CHAPTER 2.

COASTAL DEVELOPMENT AND IMPACT ASSESSMENT

In most cases, the full use of coastal zone resources requires some form of infrastructural development. For example, the enjoyment of a bathing beach by tourists may be enhanced by construction of breakwaters or by provision of adjacent accommodation and refreshment outlets; a fishing village benefits from calm moorings and storage facilities; and commercial shipping depends on adequate docking space, dredged channels and navigation markers. Increasing development of the coast requires expansion of these structures by modification of coastal environments, as with the filling of mangrove wetlands for dock expansion and a race track in St. Thomas (Towle, 1985) or river diversion during industrial development in Point Lisas, Trinidad (McShine-Mutunhu, 1985).

Problems arise in many of these situations when the structure and dynamic features of poorly understood coastal systems are altered. Negative impacts of island coastal development projects have been reported by numerous authors, and include: coral reef damage through sand extraction for the construction industry in Moorea, French Polynesia (Salvat, 1980), with similar activities threatening reefs in Guam, Ponape, Yap and other Pacific islands (Wells, 1984); beach erosion and reduction in habitat diversity in Barbados (Cambers, 1985); and loss of a phosphorescent bay through wetland reclamation at Falmouth, Jamaica (Bacon, 1987a).

It must be remembered, however, that the natural environment is extremely resilient; the Caribbean islands, for example, have been subjected frequently to marked human impact for over 300 years but remain relatively healthy and productive (Bacon, 1985). For each island there are many examples of successful development projects, which suggest that island coastal areas can be modified without causing damage or deterioration of resource values. The coastal zone manager needs to be aware of the opportunities and limitations for manipulating coastal ecosystem components. It is possible then to understand the impacts of existing developments and to prevent negative impacts resulting from proposed projects (see Bryden, 1975 & Lewsey, 1987).

This section deals with development impact assessment by examining **tourism development**, which is of primary importance in the economy of many tropical island states. The principles and techniques developed in this context can be applied to coastal residential, industrial and can be applied to coastal residential, industrial and fisheries developments.

In most tropical islands tourism is centered on the beaches. Stable deposits of clean sand and adjacent calm, clear seawater are favoured resources for this activity. It is important to maintain the quality of these resources in the face of natural changes and increasing development of coastal areas. Resort areas normally require infrastructure for marina and boating activities; and the necessary piers, breakwaters and groynes may be extensive where sailing is important or cruise ship stopovers frequent. Man-made structures in the marine environment must be constructed and located carefully to avoid problems of erosion, stagnation, wave damage, or interference with coastal current movements.

With increasing use of any coastal area by residents or visitors, waste disposal into the sea becomes a critical issue, as does disposal of effluents when recreational beaches are adjacent to industrial areas. There must be continued monitoring of water quality to ensure that the coastal seawater remains safe for human use.

Exercise 2.1 ASSESSING BEACH CHARACTER AND STABILITY

Background:

The liability of a coast to erosion and its response to varying inputs depend on a number of factors, the more important of which are listed below:

(a) **Exposure.** The exposure to wave attack, the protection by offshore reefs and headlands, and the form of the coastline in plan are all contributory factors.

(b) **Coastal type.** These are low coasts with or without dunes, rocky coasts, coasts with cliffs, all of which will behave differently.

(c) **Littoral drift.** The direction of littoral drift, and the amount of drift into and out of the stretch of beach are important.

(d) **Human interference.** The character of a beach can be completely changed by human interference with littoral processes. Among the worst forms of interference are beach sand mining, mining of coral reefs, and building in the active beach zone.

In addition to the character of a beach, it is important to determine its stability. Different kinds of stability may be recognized at any particular location. The major types are:

(a) **Long-term stability.** This is where major changes are brought about only by the largest infrequent storm waves.

(b) **Seasonal stability.** This is where the beach profile may vary cyclically through the year on account of seasonal changes in the wave climate.

(c) **Stability over a tidal cycle.** Appreciable variation over a lunar tidal cycle may be observed at many beaches.

Aims:

(a) To make an assessment of the character of a selected beach.
(b) To make an assessment of the long-term stability of the beach.
(c) To make an assessment of the seasonal and tidal stability of the beach.

Duration:

A minimum of one day in the field, and three days in the drawing office and laboratory.

Suitable Location:

Any beach that is accessible (i.e. not more than one to two hours drive away from the laboratory and drawing office). It is preferable that the beach has well-defined headlands, and that the phenomena to be studied are not too complicated. A beach located on the leeward side of the island is preferable, as the seasonal variations are better demonstrated.

Materials Required:

Topographic maps, hydrographic charts, geological maps, soil maps, aerial photographs of region under study. Where possible, maps and photographs made over several years should be examined, particularly the photographs.

Data sheets for wave direction and period and storm frequency.
Binocular microscope, oven, set of sieves (U.S. Standard 3/4 inch to No. 200; or British Standard 20 mm to 0.002 mm).
Surface floats and drogues.
Sample bags.
Level and levelling staves, 50 m tape.
A small boat with outboard motor at the site.

Instructions:

Drawing office methods

1. Review maps and materials provided on the beach site, and prepare a short note on the physical setting i.e. location, latitude, longitude, which coast, backbeach vegetation, headlands, orientation, degree of protection. (1 hour)

2. Use the optical equipment to convert maps to common scale (see Ex. 3.1). Then make comparisons of long-term erosion rate by plotting the extent of the beach in different years on a common map. If several aerial photographs are available for any one year, seasonal change in beach profile may be assessed, as well as long-term changes. (2 hours)

3. Prepare refraction diagrams from aerial photographs (Appendix 3). Estimate the wave periods from the wave

lengths shown on the photographs and depths taken from the hydrographic chart; or consult the data sheet. (1 hour)

4. Prepare refraction diagrams for extreme wave attack, using the hydrographic chart, and data sheet on hurricane waves and movement. (2 hours)

Field methods

5. Make two profiles on visit to the beach at low tide and high tide. Obtain estimates of breaker type, i.e. spilling, plunging or surging; height, and period at low and high tide (see Appendix 3).

6. Take samples of sand at mid-tide level at the same location as the profiles.

7. Measure longshore current by means of drogues and surface floats. This should be done just seaward of the breaker line. If the breakers are high, drogues should be used, while surface floats are adequate in areas of mild breakers.

8. Examine the headlands to determine the type of rock, and state of erosion, i.e. estimate whether sand is moving past the headlands, and if so, in what direction.

9. Take photographs at high and low tide of all salient features.

10. During the visit to the beach, interview users of the beach such as fishermen, bathers or surfers. Try and obtain data on the condition of the sea at various times of the year using the present state as the base, i.e. any severe storms, the extent of removal of sand by trucks, use of beach by turtles, etc..

Laboratory methods

11. On return to base, carry out sieve analysis and examine the samples under the binocular microscope to determine composition and roundness. Determine the Folk & Ward classifications, classify the sand as mineral, shell, coral or algal, and determine the likely source of the sand, (see the case study below). (2 hours)

12. Prepare the profiles. (1 hour)

13. Discuss the results. (1 hour)

14. Prepare a report on the results of the investigations. (3 hours)

Product:

The result expected from this exercise should be similar to the following **Case Study**. The information which follows is based on an actual example, although minor changes have been made in some of the details.

Physical Setting

Dickinson Bay is located on the north-west coast of Antigua (Figure 2.1) at approximately 17° 9' N latitude and 61° 51' W longitude. The beach, which is oriented in a north-east to south-west direction, is approximately 1,500 m long. The predominant geological formation along the northern part of this coast is the Antigua limestone which rises to elevations of between 60 m and 100 m above sea level. This formation outcrops at Wetherell Point, which is a prominent headland forming the northern extremity of the beach. The southern extremity of the beach is formed by the prominent headland called Corbizon Point, which is composed of an isolated outcrop of gravel cherts, locally known as the Corbizon chert beds.

The most prominent feature of the southern section of the coast is a large salina. The northern section of this wetland is separated from the sea by a strip of beach varying in width from 150 m to less than 30 m.

H.O. Chart 2064 (see Figure 2.1) shows that this section of coast is protected from the full force of the predominant waves by the outer reef (Salt Fish Tail). Further protection is afforded to Dickinson Bay by a line of reefs running from Wetherell Point due west and terminating in offshore islands (Little Sister and Great Sister) (see Figure 2.2).

Historic Erosion Pattern

Figure 2.3. shows comparisons of the 1942 and 1969 coastlines, as obtained from aerial photographs. The original scale of the aerial photography was approximately 1:20,000. This scale was too small for accurate measurement of erosion. However, it is estimated that the erosion in Dickinson Bay close to Corbizon Point between 1942 and 1968 was 30 m to 40 m.

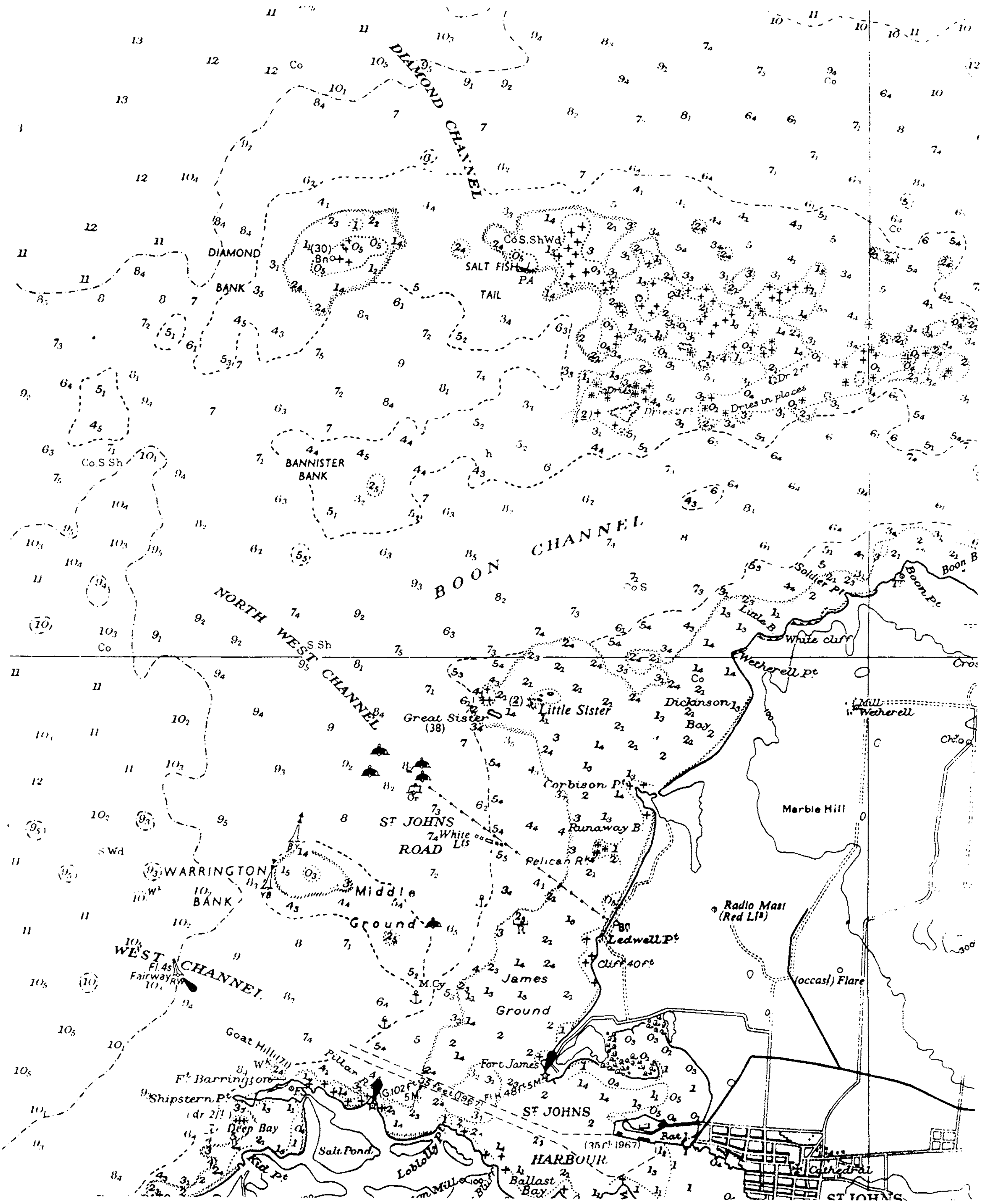

FIGURE 2.1 OFFSHORE CONDITIONS - N.W. ANTIGUA
(source: HO Chart 2064)

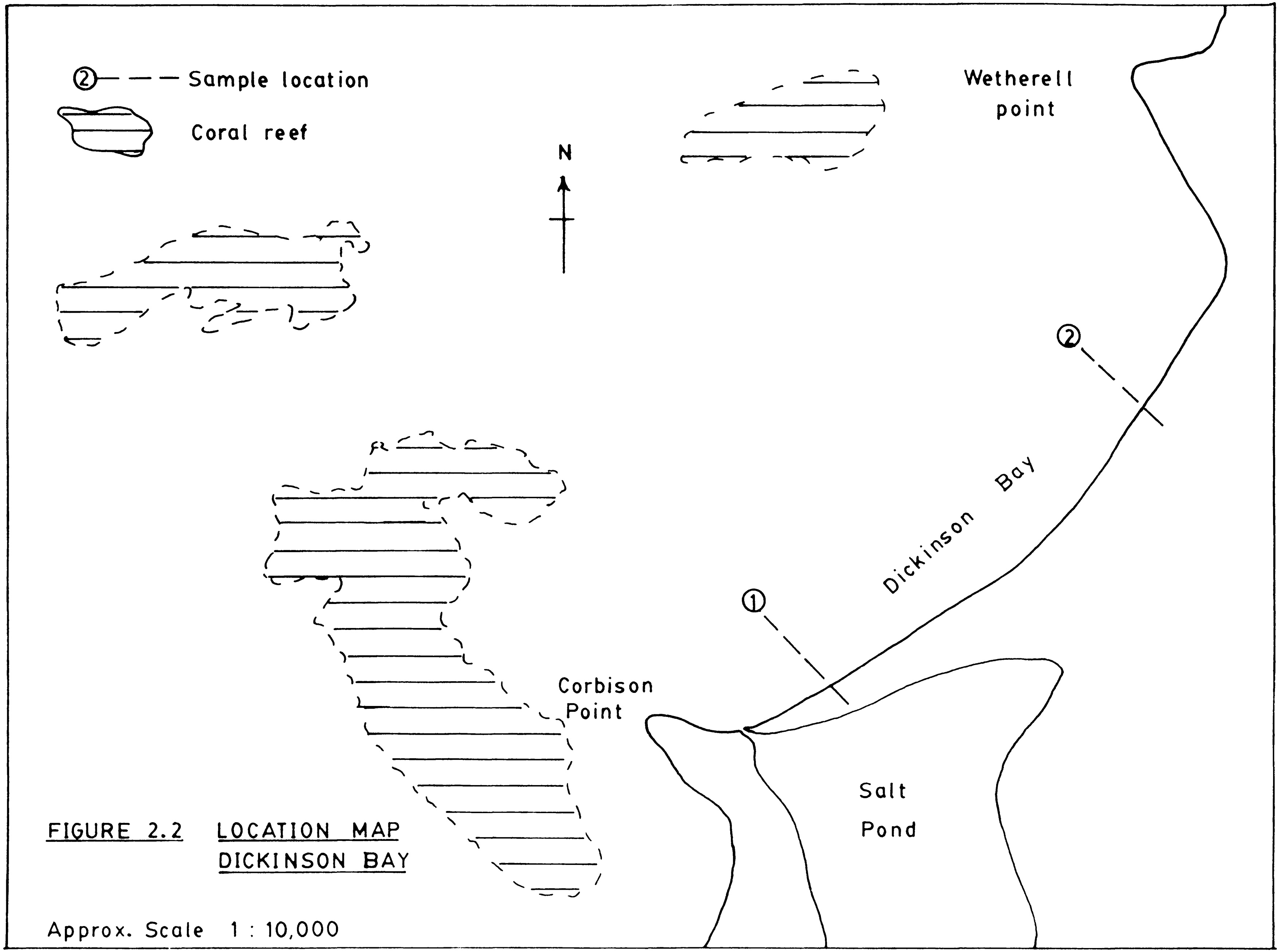

FIGURE 2.2 LOCATION MAP DICKINSON BAY

Approx. Scale 1 : 10,000

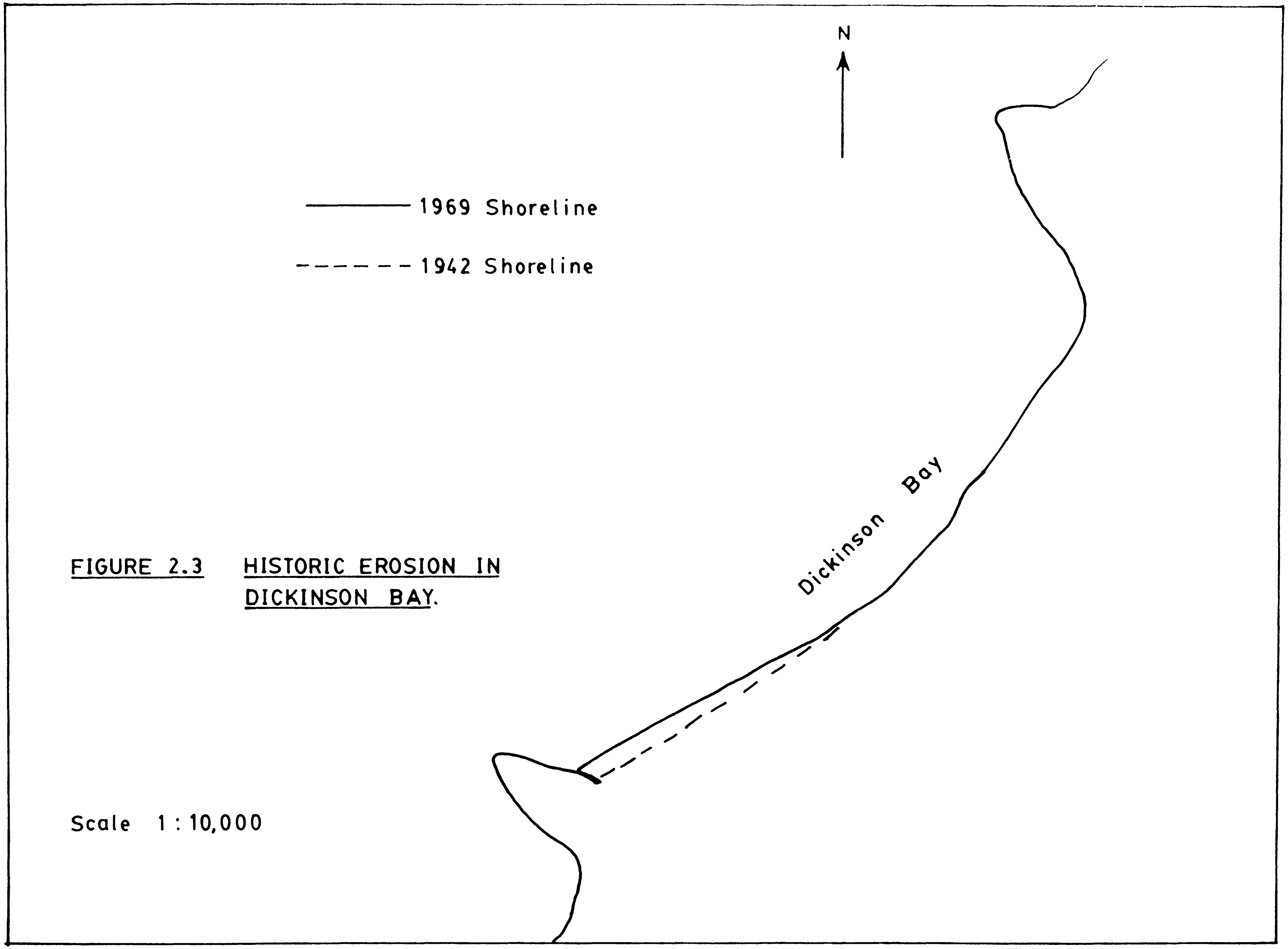

FIGURE 2.3 HISTORIC EROSION IN DICKINSON BAY.

