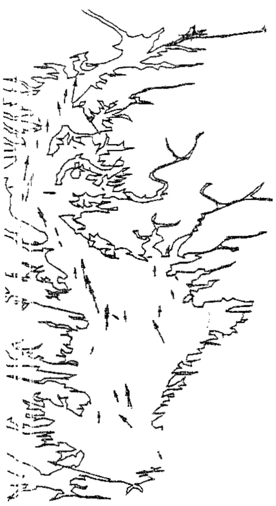
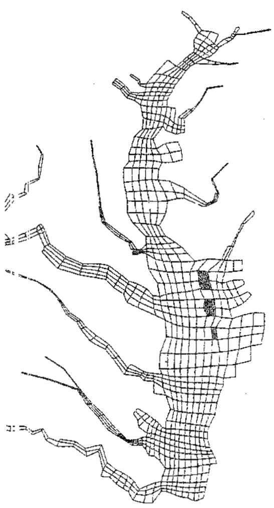
C&EE82

QmQ

S Army Corps
Engineers





HYDRAULICS
LABORATORY

TECHNICAL REPORT HL-91-1

DATA EMPLOYED IN THE DEVELOPMENT OF A THREE-DIMENSIONAL, TIME-VARYING NUMERICAL HYDRODYNAMIC MODEL OF CHESAPEAKE BAY

by

Alan F. Blumberg

HydroQual, Inc.
Mahwah, New Jersey 07430

Billy H. Johnson, Ronald H. Heath, Bernard B. Hsieh, Virginia R. Pankow

Hydraulics Laboratory

and

Keu W. Kim, H. Lee Butler

Coastal Engineering Research Center

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199

US ARMY ENGINEER WATERWAYS EXPERIMENT STATION

January 1991

Final Report

Approved for Public Release; Distribution Unlimited

Prepared for US Army Engineer District, Baltimore
Baltimore, Maryland 21203-1715

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
January 1991

3. REPORT TYPE AND DATES COVERED
Final report

4. TITLE AND SUBTITLE
Data Employed in the Development of a Three-Dimensional, Time-Varying, Numerical Hydrodynamic Model of Chesapeake Bay

5. FUNDING NUMBERS

6. AUTHOR(S)
Alan F. Blumberg, Billy H. Johnson, Ronald H. Heath, Bernard B. Hsieh, Virginia R. Pankow, Keu W. Kim, H. Lee Butler

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
HydroQual, Inc., Mahwah, NJ 07430;
USAE Waterways Experiment Station, Hydraulics Laboratory and Coastal Engineering Research Center, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199

8. PERFORMING ORGANIZATION REPORT NUMBER
Technical Report HL-91-1

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
USAE District, Baltimore, Baltimore, MD 21203-1715

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

A successful calibration/verification of a numerical hydrodynamic model applied to an estuarine/coastal area requires sets of self-consistent data. These data sets must contain freshwater inflows on tributaries; tides at ocean entrances as well as at various interior stations; meteorological data at one or more stations, from which the surface wind stress and heat flux can be determined; and currents, temperature, and salinity at several locations throughout the modeled area. In addition, the bathymetry must also be represented on the numerical grid.

This report presents data sets employed in the development of a three-dimensional hydrodynamic model of Chesapeake Bay. Since the Bay is so large, there is a lack of synoptic data throughout the Bay and its tributaries. Three relatively extensive synoptic field data sets were identified for use in this study. These data sets were collected during June-July 1980, April 1983, and September 1983. In addition, for the preliminary calibration of the hydrodynamic model, data from the physical model of Chesapeake Bay located on Kent Island, Maryland, were identified. Data from each set are presented in a combination of graphical and tabular forms.

14. SUBJECT TERMS
Chesapeake Bay
Estuary
Field data
Hydrodynamics
Numerical model
Three-dimensional

15. NUMBER OF PAGES
222

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED		

Preface

Compilation of the data described herein and preparation of this report were conducted during 1988-89 for the US Army Engineer District, Baltimore, by the US Army Engineer Waterways Experiment (WES) under the general supervision of Mr. Frank Herrmann, Chief of the Hydraulics Laboratory (HL); Dr. James Houston, Chief of the Coastal Engineering Research Center (CERC); and Messrs. M. B. Boyd, Chief of the HL Waterways Division (WD), W. A. McAnally, Chief of the HL Estuaries Division (ED), and H. L. Butler, Chief of the CERC Research Division (CR). Dr. Robert W. Whalin, Technical Director of WES, was the director of the study; Mr. D. L. Robey, Chief of the Ecosystem Research and Simulation Division, Environmental Laboratory, was the Study Manager. Mr. H. L. Butler was the coordinator for the Hydrodynamics Modeling Team.

Dr. Alan F. Blumberg of HydroQual, Inc., and Dr. Billy H. Johnson of WES prepared this report with assistance from Mr. Ronald H. Heath, WD; Dr. Bernard B. Hsieh, ED; Ms. Virginia R. Pankow, ED; and Dr. Keu W. Kim and Mr. H. Lee Butler, CR. The Chesapeake Region Intensive Modeling Program data presented in the report were obtained from Dr. William Boicourt of the University of Maryland.

This report was edited by Mrs. Jessica Ruff of the WES Information Technology Laboratory.

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

This report should be cited as follows:

Blumberg, A. F., Johnson, B. H., Heath, R. H., Hsieh, B. B., Pankow, V. R., Kim, K. W., and Butler, H. L. 1991. "Data Employed in the Development of a Three-Dimensional, Time-Varying, Numerical Hydrodynamic Model of Chesapeake Bay," Technical Report HL-91-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Contents

Conversion Factors, Non-SI to SI (Metric) Units of Measurement

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

Multiply	By	To Obtain
cubic feet	0.02831685	cubic meters
degrees (angle)	0.01745329	radians
feet	0.3048	meters
miles (US statute)	1.609347	kilometers

DATA EMPLOYED IN THE DEVELOPMENT OF A THREE-DIMENSIONAL, TIME-VARYING, NUMERICAL HYDRODYNAMIC MODEL OF CHESAPEAKE BAY

Introduction

Background

1. Chesapeake Bay is one of the Nation's most valuable natural resources. It supports important commercial and recreational fisheries, transportation, industry, recreation, and tourism, and provides irreplaceable habitat for living marine resources and wildlife. However, the estuary has been subjected to increasing environmental stress in recent decades, and the productivity and beauty of the Chesapeake Bay have significantly declined.

2. The Chesapeake Bay Program (CBP) is a unique cooperative effort between state and Federal agencies to restore the health and productivity of America's largest estuary. An important component is the development of a strategy to numerically model the hydrodynamic and water quality processes of Chesapeake Bay as a means of addressing specific management issues. This modeling effort complements other efforts, such as the long-term monitoring, data compilation and analysis, and planning, which support CBP activities.

3. The overall Chesapeake Bay modeling strategy consists of three phases. Phase I was the conversion and refinement of an existing watershed model for the Chesapeake Bay basin; Phase II was the development of a steady-state (coarse grid) water quality model for the Bay; and Phase III is the development of three-dimensional (3D), time-varying, numerical hydrodynamic and water quality models of the Chesapeake Bay. The Administrator of the US Environmental Protection Agency (USEPA) and the Secretary of the Army signed a Memorandum of Understanding, dated 28 August 1987, committing the Department of the Army to develop the 3D models.

Calibration/verification needs

4. It is well known that water quality impacts in the Chesapeake Bay cannot be successfully assessed without an accurate description of hydrodynamic processes. The modeled processes should include at least the 3D flow circulation and the vertical turbulent mixing throughout the water column. The 3D model called CH3D (with boundary-fitted coordinates) satisfies these requirements and thus is being used for hydrodynamic simulations in the Bay.

This model was developed for WES by Sheng (1986) and is being substantially modified by WES to meet the requirements of this project.

5. A successful calibration/verification of the hydrodynamic model requires sets of self-consistent data. These data sets must contain freshwater inflows on the major tributaries; tides at the Bay entrance as well as at various interior stations; meteorological data at one or more stations, from which the surface wind stress and heat flux can be determined; and currents, temperature, and salinity at several locations throughout the Bay. In addition, the Bay bathymetry must also be represented on the numerical grid.

6. The Chesapeake Bay is one of the largest estuaries in the world. As shown in Figure 1, the main Bay extends approximately 190 miles* north from the ocean entrance to the Susquehanna River. The average depth of the Bay is about 28 ft; however, a natural channel with depths greater than 50 ft traverses the Bay for more than 60 percent of its length. The Bay is irregular in shape, varying in width from 4 miles between Annapolis and Kent Island to 30 miles in the middle bay off the Potomac River. The Bay is sufficiently long to accommodate one complete tidal wave at all times.

7. Since the Bay is so large, there is a lack of synoptic data throughout the Bay and its tributaries. Three relatively extensive synoptic data sets were identified for use in this study. These data sets were collected during June-July 1980, April 1983, and September 1983. In addition, for the preliminary calibration of the hydrodynamic model, data from the previous physical model of Chesapeake Bay located on Kent Island, Maryland, were identified.

8. The data sets identified from the physical model were labeled as the Potomac Estuary Study, the Low Freshwater Inflow Study, the Baltimore Harbor and Channels Deepening Study, the Norfolk Harbor and Channels Deepening Study, and the Model Reverification Study. Data on water surface elevation, velocity, and salinity were collected throughout the physical model during the Reverification Study. Due to the wide coverage of this data set, it was selected for use in the initial calibration of the hydrodynamic model.

9. This report presents each of the three field data sets used in the model calibration/verification—the bathymetry specified on the numerical

---

* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

grid, the physical model reverification data, and the mean circulation data generated from the 1980 data set and data collected by the National Oceanic Service during 1981-83. These data are presented in a combination of graphical and tabular forms and should provide the reader with a good background for the conditions represented. However, those readers interested in using the data in future modeling activities on the Bay should request copies of floppy diskettes containing the data. The point of contact for such a request is Dr. B. H. Johnson, telephone number (601) 634-3425.

Bay Bathymetry Data

Numerical grid

10. The numerical grid employed in the 3D hydrodynamic model is shown in Figure 2. There are 734 active horizontal cells and a maximum of 15 vertical layers. To capture the important features of the hydrodynamic processes and bathymetry in the Bay, grid resolution is approximately 10 km longitudinal, 3 km lateral, and 1.52 m vertical. Major tributaries are modeled fully 3D in the lower reach and as constant width two-dimensional in the upper reach.

Water depth data

11. The water depths assigned to each of the computational cells are presented in Figure 3. These depths were obtained from a hydrographic map prepared by the Virginia Institute of Marine Science using bathymetry data obtained from the National Geophysical Data Center of the National Oceanic and Atmospheric Administration (NOAA). They roughly represent an average depth over a cell but have been selectively adjusted to better represent channels and to minimize abrupt changes in depth between cells.

Physical Model Reverification Data Set

12. As a result of concrete expansion during the summer of 1980, a rehabilitation of the Chesapeake Bay physical model was required. This necessitated a reverification of the model. Both dynamic and steady-state tests were conducted. The data set presented herein and used in the preliminary calibration of the numerical hydrodynamic model is only for the steady-state reverification test. All of the data presented and most of the narrative

below were taken from Granat, Gulbrandsen and Pankow (1985).

Boundary conditions

13. For the steady-state test, the ocean tide was a repetitive cosine tide with the M_2 frequency of 12.42 hr and a tidal range from +1.3 to −1.7 ft National Geodetic Vertical Datum (NGVD); the ocean salinity was 30 ppt. The Chesapeake and Delaware Canal (C&D) was closed at the Delaware end. The total freshwater inflow was held constant at the long-term annual average of 70,000 cfs. Table 1 gives the freshwater inflow distribution for the inflow locations shown in Figure 4.

Tide data

14. Tide data were collected at 75 locations throughout the Bay and its tributaries. These stations are shown in Figure 5 and listed in Table 2. A least-squares cosine curve fitting routine with the M_2 frequency was employed to compute physical model phase, amplitude, and offset values for comparison with M_2 values extracted from a harmonic analysis of prototype data collected during 1970–74. The collection program was conducted through contracts with several outside agencies. The M_2 tide for both physical model and prototype is reconstructed using the relation

$$h(t) = A_o + a \cos \left(\frac{2\pi\omega t}{360} - \frac{2\pi\epsilon}{360} \right) \tag{1}$$

where

$h(t)$ = M_2 tide height at time t, ft

t = time, hr

A_o = mean height above reference datum (mean tide level − sea level datum), ft

a = M_2 amplitude, ft

ω = M_2 constituent angular velocity, deg/hr

ϵ = phase angle (epoch) in degrees measured from 0 hr, the moon's transit over the 76-deg meridian

The A_o values were obtained by subtracting Sea Level Datum (SLD), 1929 NGVD, from mean tide level values obtained from the harmonic analysis (MTL − SLD).

15. Table 3 summarizes the final reverification M_2 values for physical model and prototype phase (time of arrival), amplitude, and offset (mean

tide level) for each station. The stations with no prototype data (sta 15, 23, 39, 63, 65, 71, and 73) have only physical model data listed. Sta 75, Chesapeake City in the C&D Canal, is not included because of the artificial C&D Canal boundary condition.

Current data

16. In all, 662 velocity readings during a 2-week data acquisition period were taken for comparison to the prototype. Locations of the velocity stations used in the preliminary calibration of CH3D are shown in Figure 6. As discussed by Granat, Gulbrandsen, and Pankow (1985), the record lengths of the prototype current measurements were too short to accurately extract the M_2 component, and thus some adjustment was required. The reader is referred to the referenced report for details on the approach used. Only the final results as employed in the preliminary calibration of the 3D hydrodynamic model are presented in Table 4.

17. As with the tidal data, the current data have been reduced to values of phase, amplitude, and offset by a least-squares cosine curve fit routine. Therefore, the M_2 currents are constructed from

$$V(t) = MA_o + a \cos \left[\frac{2\pi\omega t}{360} - \frac{2\pi\epsilon}{360} \right] \tag{2}$$

where

$V(t)$ = M_2 velocity at time t, fps

MA_o = mean or residual velocity, fps

a = amplitude, fps

No direction is associated with these data.

Salinity data

18. As discussed in the report by Granat, Gulbrandsen, and Pankow (1985), a bubbling system was installed in the physical model to enhance vertical mixing. For the steady-state reverification test, the bubbler system was carefully controlled to maintain a constant bubbling rate of 0.01 scfm. The source salinity at the ocean boundary was maintained at 30 ppt.

19. Figure 7 shows the location of the four salinity sampling stations at which the salinity data presented in Figure 8 were taken.

1980 CRIMP Data

20. During the Chesapeake Region Intensive Modeling Program (CRIMP),

prototype data were collected during the summer of 1980 from approximately the end of June to the end of July. The data presented are from 23 June–31 July and were collected by Dr. William Boicourt during an extensive, synoptic bay-wide field program conducted by the Chesapeake Bay Institute for the USEPA.* The period represents well-stratified conditions and is a good characterization of the summer circulation that may occur in any year.

Current meter data

21. Current speed and direction, salinity, and water temperature were measured continuously at various locations throughout Chesapeake Bay. The locations of the 18 stations situated within the confines of the bay are shown in Figure 9.

22. Table 5 summarizes the availability of data and the period of record for these stations. The measurement increment was either 10 or 30 min. Time series plots of current, salinity, and temperature data at each location and at specific depths are presented in Figures 10–75. A positive U-velocity is directed toward the north, while a positive V-velocity is directed toward the west.

Wind data

23. Surface wind observation data for the summer 1980 period were obtained from the National Climatic Data Center.** Three stations were available: the Baltimore–Washington International Airport and the Patuxent River Naval Air Station (in Maryland) and the Norfolk International Airport (in Virginia). The Baltimore–Washington International Airport data represent winds in upper Chesapeake Bay, the Patuxent River Naval Air Station data represent winds in mid-Chesapeake Bay, and the Norfolk International Airport data represent winds in lower Chesapeake Bay. The locations of the three stations are shown in Figure 9.

24. Observations were made at either 1- or 3-hr intervals. These results are presented in Figures 76–78.

Riverflow data

25. Daily riverflow data at the tributary fall-lines were obtained from US Geological Survey (USGS) Water Resources Data Reports (USGS 1981a,b). These data are presented for the James, Mattaponi, Pamunkey, Rappahannock,

---

* Personal Communication, Dr. William Boicourt, Horn Point Environmental Laboratories, Cambridge, MD.

** Personal Communication, National Climatic Data Center, Asheville, NC.

Patuxent, Potomac, and Susquehanna Rivers in Figure 79.

Tide gage data

26. Hourly tidal height data at five locations were obtained from the National Ocean Service (NOS)* for the July 1980 period. All except the Annapolis gage have been corrected to the National Geodetic Vertical Datum. Locations of these gages are shown in Figure 80. Tidal plots are presented as Figures 81-85.

Surface heat exchange data

27. In modeling the temperature of the Bay, the concept of equilibrium temperature is employed. Table 6 provides the equilibrium temperature, surface heat transfer coefficient, and short-wave solar radiation for the period 23 June-31 July 1980. These values are based on meteorological data from the Patuxent Naval Air Station.**

Spring 1983 Data

28. The spring 1983 data were obtained from a circulation survey of Chesapeake Bay conducted by the NOS during April 1983.* This data set represents conditions during a large spring runoff event.

Current meter data

29. Current meter data were available for four long-term stations (Bay Entrance (BE), Mid Bay (MB), Wolf Trap (WT), and Bay Bridge (BB)) and two short-term stations (Pooles Island (PI) and Havre de Grace (HG)).* These data include current direction and amplitude, water temperature, pressure, and conductivity. The data were measured at a 10-min interval. The temperature and conductivity were used to compute salinity from the expression below.

$$S = ((((-1.02527 * RF + 4.81236) * RF - 9.04061) * RF + 11.95364) * RF + 28.29988) * RF \tag{3}$$

where

$$RF = RT + RT * RD * TF * (BR + TF + FRT)10^{-5}$$

---

* Personal Communication, National Ocean Service, Rockville, MD.

** Personal Communication, National Climatic Data Center, Asheville, NC.

and

$$RT = C/CKT$$

$$RD = RT - 1.0$$

$$BR = (((-26.9 * RD + 3.09) * RD - 8.52) * RD + 67.1)$$

$$FRT = -0.25 * RD * TF$$

with

$$CKT = (((-2.217 * 10^{-8} * T - 2.5813 * 10^{-5}) * T + 4.6704 * 10^{-3}) * T + 0.86062) * T + 29.0473$$

$$TF = T - 15.0$$

In the above expressions, T is temperature in degrees Celcius, C is conductivity in micromhos per centimeter, and S is salinity in parts per thousand. Table 7 gives the location and period of record for each of the stations. These locations are shown in Figure 80. Plots of currents, salinity, and temperature are presented in Figures 86-109.

Wind data

30. Hourly wind data at the Baltimore-Washington International Airport, the Patuxent River Naval Air Station, and the Norfolk International Airport were available for the April 1983 period.* Figures 110-112 present these data (including wind direction and wind amplitude) for the three stations. Locations of the stations are shown in Figure 9.

Riverflow data

31. Daily riverflow data at the tributary fall-lines were obtained from USGS Water Resources Data Reports for the April 1983 period (USGS 1984a,b). These data are presented in Figure 113 for the James, York, Rappahannock, Potomac, Patuxent, Patapsco, Susquehanna, and Choptank Rivers.

Tide gage data

32. Hourly tidal height data at six locations were available from NOAA/NOS for the April 1983 period.** Locations of these gages are shown in Figure 80. The values have been corrected to the National Geodetic Vertical Datum. Tidal plots are presented in Figures 114-119.

Surface heat exchange data

33. Equilibrium temperatures, surface heat transfer coefficients, and

---

* Personal Communication, National Climatic Data Center, Asheville, NC.

** Personal Communication, National Ocean Service, Rockville, MD.

short-wave solar radiation computed from meteorological data at the Patuxent River Naval Air Station for the April 1983 period are presented in Table 8.*

Fall 1983 Data

34. The fall 1983 data were obtained from a circulation survey of Chesapeake Bay conducted by the NOS during September 1983. This data set contains a strong wind mixing event as well as an event causing rapid cooling of the surface waters.

Current meter data

35. Current meter data were available for four-long term stations: Mid Bay (MB), Bay Entrance (BE), Wolf Trap (WT), and Bay Bridge (BB).** These data include current direction and amplitude, water temperature, pressure, and conductivity. They are measured at a 10-min time interval. The temperature and conductivity were used to compute salinity from Equation 3. Table 9 gives the location and period of record for these stations, the location of which is shown in Figure 80. Plots of current magnitude and direction, salinity, and temperature are presented in Figures 120-135.

Wind data

36. Hourly wind data at the Patuxent River Naval Air Station were available for the September 1983 period.* Wind data at Baltimore-Washington International Airport and Norfolk International Airport for the September 1983 period were available in the Local Climatological Data Monthly Summary reports published by NOAA at 3-hr intervals. The wind data are given in terms of wind direction and speed. Figures 136-138 are plots of wind data from these stations. Locations of the stations are shown in Figure 9.

Riverflow data

37. Daily riverflow data at the tributary fall-lines were obtained from USGS Water Resources Data Reports for the September 1983 period (USGS 1984a,b). These data are presented for the James, York, Rappahannock, Potomac, Patuxent, Patapsco, Susquehanna, and Choptank Rivers in Figure 139.

Tide gage data

38. Hourly tidal height at six locations were available from NOAA/NOS

---

* Personal Communication, National Climatic Data Center, Asheville, NC.
** Personal Communication, National Ocean Service, Rockville, MD.

for the September 1983 period.* These locations include Havre de Grace, MD, Colonial Beach, VA, Annapolis, MD, Solomons, MD, Hampton Roads, VA, and Chesapeake Bay Tunnel, Virginia, and represent values to hundredths of feet corrected to the National Geodetic Vertical Datum. Locations of the gages are shown in Figure 80. Plots of the tidal data are presented in Figures 140–145.

Surface heat exchange data

39. Equilibrium temperatures, surface transfer coefficients, and shortwave solar radiation computed from meteorological data at the Patuxent River Naval Air Station for the September 1983 period are presented in Table 10.**

Mean Circulation Data

40. Mean circulation plots were generated from data collected from a circulation survey of Chesapeake Bay conducted by the National Ocean Service during the period 1981–83* and from the 1980 CRIMP data (paragraphs 20–27). In the NOS survey, currents were taken at 132 locations at various times during the 3-year period. These data were collected using an interval of 15 min and a variable record length of 2 to 57 days. Those records with a length of 15 days or greater were averaged and classified as surface (0 to 6 m), bottom (within last 10 m of total depth), or middepth (6 m to above last 10 m of total depth). Stations with record length less than 15 days were discarded. Figure 146 shows the locations of the current meters analyzed. Results are shown in Figures 147–152.

41. The locations of the CRIMP stations are presented in Figure 9. As with the NOS data, only those records with a length of at least 15 days were employed in constructing the mean circulation plots presented in Figures 153–156.

Summary

42. A successful calibration/verification of a 3D numerical hydrodynamic model requires sets of synoptic data. These data must include freshwater inflows, tides, meteorological data, salinity, water temperature, and

---

* Personal Communication, National Ocean Service, Rockville, MD.
** Personal Communication, National Climatic Data Center, Asheville, NC.

currents. The data employed in the development of the 3D hydrodynamic model of Chesapeake Bay have been presented herein.

43. Data from the physical model representing a steady-state test with the M_2 tide and a freshwater inflow of 70,000 cfs were presented first. Three relatively extensive synoptic field data sets were collected during June-July 1980, April 1983, and September 1983. The 1980 data set represents a stratified summer condition with the April 1983 set representing a large spring runoff event and the September 1983 a major wind mixing event. These data are presented in a combination of graphical and tabular form.

44. Finally, mean circulation plots generated from the 1980 data and data collected by the National Oceanic Service in various parts of the Bay during 1981-83 are presented.

References

Granat, M. A., Gulbrandsen, L. F., and Pankow, V. R. 1985 (Apr). "Reverification of the Chesapeake Bay Model," Technical Report HL-85-3, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Sheng, Y. P. 1986 (June). "A Three-Dimensional Model of Coastal, Estuarine and Lake Currents Using Boundary-Fitted Grid," ARAP Report Number 585, Titan Systems New Jersey, Inc., Princeton, NJ.

USGS. 1981a. "Water Resources Data—Maryland, Water Year 1980," US Geological Survey, Towson, MD.

USGS. 1981b. "Water Resources Data—Virginia, Water Year 1980," US Geological Survey, Richmond, VA.

USGS. 1984a. "Water Resources Data—Maryland, Water Year 1983," US Geological Survey, Towson, MD.

USGS. 1984b. "Water Resources Data—Virginia, Water Year 1983," US Geological Survey, Richmond, VA.

Table 1

Average Total Bay Discharge

Inflow	River	Flow, cfs (prototype)
1	Nansemond	676
2	Chickahominy	289
3	Appomattox	967
4	James	7,249
5	York	2,659
6	Rappahannock	2,842
7	Wicomico	412
8	Occoquan	2,370
9	Anacostia	582
10	Potomac	7,699
11	Patuxent	881
12	Severn	231
13	Patapsco	613
14	Gunpowder	802
15	Susquehanna	36,000
16	Bohemia	386
17	Chester	502
18	Wye	190
19	Choptank	817
20	Nanticoke	1,619
21	Pocomoke	997
22	Susquehanna	1,217
	Total	70,000

Table 2

Tide Height Stations

Station	Name	Location
1	Virginia Beach	Atlantic Ocean
2	Tue Point	Main Bay - York River
3	Old Point Comfort	James River
4	Hampton Roads	
5	Portsmouth	
6	Holliday's Point	
7	Huntington Park	
8	Burwell Bay	
9	Scotland	
10	Ferry Point	
11	Claremont	
12	Willcox Wharf	
13	Hopewell	
14	Chester	
15	Richmond	
16	Yorktown	York River
17	Kiptopeke	Lower Bay - Eastern Shore
18	Gloucester	York River
19	Cheatham Annex	York River
20	Roane Point	York River
21	West Point	York River
22	Belleville	Mobjack Bay
23	Dixie	Piankatank River
24	Jackson Creek	Piankatank River
25	Gaskin Point	Lower Bay - Eastern Shore
26	Mill Creek	Rappahannock River
27	Urbanna	
28	Bayport	
29	Wares Wharf	
30	Rappahannock	
31	Saunder's Wharf	
32	Hopyard Landing	
33	Massaponax	
34	Windmill Point	Main Bay - Rappahannock River
35	Guard Shores	Pocomoke Sound
36	Fleet Point	Mid Bay - Great Wicomico River
37	Cornfield Harbor	Potomac River
38	Lewisetta	
39	Piney Point	
40	Coles Point	
41	Colton Point	

(Continued)

Table 2 (Concluded)

Station	Name	Location
42	Dahlgren	
43	Port Tabacco	
44	Riverside	
45	Aquia Creek	Potomac River
46	Quantico	
47	Indian Head	
48	Marshall Hall	
49	Washington, DC	
50	Chance	Tangier Sound
51	Vienna	Nanticoke River
52	Hoopers Island	Mid Bay - Eastern Shore
53	Solomons Island	Patuxent River
54	Brooms Island	Patuxent River
55	Lower Marlboro	Patuxent River
56	Benedict	Patuxent River
57	Cove Point	Mid Bay - Western Shore
58	Taylors Island	Little Choptank River
59	Chesapeake Beach	Mid Bay - Western Shore
60	Cambridge	Choptank River
61	Dover Bridge	Choptank River
62	Matapeake	Upper Bay - Eastern Shore
63	Gingerville Creek	South River
64	Love Point	Upper Bay - Eastern Shore
65	Cliffs Wharf	Chester River
66	Chestertown	Chester River
67	North Point	Upper Bay - Patapsco River
68	Baltimore	Patapsco River
69	Tolchester	Upper Bay - Eastern Shore
70	Betterton	Sassafrass River
71	Town Point	Elk River
72	Havre de Grace	Susquehanna River
73	Annapolis	Severn River
74	Colonial Beach	Potomac
75	Chesapeake City	C&D Canal

Table 3

Physical Model (M) and 1970–1974 Prototype (P) M_2 Tide Data

Sta	Phase, deg M	Phase, deg P	Amplitude, ft M	Amplitude, ft P	Offset, ft M	Offset, ft P
			James River			
3	240	248	1.19	1.19	−0.44	−0.04
4	245	254	1.22	1.18	0.05	−0.03
5	251	260	1.39	1.34	−0.04	−0.03
6	276	276	1.36	1.39	−0.24	−0.04
7	263	270	1.21	1.25	−0.02	−0.07
8	292	290	1.09	1.16	0.30	0.04
9	335	332	0.91	0.88	0.29	0.07
10	2	359	0.89	0.89	0.16	0.11
11	1	2	0.84	0.82	0.13	0.11
12	43	47	0.83	0.96	0.34	0.10
13	76	77	1.02	1.10	0.42	0.21
14	106	107	1.24	1.30	0.60	0.37
15	112	—	1.22	—	0.95	—
			York River			
2	224	251	1.05	1.04	0.03	−0.13
16	253	257	1.07	1.09	−0.02	−0.09
18	255	260	1.14	1.15	0.05	−0.06
19	264	272	1.25	1.18	0.04	−0.06
20	284	298	1.42	1.35	0.08	−0.11
21	315	315	1.18	1.30	0.16	−0.05
			Rappahannock River			
34	309	309	0.55	0.55	−0.23	−0.07
26	314	320	0.68	0.59	0.17	−0.04
27	326	341	0.79	0.70	−0.29	0.07
28	347	358	0.80	0.79	0.08	0.17
29	13	12	0.83	0.83	0.12	0.22
30	31	37	0.81	0.82	0.05	0.12
31	90	96	0.76	0.69	0.14	0.25
32	181	168	0.48	0.95	0.65	0.42
33	214	189	0.53	1.13	0.91	0.47
			Potomac River			
37	15	18	0.64	0.59	−0.06	0.04
38	15	22	0.66	0.59	−0.14	0.06
39	28	—	0.72	—	0.12	—
40	30	34	0.75	0.69	0.11	0.22
41	46	47	0.82	0.80	0.09	0.18
74	63	62	0.84	0.79	0.05	0.13
42	70	65	0.83	0.76	0.33	0.12
43	88	82	0.70	0.65	0.02	0.11
44	103	101	0.68	0.56	0.06	0.12
45	160	159	0.63	0.51	0.16	0.12
46	169	178	0.64	0.62	0.20	0.14

(Continued)

Table 3 (Concluded)

Sta	Phase, deg M	Phase, deg P	Amplitude, ft M	Amplitude, ft P	Offset, ft M	Offset, ft P
			Rotomac River (Continued)			
47	193	190	0.82	0.80	0.20	0.08
48	205	207	1.02	0.99	0.13	0.18
49	224	222	1.39	1.32	0.25	0.31
			Patuxent River			
53	38	45	0.61	0.55	−0.08	0.07
54	43	56	0.72	0.64	0.04	0.11
56	52	68	0.88	0.75	0.15	0.12
55	81	98	1.02	0.83	0.14	0.20
			Main Bay – Western Shore			
1	203	211	1.48	1.59	−0.07	−0.07
3	240	248	1.19	1.19	−0.44	−0.04
2	244	251	1.05	1.04	0.03	−0.13
22	248	250	1.09	1.14	−0.07	−0.06
23	297	—	0.69	—	0.17	—
24	294	301	0.66	0.54	−0.13	−0.06
34	309	309	0.55	0.55	−0.23	−0.07
36	330	339	0.59	0.52	0.03	0.00
37	15	18	0.64	0.59	−0.06	0.04
53	38	45	0.61	0.55	−0.08	0.07
57	43	57	0.52	0.62	−0.24	0.39
59	82	101	0.46	0.46	0.12	0.13
63	117	—	0.43	—	0.13	—
73	136	—	0.40	—	−0.19	—
67	198	183	0.52	0.45	−0.03	0.09
68	183	185	0.49	0.49	0.09	0.11
72	276	281	0.94	0.83	0.34	0.35
			Main Bay – Eastern Shore and Rivers			
17	231	239	0.94	1.30	0.09	−0.08
25	312	309	0.47	0.81	0.27	−0.14
35	358	353	0.89	1.07	−0.07	0.02
50	54	29	0.34	0.95	0.19	−0.04
51	104	108	0.95	0.97	0.21	−0.06
52	30	40	0.67	0.74	−0.12	0.04
58	89	88	0.54	0.59	−0.13	0.07
60	105	105	0.72	0.77	0.16	0.01
61	166	158	0.82	0.79	0.03	0.06
62	140	140	0.37	0.46	0.10	0.02
64	171	170	0.48	0.53	0.07	0.06
65	188	—	0.61	—	0.03	—
66	211	201	0.74	0.89	0.20	0.13
69	194	195	0.55	0.54	0.11	0.07
70	243	253	0.82	0.73	0.28	0.23
71	261	—	0.89	—	0.07	—

Table 4

Physical Model Reverification Current Velocity Data

Summary Interpretation

Station	Depth	Current Velocity Data Summary* Amplitude, fps ADJ	MODEL	Phase, deg PPHSE	MPHSE	Mean fps MA_o
			Range CB-00			
CB-00-01	4	2.34	1.60	277	232	-0.95
	32	1.54	1.66	227	183	-0.05
CB-00-02	4	2.02	1.43	287	236	-0.52
	22	2.16	1.59	271	227	0.19
	42	2.13	1.52	262	224	0.38
	52	2.17	1.58	256	223	0.33
	71	1.19	1.36	246	212	0.23
CB-00-03	4	0.69	1.43	271	271	-0.57
	32	1.47	1.43	238	214	0.06
	38	1.02	1.27	216	212	0.08
CB-00-04	12	2.53	1.56	243	232	-0.18
	22	1.88	1.77	243	216	0.21
	28	1.21	1.52	217	211	0.13
CB-00-05	12	2.00	2.08	215	231	-0.20
	16	1.56	1.81	225	225	-0.17
CB-00-06	4	2.46	2.45	235	234	-0.47
	12	1.90	2.25	240	230	-0.18
CB-00-07	4	2.49	2.29	224	236	-0.40
	12	1.84	2.18	223	227	-0.14
	16	1.52	1.92	218	225	-0.04

(Continued)

Note: The depths listed are model velocity test depths. In most cases, comparisons are made with prototype data of equivalent depths. When an equivalent prototype depth does not exist, model data are compared with the nearest prototype depth available.

* Column headings are defined as follows:

Depth = Meter position in feet below NGVD.

ADJ = Adjusted prototype M_2 current velocity amplitude in feet per second.

MODEL = Model current velocity amplitude in feet per second.

PPHSE = Maximum prototype current velocity time of arrival in degrees (12.42 hr = 360 deg).

MPHSE = Maximum model current velocity time of arrival in degrees.

MA_o = Model average velocity in feet per second.

(Sheet 1 of 16)

Table 4 (Continued)

		Current Velocity Data Summary				
		Amplitude, fps		Phase, deg		Mean fps
Station	Depth	ADJ	MODEL	PPHSE	MPHSE	MA_o
		Range CB-00 (Continued)				
CB-00-08	12	2.23	2.65	225	232	-0.45
	22	2.19	2.22	220	227	-0.15
	32	1.92	2.14	214	198	-0.09
	42	1.25	1.71	214	216	0.28
CB-00-09	16	2.57	3.18	232	208	-0.05
		Range CB-01				
CB-01-01	12	0.67	1.43	256	250	-0.15
CB-01-02	12	0.79	1.43	289	253	-0.06
	16	0.48	1.33	259	255	0.02
CB-01-03	12	0.84	1.36	280	258	-0.23
	22	0.72	1.24	277	248	-0.08
CB-01-04	12	0.90	1.26	276	251	-0.23
	22	0.75	1.23	280	257	0.03
CB-01-05	12	1.86	1.55	284	259	-0.01
	37	0.70	1.29	252	239	0.19
CB-01-06	12	2.03	1.63	290	256	-0.11
	22	1.47	1.30	272	269	0.32
CB-01-07	12	2.02	1.59	298	255	-0.04
	22	1.02	1.64	98	255	0.08
	27	0.86	1.13	269	249	0.14
CB-01-08	4	2.18	1.36	276	252	-0.32
	14	1.95	1.52	284	249	-0.08
	28	1.07	1.53	261	236	0.11
CB-01-09	4	2.29	1.45	272	264	-0.34
	12	2.00	1.47	275	267	-0.23
	22	1.93	1.42	285	291	0.07
	32	1.83	1.35	280	289	0.08
	42	1.83	1.34	276	261	0.03
	52	1.52	1.38	262	266	0.02
	62	1.39	1.19	264	223	0.00
	72	0.94	1.09	263	203	0.18
CB-01-10	4	2.50	1.83	260	220	-0.50
	12	1.58	1.63	251	245	-0.22
	15	1.30	1.50	240	244	-0.13

(Continued)

Table 4 (Continued)

Station	Depth	Amplitude, fps ADJ	Amplitude, fps MODEL	Phase, deg PPHSE	Phase, deg MPHSE	Mean fps MA_o
			Current Velocity Data Summary			
			Range CB-02			
CB-02-01	4	1.37	0.93	281	286	-0.47
	12	1.85	1.08	185	260	-0.25
	18	1.08	0.88	267	249	-0.16
CB-02-02	4	1.64	1.07	307	288	-0.21
	12	2.13	0.98	312	290	0.05
	22	1.36	1.04	294	276	0.01
	26	1.20	0.89	276	265	-0.05
CB-02-03	4	1.62	1.67	322	282	-0.34
	12	1.09	1.60	313	287	-0.15
	30	0.69	1.23	280	263	0.00
CB-02-04	12	1.08	1.53	301	286	-0.16
	22	1.10	1.39	312	291	0.11
	31	0.56	1.01	266	265	-0.01
CB-02-05	12	1.99	1.35	306	260	-0.10
	22	2.12	1.36	314	287	0.15
	32	1.12	1.07	290	273	0.03
CB-02-06	4	1.71	1.38	297	293	-0.19
	12	1.70	1.42	303	291	-0.10
	22	1.74	1.41	316	291	0.08
	32	1.74	1.28	287	287	0.17
	40	0.82	1.13	284	275	0.01
CB-02-07	4	1.56	1.27	331	288	-0.29
	12	2.16	1.36	302	260	-0.16
	22	2.16	1.47	300	283	0.09
	32	1.81	1.23	297	284	0.15
	42	1.63	1.17	292	266	0.06
CB-02-08	4	1.62	1.05	316	287	-0.25
	12	2.01	1.13	303	291	-0.24
	22	2.01	1.24	303	261	-0.04
	32	1.92	1.18	289	252	0.29
	42	1.65	1.24	282	275	0.23
	52	1.55	1.22	277	266	0.06
	54	1.15	1.13	263	265	0.04
CB-02-09	4	1.16	1.15	340	286	-0.28
	12	1.96	1.27	347	283	-0.22
	22	1.89	1.34	350	279	-0.18
	30	0.87	1.08	316	281	0.15

(Continued)

Table 4 (Continued)

Station	Depth	Amplitude, fps ADJ	Amplitude, fps MODEL	Phase, deg PPHSE	Phase, deg MPHSE	Mean fps MA_o
			Range CB-02 (Continued)			
CB-02-10	4	1.95	1.24	335	269	-0.04
	12	1.69	1.28	315	264	0.06
	23	1.23	1.19	304	250	-0.09
			Range CB-03			
CB-03-01	4	1.55	1.35	340	316	-0.54
	12	1.66	1.33	323	307	-0.58
	22	1.65	1.32	323	308	-0.55
	32	1.29	1.23	254	309	-0.26
CB-03-02	4	1.64	1.71	5	342	-0.27
	12	1.57	1.42	336	341	0.09
	22	1.59	1.56	348	329	0.01
	32	1.79	1.47	338	328	0.16
	42	1.60	1.54	330	321	0.27
	49	1.11	1.97	258	10	0.13
CB-03-03	4	0.88	1.32	352	329	-0.28
	12	1.17	1.38	328	331	-0.11
	22	1.25	1.26	324	341	0.04
	32	1.34	1.27	324	333	0.17
	42	1.40	1.29	300	332	0.34
	52	1.33	1.28	287	322	0.24
	62	1.36	1.35	290	318	0.25
	67	1.19	1.22	291	308	0.16
CB-03-04	4	1.34	1.11	320	337	-0.29
	12	1.26	1.15	339	339	0.10
	32	1.35	1.11	329	332	0.26
	42	1.34	0.96	310	329	0.31
	52	1.24	1.22	316	326	0.19
	62	1.22	1.32	312	326	0.01
CB-03-05	22	1.15	1.16	323	340	0.06
	32	1.35	1.05	335	335	0.20
CB-03-06	4	1.95	1.24	335	269	-0.04
	12	1.69	1.28	315	264	0.06
	22	1.23	1.19	304	250	-0.09
	32	1.00	0.88	311	333	0.05
	37	0.88	0.84	309	326	0.05
CB-03-07	4	1.30	0.99	314	333	-0.31
	12	1.00	0.94	325	328	-0.21
	18	0.86	0.75	334	318	-0.08

(Continued)

Table 4 (Continued)

Station	Depth	Amplitude, fps ADJ	Amplitude, fps MODEL	Phase, deg PPHSE	Phase, deg MPHSE	Mean fps MA_o
			Range CB-03 (Continued)			
CB-03-08	4	0.77	0.84	306	318	-0.24
	12	0.91	0.75	309	314	-0.09
	18	0.56	0.77	305	315	0.02
CB-03-09	4	1.38	0.93	330	324	-0.17
	12	1.23	0.82	332	320	-0.09
	22	1.37	0.85	337	315	0.01
	32	1.25	0.72	327	312	0.07
	42	1.13	0.73	321	308	0.14
	52	0.76	0.63	310	300	0.18
CB-03-10	15	1.06	0.66	276	292	-0.09
			Range CB-04			
CB-04-01	4	1.38	1.07	36	47	-0.54
	12	1.62	1.17	32	46	-0.05
	22	1.62	1.11	31	45	-0.07
	32	1.60	1.04	25	12	0.07
CB-04-02	4	1.19	0.94	55	52	-0.45
	12	1.36	1.04	65	56	-0.41
	22	1.30	1.14	65	58	-0.15
	32	1.34	1.08	64	54	0.08
	42	1.57	1.03	54	46	0.02
CB-04-03	4	0.92	0.93	49	49	-0.46
	12	1.27	0.84	62	43	-0.31
	22	1.31	0.82	52	49	-0.16
	32	1.37	0.90	51	49	0.09
	42	1.41	0.83	50	47	0.18
	52	1.46	0.73	47	33	0.15
	62	1.10	0.57	49	25	0.01
CB-04-04	12	1.62	0.87	52	43	-0.34
	22	1.27	0.95	57	50	-0.21
	32	1.29	0.94	53	53	0.03
	42	1.34	0.98	44	55	0.28
	62	1.50	0.92	56	52	0.22
	72	1.55	0.98	47	45	0.14
	82	1.46	1.01	36	42	0.08
	92	1.36	1.10	43	38	0.05
GB-04-05	4	0.85	0.83	67	52	-0.54
	12	1.03	0.82	48	53	-0.44
	22	1.16	0.95	41	62	-0.12

(Continued)

Table 4 (Continued)

Station	Depth	Amplitude, fps ADJ	Amplitude, fps MODEL	Phase, deg PPHSE	Phase, deg MPHSE	Mean fps MA_o
			Current Velocity Data Summary			
			Range CB-04 (Continued)			
CB-04-05	42	1.13	0.75	49	60	0.19
(Cont'd)	52	1.23	0.87	51	49	0.29
	72	1.29	0.94	43	47	0.12
	82	0.90	0.93	34	35	0.06
	92	1.07	1.10	31	45	0.06
	97	1.24	0.99	36	40	0.06
CB-04-06	4	0.79	0.85	68	51	-0.27
	12	1.13	0.71	43	43	-0.28
CB-04-07	4	0.78	0.89	36	43	-0.26
	12	1.22	0.76	21	40	-0.14
			Range CB-05			
CB-05-01	12	1.21	0.96	106	117	-0.17
	22	0.99	0.88	105	99	-0.06
	25	0.76	0.82	64	100	-0.04
CB-05-02	12	1.13	0.85	85	125	-0.16
	22	1.11	0.88	93	132	0.01
	32	0.87	0.74	93	116	0.02
CB-05-03	12	1.30	0.83	109	131	-0.29
	42	0.93	0.94	111	130	0.16
CB-05-04	12	1.08	0.98	143	129	-0.32
	22	0.92	0.99	159	121	-0.04
	32	0.84	0.96	148	123	0.16
	42	1.09	0.92	162	121	0.28
	52	0.79	0.91	139	126	0.27
	61	0.59	0.78	125	116	0.39
CB-05-05	22	1.13	0.95	117	128	-0.03
	42	1.04	0.90	117	122	0.33
	52	1.02	0.89	111	120	0.12
	62	0.92	0.97	111	117	0.18
	72	0.92	0.97	110	118	0.29
	82	0.99	0.98	111	120	0.31
	92	0.53	1.04	92	110	0.30
	102	1.04	1.07	107	101	0.25
	112	0.91	1.06	111	104	0.23
CB-05-06	22	0.81	1.11	90	109	-0.16

(Continued)

Table 4 (Continued)

Station	Depth	Current Velocity Data Summary: Amplitude, fps: ADJ	Amplitude, fps: MODEL	Phase, deg: PPHSE	Phase, deg: MPHSE	Mean fps MA_o
			Range CB-06			
CB-06-01	4	0.91	0.83	186	136	−0.18
	12	1.13	0.81	180	144	−0.10
	18	0.67	0.69	178	132	0.01
CB-06-02						
	4	0.99	0.85	194	156	−0.24
	12	1.20	0.88	186	138	0.00
CB-06-03	16	0.97	0.84	178	132	0.06
		1.06	1.04	195	149	−0.07
	4	1.34	0.72	194	133	0.00
CB-06-04	22	0.70	0.61	167	110	0.12
	29					
		1.19	1.02	191	143	−0.34
CB-06-05	4	1.34	1.21	195	147	0.23
	22	0.97	1.09	172	115	0.30
	32					
		1.34	1.11	175	154	−0.29
	4	1.55	1.13	180	153	−0.17
	12					
			Range CB-07			
CB-07-01	4	1.53	0.96	172	160	0.14
	10	1.07	0.85	165	157	0.12
CB-07-02	4	1.85	1.37	189	177	−0.22
	13	1.78	0.82	188	169	−0.25
CB-07-03	4	2.06	1.61	225	175	−0.32
	12	2.23	2.11	201	170	0.03
	22	1.80	1.72	196	168	0.06
	27	1.33	1.38	189	182	0.00
CB-07-04	4	2.00	1.97	189	171	−0.07
	12	1.97	0.91	181	173	−0.08
	21	1.50	1.74	185	170	−0.01
CB-07-05	4	1.63	0.79	157	151	−0.01
	12	1.54	0.68	161	152	−0.07
	22	1.36	0.90	165	156	0.03
	31	1.33	1.29	162	157	−0.05
			James River			
JG-01-01	4	1.43	2.07	141	173	−0.52
	11	0.93	1.65	158	164	−0.19

(Continued)

Table 4 (Continued)

Station	Depth	Amplitude, fps ADJ	Amplitude, fps MODEL	Phase, deg PPHSE	Phase, deg MPHSE	Mean fps MA_o
			James River (Continued)			
JG-01-02	4	2.20	2.68	207	209	-0.59
	12	2.80	2.35	227	208	-0.45
	22	2.37	2.29	220	203	-0.41
	42	2.58	2.31	218	199	-0.02
JG-01-03	7	2.32	2.30	97	206	-0.43
	17	2.60	2.15	191	202	-0.24
	37	1.90	2.08	192	208	-0.16
	57	1.49	2.64	178	191	0.36
	67	1.32	2.69	149	184	0.35
	77	0.80	2.47	134	181	0.48
	83	0.54	1.98	148	180	0.33
JG-02-01	4	2.02	2.02	237	224	-0.32
	7	1.47	1.90	225	219	-0.24
JG-02-02	4	2.20	2.11	260	226	-0.45
	12	1.65	2.12	246	220	-0.15
	21	0.93	1.90	228	214	-0.01
JG-02-03	5	1.89	2.01	247	231	-0.44
	15	1.75	2.09	247	223	0.07
	25	1.79	1.89	250	220	
	35	1.54	1.91	246	217	0.33
	45	1.30	1.30	234	207	0.29
JG-03-01	4	1.71	1.84	264	241	-0.15
	12	1.39	1.74	263	243	-0.04
	15	1.59	1.51	268	240	0.02
JG-03-02	4	1.91	1.85	274	254	-0.29
	7	1.66	1.95	277	245	-0.20
	13	1.66	1.95	277	247	-0.14
	16	1.66	1.76	277	247	-0.07
JG-04-01	4	1.62	1.82	283	270	0.07
	9	1.86	1.79	294	269	0.07
	15	1.12	1.68	291	267	0.04
JG-04-02	4	1.45	1.16	297	278	0.05
	12	1.67	1.38	305	283	-0.18
	16	0.73	1.24	278	284	-0.20

(Continued)

Table 4 (Continued)

Station	Depth	Amplitude, fps ADJ	Amplitude, fps MODEL	Phase, deg PPHSE	Phase, deg MPHSE	Mean fps MA_o
			Current Velocity Data Summary			
			James River (Continued)			
JG-05-01	4	1.97	1.93	309	287	-0.12
	11	2.05	1.90	307	287	-0.09
	20	1.50	1.58	305	291	-0.03
JG-05-02	3	2.23	1.93	316	320	0.12
	13	2.14	2.04	324	320	0.12
	23	2.10	1.98	329	321	0.11
	33	2.07	1.89	328	318	0.13
	43	1.56	1.71	329	320	0.16
JG-06-01	4	1.85	1.44	331	344	-0.11
	13	1.74	1.40	333	345	-0.09
	21	1.55	1.13	331	340	-0.04
JG-07-01	4	2.20	2.06	288	348	-0.15
	13	2.03	2.12	280	344	-0.21
	23	1.38	1.65	279	344	-0.15
	27	1.67	1.66	280	343	-0.12
JG-08-01	5	2.14	2.06	12	11	-0.45
	15	2.11	1.75	4	2	-0.38
	25	1.67	1.42	8	3	-0.42
			Patuxent River			
PG-01-01	12	0.72	0.62	20	337	-0.00
	22	0.72	0.66	20	336	-0.04
	32	0.69	0.71	343	333	-0.05
	40	0.50	0.76	357	319	0.01
PG-01-02	4	1.07	0.64	351	345	0.06
	12	0.91	0.70	356	348	0.05
	22	0.90	0.71	6	344	0.01
	32	0.82	0.81	355	328	0.09
	42	0.69	0.74	358	313	0.06
PG-02-01	4	0.80	0.69	227	337	-0.09
	12	0.57	0.73	352	329	-0.04
	22	0.46	0.62	343	324	0.06
PG-02-02	4	1.05	0.72	12	336	-0.11
	12	0.85	0.73	16	335	-0.03
	22	0.67	0.68	16	334	0.02
	32	0.58	0.65	357	334	0.07
	42	0.59	0.57	8	339	0.09

(Continued)

Table 4 (Continued)

Station	Depth	Amplitude, fps ADJ	Amplitude, fps MODEL	Phase, deg PPHSE	Phase, deg MPHSE	Mean fps MA_o
			Patuxent River (Continued)			
PG-02-02	52	0.64	0.62	0	338	0.06
(Cont'd)	62	0.67	0.55	17	334	0.07
PG-03-01	4	0.88	0.82	12	341	-0.14
	12	0.86	0.78	18	339	0.07
	22	0.36	0.63	2	332	0.04
PG-04-01	4	0.93	0.90	33	351	-0.07
	12	1.01	0.96	34	347	-0.07
	22	0.97	1.03	17	344	-0.06
	32	0.60	0.99	6	347	-0.07
PG-04-02	4	1.10	1.06	358	2	0.03
	10	0.69	0.86	41	353	0.06
PG-05-01	4	1.64	1.58	55	5	-0.18
	9	0.65	0.98	42	4	-0.09
PG-06-01	4	1.02	0.86	48	16	0.05
	12	0.84	0.99	63	7	0.04
			Potomac River			
PO-01-01	4	0.87	0.71	351	338	-0.22
	12	1.78	0.79	350	336	-0.17
	22	1.34	0.64	338	328	-0.12
	23	1.34	0.64	338	313	-0.07
PO-01-02	4	0.95	0.67	357	334	-0.27
	12	1.13	0.60	0	338	-0.22
	22	1.32	0.66	352	335	0.08
	35	0.55	0.62	334	319	0.01
PO-01-03	4	1.01	0.64	344	322	-0.18
	12	1.31	0.68	351	338	-0.15
	22	1.29	0.67	353	351	0.00
	32	1.04	0.71	355	331	0.10
	38	0.61	0.62	358	320	0.15
PO-01-04	4	0.87	0.64	9	348	-0.24
	12	1.15	0.68	4	337	0.06
	22	0.90	0.67	5	328	0.13
	32	0.74	0.71	350	336	0.08
	42	0.62	0.74	337	338	0.09
	49	0.49	0.66	343	318	0.04

(Continued)

Table 4 (Continued)

Station	Depth	Amplitude, fps ADJ	Amplitude, fps MODEL	Phase, deg PPHSE	Phase, deg MPHSE	Mean fps MA_o
			Potomac River (Continued)			
PO-01-05	4	0.59	1.03	347	299	-0.13
	12	0.84	0.77	328	300	-0.09
	22	0.84	0.74	326	305	-0.06
	28	0.33	0.62	304	297	-0.15
PO-02-01	4	0.60	0.45	353	348	-0.15
	22	0.60	0.45	349	352	-0.02
	30	0.38	0.49	333	344	0.05
PO-02-02	4	0.77	0.46	0	351	-0.25
	12	0.92	0.75	353	353	0.00
	22	0.74	0.71	357	356	0.12
	32	0.61	0.69	349	344	0.13
	42	0.57	0.67	358	339	0.12
	52	0.58	0.66	347	341	0.04
	57	0.58	0.56	347	328	-0.02
PO-02-03	6	0.72	0.49	346	333	-0.12
	12	0.72	0.44	346	343	-0.04
	22	0.62	0.48	329	340	0.05
	30	0.38	0.47	315	318	0.06
PO-03-01	4	0.77	0.94	5	15	-0.36
	12	0.69	0.85	294	16	-0.06
	22	0.75	1.04	354	9	0.10
	32	0.80	1.05	357	4	0.04
	42	0.72	1.01	359	30	0.04
	52	0.72	1.13	359	357	0.00
	57	0.80	1.03	352	357	0.05
PO-03-02	4	0.63	0.76	5	6	-0.39
	22	0.88	1.06	8	1	0.14
	32	0.85	1.14	357	345	0.01
	35	0.68	1.02	340	341	-0.01
PO-04-01	4	1.00	0.84	31	23	-0.23
	12	1.09	1.08	27	18	0.05
	22	0.69	1.06	12	7	0.03
PO-04-02	4	1.20	1.14	33	41	-0.20
	12	1.31	1.06	32	38	0.01
	22	1.42	0.94	31	27	0.07
	41	0.71	0.97	10	9	0.07

Current Velocity Data Summary

(Continued)

Table 4 (Continued)

Station	Depth	Amplitude, fps ADJ	Amplitude, fps MODEL	Phase, deg PPHSE	Phase, deg MPHSE	Mean fps MA_o
			Patuxent River (Continued)			
PO-05-01	4	0.33	0.37	10	65	-0.07
	12	0.47	0.40	19	42	-0.05
PO-05-02	4	0.59	0.79	30	51	-0.19
	10	0.81	0.88	37	48	-0.05
	16	0.30	0.75	67	45	0.15
PO-05-03	4	0.92	0.98	35	44	-0.34
	10	0.89	1.05	35	57	-0.18
	19	0.43	0.69	19	64	0.23
PO-06-01	4	1.51	1.79	78	86	-0.30
	12	1.39	1.80	88	86	-0.24
	22	1.31	1.79	88	85	-0.11
	32	1.26	1.66	86	78	-0.04
	42	1.20	1.53	77	74	-0.02
	52	1.13	1.29	75	69	0.01
	61	0.99	1.30	72	60	0.05
PO-07-01	4	1.33	1.56	56	99	-0.21
	12	1.01	1.35	89	93	-0.17
PO-07-02	4	1.50	2.06	97	98	-0.44
	12	1.71	1.84	75	96	-0.13
	20	0.29	1.50	139	88	0.08
PO-08-02	10	1.35	1.55	98	108	-0.07
	17	1.05	1.43	96	104	-0.11
PO-09-01	4	0.15	1.11	137	100	-0.08
	10	0.53	1.00	80	97	-0.06
PO-09-02	4	0.43	1.28	90	114	-0.14
	11	1.38	1.16	57	109	-0.08
	21	0.92	0.95	68	105	-0.09
PO-10-01	12	1.27	1.53	114	112	-0.13
	27	1.02	1.29	114	107	-0.05
PO-10-02	4	1.36	1.33	105	120	-0.11
	12	1.26	1.37	101	124	-0.11
	22	1.04	1.38	100	131	-0.08

(Continued)

Table 4 (Continued)

Station	Depth	Current Velocity Data Summary Amplitude, fps ADJ	MODEL	Phase, deg PPHSE	MPHSE	Mean fps MA_o
		Potomac River (Continued)				
PO-11-01	4	1.41	1.73	111	138	-0.08
	12	1.44	1.58	128	131	-0.11
	22	1.31	1.51	123	130	-0.07
	30	1.17	1.43	119	124	0.00
PO-12-01						
	4	1.29	1.58	127	129	-0.20
	12	1.26	1.49	137	127	-0.23
	22	1.22	1.52	133	128	-0.19
	32	1.16	1.50	138	134	-0.06
	42	1.03	1.39	131	131	0.05
PO-13-01	52	0.92	1.25	135	129	0.06
	4	0.95	1.10	147	135	-0.33
	22	0.58	0.78	131	137	-0.24
		Patapsco River				
PR-01-01	4	0.38	0.42	104	124	-0.13
	12	0.36	0.37	111	112	-0.08
PR-01-02						
	4	0.44	0.38	90	126	-0.01
PR-01-03	13	0.39	0.37	103	119	-0.05
	4	0.56	0.27	77	80	0.10
	12	0.41	0.28	102	82	0.00
	22	0.17	0.18	138	112	0.10
	32	0.21	0.27	150	123	0.12
	38	0.17	0.27	127	115	0.08
PR-02-01	4	0.19	0.02	128	46	0.01
	13	0.31	0.09	81	100	0.01
PR-02-02						
	4	0.09	0.12	149	101	0.02
	12	0.41	0.19	139	81	-0.04
	22	0.24	0.13	100	90	0.01
	32	0.27	0.17	91	79	0.05
	39	0.26	0.10	69	64	0.02
		Rappahannock River				
RG-01-01	4	1.60	1.52	285	266	-0.06
	12	1.60	1.30	285	255	-0.16
	22	1.47	1.32	281	245	-0.02

(Continued)

Table 4 (Continued)

Station	Depth	Amplitude, fps ADJ	Amplitude, fps MODEL	Phase, deg PPHSE	Phase, deg MPHSE	Mean fps MA_o
		Current Velocity Data Summary				
		Rappahannock River (Continued)				
RG-01-02	4	1.34	1.05	296	273	-0.04
	12	1.39	1.01	302	266	0.06
	22	1.22	0.83	311	258	0.15
	31	0.74	0.73	301	232	0.11
RG-02-01	4	1.25	0.90	298	280	-0.17
	13	1.36	0.85	297	276	-0.13
	23	1.14	0.76	296	271	-0.04
RG-02-02	4	1.08	0.96	317	283	-0.34
	12	1.04	0.94	310	279	-0.20
	22	1.02	1.02	314	272	0.03
	32	0.94	0.99	319	261	0.14
	42	0.94	0.94	305	250	0.19
	52	0.79	0.63	295	252	0.15
RG-03-01	4	0.86	0.79	313	282	-0.26
	12	2.03	0.89	224	284	-0.13
	22	1.09	0.78	326	282	-0.03
	32	1.11	0.68	330	274	0.11
	42	0.99	0.94	335	287	0.02
	52	0.95	1.08	310	284	0.12
RG-03-02	4	0.83	0.75	250	286	-0.09
	13	0.78	0.67	254	270	0.02
RG-04-01	4	1.22	1.14	321	289	-0.08
	12	1.17	1.08	329	283	0.04
	20	0.81	0.92	306	277	0.13
RG-04-02	4	0.95	0.65	327	307	-0.33
	12	1.03	0.61	315	300	-0.05
	22	0.99	0.58	324	287	0.10
	32	0.69	0.65	299	287	0.24
RG-05-01	4	1.23	1.94	343	298	-0.21
	9	1.34	1.46	241	299	-0.01
	19	1.00	1.32	232	297	0.03
RG-06-01	4	1.84	1.26	2	313	-0.18
	12	1.37	1.27	350	302	-0.03
	16	0.97	1.16	333	288	-0.15

(Continued)

Table 4 (Continued)

Station	Depth	Amplitude, fps ADJ	Amplitude, fps MODEL	Phase, deg PPHSE	Phase, deg MPHSE	Mean fps MA_o
		Rappahannock River (Continued)				
RG-07-01	4	1.85	1.72	5	340	-0.29
	12	1.71	1.48	357	333	-0.11
	16	1.40	1.26	341	331	-0.02
RG-08-01						
	4	2.17	1.97	18	343	-0.43
	12	2.20	1.77	5	344	-0.29
RG-09-01	21	1.56	1.57	10	344	-0.18
RG-10-01	4	1.91	1.80	25	8	-0.05
	12	1.37	1.61	34	6	-0.12
	4	2.37	1.46	55	19	-0.14
	12	2.09	1.35	57	19	-0.09
	22	1.75	1.29	51	17	-0.06
		Susquehanna River				
SU-01-01	4	0.54	0.59	190	186	-0.59
	14	0.22	0.53	191	158	-0.51
SU-01-02	12	0.25	0.51	208	186	-0.61
	22	0.21	0.47	201	180	-0.60
	24	0.19	0.52	134	186	-0.62
		York River				
YG-01-01	15	1.32	1.04	247	202	-0.13
	23	1.09	1.00	250	196	0.02
	33	0.96	0.89	229	186	0.10
YG-01-02	15	1.20	0.81	220	211	0.14
	35	1.04	0.96	214	196	0.06
	45	1.03	1.04	213	184	0.16
	53	0.75	1.03	233	173	0.06
YG-02-01	4	1.69	1.79	258	214	-0.39
	14	1.71	1.71	265	215	-0.24
	24	1.62	1.77	271	212	-0.20
	52	1.25	1.31	246	187	0.27
	61	0.90	0.81	231	196	0.28
YG-03-01	13	1.24	1.40	251	209	-0.01
YG-03-02	3	2.03	1.64	272	223	-0.35
	13	1.98	1.58	274	215	-0.08
	23	1.53	1.42	250	206	0.19
	26	1.53	1.46	250	202	0.04

(Continued)

Table 4 (Concluded)

	Current Velocity Data Summary					
		Amplitude, fps		Phase, deg		Mean fps
Station	Depth	ADJ	MODEL	PPHSE	MPHSE	MA_o
		York River (Continued)				
YG-04-01	13	2.21	1.65	286	235	-0.11
	23	1.90	1.65	278	227	0.11
YG-05-01	4	2.75	2.55	275	242	-0.48
	14	1.39	2.46	220	237	-0.05
	23	2.14	2.12	258	228	0.11
YG-06-01	14	2.53	2.08	287	256	-0.28
	24	2.02	1.66	286	254	0.11
YG-07-01	4	1.59	2.56	306	267	-0.20
	12	1.59	2.42	306	266	-0.27
YG-07-02	11	0.83	3.34	251	261	-0.46

Table 5

Summary of the Available CRIMP Data and Period of Record

Station	Depth ft	Period of Record From mm/dd/yy/hour	Period of Record To mm/dd/yy/hour	No. of Days	Measurement Increment min	Available Data Current	Available Data Temp.	Available Data Salinity
WP	28	06/27/80/1230	07/08/80/0030	10.5	30	X	–	–
BB1	9	06/22/80/0810	07/29/80/1230	37.2	10	–	X	X
BB1	50	06/22/80/0820	07/29/80/1240	37.2	10	–	X	X
CC1	56	06/22/80/1040	07/28/80/0920	36.0	10	–	X	X
PX1	5	07/01/80/1300	08/01/80/1500	31.1	30	X	–	–
PX1	12	07/01/80/1250	08/01/80/1530	31.1	10	X	X	X
PX1	30	07/01/80/1300	08/01/80/1500	31.1	30	X	–	–
PX2	9	07/01/80/1430	08/01/80/1600	31.1	30	X	–	–
PX2	34	07/01/80/1430	08/01/80/1600	31.1	30	X	–	–
SP1	30	06/26/80/1200	07/13/80/1300	17.1	30	X	–	–
SP1	60	06/26/80/1200	07/28/80/1420	32.1	10	X	X	–
SP1	90	06/26/80/1200	07/23/80/1150	27.0	30	X	–	–
SP2	9	06/26/80/1100	07/28/80/1500	32.2	10	X	X	X
SP2	27	06/26/80/1110	07/28/80/1510	32.2	10	X	X	–
TS1	9	06/26/80/0930	07/28/80/1730	32.4	30	X	–	–
TS1	30	06/26/80/0900	07/28/80/1630	32.3	30	X	–	–
TS1	55	06/26/80/0920	07/28/80/1710	32.3	10	X	X	–
WT1	9	06/25/80/1520	07/24/80/1920	29.2	10	–	X	X
WT2	9	06/25/80/1440	07/30/80/1520	35.0	10	X	X	X
WT2	30	06/25/80/1500	07/30/80/1550	35.0	10	X	X	X
WT3	9	06/25/80/1610	07/30/80/1620	35.0	10	X	X	X
WT3	30	06/25/80/1620	07/30/80/1630	35.0	10	X	X	–
WT4	9	06/25/80/1630	07/30/80/1630	35.0	10	X	X	X
WT4	30	06/25/80/1700	07/30/80/1700	35.0	10	X	X	X
WT4	58	06/25/80/1700	07/30/80/1700	35.0	10	X	X	–
WT5	9	06/25/80/1730	07/30/80/1700	35.0	30	X	–	–
WT5	29	06/25/80/1730	07/30/80/1700	35.0	30	X	–	–
M1	9	06/23/80/0850	07/31/80/0850	38.0	10	X	X	X
M1	35	06/23/80/0900	07/31/80/0840	38.0	10	X	X	X
M1	50	06/23/80/0900	07/31/80/0900	38.0	10	X	X	X
M2	9	06/23/80/0920	07/31/80/0900	38.0	10	X	X	X
M2	20	06/23/80/0940	07/31/80/0900	38.0	10	X	X	X
M2	35	06/23/80/0940	07/31/80/0910	38.0	10	X	X	X
M2	50	06/23/80/0940	07/31/80/0920	38.0	10	X	X	X
M3	9	06/23/80/1040	07/31/80/0940	38.0	10	X	X	X
M3	20	06/23/80/1040	07/31/80/0940	38.0	10	X	X	X
M3	32	06/23/80/1030	07/31/80/0940	38.0	10	X	X	X
M4	10	06/23/80/1120	07/18/80/2250	25.5	10	X	X	X
M5	9	06/23/80/1220	07/31/80/1050	37.9	10	X	X	X
M5	30	06/23/80/1240	07/31/80/1050	37.9	10	X	X	X

Table 6

1980 Surface Heat Exchange Data

Date	Equilibrium Temperature °C	Surface Transfer Coefficient $(watts/m^2/°C)$	Short-Wave Solar Radiation langleys
6/23/80	24.7	58.2	522.8
6/24/80	24.4	90.6	429.2
6/25/80	23.5	80.2	316.7
6/26/80	22.3	59.8	278.1
6/27/80	21.7	31.0	652.2
6/28/80	24.1	23.9	531.2
6/29/80	22.9	28.6	287.1
6/30/80	26.9	49.7	492.6
7/01/80	27.3	36.6	558.8
7/02/80	27.9	29.8	559.7
7/03/80	28.0	32.0	648.2
7/04/80	26.8	48.0	588.4
7/05/80	24.7	69.1	283.9
7/06/80	24.1	47.1	286.4
7/07/80	22.2	47.5	263.0
7/08/80	24.2	34.4	659.8
7/09/80	23.4	47.7	575.8
7/10/80	23.6	31.3	302.4
7/11/80	23.4	55.7	298.9
7/12/80	26.7	43.6	465.4
7/13/80	25.9	63.9	433.6
7/14/80	24.3	24.8	343.7
7/15/80	21.3	38.6	252.3
7/16/80	22.8	52.7	280.6
7/17/80	21.3	24.6	287.1
7/18/80	19.5	33.8	268.0
7/19/80	21.7	25.9	257.0
7/20/80	23.6	25.3	270.8
7/21/80	25.4	28.5	281.7
7/22/80	27.6	31.5	283.7
7/23/80	27.2	29.2	282.7
7/24/80	26.6	40.1	397.2
7/25/80	25.3	44.9	429.9
7/26/80	26.4	42.8	561.1
7/27/80	26.3	45.9	412.5
7/28/80	27.8	30.3	445.9
7/29/80	25.7	42.8	252.4
7/30/80	25.4	35.2	229.1
7/31/80	25.5	43.1	329.2

Table 7

Location of Current Meters for Spring 1983 NOS Data Set

Location		Depth	
Latitude	Longitude	m	Period of Record
		Bay Entrance	
36° 58.8′	75° 59.88′	4.6	04/01/83 - 05/01/83
		10.4	04/01/83 - 05/01/83
		Mid Bay	
38° 18.73′	76° 18.75′	4.6	04/01/83 - 05/01/83
		14.6	04/01/83 - 04/05/83
		Wolf Trap	
37° 24.80′	76° 7.40′	4.6	04/01/83 - 05/01/83
		10.1	04/01/83 - 05/01/83
		Bay Bridge	
38° 53.75′	76° 23.36′	5.8	04/01/83 - 05/01/83
		11.3	04/01/83 - 05/01/83
		21.3	04/05/83 - 05/01/83
		Pooles Island	
39° 18.70′	76° 13.00′	5.5	04/06/83 - 04/11/83
		Havre de Grace	
39° 32.22′	76° 4.80′	3.0	04/13/83 - 05/01/83

Table 8

April 1983 Surface Heat Exchange Data

Date	Equilibrium Temperature °C	Surface Transfer Coefficient $watts/m^2/°C$	Short-Wave Solar Radiation $watts/m^2/°C$
4/01/83	13.8	15.7	455.8
4/02/83	9.6	21.7	248.9
4/03/83	14.2	29.4	310.4
4/04/83	16.2	17.4	407.8
4/05/83	14.6	11.8	266.2
4/06/83	13.7	12.4	180.6
4/07/83	14.6	12.8	174.5
4/08/83	16.7	13.6	174.2
4/09/83	12.6	23.0	177.3
4/10/83	13.8	18.7	277.5
4/11/83	12.4	21.9	305.2
4/12/83	18.2	15.3	499.3
4/13/83	15.7	19.2	458.6
4/14/83	13.1	29.2	302.6
4/15/83	13.6	33.9	183.4
4/16/83	12.1	27.7	424.4
4/17/83	14.3	18.6	508.0
4/18/83	9.9	18.7	388.4
4/19/83	4.6	26.2	202.4
4/20/83	6.5	28.4	323.2
4/21/83	18.4	15.1	546.1
4/22/83	19.1	15.8	486.0
4/23/83	14.7	19.6	283.2
4/24/83	12.4	29.6	194.1
4/25/83	7.4	30.6	207.8
4/26/83	15.2	25.3	474.9
4/27/83	20.9	18.9	432.6
4/28/83	21.8	27.1	538.3
4/29/83	17.9	32.6	241.4
4/30/83	17.9	38.8	253.9

Table 9

Location of Current Meters for Fall 1983 NOS Data Set

Location Latitude	Location Longitude	Depth m	Period of Record
		Bay Entrance	
36° 58.80′	75° 59.88′	4.6	09/01/83 – 09/30/83
		10.4	09/01/83 – 09/30/83
		Wolf Trap	
37° 24.80′	76° 7.40′	4.6	09/01/83 – 09/30/83
		10.1	09/01/83 – 09/06/83
		Mid Bay	
38° 18.73′	76° 18.75′	5.2	09/01/83 – 09/30/83
		14.9	09/01/83 – 09/30/83
		Bay Bridge	
38° 53.75′	76° 23.36′	5.8	09/01/83 – 09/30/83
		11.3	09/01/83 – 09/30/83
		21.3	09/01/83 – 09/30/83

Table 10

September 1983 Surface Heat Exchange Data

Date	Equilibrium Temperature °C	Surface Transfer Coefficient watts/m^2/°C	Short-Wave Solar Radiation watts/m^2/°C
9/01/83	26.1	26.6	315.8
9/02/83	25.4	20.4	219.2
9/03/83	27.8	18.4	337.4
9/04/83	27.7	28.6	272.1
9/05/83	31.2	22.2	334.8
9/06/83	31.2	27.0	419.2
9/07/83	31.0	21.6	346.6
9/08/83	25.9	18.6	308.8
9/09/83	28.8	18.7	448.5
9/10/83	30.2	19.4	438.8
9/11/83	28.3	27.4	429.8
9/12/83	27.4	27.5	320.8
9/13/83	22.3	27.1	164.1
9/14/83	18.1	28.65	167.1
9/15/83	20.5	24.7	431.9
9/16/83	21.9	19.7	376.1
9/17/83	24.3	21.3	289.1
9/18/83	25.2	19.7	390.8
9/19/83	25.4	31.3	403.3
9/20/83	25.1	37.8	392.0
9/21/83	21.6	38.4	157.7
9/22/83	14.7	29.2	378.0
9/23/83	18.3	14.3	364.8
9/24/83	18.6	15.1	404.7
9/25/83	20.6	13.6	389.8
9/26/83	18.2	13.3	240.2
9/27/83	22.8	15.2	374.2
9/28/83	19.0	25.6	265.7
9/29/83	15.3	33.7	175.4
9/30/83	17.4	35.5	131.9

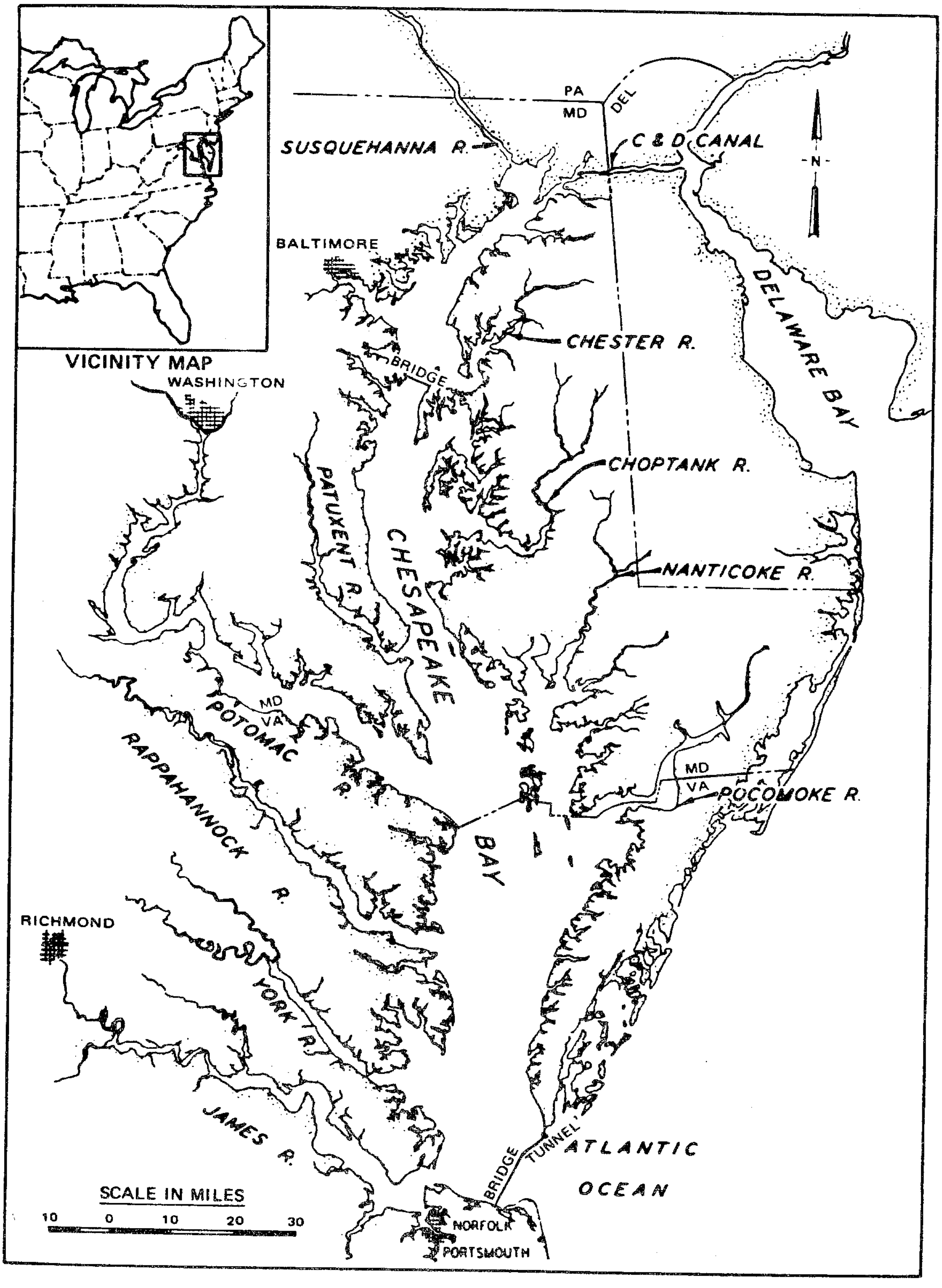


Figure 1. Chesapeake Bay

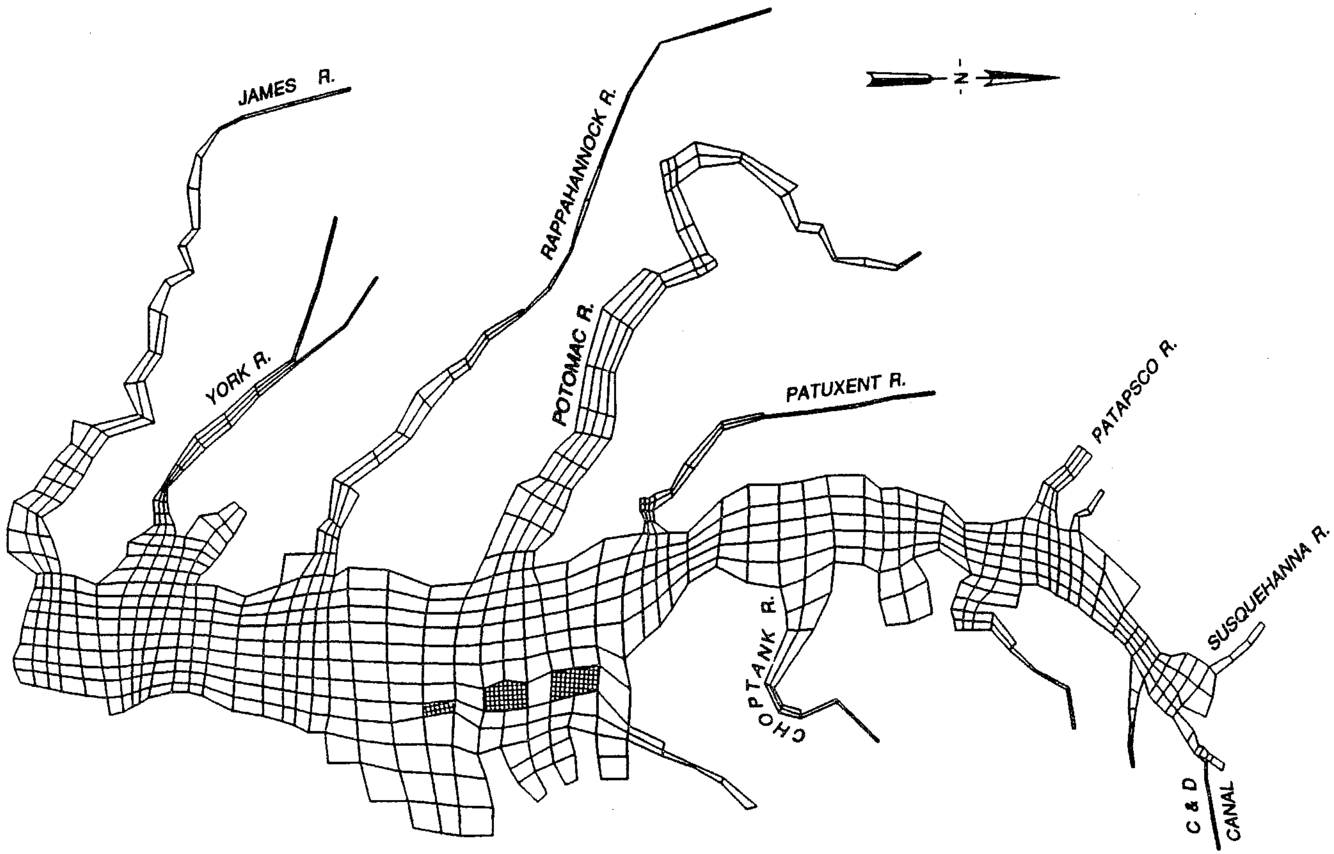


Figure 2. Planform boundary-fitted grid of Chesapeake Bay

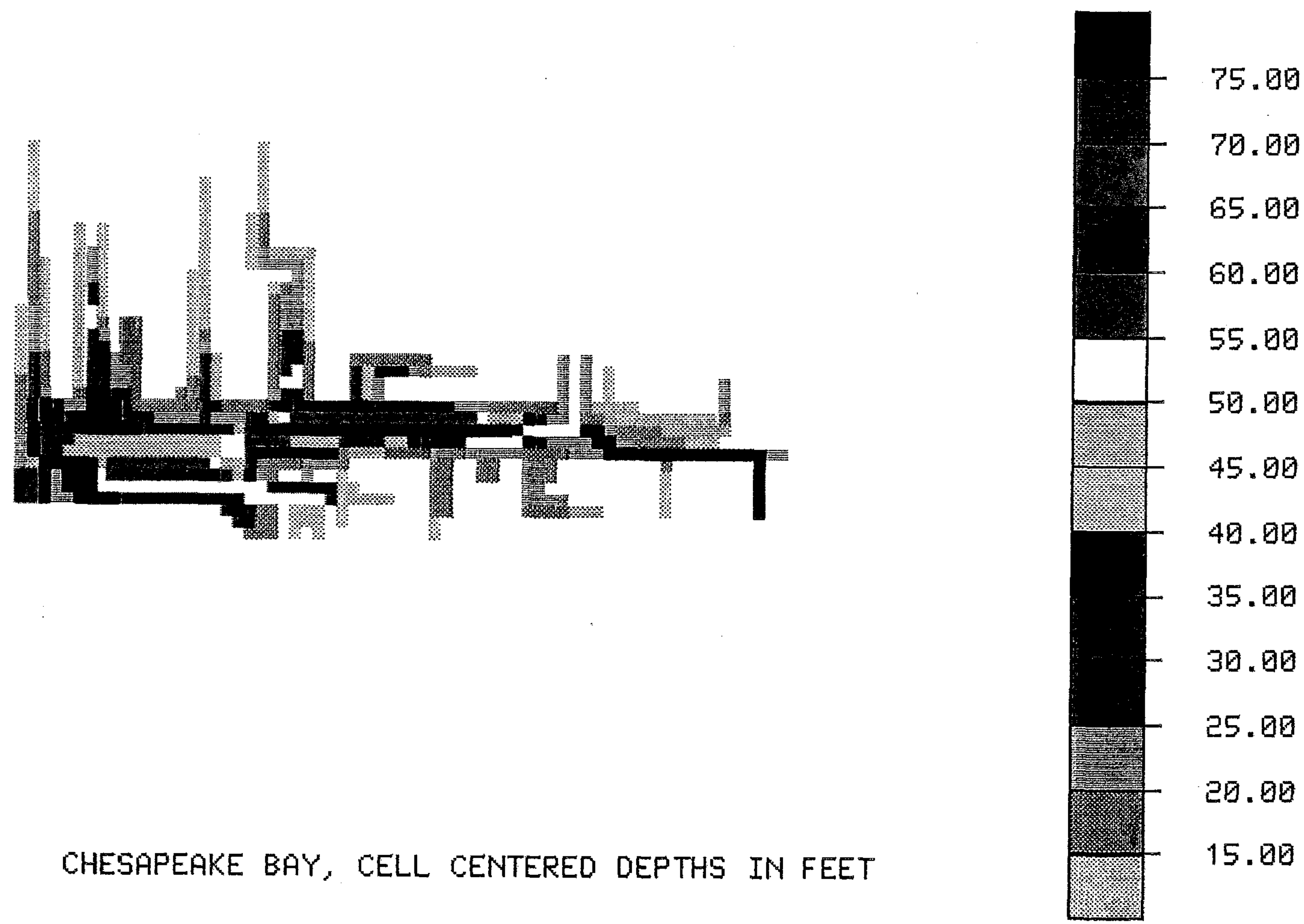


Figure 3. Chesapeake Bay bathymetry

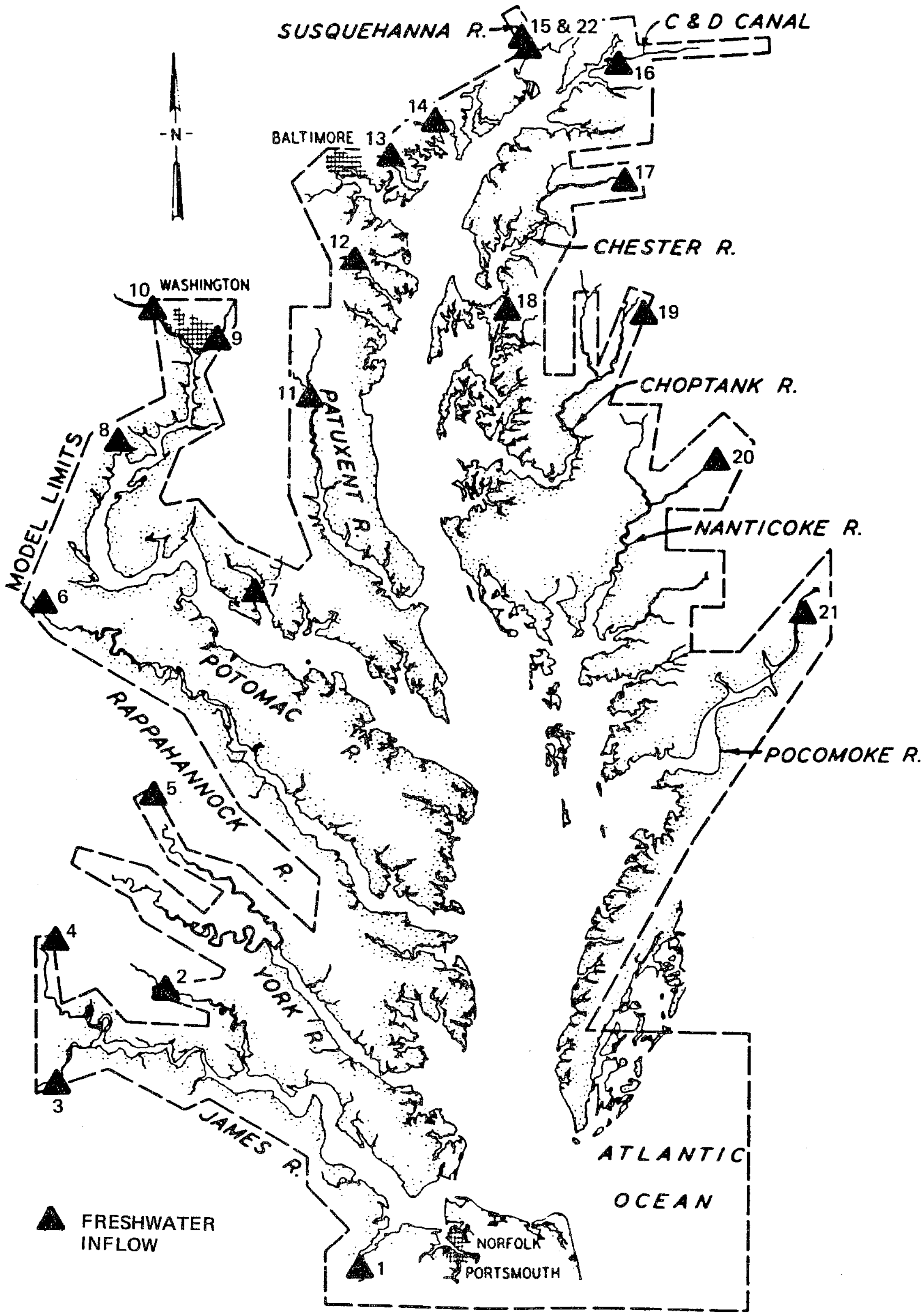


Figure 4. Physical model freshwater inflow locations

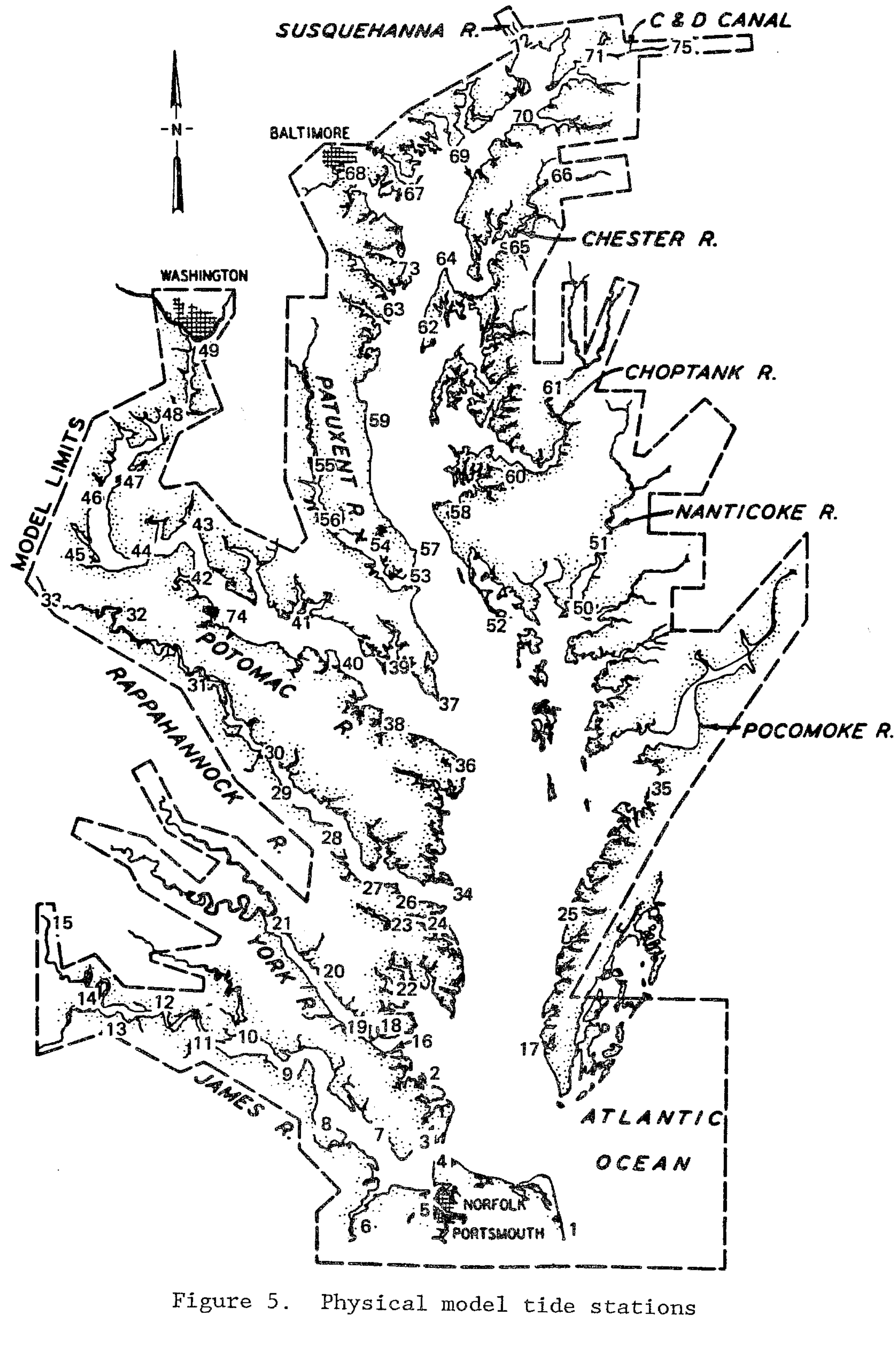


Figure 5. Physical model tide stations

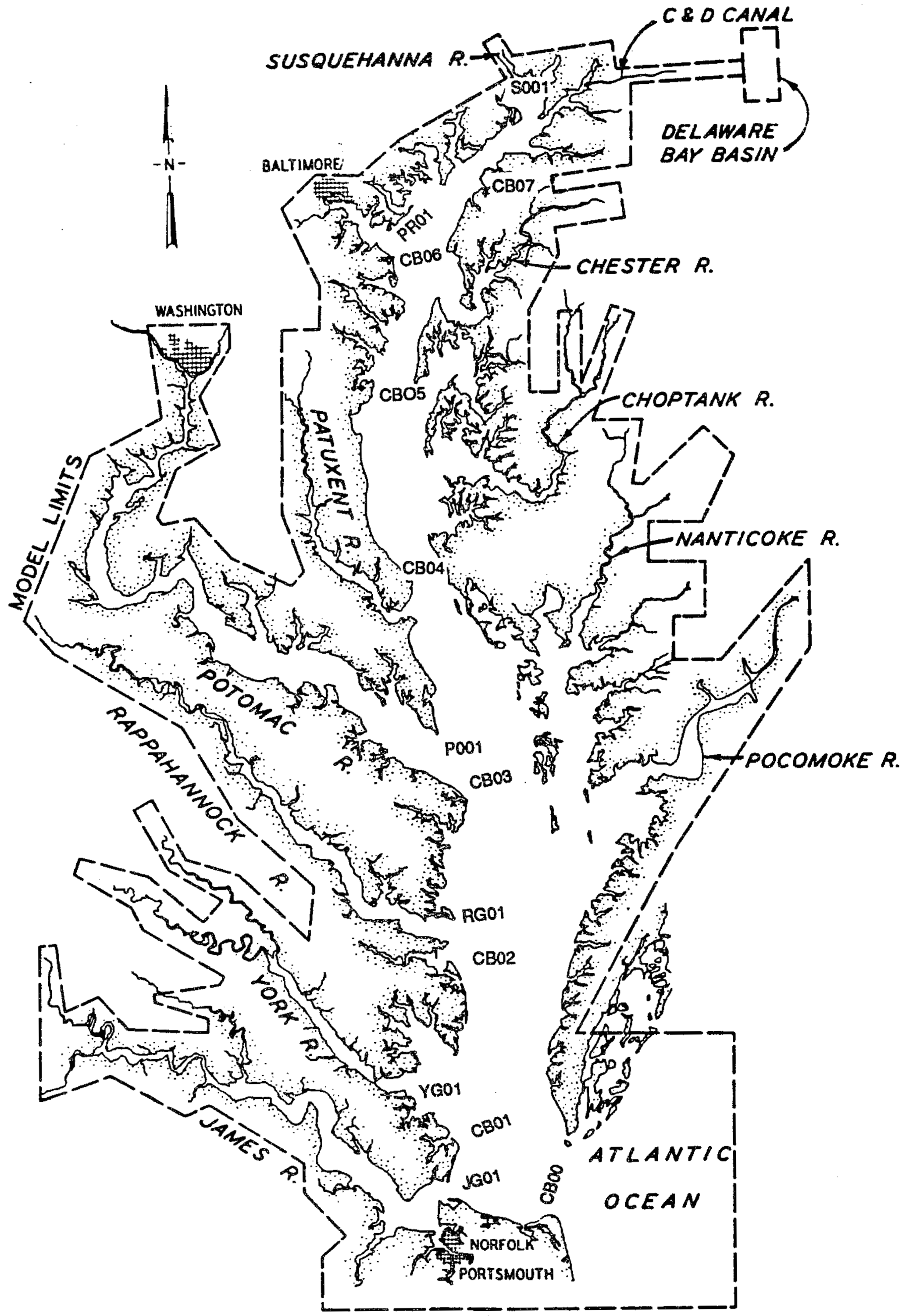


Figure 6. Physical model velocity sampling ranges along Chesapeake Bay and its major tributaries

