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Sediment Processes Monitoring Annual Report for Calendar Year 1988

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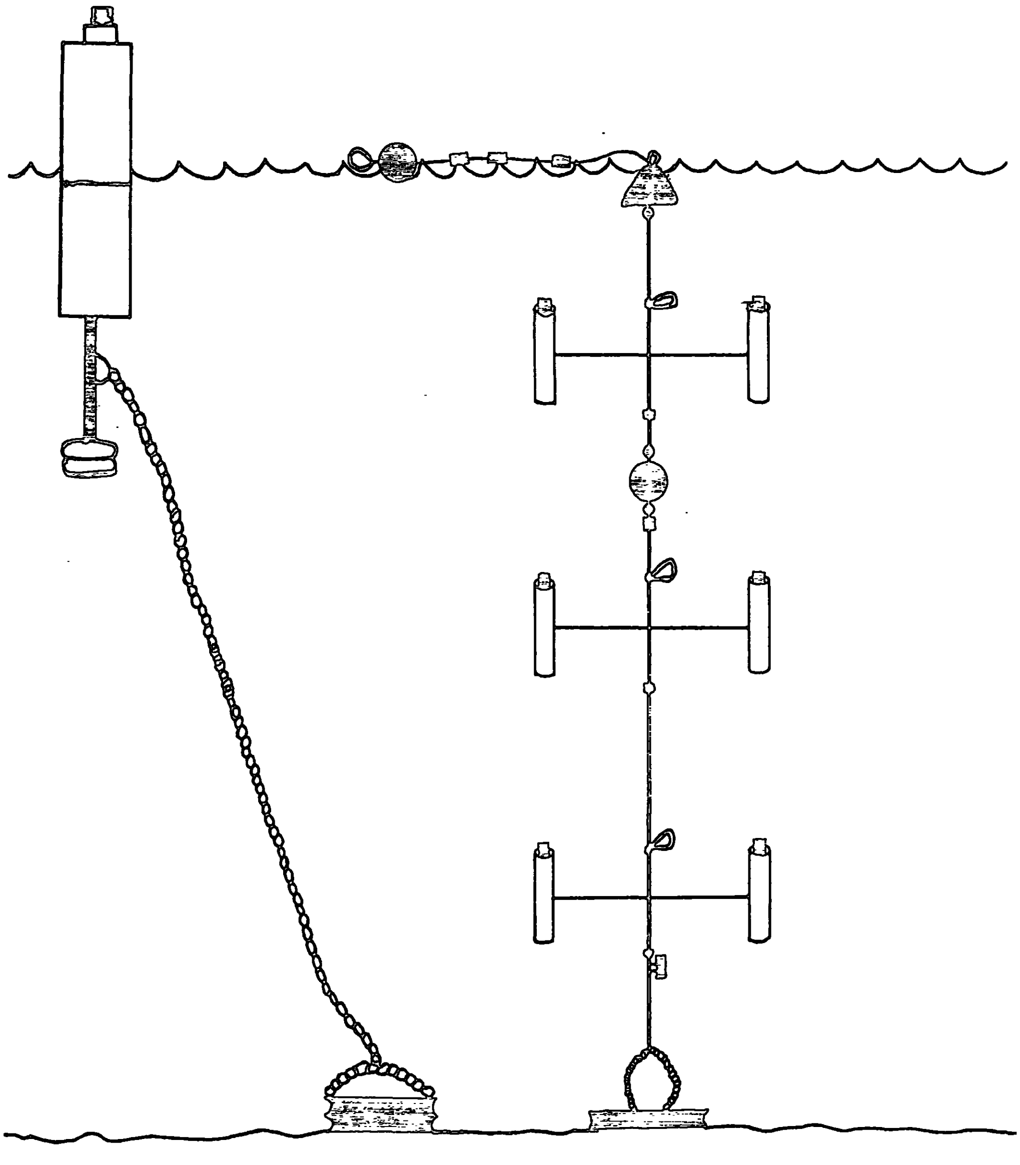
SEDIMENT PROCESSES MONITORING
ANNUAL REPORT FOR CALENDAR YEAR 1988

by Richard Wetzel and Bruce Neilson



Special Report No. 301 in Applied Marine Science & Ocean Engineering

Virginia Institute of Marine Science
The College of William & Mary in Virginia
Gloucester Point, VA 23062

SEDIMENT PROCESSES MONITORING

ANNUAL REPORT FOR CALENDAR YEAR 1988

A Report to

the Virginia Water Control Board

and

the Chesapeake Bay Liaison Office
U.S. Environmental Protection Agency

by

Richard Wetzel and Bruce Neilson

June 16, 1989

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TABLE OF CONTENTS

I. INTRODUCTION

In this report, the results of the 1988 deployment of two particle interceptor trap (PIT) arrays will be presented. Funding for these deployments came from two sources. The York River study was funded under the Cooperative State Agencies (CSA) program between the Virginia Institute of Marine Science (VIMS) and the Virginia Water Control Board (VWCB). The Chesapeake Bay study was funded by the U.S. Environmental Protection Agency (EPA) and was part of a large, bay-wide sediment processes monitoring program. The specific objectives of these two projects were to:

(1) measure, over an annual cycle, the vertical flux of suspended particulates, including particulate elemental composition as carbon, nitrogen, phosphorus, and silica content, at two stations differing in both location and water depth; and

(2) relate the vertical flux of particulates to the composition and abundance of the phytoplankton community.

In addition, the rates at which nutrients and oxygen are exchanged between the water column and the bottom sediments were measured at less frequent intervals in the York River and Chesapeake Bay.

In the next chapter, the sampling program will be described. Preliminary results of the 1988 vertical flux studies will be presented in Chapter III. Graphical and tabular presentations of much of the data are included in appendices.

II. SAMPLING PROGRAM DESIGN

Methods

Scientific studies conducted in Chesapeake Bay and its tributaries have included remineralization processes and sediment-water column exchanges. Sediment processes **monitoring** did not occur, however, until a comprehensive, long-term, bay-wide monitoring program was established by the state of Maryland. The monitoring program, mandated in a bill passed by the Maryland legislature in 1985, includes monitoring of water quality and living resources as well as sediment processes (see Magnien, 1987). With Maryland's program in place and given the need for methodological consistency to insure data comparability, we have adopted Maryland's methods until such time that the data indicate changes are needed to meet Virginia environmental conditions.

During the fall of 1987, VIMS staff participated in a "SONE" (Sediment Oxygen and Nutrient Exchange) sampling survey conducted by the staff of the Chesapeake Biological Laboratory, University of Maryland. During the late fall and early winter of that year, the necessary equipment was either purchased or fabricated. Detailed descriptions of the methods are given in the Quality Assurance Project Plan. One major difference is that VIMS has maintained traps at three depths at each sampling station, whereas Maryland places traps at two depths only.

Station Locations

The York River sediment processes monitoring began in mid-January of 1988 with a trap array located near the Coast Guard pier on the southern flank of the deep natural channel, approximately halfway between Gloucester Point and the river mouth. Subsequent to deployment, it was observed that vessel traffic to the Coast Guard pier was heavy and often close to the trap array. More importantly, the site was on the alignment for the main opening of the Coleman Bridge. Large ships approach this site and remain there for brief periods while awaiting the opening of the bridge. The first trap samples from this site were characterized by an abundance of large-grained particles. Consequently, the trap array was moved to the northern flank of the river near marker buoy RN "24" (See Figure 1 and Table 1 for both locations). Shortly after the site was changed, a cable in the mooring broke while the array was being lifted out of the water. During the following month new arrays were fabricated and the new array, which conformed more completely with Maryland's design, was re-deployed on April 4, 1988. Only the data from April through December are included in this report.

TABLE 1. STATION LOCATIONS

Station ID		Latitude	Longitude	Description
York River	CG1	37°13'47"	76°29'08"	Near Coast Guard pier
	PITY1	37°14'23"	76°25'24"	Near Buoy RN'24'
Chesapeake Bay	PITBA	37°16'02"	76°09'18"	
	PITB1	37°19'16"	76°07'37"	

The Chesapeake Bay trap array was deployed in early April at a site near the York Spit Channel. Based on discussions with water quality modelers and benthic ecologists, the station location was determined to best represent lower bay sediment conditions. Subsequent to deployment, the U.S. Army Corps of Engineers contracted for the dredging of the Baltimore channel. The sampling site was on the line connecting the dredging operation and the approved spoil disposal site. Because the vessel traffic endangered the array and was likely to affect the measurements, the station was moved to a location out of the line of travel but having similar sediment characteristics. Station locations are shown in Figure 2 and given in Table 1.

Deployment Intervals

Deployments typically lasted for two weeks during the winter, spring, and fall, and one week during the summer months. Deviations from this pattern occurred when weather conditions did not permit retrieval operations, when vessels were not available, or when other difficulties arose. The beginning and ending dates for the deployments are given in Tables 2 and 3, along with notes regarding important events.

The CSA project ended on June 30, 1988, but VIMS maintained the York River station until mid-December when both the Chesapeake Bay and York River arrays were removed. The Chesapeake Bay array was redeployed in early January of 1989 and has been maintained until the present.

