US Army Corps
of Engineers
Waterways Experiment
Station

Preliminary Data Summary for April 1995 CERC Field Research Facility

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Coastal Engineering Research Center

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April 1995
Preliminary Data Summary

by Field Research Facility

U.S. Army Corps of Engineers
Waterways Experiment Station
Coastal Engineering Research Center
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Preface

This report provides a summary of basic oceanographic, meteorological and bottom profile data for the month. The data were obtained as part of the Measurements and Analysis work units at the U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's Field Research Facility (FRF) in Duck, North Carolina. The FRF staff collected and analyzed these data. These summaries are intended to make the data readily available to all FRF users, and comments on their content and usefulness are invited.

These reports are now available via the World Wide Web at http://frf/wes/army.mil

These web pages contain general information about the Field Research Facility and data from 1980 to the present.

Please send comments to webmaster@duck.wes.army.mil .
If the web is sufficient for your needs and you no longer require hardcopies, please let us know.

1 Introduction

The U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center's (CERC) Field Research Facility (FRF) is located on the Outer Banks of North Carolina, near the village of Duck (Figure 1).

The FRF research program provides a means for obtaining high-quality field data, particularly during storms, in support of the U.S. Army Corps of Engineers' coastal engineering research missions. The research pier is a reinforced concrete structure supported on 0.9-m-diam steel piles spaced 12.2 m apart along the pier's length and 4.6 m apart across the width. The pier deck is 6.1 m wide and extends from behind the duneline to about the 6-m water depth contour at a height of 7.75 m above the National Geodetic Vertical Datum (NGVD) of the year 1929.

One of the responsibilities of the FRF research program is the collection, analysis and dissemination of data on local bathymetric, oceanographic, and meteorological conditions. This summary is intended to provide basic data as soon as possible after they are obtained. Questions and/or comments concerning the data may be directed to Mr. Clifford F. Baron at (919) 261-3511.

Chapter 2 presents the meteorological data; Chapters 3 through 6 present oceanographic data; Chapter 7 presents nearshore profiles and bathymetry; and Chapter 8, if included, documents special events that occurred at the FRF during the month.

Table 1 is a list of instruments used and their operational status during the month. Figure 2 shows weather and ocean conditions for the month. Table 2 and Figure 3 identifies the location of the instruments. The water depths at the wave gauges and current meters vary and may be determined from information contained in Figure 9. Other installation information is contained in Table 1.

Times given in the report are referenced to eastern standard time (EST).