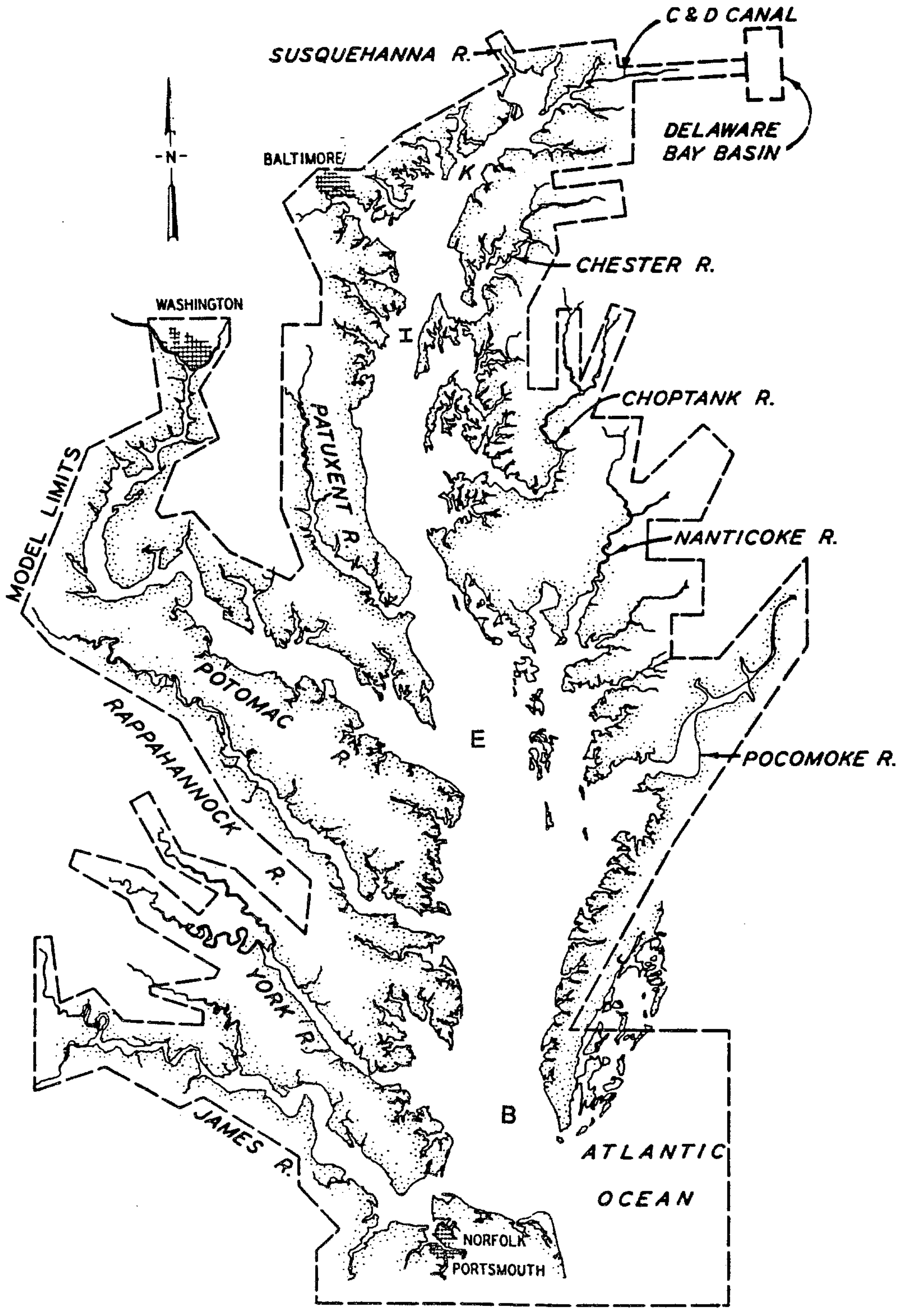


Figure 7. Physical model salinity stations

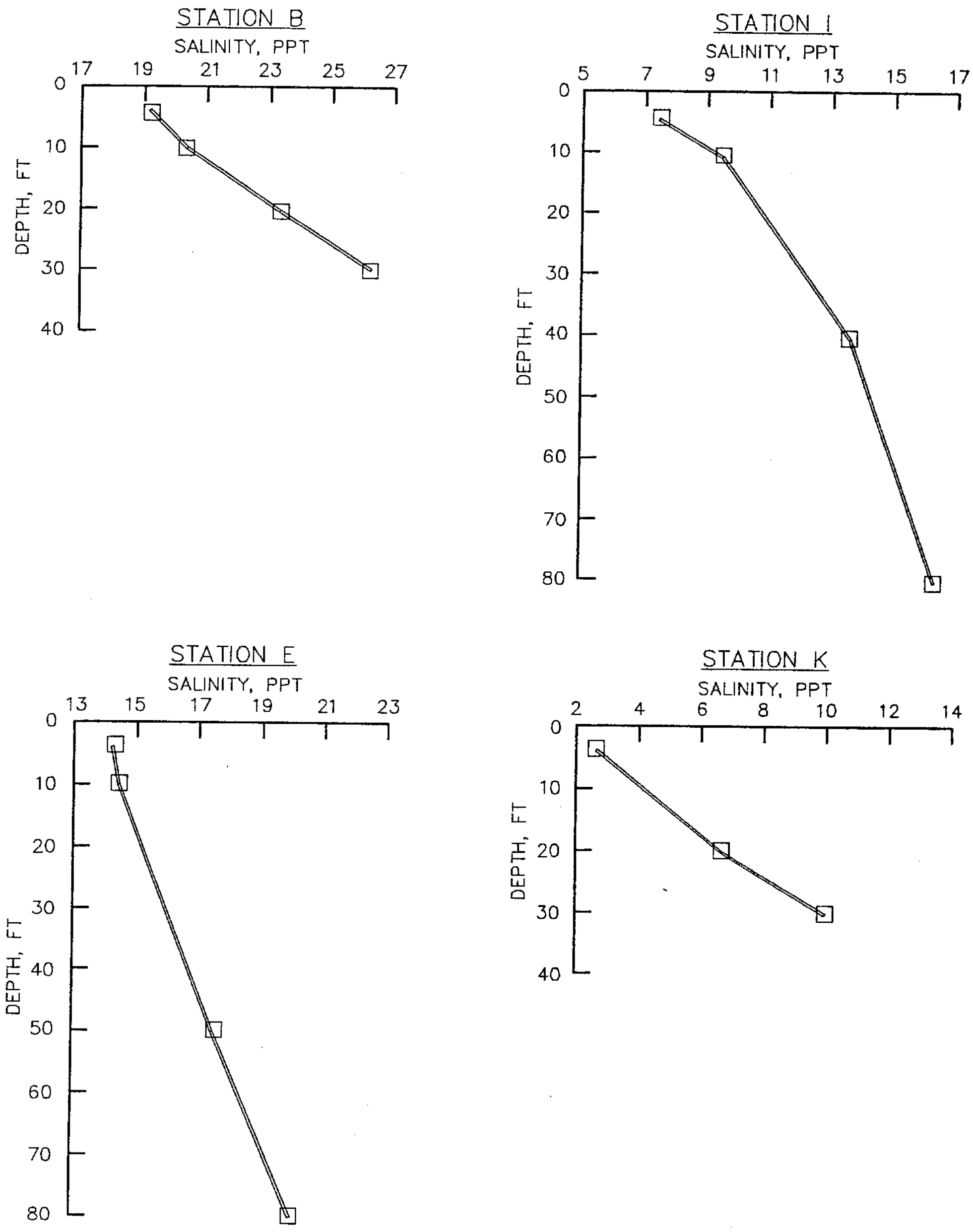


Figure 8. Salinity from physical model during steady-state testing conditions

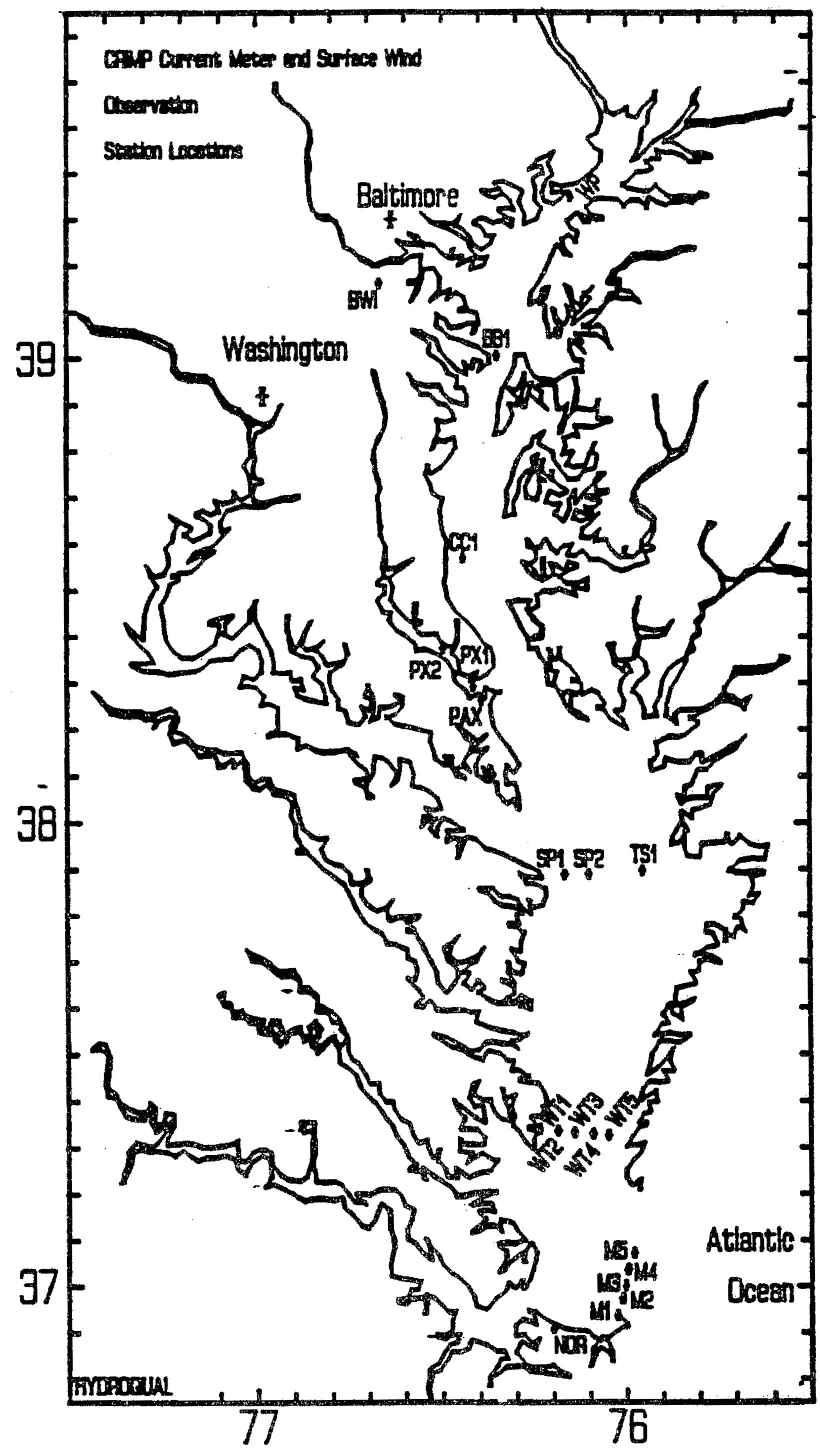
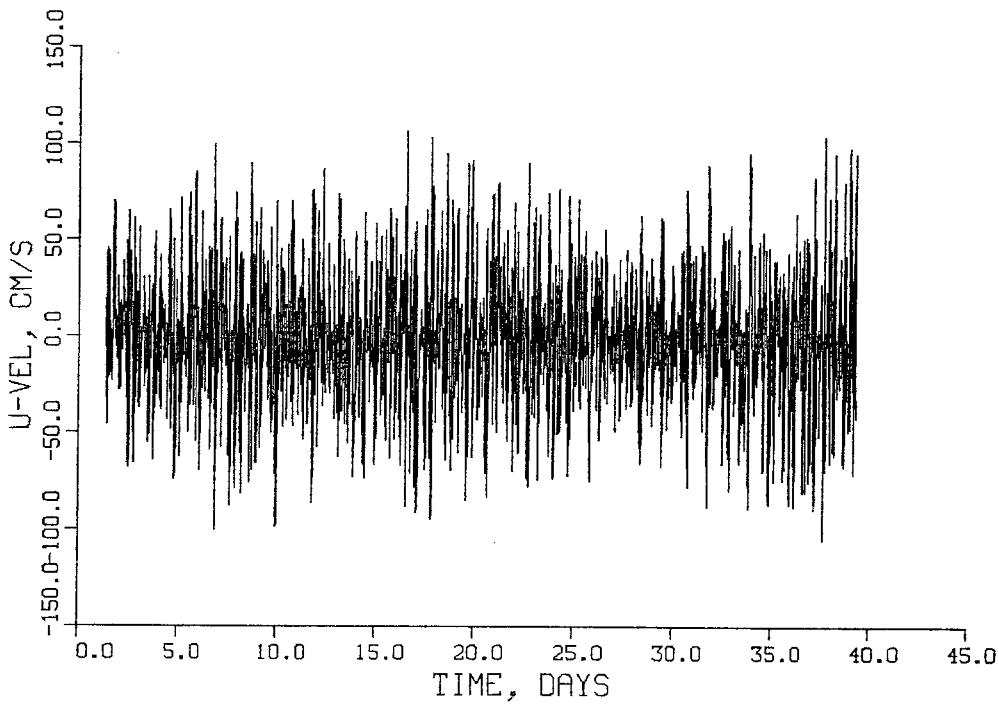
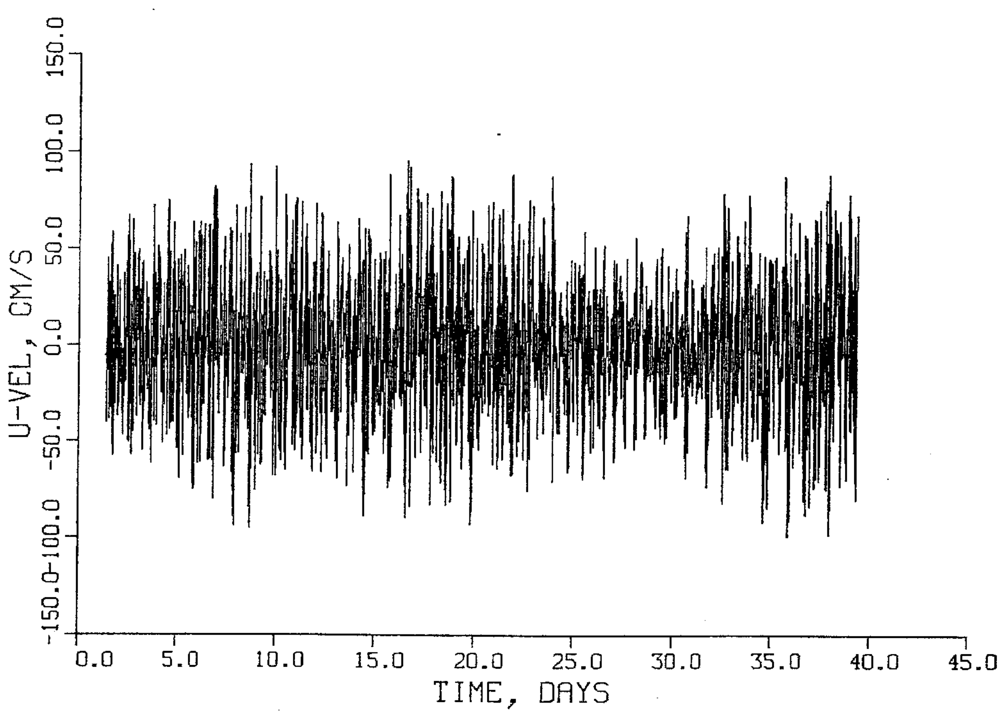


Figure 9. Location of 1980 CRIMP current meter and 1980/1983 surface wind observation stations

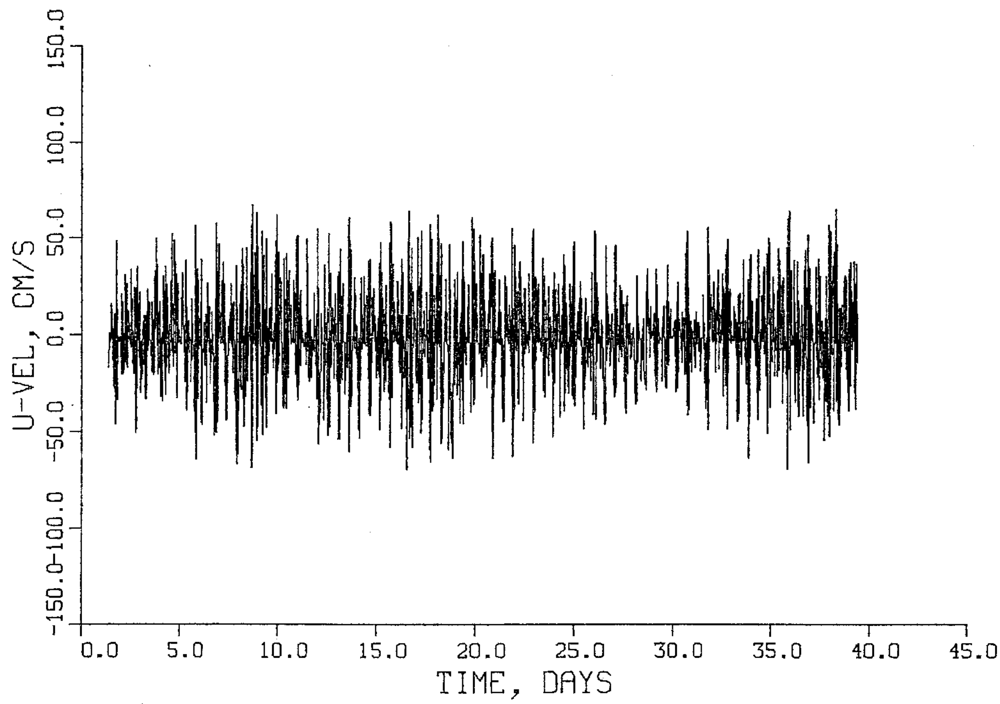


a. Depth = 9 ft



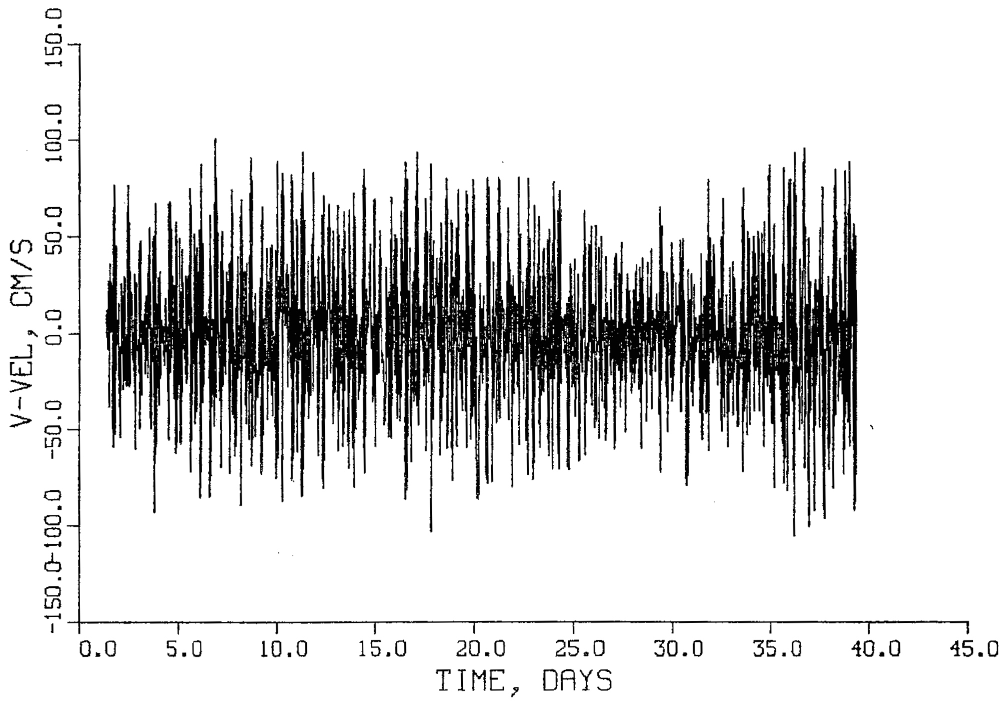
b. Depth = 35 ft

Figure 10. U-velocity at station M1 from CRIMP data (Continued)

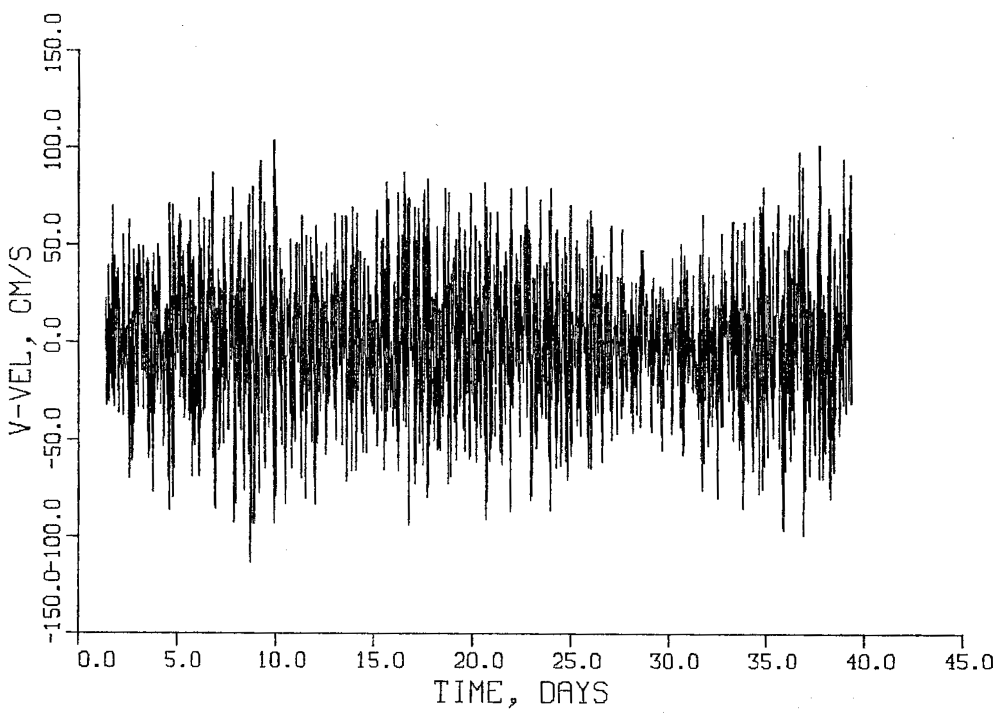


c. Depth = 50 ft

Figure 10. (Concluded)

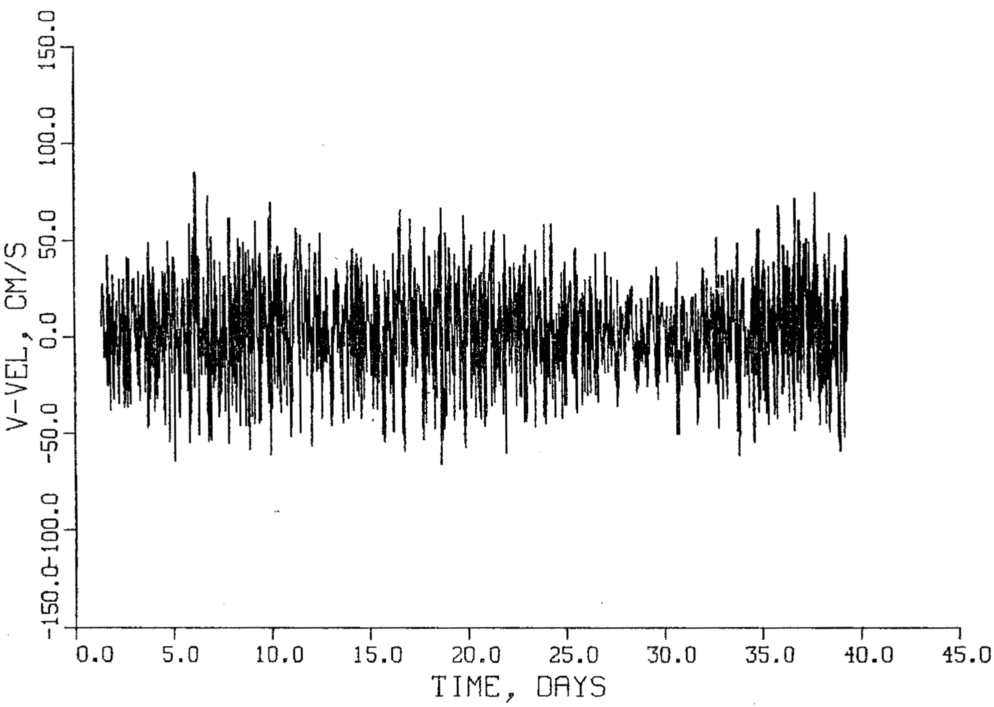


a. Depth = 9 ft



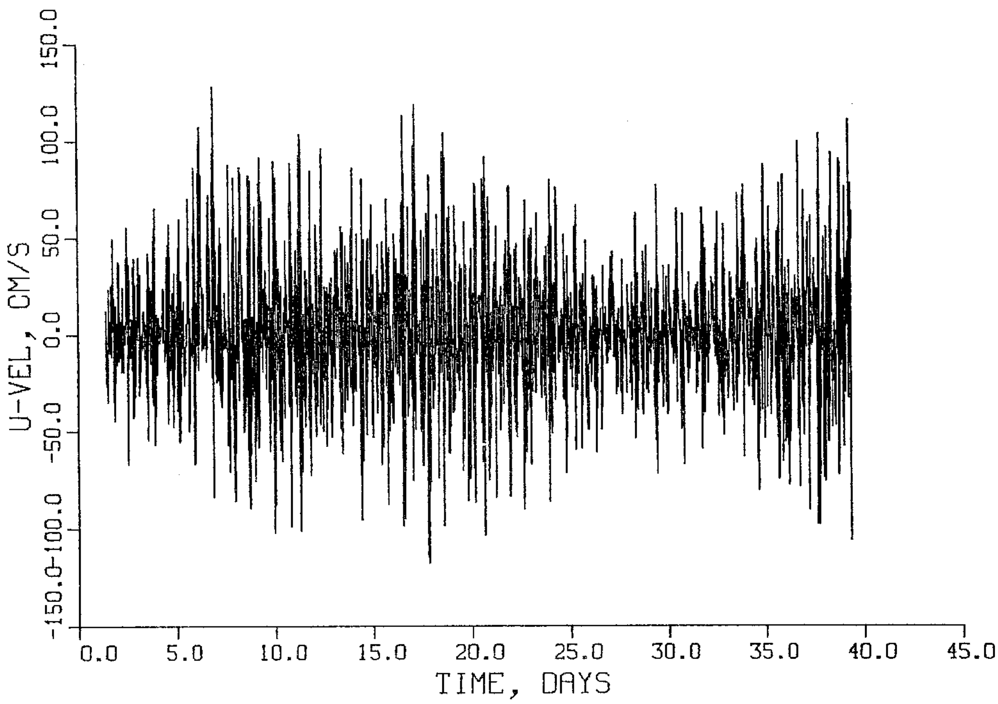
b. Depth = 35 ft

Figure 11. V-velocity at station M1 from CRIMP data (Continued)

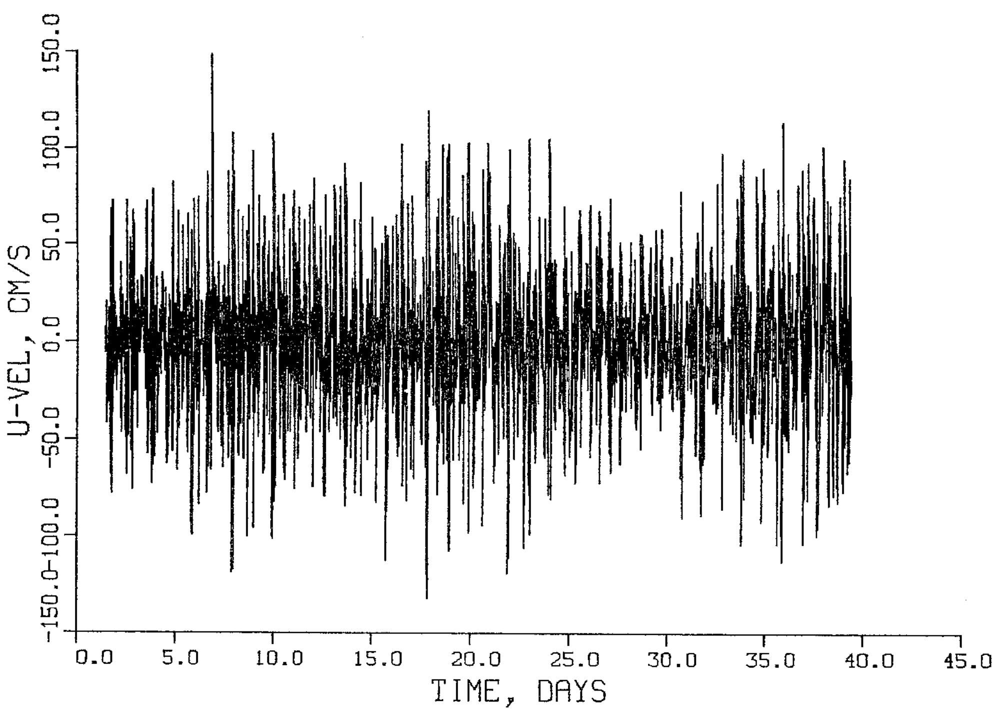


c. Depth = 50 ft

Figure 11. (Concluded)

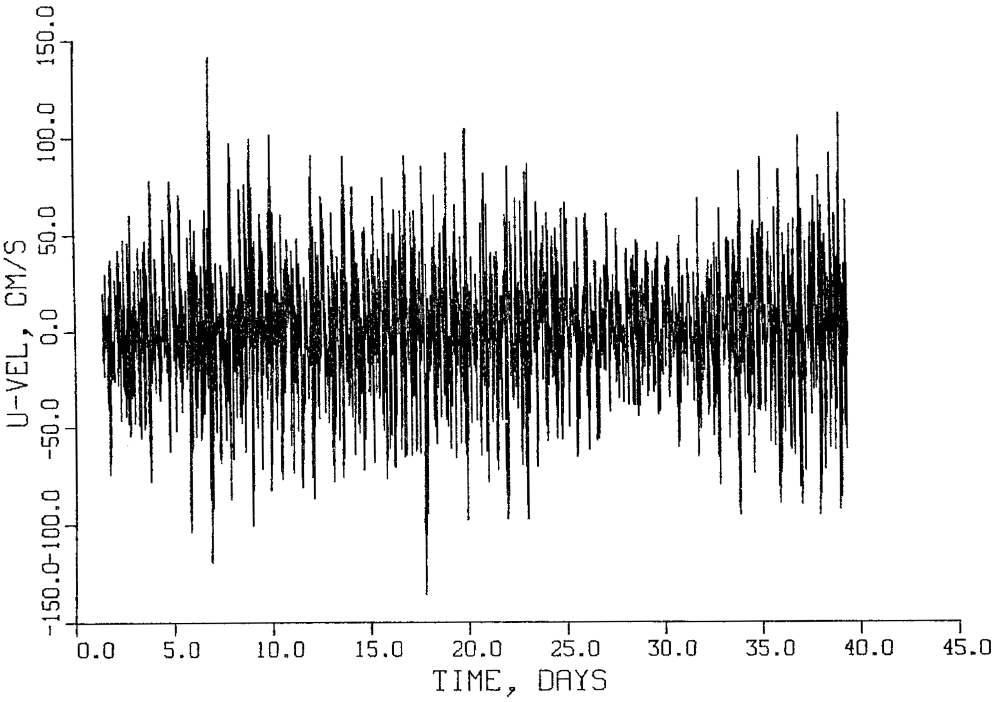


a. Depth = 9 ft

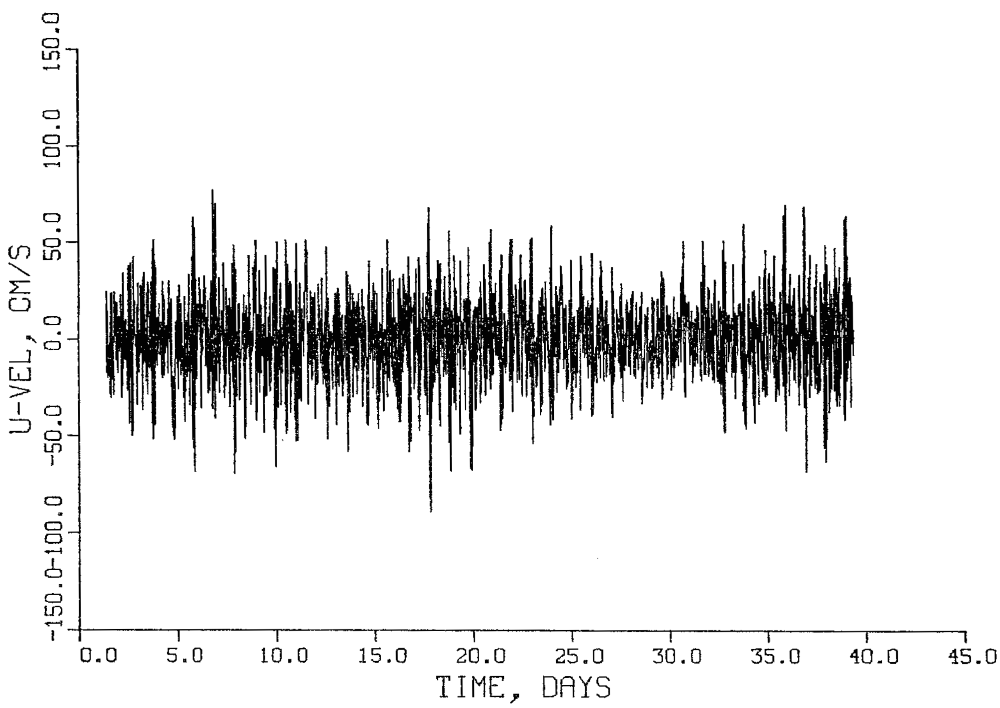


b. Depth = 20 ft

Figure 12. U-velocity at station M2 from CRIMP data (Continued)

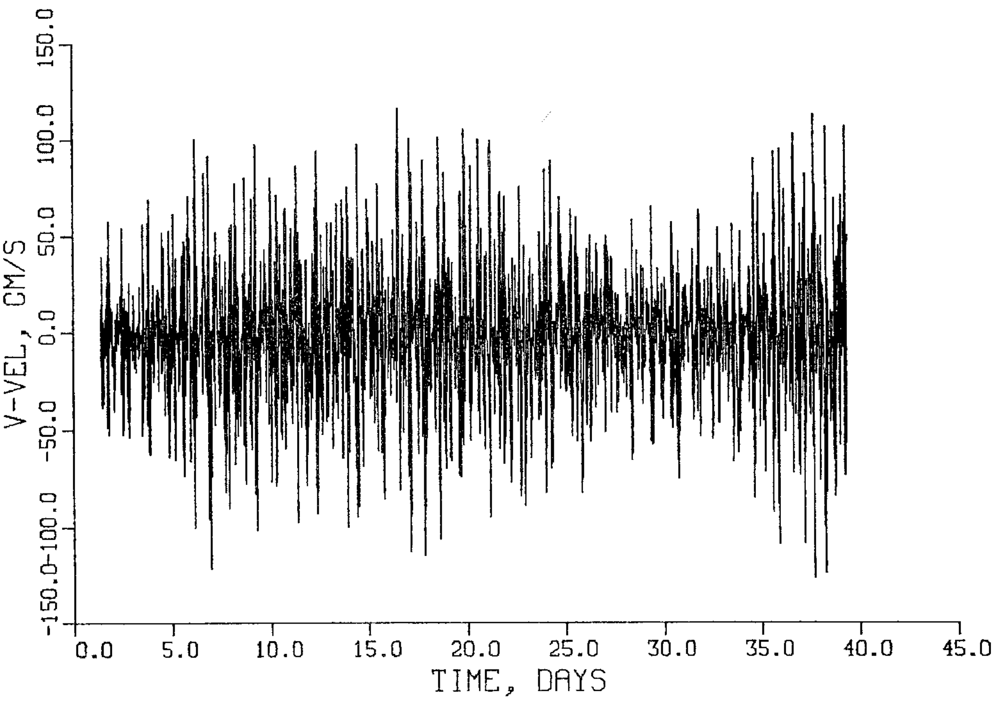


c. Depth = 35 ft

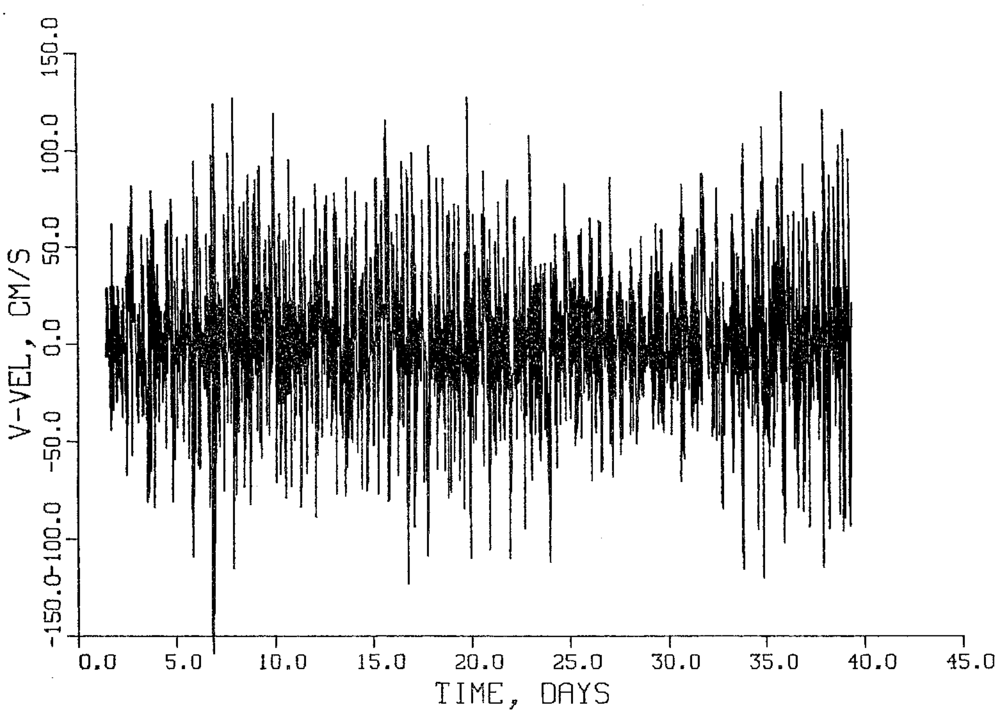


d. Depth = 50 ft

Figure 12. (Concluded)

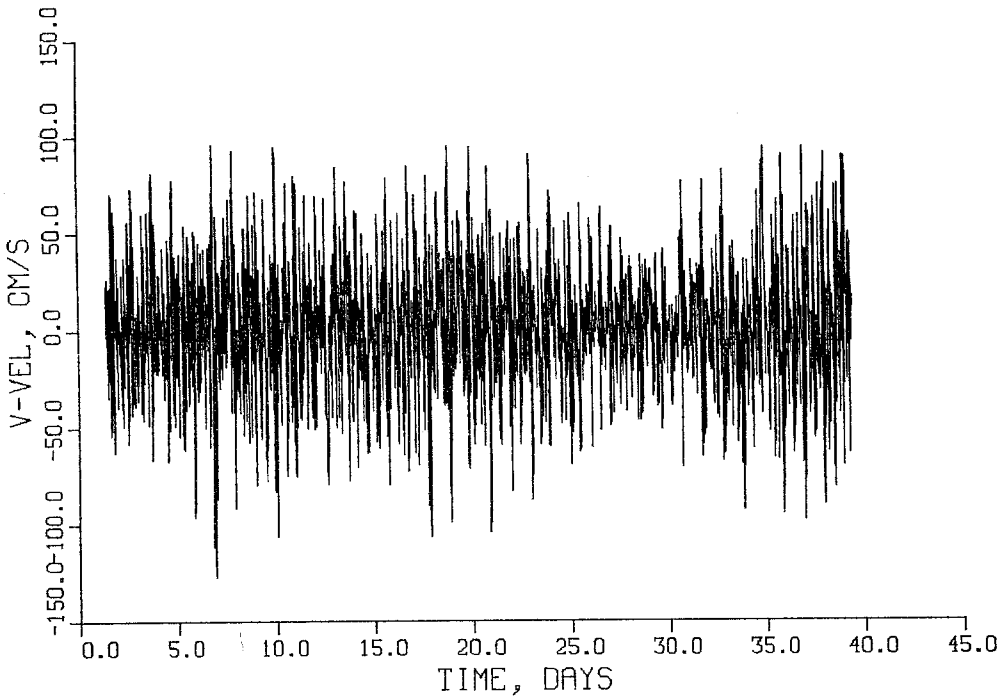


a. Depth = 9 ft

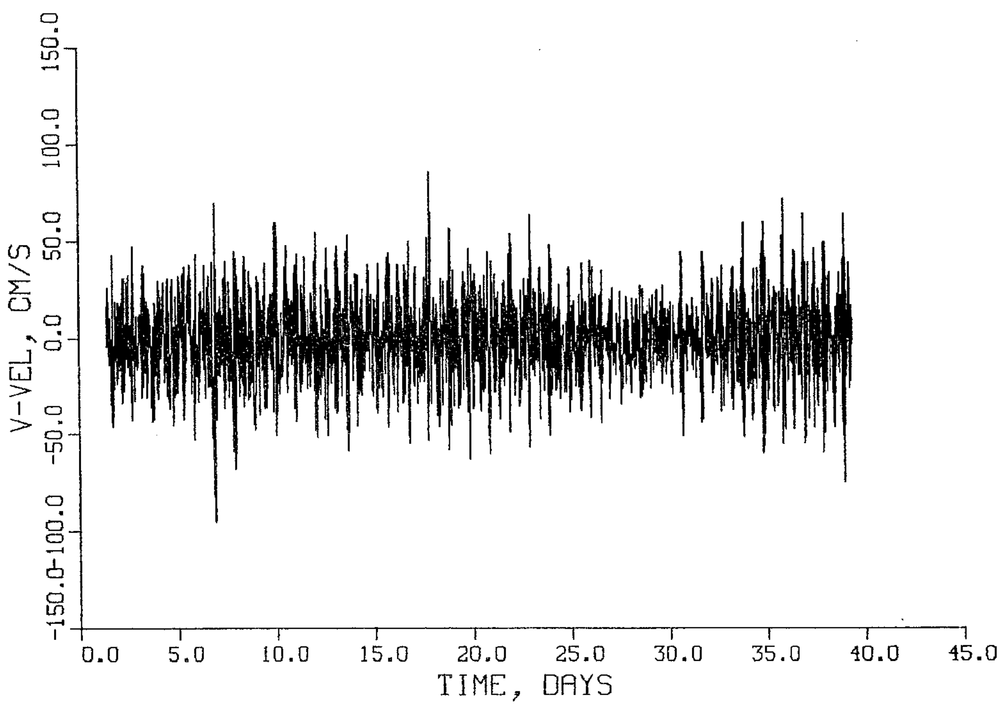


b. Depth = 20 ft

Figure 13. V-velocity at station M2 from CRIMP data (Continued)

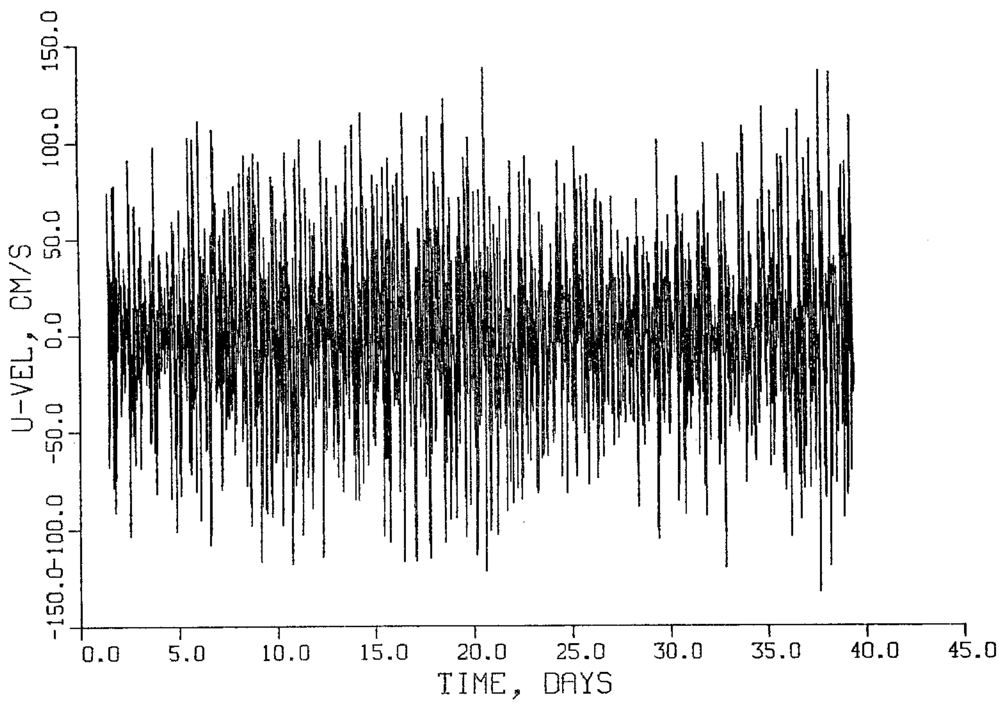


c. Depth = 35 ft

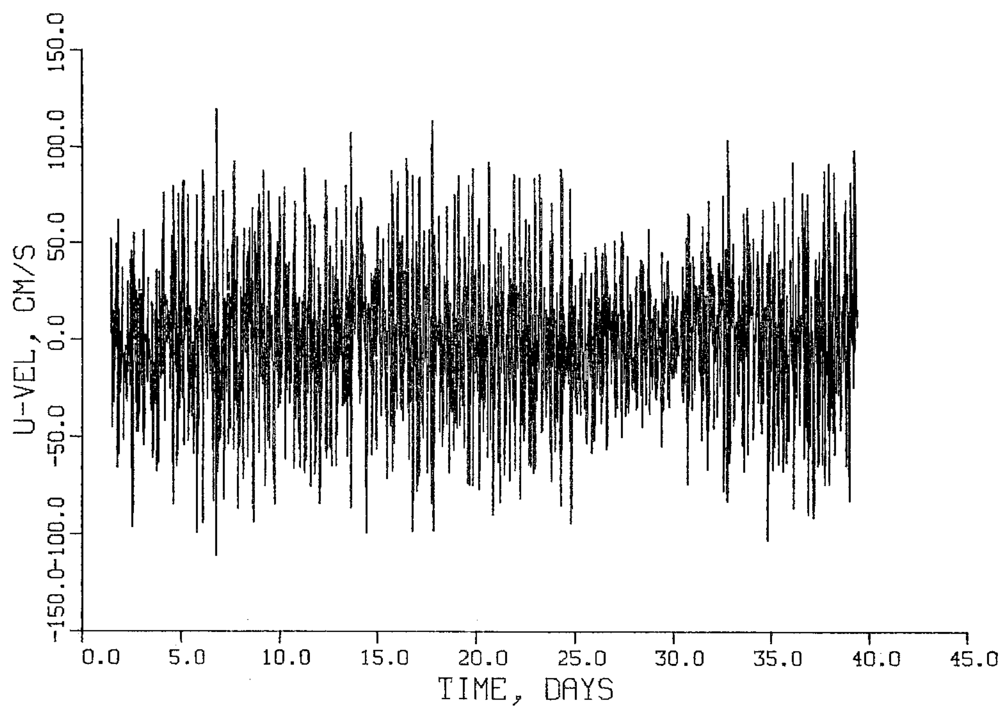


d. Depth = 50 ft

Figure 13. (Concluded)

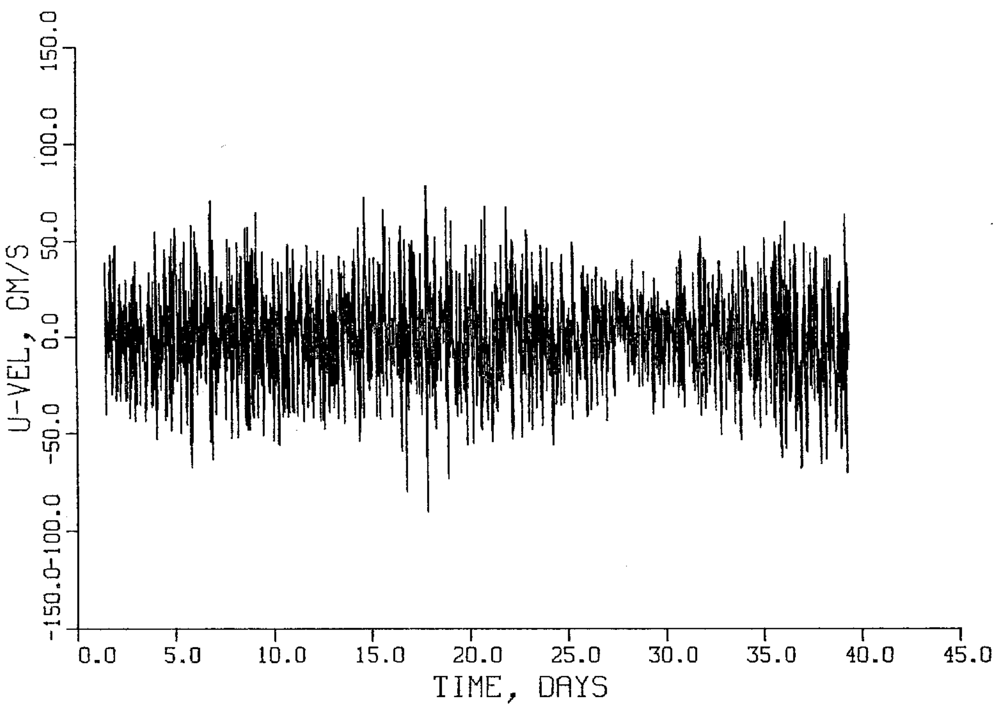


a. Depth = 9 ft



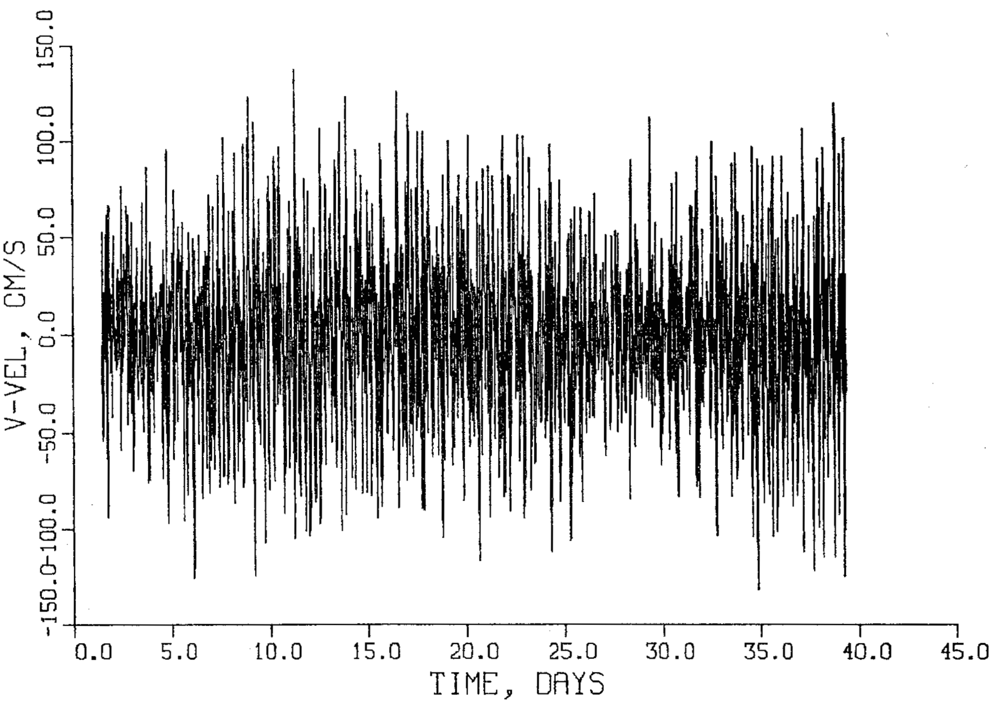
b. Depth = 20 ft

Figure 14. U-velocity at station M3 from CRIMP data (Continued)

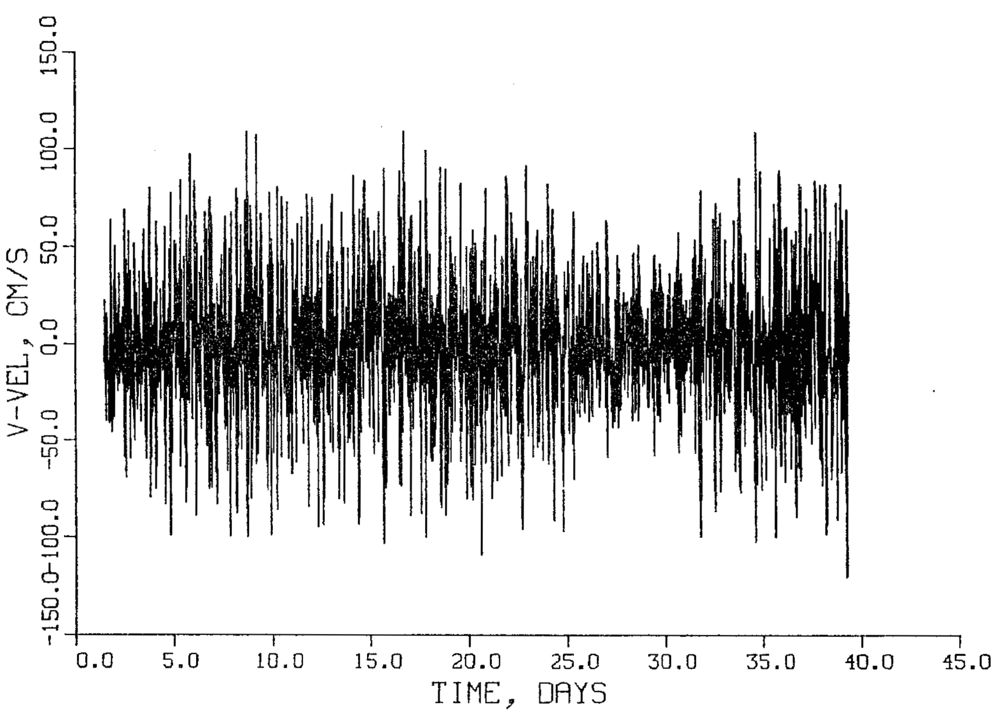


c. Depth = 32 ft

Figure 14. (Concluded)

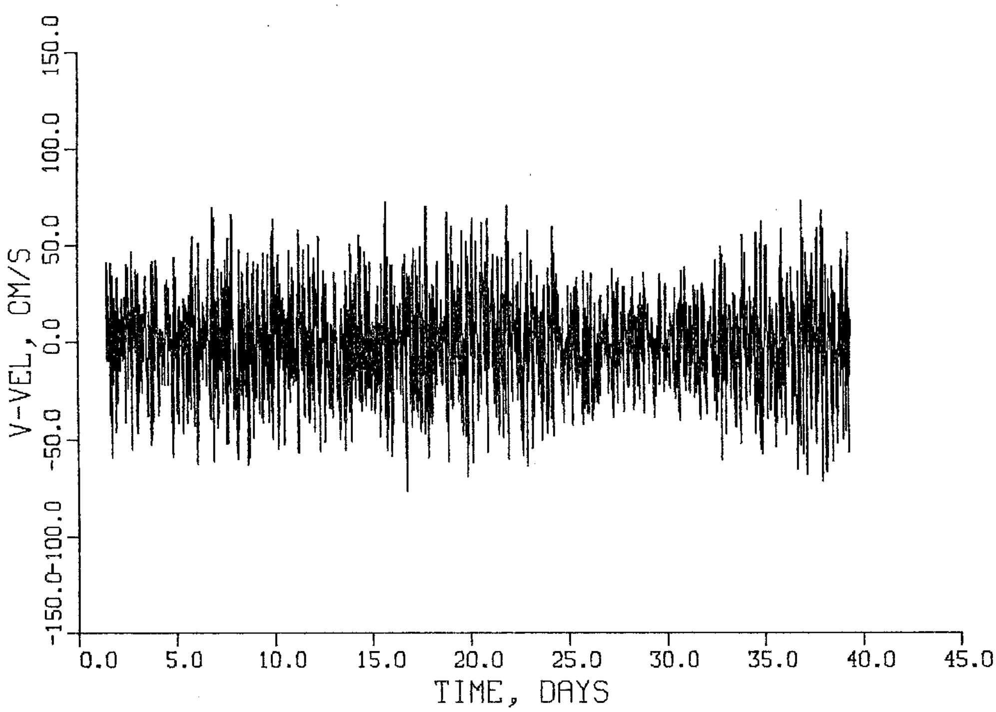


a. Depth = 9 ft



b. Depth = 20 ft

Figure 15. V-velocity at station M3 from CRIMP data (Continued)



c. Depth = 32 ft

Figure 15. (Concluded)

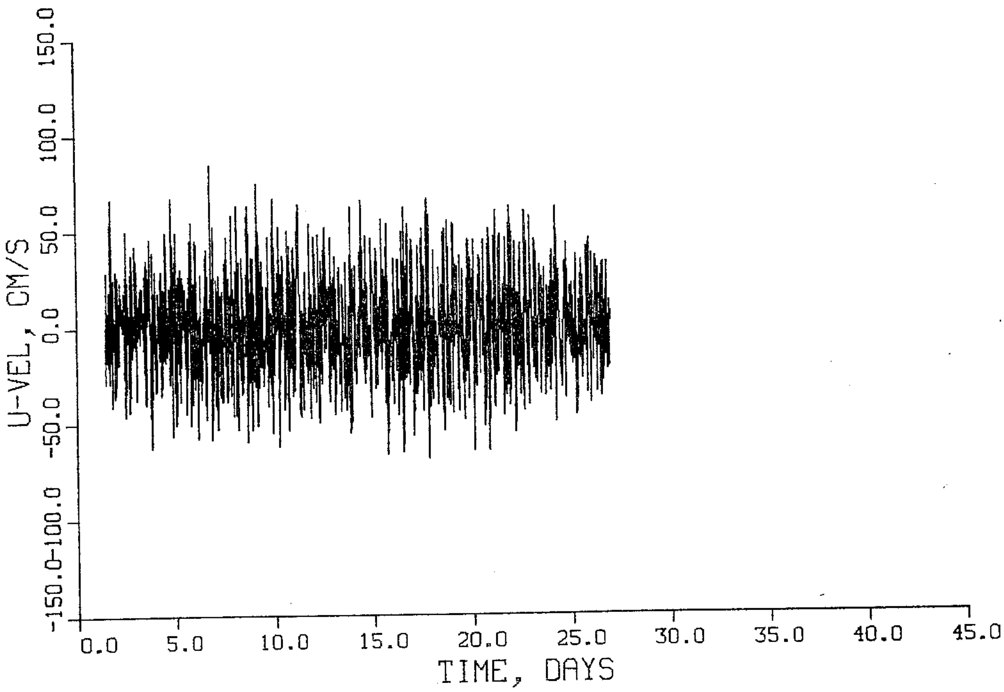


Figure 16. U-velocity at station M4 at a depth of 10 ft from CRIMP data

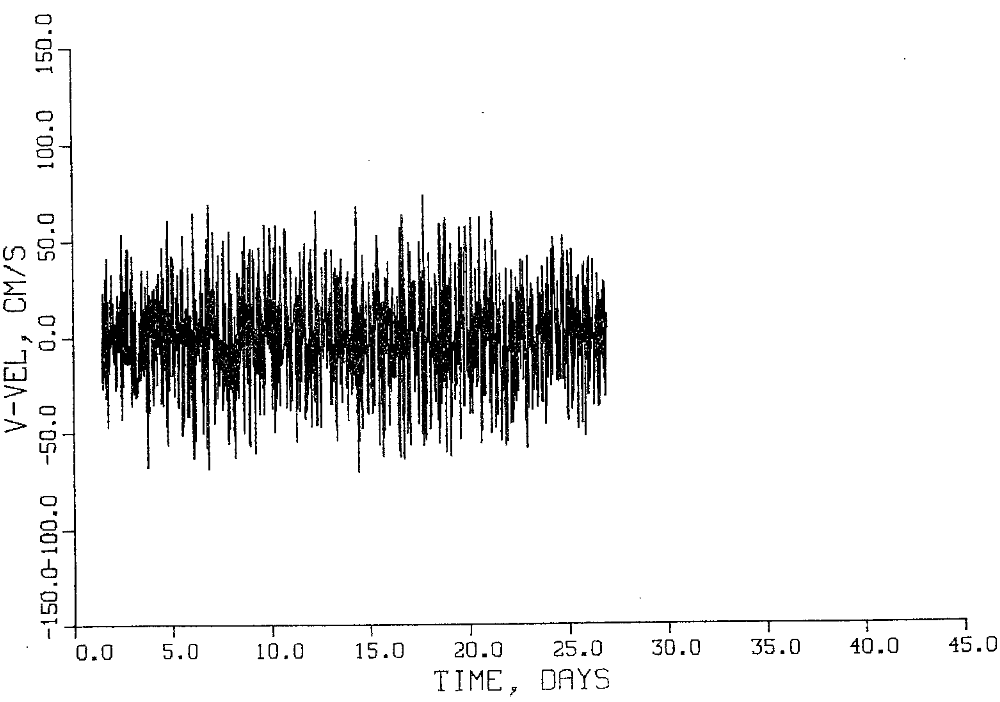
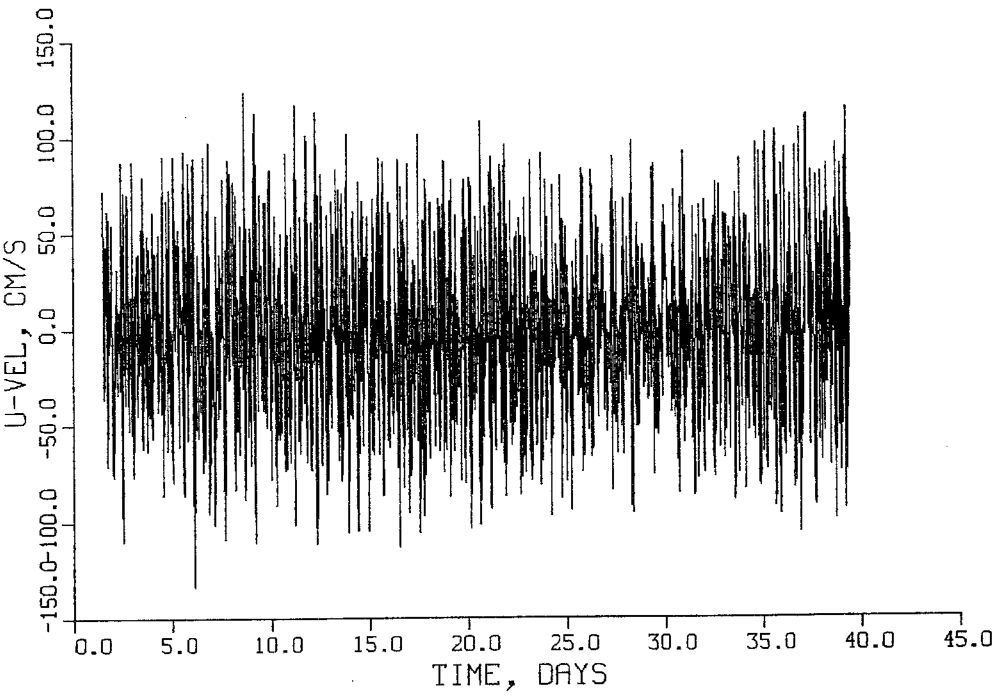
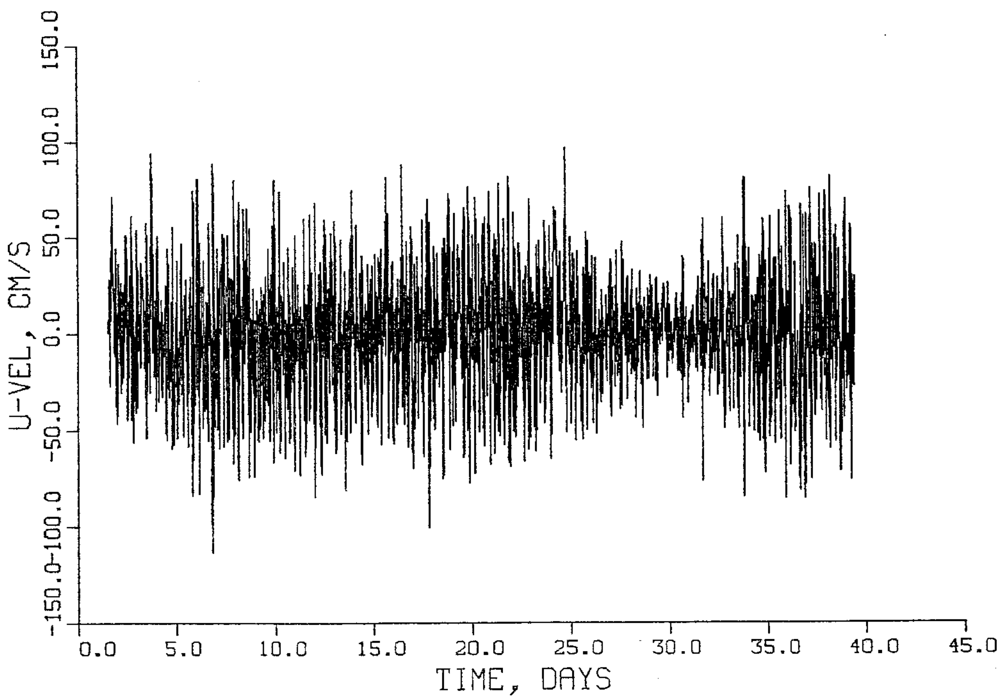


Figure 17. V-velocity at station M4 at a depth of 10 ft from CRIMP data

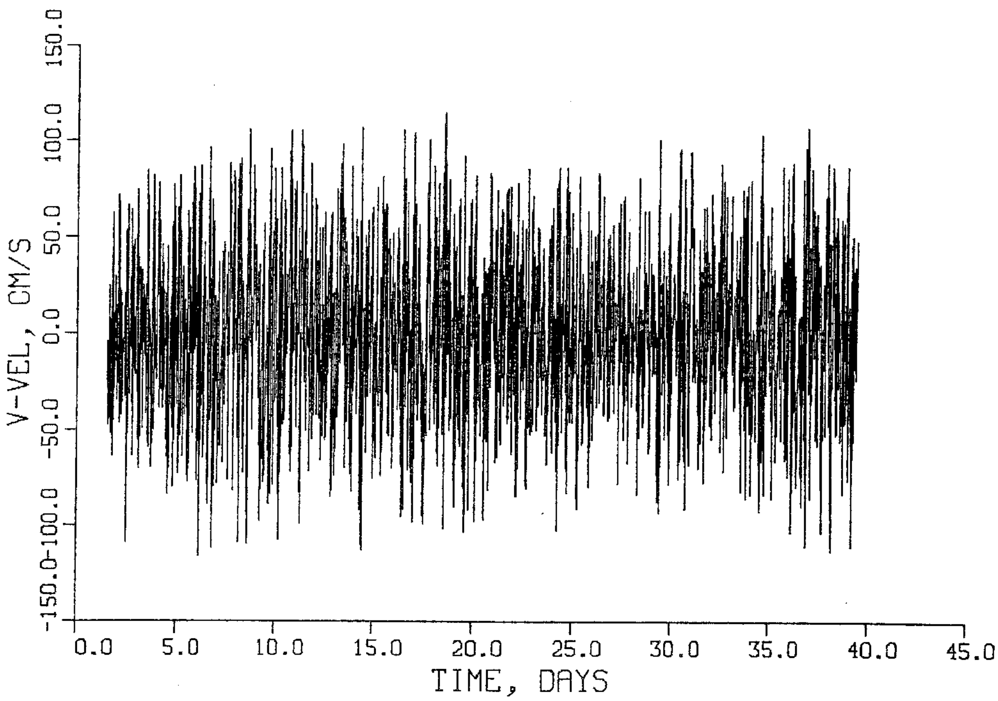


a. Depth = 9 ft

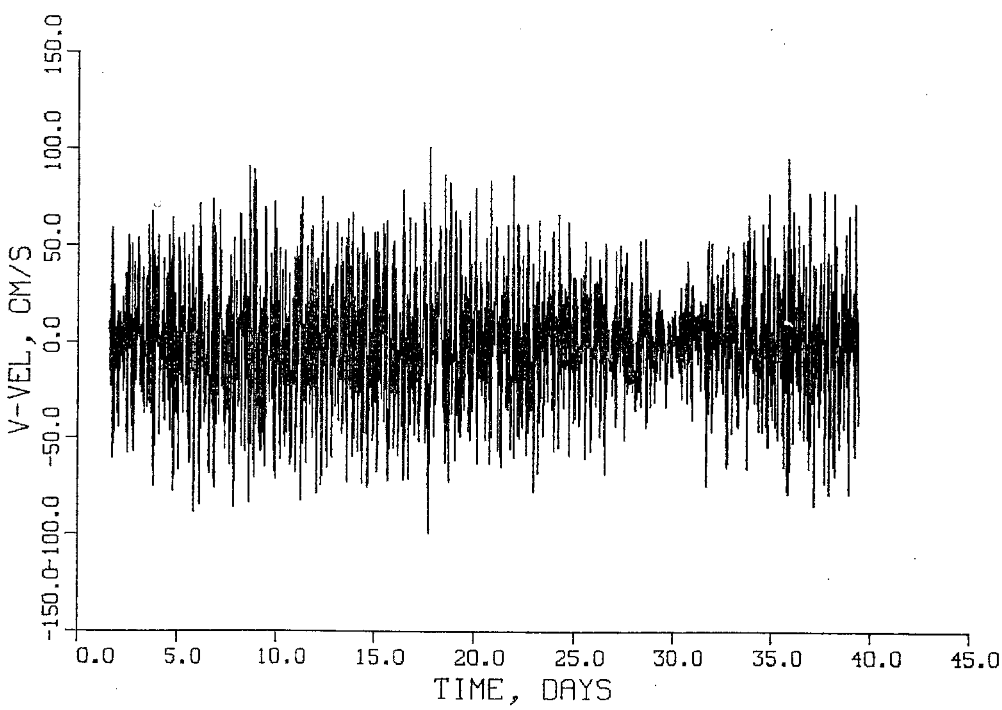


b. Depth = 30 ft

Figure 18. U-velocity at station M5 from CRIMP data

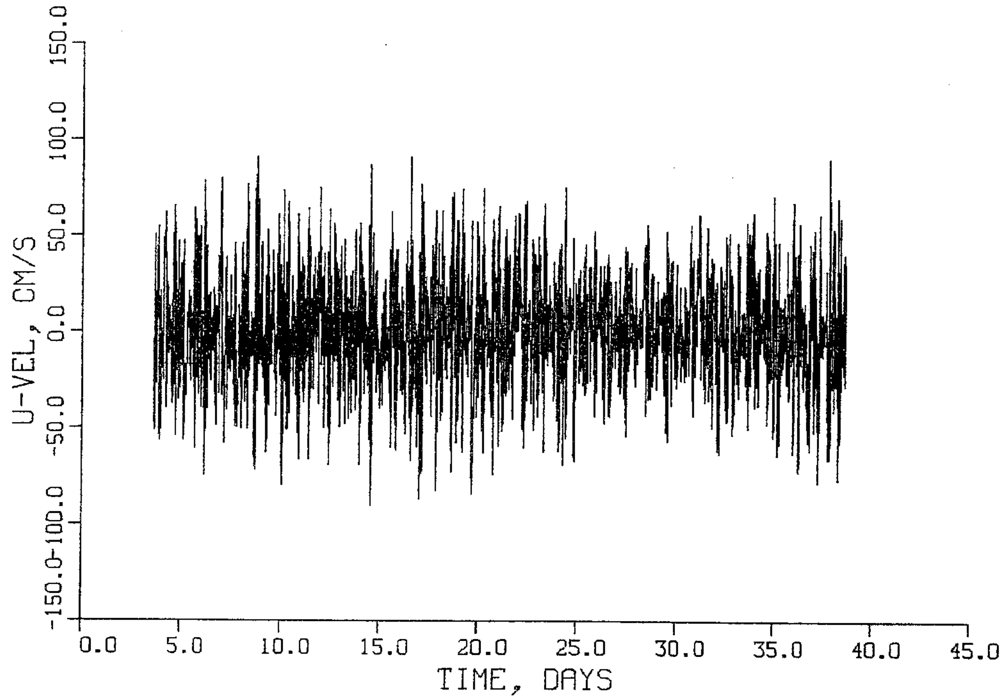


a. Depth = 9 ft

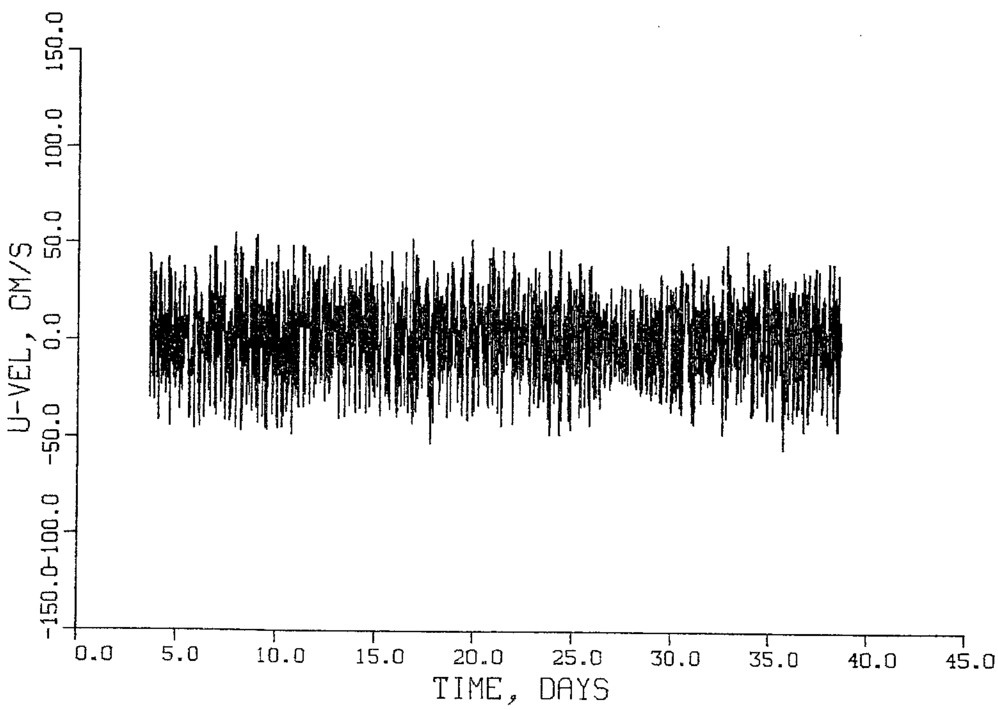


b. Depth = 30 ft

Figure 19. V-velocity at station M5 from CRIMP data

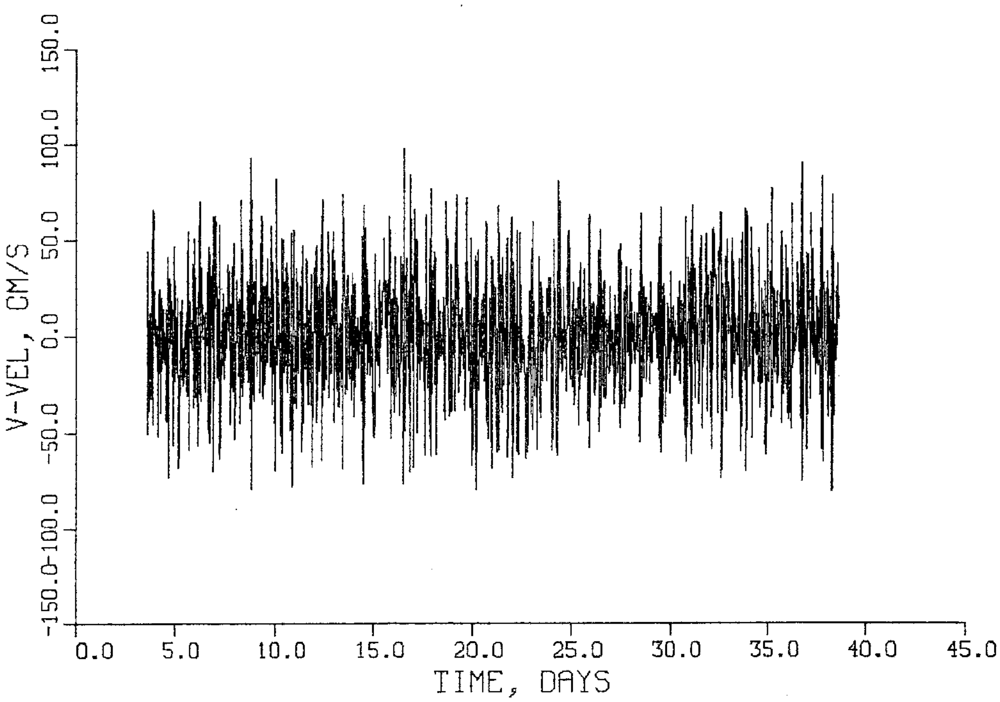


a. Depth = 9 ft

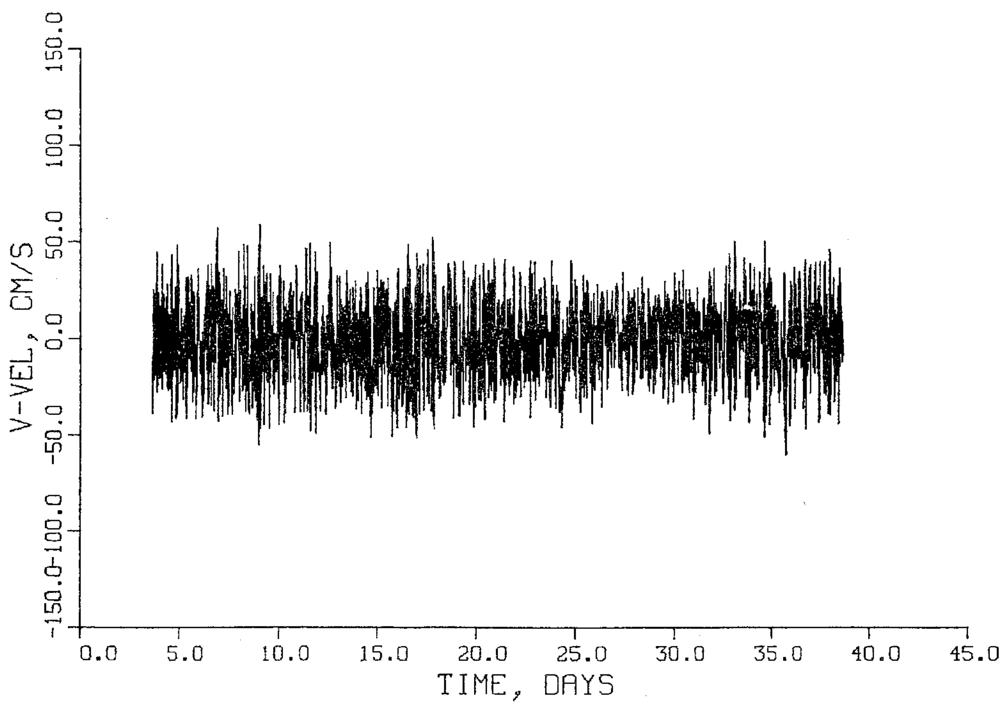


b. Depth = 30 ft

Figure 20. U-velocity at station WT2 from CRIMP data

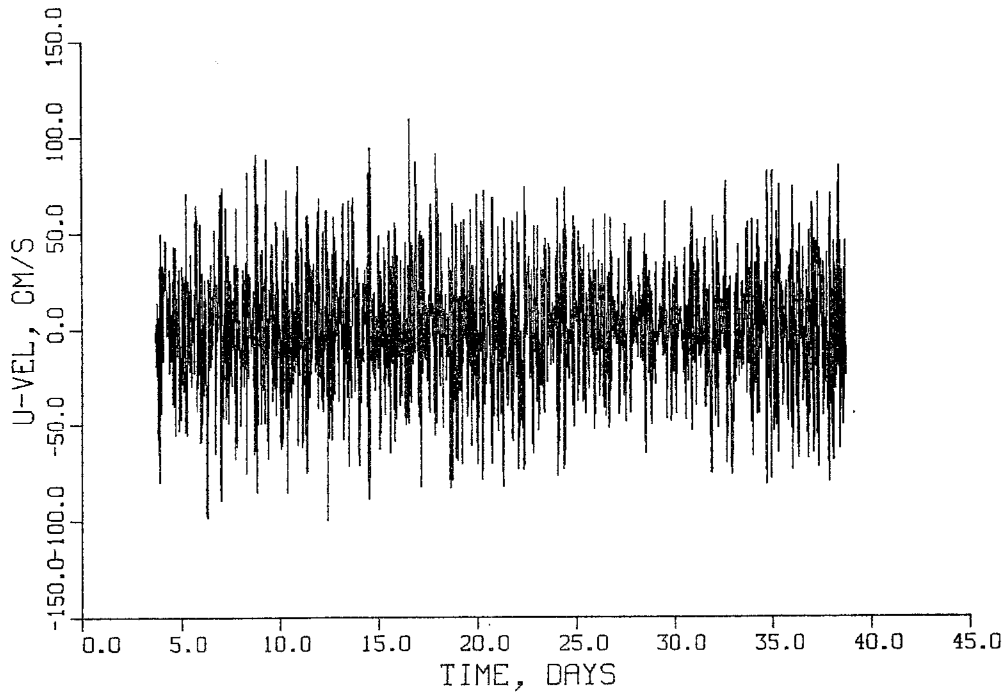


a. Depth = 9 ft

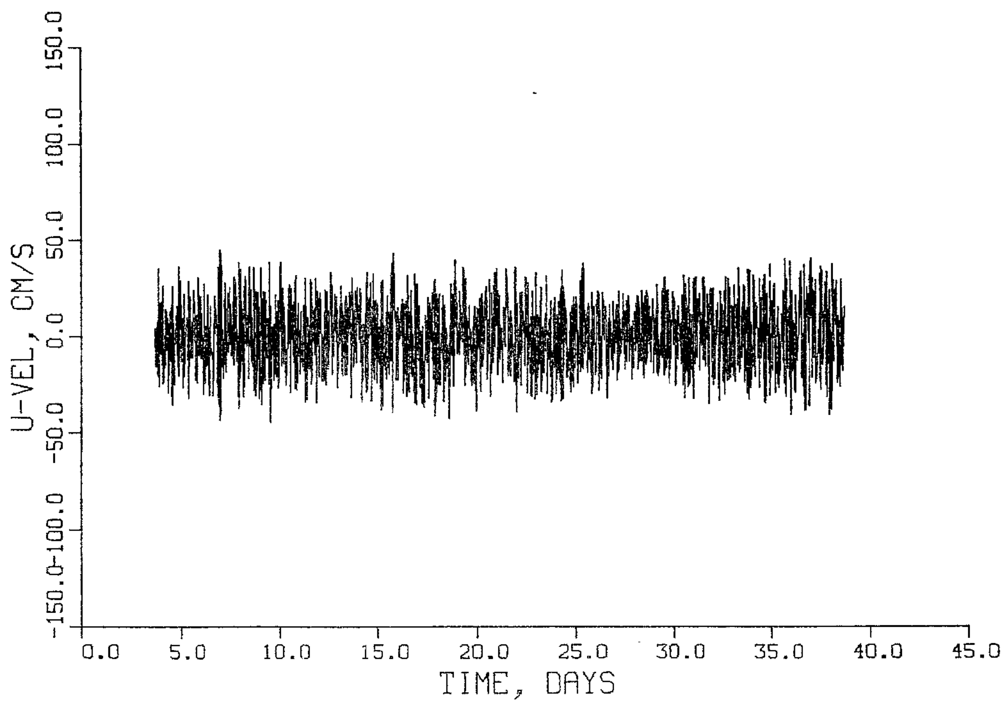


b. Depth = 30 ft

Figure 21. V-velocity at station WT2 from CRIMP data

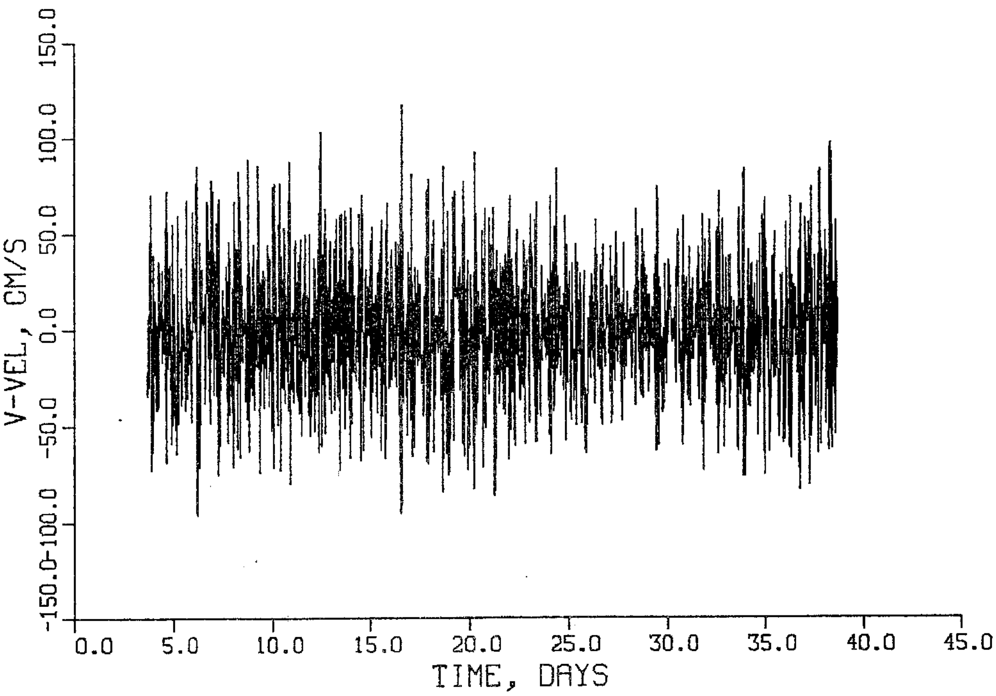


a. Depth = 9 ft

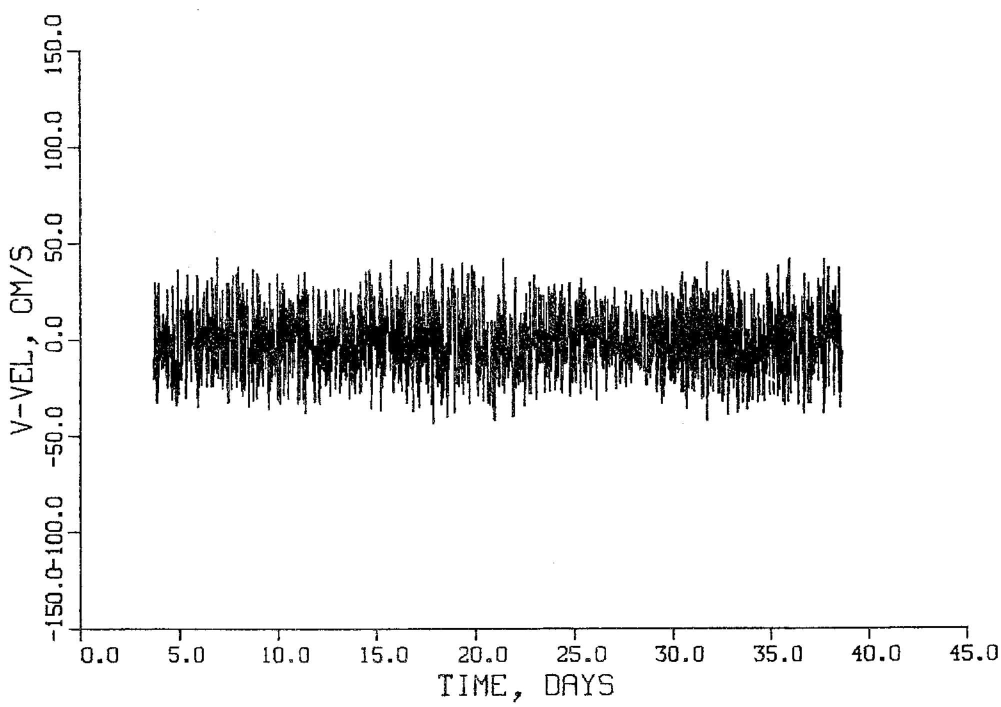


b. Depth = 30 ft

Figure 22. U-velocity at station WT3 from CRIMP data

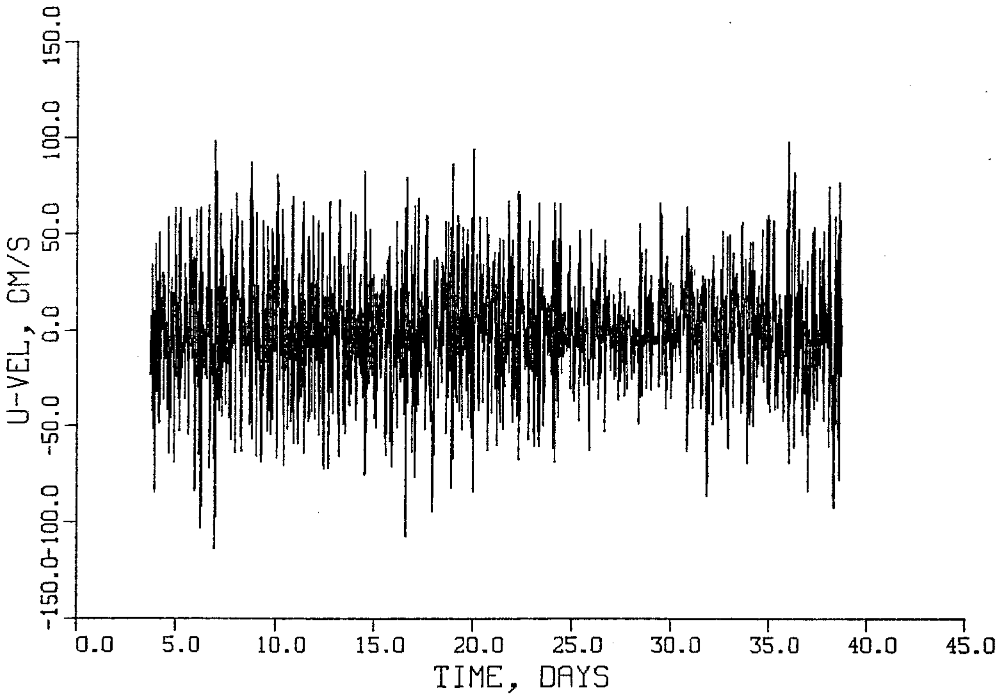


a. Depth = 9 ft

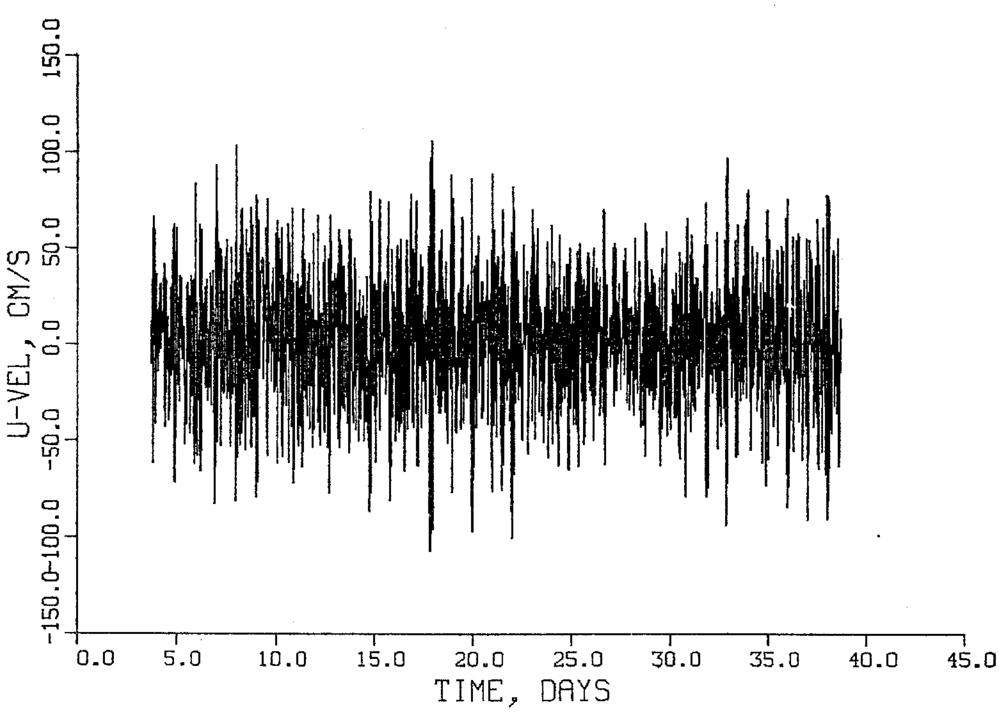


b. Depth = 30 ft

Figure 23. V-velocity at station WT3 from CRIMP data

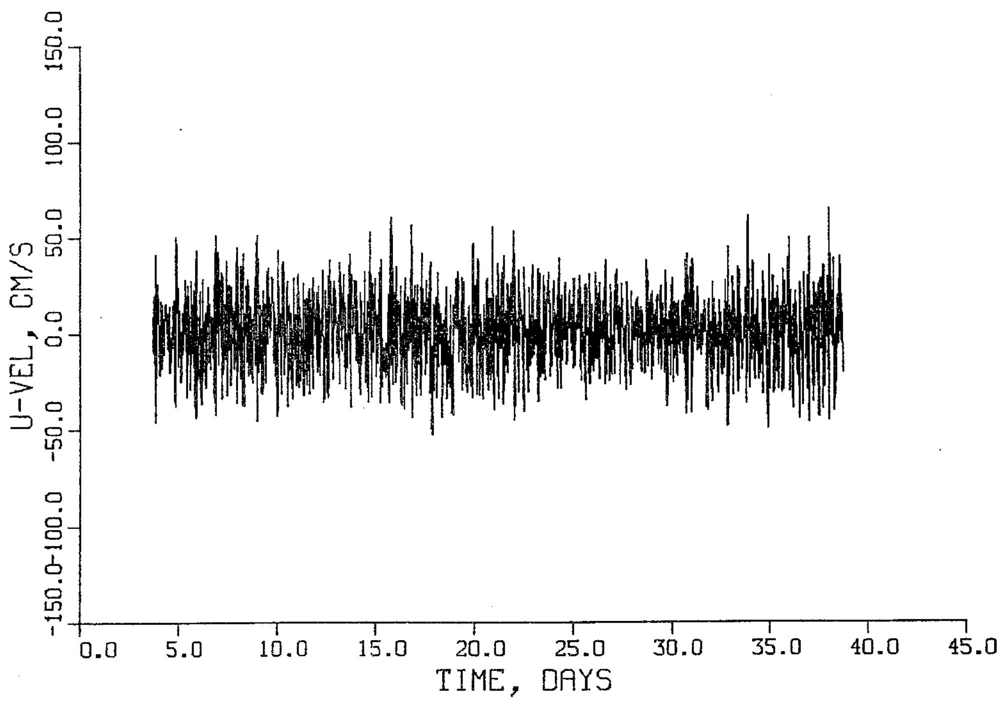


a. Depth = 9 ft



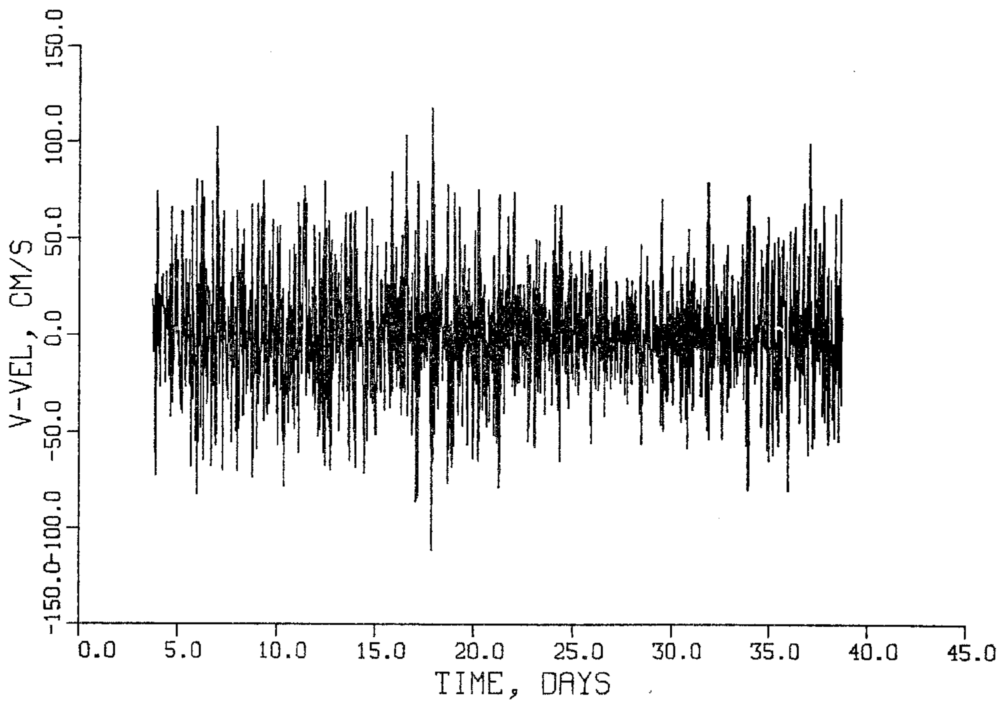
b. Depth = 30 ft

Figure 24. U-velocity at station WT4 from CRIMP data (Continued)

