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## **DREDGING RESEARCH PROGRAM**

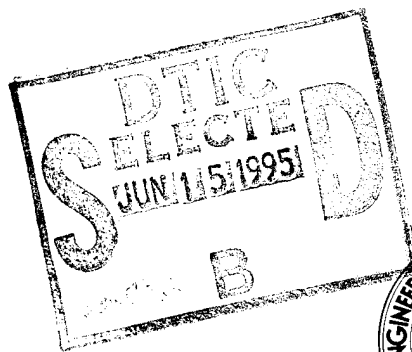
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# **LTFATE: A MODEL TO INVESTIGATE THE LONG-TERM FATE AND STABILITY OF DREDGED MATERIAL DISPOSAL SITES; USER'S GUIDE**

by

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3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199



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The Dredging Research Program (DRP) is a seven-year program of the U.S. Army Corps of Engineers. DRP research is managed in these five technical areas:

- Area 1 - Analysis of Dredged Material Placed in Open Water
- Area 2 - Material Properties Related to Navigation and Dredging
- Area 3 - Dredged Plant Equipment and Systems Processes
- Area 4 - Vessel Positioning, Survey Controls, and Dredge Monitoring Systems
- Area 5 - Management of Dredging Projects

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## Dredging Research Program Report Summary



### *LTFATE: A Model to Investigate the Long-Term Fate and Stability of Dredged Material Disposal Sites; User's Guide (IR DRP-95-1)*

**ISSUE:** The Corps of Engineers has the responsibility of keeping national navigation projects open through dredging. Disposal of this dredged material is an issue which can cause significant cost to Corps projects. One of the least costly of dredged material disposal options is to place the material in open water. Because of physical and environmental concerns, it is imperative that Corps Districts have knowledge of the stability of the disposal mound that is created by the release of dredged material.

**RESEARCH:** Work unit 32466 of the Dredging Research Program (DRP) was tasked with developing numerical simulation techniques for evaluating the fate and stability of dredged material placed in open water. As a result of this assignment, a computer program, LTFATE, was developed. A version of this program was designed for field use and is available on the PC.

**SUMMARY:** LTFATE is a numerical modeling system for systematically estimating the

long-term response of an open-water dredged material disposal site to local environmental forcings. The methodology is based on the development of databases of wave and current time series and the application of these boundary conditions to coupled hydrodynamic, sediment transport, and bathymetry change models. The approach was developed to provide an estimate of long-term material fate for use in determining whether an existing or proposed disposal site will be dispersive or nondispersive over periods of time on the order of months to years.

**AVAILABILITY OF REPORT:** The report is available through the Interlibrary Loan Service from the U.S. Army Engineer Waterways Experiment Station (WES) Library, telephone number (601) 634-2355. National Technical Information Service (NTIS) report numbers may be requested from the WES library.

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# LTFATE: A Model to Investigate the Long-Term Fate and Stability of Dredged Material Disposal Sites; User's Guide

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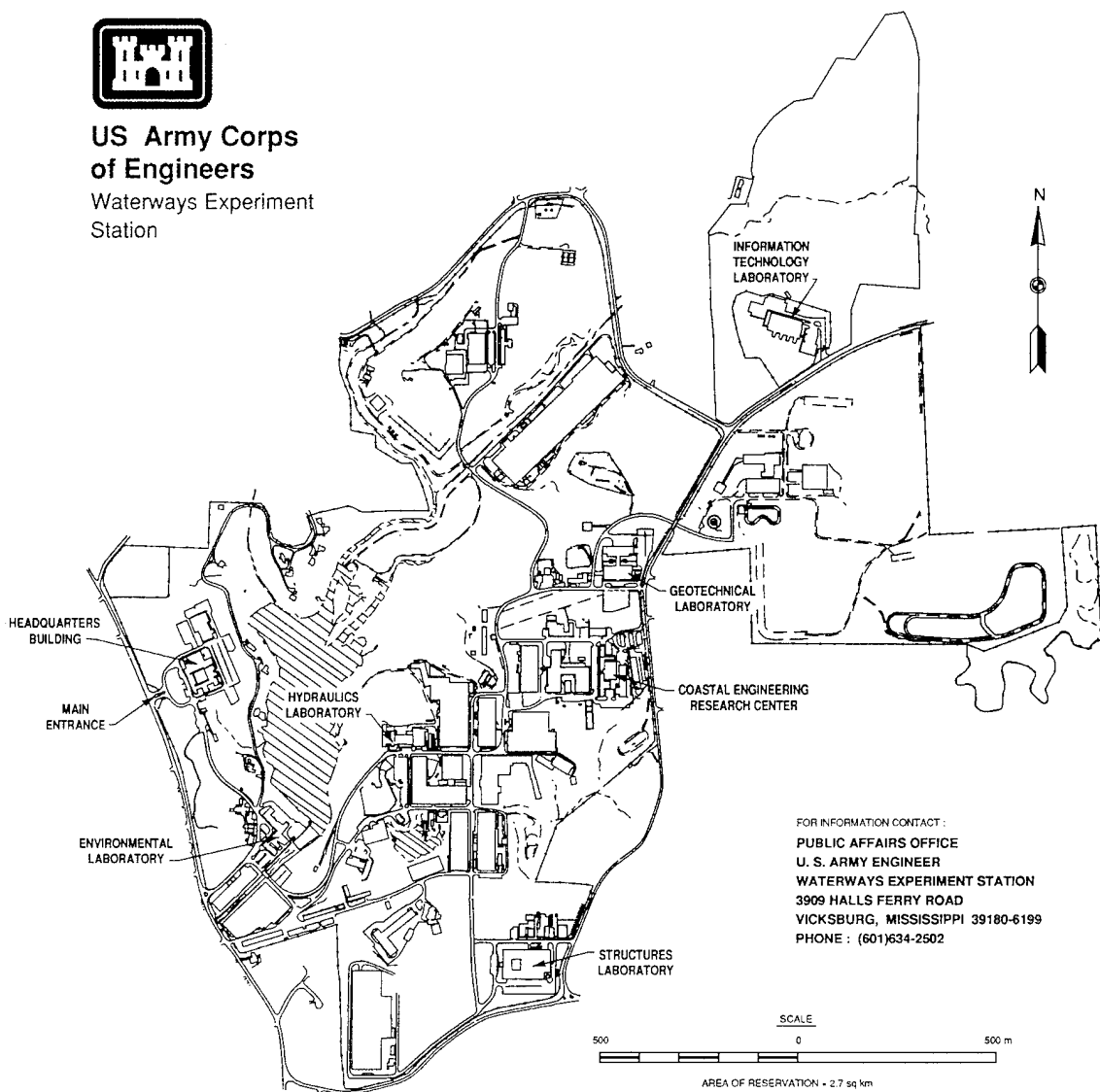
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# Preface

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The work described herein was authorized as a part of the Dredging Research Program (DRP) by Headquarters, U.S. Army Corps of Engineers (HQUSACE). Work was conducted as part of the Numerical Simulation Techniques for Evaluating the Long-Term Fate and Stability of Dredged Material Placed in Open Water Work Unit 32466 of DRP Technical Area 1 (TA1), "Analysis of Dredged Material Placed in Open Water," at the Coastal Engineering Research Center (CERC), U.S. Army Engineer Waterways Experiment Station (WES). Mr. John H. Lockhart was HQUSACE TA1 Technical Monitor for the DRP. Mr. E. Clark McNair, Jr., was Program Manager, and Dr. Lyndell Z. Hales was Assistant Program Manager. Dr. Nicholas C. Kraus, CERC, was Technical Manager of DRP TA1.

The associated studies were conducted and this report was written over the period 1 October 1988 through 31 December 1993 by staff of CERC. Dr. Norman W. Scheffner, Oceanography Branch (OB), Research Division (RD), CERC, Principal Investigator for Work Unit 32466, developed the original Long-Term FATE (LTFATE) model for the mainframe computer. Dr. James R. Tallent, formerly of the Coastal Processes Branch (CPB), RD, CERC, ported the LTFATE model from the mainframe computer for use on the personal computer and enhanced the model to include several new capabilities. Ms. Michelle M. Thevenot, CPB, RD, provided much technical assistance by verifying model consistency and ensuring proper operation of the code. She was also primarily responsible for preparing the final version of the user's manual assembled from her contributions and from various other draft reports. Mr. John M. Mason, MEVETEC Corporation contract programmer for CPB, RD, created the graphical user interface and installation program and assured that program examples were correctly described in the text.

Work was performed under the administrative supervision of Dr. James R. Houston, Director, CERC; Mr. Charles C. Calhoun, Jr., Assistant Director, CERC; Mr. H. Lee Butler, Chief, RD; Mr. Bruce A. Ebersole, Chief, CPB; and Dr. Martin C. Miller, Chief, OB.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

Additional information on this report can be obtained from Mr. E. Clark McNair, Jr., DRP Program Manager, at (601) 634-2070 or Dr. Norman W. Scheffner, Principal Investigator at (601) 634-3220.

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# Conversion Factors, Non-SI to SI Units of Measurement

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

| Multiply             | By       | To Obtain  |
|----------------------|----------|------------|
| feet                 | 0.3048   | meters     |
| miles (U.S. statute) | 1.609347 | kilometers |

# 1 Introduction

---

## Summary

This report provides guidance on the use of the Long Term FATE (LTFATE) computer program and describes its use through an interface available for the personal computer (PC). LTFATE is a site evaluation tool that estimates the dispersion characteristics of a dredged material placement site over long periods of time, ranging from days for storm events to a year or more for ambient conditions. Simulations are based on the use of local wave and current condition input. Local, site-specific hydrodynamic input information is developed from numerical model-generated databases; however, user-supplied data files can be substituted for the database-generated files described in this report.

LTFATE has the capability of simulating both noncohesive and cohesive sediment transport. In addition, avalanching of noncohesive sediments and consolidation of cohesive sediments are accounted for to accurately predict physical processes which occur at the site.

This manual outlines two examples of the use of LTFATE. The first example describes the process for using LTFATE to predict long-term (6 months) movement of a dredged material mound under normal environmental conditions. This example also outlines the wave and tidal input data and demonstrates the graphic output display associated with the model. The second example describes storm-induced mound erosion. A detailed discussion of mound topography generation is included in this example. Finally, interpretation of results is discussed to aid the user in model applications.

## Scope of Report

The purpose of this report is to provide "hands-on" guidance for implementing LTFATE, through a Graphical User Interface (GUI) available for the PC. The report is intended to describe model capabilities through example applications of the model to specific scenarios in order to ensure that the model and GUI are executing properly.

LTFATE simulates the evolution of dredged material placement sites over time scales ranging from months to years for normal wave and current conditions to a number of days in the case of storm-induced erosion and transport. LTFATE has the potential for many applications in the coastal environment and has been used to determine the fate of disposed material under normal oceanic conditions (Scheffner and Tallent 1994, Scheffner 1992) and during tropical and extratropical storms (Scheffner 1989). Research and development of LTFATE are being actively pursued in the areas of model applicability, numerical efficiency, and GUI convenience.

This manual provides an overview of LTFATE, focussing on implementation and application of the model within the user interface. Comprehensive descriptions of development, testing, and application of the model will be contained in a separate report. Verification of the model to prototype data is provided in Scheffner (1991).

## Overview of LTFATE

LTFATE is a site-analysis program that utilizes coupled hydrodynamic, sediment transport, and bathymetry change models to compute site stability over time as a function of local waves, currents, bathymetry, and sediment size. LTFATE was developed to simulate the long-term fate and stability of dredged material placed in open water with an intended use for classifying existing or proposed disposal sites as dispersive or nondispersive. If the site is demonstrated to be dispersive, model output will provide an estimate of the temporal and spatial fate of the eroded material. This determination is often difficult to quantify because the movement of sediment is a function of not only the local bathymetry and sediment characteristics, but also the time varying wave and current conditions. LTFATE overcomes these difficulties by using an information database to provide design wave and current time series boundary conditions that realistically represent conditions at the candidate disposal site.

The wave simulation methodology and the elevation and current databases referenced in this report were developed through the Dredging Research Program (DRP) at the U.S. Army Engineer Waterways Experiment Station (WES). The procedures for generating stochastic wave height, period, and direction time series are reported in Borgman and Scheffner (1991). The database of tidal elevations and currents for the east coast, Gulf of Mexico, and Caribbean Sea are described in Westerink, Luettich, and Scheffner (1993) and the database of tropical storm surge and current hydrographs is reported in Scheffner et al. (1994). These data are used to generate wave and current boundary condition data for use as input to LTFATE for evaluating mound stability. If these databases are not available for the geographic area of interest to the user, then replacement input files will have to be supplied by the user and copied into the appropriately designated files. These file names are referenced in the text.

## Noncohesive mound movement

The LTFATE model uses four coupled subroutines to predict dredged material movement of various types of noncohesive material during different stages of mound evolution. These subroutines simulate hydrodynamics, sediment transport, mound cascading, and bathymetry change. LTFATE uses the equations reported by Ackers and White (1973) as the basis for the noncohesive sediment transport model. The equations are applicable to uniformly graded noncohesive sediment with a grain diameter in the range of 0.04 to 4.0 mm (White 1972). Because many disposal sites are located in relatively shallow water, a modification of the Ackers-White equations was incorporated to reflect an increase in the transport rate when ambient currents are accompanied by surface waves. The modification is based on an application of the concepts developed by Bijker (1971) and referenced by Swart (1976). This preliminary model was verified to prototype data by Scheffner (1991) and was shown to be a viable approach to providing quantitative predictions of disposal site stability.

Kraus and Larson (1988) found that in some large wave tank cases, the local slope of a mound of noncohesive material exceeded the angle of repose due to constant waves and water levels. Therefore, the concept of slope failure was incorporated in LTFATE to ensure stability of the dredged material mound by employing an algorithm developed by Larson and Kraus (1989). The algorithm is based on laboratory studies conducted by Allen (1970), who investigated steepening of slopes consisting of granular solids. Allen (1970) recognized two limiting slopes, the angle of initial yield and the residual angle after shearing. If the slope exceeds the angle of initial yield, material is redistributed along the slope through avalanching, and a new stable slope is attained, known as the residual angle after shearing.

## Cohesive mound movement

An algorithm, developed by Teeter and Pankow (1989), was incorporated into LTFATE to account for transport of fine-grained material, i.e., silts (0.072-0.004 mm) and clays (0.004-0.00045 mm). Fine-grained sediments are hydraulically transported almost entirely in suspension rather than as bed load, therefore the Ackers-White equations are not applicable for these conditions. Teeter and Pankow reasoned that because of the differences in cohesion and settling characteristics, fine-grained sediments are sometimes characterized as the sum of algebraic expressions for settling velocity, deposition, and resuspension. Suspended sediment concentrations are assumed to be in the enhanced settling range (100-10,000 mg/l), and the functional form given by Ariathurai, MacArthur, and Krone (1977) was used to determine the settling velocity. The description of deposition, or flux of sediment material to the bed, originated by Mehta et al. (1989) as the sum over a number of fractions of settling flux times deposition probability provided this component to the model. Resuspension is related to the shear stress exceeding a critical value when particles are individually dislodged from the sediment bed as inter-aggregate bonds are broken (Ariathurai, MacArthur, and Krone 1977).

To account for consolidation of the cohesive materials, the procedure developed by Poindexter-Rollings (1990) for predicting the behavior of a subaqueous sediment mound was followed. Consolidation calculations used by Poindexter-Rollings, and implemented in LTFATE, are based on the finite strain theory first proposed by Gibson, England, and Hussey (1967). Numerical solutions of this theory were developed by Cargill (1982,1985). Finite strain theory is well-suited for the prediction of consolidation in cases of thick deposits of fine-grained material because it provides for the effect of self-weight, permeability varying with void ratio, a nonlinear void ratio-effective stress relationship, and large strains. The predictive capability of this relationship has been verified in several field studies conducted by Poindexter-Rollings (1990).

## Organization of Report

Chapter 1 of this report describes the purpose of this manual and background information on LTFATE. Chapter 2 provides information for getting started with the model, including hardware requirements, loading LTFATE onto a hard disk, and understanding the interface through which the numerical model is operated. Chapter 3 is a tutorial guiding the user in installing, running, and working through two example simulations. LESSONS 1 through 4 provide an example of LTFATE simulating mound movement under normal conditions, and LESSONS 5 and 6 describe storm-induced mound movement.

Text that is to be typed on the user's keyboard is printed in **BOLD** letters in this report. Non-character keys on the keyboard are enclosed in angular brackets. For example, the enter or return key is written as **<Enter>**.

## 2 Getting Started

---

### Required Hardware

The following are recommended minimum hardware requirements for running the LTFATE interface on a PC with a standard Disk Operating System (DOS) Version 3.3 or greater:

- a.* 386-25 MHz processor.
- b.* Math coprocessor.
- c.* 620 K resident memory.
- d.* VGA monitor (required).
- e.* Hard disk with several megabytes free.
- f.* HP Laserjet II or III (or compatible) printer for hard copy.

A compiler is not required because the LTFATE interface and model are distributed as executable files together with several data files. The PC version of the LTFATE interface may access all memory within the 640-K DOS limit. Therefore, the LTFATE interface should be run from the DOS prompt with all resident memory programs removed to ensure enough memory exists for model execution. The graphic routine provided in this package, HGRAPH,<sup>1</sup> is non-proprietary and property of the U.S. Government.

### Software

The LTFATE package presently consists of the following three main programs:

---

<sup>1</sup> The program HGRAPH was developed by Mr. David W. Hyde, Structural Engineer, WES, Structures Laboratory.

a. PC\_WAVEFIELD.

b. PC\_TIDAL.

c. PC\_LTFATE.