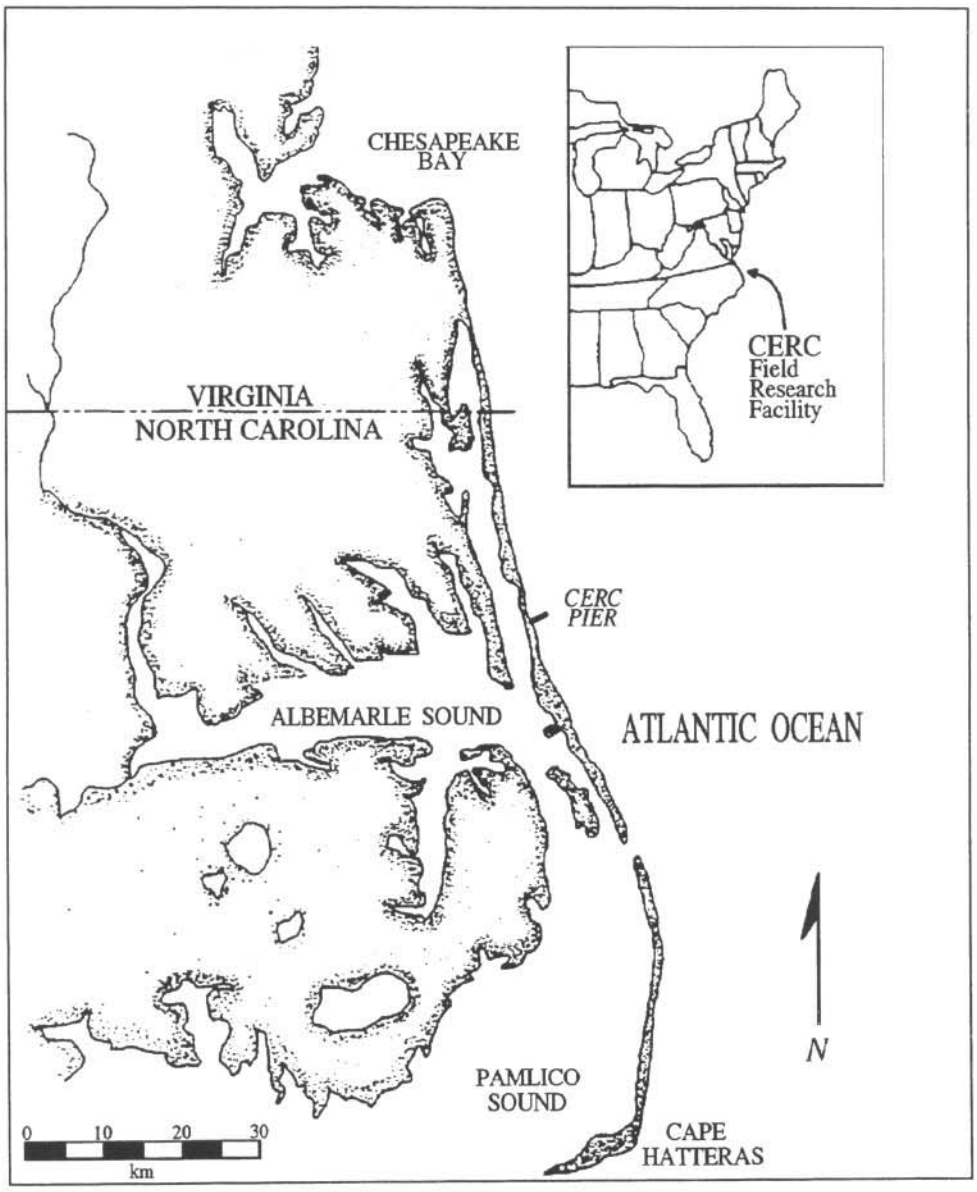

Figure 1. FRF Location Map

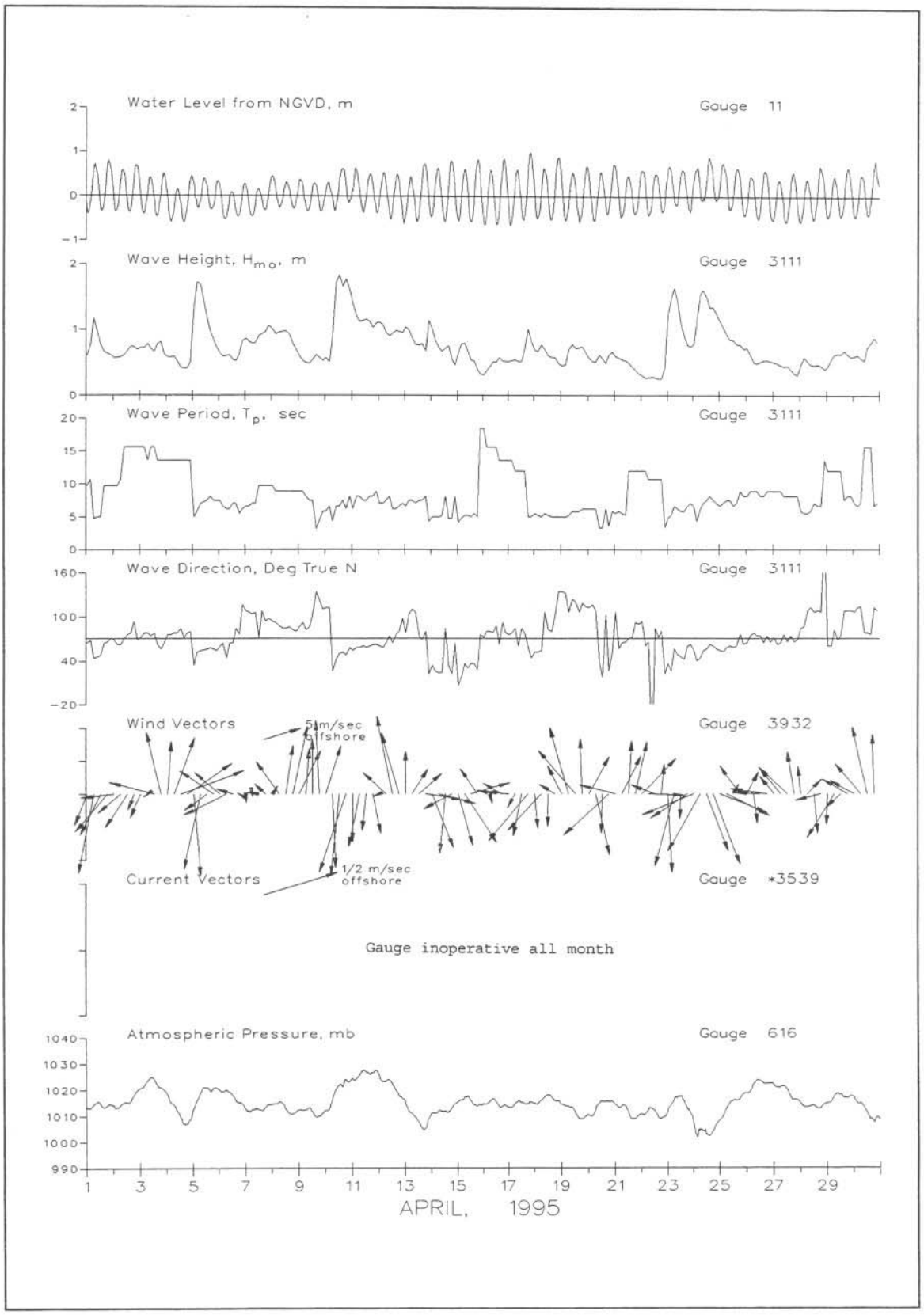

Figure 2. Month at a Glance

Table 1
Instrument Status/Data Availability

April 1995

Day of the month

Gauge ID	Description/Remarks		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
616	Atmospheric Pressure	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
604	Precipitation	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
624	Air Temperature	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
3932	Anemometer	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
641	Pressure Gauge on FRF pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
625	Baylor staff on FRF pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
3111	8 Meter Array 309 m north of FRF	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
111	Pressure Gauge center of 8 Meter Array	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
630	Waverider buoy 4.0 km offshore	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
3539	Current meter 343 m north of FRF pier (1.6 km offshore)	Gauge Status	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Data Collected	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	NOAA tide gauge at end of pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Visual Observations (daily oceanographic and meteorological observations)	Daily observation	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Gauge Status * = Operational / = Partial - = Non-Operational
Data Collected * = All / = Partial - = None
Visual Observations * = Complete / = Partial - = None

Table 2
Gauge Locations

Gauge ID	Description	Latitude Degrees N	Longitude Degrees W	FRF Coordinates Crosshore m	FRF Coordinates Longshore m	Gauge Depth NGVD, m	Water Depth NGVD, m
616	Atmospheric Pressure	36 10′ 57.03"	75 45′ 5.50"	11.60	569.00	-----	-----
3932	Anemometer	36 11′ 1.23"	75 44′ 43.07"	585.20	517.30	19.50	-----
641	Pressure Gauge	36 10′ 57.71"	75 44′ 56.23"	239.11	516.64	-1.64	-1.96
625	Baylor Staff	36 11′ 1.04"	75 44′ 43.72"	568.00	516.64	Surface	-8.36
3111	8 Meter Array North	36 11′ 19.14"	75 44′ 36.41"	915.23	990.16	-7.50	-7.90
	8 Meter Array South	36 11′ 11.28"	75 44′ 33.28"	914.20	735.37	-7.42	-7.90
	8 Meter Array East	36 11′ 13.70"	75 44′ 32.56"	954.51	800.58	-7.62	-8.13
	8 Meter Array West	36 11′ 12.48"	75 44′ 37.11"	834.66	800.37	-6.98	-7.44
111	Pressure Gauge in center of 8 M Array	36 11′ 14.06"	75 44′ 34.39"	914.43	825.52	-7.76	-8.08
630	Waverider Buoy	36 10′ 5.10"	75 41′ 59.30"	3934.96	-2400.81	Surface	-17.00
3539	Current Meter	36 11′ 23.57"	75 44′ 9.12"	1605.80	907.60	-11.60	-11.70
11	NOAA Tide Gauge	36 11′ 1.25"	75 44′ 42.60"	596.49	514.20	Surface	-7.62

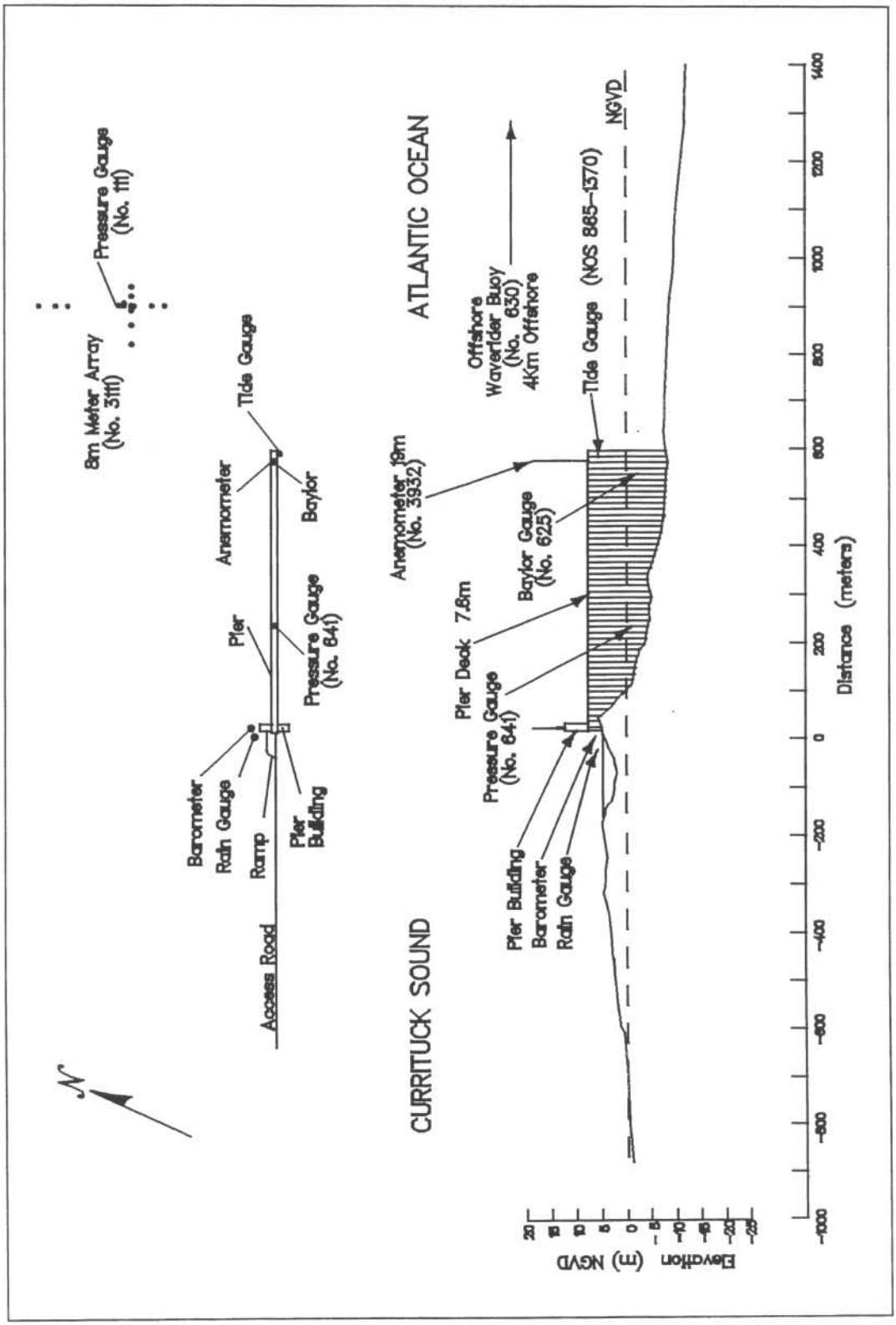

Figure 3. Instrument Locations, Elevations From NGVD

2 Meteorological Data

A variety of instruments have been installed at the FRF (Figure 3) to monitor the meteorological conditions. The data presented in Table 3 are collected and stored using a Digital Equipment Corporation VAXstation 4000. For each instrument identified in Table 1, a log is maintained and the records are stored for future reference.

Winds were measured at the end of the pier at an elevation of 19 m using a WeatherMeasure Skyvane anemometer. Monthly resultant wind speeds and directions (Figure 4) are determined by vector averaging the data. Wind directions (Table 3) indicate where the wind is coming from. Temperature and atmospheric pressure means (Table 3) are the average of the values presented for the month. Total precipitation is the sum for the month.