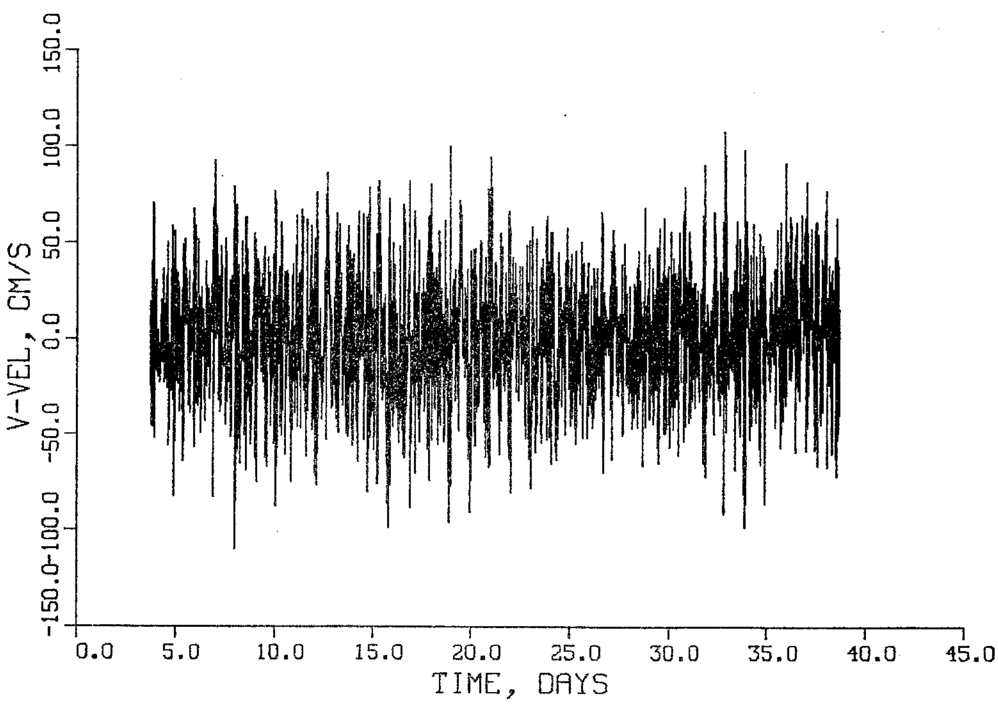


c. Depth = 58 ft

Figure 24. (Concluded)

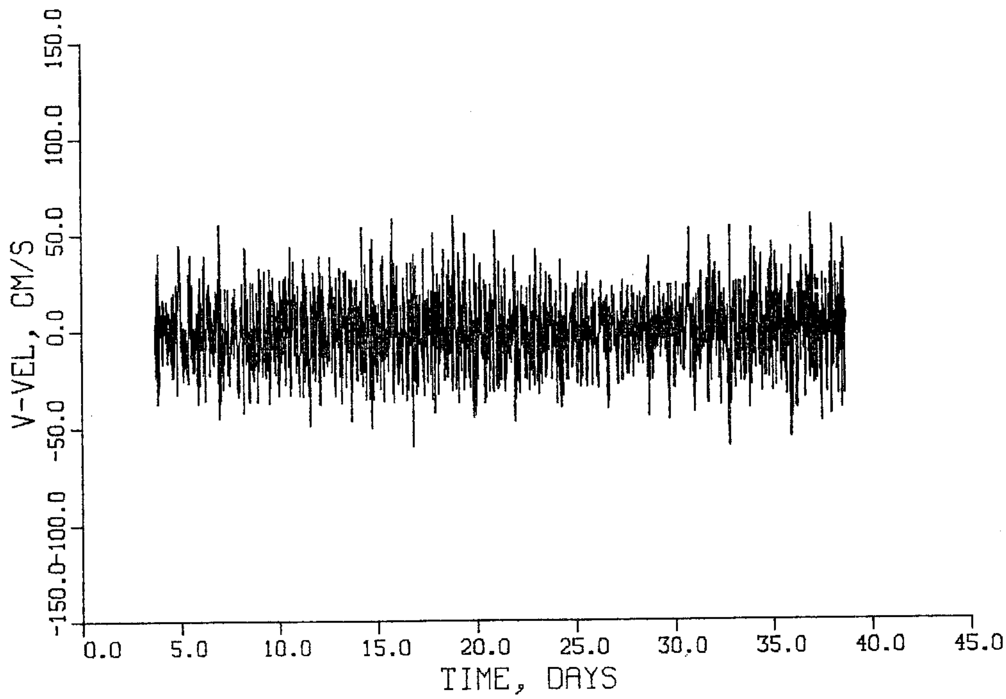


a. Depth = 9 ft



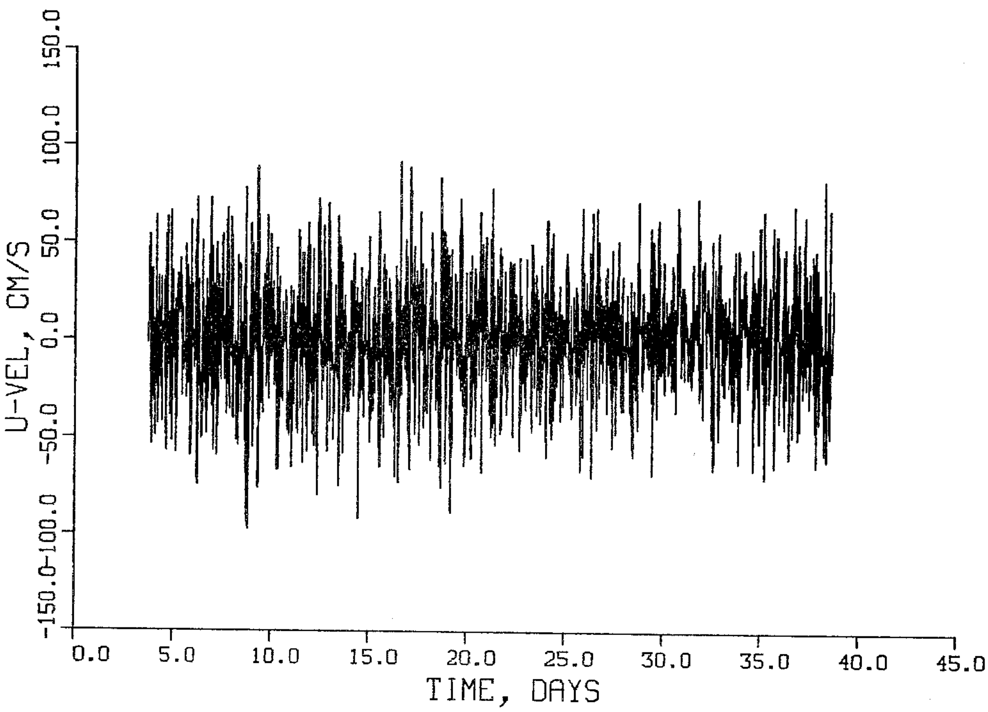
b. Depth = 30 ft

Figure 25. V-velocity at station WT4 from CRIMP data (Continued)

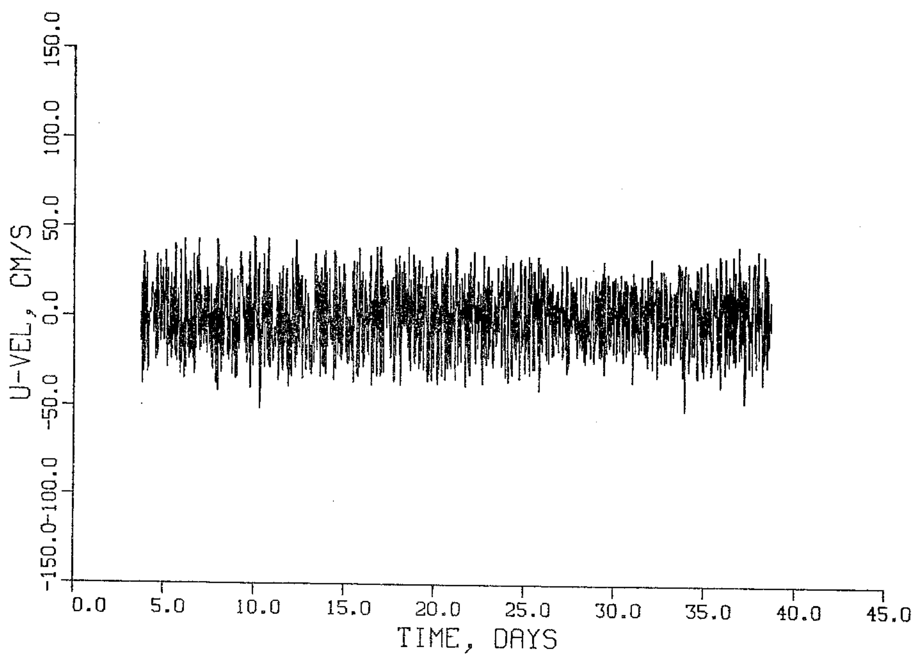


c. Depth = 58 ft

Figure 25. (Concluded)

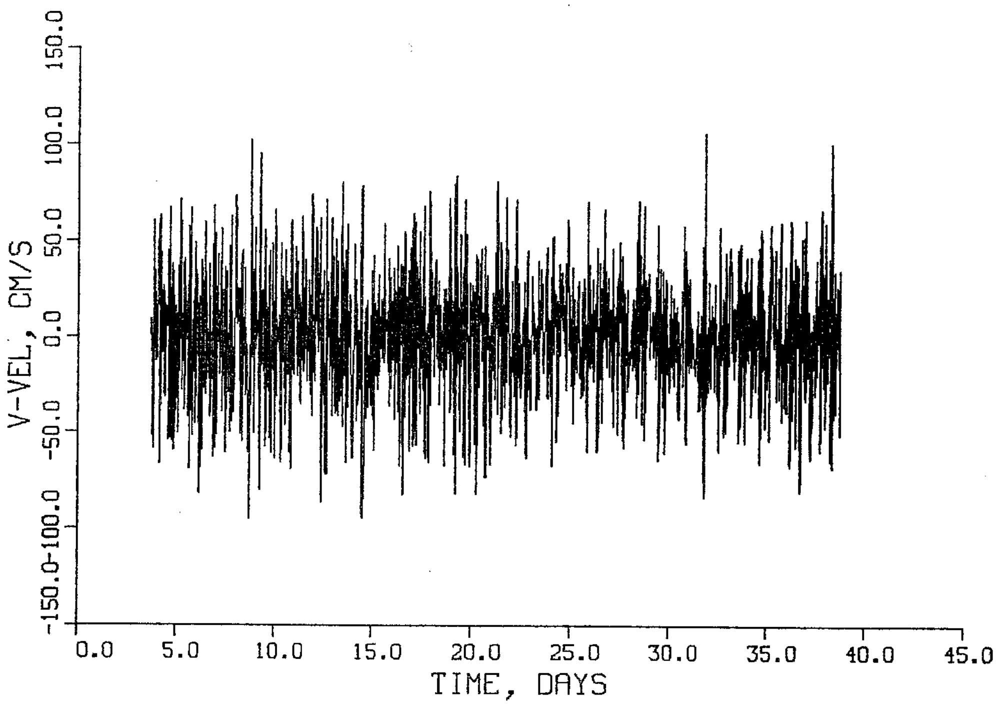


a. Depth = 9 ft

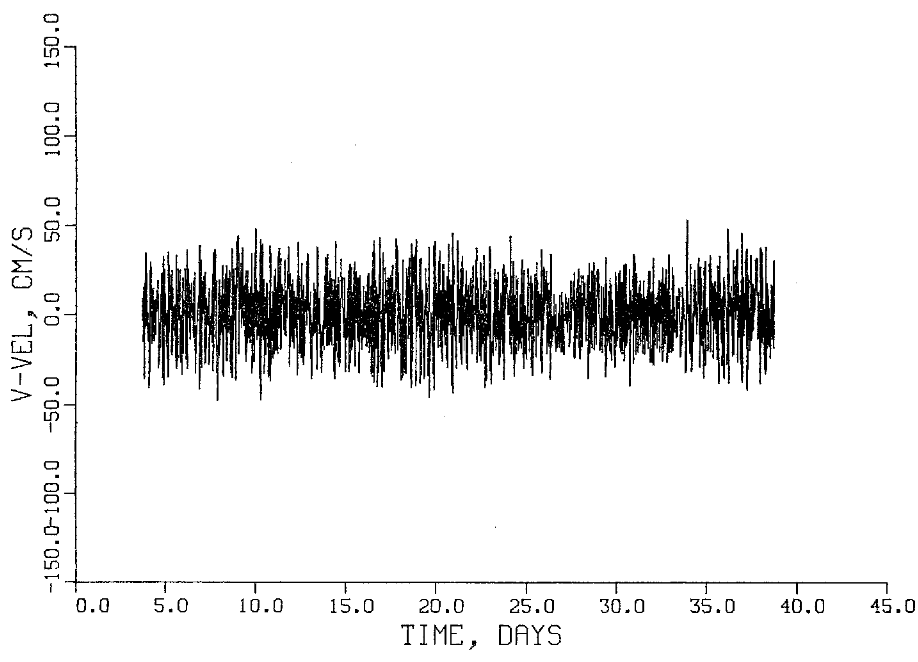


b. Depth = 29 ft

Figure 26. U-velocity at station WT5 from CRIMP data

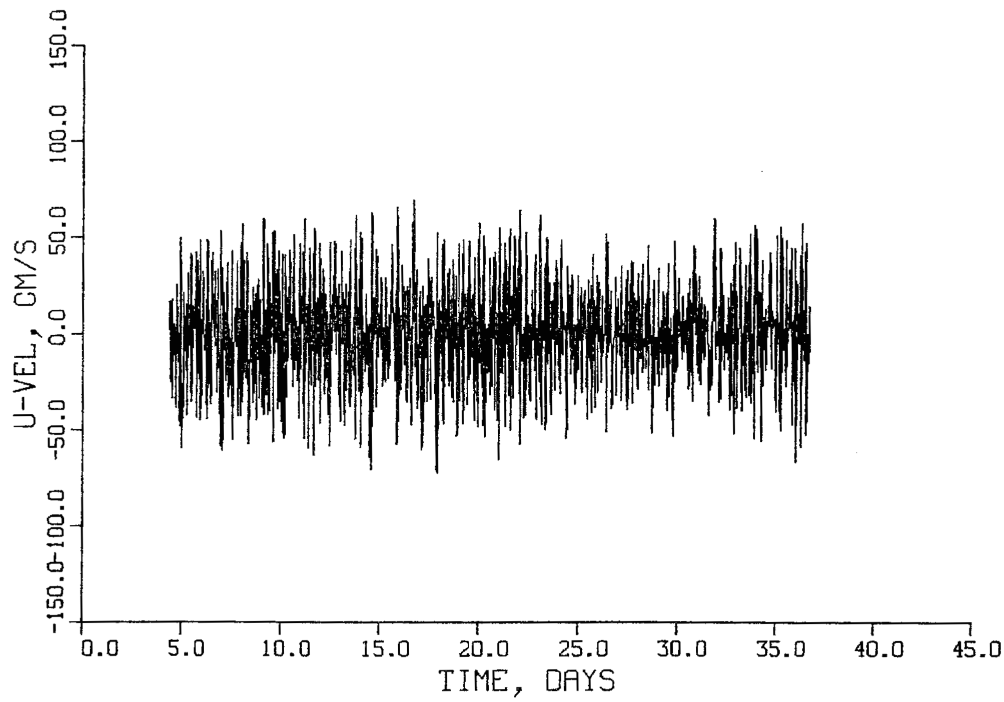


a. Depth = 9 ft

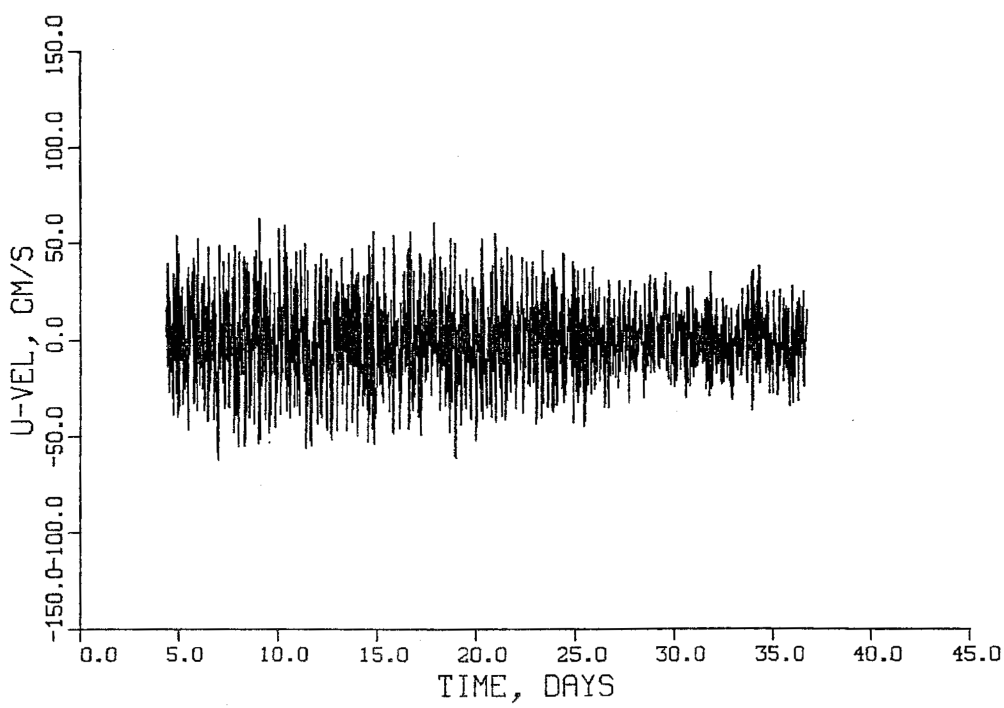


b. Depth = 29 ft

Figure 27. V-velocity at station WT5 from CRIMP data

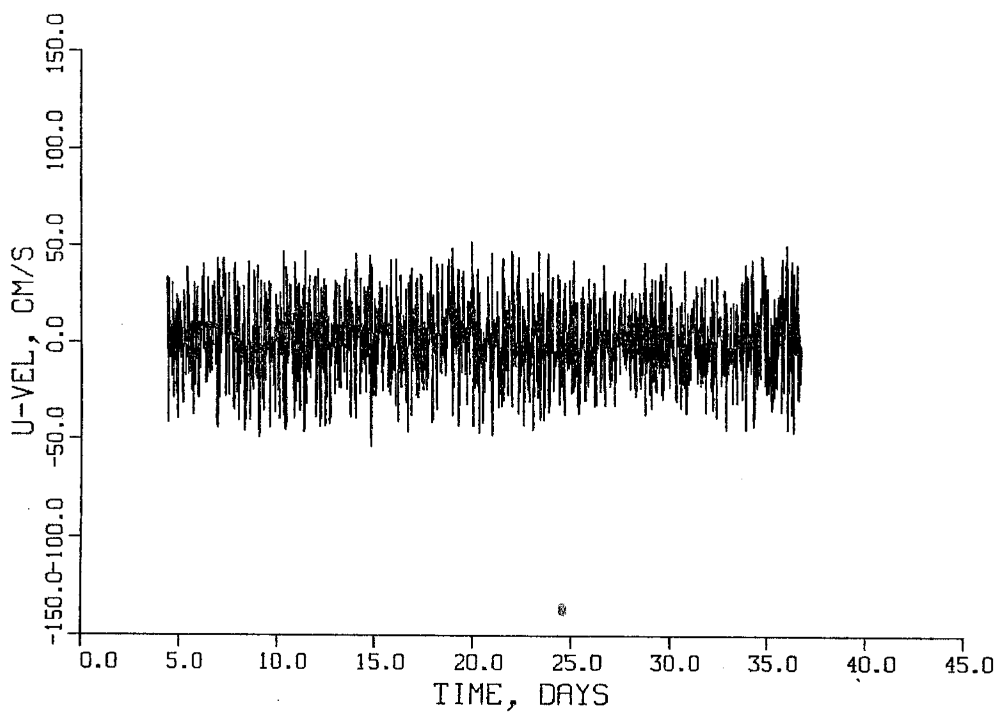


a. Depth = 9 ft



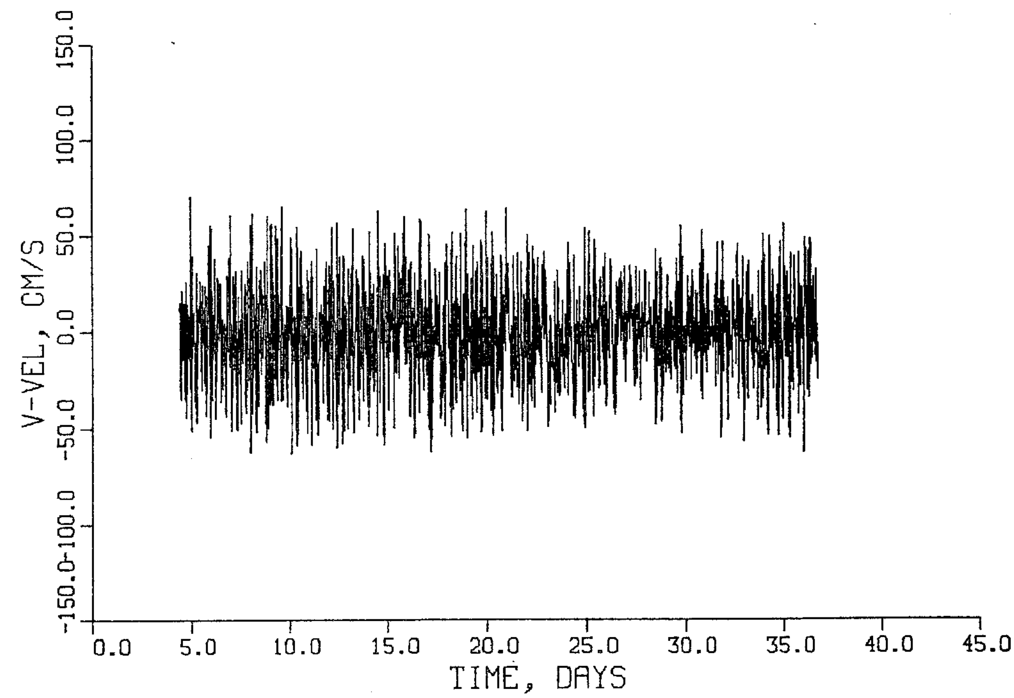
b. Depth = 30 ft

Figure 28. U-velocity at station TS1 from CRIMP data (Continued)

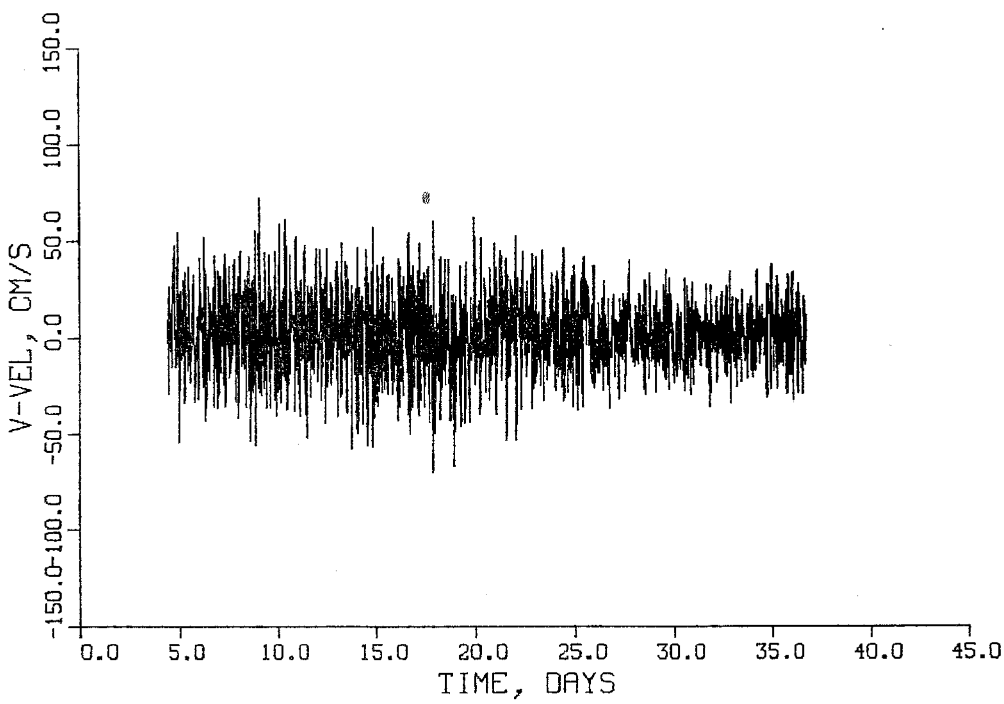


c. Depth = 55 ft

Figure 28. (Concluded)

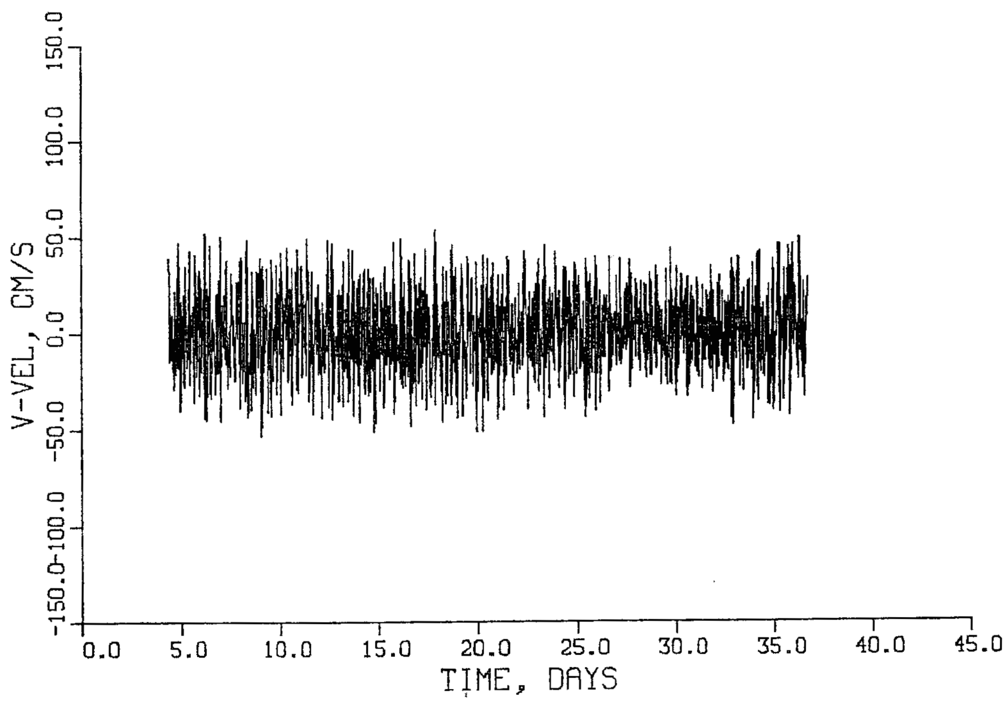


a. Depth = 9 ft



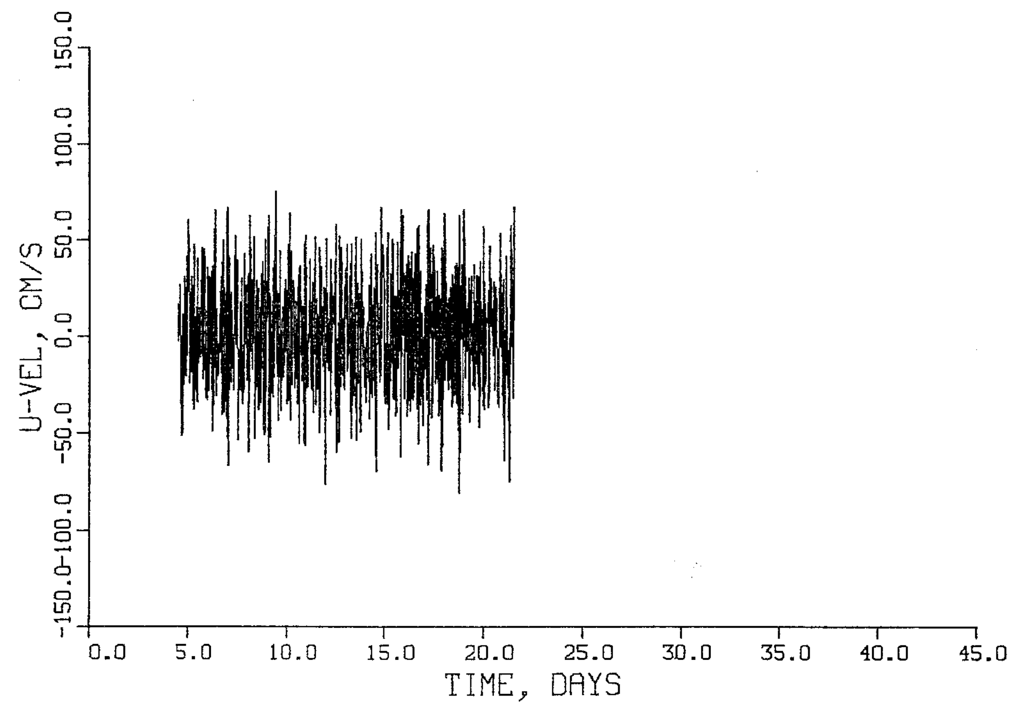
b. Depth = 30 ft

Figure 29. V-velocity at station TS1 from CRIMP data (Continued)

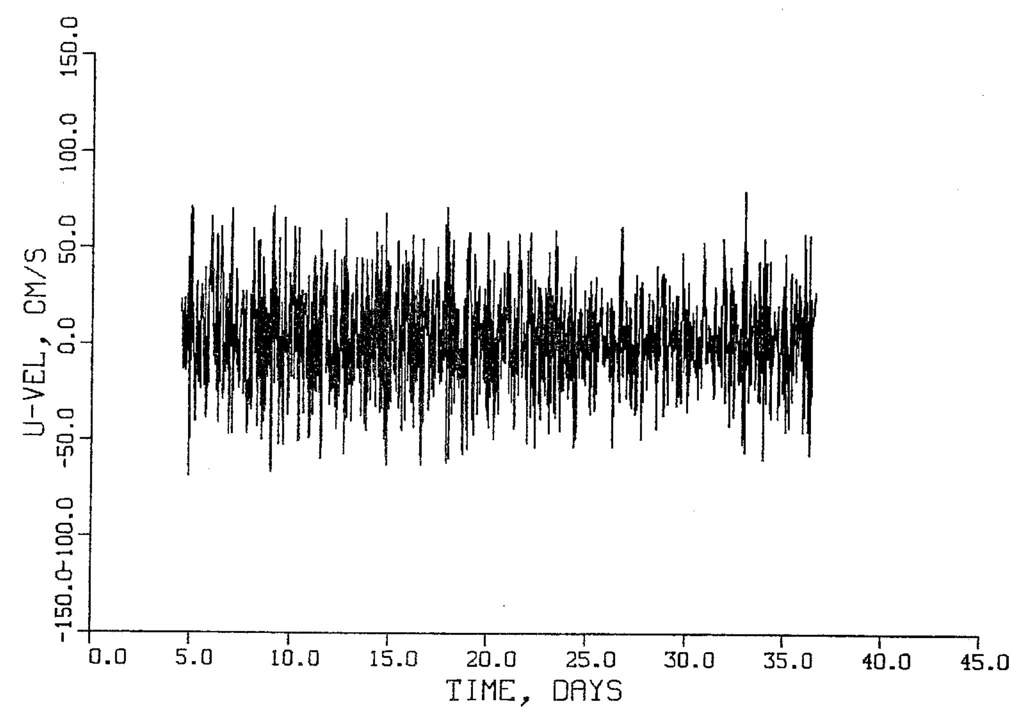


c. Depth = 55 ft

Figure 29. (Concluded)

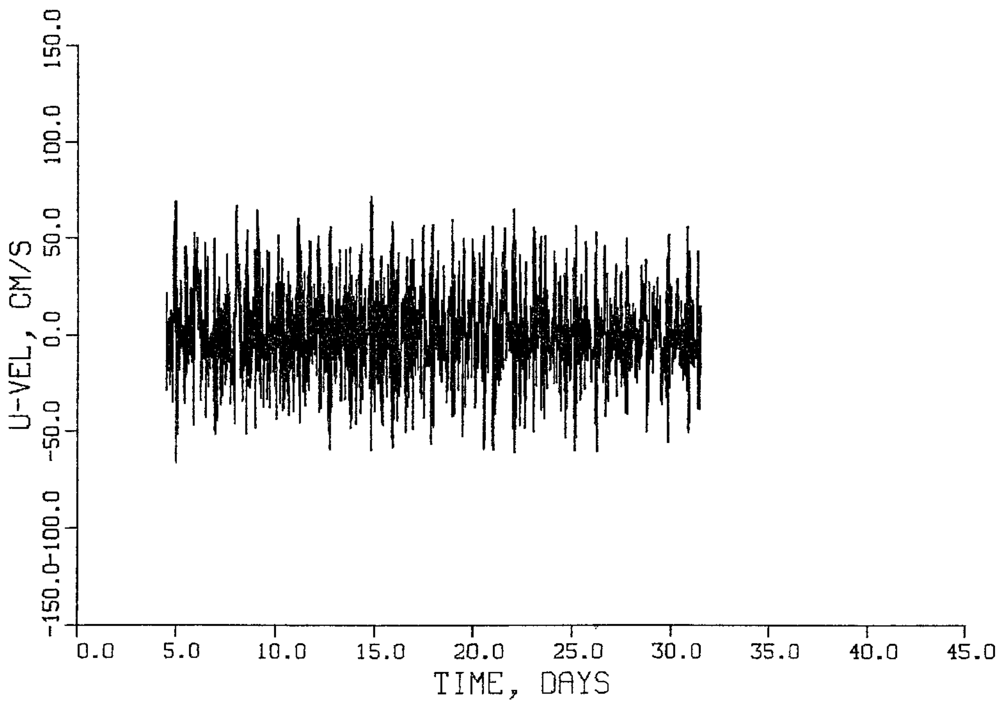


a. Depth = 30 ft



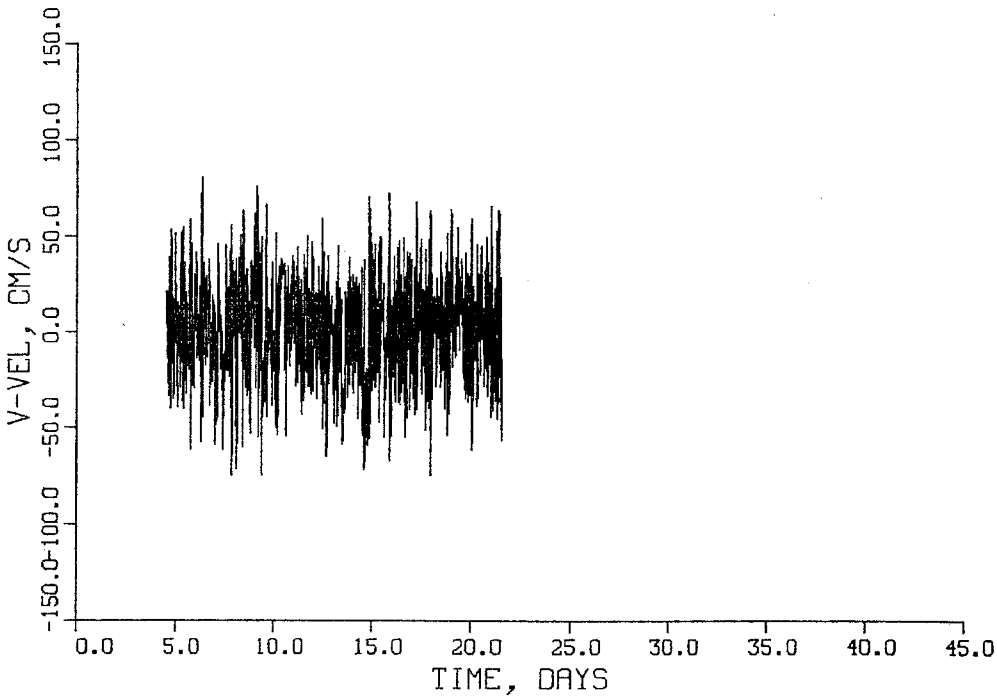
b. Depth = 60 ft

Figure 30. U–velocity at station SP1 from CRIMP data (Continued)

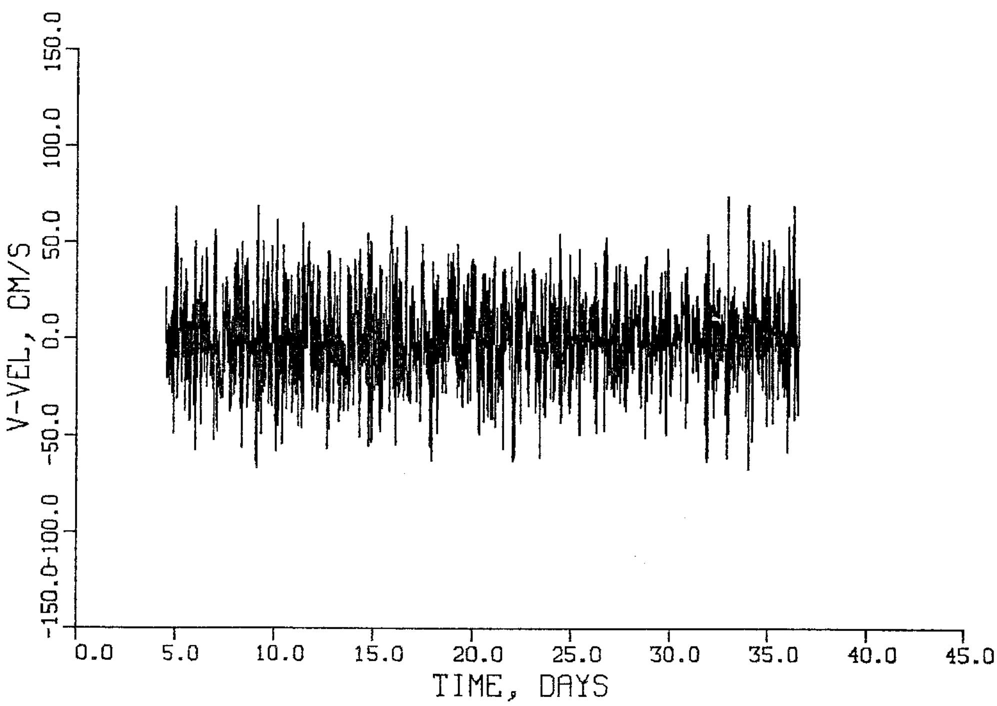


c. Depth = 90 ft

Figure 30. (Concluded)

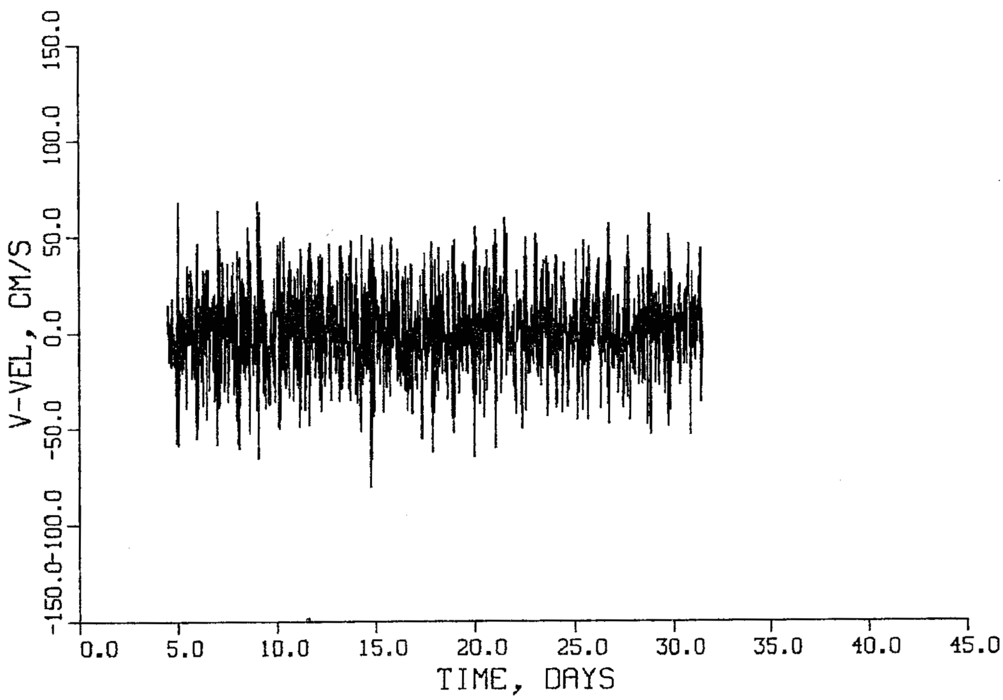


a. Depth = 30 ft



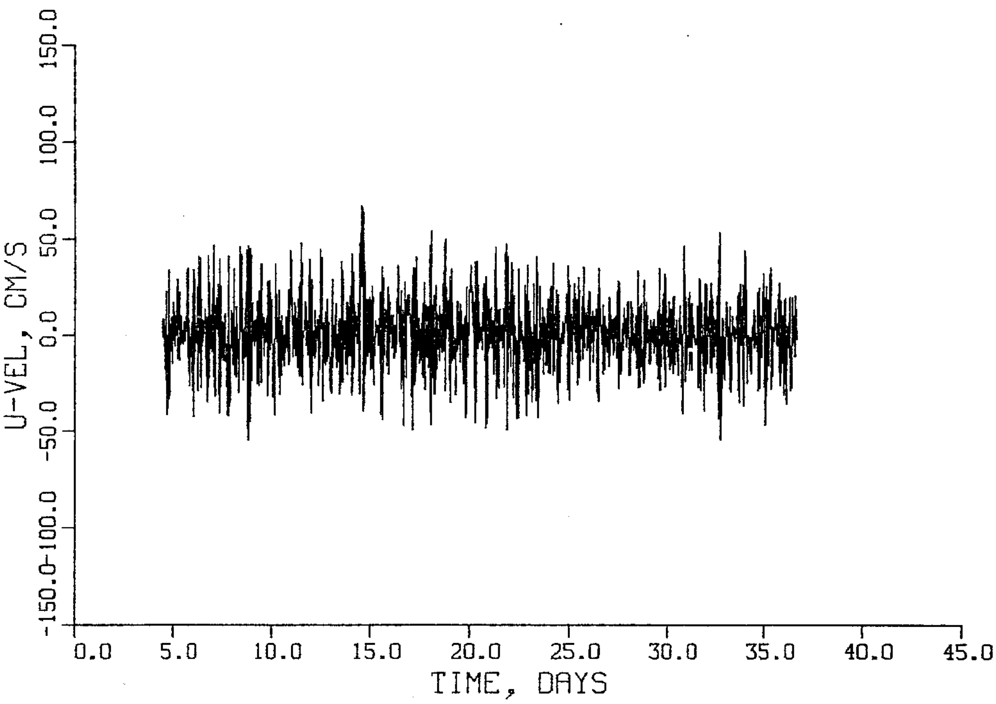
b. Depth = 60 ft

Figure 31. V-velocity at station SP1 from CRIMP data (Continued)

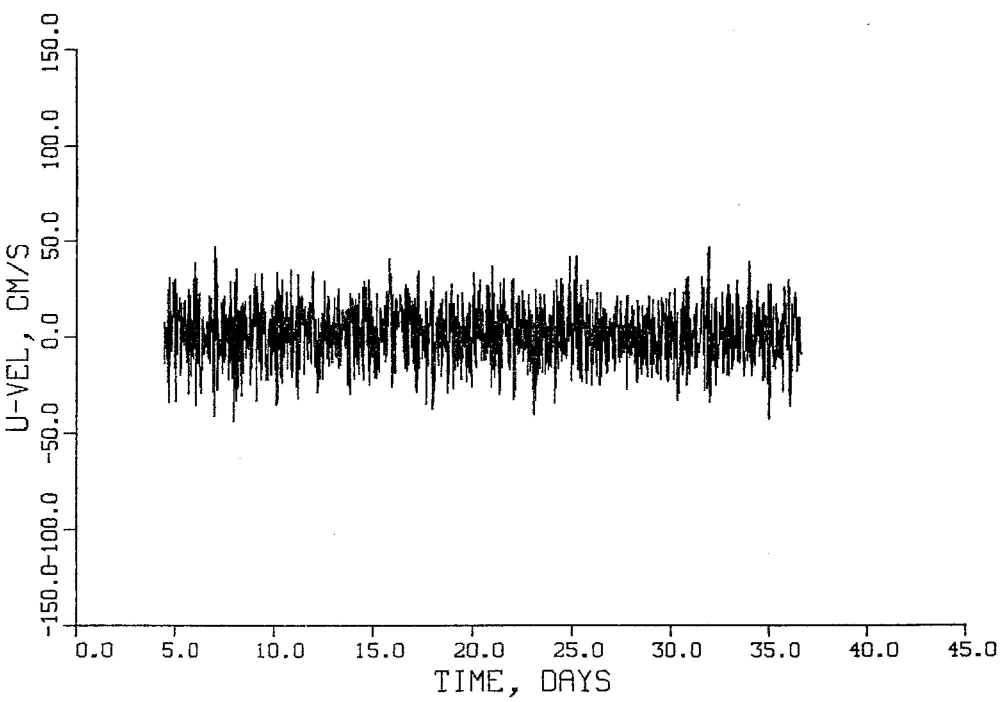


c. Depth = 90 ft

Figure 31. (Concluded)

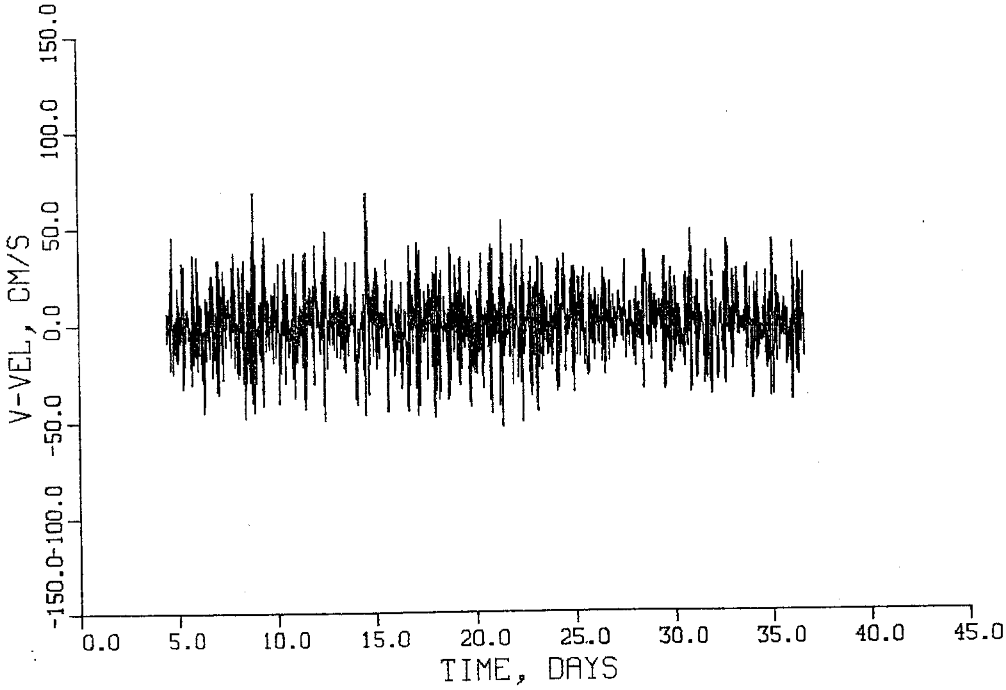


a. Depth = 9 ft

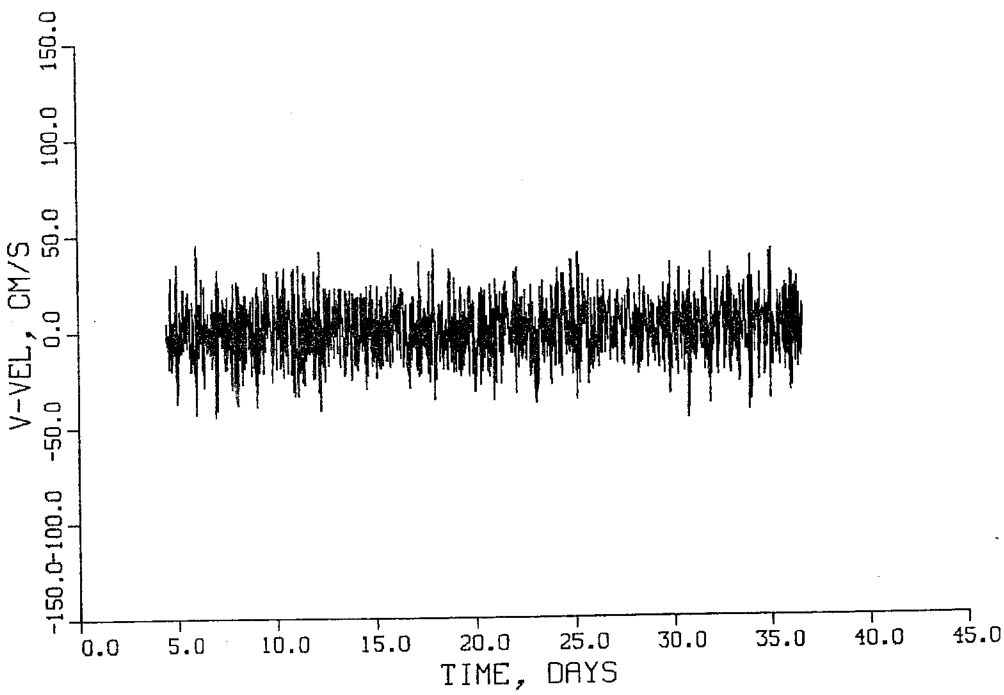


b. Depth = 27 ft

Figure 32. U-velocity at station SP2 from CRIMP data

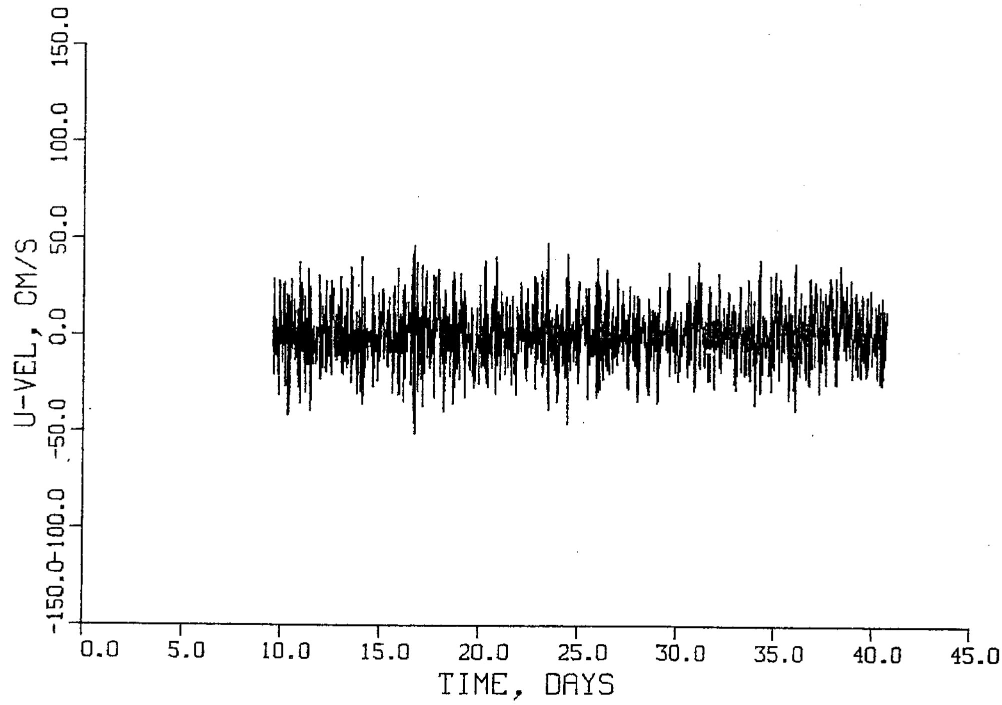


a. Depth = 9 ft

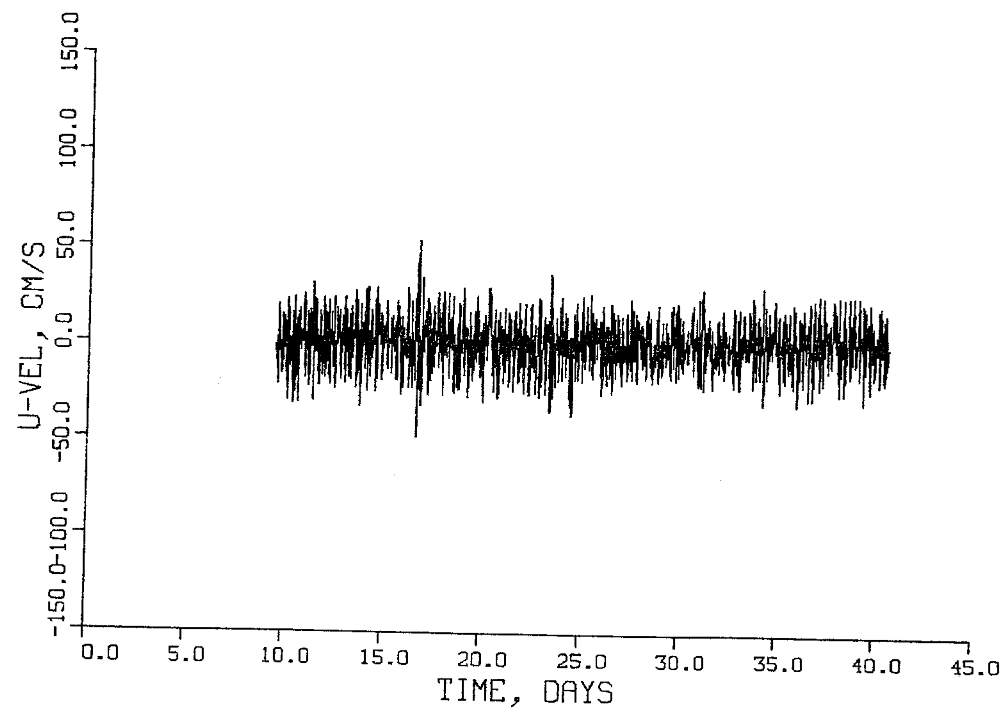


b. Depth = 27 ft

Figure 33. V-velocity at station SP2 from CRIMP data

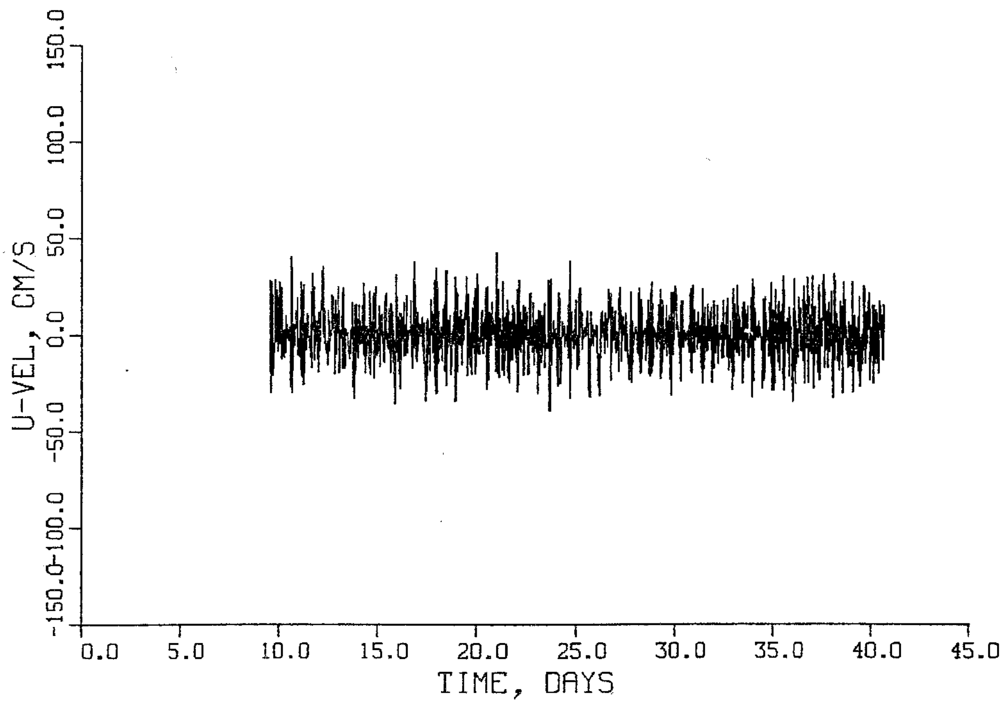


a. Depth = 5 ft



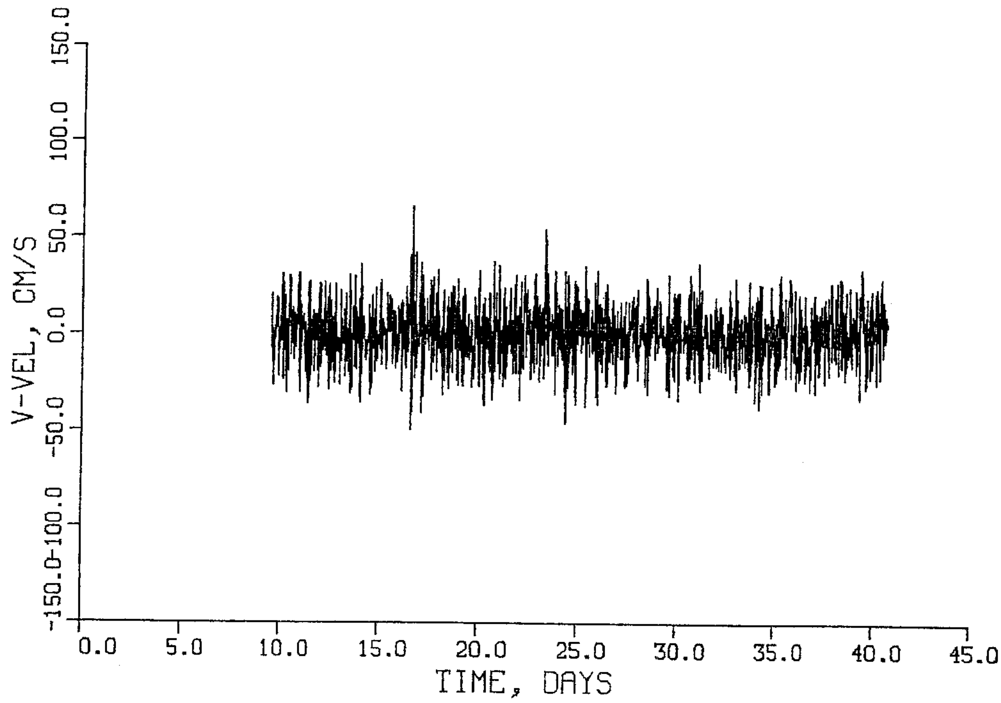
b. Depth = 12 ft

Figure 34. U-velocity at station PX1 from CRIMP data (Continued)

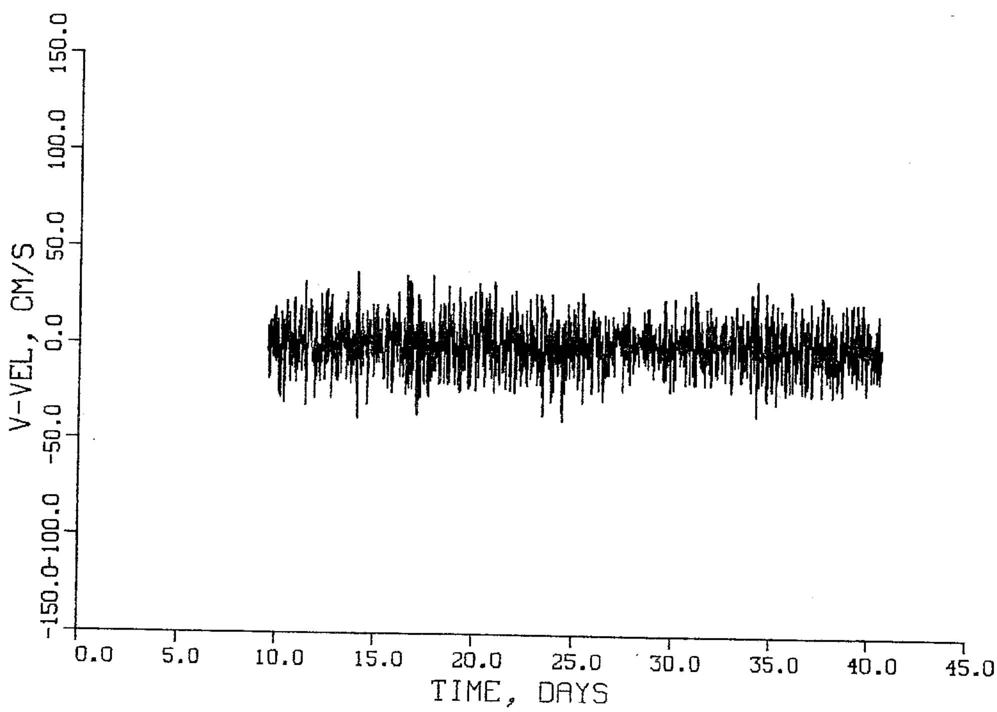


c. Depth = 30 ft

Figure 34. (Concluded)

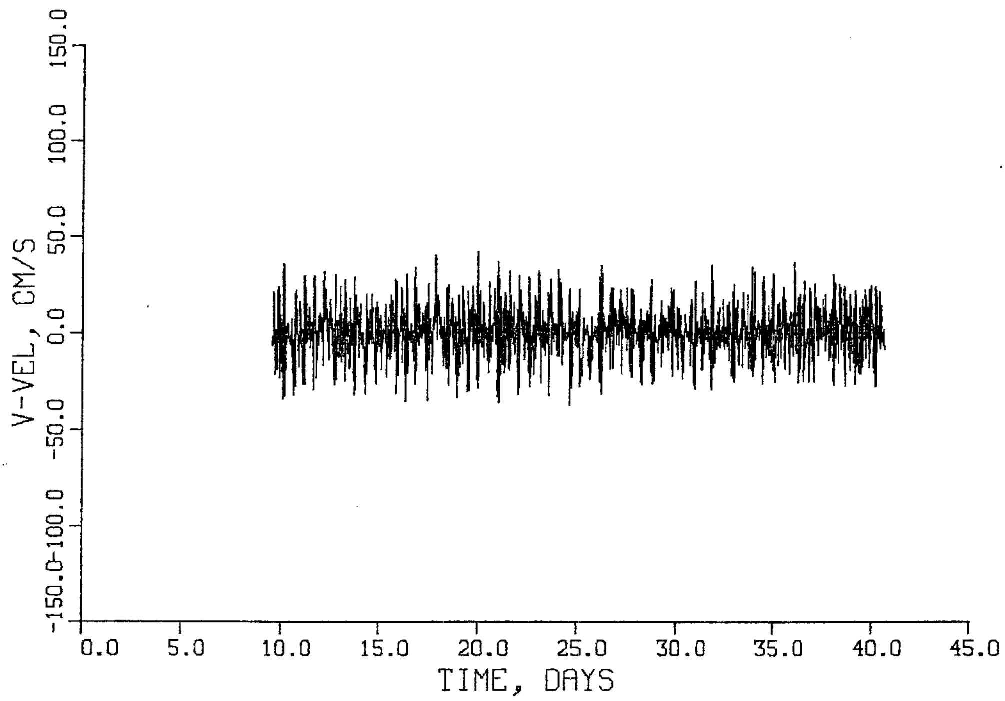


a. Depth = 5 ft



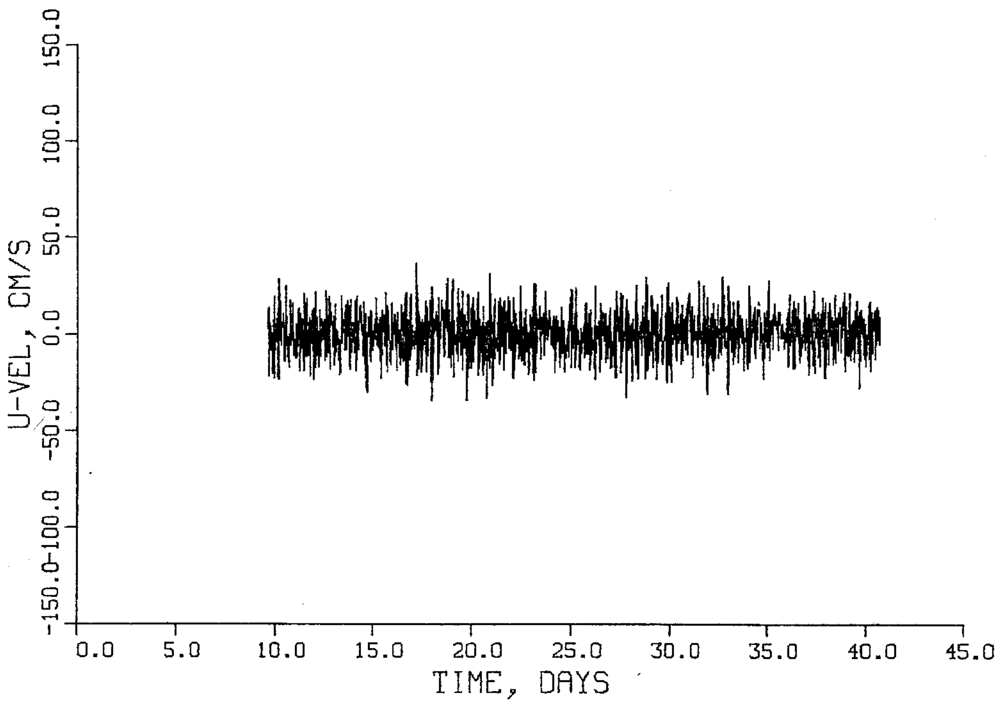
b. Depth = 12 ft

Figure 35. V-velocity at station PX1 from CRIMP data (Continued)

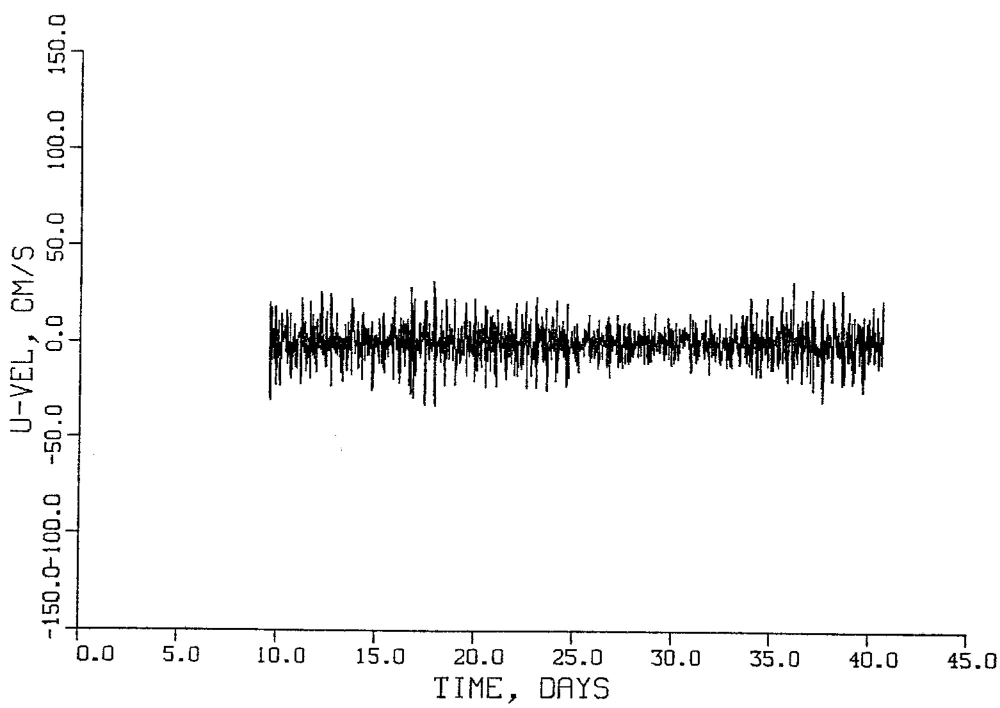


c. Depth = 30 ft

Figure 35. (Concluded)

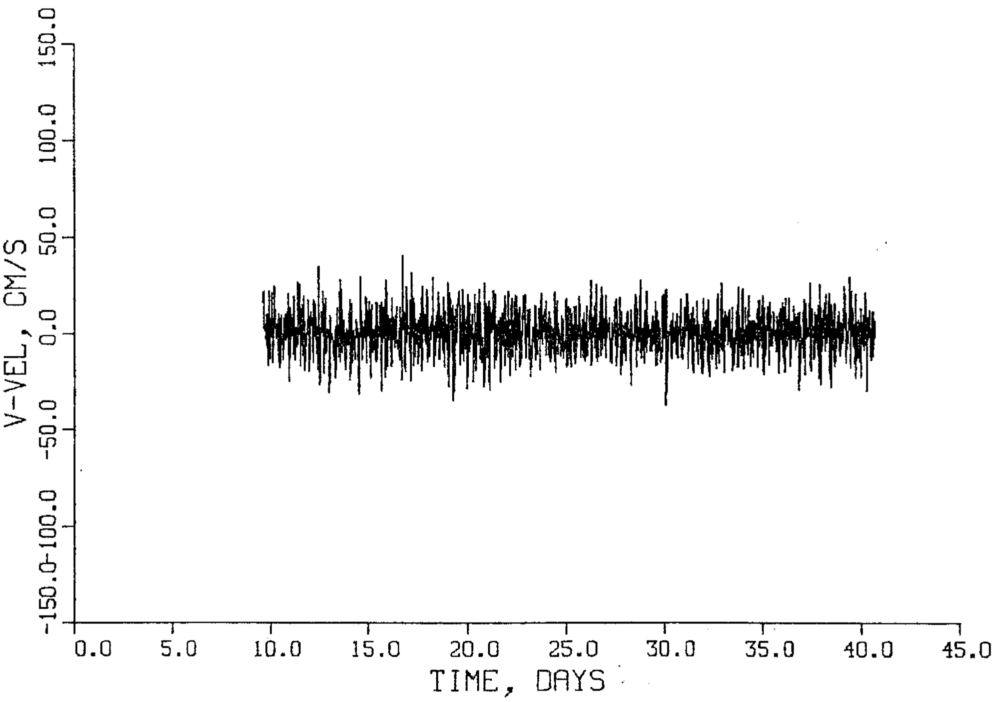


a. Depth = 9 ft

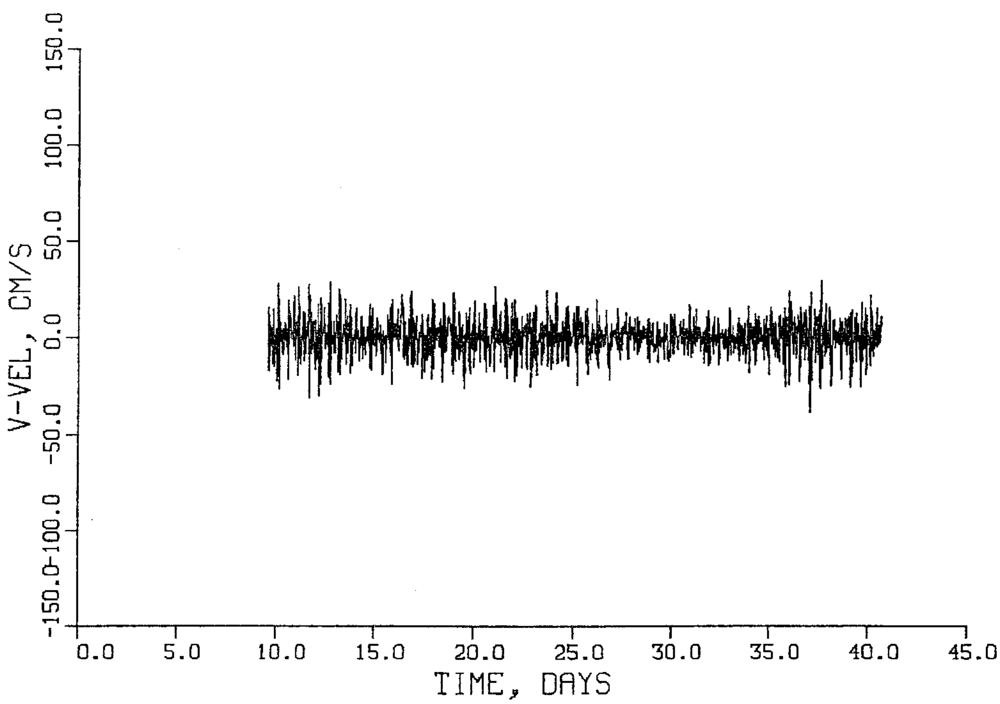


b. Depth = 34 ft

Figure 36. U-velocity at station PX2 from CRIMP data

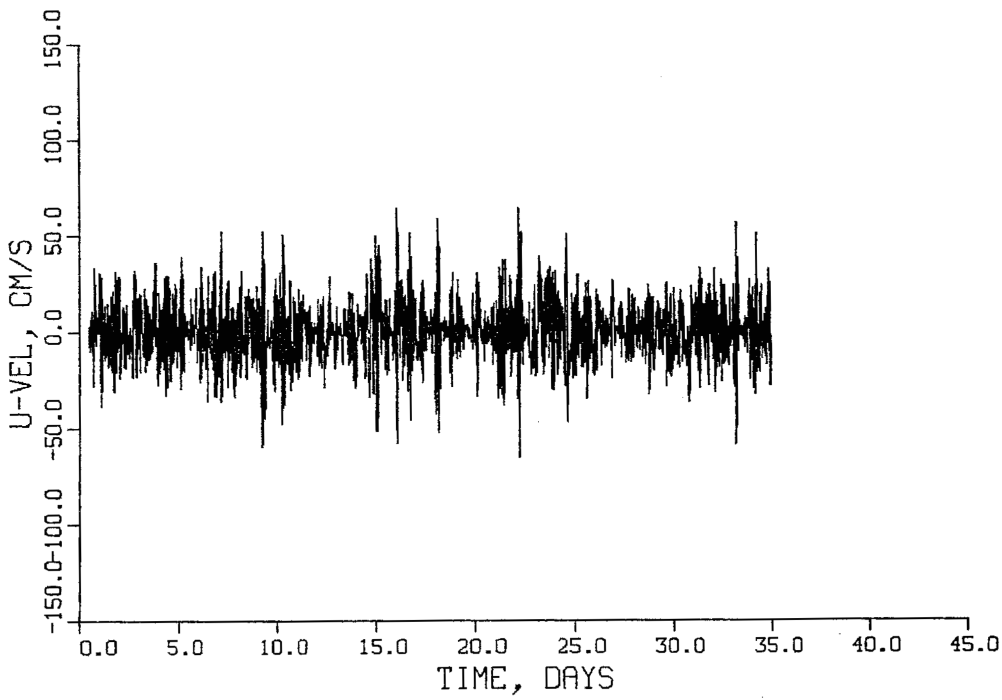


a. Depth = 9 ft

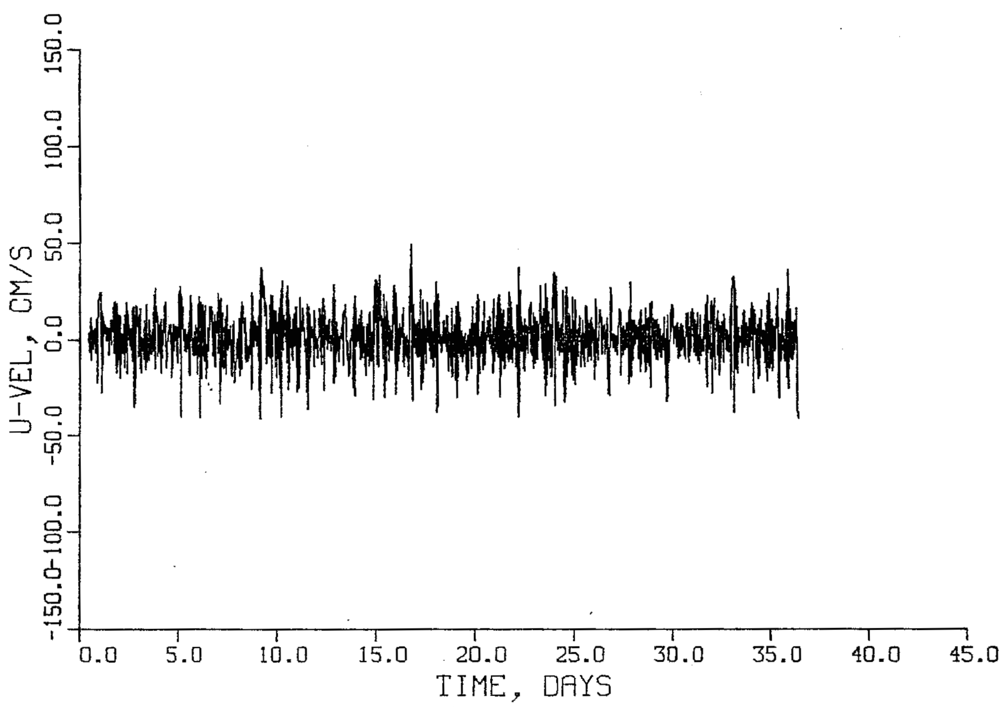


b. Depth = 34 ft

Figure 37. V-velocity at station PX2 from CRIMP data

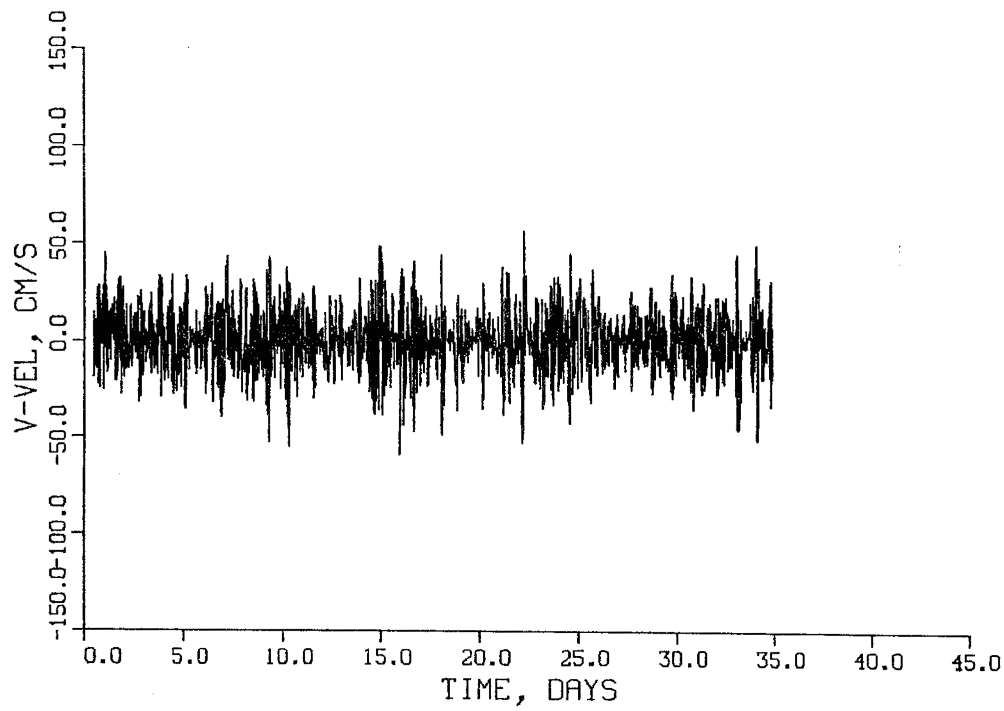


a. Depth = 30 ft

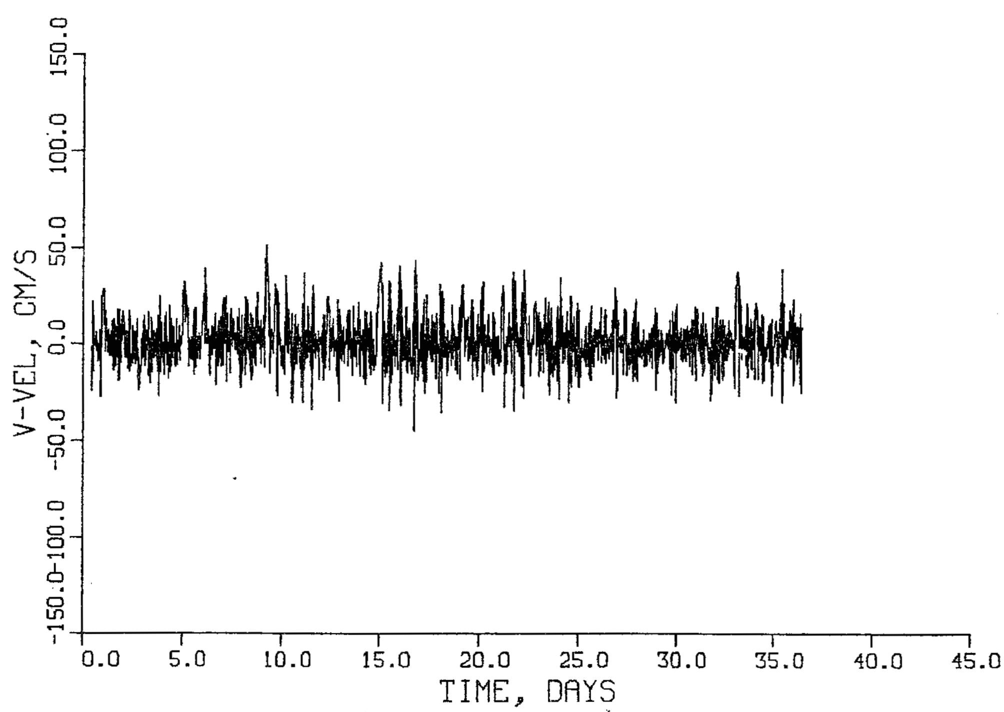


b. Depth = 56 ft

Figure 38. U-velocity at station CC1 from CRIMP data



a. Depth = 30 ft



b. Depth = 56 ft

Figure 39. V-velocity at station CC1 from CRIMP data

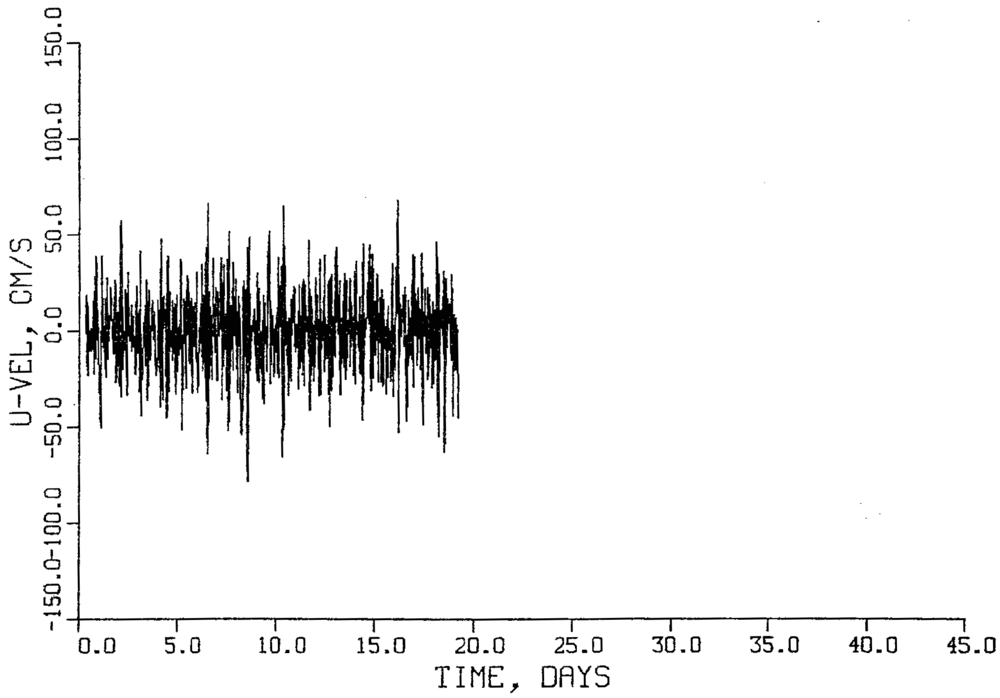


Figure 40. U-velocity at station BB1 at a depth of 9 ft from CRIMP data

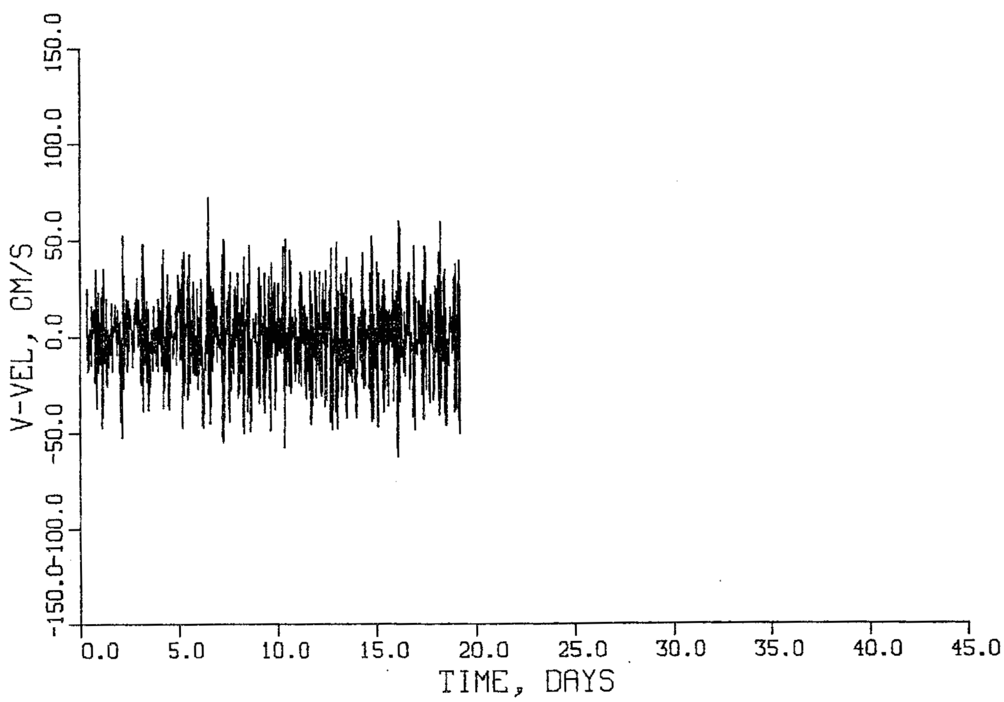


Figure 41. V-velocity at station BB1 at a depth of 9 ft from CRIMP data

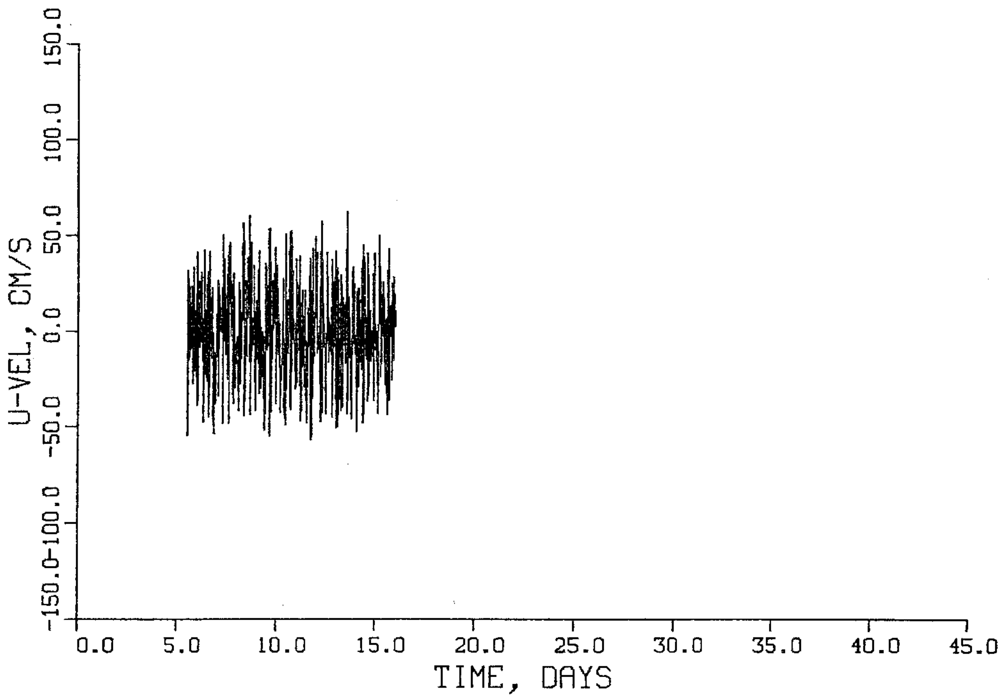


Figure 42. U-velocity at station WP at a depth of 28 ft from CRIMP data

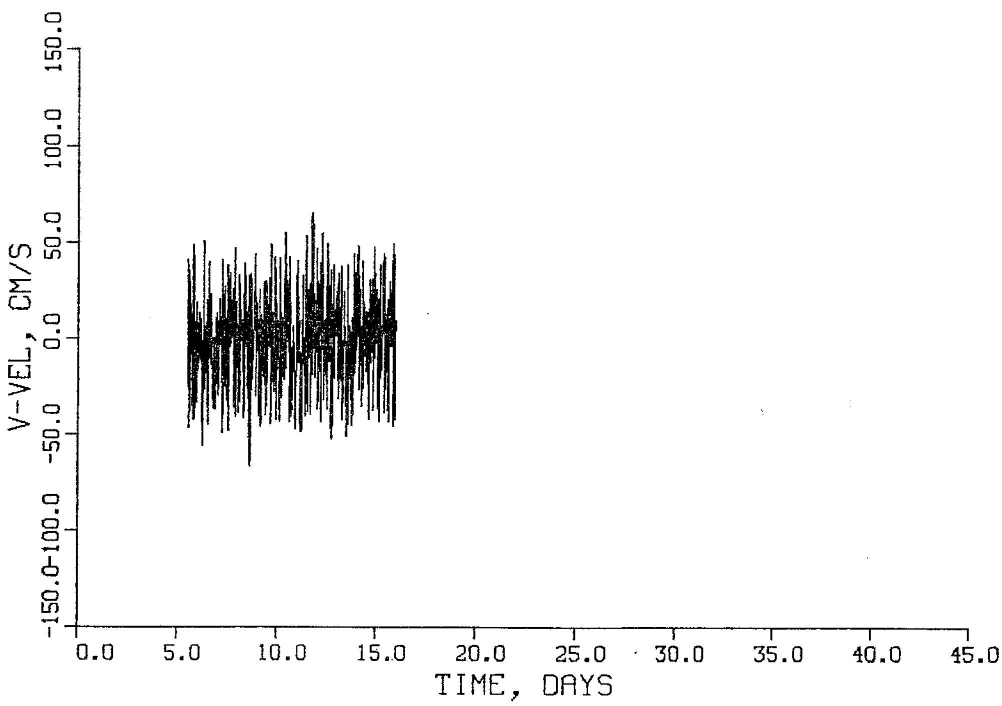
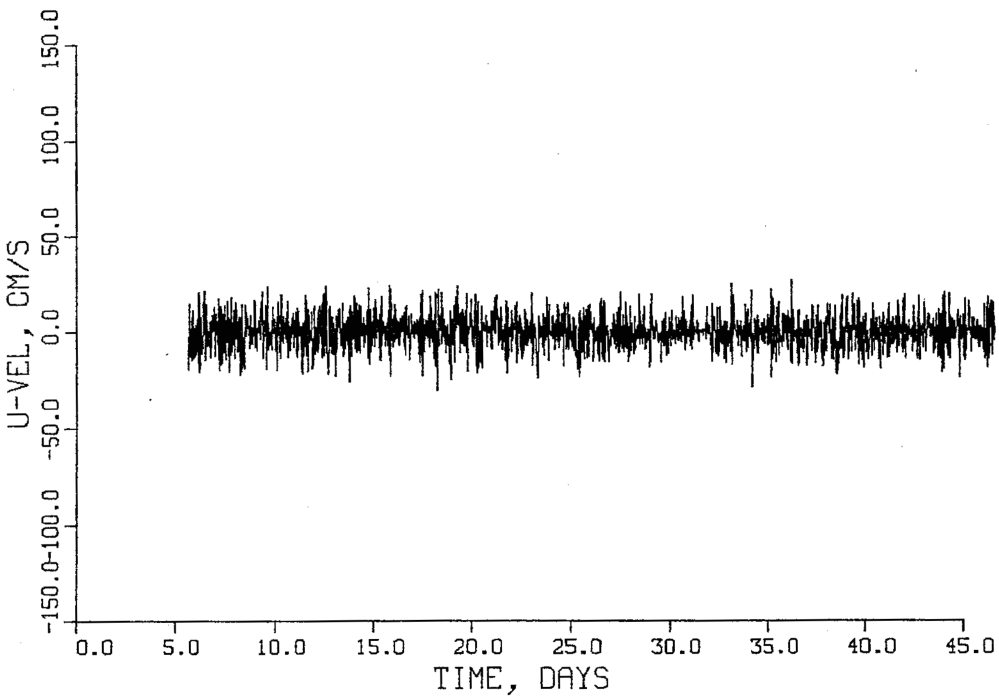
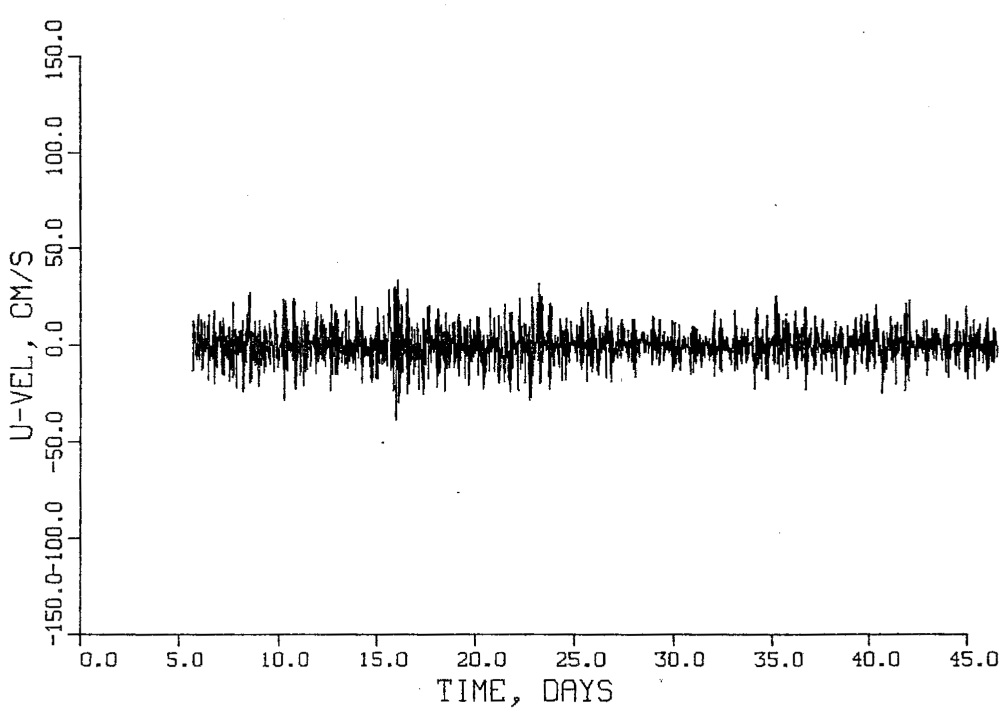


