MANUAL FOR WAVE RUNUP ANALYSIS
COASTAL FLOOD INSURANCE STUDIES

Prepared For

Federal Insurance Administration
Federal Emergency Management Agency

November 1981

Stone & Webster Engineering Corporation
Boston, Massachusetts

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

SYMBOLS

d_b - water depth at breaking (ft)

d_s - maximum water depth of slope segment intersected by stillwater level

H_b - breaking wave height (ft)

H_i - various deepwater wave heights used for wave runup computations (ft)

H_{min} - minimum wave height of H_i

H_s or H'_o - deepwater significant wave height, or design wave height (ft)

m - beach slope

R_i - wave runups corresponding to H_i (ft)

r - roughness coefficient

T_s or T - significant wave period, or design wave period (sec)

L_b - wave length at breaking (ft)

SECTION 1

INTRODUCTION

The coast of the northern Atlantic Ocean is subject to intense wave action during the hurricane and northeaster storm seasons. High astronomical tide and storm surge individually are not sufficient to inflict the types and degrees of damage observed on the coast. However, together these events combine to raise the stillwater level and allow accompanying waves to penetrate farther inland than permitted by normal water levels. Structures which in the absence of waves might experience little or no damage can be damaged when wave action is superimposed on elevated stillwater levels. The need exists to devise a method to account for this effect.

This manual describes a method developed by Stone & Webster Engineering Corporation (S&W) to determine wave crest elevations due to wave breaking and wave runup for use in Federal Emergency Management Agency (FEMA) coastal flood insurance studies. The scope of work (S&W 1979) calls for an analysis which will complement the National Academy of Sciences (NAS) wave height analysis method (NAS 1977, FEMA 1981). NAS's method had been developed for FEMA to analyze wave crest elevations seaward of the stillwater line. The wave height diminishes toward the stillwater line according to the NAS method. The S&W method determines wave crest elevations landward of the stillwater line and to a certain distance seaward of the stillwater line where it matches the NAS method. This manual has been prepared under FEMA contract No. H-4092.

The variation of wave height from initial breaking point to highest runup along a beach transect cannot be exactly specified. Existing coastal engineering literature, however, does provide a variety of graphs, reports, and laboratory and field measurements for breaking and broken wave crest analysis. The S&W method represents a simple and yet realistic wave crest profile consistent with existing state-of-the-art technology to describe wave height variation in the surf and runup zone. The references and bibliography section cites the results of a literature search initiated as part of the scope of work.

SECTION 2

BASIC CONCEPTS

Figure 2-1, Wave Crest Profile, presents a schematic of the wave crest envelope along a beach profile. The S&W method has been formulated to determine the maximum wave runup point and the wave profile between the runup point and NAS wave profile.

2.1 MAXIMUM RUNUP POINT

Runup curves (Stoa 1978b) are used in a computer program (Appendix A) to determine the maximum runup. Runup is a function of beach slope, m, deepwater wave height H_i, and wave period, T_s. H_i's are a series of wave heights ranging from a minimum wave height, H_{min} to the significant wave height, H_s for wave runup calculations. H_{min} is a small wave height with a probability of 5 percent or less in a wave spectrum. For example, H_{min} is 3 ft for 11-second period waves and 5 ft for 14-second period waves. In general, the maximum wave runup for a given wave spectrum is produced by waves of moderate height and long period (low wave steepness).

The wave runup computer program is operated with an ensemble of deepwater wave heights, H_i, a wave period, T_s, and the beach profile. The program yields corresponding wave runups, R_i, from which the maximum wave runup is obtained to define the point of maximum runup.

2.2 WAVE CREST PROFILE

The wave crest profile is constructed as follows. The profile based on the NAS methodology is drawn first. The NAS wave profile is characterized by having a wave crest which is 0.55 of its local depth above the stillwater level for open coastal areas without the presence of obstructions. A horizontal line parallel to the stillwater level is drawn from the maximum runup point toward offshore intersecting the NAS profile at a point that has the same elevation as the maximum runup point. This horizontal profile and the NAS profile seaward of the point of intersection constitute the wave crest profile along a beach transect.

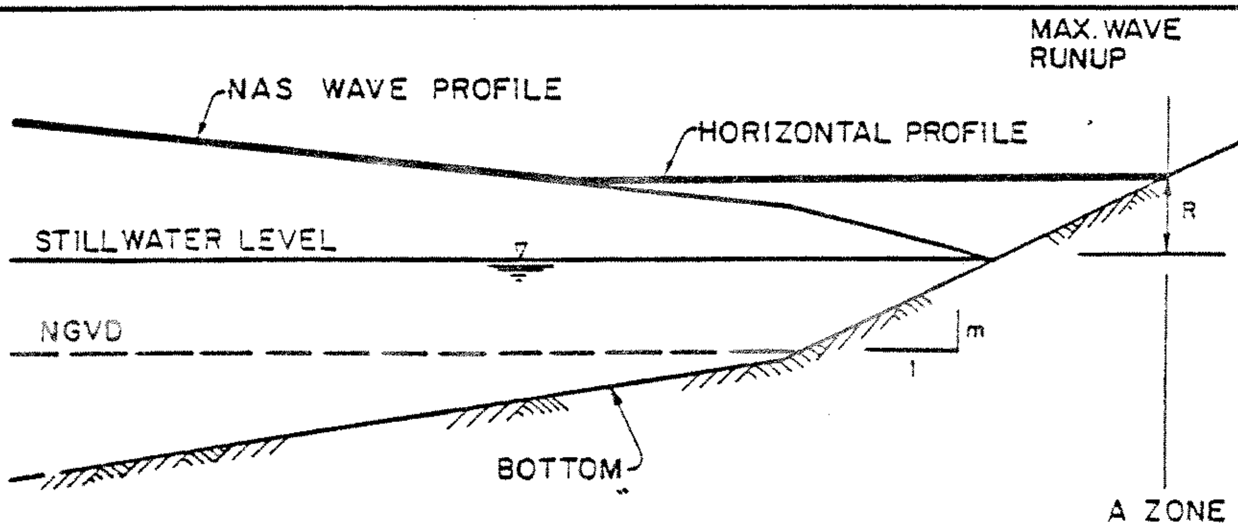


FIGURE 2-1
WAVE CREST PROFILE

SECTION 3

APPLICATION

The S&W methodology is applicable to all coastal areas subject to wind wave activities. The methodology was developed and verified for the southern Maine coastal areas which have relatively steep slopes. However, in many areas including some sections of New England coastline, the beach slopes are mild and the methodology need not be applied.

The calculated runup values on mild slopes are small and the ability of the runup to do damage is minimal. A criterion has been adopted which states that a runup value of less than 2 ft is incapable of causing significant damage. Based on the results of the Maine Flood Insurance Study, any slope less than 1 on 30 with a design wave period of 11 seconds or less, or any slope less than 1 on 35 with a design wave period of 14 seconds or less, produces less than 2 ft of runup. Since little damage occurs under these conditions, the runup calculation need not be applied when they are met. The slope cited above is defined as a straight line between two points on the ground profile; one point is 10 ft below and the other is 5 ft above the stillwater level. The slope criterion is given with the stipulation that the profile seaward of 10 ft below stillwater level is milder than the defined slope. If this is not the case the 2 ft runup slope criterion is not valid and the runup calculation should be performed.

SECTION 4

METHODOLOGY

The wave crest analysis methodology has three components, i.e., data acquisition, data reduction/analyses, and wave crest profile computations.

These three components are described below in chronological order. An example application is presented under Section 6.

4.1 DATA ACQUISITION

4.1.1 Beach Profiles

Beach profiles are required to determine breaking wave height, wave runup, and A and V zones. The user should select beach profile locations by field inspection and inspection of United States Geologic Survey (USGS) quadrangle sheets, National Ocean Survey (NOS) charts, aerial photography, and Flood Insurance Study work maps. During the inspection of these items, the user should select representative profiles for regions with similar coastal geomorphologic forms.

Coastal geomorphologic forms such as barrier beaches, headlands, tombolos, offshore islands, coves, bays, and bluffs can be identified. In addition, regions can be specified as having beach profiles of similar shape and slope. The wave crest elevations obtained from the methodology are sensitive to beach slopes and, as a consequence, care is required to assure that a representative beach profile has been selected for a given region. Generally, profile spacing should be less than 1 mile.

After the user has selected beach profiles, a field trip is required to determine beach characteristics along the profiles. Characteristics such as sediment type and structure location should be noted.

Beach profiles will change seasonally. Summer beaches generally are mildly sloped and have wide berms, while winter beaches generally are steeply sloped and have narrow berms. A winter beach profile will have higher wave crest elevations than a summer beach profile for identical stillwater level and design wave conditions.

Since most hurricanes occur during the summer and most northeasters during the winter, a selection of two beach profile/design wave pairs might be needed; one for northeasters and one for hurricanes. In certain regions of the country, these data pairs are not needed since one storm type generally dominates, e.g., in New England northeasters predominate, thus the wave crest methodology requires winter beach profile data; in the South hurricanes predominate, thus the wave crest methodology requires summer beach profile data; while in the New York region, a mix of northeasters and hurricanes occurs, thus requiring both winter and summer beach profiles for the wave crest analysis.

Unfortunately, the profile data are generally limited to NOS charts seaward of mean low water, which presents beach profile data soundings on a given chart from numerous hydrographic surveys. These surveys might have been performed at various times over the year. Therefore, it is not always possible to obtain typical winter/summer profiles. The user is advised to utilize NOS charts tied in with the FEMA work maps if no other profile data are available.

The beach profile data should be referenced to National Geodetic Vertical Datum (NGVD), which is mean sea level of 1929. The profiles should extend approximately from 40 ft below to 20 ft above stillwater level or to the highest elevation available.

Possible sources for beach profile data include:

a. National Ocean Survey (NOS) Charts
b. U.S. Geologic Survey (USGS) Quadrangle Sheets
c. FEMA Work Maps
d. Regional Coastal Information Center
e. Others: U.S. Army Coastal Engineering Research Center, U.S. Army Corps of Engineers, State Offices of Coastal Zone Management, Local Universities, communities, and surveyors

4.1.2 Stillwater Level

The stillwater level is made up of astronomical tide and storm surge components. During the duration of a storm, the storm tide will vary as a function of time. Generally, the storm tide will behave like a normal tide except that it will have higher high tide and higher low tide elevations.

The maximum water surface elevation is selected as the stillwater level for that storm. This selected stillwater level has an assigned frequency. The user may determine this level via mathematical model, frequency analysis, or literature search.

Possible data sources for stillwater level data include:

a. Federal ~~Insurance Administration~~, FEMA
b. U.S. Army Corps of Engineers
c. U.S. Army Coastal Engineering Research Center
d. National Oceanic and Atmospheric Administration
e. Regional Coastal Information Center
f. State Agencies

4.1.3 Wave Height and Period

For wave runup calculations, wave heights and corresponding wave periods shall be obtained. The spectrum of waves at a given location is dependent on the available fetches, bottom topography, and prevailing storm type.

Possible wave data sources include:

a. Environmental Data Service, NOAA

b. National Climatic Center, NOAA

c. U.S. Army Corps of Engineers

d. U.S. Army Coastal Engineering Research Center

e. National Oceanographic Data Center

f. Regional Coastal Information Center

4.2 DATA REDUCTION/ANALYSES

4.2.1 Beach Profile

The beach profile data are plotted referenced to NGVD. Summer and winter profiles, if available or needed, should be plotted on separate profile paper. A sample beach profile data tabulation sheet and a beach profile figure are presented under Section 6, Example Problem.

4.2.2 Stillwater Level

The 100-year stillwater storm tide elevation is used for determining A and V zones, while the 10-year stillwater elevation is required for numbering the A and V zones. The user should determine the variation of stillwater level along the study area. The stillwater levels are plotted with the beach profile.

4.2.3 Wave Height and Period

The range of wave heights which should be used for runup calculations in order to determine the maximum runup is generally between a minimum of 3 ft to the significant wave height, H_s, based on the wave spectrum information at a given location. The significant wave period, T_s, may be used as the corresponding wave period for all wave heights in the wave runup calculation.

4.3 WAVE CREST PROFILE COMPUTATIONS

4.3.1 Beach Profiles

The beach profile is generated by plotting ground elevations versus horizontal distances. Beach slopes must be calculated between ground elevation points and a roughness coefficient must be supplied. Typical roughness coefficients are given on Table 4-1. A roughness coefficient of 1 is suggested when no direct beach observations are available.

In addition, for each slope segment the user should compute a breaker height, H_b, for each wave height, H_i, and wave period, T_s. Figure 7-3 in the Shore Protection Manual should be used to compute H_b and is reproduced in Section 6 as Figure 6-4. This information is to be used for runup calculations.

TABLE 4-1

ROUGHNESS COEFFICIENTS
(SPM after Battjes 1974)

Slope Surface Characteristics	Placement	Roughness Coef. r
Smooth Impermeable	________	1.00
Concrete Blocks	Fitted	0.90
Basalt Blocks	Fitted	0.85-0.90
Gobi Blocks	Fitted	0.85-0.90
Grass	________	0.85-0.90
One Layer Quarrystone (Impermeable Foundation)	Random	0.80
Quarrystone	Fitted	0.75-0.80
Rounded Quarrystone	Random	0.60-0.65
Three Layers of Quarry-stone (Impermeable Foundation)	Random	0.60-0.65
Quarrystone	Random	0.50-0.55
Concrete Armor Units (50% Void Ratio)	Random	0.45-0.5

4.3.2 Wave Crest Elevations

The maximum runup point is obtained from operating the wave runup computer program. The program incorporates laboratory runup data (Stoa 1978b) and uses the composite beach slope method developed by Saville (1958). An ensemble of deepwater wave heights, H_i and wave period, T_s, is used as input to the program. The wave runup program calculates an array of wave runups, R_i, corresponding to the input wave characteristics H_i, and T_s. The user selects the maximum computed runup from the values R_i and defines the maximum runup point, R_{max}.

A detailed description of the program and operating instructions are presented in Appendix A - Wave Runup Program.

In addition, the R_{max} will require correction if a beach berm is present along the profile. The correction is given by:

$$\frac{R_{corrected}}{R_{max}} = 1 + \left(\frac{\text{Berm width}}{L_b}\right)^{3/4}$$

where L_b (wave length at breaking) can be obtained from Table 4-2, Wave Length at Breaker Depth, via log/log interpolation (Dean 1974).

TABLE 4-2

WAVE LENGTH AT BREAKER DEPTH

d_b/L_o	L_b/L_o	Notes:
0.02	0.422461	L_b - wave length at breaking
0.05	0.627344	L_o - deepwater wave length = 5.12 T^2
0.10	0.824424	d_b - breaker depth

Refer to the references of NAS 1977 and FEMA 1981 for the delineation of the NAS wave crest profile.

SECTION 5

SPECIAL SITUATIONS

The method described above has limitations for certain beach and structural sections. Special attention is needed when the following situations are encountered:

1. Convex Profile Runup Oscillation - For a convex beach profile, the runup computed by the composite slope method will oscillate between two runup values. When this occurs, the runup program prints the two runup values from the last two iterations. Engineering judgement should be exercised to select a reasonable value between these two runups.

2. Wave Overtops Profile - If the runup value overtops the profile, consult Shore Protection Manual and Coastal Engineering Technical Aid (CETA) 77-7 for methodology to estimate overtopping flow rate. A special problem report should be issued indicating the site-specific methodology to estimate overtop flooding.

3. Stillwater Level Intersects Vertical Sea Wall - User should consult Shore Protection Manual and CERC TP-78-2 for analysis of vertical runup. If this analysis shows that overtopping occurs, the user should use CETA 77-7, cited above, for determining overtopping flow rate and issue a Special Problem Report indicating the site-specific methodology used to estimate overtop flooding.

SECTION 6

EXAMPLE PROBLEM

The problem presents a wave crest analysis for a transect located in Old Orchard Beach for the coastal flood insurance study in Maine.

6.1 DATA ACQUISITION

6.1.1 Beach Profiles

The NOS Chart and Flood Insurance Work Maps needed for this analysis were obtained. Figures 6-1 and 6-2 present segments of these maps and charts. The transect of interest (Transect 71) is marked on both maps. Notice that the Maine State Coordinate Grid System is drawn on both figures. This is to ensure the transect is accurately presented on the two figures. The transect elevation data are presented on Table 6-1, Profile Data.

6.1.2 Stillwater Level

Storm tide elevations (stillwater levels) for the 10-, 50-, 100-, and 500-year events were determined for nine coastal communities in York County, Maine. The major tasks included the simulation of wind and pressure fields of northeasters and hurricanes, the determination of coastal storm surge and storm tide elevations, and the statistical analysis of storm tide elevations (S&W 1978a).

TABLE 6-1

PROFILE DATA
(TRANSECT 71, MAINE FLOOD INSURANCE STUDY)

Elevation (ft) relative to MLW	Elevation (ft) relative to NGVD	Distance (ft) from waterline MHW	Distance (ft) from waterline NGVD	Slope m	Roughness Coefficient r	Profile Section Number
-18	-22.3	2460	-2420			
				.005	1.0	1
-12	-16.3	1170	-1130			
				.011	1.0	2
-6	-10.3	630	-590			
				.014	1.0	3
(MLW) 0	-4.3	210	-170			
				.025	1.0	4
(NGVD) 4.3	0.	38	0			
(MHW) 9.0	+ 4.7	0		.125	1.0	5
	+ 5.	2	40			
				.063	1.0	6
	+ 10.	82	120			
				.028	1.0	7
	+ 15.	262	300			

NGVD - MLW = 4.3 ft.
MHW - NGVD = 4.7 ft.

Mean Tide Range = 9.0 ft.

TABLE 6-2

COASTAL FLOOD LEVELS MEASURED FROM NGVD
IN THE STUDY AREA
(S&W, 1978a)

Location	Coastal Flood Stillwater Level Measured from NGVD at Given Return Intervals (in feet)			
	10-Year	50-Year	100-Year	500-Year
Portland	8.51	9.15	9.41	10.01
Cape Elizabeth	8.28	8.93	9.19	9.79
Old Orchard Beach	8.21	8.83	9.09	9.67
Sacco Biddeford	8.09	8.73	8.99	9.59
Kennebunkport Kennebunk	8.22	8.82	9.07	9.63
Wells	7.98	8.56	8.79	9.31
Ogunquit	7.95	8.52	8.75	9.27
York	7.85	8.42	8.65	9.17
Kittery Portsmouth	7.86	8.45	8.68	9.21

The 100-year and 10-year elevations for Transect 71, which is located in the town of Old Orchard Beach, are, respectively, 9.1 ft and 8.2 ft (see Table 6-2).

6.1.3 Wave Height and Period

The significant wave height and period in this study area are determined to be 30 ft and 14 seconds, respectively. See Appendix B for details of significant wave height and period determinations. The range of wave heights, H_i, to be used for wave runup calculation is, therefore, from 5 to 30 ft. The associated wave period is 14 seconds for all wave heights.

6.2 DATA REDUCTION/ANALYSIS

6.2.1 Beach Profile

Figure 6-3 presents the beach profile data plotted on section paper.

6.2.2 Stillwater Level

The 100-year and 10-year stillwater levels are indicated on Figure 6-3.

6.3 WAVE CREST PROFILE COMPUTATIONS

6.3.1 Maximum Runup Point

Maximum runup values are obtained from the Wave Runup Computer Program.

Wave runups values are computed for each of the deepwater (unbroken) wave heights of 5, 7, 9, 11, and 13 ft with 14 second wave period for both 10- and 100- year storm tide levels. For the 10-year level a maximum runup value of 3.9 ft resulted from a deepwater wave height of 5 ft. The maximum runup of 3.7 ft for the 100-year level resulted from a 7 ft deepwater wave height. When added to the stillwater levels these runup values yield 12.1 ft and 12.8 ft NGVD runup elevations respectively for the 10- and 100-year storm levels.

The following breaker heights for those profile sections under the stillwater level and five deepwater wave heights are used as input to the Wave Runup Computer Program (see A.5.2, Appendix A).

Profile Section No.	m	Breaker Height, H_b for T = 14 seconds — Ho(ft): 5	7	9	11	13
1	.005	7.2	9.7	11.3	13.4	15.1
2	.011	8.0	10.5	12.5	14.7	16.6
3	.014	8.3	10.8	12.8	15.0	17.0
4	.025	8.9	11.5*	13.7	16.0	18.0
5	.125	10.8	13.8	16.4	19.0	21.3
6	.063	10.0	12.8	15.2	17.9	20.0

* $H_o/gT^2 = 7/(32.2 \times 196) = 0.0011$. From Figure 6-4, $H_b/H_o = 1.64$ is obtained. Hence, $H_b = 1.64 \times 7 = 11.5$

6.3.2 Wave Crest Profile

The NAS profile having a wave crest above the stillwater level of 0.55 of its local depth is calculated and plotted on the transect (Figure 6-3). The NAS wave crest profile approaches the stillwater level at the point where the stillwater intersects the ground profile. A horizontal line parallel to the stillwater level is drawn from the maximum runup point, 12.8 ft NGVD for the 100-year flood and 12.1 ft NGVD for the 10-year flood, toward offshore intersecting the NAS profile. The combination of the horizontal line and the NAS profile offshore beyond the point of intersection constitutes the final wave crest profile.

A and V zone determinations are made. The transect has been drawn previously on the work maps; and A and V zones are then transferred from the figures to the work map.

