THE UNIVERSITY OF NEW SOUTH WALES
water
research
laboratory
Manly Vale N.S.W. Australia

DATA COLLECTION FOR GEORGES BAY. ST. HELENS, TASMANIA

by

D.N.Foster, R.J.Cox and R.A. Cook

Technical Report No. 84/01

February, 1984

The University of New South Wales

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The work reported herein was carried out and is published under the direction of the Director of the Water Research Laboratory, acting on behalf of the clients, the Department of Main Roads, Tasmania.

8. ABSTRACT
In October, 1983, the Water Research Laboratory (WRL) was commissioned by the Department of Main Roads, Tasmania (DMR) to undertake data collection and analysis and to carry out other preparatory studies necessary for an hydraulic model study of proposed major breakwater walls at the entrance to Georges Bay on the north east coast of Tasmania. The results of these studies, which were carried out with the close co-operation of the DMR, are presented in this report.

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Preface

The work reported herein was carried out and is published under the direction of the Director of the Water Research Laboratory, acting on behalf of the client, the Department of Main Roads, Tasmania.

Information published in technical reports is available for general release only by permission of the client and the Director.

D.N.Foster,
Associate Professor of Civil Engineering,
Director.

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1. Introduction

In October, 1983, the Water Research Laboratory (WRL) was commissioned by the Department of Main Roads, Tasmania (DMR) to undertake data collection and analysis and to carry out other preparatory studies necessary for an hydraulic model study of proposed major breakwater walls at the entrance to Georges Bay on the north east coast of Tasmania. The results of these studies, which were carried out with the close co-operation of the DMR, are presented in this report.

Georges Bay and the town of St.Helens are shown in Figure 1. It can be seen that Georges Bay is connected to the sea by a long narrow navigable channel through extensive sand shoals from Humbug Point to Granite Rock Point. The entrance, which is subject to open sea conditions, is marred by a barway, the present position of which is indicated in Figure 1.

In 1969 the DMR constructed a length of training wall at Blanches Point with the intention of controlling the meandering navigation channels inside the entrance. Over the years the training wall has been cautiously extended and now has a total length of approximately 340 metres, the last 130 metres being constructed in February-April, 1983. The training wall has effectively controlled a navigation channel as intended and according to local reports has had the additional effect of improving conditions on the barway each time the wall was extended. It should be noted that the training wall was not constructed with the intention of controlling the barway directly. It was, however, intended for future incorporation into the major breakwater walls planned to extend seaward of Granite Rock Point to control the barway and improve all weather access to the port.

The data presented in this report, as well as providing a basis for the operation and verification of an hydraulic model, will enable an assessment of the effect of the training wall. The results of the preparatory studies include:-

(a) Data from joint WRL/DMR field excursion to Georges Bay between 14th and 18th November, 1983, comprising -

   (i) tide level variations from open sea to wharf at St. Helens,

   (ii) continuous record of tide level for period of excursion,

   (iii) tidal velocities, discharges and prisms at two channel cross sections,

   (iv) bed sediment sampling,

   (v) pathlines of drogues released near entrance.

(b) Analysis of above field data.

(c) An up-to-date hydrographic survey plan of the entrance covering the area from offshore of the barway to inshore of Pelican Point.

(d) Results of jetting survey to define any rock within the area of the above hydrographic survey.

(e) Assessment of historical changes from available historical survey data and aerial photography.

(f) Wave climate investigations comprising:-

(i) offshore wave height data from Public Works Department of NSW for Eden from 1978 to 1982,

(ii) wave direction including analysis of Bureau of Meteorology synoptic charts and other data,

(iii) spectral wave frequency - direction refraction analysis by computer techniques.

2. Tide Level Variations

2.1 Field Measurements

Temporary tide boards were installed at six locations shown in Figure 1 between the wharf at St. Helens and the boat ramp at Burns Bay, outside the entrance. All boards were levelled to Australian Height Datum (AHD) to enable comparison of recorded water levels. The variation in water levels at each tide board was observed over a tidal cycle on 15th November, 1983, using a team of observers. In addition a Stevens automatic tide recorder was installed at location 3 (Akaroa jetty) to provide continuous tide records for the period 14th to 18th November, 1983.

2.2 Results

The monitored water level variations are presented individually in Figures 2 to 7 and have been combined in Figure 8 to illustrate tidal lags.

The record from the automatic tide recorder appears as Figures 9A and 9B. For comparison the open ocean tides predicted for Eddystone Point by the Admiralty Method using harmonic constants and Form NP159 have been included in Figures 9A and 9B. The Eddystone Point chart datum has been taken as -1.00 m AHD.

2.3 Discussion

Figure 8 clearly illustrates that there is no attenuation in tidal levels from inside the training wall (gauge 5) through the channel and across Georges Bay to the wharf at St. Helens (gauge 1). Tidal lag from gauge 5 to gauge 1 is of the order of 0.5 and 1 hour for low and high tide respectively.

Comparing tidal observations at gauge 6 (open ocean at Burns Bay) and gauge 5 (inside the training wall) there appears to be a small attenuation (less than 0.1m) through the entrance evidenced by the increase in low water level. High tide level remains unaffected.

Figures 9A and 9B indicate that the open ocean tidal predictions for Eddystone Point can be applied to Georges Bay.

The longer term tidal predictions at Eddystone Point for November 1983 as shown in Figure 10 illustrate the nature of the tides in the area as being semi-diurnal with large diurnal inequalities. The important tidal level parameters for Eddystone Point and hence Georges Bay are shown in Figure 10 and summarised in Table 1.

Tidal behaviour during the period of the field excursion from 14th to 18th November 1983 (Figures 9 and 10) is seen to be relatively unaffected by the diurnal inequality with high tide levels between MHHW and MLHW and low tide levels between MHLW and MLLW.

3. Tidal Velocities, Discharge and Prisms

3.1 Field Measurements

Tide gauging over a full tidal cycle was carried out at cross section B-C (training wall) and cross section G-H (Akaroa) on 17th November 1983. Cross section locations are shown in Figure 11. Current velocity and direction readings were taken at six stations across section B-C and at five stations across section G-H using Toho Denton CM2 direction indicating current meters. The current meters were calibrated before and after use.

Hydrographic surveying to determine the cross sections B-C, D_2-E and G-H was carried out by DMR surveyors on 15th November, 1983, with additional echo sounding runs across sections B-C and G-H by WRL staff on 17th November 1983 while gauging was in progress. Cross sections reduced to AHD and showing station locations are shown in Figures 12, 13A, 13B and 14. The chainage across the section to each station was measured by DMR surveyors using EDM equipment.

In general velocity and current direction readings were taken at approximately mid depth at stations located in shallow water and at approximately one metre from bed and surface and at mid depth at stations located in deep water.

3.2 Results

Field measurements at cross section B-C and cross section G-H appear as Appendices 1 and 2 respectively. Subsequent calculation of station discharges as described in Section 3.3 are also shown.

3.3 Analysis of Field Measurements

The discharge at each station was calculated for each time at which readings were taken. At section B-C (training wall) this was taken as the product of the mean of velocity components normal to the section and the station cross sectional area. A small part of the station 5 cross section area was excluded from calculations because it lay behind a small reef. At section G-H (Akaroa) the recorded current directions (estimated using a hand compass following a meter malfunction) were less reliable and discharges were taken as the product of the mean of recorded velocities and station cross sectional area. In this manner the discharge versus time history of each station was determined for the period of observation.

The total cross section discharge versus time relationships were determined by graphically summing the component station discharge versus time histories and are shown as Figures 15 and 16.

The volumes of water passing each cross section during both ebb and flood tides were obtained by integration of the discharge versus time curves and are shown in Figures 15 and 16 and are summarised in Table 2. For comparison, the tidal prisms for the gauged tides, were estimated using the tidal ranges from the automatic tide gauge and the appropriate surface area determined from the 1:50,000 chart of Georges Bay on Chart AUS356. As no significant areas of tidal flats were exposed at the low water during gauging, high tide surface areas were used in calculations. Estimated tidal prisms are shown in Table 2.

3.4 Discussion

The measured tidal volumes at B-C and G-H are seen in Table 2 to compare very well with the estimated tidal prisms. In all cases the difference in the agreement is less than 8%.

At the entrance section B-C the ebb tide flow is marked by high velocity (about 1m/sec) currents flowing along and close to the training wall. In contrast there is very little flow close to the training wall during the flood tide.

At the Akaroa section G-H both ebb and flood tide flows take place predominantly in the navigation channel on the eastern side (i.e. stations 1,2 and 3). Only minor tidal flow occurs in the western half of the G-H sections over the sand bar (station 4) and the minor channel (station 5).

The peak discharge Q_{max} for a sinusoidal tide is given by -

$$Q_{max} = \pi P/T$$

where T = tidal period (usually 12.4 hours)

and P = tidal prism

The tidal prism P can be estimated from the upstream surface area A and the tidal range R by

$$P = AR$$

In Figure 17 the peak tidal discharge for a spring tide of range 1 metre has been calculated from the above and plotted against cross sectional area for the entrance B-C and Akaroa G-H sections. Some data from other entrances and estuaries both within Australia and overseas are also shown in Figure 17. The indicated "equilibrium" value of V_{max} the peak sectional mean spring tide velocity for the approach channels to Georges Bay is about 1.0 m/sec. This value of V_{max} agrees closely with values of 1.0 ± .15 m/sec previously reported by many investigators for a large number of ocean inlets (Bruun 1967, O'Brien 1969, Jarrett 1976).

4. Sediment Sampling

4.1 Sampling

A number of bed samples were taken by WRL staff during the November 1983 field excursion. Sample locations are shown in Figure 18. Bottom samples were obtained by means of a towed bucket sampler and beach samples taken by hand. Samples B6 to B20 were taken at the low tide level.

4.2 Analysis of Samples

Grain size analysis of the samples was carried out by DMR staff using wet sieving techniques.

4.3 Results

The test report of the sieve analysis of all bottom samples and a representative number of beach samples appears in Table 3. The results have also been presented in the form of histograms showing frequency of weight percentage versus grain diameter in Figures 19A, 19B and 19C.

4.4 Discussion

Clearly the bed samples analysed fall into one of four distinct classes in terms of sediment grading:-

(i) Uniform single sized 0.15 to 0.3mm beach sand. (Samples B1 to B20, XX, YY, 1 to 6, 8, 10, 11). All dune, beach, barway and entrance samples fall into this class. In addition, samples 6, 8, 10 and 11 taken on the sand banks between the entrance and Akaroa are of the same grading.

(ii) Coarser wider graded sands with shell. (Samples 7, 9, 12, 13, 14, 15). These samples are characterised by being coarser than (i) above and of a wider distribution with a significant content of shell larger than 5mm.

Samples 7, 9 and 12 in the navigation channel between Akaroa and the entrance have a median grain diameter of 0.4 to 0.5mm.

Samples 13, 14 and 15 further inshore of Akaroa have a slightly smaller median grain diameter of about 0.3mm.

(iii) Coarse Georges River sand/gravel material (Samples 17, 18 and 19).

Samples taken from the bed of the Georges River (19) and the delta deposits (17 and 18) into Georges Bay indicate a coarse material with sizes from 0.3 to 5mm having a median grain of 1 to 2mm.

The limited extent of penetration of the delta deposit of this material into Georges Bay is clearly defined by aerial photographs. Georges River is not a major source of sediment supply to Georges Bay.

(iv) Silt deposits. (Samples 16, 20, 23, 24 and 25). These samples can be classified as silts since most of the grains are smaller than 0.075mm.

No more detailed grain size analysis was undertaken on the finer silt fraction.

These results are in general agreement with the previous work undertaken by Davies (1965) and (1966) which included mineralogical examination of sediments in the Georges Bay area.

5. Drogue Tracking

5.1 Field Measurements

On 16th November, 1983, drogue tracking was carried out in the area of the entrance training wall over a full tidal cycle. The drogues consisted of 0.5m x 1.0m sheets of aluminium in a cross form suspended 0.5 to 1m below a float.

The tracking procedure was to release drogues at chosen locations and to follow them in a boat, fixing their positions at time intervals by taking compass bearings to the established shore stations shown in Figure 11. The station co-ordinated positions determined by DMR surveyors are shown in Table 4.

5.2 Results

The plotted pathlines of the drogues along with velocities and fixing times appear in Figures 20 to 27.

5.3 Discussion

The drogue tracking pathlines shown in Figures 20 to 27 clearly define the dominant ebb and flood tide current patterns at the various stages of the tide. Such information is necessary for the calibration of any future hydraulic model study of the entrance.

The pronounced high ebb tide currents close to and along the training wall are noted.

6. Hydrographic Survey

A detailed hydrographic survey of the area from Pelican Point to seaward of the barway was carried out by DMR surveyors in the period 14th to 18th November, 1983. The hydrographic survey plan is presented in Figures 28A and 28B.

In addition, echo sounding runs along the approximate centreline of the navigation channel from Akaroa to the entrance as shown in Figure 29 were undertaken by WRL staff on 17th November 1983.

The resulting channel long sections are presented in Figures 30A and 30B. Available mean water depths to bed are seen to exceed 4, 5, 6 and 7 metres over 95%, 75%, 50% and 15% respectively of the total 3200 metres of channel length surveyed.

Available water depths over the bar are significantly less than those in the inside channels. The minimum bed level at the navigable crossing of the bar is seen in Figure 28B to be -3 metres AHD. This bed level is confirmed by the jetting survey log information presented in Table 5 for holes 14, 15 and 16 which are located on the bar.

7. Jetting to Define Rock Areas

A jetting survey was carried out in the period 9th to 16th November, 1983, by the Marine Board drilling barge under the supervision of DMR personnel.

The jetting log information is given in Table 6 whilst locations are given in Table 5 and plotted in Figures 28A and 28B.

In all, twenty separate holes were jetted to depths up to 18 metres. Some difficulties were encountered maintaining position in certain current and wave conditions which caused hole abandonment at reduced depths for probes 6, 13, 17, 18, 19 and 20.

No rock was encountered in any location and it would appear that there is sand over the entire entrance area to a level of at least -9 metres AHD or deeper.

8. Historical Changes

Davies (1965) and (1966) has previously reported upon the geological and geographical long term history of Georges Bay.

The more recent behaviour of the sediments in the vicinity of the entrance have been examined in a study of all available aerial photography and hydrographic survey plans. Tables 7 and 8 list the aerial photography and survey information which was assembled, brought to common scales and considered.

Figures 31 and 32 reproduce the 1862 and 1950 states of the entrance as interpreted by Davies (1965) to a scale of 1:20 000. The March 1950 and November 1982 aerial photographs are presented in Figures 33 and 34 to the same scale.

Comparisons between all Figures 31 to 34 can be readily made. The long term stability of the majority of the sediment deposits is evident. Some relocation of channels and sediments in the immediate vicinity of the barway and entrance between Blanche and Granite Rock Points are the only significant changes. There appears to be negligible change inshore of Pelican Point.

The theory of the Georges Bay entrance being a "closed" sedimentary system is reinforced by the following:-

(i) The possibility of sand from the George River reaching the entrance is considered negligible. The tidal delta of the George River can be seen from Figure 35 to be limited. The deep water of Georges Bay is acting as a trap for river sediments as evidenced by the notably different river derived bed sediment samples on the southern and western sides of the bay.

(ii) There is no evidence of sediment input from Binnalong Bay to the north or around St. Helens Point from the south. Deep water bounded by rocky headlands occurs seaward of the entrance.

(iii) The sands to the north and south have been clearly differentiated from that in the entrance by Davies (1965) and (1966).

(iv) Sediment movement from the south, around St. Helens Point and into the entrance would be characterised by the following sedimentary features:-

(a) A tombola pattern of deposition between the coast and St. Helens Island.

(b) A sandspit in deepwater off St. Helens Point.

The absence of such features further negates the possibility of sediment supply reaching the entrance from the south.

(v) Wind blown sand from the beach to the east may reach the entrance. The quantities of infeed, however, would be small and could, if required, be controlled by dune stabilisation measures.

It is concluded that the Georges Bay entrance can be considered a "closed system" in respect of sedimentary processes. Reworking of the residual deposits of a past geological era appear to be limited to the area between Pelican Point and the Barway.

9. Wave Climate

9.1 Offshore Deepwater Wave Climate

Lawson (1983) recently reported on the available information concerning deep water wave climates around Australia.

The data most representative offshore of Georges Bay, Tasmania, is considered to be that from Eden, N.S.W. The wave height exceedence curve for Eden as based on the analysis of waverider buoy records taken by the Public Works Department of N.S.W. between 1978 and 1982 is given in Figure 36. For comparison the wave climates for other areas around Australia as presented by Lawson have also been shown.

9.2 Wave Direction Analysis

Waverider buoys do not indicate direction. The data presented in Figure 36 does not differentiate waves from different directions.

Wave directions offshore of Georges Bay were estimated from inspection of the 9 a.m. and 3 p.m. surface synoptic charts held by the Bureau of Meteorology for every day of 1978 and 1982. The resulting wave direction probabilities are compared with the Bureau of Meteorology wind data from St.Helens Post Office in Figures 37 and 38. The 9 a.m. and composite wind direction data are seen to give a good prediction of wave direction for waves from the north through east to south sectors. The long term St.Helens P.O. wind direction statistics from the Bureau of Meteorology are presented in Figure 39.

Based on observations from shipping, Hogden and Lumb (1967) present wave height and direction data for the defined areas around the world as shown in Figure 40. The wave height exceedence information based on such observations is not regarded as reliable as the Eden waverider buoy data presented in Figure 36. However, wave direction information from shipping for areas 43, 48 and 49 as presented in Figure 41 is worthy of consideration. The wave direction probabilities shown in Figure 41 are seen to be consistent with the long term St.Helens P.O. wind direction probabilities shown in Figure 39.

In the absence of more detailed information, wave direction probabilities offshore of Georges Bay may be reasonably predicted using either the St. Helens P.O. composite wind direction statistics or the Hogden and Lumb area 49 wave direction data.

The seasonal variation in wave direction is seen to be small from the presentation of Hogden and Lumb area 49 statistics given in Figure 42.

9.3 Offshore to Inshore Wave Refraction Analysis

The prediction of the propagation of offshore deepwater waves inshore to the 6 metre depth line at the entrance to Georges Bay as undertaken by Lawson and Treloar on behalf of WRL is detailed in Appendix 3. A thorough spectral wave frequency refraction analysis was carried out by computer modelling using reverse ray techniques.

For predicting wave heights at the 6 metre line seaward of the entrance the results of Appendix 3 may be conveniently interpreted and summarised as shown in Table 9.

9.4 Entrance Wave Climate and Utility

Lawson and Abernathy (1975) in a detailed analysis of waverider buoy data offshore of Botany Bay found that wave height and direction were generally independent, the only variation noted being a tendency for the extreme large wave storm events to occur from the south. They concluded, however, that considerably more data were needed to verify and adequately define any such dependence. In determining the wave height exceedence at the entrance to Georges Bay (given in Figure 43 below) the independence of wave height and direction has therefore been adopted.

The wave height exceedence at the 6 metre line seaward of the entrance to Georges Bay shown in Figure 43 was calculated using:-

(i) offshore deepwater wave height exceedence for Eden (Figure 36);

(ii) offshore deepwater wave direction probability from either St. Helens P.O. wind data (Figure 39) or Hogden and Lumb Area 49 ship observation of wave direction (Figure 41);

(iii) wave refraction coefficients given in Table 9.

The alternative wave direction probability predictions based on either wind or ship observations are seen to give very similar results.

The entrance wave climate (Figure 43) is relatively mild with wave heights exceeding 3m 2m and 1 metres only 0.06%, 1% and 10% of the time respectively. Clearly the entrance is well protected by a favourable northerly orientation and extensive rocky headlands to the east and west.

It is noted that wave heights on the barway will be larger than those at the 6 metre depth due to wave steepening on the abrupt sand bar. Further steepening of waves with ebb tide flows can be expected and is frequently reported by local fishermen.

10. In Conclusion

Data collection and associated analyses have been reported relevant to the formulation of a brief for further studies for the proposed major breakwater walls at the entrance to Georges Bay.

The data and contents of this report are a necessary requirement and will form the basis of possible future hydraulic model investigations.

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Table 1: Eddystone Point (Georges Bay) Tidal Levels

Highest Astronomical tide	HAT	=	0.90 m AHD
Mean High High Water	MHHW	=	0.52 m AHD
Mean Low High Water	MLHW	=	0.28 m AHD
Mean Sea Level	MSL	=	0.00 m AHD
Mean High Low Water	MHLW	=	- 0.30 m AHD
Mean Low Low Water	MLLW	=	- 0.48 m AHD
Lowest Astronomical Tide	LAT	=	- 0.80 m AHD

Table 2: Measured and Estimated Tidal Prisms

Cross Section	Tide Range (R)		Measured Tidal Prism (Pm)		Upstream Surface Area (A)	Estimated Tidal Prism (Pe = AR)	
	Ebb m	Flood m	Ebb m^3	Flood m^3	m^2	Ebb m^3	Flood m^3
B - C (Training wall)	0.65	0.57	$12.0x10^6$	$10.2x10^6$	$19.3x10^6$	$12.6x10^6$	$11.0x10^6$
G - H (Akaroa)	0.65	0.57	$9.8x10^6$	$9.2x10^6$	$16.3x10^6$	$10.6x10^6$	$9.3x10^6$

TABLE 3: GRAIN SIZE ANALYSES OF BED SAMPLES - GEORGES BAY

TEST REPORT

LAB. No: A2522 **DATE RECEIVED:** 21st November, 1983.

JOB: St. Georges Bay Bar-way, St. Helens.

MATERIALS: Sands and Muds.

SUBMITTED BY: W. Lawson for DEB.

TEST METHOD: T2 - washed sieve analysis.

SAMPLE REF:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	23	24	25	26
% PASS A.S.																									
16.0 mm																									
13.2														100	100								100		
9.5												100		99	97								98		
6.7							100		100			99	100	99	95		100	100	100				96		100
4.75		100					91		97			94	94	96	84		99	95	99		100		96		96
2.36	100	99				100	88		93			88	94	94	82	100	82	64	82		97		87		81
1.18	99	98	100			99	81	100	84	100	100	75	91	92	76	99	50	26	32		93		78	100	55
600 um	94	97	99	100	100	97	67	99	70	99	98	57	83	88	67	99	23	10	4	100	82		70	99	40
300	73	92	88	94	93	82	42	94	24	92	89	27	66	70	51	98	7	5	0.3	99	52	100	62	99	31
150	3	7	3	4	5	3	2	13	1	6	6	2	6	9	8	97	3	3	0.2	98	22	99	51	98	26
75	1.2	1.2	1.0	0.7	1.6	1.3	0.1	1.5	0.8	1.7	0	0.8	1.7	5.5	3.2	92	1.6	1.9	0.2	96	10	98	46	96	21

Table 3 (Cont'd)

SAMPLE REF:	B1	B3	B5	B6	B7	B10	B13	B16	B19	xx	yy
% PASS A.S.											
16.0 mm											
13.2											
9.5											
6.7											
4.75											
2.36											
1.18										100	
600 um	100	100	100	100	100	100	100	100	100	99	100
300	95	94	94	98	97	93	97	81	94	82	96
150	2	3	5	3	8	2	2	2	2	4	8
75	1.0	1.6	1.2	0.9	1.4	0.9	1.3	0.9	1.4	1.4	1.9

Notes: Nos. 7, 13: material +4.75 mm consists of shells.

Nos. 8, 9, 12, 14, 15: material +600 um consists of shells.

No. 24: sample as received contained approximately 60% mussel shells - these removed before sieving.

(B. Caisley)
ENGINEERING ANALYST

DATE: 30th November, 1983.

Table 4: Co-ordinated Positions of Shore Stations Co-ordinates

Co-ordinates in metres (Local DMR Survey Grid).

Station	mE	mN
A	413 026.39	427 300.85
B	411 433.64	427 608.43
C	411 102.99	427 826.31
D_1	411 043.36	426 745.79
D_2	410 870.22	426 538.83
E	410 121.99	427 124.94
F	410 570.06	426 468.19
G	410 088.16	425 206.67
H	409 757.68	425 432.32

Table 5: Co-ordinated Jetting Holes

Co-ordinates in metres (Local DMR Survey Grid)

Hole No.	mE	mN
1	411841	428659
2	411817	428604
3	411814	428711
4	411978	428568
5	411947	428552
6	411487	428041
7	411474	428016
8	411461	427996
9	411463	427919
10	411468	427895
11	411473	427708
12	411447	427620
13	411564	428073
14	411849	428452
15	411813	428416
16	411784	428355
17	411729	428210
18	411665	428147
19	411636	428105
20	411610	428098

TABLE 6 : JETTING SURVEY - ENTRANCE TO GEORGES BAY

Hole No.	Location	Date	Time	Weather	Tide E/F	Tide Height	RL Tide m AHD	Brg. From Wall Stn.	Brg. From Photo PT6	Dist. Wall Stn. m	Dist. PP6 m	Depth Water m	RL Top Sand m AHD	Depth Probe m	Dept Sand m	RL Bottom Probe m AHD	Comments
1	North Outer Bar	9/11	0718	Fine, calm	F	790	.008	18°43'50"	337°05'15"	1250	1316	2.5	-2.5	16.0	13.5	-16.0	Easy jetting to 15.0m followed by gradual slowing at 16.0m. Blowing fine,clean, white sand only. No abrupt stop. No indication of rock.
2	North Outer Bar	9/11	0747	Fine, calm	F	710	+.072	18°20'40"	335°09'10"	1191	1276	2.8	-2.7	12.0	9.2	-11.9	As # 1, pulled up in last metre but not abrupt stop. No indication of rock.
3	North Outer Bar	9/11	0809	Fine, light breeze	F	700	+.082	16°51'30"	336°53'50"	1291	1374	2.8	-2.7	15.0	12.2	-14.9	Easy jetting to 14m. followed by gradual slowing. Blowing clean,white fine,sand. No abrupt stop or indication of rock.
4	South Outer Bar	9/11	0917	Fine, breeze building 5 knots (West)	F	550	+.232	26°13'50"	341°30'00"	1219	1182	3.7	-3.5	18.0 +	14.3	-17.8	Easy jetting stopped at length of jet. Jet still going easily when stopped. Only fine, clean white sand blown up.
5	South Outer Bar	9/11	0930	Fine, 10 knots Westerly	F	480	+.302	25°15'30"	339°50'30"	1191	1177	4.1	-3.8	15.0 +	10.9 +	-14.7	Easy jetting to 15.0 metres at which barge moved and bent probe. Hole abandoned at 15 metres and still going easily. Only fine, clean, white sand blown up.
	Wind gusting at 50 knots and bar breaking - Work abandoned approximately 1000 hours.																

Hole No.	Location	Date	Time	Weather	Tide E/F	Tide Height	RL Tide	Brg From Wall Stn	Brg From Photo PT6	Dist Wall Stn m	Dist P.P.6 m	Depth Water m	RL Top Sand m AHD	Depth Probe m	Depth Sand m	RL Bottom Probe m AHD	Comments
6	Corner of Navig-ation Channel	10/11	1836	Fine, 10 knot Easterly breeze. Some break-ing waves over bar	E Strong	1140	-.358	4°49'20"	304°28'30"	569	1050	1.0	-1.4	6.5 +	5.5 +	-6.9	Easy jetting to 6.5m when barge moved in breaking waves and broke probe. Hole abandoned. Only fine, clean, white sand thrown up.
7	'Line' of train-ing wall	10/11	1849	Fine, 10 knot Easterly breeze. Some break-ing waves over bar	E Strong	1190	-.408	3°40'20"	302°55'10"	542	1047	0.5	-0.9	8.7	8.2	-9.1	Easy jetting through fine clean, white sand to 7.5m, then blacker* sand followed by abrupt stop No evidence of rock. (*Blacker means mixture of white & black sand - not ink black nor black mud).
8	'Line' of train-ing wall	10/11	1904	Fine, 10 knot Easterly breeze. Some break-ing waves over bar	E Strong	1180	-.398	2°22'30"	301°37'50"	522	1048	0.5	-0.9	10.2	9.7	-10.6	Easy jetting through fine clean, white sand to 9.5m, then blacker * sand with abrupt stop at 10.2m. No evidence of rock.
9	'Line' of train-ing wall	10/11	1908	Fine, 10 knot Easterly breeze. Some break-ing waves over bar	E Strong	1190	-.408	3°06'30"	297°57'30"	445	1007	0.9	-1.3	13.0	12.1	-13.4	Easy jetting through fine, clean, white sand to 11.5 m. Then slower, less abrupt stop with blacker * sand. No evidence of rock

Table 6 (Cont'd)

Hole No.	Location	Date	Time	Weather	Tide E/F	Tide Height	RL Tide	Brg. From Wall St.	Brg. From Photo PT6	Dist. Wall Stn m	Dist. PP6 m	Depth Water m	RL Top Sand m AHD	Depth Probe m	Depth Sand m	RL Bottom Probe m AHD	Comments
10	'Line' of training wall	10/11	1917	Fine, 10 knot Easterly breeze. Some breaking waves over bar	E Strong	1230	-.448	3°54'00"	296°51'20"	421	992	1.0	-1.5	10.3	9.3	-10.8	Easy jetting to 9.5m in fine, clean, white sand. Then blacker * sand (not as black as No.9) followed by abrupt stop at 10.3m. No evidence of rock.
11	'Line' of training wall	10/11	1935	Fine, 10 knot Easterly breeze. Some breaking waves over bar	E Easing	1250	-.468	8°11'50"	286°32'40"	236	918	0.8	-1.3	8.6	7.8	-9.1	Easy jetting to 7.5m in fine, clean, white sand, then blacker * sand followed by abrupt stop at 8.6m. No evidence of rock.
12	'Line' of training wall	10/11	1942	Fine, 10 knot Easterly breeze. Some breaking waves over bar	E Easing	1255	-.473	3°00'50"	280°52'00"	146	922	0	-0.5	10.8	10.8	-11.3	Barge aground at end of training wall - no water at jet location. Difficult to tell sand colour. Easy jetting to 9.5m to slower stop at 10.8m. No evidence of rock.
13	'Line' of training wall	10/11	1955	Fine, 10 knot Easterly breeze. Some breaking waves over bar	Slack water	1285	-.503	11°51'20"	308°28'10"	611	1007	1.0	-1.5	5m +	4m +	-5.5	Easy jetting in fine, clean, white sand until barge moved in heavy, breaking waves & bent probe. Probe still going easily when bent. Hole abandoned.
		Work ceased due to breaking waves and loss of visibility for shore survey stations															

Table 6 (Cont'd)

Hole No.	Location	Date	Time	Weather	Tide E/F	Tide Height	RL Tide	Brg. From Wall Stn.	Brg. From Photo PT 6	Dist. Wall Stn. m	Dist. PP 6 m	Depth Water m	RL Top Sand m AHD	Depth Probe m.	Depth Sand m	RL Bottom Probe m AHD	Comments
14	Middle Bar	16/11	0609	Fine	F	1770	±.270	22°42'50"	333°22'10"	1060	1125	3.3	-3.0	12.0	8.7+	-11.7	Easy jetting to end of jet (12m - shorter jet) No refusal, no indication of rock. Clean, fine, white sand only.
15	Middle Bar	16/11	0612	Fine	F	1770	±.270	21°38'30"	330°52'30"	1013	1110	3.3	-3.0	13.0	9.7+	-12.7	Ditto
16	Middle Bar	16/11	0625	Fine	F	1780	±.280	21°23'00"	327°58'30"	946	1072	3.4	-3.1	12.5	9.1+	-12.2	Ditto
17	Sand Bank	16/11	0642	Fine	F	1780	±.280	21°28'50"	320°43'20"	790	986	2.7	-2.4	11.0	8.3+	-10.7	Ditto but bent jet in waves-abandonded hole.
18	Sand Bank	16/11	0650	Fine	F	1780	±.280	18°32'00"	315°30'20"	709	982	2.4	-2.1	7.5	5.1	-7.2	Easy jetting to 7m then apparent refusal at 7.5m. Difficult to guage in breaking surf. Attempted to penetrate but barge moved and bent jet. Abandoned hole.
19	Sand Bank	16/11	0655	Fine	Slack Water	1800	±.300	17°17'30"	312°34'10"	661	974	1.9	-1.6	4.0	2.1	-3.7	Ditto
20	Sand Bank	16/11	0702	Fine	E	1800	±.300	15°19'50"	311°15'50"	647	988	2.0	-1.7	9.0	7.0	-8.7	Ditto
				All jets bent and useless				Tide ebbing in breaking surf -				Abandoned work					

Table 7: Aerial Photography for Historical Changes

Date	Project	Original Scale
March 1950	1271 *	
29.3. 1966	1588 *	
1971	F205 *	44 chains to 1 inch
1972	F305 *	1 : 40 000
1973	F359 *	1 : 34 000
1973/74	F398 *	1 : 20 000
17.4. 1975	F470	1 : 20 000
9.6. 1976	F501	1 : 20 000
8.12.1976	F535	! : 20 000
6. 4.1978	F586	1 : 20 000
8. 1.1979	F607	1 : 20 000
1979/80	M56 *	1 : 40 000
Nov. 1982	M318	1 : 20 000

* Photographs reduced to common 1:20 000 scale

Table 8: Hydrographic Survey Data for Historical Changes

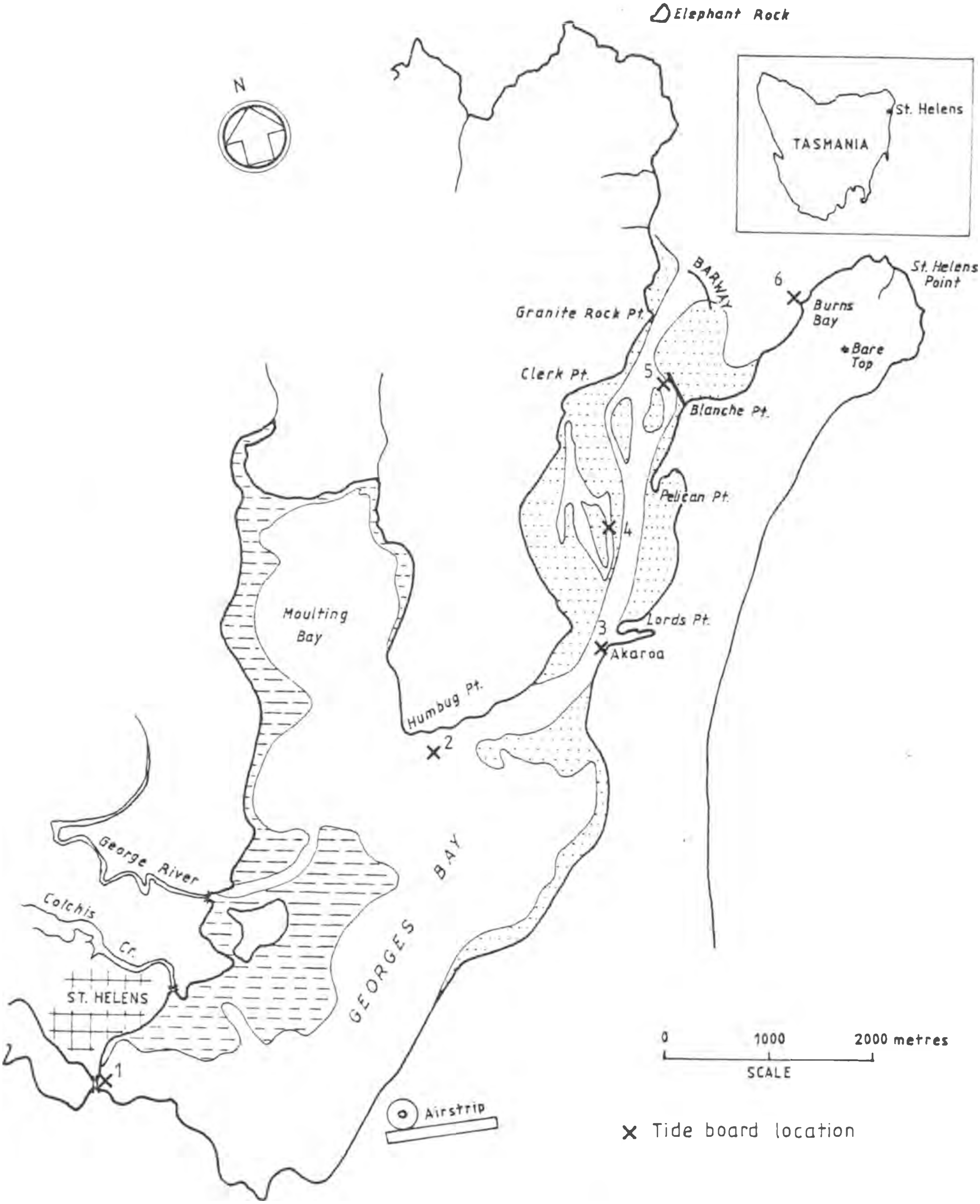
Date	Source	Area covered by Plan
1862	Admiralty	Offshore, entrance and Georges Bay.
1964-65?	DMR *	Offshore and Barway to Humbug Pt.
Nov.1967	DMR *	Granite Rock to Blanche Point.
April 1969	DMR *	Granite Rock to Blanche Point.
July 1969	DMR *	Granite Rock to Pelican Point.
Oct. 1969	DMR *	Granite Rock to Pelican Point.
March 1971	DMR *	Granite Rock to Blanche Point.
March 1972	DMR *	Barway to Pelican Point.
Nov. 1972	DMR *	Barway to Pelican Point.
June 1973	DMR *	Granite Rock to Pelican Point.
Aug. 1973	DMR *	Barway to Pelican Point.
March 1974	DMR *	South Banks and Granite Rock to Pelican Point.
March 1980	DMR *	South Banks and Granite Rock to Pelican Point.
May 1982	DMR *	Granite Rock to Pelican Point.
Nov. 1982	Marine Board*	Navigation: Barway, entrance and Georges Bay.
Nov. 1983	DMR *	Barway to Pelican Point. See Figures 28A and 28B, Section 6.