Figure 43. V-velocity at station WP at a depth of 28 ft from CRIMP data

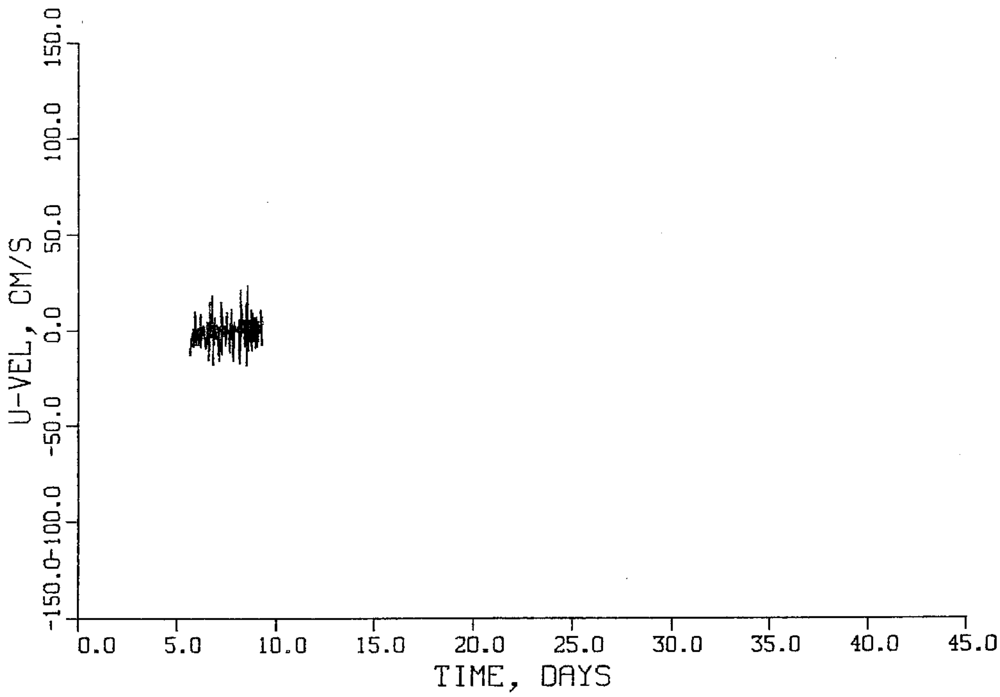


a. Depth = 5 ft



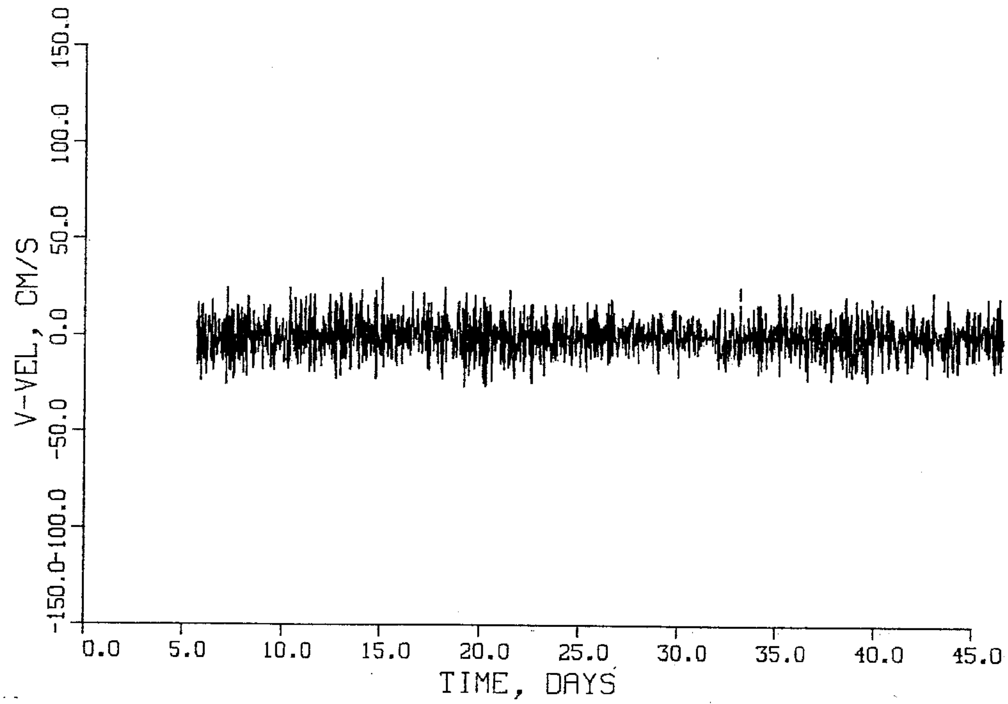
b. Depth = 28 ft

Figure 44. U-velocity at station CH1 from CRIMP data (Continued)

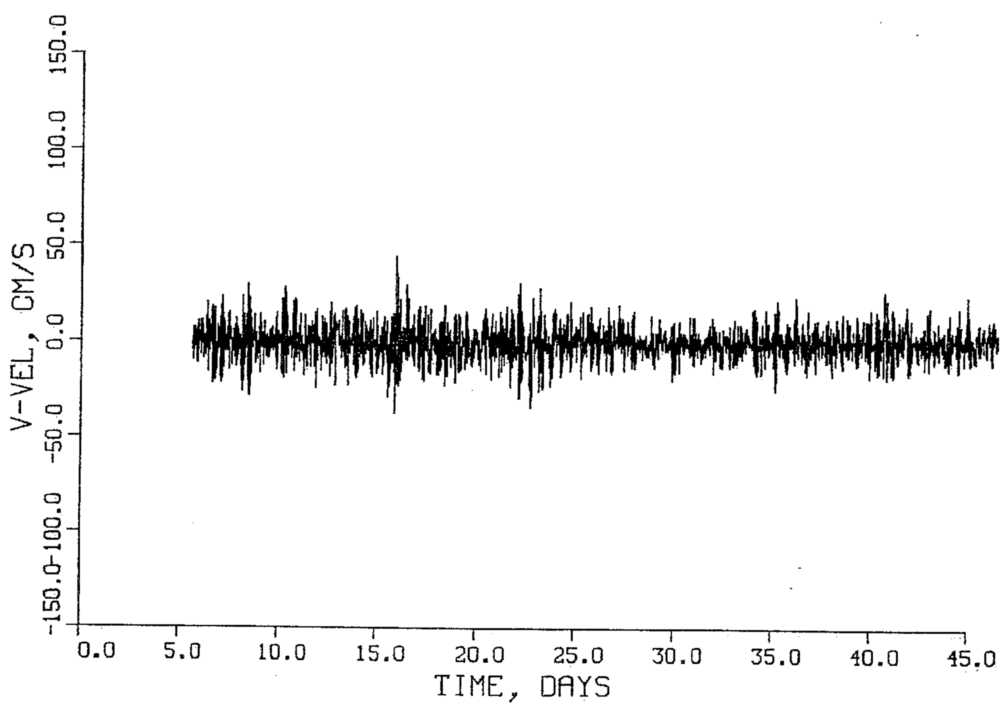


c. Depth = 36 ft

Figure 44. (Concluded)

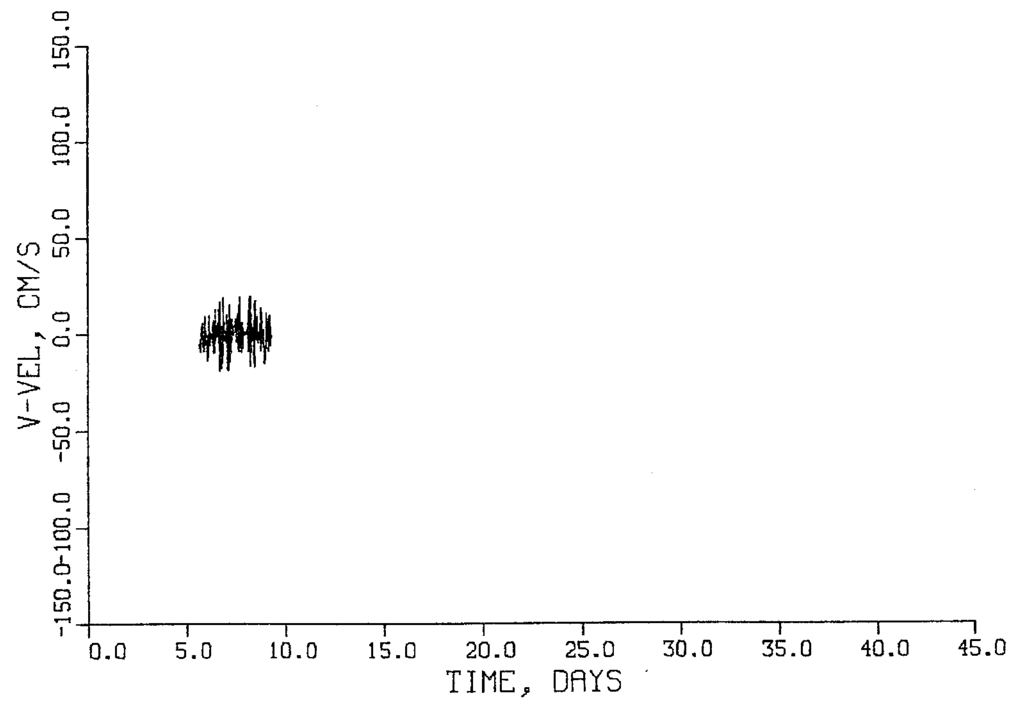


a. Depth = 5 ft



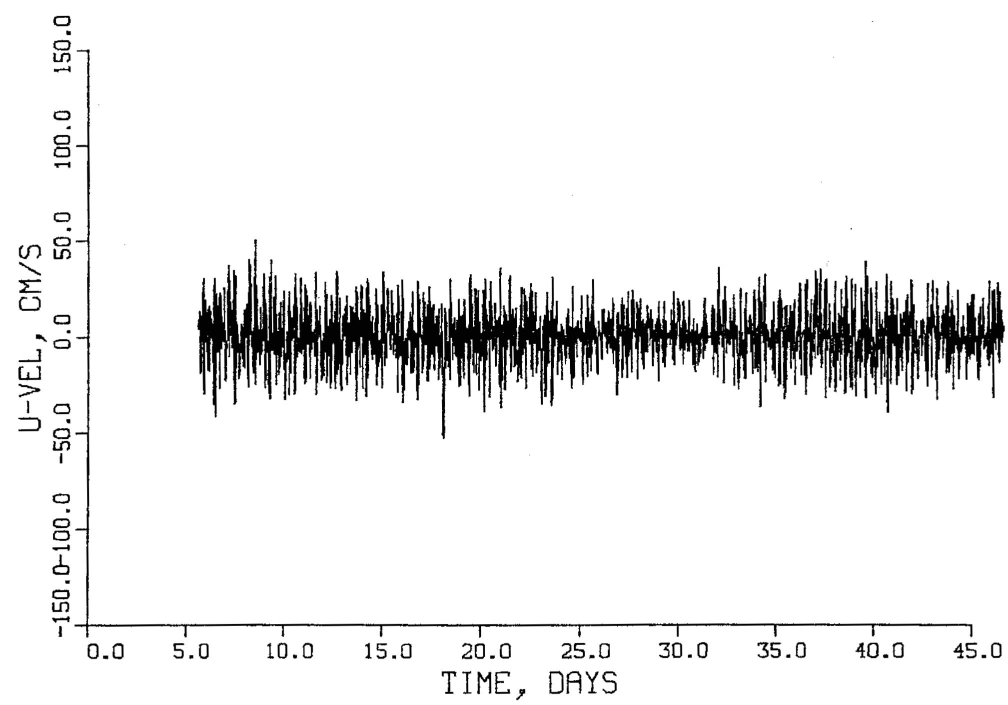
b. Depth = 28 ft

Figure 45. V-velocity at station CH1 from CRIMP data (Continued)

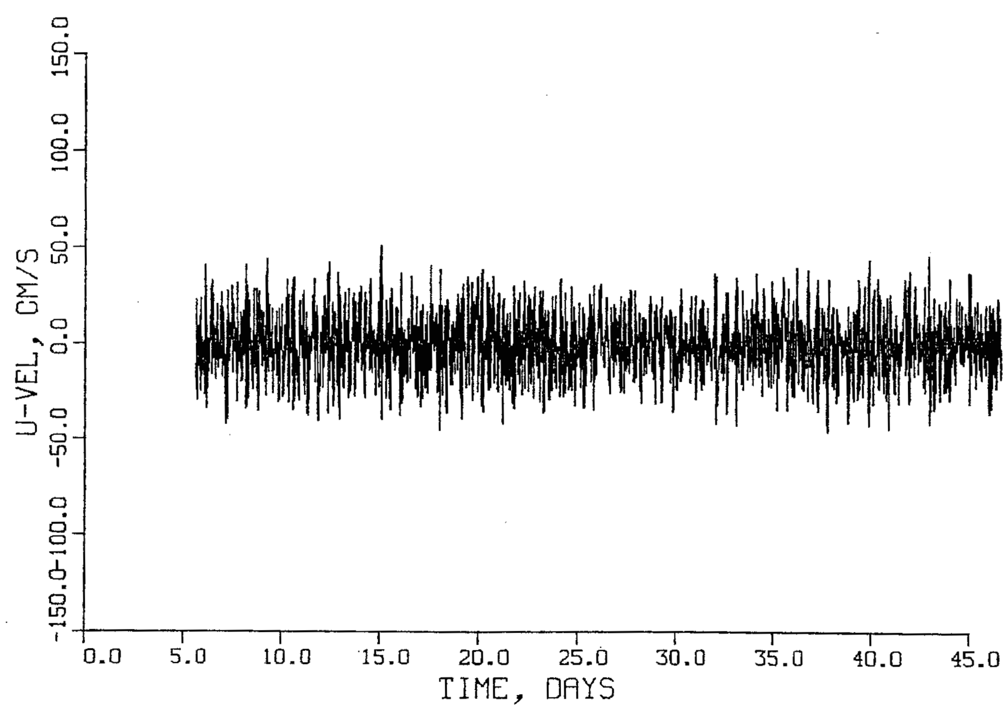


c. Depth = 36 ft

Figure 45. (Concluded)

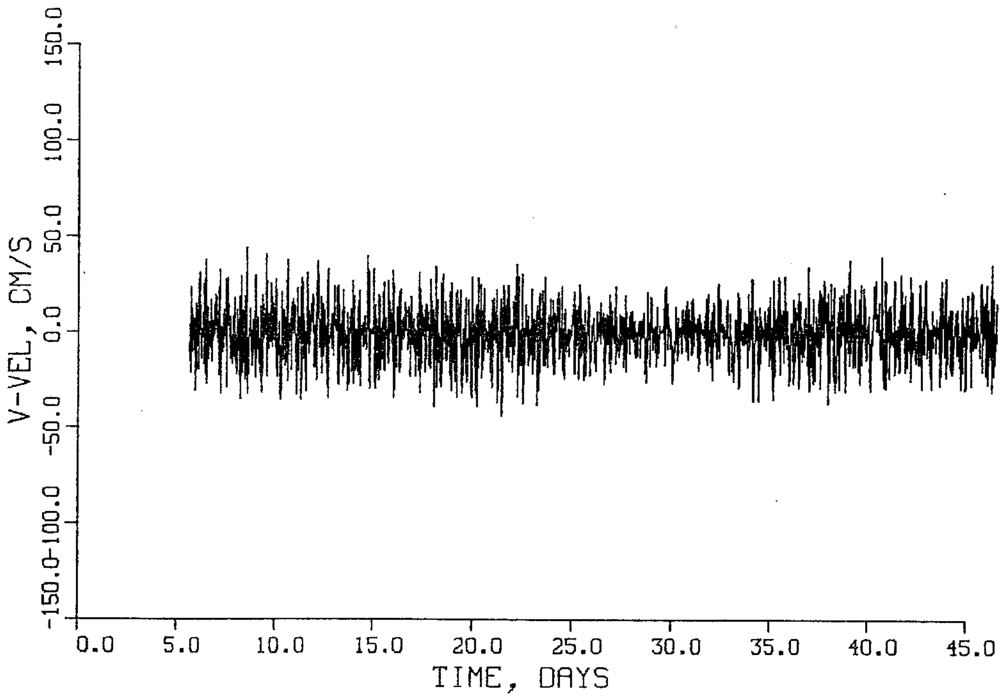


a. Depth = 8.5 ft

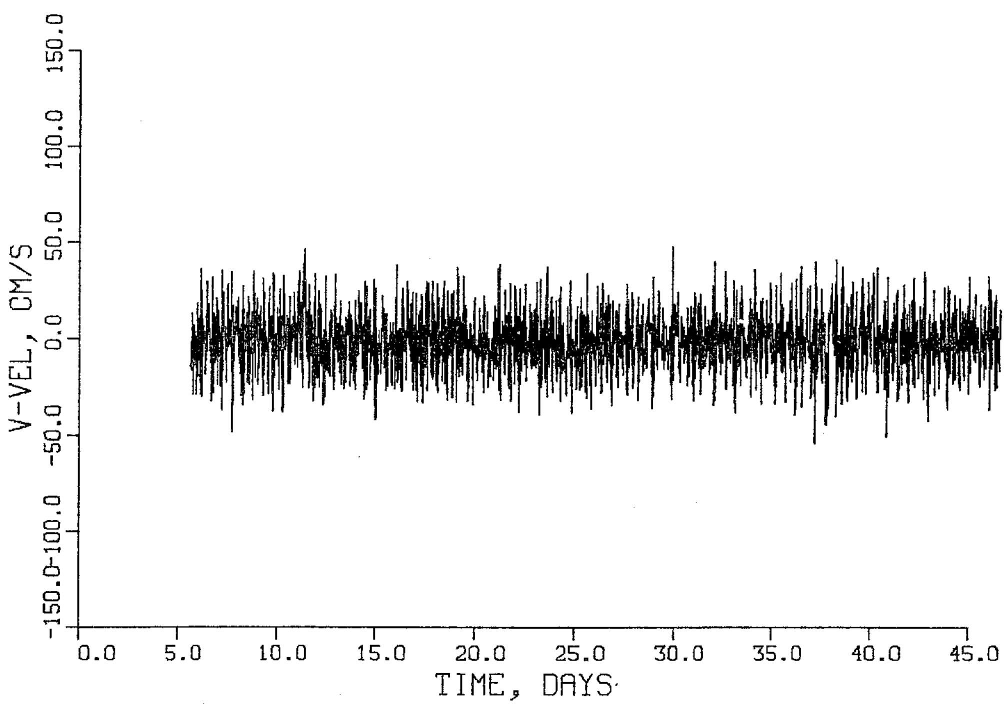


b. Depth = 31 ft

Figure 46. U-velocity at station CH2 from CRIMP data

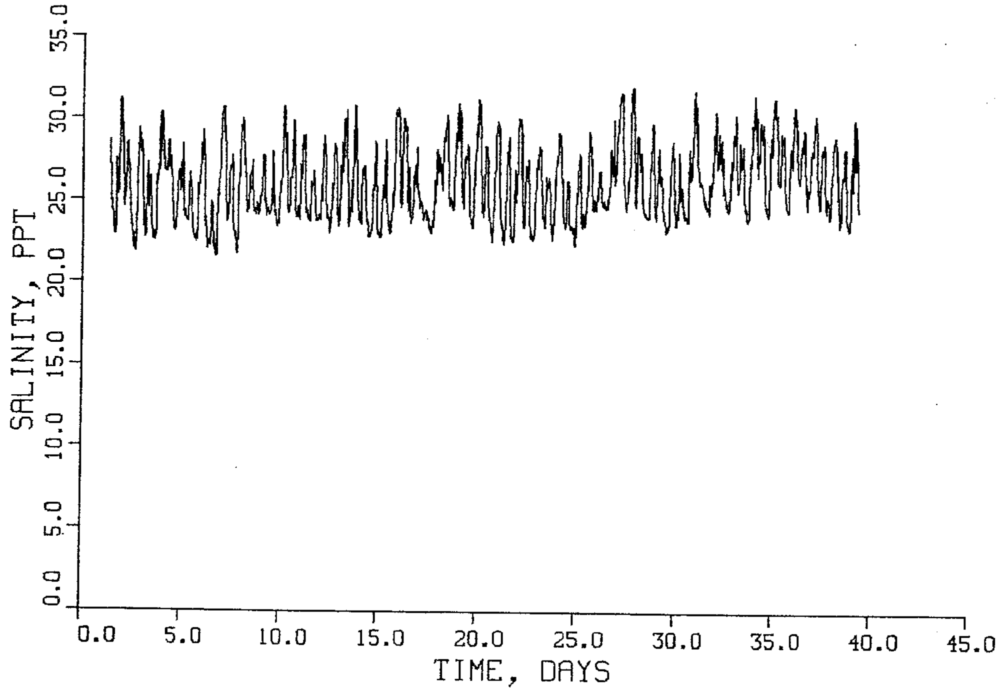


a. Depth = 8.5 ft

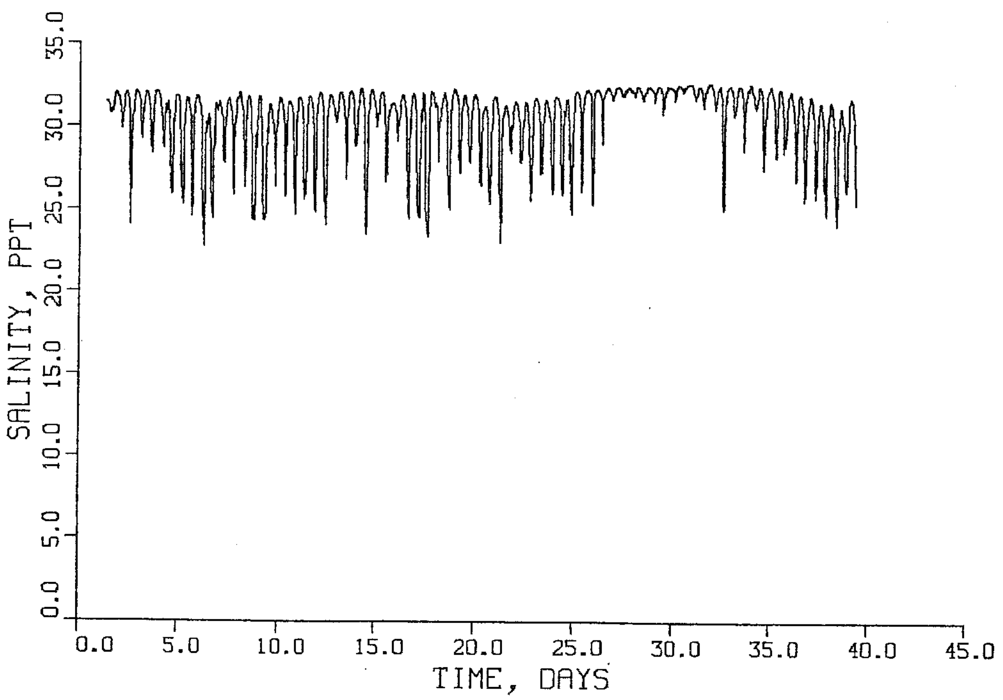


b. Depth = 31 ft

Figure 47. V-velocity at station CH2 from CRIMP data

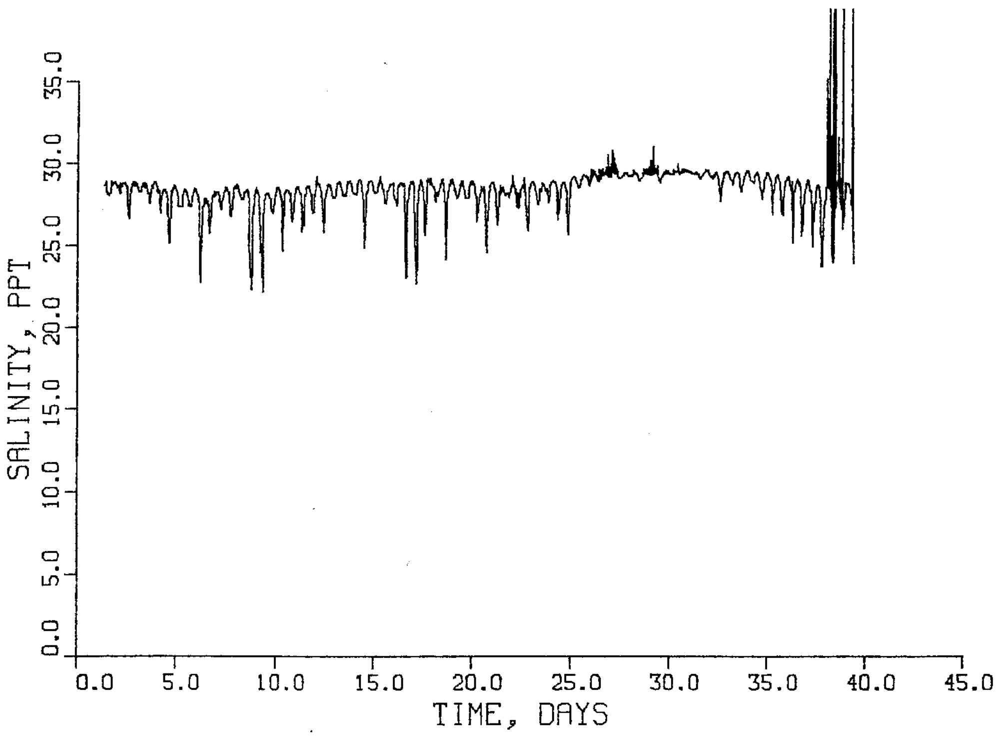


a. Depth = 9 ft



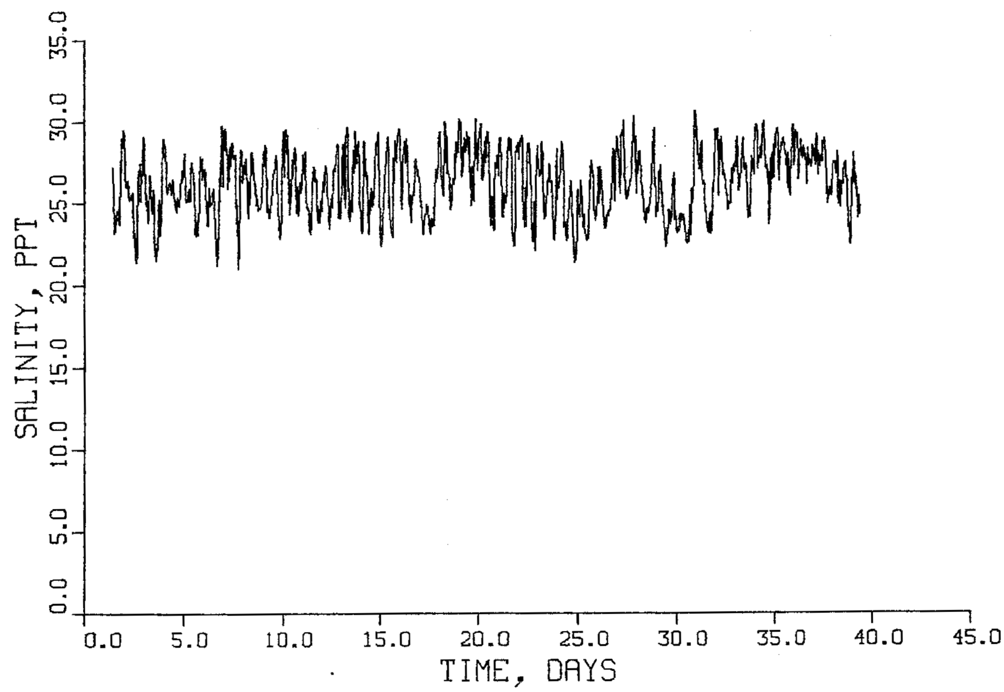
b. Depth = 35 ft

Figure 48. Salinity at station M1 from CRIMP data (Continued)

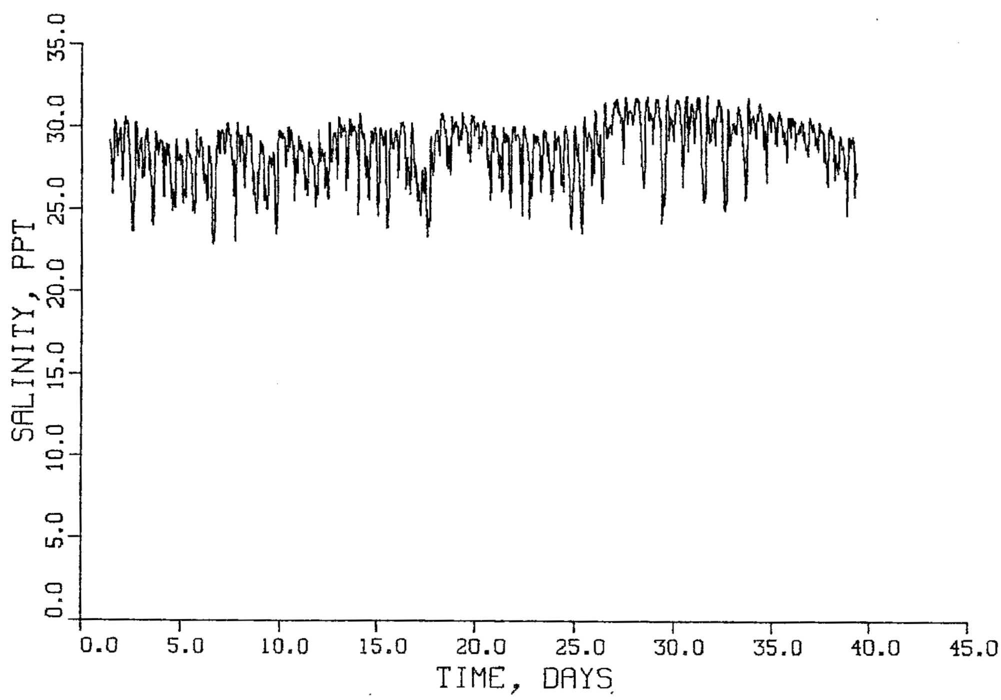


c. Depth = 50 ft

Figure 48. (Concluded)

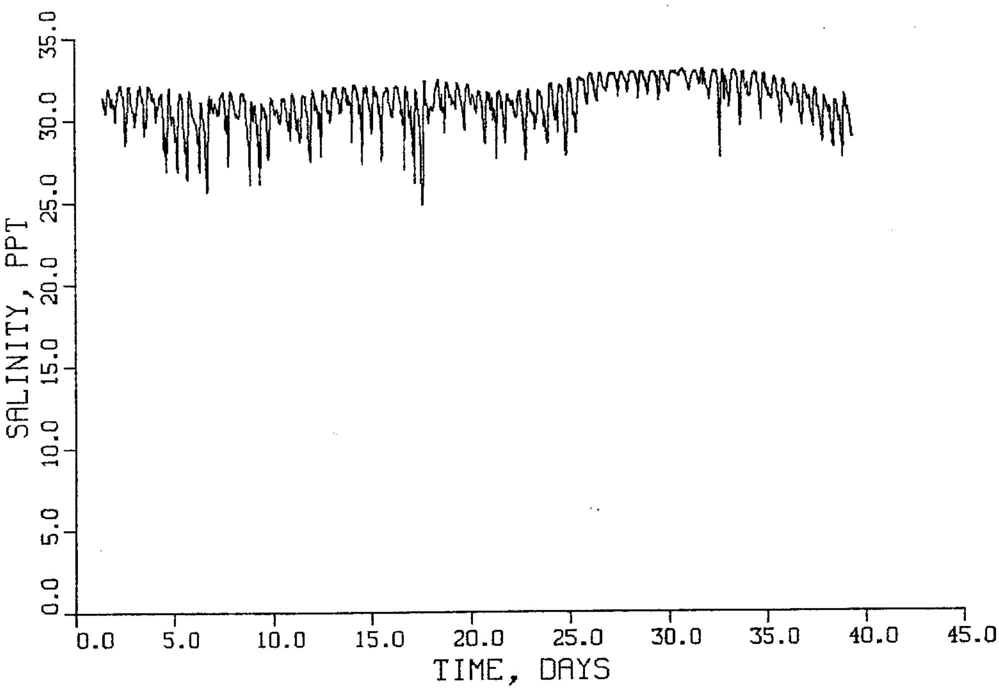


a. Depth = 9 ft

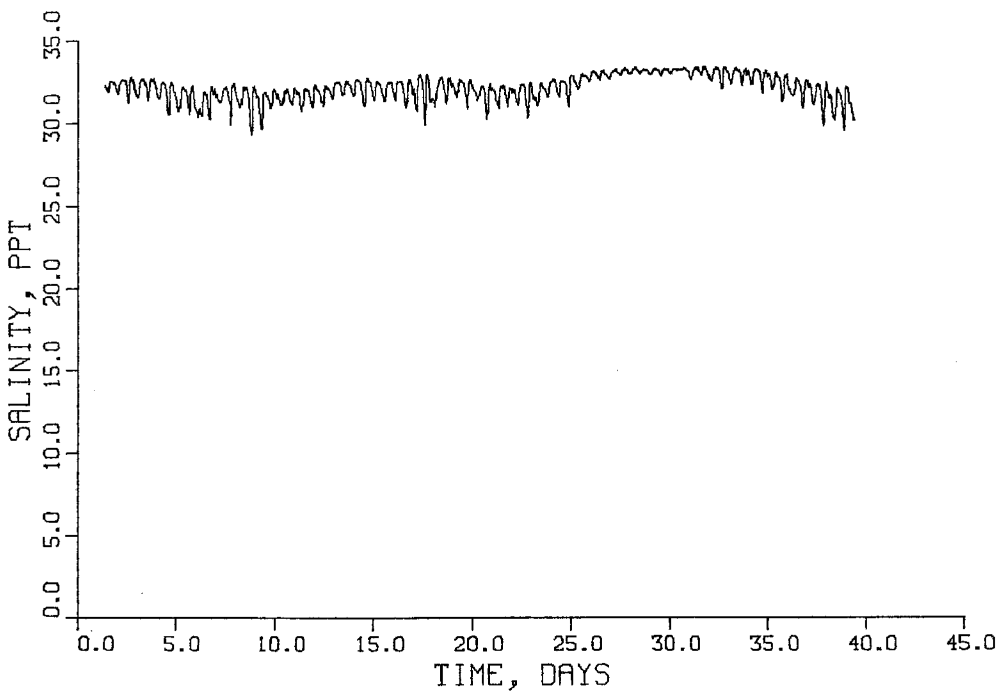


b. Depth = 20 ft

Figure 49. Salinity at station M2 from CRIMP (Continued)

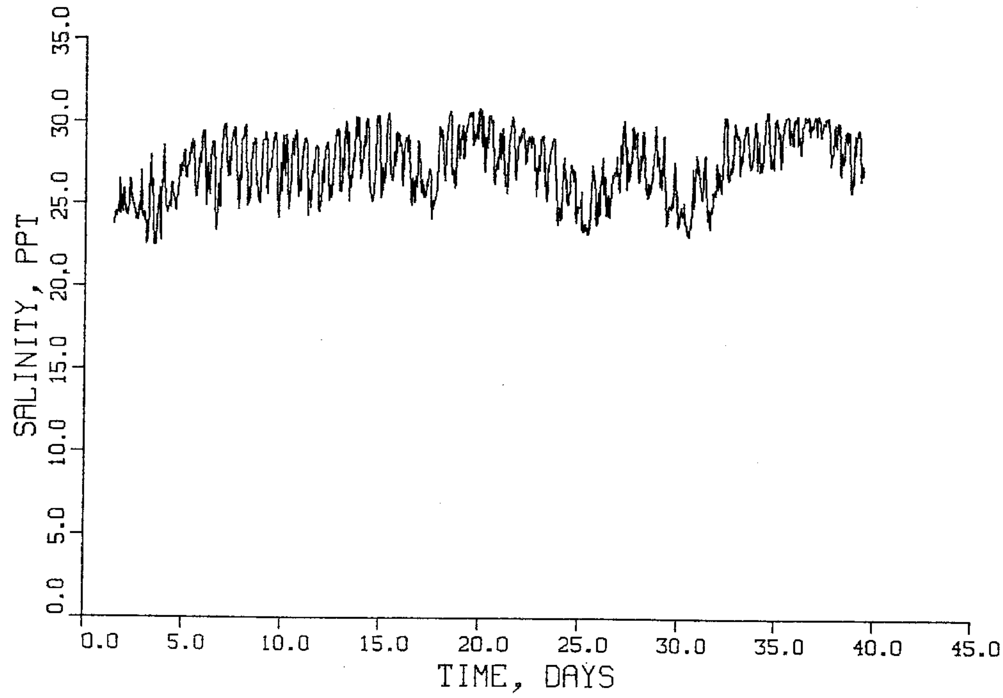


c. Depth = 35 ft

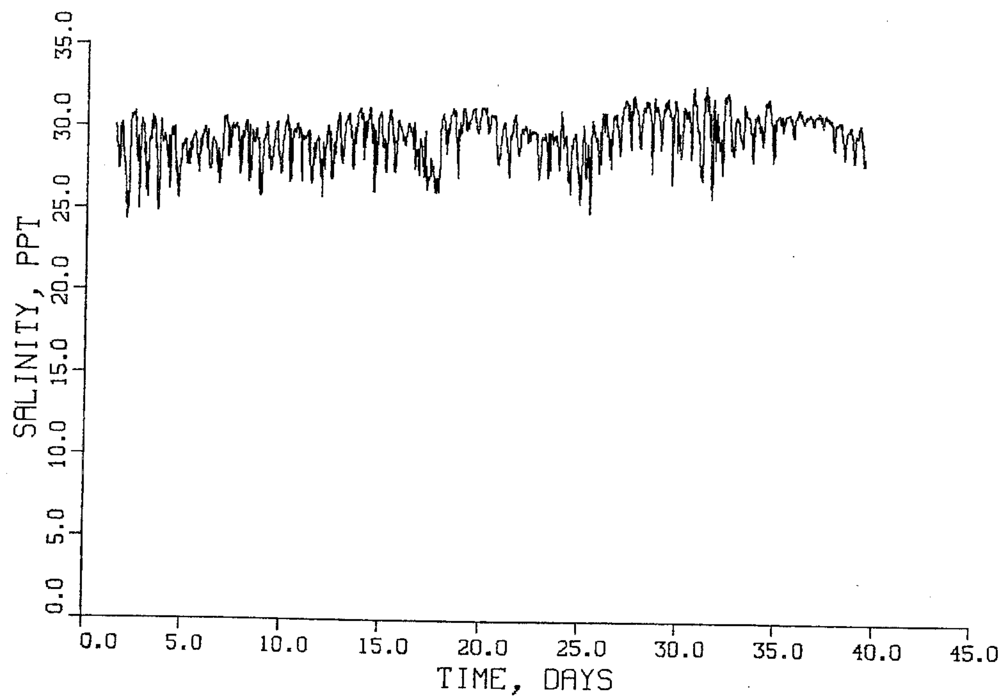


d. Depth = 50 ft

Figure 49. (Concluded)

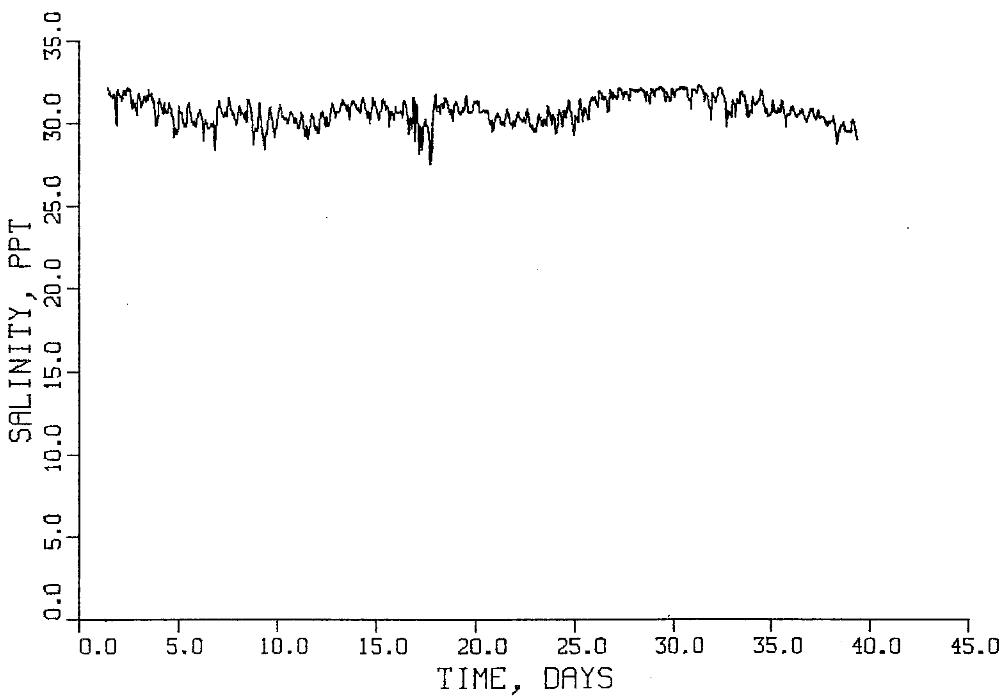


a. Depth = 9 ft



b. Depth = 20 ft

Figure 50. Salinity at station M3 from CRIMP data (Continued)



c. Depth = 32 ft

Figure 50. (Concluded)

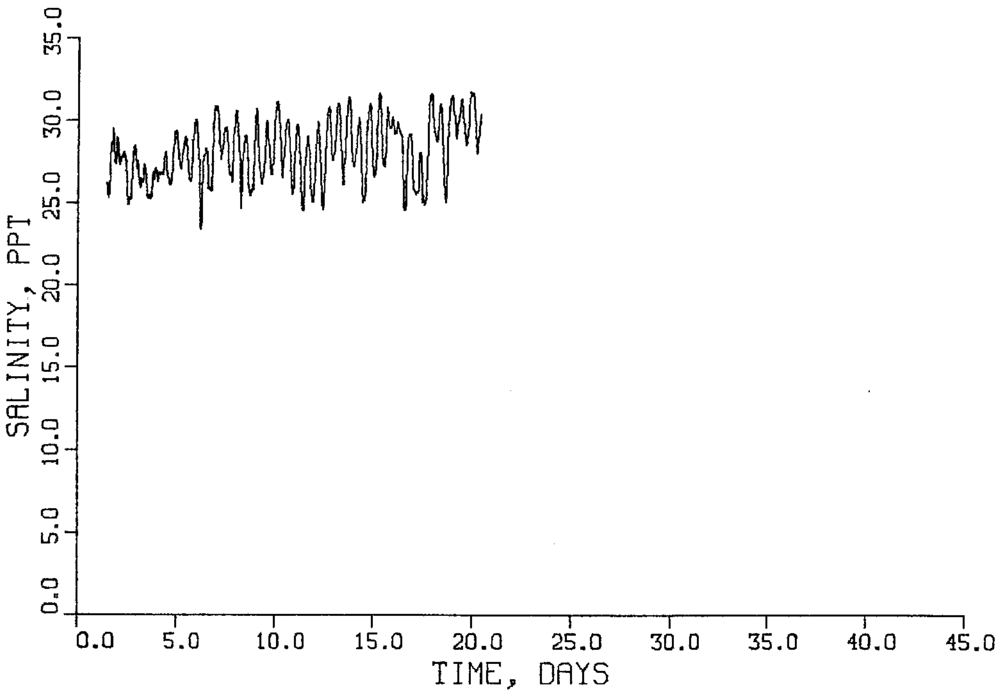
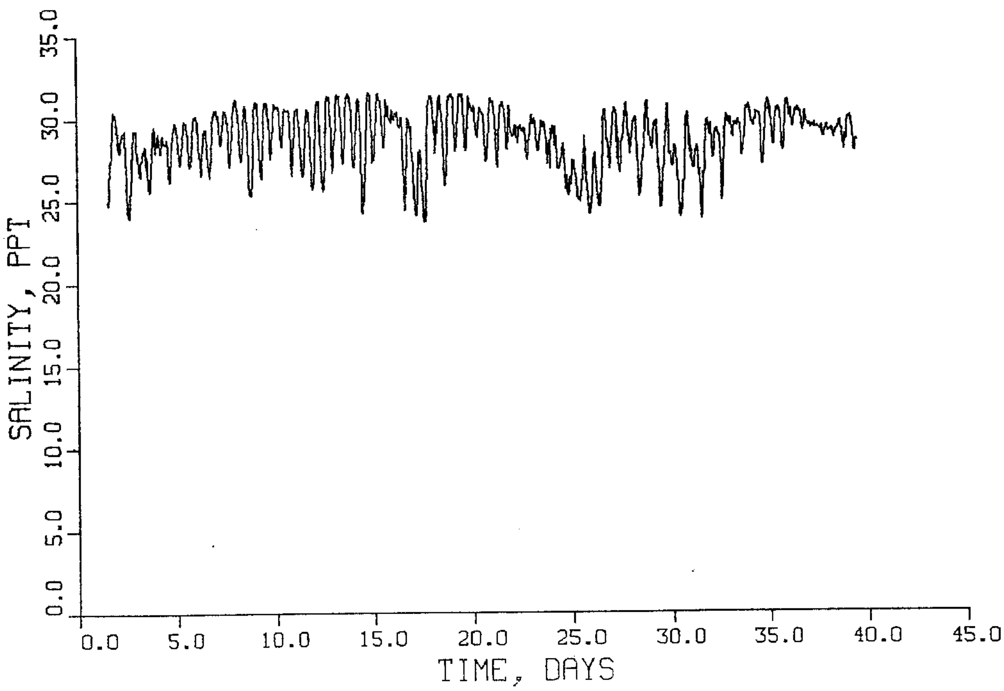
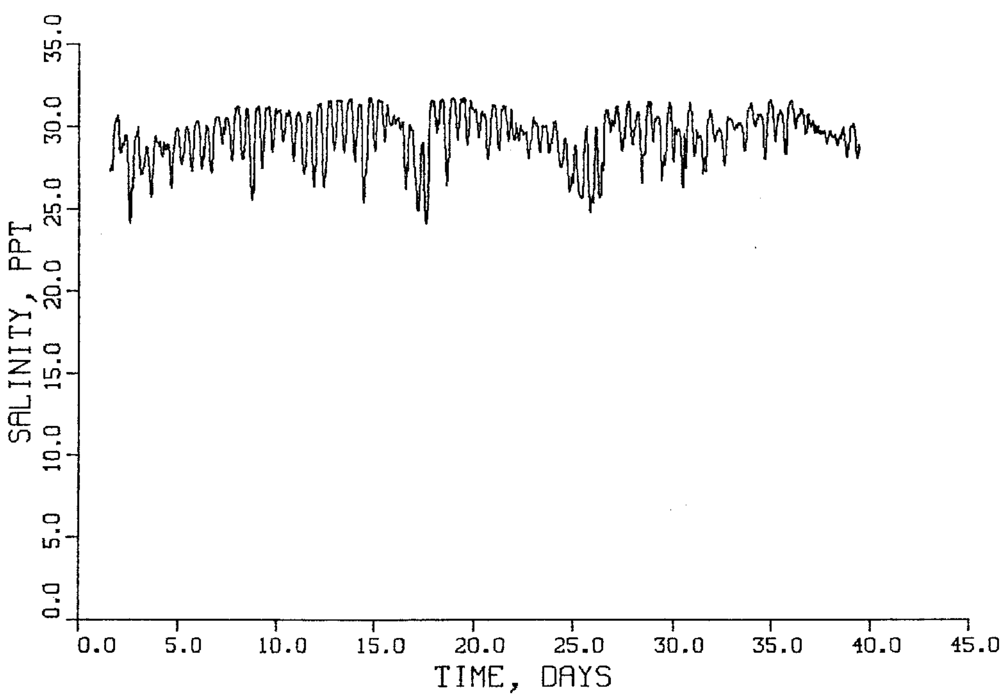


Figure 51. Salinity at station M4 at a depth of 10 ft from CRIMP data



a. Depth = 9 ft



b. Depth = 30 ft

Figure 52. Salinity at station M5 from CRIMP data

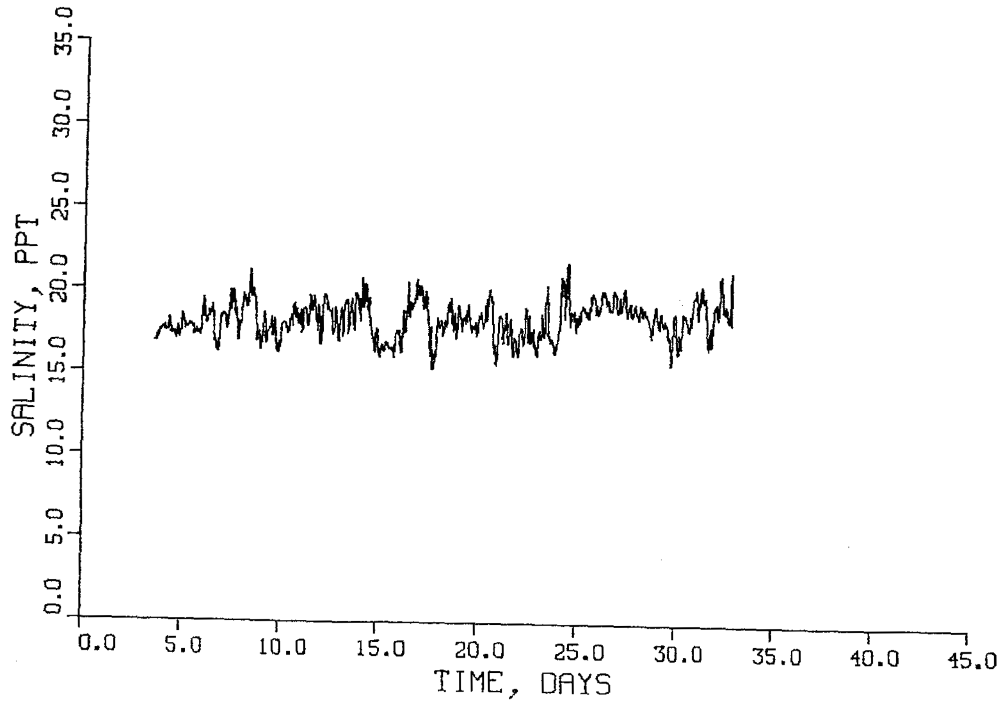
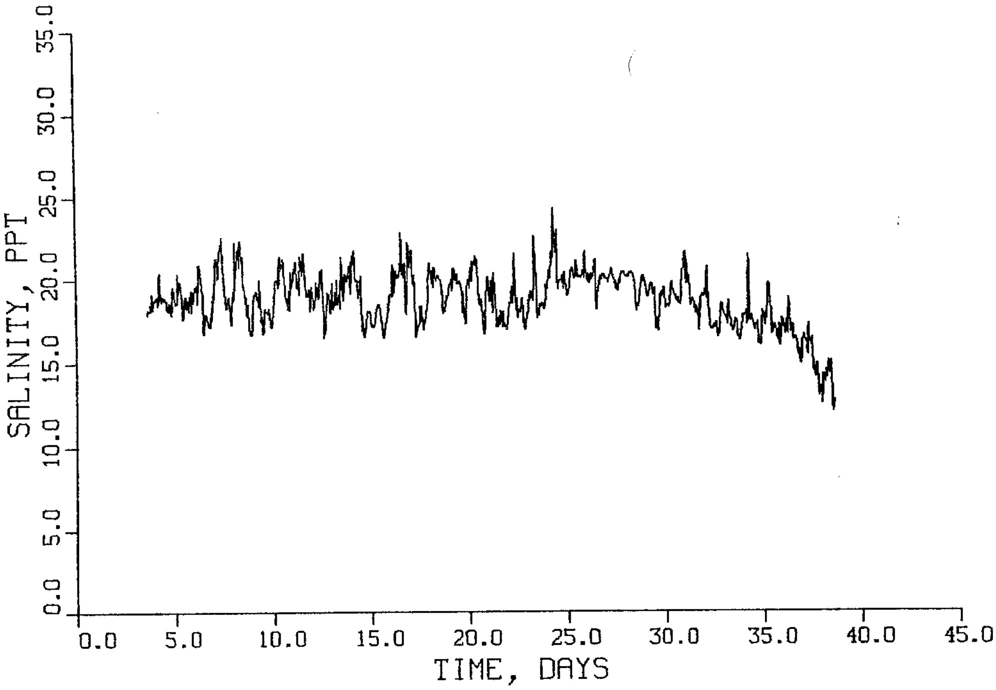
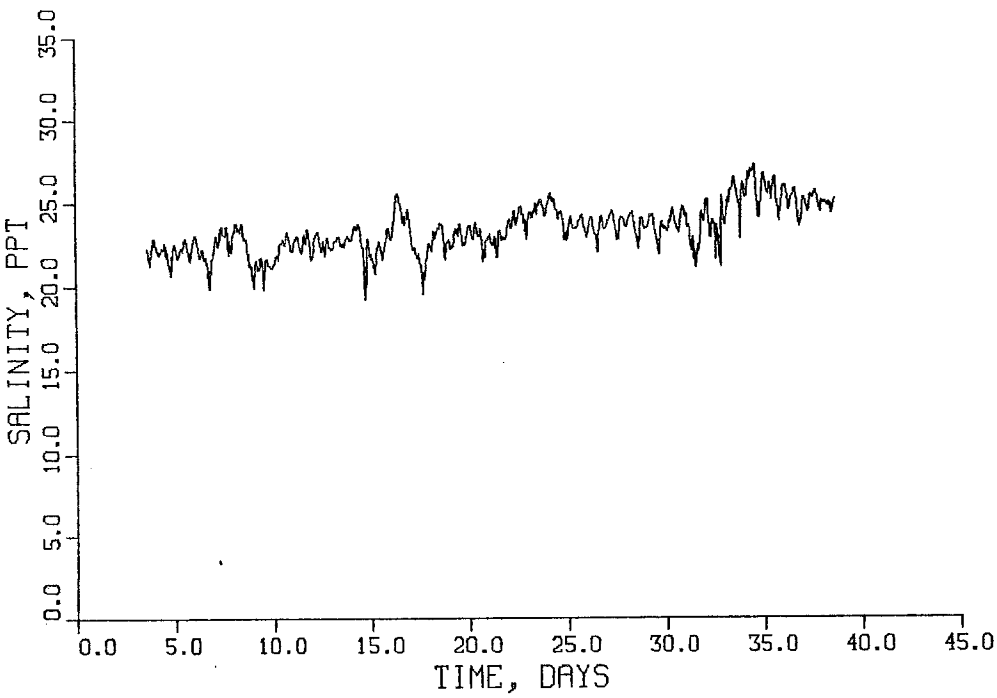


Figure 53. Salinity at station WT1 at depth of 9 ft from CRIMP data



a. Depth = 9 ft



b. Depth = 30 ft

Figure 54. Salinity at station WT2 from CRIMP data

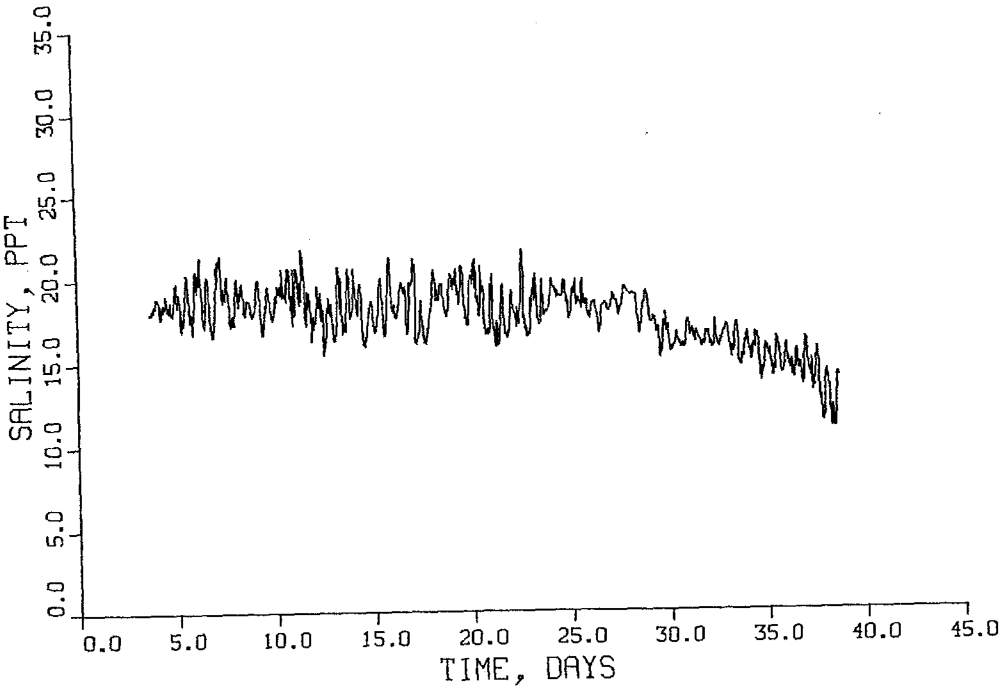
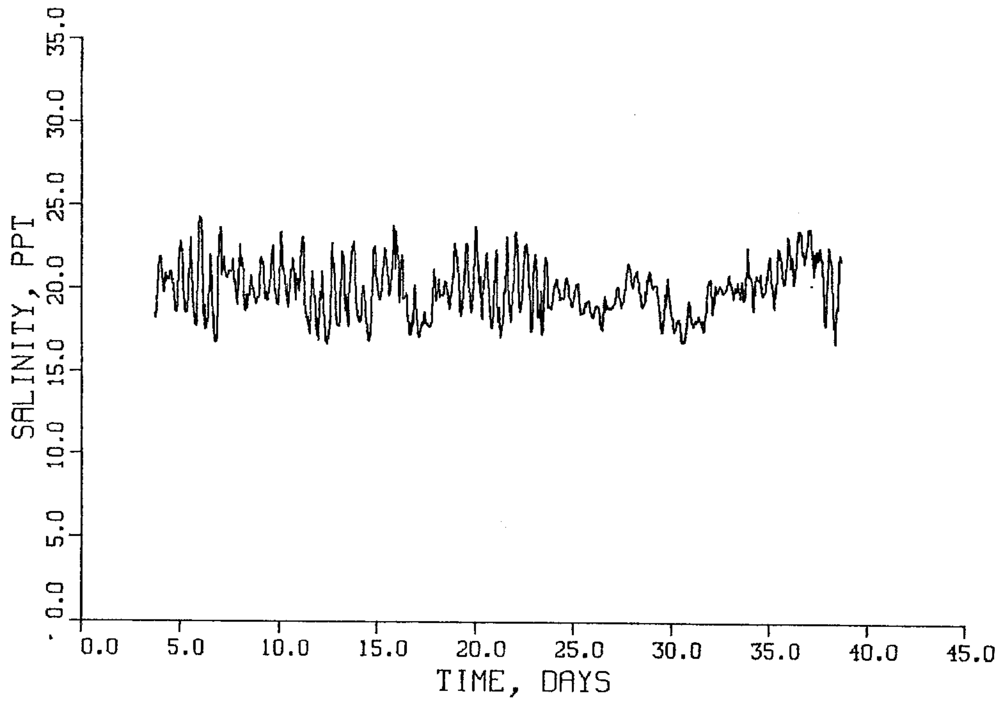
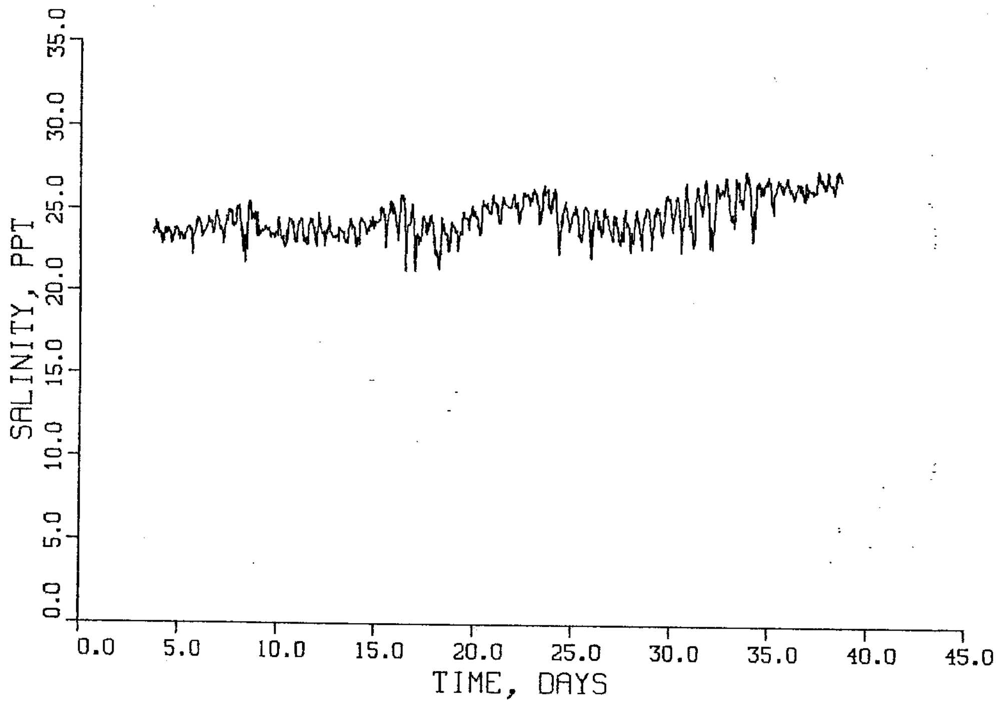


Figure 55. Salinity at station WT3 at a depth of 9 ft from CRIMP data



a. Depth = 9 ft



b. Depth = 30 ft

Figure 56. Salinity at station WT4 from CRIMP data

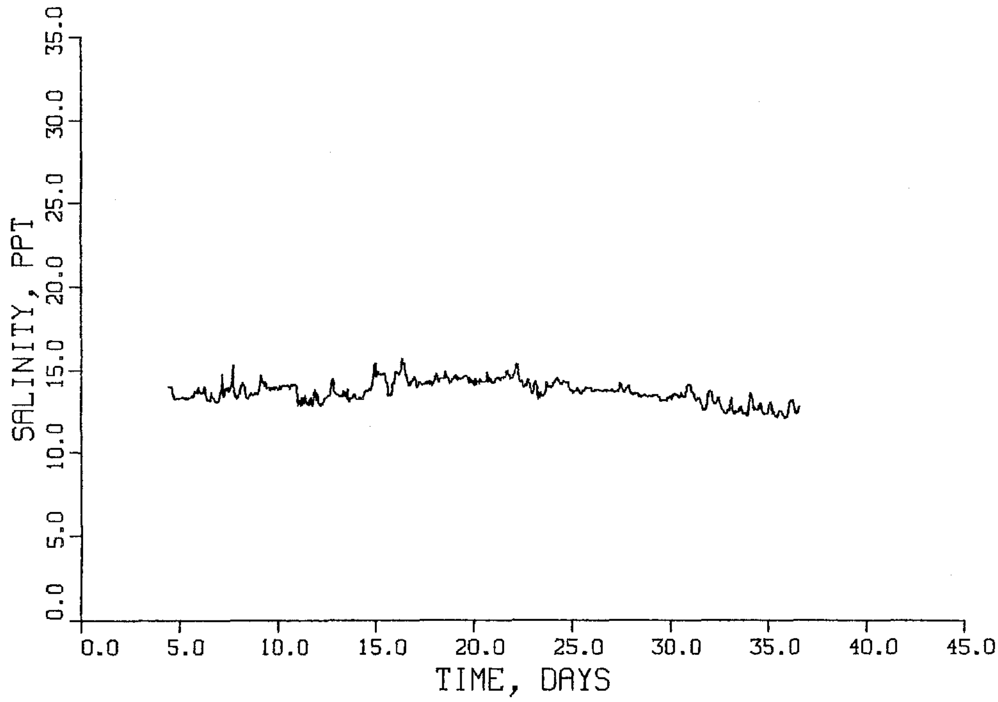


Figure 57. Salinity at station SP2 at a depth of 9 ft from CRIMP data

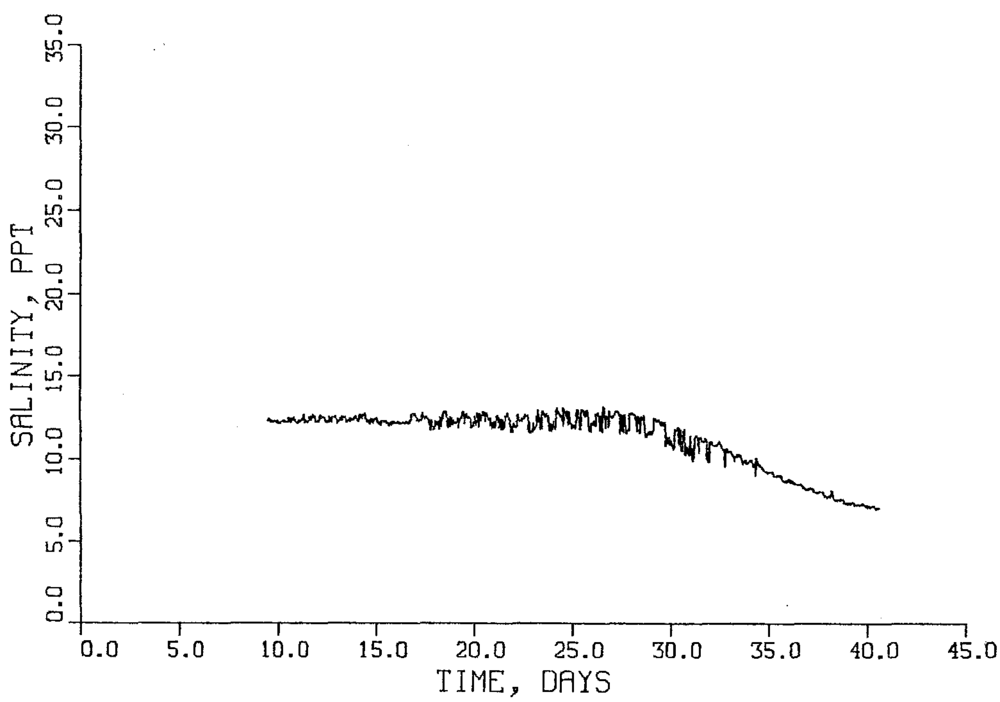


Figure 58. Salinity at station PX1 at a depth of 12 ft from CRIMP data

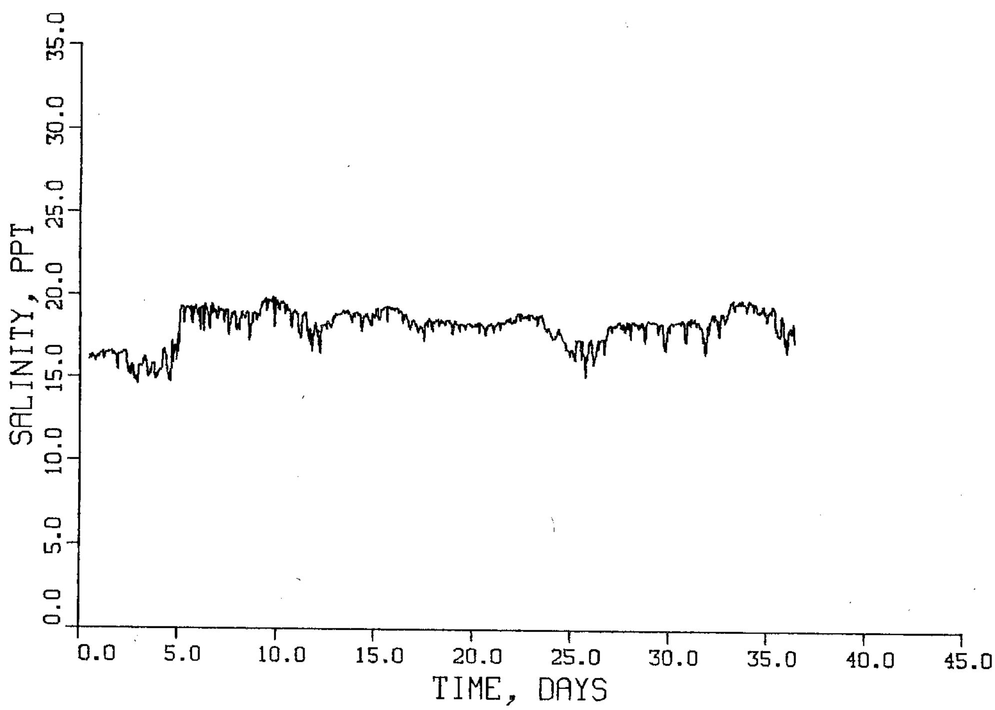
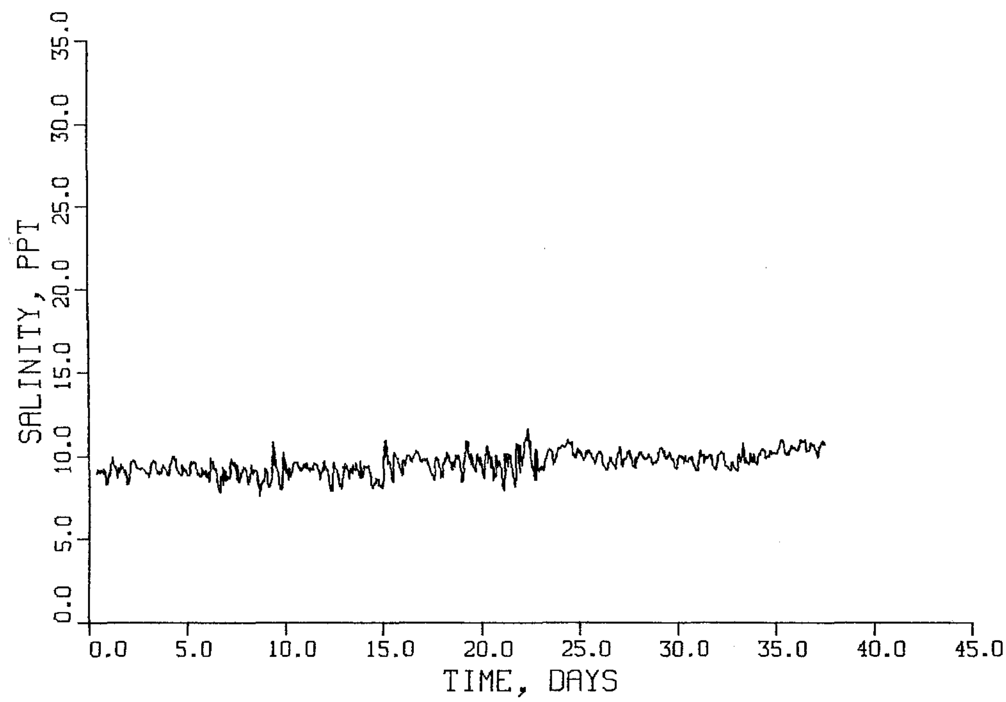
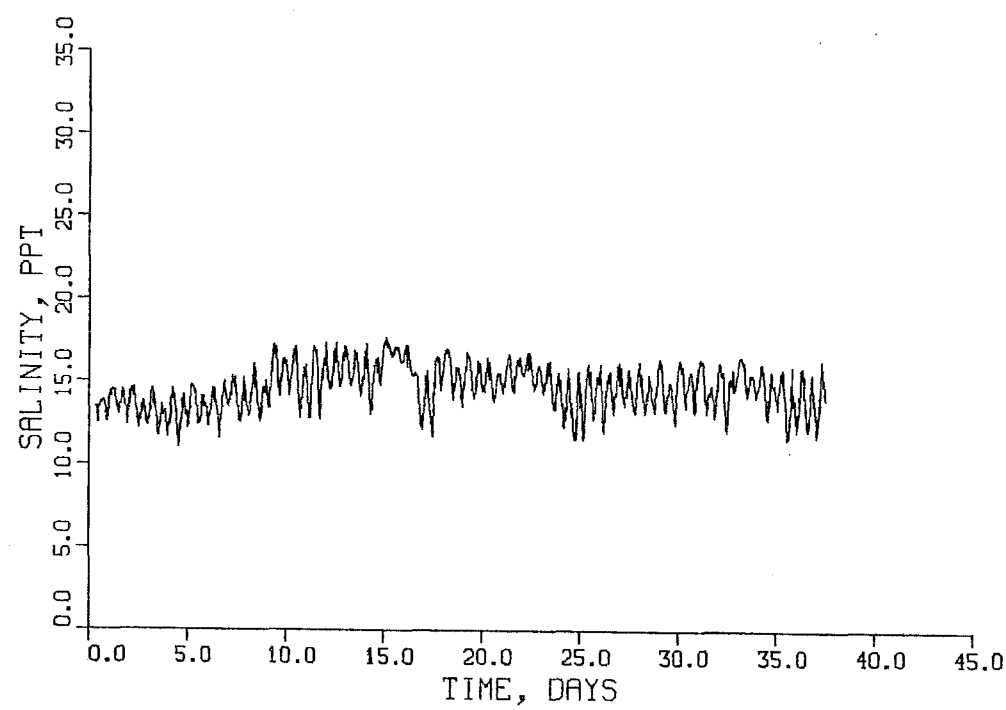


Figure 59. Salinity at station CC1 at a depth of 56 ft from CRIMP data

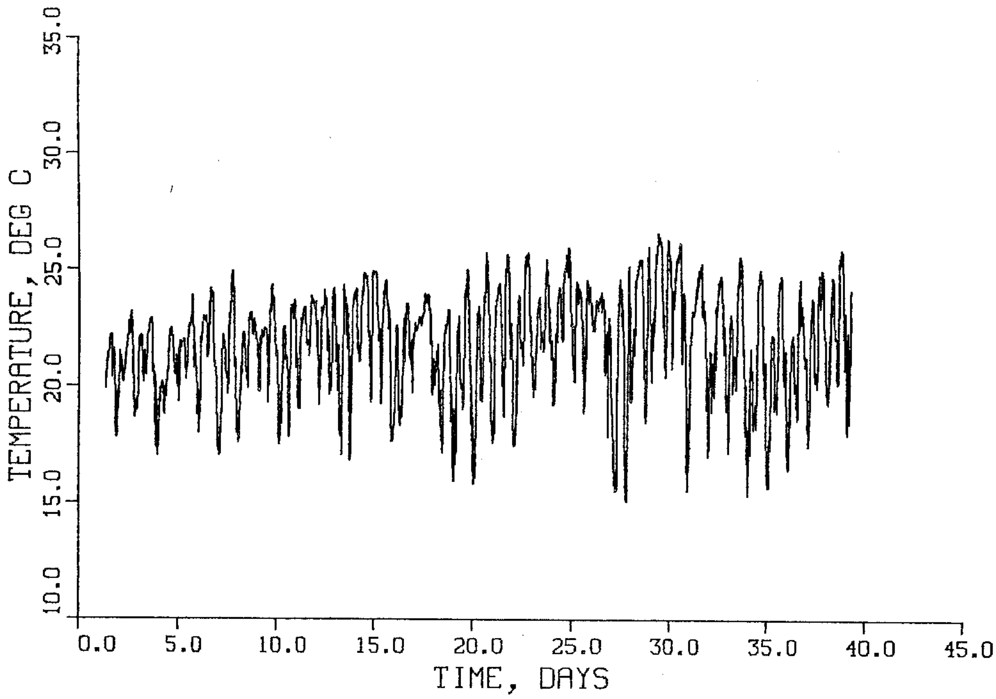


a. Depth = 9 ft

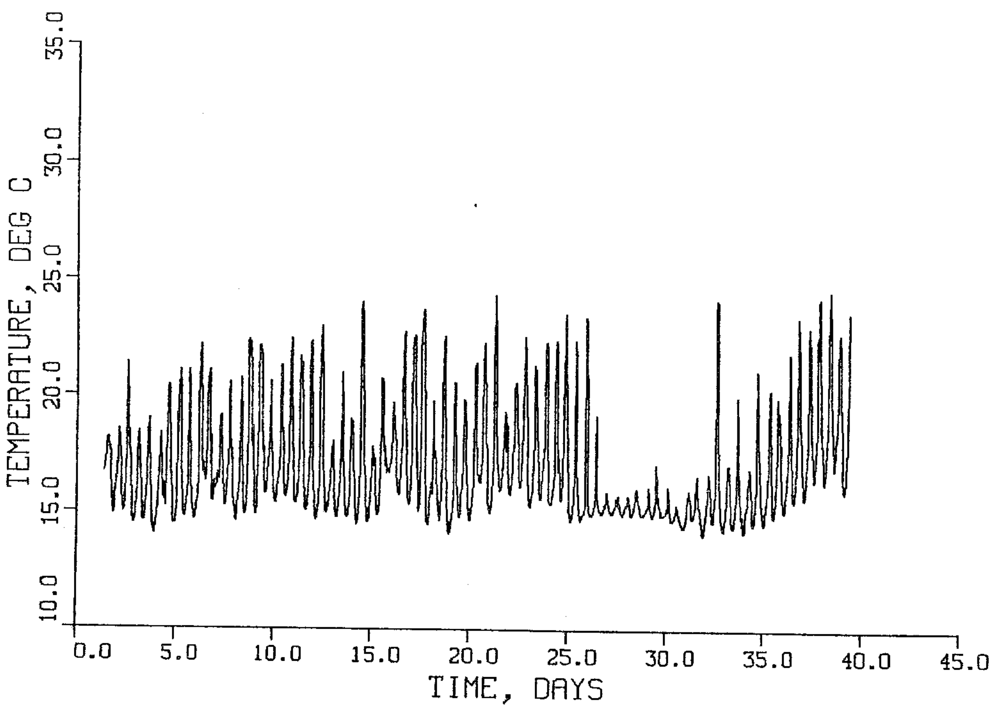


b. Depth = 50 ft

Figure 60. Salinity at station BB1 from CRIMP data

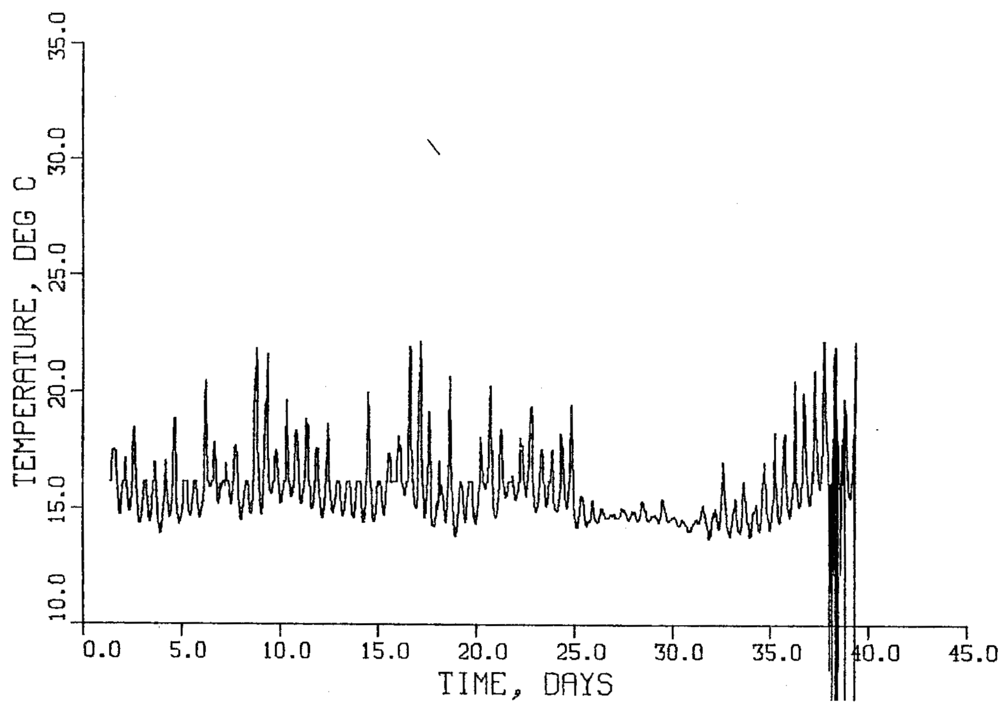


a. Depth = 9 ft



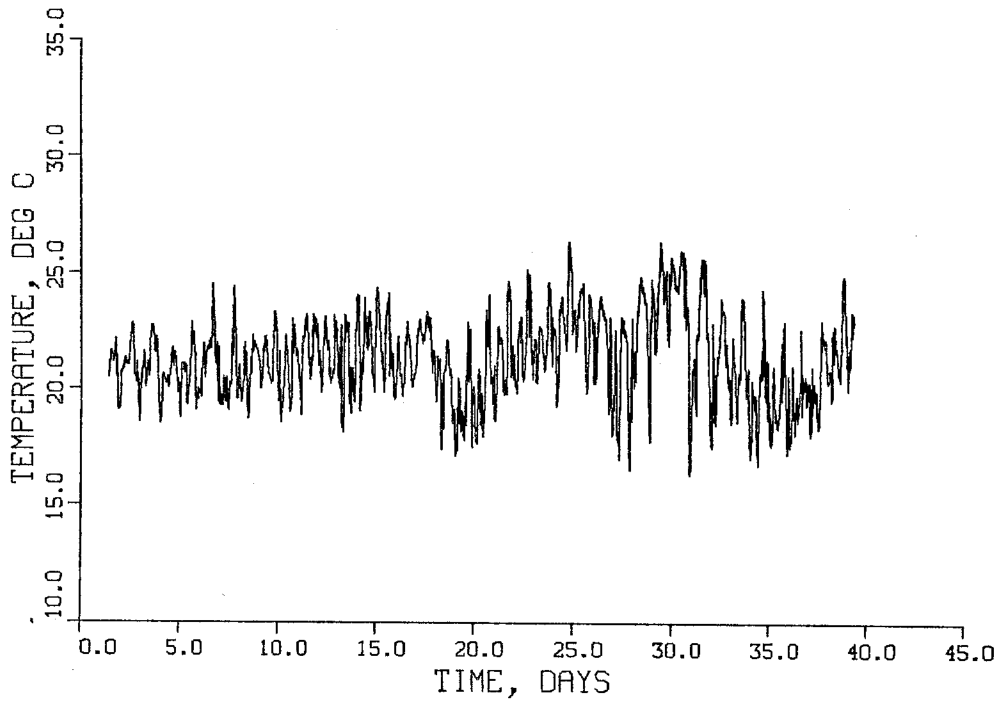
b. Depth = 35 ft

Figure 61. Temperature at station M1 from CRIMP data (Continued)

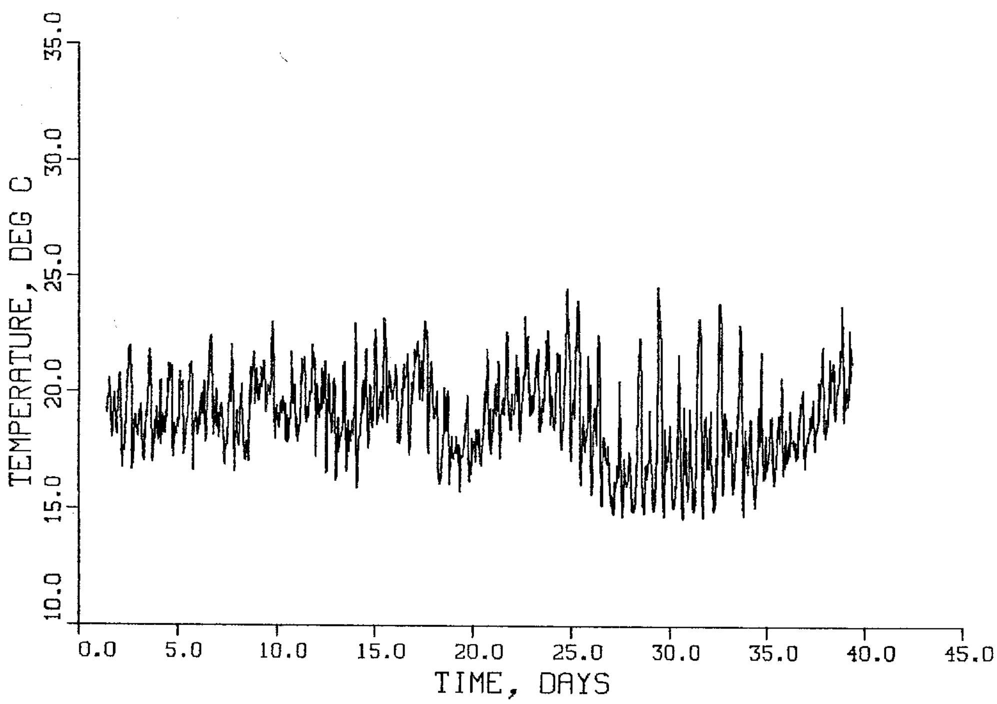


c. Depth = 50 ft

Figure 61. (Concluded)