(Saco Bay and Vicinity)

SOUNDINGS IN FEET - SCALE 1:20,000

13287

(formerly C&GS 231)

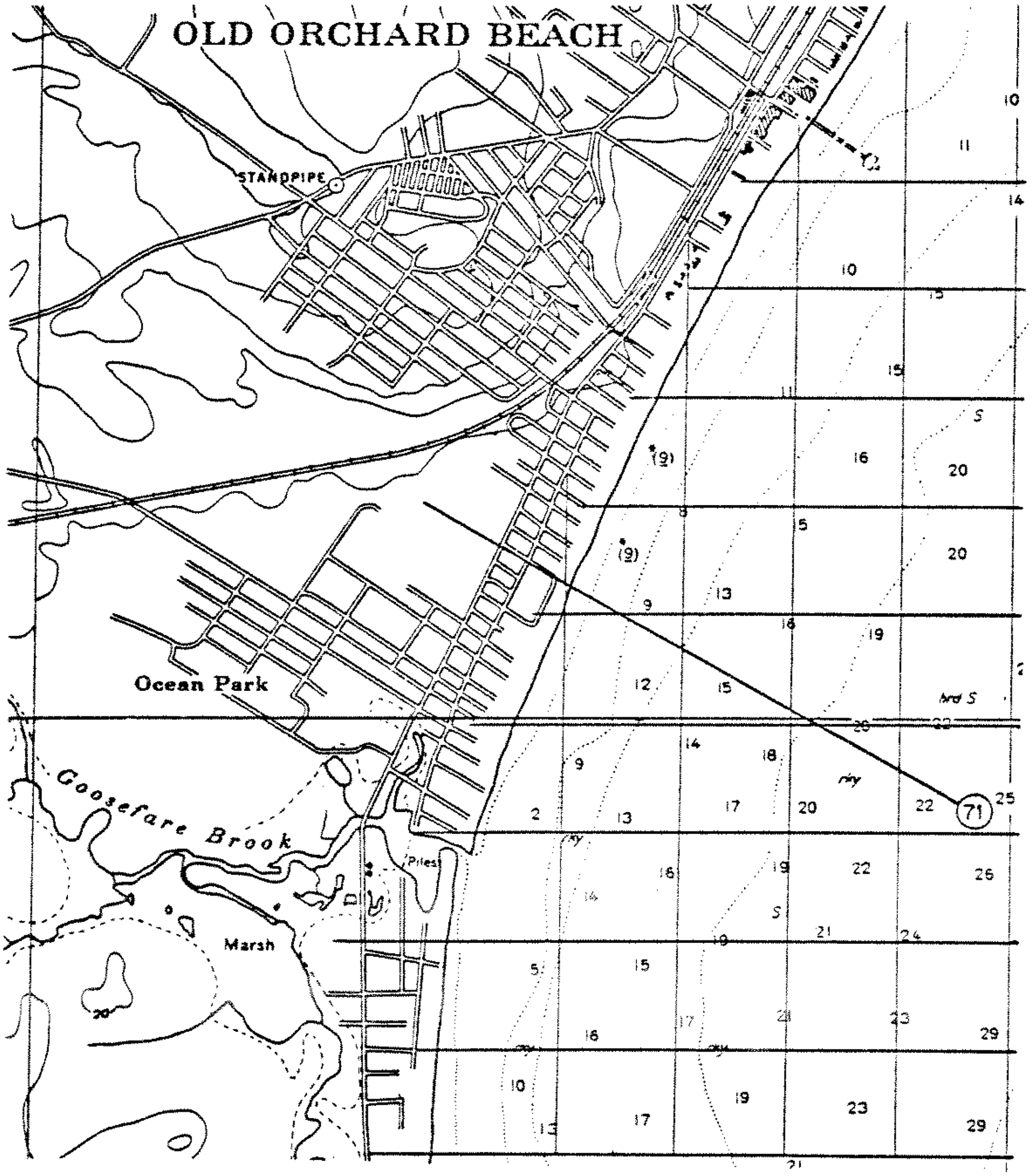


FIGURE 6-1

SEGMENT OF N.O.S. CHART

FEDERAL INSURANCE ADMINISTRATION

MANUAL FOR WAVE RUNUP ANALYSIS

COASTAL FLOOD INSURANCE STUDIES

STONE & WEBSTER ENGINEERING CORPORATION

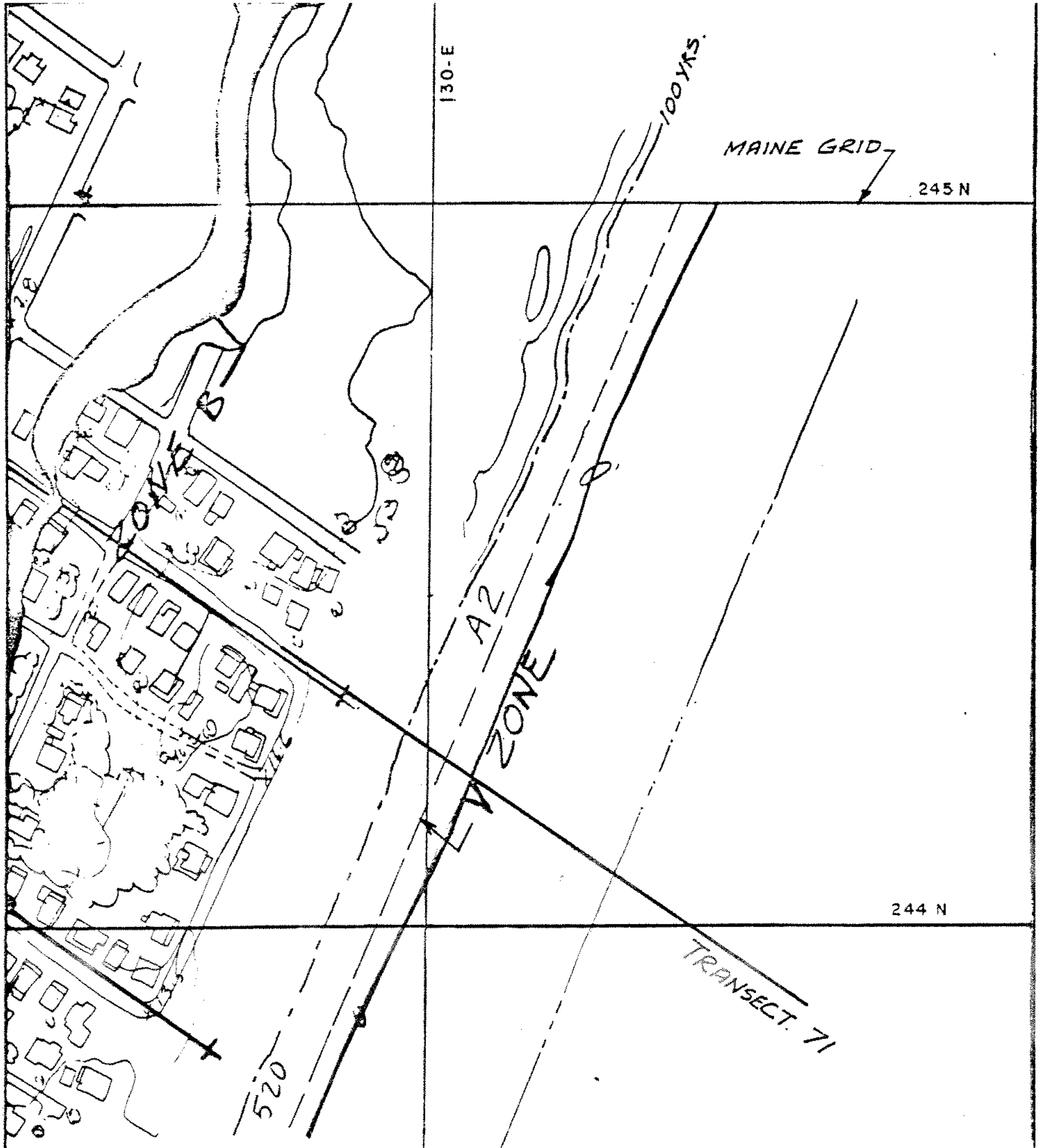


FIGURE 6-2
SEGMENT OF WORK MAP
FEDERAL INSURANCE ADMINISTRATION
MANUAL FOR WAVE RUNUP ANALYSIS
COASTAL FLOOD INSURANCE STUDIES
STONE & WEBSTER ENGINEERING CORPORATION

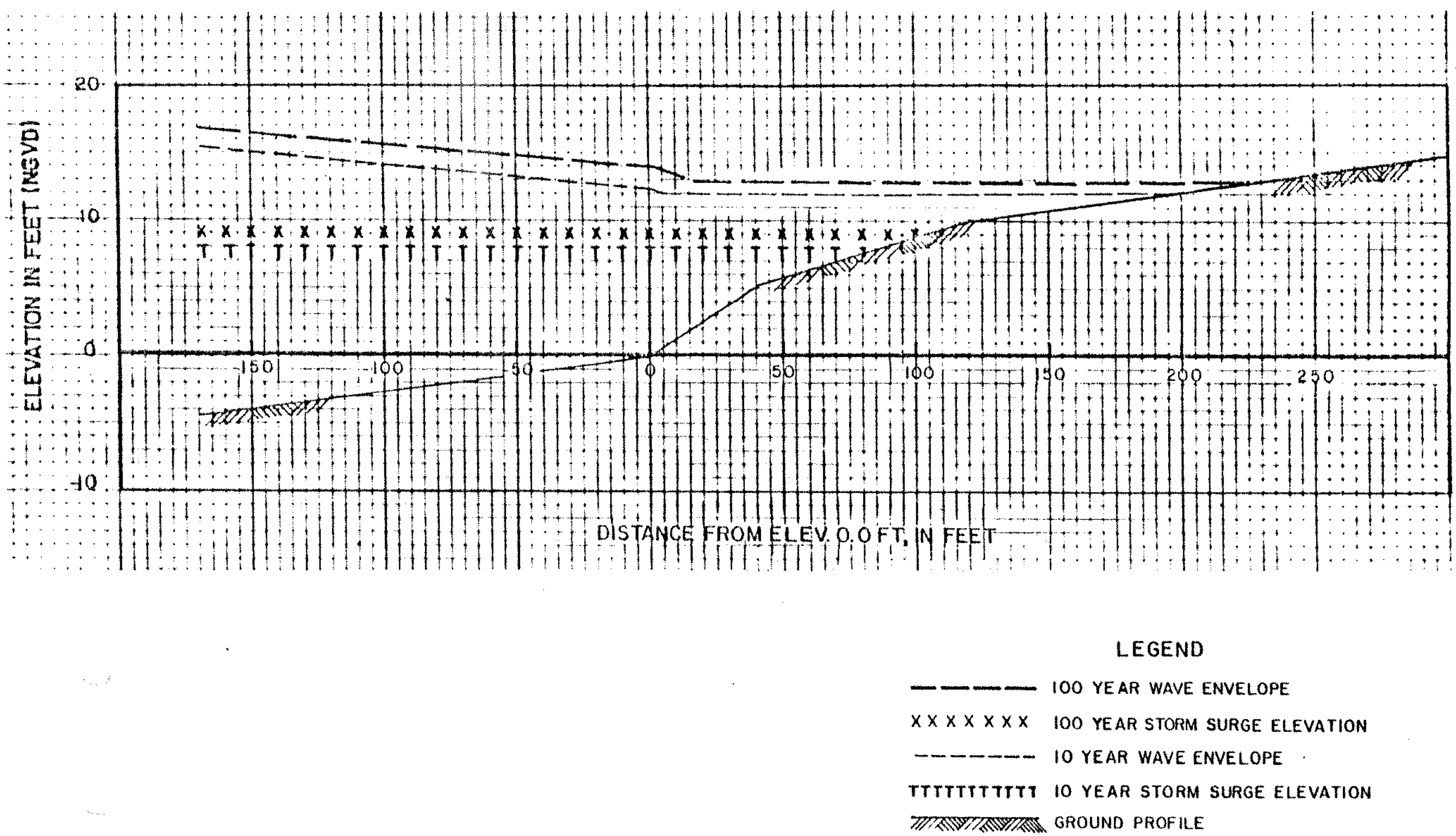
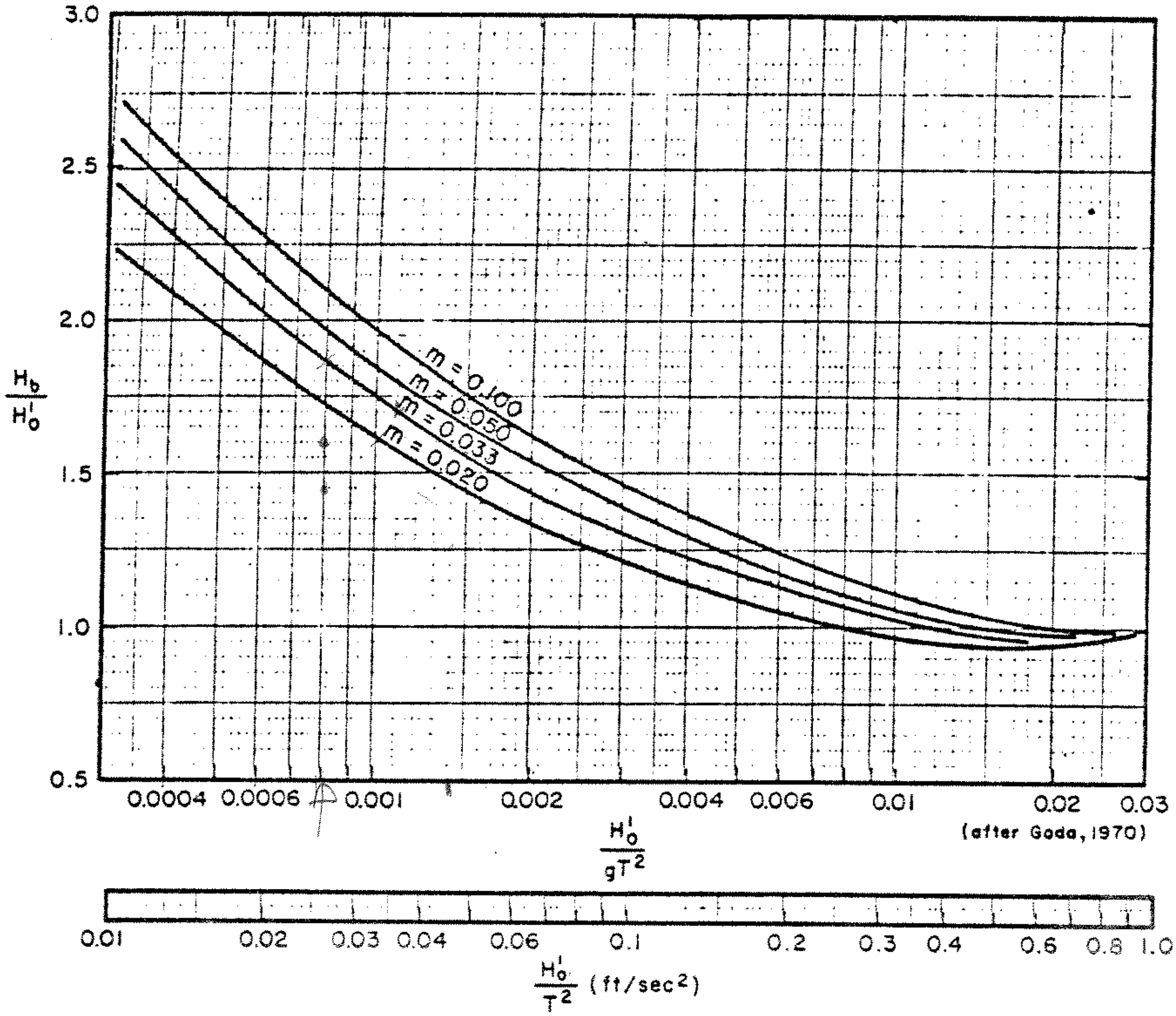


FIG. 6-3

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration
TOWN OF OLD ORCHARD BEACH, ME
(YORK CO.)

WAVE ENVELOPES

TRANSECT 71, OLD ORCHARD BEACH



Breaker Height index, H_b/H'_o Versus Deep Water Wave Steepness, H'_o/gT^2

(SHORE PROTECTION MANUAL, FIG. 7-3)

FIGURE 6-4
BREAKER HEIGHT INDEX
FEDERAL INSURANCE ADMINISTRATION
MANUAL FOR WAVE RUNUP ANALYSIS
COASTAL FLOOD INSURANCE STUDIES
STONE & WEBSTER ENGINEERING CORPORATION

SECTION 7

VERIFICATION

The wave crest profile, as determined by the method outlined in this report, has been verified with laboratory observations and actual wave damage information.

7.1 LABORATORY AND FIELD OBSERVATIONS

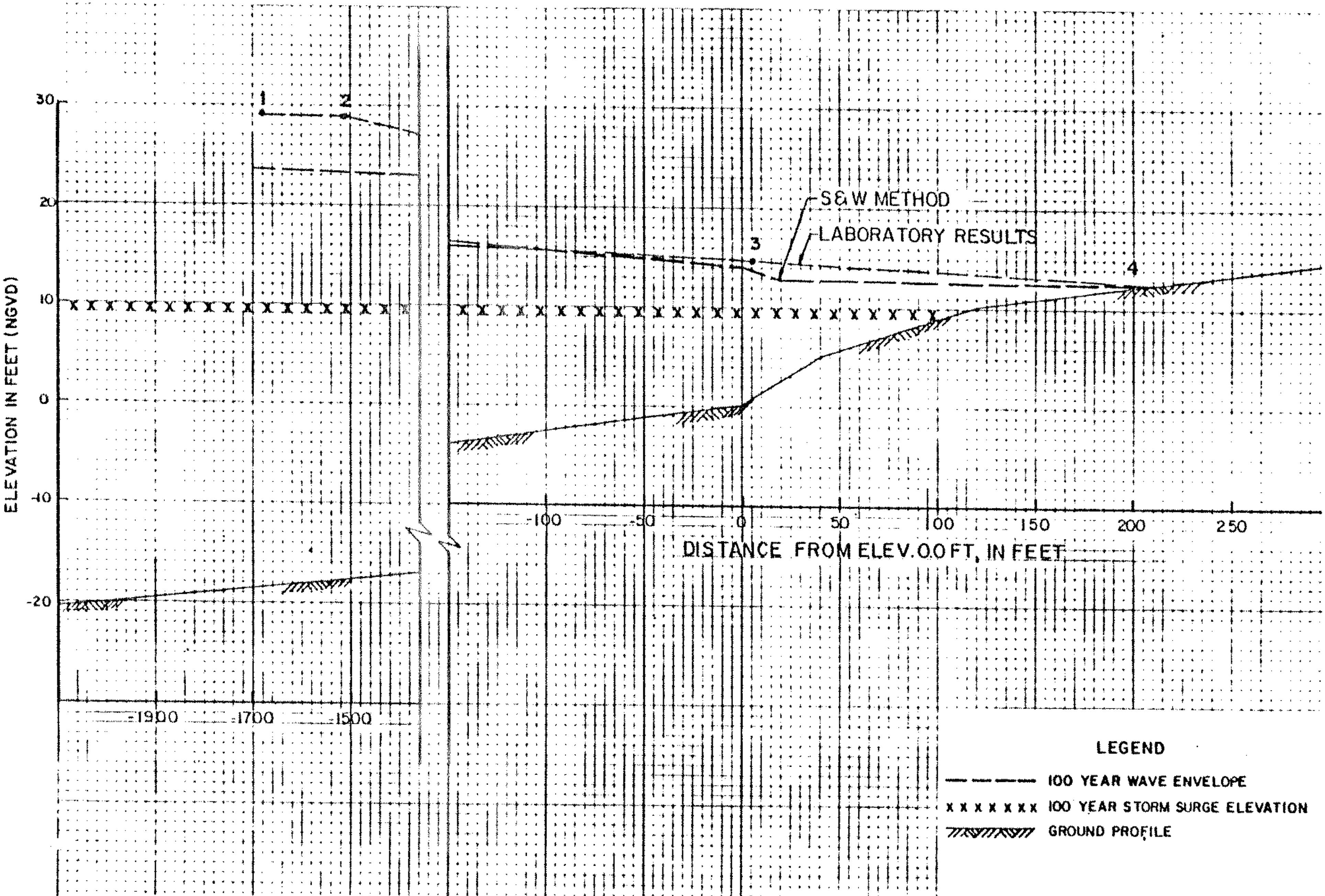
Deepwater waves are formed offshore of coastal areas due to storm activities. These storm waves have a significant wave height, H_s, and period, T_s, which represent the spectrum of wave heights and periods generated by the storm.

As the significant wave propagates toward shore, shoaling and refraction occur. Eventually it reaches a depth of water where it breaks. At this depth, d_b, the original wave height, H_s, is transformed into a breaker height, H_b, with 90 percent of the wave height above the stillwater level (U.S. CERC Shore Protection Manual, 1977). The breaking wave travels up to a distance without reducing its crest elevation and then decays to a residual wave height near the shore in a manner which can best be described by laboratory test results. The residual wave height near the shore is defined from laboratory work (Horikawa and Kuo, 1966, Nakamura et al, 1966, and Van Dorn, 1978) as occurring at a water depth of 0.3 d_b with a wave crest elevation of 0.25 H_b above the stillwater level.

The wave crest profile based on the above scenarios connecting the maximum wave runup point is compared with the S&W profile for the sample problem transect. As shown in Figure 7-1, the two 100-year wave profiles are in good agreement.

7.2 HISTORICAL DAMAGE INFORMATION

More than twenty (20) transects were taken across the reported damage areas for verification purposes. Most of the damage which occurred during the February 1978 storm in southern Maine coastal areas was above the storm tide stillwater level. The wave damaged areas are identified on the predicted 100-year wave envelope as shown in Figure 7-2 which is typical of the damaged transects. As can be seen from the figure the maximum wave runup points are above the reported damage locations.