* All plans adjusted to common scale of 1:3000

Table 9: Inshore Wave Coefficients for Position 2

Tabulated Abbreviation and Summary of Information from Appendix 3.

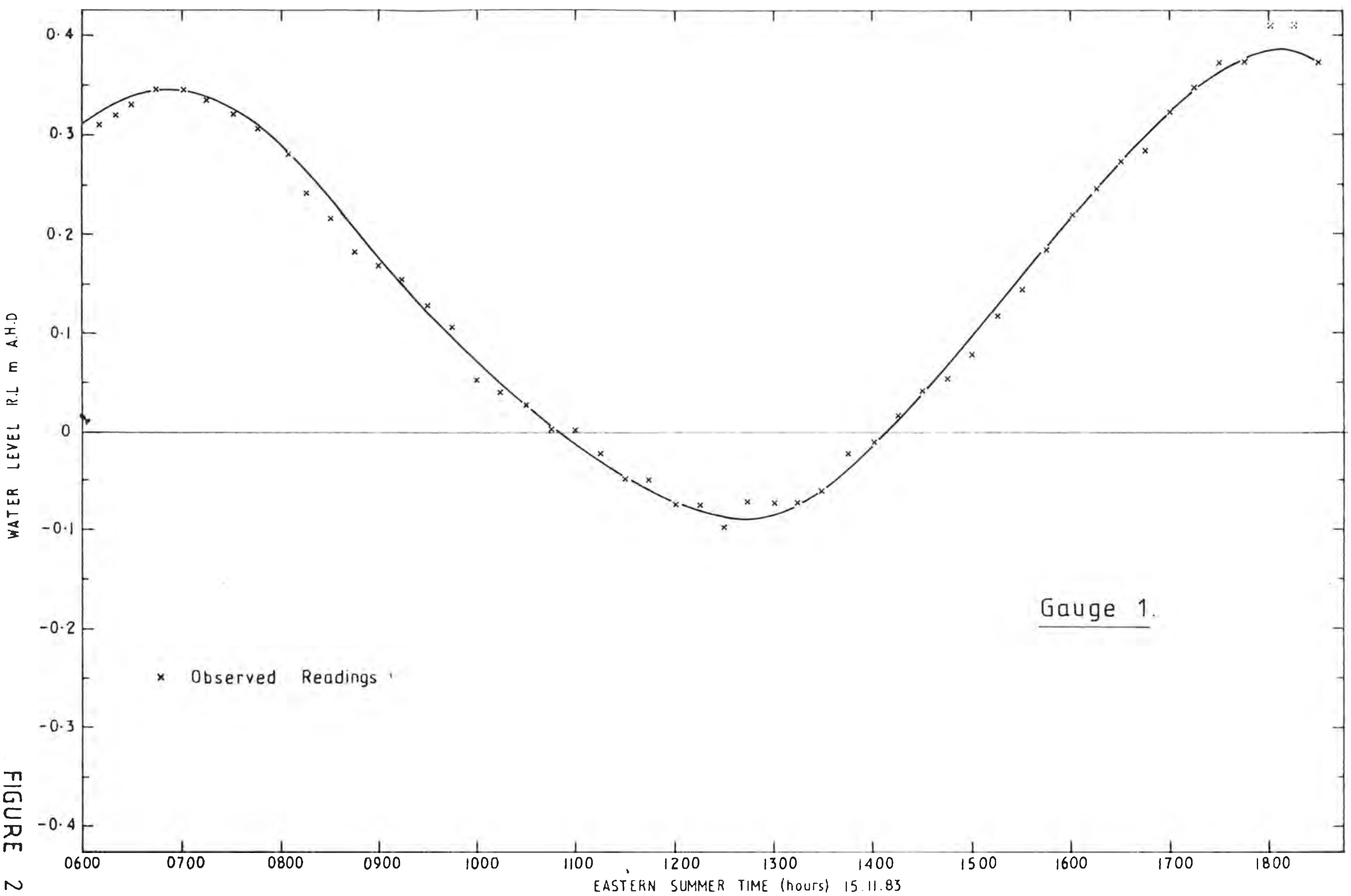
	Direction								
	180 N	202.5	225 NE	247.5	270 E	292.5	315 SE	337.5	360 S
Wave Coefficient	.50	.73	.86	.87	.82	.75	.60	.38	.17



GENERAL LAYOUT

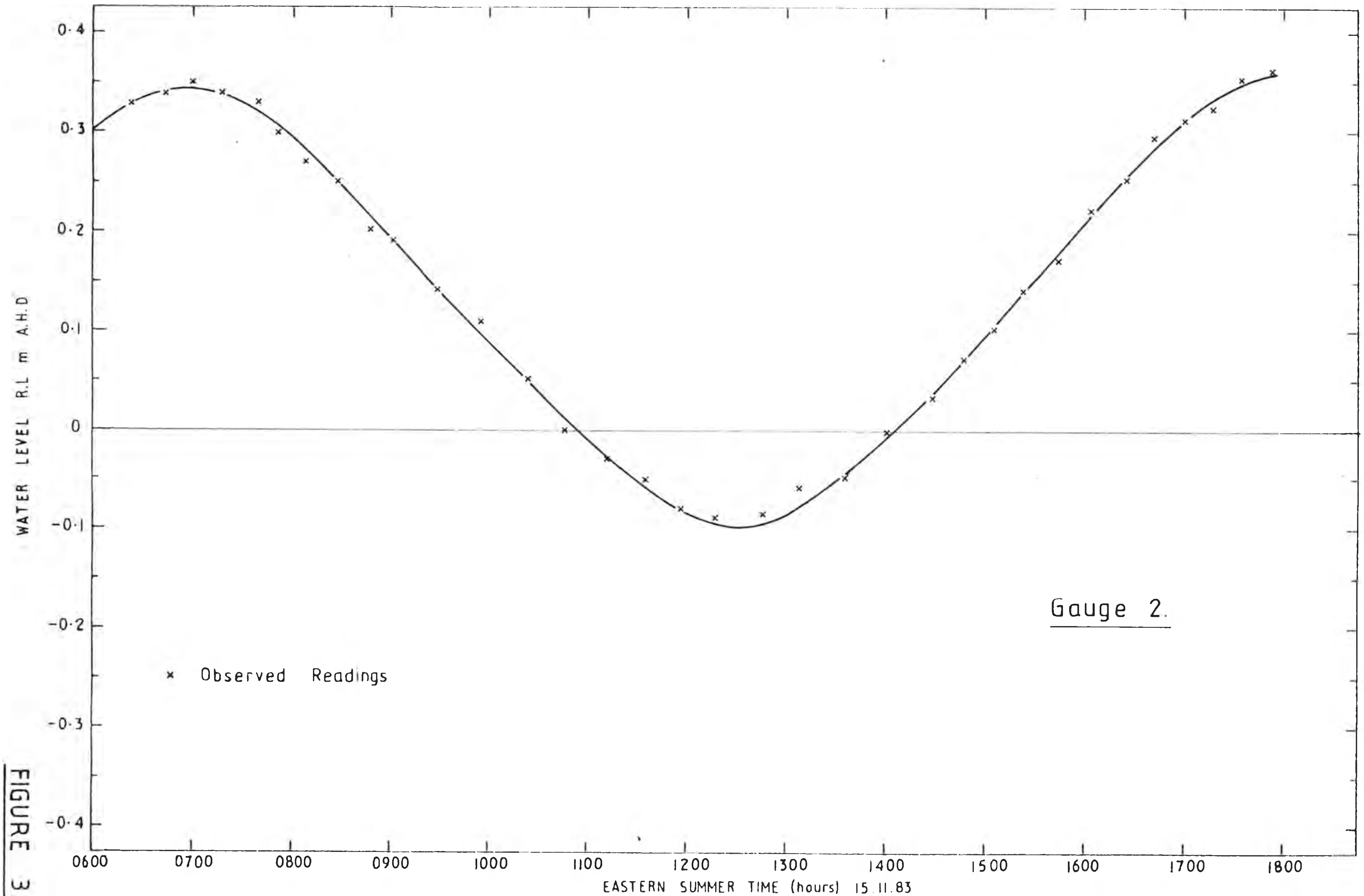
AND LOCATION OF TIDE BOARDS

FIGURE 1.



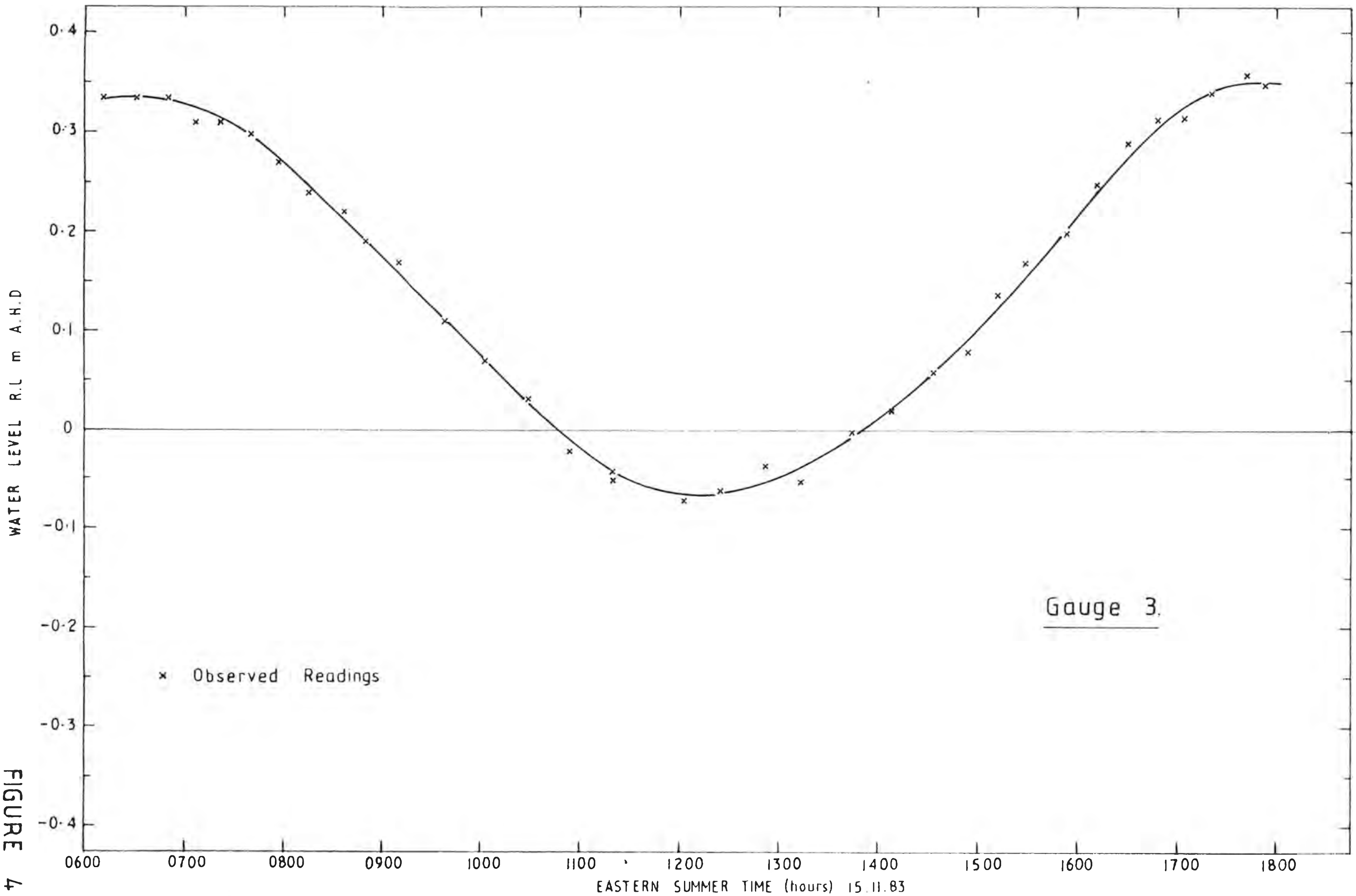
GEORGES BAY TIDAL OBSERVATIONS - TIDE BOARD 1.

FIGURE 2.



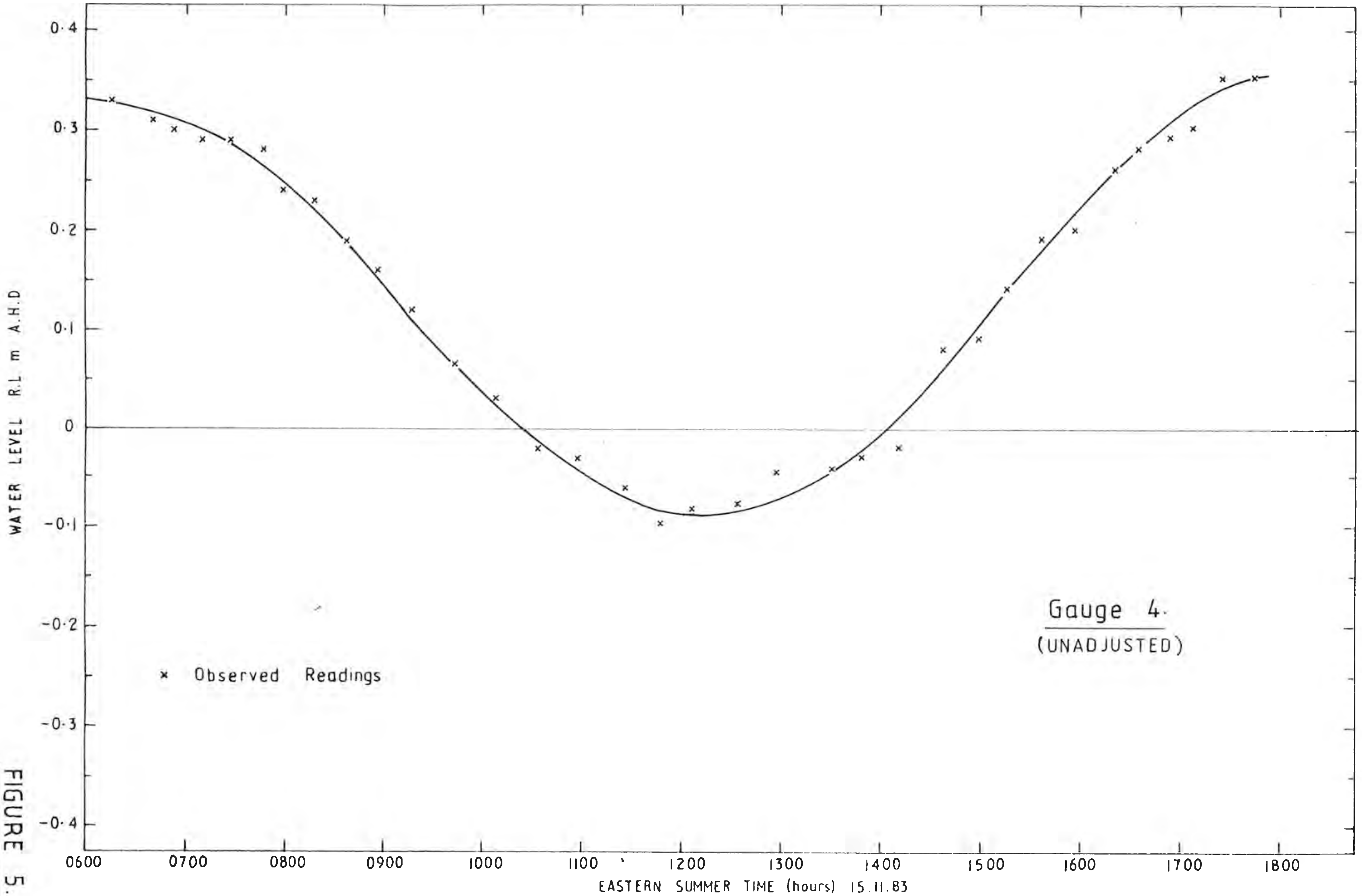
GEORGES BAY TIDAL OBSERVATIONS - TIDE BOARD 2.

FIGURE 3.



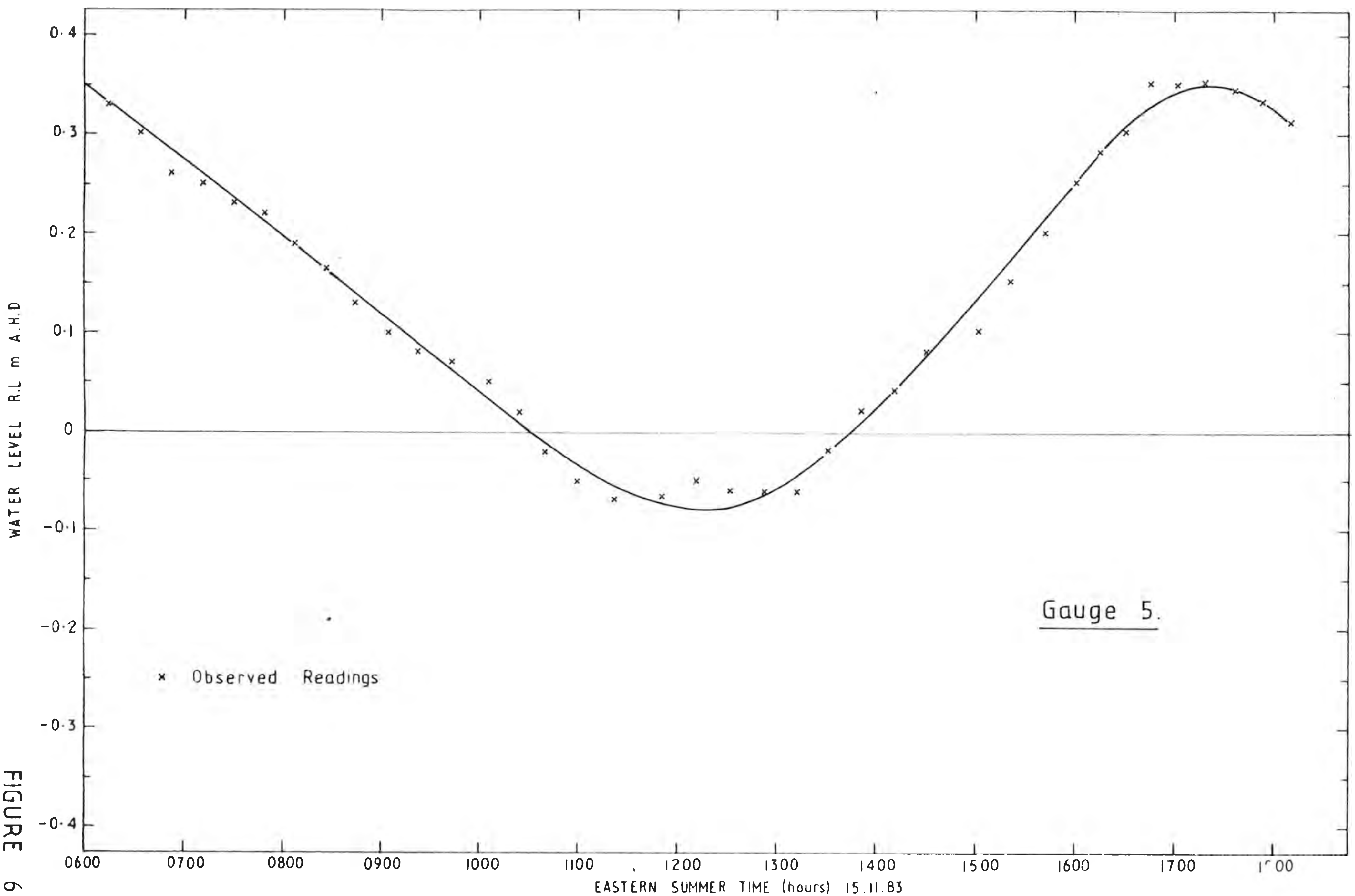
GEORGES BAY TIDAL OBSERVATIONS - TIDE BOARD 3.

FIGURE 4.



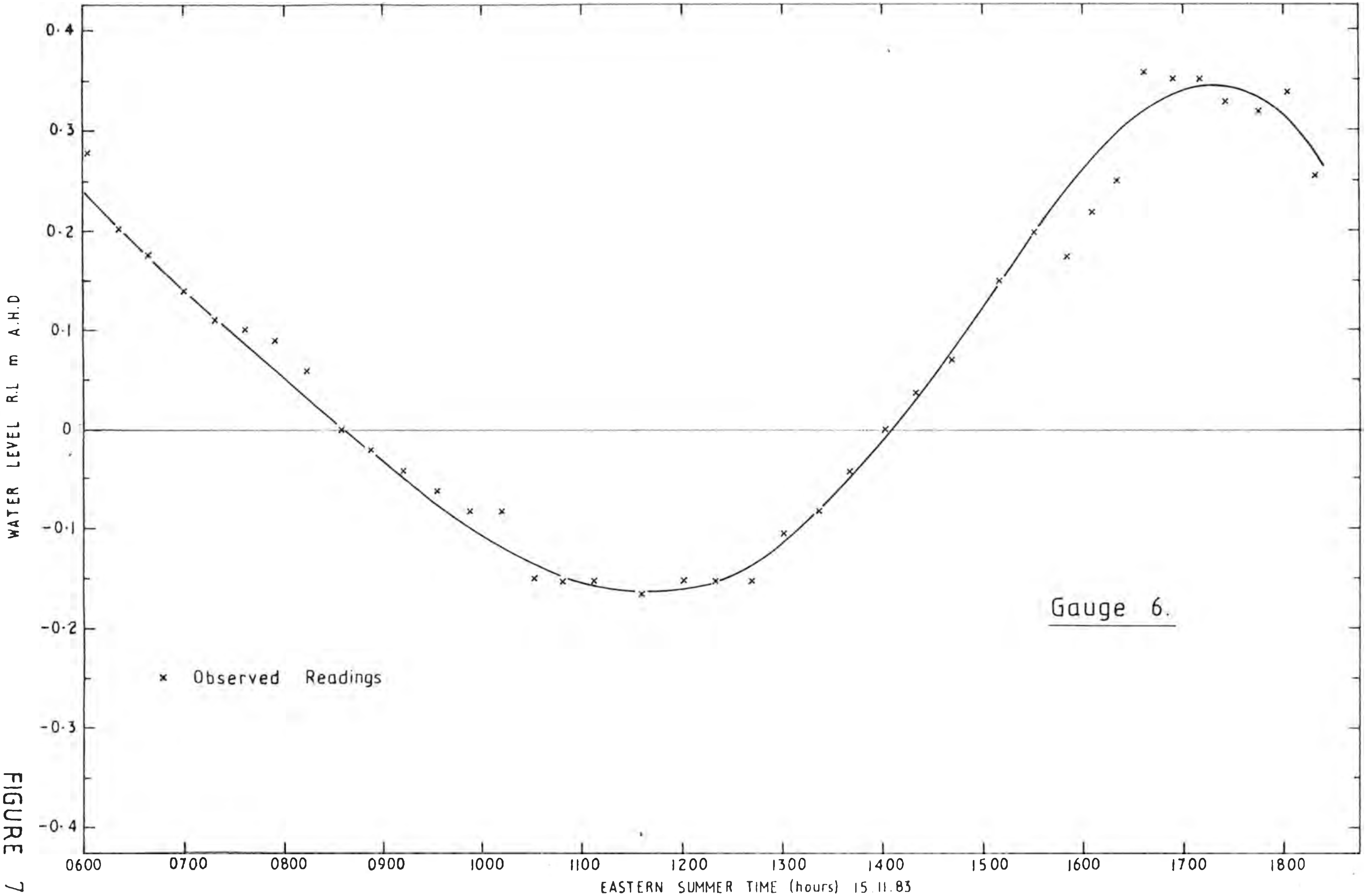
GEORGES BAY TIDAL OBSERVATIONS - TIDE BOARD 4.

FIGURE 5.



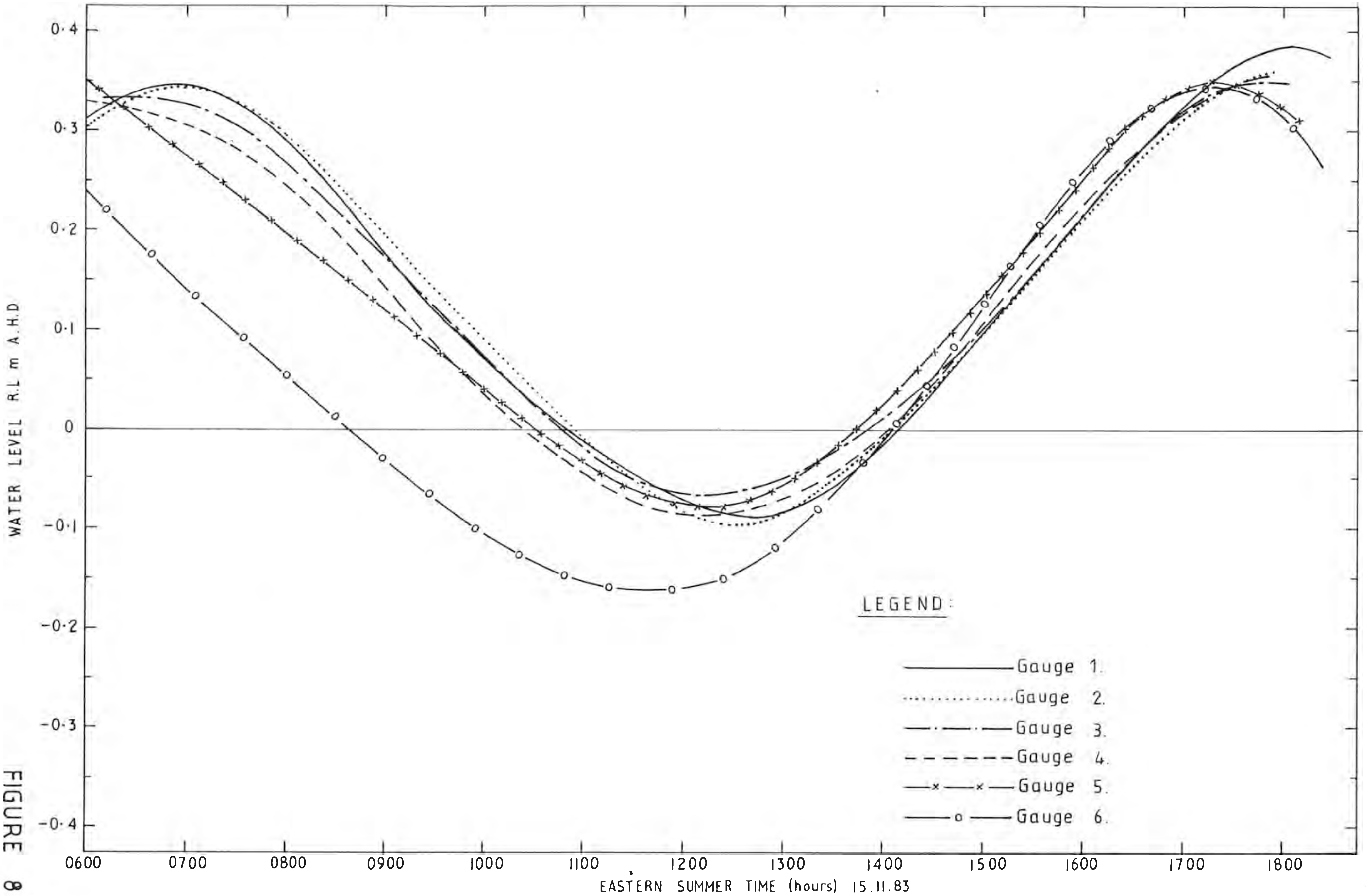
GEORGES BAY TIDAL OBSERVATIONS - TIDE BOARD 5.

FIGURE 6.



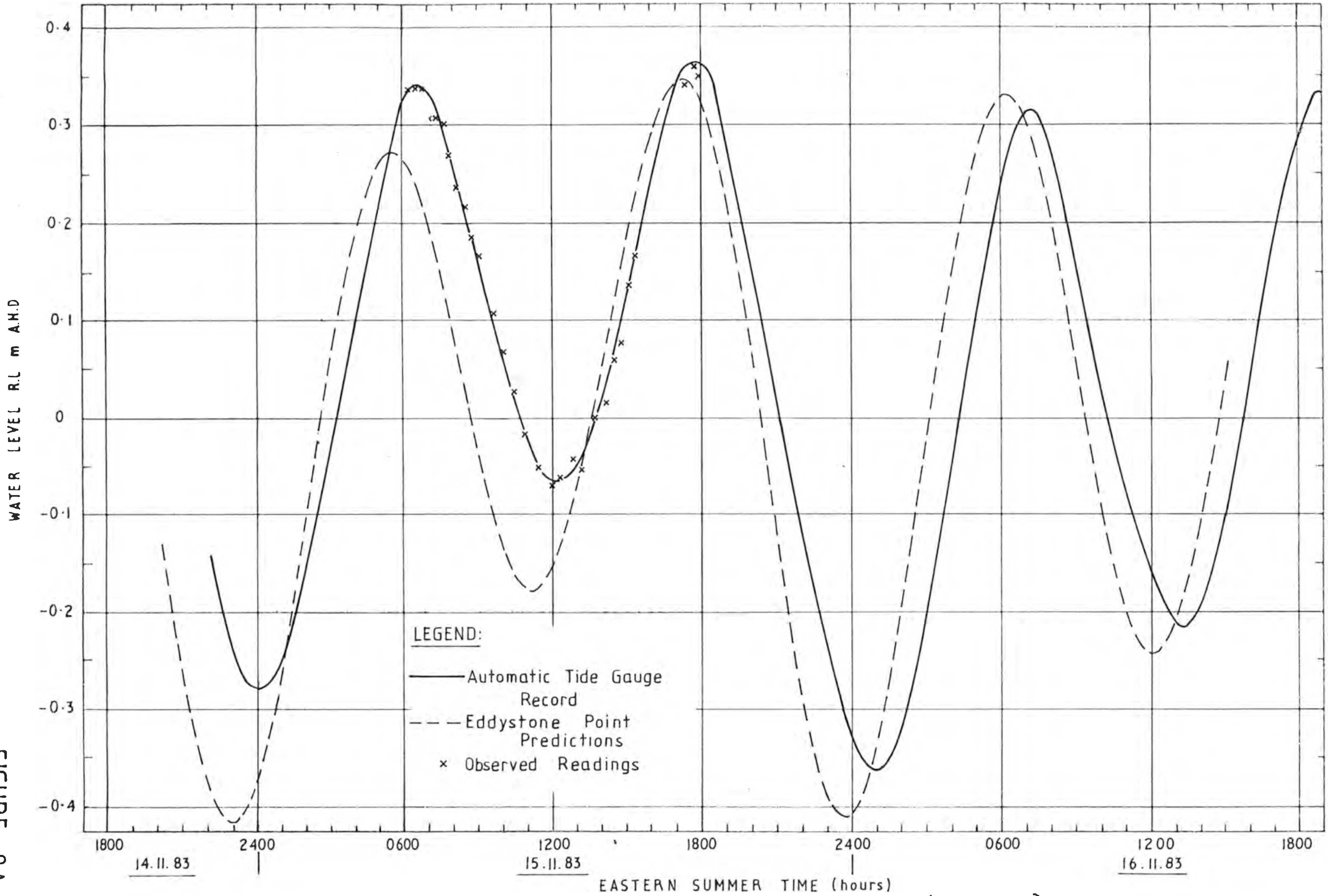
GEORGES BAY TIDAL OBSERVATIONS - TIDE BOARD 6.

FIGURE 7.



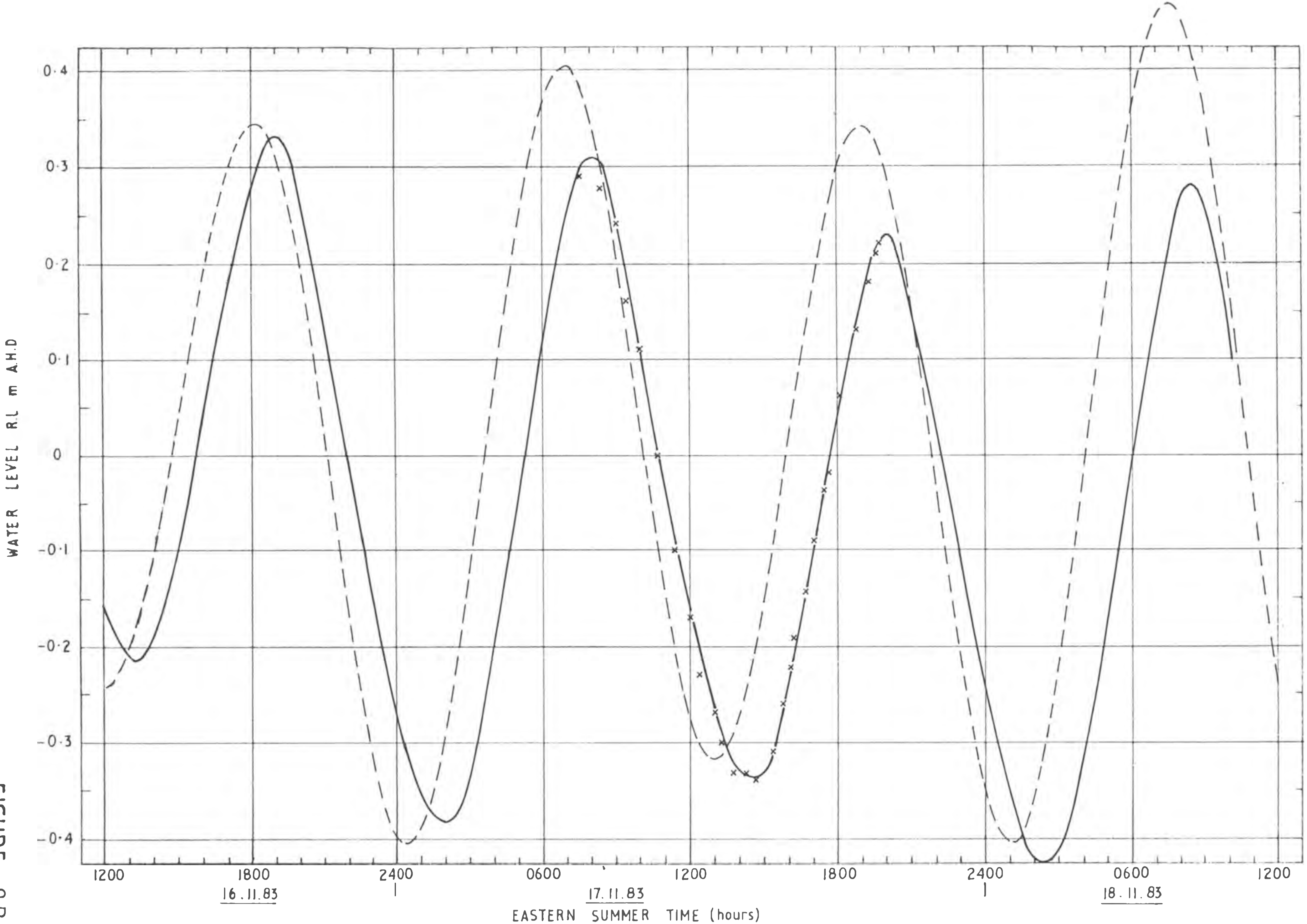
GEORGES BAY TIDAL OBSERVATIONS - TIDE BOARD 1 to 6.

FIGURE 8.