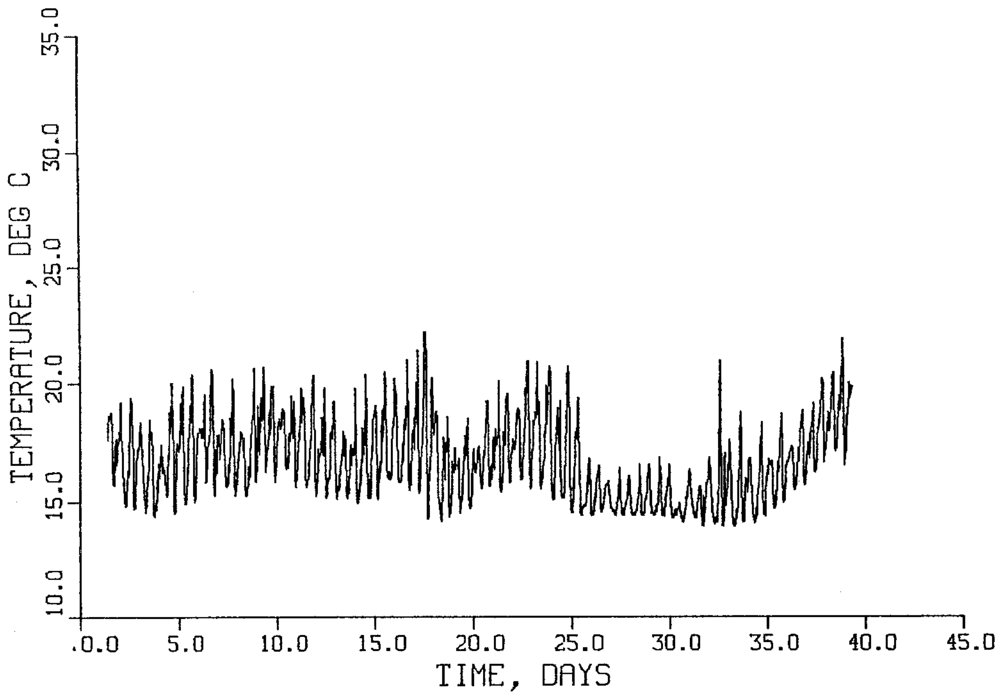


a. Depth = 9 ft

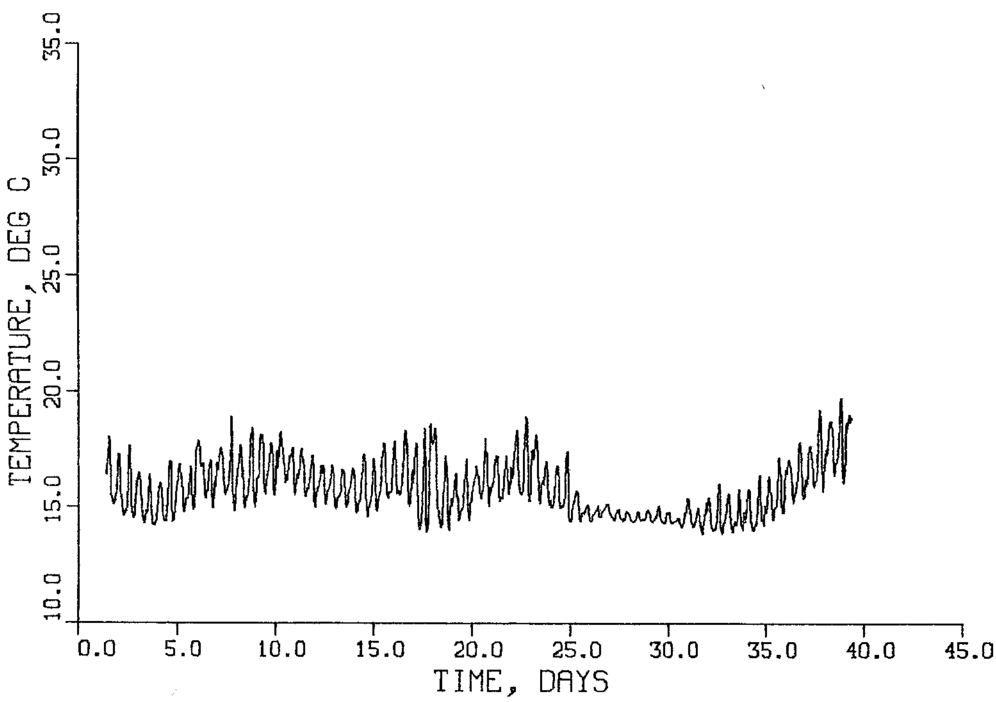


b. Depth = 20 ft

Figure 62. Temperature at station M2 from CRIMP data (Continued)

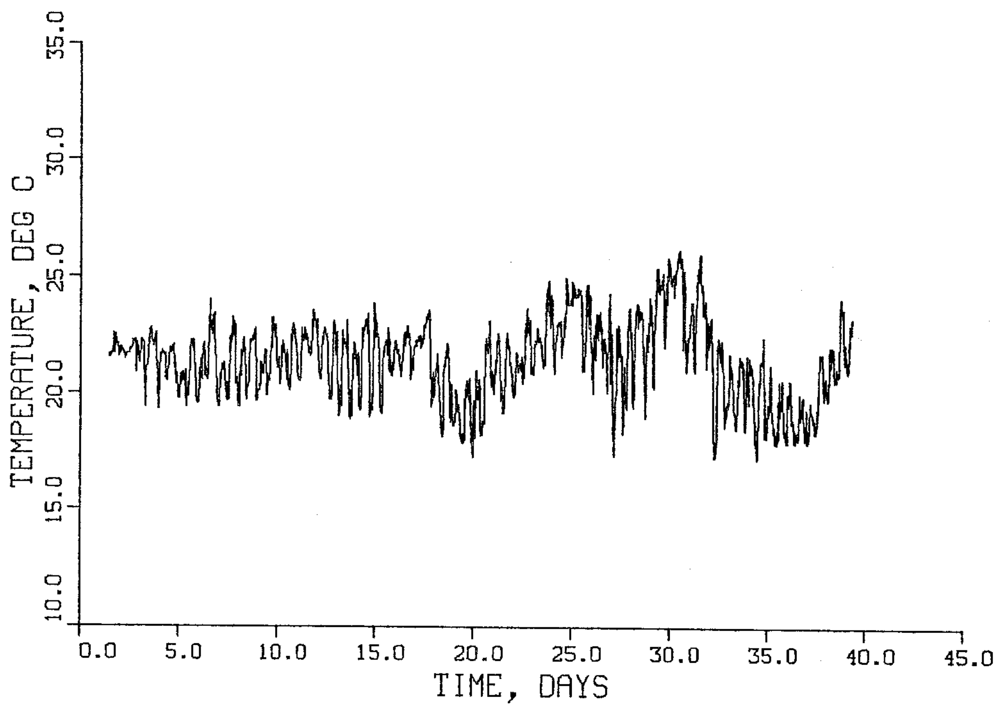


c. Depth = 35 ft

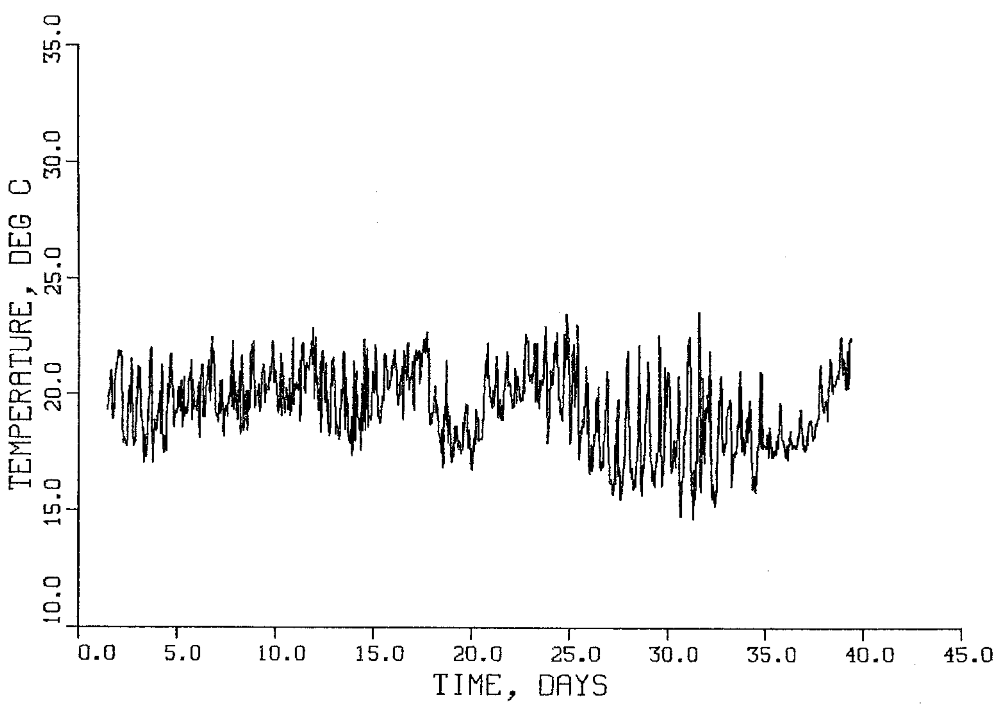


d. Depth = 50 ft

Figure 62. (Concluded)

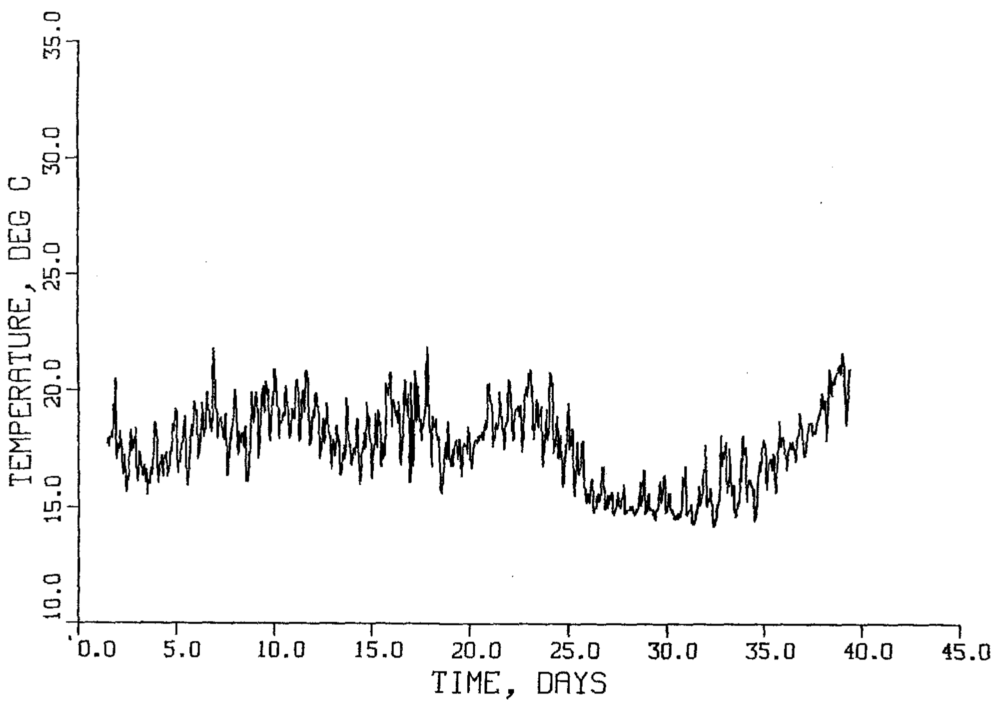


a. Depth = 9 ft



b. Depth = 20 ft

Figure 63. Temperature at station M3 from CRIMP data (Continued)



c. Depth = 32 ft

Figure 63. (Concluded)

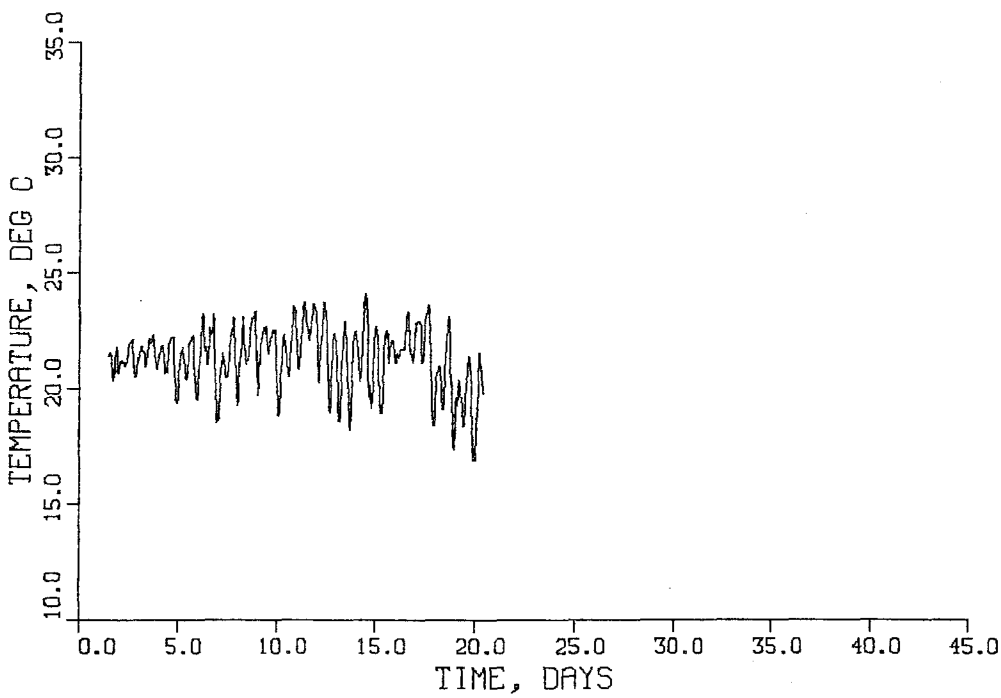
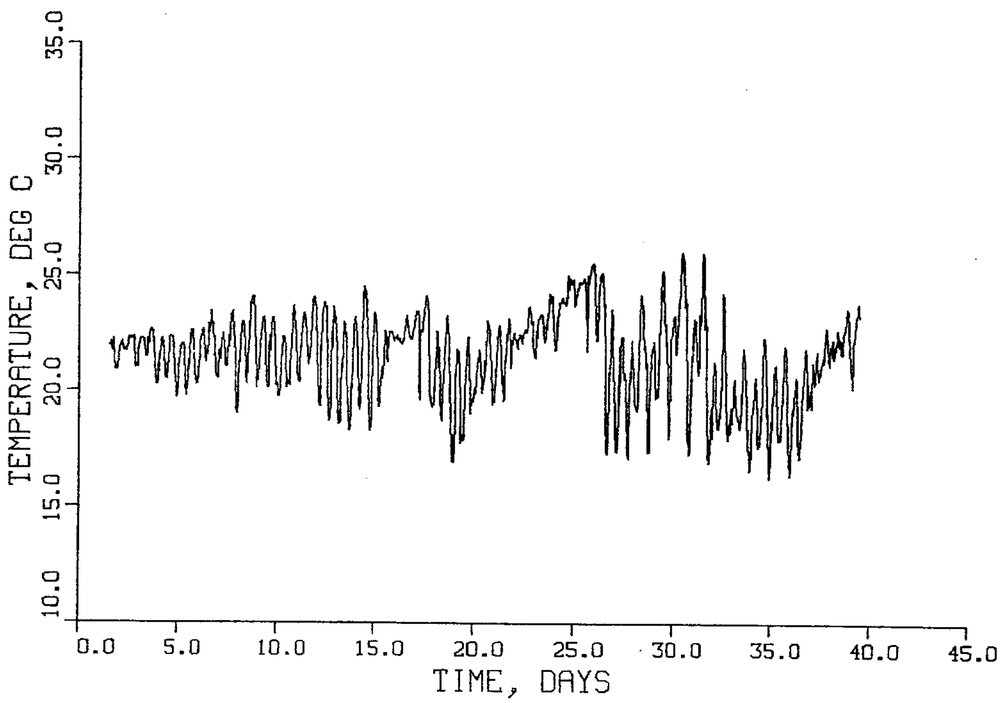
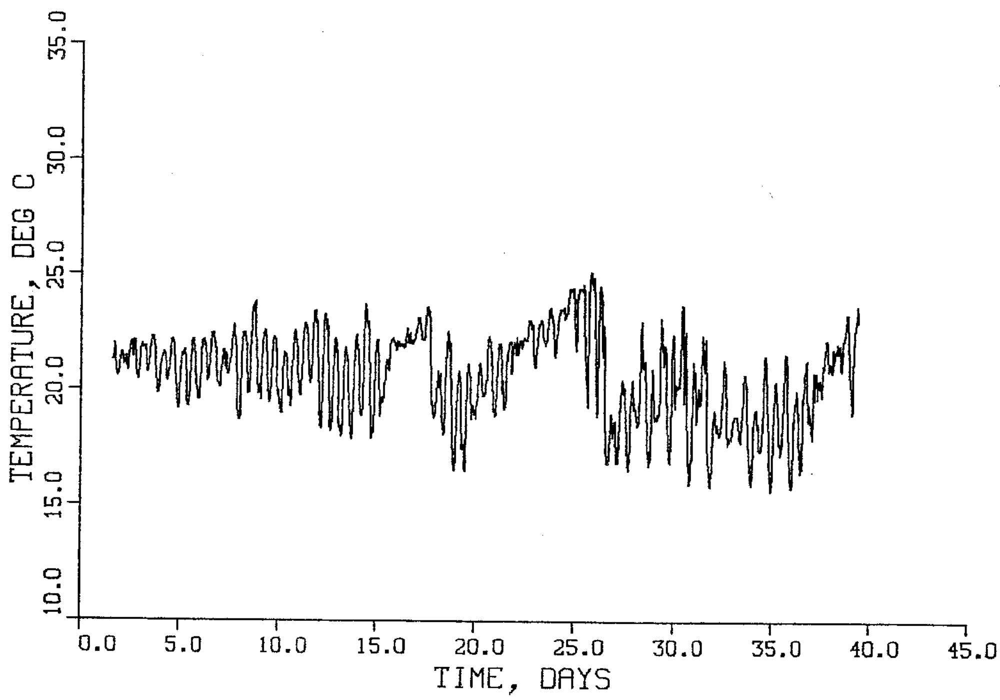


Figure 64. Temperature at station M4 at a depth of 10 ft from CRIMP data



a. Depth = 9 ft



b. Depth = 30 ft

Figure 65. Temperature at station M5 from CRIMP data

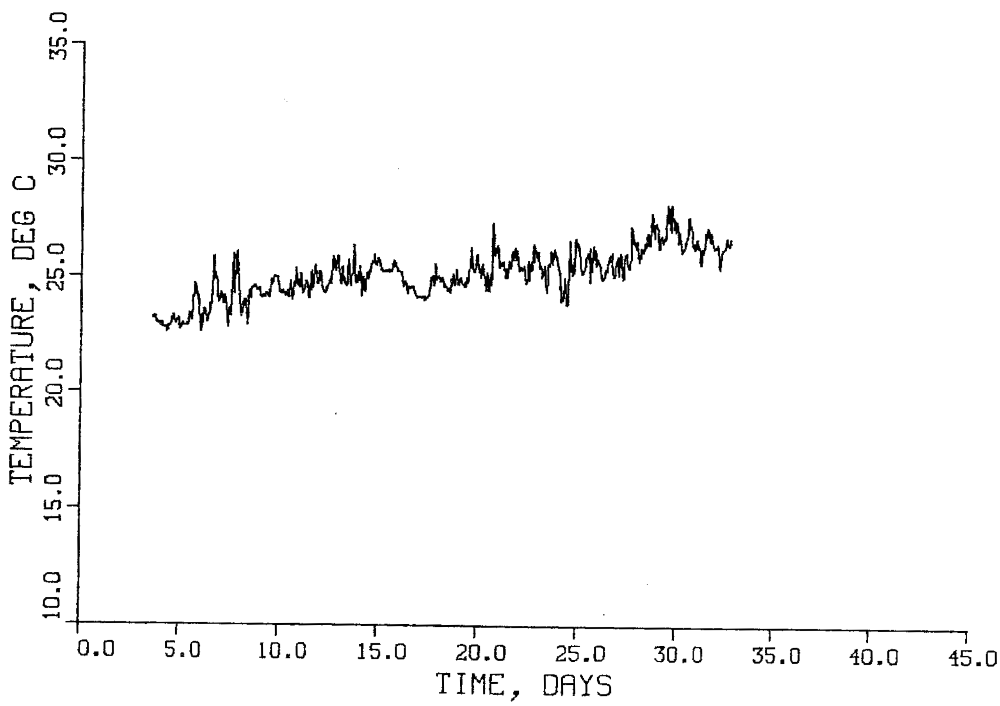
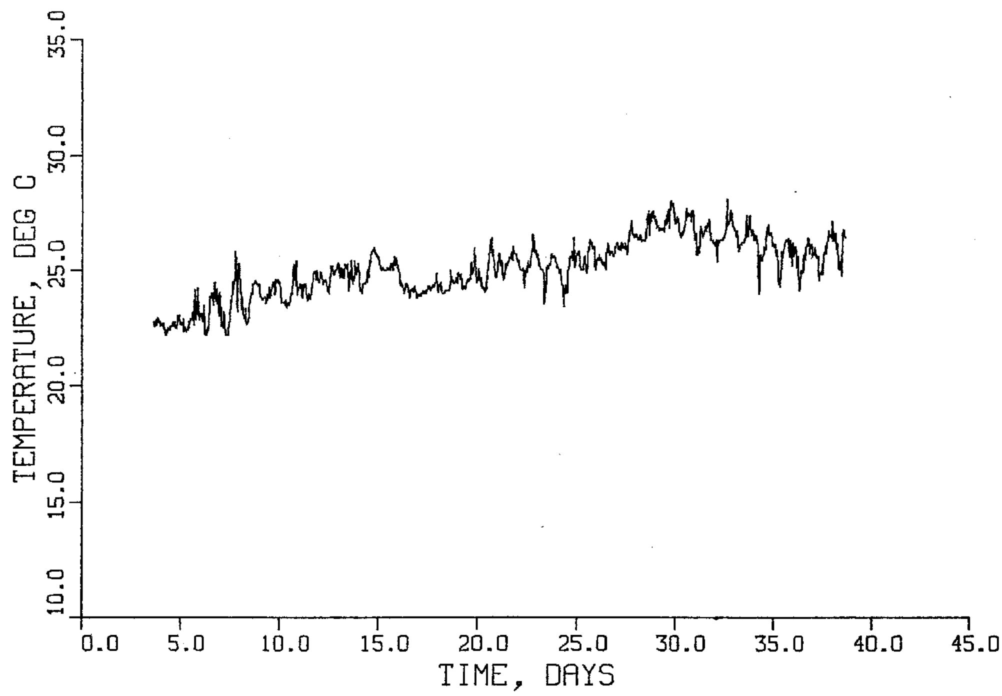
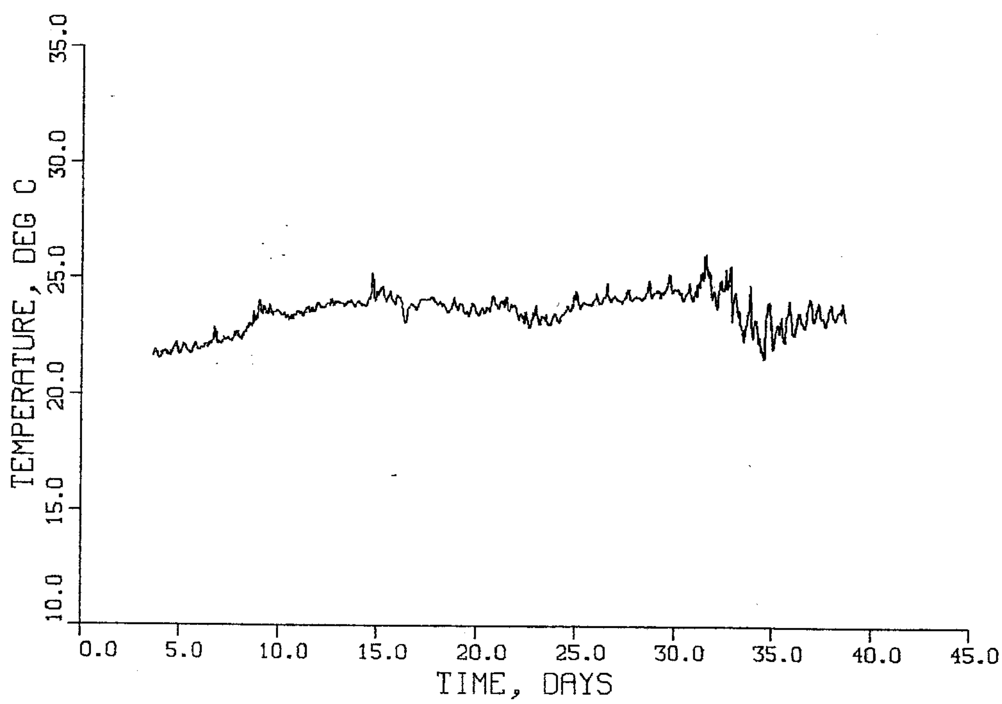


Figure 66. Temperature at station WT1 at a depth of 9 ft from CRIMP data

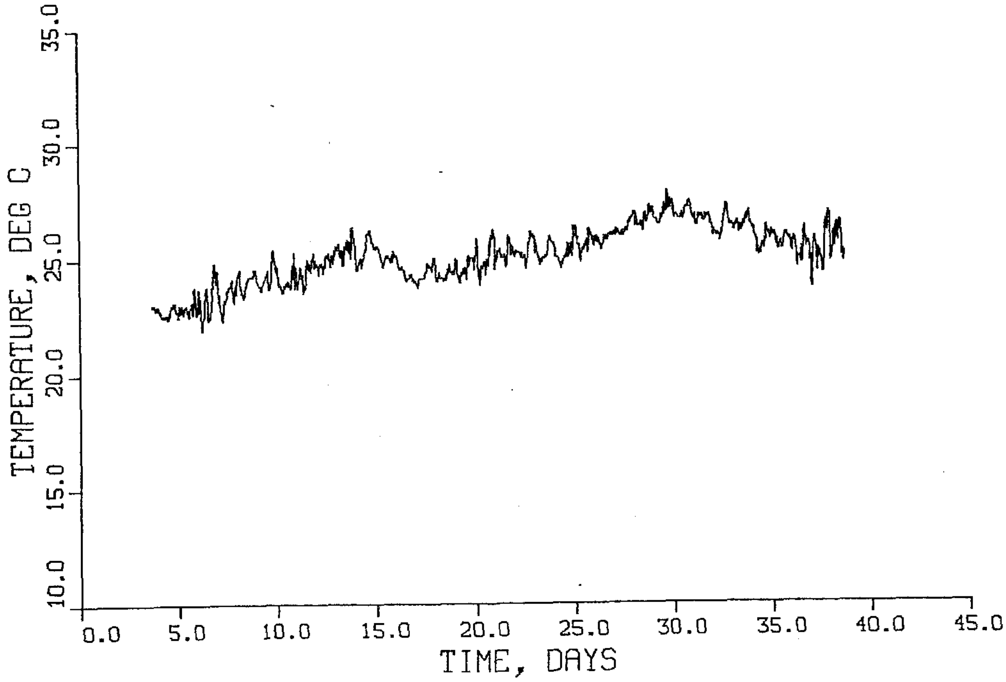


a. Depth = 9 ft

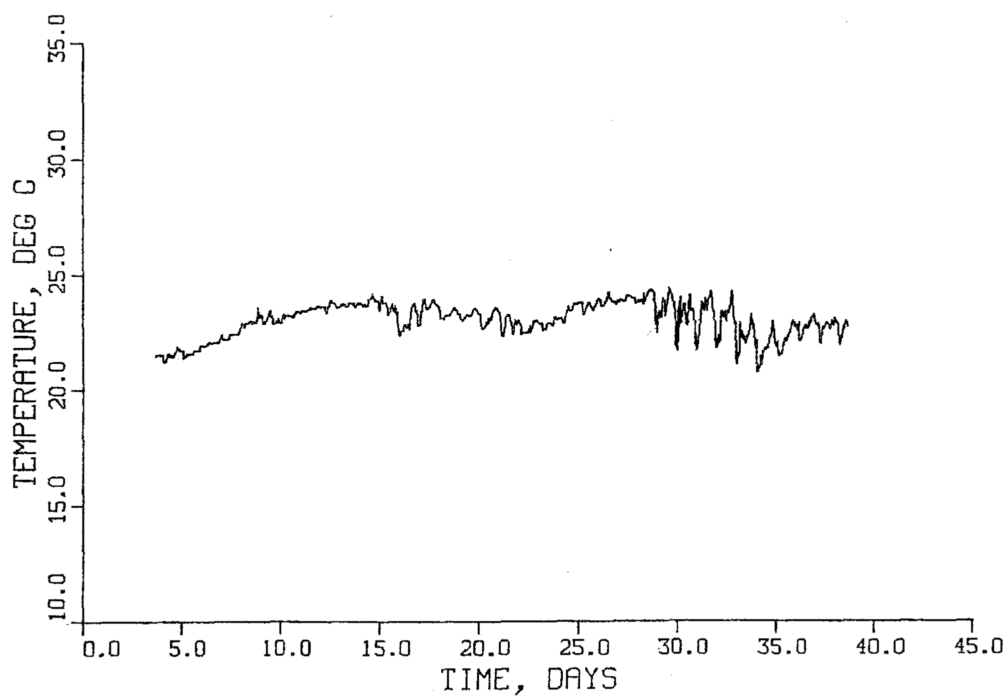


b. Depth = 30 ft

Figure 67. Temperature at station WT2 from CRIMP data

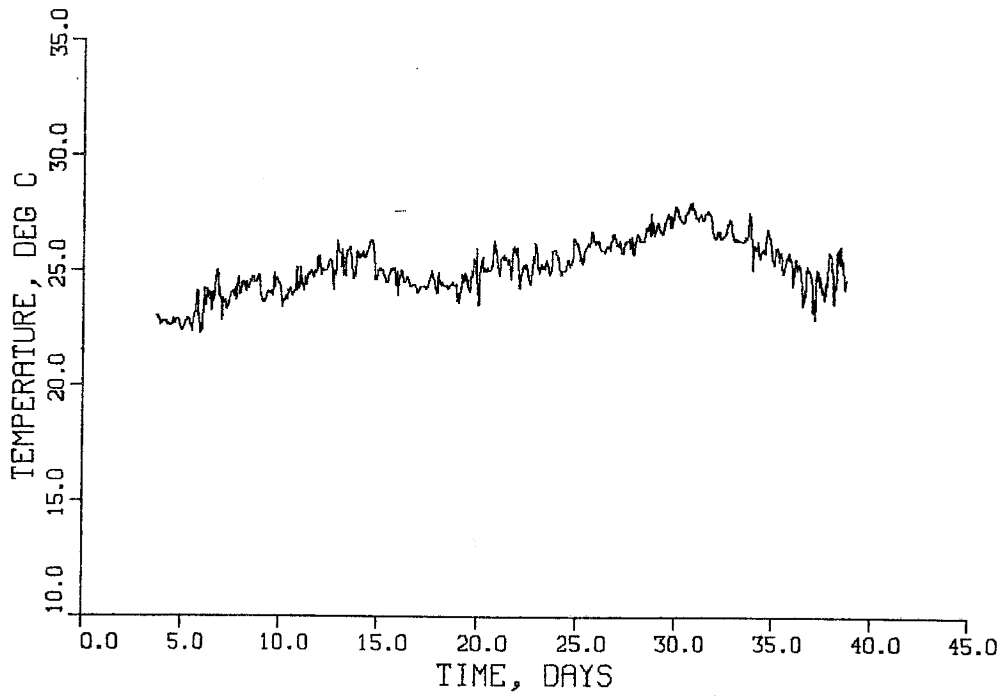


a. Depth = 9 ft

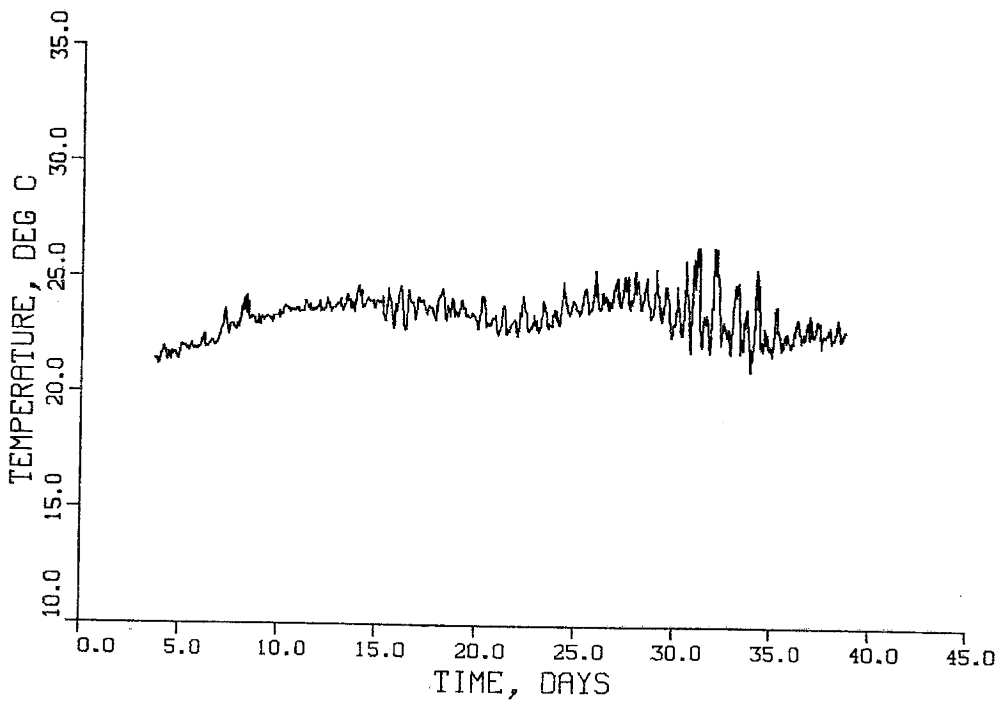


b. Depth = 30 ft

Figure 68. Temperature at station WT3 from CRIMP data

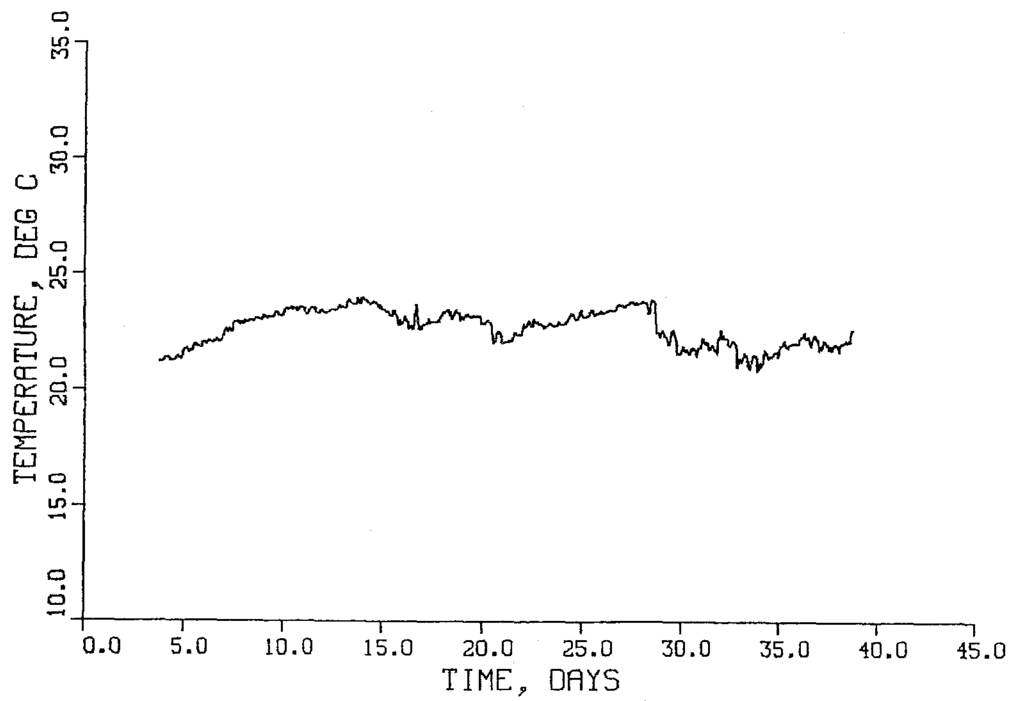


a. Depth = 9 ft



b. Depth = 30 ft

Figure 69. Temperature at station WT4 from CRIMP data
(Continued)



c. Depth = 58 ft

Figure 69. (Concluded)

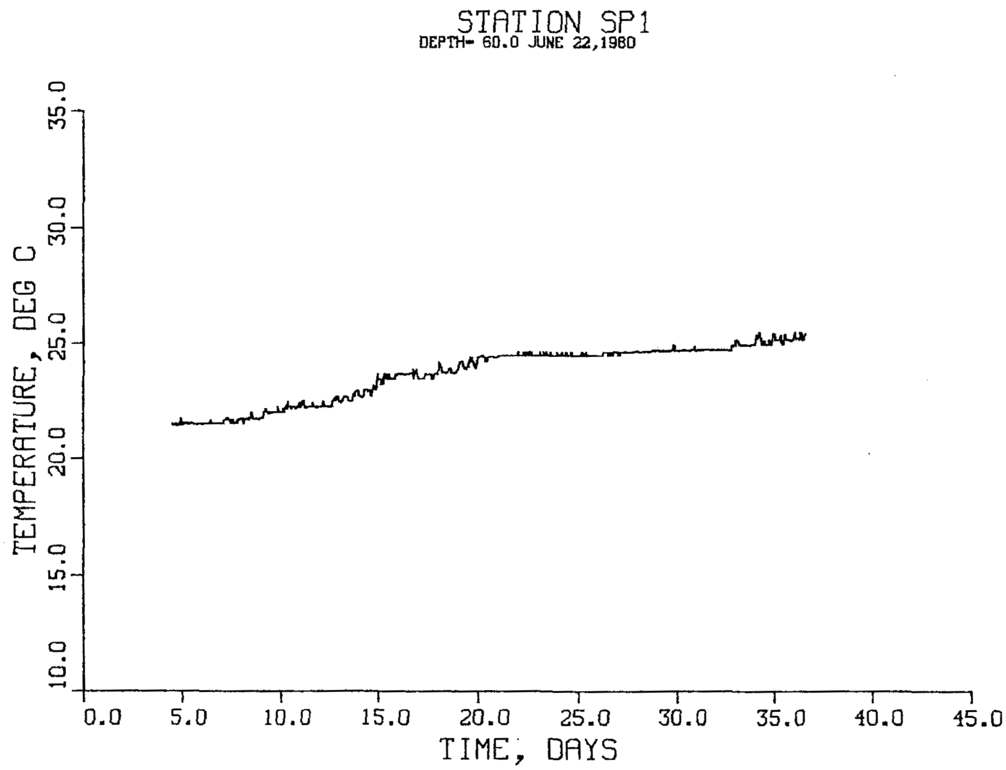
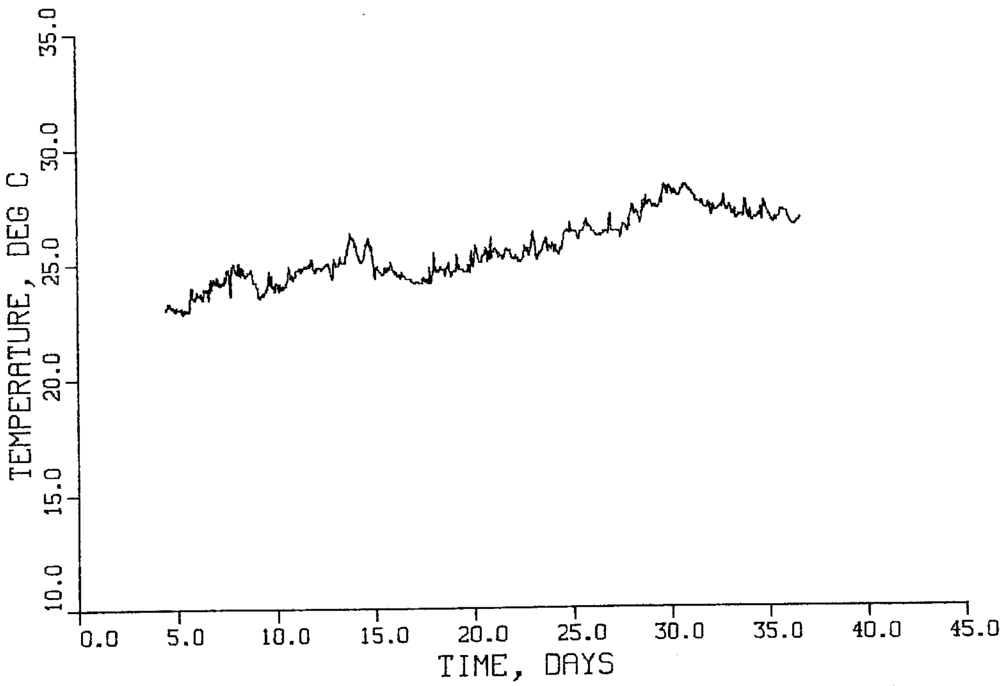
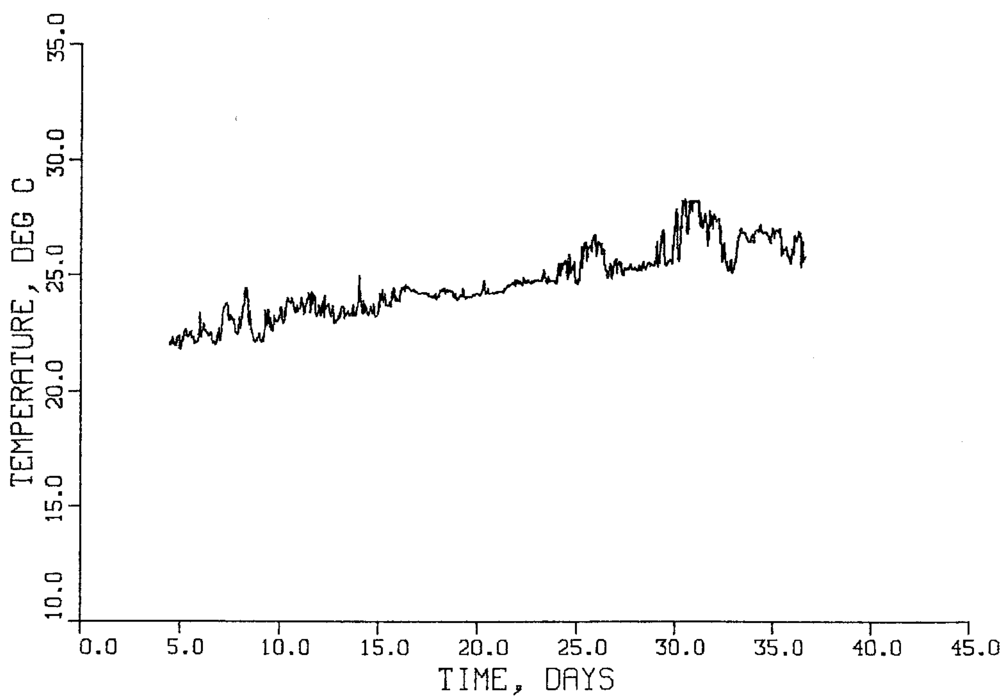


Figure 70. Temperature at station SP1 at a depth of 60 ft from CRIMP data



a. Depth = 9 ft



b. Depth = 27 ft

Figure 71. Temperature at station SP2 from CRIMP data

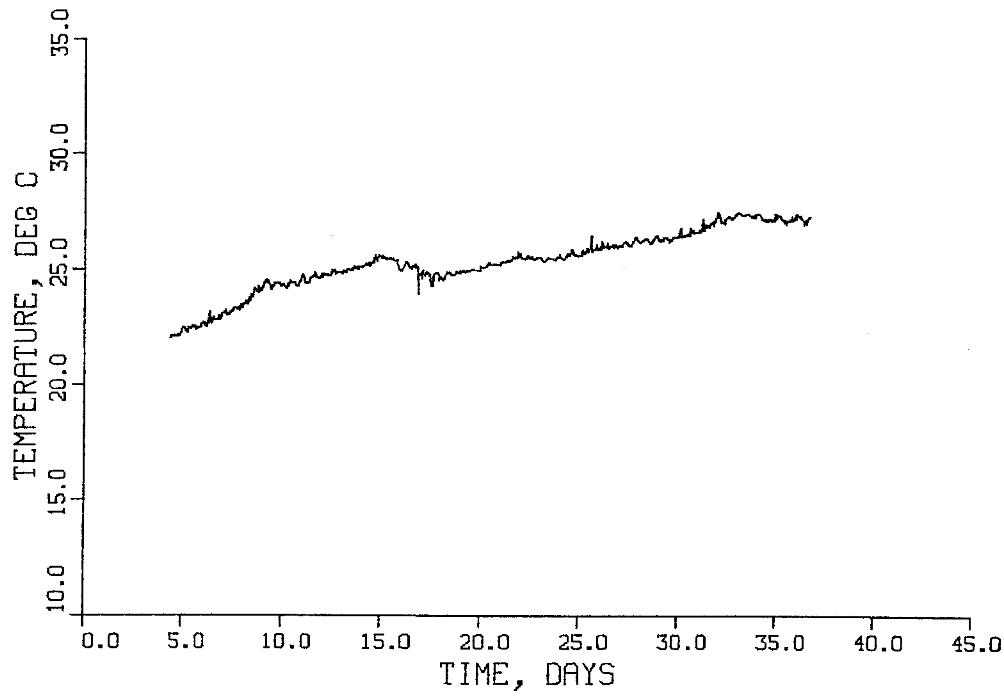


Figure 72. Temperature at station TS1 at a depth of 55 ft from CRIMP data

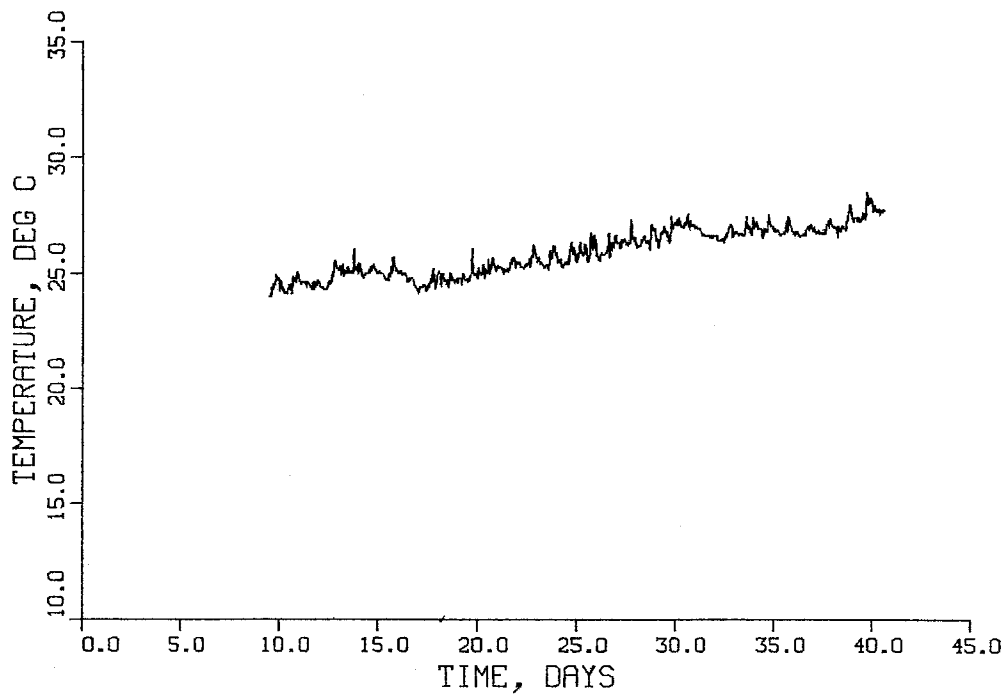


Figure 73. Temperature at station PX1 at a depth of 12 ft from CRIMP data

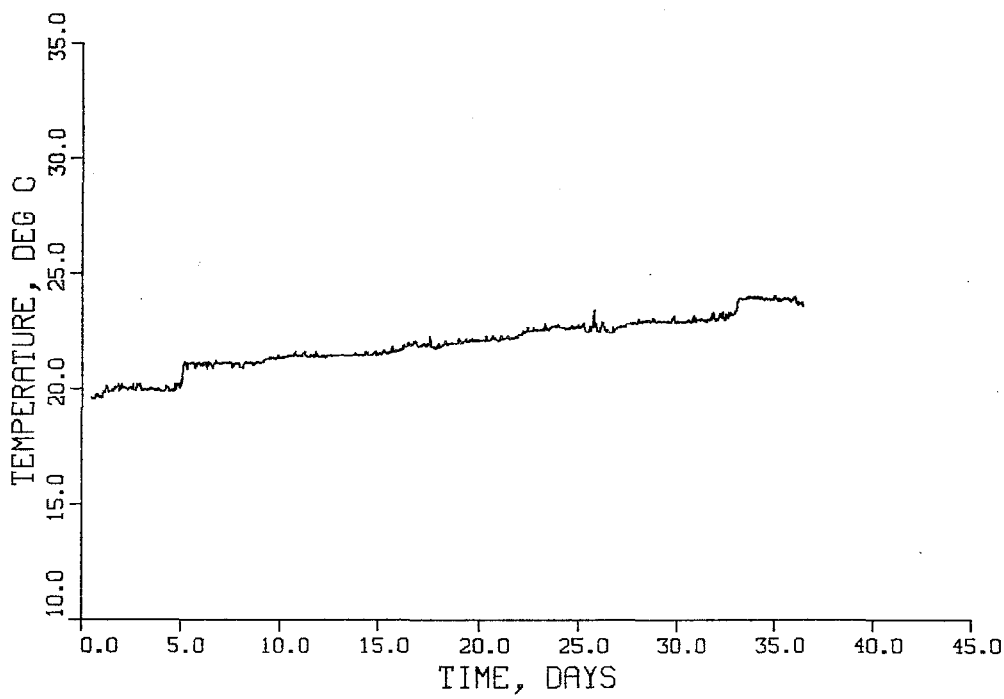
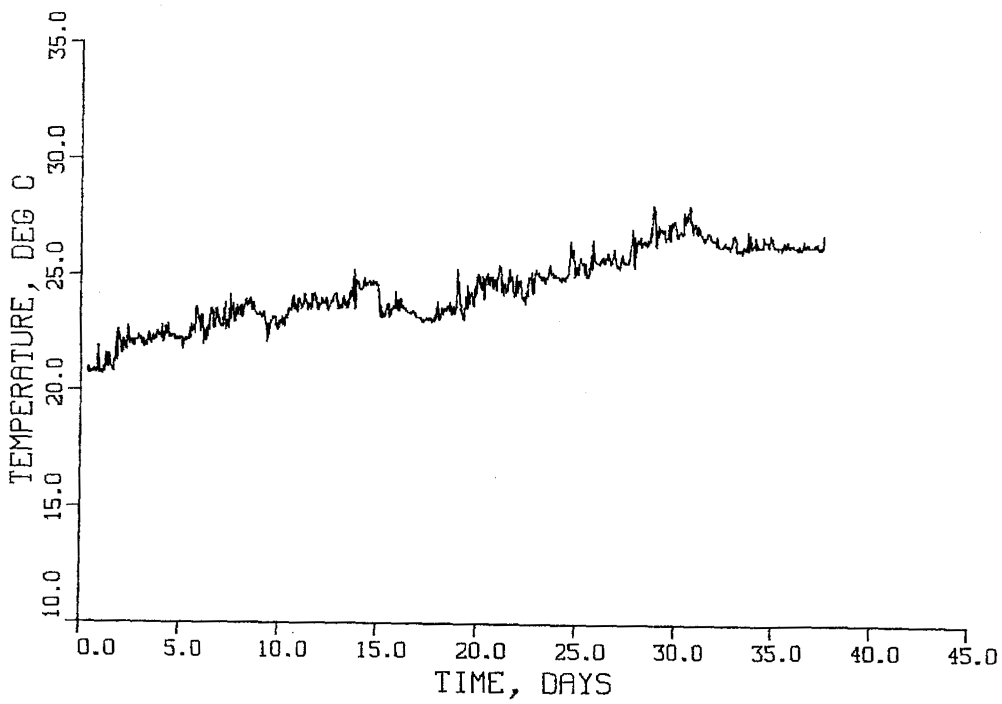
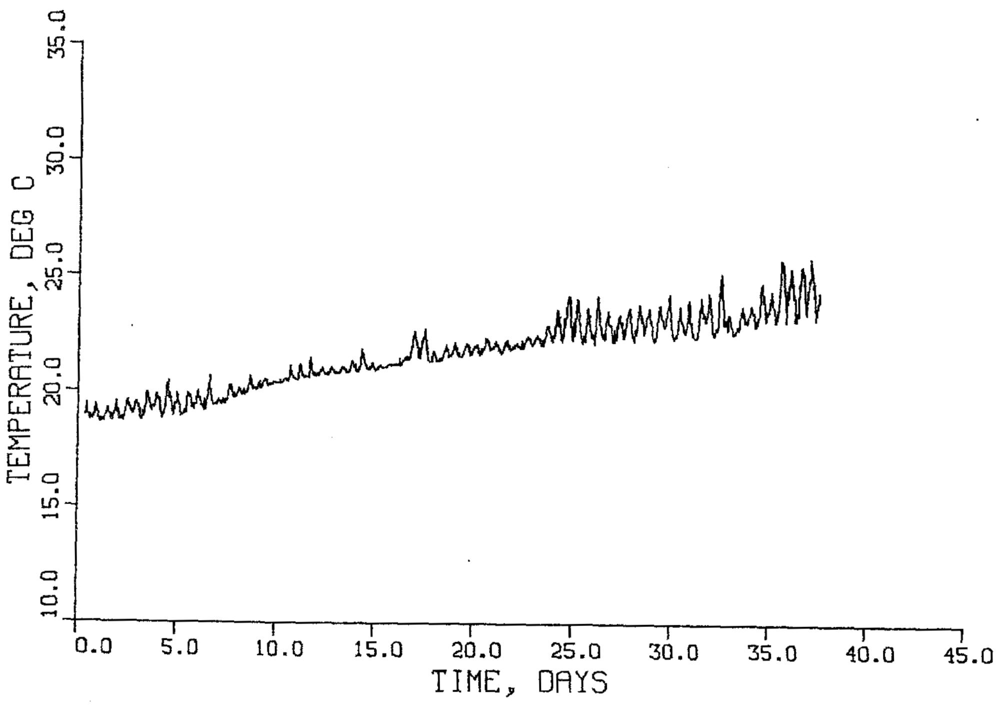


Figure 74. Temperature at station C1 at a depth of 56 ft from CRIMP data



a. Depth = 9 ft



b. Depth = 50 ft

Figure 75. Temperature at station BB1 from CRIMP data

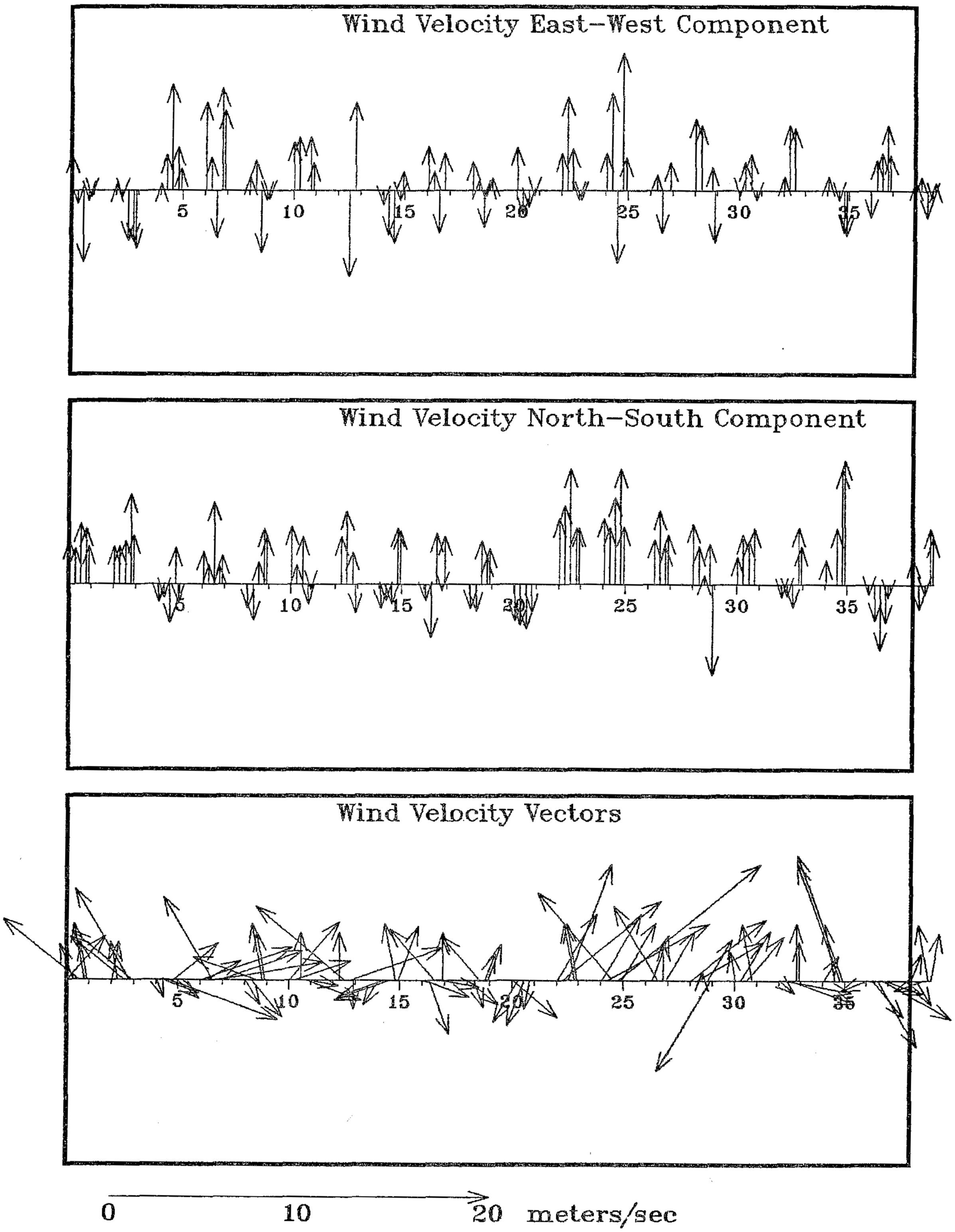


Figure 76. Wind data at the Patuxent Naval Air Station from CRIMP data

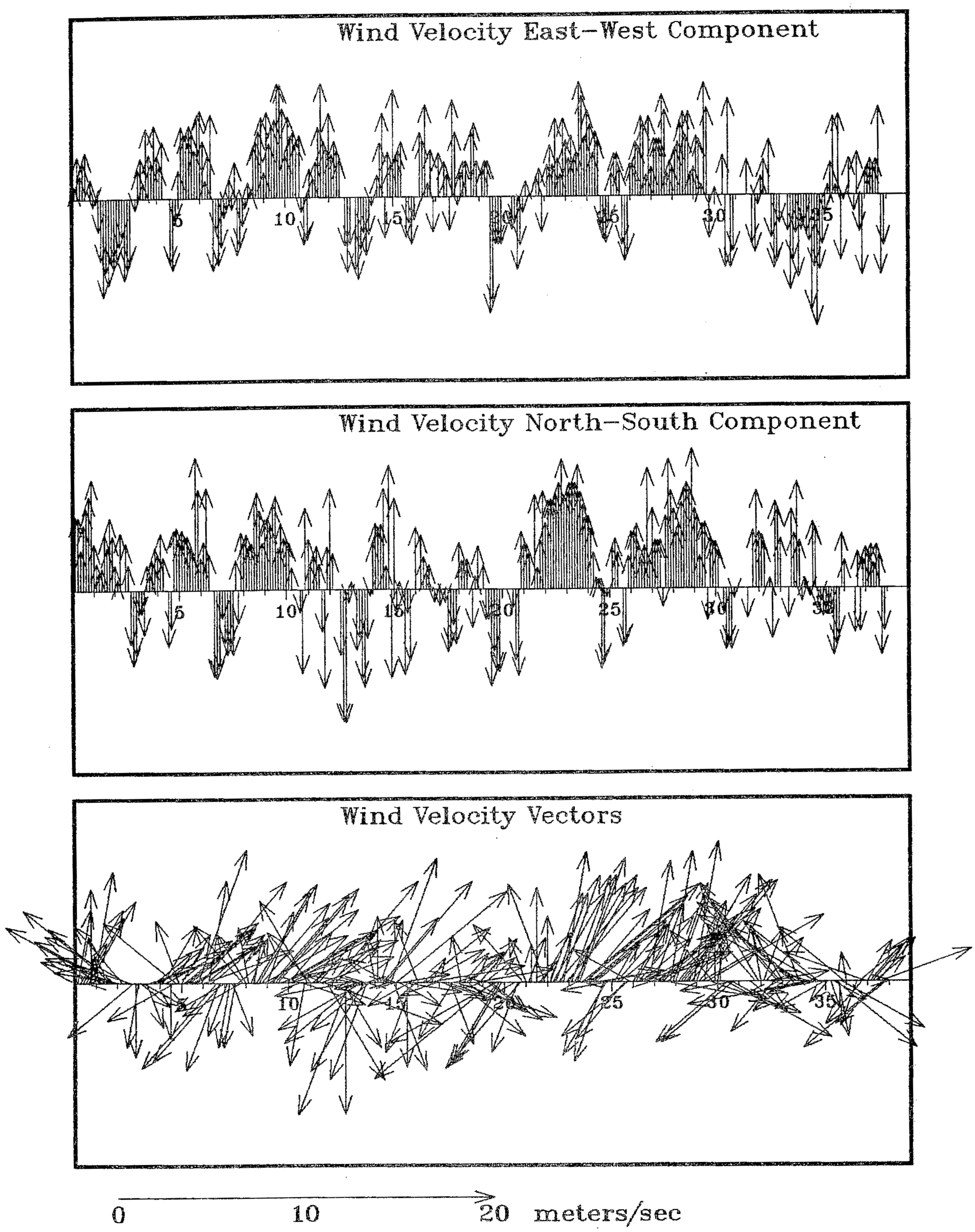


Figure 77. Wind data at Norfolk International Airport from CRIMP data

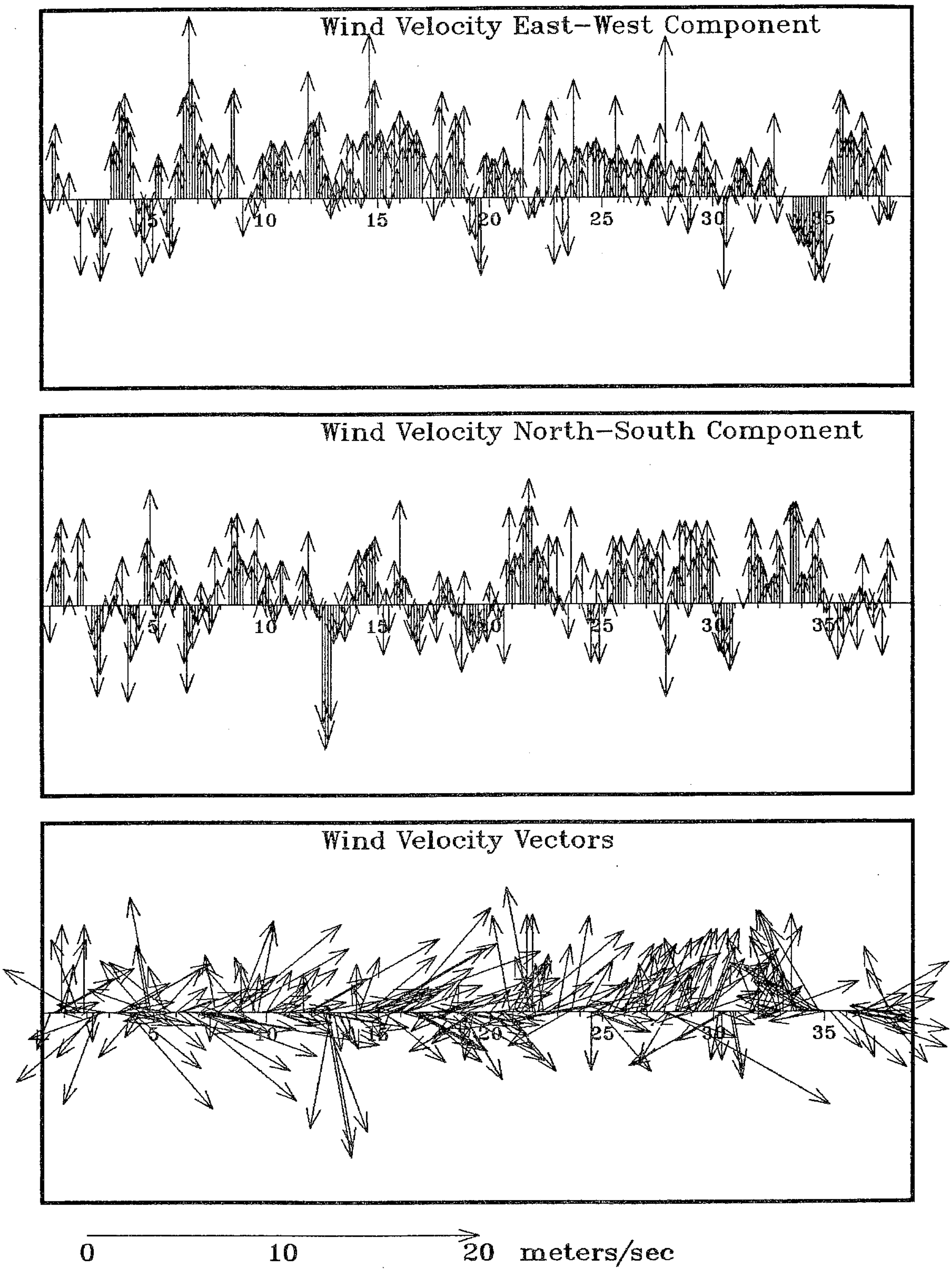
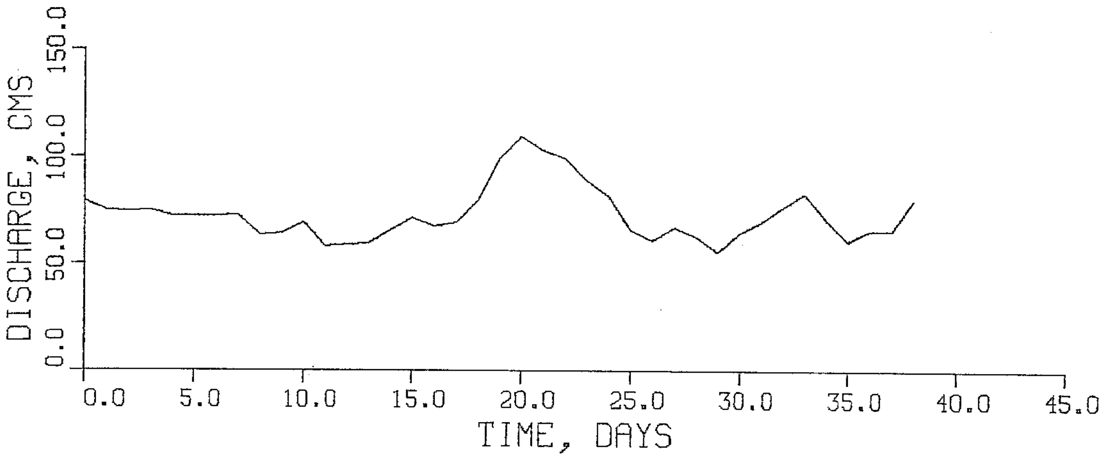
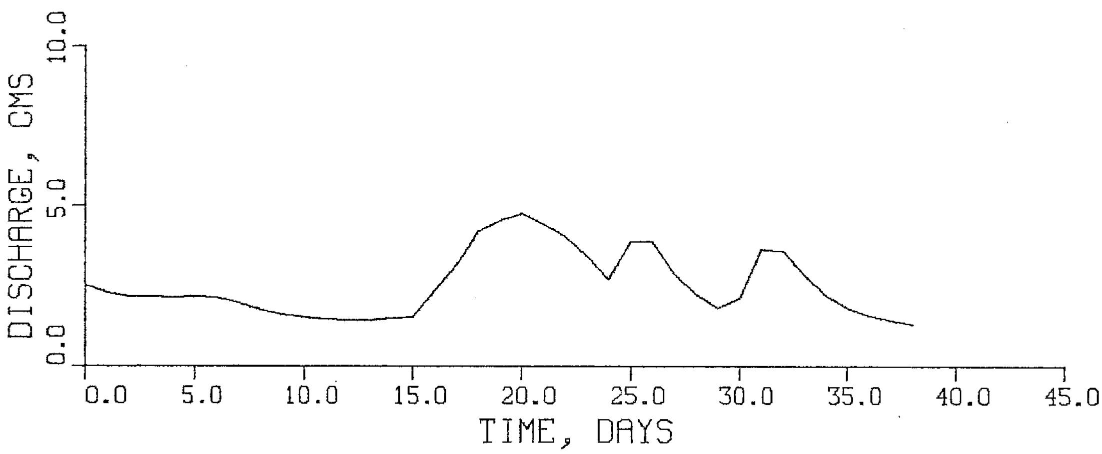


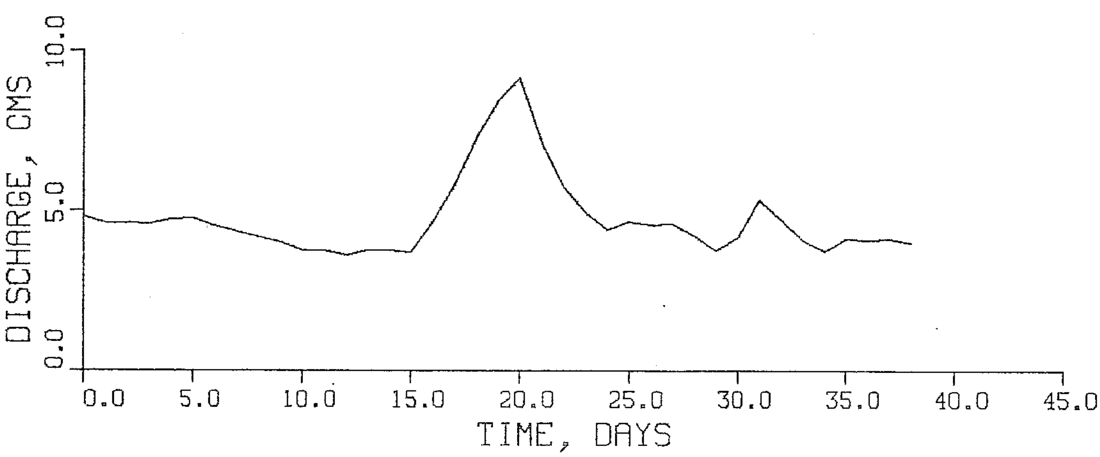
Figure 78. Wind data at Baltimore–Washington International Airport from CRIMP data



a. James River

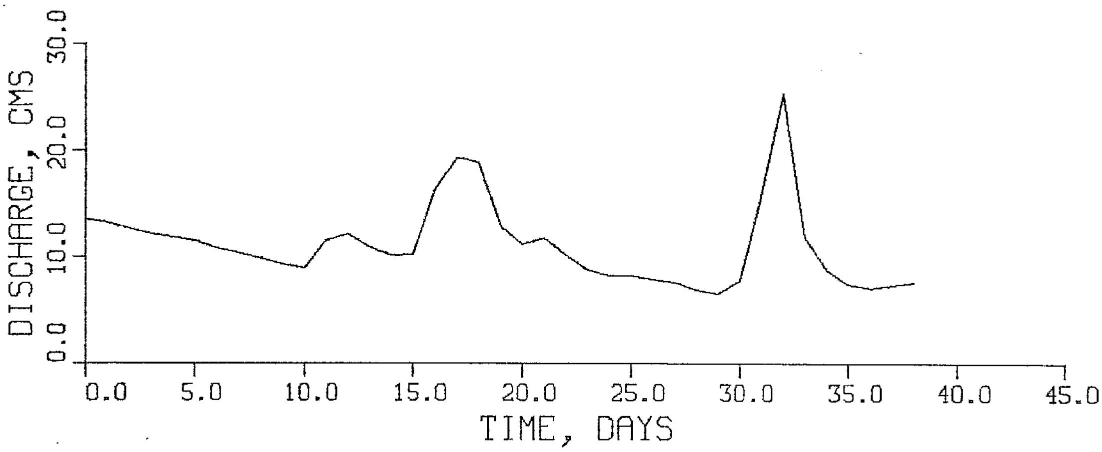


b. Mattaponi River

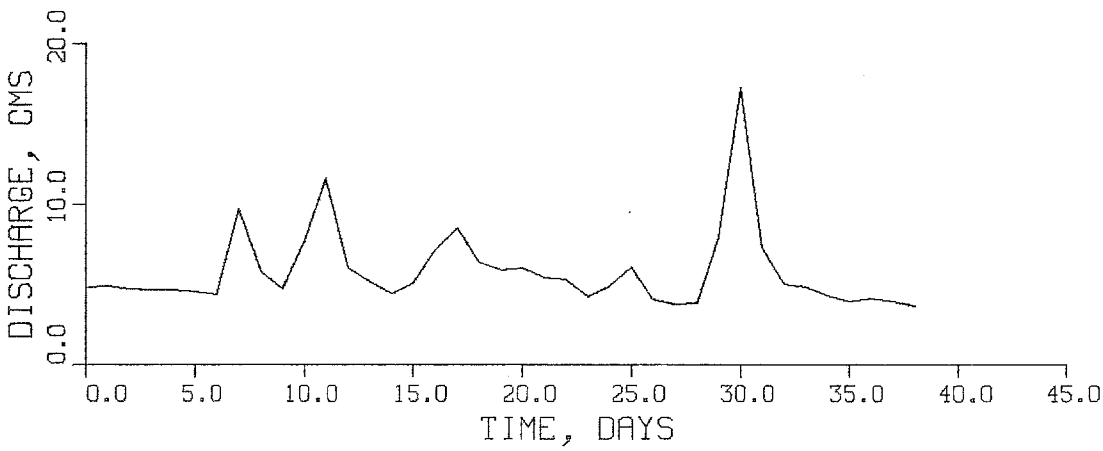


c. Pamunkey River

Figure 79. Freshwater inflows from CRIMP data (Sheet 1 of 3)

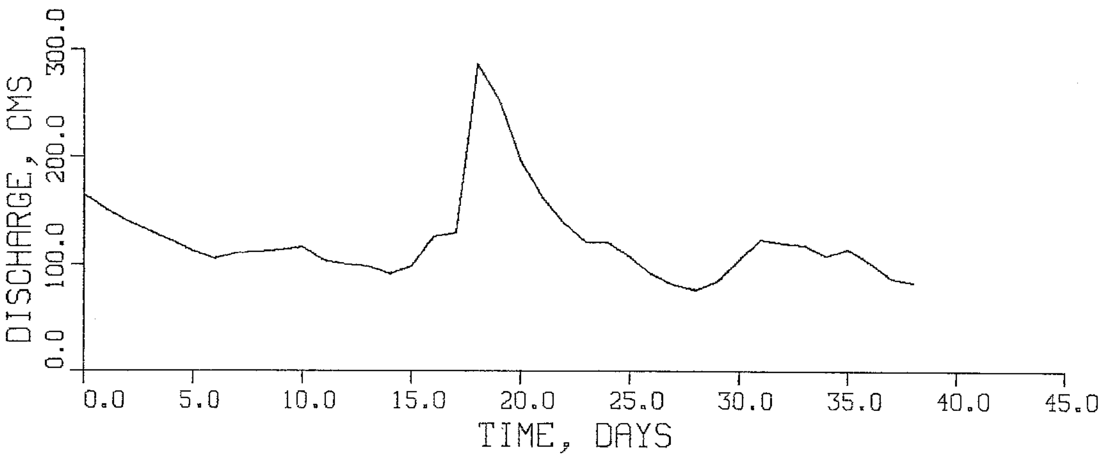


d. Rappahannock River

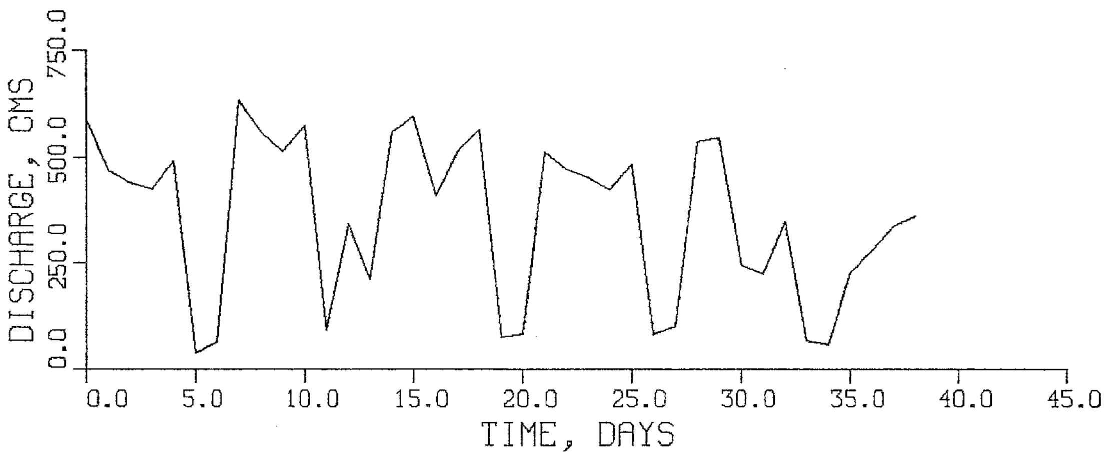


e. Patuxent River

Figure 79. (Sheet 2 of 3)



f. Potomac River



g. Susquehanna River

Figure 79. (Sheet 3 of 3)

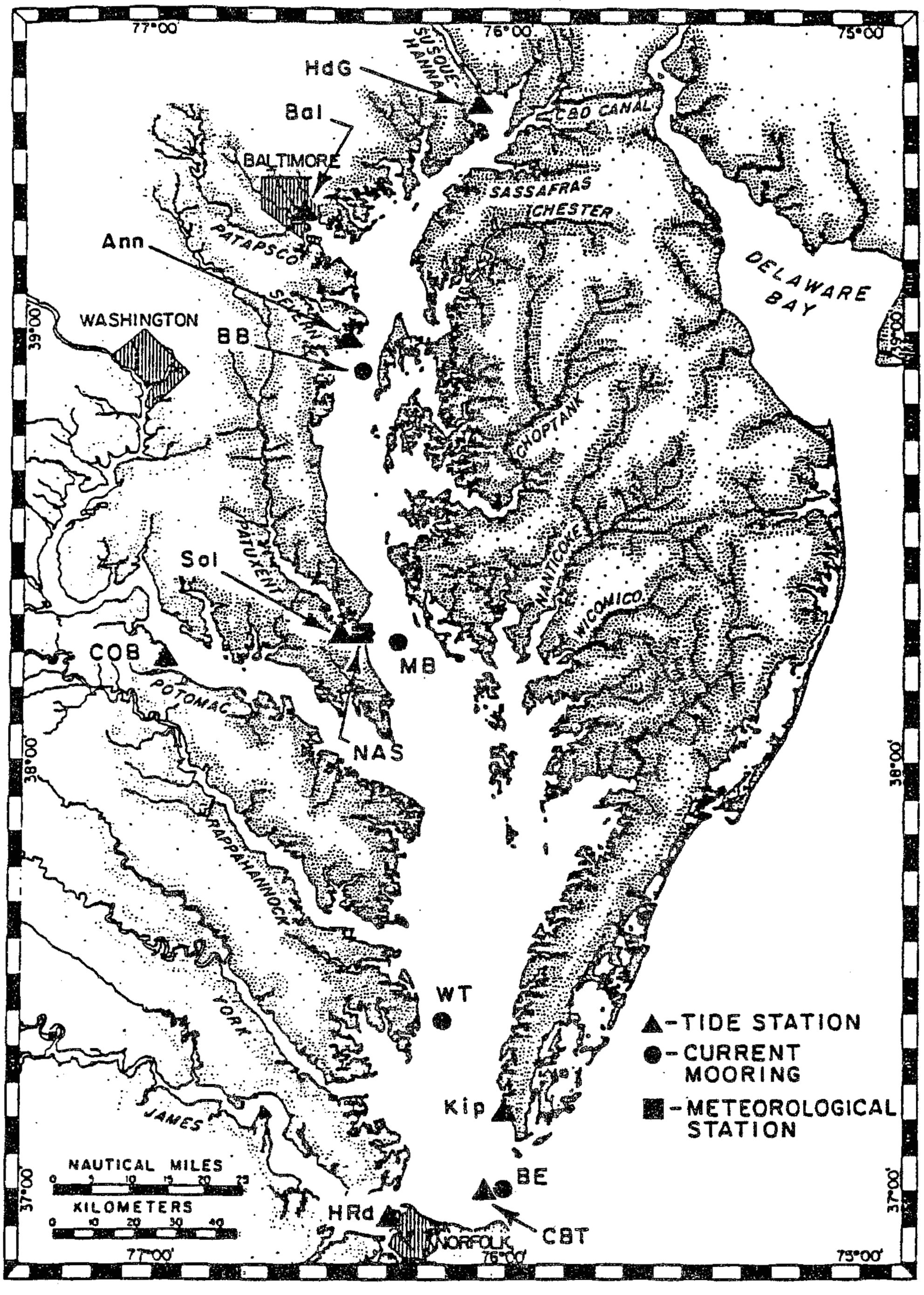


Figure 80. Location of USEPA and National Ocean Service data stations for spring and fall 1983 data sets

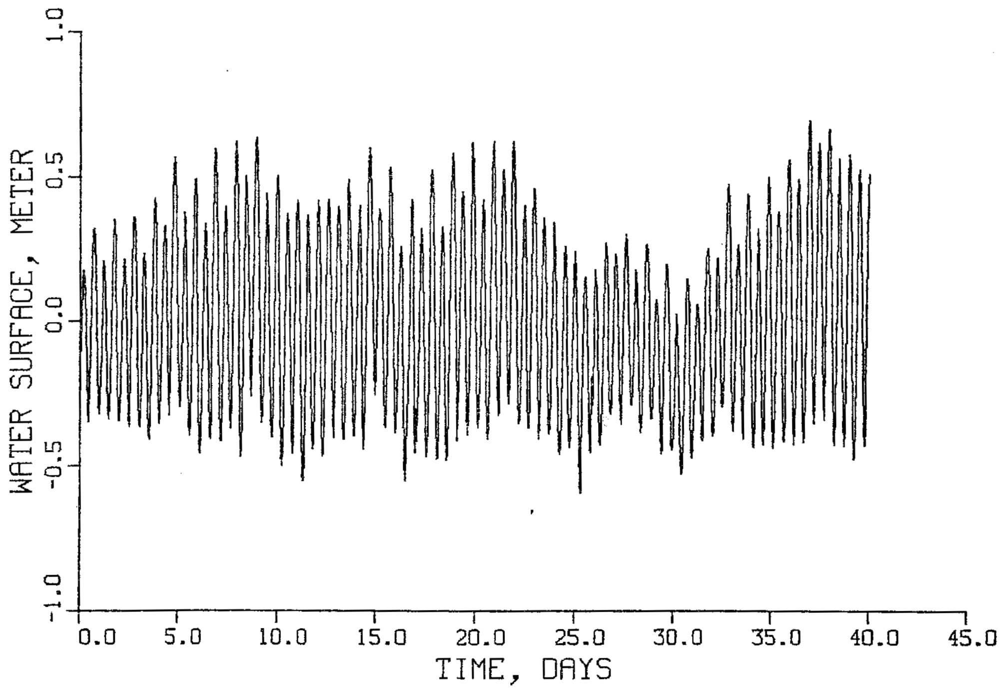


Figure 81. Tide at Bay Tunnel corrected to NGVD from CRIMP data

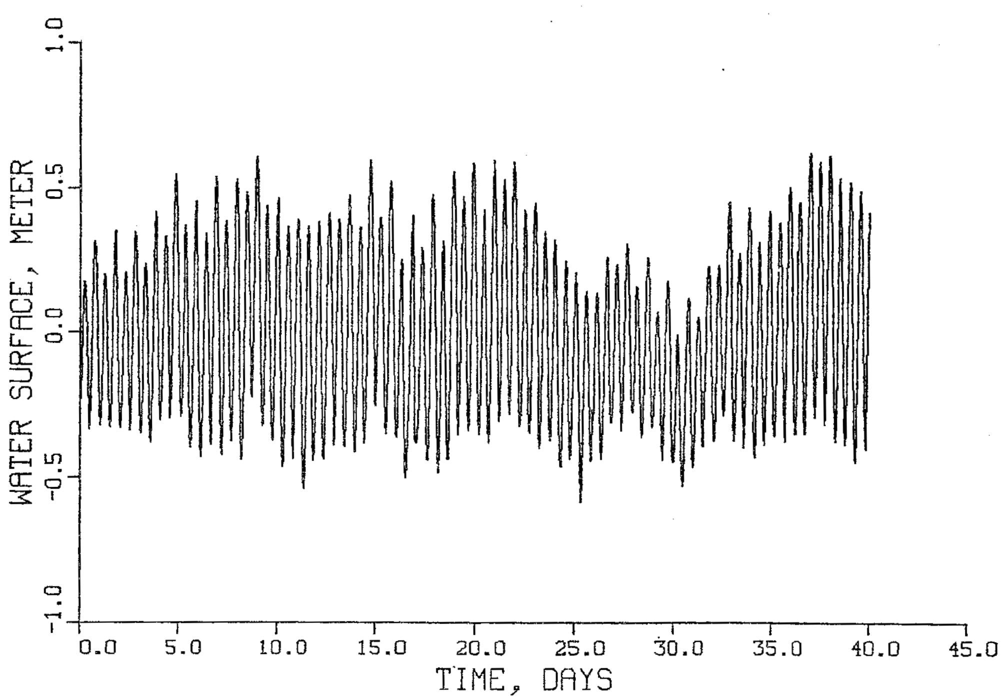


Figure 82. Tide at Hampton Roads, VA, corrected to NGVD from CRIMP data

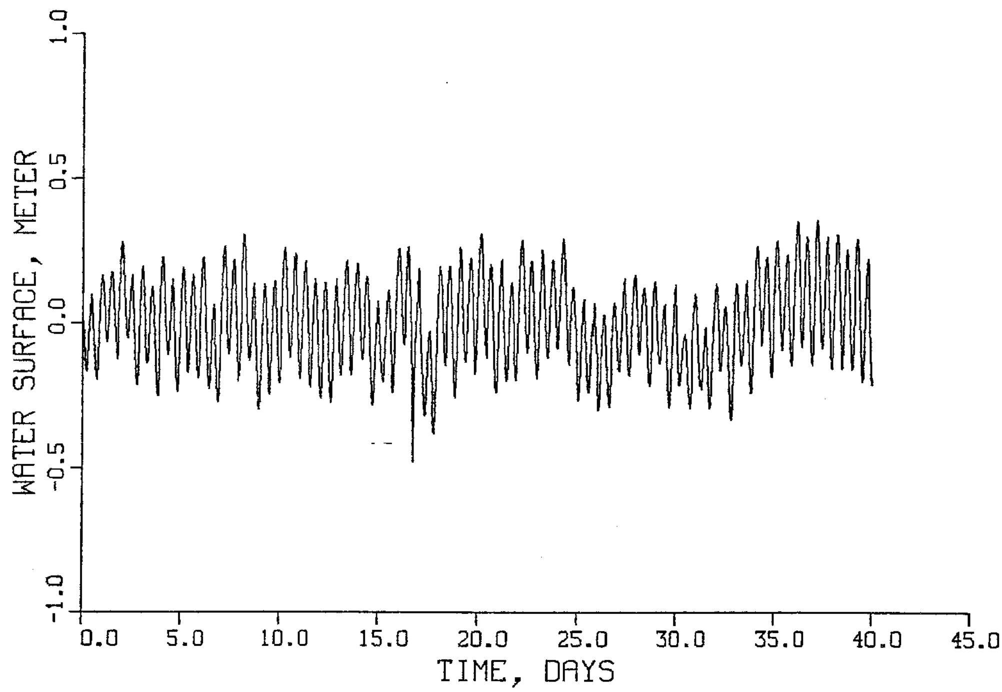


Figure 83. Tide at Solomons, MD, corrected to NGVD from CRIMP data

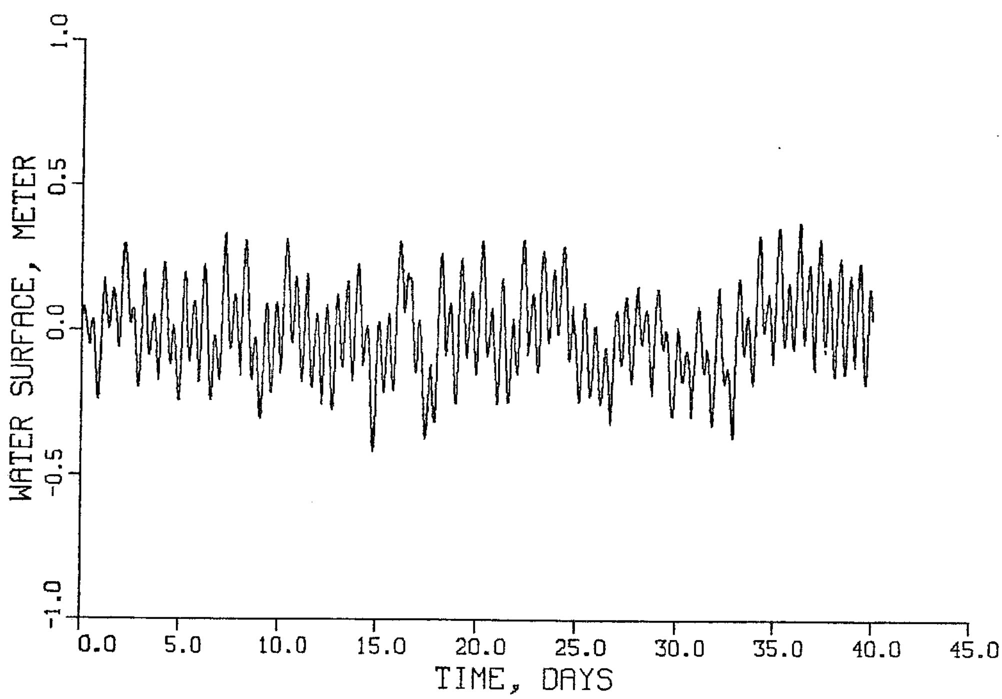


Figure 84. Tide at Annapolis, MD, from CRIMP data

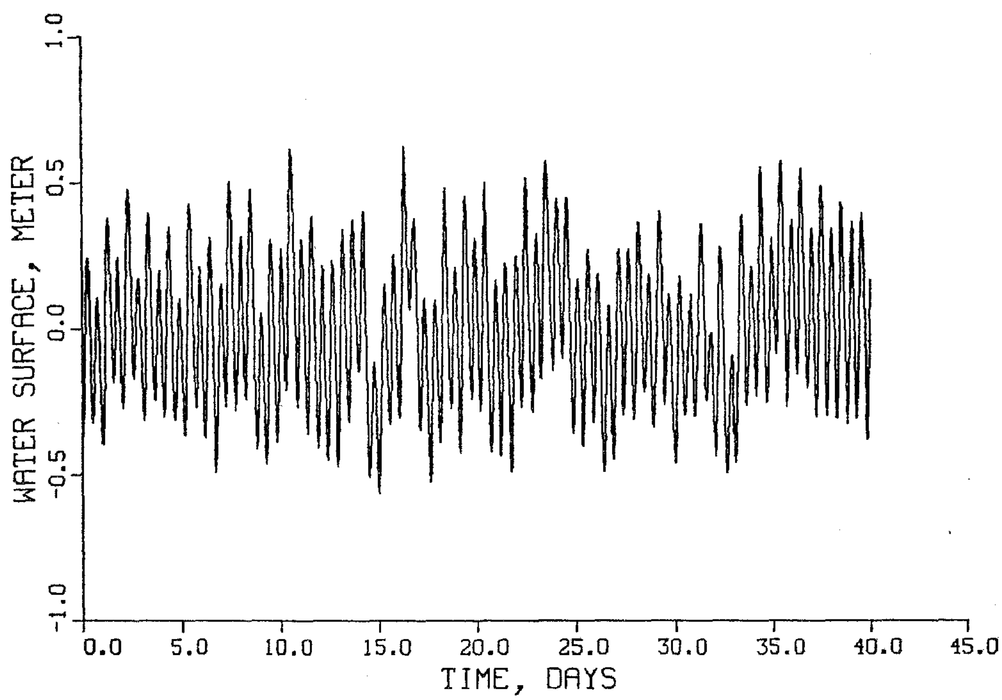
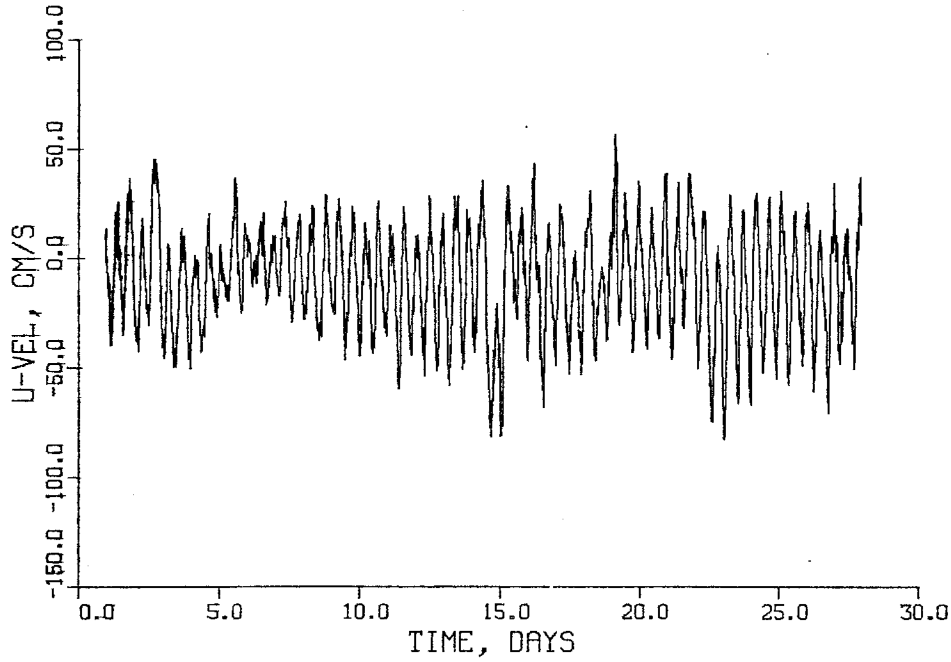
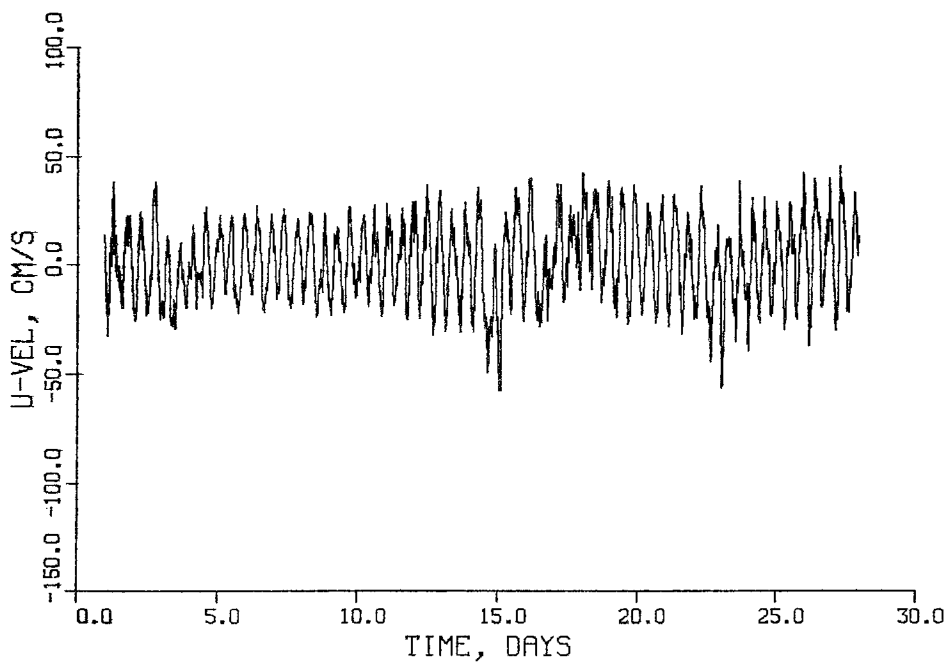