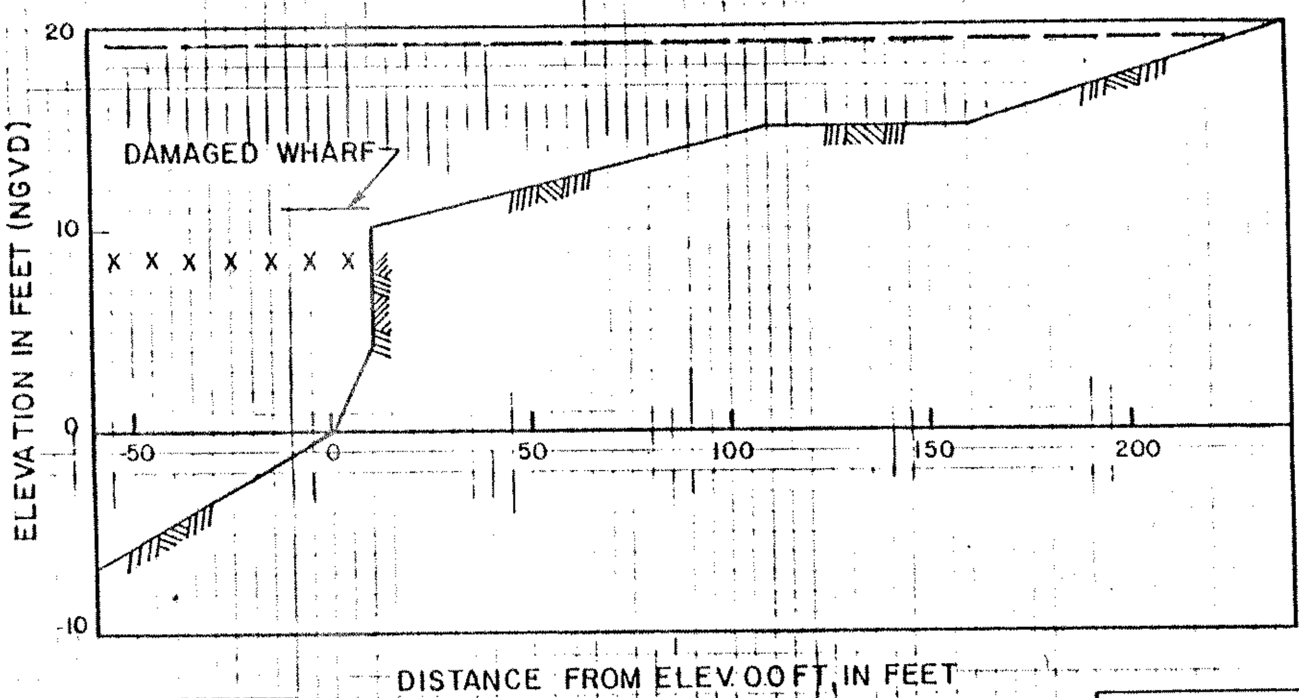


FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

WAVE ENVELOPES

TRANSECT 71

FIG. 7-1



DAMAGE INFORMATION: FRISBEE WHARF SUSTAINED DAMAGE TO PILINGS, RAMPS AND DECKING. THE DECKING IS AT APPROX. 10.9' NGVD.

LEGEND

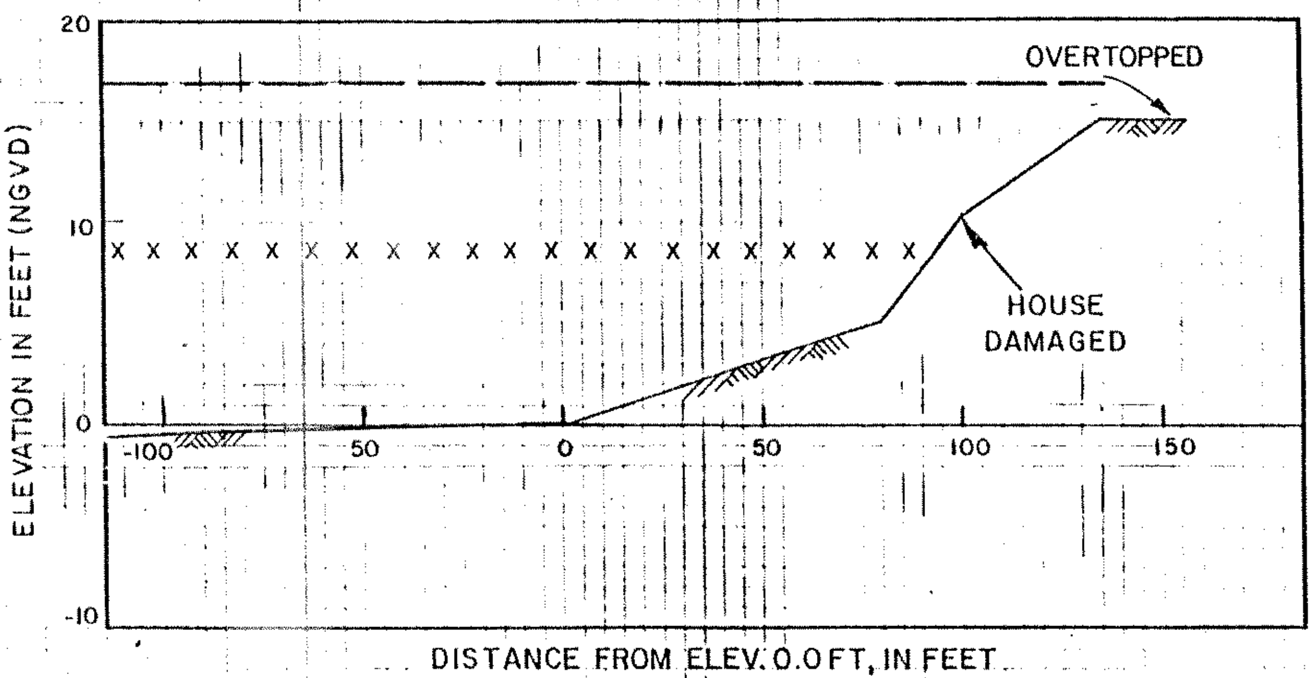
- 100 YEAR WAVE ENVELOPE
- X X X X X 100 YEAR STORM SURGE ELEVATION
- GROUND PROFILE

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration
TOWN OF KITTERY, ME
(YORK CO.)

WAVE ENVELOPES

TRANSECT 1, KITTERY

FIG. 7-2a



DAMAGE INFORMATION: HOUSE ON THE CAPE NEDDICK COVE WITH ITS BASE AT THE 10 FT NGVD LEVEL WAS DAMAGED

LEGEND

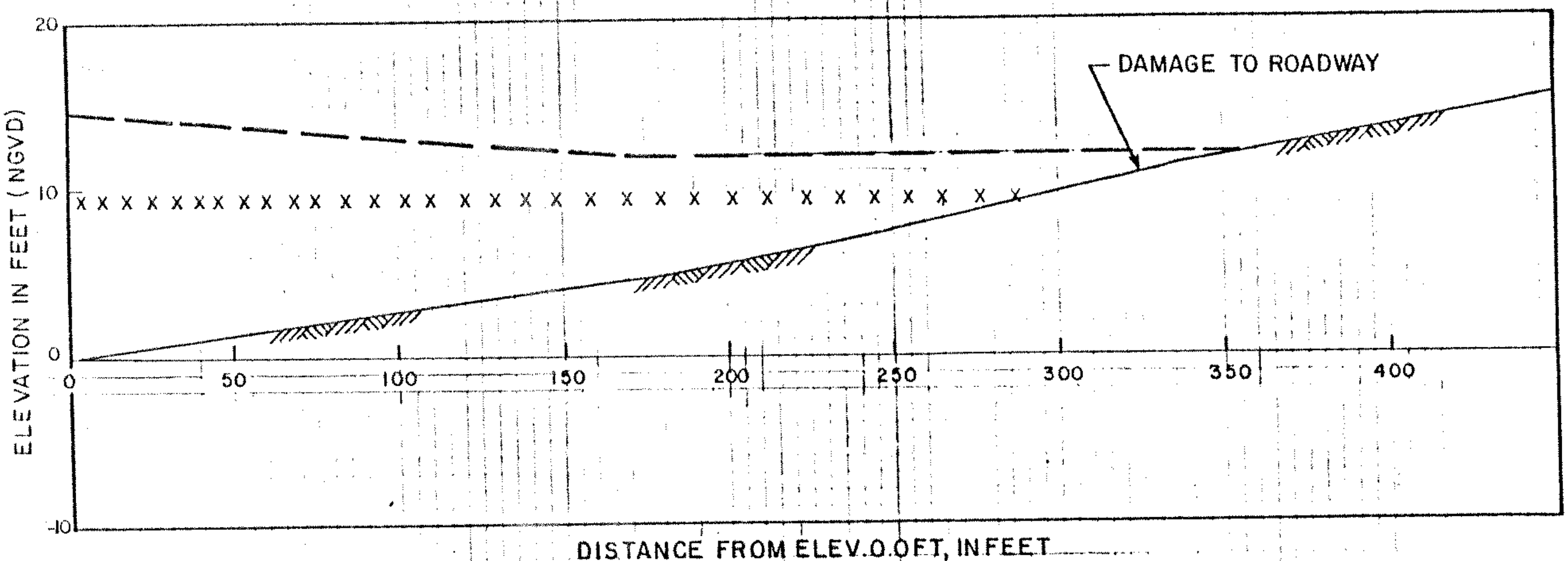
- 100 YEAR WAVE ENVELOPE
- X X X X X 100 YEAR STORM SURGE ELEVATION
- GROUND PROFILE

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration
TOWN OF YORK, ME.
(YORK CO.)

WAVE ENVELOPES

TRANSECT 19-1, YORK

FIG. 7-2b



DAMAGE INFORMATION: A ROAD ALONG THIS BEACH WAS DAMAGED DURING THE 1978 BLIZZARD. THE LOWEST ELEVATION OF THIS ROAD IS ~10.5' NGVD.

LEGEND

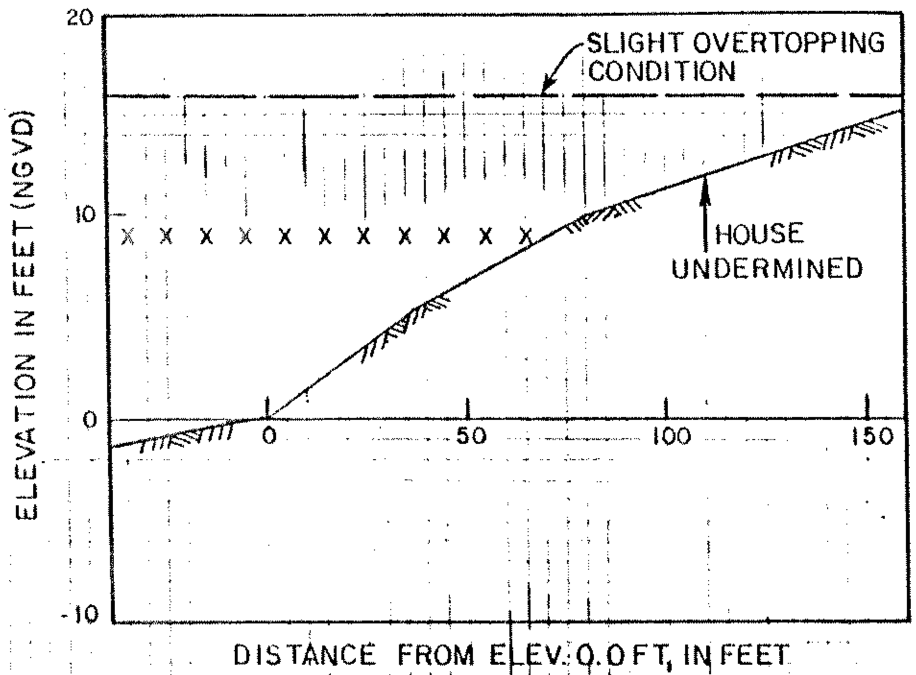
- — — — 100 YEAR WAVE ENVELOPE
- X X X X X 100 YEAR STORM SURGE ELEVATION
- ////// GROUND PROFILE

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration
TOWN OF BIDDEFORD, ME
(YORK CO.)

WAVE ENVELOPES

TRANSECT 62, BIDDEFORD

FIG. 7-2C



DAMAGE INFORMATION: IN THE CAMP ELLIS AREA A HOUSE AT ~12' NGVD WAS UNDERMINED AND TIPPED DURING THE 1978 BLIZZARD.

LEGEND

- — — — 100 YEAR WAVE ENVELOPE
- X X X X X 100 YEAR STORM SURGE ELEVATION
- (hatched line) GROUND PROFILE

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWN OF SACO, ME
(YORK CO.)

WAVE ENVELOPES

TRANSECT 68-1, SACO

FIG. 7-2d

SECTION 8

REFERENCES AND BIBLIOGRAPHY

Ahrens, John, Prediction of Irregular Wave Overtopping (Coastal Engineering Technical Aid 77-7), U.S. Coastal Engineering Research Center, Ft. Belvoir, Virginia, 1977.

Ahrens, John, Prediction of Irregular Wave Runup (Coastal Engineering Technical Aid 77-2) U.S. Coastal Engineering Research Center, Fort Belvoir, Virginia, 1977.

Balloffet, Armando and Scheffler, Michael L., "Influence of Storm Type and Urbanization on Tidal Flooding," Coastal Zone 80, Proceedings of the Second Symposium on Coastal and Ocean Management, ASCE, New York, 1980, pp. 2256-2270.

Battjes, J. A., "Surf Similarity," Proceedings of the 14th Coastal Engineering Conference, American Society of Civil Engineers, New York, 1974.

Camfield, Frederick E., A method for estimating wind-wave growth and decay in shallow water with high values of bottom friction (Coastal Engineering Technical Aid - CETA 77-6), U.S. Coastal Engineering Research Center, Ft. Belvoir, Virginia, 1977.

Conservation Foundation, Coastal Environmental Management:Guidelines for Conservation of Resources and Protection Against Storm Hazards, Federal Insurance Administration, U.S. Government Printing Office, Washington, D.C., 1980.

Cruther, H. L. and Quayle, R. G., Mariners Worldwide Climatic Guide to Tropical Storms at Sea, Naval Weather Service, Washington, D.C., March 1974.

Dean, Robert G., "Equilibrium Beach Profiles and Response to Storms," Proceedings of the 15th Coastal Engineering Conference, ASCE, New York, 1976.

Dean, Robert G., Evaluation and Development of Water Wave Theories for Engineering Applications, U.S. Coastal Engineering Research Center, Fort Belvoir, Virginia, 1974.

Ellis, Melvin Y., ed., Coastal Mapping Handbook, U.S. Department of Commerce, U.S. Government Printing Office, Washington, D.C., 1978.

Federal Emergency Management Agency, Users Manual for Wave Height Analysis, to accompany "Methodology For Calculating Wave Action Effects Associated With Storm Surveys," FEMA, Federal Insurance Administration, Washington, D.C., February 1981.

Galvin, Cyril J. Jr., "Breaker Travel and Choice of Design Wave Height," Journal of Waterways and Harbors Division, ASCE, New York, Vol. 95 WW2, May 1967, pp. 175-200.

Goda, Yoshimi, "A Sythesis of Breaker Indices," Transactions of Japanese Society of Civil Engineers, JSCE, Tokyo, Vol. 2 part 2, 1970, pp 227-230.

Herbich, John B. et al, "Effect of Wave Run-up on Composite Beaches," Journal of Waterways and Harbors Division, ASCE, New York, Vol. 89, WW2, May 1963, pp. 55-72.

Ho, Francis P., "Hurricane Time Frequencies on the Atlantic Coast," Proceedings of the 15th Coastal Engineering Conference, ASCE, New York, 1977.

Horikawa, Kiyoshi and Kuo, Chin-Tong, "A Study of Wave Transformation Inside Surface Zone," Proceedings 10th Coastal Engineering Conference, ASCE, New York, 1966, pp. 217-233.

Hwang, Li-San and Divoky, David, "Breaking Wave and Setup and Decay on Gentle Scopes," Proceedings of the 12th Coastal Engineering Conference, ASCE, New York, 1970, pp. 377-390.

James, I.D., "Non-linear Waves in the Nearshore Region: shoaling and set-up," Estuarine and Coastal Marine Service, Vol. 2, 1974, pp 107-234.

Jannuzzi, John A., "Spectral Techniques in Ocean Wave Forecasting," NOAA/NWS WR-133, October 1973.

Lesnik, John R., Wave setup on a sloping beach (Coastal Engineering Technical Aid - U.S. Coastal Engineering Research Center, CETA77-5), U.S. Coastal Engineering Research Center, Fort Belvoir, Virginia, 1977.

Myers, V. A., "Joint Probability Method of Tide Frequency Analysis Applied to Atlantic City and Long Beach New Jersey," ESSA Tech., Mem. WBTM Hydro 11, U.S. Department of Commerce, Silver Springs, Maryland, April 1970.

Nakamura, Makoto et al, "Wave Decaying Due to Breaking," Proceedings of 10th Coastal Engineering Conference," ASCE, New York, 1966, pp 234-253.

National Academy of Sciences, Methodology for Calculating Wave Action Effects Associated with Storm Surges, Washington, D.C., 1977

National Weather Service, Salt Lake City, Utah, Western Region. The SWAB (Spectral Wave and Bar) Program, Morrs S. Webb, Jr., March 1980, 36p NOAA-NWS-WRCP-9 NOAA-80051302.

Neumann, C. J. et al, Tropical Cyclones of the North Atlantic Ocean 1871-1977, National Climatic Center NOAA, Asheville, North Carolina, June 1978.

Pore, N. A. and Barrientos, C. S., "Storm Surge," Marine ECO Systems Analysis (MESA) New York Bright Atlas Monograph 6, New York Sea Grant Institute, Albany, New York, February 1976.

Pore, N. A. et al, "Forecasting Extratropical Storm Surges for the N.E. Coast of the U.S.," NOAA/NWS TDL-50, U.S. Department of Commerce, Silver Springs, Maryland, January 1974.

Saville, Thorndike Jr., "Wave Runup on Composite Slopes, "Proceedings of the 6th Conference on Coastal Engineering, ASCE, New York, 1958.

Silvester, R.," Coastal Engineering I and II, Developments in Geotechnical Engineering 4A, 4B, Elsevier, New York, 1974.

Stoa, Philip N., Wave Runup on Rough Slopes (Coastal Engineering Technical Aid - U.S. Coastal Engineering Research Center - CETA 79-1), U.S. Coastal Engineering Research Center, Ft. Belvoir, Virginia, 1979.

Stoa, Philip N., "Reanalysis of Wave Runup on Structures and Beaches," U.S. Coastal Engineering Research Center, Fort Belvoir, Virginia, March 1978.

Stoa, Philip N., Revised Wave Runup Curves for Smooth Slopes (Coastal Engineering Aid No. 78-2), U.S. Army Corps of Engineers, Coastal Engineering Research Center, Ft. Belvoir, Virginia, July 1978.

Stone & Webster Engineering Corporation, Proposal for Wave Height Analysis Flood Insurance Studies H4092 and H-4772 to Federal Emergency Management

Agency, Technical, Cost and Price Analysis, Stone & Webster Engineering Corporation, Boston, Massachusetts, August 1979.

Stone & Webster Engineering Corporation, Determination of Coastal Tide Levels, prepared for Federal Insurance Administration, Department of Housing and Urban Development, Stone & Webster Engineering Corporation, Boston, Massachusetts, 1978.

Stone & Webster Engineering Corporation, Development and Verification of a Synthetic Northeaster Model for Coastal Flood Analysis, prepared for Federal Insurance Administration, Department of Housing and Urban Development, Stone & Webster Engineering Corporation, Boston, Massachusetts, 1978.

Suhayda, Joseph N. and Pettigrew, Neal R., "Observations of Wave Height and Celerity in the Surface Zone," Journal of Geophysical Research, American Geophysical Union, Washington, D.C., Vol. 82 No. 9, March 20, 1977, pp. 1419-1424.

Svendsen, Ib A. and Hansen, F. B., "Deformation up to Breaking of Periodic Waves on a Beach," Proceedings of 15th Conference on Coastal Engineering, ASCE, New York, July 1976.

Swanson, R. L., "Tides, "Marine Eco Systems Analysis (MESA) New York Bright Atlas Monograph 4, New York Sea Grant Institute, Albany, January 1976.

Szuwalski, Andre, Bibliography of Publications of the Coastal Engineering Research Center and the Beach Erosion Board, U.S. Army Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Virginia.

Taylor, R. Bruce et al, "Wave Runup on Variable Beach Profiles," Journal of the Waterway Port, Coastal and Ocean Division, ASCE, New York, Vol. 106, WW2, May 1980, pp 169-181.

U.S. Coastal Engineering Research Center, Coastal Engineering Technical Notes: I-5; "Method of Determining Adjusted Windspeed, UA, For Wave Forecasting," I-7, "Revised Method For Wave Forecasting In Deep Water," March, 1981.

U.S. Coastal Engineering Research Center, Shore Protection Manual, U.S. Coastal Engineering Research Center, Fort Belvoir, Virginia, 1977.

Technical Advisory Committee on protection against inundation, Wave Runup and Overtopping, Government Printing Office, the Hague, 1974. (Authored by Battjes, J.A.)

Van Dorn, W. G., "Breaking invariants in shoaling waves," Journal of Geophysical Research, American Geophysical Union, Washington, D.C., Vol. 81 No. 66, June 20, 1978, pp 2981-2088.

Van Dorn, W. G., "Set-up and run-up in shoaling breakers," Proceedings of 15th International Conference on Coastal Engineering, American Society of Civil Engineers, New York, 1976, pp 738-751.

Van Dorn, W. G., "Theoretical and experimental study of wave enhancement and run-up on uniformly sloping impermeable beaches," Rf. 66-11, Scripps Institute of Oceanography, University of California, La Jolla, 1966.

Van Dorn, W. G., and Pazau, S. E., "Laboratory investigation of wave breaking, II, Deep Water Waves," Ref. 75-21, Repty. 71, Advan Ocean Eng. Lab., Scripps Institute of Oceanography, La Jolla, 1975.

Wang, Flora Chu et al, "Computer algorithm of wave runup on beaches," Proceedings of 14th Coastal Engineering Conference, ASCE, New York, 1974, pp. 1956-1975.

Weggel, J. R., "Maximum Breaker Height," Journal of Waterways, Harbors and Coastal Engineering Division, ASCE, New York Vol. 95, WW. 4, November 1976, pp 520.