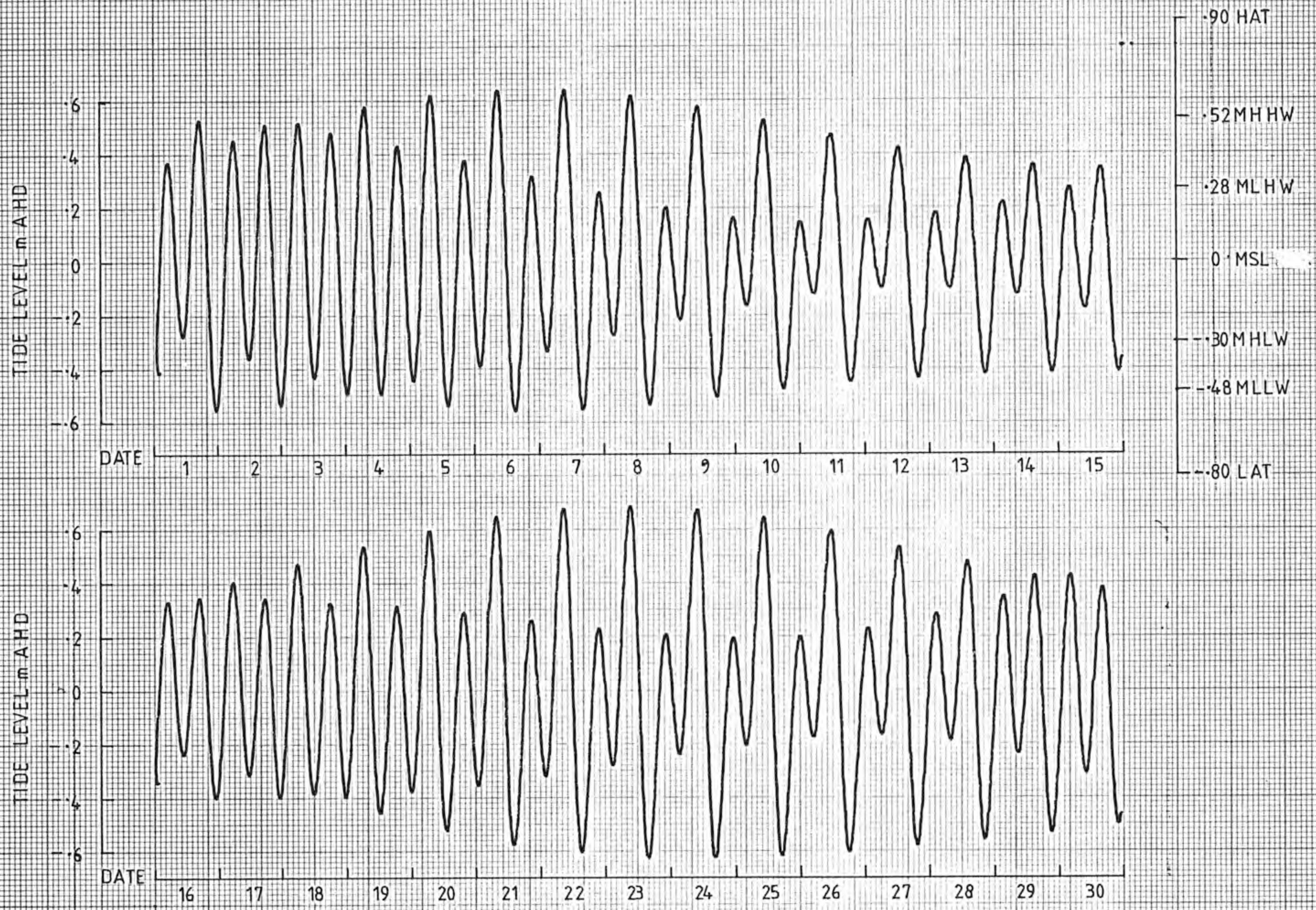
AUTOMATIC TIDE GAUGE RECORD - LOCATION 3 (AKAROA)

FIGURE 9A



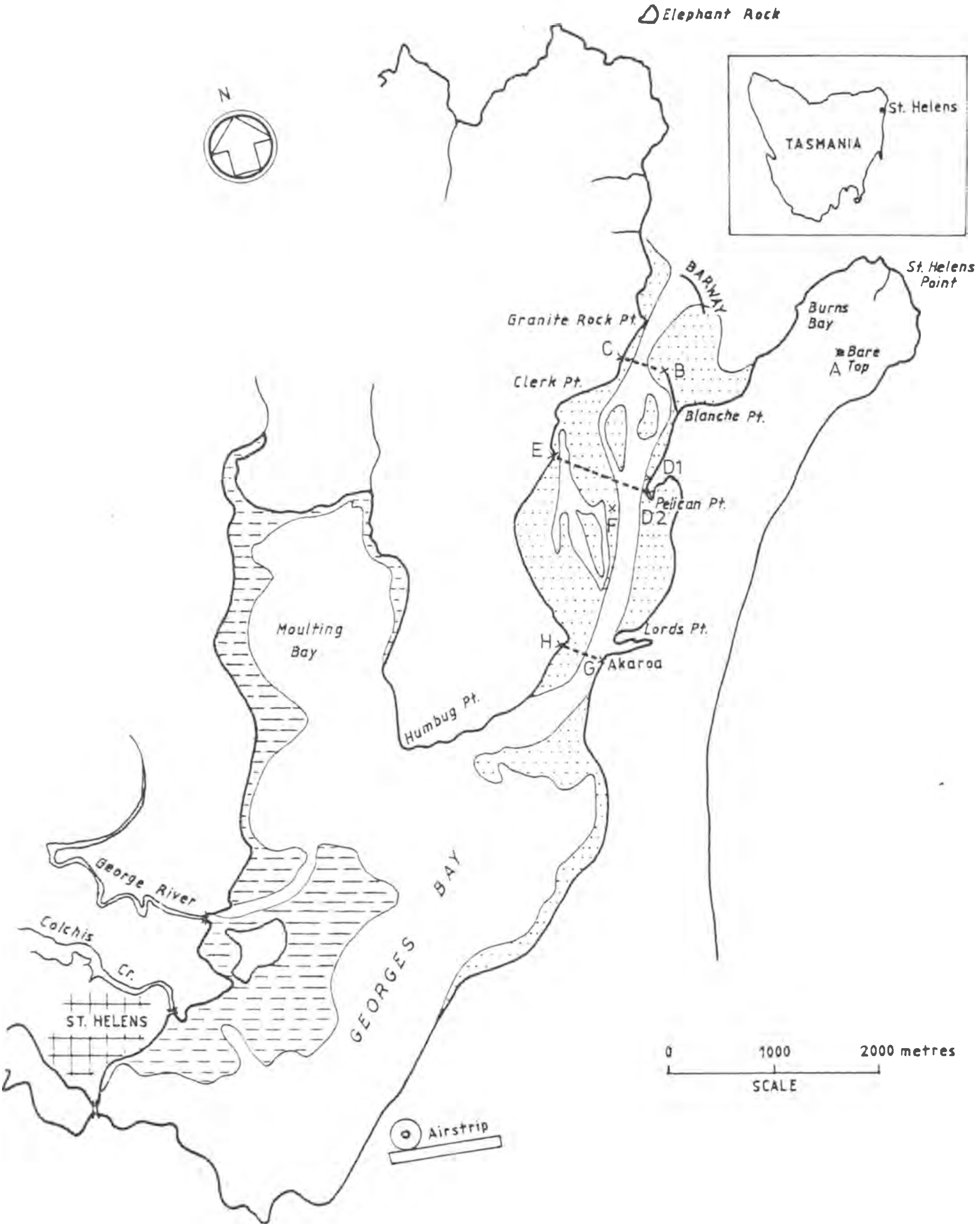
AUTOMATIC TIDE GAUGE RECORD - LOCATION 3 (AKAROA)

FIGURE 9B



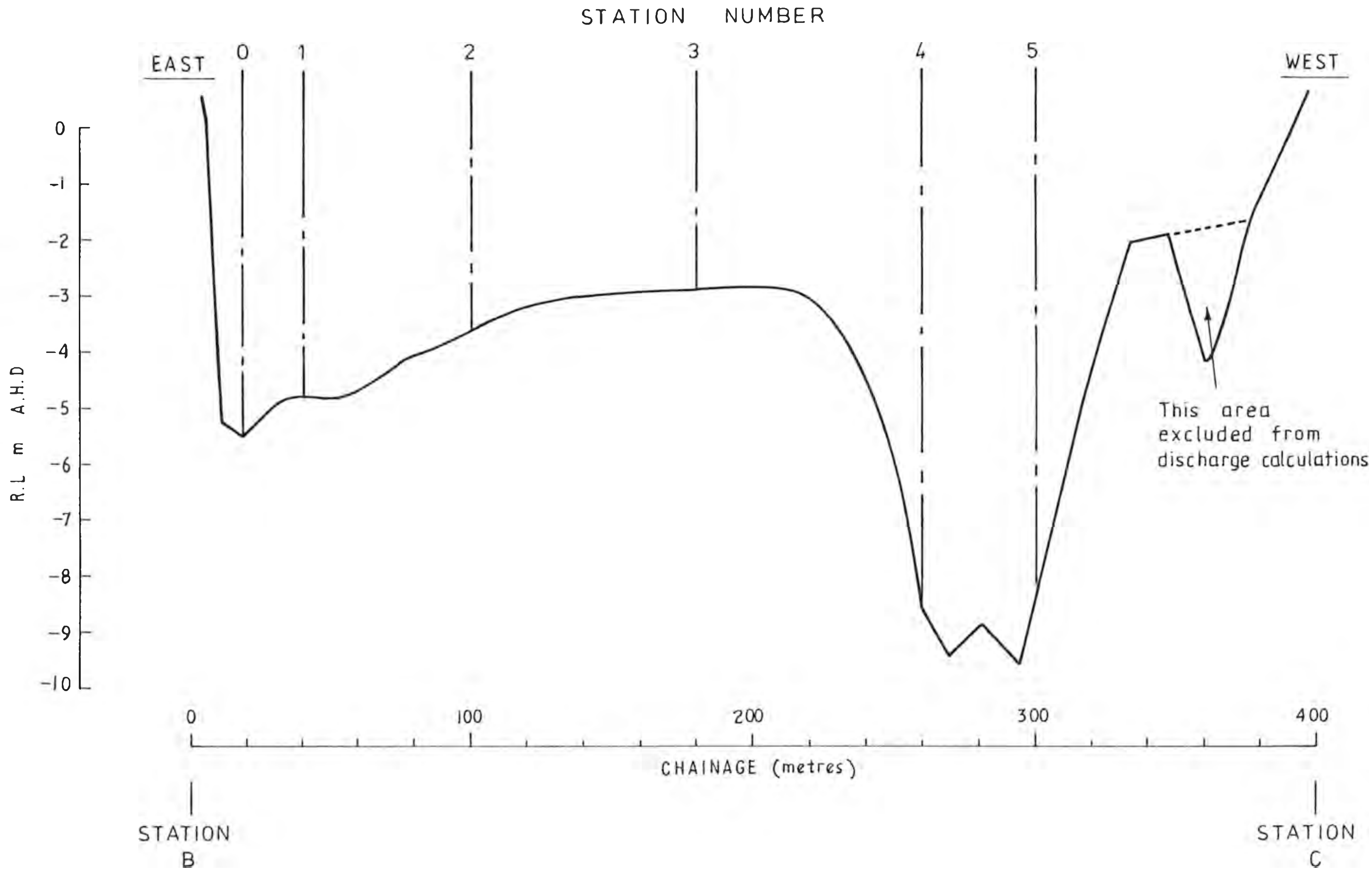
PREDICTED TIDES FOR EDDYSTONE POINT — NOVEMBER 1983

FIGURE 10



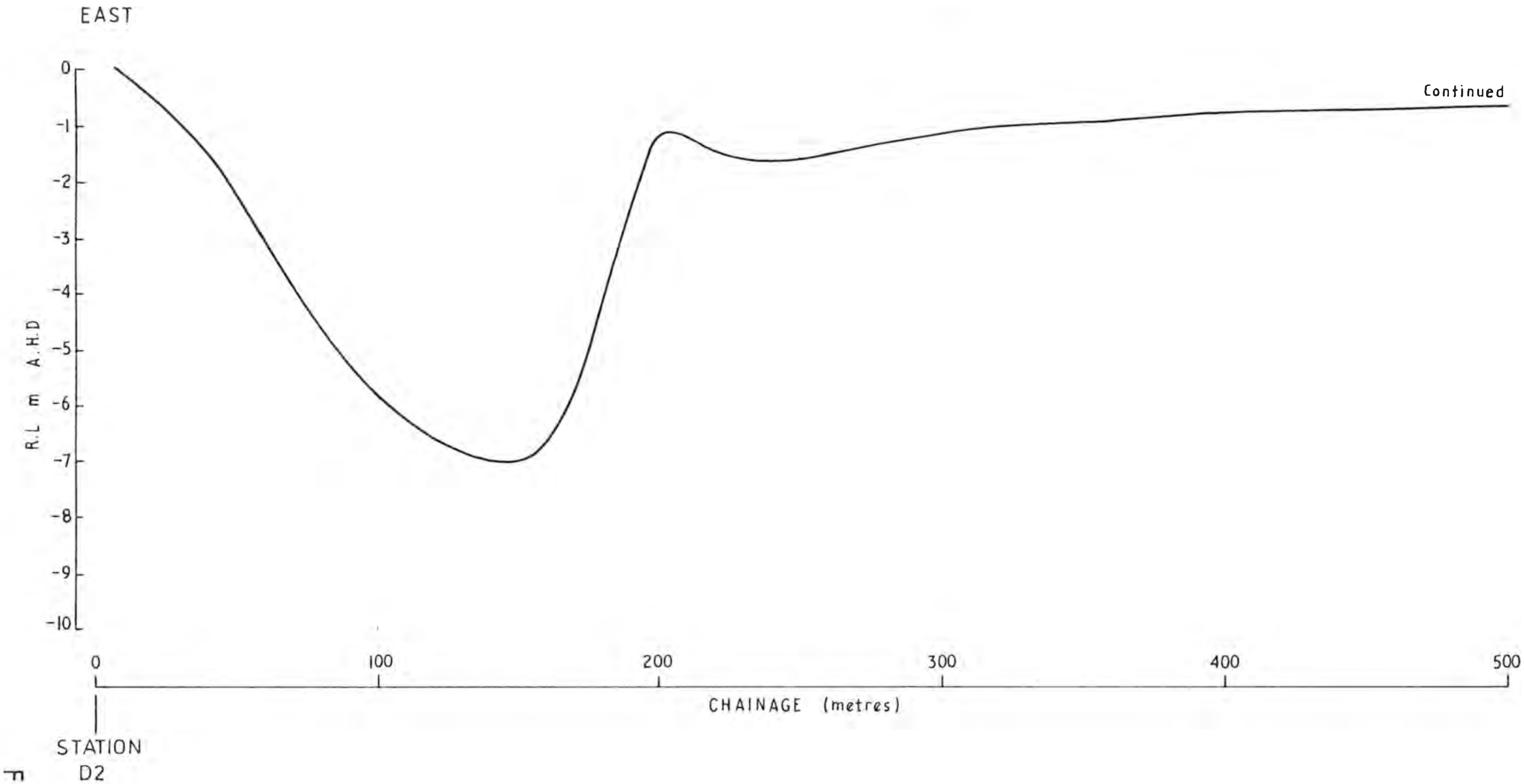
LOCATION OF SHORE STATIONS
AND CROSS SECTIONS

FIGURE 11.



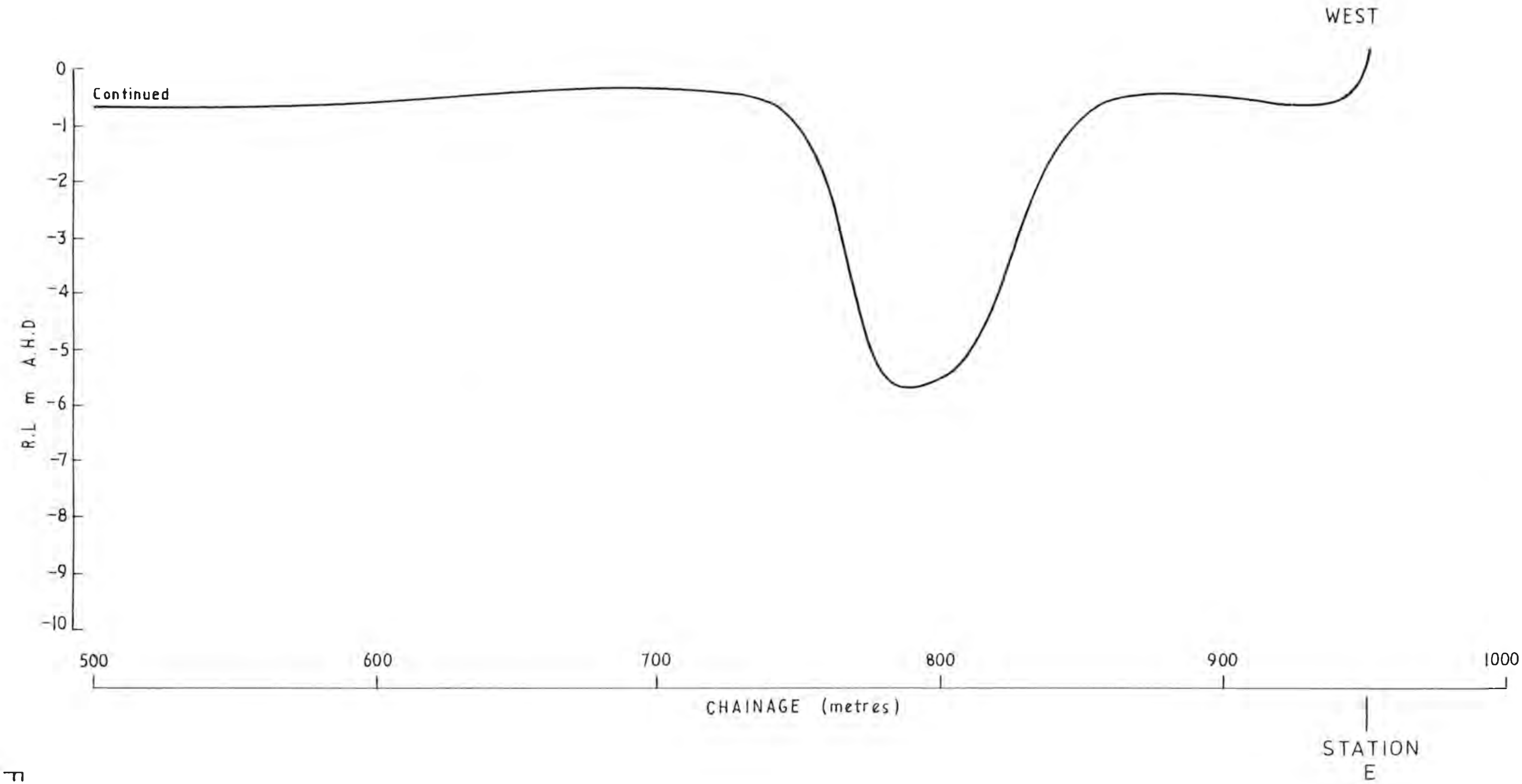
CROSS SECTION B - C (TRAINING WALL) 17. 11. 83

FIGURE 12.



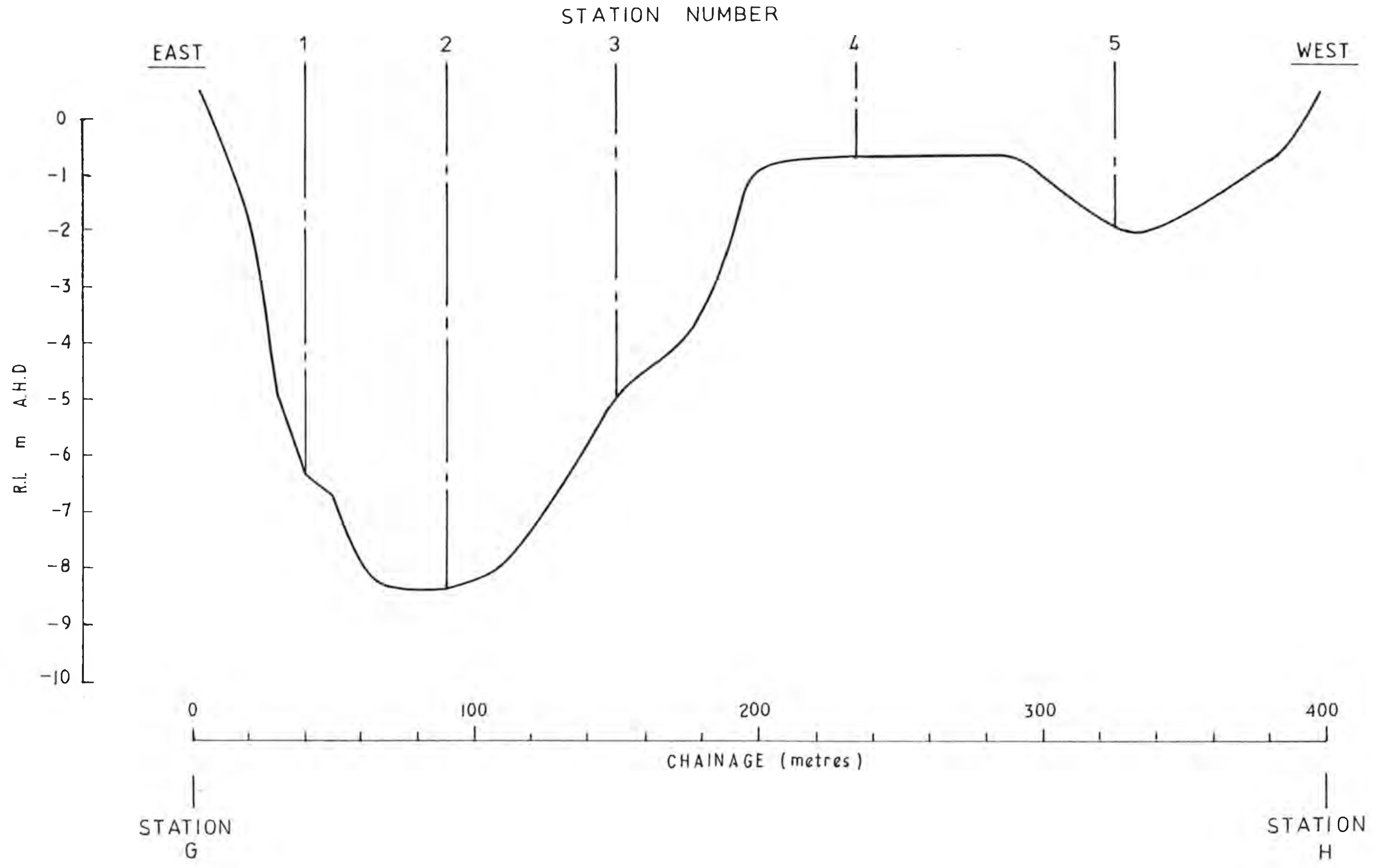
CROSS . SECTION D2 – E. 15.11.83

FIGURE 13A



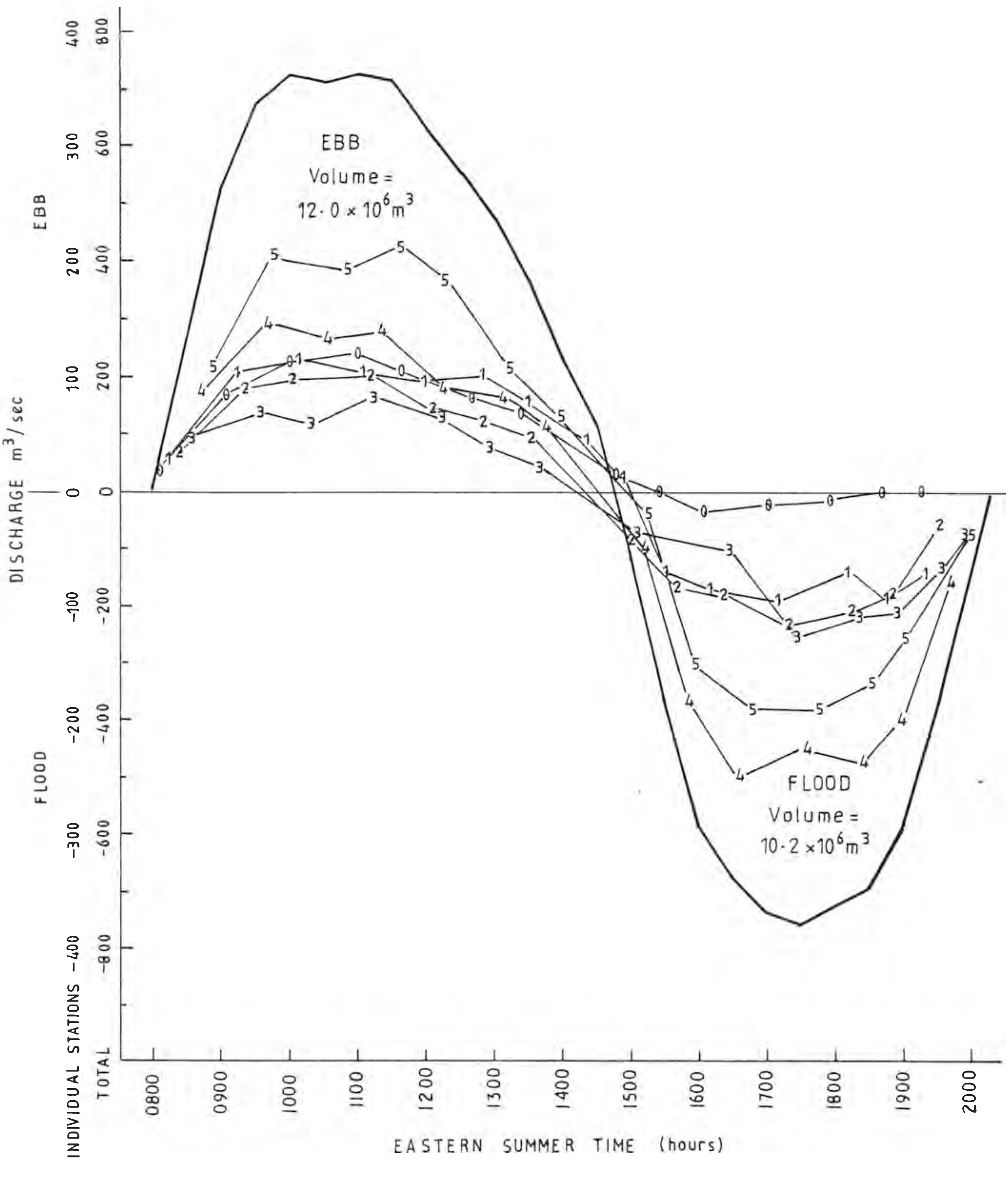
CROSS SECTION D2 - E. 15.11.83

FIGURE 13B



CROSS SECTION G-H (AKAROA) 17.11.83

FIGURE 14

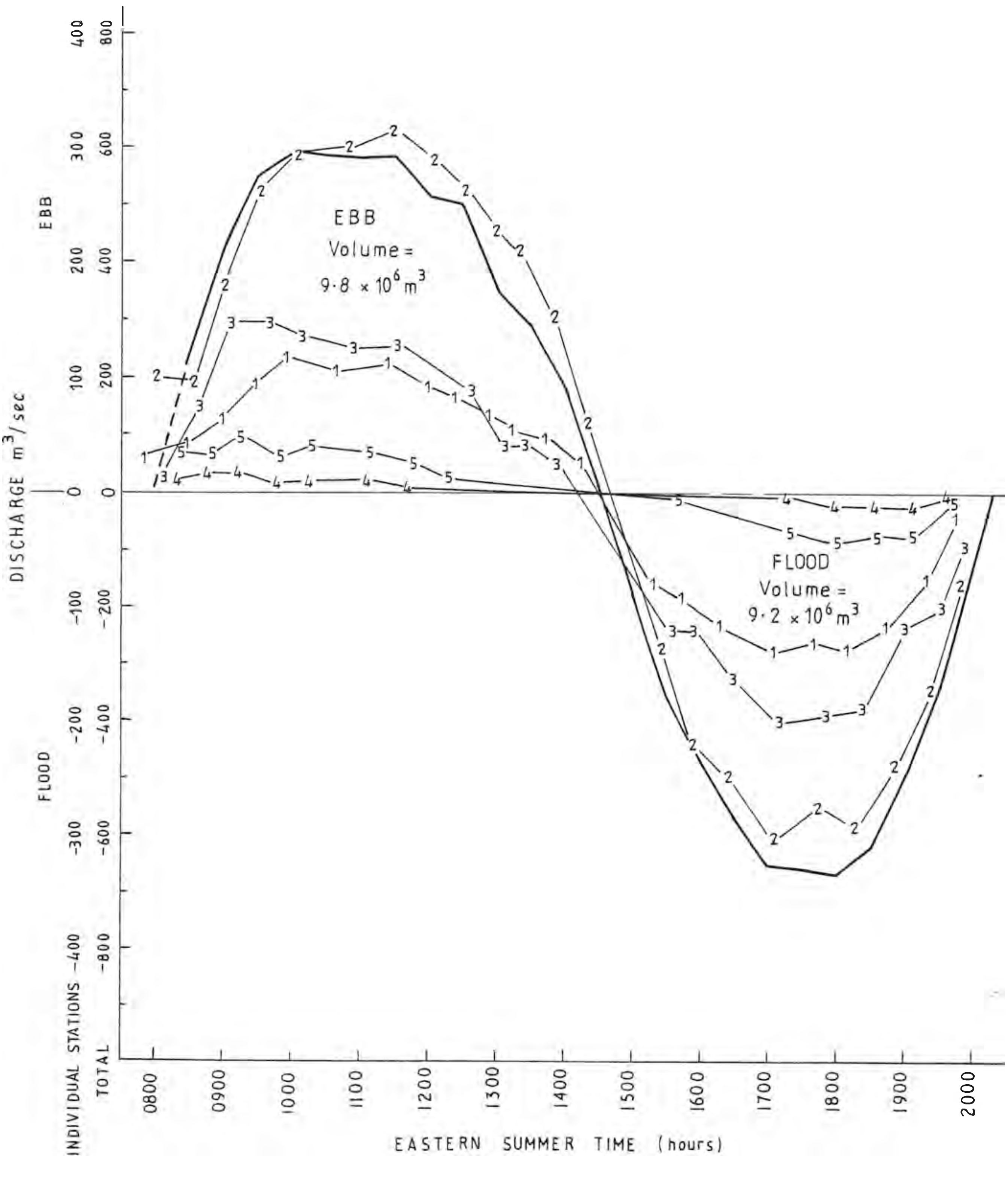


MEASURED DISCHARGE RESPONSE - GEORGES BAY

CROSS SECTION B - C (TRAINING WALL)

17.11.83

FIGURE 15



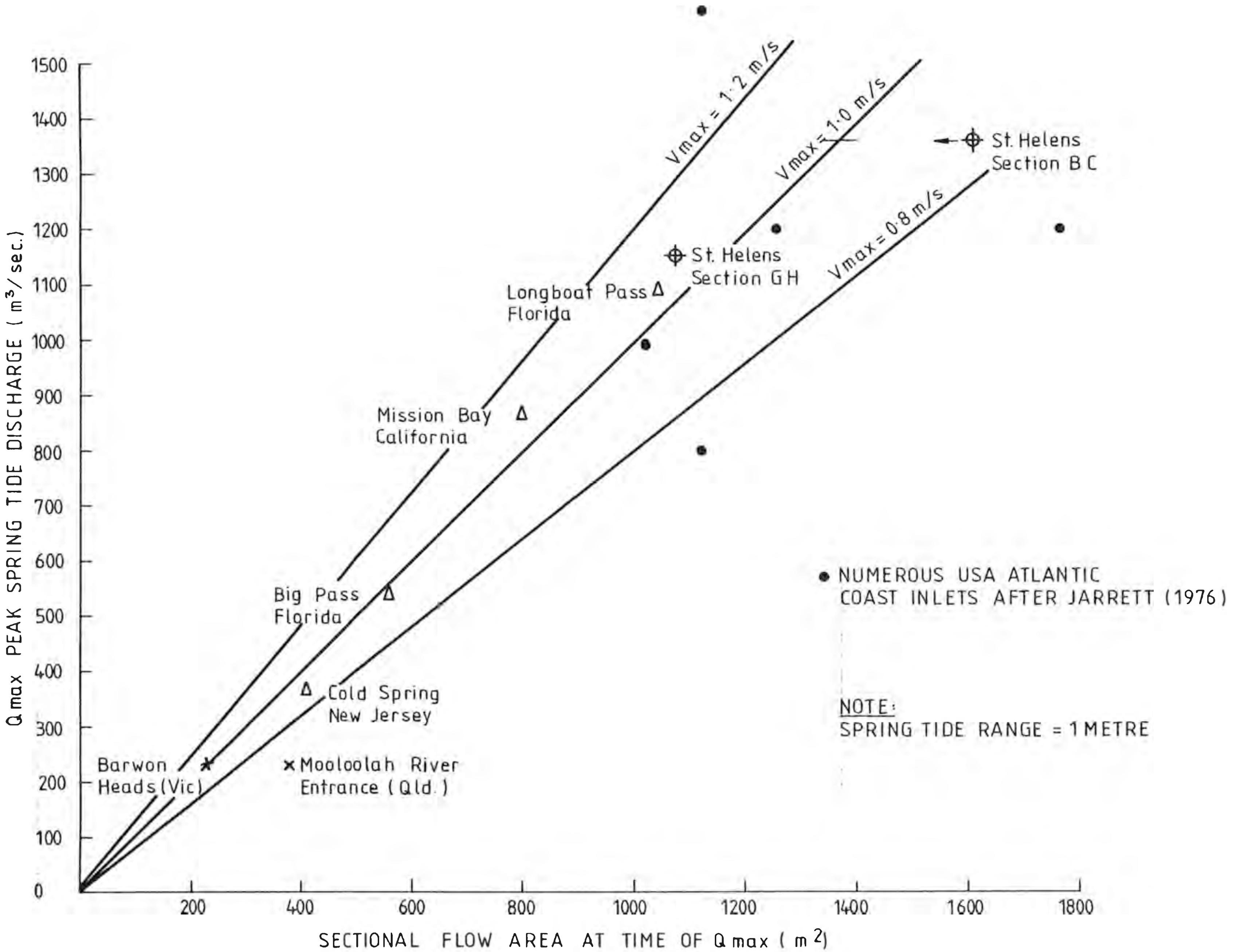
MEASURED DISCHARGE RESPONSE - GEORGES BAY

CROSS SECTION G - H (AKAROA)