LTFATE in its entirety may be used as a complete site evaluation package, or individual programs may be accessed independently for other applications. Appendix A identifies all program files, and Appendix B lists the files used in the examples discussed in Chapter 3.

PC\_WAVEFIELD creates a time series of wave height, period, and direction based on the computed intercorrelation matrix describing the statistical properties of wave height, period, and direction, and their respective interrelationships. The matrix is computed from a time series of data corresponding to the location of interest. In this application, the matrix is computed for a Wave Information Studies (WIS) station located offshore of Mobile, AL, from the Wave Information Study (WIS) 20-year wave hindcast database (Corson, Resio, and Vincent 1980). PC\_WAVEFIELD includes the following four options: (a) wave field simulation, (b) statistical analysis on the simulated wave field, (c) wave field histogram plotting, and (d) wave field time series plotting.

In PC\_TIDAL, a database containing the harmonic constituents for tidal elevation and currents for a site-specific location are used to generate an arbitrarily long sequence of tidal data. PC\_TIDAL includes the following two options: (a) simulation of the long-term tide sequence, and (b) generation of time history plots for the tide elevation, velocity components, and direction.

Lastly, the program PC\_LTFATE automatically accesses data generated by the programs PC\_WAVEFIELD and PC\_TIDAL to simulate long-term dredged material mound movement. These two programs require input files describing the statistical distribution of a site-specific wave field and tidal harmonic constituents relative to that site. As explained in the following section, if these data are not available, the user is required to supply the appropriately named files to substitute for the output files ordinarily generated by the programs PC\_WAVEFIELD and PC\_TIDAL.

PC\_LTFATE has the capability of determining the fate of noncohesive and cohesive sediments. Additionally, avalanching of noncohesive sediments and consolidation of cohesive sediments are included in the PC\_LTFATE program to account for these physical phenomena. The PC\_LTFATE program should be employed only after executing programs PC\_WAVEFIELD and PC\_TIDAL. PC\_LTFATE includes the following four options: (a) seabed geometry configuration program, (b) simulation of dredged material mound movement, consolidation, and avalanching, (c) generation of dredged material mound evolution contour plots, and (d) generation of dredged material mound evolution cross-sectional plots.

The remainder of this report provides specific guidance on the use of LTFATE and its application to specific disposal site scenarios. Example input and output are provided to demonstrate use and capabilities of the model. Databases for waves, tides, and storm surge to support LTFATE are not available for all locations or are still under development. Also, database input for applications of LTFATE to areas other than along U.S. coastlines is not available. For these applications, the user is required to supply time series data for waves and storm surge (for storm event applications) or provide tidal elevation and current constituents, and wave time series (for long-term simulations). Therefore, it is assumed that the user is proficient in the use of a PC, is able to use an editor (if necessary), and can write simple data construction programs and manipulate files. These skills are necessary in order to transfer user-supplied data into the PC and copy it into the appropriate files which are accessed by LTFATE.

## 3 Tutorial

---

### LESSON 1: Installation and Loading LTFATE

Insert the LTFATE distribution diskette into its corresponding floppy drive, referred to as the A or B drive. Type the following to run the installation program:

**A: <Enter>**

Where A is the letter of the floppy drive.

**INSTALL <Enter>**

The LTFATE 1.0 installation program should now begin execution. Enter the drive and directory where LTFATE is to be placed or press <Enter> for the default choice of C:\LTFATE. The installation program creates all directories and places all files into the specified drive and directory. After all files are successfully decompressed, the install program prompts the user with the option of choosing to update the CONFIG.SYS file and the option of rebooting the computer if changes were made to the CONFIG.SYS file. Changes will only be necessary if the FILES and BUFFERS lines of the CONFIG.SYS file are either absent or set to values that are too small.

In addition to the LTFATE executable files, three external user-supplied input files are required by the model to specify wave, tidal, and storm surge boundary conditions for a specific location of interest. Example files have been included with the LTFATE model; however, as will be discussed, site-specific files will have to be obtained or generated by the user in order to define wave and current boundary condition input corresponding to the location of interest.

The first of these external files, named TIDAL.DAT, is used to define a time series tidal elevation and current boundary condition at the subject disposal mound. The TIDAL.DAT file contains amplitude and epoch harmonic tidal constituents for both elevation and currents corresponding to the location of the mound.

Because the LTFATE model requires both tidal elevation and current (U and V) time series input, harmonic constituents for all three variables must be contained in the data file. This input file can be generated through execution of the program TIDES.EXE contained in this documentation. However, the TIDES.EXE program requires an input database of harmonic constituents at discrete locations and, through interpolation, generates elevation and current constituents for any desired location into the appropriate format in the file TIDAL.DAT. The constituent database has been generated for the east coast, Gulf of Mexico, and Caribbean Sea (Westerink, Leutlich, and Scheffner 1993) and described in DRP Technical Note DRP-1-13 (Scheffner 1994). Constituent output for a specific location can be obtained by contacting CERC. The tidal constituent database for the west coast is currently under development.

If tidal constituent coverage of the area of user interest is not available, tidal constituent data will have to be obtained from alternate sources; for example, WES technical reports, the National Oceanic and Atmospheric Administration, university sources, open literature, etc., or through harmonic analyses of available or collected elevation and current time series. Adequate data are usually available, but will have to be located and supplied by the user. An example use of external data is reported by Scheffner and Tallent (1994). If the user supplies the necessary data, it must be formatted as shown in the example in Appendix B and should be named TIDAL.DAT.

The second file required for long-term simulation of dredged material mound movement is a file containing a time series of wave height, period, and direction named HPDSIM.OUT. This file can either be user-supplied or generated internally by LTFATE and is in the format shown in Appendix B. If LTFATE generates the file, the additional file HPDPRE.OUT is required. The HPDPRE.OUT file represents the pre-computed cross-correlation matrix corresponding to a WIS station location nearest the mound. The combined LTFATE/HPDPRE.OUT wave simulation capability is described by Borgman and Scheffner (1991) and Scheffner and Borgman (1992). This approach is used to generate an arbitrarily long time sequence of simulated wave data which preserves the primary statistical properties of the full 20-year WIS hindcast, including wave sequencing and seasonality. Once the matrix has been computed, multiple wave field simulations can be performed, with each time series stored on the file HPDSIM.OUT.

The primary advantage of using this statistically based wave simulation approach is that the user is not limited to a finite length of data; instead, seasonal or yearly repetitions of time series can be used for evaluations of site stability. Each simulation will be statistically similar to the hindcast data but will contain variability consistent with observations. If HPDPRE.OUT matrix is not available for the location of interest, one can be computed by the user or by CERC through use of a WIS 20-year hindcast input file and execution of the program HPDPRE. If the location of interest is not covered by the WIS hindcast database, existing time series of wave height, period, and direction will have to be supplied by the user. Therefore, the user must do one of the following: (a) compute the HPDPRE.OUT matrix using HPDPRE (described

in Borgman and Scheffner (1991)) and use the model LTFATE to generate the HPDSIM.OUT output data file, or (b) convert the existing, user-supplied time series into the appropriate format shown in Appendix B and rename the file HPDSIM.OUT.

The long-term simulations described above, i.e., simulations of months to years, compute disposal mound stability as a function of residual currents specified by the user in LTFATE, the normal seasonal wave climate specified in the HPDSIM.OUT file, and the tidal elevation and currents computed from the specified tidal constituents in the TIDAL.DAT file. Storm event erosion calculations are based on surge elevation and currents and the wave field associated with that specific event. These data are contained in the final input file required by LTFATE, the file STORM.DAT. This file must be assembled from existing databases or generated by the user. However, the file is required only if the user desires to simulate the passage of a storm event over the disposal site.

The STORM.DAT file contains either a tropical or extratropical storm surge elevation and current time series hydrograph with a corresponding storm wave height and period corresponding to the selected event. A database of tropical storm hydrographs for 134 historically based tropical storms has been completed for the 486 WIS and offshore discrete locations along the east and Gulf of Mexico coasts and for selected stations offshore of Puerto Rico. This database is described by Scheffner et al. (1994). The companion extratropical event database for the east and Gulf coasts and Puerto Rico is under development.

A wave climate corresponding to the selected event can be obtained from either available data (if the surge is historically based) or estimated as a function of storm-associated or design peak wave height and periods. In the New York Bight Mud Dump example shown in this report, the surge elevation and velocities were obtained from numerical simulations of the December 1992 extratropical event. The wave field corresponding to the December event was obtained from National Data Buoy Center data. For future applications, surge and current information will be contained in the DRP database. If wave data are not available for the selected event, then design peak wave height and period estimates can be used.

The STORM.DAT file should be created by the user of LTFATE to describe a particular storm event or a storm event of assumed shape and duration. An example of hypothetical event use in disposal analysis is given in Scheffner and Tallent (1994). The Mud Dump example described in this report is based on hindcast and prototype data. Whether a historically based or assumed shape storm event is used in the stability analysis, the input data field containing the surge hydrograph must be consistent with the format shown in Appendix B and must be named STORM.DAT.

To start the LTFATE program, change to the drive and directory that the LTFATE software has been installed on and type **LTFATE <Enter>**.

LTFATE will display the **Main Menu** shown in Figure 1. Navigation of the LTFATE menu system can be accomplished in the following three different ways, or by using any combination of these, making it very versatile.

- a. Use **Arrow**, **Enter**, and **ESC** keys.
- b. Press the highlighted letter on the menu bar known as **<Hot Keys>**.
- c. Use mouse left button (**Enter**) and right button (**ESC**).

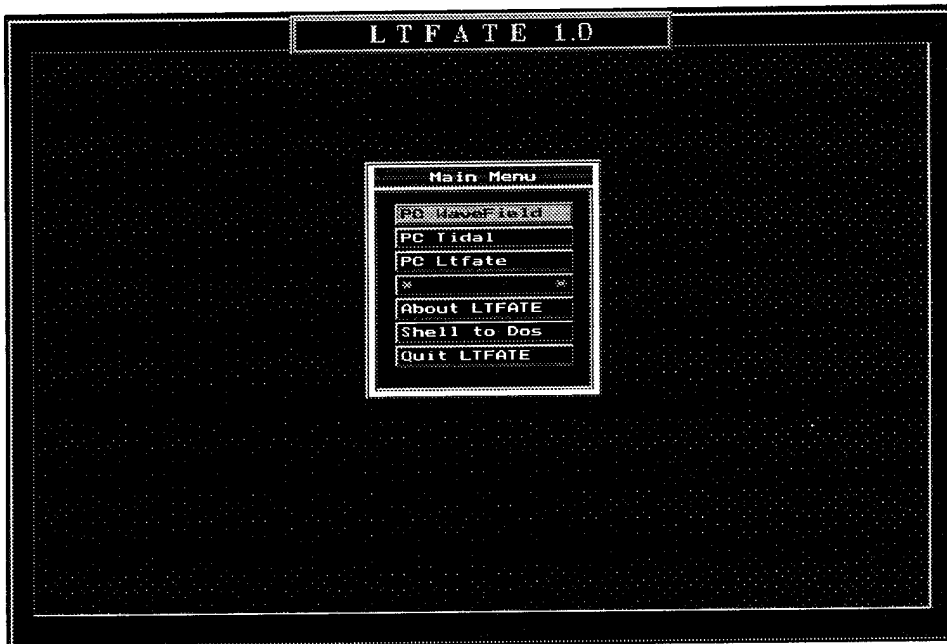


Figure 1. LTFATE Main Menu

For questions concerning LTFATE software and hardware requirements, problems, or continued development, press **A** to display the **About LTFATE** window, shown in Figure 2, containing the contact information.

## LESSON 2: Wave Simulation Package

After the necessary input data have been collected and installed, long-term or storm-induced mound migration may be simulated. In Lessons 2 through 4, the long-term movement of a dredged material mound will be simulated for a dispersive disposal mound, The Sand Island Mound located offshore of the entrance to Mobile Bay, Alabama. For this example case, a 6-month simulation period extending from March 1987 through August 1987 was selected.

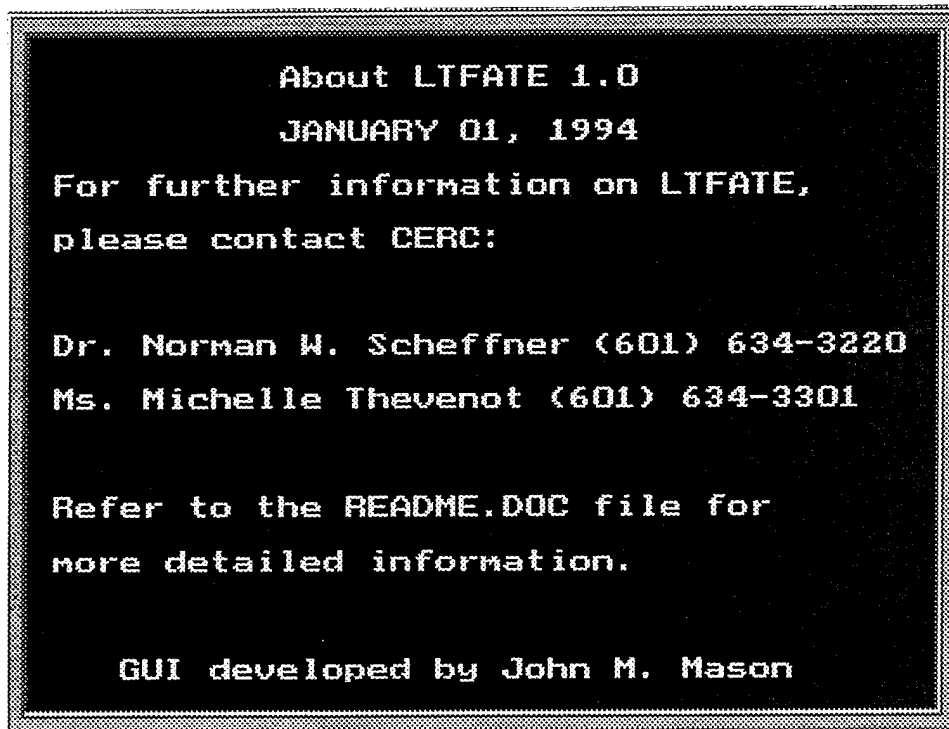


Figure 2. About LTFATE window

The bathymetry of the Sand Island Mound has been monitored over the last several years as part of a cooperative project between the DRP and the U.S. Army Engineer District, Mobile (Hands and Allison 1991). Consequently, the initial mound configuration is well approximated. This example site was selected because verification of the model to prototype data has been performed for this site (Scheffner 1991).

### Wave field simulation program

Select PC WaveField from the LTFATE Main Menu (Figure 1). The **Wave Field 1.0 Menu**, shown in Figure 3, will appear on the screen. Notice the gray lettered items in the menu list are disabled. If the wave field is supplied by the user, do not select the simulation program. The statistical program and plotting programs can be used and will access the user-supplied file HPDSIM.OUT. If the



Figure 3. Wave Field 1.0 Menu

HPDPRE.OUT file is available, choose **Simulation**

**Program** from the menu to display the **Wave Field Simulation Parameters**

data entry window, shown in Figure 4. Note that each data entry window has a corresponding instructional window displaying the valid keys to be used to perform data entry, as in Figure 5. Enter the values as

they appear in the data entry window (Figure 4). In this case, enter 3 for the Beginning Month, 1987 for the Beginning Year, 8 for the Ending Month, and 1987 for the Ending Year. Finally, enter a random number seed, i.e. 123456789. Before pressing

the **Enter** key, you can make corrections to any data entry errors by using the **TAB** or **Arrow** keys. Once all of the parameters are entered and corrected, press **ALT-S** to exit the data entry window with the changes made.

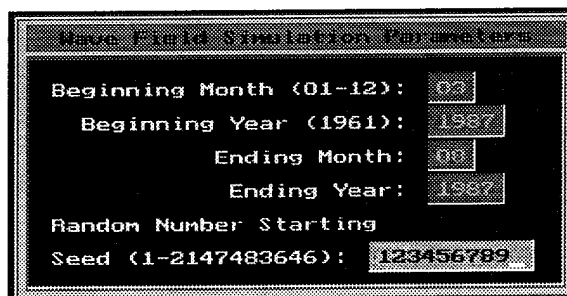


Figure 4. Wave Field Simulation Parameters

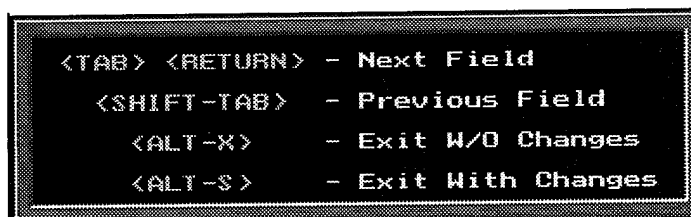


Figure 5. Valid keys window

Note that pressing the **Enter** key while positioned on the last field of the data entry screen has the same effect as pressing **ALT-S**. If the Wave Field Simulation Parameters data entry window was not the desired window, pressing **ALT-X** would exit the window and return the program to the Main Menu.

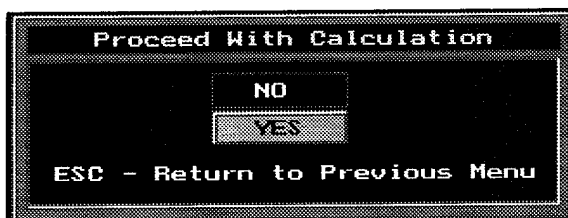


Figure 6. Proceed with Calculation window

will begin to run while displaying the message shown in Figure 7. Once all data have been generated and stored in the data file HPDSIM.OUT, the program returns to the **Wave Field 1.0 Menu** (Figure 3).

