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INTERIM REPORT

on

Contract Number NAS8-29100

WATER RESOURCES PLANNING FOR RIVERS DRAINING INTO MOBILE BAY

A USERS' MANUAL FOR THE TWO DIMENSIONAL HYDRODYNAMIC MODEL

by

Samuel Ng, Graduate Assistant
and
Gary C. April, Principal Investigator

Prepared for

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

January 1976

BER Report No. 203-112

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I. Introduction

In order to better understand and explain the complex, interactive effects influencing water movement and water quality in natural systems, several mathematical models based on the laws of conservation of mass, momentum and energy have been developed (1-7). Models describing the hydrodynamic and material transport behavior of Mobile Bay have been formulated and tested under a National Aeronautics and Space Administration, Environmental Applications Branch Contract (NAS8-29100).

This booklet shows the way in which the model describing water movement and tidal elevation is formulated, computed and used to provide basic data about the system. Mobile Bay is used in a case study with comments as to how the formulations might be expanded or focused to describe other areas which qualify under the model restrictions and assumptions.

The hydrodynamic model, as it will be called throughout the booklet, is based on two-dimensional, unsteady flow equations. The water mass is considered to be reasonably mixed such that integration (averaging) in the depth direction is a valid restriction. Convective acceleration, the Coriolis force, wind and bottom interactions are included as contributing terms in the momentum equations. The equations which makeup the hydrodynamic model include the continuity, x-momentum and y-momentum equations (Table 1).

Table 1.--Mathematical Representation and Operational Modes of the Physical Models for Mobile Bay

Name	Equation Form	Results	Modes
Continuity	$\frac{\partial Q_x}{\partial x} + \frac{\partial Q_y}{\partial y} + \frac{\partial H}{\partial t} = -(R + E)$	Tidal Height	Tidal Cycle Daily Avg Monthly Avg Seasonal
Momentum x-Component	$\frac{\partial Q_x}{\partial t} + gD\frac{\partial H}{\partial x} = KV^2\cos\psi - fQQ_xD^{-2} + Q_x(2W\sin\varphi)$	x-Component of Surface Current	Tidal Cycle Daily Avg Monthly Avg Seasonal
y-Component	$\frac{\partial Q_y}{\partial t} + gD\frac{\partial H}{\partial y} = KV^2\sin\psi - fQQ_yD^{-2} + Q_y(2W\sin\varphi)$	y-Component of Surface Current	Tidal Cycle Daily Avg Monthly Avg Seasonal

Results can be calculated for unsteady flow when boundary conditions are available as a function of time (dynamic), or for quasi-steady flow when conditions are stable for a time period encompassing several tidal cycles or longer periods (i.e. weekly, monthly, seasonally or yearly averages).

The solution of the equations shown in Table 1, applied to Mobile Bay, have been used to investigate the influence that river discharge rate, wind direction and speed, and tidal condition have on water circulation and holdup within the bay. Storm surge conditions, oil spill transport, artificial island construction, dredging and areas subject to flooding are other topics which could be investigated using the mathematical modeling approach.

To understand how the model might be applied to these topics, this booklet is subdivided into four parts for the convenience of the reader. These are, in order:

- Basic Concepts in Appling the Hydrodynamic Model to a Real System
- Model Input Requirements
- A Detailed Illustration: Application to Mobile Bay
- Hydrodynamic Model: Program Listing

Each section will be discussed separately, however, it is advisable that they be covered sequentially during the first reading to reinforce the basic concepts needed to understand and apply the model.

II. Basic Concepts in Applying the Hydrodynamic Model to a Real System

The detailed mathematical development of the model will not be discussed here. Reference to "A Hydrodynamic and Salinity Model for Mobile Bay," BER Report No. 168-112 (NAS8-29100), January 1974, by D. O. Hill and G. C. April is suggested for those interested in such a treatment. The model equations used throughout this booklet are those mentioned previously (Table 1, page 1).

The model system used for illustrative purposes in this section resembles that of Mobile Bay. Some features have been added/deleted to include features of the model not necessarily applicable to the Mobile Bay system. Users of the model should become familiar with the terminology and methodology discussed in this section. This information will be particularly helpful (a) in specifying the kind and form of data needed to execute the model for a specific system (Section III, page 17) and (b) in interpreting results calculated by the model (Section IV, page 26).

A. Real System Data

Before a mathematical model can be formulated, knowledge of the system to which the model is applied must be obtained. This includes both formal (recorded) and informal (experience) data. Some of the sources of data are discussed in this section.

1. Area Maps - Maps showing the geographical and navigational features of the system to be modeled are valuable sources of data. From these maps (or charts) information about the shape and size of the water mass, river entrances, natural and man-made passes, marshes adjacent to the water mass, sand bars and islands, channels, etc. can be identified and located.

2. Bathemetric Charts - The depth of water in an estuary can be found in navigation maps or ocean survey charts. Mean sea level is usually chosen as the reference plane on these charts. If the source of data uses a different reference plane, adjustments to mean sea level must be made. Some additional references used in charts are mean high water and mean low water.

3. Tidal Information - Tide heights are taken from appropriate tidal charts. Data measured by gauging devices near the system boundaries are preferred. However, when the system interacts with the open sea, standard tidal periods for the open sea can be used. Conversion of the data must be made to coincide with the model reference plane - mean sea level. The converted data can then be represented by a least squares method using a Fourier series of the form:

$$HXX = C1 + C2 * COS (C3 * t + C4)$$

where

HXX is the elevation of water above the reference plane

C1 is a constant used to adjust the x-axis to a plane of symmetry

C2 is a constant related to the tidal amplitude

C3 is the tidal frequency

C4 is the phase angle

t is the time

4. Wind Data - Tabulated data and data obtained from wind charts are provided by the weather bureau. When the system is large (i.e. Mobile Bay) wind conditions at several locations over the bay are necessary. This, however, is often impossible data to find and good judgement must be used when considering wind effects in the model. For periods of relatively steady wind direction and speed, no problem is encountered. Likewise, when trend analyses for long periods of time (i.e. monthly, seasonally, etc.) are desired, averaging methods can be used with good accuracy. However, when wind conditions are highly variable over short spans of time, the data frequency, precision and accuracy becomes critical. As a rule of thumb, wind speeds below 10 knots are considered to have little influence on the hydrodynamics, while winds approaching 15-25 knots can have pronounced effects on water movement and holdup in the system.

5. River Discharges - River flow information is usually available from state geolcgical surveys and/or United States surveys. When the system is located in a coastal region where navigation is prevalent, data on river flows may also be available in U. S. Corps of Engineer files. These data sources may not coincide with system boundaries requiring good engineering judgement in their interpretation and application.

B. Model System Features

Once the real system is known and the area of interest defined, the next step in the process deals with the construction of a model system having all of the features of the real one. Because the model is governed by computational laws and rules, the model system will only approximate the real system. Care, however, must be exercised to include as many of the important features of the real system as is economically feasible. Obviously, the real system can be exactly duplicated if the model dimensions are made to coincide with real system dimensions. However, computation time would become increasingly prohibitive. Once again good judgement must be exercised.

1. Model Dimensions: Grid Size - The choice of the grid size to be used in the model is a function of (a) the real system size, (b) the time increment for which a solution is desired and (c) the available computer and its costs (Figure 1). There is a direct relationship between the incremental time for which a solution is desired, model system grid size and real system depth dimensions. This is expressed in the form of a stability criteria relationship of the form:

$$t < \frac{\Delta S}{\sqrt{2gH_{max}}}$$

where H_{max} is the maximum water depth encountered in the system

g is the gravitational constant

ΔS is the grid dimension

t is the incremental time for which a solution can be specified to insure stability

The total number of grids should not exceed 2500. Since the time increment plays an important role in the total computation time, the number of grids selected is often constrained to keep computer time reasonable. Thus, final selection of the grid size for a system requires justification among the following variables:

a) size of the real system

b) time increment over which results are desired

c) economy (computer time).

2. Water Cell Segments - Water cells on each row are separated into segments by land cells encountered on a given row. For example, water cells on row 4 in Figure 2 are separated into two segments as are the cells on row 9. The water cells for most parts of the bay are segmented only once (as in row 7, Figure 2.) A water cell segment is labeled by the left most (IBNDL) and right most (IBNDR) cell numbers.

3. Sea Boundaries - Boundaries adjacent to open seas are defined as sea boundaries. These boundaries are classified into four categories (Figure 3).

. left sea boundaries (SL)

. right sea boundaries (SR)

. top sea boundaries (ST)

. bottom sea boundaries (SB)

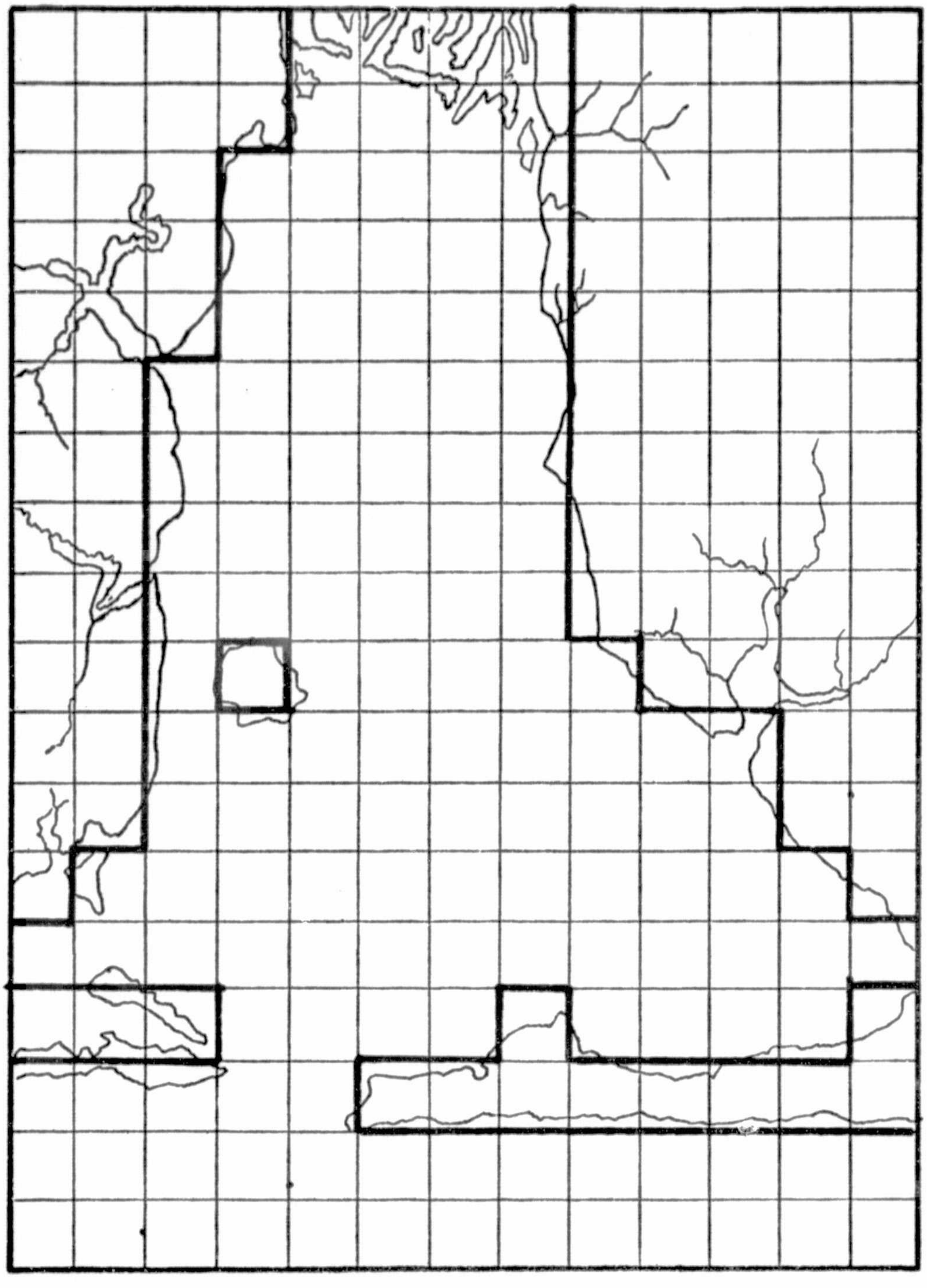


Fig. 1 - Grid

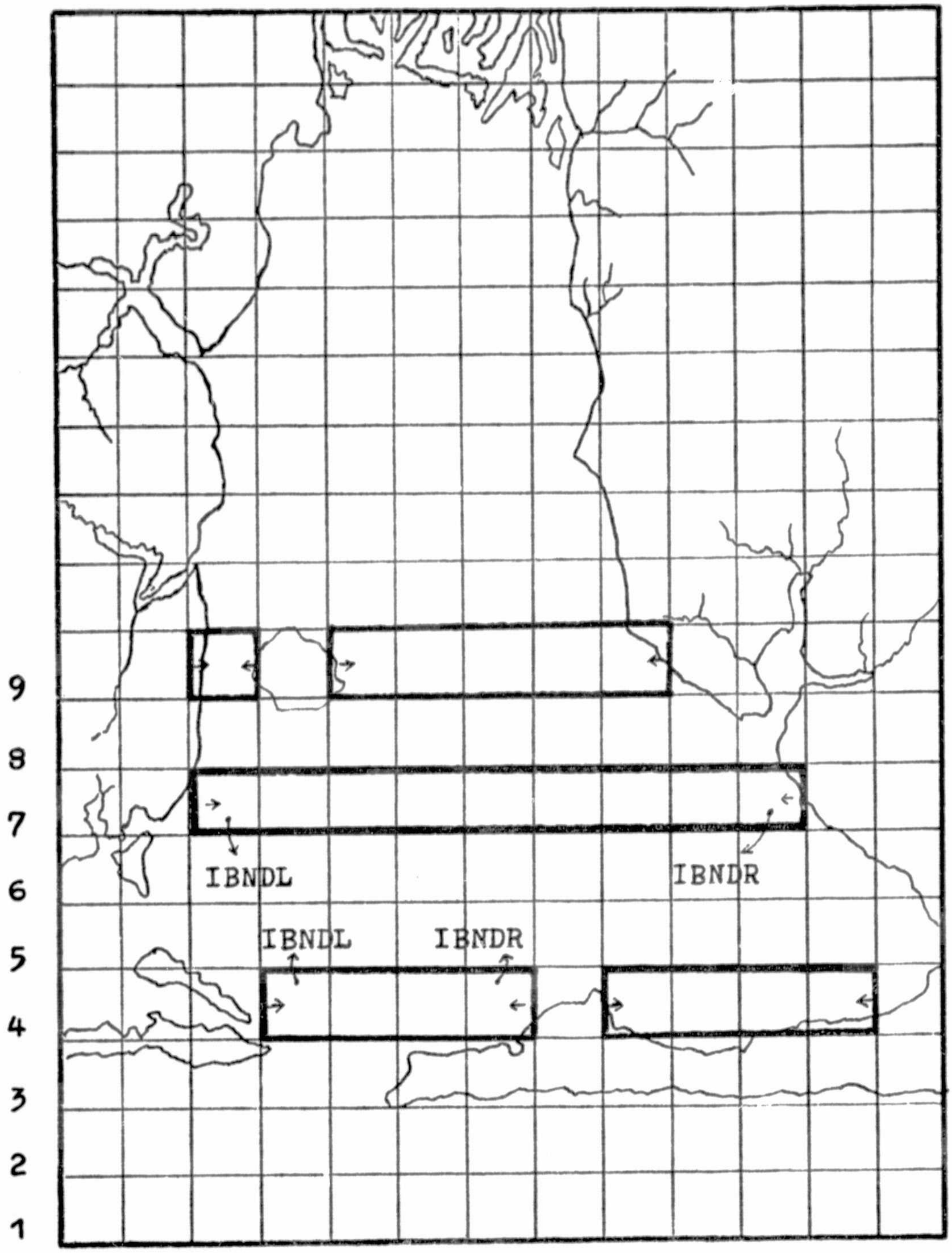
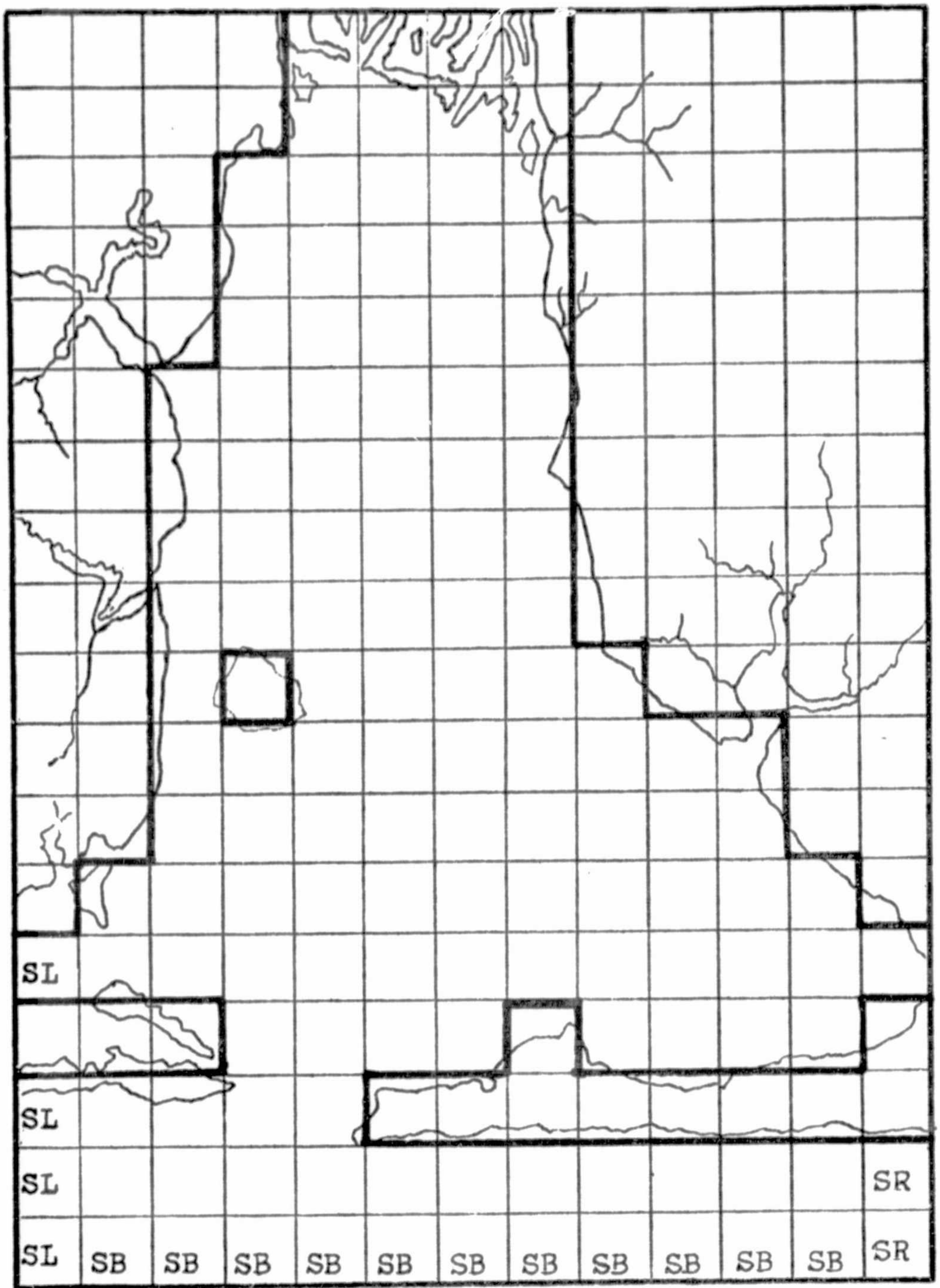


Fig. 2 - Water Cell Segments



Note: There are no ST boundaries in this example.

Fig. 3 - Sea Boundaries

Left and bottom sea boundaries are considered to be tidal driven boundaries. These are the source of the tidal driving force which interacts with the estuary.

Necessary inputs for sea boundaries include type, total number of cells, cell numbers, and tidal conditions which drive the model through the tidal cycle.

4. River Boundaries - River boundaries are boundaries where streams enter the system, and/or marsh areas adjoining the main water system are located. River discharge cells are separated into four categories (Figure 4):

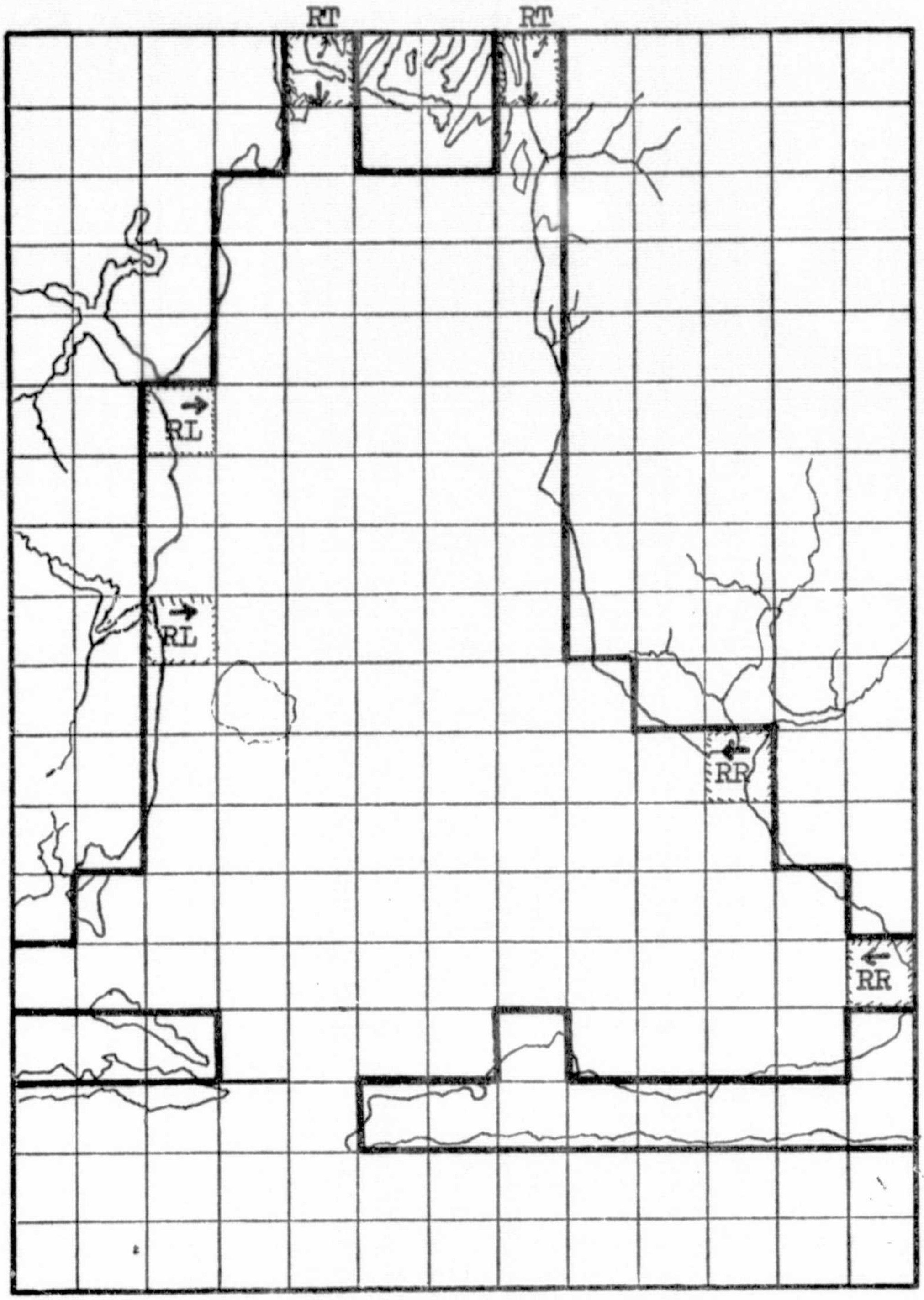
- left river boundaries (RL)
- right river boundaries (RR)
- top river boundaries (RT)
- bottom river boundaries (RB)

Necessary inputs for river boundaries include type, total number of cells, cell number and information relating the discharge rate into the system.

River discharge rates are usually modified to reflect the influence that each river entrance has on the main water movement (i.e. usually expressed in terms of cubic feet per second per foot of cell dimension). An alternate approach is available, however, when rivers are located adjacent to marshes.

River-marsh boundaries are boundaries designed to simulate the action occurring in areas which undergo rapid changes in stream dimension, velocity and hence discharge rate. By including overflow weir equations along the river course through a marsh area, drainage into or from the marshes can be regulated to produce a known water condition within the entrance cell. The marsh area serves as a capacitance element which stores river water (Figure 5a, page 11) when tidal conditions (flood) retard its entrance into the estuary, and supplies river water when tidal conditions (ebb) are less restrictive. This method also allows a constant and true river discharge to be introduced instead of the adjusted value required if marsh interaction is omitted.

River-marsh boundaries are only allowed on the top part of the estuary with the weir boundaries parallel to the y-axis. Choice of weir heights is a trial and error process depending on the tidal influence and size of the system under investigation.



Note: There are no RB boundaries in this example.

Fig. 4 - River Boundaries

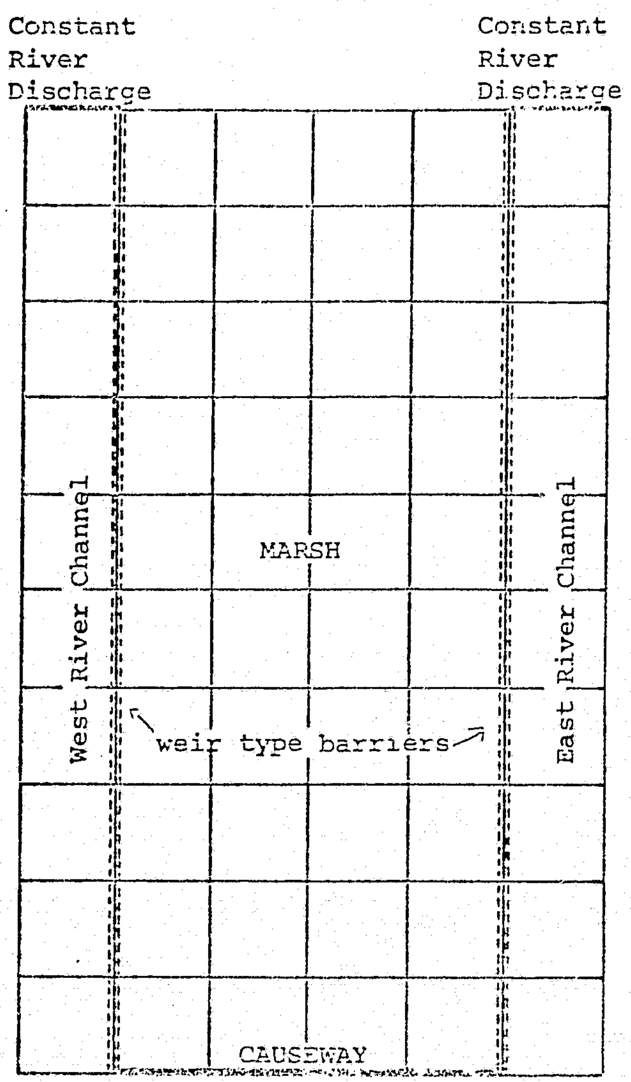


Fig. 5a - River-marsh Area in the Northern Mobile Bay Area.

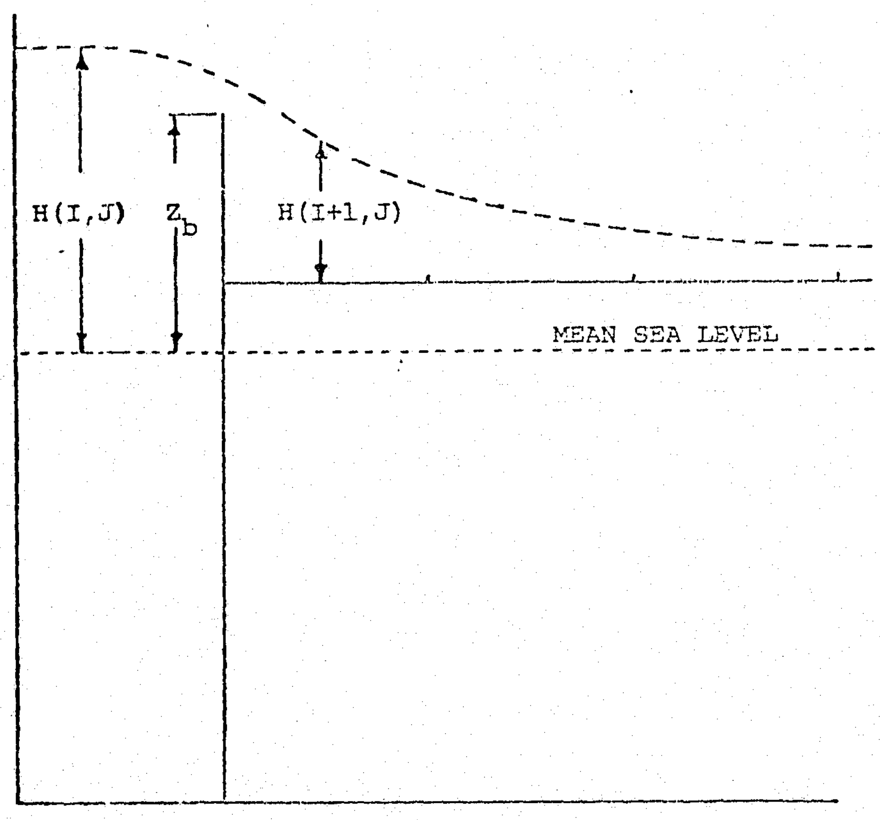


Fig. 5b - Weir Arrangement for the River-marsh Area.

5. <u>Ship Channels</u> - Channels exist in many estuary systems. The right side and/or top edge of the water cell nearest the channel are used to describe the existence of a channel passing through the water mass. The axis (either x or y) of the channel, and the depth of the spoil bank are the data necessary for the program to describe the influence of the channel. For example, channel section A in Figure 6 is described by cell 69y and 82y while channel section B is described by cell 83x.

6. <u>Bottom Roughness</u> - Bottom friction also affects flow characteristics and requires input of information. Manning's equation is used in the program to evaluate bottom frictions. Variations of bottom roughness are estimated by altering the Manning coefficients which best describes the kind of bottom located in each cell. These coefficients usually vary from 0.010 to 0.050. Marsh areas which have low flow rates may have a value close to 0.050. Oyster beds, channels and spoil banks may also have relatively high bottom friction coefficients.

7. <u>Passes</u> - The general program has the ability to calculate flow rates through vertical and horizontal passes (Figure 7). Flow rates through passes which are neither vertically or horizontally located can be calculated by arranging imaginary passes which have cells in a row or a column close to the real pass. A total material balance which involves water through the passes and water discharged by rivers over a tidal cycle provides a means of verifying the model of a system.

8. <u>Cell Modifications</u> - Cell modifications are used in the calibration phase of the study to adjust calculated results in a way that more closely agrees with observed behavior in the real system. These modifications are especially needed to introduce effects which cannot be represented by the model. For example, the channel dimensions are usually small relative to the dimensions of the estuary through which it passes. Selection of the grid size to affect solution of the model equations may seriously neglect a strong local effect caused by the channel. When these strong, but unseen (from a model point-of-view) effects are observed, cell modifications during calibration permits the incorporation of the effects. Two ways to introduce modifications include adjustments to bottom friction factors, and the inclusion of underwater barriers which restrict flow (Figure 8).

Section II presented some of the terminology and definitions used in the establishment of a model system. Section III includes a detailed listing of the variables, which, when introduced into the model program, permit one to approximate the real system. These variables are given by name, computer label and function. Their use will become more clear in Section IV where they are used to describe the Mobile Bay system.