Scale 1 : 10,000

Refraction Diagrams

Aerial photograph 99-AT.1-009, flown on 1st March 1968, shows very short-crested waves, with length 10m to 20m travelling from a north-easterly direction in Boon Channel opposite Dickinson Bay - the depth of water was 10 m to 15m. Longer waves of 60 m average length were measured approaching the coast from a north-westerly direction. The average depth of water in which these waves were observed, as given by Figure 2.1 was 3 m.

Long waves	Short waves
d = 10 m	d = 10 m to 15 m
L = 60 m	L = 10 m to 20 m
d/L = 0.166	d/L = > 0.5
From Appendix 3	Therefore L = Lo
d/Lo = 0.1293	And T = 2.5s to 3.5s

and Lo = 60/0.1293 = 464 m

But $Lo = gT^2/2\pi$ where g = gravity ($9.80665 ms^{-2}$)

And Therefore T = 17.2 s

The refraction diagram is shown in Figure 2.4.

Hurricane Wave Attack

Data on deepwater wave conditions, including hurricane attack is given in Table 2.1. Hurricanes pass Antigua, travelling in a westerly to north-westerly direction. Dickinson Bay is protected from waves travelling from all directions except between north-west and west; the direction of hurricane attack is from the west-north-west, therefore, production of a refraction diagram was not necessary.

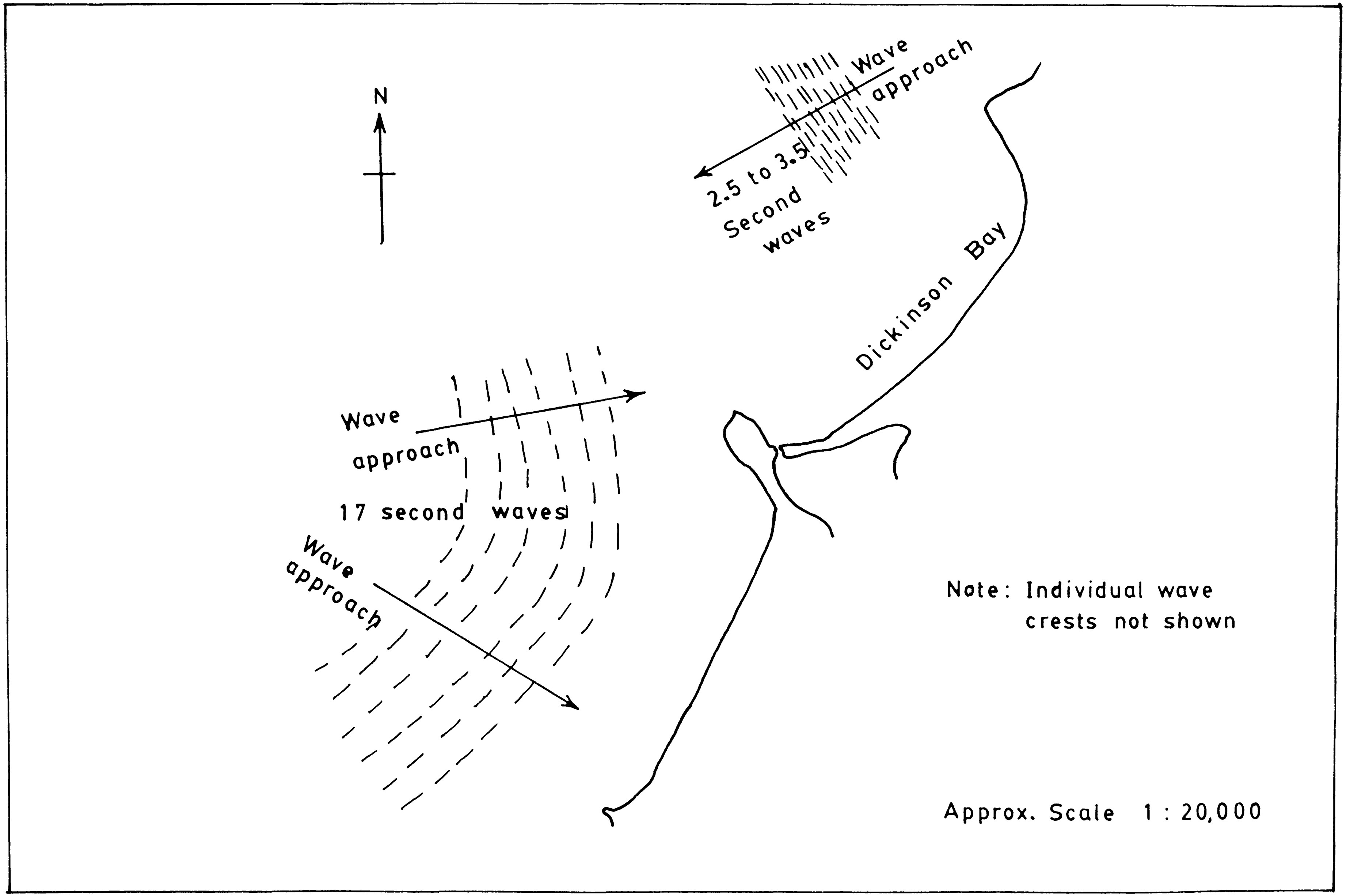

FIGURE 2.4 REFRACTION DIAGRAM FROM AERIAL PHOTOGRAPHY (1/3/68).

Table 2.1 Deepwater Wave Statistics

Frequency Occurrence Exceeded	Trade Wind waves		Northern swell		Hurricane waves	
	$H_{1/3}$(m)	T(sec)	$H_{1/3}$(m)	T(sec)	$H_{1/3}$(m)	T(sec)
50 %	3.3	7-10				
10 %	4.6	7-10				
1 %	7.0	7-10	1.5	14-16	1.5	6-8
Once/annum	8.5	7-10	3.6	16-20	3.0	6-8
Once/10 yrs	9.0	7-10	9.0	20-25	10.0	7-10
Direction of Approach	050^0 - 130^0		330^0 - 030^0		variable	

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Results of Field Visit and Laboratory Tests

Sections were taken at two locations, numbered 1 and 2 on Figure 2.2. These sections are shown on Figures 2.5 and 2.6. Samples of sand were taken at mid-tide level at the same locations as the profiles. These samples were washed and dried in an oven, and then sieved. The results of the particle analysis are given in Tables 2.2 and 2.3, while these results are plotted on semi-logarithmic paper on Figures 2.7 and 2.8. Small portions of the sand were examined under the binocular microscope and observations made of type of material present, and the shape of the particles.

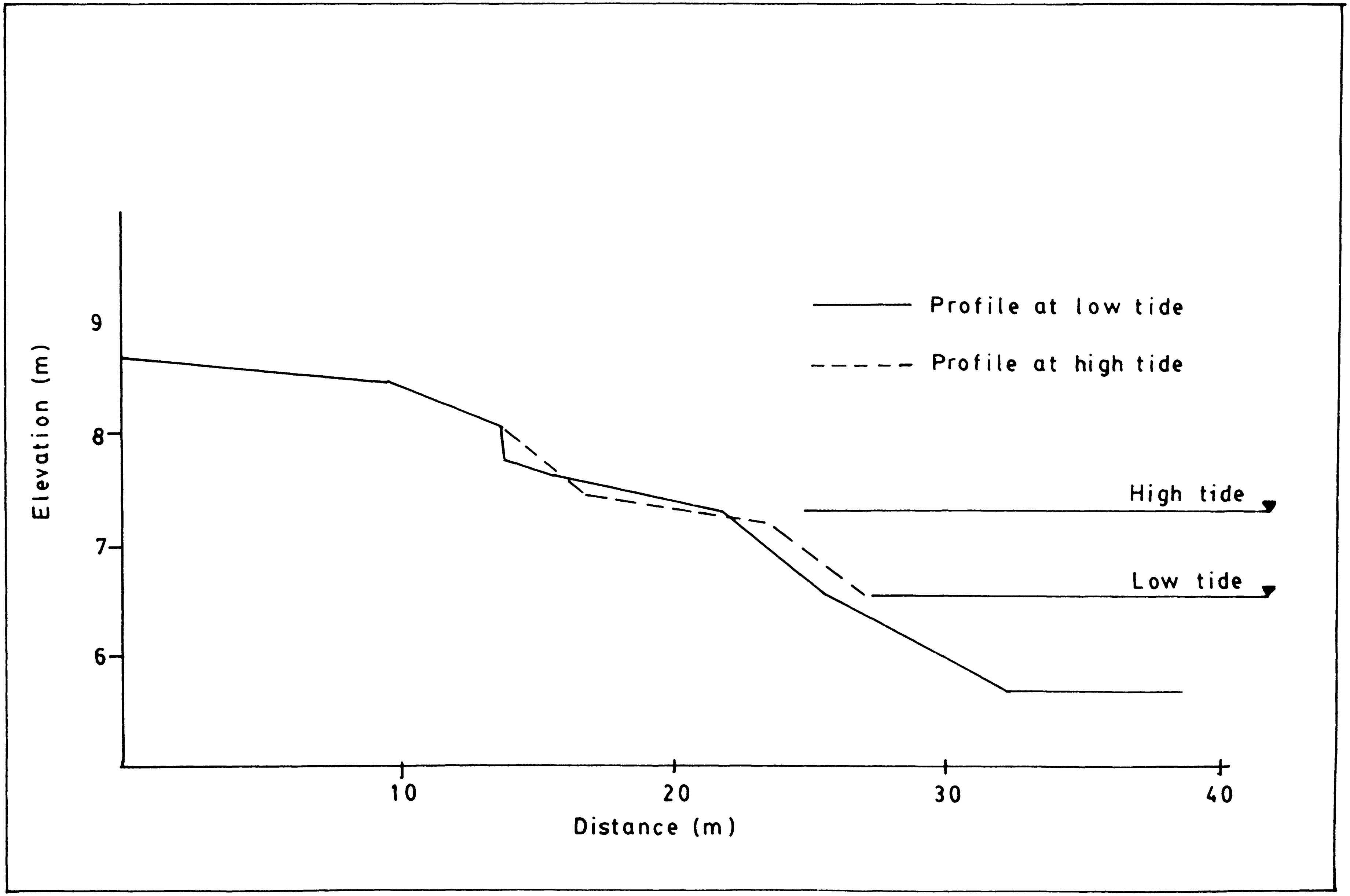

FIGURE 2.5 PROFILES AT SECTION 1 (see Fig 2.2 for location).

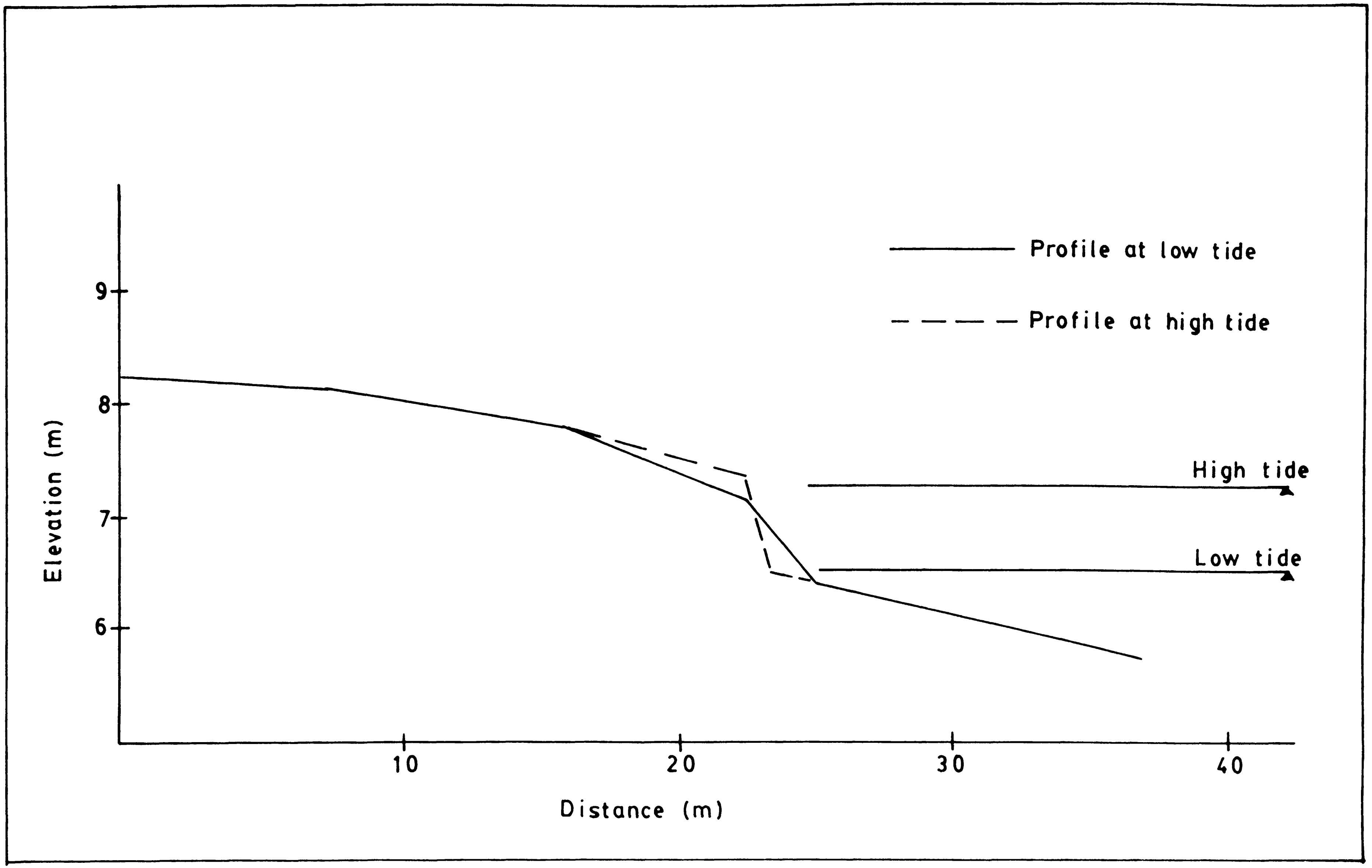

FIGURE 2.6 PROFILES AT SECTION 2. (see Figure 2 2 for location)

Table 2.2 Sieve Analysis - Data & Computation Sheet (Sample 1)

Date: 9/12/86
Sample No.2 Location of Beach: Dickinson Bay

Sample Location: Mid-tide Weight of Sample: 93.49 g

Prepared by:.............

Sieve openings Inches	mm	Sieve mesh	Weight of sand retained (g)	Percent retained	Cumulative percent finer
2.00					
1.50					
0.750					
0.375	9.530				
0.187	4.760				
0.094	2.400	7			
0.047	1.200	14	0	0	100.00
0.024	0.600	25	1.30	1.20	98.61
0.017	0.420	36	3.34	3.57	96.43
0.012	0.300	52	11.72	12.54	87.46
0.008	0.210	72	35.78	38.27	61.73
0.006	0.150	100	65.64	70.25	29.79
0.003	0.076	200	93.46	99.97	0.03

Table 2.3 Sieve Analysis - Data & Computation Sheet (Sample 2)

Date: 9/12/86
Sample No: 1

Location of Beach: Dickinson Bay

Sample Location: Mid-tide

Weight of Sample: 97.99 g

Prepared by: ....

Sieve openings Inches	mm	Sieve mesh	Weight of sand retained	Percent retained	Cumulative percent finer
2.00					
1.50					
0.750					
0.375	9.530				
0.187	4.760				
0.095	2.400	7	0	0	100.00
0.047	1.200	14	2.16	2.20	97.80
0.024	0.600	25	65.97	67.32	32.68
0.017	0.420	36	76.21	77.77	22.23
0.012	0.300	52	80.25	81.90	18.10
0.008	0.210	72	84.95	86.69	13.31
0.006	0.150	100	91.26	93.13	6.87
0.003	0.076	200	97.97	99.98	0.02

The type of breaker was observed and estimates of the breaker height were made. The breaker period was obtained by timing the passage of 10 breaker crests, using a watch. The results of the breaker observations are given in Table 2.4.