The following may be useful for converting the data in Table 3 to other frequently used units of measurement:

1. Millimeters (mm) to inches (in.) -
   mm x .03937 = in.

2. Millibars (mb) to inches of mercury (in. Hg) -
   mb x 0.02953 = in. Hg

3. Degrees Celsius (C) to degrees Fahrenheit (F) -
   (C x 9/5) + 32 = F

4. Meters per second (m/s) to knots (kn) -
   m/s x 1.943 = kn

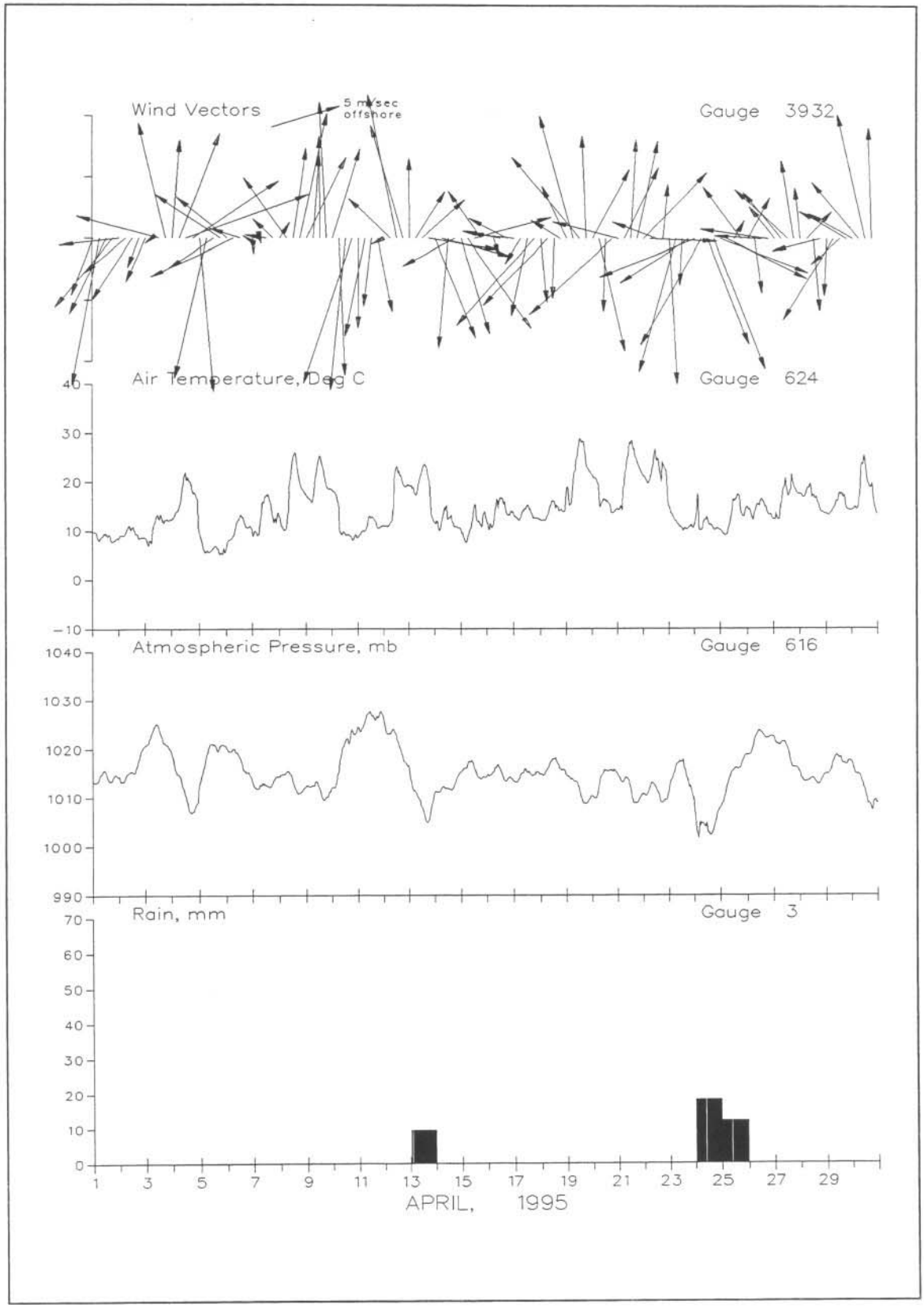

Figure 4. Meteorological Monthly Summary

Table 3
Meteorological Data

Apr 1995

Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
1	100	5	18	9.7	1013.2	0
	700	12	9	8.4	1014.8	0
	1300	7	22	9.3	1014.6	0
	1900	7	35	7.8	1014.3	0
2	100	4	82	9.0	1013.9	0
	700	4	46	9.6	1014.6	0
	1300	6	29	10.7	1015.3	0
	1900	2	18	8.3	1018.3	0
3	100	4	20	8.4	1020.9	0
	700	1	47	10.1	1023.7	0
	1300	6	107	12.3	1023.9	0
	1900	10	168	12.3	1020.9	0
4	100	8	183	12.7	1018.2	0
	700	9	197	15.4	1014.3	0
	1300	9	247	20.5	1009.6	0
	1900	7	231	17.6	1007.2	0
5	100	13	355	9.0	1013.5	0
	700	12	10	6.0	1019.1	0
	1300	4	50	6.5	1021.0	0
	1900	6	129	5.3	1020.8	0
6	100	5	134	7.6	1019.9	0
	700	6	60	9.1	1020.1	0
	1300	2	110	13.3	1017.9	0
	1900	0		10.6	1015.2	0
7	100	1	357	8.8	1012.6	0
	700	0		11.7	1012.7	0
	1300	1	99	17.4	1012.5	0
	1900	2	138	12.3	1013.6	0
8	100	1	208	12.3	1014.7	0
	700	6	149	11.8	1015.5	0
	1300	7	186	25.3	1012.6	0
	1900	10	190	19.5	1011.1	0
9	100	7	202	16.9	1012.5	0
	700	7	183	17.3	1012.5	0
	1300	8	179	25.4	1011.4	0
	1900	11	177	19.2	1010.1	0
10	100	8	194	18.1	1012.2	0
	700	11	357	10.1	1017.5	0
	1300	12	4	9.1	1022.1	0
	1900	12	16	8.1	1023.5	0

Table 3
Meteorological Data (continued)

Apr 1995

Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
11	100	7	1	9.0	1024.2	0
	700	8	9	10.1	1026.2	0
	1300	6	5	13.0	1026.8	0
	1900	6	350	10.4	1026.7	0
12	100	1	60	10.9	1024.8	0
	700	4	137	11.7	1023.5	0
	1300	12	169	23.2	1021.6	0
	1900	9	165	19.6	1017.5	0
13	100	7	179	19.2	1014.1	0
	700	4	208	17.2	1010.8	9
	1300	4	223	22.9	1007.4	0
	1900	5	280	20.3	1005.7	0
14	100	9	340	11.5	1011.3	0
	700	5	286	12.3	1012.2	0
	1300	9	4	12.7	1011.9	0
	1900	4	58	10.8	1013.3	0
15	100	8	345	9.3	1015.6	0
	700	9	329	9.1	1017.5	0
	1300	6	251	15.4	1015.6	0
	1900	4	149	10.7	1014.0	0
16	100	0		11.7	1014.7	0
	700	1	345	12.8	1016.0	0
	1300	3	102	16.7	1015.3	0
	1900	3	121	13.2	1014.0	0
17	100	3	97	13.0	1013.2	0
	700	2	27	13.0	1015.1	0
	1300	6	9	15.4	1015.3	0
	1900	9	36	12.7	1014.8	0
18	100	5	355	12.1	1014.8	0
	700	7	38	13.3	1016.2	0
	1300	5	1	15.7	1018.1	0
	1900	2	125	14.3	1015.6	0
19	100	5	157	19.0	1014.4	0
	700	10	166	21.3	1013.5	0
	1300	8	144	28.9	1010.5	0
	1900	8	178	23.4	1008.9	0
20	100	6	204	21.1	1010.2	0
	700	9	348	15.2	1013.6	0
	1300	6	1	16.3	1015.5	0
	1900	8	42	13.6	1015.4	0

Table 3
Meteorological Data (concluded)

Apr 1995

Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
21	100	5	106	14.3	1014.2	0
	700	6	202	21.8	1014.3	0
	1300	8	182	28.4	1010.3	0
	1900	8	190	23.8	1009.2	0
22	100	7	220	21.0	1010.6	0
	700	5	272	21.2	1013.0	0
	1300	3	113	24.3	1011.3	0
	1900	4	184	23.3	1009.4	0
23	100	12	357	14.8	1013.0	0
	700	11	13	12.0	1017.0	0
	1300	4	2	10.4	1017.9	0
	1900	6	53	10.7	1012.2	0
24	100	7	65	11.8	1005.8	0
	700	10	26	10.1	1004.8	18
	1300	9	342	11.7	1003.0	0
	1900	11	342	10.2	1004.8	0
25	100	7	294	9.9	1008.5	0
	700	6	301	10.1	1013.4	12
	1300	2	204	16.2	1016.1	0
	1900	5	148	13.4	1017.3	0
26	100	4	203	14.4	1018.9	0
	700	4	353	14.1	1022.6	0
	1300	3	93	16.6	1023.3	0
	1900	5	99	13.4	1022.4	0
27	100	3	146	12.3	1021.6	0
	700	5	145	15.8	1021.4	0
	1300	5	138	17.1	1019.7	0
	1900	6	172	18.9	1016.3	0
28	100	4	174	17.5	1014.3	0
	700	3	217	18.7	1013.4	0
	1300	6	355	17.4	1013.7	0
	1900	3	73	14.0	1013.5	0
29	100	5	2	13.4	1014.9	0
	700	7	27	14.6	1017.8	0
	1300	3	43	17.6	1018.4	0
	1900	4	124	14.5	1016.9	0
30	100	4	123	14.4	1016.3	0
	700	6	144	16.6	1014.8	0
	1300	10	168	24.1	1010.7	0
	1900	9	178	19.5	1007.4	0
		Resultant		Mean	Mean	Total
		1	70	14.5	1015.2	39

3 Wave Data

Wave data are collected from three different sets of instruments, as shown in Table 1 and Figure 3. The first is an array of fifteen pressure gauges, collectively referred to as gauge 3111 (gauge 111 being one of them). Directional information is computed from these gauges using a iterative maximum liklihood estimator. The second is a Baylor staff gauge (625) and a pressure gauge (641), both attached to the pier. The third is a Waverider buoy (630). The data are collected, analyzed, and stored on optical disc using a Digital Equipment Corporation VAXstation 4000. Data is sampled at 2 hertz, with five contiguous 34 minute records, for a total collection period of nearly 2 hours and 51 minutes. This report reflects the data collection periods of 0100, 0700, 1300, and 1900 EST. The results are based only on the first 34 minute record. The exception is the 8 Meter Array (3111) which condenses the first four records into one statistical value.