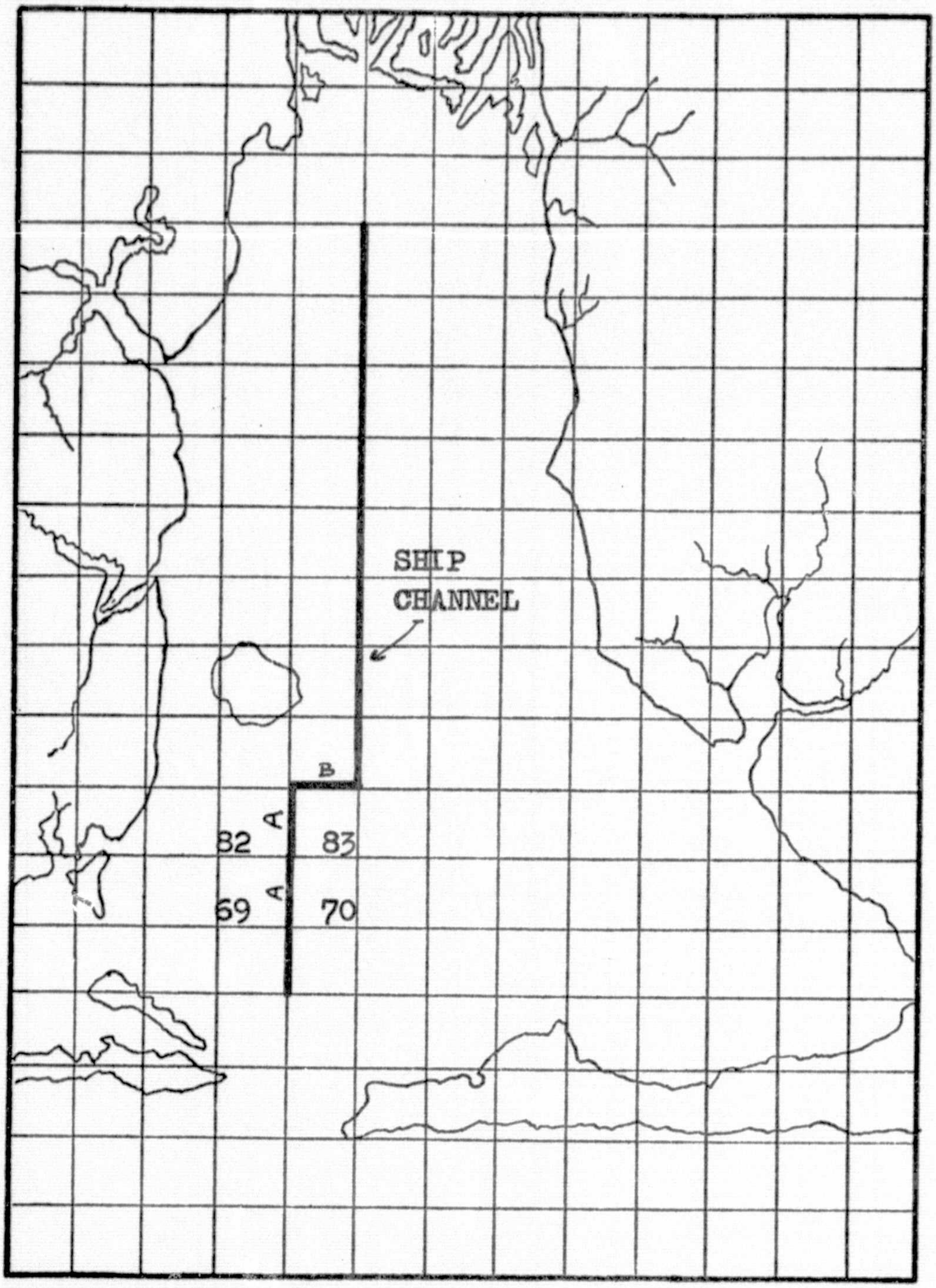


Fig. 6 - Ship Channel

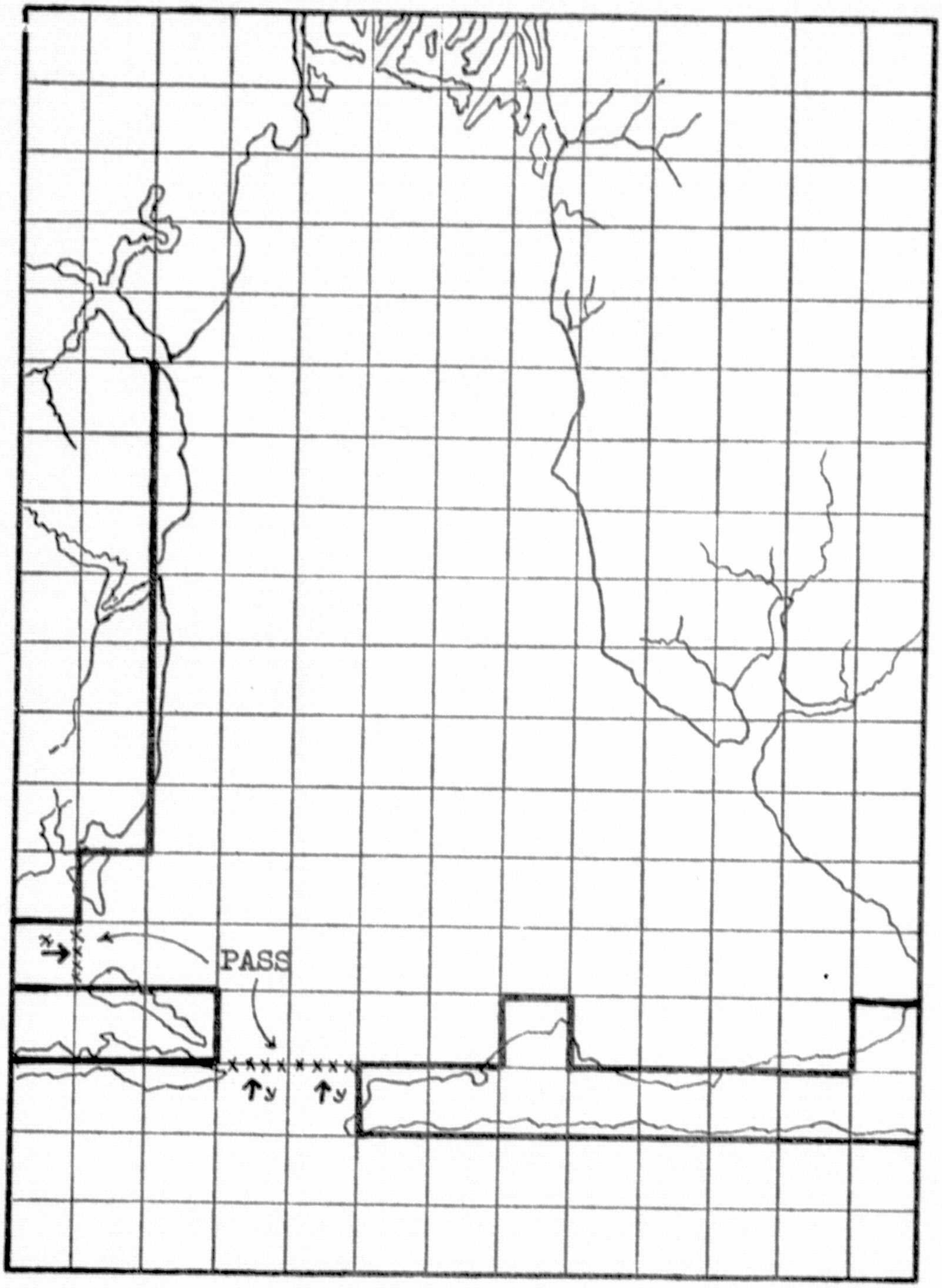


Fig. 7 - Passes

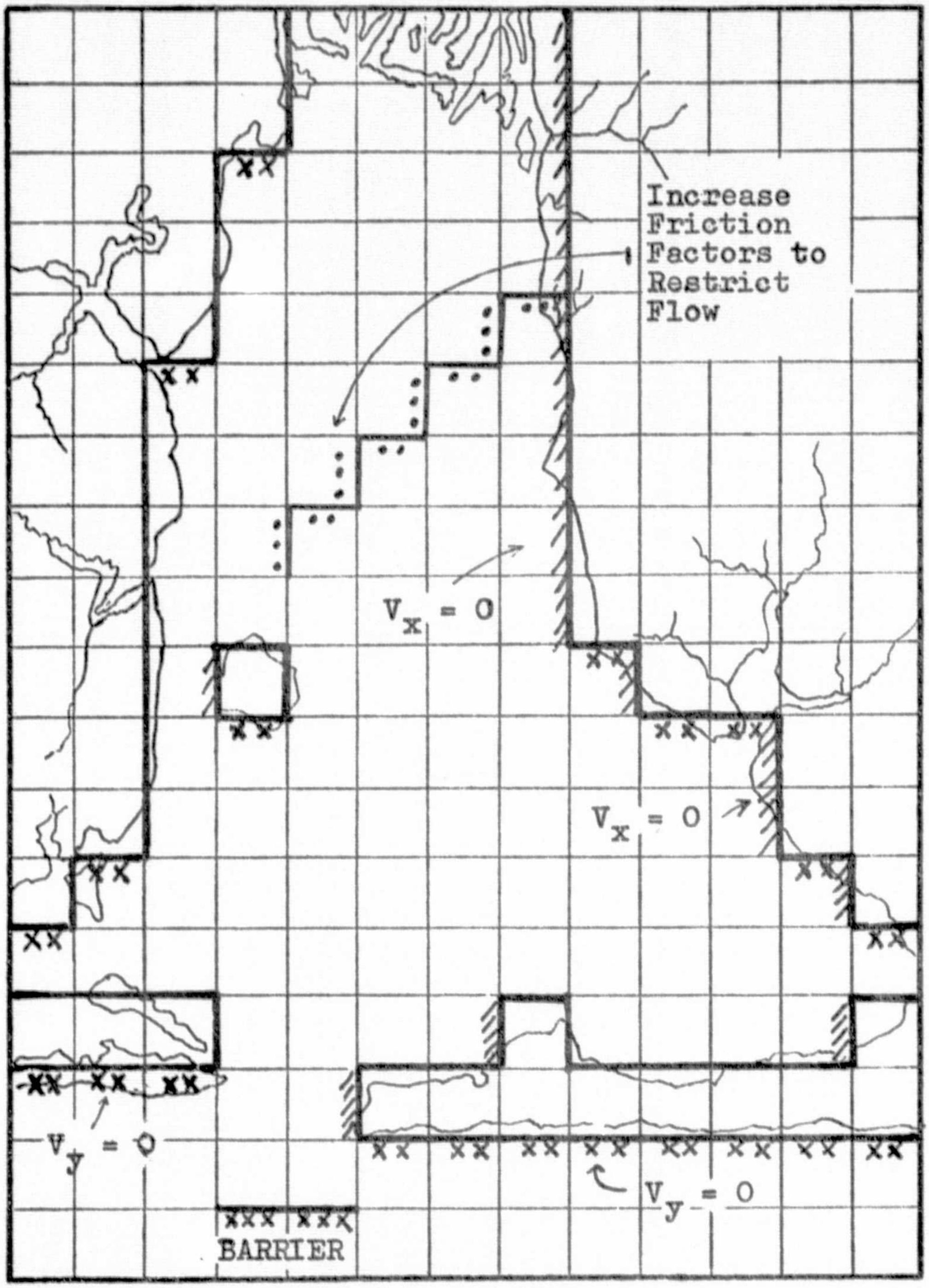


Fig. 8 - Cell Modifications

III. Model Input Requirements

This section lists all the necessary input variables, formats of the input variables, and necessary remarks for defining and using the variables to establish a model. The information is presented in the order in which it is introduced into the computer. Cross reference of material in Section III with the illustration in Section IV is recommended to better understand the function of each variable.

Program Input

1. Input #1 - Program Control Card
   Format: (11I2) Right Justified Integer Number

Column	Variables	Remark
1-2	IFMT	Ø, 5 or 6; control for width of print field Ø = default to 6 print positions 5 = print field width will be 5 print positions 6 = print field width will be 6 print positions
3-4	ICORF	Ø or 1; control for Coriolis force calculation Ø = Coriolis force equal to Ø 1 = Coriolis force equal to 0.0007.7
5-6	ICONV	Ø or 1; control convective acceleration calculation Ø = skip convective acceleration calculation 1 = perform convective acceleration calculation
7-8	IORIG	Ø or 1; control for resistance term calculation Ø = skip resistance term calculation 1 = perform resistance term calculation
9-10	IRMB	Ø or 1; does the estuary system have river marsh boundaries? Ø = no river marsh boundary 1 = perform river marsh boundary calculation
11-12	ISPBK	Ø or 1; spoil bank calculation for ship channels Ø = no ship channel 1 = perform spoil bank calculation for ship channels
13-14	IDSCH	Ø or 1; control for discharge rate calculation Ø = skip discharge rate calculation 1 = calculate discharge rate at specified location
15-16	IMODF	Ø or 1; control for friction factor modification Ø = use default value of 1 1 = modify the friction factors of specified cells

17-18	ICK	Ø or 1; read control for velocities from previous run Ø = first run, skip the read statement 1 = read velocities from previous run
19-20	IMNDP	Ø or 1; printing control for manning factors and initial depths Ø = skip printing 1 = print manning factors and initial depth
21-22	INC	Integer number; print interval 1,2,3, or ... = print intermediate velocities, heights, etc. after the specified number of increments of time

2. Input #2 - Geometrical Information
   Format: (7I5) Right Justified Integer Number

Column	Variables	Remark
1-5	ISB	Number of total water cell segments; maximum number 200.
6-10	IROW	Number of rows; maximum number 200.
11-15	IV	Number of cells that require zeroing of velocity in y-direction; maximum number 250.
16-20	IU	Number of cells that require zeroing of velocity in x-direction; maximum number 250.
21-25	IR	Number of rivers being considered; maximum number 20.
26-30	NC	Total number of cells; maximum number 2500.
31-35	NCPR	Number of cells per rows.

3. Input #3 - Physical Information
   Format: (6F10.3) Right Justified Real Number with Three Decimal Digits or Number with Decimal Point

Column	Variables	Remark
1-10	W	Wind velocity in ft/sec.
11-20	THETA	Wind direction measured from x-axis counter-clockwise.
21-30	DELS	Grid size in ft. (square grid).
31-40	DELT	Time increment in sec.

41-50	TIM	Maximum time for run in hour.
51-60	SLADJ	Sea level adjustment; reference plane is mean sea level.

4. Input #4 - Left Boundary Cells of Water Cell Segments
Format: (16I5) Right Justified Integer Number

Column	Variables	Remark
1-5	IBNDL(1)	IBNDL is the cell number of the left most cell in a segment.
6-10	IBNDL(2)	Repeat as many times as total number of segments.

5. Input #5 - Right Boundary Cells of Water Cell Segments
Format: (16I5) Right Justified Integer Number

Column	Variables	Remark
1-5	IBNDR(1)	IBNDR is the cell number of the right most cell in a segment.
6-10	IBNDR(2)	Repeat as many times as total number of segments.

6. Input #6 - Cells that Require Zeroing of Calculated Velocity in y-Direction
Format: (16I5) Right Justified Integer Number

Column	Variables	Remark
1-5	IBC(1)	IBC is the cell number of the cell that requires zeroing of calculated velocity in y-direction.
6-10	IBC(2)	Repeat as many times as IV in Input #2.

7. Input #7 - Cells that Require Zeroing of Calculated Velocity in x-Direction
Format: (16I5) Right Justified Integer Number

Column	Variables	Remark
1-5	IBD(1)	IBD is the cell number of the cell that requires zeroing of calculated velocity in x-direction.
6-10	IBC(2)	Repeat as many times as IU in Input #2.

8. **Input #8 - Discharge Rates of Rivers**
Format: (8F10.5) Right Justified Real Number with Five Decimal Digits or Number with Decimal Point

Column	Variables	Remark
1-10	RB(1)	Input discharge rate of each river in cu.ft./sec. per ft. of grid length.
11-20	RB(2)	Repeat as many times as number of rivers.

9. **Input #9 - Manning Coefficients**
Format: (26F3.0) Right Justified Real Number with Zero Decimal Digit or Number with Decimal Point

Column	Variables	Remark
1-3	AMNY(1)	Input Manning coefficient for each water cell segment by segment beginning from first segment.
4-6	AMNY(2)	Repeat as many times as number of cells in a segment, maximum 26 data per card, continue on a new card; start a new card for a new segment.

10. **Input #10 - Depths of Water for Water Cells Measured from Reference Plane**
Format: (26F3.0) Right Justified Real Number with Zero Decimal Digit or Number with Decimal Point

Column	Variables	Remark
1-3	Z(1)	Input depth of water of each water cell segment by segment beginning from first segment. If the depth is measured from a reference plane other than mean sea level, an adjustment should be made by "SLADJ" in Input #3.
4-6	Z(2)	Repeat as many times as number of cells in a segment, maximum 26 data per dard, continue on a new card; start a new card for a new segment.

<u>If IMODF = 0, skip to Input #14</u>.

11. Input #11 (Optional) - Modification of Friction Factors
Format: (2I5) Right Justified Integer Number

Column	Variables	Remark
1-5	NMODFX	Total number of cells which friction factors in the x-direction (FX) have to be modified.
6-10	NMODFY	Total number of cells which friction factors in the y-direction (FY) have to be modified.

12. Input #12 (Optional) - Cell Number and Value of Friction Factor in x-Direction for each Cell being Modified
Format: (8(I5,F15.2)) - A Right Justified Integer Number and a Right Justified Real Number with 2 Decimal Digits

Column	Variables	Remark
1-5	KC(1)	Input the cell number of the cell being modified.
6-10	VF(1)	Input the value of friction factor in x-direction for the cell.
11-15	KC(2)	Repeat KC and VF as many times as NMODFX in Input #11.
16-20	VF(2)	

13. Input #13 (Optional) - Same as Input #12, Replace FX by FY, x-Direction by y-Direction, and NMODFX by NMODFY

14. Input #14 - Starting Time and Total Number of Tide Station
Format: (F5.2,I5) Right Justified Real Number with 2 Decimal Digits and Right Justified Integer Number

Column	Variables	Remark
1-5	TMIL	Input the chosen starting time in hours (24-hour cycle) for a run.
6-10	ITSN	Input the total number of tide stations in the system.

15. Input #15 - Tide Equation Coefficients and Time Phase
Format: (5F10.6) Right Justified Real Number with 6 Decimal Digits or Number with Decimal Point

Column	Variables	Remark
1-10	C1(1)	Input coefficients of tide equation of the form:
11-20	C2(1)	HXX = C1 + C2 * Cos (C3 * T + C4) for
21-30	C3(1)	Station 1.
31-40	C4(1)	
41-50	T(1)	T is the time variable in the equation.
1-10	C1(2)	Start a new card for Station 2 and input the coefficients and the time variable as before.
11-20	C2(2)	
21-30	C3(2)	
31-40	C4(2)	
41-50	T(2)	
		Repeat the same for Station 3, 4, ... as many times as total number of station.

16. Input #16 - Total Number of Boundaries
Format: (I5) Right Justified Integer

Column	Variables	Remark
1-5	NTB	Input total number of river and sea boundaries except river marsh boundary.

<u>Repeat Input #17A, 17B, and 17C as many times as NTB in Input #16</u>.

17. Input #17A - Boundary's Nature, Total Number of Cells in the Boundary, and Relative Information Required to Perform Calculations
Format: (A2, I3, F10.3) Two Alphabetic Characters, Right Justified Integer and Right Justified Real Number with Three Decimal Digits

Column	Variables	Remark
1-2	NATURE (I)	Boundary natures are classified into eight categories (See Fig. 3 and 4). Each category requires its relative information to perform the calculation. 1. SL - Left sea boundary 2. SB - Bottom sea boundary 3. SR - Right sea boundary 4. ST - Top sea boundary
3-5	NBC(I)	
6-15	RINF(I)	

The relative information for a sea boundary is the related tide station number.

5. RL - Left river boundary
6. RB - Bottom river boundary
7. RR - Right river boundary
8. RT - Top river boundary

The relative information for a river boundary is the river discharge rate in cu.ft./sec. per feet of cell dimension.

NBC is the total number of cells in the boundary.

Input #17B - Cell Numbers of the Boundary
Format: (16I5) Right Justified Integer

Column	Variables	Remark
1-5	INBC(I,1)	Input the cell numbers of the boundary beginning from left to right or bottom to top.
6-10	INBC(I,2)	Repeat as many times as NBC(I) in Input #17A.

Input #17C (Optional) - Depth of Water Adjacent to Left Sea Boundaries or Bottom Sea Boundaries
Format: (16F5.0) Right Justified Real Number with Zero Decimal Digit or Number with Decimal Point

Column	Variables	Remark
1-5	ZB(1)	Input the depth of water left to the left sea boundaries or below the bottom sea boundaries, cell by cell. Skip this part if the boundary type is not SL or SB.
6-10	ZB(2)	Repeat as many times as NBC(I) in Input #17A.

If IRMB = 0, skip to Input #21.

18. Input #18 (Optional) - River Marsh Boundary Bottom Cells
Format: (2I5) Right Justified Integer Number

Column	Variables	Remark
1-5	IRMBB(1)	Input the two cell numbers of the river marsh
6-10	IRMBB(2)	boundary bottom cells.

19. Input #19 (Optional) - River Marsh Boundary Top Cells
Format: (2I5) Right Justified Integer Number

Column	Variables	Remark
1-5	IRMBT(1)	Input the two cell numbers of the river
6-10	IRMBT(2)	marsh boundary top cells.

20. Input #20 (Optional) - Depth of Weir Along River-Marsh Boundary
Format: (F10.5) Right Justified Real Number with 5 Decimal Digits or Number with Decimal Point

Column	Variables	Remark
1-10	ZRB	Input the depth of weir in feet along the river marsh boundary. The river marsh boundary should locate at the top part of the system with the boundary weir parallel to y-axis.

<u>If ISPBK = 0, skip to Input #23</u>.

21. Input #21 (Optional) - Total Number of Cells of Spoil Banks Along the Ship Channel
Format: (I5) - Right Justified Integer Number

Column	Variables	Remark
1-5	NSBC	Input the total number of cells of spoil banks along the ship channel.

22. Input #22 (Optional) - Cell Number, Axis of the Spoil Bank and Depth of Spoil Bank for Each Cell Along the Ship Channel
Format: (8(I5,A1,F4.1)) Right Justified Integer Number, Alphabetic Character, and Right Justified Number with 1 Decimal Digit

Column	Variables	Remark
1-5	INSBC(1)	Input the cell number.
6	IAXIS(1)	Input the spoil bank axis either x or y.
7-10	ZCH(1)	Input the depth of spoil bank in feet for the cell along the ship channel.
11-15	INSBC(2)	Repeat as many times as NSBC in Input #21; maximum eight data group a card.
16	IAXIS(2)	
17-20	ZCH(2)	

<u>If IDSCH = 0, skip Input #25</u>.

23. Input #23 - Total Number of Passes Where Discharge Rates will be Calculated
Format: (I5) Right Justified Integer

Column	Variables	Remark
1-5	LDSCH	Input the total number of passes where discharge rates will be calculated. All the cells at a location should be either on a row or a column.

24. Input #24 - Total Number of Cells at a Pass, and the Flow Direction
Format: (16(I4,A1))

Column	Variables	Remark
1-4	NCDSCH(1)	Input total number of cells at the pass.
5	IAXIS(1)	Input the flow direction either x or y.
6-9	NCDSCH(2)	Repeat as many times as LDSCH in Input #23; maximum 16 data group a card.
10	IAXIS(2)	

25. Input #25 - Cell Numbers at Each Pass
Format: (16I5) Right Justified Integer Number

Column	Variables	Remark
1-5 5-10 11-15	ICDSCH(1,1) ICDSCH(1,2) ICDSCH(1,3)	Input the cell numbers at Pass 1 from left to right or from bottom to top; repeat as many times as the number of cells in the pass.
1-5 5-10	ICDSCH(2,1) ICDSCH(2,1)	Start a new card for Pass-2 and input the cell numbers as before.
		Repeat the same for Pass 3, 4, ... As many times as total number of stations.

IV. A Detailed Illustration: Application to Mobile Bay

This section illustrates the use of the general program beginning from data collection to model verification as applied to the Mobile Bay system. In order to demonstrate all of the model features, the real system behavior has been modified to include elements which do not necessarily exist in the bay at this time (i.e. the existence of an island near the Theodore area). Figures are inserted at appropriate places to help explain the procedure. The format of this section is established to coincide with those in Section II and Section III.

A. Mobile Bay data:

1. Map and Charts:

Obtain a navigational chart of Mobile Bay and vicinity area (Figure 10) published by the U. S. Coast and Geodetic Survey (#1266) and a location map of South Alabama (Figure 9) from the Geological Survey of Alabama.

Locate the following system features: rivers, islands, channels, passes, sand bars, head lands, river marsh area, etc.

Sketch the shape of the water system selected for modeling and measure the horizontal and vertical distances which enclose the selected system.

2. Bathemetry:

Bottom elevations (Z(I)) from mean water are taken from the navigational chart (Figure 10). Adjust the values to the reference plane - mean sea level. The difference between mean sea level and mean water of the chart is 1.8 (SLADJ) supplied by the Corps of Engineers, Mobile District.

3. Tidal Information:

Tide charts (Figure 11 to Figure 15) were provided by the Corps of Engineers, Mobile, Alabama for Mobile State Docks, Dauphin Island-Gulf, Cedar Point, Bon Secour, and Great Point Clear.

Tabulate the time and tide height data for Dauphin Island-Gulf, and Cedar Point from the charts. Fit the data by least square to the equation of the form (page 30-31):

$$HDI = C1 + C2*Cos\ (C3 * t + C4)$$

where HDI = tide height
t = time
C1, C2, C3, C4 are coefficients

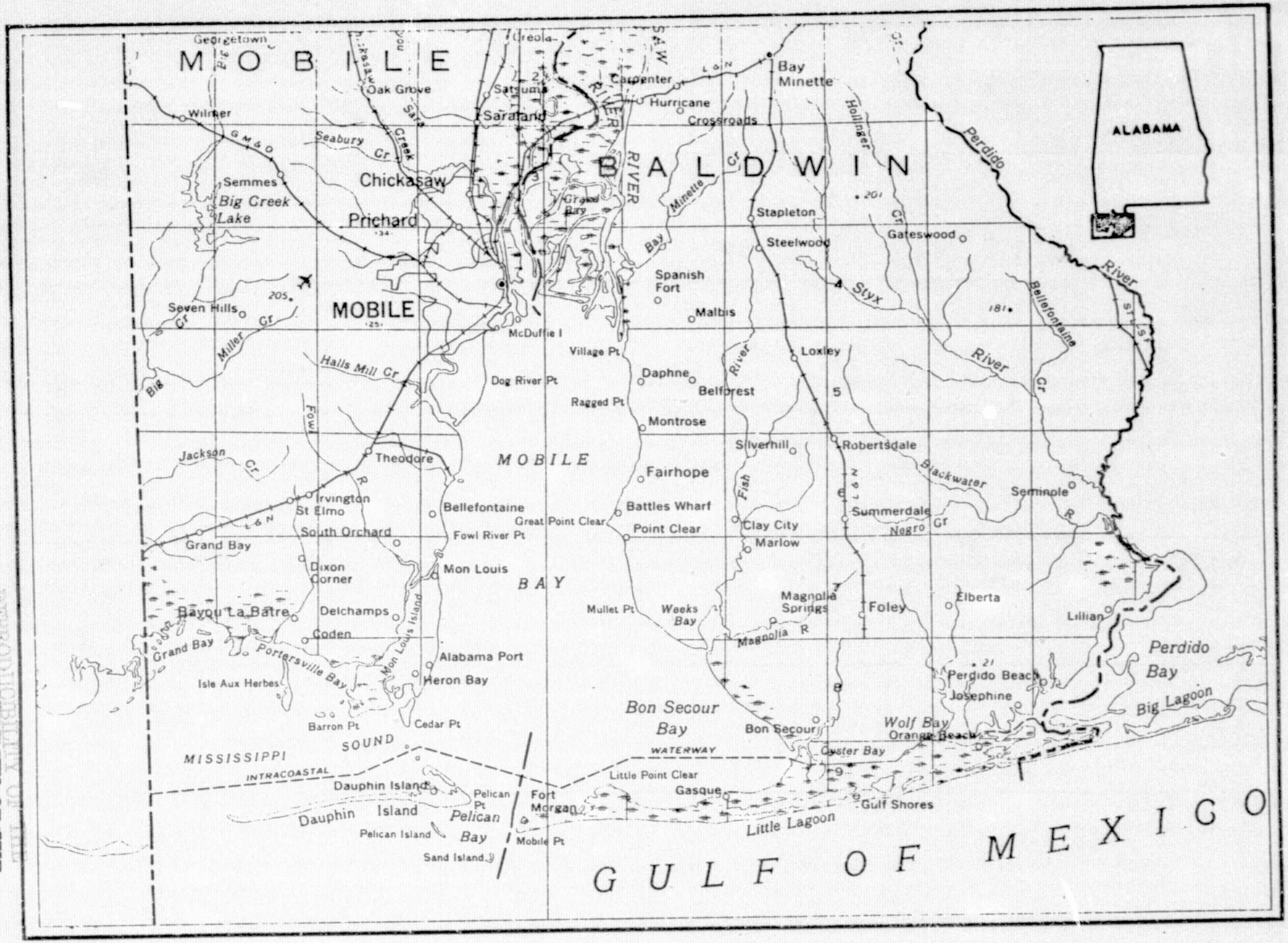


Fig. 9 - Location Map for South Alabama.