Physical Conditions

At the times of both trap deployment and retrieval, water column profiles of temperature (T), salinity (S), and dissolved oxygen (DO) concentration were made. The dates of these surveys and surface to bottom differences are given in Tables 4 and 5. It is apparent that the physical setting varies greatly over the year. Often these variations occur over short periods of time. The salinity profiles for selected sampling dates at the bay station are presented in Figure 3 to illustrate the range of physical conditions observed.

In the lower York River, stratification conditions ranged from destratified (vertical homogeneity) to highly stratified in two or more layers, to conditions which change at a reasonably constant rate with depth. In July and August, dissolved oxygen concentrations below 4 mg/l occurred during periods of relative stratification. At the bay station stratification was generally stronger and neither periods of homogeneity or dissolved oxygen concentrations less than 4 mg/l were observed.

The arrays had two particle interceptor traps at each depth. In Chesapeake Bay the traps were located at 3, 6, and 9 meters below the water surface. In the York River, the traps were located at 6, 9, and 13 meters. In general, the uppermost traps were in the surface layer and the bottom traps were below the pycnocline. The intermediate depth traps were sometimes above and sometimes below the pycnocline.

TABLE 2. LOWER YORK RIVER TRAP DEPLOYMENTS - 1988

Sampling Interval		Comments
Deployment	Retrieval	
**********	*********	
January 19	February 3	
February 3	February 17	
February 17	March 1	Broken cable, trap samples lost
- -	- -	New array being fabricated
April 4	April 20	
April 20	May 3	
May 3	May 16	
May 16	June 6	
June 6	June 14	
- -	- -	New array being fabricated
June 28	July 12	
July 12	July 21	
July 21	July 28	
July 28	August 5	
August 5	August 11	
August 11	August 18	
August 18	August 25	
August 25	September 1	
September 1	September 6	
September 6	September 12	
September 12	September 26	
Septeber 26	October 6	
October 6	October 11	
October 11	October 20	
October 20	November 4	
November 4	November 15	
November 15	November 29	
November 29	December 13	Traps hit & dragged about 300' south, returned to station on Dec. 8

TABLE 3. LOWER CHESAPEAKE BAY TRAP DEPLOYMENTS - 1988

Sampling Interval		Comments
Deployment	Retrieval	
**********	*********	
April 4	April 20	
April 20	May 3	
May 3	May 16	
May 16	?? -	Array run over
- -	- -	New array being fabricated
June 14	June 28	
June 28	July 13	
July 13	July 28	
July 28	August 5	
August 5	August 11	
August 11	August 18	
August 18	August 25	
August 25	September 1	
September 1	September 12	
September 12	September 27	
September 27	October 6	
October 6	October 11	
October 11	October 20	
October 20	***	Noted missing on October 28
November 3	November 14	
November 14	November 29	Surface and subsurface buoys hit and severely damaged
November 29	December 14	

TABLE 4. 1988 SURVEYS AT LOWER YORK RIVER TRAP STATION+

Cruise Number	Date	Surface-bottom differences S (o/oo)	T (C)	DO (mg/l)	Approximate Pycnocline Depth* (m)
PIT01	4 April	6.7	6.7	2.8	11
PIT02	20 April	1.2	0.8	0.4	10
PIT03	3 May	1.9	1.2	1.7	8
PIT04	16 May	0.3	0.1	0.5	3
PIT05	6 June	0.5	0.5	0.5	5
PIT06	14 June	0.8	1.1	2.2	10
PIT07	28 June	5.5	2.2	3.0 #	11
PIT08	12 July	1.8	1.7	1.1	9
PIT09	21 July	3.8	2.7	1.8 #	8
PIT10	28 July	3.6	3.1	6.2 ##	13
PIT11	5 August	0.7	0.1	1.9	12
PIT12	11 August	4.3	4.8	4.9 ##	10
PIT13	18 August	4.3	6.0	3.4 #	12
PIT14	25 August	5.9	6.2	6.2 #	10
PIT15	1 September	0.1	0.4	0.7	WM
PIT16	6 September	4.2	0.6	1.6	11
PIT17	12 September	1.2	0.5	4.4	12
PIT18	26 September	0.0	0.5	0.3	WM
PIT19	6 October	3.3	0.3	1.9	11
PIT20	11 October	4.5	0.6	0.3	12
PIT21	20 October	3.0	0.5	2.0	12
PIT22	4 November	4.4	0.6	1.5	14
PIT23	15 November	0.6	0.1	0.3	WM
PIT24	29 November	4.1	0.2	0.5	11
PIT25	13 December	8.4	0.3	0.7	7

# indicates dissolved oxygen less than 4 mg/l were observed.
indicates dissolved oxygen less than 2 mg/l were observed.
* Value given is depth to the mid-point of the pycnocline. The pycnocline thickness varies greatly.
WM indicates a well mixed water column with no apparent pycnocline.
+ York River station at $37^{o}14'23''$ $76^{o}25'24''$.

TABLE 5. 1988 SURVEYS AT LOWER CHESAPEAKE BAY TRAP STATION+

Cruise Number	Date	Surface-bottom differences S (o/oo)	T (C)	DO (mg/l)	Approximate Pycnocline Depth (m)
PIT01	4 April	6.5	2.0	2.0	4
PIT02	20 April	ND	ND	0.5 *	ND
PIT03	3 May	3.3	0.8	1.8	5
PIT04	16 May	3.8	1.0	1.5	2
PIT06	14 June	5.8	2.0	2.2	3
PIT07	28 June	6.7	2.3	1.8	7
PIT08	13 July	7.0	2.7	3.1 *	3
PIT10	28 July	7.5	3.7	1.3	3
PIT11	5 August	7.5	4.0	1.9	7
PIT12	11 August	6.9	2.4	2.7	6
PIT13	18 August	ND	3.3	0.6 *	ND
PIT14	25 August	6.8	3.1	2.2	5
PIT15	1 September	3.3	0.6	1.1	7
PIT17	12 September	6.8	1.4	3.3	4
PIT18	27 September	3.9	0.0	1.2	5
PIT19	6 October	3.1	0.4	1.7	6
PIT20	11 October	6.3	0.1	1.2	7
PIT21	20 October	5.0	0.0	1.1	9
PIT22	3 November	3.4	0.4	1.2	5
PIT23	14 November	4.2	0.5	1.1	10
PIT24	29 November	3.4	0.4	1.6	11
PIT25	14 December	7.5	0.2	0.6	6

ND = no data or insufficient data.

* indicates that YSI DO readings have not been corrected for T & S.

+ Chesapeake Bay station at:

37°16'02" 76°09'18" prior to 14 June 1988

37°19'16" 76°07'37" as of 14 June 1988

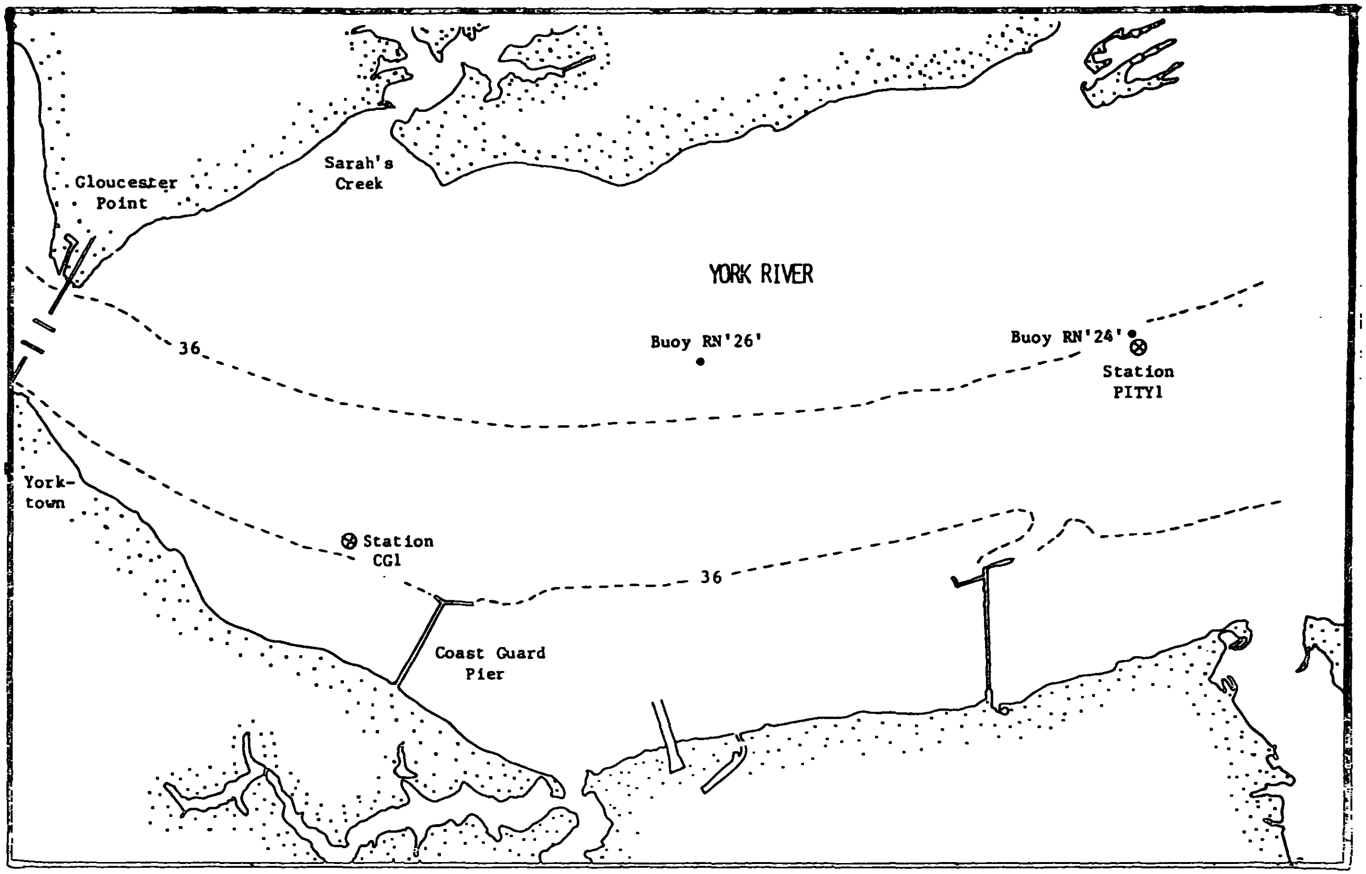


Figure 1. Map of lower York River estuary showing sampling stations.