In Figure 6, the **Proceed with Calculation** window is displayed. This window allows the options of proceeding with calculations by selecting **YES** or aborting calculations by selecting **NO**. Select **YES** and the calculation routine

## Wave field statistical program

In the next phase of the wave field simulation, statistical calculations are performed on the simulated, or user-supplied, wave field data stored in the file

HPDSIM.OUT. Select the Statistical Program menu item by using the **Arrow-Keys** or pressing **A**. The Wave Field Statistical Parameters window that appears is shown in Figure 8. The user is asked to

specify a period of simulated data (stored in the file HPDSIM.OUT) over which to perform statistical calculations. In this example, 6 months of data were simulated, and the entire 6 month period or a partial section of the data may be chosen for the statistical calculations. The 6-month period that can be selected is shown below the **Wave Field Statistical Parameters** window as in Figure 9. It may be advantageous to first employ the entire 6 months of simulated data in the statistical calculation, then after examining the histogram and time series plots, rerun the statistical program for the shorter interval.

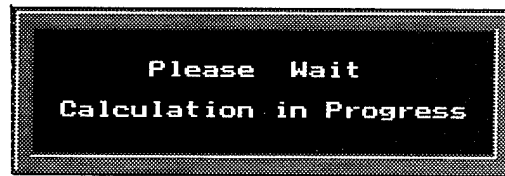


Figure 7. Please Wait window

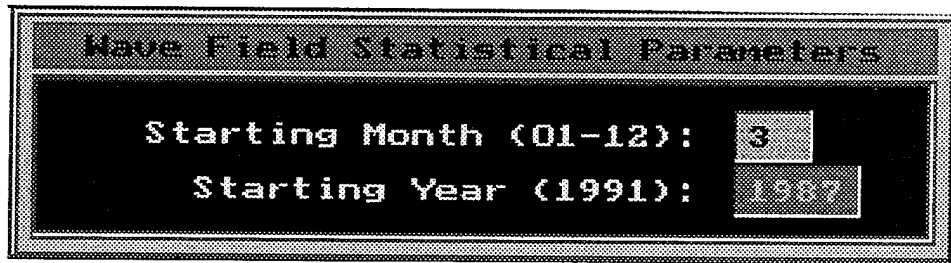


Figure 8. Wave Field Statistical Parameters

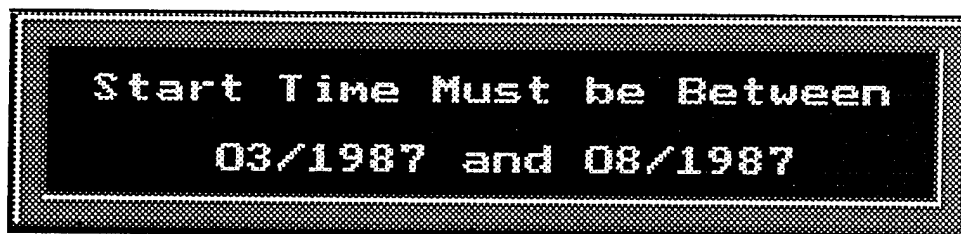


Figure 9. Example 6-month period

Input a starting date which falls between the dates shown, i.e. between 3/1987 and 8/1987 (Figure 9). Because the entire 6 months of data are to be examined, type **03** for Starting Month and **1987** for Starting Year. After pressing **Enter**, the maximum number of days of wave field data existing between the start date specified above (03, 1987) and the end of the data file HPDSIM.OUT is displayed (Figure 10). Because the entire 6 months will be examined, press **Enter** to select the default value of **184** that is displayed in Figure 11. Following this final input, calculation of the wave field statistical properties begins and the message in Figure 7 is displayed.



Figure 10. Maximum number of days for which wave data are available

Data generated by the statistical program are stored in one of the following six files:

HGT\_HST.DAT,

HGT\_TIM.DAT,

PER\_HST.DAT,

PER\_TIM.DAT,

DIR\_HST.DAT, and

DIR\_TIM.DAT. HGT, PER, and DIR represent wave height, period and direction, respectively, and HST and TIM represent the histogram and time series plot data, respectively. Immediately following data generation and storage, the program automatically returns to the **Wave Field 1.0 Menu** (Figure 3).

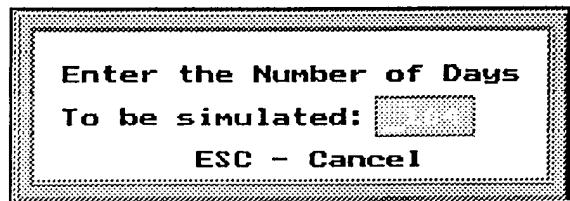


Figure 11. Days of simulation

### Wave field histogram plotting program

The purpose of this plotting package is to give the investigator an opportunity to examine the wave field data used to simulate dredged mound movement, and to generate a hard copy of the plots for the project report. Presently, the following two options exist for viewing the simulated wave-field characteristics: (a) histogram plots, and (b) time series plots. Referring back to the **Wave Field 1.0 Menu** (Figure 3) one will note that the above two plotting options can be called up after all wave field simulation and statistical calculations are complete.



Figure 12. Wave Field Histogram Plot Menu

Select **Histogram Plotting** and the **Wave Field Histogram Plot Menu** appears as shown in Figure 12. This menu has four options, one of which is to return to the **Wave Field 1.0 Menu**. In the following paragraphs the procedure for generation and output of the **Wave Height Histogram**

(Option 1) is closely ex-

amined. The basic procedure used to execute Option 1 can be used for Options 2 and 3.

Select **Wave Height Histogram** from the **Wave Field Histogram Plot Menu**. In Figure 13, the wave height histogram, the user will note three commands: **Quit**, **Zoom**, and **Print**. To execute a command, the user needs only to toggle over to the desired command using the **Arrow Keys**, then hit the **<Enter>** key. For example, to exit the plot and return to the **Histogram Plotting Menu**, toggle over to the **Quit** command and hit the **<Enter>** key. The **Zoom** command is used to cut out and zoom in on a section of the histogram plot. This feature will be discussed later. Lastly, by entering the **Print** command, the on-screen plot will be sent directly to a specified printer for output. In Figures 14 and 15, the Option 2 (wave period) and Option 3 (wave direction), histogram plots for the Sand Island Mound are given. Press **<ESC>** or **R** to return to the **Wave Field 1.0 Menu**.

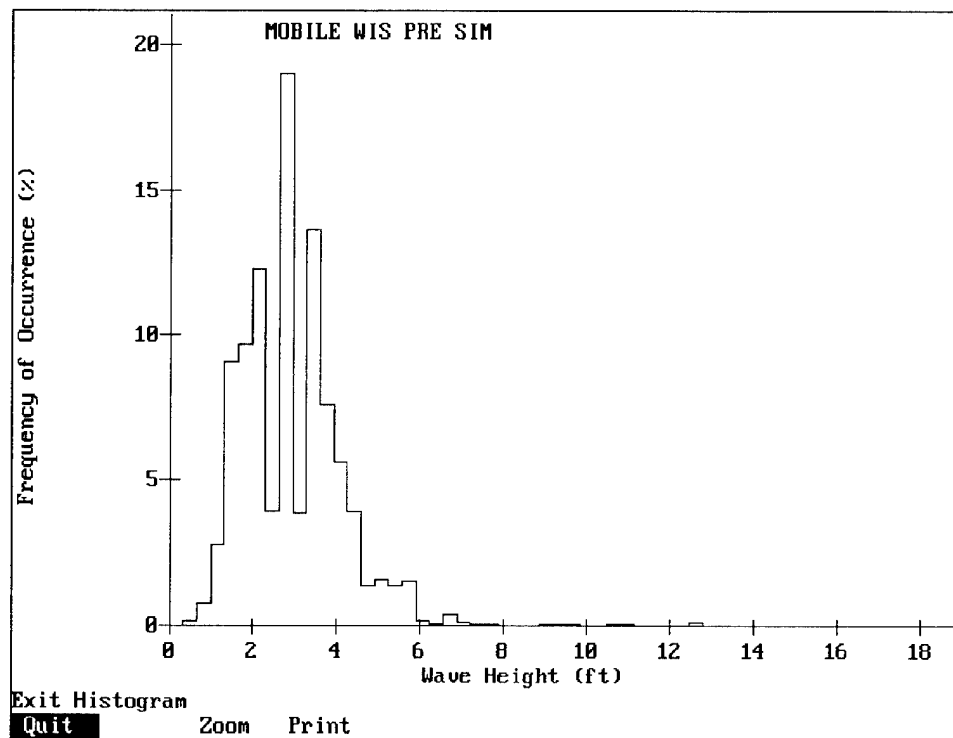


Figure 13. Wave height histogram

### Wave field time series plotting program

Select **Time Series Plotting** and the **Wave Field Time Series Plot Menu** appears as shown in Figure 16. This menu has four options, one of which is to return to the **Wave Field 1.0 Menu**. In the following paragraphs the procedure for generation and output of the **Wave Height Time Series Plot** (Option 1) is closely examined.

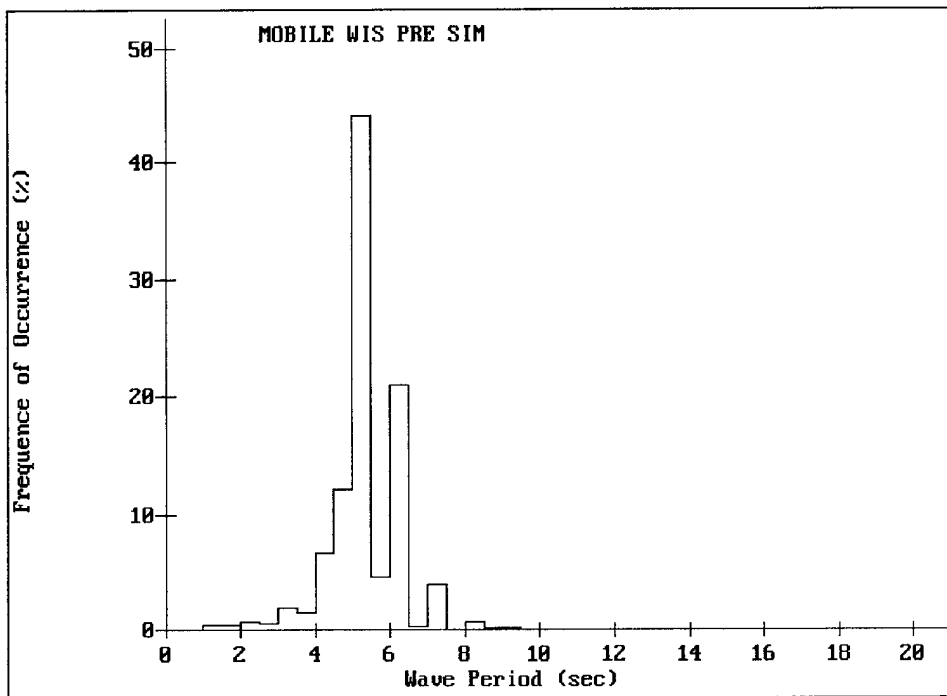


Figure 14. Wave period histogram

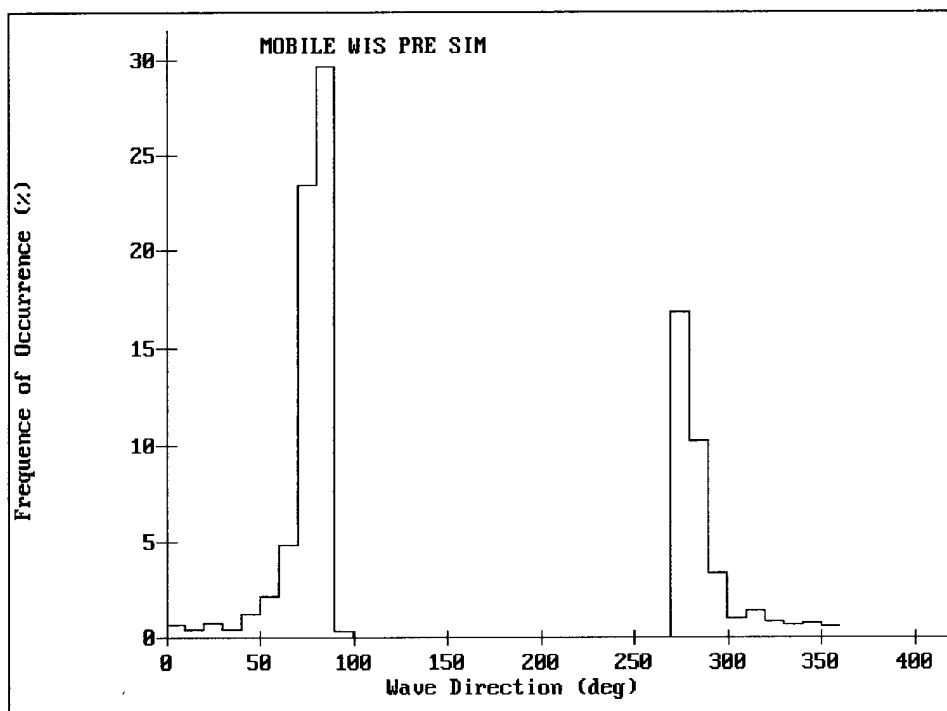


Figure 15. Wave direction histogram



Figure 16. Wave Field Time-Series Plot Menu

Once in the time series plotting menu shown above, select **Wave Height Time Series**. In Figure 17, this plot is shown for the case of the Sand Island Mound example. The three commands printed at the bottom of the on-screen plot, i.e.

**Quit, Zoom, and Print**, are discussed above. The **Zoom** command, however, may be

particularly important in this case, i.e., applications when the plot includes several months of data. For example, wave height data generated for the month of May 1987 must be examined. By recalling that 6 months of data extending from 1 March 1987 to 31 August 1987 were generated, and by making the calculation that 1 May occurs 61 days following the 1 March start date, it is possible to zoom in on this section of the time series plot. The exact procedure required to accomplish this task for a 1-month display is outlined below:

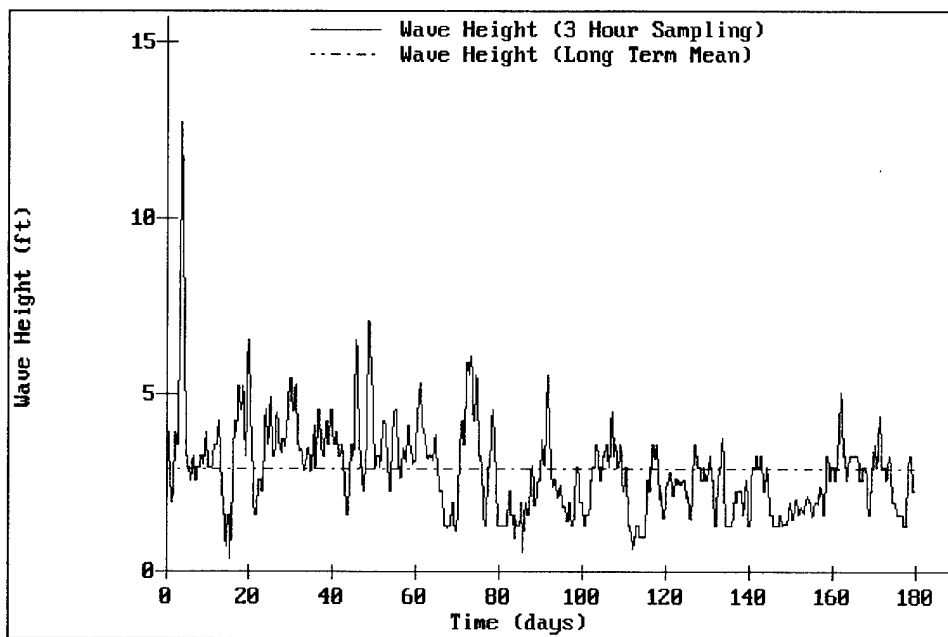


Figure 17. Wave height time series plot

- a. While in the Wave Height Time Series Plot toggle over to the **Zoom** command and press <Enter>.
- b. Next, toggle to the **Window** command and press <Enter> .
- c. A small cross-hair defining the boundary of the zoom-in section will appear on the screen.

- d. The cross-hair must be moved by use of the toggle <→> key (up, down, left, and right) until the cross-hair is near  $x=60$  days, and  $y=0$  feet. At this point, press <Enter>.
- e. Move the cross-hair vertically upward from point (60,0) until all wave height data fall below the cross-hair.
- f. Move the cross-hair horizontally towards the right-hand side of the plot until all days in the month of May are covered, i.e. approximately day=90.
- g. Lastly, press <Enter> and the program will zoom in on the month of May. The enlarged version of the Wave Height Time Series Plot is shown in Figure 18. This new plot can now be printed, re-zoomed, or returned to the original plot.