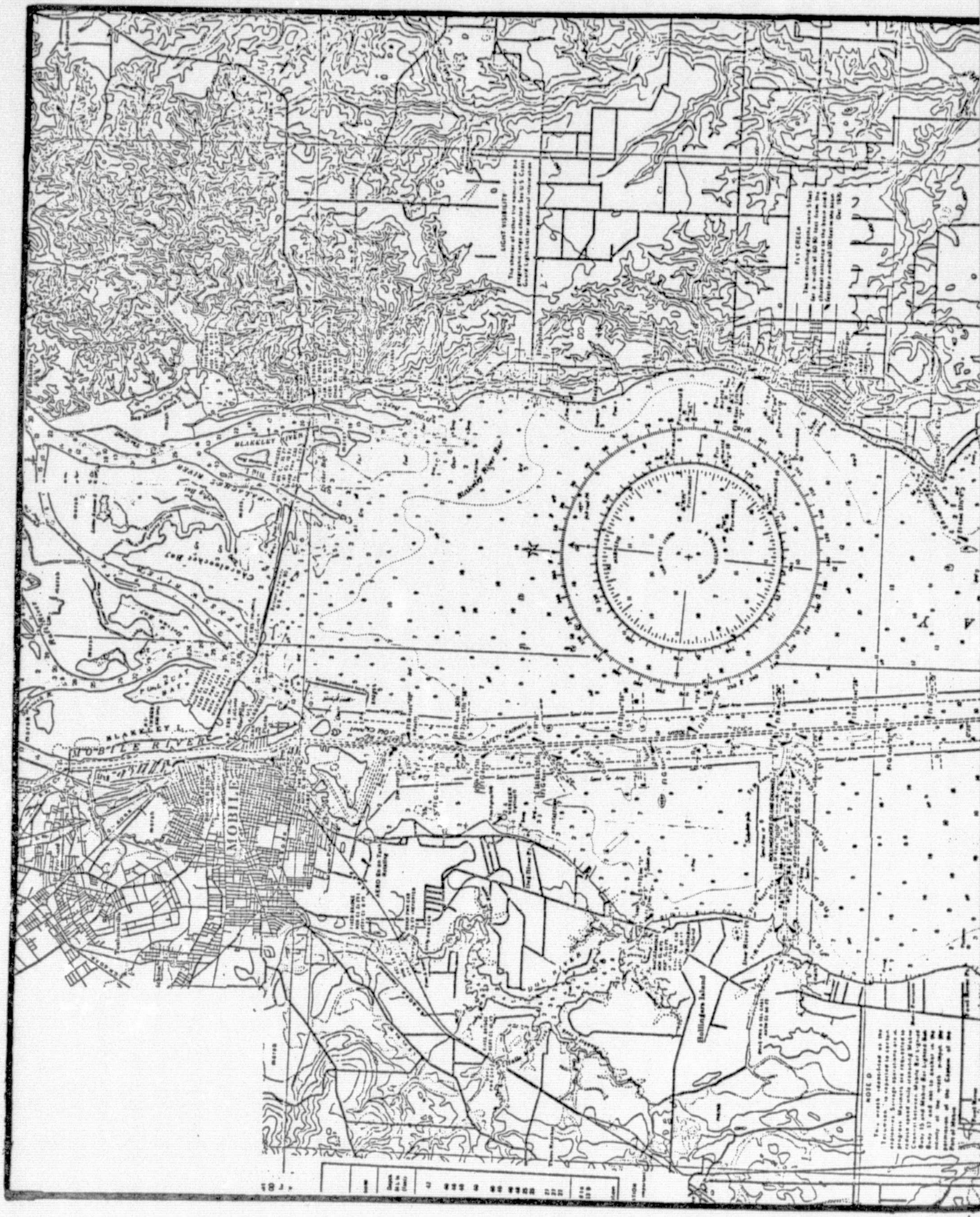
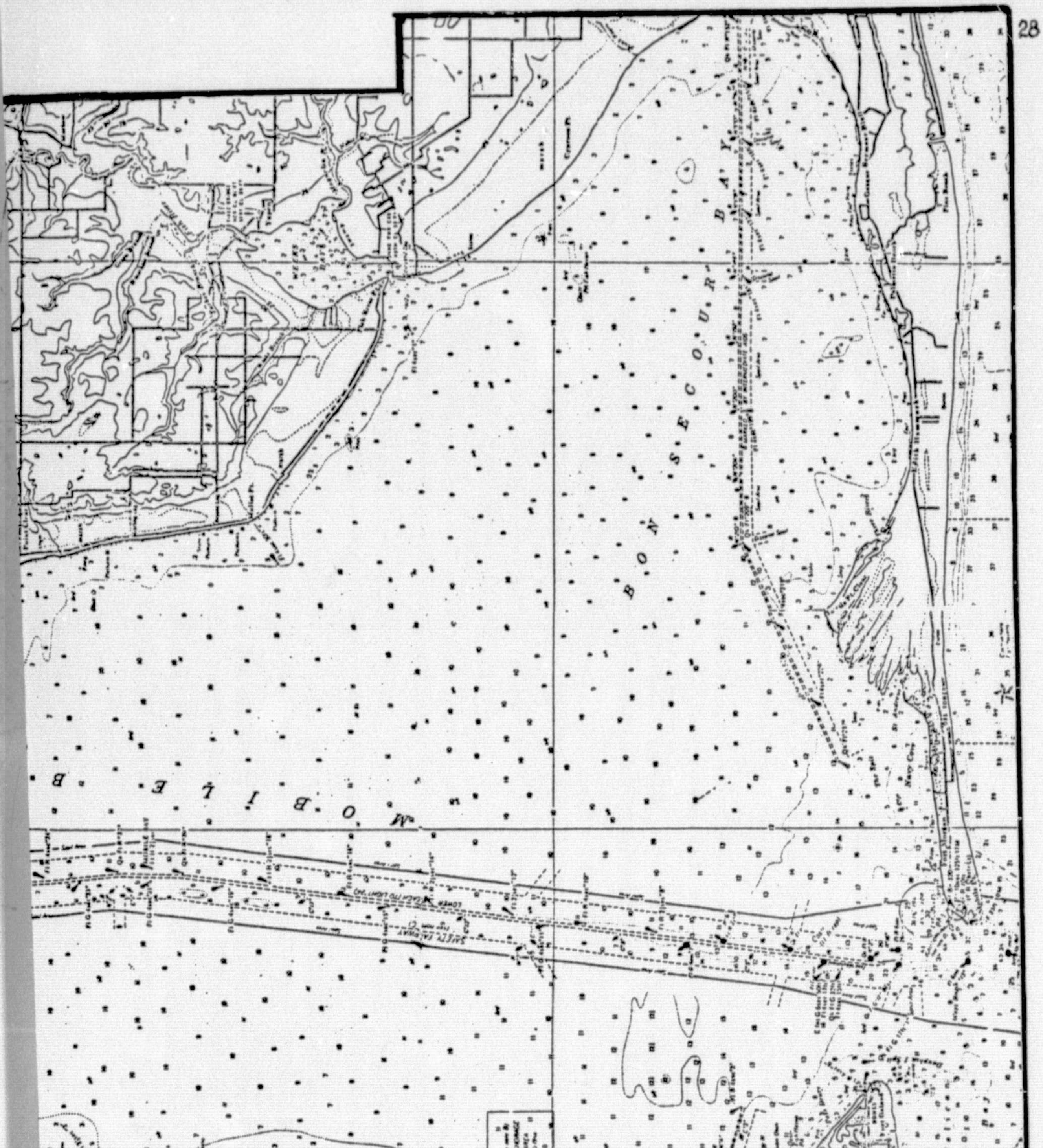


Figure 10. -- Navigational Chart for Mobile Bay and Vicinity. FOLDOUT FRAME



FOLDOUT FRAME 2

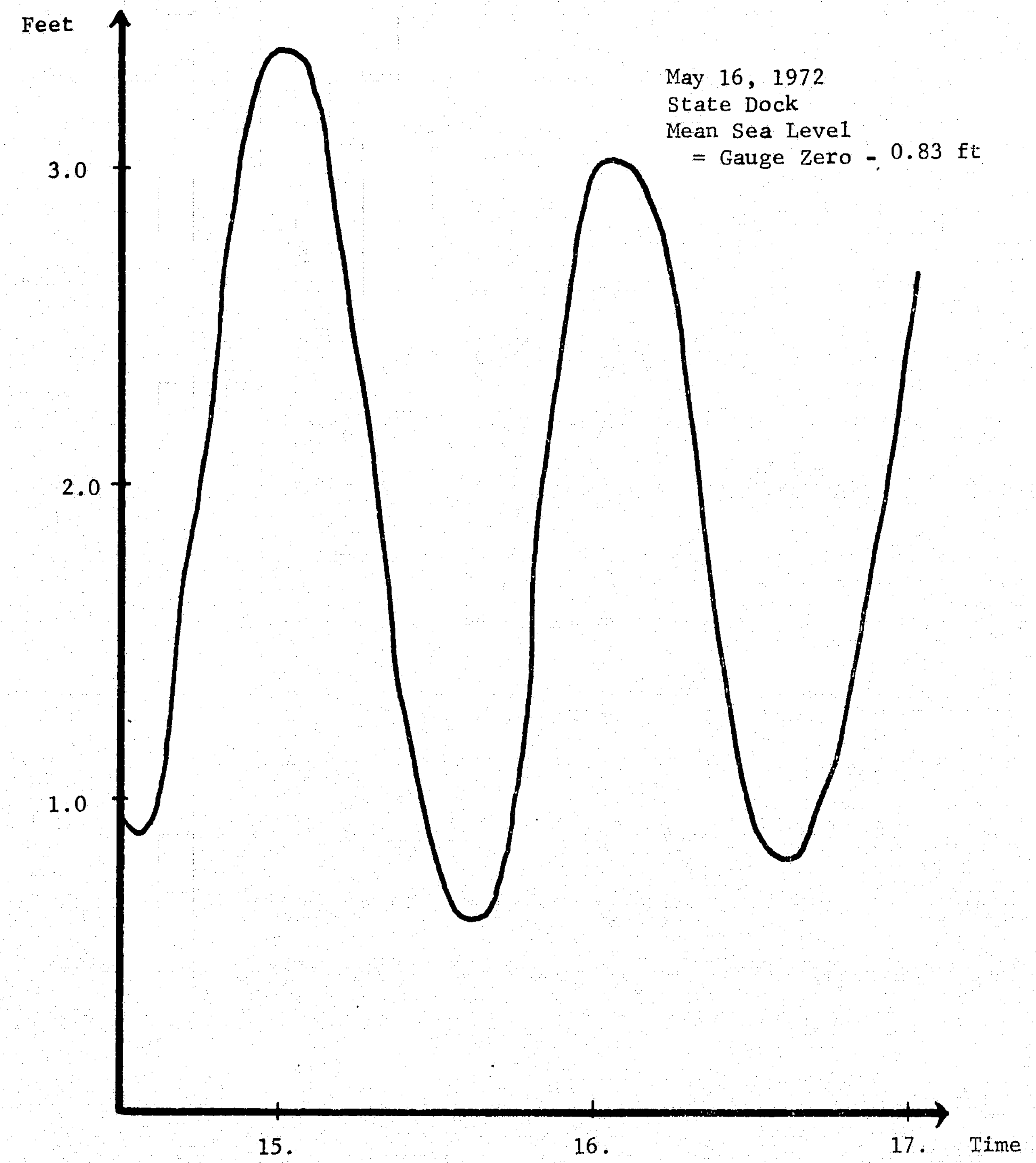


Fig. 11 - Simplified Gauge Chart for State Dock (Original Data Supplied by Corps of Engineers, Mobile, Alabama)

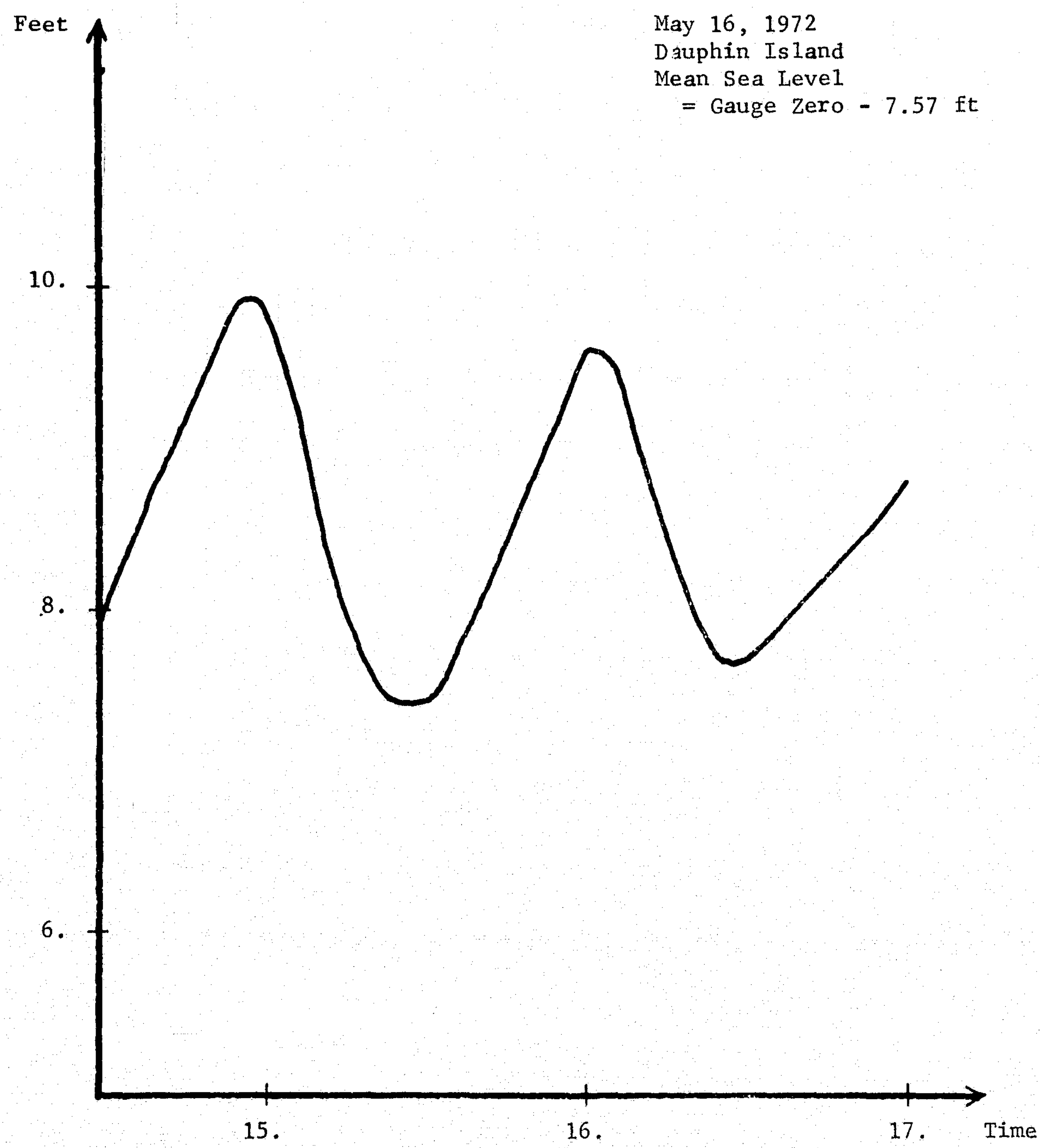


Fig. 12 - Simplified Gauge Chart for Dauphin Island (Original Data Supplied by Corps of Engineers, Mobile, Alabama)

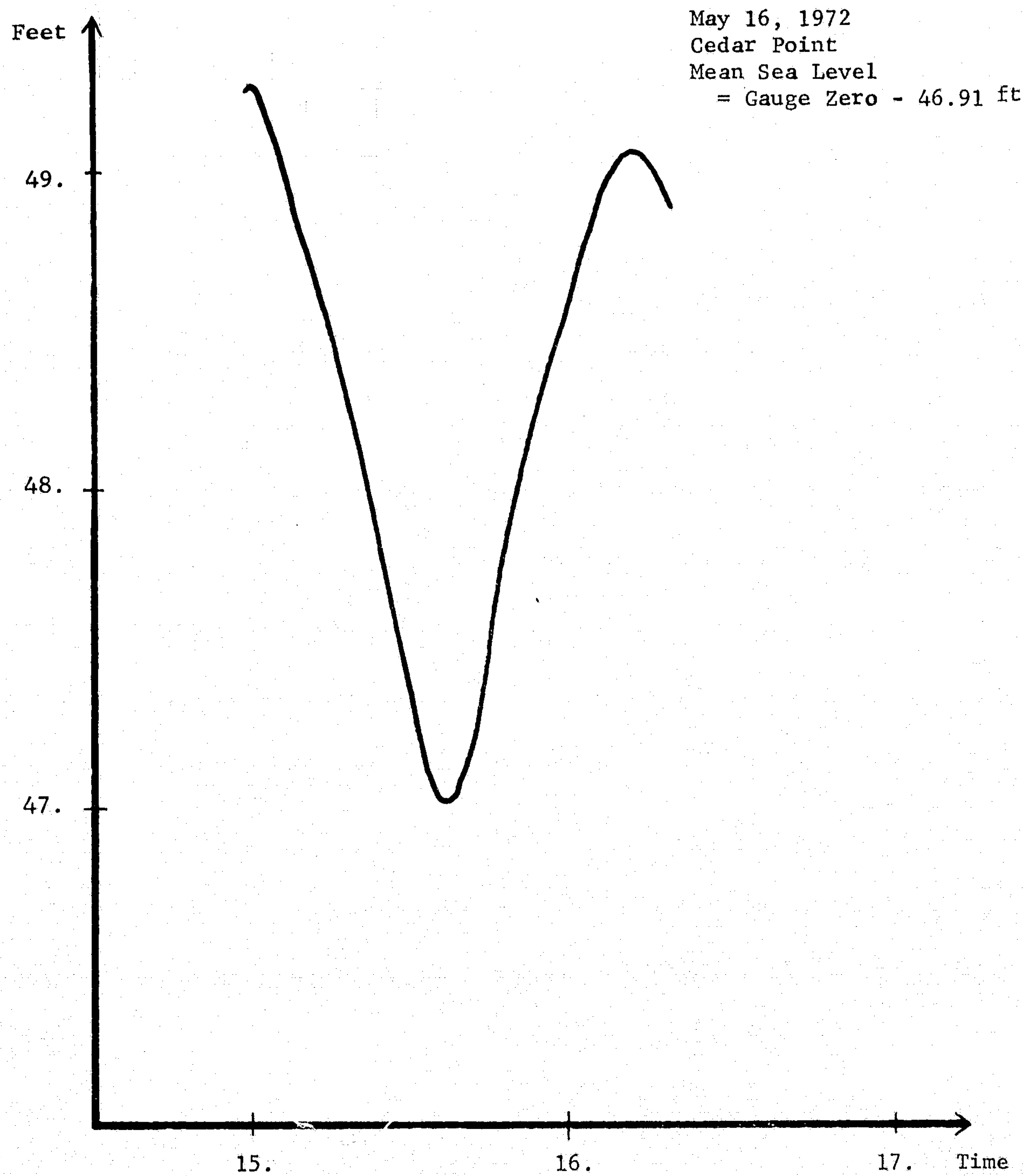


Fig. 13 - Simplified Gauge Chart for Cedar Point (Original Data Supplied by Corps of Engineers, Mobile, Alabama)

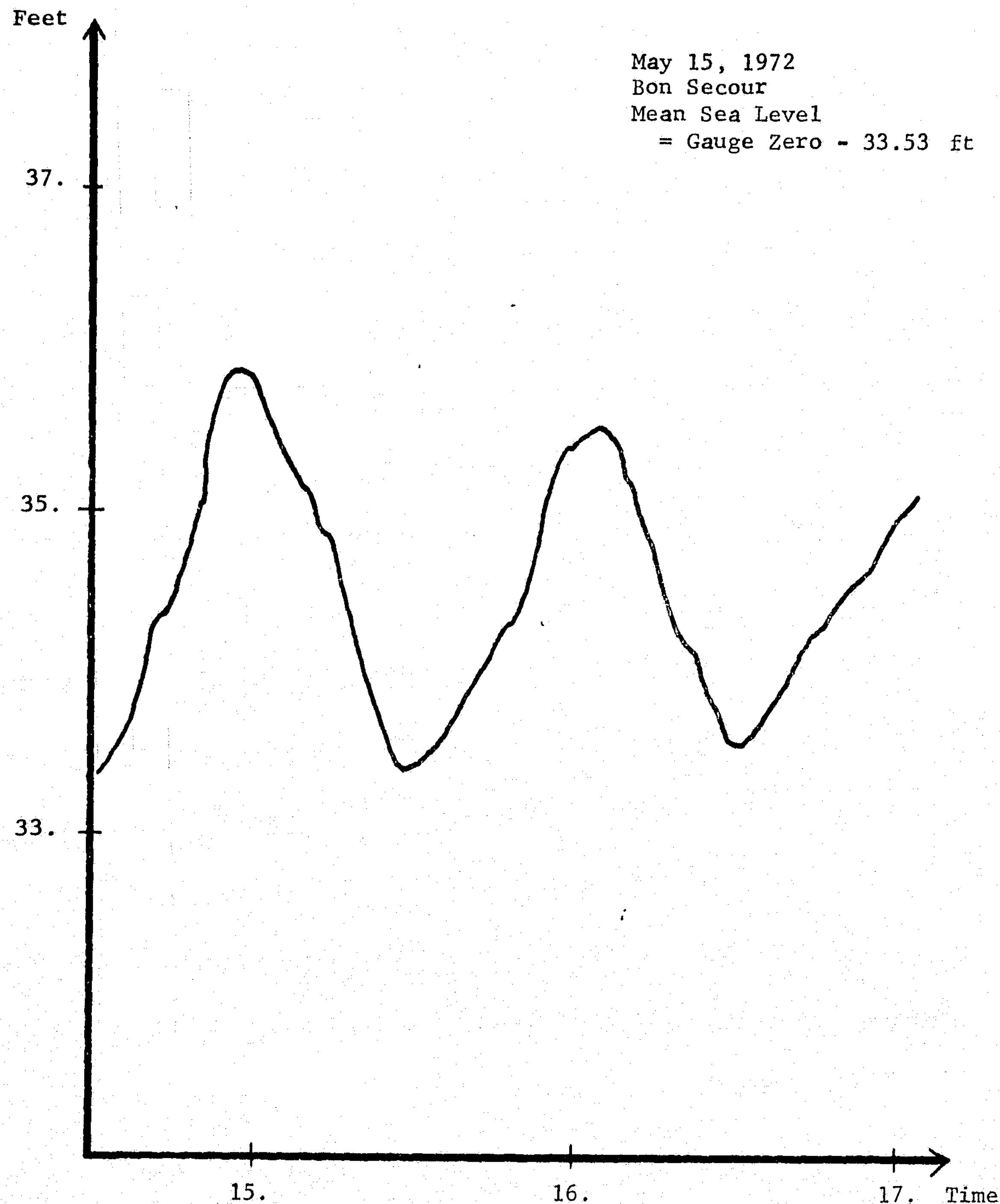


Fig. 14 - Simplified Gauge Chart for Bon Secour (Original Data Supplied by Corps of Engineers, Mobile, Alabama)

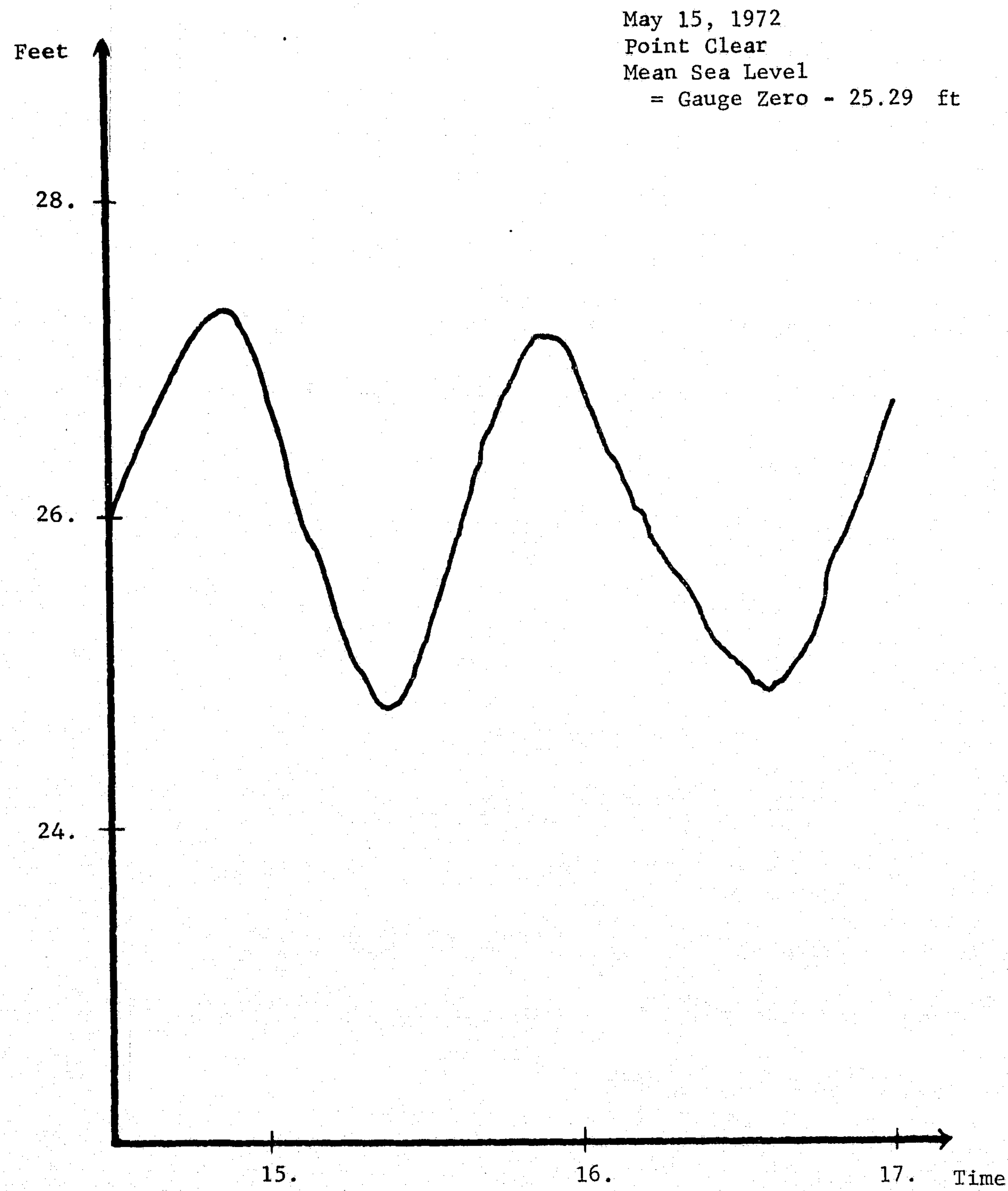


Fig. 15 - Simplified Gauge Chart for Point Clear (Original Data Supplied by Corps of Engineers, Mobile, Alabama)

The following are the least-square fit equations:

Dauphin Island -

HDB(I) = 1.090 + 1.295 * cos (0.004188**0.0567.4)

Cedar Point -

HDB(I) = 1.089 + 1.177 * cos (0.004188*-0.0032453)

4. Wind Data:

Recorder charts (Figure 16) with tabulated data were provided by the National Oceanic and Atmospheric Administration-Environmental Data Service at Ashville, Norch Carolina.

Calculate the average wind velocity in feet per second and direction measured from x-axis counter-clockwise from the charts, and use these as input data.

W = 5.60 knots
= 9.46 feet/second

THETA = 70°

5. River Flows:

Flow information (Figure 17 and Figure 18) for the Alabama River at Claiborne and the Tombigbee River at Coffeeville was provided by the U. S. Geological Survey, Montgomery, Alabama. Calculate the average discharge rate in cubic feet per second for each river and convert these values to flow rates per grid unit length. The flow rate of the Alabama River at Claiborne, Alabama from the chart is:

$$RB(1) = \frac{44000\ ft^3/sec}{6561.68\ ft} = 6.706\ ft^2/sec$$

The flow rates for the other rivers are considered zero in this example.

RB(2) = 0 (Dog River)

RB(3) = 0 (Fowl River)

RB(4) = 0 (Bon Secour River)

RB(5) = 0 (Fish River-Weeks Bay)

RB(6) = 0 (Tensas River)

MF1-10A (4-70)

U.S. DEPARTMENT OF COMMERCE
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
WEATHER BUREAU

SURFACE WEATHER OBSERVATIONS

STATION: NOAA, WSO, MOBILE, ALA

DATE: [illegible] 1972

TO CONVERT LST TO GMT ADD 6 hrs. SUBTRACT / hrs.

TYPE (1)	TIME (LST) (2)	SKY AND CEILING (Hundreds of Feet) (3)	VISIBILITY (Statute Miles) SURFACE (4)	TOWER (4a)	WEATHER AND OBSTRUCTIONS TO VISION (5)	SEA LEVEL PRESS. (Mbs.) (6)	TEMP (°F) (7)	DEW PT. (°F) (8)	WIND DIRECTION 00-36 (9)	WIND SPEED (Kts.) (10)	WIND CHARACTER (11)	ALTIMETER SETTING (Ins.) (12)	REMARKS AND SUPPLEMENTAL CODED DATA (13)	(14)
R	0056	0	10			140	65	61	00	00		995		JB
R	0158	0	10			136	64	60	33	04		994		JB
R	0257	0	10			136	63	58	34	04		994	607	JB
R	0356	0	10			140	63	58	01	07		995		JB
R	0457	0	10			144	62	57	04	05		996		JB
R	0558	0	8+			147	65	59	02	06		997		JB
7	2223	00206	62020		14718	66900			14210			63068	48562 Tide Plus 0100	JB
S	0656	300Ⓞ	8+			154	69	57	05	08		999		JB
R	0758	0	8			156	74	57	05	07		000		RS
R	0855	0	8+			156	77	55	06	07		000	110 1001	RS
R	0956	0	8+			159	79	57	25	04		001	FEW Cu FRMG SE-S	RS
R	1055	0	8+			156	81	55	06	07		000	FEW Cu 30 E-S	RS
R	1156	0	8+			150	83	54	36	09		998	FEW Cu 35 ALQDS	RS
/	72223	13609	62020		15025	11600			12507			63071	48362 TIDE PLUS 0100	/
R	1255	0	8+			144	84	55	05	08		996	FEW Cu ALQDS	RS
R	1359	0	8+			137	85	54	04	08		994		RS
R	1453	0	8+			129	85	55	07	07		992	720 1100	[illegible]
R	1558	35Ⓞ	8+			129	85	54	36	04		992		[illegible]
R	1658	140Ⓞ	8+			125	85	54	36	07		991		[illegible]
R	1756	250-Ⓞ	8+			122	82	57	36	05		990		[illegible]
/	72223	23605	62020		12228	00901			14507			63044	48662 TIDE Plus 0090	[illegible]
R	1856	250-Ⓞ	8+			125	75	64	19	07		991		[illegible]
R	1958	250-Ⓞ	12			125	71	63	20	04		991		[illegible]
R	2053	250-Ⓞ	12			129	69	63	23	06		992	307 1001	[illegible]
R	2156	250-Ⓞ	12			129	69	63	25	03		992		[illegible]
R	2256	250-Ⓞ	12			129	67	63	24	06		992		[illegible]
R	2355	0	12			126	67	63	25	03		991		RS
/	72223	02503	69010		12619	00960			17803			63047	48662 TIDE PLUS 0120	/

Fig. 16 - Typical Weather Data for the Mobile, Alabama Area.

Form 9-1536 (Rev. 4-71) PRELIMINARY RECORDS SUBJECT TO REVISION

UNITED STATES DEPARTMENT OF THE INTERIOR—GEOLOGICAL SURVEY—WATER RESOURCES DIVISION

Daily Values of Water Data

Sta. No.........

3. Shift
4. Datum
5. Aux. Datum
6. (Discharge)
7. Gage Height
8. Sediment Conc.
9. Susp. Sediment

Daily Values for Alabama River at Claiborne, Ala. for year ending Sept. 30, 19 73

Variable ID ________ Sampling Code ________ Parameter Code ________

DAY	OCT (10)	NOV (11)	DEC (12)	JAN (01)	FEB (02)	MAR (03)	DAY	APR (04)	MAY (05)	JUNE (06)	JULY (07)	AUG (08)	SEPT (09)	DAY
1						27600	1		142000	98300				1
2						28000	2		143000	102000				2
3						29000	3		132000	101000				3
4						23600	4		114000	88100				4
5						26000	5		88000	70300				5
6						32900	6		63700	58000				6
7						48800	7		39800	64300				7
8						57600	8		56900	69800				8
9						48100	9		82700	73000				9
10						41000	10	141000	94500	72300				10
11						52500	11	136000	101000	72500				11
12						65800	12	134000	103000	61100				12
13						75200	13	127000	101000	61200				13
14						81000	14	113000	97900	63000				14
15						83900	15	93100	74700	63100				15
16						88200	16	72200						16
17							17	53100						17
18							18	52900						18
19							19	58100						19
20							20	62500						20
21							21	50800						21
22							22	37600						22
23							23	24600						23
24							24	27700						24
25							25	59200						25
26							26	101000						26
27							27	114000						27
28							28	124000						28
29							29	135000						29
30							30	141000						30
31							31							31

PRELIMINARY RECORDS SUBJECT TO REVISION

PRELIMINARY RECORDS SUBJECT TO REVISION

Fig. 17 - Typical Discharge Data for the Alabama River at Claiborne, Alabama.

Form 9-1538 PRELIMINARY RECORDS
(Rev. 4-71) SUBJECT TO REVISION

UNITED STATES DEPARTMENT OF THE INTERIOR—GEOLOGICAL SURVEY—WATER RESOURCES DIVISION

Daily Values of Water Data

Sta. No.

3. Shift
4. Datum
5. Aux. Datum
6. Discharge
7. Gage Height
8. Sediment Conc.
9. Susp. Sediment

Daily Values for Tombigbee River at Coffeeville L&D nr Coffeeville, Ala., for year ending Sept. 30, 1973

Variable ID ______ Sampling Code ______ Parameter Code ______

DAY	OCT (10)	NOV (11)	DEC (12)	JAN (01)	FEB (02)	MAR (03)	DAY	APR (04)	MAY (05)	JUNE (06)	JULY (07)	AUG (08)	SEPT (09)	DAY
1						21600	1		104000	58100				1
2						22000	2		104000	62000				2
3						23700	3		104000	63000				3
4						26400	4		101000	50400				4
5						29800	5		95900	33300				5
6						33000	6		87900	34000				6
7						83900	7		75900	37900				7
8						88600	8		70700	40900				8
9						71800	9		76200	41700				9
10						57500	10	146000	76900	38000				10
11						51100	11	134000	70200	31000				11
12						56600	12	124000	71300	23900				12
13						62500	13	115000	56000	20700				13
14						64500	14	104000	43800	25000				14
15						64500	15	83900	36000	28400				15
16						65200	16	68900						16
17							17	52900						17
18							18	46800						18
19							19	53100						19
20							20	60000						20
21							21	62000						21
22							22	57000						22
23							23	49500						23
24							24	44800						24
25							25	65900						25
26							26	98000						26
27							27	100000						27
28							28	102000						28
29							29	102000						29
30							30	104000						30
31							31							31

PRELIMINARY RECORDS SUBJECT TO REVISION

PRELIMINARY RECORDS SUBJECT TO REVISION

Fig. 18 - Typical Discharge Data for the Tombigbee River at Coffeeville, Alabama.

B. Model System Features of Mobile Bay

1. Grid Size

Superimpose a two-dimensional grid over the bay area (see Figure 19). Label the cells and differentiate water and land cells. Grid spacings in x and y directions are equal and chosen as two kilometers (6561.68 feet (DELS)). There are 21 cells (NCPR) per row and 38 rows (IROW), giving 798 cells (NC). Since the deepest water in the bay is 40 feet, this sets the upper limit of the incremental time for calculations at

$$\Delta t < \frac{\Delta S}{\sqrt{2gH_{max}}}$$

$$\Delta t < 130 \text{ sec.}$$

DELT = 120 is chosen as program input.

After setting the grids, record the depth of water from mean water in each water cell from the navigation chart.