Wave height H_{mo} is an energy-based statistic equal to four times the standard deviation of the sea surface elevations. Wave height reported from the pressure gauge has been compensated for hydrodynamic attenuation using linear wave theory. Wave period is identified from the computation of a variance (energy) spectrum with 60 degrees of freedom calculated from a 34-min record. Peak wave period T_p is defined as the period associated with the maximum energy in the spectrum.

Table 4 presents the wave heights and periods for each wave record obtained at 6 hr intervals during the month. The monthly means and standard deviations from the means shown in Table 4 are average values computed from this data. Figure 5 is a time history of all H_{mo} and T_p values obtained for all gauges.

Differences in wave periods between wave gauges (Table 4 and Figure 5) may be the result of wave breaking, wave reformation, the presence of multiple wave trains containing nearly equal energy, and statistical variations in spectral estimations.

Table 4
Wave Data

Apr 1995

		641 Pressure Gauge		625 Baylor Gauge		3111 8 Meter Array			630 Waverider	
Day	Hour	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec
1	0100	0.21	10.3	0.61	9.9	0.61	9.8	64	0.64	9.9
	0700	0.77	4.5	1.13	4.6	1.17	4.8	44	1.34	5.0
	1300	0.35	4.6	0.79	4.9	0.77	5.0	48	0.84	5.0
	1900	0.36	5.1	0.68	4.6	0.63	9.8	66	0.74	4.8
2	0100	0.25	2.7	0.68	3.7	0.57	9.8	68	0.66	4.4
	0700	0.31	17.1	0.66	4.1	0.58	10.8	62	0.67	5.0
	1300	0.31	16.0	0.70	16.0	0.67	15.7	76	0.65	17.1
	1900	0.34	17.1	0.73	15.1	0.74	15.7	94	0.75	17.1
3	0100	0.27	16.0	0.66	16.0	0.72	15.7	72	0.65	15.1
	0700	0.32	15.1	0.68	15.1	0.77	13.6	78	0.66	15.1
	1300	0.25	14.3	0.68	14.3	0.66	15.7	78	0.61	14.3
	1900	0.38	13.5	0.81	14.3	0.81	13.6	56	0.88	14.3
4	0100	0.26	14.3	0.70	14.3	0.58	13.6	76	0.63	13.5
	0700	0.25	13.5	0.62	13.5	0.59	13.6	78	0.64	13.5
	1300	0.20	13.5	0.52	13.5	0.43	13.6	84	0.55	13.5
	1900	0.20	14.3	0.43	12.9	0.42	13.6	78	0.45	12.9
5	0100	0.79	4.5	1.04	4.6	1.34	5.0	34	1.29	4.6
	0700	0.80	7.2	1.58	7.8	1.67	7.1	54	1.99	7.4
	1300	0.66	6.0	1.15	6.5	1.18	7.6	56	1.34	8.3
	1900	0.36	7.8	0.97	7.8	0.84	7.6	56	1.02	7.8
6	0100	0.28	6.3	0.70	7.6	0.64	7.6	60	0.77	7.4
	0700	0.24	4.3	0.72	6.5	0.60	6.2	44	0.69	6.6
	1300	0.25	4.1	0.61	7.0	0.54	7.1	64	0.63	6.1
	1900	0.28	4.2	0.64	11.7	0.64	5.6	76	0.66	5.7
7	0100	0.58	6.6	0.91	6.6	0.86	6.6	108	1.02	6.5
	0700	0.47	7.2	0.92	7.2	0.79	7.1	104	0.90	7.2
	1300	0.56	9.2	0.92	9.2	0.90	9.8	72	0.95	8.6
	1900	0.57	9.5	1.00	9.5	0.96	9.8	94	0.92	9.2
8	0100	0.71	9.9	1.11	9.5	1.01	9.8	94	1.09	9.5
	0700	0.64	9.2	1.07	9.5	0.95	8.9	88	1.04	9.5
	1300	0.56	9.2	1.06	9.2	0.98	8.9	84	1.01	8.3
	1900	0.47	8.3	0.84	9.2	0.79	8.9	82	0.99	8.1
9	0100	0.38	6.1	0.61	8.6	0.60	8.9	86	0.80	8.9
	0700	0.28	5.5	0.57	8.6	0.50	8.2	82	0.58	8.3
	1300	0.31	7.2	0.56	8.6	0.54	7.6	104	0.62	8.1
	1900	0.34	4.5	0.63	7.6	0.62	3.1	0	0.77	7.8
10	0100	0.39	6.1	0.55	6.5	0.57	5.9	112	0.67	6.1
	0700	0.32	6.5	0.62	6.8	0.90	4.4	26	0.64	5.7
	1300	1.02	6.6	1.52	6.6	1.83	6.6	50	2.02	6.8
	1900	0.86	5.9	1.62	5.6	1.77	6.2	48	1.79	7.4

Table 4
Wave Data (continued)

Apr 1995

Day	Hour	641 Pressure Gauge Hmo,m	Tp,sec	625 Baylor Gauge Hmo,m	Tp,sec	3111 8 Meter Array Hmo,m	Tp,sec	Dir,TN	630 Waverider Hmo,m	Tp,sec
11	0100	0.79	5.6	1.30	6.1	1.40	6.2	54	1.62	6.0
	0700	0.60	5.1	1.13	8.3	1.13	8.2	58	1.27	8.1
	1300	0.52	5.6	1.12	6.8	1.16	7.6	58	1.23	7.6
	1900	0.42	4.9	0.94	8.1	1.03	8.2	62	1.03	7.8
12	0100	0.42	7.4	0.99	7.4	1.11	7.1	60	1.14	6.8
	0700	0.42	6.5	0.89	7.0	0.95	7.6	64	1.05	8.6
	1300	0.39	4.6	1.07	8.6	0.94	6.2	64	1.06	6.1
	1900	0.57	5.6	1.04	7.0	0.97	6.6	80	1.22	5.5
13	0100	0.61	6.3	1.09	7.0	1.03	6.6	78	1.13	6.8
	0700	0.57	7.2	0.99	7.2	0.87	7.6	110	0.99	7.2
	1300	0.43	7.2	0.86	7.2	0.77	7.6	74	0.79	7.4
	1900	0.47	8.1	0.83	8.1	0.67	8.2	80	0.81	7.4
14	0100	0.63	4.7	1.01	5.2	1.01	5.0	34	1.27	5.1
	0700	0.50	4.8	0.64	5.0	0.73	5.0	24	0.85	5.3
	1300	0.43	3.7	0.77	4.2	0.72	8.2	84	0.78	8.3
	1900	0.42	4.8	0.66	4.7	0.56	4.8	22	0.73	5.2
15	0100	0.46	4.2	0.79	4.4	0.65	4.2	6	0.69	4.3
	0700	0.62	5.3	0.78	5.4	0.79	5.3	36	1.00	5.2
	1300	0.23	5.4	0.53	5.2	0.53	5.0	36	0.71	5.7
	1900	0.31	5.3	0.47	5.3	0.40	5.0	28	0.63	5.1
16	0100	0.13	18.3	0.38	17.1	0.31	18.5	72	0.35	9.2
	0700	0.25	16.0	0.43	15.1	0.44	15.7	80	0.42	15.1
	1300	0.20	15.1	0.53	14.3	0.51	15.7	88	0.48	13.5
	1900	0.31	14.3	0.61	14.3	0.53	13.6	92	0.57	14.3
17	0100	0.18	13.5	0.55	12.9	0.52	13.6	76	0.50	13.5
	0700	0.30	13.5	0.61	12.9	0.54	12.0	84	0.56	12.9
	1300	0.29	12.9	0.59	12.9	0.52	12.0	84	0.56	12.2
	1900	0.57	4.4	0.98	4.5	1.02	5.0	58	0.92	5.0
18	0100	0.32	4.7	0.76	5.3	0.69	5.6	52	0.75	5.0
	0700	0.42	4.6	0.85	5.2	0.77	5.0	54	0.82	4.9
	1300	0.32	5.7	0.67	5.7	0.60	5.3	82	0.72	5.3
	1900	0.31	5.1	0.64	5.0	0.58	5.0	102	0.64	5.2
19	0100	0.27	4.9	0.53	5.0	0.46	5.0	134	0.57	5.1
	0700	0.39	5.5	0.67	5.3	0.69	5.3	106	0.78	5.0
	1300	0.51	5.9	0.80	6.0	0.72	5.9	120	0.91	5.7
	1900	0.54	6.0	0.68	6.3	0.74	6.2	118	0.92	6.3
20	0100	0.47	6.0	0.64	6.3	0.58	6.2	112	0.74	6.3
	0700	0.29	6.1	0.54	6.1	0.51	6.2	108	0.56	6.1
	1300	0.38	6.0	0.61	6.0	0.56	3.4	18	0.63	5.9
	1900	0.36	3.6	0.77	3.7	0.62	3.6	26	0.66	3.8