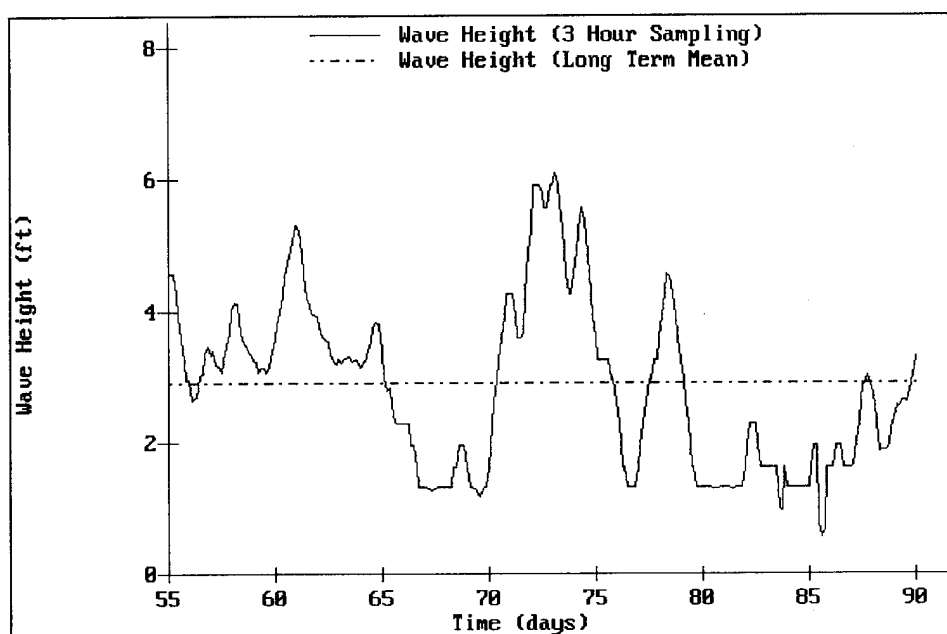


Figure 18. Wave height time series plot for May 1987

- h. To return to the original plot, toggle to the **Zoom** command, press the <Enter> key, then toggle to the **All** command and press <Enter> again.

Option 2 (Figure 19) and Option 3 (Figure 20) can be called up and manipulated using the same procedure as discussed above.

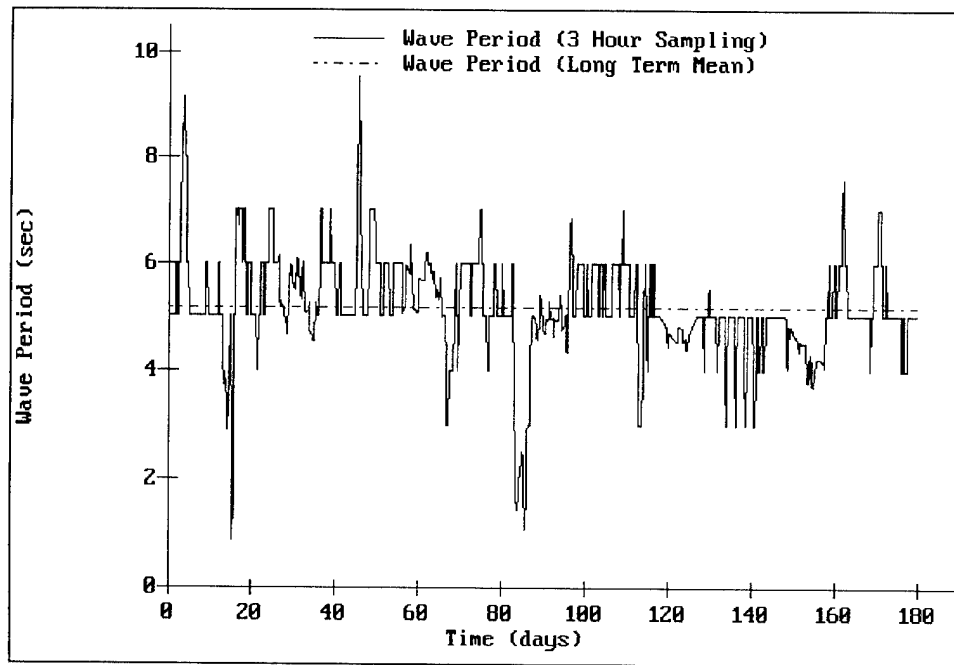


Figure 19. Wave period time series plot

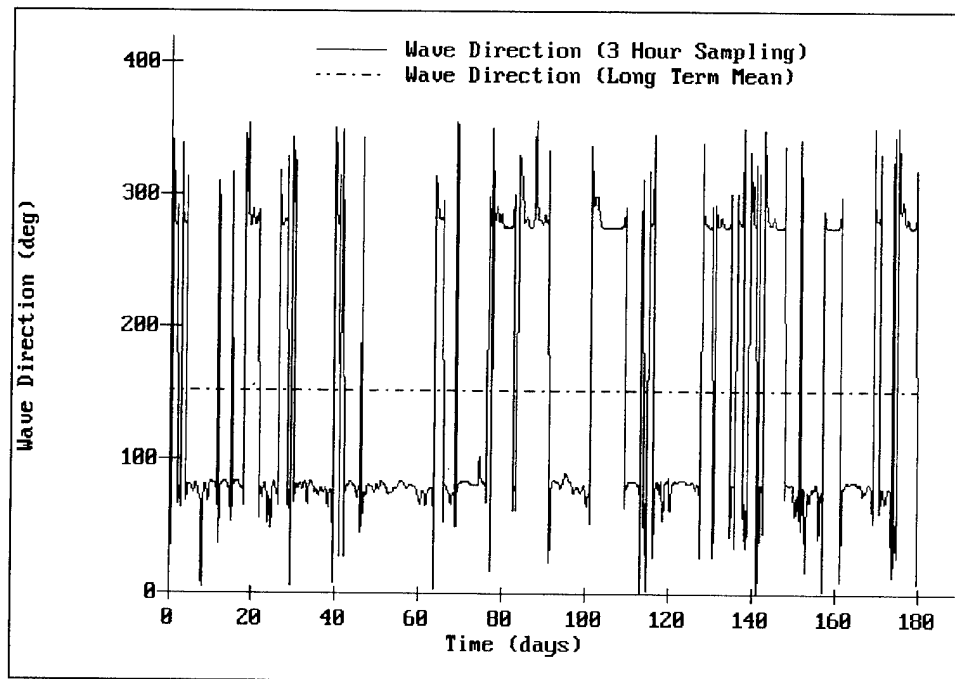


Figure 20. Wave direction time series plot

## LESSON 3: Tide Simulation Package

### Tide simulation program

The tide simulation program serves two purposes. The first and most important is to provide input data to the dredged material mound movement simulation program. The second is to provide input data to the tidal graphics program. Initiate the tide simulation program from the **LTFATE Main Menu** (Figure 1) by selecting the **PC Tidal** menu item. From the **PC Tidal Menu**, Figure 21, select the **Tide Simulation Program** menu item.

After selecting the **Tide Simulation Program** menu item, the window shown in Figure 22 appears. At this point, input the number of days of tide simulation required. For this particular case, type **184**, hit the **<Enter>** key, and choose to proceed with the calculations. Following data calculation and storage, the **Tidal Menu** returns to the screen indicating that the simulation is complete.



Figure 21. Tidal Menu

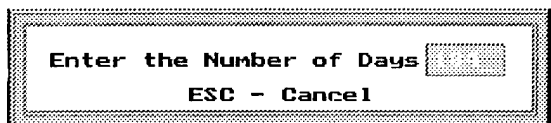


Figure 22. Days of tide simulation

### Tide plotting program

The tide plotting program can be used to examine the simulated tide data and to generate a hard copy of plots for the project report. This

program should be executed following the tidal data simulation procedure discussed above. Select the **Tide Plotting Program** from the **Tidal Menu** (Figure 21). This procedure invokes the **Tide Plotting Menu** shown in Figure 23.

The basic commands for calling up and manipulating the tidal plots are the same as in the case of the wave histogram and time series plots. Tide amplitude, velocity, and direction plots for the vicinity of the Sand Island Mound are given in Figures 24-27.

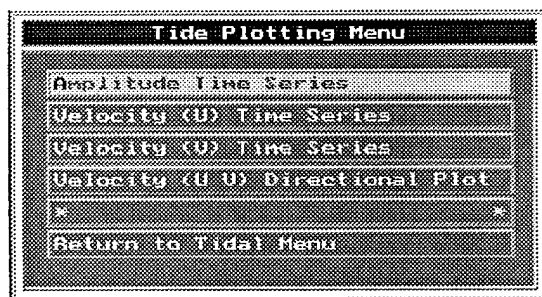


Figure 23. Tide Plot Menu

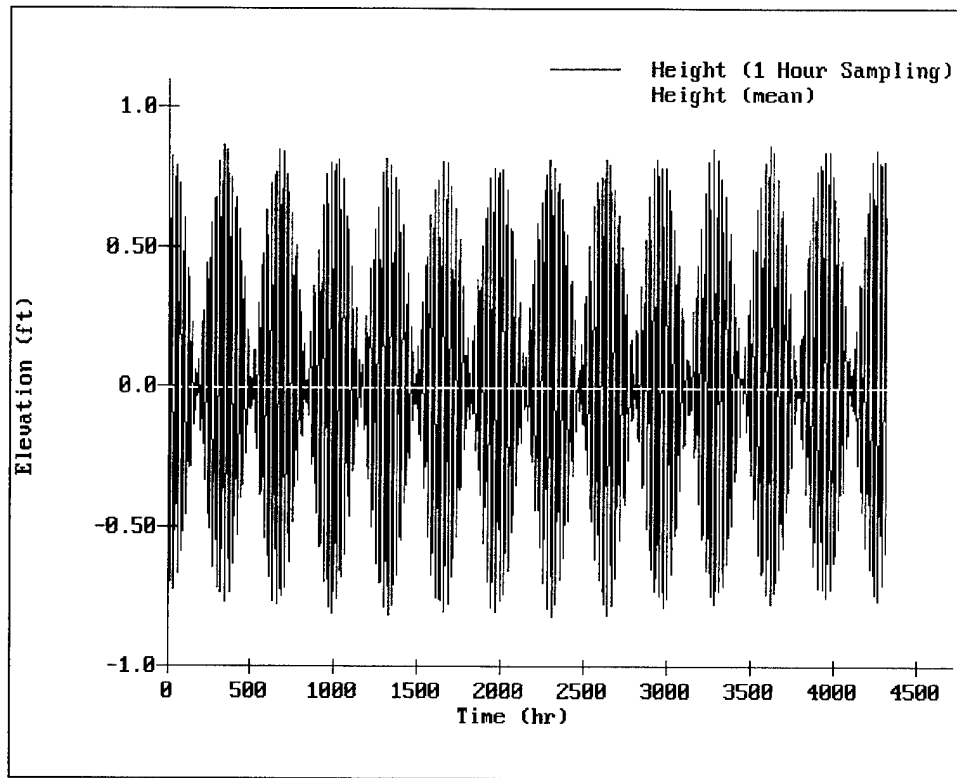


Figure 24. Tide amplitude time series plot

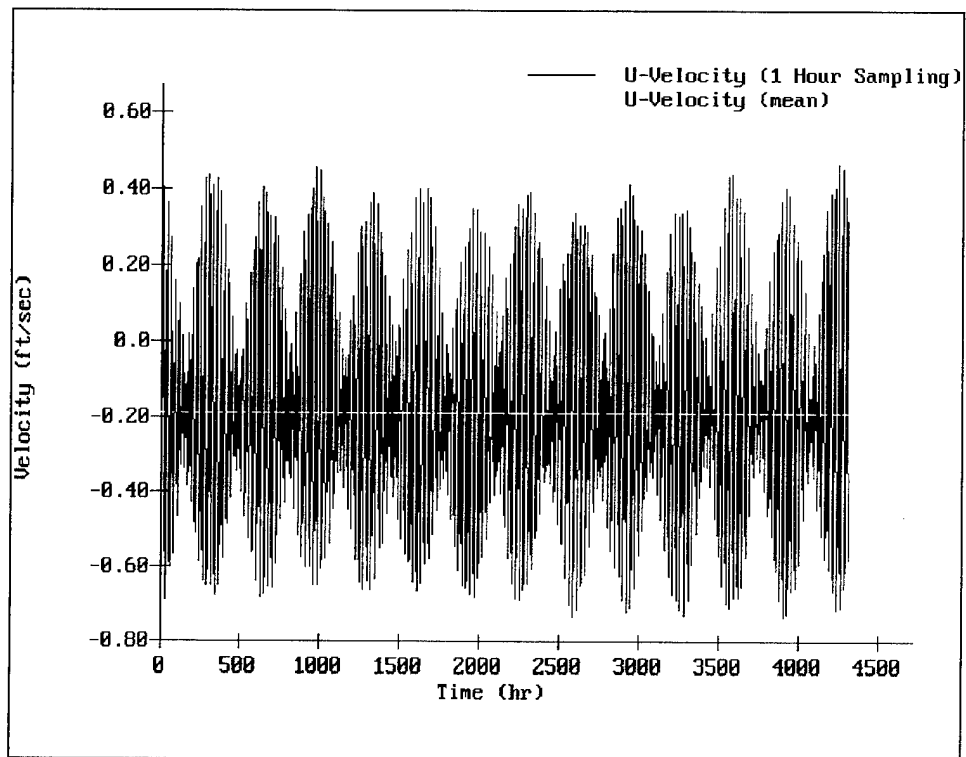


Figure 25. Tide velocity (U) time series plot

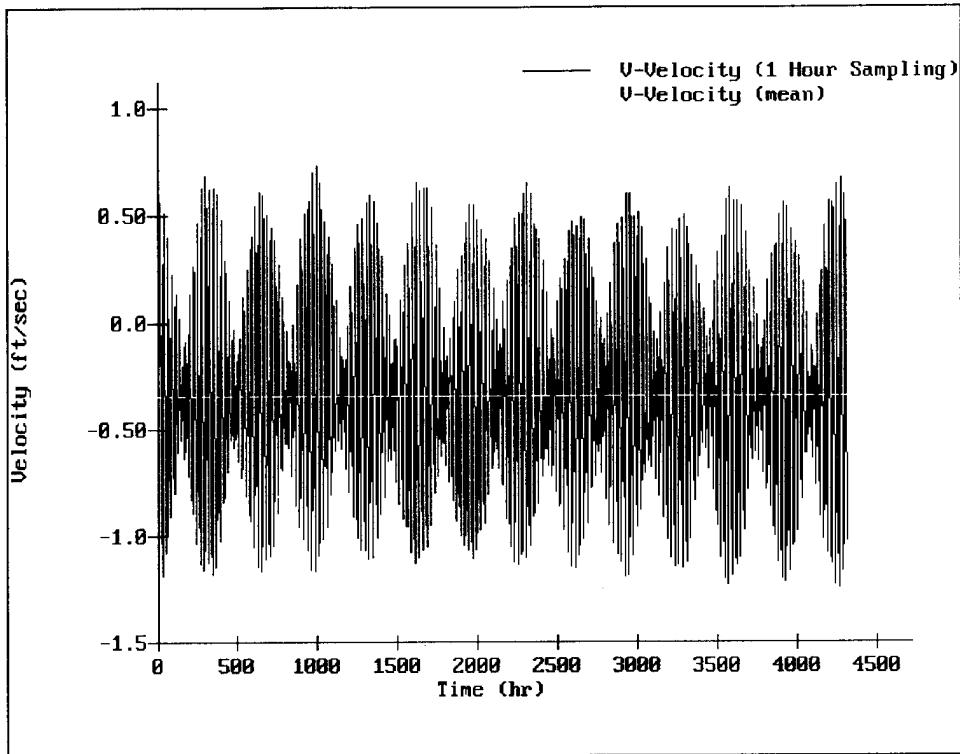


Figure 26. Tide velocity (V) time series plot

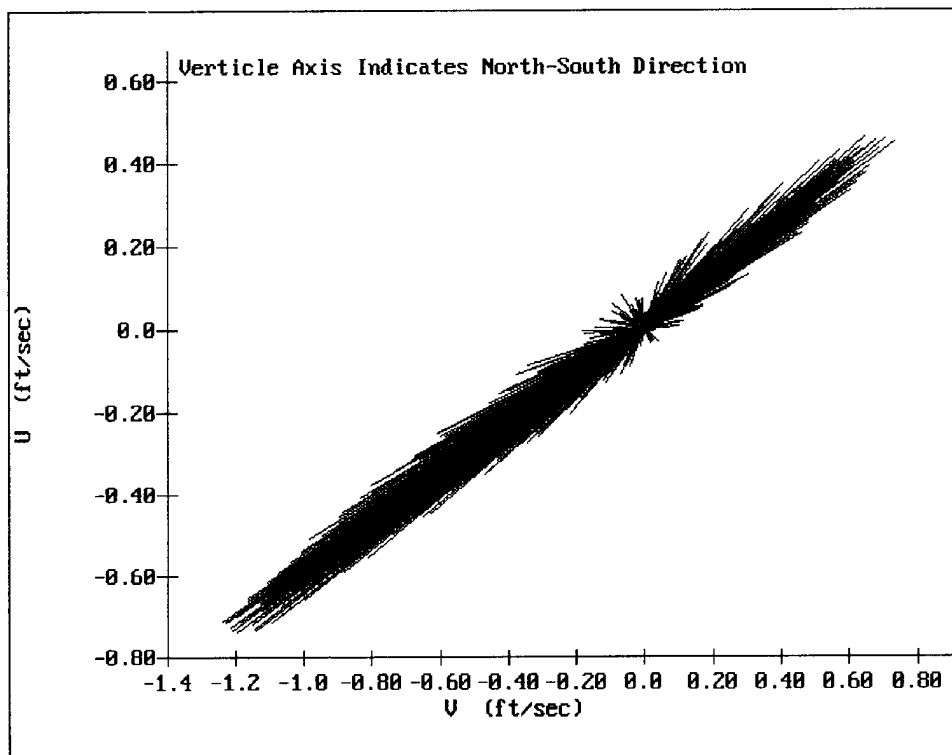


Figure 27. Tide velocity directional plot

## LESSON 4: Long-Term Mound Movement

The final procedure in the LTFATE package is the simulation and graphical display of the long-term dredged material mound movement. To run the simulation program PC\_LTFATE, the database created or supplied by the user in PC\_WAVEFIELD and PC\_TIDAL is used. The PC\_LTFATE output file is then used by the plotting program to create a series of mound contour and cross-section plots depicting long-term mound evolution. Based on these final graphic outputs, conclusions can be made concerning the mobility of the dredged material mound under the prescribed conditions.