Yasso, W. E. and Hartman, E. M. Jr., "Beach Forms and Coastal Processes, "Marine Eco Systems Analysis (MESA) New York Bright Areas Monograph 11, New York Sea Grant Institute, Albany, New York, January 1975.

Zenkovitch, V. P., Processes of Coastal Development, Interscience Publishers, New York, 1967.

APPENDIX A: WAVE RUNUP PROGRAM USER'S MANUAL

APPENDIX A

Wave Runup Program

A.1 Program Summary

Purpose: To calculate the wave runup on both single and composite slopes.

Scope: The program takes input values of the beach profile and wave characteristics to compute wave runup above the stillwater level. The computer program's data base is a discretization of Stoa's (1978b) runup curves which are derived from laboratory experiments. The program uses a single slope technique for waves that do not runup past the first slope landward of the stillwater level. The principle of Saville's (1958) Composite Slope Method is used for waves that do runup past the first landward slope. In addition, the program adjusts the computed runup for laboratory model to prototype scale differences and for roughness along the profile surface.

Input:
1. Profile points that define the shape of the beach or structure

2. Roughness correction factors for each slope section between profile points

3. Stillwater level

4. Deepwater wave height

5. Wave period

6. A breaking wave height for each slope section below the stillwater level

Output:

1. Wave and water level input parameters

2. Cotangent of each slope section

3. Slope sequence number that identifies which slope section the wave breaks on

4. Slope sequence number that identifies which slope section the runup limit reaches

5. The runup above the stillwater level

A.2 Computer Requirements

The wave runup program was developed on an IBM 370/3033, in the FORTRAN IV programming language. The IBM FORTRAN H-EXTENDED compiler was selected for the program development and for production runs.

Compilation requires approximately 5 seconds of computer time. Computer execution time requires approximately 0.2 seconds for one profile, but varies according to the number of wave conditions input and the number of iterations required for convergence. Core requirements are in the 250-300K range.

A.3 Functional Description

A.3.1 Technical Algorithm

Wave runup on a composite slope is determined by using laboratory derived curves for single slopes. The method is one of successive approximations, involving the replacement of the actual composite profile with a hypothetical single slope extending from the wave breaking point to the previously estimated runup value. A final runup is found when two successive iterations yield the same runup value.

The program input parameters are discretized (depth and length) points describing the profile, the deepwater wave height and period, and the roughness factor and breaking wave height for each slope section. The breaking wave height, H_b, is found by entering Figure 7-3 in the Shore Protection Manual (1977) with beach slope and deepwater wave steepness. The first task performed by the computer program is to find the depth, d_b, at which the incoming wave breaks. The following iterative procedure determines d_b:

1. Start at the most seaward slope section on the composite profile.

2. Calculate the breaking depth from the following Shore Protection Manual (1977) equations (2-91, 2-92, 2-93);

$$d_b = \frac{H_b}{b - (a\ H_b/gT^2)} \qquad \text{(A-1)}$$

where, $$a = 43.75\ (1-e^{-19m}), \qquad \text{(A-2)}$$

$$b = \frac{1.56}{(1 + e^{-19.5m})}, \qquad \text{(A-3)}$$

m is the slope for the given slope section and T is the wave period.

3. Check to see if the computed breaking depth, d_b, can physically exist on the current slope section given the stillwater depth above the section. If the computed d_b is not large enough, consider the next slope section landward and repeat step 2.

The proper breaking depth is found when it can exist in the water over the given slope section. If the breaking depth for a slope section is deeper than any point on the slope section, then the wave is assumed to break at the point between the current slope section and the section immediately seaward.

Once the breaking depth is found, an iterative algorithm to find the runup, R, is started. The ratio of structure depth to deep-water wave height, d_s/H_o', and the slope of the profile section immediately seaward of d_s (slope section 3 in Figure A-1) are the parameters used to determine which family of curves is used and H_o'/T^2 is computed to determine which curves within that family are used. A family of curves is defined as being one of Stoa's

(1978b) runup charts. One family is unique from other families of curves because of the structure approach slope and the d_s/H_o' ratio.

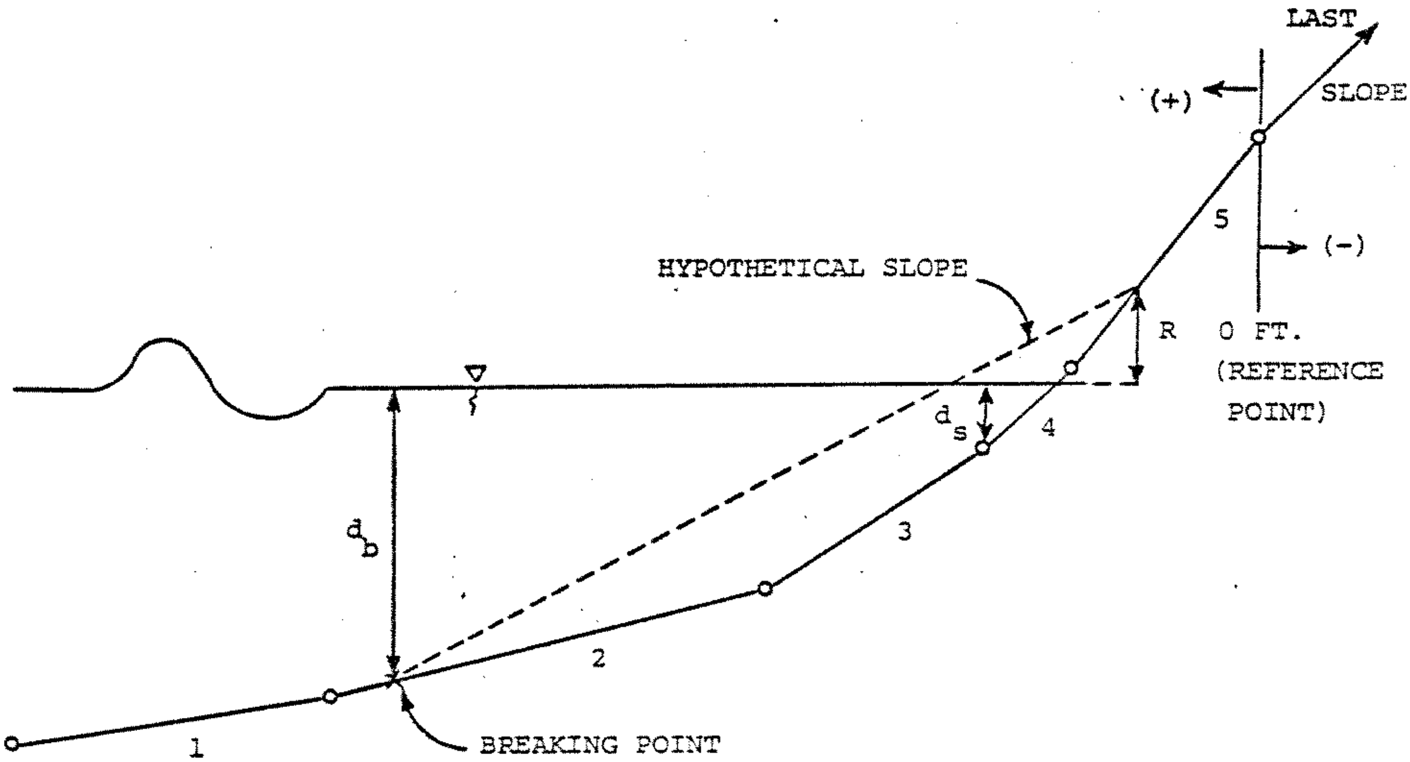


Figure A-1. Typical Composite Profile

Once the correct curves are found, the slope of the profile section where the water level intersects (slope section 4 in Figure A-1) is entered into the curves to find the surrounding R/H_o' curve values. Interpolations between the curves yields a specific R/H_o' value. Multiply this ratio by H_o' to find the runup, R, above the stillwater line. If R does not exceed the slope section that the water level intersects (slope section 4), then this computed runup is taken as the final answer. If the runup does exceed slope section 4, then the program enters the composite slope algorithm. In the composite slope method, the parameter d_s/H_o' is replaced by d_b/H_o' (Saville, 1958). The ranges for both d_b/H_o' and d_s/H_o' that indicate which family of curves to use are in Table A-1. Families of curves 1-7 are in order, Figures 8, 9, 10, 11, 2, 3, and 4 from Stoa (1978b).

TABLE A-1

Family of Curves	Approach Slope (cotθ)	Range of d_s/H_o' or d_b/H_o'
1	ANY	$0 \leq d/Ho' \leq .8$
2	ANY	$0.8 < d/Ho' \leq 1.3$
3	ANY	$1.3 < d/Ho' \leq 2.5$
4	≤30	$2.5 < d/Ho'$
5	>30	$2.5 < d/Ho' \leq 4.0$
6	>30	$4.0 < d/Ho' \leq 6.5$
7	>30	$6.5 < d/Ho'$

The program procedure from the second iteration on is as follows:

1. Determine which family of curves will be entered based on the d_b/H_o' ratio and the slope directly seaward of the breaking point (slope section 2 in Figure A-1).

2. Determine which curves will be utilized according to the H_o'/T^2 ratio.

3. Compute the cotangent of the hypothetical slope which is a straight line from the breaking point to the runup limit computed in the last iteration. The hypothetical slope is shown in Figure A-1.

4. Enter the curve found in Step 2 with the slope found in Step 3 to determine the relative runup values of R/H_o'.

5. Interpolate between curves to find the unique R/H_o' for computed H_o'/T^2 and hypothetical slope.

6. The runup $R = H_o' * R/H_o'$

7. Correct for surface roughness on the slopes above the stillwater line.

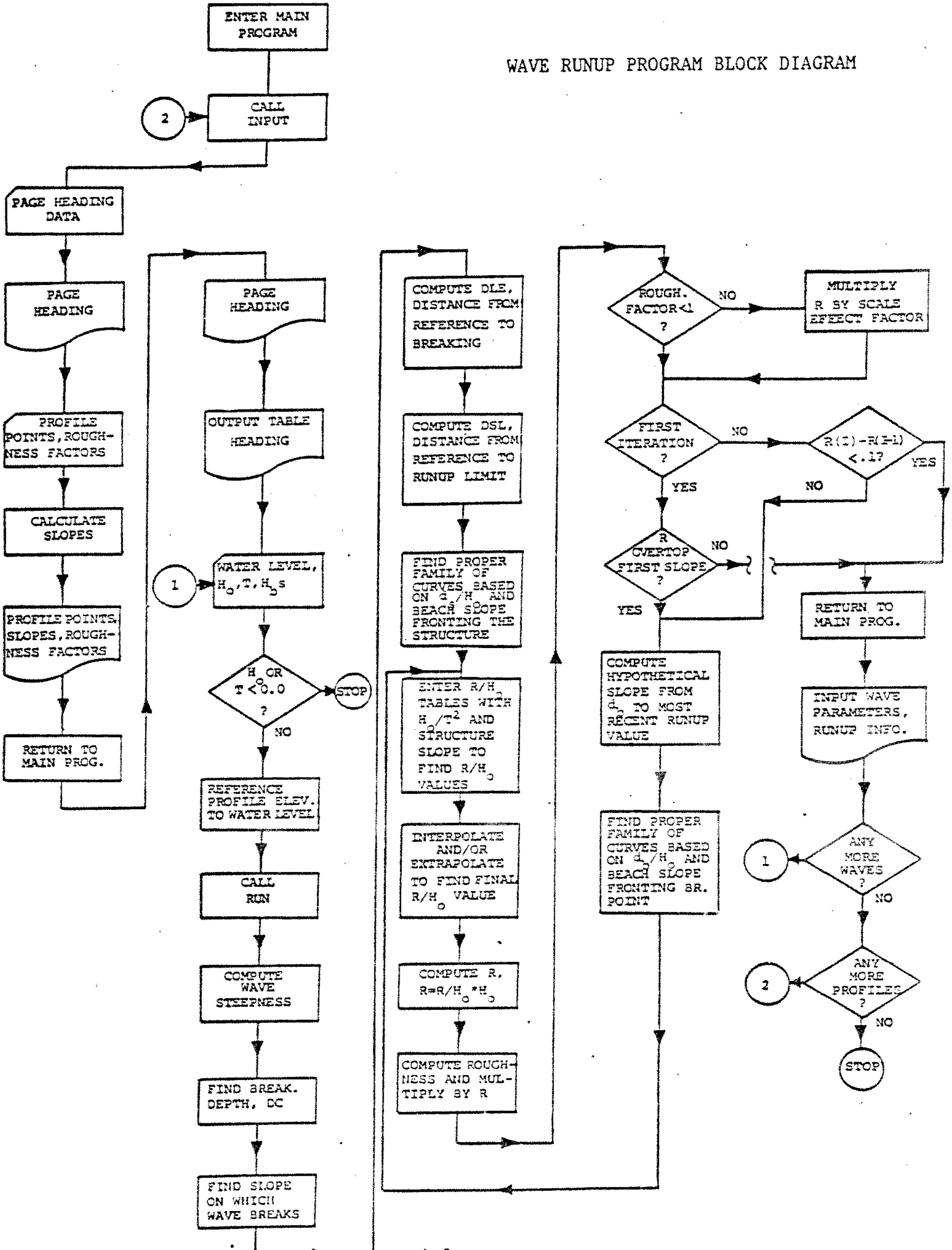
8. If the roughness correction factor is 1.00, then the runup must be corrected for scale-effect between model and prototype. The scale effect factor, K, is a function of the hypothetical slope.

9. If the calculated runup minus the runup from the previous iteration is greater than 0.1 ft., then return to Step 3 with the newly calculated runup. Otherwise the iterative process is finished.

A 3.2 Block Diagram

A summary illustration of the program's major steps is presented in a block diagram on the next page.

WAVE RUNUP PROGRAM BLOCK DIAGRAM



A.3.3 Program Description

The wave runup program consists of a main program that controls the activities of eight task orientated subroutines. The components of the program are described in a logical sequence below.

MAIN - The mainline controls the program activities. It first calls subroutine INPUT to read in the profile information. Upon returning from INPUT, MAIN reads the first set of wave and stillwater level parameters and adjusts the profile elevations so that the zero line is at the stillwater line. Then MAIN calls subroutine RUN to compute the runup. When the runup is calculated, MAIN prints it out along with the wave input information. MAIN then begins again by reading a new set of waves. As many wave and water level conditions as needed can be executed for a given profile. When all the waves for one profile have been executed, the next profile is read and its associated waves are used to compute runup values. The program stops when it runs out of wave parameter cards at the end of the last profile. Several profiles may be executed in one run provided sufficient computation time is allocated in the job control language.

INPUT - Subroutine INPUT reads the discretized profile information which consists of depth, length, and roughness values. A maximum of fifteen profile points can be read into the program. The profile is read starting at the most s award poi t and proceeds landward.

The cotangent of each slope section between profile points is computed. A last landward slope extending inland from the most landward point is also read in as a safety factor so that a computed runup will not overtop the profile causing numerical mistakes. Before returning to the MAIN program, subroutine INPUT prints out the profile points, roughness factors, and slopes.

BLOCK DATA - Subroutine BLOCK DATA contains the data which has been discretized from Stoa's (1978b) runup charts. The data base is contained in two common blocks; SY and SZ.

Common/SY/ contains three one-dimensional arrays consisting of table entry values. The runup charts require that three variables, cotangent of the slope, Ho'/T^2 and d/Ho', must be known in order to find a particular R/Ho' value. The three arrays PDB, PDB1, and PCH in SY store the table values for the three variables; slope, Ho'/T^2 and d/Ho'.

Common/SZ/ contains a series of one-dimensional arrays that contain the R/Ho' values for all seven of Stoa's (1978b) runup charts used in the program. The data in this common block is accessed from subroutine RUN by using a three-dimensional array, DB(PDB, PDB1, PCH). Each 1-D array is titled with a D followed by a three-digit number. The first digit represents the family of curves and the second two digits indicate the curve number within the family in ascending order of H_o'/T^2. For example, D211 is the eleventh curve in the second family of curves. A " - 999" in the chart indicates no data is available for that particular slope.

RUN - Subroutine RUN calculates the runup of a wave on a given profile based upon the wave characteristics and the profile configuration. The parameters needed for the runup computations are described below.

The breaking depth, DC, is computed based on Weggel's (1972) wave breaking analysis. The distance from the breaking point to the origin (0.0 ft.) is also found. This distance, called DLE, is found by a linear interpolation using the two endpoints of the slope that contain the wave breaking point.

Wave steepness (HOT2) is computed by;

HOT2 = HO/T*T

The value of DC/H_o' is sorted against bounds contained in PCH from which the applicable family of curves is chosen. The distance from the reference point to the runup limit, DSL, is calculated and is used along with variables DLE, DC, and R to compute the hypothetical slope, DCS. Using the computed hypothetical slope, the slope table, PDB, is entered to come out with pointers into the R/H_o' table, DB. Four pointers are found for each case because there are two table values of slope surrounding the hypothetical slope and two H_o'/T^2 table values surrounding the computed H_o'/T^2 for each slope value. In effect, a parallelogram surrounds the sought after R/H_o' value as shown in Figure A-2. In order to find R/H_o' a log-log interpolation is done between points 1 and 2 to get point 5 and between points 3 and 4 to get point 6. A third interpolation between points 5 and 6 gives the R/H_o' answer.

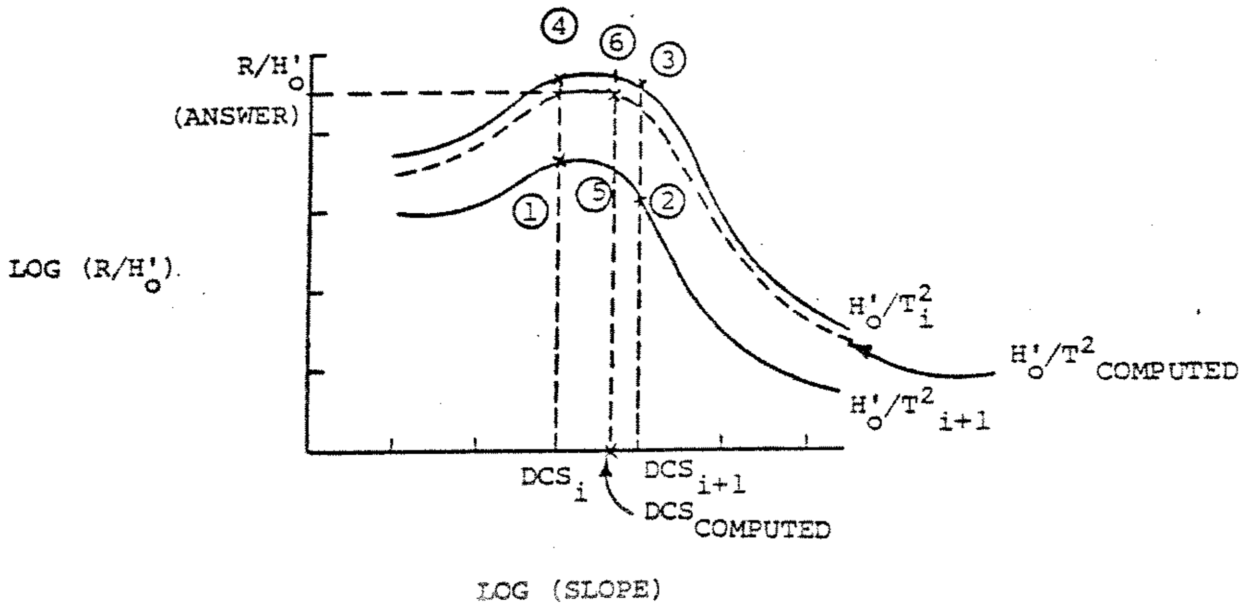


Figure A-2. R/H_o' vs Slope

At times the hypothetical slope is beyond the range of the curve, in which case a log-log extrapolation finds R/Ho'. Referring to Figure A-3, an extrapolation is performed from the last known point and the third point before the last known point. For example, points 1 and 2 are extrapolated out to point 3 and points 4 and 5 are extrapolated to point 6.

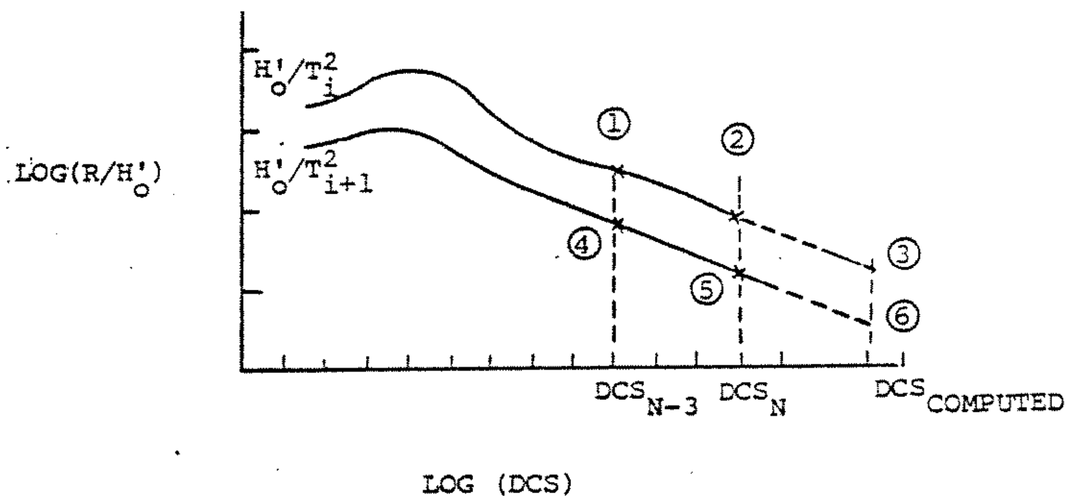


Figure A-3. Extrapolation Example

A final interpolation between points 3 and 6 finds the answer. Once an R/Ho' value is calculated, it is multiplied by Ho' to find the runup, R. Subroutine RRUFF is then called to calculate a roughness correction that is multiplied by R. If the slope is smooth, i.e., the roughness correction factor = 1.0, then the runup, R, is multiplied by a model to prototype scale correction factor. The scale effect is a function of the hypothetical slope and varies from 1.000 to 1.140 (Stoa, 1978b).

