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US Army Corps
of Engineers

GENESIS: GENERALIZED MODEL FOR SIMULATING SHORELINE CHANGE

Report 2

WORKBOOK AND SYSTEM USER'S MANUAL

by

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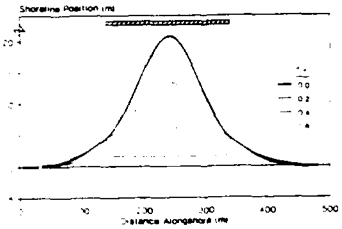

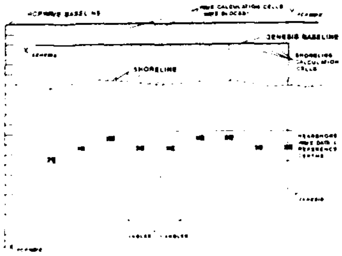

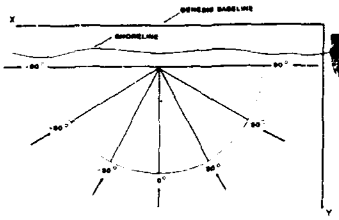

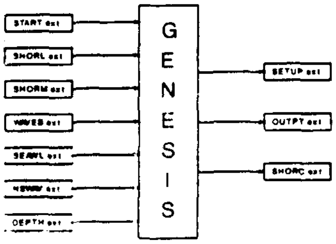

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13. ABSTRACT *(Maximum 200 words)*

This report, the second in a series, documents 13 system support computer programs developed to automate many of the tasks associated with conducting a design level numerical shoreline evolution investigation using the GENESIS model. Report 1, "Technical Reference," is dedicated to a technical description of the GENESIS model and a pedagogic case study. Report 2, "Workbook and System User's Manual," provides recommended procedures, techniques, and guidelines for preparing the required input data sets and for the overall conduct of a shoreline evolution investigation including model calibration, verification, and sensitivity testing.

The system support computer programs documented herein are first technically described, and then multiple example applications of each program are given. Source code listings of many of the system support programs (more than 4,500 lines of FORTRAN CODE) are provided as appendices to the main text. The techniques and procedures recommended in the main text stem from approximately 5 years of GENESIS prototype applications both within the United States and abroad.

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PREFACE

The study described herein was authorized as a part of the Civil Works Research and Development Program by Headquarters, US Army Corps of Engineers (HQUSACE). Work was performed under the Shoreline and Beach Topography Response Modeling Work Unit 32592, which is part of the Shore Protection and Restoration Program at the Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station (WES). The HQUSACE Technical Monitors were Messrs. John H. Lockhart, Jr.; John G. Housley; James E. Crews; and Robert E. Campbell.

This report was written by Mr. Mark B. Gravens, Hydraulic Engineer, Coastal Processes Branch (CPB), Research Division (RD), CERC; Dr. Nicholas C. Kraus, Senior Scientist, CERC; and Dr. Hans Hanson, Associate Professor, Department of Water Resources Engineering, Lund Institute of Technology, University of Lund, Sweden. Ms. Carolyn J. Dickson, CPB, assisted in formatting and organizing the report. Mr. Dorwin T. Shields, Jr., Contract Student, CPB, assisted in developing many of the computer programs discussed herein. This study was conducted under the administrative supervision of Dr. James R. Houston, Chief, CERC; Mr. Charles C. Calhoun, Jr., Assistant Chief, CERC; Mr. H. Lee Butler, Chief, RD, CERC; and Mr. Bruce A. Ebersole, Chief, CPB, CERC. Dr. Charles L. Vincent was Program Manager, Shore Protection and Restoration Program, and Mr. Gravens was Principal Investigator, Shoreline and Beach Topography Change Work Unit 32592. This report was edited by Ms. Lee T. Byrne, Information Technology Laboratory, WES.

COL Larry B. Fulton, EN, was Commander and Director of WES during report preparation. Dr. Robert W. Whalin was Technical Director.

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CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
cubic feet	0.02831685	cubic meters
cubic yards	0.7646	cubic meters
degrees (angle)	0.01745319	radians
feet	0.3048	meters
inches	25.4	millimeters
knots (international)	0.5144444	meters per second
miles (US nautical)	1.852	kilometers
miles (US statute)	1.6093	kilometers
yards	0.9144	meters

GENESIS: GENERALIZED MODEL FOR SIMULATING SHORELINE CHANGE

WORKBOOK AND SYSTEM USER'S MANUAL

PART I: INTRODUCTION

Purpose of This Report

1. This report is the second in a series documenting the numerical modeling system GENESIS. The acronym GENESIS stands for GENEralized Model for SImulating Shoreline Change and encompasses a group of programs developed for simulating wave-induced longshore sand transport and movement of the shoreline. The programs form a system in that they are integrated and function with well-established protocols for inputs and outputs. The system structure is transparent to the user of GENESIS because it is internal, already existing and functioning automatically. Report 1 in the GENESIS series (Hanson and Kraus 1989), hereafter called the Technical Reference, describes technical aspects of GENESIS, including its various internal procedures, operation of the model, and methodology for use of the modeling system in the planning process.

2. Although operation of GENESIS is central to a shoreline change simulation project, it is only one of many tasks of such a project, lying between preparation of the input data and analysis of the simulation results. These other computer-intensive tasks involve preparing various types of data needed to run GENESIS and performing preliminary analysis procedures to understand in quantitative and qualitative terms the coastal sediment transport processes and shoreline change at the project site. Similarly, the simulation results or outputs from GENESIS must be analyzed and interpreted. These tasks are external to GENESIS and are accomplished on an as-needed basis, depending on projects requirements, availability and type of data, and level of modeling to be performed.

3. The purpose of the present report, hereafter referred to as the Workbook, is to develop understanding and facility with the computer routines and associated procedures external to GENESIS. Twelve data analysis and file handling computer programs and the nearshore wave transformation model RCPWAVE (Ebersole, Cialone, and Prater 1986) are involved.

4. It is assumed that the reader has had experience in operating GENESIS and is familiar with the associated concepts and terminology. Furthermore, a basic understanding of personal computer (PC) operations and the FORTRAN computer language is assumed. This workbook provides intensive hands-on training with GENESIS and serves as a reference for the system of programs surrounding GENESIS. This workbook is for and dedicated to fellow power users of GENESIS.

GENESIS

5. GENESIS was developed to simulate long-term shoreline change on an open coast as produced by spatial and temporal differences in longshore sand transport (Hanson 1987, 1989; Hanson and Kraus 1989). The modeling system is founded on considerable research and applications of shoreline change numerical models, as described in the Technical Reference. Wave action is the mechanism producing the longshore sand transport, and, in GENESIS, spatial and temporal differences in the transport rate may be caused by such diverse factors as irregular bottom bathymetry, wave diffraction, boundary conditions, line sources and sinks of sand, and constraints on the transport (such as produced by seawalls and groins), factors that are interrelated and may work in different combinations at different times.

6. The modeling system is generalized in that a wide variety of offshore wave inputs, initial beach plan shape configurations, coastal structures, and beach fills can be specified. GENESIS is operated through a data file interface, and, although the computer code is complex, intimate knowledge of the underlying code and numerical solution procedure is not required. To operate GENESIS, the user need only become familiar with the interface and capabilities and limitations of the modeling system, described in detail in the Technical Reference.

7. The main utility of GENESIS lies in simulating shoreline response to structures and placement of beach fill. Essentially arbitrary combinations and configurations of structures (groins, jetties, detached breakwaters, and seawalls) and beach fills can be represented on a modeled reach of coast. The model is economical to run and has served as the principal predictive technology in numerous quantitative shore protection assessments. In engineering applications and tests of GENESIS, modeled shoreline reaches have ranged from

about 1 to 20 miles* with a grid resolution of 50 to 300 ft, and simulation periods have spanned from approximately 6 months to 20 years, with wave data typically entered at simulated time intervals in the range of 30 min to 6 hr.

Capabilities and Limitations of GENESIS

8. Shoreline change models, including GENESIS, are designed to describe long-term trends of the beach plan shape in the course of its approach to an equilibrium under the imposed wave conditions, boundary conditions, configurations of coastal structures, and other input parameters. In most applications of GENESIS, it is desired to calculate the shoreline response to some engineered or natural perturbation, such as construction of a detached breakwater, placement of beach fill along a certain portion of the shore, or sand discharge from a river. GENESIS and similar models work best in calculating shoreline response, because the perturbation will produce a long-term trend that is distinct from the normally occurring random movement of sand on a beach. In other words, the shoreline change model best calculates movement of the shoreline in transition from one equilibrium state to another.

9. Shoreline change models are not applicable to simulating a randomly fluctuating beach system in which no trend in shoreline position is evident. In particular, GENESIS is not applicable to calculating shoreline change in the following situations that involve beach change unrelated to coastal structures, boundary conditions, or spatial differences in wave-induced longshore sand transport: (a) beach change inside inlets or in areas dominated by tidal flow; (b) beach change produced by wind-generated currents; (c) storm-induced beach erosion in which cross-shore sediment transport processes are dominant (see Larson and Kraus (1989) and Larson, Kraus, and Byrnes (1990) for discussion of the model SBEACH developed to simulate storm-induced beach erosion and profile change); (d) and scour at structures. Table 1, taken from the Technical Reference, gives a summary of major capabilities and limitations of Version 2 of GENESIS.

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* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 10.

Table 1

Major Capabilities and Limitations of GENESIS Version 2

Capabilities

Almost arbitrary numbers and combinations of groins, jetties, detached breakwaters, beach fills, and seawalls

Compound structures such as T-shaped, Y-shaped, and spur groins

Bypassing of sand around and transmission through groins and jetties

Diffraction at detached breakwaters, jetties, and groins

Coverage of wide spatial extent

Offshore input waves of arbitrary height, period, and direction

Multiple wave trains (as from independent wave generation sources)

Sand transport due to oblique wave incidence and longshore gradient in height

Wave transmission at detached breakwaters

Limitations

No wave reflection from structures

No tombolo development (shoreline cannot touch a detached breakwater)

Minor restrictions on placement, shape, and orientation of structures

No direct provision for changing tide level

Basic limitations of shoreline change modeling theory

GENESIS Technical Reference

10. The Technical Reference (Hanson and Kraus 1989), which is the basic source for learning GENESIS, was written to serve as an authoritative and comprehensive reference for GENESIS. The Technical Reference covers the following topics:

a. Properties of GENESIS in comparison to other numerical models of shoreline and beach topography change.

b. Capabilities and limitations of the modeling system.

c. Role of shoreline change modeling in project planning, and methodology of the use of GENESIS for planners and modelers.

d. Theory of shoreline change modeling and GENESIS, including assumptions, governing equations, data requirements, boundary conditions, and associated wave models.

e. Numerical solution scheme.

f. Operation of GENESIS, including model preparation, input and output data file structure, representation of common engineering situations, and error and warning messages.

g. Detailed case study exercising many features of GENESIS.

The Technical Reference also contains an appendix reviewing previous applications of GENESIS and its predecessor model, providing a guide to techniques and results of potential utility in preparing for new projects.

11. The Technical Reference must be thoroughly studied and understood prior to operating GENESIS in an engineering project, and potential users are encouraged to attend a GENESIS workshop or work with an experienced GENESIS user until they become familiar with the modeling system. Misapplication of the model or misinterpretation of results can lead to costly mistakes, and responsibility for use of the simulation results lies with the modeler, not the modeling system.

12. As previously stated, GENESIS is called a modeling system because it is composed of several computer programs or models that communicate to simulate wave transformation, interaction of waves and structures, sediment transport, and shoreline change. Owing to its great flexibility in simulating long-term shoreline change for user-specified beach and structure configurations, GENESIS provides a framework for developing shore protection problem and solution statements, for organizing collection and analysis of relevant data, and for evaluating alternative designs and optimizing the selected design. GENESIS may be applied at either a reconnaissance level of study (called the scoping mode), in which only qualitative assessments are made based on limited amounts of data, or at the design level (called the design mode), in which all available data and ingenuity are brought to bear to quantitatively examine project alternatives.

GENESIS Interface and File Structure

13. Operation of GENESIS in design mode requires acquisition, manipulation, and, in some cases, stand-alone analysis of large quantities of input and output data. Whatever the application, as a minimum the following information must be provided to GENESIS:

a. Initial shoreline position for starting the simulation (and other measured shoreline positions at different times for performing model calibration and verification).

b. Wave data.

c. Measured beach profiles and/or knowledge of the sand grain size from which an average beach profile slope and depth of closure of active profile movement can be determined.

d. Structure and beach-fill configurations.

e. Boundary conditions (one on each end of the shoreline reach to be modeled).

Other data may be required, as listed in Table 2 of the Technical Reference. Because of the complexity of coastal processes and the wave-beach-structure interaction, modeling should not be done in isolation, but, rather, should extend and complement experience of the engineer, scientist, and planner on the target coast.

14. Preparation and analysis of the input and output data streams occupy a substantial portion (perhaps a majority) of the time spent on a GENESIS project. This aspect of the modeling process cannot be overemphasized for three reasons:

a. The accuracy and reliability of a shoreline position change simulation are directly related to the quality and completeness of the input data sets.

b. The data organization and analysis process itself forms the first and a necessary level in understanding coastal processes at the project site.

c. The simulation results must be interpreted within the context of regional and local coastal processes, and the natural variability of the coastal system.

15. The various types of data needed to operate GENESIS are contained in as many as seven input files (the exact number of input files used depends on the problem), and the modeling system sends computed results and key inputs to three output files, as shown in Figure 1. In the Technical Reference, only six input files were described. In the present report, a new file, called **NSWAV** is introduced, as described in Part VI. Preparation of the data streams needed to run GENESIS and interpretation of simulation results form the backbone of the process of conceptualizing a project; the degree of success in a shoreline change modeling effort to a large extent depends on preparation and analysis of the input data. Much of the material in this report is devoted to treatment of input data and sensitivity of calculated results to changes in the data.

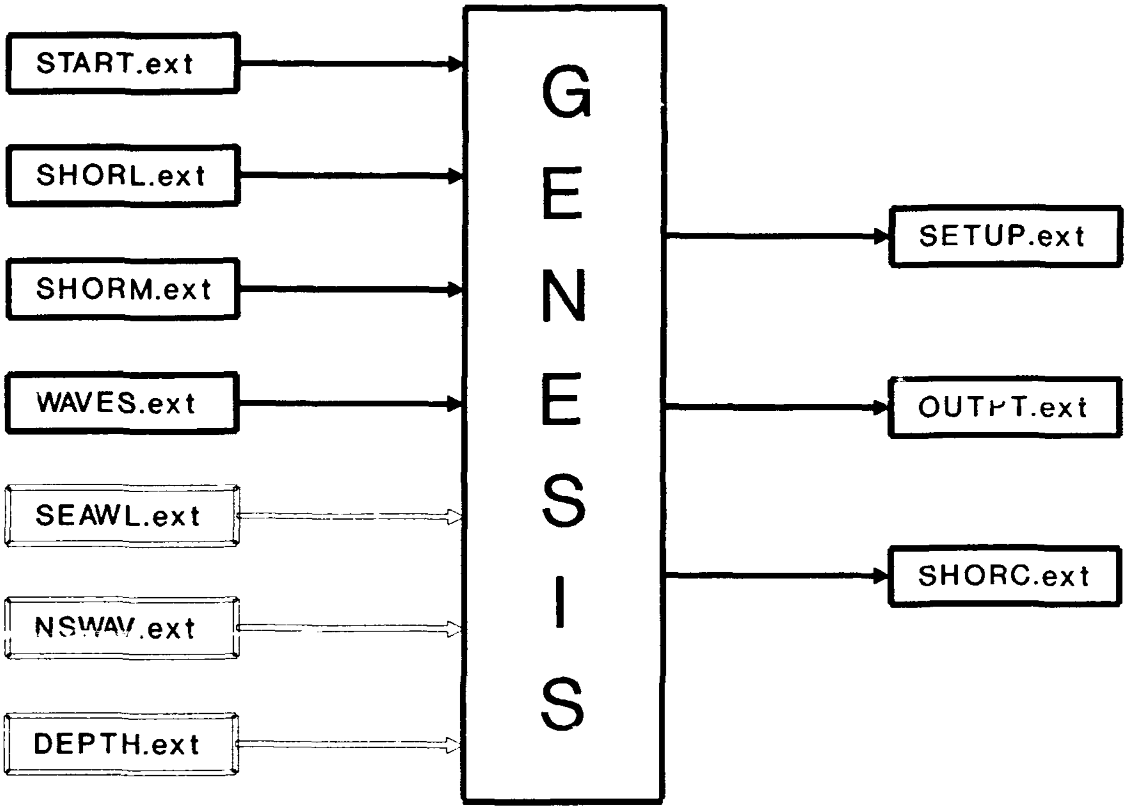


Figure 1. Input and output file structure of GENESIS

Input files

16. To run GENESIS, the four input files **START**, **WAVES**, **SHORL**, and **SHORM**, outlined with solid borders in Figure 1, must always contain data of appropriate format and amount. The files with open-line borders, **SEAWL**, **NSWAV**, and **DEPTH**, need only contain data if required by the project and START file. These files are reviewed here; the file extension ".ext" is left for user specification. GENESIS requires input files to be named as shown in Figure 1 and is designed to accept interactive user input of the extension name. For a given GENESIS simulation, all the required input files must have the same extension.

17. The file **START** contains the instructions that control the shoreline change simulation and is the principal interface between the modeler and GENESIS. These instructions include the spatial and temporal ranges of the

simulation, structure and beach-fill configurations, values of model calibration parameters, and simulated times when output is desired. **SHORL** contains the initial shoreline positions referenced to the baseline established for the calculation. **SHORM** holds measured shoreline positions to which calculated positions may be compared, such as in model calibration and verification. Even if no comparison is made, **SHORM** must contain data, for example, the initial shoreline. **WAVES** holds wave information from which longshore sand transport rates are calculated to compute shoreline change.

18. **SEAWL** contains the positions of seawalls located in the model reach; if there are no seawalls (as specified in the **START** file), **SEAWL** will not be read. **NSWAV** contains nearshore wave height and direction at each wave block alongshore on a nearshore line developed by the user. Information in **NSWAV** is usually generated with an external wave model; this new input data file is further discussed in Part VI. **DEPTH** contains water depths along the nearshore line from which GENESIS will propagate waves to breaking from values provided in **NSWAV**. **DEPTH** will not be read if an external wave model was not used to supply wave data.

Output files

19. The output file **SETUP** echoes to the modeler key parameters specified in the **START** file, providing documentation of the run; it also contains error and warning messages issued by GENESIS during the simulation. **OUTPT** contains the major results of the simulation, including final calculated shoreline position and net and gross longshore sand transport rates, among many types of output information. **SHORC** holds shoreline positions calculated at the last time-step of the simulation and can be manipulated as an input **SHORL** file for a succeeding calculation performed with a modified **START** file.

Scope of Report

20. Part I gives a general introduction to GENESIS and shoreline change modeling, and the purpose and content of this report. The main technical material in the report is contained in Parts II through VIII and the appendices. Part II gives a summary of the physical and mathematical formulation of GENESIS so that the reader need not consult the Technical Reference to answer most questions that may arise on technical material in this report. Included in Part II are discussion of the basic assumptions, review of the

governing equations, and practical considerations about the longshore sand transport rate.

21. Part III, which begins the new material contained in this report, presents two major routines used to compute potential longshore sand transport rates and to preprocess wave data time series for efficient use in GENESIS. Part IV describes the routines needed to process, analyze, and enter measured shoreline position information in GENESIS, one of the three fundamental data inputs in design mode applications of the system.

22. Parts V and VI describe procedures and computer routines to develop input wave data sets. Part V, analysis of offshore wave information, concerns the transformation of waves from deeper water to intermediate depth, and Part VI, analysis of nearshore wave information, concerns transformation of waves from intermediate depth to shallow water and near-wave breaking.

23. Part VII gives practical techniques and advice for setting up data input files and operating GENESIS with a minimal number of errors, including locating and correcting errors that are commonly encountered. Part VIII addresses an important aspect of shoreline change modeling, interpretation and presentation of the output from GENESIS, namely, longshore sand transport rates and shoreline position or change. As a simulation model, GENESIS approximates what has happened or will happen to the shoreline along the coast. Part VIII provides a framework for assessing simulation results and establishing confidence in model predictions.

24. Appendix A provides a key for interpreting flowchart symbols and a list of computer program names, in alphabetical order for convenient reference. Appendices B through L contain source listings of the major system support codes, written in the FORTRAN computer language. Appendix M lists notation and computer variables discussed in the main text of this report. Appendix N is a subject index.

PART II: REVIEW OF GENESIS

25. In this chapter, the physical picture underlying GENESIS and its mathematical representation are summarized for reference in subsequent discussion of the GENESIS system support programs. Part V of the Technical Reference may be consulted for a more detailed treatment of the mathematical representation and numerical solution scheme.

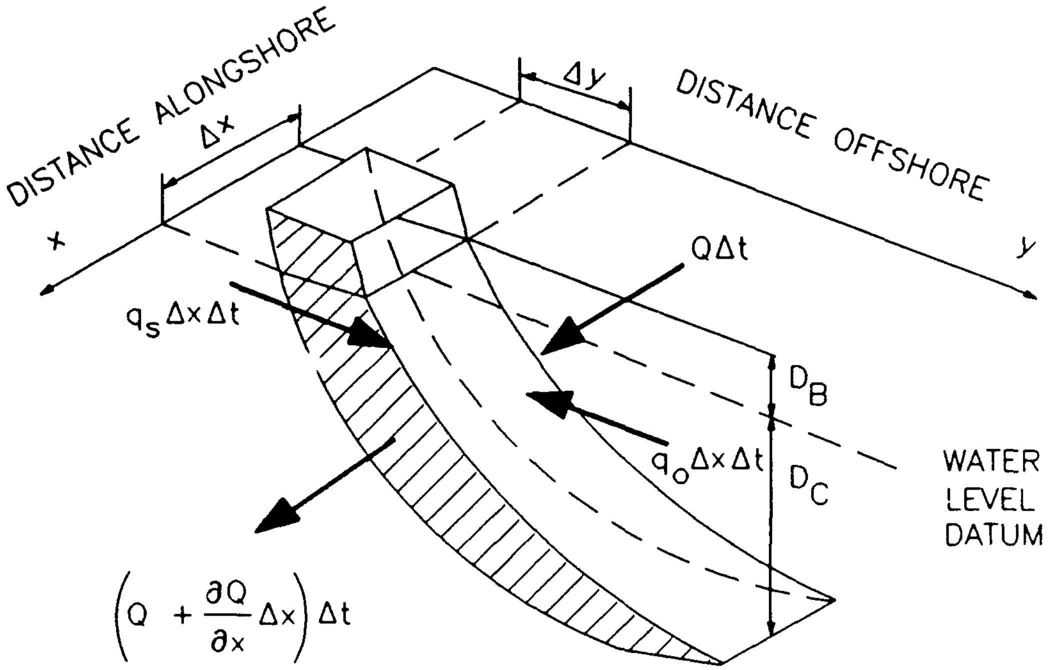
Basic Assumptions of Shoreline Change Modeling

26. The first and most basic assumption of shoreline change modeling is that the beach profile moves landward and seaward while retaining the same shape (Figure 2). Therefore, any point on the profile is sufficient to specify the horizontal location of the profile with respect to a baseline, and one contour line can be used to describe change in the beach plan shape and volume as the beach erodes and accretes. This contour line is taken as the shoreline, and the model is therefore called the "shoreline change" or "shoreline response" model. Sometimes the terminology "one-line" model, a shortening of the phrase "one-contour line" model, is used with reference to the single contour line.

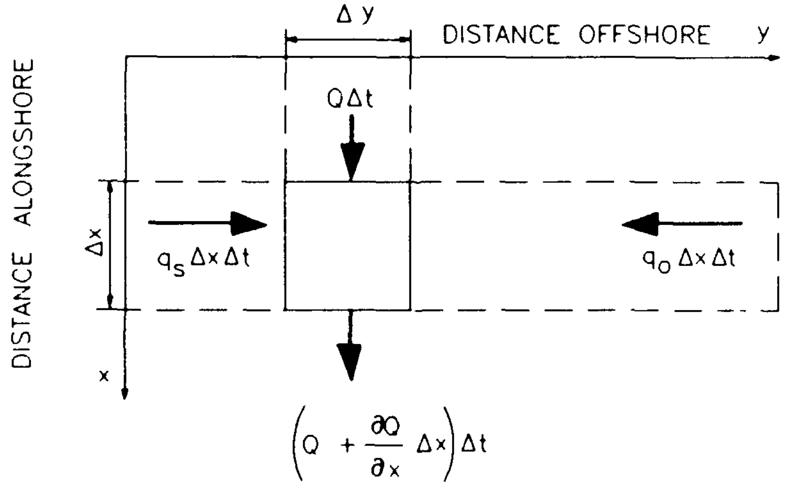
27. A second geometrical-type assumption is that sand is transported alongshore between two well-defined limiting elevations on the profile. The shoreward limit is located at the top of the active berm, and the seaward limit is located where no significant depth changes occurs, the so-called depth of profile closure. Determination of the top of the active berm is relatively straightforward, but the depth of closure is more difficult to estimate and is discussed later in this chapter.

28. The model also requires a predictive expression for the net longshore sand transport rate. For open-coast beaches, to which GENESIS pertains, the transport rate is taken to be a function of the breaking wave height and direction alongshore. The horizontal circulation in the nearshore, which actually moves the sand, is not directly considered.

29. Finally, the model must be applied where there is a long-term trend in shoreline behavior in order to separate and predict a clear signal of shoreline change from cyclical and random movement in the beach system



a. Cross-section view



b. Plan view

Figure 2. Definition sketch for shoreline change calculation

produced by storms, seasonal changes in waves, and tidal fluctuations. In essence, the assumption of a clear trend in shoreline change implies that breaking waves and boundary conditions are the major factors controlling long-term beach change. This assumption is usually well satisfied at engineering projects involving groins, jetties, and detached breakwaters, which introduce biases in the transport rate.

30. In summary, standard assumptions of shoreline change modeling include the following:

- a. The beach profile shape is constant.
- b. The shoreward and seaward limits of the profile are constant.
- c. Sand is transported alongshore by the action of breaking waves.
- d. Detailed structure of the nearshore circulation can be ignored.
- e. There is a long-term trend in shoreline evolution.

Governing Equation for Shoreline Change

31. The partial differential equation governing shoreline change in the one-line model is formulated by conservation of sand volume under the above assumptions. Consider a right-handed Cartesian coordinate system in which the y-axis points offshore and the x-axis is oriented parallel to the trend of the coast (Figures 2a and 2b). The quantity y* thus denotes shoreline position, and x denotes distance alongshore. It is assumed that the beach profile translates seaward or shoreward along a section of coast without changing shape when a net amount of sand enters or leaves the section during a time interval Δt. The change in shoreline position is Δy, the length of the shoreline segment is Δx, and the profile moves within a vertical extent defined by the berm elevation D_B and the closure depth D_C, both measured from the same vertical datum (for example, Mean Sea Level or Mean Lower Low Water).

32. The change in volume of the section, $\Delta V = \Delta x \Delta y (D_B + D_C)$, is determined by the net amount of sand that enters or exits the section from its four sides. One contribution to the volume change results if there is a difference in the longshore sand transport rate Q at the lateral sides of the section and the associated net volume change is $\Delta Q \Delta t = (\partial Q/\partial x)\Delta x \Delta t$. Another

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* For convenience, symbols and abbreviations are listed in the Notation (Appendix M).

contribution can arise from a line source or sink of sand, which adds or removes a volume of sand per unit width of beach from either the shoreward side at the rate of q_s or from the offshore side at the rate of q_o. This contribution gives a rate of $q = q_s + q_o$ and associated volume change of $\Delta q \Delta x \Delta t$. Addition of the contributions and equating them to the volume change gives $\Delta V = \Delta x \Delta y (D_B + D_C) = (\partial Q/\partial x) \Delta x \Delta t + q \Delta x \Delta t$. Rearrangement of terms and taking the limit $\Delta t \longrightarrow 0$ yields the governing equation for the rate of change of shoreline position:

$$\frac{\partial y}{\partial t} + \frac{1}{(D_B + D_C)} \left(\frac{\partial Q}{\partial x} - q \right) = 0 \qquad (1)$$

33. To solve Equation 1, the initial shoreline position over the full reach to be modeled, boundary conditions on each end of the beach, and values for Q, q, D_B, and D_C must be given. These quantities, together with information on structure configurations and beach fill, directly or indirectly comprise the main data requirements for using GENESIS.

Sand Transport Rates

Longshore sand transport

34. The empirical predictive formula for the longshore sand transport rate used in GENESIS is,

$$Q = (H^2 C_g)_b \left(a_1 \sin 2\theta_{bs} - a_2 \cos\theta_{bs} \frac{\partial H}{\partial x} \right)_b \qquad (2)$$

in which

H = wave height, m
C_g = wave group speed given by linear wave theory, m/sec
b = subscript denoting wave breaking condition
θ_{bs} = angle of breaking waves to the local shoreline

The nondimensional parameters a_1 and a_2 are given by

$$a_1 = \frac{K_1}{16(S - 1)(1 - p)(1.416)^{5/2}}$$
$$a_2 = \frac{K_2}{8(S - 1)(1 - p)\tan\beta(1.416)^{7/2}} \quad (3)$$

where

K_1 = empirical coefficient, treated as a calibration parameter

S = ρ_s/ρ

ρ_s = density of sand (taken to be 2.65 10^3 kg/m^3 for quartz sand)

ρ = density of water (1.03 10^3 kg/m^3 for seawater)

p = porosity of sand on the bed (taken to be 0.4)

K_2 = empirical coefficient, treated as a calibration parameter

$\tan\beta$ = average bottom slope from the shoreline to the depth of active longshore sand transport

35. The first term in Equation 2 corresponds to the "Coastal Engineering Research Center (CERC) formula" described in the Shore Protection Manual (SPM 1984) and accounts for longshore sand transport produced by obliquely incident breaking waves. A value of $K_1 = 0.77$ was originally determined by Komar and Inman (1970) from their sand tracer experiments, using root mean square (rms) wave height in the calculations. Kraus et al. (1982) recommended a decrease of K_1 to 0.58 on the basis of their tracer experiments. As this order of magnitude for K_1 is well known in the literature, the standard engineering quantity of significant wave height to be entered in the wave data stream is converted to an rms value in GENESIS by the factor involving 1.416 to compare values of K_1 determined by calibration of the model.

36. The second term in Equation 2 is not part of the CERC formula and describes the effect of another generating mechanism for longshore sand transport, the longshore gradient in breaking wave height $\partial H_b/\partial x$. The contribution arising from the longshore gradient in wave height is usually much smaller than that from oblique wave incidence in an open-coast situation. However, in the vicinity of structures where diffraction produces a substantial change in breaking wave height over a considerable length of beach, inclusion of the second term provides an improved modeling result. The value of K_2 is typically 0.5 to 1.0 times that of K_1. It is not recommended to vary

K_2 much beyond $1.0K_1$, as exaggerated shoreline change may be calculated in the vicinity of structures and numerical instability may also occur.

37. Although the values of K_1 and K_2 have been empirically estimated, these coefficients are treated as parameters in calibration of the model and are called "transport parameters." The transport parameter K_1 controls the time scale of the simulated shoreline change, as well as the magnitude of the longshore sand transport rate. This control of the time scale and magnitude of the longshore sand transport rate is performed in concert with the factor $1/(D_B + D_C)$ appearing in the shoreline change governing equation, Equation 1.

38. In summary, because of the many assumptions and approximations that have gone into formulation of the shoreline response model, and to account for the actual sand transport along a given coast, the coefficients K_1 and K_2 are treated as calibration parameters in GENESIS. Their values are determined by reproducing measured shoreline change and order of magnitude and direction of the longshore sand transport rate.

Sources and sinks

39. The quantity q in Equation 1 represents a line source or sink of sand along the stretch of modeled beach. Typical sources are rivers and cliffs, whereas typical sinks are inlets and entrance channels. Wind-blown sand at the shore can act as either a source or sink on the landward boundary, depending on wind direction. General predictive formulas cannot be given for the shoreward and seaward rates q_s and q_o, whose values depend on the particular situation. These quantities typically vary with time and are a function of distance alongshore. The capability to represent sources and sinks is not included in Version 2 of GENESIS. As an alternative, a direct change in shoreline position can be implemented.

Direct change in shoreline position

40. The position of the shoreline can also change directly, for example, as a result of beach fill or dredging (sand mining). In this case, the profile is translated shoreward or seaward, as required, by a specified amount, which can be a function of time and distance alongshore. GENESIS allows specification of a direct change in shoreline position, which may be positive (seaward), as caused by beach fill, or negative (landward), as by sand mining.

Empirical Parameters

Depth of longshore transport

41. The width of the profile over which longshore transport takes place under a given set of wave conditions is used by GENESIS to calculate the amount of sand bypassing (percentage of total) occurring at groins and jetties. Because the major portion of alongshore sand movement takes place in the surf zone, this distance is approximately equal to the width of the surf zone and principally depends on the breaking wave height.

42. The sand bypassing algorithm in GENESIS requires a depth of active longshore transport, which is directly related to the width of the surf zone under the assumption that the profile is a monotonically increasing function of distance offshore, as discussed in the next section. In Version 2 of GENESIS, a quantity called "the depth of active longshore transport" D_{LT} is defined and set equal to the depth of breaking of the highest one-tenth waves at the updrift side of the structure. Under standard assumptions, this depth is related to the significant wave height $H_{1/3}$ used throughout GENESIS, by

$$D_{LT} = \frac{1.27}{\gamma} (H_{1/3})_b \tag{4}$$

in which

1.27 = conversion factor between one-tenth highest wave height and significant wave height

γ = breaker index, ratio of wave height to water depth at breaking

$(H_{1/3})_b$ = significant wave height at breaking, m

If $\gamma = 0.78$ is used in Equation 4, then $D_{LT} \approx 1.6(H_{1/3})_b$. Thus, the depth defining the seaward extent of the zone of active longshore transport D_{LT} is much less than the depth of closure D_C, except under extremely high waves.

43. GENESIS uses another characteristic depth, termed the "maximum depth of longshore transport" D_{LTo}, to calculate the average beach slope $\tan\beta$ appearing in Equation 3. The quantity D_{Lto} is calculated as

$$D_{LTo} = (2.3 - 10.9H_o) \frac{H_o}{L_o} \tag{5}$$

in which

H_o/L_o = wave steepness in deep water
H_o = significant wave height in deep water, m
L_o = wavelength in deep water, m

From linear wave theory, $L_o = gT^2/2\pi$, in which g is the acceleration due to gravity (m^2/sec) and T (sec) is the wave period. If spectral wave information is given, T is taken as the peak spectral wave period; otherwise, it is the period associated with the significant waves. Equation 5 was introduced by Hallermeier (1983) to estimate an approximate annual limit depth of the littoral zone under extreme waves. In GENESIS, D_{LTo} is calculated at each time-step from the input deepwater wave data and is assumed to be valid over the entire longshore extent of the modeled reach. Because wave characteristics vary seasonally, this definition of the maximum depth of longshore transport will reflect changes in average profile shape and beach slope, as described next.

Average profile shape and slope

44. The shoreline change equation (Equation 1) was derived without reference to a specific shape for the bottom profile, requiring only that the profile maintain its shape. However, to determine the location of breaking waves alongshore and depth at the tips of structures that extend offshore, and to calculate the average nearshore bottom slope used in the longshore transport equation, a profile shape must be specified. For this purpose, the equilibrium profile shape empirically obtained by Bruun (1954) and Dean (1977) is used. They demonstrated that the average profile shape for a wide variety of beaches can be represented by the simple relation,

$$D = Ay^{2/3} \tag{6}$$

in which D is the water depth (m) and A is an empirical coefficient called the scale parameter, having the dimensions m$^{1/3}$. The scale parameter A has been shown by Moore (1982) to depend on the beach grain size. For use in GENESIS, the design curve for A given by Moore was approximated by a series of lines given as a function of the median nearshore beach grain size d_{50} (d_{50} expressed in mm):

$$
\begin{aligned}
A &= 0.41\ (d_{50})^{0.94}, && d_{50} < 0.4 \\
A &= 0.23\ (d_{50})^{0.32}, && 0.4 \le d_{50} < 10.0 \\
A &= 0.23\ (d_{50})^{0.28}, && 10.0 \le d_{50} < 40.0 \\
A &= 0.46\ (d_{50})^{0.11}, && 40.0 \le d_{50}
\end{aligned}
\tag{7}
$$

If beach survey profiles for the target beach are available, it is recommended that the modeler use curves such as given in Figure 7 of the Technical Reference as templates to determine an effective median grain size. The effective grain size, supplied to GENESIS in the **START** file, will produce an A-value that will give the most representative equilibrium profile shape. If profile survey data are lacking, the median grain size of the surf zone sand should be used.

45. The average nearshore slope $\tan\beta$ for the equilibrium profile defined by Equation 6 is calculated as the average value of the integral of the slope $\partial D/\partial y$ from 0 to y_{LT}, resulting in $\tan\beta = A(y_{LT})^{-1/3}$, in which y_{LT} is the width of the littoral zone, extending seaward to the depth D_{LTo}. Since by definition $y_{LT} = (D_{LTo}/A)^{3/2}$, the average slope is calculated to be

$$\tan\beta = \left(\frac{A^3}{D_{LTo}}\right)^{1/2} \tag{8}$$

Depth of closure

46. The depth of closure, the seaward limit beyond which the profile does not exhibit significant change in depth, is a difficult parameter to quantify. Empirically, the location of profile closure D_C cannot be identified with confidence, as small bathymetric change in deeper water is difficult to measure. This situation usually results in a depth of closure located within a wide range of values, requiring judgment to be exercised to specify a single value. If numerous "long" profile surveys are available, the standard deviation can be plotted as a function of depth. The standard deviation typically decreases sharply at a certain depth, which can be considered to be the depth of closure (Kraus and Harikai 1983). Figure 8 of the Technical Reference gives examples of such calculations. The depth of closure is typically in the range of 6 to 8 m for the open Atlantic coast, where the average wave period is about 7 sec, and 8 to 12 m on the open

Pacific coast, where the average wave period is about 10 sec. A sheltered beach is expected to have a smaller depth of closure.

47. Profile surveys are often not available to a sufficient depth and with sufficient vertical and horizontal control to allow comparisons of profiles to be made. In this situation, the depth of closure may be estimated by reference to a maximum seasonal or annual wave height. Hallermeier (1983) found that the maximum seaward limit of the littoral zone could be expressed by Equation 5 if the wave height and period are given by the averages of the highest significant waves occurring for 12 hr during the year.

48. Because the depth of closure is difficult to estimate at most sites, the modeler must use some external means to determine a value for the particular project. It is recommended that both bathymetry (profile) surveys and Equation 5 be used as a check of the consistency of values obtained. On an open-ocean coast, the depth of closure is not expected to show significant longshore variation, since the wave climate and sand characteristics would be similar.

Wave Calculation

49. Offshore wave information can be obtained from either a "numerical" gage, i.e., a hindcast calculation, or from an actual wave gage. Wave data from the gage are typically input to the model at the fixed time interval of 6 hr. The wave height and direction at the gage must then be transformed to breaking at calculation cells alongshore for input to the longshore sand transport rate calculation in GENESIS. Monochromatic wave models hold the wave period constant in this process.

50. The modeling system GENESIS is composed of two major submodels: one calculates the longshore sand transport rate and shoreline change, and the other calculates, under simplified conditions, breaking wave height and angle alongshore as determined from wave information given at a reference depth offshore. The latter submodel is called the <u>internal</u> <u>wave</u> <u>transformation</u> <u>model</u>, as opposed to another, completely independent, <u>external</u> <u>wave</u> <u>transformation</u> <u>model</u> which can be optionally used to supply nearshore wave information to GENESIS. The availability and reliability of wave data as well as the complexity of the nearshore bathymetry should be used to evaluate which wave model to apply.

51. The two possible ways of using the internal and external wave transformation models and their spatial domains are depicted in Figure 3. The internal model is applicable to a sea bottom with approximately straight, parallel contours; breaker height and angle are calculated at grid points alongshore starting from the reference depth of the offshore wave input (Figure 3a). If an external wave model is used (Figure 3b), it calculates wave transformation over the actual (irregular) bathymetry starting at the offshore reference depth. Resultant values of wave height and direction at depths alongshore for which wave breaking has not yet occurred are placed in a file (by the modeler) for input to the internal wave model. These depths, taken, for example, as the depths in each wave calculation cell (herein referred to as a wave block) immediately seaward of the 6-m contour, define a "nearshore reference line," from which the internal wave transformation model in GENESIS takes over grid cell by grid cell to bring the waves to the breaking point.

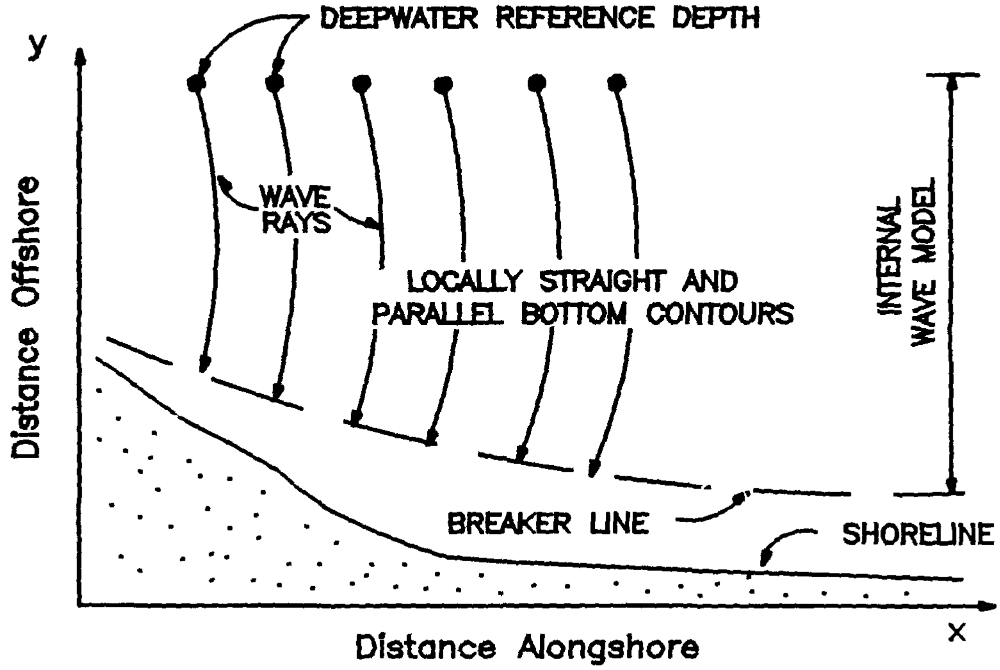
52. If structures that produce diffraction are located in the modeling reach, the internal wave transformation model will automatically include the effect of diffraction in the process of determining breaking wave characteristics. These structures should not, therefore, be included in performing calculations with an external wave transformation model.

Internal Wave Transformation Model

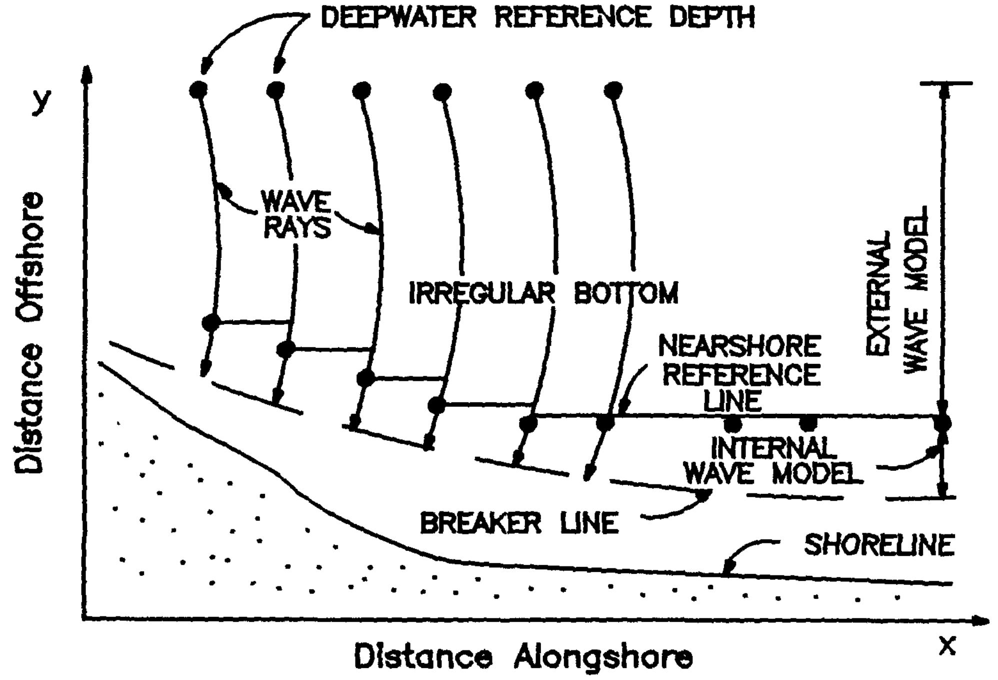
Breaking waves

53. Initially, waves are transformed from the deepwater reference depth or the nearshore reference line (depending on whether or not the external wave transformation model is used) without accounting for diffraction from structures or land masses located in the model reach. The solution strategy is to obtain a first approximation without including diffraction and then to modify the result by accounting for changes to the wave field by each diffraction source.

54. Omitting diffraction, there are three unknowns in the breaking wave calculation: wave height, wave angle, and depth at breaking; the three equations needed to obtain these quantities follow. These are the equations



a. Transformation by internal wave model only



b. Transformation by external and internal wave models

Figure 3. Operation of wave transformation models

for the breaking wave height based on reference wave data (Equation 9), a depth-limited breaking criterion (Equation 10), and Snell's Law (Equation 12), which specifies the wave angle.

55. Equation 9 is used to calculate the height of breaking waves which have been transformed by refraction and shoaling,

$$H_b = K_R K_S H_{ref} \tag{9}$$

in which

H_b = breaking wave height at an arbitrary point alongshore, m
K_R = refraction coefficient
K_S = shoaling coefficient
H_{ref} = wave height at the offshore reference depth or the nearshore reference line depending on which wave model is used, m

The refraction and shoaling coefficients are given by linear-wave theory.

56. The equation for depth-limited wave breaking is given by,

$$H_b = \gamma D_b \tag{10}$$

in which D_b is the depth at breaking and the breaker index γ is a function of the deepwater wave steepness and the average beach slope (Smith and Kraus, 1991),

$$\gamma = b - a\frac{H_o}{L_o} \quad . \tag{11}$$

in which $a = 5.00\ [1 - \exp(-43 \tan\beta)]$ and $b = 1.12/[1 + \exp(-60 \tan\beta)]$.

57. The wave angle at breaking is calculated by means of Snell's law, under the assumption of locally plane and parallel bottom contours,

$$\frac{\sin\theta_b}{L_b} = \frac{\sin\theta}{L} \tag{12}$$

in which θ_b and L_b are the angle and wavelength at the break point, and θ and L are the corresponding quantities at an offshore point, with the wavelength calculated by linear-wave theory.

58. The three unknowns H_b, D_b, and θ_b are obtained at intervals alongshore by iterative solution of Equations 9, 10, and 12 as a function of the wave height and angle at the reference depth and the wave period.

59. Wave refraction models provide the undiffracted breaking wave angle θ_b in the fixed coordinate system. With reference to Figure 4, the breaking wave angle to the local shoreline required to calculate the longshore sand transport rate, Equation 2, is obtained as

$$\theta_{bs} = \theta_b - \theta_s \tag{13}$$

in which $\theta_s = \tan^{-1}(\partial y/\partial x)$ is the angle of the shoreline with respect to the x-axis. In GENESIS, an angle of 0 deg signifies wave incidence normal to the baseline. The angle θ_b drawn in Figure 4 is positive.

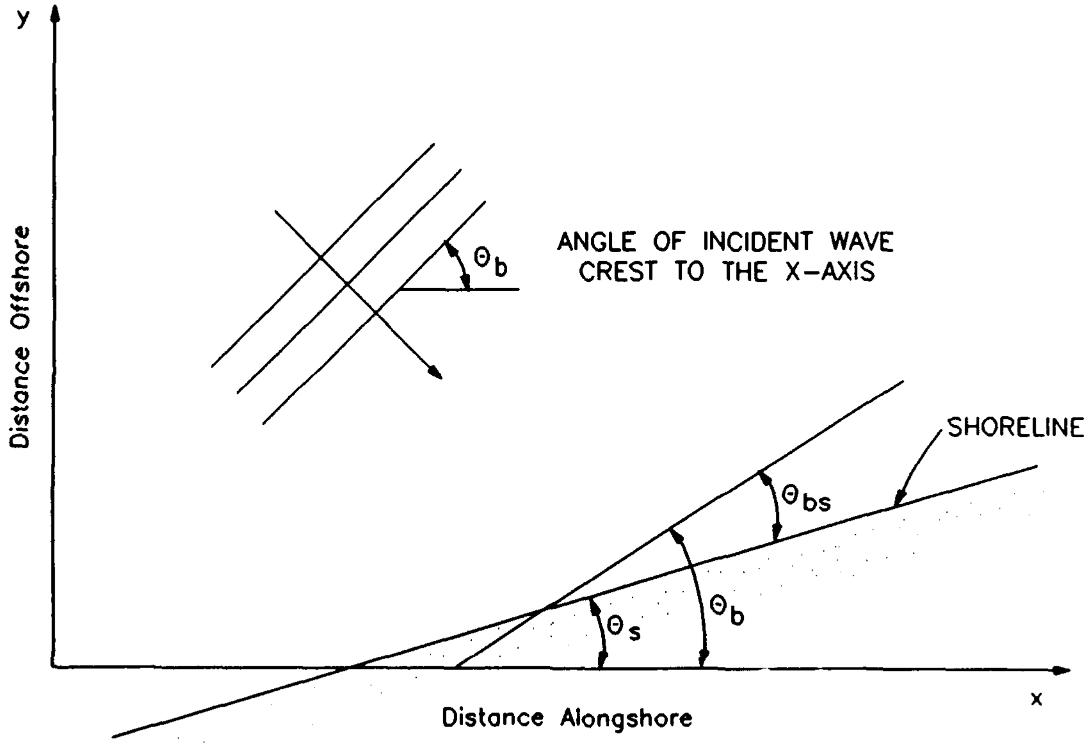


Figure 4. Definition of breaking wave angles

60. If there are no structures to produce diffraction, the undiffracted wave characteristics are used as input to the sediment transport relation (Equation 2). If such obstacles are present, breaking wave heights and angles are recalculated, as described next.

Breaking waves affected by structures

61. Structures such as detached breakwaters, jetties, and groins that extend well seaward of the surf zone intercept the incident waves prior to breaking. Headlands and islands may also intercept waves. In the following discussion, all such objects are referred to as structures. Each tip of a structure will produce a near-circular wave pattern, and this distortion of the wave field is a significant factor controlling the response of the shoreline in the lee of the structure. Sand typically accumulates in the diffraction shadow of a structure, being transported from one or both sides by the oblique wave angles in the circular wave pattern and the decrease in wave height alongshore with penetration into the shadow region. Accurate and efficient calculation of waves transforming under combined diffraction, refraction, and shoaling to breaking is required to obtain realistic predictions of shoreline change in such situations.

62. In areas where the waves have undergone diffraction, Equation 14 is used to calculate the height of breaking waves that have been transformed by diffraction, refraction, and shoaling,

$$H_b = K_D H_b' \tag{14}$$

in which

K_D = diffraction coefficient

H_b' = breaking wave height at the same cell without diffraction, m

63. The three unknowns H_b, D_b, and θ_b are obtained at intervals alongshore by iterative solution of Equation 14 together with Equations 10 and 12 as a function of the wave period and the wave height and angle at the breaking depth.

Contour modification

64. The beach plan shape changes as a result of spatial differences in longshore sand transport. The change in the beach shape, in turn, alters the refraction of the waves. This interaction between beach and waves is

represented in GENESIS by using a coordinate system rotated to align with the local contours (which change in time) at each calculation point in taking waves from a reference depth to the point of breaking.

Wave transmission at detached breakwaters

65. The design of detached breakwaters for shore protection requires consideration of many factors, including structure length, distance offshore, crest height, core composition, and gap between structures in the case of segmented breakwaters. Wave transmission, a term describing the movement of waves over and through a structure, is present in most practical applications, since it is economical and often advantageous from the perspective of beach change control to build low or porous structures to allow energy to penetrate behind them.

66. One of the principal upgrades of Version 2 of GENESIS is its capability to simulate wave transmission at detached breakwaters and its impact on shoreline change. This capability was tested with excellent results for Holly Beach, Louisiana, a site containing six breakwaters of different construction and transmission characteristics (Hanson, Kraus, and Nakashima 1989), and for Lorain, Ohio, a site having three transmissive rubble-mound breakwaters (Hanson and Kraus 1991).

67. To describe wave transmission in the modeling system, a value of a transmission coefficient K_T must be provided for each detached breakwater. The transmission coefficient, defined as the ratio of the height of the incident waves directly shoreward of the breakwater to the height directly seaward of the breakwater, has the range $0 \leq K_T \leq 1$, for which a value of 0 implies no transmission and 1 implies complete transmission.

68. The derivation of the phenomenological wave transmission algorithm in GENESIS was developed on the basis of three criteria:

a. As K_T approaches zero, the calculated wave diffraction should equal that given by standard diffraction theory for an impermeable, infinitely high breakwater.

b. If two adjacent energy windows have the same K_T, no diffraction should occur (wave height uniform at the boundary).

c. On the boundary between energy windows with different K_T, wave energy should be conveyed from the window with higher waves into the window with smaller waves. The wave energy transferred should be proportional to the ratio between the two transmission coefficients.

69. The criteria lead to the following expression for the diffraction coefficient K_{DT} for transmissive breakwaters,

$$K_{DT} = \begin{cases} K_D + R_{KT}(1 - K_D) & \textit{inside shadow zone} \\ K_D - R_{KT}(K_D - 0.5) & \textit{on border} \\ K_D(1 - R_{KT}) & \textit{outside shadow zone} \end{cases} \qquad (15)$$

in which R_{KT} is the ratio of the smaller valued transmission coefficient to the larger valued transmission coefficient for two adjacent breakwaters. The terminology "shadow zone" refers to the region shadowed to waves by the breakwater with associated value of K_{DT}.

70. Figure 5 shows a hypothetical example of shoreline change behind a transmissive detached breakwater. The breakwater is 200 m long and located 250 m offshore. Incident waves with T = 6 sec and H = 1.5 m propagate with the wave crests parallel to the initially straight shoreline, and the simulation time is 180 hr. As expected, the seaward extent of the induced large

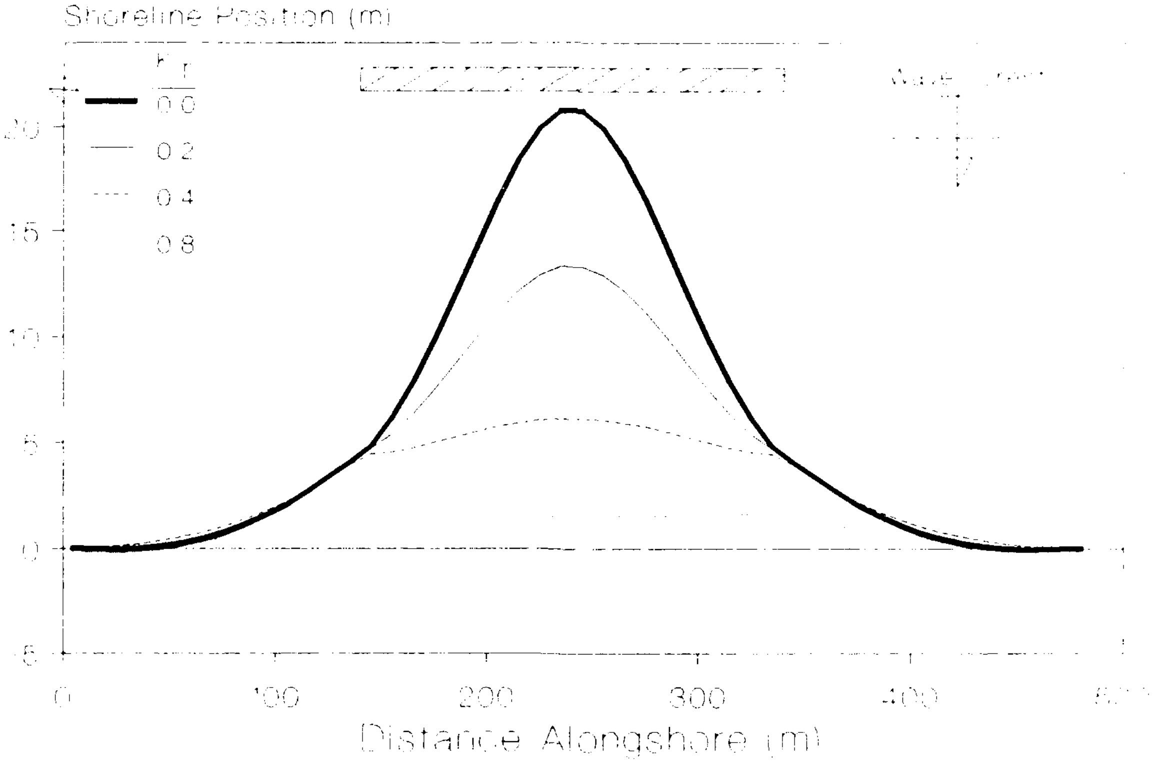


Figure 5. Shoreline change as a function of transmission

cusp (salient) decreases as wave transmission increases. Also, the salient broadens slightly with increased transmission, and the eroded areas on either side of the salient fill in.

Representative offshore contour

71. A basic assumption in the formulation of the shoreline change model is that the profile moves parallel to itself. As a consequence, offshore contours move parallel to the shoreline. If this assumption is applied directly in the internal wave transformation model, unrealistic refraction can result in regions where the shoreline position changes relatively abruptly, possibly leading to numerical instability. To overcome this limitation, GENESIS has the option of using a smoothed offshore contour in performing the internal wave calculation, as illustrated in Figure 6. In this figure, the shore-parallel contour shown changes radically at the groin. The smoothed contour is expected to better represent the offshore bathymetry. If the smoothed contour option is chosen, the contour is assumed to be representative

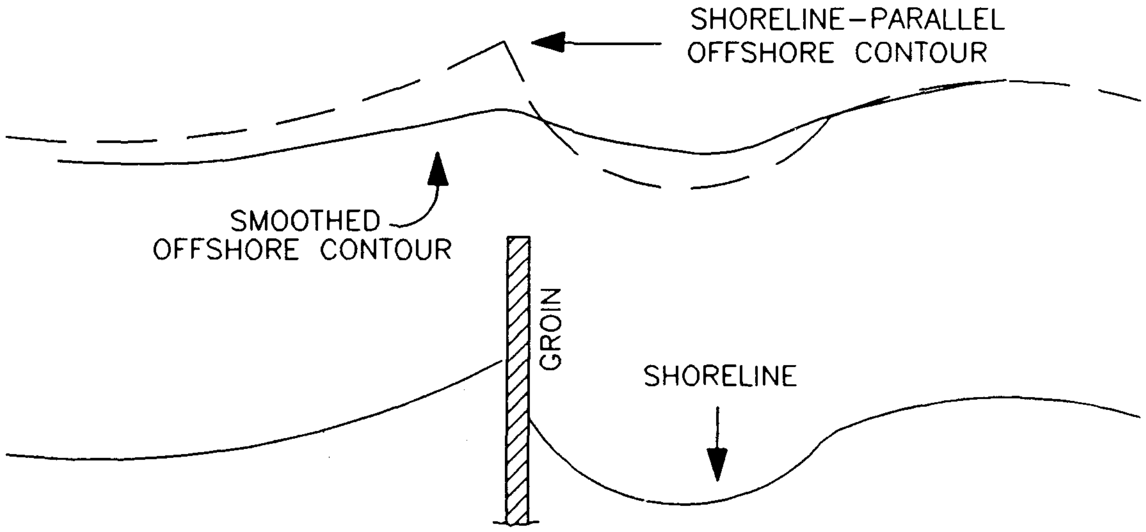


Figure 6. Example of representative contour

of all contour lines between the input wave depth and the undiffracted wave breaking depth. The orientation of the representative offshore contour is recalculated on monthly intervals using the shoreline position at that time.

External Wave Transformation Model: RCPWAVE

72. In many applications, offshore contours cannot be considered as plane and parallel. In these cases accurate modeling of shoreline change requires calculation of the nearshore waves using the actual bathymetry. For the open-coast situation, the linear-wave transformation model RCPWAVE (Regional Coastal Processes WAVE model) (Ebersole 1985; Ebersole, Cialone, and Prater 1986) has advantages for use with GENESIS:

a. It solves for wave height and angle values directly on a grid.

b. It is efficient, allowing wide-area coverage.

c. It includes diffractive effects produced by an irregular bottom, thus reducing caustic generation as well as providing better accuracy than a pure refraction model.

d. It has proven to be very stable.

73. RCPWAVE computes values of wave height and angle at grid points on a nearshore reference line, shown schematically in Figure 3b. From this line the internal wave transformation model in GENESIS brings waves to breaking. Figure 7 shows the relation between GENESIS and RCPWAVE in the overall calculation flow.

74. Shoreline change simulation intervals are typically on the order of several years and the extent of the modeled reach several kilometers, requiring hundreds of grid cells. Since the time-step for the simulation is typically 6 hr, but may be much smaller, for example, 30 min if detached breakwaters and short grid spacing are involved, thousands of wave calculations must be performed. It is impractical to run a wave transformation model such as RCPWAVE for each time-step because of the enormous execution time involved. A general wave model runs on a two-dimensional grid, and its execution time is proportional to N^2, where N is on the order of the number of grid cells in the x- and y-directions. In contrast, GENESIS is a one-dimensional model, and its execution time is proportional to N. Therefore, it is unbalanced in computational effort to perform an external wave calculation at every shoreline simulation time-step. As a related physical consideration,

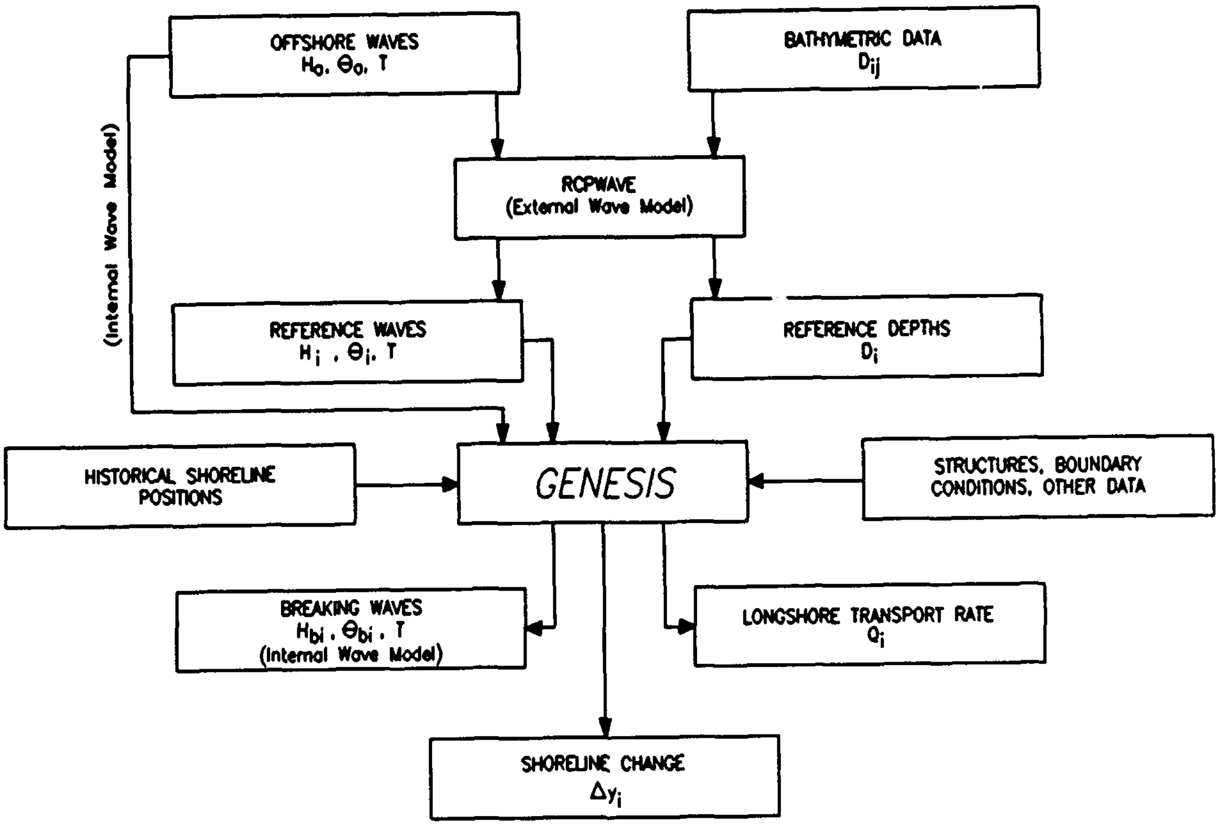


Figure 7. GENESIS, RCPWAVE, and the overall calculation flow

time series of offshore waves are usually not available or, if available, contain uncertainties, implying that an expensive, precise, but not necessarily accurate numerical wave transformation calculation would not be in balance with approximate input data.

75. Rather than running the external wave transformation model at every time-step, a time-saving technique is used in which the offshore wave conditions are divided into period and angle bands. Typically, the range in period existing in the record is divided into 2-sec intervals, and the range in direction of incident waves is divided into 22.5-deg intervals. This procedure gives on the order of 50 to 100 period-angle bands, and refraction runs are made with the external wave model using unit wave height to provide what are termed "transformation coefficients" along the nearshore reference line. To key into these calculated refraction results, the wave conditions in the offshore time series are grouped into the designated period-angle bands.

The wave height on the nearshore reference line calculated with unit offshore wave height is then given as the product of the transformation coefficient alongshore and the input offshore wave height at the time-step, which is permissible by linear wave theory. Thus, although the wave period and angle are constrained to lie in a finite number of bands, the actual offshore wave height is used. Since it is doubtful whether directional resolution greater than 11.25 or 22.5 deg can be achieved by either a deepwater wave gage or hindcast, the described procedure is an adequate representation of the data, yet it allows for efficient calculation. The procedures for defining wave period and angle bands and developing a key to locate the nearshore wave data associated with the particular offshore wave period and angle are described in Part VI.

76. Manipulation of the wave database as described previously requires substantial effort and is one of the necessary tasks that must be performed as part of the data preparation process if an external wave model is used. Practical details of the use of an external refraction model with GENESIS are given in the Part VI.

Limiting Deepwater Wave Steepness

77. The input offshore wave data may be changed for a number of reasons, for example, to examine model sensitivity, investigate extreme cases, and run waves for storm conditions. In these investigations the wave height is usually increased. In the process, if care is not taken, it is possible to specify waves of unphysically large steepness. GENESIS performs a check that the offshore input wave steepness satisfies the Mitchell (1893) limiting wave steepness criterion:

$$\frac{H_o}{L_o} = 0.142 \tag{16}$$

If the calculated wave steepness exceeds the value of 0.142, the offshore wave height, assumed to approximate the deepwater wave height, is reduced to satisfy Equation 16, maintaining input wave period at the same value. A warning message is also issued, as described in Part VII.

Wave Energy Windows

78. The concept of wave energy windows is central to GENESIS and determines its algorithmic structure. Wave energy windows provide a powerful means of describing breaking wave conditions and the associated sand transport alongshore for a wide variety of configurations of coastal structures. It is valuable to understand energy windows and transport domains for properly configuring GENESIS to model reaches containing structures as well as to interpret the results of calculations involving structures. Energy windows and transport domains are constructs internal to GENESIS and are automatically defined according to entries in the **START** file. The Technical Reference gives specific examples.

Energy windows

79. An energy window is defined as a beach area open to incident waves as viewed from that particular stretch of beach. Operationally, an energy window is defined by two boundaries regarded as limiting the penetration of waves to the target beach. Windows are separated by diffracting jetties, diffracting groins, nontransmissive detached breakwaters, and the tips of transmissive detached breakwaters. Incident wave energy must enter through one of these windows to reach a location in the nearshore area. It is possible (and common) for a location to be open to waves from more than one window.

Sand transport calculation domains

80. In GENESIS Version 2, shore-connected structures (jetties, groins, and breakwaters) are assumed not to transmit wave energy, so that waves entering on one side of such a structure cannot propagate to the other side. Based on the concept of wave energy windows and non-wave transmissibility of shore-connected structures, the shoreline is divided into what are called "sand transport calculation domains." These domains consist of segments of the coast which are bounded on each side by either a diffracting shore-connected structure or a model boundary. GENESIS solves the shoreline change equation independently for each domain, except for conditions such as sand passing around or through groins, which allow exchange of sand across the boundaries of the calculation domains. Examples illustrating wave energy

windows and transport calculation domains are given on page 78 of the Technical Reference.

Multiple diffraction

81. If an energy window is bounded by two sources of wave diffraction, one on the left (L) and one on the right (R), each will have an associated diffraction coefficient, K_{DL} and K_{DR}, respectively, as shown in Figure 8. The internal wave transformation model calculates a combined diffraction coefficient K_D for the window as:

$$K_D = K_{DL}K_{DR} \tag{17}$$

The properties of Equation 17 are such that (a) as K_{DL} and K_{DR} each approach unity, the total diffraction coefficient approaches unity (situation at large gap or far from diffraction sources in open water), and (b) the total diffraction coefficient approaches zero as either K_{DL} or K_{DR} approach zero, (situation deep inside a wave shadow zone). If an energy window is open on one side, the diffraction coefficient for that side is set equal to 1.0.

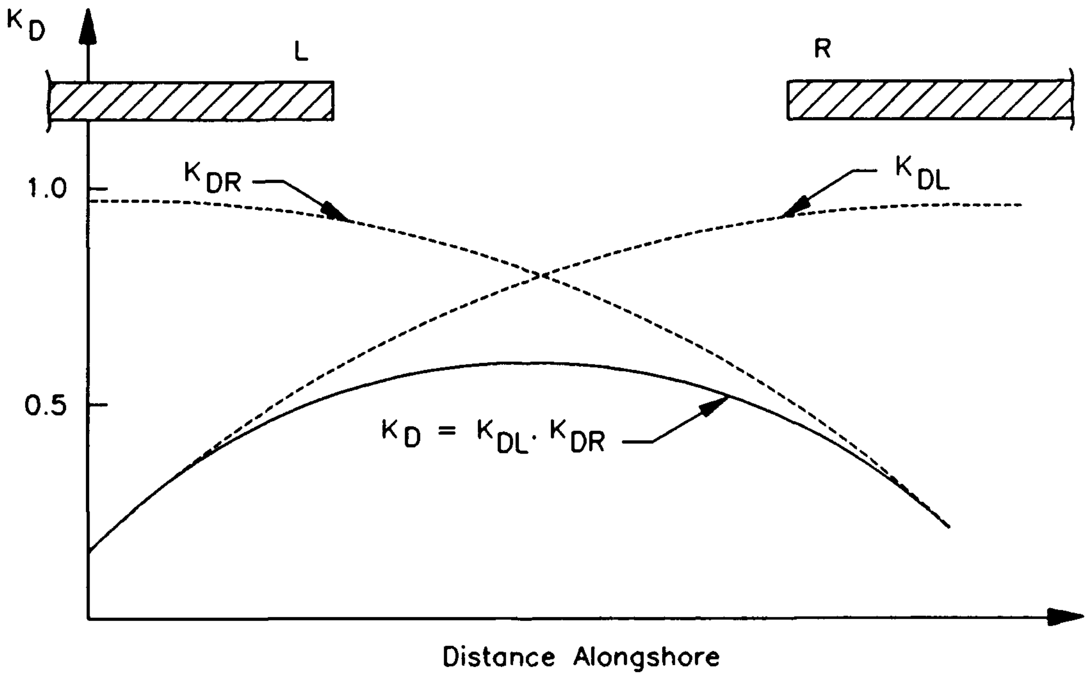


Figure 8. Diffraction coefficient for two sources

Numerical Solution Scheme

82. If all information is available to use Equation 1 (shoreline change equation), Equation 2 (longshore sand transport rate equation), and Equation 10 (wave breaking criterion), the response of the shoreline to wave action can be calculated. Under certain simplified conditions, closed-form mathematical solutions of Equation 1 can be found (see, for example, Larson, Hanson, and Kraus 1987), but in order to describe realistic structure and shoreline configurations, including waves that vary alongshore and with time, Equation 1 must be solved numerically. In a numerical solution procedure, the distance alongshore is divided into cells of a certain width (called the grid spacing), and the duration of the simulation is similarly divided into small elements (called the time-step). If the grid spacing and time-step are small, solutions of the governing partial differential equation (Equation 1) can be accurately calculated by numerical solution of the finite difference equation.

83. Numerical accuracy refers to the degree to which the numerical scheme provides an accurate solution to the partial differential equation (Equation 1). Physical accuracy refers to the degree to which Equation 1 and the associated input data represent the actually occurring processes. Physical accuracy depends on the quality of the input data and the degree to which the basic assumptions of shoreline change modeling approximate conditions at the site. Good numerical accuracy does not necessarily imply good physical accuracy. For a rapid numerical solution, the time-step should be as large as possible. On the other hand, the numerical and physical accuracy will obviously be improved if the time-step is small, since changes in the wave conditions and changes in the shoreline position itself (which feeds back to modify the breaking waves) will be better represented. Similarly, use of many small grid cells will provide more detail or improved numerical accuracy in the shoreline change calculation than use of fewer but longer cells, but the calculation time increases as the number of cells increases.

84. The allowable grid spacing and time-step of a finite difference numerical solution of a partial differential equation such as Equation 1 depend on the type of solution scheme. Under certain idealized conditions, Equation 1 can be reduced to a simpler form to examine the dependence of the solution on the time and space steps. The main assumption needed is that the angle θ_{bs} in Equation 2 is small. Equation 1 can then be expressed as,

$$\frac{\partial y}{\partial t} = (\epsilon_1 + \epsilon_2) \frac{\partial^2 y}{\partial x^2} \tag{18}$$

in which

$$\epsilon_1 = \frac{2K_1}{(D_B + D_C)} (H^2 C_g)_b \tag{19}$$

and

$$\epsilon_2 = \frac{K_2}{(D_B + D_C)} \left(H^2 C_g \cos\theta_{bs} \frac{\partial H}{\partial x} \right)_b \tag{20}$$

Because Equation 18 is a diffusion-type equation, its stability is known to be governed by the following condition:

$$R_S = \frac{\Delta t (\epsilon_1 + \epsilon_2)}{(\Delta x)^2} \tag{21}$$

In the terminology of GENESIS, the quantity R_S is called the stability parameter and referred to as "STAB" in the system interface.

85. Equation 18 (or the full shoreline change governing equation, Equation 1) can be solved by either an explicit or implicit solution scheme. If an explicit solution scheme is used to solve the diffusion equation, the following condition must be satisfied:

$$R_S \leq 0.5 \tag{22}$$

86. If the value of R_S exceeds 0.5 in the explicit solution scheme at any point on the grid, the calculated shoreline will show an unphysical oscillation that will grow in time, alternating in direction at each grid point, if R_S remains above 0.5. The quantities ϵ_1 and ϵ_2 can change greatly alongshore since they depend on the local wave conditions. Assuming that the grid cell spacing is fixed by engineering requirements, a large wave height would

necessitate a small value of Δt. Although there are calculation strategies to overcome this problem, it is inefficient to use an explicit solution scheme to solve for shoreline position in a general case.

87. Equation 1, of which Equation 18 is a special case, can also be solved using an implicit scheme in which the new shoreline position depends on values calculated on the old, as well as the new, time-step. An implicit scheme is more complex to code, but is stable for very large values of R_S. GENESIS uses an implicit solution scheme given by Kraus and Harikai (1983). By numerical experimentation, it has been found that for values of R_S less than approximately 10, the numerical error approximately equals the magnitude of R_S expressed as a percentage. Above the value of 10, the error increases at a greater than linear rate with R_S. GENESIS calculates the value of R_S at each time-step at each grid point alongshore and determines the maximum value. If R_S (or STAB) > 5 at any grid point, a warning is issued.

Grid System and Finite Difference Solution Scheme

88. In GENESIS, calculated quantities along the shoreline are discretized on a staggered grid in which shoreline positions y_i are defined at the center of the grid cells ("y-points") and transport rates Q_i at the cell walls ("Q-points"), as shown in Figure 9. The left and right boundaries are located at grid cell numbers 1 and N, respectively. In total, there are N values of the shoreline position, so the values of the initial shoreline position must be given at N points. There are N+1 values of the longshore sand transport rate since N+1 cell walls enclose the N cells. Values of the transport rate must be specified at the boundaries, Q_1 and Q_{N+1}, and the remainder of the Q_i and all y_i will be calculated. Since the Q_i are a function of the wave conditions, wave quantities are calculated at Q-points. The tips of structures are likewise located at Q-points. Beach fills, river discharges, and other sand sources and sinks are located at y-points.

Lateral Boundary Conditions and Constraints

89. GENESIS requires specification of values for Q at both boundaries, cell walls 1 and N+1, at each time-step. The importance of the lateral boundary conditions cannot be overemphasized, as calculated shoreline

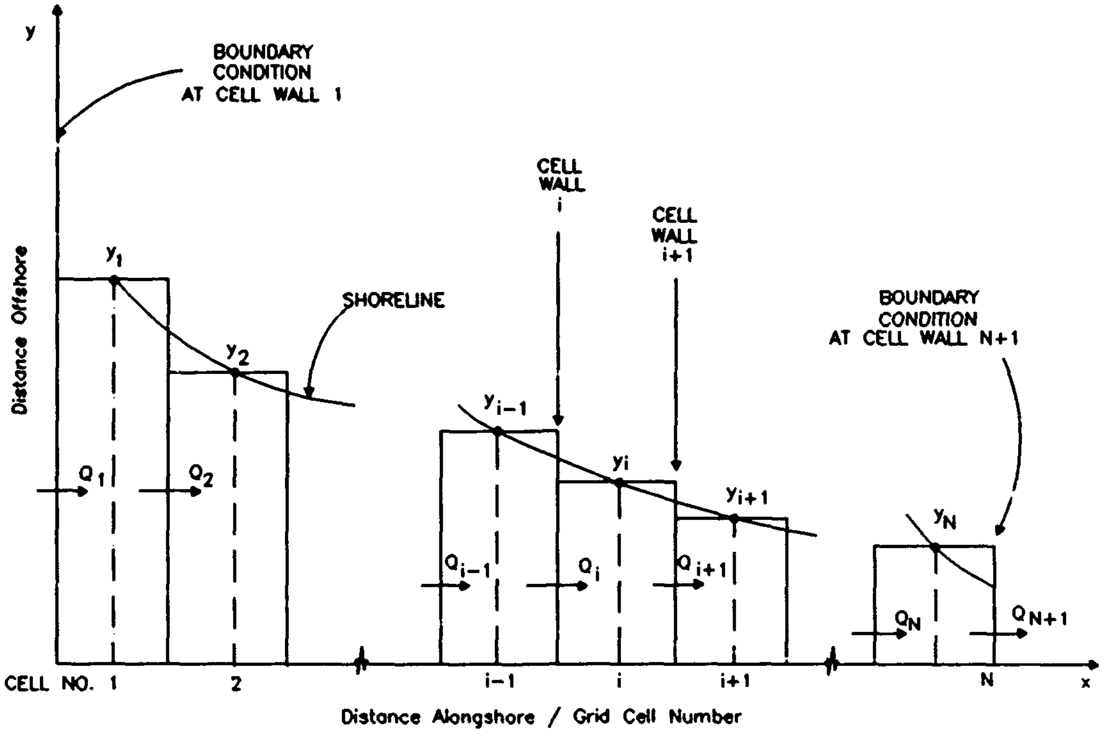


Figure 9. Finite difference staggered grid

positions on the interior of the grid depend directly upon them. The most ideal lateral boundaries are the terminal points of littoral cells, for example, long headlands or long jetties at entrances and inlets. On the other hand, engineering structures such as groins or seawalls may be present on the internal domain of the grid. These barriers interrupt the movement of sand alongshore and constrain the transport rate and/or movement of the shoreline. These constraints, which function similar to boundary conditions, must be incorporated in the simulation. In the following, commonly used boundary conditions are discussed.

Pinned-beach boundary condition

90. In the process of assembling data for running GENESIS, it is helpful to plot all available measured shoreline position surveys together to determine locations along a beach that might be used as model boundaries. In doing so it is sometimes possible to find a portion of the beach distant from the project that does not move appreciably in time. By locating the model

boundary at such a section, the modeled lateral boundary shoreline coordinate can be "pinned." Expressed in terms of the transport rate, this means,

$$Q_1 = Q_2 \tag{23}$$

if implemented on the left boundary, and

$$Q_{N+1} = Q_N \tag{24}$$

if implemented on the right boundary. These relations can be understood by reference to Equation 1; if $\Delta Q = 0$ at the boundary, then $\Delta y = 0$, indicating that y does not change. The pinned-beach boundary should be located far away from the project to assure that the conditions in the vicinity of the boundary are unaffected by changes that take place at the project.

Gated boundary condition

91. Groins, jetties, shore-connected breakwaters, and headlands that interrupt, partially or completely, the movement of sand alongshore may be incorporated as a boundary condition if one is located on an end of the calculation grid. If located on the internal domain of the grid, these objects will act to constrain the transport rate and shoreline change, automatically calculated by GENESIS. The representation is the same for both cases, although it occurs in different places in the numerical solution scheme.

92. The effect of a groin, headland, or similar object located on the boundary is formulated in terms of the amount of sand that can pass the structure. Consideration must be given to sand both entering and leaving the grid. For example, at a jetty located next to an inlet with a deeply dredged navigation channel, sand might leave the grid by bypassing the jetty during times of high waves; in contrast, no sand is expected to cross the navigation channel and jetty to come onto the grid. The jetty/channel thus acts as a selective "gate," allowing sand to move off but not onto the grid. This "gated boundary condition" was termed the "groin boundary condition" in previous descriptions of GENESIS.

93. Sand bypassing. In GENESIS, two types of sand movement past a structure are simulated: one around the seaward end of the structure, called bypassing, and the other through and over the structure, called sand transmission. Bypassing is assumed to take place if the water depth at the tip of the structure D_G is less than the depth of active longshore transport D_{LT}. Since the shape of the bottom profile is known (Equation 6), D_G is determined from knowledge of the distance between the tip of the structure and the location of the shoreline. However, because structures are located at grid cell walls between two calculated shoreline positions, this depth is not unique. In GENESIS the updrift depth is used.

94. To represent sand bypassing, a bypassing factor *BYP* is introduced, defined as,

$$BYP = 1 - \frac{D_G}{D_{LT}} , \qquad (D_G \le D_{LT}) \tag{25}$$

implying a uniform cross-shore distribution of the longshore sand transport rate. If $D_G \geq D_{LT}$, then $BYP = 0$. Values of *BYP* thus lie in the range $0 \le BYP \le 1$, with $BYP = 0$ signifying no bypassing, and $BYP = 1$ signifying that all sand can potentially pass the position of the structure. The value of *BYP* depends on the wave conditions at the given time-step, since D_{LT} is a function of the wave height and period (Equation 4).

95. Sand transmission. A permeability factor *PERM* is analogously introduced to describe sand transmission over, through, and landward of a shore-connected structure such as a groin. A high (relative to the mean water level), structurally tight groin that extends far landward so as to prevent landward sand bypassing is assigned the value $PERM = 0$, whereas a completely "transparent" structure is assigned the value $PERM = 1$. Values of *PERM* thus lie in the range of $0 \le PERM \le 1$ and must be specified through the judgment of the modeler based upon, for example, the structural characteristics of the groin (jetty, breakwater), its elevation, and the tidal range at the site. Aerial photographs are often helpful in estimating a structure's amount of void space (hence *PERM*) in relation to other structures on the model grid. The optimal value of *PERM* for each structure must then be determined in the process of model calibration.

96. With the values of BYP and $PERM$ determined, GENESIS calculates the total fraction F of sand passing over, around, or through a shore-connected structure as:

$$F = PERM(1 - BYP) + BYP \tag{26}$$

This fraction is calculated for each shore-connected (groin-type) structure defined on or at the boundaries of the grid.

Seawall

97. A seawall, or, in general, any shore-parallel nonerodible barrier such as a rocky cliff, imposes a constraint on the position of the shoreline because the shoreline cannot move landward of the wall. Hanson and Kraus (1985, 1986b) developed a procedure for calculating the position of the shoreline constrained by a seawall that is consistent with shoreline response modeling theory and has the following three properties:

a. The shoreline in front of a seawall cannot recede landward of the wall.

b. Sand volume is conserved.

c. The direction of longshore sand transport at the wall is the same as that of the potential local transport.

98. GENESIS first calculates longshore sand transport rates along the beach under the assumption that the calculated amount of sand is available for transport (the potential transport rate). At grid cells where the seawall constraint is violated, the shoreline position and the transport rate are adjusted. These quantities in neighboring cells are also adjusted, as necessary, to preserve sand volume and the direction of transport. The calculation procedure is complex, and the reader is referred to Hanson and Kraus (1986b) for full details. Flanking of the seawall is not possible since it would lead to a double-valued shoreline position at the same grid cell.

Beach Fill

99. Beach fill is a traditional and increasingly popular method of shore protection and flood control, and nourished beaches also have value for recreational, commercial, and environmental purposes. Fill is commonly placed

together with the building of coastal structures such as groin fields and detached breakwaters. GENESIS is capable of representing the behavior of fills under the following assumptions:

- a. The fill has the same median grain size as the native sand.
- b. The profile of the fill represented in the model has the equilibrium shape corresponding to its grain size.
- c. The berm height of the nourished beach is the same as the natural beach.

These assumptions are necessary because in GENESIS Version 2 the transport parameters, shape of the equilibrium beach profile, and berm height are considered constant for the entire beach being simulated.

100. Although beach fills are constructed with a certain cross-sectional area, after a certain time period, typically on the order of a few weeks to months, the fill will be redistributed by wave action to arrive at the equilibrium shape of the beach. As a shoreline response model, GENESIS interprets any added width of beach as conforming to the equilibrium shape. For implementation of fill in GENESIS, the modeler must compute the total added distance Y_{add} that the shoreline will be advanced. This distance is known since the total volume of the fill equals the product of the depth of closure plus berm height, alongshore length of the fill, and Y_{add}. The modeler must estimate if it is appropriate to remove a percentage of the total fill volume that may be lost in fines. Such material is believed to be carried offshore and out of the littoral system. GENESIS places the amount of Y_{add} on the beach in equal increments Δy of shoreline advance along the specified length of the project per time-step over the user-specified construction period of the fill. The amount Δy is added whether the waves are calm or active.

101. The input change in shoreline position can also be negative, resulting in shoreline recession instead of advance. This option is useful for describing sand mining. In this case, the shoreline cannot recede landward of a seawall.

Longshore Transport Rate: Practical Considerations

102. The empirical formula used to calculate the longshore sand transport rate in GENESIS is given by Equation 2. The transport rate is obtained

as a function of the waves and shoreline/contour orientation at each time-step and at each grid point, except at pinned-beach boundaries. In this section three important considerations are discussed that involve quantities composed of transport rates as calculated from Equation 2. The topics usually encountered in practical applications are:

a. Multiple transport rates as produced by multiple wave sources.

b. Derived transport rates (net and gross transport rates).

c. Effective threshold for longshore sand transport (calm and near-calm wave events).

The first two items are treated within GENESIS in combination with input file preparation (**START** and **WAVES**), and the third item is treated in wave data file preparation prior to running GENESIS (see Part III).

Multiple transport rates

103. Waves arriving at the shore are typically produced by several independent generating sources. Long-period swell waves were probably generated from distant storms, whereas the shorter period "chop" or sea waves were produced by local winds. Indeed, the Wave Information Study (WIS) hindcast provides information for both sea waves and swell. The modeler may have to deal with even more than two wave sources. For example, for the southern coast of California, three independent wave sources coexist during parts of the year: Northern Hemisphere swell, local sea waves, and the Southern Hemisphere swell, which arises from storms as far away as the Antarctic Ocean. The Southern Hemisphere swell occurs mainly in the interval from May through October and, in some years, may be the dominant transporting wave component along the coast of the southern California Bight.

104. The situation of multiple wave sources is handled through the assumption that each wave source gives rise to an independent longshore sand transport rate. GENESIS then calculates a total longshore sand transport rate at each grid point i by linear superposition. Let $Q_{i,m}$ be the transport rate at grid point i produced by source m, of which there are M wave sources. The total transport rate at i is,

$$Q_i = \sum_{m=1}^{M} Q_{i,m} \tag{27}$$

GENESIS uses this quantity to calculate shoreline change.

105. The **START** file requires specification of the number of wave sources (called "NWAVES" in the **START** file instead of M as above). The file holding wave data must similarly reflect this number by containing wave data in sequence for the M sources at each time-step. On the basis of this information, GENESIS calculates Q_i at each time-step, automatically accounting for the placement of beach fills, skipping over wave data for calm events, and performing other "book-keeping" tasks that depend on the time-step in combination with the number of wave sources. Each wave source increases computation time of the modeling system.

<u>Derived transport rates</u>

106. In shoreline change modeling, it is convenient to analyze longshore sand transport rates and shoreline change from the perspective of an observer standing on the beach looking toward the water. Two directions of transport can then be defined (SPM 1984, Chapter 4) as left moving, denoted by the subscripts ℓt, and right moving, denoted by the subscripts rt. The corresponding rates $Q_{\ell t}$ and Q_{rt} do not have a sign associated with them; i.e., they are intrinsically positive; information on transport direction or sign is contained in the subscripts. Use of these two rates is convenient for two reasons: first, the terminology is independent of the orientation of the coast and, therefore, provides uniformity and ready understanding independent of the coast; second, the awkwardness of dealing with the sign is eliminated. Two other very useful rates entering in engineering applications can be defined in terms of these basic quantities, the gross transport rate and the net transport rate.

107. The <u>gross transport rate</u> Q_g is defined as the sum of the transport to the right and to the left past a point (for example, grid cell i) on the shoreline in a given time period:

$$Q_g = Q_{rt} + Q_{lt} \tag{28}$$

Thus, the gross transport rate does not have a direction associated with it and is always positive. A navigation channel at a harbor or inlet and a catch basin adjacent to a jetty will trap sand arriving from either the left or the right. This quantity is estimated by computing the gross transport rate.

108. The net transport rate Q_n is the difference between the right- and left-moving transport past a point on the shoreline in a given time period and is defined as:

$$Q_n = Q_{rt} - Q_{lt} \tag{29}$$

The net rate is a vector sum of transport rates, being positive in the positive x-direction, and is the quantity needed to determine whether a section of coast will erode or accrete. The rates Q used by GENESIS to compute shoreline change through differences in transport rates alongshore are net rates.

Effective threshold for longshore transport

109. Inspection of Equation 2 describing the longshore sand transport rate shows that the first and dominant term has a dependence on breaking wave height and direction as,

$$Q \propto (H_b)^{5/2} \sin 2\theta_{bs} \tag{30}$$

because the wave group speed at breaking C_{gb} is proportional to $(H_b)^{1/2}$. Consider two breaking waves, one with height of 1 m and the other of 0.1 m, which have the same angle at breaking. By Equation 30, the 1-m wave will have a transport rate 300 times greater than the 0.1-m-high wave. Also, for the same wave period and deepwater direction, a higher wave will break at a larger angle, increasing the disparity in magnitudes of transport rates associated with high/low waves and large/small deepwater wave angles.

110. A coast open to the ocean experiences a range of wave conditions from calm to stormy. Because of the great amplification of the longshore transport rate through the wave height and, to a lesser extent, wave angle, it is reasonable to employ a cutoff or threshold to eliminate from the time series the wave conditions that have negligible transport rates and are not significant factors contributing to shoreline change.

111. Kraus, Hanson, and Larson (1988) introduced such a threshold to eliminate in an objective manner wave events expected to produce negligible longshore transport. In an example using hindcast wave data, they showed that

for a site on the Atlantic coast of the United States, as much as 86 percent of the waves could be considered as effectively calm, eliminating the necessity for performing the shoreline change calculation at the particular time-step in which the waves identified as effectively calm appeared in the time series.

112. The justification for the threshold criteria, first reported by Kraus and Dean (1987), is based on the results of field experiments performed on a medium sand beach. Complete descriptions of the experiments and listings of the data are given in CERC technical reports (Kraus, Gingerich, and Rosati 1989; Rosati, Gingerich, and Kraus 1990). An analysis of the total measured longshore sand transport rates showed a high correlation between the total volumetric longshore sand transport rate Q and a quantity R called the "longshore discharge parameter" (Kraus and Dean 1987), defined as,

$$R = VH_bX_b \tag{31}$$

where

V = mean speed of the longshore current, m/sec
H_b = significant breaking wave height, m
X_b = width of the surf zone (distance between shoreline and breaker line), m

Assuming a linear dependence exists between the immersed weight of sand transport I and R, the following regression equation plotted as the straight line in Figure 10 is obtained,

$$I = 2.7\,(R - R_c) \tag{32}$$

in which the intercept R_c = 3.9 m^3/sec is interpreted as a threshold value for significant longshore sand movement, and I is expressed in N/sec and R in m^3/sec. The quantity R_c is called "Rcrit," and a program for scanning wave data and applying the transport threshold concept is given in Part III. For Equation 32, the correlation coefficient squared was 0.76.

113. Equation 32 is valid for metric units. If American customary units are used, the empirical value of R_c = 3.9 m^3/sec should be changed to

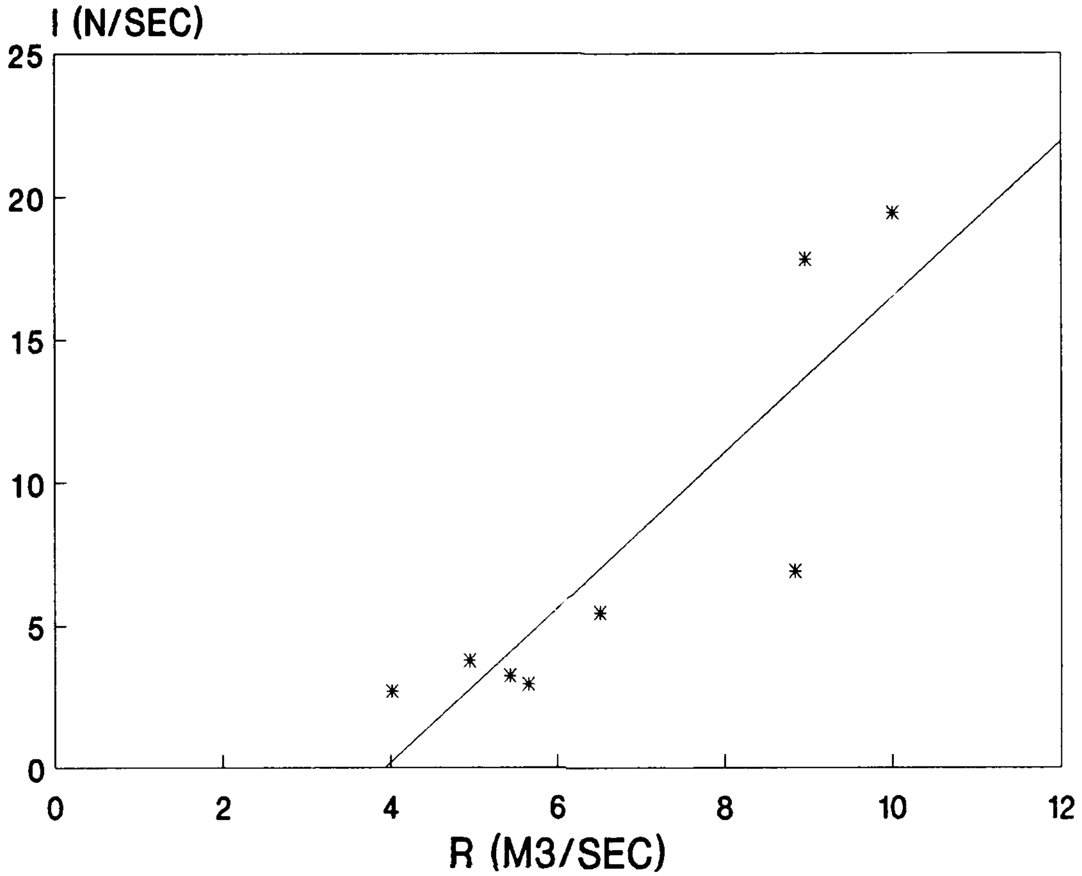


Figure 10. Determination of Rcrit

138 ft^3/sec. The value of R_c is expected to be revised as additional field data become available.

Simulation in a Grid Subsection

114. In some applications, it is desirable to perform simulations of the longshore sand transport rate and shoreline change for a subsection of a long reach that is being modeled and is already contained in the various input data files. Rather than revise the input files, GENESIS provides a convenient means of allowing the user to isolate a portion of the total grid and associated data through specification of starting and ending cells other than 1 and NN, respectively. This is done in the **START** file by specifying the cell on the left side of the subsection as *ISSTART* and the number of cells N to be included in the subsection.

115. It is cautioned that the starting cell (*ISSTART*) and the ending cell (*ISSTART* + *N*) of the subsection must be located in physically reasonable areas to produce meaningful boundary conditions. (Of course, in defining the subsection, the appropriate boundary conditions must be specified.) In almost all situations, lateral boundaries should be placed either at a long groin or jetty or at a historically stable section of coast. It is recommended that this option not be exercised until experience is gained in running *GENESIS*.

PART III: POTENTIAL TRANSPORT RATE ANALYSIS

Overview

116. In this chapter, two computer programs are introduced. Because these programs perform a distinct function and are not necessarily dependent on the output of other programs, they are presented as independent analysis functions. However, in Parts V and VI they will be embedded into complete wave data analysis procedures.

117. One of the programs, SEDTRAN, calculates potential longshore sand transport rates from an input time series of wave height, period, and direction. The other program, RCRIT, calculates the potential of an input wave height, period, and direction event for producing significant longshore sand transport. A summary description of the programs together with the input and output files involved is provided in Appendix A. A listing of the program source code for RCRIT and SEDTRAN may be found in Appendices B and C, respectively.

118. The programs presented in this chapter are not essential for operating GENESIS. However, if input wave data sets are analyzed using these program functions, much of the uncertainty associated with the outcome (in terms of the longshore sand transport rates) of a GENESIS study can be eliminated, and the modeler will achieve greater understanding of the properties of the input wave data. Furthermore, use of RCRIT will produce a significantly decreased execution time required for a given GENESIS simulation. The potential longshore sand transport rate program SEDTRAN was developed to enable the shoreline modeler to estimate both a regional and local or project-reach potential sediment budget prior to running the shoreline change modeling system.

119. Throughout this chapter, it is assumed that a computer file containing a time series of wave height, period, and direction is available and resides in the default directory. It is also assumed that an executable version of the program being discussed is available in either the default directory or the PATH specified in the **AUTOEXEC.BAT** file. The programs RCRIT and SEDTRAN as listed in Appendices B and C have been structured to read files created by one of the following Corps of Engineers data retrieval systems:

a. Coastal Engineering Data Retrieval System (CEDRS).*

b. Sea-State Engineering Analysis System (SEAS) (McAneny 1986).

However, a time series of wave height, period, and direction from any source may be used if the "READ DATA" portion of the programs is modified to read the data in the appropriate format. An example of this option is given.

RCRIT

Introduction

120. The simulation of shoreline evolution using the numerical modeling system GENESIS requires as input a time series of wave conditions that were either hindcast or measured with a directional wave gage. These time series often contain calm events (wave height, period, and direction for a given time-step) or events that may otherwise be physically irrelevant to the analysis and are expected to produce effectively negligible longshore transport. The purpose of RCRIT is to:

a. Evaluate each event in the input time series for its potential to produce a longshore transport rate in excess of a critical transport rate and to flag these events (in the output time series) in such a way that the shoreline evolution model will skip the time-step and continue the simulation.

b. Flag calm wave events in the time series.

c. Flag offshore-traveling wave events in the time series.

121. The result of such preprocessing of the input wave time series can produce a significant reduction in execution time for a given simulation. Figure 11 shows the required input and calculated output of the program RCRIT. The empirical and theoretical background underlying item a above is contained in Part II.

Calculation procedure

122. In the program RCRIT, an input significant wave height, period, angle, and water depth are required to calculate the discharge parameter R (Equation 31). This quantity is then compared with the critical discharge R_c

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* D. S. McAneny and D. L. Jones, "Coastal Engineering Data Retrieval System (CEDRS), Jacksonville District, Regions 1 and 2, Florida Coastline," unpublished report, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

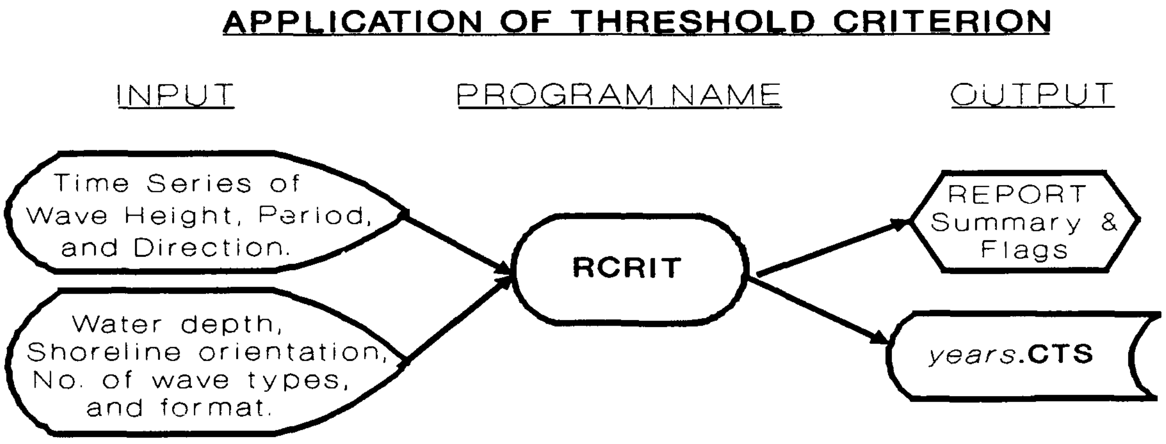


Figure 11. Threshold for longshore sand transport (RCRIT)

(taken as 3.9 m^3/sec). If the calculated discharge parameter is greater than the critical discharge, then the wave event is written to the output time series file, and the next wave event is processed. If the calculated discharge is less than the critical discharge, a new event with a negative period is written to the output time series. In addition, the input wave event is written to another output file called the report file. When the end of the input time series is reached (i.e., all input wave events were processed), summary information including the number of wave events processed and the number of wave events eliminated from the time series is written to the report file.

123. The calculation flow in RCRIT is as follows:

a. Read input file header.

b. Read wave event from input time series.

c. Determine if event is calm or if wave is propagating offshore.

d. If wave event is calm or if wave is propagating offshore, (1) write flagged wave event to output time series, and (2) write wave event to report output file. Go to step b.

e. Calculate the breaking wave height and angle with respect to the local shoreline orientation or the general orientation of the project reach (the baseline orientation). The assumption of straight and parallel bottom contours is employed together with Snell's Law and the concept of conservation of wave energy flux directed onshore.

f. Calculate the longshore discharge parameter R using Equation 31.

g. Evaluate $R \geq R_c$.

h. Write wave event to output time series (flag if $R < R_c$).

i. Write wave event to report output file if $R < R_c$.

j. Repeat steps b through g until end of input file is reached.

k. Write summary information to report file.

Example applications

124. The utility of RCRIT will now be demonstrated through three example applications using three different input time series. The input time series are listed in Figures 12, 16, and 19. These time series were obtained from three different sources as follows: SEAS (Figure 12), CEDRS (Figure 16), and processed wave gage data from a slope array gage in southern California (Figure 19).

125. Example 1. In this example, wave data as retrieved from the WIS data base using SEAS are input to the program RCRIT. The data in Figure 12 are assumed to exist in the default directory in a file named *WVSEAS.DAT*. This file name is entered when the program prompts the user for the input file name. This file must exist (it represents the input) either in the default directory or in the directory path specified when the file name was entered; if not, the program will terminate.

126. The program then prompts for the output file name; in this example, the output file name *SEASOUT* is entered. This file must not already exist in the working directory; if it is found in the directory, the program will terminate. This procedure precludes unintentional overwriting of an already processed time series. Note that the output file extension is not requested and should not be entered. The program will assign the extension .CTS to all output time series. This naming convention was developed to help the user keep track of the multitude of computer files that are generated in the course of performing a shoreline change study. In summary, any file with a .CTS extension represents a time series that has been processed by RCRIT.

127. The next prompt issued by the program requests the user to define the input data format. The available options are: (1) SEAS, (2) OUTPUT FROM ANOTHER WORKBOOK CODE (Header and Format similar to SEAS), (3) CEDRS, (4) OUTPUT FROM ANOTHER WORKBOOK CODE (Header and Format similar to CEDRS), and (5) other. In the present example, the input time series was retrieved using SEAS, so the value *1* is entered. The other options are discussed as they are encountered.

```
  A2028     48
62030500  40  3 341   0  0   0        62030800 398  7  27 535 13  74
62030503  40  3  25   0  0   0        62030803 340  7  24 550 13  73
62030506  48  3  68   0  0   0        62030806 309  7  25 532 13  73
62030509  66  4  48   0  0   0        62030809 293  7  24 494 13  71
62030512  88  4  28   0  0   0        62030812 286  7  24 443 13  71
62030515  89  4  46   0  0   0        62030815 287  7  24 397 13  69
62030518  89  4  65   0  0   0        62030818 254  6  22 385 13  67
62030521 132  5  70   0  0   0        62030821 234  6  28 356 12  67
62030600 201  6  76   0  0   0        62030900 212  6  33 326 12  67
62030603 295  7  69   0  0   0        62030903 263  7  44 255 11  69
62030606 424  8  69   0  0   0        62030906 157  5  42 253 11  68
62030609 427  9  71   0  0   0        62030909 134  5  66 216 10  70
62030612 398  8  71   0  0   0        62030912 101  4  90 189 10  72
62030615 428  8  73   0  0   0        62030915 115  5  83 165 10  74
62030618 447  9  73 262 10  68        62030918 131  5  77 146 10  76
62030621 743  9  44   0  0   0        62030921 101  4  66 133  9  77
62030700 375  7  26 652 12  71        62031000  76  4  56 125  8  78
62030703 344  7  25 653 13  74        62031003 152  4  45   0  0   0
62030706 325  7  25 624 13  77        62031006 165  5  34   0  0   0
62030709 390  7  27 607 13  78        62031009 151  4  24   0  0   0
62030712 432  7  27 619 13  77        62031012 137  4  13   0  0   0
62030715 426  7  27 610 13  77        62031015 140  4 359   0  0   0
62030718 416  7  27 584 13  76        62031018 145  5 345   0  0   0
62030721 404  7  27 548 13  75        62031021 142  5 356   0  0   0
```

Figure 12. Time series of wave conditions from SEAS

128. The next prompt issued by the program requests the user to define the input time series data type; the options available are (1) Phase I, (2) Phase II, and (3) Phase III. These data types refer to the three phases of the WIS wave data hindcasts and are described in Corson et al. (1982) and briefly in Part V. In this example, the input time series was extracted from the WIS data base using SEAS for Phase II Station 28, so the value *2* is entered.

129. Next, the program prompts for the water depth associated with the input time series (except if Phase I data are specified, because Phase I pertains to deep water). If Phase II data are specified and the station is not in the Gulf of Mexico, the deepwater condition also applies, whereas if the station is in the Gulf of Mexico, there is a depth associated with the station (see Hubertz and Brooks 1989). If the deepwater condition applies (as in this example), enter the value *-999*; otherwise, enter the water depth at the specific hindcast station. The depth should be a positive value and should be given in centimeters for format Types 1 and 2 and in meters for format Types 3 and 4.

130. The last prompt issued by the program before the computation begins is a request for the user to enter the shoreline orientation in degrees measured clockwise from north. In this example, a shoreline orientation of 54 deg was entered (corresponding to WIS Phase III Station 61). Figure 13 provides a schematic illustration of the shoreline orientation coordinate system. This particular coordinate system is identical to the one used by WIS in the Phase III hindcasts (Jensen 1983a; Jensen, Hubertz, and Payne 1989).

131. The contents of the output files **REPORT.RC** and **SEASOUT.CTS** are provided in Figures 14 and 15, respectively. The file **REPORT.RC** is a summary information file and will be overwritten each time the program is executed. Consequently, if the user wishes to save this information, the file must be

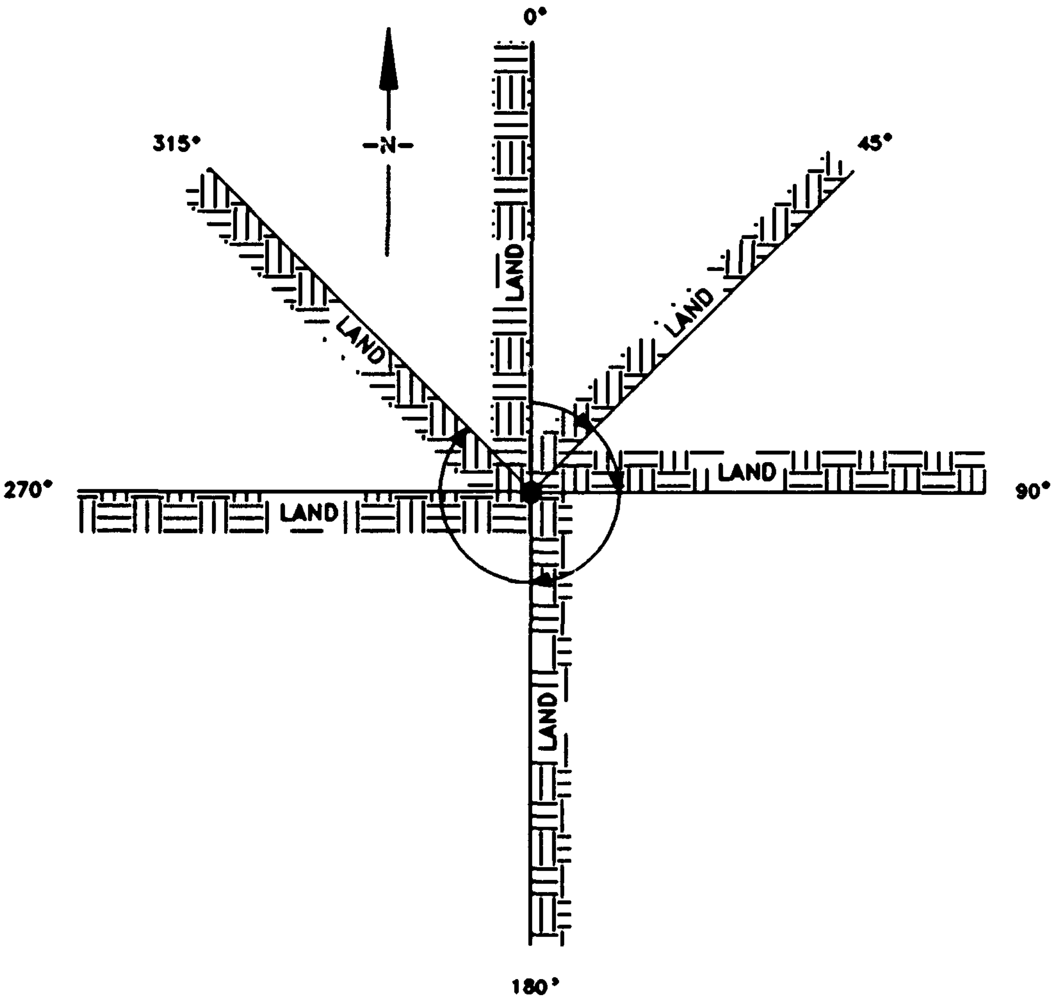


Figure 13. Schematic representation of the shoreline orientation

```
 Summary of wave events eliminated from the input time series.

WAVE       ELIMINATION
 TYPE          FLAG             DATE      HEIGHT  PERIOD  DIRECTION
--------------------------------------------------------------------
  sea    offshore traveling  62030500    40.0     3.0      341.0
 swell          calm         62030500     0.0     0.0        0.0
  sea    offshore traveling  62030503    40.0     3.0       25.0
 swell          calm         62030503     0.0     0.0        0.0
  sea     below threshold    62030506    48.0     3.0       68.0
 swell          calm         62030506     0.0     0.0        0.0
  sea    offshore traveling  62030509    66.0     4.0       48.0
 swell          calm         62030509     0.0     0.0        0.0
  sea    offshore traveling  62030512    88.0     4.0       28.0
 swell          calm         62030512     0.0     0.0        0.0
  sea    offshore traveling  62030515    89.0     4.0       46.0
 swell          calm         62030515     0.0     0.0        0.0
 swell          calm         62030518     0.0     0.0        0.0
 swell          calm         62030521     0.0     0.0        0.0
 swell          calm         62030600     0.0     0.0        0.0
 swell          calm         62030603     0.0     0.0        0.0
 swell          calm         62030606     0.0     0.0        0.0
 swell          calm         62030609     0.0     0.0        0.0
 swell          calm         62030612     0.0     0.0        0.0
 swell          calm         62030615     0.0     0.0        0.0
  sea    offshore traveling  62030621   743.0     9.0       44.0
 swell          calm         62030621     0.0     0.0        0.0
  sea    offshore traveling  62030700   375.0     7.0       26.0
  sea    offshore traveling  62030703   344.0     7.0       25.0
  sea    offshore traveling  62030706   325.0     7.0       25.0
  sea    offshore traveling  62030709   390.0     7.0       27.0
  sea    offshore traveling  62030712   432.0     7.0       27.0
  sea    offshore traveling  62030715   426.0     7.0       27.0
  sea    offshore traveling  62030718   416.0     7.0       27.0
  sea    offshore traveling  62030721   404.0     7.0       27.0
  sea    offshore traveling  62030800   398.0     7.0       27.0
  sea    offshore traveling  62030803   340.0     7.0       24.0
  sea    offshore traveling  62030806   309.0     7.0       25.0
  sea    offshore traveling  62030809   293.0     7.0       24.0
  sea    offshore traveling  62030812   286.0     7.0       24.0
  sea    offshore traveling  62030815   287.0     7.0       24.0
  sea    offshore traveling  62030818   254.0     6.0       22.0
  sea    offshore traveling  62030821   234.0     6.0       28.0
  sea    offshore traveling  62030900   212.0     6.0       33.0
  sea    offshore traveling  62030903   263.0     7.0       44.0
  sea    offshore traveling  62030906   157.0     5.0       42.0
  sea     below threshold    62031000    76.0     4.0       56.0
  sea    offshore traveling  62031003   152.0     4.0       45.0
 swell          calm         62031003     0.0     0.0        0.0
  sea    offshore traveling  62031006   165.0     5.0       34.0
 swell          calm         62031006     0.0     0.0        0.0
```

Figure 14. Example 1: Output file **REPORT.RC** (Continued)

```
  sea   offshore traveling 62031009   151.0     4.0     24.0
swell         calm         62031009     0.0     0.0      0.0
  sea   offshore traveling 62031012   137.0     4.0     13.0
swell         calm         62031012     0.0     0.0      0.0
  sea   offshore traveling 62031015   140.0     4.0    359.0
swell         calm         62031015     0.0     0.0      0.0
  sea   offshore traveling 62031018   145.0     5.0    345.0
swell         calm         62031018     0.0     0.0      0.0
  sea   offshore traveling 62031021   142.0     5.0    356.0
swell         calm         62031021     0.0     0.0      0.0

************  Summary of Operations  ************

     A total of 48 records was processed

      0 Sea events were flagged as calm
     32 Sea events were flagged as offshore traveling
      2 Sea events were flagged as below threshold
     14 Sea events exceeded the threshold criterion

     22 Swell events were flagged as calm
      0 Swell events were flagged as offshore traveling
      0 Swell events were flagged as below threshold
     26 Swell events exceeded the threshold criterion
```

Figure 14. (Concluded)

renamed. It is suggested that the extension .RC be preserved in the new file name for organizational purposes.

132. As shown in Figure 14, the output file **REPORT.RC** contains a listing of the wave events that were flagged together with the elimination code (the reason they were flagged), the event type (sea or swell), and the date and hour of the event. The output units are the same as those in the original input time series. In this case, wave heights were read in centimeters, periods in seconds, and angles in degrees. At the end of the output file **REPORT.RC**, summary information is given including the total number of records processed, calm events encountered, offshore-traveling wave events, events that fell below the threshold criterion for significant longshore sand transport, and events that exceeded the threshold criterion. This information is given for both sea and swell wave conditions if both appear in the time series.

133. The output time series is written to the file **SEASOUT.CTS** (Figure 15). This file name (without the file name extension) was specified by the user at run time. The file contains wave conditions for each event in the

```
                A2028                          48
62030500        0.0    -99.9     0.0          0.0    -99.9      0.0
62030503        0.0    -99.9     0.0          0.0    -99.9      0.0
62030506        0.0    -99.9     0.0          0.0    -99.9      0.0
62030509        0.0    -99.9     0.0          0.0    -99.9      0.0
62030512        0.0    -99.9     0.0          0.0    -99.9      0.0
62030515        0.0    -99.9     0.0          0.0    -99.9      0.0
62030518       89.0      4.0    65.0          0.0    -99.9      0.0
62030521      132.0      5.0    70.0          0.0    -99.9      0.0
62030600      201.0      6.0    76.0          0.0    -99.9      0.0
62030603      295.0      7.0    69.0          0.0    -99.9      0.0
62030606      424.0      8.0    69.0          0.0    -99.9      0.0
62030609      427.0      9.0    71.0          0.0    -99.9      0.0
62030612      398.0      8.0    71.0          0.0    -99.9      0.0
62030615      428.0      8.0    73.0          0.0    -99.9      0.0
62030618      447.0      9.0    73.0        262.0     10.0     68.0
62030621        0.0    -99.9     0.0          0.0    -99.9      0.0
62030700        0.0    -99.9     0.0        652.0     12.0     71.0
62030703        0.0    -99.9     0.0        653.0     13.0     74.0
62030706        0.0    -99.9     0.0        624.0     13.0     77.0
62030709        0.0    -99.9     0.0        607.0     13.0     78.0
62030712        0.0    -99.9     0.0        619.0     13.0     77.0
62030715        0.0    -99.9     0.0        610.0     13.0     77.0
62030718        0.0    -99.9     0.0        584.0     13.0     76.0
62030721        0.0    -99.9     0.0        548.0     13.0     75.0
62030800        0.0    -99.9     0.0        535.0     13.0     74.0
62030803        0.0    -99.9     0.0        550.0     13.0     73.0
62030806        0.0    -99.9     0.0        532.0     13.0     73.0
62030809        0.0    -99.9     0.0        494.0     13.0     71.0
62030812        0.0    -99.9     0.0        443.0     13.0     71.0
62030815        0.0    -99.9     0.0        397.0     13.0     69.0
62030818        0.0    -99.9     0.0        385.0     13.0     67.0
62030821        0.0    -99.9     0.0        356.0     12.0     67.0
62030900        0.0    -99.9     0.0        326.0     12.0     67.0
62030903        0.0    -99.9     0.0        255.0     11.0     69.0
62030906        0.0    -99.9     0.0        253.0     11.0     68.0
62030909      134.0      5.0    66.0        216.0     10.0     70.0
62030912      101.0      4.0    90.0        189.0     10.0     72.0
62030915      115.0      5.0    83.0        165.0     10.0     74.0
62030918      131.0      5.0    77.0        146.0     10.0     76.0
62030921      101.0      4.0    66.0        133.0      9.0     77.0
62031000        0.0    -99.9     0.0        125.0      8.0     78.0
62031003        0.0    -99.9     0.0          0.0    -99.9      0.0
62031006        0.0    -99.9     0.0          0.0    -99.9      0.0
62031009        0.0    -99.9     0.0          0.0    -99.9      0.0
62031012        0.0    -99.9     0.0          0.0    -99.9      0.0
62031015        0.0    -99.9     0.0          0.0    -99.9      0.0
62031018        0.0    -99.9     0.0          0.0    -99.9      0.0
62031021        0.0    -99.9     0.0          0.0    -99.9      0.0
```

Figure 15. Example 1: Output file **SEASOUT.CTS**

input time series; however, events that were calm, propagating offshore, or fell below the threshold for significant longshore sand transport were assigned a height and angle of 0 and a period of -99. These wave conditions will hereafter signify calm conditions in future computations that use this file as input, and GENESIS will skip them. The wave events that exceed the threshold criterion for significant longshore sand transport are written in the same units as those in the original input time series.

134. Example 2. In this example, a wave data set as retrieved from the WIS data base using CEDRS is input to the program RCRIT. Figure 16 lists the file *WVCEDRS.DAT* that is assumed to exist in the default directory. This file name is entered when the program prompts the user for the input file name. Note that the CEDRS time series differs from the SEAS time series (Figure 12) in that three wave events and the local wind speed and direction are contained in each record. The first two wave events are identical to those that would have been retrieved if the SEAS system had been used and represent sea and swell wave conditions. The third wave event represents combined wave conditions where the height is given as the square root of the sum of the squares of the sea and swell significant wave heights, and the wave period and direction correspond to the higher wave (e.g., if the wave height of the sea is larger, then the sea period and direction are given). The last two columns of data in the CEDRS time series file are the local wind speed (in knots) and direction (in degrees azimuth). The right-hand five columns of data in the CEDRS time series are not required in the analysis procedures presented here and are not discussed further or repeated in subsequent output files.

135. The output file name in this example is specified as *CEDRSOUT*. The input data were obtained using CEDRS, so the value *3* is entered at the input data format prompt. The input time series data type is specified as Phase II (the value *2* is entered at the data type prompt), because the time series was retrieved from the CEDRS data base for Atlantic coast WIS Phase II Station 59.

136. The value *-999* is entered at the depth prompt because the deep-water condition applies to WIS Atlantic coast Phase II stations. The shoreline orientation is specified as *348* deg (corresponding to WIS Phase III Station 136). The program then performs the prescribed computations and terminates.

```
WIS               A2059    62010100  62010621    30.26  80.98
62010100  0.4  3.0 142.  0.0  0.0    0.  0.4  3.0 142. 12 132
62010103  0.9  4.0 149.  0.0  0.0    0.  0.9  4.0 149. 18 140
62010106  1.3  5.0 155.  0.0  0.0    0.  1.3  5.0 155. 24 148
62010109  1.9  6.0 214.  0.0  0.0    0.  1.9  6.0 214. 26 173
62010112  1.9  6.0 274.  0.4  6.0 257.  1.9  6.0 274. 27 199
62010115  1.9  6.0 277.  0.4  6.0 258.  1.9  6.0 277. 28 216
62010118  1.9  6.0 280.  0.5  6.0 259.  2.0  6.0 280. 29 233
62010121  1.9  6.0 297.  0.5  7.0 144.  2.0  6.0 297. 29 264
62010200  1.9  6.0 314.  0.5  7.0 145.  2.0  6.0 314. 28 294
62010203  1.9  6.0  40.  0.5  7.0 145.  2.0  6.0  40. 29 279
62010206  2.6  7.0 126.  0.0  0.0    0.  2.6  7.0 126. 29 264
62010209  3.8  7.0 164.  0.0  0.0    0.  3.8  7.0 164. 28 274
62010212  2.8  7.0 213.  0.0  0.0    0.  2.8  7.0 213. 26 284
62010215  1.6  5.0 302.  1.8  7.0 128.  2.4  7.0 128. 24 296
62010218  1.5  5.0 314.  1.4  8.0 128.  2.1  5.0 314. 22 308
62010221  1.5  5.0 308.  1.3  8.0 124.  2.0  5.0 308. 22 313
62010300  1.5  5.0 303.  1.2  8.0 123.  1.9  5.0 303. 22 317
62010303  1.6  5.0 300.  1.1  8.0 123.  1.9  5.0 300. 23 314
62010306  1.7  5.0 297.  1.1  8.0 122.  2.0  5.0 297. 23 310
62010309  1.3  5.0 300.  1.0  8.0 122.  1.6  5.0 300. 19 307
62010312  0.8  4.0 303.  1.0  8.0 122.  1.3  8.0 122. 15 304
62010315  1.0  4.0 291.  1.0  8.0 122.  1.4  8 0 122. 14 294
62010318  1.2  5.0 280.  0.9  8.0 122.  1.5  5.0 280. 13 285
62010321  0.8  4.0 268.  0.9  8.0 122.  1.2  8.0 122. 12 274
62010400  0.5  3.0 257.  0.9  8.0 122.  1.0  8.0 122. 11 263
62010403  0.6  3.0 251.  0.9  8.0 122.  1.1  8.0 122. 13 257
62010406  0.7  4.0 245.  0.9  8.0 122.  1.1  8.0 122. 14 250
62010409  0.4  3.0 256.  0.9  8.0 122.  1.0  8.0 122. 12 255
62010412  0.3  2.0 267.  0.9  8.0 122.  0.9  8.0 122.  9 260
62010415  0.2  2.0 217.  0.9  8.0 122.  0.9  8.0 122. 10 221
62010418  0.2  2.0 166.  0.9  8.0 122.  0.9  8.0 122. 10 182
62010421  0.2  2.0 149.  0.8  8.0 122.  0.8  8.0 122. 10 159
62010500  0.4  3.0 131.  0.8  8.0 122.  0.9  8.0 122.  9 136
62010503  0.6  4.0 125.  0.8  8.0 123.  1.0  8.0 123. 11 130
62010506  0.8  4.0 120.  0.8  8.0 123.  1.1  8.0 123. 14 124
62010509  0.6  4.0 120.  0.8  8.0 123.  1.0  8.0 123. 11 124
62010512  0.4  3.0 120.  0.8  8.0 123.  0.9  8.0 123.  8 124
62010515  0.5  3.0 122.  0.8  8.0 123.  0.9  8.0 123. 13 126
62010518  0.8  4.0 126.  0.8  8.0 123.  1.1  8.0 123. 17 128
62010521  1.2  5.0 134.  0.8  8.0 123.  1.4  5.0 134. 20 134
62010600  1.6  5.0 142.  0.8  8.0 123.  1.8  5.0 142. 23 139
62010603  1.9  6.0 154.  1.0  8.0 123.  2.1  6.0 154. 23 155
62010606  1.7  6.0 166.  1.3  7.0 125.  2.1  6.0 166. 23 170
62010609  1.9  6.0 174.  1.2  8.0 124.  2.2  6.0 174. 23 174
62010612  2.6  7.0 183.  0.0  0.0    0.  2.6  7.0 183. 23 179
62010615  3.0  7.0 203.  0.0  0.0    0.  3.0  7.0 203. 26 193
62010618  3.1  7.0 223.  0.0  0.0    0.  3.1  7.0 223. 29 207
62010621  1.8  6.0 240.  1.3  7.0 129.  2.2  6.0 240. 30 215
```

Figure 16. Time series of wave conditions from CEDRS

137. The contents of the output files **REPORT.RC** and **CEDRSOUT.CTS** for this example are listed in Figures 17 and 18, respectively. The comments previously made for Example 1 concerning the output files apply also to these files.

138. Example 3. In this example, a time series from a wave gage is input to the program RCRIT. The purpose of this example is to demonstrate how to modify the source code for RCRIT (**RCRIT.FOR**) in order to use RCRIT with wave gage data that may be available. The first step is to obtain a time series of significant wave height, period, and direction. Gages do not typically output these quantities directly, but these data are available after postprocessing of the actual gage measurements. In this example, it is assumed that such a time series has been obtained, and the wave gage data are as shown in Figure 19. Each record in the wave gage time series has seven fields of data; the first field is the year, the second is the month, the third is the day, the fourth is the hour, the fifth is the wave height in centimeters, the sixth is the wave period in seconds, and the seventh is the wave angle representing the direction of wave propagation measured clockwise from north.

139. At this point the user may take one of two paths, both of which will (or should) lead to the same end. One alternative would be to write a program that converts the wave gage time series to either the SEAS or the CEDRS format. The other alternative is to modify the program RCRIT to read the wave gage time series. This second alternative will be demonstrated here.

140. Before making any changes to the file (**RCRIT.FOR**), the user is strongly recommended to copy **RCRIT.FOR** to another file name such as **RCRITWVG.FOR** (where the letters "**WVG**" denote that the program has been customized to read the user's specialized wave gage time series). In **RCRIT.FOR** there are five comment blocks that denote areas where modifications must be made. These comment blocks and the pertinent lines of FORTRAN code are listed in Figure 20.

141. The header information for the wave gage data shown in Figure 19 contains a station identification number, the number of records in the file, and the water depth in meters. These data together with the number of events per record, the conversion factor for length, and the shoreline orientation must be read and assigned to the appropriate variables as stated in the

```
Summary of wave events eliminated from the input time series.

 WAVE        ELIMINATION
 TYPE           FLAG           DATE      HEIGHT  PERIOD  DIRECTION
-------------------------------------------------------------------
  sea     below threshold   62010100      0.4      3.0      142.0
 swell         calm         62010100      0.0      0.0        0.0
 swell         calm         62010103      0.0      0.0        0.0
 swell         calm         62010106      0.0      0.0        0.0
  sea   offshore traveling  62010109      1.9      6.0      214.0
 swell         calm         62010109      0.0      0.0        0.0
  sea   offshore traveling  62010112      1.9      6.0      274.0
 swell  offshore traveling  62010112      0.4      6.0      257.0
  sea   offshore traveling  62010115      1.9      6.0      277.0
 swell  offshore traveling  62010115      0.4      6.0      258.0
  sea   offshore traveling  62010118      1.9      6.0      280.0
 swell  offshore traveling  62010118      0.5      6.0      259.0
  sea   offshore traveling  62010121      1.9      6.0      297.0
  sea   offshore traveling  62010200      1.9      6.0      314.0
 swell         calm         62010206      0.0      0.0        0.0
 swell         calm         62010209      0.0      0.0        0.0
  sea   offshore traveling  62010212      2.8      7.0      213.0
 swell         calm         62010212      0.0      0.0        0.0
  sea   offshore traveling  62010215      1.6      5.0      302.0
  sea   offshore traveling  62010218      1.5      5.0      314.0
  sea   offshore traveling  62010221      1.5      5.0      308.0
  sea   offshore traveling  62010300      1.5      5.0      303.0
  sea   offshore traveling  62010303      1.6      5.0      300.0
  sea   offshore traveling  62010306      1.7      5.0      297.0
  sea   offshore traveling  62010309      1.3      5.0      300.0
  sea   offshore traveling  62010312      0.8      4.0      303.0
  sea   offshore traveling  62010315      1.0      4.0      291.0
  sea   offshore traveling  62010318      1.2      5.0      280.0
  sea   offshore traveling  62010321      0.8      4.0      268.0
  sea   offshore traveling  62010400      0.5      3.0      257.0
  sea   offshore traveling  62010403      0.6      3.0      251.0
  sea   offshore traveling  62010406      0.7      4.0      245.0
  sea   offshore traveling  62010409      0.4      3.0      256.0
  sea   offshore traveling  62010412      0.3      2.0      267.0
  sea   offshore traveling  62010415      0.2      2.0      217.0
  sea     below threshold   62010418      0.2      2.0      166.0
  sea     below threshold   62010421      0.2      2.0      149.0
  sea   offshore traveling  62010609      1.9      6.0      174.0
  sea   offshore traveling  62010612      2.6      7.0      183.0
 swell         calm         62010612      0.0      0.0        0.0
  sea   offshore traveling  62010615      3.0      7.0      203.0
 swell         calm         62010615      0.0      0.0        0.0
  sea   offshore traveling  62010618      3.1      7.0      223.0
 swell         calm         62010618      0.0      0.0        0.0
  sea   offshore traveling  62010621      1.8      6.0      240.0
```

Figure 17. Example 2: Output file **REPORT.RC** (Continued)

```
************  Summary of Operations  ************

    A total of 48 records was processed

    0 Sea events were flagged as calm
   29 Sea events were flagged as offshore traveling
    3 Sea events were flagged as below threshold
   16 Sea events exceeded the threshold criteria
   10 Swell events were flagged as calm
    3 Swell events were flagged as offshore traveling
    0 Swell events were flagged as below threshold
   35 Swell events exceeded the threshold criteria
```

Figure 17. (Concluded)

comment block shown under the heading Area 1 in Figure 20. Figure 21 shows one way of accomplishing this task.

142. Several conventions appearing in the code presented in Figure 21 should be noted. First, the depth is given in meters, whereas the wave heights are given in centimeters. To eliminate unit mismatch, the variable *DEPTH* is immediately converted to centimeters. Second, because there is only one wave event per record, the variable *NEPR* is set equal to one. A prompt could have been issued for this quantity, but it is unlikely that the number of events per record would change for a given wave gage, so the variable is simply assigned. The length conversion factor variable *CONVLEN* is set equal to 0.01 to convert length measures from centimeters to meters. A prompt is issued for the shoreline orientation variable *SHOANG* to easily allow investigation of multiple shoreline orientations that may exist within the coastal area of interest.

143. The next section of code (Area 2 in Figure 20) that must be modified performs the operation of reading each record of data in the time series. In this particular time series, each record consists of the year, month, day, time of day, and the wave height, period, and direction. Figure 22 shows one way of accomplishing this task.