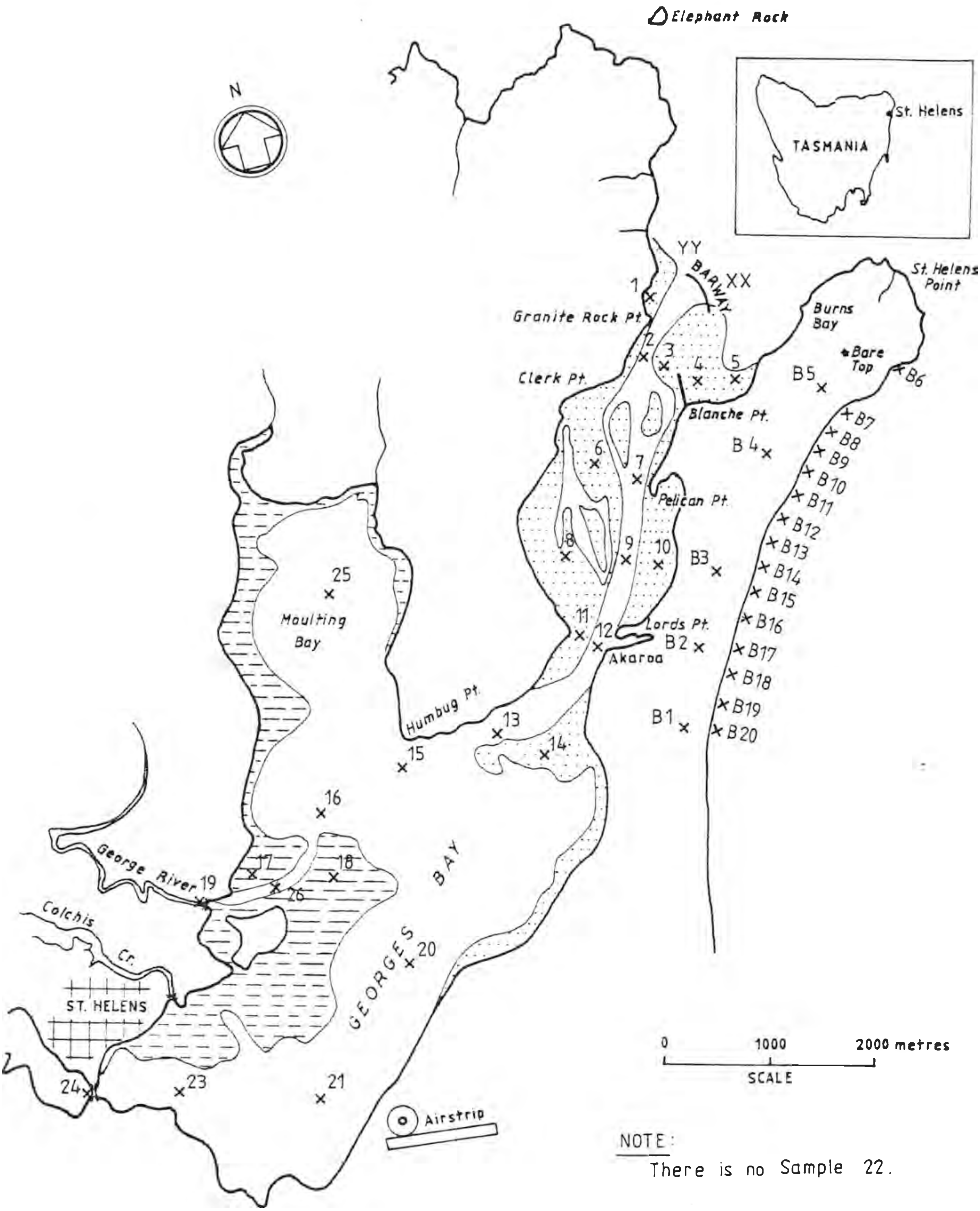
17. 11. 83

FIGURE 16

FIGURE 17

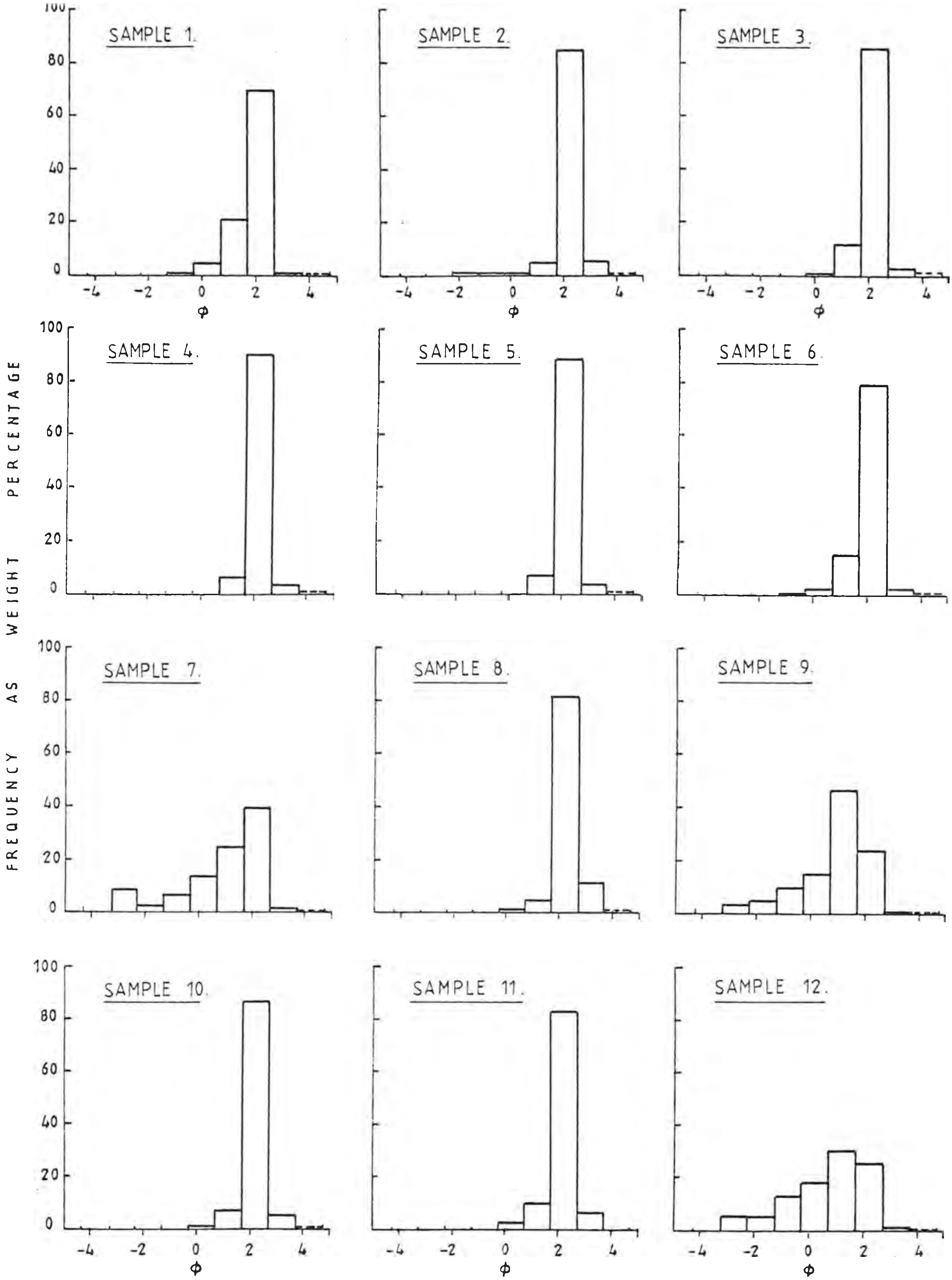


ST. HELENS ENTRANCE CHANNELS - PEAK SPRING TIDAL DISCHARGE vs FLOW AREA



LOCATION OF SEDIMENT SAMPLES

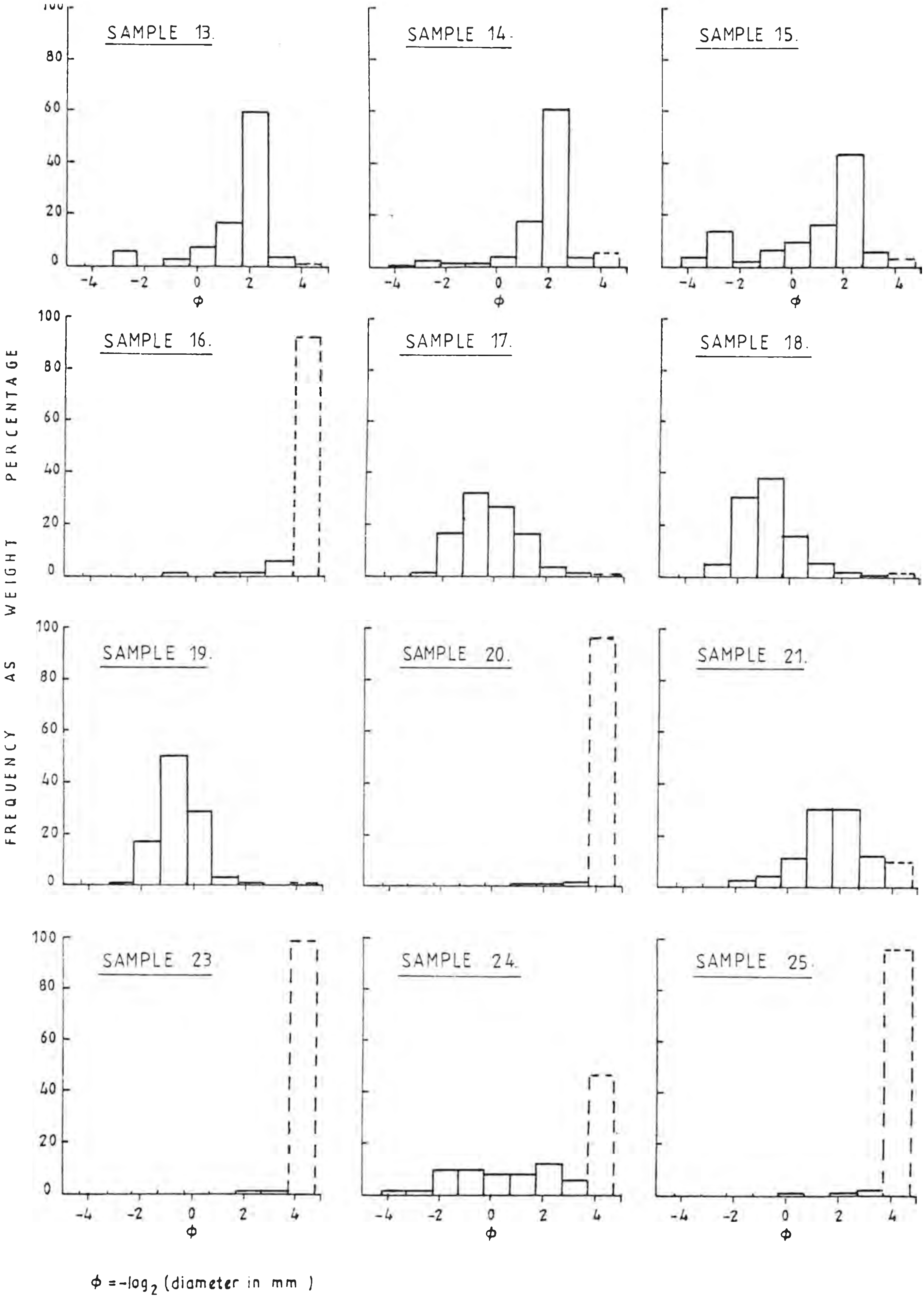
FIGURE 18



$\phi = -\log_2$ (diameter in mm)

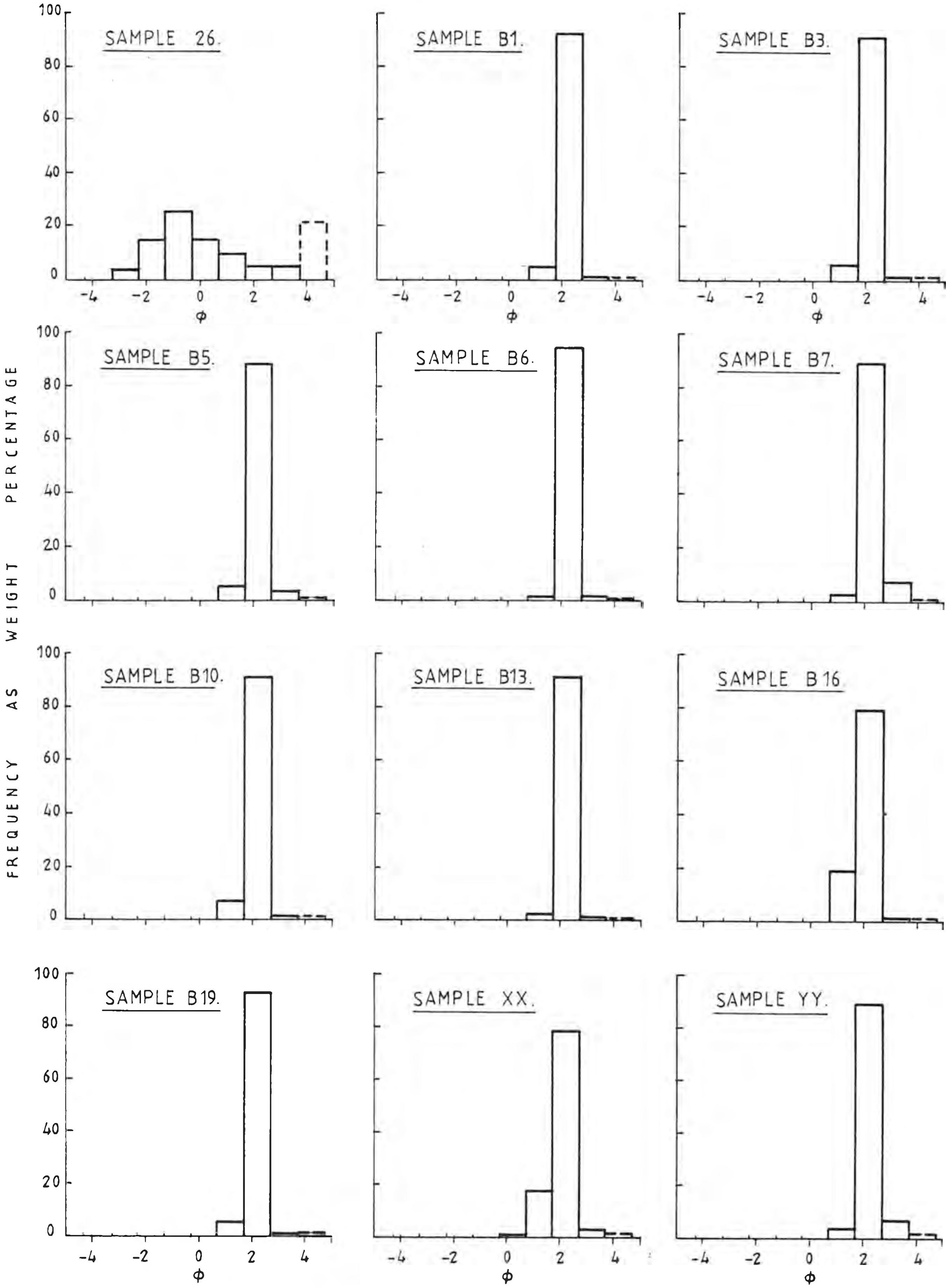
PLOTS OF FREQUENCY AS WEIGHT PERCENTAGE AGAINST SEDIMENT GRAIN DIAMETER

FIGURE 19a



PLOTS OF FREQUENCY AS WEIGHT PERCENTAGE AGAINST SEDIMENT GRAIN DIAMETER

FIGURE 19b



$\phi = -\log_2$ (diameter in mm)

PLOTS OF FREQUENCY AS WEIGHT PERCENTAGE AGAINST SEDIMENT GRAIN DIAMETER

FIGURE 19c

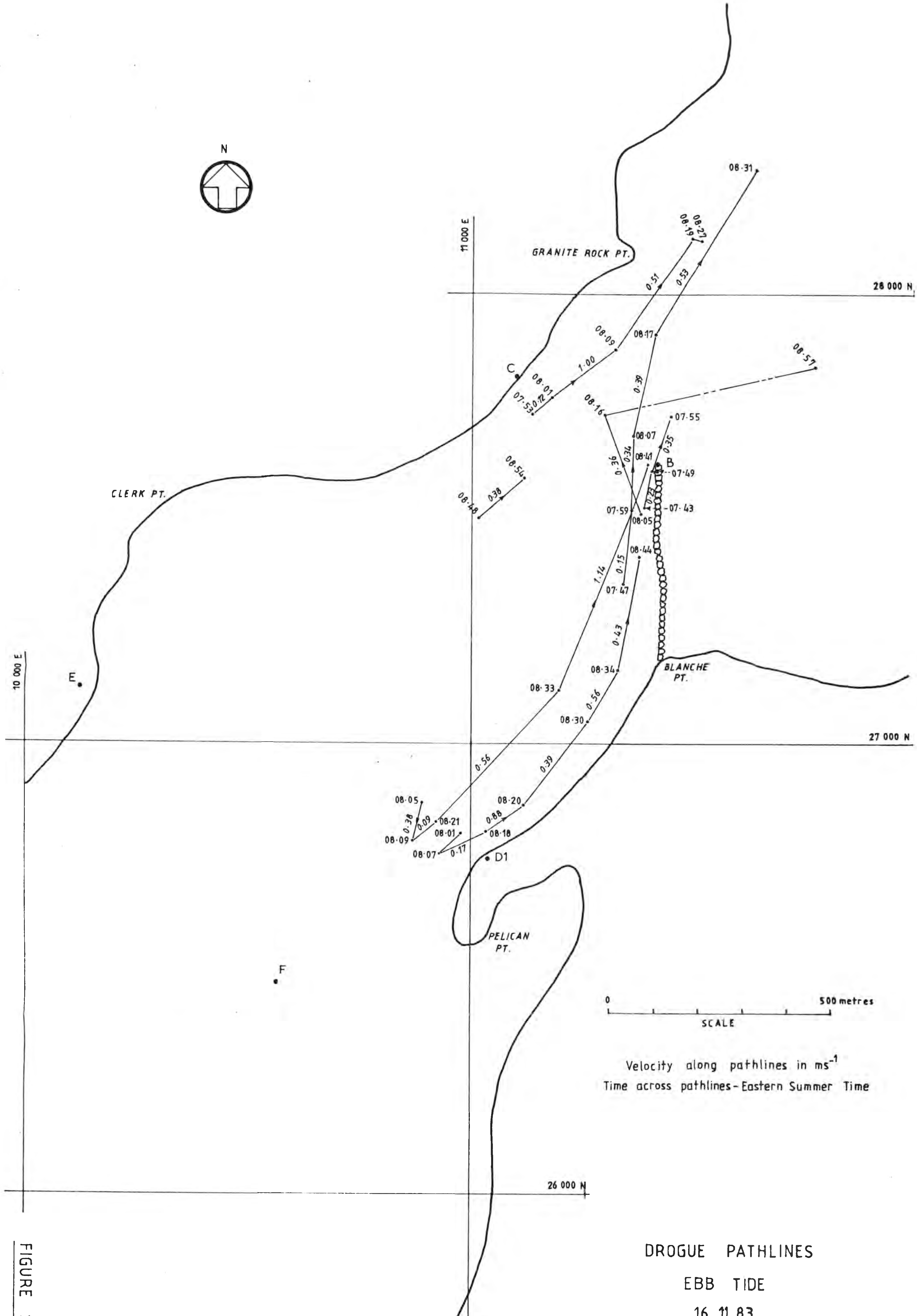


FIGURE 20

DROGUE PATHLINES

EBB TIDE

16.11.83

0730 to 0900 HRS

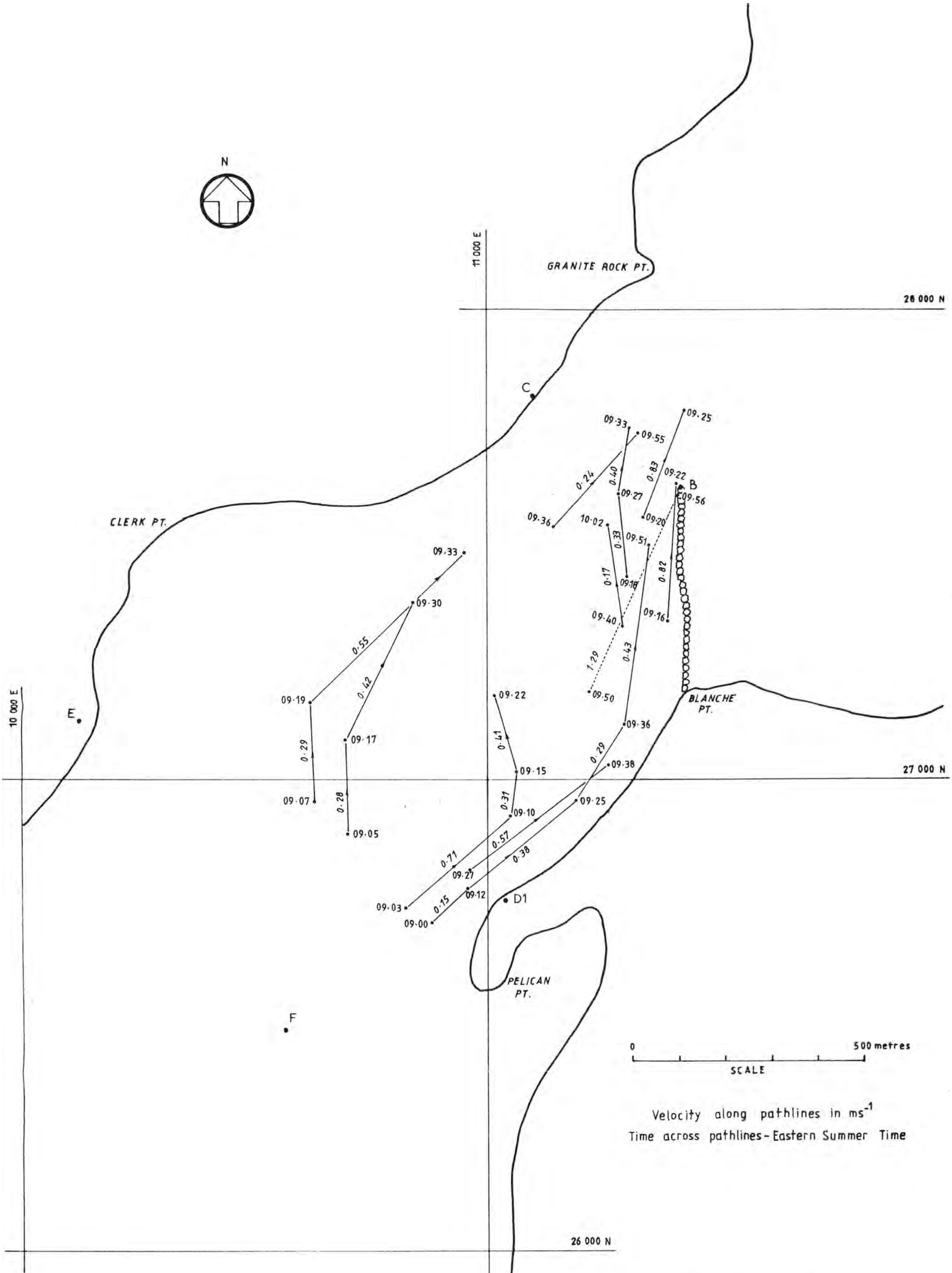


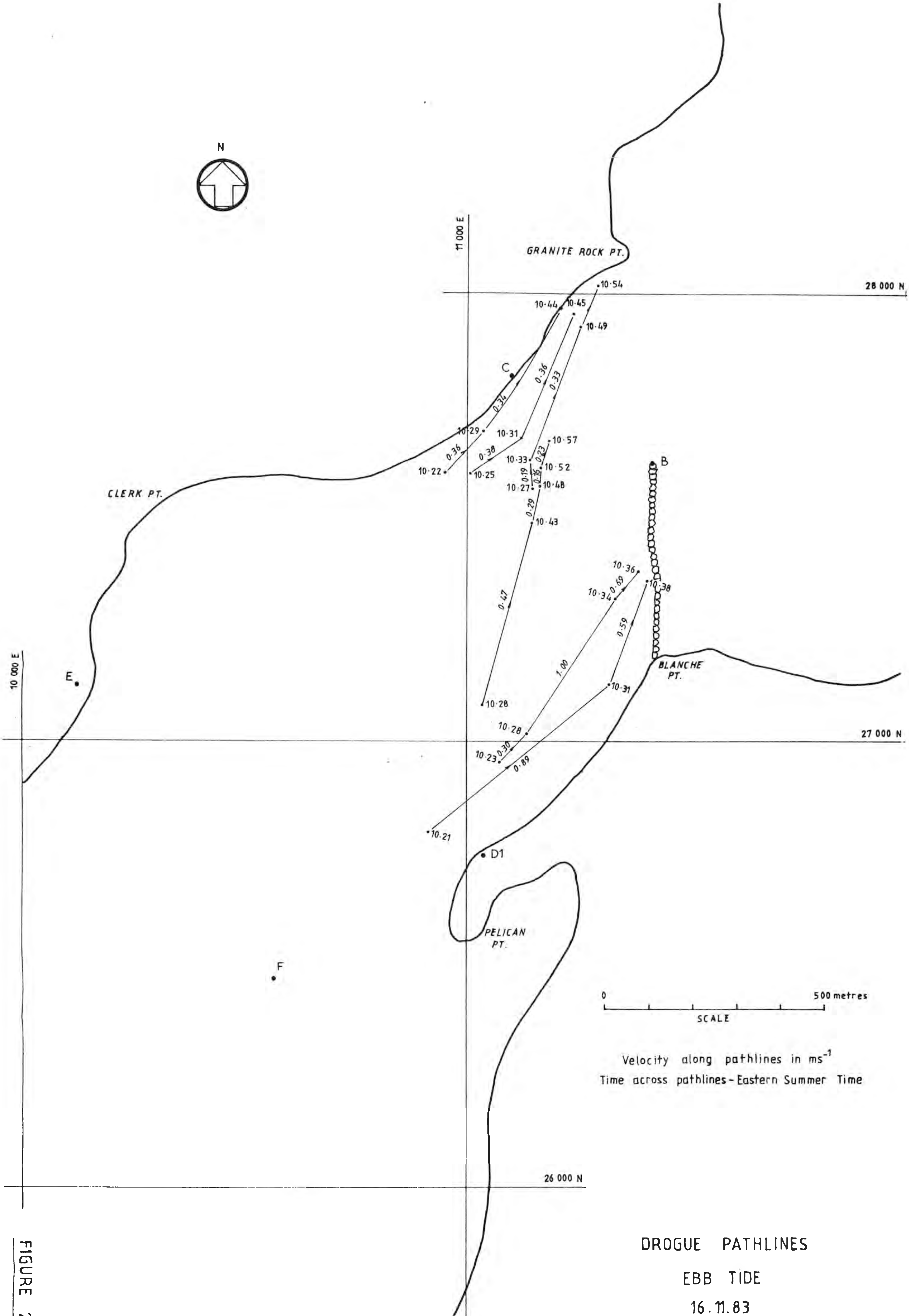
FIGURE 21.

DROGUE PATHLINES

EBB TIDE

16.11.83

0900 to 1000 HRS



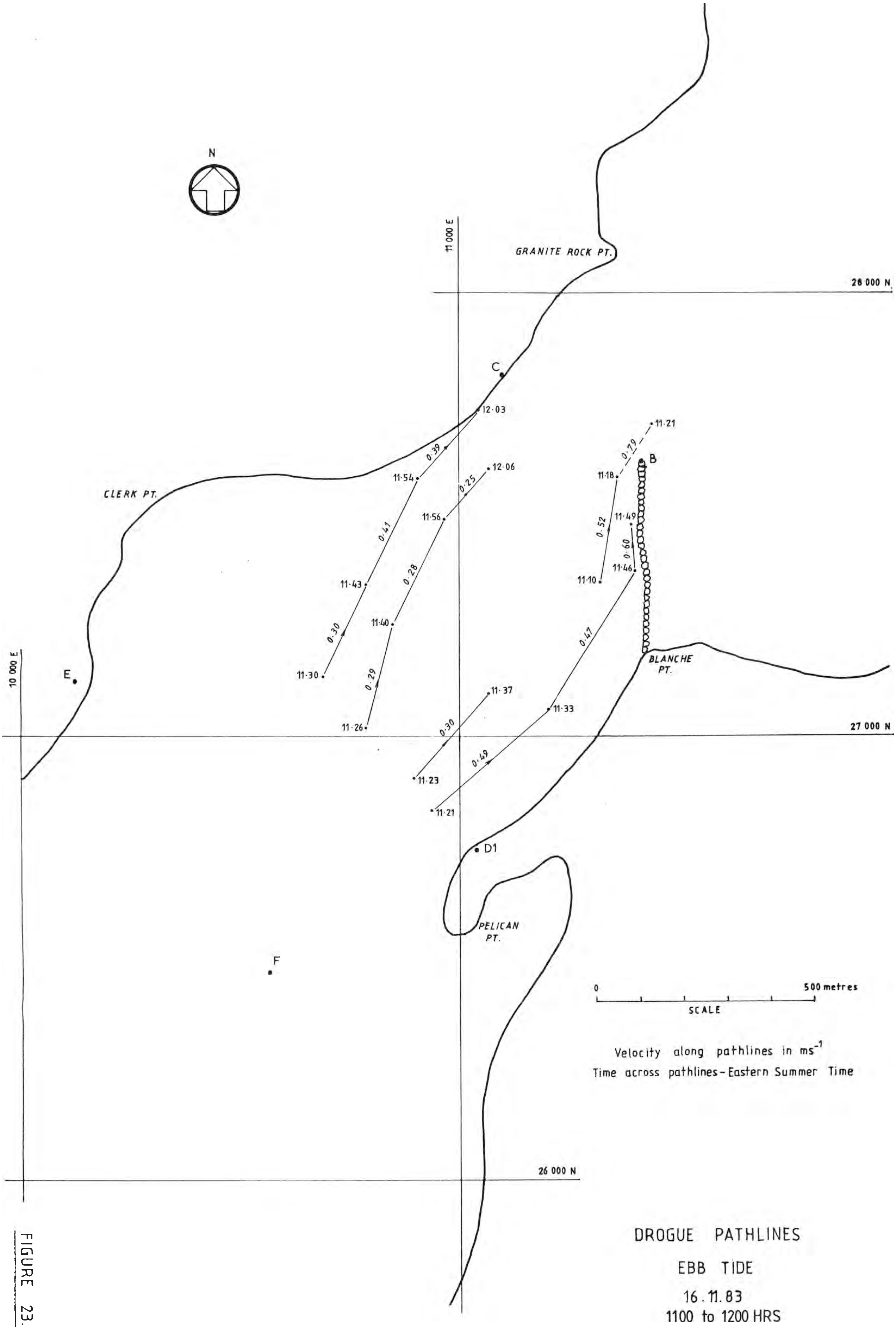
DROGUE PATHLINES

EBB TIDE

16.11.83

1000 to 1100 HRS

FIGURE 22.

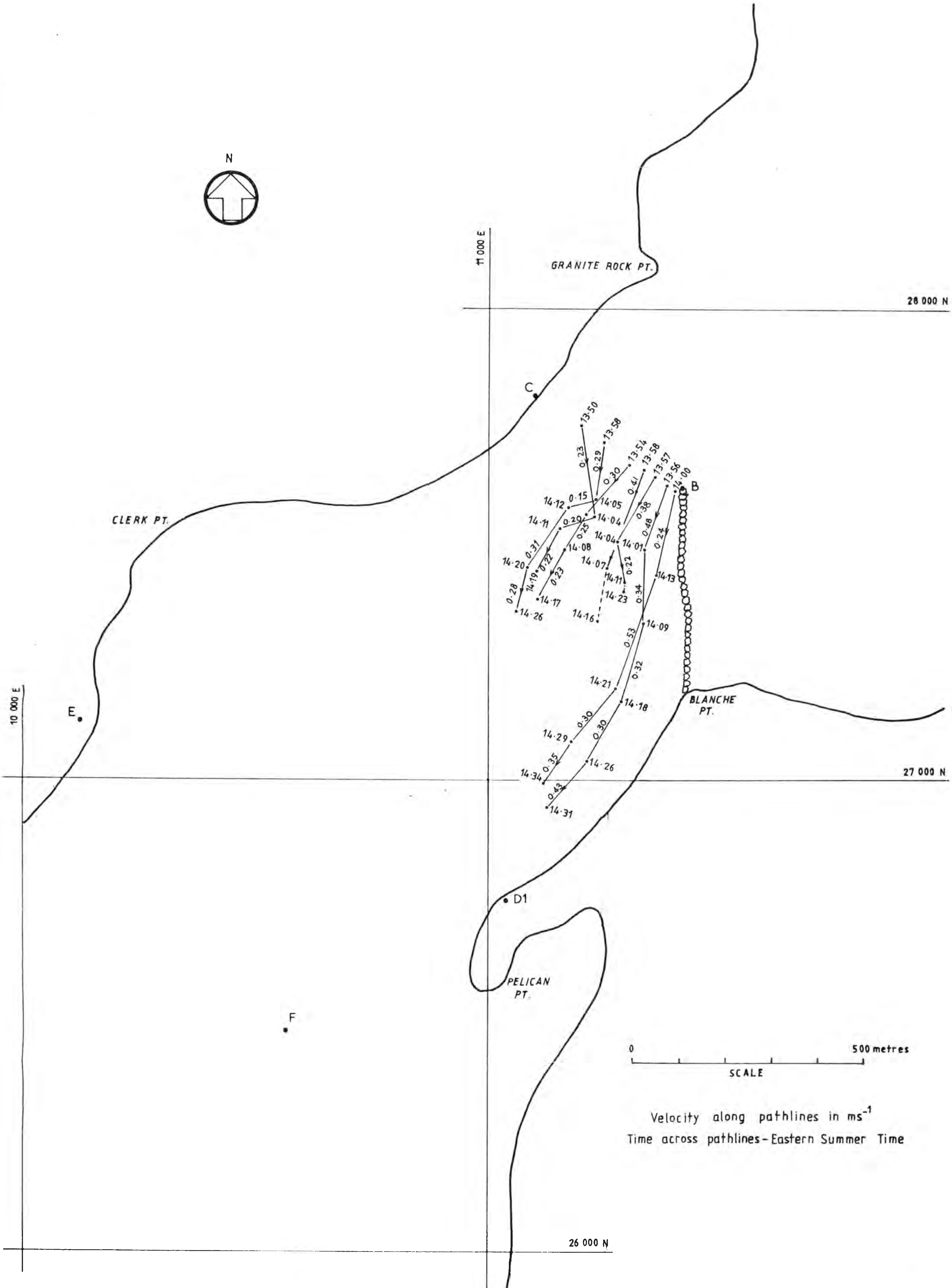


DROGUE PATHLINES

EBB TIDE

16 . 11. 83
1100 to 1200 HRS

FIGURE 23.



DROGUE PATHLINES

FLOOD TIDE

16.11.83

1330 to 1430 HRS

FIGURE 24.

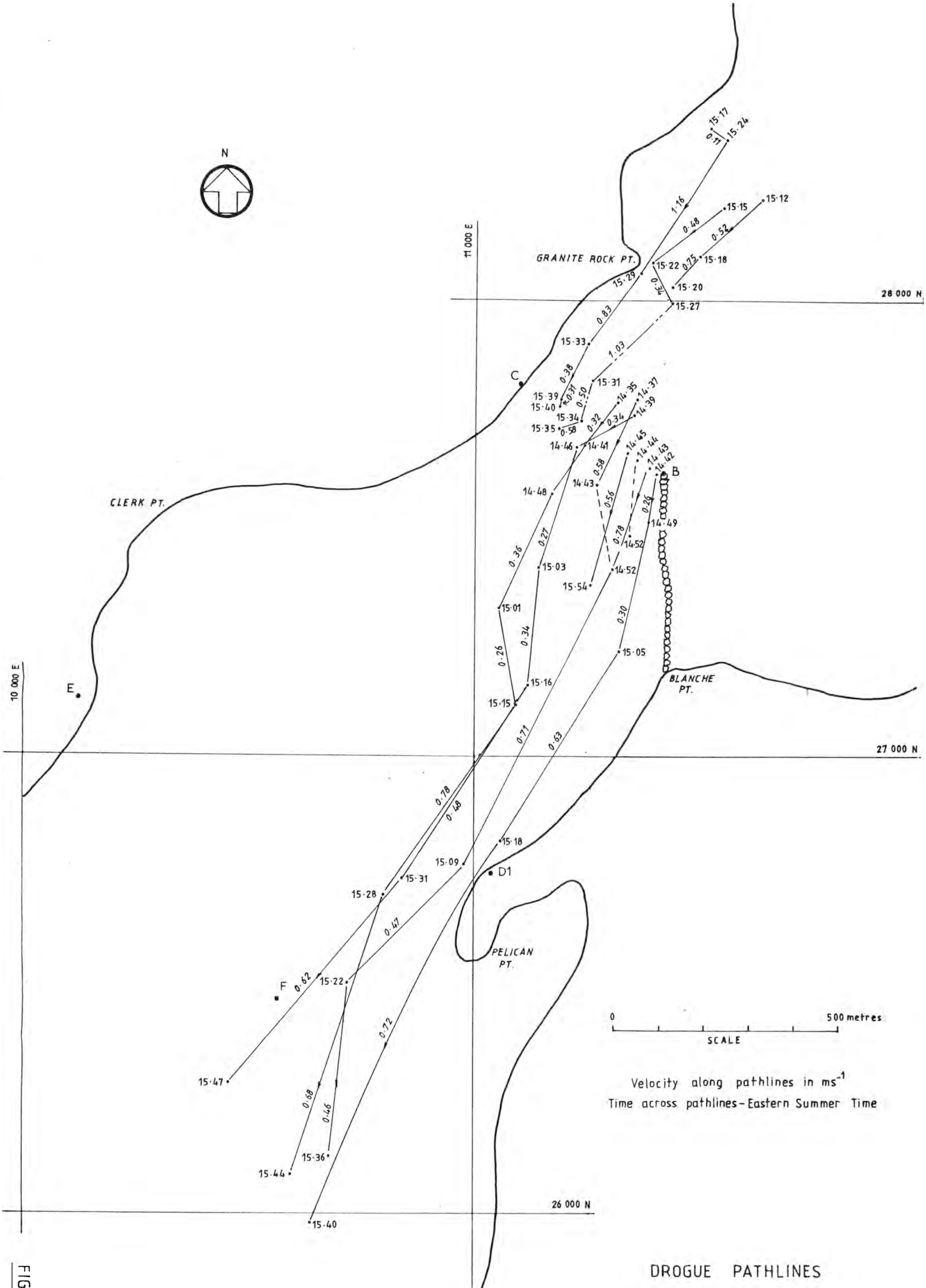


FIGURE 25.