Figure 85. Tide at Havre de Grace, MD, corrected to NGVD from CRIMP data

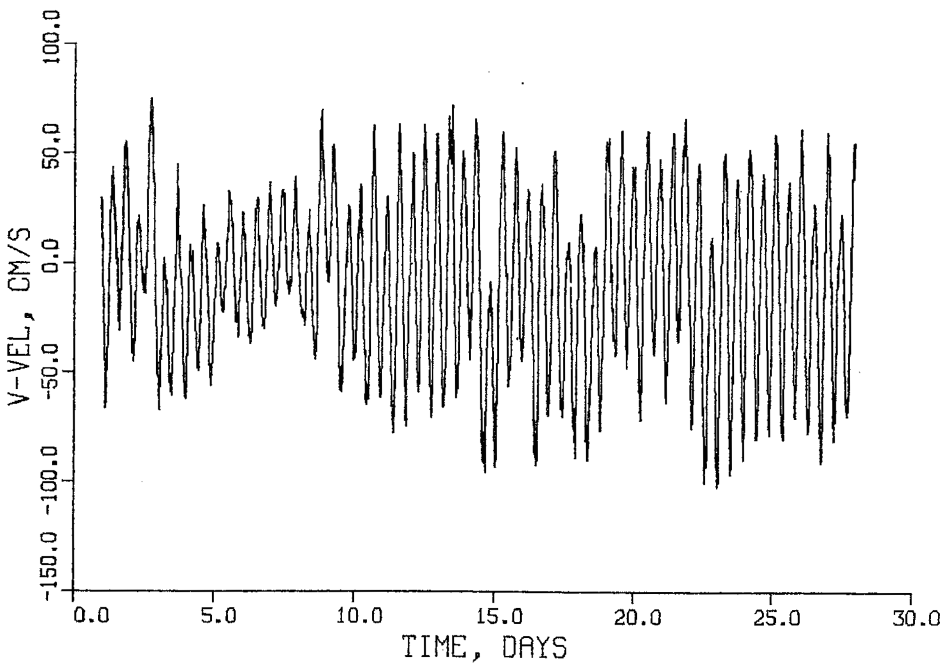


a. Depth = 4.6 m

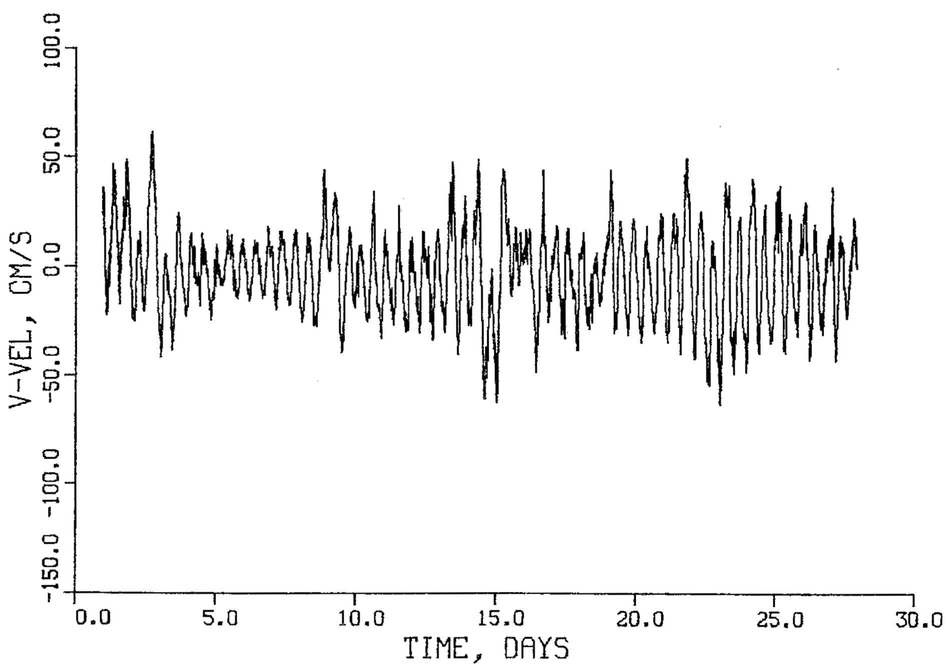


b. Depth = 10.4 m

Figure 86. U-velocity at station BE during April 1983

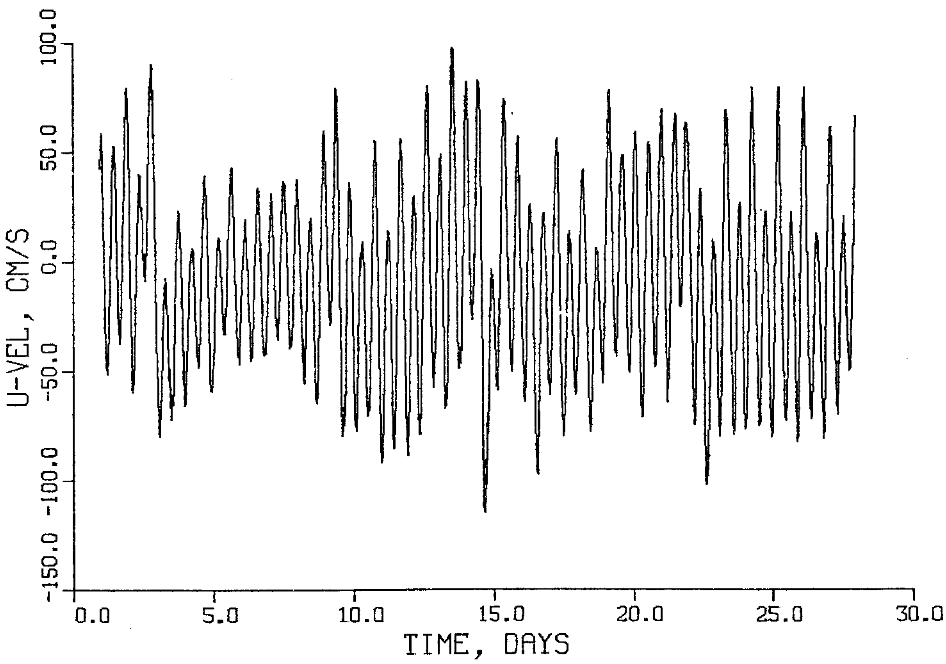


a. Depth = 4.6 m

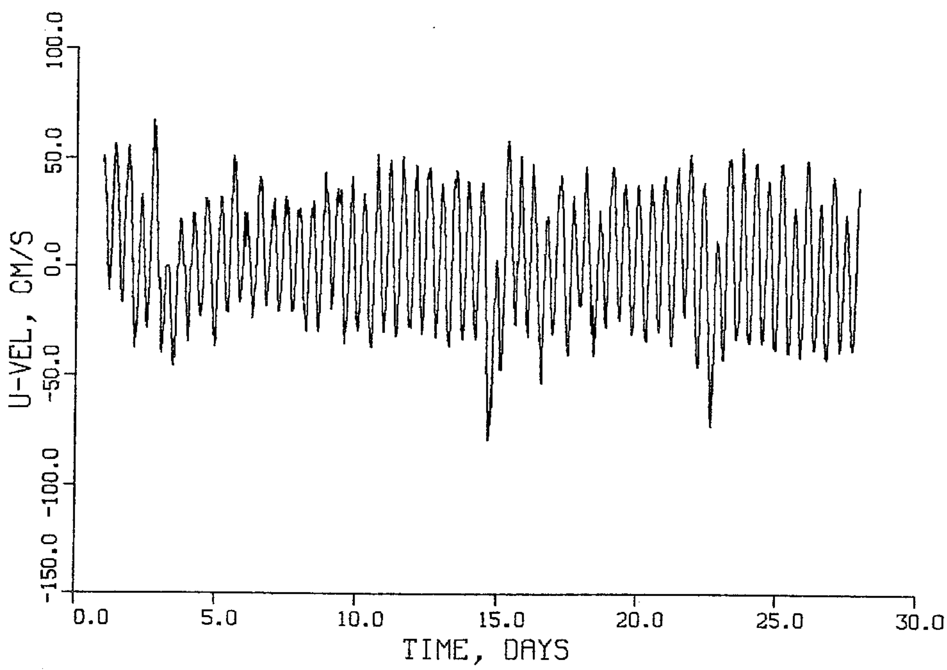


b. Depth = 10.4 m

Figure 87. V-velocity at station BE during April 1983

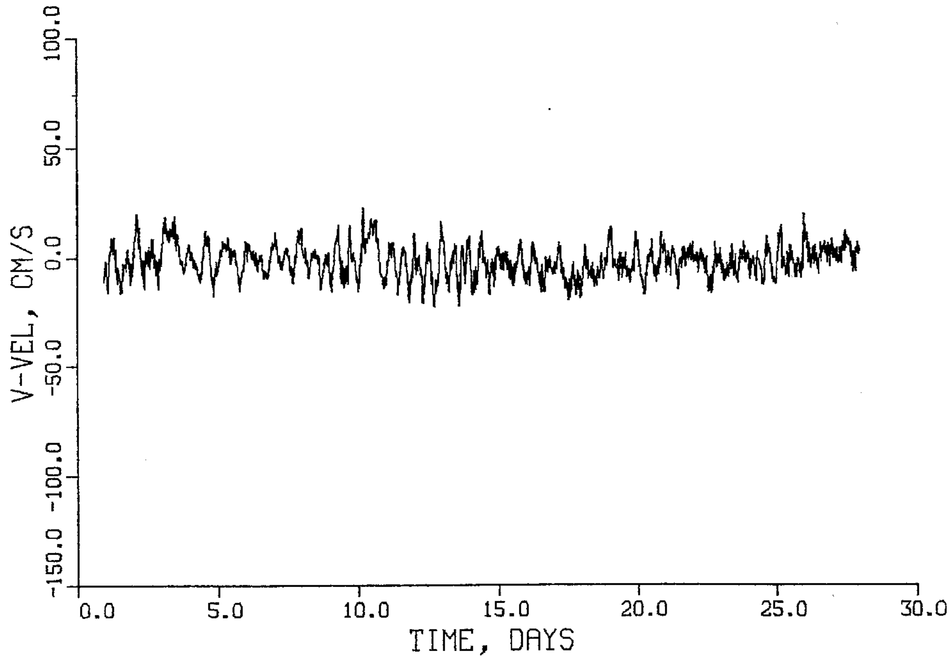


a. Depth = 4.6 m

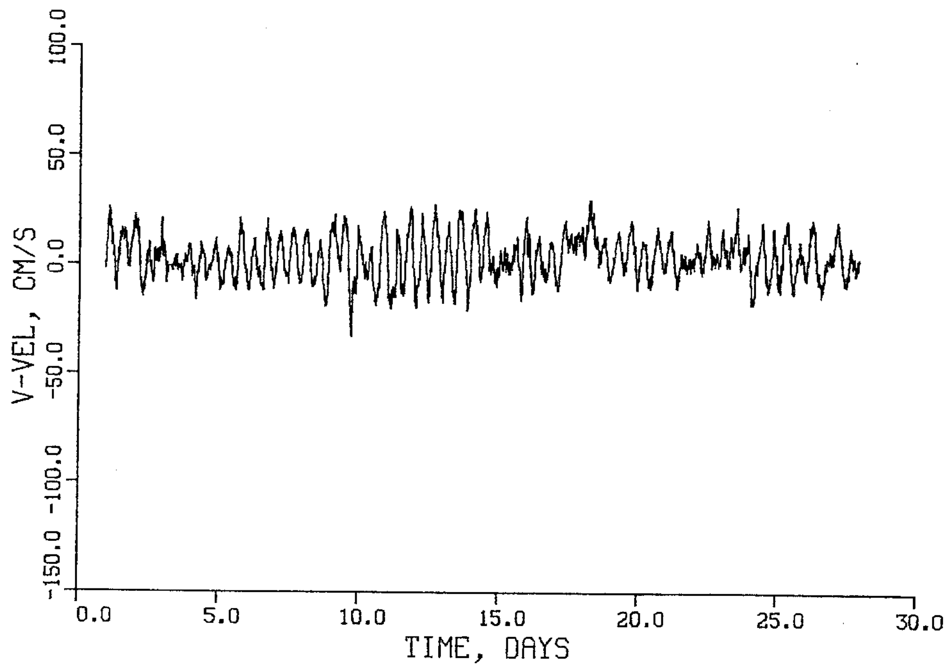


b. Depth = 10.1 m

Figure 88. U-velocity at station WT during April 1983

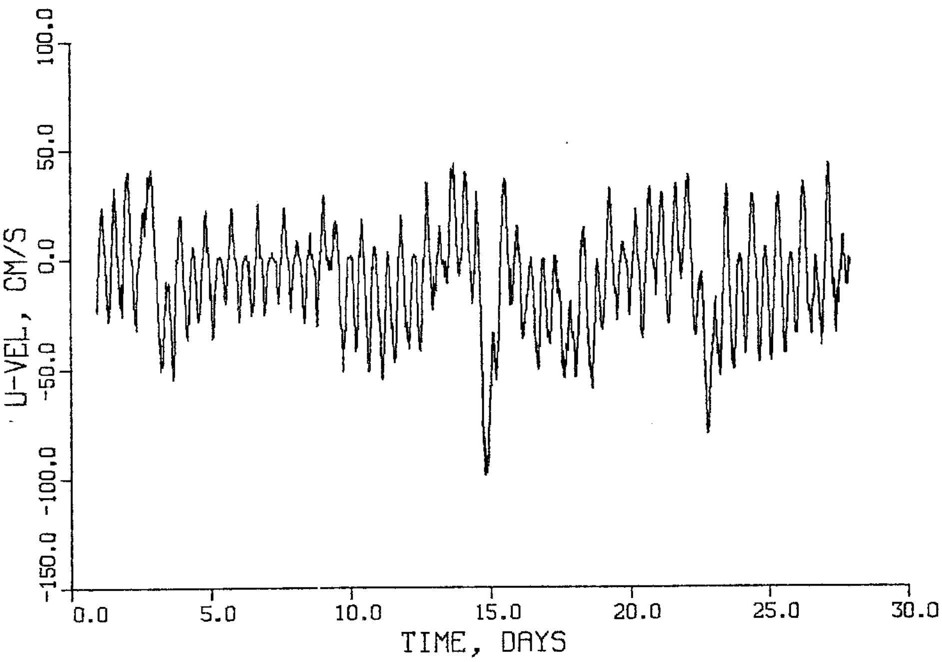


a. Depth = 4.6 m

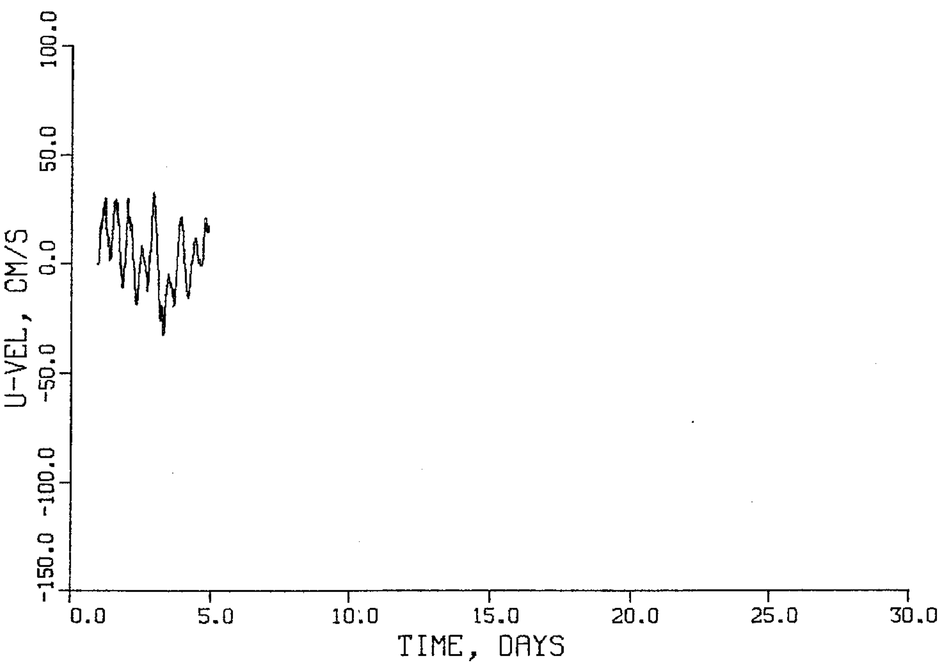


b. Depth = 10.1 m

Figure 89. V-velocity at station WT during April 1983

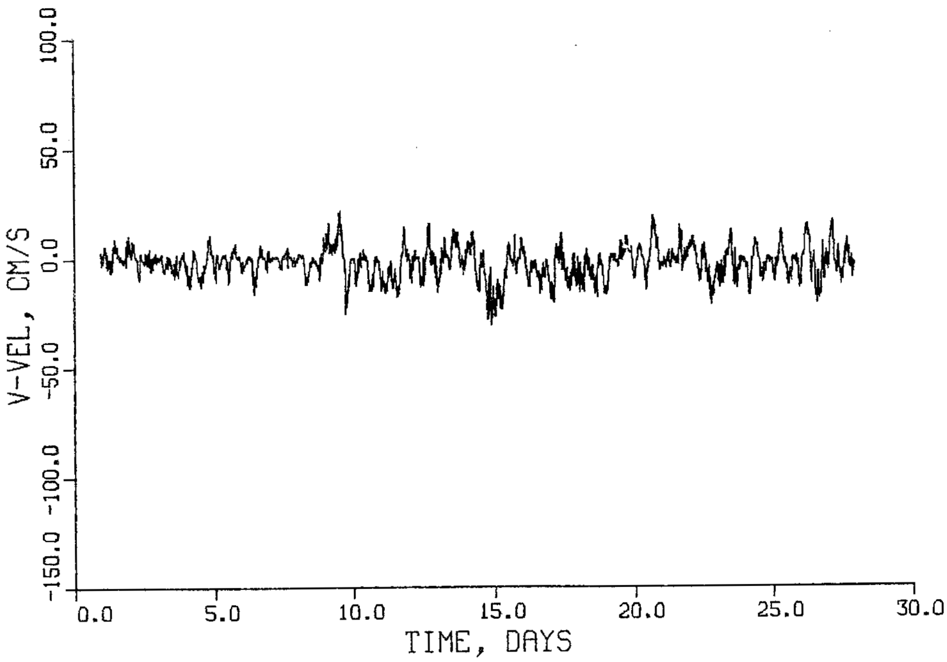


a. Depth = 4.6 m

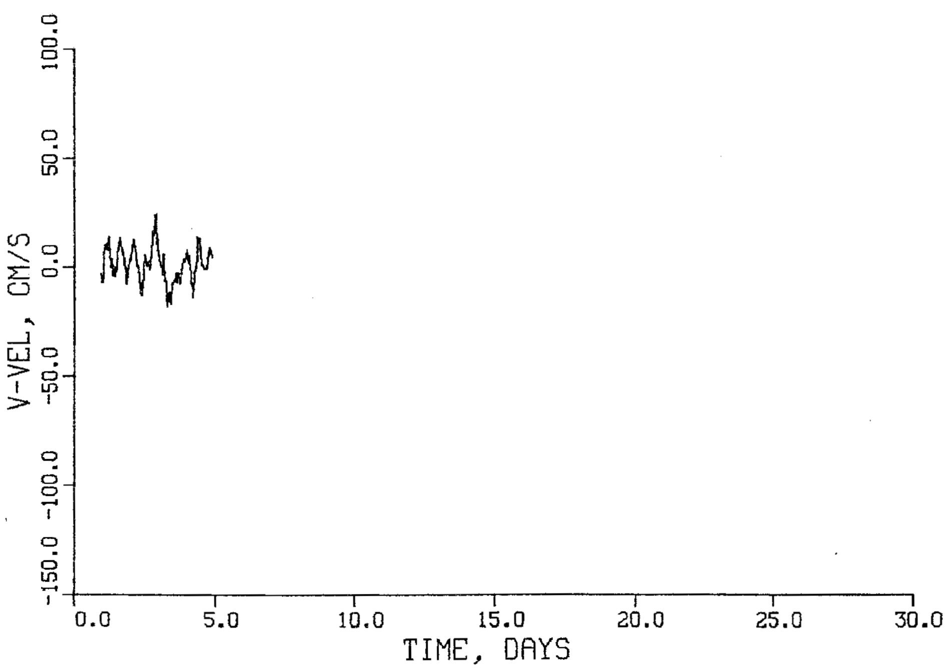


b. Depth = 14.6 m

Figure 90. U-velocity at station MB during April 1983

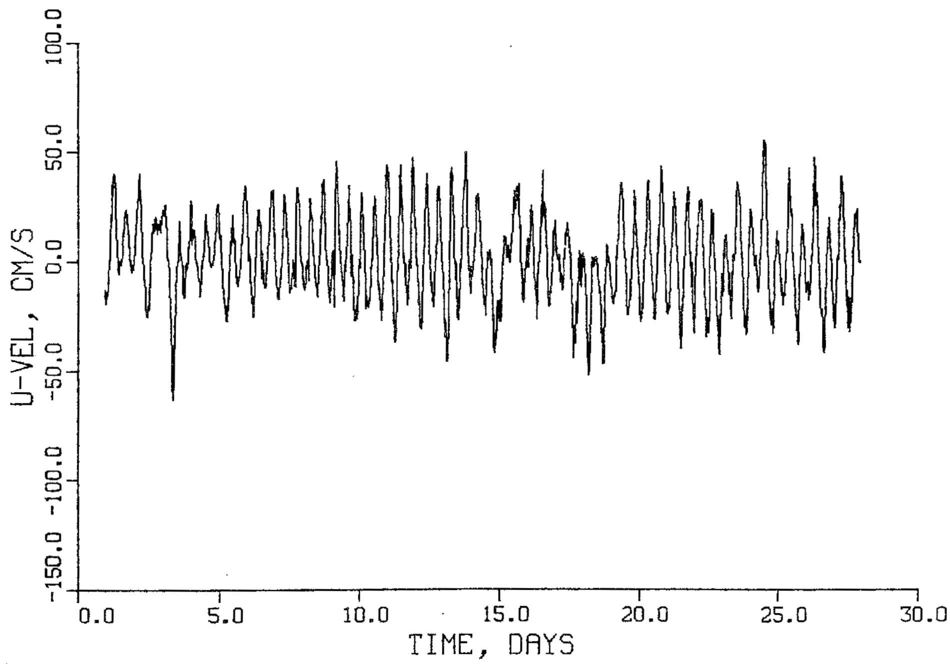


a. Depth = 4.6 m

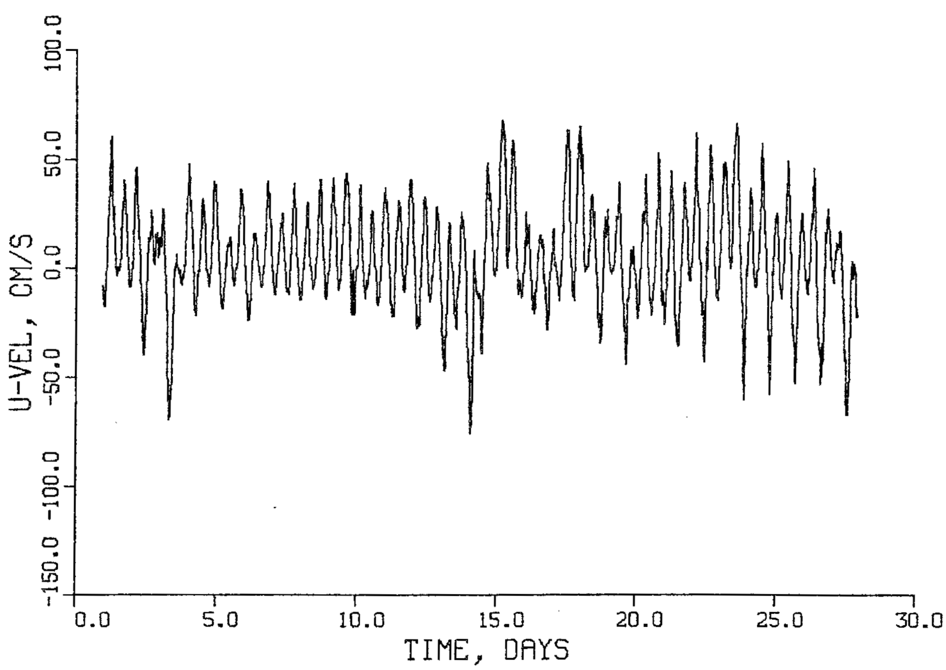


b. Depth = 14.6 m

Figure 91. V-velocity at station MB during April 1983

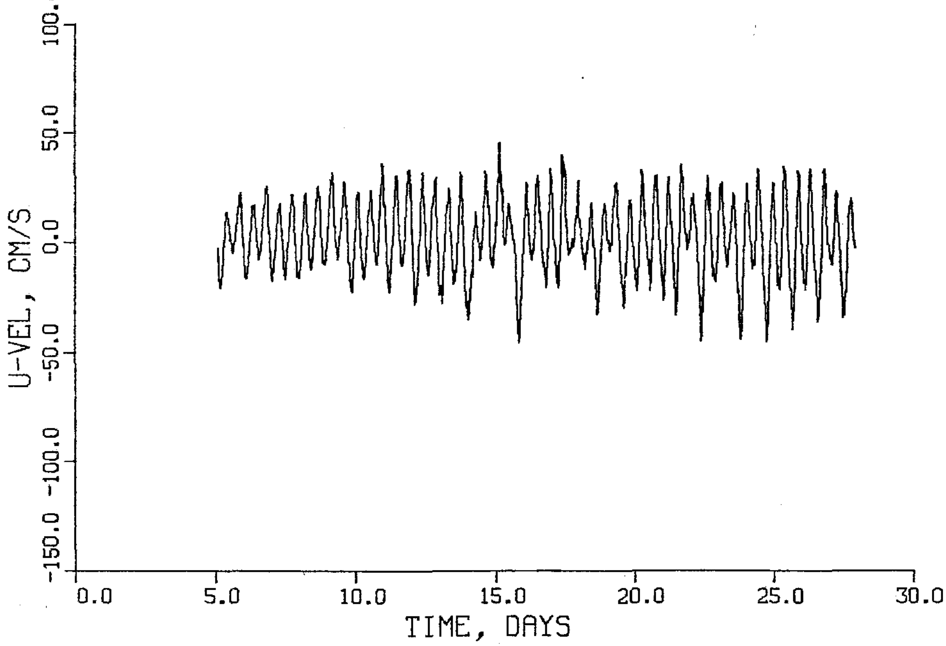


a. Depth = 5.8 m



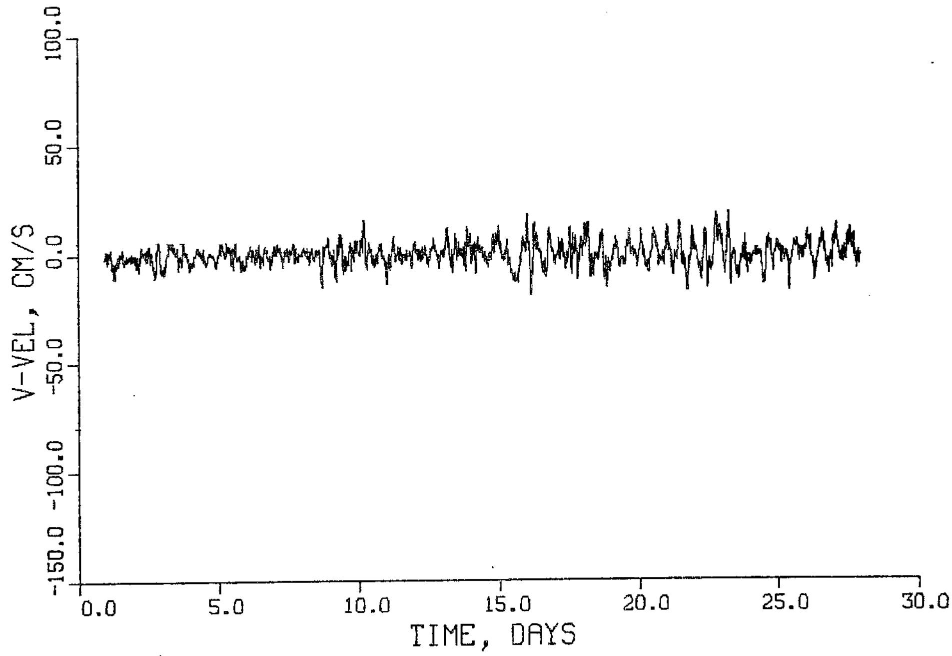
b. Depth = 11.3 m

Figure 92. U-velocity at station BB during April 1983 (Continued)

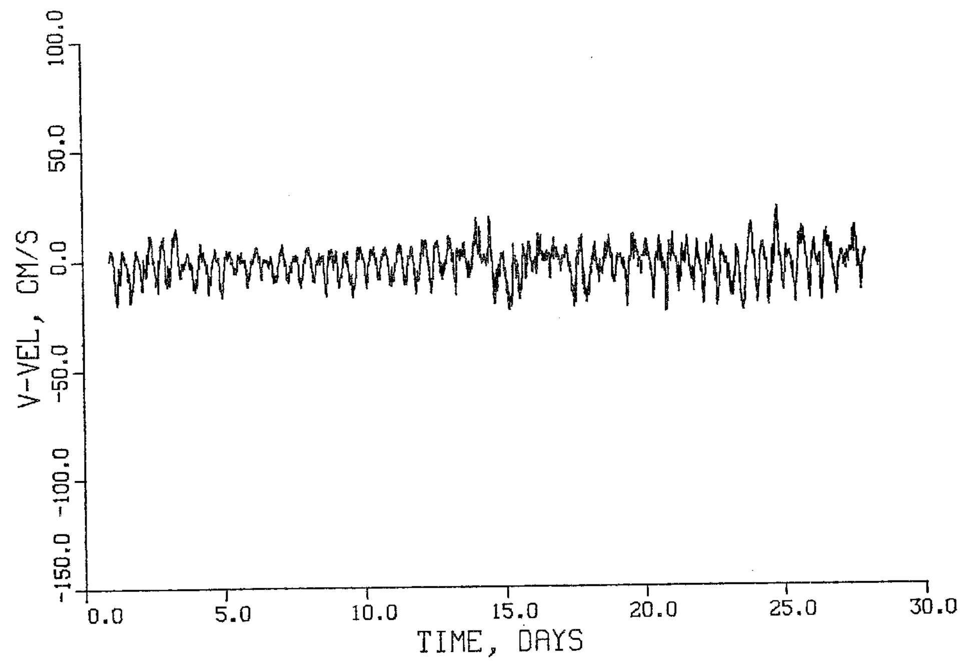


c. Depth = 21.3 m

Figure 92. (Concluded)

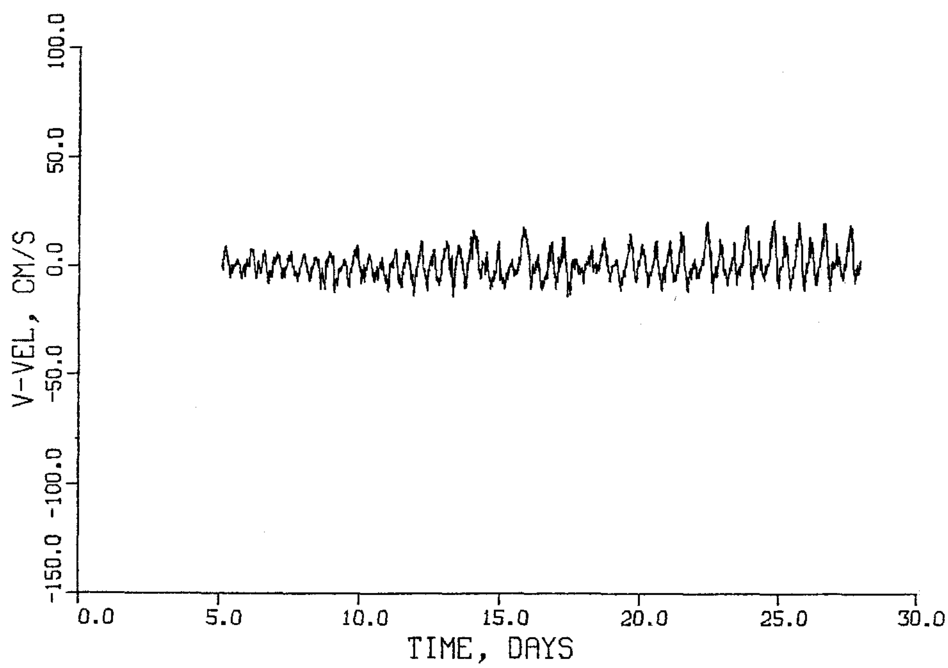


a. Depth = 5.8 m



b. Depth = 11.3 m

Figure 93. V-velocity at station BB during April 1983 (Continued)



c. Depth = 21.3 m

Figure 93. (Concluded)

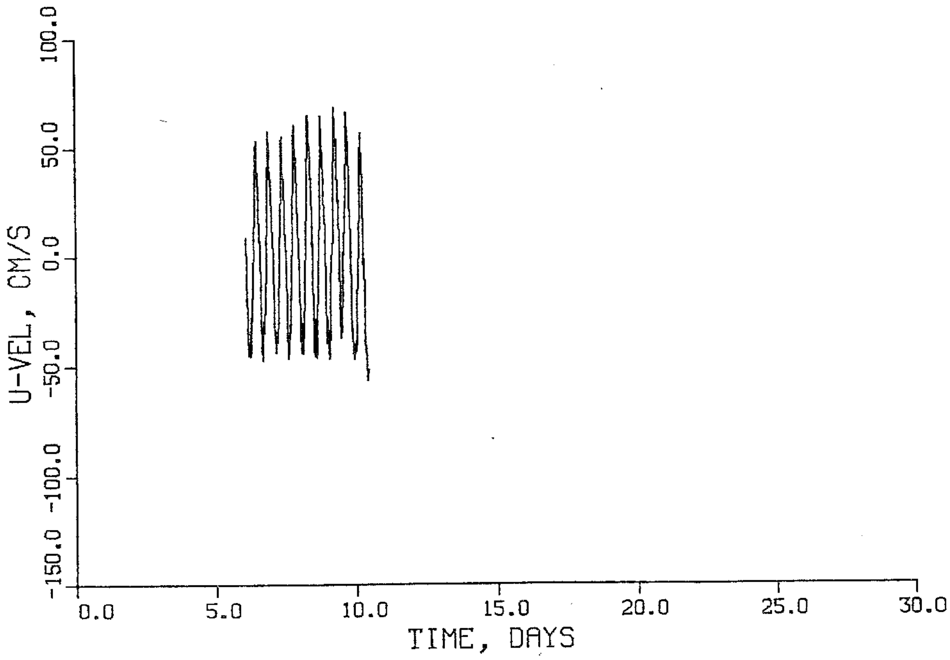


Figure 94. U-velocity at Pooles Island at a depth of 5.5 m during April 1983

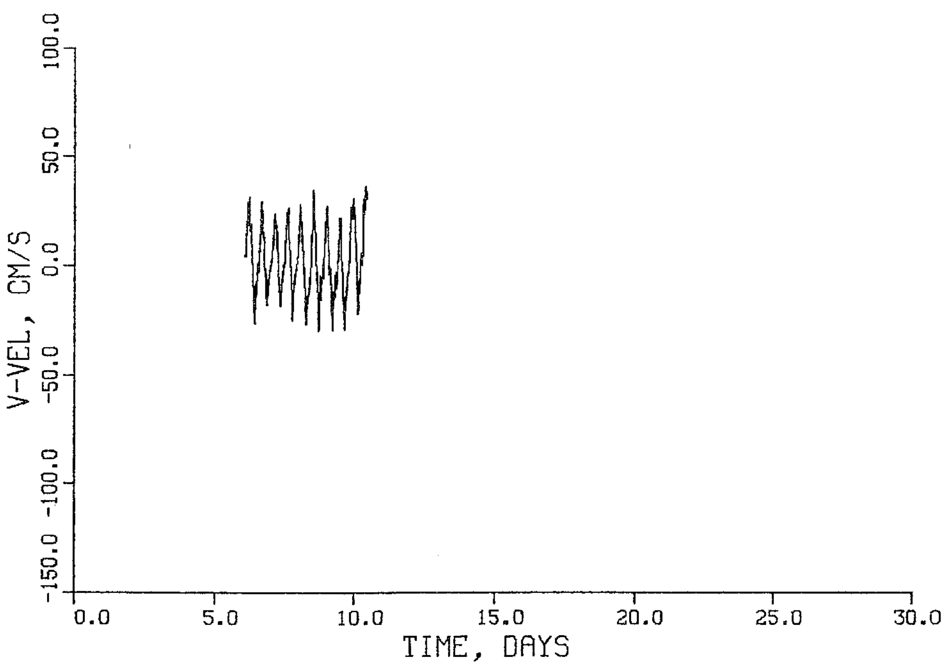


Figure 95. V-velocity at Pooles Island at a depth of 5.5 m during April 1983

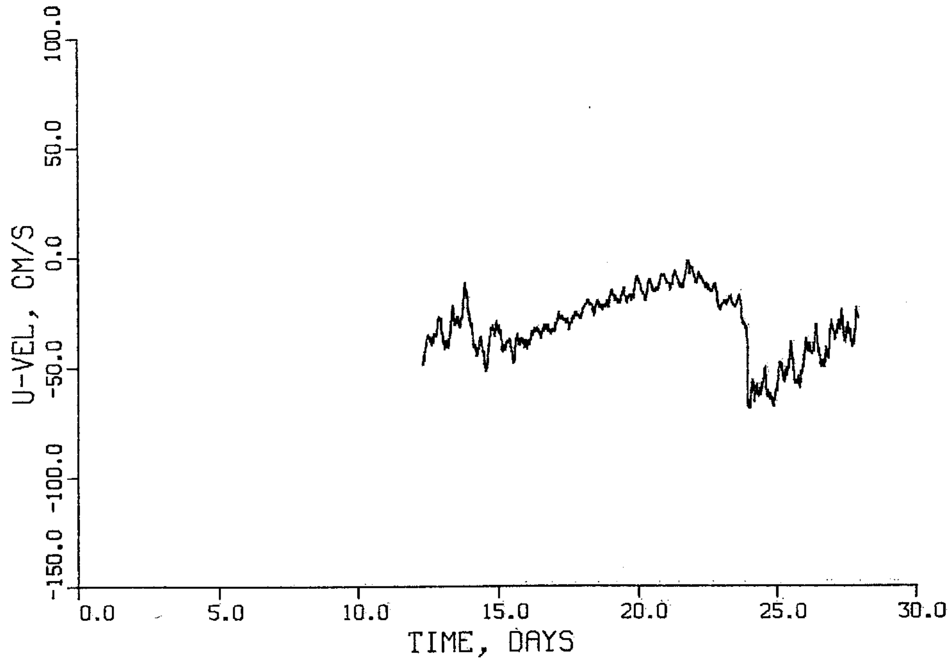


Figure 96. U-Velocity at Havre de Grace at a depth of 3.0 m during April 1983

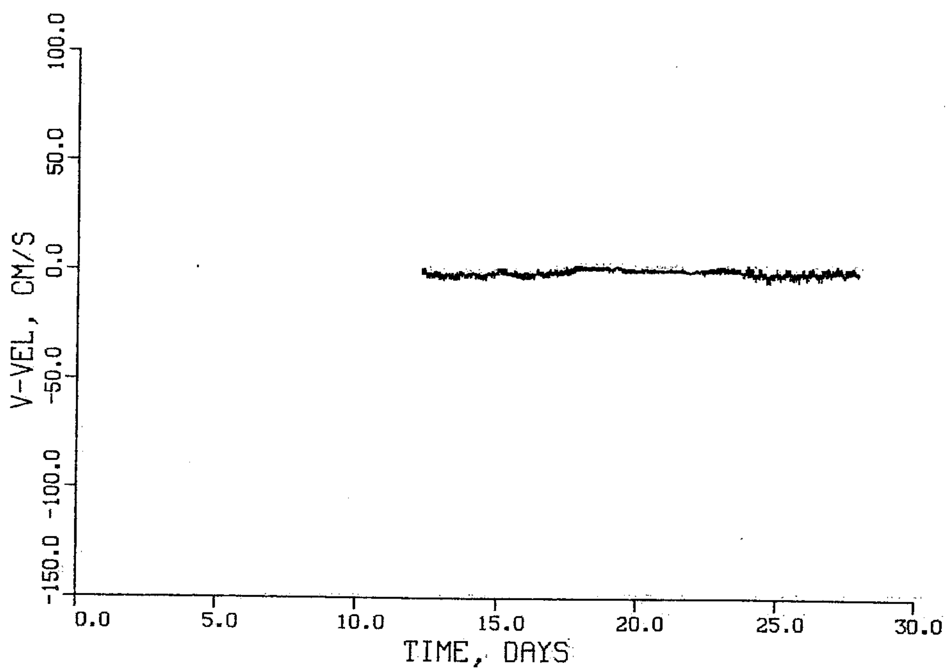
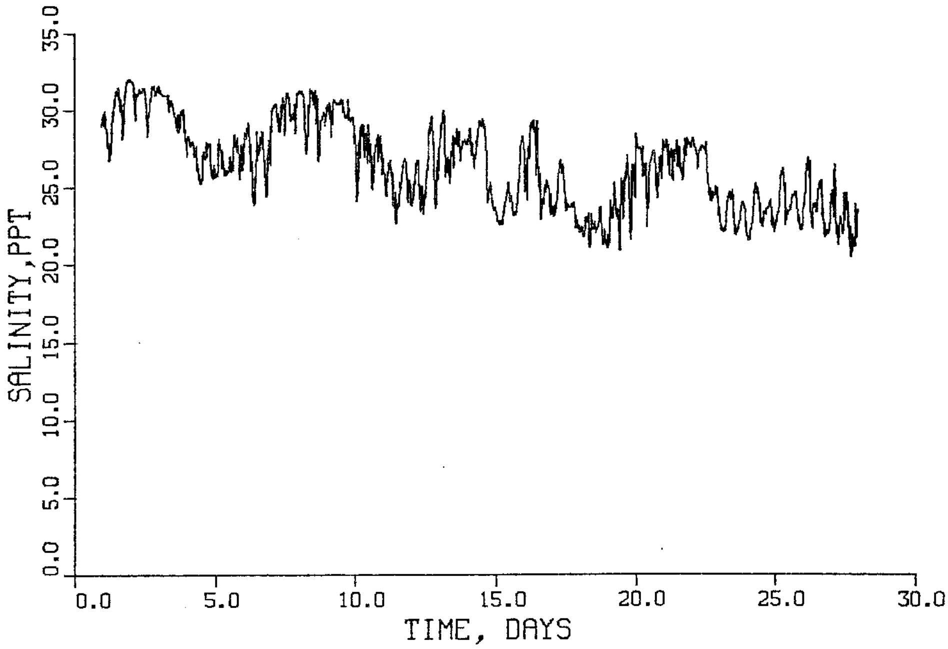
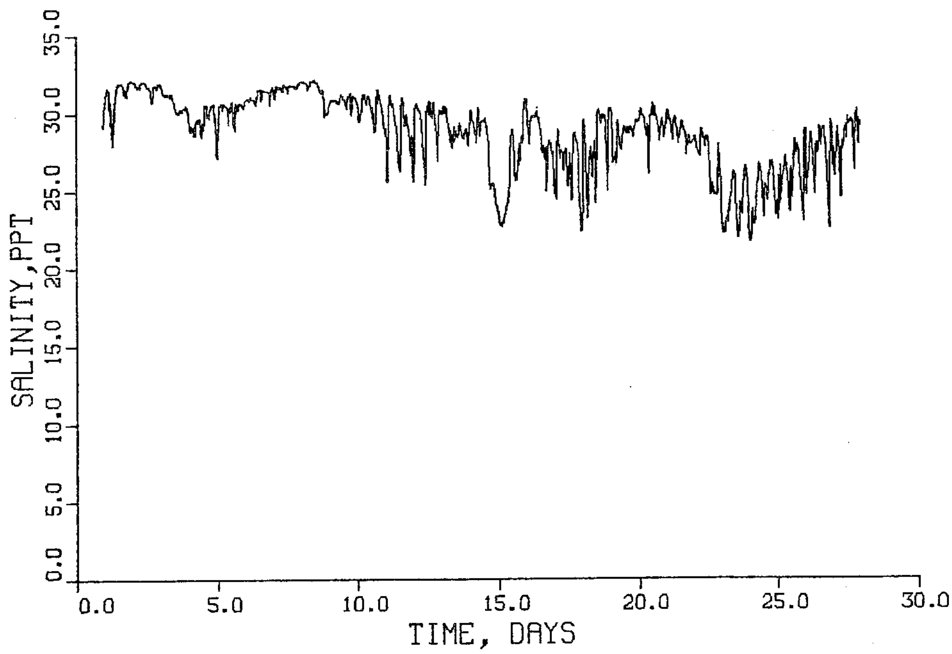


Figure 97. V-velocity at Havre de Grace at a depth of 3.0 m during April 1983

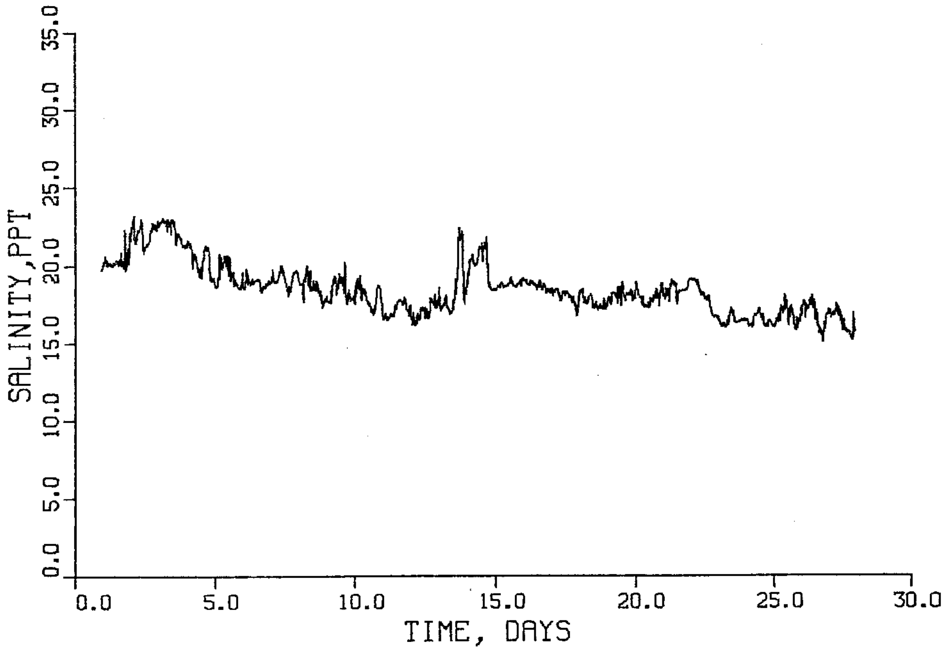


a. Depth = 4.6 m

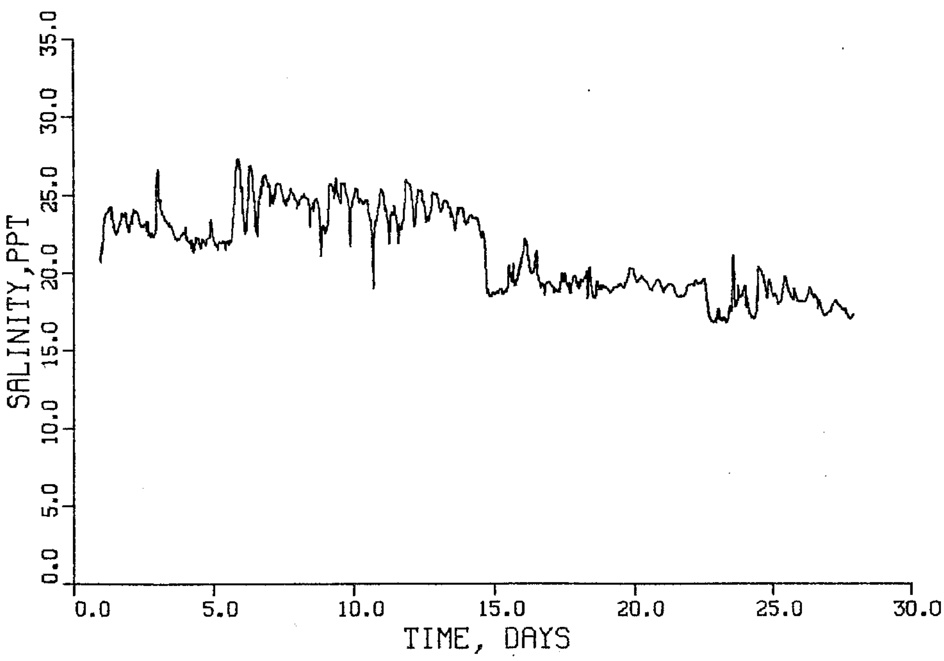


b. Depth = 10.4 m

Figure 98. Salinity at station BE during April 1983

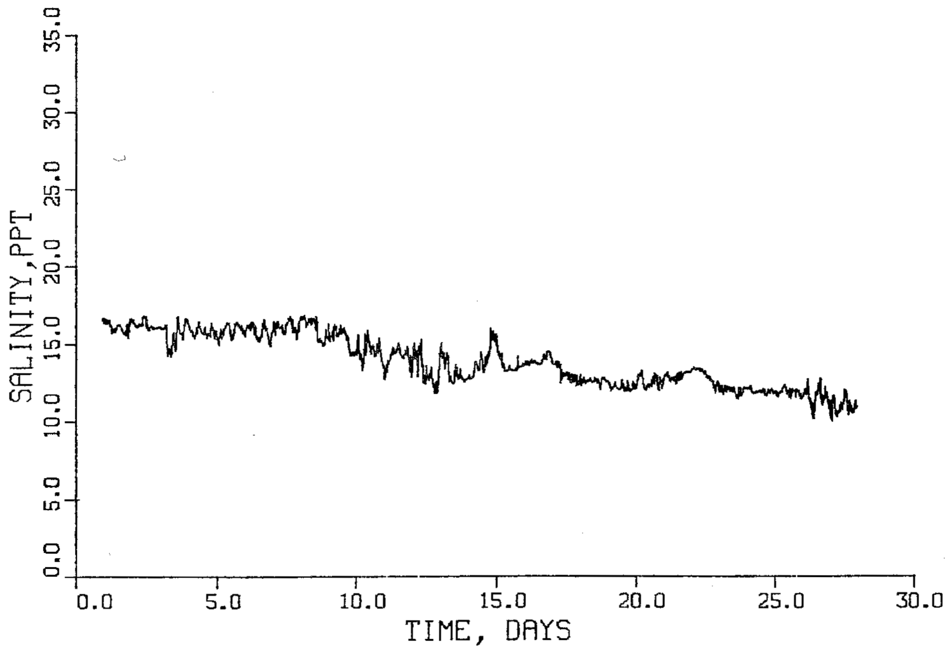


a. Depth = 4.6 m

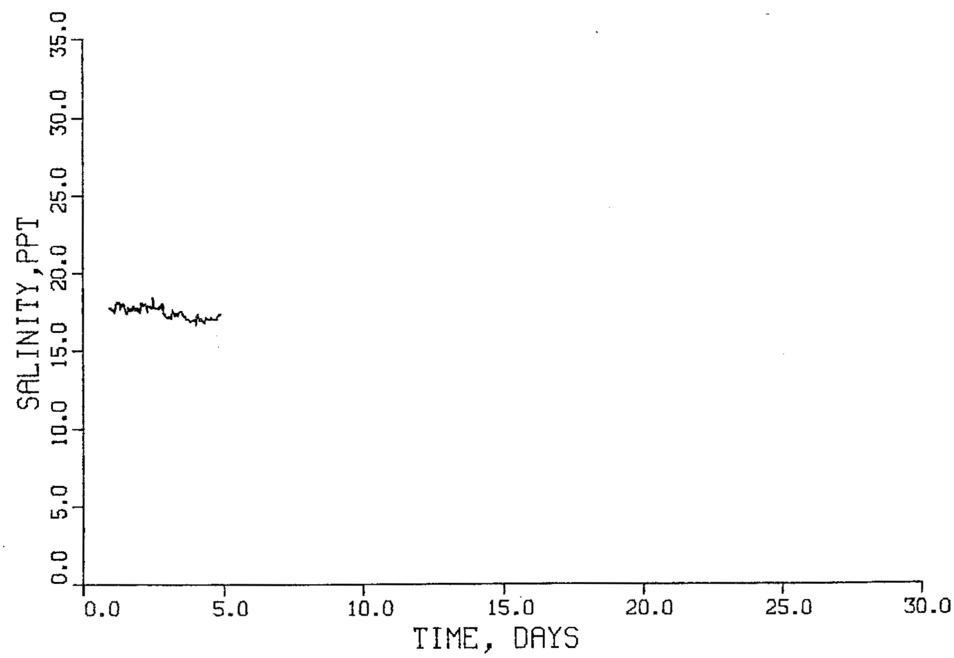


b. Depth = 10.1 m

Figure 99. Salinity at station WT during April 1983

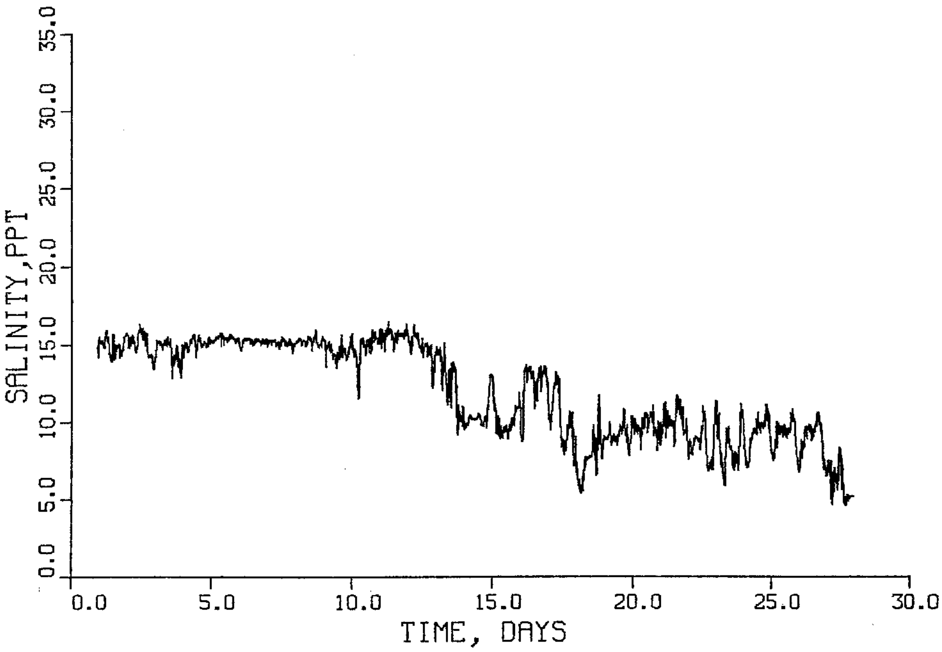


a. Depth = 4.6 m

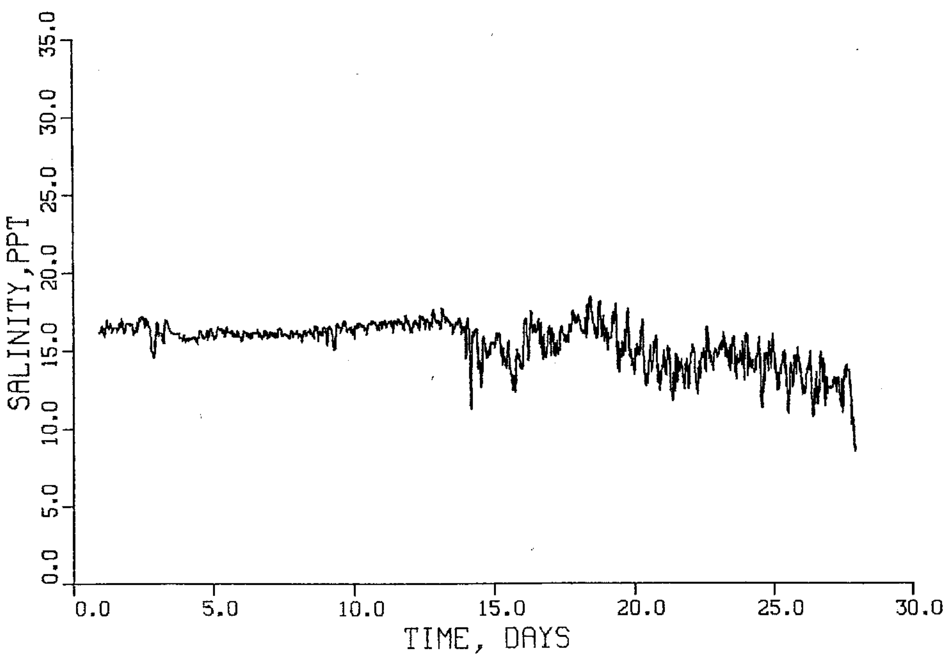


b. Depth = 14.6 m

Figure 100. Salinity at station MB during April 1983

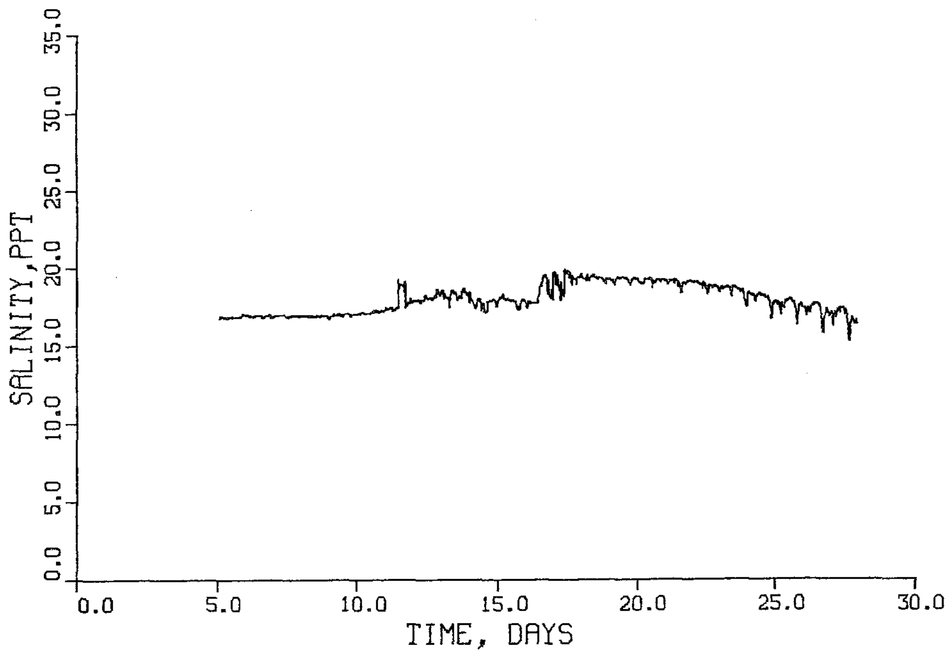


a. Depth = 5.8 m



b. Depth = 11.3 m

Figure 101. Salinity at station BB during April 1983 (Continued)



c. Depth = 21.3 m

Figure 101. (Concluded)

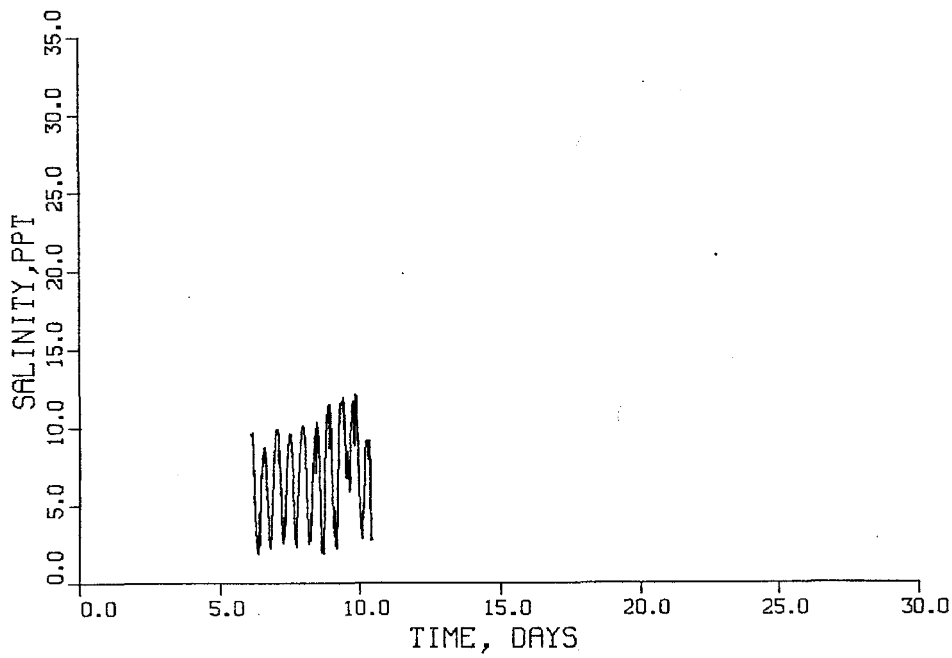


Figure 102. Salinity at Pooles Island at a depth of 5.5 m during April 1983

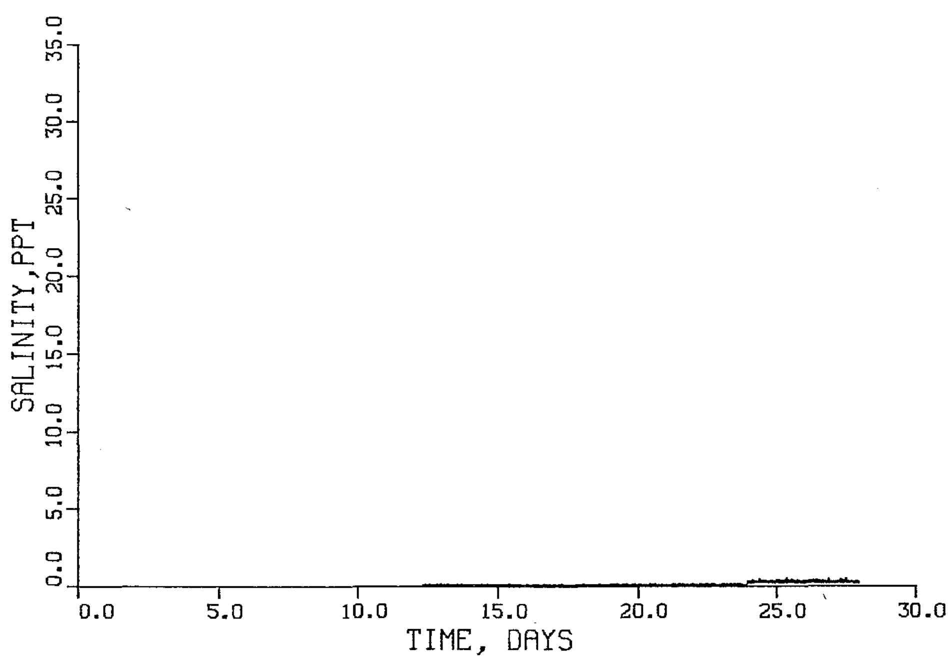
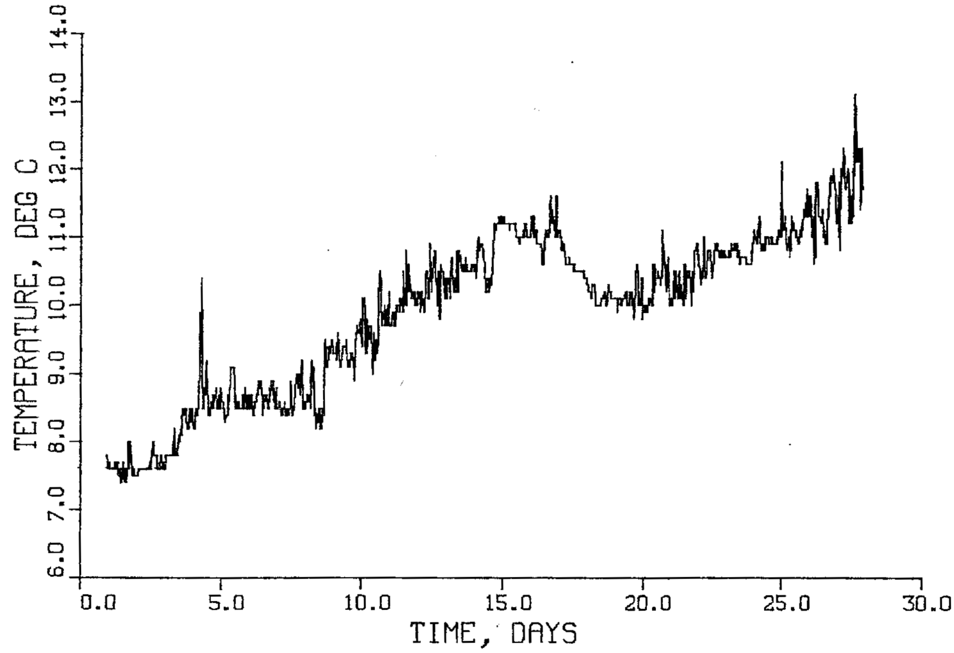
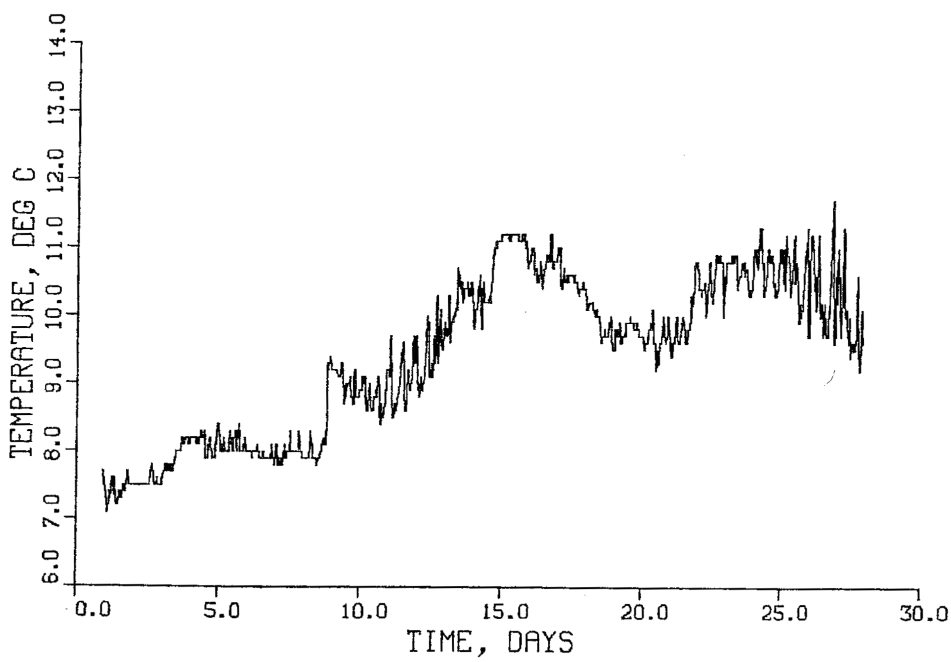


Figure 103. Salinity at a depth of 3.0 m at Havre de Grace during April 1983

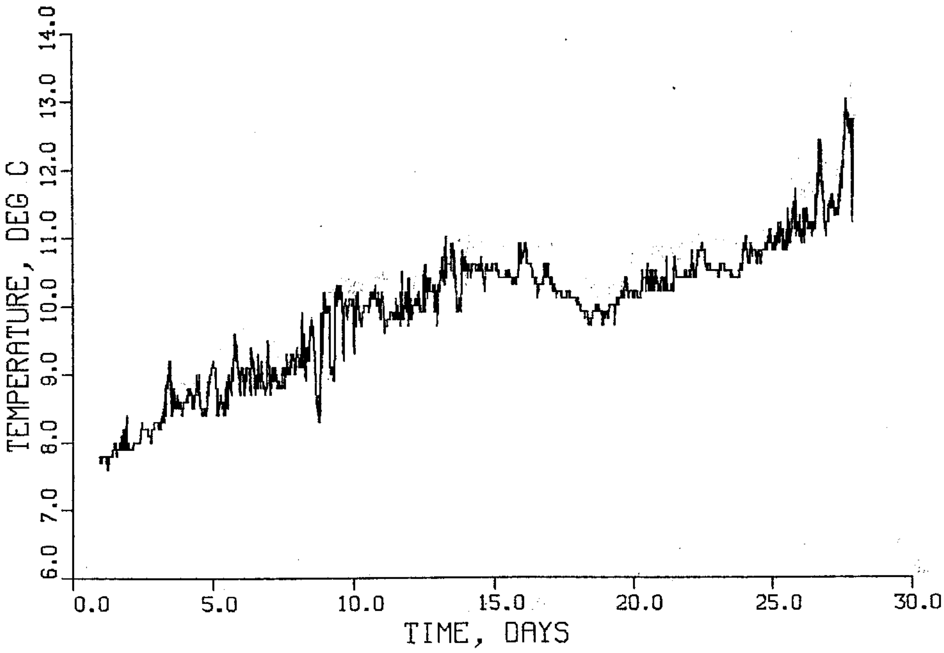


a. Depth = 4.6 m

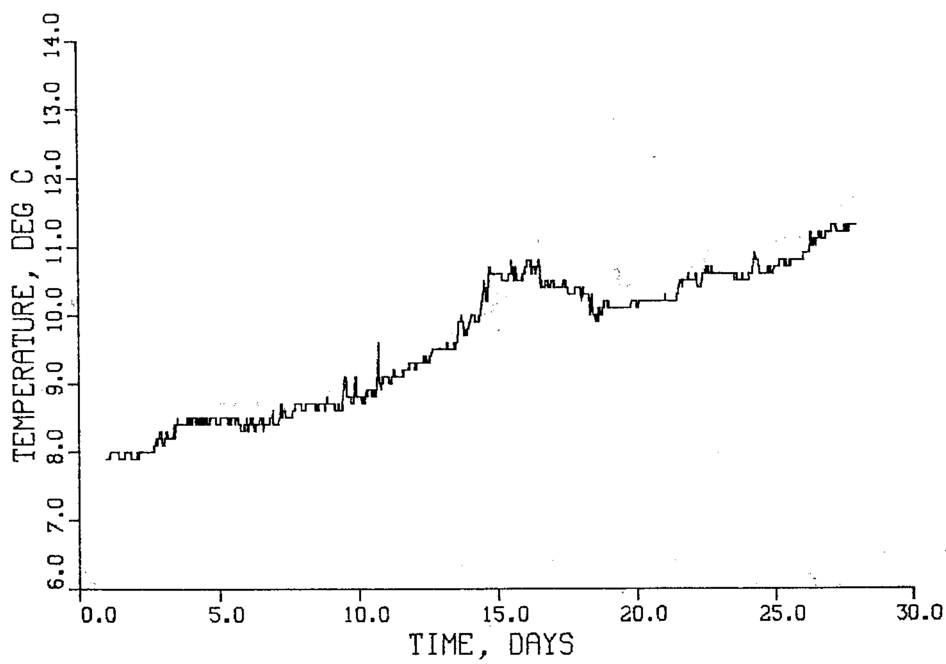


b. Depth = 10.4 m

Figure 104. Temperature at station BE during April 1983

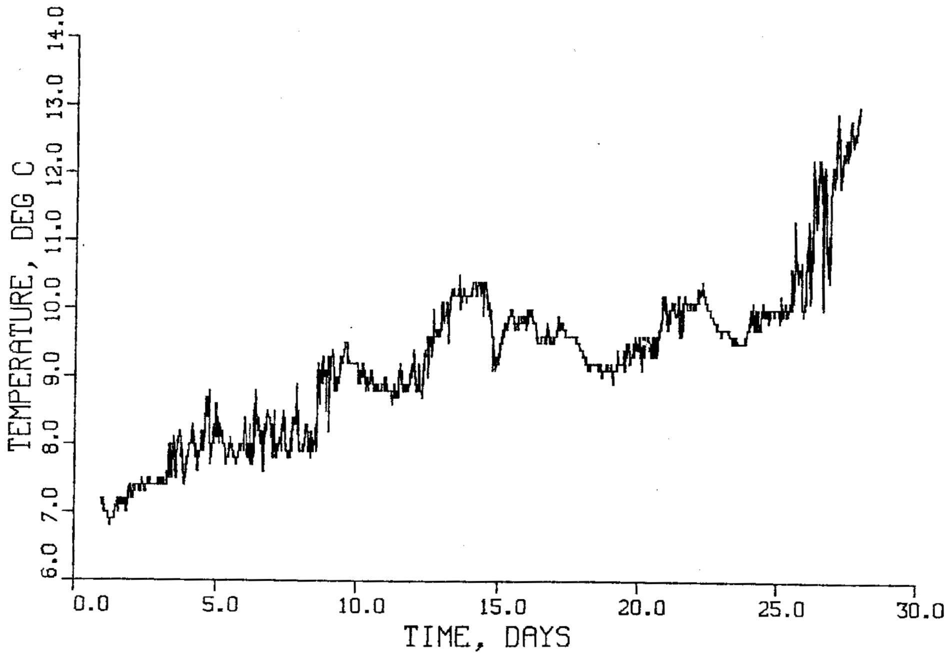


a. Depth = 4.6 m

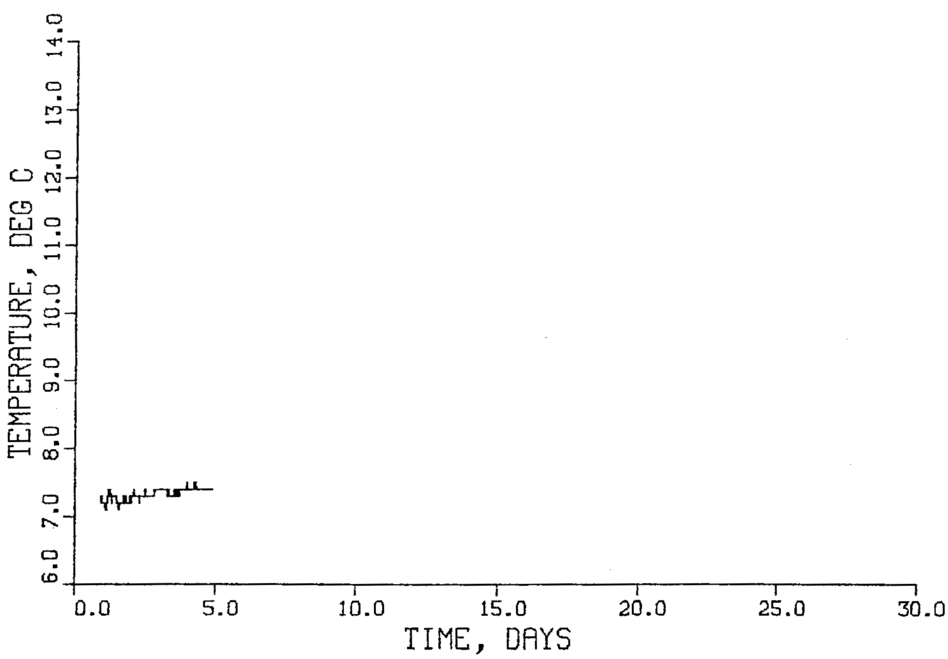


b. Depth = 10.1 m

Figure 105. Temperature at station WT during April 1983

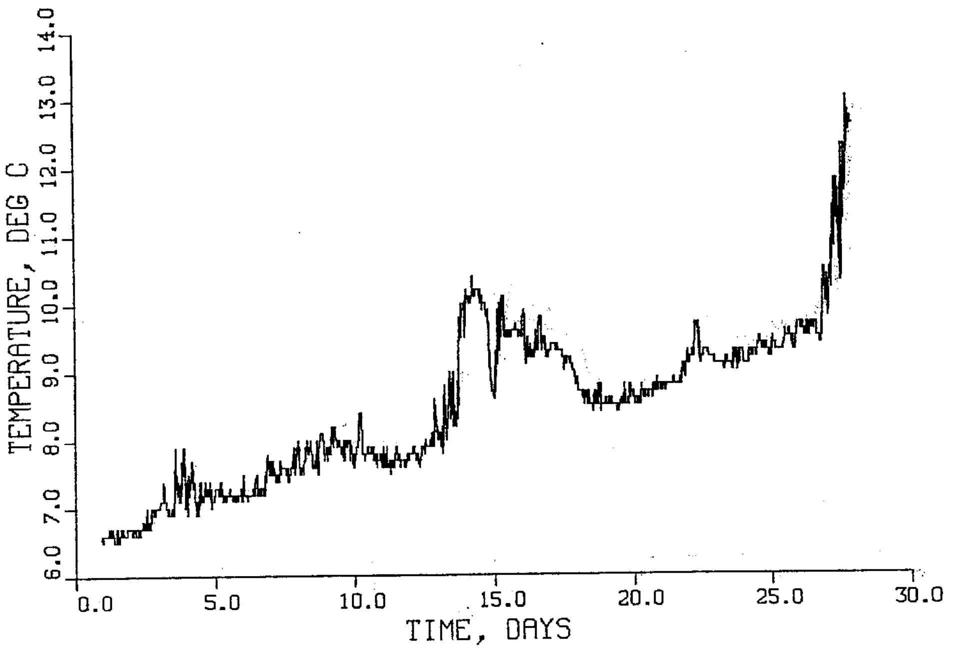


a. Depth = 4.6 m

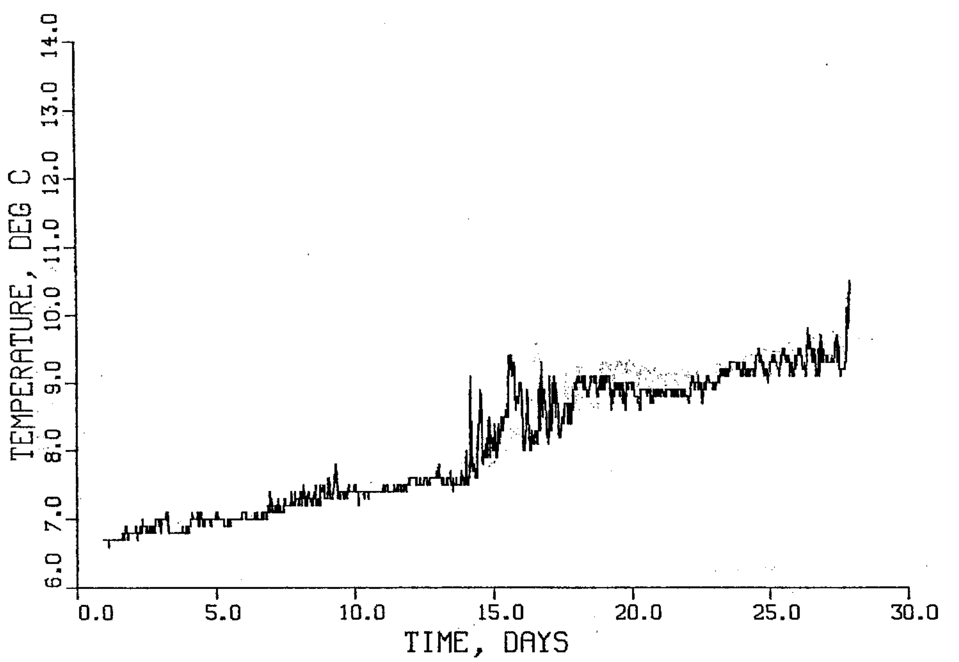


b. Depth = 14.6 m

Figure 106. Temperature at station MB during April 1983

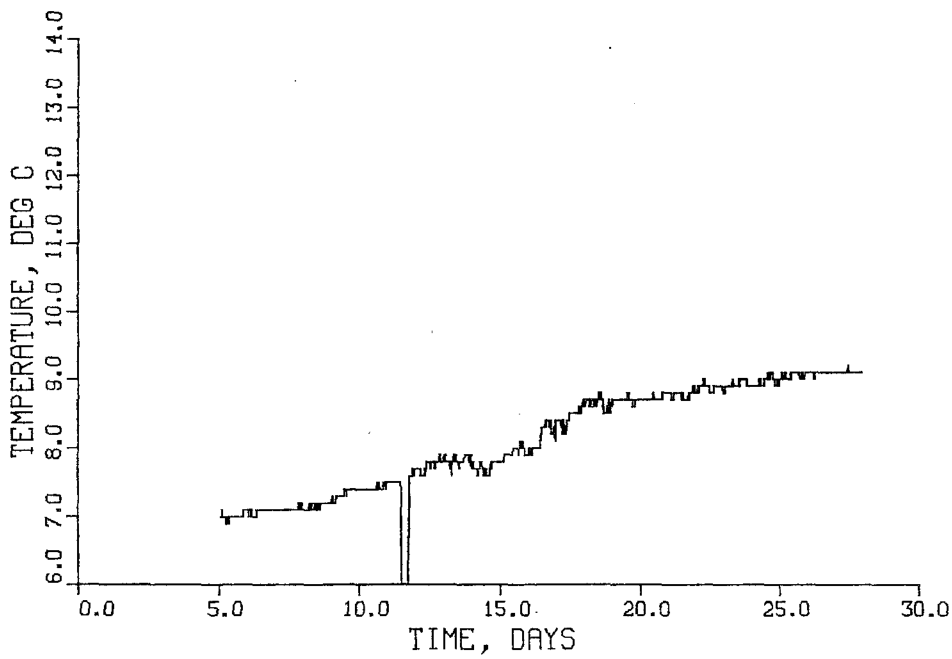


a. Depth = 5.8 m



b. Depth = 11.3 m

Figure 107. Temperature at station BB during April 1983
(Continued)



c. Depth = 21.3 m

Figure 107. (Concluded)

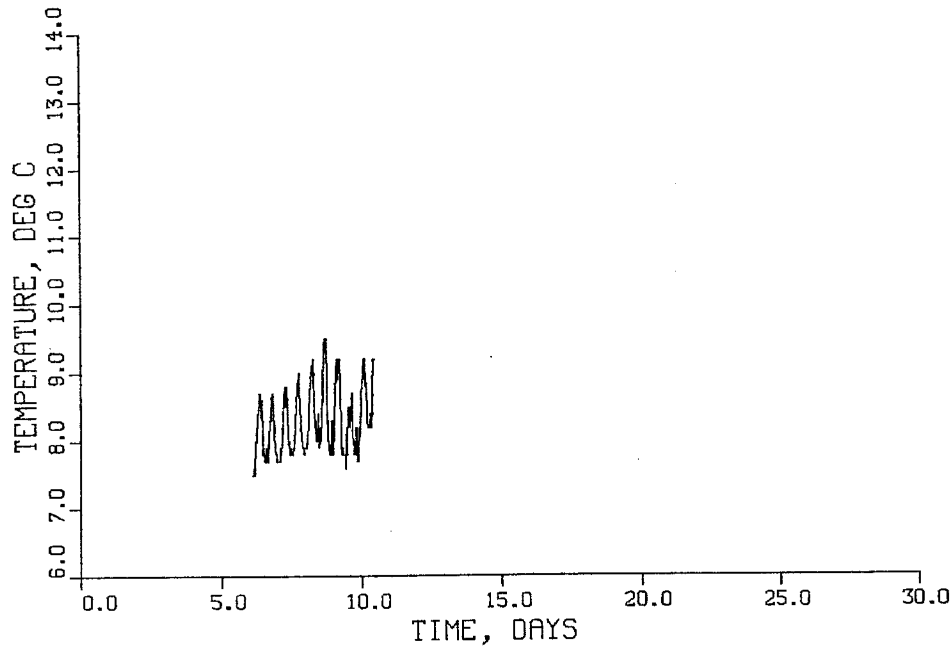


Figure 108. Temperature at Pooles Island at a depth of 5.5 m during April 1983

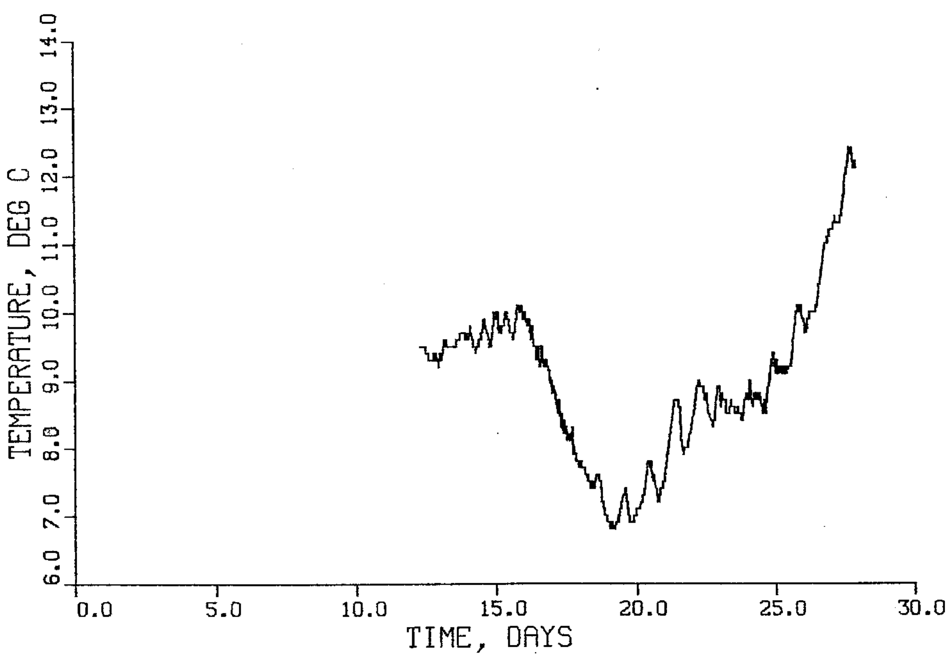


Figure 109. Temperature at Havre de Grace at a depth of 3.0 during April 1983

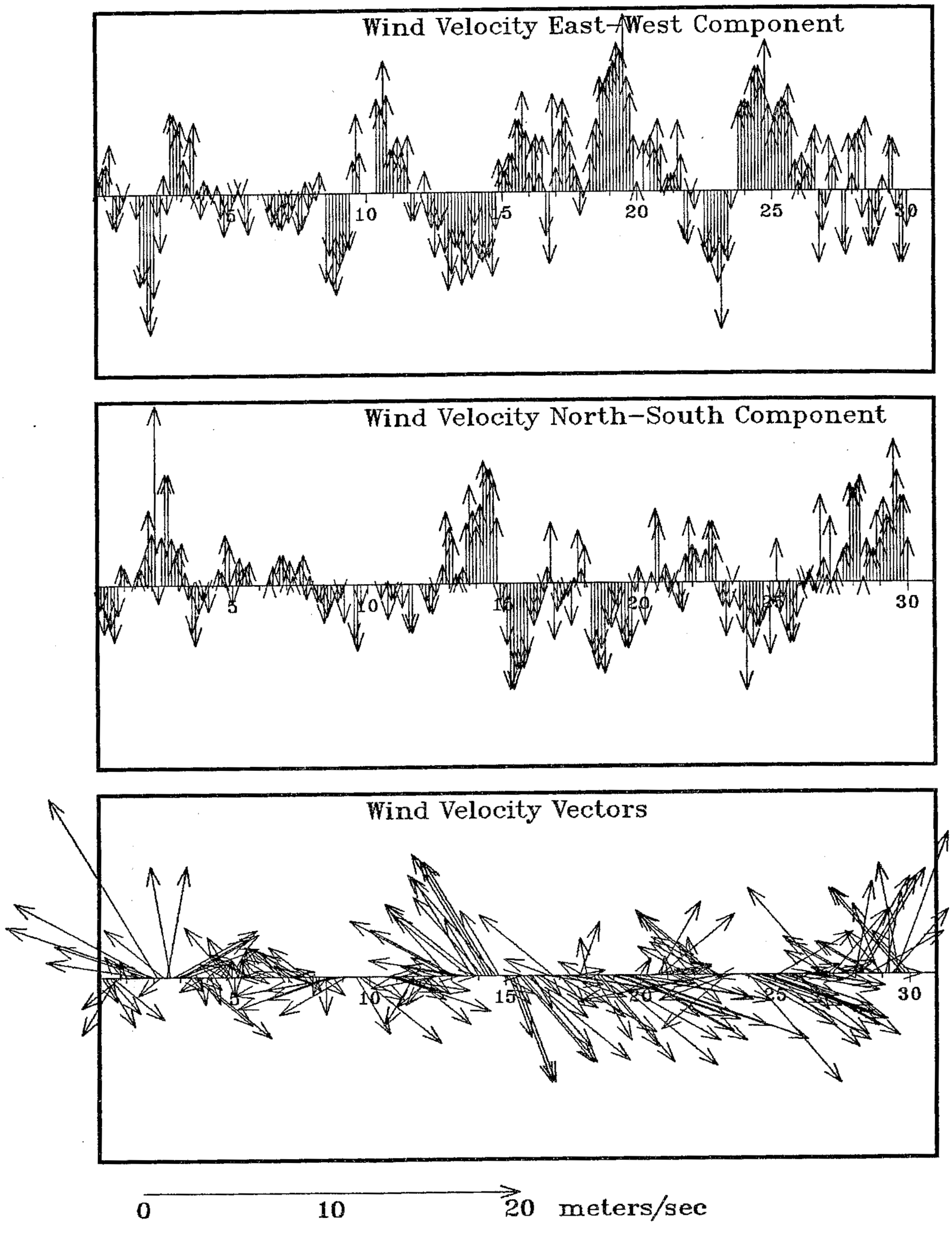


Figure 110. Wind data at Patuxent River Naval Air Station during April 1983

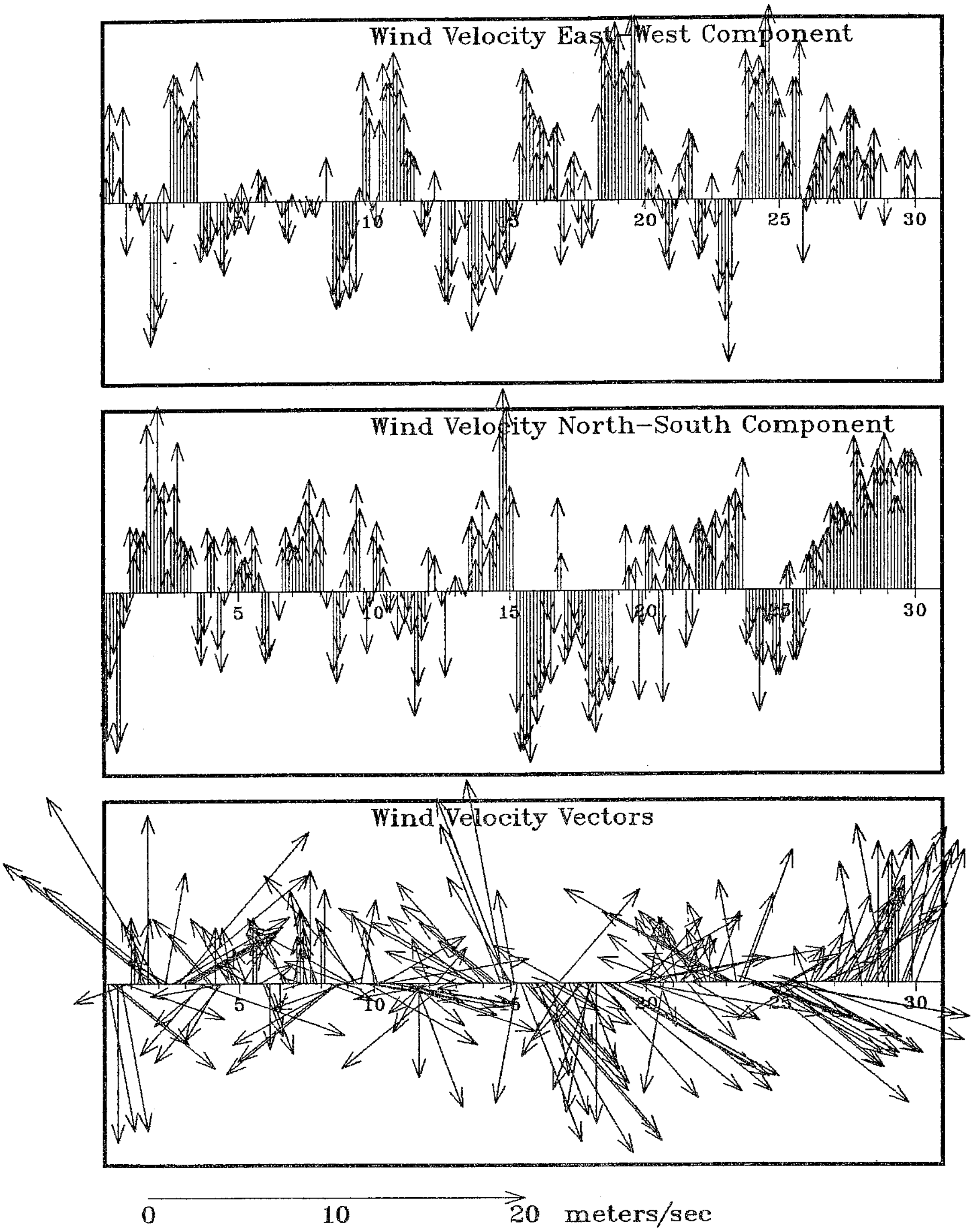


Figure 111. Wind data at Norfolk International Airport during April 1983

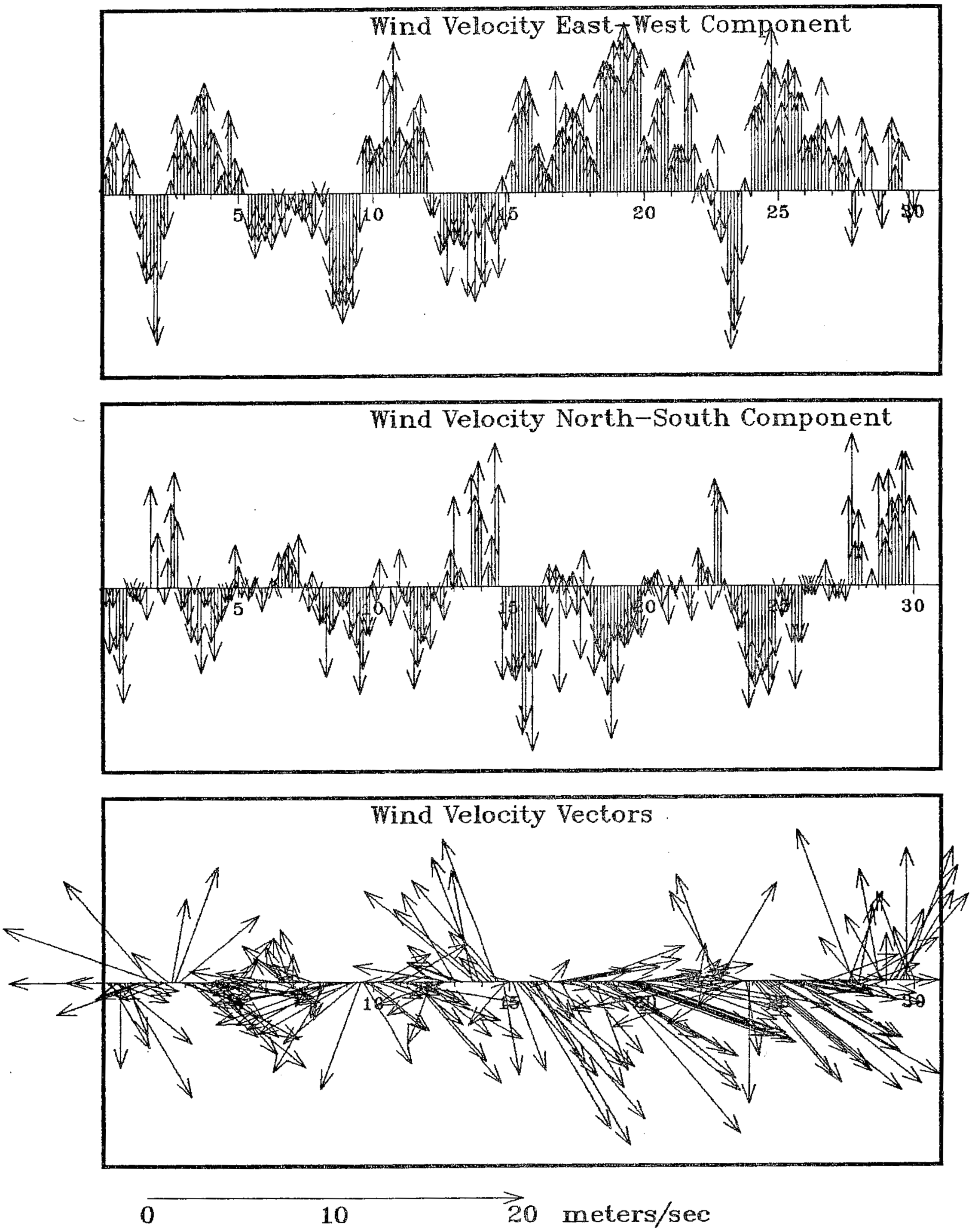
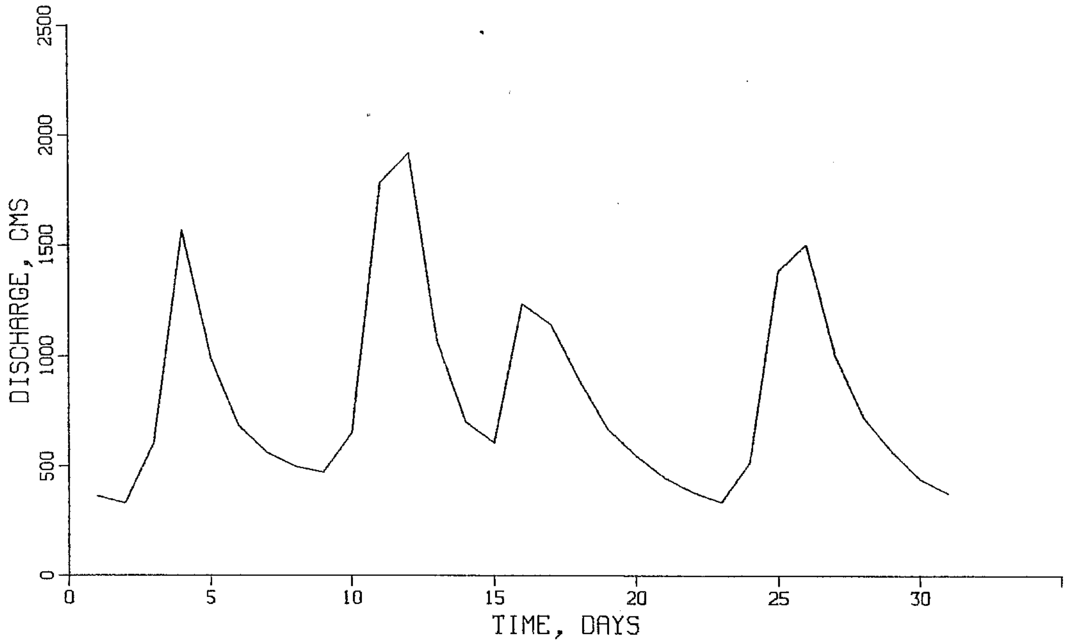
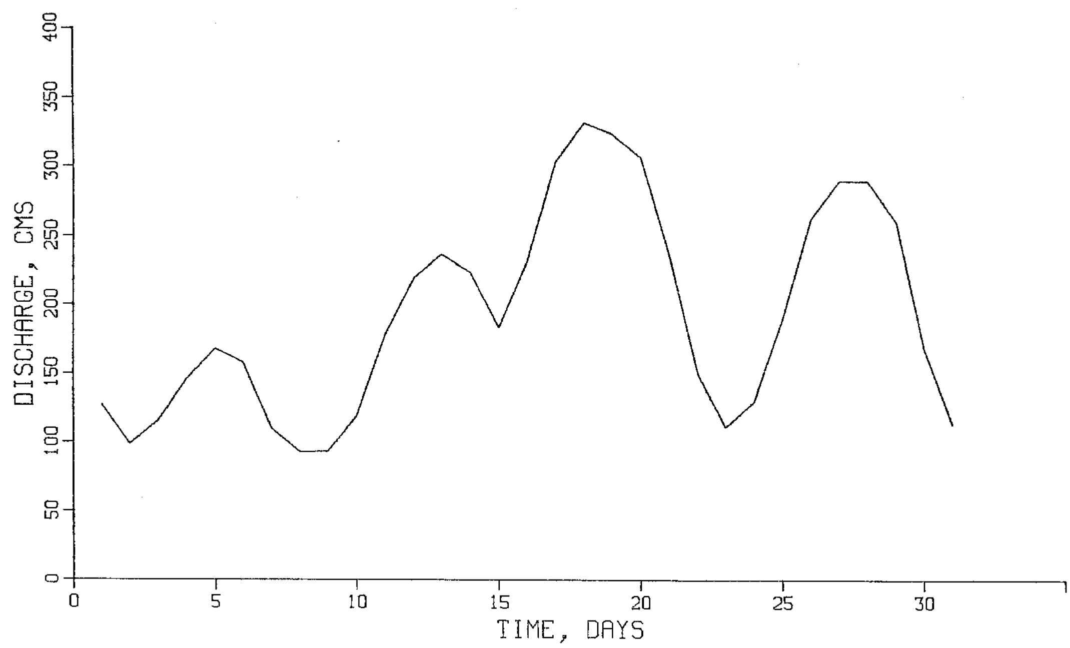