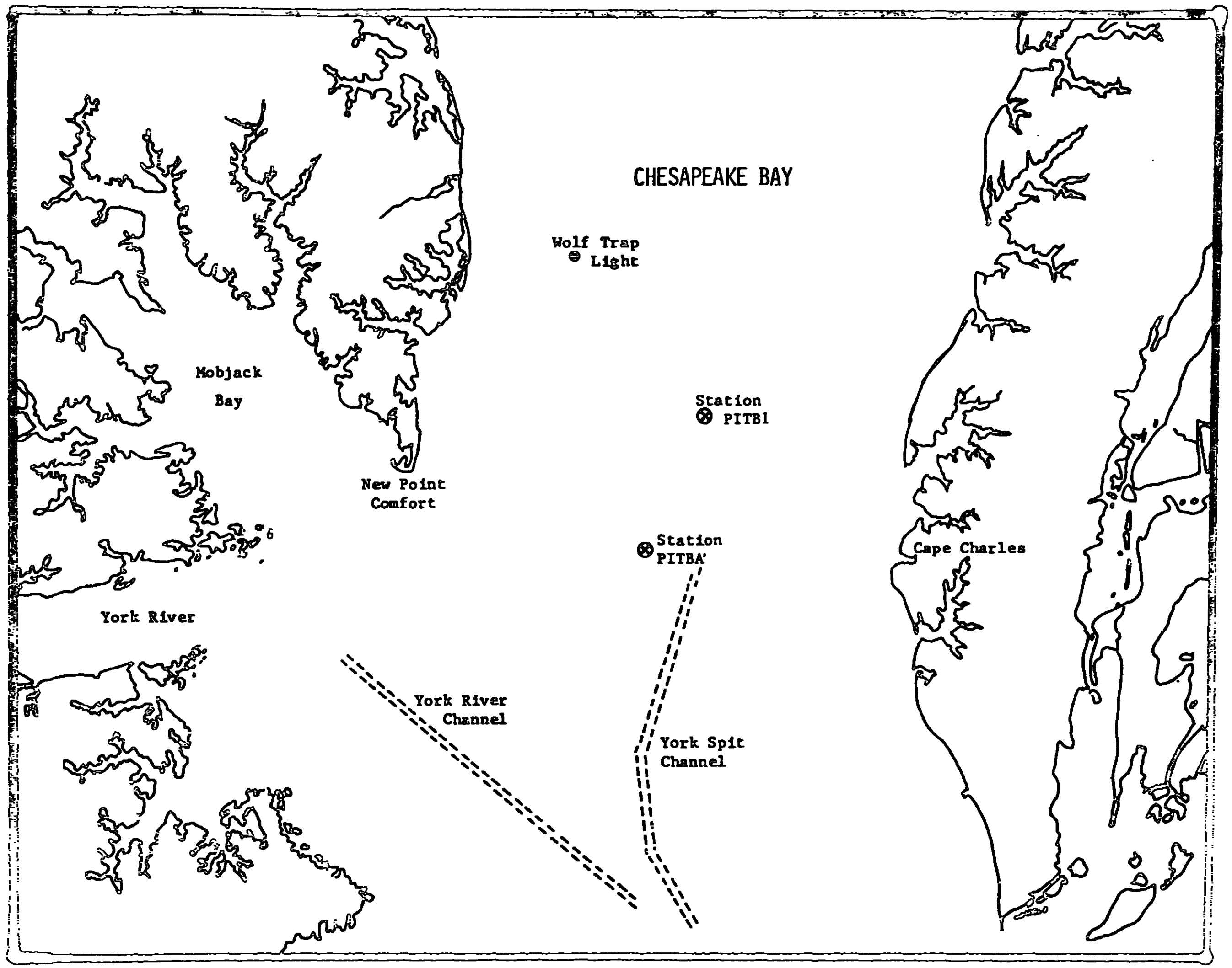


Figure 2. Map of lower Chesapeake Bay showing sampling stations.

BAY PITS STATION

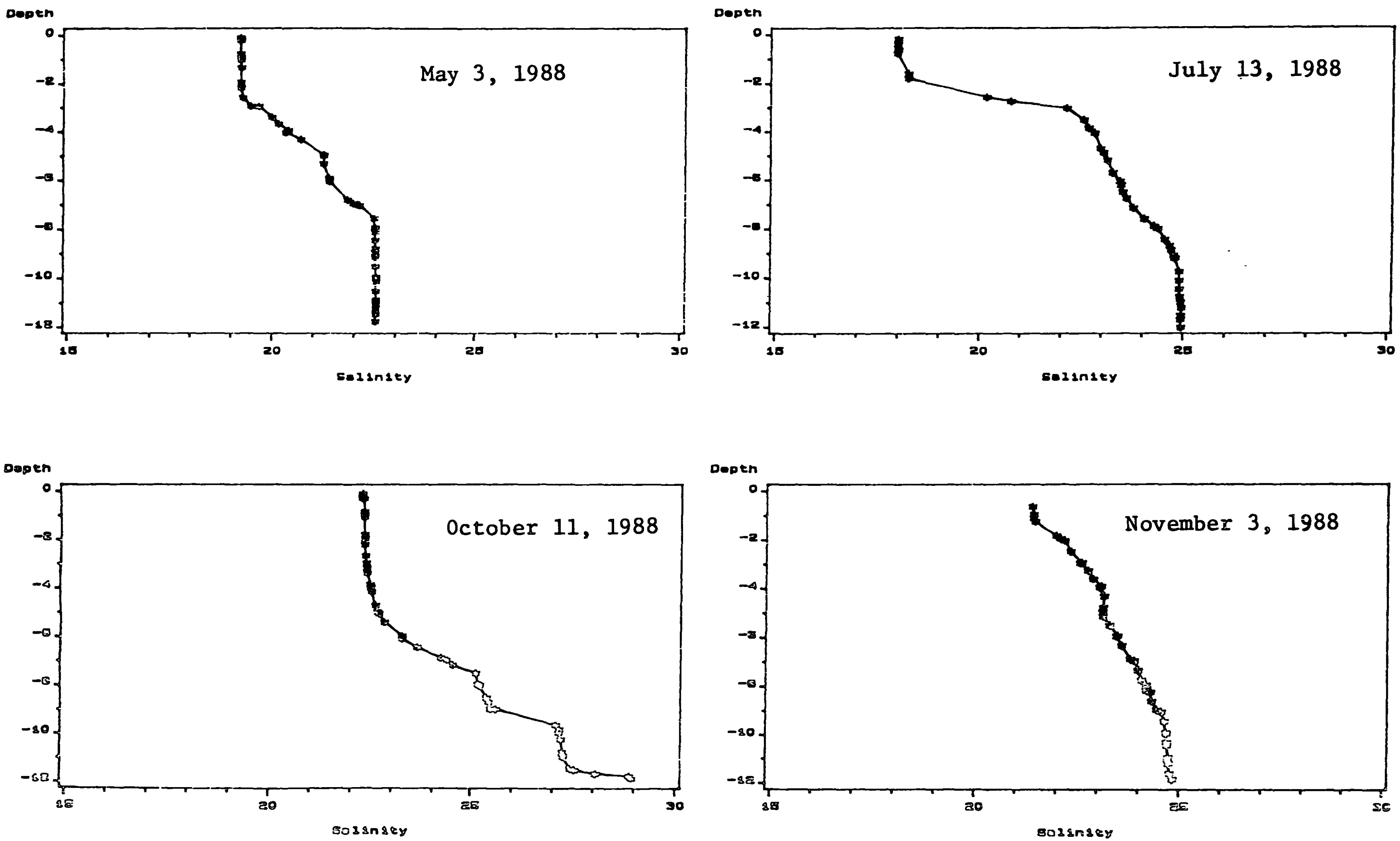


Figure 3. Salinity profiles at the lower Chesapeake Bay station on selected dates in 1988.

Chapter III. RESULTS

The data from the sediment processes monitoring program are being transferred to the computer center at the EPA Chesapeake Bay Liaison Office in Annapolis, Maryland. The results are presented graphically in the appendices. In each figure, data for a single laboratory analysis (such as total suspended solids or particulate carbon concentration) are plotted as a time series.