144. In this section the date is read into four temporary variables: *IYR* (year), *IMON* (month), *IDAY* (day), and *IHR* (time of day). Then these variables are packed into the variable *IDATE* in the same format used by the SEAS and CEDRS data bases. This identical packing is done because it is desirable to have the final output in either a SEAS- or CEDRS-type format. This format will eliminate the requirement of modifying every code presented in this workbook, saving labor and reducing opportunities for error.

```
WIS             A2059    62010100  62010626    30.26  80.98
62010100        0.0   -99.9     0.0       0.0   -99.9     0.0
62010103        0.9     4.0   149.0       0.0   -99.9     0.0
62010106        1.3     5.0   155.0       0.0   -99.9     0.0
62010109        0.0   -99.9     0.0       0.0   -99.9     0.0
62010112        0.0   -99.9     0.0       0.0   -99.9     0.0
62010115        0.0   -99.9     0.0       0.0   -99.9     0.0
62010118        0.0   -99.9     0.0       0.0   -99.9     0.0
62010121        0.0   -99.9     0.0       0.5     7.0   144.0
62010200        0.0   -99.9     0.0       0.5     7.0   145.0
62010203        1.9     6.0    40.0       0.5     7.0   145.0
62010206        2.6     7.0   126.0       0.0   -99.9     0.0
62010209        3.8     7.0   164.0       0.0   -99.9     0.0
62010212        0.0   -99.9     0.0       0.0   -99.9     0.0
62010215        0.0   -99.9     0.0       1.8     7.0   128.0
62010218        0.0   -99.9     0.0       1.4     8.0   128.0
62010221        0.0   -99.9     0.0       1.3     8.0   124.0
62010300        0.0   -99.9     0.0       1.2     8.0   123.0
62010303        0.0   -99.9     0.0       1.1     8.0   123.0
62010306        0.0   -99.9     0.0       1.1     8.0   122.0
62010309        0.0   -99.9     0.0       1.0     8.0   122.0
62010312        0.0   -99.9     0.0       1.0     8.0   122.0
62010315        0.0   -99.9     0.0       1.0     8.0   122.0
62010318        0.0   -99.9     0.0       0.9     8.0   122.0
62010321        0.0   -99.9     0.0       0.9     8.0   122.0
62010400        0.0   -99.9     0.0       0.9     8.0   122.0
62010403        0.0   -99.9     0.0       0.9     8.0   122.0
62010406        0.0   -99.9     0.0       0.9     8.0   122.0
62010409        0.0   -99.9     0.0       0.9     8.0   122.0
62010412        0.0   -99.9     0.0       0.9     8.0   122.0
62010415        0.0   -99.9     0.0       0.9     8.0   122.0
62010418        0.0   -99.9     0.0       0.9     8.0   122.0
62010421        0.0   -99.9     0.0       0.8     8.0   122.0
62010500        0.4     3.0   131.0       0.8     8.0   122.0
62010503        0.6     4.0   125.0       0.8     8.0   123.0
62010506        0.8     4.0   120.0       0.8     8.0   123.0
62010509        0.6     4.0   120.0       0.8     8.0   123.0
62010512        0.4     3.0   120.0       0.8     8.0   123.0
62010515        0.5     3.0   122.0       0.8     8.0   123.0
62010518        0.8     4.0   126.0       0.8     8.0   123.0
62010521        1.2     5.0   134.0       0.8     8.0   123.0
62010600        1.6     5.0   142.0       0.8     8.0   123.0
62010603        1.9     6.0   154.0       1.0     8.0   123.0
62010606        1.7     6.0   166.0       1.3     7.0   125.0
62010609        0.0   -99.9     0.0       1.2     8.0   124.0
62010612        0.0   -99.9     0.0       0.0   -99.9     0.0
62010615        0.0   -99.9     0.0       0.0   -99.9     0.0
62010618        0.0   -99.9     0.0       0.0   -99.9     0.0
62010621        0.0   -99.9     0.0       1.3     7.0   129.0
```

Figure 18. Example 2: Output file CEDRSOUT.CTS

```
  SC001    48  8.2
86  1  31  800    70   5   53          86  2   6  800    99    9   49
86  1  31 1400    68   5   53          86  2   6 1400   106    9   46
86  1  31 2000    79   9   53          86  2   6 2000   105    7   43
86  2   1  200   102  11   53          86  2   7  200    75    7   47
86  2   1  800   152  20   53          86  2   7  800    71   20   52
86  2   1 1400   179  13   52          86  2   7 1400    72   20   44
86  2   1 2000   167  15   50          86  2   7 2000   100   20   40
86  2   2  200   142  15   53          86  2   8  200    66    7   46
86  2   2  800   130  13   52          86  2   8  800   104   17   46
86  2   2 1400   114  13   54          86  2   8 1400    78   20   43
86  2   2 2000   105  13   54          86  2   8 2000    95   15   39
86  2   3  200   109  13   54          86  2   9  200    95   17   38
86  2   3  800   113  15   53          86  2   9  800    78   15   34
86  2   3 1400   144   7   54          86  2   9 1400    82   13   39
86  2   3 2000   188   9   51          86  2   9 2000    90   13   39
86  2   4  200   126  15   53          86  2  10  200    75   13   40
86  2   4  800   124  15   53          86  2  10  800    66   13   36
86  2   4 1400   111  15   51          86  2  10 1400    68   13   41
86  2   4 2000   105  15   50          86  2  10 2000    64   13   41
86  2   5  200    99  11   50          86  2  11  200    63   15   42
86  2   5  800    80  13   50          86  2  11  800    57   13   43
86  2   5 1400    80  13   50          86  2  11 1400    51   13   47
86  2   5 2000    78   7   49          86  2  11 2000    44   13   46
86  2   6  200   110   7   49          86  2  12  200    41   15   50
```

Figure 19. Time series of wave conditions from a wave gage

145. The next section of code that must be modified (Area 3 in Figure 20) performs the operation of converting the sea wave conditions from the coordinate system of the wave gage data to a coordinate system in which wave direction varies between ±90 deg of shore-normal. Figure 23 provides a suggested way of accomplishing this task.

146. First of all, the user must have a clear understanding of the coordinate system pertaining to the input time series. In this particular wave gage time series, the wave direction is given with respect to north, but represents the direction in which the wave is traveling. The wave direction reported in WIS Phase I and Phase II data is also defined with respect to north, but represents the direction from which the wave came. Because the final output should be in either SEAS or CEDRS format, the first step is to make this conversion, which amounts to adding 180 deg to the wave direction and checking if the angle is greater than 360 deg and, if so, subtracting 360 deg. Now the wave direction represents the direction from which the wave came. This procedure is shown as Step 1 in Figure 23. The next step is to convert the wave direction to a coordinate system in which the wave direction

Area 1

```
   15 WRITE(*,*) ' This code must be modified to read your specific'
      WRITE(*,*) ' input file header !'
      GOTO 35
C?????????????????????????????????????????????????????????????????????
C  In this section read (or prompt for) the input file header information
C  and define the system of units used in the input data file, the depth
C  corresponding to the time series, the shoreline orientation, and the
C  number of records in the file record.  Note, that each record may contain
C  more than one event (e.g.  H, T, & theta for sea waves and H, T, & theta
C  for swell waves,etc.).  Load the number of events per record into NEPR.
C  Load the conversion factor for length into the variable CONVLEN.
C  Load the depth (in meters) into the variable DEPTH.
C  Load the shoreline orientation into SHOANG.
C?????????????????????????????????????????????????????????????????????
```

Area 2

```
        ELSE
          WRITE(*,*) ' This code must be modified to read your specific
     &input time series !'
          GOTO 35
C?????????????????????????????????????????????????????????????????????
C  In this section read the wave event(s) from the input file.
C
C  Read the height, period, and angle of the first wave event into
C  CH, CT, and CTH.
C
C  If there are two events per record, read second wave event height,
C  period, and angle into SH, ST, STH.
C?????????????????????????????????????????????????????????????????????
        ENDIF
```

Area 3

```
          ELSE
            WRITE(*,*) ' This code must be modified to convert your spec
     &ific'
            WRITE(*,*) ' coordinate system to one with respect to shore-
     &normal'
            GOTO 35
C?????????????????????????????????????????????????????????????????????
C  In this section convert the wave event angle from the coordinate system
C  of the input file.
C
C  Convert wave angle to an angle in degrees with respect to shore-normal.
C  Angles counter-clockwise from shore-normal are positive.
C  Angles clockwise from shore-normal are negative.
C     -90 <= ANGLE <= 90
C?????????????????????????????????????????????????????????????????????
          ENDIF
```

Figure 20. Lines where **RCRIT.FOR** must be modified to read wave gage time series (Continued)

```
Area 4
          ELSE
            WRITE(*,*) ' This code must be modified to convert your sp
     &ecific'
            WRITE(*,*) ' coordinate system to one with respect to shor
     &e-normal'
            GOTO 35
C??????????????????????????????????????????????????????????????????????????
C  In this section convert the wave event angle from the coordinate system
C  of the input file.
C
C  Convert wave angle to an angle in degrees with respect to shore-normal.
C  Angles counter-clockwise from shore-normal are positive.
C  Angles clockwise from shore-normal are negative.
C     -90 <= ANGLE <= 90
C??????????????????????????????????????????????????????????????????????????
          ENDIF
Area 5
        ELSEIF(INFOR.EQ.5)THEN
          WRITE(*,*) ' This code must be modified to write your specific
     &'
          WRITE(*,*) ' time series output file header and wave event for
          GOTO 35
C??????????????????????????????????????????????????????????????????????????
C  In this section write your specific time series output file header, and
C  prepare to write the wave event(s) to the output time series file.
C
C  The coordinate system of choice is one in which wave angles are with
C  respect to shore-normal and reflect the direction from which they are
C  traveling.
C??????????????????????????????????????????????????????????????????????????
        ENDIF
```

Figure 20. (Concluded)

varies between ±90 deg from shore-normal. Because the wave direction now represents the direction from which the wave came (with respect to north), the procedure that converts WIS Phase I and II data can be used. The new wave direction is loaded into the variable *A1*. Additionally, the procedure for evaluating whether or not the wave is propagating offshore is again the same as for WIS Phase I and II data.

147. Because the wave gage time series contains only one event per record, no modifications are required in Area 4 shown in Figure 20. If the input time series contained two wave events per record, the swell wave condition would be converted in this section of code.

148. The next section of code (Area 5 in Figure 20) that must be modified performs the operation of writing the processed output time series.

```
C~~~
c  new section for reading the wave gage time series header
C~~~
   15 READ(99,*) STAID, NEVENTS, DEPTH
      NEPR=1
      DEPTH=DEPTH*100
      CONVLEN=.01
      WRITE(*,*) ' Enter the shoreline orientation (in degrees, clockwis
     &e from north): '
      READ(*,*) SHOANG
C~~~
c  end of new section for reading the wave gage time series header
C~~~
C      WRITE(*,*) ' This code must be modified to read your specific'
C      WRITE(*,*) ' input file header !'
C      GOTO 35
C???????????????????????????????????????????????????????????????????????????
C  In this section read (or prompt for) the input file header information
C  and define the system of units used in the input data file, the depth
C  corresponding to the time series, the shoreline orientation, and the
C  number of records in the file record.  Note, that each record may contain
C  more than one event (e.g.  H, T, & theta for sea waves and H, T, & theta
C  for swell waves, etc.).  Load the number of events per record into NEPR.
C  Load the conversion factor for length into the variable CONVLEN.
C  Load the depth (in meters) into the variable DEPTH.
C  Load the shoreline orientation into SHOANG.
C???????????????????????????????????????????????????????????????????????????
```

Figure 21. New lines of code for <u>Area 1</u>, **RCRIT.FOR**

```
        ELSE
C~~~
c  new section for reading the wave gage time series
C~~~
          READ(99,*) IYR,IMON,IDAY,IHR,CH,CT,CTH
          IDATE=IYR*1000000+IMON*10000+IDAY*100+IHR/100
C~~~
c  end of new section for reading the wave gage time series
C~~~
C          WRITE(*,*) ' This code must be modified to read your specific
C     &input time series !'
C          GOTO 35
C???????????????????????????????????????????????????????????????????????????
C  In this section read the wave event(s) from the input file.
C  Read the height, period, and angle of the first wave event into
C  CH, CT, and CTH.
C  If there are two events per record, read second wave event height,
C  period, and angle into SH, ST, STH.
C???????????????????????????????????????????????????????????????????????????
        ENDIF
```

Figure 22. New lines of code for <u>Area 2</u>, **RCRIT.FOR**

```
          ELSE
C~~~
c  new section for converting the wave gage coordinate system
C~~~
c  STEP 1:  convert wave angle from direction in which wave is traveling to
c           direction from which wave is traveling
          CTH=CTH+180
          IF(CTH.GT.360)CTH=CTH-360
c
c  STEP 2:  Convert wave angle to an angle in degrees with respect to
c           shore-normal.  Angles counter-clockwise from shore-normal
c           are positive.  Angles clockwise from shore-normal are negative.
c           -90 <= ANGLE <= 90
            A1=SHOANG+90-CTH
            IF(A1.GE.270.)A1=A1-360.
            IF(A1.LE.-270.)A1=A1+360
            IF(A1.LT.-90..OR.A1.GT.90)THEN
c
c  waves are traveling offshore!
               T1=-99.9
               H1=0.0
               A1=0.0
               ICELIM=2
               ICOFF=ICOFF+1
               GOTO 40
            ENDIF
C~~~
c  end of new section for converting the wave gage coordinate system
C~~~
C            WRITE(*,*) ' This code must be modified to convert your spec
C     &ific'
C            WRITE(*,*) ' coordinate system to one with respect to shore-
C     &normal'
C            GOTO 35
C??????????????????????????????????????????????????????????????????????????
C  In this section convert the wave event angle from the coordinate system
C  of the input file.
C
C  Convert wave angle to an angle in degrees with respect to shore-normal.
C  Angles counter-clockwise from shore-normal are positive.
C  Angles clockwise from shore-normal are negative.
C    -90 <= ANGLE <= 90
C??????????????????????????????????????????????????????????????????????????
          ENDIF
```

Figure 23. New lines of code for Area 3, RCRIT.FOR

As stated previously, it is recommended to write the time series in either SEAS or CEDRS format. The code in Figure 24 will perform this task.

149. The first item written to the output time series file (file with the **.CTS** extension) is the header. In this example, a decision was made to write the file in the format of a SEAS file. The first IF statement will write the file header consisting of the station identification *STAID* and the number of records in the time series *NEVENTS* if the present loop count is one (i.e., if it is the first time through the calculation loop). Then the status of the current event must be determined. The first step is to test the threshold flag *ICCRIT*. The value of *ICCRIT* is set to one at the top of the calculation loop and is subsequently set to minus one if the wave event falls

```
        ELSEIF(INFOR.EQ.5)THEN
C~~~
c  new section for writing the output file header and the processed
c  wave event(s)
C~~~
          IF(ICOUNT.EQ.1)WRITE(98,700) STAID, NEVENTS
          IF(ICCRIT.EQ.1)THEN                      ! satisfied RCRIT
            IF(ICELIM.EQ.0)THEN                    ! not eliminated
              WRITE(98,910) IDATE,CH,CT,CTH
            ELSE
              WRITE(98,910) IDATE,H1,T1,A1
            ENDIF
          ELSE                                     ! RCRIT not satisfied
            WRITE(98,910) IDATE,H1,T1,A1
          ENDIF
  910 FORMAT(1X,I8,3X,3F8.1)
C~~~
c  end of new section for writing the output file header and the processed
c  wave event(s)
C~~~
C          WRITE(*,*) ' This code must be modified to write your specific
C     &'
C          WRITE(*,*) ' time series output file header and wave event for
C     &mat.'
C          GOTO 35
C??????????????????????????????????????????????????????????????????????????
C  In this section write your specific time series output file header, and
C  prepare to write the wave event(s) to the output time series file.
C  The coordinate system of choice is one in which wave angles are with
C  respect to shore-normal and reflect the direction from which they are
C  traveling.
C??????????????????????????????????????????????????????????????????????????
        ENDIF
```

Figure 24. New lines of code for Area 5, RCRIT.FOR

below the prescribed threshold criterion. Therefore, if the value of *ICCRIT* is not unity, a flagged wave event should be written to the output time series. This operation is performed by the WRITE statement that follows the ELSE statement in the outside IF, ELSE, ENDIF block. Otherwise, if the value of *ICCRIT* is unity, then the wave event either exceeded the threshold criterion or was flagged because it was determined to be a calm or offshore-propagating event. The inside IF, ELSE, ENDIF block determines if the wave event was flagged by testing the elimination flag (*ICELIM*). The value of *ICELIM* is assigned the value zero at the top of the calculation loop. Therefore, if the value of *ICELIM* is zero, then the wave event was not flagged and exceeded the threshold criterion for significant longshore sand transport, and the wave event is written to the output time series exactly as it was read except that the wave direction now represents the direction from which the wave came. Otherwise, a flagged wave event is written to the output time series.

150. The program RCRITWVG is now capable of reading the input wave gage time series, performing the appropriate computations, and writing the processed output time series in a SEAS type format. The file **RCRITWVG.FOR** must now be compiled and linked to obtain an executable program. Users must perform these functions with their own software and equipment.

151. In the execution of the program RCRITWVG, the file name *WVGAGE.DAT* is entered at the prompt for the input time series file name, and the file is assumed to exist in the default directory. Otherwise, the appropriate path together with the file name must be specified.

152. The program then prompts for the output file name; in this example the output file name *GAGEOUT* is entered. Again, this file must not exist, and, if it does, the program will terminate. The program will automatically assign the extension **.CTS** to the output time series file.

153. The next prompt issued by the program requests the user to define the input data format type. Because in this case the input format is neither SEAS nor CEDRS, the value *5* is entered, indicating that a nonstandard input format is being used.

154. The last prompt issued before the computations begin is a request for the shoreline orientation in degrees measured clockwise from north. In this example, a shoreline orientation of *135* deg was entered (corresponding to the local shoreline orientation landward of the wave gage).

155. The contents of the output files **REPORT.RC** and **GAGEOUT.CTS** are provided in Figures 25 and 26, respectively. The file **REPORT.RC** is of the same format and presents the same type of information as those previously discussed. The file **GAGEOUT.CTS** contains the processed output time series in a SEAS-type format (i.e., the date is given as an eight-character integer with the first two characters representing the year; the third and fourth characters, the month; the fifth and sixth characters, the day; and the seventh and eight characters, the time of day (on a 24-hr clock); the wave height is given in centimeters, the period in seconds, and the wave direction in degrees with respect to north and representing the direction from which the wave came). The file header is also in the format of a SEAS file, which does not allow the inclusion of the water depth in the file header.

Summary

156. In principle, the program RCRIT flags only those wave events that are calm, propagate offshore, or will not produce significant longshore sand transport. However, the threshold criterion is dependent on the breaking wave angle with respect to the shoreline; therefore, those waves that have a breaking wave angle of zero (the breaking wave crest is parallel to the shoreline) will be flagged. Consequently, for a given shoreline orientation,

```
  Summary of wave events eliminated from the input time series

   WAVE         ELIMINATION
  TYPE            FLAG           DATE       HEIGHT  PERIOD  DIRECTION
------------------------------------------------------------------------
    sea      below threshold  86020714      72.0     20.0      224.0
    sea      below threshold  86020802      66.0      7.0      226.0
    sea      below threshold  86021108      57.0     13.0      223.0
    sea      below threshold  86021114      51.0     13.0      227.0
    sea      below threshold  86021120      44.0     13.0      226.0
    sea      below threshold  86021202      41.0     15.0      230.0
  ************  Summary of Operations  ************

      A total of 48 records was processed

      0 Sea events were flagged as calm
      0 Sea events were flagged as offshore traveling
      6 Sea events were flagged as below threshold
     42 Sea events exceeded the threshold criteria
```

Figure 25. Example 3: Output file **REPORT.RC**

```
SC001                      48
86013108    70.0    5.0  233.0     86020608    99.0    9.0  229.0
86013114    68.0    5.0  233.0     86020614   106.0    9.0  226.0
86013120    79.0    9.0  233.0     86020620   105.0    7.0  223.0
86020102   102.0   11.0  233.0     86020702    75.0    7.0  227.0
86020108   152.0   20.0  233.0     86020708    71.0   20.0  232.0
86020114   179.0   13.0  232.0     86020714     0.0  -99.9    0.0
86020120   167.0   15.0  230.0     86020720   100.0   20.0  220.0
86020202   142.0   15.0  233.0     86020802     0.0  -99.9    0.0
86020208   130.0   13.0  232.0     86020808   104.0   17.0  226.0
86020214   114.0   13.0  234.0     86020814    78.0   20.0  223.0
86020220   105.0   13.0  234.0     86020820    95.0   15.0  219.0
86020302   109.0   13.0  234.0     86020902    95.0   17.0  218.0
86020308   113.0   15.0  233.0     86020908    78.0   15.0  214.0
86020314   144.0    7.0  234.0     86020914    82.0   13.0  219.0
86020320   188.0    9.0  231.0     86020920    90.0   13.0  219.0
86020402   126.0   15.0  233.0     86021002    75.0   13.0  220.0
86020408   124.0   15.0  233.0     86021008    66.0   13.0  216.0
86020414   111.0   15.0  231.0     86021014    68.0   13.0  221.0
86020420   105.0   15.0  230.0     86021020    64.0   13.0  221.0
86020502    99.0   11.0  230.0     86021102    63.0   15.0  222.0
86020508    80.0   13.0  230.0     86021108     0.0  -99.9    0.0
86020514    80.0   13.0  230.0     86021114     0.0  -99.9    0.0
86020520    78.0    7.0  229.0     86021120     0.0  -99.9    0.0
86020602   110.0    7.0  229.0     86021202     0.0  -99.9    0.0
```

Figure 26. Example 3: Output file **GAGEOUT.CTS**

a wave of significant magnitude could be flagged (essentially removed from the time series) because the breaking wave angle is small and the longshore discharge parameter falls below the threshold value.

157. Often, the local shoreline orientation at a particular area of interest (project site) will vary through as much 10 to 15 deg. Therefore, a wave that falls below the threshold criterion for one local shoreline orientation may exceed the threshold criterion for another. For instance, in Example 3, if a shoreline orientation of 140 deg is specified, the wave events shown in Figure 27 would be flagged. Note that only three wave events (occurring on 86021114, 86021120, and 86021202) are common between Figures 25 and 27. Furthermore, if a shoreline orientation of 130 deg is specified together with the Example 3 input time series, the flagged wave events will be those shown in Figure 28. In this case, none of the flagged wave events are in common. This is an important and perhaps not obvious aspect of the program, and the user should exercise caution and perform sensitivity tests

WAVE TYPE	ELIMINATION FLAG	DATE	HEIGHT	PERIOD	DIRECTION
sea	below threshold	86020120	167.0	15.0	230.0
sea	below threshold	86021114	105.0	15.0	230.0
sea	below threshold	86021120	99.0	11.0	230.0
sea	below threshold	86021202	80.0	13.0	230.0
sea	below threshold	86021108	80.0	13.0	230.0
sea	below threshold	86021114	78.0	7.0	229.0
sea	below threshold	86021120	51.0	13.0	227.0
sea	below threshold	86021202	44.0	13.0	226.0
sea	below threshold	86021202	41.0	15.0	230.0

Figure 27. Flagged wave events with a shoreline orientation of 140 deg

(i.e., evaluate the range of local shoreline orientations within the project reach) when applying RCRIT in an actual shoreline modeling project.

SEDTRAN

Introduction

158. The longshore sand transport rate *Q* is the volumetric rate of sand movement parallel to the shore. Longshore transport is confined mainly to the surf zone and, on an open coast, is produced predominantly by waves breaking at an angle to the shoreline. It has been empirically determined that the longshore transport rate is proportional to a quantity referred to as the longshore energy flux, defined in terms of breaking wave conditions. The SPM (1984) provides expressions for the longshore energy flux (SPM Equation 4-39) and the longshore transport rate (SPM Equation 4-49). This method of estimating the longshore sand transport rate is oftentimes referred to as the energy flux method and is dependent only upon breaking wave conditions. The actual

WAVE TYPE	ELIMINATION FLAG	DATE	HEIGHT	PERIOD	DIRECTION
sea	below threshold	86020720	100.0	20.0	220.0
sea	below threshold	86021002	75.0	13.0	220.0
sea	below threshold	86021014	68.0	13.0	221.0
sea	below threshold	86021020	64.0	13.0	221.0

Figure 28. Flagged wave events with a shoreline orientation of 130 deg

physical situation may preclude such transport, for example, along beaches where the sand supply is deficient. The longshore transport rate estimated using the energy flux method should, therefore, be viewed as the potential transport rate.

159. The program SEDTRAN uses the energy flux method together with input wave conditions (significant wave height, period, and direction) from a time series to estimate the potential longshore sand transport rate. Although the shoreline change model GENESIS is much more sophisticated, accounts for local shoreline orientations varying in both time and space, and simulates the effect of coastal structures on the waves and longshore transport within the project reach, the potential transport rates calculated using SEDTRAN enable the user to develop a reasonable first estimate of the longshore transport rate and sediment budget for the project reach.

Calculation procedure

160. In the program SEDTRAN, an input time series of significant wave height, period, and direction together with a water depth and time-step (duration of each wave event) is required to calculate the potential sand transport volume moved alongshore. Potential longshore sand transport volumes are calculated for each wave event in the time series. When the end of the input time series is reached (i.e., all input wave events were processed), the left-directed, right-directed, and other transport volumes are divided by the duration of the time series (in years), and the potential longshore sand transport rate is the result.

161. The calculation flow in SEDTRAN is as follows:

a. Read input file header.

b. Read wave event from input time series.

c. Determine if event is calm or if wave is propagating offshore.

d. If wave event is calm or if wave is propagating offshore, go to step b.

e. Calculate the breaking wave height and angle with respect to the local shoreline orientation or the general orientation of the project reach (i.e., the baseline orientation). The assumption of straight and parallel bottom contours is employed together with Snell's Law and the concept of conservation of wave energy flux directed onshore.

f. Calculate the potential longshore sand transport volume.

g. Based on sign, add to left-directed or right-directed cumulative transport volume.

h. Repeat b through g until end of input file is reached.

i. Calculate left-directed, right-directed, net, and gross potential longshore sand transport rates. Write transport rates to output files.

162. Figure 29 shows the required input and calculated output of the program SEDTRAN. Output from SEDTRAN is written to two files with the extensions .PT and .PTR. The file with the .PT extension contains the calculated results in two tables (Table 1, calculated potential transport volumes; and Table 2, calculated potential transport rates). The file with the .PTR extension serves as an input data set for graphical visualization of the calculated results and contains the calculated potential longshore sand transport rates. More detailed discussion of these output files is given in the examples that follow.

Example applications

163. The calculation of potential longshore sand transport rates by the program SEDTRAN is demonstrated through examples using the time series given in Figures 12, 16, and 19 as input. In addition to the SEAS, CEDRS, and wave gage input time series, the output time series from the program RCRIT for the wave gage (**GAGEOUT.CTS**, Figure 26) is used as input to SEDTRAN in Example 4.

164. Example 1. In this example, wave data as retrieved from the WIS data base using SEAS are input to the program SEDTRAN. The data in Figure 12 are assumed to exist in the default directory in a file named *WVSEAS.DAT*. This file name is entered when the program prompts the user for the input file

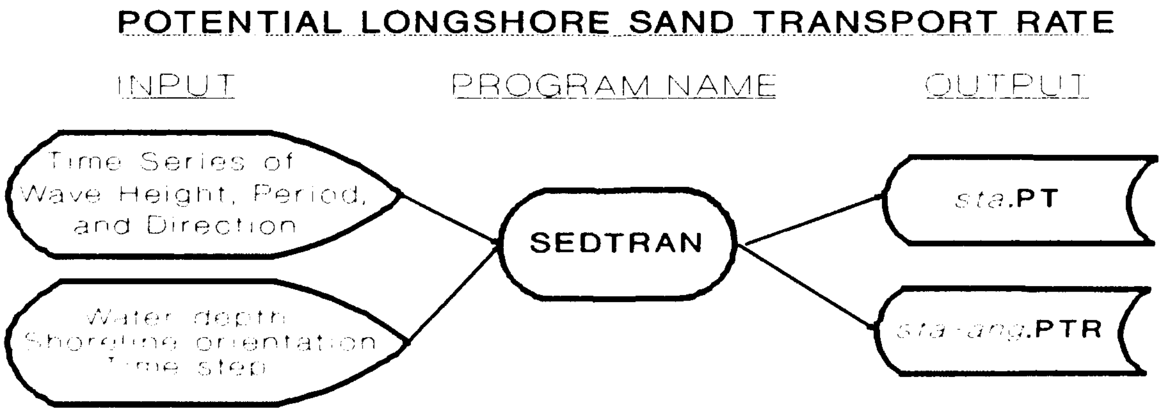


Figure 29. Potential longshore sand transport (SEDTRAN)

name. This file must exist (it represents the input) either in the default directory or in the directory path specified when the file name was entered; if not, the program will terminate.

165. The program then prompts for the output report file name; in this example, the output file name *S28-54* (indicating that the input is from the SEAS data base for Station 28 and a shoreline orientation of 54 deg) is entered. This file must not already exist in the default directory; if it is found in the directory, the program will terminate. This procedure precludes unintentional overwriting of previously created potential transport files. Notice that the output report file name extension is not requested and should not be entered. The program will assign the extension .PT to all output report files. This naming convention is designed to aid in organizing and maintaining the multitude of computer files generated in the course of performing a shoreline change study and promote uniformity among GENESIS users. Next, the program prompts for the plot data output file name; in this example, the plot data output file name *SEAS28* (indicating that the input came from the SEAS data base for Station 28) is entered. This file may or may not exist; if the file is not found in the default directory or specified path, it will be created, and the calculated potential transport rate will be written to it. However, if the file is found in the default directory or specified path, it will be opened, and the new data (potential transport rates calculated during the present program execution) will be appended to the bottom of the existing data (previously calculated potential rates). Again the file name extension is not entered; the program will assign the extension .PTR to all plot data output files. The two output files serve distinct purposes and therefore have different names and extensions. The file with the .PT extension holds the record of the estimated potential longshore sand transport rates for a unique input time series and shoreline orientation. Hence, it is recommended that the file name contain both the station number and the shoreline orientation. In contrast, the file with the .PTR extension may contain potential longshore sand transport rates for up to 20 different shoreline orientations, which may be plotted together in a littoral transport rose. Therefore, it is recommended that the plot data output file name contain only the station number.

166. The next prompt issued by the program requests the user to define the input data format. As in RCRIT, the available options as they are listed

are: (1) SEAS, (2) OUTPUT FROM ANOTHER WORKBOOK CODE (Header and Format similar to SEAS), (3) CEDRS, (4) OUTPUT FROM ANOTHER WORKBOOK CODE (Header and Format similar to CEDRS), and (5) other. In the present example, the input time series was retrieved from SEAS, so the value *1* is entered.

167. The next prompt issued by the program requests the user to define the input time series data type, and the options available are (1) Phase I, (2) Phase II, and (3) Phase III. These data types refer to the three phases of the WIS wave data hindcasts. In this example, the input time series was extracted from the WIS data base using SEAS for Phase II Station 28, so the value *2* is entered.

168. Next the program prompts for the water depth associated with the input time series. If the deepwater condition applies (as in this example), enter the value *-999*; otherwise, enter the water depth at the specific hindcast station (note, this value should be positive and given in centimeters if the input data format type is SEAS or meters if the input data type is CEDRS).

169. The next prompt issued by the program is a request to enter the shoreline orientation in degrees measured clockwise from north. In this example, a shoreline orientation of *54* deg was entered (corresponding to WIS Phase III Station 61). A schematic illustration of the shoreline orientation coordinate system was given in Figure 13. As stated previously, this coordinate system is identical to the system used by WIS in the Phase III hindcasts.

170. The last prompt issued before computations begin requests entry of the time-step of the input time series (the duration of each wave event). The WIS hindcasts have a time-step of 3 hr, so the value *3* is entered. However, because the time-step used in the shoreline change model is typically longer than 3 hr, this parameter is prompted for instead of being assigned.

171. The contents of the output files **S28-54.PT** and **SEAS28.PTR** are provided in Figures 30 and 31, respectively. Table 1 in the file **S28-54.PT** reports the cumulative estimated longshore sand transport volumes to the left, to the right, net, and gross. Table 2 in the file **S28-54.PT** reports the left-directed, right-directed, net, and gross longshore sand transport rates.

172. In addition to plot initialization data, the file **SEAS28.PTR** contains the calculated left- and right-directed potential longshore sand transport rates from which the net and gross rates can be obtained. The plot initialization information is placed on the first two lines in the **.PTR** file.

```
            ESTIMATED POTENTIAL LONGSHORE SAND TRANSPORT RATES
                         INPUT TIME SERIES: WVSEAS.DAT

                                    TABLE 1

   WAVE                           SAND TRANSPORT VOLUMES (M**3)
   TYPE            LEFT             RIGHT          NET            GROSS
-----------------------------------------------------------------------

    sea            0.00          0.436E+05      0.44E+05       0.44E+05
   swell           0.00           0.28E+06      0.28E+06       0.28E+06
  combined         0.00           0.32E+06      0.32E+06       0.32E+06

-----------------------------------------------------------------------



                                    TABLE 2

   WAVE                       SAND TRANSPORT RATES (M**3/YEAR)
   TYPE            LEFT             RIGHT          NET            GROSS
-----------------------------------------------------------------------

    sea            0.00           0.27E+07      0.27E+07       0.27E+07
   swell           0.00           0.17E+08      0.17E+08       0.17E+08
  combined         0.00           0.20E+08      0.20E+08       0.20E+08

-----------------------------------------------------------------------


                           SUMMARY OF TIME SERIES DATA
                           --------------------------

   The duration of the input time series is 0.02 years

 NOTE: Since the duration of this time series is less than one year, the
       estimates reported above may reflect a seasonal bias.

   These estimates are based on a shoreline orientation of  54 deg
           48 events were processed at a time step of 3 hr
           0 sea events were calm
          22 swell events were calm
```

Figure 30. SEDTRAN example 1: Output file **S28-54.PT**

```
           1
           6
  54  0.000      0.265E+07  0.000      0.170E+08  0.000      0.197E+08
```

Figure 31. SEDTRAN example 1: Output file **SEAS28.PTR**

The first line contains the number of X-axis values and, in this application, represents the number of shoreline orientations contained in the file. The second line contains the number of Y-axis values associated with each of the X-axis values specified in the first line and, in this application, represents the number of types of longshore sand transport rates (for example left-directed, right-directed, etc.). The graphics program that uses the .**PTR** file as input and displays these data is introduced in Part IV.

173. Specifically, the first line in the file **SEAS28.PTR** (Figure 31) contains the number "1," indicating that the file holds potential transport rates for one shoreline orientation. The second line contains the number "6," indicating that six transport rates are reported for each shoreline orientation. The third line contains seven fields of data. The first is a quantity associated with the X-axis and represents the shoreline orientation. The remaining fields represent quantities associated with the Y-axis and represent the left- and right-directed potential longshore sand transport rates for the sea wave component, the swell wave component, and the combination of the sea and swell wave components, respectively.

174. Suppose the program SEDTRAN is run again with the same input time series, the plot data output file name is again named *SEAS28*, and a shoreline orientation of 50 deg is specified. Then, the updated **SEAS28.PTR** file would be changed as follows: In the first line, the 1 would be changed to a 2, indicating that the file contains potential transport rates for two shoreline orientations; the second and third lines would not be modified; and a fourth line containing the shoreline orientation and the left- and right-directed potential longshore sand transport rates for sea, swell, and combined wave conditions would be added. Figure 32 contains a listing of the updated **SEAS28.PTR** file after this SEDTRAN run.

175. Example 2. In this example, wave data as retrieved from the CEDRS data base are input to the program SEDTRAN. The file named *WVCEDRS.DAT* (listing provided in Figure 16) is assumed to exist in the default directory. This file name is entered when the program prompts for the input file name.

```
        2
        6
  54  0.000      0.265E+07  0.000      0.170E+08  0.000      0.197E+08
  50  0.000      0.331E+07  0.000      0.205E+08  0.000      0.238E+08
```

Figure 32. Output file **SEAS28.PTR** after two SEDTRAN runs

176. The program then prompts for the output report file name; in this example, the output file name *C59-348* (indicating that the input is from the CEDRS data base for Station 59 and a shoreline orientation of 348 deg) is entered. The program will automatically assign the extension **.PT** to the output report file. Next, the program prompts for the plot data output file name; in this example, the plot data output file name *CEDRS59* (indicating that the input was retrieved using CEDRS for Station 59) is entered. Again, the program will automatically assign the extension **.PTR** to the plot data output file.

177. The next prompt issued by the program requests the user to define the input data format. In the present example, the input time series was retrieved from CEDRS, so the value *3* is entered.

178. Next the program prompts for the input time series data type. In this example, the input time series was extracted from the WIS data base using CEDRS for Phase II Station 59, so the value *2* is entered.

179. Next, the program prompts for the water depth associated with the input time series. If the deepwater condition applies (as in this example), enter the value *-999*; otherwise, enter the water depth for the specific hindcast station.

180. Next the program prompts for the shoreline orientation in degrees measured clockwise from north. In this example, a shoreline orientation of *348* deg was entered (corresponding to WIS Phase III Station 136).

181. The last prompt issued before the computations begin request entry of the time-step of the input time series (the duration of each wave event). In this example, the value *3* is entered because the input time series was retrieved directly from the WIS data base using CEDRS and was not modified.

182. Listings of the output files **C59-348.PT** and **SEAS28.PTR** are provided in Figures 33 and 34, respectively. The comments given in SEDTRAN Example 1 concerning the output files apply to these files as well.

183. Example 3. In this example, a time series from a wave gage is input to the program SEDTRAN. The purpose of this example is to demonstrate how to modify the source code for SEDTRAN (**SEDTRAN.FOR**) in order to use SEDTRAN with wave gage data The first step is to obtain a time series of significant wave height, period, and direction from the measurement record. For demonstration purposes, the time series used in the RCRIT Example 3 will be used again in this example. A listing of the wave gage time series was

```
        ESTIMATED POTENTIAL LONGSHORE SAND TRANSPORT RATES
                     INPUT TIME SERIES: WVCEDRS.DAT


                               TABLE 1

   WAVE                        SAND TRANSPORT VOLUMES (M**3)
   TYPE            LEFT            RIGHT            NET            GROSS
-----------------------------------------------------------------------

    sea          -0.93E+04      0.211E+04      -0.72E+04       0.11E+05
   swell         -0.15E+05       0.00          -0.15E+05       0.15E+05
  combined       -0.25E+05       0.21E+04      -0.23E+05       0.27E+05

-----------------------------------------------------------------------


                               TABLE 2

   WAVE                    SAND TRANSPORT RATES (M**3/YEAR)
   TYPE             LEFT           RIGHT            NET            GROSS
-----------------------------------------------------------------------

    sea          -0.57E+06       0.13E+06      -0.44E+06       0.70E+06
   swell         -0.94E+06       0.00          -0.94E+06       0.94E+06
  combined       -0.15E+07       0.13E+06      -0.14E+07       0.16E+07

------------------------------------------------ --------------------


                       SUMMARY OF TIME SERIES DATA
                       ---------------------------

   The duration of the input time series is 0.02 years

 NOTE: Since the duration of this time series is less than one year, the
       estimates reported above may reflect a seasonal bias.

   These estimates are based on a shoreline orientation of 348 deg
           48 events were processed at a time step of 3 hr
           0 sea events were calm
          10 swell events were calm
```

Figure 33. SEDTRAN Example 2: Output file **C59-348.PT**

```
         1
         6
 348 -0.567E+06  0.129E+06 -0.939E+06  0.000     -0.151E+07  0.129E+06
```

Figure 34. SEDTRAN Example 2: Output file **CEDRS59.PTR**

given in Figure 19. The recommended procedure for modifying SEDTRAN to read the wave gage time series is discussed in the following paragraphs. Another alternative would be to write a program that converts the wave gage time series to either the SEAS or CEDRS format. If this is the preferred alternative, one should consult McAneny (1986) for SEAS format or the CEDRS documentation for the regional CEDRS data base.

184. Before making any changes to the file (SEDTRAN.FOR), it is strongly recommended that the file **SEDTRAN.FOR** be copied to a file with another file name such as **SEDTRNWG.FOR** (where the **WG** portion of the name denotes that the program has been customized to read the user's specialized wave gage time series). In **SEDTRAN.FOR** there are four comment blocks that denote areas where modifications must be made. These comment blocks and the pertinent lines of FORTRAN code are listed in Figure 35.

185. The header information for the wave gage data shown in Figure 19 contains a station identification number, the number of records in the file, and the water depth in meters. These data together with the number of events per record, the conversion factor for length, the time-step of the time series, and the shoreline orientation must be read and assigned to the appropriate variables as stated in the comment block shown under the heading Area 1 in Figure 35. Figure 36 gives one way of accomplishing this task.

186. Several conventions appearing in the code presented in Figure 36 should be noted. First, the depth is given in meters, whereas the wave heights are given in centimeters. To eliminate unit mismatch, the variable *DEPTH* is immediately converted to centimeters. Second, because there is only one wave event per record, the variable *NEPR* is set equal to one. A prompt could have been issued for this quantity, but it is unlikely that the number of events per record would change for a given wave gage, so the variable is simply assigned. The length conversion factor variable *CONVLEN* is set equal to 0.01 to convert length measures from centimeters to meters. Prompts are issued for the variables *SHOANG* and *DT* to easily allow the investigation of multiple shoreline orientations that may exist within the coastal area of interest and time series with different time-steps.

187. The next section of code (Area 2 in Figure 35) that must be modified performs the operation of reading each record of data in the time series. In this particular time series, each record consists of the year, month, day, time of day, and the wave height, period, and direction. Figure 37 gives one way of accomplishing this task.

Area 1

```
   15 WRITE(*,*) ' This code must be modified to read your specific'
      WRITE(*,*) ' input file header !'
      GOTO 35
C??????????????????????????????????????????????????????????????????????????
C  In this section read (or prompt for) the input file header information
C  and define the system of units used in the input data file, the depth
C  corresponding to the time series, the time step of the events, the
C  shoreline orientation, and the number of records in the file record.
C  Note, that each record may contain more than one event (e.g.  H, T, &
C  theta for sea waves and H, T, & theta for swell waves, etc.).
C  Load the conversion factor for length into the variable CONVLEN.
C  Load the time step (hours) of the time series into DT.
C  Load the depth (in meters) into the variable DEPTH.
C  Load the number of events per record into NEPR.
C  Load the shoreline orientation into SHOANG.
C??????????????????????????????????????????????????????????????????????????
```

Area 2

```
        ELSE
          WRITE(*,*) ' This code must be modified to read your specific
     &input time series !'
          WRITE(*,*) ' This program will now terminate'
          GOTO 35
C??????????????????????????????????????????????????????????????????????????
C  In this section read the wave event(s) from the input file.
C
C  Read the height, period, and angle of the first wave event into
C  CH, CT, and CTH.
C
C  If there are two events per record, read second wave event height,
C  period, and angle into SH, ST, STH.
C??????????????????????????????????????????????????????????????????????????
        ENDIF
```

Area 3

```
          ELSE
            WRITE(*,*) ' This code must be modified to convert your spec
     &ific'
            WRITE(*,*) ' coordinate system to one with respect to shore-
     &normal'
            GOTO 35
C??????????????????????????????????????????????????????????????????????????
C  In this section convert the wave event angle from the coordinate system
C  of the input file.
C  Convert wave angle to an angle in degrees with respect to shore-normal.
C  Angles counter-clockwise from shore-normal are positive.
C  Angles clockwise from shore-normal are negitive.
C    -90 <= ANGLE <= 90
C??????????????????????????????????????????????????????????????????????????
          ENDIF
```

Figure 35. Lines where **SEDTRAN.FOR** must be modified to read wave gage time series (Continued)

Area 4

```
          ELSE
            WRITE(*,*) ' This code must be modified to convert your spec
     &ific'
            WRITE(*,*) ' coordinate system to one with respect to shore-
     &normal'
            GOTO 35
C??????????????????????????????????????????????????????????????????????????
C  In this section convert the wave event angle from the coordinate system
C  of the input file.
C
C  Convert wave angle to an angle in degrees with respect to shore-normal.
C  Angles counter-clockwise from shore-normal are positive.
C  Angles clockwise from shore-normal are negitive.
C    -90 <= ANGLE <= 90
C??????????????????????????????????????????????????????????????????????????
          ENDIF
```

Figure 35. (Concluded)

```
C---
c  new section for reading the wave gage time series header
C---
   15 READ(99,*) STAID, NEVENTS, DEPTH
      NEPR=1
      DEPTH=DEPTH*100
      CONVLEN=.01
      WRITE(*,*) ' Enter the shoreline orientation (in degrees, clockwis
     &e from north): '
      READ(*,*) SHOANG
      WRITE(*,*) ' Enter the time step of the input time series: '
      READ(*,*) DT
C---
c  end of new section for reading the wave gage time series header
C---
C      WRITE(*,*) ' This code must be modified to read your specific'
C      WRITE(*,*) ' input file header !'
C      GOTO 35
C??????????????????????????????????????????????????????????????????????????
C  In this section read (or prompt for) the input file header information
C  and define the system of units used in the input data file, the depth
C  corresponding to the time series, the time step of the events, the
C  shoreline orientation, and the number of records in the file record.
C  Note, that each record may contain more than one event (e.g.  H, T, &
C  theta for sea waves and H, T, & theta for swell waves, etc.).
C  Load the conversion factor for length into the variable CONVLEN.
C  Load the time step (hours) of the time series into DT.
C  Load the depth (in meters) into the variable DEPTH.
C  Load the number of events per record into NEPR.
C  Load the shoreline orientation into SHOANG.
C??????????????????????????????????????????????????????????????????????????
```

Figure 36. New lines of code for Area 1, SEDTRAN.FOR

```
C---
c  new section for reading the wave gage time series
C---
          READ(99,*) IDUM,IDUM,IDUM,IDUM,CH,CT,CTH
C---
c  end of new section for reading the wave gage time series
C---
C          WRITE(*,*) ' This code must be modified to read your specific
C     &input time series !'
C          WRITE(*,*) ' This program will now terminate'
C          GOTO 35
C??????????????????????????????????????????????????????????????????????
C  In this section read the wave event(s) from the input file.
C
C  Read the height, period, and angle of the first wave event into
C  CH, CT, and CTH.
C
C  If there are two events per record, read second wave event height,
C  period, and angle into SH, ST, STH.
C??????????????????????????????????????????????????????????????????????
        ENDIF
```

Figure 37. New Lines of code for Area 2, **SEDTRAN.FOR**

188. In this section of code, the only information required by the program is the wave height, period, and direction. Consequently, the date information (in this case given in the first four consecutive fields) is read into the dummy variable *IDUM*. Then the wave height, period, and direction are read into the variables *CH*, *CT*, and *CTH*, respectively. If the time series consisted of two events per record, then the wave parameters for the second event would have been read into the variables *SH*, *ST*, and *STH*.

189. The next section of code (Area 3 in Figure 35) that must be modified performs the operation of converting the sea wave conditions from the coordinate system of the wave gage data to a coordinate system in which wave direction varies between ±90 deg with respect to shore-normal. Figure 38 provides a suggested way of accomplishing this task.

190. First of all, it is important to have a clear understanding of the coordinate system pertaining to the input time series. In this particular case, the wave direction is given with respect to north and represents the direction in which the wave is traveling. The wave direction reported in WIS Phase I and Phase II data is also with respect to north, but represents the direction from which the wave came. Since the preferred coordinate system has previously been defined, the first step is to convert the wave direction fro the direction in which the wave is traveling to the direction from which the

```
          ELSE
C---
c  new section for converting the wave gage coordinate system
C---
c  STEP 1:  convert wave angle from direction in which wave is traveling to
c           direction from which wave is traveling
c
            CTH=CTH+180
            IF(CTH.GE.360)CTH=CTH-360.
c
c  STEP 2:  Convert wave angle to an angle in degrees with respect to
c           shore-normal.  Angles counter-clockwise from shore-normal
c           are positive.  Angles clockwise from shore-normal are negitive.
c           -90 <= ANGLE <= 90
c
            ZINC=SHOANG+90-CTH
            IF(ZINC.GE.270.)ZINC=ZINC-360.
            IF(ZINC.LE.-270.)ZINC=ZINC+360
            IF(ZINC.LT.-90..OR.ZINC.GT.90)THEN
C
C  Waves are traveling offshore!
C
              ICFLAG=-1
            ENDIF
C---
c  end of new section for converting the wave gage coordinate system
C---
C            WRITE(*,*) ' This code must be modified to convert your spec
C     &ific'
C            WRITE(*,*) ' coordinate system to one with respect to shore-
C     &normal'
C            GOTO 35
C?????????????????????????????????????????????????????????????????????????
C  In this section convert the wave event angle from the coordinate system
C  of the input file.
C
C  Convert wave angle to an angle in degrees with respect to shore-normal.
C  Angles counter-clockwise from shore-normal are positive.
C  Angles clockwise from shore-normal are negitive.
C    -90 <= ANGLE <= 90
C?????????????????????????????????????????????????????????????????????????
          ENDIF
```

Figure 38. New lines of code for Area 3, **SEDTRAN.FOR**

wave came; this conversion is accomplished by adding 180 deg to the wave direction and checking if the angle is greater than 360 deg, and, if so, subtracting 360 deg. This procedure is shown as Step 1 in Figure 38. The next step is to convert the wave direction to a coordinate system where the wave direction varies between ±90 deg from shore-normal. Because the wave direction now represents the direction from which the wave came (with respect to north), the procedure used to convert WIS Phase I and Phase II data can be used. The new wave direction is loaded into the variable *ZINC*. Additionally, the procedure for evaluating whether or not the wave is propagating offshore is again the same as for WIS Phase I and Phase II data.

191. Because the wave gage time series contains only one wave event per record, no modifications are required in Area 4 shown in Figure 35. If the input time series contained two events per record, the coordinate system of the swell wave condition would be converted in this section of code. A procedure identical to that used for the sea wave condition could be used.

192. The program SEDTRNWG is now capable of reading the input wave gage time series, performing the appropriate computations, and reporting the results (estimated potential longshore sand transport rates). The file **SEDTRNWG.FOR** must be compiled and linked to obtain an executable program. Users must perform these functions with their own software and equipment.

193. In the execution of the program SEDTRNWG, the file name *WVGAGE.DAT* is entered at the input time series file name prompt. Either this file must exist in the default directory, or the path to the directory where the file resides must be specified together with the file name.

194. The program then prompts for the output report file name; in this example, the output file name *WG1-135* is entered. This file name indicates that the time series is for wave gage number 1 with a shoreline orientation of 135 deg specified. The program will automatically assign the extension **.PT** to the output report file. Next, the program prompts for the plot data output file name; in this example, the plot data output file name *WGAGE1* (indicating that the input is from wave gage 1) is entered. Again, the program will automatically assign the extension **.PTR** to the plot data output file.

195. The next prompt issued by the program requests the user to define the input data format. Because the input time series is from a wave gage, the value *5* (corresponding the other option) is entered.

196. Next, the program prompts for the shoreline orientation in degrees measured clockwise from north. In this example, a shoreline orientation of *135* deg is entered (corresponding to the local shoreline orientation landward of the wave gage).

197. The last prompt issued before the computations begin requests entry of the time-step of the input time series (the duration of each wave

event). In this example, the value *6*, which corresponds to the sampling interval (in hours) of the wave gage, is entered.

198. Listings of the output files **WG1-135.PT** and **WGAGE1.PTR** are provided in Figures 39 and 40, respectively. The comments given in other SEDTRAN examples concerning the output files apply to these files as well.

199. Example 4. The purpose of this example is to provide an indication of how the various programs presented herein were developed to work together (i.e., output from one code providing input to another) and allow the user to perform a complete analysis of the data sets that will ultimately serve as input to the shoreline change model GENESIS. In this example, output from RCRIT Example 3, will be used as input to SEDTRAN. Specifically, the file name *GAGEOUT.CTS* is entered at the prompt for the input time series file name.

200. At the prompt for the output report file name, the name *GC1-135* is entered. This file name denotes that wave gage data from gage number 1, which has been processed through RCRIT, is providing the input time series and that a shoreline orientation of 135 deg was specified. Likewise, the name *WGAGEC1* is entered at the prompt for the plot data output file name.

201. SEDTRAN then prompts the user for the input data format. Recall that when RCRIT was modified to read the wave gage time series, a decision was made to write the output time series in a format similar to that used in the SEAS data retrieval system. Thus, the value *2* is entered, indicating that the input time series was generated by another workbook code and that a SEAS-type header and wave event format was adopted. Since the input time series was generated by another workbook program, a prompt requesting entry of the number of events per record is issued. For this example, the value *1* is entered.

202. The program then issues a prompt for the input time series data type. In this example, the input time series was originally from a wave gage; however, since the time series was written in a SEAS-type format and the coordinate system associated with the wave direction is with respect to north the Phase II option should be selected. Thus, the value *2* is entered.

203. Next, the program prompts for the water depth associated with the input time series. The water depth at the wave gage (*820*) is entered. Since the input time series is in a SEAS-type format, the water depth must be given in centimeters to be compatible with the wave heights, which are given in centimeters. If a CEDRS-type format were chosen, the water depth would be

```
              ESTIMATED POTENTIAL LONGSHORE SAND TRANSPORT RATES
                         INPUT TIME SERIES: WVGAGE.DAT

                                   TABLE 1

    WAVE                       SAND TRANSPORT VOLUMES (M**3)
    TYPE            LEFT          RIGHT          NET           GROSS
  ---------------------------------------------------------------------

     sea          -0.18E+05     0.288E+04     -0.15E+05      0.20E+05

  ---------------------------------------------------------------------


                                   TABLE 2

    WAVE                    SAND TRANSPORT RATES (M**3/YEAR)
    TYPE            LEFT           RIGHT          NET           GROSS
  ---------------------------------------------------------------------

     sea          -0.53E+06      0.88E+05     -0.45E+06      0.62E+06

  ---------------------------------------------------------------------


                         SUMMARY OF TIME SERIES DATA
                         ---------------------------

    The duration of the input time series is 0.03 years

  NOTE: Since the duration of the time series is less than one year, the
        estimates reported above may reflect a seasonal bias.

    These estimates are based on a shoreline orientation of 135 deg
          48 events were processed at a time step of 6 hr
          0 sea events were calm
```

Figure 39. SEDTRAN Example 3: Output file **WG1-135.PT**

```
          1
          2
  135 -0.53E+06  0.88E+05
```

Figure 40. SEDTRAN Example 3: Output file **WGAGE1.PTR**

given in meters because CEDRS wave heights are in meters.

204. Next the program prompts for the shoreline orientation in degrees measured clockwise from north. In this example, a shoreline orientation of *135* deg was entered (corresponding to the local shoreline orientation landward of the wave gage).

205. The last prompt issued before the computations begin requests the user to enter the time-step of the input time series (the duration of each wave event). In this example, the value *6*, which corresponds to the sampling interval (in hours) of the wave gage, is entered. The program then performs the prescribed computations and terminates. Figures 41 and 42 provide listings of the output files **GC1-135.PT** and **WGAGEC1.PTR**, respectively.

Summary

206. Examine the differences in the files **WG1-135.PT** and **GC1-135.PT**. It is interesting to note that the estimated net and gross potential longshore sand transport rates are equal. However, in Example 3 (output file **WG1-135.PT**), 48 wave events were processed, whereas in Example 4 (output file **GC1-135.PT**) potential transport rates were calculated for only 42 events (6 events were calm). This means that 12.5 percent fewer events were processed, but the estimated potential longshore sand transport rates are about the same. Thus, there was a significant reduction in computational effort but little difference in the final result. This example emphasizes the utility of the program RCRIT. Remember that in an actual shoreline change study, the offshore time series would be significantly longer and the number of calculations performed for each wave event is orders of magnitude greater in the shoreline change model GENESIS; consequently, the savings in terms of computational effort would be even greater.

```
           ESTIMATED POTENTIAL LONGSHORE SAND TRANSPORT RATES
                      INPUT TIME SERIES: GAGEOUT.CTS


                                 TABLE 1

   WAVE                     SAND TRANSPORT VOLUMES (M**3)
   TYPE            LEFT            RIGHT           NET            GROSS
 ----------------------------------------------------------------------

    sea         -0.17E+05      0.282E+04      -0.15E+04       0.20E+05

 ----------------------------------------------------------------------


                                 TABLE 2

   WAVE                 SAND TRANSPORT RATES (M**3/YEAR)
   TYPE            LEFT             RIGHT          NET            GROSS
 ----------------------------------------------------------------------

    sea         -0.53E+06       0.86E+05      -0.45E+06       0.62E+06

 ----------------------------------------------------------------------


                        SUMMARY OF TIME SERIES DATA
                        --------------------------

   The duration of the input time series is 0.03 years

  NOTE: Since the duration of the time series is less than one year, the
        estimates reported above may reflect a seasonal bias.


   These estimates are based on a shoreline orientation of 135 deg
           48 events were processed at a time step of 6 hr
           6 sea events were calm
```

Figure 41. SEDTRAN Example 4: Output file **GC1-135.PT**

```
          1
          2
 135 -0.53E+06  0.86E+05
```

Figure 42. SEDTRAN Example 4: Output file **WGAGEC1.PTR**

PART IV: SHORELINE POSITION ANALYSIS

207. This chapter presents procedures for assembling, analyzing, and preparing shoreline position data for input to GENESIS. The procedures, computer programs, and a methodology for their use were developed to aid the modeler in the manipulation and re-orientation of shoreline position data after the initial task of digitizing the shoreline positions has been completed. The modeler is responsible for performing the initial and usually laborious task of digitizing shoreline positions and placing the results in a computer file containing the positions in a horizontal coordinate system (alongshore, X; across-shore, Y) referenced to a datum that will be used throughout the study. At that point, the programs discussed in this chapter can be used.

208. The most common way of obtaining shoreline position data in magnetic form is to digitize measured shorelines appearing on engineering drawings or maps that were derived from either surveys or aerial photographs. There are many commercially available software packages that can be used to facilitate the digitization of shoreline positions, such as AutoCAD, INTERGRAPH, CPS-3.* In fact, most CAD software has the capability of performing the required operations to digitize shoreline positions from maps.

209. Another source for obtaining shoreline position data is through direct digitization of aerial photographs that are often more readily available than shoreline position maps. However, the techniques used to rectify aerial photographs are somewhat complex and include use of (a) a zoom transfer scope that performs an optical rectification of the photographs in two dimensions, (b) a numerical rectification procedure called rubber sheeting in which the photographs are digitized with respect to a set of control points referenced to a known coordinate system, and (c) an analytical stereo plotter, a device that optically rectifies photographs in three dimensions.

210. Regardless of the technique used to obtained the digitized shoreline position data, the programs presented in this chapter will perform their prescribed operations on the data if the data are arranged in X-Y format and

---

* AutoCAD is a registered trademark of Autodesk, Inc. INTERGRAPH is a registered trademark of Intergraph Corporation. CPS-3 and CPS/PC are registered trademarks of the Radian Corp., a company of The Hartford Steam Boiler Inspection and Insurance Company.

referenced to a known rectilinear coordinate system such as state plane coordinates.

211. Three programs (SHORLROT, CUINTP, and WTSHO) are presented in this chapter. The program SHORLROT rotates the digitized shoreline position data into the GENESIS coordinate system and translates the origin as prescribed by the modeler interactively. The program CUINTP cubically interpolates through digitized points to obtain shoreline positions at regularly spaced intervals specified by the user. The program WTSHO reads uniformly spaced shoreline position data and writes shoreline position files in the format required for input to GENESIS. The application of each of these programs is demonstrated through an example having typical input data sets that were digitized using both AutoCAD and CPS/PC. A summary description of the programs and the input and output files involved are provided in Appendix A. Listings of the source code for the programs SHORLROT, CUINTP, and WTSHO are given in Appendices D, E, and F, respectively. Figure 43 provides a schematic illustration in the form of a flowchart of the recommended program usage in the Preparation of Shoreline Position Data analysis procedure.

Baselines, Shorelines, and Bathymetries

212. The first step in the analysis of the shoreline position data is specification of the model reach or area of interest. The model reach must at a minimum encompass the project reach, but it often extends beyond the immediate project to a location where suitable boundary conditions can be established (as discussed in Part II and in the Technical Reference). The analysis begins with specification of the model baseline and digitization of the available shoreline position data with respect to the selected datum. As previously stated, the task of digitizing the shoreline positions must be performed by the modeler using available equipment and software.

213. The model baseline (a straight line usually located landward of any historical shoreline) should be orientated along the general trend of the coastal area of interest. Often it is convenient to draw this line on a map or series of maps that encompass the project. If a nearshore wave transformation model such as RCPWAVE will be used as part of the overall project study, the baseline for the RCPWAVE bathymetry grid must be identical to the GENESIS baseline in orientation; otherwise an error (transparent to the

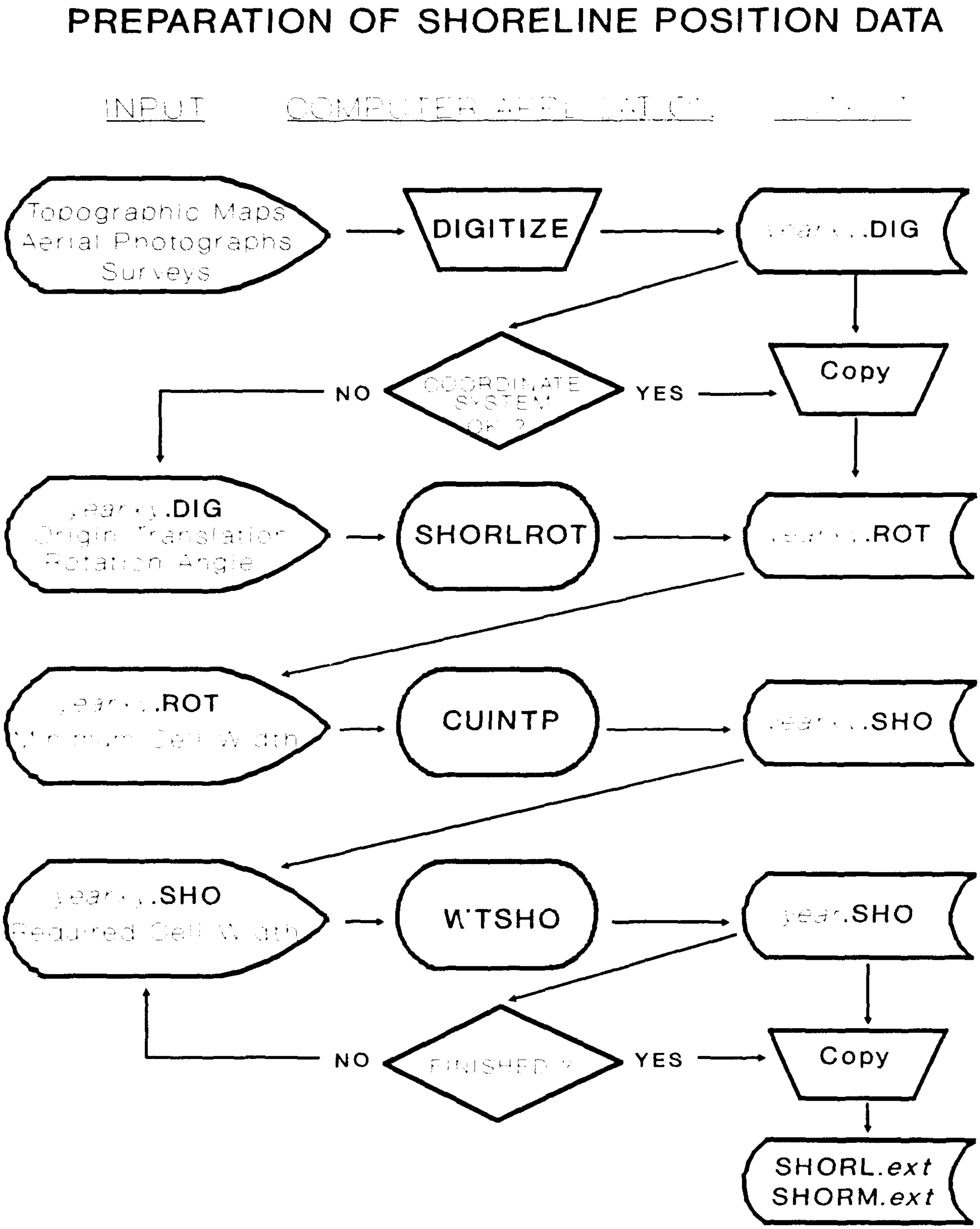


Figure 43. Shoreline data preparation procedure

modeler) will be introduced in the nearshore wave direction data. This sameness in orientation is an important factor and should not be overlooked

SHORLROT

214. The program SHORLROT performs a coordinate system rotation and origin translation using digitized shoreline position data as input. The coordinate system rotation is accomplished through application of the following equation, given here in matrix notation,

$$\begin{vmatrix} COS\theta_{rot} & -SIN\theta_{rot} \\ SIN\theta_{rot} & COS\theta_{rot} \end{vmatrix} \begin{vmatrix} X_{dig} \\ Y_{dig} \end{vmatrix} = \begin{vmatrix} X_{rot} \\ Y_{rot} \end{vmatrix} \tag{33}$$

where

θ_{rot} = user-specified rotation angle

X_{dig} = digitized X value

X_{rot} = rotated X value

Y_{dig} = digitized Y value

Y_{rot} = rotated Y value

215. Translation of the origin is performed after the coordinate system is rotated and amounts to independently adding a constant value to all the X and Y values (i.e., the user-specified values of XTRAN and YTRAN is added to all X and Y values, respectively).

216. The computational flow of the program SHORLROT is as follows:

a. Read the digitized X and Y data into X and Y arrays (maximum of 500 digitized shoreline points).

b. Compute the rotated values of the X and Y arrays using Equation 33.

c. Compute the values of the X and Y arrays after origin translation.

d. Perform a length units conversion if requested.

e. Write the rotated X and Y arrays to the output file.

CUINTP

217. The program CUINTP accepts as input the rotated shoreline position data in *X* and *Y* format and cubically interpolates the data at a fixed interval specified by the user. In operation, a cubic equation is fitted between adjacent *X*-*Y* points, and then this equation is used as the interpolating function between the *X*-*Y* points.

218. The computational flow of the program CUINTP is as follows:

a. Read the total number of *X*-*Y* pairs in the input file from the file header.

b. Read the input data into *X* and *Y* arrays.

c. Compute the coefficients of the cubic spline polynomials between each of the *X*-*Y* pairs and store them in a two-dimensional array.

d. Compute the shoreline position (*Y*-value) beginning between the first and second digitized alongshore positions ($X(1) < X < X(2)$) and continuing at the user-specified interval alongshore.

e. Write the interpolated shoreline position data to an output file.

219. In the execution of CUINTP, it is recommended that the user specify the minimum alongshore interval (cell width) expected to be used in the GENESIS simulations. If this procedure is followed, one does not have to keep track of multiple interpolated data files, thereby minimizing the potential for error in possible future analysis with a different alongshore interval.

WTSHO

220. The program WTSHO reads the interpolated shoreline position data created through the application of the program CUINTP and writes a shoreline position data file in a format suitable for input to GENESIS. Specifically, this program writes files that may be renamed to either SHORL.ext or SHORM.ext and input to GENESIS.

221. The computational flow of the program WTSHO is as follows:

a. Read the total number of *X*-*Y* pairs in the input file and the cell width from the file header.

b. Write (to the monitor) the input file cell width and prompt for the required output cell width.

c. Calculate the output interval.

d. Read the interpolated shoreline position data into *X* and *Y* arrays.

d. Write (to the monitor) the beginning *X*-value and prompt for the required beginning *X* value.

e. Write the shoreline position data (*Y*-values only) to an output file.

Example Application

Introduction

222. In this section, the three programs described previously are demonstrated through example. The intent is to demonstrate recommended usage of the programs that comprise the Preparation of Shoreline Position Data analysis procedure, shown schematically in Figure 43. In this example, National Oceanic and Atmospheric Administration (NOAA) Nautical Chart No. 11478 represents the hypothetical primary data source. Figure 44 is a schematic depiction of this chart. For this example, the shoreline given on this chart was digitized (using both AutoCAD and *CPS/PC* for the purposes of obtaining two example input data sets), and the data were operated on according to the procedures outlined in Figure 43 and detailed below.

Step 1: Digitizing (user-preferred software)

223. The shoreline shown in Figure 44 was digitized using AutoCAD. The shoreline data were output from AutoCAD using the *"DXFOUT"* command. The output file created by AutoCAD is given the name "username.**DXF**." A listing of this output file is provided in Figure 45. The extension **DXF** associated with the AutoCAD output file denotes a "Drawing Interchange" data file that allows exchange of drawing information between various other CAD software or user-written programs. These files contain all (or user-specified portions) of the information required to define the graphic image (in this case the shoreline position). The shaded values in Figure 45 are the digitized shoreline position points. The workbook programs that operate on these values (specifically the program SHORLPOT) require as input only the digitized *X*- and

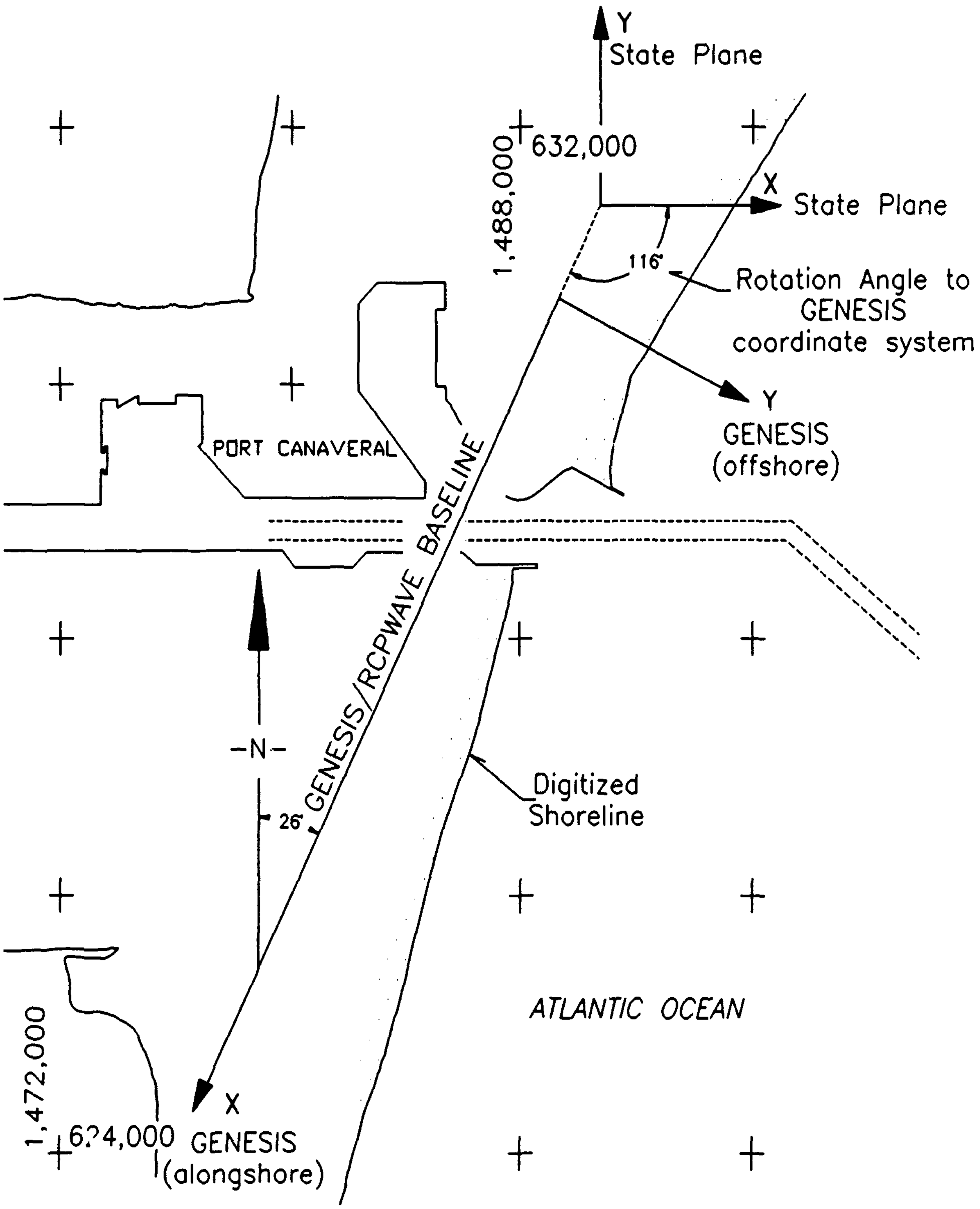


Figure 44. NOAA Nautical Chart No. 11478

```
  0
ENDTAB
  0
TABLE
  2
DWGMGR
 70
     0
  0
ENDTAB
  0
ENDSEC
  0
SECTION
  2
BLOCKS
  0
ENDSEC
  0
SECTION
  2
ENTITIES
  0
POINT
  8
0
 10
636807.99
 20
1488357.8
 30
0.0
  0
POINT
  8
0
 10
636582.89
 20
1488067.07
 30
0.0
  0
POINT
  8
0
 10
636356.59
 20
1487756.47
 30
0.0
  0
POINT
  8
0
 10
636120.98
 20
1487385.57
 30
0.0
  0
POINT
  8
0
 10
635844.1
 20
1486877.35
 30
0.0
  0
POINT
  8
0
 10
635508.08
 20
1486493.11
 30
0.0
  0
POINT
  8
0
 10
635195.42
 20
1486012.53
 30
0.0
  0
POINT
  8
0
 10
634826.79
 20
1485469.36
 30
0.0
  0
POINT
  8
0
 10
634502.24
 20
1485001.99
 30
0.0
  0
POINT
  8
0
 10
634139.26
 20
1484412.09
 30
0.0
  0
POINT
  8
0
 10
633848.36
 20
1483806.47
 30
0.0
  0
POINT
  8
0
 10
633639.79
 20
1483168.54
 30
0.0
  0
POINT
  8
0
 10
633548.69
 20
1482617.44
 30
0.0
  0
POINT
  8
0
 10
633582.32
 20
1482357.18
 30
0.0
  0
POINT
  8
0
 10
631851.21
 20
1481106.87
 30
0.0
  0
POINT
  8
0
 10
631753.45
 20
1480432.01
 30
0.0
  0
POINT
  8
0
 10
631590.62
 20
1479871.58
 30
0.0
  0
POINT
  8
0
 10
631432.3
 20
1479347.98
 30
0.0
  0
POINT
  8
0
 10
631311.09
 20
1478821.83
 30
0.0
  0
POINT
  8
0
 10
631139.54
 20
1478382.02
 30
0.0
  0
POINT
  8
0
 10
630900.98
 20
1477743.0
 30
0.0
  0
POINT
  8
0
 10
630698.07
 20
1477180.35
 30
0.0
  0
POINT
  8
0
 10
630505.62
 20
1476586.1
 30
0.0
  0
POINT
  8
0
 10
630342.33
 20
1476059.09
 30
0.0
  0
POINT
  8
0
 10
630174.2
 20
1475396.64
 30
0.0
  0
POINT
  8
0
 10
629940.14
 20
1474544.44
 30
0.0
  0
POINT
  8
0
 10
629764.92
 20
1473811.98
 30
0.0
  0
POINT
  8
0
 10
629536.57
 20
1473253.72
 30
0.0
  0
POINT
  8
0
 10
629261.21
 20
1472611.54
 30
0.0
  0
POINT
  8
0
 10
629073.56
 20
1471910.39
 30
0.0
  0
ENDSEC
  0
EOF
```

Figure 45. AutoCAD file; *EX1982*.**DXF**

Y-values, as shown in Figure 46. Therefore, the user must extract these values from the **DXF** file for input to SHORLROT. This procedure can be performed either manually or through the use of a user-written program. In this example, the shoreline position data given in Figure 46 will hereafter be referred to as the file *1982XY_1*.DIG and will be used as input to the program SHORLROT in the following section.

224. Another commercially available package known as CPS/PC is well suited for digitizing shoreline position data (and bathymetry data). In fact, CPS and AutoCAD can (if configured appropriately) operate as a shell program (overlay) within each other. The slight advantage of CPS is that the digitized shoreline position data can be output directly to a file that contains only the *X*-*Y*-*Z* information associated with the digitized points. Figure 47 contains a listing of digitized shoreline position data obtained from NOAA Chart No. 11478 as output from CPS/PC. The shoreline position data given in Figure 47 will hereafter be referred to as file *1982XY_2*.DIG and will be used as input to the program SHORLROT in the following section.

Step 2: Coordinate system rotation (SHORLROT)

225. The purpose of the program SHORLROT, as stated previously, is to transform (rotate the coordinate system and translate the origin) the digitized shoreline position data into the GENESIS coordinate system and convert units, if requested. In the following paragraphs, the program SHORLROT will rotate the two digitized data sets given in Figures 46 and 47. One limitation of the program SHORLROT as listed in Appendix D is that a maximum of 500 digitized *X*-*Y* pairs can appear in the input data file (filename.DIG). This

```
636807.99   1488357.6     633848.36   1483806.47     630900.98   1477743.0
636582.99   1488067.07    633639.79   1483168.54     630698.07   1477180.35
636356.59   1487756.47    633548.69   1482617.44     630505.62   1476586.1
636120.98   1487385.57    633582.32   1482357.18     630342.33   1476059.09
635844.1    1486977.35    631851.21   1481106.87     630174.2    1475396.64
635508.08   1486493.11    631753.45   1480432.01     629940.14   1474544.44
635195.42   1486012.53    631590.62   1479871.58     629764.92   1473911.98
634826.79   1485469.36    631432.3    1479347.98     629536.57   1473253.72
634502.24   1485001.99    631311.09   1478921.83     629261.21   1472611.54
634139.26   1484412.09    631139.54   1478388.02     629073.56   1471910.39
                                                     628922.67   1471331.74
```

Figure 46. Digitized shoreline data extracted from **DXF** file (File: *1982XY_1*.DIG)

```
636816.   .148839E+07    .000000          631851.   .148111E+07    .000000
636662.   .148819E+07    .000000          631841.   .148086E+07    .000000
636501.   .148797E+07    .000000          631780.   .148056E+07    .000000
636363.   .148777E+07    .000000          631703.   .148026E+07    .000000
636222.   .148757E+07    .000000          631625.   .148000E+07    .000000
636103.   .148736E+07    .000000          631532.   .147970E+07    .000000
635989.   .148720E+07    .000000          631447.   .147940E+07    .000000
635862.   .148700E+07    .000000          631353.   .147908E+07    .000000
635763.   .148685E+07    .000000          631249.   .147875E+07    .000000
635635.   .148668E+07    .000000          631157.   .147846E+07    .000000
635416.   .148634E+07    .000000          631047.   .147817E+07    .000000
635271.   .148613E+07    .000000          630923.   .147784E+07    .000000
635119.   .148592E+07    .000000          63079     .147749E+07    .000000
634963.   .148568E+07    .000000          630662.   .147712E+07    .000000
634781.   .148542E+07    .000000          630559.   .147679E+07    .000000
634632.   .148521E+07    .000000          630473.   .147648E+07    .000000
634506.   .148502E+07    .000000          630358.   .147614E+07    .000000
634371.   .148481E+07    .000000          630228.   .147564E+07    .000000
634258.   .148462E+07    .000000          630072.   .147502E+07    .000000
634142.   .148444E+07    .000000          629873.   .147439E+07    .000000
634041.   .148426E+07    .000000          629765.   .147401E+07    .000000
633927.   .148402E+07    .000000          629633.   .147351E+07    .000000
633814.   .148373E+07    .000000          629490.   .147315E+07    .000000
633717.   .148345E+07    .000000          629344.   .147281E+07    .000000
633634.   .148318E+07    .000000          629232.   .147246E+07    .000000
633568.   .148288E+07    .000000          629115.   .147207E+07    .000000
633543.   .148258E+07    .000000          628996.   .147168E+07    .000000
633573.   .148237E+07    .000000          628911.   .147131E+07    .000000
```

Figure 47. Digitized shoreline position data output from CPS/PC
(File: *1982XY_2*.DIG)

limitation can, however, be eliminated by increasing the value of MAX in the parameter statement at the top of the program.

226. The program is executed by issuing the command *SHORLROT* at the PC prompt. The program responds with a prompt requesting entry of the input file name and extension. In this example, the file name *1982XY_1.DIG* is entered. This file must exist in either the default directory or the directory specified when the file name is entered. If the input file is not found, the program will terminate with an error message. The extension .DIG is a recommended name for all original digitized data sets.

227. Next, the program prompts for an output file name. The name *1982XY_1* is entered. The program will automatically assign the extension .ROT (indicating that the file contains rotated digitized shoreline position data) to the user-specified output file name. If the output file already exists in the default or user-specified directory, the program will ask if the file

should be overwritten. If a negative response is given, the program will prompt for a new output file name.

228. The next prompt issued by the program requests entry of the rotation angle. The desired rotation angle of *116* deg is entered in this example. This angle is shown graphically on Figure 44.

229. Next, the program requests the origin translation distance first in the *X* direction and then in the *Y* direction. The purpose of translating the origin is to obtain positive *X*- and *Y*-values. Although use of positive *X*- and *Y*-values is not specifically necessary for correct operation of the shoreline change model GENESIS, positive shoreline positions (*Y*-values) and alongshore positions (*X*-values) ranging from just slightly negative (left of the GENESIS origin) and increasing to the end of the digitized reach have been found to be more logical than either very large or negative values. Since at this point in the analysis the user has no idea of the required origin translations, the value *0* is entered at both the *X* and *Y* origin translation prompts.

230. The program then reports (to the monitor) the coordinate system rotation and origin translation that are about to be performed and requests whether or not to continue. At a positive response, the computations are performed, whereas at a negative response, the program prompts for new inputs for the rotation angle and *X* and *Y* origin translation distances. In this example, the value *1* is entered, indicating that the computations should proceed.

231. The final prompt issued by the program requests whether or not a length units conversion should be made. At a positive response, the program requests whether to convert from meters to feet or feet to meters, whereas at a negative response, the program writes the output file (in this example, **1982XY_1**.**ROT**). A listing of this output file is provided in Figure 48.

```
          31
-1616885.0 -80091.0-1616526.0 -80166.0-1616147.0 -80233.3-1615711.0 -80282.4
-1615222.0 -80352.3-1614640.0 -80442.1-1614071.0 -80512.4-1613421.0 -80605.6
-1612859.0 -80692.4-1612169.0 -80760.1-1611497.0 -80756.1-1610833.0 -80663.8
-1610297.0 -80504.2-1610078.0 -80359.8-1608196.0 -81367.7-1607546.0 -81159.7
-1606971.0 -81060.4-1606431.0 -80973.2-1605995.0 -80895.3-1605440.0 -80815.4
-1604756.0 -80747.1-1604161.0 -80682.9-1603542.0 -80595.3-1602997.0 -80511.1
-1602328.0 -80371.8-1601460.0 -80208.6-1600814.0 -80088.8-1600123.0 -80005.5
-1599425.0 -79971.5-1598712.0 -79832.8-1598126.0 -79714.7
```

Figure 48. SHORLROT output file **1982XY_1**.**ROT** (first run)

232. The number of *X*-*Y* shoreline position points is given on the first line of the output file **1982XY_1**.**ROT**. The shaded quantities shown in Figure 48 are the most negative alongshore distance (*X* = -1616885.0) and offshore distance (*Y* = -81367.7) in the rotated shoreline position data. These values will be used as reference points for specifying the origin translation.

233. Now that reference values for the origin translation are known, the program SHORLROT is executed again. The inputs for the program prompts are as follows:

a. Input file name: *1982XY_1.DIG*
b. Output file name: *1982XY_1*
c. Overwrite the file?: *1* (YES)
d. Rotation angle: *116*
e. *X*-translation distance: *1616885.0*
f. *Y*-translation distance: *81400.0*
g. Continue?: *1* (YES)
h. System of units conversion?: *2* (NO)

234. The new output file **1982XY_1**.**ROT** is listed in Figure 49. The shaded *X*-*Y* pairs shown in Figure 49 indicate the digitized points on either side of the inlet system in the project reach (Figure 44). These points will be of importance later in execution of the program WTSHO. The coordinate system rotation and origin translation task is complete for the first data set (**1982XY**_1.DIG).

235. Now the second data set (**1982XY**_2.DIG) will be operated on. The program is executed by issuing the command *SHORLROT* at the PC prompt. The responses to the program prompts are as listed below:

a. Input file name: *1982XY_2.DIG*
b. Output file name: *1982XY_2*
c. Rotation angle: *116*
d. *X* -translation distance: *1616885.0*
e. *Y*-translation distance: *81400.0*
f. Continue?: *1* (YES)
g. System of units conversion?: *2* (NO)

236. The output file **1982XY**_2.**ROT** is generated by the program and a listing of the file is provided in Figure 50. Again, the shaded values shown in Figure 50 indicate the digitized shoreline positions immediately north and

```
        31
      -0.4    1309.0     359.4    1234.0     737.9    1166.7    1174.4    1117.6
    1662.8    1047.7    2245.4     957.9    2814.4     887.6    3464.1     794.4
    4026.5     707.6    4715.8     639.9    5387.6     643.9    6052.4     736.2
    6587.6     895.8    6806.9    1040.2    8689.5      32.3    9338.9     240.3
    9914.0     339.6   10454.0     426.8   10890.1     504.7   11445.3     584.6
   12129.4     652.9   12724.1     717.1   13342.6     804.7   13887.9     888.9
   14557.0    1028.2   15425.5    1191.4   16070.8    1311.2   16762.5    1394.5
   17460.5    1428.5   18172.9    1567.2   18759.1    1685.3
```

Figure 49. SHORLROT output file **1982XY_1.ROT** (second run)

south of the inlet. This completes Step 2 of the preparation of shoreline data procedure for both input data sets.

Step 3: Cubic spline interpolation (CUINTP)

237. This step involves interpolation of the digitized shoreline position data sets that have already been rotated to the GENESIS coordinate system. The program CUINTP performs this task and accepts as input the output file generated by the program SHORLROT. Other data files may be input to the program CUINTP provided that the file name extension is .ROT and that the data points in the file are formatted as follows:

a. Line 1: number of *X*-*Y* pairs (NPTS).

b. Lines 2 to end of file (EOF):
X(1),*Y*(1),*X*(2),*Y*(2),...,*X*(NPTS),*Y*(NPTS); FORMAT (8(F10.1)

```
        56
     -32.9    1302.0     214.4    1251.2     482.6    1202.9     722.9    1166.6
     964.5    1127.5    1205.4    1112.6    1399.1    1080.3    1634.5    1053.8
    1812.8    1030.6    2021.6     990.0    2423.3     942.3    2675.6     904.0
    2931.0     859.5    3215.0     824.4    3528.5     774.9    3782.6     733.0
    4008.6     703.0    4256.5     673.7    4476.8     655.5    4689.5     630.1
    4895.5     618.3    5161.1     621.0    5471.5     646.5    5765.6     682.1
    6044.6     725.9    6343.1     798.1    6623.9     907.1    6799.5    1026.1
    8686.8      30.8    8915.9     131.3    9212.3     208.0    9515.6     270.4
    9783.5     314.2   10093.9     362.1   10400.9     417.3   10729.6     473.0
   11071.9     524.3   11372.9     568.7   11681.6     596.9   12032.6     630.1
   12403.9     667.6   12794.1     711.2   13136.0     763.3   13452.3     821.8
   13808.3     867.5   14314.6     969.9   14940.4    1101.5   15593.8    1198.8
   15982.6    1268.3   16489.9    1368.9   16876.3    1398.1   17245.8    1415.9
   17609.4    1468.7   18011.3    1534.5   18413.9    1598.5   18783.8    1684.3
```

Figure 50. SHORLROT output file **1982XY_2.ROT**

238. The program is executed by issuing the command *CUINTP* at the PC prompt. The program responds with a prompt for the input file name; for this example, the name *1982XY_1* was entered. Note that the file name extension was not requested and should not be entered. All files input to CUINTP must have the extension **.ROT**.

239. Next, the program prompts for the output file name. For this example, the name *1982XY_1* is entered. Again, the file name extension should not be entered, because the program will automatically append the extension **.ISH** (indicating that the file contains interpolated shoreline position data) to the user-specified output file name.

240. The final prompt issued by the program before the data are interpolated is the required cell spacing. For this example, the value *50* is entered. The program CUINTP first computes cubic polynomial interpolation functions for each adjacent shoreline data pair. It is important, therefore, that the digitized data in the alongshore direction increase sequentially from the beginning of the input file to the end. Then the interpolating functions are used to compute the *X*-*Y*- shoreline positions at the user-specified alongshore spacing. Output from the program are written to the user-specified file name with the extension **.ISH** (in this example **1982XY_1.ISH**). This output file has the following format:

a. Line 1: number of *X*-*Y* pairs (NPTS) and cell spacing (DX).

b. Lines 2 to end of file (EOF):
X(1),Y(1),*X*(2),Y(2),...,*X*(NPTS),*Y*(NPTS);
FORMAT (5(1*X*,F6.0,1*X*,F8.1))

241. The file **1982XY_1.ISH** is listed in Figure 51. The shaded *X*-*Y* pairs shown in Figure 51 correspond to the nearest interpolated shoreline positions just north and south of the inlet. This completes the shoreline position interpolation task for the first data set (**1982XY_1.ROT**).

242. Now, the second data set (**1982XY_2.ROT**) will be operated on. The program is executed by issuing the command *CUINTP* at the PC prompt. The responses to the program prompts are as listed below:

a. Input file name: *1982XY_2*

b. Output file name: *1982XY_2*

c. Required cell spacing: *50*

```
          375   50.0000
     0.  1308.9     50.  1298.3    100.  1287.8    150.  1277.2    200.  1266.8
   250.  1256.4    300.  1246.1    350.  1235.9    400.  1225.9    450.  1216.0
   500.  1206.4    550.  1197.2    600.  1188.4    650.  1180.0    700.  1172.2
   750.  1165.0    800.  1158.5    850.  1152.4    900.  1146.8    950.  1141.5
  1000.  1136.3   1050.  1131.1   1100.  1125.8   1150.  1120.4   1200.  1114.6
  1250.  1108.4   1300.  1101.9   1350.  1095.1   1400.  1088.0   1450.  1080.7
  1500.  1073.2   1550.  1065.5   1600.  1057.7   1650.  1049.7   1700.  1041.8
  1750.  1033.7   1800.  1025.7   1850.  1017.7   1900.  1009.7   1950.  1001.8
  2000.   994.0   2050.   986.3   2100.   978.7   2150.   971.4   2200.   964.2
  2250.   957.3   2300.   950.6   2350.   944.1   2400.   937.8   2450.   931.6
  2500.   925.6   2550.   919.6   2600.   913.6   2650.   907.7   2700.   901.7
  2750.   895.6   2800.   889.4   2850.   883.1   2900.   876.6   2950.   870.0
  3000.   863.2   3050.   856.3   3100.   849.2   3150.   842.0   3200.   834.7
  3250.   827.3   3300.   819.8   3350.   812.2   3400.   804.4   3450.   796.6
  3500.   788.7   3550.   780.7   3600.   772.7   3650.   764.7   3700.   756.8
  3750.   748.8   3800.   741.0   3850.   733.3   3900.   725.8   3950.   718.4
  4000.   711.3   4050.   704.4   4100.   697.8   4150.   691.4   4200.   685.3
  4250.   679.5   4300.   674.0   4350.   668.8   4400.   663.9   4450.   659.3
  4500.   655.0   4550.   650.9   4600.   647.2   4650.   643.9   4700.   640.8
  4750.   638.1   4800.   635.7   4850.   633.7   4900.   632.1   4950.   630.9
  5000.   630.2   5050.   630.0   5100.   630.3   5150.   631.2   5200.   632.7
  5250.   634.8   5300.   637.5   5350.   640.9   5400.   645.0   5450.   649.8
  5500.   655.2   5550.   661.2   5600.   667.7   5650.   674.6   5700.   681.8
  5750.   689.3   5800.   697.0   5850.   704.8   5900.   712.7   5950.   720.5
  6000.   728.3   6050.   735.8   6100.   743.2   6150.   750.8   6200.   759.1
  6250.   768.4   6300.   779.4   6350.   792.3   6400.   807.8   6450.   826.2
  6500.   848.0   6550.   873.7   6600.   903.7   6650.   937.5   6700.   972.6
  6750.  1006.5   6800.  1036.5   6850.  1060.2   6900.  1077.3   6950.  1088.1
  7000.  1092.8   7050.  1091.9   7100.  1085.7   7150.  1074.4   7200.  1058.4
  7250.  1038.1   7300.  1013.8   7350.   985.8   7400.   954.4   7450.   920.0
  7500.   882.8   7550.   843.3   7600.   801.7   7650.   758.4   7700.   713.7
  7750.   668.0   7800.   621.5   7850.   574.5   7900.   527.5   7950.   480.8
  8000.   434.6   8050.   389.3   8100.   345.2   8150.   302.7   8200.   262.1
  8250.   223.7   8300.   187.8   8350.   154.9   8400.   125.1   8450.    98.8
  8500.    76.4   8550.    58.2   8600.    44.5   8650.    35.7   8700.    32.0
  8750.    33.5   8800.    39.7   8850.    50.1   8900.    63.9   8950.    80.5
  9000.    99.4   9050.   120.0   9100.   141.6   9150.   163.7   9200.   185.5
  9250.   206.6   9300.   226.3   9350.   244.0   9400.   259.4   9450.   272.6
  9500.   283.9   9550.   293.5   9600.   301.9   9650.   309.1   9700.   315.5
  9750.   321.3   9800.   326.8   9850.   332.3   9900.   337.9   9950.   344.1
 10000.   350.7  10050.   357.9  10100.   365.5  10150.   373.4  10200.   381.6
 10250.   390.2  10300.   398.9  10350.   407.9  10400.   416.9  10450.   426.1
 10500.   435.2  10550.   444.4  10600.   453.5  10650.   462.6  10700.   471.6
 10750.   480.5  10800.   489.3  10850.   497.9  10900.   506.4  10950.   514.6
 11000.   522.6  11050.   530.5  11100.   538.1  11150.   545.5  11200.   552.7
 11250.   559.6  11300.   566.3  11350.   572.8  11400.   579.1  11450.   585.2
 11500.   591.0  11550.   596.5  11600.   601.9  11650.   607.2  11700.   612.2
 11750.   617.2  11800.   622.0  11850.   626.8  11900.   631.5  11950.   636.2
 12000.   640.8  12050.   645.4  12100.   650.1  12150.   654.9  12200.   659.7
```

Figure 51. CUINTP output file **1982XY_1**.ISH (Continued)

```
12250.    664.5 12300.    669.5 12350.    674.6 12400.    679.8 12450.    685.1
12500.    690.5 12550.    696.2 12600.    701.9 12650.    707.9 12700.    714.1
12750.    720.4 12800.    727.0 12850.    733.7 12900.    740.6 12950.    747.6
13000.    754.7 13050.    762.0 13100.    769.2 13150.    776.5 13200.    783.9
13250.    791.2 13300.    798.5 13350.    805.8 13400.    813.0 13450.    820.1
13500.    827.3 13550.    834.6 13600.    842.0 13650.    849.5 13700.    857.3
13750.    865.3 13800.    873.5 13850.    882.1 13900.    891.1 13950.    900.5
14000.    910.2 14050.    920.2 14100.    930.5 14150.    941.0 14200.    951.6
14250.    962.4 14300.    973.2 14350.    984.0 14400.    994.9 14450.   1005.6
14500.   1016.3 14550.   1026.7 14600.   1037.0 14650.   1047.1 14700.   1057.0
14750.   1066.7 14800.   1076.3 14850.   1085.8 14900.   1095.1 14950.   1104.4
15000.   1113.6 15050.   1122.7 15100.   1131.8 15150.   1140.9 15200.   1149.9
15250.   1159.0 15300.   1168.2 15350.   1177.4 15400.   1186.6 15450.   1196.0
15500.   1205.5 15550.   1215.0 15600.   1224.5 15650.   1234.1 15700.   1243.6
15750.   1253.1 15800.   1262.5 15850.   1271.9 15900.   1281.1 15950.   1290.1
16000.   1299.0 16050.   1307.7 16100.   1316.1 16150.   1324.3 16200.   1332.2
16250.   1339.8 16300.   1347.0 16350.   1354.0 16400.   1360.5 16450.   1366.6
16500.   1372.4 16550.   1377.6 16600.   1382.4 16650.   1386.7 16700.   1390.5
16750.   1393.8 16800.   1396.5 16850.   1398.7 16900.   1400.5 16950.   1402.1
17000.   1403.5 17050.   1404.8 17100.   1406.2 17150.   1407.8 17200.   1409.7
17250.   1412.0 17300.   1414.8 17350.   1418.2 17400.   1422.4 17450.   1427.3
17500.   1433.3 17550.   1440.1 17600.   1447.7 17650.   1456.1 17700.   1465.2
17750.   1474.8 17800.   1484.9 17850.   1495.4 17900.   1506.2 17950.   1517.3
18000.   1528.5 18050.   1539.8 18100.   1551.0 18150.   1562.2 18200.   1573.1
18250.   1583.8 18300.   1594.4 18350.   1604.8 18400.   1615.0 18450.   1625.0
18500.   1635.0 18550.   1644.8 18600.   1654.6 18650.   1664.3 18700.   1673.9
```

Figure 51. (Concluded)

The output file **1982XY_2.ISH** is generated by the program, and the file is listed in Figure 52. Again, the shaded values shown in Figure 52 correspond to the nearest interpolated shoreline positions just north and south of the inlet.

243. This completes Step 3 of the <u>Preparation of Shoreline Position Data</u> procedure and is a good point in the analysis to closely examine the data generated so far. The format of the output data files obtained with the programs SHORLROT and CUINTP was specifically designed to be compatible with (can serve as input to) the graphics package HGRAPH,* specifically the program DPLOT of the HGRAPH package. This graphics package, including documentation, object libraries, source code, and DPLOT.EXE is available to US Army Corps of Engineers employees. The program DPLOT was used to generate the plots shown in Figures 53, 54, and 55. The plots were first output from DPLOT

---

* HGRAPH, a graphics software package developed for the PC environment by David W. Hyde, Structural Engineer, USAE Waterways Experiment Station, Structures Laboratory.

```
           375    50.0000
      0.  1295.1     50.  1284.7    100.  1274.4    150.  1264.1    200.  1254.1
    250.  1244.2    300.  1234.6    350.  1225.3    400.  1216.5    450.  1208.1
    500.  1200.2    550.  1192.9    600.  1185.7    650.  1178.3    700.  1170.4
    750.  1161.8    800.  1152.7    850.  1143.7    900.  1135.5    950.  1129.0
   1000.  1124.7   1050.  1122.0   1100.  1120.0   1150.  1117.4   1200.  1113.2
   1250.  1106.5   1300.  1097.9   1350.  1088.8   1400.  1080.2   1450.  1073.0
   1500.  1067.1   1550.  1062.0   1600.  1057.2   1650.  1052.2   1700.  1046.7
   1750.  1040.3   1800.  1032.8   1850.  1023.8   1900.  1013.9   1950.  1003.7
   2000.   993.9   2050.   985.2   2100.   977.8   2150.   971.4   2200.   965.7
   2250.   960.5   2300.   955.5   2350.   950.5   2400.   945.0   2450.   939.0
   2500.   932.2   2550.   924.9   2600.   916.9   2650.   908.5   2700.   899.6
   2750.   890.5   2800.   881.4   2850.   872.6   2900.   864.3   2950.   856.8
   3000.   850.1   3050.   844.0   3100.   838.2   3150.   832.4   3200.   826.3
   3250.   819.7   3300.   812.5   3350.   804.8   3400.   796.7   3450.   788.4
   3500.   779.8   3550.   771.2   3600.   762.6   3650.   754.1   3700.   745.8
   3750.   737.9   3800.   730.5   3850.   723.5   3900.   716.9   3950.   710.5
   4000.   704.1   4050.   697.7   4100.   691.2   4150.   685.1   4200.   679.4
   4250.   674.3   4300.   670.0   4350.   666.2   4400.   662.4   4450.   658.1
   4500.   653.0   4550.   646.9   4600.   640.5   4650.   634.4   4700.   629.1
   4750.   624.9   4800.   621.8   4850.   619.6   4900.   618.2   4950.   617.4
   5000.   617.2   5050.   617.6   5100.   618.7   5150.   620.5   5200.   623.0
   5250.   626.2   5300.   630.0   5350.   634.3   5400.   639.1   5450.   644.2
   5500.   649.6   5550.   655.3   5600.   661.2   5650.   667.3   5700.   673.6
   5750.   680.0   5800.   686.7   5850.   693.6   5900.   700.9   5950.   708.8
   6000.   717.4   6050.   727.0   6100.   737.5   6150.   748.9   6200.   761.0
   6250.   773.6   6300.   786.7   6350.   799.9   6400.   813.6   6450.   828.7
   6500.   846.2   6550.   867.2   6600.   892.9   6650.   924.1   6700.   959.5
   6750.   994.9   6800.  1026.4   6850.  1050.7   6900.  1067.4   6950.  1077.0
   7000.  1079.9   7050.  1076.4   7100.  1067.0   7150.  1052.1   7200.  1032.0
   7250.  1007.3   7300.   978.2   7350.   945.1   7400.   908.6   7450.   868.9
   7500.   826.5   7550.   781.8   7600.   735.2   7650.   687.0   7700.   637.7
   7750.   587.7   7800.   537.4   7850.   487.2   7900.   437.5   7950.   388.6
   8000.   341.0   8050.   295.2   8100.   251.4   8150.   210.1   8200.   171.7
   8250.   136.6   8300.   105.1   8350.    77.8   8400.    55.0   8450.    37.0
   8500.    24.4   8550.    17.4   8600.    16.6   8650.    22.3   8700.    34.8
   8750.    53.7   8800.    76.6   8850.   101.0   8900.   124.5   8950.   144.6
   9000.   161.0   9050.   174.4   9100.   185.8   9150.   195.9   9200.   205.6
   9250.   215.6   9300.   225.9   9350.   236.5   9400.   247.1   9450.   257.5
   9500.   267.4   9550.   276.8   9600.   285.5   9650.   293.7   9700.   301.6
   9750.   309.2   9800.   316.7   9850.   324.1   9900.   331.6   9950.   339.1
  10000.   346.9  10050.   354.9  10100.   363.1  10150.   371.7  10200.   380.6
  10250.   389.7  10300.   398.8  10350.   408.0  10400.   417.1  10450.   426.1
  10500.   434.9  10550.   443.6  10600.   452.1  10650.   460.3  10700.   468.3
  10750.   476.2  10800.   483.8  10850.   491.2  10900.   498.6  10950.   506.0
  11000.   513.4  11050.   520.9  11100.   528.7  11150.   536.5  11200.   544.4
  11250.   552.0  11300.   559.2  11350.   565.9  11400.   571.8  11450.   577.1
  11500.   581.8  11550.   586.1  11600.   590.2  11650.   594.3  11700.   598.5
  11750.   602.8  11800.   607.4  11850.   612.1  11900.   617.0  11950.   621.9
  12000.   626.8  12050.   631.8  12100.   636.8  12150.   641.9  12200.   646.9
```

Figure 52. CUINTP output file **1982XY_2**.ISH (Continued)

```
12250.   651.9 12300.   657.0 12350.   662.1 12400.   667.2 12450.   672.4
12500.   677.6 12550.   682.9 12600.   688.3 12650.   693.9 12700.   699.7
12750.   705.7 12800.   712.0 12850.   718.5 12900.   725.4 12950.   732.6
13000.   740.2 13050.   748.3 13100.   756.8 13150.   765.9 13200.   775.4
13250.   785.1 13300.   794.8 13350.   804.3 13400.   813.2 13450.   821.4
13500.   828.8 13550.   835.4 13600.   841.5 13650.   847.4 13700.   853.3
13750.   859.5 13800.   866.3 13850.   873.9 13900.   882.2 13950.   891.2
14000.   900.8 14050.   911.0 14100.   921.6 14150.   932.5 14200.   943.7
14250.   955.1 14300.   966.5 14350.   978.0 14400.   989.5 14450.  1000.8
14500.  1012.1 14550.  1023.2 14600.  1034.1 14650.  1044.8 14700.  1055.3
14750.  1065.6 14800.  1075.5 14850.  1085.1 14900.  1094.3 14950.  1103.2
15000.  1111.6 15050.  1119.7 15100.  1127.4 15150.  1134.9 15200.  1142.2
15250.  1149.4 15300.  1156.4 15350.  1163.4 15400.  1170.5 15450.  1177.6
15500.  1184.8 15550.  1192.2 15600.  1199.8 15650.  1207.6 15700.  1215.8
15750.  1224.3 15800.  1233.1 15850.  1242.2 15900.  1251.7 15950.  1261.6
16000.  1271.9 16050.  1282.6 16100.  1293.5 16150.  1304.4 16200.  1315.2
16250.  1325.9 16300.  1336.1 16350.  1345.8 16400.  1354.8 16450.  1363.0
16500.  1370.3 16550.  1376.5 16600.  1381.7 16650.  1386.0 16700.  1389.7
16750.  1392.7 16800.  1395.1 16850.  1397.2 16900.  1398.9 16950.  1400.5
17000.  1402.0 17050.  1403.8 17100.  1405.9 17150.  1408.6 17200.  1412.0
17250.  1416.3 17300.  1421.6 17350.  1427.8 17400.  1434.7 17450.  1442.3
17500.  1450.3 17550.  1458.6 17600.  1467.1 17650.  1475.6 17700.  1484.1
17750.  1492.5 17800.  1500.9 17850.  1509.1 17900.  1517.2 17950.  1525.1
18000.  1532.8 18050.  1540.3 18100.  1547.6 18150.  1555.0 18200.  1562.4
18250.  1570.1 18300.  1578.2 18350.  1586.7 18400.  1595.8 18450.  1605.7
18500.  1616.3 18550.  1627.4 18600.  1639.0 18650.  1651.1 18700.  1663.
```

Figure 52. (Concluded)

by selecting the output device "FILE." This causes the program to write the graphic image in Hewlett-Packard Graphic Language (HPGL) to an output file. HPGL is the two-letter-mnemonic graphics language understood by HP plotters and graphics printers, as well as many other hard copy output devices and commercial software packages, including graphics and word-processing programs. These output files, which contain the graphic image in HPGL, were then imported into this document. Regardless of the graphics software used, it is easiest to review and perform quality checks on digitized and/or interpolated shoreline position data by inspection of plots.

244. The four shoreline position data files generated so far are plotted in Figure 53. Square symbols represent the digitized data points after being rotated to the GENESIS coordinate system and were read from the file **1982XY_1.ROT**. The solid line is the interpolated shoreline position (read from the file **1982XY_1.ISH**) that was calculated based on the first data set. Diamond symbols represent the second set of digitized data points after rotation to the GENESIS coordinate system and were read from the file

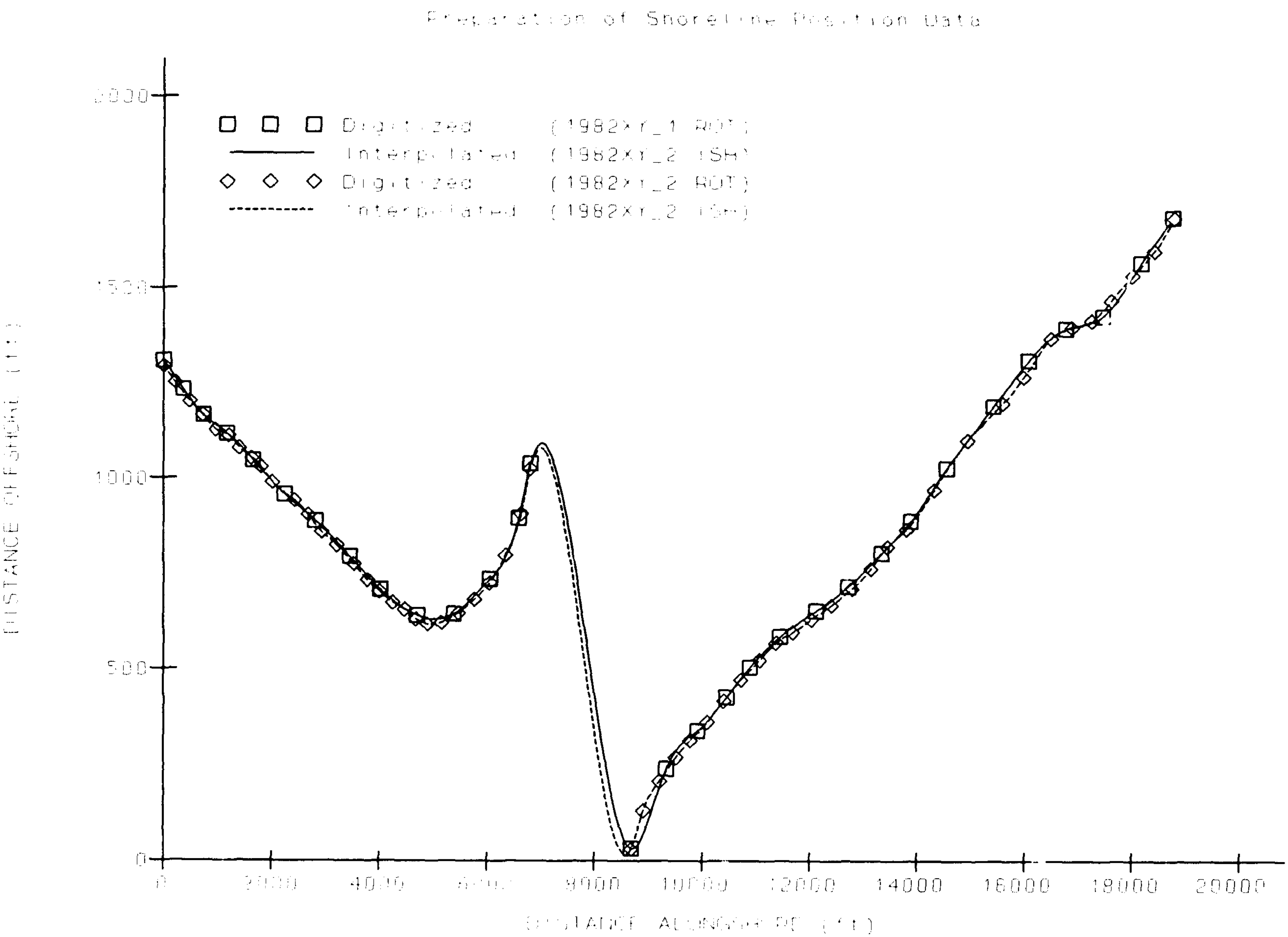


Figure 53. Digitized and interpolated shoreline position data

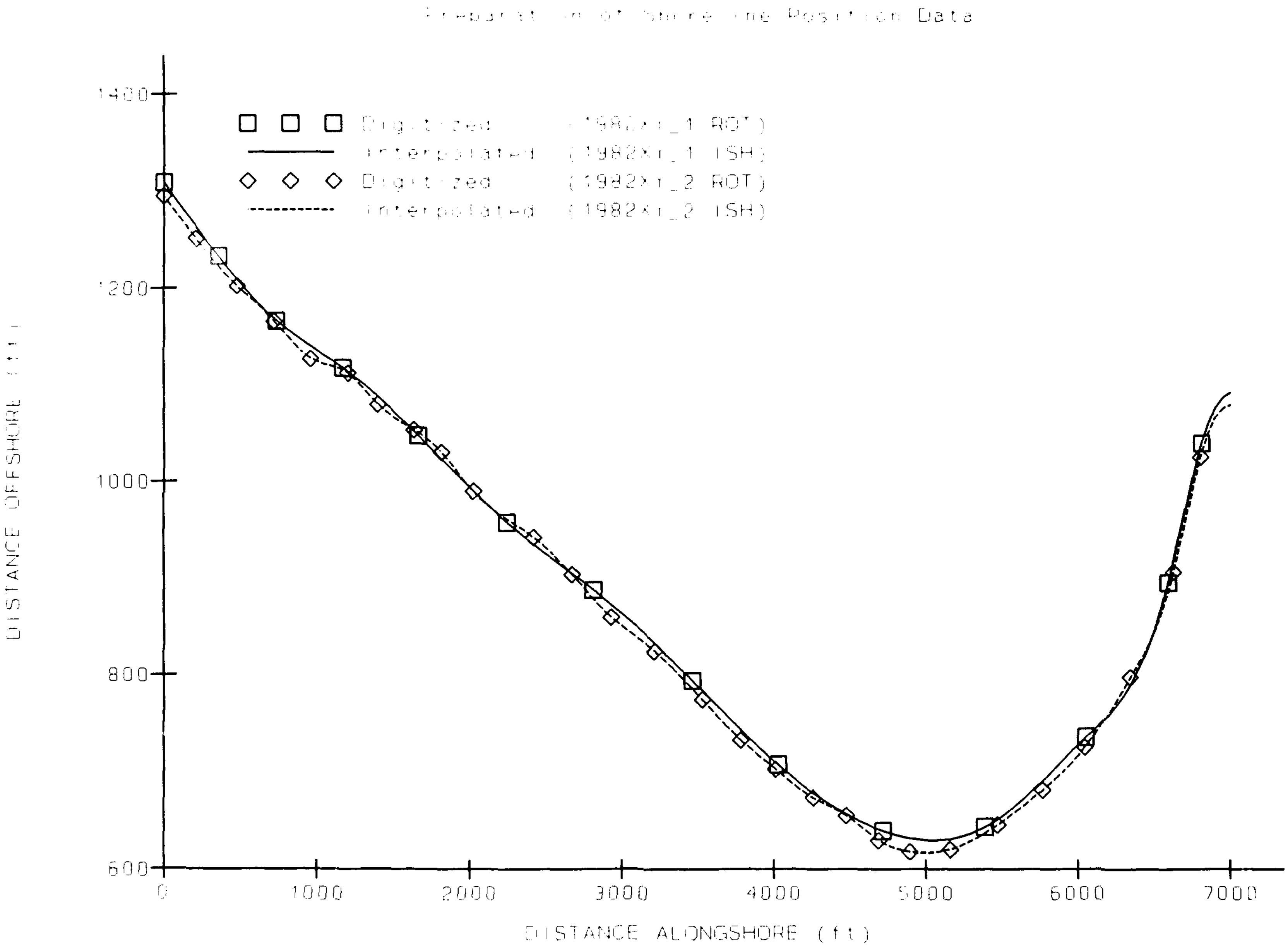


Figure 54. Digitized and interpolated shoreline position data, north reach

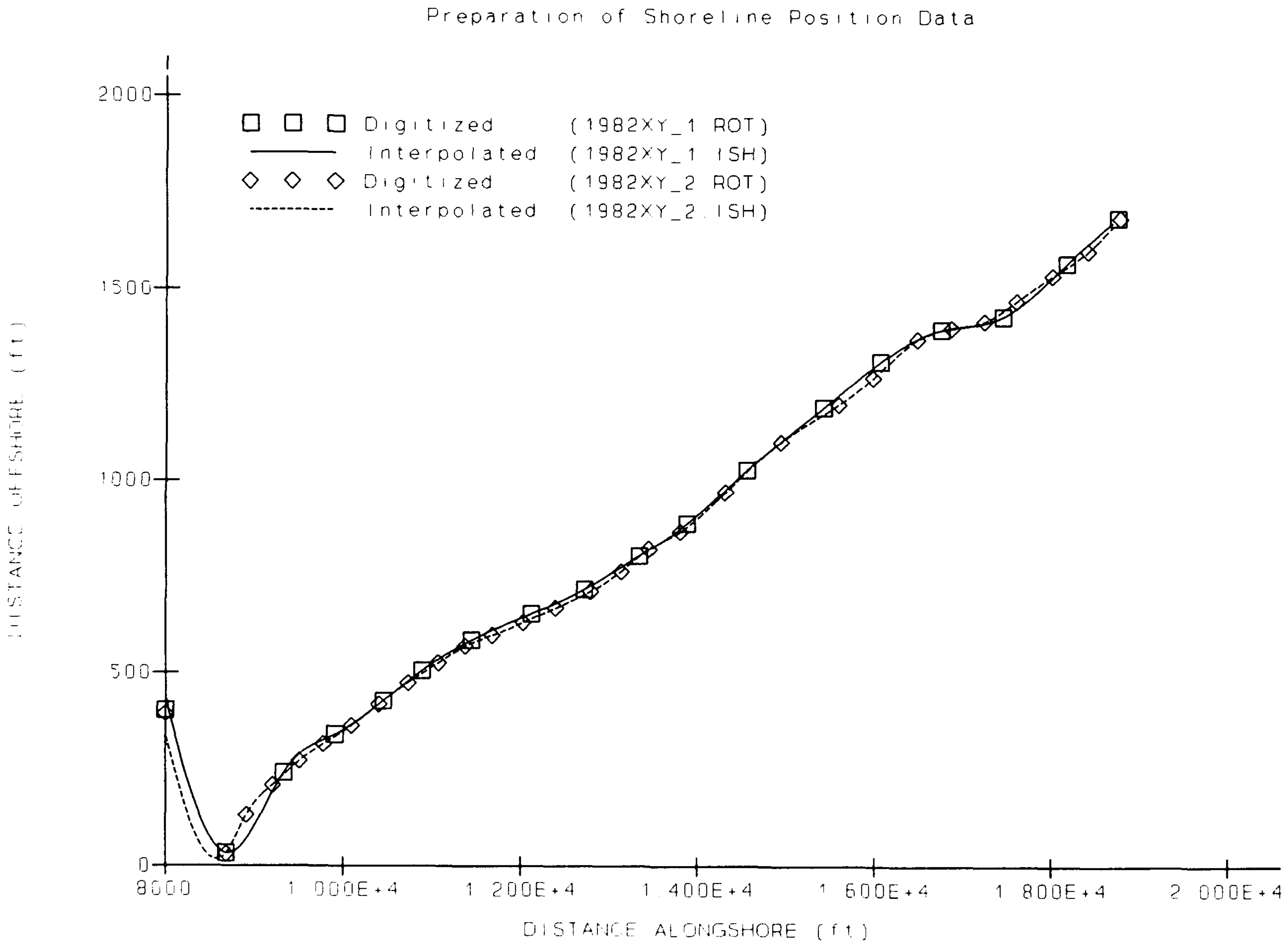


Figure 55. Digitized and interpolated shoreline position data, south reach

1982XY_2.ROT. Likewise, the dashed line is the interpolated shoreline position that was calculated from the second data set.

245. First of all, note the inlet located approximately 8,000 ft from the origin of the GENESIS coordinate system. Specification of the shoreline position in this region requires consideration not only of the shoreline but also the method of modeling the entire inlet system. The most common and recommended procedure is to divide the area of interest into two project reaches and model each separately. Another alternative would be to attempt to model across the inlet, treating the inlet throat as a fictitious shoreline. Therefore, for the remainder of this example, two model reaches will be considered, one north of the inlet and one south.

246. Figures 54 and 55 are plots of the digitized and interpolated shoreline positions for the north and south model reaches, respectively. It is observed that the second digitized data set (**1982XY_2**.ROT) contains almost double the number of digitized points as the first data set (**1982XY_1**.ROT). Consequently, the dashed shoreline that was interpolated from the second data set shows more detail and shoreline variation than the solid shoreline that was interpolated from the first data set. This is an important matter to consider when digitizing shoreline data. If the curvature of the shoreline changes steeply or there is a significant or peculiar variation in the shoreline in some area, the density of digitized points should be gradually increased as compared with areas where the shoreline is relatively straight. Note, in particular, the differences in interpolated shoreline positions at alongshore distance 5,000 ft in Figure 54 and between 9,000 and 10,000 ft in Figure 55.

247. In a given project, consistency between different shoreline positions data sets can be improved if the same individual performs all the digitizing. Two data sets digitized at different times or with different software packages should not be combined and then interpolated using the program CUINTP. Doing so may result in unrealistic shoreline undulations caused by the highly nonuniform spacing between the digitized data points and the cubic interpolation routine being used.

Step 4: Shoreline position data <u>files for input to GENESIS (WTSHO)</u>

248. This is the final step in the <u>Preparation of Shoreline Position Data</u> for input to the shoreline change model GENESIS. Because GENESIS

operates on a one-dimensional grid with alongshore cells of constant length, only the distance from the baseline (offshore distance) is required by the model to define the shoreline position. The program WTSHO will read the interpolated *X*-*Y* shoreline position data file created by the program CUINTP (a .ISH file) and write an output file containing only the distances of the shoreline from the model baseline (*Y*-value data) in a format that can be read by GENESIS. Other data files may be input to the program WTSHO provided the file name extension is .ISH and the data are in the format specified previously for .ISH files.

249. The program is executed by issuing the command WTSHO at the PC prompt. The program responds with a prompt for the input file name without an extension; in this example, the name *1982XY_1* was entered. Remember, all files input to WTSHO must have the extension .ISH.

250. Next, the program prompts for the output file name without an extension. The output file from the program WTSHO is automatically assigned the extension .SHO, indicating that the file contains shoreline position data ready for input to GENESIS. For this example, the name *1982CCN* is entered. This file name was selected because the shoreline data are for the year 1982, the hypothetical project is at Cape Canaveral (abbreviated in the file name as CC), and the letter "N" in the file name denotes that the shoreline data file is for the north reach. Similarly, the previously discussed file names all contained the year 1982 and the characters *XY*, indicating that the file contained both *X*- and *Y*-values that specified shoreline position. The extensions denoted whether the data were digitized (.DIG), rotated to the GENESIS coordinate system (.ROT), or interpolated (.ISH).

251. The program then reports to the monitor the cell spacing of the input interpolated shoreline position file and requests entry of the required cell spacing of the output file. The output cell spacing must be either equal to or an even multiple of the input file cell spacing. In this example, the value *100.0* is entered.

252. Next, the program reports to the monitor the beginning alongshore position (in this example *X* = 0.0) and the ending alongshore position (in this example *X* = 18700) read from the specified input file. The program then prompts for entry of the *X*-value at which the program should start writing the shoreline position data (in this example, the value *0.0* is entered). Then the program prompts for entry of the *X*-value at which the program should stop

writing the shoreline position data. Because an input shoreline file for the north reach is being generated, the user should stop writing the shoreline position data at the interpolated shoreline position nearest to the last digitized shoreline position north of the inlet. Recall from Figure 49 that the last digitized shoreline position north of the inlet was located at *X* = 6806.9 and *Y* = 1040.2. Therefore, the value *6800.0* is entered.

253. Next, the program prompts for information that will be written to the output file header. The first prompt requests entry of the date corresponding to the shoreline data. This date should be entered as a six-character integer; in this example, the value *820101* is entered. Next, the program prompts for entry of the system of units associated with the shoreline data. Since the interpolated shoreline position data are in feet, the value *1* is entered. If the data were expressed in meters, the value *2* would have been entered. The program then writes the specified shoreline data to the file **1982CCN.SHO** and terminates. A listing of this file is contained in Figure 56. Note that the four-line header of the file **1982CCN.SHO** contains a statement indicating that the data were measured (as opposed to predicted), the date, the cell spacing and system of units, together with the input file name from which the data were extracted, and the beginning and ending alongshore positions defining the north model reach.

254. The next step involves extracting the shoreline data for the south model reach by executing the program WTSHO again. This time, however, the specified beginning and ending alongshore positions will correspond to the south model reach. Responses to the program prompts are as follows:

- a. Input file name: *1982XY_1*
- b. Output file name: *1982CCS*
- c. Required cell spacing: *100.*

```
MEASURED SHORELINE POSITION OF 820101; CELL SPACING (DX=100. ft)
THESE DATA WERE OBTAINED FROM THE FILE: 1982xy_1.ISH
STARTING AT ALONGSHORE POSITION X=     0. AND ENDING AT X=  6800.
***************************************************************************
1308.9 1287.8 1266.8 1246.1 1225.9 1206.4 1188.4 1172.2 1158.5 1146.8
1136.3 1125.8 1114.6 1101.9 1088.0 1073.2 1057.7 1041.8 1025.7 1009.7
 994.0  978.7  964.2  950.6  937.8  925.6  913.6  901.7  889.4  876.6
 863.2  849.2  834.7  819.8  804.4  788.7  772.7  756.8  741.0  725.8
 711.3  697.8  685.3  674.0  663.9  655.0  647.2  640.8  635.7  632.1
 630.2  630.3  632.7  637.5  645.0  655.2  667.7  681.8  697.0  712.7
 728.3  743.2  759.1  779.4  807.8  848.0  903.7  972.6 1036.5
```

Figure 56. WTSHO output file **1982CCN.SHO**

d. Starting alongshore position: *8700.0*

e. Ending alongshore position: *18700.0*

f. Date of shoreline survey: *820101*

g. System of units: *1* (FEET)

255. Note that the specified output file name ends with an "S," indicating that the data pertain to the south model reach. Also, the starting alongshore position is specified at 8700. Recall from Figure 49 that this alongshore position corresponds to the nearest interpolated position to the digitized shoreline point closest to the south jetty at the inlet. The output file **1982CCS.SHO** is listed in Figure 57. Notice that the file **1982CCS.SHO** contains shoreline position data for 101 alongshore cells at a cell width of 100 ft. This number exceeds the maximum number of alongshore coordinates allowed in the PC version of the numerical model GENESIS. Therefore, the user would, at this point, have to determine if a suitable boundary condition could be implemented closer to the inlet <u>or</u> increase the cell spacing for the south model reach. This completes the <u>Preparation of Shoreline Data Analysis</u> for the first digitized data set.

256. The remaining task in this example is to generate shoreline position data files for the north and south model reaches using the second data set (**1982XY.ISH**) as input to the program WTSHO. This task is accomplished by executing the program WTSHO twice as was done previously for the first data set, except this time the name *1982XY_2* is entered at the prompt for the input file name. Listings of the two required shoreline data files for the north and south model reaches are given in Figures 58 and 59, respectively.

```
 MEASURED SHORELINE POSITION OF 820101; CELL SPACING (DX=100. ft)
 THESE DATA WERE OBTAINED FROM THE FILE: 1982xy_1.ISH
 STARTING AT ALONGSHORE POSITION X=  8700. AND ENDING AT X= 18700.
***************************************************************************
   32.0   39.7   63.9   99.4  141.6  185.5  226.3  259.4  283.9  301.9
  315.5  326.8  337.9  350.7  365.5  381.6  398.9  416.9  435.2  453.5
  471.6  489.3  506.4  522.6  538.1  552.7  566.3  579.1  591.0  601.9
  612.2  622.0  631.5  640.8  650.1  659.7  669.5  679.8  690.5  701.9
  714.1  727.0  740.6  754.7  769.2  783.9  798.5  813.0  827.3  842.0
  857.3  873.5  891.1  910.2  930.5  951.6  973.2  994.9 1016.3 1037.0
 1057.0 1076.3 1095.1 1113.6 1131.8 1149.9 1168.2 1186.6 1205.5 1224.5
 1243.6 1262.5 1281.1 1299.0 1316.1 1332.2 1347.0 1360.5 1372.4 1382.4
 1390.5 1396.5 1400.5 1403.5 1406.2 1409.7 1414.8 1422.4 1433.3 1447.7
 1465.2 1484.9 1506.2 1528.5 1551.0 1573.1 1594.4 1615.0 1635.0 1654.6
 1673.9
```

Figure 57. WTSHO output file **1982CCS.SHO**

```
 MEASURED SHORELINE POSITION OF 820101; CELL SPACING (DX=100. ft)
 THESE DATA WERE OBTAINED FROM THE FILE: 1982XY_2.ISH
 STARTING AT ALONGSHORE POSITION X=     0. AND ENDING AT X=  6800.
***************************************************************************
 1295.1 1274.4 1254.1 1234.6 1216.5 1200.2 1185.7 1170.4 1152.7 1135.5
 1124.7 1120.0 1113.2 1097.9 1080.2 1067.1 1057.2 1046.7 1032.8 1013.9
  993.9  977.8  965.7  955.5  945.0  932.2  916.9  899.6  881.4  864.3
  850.1  838.2  826.3  812.5  796.7  779.8  762.6  745.8  730.5  716.9
  704.1  691.2  679.4  670.0  662.4  653.0  640.5  629.1  621.8  618.2
  617.2  618.7  623.0  630.0  639.1  649.6  661.2  673.6  686.7  700.9
  717.4  737.5  761.0  786.7  813.6  846.2  892.9  959.5 1026.4
```

Figure 58. WTSHO output file **1982CCN2.SHO**

257. This completes the example application of the programs used in the Preparation of Shoreline Position Data analysis procedure. It is recommended that users not familiar with the procedures presented in this chapter repeat the analysis given in the example using the same two input data sets but substituting metric length units. This will require a positive response to the prompt, "*Do you want to perform a system of units conversion?*" issued during execution of the program SHORLROT. Remember that the digitized data (**1982XY_1.DIG** and **1982XY_2.DIG**) are expressed in feet so the required conversion will be from feet to meters.

```
 MEASURED SHORELINE POSITION OF 820101; CELL SPACING (DX=100. ft)
 THESE DATA WERE OBTAINED FROM THE FILE: 1982XY_2.ISH
 STARTING AT ALONGSHORE POSITION X=  8700. AND ENDING AT X= 18700.
***************************************************************************
   34.8   76.6  124.5  161.0  185.8  205.6  225.9  247.1  267.4  285.5
  301.6  316.7  331.6  346.9  363.1  380.6  398.8  417.1  434.9  452.1
  468.3  483.8  498.6  513.4  528.7  544.4  559.2  571.8  581.8  590.2
  598.5  607.4  617.0  626.8  636.8  646.9  657.0  667.2  677.6  688.3
  699.7  712.0  725.4  740.2  756.8  775.4  794.8  813.2  828.8  841.5
  853.3  866.3  882.2  900.8  921.6  943.7  966.5  989.5 1012.1 1034.1
 1055.3 1075.5 1094.3 1111.6 1127.4 1142.2 1156.4 1170.5 1184.8 1199.8
 1215.8 1233.1 1251.7 1271.9 1293.5 1315.2 1336.1 1354.8 1370.3 1381.7
 1389.7 1395.1 1398.9 1402.0 1405.9 1412.0 1421.6 1434.7 1450.3 1467.1
 1484.1 1500.9 1517.2 1532.8 1547.6 1562.4 1578.2 1595.8 1616.3 1639.0
 1663.4
```

Figure 59. WTSHO output file **1982CCS2.SHO**

Summary

258. This chapter on the analysis of shoreline position data concludes with a review of the more important points. First and foremost, if a nearshore wave transformation model is going to provide nearshore wave conditions for input to GENESIS, it is mandatory that the bathymetry grid used in the wave transformation model coincide in orientation with the shoreline grid used in GENESIS. In other words, the baselines of the two models must be parallel. Second, the density of the digitized shoreline points will determine the level of detail (and, to some degree, the accuracy) contained in the final shoreline data that will serve as input for the shoreline change simulation. In review of available shoreline survey data (maps, charts, aerial photographs) to specify the alongshore baseline, an elevation datum should also be selected, and all depths, including the shoreline position, should be referred to this datum.

259. Digitized shoreline position data should first be rotated to the GENESIS coordinate system without translating the origin. The generated output file ("filename.ROT") from this run should then be used to appropriately specify the origin translation distances. If a length units conversion is to be performed, it should be specified in the second step of the analysis, during execution of the program SHORLROT. Finally, all shoreline data written for input to the shoreline change model should be encompassed by digitized data (i.e., there should be at least one digitized shoreline point outside the interpolated data that will be input to GENESIS). This requirement applies especially to interior points such as at the inlet in the example application.

260. This analysis procedure can also be used to obtain seawall position data in the GENESIS coordinate system and format. The output file from WTSHO may, however, require some editing (entry of data points at shoreline points where a seawall does not exist (see Part VII)) prior to input to GENESIS.

PART V: OFFSHORE WAVE ANALYSIS

261. This chapter presents procedures for obtaining, analyzing, and preparing offshore wave data for input to GENESIS. The phrase "offshore wave data" refers to a time series of statistical wave height, period, and direction obtained from either a hindcast or wave measurements. These data may be input to GENESIS directly or used to drive an external wave transformation model. The procedures, computer programs, and a methodology for their use were developed to aid the modeler in the manipulation and transformation of hindcast wave data. Two data bases containing the WIS wave hindcast estimates are discussed, and an overview of the procedure for extracting a specific time series from the data base is given.

262. Three computer programs are introduced in this chapter. The first program, WAVETRAN, performs a spectral wave transformation (according to the WIS Phase III transformation procedure (Jensen 1983b)) from one depth to another. The second program, WTWAVTS, is a utility program that enables the user either to select a portion of a wave time series from a single file and write it to another file, or to append several files containing individual wave time series to obtain a single file containing a long time series. This program is needed because wave time series extracted from the CEDRS data base are limited to 1-year in length, and time series from 5 to 10 years in length are typically required in shoreline change modeling studies. The third program, WTWAVES, reads a specified WIS-type wave time series and writes a **WAVES**.ext file for input to GENESIS.

263. At the end of the chapter, a flow diagram for the analysis of offshore wave data is provided. This diagram presents the recommended sequence and usage of the analysis programs described and demonstrated in this chapter, as well as those presented and demonstrated in Part III.

Sources of Offshore Wave Information

Introduction

264. Within the Corps, there are several potential sources for obtaining wave information. These sources include the WIS hindcasts, Littoral Environment Observation (LEO) data, the Coastal Field Data Collection Program, the Monitoring Completed Coastal Projects Program, and data collected by Corps

Districts. Outside the Corps, wave data may be obtained from hindcasts performed by the Fleet Numeric Oceanographic Center of the US Navy, from the National Data Buoy Center, through the US Air Force Environmental Technical Applications Center, or from local or State agencies such as the Department of Natural Resources in California and Florida.

265. In shoreline response modeling projects, the modeler needs an uninterrupted wave record in order to perform long-term shoreline change simulations. This requirement often precludes the use of wave gage data, since the programs to collect these data are relatively new. Although sufficient for making estimates of the general characteristics of the incident wave climate, LEO data are typically not long-term or uninterrupted; and, in general, the observations are made only once daily, which is not frequent enough for use in shoreline change modeling efforts. Consequently, hindcast estimates of the incident wave conditions are most commonly used in shoreline change modeling; within the Corps, the WIS hindcast is the most comprehensive.