Figure 112. Wind data at Baltimore-Washington International Airport during April 1983

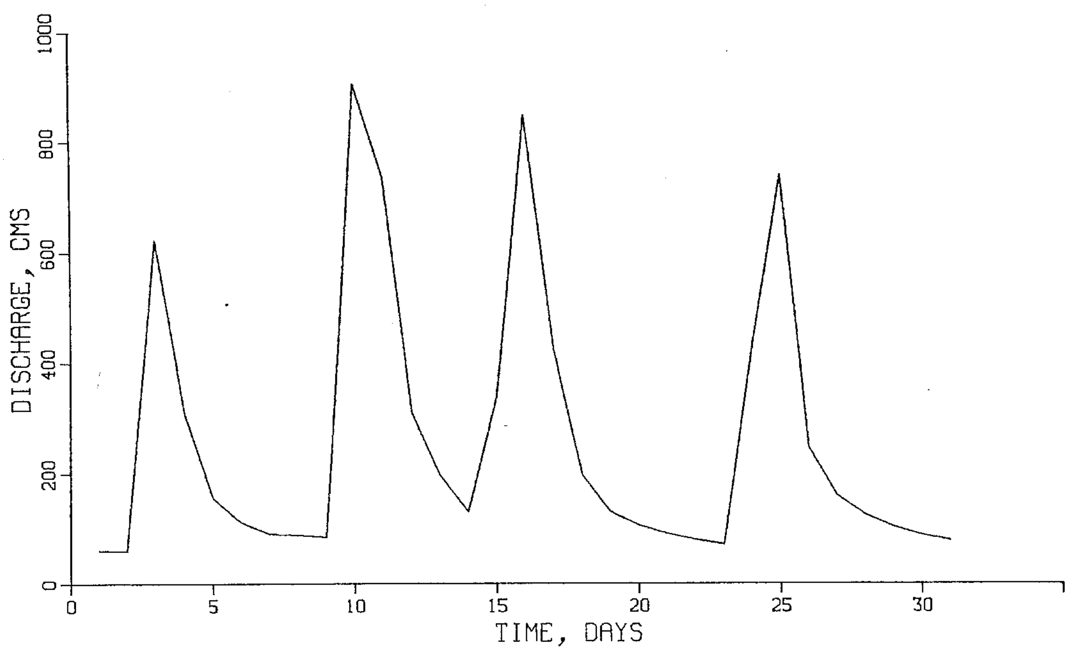


a. James River

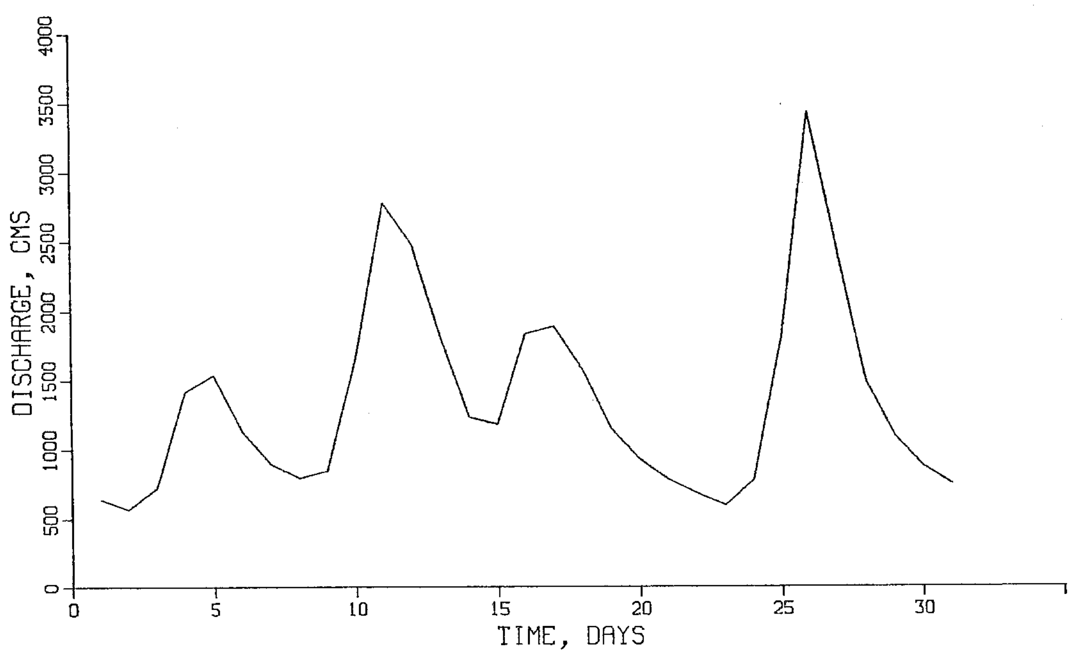


b. York River

Figure 113. Freshwater inflows during April 1983 (Sheet 1 of 4)

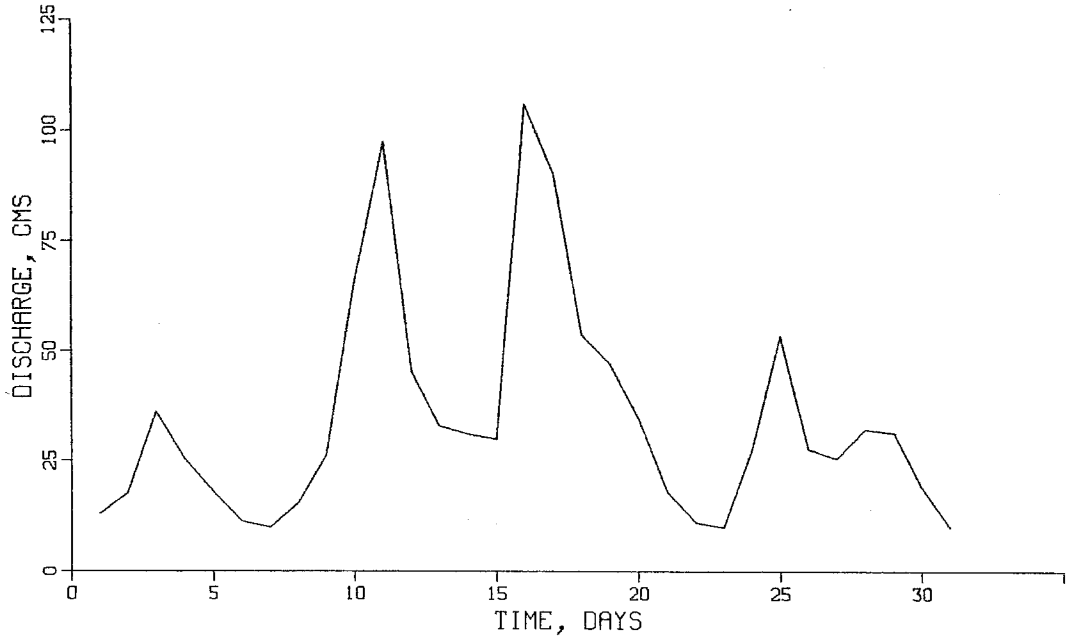


c. Rappahannock River

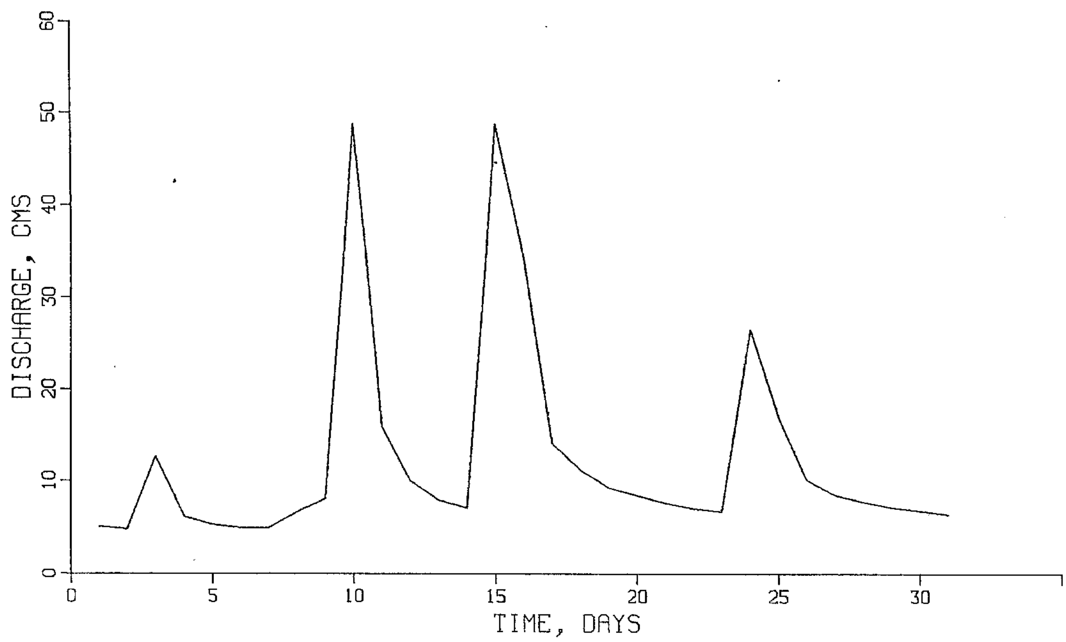


d. Potomac River

Figure 113. (Sheet 2 of 4)

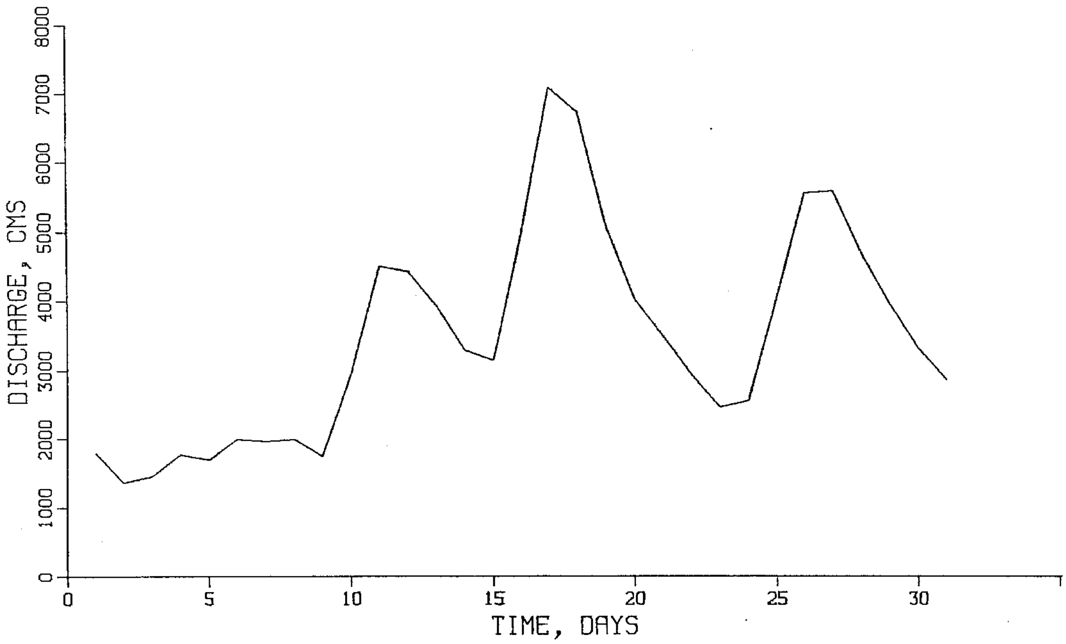


e. Patuxent River

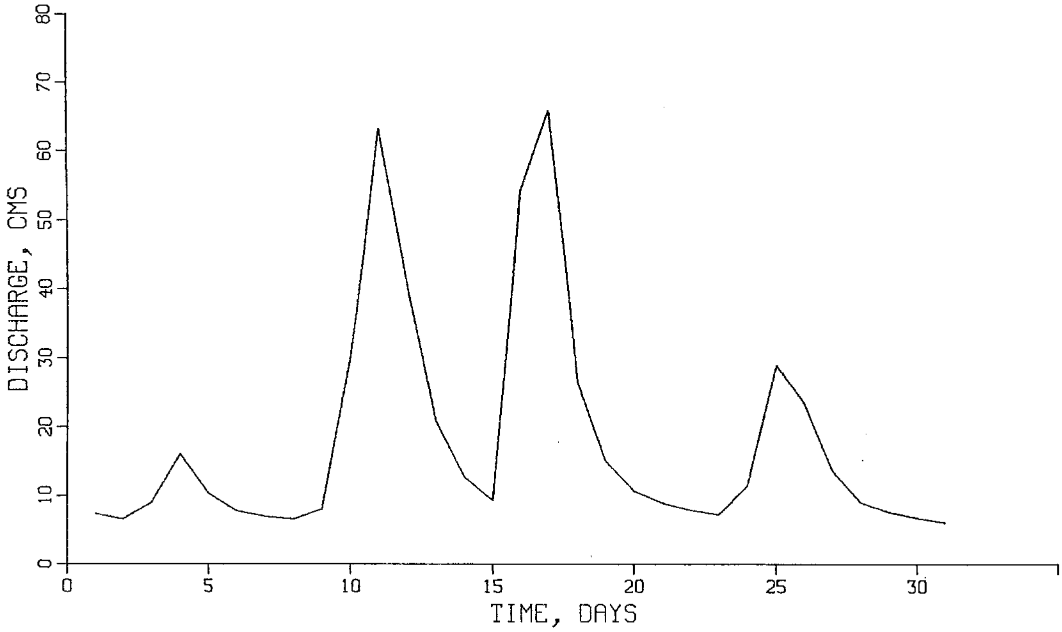


f. Patapsco River

Figure 113. (Sheet 3 of 4)



g. Susquehanna River



h. Choptank River

Figure 113. (Sheet 4 of 4)

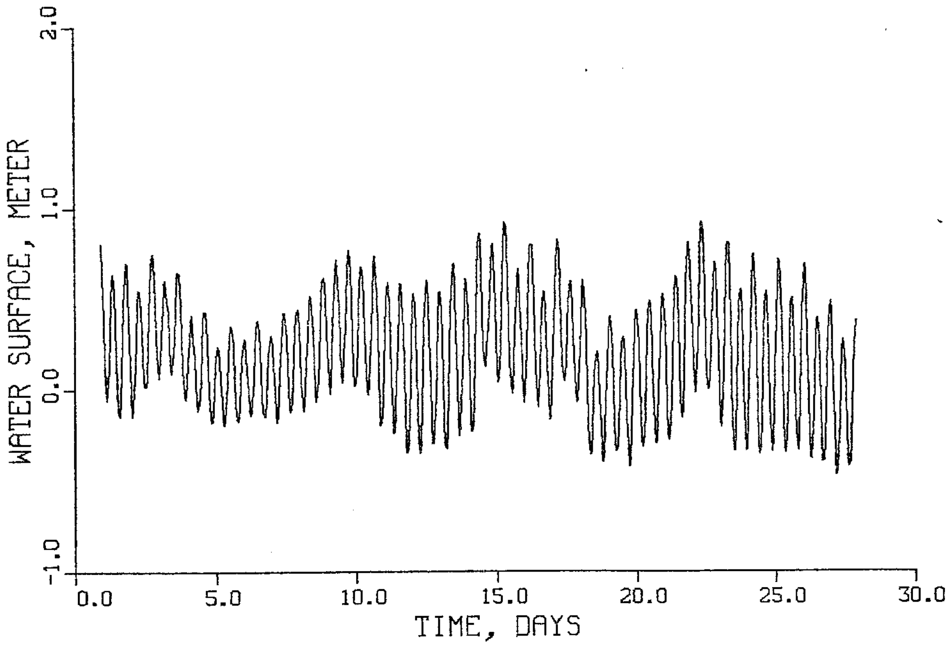


Figure 114. Tide at Chesapeake Bay Tunnel corrected at NGVD during April 1983

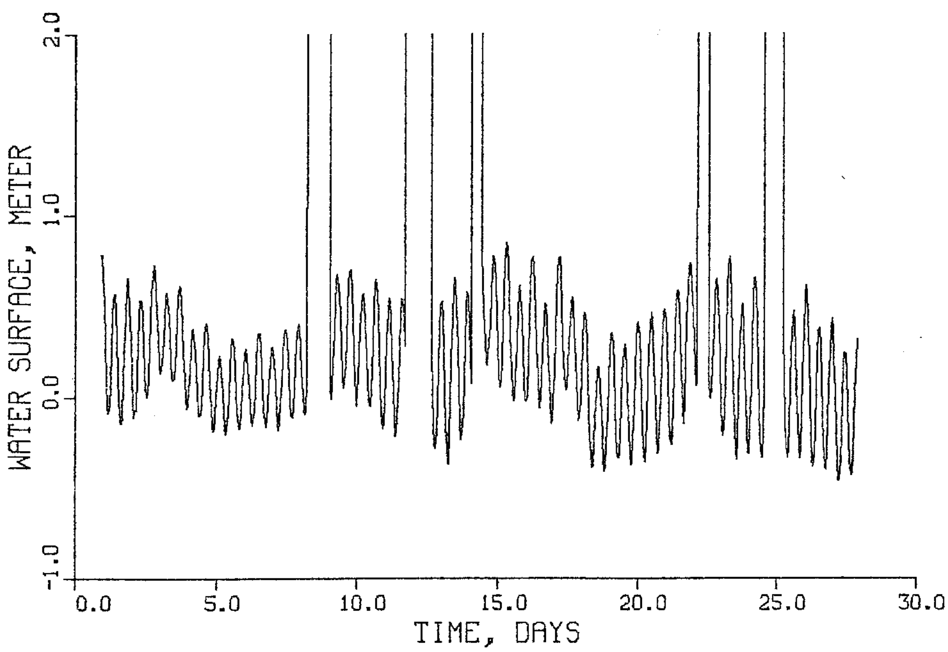


Figure 115. Tide at Hampton Roads, VA, corrected to NGVD during April 1983

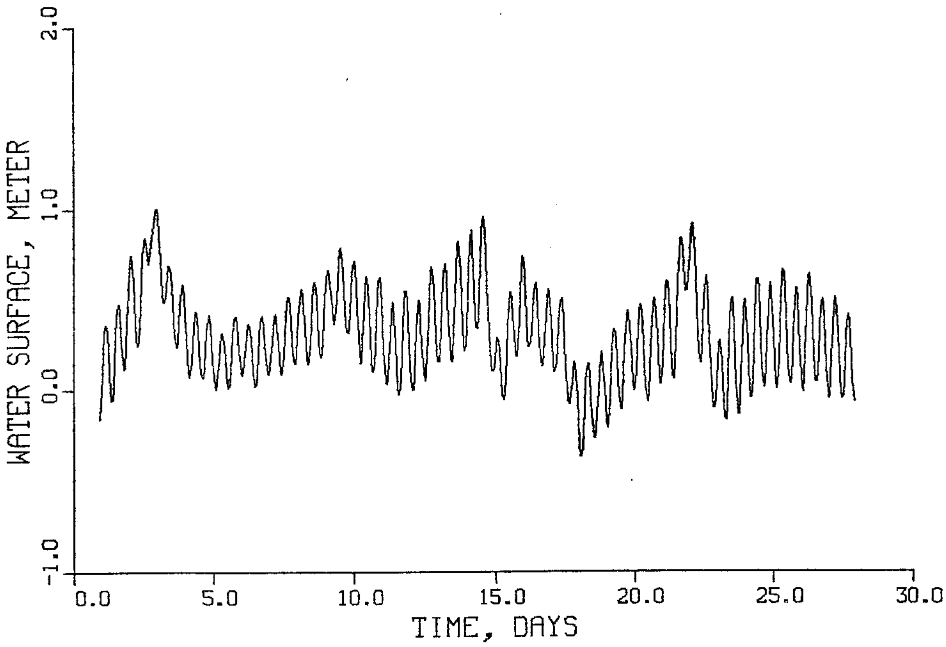


Figure 116. Tide at Colonial Beach, VA, corrected at NGVD during April 1983

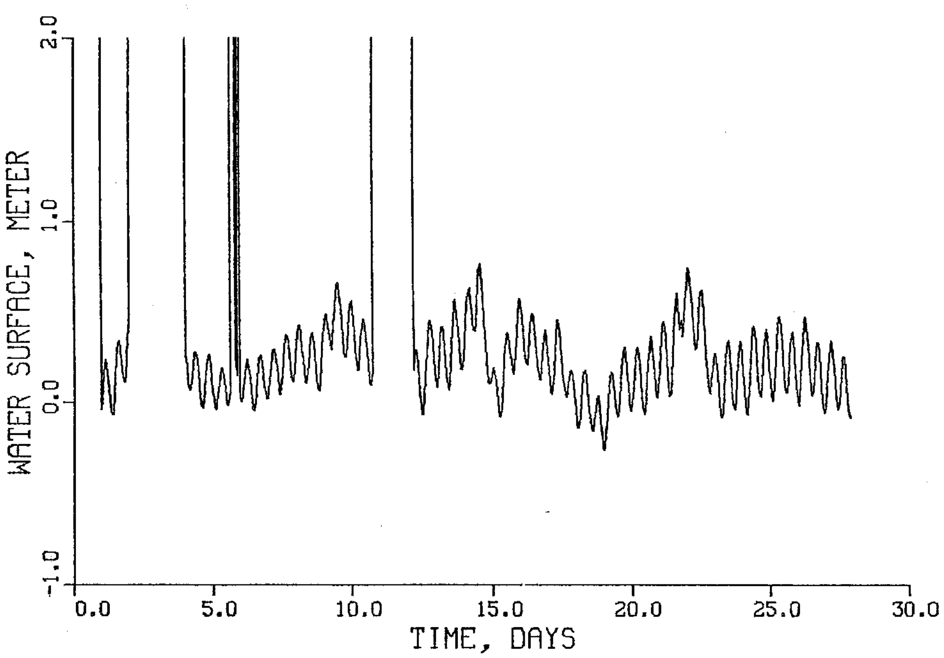


Figure 117. Tide at Solomons, MD, corrected to NGVD during April 1983

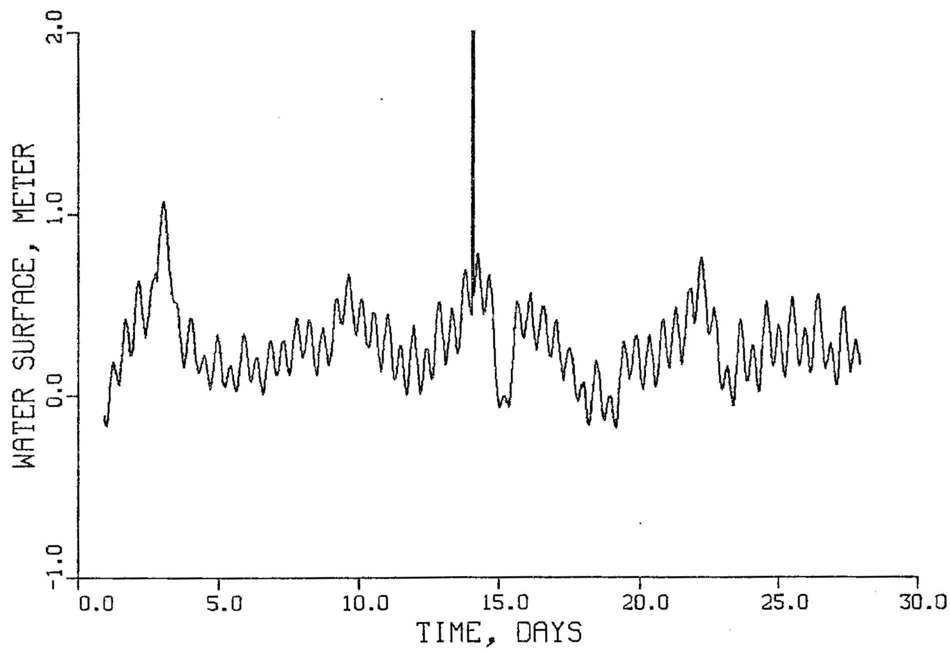


Figure 118. Tide at Annapolis, MD, corrected to NGVD during April 1983

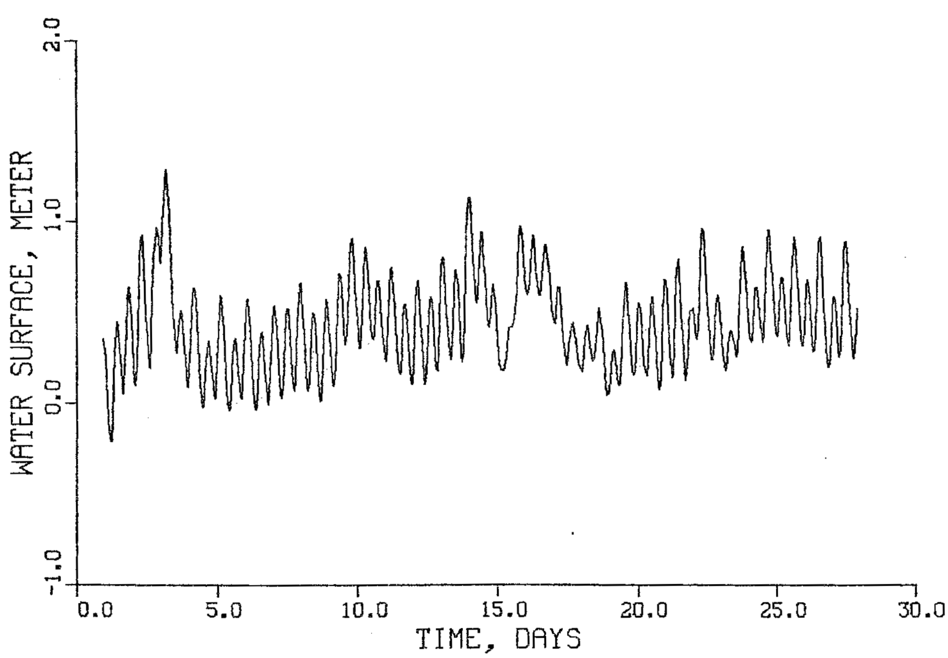
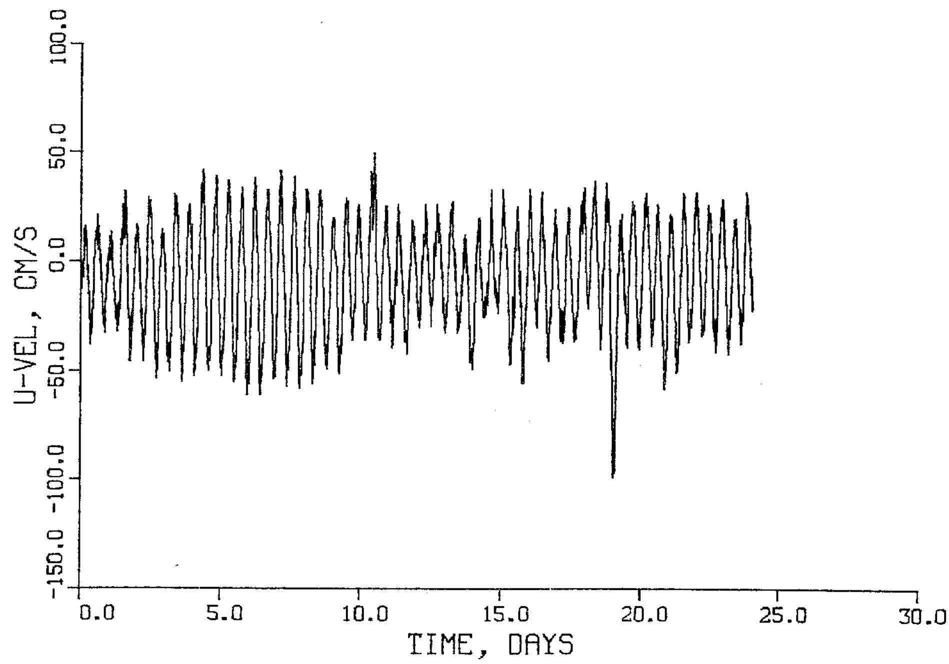
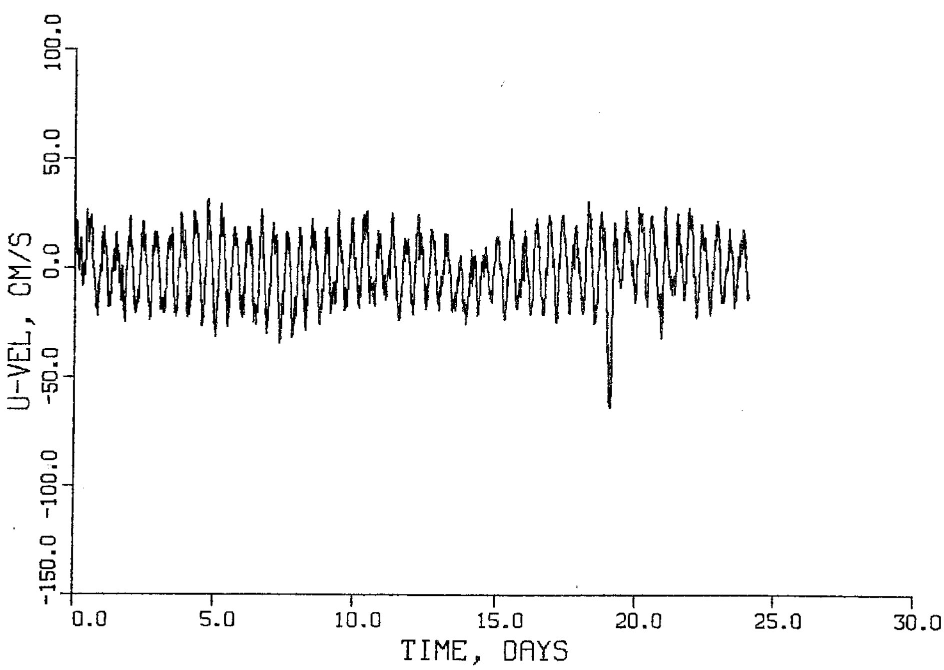


Figure 119. Tide at Havre de Grace, MD, corrected to NGVD during April 1983

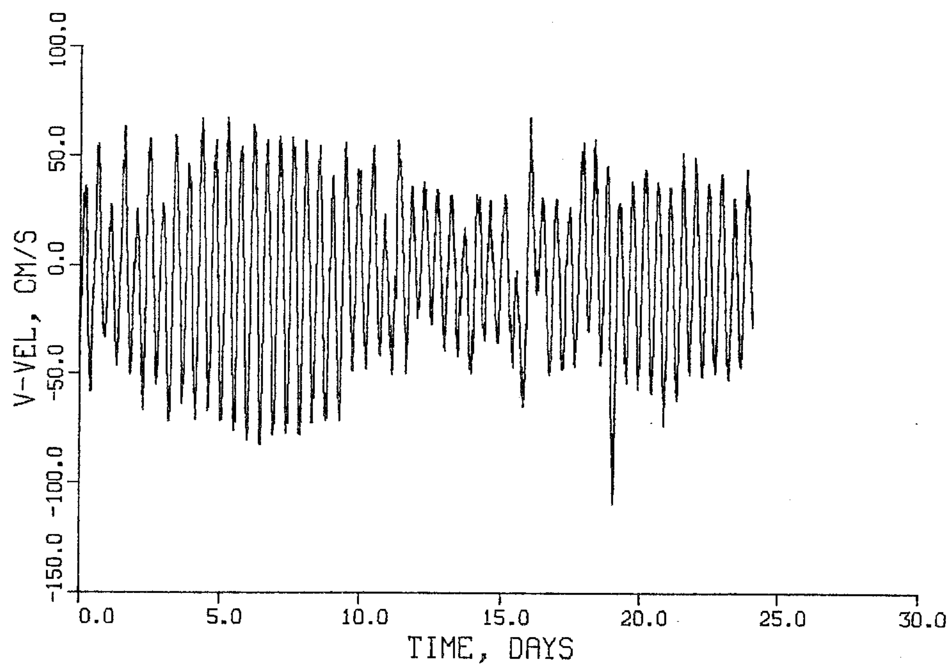


a. Depth = 4.6 m

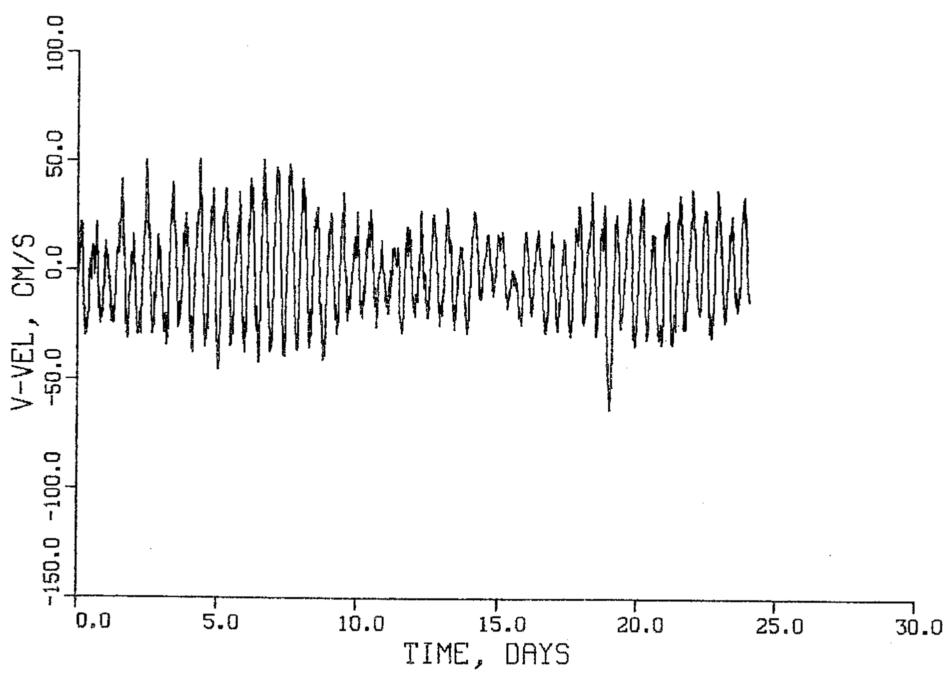


b. Depth = 10.4 m

Figure 120. U-velocity at station BE during September 1983

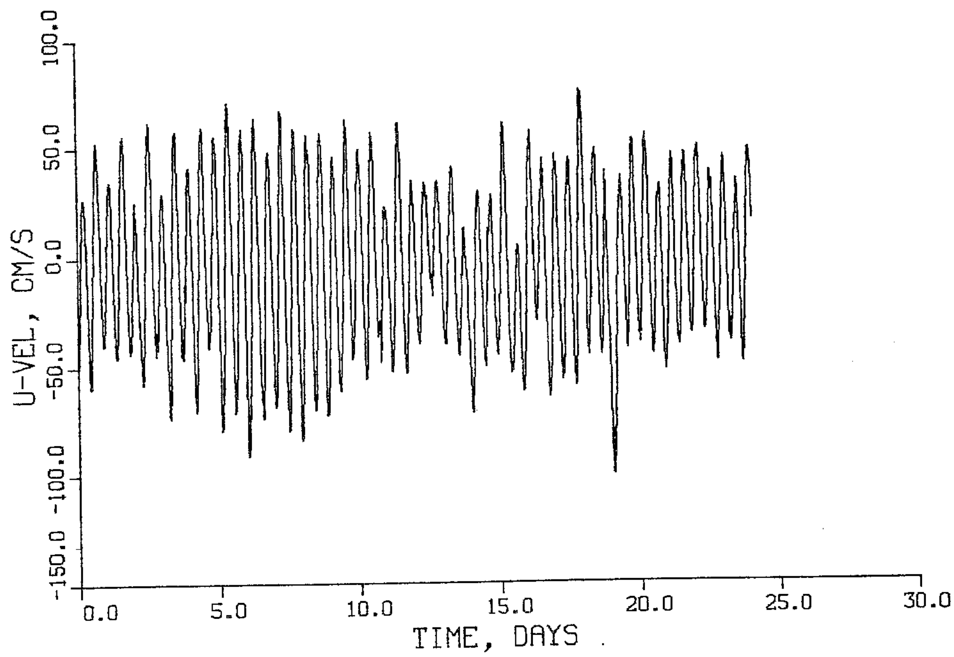


a. Depth = 4.6 m

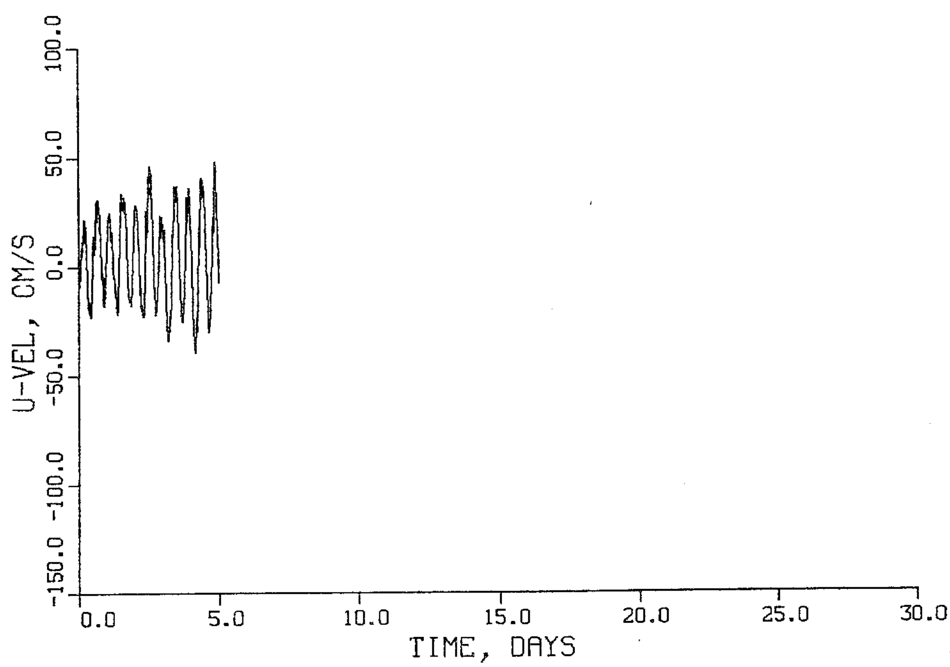


b. Depth = 10.4 m

Figure 121. V-velocity at station BE during September 1983

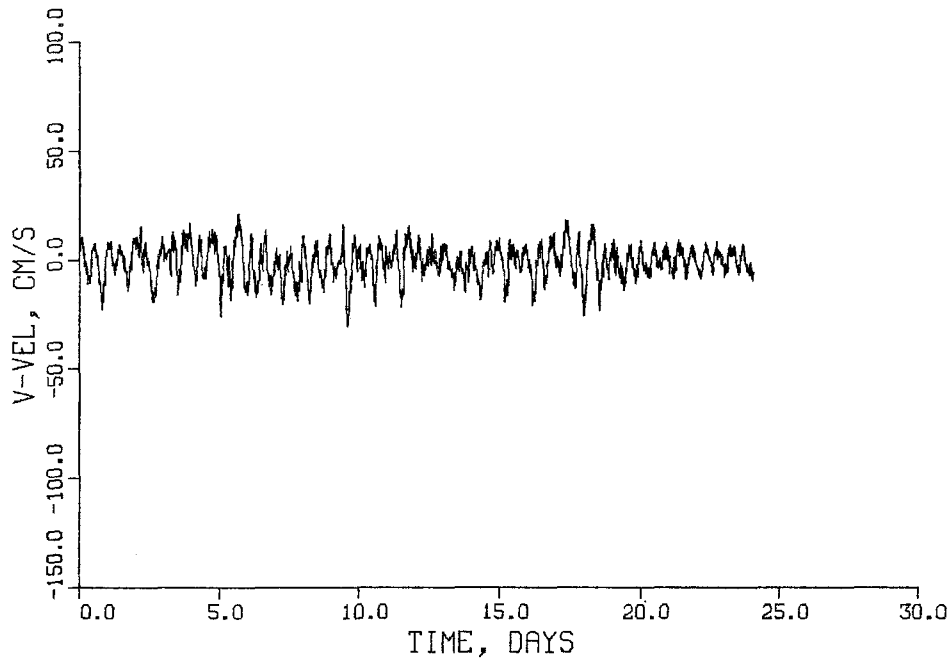


a. Depth = 4.6 m

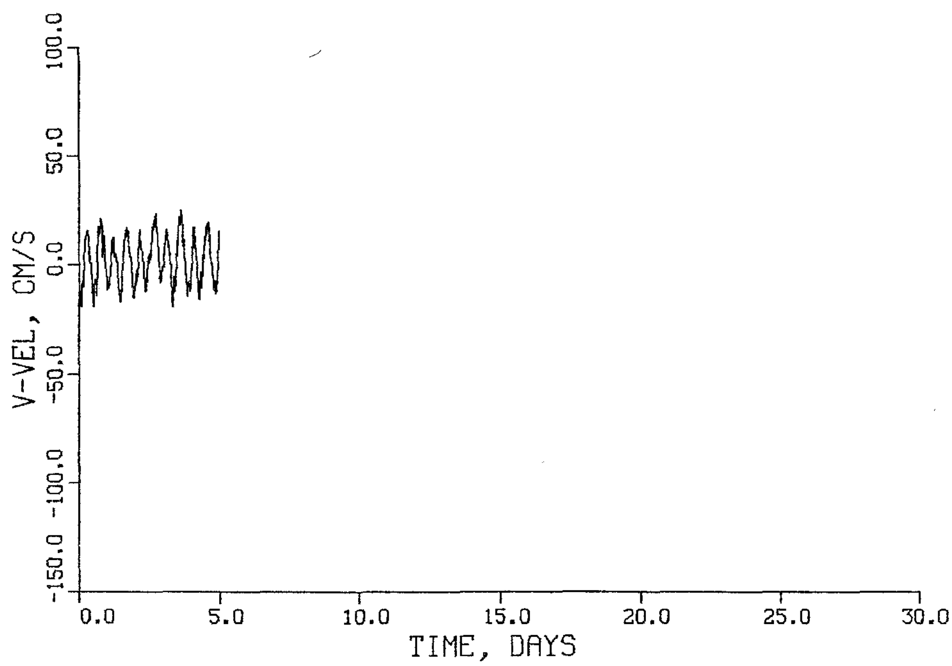


b. Depth = 10.1 m

Figure 122. U-velocity at station WT during September 1983

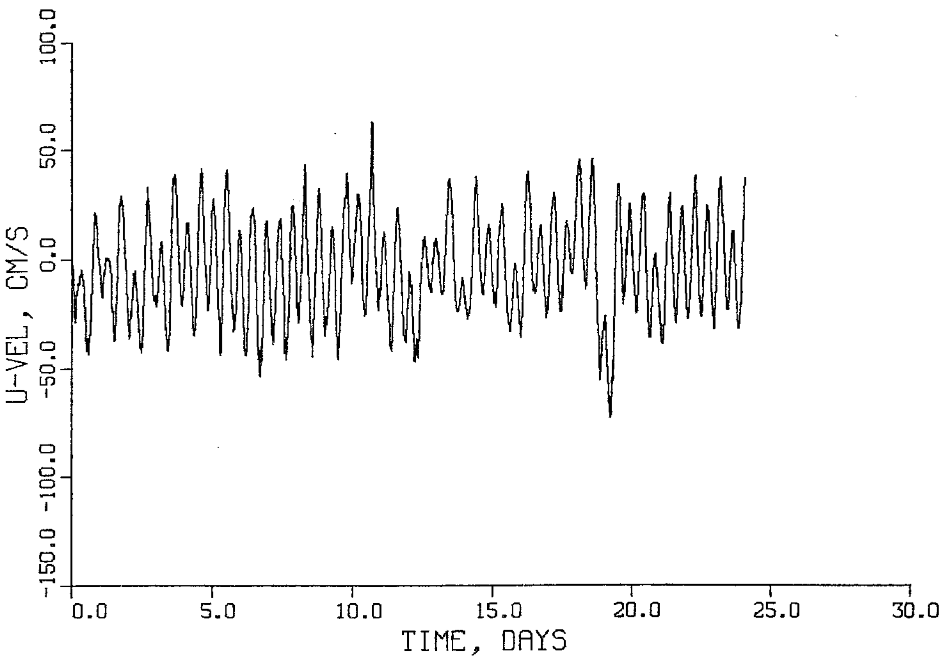


a. Depth = 4.6 m

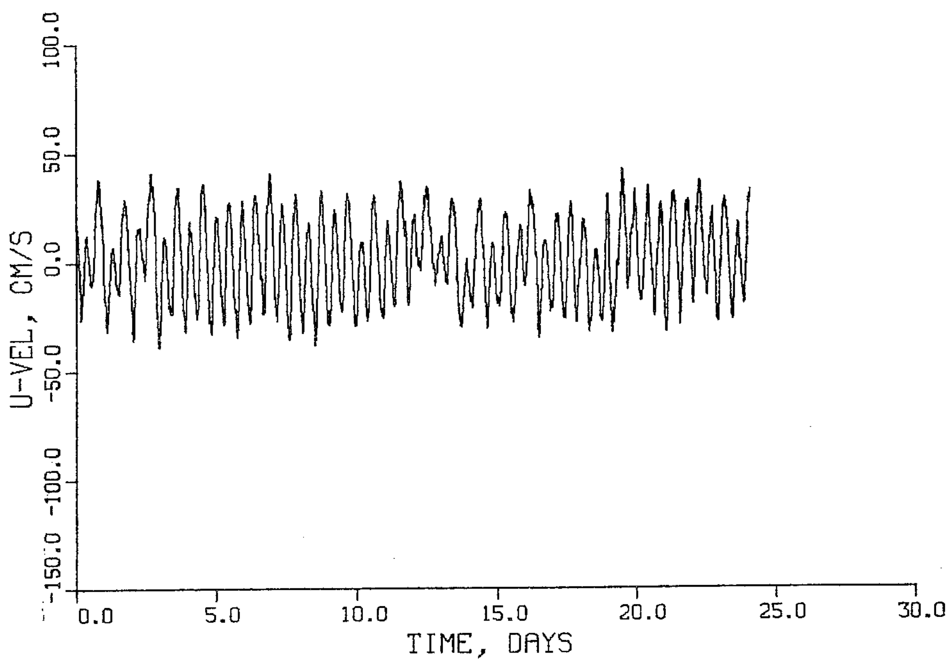


b. Depth = 10.1 m

Figure 123. V-velocity at station WT during September 1983

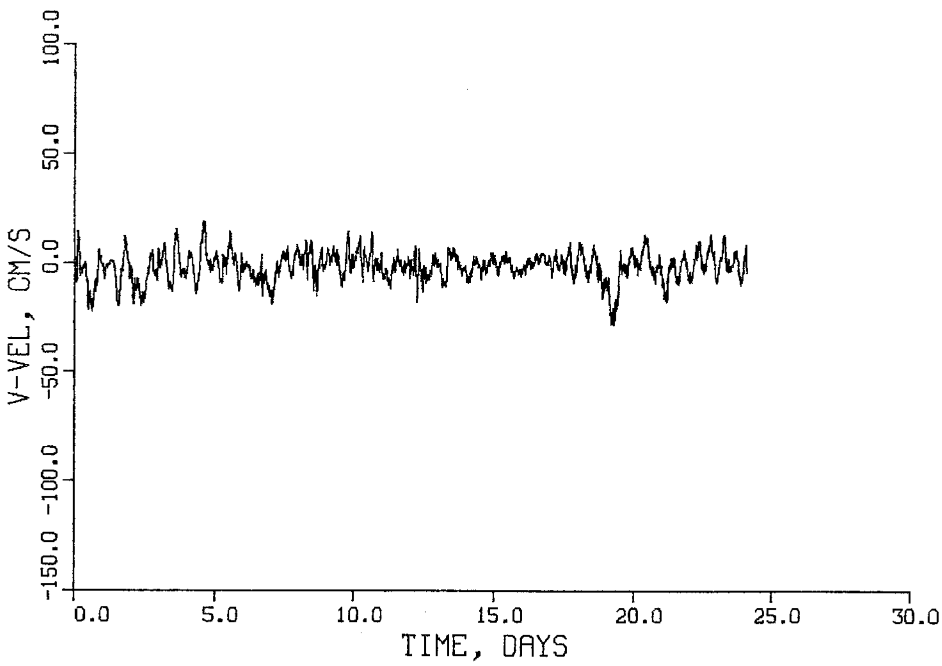


a. Depth = 5.2 m

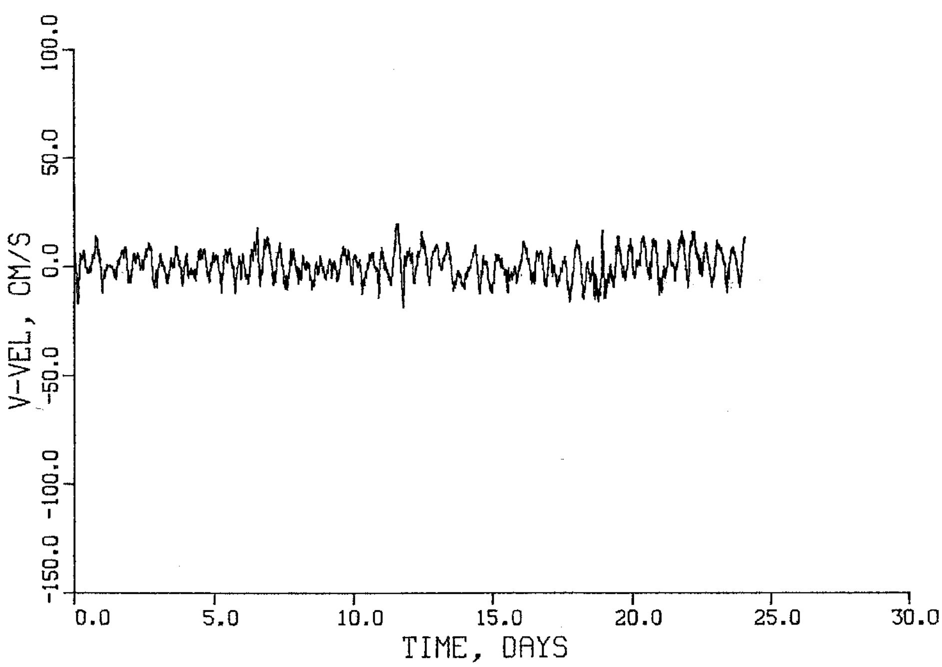


b. Depth = 14.9 m

Figure 124. U-velocity at station MB during September 1983

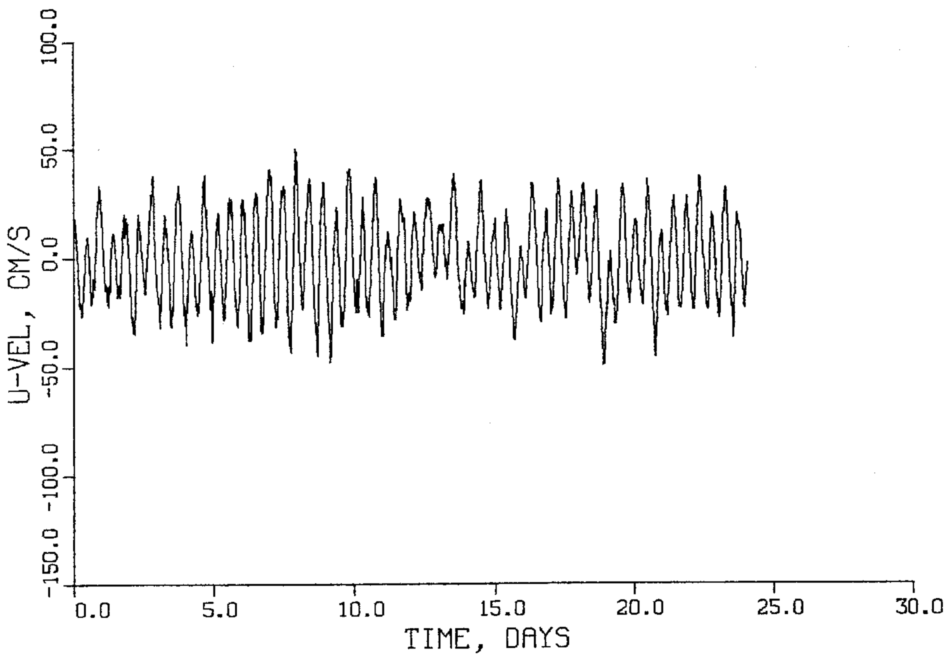


a. Depth = 5.2 m

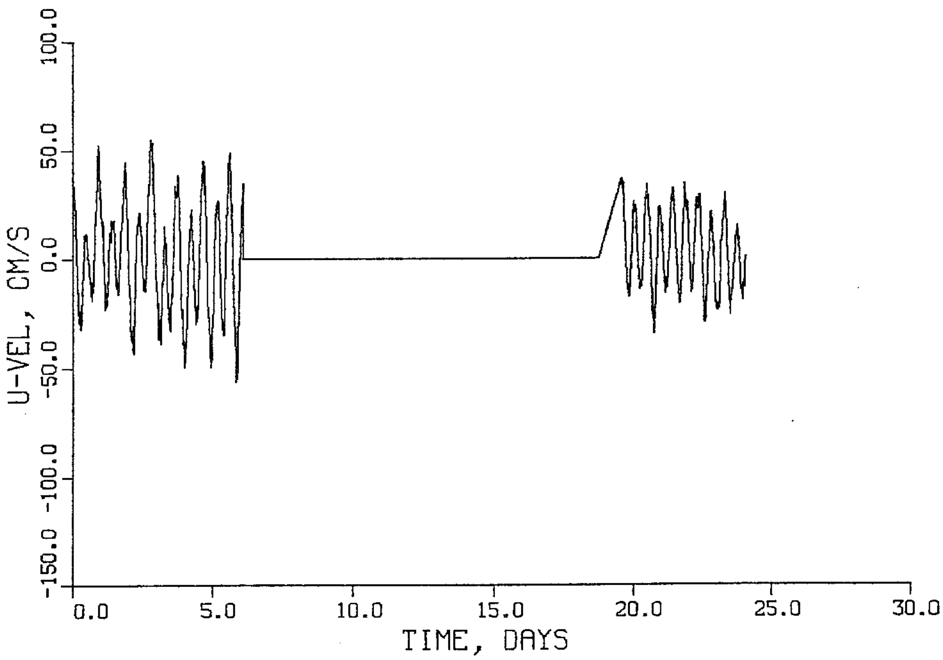


b. Depth = 14.9 m

Figure 125. V-velocity at station MB during September 1983

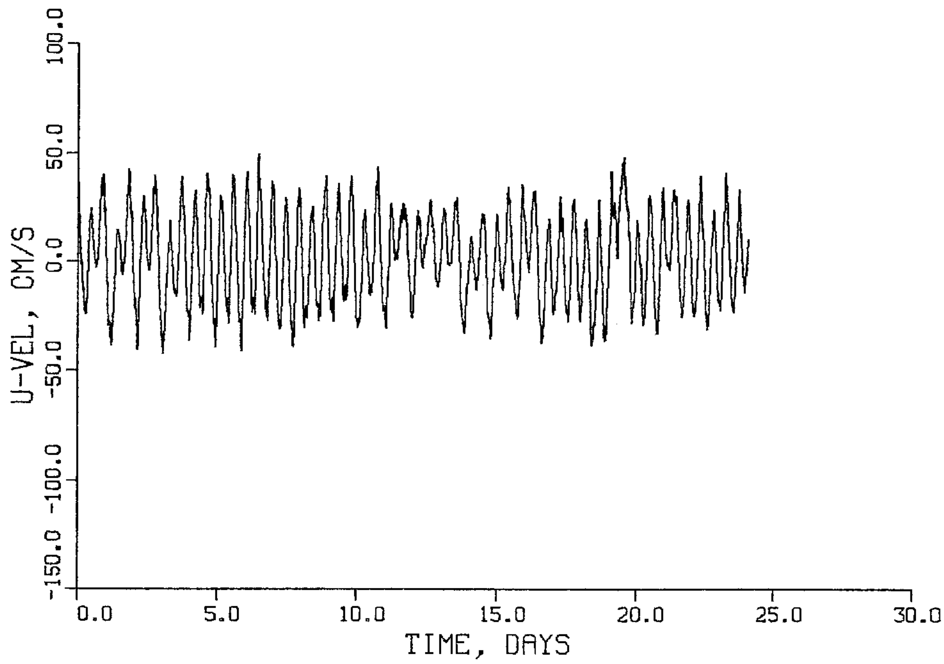


a. Depth = 5.8 m



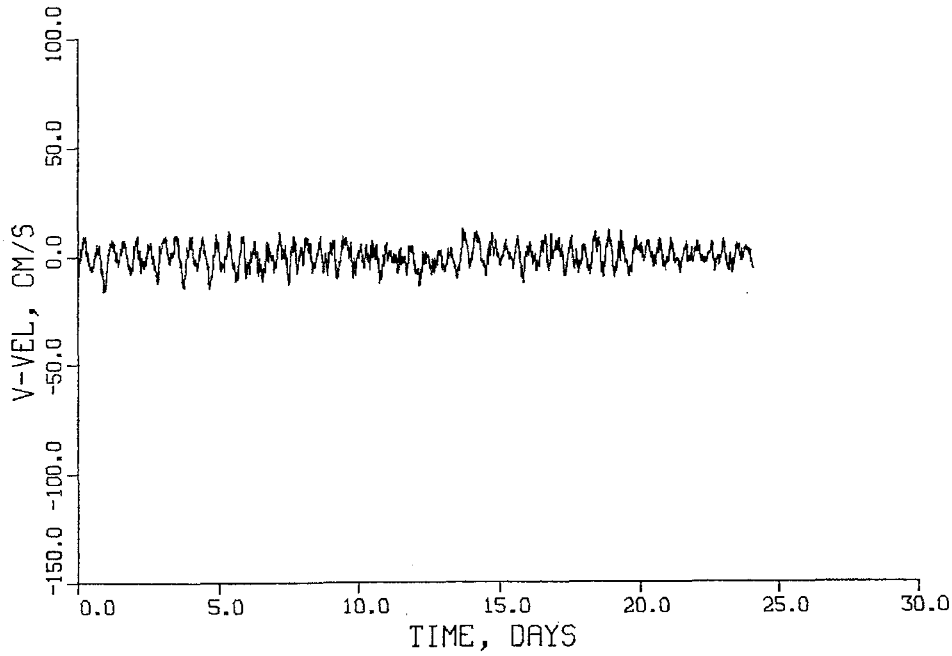
b. Depth = 11.3 m

Figure 126. U-velocity at station BB during September 1983 (Continued)

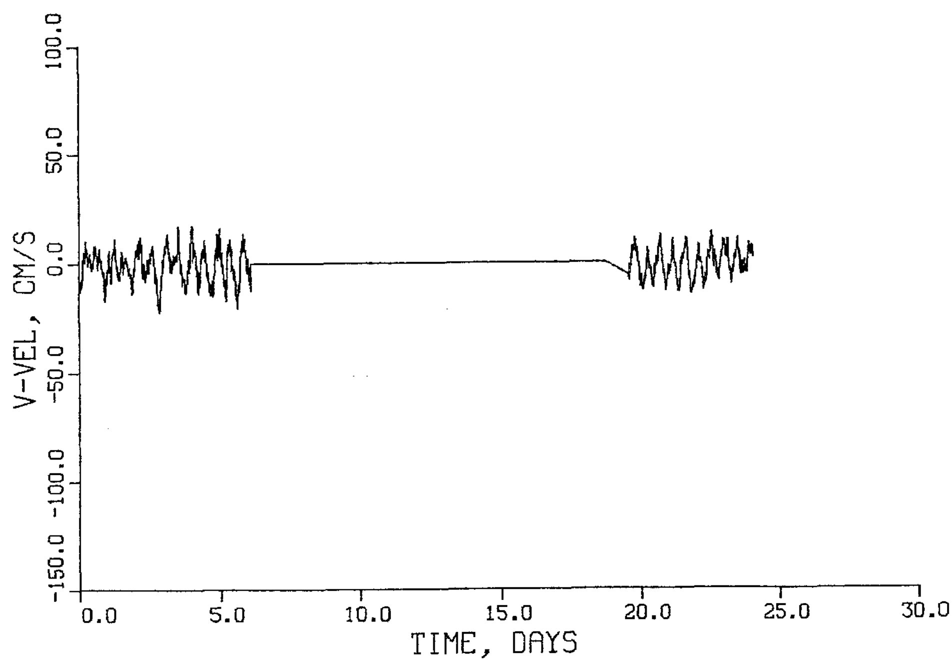


c. Depth = 21.3 m

Figure 126. (Concluded)

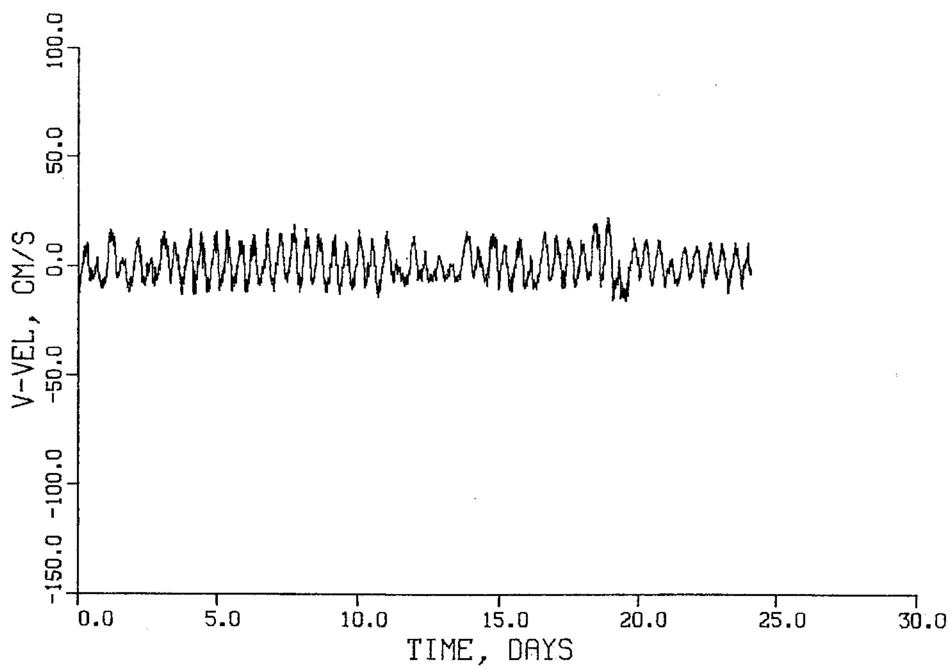


a. Depth = 5.8 m



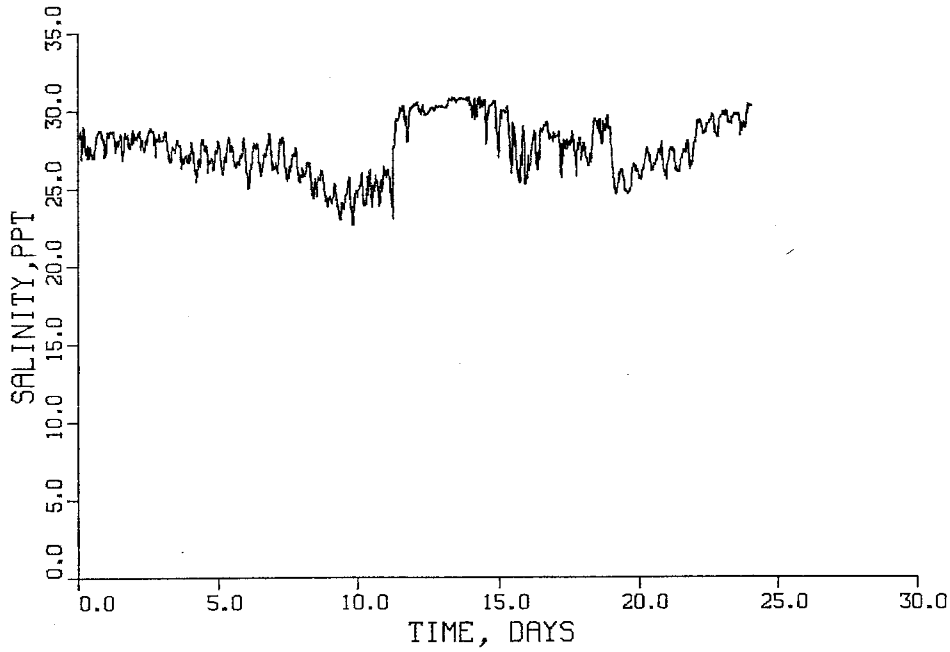
b. Depth = 11.3 m

Figure 127. V-velocity at station BB during September 1983 (Continued)

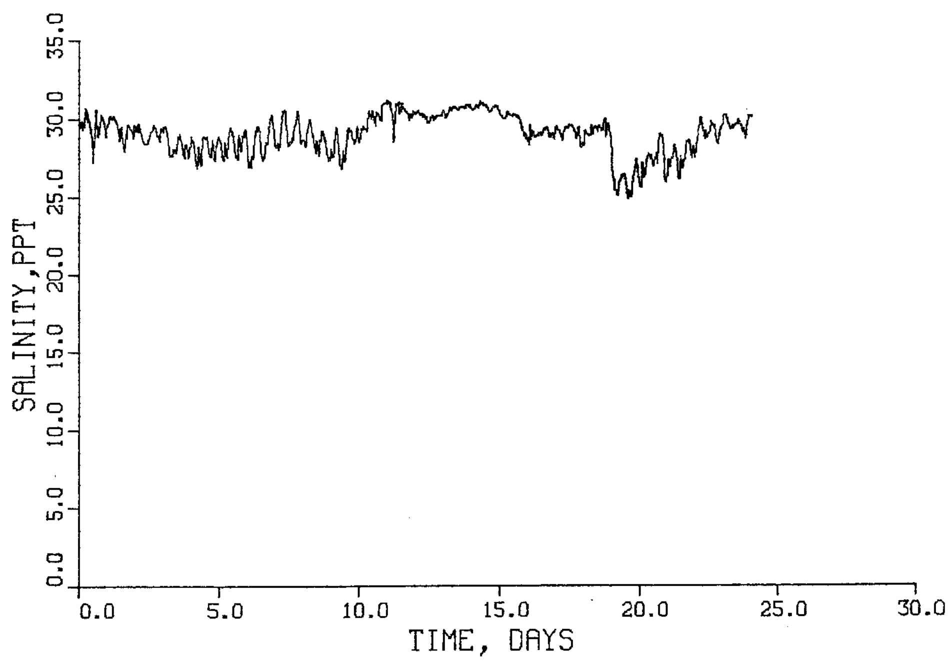


c. Depth = 21.3 m

Figure 127. (Concluded)

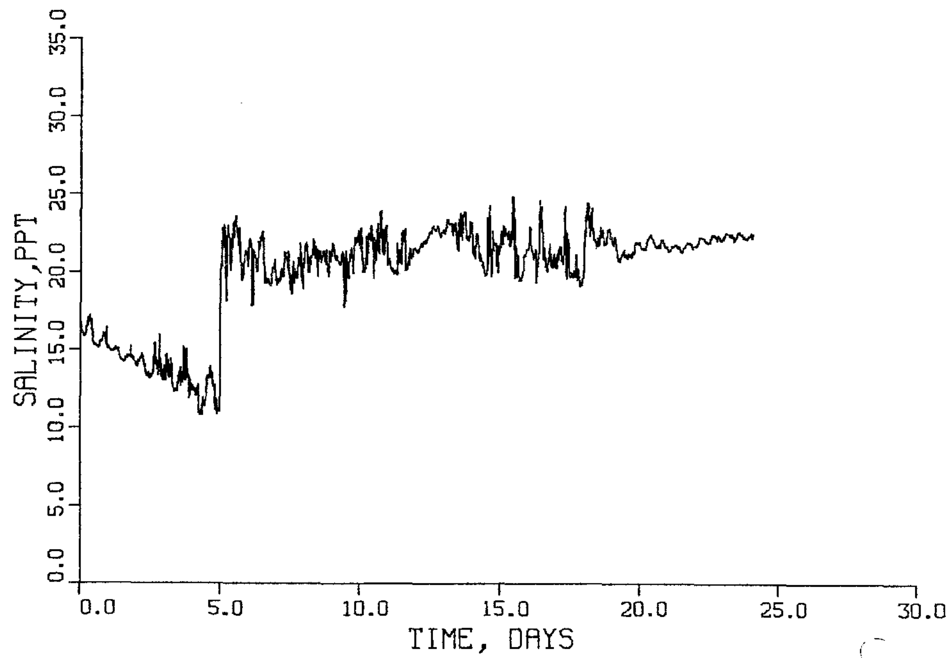


a. Depth = 4.6 m

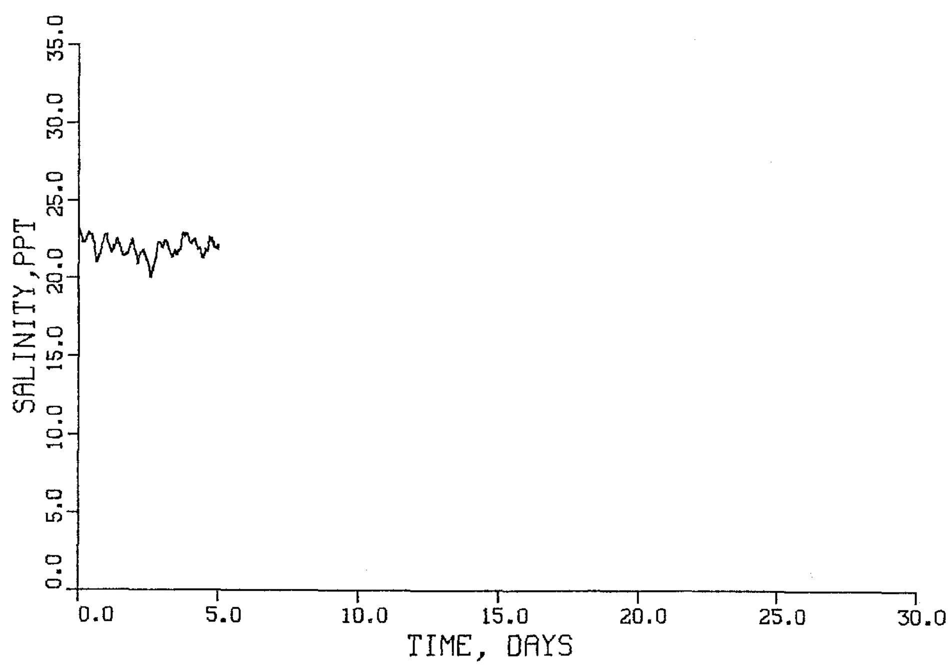


b. Depth = 10.1 m

Figure 128. Salinity at station BE during September 1983

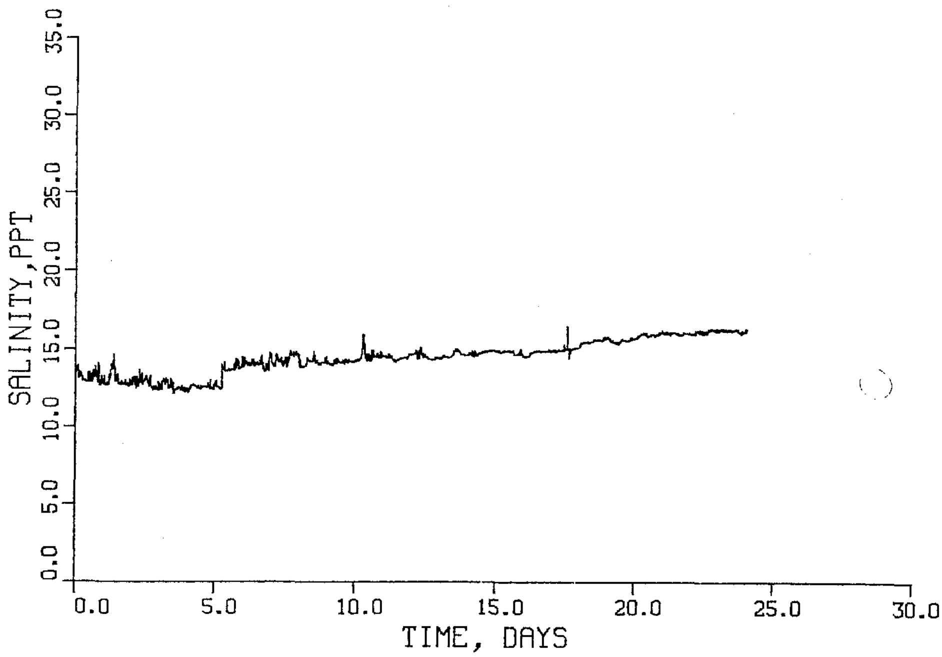


a. Depth = 4.6 m

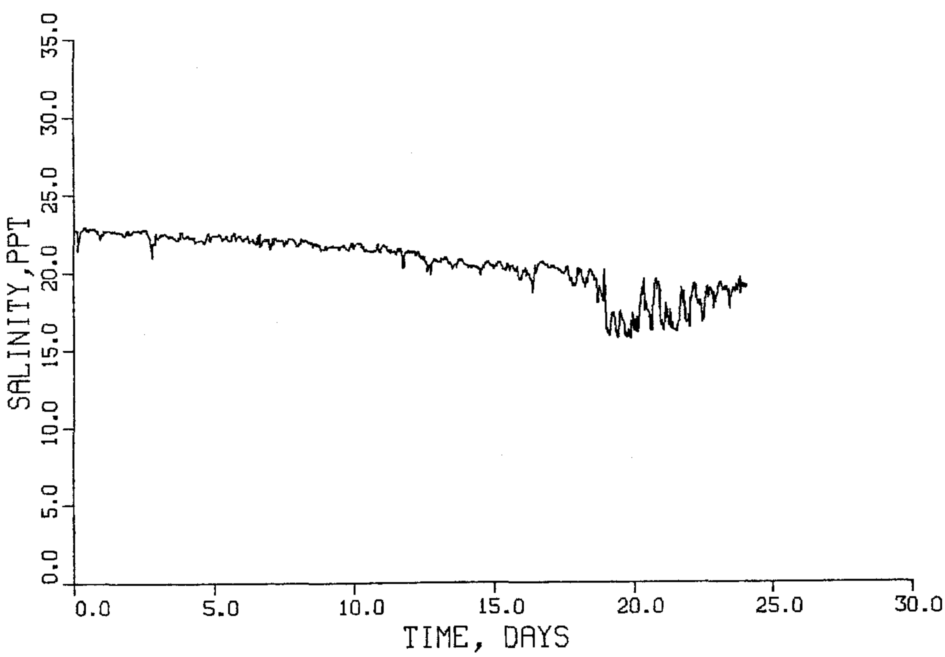


b. Depth = 10.1 m

Figure 129. Salinity at station WT during September 1983

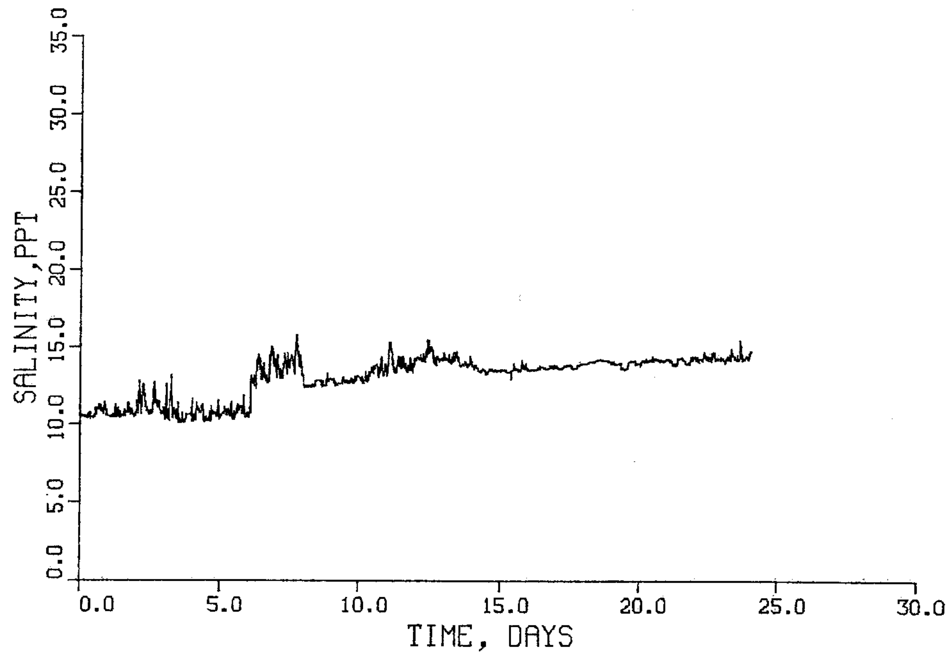


a. Depth = 5.2 m

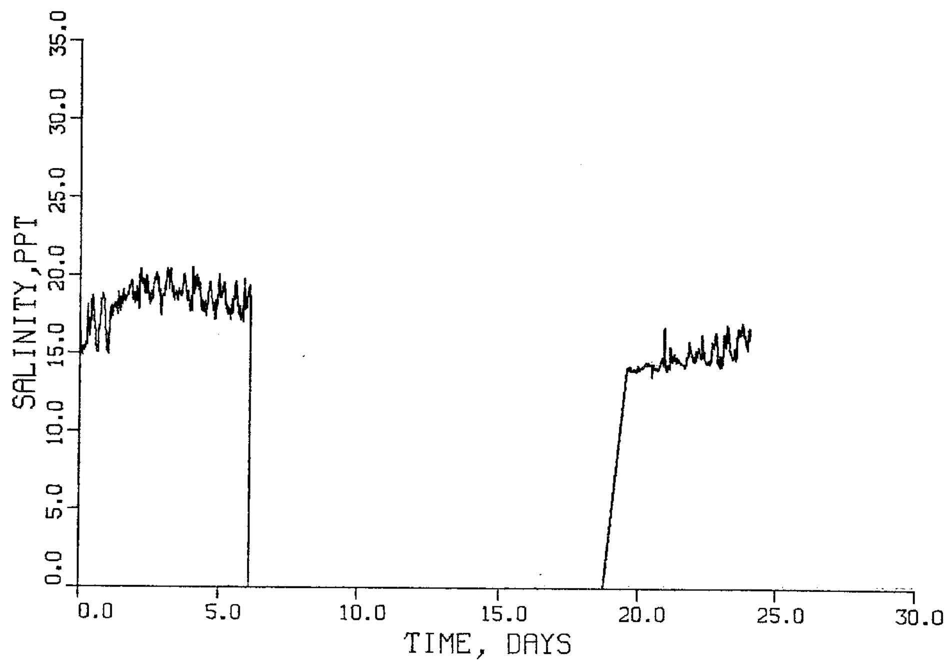


b. Depth = 14.9 m

Figure 130. Salinity at station MB during September 1983

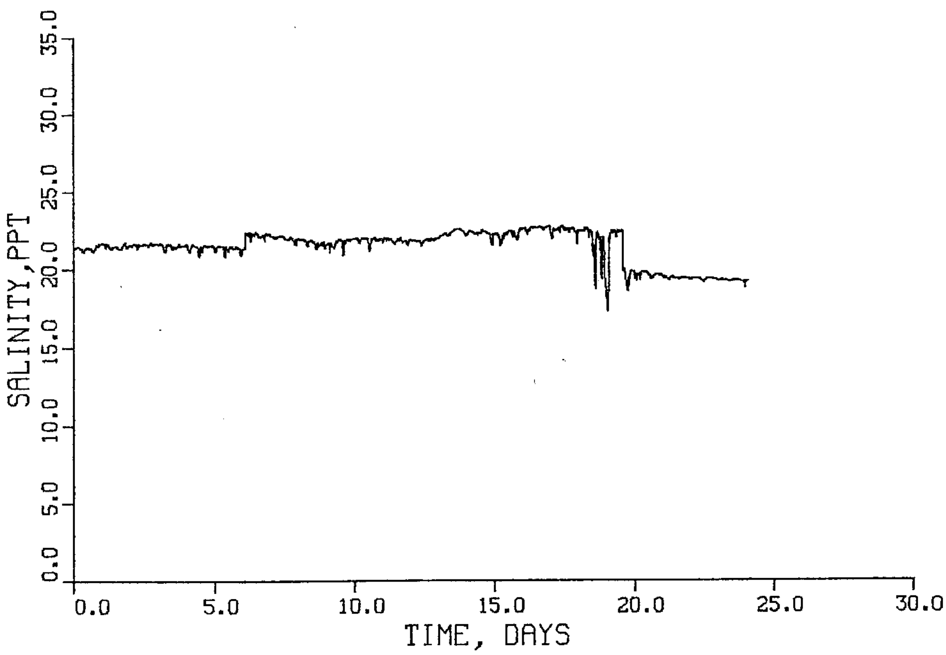


a. Depth = 5.8 m



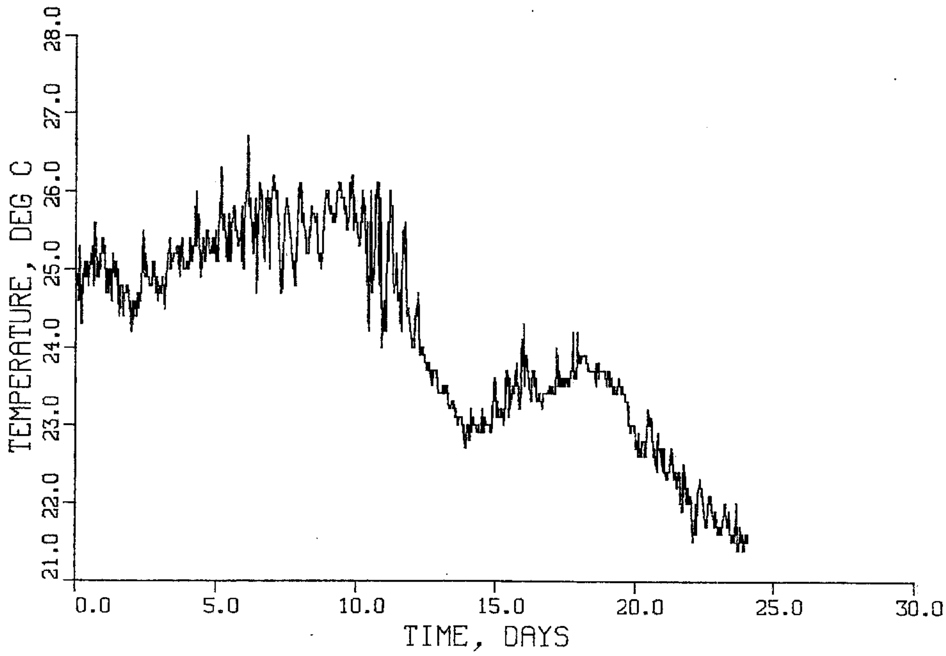
b. Depth = 11.3 m

Figure 131. Salinity at station BB during September 1983 (Continued)

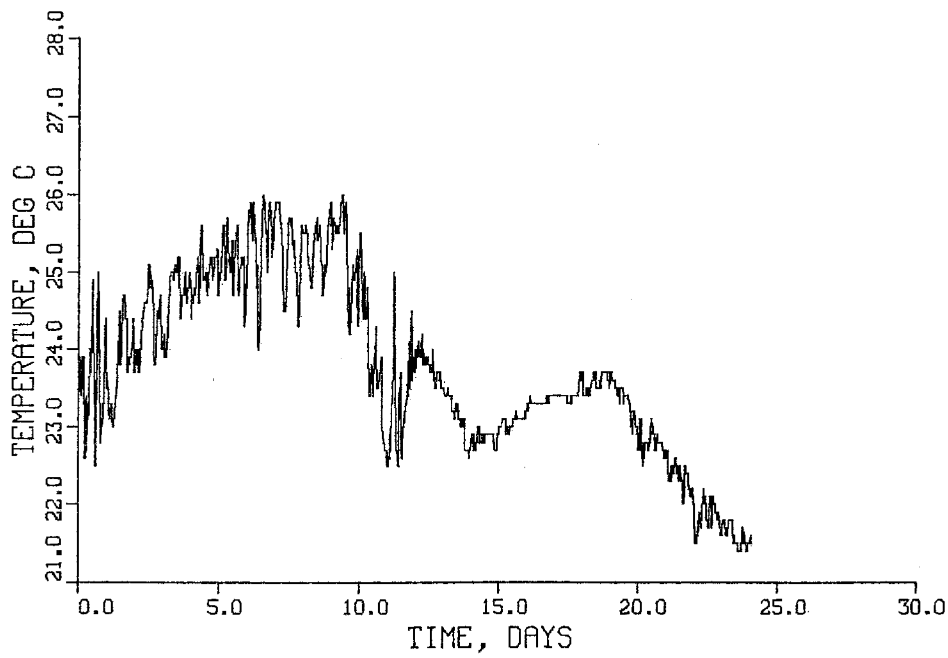


c. Depth = 21.3 m

Figure 131. (Concluded)