Table 4
Wave Data (concluded)

Apr 1995

Day	Hour	641 Pressure Gauge Hmo,m	641 Pressure Gauge Tp,sec	625 Baylor Gauge Hmo,m	625 Baylor Gauge Tp,sec	3111 8 Meter Array Hmo,m	3111 8 Meter Array Tp,sec	3111 8 Meter Array Dir,TN	630 Waverider Hmo,m	630 Waverider Tp,sec
21	0100	0.35	5.6	0.73	12.2	0.60	5.6	106	0.66	5.6
	0700	0.22	5.0	0.61	12.2	0.54	5.6	64	0.59	5.5
	1300	0.25	5.2	0.57	5.2	0.50	12.0	70	0.59	5.3
	1900	0.22	12.2	0.55	12.2	0.39	12.0	92	0.53	5.2
22	0100	0.20	6.0	0.38	11.7	0.31	12.0	94	0.36	5.6
	0700	0.13	11.2	0.33	10.7	0.28	10.8	66	0.28	11.2
	1300	0.17	12.9	0.30	11.2	0.28	10.8	84	0.30	10.7
	1900	0.12	13.5	0.36	9.9	0.26	10.8	80	0.27	10.7
23	0100	0.72	4.4	0.96	4.1	1.22	4.8	36	1.08	4.1
	0700	0.73	6.0	1.49	6.8	1.64	6.6	56	1.80	6.5
	1300	0.77	6.1	1.16	6.1	1.11	5.9	46	1.23	6.1
	1900	0.37	5.6	0.88	5.6	0.76	6.6	60	0.87	5.9
24	0100	0.48	3.6	0.96	6.5	0.78	6.6	54	0.91	6.5
	0700	0.75	5.5	1.39	6.0	1.56	6.2	44	1.67	5.9
	1300	0.91	6.6	1.38	7.2	1.50	7.6	56	1.47	7.2
	1900	0.78	4.0	1.13	7.8	1.34	7.6	60	1.36	7.6
25	0100	0.66	6.8	1.07	6.3	1.13	6.6	54	1.32	6.8
	0700	0.49	5.7	0.82	8.1	0.92	7.6	58	0.98	7.6
	1300	0.35	6.8	0.89	6.6	0.84	6.6	58	0.78	6.1
	1900	0.31	8.3	0.84	8.1	0.77	8.9	76	0.77	8.9
26	0100	0.25	8.3	0.78	8.3	0.72	8.2	64	0.75	8.1
	0700	0.23	8.3	0.70	9.5	0.51	8.9	78	0.55	8.3
	1300	0.20	7.8	0.54	8.3	0.51	8.2	74	0.47	8.1
	1900	0.24	8.9	0.57	8.3	0.54	8.9	74	0.52	8.9
27	0100	0.18	12.8	0.54	9.2	0.50	8.9	72	0.46	8.9
	0700	0.21	7.0	0.47	7.4	0.46	8.9	64	0.44	8.6
	1300	0.19	6.5	0.49	8.3	0.45	8.2	66	0.45	8.3
	1900	0.19	15.1	0.36	8.1	0.34	8.2	66	0.37	7.4
28	0100	0.18	5.1	0.36	9.2	0.47	5.9	84	0.40	5.2
	0700	0.37	6.1	0.54	5.6	0.51	5.6	108	0.61	5.6
	1300	0.28	6.0	0.64	2.8	0.46	7.1	106	0.54	6.5
	1900	0.35	6.6	0.50	13.5	0.45	6.6	106	0.49	6.5
29	0100	0.19	12.9	0.53	12.9	0.44	12.0	60	0.43	11.7
	0700	0.43	3.5	0.80	12.9	0.62	12.0	82	0.69	12.2
	1300	0.29	3.7	0.74	11.7	0.63	12.0	74	0.71	11.2
	1900	0.52	7.8	0.75	8.1	0.62	8.2	108	0.71	7.8
30	0100	0.34	8.1	0.74	7.8	0.60	7.1	106	0.66	7.6
	0700	0.38	6.8	0.60	7.0	0.57	7.1	114	0.60	7.4
	1300	0.42	3.8	0.82	15.1	0.74	15.7	78	0.76	16.0
	1900	0.67	6.5	0.92	6.1	0.88	6.6	112	1.03	6.0
Mean		0.41	7.8	0.77	8.4	0.75	8.4	71	0.82	8.0
Std dev		0.19	3.7	0.27	3.3	0.32	3.3	25	0.34	3.1

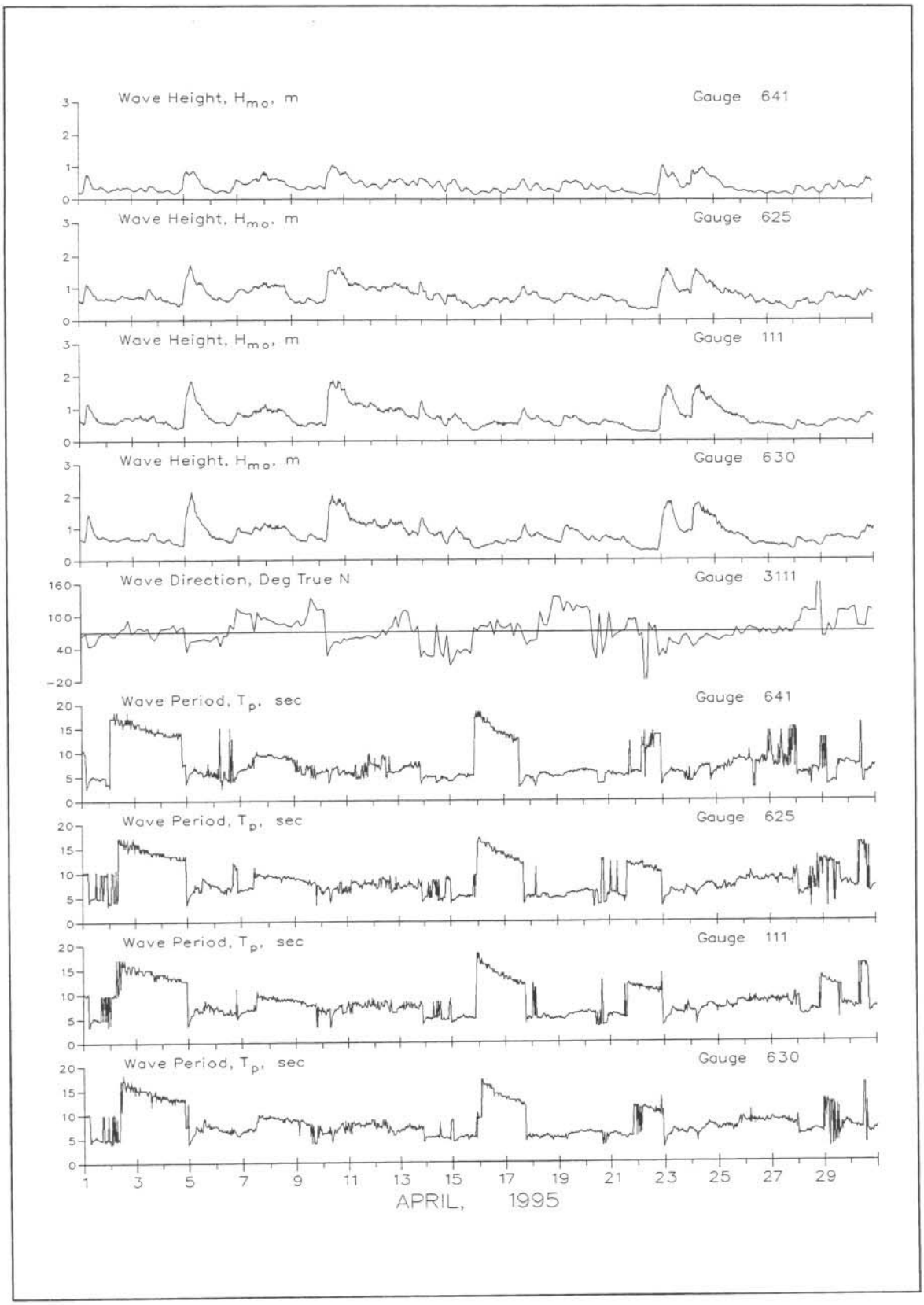

Figure 5. Wave Heights and Periods

4 Current Data

Current data (Table 5) are collected from a Marsh-McBirney electromagnetic biaxial current meter and by visually observing the movement of small drogues on the water surface in the surf and at the seaward end of the pier, as well as 500 m updrift of the pier, approximately 12 m offshore (Table 6).