If after the first iteration the runup does not overtop the first slope, then the final runup has been found. If the first slope is overtopped, run uses the composite slope methc' and iterates until an R is converged on. If after ten iterations the computed runup has not converged, an error flag is tripped and an error message alerting the user to the problem is printed.

LOOK - Subroutine LOOK is a general purpose subroutine designed to locate an input variable between two elements of a table of elements. Input to the subroutine consists of a table of values in an array, the number of elements in the array, and the value to be placed in the table. The output consists of a pointer to the table values above and below the input value. A flag is provided that signals when the input value is out of the range of the table.

RINT - Subroutine RINT executes a linear interpolation given two known values and a third independent value. RINT is used to find the horizontal distance from the reference point to the breaking point and from the reference point to the runup limit.

LOGLOG - Subroutine LOGLOG performs a log-log interpolation given two known values and a third independent value. LOGLOG is used for interpolations on the R/H_o' vs. DCS charts.

LOGLIN - Subroutine LOGLIN executes a log-linear interpolation for cases where the functional relationship has a logarithmic abscissa and a linear ordinate. LOGLIN is used for interpolations on the scale effect factor vs. slope chart.

RRUFF - Each slope section on the profile has a corresponding roughness factor. Subroutine RRUFF computes a weighted average of these roughness factors based on slope section length. The weighted average is evaluated from the stillwater line up to the estimated runup limit only. When the profile data points are input to the program, a roughness factor is also input with the data points.

A.4 Operating Instructions

A.4.1 Program Input

There are several input cards, the first two containing information about the client, engineer, and project followed by a card containing the Last Slope, and cards containing the Profile, Water Levels, and Wave Parameters as follows:

Name Card (A Format)

Col. 1-2 blank

Col. 3-28 contain client's name

Col. 29-60 blank

Col. 61-70 contain engineer's name

Col. 71-80 job number

Job Description Card (A Format)

Col. 1-2 blank

Col. 3-76 describe the project or identify the run

Col. 77-80 contain the run number

Note: The Name Card and the Job Description Card must appear before each profile.

Last Slope Card

Col. 1-4 contain the slope (cotangent) of the profile landward of the most landward point read into the program. (F4.1)

Profile Cards (not more than 15)

Each card contains one point of the beach profile and one slope section roughness factor. The profile points must appear in consecutive order from seaward to landward.

Col. 1 flag IC. The last point on the profile (most landward) is indicated by a 1. (I1) If not the last point leave blank.

Col. 2 blank

Col. 3-7 depth with respect to a vertical datum (usually NGVD) in feet. (F5.1)

Col. 8 blank

Col. 9-13 horizontal distance from the 0.0 point of the vertical datum to the point of interest in feet, positive for distance landward and negative for distance seaward. (F5.0)

*The reference point is usually taken as the most landward point on the profile but it may be any point on the profile.

Col. 15-19 The roughness factor on the first profile card is the roughness for the slope between the first two sets of profile points. The roughness factor on the second card is the roughness for the slope section between the second and third sets of profile points read into the program. The same logic continues to the last profile card which contains the roughness for the most landward slope section which was read on the Last Slope card. (F5.3)

Water Level and Wave Parameter Cards

There may be as many waves run as desired.

Col. 1 The last parameter card for a given profile is indicated by a 1. This flag notifies the program that another profile is following. Therefore, Col. 1 of the last parameter card of the last profile is left blank (I1).

Col. 2-6 stillwater level above vertical datum or NGVD, in feet. (F5.2)

Col. 7 blank

Col. 8-12 Deepwater wave height in feet. (F5.2)

Col. 13 blank

Col. 14-18 wave period in seconds. (F5.2)

In columns 20-24, 26-30, 32-36, 38-42, 44-48, 50-54, 56-60, 62-66, 68-72, and 74-78 a value of breaker height is entered for each slope section (F5.2). Breaker heights are entered starting at the most seaward slope section and proceeding landward. A maximum of ten breaker heights may be input for each deepwater wave. Therefore, only ten slope sections may be below the stillwater level on one profile.

A.4.2 Program Output

Output from the program consists of a printout of the profile, the input wave parameters and runup information. The profile is listed as a set of profile points, cotangents of the slope sections, and the roughness factors for the slopes. The wave parameters printed are the stillwater level, the deepwater wave height and the associated period. The runup output lists the sequence number of the slope section on which the incoming wave breaks, the sequence number of the slope section that the runup limit reaches and the value of runup itself. The sequence number of the slope sections as shown in Figure A-1, starts as 1 at the most seaward slope section and is increased by 1 working landward. The above output is repeated for each profile input to the program.

A.4.3 Error Messages

There are four error messages that alert the user to the most common problems encountered in the program.

<u>SOLUTION DOES NOT CONVERGE</u> - After ten iterations the generated runup and the previously generated runup differ by more than 0.1 ft. The two runups are printed along with the error message. The program is usually oscillating between these two runups when the solution does not converge.

<u>DATA EXCEEDED TABLE</u> - An entry into subroutine LOOK is not within the bounds of the table in which the value is to be placed.

<u>NEGATIVE RUN PARAMETER, PROGRAM STOPS</u> - An input value of deep water wave height or wave period is negative or zero.

<u>MORE THAN 15 POINTS IN PROFILE PROGRAM STOPS</u> - The program can handle a maximum of fifteen discrete profile points only. The program terminates if more than 15 points are input.

A.4.4 Sample IBM Job Control Language

```
1    (Job Card)
1    // MSGLEVEL=(1,1), MSGCLASS=A
1    /*JOBPARM R=300K, T=1, MAIL=YES
```

```
1    //EN057 EXEC PGM=MOD5,REGION=100K, TIME=(,10)
1    //STEPLIB DD DSN=S0952MW.WAVE.LOAD, DISP=(SHR,KEEP)
1    //FT06F001 DD SYOUT=*
1    //SYSUDUMP DD DUMMY
1    //FT05F001 DD *
```

A.5 Sample Problem

A.5.1 Problem Description

The sample case illustrates the input data format and the output results. The profile used in the sample case comes from a transect measured at Old Orchard Beach, Maine (Figure 6-1, Main Text). This is a typical profile configuration for a natural sand beach on an open coastline. The elevations on the profile are referenced to NGVD. The stillwater level represents the level computed for the 100-yr storm surge level. The wave period is the significant period for the 100-yr storm. Several wave heights ranging from 5 to 13 ft. are tried to determine which wave yields the highest runup (see Sec. 6.3, Main Text).

A.5.2 Sample Input

The printout below, generated by Stone & Webster's Input Data Traceback subroutine, illustrates the input data format for the sample case.

INPUT DATA TRACEBACK

DATA SUBMITTED ON DEVICE: 5

```
CARD# ----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
  1    FEMA                                                       MCH      1296800
  2    WAVE RUNUP      TRANSECT 71, EXAMPLE CASE, T=14SEC.                      50
  3   100
  4    -22.3 -2420   1.0
  5    -16.3 -1129   1.0
  6    -10.3  -587   1.0
  7     -4.3  -170   1.0
  8     00.0     0   1.0
  9      5.0    40   1.0
 10     10.0   120   1.0

CARD# ----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
 11  1  15.0   300   1.0
 12     9.1   5.0  14.0   7.2   8.0   8.3   8.9  10.8  10.0
 13     9.1   7.0  14.0   9.7  10.5  10.8  11.5  13.5  12.8
 14     9.1   9.0  14.0  11.3  12.5  12.8  13.7  16.4  15.2
 15     9.1  11.0  14.0  13.4  14.7  15.0  16.0  19.0  17.9
 16     9.1  13.0  14.0  15.1  16.6  17.0  18.0  21.3  20.0
 17     8.2   5.0  14.0   7.2   8.0   8.3   8.9  10.8  10.0
 18     8.2   7.0  14.0   9.7  10.5  10.8  11.5  13.5  12.8
 19     8.2   9.0  14.0  11.3  12.5  12.8  13.7  16.4  15.2
 20     8.2  11.0  14.0  13.4  14.7  15.0  16.0  19.0  17.9

CARD# ----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
 21     8.2  13.0  14.0  15.1  16.6  17.0  18.0  21.3  20.0
CARD# ----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

     * * * * * * * * * * * * * * END OF INPUT ON DEVICE 5 * * * * * * * * * * * * * *
```

A.5.3 Sample Output

The sample problem output as it appears in the computer printout is shown on the next two pages.

CLIENT- FEMA ** WAVE RUNUP COMPUTATIONS ** ENGINEERED BY MCM JOB 1296800

PROJECT-WAVE RUNUP TRANSECT 71, EXAMPLE CASE, T=14SEC. RUN 50 PAGE 1

****

CROSS SECTION PROFILE

	LENGTH	ELEV.	SLOPE	ROUGHNESS
1	-2420.0	-22.3		
			215.17	1.00
2	-1129.0	-16.3		
			90.33	1.00
3	-587.0	-10.3		
			69.50	1.00
4	-170.0	-4.3		
			39.53	1.00
5	0.0	0.0		
			8.00	1.00
6	40.0	5.0		
			16.00	1.00
7	120.0	10.0		
			36.00	1.00
8	300.0	15.0		

LAST SLOPE 10.00 LAST ROUGHNESS 1.00

****

OUTPUT TABLE

INPUT PARAMETERS			RUNUP RESULTS		
WATER LEVEL ABOVE DATUM (FT.)	DEEP WATER WAVE HEIGHT (FT.)	WAVE PERIOD (SEC.)	BREAKING SLOPE NUMBER	RUNUP SLOPE NUMBER	RUNUP ABOVE WATER LEVEL (FT.)
9.1	5.0	14.00	5	7	3.5
9.1	7.0	14.00	4	7	3.7
9.1	9.0	14.00	3	7	3.4
9.1	11.0	14.00	3	7	2.9
9.1	13.0	14.00	3	7	2.7
8.2	5.0	14.00	4	7	3.9
8.2	7.0	14.00	4	7	3.7
8.2	9.0	14.00	3	7	3.1
8.2	11.0	14.00	3	7	2.6
8.2	13.0	14.00	3	7	2.6