From the **LTFATE Main Menu** (Figure 1), select the **PC Ltfate** option. Five options are provided in the **PC Ltfate 1.0 Menu**, shown in Figure 28.

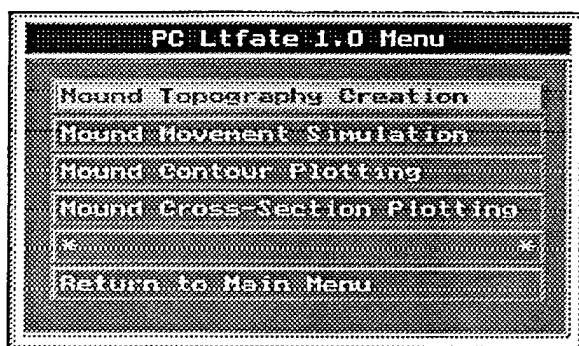


Figure 28. PC LTFATE 1.0 Menu

Execution of the **Mound Topography Creation** program (Option 1) is not required to run the **Mound Movement Simulation** program (Option 2). This program is necessary only when a new and different mound geometry of complex form (noncircular and/or multi-peaked) is required. In the Sand Island Mound example, a simple mound geometry is used, and this program is omitted. For an example application on the use of the **Mound Topography Creation** program, see LESSON 5.

### Long-term mound movement simulation

Once in the **PC Ltfate 1.0 Menu**, select the **Mound Movement Simulation** option. Upon program initiation, the choices for mound movement simulation are

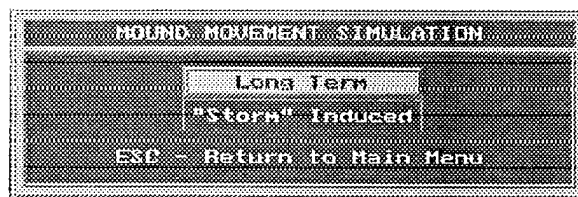


Figure 29. Mound Movement Simulation

displayed as shown in Figure 29. It is suggested that both the long-term and storm-induced mound movement be investigated for comparison purposes; this will require running the PC\_LTFATE program twice. For the case of the Sand Island Mound, select the **Long Term** simulation option. Figure 30 shows the **Mound Descriptors** data-entry window that appears after **Long Term** is selected. An average sediment diameter of 0.2 mm was determined from analyses of sediment samples collected at the Sand Island Mound. Therefore, input **0.2** at the **Sediment D50 Grain Size** prompt. Default values for both

Figure 30. Mound descriptors

the **Nontidal Residual Current Vel. (ft/sec)** and the **Nontidal Residual Direction in Degrees Measured Clockwise from North** are **0.0**. These defaults are not recommended values. Residuals should be determined from field data. After pressing **<Enter>** on the last field, the prompt for the simulation time is displayed as shown in Figure 31. It has already been determined that the simulation will be performed for 180 days, thus type **180** at the **Enter Simulation Time** prompt.

In the next prompt, the data output interval for the mound simulation is requested, Figure 32. It is important to carefully select an output interval because at each increment a mound contour database is created. If, for example, the minimum allowed output interval of 3 hr for the 180-day simulation is chosen, 1,440 data files and contour plots will be generated. To conserve both time and computer storage space while preserving mound detail, an output interval greater than 1/10 the total simulation time is suggested. In this case, a 1/5 factor is employed, resulting in an output interval of 864 hr; i.e.

Figure 31. Simulation time window

Figure 32. Output interval window

$$\frac{180 \text{ days} \times 24 \text{ hr/day}}{5} = 864$$

Therefore, press **<Enter>** to accept the calculated default value of **864** at the **Enter Output Interval** prompt.

Next, the user is given a choice between creating a simple mound geometry (approximately circular in shape) or calling up the existing dredged material mound geometry file (Figure 33). If the initial mound geometry is relatively simple (circular in diameter, and single peaked), creating a basic mound configuration is suggested. Therefore, choose the **Create a Simple Mound**

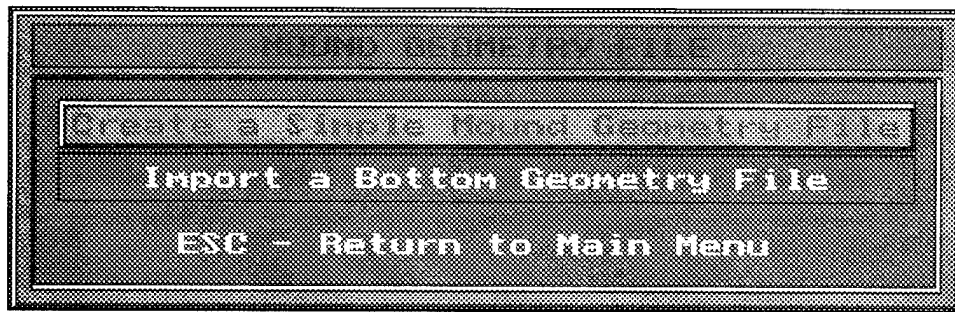


Figure 33. Mound Geometry File window

**Geometry File** option. Later, in LESSON 5, the **Import a Bottom Geometry File** option will be examined.

After selecting the **Create a Simple Mound Geometry File** option, the user will be required to answer the four prompts in the **Simple Mound Geometry Parameters** window. The four prompts and corresponding example data input are provided as shown in Figure 34. The next step is to approximate the mound material using one of the four possible choices shown in Figure 35. This particular classification plays a key role in mound consolidation calculations and determines whether the cohesive or noncohesive subroutine will be employed. In the case of the Sand Island Mound, the material generally consists of sand. Consequently, select **Pure Sand** and press **<Enter>**. The **Avalanching Data Parameters** window is displayed, as in Figure 36. The default values for the two prompts displayed can be selected by pressing **<Enter>** twice.

Figure 34. Simple Mound Geometry Parameters window

Following this final input, the mound simulation program PC LTFATE 1.0 initiates. The time required for simulation varies with input conditions, output requirements, and computer hardware. The first screen appears as shown in Figure 37.

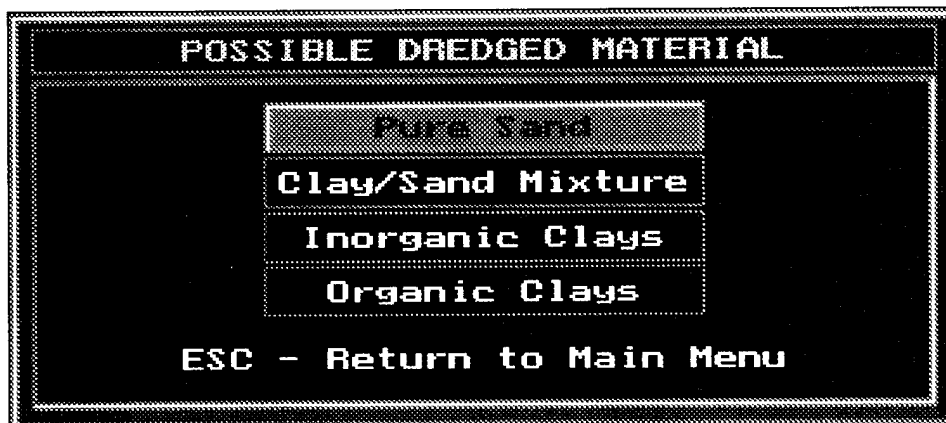


Figure 35. Possible Dredged Material

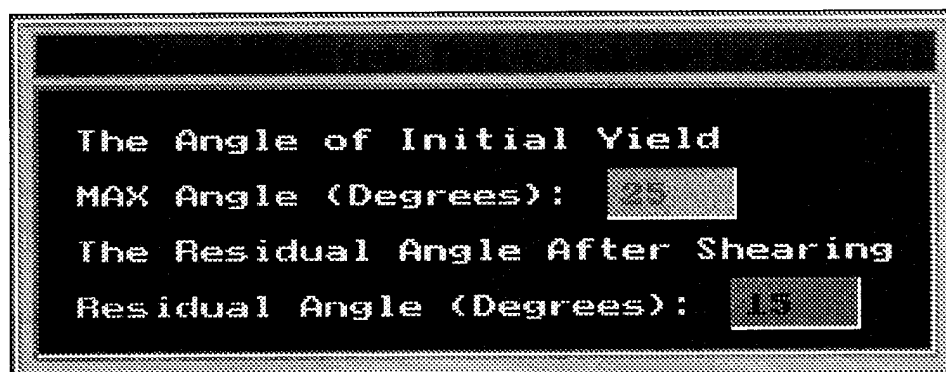


Figure 36. Avalanching Data Parameters

```

*****
* DREDGE MOUND TRANSPORT, CONSOLIDATION, *
*   AND AVALANCHING PROGRAM INITIATED   *
*****

```

| N | T   | SETT  | UVEL   | VVEL   | TIDE H | DEEP H | PERD  | X-CENT | Y-CENT |
|---|-----|-------|--------|--------|--------|--------|-------|--------|--------|
|   | hrs | ft    | ft/sec | ft/sec | ft     | ft     | sec   | ft     | ft     |
| 1 | 3   | 0.000 | -0.537 | -1.006 | 0.044  | 3.511  | 5.000 | -2.3   | -4.3   |
| 2 | 6   | 0.000 | -0.732 | -1.206 | -0.545 | 3.862  | 5.000 | -9.8   | -16.2  |
| 3 | 9   | 0.000 | -0.453 | -0.647 | -0.768 | 4.213  | 5.000 | -11.4  | -18.5  |
| 4 | 12  | 0.000 | 0.152  | 0.260  | -0.626 | 4.213  | 5.000 | -10.6  | -17.3  |
| 5 | 15  | 0.000 | 0.402  | 0.565  | -0.209 | 4.213  | 5.000 | -10.6  | -17.3  |
| 6 | 18  | 0.000 | 0.124  | 0.163  | 0.376  | 3.862  | 5.000 | -10.6  | -17.3  |
| 7 | 21  | 0.000 | -0.181 | -0.270 | 0.824  | 3.511  | 5.000 | -10.7  | -17.5  |
| 8 | 24  | 0.000 | -0.274 | -0.515 | 0.767  | 3.160  | 5.000 | -11.5  | -19.2  |
| 9 | 27  | 0.000 | -0.442 | -0.883 | 0.217  | 2.808  | 5.000 | -15.3  | -25.5  |

etc...

Figure 37. PC LTFATE 1.0 mound simulation output

N, T, SETT, TUVEL, TVVEL, TIDH, DEEPH, PERD, X-CENT, and Y-CENT represent the run number, hour, current average mound consolidation, velocity in the X-direction, velocity in the Y-direction, tidal elevation, wave height in deep water, wave period, centroid of the mound in the X-direction, and centroid of the mound in the Y-direction, respectively. Onscreen simulation output continues until the preselected final time  $T_f$  is reached. In this case,  $T_f = 4,320$  hr. To abort the simulation, simply press the <Ctrl> and the C keys simultaneously. Once the simulation is complete, the PC LTFATE 1.0 Menu automatically returns to the screen.

### Mound contour plotting program

The mound evolution graphics may now be accessed by selecting the **Mound Contour Plotting** option. The window shown in Figure 38 is displayed.

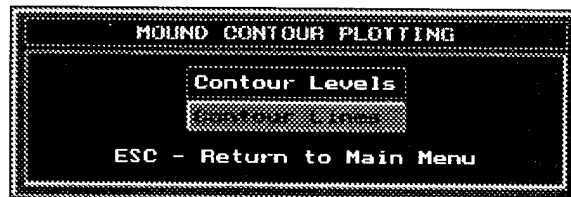


Figure 38. Mound Contour Plotting window

If using a color monitor, a color contour plot can be obtained by selecting **Contour Levels** and pressing <Enter>. This command calls the initial ( $T=0$ ) color contour to the screen. To view the evolved mound contour plots, enter the **QUIT** command and the next contour plot will be displayed. This procedure of entering **QUIT** must be repeated until all contour intervals have been displayed before returning to the PC LTFATE 1.0 Menu.

If using a black and white monitor, or if a hard copy of the contour plot is desired, it is necessary to choose the **Contour Lines** option. Choosing this command will display the windows shown in Figures 39 and 40.

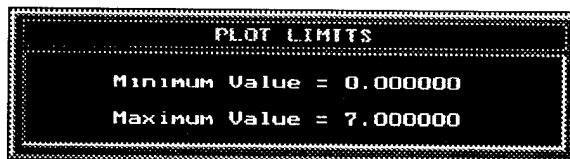


Figure 39. Plot Limits window

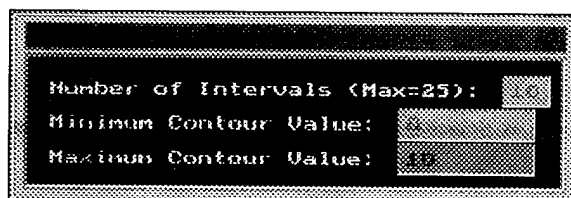


Figure 40. Contour Descriptors

For the Sand Island Mound specifications, the following parameters may be entered: **10, 0.0, 10.0**. In Figures 41-46, contour plots corresponding to time increments  $T=0$  hr,  $T=864$  hr,  $T=1,728$  hr,  $T=2,592$  hr,  $T=3,456$  hr, and  $T=4,320$  hr are shown.

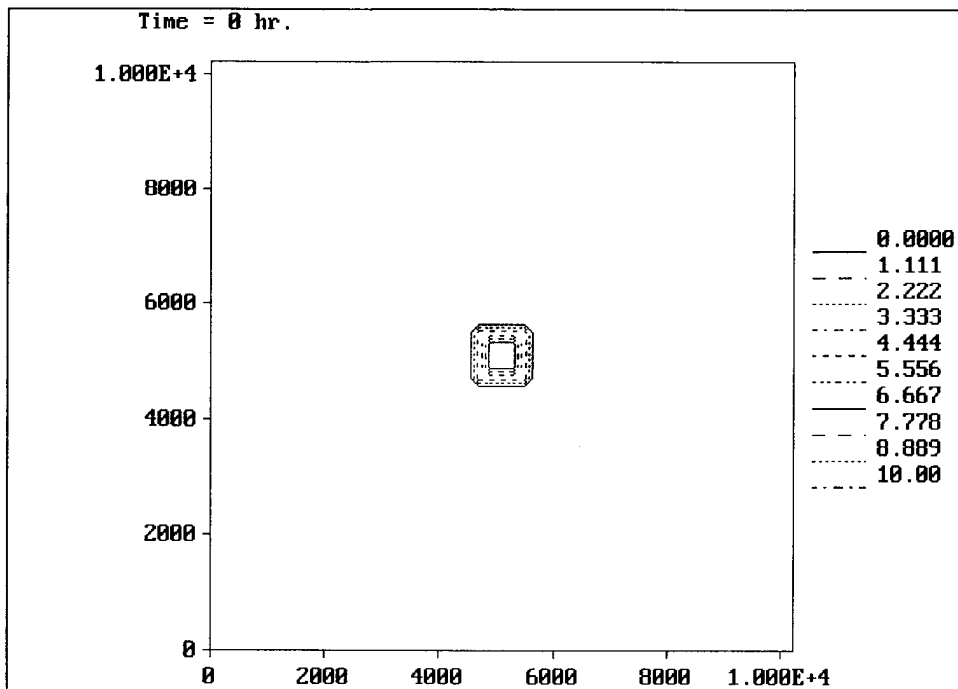


Figure 41. Initial mound contour of Sand Island Mound

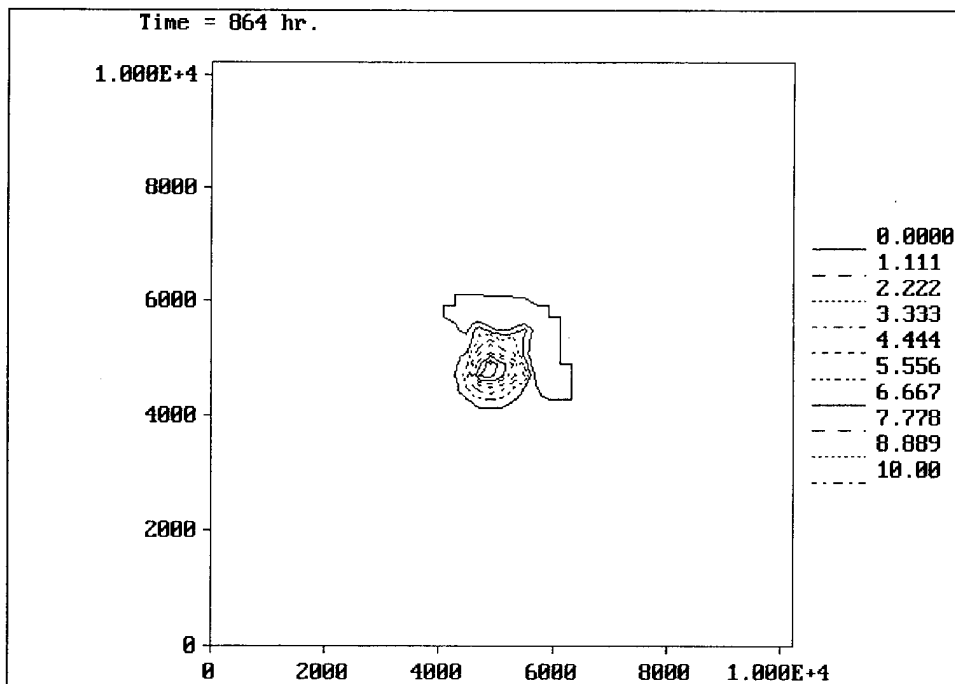


Figure 42. Simulated Sand Island Mound contour after 846 hr (36 days)