WIS hindcasts

266. The WIS hindcasts presently cover the 20-year time period between 1956 and 1975 for the Atlantic, Gulf of Mexico, and Pacific coasts, and plans exist to extend these hindcasts over the time period 1976 through 1985. In the Great Lakes, WIS hindcasts are presently being performed for the 32-year time period between 1956 and 1987. The WIS provides an extensive, comprehensive data base that typically represents the best available wave data for use in shoreline change modeling.

267. The WIS separates the wave climatology of the Atlantic and Pacific coasts into three phases:

a. Phase I - Numerical hindcast of deepwater wave data from historical surface pressure and wind data.

b. Phase II - Hindcast similar to Phase I with a finer grid and Phase I data, serving as the boundary conditions at the seaward edge of the Phase II grid.

c. Phase III - Transformation of Phase II wave data into shallow water, with simplifying assumptions.

In the Gulf of Mexico hindcast, the WIS shallow-water model was used because the gulf is a relatively small water body and certain wave frequencies will be transformed by the bathymetry. Therefore, the Gulf of Mexico hindcast differs from the Atlantic and Pacific hindcasts in that a Phase-II grid (30-nautical-mile resolution) was applied, and each WIS station is associated with a specific water depth. In the Great Lakes hindcast, the WIS deepwater model was used together with a 10-statute-mile resolution grid. Figure 60 provides a summary of WIS reports and types of data available.

WIS data bases

268. All of the WIS hindcasts are available and have been archived. Time series and/or statistical data may be obtained from several potential sources including; (a) the Sea-State Engineering Analysis System (SEAS), (b) the Coastal Engineering Data Retrieval System (CEDRS), and (c) members of the WIS staff. Statistical information for many of the WIS stations are contained in the WIS data reports listed in Figure 60.

269. The SEAS data base is a composite system that includes:

a. A data base of hindcast wave parameter data organized by location and chronologically by time interval.

b. A retrieval system to allow extraction of any subset of the data base.

c. A program library of statistical routines to produce desired data listings and reports.

Complete documentation of and a user's manual for the SEAS system is given in WIS Report 10 (McAneny 1986).

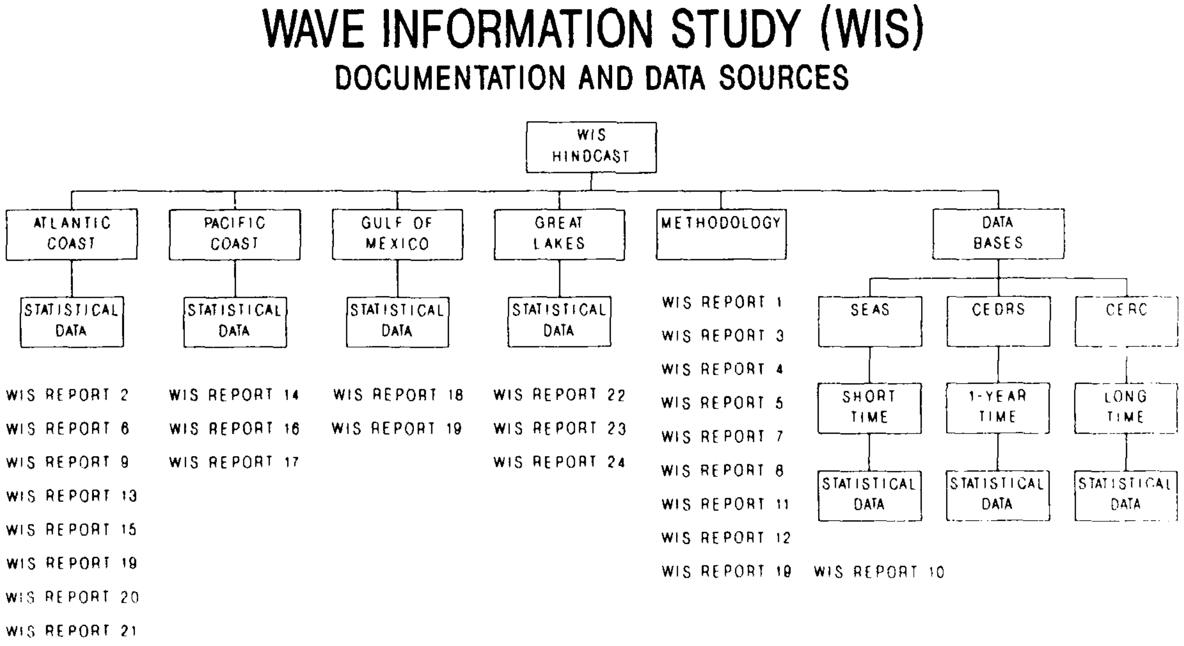


Figure 60. Summary of WIS documentation and data sources

270. The CEDRS data base is an interactive microcomputer resident data base system that provides both hindcast and measured wind and wave data for use in the field of coastal engineering. The general goal is to assemble, archive, and make available via CEDRS regional data bases containing data applicable to requirements of individual coastal Districts of the Corps of Engineers. The CEDRS data bases, as indicated, are compiled regionally, and each CEDRS data base will contain appropriate regional data from the WIS hindcasts, LEO observations, and measured wave data as well as other environmental data such as wind speed and direction. Consequently, CEDRS user's manuals are compiled individually for each region when the system is made available.

271. If neither the SEAS nor the CEDRS data base systems are available, WIS data can be obtained from the WIS staff at CERC. Requests for WIS data should be directed to "The Wave Information Study (WIS) Manager" at CERC.

WAVETRAN

Introduction

272. After WIS hindcast wave estimates are obtained, various analysis and/or transformation of the data must be performed prior to conducting a shoreline change simulation using GENESIS. Consideration should be given to the water depth associated with the data (GENESIS requires input of the water depth associated with the offshore wave input) and wave sheltering by nearby land masses or shoals. Typically, this step requires a transformation of the wave information from one water depth to a shallower depth, and the transformation may include the sheltering of wave energy from specific directions. The program WAVETRAN was designed to enable GENESIS users to perform these types of transformations. WAVETRAN, as presented in the following paragraphs, is a collection of computer programs (which have been converted into subroutines called by a main program) that were originally developed and used to produce the WIS Phase III data. The methodology for this transformation procedure is described in WIS Report 8 (Jensen 1983b). The programs are based on the assumptions of spectral transformation of sea and swell waves, with no additional energy input from wind, and straight and parallel bottom contours. These assumptions pertain to deeper water depths. Although the programs from which WAVETRAN was developed have been used operationally, they have not been

exhaustively documented and tested for general application and should be regarded as developmental software. Consequently, a source code listing of WAVETRAN is not included in the appendices. Figure 61 shows the three sources for obtaining WIS hindcast data and the input requirements of WAVETRAN, together with the generated output.

Calculation procedure

273. The basic methodology for the transformation of sea and swell waves from one depth to a shallower depth is described in detail by Jensen (1983b), and only a narrative description of the transformation will be given here. Both sea and swell waves are assumed to have a distribution of energy over a range of frequencies and directions. The energy spectrum in shallow water is governed by the TMA spectral form (Bouws et al. 1985) for both sea and swell. The acronym TMA was obtained by combining the first letter of the three data sets (Texel, MARSEN, and ARSLOE) used for field verification of the developed finite water depth spectral shape. Hughes (1984) provides a decription of the TMA and shallow-water spectrum with applications. The directional spread for sea and swell is given by the cosine function raised to the 4th and 8th power, respectively. The directional spectrum is discretized into frequency and direction components, and the components are treated independently, other than the limitation on total energy imposed by the TMA form in shallow water. Bottom contours between the WIS Phase II and Phase III points are assumed to be straight and parallel. Consequently, the selection of the shoreline orientation (assumed to be identical to the orientation of the bottom contours) should be done with care because it directly affects the transformation process. Within the start-up algorithm, an option is provided for sheltering the shallow-water point from wave energy approaching from specified wave directions. If this option is activated, wave components from the sheltered directions are deleted from the spectrum. This option is useful if the shallow-water site is partially sheltered from wave arrival by a nearby point of land or a large shoal.

274. The program WAVETRAN consists of a main program that prompts the user for the file name of the input and output time series; the format of the input time series (either SEAS or CEDRS); the local shoreline orientation (which should exactly correspond to the GENESIS and RCPWAVE baseline orientation); the water depth associated with the input time series, and the water depth to which the transformation is to be performed; the required

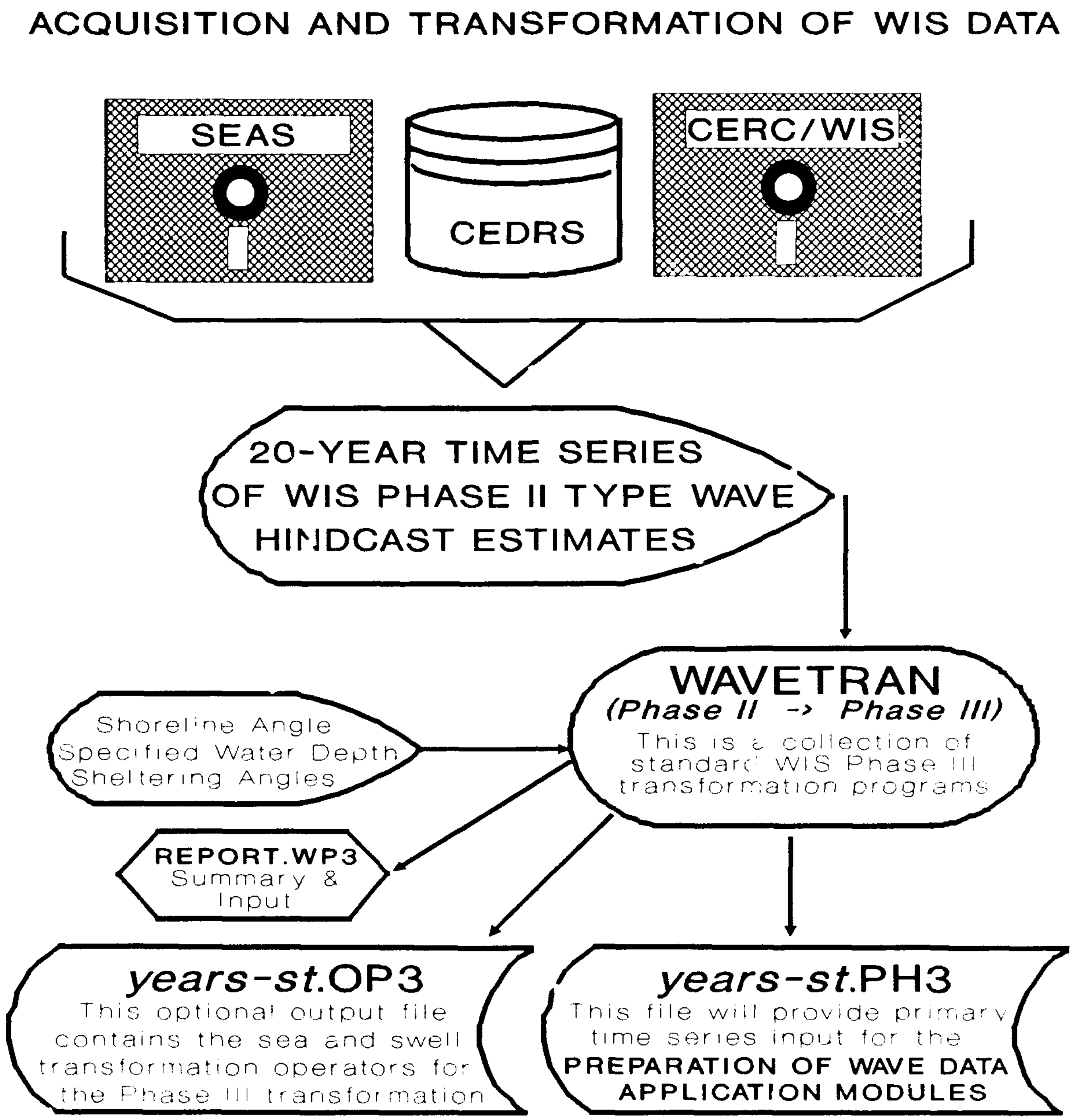


Figure 61. Data sources and transformation of WIS hindcast data

sheltering option and specification; and, finally, the transformation option that determines the disposition of the calculated transformation operators (this option and the implication of the various specifications will be discussed in detail in the examples that follow).

275. With the previously described inputs properly specified, the transformation calculations may proceed. Transformation operators are first calculated for sea conditions and then for swell conditions. Calculation of

the transformation operators requires one execution of the subroutine SPREF and two executions of the subroutines OPR1, OPR2, and COMBO (once for sea conditions and once for swell conditions), and represents approximately 95 percent of the computational effort in the transformation process.

276. The first subroutine call by the main program is to SPREF. This subroutine calculates the refraction and shoaling coefficients for each of the 40 frequency and 20 direction components of the discretized spectrum. Then the subroutine OPR1 is called by the main program. This subroutine calculates transformation operators for each of the 40 frequency bands and 20 direction bands and proceeds from shore-normal through 180 deg in a <u>counterclockwise direction</u>. The results (height and angle transformation operators) are stored in three-dimensional arrays for later use. Then the subroutine OPR2 is called by the main program. This subroutine performs the same computations as OPR1 except that the calculations proceed from shore-normal through 180 deg in a <u>clockwise direction</u>. After completion of OPR2, the main program calls the subroutine COMBO. This subroutine combines the first and second halves of the transformation operators computed by the subroutines OPR1 and OPR2 into a look-up table.

277. At this point the transformation operators for sea wave conditions have been computed. Then a flag is set for swell wave conditions and the subroutines SPREF, OPR1, OPR2, and COMBO are again called in sequence to compute transformation operators for swell wave conditions.

278. The final operation (and the actual transformation of Phase II to Phase III wave conditions) is performed by the subroutine PHASE3. This subroutine reads a set of wave parameters (wave height, period, and direction) from the input Phase II time series and interpolates the Phase III wave parameters from the look-up tables. An important aspect of this transformation procedure not readily apparent is that if a number of input time series files (for instance ten 1-year-long Phase II time series) need to be transformed to a particular Phase III site, then the transformation operators need be computed only once (the first time). In successive runs, the previously computed transformation operators can be accessed and used to perform the required transformations. This feature is enacted by the appropriate specification of the transformation option, as will be demonstrated in the following example applications.

Example applications

279. Operation and utility of the program WAVETRAN will now be demonstrated through five example applications. The first two examples demonstrate the transformation option feature, and the last three examples detail the various sheltering options.

280. Example 1. In this example, wave data in the SEAS format are used as input to the program WAVETRAN. This time series (shown in Figure 62) was fabricated specifically for the purposes of this example and does not represent an actual hindcast data set. The data in Figure 62 are assumed to exist in the default directory in a file named *TESTWP3.DAT*. This file name is entered when the program prompts the user for the input file name. This file must exist (it represents the input) in either the default directory or the directory path specified when the file name was entered; if not, the program will terminate.

281. The program then prompts for the output file name; in this example, the output file name *OUT1TST* is entered. This file name must not already exist in the working directory; if it is found in the directory, the program will terminate. This procedure precludes unintentional overwriting of an already transformed time series. Note that the output file extension is not requested and should not be entered. The program will assign the extension .PH3 to all output time series files. This naming convention was developed to help the user keep track of the multitude of computer files generated in the course of performing a shoreline change study. In summary, any file with a .PH3 extension represents a time series that has been transformed from a WIS Phase II station to a user-specified Phase III-type station via the program WAVETRAN.

282. The next prompt issued by the program requests the user to define the input data format. The two available options are either SEAS or CEDRS. In the present example, input time series were generated in the SEAS format, so the value *1* is entered. It is assumed that all input time series to the program WAVETRAN are either WIS Phase I or Phase II hindcast wave data obtained from SEAS, CEDRS, or WIS personnel at CERC.

283. The next prompt issued by the program requests entry of the local shoreline orientation in degrees measured counterclockwise from north. Figure 13 in Part III provides a schematic illustration of the shoreline

```
 A2028  51
62010100 125  3  10 125  3  10
62010103 150  3  20 150  3  20
62010106 175  3  30 175  3  30
62010109 200  3  40 200  3  40
62010112 250  3  50 250  3  50
62010115 300  3  60 300  3  60
62010118 350  3  70 350  3  70
62010121 400  3  80 400  3  80
62010200 425  3  90 425  3  90
62010203 400  3 100 400  3 100
62010206 350  3 110 350  3 110
62010209 300  3 120 300  3 120
62010212 250  3 130 250  3 130
62010215 200  3 140 200  3 140
62010218 175  3 150 175  3 150
62010221 150  3 160 150  3 160
62010300 125  3 170 125  3 170
62010303 125 10  10 125 10  10
62010306 150 10  20 150 10  20
62010309 175 10  30 175 10  30
62010312 200 10  40 200 10  40
62010315 250 10  50 250 10  50
62010318 300 10  60 300 10  60
62010321 350 10  70 350 10  70
62010400 400 10  80 400 10  80
62010403 425 10  90 425 10  90
62010406 400 10 100 400 10 100
62010409 350 10 110 350 10 110
62010412 300 10 120 300 10 120
62010415 250 10 130 250 10 130
62010418 200 10 140 200 10 140
62010421 175 10 150 175 10 150
62010500 150 10 160 150 10 160
62010503 125 10 170 125 10 170
62010506 125 25  10 125 25  10
62010509 150 25  20 150 25  20
62010512 175 25   0 175 25  30
62010515 200 25  40 200 25  40
62010518 250 25  50 250 25  50
62010521 300 25  60 300 25  60
62010600 350 25  70 350 25  70
62010603 400 25  80 400 25  80
62010606 425 25  90 425 25  90
62010609 400 25 100 400 25 100
62010612 350 25 110 350 25 110
62010615 300 25 120 300 25 120
62010618 250 25 130 250 25 130
62010621 200 25 140 200 25 140
62010700 175 25 150 175 25 150
62010703 150 25 160 150 25 160
62010706 125 25 170 125 25 170
```

Figure 62. Input time series for WAVETRAN Examples 1 through 5

orientation coordinate system used herein and in WIS. For this example, a shoreline orientation of *0* (deg) is entered.

284. Next, the program prompts for the user-specified local station identification code, which must be a five character alphanumeric identifier. It is suggested that this identification code include the Phase I or Phase II station number together with the Phase III station number. In this example, the identifier *31A28* is entered. The first three characters identify the Phase III station number (31A), and the last two characters identify the assumed Phase II station number (28).

285. The program then prompts for the water depth (in meters) associated with the input time series. If WIS provides a water depth for the Phase I or Phase II station, use it; otherwise, if deep water is assumed, enter the value -999. In this example, the value *-999* is entered. The program then prompts for the water depth (in meters) into which the transformation is to be made. For this example, the value 10 is entered.

286. The next prompt issued by the program requests specification of the sheltering option. The choices are: (0) no sheltering, (1) one-sided sheltering, and (2) two-sided sheltering. In this example, no sheltering was specified by entering the value 0. Detailed information on the specification of one-sided and two-sided sheltering are provided in Examples 3 through 5.

287. Next, the program prompts for the transformation option. The response to this prompt determines whether or not the transformation operators need to be computed, and, if so, whether they should be saved (written to a disk file). The choices are: (1) perform transformation, save transformation operators; (2) perform transformation using saved transformation operators; and (3) perform transformation, but do not save transformation operators. In this example, the value *1* is entered, indicating that the transformation operators should be saved (written to a disk file) for use in another transformation. If the response to this prompt is either *1* (as in this example) or *2*, the program prompts for the file name (without the extension) associated with the transformation operators. If transformation option *1* is selected, the computed transformation operators will be written to the file name specified (the file name extension automatically assigned by the program is .OP3). If transformation option *2* is selected, the transformation operators will be read from the specified file name (and the subroutines SPREF, OPR1, OPR2, and COMBO will be skipped, resulting in significant savings in computation time). In this example, the file name *SAVOPTST* is entered. After entering this response, the WIS Phase III computations begin.

288. In this example, three output files are generated (**REPORT.WP3**, **OUT1TST.PH3**, and **SAVOPTST.OP3**). The contents of the output file **REPORT.WP3** are shown in Figure 63. This file contains summary information including the transformed Phase II station number, the Phase III station number, shoreline orientation, Phase III water depth, and sheltering information, in addition to specific information about the sea and swell wave conditions read from the input file. **REPORT.WP3** will be overwritten each time the program is executed. Consequently, if the user wishes to save this information, the file must be renamed. It is suggested that the extension **.WP3** be preserved in the new file name for organizational purposes.

289. The transformed Phase III time series is written to the output file **OUT1TST.PH3**, shown in Figure 64. This file name (without the file name extension) was specified by the user at run time. The file contains

transformed wave conditions for each event in the input time series. Note in Figure 64 that there is symmetry in both the transformed wave height and wave angle. This correspondence results because similar symmetry existed in the hypothetical Phase II input time series (shown in Figure 62). The coordinate system for reporting the computed wave angles (Figure 64) is the same as the standard WIS Phase III coordinate system. Valid Phase III wave angles vary between 0 and 180 deg. Phase III wave angles increase from 0 in a counter-clockwise direction to 180 deg with respect to the shoreline, as shown in Figure 65.

290. The last output file (**SAVOPTST.OP3**) generated in this example application contains both the input specifications and the calculated transformation operators. This file is not shown herein because it is relatively large (356 Kb), and the data are not particularly informative to the casual observer. However, saving the transformation operators can result in significant reduction in computation time if several input time series need to be transformed to the identical Phase III station, as discussed in Example 2.

```
SEA AND SWELL INPUT DATA

TRANSFORMED PHASE 2 STATION NUMBER = A2028
PHASE 3 STATION NUMBER             = 31A28
SHORELINE ANGLE =    0.00  DEGREES AZIMUTH
PHASE III WATER DEPTH = 10.00  (m)
SHELTERING INFORMATION
     SHELTERING LEFT  =   0.00  DEGREES
     SHELTERING RIGHT = 180.00  DEGREES

          SEA OUTPUT INFORMATION

NUMBER OF FINITE SEA (P2) CONDITIONS =            51
NUMBER OF CONDITIONS PROCESSED       =            51
NUMBER OF CONDITIONS DEPTH LIMITED   =             0
NUMBER OF ZERO SEA WAVE HEIGHTS      =             0
NUMBER OF CONDITIONS GT RIGHT SHELT  =             0
NUMBER OF CONDITIONS LT LEFT  SHELT  =             0

          SWELL OUTPUT INFORMATION

NUMBER OF FINITE SWELL (P2) CONDITIONS =          51
NUMBER OF CONDITIONS PROCESSED         =          51
NUMBER OF CONDITIONS DEPTH LIMITED     =           0
NUMBER OF ZERO SWELL WAVE HEIGHTS      =           0
NUMBER OF CONDITIONS GT RIGHT SHELT    =           0
NUMBER OF CONDITIONS LT LEFT  SHELT    =           0
```

Figure 63. Example 1: Output file **REPORT.WP3**

```
                 31A28                    51
62010100        105.1    3.0   157.7     109.9    3.0   162.6
62010103        136.0    3.0   152.2     142.1    3.0   156.4
62010106        166.6    3.0   145.7     171.7    3.0   148.6
62010109        195.7    3.0   138.0     198.8    3.0   139.6
62010112        248.0    3.0   129.3     249.3    3.0   129.9
62010115        299.0    3.0   119.8     299.4    3.0   120.0
62010118        349.3    3.0   110.0     349.3    3.0   110.0
62010121        399.2    3.0   100.0     399.3    3.0   100.0
62010200        424.2    3.0    90.0     424.2    3.0    90.0
62010203        399.2    3.0    80.0     399.3    3.0    80.0
62010206        349.3    3.0    70.0     349.3    3.0    70.0
62010209        299.0    3.0    60.2     299.4    3.0    60.0
62010212        248.0    3.0    50.7     249.3    3.0    50.1
62010215        195.7    3.0    42.0     198.8    3.0    40.4
62010218        166.6    3.0    34.3     171.7    3.0    31.4
62010221        136.0    3.0    27.8     142.1    3.0    23.6
62010300        105.1    3.0    22.3     109.9    3.0    17.4
62010303         51.1   10.0   126.8      49.9   10.0   130.6
62010306         70.3   10.0   123.7      70.3   10.0   127.2
62010309         91.3   10.0   120.0      92.5   10.0   123.2
62010312        113.4   10.0   116.0     115.6   10.0   118.7
62010315        150.8   10.0   111.5     153.9   10.0   113.7
62010318        189.2   10.0   106.6     192.8   10.0   108.2
62010321        227.3   10.0   101.3     231.1   10.0   102.4
62010400        264.2   10.0    95.7     268.1   10.0    96.3
62010403        282.3   10.0    90.0     286.3   10.0    90.0
62010406        264.2   10.0    84.3     268.1   10.0    83.7
62010409        227.3   10.0    78.7     231.1   10.0    77.6
62010412        189.2   10.0    73.4     192.8   10.0    71.8
62010415        150.8   10.0    68.5     153.9   10.0    66.3
62010418        113.4   10.0    64.0     115.6   10.0    61.3
62010421         91.3   10.0    60.0      92.5   10.0    56.8
62010500         70.3   10.0    56.3      70.3   10.0    52.8
62010503         51.1   10.0    53.2      49.9   10.0    49.4
62010506         49.4   25.0   103.3      47.2   25.0   104.6
62010509         69.0   25.0   102.2      67.9   25.0   103.5
62010512         91.1   25.0   101.0      91.3   25.0   102.3
62010515        114.8   25.0    99.5     116.3   25.0   100.8
62010518        154.9   25.0    97.9     157.8   25.0    99.0
62010521        196.6   25.0    96.1     200.7   25.0    97.0
62010600        238.3   25.0    94.2     243.4   25.0    94.8
62010603        278.6   25.0    92.1     284.5   25.0    92.4
62010606        298.1   25.0    90.0     304.4   25.0    90.0
62010609        278.6   25.0    87.9     284.5   25.0    87.6
62010612        238.3   25.0    85.8     243.4   25.0    85.2
62010615        196.6   25.0    83.9     200.7   25.0    83.0
62010618        154.9   25.0    82.1     157.8   25.0    81.0
62010621        114.8   25.0    80.5     116.3   25.0    79.2
62010700         91.1   25.0    79.0      91.3   25.0    77.7
62010703         69.0   25.0    77.8      67.9   25.0    76.5
62010706         49.4   25.0    76.7      47.2   25.0    75.4
```

Figure 64. Example 1: Output file **OUT1TST.PH3**

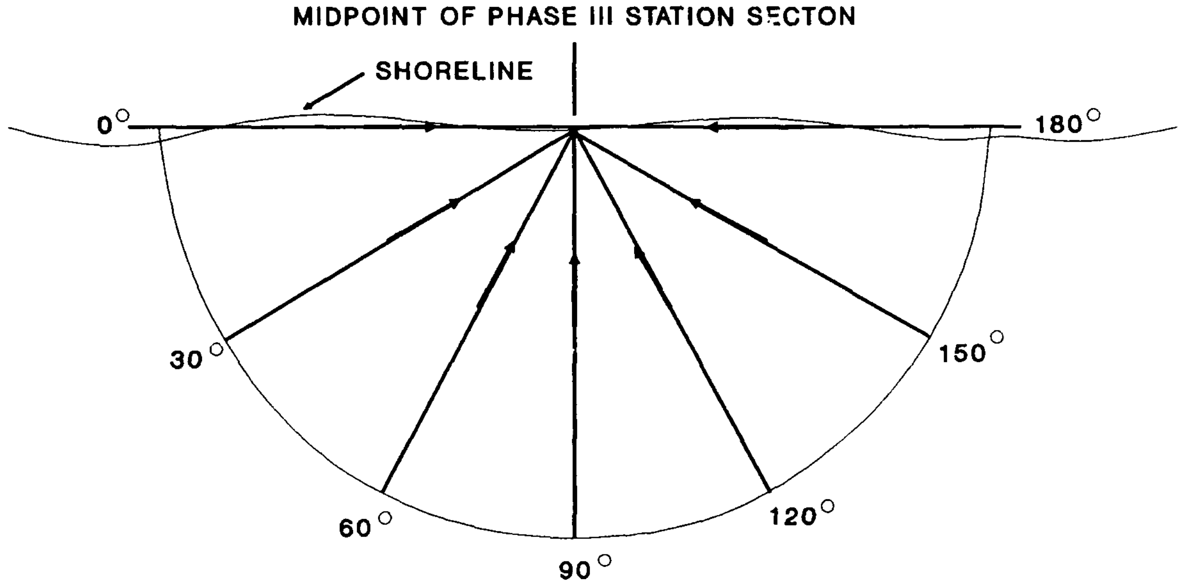


Figure 65. Phase III wave angle coordinate system convention

291. The total computation time for this example, after specification of the inputs, was approximately 40 min on a 386, 20-MHz PC with a math co-processor. Of the total computation time, approximately 39 min were spent creating the transformation operators. On a 286 processor, 10-MHz PC without a math co-processor, the computation *time for* this example is estimated (based on previous work performed by WIS) at approximately 33 hr. This much longer computation time is primarily due to the lack of a math co-processor; however, the processor clock speed is also an important performance parameter. Therefore, a PC equipped with a math co-processor is necessary for practical use of this computer program.

292. Example 2. In this example, the transformation operators generated in Example 1 will be used to transform the same input time series (shown in Figure 62) to the identically specified Phase III output station. The purpose of this example is to demonstrate the utility of saving the transformation operators when more than one input time series needs to be transformed to a given Phase III output station.

293. Execution of the program is initiated by issuing the command *WAVETRAN* at the prompt. The input specifications are nearly identical to those specified in Example 1, except that transformation option *2* (perform transformation using saved transformation operators) is selected. Regardless, responses to the program prompts are as follows:

a. Input file name: *TESTWP3.DAT*

b. Output file name: *OUT2TST*

c. Input data format: *1* (SEAS)

d. Shoreline orientation: *0*

e. Station identification code: *31B28*

f. Input water depth: *-999* (deepwater conditions)

g. Output water depth: *10*

h. Sheltering option: *0*

i. Transformation option: *2*

j. File name containing saved transformation operators: *SAVOPTST*

294. After the above inputs are specified, the transformation computations begin. First, the input specifications listed above in items c, d, f, g, and h are compared with those specified when the transformation operators were generated. If there are no differences, the transformation computations proceed; however, if differences are detected, the program writes the detected differences (to the PC monitor) between the input specification and the transformation operators and returns to the appropriate input prompt for re-specification of the differing inputs. This checking procedure was developed to preclude use of incorrect transformation operators.

295. The output files (**REPORT.WP3** and **OUT2TST.PH3**) for this example are provided in Figures 66 and 67. These output are identical to those shown in Figures 63 and 64, as they should be, because the inputs were the same. The significant point of this example is that the computation time (after specification of the inputs) was approximately 1 min.

296. Example 3. In this and the two remaining WAVETRAN examples, the specification of one- and two-sided sheltering will be demonstrated. One- and two-sided sheltering angles may be specified in 10-deg increments. Phase III wave energy sheltering is specified by selecting either sheltering option *1* (one-sided sheltering) or *2* (two-sided sheltering). If the response to the sheltering option prompt is *1*, then the program issues a prompt for the one-sided sheltering angle key (*KSH1*). If the response to the sheltering option is *2*, then the program issues a prompt for the one-sided (*KSH1*) and two-sided (*KSH2*) angle keys. Table 2 provides a listing of the valid one- and two-sided sheltering angle keys.

297. In this example the input time series shown in Figure 62 will be used as input, and one-sided sheltering between 0 and 30 deg will be specified. Responses to the program prompts are as follows:

a. Input file name: *TESTWP3.DAT*
b. Output file name: *OUT3TST*
c. Input data format: *1* (SEAS)
d. Shoreline orientation: *0*
e. Station identification code: *31C28*
f. Input water depth: *-999* (deepwater conditions)
g. Output water depth: *10*
h. Sheltering option: *1*
i. One-sided sheltering key (*KSH1*): *3*
j. Transformation option: *3*

298. At this point, all the required inputs have been specified, and the Phase III transformation begins. Note in line h (prompt for sheltering

```
SEA AND SWELL INPUT DATA

TRANSFORMED PHASE 2 STATION NUMBER = A2028
PHASE 3 STATION NUMBER             = 31B28
SHORELINE ANGLE =    0.00  DEGREES AZIMUTH
PHASE III WATER DEPTH = 10.00  (m)
SHELTERING INFORMATION
     SHELTERING LEFT  =   0.00  DEGREES
     SHELTERING RIGHT = 180.00  DEGREES

          SEA OUTPUT INFORMATION

NUMBER OF FINITE SEA (P2) CONDITIONS =          51
NUMBER OF CONDITIONS PROCESSED       =          51
NUMBER OF CONDITIONS DEPTH LIMITED   =           0
NUMBER OF ZERO SEA WAVE HEIGHTS      =           0
NUMBER OF CONDITIONS GT RIGHT SHELT  =           0
NUMBER OF CONDITIONS LT LEFT  SHELT  =           0

          SWELL OUTPUT INFORMATION

NUMBER OF FINITE SWELL (P2) CONDITIONS =        51
NUMBER OF CONDITIONS PROCESSED         =        51
NUMBER OF CONDITIONS DEPTH LIMITED     =         0
NUMBER OF ZERO SWELL WAVE HEIGHTS      =         0
NUMBER OF CONDITIONS GT RIGHT SHELT    =         0
NUMBER OF CONDITIONS LT LEFT  SHELT    =         0
```

Figure 66. Example 2: Output file **REPORT.WP3**

```
                31B28                      51
62010100     105.1     3.0   157.7      109.9      3.0   162.6
62010103     136.0     3.0   152.2      142.1      3.0   156.4
62010106     166.6     3.0   145.7      171.7      3.0   148.6
62010109     195.7     3.0   138.0      198.8      3.0   139.6
62010112     248.0     3.0   129.3      249.3      3.0   129.9
62010115     299.0     3.0   119.8      299.4      3.0   120.0
62010118     349.3     3.0   110.0      349.3      3.0   110.0
62010121     399.2     3.0   100.0      399.3      3.0   100.0
62010200     424.2     3.0    90.0      424.2      3.0    90.0
62010203     399.2     3.0    80.0      399.3      3.0    80.0
62010206     349.3     3.0    70.0      349.3      3.0    70.0
62010209     299.0     3.0    60.2      299.4      3.0    60.0
62010212     248.0     3.0    50.7      249.3      3.0    50.1
62010215     195.7     3.0    42.0      198.8      3.0    40.4
62010218     166.6     3.0    34.3      171.7      3.0    31.4
62010221     136.0     3.0    27.8      142.1      3.0    23.6
62010300     105.1     3.0    22.3      109.9      3.0    17.4
62010303      51.1    10.0   126.8       49.9     10.0   130.6
62010306      70.3    10.0   123.7       70.3     10.0   127.2
62010309      91.3    10.0   120.0       92.5     10.0   123.2
62010312     113.4    10.0   116.0      115.6     10.0   118.7
62010315     150.8    10.0   111.5      153.9     10.0   113.7
62010318     189.2    10.0   106.6      192.8     10.0   108.2
62010321     227.3    10.0   101.3      231.1     10.0   102.4
62010400     264.2    10.0    95.7      268.1     10.0    96.3
62010403     282.3    10.0    90.0      286.3     10.0    90.0
62010406     264.2    10.0    84.3      268.1     10.0    83.7
62010409     227.3    10.0    78.7      231.1     10.0    77.6
62010412     189.2    10.0    73.4      192.8     10.0    71.8
62010415     150.8    10.0    68.5      153.9     10.0    66.3
62010418     113.4    10.0    64.0      115.6     10.0    61.3
62010421      91.3    10.0    60.0       92.5     10.0    56.8
62010500      70.3    10.0    56.3       70.3     10.0    52.8
62010503      51.1    10.0    53.2       49.9     10.0    49.4
62010506      49.4    25.0   103.3       47.2     25.0   104.6
62010509      69.0    25.0   102.2       67.9     25.0   103.5
62010512      91.1    25.0   101.0       91.3     25.0   102.3
62010515     114.8    25.0    99.5      116.3     25.0   100.8
62010518     154.9    25.0    97.9      157.8     25.0    99.0
62010521     196.6    25.0    96.1      200.7     25.0    97.0
62010600     238.3    25.0    94.2      243.4     25.0    94.8
62010603     278.6    25.0    92.1      284.5     25.0    92.4
62010606     298.1    25.0    90.0      304.4     25.0    90.0
62010609     278.6    25.0    87.9      284.5     25.0    87.6
62010612     238.3    25.0    85.8      243.4     25.0    85.2
62010615     196.6    25.0    83.9      200.7     25.0    83.0
62010618     154.9    25.0    82.1      157.8     25.0    81.0
62010621     114.8    25.0    80.5      116.3     25.0    79.2
62010700      91.1    25.0    79.0       91.3     25.0    77.7
62010703      69.0    25.0    77.8       67.9     25.0    76.5
62010706      49.4    25.0    76.7       47.2     25.0    75.4
```

Figure 67. Example 2: Output file OUT2TST.PH3

Table 2

Sheltering Angle Specification (Keys)

Sheltering Option (KSH)	1-sided Sheltering Key (KHS1)	2-sided Sheltering Key (KSH2)	Sheltered Wave Angles, deg
0	not required	not required	none
1	1	not required	0 - 10
1	2	not required	0 - 20
1	3	not required	0 - 30
1	4	not required	0 - 40
1	5	not required	0 - 50
1	6	not required	0 - 60
1	7	not required	0 - 70
1	8	not required	0 - 80
1	9	not required	0 - 90
1	10	not required	80 - 180
1	11	not required	90 - 180
1	12	not required	100 - 180
1	13	not required	110 - 180
1	14	not required	120 - 180
1	15	not required	130 - 180
1	16	not required	140 - 180
1	17	not required	150 - 180
1	18	not required	160 - 180
1	19	not required	170 - 180
2	any value 1 thru 9	10	above & 80-180
2	any value 1 thru 9	11	above & 90-180
2	any value 1 thru 9	12	above & 100-180
2	any value 1 thru 9	13	above & 110-180
2	any value 1 thru 9	14	above & 120-180
2	any value 1 thru 9	15	above & 130-180
2	any value 1 thru 9	16	above & 140-180
2	any value 1 thru 9	17	above & 150-180
2	any value 1 thru 9	18	above & 160-180
2	any value 1 thru 9	19	above & 170-180

option) that the value *1* was entered indicating the user-required specification of one-sided sheltering. The next prompt (line i) requested specification of the one-sided sheltering key (*KSH1*), and the value *3* was entered, indicating that wave energy between 0 and 30 deg should be sheltered (removed from the spectra). Also, note in line j (prompt for transformation option) that the value *3* was entered, indicating that the transformation operators should not be saved. This response will prohibit the transformation operators from being written to a disk file, which may be desirable in a situation where disk space is limited or if only one input time series needs to be transformed.

299. The results of this example are written to the files **REPORT.WP3** and **OUT3TST.PH3**, and listings are provided in Figures 68 and 69. Note in Figure 68 that the left-side sheltering angle is 30 deg, which verifies that the wave energy between 0 and 30 deg was removed from the spectra. Also note in Figure 69 that the sea wave condition propagating normal to the shore in deep water (on 62010200) is slightly to the right of shore-normal at the Phase III station and that symmetry in the wave heights and angles is no longer evident. Both of these conditions result from the specified wave energy sheltering.

300. Example 4. In this example, the input time series shown in Figure 62 will again be used as input, and one-sided sheltering between 150 and 180 deg will be specified. Responses to the program prompts are as follows:

a. Input file name: *TESTWP3.DAT*
b. Output file name: *OUT4TST*
c. Input data format: *1* (SEAS)
d. Shoreline orientation: *0*
e. Station identification code: *31D28*
f. Input water depth: *-999* (deepwater conditions)
g. Output water depth: *10*
h. Sheltering option: *1*
i. One-sided sheltering key (*KSH1*): *17*
j. Transformation option: *3*

301. At this point, all the required inputs have been specified, and the Phase III transformation begins. Note that in line i the value *17* was entered as the response to the prompt for the one-sided sheltering key (*KSH1*). This entry specifies that wave energy between 150 and 180 deg (see Table 2) should be removed from the spectra.

302. The results of this example are written to the files **REPORT.WP3** and **OUT4TST.PH3**, and listings are provided in Figures 70 and 71. Note in Figure 70 that the right-side sheltering angle is 150 deg, which verifies that the wave energy between 150 and 180 deg was removed from the spectra. Again note the shift in the sea wave condition (on 62010200, compare Figures 62 and 71) from normal to the shore in deep water to slightly to the left of shore-normal at the Phase III station. Comparing Figures 71 and 69, the wave heights from north to south in Figure 69 are identical to those from south to

```
SEA AND SWELL INPUT DATA

TRANSFORMED PHASE 2 STATION NUMBER = A2028
PHASE 3 STATION NUMBER             = 31C28
SHORELINE ANGLE =   0.00  DEGREES AZIMUTH
PHASE III WATER DEPTH = 10.00  (m)
SHELTERING INFORMATION
     SHELTERING LEFT  =  30.00  DEGREES
     SHELTERING RIGHT = 180.00  DEGREES

          SEA OUTPUT INFORMATION

NUMBER OF FINITE SEA (P2) CONDITIONS =         51
NUMBER OF CONDITIONS PROCESSED       =         51
NUMBER OF CONDITIONS DEPTH LIMITED   =          0
NUMBER OF ZERO SEA WAVE HEIGHTS      =          0
NUMBER OF CONDITIONS GT RIGHT SHELT  =          0
NUMBER OF CONDITIONS LT LEFT  SHELT  =          0

          SWELL OUTPUT INFORMATION

NUMBER OF FINITE SWELL (P2) CONDITIONS =       51
NUMBER OF CONDITIONS PROCESSED         =       51
NUMBER OF CONDITIONS DEPTH LIMITED     =        0
NUMBER OF ZERO SWELL WAVE HEIGHTS      =        0
NUMBER OF CONDITIONS GT RIGHT SHELT    =        0
NUMBER OF CONDITIONS LT LEFT  SHELT    =        0
```

Figure 68. Example 3: Output file REPORT.WP3

north in Figure 71 (compare wave sea and swell wave heights from 62010100 to 62010300 in Figure 69 to those from 62010300 to 62010100 in Figure 71). Also, the shift in wave angle from shore-normal (90 deg) is identical in the same manner. This comparison demonstrates that the wave energy sheltering algorithm is being applied identically on both sides.

303. Example 5. In this example, two-sided sheltering (between 0 and 30 deg on the left, and between 150 and 180 deg on the right) is specified in the transformation of the input time series shown in Figure 62. Responses to the program prompts are as follows:

a. Input file name: *TESTWP3.DAT*

b. Output file name: *OUT5TST*

c. Input data format: *1* (SEAS)

d. Shoreline orientation: *0*

e. Station identification code: *31E28*

```
                  31C28                       51
62010100     105.1     3.0    157.7       110.0      3.0    162.6
62010103     136.0     3.0    152.2       142.1      3.0    156.4
62010106     166.6     3.0    145.7       171.7      3.0    148.6
62010109     195.7     3.0    138.0       198.8      3.0    139.6
62010112     248.0     3.0    129.3       249.3      3.0    129.9
62010115     299.0     3.0    119.8       299.4      3.0    120.0
62010118     349.3     3.0    110.0       349.3      3.0    110.0
62010121     399.2     3.0    100.0       399.3      3.0    100.0
62010200     423.7     3.0     90.1       424.2      3.0     90.0
62010203     397.0     3.0     80.6       399.1      3.0     80.0
62010206     342.9     3.0     71.9       348.2      3.0     70.3
62010209     286.0     3.0     64.2       294.8      3.0     61.3
62010212     227.2     3.0     57.7       237.3      3.0     53.5
62010215     168.6     3.0     52.2       176.4      3.0     47.2
62010218     132.3     3.0     47.7       135.4      3.0     42.4
62010221      97.7     3.0     43.9        94.5      3.0     38.8
62010300      66.8     3.0     40.7        58.3      3.0     36.1
62010303      51.1    10.0    126.8        49.9     10.0    130.6
62010306      70.3    10.0    123.7        70.3     10.0    127.2
62010309      91.3    10.0    120.0        92.5     10.0    123.2
62010312     113.4    10.0    116.0       115.6     10.0    118.7
62010315     150.8    10.0    111.5       153.9     10.0    113.7
62010318     189.2    10.0    106.6       192.8     10.0    108.2
62010321     227.3    10.0    101.3       231.1     10.0    102.4
62010400     264.2    10.0     95.7       268.1     10.0     96.3
62010403     282.1    10.0     90.0       286.3     10.0     90.0
62010406     263.5    10.0     84.5       268.1     10.0     83.8
62010409     225.5    10.0     79.3       230.7     10.0     77.7
62010412     185.5    10.0     74.5       191.3     10.0     72.1
62010415     144.9    10.0     70.4       150.2     10.0     67.3
62010418     105.7    10.0     66.8       108.8     10.0     63.3
62010421      81.5    10.0     63.8        81.5     10.0     60.1
62010500      59.1    10.0     61.3        55.6     10.0     57.7
62010503      39.7    10.0     59.1        33.7     10.0     55.9
62010506      49.4    25.0    103.3        47.2     25.0    104.6
62010509      69.0    25.0    102.2        67.9     25.0    103.5
62010512      91.1    25.0    101.0        91.3     25.0    102.3
62010515     114.8    25.0     99.5       116.3     25.0    100.8
62010518     154.9    25.0     97.9       157.8     25.0     99.0
62010521     196.6    25.0     96.1       200.7     25.0     97.0
62010600     238.3    25.0     94.2       243.4     25.0     94.8
62010603     278.5    25.0     92.1       284.5     25.0     92.4
62010606     298.0    25.0     90.0       304.4     25.0     90.0
62010609     278.0    25.0     87.9       284.4     25.0     87.6
62010612     236.8    25.0     86.0       243.1     25.0     85.3
62010615     193.5    25.0     84.2       199.5     25.0     83.1
62010618     150.1    25.0     82.6       154.7     25.0     81.3
62010621     108.5    25.0     81.2       110.6     25.0     79.8
62010700      83.0    25.0     80.1        81.9     25.0     78.6
62010703      59.7    25.0     79.1        55.3     25.0     77.7
62010706      39.8    25.0     78.2        33.2     25.0     77.1
```

Figure 69. Example 3: Output file OUT3TST.PH3

f. Input water depth: *-999* (deepwater conditions)

g. Output water depth: *10*

h. Sheltering option: *2*

i. Two-sided sheltering keys (*KSH1* and *KSH2*): *3,17*

j. Transformation option: *3*

304. The responses shown on lines h and i specify the requirement for two-sided sheltering. Note on line i that two values are entered. The first value (*3*) specifies the sheltering of wave energy from 0 to 30 deg, and the second value (*17*) specifies the sheltering of wave energy from 150 to 180 deg. The order of the two-sided sheltering angle keys is important. The first key (*KSH1*) is valid between *1* and *9* and should always be entered first; the second key (*KSH2*) is valid between *10* and *19* (see Table 2) and should always be entered last.

```
SEA AND SWELL INPUT DATA

TRANSFORMED PHASE 2 STATION NUMBER = A2028
PHASE 3 STATION NUMBER             = 31D28
SHORELINE ANGLE =   0.00  DEGREES AZIMUTH
PHASE III WATER DEPTH = 10.00  (m)
SHELTERING INFORMATION
     SHELTERING LEFT  =   0.00  DEGREES
     SHELTERING RIGHT = 150.00  DEGREES

          SEA OUTPUT INFORMATION

NUMBER OF FINITE SEA (P2) CONDITIONS =            51
NUMBER OF CONDITIONS PROCESSED       =            51
NUMBER OF CONDITIONS DEPTH LIMITED   =             0
NUMBER OF ZERO SEA WAVE HEIGHTS      =             0
NUMBER OF CONDITIONS GT RIGHT SHELT  =             0
NUMBER OF CONDITIONS LT LEFT  SHELT  =             0

          SWELL OUTPUT INFORMATION

NUMBER OF FINITE SWELL (P2) CONDITIONS =          51
NUMBER OF CONDITIONS PROCESSED         =          51
NUMBER OF CONDITIONS DEPTH LIMITED     =           0
NUMBER OF ZERO SWELL WAVE HEIGHTS      =           0
NUMBER OF CONDITIONS GT RIGHT SHELT    =           0
NUMBER OF CONDITIONS LT LEFT  SHELT    =           0
```

Figure 70. Example 4: Output file **REPORT.WP3**

```
               31D28                   51
62010100      66.8     3.0   139.3       58.3     3.0   143.9
62010103      97.7     3.0   136.1       94.5     3.0   141.2
62010106     132.3     3.0   132.3      135.4     3.0   137.6
62010109     168.6     3.0   127.8      176.4     3.0   132.8
62010112     227.2     3.0   122.3      237.3     3.0   126.5
62010115     286.0     3.0   115.8      294.8     3.0   118.7
62010118     342.9     3.0   108.1      348.2     3.0   109.7
62010121     397.0     3.0    99.4      399.1     3.0   100.0
62010200     423.7     3.0    89.9      424.2     3.0    90.0
62010203     399.2     3.0    80.0      399.3     3.0    80.0
62010206     349.3     3.0    70.0      349.3     3.0    70.0
62010209     299.0     3.0    60.2      299.4     3.0    60.0
62010212     248.0     3.0    50.7      249.3     3.0    50.1
62010215     195.7     3.0    42.0      198.8     3.0    40.4
62010218     166.6     3.0    34.3      171.7     3.0    31.4
62010221     136.0     3.0    27.8      142.1     3.0    23.6
62010300     105.1     3.0    22.3      110.0     3.0    17.4
62010303      39.7    10.0   120.9       33.7    10.0   124.1
62010306      59.1    10.0   118.7       55.6    10.0   122.3
62010309      81.5    10.0   116.2       81.5    10.0   119.9
62010312     105.7    10.0   113.2      108.8    10.0   116.7
62010315     144.9    10.0   109.6      150.2    10.0   112.7
62010318     185.5    10.0   105.5      191.3    10.0   107.9
62010321     225.5    10.0   100.7      230.7    10.0   102.3
62010400     263.5    10.0    95.5      268.1    10.0    96.2
62010403     282.1    10.0    90.0      286.3    10.0    90.0
62010406     264.2    10.0    84.3      268.1    10.0    83.7
62010409     227.3    10.0    78.7      231.1    10.0    77.6
62010412     189.2    10.0    73.4      192.8    10.0    71.8
62010415     150.8    10.0    68.5      153.9    10.0    66.3
62010418     113.4    10.0    64.0      115.6    10.0    61.3
62010421      91.3    10.0    60.0       92.5    10.0    56.8
62010500      70.3    10.0    56.3       70.3    10.0    52.8
62010503      51.1    10.0    53.2       49.9    10.0    49.4
62010506      39.8    25.0   101.8       33.2    25.0   102.9
62010509      59.7    25.0   100.9       55.3    25.0   102.3
62010512      83.0    25.0    99.9       81.9    25.0   101.4
62010515     108.5    25.0    98.8      110.6    25.0   100.2
62010518     150.1    25.0    97.4      154.7    25.0    98.7
62010521     193.5    25.0    95.8      199.5    25.0    96.9
62010600     236.8    25.0    94.0      243.1    25.0    94.7
62010603     278.0    25.0    92.1      284.4    25.0    92.4
62010606     298.0    25.0    90.0      304.4    25.0    90.0
62010609     278.5    25.0    87.9      284.5    25.0    87.6
62010612     238.3    25.0    85.8      243.4    25.0    85.2
62010615     196.6    25.0    83.9      200.7    25.0    83.0
62010618     154.9    25.0    82.1      157.8    25.0    81.0
62010621     114.8    25.0    80.5      116.3    25.0    79.2
62010700      91.1    25.0    79.0       91.3    25.0    77.7
62010703      69.0    25.0    77.8       67.9    25.0    76.5
62010706      49.4    25.0    76.7       47.2    25.0    75.4
```

Figure 71. Example 4: Output file OUT4TST.PH3

305. Figures 72 and 73 contain listings of the output files **REPORT.WP3** and **OUT5TST.PH3** generated in this example transformation. Figure 72 shows that the left-sheltering angle is 30 deg, indicating that wave energy between 0 and 30 deg is removed from the spectra and that the right-sheltering angle is 150 deg, which in turn indicates that wave energy between 150 and 180 deg is removed from the spectra during the transformation from the Phase II station to the Phase III station.

306. In Figure 73, note that after the transformation, which in this example included symmetrical sheltering, symmetry is again apparent in both wave height and angle. Also note that the estimated Phase III wave heights and angles (Figure 73) to the right of shore-normal are the same as those calculated in Example 4 (Figure 71); likewise, estimated Phase III wave heights and angles (Figure 73) to the left of shore-normal are identical to those calculated in Example 3 (Figure 69). This comparison again demonstrates that the algorithm for the sheltering of wave energy is implemented in the same manner for both one- and two-sided sheltering.

Summary

307. The WIS Phase III methodology implemented through the use of the program WAVETRAN as discussed above is a powerful tool available to the coastal engineer engaged in a shoreline change modeling study using GENESIS or any other shoreline change model. WAVETRAN allows for the transformation of hindcast wave estimates from one station to another in shallower water. Furthermore, wave energy sheltering by land, shallow shoals, and, to some extent, structures located well offshore and to the left or right of the immediate project reach can be represented by specifying sheltering angles in 10-deg increments. Sheltering angles should be evaluated by locating the project reach on a regional map and plotting potential sheltering angles. Potential longshore sand transport rates should then be calculated to determine the amount and consistency of the applied sheltering. The modeler is cautioned, however, not to use this program arbitrarily simply to achieve a desired result. A computer program should never be relied upon as a substitute for sound engineering analysis, and all input specifications, particularly sheltering, should be founded on the physical or geological setting of the particular project site.

```
SEA AND SWELL INPUT DATA

TRANSFORMED PHASE 2 STATION NUMBER = A2028
PHASE 3 STATION NUMBER             = 31E28
SHORELINE ANGLE =   0.00  DEGREES AZIMUTH
PHASE III WATER DEPTH = 10.00  (m)
SHELTERING INFORMATION
     SHELTERING LEFT  =  30.00  DEGREES
     SHELTERING RIGHT = 150.00  DEGREES

               SEA OUTPUT INFORMATION

NUMBER OF FINITE SEA (P2) CONDITIONS    =        51
NUMBER OF CONDITIONS PROCESSED          =        51
NUMBER OF CONDITIONS DEPTH LIMITED      =         0
NUMBER OF ZERO SEA WAVE HEIGHTS         =         0
NUMBER OF CONDITIONS GT RIGHT SHELT     =         0
NUMBER OF CONDITIONS LT LEFT  SHELT     =         0

               SWELL OUTPUT INFORMATION

NUMBER OF FINITE SWELL (P2) CONDITIONS =         51
NUMBER OF CONDITIONS PROCESSED          =        51
NUMBER OF CONDITIONS DEPTH LIMITED      =         0
NUMBER OF ZERO SWELL WAVE HEIGHTS       =         0
NUMBER OF CONDITIONS GT RIGHT SHELT     =         0
NUMBER OF CONDITIONS LT LEFT  SHELT     =         0
```

Figure 72. Example 5: Output file **REPORT.WP3**

WTWAVTS

Introduction

308. The program WTWAVTS is a utility program that allows manipulation of disk files containing wave data in the form of a time series. The program can select a specific time interval within a time series with a given time-step and write a new time series with a new time-step. For example, suppose that a 5-year-long time series at a time-step of 3 hr is given and the goal is to calculate the potential longshore sand transport rate of the third year using a time-step of 6 hr; the program WTWAVTS creates this specific 1-year-long time series with a 6-hr time-step. Then the program SEDTRAN (presented in Part III) can be used to calculate the potential longshore sand transport rate. WTWAVTS (through successive runs) can also be used to create a 10- or 20-year-long time series with a 6- or 9-hr time-step from ten or twenty 1-year-long time series with a 3-hr time-step. The file handling utility of

```
                  31E28                  51
62010100      66.8     3.0   139.3      58.3     3.0   143.9
62010103      97.7     3.0   136.1      94.5     3.0   141.2
62010106     132.3     3.0   132.3     135.4     3.0   137.6
62010109     168.6     3.0   127.8     176.4     3.0   132.8
62010112     227.2     3.0   122.3     237.3     3.0   126.5
62010115     286.0     3.0   115.8     294.8     3.0   118.7
62010118     342.9     3.0   108.1     348.2     3.0   109.7
62010121     396.9     3.0    99.4     399.1     3.0   100.0
62010200     423.3     3.0    90.0     424.2     3.0    90.0
62010203     397.0     3.0    80.6     399.1     3.0    80.0
62010206     342.9     3.0    71.9     348.2     3.0    70.3
62010209     286.0     3.0    64.2     294.8     3.0    61.3
62010212     227.2     3.0    57.7     237.3     3.0    53.5
62010215     168.6     3.0    52.2     176.4     3.0    47.2
62010218     132.3     3.0    47.7     135.4     3.0    42.4
62010221      97.7     3.0    43.9      94.5     3.0    38.8
62010300      66.8     3.0    40.7      58.3     3.0    36.1
62010303      39.7    10.0   120.9      33.7    10.0   124.1
62010306      59.1    10.0   118.7      55.6    10.0   122.3
62010309      81.5    10.0   116.2      81.5    10.0   119.9
62010312     105.7    10.0   113.2     108.8    10.0   116.7
62010315     144.9    10.0   109.6     150.2    10.0   112.7
62010318     185.5    10.0   105.5     191.3    10.0   107.9
62010321     225.5    10.0   100.7     230.7    10.0   102.3
62010400     263.5    10.0    95.5     268.1    10.0    96.2
62010403     282.0    10.0    90.0     286.3    10.0    90.0
62010406     263.5    10.0    84.5     268.1    10.0    83.8
62010409     225.5    10.0    79.3     230.7    10.0    77.7
62010412     185.5    10.0    74.5     191.3    10.0    72.1
62010415     144.9    10.0    70.4     150.2    10.0    67.3
62010418     105.7    10.0    66.8     108.8    10.0    63.3
62010421      81.5    10.0    63.8      81.5    10.0    60.1
62010500      59.1    10.0    61.3      55.6    10.0    57.7
62010503      39.7    10.0    59.1      33.7    10.0    55.9
62010506      39.8    25.0   101.8      33.2    25.0   102.9
62010509      59.7    25.0   100.9      55.3    25.0   102.3
62010512      83.0    25.0    99.9      81.9    25.0   101.4
62010515     108.5    25.0    98.8     110.6    25.0   100.2
62010518     150.1    25.0    97.4     154.7    25.0    98.7
62010521     193.5    25.0    95.8     199.5    25.0    96.9
62010600     236.8    25.0    94.0     243.1    25.0    94.7
62010603     278.0    25.0    92.1     284.4    25.0    92.4
62010606     297.9    25.0    90.0     304.4    25.0    90.0
62010609     278.0    25.0    87.9     284.4    25.0    87.6
62010612     236.8    25.0    86.0     243.1    25.0    85.3
62010615     193.5    25.0    84.2     199.5    25.0    83.1
62010618     150.1    25.0    82.6     154.7    25.0    81.3
62010621     108.5    25.0    81.2     110.6    25.0    79.8
62010700      83.0    25.0    80.1      81.9    25.0    78.6
62010703      59.7    25.0    79.1      55.3    25.0    77.7
62010706      39.8    25.0    78.2      33.2    25.0    77.1
```

Figure 73. Example 5: Output file OUT5TST.PH3

this program is demonstrated through six example applications in the following sections, but first a short explanation of the program flow is provided in the following section.

Calculation procedure

309. Either the program WTWAVTS copies data from an existing user-specified file (the input time series) to a new user-specified file (the output time series), or it copies data from an existing user-specified file (the input time series) and appends it to an existing user-specified file (the output file). In the case where data are to be appended to an existing file, the data in the existing output file are first copied to a "scratch" file to preserve it. Then the file header information is updated, and the old data are copied from the "scratch" file to the existing output file; finally, the new data are copied from the input file to the updated output file. Prior to copying wave data from the input file (or updating the output file header), the input file is scanned to verify that the time interval specified exists within the input time series. If the specified time interval (beginning and ending dates) is not found, the program terminates and reports the reason for termination to the PC monitor. Input requirements beyond specification of the input and output file names include: (a) input file format; (b) time-step of input time series; (c) if the input file is not a SEAS or CEDRS file, then the number of events per record (i.e., sea, swell, or both); (d) if the output file exists, whether to append or overwrite it; (e) the time interval to be copied from the input time series; and (f) the time-step associated with the new time series. The time-step of the new time series must be equal to or an even multiple of the time-step of the input time series. Output from the program WTWAVTS is either a new time series or an updated existing time series. Operation of the program is demonstrated in the following section.

Example applications

310. The operation and utility of the program WTWAVTS will now be demonstrated through six example applications. The examples use as input all five of the allowed input time series formats. Examples 3 and 5 demonstrate the *append* option, whereas Example 4 demonstrates the *overwrite* option.

311. Example 1. In this example, a standard SEAS input time series comprises the input. The file name of this input time series is **WVSEAS.DAT** and is the same input file used in the RCRIT Example 1 (file listing provided

in Figure 12) in Part III. Execution of the program is initiated by issuing the command *WTWAVTS* at the PC prompt.

312. The program responds by prompting for the input file name and extension. If the input file is not located in the default directory, the appropriate path should also be entered. For this example, the name *WVSEAS.DAT* is entered. This file must exist (it represents the input), or the program will terminate.

313. The next prompt issued by the program requests the user to define the input data format. The available options are: (1) SEAS, (2) OUTPUT FROM ANOTHER WORKBOOK CODE (Header and Format similar to SEAS), (3) CEDRS, (4) OUTPUT FROM ANOTHER WORKBOOK CODE (Header and Format similar to CEDRS), and (5) other. In the present example, the input time series was retrieved using SEAS, so the value *1* is entered.

314. The program then prompts for the time-step of the input time series. The time-step of this time series is 3 hr (see Figure 12), so the value *3* is entered.

315. Next, the program prompts for the file name of the output time series; in this example, the file name *WTOUT1* is entered. Note that the output file name extension is <u>not</u> requested and should not be entered. The program will automatically assign the extension **.OTS** (representing offshore time series) to all output time series. This file may or may not exist, because the program scans the default directory (or the specific directory entered together with the output file name) to determine the existence of the file. If the file is found, the program will ask if the file should be appended. If the response is positive, the file will be appended. If the response is negative, the program will ask if the file should be overwritten. If the user responds to this question positively, the file will be overwritten, and the data in the file will be lost. If the user responds negatively, the program will request entry of a new output file name. Examples 3, 4, and 5 will review each of these options associated with an existing output file. In this example, the directory scan determines that the file does not already exist, so the program creates the file **WTOUT1.OTS**.

316. The program then requests the time interval of the new (output) time series. First, the program prompts for the starting date; in this example, the value *62030500* (1962, March 5, midnight) is entered. This is the first record in the input time series (Figure 12). Next, the program prompts

for the ending data; and the value *62031015* (1962, March 10, 3:00 p.m.) is entered. This is the 46th record in the input time series. The required format of the date specifications is (YYMMDDHH) and is defined as follows: the first two characters (YY) are the year specification, the next two characters (MM) are the month specification, the next two characters (DD) are the day specification, and the last two characters (HH) are the hour specification.

317. The last prompt issued by the program before the output time series is copied from the input time series requests input of the required time-step of the output time series. This value must be either equal to or an even multiple of the time-step of the input time series. In this example, the value *9* is entered, indicating that the required time-step of the output time series is 9 hr.

318. At this point all the required program inputs have been specified. First, the program reads the station identification code from the input time series header. Then the program scans the input time series for the specified starting and ending dates, and at the same time counts the number of records that will be contained in the output time series. After finding the beginning and ending records of the new time series, the program writes the file header, which consists of the station identification code and the number of records. Then the input time series is rewound, and the new time series is copied from the input time series. In the present example, the first and then every third record encountered in the input time series is copied to the user-specified output file. When the specified ending date (62031015) is encountered, the program terminates.

319. A listing of the new time series created by this example application of the program WTWAVTS is provided in Figure 74. Note that the specified beginning and ending dates are included in the new time series and that the time-step is indeed 9 hr, as specified.

320. Example 2. In this example, the Phase III time series generated in WAVETRAN Example 1 and listed in Figure 64 will serve as the input time series. Responses to the program prompts are as follows:

a. Input file name: *OUT1TST.PH3*

b. Input data format: *2* (OUTPUT FROM ANOTHER WORKBOOK CODE; header and format similar to SEAS)

c. Number of events per record: *2*

d. Time-step of input time series: *3*

e. Output file name: *WTOUT2*

f. Beginning date of output time series: *62010100*

g. Ending date of output time series: *62010300*

h. Time-step of output time series: *3*

321. Note in line c of the user responses that the program requests entry of the number of events per record. This prompt was not required in Example 1 because the input time series was retrieved from the original WIS data base, which always contains two events per record. However, because the input time series in this example was generated by another workbook program, the number of events per record is unknown and must be specified by the user.

322. At this point, all the required inputs have been specified and the program begins to process the output time series. The sequence of events as described above (in Example 1) is performed, and the output time series is created. In this example, however, each event between the dates 62010100 and 62010300 inclusive is written to the output file **WTOUT2.OTS**. A listing of this output time series is provided in Figure 75. This time series will be appended in the next example, but to preserve this original time series, the file **WTOUT2.OTS** was copied to the file **WTOUT3.OTS** by issuing the command: *COPY WTOUT2.OTS WTOUT3.OTS* from the default directory.

323. Example 3. In this example, the time series generated in Example 2 (which was copied to the file named **WTOUT3.OTS**) will be appended with a

```
                          A2028      16
62030500        40.0     3.0  341.0          0.0      0.0      0.0
62030509        66.0     4.0   48.0          0.0      0.0      0.0
62030518        89.0     4.0   65.0          0.0      0.0      0.0
62030603       295.0     7.0   69.0          0.0      0.0      0.0
62030612       398.0     8.0   71.0          0.0      0.0      0.0
62030621       743.0     9.0   44.0          0.0      0.0      0.0
62030706       325.0     7.0   25.0        624.0     13.0     77.0
62030715       426.0     7.0   27.0        610.0     13.0     77.0
62030800       398.0     7.0   27.0        535.0     13.0     74.0
62030809       293.0     7.0   24.0        494.0     13.0     71.0
62030818       254.0     6.0   22.0        385.0     13.0     67.0
62030903       263.0     7.0   44.0        255.0     11.0     69.0
62030912       101.0     4.0   90.0        189.0     10.0     72.0
62030921       101.0     4.0   66.0        133.0      9.0     77.0
62031006       165.0     5.0   34.0          0.0      0.0      0.0
62031015       140.0     4.0  359.0          0.0      0.0      0.0
```

Figure 74. WTWAVTS Example 1: Output file **WTOUT1.OTS**

```
                          31A28    17
62010100     105.1    3.0  157.7      110.0    3.0  162.6
62010103     136.0    3.0  152.2      142.1    3.0  156.4
62010106     166.6    3.0  145.7      171.7    3.0  148.6
62010109     195.7    3.0  138.0      198.8    3.0  139.6
62010112     248.0    3.0  129.3      249.3    3.0  129.9
62010115     299.0    3.0  119.8      299.4    3.0  120.0
62010118     349.3    3.0  110.0      349.3    3.0  110.0
62010121     399.2    3.0  100.0      399.3    3.0  100.0
62010200     424.2    3.0   90.0      424.2    3.0   90.0
62010203     399.2    3.0   80.0      399.3    3.0   80.0
62010206     349.3    3.0   70.0      349.3    3.0   70.0
62010209     299.0    3.0   60.2      299.4    3.0   60.0
62010212     248.0    3.0   50.7      249.3    3.0   50.1
62010215     195.7    3.0   42.0      198.8    3.0   40.4
62010218     166.6    3.0   34.3      171.7    3.0   31.4
62010221     136.0    3.0   27.8      142.1    3.0   23.6
62010300     105.1    3.0   22.3      110.0    3.0   17.4
```

Figure 75. WTWAVTS Example 2: Output file **WTOUT2.OTS**

Phase III time series selected from the output time series generated in WAVETRAN Example 5 and listed in Figure 73. Responses to the program prompts are as follows:

a. Input file name: *OUT5TST.PH3*

b. Input data format: *2* (OUTPUT FROM ANOTHER WORKBOOK CODE; header and format similar to SEAS)

c. Number of events per record: *2*

d. Time-step of input time series: *3*

e. Output file name: *WTOUT3*

f. Append this file? : *Y*

g. Beginning date of output time series: *62010306*

h. Ending date of output time series: *62010706*

i. Time-step of output time series: *6*

324. At this point, all the required inputs have been specified and the program begins to process the output time series. Note in line f that the program requested the user to specify whether or not the output file should be appended. This prompt was issued after a scan of the default directory discovered that the specified output file already existed. Because the user response was positive (*yes, append the output file*), the following sequence of events occurred. First, the program read the station identification code (*STAID*) and number of records (*NEVENTS*) from the existing output file header.

Then the program copied the existing time series to a scratch file. Next, the program scanned the specified input time series for the beginning and ending dates of the new time series and added the number of records from the input time series to the number of records in the existing output time series. Finally, a new header (the station identification code and updated number of records) was written to the output file, and the existing time series was copied from the scratch file to the output file. Then, after rewinding the input time series, the program copied every other wave event (a 6-hr time-step was specified in line i above) between 62010306 and 62010706 (inclusive) from the input file to the output file. The resulting output time series (**WTOUT3.OTS**) is listed in Figure 76.

325. This example intentionally contains two fundamental errors that were included in order to caution the user against making these types of errors in an actual shoreline change study. First, the two Phase III input time series were computed with different sheltering constraints and, therefore, represent two different physical settings. Remember in WAVETRAN Example 1 that no sheltering constraints were imposed in the Phase III transformation, whereas in WAVETRAN Example 5 two-sided sheltering was specified (between 0 and 30 deg, and between 150 and 180 deg); combining these two time series is incorrect under any circumstances. Second, a new time series with a 6-hr time-step was appended to an existing time series with a 3-hr time-step, again representing a fundamentally incorrect procedure; shoreline change predictions resulting from using this time series as input to GENESIS would be erroneous. In summary, when using the program WTWAVTS to append a time series, one must ensure that the input time series are compatible and that the time-step specified for the appended wave data is identical to the time-step of the existing wave data.

326. Example 4. In this example, a standard CEDRS input time series is used as input. The file name of this input time series is **WVCEDRS.DAT** and is the same input file used in the RCRIT Example 2 (file listing provided in Figure 16) in Part III. This example will also demonstrate the consequences of various user responses to the program prompts issued when the specified output file exists. Therefore, in order to cause the program to issue the "existing output file prompts," a file named **WTOUT4.OTS** was created by issuing the command: *COPY WTOUT3.OTS WTOUT4.OTS* at the PC prompt while in the default

```
                          31A28      34
62010100      105.1     3.0   157.7      110.0      3.0   162.6
62010103      136.0     3.0   152.2      142.1      3.0   156.4
62010106      166.6     3.0   145.7      171.7      3.0   148.6
62010109      195.7     3.0   138.0      198.8      3.0   139.6
62010112      248.0     3.0   129.3      249.3      3.0   129.9
62010115      299.0     3.0   119.8      299.4      3.0   120.0
62010118      349.3     3.0   110.0      349.3      3.0   110.0
62010121      399.2     3.0   100.0      399.3      3.0   100.0
62010200      424.2     3.0    90.0      424.2      3.0    90.0
62010203      399.2     3.0    80.0      399.3      3.0    80.0
62010206      349.3     3.0    70.0      349.3      3.0    70.0
62010209      299.0     3.0    60.2      299.4      3.0    60.0
62010212      248.0     3.0    50.7      249.3      3.0    50.1
62010215      195.7     3.0    42.0      198.8      3.0    40.4
62010218      166.6     3.0    34.3      171.7      3.0    31.4
62010221      136.0     3.0    27.8      142.1      3.0    23.6
62010300      105.1     3.0    22.3      110.0      3.0    17.4
62010306       59.1    10.0   118.7       55.6     10.0   122.3
62010312      105.7    10.0   113.2      108.8     10.0   116.7
62010318      185.5    10.0   105.5      191.3     10.0   107.9
62010400      263.5    10.0    95.5      268.1     10.0    96.2
62010406      263.5    10.0    84.5      268.1     10.0    83.8
62010412      185.5    10.0    74.5      191.3     10.0    72.1
62010418      105.7    10.0    66.8      108.8     10.0    63.3
62010500       59.1    10.0    61.3       55.6     10.0    57.7
62010506       39.8    25.0   101.8       33.2     25.0   102.9
62010512       83.0    25.0    99.9       81.9     25.0   101.4
62010518      150.1    25.0    97.4      154.7     25.0    98.7
62010600      236.8    25.0    94.0      243.1     25.0    94.7
62010606      297.9    25.0    90.0      304.4     25.0    90.0
62010612      236.8    25.0    86.0      243.1     25.0    85.3
62010618      150.1    25.0    82.6      154.7     25.0    81.3
62010700       83.0    25.0    80.1       81.9     25.0    78.6
62010706       39.8    25.0    78.2       33.2     25.0    77.1
```

Figure 76. WTWAVTS Example 3: Output file **WTOUT3.OTS**

directory. Execution of the program is initiated by issuing the command *WTWAVTS* at the PC prompt. Responses to the program prompts are as follows:

a. Input file name: *WVCEDRS.DAT*

b. Input data format: *3* (CEDRS)

c. Time-step of input time series: *3*

d. Output file name: *WTOUT4*

e. Append this file? : *N*

f. Overwrite this file? : *N*

g. Output file name: *WTOUT4*

h. Append this file? : *N*

i. Overwrite this file? : Y

j. Beginning date of output time series: *62010109*

k. Ending date of output time series: *62010621*

l. Time-step of output time series: *12*

327. Note the responses shown above in lines d through i. In line d the user specified the output file name to be *WTOUT4*, and a scan of the default directory determined that the file already existed. Consequently, the program prompted for whether or not the output should be appended; the user responded negatively (line e). Then the program prompted as to whether or not the specified output file should be overwritten. This prompt represents the user's last chance to change his/her mind. The user responded negatively (*do not overwrite the output file*, line f). At this point, the program prompts for re-specification of the output time series file name (line g). The user's responses in lines h and i command the program to overwrite the specified output file (destroying the data contained within it). This procedure was designed to allow the user to change his/her mind after entering an already existing output file. A listing of the output time series (**WTOUT4.OTS**) generated in this example is provided in Figure 77.

328. Note in Figure 77 that the output time series contains a CEDRS-type file header that includes the station type (*STATYP*), station identification code (*STAID*), the beginning date and hour (62010109 representing 1962, January 1, 9:00 a.m.) and the ending date and hour, the number of records (*NEVENTS*), latitude, longitude, and water depth, which in this case is 28 m. Comparing Figure 77 with Figure 16 in Part III, it is seen that every fourth

```
   WIS       A2059     62010109  62010621    30.26   80.98
62010109          1.9       6.0  214.0        0.0     0.0     0.0
62010121          1.9       6.0  297.0        0.5     7.0   144.0
62010209          3.8       7.0  164.0        0.0     0.0     0.0
62010221          1.5       5.0  308.0        1.3     8.0   124.0
62010309          1.3       5.0  300.0        1.0     8.0   122.0
62010321          0.8       4.0  268.0        0.9     8.0   122.0
62010409          0.4       3.0  256.0        0.9     8.0   122.0
62010421          0.2       2.0  149.0        0.8     8.0   122.0
62010509          0.6       4.0  120.0        0.8     8.0   123.0
62010521          1.2       5.0  134.0        0.8     8.0   123.0
62010609          1.9       6.0  174.0        1.2     8.0   124.0
62010621          1.8       6.0  240.0        1.3     7.0   129.0
```

Figure 77. WTWAVTS Example 4: Output file **WTOUT4.OTS**

event (corresponding to a 12-hr time-step) beginning with the event occurring on 62010109 and ending with the event occurring on 62010621 was copied from the input time series to the output time series, as requested. The time series generated in this example (**WTOUT4.OTS**) will be appended in the next example, but to preserve this original time series, the file **WTOUT4.OTS** was copied to the file **WTOUT5.OTS** by issuing the command: *COPY WTOUT4.OTS WTOUT5.OTS* from the default directory.

329. Example 5. In this example, the output file (**CEDRSOUT.CTS**) containing the time series generated from RCRIT Example 2 (shown in Figure 18) will serve as the input time series. There is nothing wrong with combining a time series already processed by RCRIT with a time series that has not been processed by RCRIT provided the new time series is processed through RCRIT prior to using it as input to the shoreline change model. Responses to the program prompts for this example are as follows:

a. Input file name: *CEDRSOUT.CTS*
b. Input data format: 4 (OUTPUT FROM ANOTHER WORKBOOK CODE; header and format similar to CEDRS)
c. Number of events per record: *2*
d. Time-step of input time series: *3*
e. Output file name: *WTOUT5*
f. Append this file? : Y
g. Beginning date of output time series: *62010109*
h. Ending date of output time series: *62010621*
i. Time-step of output time series: *12*

330. Note in line c that the user must specify the number of events per record (as in Example 3) because the input file was generated by another workbook program. A listing of the output time series (**WTOUT5.OTS**) is provided in Figure 78. The time series generated in this example contains different records for the same dates. This is not necessarily a problem because the shoreline change model GENESIS does not read dates from the input wave data file, but the example does emphasize that the program WTWAVTS ignores dates in the output time series and will allow the creation of a time series with repetitive dates and/or chronologically incorrect sequencing of a time series.

331. Example 6. In this example, a time series from a wave gage is input to the program WTWAVTS. The purpose of this example is to demonstrate

```
                WIS A2059             1 62   1 62     24
62010109         1.9     6.0   214.0        0.0     0.0     0.0
62010121         1.9     6.0   297.0        0.5     7.0   144.0
62010209         3.8     7.0   164.0        0.0     0.0     0.0
62010221         1.5     5.0   308.0        1.3     8.0   124.0
62010309         1.3     5.0   300.0        1.0     8.0   122.0
62010321         0.8     4.0   268.0        0.9     8.0   122.0
62010409         0.4     3.0   256.0        0.9     8.0   122.0
62010421         0.2     2.0   149.0        0.8     8.0   122.0
62010509         0.6     4.0   120.0        0.8     8.0   123.0
62010521         1.2     5.0   134.0        0.8     8.0   123.0
62010609         1.9     6.0   174.0        1.2     8.0   124.0
62010621         1.8     6.0   240.0        1.3     7.0   129.0
62010109         0.0   -99.9     0.0        0.0   -99.9     0.0
62010121         0.0   -99.9     0.0        0.5     7.0   144.0
62010209         3.8     7.0   164.0        0.0   -99.9     0.0
62010221         0.0   -99.9     0.0        1.3     8.0   124.0
62010309         0.0   -99.9     0.0        1.0     8.0   122.0
62010321         0.0   -99.9     0.0        0.9     8.0   122.0
62010409         0.0   -99.9     0.0        0.9     8.0   122.0
62010421         0.0   -99.9     0.0        0.8     8.0   122.0
62010509         0.6     4.0   120.0        0.8     8.0   123.0
62010521         1.2     5.0   134.0        0.8     8.0   123.0
62010609         0.0   -99.9     0.0        1.2     8.0   124.0
62010621         0.0   -99.9     0.0        1.3     7.0   129.0
```

Figure 78. WTWAVTS Example 5: Output file **WTOUT5.OTS**

how to modify the source code for WTWAVTS (**WTWAVTS.FOR**) in order to use WTWAVTS with wave gage data. The input wave gage time series in the present example is the same as the one used in RCRIT Example 3 and listed in Figure 19, in Part III. Each record in the wave gage time series has seven fields of data: the first field is the year, the second is the month, the third is the day, the fourth is the hour, the fifth is the wave height in centimeters, the sixth is the wave period in seconds, and the seventh is the wave angle representing the direction of wave propagation measured clockwise from north.

332. At this point, the user may take one of two paths, both of which will (or should) lead to the same end. One alternative would be to write a program that converts the wave gage time series to either the SEAS or the CEDRS format. The other alternative is to modify the program WTWAVTS to read the wave gage time series. The second alternative will be demonstrated here.

333. Before changes are made to the file WTWAVTS.FOR, it is strongly recommended that the user copy **WTWAVTS.FOR** to another file name such as **WTWAVTSG.FOR** (where the letter G denotes that the program has been customized

to read the user's wave gage time series). In **WTWAVTS.FOR**, two comment blocks denote areas where modifications must be made. These comment blocks and the pertinent lines of FORTRAN code are listed in Figure 79.

334. The header information for the wave gage time series shown in Figure 19 contains a station identification number, the number of records in the file, and the water depth of the gage in meters. Of this information, only the station identification number is required by the program, and this is the only information in the header that will be transferred from the original input time series to the new output time series. However, the program also requires additional information, as shown in Figure 79. These additional data needs include the time-step (*FTS*) and the required format of the output time series (*NFOR*). The value assigned to the variable *NFOR* will determine the output file format. Legal values of *NFOR* are: *1* indicating that the output time series will be in the SEAS format, and *2* indicating that the output time series will be in the CEDRS format. If *NFOR* is assigned the value *1*, then the station identification code should be loaded into the program variable *STAID*; however, if *NFOR* is assigned the value *2*, then the station identification code should be loaded into the program variable *CSTAID*, and the station type should be loaded into the program variable *STATYP*. Figure 80 provides one way of satisfying the program requirements for Area 1.

335. Note in Figure 80 that the first new line of code assigns the program variable *NFOR* the value of *1*. This assignment means that the output time series will be in the format of a SEAS data file, and, according to the comment block, a station identification code should be assigned to the program variable *STAID*. Consequently, because the gage time series contains a station identification code, the next new line of code (shown in Figure 80) reads this identification code into the variable *STAID*. Other program variables that need to be assigned values are *NEPR* (number of events per record) and *FTS* (input file time-step). The variable *NEPR* is assigned the value *1* since the gage time series contains only one event per record. The other program variable, *FTS*, is obtained by issuing a user prompt and reading the response into the variable *FTS*, as shown in Figure 80.

336. The next section of code (Area 2 in Figure 79) that must be modified performs the operation of reading each record of data in the input time series. The program requires that each event be associated with a date, including the hour (loaded into the program variable *DATE*), the wave height

Area 1

```
      ELSEIF(INFOR.EQ.5)THEN
        WRITE(*,*) ' This code must be modified to read past your specif
     &ic input file header !'
        GOTO 150
C???????????????????????????????????????????????????????????????????????????
C  In this section read (or prompt for) the input file header information. ?
C  Load the number of events per record into NEPR, and the time step into  ?
C  FTS.  Also specify the output format, and load it into NFOR.            ?
C  DEFINITION OF NFOR:                                                     ?
C  NFOR= 1 -> SEAS, requires station identification (STAID)               ?
C  NFOR= 2 -> CEDRS, requires station type (STATYP) and station ID (CSTAID)?
C???????????????????????????????????????????????????????????????????????????
```

Area 2

```
      ELSE
        WRITE(*,*) ' This code must be modified to read your specific in
     &put time series !'
        GOTO 99
C???????????????????????????????????????????????????????????????????????
C  In this section read the wave event(s) from the input file.         ?
C  Read the date into DATE (YYMMDDHH).  Read the wave height, period,  ?
C  and angle of the first wave event into  HGT, PER, and ANG.          ?
C  If there are two events per record, read second wave event height,  ?
C  period, and angle into HGTS, PERS, ANGS.                            ?
C???????????????????????????????????????????????????????????????????????
      ENDIF
```

Figure 79. Lines where **WTWAVTS.FOR** must be modified to read wave gage time series

(*HGT*), wave period (*PER*), and wave angle (*ANG*); if there are two wave events per record, the second wave height, period, and angle event should be loaded into the program variables *HGTS*, *PERS*, and *ANGS*, respectively. Figure 81 shows one way of accomplishing this task.

337. Note in Figure 19 that the date in the wave gage time series is provided as four numbers separated by spaces; the program WTWAVTS, however, requires the data as an eight-character integer. To read the date information from the wave gage time series and translate it into the eight-character integer program variable, *DATE*, required by the program, the following procedure was used. First the date information was read from the wave gage time series file into four new program variables called *IGY* (year), *IGM* (month), *IGD* (day), and *IGH* (hour, 24-hr clock). This step was accomplished by the first new line of code shown in Figure 81. Then the program variable *DATE* was constructed from the four temporary variables as shown in the second new line of code listed in Figure 81. The next two lines of code convert the

```
      ELSEIF(INFOR.EQ.5)THEN
C        WRITE(*,*) ' This code must be modified to read past your specif
C     &ic input file header !'
C        GOTO 150
C??????????????????????????????????????????????????????????????????????????
C  In this section read (or prompt for) the input file header information. ?
C  Load the number of events per record into NEPR, and the time step into  ?
C  FTS.  Also specify the output format, and load it into NFOR.            ?
C  DEFINITION OF NFOR:                                                     ?
C  NFOR= 1 => SEAS, requires station identification (STAID)                ?
C  NFOR= 2 => CEDRS, requires station type (STATYP) and station id (CSTAID)?
C??????????????????????????????????????????????????????????????????????????
C---
c  new section for reading past the wave gage time series header
C---
        NFOR=1
        READ(99,*) STAID
        NEPR=1
        WRITE(*,*) '   '
        WRITE(*,*) '  Enter the time step of your input time series: '
        READ(*,*) FTS
C---
c  end of new section for reading past the wave gage time series header
C---
```

Figure 80. New lines of code for Area 1, **WTWAVTS.FOR**

wave angle from an angle that defines the direction in which the wave is traveling with respect to north to the direction from which the wave came with respect to north. This conversion is necessary for compatibility with the SEAS (WIS Phases I and II) data format and coordinate system.

338. The program WTWAVTSG is now capable of reading the input wave gage time series and writing the user-specified output time series. This program also converts the wave angle coordinate system from one defining the direction in which the wave is traveling to one defining the direction from which the wave came. This coordinate system conversion is necessary so that output files created by WTWAVTS can be used as input to other workbook programs, because the input format will be defined as SEAS-type. The file **WTWAVTSG.FOR** must now be compiled and linked to obtain an executable program. Users must perform these functions with their own software and equipment.

339. In the execution of the program WTWAVTSG, the file name *WVGAGE.DAT* is entered at the prompt for the input time series file name. The file is assumed to exist in the default directory; otherwise, the appropriate path together with the file name must be specified. The input data format is

```
      ELSE
C        WRITE(*,*) ' This code must be modified to read your specific in
C     &put time series !'
C          GOTO 99
C?????????????????????????????????????????????????????????????????????????
C In this section read the wave event(s) from the input file.           ?
C Read the date into DATE (YYMMDDHH).  Read the wave height, period,    ?
C and angle of the first wave event into  HGT, PER, and ANG.            ?
C If there are two events per record, read second wave event height,    ?
C period, and angle into HGTS, PERS, ANGS.                              ?
C?????????????????????????????????????????????????????????????????????????
C---
c new section for reading the input time series
C---
        READ(99,*) IGY,IGM,IGD,IGH,HGT,PER,ANG
        DATE=IGY*1000000+IGM*10000+IGD*100+IGH/100
        ANG=ANG+180.
        IF(ANG.GT.360.)ANG=ANG-360.
C---
c end of new section for reading the input time series
C---
      ENDIF
```

Figure 81. New lines of code for <u>Area 2</u>, **WTWAVTS.FOR**

specified as "other" by entering the value *5* at the input format prompt. At the prompt for the input time series time-step, the value *6* is entered, indicating a 6-hr time-step. At the prompt for the output file name, the name *WTOUT6* is entered. The starting date of the output time series is specified as *86013108*, and the ending date output time series is specified as *86021120*. At the prompt for the output time series time-step, the value *12* is entered indicating a 12-hr time-step.

340. At this point, all the required program inputs have been specified, and the requested output time series is written to the output file **WTOUT6.OTS**. A listing of the output time series is provided in Figure 82. From Figure 82, it is seen that the selected time series begins and ends on the dates specified above and that the time interval between events is 12 hr. Comparing this new time series with the input time series, it is noted that only the wave angles are different, and this difference is exactly 180 deg, representing a conversion of coordinates from one that defines the direction in which the wave is traveling to one that defines the direction from which the wave came. This concludes the example applications of the utility program WTWAVTS.

Summary

341. The program WTWAVTS was designed specifically to enable users of the WIS data base accessed through either the SEAS or CEDRS data retrieval systems to create wave data time series from portions of larger time series or to combine several individual time series into a single series. With modification of the program source code (listed in Appendix G) as demonstrated in Example 6 above, WTWAVTS can perform these functions using wave data time series obtained from other sources. Users are, however, cautioned to avoid the types of errors discussed in Examples 3 and 5 when combining several individual time series (appending an existing output time series).

WTWAVES

342. The program WTWAVES reads a wave time series data file that was either retrieved from the SEAS or CEDRS data retrieval systems or created (output) by one of the wave time series processing programs presented previously and then writes a wave data time series file suitable for input to GENESIS. The specific workbook programs which create wave data time series that can be read by the program WTWAVES include RCRIT, WAVETRAN, and WTWAVTS. The program WTWAVES writes files that may be renamed to **WAVES**.ext and input to GENESIS.

343. The computational flow of the program WTWAVES is as follows:

- a. Open input and output data files.
- b. Prompt for the time-step associated with the input and output time series.

```
  SC001      24
 86013108      70.0      5.0    233.0          86020608         99.0       9.0    229.0
 86013120      79.0      9.0    233.0          86020620        105.0       7.0    223.0
 86020108     152.0     20.0    233.0          86020708         71.0      20.0    232.0
 86020120     167.0     15.0    230.0          86020720        100.0      20.0    220.0
 86020208     130.0     13.0    232.0          86020808        104.0      17.0    226.0
 86020220     105.0     13.0    234.0          86020820         95.0      15.0    219.0
 86020308     113.0     15.0    233.0          86020908         78.0      15.0    214.0
 86020320     188.0      9.0    231.0          86020920         90.0      13.0    219.0
 86020408     124.0     15.0    233.0          86021008         66.0      13.0    216.0
 86020420     105.0     15.0    230.0          86021020         64.0      13.0    221.0
 86020508      80.0     13.0    230.0          86021108         57.0      13.0    223.0
 86020520      78.0      7.0    229.0          86021120         44.0      13.0    226.0
```

Figure 82. WTWAVTS Example 6: Output file **WTOUT6**.OTS

c. Prompt for the wave angle coordinate system (with respect to north (WIS Phases I or II) or with respect to the shoreline orientation (WIS Phase III)).

d. Prompt for number of events per record (*NEPR*).

e. Prompt for input file format type (SEAS or CEDRS).

f. Write output file header.

g. Read wave event(s) from input time series.

h. If wave event(s) is calm or propagating offshore, write flagged wave event, in GENESIS format, to output time series. Go to step g.

i. Convert wave angle to GENESIS coordinate system. Write wave event(s), in GENESIS format, to output time series.

j. Repeat steps g through i until end of input file is reached.

Example applications

344. Operation of the program WTWAVES will now be demonstrated through five example applications. Each of the five legal input time series data types will be used, and the program options of *append*, *overwrite*, and *re-specify* (associated with the output time series) will also be covered.

345. Example 1. In this example, a standard SEAS input time series is the input. The file name of this input time series is **WVSEAS.DAT**, the same input file used in the RCRIT Example 1 (file listing provided in Figure 12) in Part III and in the WTWAVTS Example 1 given previously in this chapter. Execution of the program is initiated by issuing the command *WTWAVES* at the PC prompt.

346. The program responds by prompting for entry of the input file name and extension. If the input file is not located in the default directory, the appropriate path should also be entered. For this example, the name *WVSEAS.DAT* is entered. This file must exist (it represents the input) or the program will terminate.

347. The next prompt issued requests entry of the file name of the output time series; in this example, the file name *SEASOUT* is entered. Note that the output file name extension is not requested and should not be entered. The program will automatically assign the extension **.WAV** (representing offshore time series) to all output time series. This file may or may not exist, and the program scans the default directory (or the specific directory entered together with the output file name) to determine the existence of the file. If the file is found, then the program will ask if the file should be

appended, *overwritten* (deleted), or *re-specified* (enter a new output file name). In this example, the directory scan determines that the file does not exist, so the program creates the file **SEASOUT.WAV**. The program options of *append*, *overwrite*, and *re-specify* are discussed in Examples 3, 5, and 4, respectively.

348. Next, the program prompts for entry of the time-step of the input time series. In this example the value *3* is entered, which corresponds to the 3-hr time-step of the input time series.

349. The program then prompts for the shoreline orientation. If the coordinate system associated with the input wave angles is with respect to north (as in WIS Phase I or Phase II data files), then the shoreline orientation with respect to north should be entered. Otherwise, if the coordinate system associated with the input time series wave angles is with respect to the shoreline orientation (as in WIS Phase III data files), then the value *-999* should be entered. This information is required in order for the program to correctly convert the wave angles to the coordinate system used in GENESIS. In GENESIS wave angles can vary between -90 and 90 deg, where 0 deg represents a wave propagating normal to the GENESIS baseline and waves propagating from the right of 0 deg are defined as negative, whereas waves propagating from the left of 0 deg are defined as positive. Figure 83 provides a schematic illustration of the wave angle coordinate system convention used in GENESIS. In the present example, the wave angles of input time series are defined with respect to north, so the value *54* is entered to indicate a shoreline orientation of 54 deg.

350. Next, the program prompts for the time-step of the output time series. The value *6* is entered indicating a time-step of 6 hr. The program then prompts for the number of events per record contained in the input time series and the value *2* is entered.

351. The next prompt issued by the program requests specification of the input time series format type; the options are CEDRS or SEAS. In this example, the input time series was retrieved from the SEAS system so the value *2* is entered. Then the program requests whether or not the input time series was generated by another workbook program. Again, because the input time series was retrieved directly from the SEAS system, the response to this prompt is *N* indicating that the input file was not generated by another workbook program.

352. The last prompt issued by the program requests specification of the required output system of units; the options are meters or feet. In the present example, the response to this prompt is *1* indicating that the wave heights should be output in meters.

353. At this point, the required inputs have been specified, and the program proceeds to copy wave events from the input time series at the specified time-step to the output file **SEASOUT.WAV**. First, the wave angle of each event is converted to the GENESIS coordinate system convention. Then a check is made to ensure that the converted wave angle is valid (between ±90 deg), and, if so, the wave height is converted to the specified system of units, and the event is written to the output file. If the converted wave angle is not valid (for example, the wave is propagating offshore or a calm event is encountered), a flagged wave event (an event denoted with a negative wave period) is written to the output file. A listing of the output file generated from this example is provided in Figure 84.

354. The file **SEASOUT.WAV** was written in the format of a GENESIS **WAVES**.ext input file that contains a four-line header followed by wave events

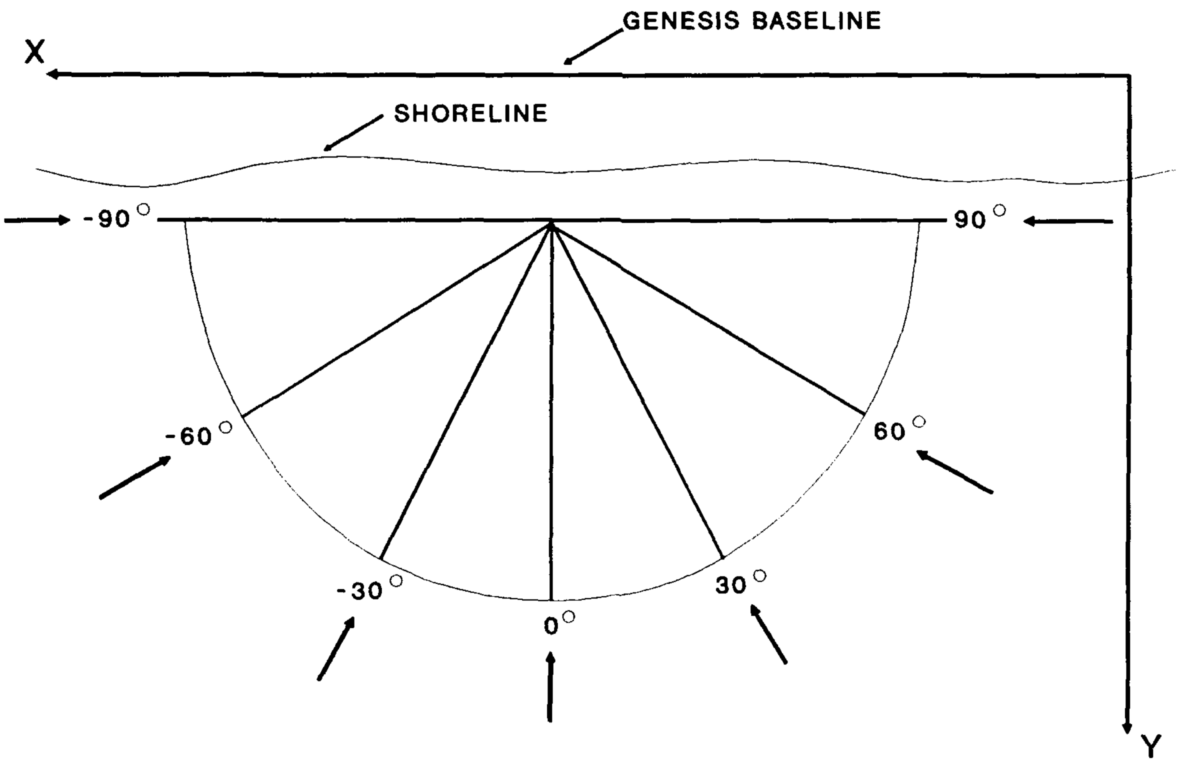


Figure 83. GENESIS wave angle coordinate system convention

```
FILE:  SEASOUT.WAV
NUMBER OF EVENTS PER TIME STEP:  2      TIME STEP:     6 HR
SYSTEM OF UNITS:  METERS
******************************************************************************
   -99.900     0.000     0.000    62030500
   -99.900     0.000     0.000    62030500 EVENT 2
     3.000     0.480    76.000    62030506
   -99.900     0.000     0.000    62030506 EVENT 2
   -99.900     0.000     0.000    62030512
   -99.900     0.000     0.000    62030512 EVENT 2
     4.000     0.890    79.000    62030518
   -99.900     0.000     0.000    62030518 EVENT 2
     6.000     2.010    68.000    62030600
   -99.900     0.000     0.000    62030600 EVENT 2
     8.000     4.240    75.000    62030606
   -99.900     0.000     0.000    62030606 EVENT 2
     8.000     3.980    73.000    62030612
   -99.900     0.000     0.000    62030612 EVENT 2
     9.000     4.470    71.000    62030618
    10.000     2.620    76.000    62030618 EVENT 2
   -99.900     0.000     0.000    62030700
    12.000     6.520    73.000    62030700 EVENT 2
   -99.900     0.000     0.000    62030706
    13.000     6.240    67.000    62030706 EVENT 2
   -99.900     0.000     0.000    62030712
    13.000     6.190    67.000    62030712 EVENT 2
   -99.900     0.000     0.000    62030718
    13.000     5.840    68.000    62030718 EVENT 2
   -99.900     0.000     0.000    62030800
    13.000     5.350    70.000    62030800 EVENT 2
   -99.900     0.000     0.000    62030806
    13.000     5.320    71.000    62030806 EVENT 2
   -99.900     0.000     0.000    62030812
    13.000     4.430    73.000    62030812 EVENT 2
   -99.900     0.000     0.000    62030818
    13.000     3.850    77.000    62030818 EVENT 2
   -99.900     0.000     0.000    62030900
    12.000     3.260    77.000    62030900 EVENT 2
   -99.900     0.000     0.000    62030906
    11.000     2.530    76.000    62030906 EVENT 2
     4.000     1.010    54.000    62030912
    10.000     1.890    72.000    62030912 EVENT 2
     5.000     1.310    67.000    62030918
    10.000     1.460    68.000    62030918 EVENT 2
     4.000     0.760    88.000    62031000
     8.000     1.250    66.000    62031000 EVENT 2
   -99.900     0.000     0.000    62031006
   -99.900     0.000     0.000    62031006 EVENT 2
   -99.900     0.000     0.000    62031012
   -99.900     0.000     0.000    62031012 EVENT 2
   -99.900     0.000     0.000    62031018
   -99.900     0.000     0.000    62031018 EVENT 2
```

Figure 84. WTWAVES Example 1: Output file **SEASOUT.WAV**

defined by the wave period, wave height, and wave angle. Each line contains only one wave event. Note in Figure 84, however, that in addition to the wave characteristics, the date of the event is also listed, and, if the time series contains two events per time-step, the phrase "EVENT 2" is listed adjacent to the date. This information is not required by GENESIS, but is included in the file to enable the user to quickly locate particular wave events of interest. Comparing the time series in Figure 84 with the **REPORT.RC** file generated in RCRIT Example 1 and listed in Figure 14, it is seen that the offshore traveling and calm wave events flagged by RCRIT were also detected and flagged by the program WTWAVES. However, the sea event occurring on 62031000 flagged by RCRIT because it fell below the threshold for significant longshore sand transport was not flagged by the program WTWAVES.

355. <u>Example 2</u>. In this example, a standard CEDRS input time series is the input. The file name of this input time series is **WVCEDRS.DAT**, the same input file used in the RCRIT Example 2 (file listing provided in Figure 16) in Part III and in the WTWAVTS Example 4 given previously in this chapter. Execution of the program is initiated by issuing the command *WTWAVES* at the PC prompt.

356. This example will demonstrate how to correct an error in the specification of the output file name. Responses to the program prompts are as follows:

<u>a</u>. Input file name: *WVCEDRS.DAT*

<u>b</u>. Ooutput file name: *SEASOUT* (output file specified in error)

<u>c</u>. Disposition of existing output file: *3* (re-specification of output file name)

<u>d</u>. Output file name: *CEDRSOUT*

<u>e</u>. Time-step of input time series: *3*

<u>f</u>. Shoreline orientation: *348*

<u>g</u>. Time-step of output time series: *12*

<u>h</u>. Number of events per record: *2*

<u>i</u>. Input file type: *1* (CEDRS)

<u>j</u>. Output from another workbook program: *N*

<u>k</u>. Output units: *1* (meters)

357. Note the response in lines <u>b</u>, <u>c</u>, and <u>d</u>. In line <u>b</u>, the user incorrectly entered the output file name *SEASOUT*, and the program scan of the default directory discovered that the file **SEASOUT.WAV** existed and

consequently prompted for specification of its disposition. The choices given are: (1) Append the file, (2) Overwrite (delete) the file, and (3) Enter a new output file name. In line c, the response to this prompt was *3*, indicating re-specification of the output file name. In line d, the new file name *CEDRSOUT* was entered.

358. A listing of the output file **CEDRSOUT.WAV** is provided in Figure 85. Again, if the file **CEDRSOUT.WAV** shown in Figure 85 is compared with the file **REPORT.RC** generated in RCRIT Example 2 and listed in Figure 17, it is seen that the offshore traveling and calm wave events flagged by RCRIT were also detected and flagged by the program WTWAVES, but the below threshold sea event occurring on 62010100 was not flagged by the program WTWAVES.

359. Example 3. In this example, the output file generated in RCRIT Example 2 will be used as input to the program WTWAVES. This input time series shown in Figure 18 in Part III is identical to the input time series used in the previous example except that it has been processed through RCRIT. This example will demonstrate the *overwrite* option to the program prompt for disposition of an existing output file. Therefore, in order to cause the program to issue the "existing output file prompts," a file named **CEDRSCTS.WAV** was created by issuing the command: *COPY CEDRSOUT.WAV CEDRSCTS.WAV* at the PC prompt while in the default directory. Responses to the program prompts are as follows:

a. Input file name: *CEDRSOUT.CTS*
b. Output file name: *CEDRSCTS*
c. Disposition of existing output file: *2* (overwrite the file)
d. Time-step of input time series: *3*
e. Shoreline orientation: *348*
f. Time-step of output time series: *12*
g. Number of events per record: *2*
h. Input file type: *1* (CEDRS)
i. Output from another workbook program: *Y*
j. Output units: *1* (meters)

360. The result of specifying that the output file should be overwritten in line c is loss of the data that originally existed in the file. Because the input time series was generated by the program RCRIT, the appropriate response in line i above is *Y*. A listing of the output file **CEDRSCTS.WAV** is provided in Figure 86. Comparing Figures 86 and 85 indicates

```
FILE:  CEDRSOUT.WAV
NUMBER OF EVENTS PER TIME STEP:  2     TIME STEP:    12
SYSTEM OF UNITS:  METERS
*******************************************************************************
     3.000     0.400   -64.000   62010100
   -99.900     0.000     0.000   62010100 EVENT 2
   -99.900     0.000     0.000   62010112
   -99.900     0.000     0.000   62010112 EVENT 2
   -99.900     0.000     0.000   62010200
     7.000     0.500   -67.000   62010200 EVENT 2
   -99.900     0.000     0.000   62010212
   -99.900     0.000     0.000   62010212 EVENT 2
   -99.900     0.000     0.000   62010300
     8.000     1.200   -45.000   62010300 EVENT 2
   -99.900     0.000     0.000   62010312
     8.000     1.000   -44.000   62010312 EVENT 2
   -99.900     0.000     0.000   62010400
     8.000     0.900   -44.000   62010400 EVENT 2
   -99.900     0.000     0.000   62010412
     8.000     0.900   -44.000   62010412 EVENT 2
     3.000     0.400   -53.000   62010500
     8.000     0.800   -44.000   62010500 EVENT 2
     3.000     0.400   -42.000   62010512
     8.000     0.800   -45.000   62010512 EVENT 2
     5.000     1.600   -64.000   62010600
     8.000     0.800   -45.000   62010600 EVENT 2
   -99.900     0.000     0.000   62010612
   -99.900     0.000     0.000   62010612 EVENT 2
```

Figure 85. WTWAVES Example 2: Output file **CEDRSOUT.WAV**

that the only difference is the sea event occurring on 62010100. In Figure 86, this event is flagged because the input time series for this example was preprocessed through RCRIT (and the event fell below the criterion for significant longshore sand transport). However, the input time series used in WTWAVES Example 2 was not preprocessed using RCRIT, so the event was not flagged.

361. Example 4. In this example, the output file generated in WAVETRAN Example 1 and listed in Figure 64 will be used as input to the program WTWAVES. Responses to the program prompts are as follows:

a. Input file name: *OUT1TST.PH3*

b. Output file name: *PHASE3_A*

c. Time-step of input time series: *3*

d. Shoreline orientation: *-999*

e. Time-step of output time series: *9*

f. Number of events per record: *2*

```
FILE:  CEDRSCTS.WAV
NUMBER OF EVENTS PER TIME STEP:  2     TIME STEP:    12
SYSTEM OF UNITS:  METERS
*******************************************************************************
   -99.900    0.000     0.000   62010100
   -99.900    0.000     0.000   62010100 EVENT 2
   -99.900    0.000     0.000   62010112
   -99.900    0.000     0.000   62010112 EVENT 2
   -99.900    0.000     0.000   62010200
     7.000    0.500   -67.000   62010200 EVENT 2
   -99.900    0.000     0.000   62010212
   -99.900    0.000     0.000   62010212 EVENT 2
   -99.900    0.000     0.000   62010300
     8.000    1.200   -45.000   62010300 EVENT 2
   -99.900    0.000     0.000   62010312
     8.000    1.000   -44.000   62010312 EVENT 2
   -99.900    0.000     0.000   62010400
     8.000    0.900   -44.000   62010400 EVENT 2
   -99.900    0.000     0.000   62010412
     8.000    0.900   -44.000   62010412 EVENT 2
     3.000    0.400   -53.000   62010500
     8.000    0.800   -44.000   62010500 EVENT 2
     3.000    0.400   -42.000   62010512
     8.000    0.800    45.000   62010512 EVENT 2
     5.000    1.600   -64.000   62010600
     8.000    0.800   -45.000   62010600 EVENT 2
   -99.900    0.000     0.000   62010612
   -99.900    0.000     0.000   62010612 EVENT 2
```

Figure 86. WTWAVES Example 3: Output file **CEDRSCTS.WAV**

g. Input file type: *2* (SEAS)

h. Output from another workbook program: *Y*

i. Output units: *1* (meters)

362. Note in line d that the value *-999* was entered at the prompt for the shoreline orientation. This response indicates to the model that the wave angles are defined with respect to the shoreline orientation (as in WIS Phase III) as defined in Figure 65. A listing of the output file **PHASE3_A.WAV** is provided in Figure 87. The time series generated in this example will be appended in the next example, but to also preserve this original time series, the file **PHASE3_A.WAV** was copied to the file **PHASE3_B.WAV** by issuing the command: *COPY PHASE3_A.WAV PHASE3_B.WAV* from the default directory.

363. Example 5. In this example, the output file generated in **WTWAVTS** Example 2 and listed in Figure 75 will be used as input to the program WTWAVES. Responses to the program prompts are as follows:

```
FILE:  PHASE3_A.WAV
NUMBER OF EVENTS PER TIME STEP:  2     TIME STEP:     9
SYSTEM OF UNITS:  METERS
*******************************************************************************
     3.000     1.051    67.700   62010100
     3.000     1.100    72.600   62010100 EVENT 2
     3.000     1.957    48.000   62010109
     3.000     1.988    49.600   62010109 EVENT 2
     3.000     3.493    20.000   62010118
     3.000     3.493    20.000   62010118 EVENT 2
     3.000     3.992   -10.000   62010203
     3.000     3.993   -10.000   62010203 EVENT 2
     3.000     2.480   -39.300   62010212
     3.000     2.493   -39.900   62010212 EVENT 2
     3.000     1.360   -62.200   62010221
     3.000     1.421   -66.400   62010221 EVENT 2
    10.000     0.703    33.700   62010306
    10.000     0.703    37.200   62010306 EVENT 2
    10.000     1.508    21.500   62010315
    10.000     1.539    23.700   62010315 EVENT 2
    10.000     2.642     5.700   62010400
    10.000     2.681     6.300   62010400 EVENT 2
    10.000     2.273   -11.300   62010409
    10.000     2.311   -12.400   62010409 EVENT 2
    10.000     1.134   -26.000   62010418
    10.000     1.156   -28.700   62010418 EVENT 2
    10.000     0.511   -36.800   62010503
    10.000     0.499   -40.600   62010503 EVENT 2
    25.000     0.911    11.000   62010512
    25.000     0.913    12.300   62010512 EVENT 2
    25.000     1.966     6.100   62010521
    25.000     2.007     7.000   62010521 EVENT 2
    25.000     2.982     0.000   62010606
    25.000     3.044     0.000   62010606 EVENT 2
    25.000     1.966    -6.100   62010615
    25.000     2.007    -7.000   62010615 EVENT 2
    25.000     0.911   -11.000   62010700
    25.000     0.913   -12.300   62010700 EVENT 2
```

Figure 87. WTWAVES Example 4: Output file **PHASE3_A.WAV**

a. Input file name: *WTOUT2.OTS*

b. Output file name: *PHASE3_B*

c. Disposition of existing output file: *1* (append the file)

d. Time-step of input time series: *3*

e. Shoreline orientation: *-999*

f. Time-step of output time series: *9*

g. Number of events per record: *2*

h. Input file type: *2* (SEAS)

i. Output from another workbook program: *Y*

j. Output units: *1* (meters)

364. A listing of the output file **PHASE3_B.WAV** is provided in Figure 88. Note that the contents of the file **PHASE3_B.WAV** (Figure 88) are identical to the contents of the file **PHASE3_A.WAV** (Figure 87) except for the last 12 wave events, which represent the data copied from the input file **WTOUT2.OTS** and appended to the output file **PHASE3_B.WAV**.

Summary

365. The program WTWAVES (source code listing provided in Appendix H) will reformat (into the GENESIS format of a **WAVES**.ext file) and change the time-step of an input time series retrieved from either the SEAS or CEDRS data retrieval systems, or, processed and output by the workbook programs RCRIT, WAVETRAN, or WTWAVTS. The entire input time series is processed. Therefore, if only a portion of a specific time series is wanted, it should be processed through the program WTWAVTS first.

Analysis of Offshore Wave Data

366. In this section, the programs RCRIT, SEDTRAN, WAVETRAN, WTWAVTS, and WTWAVES are combined into a recommended offshore wave data analysis procedure. This proposed analysis procedure is referred to as "Wave Data Analysis Stage 1" and may be thought of as a regional analysis. Figure 89 provides a general outline of the analysis. Consequently, this analysis procedure assumes access to the WIS data base.

367. The primary source for long-term wave data within the Corps is the WIS. Consequently, the first task in the analysis procedure is to obtain a WIS Phase II time series. If using the CEDRS data retrieval system, the maximum duration of the extracted time series is 1 year. The SEAS data retrieval system allows for the extraction of time series of any length, and of course the WIS staff at CERC can provide time series of any length as well. The starting point of this analysis procedure is prescribed as WIS Phase II because these data are typically referenced to north (wave angle coordinate system convention) and were developed using deepwater assumptions (at least for the Atlantic and Pacific WIS hindcasts). These conditions enable use of the program WAVETRAN (the second task of the analysis), which allows for a preliminary transformation of the wave data to satisfy site-specific

```
FILE:  PHASE3_B.WAV
NUMBER OF EVENTS PER TIME STEP:  2     TIME STEP:      9
SYSTEM OF UNITS:  METERS
*******************************************************************************
     3.000     1.051    67.700   62010100
     3.000     1.100    72.600   62010100 EVENT 2
     3.000     1.957    48.000   62010109
     3.000     1.988    49.600   62010109 EVENT 2
     3.000     3.493    20.000   62010118
     3.000     3.493    20.000   62010118 EVENT 2
     3.000     3.992   -10.000   62010203
     3.000     3.993   -10.000   62010203 EVENT 2
     3.000     2.480   -39.300   62010212
     3.000     2.493   -39.900   62010212 EVENT 2
     3.000     1.360   -62.200   62010221
     3.000     1.421   -66.400   62010221 EVENT 2
    10.000     0.703    33.700   62010306
    10.000     0.703    37.200   62010306 EVENT 2
    10.000     1.508    21.500   62010315
    10.000     1.539    23.700   62010315 EVENT 2
    10.000     2.642     5.700   62010400
    10.000     2.681     6.300   62010400 EVENT 2
    10.000     2.273   -11.300   62010409
    10.000     2.311   -12.400   62010409 EVENT 2
    10.000     1.134   -26.000   62010418
    10.000     1.156   -28.700   62010418 EVENT 2
    10.000     0.511   -36.800   62010503
    10.000     0.499   -40.600   62010503 EVENT 2
    25.000     0.911    11.000   62010512
    25.000     0.913    12.300   62010512 EVENT 2
    25.000     1.966     6.100   62010521
    25.000     2.007     7.000   62010521 EVENT 2
    25.000     2.982     0.000   62010606
    25.000     3.044     0.000   62010606 EVENT 2
    25.000     1.966    -6.100   62010615
    25.000     2.007    -7.000   62010615 EVENT 2
    25.000     0.911   -11.000   62010700
    25.000     0.913   -12.300   62010700 EVENT 2
     3.000     1.051    67.700   62010100
     3.000     1.100    72.600   62010100 EVENT 2
     3.000     1.957    48.000   62010109
     3.000     1.988    49.600   62010109 EVENT 2
     3.000     3.493    20.000   62010118
     3.000     3.493    20.000   62010118 EVENT 2
     3.000     3.992   -10.000   62010203
     3.000     3.993   -10.000   62010203 EVENT 2
     3.000     2.480   -39.300   62010212
     3.000     2.493   -39.900   62010212 EVENT 2
     3.000     1.360   -62.200   62010221
     3.000     1.421   -66.400   62010221 EVENT 2
```

Figure 88. WTWAVES Example 5: Output file **PHASE3_B.WAV**

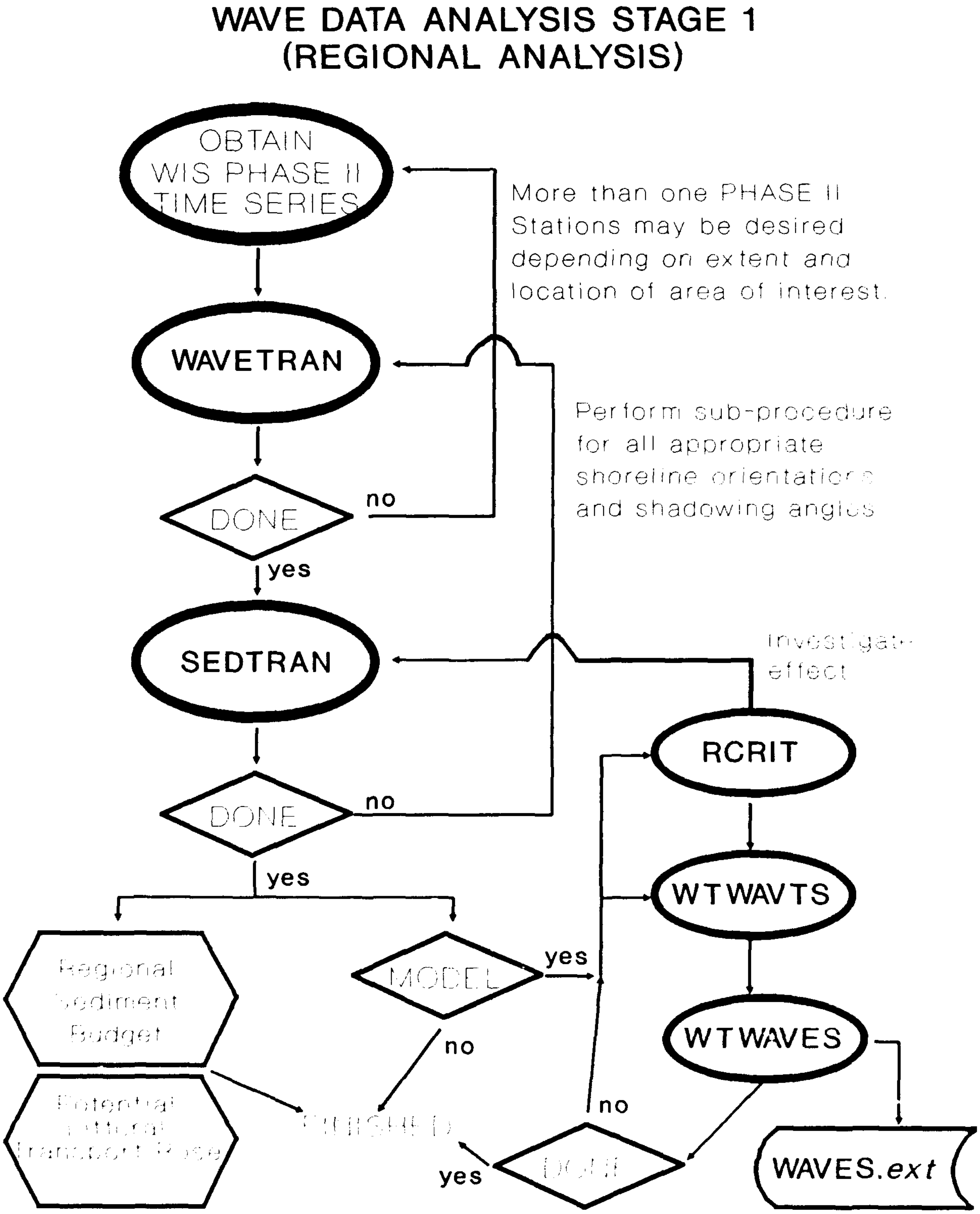


Figure 89. Wave data analysis Stage 1 (regional analysis)

conditions (specific nearshore water depth and wave energy sheltering). Depending on the alongshore extent and geological setting of the area of interest, wave data from more than one WIS Phase II Station may be required.

368. The second task in the analysis is to perform a WIS Phase III-type transformation (using the program WAVETRAN) from the Phase II Station to a Phase III-type station with a specific shoreline orientation and a specified water depth. This transformation may also include sheltering of wave energy approaching the shore from specific angles if required. WAVETRAN runs should be performed for shoreline orientations encountered along the region of interest. If a nearshore wave transformation model such as RCPWAVE will be used in the project study, the water depth specified in one of the WAVETRAN runs should correspond to the average water depth along the offshore boundary of the RCPWAVE grid, and the specified shoreline orientation should correspond to the alongshore axis of the bathymetry grid.

369. The third task of the analysis involves use of the program SEDTRAN. A SEDTRAN run should be performed for each of the unique Phase III-type stations created in the second task. This run will enable the development of a regional potential longshore sand transport sediment budget that will provide significant insight to the regional processes (magnitude and direction of sand transport rates for various shoreline orientations) at work along the project reach.

370. The analysis up to this point is general and is a good procedure for evaluating regional potential longshore sand transport processes regardless of whether or not numerical shoreline change modeling using GENESIS will be applied. If, however, the intention is to apply GENESIS, the next task involves using the program RCRIT to eliminate offshore traveling and insignificant (in terms of producing longshore sand transport) waves from the offshore time series. A good idea at this point is to calculate potential longshore transport rates using the program SEDTRAN, and inputing the time series processed through the program RCRIT to investigate the effect of RCRIT (particularly in low wave energy environments).

371. The next task is to compile a time series for the specific simulation time interval that shoreline change will be modeled. The program WTWAVTS is used to perform this task. After generating the required time series of wave conditions, the program WTWAVES is used to convert the time series to the GENESIS format and coordinate system required in the **WAVES**.ext

input file. This concludes preparation of wave data for a scoping application of GENESIS.

372. This analysis combined with the shoreline position analysis described in Part IV and outlined in Figure 43 will result in the preparation of three (**SHORL**.ext, **SHORM**.ext, and **WAVES**.ext) or four (**SEAWL**.ext is required if a seawall will be simulated) of the four or five input files required to run GENESIS in a scoping mode application. A line-by-line description and step-by-step procedure for preparing the remaining input file (**START**.ext) are provided in Part VII.

PART VI: NEARSHORE WAVE ANALYSIS

373. This chapter presents procedures for refining and expanding the wave analysis initiated in the previous chapter. The phrase "nearshore wave data" refers to wave information along a nearshore reference line that corresponds to a prebreaking condition for most of the wave events in the offshore time series. These procedures pertain specifically to use of an external wave transformation model, as opposed to the GENESIS internal wave transformation model. The GENESIS internal wave transformation model is described in Part II. Use of an external wave transformation model such as the Regional Coastal Processes Wave (RCPWAVE) propagation model developed by Ebersole (1985) and documented by Ebersole, Cialone, and Prater (1986) is recommended for design mode application of GENESIS, whereas for scoping mode applications, the simpler internal wave transformation is usually sufficient.

374. Four computer programs are introduced in this chapter. The first program, WHEREWAV, categorizes wave events in the offshore time series by wave period (referred to as "period bands") and direction of wave propagation (referred to as "angle bands"), and reports the number of wave events occurring within each of the period and angle band categories. This information is then used to define the number of nearshore wave transformation simulations required to describe the offshore time series. The second program, WTNSWAV, reads wave parameters (wave height transformation parameter and direction of propagation) along the nearshore reference line from an RCPWAVE output file, computes an offshore wave identification code, and writes the wave parameters and identification code to the nearshore wave data file (**NSWAV**.ext) for input to GENESIS. The third program, WTDEPTH, reads the RCPWAVE bathymetry data and writes the water depths along the nearshore reference line to a **DEPTH**.ext file for input to GENESIS. The fourth program, NSTRAN, calculates potential longshore sand transport rates from an input offshore time series, a data base of nearshore wave conditions, and reference nearshore water depths. This program enables refinement of the regional sand transport budget developed in the offshore wave analysis procedures to a more local (project level) potential longshore sand transport budget.

375. The programs presented in this chapter were designed to translate output from a modified version of RCPWAVE that was revised for use in concert with GENESIS. It is anticipated that the RCPWAVE modifications as discussed

herein will be incorporated into the CERC Coastal Modeling System (CMS) version of RCPWAVE. Regardless, an RCPWAVE input data set that is operational on the CMS system can be used as input to the modified version of RCPWAVE but will require editing (the addition of optional input data) to activate the new RCPWAVE features that enable the workbook program WTNSWAV to operate on the output data sets. Likewise, an RCPWAVE input data set that is operational with the modified version of RCPWAVE can be used with the CMS version.

External Wave Transformation Model (RCPWAVE)

Introduction

376. The RCPWAVE model is a major component of the CMS suite of numerical models. With slight revisions, it has become the standard monochromatic wave transformation model used for estimating open-coast nearshore wave conditions for input to GENESIS in shoreline change studies conducted at CERC. RCPWAVE calculates wave propagation over an arbitrary bathymetry. The governing equations solved in the model are a modified form of the "mild slope" equation for linear, monochromatic waves, and the equation specifying irrotationality of the wave phase function gradient. Finite-difference approximations of these equations are solved to predict wave propagation outside the surf zone. Solution of the finite-difference expressions of the governing equations is performed on a rectilinear computational grid that may be composed of either constant or variably sized rectangular grid cells. The theoretical basis for the model's development and a detailed description of the numerical solution scheme and its implementation are contained in Ebersole (1985) and Ebersole, Cialone, and Prater (1986). These sources should be consulted for technical details, as only an overview of the model (focused toward the data requirements of GENESIS) is given herein. However, one technical point of importance is the computational stability of the RCPWAVE solution scheme and the implications it has in the use of RCPWAVE together with GENESIS.

RCPWAVE computational stability

377. RCPWAVE may become unstable for input wave conditions with extremely oblique incident wave angles. Consequently, comments concerning the computational stability of RCPWAVE are in order.

378. In RCPWAVE, the aspect ratio ($\Delta y/\Delta x$) of the computational grid plays an important role in determining the computational stability of the numerical solution scheme. It has been empirically determined that the maximum allowable wave angle (in a given grid cell) may be approximated as the inverse tangent of the ratio $\Delta y/\Delta x$. Therefore, larger wave angles can be resolved by the model as this ratio increases. For example, for $\Delta y/\Delta x = 1$, the maximum local wave angle is approximately 45 deg, and for $\Delta y/\Delta x = 3$ the maximum local wave angle is approximately 71 deg. However, increasing the Δy dimension for a specific shoreline reach will decrease the number of discrete nearshore wave data points available for input to GENESIS, so there is a trade-off between the ability to resolve the transformation of extremely oblique wave conditions in RCPWAVE and the resolution of nearshore wave conditions in GENESIS. For shoreline change modeling efforts, an RCPWAVE computational grid aspect ratio between 2 and 3 is recommended, and, with regard to GENESIS, a maximum of 3 or 4 GENESIS cells per RCPWAVE cell in the alongshore direction is recommended.

379. Consequently, if stability errors are encountered while performing nearshore wave transformation simulations, one must decide whether to modify the RCPWAVE bathymetry grid or to approach the problem differently. Consideration should first be given to the actual number of events that are having stability errors. If the percentage of events is small (say less than 5 percent), it may be more appropriate to rerun the simulations using a slightly less oblique input wave angle, rather than redigitize or interpolate the RCPWAVE bathymetry grid to obtain a more favorable aspect ratio. This procedure will introduce a slight error in the nearshore wave conditions for those events, but the magnitude of the error (in the nearshore wave angle) will be less than the imposed error in the input wave angle. For instance, consider an 8-sec wave in 60-ft of water with an incident wave angle of 75 deg; assuming straight and parallel bottom contours, this wave would have an incident wave angle of 40.2 deg in 20 ft. If a shift of 10 deg (inputing a 65-deg wave angle) were imposed at the 60 ft depth (in order to eliminate stability errors in RCPWAVE), the resulting shift in the wave angle at the 20-ft depth would be only about 3 deg. This error of 3 deg in the nearshore wave angle for 5 percent of the wave events while maintaining three GENESIS cells per RCPWAVE cell may be more acceptable than changing to five GENESIS cells per RCPWAVE cell to resolve the stability problem.

Coordinate system conventions

380. To relate output from one numerical model (RCPWAVE) to another (GENESIS), it is necessary, to identify (and understand) the coordinate systems and conventions used in each. Figure 90 provides an illustration of the coordinate system and conventions used in GENESIS and RCPWAVE.

381. The conventions for describing direction of wave propagation (wave angle) in GENESIS and RCPWAVE are identical. However, as seen in Figure 90, the location of the origin in the RCPWAVE coordinate system is at the landward left-hand side of the project reach (with the Y-axis extending alongshore and X-axis extending offshore), whereas the location of the origin in the GENESIS coordinate system is at the landward right-hand side of the project reach (with the X-axis extending alongshore and the Y-axis extending offshore). This difference in coordinate systems between RCPWAVE and GENESIS requires end-for-end swapping of wave and water depth data in the alongshore direction. As shown in Figure 90, the alongshore cell spacing of the RCPWAVE

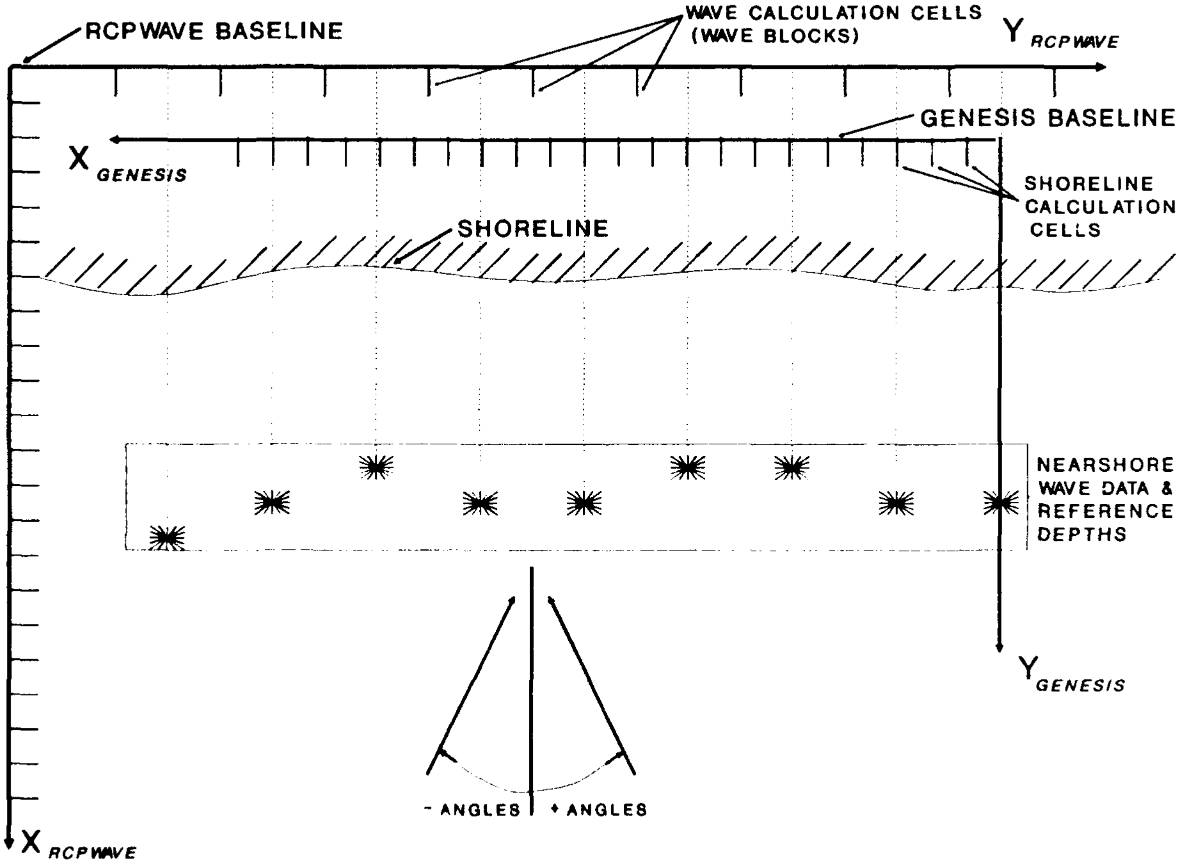


Figure 90. RCPWAVE and GENESIS coordinate systems and conventions

computational grid is oftentimes coarser than the GENESIS alongshore grid. The necessary interpolations are performed within GENESIS, with the requirement that the RCPWAVE cell spacing is a constant multiple of the GENESIS cell spacing.

382. Furthermore, because GENESIS is a one-dimensional (1-D) model, the offshore cell spacing in the RCPWAVE grid does not enter within the context of shoreline change modeling using GENESIS. The offshore location of the nearshore wave conditions in GENESIS is determined by the water depth at which the data were saved.

Wave transformation techniques

383. RCPWAVE provides a steady-state solution of the wave field over the RCPWAVE computational grid. The wave height and angle at each grid cell along the nearshore reference line depends on the water depth (a constant) and the offshore wave height, period, and angle. Because RCPWAVE is based on monochromatic wave theory, the equations governing wave refraction and shoaling do not depend on wave height, and nearshore wave transformation simulations can be performed using a unit wave height as the offshore input, leaving only two independent variables (offshore wave period and wave angle). Therefore, if the time series of offshore wave conditions is categorized into wave angle bands and period bands (with a resolution such that the difference in the transformation of wave events at the limits of the angle-period bands is small), a relatively few (typically between 50 and 100) nearshore wave transformation simulations can approximate the nearshore wave characteristics for the entire offshore wave time series. The RCPWAVE solution using this approach consists of a wave height transformation coefficient and wave angle at the center of each grid cell for each of the wave angle and period band combinations.

384. The nearshore wave data requirements of GENESIS are prebreaking wave height, angle, and water depth alongshore (and wave period, which is constant over the calculation grid for a selected wave angle and period band). Consequently, RCPWAVE generates much more information (wave characteristics over the entire RCPWAVE grid) than is required by GENESIS. In fact, GENESIS requires only the wave height and angle and the corresponding water depth at one (RCPWAVE) offshore grid cell for each of the alongshore cells within the project reach. As stated previously, GENESIS will interpolate between the alongshore RCPWAVE grid cells (referred to as "wave blocks") and GENESIS grid

cells (referred to as "shoreline calculation cells") if the wave block cell size is greater than the grid cell size in GENESIS. The next section will discuss input data requirements, generated output, as well as general operating procedures, and proposed modifications of the nearshore wave transformation model RCPWAVE.