Sediment and water column characteristics are plotted on the dates of the surveys. For the traps, the data for the two traps at each water depth are averaged and the sampling depth averages are plotted at the mid-point of the deployment interval. Data points for consecutive sampling dates have been connected by a straight line. Summary tables are provided for water column characteristics and sediment trap fluxes.

Vertical Flux of Suspended Particles

For this report, covering the period April to December 1988, the flux of particulate materials as total, non-volatile, and volatile suspended solids, and as particulate carbon, nitrogen, phosphorus, biogenic silica, and chlorophyll are presented as both areal and volumetric estimates for total flux to the depth of trap deployment. The areal rates of net downward flux are calculated by dividing the total material collected in a trap by the area of the trap opening and the duration of deployment. When the areal rates are divided by the trap depth, the rates are normalized for the volume of water above the trap. These estimates do not correct for the contribution of resuspended matter and therefore the reported values should be considered gross estimates. Preliminary analyses are given for the relative error resulting from resuspension based on the assumption that the mid-depth traps are out of the zone of resuspension and therefore are trapping only new material. Trap depths at the lower bay station were 3, 6, and 9 meters and 6, 9, and 13 meters for the York River station. Mean water column depths for all deployments and retrievals at the bay and York River stations were 12.7 ($\pm$ 0.5) and 18.0 ($\pm$ 1.5) meters, respectively.

Graphic and tabular summaries for the particulate and elemental fluxes (areal basis) are given in Appendix II. Since data collection and analysis are not yet complete, interpretation of these flux data are preliminary. However, some initial observations can be made relative to data trends, site comparisons, and resuspension effects.

Vertical flux estimates for top and mid-depth traps indicate no apparent trends that can be ascribed to seasonal effects for the period April to December. High and low flux estimates are distributed throughout the sampling period and correspond to similar patterns observed in the water column concentration data (see Appendix I). Bottom trap estimates are exceedingly high compared to other studies and suggest a large contribution by resuspended bottom sediments. Normalized flux rates (Appendix III) support this conclusion. With few exceptions, top and mid-depth flux estimates, normalized by depth of trap deployment, track and are equal in magnitude. Normalized bottom trap estimates are generally 2 to 3 times greater than top and mid-depth estimates indicating signficant resuspension effects. Resuspension effects at the bay station also appear much greater than at the York

River station and probably reflect the station's shallower depth. Further analyses of these data will include analysis of covariance relative to physical-chemical variables and regression analysis for pair-wise and multiple variants.

Site comparisons indicate the flux estimates are consistently greater at the York River station although the order of magnitude difference is difficult to determine until the flux estimates are corrected for resuspension. Once corrected, the difference in all likelihood will increase given the tentative conclusion of greater resuspension at the bay station. As a preliminary exercise, the relative errors between projected flux (i.e., the mid-depth flux estimate extrapolated to the depth of the bottom trap) and the measured bottom trap flux are given for non-volatile solids at the two stations in Figures 4 and 5. This simple analysis indicates resuspension is significant at both stations and in a relative sense is greater at the bay station. Figure 6 illustrates the projected bottom trap fluxes (corrected by the relative error terms for each interval) for the bay and York River stations and illustrates the much higher relative flux in the river for volatile suspended solids (organic matter) as well as a different temporal pattern in flux estimates. One noted difference between the stations for the data analysed to date is the degree of water column stratification. The bay station appeared to be slightly to moderately stratified on most sampling intervals while the York River station oscillated between stratified and well-mixed. Figure 7 gives the projected flux of organic matter to the deepest trap and the top-to-bottom salinity difference for the York station. Observationally, periods of high relative bottom flux correspond in part to periods of destratification (decreased surface to bottom salinity difference) though not in a linear fashion.

Further and more rigorous analysis of these data awaits completion of data collection and analysis. The actual flux estimates given in this report should be taken as first-order estimates and not accurate approximations for the flux of organic matter and nutrients to the benthos. For example, the apparent relationship between fluxes and water column stratification must be evaluated in light of water column conditions during the entire deployment, whereas data are available only at the beginning and the end. Final reporting and analysis of these data are scheduled for the fall or winter of 1989, depending on the date that sampling is discontinued.

Summary

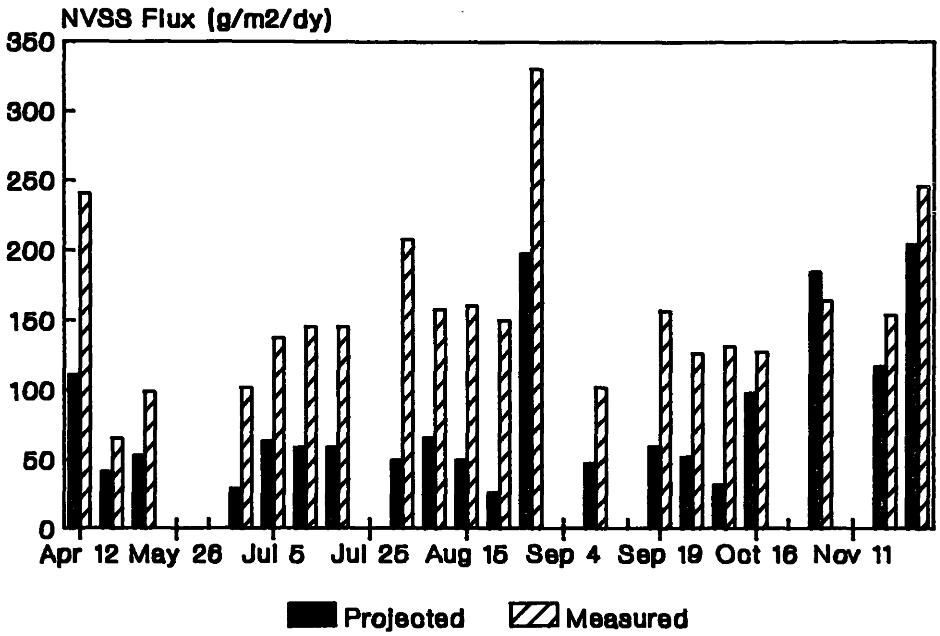
Data collected on the vertical flux of suspended particles, water column and surficial sediment characteristics, and hydrographic conditions at two sites in the lower Chesapeake Bay for the period April through December, 1988 are presented in this annual report to the Virginia Water Control Board and the Chesapeake Bay Liaison Office, U.S. Environmental Protection Agency. In-depth discussion and conclusions regarding these data must await completion of sample collections and analyses. Final report preparation and submission is scheduled for fall or winter of 1989.

Based on limited analysis of the data, we have drawn the following preliminary conclusions as a basis for further analysis and final reporting.

1. Hydrographic and water column particulate compositional data are highly variable and indicate no observationally apparent patterns or trends that can be described as "seasonal". Events of shorter time scales (e.g., advective transport, **in situ** production, water column stability) obviously interact in as yet poorly understood ways to determine the observed dynamics in suspended particulate concentrations and vertical flux estimates.
2. Vertical flux estimates as derived in this report are comparable to, if not higher than, estimates for the upper bay (see Boynton **et al.**, 1988). However, the actual difference is not known because of large resuspension effects in the flux data as presented. Corrected flux data will be presented in the final report.
3. Preliminary analysis of resuspension effects indicates that the effect is significant at both sites with the relative effect being greater at the lower bay site. Projected flux (mid-depth flux rate extrapolated to depth of bottom trap) versus measured bottom trap flux indicate relative errors of 40% to 60%, with values as high as 80%, at the lower bay station.
4. Comparison of the stations indicates flux rates are consistently higher at the York River station. Organic matter fluxes generally were two to four times higher for every

sampling interval. The resultant flux is obviously influenced by multiple factors, but two emerging principal components appear to be water column particulate concentrations and the degree of water column stratification.

The continuing effort will include completion of sampling at the bay station and sample analyses. Flux data will be corrected for resuspension effects using the approach employed in Maryland's upper bay studies (see Boynton **et al.**, 1988). Single and multi-factor analysis of variance will be employed for further data analysis and final reporting. Biological characterization studies of the water column and trapped particulates are continuing and will be included in the final report.



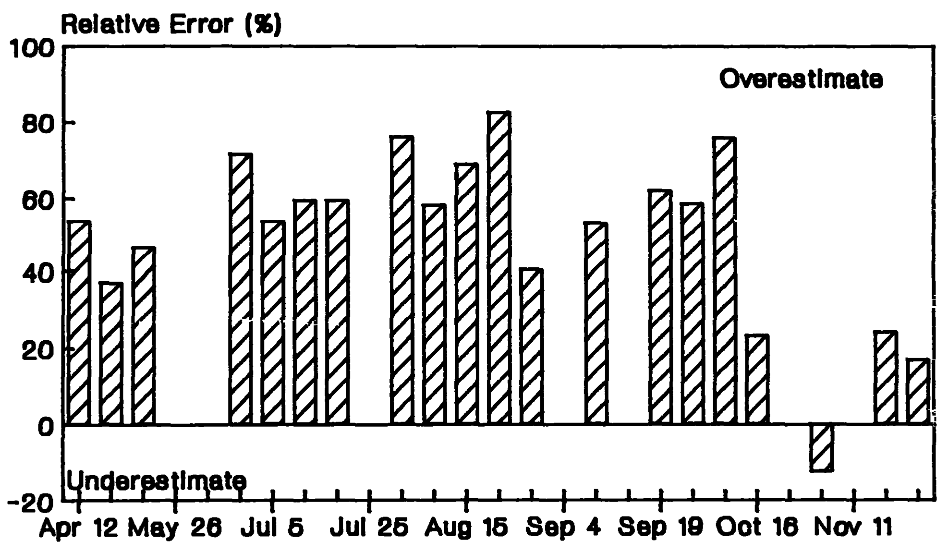


Figure 4. Relative error of projected versus measured NVSS fluxes at the mid-Bay station.