Cell No.	Depth
I	Z(I)
1	40
2	40
3	30
4	39
⋮	⋮
22	37
23	34
⋮	⋮
97	3
98	6
99	5
⋮	⋮
787	1
788	1
789	10

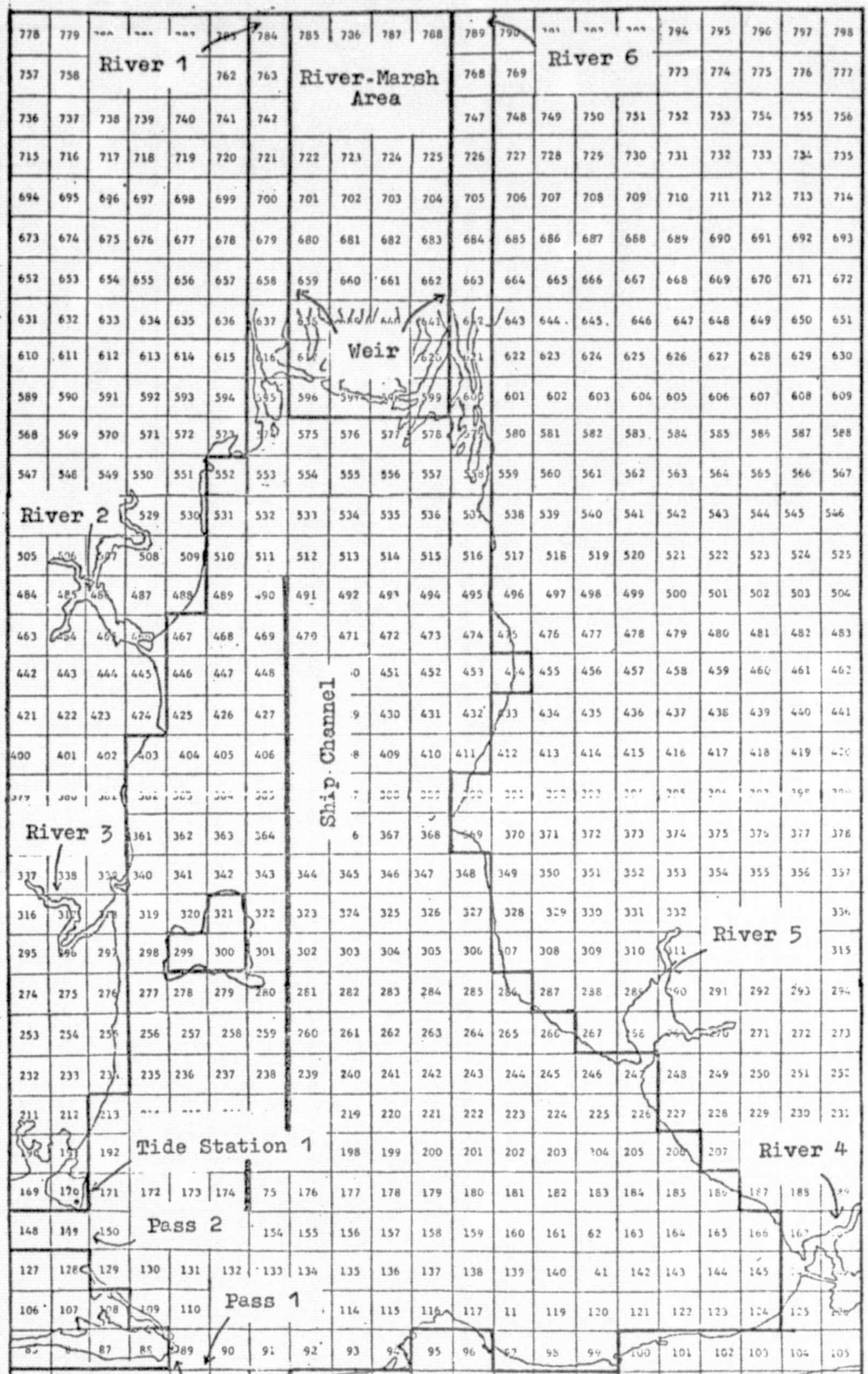


Fig. 19 - Superimposed Grid for the Mobile Bay System (2 Km).

2. Water Cell Segments (Figure 20):

Label each water cell segment by the left most boundary cell (IBNDL) and the right most boundary cell (IBNDR).

Row No.	L. Cell No.	R. Cell No.
N	IBNDL(N)	IRNDR(N)
1	1	11
2	22	32
3	43	53
4	64	70
5	89	94
6	97	99
7	109	124

3. Sea Boundaries (Figure 21):

Label the sea boundaries by SL, SB, SR, or ST. Locate tide stations, set up the necessary data.

S. Boundary No.	Type	No. of Cells	Rel. Infn.
I	NATURE(I)	NBC(I)	RINF(I)
1	SB	10	1.
2	SL	1	2.
3	SL	4	1.
4	SR	3	1.

sequence not important

S. Boundary No.	No. of Cells	Cell Nos.
I	J = NBC(I)	INBC(I)
1	10	2
		3
		⋮
2	1	149
⋮		
4	3	11
		32
		53
⋮	⋮	⋮

For SL and SB, also supply boundary depth, i.e. the depth of cells left to or below the boundary.

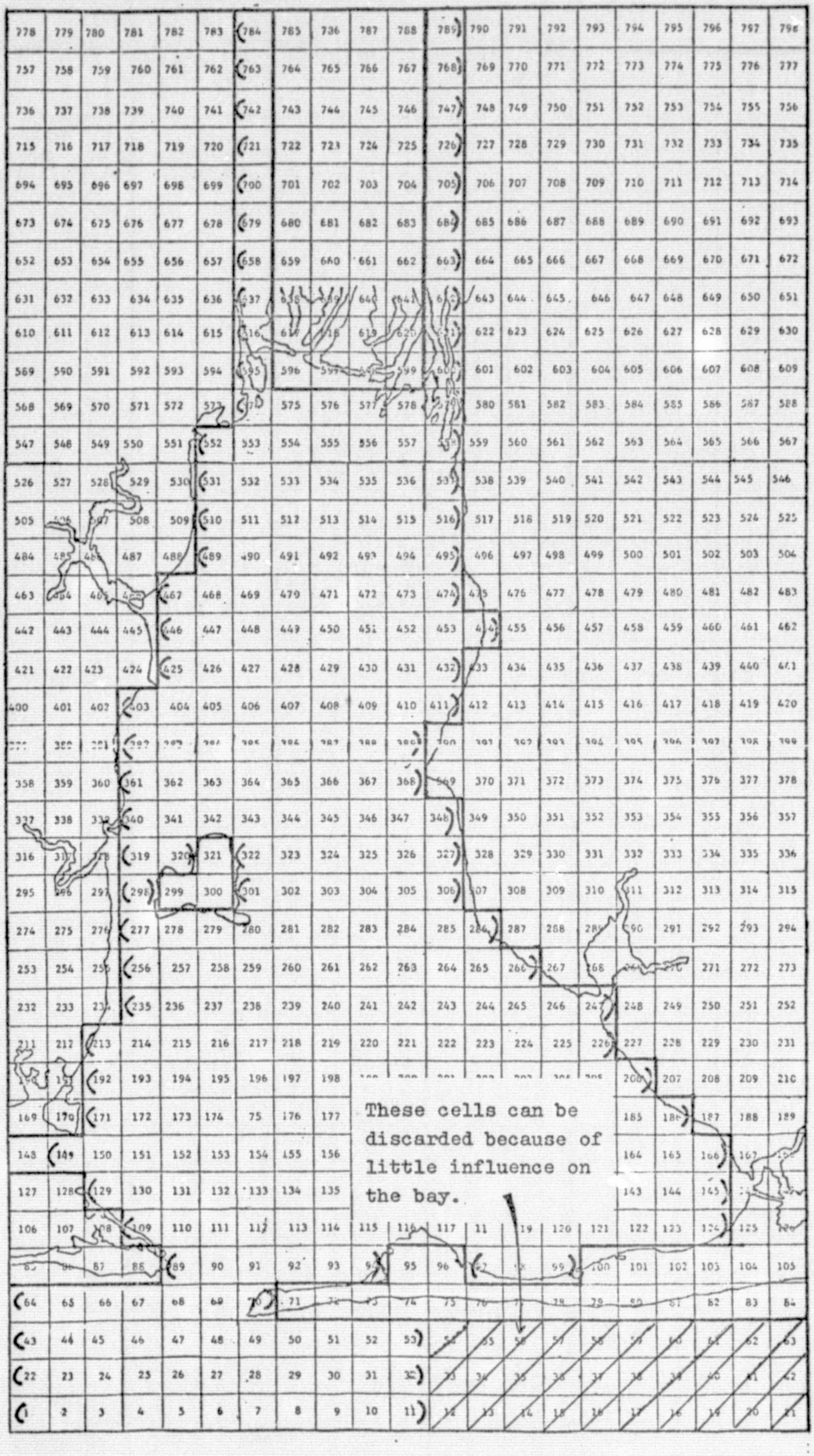


Fig. 20 - Water Cell Segments

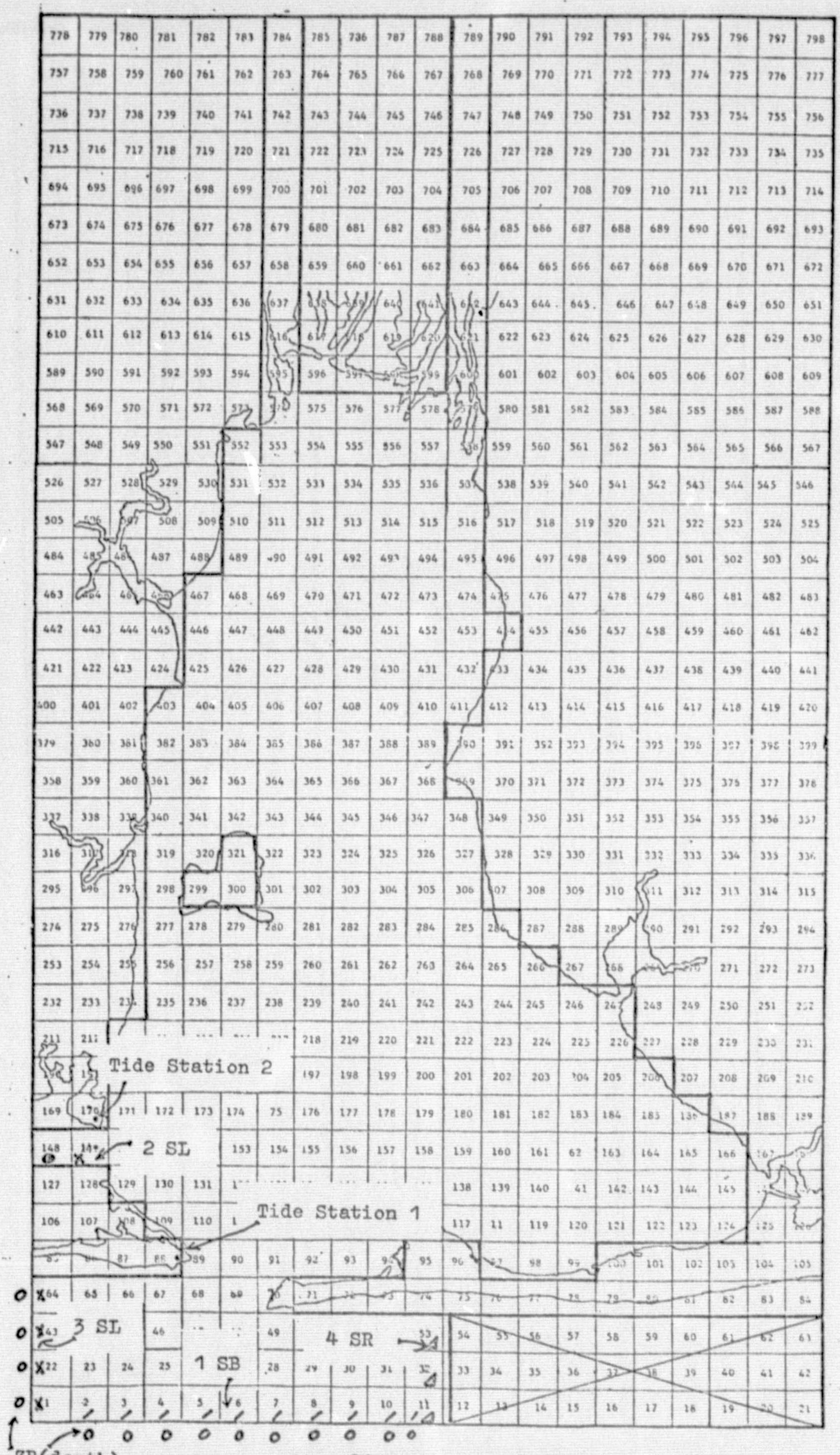


Fig. 21 - Sea Boundaries

Boundary No.	No. of Cells	Boundary Cell Depth
I	J = NBC(I)	ZB(I)
1	10	40.
		30.
		39.
		⋮
2	1	8.
3	4	42.
		40.
		⋮
⋮		

4. River Boundaries (Figure 22):

Locate the river discharge cells, and the river-marsh area. Separate the boundaries into their own categories. For river boundaries, tabulate the number of cells and flow rates. Small streams may be neglected.

R. Boundary No.	Type	No. of Cells	Flow Rate
I	NATURE(I)	NBC(I)	RB(I) or U(I)
1	RT	1	6.706
2	RL	1	0.762

For river-marsh boundaries, locate the river-marsh bottom cells and top cells.

IRMBB(1) = 595, IRMB(2) = 599, IRMBT(1) = 784, IRMBT(2) = 788.

5. Ship Channel (Figure 23):

Locate the ship channel and label the cells along the channel. Depths of spoil banks were obtained from the Corps of Engineers, Mobile, Alabama. Tabulate the cell numbers, channel axes, and depth of spoil banks of each cell along the channel.

Total No. of Cells
NSBC
22

Cell No.	Channel Axis	Depth of Spoil Bank (Ft)
INSBC(I)	IAXIS(I)	ZCH(I)
153	y	9.
174	y	7.
195	y	7.
196	x	9.
⋮	⋮	⋮

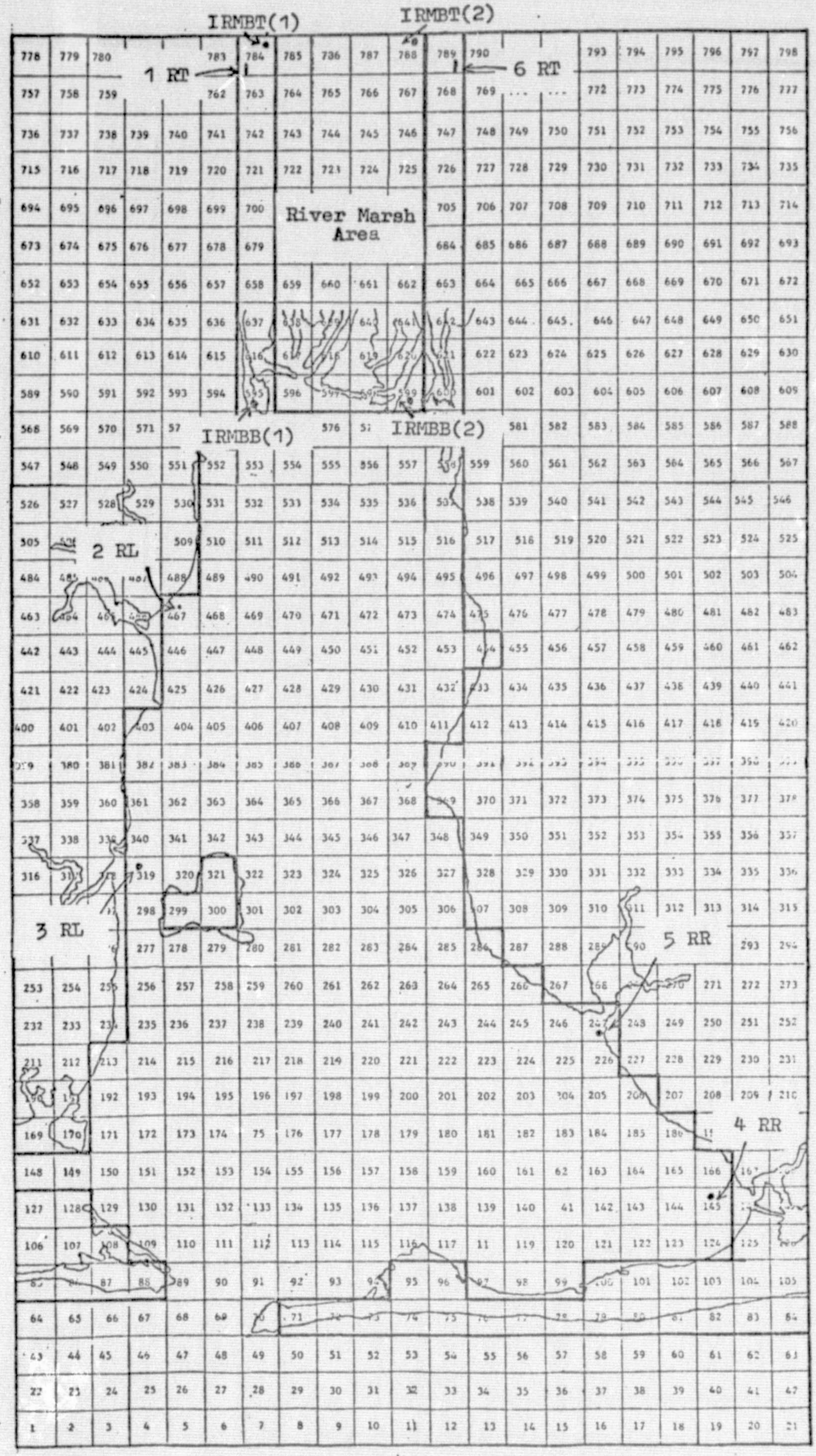


Fig. 22 - River Boundaries

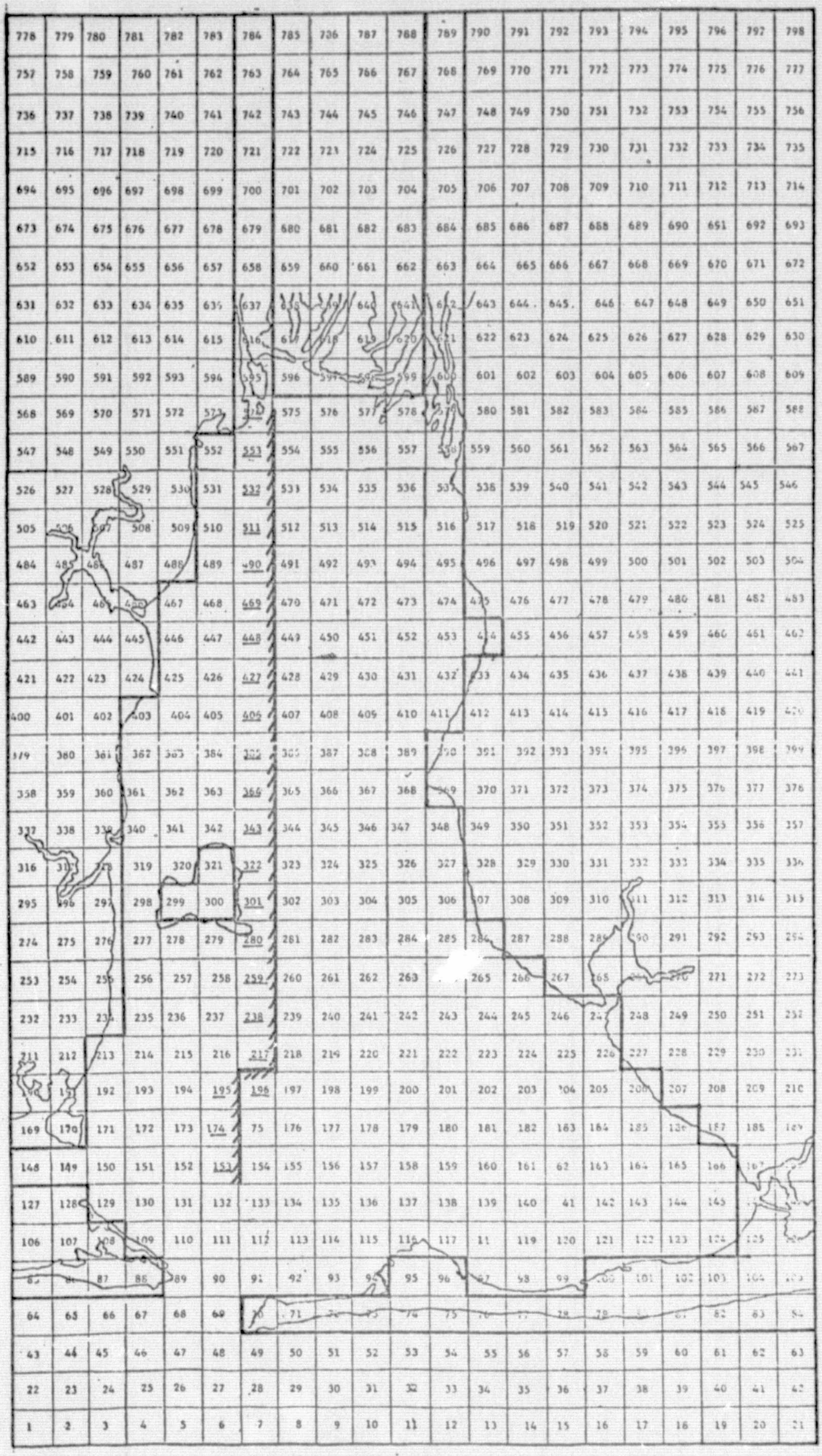


Fig. 23 - Ship Channel

6. Bottom Roughness (Figure 24):

Manning coefficients which are used to calculate the bottom friction vary from 0.010 to 0.050. A coefficient of 0.05 is used in the marsh area to simulate the low flow rates expected to this area. Values within the bay range from 0.010 to 0.018. The coefficients of water cells are read in segment by segment.

Segment	Manning Coefficients x 10^3 Z(I)
1	15. 15. 15. 15. 15. 15. 15. 15. 15. 15.
2	15. 15. 15. 15. 15. 15. 15. 15. 15. 15.
⋮	
78	15. 50. 50. 50. 50. 15.

7. Passes (Figure 25):

Label the passes by number. Count the total number of cells along each pass. Decide the flow direction either x or y through each pass.

Total No. of Passes
LDSCH
2

Pass No.	Total No. Cells (Each Pass) NDSCH(K)	Flow Direction IAXIS(K)	Cell Nos. (Each Pass) ICDSCH(K,J)
2	3	y	89
			90
			91
1	1	x	149

8. Cell Modifications:

a. Zeroing of velocities:

Cells with land boundaries or sand bars on top edges have zero flow rates across the top edges. The same implication applies to cells with land boundaries on the right side. Count total number of cells that require zeroing of Vp and Up (Figure 26 and Figure 27) respectively, and record the cell numbers.

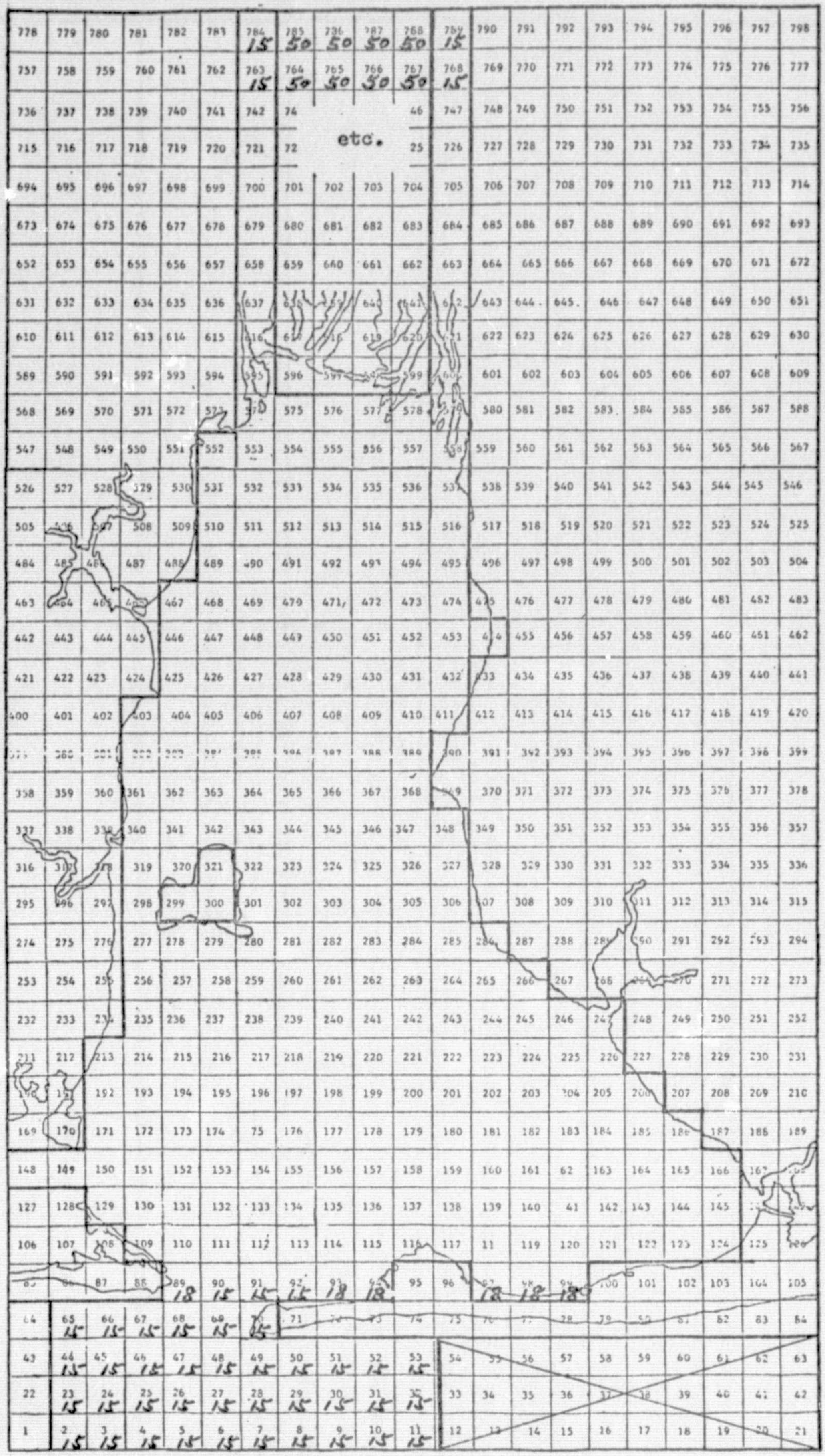


Fig. 24 - Manning Coefficients

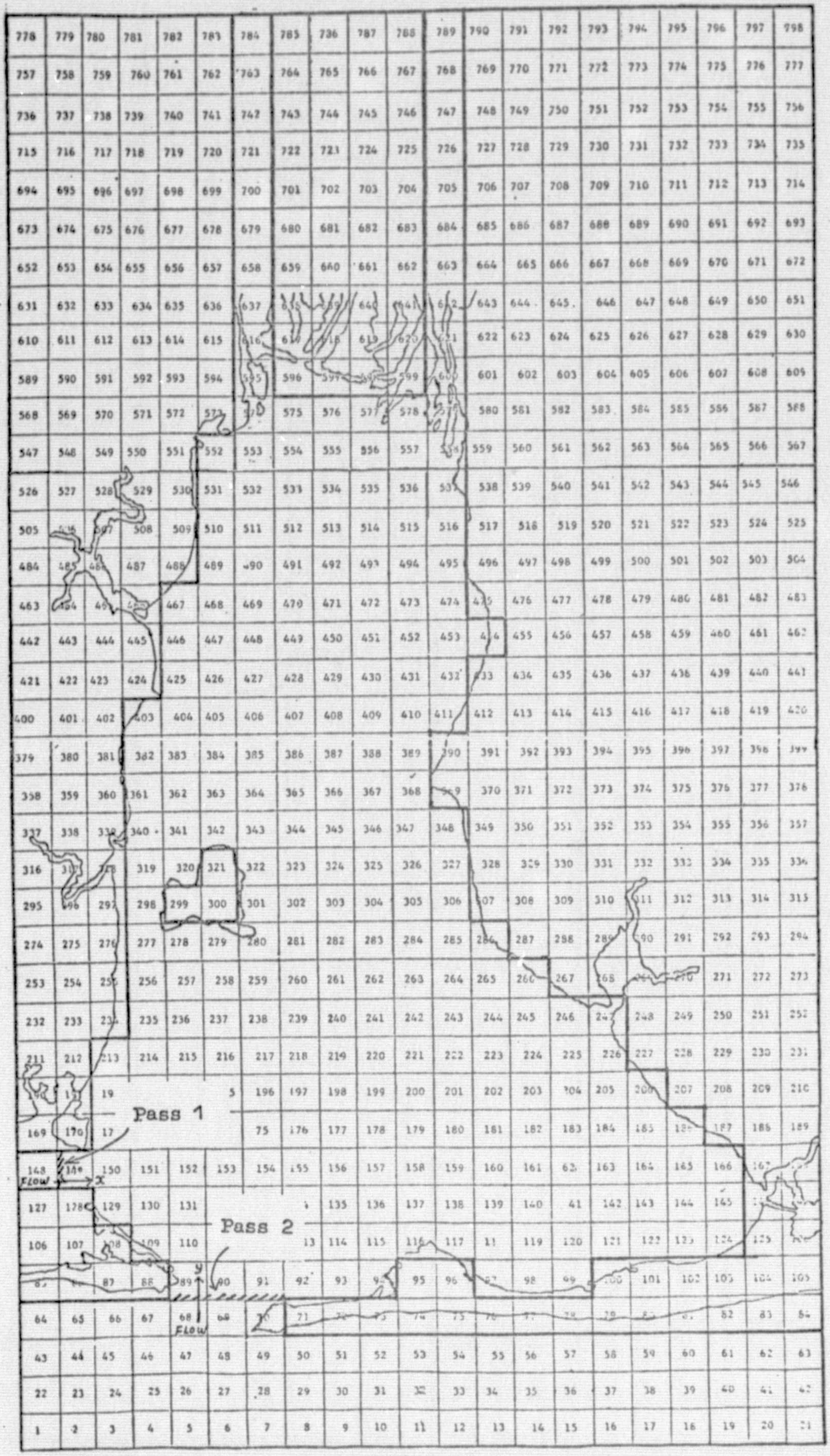


Fig. 25 - Passes

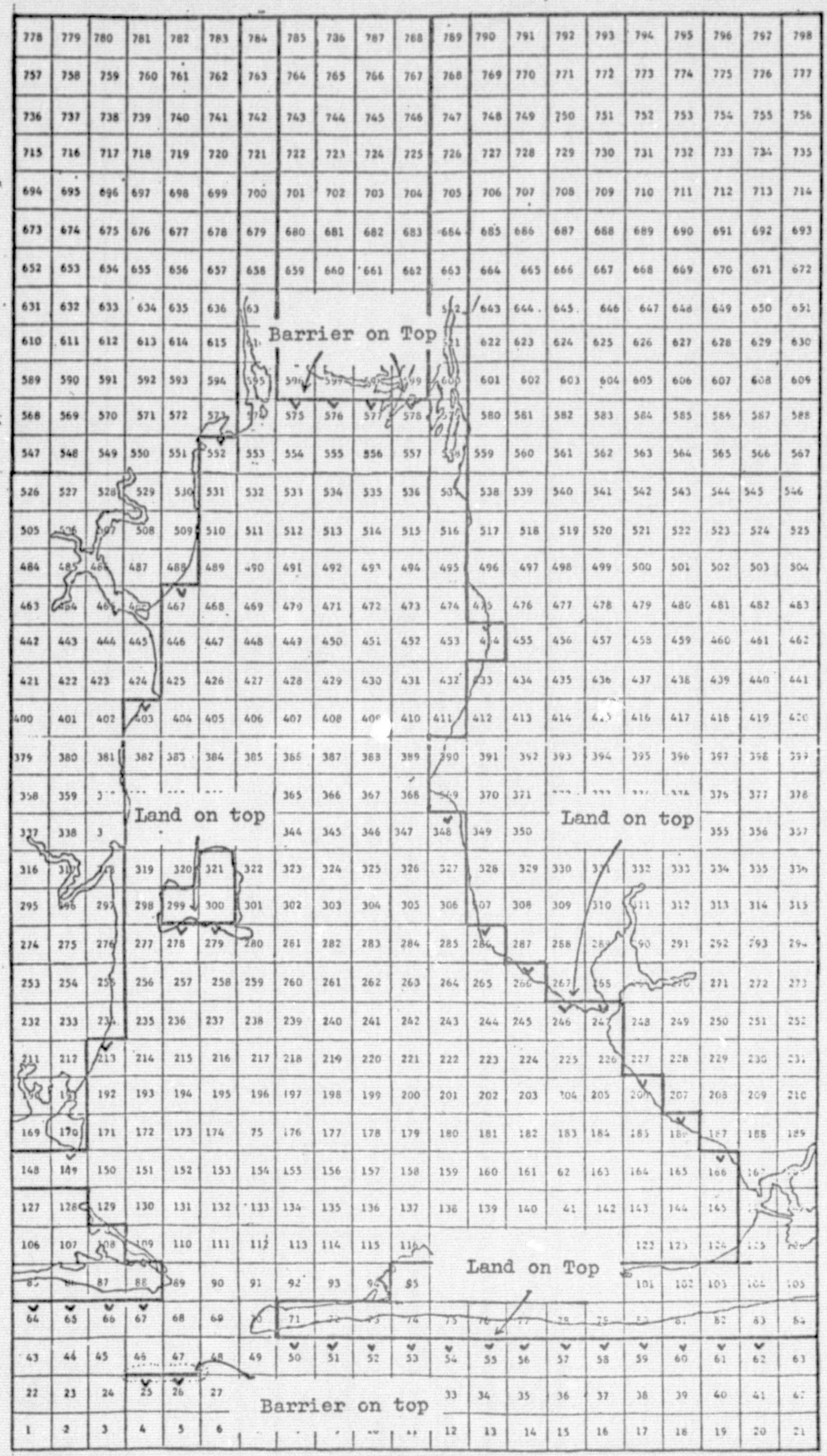


Fig. 26 - Zeroing of Vertical Velocities

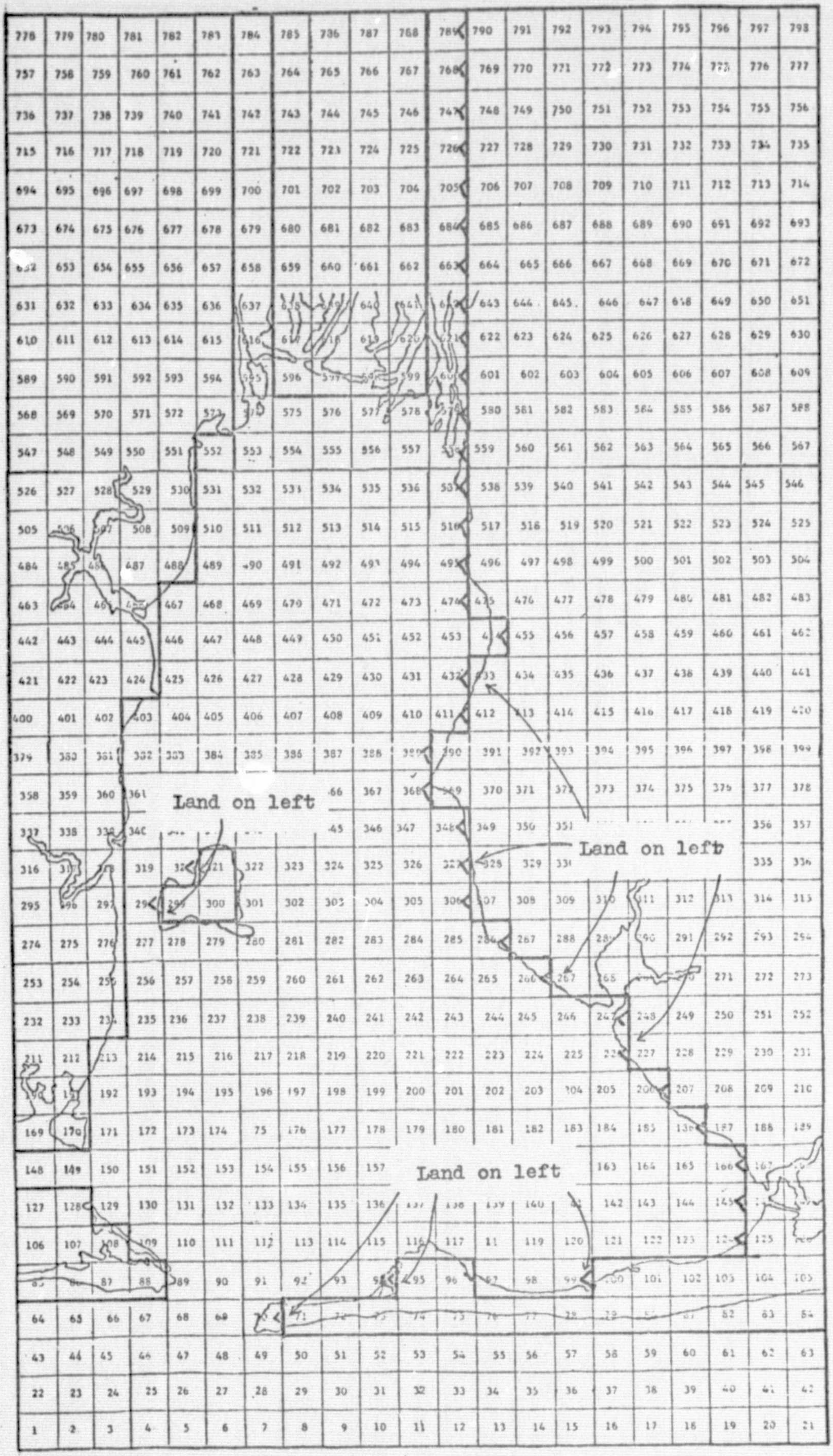


Fig. 27 - Zeroing of Horizontal Velocities

Total No. of Cells, Vp = 0	Total No. of Cells, Up = 0
IV	IU
38	38

Cell No., Vp=0
IBC(I)
25 26 64 65 66 67 etc.