RCPWAVE input and output

385. As originally developed, RCPWAVE required two input files, one containing grid information (specifically the size and number of cells in the grid), deepwater wave conditions (height, period, and direction) describing wave conditions to be simulated, and information controlling the amount of printed output. The other input file contains bathymetric data for each of the RCPWAVE grid cells.

386. These basic input requirements remain the same; however, with the incorporation of RCPWAVE into CMS, the format for their entry has changed. Because access to RCPWAVE within Corps field offices is primarily through CMS, this version of the model was adopted as the starting point for the PC version of RCPWAVE (herein referred to as PC_RCPWV) presently undergoing testing. The RCPWAVE input data set was designed to resemble the format required by the series of models released by the US Army Engineer Hydrological Engineering Center (commonly referred to as the HEC models). Since Corps personnel were already familiar with these HEC models, it was anticipated that this resemblance in format would reduce the time needed to learn the CMS system. For these reasons, this standard input data set will be used in PC_RCPWV.

387. The general format of each record in the input data set is as follows:

a. Each record is divided into 10 fields, each field containing 8 columns.

b. Field 1, columns 1 through 8, must contain a card identification label.

c. Fields 2 through 10 contain data that may be real, integer, or character in type. Integers must be right-justified. Real numbers must either either right-justified or contain a decimal point. Character data entries do not need to be justified.

d. Array data, such as bathymetry, are read with DO or implied DO loops. No label is required for array data. However, a general specification record, such as BATHSPEC for bathymetry data, must precede the array.

388. Attention to proper keying in of card identification labels and alphanumeric variables is important. Misspelled entries will result in either recognized error conditions that force the model to abort execution, or the bypassing of desired user-defined operations, such as bathymetry changes.

389. Certain variables have been assigned default values in the model to minimize input data and required computer resources. These variables and their respective default values are noted in the record description. The default values are representative of those chosen in previous studies performed by CERC. Although default values may not be applicable to all studies, they can serve as guides when selecting replacement values.

390. Default values are used if the input data record field corresponding to the variable is blank. This means that zero will not necessarily be the value assigned to a variable field left blank in the input data set. Therefore, the user must be careful when leaving blank fields in a record.

391. Not all input data records are required in each application. Some records are optional. This optional record facility was used to incorporate the additional input data requirements of PC_RCPWV that enable direct use of RCPWAVE results as input (through application of the programs WTNSWAV and WTDEPTH) to GENESIS. Tables 3 through 12 define the input records used in RCPWAVE. Figure 91 shows the RCPWAVE conventions for reading the two dimensional (2-D) bathymetry data. In Figure 91 the variable "V(I,J)" is a dummy array holding the bathymetry data. Input records and variables within records may be either required, or optional, defined as follows:

a. REQ Record or variable is required for every simulation.

b. OPT Record or variable is optional. Omitting this item results in either the default value being used or the defined operation (or option) not being performed.

The notation for specifying input data on the record is as follows:

a.	Char*8	Alphanumeric character string of up to eight characters.
b.	Integer	Integer data.
c.	Real	Real (floating point) data.
d.	A*	Alphanumeric values.
e.	+R*	Positive real values.
f.	R*	Positive or negative values.
g.	+I*	Positive integer values.
h.	I*	Positive or negative integer values.

Table 3

RCPWAVE Input Data Set, **FILES** Record: REQ

Field	Variable	Type	Status	Default	Permitted Data	Usage
1	CARDID	Char*8	REQ		FILES	Record identifier.
2	FNPRNT	Char*8	OPT	RCP_OUT	A*	File (name) to receive printed output from this simulation.

Table 4

RCPWAVE Input Data Set, **GENSPECS** Record: REQ

Field	Variable	Type	Status	Default	Permitted Data	Usage
1	CARDID	Char*8	REQ		GENSPECS	Record identifier.
2-9	TITLE	Char*64	OPT		A*	General title for simulation.
10	SUNITS	Integer	OPT	ENGLISH	ENGLISH METRIC	Declares the system of units for computations and results. UNIT ENGLISH METRIC Length ft m Time sec sec

Table 5

RCPWAVE Input Data Set, **WAVCOND** Record: REQ

Field	Variable	Type	Status	Default	Permitted Data	Usage
1	CARDID	Char*8	REQ		WAVCOND	Record identifier.
2	HDEEP	Real	REQ		+R*	Deepwater wave height (in SUNITS).
3	TDEEP	Real	REQ		+R*	Wave period.
4	ZDEEP	Real	REQ		R*	Deepwater wave angle.
5	CNTRANG	Real	OPT	0.0	R*	Offshore contour angle.
6	DIFFR	Char*8	OPT	YES	YES NO	Determine if topographic diffraction is included.

Table 6

RCPWAVE Input Data Set, **WAVMOD** Record: OPT*

Field	Variable	Type	Status	Default	Permitted Data	Usage
1	CARDID	CHAR*8	REQ		WAVMOD	Record identifier.
2	HUTIL1	Real	REQ		+R*	Wave height at J=1, I=XCELLS (in SUNITS).
3	HUTIL2	Real	REQ		+R*	Wave height at J=YCELLS, I=XCELLS (in SUNITS).
4	ZUTIL1	Real	REQ		R*	Wave angle at J=1, I=XCELLS.
5	ZUTIL2	Real	REQ		R*	Wave angle at J=YCELLS, I=XCELLS.

*Note: This record activates explicit specification of wave characteristics along the offshore boundary of the PC_RCPWV grid. If HUTIL1 and HUTIL2 are different, wave heights across the offshore boundary are linearly interpolated from the specified values at the ends; likewise, if ZUITL1 and ZUTIL2 are different wave angles are interpolated.

Table 7

RCPWAVE Input Data Set, **GRIDSPEC** Record: REQ

Field	Variable	Type	Status	Default	Permitted Data	Usage
1	CARDID	Char*8	REQ		GRIDSPEC	Record identifier.
2	GRTYPE	Char*8	OPT	RECTANG	A*	Cartesian system with constant-spaced grid cells (only available grid type in PC_RCPWV).
3	GUNITS	Char*8	OPT	ENGLISH	ENGLISH METRIC	System of units for grid data.
4	XCELLS	Integer	REG		+I*	Number of grid cells in X-direction (maximum of 75 in PC_RCPWV).
5	YCELLS	Integer	REG		+I*	Number of grid cells in Y-direction (maximum of 100 in PC_RCPWV).
6	DX	Real	REG		+R*	Spatial step size in X-direction (in GUNITS).
7	DY	Real	REG		+R*	Spatial step size in Y-direction (in GUNITS).

Table 8

RCPWAVE Input Data Set, BATHSPEC Record: REQ

Field	Variable	Type	Status	Default	Permitted Data	Usage
1	CARDID	Char*8	REQ		BATHSPEC	Record identifier.
2	BUNITS	Char*8	OPT	FEET	FEET METERS FATHOMS	Units for bathymetry/ topography array.
3	WDATUM	Real	OPT	0.	R*	Negative elevation values (depth) are added to this datum value (in BUNITS).
4	LDATUM	Real	OPT	0.	R*	Positive elevation values are added to this datum (in BUNITS).
5	DLIMIT	Real	OPT	-6000.	R*	A limiting water bathymetry value (deeper values are set to this value in BUNITS).
6	BSEQ	Char*8	OPT	XY	XY -XY X-Y -X-Y YX -YX Y-X -Y-X	The 2-D array of bathymetry and topography values (which follow this record) is read in a sequence specified by this mnemonic code (see note for conventions).
7-8	BFORM	Char*16	OPT	(8G10.3)	A*	The FORTRAN format applicable to the following 2-D bathymetry array.
9-10	BNAME	Char*16	OPT		A*	Name of bathymetry and topography data set.

Notes: (1) The actual 2-D array of bathymetry values follows this record.
(2) See Figure 91 for illustrations regarding conventions for BSEQ.

Table 9

RCPWAVE Input Data Set, CHNGBATH Record: OPT

Field	Variable	Type	Status	Default	Permitted Data	Usage
1	CARDID	Char*8	REQ		CHNGBATH	Record identifier.
2	BATH	Real	REQ		R*	New bathymetry value (in BUNITS ... the datum shifts, WDATUM and LDATUM will not be applied to this value.
3	X1INDX	Integer	REQ		I*	Collectively, these four variables declare the location of the new bathymetry value as an individual cell, a row (or column) of cells, or a subgrid of cells.
4	Y1INDX	Integer	REQ		I*	
5	X2INDX	Integer	OPT	0	I*	
6	Y2INDX	Integer	OPT	0	I*	

Notes: (1) Use one CHNGBATH record for each value.
(2) All CHNGBATH records must immediately follow the 2-D bathymetry array data.

Table 10

RCPWAVE Input Data Set, CONVERG Record: OPT

Field	Variable	Type	Status	Default	Permitted Data	Usage
1	CARDID	Char*8	REQ		CONVERG	Record identifier.
2	HCONVR	Real	OPT	0.0005	+R*	Wave height convergence criteria.
3	SCONVR	Real	OPT	0.00025	+R*	Wave angle convergence criteria.
4	ITAMAX	Integer	OPT	50	+I*	Maximum number of iterations.
5	IDIFF	Integer	OPT	15	+I*	Maximum number of iterations for diffraction.
6	STABL	Real	OPT	0.4	+R*	Stability factor.
7	DECAY	Real	OPT	0.2	+R*	Decay factor.

Table 11

RCPWAVE Input Data Set, **PRWINDOW** Record: REQ

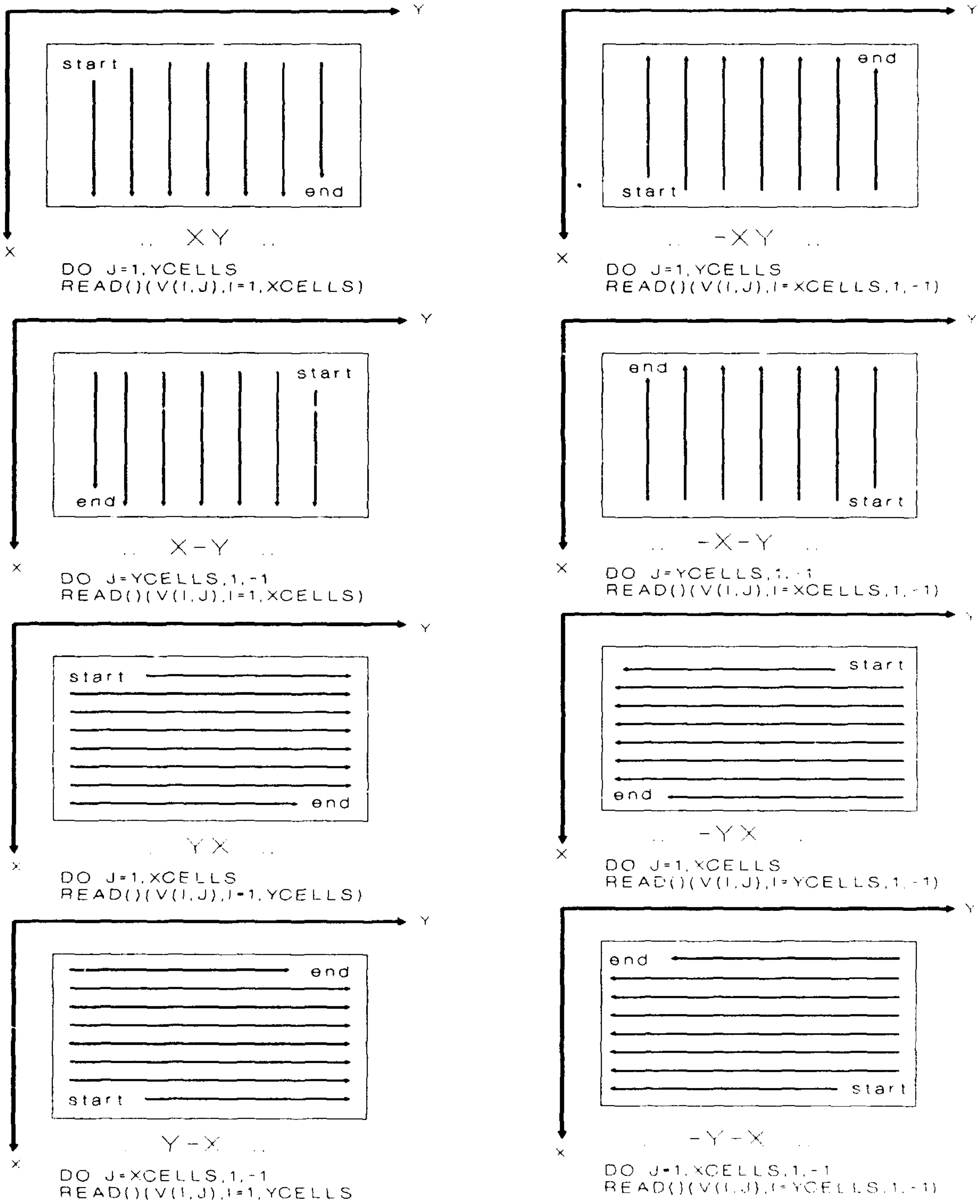
Field	Variable	Type	Status	Default	Permitted Data	Usage
1	CARDID	Char*8	REQ		PRWINDOW	Record identifier.
2	WXCEL1	Integer	OPT	1	+I*	Cell indices declaring the grid subregion for printing the selected variables. The window will be bounded by (and include the region from (WXCEL1, WYCEL1) to (WXCEL2, WYCEL2).
3	WXCEL2	Integer	OPT	XCELLS	+I*	
4	WYCEL1	Integer	OPT	1	+I*	
5	WYCEL2	Integer	OPT	YCELLS	+I*	
6-7	WPRVAR	Char*16	OPT	DAHKB	D	Bathymetry values.
					A	Wave angle.
					H	Wave height.
					K	Wave number.
					B	Breaking index.

Table 12

RCPWAVE Input Data Set, **SAVESPEC** Record: OPT*

Field	Variable	Type	Status	Default	Permitted Data	Usage
1	CARDID	Char*8	REQ		SAVESPEC	Record identifier.
2-3	FILOUT	Char*16	REQ	NSRF.OUT	A*	Output file name (for wave heights and angles along nearshore reference line.
4-5	NSRFIL	Char*16	OPT		A*	File containing the 1-D array specifying the X-cell location of the nearshore reference line (see note 3).

*Notes:
(1) This record activates the PC_RCPWV option for saving wave conditions along a nearshore reference line.
(2) The actual 1-D array containing the X-cell designation of the nearshore reference line follows this record.
(3) YCELLS values are required (one value for each alongshore cell). Reading of this array is in free format (values must be separated by a space, or a comma, or both).



XY

```
DO J=1,YCELLS
READ()(V(I,J),I=1,XCELLS)
```

-XY

```
DO J=1,YCELLS
READ()(V(I,J),I=XCELLS,1,-1)
```

X-Y

```
DO J=YCELLS,1,-1
READ()(V(I,J),I=1,XCELLS)
```

-X-Y

```
DO J=YCELLS,1,-1
READ()(V(I,J),I=XCELLS,1,-1)
```

YX

```
DO J=1,XCELLS
READ()(V(I,J),I=1,YCELLS)
```

-YX

```
DO J=1,XCELLS
READ()(V(I,J),I=YCELLS,1,-1)
```

Y-X

```
DO J=XCELLS,1,-1
READ()(V(I,J),I=1,YCELLS
```

-Y-X

```
DO J=1,XCELLS,1,-1
READ()(V(I,J),I=YCELLS,1,-1)
```

Figure 91. RCPWAVE conventions for reading of 2-D arrays

392. The two optional input records defined in Tables 6 (WAVMOD record) and 12 (SAVESPEC record) provide the input data required to activate the PC_RCPWV modifications that enable direct use of the results by the programs WTNSWAV and WTDEPTH. These modifications include: (a) explicit specification of wave conditions along the offshore boundary of the RCPWAVE computational grid, which may vary linearly in the alongshore direction (activated through the WAVMOD input record), and (b) specification of the nearshore reference line and an output file that will contain the wave heights and angles along the nearshore reference line (activated through the SAVESPEC input record).

393. A sample input data set for RCPWAVE (or PC_RCPWV) is given in Figure 92. Note that the four optional input records (three WAVMOD records and one SAVESPEC record) are contained in the sample input data set. The first WAVMOD card specifies (for the first wave condition) that the wave height at J=1 and I=40 is 0.90 ft, and at J=36 and I=40 the wave height is 1.10 ft; likewise, the wave angle at J=1 and I=40 is -14 deg, and at J=36 and I=40 the wave angle is -8 deg. If a constant wave height is required along the offshore boundary, the wave heights specified on the WAVMOD should be equal; similarly, a constant wave angle along the offshore boundary is specified by equal wave angles on the WAVMOD record. The next two WAVMOD records specify wave height and angle along the offshore boundary for the second and third wave conditions. The SAVESPEC record specifies that wave heights, wave angles, and water depths along the nearshore reference line should be written to the output file **TEST1.NSR**. The offshore location (X-axis coordinate) of the nearshore reference line is listed in the 1-D array that follows the SAVESPEC record. The nearshore reference line must be defined for each alongshore coordinate even though only a portion of it may be used (as will be shown later).

394. The output file **TEST1.NSR** contains the RCPWAVE output data required by GENESIS and is the file accessed by the programs WTNSWAV and WTDEPTH. A listing of this file is provided in Figure 93. Listings of the standard RCPWAVE output (taken from the file **RCP_OUT**) of water depths, wave angles, and wave heights, for the first wave condition are given in Figures 94, 95, and 96, respectively. Note in Figures 95 through 96 that the data are listed for I=10 through 40 and J=1 through 36 as specified in the input data set on the PRWINDOW record. The standard RCPWAVE output file **RCP_OUT** also contains, in addition to the data shown in Figures 94, 95, and

```
FILES    RCP_OUT
GENSPECS               WORKBOOK EXAMPLE                                      ENGLISH
GRIDSPEC RECTANG ENGLISH      40      36    200.0    400.0
WAVCOND       1.0      4.0   -11.0     0.0      YES
WAVMOD       0.90     1.10   -14.0    -8.0
WAVCOND       1.0      6.0   -33.0     0.0      YES
WAVMOD       0.80     1.20   -35.0   -31.0
WAVCOND       1.0      8.0    33.0     0.0      YES
WAVMOD        1.3      0.7    31.0    33.0
SAVESPEC        TEST1.NSR
15 15 15 15 15 15 14 14 14 14 14 14 14 15 15 14 14 14 13 13 13 13 14 13 13 13 13 14 14 15 16 17 17 16 16 16
PRWINDOW        1       26       1       36                         DAHKB
BATHSPEC     FEET     0.0      0.0               YX          (15F7.1)
   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0
   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0
   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0        ! ROW 1 (x=1,y=1-36)
   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0
   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0
   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0        ! ROW 2 (x=2,y=1-36
   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0
   -1.0   -1.0   -3.0   -3.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0
   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0        ! ROW 3 (x=3,y=1-36)
   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -2.5   -2.5   -2.5   -2.5   -2.5   -2.5   -2.5   -2.5   -2.5
   -2.5   -3.0   -5.5   -6.0   -5.0   -5.0   -4.5   -4.5   -4.5   -3.5   -3.5   -2.0   -4.0   -2.5   -2.5
    2.0   -2.5   -1.5   -1.5   -2.0   -2.5        ! ROW 4 (x=3,y=1-36)
   -1.0   -1.0   -1.0   -1.0   -1.0   -1.0   -5.0   -5.0   -5.0   -5.0   -5.0   -5.0   -5.0   -5.0   -5.0
   -5.0   -6.0   -8.0   -9.0  -10.0  -10.0   -9.0   -9.0   -9.0   -7.0   -7.0   -4.0   -8.0   -5.0   -5.0
   -4.0   -5.0   -3.0   -3.0   -4.0   -5.0        ! ROW 5 (x=4,y=1-36)
   -2.0   -2.0   -2.0   -2.0   -3.0   -3.5   -5.5   -5.5   -7.5   -8.0   -8.0   -8.0   -8.0   -9.5   -9.0
   -7.5   -9.5  -10.5  -11.0  -11.5  -11.0  -10.0  -10.0  -10.0   -8.5   -9.0   -8.0  -10.0   -8.5   -8.0
   -6.0   -7.5   -5.5   -5.5   -7.5   -7.5        ! ROW 6 (x=4,y=1-36)
   -4.0   -4.0   -4.0   -4.0   -6.0   -7.0   -6.0   -6.0  -10.0  -11.0  -11.0  -11.0  -11.0  -14.0  -13.0
  -10.0  -13.0  -13.0  -13.0  -13.0  -12.0  -11.0  -11.0  -11.0  -10.0  -11.0  -12.0  -12.0  -12.0  -11.0
   -8.0  -10.0   -8.0   -8.0  -11.0  -10.0        ! ROW 7
   -8.0   -8.0   -8.5   -8.5   -9.0  -10.0   -3.5   -9.5  -13.0  -12.0  -13.5  -12.5  -12.5  -14.5  -13.5
  -12.5  -13.5  -14.5  -14.0  -13.5  -13.0  -13.0  -12.5  -12.0  -12.0  -12.0  -12.5  -12.5  -12.5  -13.0
  -10.0  -11.5  -10.0  -10.0  -12.5  -12.0        ! ROW 8
  -12.0  -12.0  -13.0  -13.0  -12.0  -13.0  -13.0  -13.0  -16.0  -13.0  -16.0  -14.0  -14.0  -15.0  -14.0
  -15.0  -14.0  -16.0  -15.0  -14.0  -14.0  -15.0  -14.0  -13.0  -14.0  -13.0  -13.0  -13.0  -13.0  -15.0
  -12.0  -13.0  -12.0  -12.0  -14.0  -14.0        ! ROW 9
  -15.0  -14.5  -15.0  -15.0  -15.0  -15.5  -16.5  -16.5  -18.0  -15.0  -16.0  -15.5  -16.0  -15.5  -16.0
  -15.5  -16.5  -17.5  -14.5  -16.0  -16.0  -16.0  -14.5  -15.0  -14.5  -14.5  -14.5  -14.5  -14.5  -15.0
  -13.0  -14.5  -14.0  -13.5  -14.5  -14.5        ! ROW 10
  -18.0  -17.0  -17.0  -17.0  -18.0  -18.0  -20.0  -20.0  -20.0  -17.0  -16.0  -17.0  -18.0  -16.0  -18.0
  -16.0  -19.0  -19.0  -14.0  -18.0  -18.0  -17.0  -15.0  -17.0  -15.0  -16.0  -16.0  -16.0  -16.0  -15.0
  -14.0  -16.0  -16.0  -15.0  -15.0  -15.0        ! ROW 11
  -18.0  -17.0  -17.0  -17.0  -18.0  -18.0  -19.5  -19.5  -19.5  -18.0  -17.5  -18.0  -19.0  -17.0  -18.5
  -17.5  -19.0  -19.0  -17.5  -19.5  -19.5  -18.5  -17.0  -19.0  -18.0  -18.0  -18.0  -17.5  -17.0  -16.0
  -15.0  -16.0  -16.0  -15.5  -16.0  -16.0        ! ROW 12
  -18.0  -17.0  -17.0  -17.0  -18.0  -18.0  -19.0  -19.0  -19.0  -19.0  -19.0  -19.0  -20.0  -18.0  -19.0
  -19.0  -19.0  -19.0  -21.0  -21.0  -21.0  -20.0  -19.0  -21.0  -21.0  -20.0  -20.0  -19.0  -18.0  -17.0
  -16.0  -16.0  -16.0  -16.0  -17.0  -17.0        ! ROW 13
  -19.0  -18.5  -19.0  -19.0  -19.5  -19.0  -20.5  -20.5  -20.5  -20.0  -21.0  -20.5  -20.5  -19.5  -19.5
  -20.0  -21.0  -21.0  -22.0  -22.0  -22.0  -21.0  -21.0  -22.0  -20.5  -20.5  -20.5  -20.0  -20.0  -18.5
  -17.5  -17.0  -16.5  -17.0  -18.0  -18.5        ! ROW 14
  -20.0  -20.0  -21.0  -21.0  -21.0  -20.0  -22.0  -22.0  -22.0  -21.0  -23.0  -22.0  -21.0  -21.0  -20.0
  -21.0  -23.0  -23.0  -23.0  -23.0  -23.0  -22.0  -23.0  -23.0  -21.0  -21.0  -21.0  -22.0  -22.0  -20.0
  -19.0  -18.0  -17.0  -18.0  -19.0  -20.0        ! ROW 15
  -20.5  -20.5  -21.5  -21.5  -21.5  -21.5  -22.5  -22.5  -22.5  -22.0  -23.0  -23.0  -22.0  -21.5  -21.0
  -21.0  -23.5  -23.5  -23.5  -23.5  -23.5  -22.5  -23.5  -23.5  -22.0  -22.5  -21.5  -23.0  -23.0  -21.5
  -21.0  -19.5  -19.0  -20.0  -20.5  -21.5        ! ROW 16
  -21.0  -21.0  -22.0  -22.0  -22.0  -23.0  -23.0  -23.0  -23.0  -23.0  -23.0  -24.0  -23.0  -22.0  -22.0
  -21.0  -24.0  -24.0  -24.0  -24.0  -24.0  -23.0  -24.0  -24.0  -23.0  -24.0  -22.0  -24.0  -24.0  -23.0
  -23.0  -21.0  -21.0  -22.0  -22.0  -23.0        ! ROW 17
  -21.5  -21.5  -22.0  -22.5  -22.5  -23.0  -23.5  -23.5  -23.5  -23.0  -23.5  -24.0  -23.0  -23.0  -22.5
  -23.0  -25.0  -24.5  -24.5  -24.5  -25.0  -24.5  -25.0  -25.0  -24.0  -24.5  -23.5  -25.0  -24.5  -24.0
  -23.5  -22.0  -22.0  -23.0  -22.5  -23.5        ! ROW 18
```

Figure 92. Sample RCPWAVE input data set (Continued)

```
-22.0   -22.0   -22.0   -23.0   -23.0   -23.0   -24.0   -24.0   -24.0   -23.0   -24.0   -24.0   -23.0   -24.0   -23.0
-25.0   -26.0   -25.0   -25.0   -25.0   -26.0   -26.0   -26.0   -26.0   -25.0   -25.0   -25.0   -26.0   -25.0   -25.0
-24.0   -23.0   -23.0   -24.0   -23.0   -24.0         ! ROW 19
-22.0   -22.5   -22.5   -23.5   -23.5   -24.0   -24.5   -24.5   -24.5   -24.0   -24.5   -24.0   -23.0   -25.0   -25.0
-26.5   -26.5   -26.0   -26.0   -26.0   -26.5   -26.5   -26.5   -26.5   -26.0   -25.5   -25.5   -26.0   -26.0   -25.5
-24.5   -24.5   -24.0   -24.0   -23.5   -25.0         ! ROW 20
-22.0   -23.0   -23.0   -24.0   -24.0   -25.0   -25.0   -25.0   -25.0   -25.0   -25.0   -24.0   -23.0   -26.0   -27.0
-28.0   -27.0   -27.0   -27.0   -27.0   -27.0   -27.0   -27.0   -27.0   -27.0   -26.0   -26.0   -26.0   -27.0   -26.0
-25.0   -26.0   -25.0   -24.0   -25.0   -26.0         ! ROW 21
-22.5   -24.0   -23.5   -24.0   -24.0   -25.0   -25.5   -25.5   -25.5   -25.0   -25.0   -24.0   -23.5   -25.5   -27.0
-28.0   -27.5   -27.0   -27.0   -27.0   -27.0   -27.0   -27.5   -27.0   -27.0   -26.5   -26.5   -27.0   -27.5   -26.5
-26.0   -26.5   -26.0   -26.0   -27.0   -27.0         ! ROW 22
-23.0   -25.0   -24.0   -24.0   -24.0   -25.0   -26.0   -26.0   -26.0   -25.0   -25.0   -24.0   -24.0   -25.0   -27.0
-28.0   -28.0   -27.0   -27.0   -27.0   -27.0   -27.0   -28.0   -27.0   -27.0   -27.0   -27.0   -28.0   -28.0   -27.0
-27.0   -27.0   -27.0   -28.0   -29.0   -28.0         ! ROW 23
-24.0   -25.0   -24.0   -24.5   -24.5   -25.0   -26.0   -26.0   -26.0   -25.5   -25.5   -24.5   -24.5   -25.0   -27.0
-28.5   -28.0   -27.5   -27.5   -27.5   -27.5   -27.5   -28.0   -27.5   -27.5   -27.0   -27.5   -28.0   -28.5   -27.5
-27.5   -28.0   -27.5   -28.5   -29.0   -28.5         ! ROW 24
-25.0   -25.0   -24.0   -25.0   -25.0   -25.0   -26.0   -26.0   -26.0   -26.0   -26.0   -25.0   -25.0   -25.0   -27.0
-29.0   -28.0   -28.0   -28.0   -28.0   -28.0   -28.0   -28.0   -28.0   -28.0   -27.0   -28.0   -28.0   -29.0   -28.0
-28.0   -29.0   -28.0   -29.0   -29.0   -29.0         ! ROW 25
-26.5   -26.0   -24.5   -25.5   -25.5   -25.5   -26.0   -26.0   -26.5   -26.5   -26.5   -27.0   -26.0   -25.5   -27.5
-29.5   -28.5   -28.0   -28.0   -28.0   -28.0   -28.0   -28.0   -28.0   -28.0   -28.0   -28.5   -28.5   -29.5   -28.5
-28.5   -29.0   -29.0   -29.0   -29.0   -29.5         ! ROW 26
-28.0   -27.0   -25.0   -26.0   -26.0   -26.0   -26.0   -26.0   -27.0   -27.0   -27.0   -29.0   -27.0   -26.0   -28.0
-30.0   -29.0   -28.0   -28.0   -28.0   -28.0   -28.0   -28.0   -28.0   -28.0   -29.0   -29.0   -29.0   -30.0   -29.0
-29.0   -29.0   -30.0   -29.0   -29.0   -30.0         ! ROW 27
-27.5   -26.5   -25.5   -26.5   -26.5   -26.5   -26.5   -26.5   -27.5   -27.5   -27.0   -28.0   -27.0   -27.0   -29.0
-30.5   -29.0   -28.5   -28.5   -28.5   -28.5   -28.0   -28.0   -27.5   -28.0   -29.5   -29.5   -29.5   -30.5   -30.0
-29.5   -29.5   -30.0   -29.5   -29.5   -30.0         ! ROW 28
-27.0   -26.0   -26.0   -27.0   -27.0   -27.0   -27.0   -27.0   -28.0   -28.0   -27.0   -27.0   -27.0   -28.0   -30.0
-31.0   -29.0   -29.0   -29.0   -29.0   -29.0   -28.0   -28.0   -27.0   -28.0   -30.0   -30.0   -30.0   -31.0   -31.0
-30.0   -30.0   -30.0   -30.0   -30.0   -30.0         ! ROW 29
-26.5   -26.0   -26.5   -27.5   -27.5   -27.5   -27.5   -27.5   -28.0   -28.0   -27.5   -27.0   -27.0   -28.0   -30.0
-31.0   -29.0   -29.5   -29.0   -29.0   -28.5   -28.0   -28.0   -28.0   -29.0   -30.0   -30.0   -30.0   -31.0   -31.0
-30.5   -30.5   -30.5   -31.0   -30.5   -30.5         ! ROW 30
-26.0   -26.0   -27.0   -28.0   -28.0   -28.0   -28.0   -28.0   -28.0   -28.0   -28.0   -27.0   -27.0    28.0   -30.0
-31.0   -29.0   -30.0   -29.0   -29.0   -28.0   -28.0   -28.0   -29.0   -30.0   -30.0   -30.0   -30.0   -31.0   -31.0
-31.0   -31.0   -31.0   -32.0   -31.0   -31.0         ! ROW 31
-27.0   -27.0   -27.0   -28.0   -28.0   -29.0   -29.0   -29.0   -29.0   -29.0   -28.0   -27.0   -27.0   -29.0   -30.0
-32.0   -29.0   -31.0   -30.0   -31.0   -29.0   -29.0   -29.0   -29.0   -30.0   -30.0   -31.0   -31.0   -31.0   -31.0
-31.0   -31.0   -32.0   -32.0   -32.0   -32.0         ! ROW 32
-28.0   -30.0   -29.0   -29.0   -29.0   -29.0   -29.0   -29.0   -29.0   -29.0   -28.0   -28.0   -29.0   -30.0   -31.0
-33.0   -33.0   -31.0   -31.0   -31.0   -31.0   -31.0   -31.0   -31.0   -30.0   -30.0   -31.0   -32.0   -32.0   -32.0
-32.0   -33.0   -32.0   -32.0   -33.0   -32.0         ! ROW 33
-28.0   -29.0   -30.0   -30.0   -30.0   -29.0   -30.0   -30.0   -30.0   -29.0   -30.0   -29.0   -30.0   -30.0   -31.0
-34.0   -36.0   -31.0   -31.0   -31.0   -31.0   -31.0   -31.0   -31.0   -32.0   -32.0   -32.0   -33.0   -33.0   -32.0
-32.0   -33.0   -33.0   -33.0   -33.0   -33.0         ! ROW 34
-28.0   -29.0   -29.0   -29.0   -29.0   -29.0   -30.0   -30.0   -30.0   -30.0   -30.0   -31.0   -31.0   -31.0   -31.0
-33.0   -35.0   -35.0   -33.0   -31.0   -31.0   -31.0   -32.0   -32.0   -32.0   -32.0   -32.0   -32.0   -33.0   -33.0
-33.0    33.0   -33.0   -33.0   -33.0   -33.0         ! ROW 35
-29.0   -29.0   -29.0   -30.0   -30.0   -30.0   -30.0   -30.0   -30.0   -31.0   -32.0   -32.0   -32.0   -32.0   -34.0
-36.0   -37.0   -35.0   -33.0   -32.0   -32.0   -32.0   -32.0   -32.0   -31.0   -32.0   -33.0   -33.0   -33.0   -33.0
-33.0   -34.0   -34.0   -34.0   -33.0   -33.0         ! ROW 36
-29.0   -29.0   -30.0   -30.0   -30.0   -30.0   -30.0   -30.0   -30.0   -31.0   -31.0   -32.0   -32.0   -32.0   -34.0
-36.0   -37.0   -38.0   -33.0   -33.0   -32.0   -33.0   -33.0   -33.0   -32.0   -33.0   -33.0   -33.0   -34.0   -34.0
-34.0   -34.0   -34.0   -34.0   -34.0   -34.0         ! ROW 37
-30.0   -30.0   -30.0   -30.0   -31.0   -31.0   -31.0   -31.0   -31.0   -31.0   -32.0   -32.0   -32.0   -33.0   -33.0
-35.0   -38.0   -38.0   -35.0   -33.0   -33.0   -33.0   -33.0   -33.0   -33.0   -33.0   -34.0   -34.0   -34.0   -34.0
-34.0   -34.0   -34.0   -34.0   -34.0   -34.0         ! ROW 38
-30.0   -30.0   -31.0   -31.0   -31.0   -31.0   -31.0   -31.0   -31.0   -31.0   -32.0   -32.0   -32.0   -33.0   -33.0
-35.0   -38.0   -36.0   -37.0   -35.0   -34.0   -34.0   -34.0   -34.0   -34.0   -34.0   -34.0   -34.0   -34.0   -34.0
-35.0   -35.0   -35.0   -35.0   -35.0   -35.0         ! ROW 39
-31.0   -31.0   -31.0   -31.0   -31.0   -32.0   -32.0   -32.0   -32.0   -33.0   -33.0   -33.0   -33.0   -33.0   -34.0
-35.0   -37.0   -38.0   -36.0   -35.0   -34.0   -34.0   -34.0   -34.0   -34.0   -34.0   -34.0   -35.0   -35.0   -35.0
-35.0   -35.0   -35.0   -35.0   -35.0   -35.0         ! ROW 40
```

Figure 92. (Concluded)

```
WAVE CONDITION NUMBER  1:    HEIGHT=   1.000    PERIOD=  4.000    ANGLE= -11.000
  1 15  0.8897  -12.3520  20.00          13 14  0.9550   11.8810  20.50          25 13  0.9986  -10.3707  21.00
  2 15  0.8897  -12.3520  20.00          14 15  0.9543  -11.2445  21.00          26 13  1.0039   -9.8211  20.00
  3 15  0.8945  -12.3364  21.00          15 15  0.9476  -10.3748  20.00          27 13  1.0051   -9.3530  20.00
  4 15  0.8966  -12.3708  21.00          16 14  0.9386   -9.3968  20.00          28 14  1.0000   -8.8772  20.00
  5 15  0.8999  -12.3058  21.00          17 14  0.9312   -9.5346  21.00          29 14  0.9985   -9.4577  20.00
  6 15  0.8958  -11.6712  20.00          18 14  0.9328  -10.1067  21.00          30 15  1.0074   -9.7357  20.00
  7 14  0.8957  -11.3647  20.50          19 13  0.9405  -10.0524  21.00          31 16  1.0218   -9.5881  21.00
  8 14  0.8971  -11.8367  20.50          20 13  0.9527  -10.5243  21.00          32 17  1.0310   -9.1350  21.00
  9 14  0.9053  -12.1483  20.50          21 13  0.9656  -10.7502  21.00          33 17  1.0333   -8.3536  21.00
 10 14  0.9112  -11.7892  20.00          22 13  0.9738  -10.6319  20.00          34 16  1.0278   -7.9179  20.00
 11 14  0.9211  -11.7460  21.00          23 14  0.9816   -9.9549  21.00          35 16  1.0293   -8.1387  20.50
 12 14  0.9305  -11.9898  20.50          24 13  0.9866   -9.9323  21.00          36 16  1.0293   -8.1387  20.50
WAVE CONDITION NUMBER  2:     HEIGHT=   1.000      PERIOD=  6.000     ANGLE= -33.000
  1 15  0.8631  -30.0225  20.00          13 14  0.8837  -30.4808  20.50          25 13  0.9906  -29.4019  21.00
  2 15  0.8631  -30.0225  20.00          14 15  0.9416  -30.3020  21.00          26 13  1.0378  -28.8355  20.00
  3 15  0.8628  -30.3318  21.00          15 15  0.9799  -28.0177  20.00          27 13  1.0747  -28.0769  20.00
  4 15  0.8683  -30.4371  21.00          16 14  0.9769  -25.1004  20.00          28 14  1.0845  -26.4752  20.00
  5 15  0.8789  -30.3756  21.00          17 14  0.9413  -24.1924  21.00          29 14  1.0792  -27.1269  20.00
  6 15  0.8732  -28.3472  20.00          18 14  0.9134  -24.8196  21.00          30 15  1.0846  -27.9732  20.00
  7 14  0.8562  -27.3718  20.50          19 13  0.9008  -24.8648  21.00          31 16  1.0927  -28.5753  21.00
  8 14  0.8402  -27.9235  20.50          20 13  0.9055  -26.3819  21.00          32 17  1.1218  -28.3768  21.00
  9 14  0.8396  -28.8175  20.50          21 13  0.9214  -27.6698  21.00          33 17  1.1274  -26.7449  21.00
 10 14  0.8415  -28.2327  20.00          22 13  0.9488  -28.0188  20.00          34 16  1.1295  -25.3861  20.00
 11 14  0.8369  -28.5835  21.00          23 14  0.9484  -27.1980  21.00          35 16  1.1338  -25.8852  20.50
 12 14  0.8486  -29.5555  20.50          24 13  0.9513  -27.4717  21.00          36 16  1.1338  -25.8852  20.50
WAVE CONDITION NUMBER  3:     HEIGHT=   1.000      PERIOD=  8.000     ANGLE=  33.000
  1 15  1.3038   28.6382  20.00          13 14  1.0101   25.9374  20.50          25 13  0.8153   25.5069  21.00
  2 15  1.3038   28.6382  20.00          14 15  1.0056   26.4121  21.00          26 13  0.8032   25.7634  20.00
  3 15  1.2656   29.2892  21.00          15 15  1.0354   26.3285  20.00          27 13  0.7738   25.2467  20.00
  4 15  1.2253   28.5237  21.00          16 14  1.0505   27.8425  20.00          28 14  0.7645   24.8362  20.00
  5 15  1.1996   28.1241  21.00          17 14  1.0251   27.4160  21.00          29 14  0.7585   22.6308  20.00
  6 15  1.1867   27.8268  20.00          18 14  1.0107   26.8230  21.00          30 15  0.7725   22.7325  20.00
  7 14  1.1612   27.7163  20.50          19 13  0.9762   27.7380  21.00          31 16  0.7745   24.4143  21.00
  8 14  1.1499   26.2820  20.50          20 13  0.9307   26.7149  21.00          32 17  0.7791   25.7744  21.00
  9 14  1.1505   26.5580  20.50          21 13  0.8996   26.2424  21.00          33 17  0.7815   27.4792  21.00
 10 14  1.1296   27.5728  20.00          22 13  0.8777   25.6493  20.00          34 16  0.7750   26.9136  20.00
 11 14  1.0685   27.9094  21.00          23 14  0.8537   27.1101  21.00          35 16  0.7677   26.3395  20.50
 12 14  1.0246   26.2257  20.50          24 13  0.8293   26.3850  21.00          36 16  0.7677   26.3395  20.50
```

Figure 93. PC_RCPWV output file **TEST1.NSR**

96, a summaryof the input specifications, prototype distances in the computational grid (in the alongshore and cross-shore directions), and tables similar to those shown in Figures 94, 95, and 96, for each of the wave conditions simulated. The shaded data entries shown in Figures 94, 95, and 96 denote information along the nearshore reference line, and, through comparison with Figure 93 (wave condition number 1), it is seen that these are the data that were written to the output file **TEST1.NSR**.

395. The capability of explicitly specifying wave conditions on the offshore boundary of the RCPWAVE computational grid was developed for use with hindcast wave data that have been transformed (using the program WAVETRAN) from deepwater conditions to the specific water depth along the boundary. Prior to the addition of this feature, input wave conditions to RCPWAVE were taken as deepwater conditions, and a simple Snell's Law transformation was performed to estimate wave conditions along the offshore boundary. However,

```
                            WATER DEPTHS   (MULTIPLIED BY   10.)
I/J:      1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18
  10:   145 145 150 150 150 155 165 165 180 150 160 155 160 155 160 155 165 175
  11:   170 170 170 170 180 180 200 200 200 170 160 170 180 160 180 160 190 190
  12:   170 170 170 170 180 180 195 195 195 180 175 180 190 170 185 175 190 190
  13:   170 170 170 170 180 180 190 190 190 190 190 190 200 180 190 190 190 190
  14:   185 185 190 190 195 190 205 205 205 200 210 205 205 195 195 200 210 210
  15:   200 200 210 210 210 200 220 220 220 210 230 220 210 210 200 210 230 230
  16:   205 205 215 215 215 215 225 225 225 220 230 230 220 215 210 210 235 235
  17:   210 210 220 220 220 230 230 230 230 230 230 240 230 220 220 210 240 240
  18:   215 215 220 225 225 230 235 235 235 230 235 240 230 230 225 230 250 245
  19:   220 220 220 230 230 230 240 240 240 230 240 240 230 240 230 230 260 250
  20:   225 225 225 235 235 240 245 245 245 240 245 240 230 250 250 265 265 260
  21:   230 230 230 240 240 250 250 250 250 250 250 240 230 260 270 280 270 270
  22:   240 240 235 240 240 250 255 255 255 250 250 240 235 255 270 280 275 270
  23:   250 250 240 240 240 250 260 260 260 250 250 240 240 250 270 280 280 270
  24:   250 250 240 245 245 250 260 260 260 255 255 245 245 250 270 285 280 275
  25:   250 250 240 250 250 250 260 260 260 260 260 250 250 250 270 290 280 280
  26:   260 260 245 255 255 255 260 260 265 265 265 270 260 255 275 295 285 280
  27:   270 270 250 260 260 260 260 260 270 270 270 290 270 260 280 300 290 280
  28:   265 265 255 265 265 265 265 265 275 275 270 280 270 270 290 305 290 285
  29:   260 260 260 270 270 270 270 270 280 280 270 270 270 280 300 310 290 290
  30:   260 260 265 275 275 275 275 275 280 280 275 270 270 280 300 310 290 295
  31:   260 260 270 280 280 280 280 280 280 280 280 270 270 280 300 310 290 300
  32:   270 270 270 280 280 290 290 290 290 290 280 270 270 290 300 320 290 310
  33:   300 300 290 290 290 290 290 290 290 290 280 280 290 300 310 330 330 310
  34:   290 290 300 300 300 290 300 300 300 290 300 290 300 300 310 340 360 310
  35:   290 290 290 290 290 290 300 300 300 300 300 310 310 310 310 330 350 350
  36:   290 290 290 300 300 300 300 300 300 310 320 320 320 320 340 360 370 350
  37:   290 290 300 300 300 300 300 300 300 310 310 320 320 320 340 360 370 380
  38:   300 300 300 300 310 310 310 310 310 310 320 320 320 330 330 350 380 360
  39:   300 300 310 310 310 310 310 310 310 310 320 320 320 330 330 350 380 360
  40:   310 310 310 310 310 320 320 320 320 330 330 330 330 330 340 350 370 380

                            WATER DEPTHS   (MULTIPLIED BY   10.)
I/J:     19  20  21  22  23  24  25  26  27  28  29  30  31  32  33  34  35  36
  10:   140 160 160 160 145 150 145 145 145 145 145 150 130 145 140 135 145 145
  11:   145 180 180 170 150 170 150 160 160 160 160 150 140 160 160 150 150 150
  12:   175 195 195 185 170 190 180 180 180 175 170 160 150 160 160 155 160 160
  13:   210 210 210 200 190 210 210 200 200 190 180 170 160 160 160 160 170 170
  14:   220 220 220 210 210 220 205 205 205 200 200 185 175 170 165 170 180 180
  15:   230 230 230 220 230 230 210 210 210 220 220 200 190 180 170 180 190 190
  16:   235 235 235 225 235 235 220 225 215 230 230 215 210 195 190 200 205 205
  17:   240 240 240 230 240 240 230 240 220 240 240 230 230 210 210 220 220 220
  18:   245 245 250 245 250 250 240 245 235 250 245 240 235 220 220 230 225 225
  19:   250 250 260 260 260 260 250 250 250 260 250 250 240 230 230 240 230 230
  20:   260 260 265 265 265 265 260 255 255 260 260 255 245 245 240 240 235 235
  21:   270 270 270 270 270 270 270 260 260 260 270 260 250 260 250 240 250 250
  22:   270 270 270 270 275 270 270 265 265 270 275 265 260 265 260 260 270 270
  23:   270 270 270 270 280 270 270 270 270 280 280 270 270 270 270 280 290 290
  24:   275 275 275 275 280 275 275 270 275 280 285 275 275 280 275 285 290 290
  25:   280 280 280 280 280 280 280 270 280 280 290 280 280 290 280 290 290 290
  26:   280 280 280 280 280 280 280 280 285 285 295 285 285 290 290 290 290 290
  27:   280 280 280 280 280 280 280 290 290 290 300 290 290 290 300 290 290 290
  28:   285 285 285 280 280 275 280 295 295 295 305 300 295 295 300 295 295 295
  29:   290 290 290 280 280 270 280 300 300 300 310 310 300 300 300 300 300 300
  30:   290 290 285 280 280 280 290 300 300 300 310 310 305 305 305 310 305 305
  31:   290 290 280 280 280 290 300 300 300 300 310 310 310 310 310 320 310 310
  32:   300 310 290 290 290 290 300 300 310 310 310 310 310 310 320 320 320 320
  33:   310 310 310 310 310 310 300 300 310 320 320 320 320 330 320 320 330 330
  34:   310 310 310 310 310 310 320 320 320 330 330 320 320 330 330 330 330 330
  35:   330 310 310 310 320 320 320 320 320 320 330 330 330 330 330 330 330 330
  36:   330 320 320 320 320 320 310 320 330 330 330 330 330 340 340 340 330 330
  37:   330 330 320 330 330 330 320 330 330 330 340 340 340 340 340 340 340 340
  38:   350 330 330 330 330 330 330 330 340 340 340 340 340 340 340 340 340 340
  39:   370 350 340 340 340 340 340 340 340 340 340 340 350 350 350 350 350 350
  40:   360 350 340 340 340 340 340 340 340 350 350 350 350 350 350 350 350 350
```

Figure 94. Standard RCPWAVE output of water depths (from RCP_OUT)

```
                          WAVE ANGLES    (MULTIPLIED BY     1.)
I/J:      1    2    3    4    5    6    7    8    9   10   11   12   13   14   15   16   17   18
 10:    -11  -11  -11  -11  -11  -10  -10  -11  -12  -12  -11  -11  -11  -11  -10   -9   -8  -11
 11:    -12  -12  -12  -11  -11  -11  -11  -12  -13  -12  -11  -11  -12  -11  -10   -9   -9  -11
 12:    -12  -12  -12  -11  -11  -11  -11  -12  -12  -12  -11  -11  -12  -11  -10   -9   -9  -10
 13:    -12  -12  -12  -12  -12  -11  -11  -12  -12  -12  -12  -12  -12  -11  -10   -9   -9  -10
 14:    -12  -12  -12  -12  -12  -11  -11  -12  -12  -12  -12  -12  -12  -11  -10   -9  -10  -10
 15:    -12  -12  -12  -12  -12  -12  -12  -12  -12  -12  -12  -12  -12  -11  -10   -9  -10  -11
 16:    -13  -13  -13  -12  -12  -12  -12  -12  -12  -12  -12  -12  -12  -11  -10  -10  -10  -11
 17:    -13  -13  -13  -13  -12  -12  -12  -12  -12  -12  -12  -12  -12  -11  -10  -10  -10  -11
 18:    -13  -13  -13  -13  -12   12  -12  -12  -12  -12  -12  -12  -12  -11  -10   10  -11  -11
 19:    -13  -13  -13  -13  -12  -12  -12  -12  -12  -12  -12  -12  -11  -11  -10  -10  -11  -11
 20:    -13  -13  -13  -13  -13  -12  -12  -12  -12  -12  -12  -12  -11  -11  -10  -11  -11  -11
 21:    -13  -13  -13  -13  -13  -12  -12  -12  -12  -12  -12  -12  -11  -11  -10  -11  -11  -11
 22:    -14  -14  -13  -13  -13  -12  -12  -12  -13  -12  -12  -12  -11  -11  -10  -11  -11  -11
 23:    -14  -14  -13  -13  -13  -13  -13  -13  -13  -12  -12  -12  -12  -11  -10  -11  -11  -11
 24:    -14  -14  -13  -13  -13  -13  -13  -13  -12  -12  -12  -12  -12  -11  -10  -11  -11  -11
 25:    -14  -14  -13  -13  -13  -13  -13  -13  -12  -12  -12  -12  -12  -11  -11  -11  -11  -11
 26:    -14  -14  -13  -13  -13  -13  -13  -13  -12  -12  -12  -12  -12  -11  -11  -11  -11  -11
 27:    -13  -13  -13  -13  -13  -13  -13  -13  -12  -12  -12  -12  -12  -11  -11  -11   11  -11
 28:    -13  -13  -13  -13  -13  -13  -13  -13  -12  -13  -12  -12  -12  -11  -11  -11  -11  -11
 29.    -13  -13  -13  -13  -13  -13  -13  -13  -13  -13  -12  -12  -12  -11  -11  -11  -11  -11
 30:    -13  -13  -13  -13  -13  -13  -13  -13  -13  -12  -12  -12  -12  -11  -11  -11  -11  -11
 31:    -13  -13  -13  -13  -13  -13  -13  -13  -13  -12  -12  -12  -12  -11  -11  -11  -11  -11
 32:    -14  -14  -13  -13  -13  -13  -13  -13  -13  -12  -12  -12  -12  -11  -11  -11  -11  -11
 33:    -14  -14  -14  -13  -13  -13  -13  -13  -13  -12  -12  -12  -12  -12  -11  -11  -11  -11
 34:    -14  -14  -14  -13  -13  -13  -13  -13  -13  -12  -12  -12  -12  -12  -11  -11  -11  -11
 35:    -14  -14  -14  -13  -13  -13  -13  -13  -13  -12  -12  -12  -12  -12  -11  -11  -11  -11
 36:    -14  -14  -14  -13  -13  -13  -13  -13  -13  -12  -12  -12  -12  -12  -11  -11  -11  -11
 37:    -14  -14  -14  -13  -13  -13  -13  -13  -13  -12  -12  -12  -12  -12  -12  -11  -11  -11
 38:    -14  -14  -14  -13  -13  -13  -13  -13  -13  -12  -12  -12  -12  -12  -12  -11  -11  -11
 39:    -14  -14  -14  -13  -13  -13  -13  -13  -13  -12  -12  -12  -12  -12  -12  -11  -11  -11
 40:    -14  -14  -14  -13  -13  -13  -13  -13  -13  -12  -12  -12  -12  -12  -12  -11  -11  -11
```

```
                          WAVE ANGLES    (MULTIPLIED BY     1.)
I/J:     19   20   21   22   23   24   25   26   27   28   29   30   31   32   33   34   35   36
 10:    -10   -9  -10   11  -10   -9  -10   -9   -9   -9   -9  -11   -9   -8   -8   -7   -7   -7
 11:     -9   -9  -11  -11   -9   -9  -10   -9   -9   -9  -10  -10   -9   -8   -9   -8   -7   -7
 12:    -10  -10  -11  -11  -10  -10  -10  -10   -9   -9  -10  -10  -10   -9   -8   -7   -7   -7
 13:    -10  -11  -11  -11  -10  -10  -10  -10   -9   -9  -10  -10  -10   -9   -8   -7   -7   -7
 14:    -10  -11  -11  -10  -10  -10  -10  -10   -9   -9   -9  -10  -10   -9   -8   -7   -7   -7
 15:    -11  -11  -11  -10  -10  -10  -10  -10   -9   -9   -9  -10  -10   -9   -8   -7   -8   -8
 16:    -11  -11  -11  -10  -10  -10  -10  -10   -9   -9   -9   -9  -10   -9   -8   -8   -8   -8
 17:    -11  -11  -11  -10  -10  -10  -10  -10   -9   -9   -9   -9  -10   -9   -8   -8   -8   -8
 18:    -11  -11  -11  -11  -10  -10  -10  -10   -9   -9   -9   -9   -9   -9   -8   -8   -8   -8
 19:    -11  -11  -11  -11  -10  -10  -10  -10   -9   -9   -9   -9   -9   -9   -9   -8   -8   -8
 20:    -11  -11  -11  -11  -10  -10  -10  -10   -9   -9   -9   -9   -9   -9   -9   -8   -8   -8
 21:    -11  -11  -11  -11  -10  -10  -10  -10   -9   -9   -9   -9   -9   -9   -9   -8   -8   -8
 22:    -11  -11  -11  -11  -10  -10  -10  -10   -9   -9   -9   -9   -9   -9   -9   -8   -8   -8
 23:    -11  -11  -11  -11  -10  -10  -10  -10   -9   -9   -9   -9   -9   -9   -9   -8   -8   -8
 24:    -11  -11  -11  -11  -10  -10  -10  -10   -9   -9   -9   -9   -9   -9   -9   -8   -8   -8
 25:    -11  -11  -11  -11  -10  -10  -10   -9   -9   -9   -9   -9   -9   -9   -9   -9   -9   -9
 26:    -11  -11  -11  -11  -10  -10  -10   -9   -9   -9   -9   -9   -9   -9   -9   -9   -8   -8
 27:    -11  -11  -11  -11  -10  -10  -10   -9   -9   -9   -9   -9   -9   -9   -9   -9   -8   -8
 28:    -11  -11  -11  -11  -10  -10  -10  -10   -9   -9   -9   -9   -9   -9   -9   -9   -8   -8
 29:    -11  -11  -11  -11  -10  -10  -10  -10  -10   -9   -9   -9   -9   -9   -9   -8   -8   -8
 30:    -11  -11  -11  -10  -10  -10  -10  -10  -10   -9   -9   -9   -9   -9   -9   -8   -8   -8
 31:    -11  -11  -11  -10  -10  -10  -10  -10   -9   -9   -9   -9   -9   -9   -9   -8   -8   -8
 32:    -11  -11  -11  -10  -10  -10  -10  -10   -9   -9   -9   -9   -9   -9   -9   -8   -8   -8
 33:    -11  -11  -11  -10  -10  -10  -10  -10   -9   -9   -9   -9   -9   -9   -9   -8   -8   -9
 34:    -11  -11  -11  -10  -10  -10  -10  -10  -10   -9   -9   -9   -9   -9   -9   -8   -8   -8
 35:    -11  -11  -11  -10  -10  -10  -10  -10  -10   -9   -9   -9   -9   -9   -9   -8   -8   -8
 36:    -11  -11  -11  -10  -10  -10  -10  -10  -10   -9   -9   -9   -9   -9   -9   -8   -8   -8
 37.    -11  -11  -11  -10  -10  -10  -10  -10  -10   -9   -9   -9   -9   -9   -9   -8   -8   -8
 38:     11  -11  -11  -10  -10  -10  -10  -10  -10   -9   -9   -9   -9   -9   -9   -8   -8   -8
 39:    -11  -11  -11  -10  -10  -10  -10  -10  -10   -9   -9   -9   -9   -9   -9   -8   -8    8
 40:    -11  -11  -11  -10  -10  -10  -10  -10  -10   -9   -9   -9   -9   -9   -9   -8   -8   -8
```

Figure 95. Standard RCPWAVE output of wave angles (from RCP_OUT)

```
                         WAVE HEIGHTS    (MULTIPLIED BY    10.)
 I/J:     1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18
  10:     9   9   9   9   9   9   9   9   9   9   9   9   9   9   9   9   9   9
  11:     9   9   9   9   9   9   9   9   9   9   9   9   9   9   9   9   9   9
  12:     9   9   9   9   9   9   9   9   9   9   9   9   9   9   9   9   9   9
  13:     9   9   9   9   9   9   9   9   9   9   9   9   9   9   9   9   9   9
  14:     9   9   9   9   9   9   9   9   9   9   9   9   9   9   9   9   9   9
  15:     9   9   9   9   9   9   9   9   9   9   9   9   9  10   9   9   9   9
  16:     9   9   9   9   9   9   9   9   9   9   9   9  10  10   9   9   9   9
  17:     9   9   9   9   9   9   9   9   9   9   9   9  10  10   9   9   9  10
  18:     9   9   9   9   9   9   9   9   9   9   9   9  10  10   9   9   9  10
  19:     9   9   9   9   9   9   9   9   9   9   9   9  10  10   9   9  10  10
  20:     9   9   9   9   9   9   9   9   9   9   9   9  10  10  10  10  10  10
  21:     9   9   9   9   9   9   9   9   9   9   9   9  10  10  10  10  10  10
  22:     9   9   9   9   9   9   9   9   9   9   9   9  10  10  10  10  10  10
  23:     9   9   9   9   9   9   9   9   9   9   9   9  10  10  10  10  10  10
  24:     9   9   9   9   9   9   9   9   9   9   9   9  10  10  10  10  10  10
  25:     9   9   9   9   9   9   9   9   9   9   9   9  10  10  10  10  10  10
  26:     9   9   9   9   9   9   9   9   9   9   9  10  10  10  10  10  10  10
  27:     9   9   9   9   9   9   9   9   9   9   9  10  10  10  10  10  10  10
  28:     9   9   9   9   9   9   9   9   9   9   9  10  10  10  10  10  10  10
  29:     9   9   9   9   9   9   9   9   9   9   9  10  10  10  10  10  10  10
  30:     9   9   9   9   9   9   9   9   9   9   9  10  10  10  10  10  10  10
  31:     9   9   9   9   9   9   9   9   9   9   9  10  10  10  10  10  10  10
  32:     9   9   9   9   9   9   9   9   9   9   9  10  10  10  10  10  10  10
  33:     9   9   9   9   9   9   9   9   9   9   9  10  10  10  10  10  10  10
  34:     9   9   9   9   9   9   9   9   9   9  10  10  10  10  10  10  10  10
  35:     9   9   9   9   9   9   9   9   9  10  10  10  10  10  10  10  10  10
  36:     9   9   9   9   9   9   9   9   9  10  10  10  10  10  10  10  10  10
  37:     9   9   9   9   9   9   9   9   9  10  10  10  10  10  10  10  10  10
  38:     9   9   9   9   9   9   9   9   9  10  10  10  10  10  10  10  10  10
  39:     9   9   9   9   9   9   9   9   9  10  10  10  10  10  10  10  10  10
  40:     9   9   9   9   9   9   9   9   9  10  10  10  10  10  10  10  10  10
```

```
                         WAVE HEIGHTS    (MULTIPLIED BY    10.)
 I/J:    19  20  21  22  23  24  25  26  27  28  29  30  31  32  33  34  35  36
  10:     9   9   9  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10
  11:     9   9   9  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10
  12:     9   9  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10
  13:     9  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10
  14:     9  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10
  15:    10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10
  16:    10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10
  17:    10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10
  18:    10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10
  19:    10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10
  20:    10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10
  21:    10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  10  11  11
  22:    10  10  10  10  10  10  10  10  10  10  10  10  10  11  11  11  11  11
  23:    10  10  10  10  10  10  10  10  10  10  10  10  10  11  11  11  11  11
  24:    10  10  10  10  10  10  10  10  10  10  10  10  11  11  11  11  11  11
  25:    10  10  10  10  10  10  10  10  10  10  10  10  11  11  11  11  11  11
  26:    10  10  10  10  10  10  10  10  10  10  10  10  11  11  11  11  11  11
  27:    10  10  10  10  10  10  10  10  10  10  10  11  11  11  11  11  11  11
  28:    10  10  10  10  10  10  10  10  10  10  11  11  11  11  11  11  11  11
  29:    10  10  10  10  10  10  10  10  10  10  11  11  11  11  11  11  11  11
  30:    10  10  10  10  10  10  10  10  10  10  11  11  11  11  11  11  11  11
  31:    10  10  10  10  10  10  10  10  10  10  11  11  11  11  11  11  11  11
  32:    10  10  10  10  10  10  10  10  10  10  11  11  11  11  11  11  11  11
  33:    10  10  10  10  10  10  10  10  10  11  11  11  11  11  11  11  11  11
  34:    10  10  10  10  10  10  10  10  10  11  11  11  11  11  11  11  11  11
  35:    10  10  10  10  10  10  10  10  10  11  11  11  11  11  11  11  11  11
  36:    10  10  10  10  10  10  10  10  10  11  11  11  11  11  11  11  11  11
  37:    10  10  10  10  10  10  10  10  10  11  11  11  11  11  11  11  11  11
  38:    10  10  10  10  10  10  10  10  10  11  11  11  11  11  11  11  11  11
  39:    10  10  10  10  10  10  10  10  10  11  11  11  11  11  11  11  11  11
  40:    10  10  10  10  10  10  10  10  10  11  11  11  11  11  11  11  11  11
```

Figure 96. Standard RCPWAVE output of wave heights (from RCP_OUT)

this procedure precluded use of the more refined spectral transformation and wave sheltering features of the program WAVETRAN.

396. Note that the wave angles (Figure 95) and wave heights (Figure 96) along the offshore boundary (I=40) are not constant, but vary linearly between -14 and -8 deg for wave angles and between 0.9 and 1.1 ft for wave heights. This added feature to RCPWAVE has been found to be useful at locations where sheltering of wave energy is significant. However, evaluation of the wave height and angle gradients requires the use of two wave hindcast stations, one at each end of the project reach. In addition, the offshore time series used in GENESIS (the input file **WAVES**.ext) is developed by averaging the wave heights and angles from the two hindcast stations. This concludes the discussion of the external wave transformation model RCPWAVE.

397. Other wave transformation models could be used to estimate the nearshore wave conditions required by GENESIS, provided that prebreaking wave heights, wave angles, and associated water depths at uniform alongshore spacing are included in the output. However, use of other wave transformation models will either preclude the use of the programs WTNSWAV and WTDEPTH or require modification of these programs. The remainder of this chapter is devoted to presentation of the programs WHEREWAV, WTNSWAV, WTDEPTH, and NSTRAN.

WHEREWAV

Introduction

398. The program WHEREWAV is a utility program that computes various statistical properties of the input time series of wave conditions. Considering that there could be up to 2,920 unique offshore wave events in a typical GENESIS simulation using a 6-hr time-step and a 1-year-long offshore wave time series consisting of two wave conditions (sea and swell) per time-step, the shoreline modeler must make some assumptions concerning nearshore wave transformation and the number of simulations required. The program WHEREWAV was designed to aid in the selection of representative classes of offshore wave conditions for which nearshore wave transformation simulations should be performed, and it is based on typical procedures used in numerous shoreline change studies conducted at CERC. A listing of the source code for the program WHEREWAV is provided in Appendix I.

Calculation procedure

399. WHEREWAV categorizes wave events in the offshore time series by wave period (referred to as "period bands") and direction of wave propagation (referred to as "angle bands"), and then reports the number of wave events occurring within each of the period and angle band categories. Input requirements beyond specification of the input and output file names include: (a) input file format; (b) convention of wave angles (determined by WIS Phase type); and (c) shoreline orientation with respect to north.

400. First, the program computes the number of possible wave approach angle bands and their boundaries. This computation is achieved by comparing the user-specified shoreline orientation with a 360-deg template of sixteen 22.5-deg-wide angle bands centered on the compass directions of north, north-northeast, northeast, east-northeast, etc. Figure 97 provides a schematic illustration of the angle band template. Next, the program reads the input time series of offshore wave conditions, and, for each wave event (statistics for sea and swell wave events are computed individually), the program performs the following classification checks and computations. If the wave event is calm or describes a wave traveling offshore, it is counted (as a calm or offshore traveling event), and the next event is processed. If the event pertains to a wave traveling onshore, it is counted within its direction of approach angle band and period band (Table 13 provides a listing of the period band designations). Output for each angle band includes: (a) the number of events occurring within the angle band; (b) the overall average wave angle; (c) the overall average wave height; and (d) the period bands encountered within the angle band. Likewise, output for each period band includes: (a) the number of events occurring within the period band; (b) the overall average wave period; (c) the overall average wave height; and (d) the angle bands encountered within the period band. With these output tables the shoreline modeler can evaluate the number of nearshore wave transformation simulations required to describe the transformation of the offshore wave time series to the nearshore reference line.

Example applications

401. The following example applications demonstrate the utility of the program and provide guidance for the interpretation of the output. Input data files to the program WHEREWAV can be either standard WIS wave time series retrieved from SEAS or CEDRS, or time series generated by the workbook

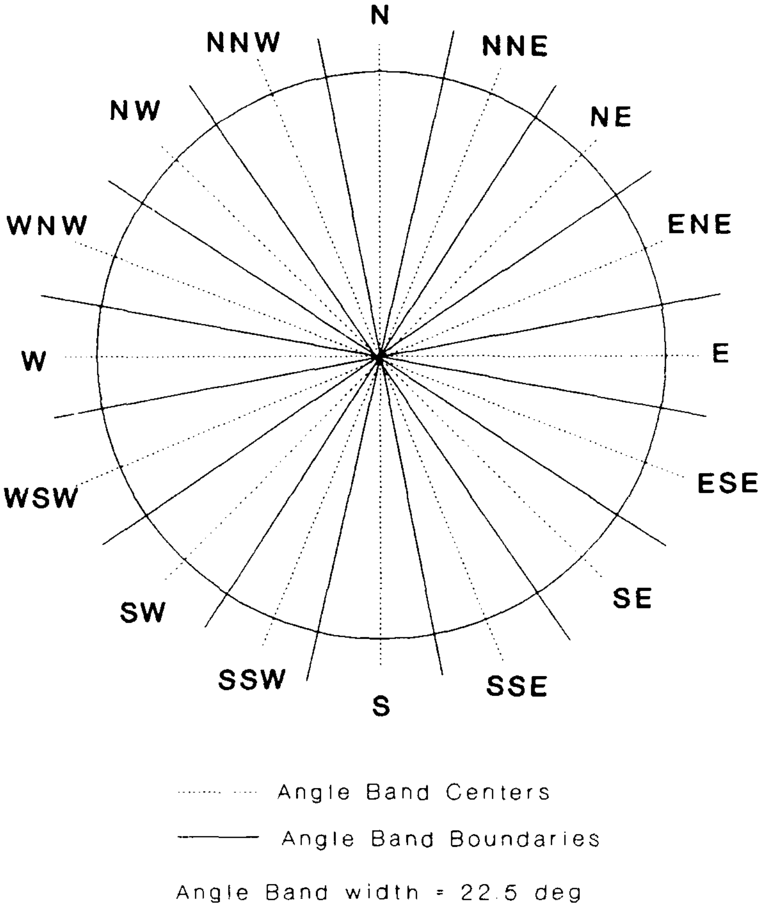


Figure 97. Template of potential wave approach angle bands

programs RCRIT, WAVETRAN, or WTWAVTS. With modification, the program WHEREWAV can be rewritten to read any wave time series, as demonstrated in Example 3.

402. Example 1. In this example, the input is a standard SEAS time series. The file name of this input file is **WVSEAS.DAT** and is the same input file used previously in the RCRIT, WTWAVTS, and WTWAVES examples (a listing of the file is provide in Figure 12). The program is executed by issuing the command *WHEREWAV* at the PC prompt.

403. The program responds by prompting for entry of the input file name and extension. If the file is not in the default directory, the appropriate path should also be entered. For this example, the name *WVSEAS.DAT* is entered. This file must exist (it represents the input), or the program will terminate.

404. The next prompt issued requests entry of the file name of the output file; in this example, the file name *SEASOUT* is entered. Note that the

Table 13

Period Band Designation Within WHEREWAV

Period Band Number	Range of Wave Period (sec)
1	$0.0 < T < 5.0$
2	$5.0 \leq T < 7.0$
3	$7.0 \leq T < 9.0$
4	$9.0 \leq T < 11.0$
5	$11.0 \leq T < 13.0$
6	$13.0 \leq T < 15.0$
7	$15.0 \leq T < 17.0$
8	$17.0 \leq T < 23.0$

output file name extension is not requested and should not be entered. The program will assign the extension **.WW** (indicating that the file is output from the program WHEREWAV) to all output files. This file may or may not exist. If the file already exists, it will be overwritten; otherwise, a new file will be created.

405. Next, WHEREWAV prompts for specification of the input data format. The available options are: (1) SEAS, (2) OUTPUT FROM ANOTHER WORKBOOK CODE (Header and Format similar to SEAS), (3) CEDRS, (4) OUTPUT FROM ANOTHER WORKBOOK CODE (Header and Format similar to CEDRS), and (5) other. In the present example, the input time series was retrieved using SEAS, so the value *1* is entered. The other options will be discussed as they are encountered.

406. The next prompt requests the user to define the input time series data type, and the options available are (1) Phase I, (2) Phase II, and (3) Phase III. These data types refer to the three phases of the WIS hindcasts, and the input is used to determine the coordinate system convention of the wave angles. In this example, the input time series was retrieved from the WIS data base using SEAS for Phase II Station 28, and the value *2* is entered. The last prompt issued by WHEREWAV before the computations begin is a request for entry of the shoreline orientation in degrees measured clockwise from north. In this example, a shoreline orientation of *54* (deg) was entered.

407. WHEREWAV then proceeds to perform the previously described computations and writes the results to the user-specified output file

(**SEASOUT.WW**). A listing of the file **SEASOUT.WW** is provided in Figure 98, which shows that the time series **WVSEAS.DAT** contains 48 records with two events (wave conditions) per record. There were 22 calm swell events and 32 offshore-traveling sea events, leaving 16 sea events and 26 swell events that will produce longshore sand transport. According to the classification of wave events by angle band, the majority (13 events) of the sea events are approaching from the angle band centered about east-northeast, and all (26 events) of the swell events are approaching from the east-northeast. The tables, which classify the waves by period, show that the sea wave conditions range between 3 and 9 sec, with the longer wave periods corresponding to larger wave heights. For swell wave conditions, wave periods range between 8 and 13 sec, and again it is noted that the longer wave periods are associated with larger wave heights. The overall average swell wave height is approximately 4.1 m, whereas the overall average sea wave height is approximately 2.2 m.

408. For complete representation of sea wave conditions contained in the offshore time series, seven nearshore wave transformation simulations should be performed; for swell wave conditions, four nearshore wave transformation simulations should be performed. A list of the deepwater wave characteristics (height, period, and angle) for these 11 nearshore wave transformation simulations is given in Table 14 (based on the data given in Figure 98).

409. Note in Table 14 that the average wave angle within a specific angle band is input in the nearshore wave transformation simulation. Likewise, the average wave period within a specific period band is input in the nearshore wave transformation simulation. The intent is to represent, as closely as possible, all wave events within a given (angle-period band) classification. Therefore, use of average conditions seems to be more appropriate than using the central value of the band, although nearshore wave transformation simulations using central values have been used with success in previous shoreline change studies.

410. Example 2. In this example, the WIS Phase III time series generated in WAVETRAN Example 1 and listed in Figure 64 will serve as the input time series. Responses to the program prompts are as follows:

a. Input file name: *OUT1TST.PH3*

b. Output file name: *PH3OUT*

```
WAVE CLASSIFICATION & STATISTICS FOR INPUT TIME SERIES:  WVSEAS.DAT
THE FOLLOWING CLASSIFICATIONS ARE BASED ON A SHORELINE ORIENTATION OF:   54.00


NUMBER OF RECORDS PROCESSED.................          48
NUMBER OF CALM SEA EVENTS...................           0
NUMBER OF CALM SWELL EVENTS.................          22
NUMBER OF OFFSHORE TRAVELING SEA EVENTS.....          32
NUMBER OF OFFSHORE TRAVELING SWELL EVENTS...           0


             DEFINITION OF ANGLE BANDS                                 DEFINITION OF PERIOD BANDS

ANGLE BAND  RANGE WITH RESPECT  RANGE WITH RESPECT         PERIOD BAND NO.              RANGE OF WAVE PERIODS
  NUMBER         TO NORTH         TO SHORE-NORMAL                 1                         0.0< T < 5.0
    1        54.00 :  56.25      90.00 :  87.75                   2                         5.0≤ T < 7.0
    2        56.25 :  78.75      87.75 :  65.25                   3                         7.0≤ T < 9.0
    3        78.75 : 101.25      65.25 :  42.75                   4                         9.0≤ T <11.0
    4       101.25 : 123.75      42.75 :  20.25                   5                        11.0≤ T <13.0
    5       123.75 : 146.25      20.25 :  -2.25                   6                        13.0≤ T <15.0
    6       146.25 : 168.75      -2.25 : -24.75                   7                        15.0≤ T <17.0
    7       168.75 : 191.25     -24.75 : -47.25                   8                        17.0≤ T <23.0
    8       191.25 : 213.75     -47.25 : -69.75                   9                        23.0≤ T
    9       213.75 : 234.00     -69.75 : -90.00



 CLASSIFICATION OF SEA WAVE EVENTS BY ANGLE BAND             CLASSIFICATION OF SEA WAVE EVENTS BY PERIOD

 ANGLE BAND   NO. OF   AVERAGE   AVERAGE   PERIOD            PERIOD BAND   NO. OF   AVERAGE   AVERAGE   ANGLE
   NUMBER     EVENTS    ANGLE    HEIGHT    BANDS               NUMBER      EVENTS   PERIOD    HEIGHT    BANDS
     1           1      88.00     76.00      1                   1            5       3.80     83.00    1 2 3
     2          13      73.69    250.38    1 2 3 4               2            5       5.20    142.60    2 3
     3           2      57.50    108.00     1 2                  3            4       7.75    386.25      2
     4           0        -         -        -                   4            2       9.00    437.00      2
     5           0        -         -        -                   5            0        -         -        -
     6           0        -         -        -                   6            0        -         -        -
     7           0        -         -        -                   7            0        -         -        -
     8           0        -         -        -                   8            0        -         -        -
     9           0        -         -        -                   9            0        -         -        -



 CLASSIFICATION OF SWELL WAVE EVENTS BY ANGLE BAND         CLASSIFICATION OF SWELL WAVE EVENTS BY PERIOD

 ANGLE BAND   NO. OF   AVERAGE   AVERAGE   PERIOD          PERIOD BAND   NO. OF   AVERAGE   AVERAGE   ANGLE
   NUMBER     EVENTS    ANGLE    HEIGHT    BANDS             NUMBER      EVENTS   PERIOD    HEIGHT    BANDS
     1           0        -         -        -                 1            0        -         -        -
     2          26      71.35    409.96    3 4 5 6             2            0        -         -        -
     3           0        -         -        -                 3            1       8.00    125.00      2
     4           0        -         -        -                 4            6       9.83    185.17      2
     5           0        -         -        -                 5            5      11.60    368.40      2
     6           0        -         -        -                 6           14      13.00    541.50      2
     7           0        -         -        -                 7            0        -         -        -
     8           0        -         -        -                 8            0        -         -        -
     9           0        -         -        -
```

Figure 98. WHEREWAV Example 1: Output file **SEASOUT.WW**

Table 14

Nearshore Wave Transformation Simulations for WHEREWAV Example 1

Simulation No.	Wave Height* m	Wave Angle deg	Wave Period sec
		Sea Wave Conditions	
1	1	88.0	3.8
2	1	73.7	3.8
3	1	73.7	5.2
4	1	73.7	7.8
5	1	73.7	9.0
6	1	57.5	3.8
7	1	57.5	5.2
		Swell Wave Conditions	
8	1	71.4	8.0
9	1	71.4	9.8
10	1	71.4	11.6
11	1	71.4	13.0

* All simulations will be performed for a unit wave height, and the RCPWAVE output height along the nearshore reference will be used as a height transformation coefficient (multiplier) for transforming the offshore wave height.

- c. Input data format: *2* (OUTPUT FROM ANOTHER WORKBOOK CODE; header and format similar to SEAS)
- d. Number of events per record: *2*
- e. Input data type: *3* (PHASE III)
- f. Shoreline orientation: *0*

411. Note in line d of the user responses that the program prompts for the number of events per record. This prompt is required because the input time series in this example was generated by another workbook program, and the time series may or may not contain two events per record.

412. A listing of the output file **PH3OUT.WW** is provided in Figure 99. This time series was fabricated for demonstrating the program WAVETRAN in Part V, and the symmetrical nature of the wave statistics is shown in Figure 99. A comparison of the average wave angle statistics reported in the sea and swell wave classification by angle band tables (Figure 99) shows a difference of less than 5 deg. Consequently, for this input time series, the RCPWAVE nearshore transformation of sea and swell wave conditions could be simulated irrespective of wave type, reducing the number of simulations from

```
WAVE CLASSIFICATION & STATISTICS FOR INPUT TIME SERIES:  OUT1TST.PH3
THE FOLLOWING CLASSIFICATIONS ARE BASED ON A SHORELINE ORIENTATION OF:     0.00


NUMBER OF RECORDS PROCESSED.................            51
NUMBER OF CALM SEA EVENTS...................             0
NUMBER OF CALM SWELL EVENTS.................             0
NUMBER OF OFFSHORE TRAVELING SEA EVENTS.....             0
NUMBER OF OFFSHORE TRAVELING SWELL EVENTS...             0


           DEFINITION OF ANGLE BANDS                                DEFINITION OF PERIOD BANDS

ANGLE BAND  RANGE WITH RESPECT  RANGE WITH RESPECT         PERIOD BAND NO.            RANGE OF WAVE PERIODS
  NUMBER        TO NORTH         TO SHORE-NORMAL
    1         0.00 :  11.25      90.00 :  78.75                  1                       0.0< T < 5.0
    2        11.25 :  33.75      78.75 :  56.25                  2                       5.0≤ T < 7.0
    3        33.75 :  56.25      56.25 :  33.75                  3                       7.0≤ T < 9.0
    4        56.25 :  78.75      33.75 :  11.25                  4                       9.0≤ T <11.0
    5        78.75 : 101.25      11.25 : -11.25                  5                      11.0≤ T <13.0
    6       101.25 : 123.75     -11.25 : -33.75                  6                      13.0≤ T <15.0
    7       123.75 : 146.25     -33.75 : -56.25                  7                      15.0≤ T <17.0
    8       146.25 : 168.75     -56.25 : -78.75                  8                      17.0≤ T <23.0
    9       168.75 : 180.00     -78.75 : -90.00                  9                      23.0≤ T



 CLASSIFICATION OF SEA WAVE EVENTS BY ANGLE BAND          CLASSIFICATION OF SEA WAVE EVENTS BY PERIOD

 ANGLE BAND   NO. OF   AVERAGE   AVERAGE   PERIOD          PERIOD BAND   NO. OF   AVERAGE   AVERAGE   ANGLE
   NUMBER     EVENTS    ANGLE    HEIGHT    BANDS             NUMBER      EVENTS   PERIOD    HEIGHT    BANDS
     1          0        -         -         -                  1          17       3.00    248.35  2 3 4 5
     2          2      64.95    120.55       1                                                        6 7 8
     3          4      44.95    165.35     1 4                  2           0        -         -        -
     4         10      21.44    160.90     1 4 9                3           0        -         -        -
     5         19       0.00    235.79     1 4 9                4          17      10.00    152.79    3 4 5
     6         10     -21.44    160.90     1 4 9                                                        6 7
     7          4     -44.95    165.35     1 4                  5           0        -         -        -
     8          2     -64.95    120.55       1                  6           0        -         -        -
     9          0        -         -         -                  7           0        -         -        -
                                                                8           0        -         -        -
                                                                9          17      25.00    157.86    4 5 6



 CLASSIFICATION OF SWELL WAVE EVENTS BY ANGLE BAND       CLASSIFICATION OF SWELL WAVE EVENTS BY PERIOD

 ANGLE BAND   NO. OF   AVERAGE   AVERAGE   PERIOD          PERIOD BAND   NO. OF   AVERAGE   AVERAGE   ANGLE
   NUMBER     EVENTS    ANGLE    HEIGHT    BANDS             NUMBER      EVENTS   PERIOD    HEIGHT    BANDS
     1          0        -         -         -                  1          17      3.00     250.82  2 3 4 5
     2          3      65.87    141.27       1                                                        6 7 8
     3          4      41.83    142.07     1 4                  2           0       -          -        -
     4         10      20.66    164.10     1 4 9                3           0       -          -        -
     5         17       0.00    256.18     1 4 9                4          17     10.00     154.98    3 4 5
     6         10     -20.66    164.10     1 4 9                                                        6 7
     7          4     -41.83    142.07     1 4                  5           0       -          -        -
     8          3     -65.87    141.27       1                  6           0       -          -        -
     9          0        -         -         -                  7           0       -          -        -
                                                                8           0       -          -        -
                                                                9          17     25.00     160.15    4 5 6
```

Figure 99. WHEREWAV Example 2: Output file PH3OUT.WW

30 to 15. Table 15 provides a listing of the RCPWAVE offshore boundary wave conditions (remember these data are not deepwater conditions).

413. Example 3. In this example, a wave data set as retrieved from the WIS data base using CEDRS is input to the program WHEREWAV. A listing of this input time series is provided in Figure 16 (Part III). Responses to the program prompts are as follows:

a. Input file name: *WVCEDRS.DAT*
b. Output file name: *CEDRSOUT*
c. Input data format: *3* (CEDRS)
d. Input data type: *2* (PHASE II)
e. Shoreline orientation: *348*

414. Figure 100 provides a listing of the output file (**CEDRSOUT.WW**) generated as a result of this example application of the program WHEREWAV. For this input time series, 10 nearshore wave transformation simulations are required to represent the transformation of the offshore wave time series to nearshore wave conditions. Table 16 provides a listing of the deepwater wave conditions that would be input to RCPWAVE (based on the data listed in Figure 100). Note that simulation numbers 5 and 10 could be combined

Table 15

Nearshore Wave Transformation Simulations for WHEREWAV Example 2*

Simulation No.	Wave Height m	Wave Angle deg	Wave Period sec
1	1	65.5	3.0
2	1	43.4	3.0
3	1	43.4	10.0
4	1	21.0	3.0
5	1	21.0	10.0
6	1	21.0	25.0
7	1	0.0	3.0
8	1	0.0	10.0
9	1	0.0	25.0
10	1	-21.0	3.0
11	1	-21.0	10.0
12	1	-21.0	25.0
13	1	43.4	3.0
14	1	43.4	10.0
15	1	65.5	3.0

* Sea and swell wave conditions.

```
WAVE CLASSIFICATION & STATISTICS FOR INPUT TIME SERIES: WVCEDRS.DAT
THE FOLLOWING CLASSIFICATIONS ARE BASED ON A SHORELINE ORIENTATION OF:   348.00


NUMBER OF RECORDS PROCESSED................          48
NUMBER OF CALM SEA EVENTS..................           0
NUMBER OF CALM SWELL EVENTS................          10
NUMBER OF OFFSHORE TRAVELING SEA EVENTS.....         29
NUMBER OF OFFSHORE TRAVELING SWELL EVENTS...          3



            DEFINITION OF ANGLE BANDS                               DEFINITION OF PERIOD BANDS

ANGLE BAND  RANGE WITH RESPECT  RANGE WITH RESPECT          PERIOD BAND NO.            RANGE OF WAVE PERIODS
  NUMBER        TO NORTH          TO SHORE-NORMAL                 1                       0.0< T < 5.0
    1       348.00 : 348.75      90.00 :  89.25                   2                       5.0≤ T < 7.0
    2       348.75 :  11.25      89.25 :  66.75                   3                       7.0≤ T < 9.0
    3        11.25 :  33.75      66.75 :  44.25                   4                       9.0≤ T <11.0
    4        33.75 :  56.25      44.25 :  21.75                   5                      11.0≤ T <13.0
    5        56.25 :  78.75      21.75 :  -0.75                   6                      13.0≤ T <15.0
    6        78.75 : 101.25      -0.75 : -23.25                   7                      15.0≤ T <17.0
    7       101.25 : 123.75     -23.25 : -45.75                   8                      17.0≤ T <23.0
    8       123.75 : 146.25     -45.75 : -68.25                   9                      23.0≤ T
    9       146.25 : 168.00     -68.25 : -90.00



  CLASSIFICATION OF SEA WAVE EVENTS BY ANGLE BAND          CLASSIFICATION OF SEA WAVE EVENTS BY PERIOD

 ANGLE BAND   NO. OF   AVERAGE   AVERAGE   PERIOD           PERIOD BAND   NO. OF   AVERAGE   AVERAGE   ANGLE
   NUMBER     EVENTS    ANGLE    HEIGHT    BANDS              NUMBER      EVENTS   PERIOD    HEIGHT    BANDS
     1          0         -         -        -                  1           11      3.27      0.53     7 8 9
     2          0         -         -        -                  2            6      5.50      1.60     4 8 9
     3          0         -         -        -                  3            2      7.00      3.20      8 9
     4          1       38.00      1.90      2                  4            0        -         -        -
     5          0         -         -        -                  5            0        -         -        -
     6          0         -         -        -                  6            0        -         -        -
     7          4      -42.50      0.58      1                  7            0        -         -        -
     8          7      -54.29      1.09    1 2 3                8            0        -         -        -
     9          7      -79.57      1.43    1 2 3                9            0        -         -        -



 CLASSIFICATION OF SWELL WAVE EVENTS BY ANGLE BAND        CLASSIFICATION OF SWELL WAVE EVENTS BY PERIOD

 ANGLE BAND   NO. OF   AVERAGE   AVERAGE   PERIOD           PERIOD BAND   NO. OF   AVERAGE   AVERAGE   ANGLE
   NUMBER     EVENTS    ANGLE    HEIGHT    BANDS              NUMBER      EVENTS   PERIOD    HEIGHT    BANDS
     1          0         -         -        -                  1            0        -         -        -
     2          0         -         -        -                  2            0        -         -        -
     3          0         -         -        -                  3           35      7.83      0.95      7 8
     4          0         -         -        -                  4            0        -         -        -
     5          0         -         -        -                  5            0        -         -        -
     6          0         -         -        -                  6            0        -         -        -
     7         26      -44.42      0.90      3                  7            0        -         -        -
     8          9      -54.44      1.09      3                  8            0        -         -        -
     9          0         -         -        -                  8            0        -         -        -
```

Figure 100. WHEREWAV Example 3: Output file CEDRSOUT.WW

Table 16

Nearshore Wave Transformation Simulations for WHEREWAV Example 3

Simulation No.	Wave Height m	Wave Angle deg	Wave Period sec
		Sea Wave Conditions	
1	1	38.0	5.5
2	1	-42.5	3.3
3	1	-54.3	3.3
4	1	-54.3	5.5
5*	1	-54.3	7.0
6	1	-79.6	3.3
7	1	-79.6	5.5
8	1	-79.6	7.0
		Swell Wave Conditions	
9	1	-44.4	7.8
10*	1	-54.4	7.8

* These simulations could be performed irrespective of wave type using a deepwater angle of -54.4 deg and wave period of 7.5 sec.

(nearshore wave transformation performed without regard to wave type), reducing the number of required simulations from 10 to 9.

415. Example 4. In this example, the output file (**CEDRSOUT.CTS**) containing the time series that was generated from RCRIT Example 2 (shown in Figure 18) serves as the input. Responses to the program prompts are as follows:

a. Input file name: *CEDRSOUT.CTS*

b. Output file name: *CEDRSCTS*

c. Input data format: *4* (OUTPUT FROM ANOTHER WORKBOOK CODE; header and format similar to CEDRS)

d. Input data type: *2* (PHASE II)

e. Number of events per record: *2*

f. Shoreline orientation: *348*

416. Note in line e of the user responses that the program prompts for the number of events per record. This prompt is required (as in Example 2) because the input time series in this example was generated by another workbook program, and the number of events per record is unknown.

417. A listing of the output file **PH3OUT.WW** is provided in Figure 101. Remember, the input time series (**CEDRSOUT.CTS**) was generated by the program

```
WAVE CLASSIFICATION & STATISTICS FOR INPUT TIME SERIES:  CEDRSOUT.CTS
THE FOLLOWING CLASSIFICATIONS ARE BASED ON A SHORELINE ORIENTATION OF:  348.00


NUMBER OF RECORDS PROCESSED.................            48
NUMBER OF CALM SEA EVENTS...................            32
NUMBER OF CALM SWELL EVENTS.................            13
NUMBER OF OFFSHORE TRAVELING SEA EVENTS.....             0
NUMBER OF OFFSHORE TRAVELING SWELL EVENTS...             0


             DEFINITION OF ANGLE BANDS                                  DEFINITION OF PERIOD BANDS

ANGLE BAND  RANGE WITH RESPECT  RANGE WITH RESPECT         PERIOD BAND NO.             RANGE OF WAVE PERIODS
  NUMBER         TO NORTH        TO SHORE-NORMAL                 1                        0.0< T < 5.0
    1       348.00 : 348.75      90.00 :  89.25                  2                        5.0≤ T < 7.0
    2       348.75 :  11.25      89.25 :  56.75                  3                        7.0≤ T < 9.0
    3        11.25 :  33.75      56.75 :  33.25                  4                        9.0≤ T <11.0
    4        33.75 :  56.25      33.25 :  11.75                  5                       11.0≤ T <13.0
    5        56.25 :  78.75      11.75 :  -0.75                  6                       13.0≤ T <15.0
    6        78.75 : 101.25      -0.75 : -33.25                  7                       15.0≤ T <17.0
    7       101.25 : 123.75     -33.25 : -56.75                  8                       17.0≤ T <23.0
    8       123.75 : 146.25     -56.75 : -78.25                  9                       23.0≤ T
    9       146.25 : 168.00     -78.25 : -90.00



 CLASSIFICATION OF SEA WAVE EVENTS BY ANGLE BAND          CLASSIFICATION OF SEA WAVE EVENTS BY PERIOD

 ANGLE BAND   NO. OF   AVERAGE   AVERAGE   PERIOD          PERIOD BAND   NO. OF   AVERAGE   AVERAGE   ANGLE
   NUMBER     EVENTS    ANGLE    HEIGHT    BANDS             NUMBER      EVENTS   PERIOD    HEIGHT    BANDS
     1          0         -         -        -                 1            8      3.63      0.63     7 8 9
     2          0         -         -        -                 2            6      5.50      1.60     4 8 9
     3          0         -         -        -                 3            2      7.00      3.20      8 9
     4          1       38.00     1.90       2                 4            0        -         -        -
     5          0         -         -        -                 5            0        -         -        -
     6          0         -         -        -                 6            0        -         -        -
     7          4      -42.50     0.58       1                 7            0        -         -        -
     8          6      -52.67     1.20     1 2 3               8            0        -         -        -
     9          5      -79.60     1.92     1 2 3               9            0        -         -        -



 CLASSIFICATION OF SWELL WAVE EVENTS BY ANGLE BAND      CLASSIFICATION OF SWELL WAVE EVENTS BY PERIOD

 ANGLE BAND   NO. OF   AVERAGE   AVERAGE   PERIOD          PERIOD BAND   NO. OF   AVERAGE   AVERAGE   ANGLE
   NUMBER     EVENTS    ANGLE    HEIGHT    BANDS             NUMBER      EVENTS   PERIOD    HEIGHT    BANDS
     1          0         -         -        -                 1            0        -         -        -
     2          0         -         -        -                 2            0        -         -        -
     3          0         -         -        -                 3           35      7.83      0.95      7 8
     4          0         -         -        -                 4            0        -         -        -
     5          0         -         -        -                 5            0        -         -        -
     6          0         -         -        -                 6            0        -         -        -
     7         26      -44.42     0.99       3                 7            0        -         -        -
     8          9      -54.44     1.09       3                 8            0        -         -        -
     9          0         -         -        -                 9            0        -         -        -
```

Figure 101. WHEREWAV Example 4: Output file **CEDRSCTS.WW**

RCRIT (using the time series **WVCEDRS.DAT** as input) in Part III. Therefore, a comparison of the WHEREWAV statistics shown in Figures 100 and 101 will reflect the effect of processing the time series **WVCEDRS.DAT** through RCRIT. Note in Figure 101 that no offshore-traveling events were encountered in the time series **CEDRSOUT.CTS** (the program RCRIT flags all offshore traveling and below threshold events as calms). Note also that the same number of nearshore wave transformation simulations would be required. RCRIT typically does not reduce the number of required nearshore wave transformation simulations, but does significantly reduce the number of computations (and execution time) required in a GENESIS simulation. Because RCRIT eliminated only three below-threshold sea events and no swell events, the statistics for swell wave conditions are identical in Figures 100 and 101. However, for sea wave conditions in angle bands 8 and 9, both the average wave height and the average wave period increased. This is a typical result of the program RCRIT (short-period, low-amplitude, wave events from oblique angle bands are eliminated from the offshore time series).

418. Example 5. In this example, a time series from a wave gage is input to the program WHEREWAV. The purpose of this example is to demonstrate how to modify the source code for WHEREWAV (**WHEREWAV.FOR**) to operate on wave gage data. A listing of the wave gage time series was given in Figure 19.

419. Before any changes are made to the file **WHEREWAV.FOR**, it is strongly recommended that the file **WHEREWAV.FOR** be copied to another file name such as **WHEREWVG.FOR** (where the letter **G** denotes that the program has been customized to read the user's wave gage time series). In **WHEREWAV.FOR** there are four comment blocks that denote areas where modifications must be made. These comment blocks and the pertinent lines of FORTRAN code are listed in Figure 102.

420. The header information for the wave gage data shown in Figure 19 contains a station identification number, the number of records in the file, and the water depth (in meters). The only portion of this header information required by the program WHEREWAV is the number of records; however, the program also requires the number of events per record and the shoreline orientation. These values are needed in Area 1 as shown in Figure 102. Figure 103 shows one way of loading this information into the program. As shown if Figure 103, the number of records in the time series (*NEVENTS*) is read from the file header, whereas a prompt is issued for the shoreline

Area 1

```
   15 WRITE(*,*) ' This code must be modified to read your specific'
      WRITE(*,*) ' input file header !'
      GOTO 35
C??????????????????????????????????????????????????????????????????????????
C  In this section read past the input file header (if any), and prompt for
C  or read the shoreline orientation.  Load the shoreline orientation
C  into the program variable SHOANG, and assign the number of events per
C  record and total number of records to the variables NPER and NEVENTS.
C??????????????????????????????????????????????????????????????????????????
```

Area 2

```
        ELSE
          WRITE(*,*) ' This code must be modified to read your specific
     &input time series !'
          GOTO 35
C??????????????????????????????????????????????????????????????????????????
C  In this section read the wave event(s) from the input file (one record
C  at time).  Read the height, period, and angle of the first wave event
C  into the program variables CH, CT, and CTH.  If there are two events per
C  record, read the second wave height, period, and angle into SH, ST, STH.
C??????????????????????????????????????????????????????????????????????????
        ENDIF
```

Area 3

```
          ELSE
            WRITE(*,*) ' This code must be modified to convert your spec
     &ific'
            WRITE(*,*) ' coordinate system to one with respect to north.'
            GOTO 35
C??????????????????????????????????????????????????????????????????????????
C  In this section, convert the first wave event angle from the coordinate
C  system of the input time series, to an angle describing the direction
C  from which the wave is propagating with respect to north, and check for
C  offshore traveling events.
C??????????????????????????????????????????????????????????????????????????
          ENDIF
```

Area 4

```
          ELSE
            WRITE(*,*) ' This code must be modified to convert your spec
     &ific'
            WRITE(*,*) ' coordinate system to one with respect to north.'
            GOTO 35
C??????????????????????????????????????????????????????????????????????????
C  In this section, convert the second wave event angle from the coordinate
C  system of the input time series, to an angle describing the direction
C  from which the wave is propagating with respect to north, and check for
C  offshore traveling events.
C??????????????????????????????????????????????????????????????????????????
          ENDIF
```

Figure 102. Lines where **WHEREWAV.FOR** must be modified to read wave gage time series

```
C   15 WRITE(*,*) ' This code must be modified to read your specific'
C      WRITE(*,*) ' input file header !'
C      GOTO 35
C?????????????????????????????????????????????????????????????????????
C  In this section read past the input file header (if any), and prompt for
C  or read the shoreline orientation.  Load the shoreline orientation
C  into the program variable SHOANG, and assign the number of events per
C  record and total number of records to the variables NPER and NEVENTS.
C?????????????????????????????????????????????????????????????????????
C~~~
c  new section for reading past the wave gage time series header
C~~~
    15 READ(99,*) STAID,NEVENTS
       WRITE(*,*) ' Enter the shoreline orientation (in degrees, clockwis
      &e from north): '
       READ(*,*) SHOANG
       NEPR=1
C~~~
c  end of new section for reading past the wave gage time series header
C~~~
```

Figure 103. New lines of code for Area 1, **WHEREWAV.FOR**

orientation and the number of events per record (*NPER*) is assigned the value 1.

421. The next section of code (Area 2 in Figure 102) that must be modified performs the operation of reading each record of data in the input time series. The program requires only the wave height, period, and angle. The date information is not required by WHEREWAV. Consequently, the date data are read into dummy variables, and the wave height, period, and angle are read into the program variables *CH*, *CT*, and *CTH*, respectively, as shown in Figure 104.

422. In Area 3 (shown in Figure 102), the wave angle (as read from the input time series) must be converted to an angle that describes the direction from which the wave is traveling, and a check for offshore traveling waves must be performed. Figure 105 provides one way of accomplishing this task.

423. Note, in Figure 105, that the wave height (*CH*) and wave period (*CT*) are assigned to the height and period transfer variables *HINC* and *TINC*, respectively. Next, the wave angle (*CTH*) is converted from an angle that describes the direction in which the wave is traveling to an angle describing the direction from which the wave is traveling. This conversion is accomplished by adding 180 deg to the wave angle (*CTH*). Then, if the converted angle is greater than 360 deg, it is reduced by 360 deg. The next task

```
        ELSE
C          WRITE(*,*) ' This code must be modified to read your specific
C     &input time series !'
C          GOTO 35
C??????????????????????????????????????????????????????????????????????????
C  In this section read the wave event(s) from the input file (one record
C  at time).  Read the height, period, and angle of the first wave event
C  into the program variables CH, CT, and CTH.  If there are two events per
C  record, read the second wave height, period, and angle into SH, ST, STH.
C??????????????????????????????????????????????????????????????????????????
C---
c  new section for reading the input time series
C---
          READ(99,*) IDUM,IDUM,IDUM,IDUM,CH,CT,CTH
C---
c  end of new section for reading the input time series
C---
        ENDIF
```

Figure 104. New lines of code for Area 2, **WHEREWAV.FOR**

```
         ELSE
C           WRITE(*,*) ' This code must be modified to convert your spec
C     &ific'
C           WRITE(*,*) ' coordinate system to one with respect to north.'
C           GOTO 35
C??????????????????????????????????????????????????????????????????????????
C  In this section, convert the first wave event angle from the coordinate
C  system of the input time series, to an angle describing the direction
C  from which the wave is propagating with respect to north, and check for
C  offshore traveling events.
C??????????????????????????????????????????????????????????????????????????
C---
c  new section for converting the input wave angles
C---
c  load transfer variables for height (HINC) and period (TINC)
           HINC=CH
           TINC=CT
c  convert wave angle -> direction from which wave is traveling
           CTH=CTH+180.
           IF(CTH.GT.360.)CTH=CTH-360.
c  compute wave angle w.r.t. shore-normal
           ZINC=SHORNORM(CTH)
c check for offshore traveling waves
           IF(ZINC.LT.-90..OR.SINC.GT.90.) THEN
             ICOFF=ICOFF+1
             ICFLAG=-1
           ENDIF
C---
c  end of new section for reading the input time series
C---
         ENDIF
```

Figure 105. New lines of code for Area 3, **WHEREWAV.FOR**

involves performing a check for offshore traveling waves; if the wave is traveling offshore, then the offshore traveling wave counter (*ICOFF*) should be incremented by one, and the offshore traveling wave flag (*ICFLAG*) should be set to -1. To accomplish this task, the wave angle is first converted to an angle with respect to shore-normal (where waves propagating from a direction to the left of shore-normal are negative and wave propagating from a direction to the right of shore-normal are positive) by calling the program function SHORNORM and assigning the result to the program variable *ZINC*. Then, if *ZINC* is greater than 90 deg, or less than -90 deg, the wave is traveling offshore and the variable *ICOFF* is incremented by 1 and the offshore traveling wave flag (*ICFLAG*) is set to -1.

424. Because the wave gage time series contains only one event per record, no modifications are required in <u>Area 4</u> shown in Figure 102. If the input time series contained two events per record, the swell wave condition would be converted in this section of code. A procedure similar to that shown in Figure 105 could be used, except that the variable names would change.

425. The program WHEREWVG is now capable of reading the input wave gage time series, performing the appropriate computations, and writing the statistical output tables. The file **WHEREWVG.FOR** must now be compiled and linked to obtain an executable program. Users must perform these functions with their own software and equipment.

426. In the execution of the program WHEREWVG, the file name *WVGAGE.DAT* is entered at the program prompt for the input file name, and the file is assumed to exist in the default directory. Otherwise, the appropriate path together with the file name must be specified.

427. The program then prompts for the output file name; in this example the output file name *GAGEOUT* is entered. The program will assign the extension **.WW** to the user-specified output file name.

428. The next prompt issued by WHEREWVG requests entry of the input data format type. Because in this case the input format is neither SEAS nor CEDRS, the value *5* is entered, indicating that a nonstandard (other) input format is being used.

429. The last prompt issued before the computations begin is a request for the shoreline orientation in degrees measured clockwise from north. In this example, a shoreline orientation of *135* deg was entered (corresponding to the local shoreline orientation landward of the gage).

430. The output file **GAGEOUT.WW** is listed in Figure 106. A total of seven nearshore wave transformation simulations would be required to represent the transformation of the input wave gage time series. Table 17 provides a listing of the RCPWAVE offshore boundary wave conditions (the wave gage time series is for a specific water depth, not deepwater conditions). Note, in Figure 106, that all the wave events in the wave gage time series occur in angle band 5, and, as seen from Table 17, the wave angle along the offshore boundary of the RCPWAVE grid is the same (-2.5 deg) for each of the wave transformation simulations. The reason for this similitude is that the wave gage data correspond to a water depth of 8.2 m, and most of the waves have

```
WAVE CLASSIFICATION & STATISTICS FOR INPUT TIME SERIES:  WVGAGE.DAT
THE FOLLOWING CLASSIFICATIONS ARE BASED ON A SHORELINE ORIENTATION OF:  135.00

NUMBER OF RECORDS PROCESSED.................        48
NUMBER OF CALM SEA EVENTS...................         0
NUMBER OF OFFSHORE TRAVELING SEA EVENTS.....         0


            DEFINITION OF ANGLE BANDS                                DEFINITION OF PERIOD BANDS

ANGLE BAND  RANGE WITH RESPECT  RANGE WITH RESPECT        PERIOD BAND NO.           RANGE OF WAVE PERIODS
  NUMBER        TO NORTH          TO SHORE-NORMAL                1                      0.0< T < 5.0
    1       135.00 : 146.25     90.00 :  78.75                   2                      5.0≤ T < 7.0
    2       146.25 : 168.75     78.75 :  56.25                   3                      7.0≤ T < 9.0
    3       168.75 : 191.25     56.25 :  33.75                   4                      9.0≤ T <11.0
    4       191.25 : 213.75     33.75 :  11.25                   5                     11.0≤ T <13.0
    5       213.75 : 236.25     11.25 : -11.25                   6                     13.0≤ T <15.0
    6       236.25 : 258.75    -11.25 : -33.75                   7                     15.0≤ T <17.0
    7       258.75 : 281.25    -33.75 : -56.25                   8                     17.0≤ T <23.0
    8       281.25 : 303.75    -56.75 : -78.75                   9                     23.0≤ T
    9       303.75 : 315.00    -78.75 : -90.00



 CLASSIFICATION OF SEA WAVE EVENTS BY ANGLE BAND           CLASSIFICATION OF SEA WAVE EVENTS BY PERIOD

 ANGLE BAND  NO. OF  AVERAGE  AVERAGE  PERIOD             PERIOD BAND  NO. OF  AVERAGE  AVERAGE  ANGLE
   NUMBER    EVENTS   ANGLE   HEIGHT   BANDS                NUMBER     EVENTS  PERIOD   HEIGHT   BANDS
     1         0        -        -       -                    1          0       -        -        -
     2         0        -        -       -                    2          2      5.00     69.00     5
     3         0        -        -       -                    3          6      7.00     96.33     5
     4         0        -        -       -                    4          4      9.00    118.00     5
     5        48      -2.48    96.25   2 3 4 5                5          2     11.00    100.50     5
                                        6 7 8                 6         16     13.00     87.13     5
     6         0        -        -       -                    7         11     15.00    105.91     5
     7         0        -        -       -                    8          7     19.14     96.00     5
     8         0        -        -       -                    9          0       -        -        -
     9         0        -        -       -
```

Figure 106. WHEREWAV Example 5: Output file **GAGEOUT.WW**

Table 17

Nearshore Wave Transformation Simulations for WHEREWAV Example 5

Simulation No.	Wave Height m	Wave Angle deg	Wave Period sec
1	1	-2.5	5.0
2	1	-2.5	7.0
3	1	-2.5	9.0
4	1	-2.5	11.0
5	1	-2.5	13.0
6	1	-2.5	15.3
7	1	-2.5	19.1

already refracted to a nearly shore-normal orientation. A more refined approximation could be achieved if the average wave angle were computed for each of the wave period bands, and the nearshore transformation simulations were performed using this average wave angle. These computations were made, and the new wave inputs are listed in Table 18.

Summary

431. The program WHEREWAV uses a pragmatic approach in the classification of offshore wave conditions, and may, for certain regions, require adjustment of the wave angle and period bands. The establishment of 22.5-deg angle bands centered on the primary compass directions, is based on the WIS wave generation and propagation numerical models that use 22.5-deg directional

Table 18

Nearshore Wave Transformation Simulations for WHEREWAV Example 5 (Refined)*

Simulation No.	Wave Height m	Wave Angle deg	Wave Period sec
1	1	-8.0	5.0
2	1	-3.0	7.0
3	1	-4.8	9.0
4	1	-6.5	11.0
5	1	-1.1	13.0
6	1	-3.0	15.3
7	1	-0.1	19.1

* The wave angles shown in this table reflect the average angle for the specific period band as opposed to the average angle for the entire angle band (shown in Table 17).

energy bins to describe the wave spectra. For other data, such as shallow-water wave gage data, narrower angle bands may allow for a more detailed description of the offshore data.

432. The division of offshore wave periods into six 2-sec period bands between 5 and 17 sec and one 6-sec period band between 17 and 23 sec, with one band covering wave periods below 5-sec and another covering wave periods above 23 sec, was developed from experience with the nearshore wave transformation model RCPWAVE. For some locations, particularly in the Great Lakes, these suggested period bands may require modification to include a more detailed description of the shorter period waves. Likewise, additional period bands for describing longer period waves may be required for sites along the Pacific coasts. However, modification of the wave angle and period bands, will require modification of not only the program WHEREWAV, but also the programs WTNSWAV NSTRAN, and a subroutine within GENESIS, and will require assistance from CERC.

WTNSWAV

433. The program WTNSWAV reads nearshore wave information from a special RCPWAVE output file (specified on the SAVESPEC input record, shown in Table 12) and writes a **NSWAV**.ext file for input to GENESIS. The **NSWAV**.ext file is a new GENESIS input file not described in the Technical Reference and is required if an external wave transformation model is being used. The data in the **NSWAV**.ext file consist of an offshore wave identification key (which relates the nearshore wave data to offshore waves occurring from a specific angle-period band and height band if required) followed by a nearshore wave height transformation coefficient (or actual wave height, if height bands are required), and wave angle. The program WTNSWAV will construct the **NSWAV**.ext file from output of the external wave transformation model RCPWAVE. A listing of the source code for WTNSWAV is provided in Appendix J.

434. The offshore wave identification key is constructed using a four-character integer. The first character designates the wave type, which can be either sea or swell. If the nearshore wave data correspond to sea wave conditions, the first character is assigned the value *1*. If the nearshore wave data correspond to swell wave conditions, the first character is assigned the value *2*. The second character designates the height band. If the nearshore

wave transformations were performed using an input unit wave height, this character is assigned the value *1*. If nearshore wave transformation simulations were performed for specific wave height bands (a maximum of nine wave height bands can be specified), the second character contains the height band number corresponding to the RCPWAVE input wave height. The third character designates the angle band. The value of the third character corresponds to the angle band number associated with the RCPWAVE input wave angle and may range between *1* and *9*. The fourth character in the offshore wave identification key designates the period band. The value of the fourth character corresponds to the period band number associated with the RCPWAVE input wave period and may range between *1* and *9*.

435. The nearshore wave data are stored in a compressed format that uses a seven-character integer variable (given the variable name *IZH* in GENESIS). The sign (first character) of *IZH* is always associated with the nearshore wave angle, because a negative wave height has no meaning. The second through fourth characters define the wave height transformation coefficient or actual wave height (if wave height bands are required). The location of the decimal is dependent on the system of units being used. If metric units are used, the decimal is located between the second and third characters (yielding wave heights to the nearest centimeter), whereas if American customary units are used, the decimal is located between the third and fourth characters (yielding wave heights to the nearest tenth of a foot). The fifth through the seventh characters designate the wave angle to the nearest tenth of a degree (the decimal is located between the sixth and seventh characters), and the sign of the angle is obtained from the sign of *IZH* (first character).

436. Similar to the other GENESIS input files, **NSWAV**.ext contains a four-line file header; however, unlike the other GENESIS input files, this header contains information required by GENESIS. Therefore, the format and positional location of the data in the **NSWAV**.ext file header are important. Specifically, the shoreline orientation (RCPWAVE and GENESIS baseline orientation) must appear in the first line of the **NSWAV**.ext file header beginning in position 62 using an F7.2 FORTRAN edit descriptor; the RCPWAVE cell associated with the first and last wave blocks must appear in the second line using an I4 FORTRAN edit descriptor and beginning in positions 21 and 31, respectively. The number of unique nearshore wave events (equal to the number of different offshore wave identification keys) must appear in the third line of the

NSWAV.ext file header beginning in position 10 using an I4 FORTRAN edit descriptor. The program WTNSWAV will construct the required file header.

Calculation procedure

437. The program WTNSWAV reads data from the RCPWAVE output file specified on the SAVESPEC record (shown in Table 12), calculates an offshore wave identification key, reformats the nearshore wave heights and angles, and writes an **NSWAV**.ext file for input to GENESIS. Output from several different nearshore wave transformation simulations (multiple input files) may be written to the same output file, as will be demonstrated in Examples 3 and 4 below.

438. Computationally, the first task performed by the program is to read the RCPWAVE input wave information (the offshore wave height, period, and angle) and compute an offshore wave identification key. Then the nearshore wave information (the nearshore wave height or transformation coefficient and nearshore wave angle) at the user-specified RCPWAVE grid cells are read and compressed into the seven-character variable (*IZH*) discussed previously and required by GENESIS. Then the key, followed by the nearshore wave information, is written to the output file, and the next wave condition is processed. When the number of user-specified wave conditions have been processed, the program prompts for another input file. Depending on the user response to this prompt, the program will either process another input file or terminate. Operation of the program is demonstrated in the following section.

Example applications

439. Operation of the program WTNSWAV will be demonstrated through five example applications. Examples 1 through 4 use the RCPWAVE output file **TEST1.NSR** (listed in Figure 93) as input. Example 5 demonstrates specification of the wave height band classification utility.

440. Example 1. Execution of the program is initiated by issuing the command *WTNSWAV* at the PC prompt. The program responds by prompting for the input file name and extension. If the input file is not located in the default directory, the appropriate path should also be entered. For this example, the name *TEST1.NSR* is entered. This file must exist (it represents the input), or the program will terminate.

441. The next prompt issued by the program requests input of the output file name without the extension. The program WTNSWAV assigns the extension **.NSW** (denoting nearshore waves) to all output files. For this example, the

name *OUT1* is entered. At this point, the program scans the default directory for the file **OUT1.NSW**. If the directory scan determines that the file does not exist, then a new file named **OUT1.NSW** is created. However, if the directory scan finds the user-specified output file, the program prompts for disposition of the existing file, which may be *append*, *overwrite*, or *enter a new output file name*. Regardless, in this example a new file is opened.

442. Next, the program prompts for the RCPWAVE baseline orientation. Remember, the RCPWAVE and GENESIS baseline orientations must be equivalent in shoreline change modeling. For this example, the value *0.0* is entered, indicating that the baseline is oriented on a north-south line with the water (ocean) on the east side.

443. The next prompt requests entry of the number of alongshore RCPWAVE cells. From the RCPWAVE input data set (GRIDSPEC record, YCELLS variable), shown in Figure 92, and defined in Tables 3 through 12, it is seen that the number of alongshore RCPWAVE cells is 36. So, for this example, the value *36* is entered. Since the RCPWAVE grid typically extends beyond the GENESIS grid in the alongshore direction, GENESIS requires only a subset of the data along the nearshore reference line. Consequently, the program requires specification of the RCPWAVE coordinates corresponding to the GENESIS model reach. Hence, the next prompt requests specification of the RCPWAVE coordinate corresponding to the first wave block. For this example, the value *4* is entered. The next prompt requests specification of the RCPWAVE coordinate corresponding to the last wave block, and, for this example, the value *33* is entered.

444. The next program prompt asks whether or not sea and swell wave types are transformed differently, and the available options are 1 (*indicating yes, sea and swell wave types are transformed differently*) and 0 (*indicating no, sea and swell wave types are not transformed differently*). For this example, the value *0* is entered, meaning that nearshore wave transformation simulations were performed without regard for wave type.

445. Next, the program prompts for entry of the system of units used in the RCPWAVE simulations. The value *1* indicates that American customary units were used or that wave heights are given in feet, whereas entering the value *2* indicates the metric units were used or that wave heights are given in meters. For this example, the value *1* is entered.

446. Next, the program prompts for entry of the number of wave cases (number of simulations) in the input file. In the present example, the input file contains three different wave conditions, so the value *3* is entered.

447. The next program prompt requests specification of the number of height bands required to describe the suite of nearshore wave transformation simulations. Normally, the use of wave height bands is not required; however, in some instances where large shallow shoals are present in the nearshore bathymetry and wave breaking occurs for larger wave heights, but not for smaller wave heights, classification of offshore wave conditions by wave height bands are required. Example 5 will demonstrate use of the wave height band classification utility. In this example, unit wave heights were input to RCPWAVE, so the value *1* is entered (indicating that only one height band is required.

448. At this point, the program WTNSWAV performs the necessary computations and writes the output nearshore wave data to a scratch file. Before writing the final output file, the program issues another prompt asking if the user wants to add another input file. If the user responds negatively to this prompt, the program writes the output file header and then copies the processed data from the scratch file to the output file and terminates. If the user responds positively to this prompt, the program WTNSWAV issues a series of input specification prompts, compares these input specifications to the previous user responses, and, if there are no differences, processes the new input data set. Therefore, more than one input data set can be processed in a single session, as will be demonstrated in Example 3. For this example, only one input data set will be processed, so the value *0* is entered, indicating a negative response to the add-another-input-file prompt. WTNSWAV then writes the output file header, copies the processed nearshore wave data from the scratch file to the output file, and terminates.

449. Figure 107 contains a listing of the output nearshore wave data file **OUT1.NSW**. Note, in Figure 107, that the output file header contains the file name, the shoreline orientation, the beginning and ending wave block numbers, the total number of alongshore RCPWAVE cells, the number of unique nearshore wave events, and the system of units associated with the height transformation coefficient. Also note that the offshore wave identification key is only three characters in length, meaning that sea and swell wave conditions within the same angle-period band classification will use the same

set of nearshore wave conditions to describe the transformation from offshore to the nearshore reference line. Consequently, the wave type indicator (the first character in the key) in the offshore wave identification key is not required.

450. In the input file (**TEST1.NSR**) shown in Figure 93, it is noted that the solutions (wave height and angle along the nearshore reference line) for three input wave conditions are contained in the file. The output file (**OUT1.NSW**) shown in Figure 107 contains three offshore wave keys, each followed by three lines of compressed nearshore wave data. Starting with the offshore wave identification keys, notice that each of the keys start with the value *1* (which is really in the second position of the key), indicating that the wave event resides within height band one. The next character indicates the angle band number, and for the first wave condition, the value is *5*. This means that the offshore wave condition came from angle band *5* which, for a shoreline orientation of 0 deg, is between 11.25 and -11.25 deg with respect to shore-normal (see Figure 99 for a definition of angle bands for a shoreline orientation of 0 deg). The second wave condition corresponds to an offshore wave from angle band 6 (between -11.25 and -33.75 deg), and the third from angle band 4 (between 33.75 and 11.25 deg). The last character in the offshore wave identification key designates the period band. Table 13 lists the range of wave periods contained within each of the period bands. Note that the first wave condition is from period band 1 (less than 5 sec), the second is from period band 2 (greater than or equal to 5 sec and less than 7

```
 FILE: OUT1.NSW                      SHORELINE ORIENTATION:     0.00
 DATA AT WAVEBLOCKS    4 THRU   33 FROM   36 ALONGSHORE RCPWAVE CELLS
 CONTAINS   3 UNIQUE NEARSHORE WAVE EVENTS.  WAVE HEIGHTS IN FEET*10.
**********************************************************************
 151
 -10084 -10091 -10096 -10097 -10095 -10089 -10094 -10098 -10104 -10099
 -10100 -10106 -10108 -10105  -9101  -9101  -9095  -9094  -9104 -10112
  -9119  -9120  -9117  -9118  -9121  -9118  -9114  -9117  -9123  -9124
 162
 -11267 -11284 -11286 -11280 -11271 -11265 -11281 -10288 -10294 -10275
  -9272  -9280  -9277  -9264  -9249  -9248  -9242 -10251 -10280  -9303
  -9305  -8296  -8286  -8282  -8288  -8279  -9274  -9283  -9304  -9304
 143
   8275   8258   8244   8227   8226   8248   8252   8258   8255   8264
   9271   9256   9262   9267  10277  10268  10274  11278  10263  10264
  10259  10262  11279  11276  12266  11263  12277  12278  12281  12285
```

Figure 107. WTNSWAV Example 1: Output file **OUT1.NSW**

sec), and the third wave condition is from period band 3 (greater than or equal to 7 sec and less than 9 sec). Consequently, the first wave condition corresponds to an offshore wave identification key of 151 (height band one, angle band five, and period band one), the second to 162 (height band one, angle band six, and period band two), and the third wave condition to 143 (height band one, angle band four, and period band three).

451. The nearshore wave height transformation coefficient and wave angle are listed in using a 10I7 FORTRAN editing format and may be decoded as follows. Note the first nearshore wave condition (listed as -10084) following the offshore wave identification key 151 in Figure 107. This nearshore wave height transformation coefficient and angle combination corresponds to the wave height and angle at alongshore RCPWAVE cell number 33 (remember, the orientation of the alongshore axis in RCPWAVE is opposite to that of GENESIS, which requires an end-for-end exchange of the data) listed as 1.0333 ft and -8.3536 deg, in Figure 93. Since the system of units is American customary, the height is converted to an integer to the nearest one-tenth of a foot, or 10, and then multiplied by 1000 to obtain 10000. Then the wave angle is converted to an integer to the nearest one-tenth of a degree or -84. The absolute value of the angle is then added to the height transformation coefficient to obtain the number 10084. Finally, the nearshore height-angle number is given the sign associated with the nearshore wave angle, which gives the final height-angle value of -10084. The remainder of the compressed nearshore wave data may be decoded in a similar manner. For instance, the last entry for the first wave condition is -9124, which corresponds to the wave height transformation coefficient of 0.8966 ft (taken as 0.9 ft or 9) and angle of -12.3708 deg (taken as -12.4 deg or 124) given for RCPWAVE alongshore coordinate number 4.

452. Example 2. This example application will use the same input data set as in Example 1, except this time the units for wave height will be specified as being meters. Again, execution of WTNSWAV is initiated by issuing the command *WTNSWAV* at the PC prompt. Responses to the program prompts in this example are as follows:

a. Input file name: *TEST1.NSR*
b. Output file name: *OUT2*
c. Baseline orientation: *0.0*
d. Number of alongshore RCPWAVE cells: *36*

e. RCPWAVE coordinate corresponding to first wave block: *4*

f. RCPWAVE coordinate corresponding to last wave block: *33*

g. Are SEA and SWELL wave types transformed differently: *0* (NO)

h. Wave height units: *2* (METERS)

i. Number of wave conditions in input file: *3*

j. Number of wave height bands: *1*

k. Process another input file: *0* (NO)

453. Figure 108 provides a listing of the output file **OUT2.NSW**. Note in Figure 108 that the offshore wave identification keys are the same as those calculated in Example 1, as they should be because there is only one height band, and the angle-period bands are independent of the system of units being used. However, the compressed nearshore wave data are different. This difference results because, if wave heights are given in meters, the height portion of the compressed nearshore wave height-angle data set is given to the nearest hundredth of a meter (centimeters). The angle portion is given to the nearest tenth of a degree, as before. Therefore, the first nearshore wave height-angle number for the first wave condition (**-103084**) corresponds to the wave height transformation coefficient of 1.0333 m and wave angle of -8.3536 deg given in Figure 93 for RCPWAVE alongshore coordinate number 33. Similarly, the last nearshore wave height-angle number for the first wave condition (**-90124**) corresponds to the wave height transformation coefficient of 0.8966 m and wave angle of -12.3708 deg given in Figure 93 for RCPWAVE alongshore coordinate number 4.

```
 FILE: OUT2.NSW                      SHORELINE ORIENTATION:     0.00
 DATA AT WAVEBLOCKS    4 THRU   33 FROM   36 ALONGSHORE RCPWAVE CELLS
 CONTAINS   3 UNIQUE NEARSHORE WAVE EVENTS.  WAVE HEIGHTS IN METERS*100
***********************************************************************
 151
-103084-103091-102096-101097-100095-100089-101094-100098-100104 -99099
 -98100 -97106 -97108 -95105 -94101 -93101 -93095 -94094 -95104 -95112
 -94119 -93120 -92117 -91118 -91121 -90118 -90114 -90117 -90123 -90124
 162
-113267-112284-109286-108280-108271-108265-107281-104288 -99294 -95275
 -95272 -95280 -92277 -91264 -90249 -91248 -94242 -98251 -98280 -94303
 -88305 -85296 -84286 -84282 -84288 -84279 -86274 -87283 -88304 -87304
 143
  78275  78258  77244  77227  76226  76248  77252  80258  82255  83264
  85271  88256  90262  93267  98277 101268 103274 105278 104263 101264
 101259 102262 107279 113276 115266 115263 116277 119278 120281 123285
```

Figure 108. WTNSWAV Example 2: Output file **OUT2.NSW**

454. Example 3. This example application will demonstrate the available program options and error checking that are enacted when the specified output file already exists. Therefore, in order to cause the program to issue the "existing output file prompts," a file named **OUT3.NSW** is created by issuing the command: *COPY OUT2.NSW OUT3.NSW* at the PC prompt while in the default directory. Responses to the program prompts are as follows:

a. Input file name: *TEST1.NSR*
b. Output file name: *OUT3*
c. Disposition of existing output file: *1* (append the file)
d. Baseline orientation: *0.0*
e. Number of alongshore RCPWAVE cells: *36*
f. RCPWAVE coordinate corresponding to first wave block: *4*
g. RCPWAVE coordinate corresponding to last wave block: *33*
h. Are SEA and SWELL wave types transformed differently: *1* (YES)
i. Wave height units: *2* (METERS)

455. At this point, the program compares the input specifications against the data contained in the existing output file, and if differences are found (as in this example), an error message is written to the PC monitor, and the program terminates. The error message displayed in this example is:

```
The append file does not agree with your inputs ...
Check your notes concerning ...

SEA and SWELL waves transformed differently:
File = NO;  Input specification = YES
```

WTNSWAV compares the input specifications given in lines d through i with the data in the existing output file. In this example, WTNSWAV detected a difference in the input specification concerning the sea and swell wave transformations. At this point, the program has terminated, and the specified input and output files are as they were before execution of the program. The user must now resolve the differences and rerun the program. In this example, the method of resolution will be to overwrite the existing output file. Responses to the program prompts are as follows:

a. Input file name: *TEST1.NSR*
b. Output file name: *OUT3*
c. Disposition of existing output file: *2* (overwrite the file)
d. Baseline orientation: *0.0*
e. Number of alongshore RCPWAVE cells: *36*

f. RCPWAVE coordinate corresponding to first wave block: *4*
g. RCPWAVE coordinate corresponding to last wave block: *33*
h. Are SEA and SWELL wave types transformed differently: *1* (YES)
i. Wave height units: *2* (METERS)
j. Number of wave conditions in input file: *3*
k. Type of wave events: *1* (SEA)
l. Number of height bands: *1*
m. Process another input file: *1* (YES)
n. Input file name: *TEST1.NSR*
o. Baseline orientation: *0.0*
p. Number of alongshore RCPWAVE cells: *36*
q. RCPWAVE coordinate corresponding to first wave block: *4*
r. RCPWAVE coordinate corresponding to last wave block: *33*
s. Are SEA and SWELL wave types transformed differently: *1* (YES)
t. Wave height units: *2* (METERS)
u. Number of wave conditions in input file: *3*
v. Type of wave events: *2* (SWELL)
w. Number of height bands: *1*
x. Process another input file: *0* (NO)

456. Note, in lines k and v, that if sea and swell waves are transformed differently, the program requires entry of the wave type. The important implication here is that the program WTNSWAV can accommodate only one wave type for a given input file. Therefore, in performing the nearshore wave transformation simulations, different runs should be made for sea and swell wave types. In line n, processing of another input file was requested; this option will allow processing of multiple RCPWAVE output data files into a single nearshore wave data base. In this example, the same input file was processed twice, once with a sea-wave type specification and the second time with a swell-wave type specification. Therefore, the output file **OUT3.NSW** should contain six unique offshore wave identification keys, but, the compressed nearshore wave data should be identical for both the sea and swell types. This is the result, as can be seen in Figure 109, which contains a listing of the file **OUT3.NSW**. Note that the offshore wave identification keys in this example contain the wave type identifier (either 1 for sea-type wave conditions, or 2 for swell-type wave conditions).

```
 FILE: OUT3.NSW                      SHORELINE ORIENTATION:     0.00
 DATA AT WAVEBLOCKS    4 THRU   33 FROM   36 ALONGSHORE RCPWAVE CELLS
 CONTAINS    6 UNIQUE NEARSHORE WAVE EVENTS.  WAVE HEIGHTS IN METERS*100
***********************************************************************
1151
-103084-103091-102096-101097-100095-100089-101094-100098-100104 -99099
 -98100 -97106 -97108 -95105 -94101 -93101 -93095 -94094 -95104 -95112
 -94119 -93120 -92117 -91118 -91121 -90118 -90114 -90117 -90123 -90124
1162
-113267-112284-109286-108280-108271-108265-107281-104288 -99294 -95275
 -95272 -95280 -92277 -91264 -90249 -91248 -94242 -98251 -98280 -94303
 -88305 -85296 -84286 -84282 -84288 -84279 -86274 -87283 -88304 -87304
1143
  78275  78258  77244  77227  76226  76248  77252  80258  82255  83264
  85271  88256  90262  93267  98277 101268 103274 105278 104263 101264
 101259 102262 107279 113276 115266 115263 116277 119278 120281 123285
2151
-103084-103091-102096-101097-100095-100089-101094-100098-100104 -99099
 -98100 -97106 -97108 -95105 -94101 -93101 -93095 -94094 -95104 -95112
 -94119 -93120 -92117 -91118 -91121 -90118 -90114 -90117 -90123 -90124
2162
-113267-112284-109286-108280-108271-108265-107281-104288 -99294 -95275
 -95272 -95280 -92277 -91264 -90249 -91248 -94242 -98251 -98280 -94303
 -88305 -85296 -84286 -84282 -84288 -84279 -86274 -87283 -88304 -87304
2143
  78275  78258  77244  77227  76226  76248  77252  80258  82255  83264
  85271  88256  90262  93267  98277 101268 103274 105278 104263 101264
 101259 102262 107279 113276 115266 115263 116277 119278 120281 123285
```

Figure 109. WTNSWAV Example 3: Output file **OUT3.NSW**

457. Example 4. The program WTNSWAV contains a feature that will allow the user to incorporate an error in the nearshore wave data base. The purpose of this example is to demonstrate how this "hook" may be set, so that the user can be forewarned. Input for this example is again the file **TEST1.NSR** listed in Figure 93, and the output file will be an appended version of the output file generated in the previous example application. To preserve the file **OUT3.NSW**, the command: *COPY OUT3.NSW OUT4.NSW* is issued at the PC prompt while in the default directory. Responses to the program prompts are as follows:

a. Input file name: *TEST1.NSR*
b. Output file name: *OUT4*
c. Disposition of existing output file: *1* (append the file)
d. Baseline orientation: *0.0*
e. Number of alongshore RCPWAVE cells: *36*
f. RCPWAVE coordinate corresponding to first wave block: *4*

g. RCPWAVE coordinate corresponding to last wave block: *33*

h. Are SEA and SWELL wave types transformed differently: *1* (YES)

i. Wave height units: *2* (METERS)

j. Number of wave conditions in input file: *3*

k. Type of wave events: *1* (SEA)

l. Number of height bands: *1*

m. Process another input file: *0* (NO)

458. The output file **OUT4.NSW** is listed in Figure 110. Note in Figure 110 that the last three nearshore wave data sets are identical (both in the offshore wave identification key and in the nearshore wave data) to the first three nearshore wave data sets. At this point, the only error is wasted file space and memory; however, if there were differences in the nearshore wave data, but the offshore wave identification keys were the same, then GENESIS would use the nearshore wave data associated with the first offshore identification key encountered and ignore the other. The program WTNSWAV performs error checking on the input specifications but does not check for duplicate offshore wave identification keys in the nearshore wave data base. This type of error in the nearshore wave data base could be manifested if the user conducted nearshore wave transformation simulations for sea- and swell-type wave conditions differently, but, for whatever reason, forgot to specify (to WTNSWAV) that sea and swell waves were transformed differently. This could result in unexplainable poor performance of the shoreline change model because the input nearshore wave data for sea and swell wave types were indiscernible.