Since the shoreline orientation is approximately N20W, longshore currents flow either toward 340 deg (i.e. northward) or toward 160 deg (i.e. southward). Similarly, cross-shore currents are either onshore (westward) or offshore (eastward). All current speeds are given in centimeters per second (cm/sec). Resultant speeds and directions are determined by vector averaging the cross-shore and longshore data. Current directions indicate the direction that the current is moving towards. Current data are plotted in Figure 2.

Table 5
Current Meter Data - Gauge 3539

APRIL 1995

Day	Time	Cross Shore	Long Shore	Speed	Dir
1	100				
	700				
	1300				
	1900				
2	100				
	700				
	1300				
	1900				
3	100		Gauge		
	700				
	1300		inoperative		
	1900				
4	100		all		
	700				
	1300		month		
	1900				
5	100				
	700				
	1300				
	1900				
6	100				
	700				
	1300				
	1900				
7	100				
	700				
	1300				
	1900				
8	100				
	700				
	1300				
	1900				
9	100				
	700				
	1300				
	1900				
10	100				
	700				
	1300				
	1900				
11	100				
	700				
	1300				
	1900				
12	100				
	700				
	1300				
	1900				
13	100		Gauge		
	700				
	1300		inoperative		
	1900				
14	100		all		
	700				
	1300		month		
	1900				
15	100				
	700				
	1300				
	1900				
16	100				
	700				
	1300				
	1900				
17	100				
	700				
	1300				
	1900				
18	100				
	700				
	1300				
	1900				
19	100				
	700				
	1300				
	1900				
20	100				
	700				
	1300				
	1900				
21	100				
	700				
	1300				
	1900				
22	100				
	700				
	1300				
	1900				
23	100		Gauge		
	700				
	1300		inoperative		
	1900				
24	100		all		
	700				
	1300		month		
	1900				
25	100				
	700				
	1300				
	1900				
26	100				
	700				
	1300				
	1900				
27	100				
	700				
	1300				
	1900				
28	100				
	700				
	1300				
	1900				
29	100				
	700				
	1300				
	1900				
30	100				
	700				
	1300				
	1900				

KEY:

+cross-shore = offshore, cm/sec
-cross-shore = onshore, cm/sec
+longshore = south, cm/sec
-longshore = north, cm/sec
Speed = Resultant speed, cm/sec
Dir = Resultant direction, degrees true north

Table 6
Visually Observed Current Data

Apr 1995

	Pier End				Mid-Surf Zone				Beach		
Day	Cross Shore	Long Shore	Speed	Dir	Cross Shore	Long Shore	Speed	Dir	Location	Speed	Dir
1	-8	55	56	169	0	55	55	160	North	37	S
2	-6	41	41	169	-3	15	15	171	North	17	S
3	-2	12	12	169	1	5	5	143	North	24	N
4	8	-51	51	349	15	-51	53	357	South	22	N
5	0	51	51	160	0	87	87	160	North	55	S
6	-6	20	21	177	5	8	10	129	North	32	N
7	2	-11	11	349	6	-41	41	349	South	30	N
8	3	-12	12	357	17	-55	58	357	South	49	N
9	17	-34	38	7	18	-24	30	17	South	20	N
10	-3	30	31	166	0	30	30	160	North	26	S
11	0	36	36	160	0	76	76	160	North	48	S
12	0	15	15	160	6	29	30	149	North	3	S
13	15	15	21	115	17	-29	34	11	South	40	N
14	4	36	36	154	5	32	32	151	North	17	S
15	0	51	51	160	-6	30	31	171	North	22	S
16	-18	36	40	187	0	0	0		North	0	
17	4	15	15	143	0	-6	6	340	South	2	N
18	-11	23	25	187	-14	23	26	191	North	11	S
19	16	-47	50	359	9	-47	48	351	South	24	N
20	0	27	27	160	0	17	17	160	North	10	S
21	11	-32	34	359	12	-27	29	4	South	14	N
22	0	18	18	160	0	0	0		North	8	N
23	-5	47	47	166	-9	87	88	166	North	44	S
24	-9	44	44	171	0	87	87	160	North	41	S
25	3	30	31	154	17	55	58	143	North	34	S
26	1	7	7	149	-2	11	11	171	North	9	S
27	4	-41	41	346	3	-21	21	349	South	16	N
28	5	-32	32	349	6	-17	18	359	South	18	N
29	-6	15	16	182	-2	8	8	171	North	12	S
30	7	-12	14	11	8	-27	28	357	South	18	N

KEY:
+cross-shore = offshore, cm/sec
-cross-shore = onshore, cm/sec
+longshore = south, cm/sec
-longshore = north, cm/sec
Speed = Resultant speed, cm/sec
Dir = Resultant direction, degrees true north

5 Visual Observations

Visual wave direction measurements (Table 7) of both the primary wave train (i.e. that having the higher wave heights) and the secondary wave train (which must be clearly distinguishable as a wave train separate from the primary waves but not surface chop or capillary waves) are taken daily at the seaward end of the pier. The direction of the primary wave train just north of the seaward end of the pier is also determined using a Raytheon Marine Pathfinder radar and measuring the alignment of the wave crests at approximately the same location as the visual measurements. The pier axis (considered perpendicular to the beach at the FRF) is oriented 70 deg east of true north; consequently, wave angles greater than 70 deg indicate that the waves were coming from the south side of the pier.

The width of the surf zone (seawardmost breaker position to shoreline) is determined from the pier deck.

Measurements of surface water temperature, density, and depth of visibility are also taken daily at the seaward end of the pier. A Bucket Thermometer is lowered about 0.3 m into the water and allowed to remain for at least one minute. The temperature is then read, and a hydrometer is used to determine the density. A Secchi disc is used to determine the depth of visibility.

Table 7
Visual Observations

Apr 1995

Day	Time	Wave Approach Angle at Pier End deg from True N Primary	Secondary	Radar Wave Angle deg from True N	Width of Surf Zone,m	Water Characteristics at Pier End Temp.,C	Density g/cc	Secchi Vis.,m
1	0952	50	25	45	115	10.0	1.0224	1.5
2	1008	70	25		5	10.6	1.0220	2.4
3	0613	70	30		112	8.0	1.0225	3.0
4	0613	70	120		91	8.6	1.0257	1.5
5	0630	55	20	55	296	8.6	1.0261	0.9
6	0619	70		70	120	8.9	1.0252	2.4
7	0626	105			129	8.9	1.0261	2.4
8	0820	95		90	132	9.4	1.0260	1.8
9	0840	85	115		86	9.7	1.0257	2.4
10	0646	85	5		5	9.7	1.0259	2.7
11	0633	55	35	60	147	10.6	1.0260	1.2
12	0620	75	60		134	11.1	1.0239	1.8
13	0630	80	120		102	10.6	1.0254	1.8
14	0745	35	60		16	11.1	1.0250	3.7
15	0755	30			34	11.7	1.0250	2.7
16	1012	120			9	12.2	1.0228	2.7
17	0613	85			9	11.9	1.0235	2.4
18	0643	40	95		9	12.5	1.0230	2.7
19	0630	80	145	85	4	13.1	1.0226	2.7
20	0718	90			58	11.7	1.0250	2.7
21	0610	60			110	13.9	1.0235	4.0
22	0900	105			5	13.3	1.0250	4.9
23	0912	50	25	50	208	13.1	1.0245	2.7
24	0640	40	25	40	195	12.8	1.0240	1.8
25	0620	55	35	55	126	12.8	1.0223	1.8
26	0626	70			5	12.5	1.0236	2.4
27	0633	65			5	13.1	1.0232	2.1
28	0608	120	80		7	11.9	1.0246	2.4
29	1000	40		55	97	13.6	1.0242	4.6
30	1014	80	130		9	14.2	1.0228	3.0

6 Water Levels

Since 1978, the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) has operated a primary tide station (No. 865-1370) at the seaward end of the FRF pier. A NOS acoustic tide gauge (Next Generation Water Level Measurement System, NGWLMS) is used to collect water level data every 6 minutes throughout the month.

The variation in water level during the month is shown in Figure 6 along with a list of means and extreme values. This presentation is useful in identifying effects of both meteorological and astronomical forces on the open coast water level. Table 8 contains the range, high, low, and mean water level for each 12.42-hr tidal cycle.