Cell No., Up=0
IBC(I)
70 94 298 320 99 124

b. Modifying Friction Factor:

Pilot runs are necessary to obtain friction factor modification information. The following modification is used to restrict flow in the upper part of the bay.

Count total number of cells which FXs have to be modified and which FYs have to be modified, respectively. Record cell nos. (Figure 28).

Total No. Cells, FX modified	Total No. Cells, FY modified
NMODFX	NMODFY
8	8

Cell No. & Value of FX KC(I), VF(I)
362 1.1 384 1.1 406 1.1 ...

Cell No. & Value of FY KC(I), VF(I)
383 1.1 405 1.1 427 1.1 ...

C. Model Input for Mobile Bay (Refer to page 17 for variable description and pages 26-51 for Mobile Bay values.)

1. Input #1 - Program Control Card

   IFMT, ICORF, ICONV, IORIG, IRMB, ISPBK, IDSCH, IMODF, ICK, IMNDP, INC.

2. Input #2 - Geometrical Information

```
12345678901234567890123456789012345678901234567890123456789012
 0 1 1 1 1 1 1 1 0 0 4

12345678901234567890123456789012345678901234567890123456789012
    39    38    38    38     6  798    21
```

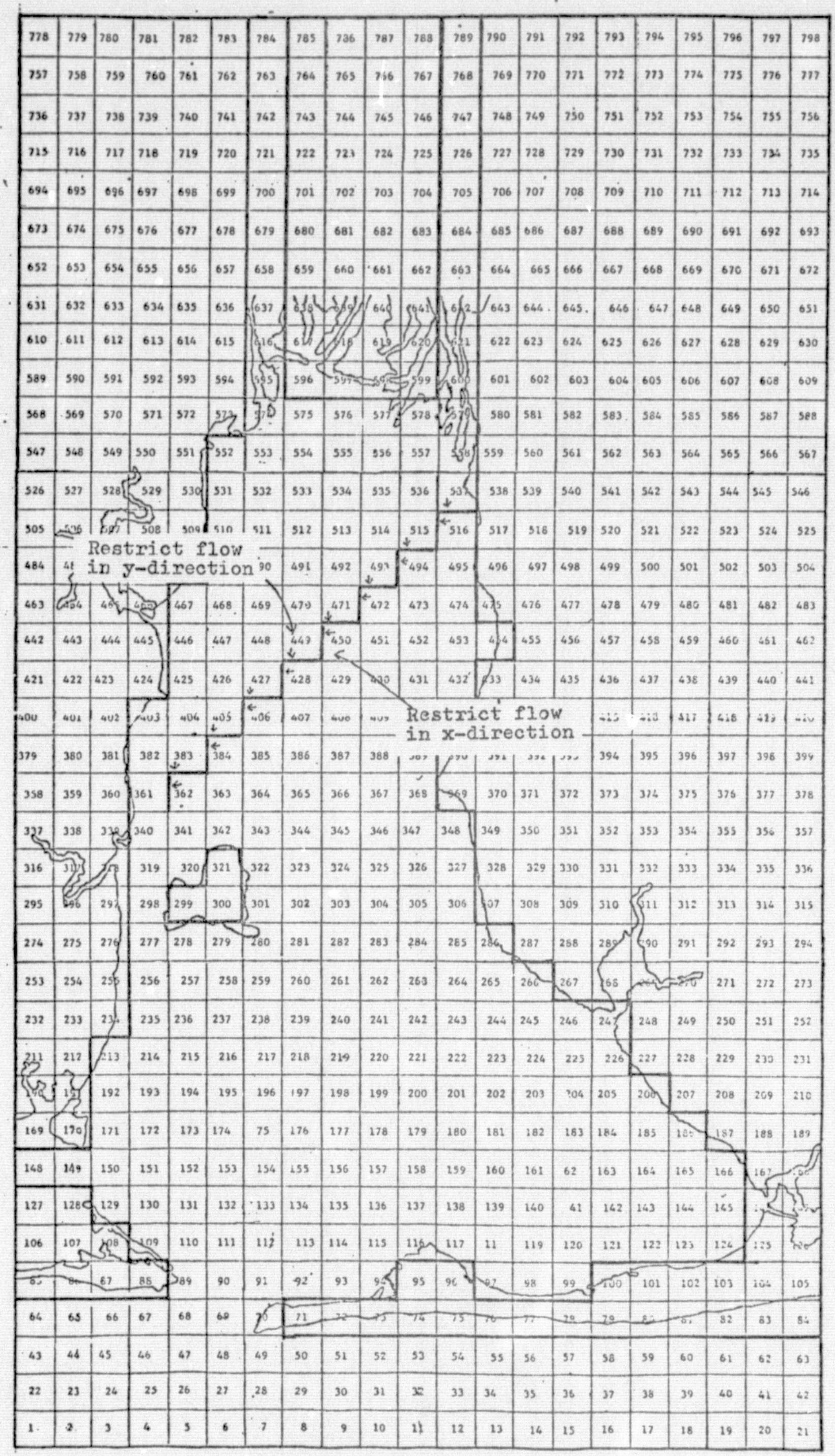


Fig. 28 - Friction Factor Modification

3. Input #3 - Physical Information

W, THETA, DELS, DELT, TIM, SLADJ

```
12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012
0.        0.          6561.68   120.      25.       0.        0.8
```

4. Input #4 - Left Boundary Cells of Each Segment

IBNDL

```
12345678901234567890123456789012345678901234567890123456789012345678901234567890
    2   23   44   65   89   97  109  129  149  170  192  213  235  256  277  298
  319  340  361  382  403  425  446  467  489  510  531  552  574  595  616  637
  658  679  700  721  742  763  784
```

5. Input #5 - Right Boundary Cells of Each Segment

IBNDR

```
12345678901234567890123456789012345678901234567890123456789012345678901234567890
   11   32   53   70   94   99  124  145  166  186  206  226  247  266  286  306
  327  348  368  389  411  432  454  474  495  516  537  558  579  600  621  642
  663  684  705  726  747  768  789
```

6. Input #6 - Cells that Require Zeroing of Calculated Vp

IBC

```
12345678901234567890123456789012345678901234567890123456789012345678901234567890
   25   26   64   65   66   67   67   50   51   52   53   54   55   56   57   58
   59   60   61   62  149  215  403  467  552  575  576  577  578  166  186  206
  247  266  286  348  454  246
```

7. Input #7 - Cells that Require Zeroing of Calculated Up

IBD

```
12345678901234567890123456789012345678901234567890123456789012345678901234567890
  70    94    99   124   145   166   186   206   226   247   2u6   286   298   306   320   327
 348   368   389   411   432   454   474   495   516   537   5ü8   579   600   621   642   663
 684   705   726   747   768   789
```

8. Input #8 - Discharge Rate of Rïvers

RB

```
123456789012345678901234567890123456789012345678901234567890123456789012
 6.70560  0.0       0.0       0.0       0.0       0.0
```

9. Input #9 - Manning Coefficient

```
123456789012345678901234567890123456789012345678901234567890123456789012
 15 15 15 15 15 15 15 15 15 15
 15 15 15 15 15 15 15 15 15 15
 15 15 15 15 15 15 15 15 15 15
 15 15 15 15 15 15
 18 15 15 15 18 18
 18 18 18
 18 18 18 18 18 15 15 18 18 18 18 18 18 18 18 18
 18 15 15 18 15 18 18 18 15 15 15 15 15 15 15 15 18
 18 18 18 18 18 18 15 18 18 18 18 18 18 18 18 18 18 18
 18 18 18 18 18 15 18 18 18 18 18 18 18 18 18 18 18
 18 18 18 18 15 18 18 18 18 18 18 18 18 18 18
 18 18 18 18 15 18 18 18 18 18 18 18 18 18
 18 18 18 15 18 18 18 18 18 18 18 18 18
 18 18 18 15 18 18 18 18 18 18 18
 18 18 18 18 15 18 18 18 18 18
 18 18 18 18 15 18 18 18 18
 18 18 18 18 15 18 18 18 18
 18 18 18 18 15 18 18 18 18
 18 18 18 18 15 18 18 18
 18 18 18 18 15 18 18 18
 18 18 18 15 18 18 18 18 18
 18 18 15 18 18 18 18 18
 10 10 10 10 18 18 18 18 18
 10 10 10 10 18 18 18 38
 12 15 10 18 18 18 18
 12 15 18 10 18 18 18
 12 15 18 18 10 18 18
 12 15 18 18 18 10 18
 15 18 18 18 18 10
 15 50 50 50 50 15
 15 50 50 50 50 15
 15 50 50 50 50 15
 15 50 50 50 50 15
 15 50 50 50 50 15
 15 50 50 50 50 15
 15 50 50 50 50 15
 15 50 50 50 50 15
 15 50 50 50 50 15
 15 50 50 50 50 15
```

10. Input #10 - Depth of Water Measured from Reference Plane

```
123456789012345678901234567890123456789012345678901234567890123456789012
 40 30 39 21 21 30 35 37 40 37
 34 39 28 17 30 30 27 38 39 40
 35 21  9  9 20 30  9 30 35 40
 29  6 11  9 23 30
  5  6 30 20 16  5
  3  6  5
  4  5  9 14 17 16 12  3  7  7  9  7  8  4  5  4
  4  8 10 10 13 12 12 12 12 12 10  9  7  8  8  8  5
 10 10 11 12 12 12 11 10 10 10 11 11 10  7  9  8  8  5
  8  8 10 12 11 11 10 10 10 10 11 11 11  7  9  8  4
  7 10 11 10 11 10 10 10 10 10 12 12 12  8  3
  3 10 11 11 12 11 11 10 11 10 10  9  7  3
  7 10 10 11 10 11 10 10 10  9  8  5  1
  7  9 10 12 10 11 11 10 10  8  2
  5  9 10 11 10 11 11 10  7  2
  6 10 10  9 12 11 11 10  5
  8 10 10  9 11 11 10 10  4
  4 10 10  9 11 12  9  7  4
  6 10 10 10 11 10  9  4
  8  9  9 10 11 10 11  6
  3  7  8 11 11 11 11  9  5
  7  8  9 10 10 11 10  9
  7  8  9 10 10 10  9 10  5
  6  6  6  6  6  7  8  8
  6 10  9 10  9  8  6
  2 10 10 10  9  7  5
  2  8 10  9  8  5 10
  2  8  5  9  6  4  3
  8  2  4  3  1  6
  8  1  1  1  1  6
 10  1  1  1  1 10
 10  1  1  1  1 10
 10  1  1  1  1 10
 10  1  1  1  1 10
 10  1  1  1  1 10
 10  1  1  1  1 10
 10  1  1  1  1 10
 10  1  1  1  1 10
 10  1  1  1  1 10
```

11. Input #11 - Modification of Friction Factor

NMODFX, NMODFY

Input #12 - Cell Number and Values of Friction Factors for FX

KC, OF

Input # 13 - Cell Number and Values of Friction Factors for FY

KC, OF

```
12345678901234567890123456789012345678901234567890123456789012345678901234567890
   8       6
  362   1.1  384   1.1  406   1.1  428   1.1  450   1.1  472   1.1  494   1.1  516   1.1
  383   1.1  405   1.1  427   1.1  449   1.1  471   1.1  493   1.1  515   1.1  537   1.1
```

12. Input #14 - Starting Time and Number of Tide Stations

TMIL, ITSN

Input #15 - Tide Equation Coefficients and Time Phase

CA, CB, CC, CD, TD

```
12345678901234567890123456789012345678901234567890123456789012345678901234567890
 13.5      3
1.03042    1.24243    0.004188  0.0567114 210.
1.08915    1.17665    0.004188  -0.003245 120.
1.18329    1.306828   0.004188  -0.182198 60.
```

13. Input #16 - Total Number of Boundaries

NTB

```
123456789012345678901234567890123456789012345678901234567890123456789012
    7
```

14. Input #17 - Boundary's Nature, Total Number of Cells in the Boundary, and Relative Information

NATURE, NBC, RZNF

Input #19 - Depth of Water Adjacent to Left or Bottom Sea Boundaries

ZB

```
123456789012345678901234567890123456789012345678901234567890123456789012
SB 10         1.
    2     3     4     5     6     7     8     9    10    11
  40.   30.   39.   21.   21.   26.   35.   37.   40.   37.
SL  1         2.
  149
  8.0
SL  4         1.
    2    23    44    65
  42.   40.   36.   36.
SR  3         1.
   11    32    53
RL  1       .762
  467
RT  1      6.7056
  784
RT  1         0.
  789
```

15. Input #20 - River Marsh Boundary Bottom Cells

IRMBB

Input #21 - River Marsh Boundary Top Cells

IRMBT

Input #22 - Depth of Weir Along River Marsh Boundary

ZRB

```
123456789012345678901234567890123456789012345678901234567890123456789012
  595  599
  784  788
1.8
```

16. Input #23 - Total Number of Cells of Spoil Banks Along Ship Channel

NSBC

Input #24 - Cell Number, Axis of the Spoil Bank in Each Cell, Depth of Spoil Bank

INSBC, IAXIS, ZCH

```
12345678901234567890123456789012345678901234567890123456789012345678901234567890
   22
  153Y  9.  174Y  7.  195Y  7.  196X  9.  217Y  9.  238Y  8.  259Y  9.  280Y  8.
  310Y  6.  322Y  5.  343Y  5.  364Y  6.  385Y  6.  406Y  7.  427Y  5.  448Y  6.
  469Y  3.  490Y  0.  511Y  0.  532Y  0.  553Y  0.  574Y  0.
```

17. Input #25 - Total Number of Passes Where Discharge Rates will be Calculated

LDSCH

Input #26 - Total Number of Cells at Each Pass, IAXIS of Flow Direction

NCDSCH, IAXIS

Input #27 - Cell Number S at Each Pass

ICDSCH

```
123456789012345678901234567890123456789012345678901234567890123456789012
    2
    3Y    1X
   89    90    91
  149
```

D. Program Output:

```
T=    300.00 DELT=       2.00   MIL. T=      18.50

TIDE HEIGHT AT STATION ( 1) =         .30
TIDE HEIGHT AT STATION ( 2) =         .87
TIDE HEIGHT AT STATION ( 3) =        1.50
VOLUME FLOW RATE AT LOCATION ( 1) =      -237910.91  CU.FT./SEC
VOLUME FLOW RATE AT LOCATION ( 2) =       138607.38  CU.FT./SEC
T=    360.00 DELT=       2.00   MIL. T=      19.50

TIDE HEIGHT AT STATION ( 1) =         .08
TIDE HEIGHT AT STATION ( 2) =         .59
TIDE HEIGHT AT STATION ( 3) =        1.17
VOLUME FLOW RATE AT LOCATION ( 1) =      -532609.66  CU.FT./SEC
VOLUME FLOW RATE AT LOCATION ( 2) =        86840.43  CU.FT./SEC
T=    420.00 DELT=       2.00   MIL. T=      20.50

TIDE HEIGHT AT STATION ( 1) =        -.09
TIDE HEIGHT AT STATION ( 2) =         .34
TIDE HEIGHT AT STATION ( 3) =         .85
VOLUME FLOW RATE AT LOCATION ( 1) =      -656387.59  CU.FT./SEC
VOLUME FLOW RATE AT LOCATION ( 2) =        28599.07  CU.FT./SEC
T=    480.00 DELT=       2.00   MIL. T=      21.50

TIDE HEIGHT AT STATION ( 1) =        -.19
TIDE HEIGHT AT STATION ( 2) =         .14
TIDE HEIGHT AT STATION ( 3) =         .54
VOLUME FLOW RATE AT LOCATION ( 1) =      -678752.15  CU.FT./SEC
VOLUME FLOW RATE AT LOCATION ( 2) =       -31559.35  CU.FT./SEC

RIVER -  1  FLOW RATE = -44000.00  CU.FT./SEC

RIVER -  2  FLOW RATE =       .00  CU.FT./SEC

RIVER -  3  FLOW RATE =       .00  CU.FT./SEC

RIVER -  4  FLOW RATE =       .00  CU.FT./SEC

RIVER -  5  FLOW RATE =       .00  CU.FT./SEC

RIVER -  6  FLOW RATE =       .00  CU.FT./SEC
```

HEIGHT FROM REFERENCE PLANE TO SURFACE

38						1.37	.00	.00	.00	.00	.59							
37						1.30	.00	.00	.00	.00	.55							
36						1.17	.00	.00	.00	.00	.51							
35						1.05	.00	.00	.00	.00	.50							
34						.95	.00	.00	.00	.00	.50							
33						.89	.00	.00	.00	.00	.51							
32						.89	.00	.00	.00	.00	.53							
31						.91	.00	.00	.00	.00	.55							
30						.93	.00	.00	.00	.00	.59							
29						.96	.00	.00	.00	.00	.65							
28						.97	.97	.98	.98	.91	.72							
27					.94	.97	.96	.97	.97	.96	.95							
26					.93	.97	.97	.98	.98	.98	.98							
25					.97	.98	.98	.98	.99	1.00	1.04							
24					.99	.99	.98	.99	1.00	1.06	1.08							
23				.97	.98	1.00	1.01	1.03	1.08	1.10	1.11							
22				1.00	1.01	1.03	1.06	1.12	1.14	1.14	1.16	1.19						
21				1.03	1.06	1.06	1.14	1.14	1.16	1.16	1.18							
20			1.07	1.08	1.09	1.13	1.15	1.15	1.16	1.17	1.20							
19			1.09	1.10	1.13	1.14	1.16	1.16	1.15	1.16								
18			1.11	1.12	1.13	1.14	1.17	1.17	1.15	1.15								
17			1.08	1.10	1.12	1.12	1.17	1.17	1.16	1.14	1.15							
16			1.07	1.08	1.10	1.11	1.15	1.15	1.15	1.13	1.13							
15			1.08	1.08	1.09	1.09	1.12	1.14	1.13	1.14	1.13							
14			1.07	1.07	1.07	1.06	1.09	1.11	1.14	1.13	1.13	1.13						
13			1.04	1.05	1.05	1.05	1.05	1.08	1.11	1.11	1.12	1.11	1.10					
12			1.02	1.03	1.03	1.03	1.02	1.06	1.08	1.09	1.09	1.12	1.10	1.08	1.05			
11		.97	.99	1.02	1.03	1.03	1.02	1.05	1.07	1.07	1.07	1.09	1.11	1.09	1.09			
10		1.00	1.00	1.01	1.01	1.03	1.03	1.02	1.06	1.06	1.07	1.07	1.11	1.11	1.13	1.17		
9	1.00	.98	.98	.99	.99	1.01	1.02	1.03	1.04	1.08	1.07	1.08	1.09	1.11	1.16	1.17	1.17	
8	1.20	1.01	.97	.96	.98	.99	1.02	1.06	1.02	1.06	1.09	1.07	1.09	1.11	1.14	1.14	1.13	1.10
7		.97	.95	.94	.96	.99	.99	1.04	1.06	1.05	1.07	1.07	1.10	1.10	1.08	1.05	1.03	1.02
6			.93	.88	.90	.91	1.01	.97	1.03	1.05	1.09	1.11	1.13	1.12	1.05	.97	.96	.97
5				.76	.80	.84	.92	.97	.98			1.16	1.19	1.20				
4	.59	.59	.64	.61	.68	.72												
3	.57	.60	.58	.63	.64	.63	.64	.59	.56	.59								
2	.59	.61	.62	.64	.66	.61	.62	.59	.59	.59								
1	.60	.57	.59	.55	.59	.55	.57	.57	.58	.56								

VELOCITIES IN X DIRECTION

39						.0	.0	.0	.0	.0	.0							
37						.0	.0	.0	.0	.0	.0							
36						.0	.0	.0	.0	.0	.0							
35						.0	.0	.0	.0	.0	.0							
34						.0	.0	.0	.0	.0	.0							
33						.0	.0	.0	.0	.0	.0							
32						.0	.0	.0	.0	.0	.0							
31						.0	.0	.0	.0	.0	.0							
30						.0	.0	.0	.0	.0	.0							
29						.0	.0	.0	.0	.0	.0							
28						.0	.2	.2	.9	1.6	3.2							
27					.0	.8	.3	.9	1.5	2.6	2.3							
26					.0	.2	.2	1.0	1.6	1.9	2.2							
25					.0	.5	.2	1.1	.4	-.2	-1.1							
24					.0	.7	.2	.5	-.8	-2.1	-.1							
23				.8	1.7	1.3	.1	-.4	-1.6	.5	.4							
22				.0	1.1	.9	-.1	-2.8	.9	1.8	1.4	-.2						
21				.0	.6	.6	-.5	2.4	2.7	3.1	2.6							
20			.0	.9	.3	-1.7	-.2	2.1	2.6	3.4	2.6							
19			.0	.5	-1.2	.4	-.2	.9	1.4	1.4								
18			.0	-.8	.8	.3	-.3	-.6	-.1	-1.0								
17			.0	-.1	.1	-.1	-.4	-2.0	-3.0	-3.8	-2.1							
16			.0	-.1	.0	-.4	-.3	-1.1	-2.2	-2.3	-1.3							
15			.0	.0	.4	.4	2.0	.2	-1.0	-1.7	-1.8							
14			.0	.9	.8	.7	2.8	.5	-.7	-2.4	-2.9	-1.4						
13			.0	.8	.8	.3	-.1	-1.6	-2.1	-3.1	-3.7	-3.0	-.9					
12			.0	.8	.8	.6	.0	-.3	-1.1	-1.8	-2.3	-2.5	-2.0	-1.3	-.3			
11		.0	1.0	.8	.5	.2	.1	-.9	-1.2	-1.9	-2.0	-1.7	-1.3	-.7	-.1			
10		.0	.3	.3	.0	.0	-.0	-.3	-.3	-.6	-1.3	-1.2	-1.1	-1.5	-.5	-.4		
9	.0	-1.8	2.9	3.0	1.5	-.1	-.6	.6	-.0	.3	-.3	-.4	-.4	-.8	-1.0	-1.1	-1.4	
8	25.7	26.2	18.9	12.1	5.9	-.0	1.1	1.3	.8	.4	.4	.5	-.4	-1.0	-.9	-1.0	-1.5	-1.9
7		.0	2.7	4.5	4.3	4.5	4.1	2.5	1.5	-.3	-.2	1.0	1.0	-.1	-.2	-.6	-.4	-.6
6			.0	2.1	1.6	3.2	3.8	1.0	.2	-1.9	-2.0	-2.1	-2.0	-1.7	-2.0	-1.7	-.8	-.3
5				.0	.4	1.3	-3.7	-4.2	-2.1			.0	-1.4	-.9				
4	-1.4	-1.9	-1.9	-2.3	-.1	-1.3												
3	-1.3	-.6	-3.3	-.9	3.7	-1.9	1.6	-2.3	-1.7	-.9								
2	-1.1	.3	4.5	2.6	.3	8.8	11.6	8.5	2.6	-.4								
1	-1.2	3.9	5.4	5.9	9.8	10.5	5.8	4.8	-.0	-9.2								

VELOCITIES IN Y DIRECTION

38						-4.3	.0	.0	.0	.0	2.2							
37						-1.9	.0	.0	.0	.0	4.2							
36						-.5	.0	.0	.0	.0	5.8							
35						.1	.0	.0	.0	.0	7.0							
34						.5	.0	.0	.0	.0	7.7							
33						.9	.0	.0	.0	.0	8.1							
32						1.7	.0	.0	.0	.0	8.4							
31						1.8	.0	.0	.0	.0	8.8							
30						2.4	.0	.0	.0	.0	9.3							
29						2.9	.0	.0	.0	.0	9.8							
28						3.8	.8	1.5	1.3	2.4	7.1							
27					.5	3.4	2.2	2.9	3.0	2.6	4.9							
26					.8	3.6	3.7	4.2	3.9	2.9	2.6							
25					1.7	3.8	5.1	4.1	3.7	2.2	3.7							
24					2.5	3.7	5.9	3.3	2.5	4.6	4.2							
23				.7	2.3	3.3	6.1	2.9	5.3	4.7	4.3							
22				1.9	2.8	3.0	4.4	7.2	7.3	5.1	3.1	1.0						
21				2.9	3.2	2.6	8.1	8.2	8.5	5.3	1.4							
20			1.3	3.1	1.8	4.7	10.9	9.5	9.9	5.6	.0							
19			2.9	1.8	4.1	4.8	12.6	10.6	10.1	4.9								
18			2.6	3.8	4.5	4.6	12.8	11.5	9.6	6.1								
17			2.5	4.7	5.1	4.9	11.6	10.6	9.2	7.1	1.6							
16			2.6	5.0	5.7	5.5	11.1	9.8	8.9	7.5	2.3							
15			2.7	5.9	6.5	6.9	9.7	8.6	8.2	7.1	3.1							
14			2.9	5.7	6.6	9.0	7.3	7.0	6.8	5.9	4.2	.9						
13			3.2	5.6	6.1	8.4	5.5	6.4	5.9	5.4	4.4	2.9	1.2					
12			3.7	5.8	5.9	7.5	5.1	5.6	4.9	5.1	4.1	3.2	2.2	1.0	.1			
11		-.8	2.9	5.4	5.5	7.4	4.2	4.7	4.6	4.2	3.9	3.6	2.6	2.2	1.3			
10		-.8	3.1	5.4	5.4	7.1	3.9	3.5	4.0	3.7	3.2	3.2	3.0	2.2	2.3	1.9		
9	.0	4.1	3.4	3.3	3.3	6.2	4.6	3.3	2.8	2.9	2.8	2.2	2.3	1.7	2.0	2.0	1.5	
8	.0	-3.0	-3.7	-3.3	-2.4	7.8	4.3	2.6	1.9	1.7	1.8	1.4	.8	.8	1.3	1.6	1.0	-.0
7		.0	-2.0	-3.6	-2.4	7.7	2.5	.8	.4	.8	1.7	.7	-.2	-.5	.2	.7	.5	-.2
6			.0	-4.4	-1.1	8.2	.9	-1.4	-2.1	.0	.0	.8	-.0	-.7	.0	.0	.0	.0
5				-4.8	-1.2	2.5	.0	.0	.0			.0	.0	.0				
4	.7	-1.0	-1.9	-2.9	-1.2	3.0												
3	1.8	-3.4	.0	.0	-3.3	3.1	-5.8	.3	-2.0	-.4								
2	3.7	1.7	-.2	-3.6	.8	6.7	-6.6	-4.6	-4.6	.7								
1	8.2	.6	-1.5	-1.0	4.2	.8	-8.4	-10.0	-13.2	10.0								