A.6 Program Listing

The FORTRAN source listing of the Wave Runup Program is presented on the following pages.

```
START
 COL  ----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
  7         BLOCK DATA
  1   C                                                                        BLOC0010
  1   C     THIS SUBROUTINE INITIALIZES MEMORY                                 BLOC0020
  1   C                                                                        BLOC0030
  1   C*****VARIABLE DICTIONARY                                                BLOC0040
  1   C                                                                        BLOC0050
  1   C     NAME MODE SIZE   DESCRIPTION                                       BLOC0060
  1   C                                                                 UNITS  BLOC0070
  1   C                                                                        BLOC0080
  1   C     PDB   I*2 27     VALUES OF SLOPE FOR ENTRY INTO DB          *100   BLOC0090
  1   C     PDB1  I*2 13     VALUES OF H/T**2 FOR ENTRY INTO DB         *1000  BLOC0100
  1   C     PCH   I*2 8      VALUES OF  D/H0  FOR ENTRY INTO DB         *10    BLOC0110
  1   C     DB    I*2 2457   VALUES OF R/H0 AS FUNCT. OF PDB,PDB1,PCH   *100   BLOC0120
  1   C     DB  CONSISTS OF THE DUMMY ARRAYS  D101-D707                        BLOC0130
  1   C     IPAGE I*4 1      CURRENT PAGE NUMBER                               BLOC0140
  1   C     DT    I*2 118    PAGE HEADING                                      BLOC0150
  1   C                                                                        BLOC0160
  1   C*****START OF SUBROUTINE                                                BLOC0170
  7         IMPLICIT INTEGER*2(D,P)                                            BLOC0180
  7         COMMON /HD/ IPAGE,DT(118)                                          BLOC0190
  7         COMMON /SY/ PDB(27),PDB1(13),PCH(8)                                BLOC0200
  7         COMMON /SZ/ D101(180),D107(171),D201(180),D207(171),D301(180),     BLOC0210
  6        1 D307(171),D401(180),D407(171),D501(180),D507(171),D601(180),      BLOC0220
  6        2 D607(171),D701(180),D707(171)                                     BLOC0230
  7         DATA DT/'CL','IE','NT','- ',16*0,'**',' H','AV','E ','RU','NU',    BLOC0240
  6        1 'P ','CO','MP','UT','AT','IO','NS',' *','* ',4*0,'EN','GI','NE',  BLOC0250
  6        2 'ER','ED',' B','Y ',6*0,'JO','B ',5*0,'PR','OJ','EC','T-',46*0,   BLOC0260
  6        3 'RU','N ',3*0,' P','AG','E ',0/,IPAGE/0/                          BLOC0270
  7         DATA PDB1/   10,   19,   29,   39,   51,   61,   74,  100,  151,   BLOC0280
  6        1            199,  251,  299,  399/                                 BLOC0290
  7         DATA  PCH/    0,    8,   13,   25, 1000, 4000, 6500,30000/         BLOC0300
  1   C                                                                        BLOC0310
  7         DATA PDB/    10,   15,   20,   30,   40,   50,   60,   80,  100,   BLOC0320
  6        1            112,  130,  150,  170,  200,  250,  300,  350,  400,   BLOC0330
  6        2            450,  500,  600,  700,  800, 1000, 1500, 2000, 3000/   BLOC0340
  1   C  FIGURE 8                                                              BLOC0350
  7         DATA D101/  600,  600,  600,  600,  600,  600,  590,  575,  560,   BLOC0360
  6        2            550,  540,  540,  540,  540,  530,  520,  500,  490,   BLOC0370
  6        3            480,  460,  410,  370,  330,  260, -999, -999, -999,   BLOC0380
  6        1            540,  540,  540,  540,  540,  540,  520,  505,  495,   BLOC0390
  6        2            490,  480,  475,  470,  460,  445,  430,  420,  410,   BLOC0400
  6        3            400,  390,  350,  290,  245,  180, -999, -999, -999,   BLOC0410
  6        1            460,  460,  460,  460,  460,  460,  460,  460,  460,   BLOC0420
  6        2            460,  460,  450,  445,  435,  420,  400,  380,  360,   BLOC0430
  6        3            340,  320,  275,  225,  190,  140, -999, -999, -999,   BLOC0440
  6        1            415,  415,  415,  415,  415,  415,  420,  430,  440,   BLOC0450
  6        2            440,  435,  430,  425,  415,  395,  375,  350,  325,   BLOC0460
  6        3            300,  270,  220,  185,  160,  120, -999, -999, -999,   BLOC0470
  6        1            365,  365,  365,  365,  365,  365,  375,  390,  395,   BLOC0480
  6        2            400,  400,  395,  390,  360,  360,  340,  310,  280,   BLOC0490
  6        3            250,  230,  190,  160,  140,  105, -999, -999, -999,   BLOC0500
  6        1            320,  320,  320,  320,  320,  320,  330,  345,  350,   BLOC0510
  6        2            355,  355,  350,  340,  330,  315,  300,  275,  245,   BLOC0520
  6        3            220,  195,  160,  140,  120,   94, -999, -999, -999,   BLOC0530
  6        1            285,  285,  285,  285,  285,  285,  295,  305,  320,   BLOC0540
```

```
START
 COL  ----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
 6                   320,  320,  315,  310,  300,  280,  255,  235,  210/  BLOC0550
 7      DATA D107/   185,  165,  140,  120,  105,   82, -999, -999, -999,  BLOC0560
 6       1           250,  250,  250,  250,  250,  250,  250,  255,  260,  BLOC0570
 6       2           265,  265,  260,  260,  245,  230,  210,  185,  165,  BLOC0580
 6       3           145,  135,  112,   97,   86,   69, -999, -999, -999,  BLOC0590
 6       1           195,  195,  195,  195,  195,  195,  200,  210,  220,  BLOC0600
 6       2           220,  220,  220,  215,  205,  185,  160,  140,  125,  BLOC0610
 6       3           110,  103,   88,   76,   68,   54, -999, -999, -999,  BLOC0620
 6       1           170,  170,  170,  170,  170,  170,  180,  190,  195,  BLOC0630
 6       2           198,  200,  198,  192,  182,  165,  145,  125,  110,  BLOC0640
 6       3            98,   88,   75,   65,   57,   47, -999, -999, -999,  BLOC0650
 6       1           155,  155,  155,  155,  155,  155,  165,  175,  180,  BLOC0660
 6       2           185,  185,  180,  175,  160,  140,  120,  105,   95,  BLOC0670
 6       3            84,   76,   65,   56,   49,   40, -999, -999, -999,  BLOC0680
 6       1           142,  142,  142,  142,  142,  142,  150,  158,  165,  BLOC0690
 6       2           168,  170,  165,  155,  142,  125,  110,   96,   85,  BLOC0700
 6       3            75,   69,   58,   50,   43,   35, -999, -999, -999,  BLOC0710
 6       1           120,  120,  120,  120,  120,  120,  130,  140,  145,  BLOC0720
 6       2           150,  150,  145,  140,  130,  112,   96,   85,   75,  BLOC0730
 6       3            67,   60,   51,   44,   37,   32, -999, -999, -999/  BLOC0740
 1  C    FIGURE 9                                                          BLOC0750
 7      DATA D201/   700,  700,  700,  700,  700,  700,  670,  640,  620,  BLOC0760
 6       2           600,  600,  600,  600,  600,  590,  570,  550,  520,  BLOC0770
 6       3           500,  470,  420,  370,  320,  250, -999, -999, -999,  BLOC0780
 6       1           660,  660,  660,  660,  660,  660,  630,  580,  550,  BLOC0790
 6       2           540,  520,  520,  520,  510,  500,  470,  440,  420,  BLOC0800
 6       3           390,  370,  330,  270,  230,  170, -999, -999, -999,  BLOC0810
 6       1           620,  620,  620,  620,  620,  620,  600,  540,  510,  BLOC0820
 6       2           500,  480,  460,  460,  460,  440,  410,  380,  360,  BLOC0830
 6       3           330,  310,  260,  215,  185,  140, -999, -999, -999,  BLOC0840
 6       1           570,  570,  570,  570,  570,  570,  540,  500,  470,  BLOC0850
 6       2           460,  440,  440,  440,  430,  400,  370,  340,  310,  BLOC0860
 6       3           285,  260,  215,  185,  160,  120, -999, -999, -999,  BLOC0870
 6       1           520,  520,  520,  520,  520,  520,  500,  470,  450,  BLOC0880
 6       2           440,  430,  420,  410,  390,  360,  340,  310,  280,  BLOC0890
 6       3           250,  220,  180,  155,  135,  105, -999, -999, -999,  BLOC0900
 6       1           480,  480,  480,  480,  480,  480,  470,  450,  430,  BLOC0910
 6       2           420,  420,  410,  400,  375,  340,  310,  285,  260,  BLOC0920
 6       3           235,  200,  170,  140,  120,   95, -999, -999, -999,  BLOC0930
 6       1           450,  450,  450,  450,  450,  450,  440,  430,  420,  BLOC0940
 6       2           410,  400,  390,  360,  360,  325,  290,  255,  225/  BLOC0950
 7      DATA D207/   200,  180,  150,  125,  110,   84, -999, -999, -999,  BLOC0960
 6       1           405,  405,  405,  405,  405,  405,  400,  395,  390,  BLOC0970
 6       2           385,  375,  365,  345,  320,  280,  250,  215,  185,  BLOC0980
 6       3           165,  145,  120,  100,   88,   70, -999, -999, -999,  BLOC0990
 6       1           345,  345,  345,  345,  345,  345,  340,  330,  325,  BLOC1000
 6       2           320,  310,  300,  290,  275,  240,  205,  175,  150,  BLOC1010
 6       3           130,  120,   96,   80,   70,   55, -999, -999, -999,  BLOC1020
 6       1           300,  300,  300,  300,  300,  300,  295,  285,  280,  BLOC1030
 6       2           278,  270,  260,  255,  235,  205,  170,  145,  125,  BLOC1040
 6       3           115,  100,   82,   70,   60,   48, -999, -999, -999,  BLOC1050
 6       1           265,  265,  265,  265,  265,  265,  260,  260,  255,  BLOC1060
 6       2           252,  240,  240,  230,  210,  182,  155,  130,  115,  BLOC1070
 6       3           100,   89,   72,   60,   52,   41, -999, -999, -999,  BLOC1080
```

```
START
 COL   ----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

  6      1            233,  233,  233,  233,  233,  233,  233,  233,  233,  BLOC1090
  6      2            233,  230,  225,  218,  195,  165,  135,  115,  100,  BLOC1100
  6      3             88,   78,   64,   53,   46,   36, -999, -999, -999,  BLOC1110
  6      1            203,  203,  203,  203,  203,  203,  203,  205,  206,  BLOC1120
  6      2            208,  205,  200,  190,  173,  146,  122,  102,   88,  BLOC1130
  6      3             76,   68,   56,   46,   40,   32, -999, -999, -999/ BLOC1140
  1  C       FIGURE 10                                                      BLOC1150
  7     DATA D301/    460,  460,  460,  460,  460,  460,  460,  460,  465,  BLOC1160
  6      2            465,  470,  480,  490,  495,  500,  505,  505,  495,  BLOC1170
  6      3            480,  470,  430,  370,  315,  235, -999, -999, -999,  BLOC1180
  6      1            395,  395,  400,  400,  400,  400,  395,  390,  395,  BLOC1190
  6      2            395,  400,  410,  420,  420,  415,  400,  390,  375,  BLOC1200
  6      3            365,  345,  315,  270,  230,  170, -999, -999, -999,  BLOC1210
  6      1            330,  330,  340,  340,  340,  350,  355,  370,  370,  BLOC1220
  6      2            380,  390,  400,  405,  400,  390,  370,  350,  330,  BLOC1230
  6      3            310,  290,  250,  220,  185,  140, -999, -999, -999,  BLOC1240
  6      1            310,  315,  320,  330,  330,  335,  340,  360,  365,  BLOC1250
  6      2            370,  400,  400,  400,  390,  380,  360,  335,  310,  BLOC1260
  6      3            285,  260,  220,  185,  160,  120, -999, -999, -999,  BLOC1270
  6      1            295,  300,  305,  310,  320,  325,  330,  350,  370,  BLOC1280
  6      2            390,  400,  400,  390,  380,  360,  345,  320,  295,  BLOC1290
  6      3            265,  240,  195,  160,  140,  105, -999, -999, -999,  BLOC1300
  6      1            270,  285,  295,  300,  305,  310,  320,  340,  360,  BLOC1310
  6      2            375,  390,  395,  395,  380,  355,  325,  295,  265,  BLOC1320
  6      3            240,  215,  175,  145,  125,   95, -999, -999, -999,  BLOC1330
  6      1            260,  265,  275,  290,  295,  305,  315,  335,  360,  BLOC1340
  6      2            375,  385,  390,  385,  365,  330,  295,  265,  235/  BLOC1350
  7     DATA D307/    205,  190,  159,  130,  110,   86, -999, -999, -999,  BLOC1360
  6      1            240,  240,  245,  245,  250,  260,  275,  300,  325,  BLOC1370
  6      2            340,  350,  350,  345,  330,  295,  255,  225,  200,  BLOC1380
  6      3            175,  160,  130,  110,   95,   74, -999, -999, -999,  BLOC1390
  6      1            210,  210,  210,  215,  220,  225,  235,  255,  270,  BLOC1400
  6      2            280,  280,  280,  275,  265,  235,  200,  175,  155,  BLOC1410
  6      3            135,  120,  100,   85,   73,   57, -999, -999, -999,  BLOC1420
  6      1            190,  190,  190,  190,  195,  200,  205,  220,  240,  BLOC1430
  6      2            245,  245,  245,  240,  230,  205,  175,  150,  135,  BLOC1440
  6      3            115,  105,   85,   70,   60,   46, -999, -999, -999,  BLOC1450
  6      1            175,  175,  175,  180,  180,  185,  190,  205,  220,  BLOC1460
  6      2            225,  225,  220,  215,  205,  180,  155,  135,  115,  BLOC1470
  6      3            105,   92,   74,   62,   53,   40, -999, -999, -999,  BLOC1480
  6      1            165,  165,  165,  165,  168,  170,  172,  185,  190,  BLOC1490
  6      2            195,  198,  195,  195,  180,  160,  135,  120,  105,  BLOC1500
  6      3             94,   82,   66,   56,   47,   36, -999, -999, -999,  BLOC1510
  6      1            145,  145,  145,  145,  145,  145,  148,  155,  165,  BLOC1520
  6      2            170,  175,  170,  165,  155,  140,  120,  105,   94,  BLOC1530
  6      3             84,   74,   60,   49,   42,   34, -999, -999, -999/ BLOC1540
  1  C       FIGURE 11                                                      BLOC1550
  7     DATA D401/    195,  210,  225,  240,  250,  255,  265,  280,  285,  BLOC1560
  6      2            290,  290,  300,  310,  320,  330,  340,  350,  355,  BLOC1570
  6      3            360,  360,  340,  310,  275,  225, -999, -999, -999,  BLOC1580
  6      1            195,  210,  225,  240,  250,  255,  265,  280,  285,  BLOC1590
  6      2            290,  290,  300,  310,  320,  330,  340,  350,  355,  BLOC1600
  6      3            335,  320,  280,  245,  215,  170, -999, -999, -999,  BLOC1610
  6      1            190,  200,  210,  230,  240,  250,  250,  260,  260,  BLOC1620
```

```
START
 COL  ----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

  6      2           270,  280,  280,  300,  310,  320,  325,  330,  325,  BLOC1630
  6      3           300,  275,  235,  200,  175,  140, -999, -999, -999,  BLOC1640
  6      1           190,  200,  210,  230,  240,  250,  250,  260,  260,  BLOC1650
  6      2           270,  280,  280,  290,  300,  310,  310,  315,  300,  BLOC1660
  6      3           265,  245,  200,  175,  150,  120, -999, -999, -999,  BLOC1670
  6      1           180,  190,  200,  220,  230,  235,  240,  255,  265,  BLOC1680
  6      2           270,  275,  280,  280,  285,  295,  300,  285,  265,  BLOC1690
  6      3           230,  205,  170,  145,  125,  100, -999, -999, -999,  BLOC1700
  6      1           170,  180,  185,  190,  205,  220,  230,  235,  250,  BLOC1710
  6      2           255,  258,  260,  262,  270,  280,  285,  270,  240,  BLOC1720
  6      3           215,  190,  155,  135,  115,   90, -999, -999, -999,  BLOC1730
  6      1           155,  165,  175,  180,  185,  195,  200,  210,  220,  BLOC1740
  6      2           225,  235,  240,  245,  250,  260,  265,  240,  210/  BLOC1750
  7     DATA D407/   185,  165,  140,  120,  103,   80, -999, -999, -999,  BLOC1760
  6      1           145,  150,  155,  165,  170,  180,  185,  192,  200,  BLOC1770
  6      2           205,  210,  215,  220,  230,  235,  225,  200,  175,  BLOC1780
  6      3           155,  140,  115,   98,   84,   66, -999, -999, -999,  BLOC1790
  6      1           120,  127,  132,  140,  148,  152,  160,  167,  177,  BLOC1800
  6      2           180,  190,  200,  205,  210,  200,  175,  155,  135,  BLOC1810
  6      3           125,  110,   90,   77,   67,   53, -999, -999, -999,  BLOC1820
  6      1           115,  120,  125,  135,  140,  145,  150,  160,  172,  BLOC1830
  6      2           175,  177,  190,  195,  195,  180,  155,  135,  120,  BLOC1840
  6      3           108,   97,   80,   67,   58,   44, -999, -999, -999,  BLOC1850
  6      1           110,  115,  120,  130,  135,  140,  145,  155,  170,  BLOC1860
  6      2           172,  180,  185,  187,  185,  168,  140,  120,  106,  BLOC1870
  6      3            93,   84,   69,   58,   50,   39, -999, -999, -999,  BLOC1880
  6      1           105,  110,  115,  120,  128,  132,  138,  147,  160,  BLOC1890
  6      2           165,  172,  180,  180,  177,  155,  130,  110,   96,  BLOC1900
  6      3            85,   75,   62,   52,   45,   35, -999, -999, -999,  BLOC1910
  6      1            92,   98,  102,  108,  115,  122,  128,  138,  150,  BLOC1920
  6      2           155,  165,  168,  165,  158,  135,  115,   97,   84,  BLOC1930
  6      3            75,   65,   53,   44,   37,   29, -999, -999, -999/  BLOC1940
  1   C       FIGURE 2                                                      BLOC1950
  7     DATA D501/   240,  270,  280,  290,  290,  295,  305,  315,  325,  BLOC1960
  6      2           335,  345,  360,  375,  400,  420,  430,  430,  430,  BLOC1970
  6      3           425,  415,  375,  325,  280,  215,  130,   90,   55,  BLOC1980
  6      1           210,  230,  240,  255,  265,  270,  275,  280,  290,  BLOC1990
  6      2           300,  310,  320,  340,  355,  380,  400,  402,  395,  BLOC2000
  6      3           365,  365,  315,  265,  220,  170,  100,   72,   45,  BLOC2010
  6      1           185,  200,  210,  225,  235,  240,  243,  247,  253,  BLOC2020
  6      2           265,  280,  295,  310,  325,  350,  360,  360,  350,  BLOC2030
  6      3           340,  315,  270,  225,  185,  140,   84,   60,   37,  BLOC2040
  6      1           160,  175,  165,  200,  200,  212,  218,  222,  230,  BLOC2050
  6      2           240,  250,  270,  280,  300,  325,  335,  330,  315,  BLOC2060
  6      3           300,  275,  230,  195,  160,  120,   73,   53,   33,  BLOC2070
  6      1           140,  152,  162,  175,  185,  192,  200,  208,  215,  BLOC2080
  6      2           230,  240,  255,  265,  280,  295,  305,  300,  285,  BLOC2090
  6      3           270,  245,  200,  165,  135,  100,   62,   43,   27,  BLOC2100
  6      1           130,  145,  155,  168,  175,  182,  188,  198,  205,  BLOC2110
  6      2           215,  230,  240,  250,  260,  280,  288,  280,  265,  BLOC2120
  6      3           245,  220,  180,  145,  120,   92,   56,   40,   26,  BLOC2130
  6      1           130,  140,  148,  158,  165,  170,  175,  182,  190,  BLOC2140
  6      2           205,  215,  230,  240,  250,  265,  270,  260,  240/  BLOC2150
  7     DATA D507/   215,  190,  160,  130,  110,   82,   50,   37,   24,  BLOC2160
```

```
START
 COL  ----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

  6      1              125,  132,  140,  150,  155,  160,  165,  170,  180,  BLOC2170
  6      2              190,  203,  215,  225,  235,  242,  240,  225,  200,  BLOC2180
  6      3              180,  155,  125,  105,   90,   68,   44,   36,   23,  BLOC2190
  6      1              120,  127,  132,  140,  145,  150,  152,  160,  168,  BLOC2200
  6      2              178,  190,  200,  207,  213,  207,  190,  170,  150,  BLOC2210
  6      3              135,  120,  100,   85,   72,   56,   37,   28,   19,  BLOC2220
  6      1              115,  122,  125,  135,  140,  145,  147,  152,  160,  BLOC2230
  6      2              170,  180,  192,  200,  203,  190,  165,  145,  125,  BLOC2240
  6      3              112,  100,   84,   72,   62,   48,   32,   24,   17,  BLOC2250
  6      1              115,  122,  125,  135,  140,  145,  147,  152,  160,  BLOC2260
  6      2              170,  180,  190,  195,  195,  180,  150,  130,  115,  BLOC2270
  6      3              100,   90,   72,   62,   53,   40,   28,   22,   16,  BLOC2280
  6      1              115,  122,  125,  135,  140,  145,  147,  152,  160,  BLOC2290
  6      2              170,  180,  190,  190,  190,  165,  142,  118,  102,  BLOC2300
  6      3               90,   80,   65,   55,   47,   36,   25,   19,   15,  BLOC2310
  6      1              110,  115,  120,  128,  132,  138,  140,  150,  155,  BLOC2320
  6      2              165,  175,  185,  185,  180,  155,  125,  105,   90,  BLOC2330
  6      3               78,   68,   55,   47,   40,   32,   22,   17,   13/  BLOC2340
  1   C        FIGURE 3                                                       BLOC2350
  7      DATA D601/     250,  265,  275,  290,  300,  310,  315,  335,  365,  BLOC2360
  6      2              380,  405,  420,  425,  430,  438,  439,  435,  432,  BLOC2370
  6      3              432,  430,  420,  380,  320,  245,  145,  100,   60,  BLOC2380
  6      1              180,  190,  195,  205,  210,  215,  220,  230,  240,  BLOC2390
  6      2              250,  265,  280,  295,  315,  340,  350,  360,  360,  BLOC2400
  6      3              360,  350,  320,  270,  220,  170,  100,   70,   42,  BLOC2410
  6      1              150,  160,  162,  170,  174,  177,  180,  188,  195,  BLOC2420
  6      2              210,  240,  260,  270,  280,  295,  305,  305,  305,  BLOC2430
  6      3              290,  275,  245,  210,  175,  135,   82,   57,   35,  BLOC2440
  6      1              135,  140,  142,  145,  150,  152,  155,  162,  175,  BLOC2450
  6      2              185,  215,  240,  250,  255,  270,  275,  280,  275,  BLOC2460
  6      3              260,  250,  205,  175,  150,  110,   70,   50,   32,  BLOC2470
  6      1              128,  130,  132,  135,  140,  142,  145,  150,  165,  BLOC2480
  6      2              175,  200,  225,  230,  240,  250,  255,  260,  260,  BLOC2490
  6      3              230,  215,  175,  145,  125,  100,   62,   44,   28,  BLOC2500
  6      1              125,  128,  130,  133,  138,  140,  142,  149,  155,  BLOC2510
  6      2              162,  190,  210,  215,  220,  230,  240,  242,  235,  BLOC2520
  6      3              210,  190,  150,  135,  115,   90,   56,   41,   26,  BLOC2530
  6      1              125,  128,  130,  135,  138,  140,  142,  150,  155,  BLOC2540
  6      2              162,  190,  200,  202,  210,  225,  230,  225,  210/  BLOC2550
  7      DATA D607/     190,  170,  140,  120,  100,   72,   53,   38,   25,  BLOC2560
  6      1              125,  128,  130,  135,  138,  140,  142,  150,  155,  BLOC2570
  6      2              165,  180,  190,  202,  210,  215,  215,  200,  180,  BLOC2580
  6      3              160,  140,  120,  105,   92,   72,   48,   35,   23,  BLOC2590
  6      1              118,  120,  121,  122,  125,  128,  132,  135,  142,  BLOC2600
  6      2              155,  170,  185,  195,  200,  202,  185,  160,  140,  BLOC2610
  6      3              120,  110,   92,   77,   68,   55,   37,   28,   19,  BLOC2620
  6      1              115,  116,  117,  119,  120,  121,  125,  135,  147,  BLOC2630
  6      2              155,  165,  175,  185,  190,  190,  175,  145,  120,  BLOC2640
  6      3              110,   97,   80,   70,   60,   47,   32,   29,   17,  BLOC2650
  6      1              115,  116,  117,  119,  120,  121,  125,  135,  147,  BLOC2660
  6      2              155,  165,  175,  185,  190,  180,  150,  130,  110,  BLOC2670
  6      3               95,   85,   70,   60,   51,   41,   28,   22,   16,  BLOC2680
  6      1              115,  116,  117,  119,  120,  121,  125,  135,  147,  BLOC2690
  6      2              152,  162,  175,  180,  180,  165,  140,  117,  100,  BLOC2700
```

```
START
 COL  ----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

  6       3            85,   75,   63,   52,   45,   35,   25,   20,   15,  BLOC2710
  6       1           105,  106,  109,  111,  115,  118,  122,  132,  143,  BLOC2720
  6       2           150,  162,  168,  169,  164,  145,  125,  108,   90,  BLOC2730
  6       3            78,   68,   56,   48,   40,   32,   23,   18,   14/  BLOC2740
  1  C         FIGURE 4                                                      BLOC2750
  7       DATA D701/  200,  205,  210,  210,  215,  220,  230,  250,  270,  BLOC2760
  6       2           280,  290,  315,  325,  345,  365,  380,  395,  405,  BLOC2770
  6       3           408,  412,  408,  360,  310,  230,  145,  100,   62,  BLOC2780
  6       1           145,  147,  148,  149,  150,  152,  154,  165,  182,  BLOC2790
  6       2           200,  230,  255,  262,  270,  280,  290,  295,  300,  BLOC2800
  6       3           305,  310,  300,  250,  215,  165,  100,   70,   43,  BLOC2810
  6       1           130,  130,  130,  130,  133,  135,  137,  145,  160,  BLOC2820
  6       2           175,  205,  220,  238,  245,  255,  265,  268,  270,  BLOC2830
  6       3           270,  265,  240,  205,  180,  135,   85,   59,   36,  BLOC2840
  6       1           120,  120,  120,  122,  125,  128,  130,  137,  145,  BLOC2850
  6       2           165,  190,  210,  220,  228,  235,  245,  250,  248,  BLOC2860
  6       3           240,  225,  195,  165,  145,  115,   74,   52,   33,  BLOC2870
  6       1           120,  120,  120,  122,  125,  128,  130,  137,  145,  BLOC2880
  6       2           160,  180,  190,  200,  210,  225,  235,  235,  225,  BLOC2890
  6       3           215,  200,  175,  150,  130,  105,   66,   47,   30,  BLOC2900
  6       1           120,  120,  120,  122,  125,  128,  130,  137,  145,  BLOC2910
  6       2           160,  170,  185,  195,  200,  210,  220,  225,  210,  BLOC2920
  6       3           195,  180,  155,  135,  120,   95,   60,   44,   27,  BLOC2930
  6       1           120,  120,  120,  122,  125,  128,  130,  137,  145,  BLOC2940
  6       2           155,  165,  180,  190,  200,  215,  220,  210,  195/  BLOC2950
  7       DATA D707/  175,  160,  135,  115,  100,   80,   53,   39,   26,  BLOC2960
  6       1           110,  112,  114,  118,  120,  122,  125,  132,  142,  BLOC2970
  6       2           150,  160,  170,  180,  190,  200,  205,  180,  160,  BLOC2980
  6       3           145,  135,  112,   98,   83,   67,   44,   33,   23,  BLOC2990
  6       1           105,  107,  109,  112,  115,  119,  122,  126,  135,  BLOC3000
  6       2           145,  155,  165,  175,  180,  190,  180,  155,  135,  BLOC3010
  6       3           120,  108,   90,   75,   66,   52,   37,   29,   20,  BLOC3020
  6       1           105,  107,  109,  112,  115,  119,  122,  126,  132,  BLOC3030
  6       2           140,  152,  162,  170,  180,  180,  155,  135,  115,  BLOC3040
  6       3           105,   92,   76,   66,   56,   46,   35,   25,   18,  BLOC3050
  6       1           105,  107,  109,  112,  115,  119,  122,  126,  132,  BLOC3060
  6       2           138,  150,  160,  168,  175,  168,  140,  120,  105,  BLOC3070
  6       3            92,   82,   70,   58,   52,   40,   29,   23,   17,  BLOC3080
  6       1           105,  107,  109,  112,  115,  119,  122,  126,  132,  BLOC3090
  6       2           140,  150,  160,  170,  170,  155,  130,  110,   95,  BLOC3100
  6       3            85,   76,   63,   53,   43,   37,   27,   22,   16,  BLOC3110
  6       1           100,  102,  106,  110,  112,  116,  118,  122,  127,  BLOC3120
  6       2           133,  148,  156,  165,  165,  140,  115,   98,   83,  BLOC3130
  6       3            75,   65,   54,   45,   40,   31,   23,   19,   14/  BLOC3140
  7       END                                                                BLOC3150
```

```
TART
COL  ----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

 7         SUBROUTINE INPUT
 1   C     THIS ROUTINE INPUTS HEADING DATA, LAST SLOPE, AND PROFILE
 1   C     AND PRINTS INPUT
 1   C
 1   C*****VARIABLE DICTIONARY
 1   C
 1   C     NAME MODE SIZE   DESCRIPTION                                   UNITS
 1   C
 1   C     DEP   I*2 16     VERT DIMENSION OF PROFILE                     FT*10
 1   C     DL    I*2 16     HORIZONTAL DIMENSION OF PROFILE               FT
 1   C     S     R*4 16     PROFILE SLOPE VALUES
 1   C     NP    I*4 1      NUMBER OF POINTS IN PROFILE
 1   C     WTL   I*2 1      WATER LEVEL                                   FT*10
 1   C     IPAGE I*4 1      CURRENT PAGE NUMBER
 1   C     DT    I*2 118    PAGE HEADING
 1   C     RDEP  R*4 16     DEPTH INPUT BUFFER,LAND TO SEA                FT
 1   C     RDL   R*4 16     LENGTH INPUT BUFFER,LAND TO SEA               FT
 1   C     FLAT  A*4 1      ALPHANUMERIC CONSTANT  'FLAT'
 1   C     BLANK A*4 1      ALPHANUMERIC CONSTANT  '    '
 1   C     SL    R*4 1      SLOPE OF LAST LANDWARD SECTION
 1   C     IC    I*4 1      FLAG TO DETECT END OF PROFILE DATA
 1   C     GA    R*4 1      USED IN SLOPE CALCULATIONS
 1   C     RDD   R*4 1      OUTPUT BUFFER OF LENGTHS                      FT
 1   C     RDP   R*4 1      OUTPUT BUFFER OF DEPTHS                       FT
 1   C     S1    R*4 1      OUTPUT BUFFER OF SLOPES
 1   C     ROUGH R*4 16     ARRAY OF ROUGHNESS VALUES
 1   C
 1   C*****START OF SUBROUTINE
 7         IMPLICIT INTEGER*2(D,P)
 7         INTEGER*2 WTL
 7         COMMON /TD/ DEP(16),DL(16),S(16),HB(16),ROUGH(16),NP,WTL
 7         COMMON /HD/ IPAGE,DT
 7         DIMENSION DT(118),RDEP(16),RDL(16)
 7         DATA FLAT,BLANK/'FLAT','    '/
 7         EQUIVALENCE (RDEP(1),S(1))
 1   C-----READ PAGE HEADING DATA
 7         READ(5,1000)  (DT(I),I=5,17),(DT(I),I=47,51),(DT(I),I=55,59),
 6        1  (DT(I),I=64,100),DT(112),DT(113)
 1   C-----WRITE HEADING DATA
 7         IPAGE =IPAGE+1
 7         WRITE(6,1100)DT,IPAGE
 1   C-----READ SLOPE, DEFAULT=0 IF SLOPE .LT. 0
 4      10 READ (5,1200) SL
 7         IF(SL.LT.0) SL=0.
 1   C-----READ IN PROFILE ALL DIMENSIONS ARE IN FEET
 7         DO 20 NP=1,15
 7         READ (5,1300) IC,RDEP(NP),RDL(NP),ROUGH(NP)
 7         IF(IC.EQ.1) GOTO 30
 4      20 CONTINUE
 1   C-----TOO MANY SLOPES IN INPUT
 7         WRITE (6,1400)
 7         STOP
 1   C-----FILL UP DEP,DL,ROUGH ARRAYS
 4      30 II=NP
```

```
.RT
OL  ----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

7         NP=NP+1                                                        INPU0560
7         DO 40 J=1,II                                                   INPU0570
7         DEP(J)=RDEP(J)*10.+ SIGN(0.1,RDEP(J))                          INPU0590
4      40 DL(J)=RDL(J)                                                   INPU0600
7         S(II)=SL                                                       INPU0610
1   C-----CALCULATE SLOPES                                               INPU0620
7         NA=NP-2                                                        INPU0630
7         DO 50 I=1,NA                                                   INPU0640
7         GA=(DEP(I+1)-DEP(I))/10.                                       INPU0650
7         IF(ABS(GA).LT.0.0001)GA=0.0001                                 INPU0660
4      50 S(I)=(DL(I+1)-DL(I))/GA                                        INPU0670
7         DEP(NP)=DEP(II)+1000                                           INPU0680
7         DL(NP)=S(II)*(DEP(NP)-DEP(II))/10                              INPU0690
1   C-----PRINT OUT PROFILE                                              INPU0700
7         WRITE (6,1500)                                                 INPU0710
7         DO 80 I=1,II                                                   INPU0720
7         RDD=DL(I)                                                      INPU0730
7         RDP=DEP(I)/10.                                                 INPU0740
7         S1=S(I)                                                        INPU0750
7         RR1=ROUGH(I)                                                   INPU0760
7         IF(S1.GT.1000) S1=FLAT                                         INPU0770
7         IF(I.EQ.II) S1=BLANK                                           INPU0780
7         IF(I.EQ.II) RR1=BLANK                                          INPU0790
7         WRITE (6,1900) I,RDD,RDP                                       INPU0800
7         IF(S1.NE.S(I)) GOTO 60                                         INPU0810
7         WRITE (6,1600) S1,RR1                                          INPU0820
7         GOTO 80                                                        INPU0830
4      60 IF(RR1.NE.ROUGH(I)) GO TO 70                                   INPU0840
7         WRITE (6,1700) S1,RR1                                          INPU0850
7         GO TO 80                                                       INPU0860
4      70 WRITE(6,1800) S1,RR1                                           INPU0870
4      80 CONTINUE                                                       INPU0880
7         WRITE (6,2000) S(II),ROUGH(II)                                 INPU0890
7         RETURN                                                         INPU0900
2    1000 FORMAT(2X,13A2,32X,10A2/2X,39A2)                               INPU0910
2    1100 FORMAT('1 ',59A2/'0 ',59A2,T119,I2//,60('**')///)              INPU0920
2    1200 FORMAT (F4.1)                                                  INPU0930
2    1300 FORMAT(I1,1X,F5.1,1X,F5.0,1X,F5.3)                             INPU0940
2    1400 FORMAT(' MORE THAN 15 POINTS IN PROFILE, PROGRAM STOPS')       INPU0950
2    1500 FORMAT(T23,'CROSS SECTION PROFILE'                             INPU0960
6        1 //T21,'LENGTH   ELEV.    SLOPE     ROUGHNESS'/)               INPU0970
2    1600 FORMAT(T38,F7.2,T51,F5.2)                                      INPU0980
2    1700 FC.  .T(T41,A4,T51,F5.2)                                       INPU0990
2    1800 FORMAT(T41,A4,T51,A4)                                          INPU1000
2    1900 FORMAT(1X,T10,I2,T20,F7.1,T30,F5.1)                            INPU1010
2    2000 FORMAT('0',T26,'LAST SLOPE',F7.2,'     LAST ROUGHNESS'F7.2)    INPU1020
7         END                                                            INPU1030
```

```
START
 COL  ----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

  7         SUBROUTINE LOGLIN(X1,X2,Y1,Y2,X,Y)                                  LOLI0010
  1   C     THIS SUBROUTINE PERFORMS A LOG-LINEAR INTERPOLATION BETWEEN TWO     LOLI0020
  1   C     KNOWN POINTS (X1,Y1) AND (X2,Y2).  THE VALUE OF X IS CONTAINED      LOLI0030
  1   C     BETWEEN X1 AND X2 ON THE LOGARITHMIC SCALE.  THE OUTPUT VALUE,      LOLI0040
  1   C     Y IS CONTAINED BETWEEN Y1 AND Y2 ON THE LINEAR SCALE.  REAL         LOLI0050
  1   C     NUMBERS ENTER THE SUBROUTINE AND THE NECESSARY LOGARITHMS ARE       LOLI0060
  1   C     DONE IN THE SUBROUTINE.                                             LOLI0070
  7         IMPLICIT INTEGER*2(X,Y)                                             LOLI0080
  7         RX1=X1                                                              LOLI0090
  7         RX2=X2                                                              LOLI0100
  7         RX=X                                                                LOLI0110
  7         RX1=ALOG10(RX1)                                                     LOLI0120
  7         RX2=ALOG10(RX2)                                                     LOLI0130
  7         RX=ALOG10(RX)                                                       LOLI0140
  7         SLOPE=(Y1-Y2)/(RX1-RX2)                                             LOLI0150
  7         Y=Y1+SLOPE*(RX-RX1)                                                 LOLI0160
  7         RETURN                                                              LOLI0170
  7         END                                                                 LOLI0180
```

```
START
 COL  ----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

  7         SUBROUTINE LOGLOG(X1,X2,Y1,Y2,X,Y)                                 LOL00010
  1   C                                                                        LOL00020
  1   C     THIS SUBROUTINE PERFORMS A LOGLOG INTERPOLATION FOR COMPUTED       LOL00030
  1   C     VALUE X CONTAINED BETWEEN KNOWN VALUES X1 AND X2.  THE OUTPUT IS   LOL00040
  1   C     THE REAL VALUE Y, WHICH IS CONTAINED BETWEEN KNOWN VALUES Y1 AND   LOL00050
  1   C     Y2.  INPUT VARIABLES TO THE SUBROUTINE ARE REAL.  THE LOGARITHM    LOL00060
  1   C     OF EACH VARIABLE IS TAKEN IN THE SUBROUTINE.                       LOL00070
  1   C                                                                        LOL00080
  7         IMPLICIT INTEGER*2(X,Y)                                            LOL00090
  7         RX1=X1                                                             LOL00100
  7         RX2=X2                                                             LOL00110
  7         RY1=Y1                                                             LOL00120
  7         RY2=Y2                                                             LOL00130
  7         RX=X                                                               LOL00140
  7         RX1=ALOG10(RX1)                                                    LOL00150
  7         RX2=ALOG10(RX2)                                                    LOL00160
  7         RY1=ALOG10(RY1)                                                    LOL00170
  7         RY2=ALOG10(RY2)                                                    LOL00180
  7         RX=ALOG10(RX)                                                      LOL00190
  7         SLOPE=(RY1-RY2)/(RX1-RX2)                                          LOL00200