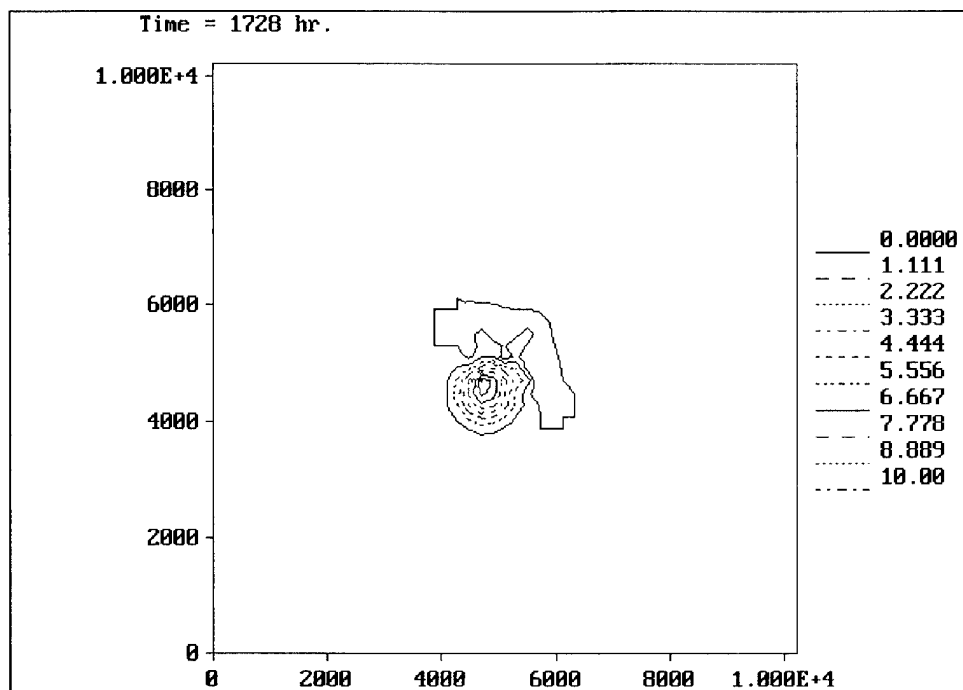


Figure 43. Simulated Sand Island Mound contour after 1,728 hr (72 days)

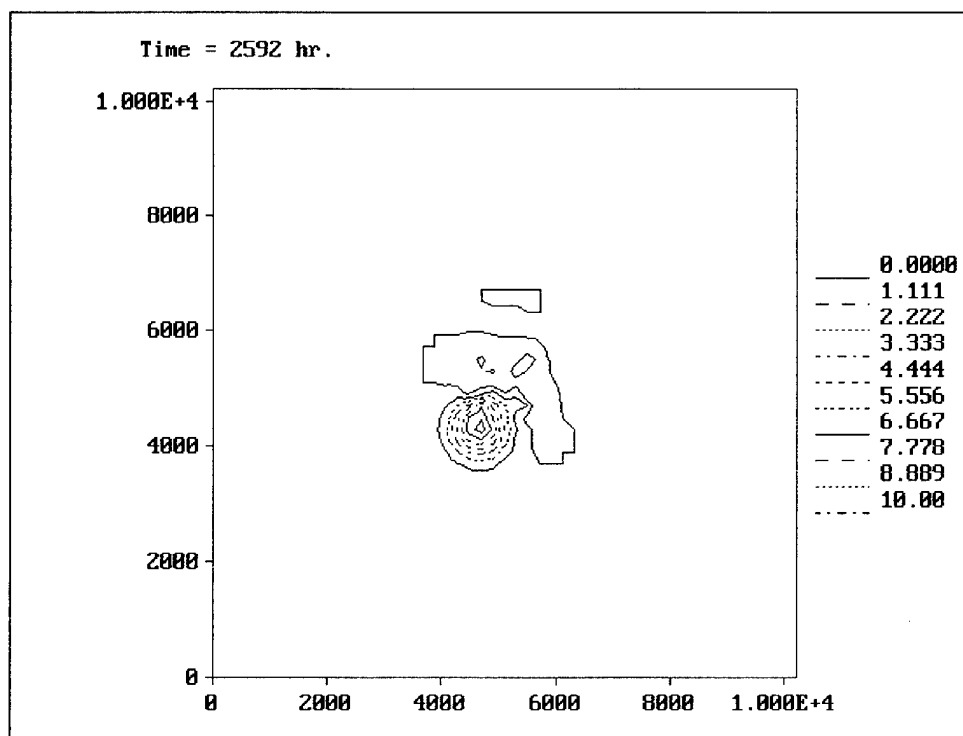


Figure 44. Simulated Sand Island Mound contour after 2,592 hr (108 days)

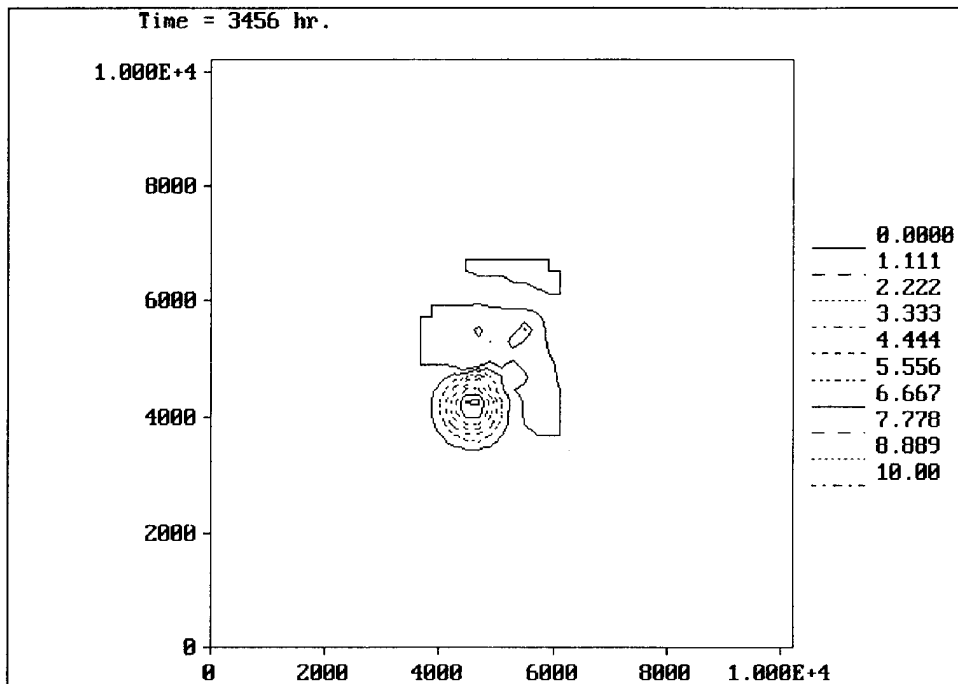


Figure 45. Simulated Sand Island Mound contour after 3,456 hr (144 days)

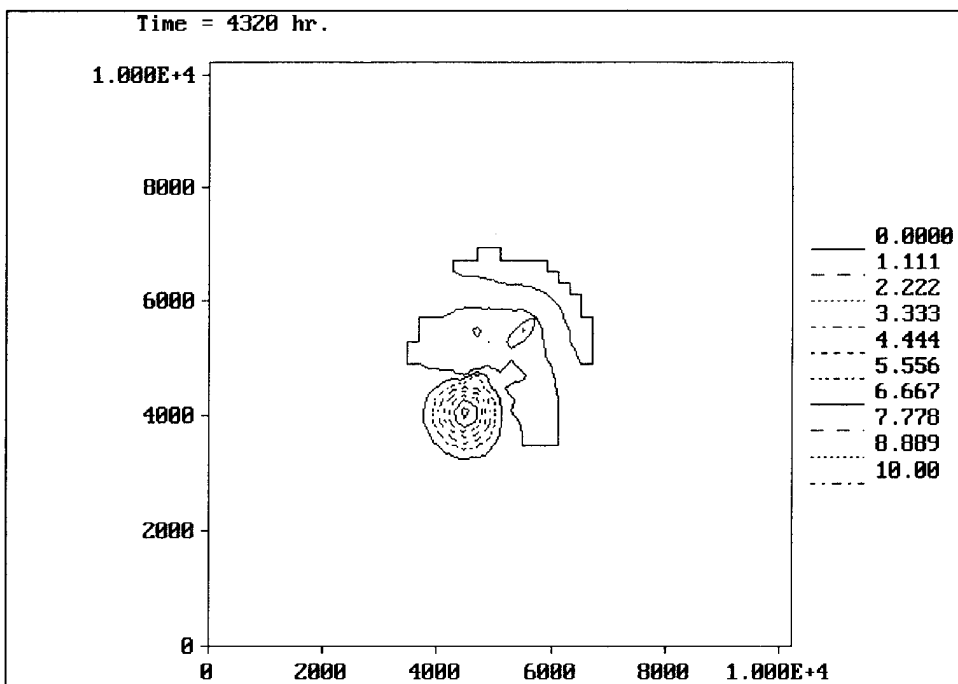


Figure 46. Simulated Sand Island Mound contour after 4,320 hr (180 days)

## Mound cross-section plotting program

Once the mound contour plotting task is complete and the **PC LTFATE 1.0 Menu** appears on the screen, select the **Mound Cross-Section** option. After pressing **Enter**, the **Mound Cross-Section Plotting** window appears as in Figure 47.

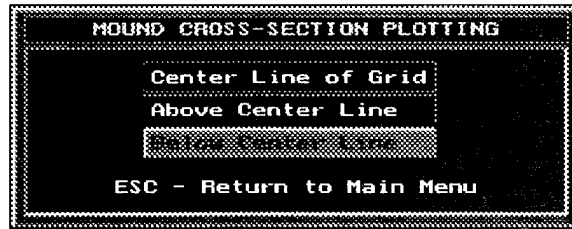


Figure 47. Mound Cross-Section Plotting window

The center line is a line running parallel to the X-Axis at the mid-point of the Y-Axis (vertical axis). Therefore, for the case of the Sand Island Mound, the center line is at Y=5,100 ft. In order to make a good selection, it is necessary to know the final (after simulation) position of the mound. Consequently, it is very helpful to have a hard copy of the final mound contour before choosing a center-line axis. If the **Center Line of Grid** option is selected, the mound cross-sectional plot at the grid center line for each time increment (T = 0 hr, T = 864 hr, T = 1,728 hr, T = 2,592 hr, T = 3,456 hr, and T = 4,320 hr) automatically appears on screen (see Figure 48 for the center-line cross section). Procedures used to manipulate the plot commands should be based on the location of the mound as determined from the contour plots. This migration is evidenced in

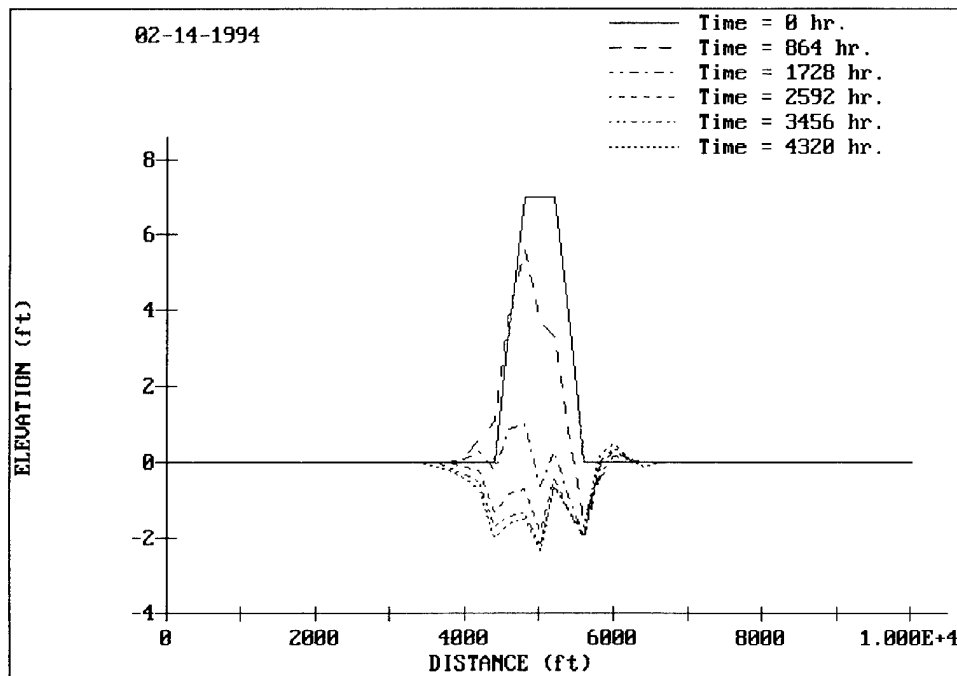


Figure 48. Simulated Sand Island Mound cross-sectional plot at center line of grid

the cross-sectional plot as the mound moves from the center-line location of Y=5,100 ft.

To view the crest of the evolved mound, plot the cross section 1,500 ft below the center line. Select the **Below Center Line** option of the **Mound Cross Section Plotting** window (Figure 47). Enter **1500** at the **Number of Feet Below The Center Line** prompt as shown in Figure 49. Figure 50 shows the cross-section plot at 1,500 ft below the center line of the grid. This process of examining different cross sections may be repeated as many times as desired.

Number of feet Below Center Line: 1500

ESC - Cancel

Figure 49. Number of Feet Below the Center Line prompt

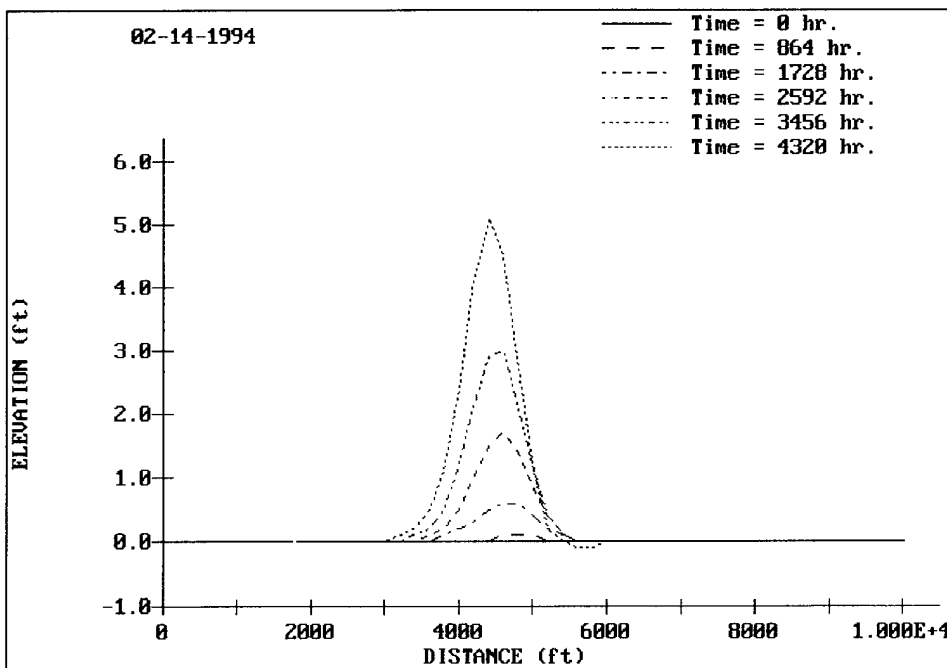


Figure 50. Simulated Sand Island Mound cross-sectional plot 1,500 ft below center line

## LESSON 5: Storm-Induced Mound Movement

LESSON 5 provides an example application of the storm-induced mound movement capabilities of the LTFATE model. The Mud Dump Site, located in New York Bight, subject to conditions similar to those produced by the December 1992 extratropical storm will be illustrated. The Mud Dump Site

has been proposed for the disposal of dredged material which will be covered or capped with large-grained material. Concern was aroused regarding the dispersive characteristics of the site when bathymetric surveys showed that the existing material had eroded as a result of the December storm. The proposed cap configuration will be examined in the example that follows.