DROGUE PATHLINES

FLOOD TIDE

16.11.83
1430 to 1545 HRS

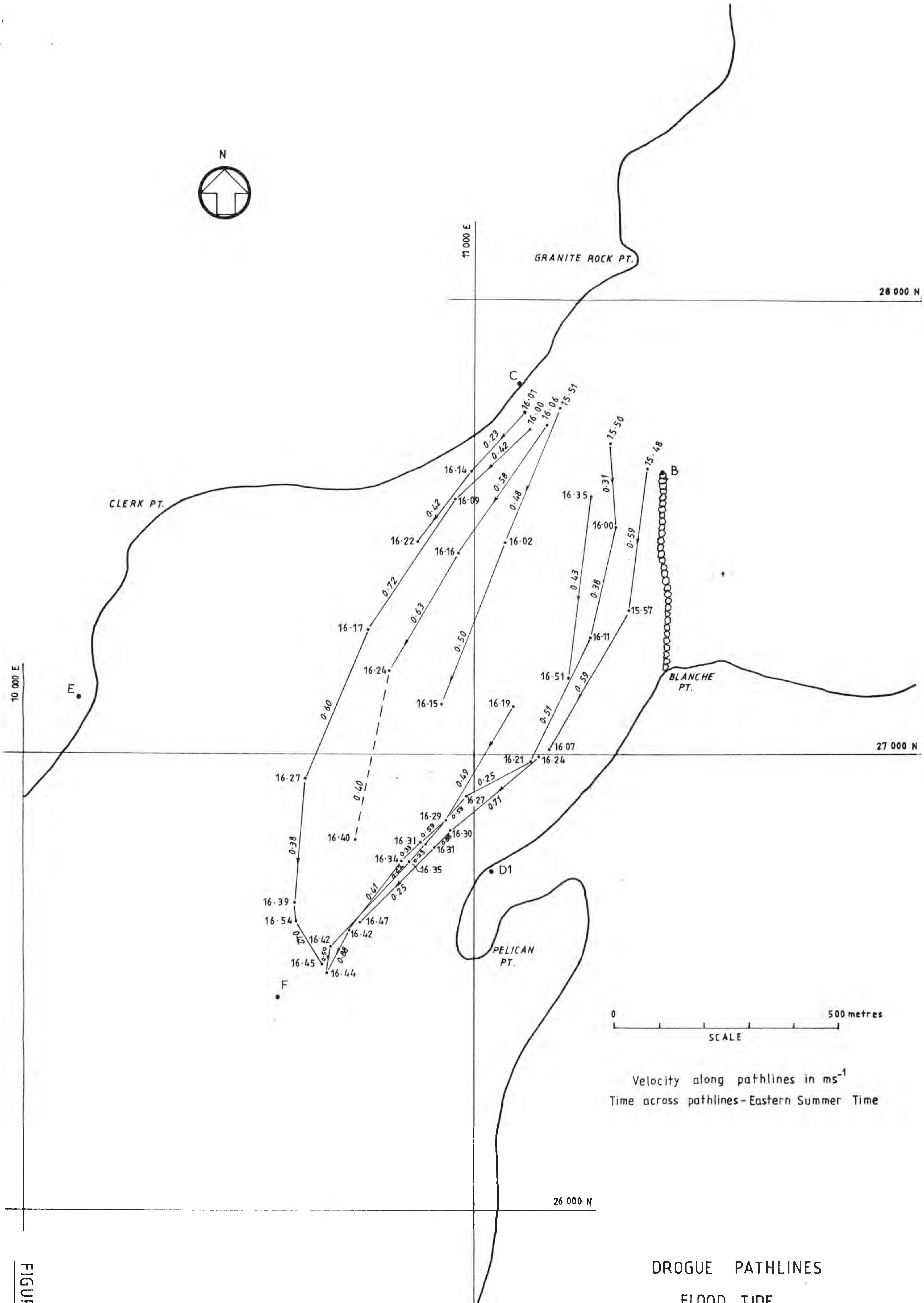


FIGURE 26.

DROGUE PATHLINES

FLOOD TIDE

16.11.83

1545 to 1700 HRS

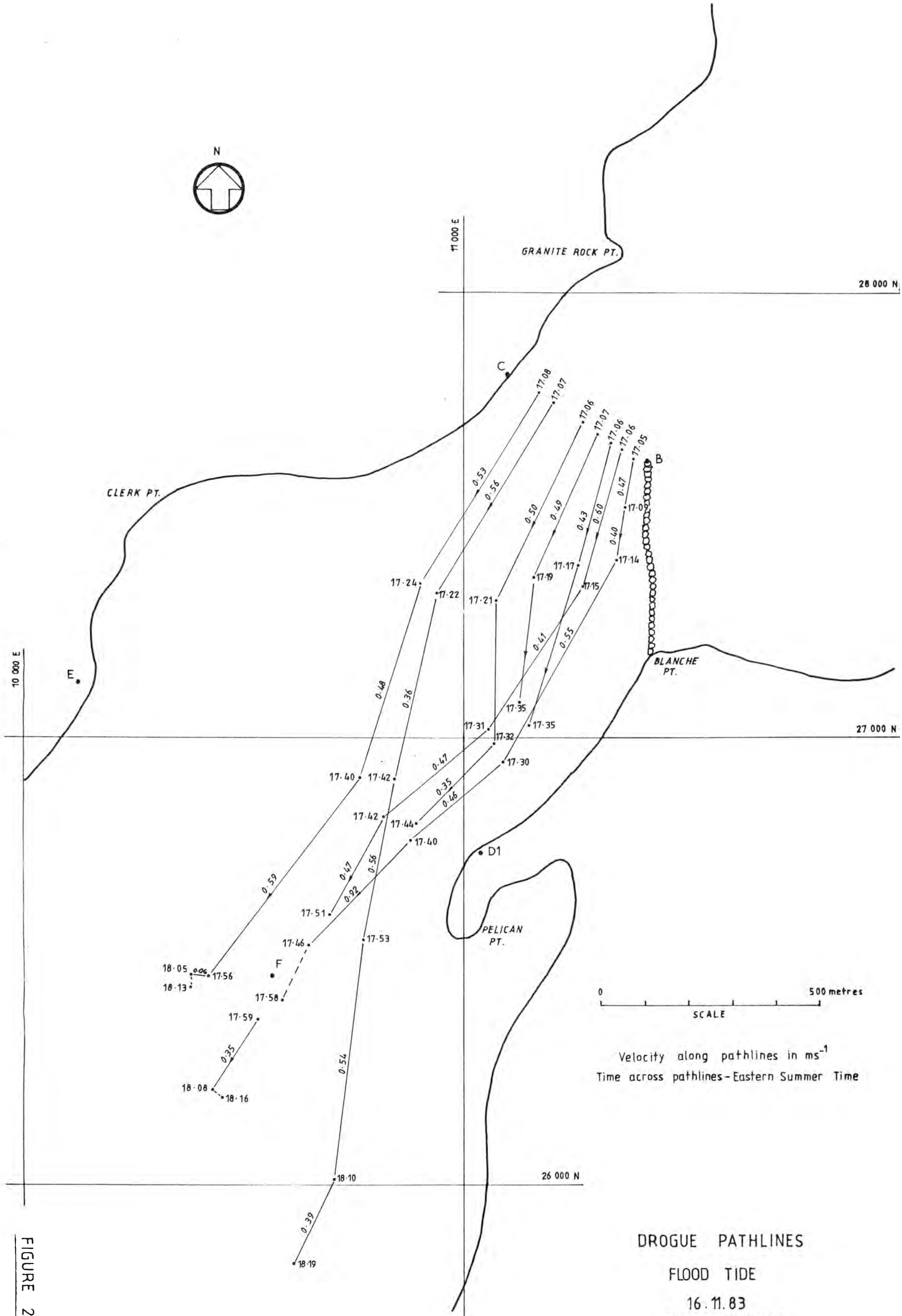


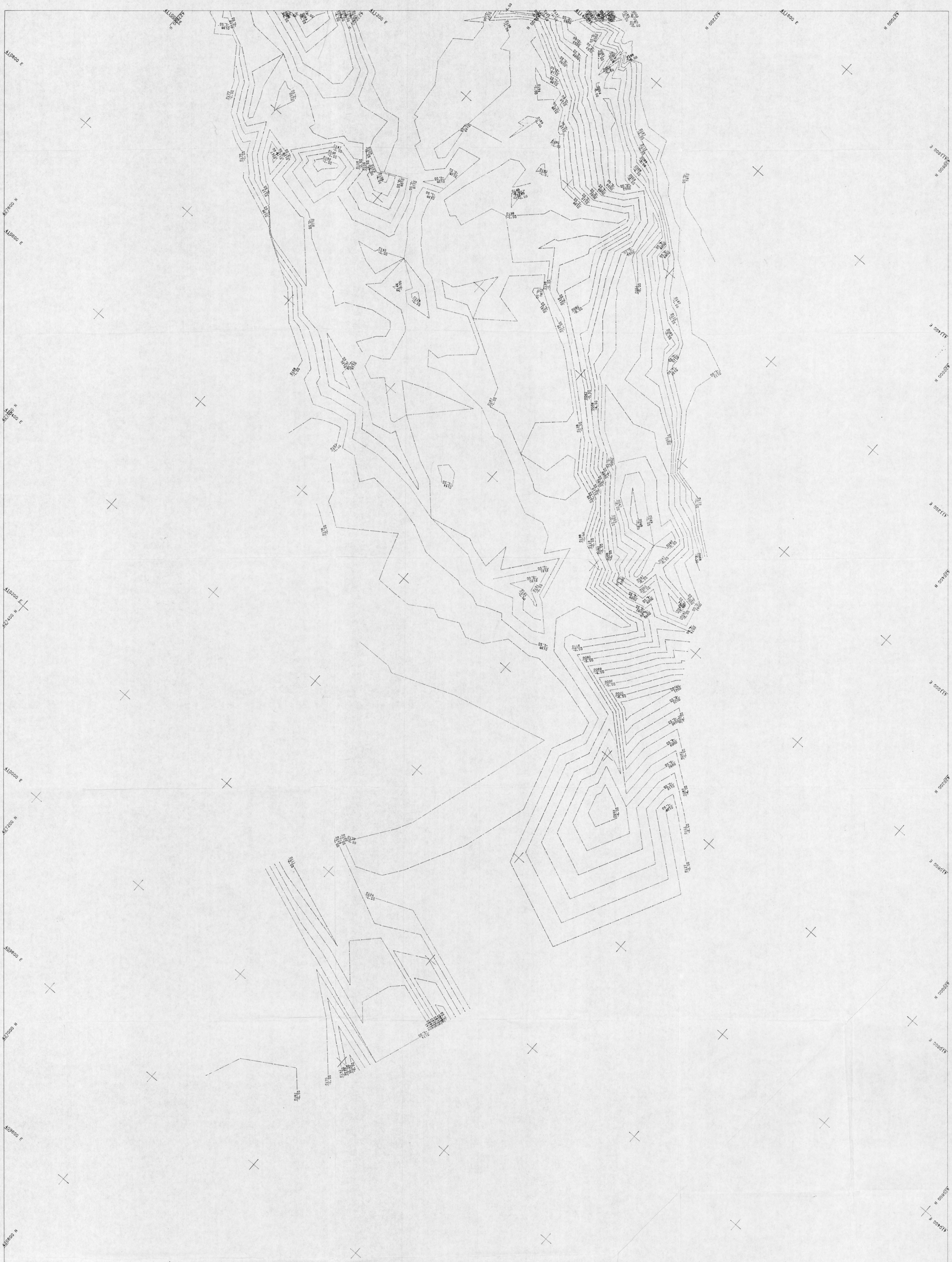
FIGURE 27.

DROGUE PATHLINES

FLOOD TIDE

16.11.83

1700 to 1820 HRS



ST. HELENS BARWAY SOUNDINGS PLAN 1 OF 2 PAGE 1/1

HYDROGRAPHIC SURVEY NOV. 1983

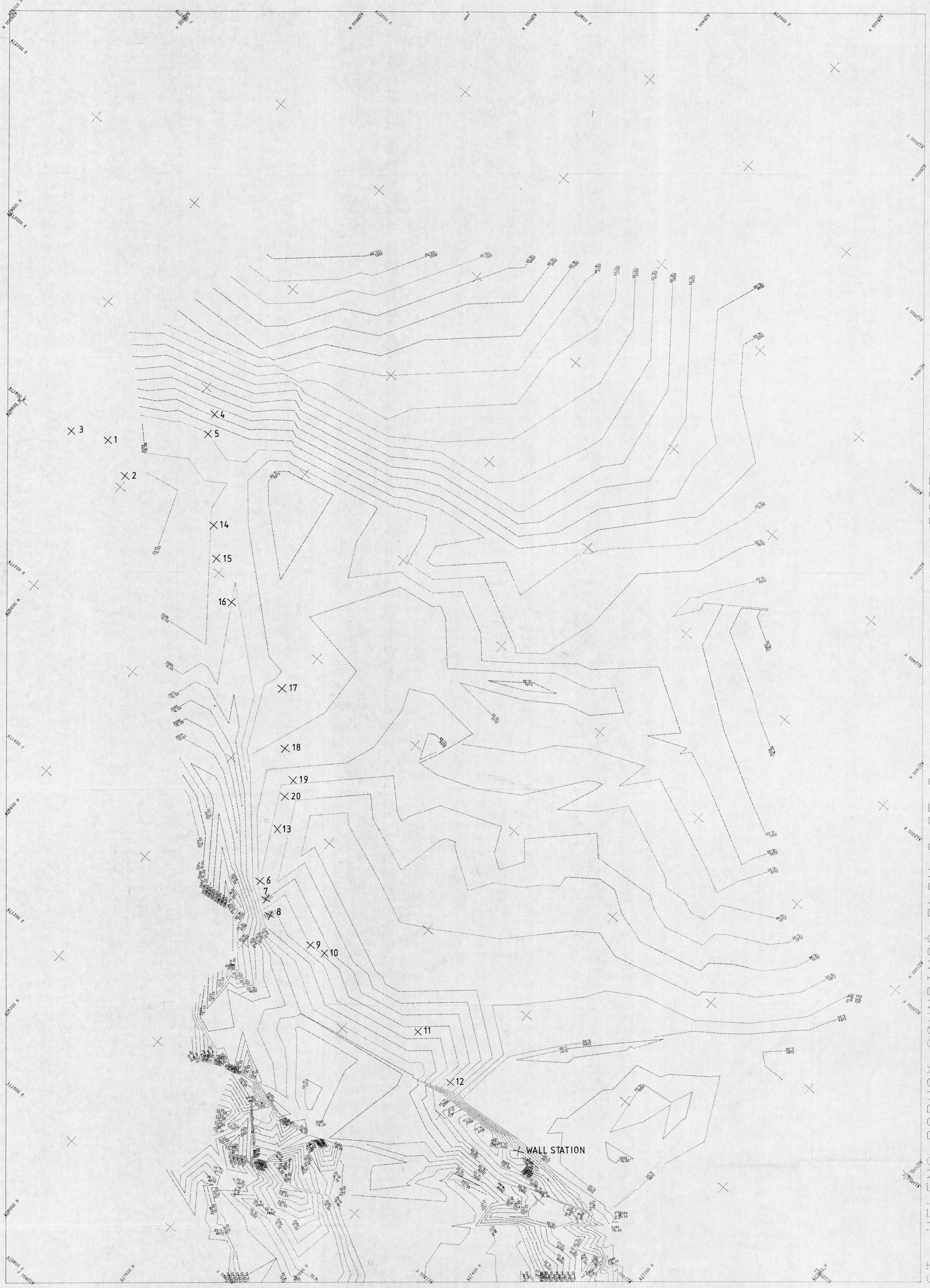
FIGURE 28A

MOSS

MOSS 07/12/83
LENGTH 97 CMS WIDTH 70 CMS RAG PAPER LARGE STEPSIZE
PLAN PLOT SCALE 1:2000
CONT BARWAY SOUNDINGS BLACK BIRO
GRIDPLOT FOLLOWS

CERNET DMR001 at 14:32 on 08/12/83 Z01-PLOT.CONT.S.SH-B-S

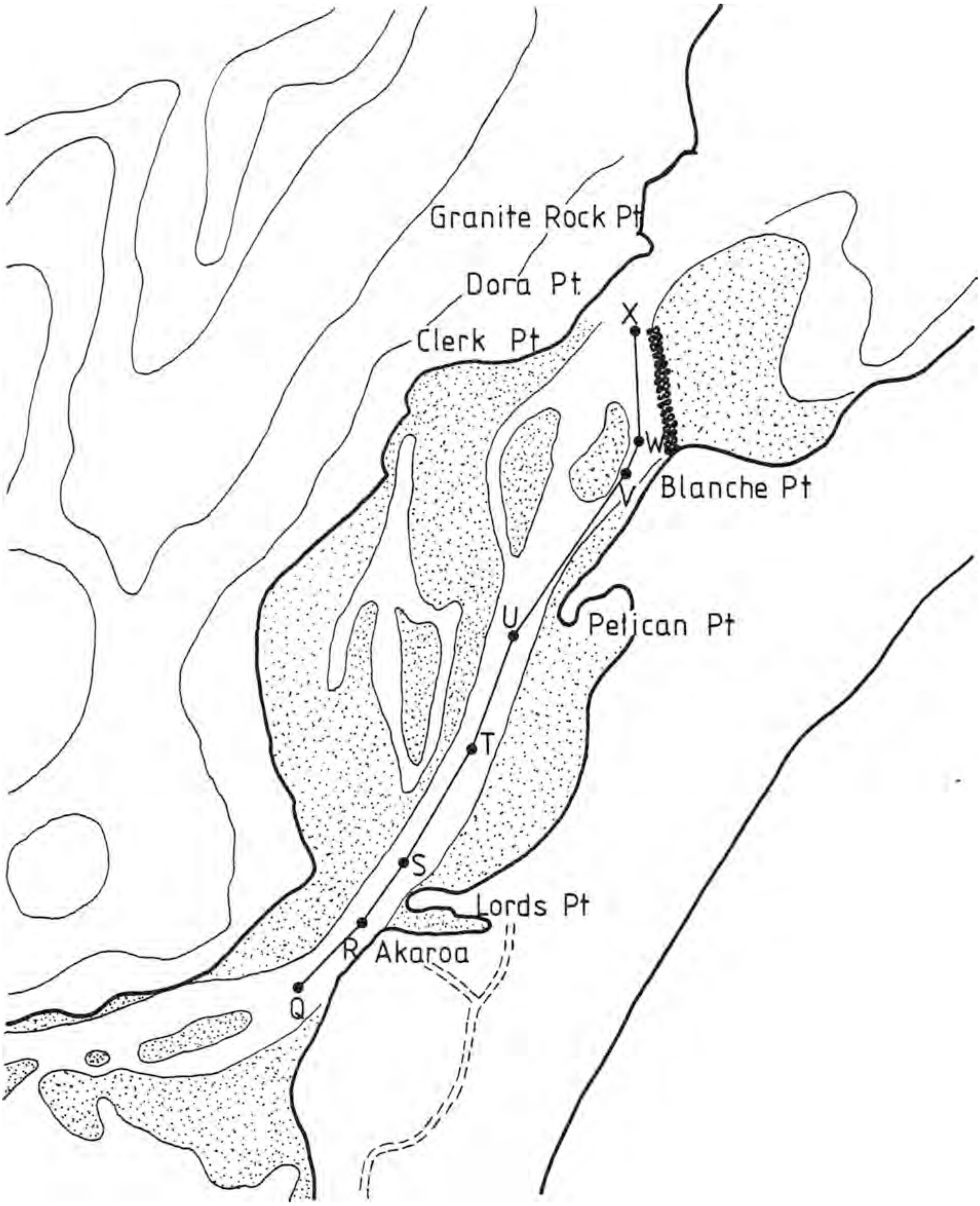
HYDROGRAPHIC SURVEY NOV. 1983



ST. HELENS BARWAY SOUNDINGS PLAN 2 OF 2 PAGE 1/1

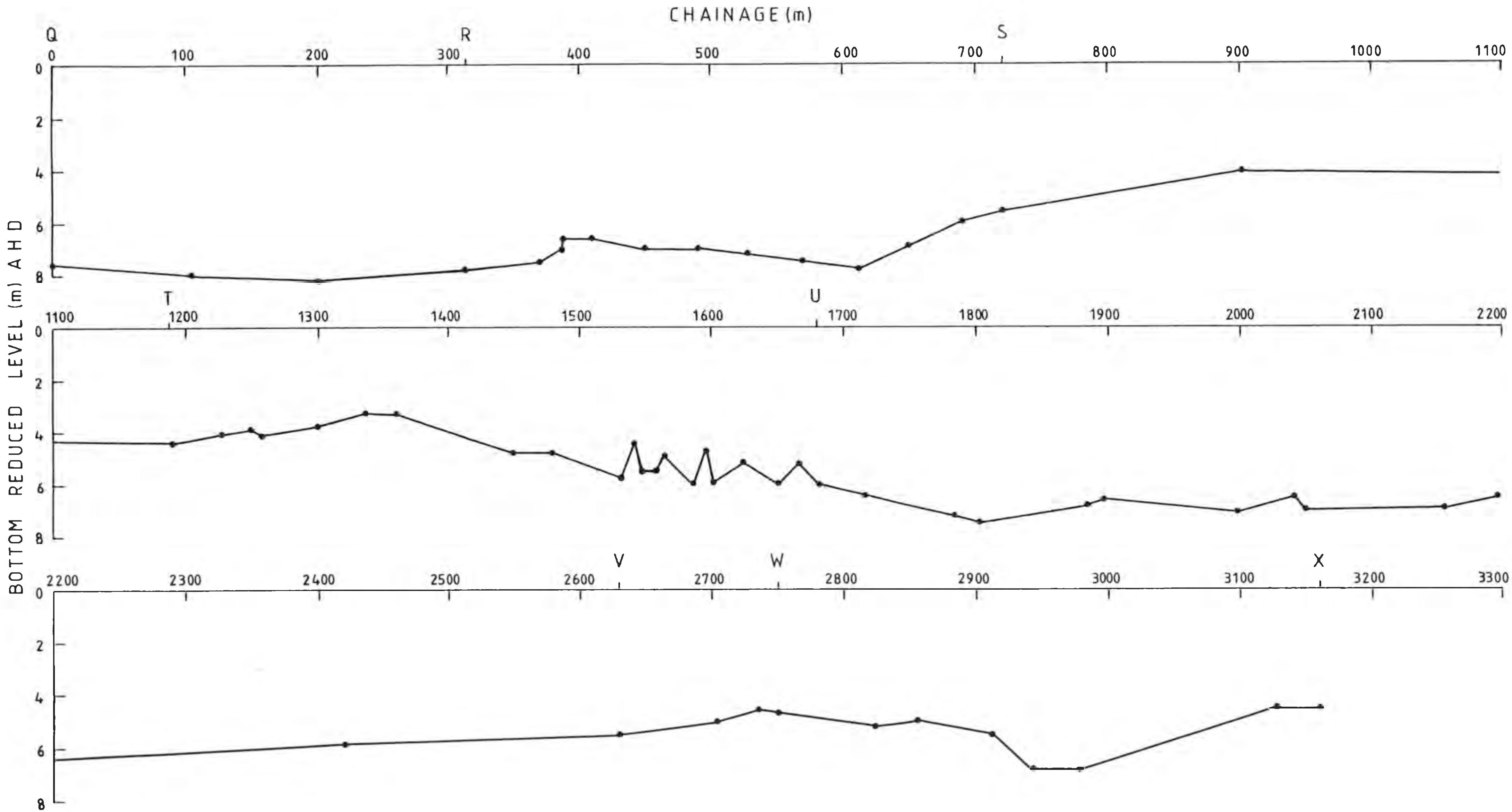
MOSS

MOSS 07/12/83
LENGTH 97 CMS WIDTH 70 CMS RAG PAPER LARGE STEPSIZE
PLAN PLOT SCALE 1:2000
CONT BARWAY SOUNDINGS BLACK BIRO
GRIDPLOT FOLLOWS



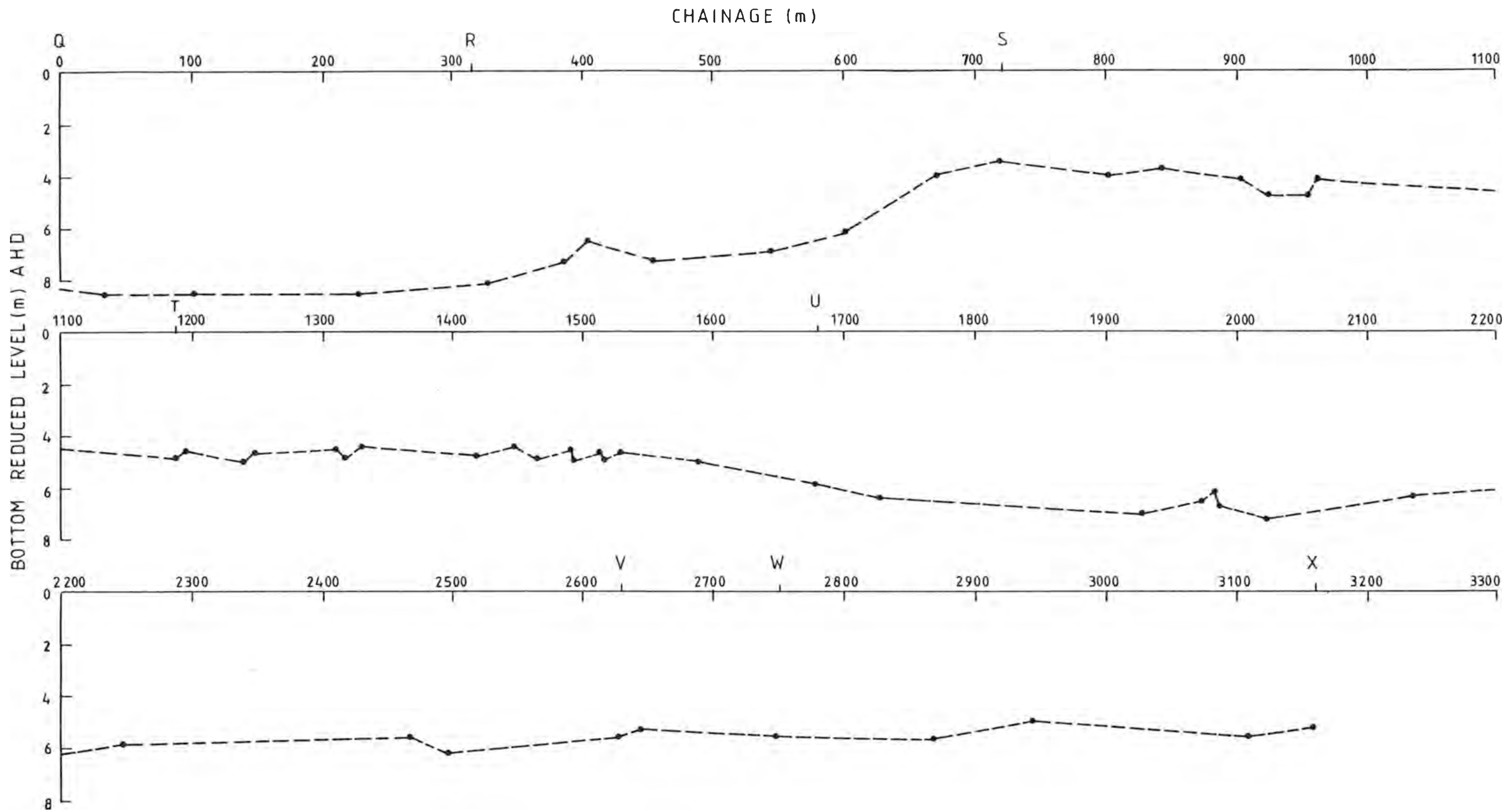
ST. HELENS CHANNEL LONG SECTIONS–ROUTE TAKEN BY RECORDING BOAT DURING MEASUREMENT

FIGURE 29



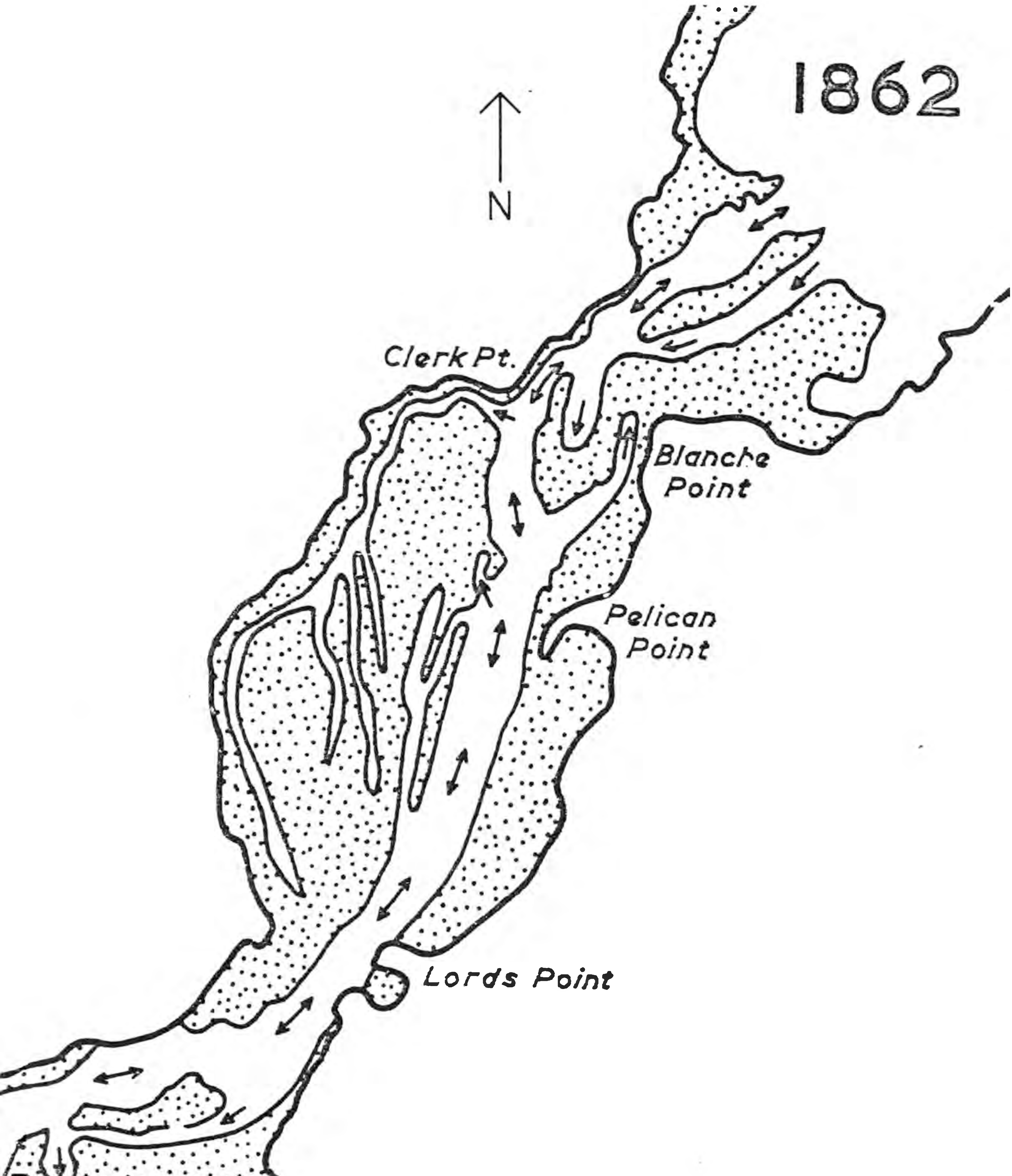
ST. HELENS CHANNEL LONG SECTIONS - RUN 1 AKAROA TO ENTRANCE

FIGURE 30A



ST. HELENS CHANNEL LONG SECTIONS - RUN 2 ENTRANCE TO AKAROA

FIGURE 30B



GEORGES BAY ENTRANCE 1862
(after Davies 1965) Scale: 1:20 000

FIGURE 31

GEORGES BAY ENTRANCE 1950
(after Davies 1965) Scale: 1:20000

FIGURE 32

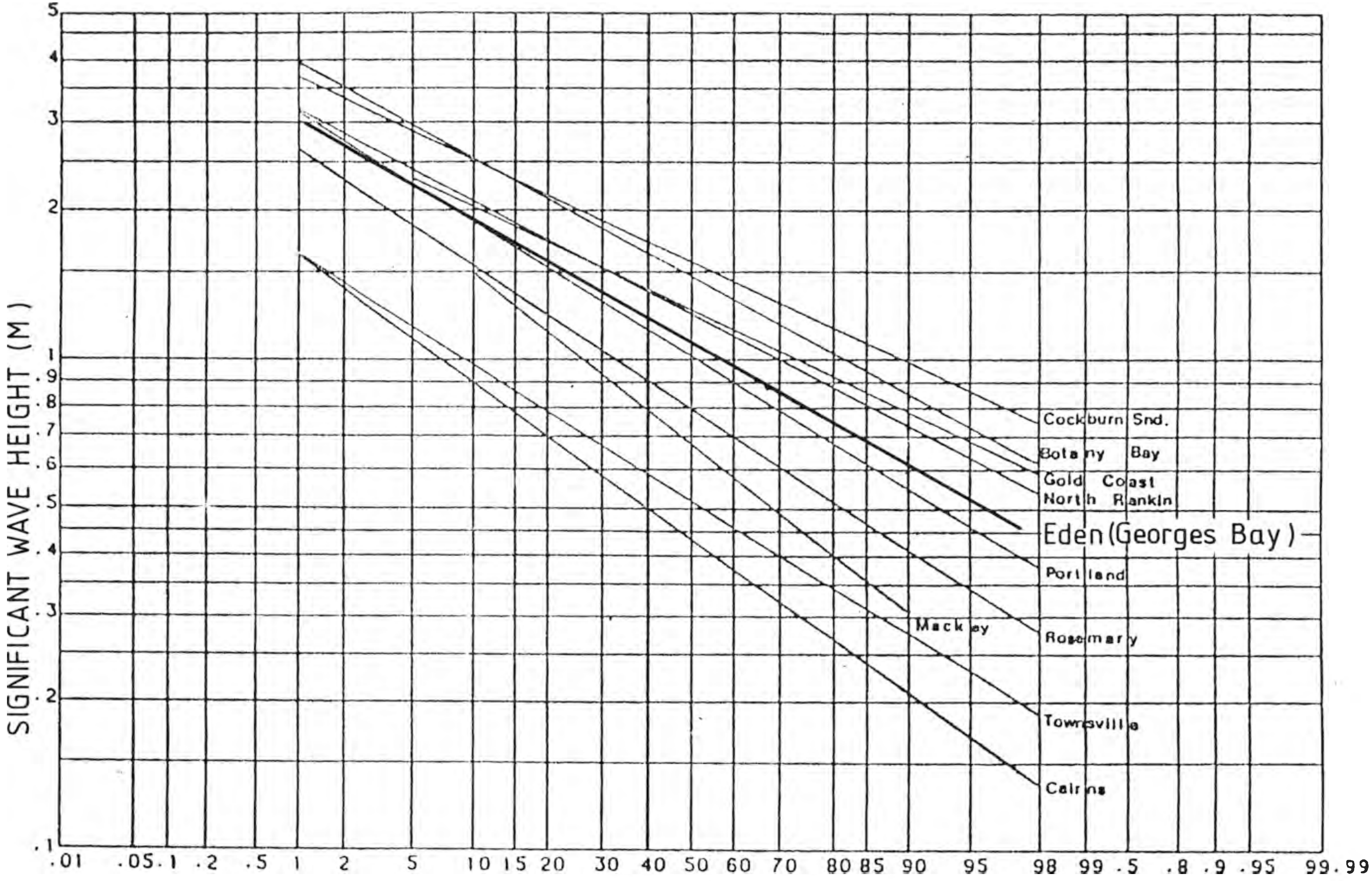
GEORGES BAY ENTRANCE 1950
March 1950 Aerial Photograph. Scale: 1:20 000