Date: 12/12/86

Sample No: 1

Beach: Dickinson Bay

Location: Close to Corbison Point

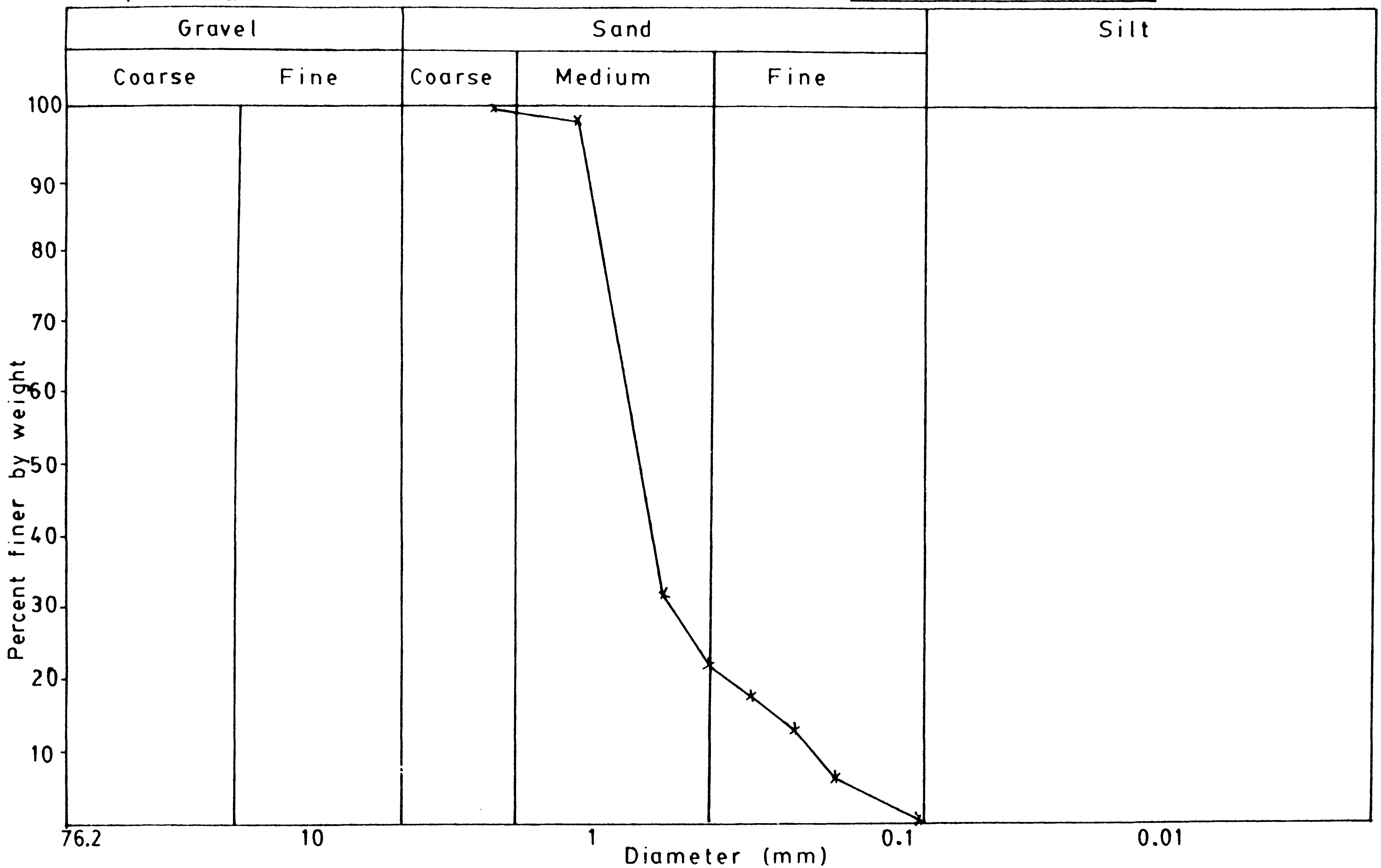

FIGURE 2.7 GRAIN SIZE DISTRIBUTION CURVE

Date: 12/12/86

Sample No: 2

Beach: Dickinson Bay

Location: Close to Halcyon Cove

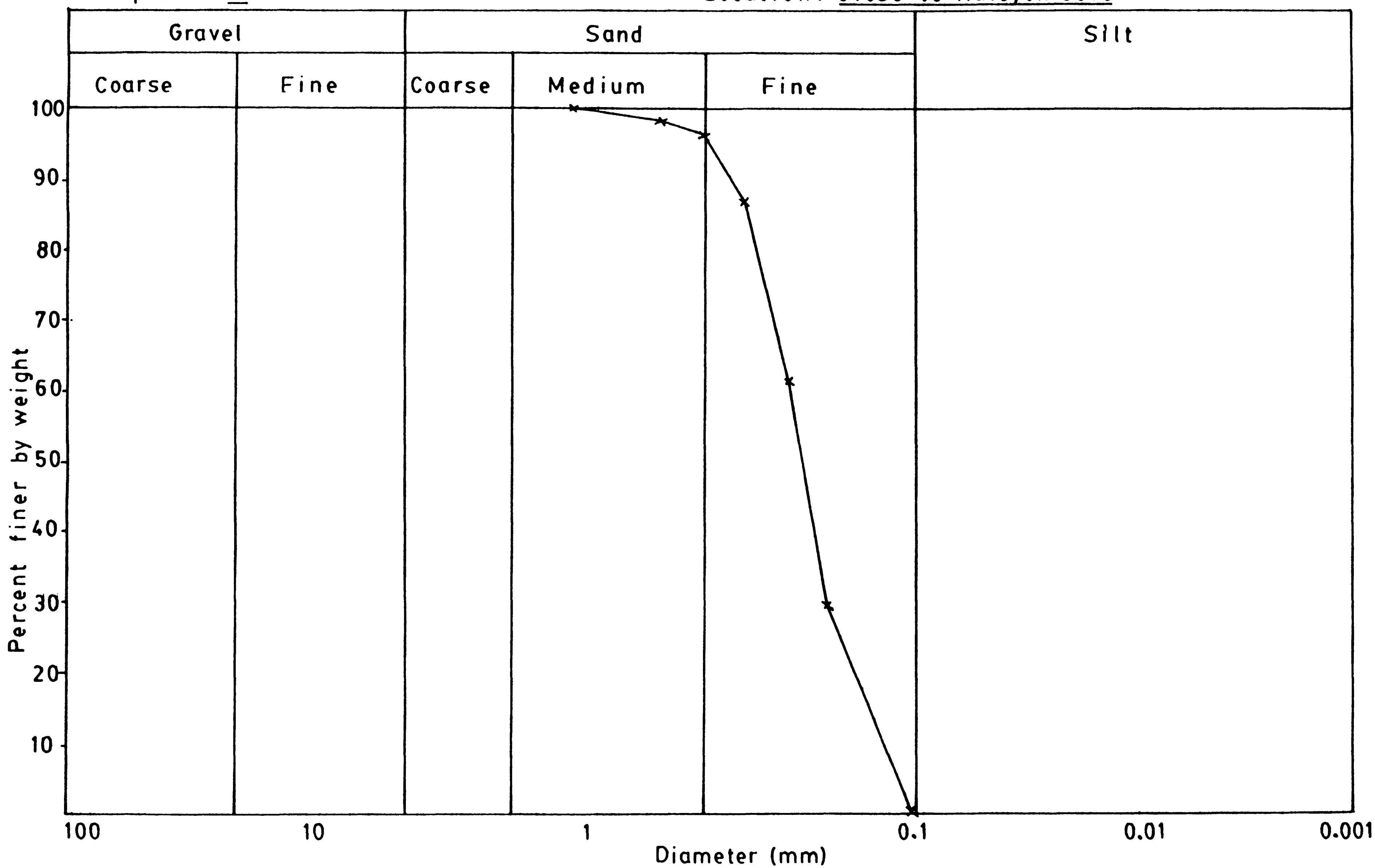

FIGURE 2.8 GRAIN SIZE DISTRIBUTION CURVE

Table 2.4 Breaker Observations

Date: 9/12/86
Beach: Dickinson Bay   Observer:.....................

Location	Time	Height (m)	Period (sec)	Type	Comments
Section 1	09.30	0.20	5.5	Spilling	High tide
Section 1	13.30	0.15	4.5	Spilling	Low tide
Section 2	09.45	0.10	2.0	Spilling	High tide
Section 2	13.45	0.10	2.5	Spilling	Low tide

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Surface currents were measured by releasing drift bottles just beyond the breaker line and measuring the time for the drift bottles to travel 10 m. The distance of 10 m was determined after making preliminary measurements to observe the speed and direction of the littoral current. The results of these measurements are given in Table 2.5.

Table 2.5 Littoral Current Observations

Location	Time	Current Speed (m/s)	Current direction	Comments
Section 1	10.30	0.01	190^0	High tide
Section 1	14.45	0.01	190^0	Low tide
Section 2	10.00	0.05	210^0	High tide
Section 2	14.15	0.03	210^0	Low tide

The headlands were examined; Wetherell Point showed very little sign of recent erosion; however, erosion was very evident at Corbizon Point. There was no evidence of recent littoral drift in either direction past Corbizon Point; but there were signs of sand entering Dickinson Bay past Wetherell Point.

Interviews with fishermen and others revealed the following:

(a) Around December or March the beach is affected by "groundswell". There were conflicting reports as to the time of occurrence of this "groundswell".

(b) Sometime in the past (the sixties ?) attempts were made to dredge an opening to the salina. Sand dredged from the opening was sold for construction purposes. The opening to the "salt pond" kept closing, and repeated attempts were made to open it, until eventually the scheme was abandoned.

(c) It was suggested that the beach close to Corbizon Point varied significantly in width, but no definitive information on the times of greatest or smallest width could be obtained.

The sea bed in Dickinson Bay, between the beach and the closer coral reefs, was covered with seagrasses and sea weeds. The dominant marine plants were the seagrasses Thalassia testudinum and Cymodocea filiforme, with upright and crustose algae, particularly Halimeda spp. growing among them.

Interpretation

Exposure: Dickinson Bay is a very protected beach, being located on the north-west coast, away from the full force of trade wind waves. The coast is protected further from the effects of northern swell and the occasional passing hurricane by the extensive reef system. For the majority of the time the coast is exposed only to very gentle locally-generated waves. During the rare periods of attack by hurricane waves or northern swell, waves approach the coast only near Corbizon Point from directions around west-north-west.

Coastal type: Dickinson Bay is a low coast without dunes.

Source of beach sand: Examination of the samples of beach sand revealed that they both originated from offshore sources, being comprised of algal, coral and shell fragments (see Table 2.6). The sample at Section 2 in the middle of the bay consisted of very well-sorted fine sand (G = 0.09 mm) with a median diameter of 0.19 mm; whereas the sample at Section 1 consisted of a less sorted medium sand with a median diameter of 0.71 mm. Section 1 was located close to the direction from which heavy wave action from hurricanes and northern swell approaches the bay.

Table 2.6 Sediment Characteristics - Dickinson Bay

Sample No.	Location	Colour	Folk & Ward Characteristics Md (mm)	Mz (mm)	E (mm)	St_1	Kg	Grain Shape & Composition
1	Close to Corbizon Point	White	0.71	0.66	0.35	2.61	0.94	Fresh, sharp fragments of marine shells & Halimeda platelets.
2	Near Halcyon Cove	White	0.19	0.19	0.09	2.74	1.14	Mainly fresh, irregular Halimeda fragments, with shell fragments.

It is concluded, therefore, that the major source of sand supply to the beach is onshore transport of products of the breakdown of the inshore reef - these materials are transported onshore close to Corbizon Point. Other sources of sand supply are littoral drift past Wetherell Point, and onshore transport of algal and shell fragments along the entire length of the beach.

Littoral drift: Figure 2.4 and the littoral current measurements (Table 2.5) suggest that littoral drift is southward for most of the time. However, the southern part of the beach can experience reversal of drift during periods of attack by hurricane waves or northern swell. The amount of littoral material moved northwards at such times may be very much greater than the normal transport rates experienced.

Long-term stability: The beach at Dickinson Bay is a barrier beach, which is an accumulation feature. The sand samples both show very high values of skewness (Table

2.7), which are typical of areas experiencing high rates of deposition. Three sources of sand supply have been identified, but no sinks for loss of sand have been found. Hence, over the long-term the beach is expected to accrete.

Table 2.7 Determination of Folk & Ward Characteristics

Location: Dickinson Bay Prepared by: ....

Characteristic	Sample 1	Sample 2
Ø 5 (mm)	0.130	0.085
Ø 16 (mm)	0.25	0.11
Ø 25 (mm)	0.49	0.14
Ø 50 (mm)	0.71	0.19
Ø 75 (mm)	0.94	0.25
Ø 84 (mm)	1.02	0.28
Ø 95 (mm)	1.16	0.39
$Median_{(md)}$ (mm)	0.71	0.19
$Mean_{(m^2)}$ (mm)	0.66	0.19
Std.deviation mm γ	0.35	0.09
Skewness SK_1	2.61	2.74
Kurtosis Kg^1	0.94	1.14

Median = Ø50

Mean = (Ø16+Ø50+Ø84)/3

Standard Deviation

= (Ø84-Ø16)/4+(Ø95-Ø5)/6.6

Skewness

$$= \frac{\text{Ø}84-\text{Ø}16+2\text{Ø}50}{2(\text{Ø}84-\text{Ø}16)}+\frac{\text{Ø}95-\text{Ø}5-2\text{Ø}50}{2(\text{Ø}95-\text{Ø}5)}$$

Kurtosis $= \frac{\text{Ø}95-\text{Ø}5}{2.44(\text{Ø}75-\text{Ø}25)}$

Seasonal stability: There are no measurements of beach profiles over different seasons. However, the northern part of the beach is very protected, and is not expected to experience much variation in wave climate during the year. On the other hand, the southern half will probably experience significant variation in wave climate during the year, and from year to year. Consequently, only the southern half of the beach is expected to experience seasonal variations in beach profile.

Tidal stability: The sections at Figures 2.5 and 2.6 suggest that significant tidal variation in beach profile should not be expected at this beach.

Human interference: The erosion shown on Figure 2.3 at the southern section of the beach has been caused most likely by human interference. It is possible that the erosion was caused by efforts to dredge an opening to the salina.

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Further Reading

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Edmunds, H. A. 1987. Coastal proceses and erosion in St. Lucia. Commonwealth Science Council Technical Publication, 227; 22 - 30.

Folk, R.L. & Ward, W.C. 1957. Brazos River Bar, a study of the significance of grain size parameters. Journal of Sedimentary Petrology, 27; 3 - 27.

King, C.A.M. 1972. Beaches and Coasts, 2nd Edit. Edward Arnold, London; 570 pages.

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Exercise 2.2 SITING COASTAL INFRASTRUCTURE

Background:

Developers frequently make alterations to coastlines without sufficient consideration of the physical processes being experienced at the site. One of the most frequent forms of change is brought about by the construction of solid breakwaters to provide calm conditions for the docking of boats.

The major factors to be considered in the design of a breakwater are its efficiency in providing sheltered conditions for docking, and the likelihood of the protected area being silted up by littoral drift. A preliminary diffraction analysis, combined with the type of information on coastal processes collected for Exercise 2.1, can provide guidelines on the probable effects of the construction of such structures, and on the suitability of the chosen site.

Other common alterations of the coastline are caused by the construction of groynes and causeways, and by small reclamations. Similar studies can provide guidelines for such constructions.

Aim:

(a) To study the effects of a rubble breakwater, constructed to provide a safe berthing area for pleasure boats, on wave action nearby.
(b) To use information from (a) above, along with information from Exercise 2.1, to predict the probable effects of the breakwater on sand movements in the coastal zone.

Duration:

Two to three hours.

Suitable Location:

Drawing office study, based on the same field site as Exercise 2.1.

Materials Required:

(a) Outputs from Exercise 2.1, i.e. hydrographic charts, refraction diagrams for normal and extreme wave action, and information on littoral drift and longshore currents.
(b) Drawing instruments.

Instructions:

1. Select a site for the breakwater, based on the depths of water and the draught of the vessels which are expected to use the facility.

2. Calculate the wave lengths for at least two conditions of attack.

3. Determine the polar coordinates of appropriate points, and use the diffraction diagram which corresponds to the directions of wave attack to determine the diffraction coefficient. Hence, obtain the reduced wave heights for the chosen points.

4. From the information obtained, make preliminary predictions of the effects of the structure on erosion and accretion of the beach.

Product:

The exercise should produce material similar to that which follows.

Nature of the alteration

It is proposed to construct a breakwater in Dickinson Bay (see Exercise 2.1) to provide safe berthing for yachts drawing up to 2.0 m of water. In order to satisfy navigation requirements, the breakwater should extend to 3.0 m of water. The location of the breakwater, shown on Figure 2.9, was determined from the underwater contours - it can be seen that any major change in its location will result in significant increase in the length of the structure. The direction of attack by trade wind waves, and by northern swell, is shown on the figure.

Calculation of wave lengths

Trade wind waves	Northern swell
H = 0.8 m T = 3.0 s	H = 0.5 m T = 15 s
Approach - 045^{O}	Approach - 290^{O}
$Lo = gT^2/2\pi = 14.1$ m	Lo = 351 m
d/Lo = 3/14.1 = 0.2128	d/Lo = 3/351 = 0.00855

From tables

d/Lo = 0.2359	d/Lo = 0.03722
and L = 12.7 m	L = 80.6 m

The templates

By measurement, the angle of approach for the trade wind waves (i.e. the angle between the direction of wave approach and the imaginary continuation of the impermeable breakwater) is 150^0 - see Figure 2.9. The appropriate template is Wave Diffraction Diagram - 150^0 Wave angle, as shown in CERC (1973) Figure 2-37 on page 2-93.

Similarly, the appropriate template for use with swell is Wave Diffraction Diagram - 45^0 Wave angle as shown on Figure 2-30 on page 2 -85 of the above reference.

It is required to determine the reduced wave height along the pier at 50 m, and 100 m from the shoreline for trade wind waves of 1 m height and 3 sec period.

Fifty metres along the pier corresponds to the polar coordinates:

60^0 , and 90 m or 90/12.7 = 7.1 L.

From Figure 2-37, diffraction Coefficient = 0.075

Therefore, reduced wave height = 0.075 m.

One hundred metres along the pier corresponds to the polar coordinates:

42^0 , and 50 m or 50/12.7 = 3.9 L.

From Figure 2-37, Diffraction Coefficient = 0.0095

Therefore, reduced wave height = 0.010 m

The use of the template is illustrated in Figure 2.10.

In order to determine:-

(a) the section along the coast north of the breakwater where the swell height is the same as before the construction.

(b) The swell height and direction in 1 m of water opposite a point on the beach 50 m north of the breakwater.