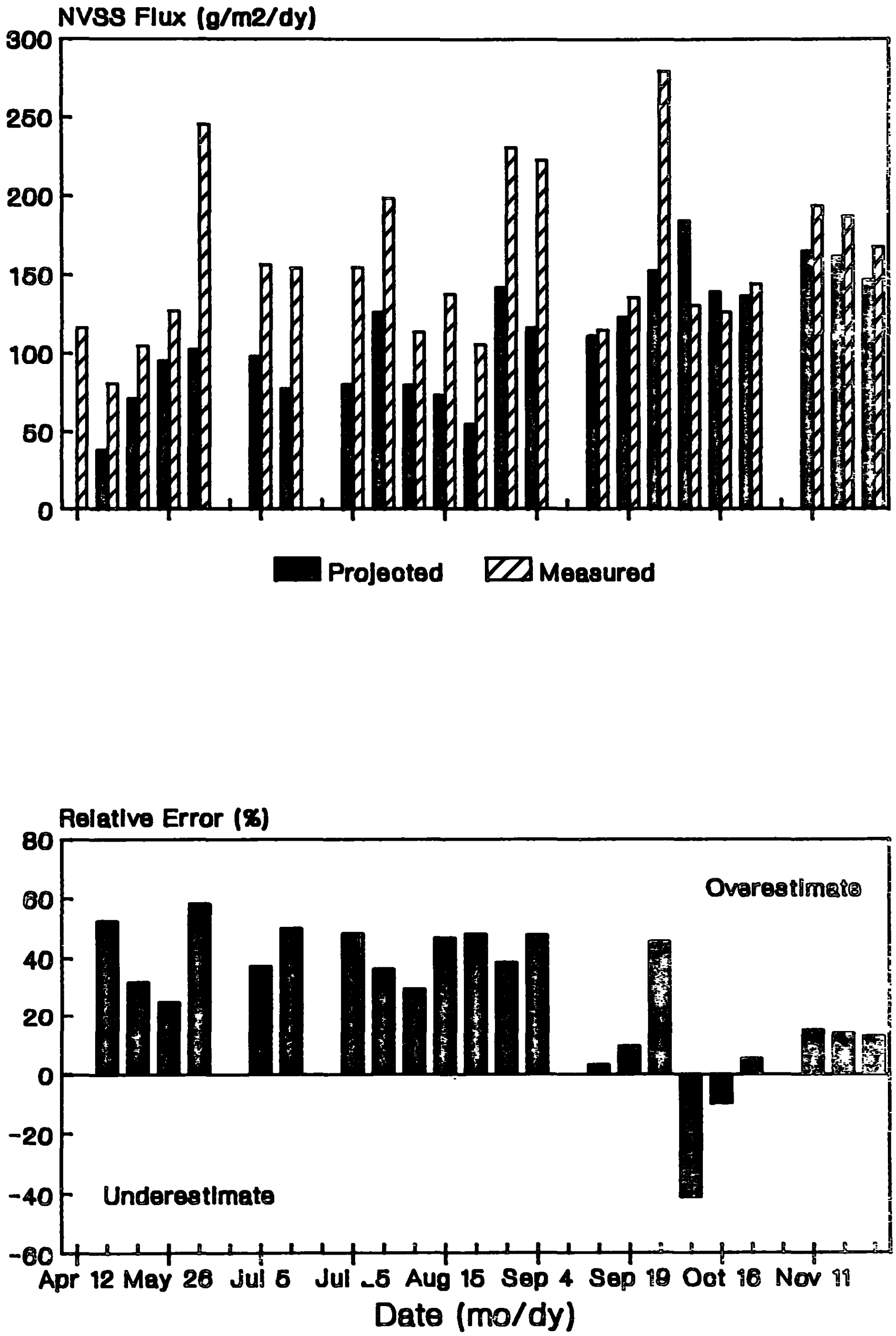


Figure 5. Relative error of projected versus measured NVSS fluxes at the York River station.

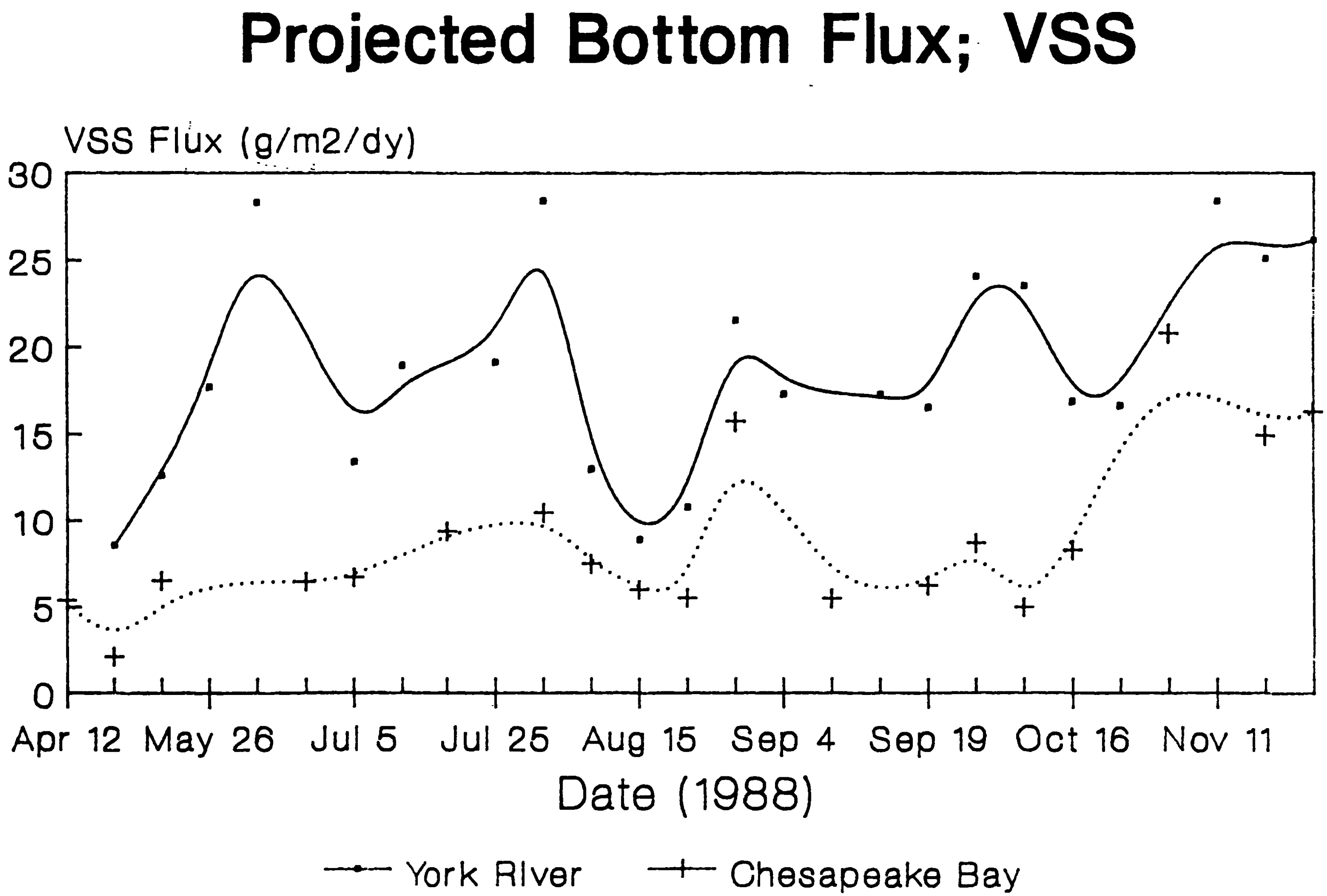


Figure 6. Projected VSS fluxes at bottom trapping depths for Chesapeake Bay (9 m) and York River (13 m) stations.