459. Example 5. This example will demonstrate how the height band classification option is invoked and how individual height bands are specified. The input for this example is contained in the file named **TEST2.NSR** and is listed in Figure 111. Note in Figure 111 that there are solutions for six offshore wave conditions and that each of the offshore wave conditions corresponds to a different input wave height. Responses to the program prompts are as follows:

a. Input file name: *TEST2.NSR*

b. Output file name: *OUT5*

c. Baseline orientation: *0.0*

d. Number of alongshore RCPWAVE cells: *36*

e. RCPWAVE coordinate corresponding to first wave block: *4*

```
 FILE: OUT4.NSW                             SHORELINE ORIENTATION:      0.00
 DATA AT WAVEBLOCKS    4 THRU    33 FROM    36 ALONGSHORE RCPWAVE CELLS
 CONTAINS    9 UNIQUE NEARSHORE WAVE EVENTS.  WAVE HEIGHTS IN METERS*100
************************************************************************
1151
-103084-103091-102096-101097-100095-100089-101094-100098-100104 -99099
 -98100 -97106 -97108 -95105 -94101 -93101 -93095 -94094 -95104 -95112
 -94119 -93120 -92117 -91118 -91121 -90118 -90114 -90117 -90123 -90124
1162
-113267-112284-109286-108280-108271-108265-107281-104288 -99294 -95275
 -95272 -95280 -92277 -91264 -90249 -91248 -94242 -98251 -98280 -94303
 -88305 -85296 -84286 -84282 -84288 -84279 -86274 -87283 -88304 -87304
1143
  78275  78258  77244  77227  76226  76248  77252  80258  82255  83264
  85271  88256  90262  93267  98277 101268 103274 105278 104263 101264
 101259 102262 107279 113276 115266 115263 116277 119278 120281 123285
2151
-103084-103091-102096-101097-100095-100089-101094-100098-100104 -99099
 -98100 -97106 -97108 -95105 -94101 -93101 -93095 -94094 -95104 -95112
 -94119 -93120 -92117 -91118 -91121 -90118 -90114 -90117 -90123 -90124
2162
-113267-112284-109286-108280-108271-108265-107281-104288 -99294 -95275
 -95272 -95280 -92277 -91264 -90249 -91248 -94242 -98251 -98280 -94303
 -88305 -85296 -84286 -84282 -84288 -84279 -86274 -87283 -88304 -87304
2143
  78275  78258  77244  77227  76226  76248  77252  80258  82255  83264
  85271  88256  90262  93267  98277 101268 103274 105278 104263 101264
 101259 102262 107279 113276 115266 115263 116277 119278 120281 123285
1151
-103084-103091-102096-101097-100095-100089-101094-100098-100104 -99099
 -98100 -97106 -97108 -95105 -94101 -93101 -93095 -94094 -95104 -95112
 -94119 -93120 -92117 -91118 -91121 -90118 -90114 -90117 -90123 -90124
1162
-113267-112284-109286-108280-108271-108265-107281-104288 -99294 -95275
 -95272 -95280 -92277 -91264 -90249 -91248 -94242 -98251 -98280 -94303
 -88305 -85296 -84286 -84282 -84288 -84279 -86274 -87283 -88304 -87304
1143
  78275  78258  77244  77227  76226  76248  77252  80258  82255  83264
  85271  88256  90262  93267  98277 101268 103274 105278 104263 101264
 101259 102262 107279 113276 115266 115263 116277 119278 120281 123285
```

Figure 110. WTNSWAV Example 4: Output file **OUT4.NSW**

f. RCPWAVE coordinate corresponding to last wave block: *33*

g. Are SEA and SWELL wave types transformed differently: *0* (NO)

h. Wave height units: *2* (METERS)

i. Number of wave conditions in input file: *6*

j. Number of height bands: *6*

k. Wave height band width: *0.5*

l. Minimum wave height *0.25*

```
WAVE CONDITION NUMBER  1:      HEIGHT=   0.500      PERIOD=  4.000      ANGLE= -11.000
  1 15  0.4788   -9.9151  20.00          13 14  0.4805  -10.6540  20.50            25 13  0.4762  -10.9617  21.00
  2 15  0.4788   -9.9151  20.00          14 15  0.4821  -10.2354  21.00            26 13  0.4762  -10.5870  20.00
  3 15  0.4806   -9.9093  21.00          15 15  0.4766   -9.6059  20.00            27 13  0.4747  -10.2937  20.00
  4 15  0.4802  -10.0069  21.00          16 14  0.4705   -8.8193  20.00            28 14  0.4705   -9.9900  20.00
  5 15  0.4798  -10.0328  21.00          17 14  0.4659   -9.1049  21.00            29 14  0.4679  -10.6956  20.00
  6 15  0.4756   -9.5536  20.00          18 14  0.4650   -9.7685  21.00            30 15  0.4698  -11.1212  20.00
  7 14  0.4730   -9.3840  20.50          19 13  0.4663   -9.7969  21.00            31 16  0.4741  -11.1525  21.00
  8 14  0.4714   -9.9785  20.50          20 13  0.4693  -10.3665  21.00            32 17  0.4762  -10.8784  21.00
  9 14  0.4730  -10.3863  20.50          21 13  0.4723  -10.7118  21.00            33 17  0.4754  -10.2407  21.00
 10 14  0.4733  -10.1493  20.00          22 13  0.4730  -10.7346  20.00            34 16  0.4719   -9.8776  20.00
 11 14  0.4754  -10.2264  21.00          23 14  0.4738  -10.2323  21.00            35 16  0.4723  -10.1729  20.50
 12 14  0.4768  -10.6078  20.50          24 13  0.4732  -10.3539  21.00            36 16  0.4723  -10.1729  20.50
WAVE CONDITION NUMBER  2:      HEIGHT=   1.000      PERIOD=  6.000      ANGLE= -33.000
  1 15  1.0589  -28.3854  20.00          13 14  1.0212  -29.3136  20.50            25 13  0.9858  -29.3351  21.00
  2 15  1.0589  -28.3854  20.00          14 15  1.0687  -29.1365  21.00            26 13  1.0205  -28.8598  20.00
  3 15  1.0583  -28.6561  21.00          15 15  1.0946  -26.9335  20.00            27 13  1.0451  -28.2008  20.00
  4 15  1.0640  -28.7442  21.00          16 14  1.0786  -24.1242  20.00            28 14  1.0415  -26.7156  20.00
  5 15  1.0737  -28.6543  21.00          17 14  1.0252  -23.3829  21.00            29 14  1.0258  -27.4516  20.00
  6 15  1.0633  -26.7102  20.00          18 14  0.9827  -24.1647  21.00            30 15  1.0173  -28.4085  20.00
  7 14  1.0388  -25.8057  20.50          19 13  0.9603  -24.3040  21.00            31 16  1.0104  -29.1373  21.00
  8 14  1.0146  -26.4565  20.50          20 13  0.9546  -25.9095  21.00            32 17  1.0233  -29.0774  21.00
  9 14  1.0078  -27.4099  20.50          21 13  0.9604  -27.2735  21.00            33 17  1.0173  -27.5324  21.00
 10 14  1.0025  -26.9072  20.00          22 13  0.9777  -27.7016  20.00            34 16  1.0109  -26.2126  20.00
 11 14  0.9883  -27.3231  21.00          23 14  0.9642  -26.9843  21.00            35 16  1.0067  -26.7954  20.50
 12 14  0.9923  -28.3713  20.50          24 13  0.9582  -27.3233  21.00            36 16  1.0067  -26.7954  20.50
WAVE CONDITION NUMBER  3:      HEIGHT=   1.500      PERIOD=  8.000      ANGLE=  33.000
  1 15  1.6618   29.9373  20.00          13 14  1.5364   26.5688  20.50            25 13  1.5635   25.6760  21.00
  2 15  1.6618   29.9373  20.00          14 15  1.5536   27.0383  21.00            26 13  1.5673   25.8965  20.00
  3 15  1.6321   30.5407  21.00          15 15  1.6289   26.9529  20.00            27 13  1.5340   25.3476  20.00
  4 15  1.6029   29.6792  21.00          16 14  1.6859   28.4589  20.00            28 14  1.5336   24.9185  20.00
  5 15  1.5933   29.2143  21.00          17 14  1.6724   27.9991  21.00            29 14  1.5387   22.6953  20.00
  6 15  1.6008   28.8381  20.00          18 14  1.6787   27.3622  21.00            30 15  1.5793   22.7882  20.00
  7 14  1.5961   28.6768  20.50          19 13  1.6593   28.2045  21.00            31 16  1.5932   24.4630  21.00
  8 14  1.6039   27.2027  20.50          20 13  1.6140   27.1090  21.00            32 17  1.6098   25.8171  21.00
  9 14  1.6284   27.4584  20.50          21 13  1.5926   26.5811  21.00            33 17  1.6189   27.5182  21.00
 10 14  1.6230   28.4044  20.00          22 13  1.5860   25.9317  20.00            34 16  1.6065   26.9490  20.00
 11 14  1.5613   28.6618  21.00          23 14  1.5683   27.3643  21.00            35 16  1.5919   26.3745  20.50
 12 14  1.5264   26.8896  20.50          24 13  1.5608   26.5888  21.00            36 16  1.5919   26.3745  20.50
WAVE CONDITION NUMBER  4:      HEIGHT=   2.000      PERIOD=  4.000      ANGLE= -11.000
  1 15  1.9311   -9.9151  20.00          13 14  1.9361  -10.6540  20.50            25 13  1.9163  -10.9617  21.00
  2 15  1.9311   -9.9151  20.00          14 15  1.9420  -10.2354  21.00            26 13  1.9167  -10.5870  20.00
  3 15  1.9382   -9.9093  21.00          15 15  1.9184   -9.6059  20.00            27 13  1.9102  -10.2937  20.00
  4 15  1.9362  -10.0069  21.00          16 14  1.8922   -8.8193  20.00            28 14  1.8921   -9.9900  20.00
  5 15  1.9342  -10.0328  21.00          17 14  1.8713   -9.1049  21.00            29 14  1.8807  -10.6956  20.00
  6 15  1.9163   -9.5536  20.00          18 14  1.8666   -9.7685  21.00            30 15  1.8878  -11.1212  20.00
  7 14  1.9056   -9.3840  20.50          19 13  1.8717   -9.7969  21.00            31 16  1.9049  -11.1525  21.00
  8 14  1.8984   -9.9785  20.50          20 13  1.8843  -10.3665  21.00            32 17  1.9133  -10.8784  21.00
  9 14  1.9047  -10.3863  20.50          21 13  1.8974  -10.7118  21.00            33 17  1.9104  -10.2407  21.00
 10 14  1.9056  -10.1493  20.00          22 13  1.9014  -10.7346  20.00            34 16  1.8964   -9.8776  20.00
 11 14  1.9144  -10.2264  21.00          23 14  1.9051  -10.2323  21.00            35 16  1.8980  -10.1729  20.50
 12 14  1.9207  -10.6078  20.50          24 13  1.9035  -10.3539  21.00            36 16  1.8980  -10.1729  20.50
WAVE CONDITION NUMBER  5:      HEIGHT=   2.500      PERIOD=  6.000      ANGLE= -33.000
  1 15  2.6518  -28.3854  20.00          13 14  2.5567  -29.3136  20.50            25 13  2.4676  -29.3351  21.00
  2 15  2.6518  -28.3854  20.00          14 15  2.6755  -29.1365  21.00            26 13  2.5546  -28.8598  20.00
  3 15  2.6503  -28.6561  21.00          15 15  2.7409  -26.9335  20.00            27 13  2.6164  -28.2008  20.00
  4 15  2.6647  -28.7442  21.00          16 14  2.7015  -24.1242  20.00            28 14  2.6076  -26.7156  20.00
  5 15  2.6891  -28.6543  21.00          17 14  2.5679  -23.3829  21.00            29 14  2.5687  -27.4516  20.00
  6 15  2.6632  -26.7102  20.00          18 14  2.4614  -24.1647  21.00            30 15  2.5473  -28.4085  20.00
  7 14  2.6019  -25.8057  20.50          19 13  2.4051  -24.3040  21.00            31 16  2.5296  -29.1373  21.00
  8 14  2.5413  -26.4565  20.50          20 13  2.3904  -25.9095  21.00            32 17  2.5617  -29.0774  21.00
  9 14  2.5239  -27.4099  20.50          21 13  2.4046  -27.2735  21.00            33 17  2.5467  -27.5324  21.00
 10 14  2.5105  -26.9072  20.00          22 13  2.4477  -27.7016  20.00            34 16  2.5309  -26.2126  20.00
 11 14  2.4748  -27.3231  21.00          23 14  2.4136  -26.9843  21.00            35 16  2.5202  -26.7954  20.50
 12 14  2.4845  -28.3713  20.50          24 13  2.3987  -27.3233  21.00            36 16  2.5202  -26.7954  20.50
```

Figure 111. Example PC_RCPWV output file **TEST2.NSR** (Continued)

```
WAVE CONDITION NUMBER  6:      HEIGHT=   3.000      PERIOD=  8.000     ANGLE=  33.000
  1 15  3.3290   29.9373  20.00          13 14  3.0785   26.5688  20.50          25 13  3.1320   25.6760  21.00
  2 15  3.3290   29.9373  20.00          14 15  3.1131   27.0383  21.00          26 13  3.1396   25.8965  20.00
  3 15  3.2694   30.5407  21.00          15 15  3.2642   26.9529  20.00          27 13  3.0730   25.3476  20.00
  4 15  3.2110   29.6792  21.00          16 14  3.3784   28.4589  20.00          28 14  3.0721   24.9185  20.00
  5 15  3.1918   29.2143  21.00          17 14  3.3511   27.9991  21.00          29 14  3.0825   22.6953  20.00
  6 15  3.2067   28.8382  20.00          18 14  3.3634   27.3622  21.00          30 15  3.1636   22.7882  20.00
  7 14  3.1974   28.6768  20.50          19 13  3.3243   28.2045  21.00          31 16  3.1913   24.4630  21.00
  8 14  3.2129   27.2027  20.50          20 13  3.2334   27.1090  21.00          32 17  3.2242   25.8171  21.00
  9 14  3.2616   27.4584  20.50          21 13  3.1904   26.5811  21.00          33 17  3.2424   27.5182  21.00
 10 14  3.2507   28.4044  20.00          22 13  3.1771   25.9317  20.00          34 16  3.2178   26.9490  20.00
 11 14  3.1272   28.6618  21.00          23 14  3.1415   27.3643  21.00          35 16  3.1885   26.3746  20.50
 12 14  3.0578   26.8896  20.50          24 13  3.1267   26.5888  21.00          36 16  3.1885   26.3746  20.50
```

Figure 111. (Concluded)

m. Process another input file: *0* (NO)

460. In line j of the user responses, the total number of height bands was specified as six. The program then acknowledged that wave height bands were required as a classification category and prompted for additional height band specifications. In line k the width (or height range) of the height bands was specified, and in line l the minimum wave height was specified. With these inputs WTNSWAV generated six height band categories, each 0.5 m in width and beginning at 0.25 m. For example, the first height band will be used to identify nearshore wave conditions for offshore wave heights between 0.25 and 0.75 m, and the third height band will be used to identify nearshore wave conditions for offshore wave heights between 1.25 and 1.75 m.

461. Figure 112 contains a listing of the output file **OUT5.NSW**. Note, that the band height indicator in the offshore wave identification key for each of the nearshore wave data sets corresponds to the input RCPWAVE offshore wave height. For example, for the second wave condition, the offshore wave height is 1.00 m, and the height band indicator in the second offshore wave identification key is 2, which denotes the second height band for offshore wave heights between 0.75 and 1.25 m. Similarly, for the fourth wave condition, the offshore wave height is 2.00 m, and the height band indicator is 4, which corresponds to the fourth height band for offshore wave heights between 1.75 and 2.25 m.

Summary

462. The program WTNSWAV enables the user to create a keyed nearshore wave data base for input to GENESIS. The program also enables creation of an additional offshore wave classification category if necessary, specifically, the wave height band category. WTNSWAV requires that all wave conditions in a given nearshore wave transformation simulation be of the same wave type (sea

```
 FILE: OUT5.NSW                        SHORELINE ORIENTATION:      0.00
 DATA AT WAVEBLOCKS    4 THRU   33 FROM   36 ALONGSHORE RCPWAVE CELLS
 CONTAINS   6 UNIQUE NEARSHORE WAVE EVENTS.  WAVE HEIGHTS IN METERS*100
***********************************************************************
 151
 -48102 -48109 -47112 -47111 -47107 -47100 -47103 -48106 -48110 -47104
 -47102 -47107 -47107 -47104 -47098 -47098 -47091 -47088 -48096 -48102
 -48107 -48106 -48102 -47101 -47104 -47100 -47094 -48096 -48100 -48100
 262
-102275-102291-101291-102284-103275-104267-105282-102289 -99293 -96273
 -96270 -98277 -96273 -95259 -96243 -98242-103234-108241-109269-107291
-102293 -99284 -99273-100269-101274-101265-104258-106267-107287-106287
 343
 162275 161258 159245 158228 154227 153249 153253 157259 156257 156266
 157274 159259 159266 161271 166282 168274 167280 169285 163270 155270
 154266 153269 156287 162284 163275 160272 160287 160288 159292 160297
 451
-191102-191109-190112-189111-188107-189100-191103-192106-192110-190104
-191102-190107-190107-188104-187098-187098-187091-189088-192096-194102
-194107-192106-191102-191101-190104-190100-191094-192096-193100-194100
 562
-255275-256291-253291-255284-257275-261267-262282-255289-247293-240273
-241270-245277-240273-239259-241243-246242-257234-270241-274269-268291
-256293-248284-247273-251269-252274-254265-260258-266267-269287-266287
 643
 324275 322258 319245 316228 308227 307249 307253 314259 313257 313266
 314274 318259 319266 323271 332282 336274 335280 338285 326270 311270
 308266 306269 313287 325284 326275 321272 320287 321288 319292 321297
```

Figure 112. WTNSWAV Example 5: Output file **OUT5.NSW**

wave conditions only, or swell wave conditions only). WTNSWAV performs error checking on user-input specifications if an existing output file is going to be appended and if more than one input file is processed in a single session. The program will permit duplicate offshore wave identification keys to exist in a single nearshore wave data file. Therefore, the user must exercise caution and be mindful of the inputs specified in use of the program WTNSWAV.

WTDEPTH

463. The program WTDEPTH reads water depth information (along the nearshore reference line) from a special RCPWAVE output file (specified on the SAVESPEC input record, shown in Table 12) and writes a **DEPTH**.ext file for input to GENESIS. The data in the **DEPTH**.ext file consists of water depths corresponding to each of the nearshore wave data points contained in the **NSWAV**.ext file.

Calculation procedure

464. The computational flow of the program WTDEPTH is straightforward and simple. First the program prompts for the input and output file names. Then, for the total number of alongshore RCPWAVE cells, and then for the specific RCPWAVE coordinates corresponding to the first and last wave blocks required by GENESIS (RCPWAVE alongshore cells defining the GENESIS model reach). With these input data specified the program reads the appropriate depth information and writes the output file in the format required for input to GENESIS.

Example application

465. Only one example application for the program WTDEPTH is given because the program was designed to read a specific input file (that specified on the SAVESPEC record in the PC_RCPWV data set) and does not have options that cause logical branches within the program. The file **TEST1.NSR** listed in Figure 93 will provide the input for this example.

466. Execution of the program is initiated by issuing the command *WTDEPTH* at the PC prompt. The program responds with a prompt for entry of the input file name and extension, and the path, if the input file does not reside in the default directory. For this example, the name *TEST1.NSR* is entered. This file must exist (it represents the input), or the program will terminate.

467. The next prompt issued by the program requests the output file name without the extension. The program WTDEPTH assigns the extension **.DEP** (denoting dep̲ths) to all output files. This file must not exist, or the program will terminate with an error. This feature will preclude the unintentional overwriting of an existing **.DEP** file. For this example, the name *TST1OUT* is entered.

468. Next, the program prompts for the number of alongshore RCPWAVE cells. From the RCPWAVE input data set (GRIDSPEC record, YCELLS variable), shown in Figure 92 and defined in Tables 3 through 12, it is seen that for this example the number of RCPWAVE cells is 36. So, the value *36* is entered. Because the RCPWAVE grid typically extends beyond the GENESIS grid in the alongshore direction, GENESIS requires only a subset of the data along the nearshore reference line. Consequently, WTDEPTH requires specification of the RCPWAVE coordinates corresponding to the GENESIS model reach, as does the program WTNSWAV. Hence, the next prompt requests specification of the RCPWAVE coordinate corresponding to the first wave block. For this example, the value

4 is entered. The next prompt requests entry of the RCPWAVE coordinate corresponding to the last wave block, and, for this example, the value 33 is entered.

469. At this point, the required inputs have been specified, and the program proceeds to read the depth data from the input file, and then writes these data to the output file in a format suitable for input to GENESIS. Figure 113 provides a listing of the file **TST1OUT.DEP** generated in this example. Notice that the file **TST1OUT.DEP** contains 30 water depths that correspond to the water depths at RCPWAVE alongshore coordinates 4 through 33 (compare data in Figure 93, fifth column, to Figure 113).

NSTRAN

470. The program NSTRAN computes potential longshore sand transport rates using processed output from RCPWAVE (nearshore wave height, period, and angle together with the nearshore water depth) and an offshore time series. As input the program requires:

a. An offshore wave time series generated by the program WTWAVES (*filename*.**WAV**).

b. A nearshore wave data base generated by the program WTNSWAV (*filename*.**NSW**).

c. A nearshore depth file generated by the program WTDEPTH (*filename*.**DEP**).

These three input files, together with user-specified input of the offshore wave time series time-step, number of events per time-step, and, if necessary, specification of required wave height bands provide the necessary input for the computations to proceed. The program NSTRAN also checks for completeness of the nearshore wave data base. Because the offshore and nearshore wave data are related (through angle-period band categorization) in NSTRAN in the same

```
********************************************************************************
 NEARSHORE DEPTH FILE CREATED FROM FILE:  TEST1.NSR
 DATA AT WAVEBLOCKS     4 THRU    33 FROM    36 ALONGSHORE RCPWAVE CELLS
********************************************************************************
  21.00  21.00  21.00  20.00  20.00  20.00  20.00  20.00  21.00  21.00
  21.00  20.00  21.00  21.00  21.00  21.00  21.00  20.00  20.00  21.00
  20.50  20.50  21.00  20.00  20.50  20.50  20.50  20.00  21.00  21.00
```

Figure 113. WTDEPTH output file **TST1OUT.DEP**

way as they are in GENESIS, it is a recommended procedure to test the nearshore wave data base with NSTRAN against all offshore time series that will be used in GENESIS simulations.

Calculation procedure

471. The potential longshore sand transport rate computations in NSTRAN are identical to the computations used in the program SEDTRAN (presented in Part III) except that the nearshore wave height, angle, and period, are used together with the nearshore reference water depth to determine the breaking wave conditions. However, NSTRAN requires a specific offshore wave event to be associated with a set of nearshore wave conditions that represent the transformation of offshore waves from a specific angle-period band (and height band if required) category. This relationship is evaluated by computing an offshore wave identification key based on the offshore wave angle and period (and height if required).

472. After the offshore wave identification key has been evaluated, the nearshore wave data base is searched for the set of nearshore wave conditions corresponding to the key. If the offshore wave identification key is not found in the nearshore wave data base, the key and corresponding offshore wave height, angle, and period are reported to the user. If the offshore wave identification key is found, the nearshore wave height-angle numbers for each of the wave blocks are decomposed into a nearshore height transformation coefficient (or actual wave height if height bands are used) and angle. If height bands are not used, the nearshore wave height is obtained by taking the product of the height transformation coefficient and the offshore wave height.

473. Once the nearshore wave height and angle have been computed, these data together with the offshore wave period and nearshore reference water depth are used to evaluate breaking wave conditions. The breaking wave conditions are in turn used to estimate potential longshore sand transport rates. This procedure is used to estimate potential transport rates at each of the nearshore wave blocks.

474. The above-described procedure completes the computations for a single offshore wave event. At this point, the magnitude and direction of the computed potential sand transport rate are saved. Each wave event in the offshore time series is processed in a similar manner, and, when the end of the time series is reached, cumulative potential longshore sand transport rates for each of the nearshore wave blocks are written to the user-specified

output file. The output file consists of two tables; the first table lists the estimated potential sand transport volume at each of the wave blocks, and the second table lists the estimated potential sand transport rate at each of the wave blocks. NSTRAN also produces an output file that contains the estimated potential longshore sand transport rates (only the numbers) for each of the nearshore wave blocks. This file is generated for plotting purposes and is in a format that is compatible with the HGRAPH graphics program DPLOT. The following section provides an example application of the program NSTRAN and describes the steps necessary to compile the required input files.

Example application

475. In this example application, a time series retrieved from the WIS data base using the SEAS system will represent the initial wave data. This time series (**WVSEAS.DAT** listed in Part III, Figure 12) is first transformed from deepwater conditions to the water depth corresponding to the offshore boundary of the RCPWAVE bathymetry grid using the program WAVETRAN (step 1 in the offshore wave analysis procedure outlined in Part V).

476. The WAVETRAN transformation was performed for a shoreline orientation of 54 deg, and no wave energy sheltering was specified. The output time series (named **NSTST.PH3** and listed in Figure 114) from WAVETRAN is then processed through the program RCRIT, which flags the calm events and events that are determined to produce an alongshore current below the threshold current necessary to produce significant longshore sand transport (step 3 in the offshore wave analysis procedure). Note that step 2 in the offshore wave analysis procedure (use of SEDTRAN) is not necessary because potential longshore sand transport rates are going to be evaluated based on nearshore wave conditions. However, for comparison purposes, the computations were performed, and the results are listed in Figure 115. The output time series from RCRIT (named **NSTST.CTS** and listed in Figure 116) was also processed through SEDTRAN to investigate the effect RCRIT had on potential sand transport rate estimated using the offshore time series. Figure 117 contains a listing of the estimates. Note that the estimated potential longshore sand transport rates listed in Figures 115 and 117 are identical. However, in the first SEDTRAN run a total of 46 sea events was computed, whereas in the second SEDTRAN run a total of 38 sea events was computed. Therefore, for this example, eight sea events and no swell events were determined to be below the threshold for significant longshore sand transport. For a long time series

```
                    NSTST                      48
62030500         0.0     0.0     0.0       0.0     0.0     0.0
62030503        16.9     3.0   171.6       0.0     0.0     0.0
62030506        41.6     3.0   155.5       0.0     0.0     0.0
62030509        45.6     4.0   164.5       0.0     0.0     0.0
62030512        40.5     4.0   170.8       0.0     0.0     0.0
62030515        59.7     4.0   165.2       0.0     0.0     0.0
62030518        75.5     4.0   157.1       0.0     0.0     0.0
62030521        97.7     5.0   148.0       0.0     0.0     0.0
62030600       131.2     6.0   138.0       0.0     0.0     0.0
62030603       160.6     7.0   136.6       0.0     0.0     0.0
62030606       206.4     8.0   130.9       0.0     0.0     0.0
62030609       202.4     9.0   127.1       0.0     0.0     0.0
62030612       198.8     8.0   130.2       0.0     0.0     0.0
62030615       219.2     8.0   129.5       0.0     0.0     0.0
62030618       217.4     9.0   126.4     112.7    10.0   129.8
62030621       220.8     9.0   135.0       0.0     0.0     0.0
62030700        84.8     7.0   150.1     269.6    12.0   119.5
62030703        75.3     7.0   150.3     277.3    13.0   114.9
62030706        71.2     7.0   150.3     276.5    13.0   114.2
62030709        91.1     7.0   149.9     272.7    13.0   113.9
62030712       100.9     7.0   149.9     274.3    13.0   114.2
62030715        99.5     7.0   149.9     270.3    13.0   114.2
62030718        97.2     7.0   149.9     255.2    13.0   114.4
62030721        94.4     7.0   149.9     236.1    13.0   114.7
62030800        93.0     7.0   149.9     227.2    13.0   114.9
62030803        72.0     7.0   150.6     229.9    13.0   115.1
62030806        67.7     7.0   150.3     222.3    13.0   115.1
62030809        62.0     7.0   150.6     199.8    13.0   115.5
62030812        60.5     7.0   150.6     179.1    13.0   115.5
62030815        60.8     7.0   150.6     155.1    13.0   115.9
62030818        58.3     6.0   156.7     145.2    13.0   116.3
62030821        64.8     6.0   155.3     137.5    12.0   120.5
62030900        67.4     6.0   154.0     125.9    12.0   120.5
62030903        95.1     7.0   145.5     105.8    11.0   124.0
62030906        78.1     5.0   159.5     103.2    11.0   124.3
62030909        95.4     5.0   150.0      95.9    10.0   129.1
62030912        97.8     4.0   141.1      86.6    10.0   128.4
62030915        94.0     5.0   140.7      77.9    10.0   127.7
62030918       102.8     5.0   144.2      70.7    10.0   126.9
62030921        86.3     4.0   156.6      68.1     9.0   128.5
62031000        58.6     4.0   161.3      68.3     8.0   131.2
62031003       100.3     4.0   165.6       0.0     0.0     0.0
62031006        68.7     5.0   162.0       0.0     0.0     0.0
62031009        62.1     4.0   171.8       0.0     0.0     0.0
62031012        38.9     4.0   174.3       0.0     0.0     0.0
62031015        20.8     4.0   177.0       0.0     0.0     0.0
62031018         0.0     0.0     0.0       0.0     0.0     0.0
62031021        13.0     5.0   169.7       0.0     0.0     0.0
```

Figure 114. WAVETRAN output file NSTST.PH3

```
          ESTIMATED POTENTIAL LONGSHORE SAND TRANSPORT RATES
                      INPUT TIME SERIES: NSTST.PH3

                                TABLE 1

   WAVE                          SAND TRANSPORT VOLUMES (M**3)
   TYPE          LEFT DIRECTED  RIGHT DIRECTED       NET          GROSS
-----------------------------------------------------------------------

    sea              0.00          0.41E+05       0.41E+05     0.41E+05
   swell             0.00          0.94E+05       0.94E+05     0.94E+05
  combined           0.00          0.14E+06       0.14E+06     0.14E+06

-----------------------------------------------------------------------



                                TABLE 2

   WAVE                      SAND TRANSPORT RATES (M**3/YEAR)
   TYPE          LEFT DIRECTED  RIGHT DIRECTED      NET           GROSS
-----------------------------------------------------------------------

    sea              0.00          0.25E+07       0.25E+07     0.25E+07
   swell             0.00          0.57E+07       0.57E+07     0.57E+07
  combined           0.00          0.82E+07       0.82E+07     0.82E+07

-----------------------------------------------------------------------



                        SUMMARY OF TIME SERIES DATA
                        ---------------------------

   The duration of the input time series is 0.02 years

  NOTE: Because the time series is less than one year in duration, the
        estimates reported above may reflect a seasonal bias.

   These estimates are based on a shoreline orientation of    0 degrees
           48 events were processed at a time step of 3 hours
            2 sea events were calm
           22 swell events were calm
```

Figure 115. SEDTRAN output using **NSTST.PH3** as input

```
                   NSTST                         48
62030500            0.0   -99.9     0.0         0.0   -99.9     0.0
62030503            0.0   -99.9     0.0         0.0   -99.9     0.0
62030506            0.0   -99.9     0.0         0.0   -99.9     0.0
62030509            0.0   -99.9     0.0         0.0   -99.9     0.0
62030512            0.0   -99.9     0.0         0.0   -99.9     0.0
62030515           59.7     4.0   165.2         0.0   -99.9     0.0
62030518           75.5     4.0   157.1         0.0   -99.9     0.0
62030521           97.7     5.0   148.0         0.0   -99.9     0.0
62030600          131.2     6.0   138.0         0.0   -99.9     0.0
62030603          160.6     7.0   136.6         0.0   -99.9     0.0
62030606          206.4     8.0   130.9         0.0   -99.9     0.0
62030609          202.4     9.0   127.1         0.0   -99.9     0.0
62030612          198.8     8.0   130.2         0.0   -99.9     0.0
62030615          219.2     8.0   129.5         0.0   -99.9     0.0
62030618          217.4     9.0   126.4       112.7    10.0   129.8
62030621          220.8     9.0   135.0         0.0   -99.9     0.0
62030700           84.8     7.0   150.1       269.6    12.0   119.5
62030703           75.3     7.0   150.3       277.3    13.0   114.9
62030706           71.2     7.0   150.3       276.5    13.0   114.2
62030709           91.1     7.0   149.9       272.7    13.0   113.9
62030712          100.9     7.0   149.9       274.3    13.0   114.2
62030715           99.5     7.0   149.9       270.3    13.0   114.2
62030718           97.2     7.0   149.9       255.2    13.0   114.4
62030721           94.4     7.0   149.9       236.1    13.0   114.7
62030800           93.0     7.0   149.9       227.2    13.0   114.9
62030803           72.0     7.0   150.6       229.9    13.0   115.1
62030806           67.7     7.0   150.3       222.3    13.0   115.1
62030809           62.0     7.0   150.6       199.8    13.0   115.5
62030812           60.5     7.0   150.6       179.1    13.0   115.5
62030815           60.8     7.0   150.6       155.1    13.0   115.9
62030818           58.3     6.0   156.7       145.2    13.0   116.3
62030821           64.8     6.0   155.3       137.5    12.0   120.5
62030900           67.4     6.0   154.0       125.9    12.0   120.5
62030903           95.1     7.0   145.5       105.8    11.0   124.0
62030906           78.1     5.0   159.5       103.2    11.0   124.3
62030909           95.4     5.0   150.0        95.9    10.0   129.1
62030912           97.8     4.0   141.1        86.6    10.0   128.4
62030915           94.0     5.0   140.7        77.9    10.0   127.7
62030918          102.8     5.0   144.2        70.7    10.0   126.9
62030921           86.3     4.0   156.6        68.1     9.0   128.5
62031000           58.6     4.0   161.3        68.3     8.0   131.2
62031003          100.3     4.0   165.6         0.0   -99.9     0.0
62031006           68.7     5.0   162.0         0.0   -99.9     0.0
62031009            0.0   -99.9     0.0         0.0   -99.9     0.0
62031012            0.0   -99.9     0.0         0.0   -99.9     0.0
62031015            0.0   -99.9     0.0         0.0   -99.9     0.0
62031018            0.0   -99.9     0.0         0.0   -99.9     0.0
62031021            0.0   -99.9     0.0         0.0   -99.9     0.0
```

Figure 116. RCRIT output file **NSTST.CTS**

```
           ESTIMATED POTENTIAL LONGSHORE SAND TRANSPORT RATES
                      INPUT TIME SERIES: nstst.cts


                               TABLE 1

   WAVE                           SAND TRANSPORT VOLUMES (M**3)
   TYPE       LEFT DIRECTED   RIGHT DIRECTED      NET           GROSS
--------------------------------------------------------------------------

    sea           0.00          0.41E+05       0.41E+05       0.41E+05
   swell          0.00          0.94E+05       0.94E+05       0.94E+05
  combined        0.00          0.14E+06       0.14E+06       0.14E+06

--------------------------------------------------------------------------



                               TABLE 2

   WAVE                       SAND TRANSPORT RATES (M**3/YEAR)
   TYPE       LEFT DIRECTED   RIGHT DIRECTED      NET           GROSS
--------------------------------------------------------------------------

    sea           0.00          0.25E+07       0.25E+07       0.25E+07
   swell          0.00          0.57E+07       0.57E+07       0.57E+07
  combined        0.00          0.82E+07       0.82E+07       0.82E+07

--------------------------------------------------------------------------



                      SUMMARY OF TIME SERIES DATA
                      --------------------------

   The duration of the input time series is 0.02 years

 NOTE: Because the time series is less than one year in duration, the
       estimates reported above may reflect a seasonal bias.

   These estimates are based on a shoreline orientation of   0 degrees
           48 events were processed at a time step of 3 hours
           10 sea events were calm
           22 swell events were calm
```

Figure 117. SEDTRAN output using **NSTST.CTS** as input

(1 year or longer) a larger number of sea and swell wave events would be eliminated from the offshore time series by the program RCRIT.

477. The next step is to generate an offshore wave data file suitable for input to GENESIS and NSTRAN using the program WTWAVES (step 5 in the offshore wave analysis procedure). If a subset of the time series **NSTST.CTS** was going to be used, or if **NSTST.CTS** was to be combined with another time series, the program WTWAVTS would be used to compile the final time series (step 4 in the offshore wave analysis procedure). However, for this example, only the time series **NSTST.CTS** is being included. The output from WTWAVES (named **NSTST.WAV** and listed in Figure 118) represents the offshore time series that will be used as input to the program NSTRAN. At this point, the analysis (and preparation) of the offshore wave time series has been completed.

478. The next step is to prepare the input files representing the required data along the nearshore reference line. This process signifies the beginning of the nearshore wave analysis procedure (the subject of this chapter). The first step is to determine what nearshore wave transformation simulations are required using the program WHEREWAV. Therefore, the next step is to run WHEREWAV using the time series **NSTST.CTS** as input.

479. Figure 119 lists the output from WHEREWAV, and it is seen that a total of 12 nearshore wave transformation simulations are required in order to represent the nearshore transformation of the offshore time series. Table 19 contains a listing of the RCPWAVE boundary input wave conditions. Note in Table 19 that, for the swell wave conditions, the input wave angles are not the average for the angle band, but rather the average for each of the specific period bands within the angle band. The average angle for each of the swell-wave period bands was evaluated from the time series **NSTST.CTS**.

480. Nearshore transformation simulations for the wave conditions shown in Table 19 were performed using PC_RCPWV. A listing of the PC_RCPWV input data sets for the sea and swell wave conditions, excluding the 2-D bathymetry array (which is the same as shown in Figure 92), is provided in Figure 120.

481. The output files containing the nearshore wave data specified on the SAVESPEC records are listed in Figures 121 and 122. These files must be processed through the program WTNSWAV to obtain the required nearshore wave data base, and then through the program WTDEPTH to obtain the nearshore reference water depths. Figure 123 contains a listing of the nearshore wave data base named **NSTST.NSW**, obtained after executing WTNSWAV using the files

```
FILE:  NSTST.WAV
NUMBER OF EVENTS PER RECORD:  2     TIME STEP:      3
SYSTEM OF UNITS:  FEET
*********************************************************************************
   -99.900      0.000      0.000   62030500
   -99.900      0.000      0.000   62030500 EVENT 2
   -99.900      0.000      0.000   62030503
   -99.900      0.000      0.000   62030503 EVENT 2
   -99.900      0.000      0.000   62030506
   -99.900      0.000      0.000   62030506 EVENT 2
   -99.900      0.000      0.000   62030509
   -99.900      0.000      0.000   62030509 EVENT 2
   -99.900      0.000      0.000   62030512
   -99.900      0.000      0.000   62030512 EVENT 2
     4.000      1.959     75.200   62030515
   -99.900      0.000      0.000   62030515 EVENT 2
     4.000      2.477     67.100   62030518
   -99.900      0.000      0.000   62030518 EVENT 2
     5.000      3.205     58.000   62030521
   -99.900      0.000      0.000   62030521 EVENT 2
     6.000      4.304     48.000   62030600
   -99.900      0.000      0.000   62030600 EVENT 2
     7.000      5.269     46.600   62030603
   -99.900      0.000      0.000   62030603 EVENT 2
     8.000      6.772     40.900   62030606
   -99.900      0.000      0.000   62030606 EVENT 2
     9.000      6.640     37.100   62030609
   -99.900      0.000      0.000   62030609 EVENT 2
     8.000      6.522     40.200   62030612
   -99.900      0.000      0.000   62030612 EVENT 2
     8.000      7.192     39.500   62030615
   -99.900      0.000      0.000   62030615 EVENT 2
     9.000      7.133     36.400   62030618
    10.000      3.698     39.800   62030618 EVENT 2
     9.000      7.244     45.000   62030621
   -99.900      0.000      0.000   62030621 EVENT 2
     7.000      2.782     60.100   62030700
    12.000      8.845     29.500   62030700 EVENT 2
     7.000      2.470     60.300   62030703
    13.000      9.098     24.900   62030703 EVENT 2
     7.000      2.336     60.300   62030706
    13.000      9.072     24.200   62030706 EVENT 2
     7.000      2.989     59.900   62030709
    13.000      8.947     23.900   62030709 EVENT 2
     7.000      3.310     59.900   62030712
    13.000      8.999     24.200   62030712 EVENT 2
     7.000      3.264     59.900   62030715
    13.000      8.868     24.200   62030715 EVENT 2
     7.000      3.189     59.900   62030718
    13.000      8.373     24.400   62030718 EVENT 2
```

Figure 118. WTWAVES output file **NSTST.WAV** (Continued)

```
  7.000    2.362   60.600   62030803
 13.000    7.543   25.100   62030803 EVENT 2
  7.000    2.221   60.300   62030806
 13.000    7.293   25.100   62030806 EVENT 2
  7.000    2.034   60.600   62030809
 13.000    6.555   25.500   62030809 EVENT 2
  7.000    1.985   60.600   62030812
 13.000    5.876   25.500   62030812 EVENT 2
  7.000    1.995   60.600   62030815
 13.000    5.089   25.900   62030815 EVENT 2
  6.000    1.913   66.700   62030818
 13.000    4.764   26.300   62030818 EVENT 2
  6.000    2.126   65.300   62030821
 12.000    4.511   30.500   62030821 EVENT 2
  6.000    2.211   64.000   62030900
 12.000    4.131   30.500   62030900 EVENT 2
  7.000    3.120   55.500   62030903
 11.000    3.471   34.000   62030903 EVENT 2
  5.000    2.562   69.500   62030906
 11.000    3.386   34.300   62030906 EVENT 2
  5.000    3.130   60.000   62030909
 10.000    3.146   39.100   62030909 EVENT 2
  4.000    3.209   51.100   62030912
 10.000    2.841   38.400   62030912 EVENT 2
  5.000    3.084   50.700   62030915
 10.000    2.556   37.700   62030915 EVENT 2
  5.000    3.373   54.200   62030918
 10.000    2.320   36.900   62030918 EVENT 2
  4.000    2.831   66.600   62030921
  9.000    2.234   38.500   62030921 EVENT 2
  4.000    1.923   71.300   62031000
  8.000    2.241   41.200   62031000 EVENT 2
  4.000    3.291   75.600   62031003
-99.900    0.000    0.000   62031003 EVENT 2
  5.000    2.254   72.000   62031006
-99.900    0.000    0.000   62031006 EVENT 2
-99.900    0.000    0.000   62031009
-99.900    0.000    0.000   62031009 EVENT 2
-99.900    0.000    0.000   62031012
-99.900    0.000    0.000   62031012 EVENT 2
-99.900    0.000    0.000   62031015
-99.900    0.000    0.000   62031015 EVENT 2
-99.900    0.000    0.000   62031018
-99.900    0.000    0.000   62031018 EVENT 2
-99.900    0.000    0.000   62031021
-99.900    0.000    0.000   62031021 EVENT 2
```

Figure 118. (Concluded)

```
WAVE CLASSIFICATION & STATISTICS FOR INPUT TIME SERIES:  NSTST.CTS
THE FOLLOWING CLASSIFICATIONS ARE BASED ON A SHORELINE ORIENTATION OF:   54.00


NUMBER OF RECORDS PROCESSED.................           48
NUMBER OF CALM SEA EVENTS...................           10
NUMBER OF CALM SWELL EVENTS.................           22
NUMBER OF OFFSHORE TRAVELING SEA EVENTS.....            0
NUMBER OF OFFSHORE TRAVELING SWELL EVENTS...            0


           DEFINITION OF ANGLE BANDS                                DEFINITION OF PERIOD BANDS

ANGLE BAND  RANGE WITH RESPECT  RANGE WITH RESPECT         PERIOD BAND NO.             RANGE OF WAVE PERIODS
  NUMBER        TO NORTH          TO SHORE-NORMAL                1                        0.0< T < 5.0
    1       54.00 :  56.25      90.00 :  87.75                   2                        5.0≤ T < 7.0
    2       56.25 :  78.75      87.75 :  65.25                   3                        7.0≤ T < 9.0
    3       78.75 : 101.25      65.25 :  42.75                   4                        9.0≤ T <11.0
    4      101.25 : 123.75      42.75 :  20.25                   5                       11.0≤ T <13.0
    5      123.75 : 146.25      20.25 :  -2.25                   6                       13.0≤ T <15.0
    6      146.25 : 168.75      -2.25 : -24.75                   7                       15.0≤ T <17.0
    7      168.75 : 191.25     -24.75 : -47.25                   8                       17.0≤ T <23.0
    8      191.25 : 213.75     -47.25 : -69.75                   9                       23.0≤ T
    9      213.75 : 234.00     -69.75 : -90.00



 CLASSIFICATION OF SEA WAVE EVENTS BY ANGLE BAND            CLASSIFICATION OF SEA WAVE EVENTS BY PERIOD

 ANGLE BAND   NO. OF   AVERAGE   AVERAGE   PERIOD           PERIOD BAND   NO. OF   AVERAGE   AVERAGE   ANGLE
   NUMBER     EVENTS    ANGLE    HEIGHT    BANDS              NUMBER      EVENTS   PERIOD    HEIGHT    BANDS
     1          0         -         -        -                  1           6       4.00      79.70     2 3
     2          9       69.92     72.26     1 2                 2          10       5.40      85.84     2 3
     3         24       57.33     95.55   1 2 3 4               3          19       7.16     105.82     3 4
     4          5       38.82    208.84     3 4                 4           3       9.00     213.53     3 4
     5          0         -         -        -                  5           0        -          -        -
     6          0         -         -        -                  6           0        -          -        -
     7          0         -         -        -                  7           0        -          -        -
     8          0         -         -        -                  8           0        -          -        -
     9          0         -         -        -                  9           0        -          -        -



 CLASSIFICATION OF SWELL WAVE EVENTS BY ANGLE BAND          CLASSIFICATION OF SWELL WAVE EVENTS BY PERIOD

 ANGLE BAND   NO. OF   AVERAGE   AVERAGE   PERIOD           PERIOD BAND   NO. OF   AVERAGE   AVERAGE   ANGLE
   NUMBER     EVENTS    ANGLE    HEIGHT    BANDS              NUMBER      EVENTS   PERIOD    HEIGHT    BANDS
     1          0         -         -        -                  1           0        -          -        -
     2          0         -         -        -                  2           0        -          -        -
     3          0         -         -        -                  3           1       8.00      68.30      4
     4         26       29.97    174.74   3 4 5 6               4           6       9.83      85.32      4
     5          0         -         -        -                  5           5      11.60     148.40      4
     6          0         -         -        -                  6          14      13.00     230.07      4
     7          0         -         -        -                  7           0        -          -        -
     8          0         -         -        -                  8           0        -          -        -
     9          0         -         -        -
```

Figure 119. WHEREWAV output file NSTST.WW

Table 19

Nearshore Wave Transformation Simulations for the Time Series NSTST.CTS

Simulation No.	Wave Height* m	Wave Angle deg	Wave Period sec
		Sea Wave Conditions	
1	1	69.9	4.0
2	1	69.9	5.4
3	1	57.3	4.0
4	1	57.3	5.4
5	1	57.3	7.2
6	1	57.3	9.0
7	1	38.8	7.2
8	1	38.8	9.0
		Swell Wave Conditions	
9	1	41.2	8.0
10	1	38.4	9.8
11	1	31.8	11.6
12	1	24.9	13.0

* All simulations will be performed for a unit wave height, and the RCPWAV output height along the nearshore reference will be used as a height transformation coefficient (multiplier) for transforming the offshore wave height.

SEAS_S.NSR and **SEAS_C.NSR** as input. The nearshore wave data between RCPWAVE longshore coordinates 9 and 28 encompass the area of interest for a total of 20 wave blocks as shown in Figure 123.

482. The final step in the preparation of the required input files for the program NSTRAN involves executing the program WTDEPTH using either the file **SEAS_S.NSR** or **SEAS_C.NSR** as input. A listing of the file **NSTST.DEP** that contains the 20 nearshore reference depths corresponding to the nearshore wave data in the file **NSTST.NSW** is contained in Figure 124.

483. At this point, the three required input files (**NSTST.WAV**, **NSTST.NSW**, and **NSTST.DEP**) have been prepared, and potential longshore sand transport rates based on the nearshore wave conditions can be estimated using the program NSTRAN. Execution of the program is initiated by issuing the command *NSTRAN* at the PC prompt.

484. The program responds by prompting for the file name of the offshore wave time series. This input file must have the extension .WAV;

```
FILES   NSTST_S
GENSPECS              Swell waves for NSTRAN example                    ENGLISH
GRIDSPEC RECTANG ENGLISH      40      36   200.0   400.0
WAVCOND       1.0     13.0    24.9     0.0      YES
WAVMOD       1.00     1.00    24.9    24.9
WAVCOND       1.0      9.8    38.4     0.0      YES
WAVMOD       1.00     1.00    38.4    38.4
WAVCOND       1.0     11.6    31.8     0.0      YES
WAVMOD       1.00     1.00    31.8    31.8
WAVCOND       1.0      8.0    41.2     0.0      YES
WAVMOD       1.00     1.00    41.2    41.2
SAVESPEC       SEAS_S.NSR
 15 15 15 15 15 15 14 14 14 14
 14 14 14 15 15 14 14 14 13 13
 13 13 14 13 13 13 13 14 14 15
 16 17 17 16 16 16
PRWINDOW        1      40       1      36                           DAHKB
BATHSPEC     FEET     0.0     0.0              YX         (10F7.1)
```

(a) Swell wave conditions

```
FILES   NSTST_C
GENSPECS              Sea waves for NSTRAN example                      ENGLISH
GRIDSPEC RECTANG ENGLISH      40      36   200.0   400.0
WAVCOND       1.0      7.2    57.3     0.0      YES
WAVMOD       1.00     1.00    57.3    57.3
WAVCOND       1.0      5.4    57.3     0.0      YES
WAVMOD       1.00     1.00    57.3    57.3
WAVCOND       1.0      4.0    57.3     0.0      YES
WAVMOD       1.00     1.00    57.3    57.3
WAVCOND       1.0      9.0    57.3     0.0      YES
WAVMOD       1.00     1.00    57.3    57.3
WAVCOND       1.0      5.4    69.9     0.0      YES
WAVMOD       1.00     1.00    69.9    69.9
WAVCOND       1.0      4.0    69.9     0.0      YES
WAVMOD       1.00     1.00    69.9    69.9
WAVCOND       1.0      7.2    38.8     0.0      YES
WAVMOD       1.00     1.00    38.8    38.8
WAVCOND       1.0      9.0    38.8     0.0      YES
WAVMOD       1.00     1.00    38.8    38.8
SAVESPEC       SEAS_C.NSR
 15 15 15 15 15 15 14 14 14 14
 14 14 14 15 15 14 14 14 13 13
 13 13 14 13 13 13 13 14 14 15
 16 17 17 16 16 16
PRWINDOW        1      40       1      36                           DAHKB
BATHSPEC     FEET     0.0     0.0              YX         (10F7.1)
```

(b) Sea wave conditions

Figure 120. PC_RCPWV input data sets

```
WAVE CONDITION NUMBER  1:      HEIGHT=   1.000     PERIOD= 13.000     ANGLE=  24.900
  1 15  1.1457   22.8084  20.00          13 14  1.0600   20.4761  20.50          25 13  1.0981   18.8950  21.00
  2 15  1.1457   22.8084  20.00          14 15  1.0442   20.8246  21.00          26 13  1.1044   19.3606  20.00
  3 15  1.1261   23.4776  21.00          15 15  1.0805   20.3602  20.00          27 13  1.0787   19.0535  20.00
  4 15  1.1092   22.8081  21.00          16 14  1.1253   21.4203  20.00          28 14  1.0711   18.6104  20.00
  5 15  1.1012   22.4281  21.00          17 14  1.1337   20.5967  21.00          29 14  1.0738   16.1141  20.00
  6 15  1.1079   22.2545  20.00          18 14  1.1587   19.7050  21.00          30 15  1.1041   15.8477  20.00
  7 14  1.1033   22.0361  20.50          19 13  1.1650   20.7193  21.00          31 16  1.1111   17.3113  21.00
  8 14  1.1171   20.3473  20.50          20 13  1.1450   19.8895  21.00          32 17  1.1205   18.6828  21.00
  9 14  1.1477   20.4066  20.50          21 13  1.1315   19.5175  21.00          33 17  1.1243   20.5107  21.00
 10 14  1.1612   21.6274  20.00          22 13  1.1304   19.1443  20.00          34 16  1.1231   20.2253  20.00
 11 14  1.1187   22.2301  21.00          23 14  1.1069   20.6834  21.00          35 16  1.1111   19.5871  20.50
 12 14  1.0831   20.7736  20.50          24 13  1.0967   19.9203  21.00          36 16  1.1111   19.5871  20.50
WAVE CONDITION NUMBER  2:      HEIGHT=   1.000     PERIOD=  9.800     ANGLE=  38.400
  1 15  1.1132   34.1305  20.00          13 14  1.0445   29.8011  20.50          25 13  1.0349   28.9697  21.00
  2 15  1.1132   34.1305  20.00          14 15  1.0642   30.4823  21.00          26 13  1.0385   29.0954  20.00
  3 15  1.0866   34.7261  21.00          15 15  1.1231   30.6616  20.00          27 13  1.0149   28.3704  20.00
  4 15  1.0629   33.6138  21.00          16 14  1.1537   32.5388  20.00          28 14  1.0175   27.9170  20.00
  5 15  1.0565   33.0376  21.00          17 14  1.1279   32.0999  21.00          29 14  1.0218   25.5930  20.00
  6 15  1.0628   32.4952  20.00          18 14  1.1222   31.4284  21.00          30 15  1.0514   25.8696  20.00
  7 14  1.0585   32.3159  20.50          19 13  1.0967   32.1724  21.00          31 16  1.0612   27.8377  21.00
  8 14  1.0624   30.7520  20.50          20 13  1.0586   30.7503  21.00          32 17  1.0751   29.3628  21.00
  9 14  1.0798   31.1121  20.50          21 13  1.0446   30.0736  21.00          33 17  1.0825   31.2205  21.00
 10 14  1.0768   31.9976  20.00          22 13  1.0428   29.2180  20.00          34 16  1.0708   30.4063  20.00
 11 14  1.0360   32.1074  21.00          23 14  1.0340   30.7843  21.00          35 16  1.0595   29.7939  20.50
 12 14  1.0221   30.0343  20.50          24 13  1.0324   29.9237  21.00          36 16  1.0595   29.7939  20.50
WAVE CONDITION NUMBER  3:      HEIGHT=   1.000     PERIOD= 11.600     ANGLE=  31.800
  1 15  1.1301   28.6210  20.00          13 14  1.0401   25.1182  20.50          25 13  1.0666   24.0665  21.00
  2 15  1.1301   28.6210  20.00          14 15  1.0475   25.5600  21.00          26 13  1.0721   24.3562  20.00
  3 15  1.1080   29.2883  21.00          15 15  1.1030   25.3746  20.00          27 13  1.0477   23.8256  20.00
  4 15  1.0882   28.4040  21.00          16 14  1.1463   26.9122  20.00          28 14  1.0459   23.3521  20.00
  5 15  1.0819   27.9182  21.00          17 14  1.1414   26.3875  21.00          29 14  1.0499   20.9229  20.00
  6 15  1.0906   27.5480  20.00          18 14  1.1499   25.6943  21.00          30 15  1.0799   20.9363  20.00
  7 14  1.0879   27.3525  20.50          19 13  1.1391   26.6638  21.00          31 16  1.0877   22.6725  21.00
  8 14  1.0965   25.7363  20.50          20 13  1.1073   25.5630  21.00          32 17  1.0991   24.1243  21.00
  9 14  1.1173   25.9743  20.50          21 13  1.0911   25.0255  21.00          33 17  1.1054   25.9747  21.00
 10 14  1.1168   27.0442  20.00          22 13  1.0881   24.3840  20.00          34 16  1.0997   25.4306  20.00
 11 14  1.0683   27.3707  21.00          23 14  1.0710   25.9189  21.00          35 16  1.0878   24.8027  20.50
 12 14  1.0394   25.5015  20.50          24 13  1.0644   25.0696  21.00          36 16  1.0878   24.8027  20.50
WAVE CONDITION NUMBER  4       HEIGHT=   1.000     PERIOD=  8.000     ANGLE=  41.200
  1 15  1.0874   36.6474  20.00          13 14  1.0355   32.3254  20.50          25 13  1.0073   31.4945  21.00
  2 15  1.0874   36.6474  20.00          14 15  1.0564   33.1114  21.00          26 13  1.0083   31.5325  20.00
  3 15  1.0596   37.1648  21.00          15 15  1.1089   33.4391  20.00          27 13  0.9858   30.7399  20.00
  4 15  1.0347   35.9948  21.00          16 14  1.1276   35.3136  20.00          28 14  0.9899   30.3303  20.00
  5 15  1.0278   35.4096  21.00          17 14  1.0961   34.8521  21.00          29 14  0.9940   28.1470  20.00
  6 15  1.0313   34.8223  20.00          18 14  1.0858   34.1707  21.00          30 15  1.0220   28.5404  20.00
  7 14  1.0291   34.6770  20.50          19 13  1.0567   34.7431  21.00          31 16  1.0335   30.5413  21.00
  8 14  1.0335   33.2113  20.50          20 13  1.0201   33.2317  21.00          32 17  1.0478   32.0422  21.00
  9 14  1.0518   33.6288  20.50          21 13  1.0098   32.5441  21.00          33 17  1.0549   33.8226  21.00
 10 14  1.0496   34.4101  20.00          22 13  1.0087   31.6451  20.00          34 16  1.0398   32.9038  20.00
 11 14  1.0157   34.4516  21.00          23 14  1.0049   33.1887  21.00          35 16  1.0300   32.3246  20.50
 12 14  1.0075   32.4232  20.50          24 13  1.0056   32.3863  21.00          36 16  1.0300   32.3246  20.50
```

Figure 121. PC_RCPWV output file **SEAS_S.NSR**

however, entry of the extension is not requested and should not be entered. The file must exist in the default directory, or the appropriate path should be entered with the file name. For this example, the name *NSTST* is entered. The next prompt requests the nearshore wave data base file name, and the name *NSTST* is entered. This file must have the extension **.NSW** and must exist in the default directory, or the path should be entered together with the file name. Next, the program prompts for the entry of the nearshore reference depths file name. Again, this file must have the extension **.DEP** and reside

```
WAVE CONDITION NUMBER  1:      HEIGHT=   1.000      PERIOD=  7.200      ANGLE=  57.300
  1 15  0.9488   48.6648  20.00          13 14  1.0086   44.7113  20.50          25 13  0.8885   42.3035  21.00
  2 15  0.9488   48.6648  20.00          14 15  1.0253   46.1518  21.00          26 13  0.8823   41.9325  20.00
  3 15  0.9085   48.6309  21.00          15 15  1.0453   46.9829  20.00          27 13  0.8588   40.6825  20.00
  4 15  0.8993   46.9461  21.00          16 14  0.9828   48.3117  20.00          28 14  0.8703   40.4609  20.00
  5 15  0.9188   46.3658  21.00          17 14  0.9224   47.1075  21.00          29 14  0.8755   38.4658  20.00
  6 15  0.9537   45.7173  20.00          18 14  0.9070   46.0532  21.00          30 15  0.9052   39.4649  20.00
  7 14  0.9988   46.2096  20.50          19 13  0.8788   45.8308  21.00          31 16  0.9220   42.0651  21.00
  8 14  1.0097   45.0916  20.50          20 13  0.8585   43.7100  21.00          32 17  0.9416   43.8857  21.00
  9 14  1.0209   45.9897  20.50          21 13  0.8686   43.0548  21.00          33 17  0.9442   45.7019  21.00
 10 14  0.9936   46.3368  20.00          22 13  0.8736   41.9097  20.00          34 16  0.9131   43.9262  20.00
 11 14  0.9558   46.0088  21.00          23 14  0.8831   43.8088  21.00          35 16  0.9072   43.3783  20.50
 12 14  0.9629   43.8981  20.50          24 13  0.8918   43.1660  21.00          36 16  0.9072   43.3783  20.50
WAVE CONDITION NUMBER  2:      HEIGHT=   1.000      PERIOD=  5.400      ANGLE=  57.300
  1 15  0.9000   50.5202  20.00          13 14  0.9472   47.5114  20.50          25 13  0.8522   45.3970  21.00
  2 15  0.9000   50.5202  20.00          14 15  0.9604   48.7602  21.00          26 13  0.8409   44.9550  20.00
  3 15  0.8740   50.4724  21.00          15 15  0.9682   49.4234  20.00          27 13  0.8198   43.7734  20.00
  4 15  0.8722   49.1172  21.00          16 14  0.9140   50.3209  20.00          28 14  0.8314   43.6800  20.00
  5 15  0.8923   48.7402  21.00          17 14  0.8735   49.2615  21.00          29 14  0.8351   42.0466  20.00
  6 15  0.9192   48.2821  20.00          18 14  0.8556   48.4120  21.00          30 15  0.8605   43.0313  20.00
  7 14  0.9514   48.8363  20.50          19 13  0.8459   48.1880  21.00          31 16  0.8792   45.3259  21.00
  8 14  0.9503   47.8929  20.50          20 13  0.8310   46.4073  21.00          32 17  0.8970   46.8967  21.00
  9 14  0.9520   48.6119  20.50          21 13  0.8400   45.9304  21.00          33 17  0.8985   48.3635  21.00
 10 14  0.9243   48.7173  20.00          22 13  0.8395   44.9414  20.00          34 16  0.8684   46.7335  20.00
 11 14  0.9017   48.3908  21.00          23 14  0.8519   46.6184  21.00          35 16  0.8661   46.3034  20.50
 12 14  0.9102   46.6884  20.50          24 13  0.8584   46.1497  21.00          36 16  0.8661   46.3034  20.50
WAVE CONDITION NUMBER  3:      HEIGHT=   1.000      PERIOD=  4.000      ANGLE=  57.300
  1 15  0.9008   54.2603  20.00          13 14  0.9226   52.8047  20.50          25 13  0.8676   51.5989  21.00
  2 15  0.9008   54.2603  20.00          14 15  0.9311   53.5984  21.00          26 13  0.8502   51.1187  20.00
  3 15  0.8949   54.2834  21.00          15 15  0.9294   53.9339  20.00          27 13  0.8323   50.1643  20.00
  4 15  0.8978   53.5713  21.00          16 14  0.8973   54.2521  20.00          28 14  0.8447   50.2882  20.00
  5 15  0.9113   53.5043  21.00          17 14  0.8849   53.6278  21.00          29 14  0.8463   49.2821  20.00
  6 15  0.9195   53.3111  20.00          18 14  0.8862   53.2225  21.00          30 15  0.8663   50.1010  20.00
  7 14  0.9271   53.7215  20.50          19 13  0.8760   53.1208  21.00          31 16  0.8871   51.6789  21.00
  8 14  0.9152   53.0417  20.50          20 13  0.8657   52.0379  21.00          32 17  0.9019   52.7110  21.00
  9 14  0.9126   53.3966  20.50          21 13  0.8710   51.8545  21.00          33 17  0.9025   53.5140  21.00
 10 14  0.8934   53.2477  20.00          22 13  0.8632   51.1979  20.00          34 16  0.8774   52.3838  20.00
 11 14  0.8917   53.0682  21.00          23 14  0.8778   52.3626  21.00          35 16  0.8790   52.1584  20.50
 12 14  0.8995   52.1530  20.50          24 13  0.8790   52.1767  21.00          36 16  0.8790   52.1584  20.50
WAVE CONDITION NUMBER  4:      HEIGHT=   1.000      PERIOD=  9.000      ANGLE=  57.300
  1 15  0.9704   47.8535  20.00          13 14  1.0335   43.4386  20.50          25 13  0.9029   40.9416  21.00
  2 15  0.9704   47.8535  20.00          14 15  1.0521   44.9447  21.00          26 13  0.8994   40.6105  20.00
  3 15  0.9235   47.8391  21.00          15 15  1.0793   45.8451  20.00          27 13  0.8750   39.3436  20.00
  4 15  0.9100   46.0164  21.00          16 14  1.0152   47.3923  20.00          28 14  0.8864   39.0630  20.00
  5 15  0.9280   45.3414  21.00          17 14  0.9454   46.1486  21.00          29 14  0.8923   36.9057  20.00
  6 15  0.9650   44.6021  20.00          18 14  0.9260   45.0115  21.00          30 15  0.9239   37.8933  20.00
  7 14  1.0140   45.0353  20.50          19 13  0.8932   44.8065  21.00          31 16  0.9395   40.6088  21.00
  8 14  1.0307   43.8198  20.50          20 13  0.8699   42.5461  21.00          32 17  0.9598   42.5303  21.00
  9 14  1.0475   44.7796  20.50          21 13  0.8800   41.8080  21.00          33 17  0.9630   44.5001  21.00
 10 14  1.0223   45.2488  20.00          22 13  0.8876   40.5985  20.00          34 16  0.9321   42.6862  20.00
 11 14  0.9778   44.9377  21.00          23 14  0.8954   42.5837  21.00          35 16  0.9243   42.0860  20.50
 12 14  0.9841   42.6526  20.50          24 13  0.9048   41.8582  21.00          36 16  0.9243   42.0860  20.50
WAVE CONDITION NUMBER  5:      HEIGHT=   1.000      PERIOD=  5.400      ANGLE=  69.900
  1 15  0.8324   58.5095  20.00          13 14  0.7761   55.9776  20.50          25 13  0.7116   52.2673  21.00
  2 15  0.8324   58.5095  20.00          14 15  0.7806   57.4389  21.00          26 13  0.6936   51.4464  20.00
  3 15  0.8520   58.5517  21.00          15 15  0.7726   57.8528  20.00          27 13  0.6712   49.9077  20.00
  4 15  0.8768   57.5246  21.00          16 14  0.7090   57.5641  20.00          28 14  0.6865   50.0449  20.00
  5 15  0.9059   57.7600  21.00          17 14  0.6931   56.1173  21.00          29 14  0.6907   48.4762  20.00
  6 15  0.9172   57.6872  20.00          18 14  0.7045   55.2831  21.00          30 15  0.7169   49.8964  20.00
  7 14  0.8616   58.3339  20.50          19 13  0.7016   54.8670  21.00          31 16  0.7376   52.6652  21.00
  8 14  0.8069   56.8240  20.50          20 13  0.6949   52.9199  21.00          32 17  0.7615   54.6018  21.00
  9 14  0.7848   57.2771  20.50          21 13  0.7077   52.6356  21.00          33 17  0.7597   56.0667  21.00
 10 14  0.7466   56.6313  20.00          22 13  0.7061   51.5046  20.00          34 16  0.7256   53.7285  20.00
 11 14  0.7396   56.1715  21.00          23 14  0.7235   53.5710  21.00          35 16  0.7269   53.3622  20.50
 12 14  0.7521   54.5954  20.50          24 13  0.7272   53.2073  21.00          36 16  0.7269   53.3622  20.50
```

Figure 122. PC_RCPWV output file **SEAS_C.NSR** (Continued)

```
WAVE CONDITION NUMBER  6:     HEIGHT=   1.000     PERIOD=  4.000     ANGLE=  69.900
  1 15  0.8842   64.7700  20.00         13 14  0.8267   63.1714  20.50         25 13  0.7461   60.3968  21.00
  2 15  0.8842   64.7700  20.00         14 15  0.8339   64.1097  21.00         26 13  0.7251   59.5058  20.00
  3 15  0.8972   65.0057  21.00         15 15  0.8311   64.3340  20.00         27 13  0.7098   58.2386  20.00
  4 15  0.8942   64.4463  21.00         16 14  0.7849   63.7614  20.00         28 14  0.7318   58.7315  20.00
  5 15  0.8944   64.6622  21.00         17 14  0.7888   63.0089  21.00         29 14  0.7370   57.7883  20.00
  6 15  0.8785   64.4851  20.00         18 14  0.7973   62.6912  21.00         30 15  0.7621   59.0678  20.00
  7 14  0.8251   64.3931  20.50         19 13  0.7833   62.4057  21.00         31 16  0.7900   61.1696  21.00
  8 14  0.7967   63.1292  20.50         20 13  0.7695   61.0774  21.00         32 17  0.8172   62.6472  21.00
  9 14  0.7996   63.4411  20.50         21 13  0.7737   60.9801  21.00         33 17  0.8157   63.4647  21.00
 10 14  0.7857   62.9361  20.00         22 13  0.7605   60.0952  20.00         34 16  0.7864   61.7448  20.00
 11 14  0.8012   62.9190  21.00         23 14  0.7848   61.7173  21.00         35 16  0.7902   61.5839  20.50
 12 14  0.8102   62.1334  20.50         24 13  0.7694   61.3616  21.00         36 16  0.7902   61.5839  20.50
WAVE CONDITION NUMBER  7:     HEIGHT=   1.000     PERIOD=  7.200     ANGLE=  38.800
  1 15  1.0793   34.9545  20.00         13 14  1.0177   31.0596  20.50         25 13  1.0053   30.3052  21.00
  2 15  1.0793   34.9545  20.00         14 15  1.0365   31.7306  21.00         26 13  1.0057   30.3801  20.00
  3 15  1.0562   35.4825  21.00         15 15  1.0853   31.9405  20.00         27 13  0.9843   29.6717  20.00
  4 15  1.0339   34.4499  21.00         16 14  1.1085   33.6590  20.00         28 14  0.9873   29.2773  20.00
  5 15  1.0272   33.9262  21.00         17 14  1.0855   33.2368  21.00         29 14  0.9906   27.1772  20.00
  6 15  1.0296   33.4226  20.00         18 14  1.0794   32.6073  21.00         30 15  1.0168   27.4936  20.00
  7 14  1.0263   33.2921  20.50         19 13  1.0562   33.2356  21.00         31 16  1.0280   29.3397  21.00
  8 14  1.0288   31.8922  20.50         20 13  1.0229   31.8947  21.00         32 17  1.0408   30.7372  21.00
  9 14  1.0439   32.2533  20.50         21 13  1.0118   31.2750  21.00         33 17  1.0474   32.4153  21.00
 10 14  1.0398   33.0332  20.00         22 13  1.0088   30.4681  20.00         34 16  1.0341   31.6213  20.00
 11 14  1.0069   33.1177  21.00         23 14  1.0043   31.9198  21.00         35 16  1.0252   31.0699  20.50
 12 14  0.9955   31.2244  20.50         24 13  1.0037   31.1621  21.00         36 16  1.0252   31.0699  20.50
WAVE CONDITION NUMBER  8:     HEIGHT=   1.000     PERIOD=  9.000     ANGLE=  38.800
  1 15  1.1072   34.5380  20.00         13 14  1.0415   30.2682  20.50         25 13  1.0289   29.4516  21.00
  2 15  1.1072   34.5380  20.00         14 15  1.0615   30.9604  21.00         26 13  1.0318   29.5596  20.00
  3 15  1.0808   35.1165  21.00         15 15  1.1184   31.1620  20.00         27 13  1.0086   28.8280  20.00
  4 15  1.0571   34.0085  21.00         16 14  1.1463   33.0197  20.00         28 14  1.0115   28.3873  20.00
  5 15  1.0506   33.4375  21.00         17 14  1.1201   32.5822  21.00         29 14  1.0157   26.1111  20.00
  6 15  1.0559   32.8934  20.00         18 14  1.1136   31.9165  21.00         30 15  1.0448   26.4080  20.00
  7 14  1.0519   32.7227  20.50         19 13  1.0878   32.6247  21.00         31 16  1.0549   28.3638  21.00
  8 14  1.0557   31.1922  20.50         20 13  1.0504   31.2023  21.00         32 17  1.0686   29.8684  21.00
  9 14  1.0729   31.5595  20.50         21 13  1.0372   30.5311  21.00         33 17  1.0759   31.6929  21.00
 10 14  1.0698   32.4191  20.00         22 13  1.0353   29.6761  20.00         34 16  1.0636   30.8692  20.00
 11 14  1.0310   32.5186  21.00         23 14  1.0278   31.2233  21.00         35 16  1.0527   30.2692  20.50
 12 14  1.0183   30.4761  20.50         24 13  1.0267   30.3839  21.00         36 16  1.0527   30.2692  20.50
```

Figure 122. (Concluded)

either in the default directory or in the specified path. For this example, the name *NSTST* is entered. NSTRAN then prompts for entry of the output file name without the extension. NSTRAN writes output data in two files, one with the extension .NSV, and another with the extension .PLD. For this example, the name *NSTNP* is entered.

485. At this point the input and output files have been specified, and the program prompts for specification of the time-step associated with the offshore wave time series. For this example, the value *3* is entered, indicating a 3-hr time-step. Next, the program prompts for the number of wave events per time-step. Because the offshore time series contains both sea and swell wave events, the value *2* is entered.

486. The next prompt issued by NSTRAN states that if height bands are required, the number of height bands is entered; otherwise, the value *1* is entered. Because height bands are not required (for this example), the value *1* is entered. If more than one height band is specified, the program

```
 FILE: NSTST.NSW                        SHORELINE ORIENTATION:    54.00
 DATA AT WAVEBLOCKS    9 THRU   28 FROM   36 ALONGSHORE RCPWAVE CELLS
 CONTAINS  12 UNIQUE NEARSHORE WAVE EVENTS.  WAVE HEIGHTS IN FEET*10.
**************************************************************************
2146
  11186  11191  11194  11189  11199  11207  11191  11195  11199  12207
  12197  11206  11214  11204  10208  11205  11208  11222  12216  11204
2144
  10279  10284  10291  10290  10299  10308  10292  10301  11308  11322
  11314  11321  12325  11307  11305  10298  10300  10321  11320  11311
2145
  10234  10238  11244  11241  11251  11259  11244  11250  11256  11267
  11257  11264  11269  11254  10256  10251  10255  11274  11270  11260
2143
  10303  10307  10315  10315  10324  10332  10316  10325  10332  11347
  11342  11349  11353  11334  11331  10323  10324  10345  10344  11336
1133
   9405   9407   9419   9423   9432   9438   9419   9431   9437   9458
   9461   9471  10483  10470  10462  10447  10439  10460  10463  10460
1132
   8437   8438   8450   9454   9461   9466   8449   8459   8464   8482
   9484   9493   9503  10494  10488   9475   9467   9484   9487  10486
1131
   8503   8502   9511   9516   9522   9524   9512   9519   9520   9531
   9532   9536   9543   9539   9536   9528   9522   9531   9532   9534
1134
   9391   9393   9406   9409   9419   9426   9406   9418   9425   9448
   9450   9461  10474  11458  11449  10434  10427  10449  10452  10448
1122
   7500   7499   7514   7523   7532   7536   7515   7526   7529   7549
   7553   7561   7576   8579   8574   8560   8546   7562   7566   8573
1121
   7587   7582   7595   7604   8614   8617   8601   8610   8611   8624
   8627   8630   8638   8643   8641   8632   8621   8629   8629   8634
1143
  10293  10297  10304  10303  10312  10319  10305  10313  10319  11332
  11326  11332  11337  11319  10317  10311  10312  10331  10330  10323
1144
  10284  10288  10296  10295  10304  10312  10297  10305  11312  11326
  11319  11326  11330  11312  11310  10303  10305  10325  11324  11316
```

Figure 123. WTNSWAV output file **NSTST.NSW**

```
****************************************************************************
 NEARSHORE DEPTH FILE CREATED FROM FILE:  SEAS_S.NSR
 DATA AT WAVEBLOCKS    9 THRU   28 FROM   36 ALONGSHORE RCPWAVE CELLS
****************************************************************************
  20.00  20.00  20.00  21.00  21.00  21.00  20.00  21.00  21.00  21.00
  21.00  21.00  20.00  20.00  21.00  20.50  20.50  21.00  20.00  20.50
```

Figure 124. WTDEPTH output file **NSTST.DEP**

prompts for entry of the wave height band width, and then the minimum wave height.

487. At this point, the required inputs have been specified, and the program proceeds to compute the potential longshore sand transport rates. As stated previously, NSTRAN writes output to two output files. The output file with the **.NSV** extension contains two tables; one lists the estimated cumulative volume of sand transported (at each wave block contained in the nearshore wave data base) for sea and swell wave events individually and combined. The other table lists the estimated potential longshore sand transport rates, again for sea and swell wave events individually and combined. Both tables list left-directed, right-directed, net, and gross values. The output file **NSTNP.NSV** generated in this example application of the program NSTRAN is listed in Figure 125. The output file with the **.PLD** extension (for plot data) contains (for each wave block) the estimated left-directed and right-directed longshore sand transport rates for sea, and swell wave events individually and combined. This file was designed for plotting purposes, and the data are written to the file in a format that is accepted by the graphics program DPLOT. A listing of the file **NSTMP.PLD** generated in this example is provided in Figure 126. In Figure 126, the number 20 in the first line indicates to the program DPLOT that the file contains 20 X-values, and the second line indicates that for each of the X-values there are 6 corresponding Y-values (or that there are 6 curves). The remaining line in the file **NSTNP.PLD** contains the X-value (which corresponds to the wave block number followed by the left-directed and right-directed transport rates for sea wave conditions, the left-directed and right-directed transport rates for swell wave conditions, and the left-directed and right-directed transport rates for sea and swell wave conditions combined). Figure 127 provides a typical example of the graphical output that can be obtained using the program DPLOT and the file **NSTNP.PLD** as input. For comparison, a plot of the potential longshore sand transport rates estimated using the offshore wave time series (**NSTST.CTS**) and the program SEDTRAN is given in Figure 128.

Summary

488. In summary, NSTRAN uses GENESIS format input files for the offshore wave time series, the nearshore wave data base, and the nearshore reference water depths, and it computes potential longshore sand transport rates at each of the wave blocks contained in the nearshore wave data base.

```
                    ESTIMATED POTENTIAL LONGSHORE SAND TRANSPORT RATES

INPUT OFFSHORE TIME SERIES:  NSTST.WAV
INPUT NEARSHORE WAVE CONDITIONS:  NSTST.NSW
NEARSHORE WAVE BLOCK WATER DEPTHS:  NSTST.DEP


                                        TABLE 1
                                            SAND TRANSPORT VOLUMES (M**3)
                            WAVE     WAVE       LEFT       RIGHT
                           BLOCK     TYPE     DIRECTED   DIRECTED      NET        GROSS
                              1      SEA       0.00      0.29E+05   0.29E+05   0.29E+05
                              1     SWELL      0.00      0.89E+05   0.89E+05   0.89E+05
                              1    COMBINED    0.00      0.12E+06   0.12E+06   0.12E+06
                              2      SEA       0.00      0.29E+05   0.29E+05   0.29E+05
                              2     SWELL      0.00      0.91E+05   0.91E+05   0.91E+05
                              2    COMBINED    0.00      0.12E+06   0.12E+06   0.12E+06
                              3      SEA       0.00      0.30E+05   0.30E+05   0.30E+05
                              3     SWELL      0.00      0.95E+05   0.95E+05   0.95E+05
                              3    COMBINED    0.00      0.12E+06   0.12E+06   0.12E+06
                              4      SEA       0.00      0.30E+05   0.30E+05   0.30E+05
                              4     SWELL      0.00      0.93E+05   0.93E+05   0.93E+05
                              4    COMBINED    0.00      0.12E+06   0.12E+06   0.12E+06
                              5      SEA       0.00      0.30E+05   0.30E+05   0.30E+05
                              5     SWELL      0.00      0.97E+05   0.97E+05   0.97E+05
                              5    COMBINED    0.00      0.13E+06   0.13E+06   0.13E+06
                              6      SEA       0.00      0.30E+05   0.30E+05   0.30E+05
                              6     SWELL      0.00      0.10E+06   0.10E+06   0.10E+06
                              6    COMBINED    0.00      0.13E+06   0.13E+06   0.13E+06
                              7      SEA       0.00      0.30E+05   0.30E+05   0.30E+05
                              7     SWELL      0.00      0.94E+05   0.94E+05   0.94E+05
                              7    COMBINED    0.00      0.12E+06   0.12E+06   0.12E+06
                              8      SEA       0.00      0.29E+05   0.29E+05   0.29E+05
                              8     SWELL      0.00      0.95E+05   0.95E+05   0.95E+05
                              8    COMBINED    0.00      0.12E+06   0.12E+06   0.12E+06
                              9      SEA       0.00      0.32E+05   0.32E+05   0.32E+05
                              9     SWELL      0.00      0.98E+05   0.98E+05   0.98E+05
                              9    COMBINED    0.00      0.13E+06   0.13E+06   0.13E+06
                             10      SEA       0.00      0.35E+05   0.35E+05   0.35E+05
                             10     SWELL      0.00      0.12E+06   0.12E+06   0.12E+06
                             10    COMBINED    0.00      0.15E+06   0.15E+06   0.15E+06
                             11      SEA       0.00      0.35E+05   0.35E+05   0.35E+05
                             11     SWELL      0.00      0.12E+06   0.12E+06   0.12E+06
                             11    COMBINED    0.00      0.15E+06   0.15E+06   0.15E+06
                             12      SEA       0.00      0.35E+05   0.35E+05   0.35E+05
                             12     SWELL      0.00      0.10E+06   0.10E+06   0.10E+06
                             12    COMBINED    0.00      0.14E+06   0.14E+06   0.14E+06
                             13      SEA       0.00      0.38E+05   0.38E+05   0.38E+05
                             13     SWELL      0.00      0.10E+06   0.10E+06   0.10E+06
                             13    COMBINED    0.00      0.14E+06   0.14E+06   0.14E+06
                             14      SEA       0.00      0.40E+05   0.40E+05   0.40E+05
                             14     SWELL      0.00      0.10E+06   0.10E+06   0.10E+06
                             14    COMBINED    0.00      0.14E+06   0.14E+06   0.14E+06
                             15      SEA       0.00      0.36E+05   0.36E+05   0.36E+05
                             15     SWELL      0.00      0.81E+05   0.81E+05   0.81E+05
                             15    COMBINED    0.00      0.12E+06   0.12E+06   0.12E+06
                             16      SEA       0.00      0.33E+05   0.33E+05   0.33E+05
                             16     SWELL      0.00      0.96E+05   0.96E+05   0.96E+05
                             16    COMBINED    0.00      0.13E+06   0.13E+06   0.13E+06
                             17      SEA       0.00      0.33E+05   0.33E+05   0.33E+05
                             17     SWELL      0.00      0.97E+05   0.97E+05   0.97E+05
                             17    COMBINED    0.00      0.13E+06   0.13E+06   0.13E+06
                             18      SEA       0.00      0.33E+05   0.33E+05   0.33E+05
                             18     SWELL      0.00      0.10E+06   0.10E+06   0.10E+06
                             18    COMBINED    0.00      0.14E+06   0.14E+06   0.14E+06
                             19      SEA       0.00      0.36E+05   0.36E+05   0.36E+05
                             19     SWELL      0.00      0.12E+06   0.12E+06   0.12E+06
                             19    COMBINED    0.00      0.16E+06   0.16E+06   0.16E+06
                             20      SEA       0.00      0.36E+05   0.36E+05   0.36E+05
                             20     SWELL      0.00      0.10E+06   0.10E+06   0.10E+06
                             20    COMBINED    0.00      0.14E+06   0.14E+06   0.14E+06
```

Figure 125. NSTRAN output file **NSTNP.NSV** (Continued)

```
                          TABLE 2
                             SAND TRANSPORT RATES (M**3/YEAR)
  WAVE         WAVE        LEFT        RIGHT
  BLOCK        TYPE      DIRECTED    DIRECTED        NET        GROSS
    1          SEA        0.00       0.18E+07    0.18E+07    0.18E+07
    1          SWELL      0.00       0.54E+07    0.54E+07    0.54E+07
    1        COMBINED     0.00       0.72E+07    0.72E+07    0.72E+07
    2          SEA        0.00       0.18E+07    0.18E+07    0.18E+07
    2          SWELL      0.00       0.55E+07    0.55E+07    0.55E+07
    2        COMBINED     0.00       0.73E+07    0.73E+07    0.73E+07
    3          SEA        0.00       0.18E+07    0.18E+07    0.18E+07
    3          SWELL      0.00       0.58E+07    0.58E+07    0.58E+07
    3        COMBINED     0.00       0.76E+07    0.76E+07    0.76E+07
    4          SEA        0.00       0.18E+07    0.18E+07    0.18E+07
    4          SWELL      0.00       0.57E+07    0.57E+07    0.57E+07
    4        COMBINED     0.00       0.74E+07    0.74E+07    0.74E+07
    5          SEA        0.00       0.18E+07    0.18E+07    0.18E+07
    5          SWELL      0.00       0.59E+07    0.59E+07    0.59E+07
    5        COMBINED     0.00       0.77E+07    0.77E+07    0.77E+07
    6          SEA        0.00       0.18E+07    0.18E+07    0.18E+07
    6          SWELL      0.00       0.61E+07    0.61E+07    0.61E+07
    6        COMBINED     0.00       0.79E+07    0.79E+07    0.79E+07
    7          SEA        0.00       0.18E+07    0.18E+07    0.18E+07
    7          SWELL      0.00       0.57E+07    0.57E+07    0.57E+07
    7        COMBINED     0.00       0.75E+07    0.75E+07    0.75E+07
    8          SEA        0.00       0.18E+07    0.18E+07    0.18E+07
    8          SWELL      0.00       0.58E+07    0.58E+07    0.58E+07
    8        COMBINED     0.00       0.76E+07    0.76E+07    0.76E+07
    9          SEA        0.00       0.19E+07    0.19E+07    0.19E+07
    9          SWELL      0.00       0.59E+07    0.59E+07    0.59E+07
    9        COMBINED     0.00       0.79E+07    0.79E+07    0.79E+07
   10          SEA        0.00       0.21E+07    0.21E+07    0.21E+07
   10          SWELL      0.00       0.73E+07    0.73E+07    0.73E+07
   10        COMBINED     0.00       0.94E+07    0.94E+07    0.94E+07
   11          SEA        0.00       0.21E+07    0.21E+07    0.21E+07
   11          SWELL      0.00       0.70E+07    0.70E+07    0.70E+07
   11        COMBINED     0.00       0.92E+07    0.92E+07    0.92E+07
   12          SEA        0.00       0.21E+07    0.21E+07    0.21E+07
   12          SWELL      0.00       0.61E+07    0.61E+07    0.61E+07
   12        COMBINED     0.00       0.82E+07    0.82E+07    0.82E+07
   13          SEA        0.00       0.23E+07    0.23E+07    0.23E+07
   13          SWELL      0.00       0.64E+07    0.64E+07    0.64E+07
   13        COMBINED     0.00       0.87E+07    0.87E+07    0.87E+07
   14          SEA        0.00       0.24E+07    0.24E+07    0.24E+07
   14          SWELL      0.00       0.61E+07    0.61E+07    0.61E+07
   14        COMBINED     0.00       0.85E+07    0.85E+07    0.85E+07
   15          SEA        0.00       0.22E+07    0.22E+07    0.22E+07
   15          SWELL      0.00       0.49E+07    0.49E+07    0.49E+07
   15        COMBINED     0.00       0.71E+07    0.71E+07    0.71E+07
   16          SEA        0.00       0.20E+07    0.20E+07    0.20E+07
   16          SWELL      0.00       0.58E+07    0.58E+07    0.58E+07
   16        COMBINED     0.00       0.78E+07    0.78E+07    0.78E+07
   17          SEA        0.00       0.20E+07    0.20E+07    0.20E+07
   17          SWELL      0.00       0.59E+07    0.59E+07    0.59E+07
   17        COMBINED     0.00       0.79E+07    0.79E+07    0.79E+07
   18          SEA        0.00       0.20E+07    0.20E+07    0.20E+07
   18          SWELL      0.00       0.64E+07    0.64E+07    0.64E+07
   18        COMBINED     0.00       0.84E+07    0.84E+07    0.84E+07
   19          SEA        0.00       0.22E+07    0.22E+07    0.22E+07
   19          SWELL      0.00       0.76E+07    0.76E+07    0.76E+07
   19        COMBINED     0.00       0.97E+07    0.97E+07    0.97E+07
   20          SEA        0.00       0.22E+07    0.22E+07    0.22E+07
   20          SWELL      0.00       0.61E+07    0.61E+07    0.61E+07
   20        COMBINED     0.00       0.82E+07    0.82E+07    0.82E+07

             SUMMARY OF TIME SERIES DATA

        The duration of the input time series is   0.02 years
 NOTE:  Since the time series is less than one year in duration, the
        estimates reported above may reflect a seasonal bias.
        These estimates are based on a baseline orientation of  54.00 degrees
          48 events were processed at a time step of  3. hours
          10 sea events were calm
          22 swell events were calm
```

Figure 125. (Concluded)

```
        20
         6
  1  0.000       0.177E+07  0.000       0.543E+07  0.000       0.720E+07
  2  0.000       0.178E+07  0.000       0.555E+07  0.000       0.732E+07
  3  0.000       0.179E+07  0.000       0.580E+07  0.000       0.759E+07
  4  0.000       0.180E+07  0.000       0.565E+07  0.000       0.745E+07
  5  0.000       0.182E+07  0.000       0.588E+07  0.000       0.770E+07
  6  0.000       0.183E+07  0.000       0.606E+07  0.000       0.789E+07
  7  0.000       0.181E+07  0.000       0.574E+07  0.000       0.754E+07
  8  0.000       0.179E+07  0.000       0.580E+07  0.000       0.759E+07
  9  0.000       0.192E+07  0.000       0.594E+07  0.000       0.786E+07
 10  0.000       0.211E+07  0.000       0.732E+07  0.000       0.943E+07
 11  0.000       0.213E+07  0.000       0.705E+07  0.000       0.918E+07
 12  0.000       0.214E+07  0.000       0.611E+07  0.000       0.824E+07
 13  0.000       0.233E+07  0.000       0.636E+07  0.000       0.870E+07
 14  0.000       0.243E+07  0.000       0.608E+07  0.000       0.850E+07
 15  0.000       0.222E+07  0.000       0.490E+07  0.000       0.712E+07
 16  0.000       0.200E+07  0.000       0.584E+07  0.000       0.784E+07
 17  0.000       0.200E+07  0.000       0.591E+07  0.000       0.791E+07
 18  0.000       0.200E+07  0.000       0.638E+07  0.000       0.838E+07
 19  0.000       0.216E+07  0.000       0.757E+07  0.000       0.973E+07
 20  0.000       0.217E+07  0.000       0.607E+07  0.000       0.825E+07
```

Figure 126. NSTRAN output file **NSTNP.PLD**

The output is written to two output files, one that contains tables of the transport volume and transport rates, and another that may be used together with the graphics program DPLOT to display the estimated potential longshore sand transport rates.

489. The program NSTRAN also provides a check of compatibility of the nearshore wave data base and the offshore time series. This compatibility check is possible because NSTRAN and GENESIS relate the offshore wave time series and the nearshore wave data base in the same way (through the use of an offshore wave identification key).

Analysis of Nearshore Wave Data

490. In this section the programs PC_RCPWV, WHEREWAV, WTNSWAV, WTDEPTH, and NSTRAN are assembled into a suggested nearshore wave data analysis flow procedure that is referred to as "Wave Data Analysis Stage 2" and may be thought of as a local analysis. Figure 129 provides a general outline of the analysis. As indicated in Figure 129, the analysis of nearshore wave data begins with completion of the analysis of the offshore wave data as outlined in Part V (before a nearshore analysis can proceed the offshore analysis must be completed).

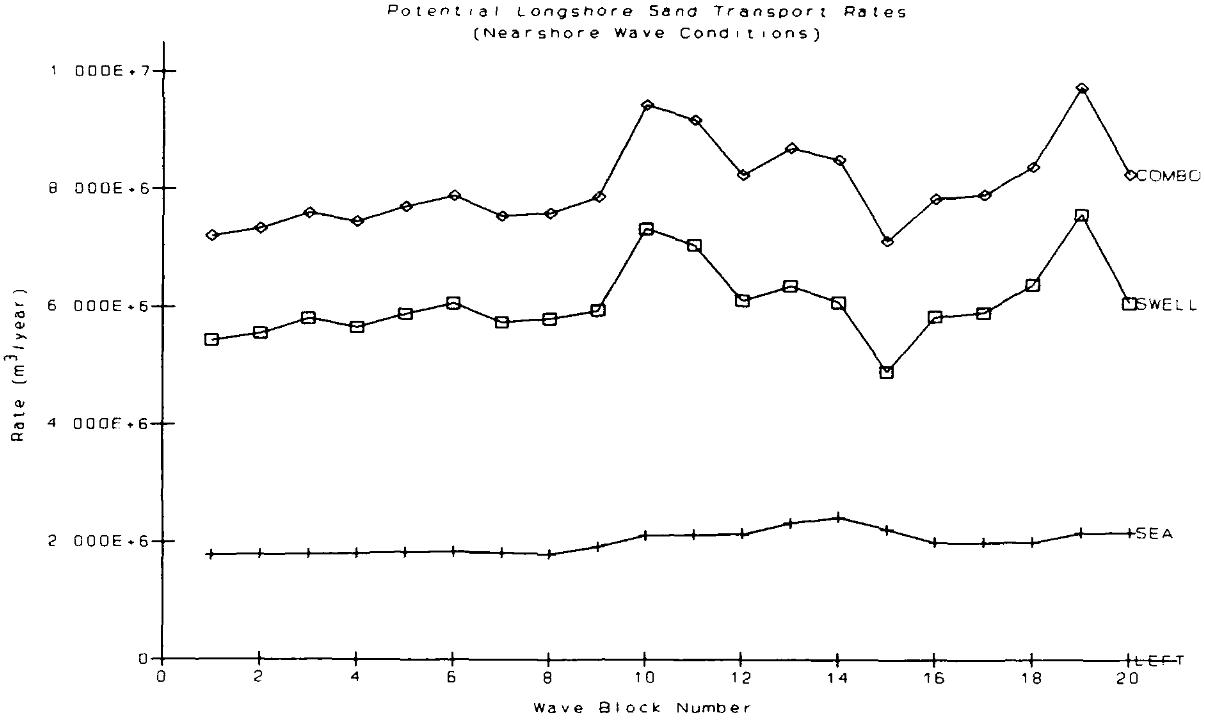


Figure 127. Potential longshore sand transport rates based on nearshore wave data

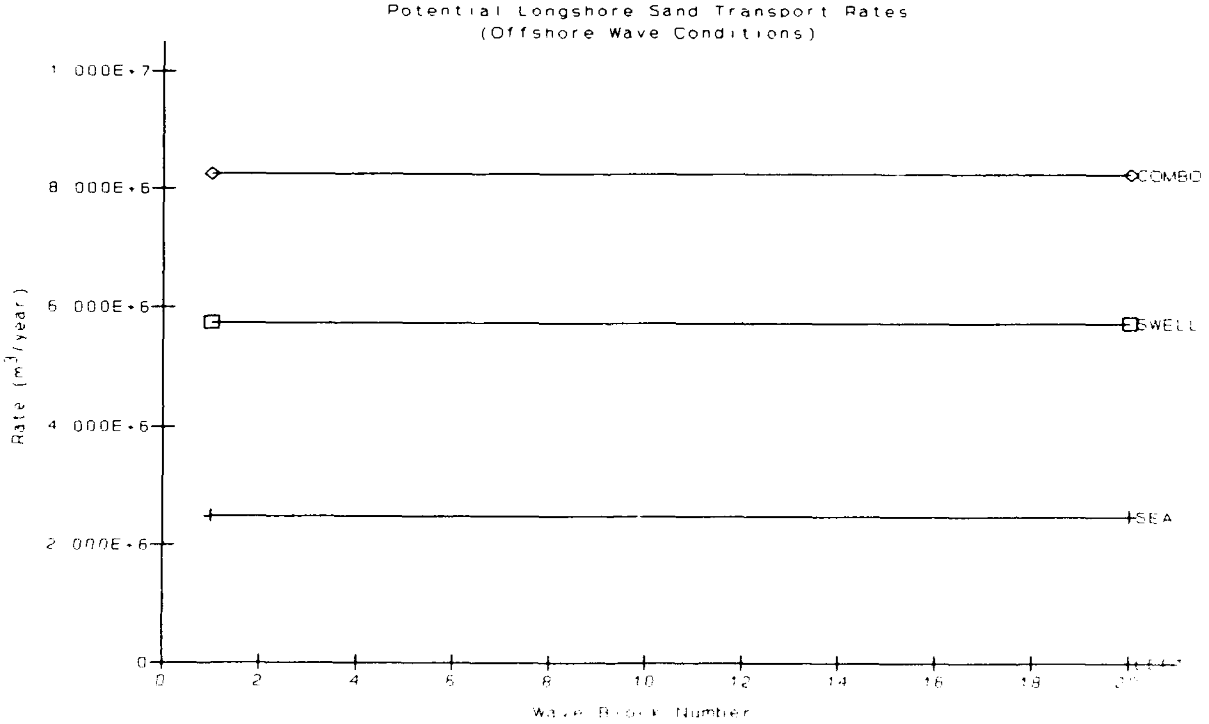


Figure 128. Potential longshore sand transport rates based on offshore wave data

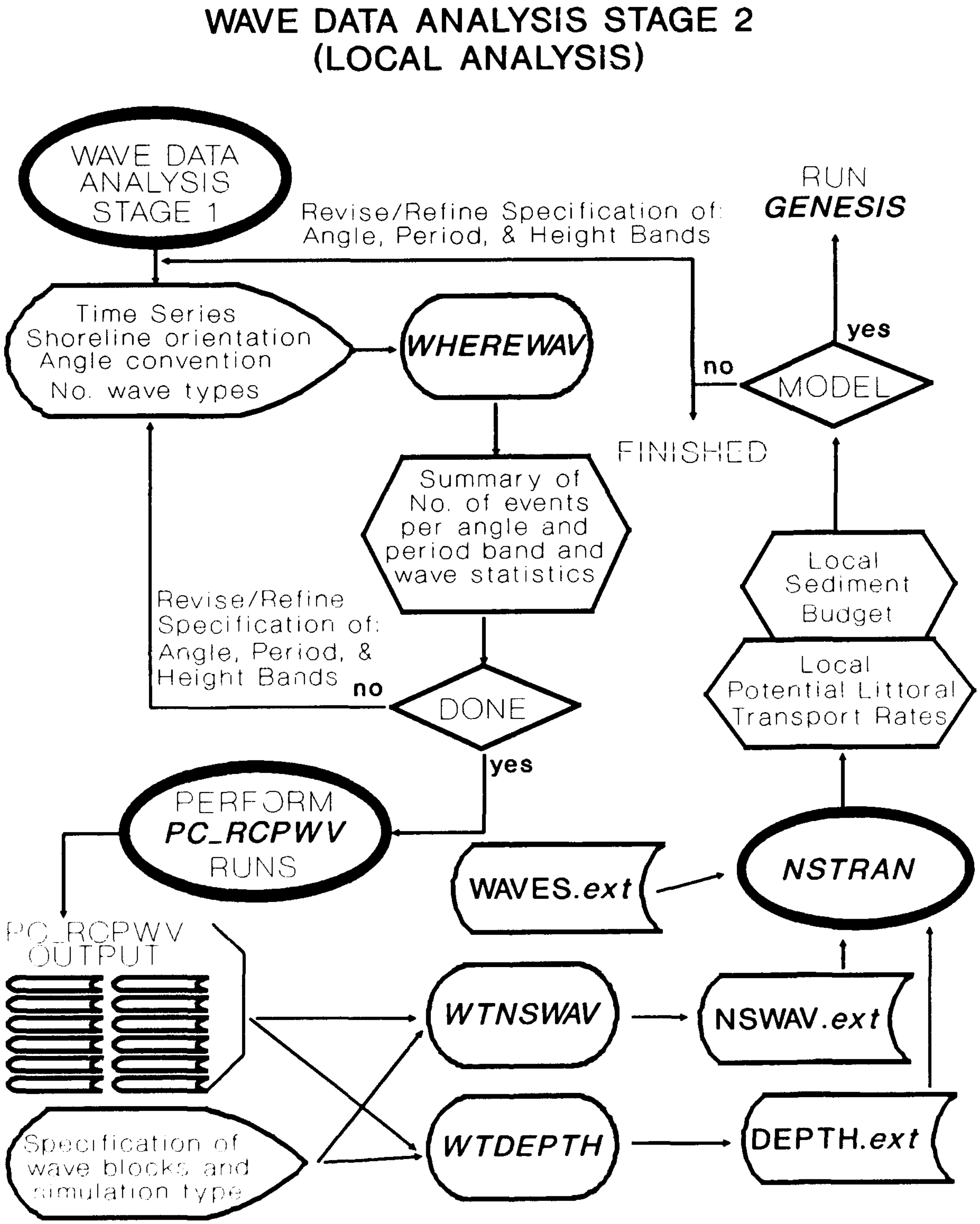


Figure 129. Wave data analysis Stage 2 (local analysis)

491. The first step involves running the program WHEREWAV. Output from this program defines the number and specific wave conditions that should be transformed from offshore to the nearshore reference line using the wave transformation model PC_RCPWV. As indicated in the section on WHEREWAV, the user may choose to refine the wave classification system suggested by the program WHEREWAV at this stage. This refinement may include the addition of a height band classification category, or just a more refined description of the wave conditions that will be input to PC_RCPWV (such as using the average angle for each period band within a given angle band).

492. The second step in the analysis involves performing the required PC_RCPWV simulations. This step often involves several individual simulations. Remember, sea and swell wave transformations should be computed as different PC_RCPWV simulations because the program WTNSWAV allows only one wave type per input file.

493. The third and fourth steps in the analysis involve using the programs WTNSWAV and WTDEPTH. Both programs read output from PC_RCPWV and write data in a format suitable for input to GENESIS. Specifically, the program WTNSWAV writes a nearshore wave data base to an output file with the extension **.NSW**, this file may subsequently be copied to a file named **NSWAV**.ext and input to GENESIS. The program WTDEPTH writes the nearshore reference depths to a file with the extension **.DEP**, which may subsequently be copied to a file named **DEPTH**.ext and input to GENESIS.

494. The fifth and final step in the analysis is computation of potential longshore sand transport rates based on the nearshore wave data base, and involves using the program NSTRAN. The result of this step will allow the user to develop a local sediment budget and identify gradients in the longshore sand transport rate that will indicate zones susceptible to shoreline erosion or accretion.

495. This analysis, when combined with the shoreline analysis described in Part IV and outlined in Figure 43, and the Wave Data Analysis Stage 1 procedure described in Part V and outlined in Figure 89, will result in the preparation of all the input data files (**SHORL**.ext, **SHORM**.ext, **WAVES**.ext, **NSWAV**.ext, **DEPTH**.ext, and, if necessary, **SEAWL**.ext) required for operating GENESIS in the design mode, except the **START**.ext file. A line-by-line description and step-by-step procedure for preparing the remaining input file (**START**.ext) is provided in Part VII.

PART VII: INPUT FILES--STRUCTURE AND ERRORS

496. The first part of this chapter briefly discusses the input files comprising the GENESIS user interface. Part VI of the Technical Reference presents a more thorough description of the general structure and operation of the interface together with the preparations that must be made prior to running the modeling system. Appendix B of the Technical Reference gives blank copies of input files that may be photocopied for use in projects. It should be noted, however, that the format for entering the input wave data has been changed from that described in the Technical Reference.

497. The second part of this chapter contains a list of error and warning messages that are presently incorporated in GENESIS. The error trapping capability is continuously being enhanced, and some messages have been added or changed since publication of the Technical Reference.

Input and Output Files

498. GENESIS is operated through use of seven input data files, as illustrated in Figure 1, Part I. It should be noted that one input data file has been added to the configuration given in the Technical Reference. Input and output file names consist of five letters with a three-letter extension. GENESIS prompts for this extension, denoted by *.ext* in the figure, during execution, and it may be specified by the modeler, provided all necessary input files with the same extension exist. GENESIS reads the input files and performs the shoreline change simulation according to the instructions and data contained in them. When the simulation is completed, the output from GENESIS is placed in three files having the same extension as the input files, as shown in Figure 1, Part I.

499. All input files must begin with four header lines, and GENESIS skips over these when the files are read (except for the input file **NSWAV**.ext, see Part VI). If the four header lines are not present, GENESIS will begin reading data at an incorrect position with a possible undetected computation error, give an error message that the data file holds too few values, complain about the data input format, or give a run-time error that will be very difficult to trace, since the false data may cause a program crash at an arbitrary line in the program.

500. The seven input files that GENESIS will look for when it is executed are named **START**.ext, **SHORL**.ext, **SHORM**.ext, **WAVES**.ext, **SEAWL**.ext, **NSWAV**.ext, and **DEPTH**.ext, where ".ext" stands for the three-letter extension specified by the modeler. Of these files, **START**, **SHORL**, **SHORM**, and **WAVES** are always required, whereas **SEAWL**, **NSWAV**, and **DEPTH** may or may not be called by GENESIS, depending on instructions entered by the user in the **START** file.

START

501. The input file **START**.ext contains the instructions that control the shoreline change simulation and is the principal interface between the modeler and GENESIS. The **START** file contains requests for information in a series of lines arranged in sections according to the general subject. The number of lines holding values in response to a specific request is arbitrary. Unless instructed otherwise, a response (an alphanumeric character) must be given to a request. Because the data are read in free format, if several values are required, they may be separated by a space or by a comma, or both. However, the line request identifier letter (A.1, B.1, C.1,...) should not be moved from column 1, as GENESIS looks for it there. Because a new input file containing nearshore wave data has been added to GENESIS, the **START**.ext file has been changed. The next section provides line-by-line instructions for compiling the **START** file.

SHORL

502. The input file **SHORL**.ext holds the position of the shoreline used by GENESIS at the start of calculation. Positions of the shoreline are given in the units selected at Line A.2 of the **START** file and are measured from the baseline (x-axis). A shoreline position must be given for each grid cell. It is important to note that even if only a subsection of the shoreline is used in the simulation, shoreline positions must still be given for the full range of the calculation grid (*NN* points), as GENESIS will load positions of the shoreline subsection with reference to the original, full grid. Shoreline positions may be entered in "free format," provided that exactly 10 entries are placed on each line, except for the last line. Figures 56 through 59 in Part IV give examples of a **SHORL** file.

SHORM

503. The input file **SHORM**.ext holds the position of the measured shoreline to be reproduced in the procedure of calibrating or verifying the model.

The format and rules for entering data into **SHORM**.ext are the same as for **SHORL**.ext.

WAVES

504. The input file **WAVES**.ext holds offshore wave information. If an external wave refraction model is not used (*NWD* = 0 on Line B.3 of the **START** file), the offshore waves drive the shoreline change simulation. If an external wave refraction model is used (*NWD* = 1), the shoreline change simulation portion of GENESIS uses nearshore wave information read from the NSWAV file as discussed in the following paragraphs. At each wave data time-step *DTW* (specified at Line B.6 of the **START** file), the **WAVES**.ext file must contain a triplet of wave period, height, and direction at the depth *DZ* (specified at Line B.2 of the **START** file).

505. The three offshore quantities of wave period, height, and direction are placed on the same line and may be entered in "free format." An example of a **WAVES** file with only one wave component (*NWAVES* = 1) is given in Figure 130, where each line corresponds to one time-step. As demonstrated in the figure, the modeler is free to write a comment after the three wave quantities. GENESIS reads only three values on each line.

SEAWL

506. The input file **SEAWL**.ext holds the positions of one or more seawalls or effective seawalls with respect to the baseline and specified in the proper length units. Figure 26 in the Technical Reference gives an example of a **SEAWL** file. The format and rules for entering data into **SEAWL**.ext are the same as for SHORL.ext. Seawall positions are entered at shoreline position points, i.e., at the centers of grid cells.

DEPTH

507. The input file **DEPTH**.ext is read if an external wave refraction model has previously been run to provide wave data. **DEPTH** holds depths along the nearshore reference line from which GENESIS will continue to propagate waves using its own wave transformation routines, and the wave data held in input file **NSWAV** will bear a one-to-one correspondence with these depths in order of grid cell number. If an external wave refraction model was not used, this file will not be read. The format and rules for entering data into **DEPTH**.ext are the same as for **SHORL**.ext. Figure 113 gives an example of a **DEPTH**.ext file.

```
***********************************************************************
WAVES FOR ILLUSTRATIVE EXAMPLE IN WORKBOOK.
FILE WAVES.WKB CONTAINS OFFSHORE WAVE DATA.  DT = 6 HR.  DX = 15 FT.
***** ***** ***** ********
  2.0  1.00 -30.0 JAN 1987
  2.0  1.00  00.0
  2.0  1.00  00.0
  3.0  1.00 -30.0
  2.0  1.00  00.0
  2.0  1.00  00.0
  3.0  2.00  15.0
  2.0  1.00  00.0
  2.0  1.00  00.0
  3.0  2.00  15.0
  2.0  1.00  00.0
  2.0  1.00  00.0
  3.0  1.00  15.0
  2.0  1.00  00.0
  2.0  1.00  00.0
  3.0  2.00  38.0
  2.0  1.00  00.0
```

Figure 130. Example **WAVES** file

NSWAV

508. If an external wave refraction model is used ($NWD = 1$ on Line B.3 of the **START** file), the input file **NSWAV**.ext holds nearshore wave information that drives the shoreline change simulation in GENESIS through calculation of the wave-induced longshore sand transport rate. **NSWAV** must contain the wave height and direction for each point on the nearshore depth reference line. The wave period is assumed to be constant alongshore and is read from the **WAVES** file holding the offshore wave conditions. Each offshore wave event contained in the **WAVES**.ext file is mapped to a set of nearshore wave conditions through the offshore wave identification key as discussed in Part VI.

509. The nearshore wave height and direction are held in "compressed format" to minimize storage space. Thus, values of individual pairs of wave height H and wave direction Z at nearshore grid points are held in a quantity IZH and read in the integer format 10I7. The integer IZH will be converted to real numbers by GENESIS. If the wave direction is negative, IZH should be given a negative sign. Example 1: If $ICONV = 1$ (metric units selected at Line A.2 in the **START** file), $H = 2.18$ m and $Z = 10.7$ deg will produce the value $IZH = 218107$. Example 2: If $ICONV = 2$ (American customary units selected), $H = 10.1$ ft and $Z = -21.0$ deg will produce the value $IZH = -101210$.

510. If an external wave transformation model is not used (*NWD* = 0 on Line B.3 of the **START** file), **NSWAV** will not be read. An example of an **NSWAV** file is given in Figure 131. Each data block, comprising three lines with 10 values preceded by an offshore wave identification key as described in Part VI.

Preparation of the **START** File

511. The input file **START**.ext contains the instructions that control the shoreline change simulation and is the principal interface between the modeler and GENESIS. Once a generic **START** file for a project is prepared, typically only a few quantities in it will need to be changed during the course of verification, sensitivity testing, design optimization, etc.

```
 FILE: OUT4.NSW                      SHORELINE ORIENTATION:     0.00
 DATA AT WAVEBLOCKS    4 THRU   33 FROM   36 ALONGSHORE RCPWAVE CELLS
 CONTAINS    6 UNIQUE NEARSHORE WAVE EVENTS.  WAVE HEIGHTS IN METERS/100.
************************************************************************
1143
  78275  78258  77244  77227  76226  76248  77252  80258  82255  83264
  85271  88256  90262  93267  98277 101268 103274 105278 104263 101264
 101259 102262 107279 113276 115266 115263 116277 119278 120281 123285
1151
-103084-103091-102096-101097-100095-100089-101094-100098-100104 -99099
 -98100 -97106 -97108 -95105 -94101 -93101 -93095 -94094 -95104 -95112
 -94119 -93120 -92117 -91118 -91121 -90118 -90114 -90117 -90123 -90124
1162
-113267-112284-109286-108280-108271-108265-107281-104288 -99294 -95275
 -95272 -95280 -92277 -91264 -90249 -91248 -94242 -98251 -98280 -94303
 -88305 -85296 -84286 -84282 -84288 -84279 -86274 -87283 -88304 -87304
2143
  78275  78258  77244  77227  76226  76248  77252  80258  82255  83264
  85271  88256  90262  93267  98277 101268 103274 105278 104263 101264
 101259 102262 107279 113276 115266 115263 116277 119278 120281 123285
2151
-103084-103091-102096-101097-100095-100089-101094-100098-100104 -99099
 -98100 -97106 -97108 -95105 -94101 -93101 -93095 -94094 -95104 -95112
 -94119 -93120 -92117 -91118 -91121 -90118 -90114 -90117 -90123 -90124
2162
-113267-112284-109286-108280-108271-108265-107281-104288 -99294 -95275
 -95272 -95280 -92277 -91264 -90249 -91248 -94242 -98251 -98280 -94303
 -88305 -85296 -84286 -84282 -84288 -84279 -86274 -87283 -88304 -87304
```

Figure 131. Example **NSWAV** file

512. Figure 132 shows an example of a **START** file. The **START** file contains requests for information in a series of lines that are arranged in sections according to general subject. Lines of text (the request portion) should be neither added nor deleted from the **START** file, as GENESIS will skip over these request lines to read the input values. Also, the line request identifier letter (A.1, B.1, C.1,...) should not be moved from column 1, as GENESIS looks for it there. However, the number of lines holding values in response to a specific request is arbitrary. Unless instructed otherwise, a response (an alphanumeric character) must be given to a request. If several values are required, they may be separated by a space or by a comma, or both.

513. Names of internal variables, particularly values that are be used to dimension arrays, are given in parentheses in the requests. As an aid in using this manual, the key variable associated with the request is given at the start of each of the following paragraphs. These names also appear in error messages and are needed when discussing START file configurations with others.

A. Model setup

514. Line A.1: *TITLE* . The first line of the **START** file requests a project title, which may be up to 70 characters long. The title line normally contains descriptive information about the particular run, for example, "ILLUSTRATIVE EXAMPLE FOR WORKBOOK."

515. Line A.2: *ICONV* . The variable *ICONV* is a flag telling GENESIS the length units of the calculation. Calculations are performed by using either meters or feet, as selected at Line A.2. All length, height, and depth inputs, including wave height, water depths, seawall positions, etc., must be given in the specified units, and output will similarly be expressed in these units. (The only exception is median grain size diameter on Line C.1, which must be given in millimeters.)

516. Line A.3: *NN, DX*. The total number of calculation cells *NN* (called "*N*" in the text of this report) and the cell length *DX* (called " *x*") are entered here. The product of *NN* and *DX* gives the total length of the modeled reach.

517. Line A.4: *ISSTART, N* . This request allows the user to perform simulations over a portion of the grid through specification of starting and ending grid cells (boundaries) other than 1 and *N*+1, respectively. This option is useful if a long grid has originally been prepared but, in a

```
                **************************************************
                * INPUT FILE  START.ext FOR GENESIS VERSION 2.0  *
                **************************************************
A-------------------------- MODEL SETUP ----------------------------A
A.1  RUN TITLE
     ILLUSTRATIVE EXAMPLE FOR WORKBOOK
A.2  INPUT UNITS (METERS=1; FEET=2): ICONV
     2
A.3  TOTAL NUMBER OF CALCULATION CELLS AND CELL LENGTH: NN, DX
     37 200
A.4  GRID CELL NUMBER WHERE SIMULATION STARTS AND NUMBER OF CALCULATION
     CELLS (N = -1 MEANS N = NN): ISSTART, N
     1 -1
A.5  VALUE OF TIME STEP IN HOURS: DT
     12
A.6  DATE WHEN SHORELINE SIMULATION STARTS
     (DATE FORMAT YYMMDD: 1 MAY 1992 = 920501): SIMDATS
     870101
A.7  DATE WHEN SHORELINE SIMULATION ENDS OR TOTAL NUMBER OF TIME STEPS
     (DATE FORMAT YYMMDD: 1 MAY 1992 = 920501): SIMDATE
     870131
A.8  NUMBER OF INTERMEDIATE PRINT-OUTS WANTED: NOUT
     1
A.9  DATES  OR  TIME STEPS  OF INTERMEDIATE PRINT-OUTS
     (DATE FORMAT YYMMDD: 1 MAY 1992 = 920501, NOUT VALUES): TOUT(I)
     870115
A 10 NUMBER OF CALCULATION CELLS IN OFFSHORE CONTOUR SMOOTHING WINDOW
     (ISMOOTH = 0 MEANS NO SMOOTHING, ISMOOTH = N MEANS STRAIGHT LINE.
     RECOMMENDED VALUE = 11): ISMOOTH
     11
A.11 REPEATED WARNING MESSAGES (YES=1; NO=0): IRWM
     1
A.12 LONGSHORE SAND TRANSPORT CALIBRATION COEFFICIENTS: K1, K2
     .77 .38
A.13 PRINT-OUT OF THE TIME STEP NUMBERS? (YES=1, NO=0): IPRINT
     1
B------------------------------ WAVES -------------------------------B
B.1  WAVE HEIGHT CHANGE FACTOR. WAVE ANGLE CHANGE FACTOR AND AMOUNT (DEG)
     (NO CHANGE: HCNGF=1, ZCNGF=1, ZCNGA=0): HCNGF, ZCNGF, ZCNGA
     1 1 0
B.2  DEPTH OF OFFSHORE WAVE INPUT: DZ
     60
B.3  IS AN EXTERNAL WAVE MODEL BEING USED (YES=1; NO=0): NWD
     0
B.4  COMMENT: IF AN EXTERNAL WAVE MODEL IS NOT BEING USED, CONTINUE TO B.6
B.5  NUMBER OF SHORELINE CALCULATION CELLS PER WAVE MODEL ELEMENT: ISPW
     1
B.6  NUMBER OF HEIGHT BANDS USED IN THE EXTERNAL WAVE MODEL TRANSFORMATIONS
     (MINIMUM IS 1, MAXIMUM IS 9): NHBANDS
     9
```

Figure 132. Example **START** file (Sheet 1 of 3)

```
B.7  COMMENT: IF ONLY ONE HEIGHT BAND WAS USED CONTINUE TO B.9
B.8  MINIMUM WAVE HEIGHT AND BAND WIDTH OF HEIGHT BANDS: HBMIN, HBWIDTH
     1.0 2.0
B.9  VALUE OF TIME STEP IN WAVE DATA FILE IN HOURS (MUST BE AN EVEN MULTIPLE
     OF, OR EQUAL TO DT): DTW
     12
B.10 NUMBER OF WAVE COMPONENTS PER TIME STEP: NWAVES
     1
B.11 DATE WHEN WAVE FILE STARTS (FORMAT YYMMDD: 1 MAY 1992 = 920501): WDATS
     870101
C---------------------------- BEACH -------------------------------C
C.1  EFFECTIVE GRAIN SIZE DIAMETER IN MILLIMETERS: D50
     0.25
C.2  AVERAGE BERM HEIGHT FROM MEAN WATER LEVEL: ABH
     3
C.3  CLOSURE DEPTH: DCLOS
     15
D----------------------- NONDIFFRACTING GROINS -----------------------D
D.1  ANY NONDIFFRACTING GROINS? (NO=0, YES=1): INDG
     1
D.2  COMMENT: IF NO NONDIFFRACTING GROINS, CONTINUE TO E.
D.3  NUMBER OF NONDIFFRACTING GROINS: NNDG
     1
D.4  GRID CELL NUMBERS OF NONDIFFRACTING GROINS (NNDG VALUES): IXNDG(I)
     15
D.5  LENGTHS OF NONDIFFRACTING GROINS FROM X-AXIS (NNDG VALUES): YNDG(I)
     200
E---------------- DIFFRACTING (LONG) GROINS AND JETTIES ----------------E
E.1  ANY DIFFRACTING GROINS OR JETTIES? (NO=0, YES=1): IDG
     1
E.2  COMMENT: IF NO DIFFRACTING GROINS, CONTINUE TO F.
E.3  NUMBER OF DIFFRACTING GROINS/JETTIES: NDG
     1
E.4  GRID CELL NUMBERS OF DIFFRACTING GROINS/JETTIES (NDG VALUES): IXDG(I)
     5
E.5  LENGTHS OF DIFFRACTING GROINS/JETTIES FROM X-AXIS (NDG VALUES): YDG(I)
     230
E.6  DEPTHS AT SEAWARD END OF DIFFRACTING GROINS/JETTIES(NDG VALUES): DDG(I)
     5
F--------------------- ALL GROINS/JETTIES -----------------------------F
F.1  COMMENT: IF NO GROINS OR JETTIES, CONTINUE TO G.
F.2  REPRESENTATIVE BOTTOM SLOPE NEAR GROINS: SLOPE2
     0.062
F.3  PERMEABILITIES OF ALL GROINS AND JETTIES (NNDG+NDG VALUES): PERM(I)
     0.0 .1
F.4  IF GROIN OR JETTY ON LEFT-HAND BOUNDARY, DISTANCE FROM SHORELINE
     OUTSIDE GRID TO SEAWARD END OF GROIN OR JETTY: YG1

F.5  IF GROIN OR JETTY ON RIGHT-HAND BOUNDARY, DISTANCE FROM SHORELINE
     OUTSIDE GRID TO SEAWARD END OF GROIN OR JETTY: YGN
```

Figure 137. (Sheet 2 of 3)

```
G------------------------ DETACHED BREAKWATERS -------------------------G
G.1  ANY DETACHED BREAKWATERS? (NO=0, YES=1): IDB
     1
G.2  COMMENT: IF NO DETACHED BREAKWATERS, CONTINUE TO H.

G.3  NUMBER OF DETACHED BREAKWATERS: NDB
     1
G.4  ANY DETACHED BREAKWATER ACROSS LEFT-HAND CALCULATION BOUNDARY
     (NO=0, YES=1): IDB1
     0
G.5  ANY DETACHED BREAKWATER ACROSS RIGHT-HAND CALCULATION BOUNDARY
     (NO=0, YES=1): IDBN
     0
G.6  GRID CELL NUMBERS OF TIPS OF DETACHED BREAKWATERS:
     (2 * NDB - (IDB1+IDBN) VALUES): IXDB(I)
     20 30
G.7  DISTANCES FROM X-AXIS TO TIPS OF DETACHED BREAKWATERS
     (1 VALUE FOR EACH TIP SPECIFIED IN G.6): YDB(I)
     450 450
G.8  DEPTHS AT DETACHED BREAKWATER TIPS (1 VALUE FOR EACH TIP
     SPECIFIED IN G.6): DDB(I)
     15  15
G.9  DETACHED BREAKWATER TRANSMISSION COEFFICIENTS (NDB VALUES): TRANDB(I)
     0
H----------------------------  SEAWALLS  ------------------------------H
H.1  ANY SEAWALL ALONG THE SIMULATED SHORELINE? (YES=1; NO=0): ISW
     1
H.2  COMMENT: IF NO SEAWALL, CONTINUE TO I.
H.3  GRID CELL NUMBERS OF START AND END OF SEAWALL (ISWEND = -1 MEANS
     ISWEND = N): ISWBEG, ISWEND
     5 16
I---------------------------  BEACH FILLS  ----------------------------I
I.1  ANY BEACH FILLS DURING SIMULATION PERIOD? (NO=0, YES=1): IBF
     1
I.2  COMMENT: IF NO BEACH FILLS, CONTINUE TO K.
I.3  NUMBER OF BEACH FILLS DURING SIMULATION PERIOD: NBF
     1
I.4  DATES OR TIME STEPS WHEN THE RESPECTIVE FILLS START
     (DATE FORMAT YYMMDD: 1 MAY 1992 = 920501, NBF VALUES): BFDATS(I)
     870101
I.5  DATES OR TIME STEPS WHEN THE RESPECTIVE FILLS END
     (DATE FORMAT YYMMDD: 1 MAY 1992 = 920501, NBF VALUES): BFDATE(I)
     870115
I.6  GRID CELL NUMBERS OF START OF RESPECTIVE FILLS (NBF VALUES): IBFS(I)
     20
I.7  GRID CELL NUMBERS OF END OF RESPECTIVE FILLS (NBF VALUES): IBFE(I)
     33
I.8  ADDED BERM WIDTHS AFTER ADJUSTMENT TO EQUILIBRIUM CONDITIONS
     (NBF VALUES): YADD(I)
     30
K----------------------------  COMMENTS  ------------------------------K
     * COMMENTS AND VERSION UPDATE INFORMATION PLACED HERE
------------------------- END OF START.ext ----------------------------
```

Figure 132. (Sheet 3 of 3)

particular application, details of shoreline change along a subsection are to be studied. It is cautioned that the numbers of the starting cell *ISSTART* and ending cell *N* of the subsection grid must be located in physically reasonable areas for meaningful results to be obtained. In almost all circumstances, lateral boundaries should be placed either at a long groin or jetty or at a historically stable section of coast. It is recommended that this option not be exercised until experience is gained running GENESIS. If simulation of shoreline change in a subsection is not performed, the values of *ISSTART* and *N* should be 1 and *NN* (as specified on Line A.3), respectively. By setting *N* equal to -1, GENESIS will set *N* equal to *NN*, and the value of *N* does not have to be changed for each new application.

518. Line A.5: *DT*. For a specific simulation interval, smaller values of the duration of the time-step *DT* (called " t" in the main text of this report) increase the computational run time, whereas larger values of *DT* result in a less accurately predicted shoreline position. A time-step of 6 hr is recommended for design, but longer time-steps may be used, for example, 24 hr, depending on the variability of the input waves. Scoping applications typically use a long time-step (on the order of 24 hr). The wave data input file (**WAVES**) must provide wave data at the specified time-step. To satisfy this requirement, *DT* must be a proper fraction (e.g., 1/2, 1/4) of the time-step *DTW* defining entries in the wave file (Line B.6).

519. Line A.6: *SIMDATS*. The date when the calculation starts *SIMDATS* is needed to key GENESIS for selecting the correct season of waves, coordinating beach fills, and entering changes in structure configurations. The input format is defined as a six-digit number, with two digits each representing the year (YY), month (MM), and day (DD) in that order, i.e., YYMMDD. A full six-digit number must be specified for proper starting of the **WAVES** file.

520. Line A.7: *SIMDATE*. The simulation interval can be specified in terms of either the number of time-steps or the date *SIMDATE* in simulation time. During testing and scoping, for which the model is run for only a few time-steps, it is convenient to use the number of time-steps. In design mode the dates of measured shorelines are known, and it is convenient to work in simulation time. GENESIS distinguishes time-step and date input through the magnitude of the value of *SIMDATE*; if *SIMDATE* is greater than or equal to 180,000, GENESIS will interpret it as a date, whereas if the value is smaller than 180,000, GENESIS will interpret it as the number of time-steps.

521. Line A.8: *NOUT*. In many situations, it is very informative to study the time evolution of the calculated shoreline change. For example, in design mode, for which simulations are made over several years, the shoreline location at the end of each month or each year may be desired. The value entered here *NOUT* specifies the total number of simulated times when output should be written to file (**OUTPT**.ext, discussed in the following paragraph). The output of data at the final time-step does not have to be included, since it is a default output.

522. Line A.9: *TOUT(I)*. Output may be specified by either the number of time-steps or the corresponding dates in simulation time. The number of outputs TOUT(I) (time-steps or dates) specified must match the number entered on Line A.8.

523. Line A.10: *ISMOOTH*. The representative contour used in the internal wave calculation is determined through an alternating- direction moving average algorithm. The variable *ISMOOTH* specifies the size of the moving window over which the average is calculated. If *ISMOOTH* is set equal to 0, no smoothing is performed, and the representative contour will follow the shoreline. If *ISMOOTH* is set to *N*, the representative contour will be a straight line parallel to one drawn between the two end points of the shoreline.

524. Line A.11: *IRWM*. The variable *IRWM* allows the user to suppress print out of repeated warning messages (see the section "Warning Messages"). For example, if a preliminary or scoping analysis is being performed with a long time-step, the value of the stability parameter *STAB* (called R_S in the main text) is likely to exceed 5.0, and a warning message will be issued at every time-step. If *IRWM* is set equal to zero, only one warning message will be given, and the screen and output file **SETUP** will not be cluttered with warning messages. In planning and designing applications, the modeler will want to be aware of potentially undesirable conditions and should set *IRWM* = 1.

525. Line A.12: *K1 K2*. Values of the longshore sand transport calibration coefficients *K1* and *K2* (called K_1 and K_2 in the main text) require adjustment in the process of model calibration. For sandy beaches, experience has shown that values are typically in the ranges of $0.1 < K1 < 1.0$ and $0.5\ K1 < K2 < 1.5\ K1$. Initial trial runs might use $K1 = 0.5$ and $K2 = 0.25$. The transport parameter *K1* controls the time scale of the calculation and is

the principal calibration coefficient in GENESIS. Further discussion is given in Part II. (Note: the above-mentioned values of *K1* and *K2* correspond to rms wave height. Significant wave height should be entered in the **WAVES** file, however, because GENESIS automatically converts heights in the wave file from significant to rms.)

526. Line A.13: *IPRINT*. A computer program, in this cases GENESIS, can be executed in two ways on most mainframe computers, by interactive mode (sometimes called demand mode) and by batch mode. In interactive mode, instructions are entered from the keyboard and reproduced on the monitor or printer; in this mode, the terminal launching the job is devoted fully to execution of the program. In batch mode, the job is launched through a batch file devised by the user. The batch file contains commands and other data required to run the program and acts as a substitute for entries made at the keyboard. A job launched in batch mode will execute in the background and free the user's terminal for other applications. If GENESIS is executed in interactive mode, a counter can be requested through *IPRINT* to appear on the screen to show the time-step presently being executed. The counter will be updated without causing the screen to scroll. If the counter is activated in batch mode, one line will be printed in the default "log" file at each time-step. The time-step counter is activated by etting *IPRINT* = 1 and suppressed by setting *IPRINT* = 0.

B. Waves

527. Line B.1: *HCNGF, ZCNGF, ZCNGA*. The wave height change factor *HCNGF* multiplies the wave height along the reference line (or multiplies the deepwater wave height if the internal wave model in GENESIS is used; see Line B.3). The wave angle change factor *ZCNGF* performs a similar operation on the wave angle. The wave angle amount *ZCNGA* is added to (or subtracted from, if negative) wave angles along the nearshore reference line (or from the deepwater wave angle if nearshore wave data are not used). The change parameters allow quick answers to be obtained to scoping questions, such as "What if the waves are 20 percent higher" or "What if the waves arrive from 5 deg farther out of the east than the hindcast indicates?" In order to run with the original, unchanged wave input (the normal situation), the value of the wave height change factor is 1.0, the wave angle change factor is 1.0, and the wave angle change amount is 0.0.

528. Line B.2: *DZ*. The depth of the offshore wave input *DZ* is required in order to refract waves to breaking. This depth corresponds to the depth at which waves originated if a refraction model was used to bring waves to a nearshore reference line or the depth of the input wave record if a refraction model was not used, as specified on Line B.3.

529. Line B.3: *NWD*. The value specified for the flag *NWD* determines whether the waves will be refracted internally by GENESIS from the wave data contained in the input file **WAVES**.ext (in which case *NWD* = 0 and the input wave data correspond to an offshore location) or if the file **NSWAV**.ext contains wave information along the nearshore reference depth line (*NWD* = 1), in which case a refraction routine (for example, RCPWAVE) has already been used to bring waves to relatively shallow water.

530. Line B.5: *ISPW*. For simulations covering large spatial extent, it may not be computationally feasible to run the wave refraction model using the same (relatively fine) spatial alongshore resolution as that specified in GENESIS. By setting *ISPW* to an integer greater than unity, the size of the wave calculation cells alongshore will be a multiple of the cell length used by GENESIS.

531. Line B.6: *NHBANDS*. This input specifies whether or not wave height bands were used as a classification category in the nearshore transformation simulations. Normally wave height bands are not required (see Part VI). If wave height bands were not used, the value 1 should be entered. If wave height bands were used, then the number of height bands should be entered. The maximum number of height bands permitted is 9.

532. Line B.8: *HBMIN, HBWIDTH*. This input defines the boundaries of the height bands specified in Line B.6 (*NHBANDS*). If *NHBANDS* = 1, this line may be left blank. However, if NHBANDS is greater than 1, then the minimum offshore wave height and the wave height band width should be entered. For example, in Figure 132, nine wave height bands are specified in Line B.6, and in Line B.8 the minimum offshore wave height (*HBMIN*) is specified at 1.0 (ft) and the height band width (*HBWIDTH*) is specified at 2.0 (ft). Therefore, GENESIS will establish the following offshore wave height bands: height band number 1, for offshore wave heights between 1.0 and 3.0 ft; height band number 2, for offshore wave height between 3.0 and 5.0 ft; etc.

533. Line B.9: *DTW*. In situations where the temporal resolution of the available wave data is not as great as the time-step *DT* to be used in the

simulation, it is possible to run GENESIS with repeated wave conditions at each time-step, as specified by the variable *DTW*. As an example, suppose wave data are available only at 24-hr intervals, but the model is to be run at the standard 6-hr time-step to maintain numerical accuracy and/or stability; then by specifying *DTW* = 24 on line B.6 (and DT = 6 on line A.5), each set of wave conditions in the **WAVES** file will be run four times. Repetition of wave data is also used in the modeling of simple hypothetical cases in which constant wave conditions may be acceptable throughout the entire simulation; *DTW* can be set to be equal to or greater than the total simulation time in hours determined by the values specified at Lines A.5 through A.7. Then the first wave condition in the **WAVES** file will be run at every step.

534. <u>Line B.10: *NWAVES*</u>. The variable *NWAVES* provides the number of independent wave sources per step. Wave measurements often show two or more spectral peaks, indicating the presence of distinct wave trains. For example, swell may arrive from a distant storm, whereas sea waves are generated by local winds. These two types of waves are independent and will have different heights, periods, and directions. Also, WIS provides sea and swell components separately. GENESIS allows input of an arbitrary number of wave components. These are treated independently, with each component generating a longshore sand transport rate. The transport rates from each wave component at a given time-step are added linearly, including sign, to give the net transport rate at that time-step.

535. As another situation in which an extra wave component might enter a simulation, a long jetty may reflect a significant portion of the incident wave energy. If reflected waves are believed to appear in the breaking wave climate and influence shoreline evolution in the area, a time series of these waves may be included as a component in the **WAVES** file.

536. <u>Line B.11: *WDATS*</u>. The starting date of the shoreline change simulation was given at Line A.6. From the date of the start of the wave file *WDATS* entered at the present line, GENESIS determines the location in the **WAVES** file corresponding to the start of the simulation. In most verifications and in all predictions, contemporaneous measured wave data do not exist for the simulation interval, and the input file WAVES is viewed as holding representative wave data for a number of typical years. Therefore, it is the number of years, starting from a particular month and day (season) that is usually important, not the actual date of the year. Simulation results for a

beach fill placed in late spring or early summer will probably be much different than if the fill were placed under stormy winter waves. By beginning the simulation at the appropriate month and day, the phase of seasonality is preserved. It is a happy day in a modeler's life if gage or hindcast wave data are available over the full calibration or verification interval. If so, these data should be used.

537. The modeler will normally specify the date of the start of the **WAVES** file, i.e. *WDATS*, such that the simulation will begin at the first month and day occurring in that file. If it is desired to start the simulation in a year other than the first year appearing in the **WAVES** file, then the starting date of the **WAVES** file should be changed to move the starting pointer to the required year, month, and day. As a specific example, if the modeler wants to start the simulation in the second year of the wave data set rather than the first year, the starting date of the **WAVES** file should be set to 1 year later. The effect of seasonality in the wave data on shoreline response can be investigated by starting the **WAVES** file in different months.

C. Beach

538. Line C.1: *D50*. GENESIS uses the median diameter of the sand to compute an equilibrium profile shape. The profile shape determines the distance from the shoreline to the point of wave breaking at each grid cell and hence the effective zone of longshore sand transport. The location of breaking also determines whether diffraction will take place, as sources of diffraction must lie seaward of the breaker zone. Figure 7 in the Technical Reference can be consulted for selecting an appropriate value of d_{50}.

539. Line C.2: *ABH*. The average berm height *ABH* (called D_B in the main text) above the mean water level or the datum used in the modeling is entered here.

540. Line C.3: *DCLOS*. The closure depth *DCLOS* (called "D_C" in the main text) defines the seaward limiting depth of profile movement. It is entered here, referenced to the same datum as the average berm height.

D. Nondiffracting groins

541. The lengths of groins and short jetties are normally on the order of the average width of the surf zone; wave diffraction produced by such structures can be considered to be negligible, since in shallow water the waves will arrive almost normal to the tip of the structure or will have

already broken. Thus, typical groins used for shore protection and short jetties should be treated as nondiffracting structures.