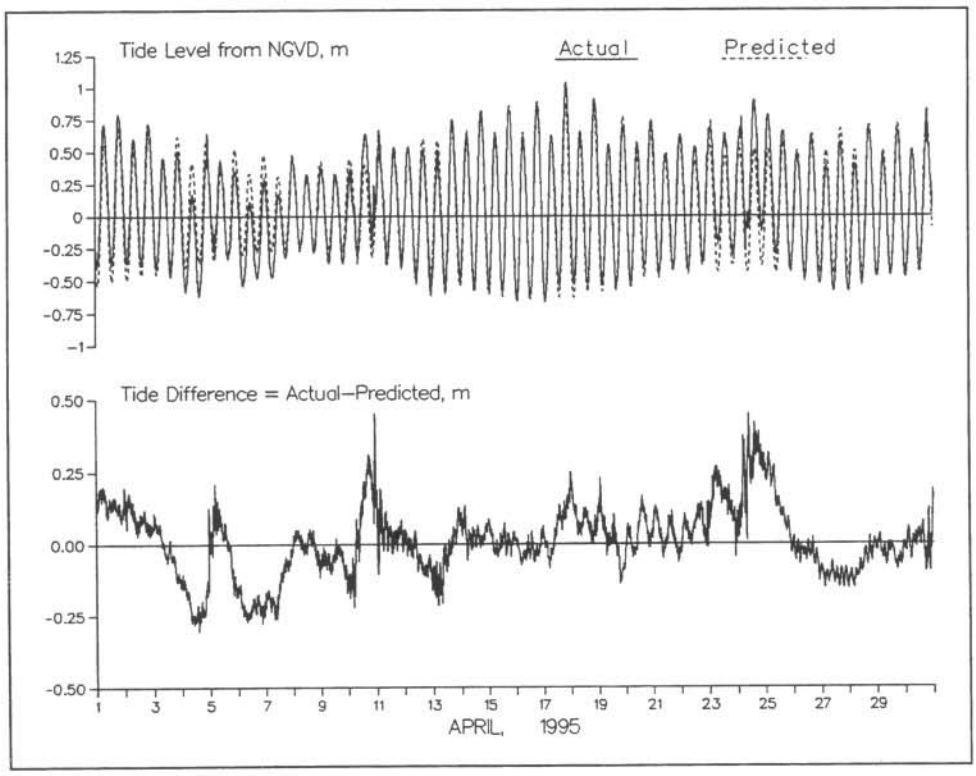

Figure 6. Water Level Variation

Table 8
Water Levels, m NGVD

APR 1995 Tide Levels

	High			Low		Mean	Range		High			Low		Mean	Range
Day	Time	m	Day	Time	m	m	m	Day	Time	m	Day	Time	m	m	m
1	0754	0.72	1	0142	-0.40	0.17	1.12	16	0736	0.62	16	0148	-0.66	-0.02	1.28
1	1954	0.79	1	1412	-0.38	0.21	1.18	16	1954	0.86	16	1300	-0.64	0.11	1.50
2	0854	0.60	2	0236	-0.37	0.11	0.97	17	0818	0.61	17	0224	-0.67	-0.02	1.28
2	2030	0.72	2	1436	-0.38	0.16	1.10	17	2036	1.04	17	1424	-0.54	0.24	1.58
3	0848	0.44	3	0318	-0.41	0.02	0.86	18	0912	0.65	18	0312	-0.54	0.07	1.19
3	2112	0.51	3	1454	-0.47	0.01	0.98	18	2136	0.91	18	1524	-0.54	0.19	1.45
4	1000	0.17	4	0400	-0.59	-0.21	0.76	19	1006	0.55	19	0400	-0.54	0.03	1.09
4	2306	0.64	4	1536	-0.63	-0.06	1.27	19	2248	0.71	19	1554	-0.58	0.07	1.28
5	1012	0.44	5	0512	-0.30	0.08	0.73	20	1100	0.57	20	0518	-0.56	0.02	1.12
5	2248	0.35	5	1636	-0.34	-0.01	0.68	20	2354	0.75	20	1654	-0.40	0.17	1.14
6	1142	0.11	6	0530	-0.54	-0.22	0.66	21	1306	0.48	21	0600	-0.47	0.02	0.95
6	2354	0.30	6	1730	-0.48	-0.12	0.78	22	0030	0.63	21	1818	-0.43	0.11	1.06
7	1248	0.17	7	0712	-0.48	-0.16	0.65	22	1324	0.53	22	0730	-0.43	0.07	0.96
8	0024	0.47	7	1806	-0.33	0.07	0.80	23	0242	0.74	22	1918	-0.36	0.19	1.10
8	1312	0.33	8	0654	-0.27	0.03	0.60	23	1424	0.63	23	0842	-0.23	0.21	0.87
9	0100	0.39	8	1930	-0.29	0.05	0.67	24	0436	0.77	23	2200	-0.35	0.20	1.11
9	1324	0.33	9	0824	-0.37	-0.01	0.69	24	1506	0.89	24	0736	-0.28	0.34	1.17
10	0318	0.37	9	2042	-0.37	-0.02	0.74	25	0336	0.78	24	2124	-0.13	0.32	0.91
10	1542	0.63	10	0848	-0.37	0.20	1.00	25	1630	0.66	25	0936	-0.30	0.18	0.96
11	0306	0.67	10	2112	-0.25	0.20	0.91	26	0406	0.47	25	2236	-0.44	0.03	0.92
11	1606	0.53	11	0918	-0.38	0.09	0.91	26	1636	0.62	26	1100	-0.51	0.06	1.13
12	0448	0.54	11	2206	-0.41	0.09	0.95	27	0536	0.39	27	0000	-0.53	-0.07	0.92
12	1654	0.52	12	1054	-0.53	0.02	1.05	27	1742	0.57	27	1118	-0.59	-0.01	1.16
13	0524	0.51	12	2300	-0.62	-0.06	1.14	28	0600	0.40	28	0024	-0.59	-0.09	0.99
13	1736	0.75	13	1136	-0.61	0.09	1.35	28	1754	0.69	28	1206	-0.54	0.08	1.23
14	0618	0.66	14	0006	-0.50	0.08	1.16	29	0648	0.49	29	0030	-0.48	0.00	0.96
14	1836	0.82	14	1154	-0.58	0.13	1.40	29	1906	0.66	29	1254	-0.47	0.09	1.13
15	0624	0.64	15	0106	-0.57	0.03	1.21	30	0730	0.51	30	0106	-0.48	0.01	0.99
15	1848	0.84	15	1242	-0.60	0.12	1.44	30	1954	0.82	30	1330	-0.44	0.15	1.27

7 Bathymetry

A. Nearshore Profiles. In order to document profile response away from the pier, surveys of four profile lines extending 900 to 1,000 m from shore and located 489 and 581 m north and 517 and 608 m south of the FRF pier are conducted bi-weekly, after storms, and during more complete bathymetric surveys.

These profiles are obtained using the CRAB-Geodimeter surveying system; a Geodimeter 140-T self-tracking, electronic theodolite, distance meter, in combination with the Coastal Research Amphibious Buggy (CRAB), a 10.7 m high, self-powered, mobile tripod on wheels.

Figure 7 shows the last survey in March 1995 and the survey(s) in April 1995 on profile line 188, located 517 m south of the pier.

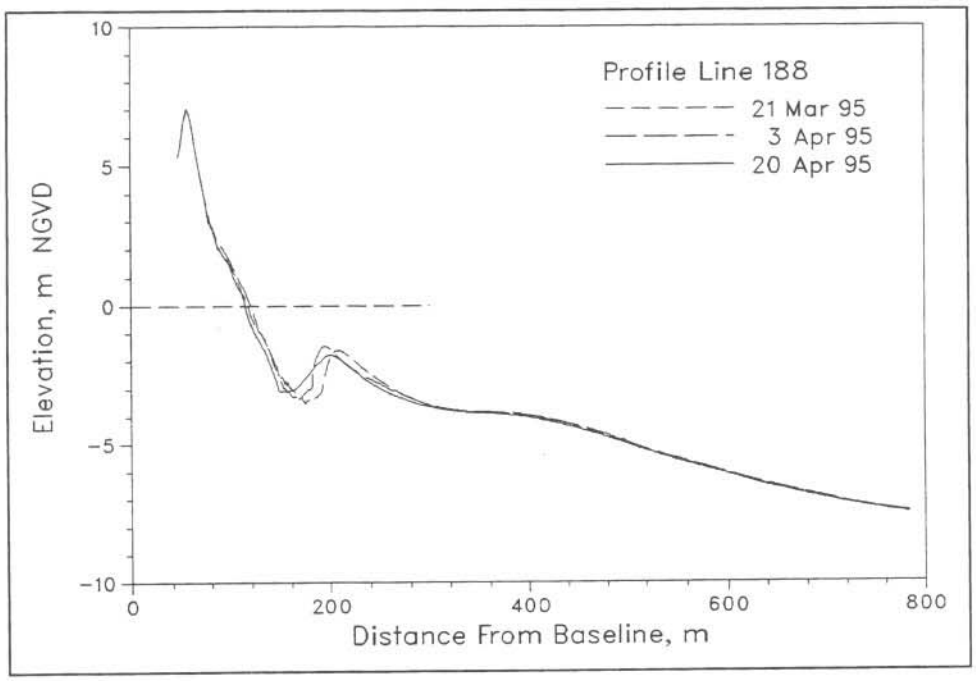

Figure 7. Monthly CRAB Profiles on Profile Line 188.