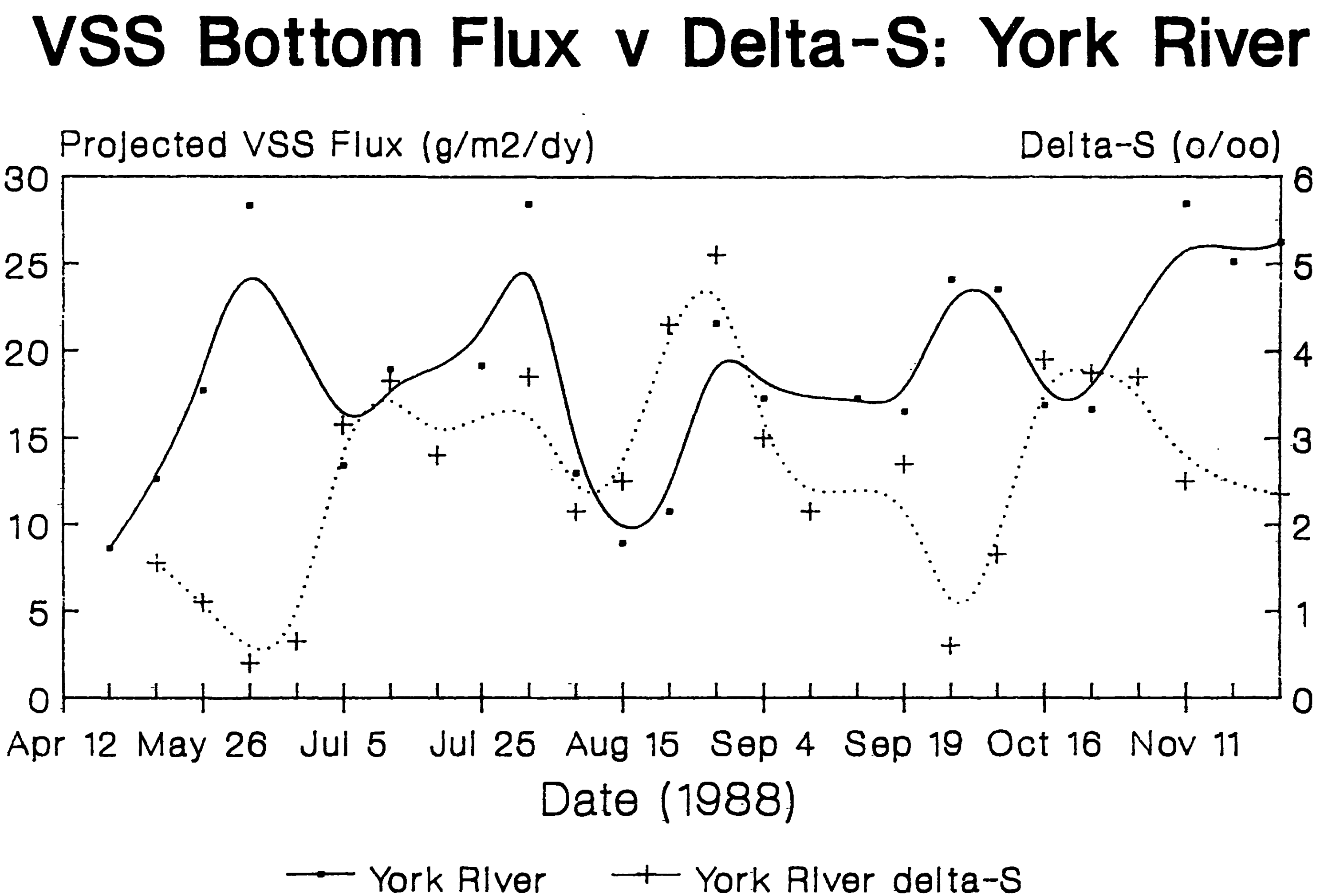


Figure 7. Projected VSS bottom fluxes versus top to bottom salinity differences at the York River station.

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Boynton, W. R., W. M. Kemp, J. Garber, J. M. Barnes, L. L. Robertson, and J. L. Watts. "Ecosystem Processes Component (EPC) Level I Report No. 5 (July 1987 - December 1987), Center for Environmental and Estuarine Studies, University of Maryland, June 1988, 98 pp.

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APPENDIX I. WATER COLUMN CHARACTERISTIS

A. Summary Tables

B. Plots of Concentration versus Time

1. Lower Chesapeake Bay Station *
2. Lower York River Station*

* See main body of report for exact location and other information regarding the lower Chesapeake Bay station ("Bay station") and the lower York River station ("York station").

Total Suspended Solids

Bay Station...........

Depth (m)	Total Suspended Solids		
	Mean	Minimum	Maximum
3..................	9.77	3.20	23.60
6..................	10.47	4.70	26.20
9..................	13.19	6.00	29.20

York Station..........

Depth (m)	Total Suspended Solids		
	Mean	Minimum	Maximum
6..................	12.64	5.90	30.50
9..................	12.17	5.40	26.70
13.................	15.54	7.50	33.10

Notes:

Concentration as mg/l

Total Volatile Solids

Bay Station...........

Depth (m)	Total Volatile Solids		
	Mean	Minimum	Maximum
3..................	2.32	0.80	5.00
6..................	2.22	0.90	6.60
9..................	2.15	0.80	4.30

York Station..........

Depth (m)	Total Volatile Solids		
	Mean	Minimum	Maximum
6..................	2.39	1.10	4.80
9..................	2.39	0.30	4.50
13.................	2.78	1.00	4.90

Notes:

Concentration as mg/l

Total Non-Volatile Solids

Bay Station..........

Depth (m)	Total Non-Volatile Solids		
	Mean	Minimum	Maximum
3.................	7.73	2.30	20.70
6.................	8.58	2.10	22.10
9.................	11.34	3.20	25.20

York Station..........

Depth (m)	Total Non-Volatile Solids		
	Mean	Minimum	Maximum
6.................	10.49	3.80	26.40
9.................	10.05	3.70	23.30
13................	12.77	5.90	29.10

Notes:

Concentration as mg/l

Particulate Carbon

Bay Station..........

Depth (m)	Particulate Carbon		
	Mean	Minimum	Maximum
3..................	0.822	0.429	1.603
6..................	0.615	0.104	1.122
9..................	0.643	0.302	1.423

York Station.........

Depth (m)	Particulate Carbon		
	Mean	Minimum	Maximum
6..................	0.632	0.163	1.595
9..................	0.742	0.291	2.164
13.................	0.753	0.354	1.402

Notes:

Concentration as mg/l

Particulate Nitrogen

Bay Station...........

Depth (m)	Particulate Nitrogen		
	Mean	Minimum	Maximum
3..................	0.117	0.068	0.187
6..................	0.110	0.037	0.439
9..................	0.097	0.040	0.234

York Station..........

Depth (m)	Particulate Nitrogen		
	Mean	Minimum	Maximum
6..................	0.108	0.031	0.234
9..................	0.112	0.048	0.197
13.................	0.116	0.055	0.185

Notes:

Concentration as mg/l

Particulate Phosphorus

Bay Station...........

Depth (m)	Particulate Phosphorus		
	Mean	Minimum	Maximum
3	0.014	0.007	0.020
6	0.013	0.004	0.017
9	0.013	0.005	0.028

York Station..........

Depth (m)	Particulate Phosphorus		
	Mean	Minimum	Maximum
6	0.016	0.007	0.039
9	0.016	0.008	0.037
13	0.019	0.009	0.044

Notes:

Concentration as mg/l

Biogenic Silica

Bay Station...........

Depth (m)	Biogenic Silica		
	Mean	Minimum	Maximum
3..................	0.127	0.047	0.245
6..................	0.133	0.041	0.300
9..................	0.239	0.068	0.567

York Station..........

Depth (m)	Biogenic Silica		
	Mean	Minimum	Maximum
6..................	0.261	0.107	0.631
9..................	0.299	0.119	0.756
13.................	0.394	0.110	0.879

Notes:

Concentration as mg/l

Chlorophyll-A

Bay Station...........

Depth (m)	Chlorophyll-A		
	Mean	Minimum	Maximum
3	5.034	2.153	8.837
6	3.296	1.136	5.792
9	2.647	1.077	6.454

York Station..........

Depth (m)	Chlorophyll-A		
	Mean	Minimum	Maximum
6	4.548	1.676	8.853
9	3.784	1.250	7.617
13	3.307	1.179	6.024

Notes:

Concentration as ug/l
Chlorophyll

Pheophytin

Bay Station..........

Depth (m)	Pheophytin		
	Mean	Minimum	Maximum
3..................	2.617	0.100	5.435
6..................	2.313	0.784	5.962
9..................	2.165	0.936	4.805

York Station..........