542. GENESIS distinguishes between groins (and jetties) that produce or do not produce wave diffraction. Model computation time associated with a diffracting structure is much greater than for a nondiffracting structure; therefore, the number of diffracting groins should be minimized. The diffraction option, starting at Line E.1, is mainly used to describe long jetties (jetties with lengths on the order of several surf zone widths) and harbor breakwaters that act as a long jetty by almost completely blocking longshore sand transport; these types of structures extend well beyond the surf zone where waves may arrive at a large oblique angle, resulting in a wide diffraction zone. They also block sand transport alongshore and, therefore, are functionally equivalent to groins with regard to shoreline change.

543. Line D.1: *INDG*. Line D.1 asks whether there are groins and short jetties on the calculation grid used in the particular simulation, setting the flag *INDG*. The great majority of groins as well as jetties at small channels do not extend beyond the average width of the surf zone; therefore, they should be treated as nondiffracting structures that interrupt the movement of sand alongshore. Bypassing of sand seaward around such structures is automatically calculated by GENESIS. If the value 1 ("yes") is placed at Line D.1, then responses are required at Lines D.3-D.5. If there are no short (nondiffracting) groins or jetties on the grid, a value of 0 ("no") should be placed at Line D.1, and no other questions beginning with the letter "D" need to be answered. (If 0 is placed at Line D.1, Lines D.3-D.5 will not be read by GENESIS, and values remaining there may be arbitrary.)

544. Line D.3: *NNDG*. Enter the number of nondiffracting groins and jetties *NNDG* located on the grid. This number also includes structures that may serve as a groin boundary condition on one or both lateral ends of the grid.

545. Line D.4: *IXNDG(I)*. Enter the grid cell numbers of nondiffracting groins and jetties *IXNDG(I)* in order of increasing cell number. The number of grid cell locations given here should equal the number of nondiffracting groins specified at Line D.3 (*NNDG* values).

546. Line D.5: *YNDG(I)*. Enter the lengths of the nondiffracting groins and jetties *YNDG(I)* (as measured from the x-axis to the seaward tip of the structure) in the order of cell number in which they occur (*NNDG* values in

increasing order of cell numbers corresponding to the locations given at Line D.4).

E. Diffracting
(long) groins and jetties.

547. Line E.1: *IDG*. If there are long jetties and long groins on the grid (i.e., structures extending past the breaking wave zone and into relatively deep water for almost all wave conditions), they should be treated as diffracting structures, and the value 1 ("yes") placed here in the flag *IDG*. If there are no such structures on the grid, including the boundaries, then respond with the value 0 ("no"), and skip questions E.3-E.6. (If 0 is placed at Line E.1, Lines E.3-E.6 will not be read by GENESIS, and values remaining there may be arbitrary.)

548. Line E.3: *NDG*. Enter the number of diffracting groins and jetties *NDG* that are on the grid. This number includes structures which may serve as boundary conditions (at grid points 1 and N+1).

549. Line E.4: *IXDG(I)*. Enter the grid cell numbers of diffracting groins and jetties *IXDG(I)* in order of increasing cell number. There should be the same number of grid cell locations as the number of diffracting groins and jetties specified at Line E.3 (*NDG* values from small to large cell numbers).

550. Line E.5: *YDG(I)*. Enter the lengths of the diffracting groins and jetties *YDG(I)* as measured from the x-axis in the order of cell number in which they occur (*NDG* values from small to large cell numbers corresponding to the locations given at Line E.4).

551. Line E.6: *DDG(I)*. Enter the depths at the tips of the diffracting groins and jetties *DDG(I)* in the order of cell number in which they occur (*NDG* values from small to large cell numbers corresponding to the locations given at Line E.4).

F. Groins/jetties

552. Line F.1. This section requests general information pertaining to both nondiffracting and diffracting groins and jetties (and shore-connected breakwaters). If there are no groins or jetties on the grid (values of 0 entered at both Lines D.1 and E.1), then Lines F.2-F.5 may be skipped. If there are groins of any type, responses to Lines F.2-F.5 must be given. (If there are no groins or jetties on the grid, Lines F.2-F.5 will not be read by GENESIS, and values remaining there may be arbitrary.)

553. Line F.2: *SLOPE2*. Groins impound sand on the side of predominant direction of drift, implying that the beach slope near a groin is milder than the equilibrium slope. An estimate of this slope *SLOPE2* should be made by reference to measurements at the site or to other data. GENESIS uses this value in calculation of sand bypassing around the seaward tips of groins and jetties.

554. Line F.3: *PERM(I)*. Permeabilities *PERM(I)* of the groins and jetties must be assigned. Permeabilities should be given in order of increasing cell location of the structures as they appear on the grid, irrespective of whether the structure is nondiffracting or diffracting.

555. The permeability coefficient empirically accounts for transmission of sand through and over a groin. (Bypassing of sand around the seaward end of groins is automatically calculated by GENESIS.) A permeability value of 1.0 implies a completely transparent groin, whereas a value of 0.0 implies a high, impermeable groin that does not allow sand to pass through or over it.

556. Since a methodology does not presently exist to allow GENESIS or the modeler to calculate groin permeability by a standard or objective procedure, this quantity is best determined as part of model calibration. If a shoreline reach has numerous groins of various construction types and states of functioning, it is recommended that estimates of relative permeability be given initially and then refined in the course of the model calibration by observing the trend of shoreline change near the groins. As a rule of thumb, an apparently fully functioning groin with a crest above mean sea level (MSL) for most tides is assigned an initial permeability value in the range of 0.0 to 0.1, whereas a groin that has gaps or is overtopped during parts of the tidal cycle may have a permeability in the range of 0.1 to 0.5. An effective method of estimating relative groin permeability is to compare the condition (number and width of gaps, thickness and height of groin) of groins on aerial photographs of the model reach.

557. Lines F.4 and F.5: *YG1*, *YGN*. If a groin or jetty is located on a boundary (grid cell number 1 or *N*+1), the distance from the shoreline outside the grid to the seaward end of the structure *YG1* and/or *YGN* must be specified (called "y_{G1}" and "y_{GN}" in the main text). Since this location is "off the grid," it must be given externally (by the modeler) and cannot be calculated. This distance is used in the sand bypassing calculation for the structure in situations where sand may be transported onto the grid.

G. Detached breakwaters

558. GENESIS treats a detached breakwater as a structure with two diffracting ends. The tips of detached breakwaters can be placed at different distances from the x-axis, and gap widths and breakwater lengths can also be arbitrary if a line of segmented detached breakwaters is to be represented. Generally speaking, detached breakwaters should be placed offshore at least as far as the average wave breaker line, to simulate the full diffracting effect of the detached breakwaters. If at any time-step the waves break seaward of a detached breakwater, the wave height at the diffracting tip will be set equal to the depth-limited wave height determined by the relation $H_b = D_b$.

559. GENESIS Version 2.0 will terminate the simulation if formation of a tombolo, i.e., the model will stop and issue a messge if the shoreline reaches or comes close to the breakwater. It should also be noted that common diffraction theories, including the one used in GENESIS, are technically invalid if the structure is very short (a fraction of a wavelength) or for distances from the breakwater less than about one wavelength. Placement of detached breakwaters should be made carefully in light of these limitations.

560. <u>Line G.1: *IDB*</u>. If there are detached breakwaters on the model grid, the value *1* ("yes") of the flag *IDB* is entered here. If there are no such structures on the grid, including the boundaries, answer with the value *0* ("no"), and skip Lines G.3-G.9. (If the value *0* is placed at Line G.1, Lines G.3-G.9 will not be read by GENESIS, and values remaining there may be arbitrary.)

561. <u>Line G.3: *NDB*</u>. Enter the number of detached breakwaters *NDB* that appear on the grid.

562. <u>Lines G.4 and G.5: *IDB1*, *IDBN*</u>. The flags *IDB1* and *IDBN* tell GENESIS if there are detached breakwaters crossing the boundaries (no = 0; yes = 1). If a model boundary is placed across a detached breakwater, waves diffracted by the tip of the breakwater located outside of the grid will not be taken into account. Thus, such a structure will be regarded as semi-infinite with only the tip of the breakwater lying within the grid to produce diffraction.

563. The capability of placing detached breakwaters across grid boundaries should be used with caution. If a groin is not simultaneously located on the boundary, GENESIS will apply the default pinned-beach boundary condition, which may not be appropriate in the shadow zone of the detached

breakwater. The true meaning of the pinned-beach boundary condition is "the beach does not want to move"; if the pinned-beach boundary condition is improperly used, it may incorrectly mean "the beach is not allowed to move."

564. Line G.6: *IXDB(I)*. Enter the grid cell numbers of the tips of detached breakwaters *IXDB(I)* in ascending order of cell number. There should be two values for each detached breakwater located entirely within the calculation grid and one value for each additional detached breakwater extending across the calculation boundary.

565. Line G.7: *YDB(I)*. Enter the distances from the tips of the breakwaters to the x-axis *YDB(I)* in ascending order of cell number. There should be the same number of values as specified at Line G.6.

566. Line G.8: *DDB(I)*. Enter the depths *DDB(I)* at the tips of the breakwaters in ascending order of cell number. There should be the same number of values as specified at Line G.6.

567. Line G.9: *TRANDB(I)*. Enter the value of the wave transmission coefficient *TRANDB(I)* (called "K_T" in the main text) for the individual breakwaters (*NDB* values) in ascending order as the structures appear on the grid. This empirical coefficient accounts for wave transmission through a breakwater and by overtopping, and it must be evaluated either externally or as part of the calibration process, similar to the case of groin/jetty impermeability. The value of the wave transmission coefficient varies between 0.0 and 1.0, where the value 0.0 describes a high, impermeable breakwater with no wave transmission through the structure by any means, and the value 1.0 describes a completely wave-transparent, ineffective structure.

H. Seawalls

568. A seawall constrains the allowable position of the shoreline because the beach cannot erode landward of the wall. Formally, GENESIS can describe only one seawall. However, noncontiguous sections of a seawall can be represented by placing the number -9999 in the **SEAWL** input file along the shore where seawalls are not present. Values of -9999 are assumed to place the seawall at locations so far landward that the wall would never come into play in the longshore transport and shoreline change calculations.

569. Line H.1: *ISW*. If there is one or more seawall sections along the modeled beach, the value 1 ("yes") is entered here for the flag *ISW*. If there are no seawalls, the value 0 ("no") is entered, and Line H.3 can be skipped. (If the value 0 is entered at Line H.1, Line H.3 will not be read by

GENESIS, and values remaining at Line H.3 may be arbitrary.) If there are no seawalls present, GENESIS will not read from the input file **SEAWL** and will place the seawall at -9999 distance units as a default; values in the **SEAWL** file may be arbitrary in this case since the file will not be read.

570. Line H.3: *ISWBEG, ISWEND*. As stated in the preceding two paragraphs, if several seawall sections are present, they will be treated as a single seawall but with the sections between them located far landward of the shoreline. The grid cell numbers to be entered at this line correspond to the beginning *ISWBEG* and ending *ISWEND* of the single, continuous seawall. The two grid cell numbers are entered in ascending order. If *ISWEND* is set equal to -1 at line H.3, internally GENESIS will set $ISWEND = N$, which is a convenient default if all applications or variations for a project have a seawall running from ISWBEG to N.

I. Beach fills

571. If more than one beach fill occurs, information must be entered in the order of occurrence of the fills. Fills may overlap in time and location, but information must be entered in the same order at each request. GENESIS treats the fill as having the same grain size and berm height as the original beach.

572. GENESIS does not operate by direct use of fill volume but through the total distance of shoreline advance after the fill and beach profile have been molded to an equilibrium shape by wave action. (This distance must be specified by the modeler at Line I.8.) GENESIS places the fill by advancing the shoreline position in equal amounts at each time-step between the starting and ending dates of the operation and within the cells defining the fill, as specified at the **START** file line numbers described in the following paragraphs. The fill is placed at each time-step specified even if wave conditions are calm and shoreline change computations are not carried out.

573. Because GENESIS places fill by advancing the shoreline in equal daily amounts over the duration of the nourishment operation, a single fill advances uniformly over its longshore extent. A nonuniform advance over a given reach can be simulated by specifying several fills of different amounts on different sections of a total reach but placed within the same period.

574 Line I.1: *IBF*. If one or more beach fills is placed during the simulation period, a value of 1 ("yes") should be entered for the flag *IBF* and responses given at Lines I.3-I.8. If there are no beach fills, a value of 0

("no") should be entered, and the remaining questions in this subsection may be disregarded. (If 0 is placed at Line I.1, Lines I.3-I.8 will not be read by GENESIS, and values remaining there may be arbitrary.)

575. Line I.3: *NBF*. The number of beach fills *NBF* that occurs during the simulation period is entered here.

576. Lines I.4 and I.5: *BFDATS(I), BFDEND(I)*. The dates or time-steps when placement of the fill(s) is begun *BFDATS(I)* and ended *BFDEND(I)* are entered at these two lines, in chronological or increasing order from the beginning dates or time-steps of the fills (*NBF* values, corresponding to line I.3). GENESIS keeps track of the date from the start of the simulation (Line A.6), and, if the fills are specified in terms of dates, GENESIS begins placing the fill on the beach at the date(s) specified.

577. Lines I.6 and I.7: *IBFS(I), IBFE(I)*. The grid cell numbers of the starting *IBFS(I)* and ending *IBFE(I)* locations of the fills are entered at Lines I.6 and I.7, respectively, in the same order as entered at Lines I.4 and I.5 (*NBF* values). The cell number where a particular fill is started must be smaller than the cell number where it is ended. The fill is placed in all cells between and including the starting and ending cells.

578. Line I.8: *YADD(I)*. The amount of shoreline advance *YADD(I)* that will be added to the existing shoreline by GENESIS between the beginning and completion dates of the fill is given here. The distances of shoreline advance should be entered in the same order as in Lines I.4-I.7.

579. For a certain time period (on the order of weeks or months) after placement of a fill, waves and currents will remold the material to an equilibrium shape as determined by the grain size of the fill and the wave conditions. Fine particles, if present, will move offshore and out of the effective zone of longshore transport. Also, the berm of the initial fill may be higher than that of the original and neighboring beach. In the initial process of readjustment, therefore, the volume of the fill may decrease from that which was initially emplaced. It is presently beyond the scope of GENESIS to compute the volume of the fill remaining after the transient readjustment period. The engineer operating GENESIS must judge conditions and make an external calculation to estimate the average distance the shoreline will advance after the fill has adjusted. (The fill volume per unit length of beach after equilibrium has been established can be calculated by multiplying the horizontal distance of berm advance, Line I.8, by the vertical distance

from the berm crest, Line C.2, to the depth of closure, Line C.3, i.e., *YADD* (*ABH+DCLOS*) .

Simple Configurations

580. A project may require many versions of the input files, particularly **START** files, because this file contains most of the information specifying project alternatives. As an example, Figure 133 shows a simple situation involving multiple **START** files. If only two alternatives are considered in the project, groins as one alternative and detached breakwaters as the other, the modeler would construct two **START** files, possibly named **START.GRO** and **START.DBW**. When he or she is ready to run GENESIS for the detached breakwater alternative, the file **START.DBW**, together with the other input files with extension .**DBW** would be used in the simulation, resulting in the corresponding output files with the same extension. When the groin alternative is to be run, the modeler would specify the extension .**GRO** to use **START.GRO** and other

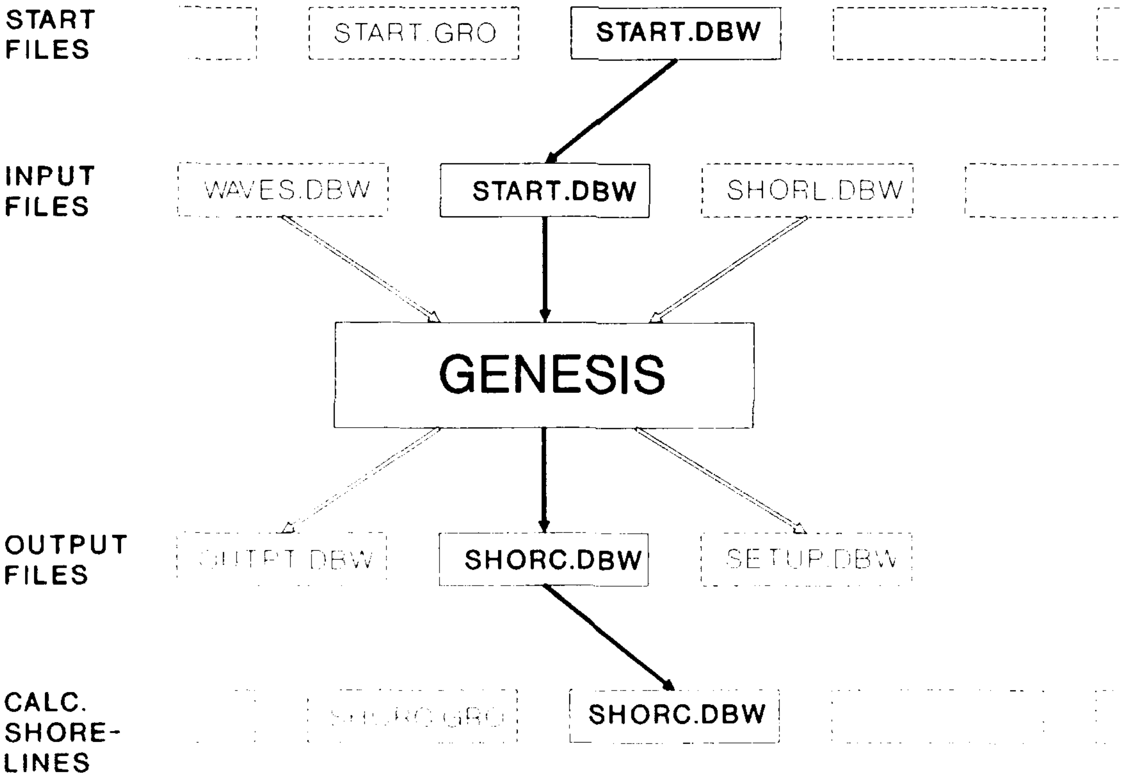


Figure 133. File name extension controlling single stage simulation

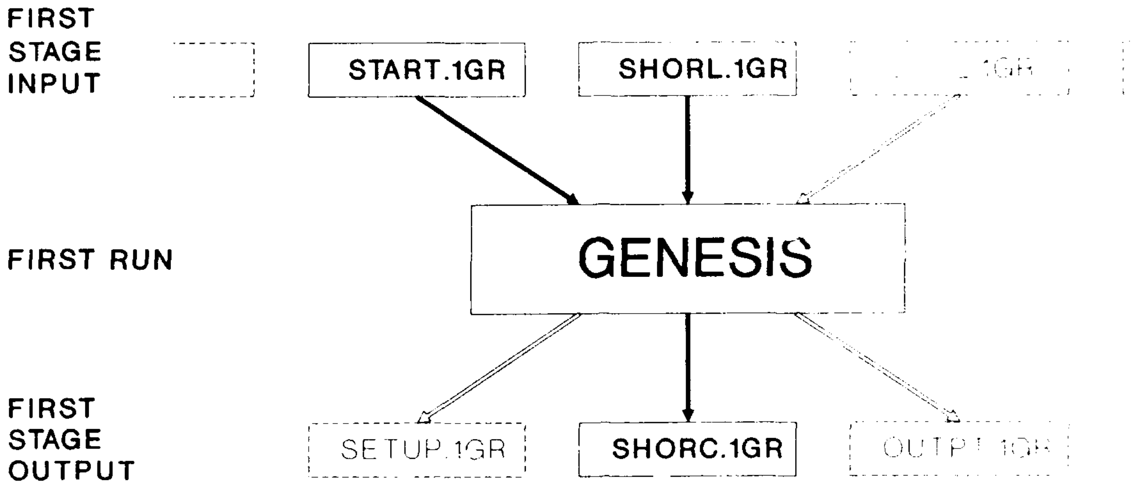
.GRO files as input to GENESIS. The various input files employed may be saved under their original names or renamed together with the output files to document the process of evaluating the alternatives and results.

Time-Varying Structure Configurations

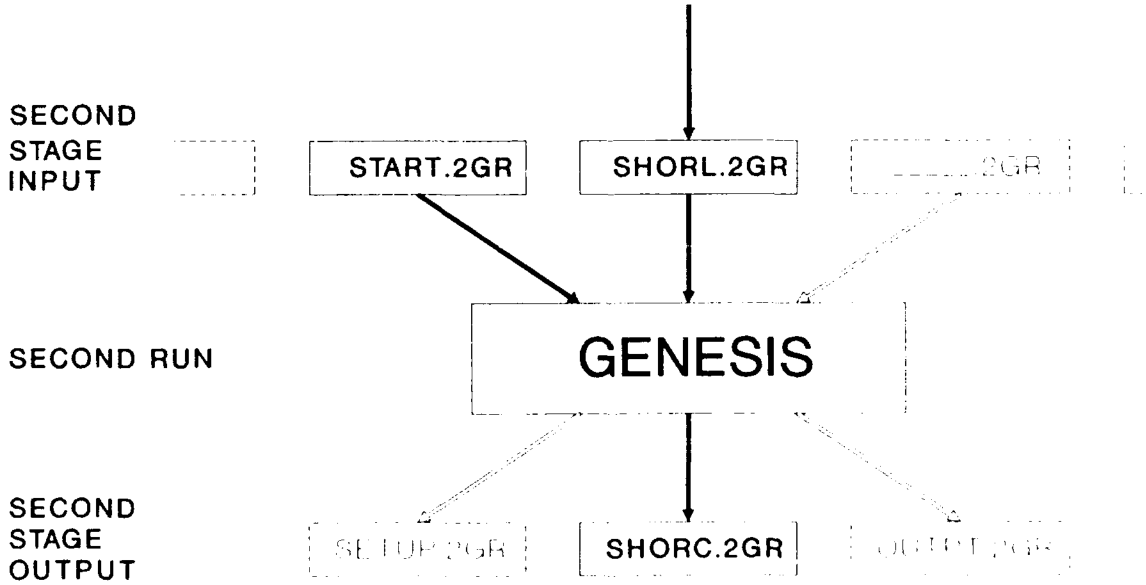
581. In many modeling projects, structures are built, modified, or destroyed during the course of a shoreline change simulation time period. The simulation must be performed in stages in such a case. A **START** file with the initial configuration would run GENESIS until the time-step of the change in a structure; the **SHORC** file (calculated shoreline) from this first stage would then be copied to a **SHORL** file (initial shoreline) for the next stage of the simulation, and another **START** file describing the new configuration would be used to continue. As an example, Figure 134 shows a situation involving two stages of simulations.

582. During the first stage of simulation, the modeled beach contains only one groin. Thus, a **START** file (possibly called **START.1GR**) that contains only this structure is constructed. GENESIS is then run using this and other input files with the same extension **.1GR**, resulting in three output files. At the beginning of the second stage of simulation, another groin was added to the modeled beach. This new configuration, and other conditions describing this stage, is held in another **START** file, possibly called **START.2GR**. The calculated shoreline at the end of stage 1 will then be copied to **SHORL.2GR** to represent the initial shoreline for the second stage of simulation. GENESIS is run again, using these and other input files with the extension **.2GR**.

583. In the illustrated example, the modeler chose to divide the total simulation interval into two stages only. However, it is possible to divide the interval into any number of stages. If the construction of the second groin would cover a significant portion of time, it might have been better to have introduced the structure with a very small length (or high permeability depending on how the construction was performed). The length of the groin could then be gradually extended (or specified as less permeable) in several stages. The number of stages is, as usual, a compromise between calculation accuracy and simulation time/effort that the modeler has to determine from his or her engineering experience.



a. First stage simulation



b. Second stage simulation

Figure 134. File name extension controlling multiple stage simulations

584. This procedure can be chained for describing any number of modifications in structure configurations and boundary conditions. Most computer systems allow creation of a batch file to automate successive simulations.

Error Messages

585. After all needed input files are prepared and available to be called by GENESIS, the program can be run. At the beginning of a modeling project, it is not uncommon and should not be unexpected to have data mismatch errors, particularly in the **START** file. GENESIS provides a number of error and warning messages that give the user recovery information for the more common mistakes and notification of potentially undesirable conditions encountered during a simulation. These messages are printed to the screen and the output file **SETUP**. Error and warning messages together with suggested recovery procedures are discussed in the following paragraphs.

586. One strategy that has been found useful for reducing errors is to introduce project complexity in the **START** file in stages, testing (running) the model for a few time-steps at each stage. For example, if the project has several structures and beach fills, the **START** file would first be constructed with only the boundary conditions and tested. Next, perhaps only nondiffracting groins would be placed on the internal grid, if there are such structures. Then, diffracting structures would be introduced. Finally, after successful testing at each stage, the beach fills would be placed in the **START** file. In this way, errors can be more easily isolated.

587. An error message gives information about a "fatal" error, that is, an error detected that would stop the calculation. On the data entry level, these errors might be caused by inconsistencies in specified quantities (for example, specifying three groins but only giving positions for two) or a serious problem in the calculation (for example, running many high waves at extremely oblique incident wave angles). GENESIS is based on physical assumptions and calculation techniques that have limitations. If these limitations are exceeded, the simulation may fail or give an erroneous result. Experience with GENESIS in a variety of projects indicates it will perform satisfactorily if prudence is taken to represent realistic wave, structure, and shoreline position conditions.

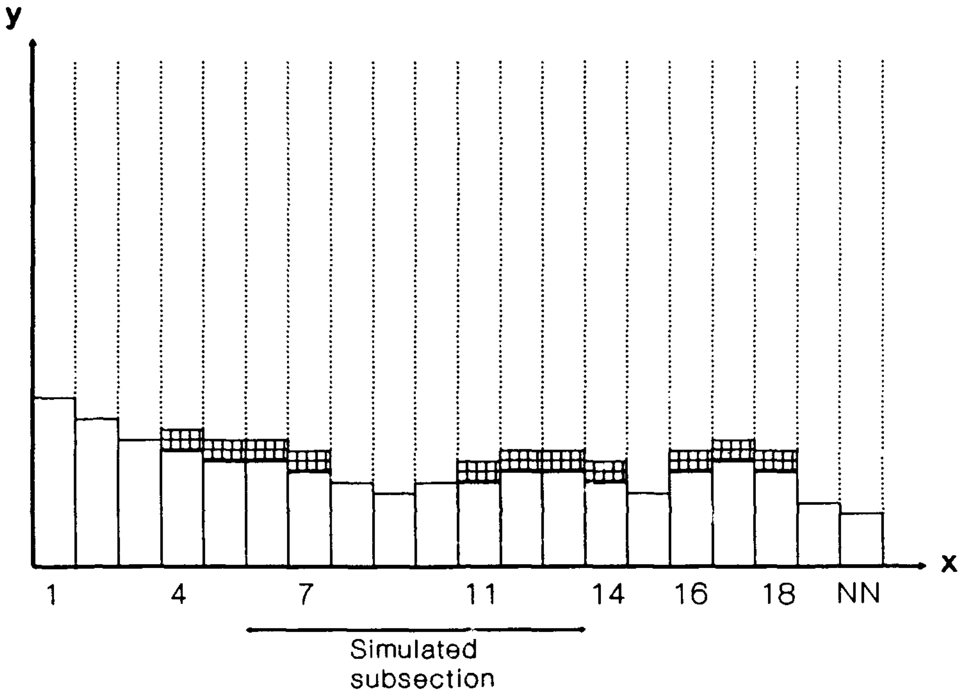
588. Messages are given in alphabetical order in bold capital letters, followed by a short explanation and suggested error-recovery procedure. For several of the errors, more than one remedial measure is suggested. It is up to the modeler to chose the appropriate alternative that should provide the best representation of the true configuration. Only those values subject to correction are reported in the error recovery procedure. In the explanatory figures, cells of special importance are marked with their number.

589. For a more extensive discussion of the respective errors, please refer to Appendix C in the Technical Reference. The messages given in the following paragraphs are repetitive to avoid cross-references.

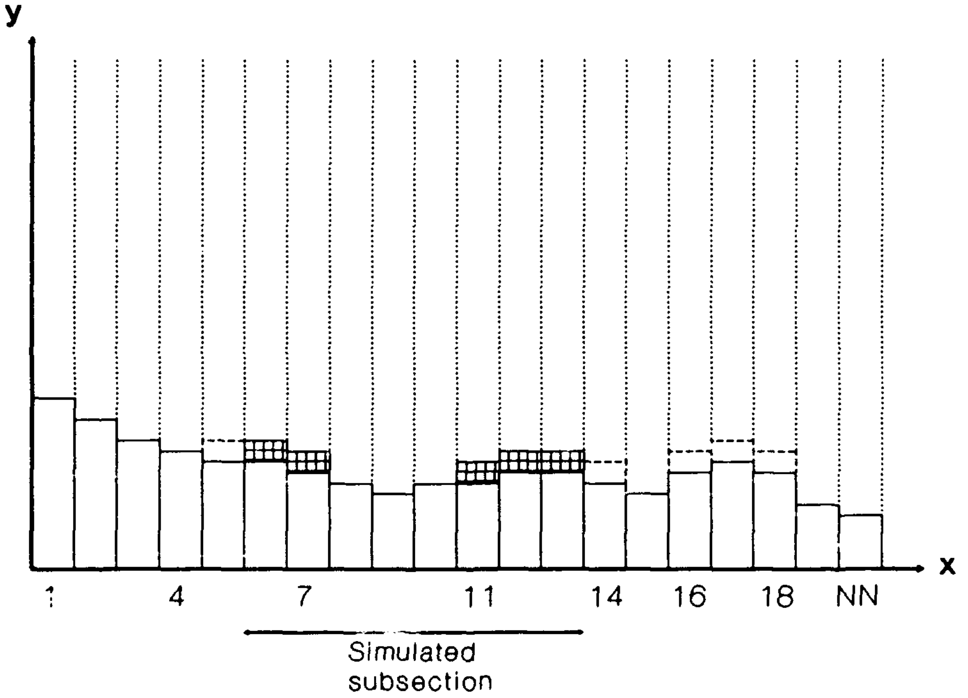
590. **ERROR. BAD BALANCE IN WAVE INPUT PARAMETERS CAUSING DLTZ TO BE NEGATIVE. Reason for error:** The depth of longshore sand transport is negative. This condition may occur if the input offshore wave data was manipulated, for example, to investigate model sensitivity, the effect of extreme conditions, or for simulation of hypothetical cases. **Remedial measure:** Change the wave height or period in the **WAVES** file to represent physically reasonable waves.

591. **ERROR. BEACH FILL IS OUTSIDE CALCULATION GRID. Reason for error:** The grid cell numbers for a beach fill, as specified on Lines I.6 and I.7 in the **START** file, fall outside the subsection of the beach presently being modeled as specified on Line A.4. The error may also occur as a result of a mistake in entering the cell numbers, e.g. if 84 instead of 48 is entered and the total beach consists of only 50 calculation cells. **Remedial measure:** If the entire fill lies outside the subsection of beach, the error is remedied by omitting corresponding values on Lines I.4-I.8 in the **START** file. If the fill is only partially outside the subsection of beach, the error is remedied by setting *IBFS* on Line I.6 equal to the grid cell number where the simulated subsection starts, if the left side of the beach fill is outside the grid, or by setting *IBFE* equal to the grid cell number where the simulated subsection ends, if the right side of the beach fill is outside the grid. Figure 135 illustrates the three types of illegal fill specifications and the appropriate corrections. As only a subsection, comprising *N* = 8 cells, of the total beach is included in the simulation, the total number of cells for the entire grid is denoted by *NN*.

592. The two examples with *NN* = 20, *ISSTART* = 6, and *N* = 8 in Figure 135 are characterized by: (a) illegal configuration; *NBF* = 3; *IBFS* = 4, 11,



a. Illegal beach-fill specification



b. Corrected beach-fill specification

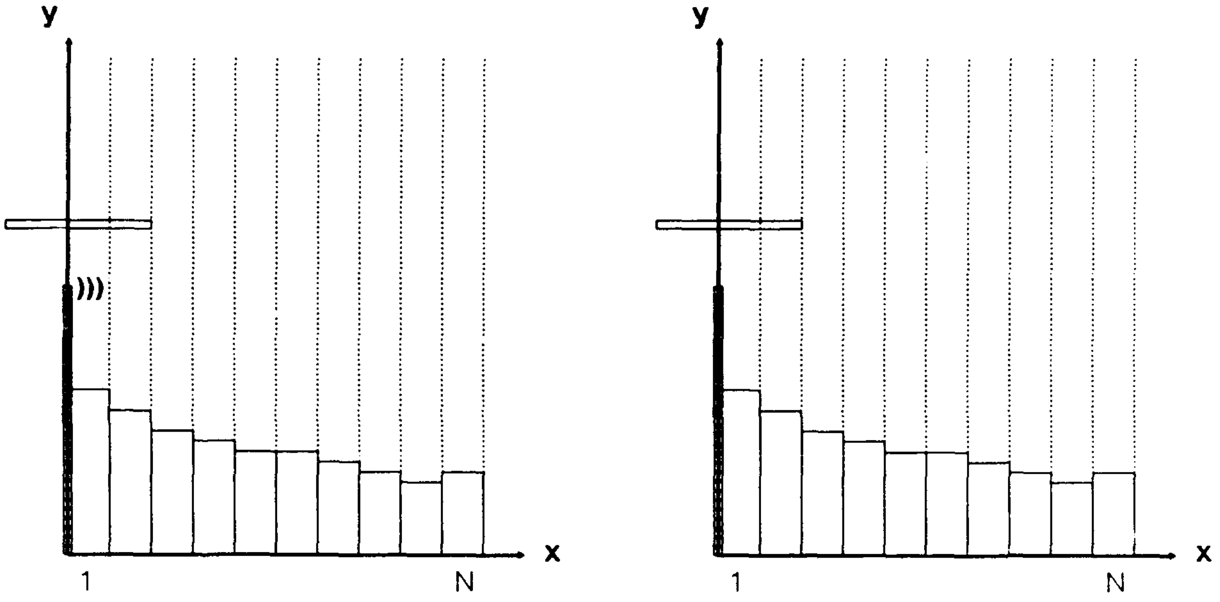
Figure 135. Specification of beach fills

16; *IBFE* = 7, 14, 18; and (b) corrected configuration; *NBF* = 2; *IBFS* = 6, 11; *IBFE* = 7, 13.

593. **ERROR. BOTH SEMI-INFINITE DETACHED BREAKWATER AND A DIFFRACTING GROIN ON LEFT-HAND BOUNDARY NOT ALLOWED. Reason for error:** A detached breakwater is specified on Line G.4 in the **START** file to cross the left-hand boundary, and, at the same time, a diffracting groin is located in cell number 1 on Line E.4 in the **START** file. **Remedial measure:** Do any of the three alternatives: (a) replace the diffracting groin with a nondiffracting groin; (b) extend the diffracting groin to attach to the detached breakwater, specify that the detached breakwater does not cross the left-hand boundary by setting *IDB1* = 0 on Line G.4 in the **START** file, and at the same time specify that the detached breakwater starts in cell number 1 on Line G.6 in the **START** file; or (c) move the diffracting groin so that it will no longer be inside the detached breakwater, which means that *IXDG*(1) on Line E.4 in the **START** file must be greater than or equal to *IXDB*(1) on Line G.6. Figure 136 illustrates the error and possible remedial measures.

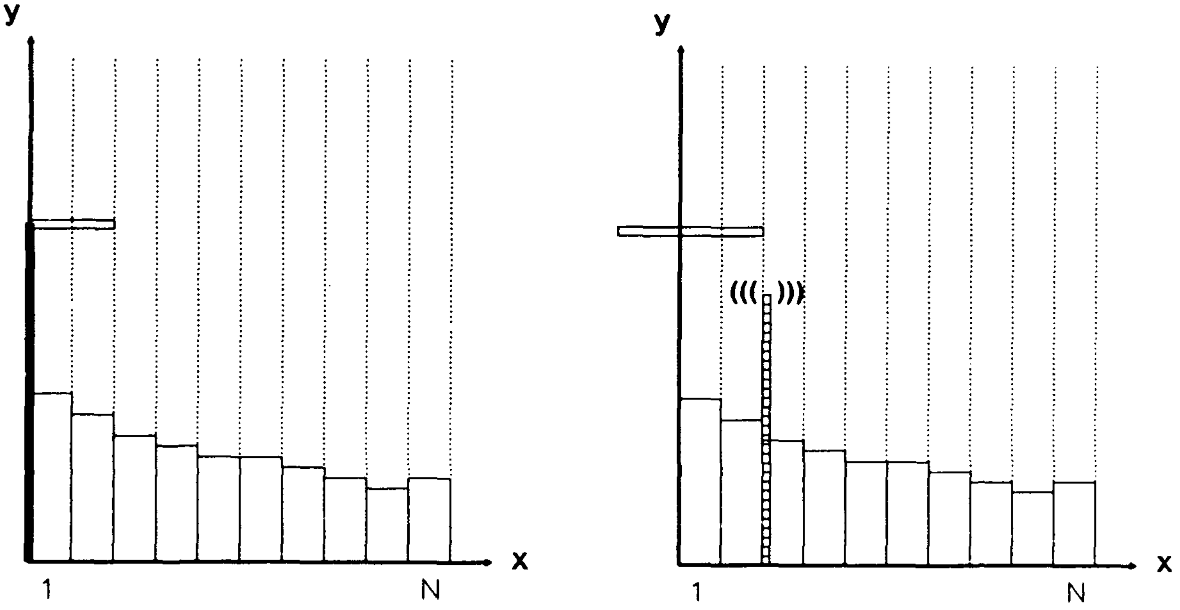
594. The four examples in Figure 136 are characterized by: (a) illegal configuration; *INDG* = 0; *IDG* = 1; *IXDG* = 1; *YDG* = 50; *IDB1* = 1; *IXDB* = 3; *YDB* = 70; (b) corrected configuration; *INDG* = 1; *IXNDG* = 1; *YNDG* = 50; *IDG* = 0; *IDB1* = 1; *IXDB* = 3; *YDB* = 70; (c) corrected configuration; *INDG* = 0; *IDG* = 1; *IXDG* = 1; *YDG* = 70; *IDB1* = 0; *IXDB* = 1, 3; *YDB* = 70, 70; and (d) corrected configuration; *INDG* = 0; *IDG* = 1; *IXDG* = 3; *YDG* = 50; *IDB1* = 1; *IXDB* = 3; *YDB* = 70.

595. **ERROR. BOTH SEMI-INFINITE DETACHED BREAKWATER AND A DIFFRACTING GROIN ON RIGHT-HAND BOUNDARY NOT ALLOWED. Reason for error:** A detached breakwater is specified on Line G.5 in the **START** file to cross the right-hand boundary, and, at the same time, a diffracting groin is located in cell number *N*+1 on Line E.4 in the **START** file. **Remedial measure:** Do any of the three alternatives: (a) replace the diffracting groin with a nondiffracting groin; (b) extend the diffracting groin to attach detached breakwater, specify that the detached breakwater does not cross the right-hand boundary by setting *IDBN* = 0 on Line G.5 in the **START** file, and at the same time specify that the detached breakwater ends in cell number *N*+1 on Line G.6 in the **START** file; or (c) move the diffracting groin so that it will no longer be inside the detached breakwater by specifying that the diffracting groin is located in the same cell that the breakwater begins, which means that *IXDG*(NDG) (last



a. Illegal configuration

b. Corrected configuration (alternative 1)



c. Corrected configuration (alternative 2)

d. Corrected configuration (alternative 3)

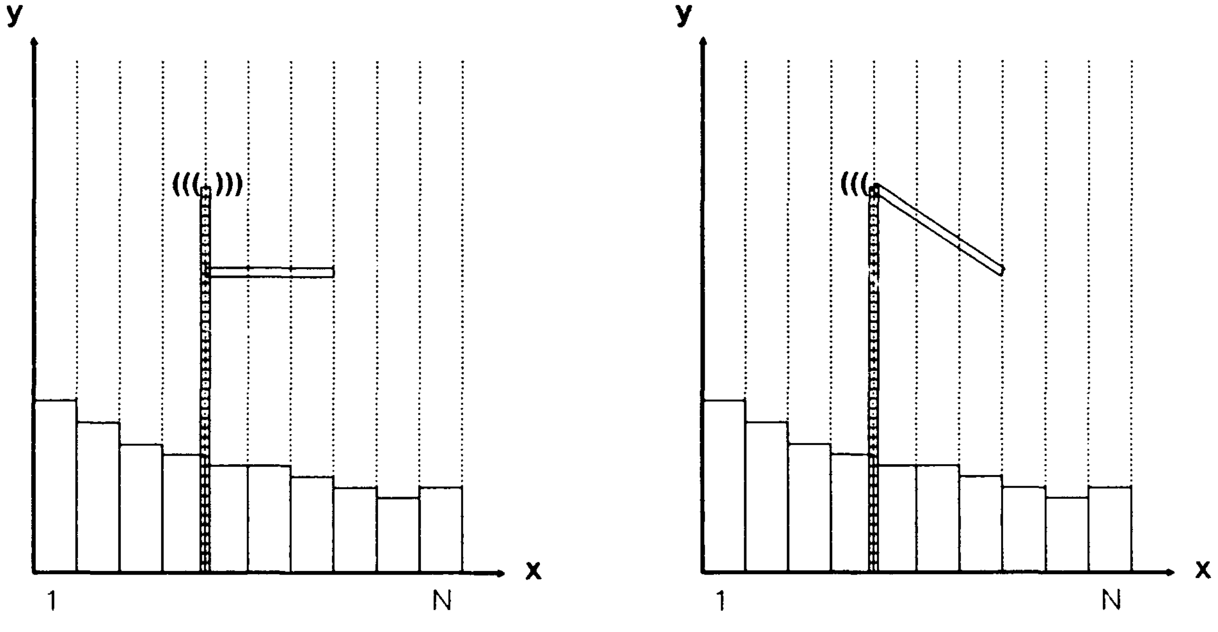
Figure 136. Placement of groin and breakwater on boundary

diffracting groin) on Line E.4 in the **START** file must be less than or equal to *IXDB*(NDB*2) (last detached breakwater tip in the simulation reach) on Line G.6. Figure 136 illustrates the corresponding error on the left-hand boundary and possible remedial measures that are easily translated to the right-hand boundary.

596. ERROR. **DETACHED BREAKWATER CAN ONLY CONNECT TO A GROIN AT THE GROIN TIP. Reason for error:** A detached breakwater is connected to a diffracting groin other than at its tip. **Remedial measure:** Move the detached breakwater tip to the end of the groin **or** move either of the two structures to separate them. Figure 137 illustrates the error and a possible remedial measure.

597. The two examples in Figure 137 are characterized by: (a) illegal configuration; *YDG* = 70; *YDB* = 50, 50;and (b) corrected configuration; *YDG* = 70; *YDB* = 70, 50.

598. ERROR. **DETACHED BREAKWATER ENDING ON OPEN LEFT-HAND BOUNDARY NOT ALLOWED. Reason for error:** A breakwater tip is located in cell number 1 as specified on Line G.6 in the **START** file. **Remedial measure:** Either consider the detached breakwater as being semi-infinite by setting *IDB1* = 1 on Line G.4



a. Illegal configuration b. Corrected configuration

Figure 137. Placement of connecting groin and breakwater

in the **START** file or specify the first cell number to be 2 or higher, as given on Line G.6 and setting *IDB1* = 0 on Line G.4 in the **START** file. Figure 138 illustrates the error and possible remedial measures.

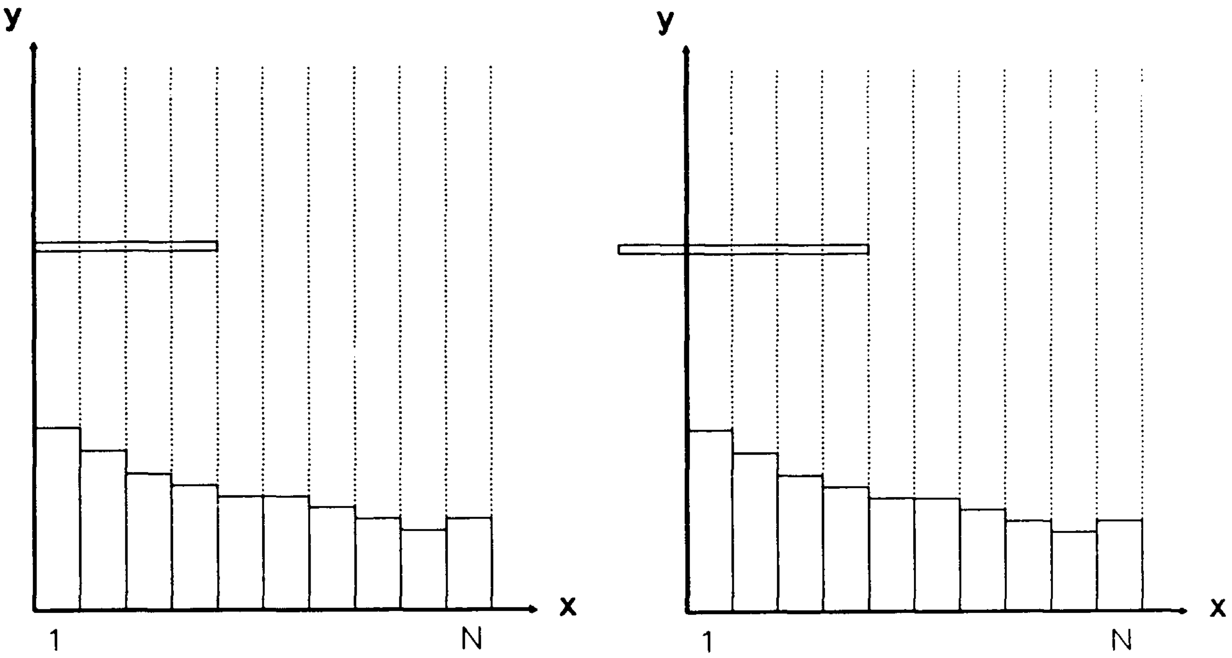
599. The three examples in Figure 138 are characterized by: (a) illegal configuration; *IDB1* = 0; *IXDB* = 1, 5; (b) corrected configuration; *IDB1* = 1; *IXDB* = 5; and (c) corrected configuration; *IDB1* = 0; *IXDB* = 2, 5.

600. **ERROR. DETACHED BREAKWATER ENDING ON OPEN RIGHT-HAND BOUNDARY NOT ALLOWED. Reason for error:** A breakwater tip is specified in cell number *N*+1 on Line G.6 in the **START** file. **Remedial measure:** Either consider the detached breakwater as being semi-infinite by setting *IDBN* = 1 on Line G.5 in the **START** file or specify the last cell number to be *N* or less as given on Line G.6 and setting *IDBN* = 0 on Line G.4 in the **START** file. Figure 138 illustrates the corresponding error for the left-hand boundary and possible remedial measures, which are easily translated for the right-hand boundary.

601. **ERROR. DETACHED BREAKWATER TIP OUTSIDE CALCULATION GRID. Reason for error:** The grid cell numbers for a detached breakwater, as specified on Line G.6 in the **START** file fall outside the subsection of the beach presently being modeled as specified on Line A.4. **Remedial measure:** If only one end of the breakwater is outside the modeled subsection of beach, remove this grid cell number from Line G.6 and the corresponding distance from x-axis and depth on Lines G.7 and G.8, respectively. In addition, the detached breakwater has to be considered as being semi-infinite by setting *IDB1* = 1 on Line G.4 or *IDBN* = 1 on Line G.5 in the **START** file. If the entire detached breakwater is outside the modeled subsection of beach, the corresponding transmission coefficient as specified on Line G.9 must also be removed. Figure 139 illustrates the three types of illegal breakwater specifications and the appropriate corrections. As only a subsection, comprising *N* = 8 cells, of the total beach is included in the simulation, the total number of cells for the entire grid is denoted by *NN*.

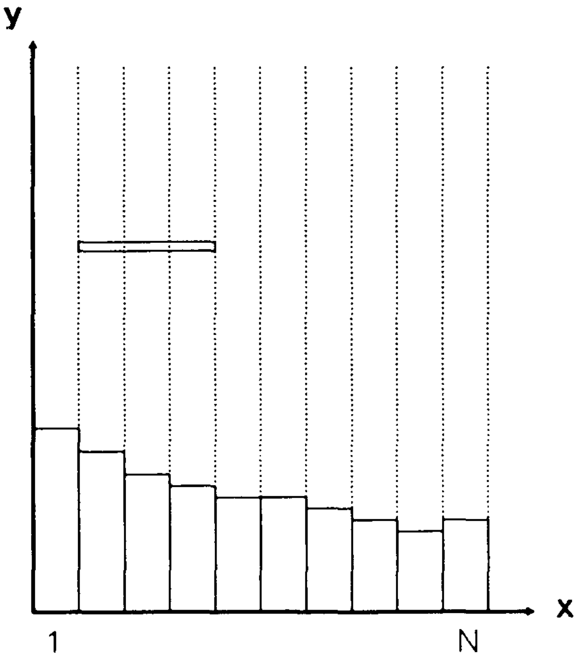
602. The two examples with *NN* = 20, *ISSTART* = 6, and *N* = 8 in Figure 139 are characterized by: (a) illegal configuration; *NDB* = 3; *IDB1* = 0; *IDBN* = 0; *IXDB* = 2, 7, 11, 17, 18, 20;and (b) corrected configuration; *NDB* = 2; *IDB1* = 1; *IDBN* = 1; *IXDB* = 7, 11.

603. **ERROR. DIFFRACTING GROIN OUTSIDE CALCULATION GRID. Reason for error:** The grid cell number for a diffracting groin, as specified on Line E.4 in the **START** file fall outside the subsection of the beach presently being



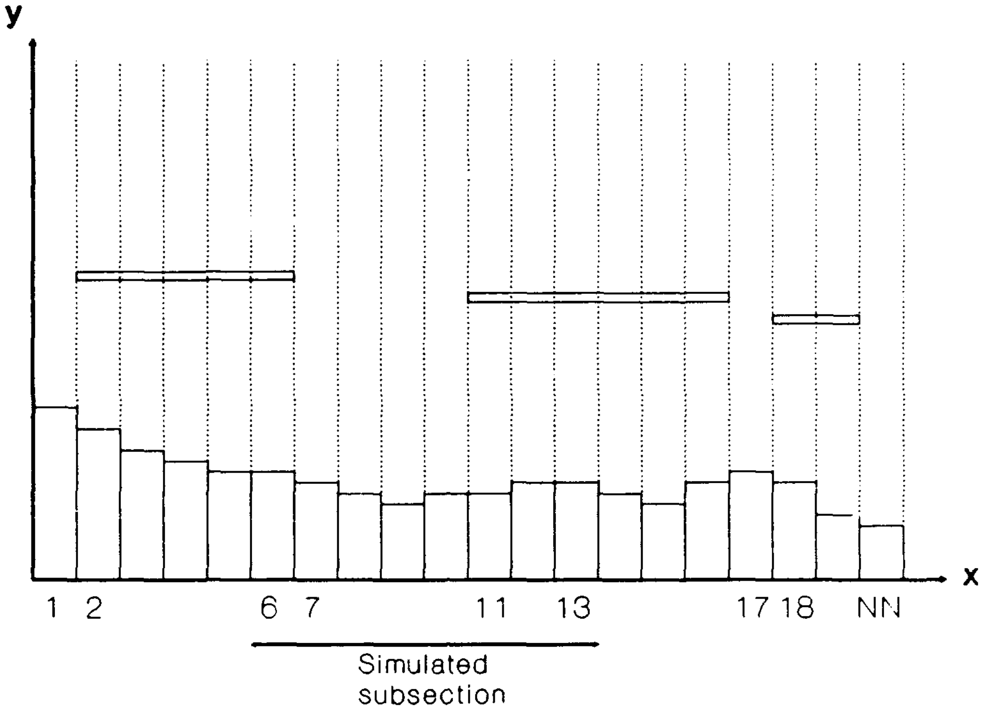
a. Illegal configuration

b. Corrected configuration
(alternative 1)

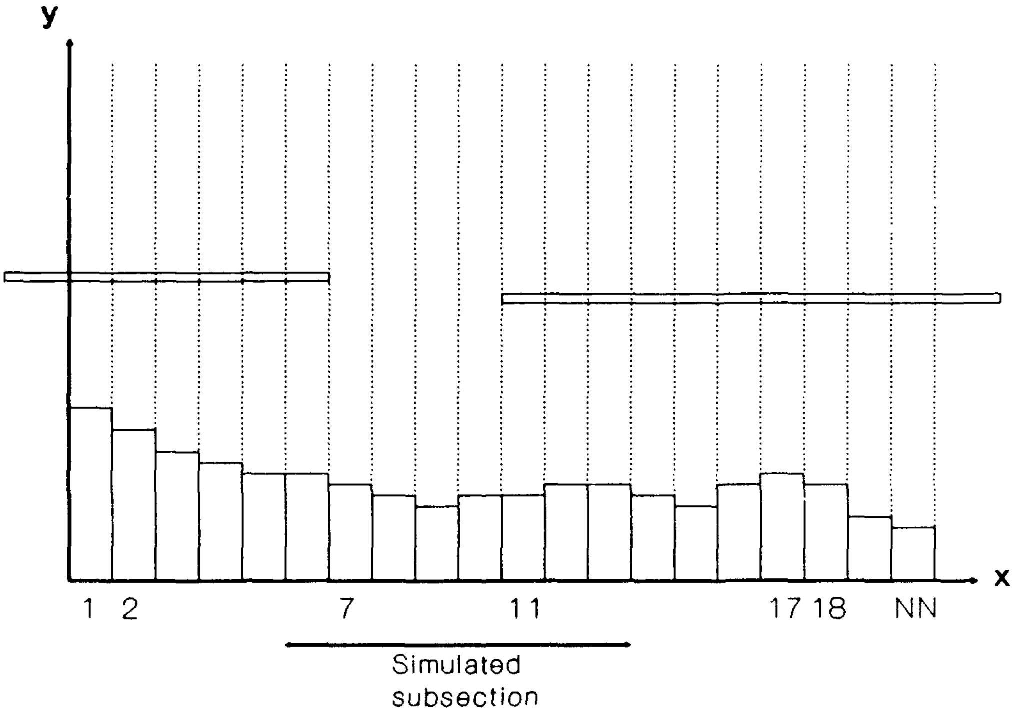


c. Corrected configuration
(alternative 2)

Figure 138. Specification of detached breakwater on boundary



a. Illegal configuration



b. Corrected configuration

Figure 139. Specification of detached breakwaters

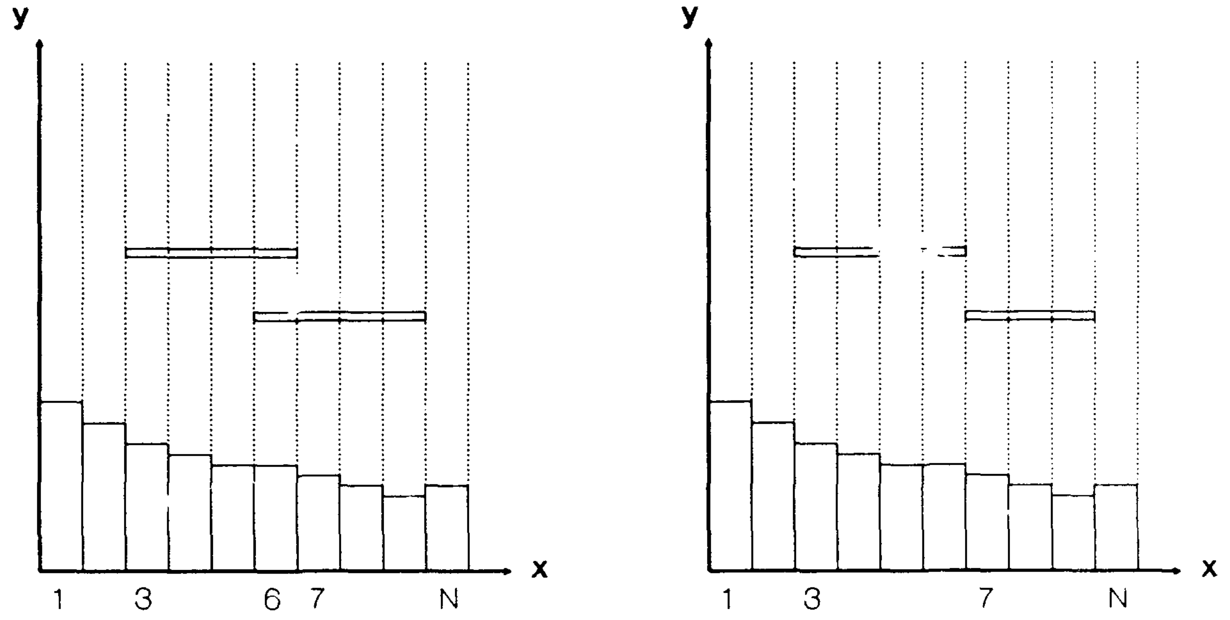
modeled as specified on Line A.4. **Remedial measure:** Omit the grid cell number from Line E.4 and the corresponding length and depth on Lines E.5 and E.6, respectively. In addition, the number of diffracting groins *NDG* on Line E.3 has to be corrected (decreased). If there are no more diffracting groins inside the subsection of beach, set *IDG* = 0 on Line E.1.

604. **ERROR. DIFFRACTING STRUCTURES OVERLAP. Reason for error:** Either a diffracting groin is specified on Line E.4 in the **START** file to be located in a cell between the two tips of a detached breakwater as specified on Line G.6, or two detached breakwaters overlap. **Remedial measure:** If a diffracting groin is placed inside a detached breakwater, the error is remedied by any of three alternatives: (a) replace the diffracting groin with a nondiffracting groin by transferring the appropriate values from Section E (Diffracting Groins and Jetties) to Section D (Nondiffracting Groins) in the **START** file; (b) extend the diffracting groin to attach to the detached breakwater and at the same time divide the detached breakwater into two detached breakwaters, specified on Lines G.3 and G.6-G.8, each attaching to the tip of the groin, together constituting a T-groin; or (c) move the diffracting groin so that it will no longer be inside the detached breakwater as specified on Line G.6 in the **START** file. If two detached breakwaters overlap, move one or both detached breakwaters to make the two structures end at the same cell wall, specified on Line G.6. Figure 140 illustrates the illegal case of two overlapping detached breakwaters and one possible correction.

605. The two examples in Figure 140 are characterized by: (a) illegal configuration; *IXDB* = 3, 7, 6, 9; or (b) corrected configuration; *IXDB* = 3, 6, 6, 9. Figure 141 illustrates the illegal case of a diffracting groin inside of a detached breakwater and the appropriate corrections.

606. The four examples in Figure 141 are characterized by: (a) illegal configuration; *IXDG* = 5; *YDG* = 50; *NDB* = 1; *IXDB* = 3, 6; *YDB* = 70, 70; (b) corrected configuration; *IXNDG* = 5; *YNDG* = 50; *NDB* = 1; *IXDB* = 3, 6; *YDB* = 70, 70; (c) corrected configuration; *IXDG* = 5; *YNDG* = 70; *NDB* = 2; *IXDB* = 3, 5, 5, 6; *YDB* = 70, 70, 70, 70; and (d) corrected configuration; *IXDG* = 6; *YDG* = 50; *NDB* = 1; *IXDB* = 3, 6; *YDB* = 70, 70.

607. **ERROR. END X-COORDINATE OF SEAWALL MUST BE GREATER THAN THE START X-COORDINATE. Reason for error:** *ISWBEG* is specified to be greater than *ISWEND* on Line H.3 in the **START** file. **Remedial measure:** Correct the numbers on Line H.3.



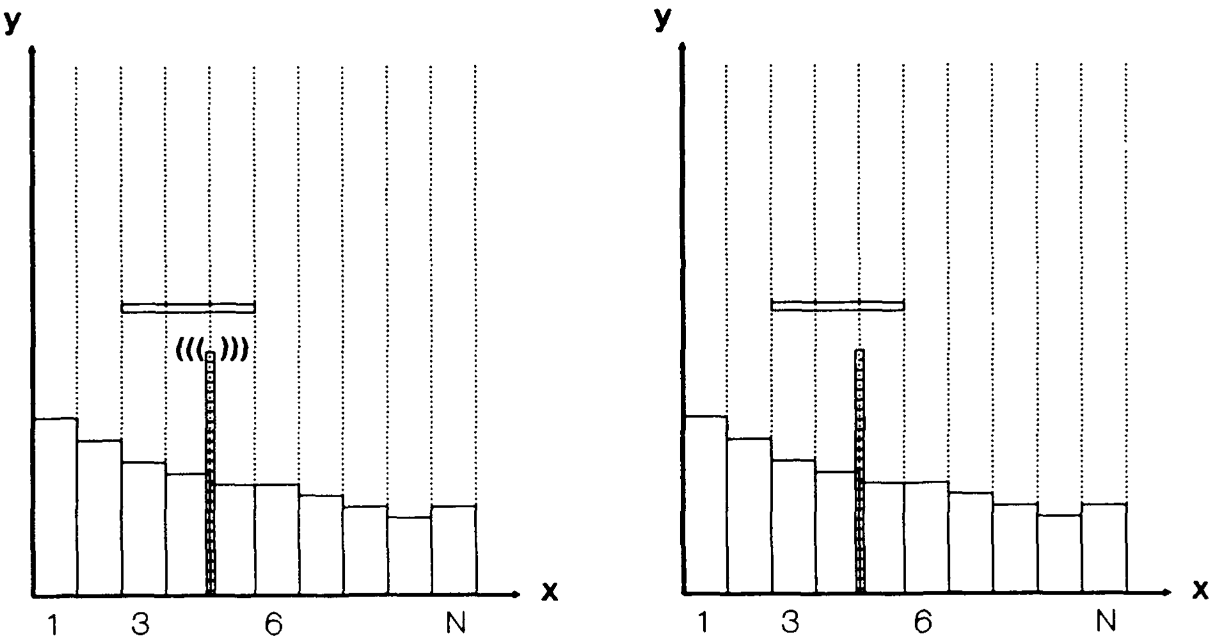
a. Illegal Configuration

b. Corrected configuration

Figure 140. Overlapping detached breakwaters

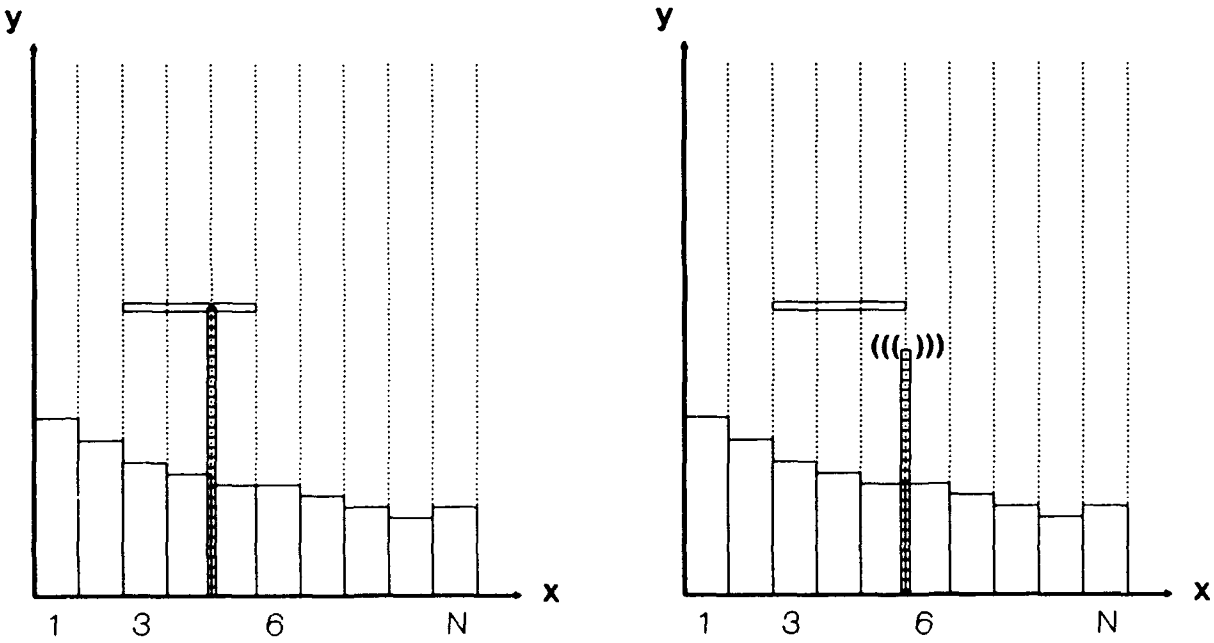
608. **ERROR FOUND IN DEPIN. FILES DEPTH (AND WAVES) CONTAIN TOO FEW VALUES. Reason for error:** An external wave transformation model is used to calculate the nearshore wave conditions along the nearshore reference line, as specified on Line B.3 in the **START** file. The end of the **DEPTH** file is prematurely encountered. **Remedial measure:** Make sure the data files contain four lines of header. If so, add more values to the **DEPTH** file, correct (increase) the number of shoreline calculation cells per wave model element on Line B.5, correct (decrease) the value of total number of calculation cells on Line A.3, *or* correct the grid cell numbers where the calculation starts and/or ends on Line A.4.

609. **ERROR FOUND IN KDGODA. KD CALCULATION DID NOT CONVERGE. Reason for error:** The search procedure for the diffracted breaking wave conditions has not converged within 20 iterations. If the error persists, it probably signals a significant flaw in the wave, depth, or structure configuration input data.



a. Illegal configuration

b. Corrected configuration (alternative 1)



c. Corrected configuration (alternative 2)

d. Corrected configuration (alternative 3)

Figure 141. Diffracting groin inside detached breakwater

610. **ERROR FOUND IN SHOIN. FILE SHORM CONTAINS TOO FEW VALUES. Reason for error:** The end of the **SHORM** file is prematurely encountered. **Remedial measure:** Make sure the data file contains four lines of header. If so, add more values to the file, change the value of the total number of calculation cells on Line A.3, or change the grid cell numbers where the calculation starts and/or the value of the calculation cells on Line A.4.

611. **ERROR FOUND IN SHOIN. FILE SHORL CONTAINS TOO FEW VALUES. Reason for error:** The end of the **SHORL** file is prematurely encountered. **Remedial measure:** Make sure the data file contains four lines of header. If so, add more values to the file, change the value of the total number of calculation cells on Line A.3, or change the grid cell numbers where the calculation starts and/or the value of the calculation cells on Line A.4.

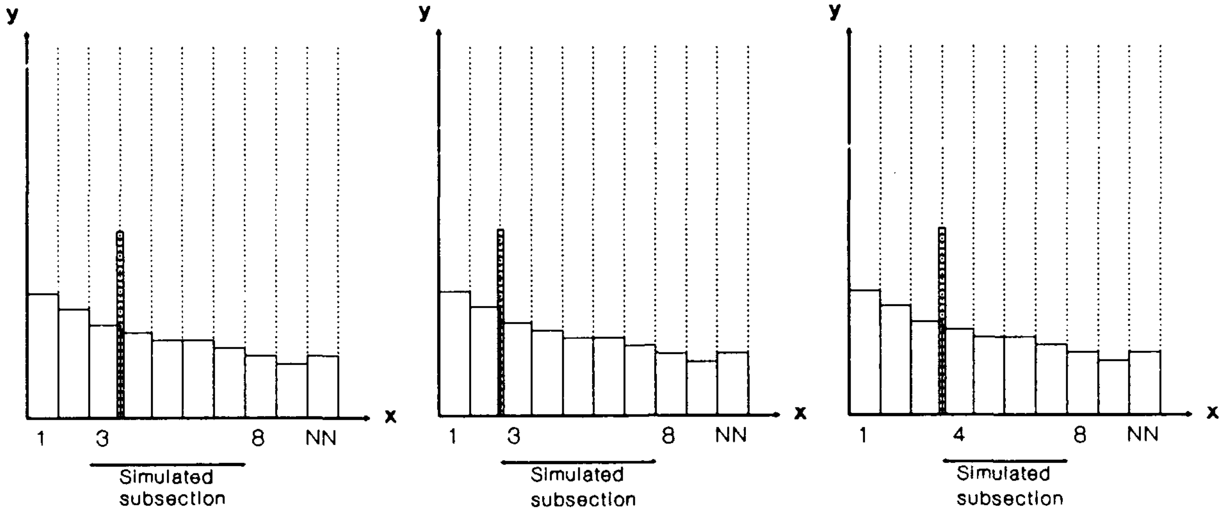
612. **ERROR FOUND IN SWLIN. FILE SEAWL CONTAINS TOO FEW VALUES. Reason for error:** The end of the **SEAWL** file is prematurely encountered. **Remedial measure:** Make sure the data file contains four lines of header. If so, add more values to the file, change the value of the total number of calculation cells on Line A.3, or change the grid cell numbers where the calculation starts and/or the value of the calculation cells on Line A.4.

613. **ERROR FOUND IN WAVIN. KEY NOT FOUND IN NEARSHORE WAVE FILE. Reason for error:** An external wave transformation model is used to calculate the nearshore wave conditions along the nearshore reference line, as specified on Line B.3 in the **START** file. An offshore wave identification key was computed from an event read from the **WAVES** file but was not found in the **NSWAV** file. **Remedial measure:** Identify the responsible offshore wave event by running the program NSTRAN (discussed in Part VI), and then perform the necessary nearshore wave transformation simulation or simulations.

614. **ERROR. GROIN CONNECTED TO A DETACHED BREAKWATER MUST BE CLASSIFIED AS A DIFFRACTING GROIN. Reason for error:** A detached breakwater is attached to a nondiffracting groin. **Remedial measure:** Replace the nondiffracting groin with a diffracting groin by transferring the appropriate values from Section D (Nondiffracting Groins) to Section E (Diffracting Groins and Jetties) in the **START** file.

615. **ERROR. GROIN NEXT TO GRID BOUNDARY. Reason for error:** A groin is placed one calculation cell away from either end of the numerical grid. **Remedial measure:** The error is remedied by any of four alternatives: (a) move the groin to the end of the grid; (b) move the groin at least one

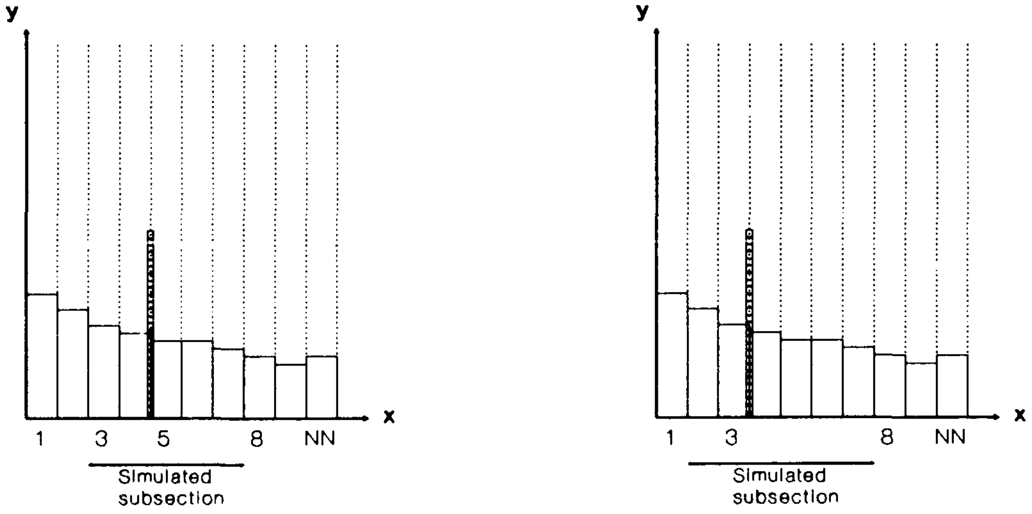
cell away from the end of grid; (c) move the end of the grid to the location of the groin; <u>or</u> (d) move the end of the grid at least one cell away from the groin. Figure 142 illustrates errors appearing near the left-hand boundary and possible remedial measures, which are easily translated to the right-hand boundary. As only a subsection, comprising *N* = 5 cells, of the total beach is included in the simulation, the number of cells for the entire grid is denoted by *NN*.



a. Illegal configuration

b. Corrected configuration

c. Corrected configuration



d. Corrected configuration

e. Corrected configuration

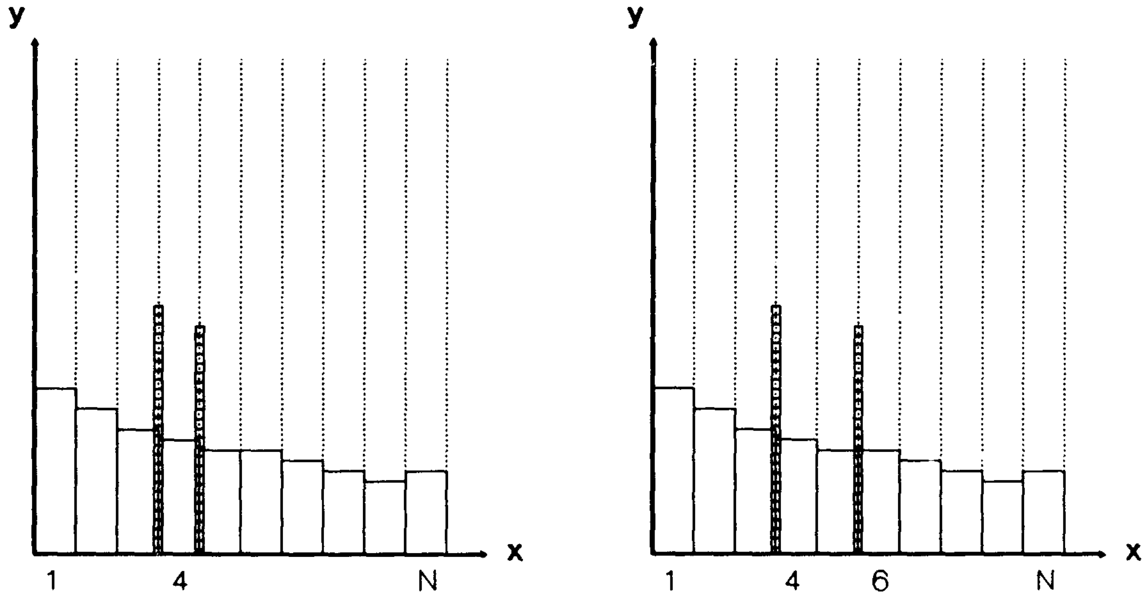
Figure 142. Groin next to grid boundary

616. The five examples in Figure 142 are characterized by: (a) illegal configuration; *ISSTART* = 3; *IXNDG* = 4; (b) corrected configuration; *ISSTART* = 3; *IXNDG* = 3; (c) corrected configuration; *ISSTART* = 4; *IXNDG* = 4; (d) corrected configuration; *ISSTART* = 3; *IXNDG* = 5; and (e) corrected configuration; *ISSTART* = 1; *IXNDG* = 3.

617. **ERROR. GROINS MUST BE SEPARATED BY AT LEAST TWO CALCULATION CELLS. Reason for error:** Two groins are placed with only one calculation cell between them. **Remedial measure:** Move one of the groins at least one cell farther away from the other groin. Figure 143 illustrates the error and an appropriate correction.

618. The two examples in Figure 143 are characterized by: (a) illegal configuration; *IXNDG* = 4, 5; and(b) corrected configuration; *IXNDG* = 4, 6.

619. **ERROR IN CALCULATION OF BREAKING WAVE HEIGHT. THE WAVE DID NOT BREAK. Reason for error:** The search procedure to obtain the undiffracted breaking wave conditions has not converged within 20 iterations. **Remedial measure:** Change what is probably an unphysical wave height with respect to the nearshore depth (or vice versa). If the error persists, it probably signals a significant flaw in the wave, depth, or structure configuration input.



a. Illegal configuration

b. Corrected configuration

Figure 143. Groins too close together

620. **ERROR. INCORRECT FORMAT FOR BEACH FILL DATES. Reason for error:** For *BFDATS* and/or *BFDATE* entered on Lines I.4 and I.5, respectively, the number of the day is greater than 31 or the number of the month is greater than 12. **Remedial measure:** Make sure each date is entered as one number in the format YYMMDD.

621. **ERROR. INCORRECT FORMAT OF SIMULATION START DATE. Reason for error:** For SIMDATS entered on Line A.6 in the **START** file, the number of the day is greater than 31 or the number of the month is greater than 12. **Remedial measure:** Make sure the date is entered as one number in the format YYMMDD.

622. **ERROR. SEAWALL IS OUTSIDE CALCULATION GRID. Reason for error:** The grid cell numbers for a seawall *ISWBEG* and/or *ISWEND*, as specified on Line H.3 in the **START** file, fall outside the subsection of the beach presently being modeled as specified on Line A.4. **Remedial measure:** If the entire seawall lies outside the subsection of beach, the error is remedied by setting *ISW* = 0, indicating there is no seawall present. If the seawall is only partially outside the subsection of beach, the error is remedied by setting *ISWBEG* on Line H.3 equal to the grid cell number where the simulated subsection starts, if the left side of the seawall is outside the grid, or by setting *ISWEND* equal to the grid cell number where the simulated subsection ends, if the right side of the seawall is outside the grid.

623. **ERROR. SIMULATION ENDING DATE MUST BE GREATER THAN THE STARTING DATE. Reason for error:** The ending date of the simulation *SIMDATE* as specified on Line A.7 in the **START** is earlier than the starting date of the simulation *SIMDATS* on Line A.6. **Remedial measure:** Make sure both dates are given as one number in the format YYMMDD.

624. **ERROR. SMALL GROIN OUTSIDE CALCULATION GRID. Reason for error:** The grid cell number for a nondiffracting groin, as specified on Line D.4 in the **START** file, fall outside the subsection of the beach presently being modeled as specified on Line A.4. **Remedial measure:** Omit the grid cell number from Line D.4 and the corresponding length on Line D.5. In addition, the number of nondiffracting groins *NNDG* on Line E.3 has to be corrected (decreased). If there are no more nondiffracting groins inside the subsection of beach, set *INDG* = 0 on Line D.1.

625. **ERROR. TOO MANY BEACH FILLS. Reason for error:** The number of beach fills *NBF* on Line I.3 is greater than the maximum allowed number as

specified in the PARAMETER statement in GENESIS. At present, the number is set to 50 for mainframe installations and to 10 for PC versions. **Remedial measure**: Reduce *NBF* accordingly. As *NBF* is changed, corresponding changes must be introduced on Lines I.4 and I.5. The number of beach fills can be reduced by splitting up the beach in portions and then performing the simulations for one portion of the beach at a time.

626. **ERROR. TOO MANY DETACHED BREAKWATERS. Reason for error**: The number of detached breakwaters *NDB* on Line G.3 is greater than the maximum allowed number as specified in the PARAMETER statement in GENESIS. At present, the number is set to 20 for mainframe installations and to 15 for PC versions. **Remedial measure**: Reduce *NDB* accordingly. As *NDB* is changed, corresponding changes must be introduced on Lines G.4 to G.9. The number of structures can be reduced by splitting up the beach in portions and then performing the simulations for one portion of the beach at a time.

627. **ERROR. TOO MANY DIFFRACTING GROINS. Reason for error**: The number of diffracting groins *NDG* on Line E.3 is greater than the maximum allowed number as specified in the PARAMETER statement in GENESIS. At present, the number is set to 20 for mainframe installations and to 15 for PC versions. **Remedial measure**: Reduce *NDG* accordingly. As *NDG* is changed, corresponding changes must be introduced on Lines E.4 to E.6. The number of structures can be reduced by splitting up the beach in portions and then performing the simulations for one portion of the beach at the time.

628. **ERROR. TOO MANY INTERMEDIATE PRINT-OUTS REQUESTED. Reason for error**: The number of requested print-outs *NOUT* on Line A.8 in the **START** file is greater than the maximum allowed number as specified in the PARAMETER statement in GENESIS. At present, the number is set to 30 for mainframe installations and to 15 for PC versions. **Remedial measure**: Reduce *NOUT* accordingly.

629. **ERROR. TOO MANY NON-DIFFRACTING GROINS. Reason for error**: The number of nondiffracting groins *NNDG* on Line D.3 is greater than the maximum allowed number as specified in the PARAMETER statement in GENESIS. At present, the number is set to 50 for mainframe installations and to 40 for PC versions. **Remedial measure**: Change *NNDG* accordingly. As *NNDG* is changed, corresponding changes must be introduced on Lines D.4 and D.5. The number of structures can be reduced by splitting up the beach in portions and then performing the simulations for one portion of the beach at a time.

630. **ERROR. TOO MANY SHORELINE CELLS. Reason for error:** The number of shoreline cells alongshore *NN* on Line A.3 in the **START** file is greater than the maximum allowed number as specified in the PARAMETER statement in GENESIS. At present, the number is set to 600 for mainframe installations and to 100 for PC versions. **Remedial measure:** Reduce *NN* accordingly.

631. **ERROR. WAVE DATA FILE STARTS LATER THAN THE SIMULATION. Reason for error:** The simulation starts later than the starting date of the wave data file as specified on Lines A.6 and B.8. **Remedial measure:** Make sure the date when the simulation starts *SIMDATS* is later than or the same as the date when the wave file starts *WDATS*. The respective dates must be given as one number in the format YYMMDD.

632. **ERROR. WRONG VALUE OF "ICONV". Reason for error:** A number other than 1 (meters) or 2 (feet) is given for the specification of input units *ICONV*. **Remedial measure:** Change *ICONV* accordingly.

Warning Messages

633. Warnings are given if a potentially undesirable condition is detected in the course of calculation. One of the more common warnings is that the stability parameter *STAB* (called R_S in the main text) has exceeded the value 5.0 during a particular time-step (see Part II). As opposed to errors, warning messages will not stop the model calculation. The messages contain information for the modeler to determine the seriousness of the problem, but it is up to the modeler to remedy the cause of the warning or decide not to change the model configuration.

634. **WARNING. INPUT WAVE ALREADY BROKEN. Reason for warning:** An external wave transformation is used as specified on Line B.3 in the **START** file. The wave height on the reference line exceeds the depth-limited wave height. **Remedial measure:** Either decrease the input wave height in the **WAVES** file or increase the reference depth in the **DEPTH** file.

635. **WARNING. SHORELINE CHANGE RESULTING FROM LONG Time-step IS _ IN CELL NO. _. Reason for warning:** GENESIS uses two independent algorithms for calculating the alongshore distribution of sand transport rates. These algorithms should, of course, give the same transport rate. However, for large values of the stability parameter or due to the presence of detached breakwaters, especially if they are transmissive, the two algorithms may give

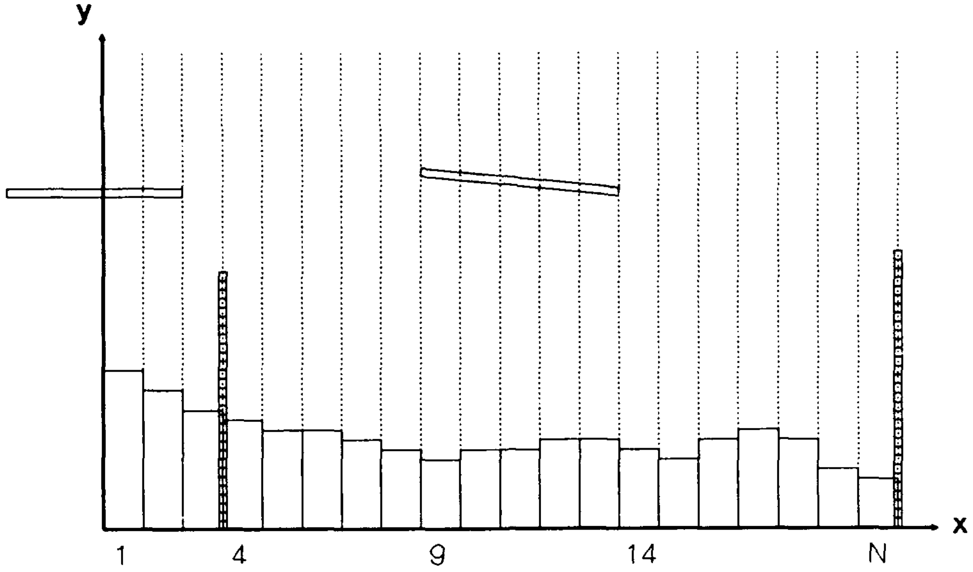
slightly different results. The warning is issued if, at any cell alongshore, the difference in the two calculated transport rates is greater than 0.0005 m^3/sec. At the end of the simulation, the accumulated error, in terms of shoreline change, is presented on the screen and in the **SETUP** file. **Remedial measure**: Decrease the stability ratio, which in turn is done by decreasing the time-step *DT* on Line A.5, by increasing the grid cell size *DX* on Line A.2, or by decreasing the wave height, either for specific values in the **WAVES** file or universally on Line B.1 in the **START** file. The waves should only be manipulated, for example, to investigate model sensitivity, the effect of extreme conditions or in hypothetical simulations. Extremely high angles of wave incidence may also produce this error.

636. **WARNING THE STABILITY PARAMETER IS ____.** **Reason for error**: The value of the stability parameter R_S is greater than 5 for at least one grid point. **Remedial measure**: Either decrease the time-step *DT* at Line A.5 or increase the grid cell size *DX* at Line A.3. Normally the time-step is reduced, at the cost of longer simulations, since considerable effort is involved in developing a grid.

637. **WARNING. UNPHYSICAL DEEPWATER WAVE STEEPNESS.** **Reason for error**: The input offshore wave data may be manipulated, for example, to investigate model sensitivity, or the effect of extreme conditions. This message is issued if waves are specified to have a steepness H_0/L_0 exceeding 0.142. GENESIS checks that the offshore wave steepness does not exceed the value of 0.142, and, if it does, reduces the deepwater wave height to satisfy this condition. **Remedial measure**: Decrease the wave height, either for specific values in the **WAVES** file or universally on Line B.1 in the **START** file, or increase the input wave period in the **WAVES** file.

Example Configurations

638. When working with GENESIS the first few times, the unexperienced modeler will find it a bit difficult to keep in mind what activities are located in cells and on cell walls, respectively. To remedy this problem, Figures 144 and 145 gives a comprehensive overview of the available coastal protection elements and how they are specified in the **START** file.

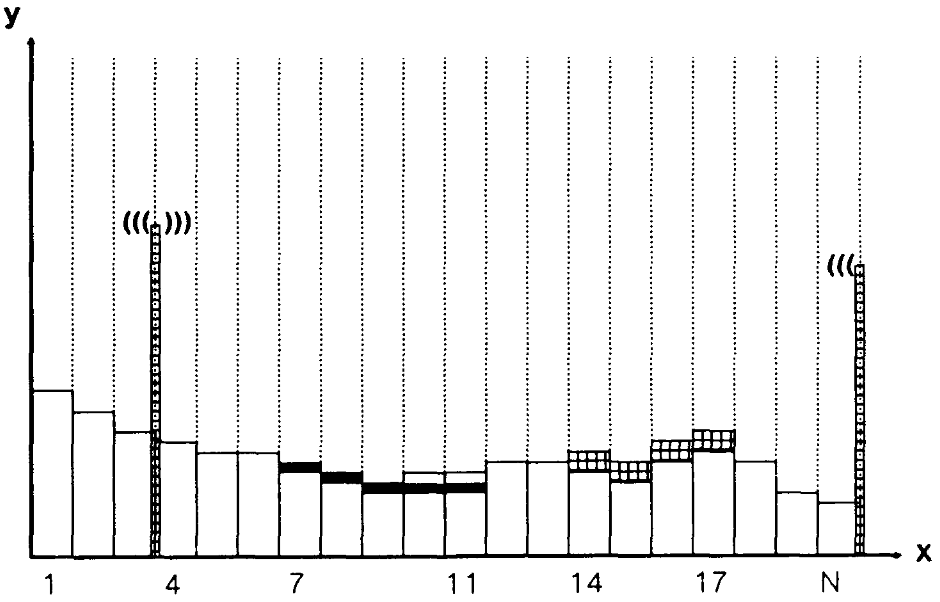


IXNDG = 4, N+1
YNDG = 150, 170

IXDB = 3, 9, 14
YDB = 200, 220, 200

IDB1 = 1
IDBN = 0

Figure 144. Specification of non-diffracting groins and detached breakwaters



IXDG = 4, N+1
IXDB = 4, 8

ISWBEG = 7
ISWEND = 11

IBFS = 14
IBFE = 17

Figure 145. Specification of diffracting groins, seawalls, and beach fills

PART VIII: INTERPRETATION AND PRESENTATION OF GENESIS RESULTS

Evaluation of Calibration and Verification Simulations

639. As described in the Technical Reference, calibration refers to the procedure of determining values of adjustable coefficients that allow the model to reproduce changes in shoreline position measured over a certain time interval. The term verification refers to the procedure of applying the model with the coefficient values determined in the calibration to reproduce changes measured over a time interval different from the calibration interval. Successful verification is taken to indicate that model predictions are independent of the simulation interval. In this procedure, it is assumed that project conditions are known through time. Therefore, the modeler must be aware of significant changes in the physical situation that might require changes in the model configuration or invalidate extension of the calibration results to the verification period. For example, if boundary conditions change between the calibration and verification periods, such as might be caused by extension of a jetty, these changes have to be incorporated in the verification. Similarly, if the sediment supply at the beach is nearly exhausted as compared with the calibration period that occurred, say, prior to the verification period, the value of the transport coefficient K_1 determined in the calibration will probably be inappropriate, requiring a second calibration for the more modern period. In general, it is recommended to verify in the most recent period possible.

640. Model predictions are conveniently, although somewhat subjectively, compared by graphical means. To provide an objective measure of goodness of fit, GENESIS calculates a single number called the "Calibration/ Verification Error" expressing the average absolute difference between calculated and measured shoreline positions at each grid point. However, as judgment of the goodness of fit in minimizing the discrepancy between calculated and measured shoreline positions may be biased positively or negatively for some portions of the beach than for others (for example, more weighting given to a beach with residential development as compared with a park with no development), an average mathematically based criterion must be checked by visual inspection of shoreline position. In such a case, the calibration/-

verification effort might focus on reproducing as accurately as possible shoreline changes along what are considered to be sensitive portions of the beach at the expense of good average agreement for the whole modeled reach.

641. Although the general aim of shoreline modeling is to simulate long-term change in shoreline position, tracking of volumetric changes often serves as a valuable and sensitive tool in the calibration/verification procedure. In addition, the performance of beach-fill operations is often evaluated in terms of volumetric changes rather than shoreline position change, and sand bypassing projects directly involve longshore sand transport rates. Gravens (1989, 1990) describes a GENESIS study involving bypassing at proposed entrance channel jetties in which calculated net and gross transport rates were essential in evaluating in the project alternatives. A case study documented in Part VIII of the Technical Reference gives extensive discussion on use of volumetric changes as a means of optimizing model parameters as well as in interpreting and evaluating modeling results in a detached breakwater project (see also, Hanson and Kraus (1991b) for a summary and further information on the case study).

642. In simulations involving long time intervals, the available wave data may not span the full simulation period. Instead, a shorter wave data file may be used and repeated. However, because the wave climate changes over time, the available wave data set may better represent the wave climate that existed during certain periods than other periods. To some extent, expected changes in wave conditions may be represented by adjusting the wave height and direction using the parameters *HCNGF*, *ZCNGF*, and *ZCNGA* as specified in the **START** file. Therefore, it may be necessary to use different values of these parameters for the verification period than were used for the calibration period. In special cases, other input parameter values may have to be altered in order to obtain good representation by GENESIS of shoreline change and longshore transport rates in a particular time period.

643. The problem of determining a representative wave data set for a verification interval was clearly demonstrated in the case study for Lakeview Park, Lorain, Ohio, as presented in the Technical Reference. Figure 146 plots measured volumetric changes within the study area using the October 1977 volume as reference. Because the volumetric change varied significantly with season, only the fall season values are displayed. Resources pertaining to this pedagogic study allowed development of only a 1-year record of wave data.

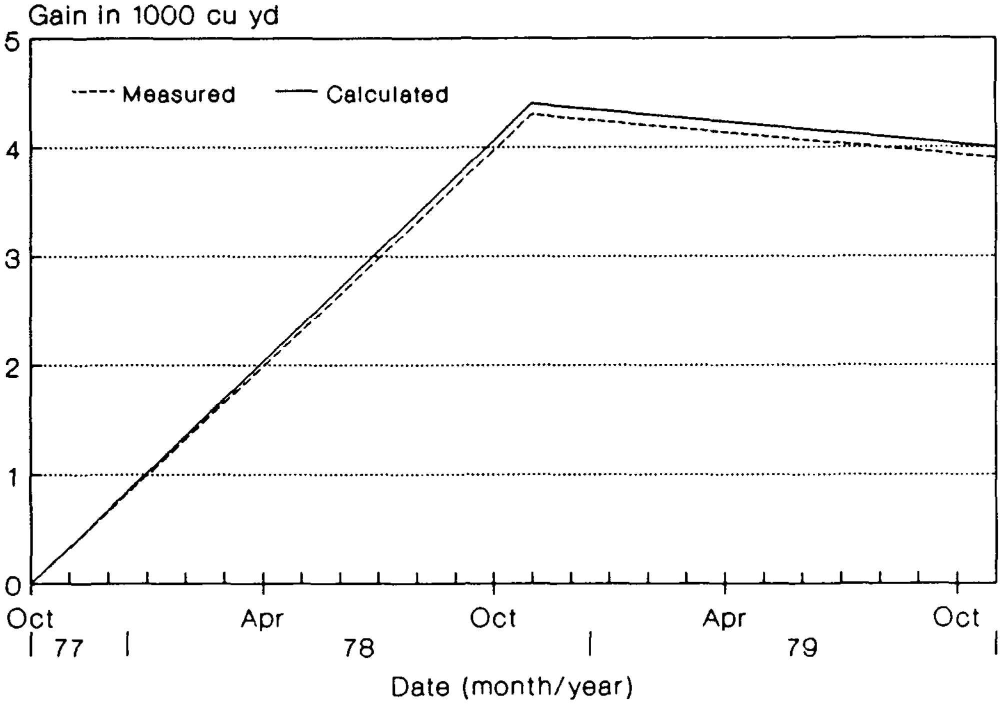


Figure 146. Volume changes at Lakeview Park, Lorain, Ohio

Also, aerial photographs showed that the length of the groin on the eastern boundary of the project and model grid changed over the time period studied. Therefore, it was doubtful that the same wave conditions that resulted in a net gain of about 4,300 cu yd of sand calculated for the calibration period would likely produce a net loss of about 300 cu yd for the verification period if all other input parameters were left unchanged.

644. Thus, in the modeling of this project, the distance *YG1*, which to a large extent controls the gated boundary condition at the east boundary and was specified in the **START** file, was indicated to be different for the calibration and verification periods, as determined from measurements of shoreline position and groin length on aerial photographs. In addition, the verification indicated that the value of the Wave Height Change Factor *HCNGF* should to be set to 1.1, resulting in a 10-percent increase in offshore wave height, to obtain good agreement between measured and calculated volumetric change as well as shoreline position. As seen from Figure 146, the agreement between the measured and the calculated volumetric changes was very good, as was the case for calculated shoreline positions, which is illustrated in the Technical Reference.

Variability in Coastal Processes

Problem of nearshore variability

645. Incident waves vary with many scales in space and time, and sediment particles of various sizes and shapes move along and across the shore controlled by laws that are not well known. The sediment is transported in complex three-dimensional circulation patterns of various spatial and time scales that contain a substantial degree of randomness caused by turbulence in the water motion. The beach and back-beach also exhibit distinct textural properties that vary alongshore, across-shore, and with time. In light of the profound variability of coastal processes, a single answer obtained with a deterministic simulation model must be viewed as a representative result that has smoothed over a large number of unknown and highly variable conditions.

646. Similarly, in the use of a deterministic model in a predictive mode, the driving force (waves) responsible for beach change will not be known exactly. Nevertheless, a time series of wave height, period, and direction must be forecast for use in prediction and can be considered as only one of many possible wave climates that might occur. Gravens, Scheffner, and Hubertz (1989) present a methodology for selecting a representative time series of wave conditions for use in shoreline change modeling.

Accounting for variability

647. Because of the great variability in the nearshore system, any one prediction of shoreline change cannot be accepted as the correct answer. A simple procedure used at CERC to estimate the effect of wave variability is to compute the standard deviation of the wave height and direction in the input wave time series and then adjust values of the input waves through a range defined by these deviations (Kraus and Harikai 1983; Kraus, Hanson, and Harikai 1984). GENESIS allows adjustment of wave height and direction by user-specified amounts through the parameters *HCNGF*, *ZCNGF*, and *ZCNGA* as specified in the **START** file. Wave period is not normally varied, but in certain applications, such as a situation involving long wave periods or a sea bottom with highly irregular features, the refraction pattern will be particularly sensitive to wave period. An adjustment of the wave period is performed by direct manipulation of the **WAVES** file. By varying the input wave height and direction within a physically reasonable range, a series of shoreline change predictions is made within which the actual change is expected to lie.

This procedure must be performed for all alternative designs and can involve many simulations.

648. A more sophisticated and rigorous way to estimate the effect of wave variability is through use of different hindcast time series. A statistically correct procedure for generating appropriate time series has recently been introduced by Borgman and Scheffner (1991). The time series thus obtained contain valid short-term and seasonal variations of the original data set. At CERC, this procedure is applied to the 20- or 30-year WIS hindcast time series pertaining to the particular project area to generate a number (typically, 5 to 20) of synthetic time series of needed length that preserve essential physical characteristics of the original time series. The same random time series are repeated for each alternative.

Shoreline position

649. Plots of shoreline positions can reveal data errors and shoreline change trends that are not discernible in a simple listing. As much as possible, the two surveys defining the calibration and verification intervals should correspond to the same season to minimize the effect of the seasonal cyclical displacement of the shoreline.

Offshore waves

650. Shoreline change is sensitive to wave direction, and this quantity is the most difficult to measure or estimate. If information on wave direction is not available, wind direction from a nearby meteorological station, buoy, US Coast Guard station, or airport may be useful, as well as consideration of possible fetches. The effects of the coastal boundary layer and daily and seasonal trends in wind speed, gustiness, and direction may have to be considered (Hsu 1988).

651. The wave input interval (time-step), statistics of the waves, and the period to be covered must also be determined. For shoreline change model calibration and verification, either hindcast data or the actual wave record occurring over the simulation interval are used, if available. In simulations involving long time periods and wide longshore extent, it may be impractical to handle a wave data file covering the full simulation period, depending on the computer equipment at hand. Instead, a shorter wave data file can be used and repeated, a capability provided by GENESIS and particularly useful in scoping mode applications. The shorter record is fabricated by comparing statistics of the total available wave data set (gage or hindcast) by year,

season, and month. Typical quantities to be preserved are average significant wave height and period, maxima of these quantities, average wave direction, and occurrence of storms. For example, a 5-year record might be composed of 1 year of more frequent storms (but not the extreme year, as that would not be representative), a year of relatively low waves, and 3 years judged to be "typical."

Bathymetry and profiles

652. If an external wave refraction model is used, hydrographic charts are needed to digitize the bathymetry onto the numerical grid. For users with sufficient computer hardware and related capabilities, bathymetric data for US coasts may be obtained on magnetic media from NOAA and then interpolated to the grid. The nearshore information from bathymetric charts can be compared with available beach profile surveys. Profile surveys often extend to a nominal depth of 10 m (30 ft), providing information to supplement the charts. If calibration and verification simulation intervals are in the far past (for example, in the 19th century), bathymetric data from that period should be used, not the present bathymetry. This application is especially pertinent if an inlet is included in the wave modeling grid, since ebb shoals can greatly change in time.

653. Beach profile data are used to estimate three quantities required to operate GENESIS: average height of the berm, depth of closure (seaward limit of significant sediment movement), and average profile slope.

654. Variation of model setup parameters is also part of the sensitivity analysis performed to estimate the dependence of the calculated result on model setup and empirical parameters, as discussed next.

Sensitivity Testing

655. Sensitivity testing refers to the process of examining changes in the output of a model resulting from intentional changes in the input. If large variations in model predictions are produced by small changes in the input, calculated results will depend greatly on the quality of the verification, which is usually in some degree of doubt in practical applications (owing to absence of a complete data for the verification). A second reason for conducting sensitivity tests concerns the natural variability existing in the nearshore system, as discussed in the previous section. No single model

prediction can be expected to provide the correct answer, and a range of predictions has to be made and judgment exercised to select the most probable or reasonable result. If the model is sensitive to small changes in input values, the range of predictions will be too broad and, in essence, provide no information. Experience has shown that GENESIS is usually insensitive to small changes in parameter values. Nevertheless, sensitivity testing should always be done.

Wave input errors

656. Measurement of wave height, period, and direction in the field is a difficult and expensive task. When using such data as input to a simulation model, it is important to be aware of the potential uncertainties involved in the measurements, as well as the effects any errors might have on model predictions. In this section, a simple sensitivity analysis is made to illustrate in a quantitative way the consequence of small errors or uncertainties in the breaking wave height and angle.

657. The change in the calculated value of the longshore sand transport rate Q is used as the sensitivity criterion, as this quantity is the primary variable for calculating shoreline change. The analysis is carried out to first order, which is expected to be accurate to within a few percent under typical conditions. At the location of wave breaking, the wave group velocity C_{gb} can be approximated as,

$$C_{gb} \approx C_b \approx \sqrt{gD_b} = \sqrt{gH_b/\gamma} \tag{34}$$

where C_b is the celerity (m/sec) of the breaking wave, γ is the breaker index ($\gamma = 0.78$), and g is the acceleration due to gravity (m/sec^2). This relation inserted into Equation 2 (given in Part II) with $a_2 = 0$ (for simplicity) and using the notation α as an abbreviation for α_{bs} yields:

$$Q = Q(H,\alpha) = (H^{5/2} \sin 2\alpha)_b \, a_1 \sqrt{g/\gamma} \tag{35}$$

658. The relative error in Q caused by a small uncertainty or error ΔH in the breaking wave height can be determined to first order in a Taylor series (omitting the subscript b for breaking):

$$\frac{Q(H\pm\Delta H,\alpha)}{Q(H,\alpha)} = \frac{(H\pm\Delta H)^{5/2}}{H^{5/2}} \approx 1 \pm \frac{5}{2}\frac{\Delta H}{H} \tag{36}$$

A similar analysis for the uncertainty or error in wave angle $\Delta\alpha$ gives:

$$\frac{Q(H,\alpha \pm \Delta\alpha)}{Q(H,\alpha)} = \frac{\sin(2\alpha \pm 2\Delta\alpha)}{\sin(2\alpha)} \approx \frac{2\alpha \pm 2\Delta\alpha}{2\alpha} \approx 1 \pm \frac{\Delta\alpha}{\alpha} \tag{37}$$

Consequently, if the two uncertainties or errors occur simultaneously, the relative error in Q would be:

$$\frac{Q(H \pm \Delta H,\alpha \pm \Delta\alpha)}{Q(H,\alpha)} \approx \left(1 \pm \frac{5}{2}\frac{\Delta H}{H}\right) \cdot \left(1 \pm \frac{\Delta\alpha}{\alpha}\right) = 1 \pm \frac{5}{2}\frac{\Delta H}{H} \pm \frac{\Delta\alpha}{\alpha} \tag{38}$$

Assuming the errors ΔH and $\Delta\alpha$ to be 10 percent each (and to have the same sign), the relative uncertainty or error in Q comes to 35 percent. Thus, it is seen that even a small uncertainty or error in specification of the breaking wave height and angle results in a significant uncertainty in the longshore sand transport rate. Viewing Equation 1 (given in Part II), it is seen that deviations of the same order will appear in the shoreline change calculation. With this in mind, it is reasonable to expect variations in model calibration parameters (particularly K) by a factor of 2 or more from one site application to another.

659. An illustration of the effect of changing magnitude of wave height and direction is given in Figure 147. The wave climate was held constant during the respective simulation with a period of 4 sec for a total simulation time of 100 hr. The shoreline response to increasing obliqueness of the incident waves(indicated by the thick and thin solid lines in Figure 147) shows remarkable linearity. The maximum shoreline advance close to the groin and the accumulated volume almost exactly double as the wave angle is doubled from 10 to 20 deg. This increase confirms findings in Larson, Hanson, and Kraus (1987) that the sand transport relation is relatively linear with respect to wave angle if the breaking wave angle is less than about 30 deg.

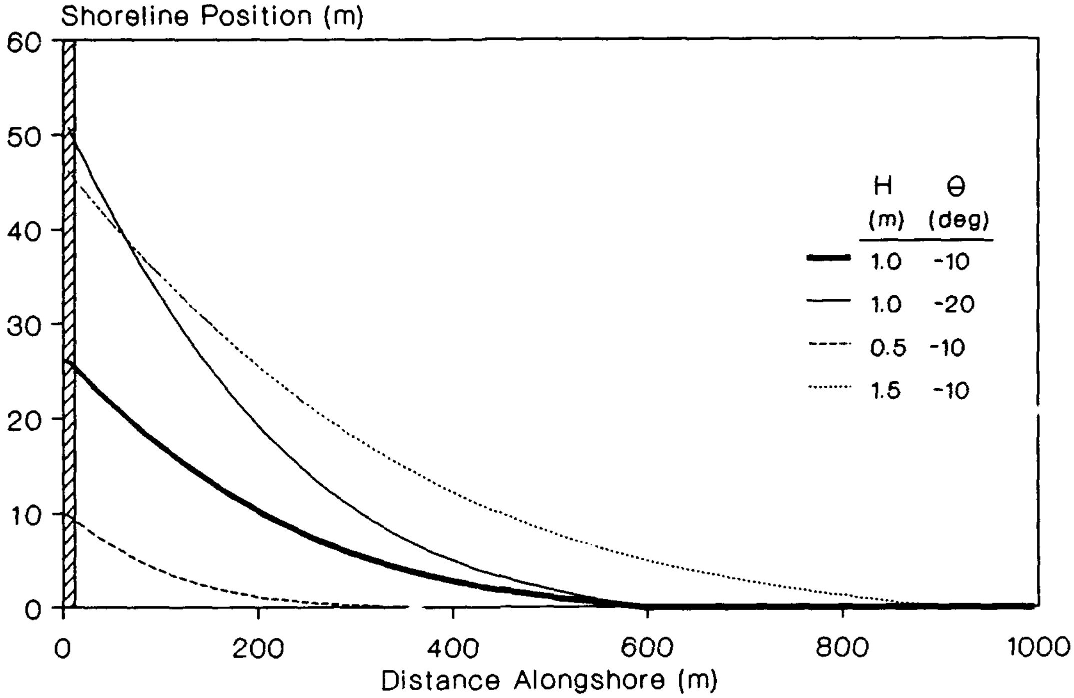


Figure 147. Influence of wave height and direction on shoreline change near a groin

660. Not unexpectedly, variations in the wave height (illustrated by the thick solid, the dashed, and the dotted lines in Figure 147) show a much greater degree of nonlinearity. Doubling of the wave height from 0.5 to 1.0 m results in an increased shoreline advance near the groin by a factor of 2.7 and an increased accumulated sand volume by a factor of about 5. An increase in wave height by 50 percent doubles the shoreline advance and accumulated volume (beach plan surface area).

661. An illustration of the effect of changing magnitudes on wave period is given in Figure 148. The wave climate was otherwise held constant during the respective simulation with a wave height of 1 m, normally incident wave crests, and a total simulation time of 100 hr.

662. As seen from Figure 148, increasing wave period results in a larger salient behind the structure segment. The explanation for this phenomenon is given in Figure 149, which illustrates the associated wave height distributions inside the detached breakwater corresponding to the three simulations in Figure 148. In Figure 149, the wave height distributions associated with waves entering from the sides of the breakwater are shown

separately. The longer waves shoal sooner or more seaward as compared with the shorter waves, resulting in a greater breaking wave height. This occurrence means that for longer waves, the first term in the transport Equation (K_1 term) will transport more sand into the area behind the breakwater. Also, according to the method of Goda, Takayama, and Suzuki (1978) for calculating diffraction of random waves, the wave height for diffracting longer period waves decreases more steeply than that of shorter period waves. This decrease means that for the longer waves, the second term in the transport equation (K_2 term) with a higher $\partial H/\partial x$-value, will transport more sand into the area behind the breakwater.

Wave variability

663. Another basic property of a wave time series, besides the mean value as discussed, is the standard variation. As mentioned previously, the standard deviation can be used as a measure of wave variability and is related to the probability and magnitude of extreme events. In a forecasting situation, it is therefore of great importance to investigate the effect of changing the variability (for example, through the standard deviation) on the resulting shoreline change.

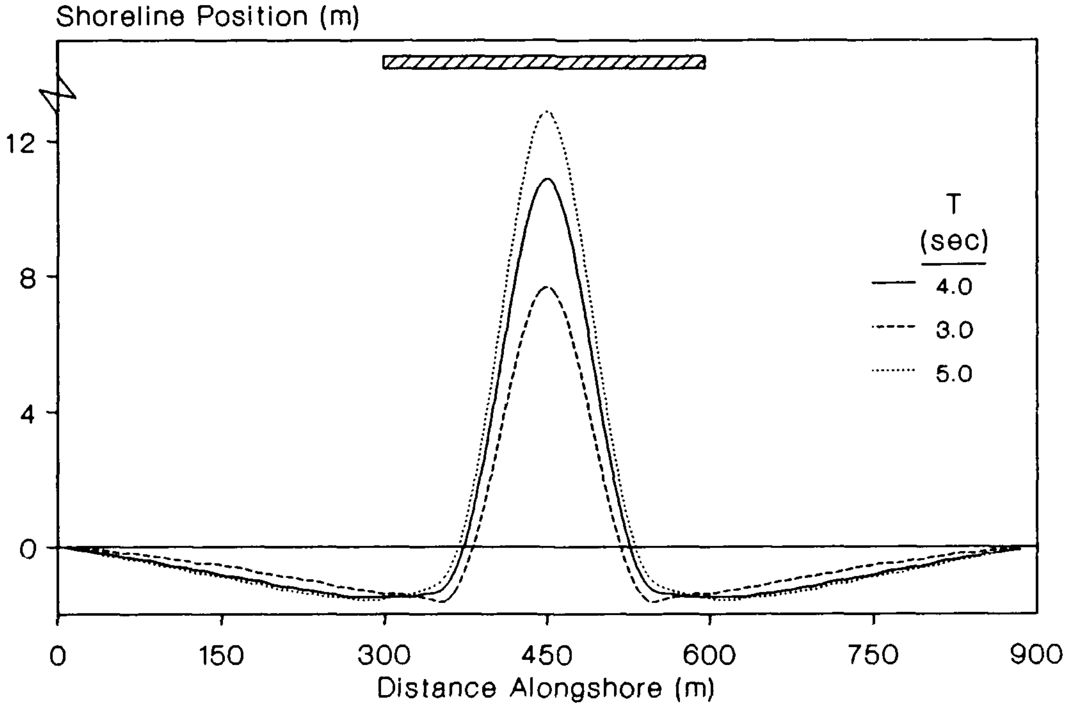


Figure 148. Influence of wave period on shoreline change behind a detached breakwater

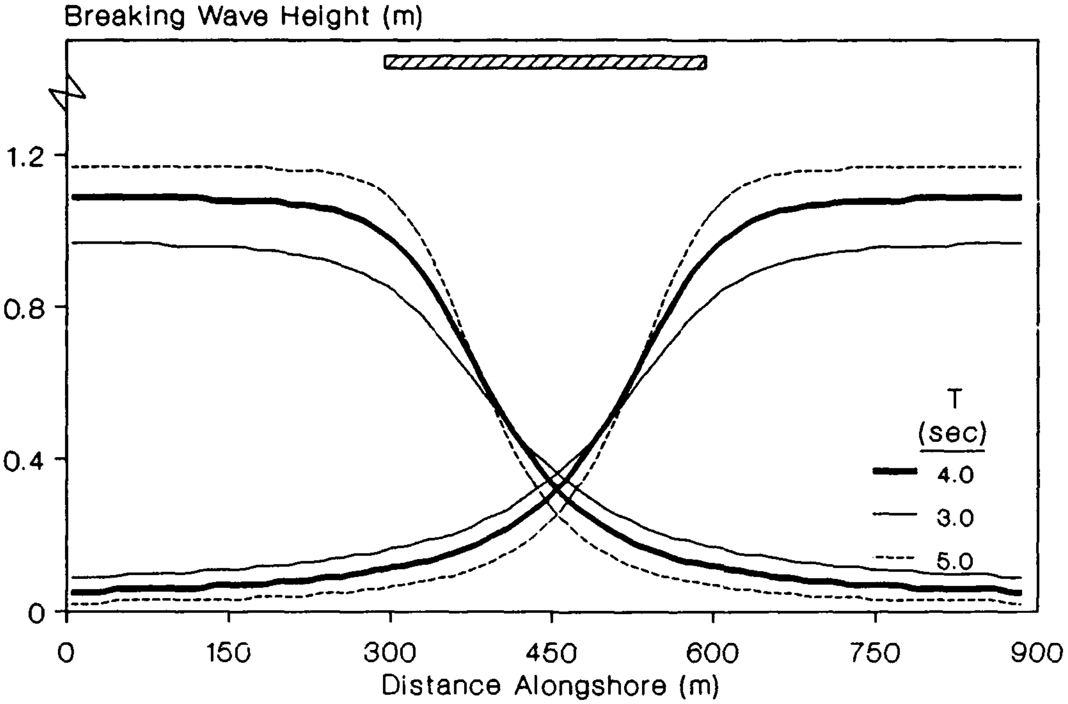


Figure 149. Influence of wave period on wave height distribution near a detached breakwater

664. Figure 150 illustrates an example showing accumulation behind a 200-m-long detached breakwater located 200 m from an initially straight shoreline. The mean values characterizing the wave climate are $T = 4$ sec, $H = 1$ m, and $\theta = 0$ deg. The thin solid line represents the result with a constant wave climate with T, H, and θ at their mean values. In the other three simulations, all wave parameters except one, denoted by the subscript on the standard deviation symbol σ, were held at the same (mean) value.

665. As seen from Figure 150, allowing the wave period T and height H to vary has very little effect on the shoreline response behind the breakwater. In contrast, increased variability in the wave direction dramatically increases accumulation behind the structure. The main reason for this increase is that moderate variation of T and H around their respective mean values merely redistributes the incident wave energy in time but does not significantly change the magnitude of the total longshore wave energy flux. A deviation of the wave direction from normal in any direction, however, increases the longshore component of wave energy flux, which in turn causes more sand to move alongshore. Because of shadowing by the structure, sand

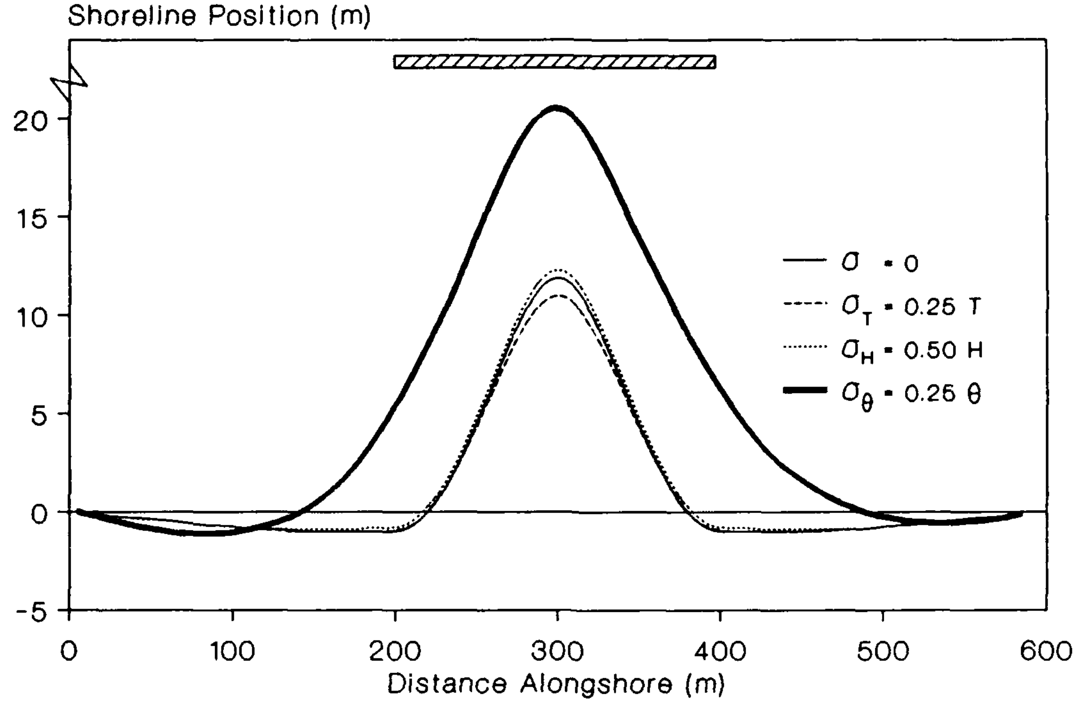


Figure 150. Influence of wave variability on shoreline change behind a detached breakwater

tends to be transported into rather than out of the shadow region, producing large growth of the salient.

Boundary conditions

666. As described in the Technical Reference, GENESIS allows implementation of two types of lateral boundary conditions, a "gated" boundary and a "pinned-beach" boundary. The default condition is the pinned beach; if a groin, jetty, or shore-connected breakwater is not placed on a boundary, pinned beach will be specified, allowing sand to move freely across the boundary from both sides. If a structure is placed on the boundary, the amount of sand entering or leaving the grid is determined by the distances from the shorelines on either sides of the groin to the seaward end of the groin, the beach slope near the groin, and the permeability of the groin. Needless to say, the location and specification of the lateral boundaries influence the simulated shoreline response along the entire project. The degree of this influence is analyzed through sensitivity testing.

667. Pinned-beach boundary. The pinned-beach boundary can be used in a situation where a long sandy beach is located far from the project site and

has not or is not expected to change greatly in position. However, care should be taken not to place the pinned boundary too close to the project. The true interpretation of the boundary condition is that "the beach does not want to move," but by placing the boundary too close, the implementation of the condition will be that "the beach is not allowed to move." The independence of the result on this distance is checked by varying the distance. An example of such an analysis is shown in Figure 151.

668. Figure 151 displays three simulations of accretion updrift of a 200-m-long jetty connected to a 100-m-long detached breakwater (spur). The constant wave conditions were T = 4 sec, H = 1 m, and θ = -10 deg. The pinned beach is placed far enough from the jetty to make the location of the simulated beach independent of the distance for the time period of the calculation. More cells give a more accurate result, but cost more time and/or money to perform the simulations. As seen in the figure, the difference in calculated shoreline position between placing the boundary 600 and 900 m from the jetty is marginal. In contrast, placing the boundary only 300 m from the jetty is seen to hold the shoreline back significantly. Thus, placing the boundary

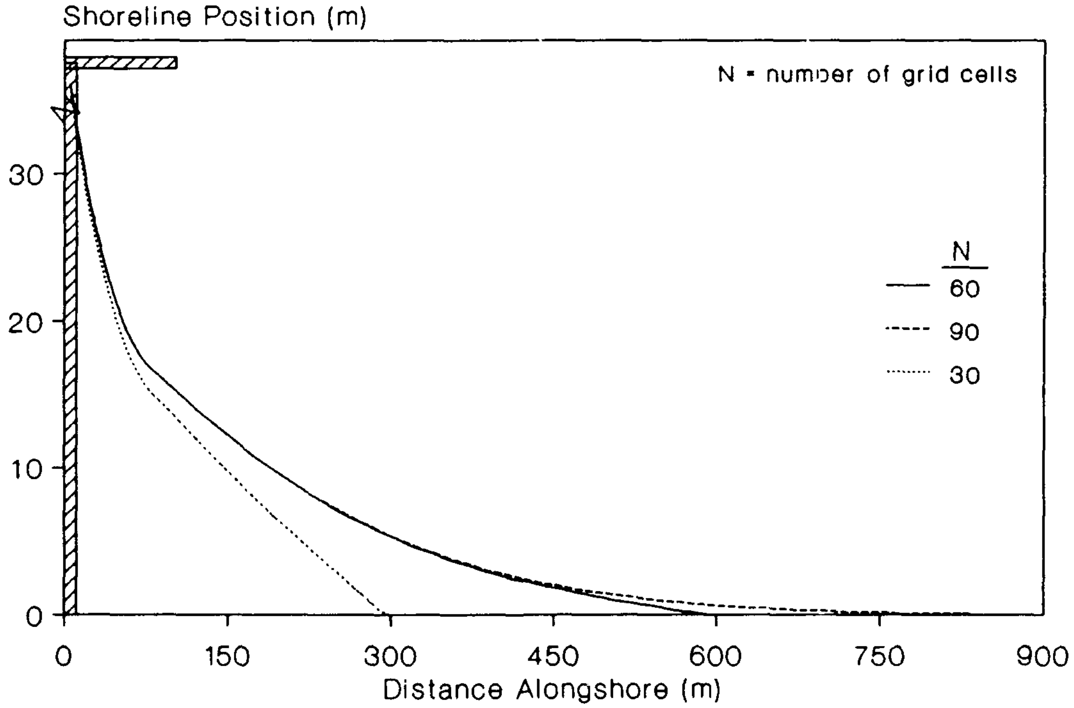


Figure 151. Influence of location of a pinned beach on shoreline change near a groin

600 m from the jetty seems like a good compromise for the particular simulation interval involved.

669. Gated boundary. The gated boundary condition offers the modeler considerable flexibility in controlling the rate of sand transport across a boundary. Apart from representing groins and jetties on the two lateral boundaries of a grid, this boundary condition is often used to represent relatively unknown transport rates past headlands and other areas of a beach where limited amounts of sand are available or where the physical situation is obscure (for example, by submarine ramps extending from cliffs, rocks, and submarine canyons close to shore). Assuming the gated boundary is implemented at cell wall 1, the amount of sand entering the grid is controlled by the distance Y_{G1} from the shoreline to the seaward end of the groin/jetty outside the grid (c.f. Figure 20 in the Technical Reference) and the permeability *PERM* of the groin. On the same boundary, the amount of sand leaving the grid is controlled by the distance $GL - y_1$ measured from the location of the shoreline at the particular time-step to the seaward end of the groin/jetty inside the grid, where *GL* is the groin length and y_1 is the shoreline location in the first cell; the beach slope *SLOPE2* near the groin; and the permeability *PERM* of the groin.

670. Figure 152 illustrates the effect of varying the parameters controlling the sand transport across the gated boundary. The wave climate is represented by constant wave period $T = 4$ sec and wave height $H = 1$ m. The wave direction is normally distributed around $\theta = 0$ deg with a standard deviation of 25 deg. This distribution means that, along unobstructed portions of beach parallel to the x-axis, there are considerable and almost equal amounts of sand being transported in either direction.

671. The thick solid line represents a case with a distance of 50 m from the tip of the groin to the shorelines on either side of the structure. With a beach slope of 1:100, the depth at the groin tip is 0.5 m. Thus, in this case, a considerable portion of sand is expected to bypass the structure in either direction because the waves break at a depth greater than the tip of the structure, resulting in only minor shoreline change near the groin. This situation is confirmed by the simulation.

672. By increasing y_{G1} to 200 m, virtually no sand will be transported onto the grid, whereas sand transport out of the grid is the same as in the previous example. This configuration will result in a loss of sand over the

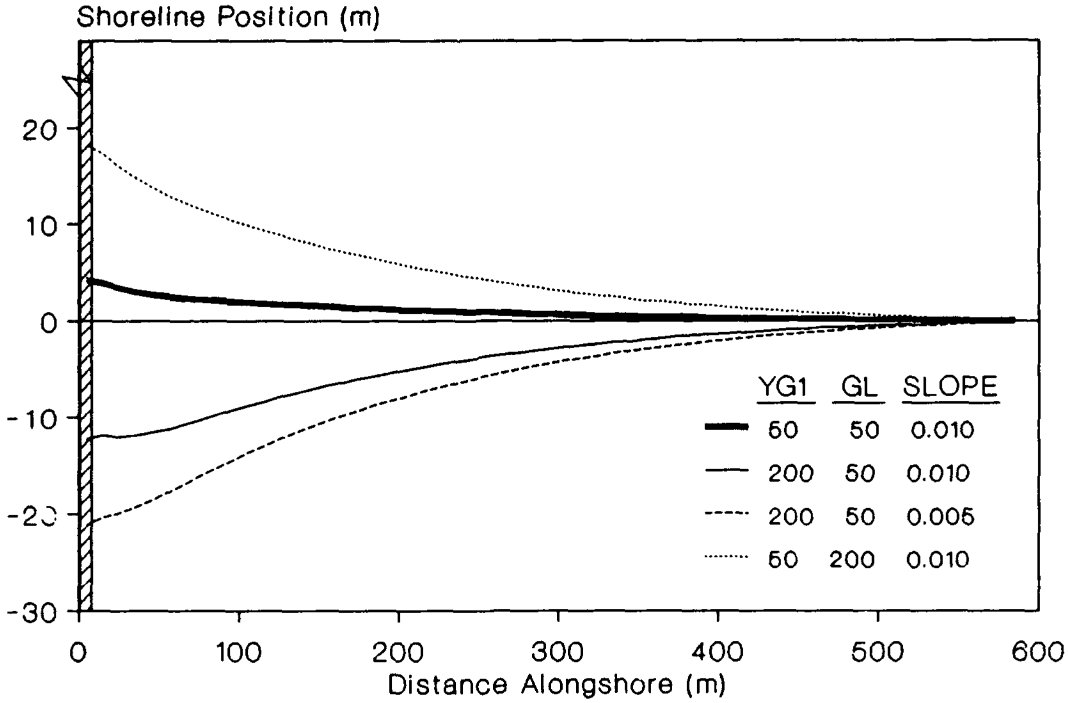


Figure 152. Influence of gated boundary parameters on shoreline change near a groin

gated boundary and associated erosion, as illustrated by the thin solid line in the figure. A more gently sloping bottom, represented by a dashed line in the figure, will allow more sand to bypass the tip of the structure and off the grid. However, the distance from the groin tip to the shoreline outside the grid is still too long to allow any significant sand transport onto the grid for the particular wave conditions. Thus, erosion near the groin will increase. In the final example in this series, shown as a dotted line, y_{G1} is reset to 50 m, and the groin length is increased to 200 m. In this case, sand may enter but not leave the grid, resulting in considerable accretion near the groin.

673. As shown by the examples, through the gated boundary condition, transport onto and off a grid may be varied independently to control the sand transport across the boundary. For the case of a short, nondiffracting groin, the gated boundary condition is expected to fairly well represent conditions in the prototype, for which case y_{G1} may be taken directly as the true distance. However, for long, diffracting jetties, diffraction outside the grid is not taken into account, and this condition may have to be compensated

for by changing the distance y_{G1} from its true value. If the gated condition is used to represent headlands or a situation of limited sand availability, y_{G1} does not have a true correspondence in the prototype, but is an artifice that allows control of transport rates across the boundary. The appropriate target transport rates to be simulated in this situation will depend on experience at the coast, sensitivity tests with the gated boundary conditions, and judgment. The effect of varying the groin permeability is discussed later in this chapter.

Wave sequencing

674. Even if the statistical properties of the future wave climate, such as means, extremes, and seasonal trends, have been well estimated (which is a difficult task in itself), the exact sequence of future events cannot be known. However, as shown by Le Méhauté, Wang, and Lu (1983), the calculated shoreline position is sensitive to the order of wave angle sequence, particularly for open beaches not affected by diffractive structures. Therefore, when forecasting shoreline evolution for project design, the strategy has evolved in modern shoreline change modeling procedure to predict a range of possible future shoreline configurations, rather than a single line. This prediction is accomplished by using waves with different sequences and, possibly, different statistical properties, resulting in a band or envelope of shorelines within which the "true" shoreline position can be expected to lie (Hanson and Kraus 1986a).

675. In order to investigate the influence of wave angle sequence in GENESIS, shoreline evolution near a groin is simulated. For this objective, a set of 320 wave triplets (H, T, θ) was produced; this set was used to produce all shorelines shown in Figure 153. Only the relative order of the triplets was varied, thus holding the total incident wave energy flux constant. In all runs, the breaking wave height was constant (1.4 m), and the breaker angle was varied. The total simulation time was 480 hr.

676. As an attempt to obtain the maximum impact of resequencing, two unrealistic, ordered wave sequences were examined (Hanson and Kraus 1986a). In the first set, the wave angle increased linearly from -15 to 15 deg, and in the second the angle decreased linearly between the two limits. As seen, the two sets of waves result in fundamentally different shorelines. In addition, a large number of shorelines were simulated using wave sets obtained with a Monte-Carlo simulation technique to resequence the original data set. Four of

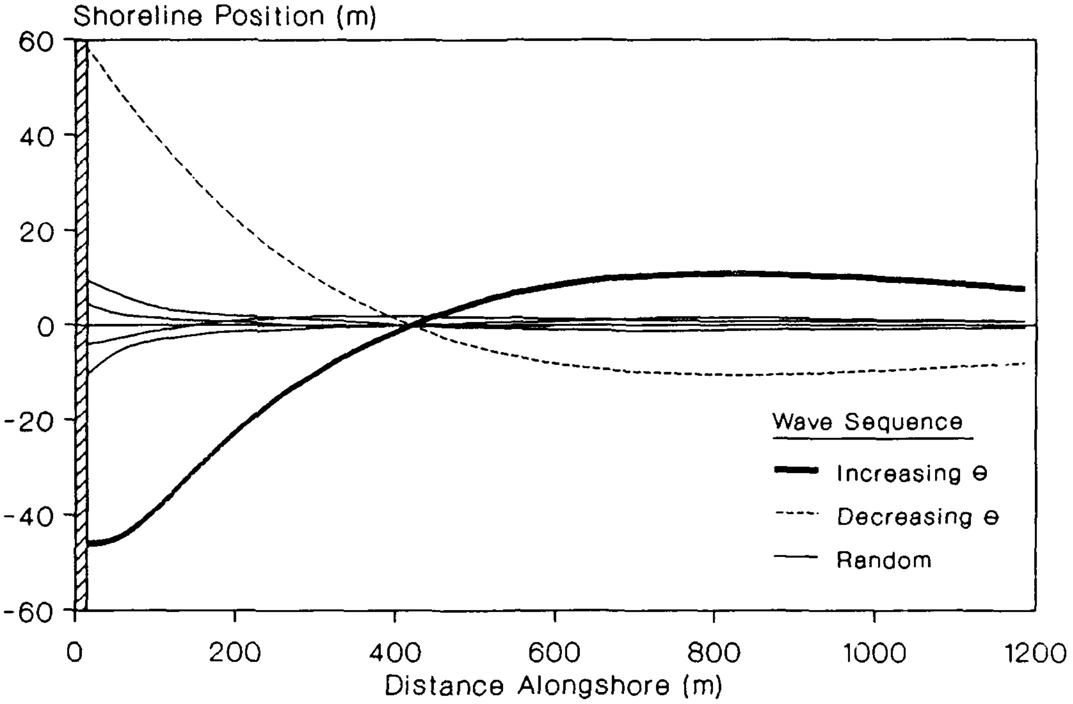


Figure 153. Influence of wave angle sequence on shoreline change near a groin

these are shown as thin solid lines in the figure. Shoreline change for these simulations was rather small, as expected, because the angle varied randomly around its mean value ($\theta = 0$).

677. The analysis can be extended to include variations in wave height. In the simulations shown in Figure 154, the breaking wave angle was held constant ($\theta = -15$ deg), and the breaking wave height was varied between 0 and 1.4 m, thus having the same average height (but not the same energy flux) as in the previous case. The figure shows small differences between the two extreme sequences with the wave height increasing and decreasing linearly between the two limits, consistent with the observation made by Le Méhauté, Wang, and Lu (1983). As clearly demonstrated by the dashed line, the average situation cannot be represented by the average wave height. In this simulation, the total energy flux is less than for the other cases shown, explaining why the shoreline lies well behind the others. If, instead, a constant wave height corresponding to the mean wave energy flux is used, a shoreline (dotted line) falling between the two extremes is produced. Numerous Monte-Carlo

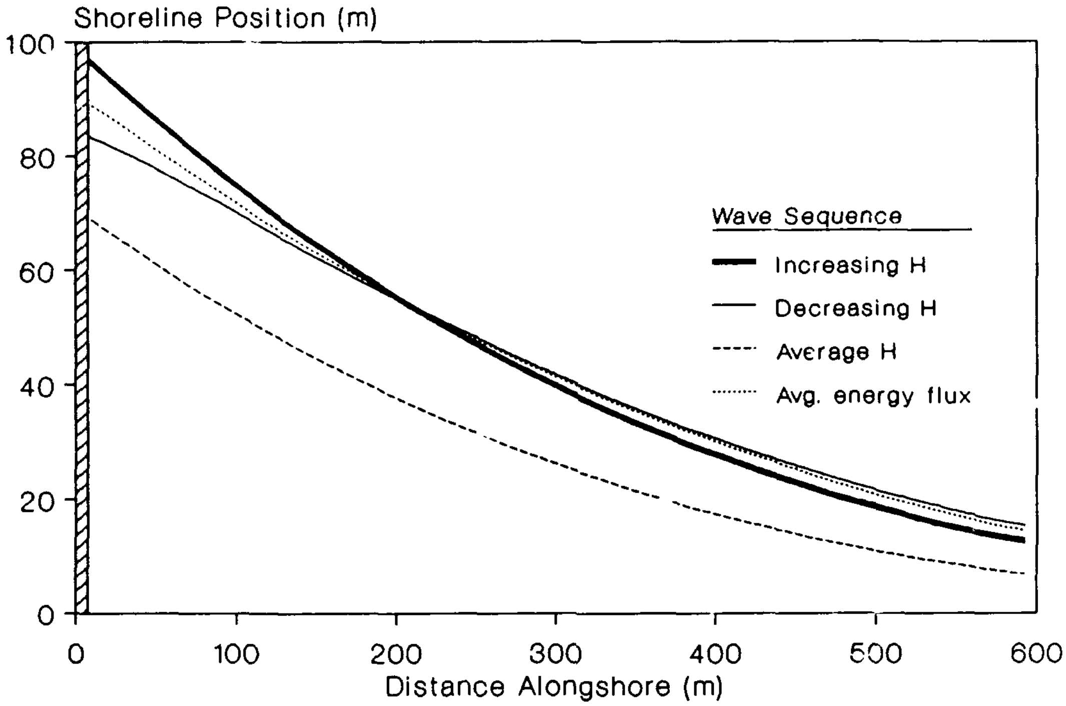


Figure 154. Influence of wave height sequence on shoreline change near a groin

simulations were also made, but since they all fell almost on top of the solid and dotted lines, they were not included in the figure.