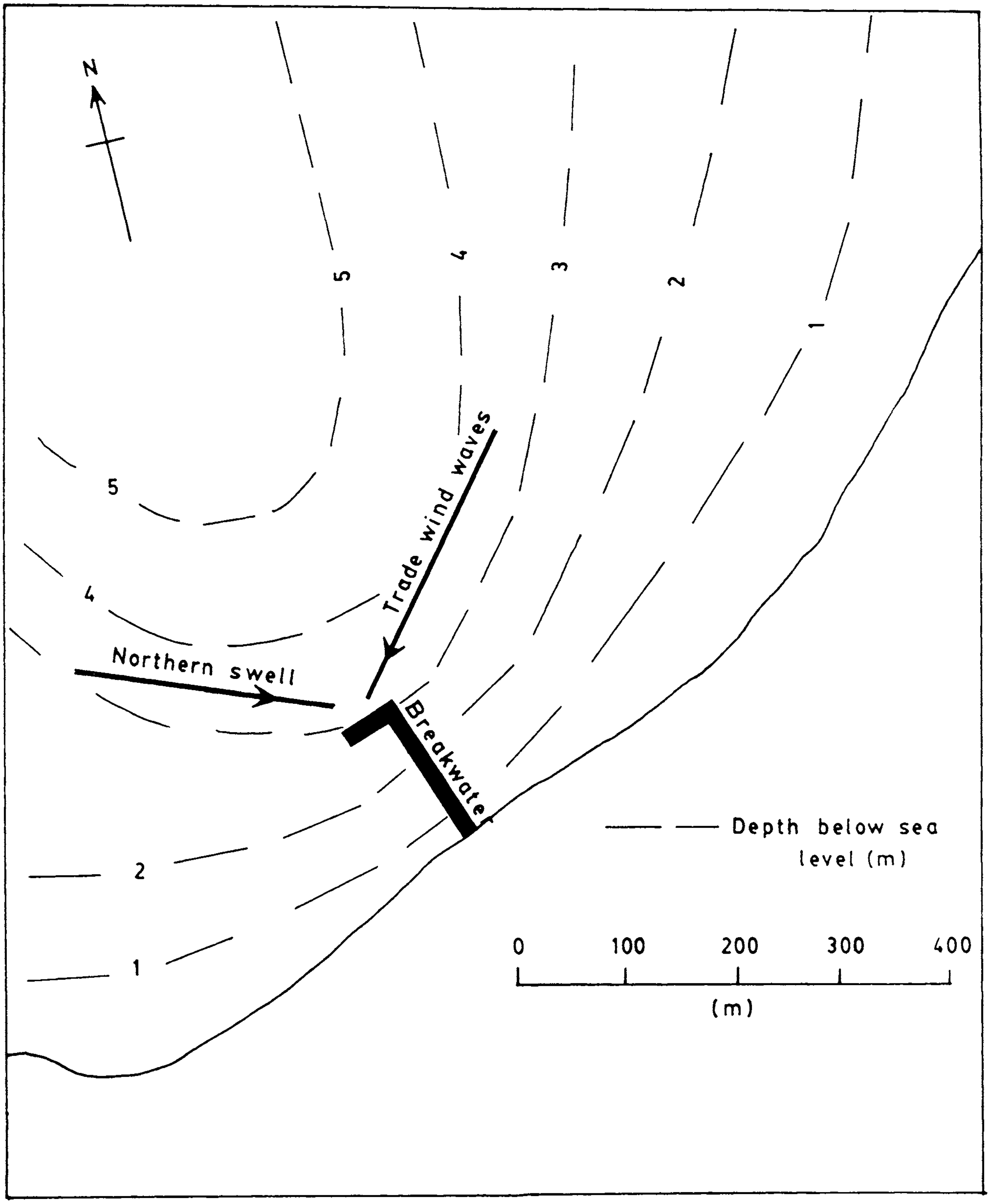

FIGURE 2.9 LOCATION OF BREAKWATER - DICKINSON BAY

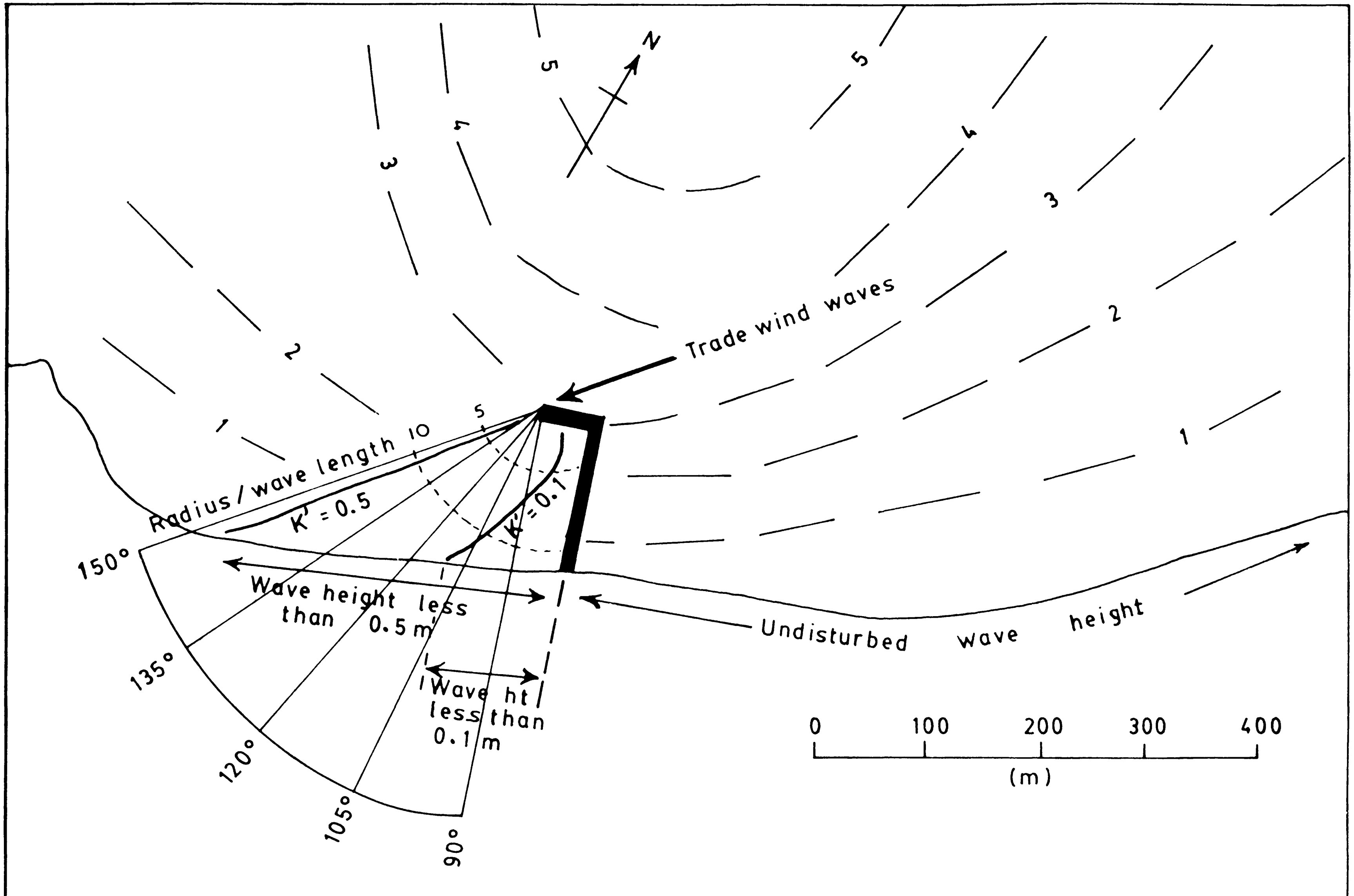

FIGURE 2.10 EFFECT OF TRADE WIND WAVES

Use the following swell conditions at the breakwater tip:

swell height = 0.5 m period = 15 s direction = 290^0

The area where swell heights are undisturbed relates to the area where the diffraction coefficient is 1.0. The area is shown on Figure 2.11.

Polar coordinates of the junction of the 1 m contour and the section 50 m north of the breakwater are:

15^0 , 120 m or 120/80 i.e. 1.5 L

Using Figure 2 -30 on page 2 -85 of the above reference, the diffraction coefficient is 0.37.

Interpretation

(a) The breakwater will provide very safe conditions for berthing for the majority of the year, when seas are dominated by mild trade-wind generated waves. Wave heights of less than 0.1 m in the protected area to the south can be expected at such times.

(b) The berths are subject to attack by the full force of northern swell and waves generated by the passing hurricane.

(c) The structure will stop the southward littoral transport of sand during periods of attack by trade wind waves.

(d) The cessation of southward transport of sand is likely to lead to the build up of sand on the northern side of the breakwater, and erosion on its southern portion.

(e) During periods of swell and hurricane attack, the northward transport of sand brought onshore will cease.

(f) The cessation of the sporadic transport of sand northward will lead to sand build up on the southern portion of the structure, and erosion on the northern portion. The erosion is likely to be most severe over 50 m closest to the breakwater.

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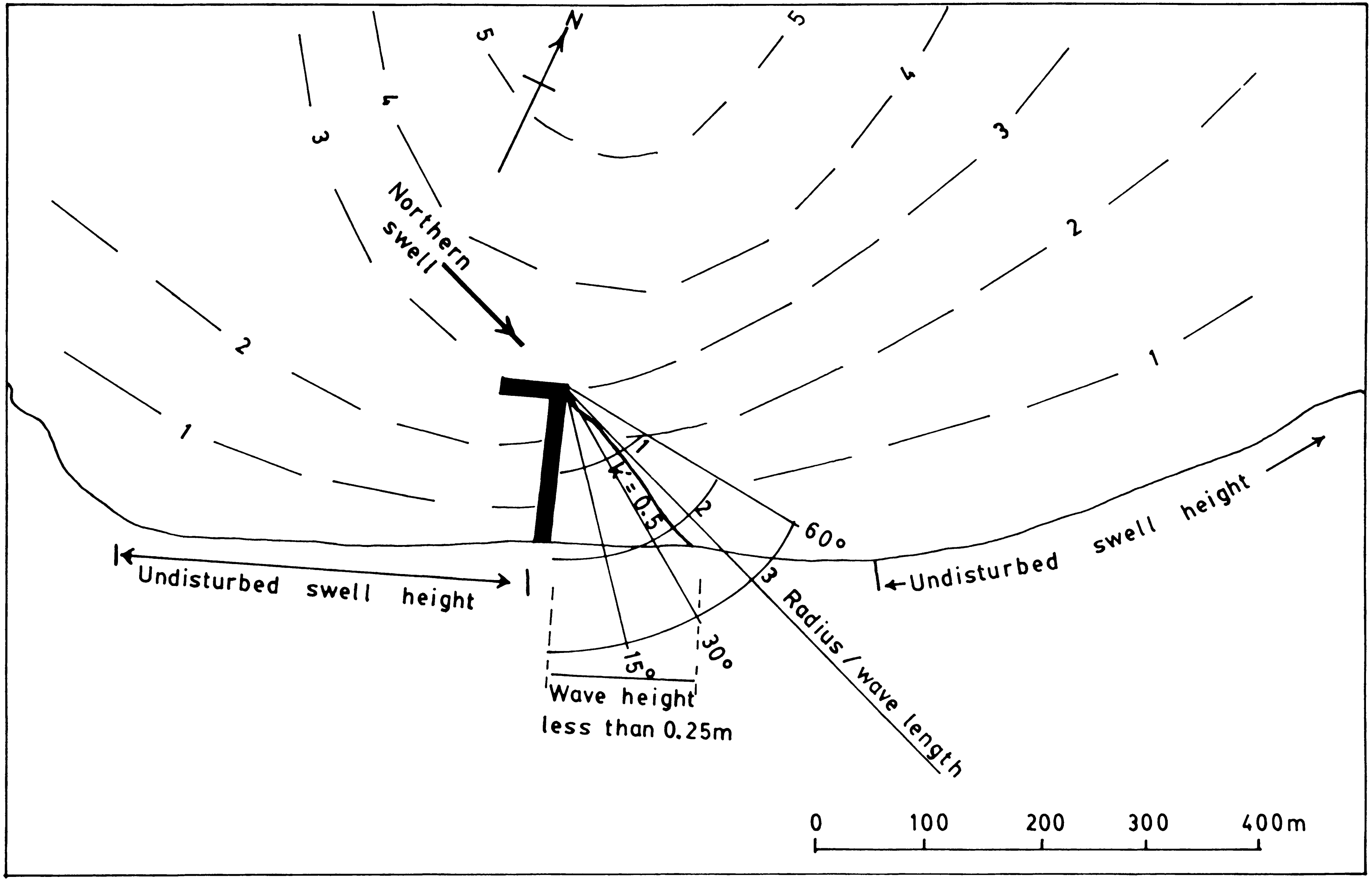

FIGURE 2.11 EFFECT OF NORTHERN SWELL

Further Reading:

CERC 1984. Shore Protection Manual. U.S. Army Coastal Engineering Research Center, Department of the Army, Corps of Engineers.

Geoghegan, T. 1985. Proceedings of the Caribbean Seminar on Environmental Impact Assesment, Barbados May/June 1985; 287 pages.

* * *

Exercise 2.3 DISPOSING OF WASTES IN THE SEA

Background:

Discharge of wastewater effluents into estuaries and seas is the most common method for the disposal of liquid wastes. The dilution of the effluent in the receiving water and the action of naturally occurring aquatic organisms can complete the treatment started on land in a wastewater treatment plant. Estuaries and coastal waters are used also to dissipate heat from once-through cooling systems such as large power stations, refineries, petrochemical plants, and liquefied natural gas (LNG) facilities.

Wastewater is subjected normally to one or more of the following processes:-

Primary treatment which removes coarse materials which may settle to form bottom deposits; and removes floating materials such as debris, grease and oil.

Secondary treatment which considerably reduces the concentration of substances imparting taste, odour, colour or turbidity to the water: and removes substances that are toxic or harmful to humans, or aquatic plant or animal life.

Tertiary treatment which considerably reduces the concentration of refractory organic materials, and nutrients - usually nitrogen (N) and phosphorus (P).

After treatment, the natural dispersion of wastewater effluents in coastal waters is achieved by dilution and chemical diffusion. The waste is less dense than seawater and consequently will float on the surface unless introduced at some depth.

Initial Mixing: If the waste is introduced as a high velocity jet, momentum entrainment will mix the volume containing the wastes with the receiving waters, rapidly diluting the wastes. If wastewaters are discharged directly from the shore, the degree of initial mixing is almost nil, and subsequent dilution and overall dispersion occur very slowly, since the polluted field stays in proximity to the shore. To achieve initial mixing it is advisable therefore to discharge effluents at some distance from the shore, and at some depth below the surface. The initial mixing terminates in the development of a more or less diluted, homogeneous field.

Dilution and Dispersion: The enlarged and diluted waste volume is subjected to the complex physical processes of dispersion and movement. Pathogens in the water are subject to die-off (see Ex. 2.4).

The rate of dilution and dispersion is dependent on the velocity of the currents in the receiving water (see Sherwin & Deeming, 1980).

Aim:

To investigate possible alternative locations for outfalls from a central sewage treatment plant.

Duration:

Two days (one day field work; one day in the drawing office).

Suitable Location:

A suitable location is one where there are nearby recreational beaches and coral reefs. Preferably there should be changes in coastline orientation, so that different current velocities may be experienced.

Materials Required:

Topographic maps, hydrographic charts, and aerial photographs of region under study,

Fullest available information on currents in the seas around the island. (Sources of information are Sailing Directions, and Oceanographic Atlases)

Suitable dye (Rhodamine B, for example).
Cameras.
Fishing or other suitable small boat.
Light aeroplane (see Appendix 2).

Instructions:

1. Data on currents should be extracted from the information sources presented.

2. Flow patterns around the island should then be drawn, using the methods of Appendix 4.

3. Information on tidal currents should be extracted from the sources given.

4. The location of important natural features, such as reefs or seagrass beds, should be mapped from the

aerial photographs, (see Exercises 1.2 & 1.3).

5. Select three (3) alternative locations for the sewer outfall, and estimate the probable length of outfall needed for each case.

6. At each of the selected sites, anchor a boat and let out a steady stream of dye for fifteen (15) minutes. Dye should be released at each site on both falling and rising tide.

7. From the air, obtain photographs of the dye dispersal pattern within half an hour of release.

8. Prepare a report on the result of the investigations.

Product:

The information below is based on an actual example, although changes have been made in some details.

The Problem

A major resort complex is planned for the westernmost portion of the island of Tobago, as shown on Figure 2.12, in an attempt to boost the tourism industry. The major reefs and wetlands of Tobago are located in this area, and are advertised extensively for tourism promotion. It is necessary to provide maximum protection to these natural attractions, and, as a result, it was decided to construct a central sewage treatment plant with an outfall to the sea in an appropriate place. The sewage from the environs of the main town of Scarborough will be treated separately and discharged close to that town.

The Natural Features

The major natural features are shown on Figure 2.13, which was drawn from maps and aerial photographs. Three possible alternative locations for the sewer outfall are shown on that figure.

The Oceanic Currents

The following information on currents around Tobago was obtained:-

(a) H.O. Publication 22 (1963) reports that "between Tobago and Barbados the currents usually set north-

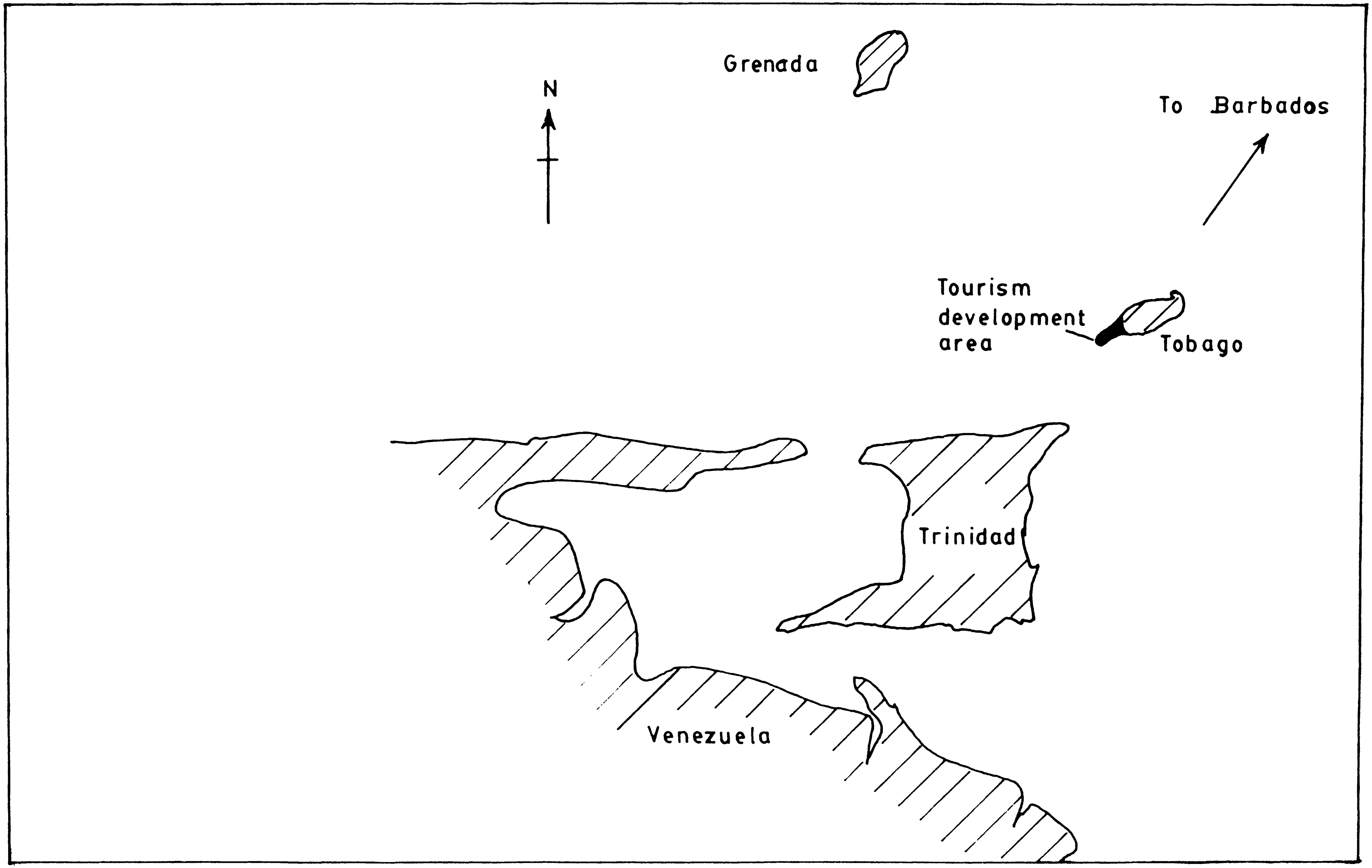

FIGURE 2.12 LOCATION MAP - TOBAGO.

