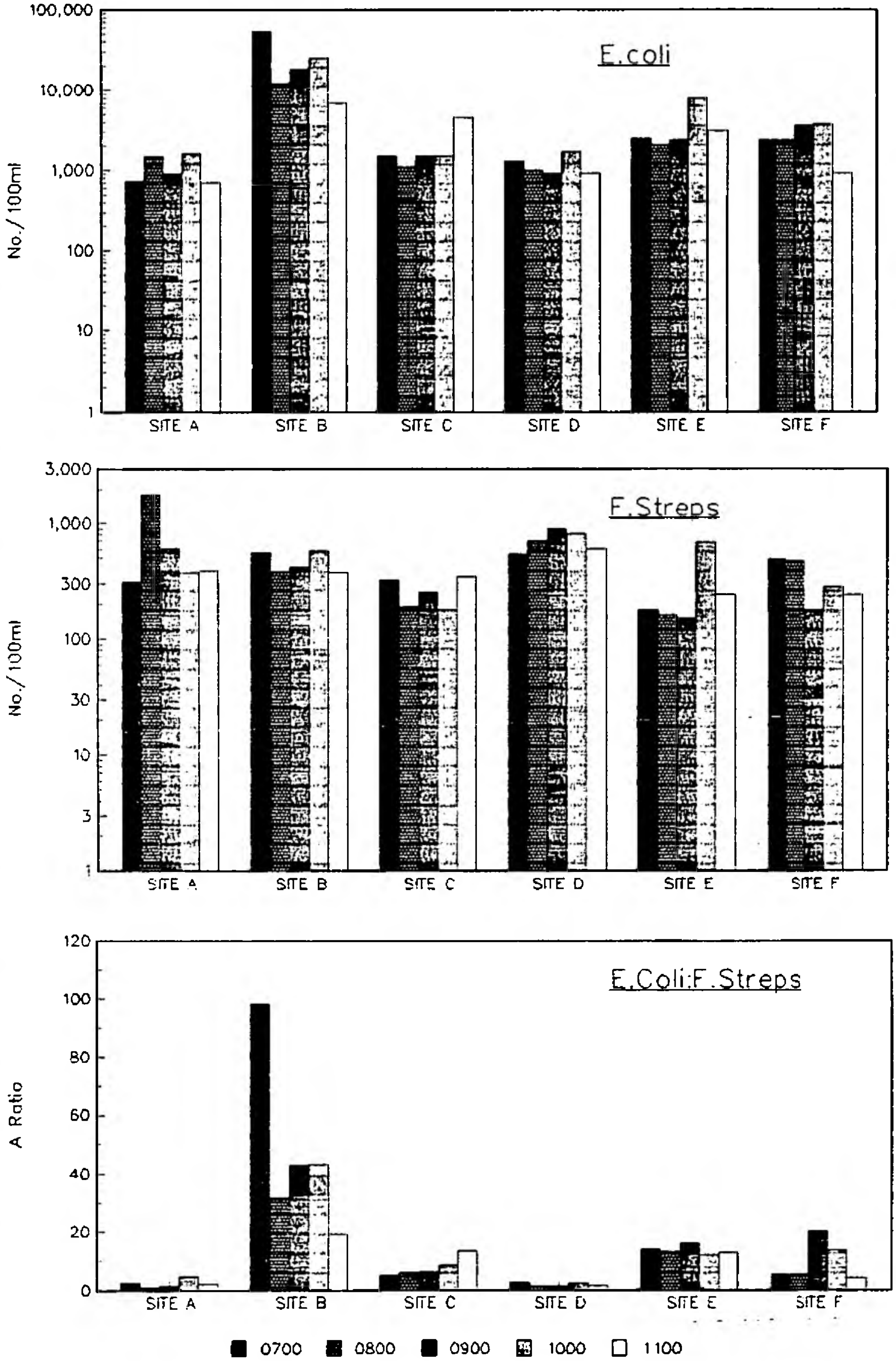

Fig. 8: Wembury Stream Dry Weather Survey 26.07.91