### Mound topography creation program

To create a complex mound geometry, select the **Mound Topography Creation** option from the **PC LTFATE 1.0 Menu**. The mound to be created lays within a 51 x 51 grid of arbitrary spacing. After pressing <Enter>, the **Mound Topography Creation** window appears as shown in Figure 51. This window provides the user with the option of creating a new mound geometry file or editing an existing one. Select the **Create a new mound geometry file** option. The **Create a new Sea Bed Geometry** window is displayed as shown

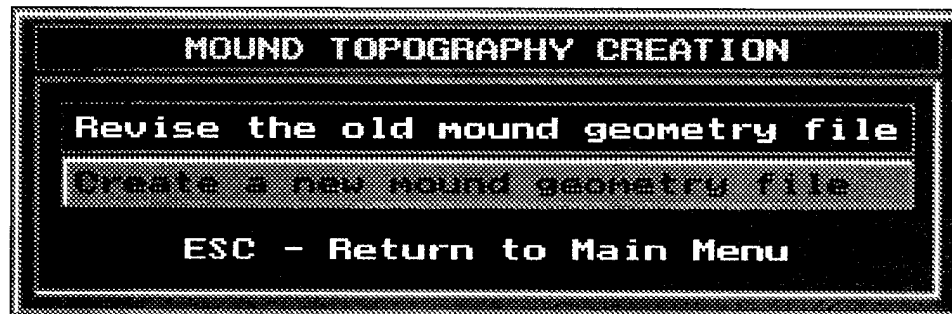


Figure 51. Mound Topography Creation window

in Figure 52. After the window appears, input the necessary file storage information. The user may store the new file on either a floppy or hard disk. The topography representing the Mud Dump Site will be called TOPO.DAT; therefore, enter C:\LTFATE\TOPO.DAT for the **Drive, Directory, and Filename** of the file to create prompt.

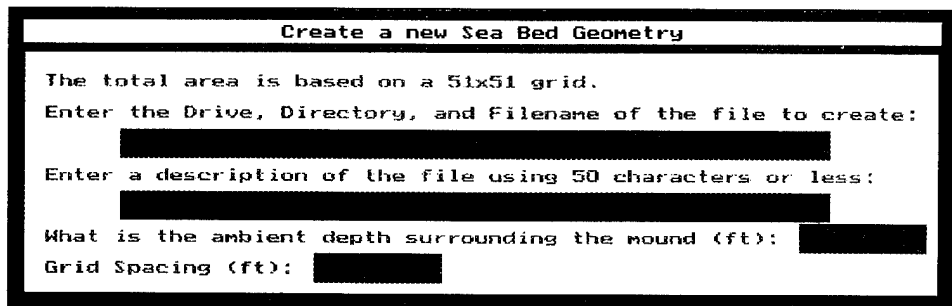


Figure 52. Create a New Sea Bed Geometry window

After the **description of the file** prompt, site-specific information can be recorded such as the name of the placement area, station identification

numbers, and date of data entry. This site description may prove to be quite helpful if, at a later date, the geometry file is to be reused or modified. Input **NEW YORK BIGHT MUD DUMP SITE** in response to this prompt.

For the case of the Mud Dump Site, the ambient depth or averaged depth surrounding the mound is about 83 ft; therefore, enter **83** after the prompt.

The grid spacing is the length of the grid cell used in numerical calculations. Smaller increments result in higher resolution and a greater simulation time. If the increment is too small, the dredge mound may move out of the grid, causing errors. Therefore, it is important to choose the appropriate increment for each application. The suggested grid spacing ranges from 100 to 500 ft. For large mounds in shallow water exposed to high currents, a larger spatial increment should be employed. Determination of the grid spacing may require some experimentation. In the case of the Mud Dump Site, a grid spacing of 200 ft is used. Therefore, enter **200** after the prompt.

Now that the basic file and grid information have been stored, the mound design process may begin. The user is asked to define the mound region within the 51x51 grid to be modified. It is necessary to have a well-planned-out data input scheme similar to Figure 53, which illustrates the array of numbers that must be input to describe the Mud Dump Site.

|   |      | X    |      |      |      |      |      |      |      |      |      |      |      |      |
|---|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
|   |      | 1000 | 1200 | 1400 | 1600 | 1800 | 2000 | 2200 | 2400 | 2600 | 2800 | 3000 | 3200 | 3400 |
| Y | 2000 | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    |
|   | 2200 | 0    | 2    | 2    | 2    | 2    | 2    | 2    | 2    | 2    | 2    | 2    | 2    | 0    |
|   | 2400 | 0    | 2    | 4    | 4    | 4    | 4    | 4    | 4    | 4    | 4    | 4    | 4    | 0    |
|   | 2600 | 0    | 2    | 4    | 6    | 6    | 6    | 6    | 6    | 6    | 6    | 6    | 4    | 0    |
|   | 2800 | 0    | 2    | 4    | 6    | 8    | 8    | 8    | 8    | 8    | 8    | 6    | 4    | 0    |
|   | 3000 | 0    | 2    | 4    | 6    | 8    | 8    | 8    | 8    | 8    | 8    | 6    | 4    | 0    |
|   | 3200 | 0    | 2    | 4    | 6    | 8    | 8    | 8    | 8    | 8    | 8    | 6    | 4    | 0    |
|   | 3400 | 0    | 2    | 4    | 6    | 8    | 8    | 8    | 8    | 8    | 8    | 6    | 4    | 0    |
|   | 3600 | 0    | 2    | 4    | 6    | 8    | 8    | 8    | 8    | 8    | 8    | 6    | 4    | 0    |
|   | 3800 | 0    | 2    | 4    | 6    | 6    | 6    | 6    | 6    | 6    | 6    | 6    | 4    | 0    |
|   | 4000 | 0    | 2    | 4    | 4    | 4    | 4    | 4    | 4    | 4    | 4    | 4    | 4    | 0    |
|   | 4200 | 0    | 2    | 2    | 2    | 2    | 2    | 2    | 2    | 2    | 2    | 2    | 2    | 0    |
|   | 4400 | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    |

Figure 53. Input array for Mud Dump Site

The region of modification is defined by entering the maximum and minimum X and Y boundary values. For example, the first prompt asks for the minimum X value, with a possible X range of 200 to 10,000 ft. This range will vary with the entered grid spacing value.

In the following example, the mound is bounded by  $X_{(min)} = 1200$ ,  $X_{(max)} = 3200$ ,  $Y_{(min)} = 2200$ , and  $Y_{(max)} = 4200$  ft. Therefore, in the series of prompts listed below in Figure 54, input the following X and Y boundary values: **1200, 3200, 2200, and 4200.**

| Boundary Values of the Grid Region |                      |
|------------------------------------|----------------------|
| Minimum Boundary Value of X (ft):  | <input type="text"/> |
| Maximum Boundary Value of X (ft):  | <input type="text"/> |
| Minimum Boundary Value of Y (ft):  | <input type="text"/> |
| Maximum Boundary Value of Y (ft):  | <input type="text"/> |

Figure 54. Boundary Values of the Grid Region

After entering the above X and Y boundary values, a Scrolling List Editor (SLED) appears as shown in Figure 55, containing the series of mound elevations corresponding to the boundary conditions entered in Figure 54. It is important to have documented the grid position and corresponding elevation before beginning mound elevation input. Consider a schematic similar to Figure 53 as a mound geometry design aid and elevation data record. Press the **TAB** key to move the cursor to the elevation column prompt. Enter the mound height (elevation) above ambient surroundings (X,Y) for each row. Use the **UP and DOWN Arrow Keys** to move the cursor from one row to the previous or next. At the bottom of the SLED window, the rows will automatically scroll up revealing the next (X,Y) prompt. Enter the remaining elevation values into the SLED window. Changes can be made to these values until you have exited the SLED (Figure 56). Press **ALT-S** to save all of the mound elevation input values that were entered and to proceed to the next menu.

| MOUND ELEVATION INPUT MENU   |           |           |
|------------------------------|-----------|-----------|
| Ambient Depth for Grid: 83.0 |           |           |
| X<br>(ft)                    | Y<br>(ft) | Elevation |
| 1200.0                       | 2200.0    | 2         |
| 1200.0                       | 2400.0    | 2         |
| 1200.0                       | 2600.0    | 2         |
| 1200.0                       | 2800.0    | 2         |
| 1200.0                       | 3000.0    | 2         |
| 1200.0                       | 3200.0    | 2         |
| 1200.0                       | 3400.0    | 2         |
| 1200.0                       | 3600.0    | 2         |

Figure 55. Mound Elevation Input Editor

| MOUND ELEVATION INPUT MENU   |           |           |
|------------------------------|-----------|-----------|
| Ambient Depth for Grid: 83.0 |           |           |
| X<br>(ft)                    | Y<br>(ft) | Elevation |
| 2200.0                       | 2800.0    | 8         |
| 2200.0                       | 3000.0    | 8         |
| 2200.0                       | 3200.0    | 8         |
| 2200.0                       | 3400.0    | 8         |
| 2200.0                       | 3600.0    | 8         |
| 2200.0                       | 3800.0    | 6         |
| 2200.0                       | 4000.0    | 4         |
| 2200.0                       | 4200.0    | 2         |

Figure 56. Revised Mound Elevation Input Editor

Select a current contour viewing option from the **Contour Selection** window (Figure 57). After viewing the contour, the PC Dredge 1.0 Menu (Figure 28) reappears. For details on contour plotting operations, see LESSON 4.

| CONTOUR SELECTION         |  |
|---------------------------|--|
| Color Contour Levels      |  |
| Contour Lines             |  |
| ESC - Return to Main Menu |  |

Figure 57. Contour Selection

To make changes to the new contour file, select the **Topography Creation Program** and then select the **Revise an existing geometry file** prompt (Figure 51).

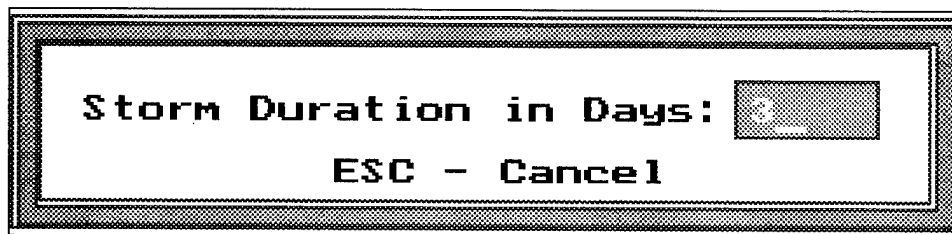
### Storm-induced mound movement simulation

Once in the **PC LTFATE 1.0 Menu** again, select the **Mound Movement Simulation** option. Select the **"Storm" Induced** option shown in Figure 29. To run the storm-induced mound movement simulation, the file STORM.DAT,

which contains the characteristics (i.e. storm surge elevations, currents and associated waves) of the storm to be simulated (see Appendix B for listing) is required.

Refer to LESSON 4 for figures of all menus. As in the long-term movement simulation, the grain size diameter is required. The capping material was designed to have a  $D_{50}$  of 0.3 mm. Therefore, enter **0.3** for the **Sediment D50 Grain Size** prompt, and press <Enter> to accept the default values for the Nontidal Residual prompts (Figure 30).

The Storm Duration window is displayed as shown in Figure 58. Respond to the number of **Storm Duration (Days)** prompt with the number of days of data records located in the STORM.DAT file. In the case of the Mud Dump Site, enter **3**. The output interval is required and should be selected according to the discussion in LESSON 4 (Figure 32). For this example of the Mud Dump Site, enter **9** for the output interval. Remember that the output interval must be a multiple of 3.

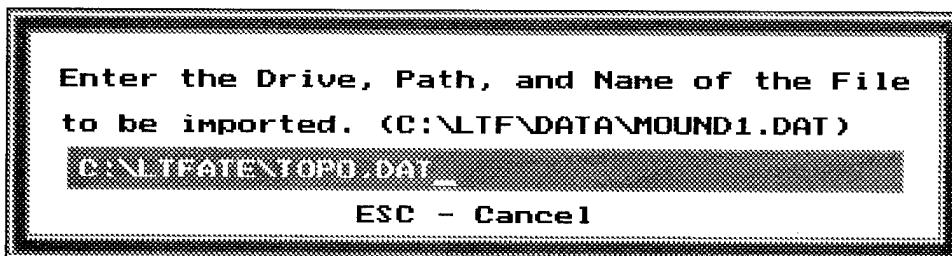


Storm Duration in Days: 3

ESC - Cancel

Figure 58. Storm Duration window

At the next window, the user is given a choice between creating a simple mound geometry (see LESSON 4) or calling up the existing dredged material mound geometry file (Figure 33). Select the **Import a Bottom Geometry File** option. Recall that the mound geometry stored in file TOPO.DAT corresponds to the Mud Dump Site mound geometry. Consequently, enter **C:\LTFATE\TOPO.DAT** as shown in Figure 59.



Enter the Drive, Path, and Name of the File  
to be imported. (C:\LTF\DATA\MOUND1.DAT)

C:\LTFATE\TOPO.DAT

ESC - Cancel

Figure 59. Import a Bottom Geometry File

The next step is to approximate the mound material using one of the four possible choices shown previously in Figure 35. In the case of the Mud Dump Site, the material generally consists of sand. Consequently, select the Pure

Sand option. Refer to LESSON 4 (Figure 36), for entering the Avalanching Data Parameter values and select the default values.

Once the simulation is complete, use the mound cross-section plotting and contour plotting (described in LESSON 4) to view the results.

## LESSON 6: Interpreting Results

Figure 60, the mound cross-section plot, indicates that little movement of the mound located at the Mud Dump Site occurs along the Y-axis. The initial and final contours are shown in Figures 61 and 62, respectively. From these figures, it is observed that the small amount of movement is representative of the entire mound in any direction. The mound configuration is concluded to be nondispersive under the conditions simulated in LESSON 5.

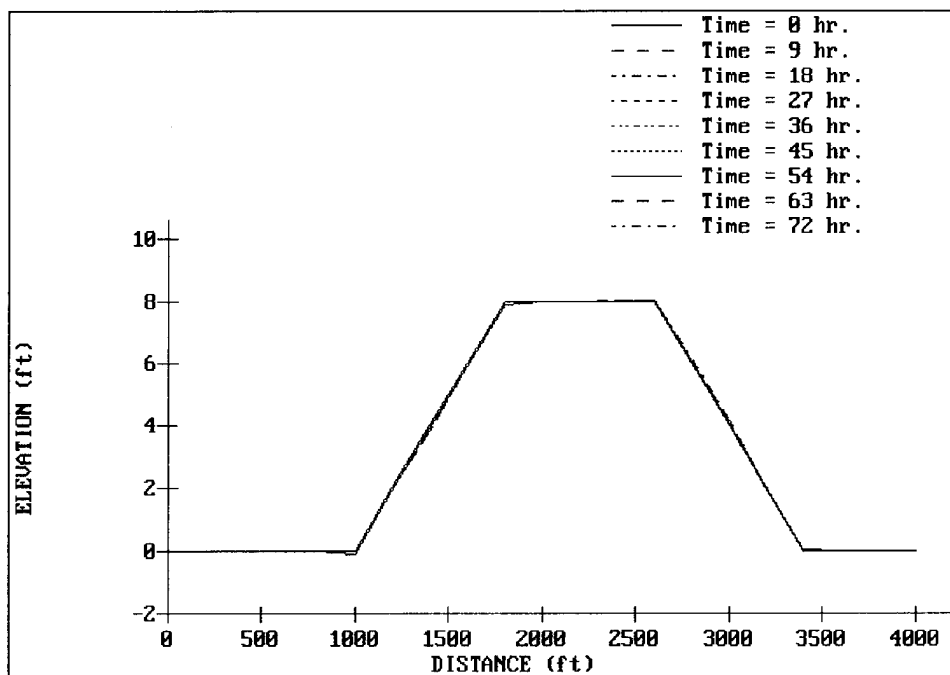


Figure 60. Mud Dump Site cross-sectional plot 1,500 ft below center line of grid

Recall that erosion was observed in bathymetric surveys of the existing Mud Dump Site under storm conditions similar to those simulated. The reason that the existing material eroded but the proposed disposal material is anticipated to be stable is that the material existing at the Mud Dump Site is significantly smaller than the material proposed for capping ( $\approx 0.06$  mm compared to 0.3 mm). If the LTFATE program is run with the same conditions but with a grain size of 0.06 mm instead of 0.3 mm, erosion will be observed (Scheffner 1989). This is left for an exercise by the user.