MAGNITUDE AND DIRECTION OF VELOCITIES

38					.0	.0	.0	.0	.0	.0				
38					.0	.0	.0	.0	.0	.0				
37					.3	.0	.0	.0	.0	.3				
37					270.0	.0	.0	.0	.0	90.0				
36					.1	.0	.0	.0	.0	.5				
36					270.0	.0	.0	.0	.0	80.0				
35					.0	.0	.0	.0	.0	.6				
35					270.0	.0	.0	.0	.0	90.0				
34					.0	.0	.0	.0	.0	.7				
34					90.0	.0	.0	.0	.0	80.0				
33					.1	.0	.0	.0	.0	.8				
33					90.0	.0	.0	.0	.0	90.0				
32					.1	.0	.0	.0	.0	.8				
32					90.0	.0	.0	.0	.0	90.0				
31					.2	.0	.0	.0	.0	.8				
31					90.0	.0	.0	.0	.0	90.0				
30					.2	.0	.0	.0	.0	.9				
30					90.0	.0	.0	.0	.0	90.0				
29					.3	.0	.0	.0	.0	1.4				
29					90.0	.0	.0	.0	.0	80.0				
28					.4	.1	.2	.4	1.4	1.3				
28					88.6	66.7	54.3	28.9	26.8	79.3				
27				.2	.4	.3	.3	.4	.7	1.6				
27				32.6	81.3	68.9	61.1	46.6	45.3	79.0				
26				.2	.4	.3	.4	.4	.6	.4				
26				81.2	86.6	78.7	70.4	63.1	53.0	73.7				
25				.4	.3	.4	.4	.4	.3	.5				
25				79.4	84.9	82.0	80.0	88.2	103.8	99.9				
24				.3	.3	.6	.3	.3	.4	.6				
24				80.8	83.3	86.2	91.8	114.4	107.5	90.6				
23			.2	.4	.5	.9	.5	.5	.5	.5				
23			15.0	57.9	78.5	91.7	108.6	98.0	84.5	87.6				
22			.2	.3	.3	.5	.5	.6	.5	.3	.0			
22			67.9	69.0	82.5	105.3	101.0	78.3	72.3	80.6	180.0			
21			.3	.3	.3	.6	.7	.7	.5	.3				
21			83.1	79.3	89.4	81.2	71.5	69.7	61.3	60.4				
20		.2	.4	.3	.3	.8	.8	.8	.6	.2				
20		54.5	78.2	105.7	104.8	84.4	75.3	72.1	61.3	28.5				
19		.2	.2	.3	.4	1.0	.9	.8	.7					
19		82.7	98.0	98.4	89.0	88.2	83.5	82.2	82.6					
18		.4	.3	.4	.4	1.0	1.0	1.0	1.1					
18		98.0	90.0	82.8	89.9	92.0	91.8	93.3	95.3					
17		.5	.4	.4	.5	1.0	.9	1.0	.9	.3				
17		91.5	89.9	90.0	93.2	95.5	102.7	109.8	114.3	142.6				
16		.3	.4	.5	.5	.9	.8	.8	.7	.4				
16		91.0	90.5	92.1	94.0	93.7	99.3	103.9	104.1	108.8				
15		.4	.5	.6	.6	.8	.8	.7	.7	.5				
15		90.0	87.8	86.0	79.1	84.0	92.5	99.0	103.6	108.4				
14		.5	.6	.6	.7	.8	.6	.6	.6	.5	.3			
14		80.9	81.8	83.6	77.5	78.7	90.7	102.0	112.5	120.0	147.5			
13		.4	.6	.6	.7	.6	.6	.6	.6	.5	.3	.2		
13		82.5	82.1	85.2	89.3	97.3	105.1	112.4	121.4	128.1	136.6	126.2		
12		.4	.5	.5	.7	.5	.5	.5	.5	.4	.4	.3	.2	.1
12		83.6	82.3	83.5	87.8	91.9	96.6	104.5	111.3	119.2	126.1	133.8	147.7	168.3
11	.2	.3	.5	.5	.6	.4	.4	.5	.4	.4	.3	.3	.2	.2
11	320.0	74.8	83.5	86.7	89.0	95.1	101.5	108.0	112.6	114.9	113.6	112.3	103.9	93.1

Magnitude and Direction of Velocities (Continued)

10		.1	.3	.4	.5	.6	.4	.4	.4	.4	.3	.3	.2	.2	.2	.2		
10		260.3	84.6	88.3	89.6	90.1	92.6	94.3	95.9	103.3	109.0	108.3	114.6	113.9	104.2	102.4		
9	.1	.2	.4	.4	.4	.6	.4	.3	.3	.3	.3	.2	.2	.3	.2	.3	.2	
9	180.0	71.6	47.6	62.7	81.3	93.1	90.1	85.3	87.9	90.1	96.8	98.4	102.4	114.4	116.0	122.1	132.3	
8	2.3	2'.0	1.3	.7	.2	.5	.4	.3	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
8	.0	1.4	359.4	.2	8.3	85.5	74.4	63.9	75.9	81.0	79.1	88.1	114.1	127.5	120.4	125.1	143.4	180.8
7		.4	.5	.5	.5	.6	.4	.2	.1	.1	.1	.1	.1	.0	.1	.1	.1	.1
7		311.9	321.6	321.8	331.1	60.9	46.0	41.6	63.1	100.5	76.7	45.3	32.6	137.7	118.9	112.7	123.1	203.8
6			.3	.7	.3	.6	.2	.0	.1	.5	.3	.3	.2	.2	.2	.3	.1	.0
6			316.4	294.7	323.6	66.3	35.9	334.6	224.0	168.2	157.6	160.2	182.7	197.3	177.6	164.5	155.7	221.2
5				.8	.2	.2	.2	.2	.2			.2	.2	.1				
5				272.6	306.6	102.4	173.3	192.8	224.3			149.3	180.1	214.6				
4	.1	.3	.2	.4	.1	.1												
4	168.1	195.5	203.9	252.5	239.2	103.5												
3	.0	.1	.2	.2	.3	.1	.3	.1	.0	.0								
3	126.7	228.7	203.7	313.4	279.3	92.5	263.5	175.7	217.0	204.5								
2	.1	.1	.1	.1	.2	.4	.4	.2	.1	.0								
2	97.9	340.2	358.8	308.7	316.7	25.7	328.4	338.5	287.9	147.6								
1	.2	.2	.1	.4	.5	.3	.3	.2	.2	.2								
1	77.2	13.8	351.8	343.7	13.9	24.8	305.2	287.8	242.5	130.8								

CONVECTIVE ACCELERATION

38					.000	.000	.000	.000	.000	.000				
38					.000	.000	.000	.000	.000	.000				
37					.000	.000	.000	.000	.000	.000				
37					.000	.000	.000	.000	.000	.000				
36					.000	.000	.000	.000	.000	.000				
36					.000	.000	.000	.000	.000	.000				
35					.000	.000	.000	.000	.000	.000				
35					.000	.000	.000	.000	.000	.000				
34					.000	.000	.000	.000	.000	.000				
34					.000	.000	.000	.000	.000	.000				
33					.000	.000	.000	.000	.000	.000				
33					.000	.000	.000	.000	.000	.000				
32					.000	.000	.000	.000	.000	.000				
32					.000	.000	.000	.000	.000	.000				
31					.000	.000	.000	.000	.000	.000				
31					.000	.000	.000	.000	.000	.000				
30					.000	.000	.000	.000	.000	.000				
30					.000	.000	.000	.000	.000	.000				
29					.000	.000	.000	.000	.000	.000				
29					.000	.000	.000	.000	.000	.000				
28					.000	.000	.000	.000	.000	.000				
28					.000	.000	.000	.000	.000	.000				
27				-.009	.001	.000	.001	-.017	-.008	.000				
27				.000	-.006	.016	.007	.014	-.023	-.067				
26				.001	.000	.000	-.008	-.019	-.035	.000				
26				-.003	.003	.014	.010	.009	.011	-.044				
25				-.000	.000	-.006	-.008	-.016	-.022	.000				
25				.008	.001	.014	-.004	-.002	-.010	.018				
24				.004	-.000	-.009	-.009	.002	.010	.000				
24				.008	.000	.007	-.005	-.012	.018	.004				
23			-.012	-.002	-.000	-.015	.007	.006	.012	.000				
23			.000	-.013	-.003	.005	-.001	.025	-.004	.000				
22			-.005	-.002	-.004	.009	.012	.014	.010	.000	.000			
22			.001	-.001	.002	-.017	.040	.028	.012	-.007	.000			
21			-.003	-.013	-.001	-.019	-.001	.004	.002	.000				
21			.003	.005	.001	.061	-.003	.027	.020	-.004				
20		-.005	-.010	-.005	.003	-.027	-.019	-.031	-.018	.000				
20		.000	-.001	-.011	.019	.033	.030	.035	.032	.014				
19		-.009	-.003	-.001	.001	-.030	-.030	-.041	.000					
19		.008	-.009	.018	.002	.027	.033	.001	.012					
18		-.005	-.006	-.004	-.001	-.032	-.035	-.048	-.057					
18		.001	.015	.001	.003	.007	.032	-.017	.050					
17		.007	-.002	-.005	-.004	-.031	-.056	-.026	-.006	.000				
17		.004	.006	.014	.010	-.013	-.029	-.009	-.007	-.032				
16		.000	.004	-.003	-.001	.013	.015	.031	.019	.000				
16		.002	.002	.014	.013	.020	-.015	-.007	-.023	-.028				
15		.008	.003	.003	.000	.008	.017	.012	.011	-.014				
15		.002	.014	.020	.027	-.030	-.018	-.024	-.025	-.016				
14		-.004	.001	-.004	-.070	-.029	.003	-.008	.008	-.002	-.004			
14		.002	-.005	.001	.024	-.054	-.023	-.022	-.027	-.015	-.021			
13		-.003	-.000	.005	-.040	-.025	-.020	-.009	.001	.010	-.003	-.008		
13		-.007	-.007	-.009	-.035	-.027	-.009	-.004	-.013	-.014	-.010	-.004		
12		-.001	-.003	-.006	-.001	.013	.009	.013	.014	.008	-.002	-.000	-.000	.000
12		-.001	-.002	-.004	-.020	-.006	-.012	-.013	-.008	-.015	-.003	-.003	-.004	.000
11	-.012	-.005	-.004	-.001	-.001	-.005	-.003	.001	.007	.008	.006	.004	.001	-.001
11	.000	-.023	-.007	-.004	.000	-.018	-.008	-.004	-.009	-.009	-.001	-.000	.001	-.001

Convective Acceleration (Continued)

10		.007	.021	.014	-.002	-.000	.003	.008	.008	.008	.005	.000	.001	-.002	-.002	-.008		
10		.003	-.001	.000	-.001	-.002	-.002	-.018	-.005	-.010	-.012	-.011	.000	-.001	.005	-.001		
9	.030	.045	.055	.036	-.001	-.002	.005	.002	.002	.005	.005	.003	.003	-.001	-.005	.001	-.007	
9	.000	.001	-.008	-.029	-.032	-.014	.007	-.007	-.013	-.005	-.009	-.007	-.005	-.008	-.006	.003	-.006	
8	-.252	.236	.134	.055	.028	.021	.008	.006	-.006	-.003	.002	.001	.002	-.000	-.002	-.002	.015	.000
8	.000	-.223	-.057	-.054	-.044	.024	-.002	.002	-.017	-.010	-.005	-.008	-.010	-.009	-.001	.000	-.006	-.006
7		-.008	-.012	.014	-.007	.005	-.006	.002	-.001	-.004	-.010	-.006	-.001	.001	.003	.004	.005	.000
7		.116	.073	.045	-.031	-.031	-.015	-.002	-.003	-.006	-.003	-.003	-.003	-.006	-.007	-.007	-.006	-.005
6			-.009	.011	-.022	-.059	.001	.000	.007	-.001	.002	.000	-.001	.008	.016	.006	.001	.000
6			.002	-.008	-.071	-.048	.025	-.005	-.003	-.003	-.009	-.001	.001	.006	.002	-.006	-.004	.000
5				.001	-.012	-.019	.012	.013	.000			.004	.003	.000				
5				.014	-.046	-.070	-.002	.008	.022			.001	-.002	.008				
4	-.000	-.001	.040	-.011	-.002	.004												
4	.000	.000	.000	.024	-.005	.001												
3	-.001	.027	.003	-.038	.013	-.001	.021	.001	.001	.000								
3	.001	-.001	.004	.010	-.001	.003	-.007	.000	.000	.000								
2	.001	-.014	-.001	.009	-.049	-.046	.017	.013	.001	.000								
2	.002	.011	-.004	.000	.067	-.036	.002	-.008	.001	.000								
1	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000								
1	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000								

DISPERSION COEFFICIENTS

38					0.	7.	0.	0.	0.	7.				
38					9.	1.	1.	1.	1.	6.				
37					0.	6.	0.	0.	0.	6.				
37					9.	1.	0.	0.	0.	7.				
36					0.	6.	0.	0.	0.	5.				
36					10.	0.	0.	0.	0.	8.				
35					0.	5.	0.	0.	0.	5.				
35					10.	0.	0.	0.	0.	8.				
34					0.	6.	0.	0.	0.	5.				
34					10.	0.	0.	0.	0.	10.				
33					0.	6.	0.	0.	0.	4.				
33					10.	0.	0.	0.	0.	10.				
32					0.	7.	1.	0.	0.	5.				
32					10.	0.	0.	0.	0.	11.				
31					0.	4.	0.	0.	0.	4.				
31					11.	0.	0.	0.	0.	11.				
30					0.	4.	0.	0.	0.	5.				
30					11.	0.	0.	0.	0.	12.				
29					0.	4.	1.	0.	0.	4.				
29					11.	0.	0.	0.	0.	12.				
28					0.	2.	1.	2.	3.	5.				
28					11.	1.	2.	1.	2.	8.				
27				0.	2.	1.	2.	3.	4.	3.				
27				2.	10.	3.	3.	3.	3.	5.				
26				0.	1.	1.	2.	3.	3.	3.				
26				2.	10.	4.	4.	4.	3.	3.				
25				0.	1.	1.	2.	1.	1.	1.				
25				3.	9.	5.	5.	4.	2.	4.				
24				0.	1.	1.	1.	1.	2.	1.				
24				5.	8.	6.	5.	3.	5.	4.				
23			1.	2.	2.	1.	1.	2.	1.	1.				
23			3.	5.	7.	6.	3.	6.	5.	4.				
22			0.	1.	1.	1.	3.	1.	2.	2.	1.			
22			5.	6.	6.	4.	7.	7.	5.	4.	0.			
21			0.	1.	2.	1.	3.	3.	3.	3.				
21			6.	6.	5.	8.	8.	8.	6.	3.				
20		0.	3.	2.	2.	1.	2.	3.	3.	3.				
20		3.	6.	4.	7.	10.	9.	9.	6.	0.				
19		0.	2.	2.	1.	1.	2.	2.	2.					
19		5.	4.	6.	8.	12.	10.	9.	5.					
18		0.	1.	1.	1.	1.	1.	1.	1.					
18		4.	6.	7.	7.	12.	11.	9.	6.					
17		0.	1.	1.	1.	1.	1.	2.	3.	2.				
17		5.	7.	7.	7.	11.	11.	9.	7.	3.				
16		0.	1.	0.	1.	1.	1.	2.	2.	2.				
16		5.	8.	8.	8.	12.	10.	10.	8.	4.				
15		0.	0.	1.	3.	6.	4.	2.	1.	1.				
15		5.	9.	9.	10.	11.	10.	9.	8.	5.				
14		0.	1.	1.	3.	8.	3.	1.	1.	3.	3.			
14		6.	9.	12.	15.	8.	8.	8.	8.	6.	3.	2.		
13		0.	1.	2.	1.	1.	1.	2.	2.	3.	3.	3.		
13		7.	10.	11.	15.	8.	9.	8.	7.	6.	5.	2.		
12		0.	2.	2.	2.	0.	1.	2.	2.	2.	2.	4.	2.	2.
12		9.	11.	11.	15.	10.	9.	8.	7.	6.	5.	2.	2.	2.
11	0.	4.	3.	3.	3.	1.	2.	3.	3.	2.	2.	2.	2.	1.
11	4.	10.	12.	12.	15.	12.	10.	8.	7.	5.	5.	4.	3.	2.

Dispersion Coefficients (Continued)

10		0.	3.	3.	2.	1.	1.	3.	4.	5.	4.	3.	3.	3.	2.	1.		
10		7.	10.	12.	12.	16.	15.	12.	9.	7.	5.	5.	3.	2.	2.	1.		
9	0.	9.	6.	4.	2.	1.	6.	7.	8.	7.	7.	6.	4.	3.	2.	2.	1.	
9	0.	8.	10.	12.	14.	22.	17.	12.	10.	7.	5.	4.	3.	1.	1.	1.	1.	
8	16.	16.	8.	6.	4.	1.	8.	10.	10.	10.	9.	8.	5.	4.	3.	2.	2.	2.
8	0.	5.	7.	12.	15.	31.	19.	13.	12.	6.	5.	3.	3.	2.	1.	1.	1.	1.
7		0.	6.	7.	6.	3.	12.	14.	14.	15.	13.	10.	7.	4.	3.	2.	3.	2.
7		0.	6.	13.	20.	45.	22.	16.	11.	4.	2.	2.	2.	2.	1.	1.	1.	1.
6			0.	8.	7.	6.	24.	21.	16.	11.	7.	6.	4.	3.	3.	2.	2.	1.
6			0.	12.	26.	64.	20.	14.	8.	0.	0.	3.	1.	2.	0.	0.	0.	0.
5				0.	7.	16.	43.	23.	9.			0.	2.	2.				
5				18.	39.	86.	0.	0.	0.			0.	0.	0.				
4	35.	15.	14.	15.	14.	16.												
4	18.	10.	6.	12.	40.	78.												
3	38.	19.	24.	14.	15.	16.	32.	25.	11.	8.								
3	20.	25.	0.	0.	44.	64.	30.	32.	29.	27.								
2	39.	26.	27.	19.	31.	24.	33.	31.	25.	15.								
2	16.	28.	31.	30.	36.	49.	32.	34.	31.	26.								
1	43.	26.	24.	17.	21.	39.	24.	23.	14.	9.								
1	42.	32.	41.	23.	28.	34.	41.	40.	42.	39.								

NET VELOCITIES IN X-Y DIRECTION * 1000

38					0.	600.	2.	2.	2.	-36.				
38					-545.	406.	412.	410.	411.	36.				
37					0.	119.	58.	7.	-37.	-14.				
37					-528.	199.	226.	228.	202.	51.				
36					0.	89.	52.	9.	-28.	-8.				
36					-516.	151.	172.	175.	163.	59.				
35					0.	74.	48.	10.	-26.	-10.				
35					-504.	121.	136.	139.	125.	70.				
34					0.	68.	44.	11.	-20.	-7.				
34					-494.	99.	110.	113.	107.	78.				
33					0.	76.	46.	12.	-21.	-9.				
33					-482.	72.	84.	89.	80.	88.				
32					0.	74.	47.	13.	-22.	-9.				
32					-471.	47.	59.	64.	59.	98.				
31					0.	65.	43.	10.	-24.	-10.				
31					-461.	30.	37.	40.	36.	108.				
30					0.	69.	41.	8.	-25.	-10.				
30					-450.	13.	17.	19.	16.	119.				
29					0.	64.	38.	7.	-25.	-14.				
29					-540.	0.	0.	0.	0.	190.				
28					0.	95.	45.	49.	121.	78.				
28					-510.	-22.	-3.	25.	43.	111.				
27				0.	-45.	43.	37.	58.	85.	93.				
27				-150.	-439.	6.	5.	24.	31.	59.				
26				0.	-11.	21.	38.	37.	39.	20.				
26				-192.	-404.	19.	1.	13.	17.	12.				
25				0.	-22.	19.	27.	21.	-2.	-8.				
25				-299.	-287.	28.	-7.	-11.	8.	27.				
24				0.	-33.	19.	8.	-9.	3.	16.				
24				-164.	-238.	21.	-23.	-1.	16.	8.				
23			108.	2.	-34.	22.	-28.	6.	33.	18.				
23			-105.	-200.	-332.	-25.	-3.	29.	0.	-10.				
22			0.	-33.	-27.	14.	18.	37.	26.	16.	0.			
22			-129.	-150.	-184.	-9.	18.	9.	-8.	-23.	0.			
21			0.	-38.	-61.	4.	43.	23.	10.	1.				
21			-171.	-181.	-118.	28.	-0.	-5.	-15.	-27.				
20		0.	-40.	-48.	32.	3.	2.	-3.	-19.	-45.				
20		-91.	-187.	-90.	-128.	25.	-4.	-18.	-25.	0.				
19		0.	-46.	31.	9.	2.	-17.	-13.	-26.					
19		-85.	-71.	-103.	-148.	7.	-2.	-21.	-12.					
18		0.	15.	-0.	-16.	1.	-26.	-35.	-55.					
18		-89.	-79.	-109.	-130.	-19.	-10.	-20.	32.					
17		0.	-1.	-22.	-24.	0.	-20.	-47.	-40.	-32.				
17		-132.	-100.	-109.	-121.	-41.	-25.	-8.	39.	33.				
16		0.	7.	0.	-4.	3.	15.	38.	47.	35.				
16		-59.	-108.	-113.	-114.	-29.	-9.	3.	-1.	-2.				
15		0.	0.	21.	58.	109.	76.	44.	20.	-2.				
15		-77.	-87.	-82.	-29.	-66.	-41.	-24.	-24.	1.				
14		0.	2.	1.	-12.	-47.	9.	8.	-11.	-23.	-59.			
14		-90.	-97.	-97.	-52.	-26.	-43.	-42.	-33.	-0.	59.			
13		0.	-8.	-8.	-6.	-7.	-9.	-7.	-6.	-3.	-10.	-15.		
13		-77.	-100.	-97.	-49.	-28.	-41.	-42.	-30.	-5.	19.	16.		
12		0.	-20.	-29.	-27.	0.	10.	21.	36.	35.	20.	-5.	-19.	-17.
12		-106.	-101.	-99.	-29.	-17.	-32.	-32.	-30.	-23.	-7.	4.	7.	18.
11	0.	-24.	-47.	-68.	-86.	-5.	9.	23.	30.	33.	33.	25.	20.	14.
11	-70.	-104.	-114.	-116.	55.	-2.	-21.	-22.	-27.	-23.	-15.	-6.	-8.	3.

Net Velocities in X-Y Direction * 1000 (Continued)

10		0.	-61.	-60.	-56.	-11.	-1.	22.	30.	32.	33.	20.	8.	-2.	2.	6.		
10		-118.	-109.	-107.	-85.	67.	19.	-16.	-21.	-29.	-33.	-25.	-12.	-1.	2.	-6.		
9	0.	-312.	-184.	-105.	-65.	-8.	47.	45.	33.	24.	21.	15.	12.	11.	8.	-2.	-0.	
9	0.	-16.	-49.	-54.	-21.	119.	12.	-30.	-31.	-31.	-36.	-30.	-18.	-5.	-7.	1.	1.	
8	88.	92.	90.	31.	-5.	-11.	39.	44.	18.	6.	7.	7.	14.	14.	4.	-1.	-3.	-6.
8	0.	-9.	-101.	-91.	-25.	156.	11.	-59.	-46.	-31.	-35.	-25.	-23.	-14.	-11.	-1.	1.	6.
7		0.	9.	3.	-23.	-47.	60.	38.	-38.	-78.	-54.	-16.	21.	23.	9.	5.	4.	4.
7		0.	-142.	-137.	-72.	247.	-13.	-129.	-81.	-4.	9.	9.	-27.	-28.	-16.	-3.	-0.	3.
6			0.	217.	215.	252.	91.	9.	-54.	-181.	-55.	-68.	-42.	-34.	-17.	-3.	3.	3.
6			0.	-138.	70.	74.	-88.	-145.	-69.	0.	0.	27.	-11.	-13.	0.	0.	0.	0.
5				0.	68.	-40.	-235.	-199.	-166.			0.	-31.	-17.				
5				-102.	-289.	-68.	0.	0.	0.			0.	0.	0.				
4	-7.	-170.	-5.	-33.	-44.	-37.												
4	-24.	133.	-20.	-138.	-46.	-39.												
3	-3.	-65.	-123.	-95.	18.	-237.	-1001.	-315.	-170.	-74.								
3	-55.	63.	0.	0.	-424.	-138.	44.	117.	85.	75.								
2	1.	-53.	-117.	-71.	25.	109.	258.	202.	167.	92.								
2	-119.	5.	79.	103.	-196.	-16.	43.	63.	4.	-16.								
1	4.	-29.	30.	54.	-69.	-64.	-33.	53.	-6.	-34.								
1	-126.	72.	61.	-39.	-314.	8.	124.	4.	-22.	19.								

TOTAL + DISCHARGE AT LOCATION (1) = .2614449+11
TOTAL - DISCHARGE AT LOCATION (1) = -.2722625+11

TOTAL + DISCHARGE AT LOCATION (2) = .3146757+10
TOTAL - DISCHARGE AT LOCATION (2) = -.2302525+10

@FIN

E. System Verification:

1. The first step in the verification process is checking the tide heights at each tide station with actual data. Actual data obtained from tide charts are plotted with the data predicted by the model. Comparison of the tidal amplitudes and phases between each set of data is then made. An example is shown in Figure 29.

2. The second step in the verification process involves the comparison of discharge rates at each pass within the system. Field measurements taken by the Corps of Engineers at Main Pass and Cedar Point are plotted with the model predicted values. Figure 30 and 31 illustrate this method.

3. The third step in the verification process depends on the successful completion of a cyclic material balance. In this case all of the input terms contributing to system mass minus all of the mass output terms should be close to zero for the tidal cycle (under normal conditions). Input terms include river discharge rates and positive discharges at each pass, while output terms include negative discharges at each pass and/or river or channel. Table summarizes the material balance concept for a condition in which bay behavior was normal (i.e. no unusual wind, tidal or river flow conditions).

4. The last step in the verification procedure involves checking the flow direction and speed at various locations within the system. This method is dependent upon the availability of velocity data for point within the bay and, perhaps in some cases where surface or bottom data are taken, the interpretation of data to conform to the model base (average over depth and within the grid area). In most cases, this comparison provides trend assessment rather than a specific, quantitative check on the system. An illustration is shown in Figure 32 and Figure 33 for the entire bay. Data used were taken from McPhearson (10) and includes ebb flow and flood flow conditions.

F. The Use of the Hydrodynamic Model:

The hydrodynamic model developed for the Mobile Bay system has been used in several studies. Results show that the model has the capability of handling a wide variety of problems and of providing important information about the system over several different time frames. A list of research studies shown below will give users an insight into several model capabilities.

1. Hydrodynamic parametric studies in 1972 by Hill and April (7) were conducted to determine the affects of wind direction and speed, river flow rate changes, channel effects, convective acceleration effects and Coriolis effects on Mobile Bay water movement.

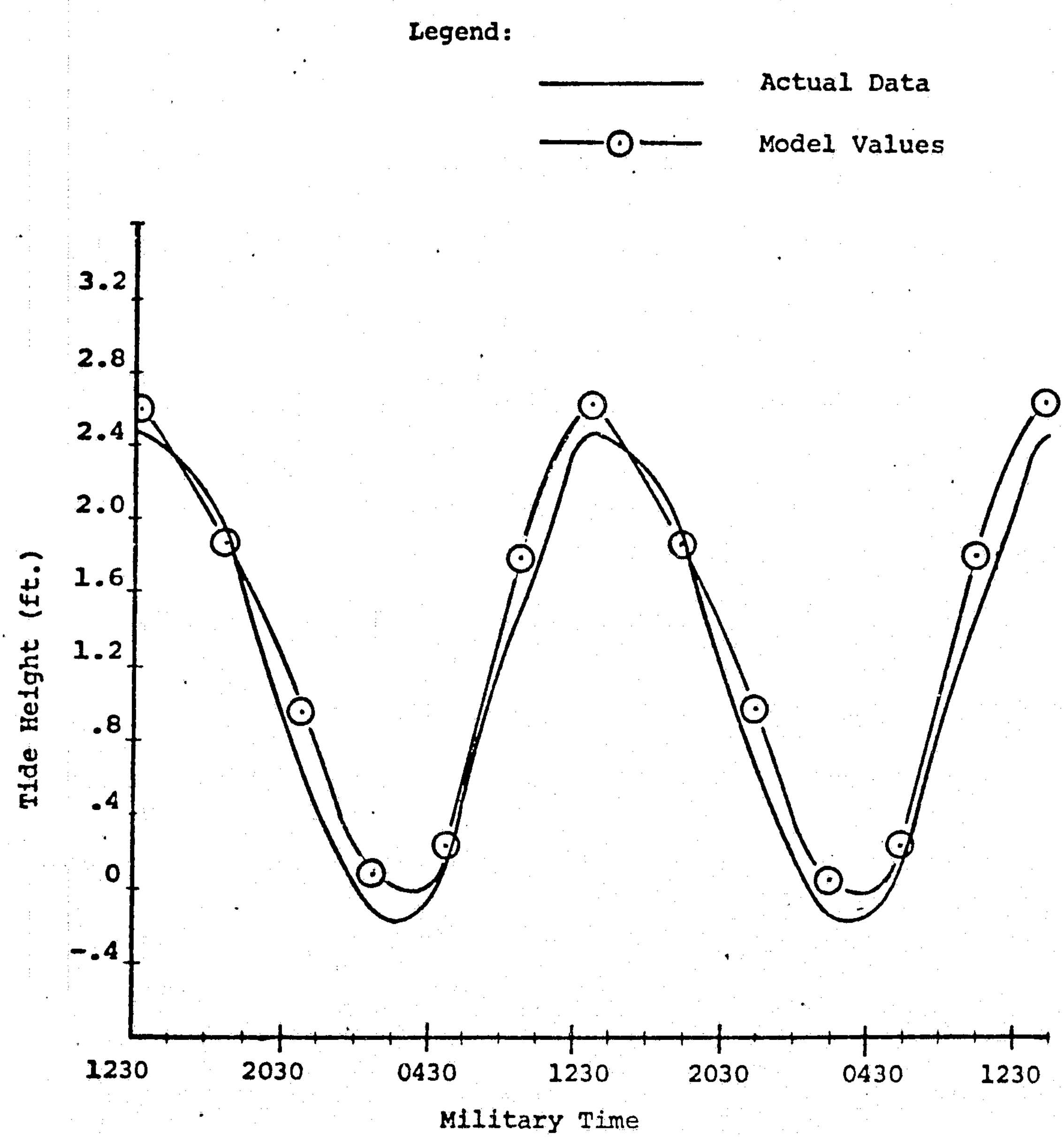


Figure 29. -- Comparison of Tidal Amplitude and Phases at a Location in Mobile Bay.

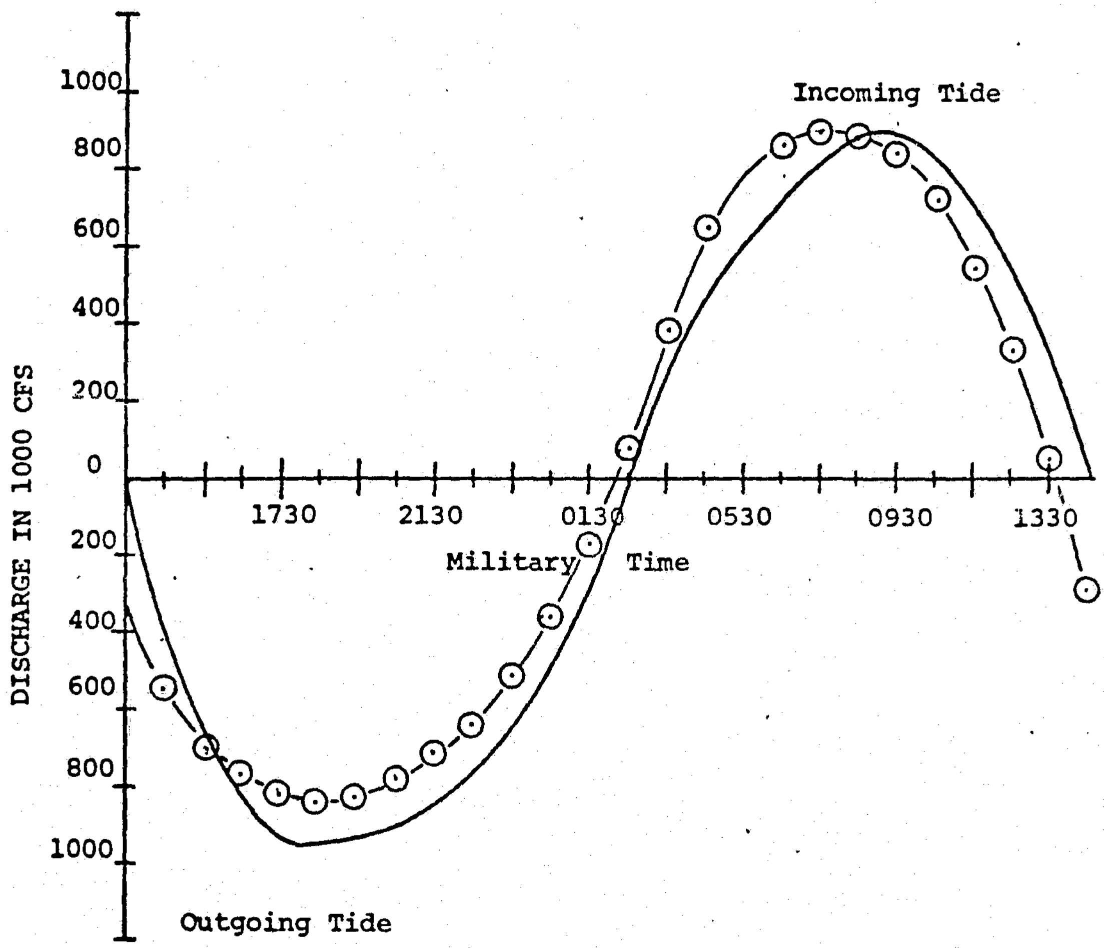


Fig. 30.--Comparison of discharge rates calculated by the hydrodynamic model with actual field data taken May 15 and 16, 1972, for Main Pass in Mobile Bay.