FIGURE 33

GEORGES BAY ENTRANCE 1982
Nov. 1982 Aerial Photograph. Scale: 1:20 000

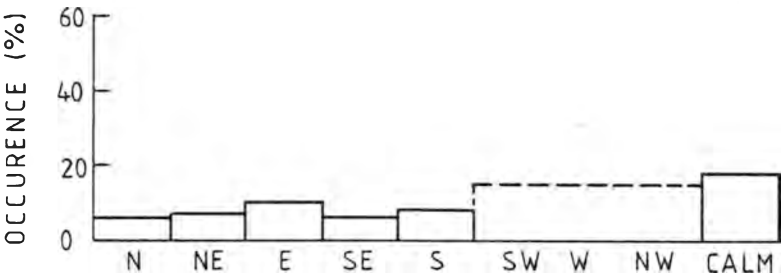
FIGURE 34

FIGURE 35
GEORGES BAY 1979 / 80

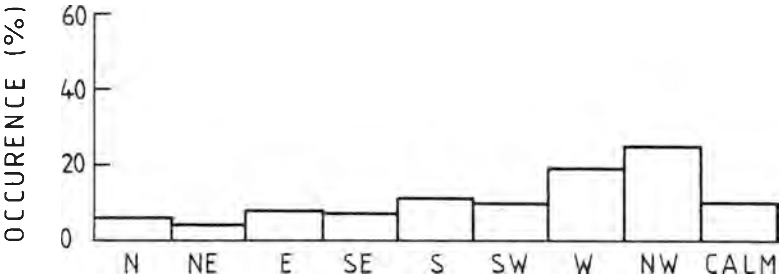


WAVE CLIMATE AROUND AUSTRALIA

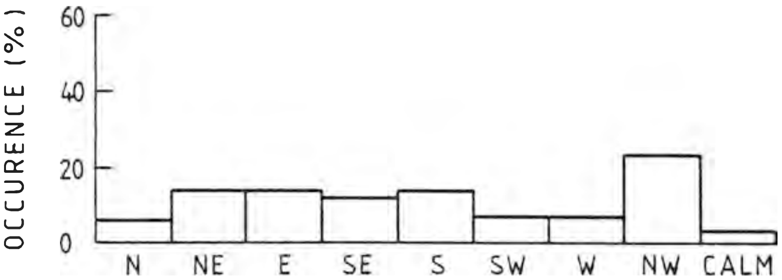
FIGURE 36



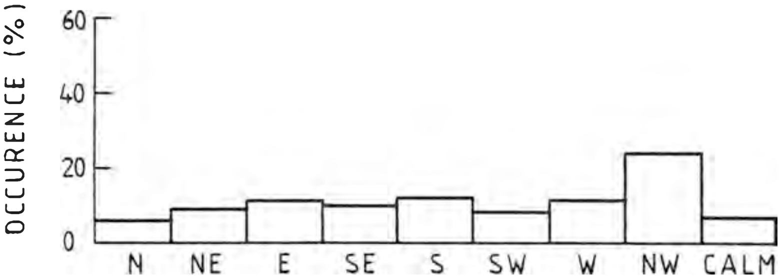
SYNOPTIC CHART WAVE DIRECTION



ST. HELENS P.O. WIND DIRECTION 0900 HRS



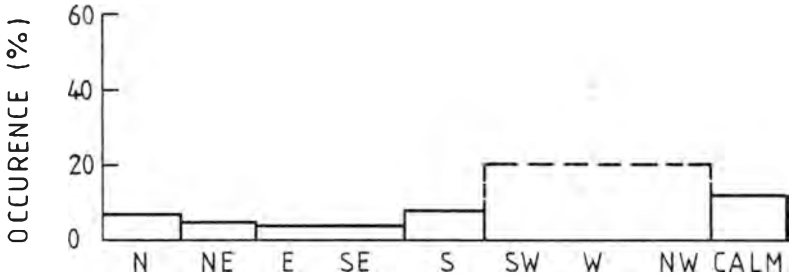
ST. HELENS P.O. WIND DIRECTION 1500 HRS



ST. HELENS P.O. WIND DIRECTION COMPOSITE

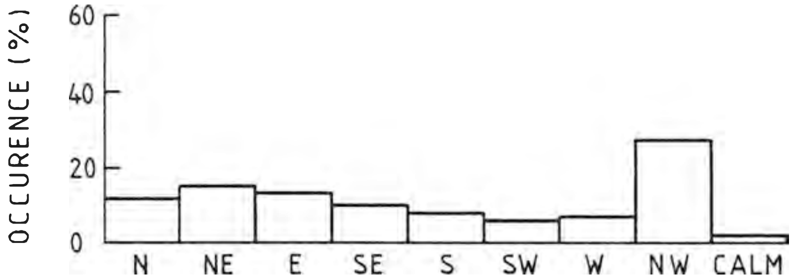
ST. HELENS WAVE CLIMATE 1978

FIGURE 37

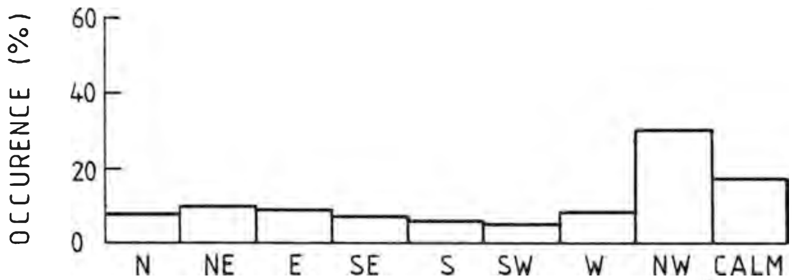


SYNOPTIC CHART WAVE DIRECTION

ST. HELENS P.O. WIND DIRECTION 900 HRS



ST. HELENS P.O. WIND DIRECTION 1500 HRS

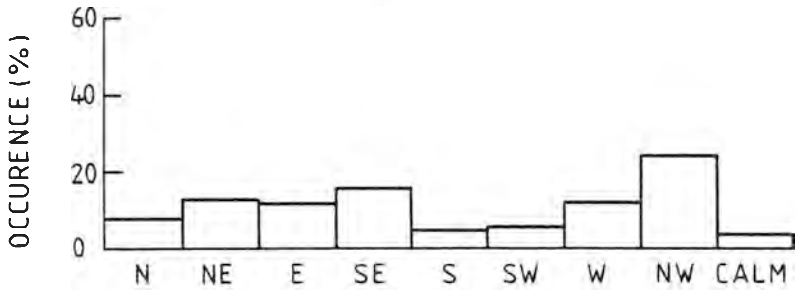


ST. HELENS P.O. WIND DIRECTION COMPOSITE

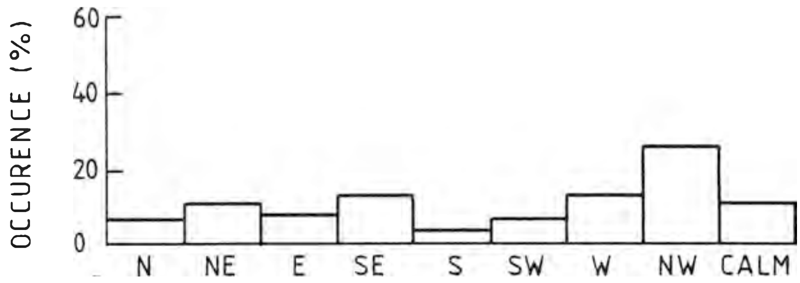
ST. HELENS WAVE CLIMATE 1982

FIGURE 38

ST. HELENS P.O. WIND DIRECTION 0900 HRS



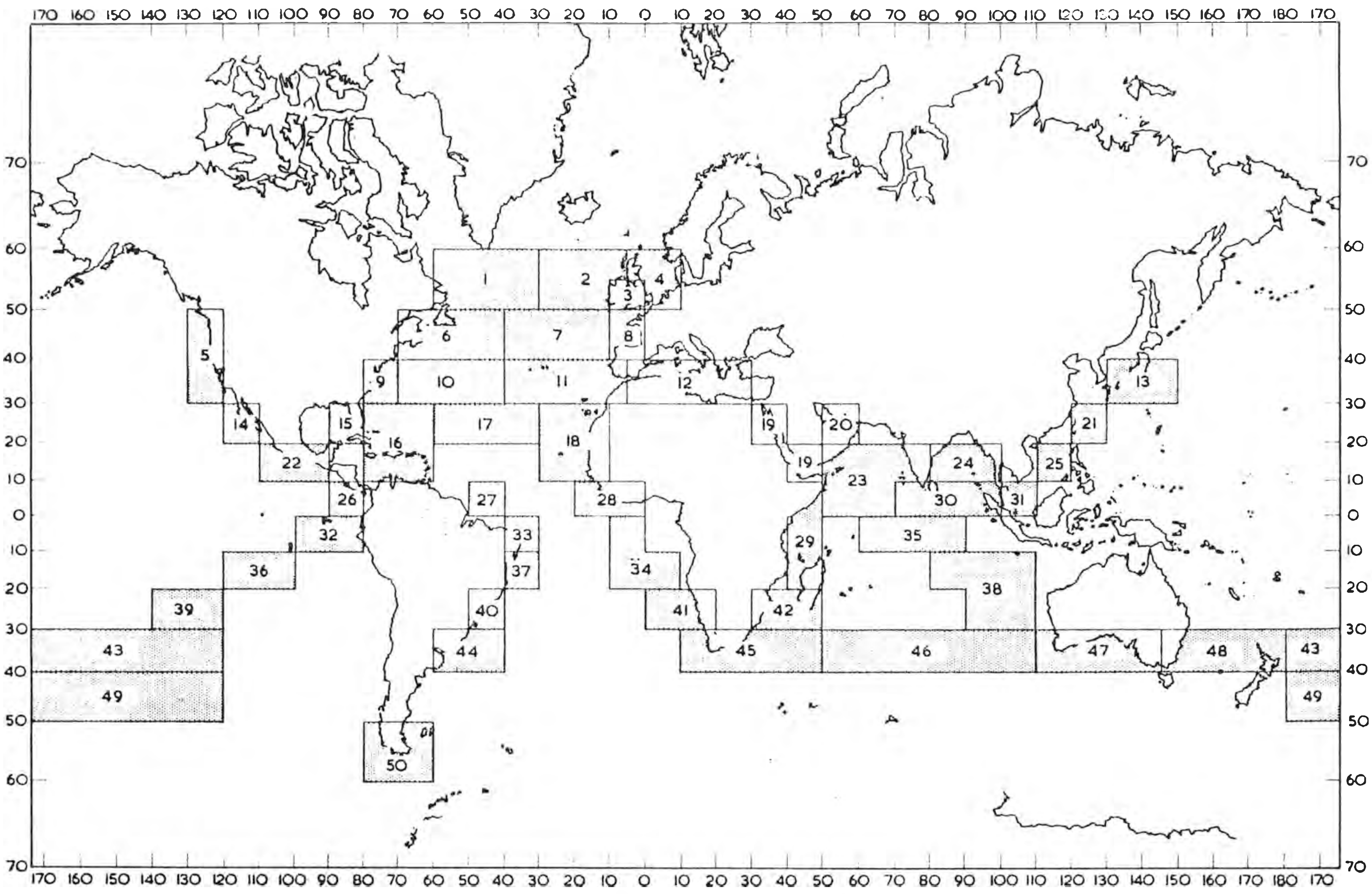
ST. HELENS P.O. WIND DIRECTION 1500 HRS



ST. HELENS P.O. WIND DIRECTION COMPOSITE

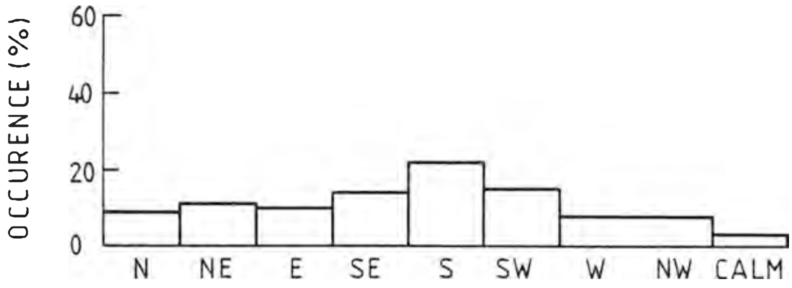
ST. HELENS LONG TERM WIND DATA

FIGURE 39

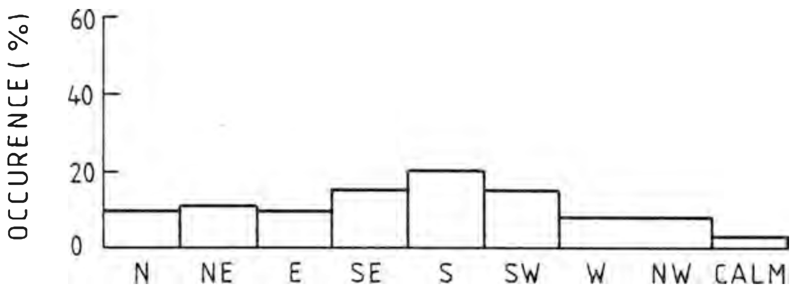


AREAS DEFINED IN OCEAN WAVE STATISTICS BY N. HOGBEN AND F.E. LUMB (HMSO 1967)

FIGURE 40



AREA 43



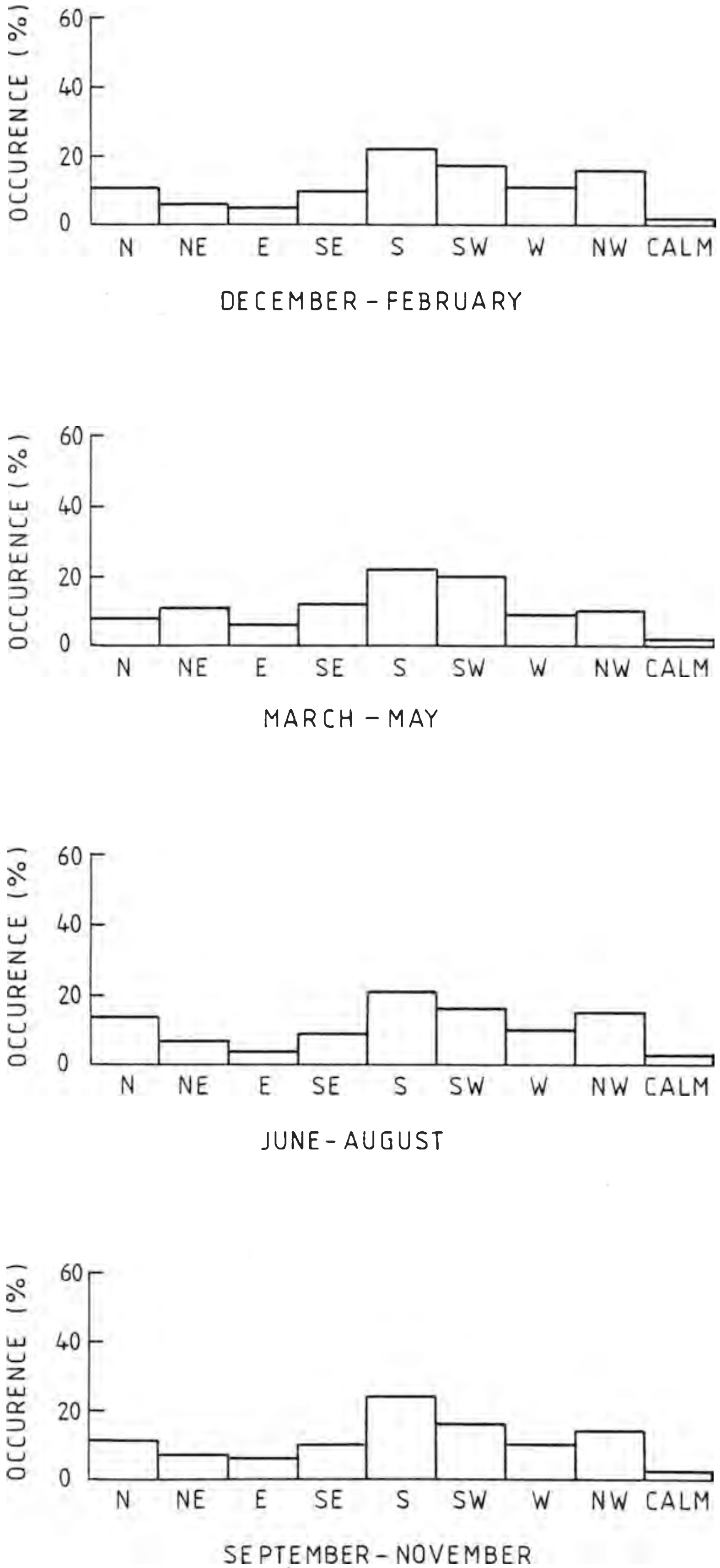
AREA 48

AREA 49

OFFSHORE WAVE CLIMATES

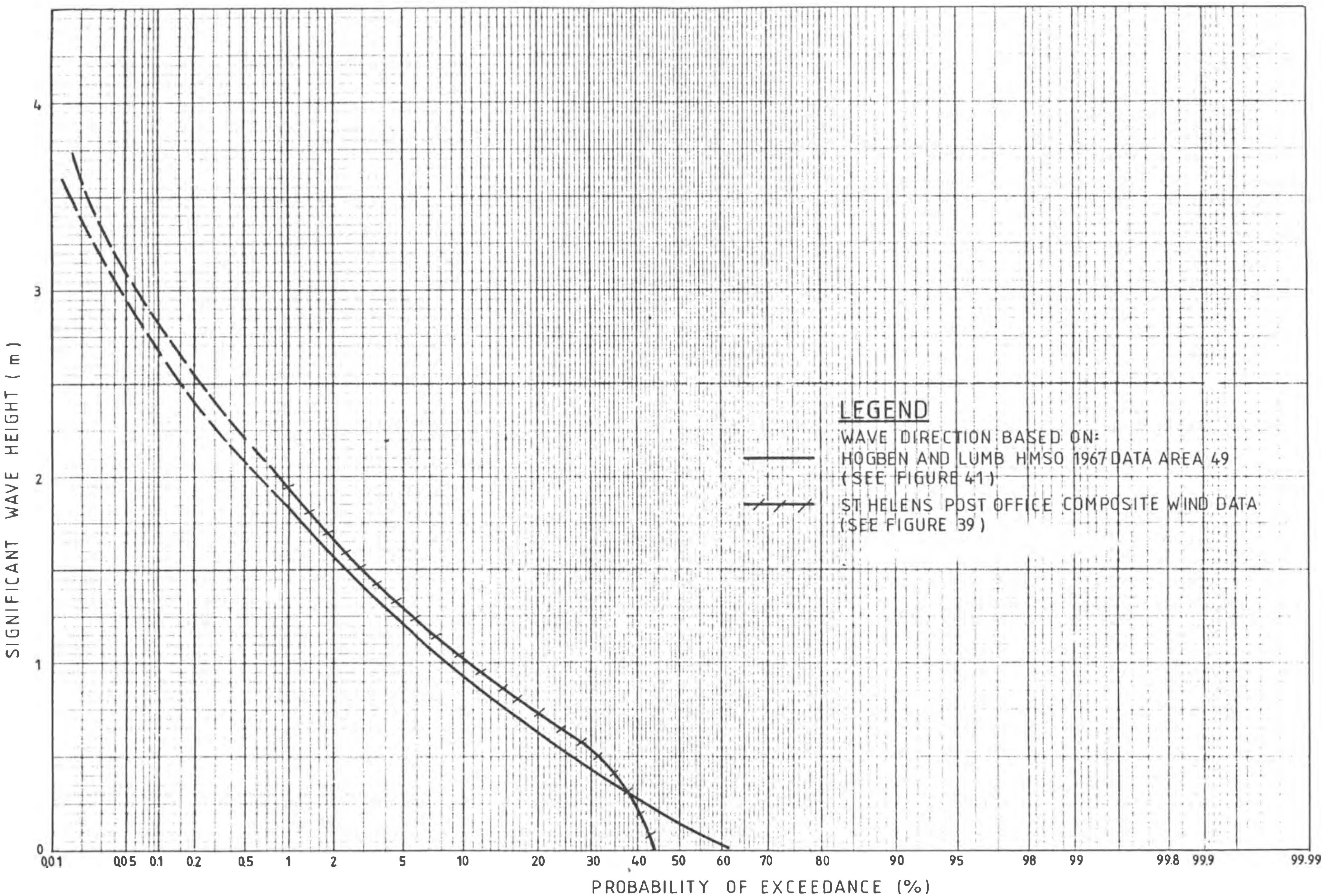
(DERIVED FROM OCEAN WAVE STATISTICS BY N. HOGBEN AND F.E. LUMB H.M.S.O. 1967)

FIGURE 41



SEASONAL EFFECT IN OFFSHORE WAVE CLIMATE FOR AREA 49
(DERIVED FROM OCEAN WAVE STATISTICS BY N. HOGBEN AND F.E. LUMB HMSO 1967)

FIGURE 42



WAVE CLIMATE AT ENTRANCE TO GEORGES BAY AT LOCATION 2 AT DEPTH OF 6 METRES

FIGURE 43

Appendix 1

Field Velocity Measurements

and Station Discharge Calculations

17.11.1983

Cross Section B-C

(Training Wall)

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER: ST. HELENS

DATE: 17.11.83

SECTION: TRAINING WALL B-C

CURRENT METER: 6724

SECTION BEARING α: 109 mag

WORKED BY: Cook

SHEET: 1 / 16

DATUM: A.H.D

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation $\sigma = \vert\alpha - \beta\vert$	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
0	0805	0.31	2.5		0.15	350	241	0.13			Bed 5.0
								0.13	121.7	15.8	
1	0813	0.31	4.0		0.15	330	221	0.10			Bed 5.0
			2.5		0.20	330	221	0.13			
			1.0		0.20	350	241	0.17			
								0.13	200.8	26.1	
2	0822	0.31	3.0		0.10	330	221	0.07			Bed 3.8
			2.0		0.15	350	241	0.13			
			1.0		0.15	350	241	0.13			
								0.11	273.7	30.1	
3	0833	0.30	2.0		0.20	350	241	0.17			Bed 2.5
			0.5		0.20	360	251	0.19			
								0.18	260.0	46.8	
4	0844	0.28	8.0		0.23	360	251	0.22			Bed 9.0
			4.5		0.20	010	99	0.20			
			1.0		0.25	020	89	0.25			
								0.22	393.8	86.6	
5	0854	0.25	8.0		0.10	360	251	0.09			Bed 9.0
			4.5		0.35	030	79	0.34			
			1.0		0.35	060	49	0.26			
								0.23	475.1	109.3	

Ebb

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER: ST. HELENS

DATE: 17.11.83

SECTION: TRAINING WALL B-C.

CURRENT METER: 6724

SECTION BEARING α: 109 mag

WORKED BY: Cook

SHEET: 2 / 16

DATUM: A.H.D

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation σ = |α − β|	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
0	0904	0.21	4.0		0.60	020	89	0.60			Bed 5.0
			2.5		0.75	030	79	0.74			
			1.0		0.75	020	89	0.75			
								0.70	119.3	83.5	
1	0914	0.20	4.0		0.50	360	251	0.47			
			2.5		0.60	350	241	0.52			
			1.0		0.65	350	241	0.57			
								0.52	196.4	102.1	
2	0922	0.19	3.0		0.35	360	251	0.33			
			2.0		0.45	350	241	0.39			
			1.0		0.45	330	221	0.30			
								0.34	265.3	90.2	
3	0933	0.18	2.0		0.30	005	104	0.29			
			0.5		0.35	340	231	0.27			
								0.28	250.4	70.1	
4	0938	0.15	8.0		0.35	020	89	0.35			
			4.5		0.40	040	69	0.37			
			1.0		0.45	040	69	0.42			
								0.38	386.0	146.7	
5	0945	0.13	8.0		0.40	010	99	0.40			
			4.5		0.55	040	69	0.51			
			1.0		0.55	060	49	0.42			
								0.44	461.5	203.1	

Ebb

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER ST. HELENS

DATE 17.11.83

SECTION TRAINING WALL B-C

CURRENT METER 6724

SECTION BEARING α 109 mag

WORKED BY Cook/Cox

SHEET 3 / 16

DATUM A.H.D

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation σ = |α − β|	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
0	0958	0.11	4.0		0.75	010	99	0.74			Dragged anchor.
			2.5		1.10	020	89	1.10			Motor required to maintain
			1.0		1.10	030	79	1.08			position.
								0.97	116.9	113.4	
1	1002	0.10	4.0		0.60	360	251	0.57			
			2.5		0.70	330	221	0.46			
			1.0		0.90	340	231	0.70			
								0.58	192.4	111.6	
2	1005	0.10	3.0		0.40	360	251	0.38			
			2.0		0.50	330	221	0.33			
			1.0		0.55	340	231	0.43			
								0.38	259.0	98.4	
3	1020	0.06	2.0		0.30	360	251	0.28			
			0.5		0.20	360	251	0.19			
								0.24	240.8	57.8	
4	1028	0.03	7.0		0.45	040	69	0.42			Bed 8.0
			3.5		0.40	080	29	0.19			
			1.0		0.45	020	89	0.45			Checked direction with hand
								0.35	378.8	132.6	held compass.
5	1047	0.00	7.5		0.10	010	99	0.10			Bed 8.5. Cox starts
			4.5		0.60	015	94	0.60			
	1055		1.0		0.60	015	94	0.60			Dirn. checked
								0.43	446.8	192.1	

Ebb

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER ST. HELENS

DATE 17.11.83

SECTION TRAINING WALL B-C

CURRENT METER 6724

SECTION BEARING α 109 mag.

WORKED BY Cox

SHEET 4 / 16

DATUM A.H.D

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation σ = |α − β|	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
0	1059	-0.04	1.0		1.20	010	99	1.19			
			2.5		0.95	015	94	0.95			
	1102		4.0		1.00	020	89	1.00			
								1.05	113.4	119.1	
1	1105	-0.06	3.75		0.67	350	241	0.59			Bed 4.25
			2.0		0.86	335	226	0.62			
	1107		0.5		0.90	320	211	0.46			
								0.56	186.0	104.2	
2	1109	-0.07	2.75		0.50	340	231	0.39			Bed 3.25
			1.75		0.45	330	221	0.30			
	1112		0.75		0.62	350	241	0.54			
								0.41	247.1	101.3	
3	1114	-0.08	1.75		0.34	355	246	0.31			Bed 2.25
			0.75		0.42	360	251	0.40			
								0.36	229.6	82.7	
4	1120	-0.09	7.0		0.45	030	79	0.44			Bed 8.0
			4.0		0.37	025	84	0.37			
	1122		1.0		0.38	055	54	0.31			
								0.37	371.6	137.5	
5	1127	-0.10	6.5		0.48	—	89	0.48			Bed 7.5. Take dirn as 020
			4.0		0.52	—					
			1.0		0.52	015	94	0.52			
			2.0		0.53	010	99	0.52			
			3.0		0.52	010	99	0.51			
			4.0		0.51	015	94	0.51			
	1133		6.0		0.42	020	89	0.42			
								0.44	435.7	213.5	

Ebb

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER ST. HELENS

DATE 17.11.83

SECTION TRAINING WALL B-C

CURRENT METER 6724

SECTION BEARING α 109 mag

WORKED BY Cox

SHEET 5 / 16

DATUM A.H.D

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation $\sigma = \lvert\alpha-\beta\rvert$	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
0	1141	-0.13	1.0		0.91	020	89	0.91			
			2.5		1.05	020	89	1.05			
	1143		4.0		0.80	025	84	0.80			Vel. varies 0.6-0.9
								0.92	111.2	102.3	
1	1200	-0.16	3.0		0.70	330	221	0.46			Bed 4.0
			2.0		0.70	340	231	0.54			
	1202		1.0		0.76	335	226	0.55			
								0.52	182.0	94.6	
2	1206	-0.17	2.0		0.43	340	231	0.33			Bed 3.0
			1.0		0.48	320	211	0.25			
	1209		1.5		0.50	325	216	0.29			
								0.29	240.1	69.6	
3	1212	-0.18	1.5		0.25	010	99	0.25			Bed 2.0
			0.5		0.33	010	99	0.33			
								0.29	221.6	64.3	
4		-0.19	7.0		0.33	085	24	0.13			Bed 8.0
			4.0		0.33	050	59	0.28			
	1218		1.0		0.32	020	89	0.32			
								0.24	365.6	87.7	
5	1220	-0.20	7.0		0.45	—	89	0.45			Bed 8.25 Take dirn as 020
			4.0		0.48	—					
	1222		1.0		0.38	020	89	0.38			
			2.0		0.42	015	94	0.42			
			3.0		0.40	010	99	0.40			
			4.0		0.48	020	89	0.48			
			6.0		0.44	020	89	0.44			
								0.43	424.6	182.6	

Ebb

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GAUGING AND COMPUTATION SHEET

RIVER ST. HELENS

DATE 17.11.83

SECTION TRAINING WALL B-C

CURRENT METER 6724

SECTION BEARING α 109 mag

WORKED BY Cox

SHEET 6 / 16

DATUM A.H.D

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation σ = |α − β|	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
0	1240	-0.23	3.0		0.65	010	99	0.64			Bed 3.75
			2.0		0.80	025	84	0.80			
			1.0		0.88	355	246	0.80			
								0.75	108.9	81.7	
1	1248	-0.24	1.0		0.68	348	239	0.58			Bed 4.0 Calm
			2.0		0.66	350	241	0.58			
	1249		3.0		0.60	350	241	0.52			
								0.56	178.8	100.1	
2	1251	-0.25	2.0		0.33	350	241	0.29			Bed 3.0 Windshift to N
			1.0		0.30	340	231	0.23			0-5 knots
								0.26	234.5	61.0	
3	1256	-0.26	1.5		0.17	030	79	0.17			Bed 2.25
			0.5		0.21	350	241	0.18			
								0.18	215.2	38.7	
4		-0.27	7.0		0.17	040	69	0.16			Bed 8.0
	1306		4.0		0.25	010	99	0.25			
			1.0		0.27	010	99	0.27			
								0.23	360.8	83.0	
5	1311	-0.28	7.0		0.05	020	89	0.05			Bed 7.75
			4.0		0.35	010	99	0.35			
			5.5		0.30	010	99	0.30			
	1315		1.0		0.33	0	109	0.31			
								0.25	415.8	104.0	
	1319										Gauge 5 1150

Ebb

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER ST. HELENS
DATE 17.11.83
SECTION TRAINING WALL B-C
CURRENT METER 6724
SECTION BEARING α 109 mag
WORKED BY Cox
SHEET 7 / 16
DATUM A.H.D

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation σ = |α − β|	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
0	1324	-0.30	3.0		0.63	020	89	0.63			Bed 4.0
			2.0		0.65	030	79	0.64			
	1326		1.0		0.65	360	251	0.61			
								0.63	107.2	67.5	
1		-0.31	3.5		0.50	350	241	0.44			Bed 4.5
			2.5		0.50	350	241	0.44			
	1332		1.0		0.52	350	241	0.45			
								0.44	176.0	77.4	
2	1334	-0.31	2.0		0.25	340	231	0.19			Bed 3.0
			1.0		0.27	340	231	0.21			
								0.20	230.3	46.1	
3	1340	-0.32	2.0		0.12	0	109	0.11			Bed 2.5
			1.0		0.12	340	231	0.09			
								0.10	210.4	21.0	
4	1347	-0.32	7.0		0.03	0	109	0.03			Bed 9.0
			5.0		0.20	010	99	0.20			
			3.0		0.22	020	89	0.22			
			1.0		0.18	010	99	0.18			
								0.16	357.8	57.2	
5	1357	-0.33	1.0		0.17	020	89	0.17			Hand held compass 050-060
			3.0		0.15	010	99	0.15			" " " 010
			5.0		0.15	020	89	0.15			
			6.0		0.12	015	94	0.12			Bed 7.0
								0.15	410.4	61.6	
1405											Gauge 5 1150. Est. slack water at 1411

EH

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER ST. HELENS

DATE 17.11.83

SECTION TRAINING WALL B-C

CURRENT METER 6724

SECTION BEARING α 109 mag.

WORKED BY Cox

SHEET 8 / 16

DATUM A.H.D

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation σ = |α − β|	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
1	1422	-0.33	3.5		0.30	—	241	0.26			Bed 4.5 Fairly slack
			1.0		0.28	350	241	0.24			Breeze N 0-3 knots
			2.0		0.30	350	241	0.26			
								0.25	175.2	43.8	
	1439										Gauge 5 1175 Slack water

Ebb

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER ST. HELENS

DATE 17.11.83

SECTION TRAINING WALL B-C

CURRENT METER 6724

SECTION BEARING α 109 mag

WORKED BY Cox

SHEET 9 / 16

DATUM A.H.D

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation $\sigma = \lvert\alpha - \beta\rvert$	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
0		-0.33	4.0		0.10	010	99	0.10			Bed 5.25
			2.0		0.15	010	99	0.15			
	1450		1.0		0.15	010	99	0.15			
								0.13	106.5	13.8	
1	1453	-0.33	1.0		0.15	350	241	0.13			Bed 4.5
			4.0		0.00	—		0			No flow
	1455		2.5		0.02	010	99	0.02			Flood flow
								0.05	175.2	8.8	
2	1500	-0.33	2.0		0.20	190	81	-0.20			Bed 3.0
			1.0		0.20	190		-0.20			
								-0.20	228.9	-45.8	
3	1505	-0.32	2.0		0.15	220	111	-0.14			Bed 2.5
	1507		1.0		0.20	220	111	-0.19			V light breeze
								-0.17	210.4	-35.8	
4	1510	-0.32	1.0		0.17	220	111	-0.16			Bed 9.0
			7.0		0.15	200	91	-0.15			
	1512		4.0		0.12	210	101	-0.12			
								-0.14	357.8	-50.1	
5	1514	-0.31	8.0		0.02	—		-0.02			Bed 10.25 Take dirn as 190
			6.0		0.04	—		-0.04			
			4.0		0.05	190	81	-0.05			
			2.0		0.10	185	76	-0.10			
								-0.05	412.5	-20.6	
	1521										Gauge 5 1240

Flood

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER ST. HELENS

SECTION TRAINING WALL B-C

SECTION BEARING α 109 mag

DATUM A.H.D

DATE 17.11.83

CURRENT METER 6724

WORKED BY Cox

SHEET 10.1.16

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation σ = |α−β|	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
0	1526	-0.30	1.0		0.20	300 330	206	0.09			Boiling recirc large eddies
			4.5		0.12	170	61	+0.10			at tip of training wall
	1529		2.0		0.05	210	101	-0.05			Bed 5.5
								-0.02	107.2	-2.1	
1	1531	-0.29	3.5		0.36	200	91	-0.36			Bed 4.5
			2.0		0.37	200	91	-0.37			
			1.0		0.48	195	86	-0.48			
								-0.40	176.8	-70.7	
2	1540	-0.28	2.0		0.38	195	86	-0.38			Bed 3.0
	1542		1.0		0.34	200	91	-0.34			
								-0.36	232.4	-83.7	
3		-0.27	2.0		0.35	200	91	-0.35			Bed 2.5
			1.0		0.40	205	96	-0.40			
								-0.38	214.4	-81.5	
4	1550	-0.26	8.0		0.55	200	91	-0.55			Bed 9.5
			5.0		0.58	185	76	-0.56			
	1553		1.0		0.45	180	71	-0.43			
								-0.51	361.4	-184.3	
5		-0.25	8.0		0.48	200	91	-0.48			Bed 10.0
			5.0		0.30	190	81	-0.30			
			1.0		0.33	180	71	-0.31			
								-0.36	419.1	-150.9	

Flood

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER ST. HELENS

DATE 17.11.83

SECTION TRAINING WALL B-C

CURRENT METER 6724

SECTION BEARING α 109 mag

WORKED BY Cox / Cook

SHEET 11 / 16

DATUM A.H.D

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation σ = |α − β|	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
0	1606	-0.23	4.5		0.15	180	71	-0.14			Bed 5.5
			2.5		0.18	190	81	-0.18			
	1609		1.0		0.20	180 to 270	116	-0.18			Eddying. Take dirn as 225°
								-0.17	108.9	-18.5	
1	1612	-0.22	4.0		0.60	175	66	-0.55			Bed 4.75
			2.5		0.45	185	76	-0.44			
	1615		1.0		0.45	200	91	-0.45			
								-0.48	179.6	-86.2	Cook starts
2	1622	-0.20	2.5		0.45	180	71	-0.43			Bed 3.5. Hand compass 180
			1.5		0.35	180	71	-0.33			
	1625		0.5		0.40	180	71	-0.38			
								-0.38	238.0	-90.4	
3	1627	-0.18	2.0		0.40	190	81	-0.40			Bed 3.0
	1631		1.0		0.05	180	71	-0.05			
								-0.23	221.6	-51.0	
4	1634	-0.16	8.0		0.75	190	81	-0.74			Bed 9.5
			5.0		0.70	190	81	-0.69			Vel varies 0.6–0.8
	1640		1.0		0.65	180	71	-0.61			Hand compass 180
								-0.68	367.4	-249.8	
5	1644	-0.14	8.0		0.30	180	71	-0.28			Bed 9.5
			5.0		0.40	190	81	-0.40			
	1651		1.0		0.65	200	91	-0.64			Hand compass 200
								-0.44	431.2	-189.7	

Flood

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER	ST. HELENS	DATE	17.11.83
SECTION	TRAINING WALL B-C	CURRENT METER	6724
SECTION BEARING α	109 mag	WORKED BY	Cook
DATUM	A.H.D	SHEET	12 / 16

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation σ = |α − β|	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
0	1700	-0.09	4.5		0.15	190	81	-0.15			Bed 5.25. Eddy
			2.5		0.10	180 to 270	116	-0.09			Yawing. Take dirn. as 225
	1707		1.0		0.15	180 to 360	161	-0.05			'yawing'. Check with hand
								-0.10	112.2	-11.2	compass. Take dirn. as 270
1	1709	-0.08	3.5		0.50	180	71	-0.47			Bed 4.5
			2.5		0.60	190	81	-0.59			
	1715		1.0		0.50	200	91	-0.50			Checked with hand compass.
								-0.52	185.2	-96.3	
2	1718	-0.05	2.5		0.45	200	91	-0.45			Bed 3.5
	1722		1.0		0.50	200	91	-0.50			
								-0.48	248.5	-119.3	
3	1724	-0.04	2.0		0.50	190	81	-0.49			Bed 3.0
	1728		1.0		0.60	190	81	-0.59			
								-0.54	232.8	-125.7	
4	1731	-0.03	8.0		0.60	210	101	-0.59			Bed 9.5
			5.0		0.60	200	91	-0.60			
	1738		2.0		0.60	200	91	-0.60			
								-0.60	375.2	-225.1	
5	1740	-0.01	8.0		0.25	190	81	-0.25			Bed 10.0
			5.0		0.50	190	81	-0.49			
			2.0		0.55	190	81	-0.54			
								-0.43	445.7	-191.7	

Flood

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER ST. HELENS
DATE 17.11.83
SECTION TRAINING WALL B-C
CURRENT METER 6724
SECTION BEARING α 109 mag
WORKED BY Cook
SHEET 13 / 16
DATUM A.H.D

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation σ = |α − β|	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
0	1753	0.02	4.5		Var 0.1	180	71	-0.09			Bed 5.75. Eddies.
			2.5		Var. 0.1	180 to 270	116	-0.09			Take dirn as 225
	1802		1.0		0.10	270 to 360	206	0.04			Checked dirn with hand
								-0.07	114.8	-8.0	compass. Take dirn. as 315
1	1809	0.06	4.0		0.50	180	71	-0.47			Bed 4.75
			2.5		0.35	180	71	-0.33			
	1813		1.0		0.35	200	91	-0.35			Hand compass 180
								-0.38	190.8	-72.5	
2	1815	0.08	2.5		0.45	190	81	-0.44			Bed 3.5
	1818		1.0		0.40	180	71	-0.38			
								-0.41	257.6	-105.6	
3	1820	0.09	2.0		0.40	190	81	-0.40			Bed 3.0
	1822		1.0		0.50	190	81	-0.49			
								-0.45	243.2	-109.4	
4	1823	0.10	8.0		0.50	210	101	-0.49			Bed 10.0. Cable streaming
			5.0		0.70	190	81	-0.69			at 30° to vertical.
	1827		2.0		0.70	190	81	-0.69			
								-0.62	383.0	-237.5	
5	1830	0.11	8.0		0.30	190	81	-0.30			Bed 9.5. Cable streaming
			5.0		0.40	190	81	-0.40			at 10° to vertical
	1833		2.0		0.40	190	81	-0.40			
								-0.37	459.2	-169.9	

Flood

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER: ST. HELENS

DATE: 17.11.83

SECTION: TRAINING WALL B-C

CURRENT METER: 6724

SECTION BEARING α: 109 mag

WORKED BY: Cook

SHEET: 14 / 16

DATUM: A.H.D

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation $\sigma = \lvert\alpha - \beta\rvert$	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
0	1838	0.12	4.5		0.05	180 to 360	161	-0.02			Bed 5.5. Eddying. Take dirn. as 270.
			2.5		0.05	90 to 360	116	-0.04			Take dirn. as 225
	1841		1.0		0.05	360	251	0.05			
								-0.003	117.2	-0.4	
1	1845	0.14	4.0		0.50	190	81	-0.49			Bed 5.0
			2.5		0.50	200	91	-0.50			
	1848		1.0		0.50	210	101	-0.49			
								-0.49	194.0	-95.1	
2	1850	0.15	2.5		0.40	190	81	-0.40			Bed 3.5
	1852		1.0		0.30	190	81	-0.30			Hand compass 190
								-0.35	262.5	-91.9	
3	1855	0.16	2.0		0.40	190	81	-0.40			Bed 3.0
			1.0		0.45	190	81	-0.44			Hand compass 190
								-0.42	248.8	-104.5	
4	1858	0.16	8.0		0.50	190	81	-0.49			Bed 9.5
			5.0		0.60	190	81	-0.59			
	1900		2.0		0.50	180	71	-0.47			
								-0.52	386.6	-201.0	
5	1902	0.17	8.0		0.20	190	81	-0.20			Bed 10.0
			6.0		0.30	210	101	-0.29			
			4.0		0.30	190	81	-0.30			
	1906		2.0		0.30	180	71	-0.28			Hand compass 180
								-0.27	466.0	-125.8	

Flood

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER: ST. HELENS
DATE: 17.11.83
SECTION: TRAINING WALL B-C
CURRENT METER: 6724
SECTION BEARING α: 109 mag
WORKED BY: Cook / Cox
SHEET: 15 / 16
DATUM: A.H.D

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation σ = |α-β|	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
	1910										Gauge 5 1660
0	1915	0.19	4.0		0.10	180	71	-0.09			Bed 5.5
	1917		1.5		0.10	360	251	0.09			Current meter checked O.K in
								0	118.8	0	boat
1	1918	0.20	4.0		0.40	180	71	-0.38			Bed 4.8. Pulsating 0.3 to 0.5
			2.5		0.40	200	91	-0.40			Steady
			1.0		0.30	210	101	-0.29			Hand compass 210
								-0.36	196.4	-70.7	
	1924										Gauge 5 1680. Cox starts
2	1930	0.21	2.5		0.15	205	96	-0.15			Bed 3.5
	1932		1.0		0.07	185	76	-0.07			
								-0.11	266.7	-29.3	
3	1935	0.21	2.5		0.26	205	96	-0.26			Bed 3.0
	1936		1.0		0.25	210	101	-0.25			
								-0.26			
4	1940	0.22	8.0		0.15	340*	81	-0.15			Bed 9.25 * Hand compass
			5.0		0.22	190	81	-0.22			shows 190 for all
			6.0		0.22	320*	81	-0.22			readings.
			4.0		0.25	—	81	-0.25			
			2.0		0.16	190	81	-0.16			
								-0.20	390.2	-78.0	
5	1954	0.23	8.0		0.02	180	71	-0.02			Bed 9.5
			6.0		0.08	170	61	-0.07			
			4.0		0.13	180	71	-0.12			
			2.0		0.12	180	71	-0.11			
								-0.08	472.8	-37.8	

Flood

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER ST. HELENS

SECTION TRAINING WALL B-C

SECTION BEARING α 109 mag

DATUM A.H.D

DATE 17.11.83

CURRENT METER 6724

WORKED BY Cox

SHEET 16 / 16

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation $\sigma = \lvert\alpha - \beta\rvert$	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
3	1959	0.23	2.0		0.10	190	81	-0.10			Bed 3.0
			1.0		0.15	200	91	-0.15			
								-0.13	2544	-331	
	2002										Gauge 5 1730. Slack water.