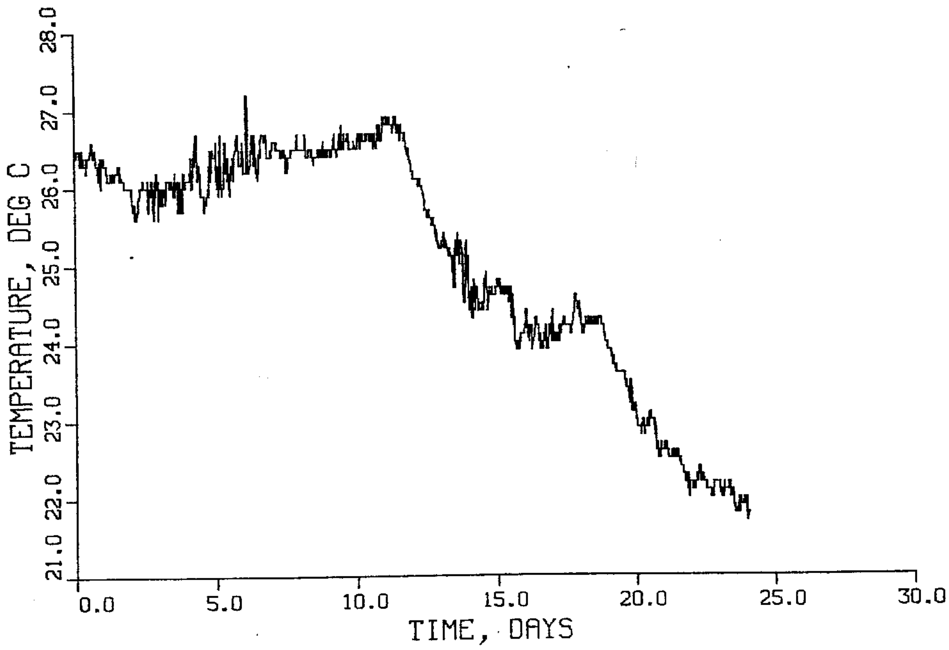


a. Depth = 4.6 m

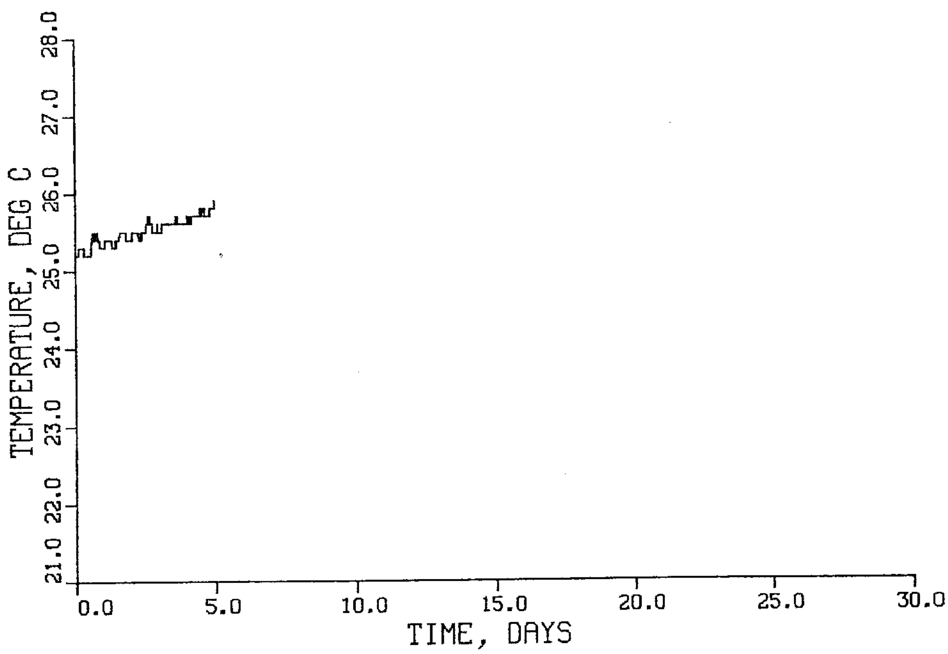


b. Depth = 10.1 m

Figure 132. Temperature at station BE during September 1983

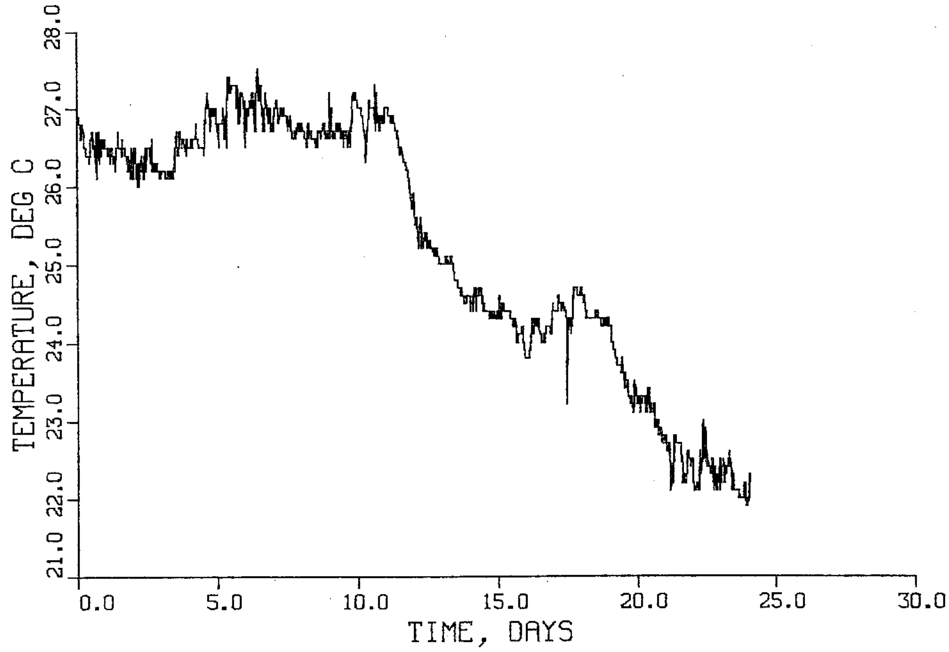


a. Depth = 4.6 m

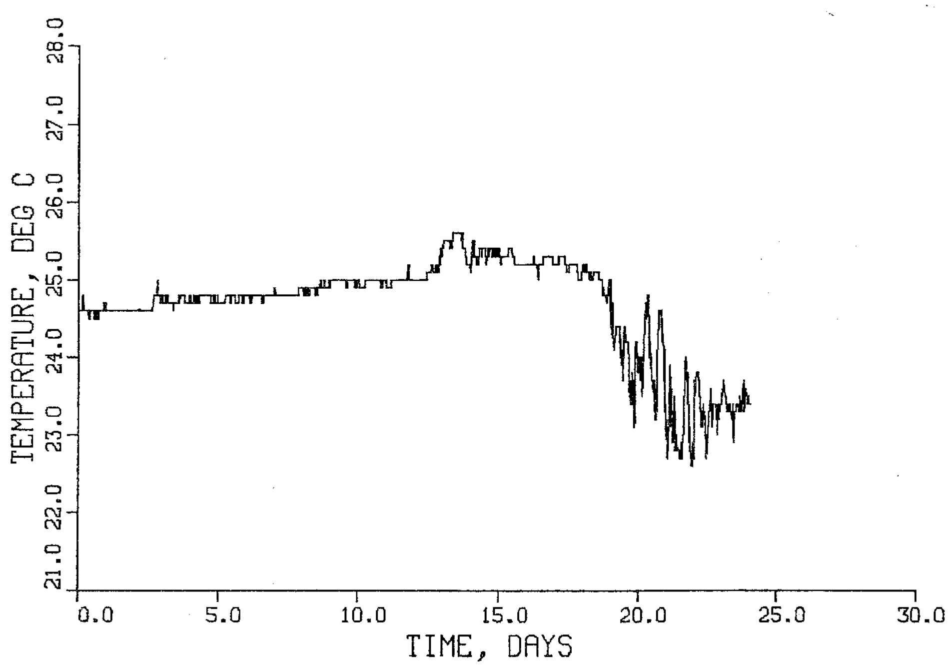


b. Depth = 10.1 m

Figure 133. Temperature at station WT during September 1983

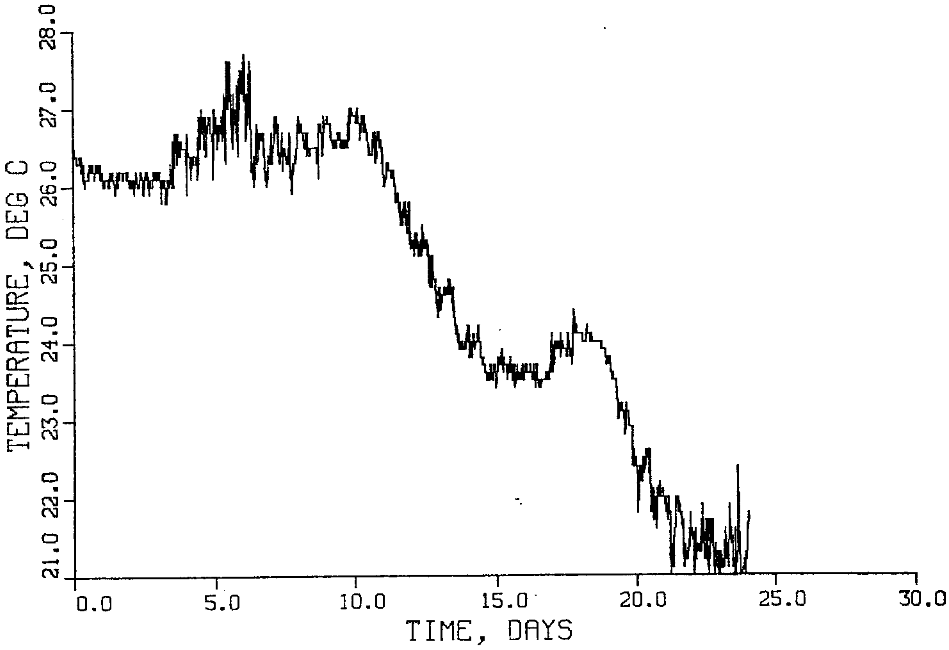


a. Depth = 5.2 m

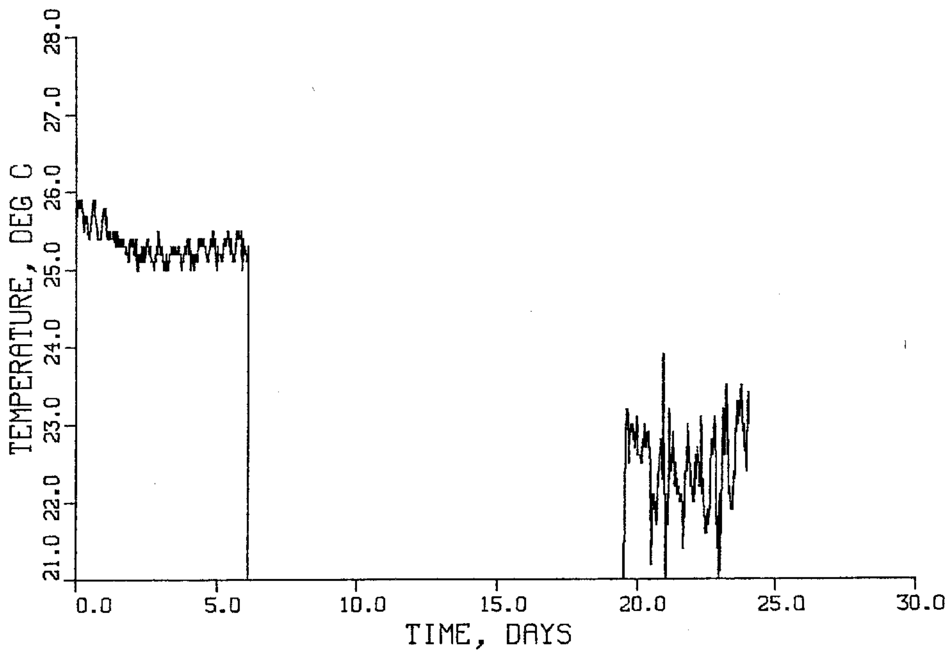


b. Depth = 14.9 m

Figure 134. Temperature at station MB during September 1983

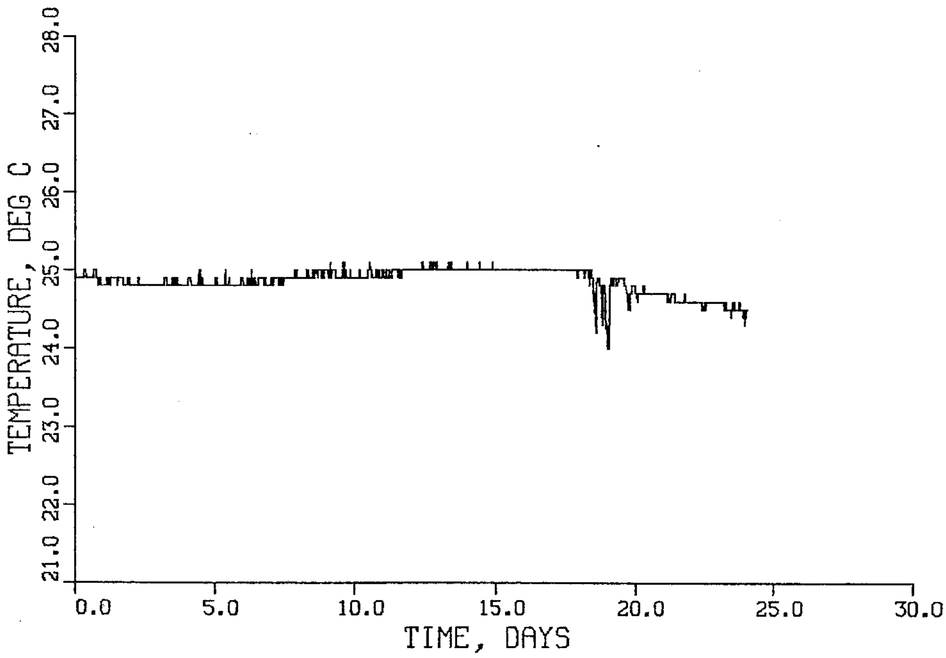


a. Depth = 5.8 m



b. Depth = 11.3 m

Figure 135. Temperature at station BB during September 1983 (Continued)



c. Depth = 21.3 m

Figure 135. (Concluded)

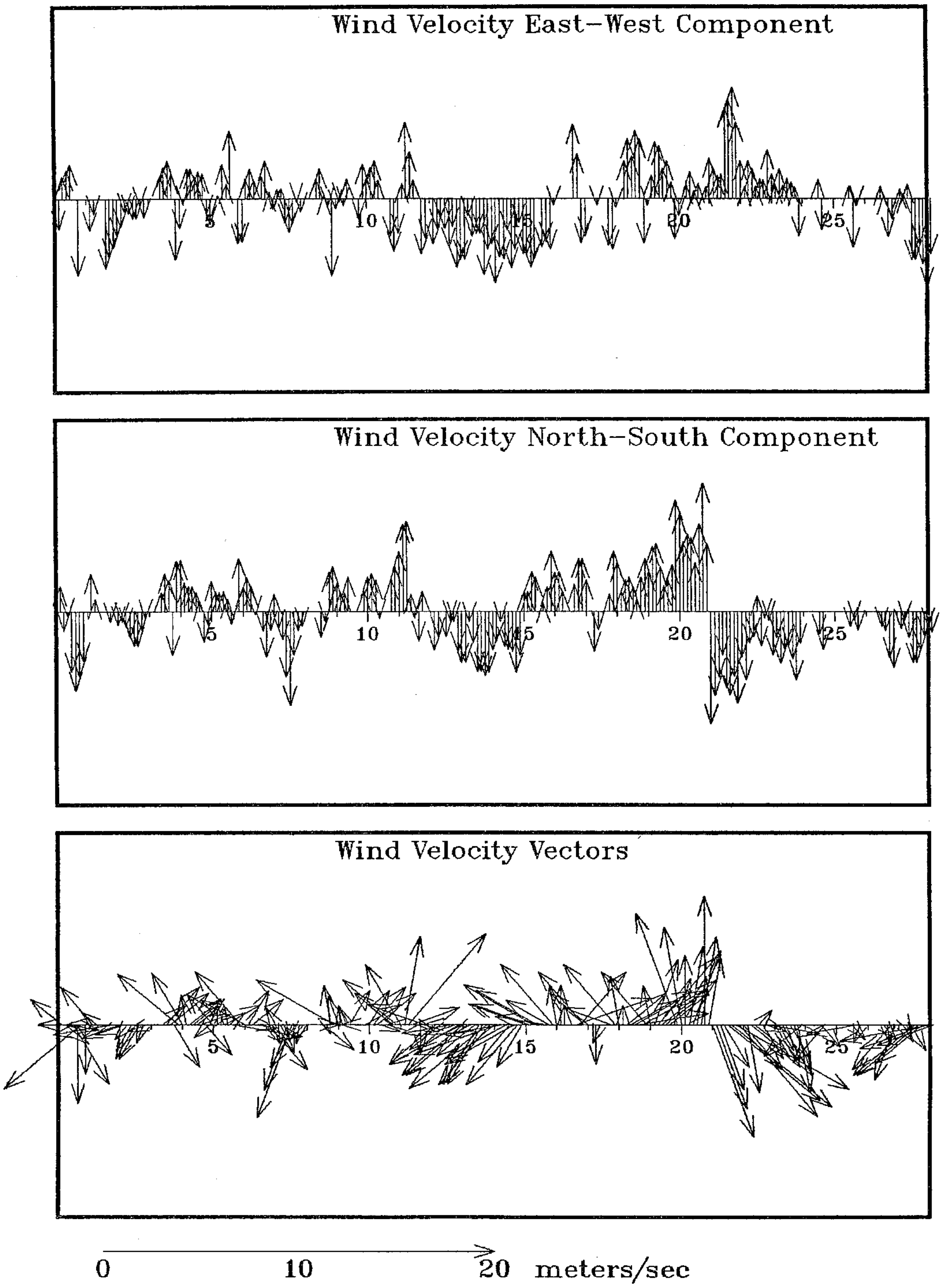


Figure 136. Wind data at Patuxent River Naval Air Station during September 1983

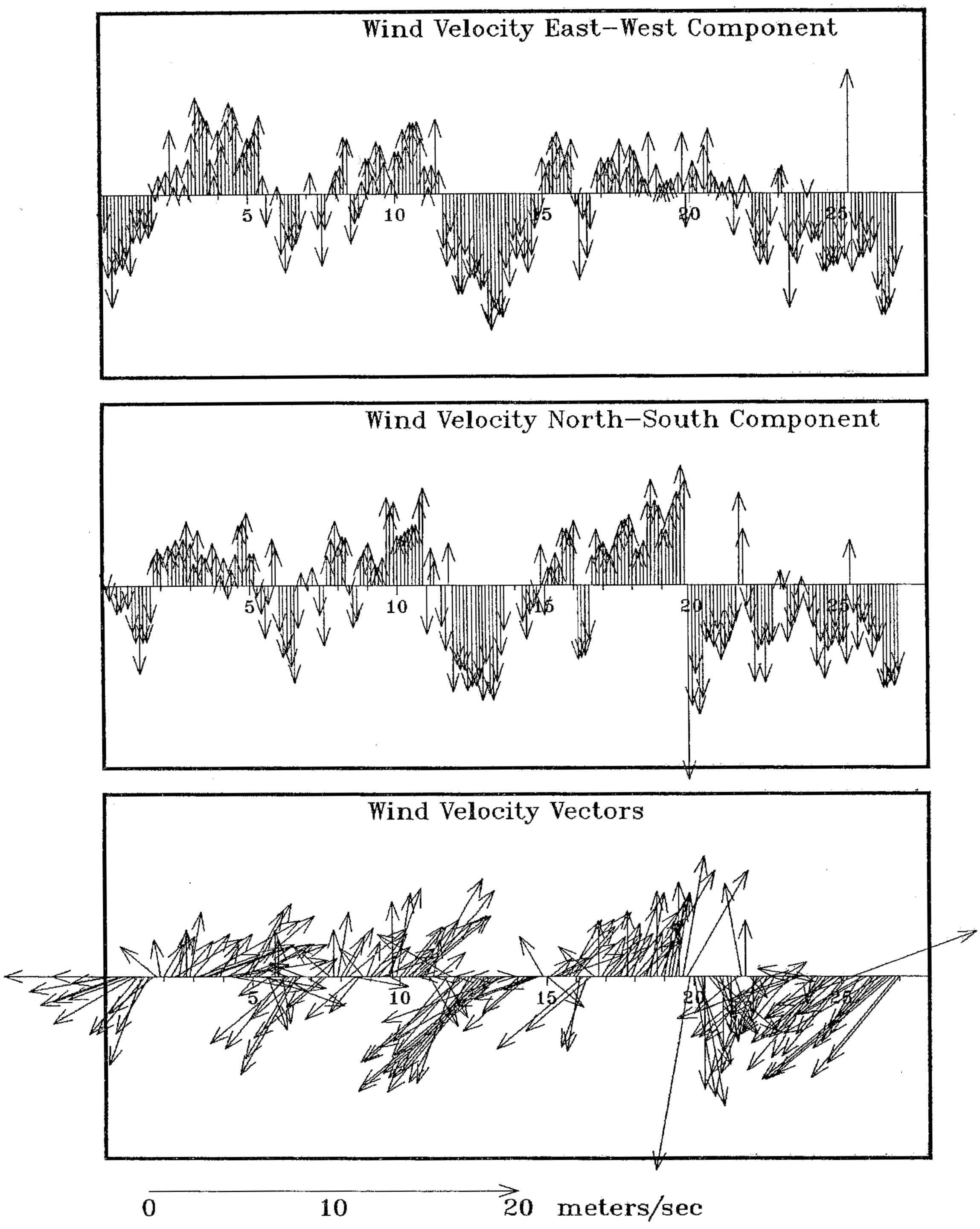


Figure 137. Wind data at Norfolk International Airport during September 1983

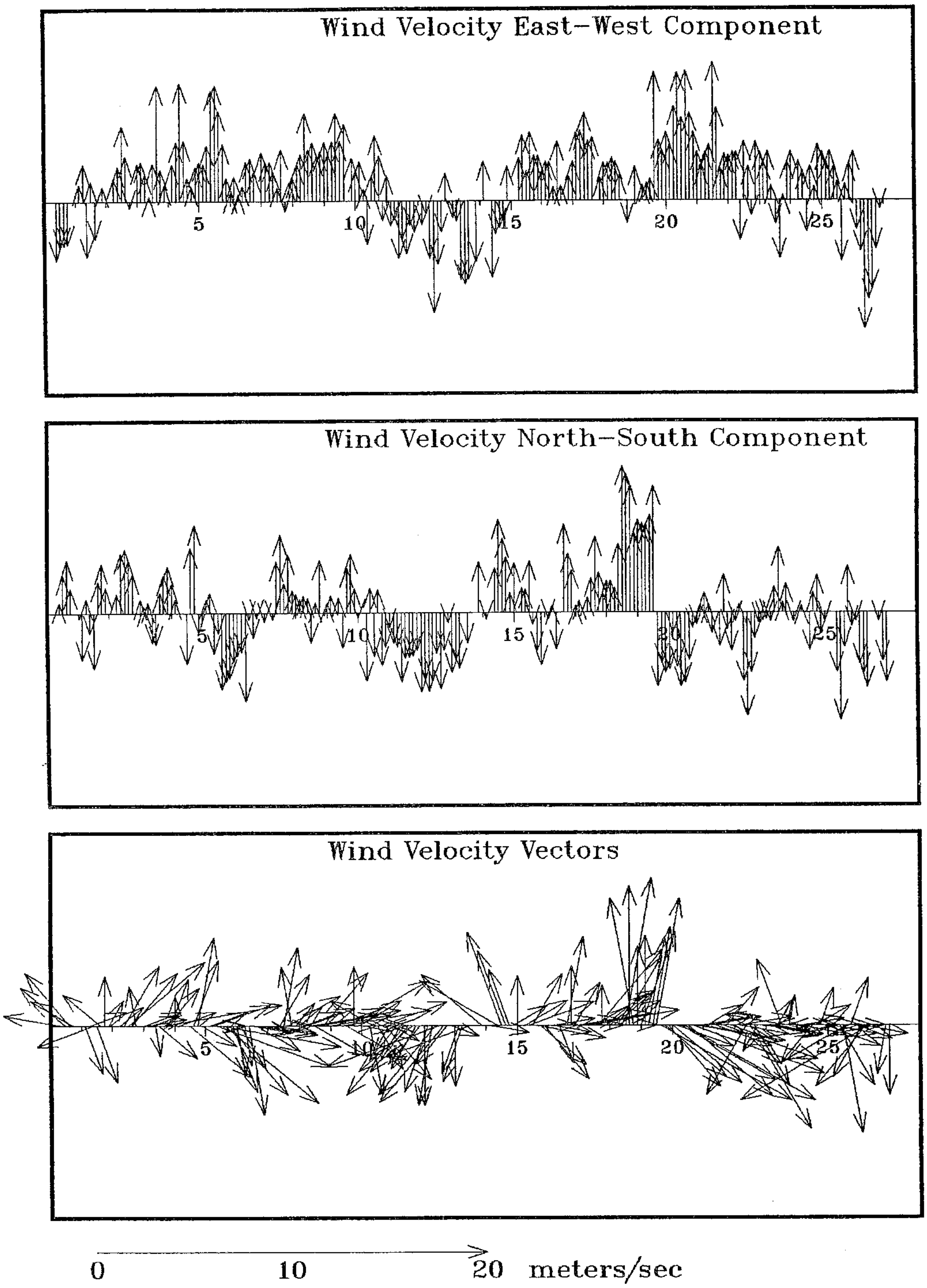
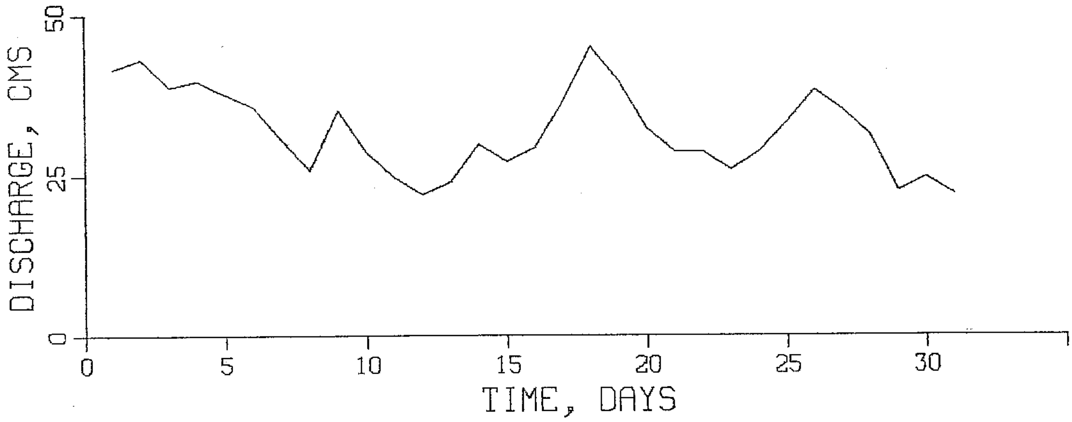
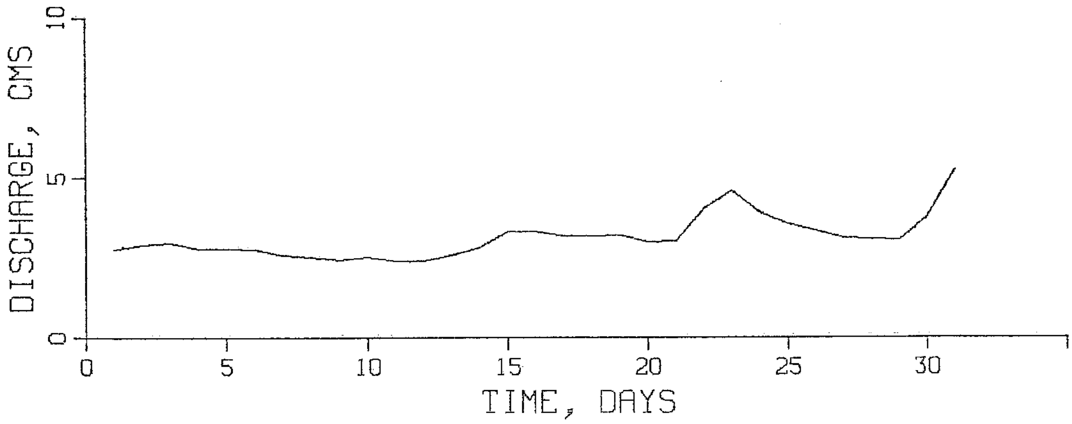


Figure 138. Wind data at Baltimore–Washington International Airport during September 1983

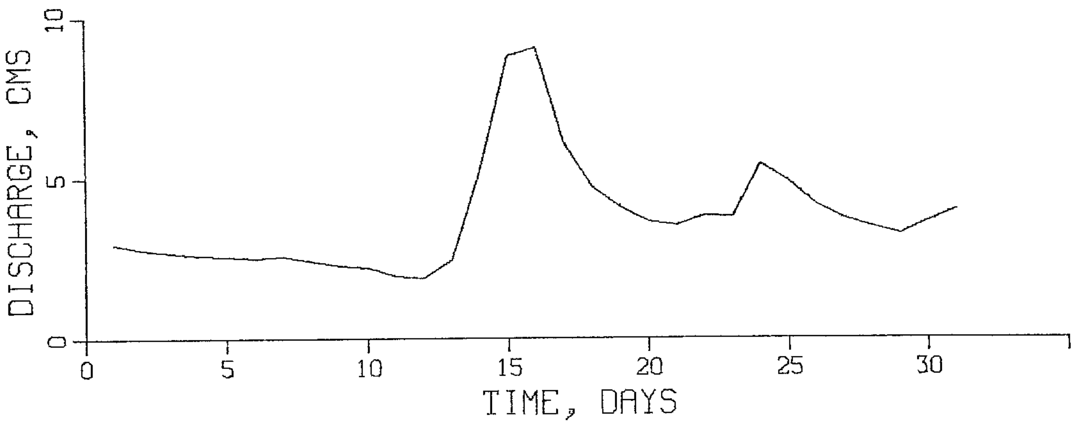


a. James River

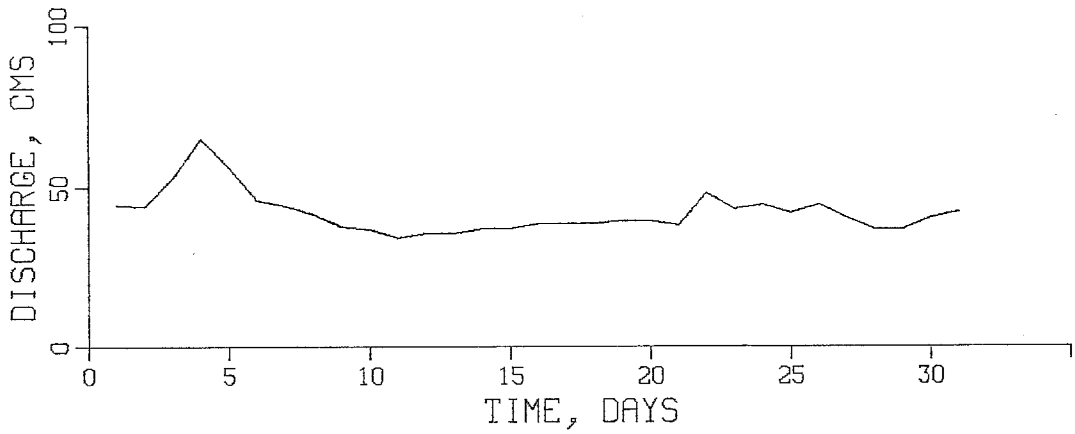


b. York River

Figure 139. Freshwater inflows during September 1983
(Sheet 1 of 4)

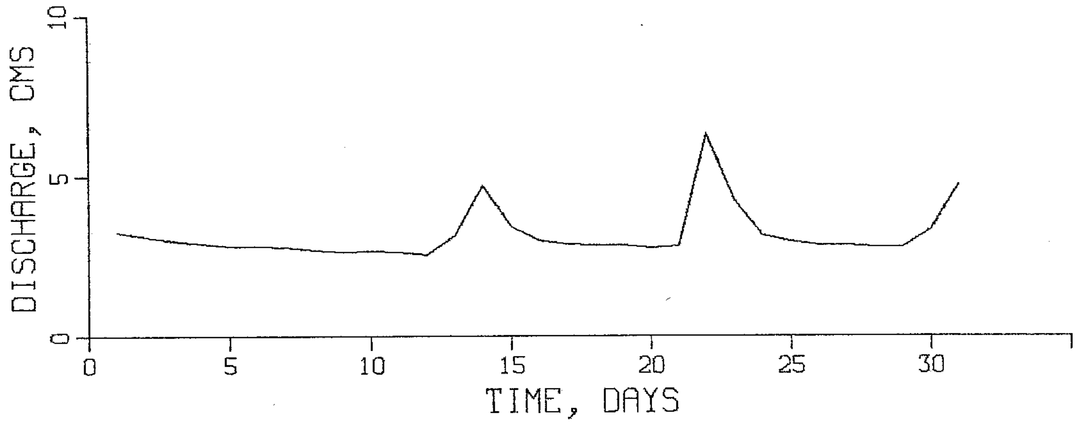


c. Rappahannock River

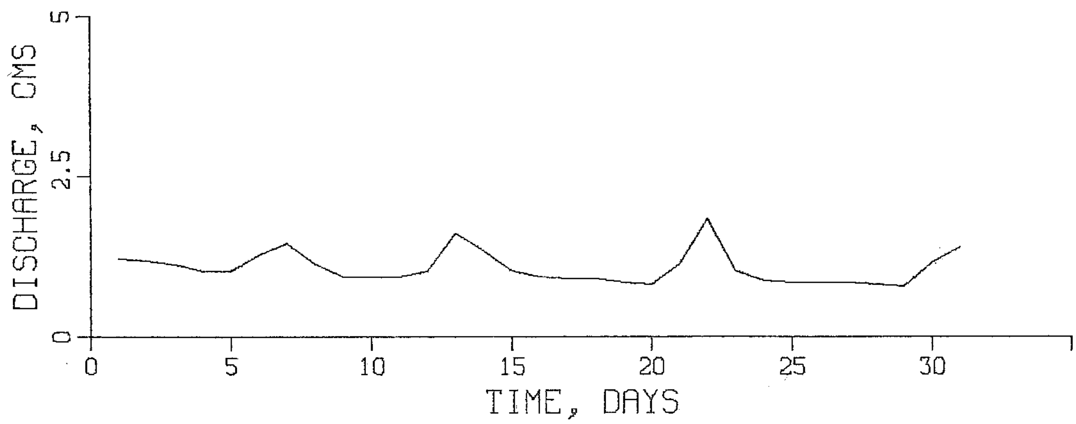


d. Potomac River

Figure 139. (Sheet 2 of 4)

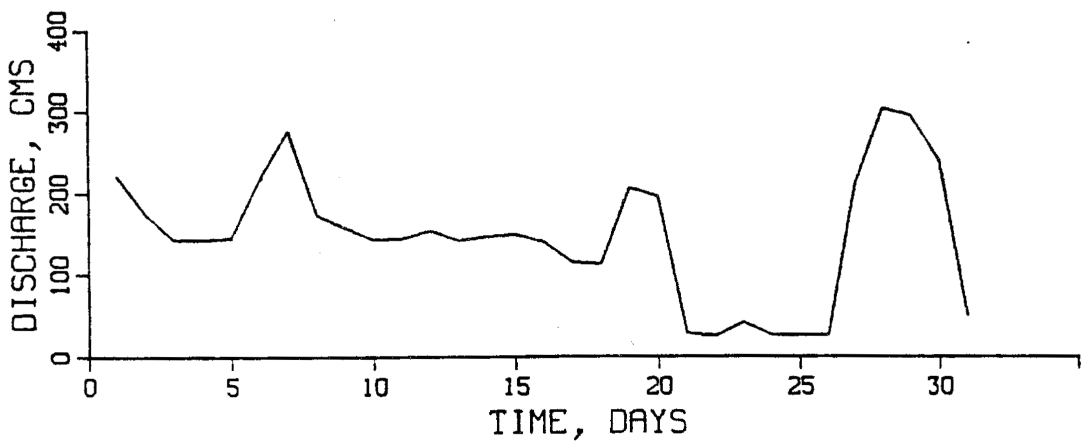


e. Patuxent River

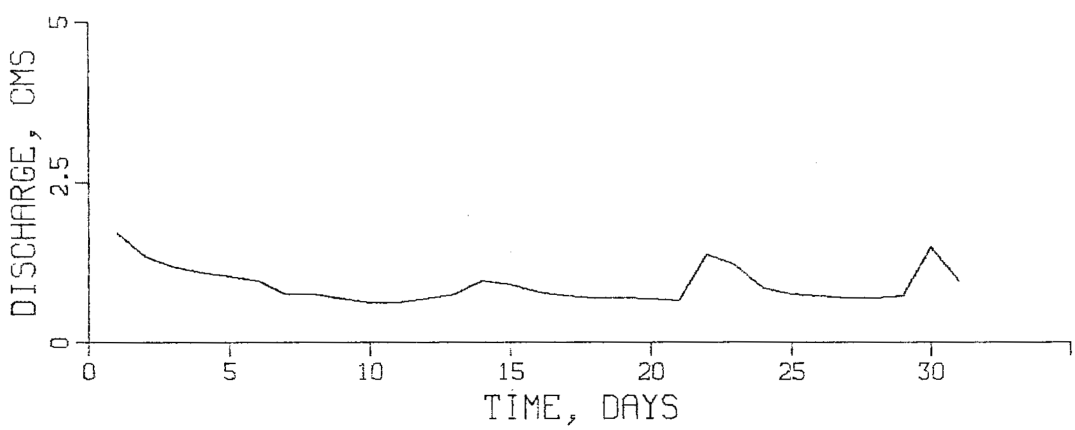


f. Patapsco River

Figure 139. (Sheet 3 of 4)



g. Susquehanna River



h. Choptank River

Figure 139. (Sheet 4 of 4)

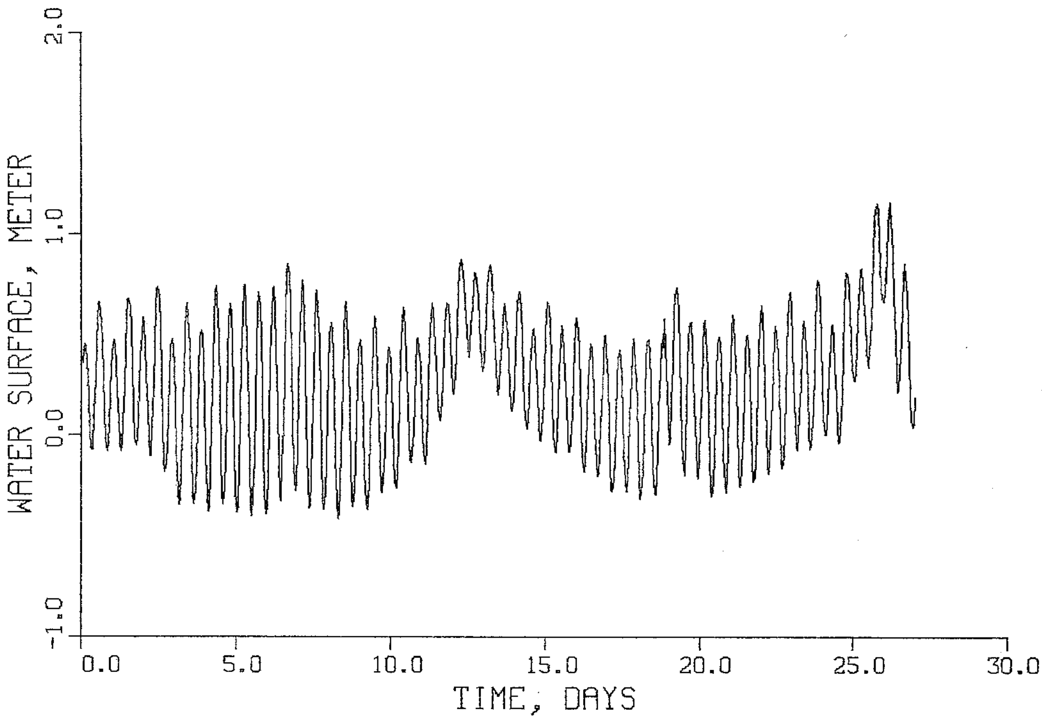


Figure 140. Tide at Chesapeake Bay Tunnel corrected to NGVD during September 1983

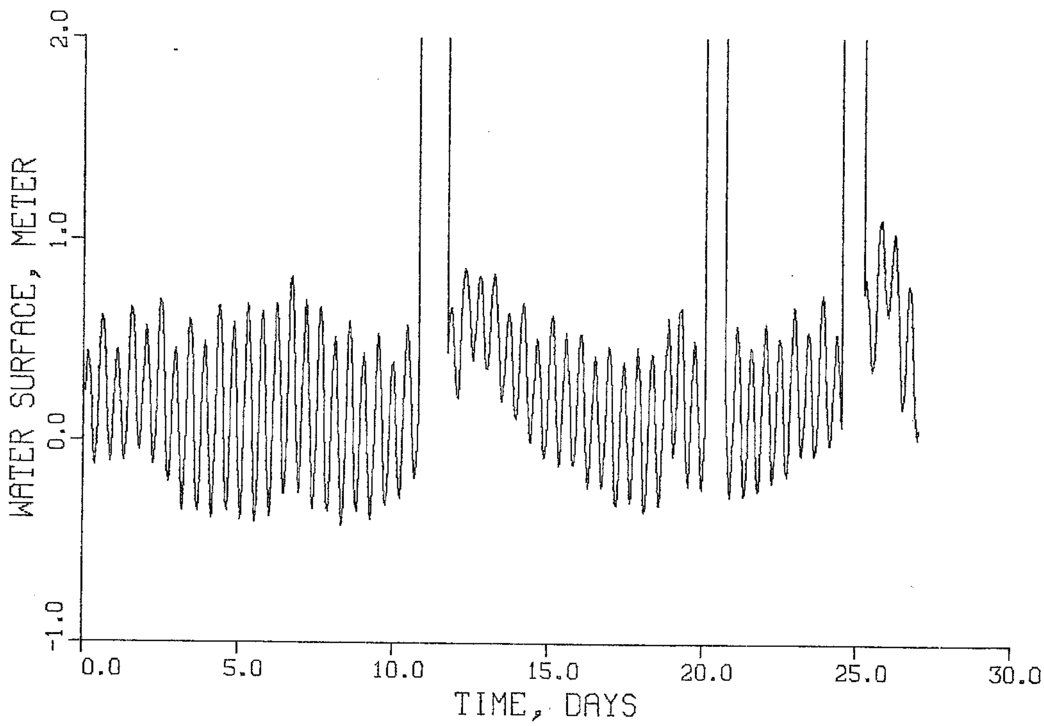


Figure 141. Tide at Hampton Roads, VA, corrected to NGVD during September 1983

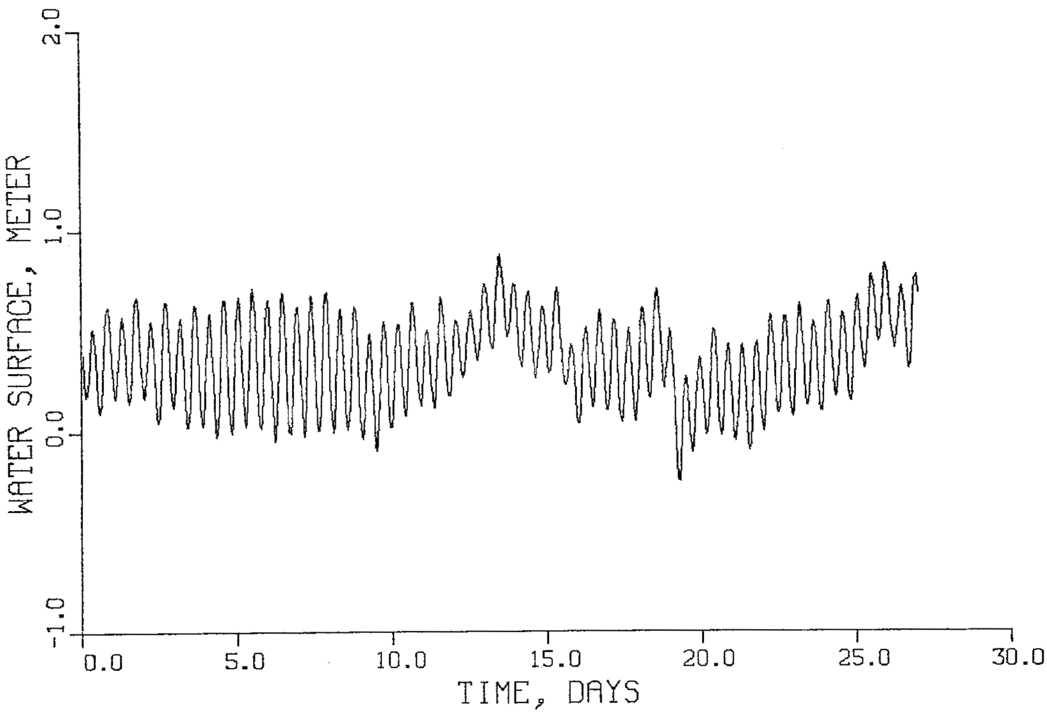


Figure 142. Tide at Colonial Beach, VA, corrected to NGVD during September 1983

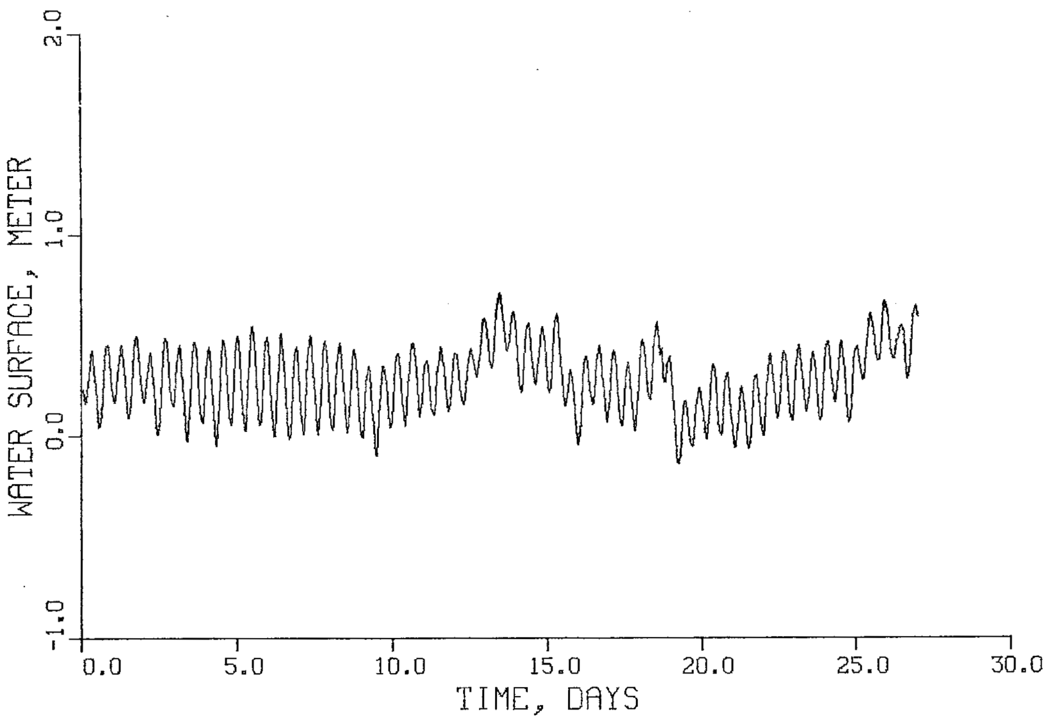


Figure 143. Tide at Solomons, MD, corrected to NGVD during September 1983

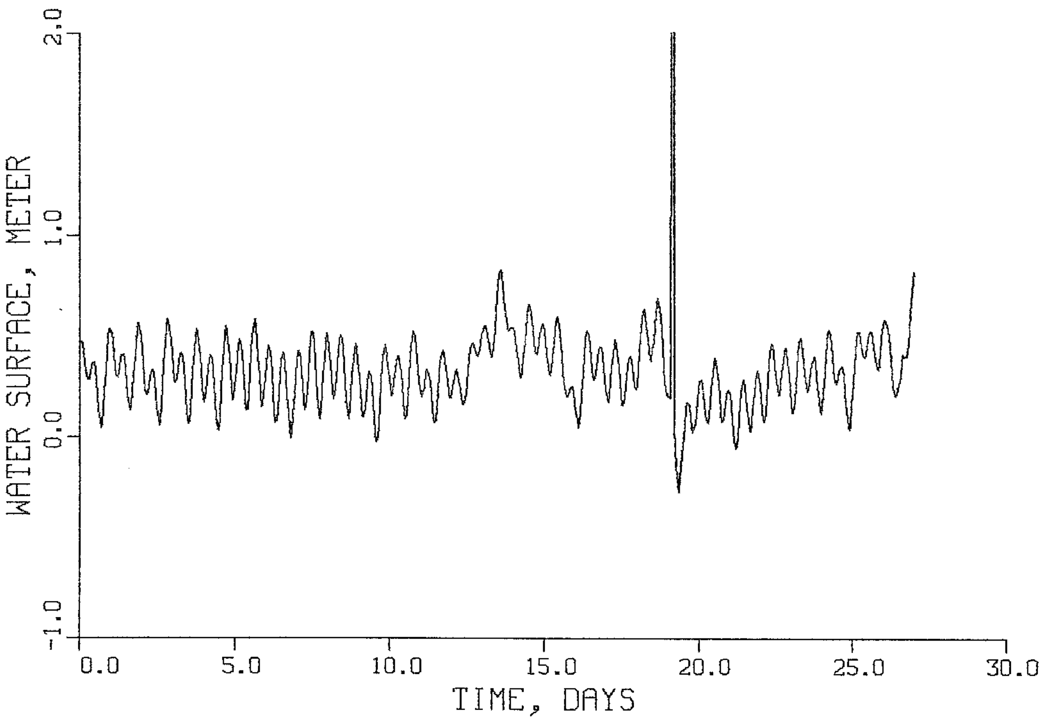


Figure 144. Tide at Annapolis, MD, corrected to NGVD during September 1983

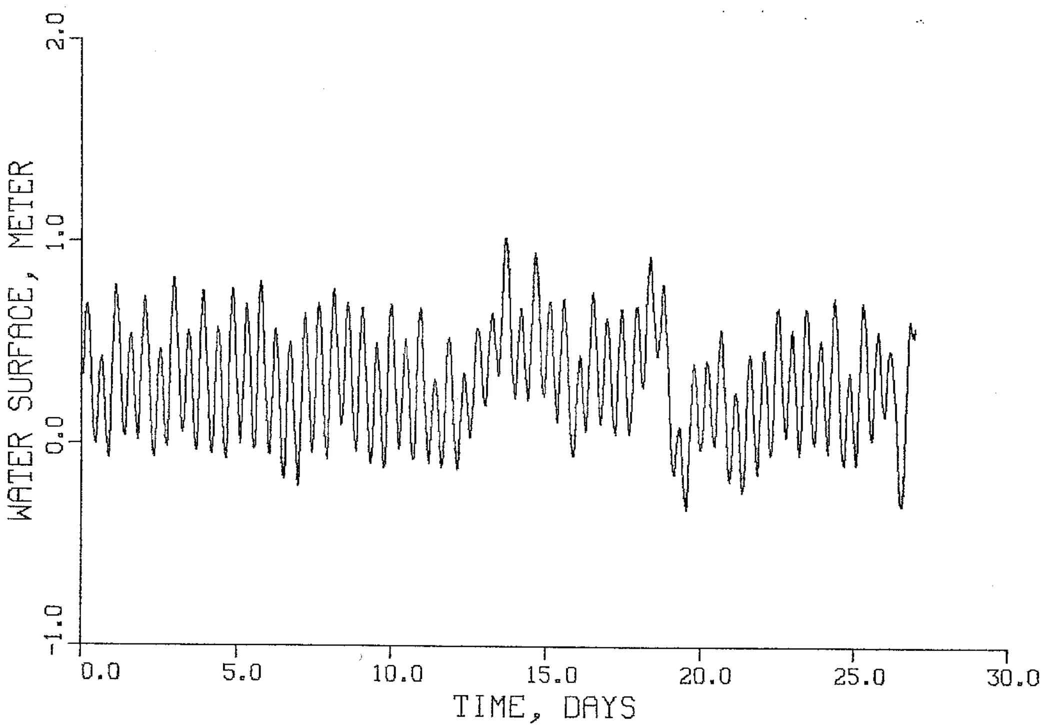


Figure 145. Tide at Havre de Grace, MD, corrected to NGVD during September 1983

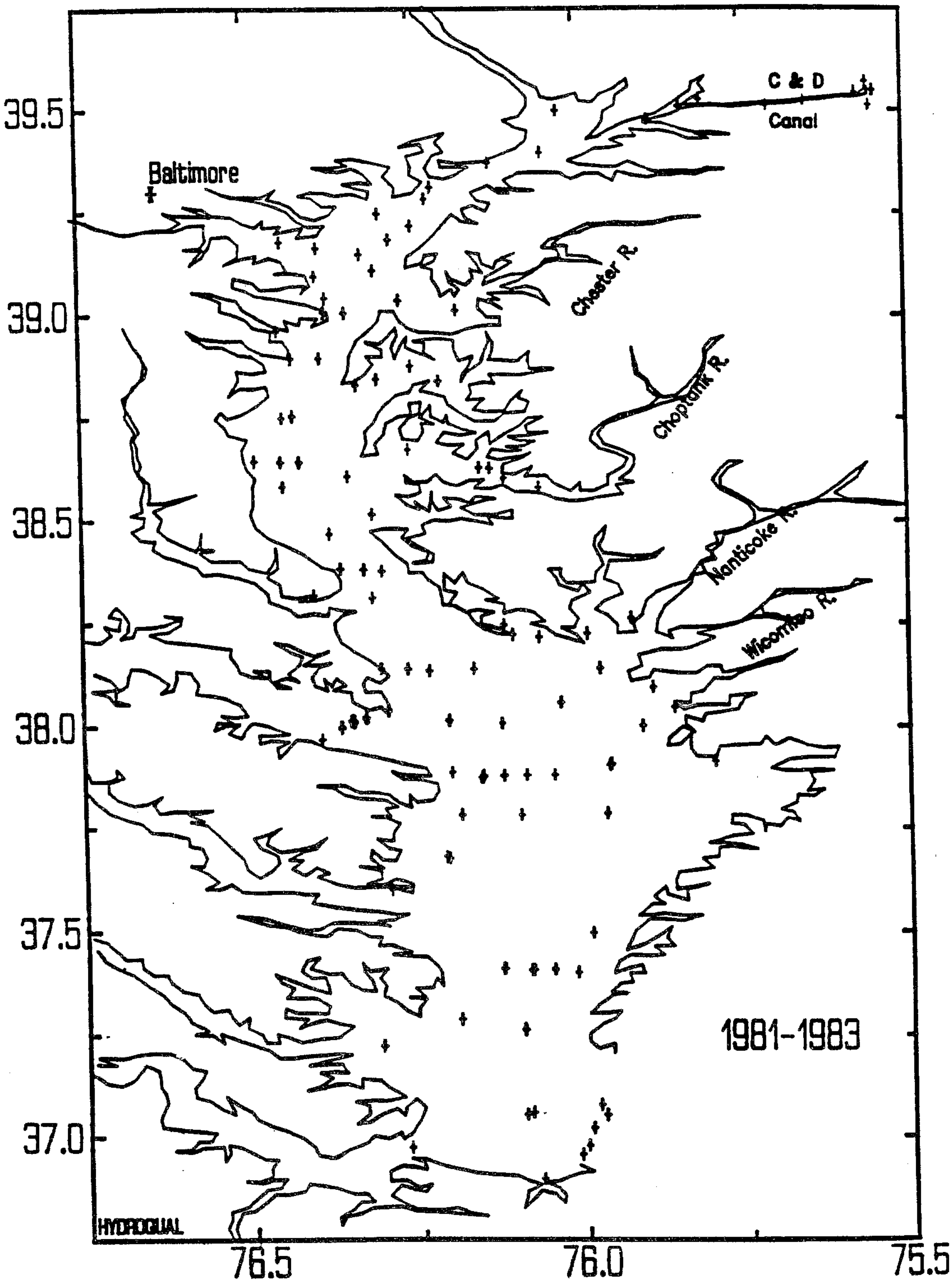


Figure 146. Location of the current meter stations used from the 1981-83 NOS survey

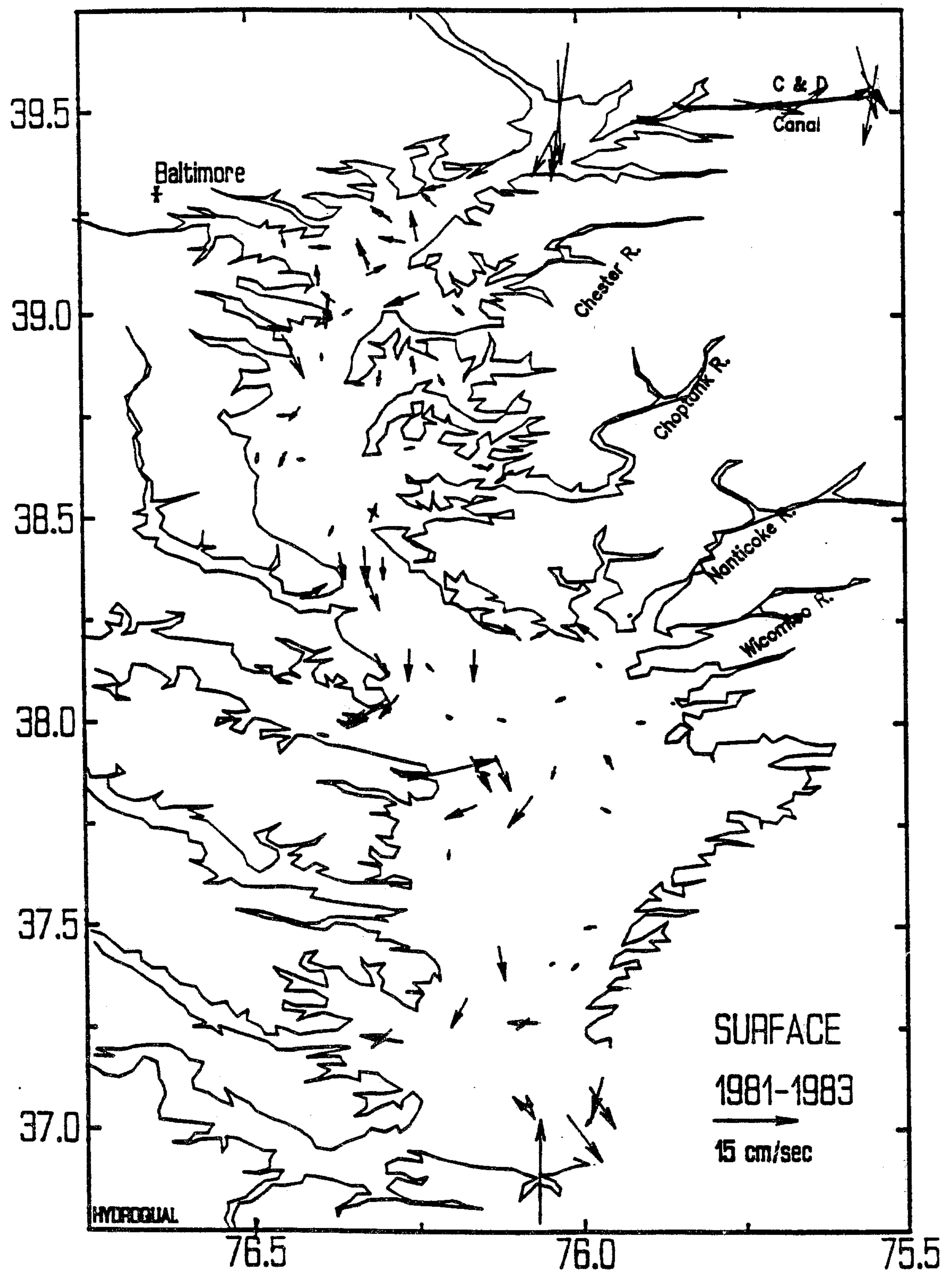


Figure 147. Long-term mean surface circulation in Chesapeake Bay from the 1981-83 NOS data

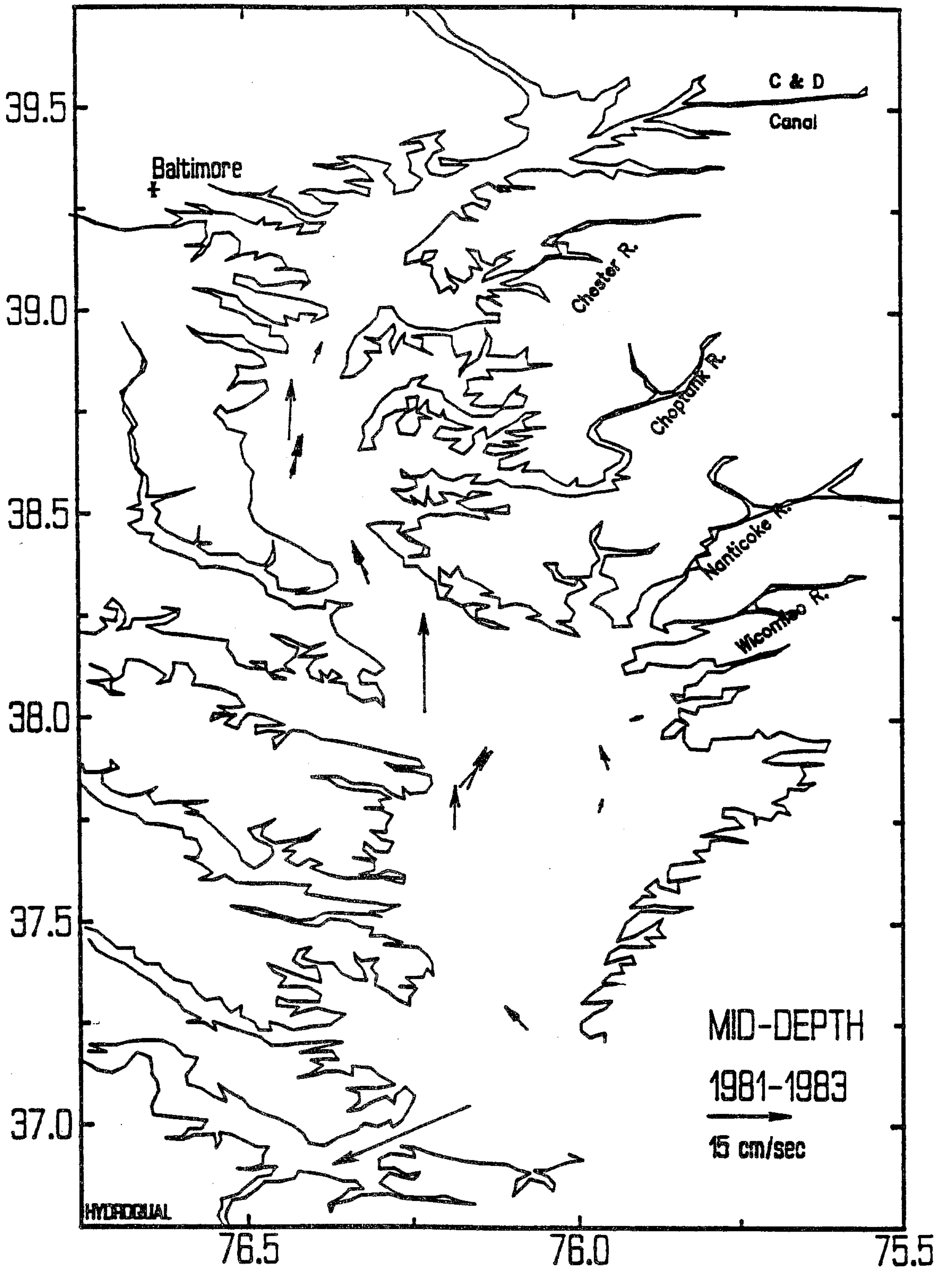


Figure 148. Long-term mean middepth circulation in Chesapeake Bay from the 1981-83 NOS data

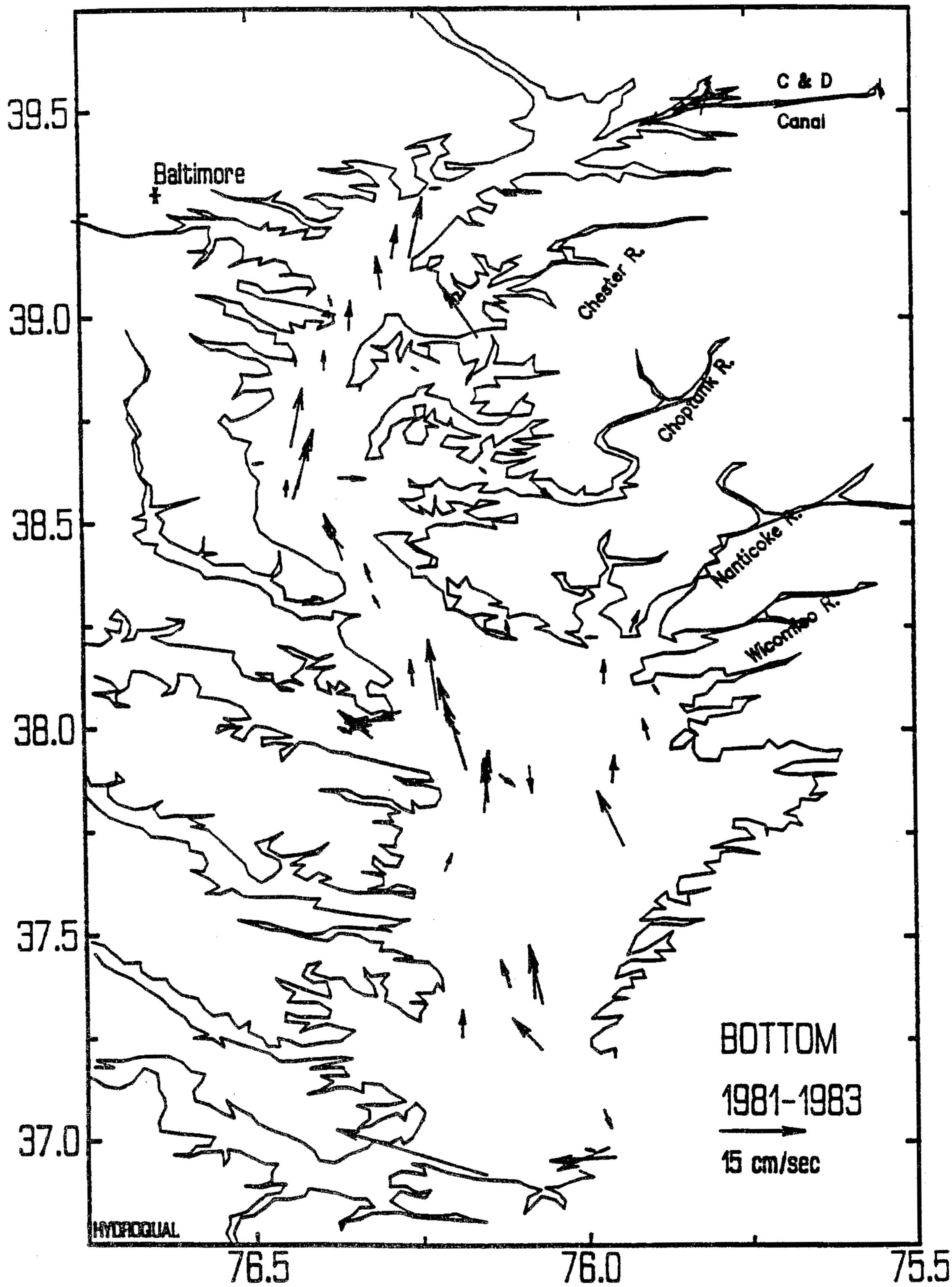


Figure 149. Long-term mean bottom circulation in Chesapeake Bay from the 1981-83 NOS data

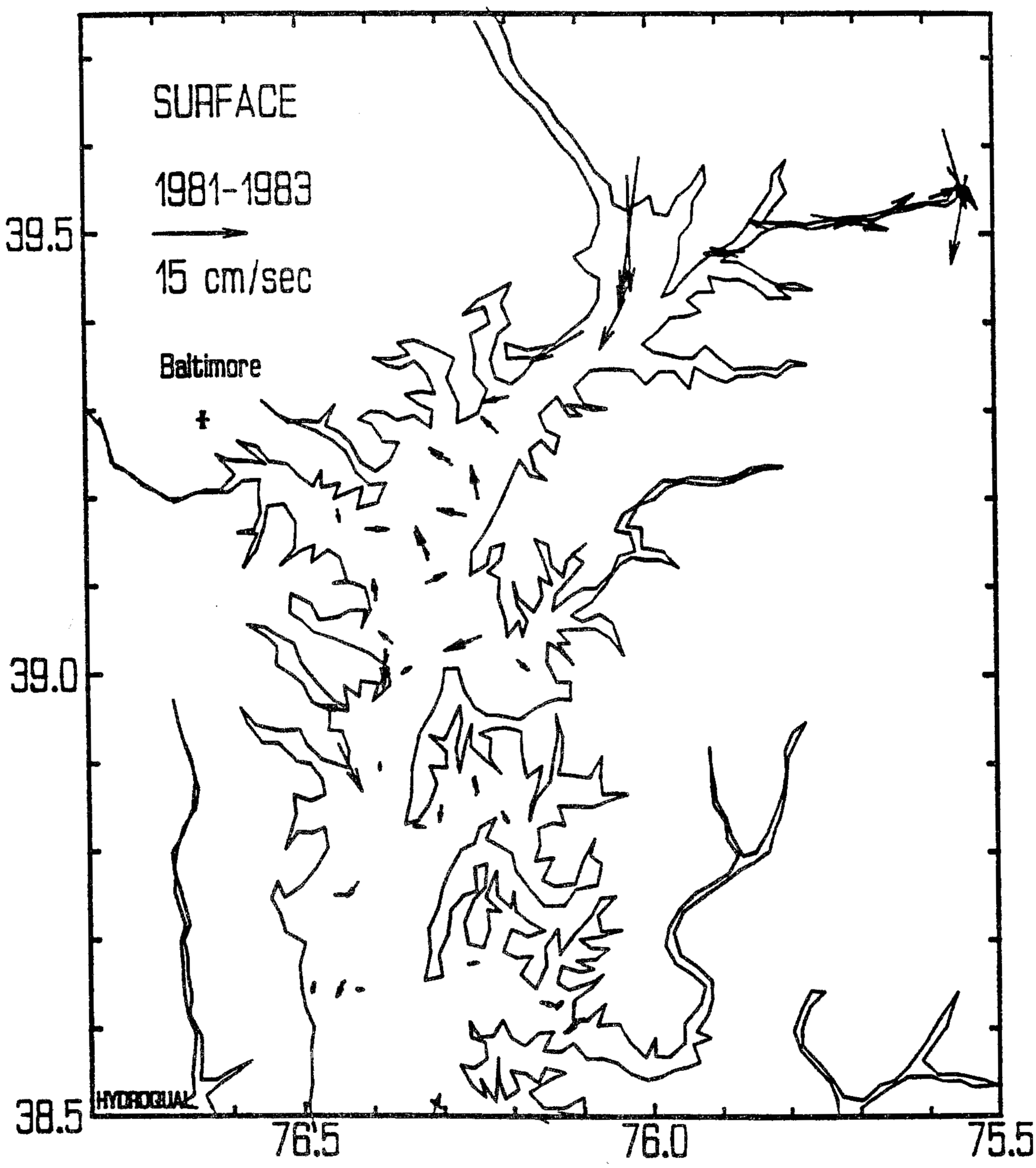


Figure 150. Long-term mean surface circulation in upper Chesapeake Bay from the 1981-83 NOS data

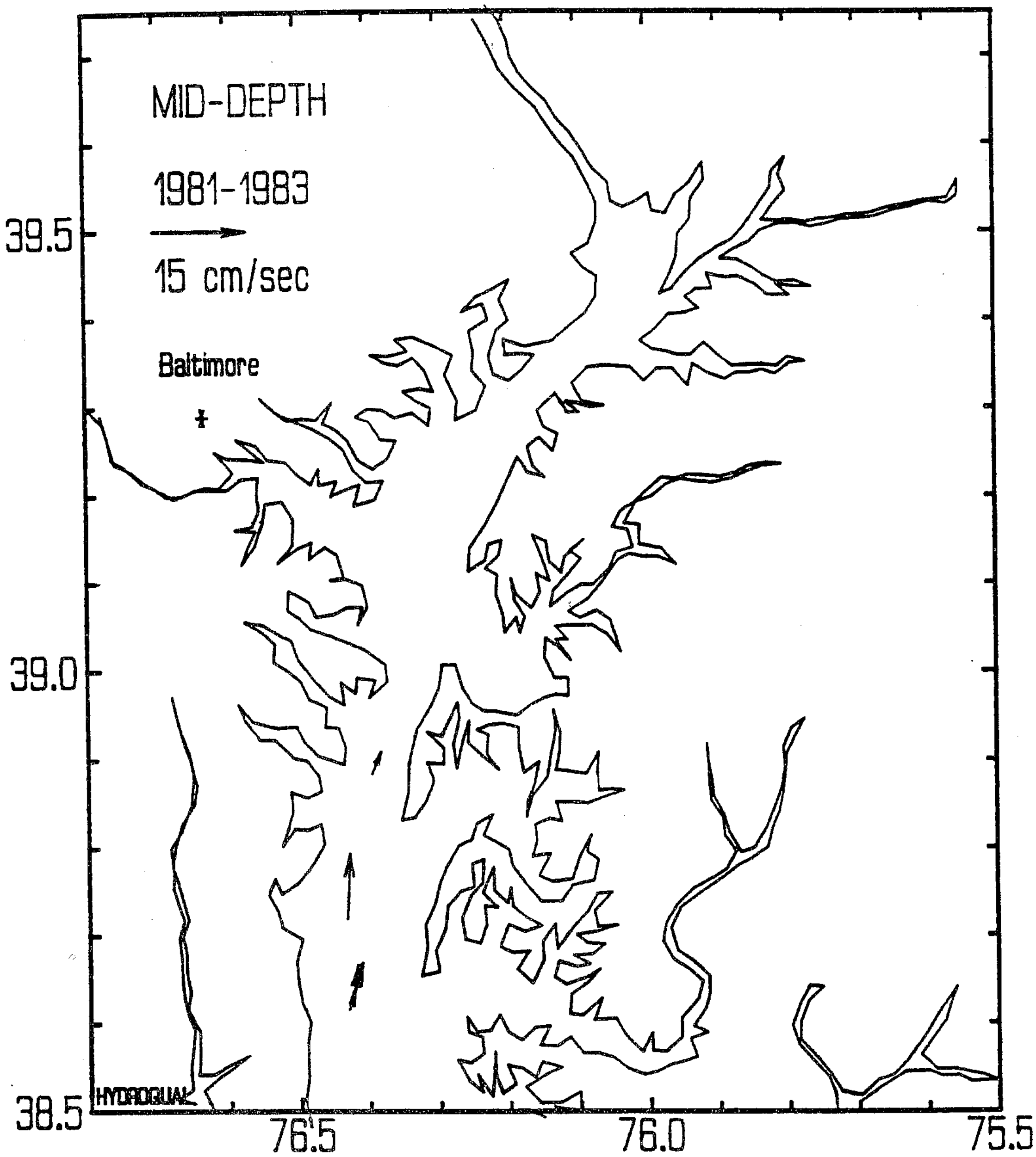


Figure 151. Long-term mean middepth circulation in upper Chesapeake Bay from the 1981-83 NOS data

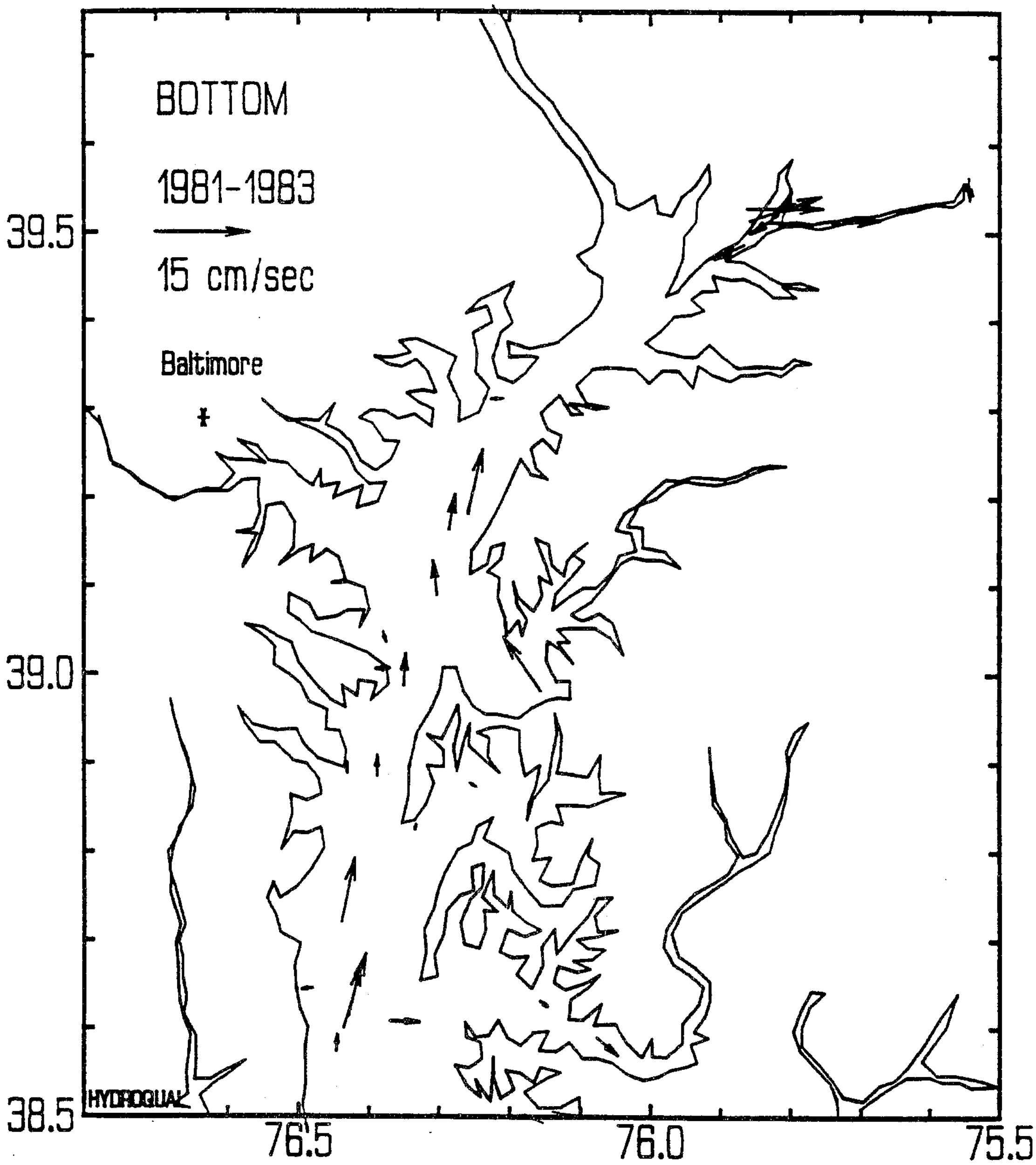


Figure 152. Long-term mean bottom circulation in upper Chesapeake Bay from the 1981-83 NOS data

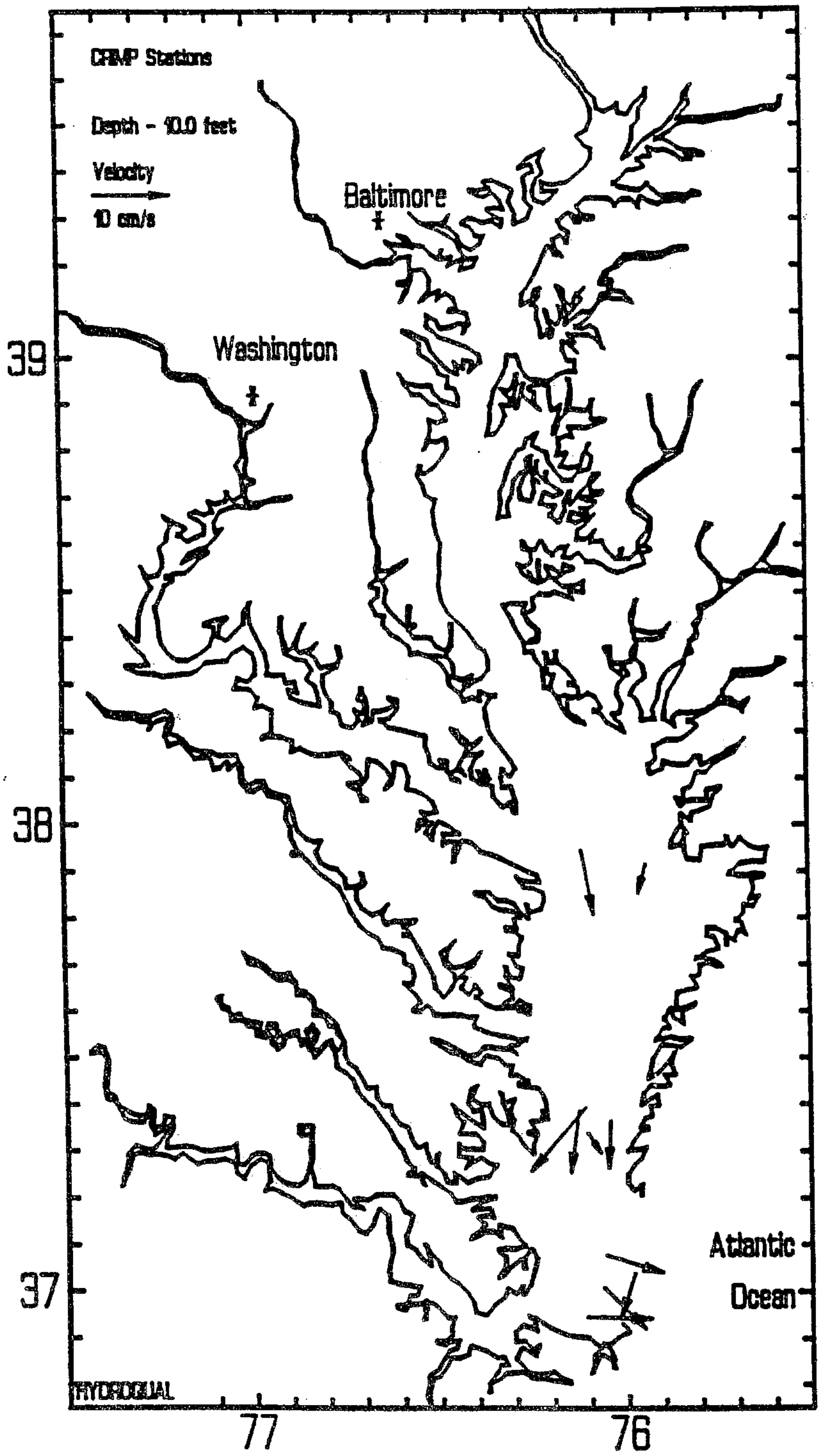


Figure 153. Average currents at 10 ft from CRIMP data

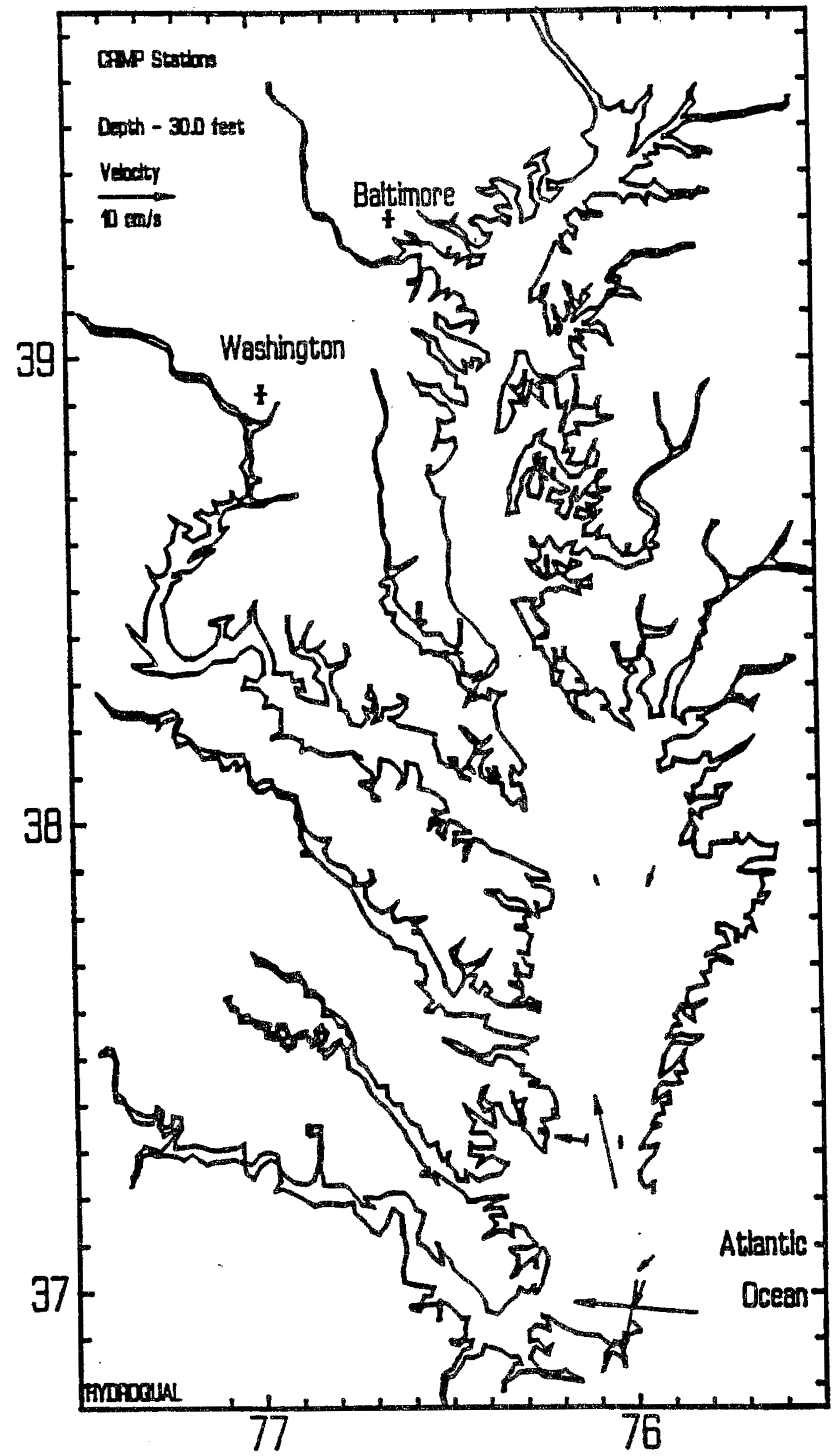


Figure 154. Average currents at 30 ft from CRIMP data

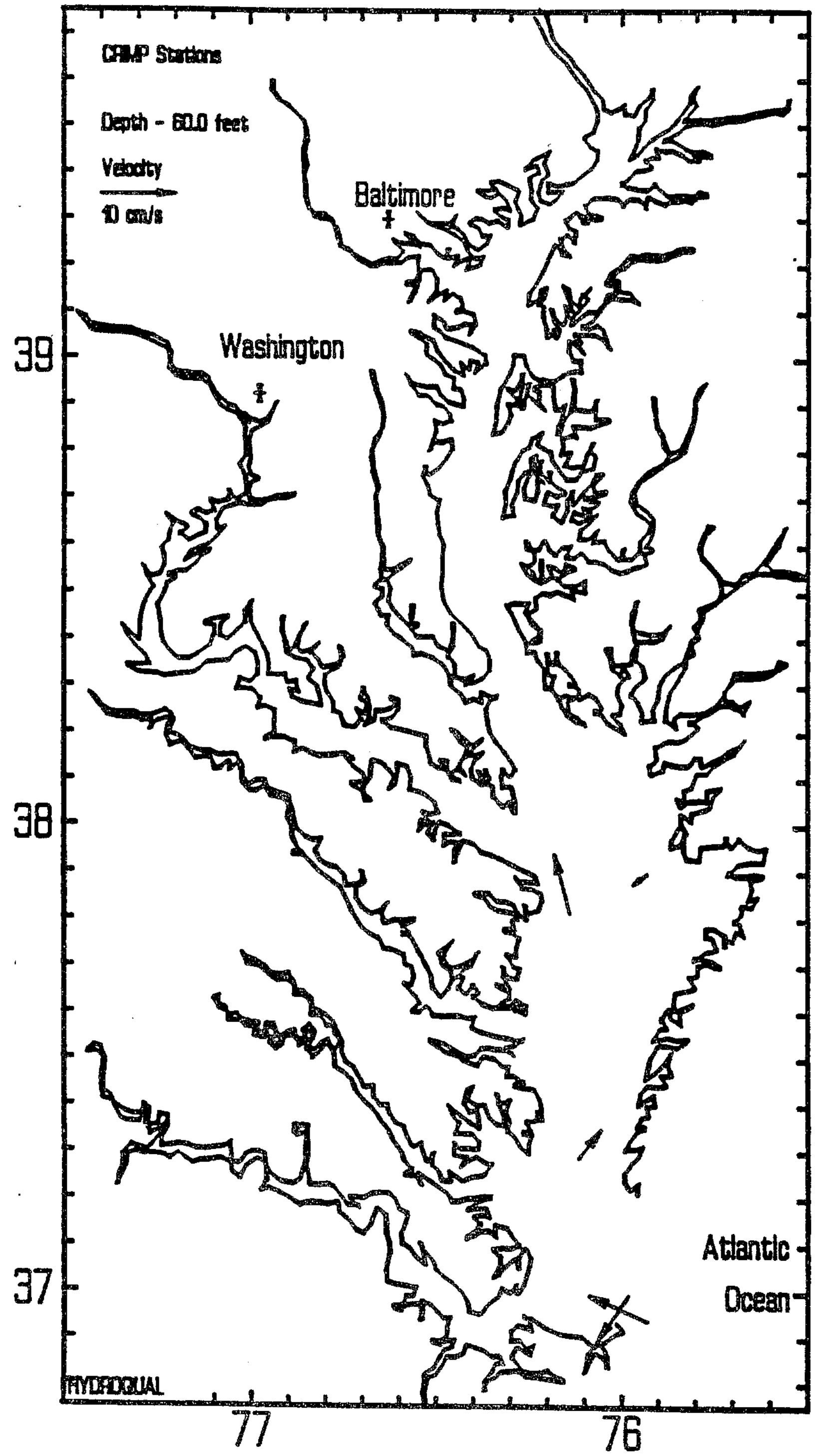


Figure 155. Average currents at 60 ft from CRIMP data

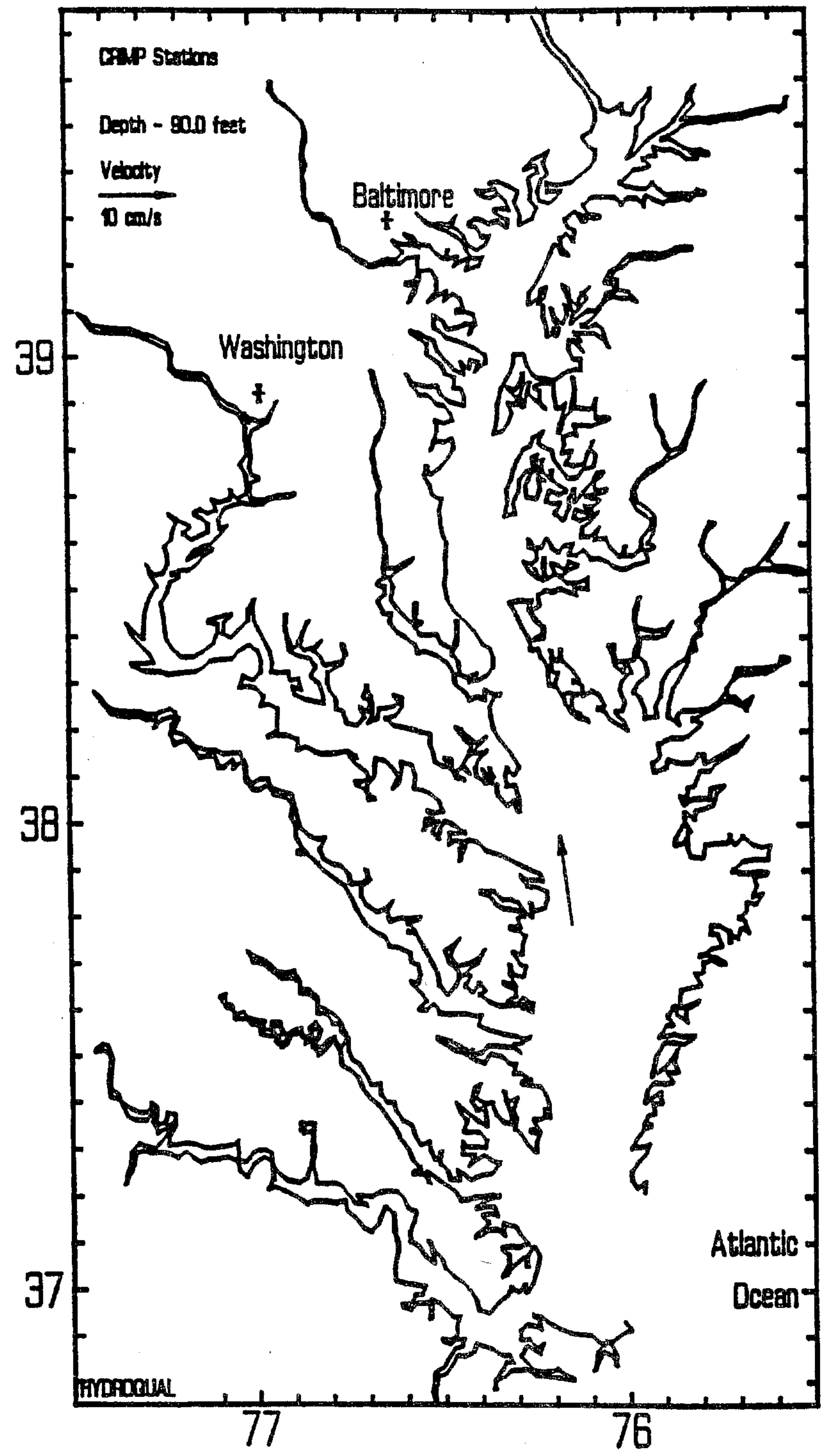


Figure 156. Average currents at 90 ft from CRIMP data