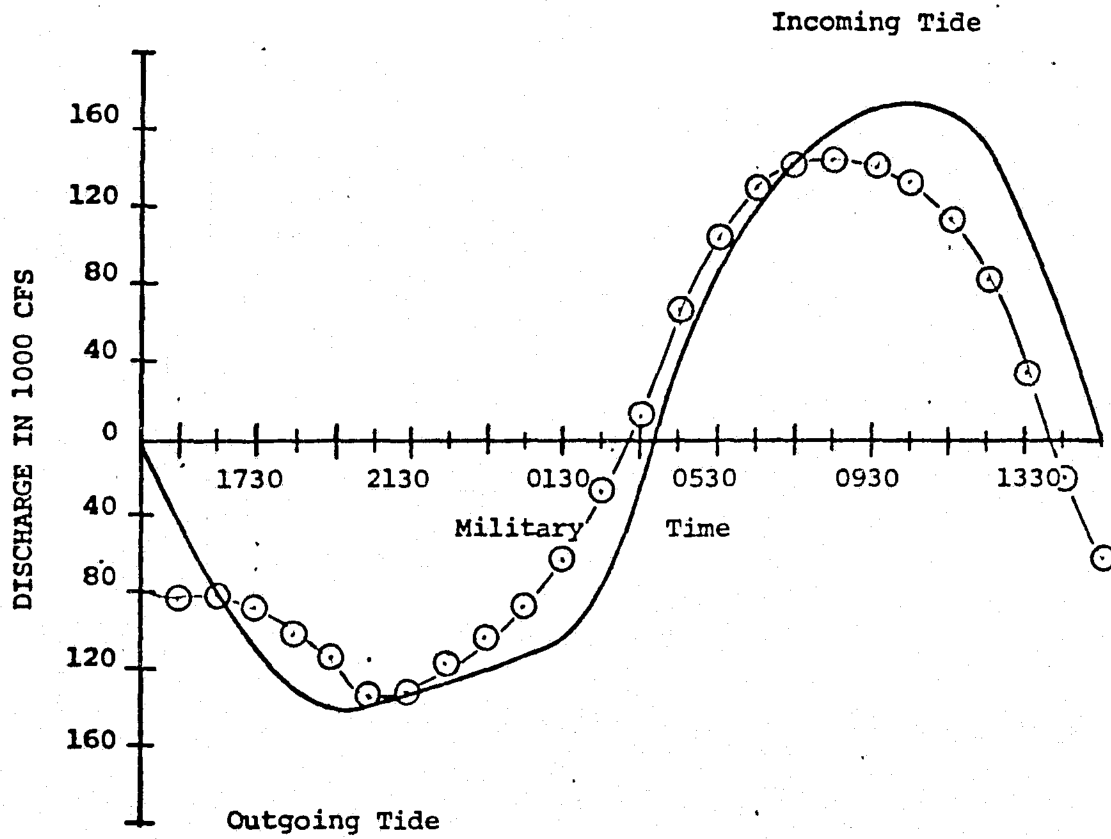


Fig. 31.--Comparison of discharge rates calculated by the hydrodynamic model with actual field data taken May 15 and 16, 1972, for Cedar Point in Mobile Bay.

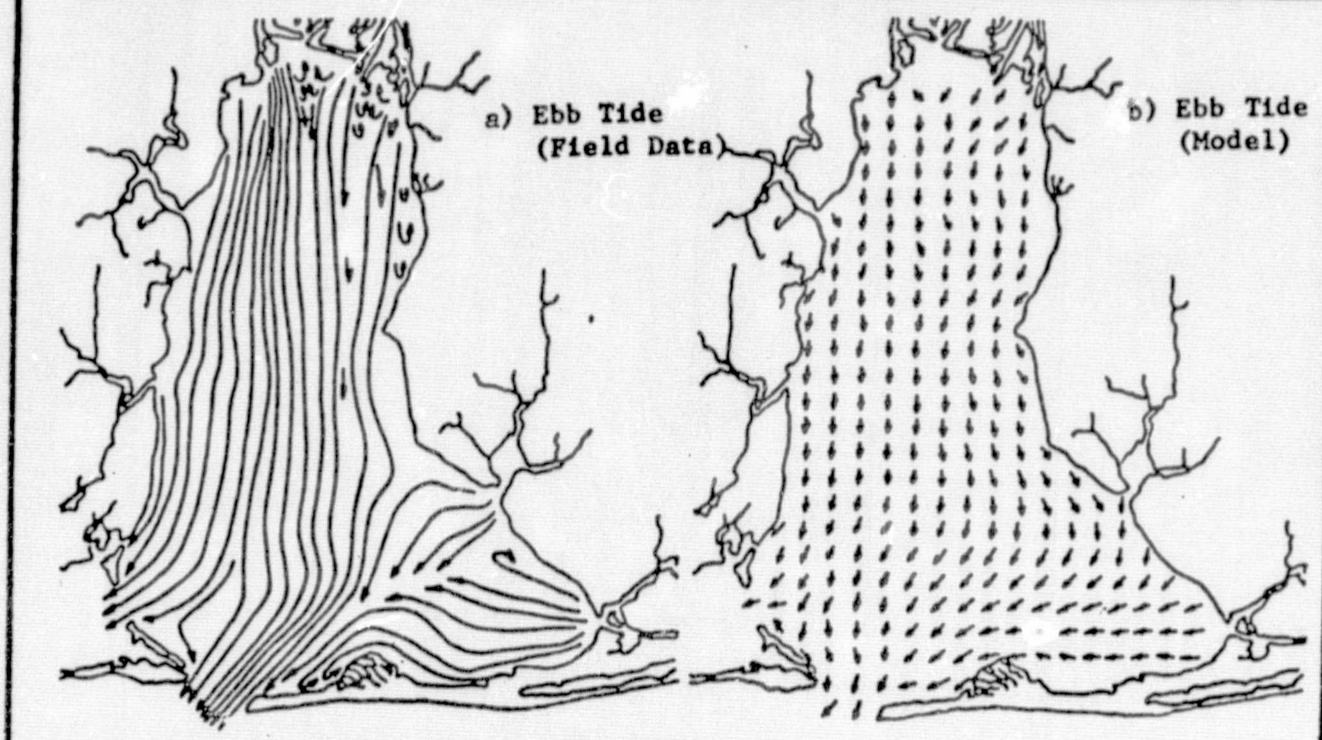


Figure 32 - Velocity Patterns for Ebb Tide Conditions in Mobile Bay.

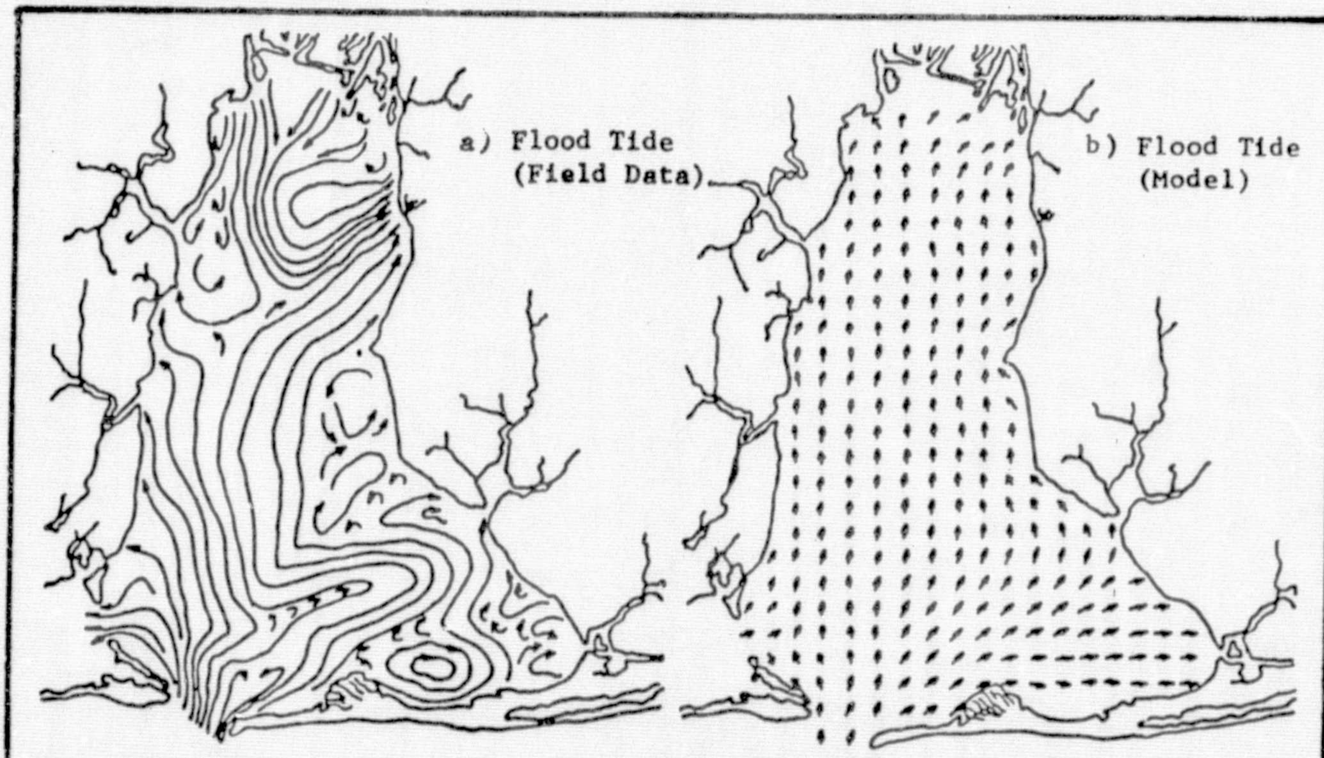


Figure 33 - Velocity Patterns for Flood Tide Conditions in Mobile Bay.

2. Mobile Bay salinity distributions were studied using the hydrodynamic model to provide average velocity and dispersion data on a tidal cycle average time frame. This study included the investigation of wind effects and river flow rates on salinity patterns within the bay. An extension of this work could relate the flushing characteristics of the bay during seasonal variations. (7)

3. Total coliform group distribution studies were studied by Liu and April (8) in a non conservative species transport model. The hydrodynamic model was used to furnish net velocities over the tidal cycle and maximum velocities for each water cell within the system. Dispersion coefficients were also provided in this study.

4. April and Brett (9) used the hydrodynamic model to provide current data for isolated sections of the bay in which maintenance dredging activities were concentrated. In these investigations, transport and distribution of sediment brought up from the bay bottom during dredging were predicted using a modified conservative species model. This model included resuspension of sediment from the bay bottom, settling and hindered settling mechanisms. Also studied were trend behavior of sediment transport over long periods including an assessment of the impact of Mobile ship channel construction on bay bottom configuration and sediment deposition patterns.

5. The hydrodynamic behavior of Little Dauphin Bay has been investigated using the hydrodynamic model. The initial goal of the project is to predict the distribution and flushing characteristics of pollutants within this restricted tidal water body.

In addition to the above on-going investigations, the hydrodynamic model will also be utilized in the following future studies:

1. Storm surge effects on estuary system behavior.

2. Continued sediment and turbidity distribution studies.

3. Adaptation of remote sensing data collection methods to mathematical modeling techniques.

4. Mississippi Sound-Mobile Bay interactions at Cedar Point.

5. Interactive coupling of the hydrodynamic model with the various transport models, energy model and other related models.

G. Limitations of the Hydrodynamic Model:

At the present time the hydrodynamic model is operational and is capable of handling a wide variety of problems. However, there are some restrictions which are placed on its formulation to make it functional at an economic level. Plans to continue investigations to modify the model and thereby remove some of the restrictions are underway. These modifications will thus provide a model suitable of an even wider range of applications for which bay system behavior is needed.

In its present form the hydrodynamic model is restricted by the following:

1. Only rigid (fixed) boundaries can be handled in the current hydrodynamic model. Land areas which could become flooded during high water periods are not accounted for (except in the river-marsh area in the northern bay).

2. The model assumes a constant density throughout the system. Thus density induced currents are considered negligible. Simulation of salt wedge effects (stratification) is possible in those portions of the system where this behavior is known to exist.

3. Wind velocities are restricted to values below 25 knots. This condition is partly related to the ability of the model to handle only predesignated water cells under restriction number 1 above.

V. Acknowledgement

The development of the general program for the hydrodynamic model was accomplished under the sponsorship of a National Aeronautics and Space Administration contract (NAS8-29100), the help of Geological Survey of Alabama and the computer center of The University of Alabama. Their help and support are gratefully acknowledged.

VI. References

1. Schanker, Frank D., et al. A Numerical Model for the Simulation of Tidal Hydrodynamics in Shallow Irregular Estuaries. Austin, Texas, Texas University, Report PB-184-834 (Feb., 1969), 1-122.

2. Masch, P. E., Hydrodynamics and Transport Models for Galveston Bay - Recommended Models and Model Structure. Austin, Texas, Report to the Texas Water Quality Board, Aug., 1968.

3. Water Resources Engineers, Inc., A Hydraulic-Water Quality Model of Suisum and San Pablo Bays. Report to FWPCA, March, 1966.

4. Simmons, H. B., "Use of Models in Resolving Tidal Problems." Journal of the Hydraulic Division, ASCE, XCV (Jan., 1969), 125-146.

5. Masch, F. D. and Schanker, A. J., Mathematical Simulation of Two Dimensional Horizontal, Convective Dispersion in Well Mixed Estuaries. Austin, Texas, University of Texas, Tech. Rep. C-32, 1-9.

6. Ross, B. E., Mathematical Model of Tampa Bay. Tampa, Fla., University of South Florida, Tech. Rep. DACW17-71-C-0001 (July, 1971), 41-54.

7. Hill, Donald O. and April, Gary C., A Hydrodynamic and Salinity Model for Mobile Bay, Report to NASA, The University of Alabama, BER Report No. 169-112, University, Alabama, May, 1974.

8. Liu, Hua-An and April, Gary C., A Non-Conservative Species Transport Model for Mobile Bay, Report to NASA, The University of Alabama, BER Report No. 185-112, University, Alabama, January, 1975.

9. April, G. C. and C. E. Brett, Predicting Sediment Transport and Deposition Patterns in Mobile Bay, Alabama, Paper E-3, 1st International Symposium on Dredging Technology, Canterbury, England, Sept. 17-19, 1975.

10. McPhearson, Roland M., Jr., The Hydrography of Mobile Bay and Mississippi Sound, Alabama, Journal of Marine Science, I (Aug., 1970), 1-83.

VII. Appendix A

This appendix contains a detailed program listing of the general hydrodynamic model.

```
@ELT,L SAM.MAIN
ELT007 RL1B70 01/29-17:45:51-(60,)
056   C
057   C       +
057   C       GENERAL HYDRODYNAMIC PROGRAM - VERSION 1.28.76
057   C       +
057   C
056           DIMENSION VOL(20), RB(20),  KC(100), VF(100), AMNY(2500),
056          1IBC(250), IBD(250), ISPACE(3), FX(2500), FY(2500),
056          2TD(20), HDB(20), DISR(20), SDISRP(20), SDISRN(20)
056   C
056           COMMON /A/ Z(2500), H(2500), D(2500), IBNDL(200), IBNDR(200),
056          1NUM(100), IREP(200)
056   C
056           COMMON /B/ VMAG(2500), BETA(2500), AH1(2500), AH2(2500),
056          1SUMX(2500), SUMY(2500), SUMXNT(2500), SUMYNT(2500),
056          2U(2500), V(2500), UP(2500), VP(2500)
056   C
056           COMMON /C/ NCPR, NC, IROW, ISB, INP, IP, IPRNT(6), IFRM(10),
056          1IFLD(4), INDENT(100)
056   C
056           DATA IPRNT /'H ', 'H0', 'H1', 'H+', ',I3,T', '    ,T'/
056   C
056           DATA IFRM /'(1', 'H0', '    ', '    ', ' ,', '    ',
056          1'F6','.1', '    ', ' )'/
056   C
056           DATA IFLD /'.0', '.1', '.2', '.3'/
056   C
056           DATA ISPACE /'F5','F6','F7'/
056   C
056           DATA INDENT /'1','2','3','4','5','6','7','8','9','10',
056          *'11','12','13','14','15','16','17','18','19','20',
056          *'21','22','23','24','25','26','27','28','29','30',
056          *'31','32','33','34','35','36','37','38','39','40',
056          *'41','42','43','44','45','46','47','48','49','50',
056          *'51','52','53','54','55','56','57','58','59','60',
056          *'61','62','63','64','65','66','67','68','69','70',
056          *'71','72','73','74','75','76','77','78','79','80',
056          *'81','82','83','84','85','86','87','88','89','90',
056          *'91','92','93','94','95','96','97','98','99','100'/
056   C
056   C       PRINTER
056           IP = 6
056   C       TAPE
056           ITAPE2 = 2
056           ITAPE3 = 3
056   C       READER
056           INP = 5
056   C
056           IIC = 0
056           PI = 4.*ATAN(1.)
056           ANRAD = 180./PI
056           DO 5 I = 1, 20
056           DISR(I) = 0.
056   5       CONTINUE
056           IJAM = 4
056           ILP = 3
```

```
056        ISET1 = 1
056        ISET2 = 1
056        ISET3 = 1
056        WRITE(IP,9)
056    9   FORMAT('1',T10,'***  INPUT DATA CHECK  ***',///)
056    C   READ IN PROGRAM CONTROL CARD
056        READ(INP,10) IFMT, ICORF, ICONV, IORIG, IRMB, ISPBK, IDSCH,
056       1IMODF, ICK, IMNDP, INC
056   10   FORMAT(11I2)
056        WRITE(IP,11) IFMT, ICORF, ICONV, IORIG, IRMB, ISPBK, IDSCH,
056       1IMODF, ICK, IMNDF, INC
056   11   FORMAT(' ',11I2)
056        IF (IFMT.EQ.0) IFMT = 6
056        IFRM(7) = ISPACE(IFMT-4)
056    C   READ IN GEOMETRICAL INFORMATION
056        READ(INP,30) ISB, IROW, IV, IU, IR, NC, NCPR
056   30   FORMAT(7I5)
056        WRITE(IP,31) ISB, IROW, IV, IU, IR, NC, NCPR
056   31   FORMAT(' ',7I5)
056    C   READ IN PHYSICAL INFORMATION
056        READ(INP,40) W, THETA, DELS, DELT, TIM, SLADJ
056   40   FORMAT(7F10.3)
056        WRITE(IP,41) W, THETA, DELS, DELT, TIM, SLADJ
056   41   FORMAT(' ',7F10.3)
056        FAA = DELT/4.
056        FAB = DELT/DELS
056        FAC = 16.1*DELT/DELS
056        TIM = TIM*3600.
056        INC = INC*3600
056        T = 0.
056    C   READ IN LEFT AND RIGHT BOUNDARY CELLS OF WATER CELL SEGMENTS
056        READ(INP,60)(IBNDL(I), I=1,ISB)
056        READ(INP,60)(IBNDR(I), I=1,ISB)
056   60   FORMAT((16I5))
056        WRITE(IP,61)(IBNDL(I), I=1,ISB)
056        WRITE(IP,61)(IBNDR(I), I=1,ISB)
056   61   FORMAT(' ',16I5)
056    C   IREP(I) # OF PRINT REPETITIONS FOR EACH SEGMENT IN A ROW
056        DO 65 I = 1,ISB
056   65   IREP(I) = IBNDR(I) - IBNDL(I) + 1
056    C   NUM(I) IS THE SPACE INDENTED BEFORE PRINTING BEGINS IN EACH ROW
056        NUM(1) = (IBNDL(1) -1 )*IFMT +  5
056        DO 74 J = 2,ISB
056        KK = IBNDL(J) - IBNDL(J)/NCPR*NCPR - 1
056    C   PRINT FORMAT IS F(IFMT).I, THEREFORE KK*IFMT
056        NUM(J) = KK*IFMT + 5
056   74   CONTINUE
056    C   READ IN CELLS THAT REQUIRE ZEROING OF CALCULATED VEL.
056        READ(INP,80)(IBC(I), I=1,IV)
056        READ(INP,80)(IBD(I), I=1,IU)
056   80   FORMAT(16I5)
056        WRITE(IP,81)(IBC(I), I=1,IV)
056        WRITE(IP,81)(IBD(I), I=1,IU)
056   81   FORMAT(' ',16I5)
056    C   READ IN DISCHARGE RATES OF RIVERS
056        READ(INP,90)(RQ(I), I=1,IR)
056   90   FORMAT((8F10.5))
```

```
056          WRITE(IP,91)(RE(I), I=1,IR)
056     91   FORMAT(' ',(8F10.5))
056          DO 85 I = 1,NC
056          AMNY(I) = 0.0
056     85   Z(I) = 0.0
056          DO 95 K = 1,ISB
056          KF = IBNDL(K)
056          KL = IBNDR(K)
056     C    READ IN MANNING COEFFICIENTS
056          READ(INP,100) (AMNY(I),I=KF,KL)
056     100  FORMAT((26F3.0))
056     95   WRITE(IP,101) (AMNY(I),I=KF,KL)
056     101  FORMAT(' ',(26F3.0))
056          DO 110 I = 1,NC
056     110  AMNY(I) = AMNY(I)/1000.
056          DO 120  K = 1,ISB
056          KF = IBNDL(K)
056          KL = IBNDR(K)
056     C    READ IN DEPTHS OF WATER CELLS
056          READ(INP,140)(Z(I), I=KF,KL)
056     140  FORMAT((26F3.0))
056     120  WRITE(IP,141)(Z(I), I=KF,KL)
056     141  FORMAT(' ',(26F3.0))
056          DO 155 K = 1, ISB
056          ISTRT = IBNDL(K)
056          IQUIT = IBNDR(K)
056          DO 154 I = ISTRT, IQUIT
056     154  Z(I) = Z(I)+SLADJ
056     155  CONTINUE
056     C
056     C    INITIALIZATION
056     C
056          DO 170 I = 1,NC
056          U(I) = 0.0
056          V(I) = 0.0
056          UP(I) = 0.0
056          VP(I) = 0.0
056          H(I) = 0.0
056          D(I) =  Z(I)
056          VMAG(I) = 0.0
056          BETA(I) = 0.0
056          SUMX(I) = 0.0
056          SUMY(I) = 0.0
056          SUMXNT(I) = 0.0
056          SUMYNT(I) = 0.0
056          FX(I) = 1.0
056          FY(I) = 1.0
056     170  CONTINUE
056          R = 0.0
056     C    VELOCITIES MODIFICATION FACTOR
056          IF (IMODF.EQ.0) GO TO 190
056     C    INPUT NO OF CELLS TO BE MODIFIED
056          READ(INP,172) NMODFX, NMODFY
056     172  FORMAT(2I5)
056          WRITE(IP,173) NMODFX, NMODFY
056     173  FORMAT(' ',2I5)
056     C    INPUT CELL NO & VELOCITY MODIFICATION FACTOR
```

```
056   C     X-DIRECTION
056         IF (NMODFX.EQ.0) GO TO 180
056         READ(INP,175) (KC(I),VF(I),I=1,NMODFX)
056   175   FORMAT(8(I5,F5.2))
056         WRITE(IP,176) (KC(I),VF(I),I=1,NMODFX)
056   176   FORMAT(' ',8(I5,F5.2))
056         DO 179 I = 1,NMODFX
056         J = KC(I)
056   179   FX(J) = VF(I)
056   C     Y-DIRECTION
056   180   IF (NMODFY.EQ.0) GO TO 190
056         READ(INP,185) (KC(I),VF(I),I=1,NMODFY)
056   185   FORMAT(8(I5,F5.2))
056         WRITE(IP,186) (KC(I),VF(I),I=1,NMODFY)
056   186   FORMAT(' ',8(I5,F5.2))
056         DO 189 I = 1,NMODFY
056         J = KC(I)
056   189   FY(J) = VF(I)
056   190   CONTINUE
056   C
056   C     CALCULATE WIND STRESS
056   C
056         IF (W.LT.23.64) GO TO 220
056         AK = (.00011 + .00025*(1.-23.6446/W))/100.
056         GO TO 230
056   220   AK = .0000011
056   230   CONTINUE
056   C
056   C     REMEMBER TO MENTION THE DIRECTION OF CALCULATION
056   C     THETA IS MEASURED FROM X-AXIS COUNTER-CLOCKWISE
056   C
056         X = AK*W*W*COS(THETA)
056         Y = AK*W*W*SIN(THETA)
056   C
056   C
056   C     CALCULATE CORIOLIS FORCE
056   C
056         COR = 0.0000727
056         IF (ICORF.EQ.0) COR=0.0
056   C
056   C     PRINTING CONTROL FOR MANNING FRICTION FACTOR AND INITIAL DEPTH
056   C
056   C
056         IF (IMNDP.EQ.0) GO TO 245
056         CALL PRINT1(4,AMNY,
056        1'MANNING FRICTION FACTOR                                             ')
056         CALL PRINT1(2,Z,
056        1'DEPTH OF WATER FROM BOTTOM OF BAY TO REFERENCE PLANE                ')
056   245   DO 250 I = 1,NC
056   250   AMNY(I) = 14.57*(AMNY(I)**2)
056         ITC = INC + T
056         CALL BOUND1(INP,IP,TMIL,ITSN,TD,HDB,FAB,FAC,DELT,DELS,NCPR,R)
056   C     READ TAPE
056         IF (ICK.EQ.0) GO TO 450
056         REWIND ITAPE3
056         READ(ITAPE3,400)(H(I), I=1,NC)
056         READ(ITAPE3,400)(U(I), I=1,NC)
```

```
056       READ(ITAPE3,400)(V(I), I=1,NC)
056  400  FORMAT(T2,10F7.3/T2,11F7.3)
056  450  CONTINUE
056       IF (ISET1.EQ.2) GO TO 460
056       CALL VEL1(INP,IP,IRMB,NCPR,NC,DELT,DELS,IORIG,ICONV,AMNY,COR,IU,
056      1IV,IBD,IBC,ISB,FX,FY,FAA,FAB,FAC,X,Y)
056       ISET1 = 2
056       GO TO 470
056  460  CALL VEL2(INP,IP,IRMB,NCPR,NC,DELT,DELS,IORIG,ICONV,AMNY,COR,IU,
056      1IV,IBD,IBC,ISB,FX,FY,FAA,FAB,FAC,X,Y)
056  470  IF (ISPBK.EQ.0) GO TO 500
056       IF (ISET2.EQ.2) GO TO 480
056       CALL SBANK1(INP,IP,NCPR,DELT,DELS,FAA,FAC,COR,X,Y)
056       ISET2 = 2
056       GO TO 500
056  480  CALL SBANK2(INP,IP,NCPR,DELT,DELS,FAA,FAC,COR,X,Y)
056  500  CONTINUE
056       IF (IDSCH.EQ.0) GO TO 550
056       IF (ISET3.EQ.2) GO TO 540
056       CALL DISCH1(INP,IP,DELS,DELT,VOL,DISR,SDISRP,SDISRN,LDSCH)
056       ISET3 = 2
056       GO TO 550
056  540  CALL DISCH2(INP,IP,DELS,DELT,VOL,DISR,SDISRP,SDISRN,LDSCH)
056  550  CONTINUE
056       DO 590 J = 1,ISB
056       ISTRT = IBNDL(J)
056       IQUIT = IBNDR(J)
056       DO 590 I = ISTRT,IQUIT
056       XXX = SUMX(I)
056       XXP = ABS(UP(I))
056       IF (XXP.GT.XXX) SUMX(I) = XXP
056       YYY = SUMY (I)
056       YYP = ABS(VP(I))
056       IF (YYP.GT.YYY) SUMY(I) = YYP
056  590  CONTINUE
056  C    CONVERT VP TO V AND UP TO U
056       DO 600 J = 1,ISB
056       ISTRT = IBNDL(J)
056       IQUIT = IBNDR(J)
056       DO 600 I = ISTRT,IQUIT
056       SUMXNT(I) = SUMXNT(I) + UP(I)/D(I)
056       SUMYNT(I) = SUMYNT(I) + VP(I)/D(I)
056       U(I) = UP(I)
056  600  V(I) = VP(I)
056  C    CALCULATE TIDE HEIGHT IN BAY
056       DO 610 J = 1,ISB
056       IF (IBNDL(J).GE.(NC-NCPR)) GO TO 615
056       ISTRT = IBNDL(J)
056       IQUIT = IBNDR(J)
056       DO 610 I = ISTRT,IQUIT
056  610  H(I) = H(I) + FAB*(UP(I)+VP(I)-UP(I+1)-VP(I+NCPR))+R*DELT
056  615  CONTINUE
056       IF (AMOD(TMIL,1440.).LT.0.0001) TMIL=0.0
056       T = T + DELT
056       TMIL = TMIL + DELT/60.
056       CALL BOUND2(INP,IP,TMIL,ITSN,TD,HDB,FAB,FAC,DELT,DELS,NCPR,R)
056       IT = T
```

```
@ELT,L SAM.SUB1
ELT0T7 RL1B70 01/29-17:45:58-(24,)
024   C
024   C        +
024   C        VERSION 1.28.76
024   C        +
024   C
020            SUBROUTINE PRINT1(IXY,STORE1,X)
020            DIMENSION STORE1(2500), STORE2(2500), X(11)
020            COMMON /A/ Z(2500), H(2500), D(2500), IBNDL(200), IBNDR(200),
020           1NUM(100),IREP(200)
020            COMMON /C/ NCPR, NC, IROW, ISB, INP, IP, IPRNT(6), IFRM(10),
020           1IFLD(4), INDENT(100)
020            IPASS = 1
020            GO TO 5
020            ENTRY PRINT2(IXY,STORE1,STORE2,X)
020            IPASS = 2
020      5     WRITE(IP,10) X
020      10    FORMAT('1',T2,11A6)
020            IFRM(3) = IPRNT(5)
020            IFRM(8) = IFLD(IXY)
020            JK = ISB
020            M = 0
020            DO 70 K = 1,IROW
020            M = IROW - K + 1
020            IFRM(2) = IPRNT(1)
020            JL = JK
020      51    JL = JL-1
020            IF (JL.EQ.0) GO TO 52
020            IF ((IBNDL(JL)/NCPR+1).EQ.M) GO TO 51
020      52    JF = JL
020      54    JL = JL + 1
020            NM = NUM(JL)
020            IFRM(4) = INDENT(NM)
020            IR = IREP(JL)
020            IFRM(6) = INDENT(IR)
020            ISTRT = IBNDL(JL)
020            IQUIT = IBNDR(JL)
020            IF (IPASS.EQ.3) GO TO 55
020            WRITE(IP,IFRM) M,(STORE1(I),I=ISTRT,IQUIT)
020            IF (JL.EQ.1) GO TO 58
020            IF (JL.EQ.JK) GO TO 58
020            GO TO 56
020      55    WRITE(IP,IFRM) M,(STORE2(I),I=ISTRT,IQUIT)
020            IF (JL.EQ.1) GO TO 70
020            IF (JL.EQ.JK) GO TO 59
020      56    IFRM(2) = IPRNT(4)
020            GO TO 54
020      58    IF (IPASS.EQ.1) GO TO 60
020            IFRM(2) = IPRNT(1)
020            IPASS = 3
020            JL = JF
020            GO TO 54
020      59    IPASS = 2
020      60    JK = JF
020            IFRM(2) = IPRNT(1)
020      70    CONTINUE
020            RETURN
020            END

END ELT.
```

```
@ELT,L SAM.SUB2
ELT0T7 RLIB70 01/29-17:46:02-(52,)
052   C
052   C       *   .
052   C       VERSION 1.28.76
052   C       *
052   C
048           SUBROUTINE REPRT1(IP,INP,ILP,LDSCH,IDSCH,IR,RB,IJAM,IT,ITC,
048          1INC,DELT,DELS,T,TIM,VOL,NC,ITAPE2,ITAPE3,$,$,$)
048           DIMENSION VOL(20), RB(20), RF(20)
048           COMMON /A/ Z(2500), H(2500), D(2500), IBNDL(200), IBNDR(200),
048          1NUM(100), IREP(200)
048           COMMON /B/ VMAG(2500), BETA(2500), AH1(2500), AH2(2500),
048          1SUMX(2500), SUMY(2500), SUMXNT(2500), SUMYNT(2500),U(2500),
048          2V(2500),UP(2500),VP(2500)
048           IF (ILP.LT.3) GO TO 90
048           IF (IDSCH.EQ.0) GO TO 30
048           DO 10 I = 1,LDSCH
048   10      WRITE(IP,20) I, VOL(I)
048   20      FORMAT(T2,'VOLUME FLOW RATE AT LOCATION (',I2,') =',F15.2,
048          12X,'CU.FT./SEC')
048   30      CONTINUE
048           IJAM = IJAM + 1
048           IF (IT.EQ.ITC) GO TO 35
048           RETURN20
048   35      CONTINUE
048           DO 40 I = 1,IR
048           RF = RB(I)*DELS
048           WRITE(IP,38)
048   38      FORMAT(' ',/)
048   40      WRITE(IP,50) I, RF(I)
048   50      FORMAT(T2,'RIVER - ',I2,2X,'FLOW RATE =',F10.2,2X,
048          1'CU.FT./SEC')
048           ITC = ITC + INC
048           CALL PRINT1(3,H,
048          1'HEIGHT FROM REFERENCE PLANE TO SURFACE                   ')
048           CALL PRINT1(2,U,
048          1'VELOCITIES IN X DIRECTION                                ')
048           CALL PRINT1(2,V,
048          1'VELOCITIES IN Y DIRECTION                                ')
048           CALL PRINT2(2,VMAG,BETA,
048          2'MAGNITUDE AND DIRECTION OF VELOCITIES                    ')
048           CALL PRINT2(4,AH1,AH2,
048          1'CONVECTIVE ACCELERATION                                  ')
048   90      CONTINUE
048           ENTRY REPRT2(IP,INP,ILP,LDSCH,IDSCH,IR,RB,IJAM,
048          1IT,ITC,INC,DELT,DELS,T,TIM,VOL,NC,ITAPE2,ITAPE3,$,$,$)
048           DO 95 I = 1,NC
048   95      D(I) = Z(I) + H(I)
048           IF (ILP.LT.3) RETURN21
048           IF (T.LT.TIM) RETURN22
048           DO 100 I = 1,NC
048           SUMXNT(I) = SUMXNT(I)*DELT/TIM
048   100     SUMYNT(I) = SUMYNT(I)*DELT/TIM
048           CALL PRINT2(1,SUMX,SUMY,
048          1'DISPERSION COEFFICIENTS                                  ')
048           REWIND ITAPE2
048           REWIND ITAPE3
048           WRITE(ITAPE2,110) (SUMX(I),I=1,NC)
048           WRITE(ITAPE2,110) (SUMY(I),I=1,NC)
048           WRITE(ITAPE2,110) (SUMXNT(I),I=1,NC)
048           WRITE(ITAPE2,110) (SUMYNT(I),I=1,NC)
048   110     FORMAT((T2,7F8.0,/))
048           WRITE(ITAPE3,115) (H(I),I=1,NC)
048           WRITE(ITAPE3,115) (U(I),I=1,NC)
048           WRITE(ITAPE3,115) (V(I),I=1,NC)
048   115     FORMAT(T2,10F7.3/T2,11F7.3)
048           DO 117 I = 1,NC
048           SUMXNT(I) = SUMXNT(I)*1000
048   117     SUMYNT(I) = SUMYNT(I)*1000
048           CALL PRINT2(1,SUMXNT,SUMYNT,
048          2'NET VELOCITIES IN X-Y DIRECTION * 1000                   ')
048           DO 120 I = 1,NC
048           SUMXNT(I) = SUMXNT(I)/1000.
048   120     SUMYNT(I) = SUMYNT(I)/1000.
048           RETURN21
048           END

END ELT.
```

```
@ELT,L SAM.SUB3
ELT0T7 RL1B70 01/29-17:46:09-(9,)
       006   C
       006   C       +
       006   C       VERSION 1.28.76
       006   C       +
       006   C
       005           SUBROUTINE VEL1(INP,IP,IRMB,NCPR,NC,DELT,DELS,IORIG,ICONV,AMNY,
       005          1COR,IU,IV,IBD,IBC,ISB,FX,FY,FAA,FAB,FAC,X,Y)
       005           DIMENSION AMNY(2500), IRMBB(2), IRMBT(2), FX(2500),
       005          1FY(2500), IBC(250), IBD(250)
       005           COMMON /A/ Z(2500), H(2500), D(2500), IBNDL(200), IBNDR(200),
       005          1NUM(100), IREP(200)
       005           COMMON /B/ VMAG(2500), BETA(2500), AH1(2500), AH2(2500),
       005          1SUMX(2500), SUMY(2500), SUMXNT(2500), SUMYNT(2500), U(2500),
       005          2V(2500), UP(2500), VP(2500)
       005   C
       005   C
       005   C       CALCULATE VELOCITIES IN X-Y DIRECTIONS
       005   C       THIS SECTION IS DESIGNED FOR THE RIVER MARSH BOUNDARY IN MOBIL
       005   C       BAY SYSTEM OR SIMILAR SYSTEM
       005           IFROW = 99999
       005           IF (IRMB.EQ.0) GO TO 100
       005           READ(INP,50) (IRMBB(I),I=1,2)
       005   50      FORMAT(2I5)
       005           WRITE(IP,51) (IRMBB(I),I=1,2)
       005   51      FORMAT(' ',2I5)
       005           READ(INP,50) (IRMBT(I),I=1,2)
       005           READ(INP,60) ZRB
       005   60      FORMAT(F10.5)
       005           WRITE(IP,51) (IRMBT(I),I=1,2)
       005           WRITE(IP,61) ZRB
       005   61      FORMAT(' ',F10.5)
       005   80      DO 90 I = 1,NC
       005   90      D(I) = H(I) + Z(I)
       005           IFROW = IRMBB(1)/NCPR + 1
       005           ENTRY VEL2(INP,IP,IRMB,NCPR,NC,DELT,DELS,IORIG,ICONV,AMNY,COR,IU,
       005          1IV,IBD,IBC,ISB,FX,FY,FAA,FAB,FAC,X,Y)
       005   100     DO 310 J = 1,ISB
       005           IF (IBNDL(J).GE.(NC-NCPR)) GO TO 350
       005           ISTRT = IBNDL(J)
       005           IQUIT = IBNDR(J)
       005           UCONVA = 0.0
       005           VCONVA = 0.0
       005           DO 310 I = ISTRT,IQUIT
       005           IH = I + NCPR
       005           S1 = V(I) + V(I+1) + V(IH) + V(IH+1)
       005           S2 = U(I) + U(I+1) + U(IH) + U(IH+1)
       005           IF ((IQUIT-ISTRT).EQ.0) S2 = 0.
       005   CCC
       005   C
       005   C
       005           IF (ICONV.EQ.0) GO TO 150
       005           IF ((ISTRT/NCPR).LT.1) GO TO 150
       005           IF (J.GE.IFROW) GO TO 150
       005           FACC = DELT/(DELS*(Z(I)+Z(I+1)))
       005           FACD = DELT/(DELS*(Z(I)+Z(IH)))
```

```
005           XCK = U(I+1)
005           YCK = V(IH)
005           IF (XCK.LT.0.0) GO TO 110
005           UCONVA = -(4.*U(I+1)*(U(I+1)-U(I))+U(I+1)*(V(IH)+V(IH+1)-V(I)
005          1-V(I+1))+S1*(U(I+1)-U(I-NCPR+1))/2.)*FACC
005           GO TO 115
005     110   UCONVA = -(4.*U(I+1)*(U(I+2)-U(I+1))+U(I+1)*(V(IH)+V(IH+1)-V(I)
005          1-V(I+1))+S1*(U(IH+1)-U(I+1))/2.)*FACC
005     115   CONTINUE
005           IF (YCK.LT.0.0) GO TO 120
005           VCONVA = -(4.*V(IH)*(V(IH)-V(I))+V(IH)*(U(I+1)+U(IH+1)-
005          1U(I)-U(IH))+S2*(V(IH)-V(IH-1))/2.)*FACD
005           GO TO 125
005     120   VCONVA = -(4.*V(IH)*(V(IH+NCPR)-V(IH))+V(IH)*(U(IH+1)+
005          1U(I+1)-U(I)-U(IH))+S2*(V(IH+1)-V(IH))/2.)*FACD
005     125   CONTINUE
005           IF ((IQUIT-ISTRT).EQ.0) UCONVA = 0.
005           AH1(I) = UCONVA
005           AH2(I) = VCONVA
005     150   CONTINUE
005           IF (IORIG.EQ.0) GO TO 200
005           F = AMNY(I)/(D(I)**0.3333)
005           G1 = 1.+F*DELT*((16.*U(I+1)*U(I+1)+S1*S1)**0.5)/((D(I)+D(I+1))**2)
005           A1 = U(I+1)+FAC*(D(I)+D(I+1))*(H(I)-H(I+1))+X*DELT+FAA*S1*COR
005          1+UCONVA
005           G2 = 1.+F*DELT*((16.*V(IH)*V(IH)+S2*S2)**0.5)/((D(I)+D(IH))**2)
005           A2 = V(IH)+FAC*(D(I)+D(IH))*(H(I)-H(IH))+Y*DELT-FAA*S2*COR+VCONVA
005           UP(I+1) = A1/(G1*FX(I+1))
005           VP(IH) = A2/(G2*FY(IH))
005           GO TO 300
005     200   CONTINUE
005           F = AMNY(I)
005           UP(I+1) = U(I+1)+FAA*S1*COR+FAC*(D(I)+D(I+1))*(H(I)
005          1-H(I+1))+X*DELT-F*DELT*U(I+1)*ABS(U(I+1))/(((D(I)
005          2+D(I+1))/2.)**2.3333)
005           VP(IH) = V(IH)+FAA*S2*COR+FAC*(D(I)+D(IH))*(H(I)-H(IH))
005          1+Y*DELT-F*DELT*V(IH)*ABS(V(IH))/(((D(I)+D(IH))/2.)**2.3333)
005     300   CONTINUE
007           IF ((IQUIT-ISTRT).NE.0) GO TO 310
005           UP(IQUIT) = 0.
005     305   UP(IQUIT+1) = 0.
005     310   CONTINUE
005     CC
005     350   LL = J
005     355   ISTRT = IBNDL(LL)
005           IQUIT = IBNDR(LL)
005           DO 380 I = ISTRT,IQUIT
005           IF ((ISTRT-IQUIT).EQ.0) GO TO 360
005           F = AMNY(I)/(D(I)**0.3333)
005           S1 = V(I) + V(I+1)
005           G1 = 1.+F*DELT*((16.*U(I+1)*U(I+1)+S1*S1)**0.5)/
005          1((D(I)+D(I+1))**2)
005           A1 = U(I+1)+FAC*(D(I)+D(I+1))*(H(I)-H(I+1))+X*DELT
005          1+FAA*S1*COR
005           UP(I+1) = A1/G1
005           GO TO 380
005     360   UP(I+1) = 0.
```

```
005          UP(IQUIT) = 0.                                                 3VEL1130
005    380   CONTINUE                                                       3VEL1140
005          LL = LL+1                                                      3VEL1150
007          IF (LL.LE.ISB) GO TO 355                                       3VEL1160
005    C     RIVER MARSH B.                                                 3VEL1170
005    C                                                                    3VEL1180
005    C                                                                    3VEL1190
005          IF (IFPOW.EQ.99999) GO TO 490                                  3VEL1200
005          DO 450 K = 1,2                                                 3VEL1210
005          ISTRT = IRMPB(K)                                               3VEL1220
005          IQUIT = IRMPT(K)                                               3VEL1230
005          DO 450 I = ISTRT,IQUIT,NCPR                                    3VEL1240
005          IF ((I+NCPR).GT.NC) GO TO 390                                  3VEL1250
005          S1 = V(I) + V(I+1) + V(I+NCPR) + V(I+NCPR+1)                   3VEL1260
005          GO TO 395                                                      3VEL1270
005    390   S1 = V(I) +V(I+1)                                              3VEL1280
005    395   HCK1 = H(I) - H(I+1)                                           3VEL1290
005          HCK2 = ZRB - H(I+1)                                            3VEL1300
005          HCK3 = H(I) - ZRB                                              3VEL1310
005          IF (HCK1) 401,400,402                                          3VEL1320
005    402   IF (HCK3) 400,400,410                                          3VEL1330
005    401   IF (HCK2) 410,400,400                                          3VEL1340
005    410   DB = 0.5*(H(I+1)+H(I))-ZRB                                     3VEL1350
005          A1 = U(I+1)+FAC*(D(I)+D(I+1))*(H(I)-H(I+1))+X*DELT+FAA*S1*COR  3VEL1360
007          G1 = 1.+DELT*(D(I+1)+D(I))*ABS(U(I+1))/(0.18*DB*DB*DELS)       3VEL1370
005          UP(I+1) = A1/G1                                                3VEL1380
005          GO TO 450                                                      3VEL1390
005    400   UP(I+1) = 0.0                                                  3VEL1400
005    450   CONTINUE                                                       3VEL1410
005    490   DO 500 I = 1,IV                                                3VEL1420
005          J = IBC(I)                                                     3VEL1430
005    500   VP(J+NCPR) = 0.0                                               3VEL1440
005    CC    NO NEED TO ZERO THE VELOCITIES OF THE RIGHT MOST CELL          3VEL1450
005    CC    ON EACH SEGMENT                                                3VEL1460
005          DO 510 I = 1,IU                                                3VEL1470
005          J = IBD(I)                                                     3VEL1480
005    510   UP(J+1) = 0.0                                                  3VEL1490
005          RETURN                                                         3VEL1500
005          END                                                            3VEL1510
```