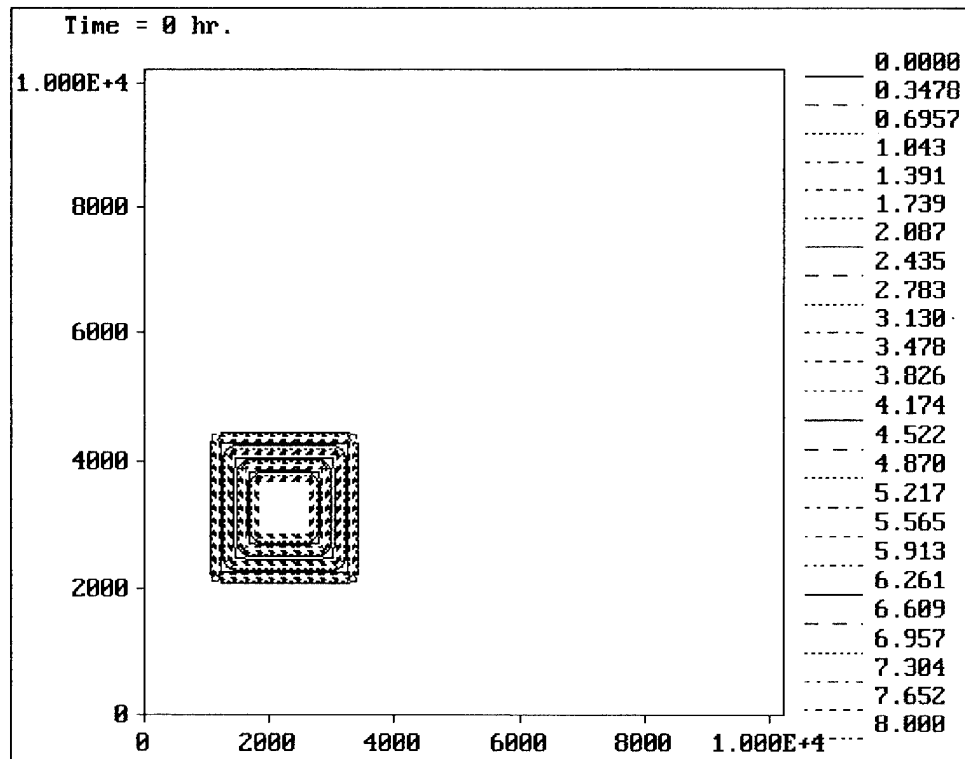


Figure 61. Initial mound contour of Mud Dump Site

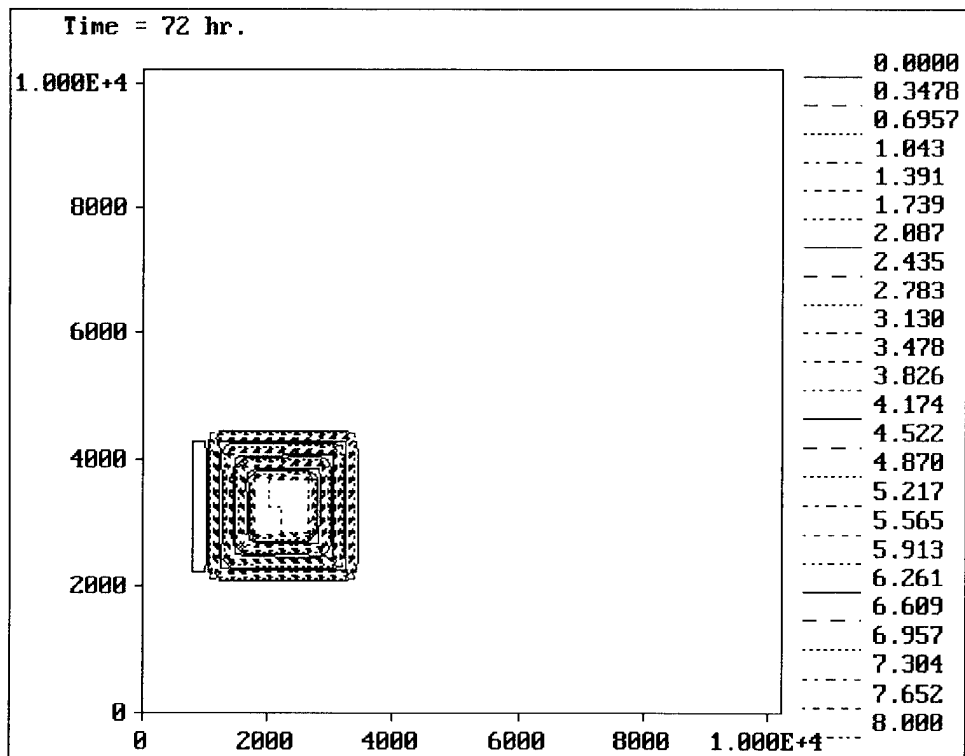


Figure 62. Simulated Mud Dump Site mound contour after 72 hr

## 4 Conclusions

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This report describes application of LTFATE, a numerical modeling system for systematically estimating the long-term response of a dredged material site, to local environmental forcings. The methodology is based on the development of user-accessible databases of wave and current time series and the subsequent application of these boundary conditions to coupled hydrodynamic, sediment transport, and bathymetry change models. The approach was developed to provide an estimate of long-term material fate for use in determining whether an existing or proposed disposal site will be dispersive or nondispersive over periods of time on the order of months to years.

The database of environmental forcings was developed to provide a means of defining realistic boundary conditions at a proposed or existing disposal site without the requirement of gathering prototype data. These databases have been used in the example applications presented in this report. However, as stated in the report, each of the required input files can be supplied by the user with the only stipulation being that the format of the data files must be identical to the corresponding formats presented in Appendix B of this report.

This report demonstrates application of the LTFATE model to a variety of applications ranging from long-term stability analyses to short-term storm surge computations. The examples presented serve to demonstrate the various capabilities of the LTFATE model as well as to provide input/output examples for user verification that the provided executable code is operating correctly. The modeling concept that accurate estimates of site behavior can be obtained if the computations are based on realistic wave, elevation, and current boundary conditions has been demonstrated. As with any model, improvements can be made which will enhance the operational capabilities of the model. Because this report represents the first release of the LTFATE model, user comments and suggestions are welcomed by the authors of the report. Similarly, any difficulties encountered in attempting to apply the model to specific applications should be reported to the authors.

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# Appendix A

## File Identification

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In this appendix, all files used in the three main packages are listed and described in the order of their use. These three packages are: PC\_WAVEFIELD, PC\_TIDAL, and PC\_LTFATE.

### PC\_WAVEFIELD Package

1. **LTD3.EXE** - PASCAL menuing program for PC\_WAVEFIELD.
2. **HPDSIM.EXE** - FORTRAN program used to simulate a wave height, period, and direction time series.
3. **HPDPRE.OUT** - Matrix of coefficient multipliers which contains the statistical correlation of the wave field parameters for a Wave Information Studies (WIS) station (this database is automatically accessed by program HPDSIM.EXE).
4. **HPDSIM.OUT** - Database of wave height, period, and direction generated by program HPDSIM.EXE.
5. **HPDCOMPR.EXE** - FORTRAN program used to statistically analyze data stored in HPDSIM.OUT.
6. **HGT\_HIST.DAT** - Wave height histogram database generated by HPDCOMPR.EXE.
7. **PER\_HIST.DAT** - Wave period histogram database generated by HPDCOMPR.EXE.
8. **DIR\_HIST.DAT** - Wave direction histogram database generated by HPDCOMPR.EXE.
9. **HGT\_TIM.DAT** - Wave height time series database generated by HPDCOMPR.EXE.
10. **PER\_TIM.DAT** - Wave period time series database generated by HPDCOMPR.EXE.
11. **DIR\_TIM.DAT** - Wave direction time series database generated by HPDCOMPR.EXE.
12. **HIST.EXE** - FORTRAN program used to create the histogram graphic output by accessing the database stored in files 6-8 above.
13. **HPDT.EXE** - FORTRAN program used to create the time series graphic output by accessing the database stored in files 9-11 above.

### PC\_TIDAL Package

1. **LTD5.EXE** - PASCAL menuing program for PC\_TIDE.
2. **TIDE.EXE** - FORTRAN program used to generate an arbitrary length of tidal elevation, current, and direction time series based on a database of tidal constituents.
3. **TIDAL.DAT** - Database of tidal constituents accessed by program TIDE.EXE.
4. **TIDE.DAT** - Tide elevation, current, and direction time series generated by program TIDE.EXE.
5. **TDPL.EXE** - FORTRAN program used to create the time series graphic output by accessing database stored in TIDE.DAT.

#### PC\_LTFATE Package

1. **LTD4.EXE** - PASCAL menuing program for PC\_LTFATE.
2. **TOPO.EXE** - FORTRAN program used to generate an initial bottom geometry file for input to program PCDREDGE.EXE.
3. **PCDREDGE.EXE** - FORTRAN program used to simulate the long-term (up to 1-year) movement of noncohesive bed materials, this program automatically accesses the wave height, period, and direction time series, and the tide database stored in files HPDSIM.OUT and TIDAL.DAT, respectively.
4. **PCDDF2.DAT** - Database of void ratio versus effective stress for sand and clay mixture (SC), used for consolidation purposes.
5. **PCDDF3.DAT** - Database of void ratio versus effective stress for inorganic clays (CH), used for consolidation purposes.
6. **PCDDF4.DAT** - Database of void ratio versus effective stress for organic clays (OH), used for consolidation purposes.
7. **PCDREDGE.OUT** - Database of time series of wave, tide, current, consolidation, and sediment transport parameters output from the simulation model PCDREDGE.EXE.
8. **PLOTBATH.DAT** - Database of evolved seafloor geometry generated by the simulation model PCDREDGE.EXE.
9. **CONTOUR.EXE** - FORTRAN program used to create the seafloor contour graphic output by accessing the database stored in file PLOTBATH.DAT.
10. **XY.EXE** - FORTRAN program used to create the seafloor cross-sectional graphic output by accessing the database stored in file PLOTBATH.DAT.

# Appendix B

## Required Input

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In this appendix, the input files (HPDSIM.OUT, TIDAL.DAT, and STORM.DAT) used to run the long-term fate model in the examples given in the text are listed. The following summarize the input parameters of each file and their respective formats for use in constructing user-supplied files.

**HPDSIM.OUT:** Nine lines of dummy header information followed by sequential lines of year, month, day, and hour (date information is not read in the program; however, the data must correspond to a 3-hr-increment time series) followed by the variables **H** (wave height in meters) and **TDEEP** (wave period in seconds) and direction (not used by the program). These two variables are read from a `FORMAT(14X,2F12.5)` statement. If the user constructs an HPDSIM.OUT file, the data must be placed according to this format.

**TIDAL.DAT:** Two lines of informational data are followed by the variables **NHARM**, **H0**, **U0**, and **V0** representing the number of harmonic constituents in the file, and the average elevation (meters), **U** and **V** velocity components (cm/sec) corresponding to the harmonic analysis. One additional line of information is then followed by the constituent data for each constituent. These data are **SPEED(M)** (speed of constituent **M** in deg/hr), **AH(M)** (elevation amplitude of constituent **M** in meters), and **EH(M)** (phase of constituent **M** in deg). Speed, amplitude, and epoch data are read from a `FORMAT(10X,F10.6,6F10.2)` statement. If the user constructs a TIDAL.DAT file, the data must be placed according to this format.

**STORM.DAT:** Storm data are contained in a sequential file containing the date (time data is not read in the program; however, the data must correspond to a 3-hr increment time series) followed by **HS** (storm wave height in meters), **TS** (storm wave period in sec), **SU** (storm surge **U** velocity component in cm/sec), **SV** (storm surge **V** velocity component in cm/sec), and **SRG** (surge surface elevation in meters). The above wave and surge data are read in according to a `FORMAT(19X,2F10.3,3F9.3)`. When the user constructs a STORM.DAT file, the data must be placed according to this format.

The following three pages list the data, or portions thereof, used in the examples presented in the text of this report. As stated above, user-constructed input files must contain the data described above (in bold) and must be in the format described above and shown in the following file examples.

# HPDSIM.OUT

START MO = 3 START YR =1987 END MO = 8 END YR =1987

NYR,NNY,NMO= 20 20 12

IYEARS= 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

MONTHS= 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

CUTOFF= 0.083333 0.083333 0.083333 0.083333 0.083333

CUTOFF= 0.083333 0.083333 0.083333 0.083333 0.083333

CUTOFF= 0.083333 0.083333

IJY= 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

IJM= 1 2 3 4 5 6 7 8 9 10 11 12

|            |         |         |           |
|------------|---------|---------|-----------|
| 198703 100 | 1.00000 | 5.00002 | 343.83057 |
| 198703 103 | 1.10000 | 5.00000 | 35.42109  |
| 198703 106 | 1.20000 | 5.00001 | 52.58537  |
| 198703 109 | 1.20000 | 5.00000 | 58.00993  |
| 198703 112 | 1.20000 | 5.00000 | 53.44814  |
| 198703 115 | 1.10000 | 5.00000 | 36.73721  |
| 198703 118 | 1.00000 | 5.00000 | 340.76096 |
| 198703 121 | 0.90000 | 5.00000 | 293.34930 |
| 198703 200 | 0.80000 | 5.00000 | 283.34152 |
| 198703 203 | 0.76876 | 5.00000 | 279.52328 |
| 198703 206 | 0.70000 | 5.00000 | 277.62357 |
| 198703 209 | 0.60000 | 5.00001 | 276.96350 |
| 198703 212 | 0.60000 | 5.00000 | 276.80725 |
| 198703 215 | 0.70000 | 5.00001 | 277.28809 |

|            |         |         |          |
|------------|---------|---------|----------|
| 1987082903 | 0.90000 | 6.00001 | 81.11949 |
| 1987082906 | 0.90000 | 6.00002 | 81.50021 |
| 1987082909 | 0.90000 | 5.00002 | 81.90755 |
| 1987082912 | 0.80001 | 5.00003 | 82.21406 |
| 1987082915 | 0.80000 | 5.00001 | 82.76773 |
| 1987082918 | 0.70000 | 5.00002 | 83.25628 |
| 1987082921 | 0.60000 | 5.00000 | 83.61486 |
| 1987083000 | 0.60000 | 5.00000 | 83.84423 |
| 1987083003 | 0.60000 | 5.00002 | 83.97083 |
| 1987083006 | 0.50000 | 5.00001 | 84.04659 |
| 1987083009 | 0.50000 | 5.00001 | 84.10904 |
| 1987083012 | 0.50000 | 5.00000 | 84.17479 |
| 1987083015 | 0.50000 | 5.00000 | 84.23292 |
| 1987083018 | 0.50000 | 5.00000 | 84.25816 |
| 1987083021 | 0.60000 | 5.00003 | 84.26725 |
| 1987083100 | 0.80000 | 5.00003 | 84.27031 |
| 1987083103 | 0.90000 | 5.00002 | 84.25816 |
| 1987083106 | 1.00000 | 6.00002 | 84.21492 |
| 1987083109 | 1.10000 | 6.00001 | 83.96118 |
| 1987083112 | 1.10000 | 6.00001 | 83.34565 |

TIDAL.DAT

MOBILE, ALABAMA

TIDAL HEIGHT HARMONIC CONSTITUENTS (CM/SEC)

6 0.0 -5.8 -10.4

CONST SPEED-D/H AMP-M EPOCH-D AMP-C/S EPOCH-D  
AMP-C/S EPOCH-D

|    |           | HEIGHT |        | VEL-U |      | 6 VEL-V   |
|----|-----------|--------|--------|-------|------|-----------|
| M2 | 28.984104 | .01    | 321.00 | 4.3   | 46.  | 6.7 41.   |
| S2 | 30.000000 | .01    | 309.60 | 1.2   | 47.  | 1.8 5.    |
| N2 | 28.439730 | .00    | 339.10 | 0.6   | 317. | 1.2 255.  |
| K1 | 15.041069 | .13    | 325.70 | 8.5   | 229. | 14.3 231. |
| O1 | 13.943036 | .12    | 313.30 | 6.7   | 242. | 10.4 235. |
| M1 | 14.492754 | .00    | 332.80 | 0.6   | 330  | 0.6 346   |

\*\*\*\*\*

# STORM.DAT

|      |    |         |       |        |         |        |        |
|------|----|---------|-------|--------|---------|--------|--------|
| 1992 | 12 | 10 0058 | 0.587 | 3.303  | 1.283   | -1.029 | -0.631 |
| 1992 | 12 | 10 0358 | 0.713 | 3.657  | -11.746 | 5.249  | -0.042 |
| 1992 | 12 | 10 0658 | 0.617 | 3.950  | -8.970  | 2.484  | 0.974  |
| 1992 | 12 | 10 0958 | 0.640 | 3.950  | 15.371  | -6.767 | 0.612  |
| 1992 | 12 | 10 1258 | 1.227 | 4.603  | 11.700  | -0.332 | -0.083 |
| 1992 | 12 | 10 1558 | 1.960 | 5.773  | 11.070  | 3.875  | -0.145 |
| 1992 | 12 | 10 1858 | 2.680 | 6.530  | 1.812   | 9.438  | 1.092  |
| 1992 | 12 | 10 2158 | 3.310 | 7.537  | 35.848  | -3.268 | 1.430  |
| 1992 | 12 | 11 0058 | 4.413 | 8.583  | 34.661  | 5.860  | 0.537  |
| 1992 | 12 | 11 0358 | 5.823 | 9.393  | 34.234  | 10.289 | 0.980  |
| 1992 | 12 | 11 0658 | 6.487 | 10.370 | 27.784  | 14.622 | 2.003  |
| 1992 | 12 | 11 0958 | 6.603 | 10.923 | 52.071  | 6.636  | 2.281  |
| 1992 | 12 | 11 1258 | 7.643 | 11.573 | 46.666  | 11.619 | 1.872  |
| 1992 | 12 | 11 1558 | 8.513 | 12.500 | 49.369  | 6.463  | 0.984  |
| 1992 | 12 | 11 1858 | 7.650 | 13.097 | 12.558  | 19.718 | 0.936  |
| 1992 | 12 | 11 2158 | 6.430 | 13.693 | 20.555  | 10.345 | 2.341  |
| 1992 | 12 | 12 0058 | 6.153 | 14.290 | 36.161  | 4.061  | 0.523  |
| 1992 | 12 | 12 0358 | 6.020 | 13.097 | 12.441  | 18.746 | 0.531  |
| 1992 | 12 | 12 0658 | 5.757 | 12.500 | 30.896  | 9.669  | 1.131  |
| 1992 | 12 | 12 0958 | 5.730 | 11.793 | 22.304  | 10.377 | 1.615  |
| 1992 | 12 | 12 1258 | 5.793 | 12.387 | 31.853  | 4.810  | 1.106  |
| 1992 | 12 | 12 1558 | 5.153 | 12.500 | 24.369  | 11.801 | -0.009 |
| 1992 | 12 | 12 1858 | 5.730 | 12.500 | 12.598  | 16.417 | 0.937  |
| 1992 | 12 | 12 2158 | 5.290 | 11.800 | 24.480  | 6.880  | 1.395  |

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