The profile envelope (Figure 8) reflects the maximum changes that occurred on the profile during 1995. Cross-hatched areas indicate changes to the annual envelope which occurred in April.

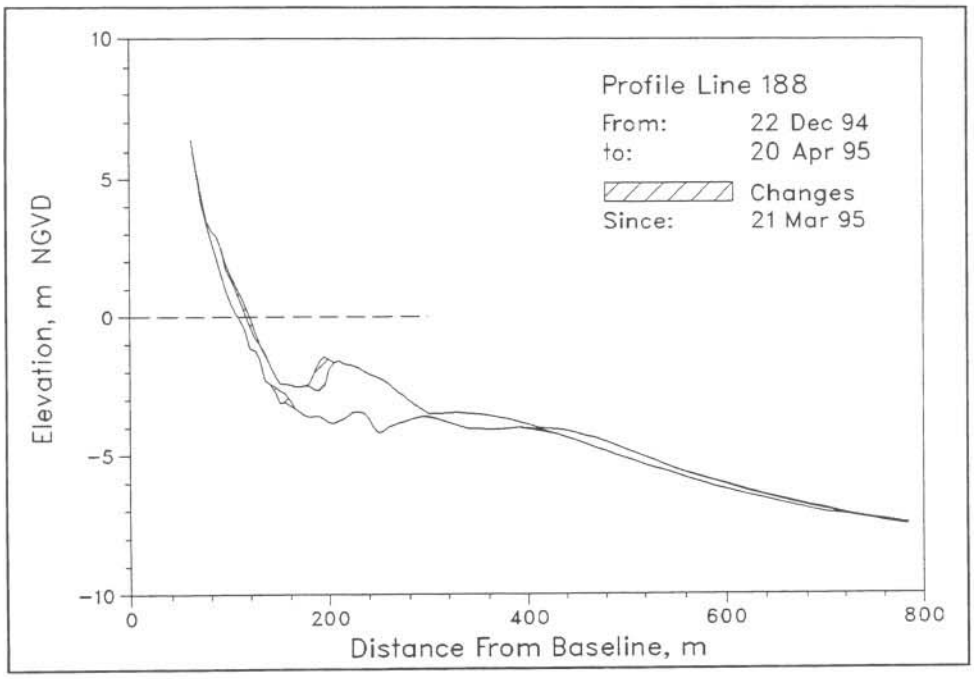

Figure 8. Profile Envelope - Profile Line 188.

B. Bathymetry. Figure 9 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 21 April. Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition.

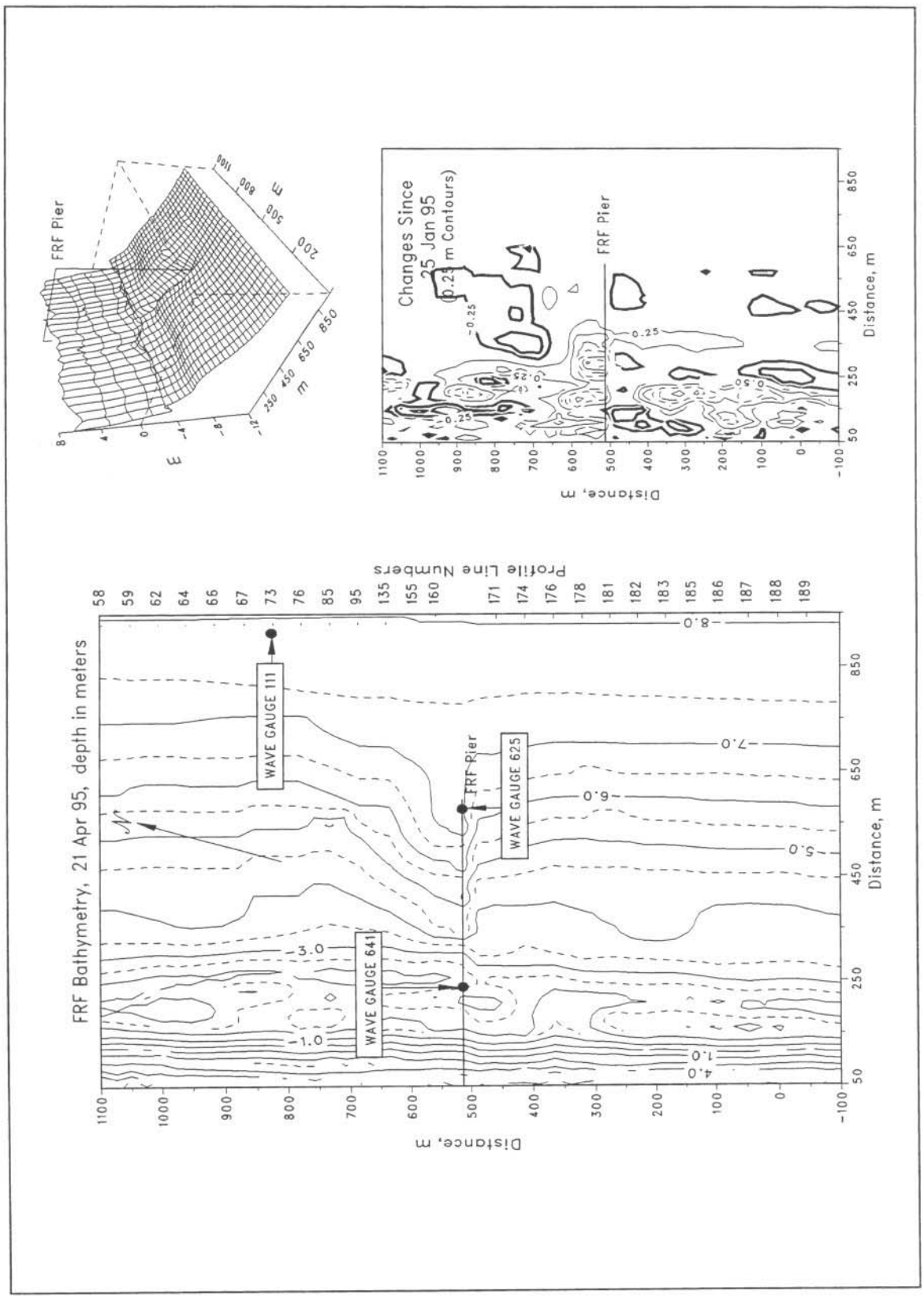

Figure 9. FRF Bathymetry, Depths Relative to NGVD

Distribution List

Government Agencies:

Back Bay National Wildlife Refuge
USACE-OCE
USACE-SAD
USACE-NAP
USACE-SAW
USACE-WES
NAVSAC
NOAA/NOS/OMS
National Marine Fisheries
U.S. Geological Survey
U.S. Library of Congress
U.S. National Park Service
U.S. National Weather Service
U.S. Naval Academy
U.S. Naval Civil Eng. Lab
U.S. Naval Oceanographic Off.
U.S. Naval Research Lab

Colleges/Universities:

Bucknell University
California Inst. of Tech.
Duke Marine Lab
East Carolina University
Florida Inst. of Tech.
M.I.T.
Naval Post Graduate School
NC State University
Old Dominion University
Oregon State University
Prince George's College
Scripps Institution of Oceanography
Stockton State College
University Calif-Berkeley
University of Florida
University of Maryland-College Park
University of Maryland-Baltimore
University of North Carolina
University of N C-Seagrant Program
University of Virginia
Va. Inst. of Marine Science
Rutgers University

Others:

Allied Signal Aerospace Co.
Applied Physics Lab
Cape Hatteras Nat. Seashore
Coastal and Est. Res., Inc.
Coastal Science & Eng., Inc.
Dr. Cy Galvin
GEOMET Tech., Inc.
Mr. Hodges
Dr. Hylton
Mr. Mason
Mr. Rodgers
WCTI-TV
MEC Systems Corporation
Moffatt & Nichol, Eng.
N.C. Div. Coastal Management
Oregon Inlet & Waterways Commis.
Raleigh-Durham Airport
Mr. Rowland
Mr. Savage
Science Application Int'l. Corp
Sherwood Industries
SEASUN Power Systems

Foreign:

Christchurch, Barbados
Ministry of Works, Bahamas
Dalhousie University, Halifax Nova Scotia
Queen's University, Ontario (Canada)
Ministry of Construction, Coastal Division (Japan)
Norwegian Hydrodynamic Laboratories (Norway)
University of Sydney (Australia)