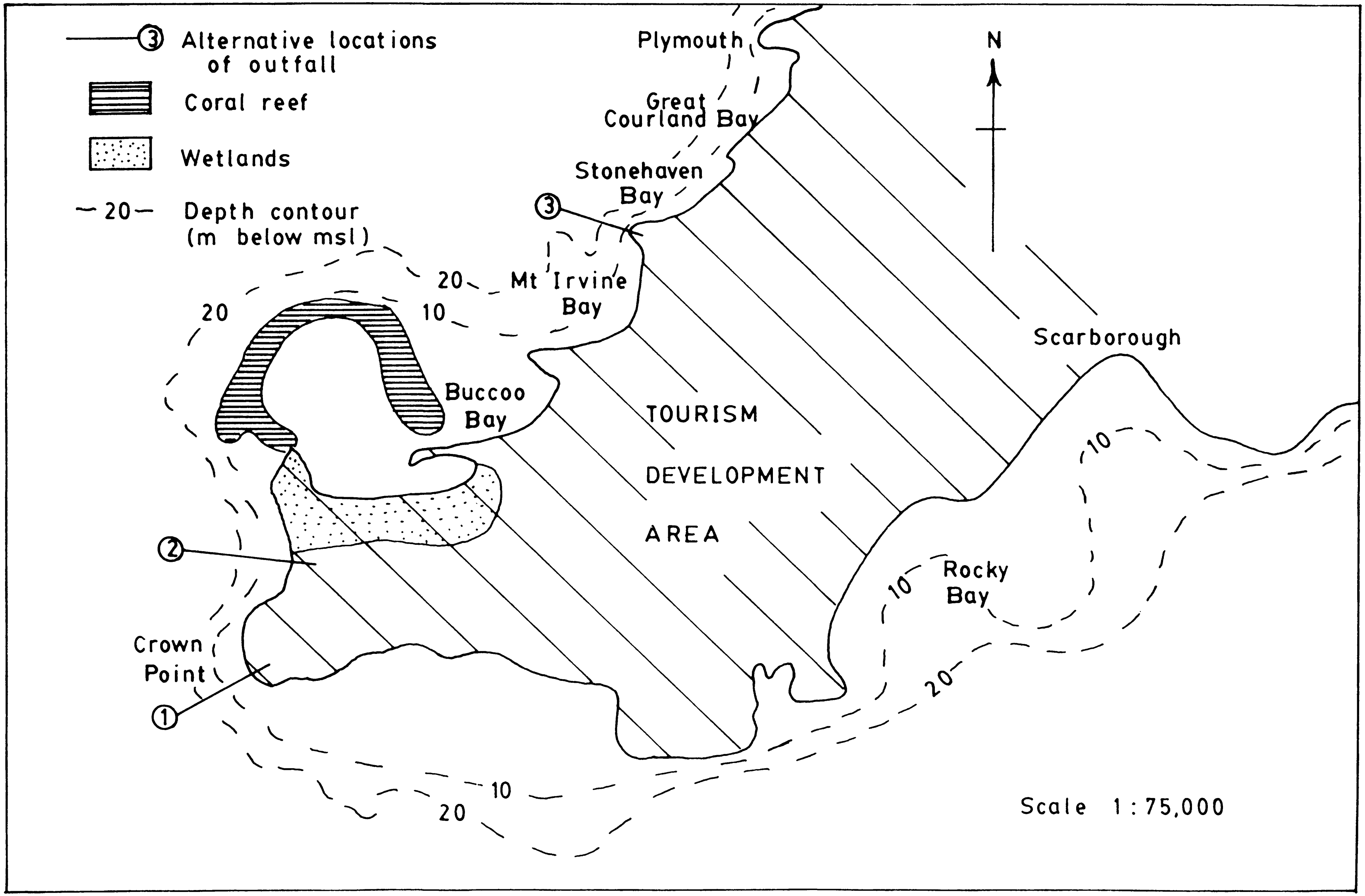

FIGURE 2.13 NATURAL FEATURES - NW TOBAGO

westward at rates of 1 to 2 knots, but in May to July rates of 2 to 3 knots have been recorded".

(b) The above publication reports also that "the velocity of the current between Tobago and Trinidad varies from 2 to 4 knots".

(c) Admiralty Hydrographic Chart 505 (1969) reports that "the South Equatorial Current flows in a predominantly north-westerly direction. Its rate is generally up to about 3 knots, but on striking Tobago it divides locally and passes the north-eastern extremity of the island at a rate of 3 to 4 knots".

The above information reveals that the currents around the island originate in the South Equatorial Current, and that because of the crowding of the streamlines as the current passes between Tobago and Trinidad high current velocities are experienced off the north-western tip of Tobago. Statistical data on the South Equatorial Current as, extracted from H.O. Publ. No. 700 (1965) is presented in Table 2.8.

Table 2.8 Ocean Currents off Tobago

Season	Direction	Occurrence %	Average Speed Knots
Winter (Jan-March)	N - W	50	1.3
	W	30	1.2
	other	20	0.8
Summer (July-Sept)	N - W	50	1.1
	W	20	0.9
	other	30	0.7

Source: U.S. Navy Hydrographic Office (1965) - Oceanographic Atlas of the North Atlantic Ocean, Section 1 - Tides and Currents. H.O. Publ. No. 700.

Flow Patterns

Patterns for westerly and north-westerly flow of the ocean current are shown on Figures 2.14 and 2.15 respectively. Figure 2.14 shows that when the current is flowing in a

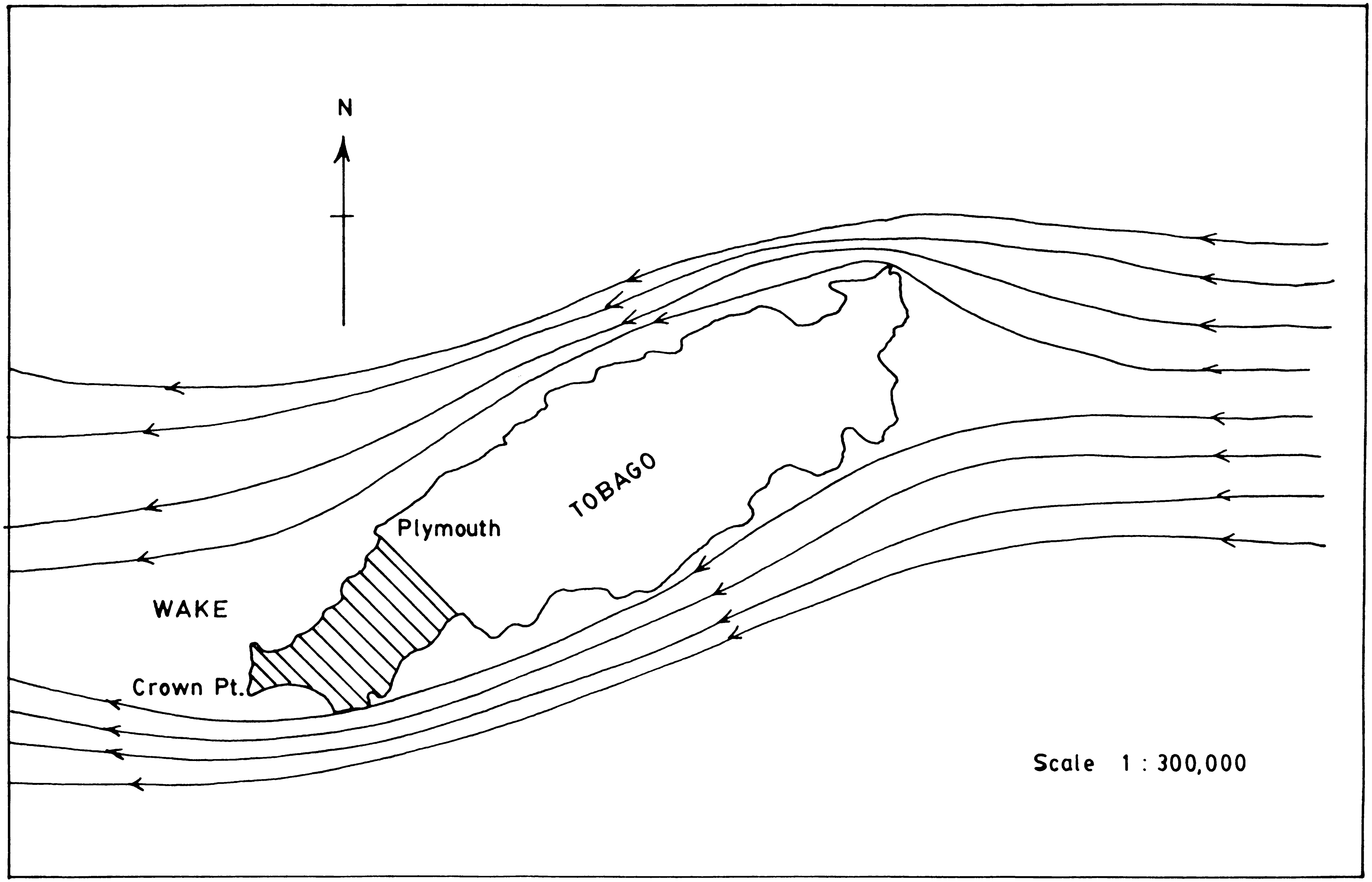

FIGURE 2.14 STREAMLINES: WESTERLY OCEANIC CURRENT

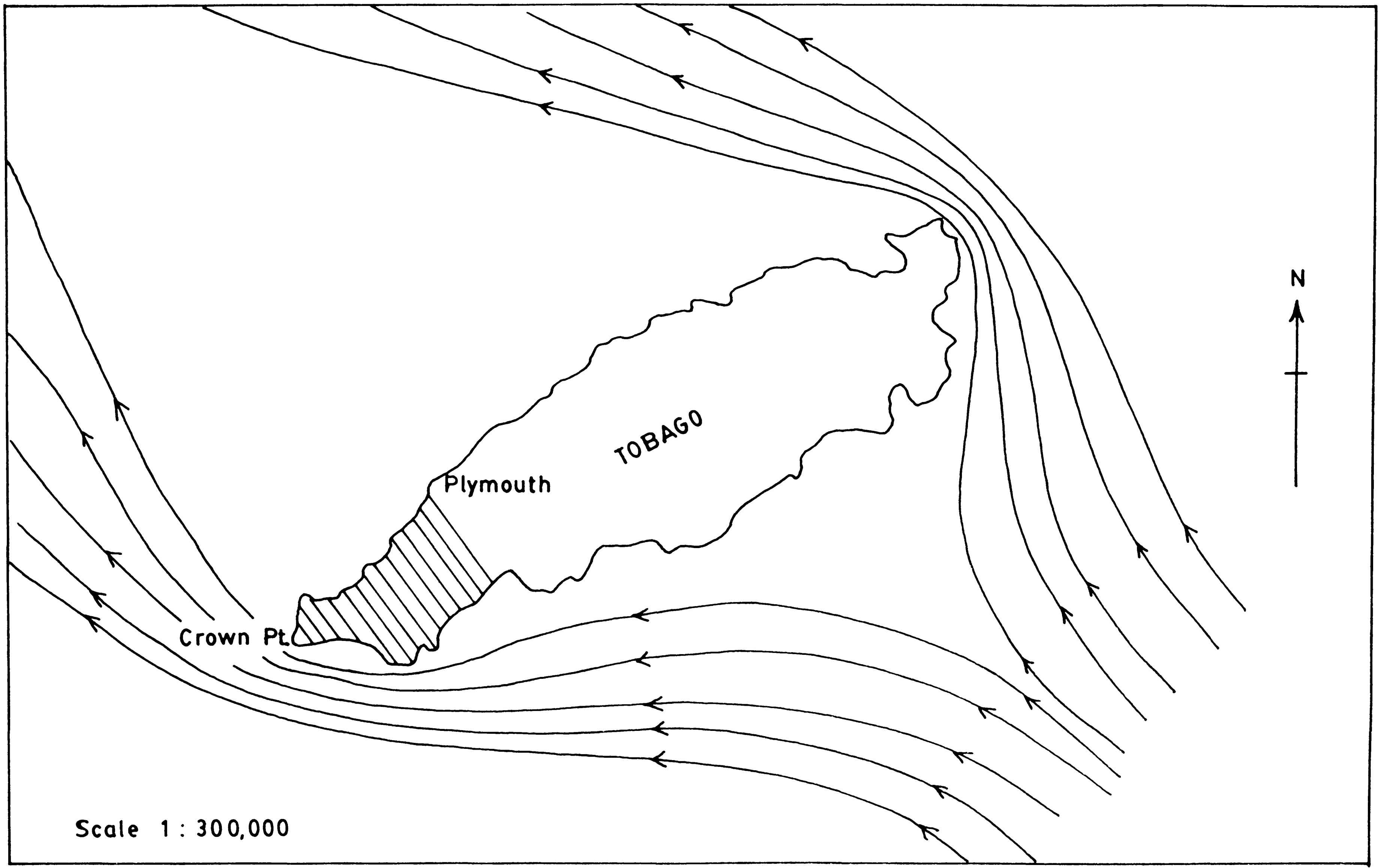

FIGURE 2.15 STREAMLINES: NORTH WESTERLY - OCEANIC CURRENT

westerly direction a small wake is formed off the north coast between Plymouth and Crown Point. No attempt has been made to categorize the wake, but it is expected that water movement in it will be very low. Small eddies are expected to break off the main wake and circulate in Little Courland, Stonehaven and Great Courland Bays. The net water movements in those bays due to the oceanic current is expected to be very low, therefore.

Figure 2.15 shows that when the oceanic current flows in a north-westerly direction, points of flow separation will form off Crown Point and the extreme north-western tip of Tobago. In this case the wake is larger. The net water movement due to the oceanic current in the bays of the north-western coast is again expected to be very low.

Tidal Currents

The following information has been extracted from H.O. Publication 22:

"The tidal currents in the vicinity of Tobago are variable and weak. The flood tidal currents accelerate the north-westerly sets and the ebb tidal currents slightly retard them,causing a cessation for a short time. The set is usually north-westward at a considerable rate, however."

"At the west end of Tobago, the south-east going tidal current, during its strength, sets close around Crown Point for about two hours just checking and diverting the north-west going current. Near the coast during the rising tide a slight eddy sets eastward into Great Courland bay, Stonehaven and Little Courland Bays. During the falling tide there is a set in the opposite direction which sometimes attains a rate of 1 knot near Buccoo Reef."

Results of the Field Tests

The dye was released on Monday 16th March, 1987. The predicted times and heights of the tide on that day were:-

Time	Height(m)
0428	0.91
1037	0.26
1639	0.98
2258	0.24

These values were representative of spring tide conditions, as new moon was on the 15th March.

The patterns of dye dispersal are shown on Figure 2.16, 2.17 and 2.18, for sites 1,2 and 3 as shown on Figure 2.13.

Interpretation

The theoretical streamlines, drawn on Figures 2.14 and 2.15, suggest that there is very little net water movement at sites 2 and 3. These were confirmed by the dye dispersal studies, as shown on Figures 2.17 and 2.18. At site 3, the dye dispersal studies suggest that there is current movement towards the shore at the rising tide.

This information suggests that the siting of an outfall at either sites 2 or 3 should be done with extreme caution, as there appears to be a possibility that the effluent will return to the shore and move towards the reef. On the other hand, both theoretical streamlines and the dye dispersal pattern shown on Figure 2.16 suggest that there will be significant dilution if the effluent is discharged around site 1. It appears also that the effluent will be swept away from the shore if discharged near this site.

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Further Reading

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UN/WHO 1982. Waste Discharge into the Marine Environment. Principles and Guidelines for the Mediterranean Action Plan, United Nations Environmental Programme/World Health Organisation, Pergamon Press, Oxford; 422 pages.

Ferguson-Wood, E.J. & Johannes, R.E. 1975 Tropical Marine ollution. Elsevier Publishing Co., Amsterdam; 188 pages.

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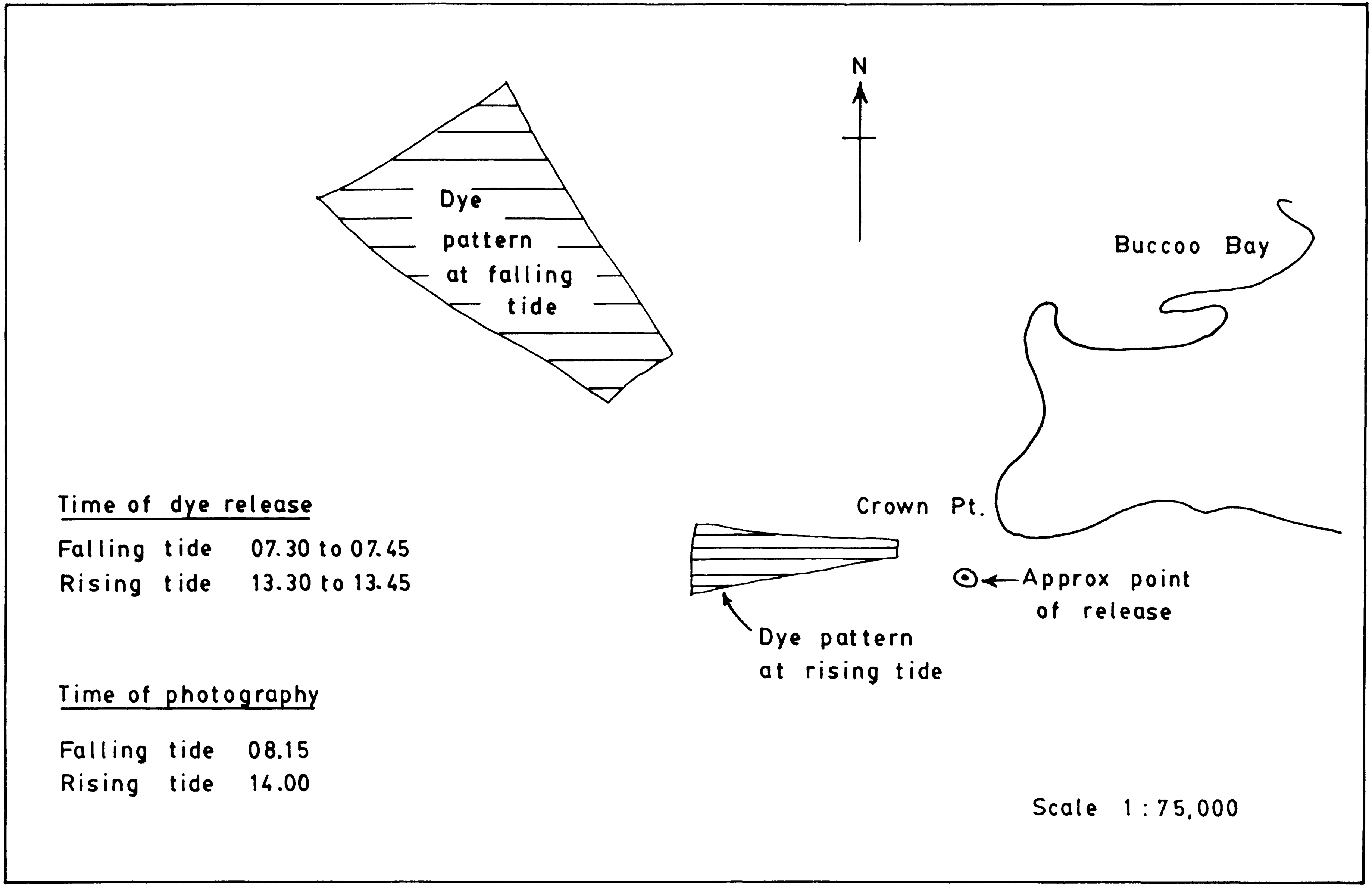