Flood

Appendix 2

Field Velocity Measurements

and Station Discharge Calculations

17.11.1983

Cross Section G-H

(Akaroa)

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER ST. HELENS

SECTION AKAROA G-H

SECTION BEARING α 110 mag

DATUM A.H.D.

DATE 17.11.83

CURRENT METER 6435

WORKED BY Cox

SHEET 1, 22

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation $\sigma = \lvert\alpha-\beta\rvert$	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
	0733										Gauge 3 1730
1	0750	0.31	5.5		0.10	180					Bed 6.5
			3.0		0.17	180					
			1.0		0.10	180					
					0.12				251.5	30.2	
2	0801	0.31	7.5		0.17	180					Bed 8.5
			4.0		0.19	180					
			1.0		0.23	180					
					0.20				504.6	100.9	
3	0807	0.31	4.0		0.08	180					Bed 5.0
			2.5		0.03	180					
	0809		1.0		0	–					
					0.04				374.8	15.0	
4	0814	0.31	0.5		0.12	150					Bed 1.0
					0.12				89.9	10.8	
5	0820	0.30	1.5		0.17	135					Bed 2.0
			0.5		0.25	030					
					0.21				165.4	34.7	

Ebb

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER ST. HELENS

DATE 17.11.83

SECTION AKAROA G-H

CURRENT METER 6435

SECTION BEARING α 110 mag

WORKED BY Lawson

SHEET 2 / 22

DATUM A.H.D.

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation σ = |α − β|	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
	0827										Gauge 3 1720
1	0830	0.30	5.5		0.12	150					Bed 6.5
	0834		3.0		0.21	030					
					0.17				251.0	42.7	
2	0836	0.29	7.5		0.14	090					Bed 8.5
			4.0		0.25	030					
	0838		1.0		0.18	110					
					0.19				503.4	95.6	
3	0840	0.28	4.0		0.20	160					Bed 5.0
			2.5		0.20	150					
	0842		1.0		0.20	150					
					0.20				372.4	74.5	
4	0845	0.27	0.5		0.18	150					Bed 1.0
					0.18				86.3	15.5	
5	0848	0.26	1.5		0.20	130					Bed 2.0
			0.5		0.18	130					
					0.19				161.2	30.6	

Estimated

Ebb

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER ST. HELENS
DATE 17.11.83
SECTION AKAROA G-H
CURRENT METER 6435
SECTION BEARING α 110 mag
WORKED BY Lawson
SHEET 3 / 22
DATUM A.H.D.

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation $\sigma = \lvert\alpha-\beta\rvert$	Normal Velocity Vp sin σ m/s	Area m^2	Discharge m^3/s	
	0856										Gauge 3 1680
1	0858	0.24	5.2		0.28	140					Bed 6.2
			3.0		0.26	150					
			1.0		0.23	150					
					0.26				247.7	64.4	
2	0901	0.24	7.2		0.31	150					Bed 8.2
			4.0		0.37	135					
			1.0		0.36	150					
					0.35				500.4	175.1	
3	0906	0.23	4.0		0.30	140					Bed 5.0
			2.5		0.38	150					
	0908		1.0		0.53	060					
					0.40				368.4	147.4	
4	0910	0.22	0.5		0.22	130					Bed 0.8
					0.22				81.8	18.0	
5	0913	0.21	1.5		0.26	080					Bed 2.0
	0916		0.5		0.35	110					
					0.31				155.9	48.3	

Estimated

El.6

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER ST. HELENS

DATE 17.11.83

SECTION AKAROA G-H

CURRENT METER 6435

SECTION BEARING α 110 mag

WORKED BY Lawson

SHEET 4 / 22

DATUM A.H.D.

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation σ = |α − β|	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
	0926										Gauge 3 1600
1	0928	0.18	5.0		0.32	080					Bed 6.0
			3.0		0.36	120					
	0931		1.0		0.48	060					
					0.39				244.5	95.4	
2	0932	0.16	7.0		0.42	130					Bed 8.5, meter streaming,
			4.0		0.56	090					true depth 8.0
	0935		1.0		0.62	090					
					0.53				495.6	262.7	
3	0938	0.15	4.0		0.28	140					Bed 5.0
			2.5		0.35	040					
	0942		1.0		0.60	040					
					0.41				362.0	148.4	
4	0945	0.14	0.3		0.12	150					Bed 0.5
					0.12				74.6	9.0	
5	0948	0.13	1.5		0.15	150					Bed 2.0
			0.5		0.25	120					
					0.20				147.5	29.5	

Estimated

Ebb

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER ST. HELENS

DATE 17.11.83

SECTION AKAROA G-H

CURRENT METER 6435

SECTION BEARING α 110 mag

WORKED BY Lawson

SHEET 5 / 22

DATUM A.H.D.

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation σ = |α − β|	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
	0956										Gauge 3 1550
1	0957	0.18	5.0		0.40	050					Bed 6.0
			3.0		0.45	110					
			1.0		0.63	050					
					0.39				244.5	95.4	
2	1004	0.16	7.0		0.45	090					Bed 8.0
			4.0		0.71	110					
	1006		1.0		0.65	050					
					0.53				495.6	262.7	
3	1008	0.15	4.0		0.36	140					Bed 5.0
			2.5		0.45	120					
			1.0		0.32	080					
					0.41				362.0	148.4	
4	1013	0.14	0.3		0.15	150					Bed 0.5
					0.12				74.6	9.0	
5		0.13	1.0		0.28	130					Bed 1.8
	1016		0.5		0.30	100					
					0.20				147.5	29.5	

Estimated

Ebb

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER ST. HELENS

DATE 17.11.83

SECTION AKAROA G-H

CURRENT METER 6435

SECTION BEARING α 110 mag

WORKED BY Lawson

SHEET 6 / 22

DATUM A.H.D.

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation σ = |α − β|	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
	1040										Gauge 3 1440
1		-0.01	5.0		0.32	140					Bed 5.8
			3.0		0.45	110					
	1044		1.0		0.58	050					
					0.45				235.0	105.8	
2	1046	-0.01	7.0		0.55	060					Bed 8.0
			4.0		0.65	060					
	1052		1.0		0.65	040					Dirn. checked with hand
					0.62				485.4	300.9	compass
3	1054	-0.04	3.5		0.32	140					Bed 4.5
			2.0		0.42	020					
	1101		1.0		0.34	030					
					0.36				346.8	124.8	
4	1103	-0.05	0.5		0.20	140					Bed 0.5
					0.20				57.5	11.5	
5	1106	-0.06	1.0		0.25	130					Bed 1.5
	1110		0.5		0.32	050					
					0.29				127.8	37.1	
						Estimated					

Elli

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER ST. HELENS

SECTION AKAROA G-H

SECTION BEARING α 110 mag

DATUM A.H.D.

DATE 17.11.83

CURRENT METER 6435

WORKED BY Lawson

SHEET 7 / 22

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation σ = |α − β|	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
	1120										Gauge 3 1340
1	1123	−0.10	5.0		0.30	140					Bed 5.8
			3.0		0.58	050					
	1127		1.0		0.58	050					
					0.49				229.8	112.6	
2	1129	−0.11	7.0		0.68	100					Bed 8.0
			4.0		0.66	030					
	1131		1.0		0.64	045					
					0.66				479.4	316.4	
3	1133	−0.12	3.5		0.37	030					Bed 4.5
			2.0		0.38	040					
	1137		1.0		0.38	040					
					0.38				340.4	129.4	
4	1139	−0.13	0.5		0.10	050					Bed 0.5
					0.10				50.3	5.0	
5	1146	−0.14	1.0		0.22	080					Bed 1.5
					0.22				119.7	26.3	

Estimated

Ebb

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER ST. HELENS

DATE 17.11.83

SECTION AKAROA G-H

CURRENT METER 6435

SECTION BEARING α 110 mag

WORKED BY Lawson

SHEET 8 / 22

DATUM A.H.D.

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation $\sigma = \lvert\alpha-\beta\rvert$	Normal Velocity Vp sinσ m/s	Area m²	Discharge m³/s	
	1158										Gauge 3 1270
1	1200	-0.16	4.5		0.35	130					Bed 5.5
			2.5		0.48	050					
	1203		1.0		0.40	055					
					0.41				226.8	93.0	
2	1204	-0.17	6.5		0.60	—					Bed 7.5
			3.5		0.62	050					
	1207		1.0		0.60	050					
					0.61				475.8	290.2	
3	1209	-0.18	3.5		0.12	045					Bed 4.5
			2.0		0.32	045					
			1.0		0.35	045					
					0.26				335.8	87.3	
4					0						Insufficient depth. No surface
					0				45.8	0	flow
5	1216	-0.19	1.0		0.10	050					Bed 1.5
					0.10				114.6	11.5	
						Estimated					

Ebb

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER: ST. HELENS
DATE: 17.11.83
SECTION: AKAROA G-H
CURRENT METER: 6435
SECTION BEARING α: 110 mag
WORKED BY: Lawson
SHEET: 9 / 22
DATUM: A.H.D.

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β	Deviation σ = |α−β|	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
	1228										Gauge 3 1210
1	1225	-0.21	4.5		0.35	—					Bed 5.5
			2.5		0.40	050					
	1220		1.0		0.35	050					
					0.37				224.3	83.0	
2	1232	-0.22	6.5		0.55	—					Bed 7.5
			4.0		0.58	050					
	1235		1.0		0.56	050					
					0.56				472.8	264.8	
3	1237	-0.23	3.5		0.25	055					Bed 4.5
			2.0		0.26	050			331.6	86.2	
	1240		1.0		0.28	050					
					0.27						
4		-0.23									Insufficient depth
									41.3	—	
5		-0.23									Inaccessible
									110.6	—	

Estimated

Ebb

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER ST. HELENS

DATE 17.11.83

SECTION AKAROA G-H

CURRENT METER 6435

SECTION BEARING α° 110 mag

WORKED BY Lawson

SHEET 10 / 22

DATUM A.H.D.

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β°	Deviation σ = |α−β|°	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
	1253										Gauge 3 1170
1	1255	-0.25	4.5		0.25	—					Bed 5.5
			2.5		0.33	050					
	1259		1.0		0.32	030					
					0.30				222.3	66.7	
2	1300	-0.26	6.5		0.50						Bed 7.5
			4.0		0.48	040					
	1305		1.0		0.46	040					
					0.48				470.4	225.8	
3	1308	-0.28	3.5		0.10	050					Bed 4.5
			2.0		0.20	040					
			1.0		0.05	070					
					0.12				327.6	39.3	
4		-0.28									Insufficient depth
									36.3	—	
5		-0.28									Inaccessible
									105.6	—	
						Estimated					

Ebb

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER ST. HELENS

DATE 17.11.83

SECTION AKAROA G-H

CURRENT METER 6435

SECTION BEARING α° 110 mag

WORKED BY Lawson

SHEET 11 / 22

DATUM A.H.D.

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β°	Deviation $\sigma = \lvert\alpha-\beta\rvert^\circ$	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
	1313										Gauge 3 1140
1	1316	-0.29	4.5		0.15						Bed 5.5
			2.5		0.33	045					
			1.0		0.27	045					
					0.25				220.3	55.1	
2	1321	-0.29	6.5		0.46	—					Bed 7.5
			4.0		0.46	040					
			1.0		0.43	040					
					0.45				468.6	210.9	
3	1326	-0.30	3.5		0.10	040					Bed 4.5
			2.0		0.15	040					
			1.0		0.15	040					
					0.13				326.0	42.4	
4		-0.30									
									35.0	—	
5		-0.30									
									103.6	—	
						Estimated					

Ebb

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER ST. HELENS

DATE 17.11.83

SECTION AKAROA G-H

CURRENT METER 6435

SECTION BEARING α° 110 mag

WORKED BY Lawson

SHEET 12 / 22

DATUM A.H.D.

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β°	Deviation $\sigma = \lvert\alpha-\beta\rvert^\circ$	Normal Velocity Vp sinσ m/s	Area m²	Discharge m³/s	
	1345										Gauge 3 1110
1	1346	-0.32	4.5		0.15	050					Bed 5.5
			2.5		0.30	050					
	1348		1.0		0.22	050					
					0.22				218.8	48.1	
2		-0.33	6.5		0.35	—					Bed 7.5
			4.0		0.35	045					
	1352		1.0		0.30	040					Swinging
					0.33				466.2	153.8	
3		-0.33	3.5		0.18	—					Bed 4.5
			2.0		0.05	—					
	1357		1.0		0	—					
					0.08				323.6	24.8	
4		-0.33									
									32.3	—	
5		-0.33									
									100.7	—	
						Estimated					

Ebb

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER ST. HELENS

DATE 17.11.83

SECTION AKAROA G-H

CURRENT METER 6435

SECTION BEARING α° 110 mag

WORKED BY Lawson

SHEET 13 / 22

DATUM A.H.D.

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β°	Deviation $\sigma = \lvert\alpha - \beta\rvert$°	Normal Velocity Vp sinσ m/s	Area m²	Discharge m³/s	
	1412										Gauge 3 1110
1		-0.33	4.5		0.15	—					Bed 5.5 . Swinging
			2.5		0.15	—					"
			1.0		0.05	—					"
					0.12				218.3	26.2	
2	1418	-0.33	6.5		0.15	—					Bed 7.5 "
			4.0		0.10	—					"
			1.0		0.15	—					"
					0.13				466.2	60.6	
3		-0.32									
									324.4	—	
4		-0.32									
									33.2	—	
5		-0.32									
									101.7	—	

Ebb

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER: ST. HELENS

SECTION: AKAROA G-H

SECTION BEARING α°: 110 mag

DATUM: A.H.D.

DATE: 17.11.83

CURRENT METER: 6435

WORKED BY: Lawson

SHEET: 14 / 22

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β°	Deviation σ = |α − β|°	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
	1442										Gauge 3 1100
	1520										Gauge 1130
1	1521	-0.31	4.5		0.33	—					Bed 5.5
			2.5		0.40	220					
			1.0		0.36	220					
					-0.36				219.3	-78.9	
2	1525	-0.30	6.5		0.27	—					Bed 7.5
			4.0		0.29	225					
	1530		1.0		0.32	220					
					-0.29				468.0	-135.7	
3		-0.29	2.5		0.38	220					Bed 3.5. Dinghy laying
			1.0		0.36	220					west.
					-0.37				326.8	-120.9	
4		-0.29									Bed 0.3 Insufficient depth
									35.9	—	
5	1540	-0.28	1.0		0.05	—					Bed 1.5 Swinging
					-0.05				105.6	-5.3	

Estimated

Flood

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER ST. HELENS DATE 17.11.83

SECTION AKAROA G-H CURRENT METER 6435

SECTION BEARING α° 110 mag WORKED BY Lawson

DATUM A.H.D. SHEET 15 / 22

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β°	Deviation σ = |α−β|°	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
	1545										Gauge 3 1180
1		-0.26	4.5		0.37	—					Bed 5.5
			2.5		0.45	225					
	1551		1.0		0.42	225					
					0.41				221.8	-90.9	
2		-0.25	7.0		0.41	—					Bed 8.0
			4.0		0.47	230					
	1555		1.0		0.52	230					
					0.47				471.0	-221.4	
3		-0.24	3.0		0.35	235					Bed 4.0
			2.0		0.38	225					
			1.0		0.35	220					
					0.36				330.8	-119.1	
4		-0.24									
									40.4	—	
5		-0.24									
									109.6	—	

Estimated

Flood

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER: ST. HELENS

DATE: 17.11.83

SECTION: AKAROA G-H

CURRENT METER: 6435

SECTION BEARING α°: 110 mag

WORKED BY: Lawson

SHEET: 16 / 22

DATUM: A.H.D.

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β°	Deviation $\sigma = \lvert\alpha - \beta\rvert$°	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
	1604										Gauge 3 1220
	1617										Gauge 3 1250
1	1618	-0.19	5.5		0.48	—					Bed 6.0
			3.0		0.55	220					
			1.0		0.50	220					
					0.51				225.3	-114.9	
2	1623	-0.19	7.0		0.40	—					Bed 8.0
			4.0		0.55	225					
			1.0		0.60	225					
					0.52				474.6	-246.8	
3	1628	-0.18	3.0		0.48	230					Bed 4.0
			2.0		0.45	230					
			1.0		0.50	230					
					0.48				335.6	161.1	
4		-0.17									Bed 0.3. Insufficient depth
									46.7	—	
5	1636	-0.15	1.0		0	—					Bed 1.5
									118.7	—	
	1642										Gauge 3 1300

Estimated

Flood

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER: ST. HELENS

DATE: 17.11.83

SECTION: AKAROA G-H

CURRENT METER: 6435

SECTION BEARING α°: 110 mag

WORKED BY: Cox

SHEET: 17/22

DATUM: A.H.D.

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β°	Deviation $\sigma = \|\alpha - \beta\|$°	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
	1700										Gauge 3 1350
1	1702	-0.09	5.0		0.58	195					Bed 6.0 Cox starts.
			3.0		0.62	200					
	1705		1.0		0.57	210					
					0.59				230.4	-135.9	
2	1707	-0.08	7.0		0.55	190					Bed 8.5
			4.0		0.68	190					
	1710		1.0		0.66	185					
					0.63				481.2	-303.2	
3	1712	-0.07	3.0		0.55	200					Bed 4.0
			2.0		0.58	190					
			1.0		0.60	195					
					0.58				344.4	-199.8	
4	1715	-0.06	0.3		0.07	210 to 240					Bed 0.5
					0.07				56.6	-4.0	
5	1719	-0.05	1.0		0.25	195					Bed 1.5
			0.5		0.27	200					Hand compass 220
					0.26				128.9	-33.5	
	1727										Gauge 3 1405

Flood

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER: ST. HELENS
DATE: 17.11.83
SECTION: AKAROA G-H
CURRENT METER: 6435
SECTION BEARING α°: 110 mag
WORKED BY: Lawson
SHEET: 18 / 22
DATUM: A.H.D.

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β°	Deviation $\sigma = \lvert\alpha - \beta\rvert^\circ$	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
	1738										Gauge 3 1420 Lawson starts
1	1739	0	5.0		0.48	—					Bed 6.0
			3.0		0.62	220					
	1743		1.0		0.55	225					
					0.55				235.0	129.3	
2	1745	0.01	7.0		0.61	230					Bed 8.5
			4.0		0.67	230					
	1749		1.0		0.40	220					
					0.56				486.6	272.5	
3	1751	0.02	3.0		0.53	235					Bed 4.0
			2.0		0.56	225					
			1.0		0.56	225					
					0.55				351.6	193.4	
4	1756	0.03	0.5		0.18	225					Bed 0.5
					0.18				64.7	11.6	
5	1800	0.04	1.0		0.32	250					Bed 2.0
					0.32				138.1	44.2	

Estimated

Flood

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER: ST. HELENS
DATE: 17.11.83
SECTION: AKAROA G-H
CURRENT METER: 6435
SECTION BEARING α°: 110 mag
WORKED BY: Lawson
SHEET: 19 / 22
DATUM: A.H.D.

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β°	Deviation σ = |α−β|°	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
	1808										Gauge 3 1500
1		0.06	5.5		0.59	225					Bed 6.5
			3.0		0.60	225					
			1.0		0.53	225					
					0.57				238.1	-135.7	
2	1816	0.08	7.0		0.58	—					Bed 8.5
			4.0		0.67	220					
	1820		1.0		0.52	220					
					0.59				490.8	-289.6	
3	1823	0.09	3.0		0.50	225					Bed 4.0
			2.0		0.53	225					
			1.0		0.52	225			357.2	-185.7	
					0.52						
4	1829	0.11	0.5		0.16	245					Bed 0.5
					0.16				71.9	-11.5	
5	1833	0.12	1.0		0.25	230					Bed 2.0
					0.25				146.4	-36.6	

Estimated

Flood

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER	ST. HELENS	DATE	17.11.83
SECTION	AKAROA G-H	CURRENT METER	6435
SECTION BEARING α°	110 mag	WORKED BY	Lawson
DATUM	A.H.D.	SHEET	20 / 22

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β°	Deviation σ = |α − β|°	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
	1843										Gauge 3 1570
1		0.14	5.0		0.47	—					Bed 6.5
			3.0		0.53	220					
	1850		1.0		0.45	215					
					0.48				242.4	116.3	
2		0.15	7.0		0.45	—					Bed 8.5
			4.0		0.55	230					
	1855		1.0		0.45	230					
					0.48				495.0	237.6	
3		0.16	3.0		0.30	215					Bed 4.5
	1900		1.0		0.33	215					
					0.32				362.8	116.1	
4		0.17	0.5		0.18	215					Bed 0.5
					0.18				77.3	13.9	
5	1906	0.17	1.0		0.25	250					Bed 2.0
					0.25				151.7	37.9	

Estimated

Flood

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER: ST. HELENS

DATE: 17.11.83

SECTION: AKAROA G-H

CURRENT METER: 6435

SECTION BEARING α°: 110 mag

WORKED BY: Lawson

SHEET: 21/22

DATUM: A.H.D.

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β°	Deviation σ = |α − β|°	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
	1918										Gauge 3 1620
1		0.20	5.0		0.25	—					Bed 6.0
			3.0		0.38	195					
	1923		1.0		0.31	220					
					0.31				245.6	-76.1	
2		0.20	7.0		0.35	—					Bed 8.5
			4.0		0.39	245					
	1929		1.0		0.28	230					
					0.34				498.0	-169.3	
3		0.21	3.0		0.25	200					Bed 4.5
			1.0		0.28	225					
					0.27				366.8	-99.0	
4		0.21	0.5		0.05	—					Bed 0.5 Swinging
					0.05				80.9	-4.0	
5	1939	0.22	1.0		0.05	—					Bed 2.0 Swinging
					0.05				157.0	-7.8	
						Estimated					

Flood

THE UNIVERSITY OF NEW SOUTH WALES - WATER RESEARCH LABORATORY

GAUGING AND COMPUTATION SHEET

RIVER: ST. HELENS
DATE: 17.11.83

SECTION: AKAROA G-H
CURRENT METER: 6435

SECTION BEARING α°: 110 mag
WORKED BY: Lawson

SHEET: 22/22

DATUM: A.H.D.

Station	Time	W.L. R.L. m	Depth to Meter m	R.L. of Meter m	Velocity Vp m/s	Direction β°	Deviation $\sigma = \lvert\alpha - \beta\rvert^\circ$	Normal Velocity Vp sin σ m/s	Area m²	Discharge m³/s	
	1942										Gauge 3 1650
1		0.22	5.0		0.03	—					Bed 6.0 Swinging
			3.0		0.10	—					"
			1.0		0.10	—					"
					0.08				246.6	+19.7	
2	1948	0.23	4.0		0.18	—					"
			1.0		0.14	—					"
					0.16				499.2	+79.9	
3	1953	0.22	3.0		0.10	—					"
			1.0		0.15	—					"
					0.13				367.6	-47.8	
4		0.22									
									81.8	—	
5		0.22									
									157.0	—	
	1955										Gauge 3 1660

Flood

APPENDIX 3

WAVE REFRACTION STUDY

ST. HELENS

Prepared for

Water Research Laboratory

Lawson and Treloar Pty Ltd,
Coastal, Ocean and Port Consulting Engineers,
Suite 601, 144 Pacific Highway,
North Sydney NSW (02) 922 2288

December 1983

SYNOPSIS

This report presents the results of a wave refraction study carried out for the port of St. Helens on the east coast of Tasmania. The work was performed under instructions from Professor D N Foster and Dr R Cox of the Water Research Laboratory, University of New South Wales.

The results are presented in terms of wave coefficents and average inshore wave directions for a range of offshore directions and average zero crossing periods.

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1 INTRODUCTION

Lawson and Treloar Pty Ltd were engaged by Unisearch Ltd to carry out a wave refraction study for the St. Helens area on the eastern Tasmanian coast. This site is shown on Figure 1. Following instructions from Professor D N Foster and Dr R Cox of the Water Research Laboratory, University of New South Wales, three sites were chosen in the entrance to Georges Bay and on the 3 fathom line, see Figure 1.

The port of St. Helens is principally a fishing port and this work forms part of an overall study leading to development proposals. The coastline falls steeply away from the port entrance and bed friction is not likely to be important.

2 MODEL SET-UP

The refraction model used in this work was the HRS, Wallingford, UK, model, RAYTRK, described in Appendix A. This program uses an equilateral triangle grid system to represent the sea bed bathymetry. The area to be modelled is enclosed by a series of 60 degree parallelograms, (in which the triangles are constructed by the program). Each parallelogram may have a different grid size and this grid size is the length of the triangle sides. In this way grid sizes may be chosen to suit the bathymetry changes, or according to the data available.

For this study 14 zones were used with grid sizes ranging from 375m to 3000m. Choosing a number of zones also enables one to digitize only those sea bed areas through which ocean wave energy will pass on its way into the port area. Bathymetric data for this work was drawn from chart AUS356, "St. Helens Point to Low Head".

From each of the three inshore locations a number of wave rays were generated at the monochromatic wave periods of 4, 6, 8, 10, 12 and 14 seconds. The initial angular interval varied for each period as the effective window to the open ocean depends upon the wave period. These rays propagate out from the starting point and eventually leave the modelled zone by crossing a northern, eastern or southern boundary. Rays for periods shorter than 4 seconds are included, but are assumed to be straight lines. They will also have a larger window and the shorter period wave coefficients are often closer to unity than those for the longer periods. However, the effect of the seabed in focussing wave energy may change this.

A total of 9 mean offshore wave directions were used together with 6 zero crossing periods to form the wave coefficent and direction matrices. Offshore frequency direction spectra were assumed to have directional standard deviations of 20 degrees. However, at Point 2, standard deviations of 15 and 25 degrees were also investigated.

Tide level was taken to be about the mean water level as this is the most likely water level. However, wave coefficients were also investigated at Point 1 for a tide level equal to spring tide, 1.5m above chart datum.

3 RESULTS

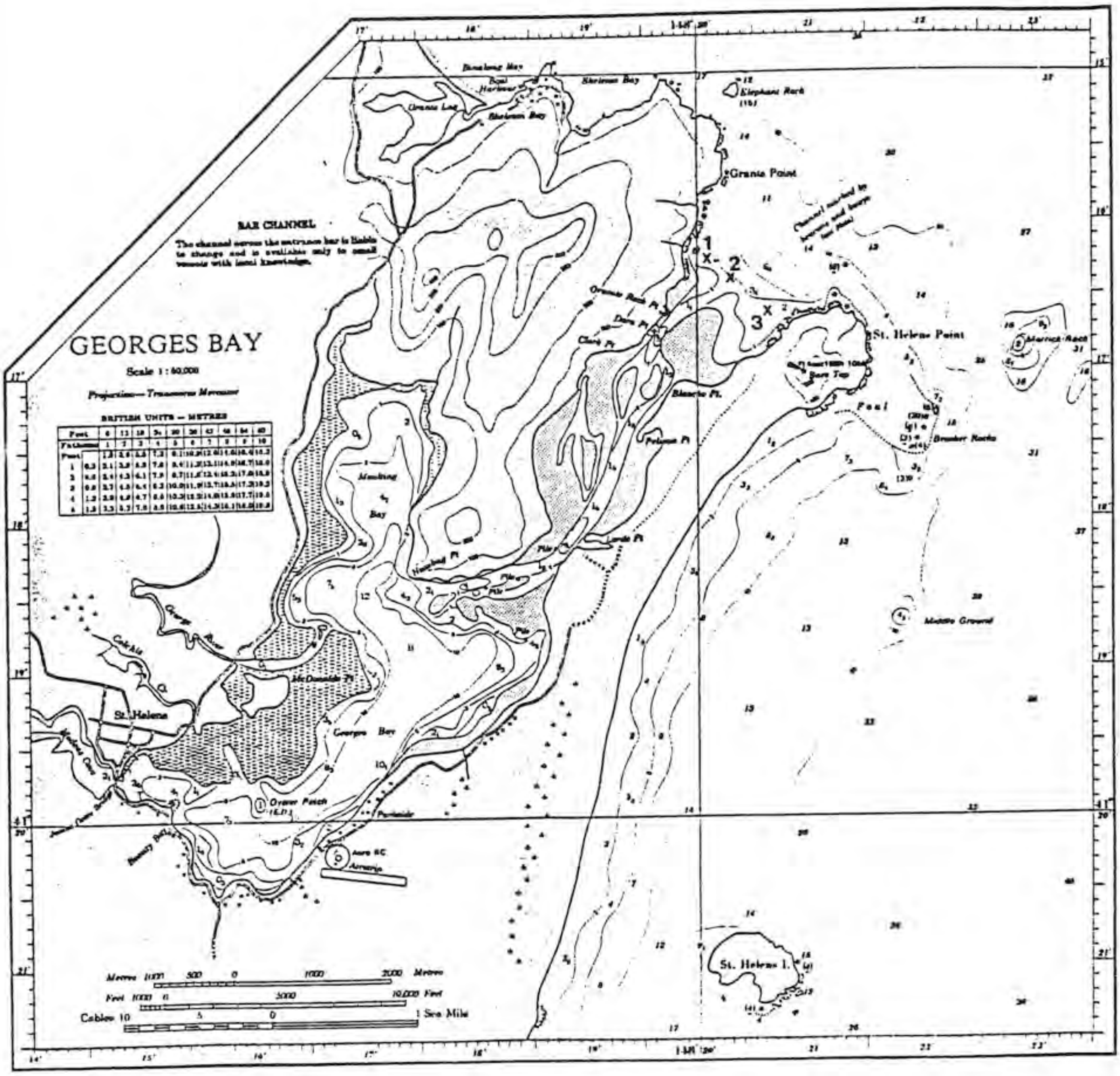
The results of the refraction analysis are shown in Tables 1 to 6. It should be pointed out that direction in these tables is defined to be the direction of wave propagation, that is northerly waves propagate in a direction of 180 degrees. The differences among the three points are shown in the first 3 tables. It is quite clear that the northern point, Number 1, is partially sheltered from northerly waves and less sheltered from southerly waves than point Number 3 in the south. Long period ocean swells from the south are gently attenuated. It appears that waves from east-north-east to east-south-east have the greatest capacity to enter the harbour.

A comparison between Tables 1 and 4 shows that tide level makes very little difference to wave coefficients at point Number 1. This is also likely to be true for the other locations.

A comparison between Tables 2, 5 and 6 shows that the choice of standard deviation in directional spread is not particularly important, except for waves coming from a southerly direction.

4 CONCLUDING REMARKS

The matrices of wave coefficients have a physically reasonable appearance with respect to each other and the seabed bathymetry. It is believed that the techniques used provide reliable and stable estimates of wave coefficients. If more bathymetric data were available in the nearshore regions somewhat better results would be possible. The inshore wave directions for southerly offshore waves will be influenced by the short period local waves, even for the longer period cases, because no long period rays actually penetrate from that direction.