  7         Y=10**(RY1+SLOPE*(RX-RX1))                                         LOL00210
  7         RETURN                                                             LOL00220
  7         END                                                                LOL00230
```

```
PROJECT: S0952MW            MEMBER: LOOK                DATE: 81/10/26
LIBRARY: EN57               LEVEL:  01.00               TIME: 11:13
TYPE:    DATA3              USERID: S4692MW             PAGE: 01 OF 01
START
 COL  ----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

  7         SUBROUTINE LOOK(X,N,IV,L,M,IFG)                                     LOOK0010
  1   C      LOOK --  DIGITIZE ANALOG INPUT VALUE BY MODIFIED BINARY SEARCH    LOOK0020
  1   C     OUTPUT POINTERS TO VALUES IMMEDIATELY BEFORE AND AFTER INPUT VALUELOOK0030
  1   C                                                                         LOOK0040
  1   C*****VARIABLE DICTIONARY                                                 LOOK0050
  1   C                                                                         LOOK0060
  1   C     NAME MODE SIZE   DESCRIPTION                                        LOOK0070
  1   C                                                                         LOOK0080
  1   C     X      I*2       TABLE TO BE LOOKED INTO (ASCENDING ORDER )         LOOK0090
  1   C     N      I*4 1     NUMBER OF ELEMENTS IN TABLE                        LOOK0100
  1   C     IV     I*2 1     ANALOG INPUT VALUE                                 LOOK0110
  1   C     L      I*4 1     POINTER TO ENTRY IN X BEFORE IV                    LOOK0120
  1   C     M      I*4 1     POINTER TO ENTRY IN X AFTER IV                     LOOK0130
  1   C     IFG    I*4 1     TABLE EXCEEDED FLAG                                LOOK0140
  1   C                                                                         LOOK0150
  1   C*****START OF SUBROUTINE                                                 LOOK0160
  7         INTEGER*2 IV,X(1)                                                   LOOK0170
  7         L=1                                                                 LOOK0180
  7         M=N                                                                 LOOK0190
  1   C-----CHECK TO SEE IF DATA EXCEEDS TABLE                                  LOOK0200
  7         IF(X(L).GT.IV) GOTO 30                                              LOOK0210
  7         IF(X(M)-IV)40,20,20                                                 LOOK0220
  1   C-----PERFORM LOOKUP                                                      LOOK0230
  4      10 IF(X(M).GT.IV) GOTO 20                                              LOOK0240
  1   C-----MOVE LOW POINTER UP                                                 LOOK0250
  7         L=M                                                                 LOOK0260
  7         M=MO                                                                LOOK0270
  1   C-----MOVE HI POINTER DOWN                                                LOOK0280
  4      20 MO=M                                                                LOOK0290
  7         M=(M-L)/2+L                                                         LOOK0300
  1   C-----CHECK TO SEE IF DONE                                                LOOK0310
  7         IF(M.NE.L) GOTO 10                                                  LOOK0320
  7         IF(M.NE.M) M=L+1                                                    LOOK0330
  7         RETURN                                                              LOOK0340
  1   C-----DATA LESS THAN 1ST ENTRY IN TABLE                                   LOOK0350
  4      30 M=1                                                                 LOOK0360
  7         IFG=1                                                               LOOK0370
  7         RETURN                                                              LOOK0380
  1   C----- DATA GREATER THAN LAST ENTRY IN TABLE                              LOOK0390
  4      40 L=N                                                                 LOOK0400
  7         IFG=1                                                               LOOK0410
  7         RETURN                                                              LOOK0420
  7         END                                                                 LOOK0430
```

```
START
 COL  ----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

  1   C     PROGRAM RUNUP                                                     MAIN0010
  1   C     THIS PROGRAM CALCULATES THE RUNUP OF A WAVE ON A COMPOSITE SLOPE  MAIN0020
  1   C                                                                       MAIN0030
  1   C*****VARIABLE DICTIONARY                                               MAIN0040
  1   C                                                                       MAIN0050
  1   C     NAME MODE SIZE   DESCRIPTION                               UNITS  MAIN0060
  1   C                                                                       MAIN0070
  1   C     DEP   I*2 16     VERT DIMENSION OF PROFILE,SEA TO LAND     FT*10  MAIN0080
  1   C     DL    I*2 16     HORIZ DIMENSION OF PROFILE,SEA TO LAND    FT     MAIN0090
  1   C     S     R*4 16     SLOPES OF PROFILE                                MAIN0100
  1   C     NP    I*4 1      NUMBER OF POINTS IN PROFILE                      MAIN0110
  1   C     IPAGE I*4 1      CURRENT PAGE NUMBER                              MAIN0120
  1   C     DT    I*2 118    PAGE HEADING                                     MAIN0130
  1   C     H     R*4 1      HEIGHT OF DEEP-WATER WAVE                 FEET   MAIN0140
  1   C     T     R*4 1      PERIOD OF DEEP-WATER WAVE                 SEC    MAIN0150
  1   C     R     R*4 1      CALCULATED RUNUP                          FEET   MAIN0160
  1   C     II    I*4 1      NO. OF SLOPE ON WHICH WAVE BREAKS                MAIN0170
  1   C     ISL   I*4 1      NO. OF SLOPE ON WHICH RUNUP LIMIT FALLS          MAIN0180
  1   C     IFC   I*4 16     CONVERGENCE FLAGS                                MAIN0190
  1   C     IFG   I*4 16     EXCEED TABLE FLAG                                MAIN0200
  1   C     IFD   I*4 1      DUMMY                                            MAIN0210
  1   C     LISL  I*4 16     TABLE OF STARTING SLOPES                         MAIN0220
  1   C     LII   I*4 16     TABLE OF ENDING SLOPES                           MAIN0230
  1   C     RAS   R*4 16     TABLE OF CALCULATED RUNUPS                FEET   MAIN0240
  1   C     WTB   R*4 1      INPUT WATER LEVEL                                MAIN0250
  1   C     WTL   I*2 1      WATER LEVEL MULTIPLIED BY 10              FT*10  MAIN0260
  1   C     WTTL  I*2 1      VALUE OF WTL AT PREVIOUS STEP             FT*10  MAIN0270
  1   C     IZ    I*4 1      POINTER INTO ARRAYS OF ANSWERS AND FLAGS         MAIN0280
  1   C     IM    I*4 1      POINTER TO MAXIMUM RUNUP                         MAIN0290
  1   C     DA    I*2 25     ARRAY OF ERROR CODES                             MAIN0300
  1   C                                                                       MAIN0310
  1   C*****START OF PROGRAM                                                  MAIN0320
  7         IMPLICIT INTEGER*2(D,P)                                           MAIN0330
  7         INTEGER*2 WTL,WTTL                                                MAIN0340
  7         COMMON /OUT/ LISL(16),LII(16),RAS(16),IFG(16),IFC(16)             MAIN0350
  7         COMMON /TD/ DEP(16),DL(16),S(16),WB(16),ROUGH(16),NP,WTL          MAIN0360
  7         COMMON /HD/ IPAGE,DT                                              MAIN0370
  7         DIMENSION DA(25),DT(118)                                          MAIN0380
  7         DATA DA/'  ','SO','LU','TI','ON',' D','OE','S ','NO','T ','CO',   MAIN0390
  6        1'NV','ER','GE','  ','DA','TA',' E','XC','EE','DE','D ','TA','BL', MAIN0400
  6        2'E '/                                                             MAIN0410
  1   C_____READ IN PROFILE                                                   MAIN0420
  4      10 CALL INPUT                                                        MAIN0430
  7         IJK=0                                                             MAIN0440
  7         WTTL=0                                                            MAIN0450
  7         K=0                                                               MAIN0460
  7         IPAGE =IPAGE+1                                                    MAIN0470
  7         WRITE(6,1100) DT,IPAGE                                            MAIN0480
  1   C_____OUTPUT TABLE                                                      MAIN0490
  7         WRITE(6,1300)                                                     MAIN0500
  4      20 IF(K.EQ.1)GO TO 10                                                MAIN0510
  7         IF(IJK.GT.0) WTTL=WTB*10                                          MAIN0520
  7         READ(5,1000,END=70)K,WTB,H0,T,(WB(I),I=1,10)                      MAIN0530
  1   C_____BRANCH ON NEGATIVE RUN PARAMETERS                                 MAIN0540
```

```
START
 COL  ----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

  7         IF(HO.LE.0.OR.T.LE.0) GOTO 80                                        MAIN0550
  7         HTL=HTB*10.                                                          MAIN0560
  7         IQ=1                                                                 MAIN0570
  1   C_____REFERENCE PROFILE TO STILL WATER LEVEL                               MAIN0580
  7         DO 30 I=1,NP                                                         MAIN0590
  4      30 DEP(I)=DEP(I)-HTL+HTTL                                               MAIN0600
  7         IJK=IJK+1                                                            MAIN0610
  7         HTL=0                                                                MAIN0620
  4      40 CALL RUN(HO,T,R,II,IQ)                                               MAIN0630
  1   C                                                                          MAIN0640
  7         IM=IQ-1                                                              MAIN0650
  7         IF(IFG(IQ).EQ.1) GO TO 60                                            MAIN0660
  7         IF(IFC(IQ).EQ.1) GO TO 50                                            MAIN0670
  7         WRITE (6,1400) HTB,HO,T,LII(IQ),LISL(IQ),RAS(IQ)                     MAIN0680
  7         GO TO 20                                                             MAIN0690
  4      50 WRITE (6,1500) HTB,HO,T,LII(IQ),LISL(IQ),RAS(IM),RAS(IQ),(DA(J),J=MAIN0700
  6        1  1,14)                                                              MAIN0710
  7         GO TO 20                                                             MAIN0720
  4      60 WRITE (6,1600) HTB,HO,T,(DA(J),J=1,25)                               MAIN0730
  7         GOTO 20                                                              MAIN0740
  4      70 STOP                                                                 MAIN0750
  4      80 WRITE (6,1200)                                                       MAIN0760
  7         STOP                                                                 MAIN0770
  2    1000 FORMAT(I1,F5.2,12(1X,F5.2))                                          MAIN0780
  2    1100 FORMAT('1 ',59A2/'0',59A2,T11',I2//,60('**')///)                     MAIN0790
  2    1200 FORMAT(' NEGATIVE RUN PARAMETER, PROGRAM STOPS')                     MAIN0800
  2    1300 FORMAT(T45,'OUTPUT TABLE'/T45,6('--')////T20,'INPUT PARAMETERS',     MAIN0810
  6        1T69,'RUNUP RESULTS',/T20,8('--'),T69,13('-')//T9,'WATER LEVEL',      MAIN0820
  6        2T24,'DEEP WATER',T58,'BREAKING SLOPE',T76,'RUNUP SLOPE',T91,         MAIN0830
  6        3'RUNUP ABOVE'/T9,'ABOVE DATUM',T24,'WAVE HEIGHT',T39,                MAIN0840
  6        4'WAVE PERIOD',T62,'NUMBER',T79,'NUMBER',T91,'WATER LEVEL'/T12,       MAIN0850
  6        5'(FT.)',T27,'(FT.)',T42,'(SEC.)',T94,'(FT.)'/)                       MAIN0860
  2    1400 FORMAT(/T10,F6.1,T25,F6.1,T40,F6.2,T64,I2,T81,I2,T95,F4.1)           MAIN0870
  2    1500 FORMAT(/T10,F6.1,T25,F6.1,T40,F6.2,T64,I2,T81,I2,T89,F4.1,           MAIN0880
  6        1T95,F4.1,T99,14A2)                                                   MAIN0890
  2    1600 FORMAT(/T10,F6.1,T25,F6.1,T40,F6.2,T55,25A2)                         MAIN0900
  7         END                                                                  MAIN0910
```

```
      PROJECT: S0952MH              MEMBER: RINT                DATE: 81/10/26               RINT
      LIBRARY: EN57                 LEVEL:  01.00               TIME: 11:13
      TYPE:    DATA3                USERID: S4692MH             PAGE: 01 OF 01
START
 COL  ----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

  7         SUBROUTINE RINT(X1,X2,Y1,Y2,X,Y)                                   RINT0010
  1   C       RINT  -- SINGLE LINEAR INTERPOLATION BY METHOD Y=MX+B            RINT0020
  1   C     INPUT KNOWN DATA POINTS  (X1,Y1),(X2,Y2)                           RINT0030
  1   C     GIVEN X FIND Y=F(X)=MX+B   M=SLOPE  B=START VALUE                  RINT0040
  1   C     OUTPUT  (X,Y)                                                      RINT0050
  1   C                                                                        RINT0060
  1   C*****VARIABLE DICTIONARY                                                RINT0070
  1   C                                                                        RINT0080
  1   C     ALL INPUT AND OUTPUT IS  I*2                                       RINT0090
  1   C                                                                        RINT0100
  1   C*****START OF SUBROUTINE                                                RINT0110
  7         IMPLICIT INTEGER*2(X,Y)                                            RINT0120
  7         G=X2-X1                                                            RINT0130
  1   C-----DIVISION BY ZERO CHECK                                             RINT0140
  7         IF(G.NE.0.) GOTO 10                                                RINT0150
  7         Y=Y1                                                               RINT0160
  7         RETURN                                                             RINT0170
  4      10 RAT=(X-X1)/G                                                       RINT0180
  7         Y=(Y2-Y1)*RAT+Y1                                                   RINT0190
  7         RETURN                                                             RINT0200
  7         END                                                                RINT0210
```

```
ART
CL  ----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

7          SUBROUTINE RRUFF(R1,FROUGH,N)                                        RUFF0010
1    C                                                                          RUFF0020
1    C     COMPUTATION OF WEIGHTED ROUGHNESS FACTOR FROM                        RUFF0030
1    C     WTL TO WAVE RUNUP LIMIT                                              RUFF0040
1    C                                                                          RUFF0050
1    C***** VARIABLE DICTIONARY ****                                            RUFF0060
1    C                                                                          RUFF0070
1    C     NAME   MODE SIZE                                                     RUFF0080
1    C                                                                          RUFF0090
1    C     SLPLEN R*4  1    DISTANCE ALONG ONE SLOPE                            RUFF0100
1    C     ROUGH  R*4  16   ROUGHNESS FACTOR ON ONE SLOPE                       RUFF0110
1    C     FROUGH R*4  1    FINAL ROUGHNESS FACTOR FOR THE TOTAL SLOPE          RUFF0120
1    C                      LENGTH FROM WTL TO RAS(IM)                          RUFF0130
1    C     NM1    I*4  1    NO. OF POINTS IN THE PROFILE                        RUFF0140
1    C     TOTLEN R*4  1    TOTAL SLOPE LENGTH FROM WTL TO RAS(IM)              RUFF0150
1    C     RL     R*4  1    ROUGHNESS FACTOR TIMES SLOPE LENGTH                 RUFF0160
1    C                                                                          RUFF0170
7          IMPLICIT INTEGER*2(D,P)                                              RUFF0180
7          INTEGER*2 WTL                                                        RUFF0190
7          COMMON /TD/ DEP(16),DL(16),S(16),HB(16),ROUGH(16),NP,WTL             RUFF0200
7          NM1=NP-1                                                             RUFF0210
7          TOTLEN=0.0                                                           RUFF0220
7          TOTRL=0.0                                                            RUFF0230
1    C_____FIND SLOPE THAT STILL WATER LEVEL INTERSECTS, LI                     RUFF0240
7          IF(N.GT.1) GO TO 30                                                  RUFF0250
7          DO 10 J1=1,NM1                                                       RUFF0260
7          IF(WTL.LT.DEP(J1+1)) GO TO 20                                        RUFF0270
4       10 CONTINUE                                                             RUFF0280
4       20 LI=J1                                                                RUFF0290
4       30 DDTR=WTL+R1*10                                                       RUFF0300
1    C_____FIND SLOPE THAT RUNUP INTERSECTS, LIS                                RUFF0310
7          DO 40 J2=1,NM1                                                       RUFF0320
7          IF(DDTR.LT.DEP(J2+1)) GO TO 50                                       RUFF0330
4       40 CONTINUE                                                             RUFF0340
4       50 LIS=J2                                                               RUFF0350
7          DO 60 K=LI,LIS                                                       RUFF0360
1    C_____FIND LENGTH OF INDIVIDUAL SLOPE SECTION                              RUFF0370
7          SLPLEN=(((DEP(K+1)-DEP(K))/10.)**2+(DL(K+1)-DL(K))**2)**0.5          RUFF0380
1    C_____MULTIPLY SLOPE SECTION LENGTH BY ROUGHNESS FACTOR                    RUFF0390
7          RL=SLPLEN*ROUGH(K)                                                   RUFF0400
7          IF(K.EQ.LI)SLPLEN=((((DEP(LI+1)-WTL)*S(LI))/10.)**2+((DEP(LI+1)-     RUFF0410
6         1 WTL)/10.)**2)**0.5                                                  RUFF0420
7          IF(K.EQ.LI) RL=SLPLEN*ROUGH(LI)                                      RUFF0430
7          IF(K.EQ.LIS)SLPLEN=(((R1-(DEP(LIS)/10.))*S(LIS))**2+(R1-(DEP(LIS)/RUFF0440
6         1 10.))**2)**0.5                                                      RUFF0450
7          IF(K.EQ.LIS) RL=SLPLEN*ROUGH(LIS)                                    RUFF0460
1    C_____ADD UP SLOPE SECTION LENGTHS                                         RUFF0470
7          TOTLEN=TOTLEN+SLPLEN                                                 RUFF0480
1    C_____ADD UP (SLOPE LENGTH * ROUGHNESS FACTOR) VALUES                      RUFF0490
4       60 TOTRL=TOTRL+RL                                                       RUFF0500
1    C_____COMPUTE FINAL ROUGHNESS FACTOR                                       RUFF0510
7          FROUGH=TOTRL/TOTLEN                                                  RUFF0520
7          RETURN                                                               RUFF0530
7          END                                                                  RUFF0540
```

```
START
 COL  ----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

  7          SUBROUTINE RUN(H0,T,R,II,IQ)                                          RUN00010
  1    C     THIS ROUTINE CALCULATES THE RUN-UP OF A WAVE                          RUN00020
  1    C     BASED UPON THE PROFILE AND WAVE PARAMETERS                            RUN00030
  1    C                                                                           RUN00040
  1    C*****VARIABLE DICTIONARY                                                   RUN00050
  1    C                                                                           RUN00060
  1    C     NAME MODE SIZE   DESCRIPTION                                   UNITS  RUN00070
  1    C                                                                           RUN00080
  1    C     R    R*4 1       CALCULATED RUNUP                              FEET   RUN00090
  1    C     S    R*4 15      PROFILE SLOPES                                       RUN00100
  1    C     T    R*4 1       PERIOD OF DEEP WATER WAVE                     SEC    RUN00110
  1    C     DB   I*2 27,13,7 VALUES OF R/H0 FUNCTION OF PDB,PDB1,PCH       *100   RUN00120
  1    C     DL   I*2 15      HORIZONTAL DISTANCE FROM ORIGIN,              FEET   RUN00130
  1    C                      INCREASING FROM LAND TO SEA                          RUN00140
  1    C     D1   I*2 1       FIRST INTERPOLATION VALUE OF R/H0                    RUN00150
  1    C     D2   I*2 1       SECOND INTERPOLATION VALUE OF R/H0                   RUN00160
  1    C     D3   I*2 1       THIRD INTERPOLATION VALUE OF R/H0                    RUN00170
  1    C     H0   R*4 1       HEIGHT OF DEEP WATER WAVE                     FEET   RUN00180
  1    C     II   I*4 1       NO. OF SLOPE ON WHICH WAVE BREAKS                    RUN00190
  1    C     IQ   I*4 1       POINTER INTO ARRAYS OF ANSWERS AND FLAGS             RUN00200
  1    C     NP   I*4 1       NUMBER OF POINTS IN PROFILE                          RUN00210
  1    C     DCS  I*2 1       HYPOTHETICAL SLOPE                            *100   RUN00220
  1    C     DEP  I*2 15      PROFILE HEIGHT ASCENDING ORDER                FT*10  RUN00230
  1    C     IFC  I*4 16      CONVERGENCE FLAGS                                    RUN00240
  1    C     IFD  I*4 1       DUMMY FLAG                                           RUN00250
  1    C     IFG  I*4 16      EXCEED TABLE FLAG                                    RUN00260
  1    C     ISL  I*4 1       NO. OF SLOPE ON WHICH RUNUP LIMIT LIES               RUN00270
  1    C     LII  I*4 16      TABLE OF ENDING SLOPES                               RUN00280
  1    C     PCH  I*2 5       VALUES OF  D/H0  FOR ENTRY INTO DB            *10    RUN00290
  1    C     PDB  I*2 27      VALUES OF SLOPE FOR ENTRY INTO DB*100                RUN00300
  1    C     RAS  R*4 16      TABLE OF CALCULATED RUNUPS                    FEET   RUN00310
  1    C     SCC  I*2 12      SCALING FACTORS AS A FUNCTION OF SLOPE               RUN00320
  1    C     SLO  I*2 12      SLOPE(TAN*10) FOR USE IN SCALING                     RUN00330
  1    C     WTL  I*2 1       WATER LEVEL                                   FT*10  RUN00340
  1    C     DCHB I*2 1       BREAKER DEPTH BY BREAKER HEIGHT RATIO                RUN00350
  1    C     HOT2 I*2 1       H0/T**2                                       *1000  RUN00360
  1    C     LISL I*4 16      TABLE OF STARTING SLOPES                             RUN00370
  1    C     PDB1 I*2 13      VALUES OF H0/T**2 FOR ENTRY INTO DB           *1000  RUN00380
  1    C                                                                           RUN00390
  1    C*****START OF SUBROUTINE                                                   RUN00400
  1    C                                                                           RUN00410
  7          IMPLICIT INTEGER*2(D,P)                                               RUN00420
  7          INTEGER*2 HOT2,WTL,SLO(12),SCC(12),RS                                 RUN00430
  1    C                                                                           RUN00440
  7          COMMON /OUT/ LISL(16),LII(16),RAS(16),IFG(16),IFC(16)                 RUN00450
  7          COMMON /TD/ DEP(16),DL(16),S(16),HB(16),ROUGH(16),NP,WTL              RUN00460
  7          COMMON /SY/ PDB(27),PDB1(13),PCH(8)                                   RUN00470
  7          COMMON /SZ/ DB(27,13,7)                                               RUN00480
  1    C                                                                           RUN00490
  7          DATA SLO/   10,   20,   40,   60,   80,  100,  140,  200,  300,       RUN00500
  6         1           500,  800, 1500/                                           RUN00510
  7          DATA SCC/ 1000, 1049, 1097, 1119, 1131, 1136, 1140, 1136, 1120,       RUN00520
  6         1          1089, 1052, 1000/                                           RUN00530
  1    C                                                                           RUN00540
```

```
START
 COL  ----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

  1  C     SLOPE FUNCTIONS TO CALCULATE BREAKING DEPTH AS A FUNCTION OF      RUN00550
  1  C     BOTTOM SLOPE AND WAVE STEEPNESS (WEGGEL'S ANALYSIS,1972)          RUN00560
  7        B(SLOPE)=1.0/(0.64*(1.0+EXP(-19.5/SLOPE)))                       RUN00570
  7        A(SLOPE)=1.36*(1.0-EXP(-19.0/SLOPE))                              RUN00580
  1  C                                                                       RUN00590
  7        IFG(IQ)=0                                                         RUN00600
  7        IFC(IQ)=0                                                         RUN00610
  1  C_____WAVE STEEPNESS                                                    RUN00620
  7        HOT2=H0*1000/(T*T)+.5                                             RUN00630
  1  C                                                                       RUN00640
  1  C_____COMPUTATION TO FIND BREAKING DEPTH AND SLOPE ON WHICH WAVE BREAKS RUN00650
  1  C                                                                       RUN00660
  7        DO 10 IX=1,10                                                     RUN00670
  7        IF(HB(IX).EQ.0.0) GO TO 10                                        RUN00680
  7        SLP=S(IX)                                                         RUN00690
  7        DCHB=10./(B(SLP)-A(SLP)*HB(IX)/(T*T))                             RUN00700
  7        DC=DCHB*HB(IX)                                                    RUN00710
  7        DTT=HTL-DC                                                        RUN00720
  7        ADC=DC/10.                                                        RUN00730
  7        IF(DTT.LT.DEP(IX+1)) GO TO 20                                     RUN00740
  7        IF(DTT.GT.DEP(NP-1)) GO TO 40                                     RUN00750
  4     10 CONTINUE                                                          RUN00760
  1  C_____WAVE CANNOT BREAK ON SLOPE BEFORE SLOPE IX                        RUN00770
  4     20 IF(DTT.GE.DEP(IX)) GO TO 30                                       RUN00780
  7        DC=HTL-DEP(IX)                                                    RUN00790
  7        DTT=HTL-DC                                                        RUN00800
  4     30 II=IX                                                             RUN00810
  7        JJ=IX+1                                                           RUN00820
  1  C_____COMPUTE DISTANCE FROM REFERENCE TO BREAKING POINT                 RUN00830
  7        CALL RINT(DEP(II),DEP(JJ),DL(II),DL(JJ),DTT,DLE)                  RUN00840
  7        IFD=0                                                             RUN00850
  7        GO TO 50                                                          RUN00860
  4     40 II=NP-1                                                           RUN00870
  7        DLE=DL(II)+((HTL-DC-DEP(II))*S(II))/10.+.5                        RUN00880
  1  C_____FIND FAMILY OF CURVES                                             RUN00890
  4     50 R=0.                                                              RUN00900
  7        IF (H0.EQ.0.) GOTO 220                                            RUN00910
  7        DH=DC/H0                                                          RUN00920
  1  C_____LOOP UNTIL R SAME AS R1                                           RUN00930
  7        CALL LOOK(PDB1,13,HOT2,KK,LL,IFG(IQ))                             RUN00940
  7        IFD=0                                                             RUN00950
  7        DO 210 N=1,10                                                     RUN00960
  7        IFD=0                                                             RUN00970
  7        R10=R*10.                                                         RUN00980
  7        DTR=HTL+R10                                                       RUN00990
  7        NPP=NP-1                                                          RUN01000
  1  C_____FIND SLOPE THAT RUNUP LIMIT INTERSECTS                            RUN01010
  7        DO 60 IT=1,NPP                                                    RUN01020
  7        IF(DTR.LT. DEP(IT)) GO TO 70                                      RUN01030
  4     60 CONTINUE                                                          RUN01040
  7        GO TO 80                                                          RUN01050
  4     70 IAL=IT-1                                                          RUN01060
  7        ISL1=IT                                                           RUN01070
  1  C_____COMPUTE DSL, THE DISTANCE FROM REFERENCE TO THE RUNUP LIMIT       RUN01080
```

```
START
 COL  ----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

  7         CALL RINT(DEP(IAL),DEP(ISL1),DL(IAL),DL(ISL1),DTR,DSL)          RUN01090
  1   C                                                                     RUN01100
  1   C_____DETERMINE IF HAVE OVERTOPS SLOPE THAT WATER LEVEL INTERSECTS    RUN01110
  1   C_____IF NOT, THE COMPOSITE SLOPE METHOD IS NOT REQUIRED AND A ONE STEP RUN01120
  1   C_____HAVE RUNUP CALCULATION IS PERFORMED                             RUN01130
  7         IF(R.EQ.0) GO TO 100                                            RUN01140
  7         GO TO 90                                                        RUN01150
  4      80 IAL=NP-1                                                        RUN01160
  1   C_____COMPUTE DSL, THIS EQUATION COMPUTES DSL WHEN  THE RUNUP LIMIT   RUN01170
  1   C_____IS ON THE LAST LANDWARD SLOPE                                   RUN01180
  7         DSL=DL(IAL)+((R10+HTL-DEP(IAL))*S(IAL))/10.+.5                  RUN01190
  4      90 DCS=1000*(DSL-DLE)/(DC+R10)                                     RUN01200
  7         GO TO 120                                                       RUN01210
  3     100 DS=-DEP(IAL)/H0                                                 RUN01220
  7         IF(DS.LE.25) GO TO 110                                          RUN01230
  7         IF(S(IAL-1).GT.30) DS=DS*100                                    RUN01240
  3     110 CALL LOCK(PCH,8,DS,IZ,K,IFD)                                    RUN01250
  7         DCS=S(IAL)*100                                                  RUN01260
  1   C                                                                     RUN01270
  3     120 IF(DCS.LT.1000) GO TO 140                                       RUN01280
  7         IF(DCS.LT.3000.AND.IZ.GT.4) GO TO 140                           RUN01290
  1   C_____EXTRAPOLATE TO GET R                                            RUN01300
  7         XN=ALOG10(DCS/100.)                                             RUN01310
  7         IF(IZ.LE.4) GO TO 130                                           RUN01320
  1   C                                                                     RUN01330
  1   C     EXTRAPOLATE IN STOA TABLES 2,3,4                                RUN01340
  7         Y7K=DB(27,KK,IZ)                                                RUN01350
  7         Y7K=ALOG10(Y7K)                                                 RUN01360
  7         Y4K=DB(24,KK,IZ)                                                RUN01370
  7         Y4K=ALOG10(Y4K)                                                 RUN01380
  7         Y7L=DB(27,LL,IZ)                                                RUN01390
  7         Y7L=ALOG10(Y7L)                                                 RUN01400
  7         Y4L=DB(24,LL,IZ)                                                RUN01410
  7         Y4L=ALOG10(Y4L)                                                 RUN01420
  7         D1=10**(((Y7K-Y4K)/0.477)*(XN-1.477)+Y7K)                       RUN01430
  7         D2=10**(((Y7L-Y4L)/0.477)*(XN-1.477)+Y7L)                       RUN01440
  7         GO TO 150                                                       RUN01450
  1   C                                                                     RUN01460
  1   C     EXTRAPOLATE IN STOA TABLES 8,9,10,11                            RUN01470
  3     130 Y7K=DB(24,KK,IZ)                                                RUN01480
  7         Y7K=ALOG10(Y7K)                                                 RUN01490
  7         Y4K=DB(21,KK,IZ)                                                RUN01500
  7         Y4K=ALOG10(Y4K)                                                 RUN01510
  7         Y7L=DB(24,LL,IZ)                                                RUN01520
  7         Y7L=ALOG10(Y7L)                                                 RUN01530
  7         Y4L=DB(21,LL,IZ)                                                RUN01540
  7         Y4L=ALOG10(Y4L)                                                 RUN01550
  7         D1=10**(((Y7K-Y4K)/0.222)*(XN-1.000)+Y7K)                       RUN01560
  7         D2=10**(((Y7L-Y4L)/0.222)*(XN-1.000)+Y7L)                       RUN01570
  7         GO TO 150                                                       RUN01580
  1   C                                                                     RUN01590
  1   C_____PULL DATA OUT OF TABLE DB                                       RUN01600
  3     140 CALL LOCK(PDB,27,DCS,IH,JJ,IFG(IQ))                             RUN01610
  1   C_____INTERPOLATE TO FIND R                                           
                                                                            RUN01620
```

```
START
 COL  ----+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8

  7         CALL LOGLOG(PDB(IH),PDB(JJ),DB(IH,KK,IZ),DB(JJ,KK,IZ),DCS,D1)   RUN01630
  7         CALL LOGLOG(PDB(IH),PDB(JJ),DB(IH,LL,IZ),DB(JJ,LL,IZ),DCS,D2)   RUN01640
  3     150 CALL LOGLOG(PDB1(KK),PDB1(LL),D1,D2,HOT2,D3)                    RUN01650
  7         R1=H0*D3/100.                                                   RUN01660
  7         CALL RRUFF(R1,FROUGH,N)                                         RUN01670
  7         R1=R1*FROUGH                                                    RUN01680
  7         IF((1.0-FROUGH).GT.0.01) GO TO 180                              RUN01690
  1   C_____SCALE EFFECT                                                    RUN01700
  7         IF((DCS.LT.1500).AND.(DCS.GT.10)) GO TO 160                     RUN01710
  7         RS=1000                                                         RUN01720
  7         GO TO 170                                                       RUN01730
  3     160 CALL LOOK(SLO,12,DCS,IP,IP1,IFD)                                RUN01740
  1   C_____INTERPOLATE TO FIND SCALE EFFECT                                RUN01750
  7         CALL LOGLIN(SLO(IP),SLO(IP1),SCC(IP),SCC(IP1),DCS,RS)           RUN01760
  3     170 R1=R1*RS/1000.                                                  RUN01770
  3     180 IF(R.NE.0.) GO TO 200                                           RUN01780
  7         IF((R1*10).LT.DEP(ISL1)) GO TO 230                              RUN01790
  7         .(DH.LE.25) GO TO 190                                           RUN01800
  7         IF(S(II).GT.30) DH=DH*100                                       RUN01810
  3     190 CALL LOOK(PCH,8,DH,IZ,K,IFD)                                    RUN01820
  1   C_____CHECK FOR CONVERGENCE OF RUNUP                                  RUN01830
  3     200 IF(ABS(R-R1).LT.0.1) GOTO 220                                   RUN01840
  7         LISL(IQ)=IAL                                                    RUN01850
  7         LII(IQ)=II                                                      RUN01860
  7         R=R1                                                            RUN01870
  7         RAS(IQ)=R                                                       RUN01880
  7         IQ=IQ+1                                                         RUN01890
  3     210 CONTINUE                                                        RUN01900
  7         IQ=IQ-1                                                         RUN01910
  7         IFC(IQ)=1                                                       RUN01920
  3     220 LISL(IQ)=IAL                                                    RUN01930
  7         LII(IQ)=II                                                      RUN01940
  7         RAS(IQ)=R                                                       RUN01950
  7         RETURN                                                          RUN01960
  3     230 LISL(IQ)=IAL                                                    RUN01970
  7         LII(IQ)=II                                                      RUN01980
  7         RAS(IQ)=R1                                                      RUN01990
  7         RETURN                                                          RUN02000
  7         END                                                             RUN02010
```