678. As a conclusion, shoreline evolution is sensitive to wave angle sequence, whereas for the wave height, an energy flux weighted mean can be used, provided that the wave height is only weakly dependent on wave direction. Because wave direction often has a seasonal trend, care should be taken not to reduce a seasonal bias in the calibration process.

Discretization in space and time

679. The size *DX* of the calculation cells is determined on the basis of a compromise between computer execution time, memory, usage charge, and the required spatial resolution. The time-step *DT* is determined in a similar way. In addition, the requirement of updating the waves with a certain periodicity, as well as limited information about the waves will also control choice of *DT*. Typically, the value of *DX* is fixed early in the study in digitization of the shoreline position and placement of structures and beach fills on the grid, leaving only *DT* to be conveniently varied according to requirements on numerical and physical accuracy, and computation time.

680. In addition to these considerations, for any type of numerical model, it must in principal be assured that the calculated results are grid and time-step independent, although in practice for typical projects conventional and common-sense values are used without performing such an analysis. In order to investigate the sensitivity of model results to the size of the space and time-steps, a series of calculations was performed. In all cases, the stability parameter was held constant at $R_s = 0.26$, and the calculation time in each simulation was 480 hr. Other parameters were varied according to Figure 155, which shows only that part of the beach closest to the groin. In all runs, the breaking wave height and angle were held constant at 0.7 m and -15 deg. The run with $DT = 6$ hr and $DX = 60$ m represents typical values of DX and DT for field applications for modeled reaches on the order of a few kilometers or more. For these simulations, the differences are very small even for extremely large time-steps, indicating negligible grid and time-step dependence.

681. However, for simulations involving transmissive detached breakwaters, dependencies on time-step and grid-cell sizes could be an important

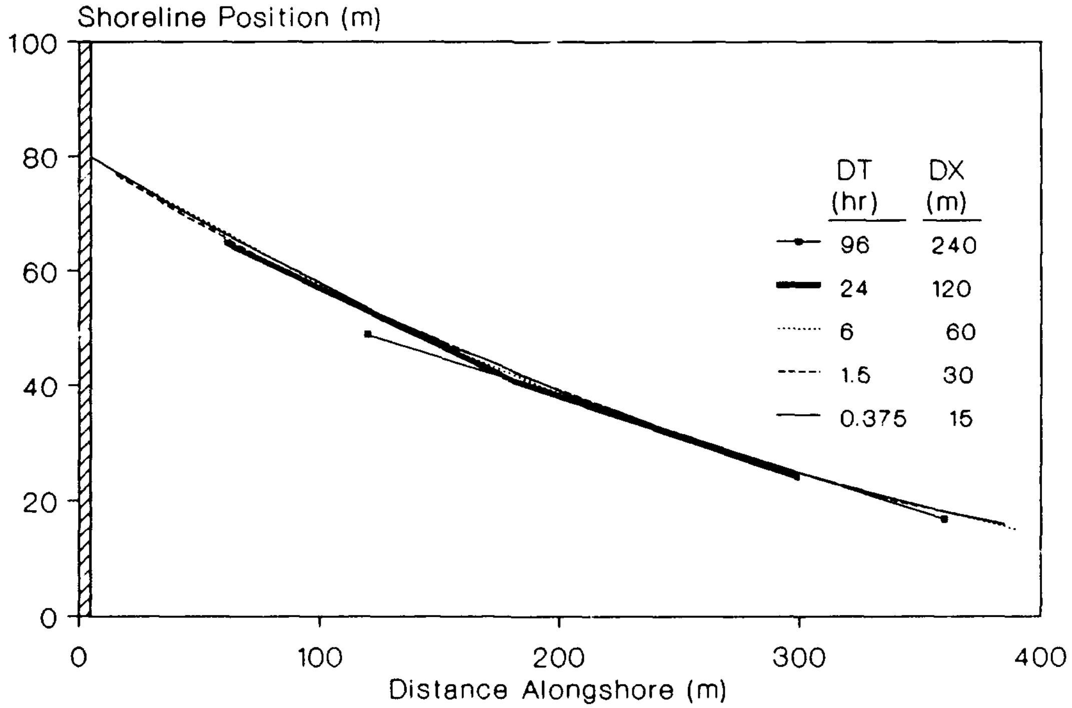


Figure 155. Influence of grid size and time-step on the calculated accumulation updrift of a groin

factor. In such cases, a sensitivity analysis may have to be performed before final determination of *DX* and *DT* can be made. As stated in Part VII of the Technical Reference, it is recommended that nine grid points (eight cells) be placed behind detached breakwaters and between groins in design mode simulations and five points (four cells) in scoping mode. The larger value will usually put a severe restriction on the size of the allowable time-step, particularly if transmissive breakwaters are involved, since the numerical solution scheme is almost explicit for situations involving transmissive breakwaters.

Groin permeability

682. Groins typically allow sand to pass through or over them, but it is difficult to quantify the sand permeability of such structures. Therefore, the sensitivity of GENESIS to variations in the value of this parameter is investigated. Here, a series of simulations are presented to illustrate the influence of permeability on the sand accumulation updrift of a groin exposed to 0.7-m-high breaking waves with an angle of -15 deg to the x-axis for 480 hr. The result of the simulations is displayed in Figure 156.

683. If the longshore sand transport rate were independent of the shoreline orientation $\partial y/\partial x$, the difference in shoreline location close to the groin would be proportional to the difference in permeability. However, in the course of the beach accreting near the groin, the change in shoreline orientation and bottom contours will feed back to influence wave refraction. Due to associated changes in the wave direction and height near the groin, the sand transport rate will decrease with distance from the groin. As a result, the decrease in sand accumulation caused by the permeability is partly compensated by the reduced rate at which the sand transport rate decreases updrift of the groin. This situation is confirmed in Figure 156, where the differences between the runs are very small. If diffraction were omitted, the eroded shoreline downdrift of the groin would appear antisymmetric to the accreted shoreline on the updrift side.

684. Fortunately, although a precise determination of groin permeability is not possible to make, it is concluded that the present implementation of permeability in GENESIS is rather insensitive to changes in this value. At the same time, it is noted that the effect of groin permeability in GENESIS is dependent on the representation of the groin as a gated boundary condition. At present, the amount of sand allowed to pass through a groin is

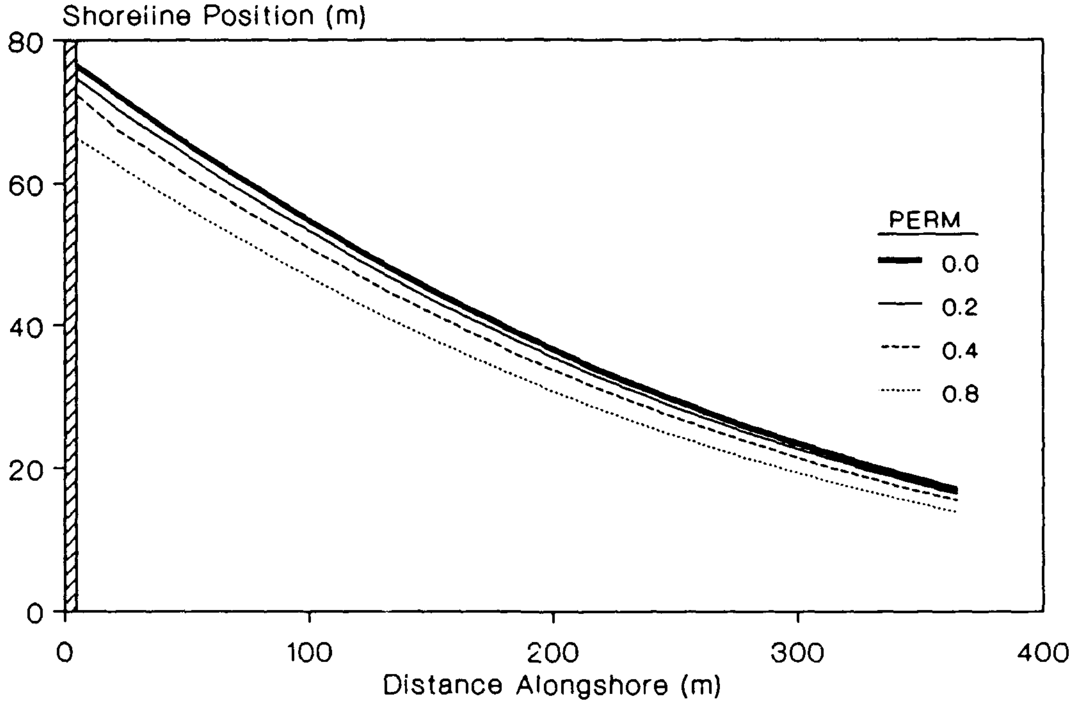


Figure 156. Influence of groin permeability on shoreline change near a groin

proportional to the transport rate at the first updrift grid cell from the structure (Perlin and Dean 1978). As a result of ongoing research, *GENESIS* is expected to undergo revision in this capability, as discussed in Gravens and Kraus (1989). Comparative calculations have shown that there are alternative representations of the groin boundary condition (for example, Hanson and Kraus 1980) that provide greater sensitivity of shoreline position on permeability than the one presently implemented in GENESIS.

Detached breakwater transmissivity

685. In most cases, detached breakwaters for shore protection are designed to allow some portion of wave energy to pass through and over them, because it is economical and often advantageous from the perspective of beach change control to suppress tombolo formation (connection of the shoreline to the structure). Wave transmission, referring to waves passing through as well as over a structure, is difficult to quantify. In order to describe wave transmission in the modeling system, a value of a transmission coefficient K_T must be specified for each detached breakwater. The transmission coefficient, defined as the ratio of the height of the incident waves directly shoreward of

the breakwater to the height directly seaward of the breakwater, has the range $0 \leq K_T \leq 1$, for which a value of 0 implies no transmission and 1 implies complete transmission.

686. In order to demonstrate the sensitivity of GENESIS to variations in wave transmission, a series of simulations is presented to illustrate sand accumulation in the lee of a shore-parallel breakwater, as illustrated in Figure 157. The breakwater is 200 m long and is located 250 m offshore; waves with T = 6 sec and H = 1.5 m are incident with crests parallel to the initially straight shoreline. The simulation time was 180 hr. As expected, the seaward extent of the induced large salient decreases as wave transmission increases.

687. In comparison of Figures 156, illustrating the influence of groin permeability, and 157, it is seen that shoreline response is much more sensitive to breakwater transmission than to groin permeability. For example, 20-percent transmission reduces the maximum shoreline advance by 36 percent and the accumulated volume by 25 percent. Because of the difficulty of determining the transmissivity of real structures, the value of the parameter is often best determined in the calibration procedure.

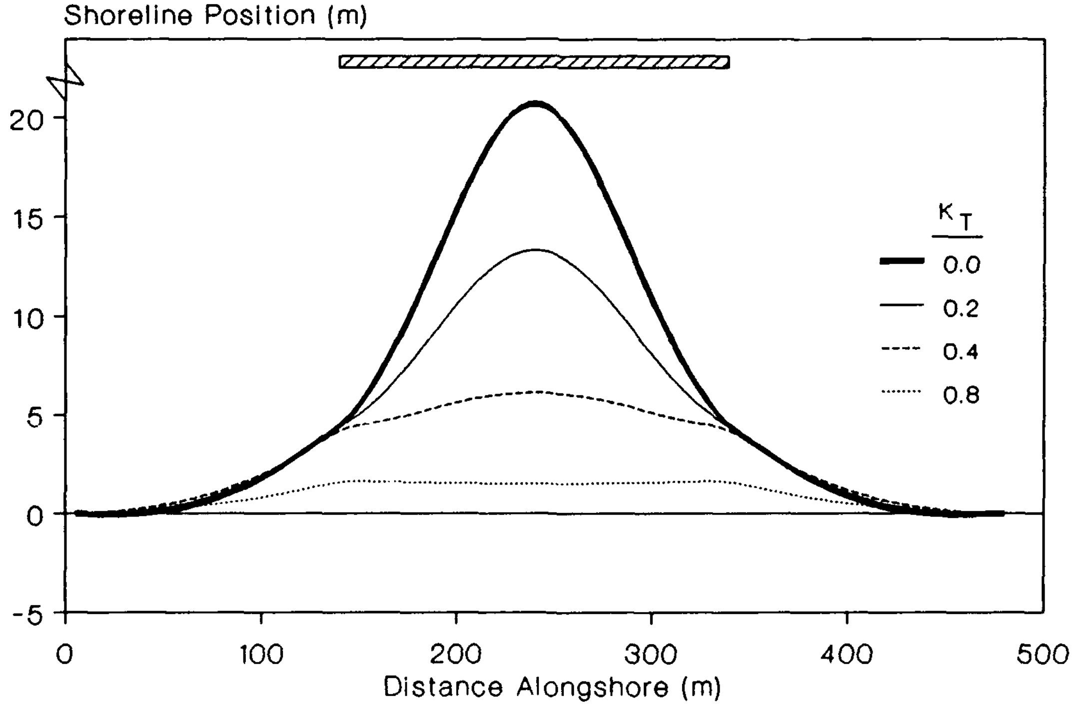


Figure 157. Shoreline change as a function of wave transmission

688. The capability to simulate wave transmission at detached breakwaters and its impact on shoreline change was first tested at Holly Beach, Louisiana, a site containing six breakwaters of different construction and transmission characteristics. Excellent results were obtained (Hanson, Kraus, and Nakashima 1989). This application also showed that it would not be possible to obtain good agreement between prototype measurements and model predictions if wave transmission were not taken into account.

689. Hanson and Kraus (1991a) describe a computation-intensive application of GENESIS to develop general guidance for predicting shoreline response behind detached breakwaters as a function of all known primary parameters, including wave transmission. The results are presented as response criteria for distinguishing tombolo development, salient development, or no effective shoreline change (for example, transient or seasonal response or relatively minor response). The Technical Reference and Hanson and Kraus (1991b) also discuss modeling results for the three transmissive detached breakwaters at Lorrain, Ohio.

Sand grain size

690. The sand grain size enters GENESIS through the equilibrium beach profile. A finer sand results in a gentler beach profile slope, causing waves to break farther offshore. However, the breaking wave height is unchanged in areas not influenced by diffraction. Nevertheless, the calculated transport rate will change in these areas because the average beach slope $\tan\beta$ appears in the second term in the transport equation (c.f. Equation 3, in Part II), and a steeper beach acts to decrease the influence of this term.

691. Inside a wave diffraction zone, the breaking wave height and angle are sensitive to beach slope, because these quantities depend on the location of the breaking waves. The general implication is that a coarser bed material results in less shoreline change. On the downdrift side of a groin, coarser sand beaches will cause the waves to break closer to shore, deeper into the shadow region. The breaking wave heights and angles will be smaller, resulting in less erosion close to the groin. In addition, the wave height gradient, $\partial H/\partial x$, will increase close to the groin, again resulting in less erosion.

692. A fundamentally different situation is displayed in Figure 158, showing the shoreline change behind a detached breakwater exposed to 1.4-m-high breaking waves with a period of 5 sec and direction normal to the initial straight shoreline. The simulation time was 50 hr. The breakwater is 200 m

long and placed 200 m from the initial shoreline. The influence of grain size is similar to that in the groin case, with a finer bed material causing the waves to break farther offshore. As a result, breaking wave heights will be smaller, and the waves will be directed more into the shadow zone. Thus, both terms in the transport relation (Equation 2), through θ_{bs} and $\partial H/\partial x$, promote sand transport into the shadow zone behind the breakwater, resulting in larger salients for finer sand beaches.

693. Although the impact of sand grain size can be determined qualitatively, a quantitative measure cannot be given. In the situation of a detached breakwater, as discussed previously, the grain size effect is not only related to physical parameters such as wave period, length of the breakwater, and its distance from the shoreline, but also to the values of the model calibration parameters, K_1 and K_2. For the example above, these were arbitrarily set to 0.5 and 0.3, respectively.

694. For simulating measured beach change, the choice of a representative sand grain size has to rest in part on engineering judgment. For many beaches, significant variations appear both in the alongshore and cross-shore

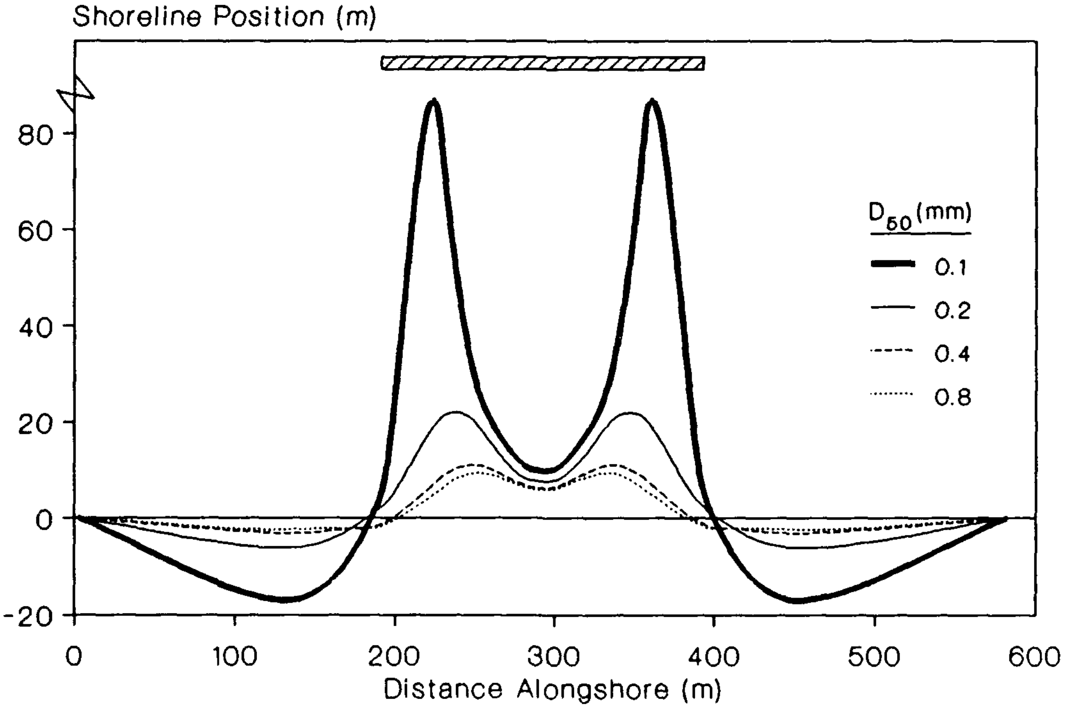


Figure 158. Influence of sand grain size on shoreline change behind a detached breakwater

distributions of the grain size, the latter usually being the greater. Bascom (1951) showed, on the basis of data on the US Pacific coasts, that the cross-shore distribution of median sand grain size varies by a factor of about two in the nearshore area. For implementation into GENESIS, it is recommended that measured profiles be matched with templates (see Technical Reference) to determine the appropriate effective sand grain size.

Berm height and depth of closure

695. As seen from Equation 1, for a given alongshore sand transport gradient, the shoreline change is inversely proportional to the vertical extent of the active profile $D_B + D_C$. As discussed in the Technical Reference, the depth of closure can be determined from profile surveys or estimated by reference to a maximum seasonal or annual wave height. The berm height is similarly specified by the user on the basis of berm profile measurements. For some beaches, it may be difficult to assign a representative value to the berm height. As a result, the user-specified average berm height value will exceed the real height on some parts of the beach and be below on others. The modeler therefore needs to know the sensitivity of the model to variations in these two parameters and how an overestimation or underestimation may change the simulated shoreline change.

696. Four runs of evenly spaced values of $1/(D_B + D_C)$ were made. The beach was exposed to 0.7-m-high waves with an angle of -15 deg to the x-axis, and the simulation time was 480 hr. As illustrated in Figure 159, the simulations show the same qualitative features as the groin permeability simulations discussed previously. Again, the interconnection between shoreline orientation and sand transport rate explains the relative small sensitivity of GENESIS to changes in the input parameters. Although the depth of closure between the first and the fourth runs was increased by a factor of four, the calculated shoreline change decreased by only about 50 percent.

Calibration and Verification Strategies

697. Model calibration and verification should, in a strict sense, be performed only to determine the values of the calibration coefficients K_1 and K_2. All other input values should, in principle, be available and determined prior to the modeling. However, in practice, complete data sets are usually lacking. Therefore, the modeler must use his or her coastal experience as

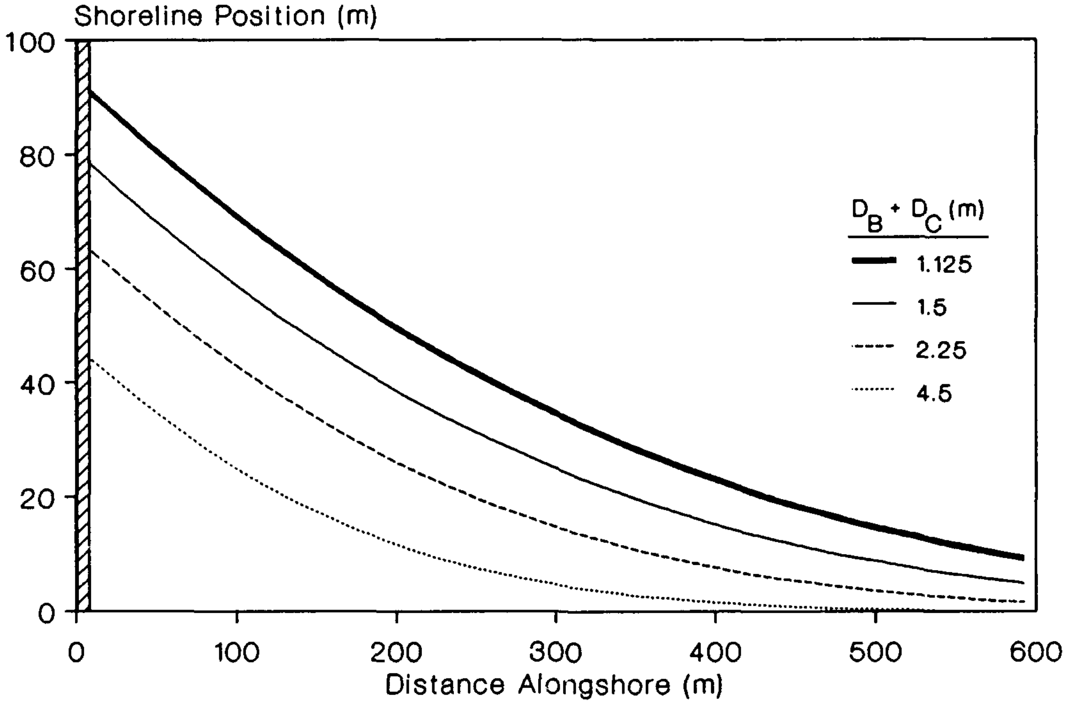


Figure 159. Influence of berm height and depth of closure on shoreline change near a groin

well as experience with numerical models in general and with GENESIS in particular to estimate the lacking input values. Often it is necessary to use GENESIS in a systematic approach to accomplish this goal. In such cases, the calibration/verification procedure may encompass determination of several input parameters.

698. Usually, only one model parameter at a time is changed in order to isolate its effect and understand its role in the overall balance with other parameters for the particular project. In addition, the strategy is to first determine values of main parameters controlling known quantities, often the annual gross and net transport rates, or volumetric changes within the study area. In a second stage of calibration, parameters having mainly local and minor influence should then be determined to optimize the calibration.

699. As illustrated in the examples presented above, each input parameter has an identifiable influence on the calculated shoreline location. Table 20 gives a general description of how a change in value of the more common input parameters is likely to affect the simulation. However, it is emphasized that the table contains broad guidance. Different configurations

and applications will require determination of different combinations of parameters, and, in special cases, the actual change in a parameter value may produce a somewhat different result than described in Table 20.

700. As seen from Equations 2 and 3, the two terms in the sand transport relation, as controlled by the calibration coefficients K_1 and K_2, tend to be dominant in different modeling regions; the first term is proportional to the magnitude of the wave height, whereas the second term is proportional to the wave height gradient alongshore. This occurrence means that the calculated shoreline is sensitive to the K_1-value in regions of high waves, such as on the updrift side of groins, whereas the K_2-value exerts influence in regions with strong wave height gradients alongshore, such as in the lee of diffracting jetties and detached breakwaters. Figure 160 shows a hypothetical example demonstrating the relative influence of K_1 and K_2 on shoreline evolution behind a detached breakwater. An increase in K_1 tends to flatten out the salient behind the breakwater, whereas an increase in K_2 tends to promote growth of the salient.

701. The following examples illustrate possible calibration/verification strategies for applying GENESIS to different schematized configuration. However, the modeler should keep in mind that each project is unique and may require creative application of GENESIS. Little standard operating procedure is available when dealing with coastal sediment processes.

Simple Groin Configuration Example

702. A groin is located along an open beach for which the shoreline position has been surveyed three times, at t_1, t_2, and t_3, as displayed in Figure 161. The first survey was taken just prior to the construction of the groin. The groin is 150 m long, with its seaward end located 100 m seaward of the baseline coinciding with the initial, approximately straight shoreline. Thus, the groin is specified as a difracting groin in the **START** file. Wave data covering an appropriate time interval are available. The task of the modeler is summarized as:

a. Calibrate the model.

b. Verify the model.

c. Predict the shoreline location at time t_4.

Table 20

Control of Selected Parameters on Calculated Shoreline Position

Name	Function	Value Range (Recommended)	Primary Control
K1	Primary calibration coefficient	>0 (0.1 to 1.0)	Magnitude of longshore sand transport rate.
K2	Secondary calibration coefficient	>0 ($0.5\ K_1$ to $1.5\ K_1$)	Distribution of sand within calculation area.
ISMOOTH	Size of off-shore smoothing window	1 to N (11)	Time scale of shoreline response and equilibrium shape of shore.
HCNGF	Wave height change factor	>0 (0.2 to 1.0)	Breaking wave height and location.
ZCNGA	Wave angle change amount	-180 to 180 (-30 to 30)	Amount and direction of sand transport.
ZCNGF	Wave angle change factor	>0 (0.2 to 1.0)	Directional variability of waves.
IX-	Grid cell number of structure tip	1 to N+1	Shape and <u>location</u> of of shoreline change.
Y-	Distance of structure tip to x-axis	unrestricted	<u>Shape</u> and location of shoreline change.
D-	Depth at structure tip	>0.01	Wave height and direction at diffracting tip; <u>shape</u> and and location of shoreline change.
SLOPE2	Bottom slope near groins	>0	Groin bypassing; shoreline change near groins.
PERM	Groin permeability	0 to 1	Amount of sand passing through groins; shoreline change near groins.
YG-	Distance from shoreline outside grid to groin tip	>0	Amount of sand entering the calculation area.
TRANDB	Transmission coefficient for detached breakwater	0 to 1	Amount of wave energy passing through and over detached breakwater; shape of shoreline.

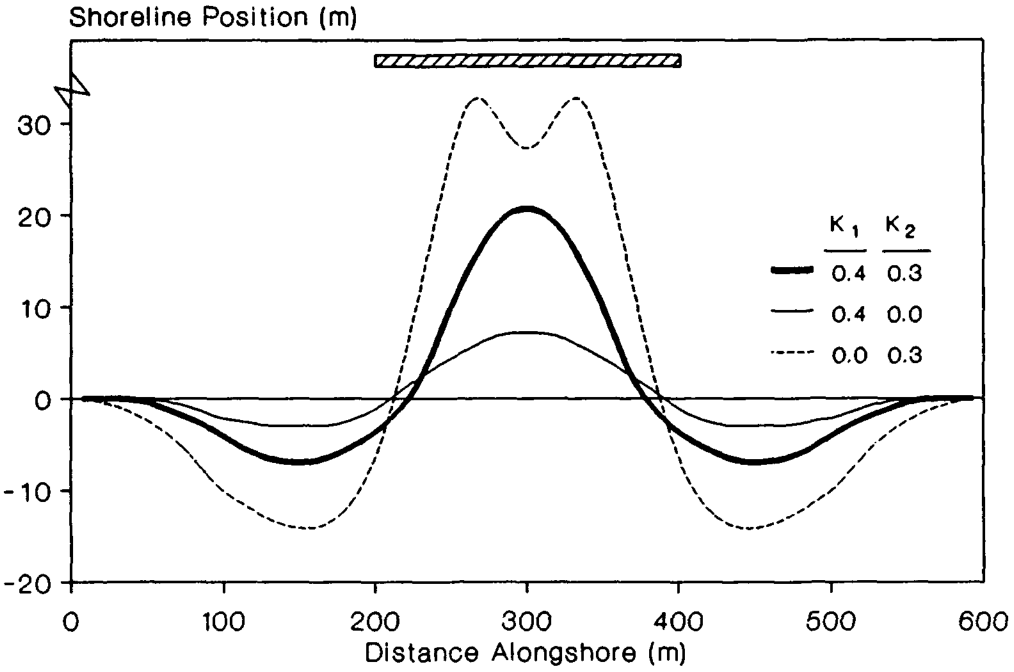


Figure 160. Hypothetical example illustrating the influence of the adjustable parameters in the sand transport equation. H_b = 1 m, θ_b = 0 deg, T = 3.5 sec. Simulation time = 90 days

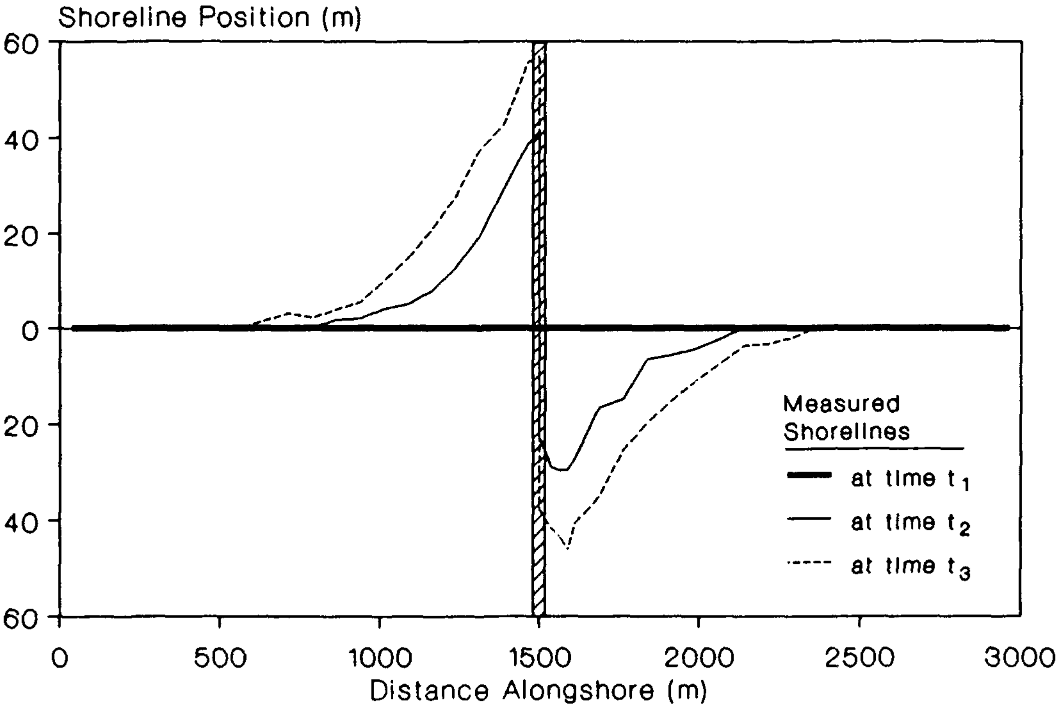


Figure 161. Measured shorelines for hypothetical groin case

703. As a first attempt, standard design mode values are chosen for the input parameters: $DX = 50$ m and $DT = 6$ hr. During the course of the simulation, these values may have to be changed on the basis of warning messages issued from GENESIS. Also, checks for grid independence may be performed. Other values, for example, effective grain size, berm height, and depth of closure, are determined from available preproject reconnaissance information.

704. The calibration interval is chosen to be from t_1 to t_2. Because shoreline evolution on the updrift side of a groin is usually insensitive to variations in K_2, the first step in the calibration procedure will be to determine K_1 by reproducing the shoreline change updrift of the groin, as shown in Figure 162. While doing this, little attention is paid to the downdrift side of the groin. For this example, the best agreement was found for $K_1 = 0.5$. In the case of several groins, K_1 would be set to match the measured updrift accretion on one of the groins while exceeding it on the other groins, other parameters expected to allow "backing off" from the overshooting of the shoreline change. For simulated groins producing excessive accretion, groin permeability is set to decrease the accretion to obtain the best possible match. If information on annual gross and/or net transport rates is available (for example, from dredging volumes or surveys of impoundment or erosion), K_1 is set to reproduce these conditions.

705. The next step is to determine K_2 by reproducing the downdrift conditions while holding K_1 fixed, as shown in Figure 163. Even though good and almost identical agreement was found using $K_2 = 0.5$ and $K_2 = 0.4$, the smaller value is selected with the philosophy of minimizing potential exaggerations later if the structure is modified. In more realistic and complex situations, it may be necessary to repeat these two calibration steps to fine-tune the two calibration coefficient values and other parameters that may not be well known from the available data. At this stage, it is also recommended that the modeler examine the result to see if there is a reasonable balance among the input parameters.

706. When the calibration is completed, the model is verified by reproducing measured shoreline change from t_2 to t_3 (Figure 164) while holding fixed all parameter values determined in the calibration, unless some physical condition has changed that requires modification of model setup or configuration parameters. If the available wave data time series does not cover the calibration/verification interval and if, in addition, it is believed that the

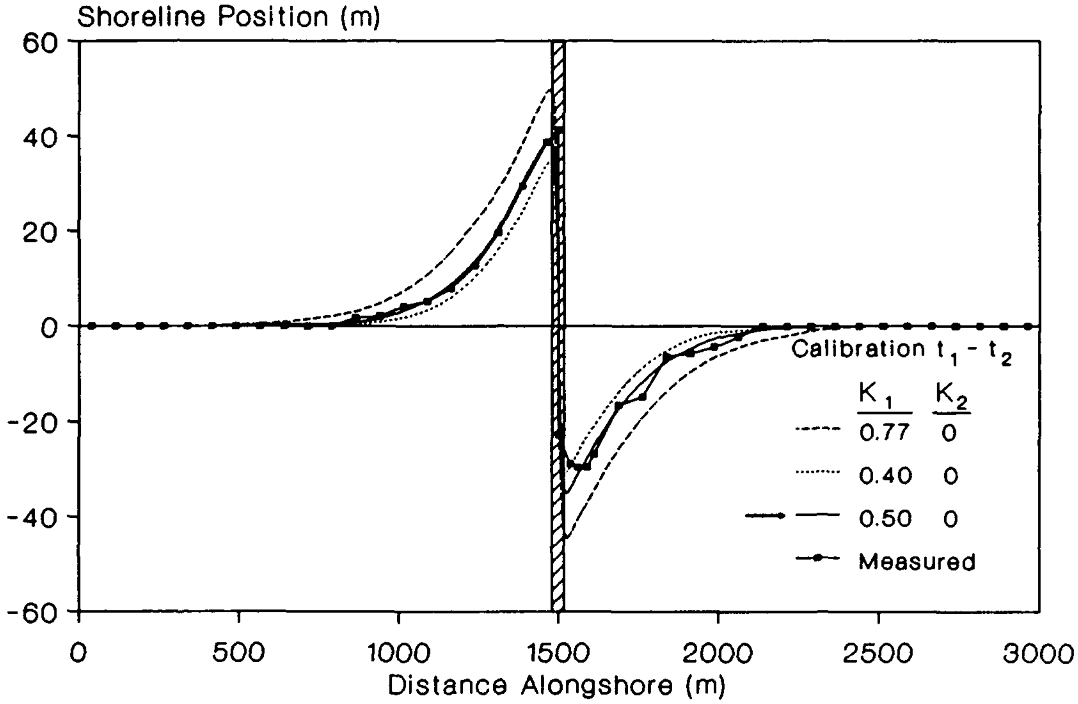


Figure 162. Calibration to determine the value of K_1

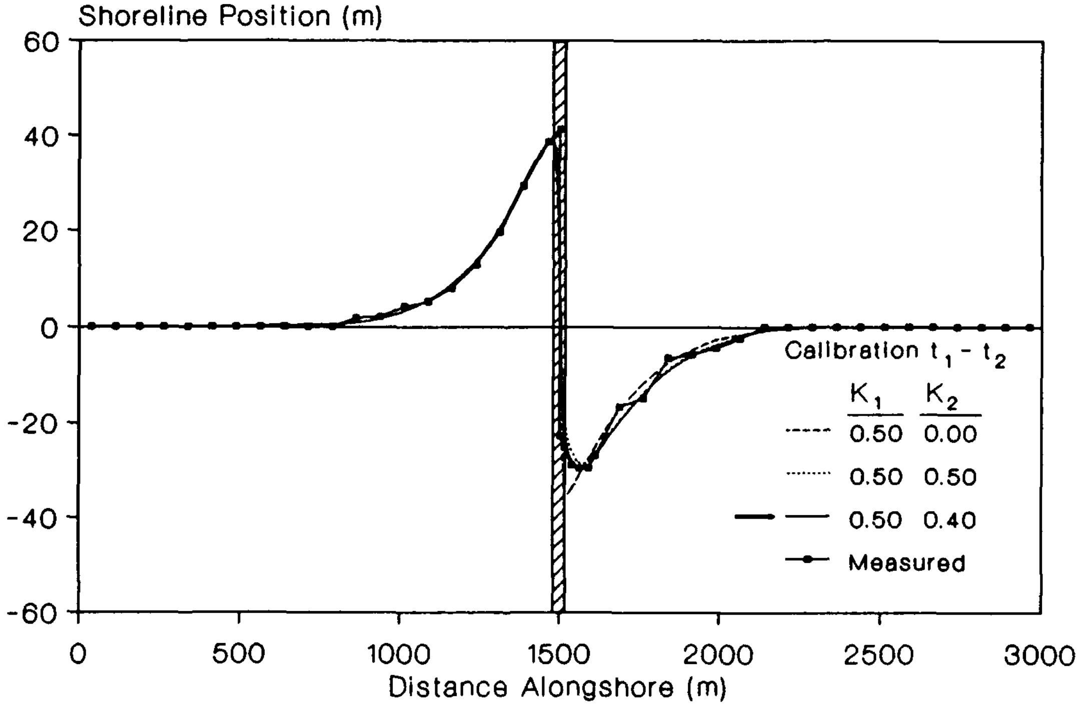


Figure 163. Calibration to determine the value of K_2

wave climates were different during the calibration and verification intervals (for example, caused by long-term weather cycles), these conditions may be partly compensated for by adjusting wave heights and angles through the use of *HCNGF*, *ZCNGF*, or *ZCNGA*.

707. With the model verified, it is now possible to examine future shoreline change. The first application would be to use the present configuration to identify potential problems and to perform sensitivity analyses. Figure 165 shows such a forecast from time t_3 to t_4, including a simple wave height sensitivity test; a 10-percent increase or decrease in the mean wave height produces relatively minor changes in the shoreline position. After more realistic sensitivity testing to obtain a range of shoreline predictions, the model may be used to perform a series of simulations for evaluating alternative protective plans, including use of various different representative wave data sets to obtain a range of predictions for all alternatives.

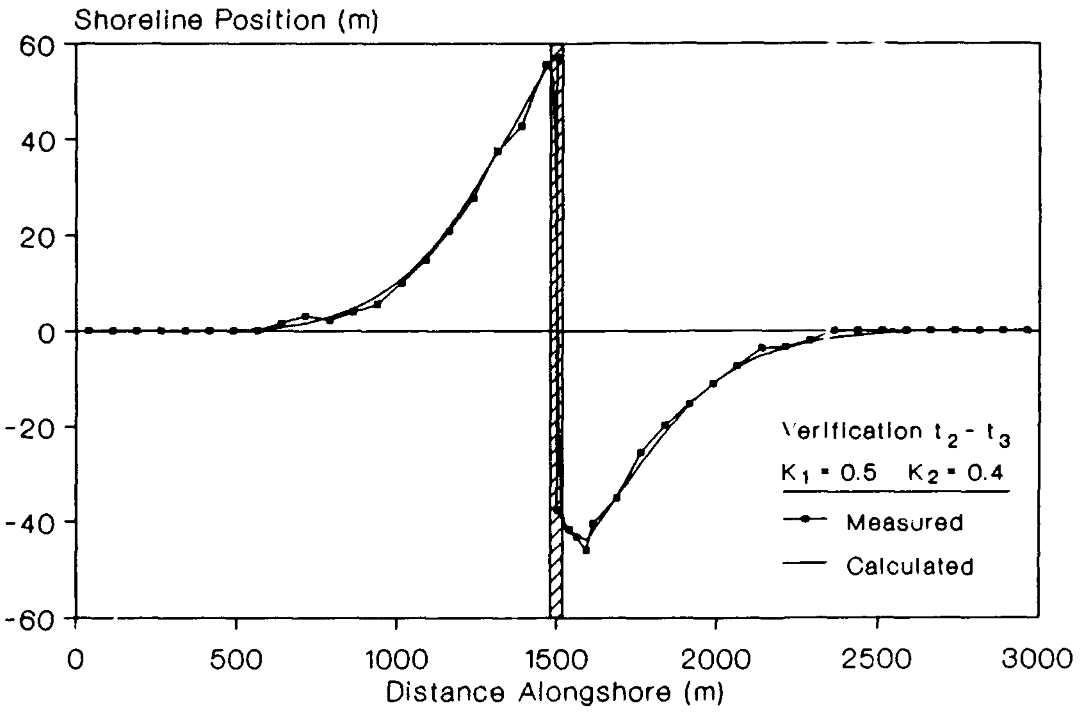


Figure 164. Model verification of a hypothetical example

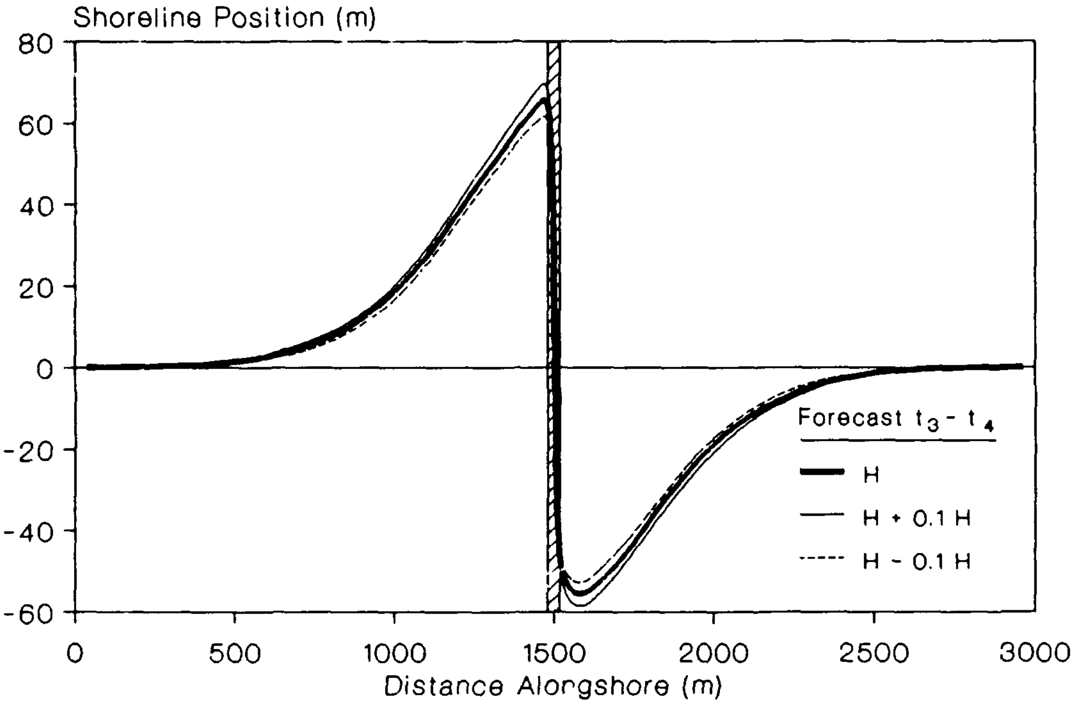


Figure 165. Forecasting and sensitivity test

Detached Breakwater Example

708. As described in Table 20 and Part II, the magnitude of the sand transport rate is mainly controlled by K_1. Also, as shown in the previous section, shoreline response updrift of groins is sensitive to changes in K_1. In contrast, shoreline change in the lee of detached breakwaters is often more sensitive to variations in K_2 than to variations in K_1 (Kraus 1983; Mimura Shimizu, and Horikawa 1983). This result means that in situations where the annual gross and net transport rates are not well known and where no groins are present it may sometimes be difficult to determine "true" values (if such things exist) of K_1 and, consequently, the associated value of K_2. As illustrated in Figure 160, the two K-terms tend to counteract each other behind detached breakwaters in the sense that K_1 tends to flatten the salient behind the breakwater, whereas K_2 tends to promote growth of the salient. More than one combination of values for the two K-terms may therefore produce reasonable results. In such cases, the selection of calibration values must again rest on the judgment of the modeler, in this case especially in terms of estimation of annual transport rates.

709. The typical steps in calibrating GENESIS in a detached breakwater project are summarized in the Technical Reference (see Figure 166, Hanson and Kraus (1989); also Hanson and Kraus (1991b)), using the case study of the three breakwaters at Lakeview Park, Lorain, Ohio. Since the time-consuming assembly and analysis of data are thoroughly presented in the Technical Reference, this part of the study is not discussed here.

710. The grid spacing was set at 25 ft (7.6 m) to give 10 cells per breakwater, which were 250 ft (760 m) long. Because of this relatively small grid spacing, in the course of model calibration the time interval was set to 0.3 hr. In summary, the calibration/verification procedure for the detached breakwater case study was performed as follows:

- a. K_1 was varied to reproduce historic longshore sand transport rates estimated in previous studies.
- b. K_2 and the distance *YG1* to the shoreline outside the grid to the seaward end of the western (left-hand) groin were varied to obtain the approximate magnitude of net inflow of sand to the study area from the west. At this point, all breakwaters were still considered impermeable. Therefore, all calculated salients were at least as large as the measured ones.

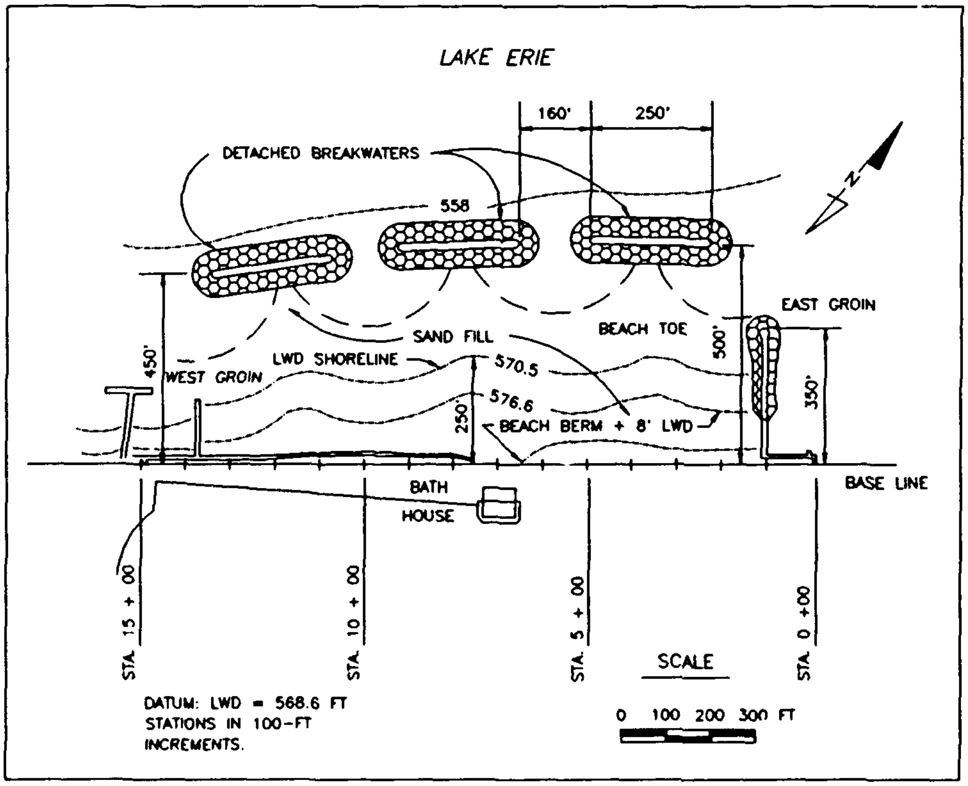


Figure 166. Project Design, Lakeview Park

c. The transmission coefficients of the breakwaters were adjusted (increased from 0) to obtain the correct (decreased) size of the salients behind the structures.

d. The longshore location of the eastern detached breakwater was translated two grid cells to the east to obtain better agreement between the calculated and measured position of the easternmost salient. This adjustment was probably needed to compensate for the effects of irregular bottom bathymetry at the site on wave refraction, whereas in the model straight and parallel contours were used.

e. For the verification, the distance *YG1* was increased, as read from aerial photographs.

f. Although reasonable agreement was obtained for the verification interval using the same 1-year-long wave data set as during calibration, still better agreement was obtained by increasing the input wave height by 10 percent ($HCNGF = 1.1$).

Interpretation of Results

711. Results are always checked for general reasonability. In this regard, an overview of regional and local coastal processes and the sediment budget calculation or first-order modeling discussed previously are employed to judge model results. For example, is the overall trend of the calculated shoreline position correct and not just the dominant feature? Do the magnitude and direction of the calculated longshore sand transport rate agree with independent estimates? Experience gained in the verification, sensitivity analysis, and modeling of alternative plans will help uncover erroneous or misleading results. Plots of computed shoreline positions reveal obvious modeling mistakes, whereas more subtle errors of either the model or modeler may be found in the sensitivity analysis through understanding of basic dependencies of shoreline change on the wave input and boundary conditions.

712. Shoreline change is governed by nonlinear processes, many of which are represented in GENESIS. Complex beach configurations and time-dependent wave input will produce results that cannot be extrapolated from experience. However, as much as possible, experience should be called upon to evaluate the correctness of results and to comprehend the trends in shoreline change produced.

713. Finally, the user must maintain a certain distance from model results. Obliquely incident waves are not responsible for all longshore sand transport and shoreline change. Potential errors also enter the hindcast of

the incident waves, in representing an irregular wave field by monochromatic waves, and sometimes through undocumented human activities and extreme wave events that have modified the beach. The probable range in variability of coastal processes must also be considered when interpreting model results.

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APPENDIX A: SUMMARY OF GENESIS SYSTEM-SUPPORT COMPUTER PROGRAMS

1. The GENESIS (GENEralized Model for SIulating Shoreline Change) system-support computer programs presented in the main text were developed to automate many of the computations and analysis required prior to performing shoreline evolution simulations using GENESIS. The system-support programs and recommended analysis procedures are illustrated in flow diagrams in Parts III, IV, V, and VI. Figure A1 provides definitions of the symbols appearing in the flow diagrams.

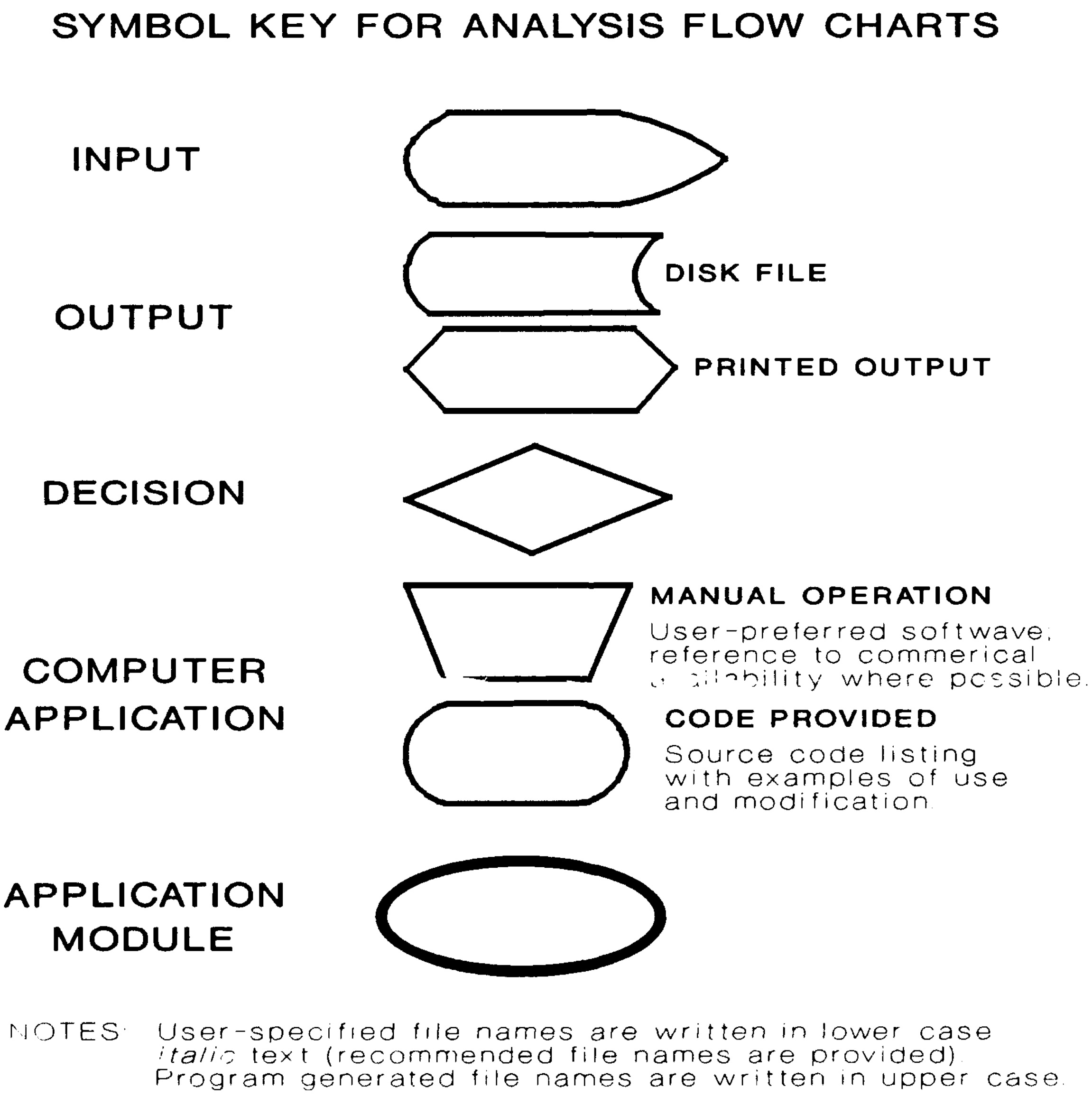

Figure A1. Definitions for flow diagram symbols

2. A summary description of each of the GENESIS system-support programs is provided in Table A1. The first column in this table lists the program name, the second column provides a summary description of the program function, and the third column lists the analysis application as discussed in the main text. Table A2 provides a listing of the main input and output file names associated with the GENESIS system-support programs. The specific file name is listed in the first column in the table. File names that are capitalized and bolded denote required names and/or extensions. File names that are lower case and italic are user-specified names and extensions (recommended names are listed). File names and extensions that are neither capitalized nor italicized may be assigned at the user's discretion. The second column in Table A2 provides a summary description of the data contained within the file. The third column lists the pertinent computer programs associated with the file. Program names within parentheses denote the program that generates the file, whereas the other program names listed can accept the file as input.

Table A1

Summary Description of the GENESIS System Support Programs

Program Name	Function	Analysis Procedure
CUINTP	Performs cubic spline interpolation of digitized X-Y shoreline position data.	Shoreline Preparation
NSTRAN	Calculates potential longshore sand transport rates using nearshore wave data.	Wave Data Analysis 2
RCRIT	Calculates the potential of a given wave height, period, and direction for producing significant longshore sand transport.	Wave Data Analysis 1
SEDTRAN	Calculates potential longshore sand transport rates using offshore wave data.	Wave Data Analysis 1
SHORLROT	Performs a coordinate system rotation and origin translation of digitized X-Y shoreline position data.	Shoreline Preparation
WAVETRAN	Performs a Wave Information Study (WIS) Phase III-type transformation of a deepwater time series of wave height, period, and direction.	Acquisition of WIS Data
WHEREWAV	Calculates the number of events in an input time series of wave height, period, and direction occurring within user-specified angle, and period bands.	Wave Data Analysis 2
WTDEPTH	Writes a **DEPTH**.ext-type file for input to GENESIS.	Wave Data Analysis 2
WTNSWAV	Writes a keyed data base of nearshore wave conditions from RCPWAVE output for input to GENESIS (a **NSWAV**.ext-type file).	Wave Data Analysis 2
WTSHO	Writes a **SHORL**.ext-type file for input to GENESIS.	Shoreline Preparation
WTWAVES	Writes a **WAVES**.ext-type file for input to GENESIS.	Wave Data Analysis 1
WTWAVTS	Writes a time series of wave height, period, and direction, for a user-specified time interval, time step, and coordinate system from a WIS Phase III-type time series.	Wave Data Analysis 1

Table A2

System Support Program Input and Output Files (Continued)

File Name	Description	Program (OUTPUT) INPUT
DEPTH.*ext*	GENESIS input file (used to specify nearshore reference water depths).	(<COPY>)* GENESIS
NSWAV.*ext*	GENESIS input file (used to specify nearshore wave conditions for specific classes of offshore waves).	(<COPY>) GENESIS
project.**DEP**	Nearshore reference water depths in GENESIS input format (e.g. **DEPTH**.*ext*).	(WTDEPTH) NSTRAN <COPY>
project.**NSV**	Estimated potential longshore sand transport rates based on nearshore wave information.	(NSTRAN)
project.**NSW**	Nearshore reference water depths in GENESIS input format (e.g. **NSWAV**.*ext*).	(WTDEPTH) NSTRAN <COPY>
SHORL.*ext*	GENESIS input file (to specify the initial shoreline position).	(<COPY>) GENESIS
SHORM.*ext*	GENESIS input file (to specify the measured shoreline position at the end of calibration and verification simulations).	(<COPY>) GENESIS
sta-ang.**PTR**	Estimated potential longshore sand transport rates for a user-specified input time series (offshore) and shoreline orientation.	(SEDTRAN)
START.*ext*	GENESIS input file (to specify project and model configuration and setup).	(<COPY>) GENESIS
station.**PH3**	Offshore time series of wave height, period, and direction (FORMAT: WIS).	(WAVETRAN)
station.**WW**	Statistics of an offshore wave time series by angle and period bands.	(WHEREWAV)
WAVES.*ext*	GENESIS input file (to specify input wave conditions at each time step).	(<COPY>) GENESIS

(Continued)

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* <COPY> denotes that a file will be copied to or from the related file.

Table A2 (Concluded)

File Name	Description	Program (OUTPUT) INPUT
year.SHO	Shoreline position data in GENESIS input format (e.g., **SHORL**, **SHORM**)	(WTSHO) <COPY>*
years.CTS	Offshore time series of wave conditions, all of which have the potential to produce significant longshore sand transport (FORMAT: WIS).	(RCRIT) SEDTRAN WTWAVTS
years.OTS	Offshore time series of wave height, period, and direction at a user-specified time step, record length, and baseline orientation (FORMAT: WIS).	(WTWAVTS) SEDTRAN RCRIT WTWAVES
years.**WAV**	Offshore time series of wave height, period, and direction for input to GENESIS (e.g., **WAVES**.*ext*).	(WTWAVES) WHEREWAV NSTRAN <COPY>
yearxy.dig	Shoreline position data as it was digitized (FORMAT: X_1 Y_1 X_2 Y_2 X_3 Y_3 ...).	(USERSOFT) SHORLROT
yearxy.ROT	Digitized shoreline position data rotated into a user-specified coordinate system (FORMAT: X_1 Y_1 X_2 Y_2 X_3 Y_3 ...).	(SHORLROT) CUINTP

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[*] <COPY> denotes that a file will be copied to or from the related file.

APPENDIX B: SYSTEM SUPPORT PROGRAM RCIRT

```
      PROGRAM RCRIT
c***********************************************************************
C     This Program reads an input time series in an event by event manner
C     and calculates the potential for the given event to produce significant
C     longshore sand transport.  Output from this program is written to 2
C     files ([filename].CTS & REPORT.RC).  The file [filename].CTS contains a
C     new time series in which wave conditions that do not satisfy the thres-
C     hold criteria are flagged (i.e. given a negative wave height and period).
C     The file REPORT.RC contains the wave events which were flagged and a
C     summary of the number of wave types and events processed.
c///////////////////////////////////////////////////////////////////////
c\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
C     Two pre-determined input file formats may be used for input.  These are
C     either a SEAS "USER" file or a CEDRS file which resulted from an extract
C     data operation.  There is also a section in which the user can specify
C     the unique format of his specific input wave time series.
C
C     All calculations within the program are performed in SI units.  However,
C     input and output units may (must) be specified.
c***********************************************************************
C  Define variable types.
      IMPLICIT REAL (A-H,Q-Z)
      CHARACTER*28 FIN,FOUT
      CHARACTER*15 STATYP,STAID
C
C  Prompt and Read Basic information
C
      WRITE(*,*) ' Enter your input filename and extension (including th
     &e path if the file is'
      WRITE(*,*) ' not in the default directory): (MAXIMUM OF 28 CHARACT
     &ERS)'
      WRITE(*,*) '   '
      READ(*,*) FIN
      OPEN(UNIT=99, FILE=FIN, STATUS='OLD')
      WRITE(*,*) '   '
      WRITE(*,*) '   '
      WRITE(*,*) ' Enter your output filename without the extenstion (in
     &cluding the path if the'
      WRITE(*,*) ' file is to be written to another directory): (MAXIMUM
     & OF 24 CHARACTERS)'
      WRITE(*,*) '   '
      READ(*,*) FOUT
      WRITE(*,*) '   '
      WRITE(*,*) '   '
      WRITE(*,*) ' The file REPORT.RC will be written to the default dir
     &ectory (if it exists it'
      WRITE(*,*) ' will be over-written): '
      WRITE(*,*) '   '
      WRITE(*,*) '   '
      LENGTH=SIZEOF(FOUT)
      FOUT(LENGTH+1:LENGTH+4)='.CTS'
      OPEN(UNIT=98, FILE=FOUT, STATUS='NEW')
      OPEN(UNIT=97, FILE='REPORT.RC', STATUS='UNKNOWN')
    5 WRITE(*,*) ' Define your input data format: '
      WRITE(*,*) '    1 = SEAS'
      WRITE(*,*) '    2 = OUTPUT FROM ANOTHER WORKBOOK CODE (Header & For
     &mat like SEAS)'
      WRITE(*,*) '    3 = CEDRS'
      WRITE(*,*) '    4 = OUTPUT FROM ANOTHER WORKBOOK CODE (Header & For
     &mat like CEDRS)'
      WRITE(*,*) '    5 = other'
      WRITE(*,*) '   '
      WRITE(*,*) '    Enter the value corresponding to your input data: '
      READ(*,*) INFOR
      WRITE(*,*) '   '
      IF(INFOR.LE.4)THEN
        IF(INFOR.EQ.2.OR.INFOR.EQ.4)THEN
          WRITE(*,*)' Enter the number of events per record: '
```

```
          READ(*,*) NEPR
          WRITE(*,*) '   '
        ELSE
          NEPR=2
        ENDIF
        GOTO 10
      ELSEIF(INFOR.EQ.5)THEN
        GOTO 15
      ELSE
        WRITE(*,*) '   '
        WRITE(*,*) 'Illegal input !'
        WRITE(*,*) '   '
        GOTO 5
      ENDIF
   10 WRITE(*,*) ' Define your input time series data type: '
      WRITE(*,*) ' 1 = Phase I  '
      WRITE(*,*) ' 2 = Phase II  '
      WRITE(*,*) ' 3 = Phase III  '
      WRITE(*,*) '   '
      WRITE(*,*) '   Enter the value corresponding to your input data: '
      READ(*,*) IPHASE
      IF(IPHASE.EQ.1)THEN
        IF(INFOR.EQ.3.OR.INFOR.EQ.4)GOTO 20
        DEPTH = -999.
        WRITE(*,*) ' Enter the shoreline orientation (in degrees, clockw
     &ise from north): '
        READ(*,*) SHOANG
      ELSEIF(IPHASE.EQ.2)THEN
        WRITE(*,*) '   '
        WRITE(*,*) ' Enter water depth (cm for SEAS and m for CEDRS) for
     & the input time series: '
        WRITE(*,*) ' (enter -999 for deep water conditions): '
        READ(*,*) DEPTH
        WRITE(*,*) '   '
        WRITE(*,*) ' Enter the shoreline orientation (in degrees, clockw
     &ise from north): '
        READ(*,*) SHOANG
      ELSEIF(IPHASE.EQ.3)THEN
        WRITE(*,*) '   '
        WRITE(*,*) ' Enter water depth for the input time series: '
        READ(*,*) DEPTH
        WRITE(*,*) '   '
        WRITE(*,*) ' Enter the shoreline orientation (in degrees, clockw
     &ise from north): '
        READ(*,*) SHOANG
      ELSE
   20   WRITE(*,*) '   '
        WRITE(*,*) 'Illegal input !'
        WRITE(*,*) '   '
        GOTO 10
      ENDIF
      GOTO 25
   15 WRITE(*,*) ' This code must be modified to read your specific'
      WRITE(*,*) ' input file header !'
      GOTO 35
C???????????????????????????????????????????????????????????????????????????
C  In this section read (or prompt for) the input file header information
C  and define the system of units used in the input data file, the depth
C  corresponding to the time series, the shoreline orientation, and the
C  number of records in the file record.  Note, that each record may contain
C  more than one event (e.g.  h, t, & theta for sea waves and h, t, & theta
C  for swell waves etc.).  Load the number of events per record into NEPR.
C  Load the conversion factor for length into the variable CONVLEN.
C  Load the depth (in meters) into the variable DEPTH.
C  Load the shoreline orientation into SHOANG.
C???????????????????????????????????????????????????????????????????????????
   25 IF(INFOR.EQ.1.OR.INFOR.EQ.2)THEN
        CONVLEN = .01
        READ(99,*) STAID, NEVENTS
      ELSEIF(INFOR.EQ.3.OR.INFOR.EQ.4)THEN
        CONVLEN = 1.
        READ(99,*) STATYP, STAID, ISMO, ISYR, IEMO, IEYR, NEVENTS
```

```
      ENDIF
C
C     Begin calculation loop
C
C     At this point the following variables
C     must contain meaningful values.
C          CONVLEN: Length conversion factor.
C          DEPTH: Water depth of input time series.
C          NEVENTS: Number of records in time series.
C          NEPR: Number of wave events per record (maximum is two).
C          SHOANG: Shoreline orientation with respect to north.
C
      IF(NEPR.GT.2)THEN
        WRITE(*,*) ' To many wave events per record!'
        GOTO 35
      ENDIF
      DO 30 I=1,NEVENTS
        IF(INFOR.LE.4)THEN
          IF(INFOR.EQ.2.OR.INFOR.EQ.4)THEN
            IF(NEPR.EQ.2)THEN
              READ(99,*)IDATE,CH,CT,CTH,SH,ST,STH
            ELSE
              READ(99,*)IDATE,CH,CT,CTH
            ENDIF
          ENDIF
          IF(INFOR.EQ.1)THEN
            READ(99,990)IDATE,ICH,ICT,ICTH,ISH,IST,ISTH
            CH=FLOAT(ICH)
            CT=FLOAT(ICT)
            CTH=FLOAT(ICTH)
            SH=FLOAT(ISH)
            ST=FLOAT(IST)
            STH=FLOAT(ISTH)
          ENDIF
          IF(INFOR.EQ.3)THEN
            READ(99,980)IDATE,CH,CT,CTH,SH,ST,STH
          ENDIF
        ELSE
          WRITE(*,*) ' This code must be modified to read your specific
     &input time series !'
          GOTO 35
C?????????????????????????????????????????????????????????????????????????????
C  In this section read the wave event(s) from the input file.
C
C  Read the height, period, and angle of the first wave event into
C  CH, CT, and CTH.
C
C  If there are two events per record, read second wave event height,
C  period, and angle into SH, ST, STH.
C?????????????????????????????????????????????????????????????????????????????
        ENDIF
        ICOUNT=ICOUNT+1
        ICFLAG=1
        ISFLAG=1
        ICCRIT=1
        ISCRIT=1
        ICELIM=0
        ISELIM=0
        IF(CT.LE.0.0)THEN
          ICFLAG=-1
          ICCALM=ICCALM+1
          T1=-99.9
          H1=0.0
          A1=0.0
          ICELIM=1
          GOTO 40
        ENDIF
C
C  Test for competence of SEA wave power of the present event
C  to move sand.  Variables passed are:
C       {H1}=m;     wave height
C       {T1}=sec;   wave period
```

```
C       [D1]=m;      water depth
C       [A1]=deg;    wave angle in degrees with respect to shore-normal
C                    (+ angles are ccw, - angles are cw).
C
        IF(ICFLAG.GT.0)THEN
          T1=CT
          H1=CH*CONVLEN
          D1=DEPTH*CONVLEN
C
C  Convert wave angle to an angle in degrees with respect to shore-normal.
C  Angles counter-clockwise from shore-normal are positive.
C  Angles clockwise from shore-normal are negitive.
C    -90 <= ANGLE <= 90
C
          IF(INFOR.LE.0)THEN
            IF(IPHASE.LE.2)THEN
              A1=SHOANG+90-CTH
              IF(A1.GE.270.)A1=A1-360.
              IF(A1.LE.-270.)A1=A1+360
              IF(A1.LT.-90..OR.A1.GT.90)THEN
C
C  Waves are traveling offshore!
C
                T1=-99.9
                H1=0.0
                A1=0.0
                ICELIM=2
                ICOFF=ICOFF+1
                GOTO 40
              ENDIF
            ELSE
              A1=CTH-90.
            ENDIF
          ELSE
            WRITE(*,*) ' This code must be modified to convert your spec
    &ific'
            WRITE(*,*) ' coordinate system to one with respect to shore-
    &normal'
            GOTO 35
C????????????????????????????????????????????????????????????????????????????????
C  In this section convert the wave event angle from the coordinate system
C  of the input file.
C
C  Convert wave angle to an angle in degrees with respect to shore-normal.
C  Angles counter-clockwise from shore-normal are positive.
C  Angles clockwise from shore-normal are negitive.
C    -90 <= ANGLE <= 90
C????????????????????????????????????????????????????????????????????????????????
          ENDIF
          CALL RCALC(T1,H1,A1,D1,ICCRIT)
          IF(T1.LT.0)THEN
            ICKILL=ICKILL+1
            ICELIM=3
          ENDIF
        ENDIF
C
C  Write eliminated SEA events to output file REPORT.RC
C  with elimination code (reason for elimination).
C
   40   IF(ICOUNT.EQ.1)THEN
          WRITE(97,*) 'Summary of wave events eliminated from the input
    &time series.'
          WRITE(97,*) ' '
          WRITE(97,*) ' WAVE       ELIMINATION'
          WRITE(97,*) ' TYPE          FLAG          DATE     HEIGHT  PER
    &IOD  DIRECTION'
          WRITE(97,*) '-------------------------------------------------
    &-----------------'
          WRITE(*,*) ' '
        ENDIF
        IF(ICELIM.EQ.1)WRITE(97,100) IDATE,CH,CT,CTH
        IF(ICELIM.EQ.2)WRITE(97,200) IDATE,CH,CT,CTH
```

```
        IF(ICELIM.EQ.3)WRITE(97,300) IDATE,CH,CT,CTH
C
C  Test for competence of SWELL wave power of the present event
C  to move sand.  Variables passed are:
C       [H2]=m;      wave height
C       [T2]=sec;    wave period
C       [D2]=m;      water depth
C       [A2]=deg;    wave angle in degrees with respect to shore-normal
C                    (+ angles are ccw, - angles are cw).
C
        IF(NEPR.EQ.2)THEN
          IF(ST.LE.0.0)THEN
            ISFLAG=-1
            ISCALM=ISCALM+1
            T2=-99.9
            H2=0.0
            A2=0.0
            ISELIM=1
          ENDIF
          IF(ISFLAG.GT.0)THEN
            T2=ST
            H2=SH*CONVLEN
            D2=DEPTH*CONVLEN
C
C  Convert wave angle to an angle in degrees with respect to shore-normal.
C  Angles counter-clockwise from shore-normal are positive.
C  Angles clockwise from shore-normal are negitive.
C    -90 <= ANGLE <= 90
C
            IF(INFOR.LE.4)THEN
              IF(IPHASE.LE.2)THEN
                A2=SHOANG+90-STH
                IF(A2.GE.270.)A2=A2-360.
                IF(A2.LE.-270.)A2=A2+360
                IF(A2.LT.-90..OR.A2.GT.90)THEN
C
C  Waves are traveling offshore!
C
                  T2=-99.9
                  H2=0.0
                  A2=0.0
                  ISELIM=2
                  ISOFF=ISOFF+1
                  GOTO 45
                ENDIF
              ELSE
                A2=STH-90.
              ENDIF
            ELSE
              WRITE(*,*) ' This code must be modified to convert your sp
     &ecific'
              WRITE(*,*) ' coordinate system to one with respect to shor
     &e-normal'
              GOTO 35
C??????????????????????????????????????????????????????????????????????????????
C  In this section convert the wave event angle from the coordinate system
C  of the input file.
C
C  Convert wave angle to an angle in degrees with respect to shore-normal.
C  Angles counter-clockwise from shore-normal are positive.
C  Angles clockwise from shore-normal are negitive.
C    -90 <= ANGLE <= 90
C??????????????????????????????????????????????????????????????????????????????
            ENDIF
            CALL RCALC(T2,H2,A2,D2,ISCRIT)
            IF(T2.LT.0)THEN
              ISKILL=ISKILL+1
              ISELIM=3
            ENDIF
          ENDIF
C
C  Write eliminated SWELL events to output file REPORT.RC
```

```
C  with elimination code (reason for elimination).
C
   45     IF(ISELIM.EQ.1)WRITE(97,400) IDATE,SH,ST,STH
          IF(ISELIM.EQ.2)WRITE(97,500) IDATE,SH,ST,STH
          IF(ISELIM.EQ.3)WRITE(97,600) IDATE,SH,ST,STH
        ENDIF
C
C  Write event to the output time series file specified above!
C
        IF(ICOUNT.EQ.1)THEN
          IF(INFOR.EQ.1.OR.INFOR.EQ.2)THEN
            WRITE(98,700) STAID, NEVENTS
          ELSEIF(INFOR.EQ.3.OR.INFOR.EQ.4)THEN
            WRITE(98,800) STATYP, STAID, ISMO, ISYR, IEMO, IEYR, NEVENTS
          ENDIF
        ENDIF
        IF(INFOR.LE.4)THEN
          IF(ICCRIT.EQ.1.AND.ISCRIT.EQ.1)THEN             ! satisfied RCRIT
            IF(ICELIM.EQ.0.AND.ISELIM.EQ.0)THEN           ! not eliminated
              WRITE(98,900) IDATE,CH,CT,CTH,SH,ST,STH
            ELSEIF(ICELIM.EQ.0.AND.ISELIM.GT.0)THEN       ! sea not eliminated
              WRITE(98,900) IDATE,CH,CT,CTH,H2,T2,A2
            ELSEIF(ICELIM.GT.0.AND.ISELIM.EQ.0)THEN       ! swell not eliminated
              WRITE(98,900) IDATE,H1,T1,A1,SH,ST,STH
            ELSEIF(ICELIM.GT.0.AND.ISELIM.GT.0)THEN       ! sea & swell eliminated
              WRITE(98,900) IDATE,H1,T1,A1,H2,T2,A2
            ENDIF
          ELSEIF(ICCRIT.EQ.1.AND.ISCRIT.EQ.0)THEN         ! sea satisfied RCRIT
            IF(ICELIM.EQ.0)THEN                           ! sea not eliminated
              WRITE(98,900) IDATE,CH,CT,CTH,H2,T2,A2
            ELSE                                          ! sea eliminated
              WRITE(98,900) IDATE,H1,T1,A1,H2,T2,A2
            ENDIF
          ELSEIF(ICCRIT.EQ.0.AND.ISCRIT.EQ.1)THEN         ! swell satisfied RCRIT
            IF(ISELIM.EQ.0)THEN                           ! swell not eliminated
              WRITE(98,900) IDATE,H1,T1,A1,SH,ST,STH
            ELSE                                          ! swell eliminated
              WRITE(98,900) IDATE,H1,T1,A1,H2,T2,A2
            ENDIF
          ELSEIF(ICCRIT.EQ.0.AND.ISCRIT.EQ.0)THEN         ! RCRIT not satisfied
            WRITE(98,900) IDATE,H1,T1,A1,H2,T2,A2
          ENDIF
        ELSEIF(INFOR.EQ.5)THEN
          WRITE(*,*) ' This code must be modified to write your specific
     &'
          WRITE(*,*) ' time series output file header and wave event for
     &mat.'
          GOTO 35
C???????????????????????????????????????????????????????????????????????
C  In this section write your specific time series output file header, and
C  prepare to write the wave event(s) to the output time series file.
C
C  The coordinate system of choice is one in which wave angles are with respect
C  to shore-normal and reflect the direction from which they are traveling.
C?????????.?????????????????????????????????????????????????????????????
        ENDIF
   30 CONTINUE
      WRITE(97,*) '  '
      WRITE(97,*) ' ************  Summary of Operations  ************'
      WRITE(97,*) '  '
      WRITE(97,99) ICOUNT
      WRITE(97,*) '  '
      WRITE(97,*) ICCALM,' Sea events were flagged as calm.'
      WRITE(97,*) ICOFF,' Sea events were flagged as offshore traveling.
     &'
      WRITE(97,*) ICKILL,' Sea events were flagged as below threshold.'
      WRITE(97,*) ICOUNT-ICCALM-ICOFF-ICKILL,' Sea events exceeded the t
     &hreshold criteria.'
      IF(NEPR.EQ.2)THEN
        WRITE(97,*) '  '
        WRITE(97,*) ISCALM,' Swell events were flagged as calm.'
        WRITE(97,*) ISOFF,' Swell events were flagged as offshore travel
```

```
     &ing.'
        WRITE(97,*) ISKILL,' Swell events were flagged as below threshol
     &d.'
        WRITE(97,*) ICOUNT-ISCALM-ISOFF-ISKILL,' Swell events exceeded t
     &he threshold criteria.'
      ENDIF
      WRITE(*,*) '  '
      WRITE(*,*) ' ************  Summary of Operations  ************'
      WRITE(*,*) '  '
      WRITE(*,99) ICOUNT
      WRITE(*,*) '  '
      WRITE(*,*) ICCALM,' Sea events were flagged as calm.'
      WRITE(*,*) ICOFF,' Sea events were flagged as offshore traveling.'
      WRITE(*,*) ICKILL,' Sea events were flagged as below threshold.'
      WRITE(*,*) ICOUNT-ICCALM-ICOFF-ICKILL,' Sea events exceeded the th
     &reshold criteria.'
      IF(NEPR.EQ.2)THEN
      WRITE(*,*) '  '
        WRITE(*,*) ISCALM,' Swell events were flagged as calm.'
        WRITE(*,*) ISOFF,' Swell events were flagged as offshore traveli
     &ng.'
        WRITE(*,*) ISKILL,' Sea events were flagged as below threshold.'
        WRITE(*,*) ICOUNT-ISCALM-ISOFF-ISKILL,' Swell events exceeded th
     &e threshold criteria.'
      ENDIF
   35 CONTINUE
   99 FORMAT (1X,' A total of ',I5,' records was processed.')
  100 FORMAT (1X,' sea          calm ',7X,I8,1X,F7.1,1X,F7.1,3X,F7.1)
  200 FORMAT (1X,' sea   offshore traveling ',I8,1X,F7.1,1X,F7.1,3X,F7.1
     &)
  300 FORMAT (1X,' sea     below threshold ',1X,I8,1X,F7.1,1X,F7.1,3X,F7
     &.1)
  400 FORMAT (1X,'swell        calm ',7X,I8,1X,F7.1,1X,F7.1,3X,F7.1)
  500 FORMAT (1X,'swell  offshore traveling ',I8,1X,F7.1,1X,F7.1,3X,F7.1
     &)
  600 FORMAT (1X,'swell    below threshold ',1X,I8,1X,F7.1,1X,F7.1,3X,F7
     &.1)
  700 FORMAT(1X,A,I15)
  800 FORMAT(1X,A,A,2(2X,2I3),I10)
  900 FORMAT(1X,I8,3X,3F8.1,3X,3F8.1)
  980 FORMAT(1X,I8,2(F5.1,F5.1,F5.0)) ! CEDRS format (WIS data)
  990 FORMAT(2X,I8,2(I4,I3,I4))       ! SEAS format (WIS data)
      STOP
      END

      FUNCTION SIZEOF(STRING)
C
C  A function which determines the length of a string (excluding white space).
C
      CHARACTER*(*) STRING
      LENGTH=LEN(STRING)
      I=LENGTH
    5 I=I-1
      IF(STRING(I:I).EQ.' ')GOTO 5
      IF(I.GE.24)I=24
      IF(I.EQ.0)I=1
      SIZEOF=I
      RETURN
      END

      SUBROUTINE RCALC(T,HD,AD,D,IFLAG)
C****************************************************************************C
C   PROGRAM  RCALC.FOR :  This program will transform the offshore wave event
C                         (WIS or gage data) assuming straight and parallel
C                         contours to breaking and calulate the discharge
C                         parameter " R ".  R will be compared to Rc (the
C                         critical discharge for significant longshore
C                         sediment transport, determined from DUCK data).
C                         insignificant waves (those below the threshold)
C                         will be flagged!
C****************************************************************************C
C****************************************************************************C
```

```
C   LIST OF VARIABLES SENT TO SUBROUTINES                                    C
C                                                                            C
C       K= TRANSFORMED WAVE NUMBER                                           C
C       H= TRANSFORMED WAVE HEIGHT (IN METERS, WITH NO MULTIPLIER)           C
C     ANG= TRANSFORMED WAVE ANGLE                                            C
C      CG= TRANSFORMED GROUP WAVE VELOCITY                                   C
C      KD= "OFFSHORE" WAVE NUMBER                                            C
C      HD= "OFFSHORE" WAVE HEIGHT  (IN METERS, WITH NO MULTIPLIER)           C
C    DANG= "OFFSHORE" WAVE APPROACH ANGLE RELATIVE TO STRAIGHT               C
C          AND PARALLEL DEPTH CONTOURS                                       C
C     CGD= "OFFSHORE" GROUP WAVE VELOCITY                                    C
C****************************************************************************C
      REAL KD,K,KWAV
      COMMON SIGMA,KWAV
      PI=3.14159
      DTR=PI/180.
      DANG=AD*DTR
      SIGMA=PI*2./T
      KWAV=SIGMA**2./9.807
C
C    GIVEN DEPTH AT THE GAGE OR STATION AND SENDING SIGMA AND KWAV VIA
C    A COMMON STATEMENT, CALCULATE WAVE CHARACTERISTICS AFTER REFRACTION
C
      IF(D.LT.0.)THEN
        KD=(2*PI)**2./(9.807*T**2.)
        CGD=.5*SQRT(9.807/KD)
        D=.5*(9.807*T**2./(2*PI))
        IF(D.LT.2.)D=2.
      ELSE
        CALL SNELL(DUM,DUM,DUM,DUM,D,K,DUM,DUM,CG)
        CGD=CG
        KD=K
      ENDIF
C
C    CALCULATE THE WAVE HEIGHT AND ANGLE AT THE POINT
C    OF BREAKING (H=0.78D)
C
        CALL FINDBR(KD,HD,DANG,CGD,D,K,H,ANG,CG,NOCON)
C
C    CALCULATE "R" FOR WAVE CONDITIONS
C
        R=86.27*H**3.*SIN(2.*ANG)
        IF(ABS(R) .LT. (3.94)/2.) THEN
          T=-99.9
          HD=0.0
          AD=0.0
          IFLAG=0
        ENDIF
      RETURN
      END

C************************************************************************
      SUBROUTINE SNELL(KD,HD,DANG,CGD,D,K,H,ANG,CG)
C************************************************************************
C
C  COMPUTES REFRACTION COEFFICIENT FOR LINEAR WAVES USING
C  SNELL'S LAW AND THE SHOALING COEFFICIENT.
C
      REAL KD,K,KS,KR,KAP,KWAV
      DIMENSION A(9)
      DATA A/0.66667,0.35555,0.16084,0.06320,0.02174,0.00654,0.00171,
     &0.00039,0.00011/
      COMMON SIGMA,KWAV
C
C  CALCULATE K USING A PADE APPROXIMATION
C
      Y=KWAV*D
      KAP=Y+1./(1.+Y*(A(1)+Y*(A(2)+Y*(A(3)+Y*(A(4)+Y*(A(5)+Y*(A(6)+Y*(A(
     &    7)+Y*(A(8)+Y*A(9)))))))))
      K=SQRT(KWAV*KAP/D)
      SANG=KD*SIN(DANG)/K
      ANG=ASIN(SANG)
```

```
      KR=SQRT(ABS(COS(DANG)/COS(ANG)))
      arg=2.*K*D
      IF(ARG .GT. 88.)arg=88.
      CG=.5*(1.+(2.*K*D)/SINH(arg))*(SIGMA/K)
      KS=SQRT(CGD/CG)
      H=HD*KR*KS
C      WRITE(*,*)'Y= ',Y,'KAP= ',KAP,'K= ',K,'DANG= ',DANG*(180/3.14159)
C      WRITE(*,*)'ANG= ',ANG*(180/3.14159),'KR= ',KR,'CG= ',CG,'KS= ',KS
C      WRITE(*,*)'HD= ',HD,'H= ',H
      RETURN
      END

C***************************************************************************
      SUBROUTINE FINDBR(KD,HD,DANG,CGD,D,K,H,ANG,CG,NOCON)
C***************************************************************************
C
C  COMPUTES BREAKING WAVE HEIGHT AND ANGLE WITHOUT CONSIDERING
C  DIFFRACTION
C
      REAL KD,K
      DDEEP=D
      DSHAL=.01
      K=KD
      H=HD
      ANG=DANG
      CG=CGD
      IBIT=0
  200 CONTINUE
      IBIT=IBIT+1
      IF(IBIT .EQ. 20) GOTO 120
      HB=.78*D
      IF(ABS(HB-H) .LE. .05) GOTO 120
      IF(H .LT. HB) GOTO 110
      DSHAL=D
C      WRITE(*,*)'HB= ',HB,'H= ',H,'IBIT= ',IBIT
      IF(IBIT .EQ. 1) THEN
        H=HB
        ANG=DANG
        CALL SNELL(DUM,DUM,DUM,CGD,D,K,DUM,DUM,CG)
        GOTO 120
      ELSE
        D=.5*(DDEEP+D)
      ENDIF
      CALL SNELL(KD,HD,DANG,CGD,D,K,H,ANG,CG)
      GOTO 200
110   CONTINUE
      DDEEP=D
      D=.5*(DSHAL+D)
      CALL SNELL(KD,HD,DANG,CGD,D,K,H,ANG,CG)
      GOTO 200
120   CONTINUE
      IF(IBIT .EQ. 20) THEN
      WRITE(*,*) 'ERROR IN "FINDBR".'
      WRITE(*,*) 'THE CALCULATION FOR HB DID NOT CONVERGE!!'
      NOCON=1
      ENDIF
      RETURN
      END

```

APPENDIX C: SYSTEM SUPPORT PROGRAM SEDTRAN

```
      PROGRAM SEDTRAN
c******************************************************************************
C     This program reads an input time series in an event by event manner
C     and calculates the potential longshore sand transport rate for each
C     wave event in the time series.  Output from this program is written to
C     output files ([filename].PTR & [filename].PT).  The file [filename].PT
C     contains tables of the estimated total sand transport volumes and
C     transport rates together with summary information about the time series.
C     The file [filename].PTR contains only the numerical values from the tables given
C     in [filename].PT, this file may be used for plotting purposes.
c//////////////////////////////////////////////////////////////////////////////
c\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
C     Two pre-determined input file formats may be used for input.  These are
C     either a SEAS "USER" file or a CEDRS file which resulted from an extract
C     data operation.  There is also a section in which the user can specify
C     the unique format of his specific input wave time series.
C
C     All calculations within the program are performed in SI units.  However,
C     input and output units may (must) be specified.
c******************************************************************************
C  Define variable types.
      IMPLICIT REAL (A-H,Q-Z)
      INTEGER OSHOANG(20)
      REAL OLDPTS(20,13),PI
      CHARACTER*28 FIN,FOUT,F1OUT,F2OUT
      CHARACTER*15 STATYP,STAID
C
C  Initialize One Variable
C
      PI=3.14159265
C
C  Prompt and Read Basic information
C
      WRITE(*,*) ' Enter your input filename and extension (including th
     &e path if the file is'
      WRITE(*,*) ' not in the default directory): (MAXIMUM OF 28 CHARACT
     &ERS)'
      WRITE(*,*) '   '
      READ(*,*) FIN
      OPEN(UNIT=99, FILE=FIN, STATUS='OLD')
      WRITE(*,*) '   '
      WRITE(*,*) '   '
      WRITE(*,*) ' Enter your output filename without the extenstion (in
     &cluding the path if the'
      WRITE(*,*) ' file is to be written to another directory): (MAXIMUM
     & OF 24 CHARACTERS)'
      WRITE(*,*) '   '
      READ(*,*) FOUT
      F2OUT=FOUT
      LENGTH=SIZEOF(FOUT)
      F2OUT(LENGTH+1:LENGTH+3)='.PT'
      OPEN(UNIT=97, FILE=F2OUT, STATUS='NEW')
      WRITE(*,*) '   '
      WRITE(*,*) ' Enter your plot data output filename without the exte
     &nstion (including the'
      WRITE(*,*) ' path if the file is to be written to another director
     &y): '
      WRITE(*,*)' (MAXIMUM OF 24 CHARACTERS)'
      WRITE(*,*) '   '
      READ(*,*) FOUT
      F1OUT=FOUT
      LENGTH=SIZEOF(FOUT)
      F1OUT(LENGTH+1:LENGTH+4)='.PTR'
      OPEN(UNIT=98, FILE=F1OUT, STATUS='UNKNOWN')
    5 WRITE(*,*) ' Define your input data format: '
      WRITE(*,*) '    1 = SEAS'
      WRITE(*,*) '    2 = OUTPUT FROM ANOTHER WORKBOOK CODE (Header & For
     &mat like SEAS)'
```

```
      WRITE(*,*) '   3 = CEDRS'
      WRITE(*,*) '   4 = OUTPUT FROM ANOTHER WORKBOOK CODE (Header & For
     &mat like CEDRS)'
      WRITE(*,*) '   5 = other'
      WRITE(*,*) '   '
      WRITE(*,*) '   Enter the value corresponding to your input data: '
      READ(*,*) INFOR
      WRITE(*,*) '   '
      IF(INFOR.LE.4)THEN
       IF(INFOR.EQ.2.OR.INFOR.EQ.4)THEN
        WRITE(*,*)'  Enter the number of events per record: '
        READ(*,*) NEPR
        WRITE(*,*) '   '
       ELSE
        NEPR=2
       ENDIF
       GOTO 10
      ELSEIF(INFOR.EQ.5)THEN
       GOTO 15
      ELSE
       WRITE(*,*) '   '
       WRITE(*,*) 'Illegal input !'
       WRITE(*,*) '   '
       GOTO 5
      ENDIF
   10 WRITE(*,*) ' Define your input time series data type: '
      WRITE(*,*) ' 1 = Phase I  '
      WRITE(*,*) ' 2 = Phase II  '
      WRITE(*,*) ' 3 = Phase III  '
      WRITE(*,*) '   '
      WRITE(*,*) '   Enter the value corresponding to your input data: '
      READ(*,*) IPHASE
      IF(IPHASE.EQ.1)THEN
       IF(INFOR.EQ.3.OR.INFOR.EQ.4)GOTO 20
       DEPTH = -999.
       WRITE(*,*) ' Enter the shoreline orientation (in degrees, clockw
     &ise from north): '
       READ(*,*) SHOANG
       WRITE(*,*) ' Enter the time step (hours) of the input time serie
     &s: '
       READ(*,*) DT
      ELSEIF(IPHASE.EQ.2)THEN
       WRITE(*,*) '   '
       WRITE(*,*) ' Enter water depth (cm for SEAS & m for CEDRS) for t
     &he input time series: '
       WRITE(*,*) ' (enter -999 for deep water conditions): '
       READ(*,*) DEPTH
       WRITE(*,*) '   '
       WRITE(*,*) ' Enter the shoreline orientation (in degrees, clockw
     &ise from north): '
       READ(*,*) SHOANG
       WRITE(*,*) '   '
       WRITE(*,*) ' Enter the time step (hours) of the input time serie
     &s: '
       READ(*,*) DT
      ELSEIF(IPHASE.EQ.3)THEN
       IF(INFOR.LE.4)THEN
        WRITE(*,*) ' Enter water depth (cm for SEAS & m for CEDRS) for
     & the input time series: '
        READ(*,*) DEPTH
        WRITE(*,*) ' Enter the time step of the input time series: '
        READ(*,*) DT
       ENDIF
      ELSE
   20  WRITE(*,*) '   '
       WRITE(*,*) 'Illegal input !'
       WRITE(*,*) '   '
       GOTO 10
      ENDIF
      GOTO 25
   15 WRITE(*,*) ' This code must be modified to read your specific'
      WRITE(*,*) ' input file header !'
```

```
      GOTO 35
C??????????????????????????????????????????????????????????????????????????????
C  In this section read (or prompt for) the input file header information
C  and define the system of units used in the input data file, the depth
C  corresponding to the time series, the time step of the events, the shoreline
C  orientation, and the number of records in the file record.  Note, that each
C  record may contain more than one event (e.g.  h, t, & theta for sea waves
C  and h, t, & theta for swell waves etc.).
C  Load the conversion factor for length into the variable CONVLEN.
C  Load the time step (hours) of the time series into DT.
C  Load the depth (in meters) into the variable DEPTH.
C  Load the number of events per record into NEPR.
C  Load the shoreline orientation into SHOANG.
C??????????????????????????????????????????????????????????????????????????????
   25 IF(INFOR.EQ.1.OR.INFOR.EQ.2)THEN
        CONVLEN = .01
        READ(99,*) STAID, NEVENTS
      ELSEIF(INFOR.EQ.3.OR.INFOR.EQ.4)THEN
        CONVLEN = 1.
        READ(99,*) STATYP, STAID, IDUM, IDUM, IDUM, IDUM, NEVENTS
      ENDIF
C
C     Begin calculation loop
C
C     At this point the following variables
C     must contain meaningful values.
C          CONVLEN: Length conversion factor.
C          DEPTH: Water depth of input time series.
C          NEVENTS: Number of records in time series.
C          NEPR: Number of wave events per record (maximum is two).
C          SHOANG: Shoreline orientation with respect to north.
C          DT: Time step of the input time series.
C
      IF(NEPR.GT.2)THEN
        WRITE(*,*) ' To many wave events per record!'
        GOTO 35
      ENDIF
      DO 30 I=1,NEVENTS
        IF(INFOR.LE.4)THEN
          IF(INFOR.EQ.2.OR.INFOR.EQ.4)THEN
            IF(NEPR.EQ.2)THEN
              READ(99,*)IDATE,CH,CT,CTH,SH,ST,STH
            ELSE
              READ(99,*)IDATE,CH,CT,CTH
            ENDIF
          ENDIF
          IF(INFOR.EQ.1)THEN
            READ(99,990)IDATE,ICH,ICT,ICTH,ISH,IST,ISTH
            CH=FLOAT(ICH)
            CT=FLOAT(ICT)
            CTH=FLOAT(ICTH)
            SH=FLOAT(ISH)
            ST=FLOAT(IST)
            STH=FLOAT(ISTH)
          ENDIF
          IF(INFOR.EQ.3)THEN
            READ(99,980)IDATE,CH,CT,CTH,SH,ST,STH
          ENDIF
        ELSE
          WRITE(*,*) ' This code must be modified to read your specific
     &input time series !'
          WRITE(*,*) ' This program will now terminate'
          GOTO 35
C??????????????????????????????????????????????????????????????????????????????
C  In this section read the wave event(s) from the input file.
C
C  Read the height, period, and angle of the first wave event into
C  CH, CT, and CTH.
C
C  If there are two events per record, read second wave event height,
C  period, and angle into SH, ST, STH.
C??????????????????????????????????????????????????????????????????????????????
```

```
        ENDIF
        ICOUNT=ICOUNT+1
        ICFLAG=1
        ISFLAG=1
        IF(CT.LE.0.0)THEN
          ICFLAG=-1
          ICCALM=ICCALM+1
        ENDIF
        IF(ICFLAG.GT.0)THEN
          TINC=CT
          HINC=CH*CONVLEN
          DIN=DEPTH*CONVLEN
C
C  Convert wave angle to an angle in degrees with respect to shore-normal.
C  Angles counter-clockwise from shore-normal are positive.
C  Angles clockwise from shore-normal are negitive.
C    -90 <= ANGLE <= 90
C
          IF(INFOR.LE.4)THEN
            IF(IPHASE.LE.2)THEN
              ZINC=SHOANG+90-CTH
              IF(ZINC.GE.270.)ZINC=ZINC-360.
              IF(ZINC.LE.-270.)ZINC=ZINC+360
              IF(ZINC.LT.-90..OR.ZINC.GT.90)THEN
C
C  Waves are traveling offshore!
C
                ICFLAG=-1
              ENDIF
            ELSE
              ZINC=CTH-90.
            ENDIF
          ELSE
            WRITE(*,*) ' This code must be modified to convert your spec
     &ific'
            WRITE(*,*) ' coordinate system to one with respect to shore-
     &normal'
            GOTO 35
C??????????????????????????????????????????????????????????????????????????????
C  In this section convert the wave event angle from the coordinate system
C  of the input file.
C
C  Convert wave angle to an angle in degrees with respect to shore-normal.
C  Angles counter-clockwise from shore-normal are positive.
C  Angles clockwise from shore-normal are negitive.
C    -90 <= ANGLE <= 90
C??????????????????????????????????????????????????????????????????????????????
          ENDIF
        ENDIF
        IF(ST.LE.0.0)THEN
          ISFLAG=-1
          ISCALM=ISCALM+1
        ENDIF
        IF(ISFLAG.GT.0)THEN
          TINS=ST
          HINS=SH*CONVLEN
          DIN=DEPTH*CONVLEN
C
C  Convert wave angle to an angle in degrees with respect to shore-normal.
C  Angles counter-clockwise from shore-normal are positive.
C  Angles clockwise from shore-normal are negitive.
C    -90 <= ANGLE <= 90
C
          IF(INFOR.LE.4)THEN
            IF(IPHASE.LE.2)THEN
              ZINS=SHOANG+90-STH
              IF(ZINS.GE.270.)ZINS=ZINS-360.
              IF(ZINS.LE.-270.)ZINS=ZINS+360
              IF(ZINS.LT.-90..OR.ZINS.GT.90)THEN
C
C  Waves are traveling offshore!
C
```

```
                ISFLAG=-1
              ENDIF
            ELSE
              ZINS=STH-90.
            ENDIF
          ELSE
            WRITE(*,*) ' This code must be modified to convert your spec
     &ific'
            WRITE(*,*) ' coordinate system to one with respect to shore-
     &normal'
            GOTO 35
C??????????????????????????????????????????????????????????????????????????????
C  In this section convert the wave event angle from the coordinate system
C  of the input file.
C
C  Convert wave angle to an angle in degrees with respect to shore-normal.
C  Angles counter-clockwise from shore-normal are positive.
C  Angles clockwise from shore-normal are negitive.
C    -90 <= ANGLE <= 90
C??????????????????????????????????????????????????????????????????????????????
          ENDIF
        ENDIF
C
C  For each event calculate the potential longshore sand transport volume.
C
        IF(ICFLAG.GT.0)THEN
          ZINC=ZINC*PI/180.
          CALL TVOL(HINC,TINC,ZINC,DIN,DT,V)
          IF(V.LT.0.)THEN
            VCL=VCL+V
          ELSE
            VCR=VCR+V
          ENDIF
        ENDIF
        IF(ISFLAG.GT.0)THEN
          ZINS=ZINS*PI/180.
          CALL TVOL(HINS,TINS,ZINS,DIN,DT,V)
          IF(V.LT.0.)THEN
            VSL=VSL+V
          ELSE
            VSR=VSR+V
          ENDIF
        ENDIF
   30 CONTINUE
C
C  SUMMARIZE THE FINDINGS: report total volumes in transit, period of record,
C                              if less than a year note that the annualized values may
reflect
C                            may reflect a seasonal bias.
C
      YRS=ICOUNT*DT/8760.
      WRITE(*,*)'  '
      WRITE(*,*) '         ESTIMATED POTENTIAL LONGSHORE SAND TRANSPORT
     & RATES'
      WRITE(*,*)'                 INPUT TIME SERIES: ',FIN
      WRITE(*,*)'  '
      WRITE(*,*)'  '
      WRITE(*,*)'                                TABLE 1'
      WRITE(*,*)'                     SAND TRANSPORT VOLUMES (M**3)'
      WRITE(*,*)'  '
      WRITE(*,*)'  WAVE           LEFT           RIGHT'
      WRITE(*,*)'  TYPE         DIRECTED         DIRECTED         NET
     &         GROSS'
      WRITE(*,*)'---------------------------------------------------------------
     &----------------'
      WRITE(*,*)'  '
      WRITE(*,100) VCL,VCR,VCL+VCR,VCR-VCL
      IF(NEPR.EQ.2)THEN
        WRITE(*,200) VSL,VSR,VSL+VSR,VSR-VSL
        WRITE(*,300) VCL+VSL,VCR+VSR,VCL+VSL+VCR+VSR,VCR-VCL+VSR-VSL
      ENDIF
      WRITE(*,*)'  '
```

```
      WRITE(*,*)'-------------------------------------------------------
     &----------------'
      WRITE(*,*)'  '
      WRITE(*,*)'  '
      WRITE(*,*)'  '
      WRITE(*,*)'  '
      WRITE(*,*)'                                 TABLE 2'
      WRITE(*,*)'                     SAND TRANSPORT RATES (M**3/YEAR)'
      WRITE(*,*)'  '
      WRITE(*,*)'   WAVE           LEFT            RIGHT'
      WRITE(*,*)'   TYPE         DIRECTED         DIRECTED         NET
     &         GROSS'
      WRITE(*,*)'-------------------------------------------------------
     &----------------'
      WRITE(*,*)'  '
      WRITE(*,400) VCL/YRS,VCR/YRS,(VCL+VCR)/YRS,(VCR-VCL)/YRS
      IF(NEPR.EQ.2)THEN
        WRITE(*,500) VSL/YRS,VSR/YRS,(VSL+VSR)/YRS,(VSR-VSL)/YRS
        WRITE(*,600) (VCL+VSL)/YRS,(VCR+VSR)/YRS,(VCL+VSL+VCR+VSR)/YRS,
     &(VCR-VCL+VSR-VSL)/YRS
      ENDIF
      WRITE(*,*)'  '
      WRITE(*,*)'-------------------------------------------------------
     &----------------'
      WRITE(*,*)'  '
      WRITE(*,*)'  '
      WRITE(*,*)'  '
      WRITE(*,*)'                       SUMMARY OF TIME SERIES DATA'
      WRITE(*,*)'                       ---------------------------'
      WRITE(*,*)'  '
      WRITE(*,610) YRS
      IF(YRS.LT.1.)THEN
      WRITE(*,*)'  '
        WRITE(*,*) ' NOTE: Since the duration of this time series is les
     &s than one year, the'
        WRITE(*,*) '       estimates reported above may reflect a season
     &al bias.'
        WRITE(*,*)'  '
      ENDIF
      WRITE(*,620) INT(SHOANG)
      WRITE(*,630) ICOUNT, INT(DT)
      WRITE(*,*) ICCALM,' sea events were calm.'
      IF(NEPR.EQ.2)THEN
        WRITE(*,*) ISCALM,' swell events were calm.'
      ENDIF
      WRITE(97,*)'  '
      WRITE(97,*) '        ESTIMATED POTENTIAL LONGSHORE SAND TRANSPORT
     &RATES'
      WRITE(97,*)'                   INPUT TIME SERIES: ',
     &FIN
      WRITE(97,*)'  '
      WRITE(97,*)'  '
      WRITE(97,*)'                                 TABLE 1'
      WRITE(97,*)'                      SAND TRANSPORT VOLUMES (M**3)'
      WRITE(97,*)'  '
      WRITE(97,*)'   WAVE            LEFT            RIGHT'
      WRITE(97,*)'   TYPE          DIRECTED         DIRECTED         NET
     &           GROSS'
      WRITE(97,*)'------------------------------------------------------
     &------------------'
      WRITE(97,*)'  '
      WRITE(97,100) VCL,VCR,VCL+VCR,VCR-VCL
      IF(NEPR.EQ.2)THEN
        WRITE(97,200) VSL,VSR,VSL+VSR,VSR-VSL
        WRITE(97,300) VCL+VSL,VCR+VSR,VCL+VSL+VCR+VSR,VCR-VCL+VSR-VSL
      ENDIF
      WRITE(97,*)'  '
      WRITE(97,*)'------------------------------------------------------
     &------------------'
      WRITE(97,*)'  '
      WRITE(97,*)'  '
      WRITE(97,*)'  '
```

```
      WRITE(97,*)'  '
      WRITE(97,*)'                                TABLE 2'
      WRITE(97,*)'                    SAND TRANSPORT RATES (M**3/YEAR)'
      WRITE(97,*)'  '
      WRITE(97,*)'   WAVE            LEFT            RIGHT'
      WRITE(97,*)'   TYPE          DIRECTED         DIRECTED         NET
     &           GROSS'
      WRITE(97,*)'----------------------------------------------------
     &------------------'
      WRITE(97,*)'  '
      WRITE(97,400) VCL/YRS,VCR/YRS,(VCL+VCR)/YRS,(VCR-VCL)/YRS
      IF(NEPR.EQ.2)THEN
        WRITE(97,500) VSL/YRS,VSR/YRS,(VSL+VSR)/YRS,(VSR-VSL)/YRS
        WRITE(97,600) (VCL+VSL)/YRS,(VCR+VSR)/YRS,(VCL+VSL+VCR+VSR)/YRS,
     &(VCR-VCL+VSR-VSL)/YRS
      ENDIF
      WRITE(97,*)'  '
      WRITE(97,*)'----------------------------------------------------
     &------------------'
      WRITE(97,*)'  '
      WRITE(97,*)'  '
      WRITE(97,*)'  '
      WRITE(97,*)'  '
      WRITE(97,*)'  '
      WRITE(97,*)'                      SUMMARY OF TIME SERIES DATA'
      WRITE(97,*)'                      ---------------------------'
      WRITE(97,*)'  '
      WRITE(97,610) YRS
      IF(YRS.LT.1.)THEN
      WRITE(97,*)'  '
        WRITE(97,*) ' NOTE: Since the duration of this time series is le
     &ss than one year, the'
        WRITE(97,*) '       estimates reported above may reflect a seaso
     &nal bias.'
        WRITE(97,*)'  '
      ENDIF
      WRITE(97,620) INT(SHOANG)
      WRITE(97,630) ICOUNT, INT(DT)
      WRITE(97,*) ' ',ICCALM,' sea events were calm.'
      IF(NEPR.EQ.2)THEN
        WRITE(97,*) ' ',ISCALM,' swell events were calm.'
      ENDIF
C
C  WRITE DATA TO PLOT FILE
C  (if the file exists update it!)
C
      READ(98,*,END=40) NPTS
      NPTS=NPTS+1
      IF(NPTS.GE.20)THEN
        WRITE(*,*) 'The current [filename].PTR file is full (increase th
     &e dimension of the arrays'
        WRITE(*,*) 'OSHOANG from (20) to (>20) and OLDPTS from (20,13) t
     &o (>20,13)'
        GOTO 35
      ENDIF
      READ(98,*)NYPTS
      DO 45 I=1,NPTS-1
        READ(98,*) OSHOANG(I),(OLDPTS(I,II),II=1,NYPTS)
   45 CONTINUE
      REWIND(98)
      WRITE(98,*)NPTS
      WRITE(98,*)NYPTS
      DO 50 I=1,NPTS-1
        IF(NYPTS.EQ.2)THEN
          WRITE(98,700) OSHOANG(I),(OLDPTS(I,II),II=1,NYPTS)
        ELSE
          WRITE(98,[illegible]) OSHOANG(I),(OLDPTS(I,II),II=1,NYPTS)
        ENDIF
   50 CONTINUE
      IF(NYPTS.EQ.2)THEN
        WRITE(98,700)INT(SHOANG ,VCL/YRS,VCR/YRS
      ELSE
```

```
        WRITE(98,800)INT(SHOANG),VCL/YRS,VCR/YRS,VSL/YRS,VSR/YRS,
     &(VCL+VSL)/YRS,(VCR+VSR)/YRS
      GOTO 35
      ENDIF
   40 CONTINUE
      REWIND(98)
      NPTS=1
      IF(NEPR.EQ.1)THEN
        NYPTS=2
      ELSE
        NYPTS=6
      ENDIF
      WRITE(98,*)NPTS
      WRITE(98,*)NYPTS
      IF(NYPTS.EQ.2)THEN
        WRITE(98,700)INT(SHOANG),VCL/YRS,VCR/YRS
      ELSE
        WRITE(98,800)INT(SHOANG),VCL/YRS,VCR/YRS,VSL/YRS,VSR/YRS,
     &(VCL+VSL)/YRS,(VCR+VSR)/YRS
      ENDIF
  100 FORMAT(1X,'   sea   ',8X,G9.2,6X,G9.2,6X,G9.2,6X,G9.2)
  200 FORMAT(1X,'  swell  ',8X,G9.2,6X,G9.2,6X,G9.2,6X,G9.2)
  300 FORMAT(1X,' combined',8X,G9.2,6X,G9.2,6X,G9.2,6X,G9.2)
  400 FORMAT(1X,'   sea   ',8X,G9.2,6X,G9.2,6X,G9.2,6X,G9.2)
  500 FORMAT(1X,'  swell  ',8X,G9.2,6X,G9.2,6X,G9.2,6X,G9.2)
  600 FORMAT(1X,' combined',8X,G9.2,6X,G9.2,6X,G9.2,6X,G9.2)
  610 FORMAT('   The duration of the input time series is ',F4.2,' years
     &.')
  620 FORMAT('   These estimates are based on a shoreline orientation of
     &',I4,' deg.')
  630 FORMAT(I13,' events were processed at a time step of',I2,' hr.')

  700 FORMAT(I5,2(1X,G10.3))
  800 FORMAT(I5,6(1X,G10.3))
  980 FORMAT(1X,I8,2(F5.1,F5.1,F5.0)) ! CEDRS format (WIS data)
  990 FORMAT(2X,I8,2(I4,I3,I4))       ! SEAS format (WIS data)
   35 CONTINUE
      STOP
      END


      SUBROUTINE TVOL(H,T,Z,DIN,DT,V)
c*****************************************************************************
C     This subroutine calculates the potential longshore sand transport volume
C     for a given input wave height, period, and direction combination together
C     with the time step associated with the wave event.
C
C     All calculations within this subroutine are performed in SI units.
c*****************************************************************************
      REAL KD,K,KWAV
      COMMON SIGMA,KWAV
      PI=3.14159
      HD=H
      DANG=Z
      SIGMA=PI*2./T
      KWAV=SIGMA**2./9.807
C
C    GIVEN DEPTH AT THE GAGE OR STATION AND SENDING SIGMA AND KWAV VIA
C    A COMMON STATEMENT, CALCULATE WAVE CHARACTERISTICS AFTER REFRACTION
C
      IF(DIN.LT.0.)THEN
        KD=(2*PI)**2./(9.807*T**2.)
        CGD=.5*SQRT(9.807/KD)
        D=.5*(9.807*T**2./(2*PI))
        IF(D.LT.2.)D=2.
      ELSE
        D=DIN
        CALL SNELL(DUM,DUM,DUM,DUM,D,K,DUM,DUM,CG)
        CGD=CG
        KD=K
      ENDIF
C
```

```
C    CALCULATE THE WAVE HEIGHT AND ANGLE AT THE POINT
C    OF BREAKING (H=0.78D)
C
        CALL FINDBR(KD,HD,DANG,CGD,D,K,H,ANG,CG,NOCON)
        HBR=H
        ZBR=ANG
C
C  Calculate the potential longshore sand transport volume (M**3)
C
      Q=HBR**(2.5)*(.07579*SIN(2.*ZBR))
      V=Q*3600.*DT
      RETURN
      END

      FUNCTION SIZEOF(STRING)
C
C  A function which determines the length of a string (excluding white space).
C
      CHARACTER*(*) STRING
      LENGTH=LEN(STRING)
      I=LENGTH
    5 I=I-1
      IF(STRING(I:I).EQ.' ')GOTO 5
      IF(I.GE.24)I=24
      IF(I.EQ.0)I=1
      SIZEOF=I
      RETURN
      END

C************************************************************************
      SUBROUTINE SNELL(KD,HD,DANG,CGD,D,K,H,ANG,CG)
C************************************************************************
C
C  COMPUTES REFRACTION COEFFICIENT FOR LINEAR WAVES USING
C  SNELL'S LAW AND THE SHOALING COEFFICIENT.
C
      REAL KD,K,KS,KR,KAP,KWAV
      DIMENSION A(9)
      DATA A/0.66667,0.35555,0.16084,0.06320,0.02174,0.00654,0.00171,
     &0.00039,0.00011/
      COMMON SIGMA,KWAV
C
C  CALCULATE K USING A PADE APPROXIMATION
C
      Y=KWAV*D
      KAP=Y+1./(1.+Y*(A(1)+Y*(A(2)+Y*(A(3)+Y*(A(4)+Y*(A(5)+Y*(A(6)+Y*(A(
     &    7)+Y*(A(8)+Y*A(9)))))))))))
      K=SQRT(KWAV*KAP/D)
      SANG=KD*SIN(DANG)/K
      ANG=ASIN(SANG)
      KR=SQRT(ABS(COS(DANG)/COS(ANG)))
      ARG=2.*K*D
      IF(ARG .GT. 88.)arg=88.
      CG=.5*(1.+(ARG)/SINH(ARG))*(SIGMA/K)
      KS=SQRT(CGD/CG)
      H=HD*KR*KS
C      WRITE(*,*)'Y= ',Y,'KAP= ',KAP,'K= ',K,'DANG= ',DANG*(180/3.14159)
C      WRITE(*,*)'ANG= ',ANG*(180/3.14159),'KR= ',KR,'CG= ',CG,'KS= ',KS
C      WRITE(*,*)'HD= ',HD,'H= ',H
      RETURN
      END

C************************************************************************
      SUBROUTINE FINDBR(KD,HD,DANG,CGD,D,K,H,ANG,CG,NOCON)
C************************************************************************
C
C  COMPUTES BREAKING WAVE HEIGHT AND ANGLE WITHOUT CONSIDERING
C  DIFFRACTION
C
      REAL KD,K
      DDEEP=D
      DSHAL=.01
```

```
      K=KD
      H=HD
      ANG=DANG
      CG=CGD
      IBIT=0
  200 CONTINUE
      IBIT=IBIT+1
      IF(IBIT .EQ. 20) GOTO 120
      HB=.78*D
      IF(ABS(HB-H) .LE. .05) GOTO 120
      IF(H .LT. HB) GOTO 110
      DSHAL=D
      IF(IBIT .EQ. 1) THEN
        H=HB
        ANG=DANG
        CALL SNELL(DUM,DUM,DUM,CGD,D,K,DUM,DUM,CG)
        GOTO 120
      ELSE
        D=.5*(DDEEP+D)
      ENDIF
      CALL SNELL(KD,HD,DANG,CGD,D,K,H,ANG,CG)
      GOTO 200
 110  CONTINUE
      DDEEP=D
      D=.5*(DSHAL+D)
      CALL SNELL(KD,HD,DANG,CGD,D,K,H,ANG,CG)
      GOTO 200
 120  CONTINUE
      IF(IBIT .EQ. 20) THEN
        WRITE(*,*) 'ERROR IN "FINDBR" '
        WRITE(*,*) 'THE CALCULATION FOR HB DID NOT CONVERGE!!'
        NOCON=1
      ENDIF
      RETURN
      END
```

APPENDIX D: SYSTEM SUPPORT PROGRAM SHORLROT

```
      PROGRAM SHORLROT
c**********************************************************************
C     This Program will read shoreline position data in an x- y-
C     format and calculate the corresponding x- y- values for a
C     rotated coordinate system and translated origin as specified.
c**********************************************************************
C  Define variable types
      IMPLICIT REAL (A-H,Q-Z)
      CHARACTER*28 FIN,FOUT
      DIMENSION X(500),Y(500)
      NPTS=0
C
C  Prompt and Read Basic information
C
      WRITE(*,*) ' Enter your input filename and extension (including th
     &e path if the file is'
      WRITE(*,*) ' not in the default directory): (MAXIMUM OF 28 CHARACT
     &ERS)'
      WRITE(*,*) '   '
      READ(*,*) FIN
      OPEN(UNIT=99, FILE=FIN, STATUS='OLD')
      WRITE(*,*) '   '
    4 WRITE(*,*) '   '
      WRITE(*,*) ' Enter your output filename without the extenstion (in
     &cluding the path if the'
      WRITE(*,*) ' file is to be written to another directory): (MAXIMUM
     & OF 24 CHARACTERS)'
      WRITE(*,*) '   '
      READ(*,*) FOUT
      LENGTH=SIZEOF(FOUT)
      FOUT(LENGTH+1:LENGTH+4)='.ROT'
      OPEN(UNIT=98, FILE=FOUT, ERR=5, STATUS='NEW')
      GOTO 10
    5 WRITE(*,*) 'SPECIFIED OUTPUT FILE ALREADY EXIST!'
      WRITE(*,*) 'OVERWRITE THE FILE:  ',FOUT
      WRITE(*,*) '               (1) = YES'
      WRITE(*,*) '               (2) = NO'
      WRITE(*,*) '   '
      READ(*,*)IANS
      IF(IANS.NE.1)THEN
        IF(IANS.EQ.2)THEN
          GOTO 4
        ELSE
          WRITE(*,*) ' Illegal input !'
          GOTO 5
        ENDIF
      ENDIF
      OPEN(UNIT=98, FILE=FOUT, STATUS='UNKNOWN')
   10 WRITE(*,*) '   '
      WRITE(*,*) ' Enter Rotation Angle: '
      READ(*,*) ROTANG
      WRITE(*,*) '   '
      WRITE(*,*) ' Enter the origin translation distance in X: '
      READ(*,*) XTRAN
      WRITE(*,*) '   '
      WRITE(*,*) ' Enter the origin translation distance in Y: '
      READ(*,*) YTRAN
      WRITE(*,*) '   '
      WRITE(*,*) '   '
   20 WRITE(*,*) ' The coordinate system will now be rotated',ROTANG,' d
     &eg clockwise'
      WRITE(*,*) ' The origin will be translated',XTRAN,'and',YTRAN,' un
     &its in the X and Y directions, respectively'
      WRITE(*,*) '   '
      WRITE(*,*) ' Continue ? '
      WRITE(*,*) '               (1) = YES'
      WRITE(*,*) '               (2) = NO'
      WRITE(*,*) '
```

```
      READ(*,*)IANS
      IF(IANS.NE.1)THEN
        IF(IANS.EQ.2)THEN
          GOTO 10
        ELSE
          WRITE(*,*) ' Illegal input !'
          GOTO 20
        ENDIF
      ENDIF
      WRITE(*,*) '   '
      WRITE(*,*) '   '
      WRITE(*,*) '  NOTE:  The number of digitized shoreline position po
     &ints in your'
      WRITE(*,*) '          input file must NOT exceed 500!'
      WRITE(*,*) '   '
      ROTANG=ROTANG*3.14159/180.
      DO 30 I=1,500
        READ(99,*,END=40) XO,YO
        NPTS=NPTS+1
        X(I)=XO*COS(ROTANG)-YO*SIN(ROTANG)
        Y(I)=XO*SIN(ROTANG)+YO*COS(ROTANG)
        X(I)=X(I)+XTRAN
        Y(I)=Y(I)+YTRAN
   30 CONTINUE
      READ(99,*,END=40) XO,YO
      WRITE(*,*) ' WARNING:  More than 500 shoreline positions points ex
     &ist in your input file.'
      WRITE(*,*) ' NOTE:  ONLY the FIRST 500 points will be considered.'
   40 CONTINUE
      WRITE(*,*) '   '
      WRITE(*,*) ' Do you want to perform a system of units conversion?'
      WRITE(*,*) '               (1) = YES'
      WRITE(*,*) '               (2) = NO'
      WRITE(*,*) '   '
      READ(*,*)IANS
      IF(IANS.NE.1.AND.IANS.NE.2)GOTO 40
   45 IF(IANS.EQ.1)THEN
        WRITE(*,*) ' Which conversion do you want to make?'
        WRITE(*,*) '          (1) = convert meters to feet'
        WRITE(*,*) '          (2) = convert feet to meters'
        WRITE(*,*) '   '
        READ(*,*)IANS
      ELSE
        GOTO 50
      ENDIF
      IF(IANS.NE.1.AND.IANS.NE.2)GOTO 45
      IF(IANS.EQ.1)THEN
        CONV=3.280839895
      ELSE
        CONV=0.3048
      ENDIF
      DO 55 I=1,NPTS
        X(I)=X(I)*CONV
        Y(I)=Y(I)*CONV
   55 CONTINUE
   50 WRITE(98,*) NPTS
      WRITE(98,100) (X(I),Y(I),I=1,NPTS)
  100 FORMAT(8(F10.1))
      STOP
      END

      FUNCTION SIZEOF(STRING)
C
C  A function which determines the length of a string (excluding white space).
C
      CHARACTER*(*) STRING
      LENGTH=LEN(STRING)
      I=LENGTH
    5 I=I-1
      IF(STRING(I:I).EQ.' ')GOTO 5
      IF(I.GE.24)I=24
      IF(I.EQ.0)I=1
```

```
      SIZEOF=I
      RETURN
      END
```

APPENDIX E: SYSTEM SUPPORT PROGRAM CUINTP

```
      Program CUINTP
c**************************************************************
C     This program will read shoreline position data which have
C     been rotated to the preferred baseline orientation using
C     the program SHORLROT.  The input data need not be in
C     regularly spaced intervals.  This program will then
C     compute regularly spaced shoreline position data points
C     using a NATURAL CUBIC SPLINE interpolating function.
c**************************************************************
C  Define variable types
      IMPLICIT REAL (A-H, Q-Z)
      CHARACTER*28 FIN,FOUT
      DIMENSION X(500),Y(500),XNEW(1500),YNEW(1500),A(500,4)
C
C  Prompt and Read Basic information
C
      WRITE(*,*) ' Enter your input filename without the extension (incl
     &uding the path if the '
      WRITE(*,*) ' file is not in the default directory): (MAXIMUM OF 24
     & CHARACTERS)'
      WRITE(*,*) '   '
      READ(*,*) FIN
      LENGTH=SIZEOF(FIN)
      FIN(LENGTH+1:LENGTH+4)='.ROT'
      OPEN(UNIT=99, FILE=FIN, STATUS='OLD')
      WRITE(*,*) '   '
    4 WRITE(*,*) ' Enter your output filename without the extenstion (in
     &cluding the path if the'
      WRITE(*,*) ' file is to be written to another directory): (MAXIMUM
     & OF 24 CHARACTERS)'
      WRITE(*,*) '   '
      READ(*,*) FOUT
      LENGTH=SIZEOF(FOUT)
      FOUT(LENGTH+1:LENGTH+4)='.ISH'
      OPEN(UNIT=98, FILE=FOUT, ERR=5, STATUS='NEW')
      GOTO 10
    5 WRITE(*,*) 'SPECIFIED OUTPUT FILE ALREADY EXIST!'
      WRITE(*,*) 'OVERWRITE THE FILE:  ',FOUT
      WRITE(*,*) '              (1) = YES'
      WRITE(*,*) '              (2) = NO'
      WRITE(*,*) '   '
      READ(*,*)IANS
      IF(IANS.NE.1)THEN
        IF(IANS.EQ.2)THEN
          GOTO 4
        ELSE
          WRITE(*,*) ' Illegal input !'
          GOTO 5
        ENDIF
      ENDIF
      OPEN(UNIT=98, FILE=FOUT, STATUS='UNKNOWN')
   10 WRITE(*,*) '   '
      WRITE(*,*) ' Enter the required cell spacing: '
      READ(*,*) DX
      READ(99,*) NPTS
      READ(99,100) (X(I),Y(I),I=1,NPTS)
      CALL CUBSPL(X,Y,NPTS,A)
      DO 20 I=0,9999
        XX=FLOAT(I)*DX
        IF(XX.GT.X(NPTS)) GOTO 30
        IF(XX.LT.X(1)) GOTO 20
        CALL VALSPL(A,X,XX,NPTS,YNEW(I+1))
        XNEW(I+1)=XX
 20   CONTINUE
      WRITE(*,*) '  The last interpolated shoreline point was at X=',
     &XNEW(1500)
      WRITE(*,*) '  However, the input data extends to X=',X(NPTS)
      WRITE(*,*) '  You may want to increase the value of DX and re-run
```

```
     &the program.'
 30   ISTOP=I-1
      WRITE(98,*) ISTOP,DX
      WRITE(98,200) (XNEW(I),YNEW(I),I=1,ISTOP)
  100 FORMAT(8(F10.1))
  200 FORMAT(5(1X,F6.0,1X,F8.1))
      STOP
      END

      SUBROUTINE CUBSPL(X,Y,N,A)
c*********************************************************************
C This routine calculates the coefficients to cubic spline polynomials
C for two corresponding sets of values X and Y. The coefficients are
C stored in the matrix A.
C*********************************************************************
      INTEGER NR,N,NM1,NM2,J
      PARAMETER(NR=500)
      REAL X(NR),Y(NR),S(NR),A(NR,4)
      REAL DX1,DY1,DX2,DY2
      NM2=N-2
      NM1=N-1
      DX1=X(2)-X(1)
      DY1=(Y(2)-Y(1))/DX1*6.
C
C Determine coefficients in martix for solution of
C the linear system of simultaneous equations
      DO 10 I=1,NM2
         DX2=X(I+2)-X(I+1)
         DY2=(Y(I+2)-Y(I+1))/DX2*6.
         A(I,1)=DX1
         A(I,2)=2.*(DX1+DX2)
         A(I,3)=DX2
         A(I,4)=DY2-DY1
         DX1=DX2
         DY1=DY2
10    CONTINUE
C
C Solve system of simultaneous equations
      DO 20 I=2,NM2
         A(I,2)=A(I,2)-A(I,1)/A(I-1,2)*A(I-1,3)
         A(I,4)=A(I,4)-A(I,1)/A(I-1,2)*A(I-1,4)
 20   CONTINUE
      A(NM2,4)=A(NM2,4)/A(NM2,2)
      DO 30 I=2,NM2
         J=NM1-I
         A(J,4)=(A(J,4)-A(J,3)*A(J+1,4))/A(J,2)
 30   CONTINUE
      DO 40 I=1,NM2
         S(I+1)=A(I,4)
 40   CONTINUE
C
C Specify the second derivative at the end points (assume linear)
      S(1)=0
      S(N)=0
C
C Calcuate the coefficients for the spline polynomials
      DO 11 I=1,N-1
         A(I,1)=(S(I+1)-S(I))/6./(X(I+1)-X(I))
         A(I,2)=S(I)/2
         A(I,3)=(Y(I+1)-Y(I))/(X(I+1)-X(I))-(X(I+1)-X(I))*(2*S(I)+
     &          S(I+1))/6
         A(I,4)=Y(I)
11    CONTINUE
      RETURN
      END

      SUBROUTINE VALSPL(A,X,XX,NRV,YVAL)
c*********************************************************************
C This routine calculates the offshore (Y) shoreline position at a at
C a specified point (XX) alongshore from the cubic spline polynomials.
c*********************************************************************
      INTEGER I,NRV
```

```
      REAL A(500,4),X(500),XX,YVAL
      DO 10 I=1,NRV-1
         IF(X(I).LE.XX.AND.X(I+1).GE.XX)THEN
            YVAL=A(I,1)*(XX-X(I))**3+A(I,2)*(XX-X(I))**2+
     &      A(I,3)*(XX-X(I))+A(I,4)
            RETURN
         ENDIF
10    CONTINUE
      RETURN
      END

      FUNCTION SIZEOF(STRING)
C
C  A function which determines the length of a string (excluding white space).
C
      CHARACTER*(*) STRING
      LENGTH=LEN(STRING)
      I=LENGTH
    5 I=I-1
      IF(STRING(I:I).EQ.' ')GOTO 5
      IF(I.GE.24)I=24
      IF(I.EQ.0)I=1
      SIZEOF=I
      RETURN
      END
```

APPENDIX F: SYSTEM SUPPORT PROGRAM WTSHO

```
      Program WTSHO
c**********************************************************************
C     This program will read shorline position data which have
C     been rotated to the preferred baseline orientation using
C     the program SHORLROT and interpolated to regularly spaced
C     intervals using the program CUINTP.  The program will then
C     write a shoreline data file (for use as either a SHORL.ext
C     or SHORM.ext) in a format suitable for input to GENESIS.
C     The user may specify a cell spaceing equal to or at any
C     multiple of the input data.
c*********************************************************************
C  Define variable types
      IMPLICIT REAL (A-H, Q-Z)
      CHARACTER*28 FIN,FOUT
      DIMENSION X(1500),Y(1500)
C
C  Prompt and Read Basic information
C
      WRITE(*,*) ' Enter your input filename without the extension (incl
     &uding the path if the '
      WRITE(*,*) ' file is not in the default directory): (MAXIMUM OF 24
     & CHARACTERS)'
      WRITE(*,*) '  '
      READ(*,*) FIN
      LENGTH=SIZEOF(FIN)
      FIN(LENGTH+1:LENGTH+4)='.ISH'
      OPEN(UNIT=99, FILE=FIN, STATUS='OLD')
      WRITE(*,*) '  '
    4 WRITE(*,*) ' Enter your output filename without the extenstion (in
     &cluding the path if the'
      WRITE(*,*) ' file is to be written to another directory): (MAXIMUM
     & OF 24 CHARACTERS)'
      WRITE(*,*) '  '
      READ(*,*) FOUT
      WRITE(*,*) '  '
      LENGTH=SIZEOF(FOUT)
      FOUT(LENGTH+1:LENGTH+4)='.SHO'
      OPEN(UNIT=98, FILE=FOUT, ERR=5, STATUS='NEW')
      GOTO 9
    5 WRITE(*,*) 'SPECIFIED OUTPUT FILE ALREADY EXIST!'
      WRITE(*,*) 'OVERWRITE THE FILE:  ',FOUT
      WRITE(*,*) '              (1) = YES'
      WRITE(*,*) '              (2) = NO'
      WRITE(*,*) '  '
      READ(*,*)IANS
      IF(IANS.NE.1)THEN
        IF(IANS.EQ.2)THEN
          GOTO 4
        ELSE
          WRITE(*,*) ' Illegal input !'
          GOTO 5
        ENDIF
      ENDIF
      OPEN(UNIT=98, FILE=FOUT, STATUS='UNKNOWN')
    9 READ(99,*) NPTS,DXOLD
   10 WRITE(*,*) ' The input data set is at a cell spacing of: ',DXOLD
      WRITE(*,*) ' Enter the required cell spacing (must be equal to or
     &an even multiple of'
      WRITE(*,*) ' the cell spacing of the input data set): '
      READ(*,*) DX
      IF(AMOD(DX,DXOLD).NE.0)GOTO 10
      ISKIP=INT(DX/DXOLD)
      READ(99,500) (X(I),Y(I),I=1,NPTS)
      WRITE(*,*) ' The input data set starts at X= ',X(1),' and ends at
     &X= ',X(NPTS)
      WRITE(*,*) '  '
      WRITE(*,*) ' At what value of X do you wish to START writing the s
     &horeline data: '
```

```
      READ(*,*) XSTART
      WRITE(*,*) ' At what value of X do you wish to STOP writing the sh
     &oreline data: '
      READ(*,*) XSTOP
      DO 15 I=1,NPTS
        IF(X(I).GE.XSTART)THEN
          ISTART=I
          GOTO 20
        ENDIF
   15 CONTINUE
   20 ICNT=0
      DO 30 I=ISTART,NPTS,ISKIP
        ICNT=ICNT+1
        Y(ICNT)=Y(I)
        IF(X(I+ISKIP).GT.XSTOP.OR.I.EQ.NPTS)THEN
          X(ICNT)=X(I)
          GOTO 35
        ENDIF
   30 CONTINUE
   35 WRITE(*,*) ' Enter the date corresponding to the shoreline data (Y
     &YMMDD): '
      READ(*,*) IDATE
   40 WRITE(*,*) ' Enter the system of units associated with your input'
      WRITE(*,*) '              (1) = FEET'
      WRITE(*,*) '              (2) = METERS'
      WRITE(*,*) '    '
      READ(*,*)IANS
      IF(IANS.NE.1.AND.IANS.NE.2)GOTO 40
      IF(IANS.EQ.1) WRITE(98,100) IDATE,DX
      IF(IANS.EQ.2) WRITE(98,150) IDATE,DX
      WRITE(98,200) FIN
      WRITE(98,300) X(ISTART),X(ICNT)
      WRITE(98,*) '*****************************************************
     &**********************'
      WRITE(98,400) (Y(I),I=1,ICNT)
  100 FORMAT(1X,'MEASURED SHORELINE POSITION OF ',I6,'; CELL SPACING (DX
     &=',F4.0,' ft)')
  150 FORMAT(1X,'MEASURED SHORELINE POSITION OF ',I6,'; CELL SPACING (DX
     &=',F4.0,' m)')
  200 FORMAT(1X,'THESE DATA WERE OBTAINED FROM THE FILE: ',28A)
  300 FORMAT(1X,'STARTING AT ALONGSHORE POSITION X= ',F6.0,' AND ENDING
     &AT X= ',F6.0)
  400 FORMAT(10F7.1)
  500 FORMAT(5(1X,F6.0,1X,F8.1))
      STOP
      END

      FUNCTION SIZEOF(STRING)
C
C  A function which determines the length of a string (excluding white space).
C
      CHARACTER*(*) STRING
      LENGTH=LEN(STRING)
      I=LENGTH
    5 I=I-1
      IF(STRING(I:I).EQ.' ')GOTO 5
      IF(I.GE.24)I=24
      IF(I.EQ.0)I=1
      SIZEOF=I
      RETURN
      END
```