UNISEARCH LTD - WATER RESEARCH LABORATORY

LOCALITY PLAN WAVE REFRACTION STUDY ST HELENS	LAWSON AND TRELOAR PTY LTD	
	DATE 29:12:83	FIG. 1

LOW WATER

WAVE CLIMATE STUDY

ST HELENS

INSHORE WAVE CONDITIONS FOR POSITION 1 — LOW WATER.
DIRECTION STANDARD DEVIATION 20.0

WAVE COEFICIENTS

ZERO CROSSING PERIOD	N 180.0	202.5	225.0	247.5	DIRECTION 270.0	292.5	315.0	337.5	S 360.0
3.5	0.44	0.70	0.86	0.88	0.80	0.71	0.69	0.58	0.35
4.5	0.40	0.69	0.85	0.86	0.76	0.63	0.56	0.45	0.26
5.5	0.40	0.70	0.86	0.84	0.75	0.63	0.50	0.36	0.20
6.5	0.41	0.71	0.86	0.84	0.76	0.67	0.51	0.31	0.16
7.5	0.41	0.71	0.85	0.84	0.79	0.74	0.54	0.29	0.13
8.5	0.40	0.69	0.84	0.83	0.82	0.79	0.57	0.29	0.11

INSHORE DIRECTIONS

3.5	206.63	217.77	229.54	244.12	259.51	276.26	290.22	297.12	301.75
4.5	213.36	221.28	230.49	242.50	255.00	268.25	282.98	292.80	299.16
5.5	218.27	223.93	231.21	241.09	251.42	260.50	272.36	286.08	295.00
6.5	222.00	226.04	231.88	240.10	248.71	255.05	262.57	276.57	289.53
7.5	225.11	228.13	232.83	239.48	246.38	250.78	255.22	265.80	281.91
8.5	227.47	229.91	233.78	239.16	244.85	248.23	251.09	257.78	272.68

TABLE 1: POINT NUMBER 1

WAVE CLIMATE STUDY

ST HELENS

INSHORE WAVE CONDITIONS FOR POSITION 2
DIRECTION STANDARD DEVIATION 20.0

WAVE COEFICIENTS

DIRECTION

ZERO CROSSING PERIOD	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5	360.0
3.5	0.61	0.81	0.90	0.89	0.78	0.71	0.68	0.45	0.18
4.5	0.50	0.75	0.89	0.88	0.77	0.63	0.53	0.34	0.13
5.5	0.46	0.73	0.88	0.88	0.79	0.64	0.47	0.27	0.11
6.5	0.44	0.73	0.89	0.88	0.81	0.72	0.52	0.26	0.09
7.5	0.42	0.72	0.89	0.88	0.86	0.87	0.66	0.32	0.10
8.5	0.39	0.69	0.88	0.88	0.91	0.99	0.80	0.39	0.11

INSHORE DIRECTIONS

3.5	199.39	212.20	227.16	243.18	258.79	277.82	287.77	291.23	294.12
4.5	204.20	216.00	227.92	241.27	253.73	269.21	282.66	287.88	290.01
5.5	209.53	218.58	227.90	239.23	249.72	259.53	272.01	280.89	282.37
6.5	213.56	220.34	227.81	237.32	246.72	252.64	258.62	266.98	272.67
7.5	216.77	222.11	227.99	235.62	244.09	248.20	250.04	252.97	258.39
8.5	219.39	223.69	228.31	234.50	242.45	246.18	247.05	247.78	250.15

TABLE 2: POINT NUMBER 2

WAVE CLIMATE STUDY

ST HELENS

INSHORE WAVE CONDITIONS FOR POSITION 3
DIRECTION STANDARD DEVIATION 20.0

WAVE COEFICIENTS

ZERO CROSSING PERIOD	DIRECTION								
	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5	360.0
3.5	0.62	0.79	0.84	0.80	0.77	0.61	0.36	0.19	0.08
4.5	0.47	0.67	0.80	0.76	0.64	0.46	0.25	0.12	0.05
5.5	0.38	0.61	0.78	0.79	0.64	0.41	0.21	0.09	0.03
6.5	0.34	0.58	0.77	0.83	0.74	0.48	0.22	0.08	0.03
7.5	0.32	0.56	0.73	0.88	0.92	0.65	0.29	0.09	0.02
8.5	0.30	0.51	0.68	0.91	1.07	0.80	0.36	0.10	0.02

INSHORE DIRECTIONS

3.5	194.85	206.26	220.36	236.71	253.30	265.16	285.00	310.05	320.36
4.5	197.21	209.42	220.69	231.67	246.43	259.86	278.58	306.50	319.71
5.5	200.65	211.80	220.44	228.03	237.48	249.21	266.11	296.44	316.80
6.5	204.71	212.94	219.77	225.99	231.12	236.75	246.77	273.68	307.60
7.5	208.04	213.42	219.19	224.91	227.72	229.73	233.80	249.16	289.66
8.5	210.01	213.77	219.02	224.51	226.48	227.57	229.66	237.38	269.65

TABLE 3: POINT NUMBER 3

WAVE CLIMATE STUDY

ST HELENS

INSHORE WAVE CONDITIONS FOR POSITION 1 - HW
DIRECTION STANDARD DEVIATION 20.0

WAVE COEFICIENTS

DIRECTION

ZERO CROSSING PERIOD	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5	360.0
3.5	0.43	0.70	0.87	0.89	0.81	0.73	0.72	0.59	0.33
4.5	0.40	0.69	0.86	0.86	0.77	0.65	0.58	0.44	0.23
5.5	0.39	0.69	0.86	0.85	0.75	0.64	0.51	0.35	0.18
6.5	0.41	0.71	0.86	0.84	0.76	0.68	0.51	0.31	0.14
7.5	0.41	0.71	0.85	0.83	0.80	0.75	0.56	0.30	0.12
8.5	0.40	0.69	0.83	0.83	0.83	0.83	0.62	0.31	0.11

INSHORE DIRECTIONS

3.5	206.32	217.58	229.50	244.52	260.36	278.46	293.82	303.37	316.94
4.5	212.95	220.91	230.36	242.89	255.93	270.29	286.34	297.68	310.65
5.5	217.77	223.46	231.02	241.42	252.30	262.29	275.55	289.87	303.30
6.5	221.47	225.55	231.66	240.36	249.50	256.41	264.95	279.43	295.53
7.5	224.61	227.67	232.60	239.71	247.12	251.82	256.52	266.66	284.47
8.5	227.00	229.50	233.58	239.38	245.61	249.27	252.20	257.91	271.81

TABLE 4: POINT NUMBER 1 AT HIGH WATER

WAVE CLIMATE STUDY

ST HELENS

INSHORE WAVE CONDITIONS FOR POSITION 2
DIRECTION STANDARD DEVIATION 15.0

WAVE COEFICIENTS

DIRECTION

ZERO CROSSING PERIOD	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5	360.0
3.5	0.58	0.83	0.92	0.91	0.77	0.68	0.74	0.40	0.09
4.5	0.46	0.76	0.91	0.90	0.77	0.60	0.56	0.29	0.07
5.5	0.40	0.75	0.92	0.89	0.80	0.63	0.46	0.23	0.06
6.5	0.38	0.75	0.92	0.88	0.81	0.75	0.50	0.20	0.06
7.5	0.35	0.73	0.93	0.88	0.84	0.92	0.66	0.22	0.05
8.5	0.31	0.70	0.93	0.87	0.87	1.06	0.80	0.26	0.04

INSHORE DIRECTIONS

3.5	195.53	209.68	226.42	244.56	259.80	280.28	289.02	293.18	298.79
4.5	199.36	213.41	226.90	242.47	255.05	271.54	285.49	290.12	289.88
5.5	205.02	216.26	226.97	240.11	251.14	260.44	277.02	284.83	276.00
6.5	209.94	218.29	227.05	237.88	248.08	252.92	261.60	274.80	269.57
7.5	213.65	220.31	227.40	235.79	245.01	248.58	250.61	257.87	264.39
8.5	216.59	222.11	227.82	234.34	242.89	246.68	247.12	249.38	258.26

TABLE 5: POINT NUMBER 2 - STANDARD DEVIATION 15 DEGREES

WAVE CLIMATE STUDY

ST HELENS

INSHORE WAVE CONDITIONS FOR POSITION 2
DIRECTION STANDARD DEVIATION 25.0

WAVE COEFICIENTS

DIRECTION

ZERO CROSSING PERIOD	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5	360.0
3.5	0.62	0.79	0.88	0.87	0.79	0.72	0.64	0.47	0.25
4.5	0.53	0.74	0.86	0.86	0.76	0.64	0.52	0.36	0.18
5.5	0.50	0.72	0.85	0.86	0.78	0.64	0.48	0.30	0.15
6.5	0.49	0.72	0.85	0.87	0.81	0.71	0.53	0.31	0.14
7.5	0.46	0.71	0.85	0.88	0.86	0.83	0.66	0.40	0.17
8.5	0.44	0.69	0.85	0.89	0.92	0.93	0.78	0.47	0.20

INSHORE DIRECTIONS

3.5	203.18	214.77	227.98	242.19	257.76	274.85	285.47	289.69	291.98
4.5	208.38	218.53	229.00	240.39	252.38	266.34	278.81	285.34	288.27
5.5	213.13	220.80	228.99	238.56	248.26	257.73	267.75	276.17	280.75
6.5	216.45	222.23	228.79	236.98	245.36	251.60	256.62	262.16	267.81
7.5	219.23	223.71	228.86	235.70	243.09	247.47	249.49	251.26	253.86
8.5	221.51	225.04	229.12	234.98	241.80	245.55	246.77	247.36	248.18

TABLE 6: POINT NUMBER 2 - STANDARD DEVIATION 25 DEGREES

APPENDIX A

WAVE REFRACTION USING REVERSE RAY TECHNIQUE

INTRODUCTION

The generally accepted method of wave refraction studies for coastal engineering investigations is to project parallel rays (orthogonals) from offshore deepwater towards some chosen area of coastline. If these rays have an initial spacing of bo, and this spacing becomes b in shallow water, then refraction coefficient, Kr, is simply defined as

$$Kr = (bo/b)^{\frac{1}{2}} \qquad (1)$$

This technique is suitable for simple locations where there are no abrupt bathymetric changes. However, in these instances, ray paths are quite complex and one may have a refraction diagram such as that shown in Figure 1. These rays began in deep water and were initially parallel and equidistant apart. The deep water origin is not shown, but it is obvious that interpretation is difficult, if not impossible. Even where ray paths have not crossed, a large gradient in inshore ray spacing can make it difficult to interpret the results and obtain reliable estimates of refraction coefficients. The result depends upon the chosen values of bo. Thus one can see that general refraction results for a length of coastline can be obtained in this way, but there is virtually no detail at any particular point.

At this stage it is important to ask oneself, "What is my purpose in carrying out a wave refraction study?" If the purpose is to use these results to obtain inshore wave climate from offshore wave data, then it is obvious, (refer to Figure 1), that the forward ray technique is generally inadèquate. By wave climate we here mean wave-height exceedance and wave direction information. A large amount of wave data is collated in terms of Tz, average zero crossing period. Forward ray projection, using monochromatic wave periods, does not facilitate the use of these data and requires "adaptation" from the more realistic condition. Further, offshore waves virtually never occur with a single direction. Thus it is desirable to use a technique which can take this aspect into account in a physically acceptable manner. This work has the objective of describing a technique which overcomes most of these problems. It is one which was originally developed at the Hydraulics Research Station Wallingford, England, and has been further developed by Lawson and Treloar Pty. Ltd.

REVERSE RAY TECHNIQUE

The HRS program, RAYTRK, calculates orthogonal paths using the basic refraction initial value equation

$$d\alpha/ds = -1/C \; dC/dn$$

where α is ray bearing
s is distance along the ray
n is the inward normal direction
C is the wave celerity

The seabed is schematised on a grid of equilateral triangles contained within zones which are parallelograms. Within each zone all triangles are of the same size, but the triangle size may vary among the zones. In this way it is possible to develop the seabed in some detail where necessary, yet be economical in deeper water where data points can be further apart.

An inshore location is chosen and fans of rays are projected from there to deep water with wave periods of say 4,6,8,10,12 and 14 seconds. The inshore orthogonal bearings, ϕ, are generated at intervals of $d\phi$, which may range from less than 1 degree to 5 degrees, depending upon the site and the window to deep water. The results of this are a series of ϕ-θ plots (in theory only, as they are never in fact drawn), where θ is the offshore orthogonal bearing. The required result, then, of the ray calculation procedure is the ϕ-θ relationship for each ray. Figure 2A shows one such plot. It will be seen that ϕ can be multi-valued for some θ values as in this example. These areas exhibit the effect of caustics, which in effect are those events in the forward ray technique where neighbouring rays cross. In such a case the logical conclusion from equation (1) would be that Kr tends towards infinity. However, we know that this is not so and that wave diffraction causes a lateral transfer of wave energy so that the total spectral energy remains constant, except for some dissipation by breaking. Refraction and diffraction are not independent phenomena.

The next step is to make the reasonable proposal that an offshore frequency direction spectrum can be assumed to be made up of the linear product of the separate frequency and direction spectra. The form of these can be freely chosen but the modified Moskowitz spectrum and Gaussian distribution are usually chosen for the frequency and direction spectra respectively. This follows the work of Abernethy and Gilbert, (1975). Thus,

$$S(f,\theta) = S1(f).S2(\theta) \qquad (2)$$

where $$S1(f) = (Hs^2 u^{-5})/4\pi fz \; \exp(-u^{-4}/\pi) \qquad (3)$$

$$S2(\theta) = 1/\sigma\sqrt{2\pi} \; \exp(-(\mu-\theta)^2/2\sigma^2) \qquad (4)$$

where μ is mean offshore direction
σ is the standard deviation in wave direction
f is wave frequency
u is f/fz
fz is 1/Tz

At the present stage the choice of σ is somewhat arbitrary. A value of 10 degrees provides stable results when one has parallel offshore contours, but a value of 40 degrees has been obtained from ocean wave measurements carried out by Cartwright, Longuet-Higgins and Smith, (1963). It is believed that σ will depend on the site and will have its own statistical distribution. A value of 25 degrees is generally used, but if insight into the effect of a narrower direction spectrum is desired, a smaller σ value should be tried. The 25 degrees value results from analyses of wave data recovered in Bass Strait.

Figures 2A-C show the essential steps in the method. Suppose that from an inshore location a fan of wave orthogonals has been projected out to deep water for some chosen frequency, f1, and their directions plotted as the $\phi-\theta$ curve of Figure 2A. A set of such curves at several frequencies will contain the full description of the refracting effect of the seabed topography between A and the ocean.

Figure 2B, on the other hand, depicts the "climatic" input to the problem: this is a spectrum shown as the contoured surface of $S(f,\theta)$, the more familiar one-dimensional components being indicated on the axes. The shape of the spectrum is decided by the choice of equations (3) and (4). Its position in the $f-\theta$ plane depends upon the choice of Tz and μ. Hs can be assigned an arbitrary value since we follow usual practice in neglecting non-linear effects and so making Kr independent of Hs.

The spectrum at A that results from combining the deep water spectrum of Figure 2B with the refracting properties of Figure 2A is constructed in Figure 2C as a set of contours on the f,ϕ plane. Its method of construction is thus: for any point $f1,\phi1$ of Figure 2C the conjugate value of $\theta1$ is found by reference to Figure 2A. The point $f1,\theta1$ is located in Figure 2B and its ordinant, $S(f1,\theta1)$, read there. This value is transferred directly to the location $f1,\phi1$ in Figure 2C, after adjustment according to the equation

$$S(f,\phi) = (Cgo.Co)/(Cg.C).S(f,\theta) \qquad (5)$$

Equation (5) was first presented by Longuet-Higgins (1957) in wave number space and its derivation can be summarised as follows. Consider (in the context of conventional forward projected wave rays) a small element of wave energy which in deep water is contained between two rays at spacing bo, and which is distributed over small ranges of frequency and direction, df and $d\theta$. At A the ray separation is b and the corresponding ranges of frequency and direction will be df and $d\phi$. Equating energy fluxes we have

$$S(f,\theta).df.d\theta.Cgo.bo = S(f,\phi).df.d\phi.Cg.b \qquad (6)$$

which, by introducing $Kr^2 = bo/b$ and substituting

$$Kr^2 = (Co/C).d\phi/d\theta$$

a relationship developed by Dorrestein (1960), produces the form shown in equation (5).

Calculation of the inshore root-mean-square wave-height is then simply given by

$$Hrms^2 = 8\int\int S(f,\phi).df.d\phi \qquad (7)$$

The inshore mean wave direction is given by

$$\phi m = (\int\int \phi S(f,\phi).df.d\phi)/(\int\int S(f,\phi).df.d\phi) \qquad (8)$$

The inshore zero crossing period can also be determined from

$$Tz = (\int\int S(f,\phi).df.d\phi)/(\int\int f^2 S(f,\phi).df.d\phi) \qquad (9)$$

The equations are evaluated numerically. Note that equation (9) demonstrates the change in Tz as refraction occurs. This aspect can not be obtained from the forward ray technique.

The method is quite versatile and is applicable where one has islands which intercept some orthogonals and severely refract others. Figure 3A-B shows an idealized example of such a bed area and the resulting ϕ-θ diagram. The important aspect is the discontinuity in ϕ which will appear in the inshore spectrum as a break or depression, i.e. there will be two humps of energy. Wave diffraction would of course mean that the spectrum is not discontinuous, but due account of the effect of the island should be taken.

Table 1 is an example of the results obtained from this method. The first block is an array of wave coefficients arranged in columns for directions and rows for zero crossing period. Note that this method does not obtain separate refraction and shoaling coefficients, as shoaling coefficient and Tz are not directly related. However, each spectral ordinant is correctly transformed. If desired, wave coefficients at each of the monochromatic periods can be determined, each of these being averaged over the direction spectrum.

CALCULATION OF INSHORE WAVE CLIMATE

Wave-height statistics generally fall into four areas. These are

(1) Short term statistical distribution - Rayleigh Distribution

(2) Long term wave-height exceedance statistics - Log-normal or Weibull Distributions.
(3) Storm Duration-Return Interval studies.
(4) Wave group statistics.

This study is concerned with the first two of these, the first in an implicit sense and the second directly. Where adequate data are available they are collated in a form whereby they are divided into groups, each referred to by an offshore direction and period. This means that all wave observations falling within a 22.5 degree sector, for example, are assigned to the central direction and all observations within a 1 second zero crossing period band are assigned to the central period. Thus it is possible to prepare the data in the form shown in Figure 4. In that figure, p1, is the probability that the particular offshore direction-period event will occur. The plot then shows the conditional probability of wave height exceedance. The data are usually drawn up in terms of Hs. Thus one has a number of such plots, one for each direction-period case. Each is completely described by choosing two pairs of wave-height and probability points, including p1, and given that the distribution is log-normal.

In order to calculate inshore wave-height exceedance statistics, one first selects a list of wave-heights. Then, taking the smallest, say H1, it is divided by the wave coefficient for the first direction period condition to determine the offshore wave-height, Ho1, necessary to generate that inshore wave-height. The wave-height exceedance plot is then entered at Ho1 on the vertical axis and the conditional probability p2 determined. The product p1*p2 then provides the partial probability of H1 being exceeded. By repeating this process for all offshore conditions and summing all partial probabilities, the total probability of H1 being exceeded will be produced. The procedure is then repeated for each choice of H1. The total wave-height exceedance plot can then be determined by calculating successive probabilities of exceedance.

It should be noted that the breaking wave-height limitation is not included. If a particular design probability be chosen, then this wave-height can be matched to a water level taking into account the change in inshore wave-height with change in water level. The effects of bed friction can be included by calculating wave conditions at a number of locations between deep water and the shoreline. This is necessary because turbulent flow energy dissipation depends upon wave-height itself and the wave height must be included in each calculation of Kf, the friction coefficient.

A further calculation may be performed and this is the weighted mean inshore wave direction. Based on the premise that wave energy is a more relevant parameter than wave-height in many situations, He, the effective wave-height is calculated as

$$He^2 = \int H^2 p(H) dH$$

where p(H) is the log-normal distribution. Then, following from the general sediment transport equations in which, Q, rate of transport, is described by

$$Q \propto H^2 T \qquad \text{i.e. wave power}$$

one determines weighting factors Eo thus

$$Eo = p1(Tz,\mu).Tz.He^2 \qquad \text{for each } Tz\text{-}\mu \text{ pair}$$

Thus Q can be written further

$$Q \propto Eo.Kw^2 \qquad \text{for each } Tz\text{-}\mu \text{ pair}$$

Thus the total average sediment transport could be obtained by summing these Q values over all Tz-μ pairs. Note that this procedure, as presented, should not be used for sediment transport as no account of threshold velocities has been included. The Eo and Kw value can then be used to calculate the weighted mean inshore direction. This mean direction is also useful for offshore berth investigations.

Additionally it is possible to divide the inshore directions up into sectors for studies involving ship movement. Diffraction effects can also be included by further analysis.

The processes presented above have been well tested and are believed to provide the most reliable inshore wave-height information in a form which is readily usable in further studies. Although the method has been presented in terms of Tz, many aspects can be used in a monochromatic period study or use can be made of other period parameters.

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WAVE CLIMATE STUDY

MERMAID SOUND

INSHORE WAVE CONDITIONS FOR POSITION XX
DIRECTION STANDARD DEVIATION 25.0

WAVE COEFFICIENTS

WAVE PROPAGATION DIRECTION

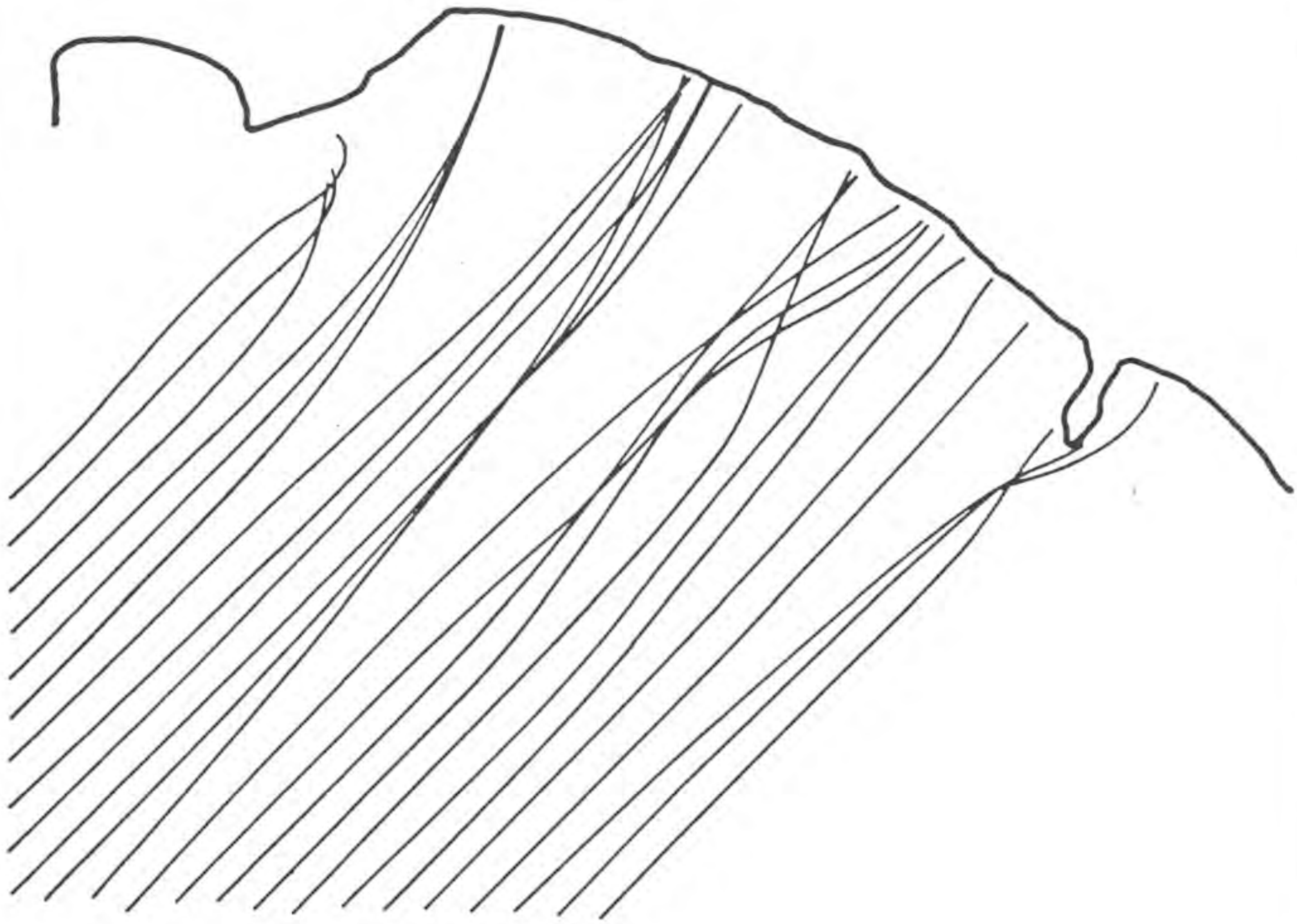
ZERO CROSSING PERIOD	135.0	157.5	180.0	202.5	225.0	247.5	270.0
4.5	0.84	0.93	0.94	0.91	0.82	0.66	0.48
5.5	0.82	0.89	0.89	0.85	0.73	0.55	0.37
6.5	0.81	0.85	0.84	0.80	0.69	0.51	0.32
7.5	0.81	0.82	0.80	0.76	0.67	0.51	0.33
8.5	0.81	0.80	0.77	0.73	0.67	0.54	0.35
9.5	0.81	0.79	0.76	0.72	0.67	0.55	0.37
10.5	0.81	0.79	0.75	0.72	0.68	0.56	0.38
11.5	0.81	0.79	0.75	0.72	0.68	0.57	0.38
12.5	0.81	0.79	0.74	0.71	0.68	0.57	0.38

INSHORE WAVE PROPAGATION DIRECTIONS

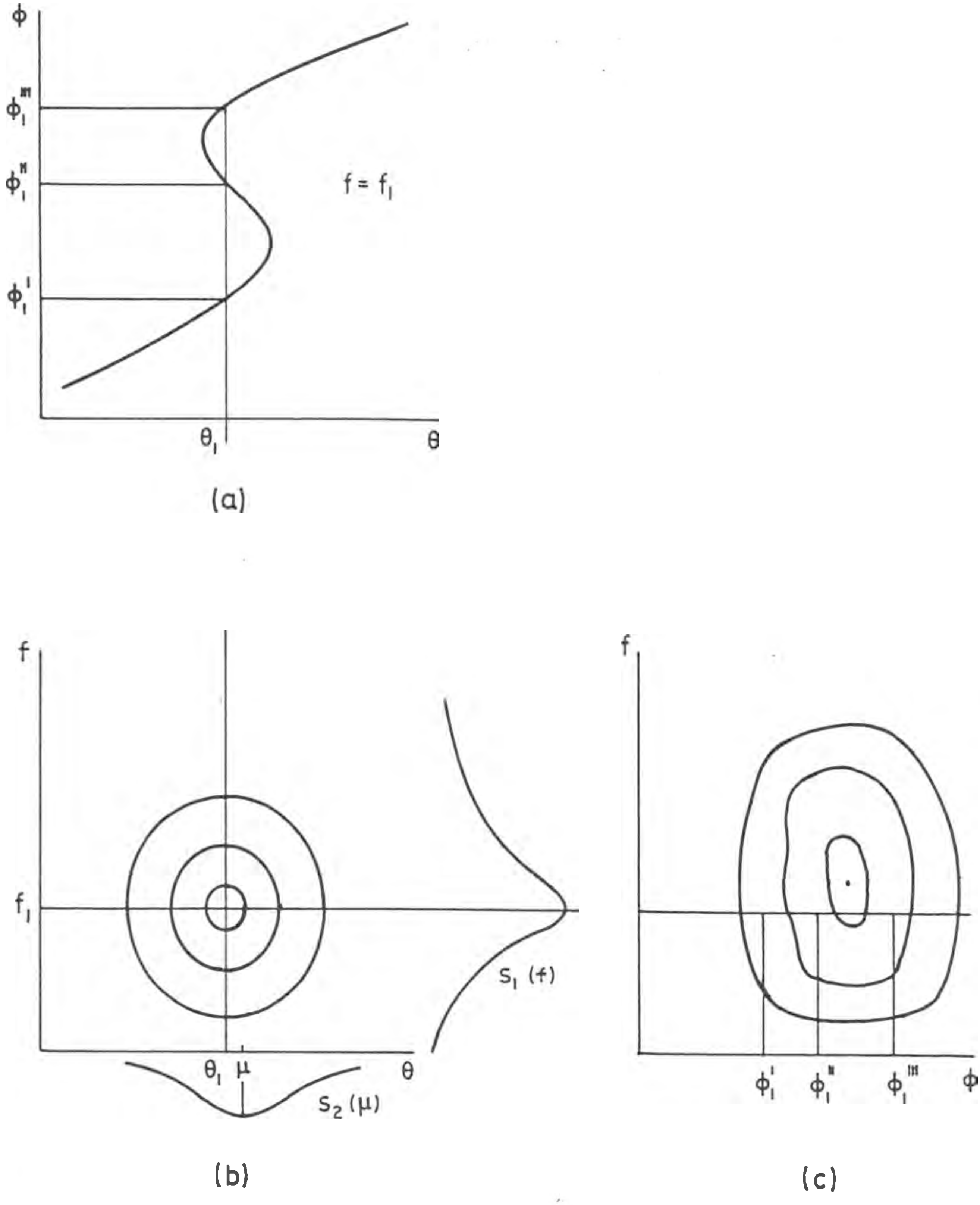
4.5	146.99	161.08	179.27	197.52	214.76	231.93	246.24
5.5	147.21	161.03	178.23	194.48	209.01	224.64	240.76
6.5	147.83	161.19	177.23	191.85	203.92	215.99	230.05
7.5	149.44	161.84	176.13	189.16	199.11	207.19	215.53
8.5	151.18	162.61	175.18	186.95	195.66	201.75	206.72
9.5	152.20	163.08	174.64	185.71	193.96	199.43	203.32
10.5	152.73	163.33	174.36	185.09	193.15	198.42	201.92
11.5	153.01	163.47	174.21	184.75	192.73	197.92	201.26
12.5	153.18	163.55	174.12	184.56	192.49	197.65	200.90

WEIGHTED MEAN INSHORE ORTHOGONAL DIRECTION 179.59

TABLE 1: INSHORE WAVE CONDITIONS



FORWARD PROJECTED RAYS SHOWING CAUSTICS CAUSED BY TOPOGRAPHY	LAWSON AND TRELOAR PTY LTD
	DATE 22:11:82 — FIG. 1



TRANSFORMATION OF AN OFFSHORE SPECTRUM TO AN INSHORE SITE

LAWSON AND TRELOAR PTY LTD

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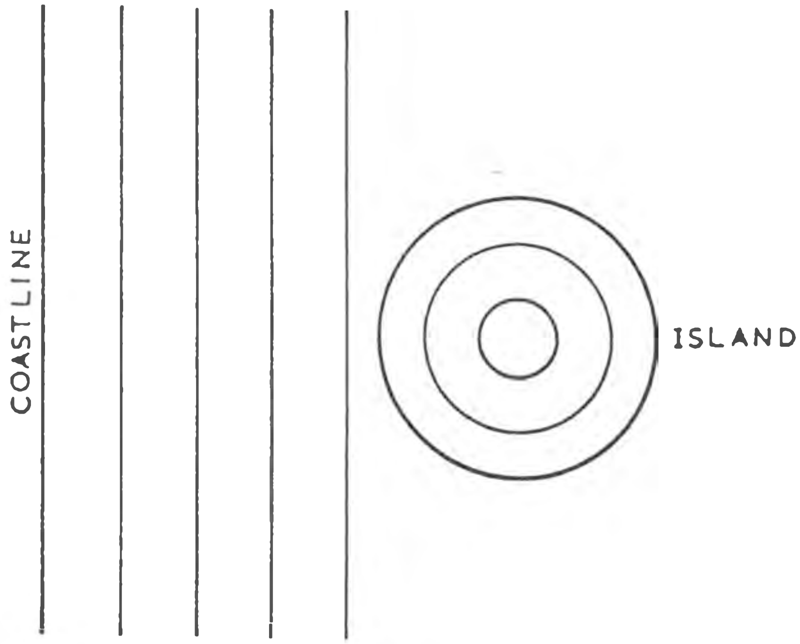
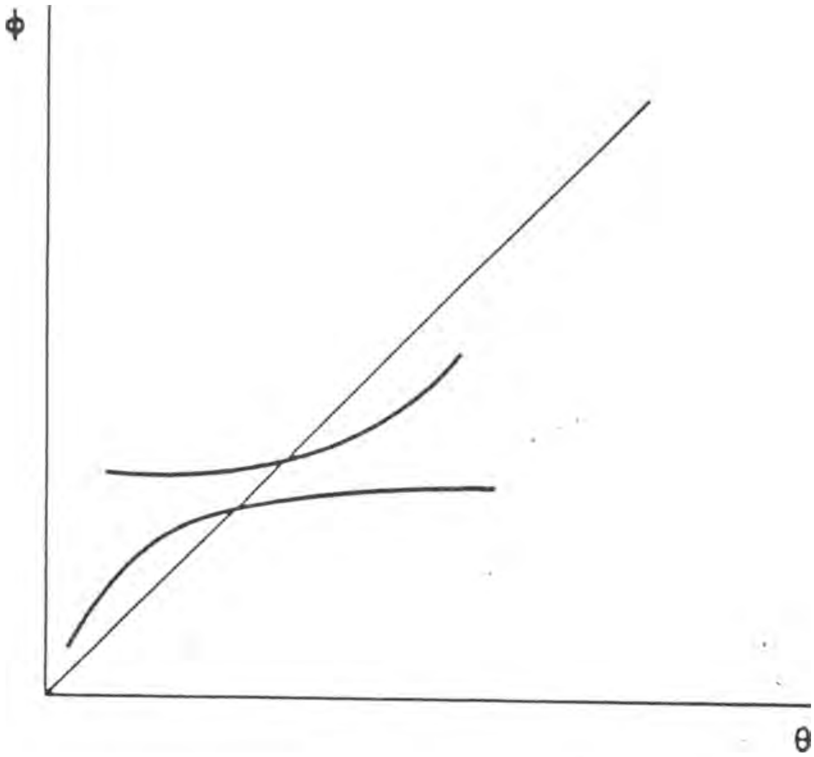
FIG. 2



(a)



(b)

SPECTRAL TREATMENT OF SHOALS AND ISLANDS

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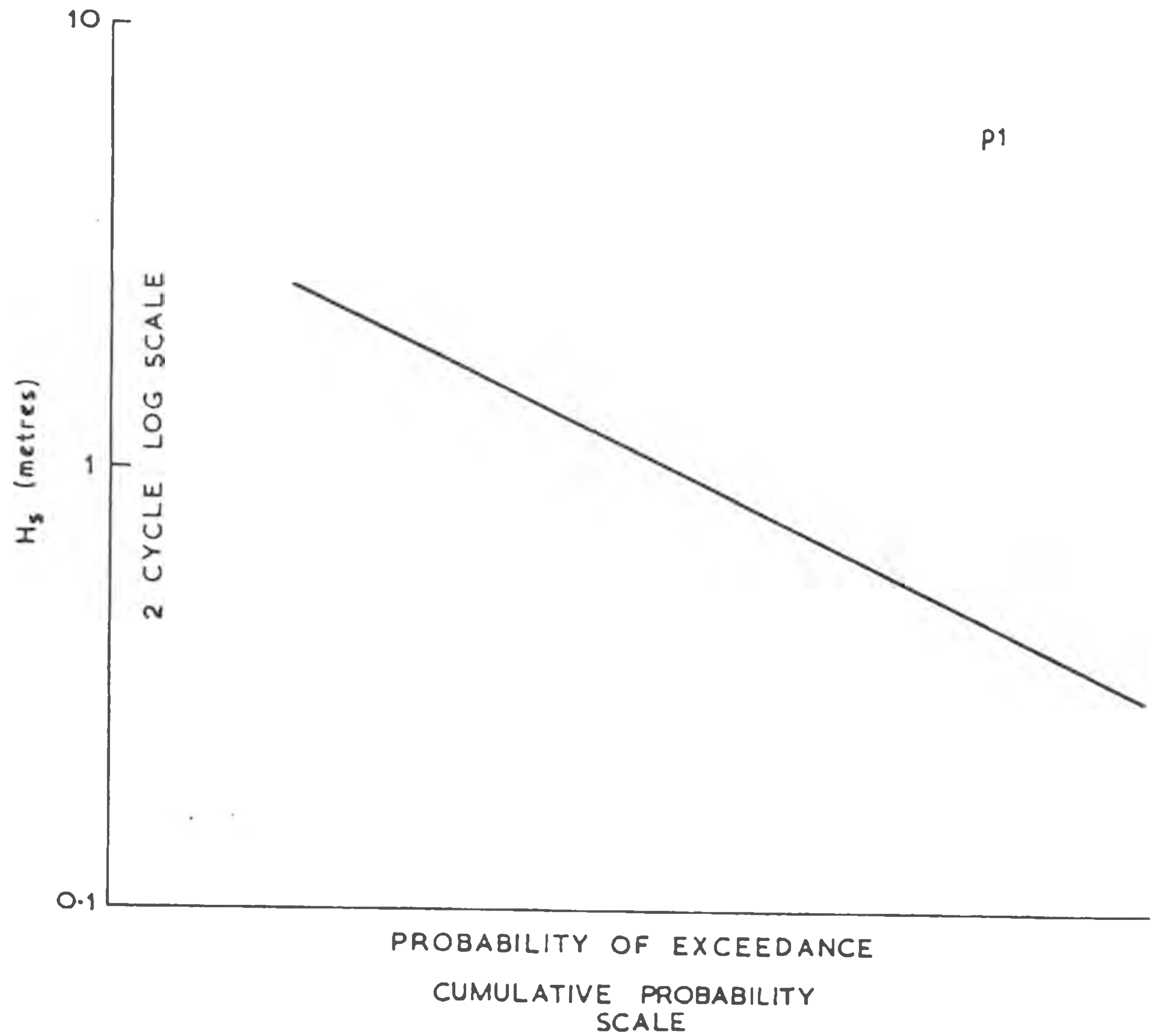
FIG. 3



CUMULATIVE PROBABILITY OF EXCEEDANCE VERSUS SIGNIFICANT WAVE-HEIGHT

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FIG. 4