FIGURE 2.16 DYE PATTERN AT STATION 1

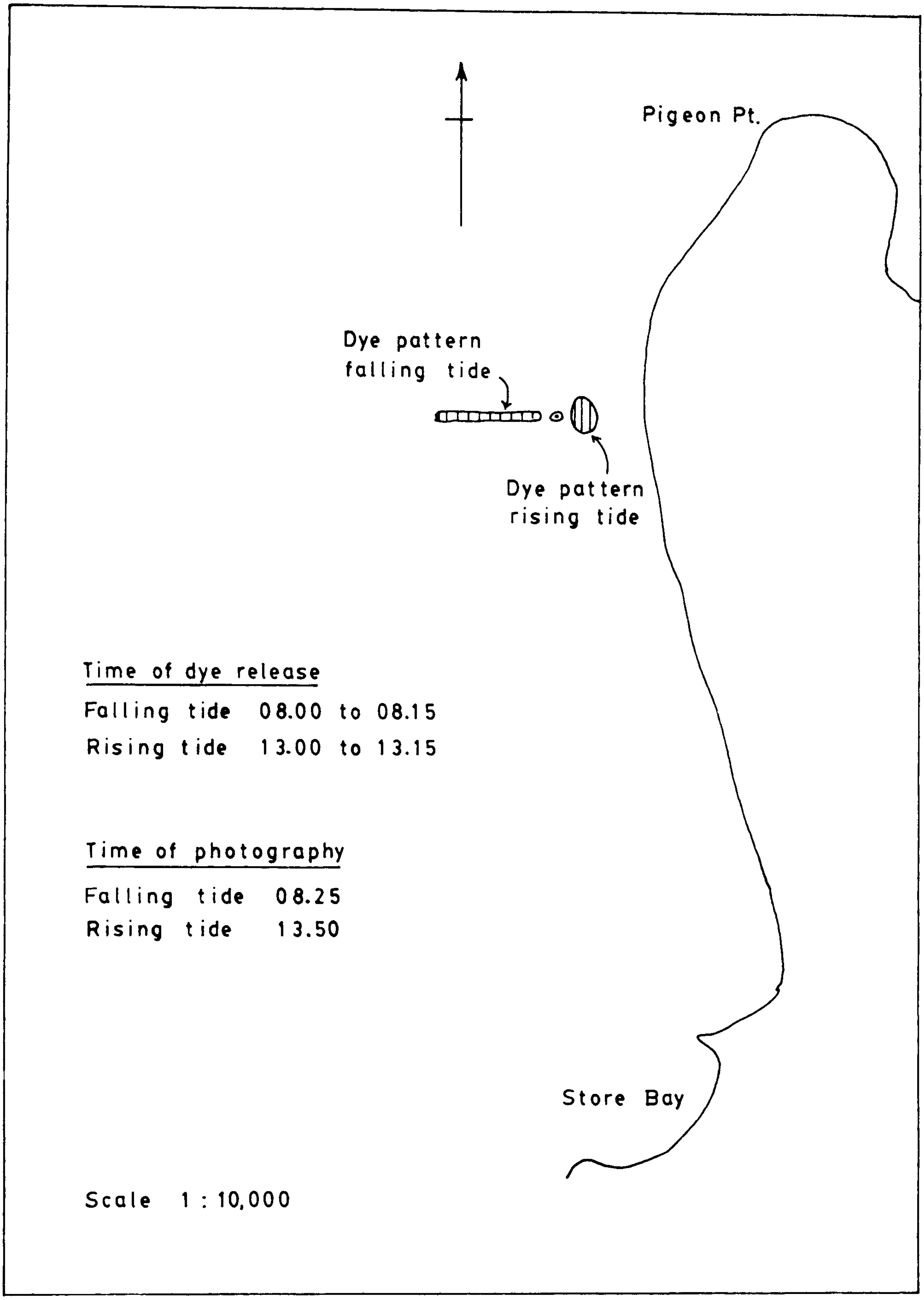

FIGURE 2.17 DYE PATTERN AT STATION 2

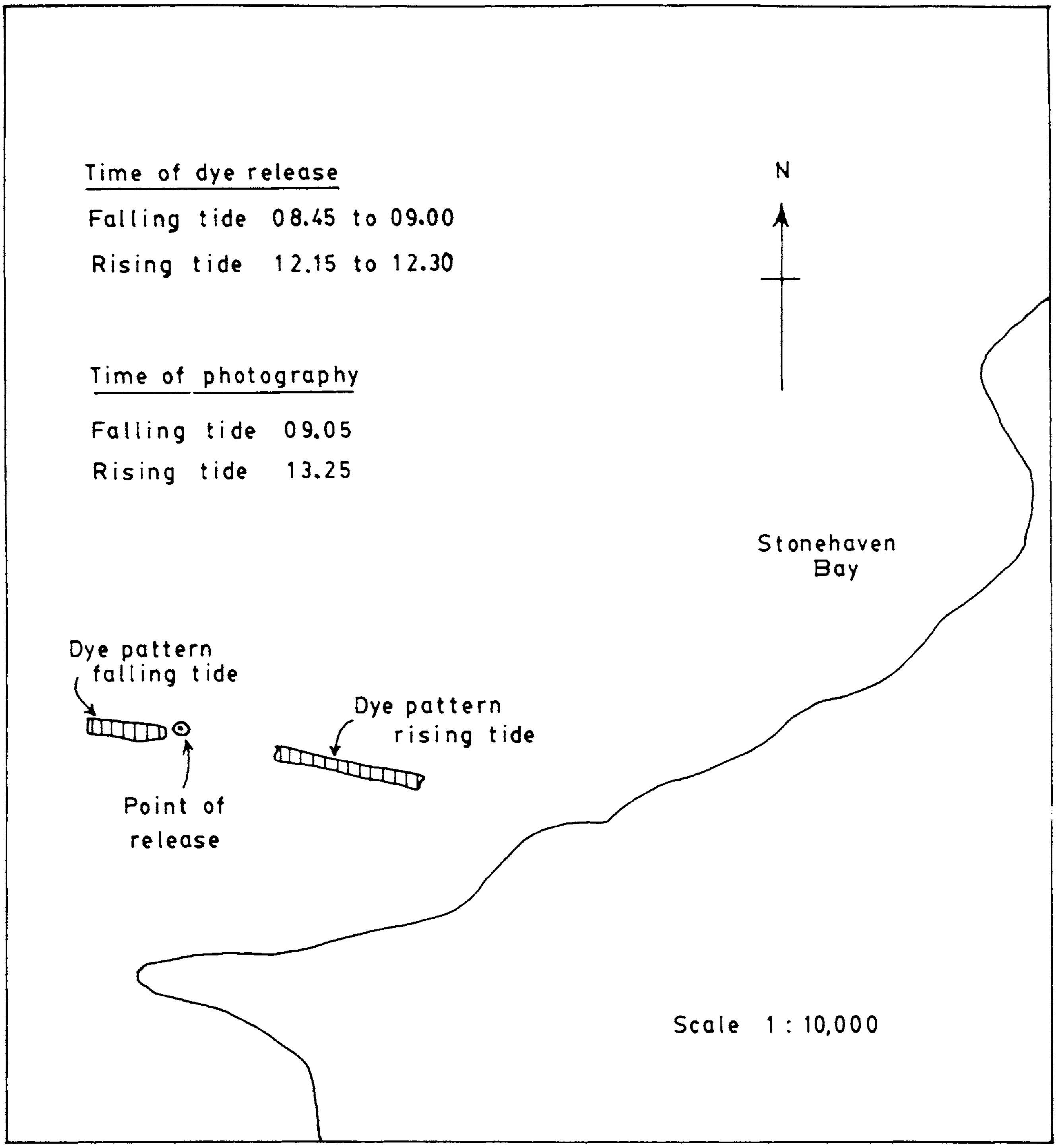

FIGURE 2.18 DYE PATTERN AT STATION 3

Exercise 2.4 MONITORING WATER QUALITY

Background:

As mentioned in Exercise 2.3, discharge of wastewater effluent into estuaries and seas is the most common method for the disposal of liquid wastes. The dilution of the effluent in the receiving water and the action of naturally occurring aquatic organisms can complete the treatment started on land in a wastewater treatment plant.

When domestic and similar pollutants are discharged into water, a succession of water quality changes take place. The water becomes turbid, sunlight is shut out of the depths, and marine plants, which by photosynthesis remove carbon dioxide from the water and release oxygen to it, die off. Scavenging organisms increase in number until they match the food supply. The intensity of their life activities is mirrored in the intensity of the biochemical oxygen demand (BOD).

Suspended matter is carried by the water or removed to the bottom by sedimentation. Bottom (benthic) deposits are laid down in thicknesses varying from a thin carpet to heavy sludge banks. Decomposition of the benthic deposits varies with the depth of deposit from aerobic to anaerobic. Pathogens are emitted to receiving bodies of water by municipal sewage discharge, discharge of sludges, discharge of some industrial wastes and in animal wastes. Runoff water, especially from animal husbandry and agricultural areas may also contain animal pathogens (Ward, 1984).

The hazards to human health from bathing waters arise from direct skin contact or from the swallowing of polluted waters. It is therefore important that coastal bathing waters be sufficiently free of pathogenic microbial life that water-borne infections do not pose a significant health risk to those who use them for recreation. There is agreement that the main indicator organisms for the contamination of recreational water by human pathogens are the faecal coliform group of bacteria.

Tests for **faecal coliforms** are also relatively simple, and the results readily understood. Their interpretation is aided by environmental health standards established by various agencies. For example, seawater is considered fit for **recreational use** when the faecal coliform count does not exceed 100 E. coli bacteria per 100 ml in 80 % of samples (E.E.C., 1976). E. coli is the commonly used faecal indicator bacterium Escherichia coli.

Faecal coliform counts can be conducted near beaches used for recreation or fisheries activities to gain insight into levels of contamination. Gradients of concentration along coastal transects can be used to locate sewage outfalls, so that appropriate steps can be taken to reduce health risks. This exercise is designed to demonstrate simple laboratory procedures for obtaining information on levels of contamination by sewage. Assistance should be sought from the Government Microbiology Unit, the Government Chemist, or biological laboratory of a local college for loan of apparatus or use of the laboratory for sample analysis. This should be arranged well in advance of the exercise session.

Aim:

To test seawater quality at selected sites.

Duration:

Two half-day periods; samples incubated overnight.

Suitable location:

To obtain a range of samples, water should be collected as follows:

(a) Near a known sewage outfall of a major town.
(b) In the same bay or lagoon far distant from the sewage outfall.
(c) From a recreational area near human habitation or hotels.
(d) From a recreational area away from human habitation.

Materials Required:

Sterile containers - preferably 100 ml glass bottles. Three replicate samples should be taken at each site.

Ice - sufficient to keep samples cool in the field.

Labels

1 pipette (10 ml capacity), 1 pipette (1 ml capacity)

Test tubes - 9 per sample: 3 large (22 x 175 mm)
6 medium (15 x 150 mm)

Test tube rack

Durham fermentation tubes - 9 per sample. If not available these can be made by cutting and sealing sections of glass tubing 6 x 50 mm in size.

Cotton wool

Cotton wool
Centrifuge
Incubator, or oven with thermostat.

Lactose broth - Two solutions are required, Single Strength Medium (SSM) prepared by adding 3.0 g beef extract, 5.0 g peptone, 5.0 g lactose to 1000 ml distilled water; stiring slowly in a water bath and adjusting pH to be between 6.8 - 7.0 after sterilization, according to methods of the American Public Health Association (1976); and Double Strength Medium (DSM). For each sample make up 30 ml SSM and 60 ml DSM.

Instructions:

Field methods

1. Water samples can be collected using a boat or from a jetty or pier.

2. Place the un-stoppered sterile container just below the surface of the water and fill completely.

3. Replace the stopper and store on ice in the dark until it can be transferred to the laboratory.

4. Observe the surroundings and note any visual or odour signs of pollution, and record human activities for possible correlation with the sample results.

Laboratory procedure

5. If the exercise is being carried out by a group, each member should take responsibility for one sample or sample site.

6. Bacteriological analysis must be carried out within 4-6 hours of collection.

7. For each sample site, set up the test tubes as follows:

   Place 10ml lactose broth in each of 9 test tubes, as shown in Figure 2.19.

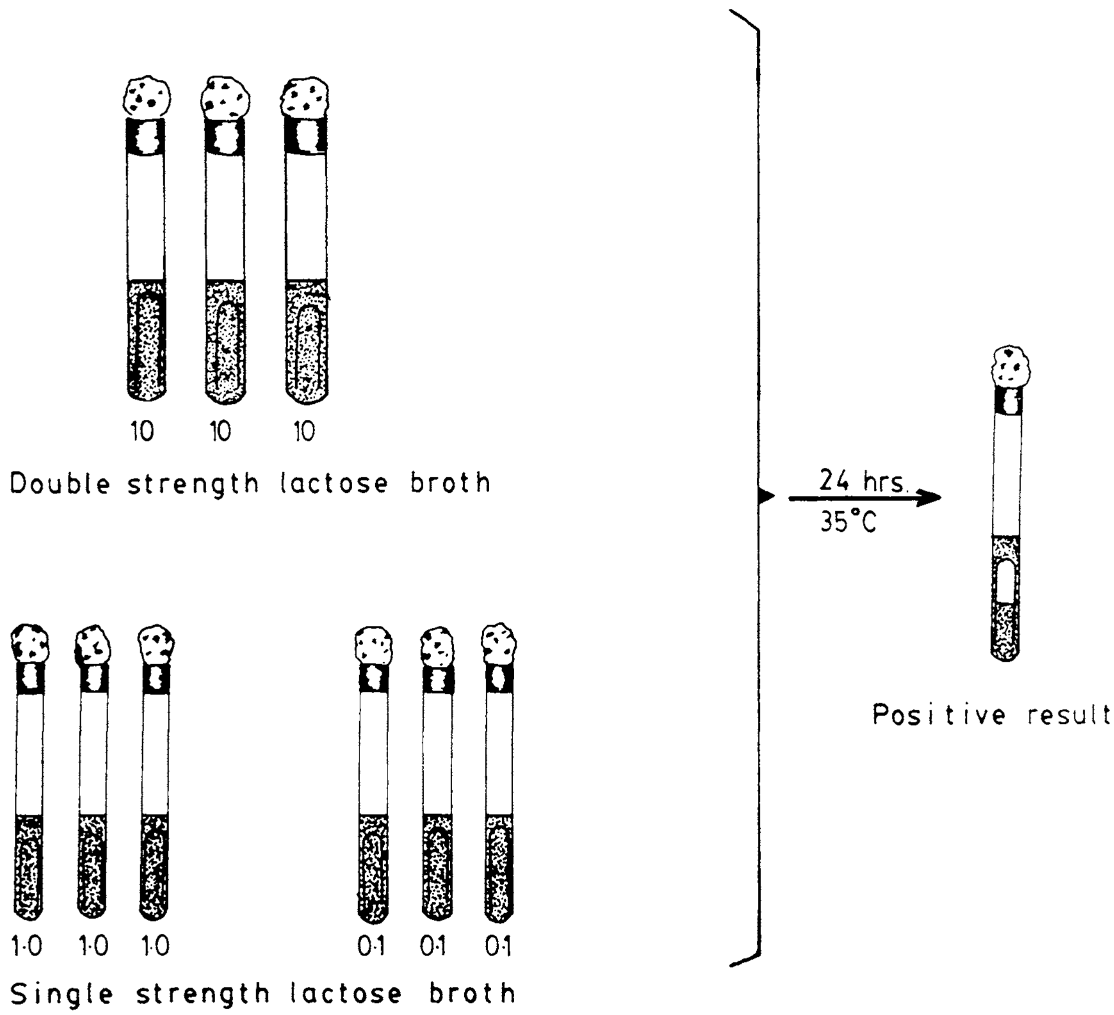

FIGURE 2.19 LABORATORY SET UP FOR BACTERIOLOGICAL ANALYSIS OF SEA WATER

Invert a Durham fermentation tube in each test tube. Place the batch of test tubes in a centrifuge and spin for 3-5 minutes to remove all air from the Durham fermentation tubes and fill them with medium.

8. Label the first three (large) test tubes 10ml, the middle three 1.0 ml, and the last three 0.1 ml, to indicate the amount of sample water that will be placed in each one.

9. Shake the water sample bottle thoroughly.

10. Use the 10 ml pipette to place 10ml of sample water into each of the first three tubes (DSM).

11. Use the 1 ml pipette to place 1 ml of sample water into each of the middle three tubes (SSM), and 0.1 ml into each of the last three tubes (SSM).

12. Shake the test tubes gently to mix.

13. Plug all test tubes with a cotton wool stopper.

14. Place sample tubes in an incubator for 24 hours at 35oC.

15. Examine the tubes for positive or negative evidence of the presence of coliform bacteria, as indicated in Figure 2.19.

Interpretation and presentation of results

Coliform bacteria ferment lactose to produce gas. If 10% or more gas is present in any one of the nine Durham fermentation tubes after incubation for 24 hours, this is presumptive evidence of the presence of coliforms. How many coliforms are present can be estimated from the total number of tubes showing positive results, using Table 2.9. This gives an estimate of the Most Probable Number (MPN) of coliforms in 100 ml of water, from which one can decide whether or not the water sample is polluted with sewage. In order to do this, present your results in tabular forms, as shown in Table 2.10 below.

Evidence of sewage pollution is so far "presumptive". In order to confirm that the gas is produced by coliform bacteria further tests should be carried out. If you are not satisfied with the presumptive evidence derived from your preliminary test consult with a microbiologist for further assistance or refer to the literature suggested below. Complete confirmatory tests will require a minimum of 48 hours further work.

Table 2.9 Coliform Bacteria MPN Determination from a Multiple Tube Test (Modified from Standard Methods of American Public Health Association).

Water Quality	No. of Tubes showing positive			MPN Index per 100 ml	95 % Confidence limits	
	3 of 10 ml each	3 of 1 ml each	3 of 0.1 ml each		lower	upper
Water satisfactory	0	0	0			
Water needs further testing	0	0	1	3	<0.5	9
	0	1	0	3	<0.5	13
	1	0	0	4	<0.5	20
	1	0	1	7	1	21
	1	1	0	7	1	23
Water un-satisfactory	1	1	1	11	3	36
	1	2	0	11	3	36
	2	0	0	9	1	36
	2	0	1	14	3	37
	2	1	0	15	3	44
	2	1	1	20	7	89
	2	2	0	21	4	47
	2	2	1	28	10	150
	3	0	0	23	4	120
	3	0	1	39	7	130
	3	0	2	64	15	380
	3	1	0	43	7	210
	3	1	1	75	14	230
	3	1	2	120	30	380
	3	2	0	93	15	380
	3	2	1	150	30	440
	3	2	2	210	35	470
	ETC.........					

<u>Example</u>: If gas is present in the first three tubes, and one each of the middle three and last three tubes, the test result is 3-1-1. This indicates a MPN of 75 bacteria per 100 ml, i.e. water quality is <u>unsatisfactory</u>. (The MPN is a statistical probability figure, with 95% probability of being between 14 - 230 bacteria).

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Table 2.10 Sample Data Table for Coastal Water Quality Analysis.

Date:.................   Observers:....................
....

Location No.	Observation colour	odour	flotsam	Sample No 1	2	3	Mean MPN	Comment * S	FT	U
ETC.										

* Refer to Table 2.9

S = satisfactory water quality
FT = further testing needed
U = unsatisfactory water quality

....

Product Expected

1. The group's results should be pooled on Table 2.10, to indicate which coastal sites are thought to be contaminated with sewage.

2. Discuss the results and relate these to your field observations about possible sources of contamination.

3. Discuss and list possible future actions to improve water quality at the contaminated coastal sites.

Alternative Exercises:

1. Survey of Beach Tar Deposits

Petroleum hydrocarbon residues may be present in seawater, submarine sediments and organisms, and on beaches. Oil slicks or sheens reduce water quality for some forms of coastal recreation, whereas many aspects of oil pollution are less easily noticed. One serious nuisance factor is the presence of beach tar, which reaches island coasts from deliberate or accidental spillage of oil largely on the open ocean.

Beach tar deposits can be estimated in the following manner: A beach is visited and all lumps of tar scooped into a weighed container from a transect perpendicular to the sea. The collection area should be 2 m wide and stretch from the water's edge up to the beach vegetation. Replicate samples should be taken at 30 m intervals along a beach, preferably sampling at low tide. The samples are returned to the laboratory, weighed, and the weight for each transect recorded. A mean weight per beach should be calculated. Windward and leeward beaches should be compared.

The analysis should be concerned with (a) the magnitude of the beach tar pollution, and (b) its relative distribution in relation to the degree of beach use for recreation.

The exercise could be extended by calculating the costs of a clean-up operation (see also Knap et al., 1980).