END ELT.

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WELT,L SAM.SUB4
ELT0T7 RL1B70 01/29-17:46:15-(28,)
 026    C
 026    C         *  '
 026    C         VERSION 1.28.76
 026    C         *
 026    C
 024              SUBROUTINE SBANK1(INP,IP,NCPR,DELT,DELS,FAA,FAC,COR,X,Y)
 024              DIMENSION INSBC(100), ZCH(100), IAXIS(100)
 024              COMMON /A/ Z(2500), H(2500), D(2500), IBNDL(200), IBNDR(200),
 024             1NUM(100), IREP(200)
 024              COMMON /B/ VMAG(2500), BETA(2500), AH1(2500), AH2(2500),
 024             1SUMX(2500), SUMY(2500), SUMXNT(2500), SUMYNT(2500),
 024             2U(2500), V(2500), UP(2500), VP(2500)
 024              INTEGER TEST(2) /'X','Y'/
 024              READ(INP,10) NSBC
 024      10      FORMAT(I5)
 024              WRITE(IP,11) NSBC
 024      11      FORMAT(' ',I5)
 024              READ(INP,20) (INSBC(I),IAXIS(I),ZCH(I),I=1,NSBC)
 024      20      FORMAT(8(I5,A1,F4.1))
 024              WRITE(IP,21) (INSBC(I),IAXIS(I),ZCH(I),I=1,NSBC)
 024      21      FORMAT(' ',8(I5,A1,F4.1))
 024              ENTRY SBANK2(INP,IP,NCPR,DELT,DELS,FAA,FAC,COR,X,Y)
 024              DO 100 J = 1,NSBC
 024              I = INSBC(J)
 024              IF (IAYIS.EQ.TEST(1)) GO TO 50
 024              IF (IAXIS.EQ.TEST(2)) GO TO 30
 024    CCC
 024    CC
 024    C         CALL ERROR(                                           )
 024      30      DB = 0.5*(H(I)+H(I+1))-ZCH(I)
 024              S1 = V(I)+V(I+1)+V(NCPR+I)+V(NCPR+I+1)
 024              IF(DB.LT.0.0) GO TO 70
 024              G1 = 1.+DELT*(D(I+1)+D(I))*ABS(U(I+1))/(0.18*DB*DB*DELS)
 024              A1 = U(I+1)+FAC*(D(I)+D(I+1))*(H(I)-H(I+1))
 024             1+X*DELT+FAA*S1*COR
 024              UP(I+1) = A1/G1
 024              GO TO 100
 024      50      DB = 0.5*(H(I)+H(I+NCPR))-ZCH(I)
 024              S2 = U(I)+U(I+1)+U(NCPR+I)+U(NCPR+I+1)
 024              IF (DB.LT.0.0) GO TO 80
 024              G2 = 1.+DELT*(D(I+NCPR)+D(I))*ABS(V(I+NCPR))/
 024             1(0.18*DB*DB*DELS)
 024              A2 = V(I+NCPR)+FAC*(D(I)+D(I+NCPR))*(H(I)-H(I+NCPR))
 024             1+Y*DELT-FAA*S2*COR
 024              VP(I+NCPR) = A2/G2
 024              GO TO 100
 024      70      UP(I+1) = 0.0
 024              GO TO 100
 024      80      VP(I+NCPR) = 0.0
 024     100      CONTINUE
 024              RETURN
 024              END

END ELT.
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```
@ELT,L SAM.SUBS
ELT0T7 RL1B70 01/29-17:46:19-(24,)
 024   C
 024   C      +
 024   C      VERSION 1.28.76
 024   C      +
 024   C
 020          SUBROUTINE MAGDIR(ISB,NCPR,NC,ANRAD,PI)
 020   CC     DIRECTION IS MEASURED FROM X-AXIS COUNTER-CLOCKWISE
 020   CC
 020          COMMON /A/ Z(2500), H(2500), D(2500), IBNDL(200), IBNDR(200),
 020         1NUM(100), IREP(200)
 020          COMMON /B/ VMAG(2500), BETA(2500), AH1(2500), AH2(2500),
 020         1SUMX(2500), SUMY(2500), SUMXNT(2500), SUMYNT(2500),
 020         2U(2500), V(2500), UP(2500), VP(2500)
 020          DO 150 K = 1,ISB
 020          IF (IBNDL(K).GT.(NC-NCPR)) GO TO 160
 020          ISTRT = IBNDL(K)
 020          IQUIT = IBNDR(K)
 020          DO 100 I = ISTRT,IQUIT
 020          IF ((IQUIT-ISTRT).EQ.0) GO TO 30
 020          GO TO 40
 020   30     VV = V(I)
 020          UU = 0.
 020          GO TO 50
 020   40     UU = (U(I)+U(I+1))/2.
 020          VV = (V(I)+V(I+NCPR))/2.
 020   50     IF (UU) 70,85,60
 020   60     IF (VV) 80,90,90
 020   70     BETA(I) = (ATAN(VV/UU)+PI)*ANRAD
 020          VMAG(I) = ((UU*UU+VV*VV)**0.5)/D(I)
 020          GO TO 100
 020   80     BETA(I) = (ATAN(VV/UU)+2.*PI)*ANRAD
 020          VMAG(I) = ((UU*UU+VV*VV)**0.5)/D(I)
 020          GO TO 100
 020   CC     CHECK ABOVE
 020   85     IF(VV)86,100,87
 020   86     BETA(I) = 270.
 020          VMAG(I) = ABS(VV)/D(I)
 020          GO TO 100
 020   87     BETA(I) = 90.
 020          VMAG(I) = VV/D(I)
 020          GO TO 100
 020   90     BETA(I) = (ATAN(VV/UU))*ANRAD
 020          VMAG(I) = ((UU*UU+VV*VV)**0.5)/D(I)
 020   100    CONTINUE
 020   150    CONTINUE
 020   160    RETURN
 020          END

END ELT.
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WELT,L SAM.SUB6
ELT0T7 RL1b70 01/29-17:46:24-(59,)
 059   C
 059   C       +
 059   C       VERSION 1.28.76
 059   C       +
 059   C
 055           SUBROUTINE DISCH1(INP,IP,DELS,DELT,VOL,DISR,SDISRP,SDISRN,LDSCH)
 055           DIMENSION DISR(20),SDISRP(20),SDISRN(20),VOL(20),NCDSCH(20),
 055          1ICDSCH(20,50), IAXIS(20)
 055           COMMON /A/ Z(2500), H(2500), D(2500), IBNDL(200), IBNDR(200),
 055          1NUM(100),IREP(200)
 055           COMMON /B/ VMAG(2500), BETA(2500), AH1(2500), AH2(2500),
 055          1SUMX(2500), SUMY(2500), SUMXNT(2500), SUMYNT(2500),
 055          2U(2500), V(2500), UP(2500), VP(2500)
 055           INTEGER ITEST(2) /'X','Y'/
 055           READ(INP,10) LDSCH
 055    10     FORMAT(I5)
 055           WRITE(IP,11) LDSCH
 055    11     FORMAT(' ',I5)
 055           DO 15 I = 1,LDSCH
 055           DISR(I) = 0.0
 055           VOL(I) = 0.0
 055           SDISRP(I) = 0.0
 055    15     SDISRN(I) = 0.0
 055           READ(INP,20) (NCDSCH(K), IAXIS(K), K=1,LDSCH)
 055    20     FORMAT(16(I4,A1))
 055           WRITE(IP,21) (NCDSCH(K), IAXIS(K), K=1,LDSCH)
 055    21     FORMAT(' ',16(I4,A1))
 055           DO 28 J = 1,LDSCH
 055           JJ = NCDSCH(J)
 055           READ(INP,25)(ICDSCH(K,J),K=1,JJ)
 055    25     FORMAT(16I5)
 055    28     WRITE(IP,26)(ICDSCH(K,J),K=1,JJ)
 055    26     FORMAT(' ',16I5)
 055           ENTRY DISCH2(INP,IP,DELS,DELT,VOL,DISR,SDISRP,SDISRN,LDSCH)
 055           DO 100 I = 1,LDSCH
 055           TOTALV = 0.
 055           TOTALU = 0.
 055           NK = NCDSCH(I)
 055           IF (IAXIS(I).EQ.ITEST(1)) GO TO 30
 055           IF (IAXIS(I).EQ.ITEST(2)) GO TO 40
 055   C       CALL ERROR(                                    )
 055    30     DO 50 J = 1,NK
 055           KK = ICDSCH(J,I)
 055           TOTALU = U(KK) + TOTALU + UP(KK)
 055    50     CONTINUE
 055           DISR(I) = DISR(I) + TOTALU/2.
 055           GO TO 100
 055    40     DO 60 J = 1,NK
 055           KK = ICDSCH(J,I)
 055           TOTALV = V(KK) + TOTALV + VP(KK)
 055    60     CONTINUE
 055           DISR(I) = DISR(I) + TOTALV/2.
 055   100     CONTINUE
 055           RETURN
 055           ENTRY DISCH3(INP,IP,DELS,DELT,VOL,DISR,SDISRP,SDISRN,LDSCH)
 055           DO 150 I = 1,LDSCH
 055           VOL(I) = DISR(I)*DELS*DELT/3600.
 055           IF (VOL(I)) 110,111,112
 055   110     SDISRN(I) = SDISRN(I) + VOL(I)*3600.
 055           GO TO 111
 055   112     SDISRP(I) = SDISRP(I) + VOL(I)*3600.
 055   111     CONTINUE
 055           DISR(I) = 0.0
 055   150     CONTINUE
 055           RETURN
 055           END

END ELT.
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WELT,L SAM.SUB7
ELT0T7 RLIB70 01/29-17:46:29-(46,)
046  C
046  C       +
046  C       VERSION 1.28.76
046  C       +
046  C
042          SUBROUTINE BOUND1(INP,IP,TMIL,ITSN,TD,HDB,FAB,FAC,DELT,DELS,
042         1NCPR,R)
042          DIMENSION HDB(20),TD(20),CA(20),CB(20),CC(20),CD(20),
042         1NBC(20),NATURE(20),RINF(20),INBC(20,50),ZB(20,50)
042          COMMON /A/ Z(2500), H(2500), D(2500), IBNDL(200), IBNDR(200),
042         1NUM(100), IREP(200)
042          COMMON /B/ VMAG(2500), BETA(2500), AH1(2500), AH2(2500),
042         1SUMX(2500), SUMY(2500), SUMXNT(2500), SUMYNT(2500),
042         2U(2500), V(2500), UP(2500), VP(2500)
042          INTEGER TEST(8) /'SL','SB','SR','ST','RL','RB','RR','RT'/
042  C       BOUNDARY CELLS ARE THOSE CELLS NEST TO THE LEFT , RIGHT,
042  C       TOP, OR BOTTOM MOST CELLS IN EACH ROW OR COLOUMN
042  C
042  CCC     READ IN BOUNDARY CONDITIONS
042  CC      INITIAL CALCULATIONS
042  C       READ IN STARTING TIME & # OF TIDE STATION WILL BE USED
042          READ(INP,100) TMIL,ITSN
042  100     FORMAT(F5.2,I5)
042          WRITE(IP,101) TMIL,ITSN
042  101     FORMAT(' ',F5.2,I5)
042          TMIL = TMIL*60.
042  C       READ IN COEFS AND TIME PHASE USED TO CAL THE TIDE FUNCTIONS
042          DO 150 I = 1,ITSN
042          READ(INP,120) CA(I),CB(I),CC(I),CD(I),TD(I)
042  120     FORMAT(5F10.6)
042          WRITE(IP,121) CA(I),CB(I),CC(I),CD(I),TD(I)
042  121     FORMAT(' ',5F10.6)
042          TD(I) = TD(I) + 0.5*DELT/60.
042  150     HDB(I) = CA(I)+CB(I)*COS(CC(I)*TD(I)+CD(I))
042  C       READ TOTAL # OF BOUNDARIES NOT INCLUDING RIVER MARSH BOUNDARIES
042          READ(INP,180) NTB
042  180     FORMAT(I5)
042          WRITE(IP,181) NTB
042  181     FORMAT(' ',I5)
042  C       SPECIFICATION OF BOUNDARIES
042          DO 400 I = 1,NTB
042  C       READ IN # OF CELLS IN THE BOUNDARY, ITS NATURE, AND INF
042          READ(INP,300) NATURE(I),NBC(I),RINF(I)
042  300     FORMAT(A2,I3,F10.3)
042          WRITE(IP,301) NATURE(I),NBC(I),RINF(I)
042  301     FORMAT(' ',A2,I3,F10.3)
042  C       EXPLAIN ABOVE
042  C       READ IN CELL #S
042          NK = NBC(I)
042          READ(INP,305) (INBC(I,J),J=1,NK)
042  305     FORMAT(16I5)
042          WRITE(IP,306) (INBC(I,J),J=1,NK)
042  306     FORMAT(' ',16I5)
042          IF ((NATURE(I).EQ.TEST(1)).OR.(NATURE(I).EQ.TEST(2)))GO TO 307
042          GO TO 331
```

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042   307   READ(INP,308) (ZB(I,K), K = 1,NK)                                      7BND0560
042   308   FORMAT(16F5.0)                                                         7BND0570
042         WRITE(IP,309) (ZB(I,K), K = 1,NK)                                      7BND0580
042   309   FORMAT(' ',16F5.0)                                                     7BND0590
042   310   IF (NATURE(I).EQ.TEST(1)) GO TO 315                                    7BND0600
042         GO TO 321                                                              7BND0610
042   315   DO 320 K = 1,NK                                                        7BND0620
042         KK = INBC(I,K)                                                         7BND0630
042         JJ = RINF(I)                                                           7BND0640
042         UP(KK) = U(KK)+FAC*(D(KK)+HDB(JJ)+ZB(I,K))*(HDB(JJ)-H(KK))             7BND0650
042   320   CONTINUE                                                               7BND0660
042         GO TO 400                                                              7BND0670
042   321   IF (NATURE(I).EQ.TEST(2)) GO TO 325                                    7BND0680
042         GO TO 331                                                              7BND0690
042   325   DO 330 K = 1,NK                                                        7BND0700
042         KK = INBC(I,K)                                                         7BND0710
042         JJ = RINF(I)                                                           7BND0720
042   330   VP(KK) = V(KK)+FAC*(D(KK)+HDB(JJ)+ZB(I,K))*(HDB(JJ)-H(KK))             7BND0730
042         GO TO 400                                                              7BND0740
042   331   IF (NATURE(I).EQ.TEST(3)) GO TO 335                                    7BND0750
042         GO TO 341                                                              7BND0760
042   C     RIGHT MOST BOUNDARY                                                    7BND0770
042   335   DO 340 K = 1,NK                                                        7BND0780
042         KK = INBC(I,K)                                                         7BND0790
042         JJ = RINF(I)                                                           7BND0800
042   340   H(KK) = HDB(JJ)                                                        7BND0810
042         GO TO 400                                                              7BND0820
042   341   IF (NATURE(I).EQ.TEST(4)) GO TO 345                                    7BND0830
042         GO TO 351                                                              7BND0840
042   C     TOP BOUNDARY                                                           7BND0850
042   345   DO 350 K = 1,NK                                                        7BND0860
042         KK = INBC(I,K)                                                         7BND0870
042         JJ = RINF(I)                                                           7BND0880
042   350   H(KK) = HDB(JJ)                                                        7BND0890
042         GO TO 400                                                              7BND0900
042   351   IF (NATURE(I).EQ.TEST(5)) GO TO 355                                    7BND0910
042         GO TO 361                                                              7BND0920
042   C     RIVER ENTRANCE FROM LEFT                                               7BND0930
042   355   DO 360 K = 1,NK                                                        7BND0940
042         KK = INBC(I,K)                                                         7BND0950
042         UP(KK) = RINF(I)                                                       7BND0960
042   360   U(KK) = RINF(I)                                                        7BND0970
042         GO TO 400                                                              7BND0980
042   361   IF (NATURE(I).EQ.TEST(6)) GO TO 365                                    7BND0990
042         GO TO 371                                                              7BND1000
042   365   DO 370 K = 1,NK                                                        7BND1010
042         KK = INBC(I,K)                                                         7BND1020
042         VP(KK) = RINF(I)                                                       7BND1030
042   370   V(KK) = RINF(I)                                                        7BND1040
042         GO TO 400                                                              7BND1050
042   371   IF(NATURE(I).EQ.TEST(7)) GO TO 375                                     7BND1060
042         GO TO 381                                                              7BND1070
042   375   DO 380 K = 1,NK                                                        7BND1080
042         KK = INBC(I,K)                                                         7BND1090
044         RB = -RINF(I)                                                          7BND1100
042   380   H(KK) = H(KK)+FAB*(UP(KK)+VP(KK)-RB-VP(KK+NCPR))+R*DELT                7BND1110
042         GO TO 400                                                              7BND1120
```

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042   381   IF (NATURE(I).EQ.TEST(8)) GO TO 385
042   C     CALL ERROR(                         )
042   385   DO 390 K = 1,NK
042         KK = INBC(I,K)
044         RB = -RINF(I)
042   390   H(KK) = H(KK)+FAB*(UP(KK)+VP(KK)-UP(KK+1)-RB)+R*DELT
042   400   CONTINUE
042         RETURN
042         ENTRY BOUND2(INP,IP,TMIL,ITSN,TD,HDB,FAB,FAC,DELT,DELS,NCPR,R)
042   CC    CALCULATE TID HEIGHTS FOR T AND DELT
042         DO 550 I = 1,ITSN
042         TD(I) = TD(I) + DELT/60.
042   550   HDB(I) = CA(I)+CB(I)*COS(CC(I)*TD(I)+CD(I))
042         DO 700 I = 1,NTB
042         NK = NBC(I)
042         IF (NATURE(I).EQ.TEST(1)) GO TO 615
042         GO TO 621
042   615   IF (NK.GT.1) GO TO 618
042         KK = INBC(I,1)
042         JJ = RINF(I)
042         UP(KK) = U(KK) + FAC*(D(KK) + HDB(JJ) + ZB(I,1))*(HDB(JJ)-H(KK))
042         GO TO 700
042   618   DO 620 K = 1,NK
042         KK = INBC(I,K)
042         JJ = RINF(I)
042         G1 = 1.+DELT*(D(KK)+ZB(I,K)+HDB(JJ))*ABS(U(KK))/(18.*DELS)
042         A1 = U(KK)+FAC*(D(KK)+HDB(JJ)+ZB(I,K))*(HDB(JJ)-H(KK))
042   620   UP(KK) = A1/G1
042         GO TO 700
042   621   IF (NATURE(I).EQ.TEST(2)) GO TO 625
042         GO TO 631
042   625   DO 630  K = 1,NK
042         KK = INBC(I,K)
042         JJ = RINF(I)
042   630   VP(KK) = V(KK)+FAC*(D(KK)+HDB(JJ)+ZB(I,K))*(HDB(JJ)-H(KK))
042         GO TO 700
042   631   IF (NATURE(I).EQ.TEST(3)) GO TO 635
042         GO TO 641
042   C     RIGHT MOST
042   635   DO 640 K = 1,NK
042         KK = INBC(I,K)+1
042         KJ = INBC(I,K)
042         JJ = RINF(I)
042         H(KK) = HDB(JJ)
042         G1 = 1.+DELT*(D(KJ)+Z(KK)+H(KK))*ABS(U(KK))/(18.*DELS)
042         A1 = U(KK)+FAC*(D(KJ)+Z(KK)+H(KK))*(H(KJ)-HDB(JJ))
042   640   UP(KK) = A1/G1
042         GO TO 700
042   641   IF (NATURE(I).EQ.TEST(4)) GO TO 645
042         GO TO 651
042   C     TOP MOST
042   645   DO 650 K = 1, NK
042         KK = INBC(I,K)
042         JJ = RINF(I)
042   650   H(KK) = HDB(JJ)
042         GO TO 700
042   651   IF (NATURE(I).EQ.TEST(5)) GO TO 655
```

```
042       GO TO 661
042  655  DO 660 K = 1,NK
042       KK = INBC(I,K)
042       UP(KK) = RINF(I)
042  660  U(KK) = RINF(I)
042       GO TO 700
042  661  IF (NATURE(I).EQ.TEST(6)) GO TO 665
042       GO TO 671
042  665  DO 670 K = 1,NK
042       KK = INBC(I,K)
042       VP(KK) = RINF(I)
042  670  V(KK) = RINF(I)
042       GO TO 700
042  671  IF (NATURE(I).EQ.TEST(7)) GO TO 675
042       GO TO 681
042  675  DO 680 K = 1,NK
042       KK = INBC(I,K)
044       RB = -RINF(I)
042  680  H(KK) = H(KK)+FAB*(UP(KK)+VP(KK)-RB-VP(KK+NCPR))+R*DELT
042       GO TO 700
042  681  IF (NATURE(I).EQ.TEST(8)) GO TO 685
042  C    CALL ERROR(                      )
042  685  DO 690 K = 1,NK
042       KK = INBC(I,K)
044       RB = -RINF(I)
042       H(KK) = H(KK)+FAB*(UP(KK)+VP(KK)-UP(KK+1)-RB)+R*DELT
042  690  CONTINUE
042  700  CONTINUE
042       RETURN
042       END

END ELT.
```