APPENDIX B

DETERMINATION OF SIGNIFICANT WAVE HEIGHT AND PERIOD

In the absence of a particular synthetic storm to be used to generate 100-year wave conditions, a reasonable choice of wind parameters needs to be made and a corresponding sea state computed.

a. If the 100-year elevation can be linked to a particular storm (e.g., February 1978), then an appropriate set of wind data exists for modeling the sea state. Given wind speed, duration, and fetch, the significant wave parameters (height, period) can be computed. These waves will not be the most extreme which may be experienced but they will be waves which the coast will be subject to over the duration of the storm and represent the average state of the highest waves generated. This "average state" will be considered appropriate for computing wave runup.

Wave information can be obtained in a number of ways:

i. Specific Storm Reports (e.g., "The Blizzard of 1978" - Its Effects on the Coastal Environments of Southeastern New England - Conference, Boston State College, Boston, Massachusetts, 1978).

ii. Wave data recorded at Coast Guard stations and available from the National Weather Service.

iii. Generation of wave characteristics using actual or synthesized wind data and the techniques commonly adopted for wave prediction, e.g., Sverdrup-Munk-Bretschneider (SMB) as set forth in Shore Protection Manual.

b. If the 100-year stillwater elevation cannot be related in approximate fashion to a specific storm, then, possibly, some general historical perspective can be gained by a knowledge of the characteristics of the historical storms which have impacted the area of interest. Using this knowledge, a synthetic storm could be pieced together which could subsequently be used to generate a wave field.

c. The pertinent wind parameters can be independently adjusted to produce a given surge. However, this surge must be coupled with an astronomical tide to result in a total stillwater elevation equal to the 100-year elevation.

Approach (a) is the most desirable, followed by Approach (b). There are obvious difficulties with Approach (c) as the relative magnitude of the components of the 100-year elevation (surge, astronomical tide) is not known nor is it unique, i.e., numerous combinations are possible.

In this sample problem, Approach (a) was used to estimate the design deepwater wave parameters. Two gaging stations at Portsmouth and Portland represent the southern and northern limits of the study area.

Statistical analysis of tidal records for Portsmouth, New Hampshire, yields a 100-year elevation of 8.7 ft. The February 6-7, 1978, northeaster produced an elevation of 8.7 ft. At Portland, Maine, the corresponding numbers are 9.4 ft and 9.6 ft, respectively. This demonstrates that the February 1978 storm has the characteristics of the 100-year flood producing storm.

Wind data are readily available for the Boston area. Because of the size of the storm, these data are assumed valid for the southern Maine coastline as well. Wave hindcasting was done using the recently published Coastal Engineering Technical Notes (U.S. Coastal Engineering Research Center, March, 1981).

Since the southern Maine area has a large open ocean to the east, it is the magnitude, i.e., physical dimensions of the storm, which will determine the effective fetch.

The significant wave period and height predicted for the study area were 13.8 sec and 30 ft, respectively.

As collaboration for this computation the National Weather Service reported that during the February 1978 storm seas in open waters were 20-30 ft high. Referring to the wave forecasting charts, these wave heights yield a corresponding significant wave period from 12 to 14 sec. In addition, a 26-foot wave was reported at a drill rig near Hampton Harbor.

For the area under consideration, no distinction is made between the 10-year and 100-year wave conditions. This is because comparable storms producing comparable surge and wave magnitudes may not produce comparable stillwater elevations due to a difference in the astronomical tide component. Furthermore, the difference between the 10-year and 100-year stillwater elevations is small ($\cong$ 1 ft).

In summary, the above computation and observations suggests a reasonable H_s = 30 ft and T_s = 14 sec.