2. Survey of Beach Litter

One common source of visual pollution in coastal environments is the accumulations of man-made waste materials as litter on beaches (Dixon & Dixon, 1981). These include materials with high persistence (more than three years) such as plastics, bottles, rubber, aluminium cans; those with moderate persistence (one to three years) such as cloth, iron, and steel cans; and low persistence materials (less than one year) such as paper, cardboard and food wastes. Beach litter originates from two main sources, that left on the beach by visitors and that stranded after being washed in from the sea.

The quantity and origins of litter can be investigated by the following method: At 20-30m intervals, depending on length of the beach, all litter is collected into labelled plastic bags from a transect perpendicular to the sea. The collection area should be 1-2 m wide and extend from the berm at the high water mark to the back beach vegetation. Siung-Chang & Deane (1984) sampled Trinidad beaches after the weekend when fresh supplies of visitor-deposited litter were present. They considered that litter from the first two meters of the transect was stranded by the sea and that further back had been left by the visitors.In the laboratory, litter for each beach should be sorted into categories (either by type of object; type of substance; or degree of persistence; or all three if time allows) and a weight obtained for each category.

Relative amounts of litter on beaches can be compared in several ways:

(a) Windward and leeward shores, to assess relative importance of sea-borne items.
(b) Litter quantity in relation to visitor use.
(c) Beaches near town, from which garbage is derived via storm drains, compared with those at a distance.

Further investigations could identify products by trade label, e.g. drink cans, and suggest strategies for approaching the industries concerned. The costs of regular beach clean-up operations could be assessed also.

3. Measurement of BOD and Temperature

When domestic and related pollutants are discharged into coastal waters, a succession of changes in water quality takes place. The water becomes turbid, sunlight is shut out of the depths, and green plants, which by photosynthesis remove carbon dioxide from the water and release oxygen into it, die off. Decomposer organisms increase in number until they match the food supply. The intensity of their life activities is mirrored in the intensity of the biochemical oxygen demand (BOD).

BOD tests are widely used, as they give a very good indication of the condition of the receiving water, as well as the progress of decomposition of organic substances in that water. The BOD test is in itself a functional test, predicting the oxygen requirements of effluents. The tests are akso simple to perform.

Thermal pollution is of particular interest in tropical countries, as the water temperature is already close to the upper limit for sustained life. In addition, there is not much of a temperature gradient in coastal waters. Discharge of large amounts of cooling water can lead, therefore, to "dead" water over large areas, temperatures are easy to measure with standard thermometers, and can be combined with the measurement of BOD to indicate coastal water quality (see also Agard, 1984).

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Further Reading

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Lewsey, C. D. 1987. The effects of tourism development on natural resources and infrastructural facilities - the case of Barbados. Commonwealth Science Council Technical Publication, 227; 148 - 180.

WHO 1981. Coastal Water quality Control in the Mediterranean. Final Report on the Joint WHO/UNEP Coordinated pilot Project [MED VII][1976 - 1980], World Health Organisation.

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Exercise 2.5 PREPARING AN ENVIRONMENTAL IMPACT ASSESSMENT OF A COASTAL DEVELOPMENT PROJECT

Background:

Any development project in the coastal zone must, of necessity, alter associated environments. It will **impact** upon natural ecosystem structure and processes, social systems and economic conditions. The objective of most developments is to improve socioeconomic conditions in an area for a specific group of people; but the overall value of the project would be reduced if, simultaneously, it decreased living standards for any other local group or caused adverse environmental perturbation.

During the planning phase it is impossible to measure accurately all the consequences of a coastal development, but many of these can be **predicted.** If potentially adverse environmental impacts can be identified early enough, they can be avoided by appropriate modification to project design, One process by which impact of a project is determined is **Environmental Impact Assessment** (EIA). The assessment is made in the context of social values, existing legislation, economic and institutional constraints. It is based on an Environmental Impact **Analysis**, generally carried out by specialists using a variety of scientific and technical methods. The EIA resulting from the EI Analysis is formulated as an Environmental Impact **Statement** (EIS) and sent to the planners to aid in decision-making.

Ideally, EIA should be an integral part of project design, but frequently government agencies or regulatory authorities are called upon to conduct an EIA after the design has been completed by the developer. When this happens, EIA may appear to be a hindrance to development, rather than being seen as an aid to environmentally compatible utilisation of resources. Originally, the term "environmental" was used in the sense of adverse effects on natural ecosystems, plants or animals; the better usage includes the whole human environment with its economics and social aspects such as health and general welfare. In this sense, EIA must be seen as a valuable socioeconomic and aesthetic benefits to the nation. It is obvious, therefore, that EIA can be very complex as it attempts to predict a wide range of effects in the short- and long-term; it can also take a considerable period of time and require a range of expertise. However, the principles of Environmental Impact Assessment technique are very straightforward, and can be illustrated by a simple exercise and the case study below. Each of the stages of preparing an impact statement can be extended and refined if the available database is adequate or expertise and time are available for further research. The nature of the EIA will depend on the complexity of the specific development project, but also its similarity to previous projects on which EIA's were conducted and from which information can be extrapolated.

Aim:

To plan the strategy for an Environmental Impact Assessment of a minor coastal tourism development.

Duration:

One to two days

Suitable Location:

Drawing Office/Laboratory

Materials Required:

Plans and drawings of a proposed development in the target island.
Maps and/or charts and aerial photographs of the development area as it is at present.
Background data files (or Data Atlas if available) on development area and associated areas, containing information on;

- natural ecosystem
- settlement patterns
- present activities and land-use
- economic conditions in area
- list and summary details of other planned developments for the area under study
- documents dealing with national development plans and objectives
- copies of laws or regulations concerning use of the area's resources.

Typing or word processing equipment.

Instructions:

1. Review available data on the development area. Identify key ecosystems and/or socioeconomic features which could be altered by development activities.

2. Review the development plans and drawings, and identify the key elements in the proposals, i.e. what aspects/actions in the development proposal need to be examined for possible effects on features identified above?

3. Refer to the outline for Environmental Impact Statements given in Table 2.11 and write out the EIS step by step. It is unlikely that all the information you require has been provided, so an important part of the strategy of preparing for an EIS is to identify data needs and appropriate methodologies for obtaining required data. List these requirements and indicate what information sources should be investigated or what field research should be conducted.

Table 2.11 Outline for Environmental Impact Assessments

1. Project Description:

   1.1 Purpose of porposed action/s.
   1.2 Description of proposed action/s (i.e. title, summary of activities).
   1.3 Environmental setting (i.e. nature and status of environment prior to action; related environmental aspects).

2. Land-use Relationships:

   2.1 Conformity or conflict with other land-use plans, policies and controls (national, regional, local; relevant legislation).
   2.2 Conflicts with other land-use plans; extent of possible reconciliation; reasons for proceeding with proposed action/s despite conflicts.

3. Probable Impact of the Proposed Action on the Environment:

   3.1 Direct (primary) negative and positive effects on

   - environmental factors.
   - national environments (and possibly international environment).

   3.2 Indirect (secondary) effects and consequences.
   3.3 General impact of proposed action.

4. Probable Adverse Environmental Impacts which Cannot be Avoided:

   4.1 Description of unavoidable impacts and their consequences.
   4.2 How unavoidable adverse impacts will be mitigated.

Table 2.11 continued..

5. Alternatives to the Proposed Action/s:

5.1 Alternatives which might avoid some adverse effects.
5.2 Alternatives which might avoid all adverse effects.
5.3 Alternatives which might enhance environmental quality.
5.4 Analysis of alternatives (Benefits, costs, risks).

6. Relationship between Local Short-term Uses of the Environment and the Maintenance and Enhancement of Long-term Productivity:

6.1 Trade-of between short-term environmental gains at the expense of long-term losses.
6.2 Trade-of between long-term environmental gains at the expense oif short-term losses.
6.3 Extent to which proposed action forecloses future options.

7. Irreversible Commitments of Resources

7.1 Unavoidable impacts irreversibly curtailing the range of potential uses of any part of the environment;

- natural resources
- materials
- cultural resources
- human resources.

8. Interests and Considerations of National Policy that Offset any Adverse Environmental Effects of the Proposed Plans:

8.1 Countervailing benefits of proposed action/s.
8.2 Countervailing benefits of any alternative action/s.

9. Statement of Conclusions:

9.1 Approval of proposed action/s, with supporting rationale; or
Approval, with recommended modification/s of proposal; or
Disapproval of proposed action/s, with supporting rationale.
9.2 Recommendations for action, or further investigation (e.g. by the developer, responsible agency or government).

....

4. The identification of probable impacts (step 3 on Table 2.11) is critical to the EIS. Where a project has many "actions" which might impact on a varied natural and man-made environment, their interactions at primary and secondary level can be clarified by presentation in the form of a matrix or similar format, as is done for the information from the case study (Figures 2.20 & 2.21) shown in Figure 2.22. Impacts have been identified, then assigned categories and values, to indicate negative or positive qualities and whether these are minor, moderate or major. This form of presentation draws attention to significant impacts, so that the whole range of impacts can be dealt with but in order of priority.

   Identify primary and secondary negative and positive impacts of the proposed development, and present these in tabular or graphic format.

5. Consider each potential impact in turn while referring to steps 4-6 in Table 2.11.

6. Move to the recommendations phase of the EIS by reference to steps 7 & 8 in Table 2.11. As with many of the other aspects of coastal zone management (previous exercises Chapter 2 and Chapter 3), the possible negative effects of the proposed development must be weighed against considerations of national development policy. For example, if the island government is desirous of expanding the tourism industry, some disturbance of coastal ecosystems and displacement of traditional activities may be justifiable. These, probably negative, impacts may be outweighed by the need to improve water quality in the target area or by new jobs created in the tourism service industries. Weigh up the implications of the proposed development and identify impacts which could be considered justifiable in relation to national policy guidelines and existing legislation. (N.B. Economic aspects are considered in greater detail in the following exercise, no. 2.6).

7. Write a brief concluding statement which does or does not recommend that the proposed development should be approved. This should be supported by clearly stated reasons, including instructions for further research or study where the development permit should be withheld because of inadequate information.

8. The final product should be an Environmetnal Impact Statement along the lines of Table 2.11, supported by appropriate maps and diagrams.

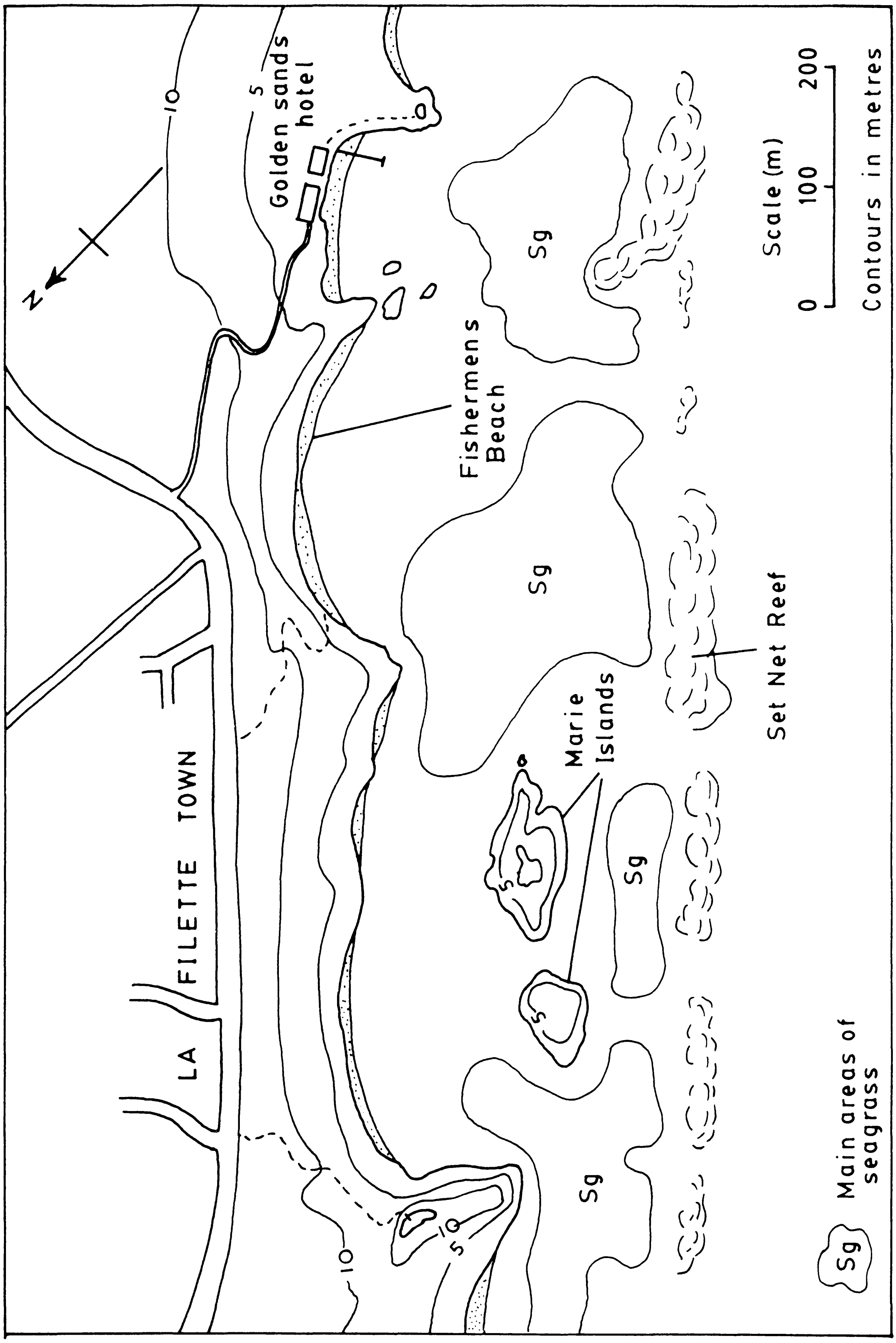

FIGURE 2.20 NATURAL FEATURES - LA FILETTE

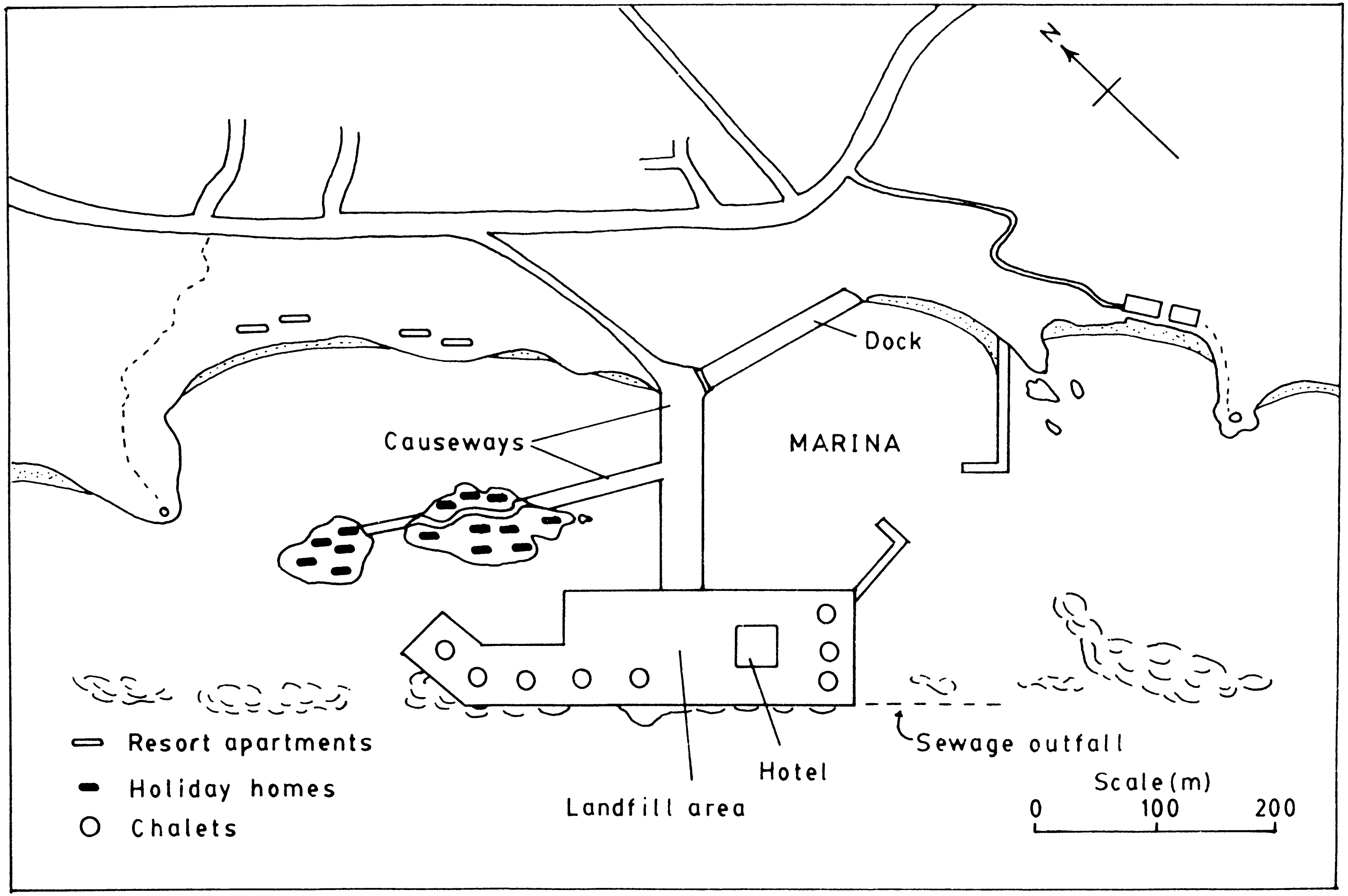

FIGURE 2.21 LA FILETTE DEVELOPMENT PROPOSAL (simplified)

	PRIMARY IMPACTS 2 / 1 ACTIONS	Natural environment						Socioeconomic environment						
		Decrease water circulation	Increase turbidity	Decrease oxygenation	Decrease coral reef area	Disturb seagrass beds		Increase traffic	Increase local population	Displace traditional uses	Increase employment			
		2a	2b	2c	2d	2e	2f	2g	2h	2i	2j	2k	2l	2m
1a	Landfill-new island	2	3	1	3	1		0	1	2	3			
1b	Landfill-causeways	3	2	2	1	3		1	1	2	1			
1c	Dredging marina pool	0	3	3	0	3				3				
1d	Construction work							3		2	3			
1e														
1f	Small boat use	0	0	0	0	2				3	1			
1g	Sewage disposal		2		1									
3a	Primary production	-2	-3	-2	-1	-3								
3b	Fishery yield	-2	-2	-1	-3	-3				-2				
3c	Coastal protection	0	0	0	-3	-1								
3d	Property values							-1	+2	0	+3			
3e														

1 minor 2 moderate 3 major + positive - negative

FIGURE 2.22 EIA MATRIX FOR THE LA FILETTE DEVELOPMENT (simplified and partially completed)

Case Study:

The National Physical Development Plan, vol.2 1986, identified several areas of the northeast coast for development, as part of the government's attempt to spread the benefits of a rapidly expanding tourism industry away from the overcrowded west coast resorts. One town which was in serious need for economic revival since the decline of its fruit export trade was La Filette, situated opposite the Marie Islands in the lee of Set Net Reef (Figure 2.20). A development company proposed the construction of a resort complex at La Filette, which would include an hotel and restaurant on landfill on the main reef, holiday flats on the Marie Islands and a marina/boating area at the site of the present fishermens' beach. The resort infrastructure was to be linked throughout by solid-fill causeways, and a series of groynes would ensure water quality and safety for recreationers (Figure 2.21).