APPENDIX G: SYSTEM SUPPORT PROGRAM WTWAVTS

```
      PROGRAM WTWAVTS
C*******************************************
c   WTWAVTS-- WRITE WAVE TIME SERIES      *
C   THIS PROGRAM WRITES A TIME SERIES FOR *
C   INPUT START AND END DATES OF A LARGER *
C   TIME SERIES                           *
C*******************************************
      CHARACTER ANS
      CHARACTER*4 STATYP
      CHARACTER*5 STAID
      CHARACTER*12 CSTAID
      CHARACTER*28 FIN,FOUT
      CHARACTER*80 LINE
      INTEGER*4 SY,SM,SD,SH,EY,EM,ED,EH,FY,FM,FD,FH,FTS,ITS,NEPR,INFOR,
     &NFOR
      LOGICAL OKAY,READREC,APPEND
      INTEGER*4 DATE,NEVENTS
C*******************************************
C  THESE COMMON BLOCKS ARE UPDATED EACH    *
C  TIME A CALL IS MADE TO READREC.  THEY   *
C  ARE USED BY WRITREC TO WRITE THE        *
C  OUTPUT TIME SERIES.                     *
C*******************************************
      COMMON /FILEDATES/ FY,FM,FD,FH,DATE
      COMMON /SEA/ HGT,PER,ANG
      COMMON /SWELL/ HGTS,PERS,ANGS
C*******************************************
C  THIS INFORMATION BLOCK TELLS READREC & *
C  WRITREC THE INPUT FILE FORMAT, AND THE *
C  NUMBER OF EVENTS PER RECORD            *
C*******************************************
      COMMON /INFO/ NEPR,INFOR
      APPEND=.FALSE.
C*******************************************
C  GET USER INPUT...                       *
C*******************************************
      WRITE(*,*) ' Enter your input filename and extension (including th
     &e path if the file is'
      WRITE(*,*) ' not in the default directory): (MAXIMUM OF 28 CHARACT
     &ERS) '
      READ(*,*) FIN
      WRITE(*,*)
      OPEN(UNIT=99,FILE=FIN,STATUS='OLD')
C*********************************
C  GET INPUT TIME SERIES FORMAT *
C  NUMBER OF EVENTS PER RECORD  *
C  AND TIME STEP                *
C*********************************
    5 WRITE(*,*) ' Define your input data format: '
      WRITE(*,*) '   1 = SEAS'
      WRITE(*,*) '   2 = OUTPUT FROM ANOTHER WORKBOOK CODE (Header & For
     &mat like SEAS)'
      WRITE(*,*) '   3 = CEDRS'
      WRITE(*,*) '   4 = OUTPUT FROM ANOTHER WORKBOOK CODE (Header & For
     &mat like CEDRS)'
      WRITE(*,*) '   5 = other'
      WRITE(*,*) '   '
      WRITE(*,*) '   Enter the value corresponding to your input data: '
      READ(*,*) INFOR
      WRITE(*,*) '   '
      IF(INFOR.LE.4)THEN
        IF(INFOR.EQ.2.OR.INFOR.EQ.4)THEN
          WRITE(*,*)'  Enter the number of events per record: '
          READ(*,*) NEPR
          WRITE(*,*) '   '
        ELSE
          NEPR=2
        ENDIF
```

```
        WRITE(*,*) '   '
        WRITE(*,*) '  Enter the time step of your input time series: '
        READ(*,*) FTS
C******************************************
C READ PAST INPUT TIME SERIES FILE HEADER *
C******************************************
        IF(INFOR.LE.2) THEN
          READ(99,*) STAID
        ELSE
          READ(99,*) STATYP,CSTAID
        ENDIF
        GOTO 10
      ELSEIF(INFOR.EQ.5)THEN
        WRITE(*,*) ' This code must be modified to read past your specif
     &ic input file header !'
        GOTO 150
C??????????????????????????????????????????????????????????????????????????
C  In this section read (or prompt for) the input file header information. ?
C  Load the number of events per record into NEPR, and the time step into  ?
C  FTS.  Also specify the output format, and load it into NFOR.            ?
C  DEFINITION OF NFOR:                                                     ?
C  NFOR= 1 => SEAS, requires station identification (STAID)                ?
C  NFOR= 2 => CEDRS, requires station type (STATYP) and station id (CSTAID)?
C??????????????????????????????????????????????????????????????????????????
      ELSE
        WRITE(*,*) '   '
        WRITE(*,*) 'Illegal input !'
        WRITE(*,*) '   '
        GOTO 5
      ENDIF
C**************************
C  GET OUTPUT TIME SERIES *
C  FILENAME AND DETERMINE *
C  STATUS                 *
C**************************
   10 WRITE(*,*) ' Enter your output filename without the extension (inc
     &luding the path if the'
      WRITE(*,*) ' file is to be written to another directory): (MAXIMUM
     & OF 24 CHARACTERS) '
      READ(*,*) FOUT
      LENGTH=SIZEOF(FOUT)
      FOUT(LENGTH+1:LENGTH+4)='.OTS'
      INQUIRE(FILE=FOUT,EXIST=OKAY) !does the file exist? [okay=1(yes);0(no)]
      IF(.NOT.OKAY) THEN
        OPEN(UNIT=98,FILE=FOUT,STATUS='NEW') !file does not exist... open 'new'
        NEVENTS=0
      ELSE                                  !file does exist... what to do ?
   15   WRITE(*,*) 'Do you want to append to this file? (y/n) '
        READ(*,*) ANS
        IF (ANS.NE.'Y'.AND.ANS.NE.'y') THEN
          IF (ANS.NE.'N'.AND.ANS.NE.'n') THEN
            GOTO 15                             ! illegal answer ... try again
          ELSE                                  ! The append ?  answer was no
   20       WRITE(*,*) 'Do you want to overwrite this file? (y/n) '
            READ(*,*) ANS
            IF (ANS.NE.'Y'.AND.ANS.NE.'y') THEN
              IF (ANS.NE.'N'.AND.ANS.NE.'n') THEN
                GOTO 20                      ! illegal answer ... try again
              ENDIF
              GOTO 10                       ! The overwrite ?  answer was no
            ELSE                            ! The overwrite ?  answer was yes
               OPEN(UNIT=98,FILE=FOUT,STATUS='OLD')
               CLOSE(98,STATUS='DELETE')
               OPEN(UNIT=98,FILE=FOUT,STATUS='NEW')
            ENDIF
          ENDIF
        ELSE                                    ! The append ?  answer was yes
C*****************
C  OPEN OLD FILE *
C    AND FAST    *
C   FORWARD IT   *
C*****************
```

```
          APPEND=.TRUE.
          OPEN(UNIT=98,FILE=FOUT,STATUS='OLD')
          OPEN(UNIT=97,STATUS='SCRATCH')
          IF(INFOR.LE.4)THEN
            IF(INFOR.LE.2)THEN
              READ(98,*) STAID, NEVENTS
            ELSE
              READ(98,*) STATYP, STAID, ISMO, ISYR, IEMO,IEYR, NEVENTS
            ENDIF
          ELSE
            IF(NFOR.EQ.1)THEN
              READ(98,*) STAID, NEVENTS
            ELSEIF(NFOR.EQ.2)THEN
              READ(98,*) STATYP, STAID, ISMO, ISYR, IEMO,IEYR, NEVENTS
            ENDIF
          ENDIF
   30   READ(98,400,END=50) LINE  ! Read existing time series
        WRITE(97,400) LINE        ! Write existing time series to scratch file
        GOTO 30
        ENDIF                     ! Finished with an existing file !!!
      ENDIF                       ! Output file is open !!!
C*********************************************************************
C   READ PERTINENT TIME SERIES DATA:  START AND END DATES FOR SERIES *
C   TO BE CREATED AND THE TIME STEP OF THE SERIES TO BE CREATED..    *
C*********************************************************************
  50  WRITE(*,*) ' Enter the time interval of the new time series '
      WRITE(*,*) 'START <YYMMDDHH>:  '
      READ(*,100) SY,SM,SD,SH !  START: YEAR, MONTH, DAY, AND HOUR
      IF(INFOR.EQ.3.OR.INFOR.EQ.4.OR.NFOR.EQ.2)THEN
        IF(.NOT.APPEND)THEN
          ISMO=SM
          ISYR=SY
        ENDIF
      ENDIF
      WRITE(*,*) 'END   <YYMMDDHH>:  '
      READ(*,100) EY,EM,ED,EH !  END:   YEAR, MONTH, DAY, AND HOUR
      IF(INFOR.EQ.3.OR.INFOR.EQ.4.OR.NFOR.EQ.2)THEN
        IEMO=EM
        IEYR=EY
      ENDIF
  60  WRITE(*,*) ' Enter the time step of the new time series: '
      READ(*,*) ITS
      IF(MOD(ITS,FTS).NE.0) THEN
        WRITE(*,*) 'MUST BE AN EVEN MULTIPLE OF INPUT FILE TIME STEP '
        WRITE(*,*) ' '
        GOTO 60
      ENDIF
C************************
C FIND STARTING RECORD *
C************************
  70  OKAY=READREC()
      IF(.NOT.OKAY) THEN
        WRITE(*,*) 'STARTING RECORD NOT FOUND'
        GOTO 150
      ENDIF
      IF(FY.EQ.SY.AND.FM.EQ.SM.AND.FD.EQ.SD.AND.FH.EQ.SH) THEN
        NEVENTS=NEVENTS+1
        GOTO 75
      ELSE
        GOTO 70
      ENDIF
C*************************
C COUNT NUMBER OF EVENTS *
C*************************
   75 IF(FY.EQ.EY.AND.FM.EQ.EM.AND.FD.EQ.ED.AND.FH.EQ.EH) GOTO 78
      DO 76 I=1,ITS/FTS
        OKAY=READREC()
   76 CONTINUE
      IF(.NOT.OKAY) THEN
        IF(FY.EQ.EY.AND.FM.EQ.EM.AND.FD.EQ.ED.AND.FH.EQ.EH) THEN
          GOTO 77
        ELSE
```

```
            WRITE(*,*) 'FILE HAS ENDED PREMATURELY, STOPPED AT:  ',DATE
            GOTO 150
          ENDIF
        ENDIF
        NEVENTS=NEVENTS+1
        GOTO 75
C***********************************
C REWIND INPUT FILE & READ HEADER  *
C WRITE UPDATED OUTPUT FILE HEADER *
C***********************************
   77 NEVENTS=NEVENTS+1
   78 REWIND(39)
      READ(99,*)
      REWIND(98)
      IF(INFOR.LE.4)THEN
        IF(INFOR.LE.2)THEN
          WRITE(98,300) STAID, NEVENTS
        ELSE
          WRITE(98,200) STATYP, CSTAID, ISMO, ISYR, IEMO, IEYR, NEVENTS
        ENDIF
      ELSE
        IF(NFOR.EQ.1)THEN
          WRITE(98,300) STAID, NEVENTS
        ELSEIF(NFOR.EQ.2)THEN
          WRITE(98,200) STATYP, STAID, ISMO, ISYR, IEMO, IEYR, NEVENTS
        ENDIF
      ENDIF
      WRITE(*,*) 'The new time series will have',NEVENTS,' events'
      IF(APPEND)THEN
        REWIND(97)
   81   READ(97,400,END=79) LINE ! Read existing time series from scratch file
        WRITE(98,400) LINE       ! Write existing time series to output file
        GOTO 81
      ENDIF
C*****************************
C FIND STARTING RECORD AGAIN *
C*****************************
  79  OKAY=READREC()
      IF(FY.EQ.SY.AND.FM.EQ.SM.AND.FD.EQ.SD.AND.FH.EQ.SH) THEN
        GOTO 80
      ELSE
        GOTO 79
      ENDIF
C***************************
C BEGIN WRITING NEW SERIES *
C***************************
  80  CALL WRITREC
  90  IF(FY.EQ.EY.AND.FM.EQ.EM.AND.FD.EQ.ED.AND.FH.EQ.EH) GOTO 120
      DO 110 I=1,ITS/FTS
        OKAY=READREC()
 110  CONTINUE
      IF(.NOT.OKAY) THEN
        IF(FY.EQ.EY.AND.FM.EQ.EM.AND.FD.EQ.ED.AND.FH.EQ.EH) THEN
          GOTO 120
        ENDIF
      ENDIF
      CALL WRITREC
      GOTO 90
  100 FORMAT(I2,I2,I2,I2)
  200 FORMAT(1X,A4,A12,4X,I2,1X,I2,2X,I2,1X,I2,1X,I6)
  300 FORMAT(5X,A5,1X,I6)
  400 FORMAT(1X,A80)
  120 CLOSE(99)
      CLOSE(98)
  150 STOP
      END

      FUNCTION SIZEOF(STRING)
C
C  A FUNCTION WHICH DETERMINES THE LENGTH OF A STRING (EXCLUDING WHITE SPACE)
C
      CHARACTER*(*) STRING
```

```
      LENGTH=LEN(STRING)
      I=LENGTH
    5 I=I-1
      IF(STRING(I:I).EQ.' ')GOTO 5
      IF(I.GE.24)I=24
      IF(I.EQ.0)I=1
      SIZEOF=I
      RETURN
      END

      SUBROUTINE WRITREC
C**************************
C  WRITES THE FILEDATES,  *
C  SEA, AND SWELL DATA TO *
C  THE OUTPUT TIME SERIES *
C**************************
      INTEGER*4 FY,FM,FD,FH,NEPR,INFOR
      REAL HGT,PER,ANG,HGTS,PERS,ANGS
      INTEGER*4 DATE
C*******************************************
C  THESE COMMON BLOCKS ARE USED BY WRITREC *
C  TO WRITE THE OUTPUT TIME SERIES.        *
C*******************************************
      COMMON /FILEDATES/ FY,FM,FD,FH,DATE
      COMMON /SEA/ HGT,PER,ANG
      COMMON /SWELL/ HGTS,PERS,ANGS
C******************************************
C  THIS INFORMATION BLOCK TELLS READREC & *
C  WRITREC THE INPUT FILE FORMAT, AND THE *
C  NUMBER OF EVENTS PER RECORD            *
C******************************************
      COMMON /INFO/ NEPR,INFOR
       IF(NEPR.EQ.1) THEN
        WRITE(98,100) DATE,HGT,PER,ANG
       ELSE
        WRITE(98,200) DATE,HGT,PER,ANG,HGTS,PERS,ANGS
       ENDIF
  100 FORMAT(1X,I8,3X,3F8.1)
  200 FORMAT(1X,I8,3X,3F8.1,3X,3F8.1)
      RETURN
      END

      LOGICAL FUNCTION READREC()
C****************************
C  READS THE FILEDATES,     *
C  SEA, AND SWELL DATA FROM *
C  THE INPUT TIME SERIES    *
C  RETURNS A VALUE OF FALSE *
C  IF END-OF-FILE OCCURED   *
C****************************
      INTEGER*4 FY,FM,FD,FH,NEPR,INFOR
      REAL HGT,PER,ANG,HGTS,PERS,ANGS
      INTEGER*4 DATE
      READREC=.TRUE.
C******************************************
C  THESE COMMON BLOCKS ARE UPDATED EACH   *
C  TIME A CALL IS MADE TO READREC.        *
C******************************************
      COMMON /FILEDATES/ FY,FM,FD,FH,DATE
      COMMON /SEA/ HGT,PER,ANG
      COMMON /SWELL/ HGTS,PERS,ANGS
C******************************************
C  THIS INFORMATION BLOCK TELLS READREC & *
C  WRITREC THE INPUT FILE FORMAT, AND THE *
C  NUMBER OF EVENTS PER RECORD            *
C******************************************
      COMMON /INFO/ NEPR,INFOR
      IF(INFOR.LE.4) THEN
        IF(INFOR.EQ.2.OR.INFOR.EQ.4)THEN
          IF(NEPR.EQ.1) THEN
            READ(99,*,END=99) DATE,HGT,PER,ANG
          ELSE
```

```
            READ(99,*,END=99) DATE,HGT,PER,ANG,HGTS,PERS,ANGS
          ENDIF
        ELSEIF(INFOR.EQ.1)THEN
          READ(99,100,END=99) DATE,HGT,PER,ANG,HGTS,PERS,ANGS
        ELSE
          READ(99,200,END=99) DATE,HGT,PER,ANG,HGTS,PERS,ANGS
        ENDIF
      ELSE
        WRITE(*,*) ' This code must be modified to read your specific in
     &put time series !'
          GOTO 99
C??????????????????????????????????????????????????????????????????????????????
C  In this section read the wave event(s) from the input file.
C  Read the date into DATE.  Read the wave height, period, and angle of
C  the first wave event into  HGT, PER, and ANG.
C  If there are two events per record, read second wave event height,
C  period, and angle into HGTS, PERS, ANGS.
C??????????????????????????????????????????????????????????????????????????????
      ENDIF
      CALL BREAKDATE
      RETURN
  99  CALL BREAKDATE
      READREC=.FALSE.
 100  FORMAT(2X,I8,2(F4.0,F3.0,F4.0))
 200  FORMAT(1X,I8,2(F5.1,F5.1,F5.0))
      RETURN
      END

      SUBROUTINE BREAKDATE
C*************************************
C  SUBROUTINE BREAKDATE--BREAK INT*4 *
C  DATE INTO CONSTIUENT PARTS...     *
C  IN:  INT*4 DATE THROUGH COMMON    *
C       FILEDATES                    *
C  OUT:  FY,FM,FD,FH THROUGH COMMON  *
C       FILEDATES (YEAR,MONTH,DAY,   *
C       HOUR                         *
C*************************************
      INTEGER*4 DATE,DUMDATE
      INTEGER*4 FY,FM,FD,FH
      COMMON /FILEDATES/ FY,FM,FD,FH,DATE
      DUMDATE=DATE
      FY=DUMDATE/1000000
      DUMDATE=DATE-FY*1000000
      FM=DUMDATE/10000
      DUMDATE=DUMDATE-FM*10000
      FD=DUMDATE/100
      DUMDATE=DUMDATE-FD*100
      FH=DUMDATE
      RETURN
      END
```

APPENDIX H: SYSTEM SUPPORT PROGRAM WTWAVES

```
      PROGRAM WTWAVES
C*******************************************
C   WTWAVES-- WRITE WAVES.ext TIME SERIES *
C    THIS PROGRAM CREATES A GENESIS       *
C   COMPATIBLE FILE FOR A INPUT TIME STEP *
C*******************************************
      CHARACTER*28 FIN,FOUT
      CHARACTER IANS2
      REAL*4 SHOANG
      INTEGER*2 ITS,NEPR
      LOGICAL OKAY,READREC,RFOR
      INTEGER*4 DATE
      COMMON /SHOANG/ SHOANG
C*******************************************
C  GET USER INPUT                          *
C*******************************************
      WRITE(*,*) ' Enter your input filename and extension (including th
     &e path if the file is'
      WRITE(*,*) ' not in the default directory): (maximum of 28 charact
     &ers)'
      WRITE(*,*) '     '
      READ(*,*) FIN
  1   OPEN(UNIT=10,FILE=FIN,STATUS='OLD')
 75     WRITE(*,*) ' Enter your output filename without the extension (in
     &cluding the path if the'
      WRITE(*,*) ' file is to be written to antoher directory): (maximum
     & of 24 characters)'
      WRITE(*,*) '     '
      READ(*,*) FOUT
      LENGTH=SIZEOF(FOUT)
      FOUT(LENGTH+1:LENGTH+4)='.WAV'
      INQUIRE(FILE=FOUT,EXIST=OKAY)
      IF(.NOT.OKAY) THEN
        OPEN(UNIT=15,FILE=FOUT,STATUS='NEW')
        IANS=2
      ELSE
        WRITE(*,*) 'Do you wish to ...'
        WRITE(*,*) '  1.  Append to the file'
        WRITE(*,*) '  2.  Overwrite (delete) the old file'
        WRITE(*,*) '  3.  Enter a new file name'
        WRITE(*,*)
   90   WRITE(*,*) '?  '
        READ(*,*) IANS
        IF (IANS.LT.1.OR.IANS.GT.3) THEN
          WRITE(*,*) 'ILLEGAL INPUT !! '
          GOTO 90
        ENDIF
        IF (IANS.EQ.3) GOTO 75
C*****************
C  OPEN NEW FILE *
C*****************
        IF (IANS.EQ.1) THEN
C*****************
C  OPEN OLD FILE *
C    AND FAST    *
C   FORWARD IT   *
C*****************
          OPEN(UNIT=15,FILE=FOUT,STATUS='OLD')
  10      READ(15,*,END=11)
          GOTO 10
        ENDIF
        IF (IANS.EQ.2) THEN
C*******************
C  DELETE OLD FILE *
C  OPEN A NEW ONE  *
C  WITH SAME NAME  *
C*******************
          OPEN(UNIT=15,FILE=FOUT,STATUS='OLD')
```

```
          CLOSE(15,STATUS='DELETE')
          OPEN(UNIT=15,FILE=FOUT,STATUS='NEW')
        ENDIF
      ENDIF !OKAY
C*********************************************************
C   READ PERTINENT TIME SERIES DATA:  INPUT & OUTPUT TIME *
C   SERIES TIME STEP AND SHORELINE ORIENTATION            *
C*********************************************************
 11   CONTINUE
C********************
C GET INPUT SERIES  *
C    TIME STEP      *
C********************
      WRITE(*,*) 'Please enter the time step of the input file:  '
      READ(*,*) ITS
C*******************
C GET DESIRED TIME *
C    TIME STEP     *
C*******************
 110  WRITE(*,*) 'If your input wave angles are with respect to north (W
     &IS Phase I or II) then'
      WRITE(*,*) 'enter the shoreline orientation.  If your wave input w
     &ave angles are with'
      WRITE(*,*) 'respect to the shoreline orientation (WIS Phase III) t
     &hen enter -999: '
      READ(*,*) SHOANG
      WRITE(*,*) 'Please enter the time step for the output file:  '
      READ(*,*) IGTS                ! OUTPUT TIME STEP
      IF(MOD(IGTS,ITS).NE.0) THEN
        WRITE(*,*) 'MUST BE AN EVEN MULTIPLE OF ',ITS,'.'
        GOTO 110
      ENDIF
      IF(IGTS.EQ.0) IGTS=ITS !ERROR CHECKING, RETURN=DEFAULT
C***********************
C HOW MANY WAVE EVENTS *
C    PER TIME STEP     *
C***********************
 105  WRITE(*,*) 'How many events per record?  '
      READ(*,*) NEPR
      IF (NEPR.GT.2.OR.NEPR.LT.1) THEN
        WRITE(*,*)'INVALID NUMBER OF EVENTS PER RECORD..'
        GOTO 105
      ENDIF
C***************
C  CONVERSION  *
C***************
      RFOR=.FALSE.
 900  WRITE(*,*) 'Enter input file type 1=CEDRS 2=SEAS:  '
      READ(*,*) INUNIT
      IF(INUNIT.NE.1.AND.INUNIT.NE.2) GOTO 900
 901  WRITE(*,*) 'Is your input an output file from another workbook pro
     &gram? (y/n) '
      READ(*,*) IANS2
      IF (IANS2.NE.'Y'.AND.IANS2.NE.'y') THEN
        IF (IANS2.NE.'N'.AND.IANS2.NE.'n') THEN
          GOTO 901                              ! illegal answer ... try again
        ELSE
          RFOR=.TRUE.
        ENDIF
      ENDIF
 905  WRITE(*,*) 'Enter desired output units 1=METERS 2=FEET:  '
      READ(*,*) IOUTUNIT
      IF(IOUTUNIT.NE.1.AND.IOUTUNIT.NE.2) GOTO 905
      IF (INUNIT.EQ.1.AND.IOUTUNIT.EQ.1) THEN
        CONV=1.
      ELSEIF(INUNIT.EQ.1.AND.IOUTUNIT.EQ.2) THEN
        CONV=3.28083989401
      ELSEIF(INUNIT.EQ.2.AND.IOUTUNIT.EQ.1) THEN
        CONV=.01
      ELSEIF(INUNIT.EQ.2.AND.IOUTUNIT.EQ.2) THEN
        CONV=.01*3.28083989401
      ENDIF
```

```
      IF(IANS.EQ.2) THEN
        CALL WRITEHEAD(FOUT,IGTS,NEPR,IOUTUNIT)
      ENDIF
C****************************
C READ INPUT FILE'S HEADER *
C****************************
      READ(10,*)
C****************************
C BEGIN WRITING NEW SERIES *
C****************************
      READREC=.TRUE.
      IF(NEPR.EQ.1) THEN
           READ(10,*,END=70) DATE,HGT,PER,ANG
      ELSE
        IF(.NOT.RFOR)THEN
          READ(10,*,END=70) DATE,HGT,PER,ANG,HGTS,PERS,ANGS
        ELSE
          IF(INUNIT.EQ.1)THEN
            READ(10,80,END=70) DATE,HGT,PER,ANG,HGTS,PERS,ANGS
          ELSE
            READ(10,82,END=70) DATE,HGT,PER,ANG,HGTS,PERS,ANGS
          ENDIF
        ENDIF
      ENDIF
      GOTO 55
 70   READREC=.FALSE.
 55   OKAY=READREC
      IF(NEPR.EQ.1.) THEN
        IF(PER.GE.0) THEN
          IF(PER.EQ.0.)THEN
            PER=-99.9
            HGT=0.0
            ANG=0.0
            WRITE(15,76) PER,HGT*CONV,ANG,DATE
          ELSEIF(SHORNORM(ANG).GT.90..OR.SHORNORM(ANG).LT.-90.)THEN
            PER=-99.9
            HGT=0.0
            ANG=0.0
            WRITE(15,76) PER,HGT*CONV,ANG,DATE
          ELSE
            WRITE(15,76) PER,HGT*CONV,SHORNORM(ANG),DATE
          ENDIF
        ELSE
          WRITE(15,76) PER,HGT*CONV,ANG,DATE
        ENDIF
      ELSE
        IF(PER.GE.0) THEN
          IF(PER.EQ.0.)THEN
            PER=-99.9
            HGT=0.0
            ANG=0.0
            WRITE(15,76) PER,HGT*CONV,ANG,DATE
          ELSEIF(SHORNORM(ANG).GT.90..OR.SHORNORM(ANG).LT.-90.)THEN
            PER=-99.9
            HGT=0.0
            ANG=0.0
            WRITE(15,76) PER,HGT*CONV,ANG,DATE
          ELSE
            WRITE(15,76) PER,HGT*CONV,SHORNORM(ANG),DATE
          ENDIF
        ELSE
          WRITE(15,76) PER,HGT*CONV,ANG,DATE
        ENDIF
        IF(PERS.GE.0) THEN
          IF(PERS.EQ.0.)THEN
            PERS=-99.9
            HGT=0.0
            ANG=0.0
            WRITE(15,78) PERS,HGT*CONV,ANG,DATE,' EVENT 2'
          ELSEIF(SHORNORM(ANGS).GT.90..OR.SHORNORM(ANGS).LT.-90.)THEN
            PERS=-99.9
            HGTS=0.0
```

```
         ANGS=0.0
         WRITE(15,78) PERS,HGTS*CONV,ANGS,DATE,' EVENT 2'
        ELSE
         WRITE(15,78) PERS,HGTS*CONV,SHORNORM(ANGS),DATE,' EVENT 2'
        ENDIF
       ELSE
        WRITE(15,78) PERS,HGTS*CONV,ANGS,DATE,' EVENT 2'
       ENDIF
      ENDIF
  130 DO 125 I=1,IGTS/ITS
       READREC=.TRUE.
       IF(NEPR.EQ.1) THEN
        READ(10,*,END=72) DATE,HGT,PER,ANG
       ELSE
        IF(.NOT.RFOR)THEN
         READ(10,*,END=72) DATE,HGT,PER,ANG,HGTS,PERS,ANGS
        ELSE
         IF(INUNIT.EQ.1)THEN
          READ(10,80,END=72) DATE,HGT,PER,ANG,HGTS,PERS,ANGS
         ELSE
          READ(10,82,END=72) DATE,HGT,PER,ANG,HGTS,PERS,ANGS
         ENDIF
        ENDIF
       ENDIF
       GOTO 50
  72   READREC=.FALSE.
  50   OKAY=READREC
  125 CONTINUE
      IF (.NOT.OKAY) GOTO 5
      IF(NEPR.EQ.1) THEN
       IF(PER.GE.0) THEN
        IF(PER.EQ.0.)THEN
         PER=-99.9
         HGT=0.0
         ANG=0.0
         WRITE(15,76) PER,HGT*CONV,ANG,DATE
        ELSEIF(SHORNORM(ANG).GT.90..OR.SHORNORM(ANG).LT.-90.)THEN
         PER=-99.9
         HGT=0.0
         ANG=0.0
         WRITE(15,76) PER,HGT*CONV,ANG,DATE
        ELSE
         WRITE(15,76) PER,HGT*CONV,SHORNORM(ANG),DATE
        ENDIF
       ELSE
        WRITE(15,76) PER,HGT*CONV,ANG,DATE
       ENDIF
      ELSE
       IF(PER.GE.0) THEN
        IF(PER.EQ.0.)THEN
         PER=-99.9
         HGT=0.0
         ANG=0.0
         WRITE(15,76) PER,HGT*CONV,ANG,DATE
        ELSEIF(SHORNORM(ANG).GT.90..OR.SHORNORM(ANG).LT.-90.)THEN
         PER=-99.9
         HGT=0.0
         ANG=0.0
         WRITE(15,76) PER,HGT*CONV,ANG,DATE
        ELSE
         WRITE(15,76) PER,HGT*CONV,SHORNORM(ANG),DATE
        ENDIF
       ELSE
        WRITE(15,76) PER,HGT*CONV,ANG,DATE
       ENDIF
       IF(PERS.GE.0) THEN
        IF(PERS.EQ.0.)THEN
         PERS=-99.9
         HGT=0.0
         ANG=0.0
         WRITE(15,78) PERS,HGT*CONV,ANG,DATE,' EVENT 2'
        ELSEIF(SHORNORM(ANGS).GT.90..OR.SHORNORM(ANGS).LT.-90.)THEN
```

```
            PERS=-99.9
            HGTS=0.0
            ANGS=0.0
            WRITE(15,78) PERS,HGTS*CONV,ANGS,DATE,' EVENT 2'
          ELSE
            WRITE(15,78) PERS,HGTS*CONV,SHORNORM(ANGS),DATE,' EVENT 2'
          ENDIF
        ELSE
          WRITE(15,78) PERS,HGTS*CONV,ANGS,DATE,' EVENT 2'
        ENDIF
      ENDIF
   76 FORMAT(3F10.3,1X,I10)
   78 FORMAT(3F10.3,1X,I10,A)
   80 FORMAT(1X,I8,2(F5.1,F5.1,F5.0))
   82 FORMAT(2X,I8,2(F4.0,F3.0,F4.0))
      GOTO 130
    5 CLOSE(10)
      CLOSE(15)
      END

      FUNCTION SIZEOF(STRING)
C
C  A FUNCTION WHICH DETERMINES THE LENGTH OF A STRING (EXCLUDING WHITE SPACE).
C
      CHARACTER*(*) STRING
      LENGTH=LEN(STRING)
      I=LENGTH
    5 I=I-1
      IF(STRING(I:I).EQ.' ')GOTO 5
      IF(I.GE.24)I=24
      IF(I.EQ.0)I=1
      SIZEOF=I
      RETURN
      END

      SUBROUTINE WRITEHEAD(FOUT,IGTS,NEPR,IOUTUNIT)
      CHARACTER*28 FOUT
      INTEGER*2 IGTS,NEPR
C*********************
C WRITE FILE HEADER *
C*********************
      WRITE(15,*) 'FILE:  ',FOUT
      WRITE(15,10) 'NUMBER OF EVENTS PER RECORD:  ',NEPR,' TIME STEP:  '
     &,IGTS
   10 FORMAT(A,I1,4X,A,I4)
      IF(IOUTUNIT.EQ.1) THEN
        WRITE(15,*) 'SYSTEM OF UNITS:  METERS'
      ELSE
        WRITE(15,*) 'SYSTEM OF UNITS:  FEET'
      ENDIF
      WRITE(15,*) '**********************************************************
     &******************************'
      RETURN
      END

      REAL FUNCTION SHORNORM(ANG)
C**************************************************
C     FUNCTION SHORNORM USES SHOANG FROM COMMON *SHOANG* TO
C     CONVERT THE INPUT ANGLE (ANG) TO SHORE-NORMAL
C***************************************************
      REAL ANG,SHOANG,ZERO
      COMMON /SHOANG/ SHOANG
      IF(SHOANG.EQ.-999.0)THEN
        IF(ANG.GE.90)THEN
          SHORNORM=ANG-90.
        ELSE
          SHORNORM=-90.+ANG
        ENDIF
        RETURN
      ENDIF
      IF (ANG.EQ.360.) THEN
        ANG=0.
```

```
      ENDIF
      IF ((SHOANG.GE.0.).AND.(SHOANG.LT.270.)) THEN
        ZERO=SHOANG+90.
      ELSE
        ZERO=SHOANG-270.
      ENDIF
      IF ((ZERO.GT.270.).AND.(ANG.LT.90.)) THEN
        SHORNORM=-((360.-ZERO)+ANG)
      ELSEIF((ZERO.LT.90..AND.ANG.GT.270.)) THEN
        SHORNORM=ZERO+(360.-ANG)
      ELSE
        SHORNORM=-(ANG-ZERO)
      ENDIF
      RETURN
      END
```

APPENDIX I: SYSTEM SUPPORT PROGRAM WHEREWAVE

```
      PROGRAM WHEREWAVE
C*****************************************************************************
C      THIS PROGRAM READS AN INPUT TIME SERIES IN AN EVENT BY EVENT MANNER
C      AND CALCULATES THE ANGLE BAND AND PERIOD BAND FOR EACH WAVE
C      EVENT IN THE TIME SERIES.  OUTPUT FROM THIS PROGRAM IS WRITTEN TO AN
C      OUTPUT FILE ([FILENAME].WW).  THE FILE [FILENAME].WW CONTAINS TABLES OF
C      THE STATISTICS FOR THE ASSIMILATED WAVE DATA
C/////////////////////////////////////////////////////////////////////////////
C\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
C      TWO PRE DETERMINED INPUT FILE FORMATS MAY BE USED FOR INPUT.  THESE ARE
C      EITHER A SEAS "USER" FILE OR A CEDRS FILE WHICH RESULTED FROM AN EXTRACT
C      DATA OPERATION.  THERE IS ALSO A SECTION IN WHICH THE USER CAN SPECIFY
C      THE UNIQUE FORMAT OF HIS OR HER SPECIFIC INPUT WAVE TIME SERIES
C
C      ALL CALCULATIONS WITHIN THE PROGRAM ARE PERFORMED IN SI UNITS.  HOWEVER,
C      INPUT AND OUTPUT UNITS MAY (MUST) BE SPECIFIED.
C*****************************************************************************

C  DEFINE VARIABLE TYPES
      IMPLICIT REAL (A-H,O-Z)
      CHARACTER*28 FIN,FOUT
      CHARACTER*15 STATYP,STAID
      REAL SHOANG,HST,T,THETA,BANDANG(10),PB(9)
      REAL ANGANGS(10),HSTANGS(10),PERPERS(9),HSTPERS(9)
      REAL ANGANG(10),HSTANG(10),PERPER(9),HSTPER(9)
      REAL AVGANGANG(10),AVGHSTANG(10),AVGPERPER(9),AVGHSTPER(9)
      REAL NBAND(9),NPERBAND(9)
      REAL NBANDS(9),NPERBANDS(9)
      INTEGER NUMBAND,PER,BAND
      INTEGER PERSWELL(9,9),PERSEA(9,9),ANGSWELL(9,9),ANGSEA(9,9)
      !IS PERIOD IN ANGLEBAND? 1 IS TRUE, 0 IS FALSE
      INTEGER ARRY(9,9),ARRY2(9,9)
      CHARACTER*18 STR
      DATA PB/0.,5.,7.,9.,11.,13.,15.,17.,23./
      COMMON /BANDINFO/ BANDANG,NUMBAND
      COMMON /CLASS/ BAND,PER
      COMMON /STRING/ J,STR
      COMMON /MAKSTR/ ARRY
      COMMON /MAKSTR2/ ARRY2
      COMMON /SHOANG/ SHOANG
C
C  PROMPT AND READ BASIC INFORMATION
C
       WRITE(*,*) ' Enter your input filename and extension (including th
     &e path if the file is'
       WRITE(*,*) ' not in the default directory): (maximum of 28 charact
     &ers)'
       WRITE(*,*) '     '
       READ(*,*) FIN
       OPEN(UNIT=99, FILE=FIN, STATUS='OLD')
       WRITE(*,*) '     '
       WRITE(*,*) '     '
        WRITE(*,*) ' Enter your output filename without the extension (in
     &cluding the path if the'
       WRITE(*,*) ' file is to be written to another directory): (maximum
     & of 24 characters)'
       WRITE(*,*) '     '
       READ(*,*) FOUT
       WRITE(*,*) '     '
       WRITE(*,*) '     '
       LENGTH=SIZEOF(FOUT)
       FOUT(LENGTH+1:LENGTH+4)='.WW'
       OPEN(UNIT=98, FILE=FOUT, STATUS='UNKNOWN')
     ` WRITE(*,*) ' Define your input data format: '
       WRITE(*,*) '     1 = SEAS'
       WRITE(*,*) '     2 = OUTPUT FROM ANOTHER WORKBOOK CODE (HEADER & FOR
     &MAT LIKE SEAS)'
       WRITE(*,*) '     3 = CEDRS'
```

```
      WRITE(*,*) '    4 = OUTPUT FROM ANOTHER WORKBOOK CODE (HEADER & FOR
     &MAT LIKE CEDRS)'
      WRITE(*,*) '    5 = OTHER'
      WRITE(*,*) '    '
      WRITE(*,*) '    Enter the value corresponding to your input data  '
      READ(*,*) INFOR
      WRITE(*,*) '    '
      IF(INFOR.LE.4)THEN
        IF(INFOR.EQ.2.OR.INFOR.EQ.4)THEN
          WRITE(*,*)'  Enter the number of events per record  '
          READ(*,*) NEPR
          WRITE(*,*) '    '
        ELSE
          NEPR=2
        ENDIF
        GOTO 10
      ELSEIF(INFOR.EQ.5)THEN
        GOTO 15
      ELSE
        WRITE(*,*) '    '
        WRITE(*,*) 'ILLEGAL INPUT !'
        WRITE(*,*) '    '
        GOTO 5
      ENDIF
   10 WRITE(*,*) ' Define your input time series data type: '
      WRITE(*,*) ' 1 = PHASE I  '
      WRITE(*,*) ' 2 = PHASE II  '
      WRITE(*,*) ' 3 = PHASE III  '
      WRITE(*,*) '    '
      WRITE(*,*) '    Enter the value corresponding to your input data  '
      READ(*,*) IPHASE
      IF(IPHASE.LT.1.OR.IPHASE.GT.3)THEN
        WRITE(*,*) '    '
        WRITE(*,*) 'ILLEGAL INPUT !'
        WRITE(*,*) '    '
        GOTO 10
      ENDIF
      WRITE(*,*) '    '
      WRITE(*,*) '    '
      WRITE(*,*) ' Enter the shoreline orientation (in degrees, clockwis
     &e from north):  '
      READ(*,*) SHOANG
      GOTO 20
   15 WRITE(*,*) ' This code must be modified to read your specific'
      WRITE(*,*) ' input file header !'
      GOTO 35
C??????????????????????????????????????????????????????????????????????????
C  IN THIS SECTION READ (OR PROMPT FOR) THE INPUT FILE HEADER INFORMATION
C  AND DEFINE THE SYSTEM OF UNITS USED IN THE INPUT DATA FILE, THE DEPTH
C  CORRESPONDING TO THE TIME SERIES, THE TIME STEP OF THE EVENTS, THE SHORELINE
C  ORIENTATION, AND THE NUMBER OF RECORDS IN THE FILE RECORD.  NOTE, THAT EACH
C  RECORD MAY CONTAIN MORE THAN ONE EVENT (E.G.  H, T, & THETA FOR SEA WAVES
C  AND H, T, & THETA FOR SWELL WAVES ETC.).
C  LOAD THE CONVERSION FACTOR FOR LENGTH INTO THE VARIABLE CONVLEN.
C  LOAD THE TIME STEP (HOURS) OF THE TIME SERIES INTO DT.
C  LOAD THE DEPTH (IN METERS) INTO THE VARIABLE DEPTH.
C  LOAD THE NUMBER OF EVENTS PER RECORD INTO NEPR
C  LOAD THE SHORELINE ORIENTATION INTO SHOANG.
C??????????????????????????????????????????????????????????????????????????
   20 IF(INFOR.EQ.1.OR.INFOR.EQ.2)THEN
        READ(99,*) STAID, NEVENTS
      ELSEIF(INFOR.EQ.3.OR.INFOR.EQ.4)THEN
        READ(99,*) STATYP, STAID, IDUM, IDUM, IDUM, IDUM, NEVENTS
      ENDIF
C
C     BEGIN CALCULATION LOOP
C
C     AT THIS POINT THE FOLLOWING VARIABLES
C     MUST CONTAIN MEANINGFUL VALUES
C          CONVLEN  LENGTH CONVERSION FACTOR
C          DEPTH  WATER DEPTH OF INPUT TIME SERIES
C          NEVENTS  NUMBER OF RECORDS IN TIME SERIES
```

```
C          NEPR: NUMBER OF WAVE EVENTS PER RECORD (MAXIMUM IS TWO)
C          SHOANG. SHORELINE ORIENTATION WITH RESPECT TO NORTH
C          DT. TIME STEP OF THE INPUT TIME SERIES
C
      IF(NEPR.GT.2)THEN
        WRITE(*,*) ' Too many wave events per record!'
        GOTO 35
      ENDIF
      DO 30 I=1,NEVENTS
        IF(INFOR.LE.4)THEN
          IF(NEPR.EQ.2)THEN
            READ(99,*)IDUM,CH,CT,CTH,SH,ST,STH
          ELSE
            READ(99,*)IDUM,CH,CT,CTH
          ENDIF
        ELSE
          WRITE(*,*) ' This code must be modified to read your specific
     &input time series !'
          WRITE(*,*) ' This program will now terminate'
          GOTO 35
C??????????????????????????????????????????????????????????????????????????????
C  IN THIS SECTION READ THE WAVE EVENT(S) FROM THE INPUT FILE
C
C  READ THE HEIGHT, PERIOD, AND ANGLE OF THE FIRST WAVE EVENT INTO
C  CH, CT, AND CTH.
C
C  IF THERE ARE TWO EVENTS PER RECORD, READ SECOND WAVE EVENT HEIGHT,
C  PERIOD, AND ANGLE INTO SH, ST, STH.
C??????????????????????????????????????????????????????????????????????????????
        ENDIF
        ICOUNT=ICOUNT+1
        ICFLAG=1
        ISFLAG=1
        IF(CT.LE.0.0)THEN
          ICFLAG=-1
          ICCALM=ICCALM+1
        ENDIF
        IF(ICFLAG.GT.0)THEN
          HINC=CH
          TINC=CT
          IF(INFOR.LE.4)THEN
            IF(IPHASE.LE.2)THEN
              ZINC=SHOANG+90-CTH
              IF(ZINC.GE.270.)ZINC=ZINC-360.
              IF(ZINC.LE.-270.)ZINC=ZINC+360
              IF(ZINC.LT.-90..OR.ZINC.GT.90)THEN
C
C  WAVES ARE TRAVELING OFFSHORE!
C
                ICFLAG=-1
                ICOFF=ICOFF+1
              ENDIF
            ELSE
              ZINC=CTH-90.
            ENDIF
          ELSE
            WRITE(*,*) ' This code must be modified to convert your spec
     &ific'
            WRITE(*,*) ' coordinate system to one with respect to shore-
     &normal'
            GOTO 35
C??????????????????????????????????????????????????????????????????????????????
C  IN THIS SECTION CONVERT THE WAVE EVENT ANGLE FROM THE COORDINATE SYSTEM
C  OF THE INPUT FILE.
C
C  CONVERT WAVE ANGLE TO AN ANGLE IN DEGREES WITH RESPECT TO SHORE-NORMAL.
C  ANGLES COUNTER-CLOCKWISE FROM SHORE-NORMAL ARE POSITIVE.
C  ANGLES CLOCKWISE FROM SHORE NORMAL ARE NEGATIVE.
C     -90 <= ANGLE <= 90
C??????????????????????????????????????????????????????????????????????????????
          ENDIF
        ENDIF
```

```
        IF(ST.LE.0.0)THEN
          ISFLAG=-1
          ISCALM=ISCALM+1
        ENDIF
        IF(ISFLAG.GT.0)THEN
          HINS=SH
          TINS=ST
C
C  CONVERT WAVE ANGLE TO AN ANGLE IN DEGREES WITH RESPECT TO SHORE-NORMAL.
C  ANGLES COUNTER-CLOCKWISE FROM SHORE-NORMAL ARE POSITIVE.
C  ANGLES CLOCKWISE FROM SHORE-NORMAL ARE NEGATIVE.
C    -90 <= ANGLE <= 90
C
          IF(INFOR.LE.4)THEN
            IF(IPHASE.LE.2)THEN
              ZINS=SHOANG+90-STH
              IF(ZINS.GE.270.)ZINS=ZINS-360.
              IF(ZINS.LE.-270.)ZINS=ZINS+360
              IF(ZINS.LT.-90..OR.ZINS.GT.90)THEN
C
C  WAVES ARE TRAVELING OFFSHORE!
C
                ISFLAG=-1
                ISOFF=ISOFF+1
              ENDIF
            ELSE
              ZINS=STH-90.
            ENDIF
          ELSE
            WRITE(*,*) ' This code must be modified to convert your spec
     &ific'
            WRITE(*,*) ' coordinate system to one with respect to shore-
     &normal'
            GOTO 35
C????????????????????????????????????????????????????????????????????????????
C  IN THIS SECTION CONVERT THE WAVE EVENT ANGLE FROM THE COORDINATE SYSTEM
C  OF THE INPUT FILE.
C
C  CONVERT WAVE ANGLE TO AN ANGLE IN DEGREES WITH RESPECT TO SHORE-NORMAL.
C  ANGLES COUNTER-CLOCKWISE FROM SHORE-NORMAL ARE POSITIVE.
C  ANGLES CLOCKWISE FROM SHORE-NORMAL ARE NEGITIVE.
C    -90 <= ANGLE <= 90
C????????????????????????????????????????????????????????????????????????????
          ENDIF
        ENDIF
C  PROCESS WAVE DATA
C  BANDANG HOLDS TOP BAND ANGLES FOR EACH BAND
C  ANGANG,HGTANG,ANGPER,HGTPER HOLD RUNNING TOTALS OF ANGLE BAND
C  STATISTICS FOR ANGLE BAND AVG. HEIGHT, PERIOD BAND AVG. HEIGHT,ETC.
C  NUMBAND,NBAND HOLD NUMBER OF BANDS AND NUMBER OF WAVES PER BAND
C  NUMWAVES HOLDS TOTAL NUMBER OF WAVES
C  BAND HOLDS THE BAND NUMBER FOR THE CURRENT WAVE
C  PER HOLDS THE PERIOD NUMBER FOR THE CURRENT WAVE

          IF (I.EQ.1) THEN
C CREATE ANGLE BANDS USING SHOANG OFFSET THROUGH COMMON BANDSET
            CALL BANDSET
          ENDIF

        IF(ICFLAG.GT.0)THEN
          THETA=CTH
          HGT=HINC
          T=TINC
C CONVERT PHASE III ANGLES TO ANGLES WITH RESPECT TO NORTH
          IF(IPHASE.EQ.3)THEN
            THETA=SHOANG+180-CTH
          ENDIF
C RETURN ANGLE BAND AND PERIOD THROUGH COMMON
          CALL CLASS(THETA,T,BANDANG,PB,NUMBAND)
C RUN STATISTICS
C****************************************
          PERSEA(BAND,PER)=1
```

```
          ANGSEA(PER,BAND)=1
C----------------------------------------
C   PERSEA, ANGSEA, PERSWELL, AND ANGSWELL ARE BOOLEAN ARRAYS
C   WHICH ARE USED TO CREATE THE STATISTICS WHICH TELL IF
C   A WAVE IN AN ANGLE BAND EXISTS IN A PERIOD BAND (AND VICE-VERSA).
C   IN PERSEA AND PERSWELL, BANDS INDEX ROWS IN THE BOOLEAN MATRIX,
C   PERIODS INDEX THE COLUMNS.  THE OPPOSITE IS TRUE OF THE ANGSEA AND
C   ANGSWELL MATRICES.  IF PERSEA(3,2) IS SET, THIS MEANS THAT A WAVE
C   EVENT OCCURRED IN ANGLE BAND 3 PERIOD 2.  PERSEA IS USED TO CREATE
C   A STRING WHICH TELLS WHICH PERIODS HAVE HAD AN EVENT IN A PERIOD BAND,
C   AS IS PERSWELL.  ANGSEA AND ANGSWELL ARE USED TO CREATE STRINGS WHICH
C   TELL WHICH ANGLEBANDS WAVES HAVE COME FROM IN A PERIOD.
          NPERBAND(PER)=NPERBAND(PER)+1
          NBAND(BAND)=NBAND(BAND)+1
          ANGANG(BAND)=ANGANG(BAND)+THETA
          PERPER(PER)=PERPER(PER)+T
          HGTANG(BAND)=HGTANG(BAND)+HGT
          HGTPER(PER)=HGTPER(PER)+HGT
        ENDIF !ICFLAG
        IF(ISFLAG.GT.0)THEN
          THETA=STH
          HGT=HINS
          T=TINS
C CONVERT PHASE III ANGLES TO ANGLES WITH RESPECT TO NORTH
          IF(IPHASE.EQ.3)THEN
            THETA=SHOANG+180-STH
          ENDIF
C RETURN ANGLE BAND AND PERIOD THROUGH COMMON CLASS
          CALL CLASS(THETA,T,BANDANG,PB,NUMBAND)
C RUN STATISTICS
          PERSWELL(BAND,PER)=1
          ANGSWELL(PER,BAND)=1
          NPERBANDS(PER)=NPERBANDS(PER)+1
          NBANDS(BAND)=NBANDS(BAND)+1
          ANGANGS(BAND)=ANGANGS(BAND)+THETA
          PERPERS(PER)=PERPERS(PER)+T
          HGTANGS(BAND)=HGTANGS(BAND)+HGT
          HGTPERS(PER)=HGTPERS(PER)+HGT
        ENDIF !ISFLAG
   30 CONTINUE !NEVENTS
C  DATA
      WRITE(98,'(////////)')
      WRITE(98,400) 'WAVE CLASSIFICATION & STATISTICS FOR INPUT TIME SER
     &IES:',FIN
  400 FORMAT(A,2X,A)
      WRITE(98,402) 'THE FOLLOWING CLASSIFICATIONS ARE BASED ON A SHOREL
     &INE ORIENTATION OF:',SHOANG
  402 FORMAT(A,2X,F6.2)
      WRITE(98,*)
      WRITE(98,*) 'NUMBER OF RECORDS PROCESSED.................',NEVENTS
      WRITE(98,*) 'NUMBER OF CALM SEA EVENTS...................',ICCALM
      IF (NEPR.GT.1) THEN
       WRITE(98,*) 'NUMBER OF CALM SWELL EVENTS.................',ISCALM
      ENDIF
      WRITE(98,*) 'NUMBER OF OFFSHORE TRAVELING SEA EVENTS.....',ICOFF
      IF (NEPR.GT.1) THEN
       WRITE(98,*) 'NUMBER OF OFFSHORE TRAVELING SWELL EVENTS...',ISOFF
      ENDIF
      WRITE(98,'(//)')
C
C  REPORT FINDINGS TO FILE [FILENAME.WW]
C
      WRITE(98,'(A53/)') 'DEFINITION OF ANGLE BANDS'
      WRITE(98,404)
      WRITE(98,405)
  404 FORMAT(5X,'ANGLE BAND',9X,'RANGE WITH RESPECT',7X,'RANGE WITH RESP
     &ECT TO')
  405 FORMAT(7X,'NUMBER',16X,'TO NORTH',17X,'SHORE-NORMAL')
      DO 250 J=1,NUMBAND
        WRITE(98,406) J,BANDANG(J),BANDANG(J+1),SHORNORM(BANDANG(J)),
     &SHORNORM(BANDANG(J+1))
  250 CONTINUE
```

```
  406 FORMAT(9X,I1,17X,F6.2,' : ',F6.2,10X,F7.2,' : ',F7.2)
      WRITE(98,'(//)')
      WRITE(98,'(A53/)') 'DEFINITION OF PERIOD BANDS'
      WRITE(98,408)
  408 FORMAT(14X,'PERIOD BAND NO.',14X,'RANGE OF WAVE PERIODS')
      DO 252 J=1,8
        WRITE(98,410) J,PB(J),PB(J+1)
  410   FORMAT(21X,I1,23X,F4.1,'< T <',F4.1)
  252 CONTINUE
      WRITE(98,411) 9,PB(9)
  411 FORMAT(21X,I1,23X,F4.1,'< T')
C  ICFLAG AVERAGES
        DO 200 J=1,NUMBAND
          IF (NBAND(J).EQ.0.) THEN
            AVGANGANG(J)=0
            AVGHGTANG(J)=0
          GOTO 200
          ENDIF
          AVGANGANG(J)=ANGANG(J)/NBAND(J)
          AVGHGTANG(J)=HGTANG(J)/NBAND(J)
 200    CONTINUE
        DO 205 J=1,9
          IF(NPERBAND(J).EQ.0.) THEN
            AVGPERPER(J)=0
            AVGHGTPER(J)=0
          GOTO 205
          ENDIF
          AVGPERPER(J)=PERPER(J)/NPERBAND(J)
          AVGHGTPER(J)=HGTPER(J)/NPERBAND(J)
 205     CONTINUE

        WRITE(98,'(A)') CHAR(12)
        WRITE(98,600)'CLASSIFICATION OF SEA WAVE EVENTS BY ANGLE BAND'
        WRITE(98,*)
        WRITE(98,702)
        WRITE(98,704)
        DO 315 J=1,NUMBAND
          DO 266 K=1,9
            DO 268 L=1,9
              ARRY2(K,L)=PERSEA(K,L)
  268       CONTINUE
  266     CONTINUE
          IF(INT(NBAND(J)).EQ.0)THEN
            WRITE(98,711)J,INT(NBAND(J))
            GOTO 315
          ENDIF
          CALL MAKSTR2 !CREATE PERIOD BAND STRING
          WRITE(98,710)J,INT(NBAND(J)),SHORNORM(AVGANGANG(J)),
     &                 AVGHGTANG(J),STR
 315    CONTINUE
        WRITE(98,'(/)')
        WRITE (98,600) 'CLASSIFICATION OF SEA WAVE EVENTS BY PERIOD'
        WRITE(98,*)
        WRITE(98,706)
        WRITE(98,708)
        DO 320 J=1,9
          DO 270 K=1,9
            DO 272 L=1,9
              ARRY(K,L)=ANGSEA(K,L)
  272          CONTINUE
  270     CONTINUE
          IF(INT(NPERBAND(J)).EQ.0)THEN
            WRITE(98,711)J,INT(NPERBAND(J))
            GOTO 320
          ENDIF
          CALL MAKSTR !CREATE ANGLE BAND STRING
          WRITE(98,710)J,INT(NPERBAND(J)),AVGPERPER(J),AVGHGTPER(J),STR
 320  CONTINUE
C  ISFLAG (SWELL) AVERAGES
      IF(NEPR.GT.1) THEN
        DO 210 J=1,NUMBAND
          IF (NBANDS(J).EQ.0.) THEN
```

```
           AVGANGANG(J)=0
           AVGHGTANG(J)=0
           GOTO 210
         ENDIF
         AVGANGANG(J)=ANGANGS(J)/NBANDS(J)
         AVGHGTANG(J)=HGTANGS(J)/NBANDS(J)
 210   CONTINUE
       DO 215 J=1,9
         IF (NPERBANDS(J).EQ.0.) THEN
           AVGPERPER(J)=0
           AVGHGTPER(J)=0
           GOTO 215
         ENDIF
         AVGPERPER(J)=PERPERS(J)/NPERBANDS(J)
         AVGHGTPER(J)=HGTPERS(J)/NPERBANDS(J)
 215   CONTINUE
C
C  REPORT FINDINGS TO FILE [FILENAME.WW]
C
       WRITE(98,'(/)')
      WRITE(98,600) 'CLASSIFICATION OF SWELL WAVE EVENTS BY ANGLE BAND'
       WRITE(98,*)
       WRITE(98,702)
       WRITE(98,704)
       DO 325 J=1,NUMBAND
         DO 260 K=1,9
           DO 258 L=1,9
             ARRY2(K,L)=PERSWELL(K,L)
  258         CONTINUE
  260    CONTINUE
         IF(INT(NBANDS(J)).EQ.0)THEN
           WRITE(98,711)J,INT(NBANDS(J))
           GOTO 325
         ENDIF
         CALL MAKSTR2 !CREATE PERIOD BAND STRING
         WRITE(98,710)J,INT(NBANDS(J)),SHORNORM(AVGANGANG(J)),
     &                 AVGHGTANG(J),STR
 325   CONTINUE
       WRITE(98,'(/)')
       WRITE(98,600) 'CLASSIFICATION OF SWELL WAVE EVENTS BY PERIOD'
       WRITE(98,*)
       WRITE(98,706)
       WRITE(98,708)
       DO 335 J=1,9
         DO 264 K=1,9
           DO 262 L=1,9
             ARRY(K,L)=ANGSWELL(K,L)
  262         CONTINUE
  264    CONTINUE
         IF(INT(NPERBANDS(J)).EQ.0)THEN
           WRITE(98,711)J,INT(NPERBANDS(J))
           GOTO 335
         ENDIF
         CALL MAKSTR !CREATE ANGLE BAND STRING
         WRITE(98,710)J,INT(NPERBANDS(J)),AVGPERPER(J),AVGHGTPER(J),STR
  335  CONTINUE
      ENDIF !NEPR
  600  FORMAT(A65)
  602  FORMAT(1X,'  OFFSHORE REPRESENTATIVE ANGLE:  ',F6.2,' DEGREES')
  706  FORMAT(2X,'PERIOD BAND',4X,'NUMBER OF',8X,'AVERAGE',
     &10X,'AVERAGE',7X,' ANGLE')
  708  FORMAT(5X,'NUMBER',7X,'EVENTS',11X,'PERIOD',8X,
     &'WAVE HEIGHT',6X,'BANDS')
  702  FORMAT(3X,'ANGLE BAND',3X,'NUMBER OF',3X,'AVERAGE WAVE ANGLE',
     &6X,'AVERAGE',7X,'PERIOD')
  704  FORMAT(5X,'NUMBER',6X,'EVENTS',4X,'(W.R.T. SHORE-NORMAL)',3X,
     &'WAVE HEIGHT',4X,'BANDS')
  710  FORMAT(7X,I1,9X,I5,10X,F8.2,9X,F8.2,2X,A18)
  711  FORMAT(7X,I1,9X,I5,10X,'     -   ',9X,'     -   ','              ')
  700  FORMAT(I4,4(1X,G9.2))
  800  FORMAT(I4,12(1X,G9.2))
   35  CONTINUE
```

```
      STOP
      END

      SUBROUTINE BANDSET
C*******************************************************************
C BANDSET-- INPUT  DATA: SHOANG THROUGH COMMON SHOANG
C           OUTPUT DATA: BANDANG & NUMBAND
C     BANDANG(10) HOLDS THE BOTTOM AND TOP ANGLE VALUES FOR THE EIGHT
C       OR NINE ANGLE BANDS CREATED IN THIS SUBROUTINE
C     NUMBAND TELLS IF EIGHT OR NINE ANGLE BANDS ARE CREATED:  EIGHT
C      IF THE SHORELINE ORIENTATION EXISTED ON AN ANGLE BAND DEFAULT
C      ANGLE, NINE OTHERWISE.
C************·    ****************************************************
      REAL SHOANG,BANDANG(10),ANGLES(16)
      INTEGER NUMBAND
      DATA ANGLES /11.25,33.75,56.25,78.75,101.25,123.75,
     &146.25,168.75,191.25,213.75,236.25,258.75,281.25,303.75,
     &326.25,348.75/
      COMMON /BANDINFO/ BANDANG,NUMBAND
      COMMON /SHOANG/ SHOANG
C********************************************
C CHECK FOR SHORELINE ON A BAND BOUNDARY TO SET TOTAL NUMBER OF BANDS
      DO 100 I=0,15
        IF (SHOANG.EQ.(11.25+I*22.5)) THEN
          NUMBAND=8
          GOTO 10
        ELSE
          NUMBAND=9
        ENDIF
  100 CONTINUE
C*****************************************
C  DEFINE ANGLEBANDS FOR WAVE CLASSIFICATION
  10  BANDANG(1)=SHOANG
      IF (((SHOANG.GT.348.75).AND.(SHOANG.LT.360))) THEN
        IBAND=16
        GOTO 20
      ENDIF
      IF (((SHOANG.GE.0).AND.(SHOANG.LT.11.25))) THEN
        IBAND=16
        GOTO 20
      ENDIF
      DO 110 I=1,16
        IF((SHOANG.GT.ANGLES(I)).AND.(SHOANG.LT.ANGLES(I+1))) THEN
          IBAND=I
          GOTO 20
        ENDIF
 110  CONTINUE
  20  K=2
      DO 115 WHILE(K<(NUMBAND+1))
        IF (IBAND.EQ.16) THEN
          IBAND=0
        ENDIF
        IBAND=IBAND+1
        BANDANG(K)=ANGLES(IBAND)
        K=K+1
 115  CONTINUE
      IF(BANDANG(1).LT.180) THEN
        BANDANG(K)=BANDANG(1)+180.
      ELSE
        BANDANG(K)=BANDANG(1)-180.
      ENDIF
      RETURN
      END

      SUBROUTINE CLASS(THETA,T,BANDANG,PB,NUMBAND)
C********************************************************
C   SUBROUTINE CLASS
C     INPUT: THETA,T,BANDANG,PB,NUMBAND
C       THETA IS THE WAVE EVENT'S ANGLE
C       T IS THE WAVE EVENT'S PERIOD
C       BANDANG IS THE ANGLE BAND BOUNDARY ARRAY
C       PB IS THE PERIOD BAND BOUNDARY ARRAY
```

```
C       NUMBAND TELLS IF THERE ARE EIGHT OR NINE PERIOD BANDS
C   THIS PROGRAM TAKES THIS DATA AND CLASSIFIES THE WAVE EVENT DESCRIBED
C   ACCORDING TO ITS ANGLE BAND AND PERIOD BAND CLASSIFICATION
C     OUTPUT: BAND & PER THROUGH COMMON BLOCK *CLASS*
C       BAND: EVENT'S ANGLE BAND CLASSIFICATION
C       PER: EVENT'S PERIOD BAND CLASSIFICATION
C************************************************************
      REAL THETA,T,BANDANG(10),PB(9)
      INTEGER BAND, PER
      COMMON /CLASS/ BAND,PER

      DO 120 I=1,NUMBAND
        IF ((THETA.GE.BANDANG(I)) .AND. (THETA.LT.BANDANG(I+1))) THEN
          BAND=I
          GOTO 121
        ENDIF
        IF(BANDANG(I).GE.348.75.AND.BANDANG(I+1).EQ.11.25)THEN
          IF (THETA.GE.BANDANG(I).OR.THETA.LT.BANDANG(I+1)) THEN
            BAND=I
            GOTO 121
          ENDIF
        ENDIF
 120  CONTINUE
 121  CONTINUE
      IF (T.GE.PB(9)) THEN
        PER=9
        RETURN
      ENDIF
      DO 125 I=1,8
        IF((T.GE.PB(I)).AND.(T.LT.PB(I+1))) THEN
          PER=I
          ENDIF
 125  CONTINUE
      RETURN
      END



      FUNCTION SIZEOF(STRING)
C
C  A FUNCTION WHICH DETERMINES THE LENGTH OF A STRING (EXCLUDING WHITE SPACE).
C
      CHARACTER*(*) STRING
      LENGTH=LEN(STRING)
      I=LENGTH
    5 I=I-1
      IF(STRING(I:I).EQ.' ')GOTO 5
      IF(I.GE.24)I=24
      IF(I.EQ.0)I=1
      SIZEOF=I
      RETURN
      END

      SUBROUTINE MAKSTR2 !PER BAND STRINGS FROM ANGLEBAND
C*****************************************************
C  SUBROUTINE MAKSTR2
C  THIS SUBROUTINE CREATES AN 18 CHARACTER LONG STRING WHICH HOLDS
C  THE PERIOD BANDS FOUND WITHIN A GIVEN ANGLEBAND
C  INPUT: ARRY2,J
C    ARRY2:  PERIOD BAND ARRAY SUCH AS PERSWELL
C     J: THE ANGLEBAND NUMBER TO BE SEARCHED
C  OUTPUT: STR...THE STRING NEEDED FOR PRINTING
C*****************************************************
      INTEGER J,ARRY2(9,9),K
      CHARACTER*18 STR,DUM
      COMMON /MAKSTR2/ ARRY2
      COMMON /STRING/ J,STR
      DUM=' '
      K=1
      STR(1:1)=' '
      DO 100 I=1,9
        IF (ARRY2(J,I).EQ.1) THEN
```

```
            STR(K:K+2)=STR(K:K)//CHAR(I+48)//' '
            K=K+2
          ENDIF
  100 CONTINUE
      STR(K:18)=' '
      IF((18-K).GT.1) THEN
        I=(18-K)/2
        DUM(I:(I+K))=STR(1:K)
        STR=DUM
      ENDIF
      RETURN
      END

      SUBROUTINE MAKSTR !ANGLE BAND STRINGS FROM PERIOD BAND
C**********************************************
C  SUBROUTINE MAKSTR
C  THIS SUB FUNCTIONS AS MAKSTR2 BUT USES COMMON *MAKSTR* TO
C  CREATE ANGLE BAND STRINGS RATHER THAN THE PERIOD BAND STRINGS
C***********************************************
      INTEGER J,ARRY(9,9),K
      CHARACTER*18 STR,DUM
      COMMON /MAKSTR/ ARRY
      COMMON /STRING/ J,STR
      DUM=' '
      K=1
      STR(K:K)=' '
      DO 100 I=1,9
        IF (ARRY(J,I).EQ.1) THEN
          STR(K:K+2)=STR(K:K)//CHAR(I+48)//' '
          K=K+2
        ENDIF
  100 CONTINUE
      STR(K:18)=' '
      IF((18-K).GT.1) THEN
        I=(18-K)/2
        DUM(I:(I+K))=STR(1:K)
        STR=DUM
      ENDIF
      RETURN
      END

      REAL FUNCTION SHORNORM(ANG)
C************************************************
C     FUNCTION SHORNORM USES SHOANG FROM COMMON *SHOANG* TO
C     CONVERT THE INPUT ANGLE (ANG) TO SHORE-NORMAL
C***************************************************
      REAL ANG,SHOANG,ZERO
      COMMON /SHOANG/ SHOANG
      IF (ANG.EQ.360.) THEN
        ANG=0.
      ENDIF
      IF ((SHOANG.GE.0.).AND.(SHOANG.LT.270.)) THEN
        ZERO=SHOANG+90.
      ELSE
        ZERO=SHOANG-270.
      ENDIF
      IF ((ZERO.GT.270.).AND.(ANG.LT.90.)) THEN
        SHORNORM=-((360.-ZERO)+ANG)
      ELSEIF((ZERO.LT.90..AND.ANG.GT.270.)) THEN
        SHORNORM=ZERO+(360.-ANG)
      ELSE
        SHORNORM=-(ANG-ZERO)
      ENDIF
      RETURN
      END
```

APPENDIX J: SYSTEM SUPPORT PROGRAM WTNSWAV

```
      PROGRAM WTNSWAV
C*********************************************************
C THIS PROGRAM GENERATES A KEY FROM RCPWAVE OUTPUT FILES *
C AND WRITES A NEW FILE NSWAV.ext FOR INPUT TO GENESIS   *
C*********************************************************
      CHARACTER*28 FIN,FOUT
      CHARACTER*75 LIN
      CHARACTER*3 UNITS
      LOGICAL OKAY,APP,TYPES,TYPESO
      INTEGER BAND,PER,HBAND
      REAL SHOANG,HB(10),HGT(100),ANG(100),BANDANG(10),PB(9)
      INTEGER*4 DATA(100),DUM(10)
      INTEGER*2 IDUM,NUM,NUMT,IYSTART,IYEND
      DATA PB/0.,5.,7.,9.,11.,13.,15.,17.,23./

C****************************
C DEFINE COMMON INPUT UNITS *
C TO BANDSET AND CLASS      *
C****************************
      COMMON /SHOANG/ SHOANG
      COMMON /BANDINFO/ BANDANG,NUMBAND
      COMMON /CLASS/ BAND,PER,HBAND
      APP=.FALSE. !NO AUTO APPEND FIRST TIME THROUGH!
      TYPESO=.FALSE.
      TYPES=.FALSE.
C*****************************************
C  GET USER INPUT...                     *
C*****************************************
      OPEN(16,FILE='TMP.SSS',STATUS='UNKNOWN')
  320 WRITE(*,*) ' Enter your input filename and extension (including th
     &e path if the file is'
      WRITE(*,*) ' not in the default directory): (maximum of 28 charact
     &ers)'
      WRITE(*,*) '      '
      READ(*,*) FIN
    1 OPEN(UNIT=10,FILE=FIN,STATUS='OLD')
   75 WRITE(*,*) ' Enter your output filename without the extension (in
     &cluding the path if the'
      WRITE(*,*) ' file is to be written to antoher directory): (maximum
     & of 24 characters)'
      WRITE(*,*) '      '
      READ(*,*) FOUT
      LENGTH=SIZEOF(FOUT)
      FOUT(LENGTH+1:LENGTH+4)='.NSW'
      INQUIRE(FILE=FOUT,EXIST=OKAY)
        IF(.NOT.OKAY) THEN
          OPEN(UNIT=15,FILE=FOUT,STATUS='NEW')
          GOTO 11
        ENDIF
        WRITE(*,*) ' Do you wish to ...'
        WRITE(*,*) '  1.  Append to the file'
        WRITE(*,*) '  2.  Overwrite (delete) the old file'
        WRITE(*,*) '  3.  Enter a new file name'
        WRITE(*,*)
   90   WRITE(*,*) '?  '
        READ(*,*) IANS
        IF (IANS.LT.1.OR.IANS.GT.3) THEN
          WRITE(*,*) 'ILLEGAL!! '
          GOTO 90
        ENDIF
        IF (IANS.EQ.3) GOTO 75
C*****************
C  OPEN NEW FILE *
C*****************
        IF (IANS.EQ.1) THEN
C*****************
C  OPEN OLD FILE *
C    AND FAST    *
```

```
C   FORWARD IT   *
C******************
          APP=.TRUE.
          OPEN(UNIT=15,FILE=FOUT,STATUS='OLD')
c
C  read existing NSWAV file header !!!
c
c  shoreline orientation
c
          READ(15,900) SHOANGO
  900     FORMAT(61X,F7.2)
c
c  start and end waveblocks, and RCPWAVE alongshore cells
c
          READ(15,902) IYSTARTO,IYENDO,NUMTO
  902     FORMAT(20X,I4,2(6X,I4))
c
c  number of existing keys, AND system of units
c
          READ(15,901) NUMO,UNITS
  901     FORMAT(9X,I4,48X,A3)
          IF(UNITS.EQ.'MET') THEN
            ISYSO=2
          ELSE
            ISYSO=1
          ENDIF
          READ(15,*)
c
c  copy existing data to scratch file (TMP.$$$)
c
          NDP=IYENDO-IYSTARTO+1
          DO 710 J=1,NUMO
            READ(15,'(I4)') KEY
            IF(J.EQ.1)THEN
              IF(INT(KEY/1000).EQ.1.OR.INT(KEY/1000).EQ.2) THEN
                TYPESO=.TRUE.
              ENDIF
            ENDIF
            WRITE(16,'(I4)') KEY
            DO 720 K=1,(NDP/10)
              READ(15,490,END=2) (DUM(I),I=1,10)
              WRITE(16,490) (DUM(I),I=1,10)
  720       CONTINUE
            IF(MOD(NDP,10).NE.0)THEN
              READ(15,490) (DUM(I),I=1,MOD(NDP,10))
              WRITE(16,490) (DUM(I),I=1,MOD(NDP,10))
            ENDIF
  710     CONTINUE
          GOTO 11
    2     WRITE(*,*) ' HEADER INFORMATION AND DATA DO NOT AGREE'
          STOP
        ELSE
C*******************
C  DELETE OLD FILE *
C  OPEN A NEW ONE  *
C  WITH SAME NAME  *
C*******************
          OPEN(UNIT=15,FILE=FOUT,STATUS='OLD')
          CLOSE(15,STATUS='DELETE')
          OPEN(UNIT=15,FILE=FOUT,STATUS='NEW')
        ENDIF
C***************************
C GET INPUT DATA FROM USER *
C***************************
   11 CONTINUE
      WRITE(*,*) ' Enter RCPWAVE baseline orientation:  '
      READ(*,*) SHOANG
      WRITE(*,*) ' Enter number of alongshore RCPWAVE cells:  '
      READ (*,*) NUMT
      WRITE(*,*) ' Enter the RCPWAVE coordinate corresponding to the fir
     &st wave block:  '
      READ(*,*) IYSTART
```

```
      WRITE(*,*) ' Enter the RCPWAVE coordinate corresponding to the las
     &t wave block:  '
      READ(*,*) IYEND
      WRITE(*,*) ' Are SEA and SWELL wave types transformed differently?
     & (1=YES 0=NO):  '
      READ(*,*) IDIF
      IF (IDIF.EQ.1) TYPES=.TRUE.
   36 WRITE(*,*) ' Enter the unit system for the input file. (1=FEET 2=M
     &ETERS):  '
      READ(*,*) ISYS
      IF(ISYS.NE.1.AND.ISYS.NE.2) THEN
        WRITE(*,*)'INVALID RESPONSE'
        GOTO 36
      ENDIF
c
c  check header data against user input
c
      IF(APP)THEN
        IF(SHOANG.NE.SHOANGO)THEN
          WRITE(*,37)
          WRITE(*,*) ' RCPWAVE baseline orientation:'
          WRITE(*,*) ' File =',SHOANGO,'; Input specification =',SHOANG
          STOP
        ENDIF
        IF(NUMT.NE.NUMTO)THEN
          WRITE(*,37)
          WRITE(*,*) ' Number of alongshore RCPWAVE cells:'
          WRITE(*,*) ' File =',NUMTO,'; Input specification =',NUMT
          STOP
        ENDIF
        IF(IYSTART.NE.IYSTARTO.OR.IYEND.NE.IYENDO)THEN
          WRITE(*,37)
          WRITE(*,*) ' Starting wave block: '
          WRITE(*,*) ' File =',IYSTARTO,'; Input specification =',
     &IYSTART
          WRITE(*,*) ' '
          WRITE(*,*) ' Ending wave block: '
          WRITE(*,*) ' File =',IYENDO,'; Input specification =',IYEND
          STOP
        ENDIF
        IF(TYPES)THEN
          IF(.NOT.TYPESO)THEN
            WRITE(*,37)
            WRITE(*,*) ' SEA and SWELL waves transformed differently?'
            WRITE(*,*) ' File = NO; Input specification = YES'
            STOP
          ENDIF
        ELSEIF(TYPESO)THEN
          IF(.NOT.TYPES)THEN
            WRITE(*,37)
            WRITE(*,*) ' SEA and SWELL waves transformed differently?'
            WRITE(*,*) ' File = YES; Input specification = NO'
            STOP
          ENDIF
        ENDIF
        IF(ISYS.NE.ISYSO)THEN
          WRITE(*,37)
          IF(ISYS.EQ.1) WRITE(*,*) ' System of units:  File = METERS; In
     &put specification = FEET'
          IF(ISYS.EQ.2) WRITE(*,*) ' System of units:  File = FEET; Inpu
     &t specification = METERS'
          STOP
        ENDIF
  37    FORMAT(' The append file does not agree with your inputs ....',/
     &,' Check your notes concerning ...',/)
      ENDIF
      WRITE(*,*) ' Enter the number of cases in this file:  '
      READ(*,*) NOCASES
      IF(TYPES)THEN
  28    WRITE(*,*) ' Enter type of events. (1=SEA 2=SWELL):  '
        READ(*,*) ITYPE
        IF((ITYPE.NE.2.AND.ITYPE.NE.1)) THEN
```

```
          WRITE(*,*) 'INVALID RESPONSE...'
          GOTO 28
        ENDIF
      ENDIF
   30 WRITE(*,*) ' If nearshore wave transformation simulations are heig
     &ht dependent'
      WRITE(*,*) ' Enter the number of height bands required (MAXIMUM =
     &9).'
      WRITE(*,*) ' Otherwise, enter 1 if unit wave heights were used:  '
      READ(*,*) IHBNUM
      IF((IHBNUM.LT.1).OR.(IHBNUM.GT.9)) THEN
        WRITE(*,*) 'INVALID RESPONSE...'
        GOTO 30
      ENDIF
      IF(IHBNUM.NE.1) THEN
        WRITE(*,*) ' Enter the wave height band width:  '
        READ(*,*) DIFF
        WRITE(*,*) ' Enter the minimum wave height:  '
        READ(*,*) HB(1)
        DO 34 I=2,IHBNUM+1
          HB(I)=HB(I-1)+DIFF
   34   CONTINUE
      ELSE
        HB(1)=-999
        HB(2)=999
      ENDIF
      IF(ISYS.EQ.1) THEN      !  FEET
        CONV=.01
      ELSE                    !  METERS
        CONV=.1
      ENDIF
C****************
C PROCESS DATA *
C****************
c
c  read 1ST boundary wave condition
c
  555 READ (10,40) IDUM,H,T,THETA
   40 FORMAT(22X,I2,15X,F6.3,13X,F6.3,12X,F7.3)
c
c  compute angle band boundaries w.r.t. north then convert to shore-normal
c
      CALL BANDSET
      DO 367 L=1,NUMBAND+1
        BANDANG(L)=SHORNORM(BANDANG(L))
  367 CONTINUE
c
c  classify 1ST wave bounary wave condition and compute key
c
      CALL CLASS(THETA,T,BANDANG,PB,NUMBAND,HB,IHBNUM,H)
      KEY=ITYPE*1000+HBAND*100+BAND*10+PER
      IF(.NOT.APP) THEN
        NUMO=0
        NDP=IYEND-IYSTART+1
      ENDIF
C****************************
C  WORK DATA FOR EACH CASE *
C****************************
      DO 100 J= 1, NOCASES
c
c  find start of input
c
   60   CONTINUE
        READ(10,42) IDUM,HGT(1),ANG(1)
        HGT(1)=HGT(1)*CONV
        IF(IDUM.EQ.IYSTART) GOTO 102
        GOTO 60
c
c  read data points and convert heights (feet to tenths, meters to hundredths)
c
  102   DO 70 I=2,NDP
          READ(10,42,END=53) IDUM,HGT(I),ANG(I)
```

```
   42     FORMAT(1X,I4,4X,2F10.4)
          HGT(I)=HGT(I)*CONV
   70   CONTINUE
c
c  read past end points
c
        DO 59 II = IYEND+1, NUMT
          READ(10,*,END=53)
   59   CONTINUE
c
c  write data to scratch file (TMP.$$$)
c
        WRITE(16,'(I4)') KEY
        DO 54 K=1,NDP
          DATA(K)=(NINT(HGT(K)*1000))*1000+ABS(NINT(ANG(K)*10))
          IF(ANG(K).LT.0.0) DATA(K) = 0.0-DATA(K)
   54   CONTINUE
        WRITE(16,490) (DATA(K),K=NDP,1,-1)
  490   FORMAT(10I7)
c
c  read, classify and compute KEY for next boundary wave condition
c
        IF(J.LE.NOCASES-1)THEN
          READ(10,40,END=53) IDUM,H,T,THETA
          CALL CLASS(THETA,T,BANDANG,PB,NUMBAND,HB,IHBNUM,H)
          KEY=ITYPE*1000+HBAND*100+BAND*10+PER
        ENDIF
 100  CONTINUE
c
c  update counters and prepare for adding another file
c
      NUM=NUMO + NOCASES
      NUMO=NUM
      NUMTO=NUMT
      IYSTARTO=IYSTART
      IYENDO=IYEND
      ISYSO=ISYS
      TYPESO=TYPES
      SHOANGO=SHOANG
      GOTO 101
C*******************************************************
   53 WRITE(*,*) 'FILE ENDED PREMATURELY...'
      STOP
 101  WRITE(*,*) ' ADD ANOTHER FILE? (1=YES 0=NO)  '
      READ(*,*) IANS
  225 IF(IANS.EQ.1) THEN
        APP=.TRUE.
        CLOSE(10)
        WRITE(*,*) ' Enter your input filename and extension (including
     &the path if the file is'
        WRITE(*,*) ' not in the default directory): (maximum of 28 chara
     &cters)'
        WRITE(*,*) '      '
        READ(*,*) FIN
        OPEN(UNIT=10,FILE=FIN,STATUS='OLD')
        GOTO 11
      ENDIF
 449  REWIND(16)
      REWIND(15)
      CALL WRITEHEAD(NUM,NUMT,FOUT,ISYS,IYSTART,IYEND)
 444  READ(16,'(A75)',END=455) LIN
      WRITE(15,'(A75)') LIN
      GOTO 444
 455  CLOSE(16,STATUS='DELETE')
      CLOSE(15)
      END

      SUBROUTINE BANDSET
C*******************************************************************
C BANDSET-- INPUT  DATA: SHOANG THROUGH COMMON SHOANG
C                OUTPUT DATA: BANDANG & NUMBAND
C     BANDANG(10) HOLDS THE BOTTOM AND TOP ANGLE VALUES FOR THE EIGHT
```

```
C        OR NINE ANGLE BANDS CREATED IN THIS SUBROUTINE
C      NUMBAND TELLS IF EIGHT OR NINE ANGLE BANDS ARE CREATED:  EIGHT
C       IF THE SHORELINE ORIENTATION EXISTED ON AN ANGLE BAND DEFAULT
C       ANGLE, NINE OTHERWISE.
C*****************************************************************************
      REAL SHOANG,BANDANG(10),ANGLES(16)
      INTEGER NUMBAND
      DATA ANGLES /11.25,33.75,56.25,78.75,101.25,123.75,
     &146.25,168.75,191.25,213.75,236.25,258.75,281.25,303.75,
     &326.25,348.75/
      COMMON /BANDINFO/ BANDANG,NUMBAND
      COMMON /SHOANG/ SHOANG
C********************************************
C CHECK FOR SHORELINE ON A BAND BOUNDARY TO SET TOTAL NUMBER OF BANDS
      DO 100 I=0,15
        IF (SHOANG.EQ.(11.25+I*22.5)) THEN
          NUMBAND=8
          GOTO 10
        ELSE
          NUMBAND=9
        ENDIF
  100 CONTINUE
C********************************************
C  DEFINE ANGLEBANDS FOR WAVE CLASSIFICATION
   10 BANDANG(1)=SHOANG
      IF (((SHOANG.GT.348.75).AND.(SHOANG.LT.360))) THEN
        IBAND=16
        GOTO 20
      ENDIF
      IF (((SHOANG.GE.0).AND.(SHOANG.LT.11.25))) THEN
        IBAND=16
        GOTO 20
      ENDIF
      DO 110 I=1,16
        IF((SHOANG.GT.ANGLES(I)).AND.(SHOANG.LT.ANGLES(I+1))) THEN
          IBAND=I
          GOTO 20
        ENDIF
  110 CONTINUE
   20 K=2
      DO 115 WHILE(K<(NUMBAND+1))
        IF (IBAND.EQ.16) THEN
          IBAND=0
        ENDIF
        IBAND=IBAND+1
        BANDANG(K)=ANGLES(IBAND)
        K=K+1
  115 CONTINUE
      IF(BANDANG(1).LT.180) THEN
        BANDANG(K)=BANDANG(1)+180
      ELSE
        BANDANG(K)=BANDANG(1)-180
      ENDIF
      RETURN
      END

      SUBROUTINE CLASS(THETA,T,BANDANG,PB,NUMBAND,HB,IHBNUM,HGT)
C*************************************************************
C   SUBROUTINE CLASS
C     INPUT. THETA,T,BANDANG,PB,NUMBAND
C       THETA IS THE WAVE EVENT'S ANGLE
C       T IS THE WAVE EVENT'S PERIOD
C       BANDANG IS THE ANGLE BAND BOUNDARY ARRAY
C       PB IS THE PERIOD BAND BOUNDARY ARRAY
C       NUMBAND TELLS IF THERE ARE EIGHT OR NINE PERIOD BANDS
C   THIS PROGRAM TAKES THIS DATA AND CLASSIFIES THE WAVE EVENT DESCRIBED
C   ACCORDING TO ITS ANGLE BAND AND PERIOD BAND CLASSIFICATION
C     OUTPUT. BAND & PER THROUGH COMMON BLOCK *CLASS*
C       BAND. EVENT'S ANGLE BAND CLASSIFICATION
C       PER. EVENT'S PERIOD BAND CLASSIFICATION
C*****************************************************************
      REAL THETA,T,BANDANG(10),PB(9),HB(22)
```

```
      INTEGER BAND,PER,HBAND
      COMMON /CLASS/ BAND,PER,HBAND

      DO 120 I=1,NUMBAND
        IF ((THETA.LE.BANDANG(I)) .AND. (THETA.GT.BANDANG(I+1))) THEN
          BAND=I
          GOTO 121
        ENDIF
        IF(I.EQ.NUMBAND) WRITE(*,*) 'ANGLE BAND NOT FOUND (THETA=',
     $THETA,' )'
 120  CONTINUE
 121  CONTINUE
      IF (T.GE.PB(9)) THEN
        PER=9
        RETURN
      ENDIF
      DO 125 I=1,8
        IF((T.GE.PB(I)).AND.(T.LT.PB(I+1))) THEN
          PER=I
          ENDIF
 125  CONTINUE
      IF (IHBNUM.EQ.1) THEN
        HBAND=1
        RETURN
      ENDIF
      DO 128 I=1,IHBNUM
        IF ((HGT.GE.HB(I)) .AND. (HGT.LT.HB(I+1))) THEN
          HBAND=I
          RETURN
        ENDIF
 128  CONTINUE
      RETURN
      END

      FUNCTION SIZEOF(STRING)
C
C  A FUNCTION WHICH DETERMINES THE LENGTH OF A STRING (EXCLUDING WHITE SPACE)
C
      CHARACTER*(*) STRING
      LENGTH=LEN(STRING)
      I=LENGTH
    5 I=I-1
      IF(STRING(I:I).EQ.' ')GOTO 5
      IF(I.GE.24)I=24
      IF(I.EQ.0)I=1
      SIZEOF=I
      RETURN
      END

      SUBROUTINE WRITEHEAD(NUM,NUMT,FOUT,ISYS,IYSTART,IYEND)
      COMMON /SHOANG/ SHOANG
      INTEGER*2 NUM,NUMT,IYSTART,IYEND
      CHARACTER*28 FOUT
      WRITE(15,30) ' FILE:  ',FOUT,' SHORELINE ORIENTATION:  ',SHOANG
 30   FORMAT(A7,A28,A26,F7.2)
      WRITE(15,35) IYSTART,IYEND,NUMT
 35   FORMAT(' DATA AT WAVEBLOCKS ',I4,' THRU ',I4,' FROM ',I4,' ALONGSH
     &ORE RCPWAVE CELLS')
      IF (ISYS.EQ.1) THEN
        WRITE(15,40) NUM
      ELSE
        WRITE(15,41) NUM
      ENDIF
 40   FORMAT(' CONTAINS',I4,' UNIQUE NEARSHORE WAVE EVENTS.  WAVE HEIGHT
     &S IN FEET/10.')
 41   FORMAT(' CONTAINS',I4,' UNIQUE NEARSHORE WAVE EVENTS.  WAVE HEIGHT
     &S IN METERS/100.')
      WRITE(15,*) '**************************************************
     &*********************'
      RETURN
      END
```

```
      REAL FUNCTION SHORNORM(ANG)
C***********************************************
C     FUNCTION SHORNORM USES SHOANG FROM COMMON *SHOANG* TO
C     CONVERT THE INPUT ANGLE (ANG) TO SHORE-NORMAL
C**************************************************
      REAL ANG,SHOANG,ZERO
      COMMON /SHOANG/ SHOANG
      IF (ANG.EQ.360.) THEN
        ANG=0.
      ENDIF
      IF ((SHOANG.GE.0.).AND.(SHOANG.LT.270.)) THEN
        ZERO=SHOANG+90.
      ELSE
        ZERO=SHOANG-270.
      ENDIF
      IF ((ZERO.GT.270.).AND.(ANG.LT.90.)) THEN
        SHORNORM=-((360.-ZERO)+ANG)
      ELSEIF((ZERO.LT.90..AND.ANG.GT.270.)) THEN
        SHORNORM=ZERO+(360.-ANG)
      ELSE
        SHORNORM=-(ANG-ZERO)
      ENDIF
      RETURN
      END
```

APPENDIX K: SYSTEM SUPPORT PROGRAM WTDEPTH

```
      PROGRAM WTDEPTH
      PARAMETER(MNX=100)
C************************************************
C THIS PROGRAM READS AN RCPWAVE BATHYMETRY FILE *
C AND WRITES A DEPTH.ext FILE FOR USE WITH      *
C GENESIS OR NSTRAN                             *
C************************************************
      CHARACTER*28 FIN,FOUT
      REAL DEPTH(MNX)
      WRITE(*,*) 'Enter your input filename and extension (including the
     & path if the file is'
      WRITE(*,*) 'not in the default directory): (maximum of 28 characte
     &rs)  '
      WRITE(*,*) '     '
      READ(*,*) FIN
    1 OPEN(UNIT=10,FILE=FIN,STATUS='OLD')
   75 WRITE(*,*) 'Enter your output filename without the extension (incl
     &uding the path if the'
      WRITE(*,*) 'file is to be written to another directory): (maximum
     &of 24 characters)  '
      WRITE(*,*) '     '
      READ(*,*) FOUT
      LENGTH=SIZEOF(FOUT)
      FOUT(LENGTH+1:LENGTH+4)='.DEP'
      OPEN(UNIT=15,FILE=FOUT,STATUS='NEW')
      WRITE(*,*) ' Enter number of alongshore RCPWAVE cells:  '
      READ (*,*) NUMT
      WRITE(*,*) ' Enter the RCPWAVE coordinate corresponding to the fir
     &st wave block:  '
      READ(*,*) IYSTART
      WRITE(*,*) ' Enter the RCPWAVE coordinate corresponding to the las
     &t wave block:  '
      READ(*,*) IYEND
      NUM=IYEND-IYSTART+1
C*****************************
C     FIND START POSITION    *
C*****************************
      READ(10,*)
  100 CONTINUE
      READ(10,*,END=10000) IDUM
      IF(IYSTART.EQ.IDUM) THEN
        BACKSPACE(10)
        GOTO 101
      ELSE
        GOTO 100
      ENDIF
10000 WRITE(*,*) 'END OF FILE ENCOUNTERD...START COORDINATE NOT FOUND '
      STOP
101   DO 907 L=1,NUM
        READ(10,102,END=908) DEPTH(L)
  907 CONTINUE
  102 FORMAT(29X,F10.2)
      CALL WRITHEAD(FIN,IYSTART,IYEND,NUMT)
      WRITE(15,920) (DEPTH(J),J=NUM,1,-1)
  920 FORMAT(10F7.2)
      GOTO 105
  908 WRITE(*,*) 'END OF FILE ENCOUNTERED...'
  105 STOP
      END

      FUNCTION SIZEOF(STRING)
C
C  A FUNCTION WHICH DETERMINES THE LENGTH OF A STRING (EXCLUDING WHITE SPACE).
C
      CHARACTER*(*) STRING
      LENGTH=LEN(STRING)
      I=LENGTH
    5 I=I-1
```

```
      IF(STRING(I:I).EQ.' ')GOTO 5
      IF(I.GE.24)I=24
      IF(I.EQ.0)I=1
      SIZEOF=I
      RETURN
      END

      SUBROUTINE WRITHEAD(FIN,IYSTART,IYEND,NUMT)
      CHARACTER*28 FIN
      WRITE(15,*) '*****************************************************
     &************************'
      WRITE(15,*) ' NEARSHORE DEPTH FILE CREATED FROM FILE:  ',FIN
      WRITE(15,35) IYSTART,IYEND,NUMT
  35  FORMAT(' DATA AT WAVEBLOCKS ',I4,' THRU ',I4,' FROM ',I4,' ALONGSH
     &ORE RCPWAVE CELLS')
      WRITE(15,*) '*****************************************************
     &************************'
      RETURN
      END

```

APPENDIX L: SYSTEM SUPPORT PROGRAM NSTRAN

```
      PROGRAM NSTRAN
      PARAMETER(MNX=100)
C********************************
C WRITES NEARSHORE TRANSPORTS  *
C USING OFFSHORE-GENERATED     *
C KEYS AND NEARSHORE DATABASES *
C********************************
      CHARACTER*28 FOUT,FIN,FIN1,FIN2,FIN3
      CHARACTER*3 CHUNIT
      REAL DEPTH(MNX),VOLL(MNX),VOLR(MNX)
      REAL SVOLL(MNX),SVOLR(MNX)
      REAL SHOANG,HB(9),HGT,ANG,BANDANG(10),PB(9),HGTS,ANGS,TS,T
      INTEGER BAND,PER,HBAND,NEVENTS
      INTEGER*4 KEY,KEYNOTFOUND(MNX)
      INTEGER KNF,IHBNUM,NEAR(MNX,MNX+1)
      KNF=0
      ISCALM=0
      ICCALM=0
      DATA PB/0.,5.,7.,9.,11.,13.,15.,17.,23./
C*****************************
C DEFINE COMMON INPUT UNITS *
C TO BANDSET AND CLASS      *
C*****************************
      COMMON /SHOANG/ SHOANG
      COMMON /BANDINFO/ BANDANG,NUMBAND
      COMMON /CLASS/ BAND,PER,HBAND
C**************************************************
C GET INPUT FILES:  name.WAV, name.NSW, name.DEP *
C**************************************************
      WRITE(*,*) ' This program requires GENESIS format input files gene
     &rated by the'
      WRITE(*,*) ' workbook programs WTWAVES, WTNSWAV, and WTDEPTH.  Out
     &put from these'
      WRITE(*,*) ' programs are stored in files with the extensions .WAV
     &, .NSW, and .DEP'
      WRITE(*,*)
      WRITE(*,*) ' Enter the input offshore time series filename (name.W
     &AV):  '
      READ(*,*) FIN
      LENGTH=SIZEOF(FIN)
      FIN(LENGTH+1:LENGTH+4)='.WAV'
      FIN1=FIN
      OPEN(UNIT=25,FILE=FIN,STATUS='OLD')
      WRITE(*,*) ' Enter the input nearshore wave data base filename (na
     &me.NSW):  '
      READ(*,*) FIN
      LENGTH=SIZEOF(FIN)
      FIN(LENGTH+1:LENGTH+4)='.NSW'
      FIN2=FIN
      OPEN(UNIT=10,FILE=FIN,STATUS='OLD')
      WRITE(*,*) ' Enter the input nearshore water depths filename (name
     &.DEP):  '
      READ(*,*) FIN
      LENGTH=SIZEOF(FIN)
      FIN(LENGTH+1:LENGTH+4)='.DEP'
      FIN3=FIN
      OPEN(UNIT=20,FILE=FIN,STATUS='OLD')
      WRITE(*,*) '      '
      WRITE(*,*) 'Enter your output filename without the extension (incl
     &uding the path if the'
      WRITE(*,*) 'file is to be written to another directory): (maximum
     &of 24 characters)  '
      WRITE(*,*) '      '
      READ(*,*) FOUT
      LENGTH=SIZEOF(FOUT)
      FOUT(LENGTH+1:LENGTH+4)='.NSV'
      OPEN(UNIT=15,FILE=FOUT,STATUS='NEW')
      FOUT(LENGTH+1:LENGTH+4)='.PLD'
```

```
      OPEN(UNIT=16,FILE=FOUT,STATUS='NEW')
C****************************
C  GET INFO FROM NEARSHORE *
C      WAVE FILE HEADER    *
C****************************
 11   READ(10,'(61X,F7.2)') SHOANG
      READ(10,'(20X,I4,6X,I4)') IYSTART,IYEND
      NUM=IYEND-IYSTART+1
      READ(10,'(9X,I4,48X,A3)') NUMKEYS,CHUNIT
      IF(CHUNIT.EQ.'MET') THEN
        INUNIT=1 !METERS
        CONV=1.
      ELSE
        INUNIT=2 !FEET
        CONV=0.3048
      ENDIF
C
C  READ NEARSHORE DATA BASE
C
      READ(10,*)
      DO 15 J=1,NUMKEYS
        READ(10,'(I4)') NEAR(J,1)
        READ(10,'(10I7)') (NEAR(J,I),I=2,NUM+1)
   15 CONTINUE
      IF((NEAR(1,1)/1000).EQ.1.OR.(NEAR(1,1)/1000).EQ.2)THEN
        ITYPE=1.
      ELSE
        ITYPE=0.
      ENDIF
      CALL BANDSET         !  SET BAND CHARACTERISTICS
      DO 557 L=1,10
        BANDANG(L)=SHORNORM(BANDANG(L))
 557  CONTINUE
C
C  READ NEARSHORE DEPTHS
C
      DO 800 I=1,4
        READ(20,*)
        READ(25,*)
 800  CONTINUE
      READ(20,*) (DEPTH(I),I=1,NUM)
C
C  GET WAVE DATA
C
      WRITE(*,*) 'Enter the offshore wave time series time step:  '
      READ(*,*) DT
  700 WRITE(*,*) 'Enter the number of wave events per time step:  '
      READ(*,*) NEPR
      IF(NEPR.NE.1.AND.NEPR.NE.2) THEN
        WRITE(*,*) 'ILLEGAL INPUT...'
        GOTO 700
      ENDIF
C*********************
C  GET HEIGHT BANDS *
C*********************
 30   WRITE(*,*) ' If height bands are required, enter the number of hei
     &ght bands to create.'
      WRITE(*,*) ' Otherwise enter 1.  (MAXIMUM = 9):  '
      READ(*,*) IHBNUM
      IF((IHBNUM.LT.1).OR.(IHBNUM.GT.9)) THEN
        WRITE(*,*) 'INVALID RESPONSE...'
        GOTO 30
      ENDIF
      IF(IHBNUM.NE.1) THEN
        WRITE(*,*) ' Enter the wave height band width:  '
        READ(*,*) DIFF
        WRITE(*,*) ' Enter the minimum wave height:  '
        READ(*,*) HB(1)
        DO 34 I=2,IHBNUM+1
          HB(I)=HB(I-1)+DIFF
   34   CONTINUE
      ELSE
```

```
        HB(1)=-999
        HB(2)=999
      ENDIF
C************************************
C  BEGIN CALCULATIONS HERE BASED   *
C     ON OFFSHORE TIME SERIES      *
C************************************
      NEVENTS=0
  499 CONTINUE
      IF(NEPR.EQ.1) THEN
        READ(25,*,END=70) T,HGT,ANG
        NEVENTS=NEVENTS+1
        IF(T.LE.0.0) THEN
          ICCALM=ICCALM+1
          GOTO 499
        ENDIF
      ELSE
        READ(25,*,END=70) T,HGT,ANG
        READ(25,*,END=70) TS,HGTS,ANGS
        NEVENTS=NEVENTS+1
        IF(T.LE.0.0.OR.TS.LE.0) THEN
          IF(T.LE.0.0) THEN
            ICCALM=ICCALM+1
            GOTO 1499
          ENDIF
        ENDIF
      ENDIF
C
C  COMPUTE SEA TRANSPORT VOLUMES
C
      HGT1=HGT
      CALL CLASS(ANG,T,BANDANG,PB,NUMBAND,HB,IHBNUM,HGT1)
      IF(ITYPE.NE.0) THEN
        KEY=1000+HBAND*100+BAND*10+PER
      ELSE
        KEY=HBAND*100+BAND*10+PER
      ENDIF
C
C  SEARCH NEARSHORE DATA BASE FOR KEY
C
      DO 235 L=1,NUMKEYS
        IF(KEY.EQ.NEAR(L,1)) GOTO 236
  235 CONTINUE
      WRITE(*,'(1X,A,I4)') 'KEY NOT FOUND FOR SEA EVENT ',NEVENTS
      WRITE(*,'(1X,A,F6.2,1X,F6.2,1X,F6.2)')'HEIGHT, PERIOD, THETA:  '
     &,HGT,T,ANG
      KNF=KNF+1
      KEYNOTFOUND(KNF)=KEY
      GOTO 1499
C
C  DO FOR ALL WAVE BLOCKS
C
  236 DO 240 J=2,NUM+1
        IF(NEAR(L,J).LT.0) THEN
          SIGN=-1.
        ELSE
          SIGN=1.
        ENDIF
        HGT=FLOAT(ABS(NEAR(L,J)/1000))
        ANG=FLOAT(ABS(NEAR(L,J))-HGT*1000.)
        ANG=ANG*.1*SIGN
        IF(IHBNUM.NE.1) THEN
          IF (INUNIT.EQ.2) THEN !FEET
            HGT=HGT/10.*CONV
          ELSE !METERS
            HGT=HGT/100.
          ENDIF
        ELSE
          IF (INUNIT.EQ.2) THEN !FEET
            HGT=(HGT/10.*HGT1)*CONV
          ELSE !METERS
            HGT=HGT/100.*HGT1
```

```
          ENDIF
        ENDIF
        ANG=ANG*(3.141592654/180)
        CALL TVOL(HGT,T,ANG,DEPTH(J-1),DT,V)
        IF(V.GE.0) THEN
          VOLR(J-1)=VOLR(J-1)+V
        ELSE
          VOLL(J-1)=VOLL(J-1)+V
        ENDIF
  240 CONTINUE
C
C  COMPUTE SWELL TRANSPORT VOLUMES
C
 1499 IF(NEPR.EQ.2) THEN
        IF(TS.LE.0.0) THEN
          ISCALM=ISCALM+1
          GOTO 499
        ENDIF
        HGT1=HGTS
        CALL CLASS(ANGS,TS,BANDANG,PB,NUMBAND,HB,IHBNUM,HGT1)
        IF(ITYPE.NE.0) THEN
          KEY=2000+HBAND*100+BAND*10+PER
        ELSE
          KEY=HBAND*100+BAND*10+PER
        ENDIF
C
C  SEARCH NEARSHORE DATA BASE FOR KEY
C
        DO 237 L=1,NUMKEYS
          IF(NEAR(L,1).EQ.KEY)GOTO 238
  237   CONTINUE
        WRITE(*,'(1X,A,I4)') 'KEY NOT FOUND FOR SWELL EVENT ',NEVENTS
        WRITE(*,'(1X,A,F6.2,F6.2,F6.2)') 'HEIGHT, PERIOD, THETA:  ',HG
     &  TS,TS,ANGS
        KNF=KNF+1
        KEYNOTFOUND(KNF)=KEY
        GOTO 499
C
C  DO FOR ALL WAVE BLOCKS
C
  238   DO 245 J=2,NUM+1
          IF (NEAR(L,J).LT.0) THEN
            SIGN=-1.
          ELSE
            SIGN=1.
          ENDIF
          HGTS=FLOAT(ABS(NEAR(L,J)/1000))
          ANGS=FLOAT(ABS(NEAR(L,J))-HGTS*1000.)
          ANGS=ANGS*.1*SIGN
          IF(IHBNUM.NE.1) THEN
            IF (INUNIT.EQ.2) THEN !FEET
              HGTS=HGTS/10.*CONV
            ELSE !METERS
              HGTS=HGTS/100.
            ENDIF
          ELSE
            IF (INUNIT.EQ.2) THEN !FEET
              HGTS=(HGTS/10.*HGT1)*CONV
            ELSE !METERS
              HGTS=HGTS/100.*HGT1
            ENDIF
          ENDIF
          ANGS=ANGS*(3.141592654/180.)
          CALL TVOL(HGTS,TS,ANGS,DEPTH(J-1),DT,V)
          IF(V.GE.0.) THEN
            SVOLR(J-1)=SVOLR(J-1)+V
          ELSE
            SVOLL(J-1)=SVOLL(J-1)+V
          ENDIF
  245   CONTINUE
      ENDIF
      GOTO 499
```

```
   70 CONTINUE
C**********************
C  WRITE SUMMARY DATA *
C**********************
      YRS=FLOAT(NEVENTS)*DT/8760.
      WRITE(15,*)
      WRITE(15,'(15X,A)') 'ESTIMATED POTENTIAL LONGSHORE SAND TRANSPORT
     &RATES'
      WRITE(15,*)
      WRITE(15,*) 'INPUT OFFSHORE TIME SERIES:  ',FIN1
      WRITE(15,*) 'INPUT NEARSHORE WAVE CONDITIONS:  ',FIN2
      WRITE(15,*) 'NEARSHORE WAVE BLOCK WATER DEPTHS:  ',FIN3
      WRITE(15,'(//)')
      WRITE(15,'(36X,A)') 'TABLE 1'
      WRITE(15,'(38X,A)') 'SAND TRANSPORT VOLUMES (M**3)'
      WRITE(15,2501) 'WAVE','WAVE','LEFT','RIGHT'
 2501 FORMAT(10X,3X,A4,3X,3X,A4,3X,3X,A4,3X,3X,A5,2X)
      WRITE(15,2502)'BLOCK','TYPE','DIRECTED','DIRECTED','NET','GROSS'
 2502 FORMAT(10X,2X,A5,3X,3X,A4,3X,1X,A8,1X,1X,A8,1X,4X,A3,3X,3X,A5)
      WRITE(15,2503)
 2503 FORMAT(10X,'------------------------------------------------------------
     &------')
      DO 2600 I=1,NUM
        WRITE(15,2504)I,'SEA',VOLL(I),VOLR(I),VOLL(I)+VOLR(I),
     &  ABS(VOLL(I))+VOLR(I)
 2504   FORMAT(10X,3X,I4,3X,4X,A3,3X,G9.2,1X,G9.2,1X,G9.2,1X,G9.2)
        IF(NEPR.EQ.2) THEN
          WRITE(15,2505)I,'SWELL',SVOLL(I),SVOLR(I),SVOLL(I)+SVOLR(I),
     &    ABS(SVOLL(I))+SVOLR(I)
 2505     FORMAT(10X,3X,I4,3X,3X,A5,2X,G9.2,1X,G9.2,1X,G9.2,1X,G9.2)
          WRITE(15,2506)I,'COMBINED',SVOLL(I)+VOLL(I),SVOLR(I)+VOLR(I),
     &    SVOLL(I)+SVOLR(I)+VOLL(I)+VOLR(I),ABS(SVOLL(I))+SVOLR(I)+
     &    ABS(VOLL(I))+VOLR(I)
 2506     FORMAT(10X,3X,I4,3X,1X,A8,1X,G9.2,1X,G9.2,1X,G9.2,1X,G9.2)
        ENDIF
 2600 CONTINUE
      WRITE(15,'(A1,//)') CHAR(12)
      WRITE(15,'(36X,A)') 'TABLE 2'
      WRITE(15,*)
      WRITE(15,'(38X,A)') 'SAND TRANSPORT RATES (M**3/YEAR)'
      WRITE(15,*)
      WRITE(15,1501) 'WAVE','WAVE','LEFT','RIGHT'
 1501 FORMAT(10X,3X,A4,3X,3X,A4,3X,3X,A4,3X,3X,A5,2X)
      WRITE(15,1502)'BLOCK','TYPE','DIRECTED','DIRECTED','NET','GROSS'
 1502 FORMAT(10X,2X,A5,3X,3X,A4,3X,1X,A8,1X,1X,A8,1X,4X,A3,3X,3X,A5)
      WRITE(15,1503)
 1503 FORMAT(10X,'------------------------------------------------------------
     &------')
      DO 1600 I=1,NUM
        WRITE(15,1504)I,'SEA',VOLL(I)/YRS,VOLR(I)/YRS
     &  ,(VOLL(I)+VOLR(I))/YRS,(ABS(VOLL(I))+VOLR(I))/YRS
 1504   FORMAT(10X,3X,I4,3X,4X,A3,3X,G9.2,1X,G9.2,1X,G9.2,1X,G9.2)
        IF(NEPR.EQ.2) THEN
          WRITE(15,1505)I,'SWELL',SVOLL(I)/YRS,SVOLR(I)/YRS,
     &    (SVOLL(I)+SVOLR(I))/YRS,(ABS(SVOLL(I))+SVOLR(I))/YRS
 1505     FORMAT(10X,3X,I4,3X,3X,A5,2X,G9.2,1X,G9.2,1X,G9.2,1X,G9.2)
          WRITE(15,1506)I,'COMBINED',(SVOLL(I)+VOLL(I))/YRS
     &    ,(SVOLR(I)+VOLR(I))/YRS
     &    ,(SVOLL(I)+SVOLR(I)+VOLL(I)+VOLR(I))/YRS
     &    ,(ABS(SVOLL(I))+SVOLR(I)+ABS(VOLL(I))+VOLR(I))/YRS
 1506     FORMAT(10X,3X,I4,3X,1X,A8,1X,G9.2,1X,G9.2,1X,G9.2,1X,G9.2)
        ENDIF
 1600 CONTINUE
      WRITE(15,*)
      WRITE (15,'(26X,A)') 'SUMMARY OF TIME SERIES DATA'
      WRITE (15,'(26X,A)') '---------------------------'
      WRITE(15,*)
      X=NEVENTS*DT/(365.*24.)
      WRITE(15,'(A,F6.2,A)') '       The duration of the input time seri
     &es is ',X,' years'
      WRITE(15,*)
      IF(X.LT.1.) WRITE(15,*) 'NOTE:  Since the time series is less than
```

```
     & one year in duration, the','       estimates reported above may r
     &eflect a seasonal bias.',CHAR(13)
      WRITE(15,'(A,F6.2,A)') '       These estimates are based on a base
     &line orientation of ',SHOANG,' degrees'
      WRITE(15,'(I12,A,F3.0,A)') NEVENTS,' events were processed at a ti
     &me step of ',DT,' hours'
      WRITE(15,*) ICCALM,' sea events were calm'
      IF(NEPR.EQ.2) WRITE(15,*) ISCALM,' swell events were calm'
      IF(KNF.NE.0) THEN
        WRITE(15,*)
        WRITE(15,*) 'KEYS NOT FOUND IN THIS SERIES WERE:  '
        WRITE(15,*) (KEYNOTFOUND(I),I=1,KNF)
      ENDIF
      IF(NEPR.EQ.1)THEN
        NYPTS=2
      ELSE
        NYPTS=6
      ENDIF
      WRITE(16,*) NUM
      WRITE(16,*) NYPTS
      DO 1610 I=1,NUM
        IF(NYPTS.EQ.2)THEN
          WRITE(16,1611)I,VOLL(I)/YRS,VOLR(I)/YRS
        ELSE
          WRITE(16,1612)I,VOLL(I)/YRS,VOLR(I)/YRS,SVOLL(I)/YRS,
     &SVOLR(I)/YRS,(SVOLL(I)+VOLL(I))/YRS,(SVOLR(I)+VOLR(I))/YRS
        ENDIF
 1610 CONTINUE
      WRITE(16,*)
 1611 FORMAT(I5,2(1X,G10.3))
 1612 FORMAT(I5,6(1X,G10.3))
      STOP
      END

      SUBROUTINE BANDSET
C**********************************************************************
C BANDSET-- INPUT  DATA: SHOANG THROUGH COMMON SHOANG
C           OUTPUT DATA: BANDANG & NUMBAND
C     BANDANG(10) HOLDS THE BOTTOM AND TOP ANGLE VALUES FOR THE EIGHT
C       OR NINE ANGLE BANDS CREATED IN THIS SUBROUTINE
C     NUMBAND TELLS IF EIGHT OR NINE ANGLE BANDS ARE CREATED:  EIGHT
C      IF THE SHORELINE ORIENTATION EXISTED ON AN ANGLE BAND DEFAULT
C      ANGLE, NINE OTHERWISE.
C**********************************************************************
      REAL SHOANG,BANDANG(10),ANGLES(16)
      INTEGER NUMBAND
      DATA ANGLES /11.25,33.75,56.25,78.75,101.25,123.75,
     &146.25,168.75,191.25,213.75,236.25,258.75,281.25,303.75,
     &326.25,348.75/
      COMMON /BANDINFO/ BANDANG,NUMBAND
      COMMON /SHOANG/ SHOANG
C*********************************************
C CHECK FOR SHORELINE ON A BAND BOUNDARY TO SET TOTAL NUMBER OF BANDS
      DO 100 I=0,15
        IF (SHOANG.EQ.(11.25+I*22.5)) THEN
          NUMBAND=8
          GOTO 10
        ELSE
          NUMBAND=9
        ENDIF
  100 CONTINUE
C******************************************
C  DEFINE ANGLEBANDS FOR WAVE CLASSIFICATION
   10 BANDANG(1)=SHOANG
      IF (((SHOANG.GT.348.75).AND.(SHOANG.LT.360))) THEN
        IBAND=16
        GOTO 20
      ENDIF
      IF (((SHOANG.GE.0).AND.(SHOANG.LT.11.25))) THEN
        IBAND=16
        GOTO 20
      ENDIF
```

```
      DO 110 I=1,16
        IF((SHOANG.GT.ANGLES(I)).AND.(SHOANG.LT.ANGLES(I+1))) THEN
          IBAND=I
          GOTO 20
        ENDIF
  110 CONTINUE
   20 K=2
      DO 115 WHILE(K<(NUMBAND+1))
        IF (IBAND.EQ.16) THEN
          IBAND=0
        ENDIF
        IBAND=IBAND+1
        BANDANG(K)=ANGLES(IBAND)
        K=K+1
  115 CONTINUE
      IF(BANDANG(1).LT.180) THEN
        BANDANG(K)=BANDANG(1)+180.
      ELSE
        BANDANG(K)=BANDANG(1)-180.
      ENDIF
      RETURN
      END

      REAL FUNCTION SHORNORM(ANG)
C***********************************************
C     FUNCTION SHORNORM USES SHOANG FROM COMMON *SHOANG* TO
C     CONVERT THE INPUT ANGLE (ANG) TO SHORE-NORMAL
C**************************************************
      REAL ANG,SHOANG,ZERO
      COMMON /SHOANG/ SHOANG
      IF (ANG.EQ.360.) THEN
        ANG=0.
      ENDIF
      IF ((SHOANG.GE.0.).AND.(SHOANG.LT.270.)) THEN
        ZERO=SHOANG+90.
      ELSE
        ZERO=SHOANG-270.
      ENDIF
      IF ((ZERO.GT.270.).AND.(ANG.LT.90.)) THEN
        SHORNORM=-((360.-ZERO)+ANG)
      ELSEIF((ZERO.LT.90..AND.ANG.GT.270.)) THEN
        SHORNORM=ZERO+(360.-ANG)
      ELSE
        SHORNORM=-(ANG-ZERO)
      ENDIF
      RETURN
      END

      SUBROUTINE CLASS(THETA,T,BANDANG,PB,NUMBAND,HB,IHBNUM,HGT)
C********************************************************
C   SUBROUTINE CLASS
C     INPUT: THETA,T,BANDANG,PB,NUMBAND
C       THETA IS THE WAVE EVENT'S ANGLE
C       T IS THE WAVE EVENT'S PERIOD
C       BANDANG IS THE ANGLE BAND BOUNDARY ARRAY
C       PB IS THE PERIOD BAND BOUNDARY ARRAY
C       NUMBAND TELLS IF THERE ARE EIGHT OR NINE PERIOD BANDS
C   THIS PROGRAM TAKES THIS DATA AND CLASSIFIES THE WAVE EVENT DESCRIBED
C   ACCORDING TO ITS ANGLE BAND AND PERIOD BAND CLASSIFICATION.
C     OUTPUT: BAND & PER THROUGH COMMON BLOCK *CLASS*
C       BAND: EVENT'S ANGLE BAND CLASSIFICATION
C       PER: EVENT'S PERIOD BAND CLASSIFICATION
C************************************************************
      REAL THETA,T,BANDANG(10),PB(9),HB(22)
      INTEGER BAND,PER,HBAND
      COMMON /CLASS/ BAND,PER,HBAND
      DO 120 I=1,NUMBAND
        IF ((THETA.LE.BANDANG(I)) .AND. (THETA.GT.BANDANG(I+1))) THEN
          BAND=I
          GOTO 121
        ENDIF
        IF(I.EQ.NUMBAND) WRITE(*,*) 'ANGLE BAND NOT FOUND (THETA=',
```

```
     $THETA,' )'
  120 CONTINUE
  121 CONTINUE
      IF (T.GE.PB(9)) THEN
        PER=9
        RETURN
      ENDIF
      DO 125 I=1,8
        IF((T.GE.PB(I)).AND.(T.LT.PB(I+1))) THEN
          PER=I
          ENDIF
  125 CONTINUE
      IF (IHBNUM.EQ.1) THEN
        HBAND=1
        RETURN
      ENDIF
      DO 128 I=1,IHBNUM
        IF ((HGT.GE.HB(I)) .AND. (HGT.LT.HB(I+1))) THEN
          HBAND=I
          RETURN
        ENDIF
  128 CONTINUE
      RETURN
      END

      SUBROUTINE TVOL(H,T,Z,DIN,DT,V)
c*****************************************************************************
C     This subroutine calculates the potential longshore sand transport volume
C     for a given input wave height, period, and direction combination together
C     with the time step associated with the wave event.
C
C     All calculations within this subroutine are performed in SI units.
c*****************************************************************************
      REAL KD,K,KWAV
      COMMON SIGMA,KWAV
      PI=3.14159
      HD=H
      DANG=Z
      SIGMA=PI*2./T
      KWAV=SIGMA**2./9.807
C
C    GIVEN DEPTH AT THE GAGE OR STATION AND SENDING SIGMA AND KWAV VIA
C    A COMMON STATEMENT, CALCULATE WAVE CHARACTERISTICS AFTER REFRACTION
C
      IF(DIN.LT.0.)THEN
        KD=(2*PI)**2./(9.807*T**2.)
        CGD=.5*SQRT(9.807/KD)
        D=.5*(9.807*T**2./(2*PI))
      ELSE
        D=DIN
        CALL SNELL(DUM,DUM,DUM,DUM,D,K,DUM,DUM,CG)
        CGD=CG
        KD=K
      ENDIF
C
C    CALCULATE THE WAVE HEIGHT AND ANGLE AT THE POINT
C    OF BREAKING (H=0.78D)
C
        CALL FINDBR(KD,HD,DANG,CGD,D,K,H,ANG,CG,NOCON)
        HBR=H
        ZBR=ANG
C
C  Calculate the potential longshore sand transport volume (M**3)
C
      Q=HBR**(2.5)*(.07579*SIN(2.*ZBR))
      V=Q*3600.*DT
      RETURN
      END

      FUNCTION SIZEOF(STRING)
C
C  A function which determines the length of a string (excluding white space).
```

```
C
      CHARACTER*(*) STRING
      LENGTH=LEN(STRING)
      I=LENGTH
    5 I=I-1
      IF(STRING(I:I).EQ.' ')GOTO 5
      IF(I.GE.24)I=24
      IF(I.EQ.0)I=1
      SIZEOF=I
      RETURN
      END

C***********************************************************************
      SUBROUTINE SNELL(KD,HD,DANG,CGD,D,K,H,ANG,CG)
C***********************************************************************
C
C  COMPUTES REFRACTION COEFFICIENT FOR LINEAR WAVES USING
C  SNELL'S LAW AND THE SHOALING COEFFICIENT.
C
      REAL KD,K,KS,KR,KAP,KWAV
      DIMENSION A(9)
      DATA A/0.66667,0.35555,0.16084,0.06320,0.02174,0.00654,0.00171,
     &0.00039,0.00011/
      COMMON SIGMA,KWAV
C
C  CALCULATE K USING A PADE APPROXIMATION
C
      Y=KWAV*D
      KAP=Y+1./(1.+Y*(A(1)+Y*(A(2)+Y*(A(3)+Y*(A(4)+Y*(A(5)+Y*(A(6)+Y*(A(
     &    7)+Y*(A(8)+Y*A(9))))))))))
      K=SQRT(KWAV*KAP/D)
      SANG=KD*SIN(DANG)/K
      ANG=ASIN(SANG)
      KR=SQRT(ABS(COS(DANG)/COS(ANG)))
      arg=2.*K*D
      IF(ARG .GT. 88.)arg=88.
      CG=.5*(1.+(2.*K*D)/SINH(arg))*(SIGMA/K)
      KS=SQRT(CGD/CG)
      H=HD*KR*KS
C      WRITE(*,*)'Y= ',Y,'KAP= ',KAP,'K= ',K,'DANG= ',DANG*(180/3.14159)
C      WRITE(*,*)'ANG= ',ANG*(180/3.14159),'KR= ',KR,'CG= ',CG,'KS= ',KS
C      WRITE(*,*)'HD= ',HD,'H= ',H
      RETURN
      END

C***********************************************************************
      SUBROUTINE FINDBR(KD,HD,DANG,CGD,D,K,H,ANG,CG,NOCON)
C***********************************************************************
C
C  COMPUTES BREAKING WAVE HEIGHT AND ANGLE WITHOUT CONSIDERING
C  DIFFRACTION
C
      REAL KD,K
      DDEEP=D
      DSHAL=.01
      K=KD
      H=HD
      ANG=DANG
      CG=CGD
      IBIT=0
  200 CONTINUE
      IBIT=IBIT+1
      IF(IBIT .EQ. 20) GOTO 120
      HB=.78*D
      IF(ABS(HB-H) .LE. .05) GOTO 120
      IF(H .LT. HB) GOTO 110
      DSHAL=D
C      WRITE(*,*)'HB= ',HB,'H= ',H,'IBIT= ',IBIT
      IF(IBIT .EQ. 1) THEN
        H=HB
        ANG=DANG
        CALL SNELL(DUM,DUM,DUM,CGD,D,K,DUM,DUM,CG)
```

```
        IF(IWARN.EQ.0) THEN
          WRITE(*,*) 'WARNING. INPUT WAVE ALREADY BROKEN.'
          WRITE(*,*) 'HD =',HD,'.  SET = 0.78*D =',HB
          WRITE(*,*) 'MAY HAPPEN AGAIN. '
          WRITE(*,*) 'ONLY ONE WARNING WILL BE GIVEN.'
        ENDIF
        IWARN=1
        GOTO 120
      ELSE
        D=.5*(DDEEP+D)
      ENDIF
      CALL SNELL(KD,HD,DANG,CGD,D,K,H,ANG,CG)
      GOTO 200
110   CONTINUE
      DDEEP=D
      D=.5*(DSHAL+D)
      CALL SNELL(KD,HD,DANG,CGD,D,K,H,ANG,CG)
      GOTO 200
120   CONTINUE
      IF(IBIT .EQ. 20) THEN
        WRITE(*,*) 'ERROR IN "FINDBR".'
        WRITE(*,*) 'THE CALCULATION FOR HB DID NOT CONVERGE!!'
        NOCON=1
      ENDIF
      RETURN
      END
```

APPENDIX M: NOTATION

This appendix contains separate lists for mathematical notation and the names of variables in the computer program that appear in the input START file and elsewhere. Length units are given as meters (m), but "feet" (ft) may be substituted if American customary units are selected in the modeling.

Mathematical Notation

A	Bottom profile shape parameter, $m^{1/3}$
b	Subscript denoting wave breaking condition
BYP	A bypassing factor
C_b	Wave speed given by linear wave theory, m/sec
C_g	Wave group speed given by linear wave theory, m/sec
C_{gb}	Wave group speed at breaking, m/sec
D	Water depth, m
D_b	Depth at breaking, m
D_B	Berm elevation, m
D_C	Closure depth, m
D_G	Water depth at the tip of the structure, m
D_{LT}	Depth of active longshore transport, m
D_{LTo}	Maximum depth of longshore transport, m
DT	Model time-step, hr
DX	Model grid cell width, m
F	Total fraction of sand passing over, around, or through a shore-connected structure
g	Acceleration due to gravity, m^2/sec
GL	Groin length from model baseline to groin tip, m
H	Wave height, m
H_o	Deepwater wave height, m
H_b	Breaking wave height, m
$(H_{1/3})_b$	Significant wave height at breaking, m
H_{ref}	Wave height at the offshore reference depth or the nearshore reference line depending on which wave model is used, m
H_o/L_o	Wave steepness in deep water
i	Subscript denoting grid cell number; also arbitrary counter
K_1	Empirical coefficient, treated as a calibration parameter

K_2	Empirical coefficient, treated as a calibration parameter
K_D	Diffraction coefficient
K_{DL}	Diffraction coefficient for diffracting source on left
K_{DR}	Diffraction coefficient for diffracting source on right
K_{DT}	Wave diffraction coefficient for a transmissive structure
K_R	Refraction coefficient
K_s	Shoaling coefficient
K_T	Transmission coefficient
L	Wavelength, m
L_b	Wavelength at the break point, m
L_o	Wavelength in deep water, m
p	Porosity of sand on the bed (taken to be 0.4)
q_o	Cross-shore sand transport rate from offshore, m^3/sec/m
q_s	Cross-shore sand transport rate from the shore, m^3/sec/m
Q	Longshore sand transport rate, m^3/sec
Q_g	Gross longshore sand transport rate, m^3/sec
Q_i	Longshore sand transport rate at the cell wall, m^3/sec
$Q_{i,m}$	Longshore sand transport rate at the cell wall due to wave condition m, m^3/sec
Q_{lt}	Longshore sand transport rate directed to the left, m^3/sec
Q_n	Net longshore sand transport rate, m^3/sec
Q_{rt}	Longshore sand transport rate directed to the right, m^3/sec
R	Longshore discharge parameter, m^3/sec
R_c	Threshold discharge parameter for significant longshore sand transport (taken to be 3.9 m^3/sec)
R_s	Stability parameter
T	Wave period, sec
V	Mean speed of the longshore current, m/sec
x	Distance alongshore, m
X_b	Width of surf zone (distance between shoreline and breaker line), m
X_{dig}	Digitized X value, ft or m
X_{rot}	Rotated X value, ft or m
y	Shoreline position, m
y_1	Shoreline position at grid cell 1, m
y_{G1}	Distance from shoreline to tip of groin on left side of cell 1, m
Y_{add}	Added shoreline width of a beach fill, m

Y_{dig}	Digitized Y value, ft or m
y_{LT}	Width of littoral zone, m
Y_{rot}	Rotated Y value
Z	Wave direction, deg
β	Average nearshore bottom slope, deg
Δy	Change in shoreline position
Δt	Time interval
Δx	Length of the shoreline segment
θ	Angle of wave crests at an offfshore point, deg
θ_b	Angle of wave crests to x-axis at the break point, deg
θ_{bs}	Angle of wave crests to the local shoreline at the break point, deg
θ_{rot}	User-specified rotation angle, deg
ρ	Density of water (1.03 10^3 kg/m^3 for sea water)
ρ_s	Density of sand (taken to be 2.65 10^3 kg/m^3 for quartz sand)
γ	Breaker index, ratio of wave height to water depth at breaking
ϵ	Calculation scheme stability coefficient, m^2/sec
ϵ_1	Calculation scheme stability coefficient, m^2/sec
ϵ_2	Calculation scheme stability coefficient, m^2/sec

Program Variable Names

A1	Temporary variable containing the wave angle, deg
ABH	Average berm height (also, D_B), m
ANG	Wave angle (sea), deg
ANGS	Wave angle (swell), deg
BFDATE	Array holding ending dates of beach fills
BFDATS	Array holding starting dates of beach fills
BYP	Groin bypassing factor
CH	Wave height (sea), ft or m
CONVLEN	Conversion factor for length
CT	Wave period (sea), sec
CTH	Wave angle (swell), deg
CSTAID	Coastal Engineering Data Retrieval System (CEDRS) station identification number
D	Water depth, m
DATE	Date

DDB	Array holding depths at tips of detached breakwaters, m
DDG	Array holding depths at seaward ends of diffracting groins and jetties, m
D50	Median grain size, mm
DCLOS	Depth of closure (also, D_C), m
DEPTH	Depth, m
DT	Time-step, hr
DTW	Time increment in the WAVES data file, hr
DX	Longshore cell length, m
DZ	Depth of offshore wave input, m
FTS	File time-step, hr
H	Wave height, m
H1	Temporary variable containing the wave height, m
HCNGF	Wave height change factor; a factor that can be applied to increase or decrease the input wave height HGT
HGTS	Wave height (swell), ft or m
HINC	Transfer variavle containing (sea) wave height, m
I	As the first letter of a variable, denotes that the variable is an integer or an array of integers
IBFE	Array holding grid cell numbers of end (right side) of beach fills
IBFS	Array holding grid cell numbers of start (left side) of beach fills
ICCRIT	Threshold flag
ICELIM	Elimination flag
ICFLAG	Offshore traveling wave flag
ICOFF	Offshore traveling wave event flag for sea conditions
ICONV	Toggle specifying a conversion factor for whether metric (1) or American customary length units (2) will be input
IDAY	Day
IDUM	Dummy variable
IHR	Time of day, (24-hr clock)
IMON	Month
IDB	Toggle denoting existence of detached breakwaters; no (0), yes (1)
IDB1	Toggle denoting existence of a detached breakwater crossing the left boundary; no (0), yes (1)
IDBN	Toggle denoting existence of a detached breakwater crossing the right boundary; no (0), yes (1)
IDG	Toggle denoting existence of diffracting groins; no (0), yes (1)

IGD	Day
IGM	Month
IGY	Year
INDG	Toggle denoting existence of nondiffracting groins; no (0), yes (1)
IPRINT	Toggle turning the time-step display off (0) and on (1)
ISMOOTH	Number of calculation cells included in smoothing the shoreline to define the shape of a representative offshore contour
ISBW	Number of shoreline calculation cells per wave model element (valid only if an external wave model was used, NWD = 1)
ISW	Toggle denoting existence of a seawall; no (0), yes (1)
ISWBEG	Beginning grid cell number of the seawall
ISWEND	Ending grid cell number of the seawall
IXDB	Array holding grid cell locations of detached breakwaters
IXGD	Array holding grid cell numbers of diffracting groins
IXNDG	Array holding grid cell numbers of nondiffracting groins
IYR	Year
IZH	Integer variable holding compressed wave data
K1	Longshore transport rate calibration parameter for oblique wave incidence
K2	Longshore transport rate calibration parameter for longshore gradient in wave height
NBF	Number of beach fills during the simulation period
NDB	Number of detached breakwaters
NDG	Number of diffracting groins
NEPR	Number of wave events per record
NEVENTS	Number of records in the time series
NFOR	Input file format type
NN	Number of calculation grid cells
NNDG	Number of nondiffracting groins
NOUT	Number of intermediate outputs (not including that from the last time-step, which is a default output)
NWD	Toggle specifying whether an external wave model was used to provide a nearshore wave data input file; no (0), yes (1)
NWAVES	Number of wave components per time-step
PER	Wave period (sea), sec
PERS	Wave period (swell), sec
PERM	Array of groin permeability coefficients (empirical)

R	Longshore discharge parameter
R_s	Stability parameter
SH	Wave height (swell), ft or m
SHOANG	Shoreline orientation variable, deg
SIMDATE	Ending date of the simulation
SIMDATS	Starting date of the simulation
SLOPE2	Representative bottom slope near groins
ST	Wave period (swell), sec
STAB	Stability parameter
STAID	Station identification
STATYP	CEDRS station type
STH	Wave angle (swell), deg
T1	Temporary variable containing wave period, sec
TINC	Transfer variable containing wave period, sec
TRANDB	Array holding transmission coefficients of detached breakwaters (empirical)
WDATS	Starting date of WAVES file
X	Alongshore position, m
Y	Shoreline position, m
YADD	Added shoreline width of a beach fill after adjustment of fill to equilibrium, m
YDB	Array holding distances of detached breakwater tips measured from the x-axis, m
YDG	Array holding distances of diffracting groins tips measured from the x-axis, m
YDIFF	Difference in calculated and measured shoreline positions, m
YG1	Length of groin on left side of cell 1, m
YGN	Length of groin on right side of cell N, m
YLT	Width of littoral zone, m
YNDG	Array holding lengths of nondiffracting groins, measured from the x-axis, m
Z	As a first letter, denotes an angle
ZCNGA	Wave angle change amount; an angle (positive or negative) that can be applied to shift all input wave angles by the specified amount, deg
ZCNGF	Wave angle change factor; a factor that can be applied to the input wave angle which acts to increase or decrease the wave angle range (compress or expand the wave rose)
ZINC	Transfer variable containing wave angle, deg

APPENDIX N: INDEX