During the preliminary phase of an EIA, the Department of Natural Resources identified and assessed possible impacts of the proposed development, and prepared this in the form of an EIA Matrix to be used during discussions with relevant government agencies. This matrix is shown in Figure 2.22.

The matrix can be interpreted by reading from Development Actions (1, top left) which impact on the components or processes of the environment (2, top centre), with a type and scale of impact shown in the body of the matrix. An identified Primary Impact at (2) can be expected to have any of the Secondary Impacts shown (3, bottom left). For example, Landfill for causeway construction (1b) is expected to reduce water circulation (2a) having a major impact on the environment (scale 3), and leading to negative secondary impacts such as a reduction in primary production of benthic plants (3a) and of fisheries production in the bay (3b).

In this Case Study, the matrix highlighted several major negative impacts on the natural environment and on the local fishing community. Even before the economic benefit-cost analysis was complete, these possible impacts were considered sufficiently serious for the developer to be asked by government to redesign the basic engineering in the proposal. (This Case Study is hypothetical)

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Alternative Exercises:

1. Environmental Impact Analysis is an extension of more conventional Cost-Benefit Analysis of the economics of development projects. EIA attempts to do the equivalent of a Cost-Benefit Analysis on less easily quantified aspects of the total environment, such as the costs of ecological disruption or loss of aesthetic resources. Translating some environmental or resource values into dollar equivalents is often difficult, but is essential for management of the total resource capital of island coastlines.

   Select a coastal development project, such as the Case Study presented above, and conduct analyses of two components, as follows:

   (a) compare the cost of one aspect of construction (e.g. building a new hotel) with the expected income (benefit). This ordinary Cost-Benefit Analysis will almost certainly show a net profit.
   (b) Compare the cost of construction above with the possible costs of damage caused by a storm, after the land-fill operation has destroyed the protective coral reef; i.e. attempt to put a dollar value on the protective functions of the healthy reef.

2. Assess the impacts of tourism development on adjacent areas and their infrastructure. The main exercise above concerned EIA at the site of development, but the introduction of tourism into a bay also affects the supporting town and neighbouring areas. Take into account likely effects on the system of roads, power supplies, water and sewage (treatment and disposal), displacement of people from the development area and migrations of people into the area (transport, housing, shifts in the economy).

3. Assess the impacts of a mariculture development project. The above exercises have been concerned largely with land-based activities, but the growing popularity of the culture of marine organisms in coastal waters is causing problems in many areas. Not only are there problems for the mariculturist trying to raise food organisms in polluted waters, but the presence of culture frames, rafts, submerged cages and other structures impacts on the natural environment and on economic activities in the coastal zone. Examine a functioning or proposed mariculture scheme and assess its impacts; including the used of local material in construction, effects on freedom of navigation on that part of the coast, on traditional uses of the area, on the local economy and water

quality.

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Further Reading

Devaux, R. J. 1987. The impact of the Rodney Bay Project on coastal processes. Commonwealth Science Council Technical Publication, 227; 117 - 131.

Kapetsky, J. M. 1981. Some considerations for the management of coastal lagoon and estuarine fisheries. FAO Fisheries Technical Paper, 218; 47 pages.

Lewsey, C. C. 1987. The effects of tourism development on natural resources and infrastructural facilities - the case of Barbados. Commonwealth Science Council Technical Publication, 227 148 - 180.

Marshall, B. V. 1975. Comprehensive Economics, pt. 2. Analytical and applied (2nd Edit.). Longman, London; 695 - 1163.

Odum, W. E. 1974. Potential effects of aquaculture on inshore coastal environments. Environmental Conservation, 1; 25 - 47.

Shopley, J. B. & Fuggle, R. F. 1984. A comprehensive review of current Environmental Impact Assessment methods and techniques. Journal of Environmental Management, 18; 25 - 47.

Williams, M. C. 1987. Environmental Impact Assessment in the physical planning process with special reference to the coastal zone. Commonwealth Science Council Technical Publication, 227; 59 - 83.

* * *

Exercise 2.6 ANALYSING THE ECONOMIC BENEFITS, COSTS AND RISKS OF COASTAL AREA DEVELOPMENTS

Background

Previous exercises in this Chapter have not dealt with the economic aspects of coastal development, although these have been implicit throughout. As examples, (a) construction of a breakwater (Ex. 2.2) will be of cost to the developer, but if erosion results this will reduce the value of the beach for residents and tourists; (b) a suitable location for a sewage outfall can be chosen (Ex. 2.3, but the best site on technical and environmental grounds could also be the most expensive in terms of pipe laying or distance from the treatment plant; (c) maintaining bathing waters free from coliform bacteria (Ex. 2.4) requires expenditure on monitoring services, and the higher the standard of coastal cleanliness required the higher the costs of waste disposal. However, if water quality standards are not maintained, financial losses might occur through increased medical bills or reduction in tourist numbers; (d) enviromental impacts of a resort development project were reviewed (Ex. 2.5), but there will be impacts on many sectors of the economy to be considered also. The developer will invest money and expect profits, and employees and service industries will receive and pass on money. But while this multiplier effect spreads the benefits through some parts of society, adverse impacts of the project might involve the government or small groups of citizens in a loss f revenue. On the other hand, if a different type of development had taken place in the area, such as La Filette Bay (Ex. 2.5), profits might have been smaller but the environmental damage and resulting costs to society negligible.

The outline for preparing Environmental Impact Statements for development projects requires consideration of alternatives to the proposed action (Table 2.11, Item 5). This includes an analysis of these alternative in terms of the **benefits, costs,** and **risks**; which helps the coastal zone manager to progress from what it is feasible to do on technical or environmental grounds, to what is advisable to do on economic grounds. In other words, over and above the environmental opportunities and constraints on coastal resource development, the manager must make an **economic choice**, in deciding between different uses of a resource, and must **allocate resources** between competing user groups in order to **maximise economic returns.** He must consider the effects of the development on both **private** and **public** sectors and take into account **short term** and **long term** benefits and costs (see Beckhuis, 1981).

The exercise which follows is an introduction to some of the economic aspects of coastal area development, designed for trainees with little previous knowledge of economics. It concentrates on some of the concepts involved in decision-making, and on developing a strategy for reviewing the economic implications of alternative proposals, rather than detailed monetary calculations. However, the instructor could replace the hypothetical case study presented with a local example for which financial predictions have been made, if the level of understanding of economics among the trainees merits this.

Aim:

To make a preliminary benefit/cost analysis of alternative uses of a coastal wetland area.

Duration:

One day (minimum).

Suitable Location:

Drawing office or laboratory, using the information provided.

Materials Required:

Report writing materials
Word processor or word processing facilities
Copies of the following reports (which are reproduced at the end of this exercise, below):

- "Summary of Bogue Swamp Development Plan"
- "Review of the Bogue Recreation Park Proposal"

A list of local financial information, (such as house prices, hotel rates, construction costs, transport fuel costs, labour costs, insurance and import charges), which should be provided by the instructor.
Pocket calculators

Instructions:

1. Review the documents provided. Discuss these with the instructor and ensure that you have a clear picture of the type and magnitude of the proposed developments.

2. Note the estimated costs of the proposed projects, and that the two competing investors are the Government (using public funds) and a private company (using share capital or loans). Make a list of the different ways the money will be spent (eg. materials, labour),

and from this a list of the groups of people who will benefit during the construction phase of each development. It is not necessary to estimate actual earnings or to calculate the cash flow, as you are concerned with where the benefits will be felt and the relative scale of benefits. However, if local financial data is available for comparison, advanced trainees may wish to do this.

3. Take each development in turn and list the types and likely number of persons who will benefit directly from it once it is operational. This should include (a) persons involved in operating the facilities, and (b) the visitors and others who will enjoy the facilities.

4. Compare the benefits to be derived from the two proposed developments (combined construction and operation phases). The comparison should examine numbers of persons who benefit or the likely cash flow paths through society. (It is not necessary to attempt monetary calculations for trainees to appreciate relative benefits of the competing proposals). Does it appear that the greatest benefits are likely to arise from the more costly development? If not, how do you account for this?

5. Before choosing to allocate the natural resources of the target area to the more competitive proposal, consider some of the indirect costs of either development. The area has a range of values at present, and "developing" it would mean some loss of value to current user groups. These include:

   (a) Fishermen - would incur loss of income from fishing in the swamp. Would also be displaced from fishing and mooring boats in this area.
   - might incur loss of income from fishing on the reef, if removal of mangroves upsets local marine food chains or reduces the supply of nutrients to the reef.

   (b) Recreationers - would no longer have free access to the swamp area for boating, swimming or other recreation and enjoyment.

   (c) Residents - amenity value would be reduced; loss of scenic qualities and increases in traffic, etc., are likely to affect house prices and use of guest houses on Jack's Hill.

Private costs, of investment by the developer, are more easily appreciated than **social costs**, such as loss of traditional employment by fishermen or loss of amenity value by residents and visitors. Discuss how important you consider these losses to be, and identify any other probable social costs of the proposed developments.

6. Calculate the **opportunity costs** of the existing uses of the Bogue Swamp area. An opportunity cost is a measure of what the user has given up in order to enjoy a resource. For example, an islander was prepared to give up buying other luxury items in order to buy fuel to drive his family to the Bogue Swamp for a picnic. Instead of buying a new stereo set, another person bought a second hand canoe in order to enjoy boating in the lagoon. The expenses of these two users can be considered as part of the value that people place on this natural area.

   Refer to the reports on the Bogue Swamp area and make a list of the types and numbers of persons who use or benefit from the area in its present condition.

   Calculate the opportunity costs for each group, as in the following example: Residents from different parts of the island visit the Bogue area for recreational purposes, and spend money on fuel, food, drink and photographic materials. If there were 9,500 visitor days last year and visitors spent on average $15, the opportunity cost for this user group was approximately $142,500 per year. If we had been considering a group of foreign tourists visiting the area by taxi and buying their food in the guest house, and spending on average $30, the opportunity costs would be doubled.

7. The total opportunity costs, calculated for the area without development, should be balanced against the proposed developments. Loss of opportunity should be considered a cost item; to what extent does it reduce the expectd benefits?

8. The two proposed developments modify the Bogue Swamp area to different degrees. Re-examine the proposals and assess which has the lower effect on present opportunity costs; for example, if residents value living above the Swamp because of its scenic character, which development disturbs scenic values less? Is the potentially lower profit from this "more acceptable" project justified by the scenic values which have been preserved?

9. Review the benefit/cost analysis conducted thus far and, in the light of the issues raised, draft a strategy for approaching a similar analysis with

another proposal. The strategy should list the actions to be taken in order of priority.

10. Conduct a **risk analysis** of the Bogue Freeport development. The benefit/cost analysis above has assumed, thus far, that certain benefits will accrue when the development takes place. Once cruise ships arrive and tourists spend money in the duty free shops, there will be benefits to the economy that repay investments and outweigh identified social costs. But what happens if tourists are not attracted to the area, or not in sufficient numbers?

This question will have been faced by the investors at an early stage of preparing the development project proposal. They will have considered the risks involved and assessed the likelihood that their project will succeed (i.e. make a profit or improve conditions in the area).

Activity 1: Students should list the types of information they would need for an economic risk analysis of the Bogue Swamp Development Project. This might include:

- Outline of government policy on tourism sector expansion.
- Predicted trends in tourist arrivals to the island.
- The National (5 year) Development Plan, containing the projections on potential competing or supporting developments in or adjacent to the target area.
- Data on the loans policy for tourism-type developments of the major local financial institutions.
- other........

Students should refer to qualified resource persons for help with identifying needs for economic risk analysis.

Activity 2: Students should also analyse the risk of economic losses resulting from (unexpected) environmental problems. For example, removal of mangroves and cutting of the navigation channel might result in deterioration of the fringing reef which protects popular bathing beaches and commercial waterfront property adjacent to the development site. Do the benefits to be derived from the proposed Bogue Development outweight the possible costs of increased wave and storm, damage to these neighbouring features? What is the risk and is it worth taking? (The likelihood of reef damage occurring would be assessed by standard of EIA procedures. These would provide a prediction, and stated degree of certainty. The coastal zone manager should consider the chances, but assess the economic risks on the basis that damage can be expected).

List the types of information required to decide whether the private and social costs that can be expected following reef damage seriously detract from the potential value of the development. Is the economic risk high or low in this respect?

11. Prepare a written summary outlining the economic benefits, costs and risks involved in the proposed Bogue Swamp area developments. Give an overall assessment of the economic viability of both proposals.

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Alternative Exercises:

1. Students should make a study of opportunity costs during a field visit to a small recreational site, near the training centre. The numbers of persons using the site (preferably at peak time) should be estimated and the costs of running the site investigated. Students should conduct interviews, using a pre-prepared questionnaire, in order to find out how much visitors have spent to reach the site and how much they expect to spend in order to enjoy the site. Use these figures obtained from a small sample of the visitors to estimate the total opportunity cost.

   Follow the above study by drawing up a plan to attract twice as many visitors to the site. Estimate what it would cost to attract and cater for the increased visitor numbers (publicity, infrastructure and facilities, wardens, life guards or whatever is appropriate). Then compare the costs of running the improved recreational site with the estimated opportunity costs. Do you consider that the benefits of the proposed development would outweigh the investment and running costs?

Further Reading:

Dixon, J. A. & Hufschmidt, M. M. (Eds) 1986. Economic Valuation Techniques for the Environment. John Hopkins University Press, Baltimore, USA.

Gamman, J. K. & McCreary, S. T. 1988. Suggestions for integrating EIA and economic development in the Caribbean Region, Environmental Impact Assessment Review, 8; 43 - 60.

Koester, S. K. 1986. Socioeconomic and cultural role of fishing and shellfishing in the Virgin Islands Biosphere Reserve. Virgin Islands Resource Management Cooperative, Biosphere Reserve Research Report, 12; 24 pages.

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Exercise 2.6: **Supporting Document No. 1**

SUMMARY OF BOGUE SWAMP DEVELOPMENT PLAN

This summary is designed to help agency personnel obtain an overview of the proposed development of a tourism/freeport centre at the Bogue Lands, the details of which may be found in Ministry Document 42/87/216.

A. Existing Conditions

1. Bogue Swamp is the largest area of mangroves on the north coast, covering approximately 320 acres. The Swamp consists of seven mangrove-covered islands with shallow channels between, and two lagoons. The inner lagoon is also shallow, with a firm sandy bottom and patches of seagrass and is well known for its rich and varied fish life. The outer lagoon is deeper, falling to 12 ft in places, and separates the mangrove area from the coral reef. The reef is passable only by small canoes, except at the southern end where small yachts and motor craft can pass at high tide. The mangrove islands shelter the beach on the south (landward) side, giving very calm conditions much liked by families with children. Longshore currents keep seaweed and other debris off the beach and bathing area. Although less than one mile from the town, there have been no complaints of pollution of the beach or swamp area by oil, garbage or other offensive materials.

2. Ten fishermen reported regular fishing in the Bogue area, five on a full time basis, the others regularly in between other forms of employment. Trap fishing in the outer lagoon is practiced regularly by all fishermen interviewed. Some shrimp, used largely for bait, crabs of three species, lobster and some scalefish are also taken in the inner lagoon and among mangroves. About half the catch is sold to the quest houses on Jack's Hill, the balance is either sold on the beach at the eastern end where the fishermen moor their boats, or used for home consumption. The fishermens' families benefiting from use of the Bogue area number approximately 62 persons.

3. Recreational fishing is carried out throughout the area, but no estimate is available. The number of visitor days recorded during the last 12 months (by survey of persons entering he beach area from Hillside Lane) was 12,740. The largest number were islanders, totalling 9,500, while the balance were guided tour parties of foreign tourists staying in the main town.

4. Bogue Swamp is overlooked by Jack' Hill, probably the most exclusive housing area in the north. Property on the Hill fetches high prices, due to the spectacular views over the swamp and reef, the unspoiled nature of the local environment and general quietness (which is in contrast to the main town round the bay to the east). Jack's Hill has two guest houses, which boast 80 - 90 % occupancy throughout the year. "Hillcrest" caters to day trippers, especially foreign tour parties, and the view from the guest house verandah is probably one of the most photographed on the north coast. During the last 12 months this guest house recorded 8,320 day-trippers.

B. Features of the Development Plan

1. All mangrove will be cleared from the site; bottom material dredged from the outer lagoon and used to fill the Freeport site. An elongated landfill area of 120 acres will be levelled and joined to the base of Jack's Hill (present beach area). The following facilities will be constructed on the landfill site:

- Dock area with three berths (designed to receive cruise ships and freighters).
- Customs shed and warehouse.
- Six factory units (free zone manufacturing for export, expected to employ 300 workers).
- Enlarged access road, with guard post (there will be restricted entry to the Development Area) - Parking facilities.
- 12 chalets for duty free shopping; one restaurant with gardens, toilets and staff lounge.
- Navigation channel. A channel will be cut through the reef opposite the cruise ship dock (using mechanical means), large enough to permit entry by ocean-going vessels. Marker buoys and moorings will be provided.

2. Costs of construction are estimated at $40 million.
3. Construction time is estimated at 18 months to reception of the first party of cruise ship tourists, and 24 months to full operation of the facility.
4. Estimates show two cruise ships per week can be expected. There are no estimates of revenue from free zone operations which will be put out to tender.
5. The Ministry of Works will contract out construction work through normal tendering routes.
6. The Tourist Board will be mandated to manage the Feeport Development, probably through the establishment of a Bogue Freeport Development Authority.

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Exercise 2.6 **Supporting Document No. 2**

REVIEW OF THE BOGUE RECREATION PARK PROPOSAL

The alternative proposal submitted by "Leisure Investments Ltd." to the Department of Planning on 15th June 1988 concerns plans to build a recreation park on a site known as Bogue Swamp. The "Swamp" is Government land consisting of mangrove islands, lagoons and a beach fringing the northern side of Jack's Hill (a private residential area not included in the development area). The proposal has the following features:

1. Five of the mangrove islands will be graded and the major portion of the mangroves removed to make way for picnic and barbecue sites. These sites will include wooden shelters covered with palm leaves, with seating and wooden table.
2. Channels between and around all islands will be dredged to permit access by small pleasure craft. Landing stages will be constructed on each island.
3. An hotel will be constructed at the eastern side of the development area. This will be an exclusive 40 bed hotel in the form of separate cabinas/chalets, with tennis courts and freshwater swimming pool.
4. The hotel will be fronted by a marina, capable of berthing up to 50 pleasure craft, with full service facilities but not repair facilities. It is expected that the marina will be used largely by hotel guests (who will arrive by boat).
5. A channel will be dredged from the marina, through the inner lagoon to the western and of the swamp, where a passage to the sea already exists. A survey is being conducted at present to determine the necessity of deepening or widening the channel through the reef.
6. The beach area will be retained. Local residents will be permitted to use the beach, but an entrance fee will be charged. Licensed concessions will provide refreshments and watersports equipment; these will be controlled by the developer directly.
7. Construction costs are estimated at $20 million.
8. The first phase, continuing the hotel and marina facility, will be operational within 18 months. Navigation channel dredging will proceed simultaneously. The second phase which will begin once Phase 1 is completed will develop the picnic sites and other recreational facilites which will be used largely by islanders. Phase 2 should be completed within six months.
9. When fully operational, the Recreational Park is expected to employ 30 -40 persons full time. Extra part time staff will be required from time to time.

10. The report concludes with financial projections which suggest profits on the initial investments will be realised by the middle of year three.

* * *