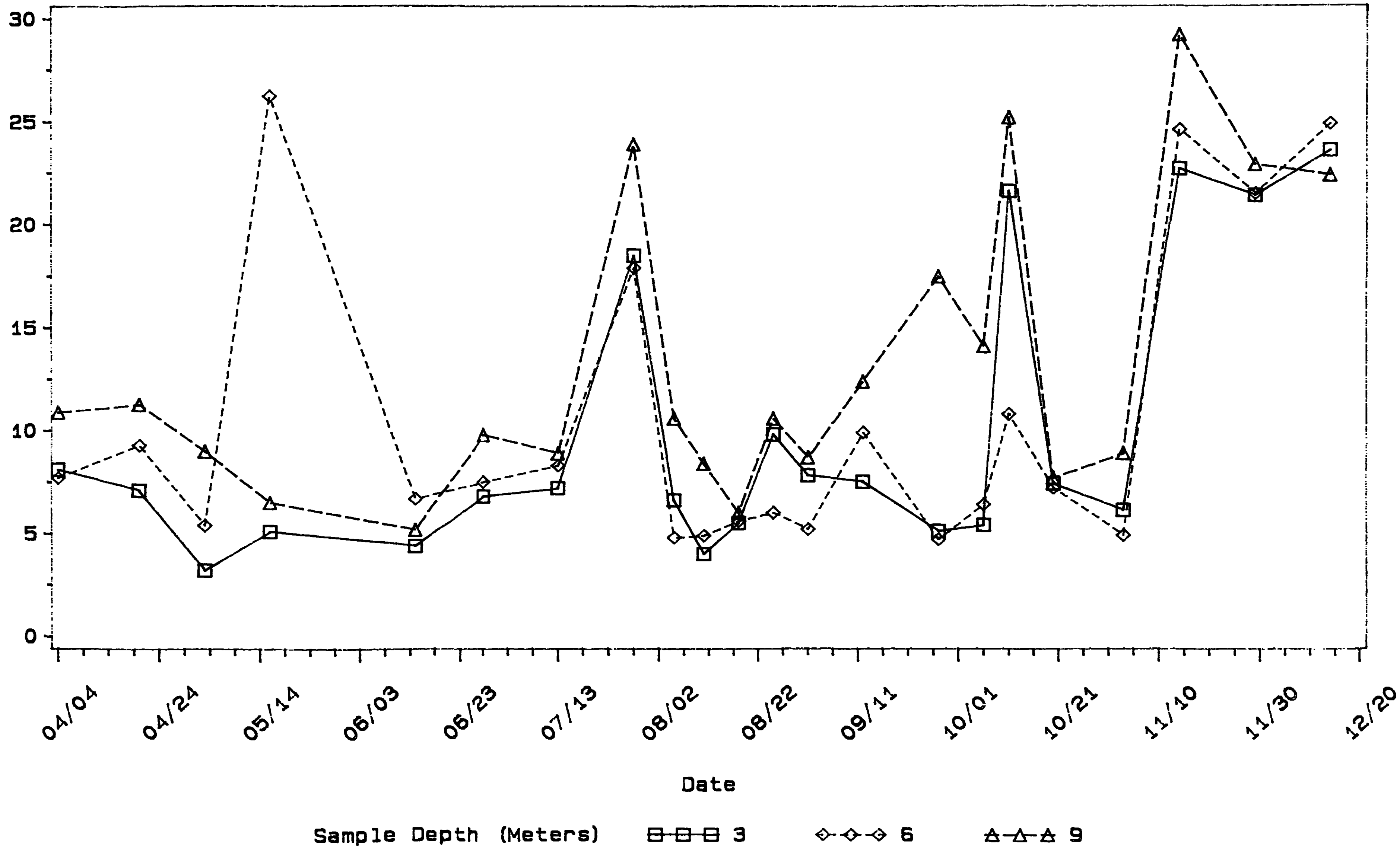
Depth (m)	Pheophytin		
	Mean	Minimum	Maximum
6..................	3.175	0.991	5.406
9..................	2.963	0.146	5.819
13..................	3.570	1.764	5.503

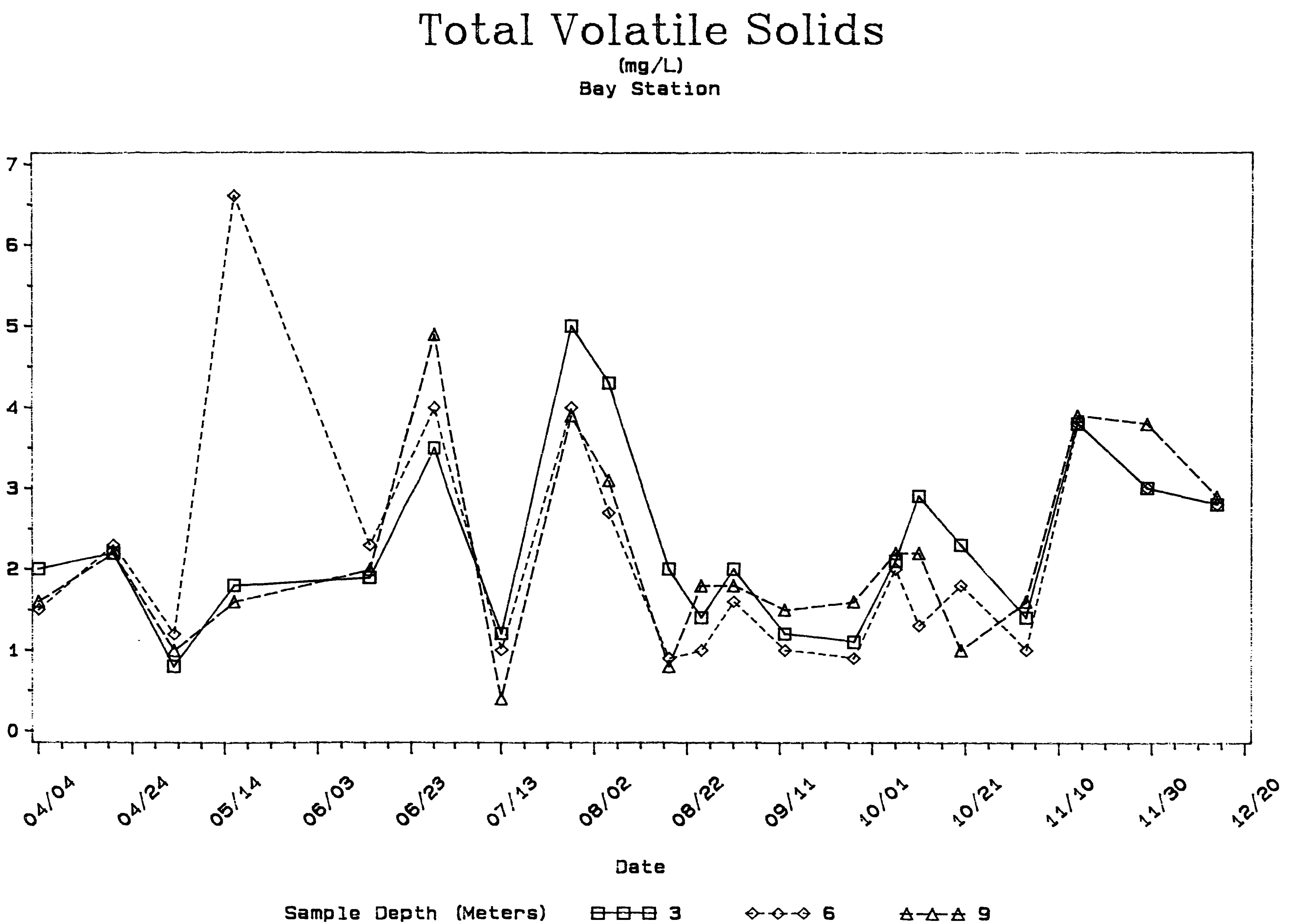
Notes:

Concentration as ug/l
Chlorophyll

Total Suspended Solids

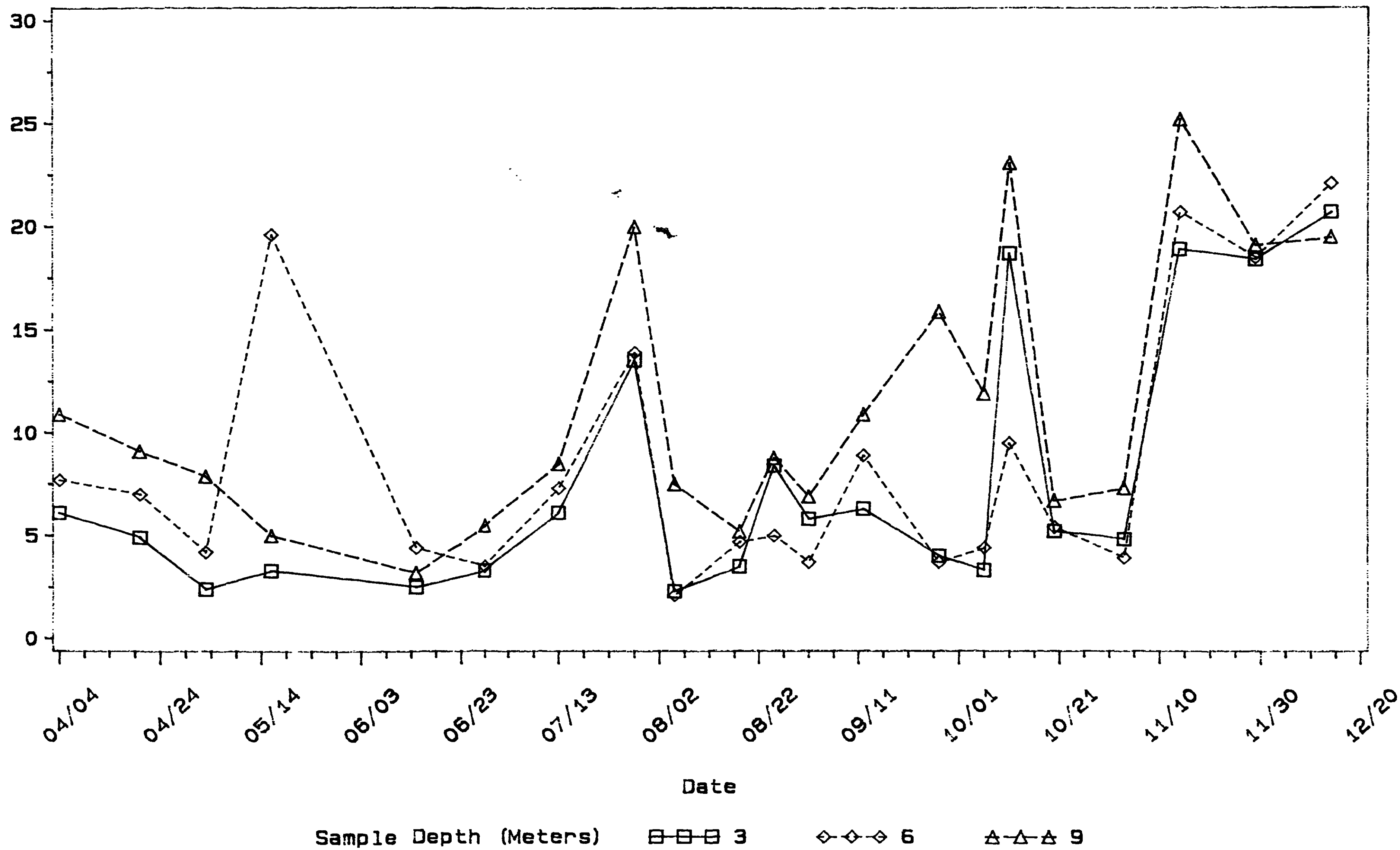
(mg/L)
Bay Station




Total Volatile Solids
(mg/L)
Bay Station
0
1
2
3
4
5
6
7
04/04
04/24
05/14
06/03
06/23
07/13
08/02
08/22
09/11
10/01
10/21
11/10
11/30
12/20
Date
Sample Depth (Meters)
3
6
9

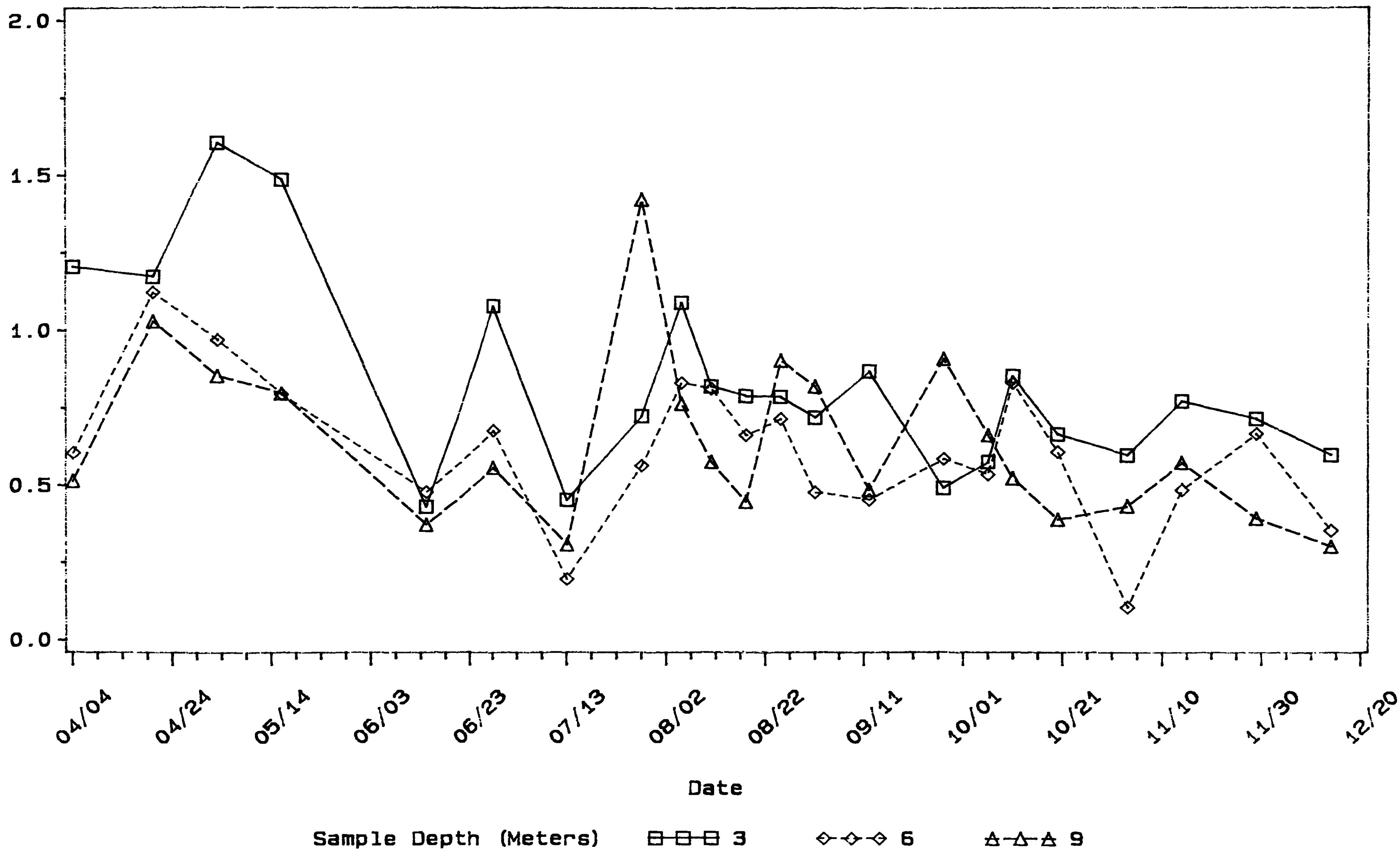
Total Non-Volatile Solids

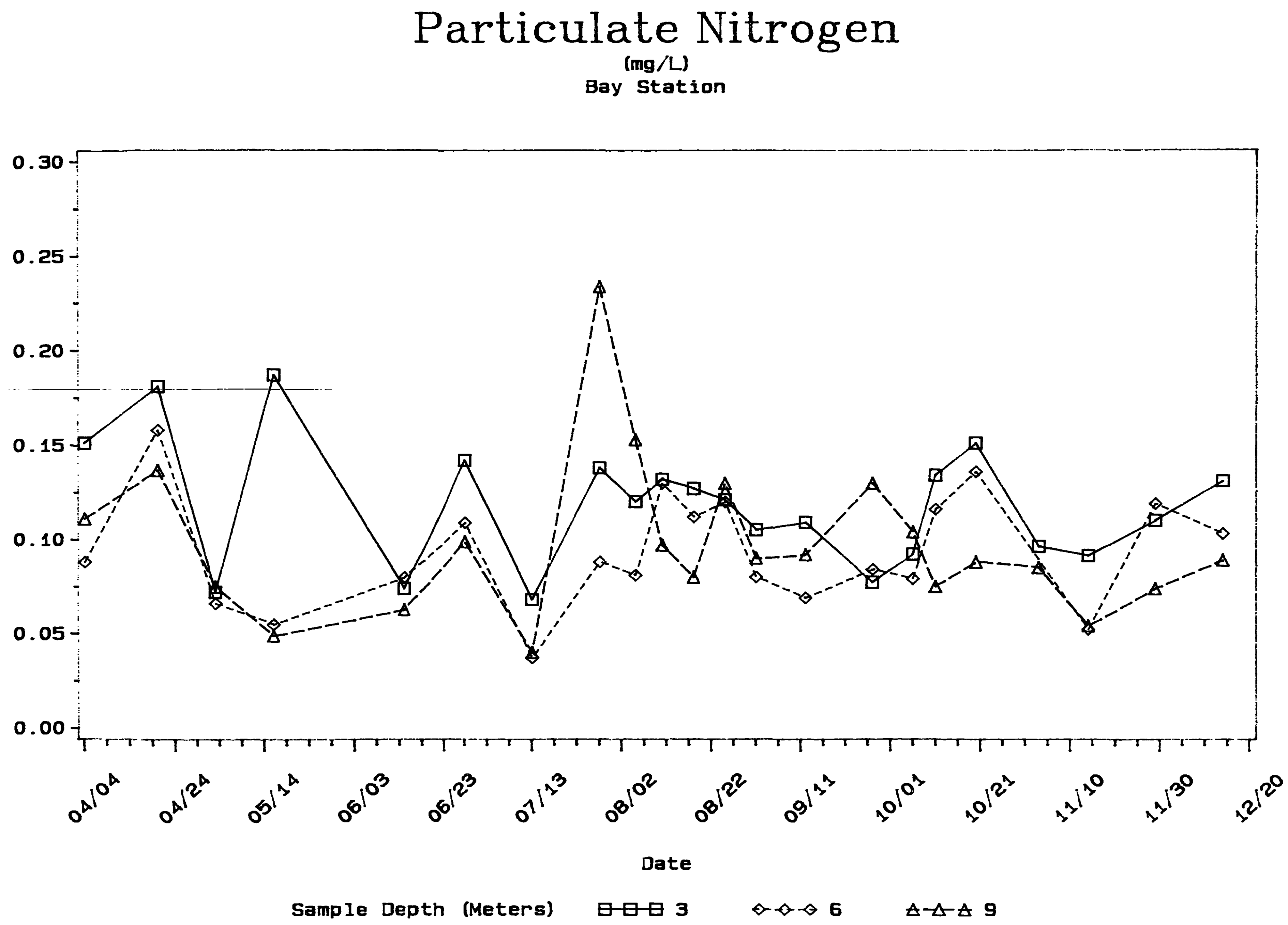
(mg/L)
Bay Station



Particulate Carbon

(mg/L)
Bay Station

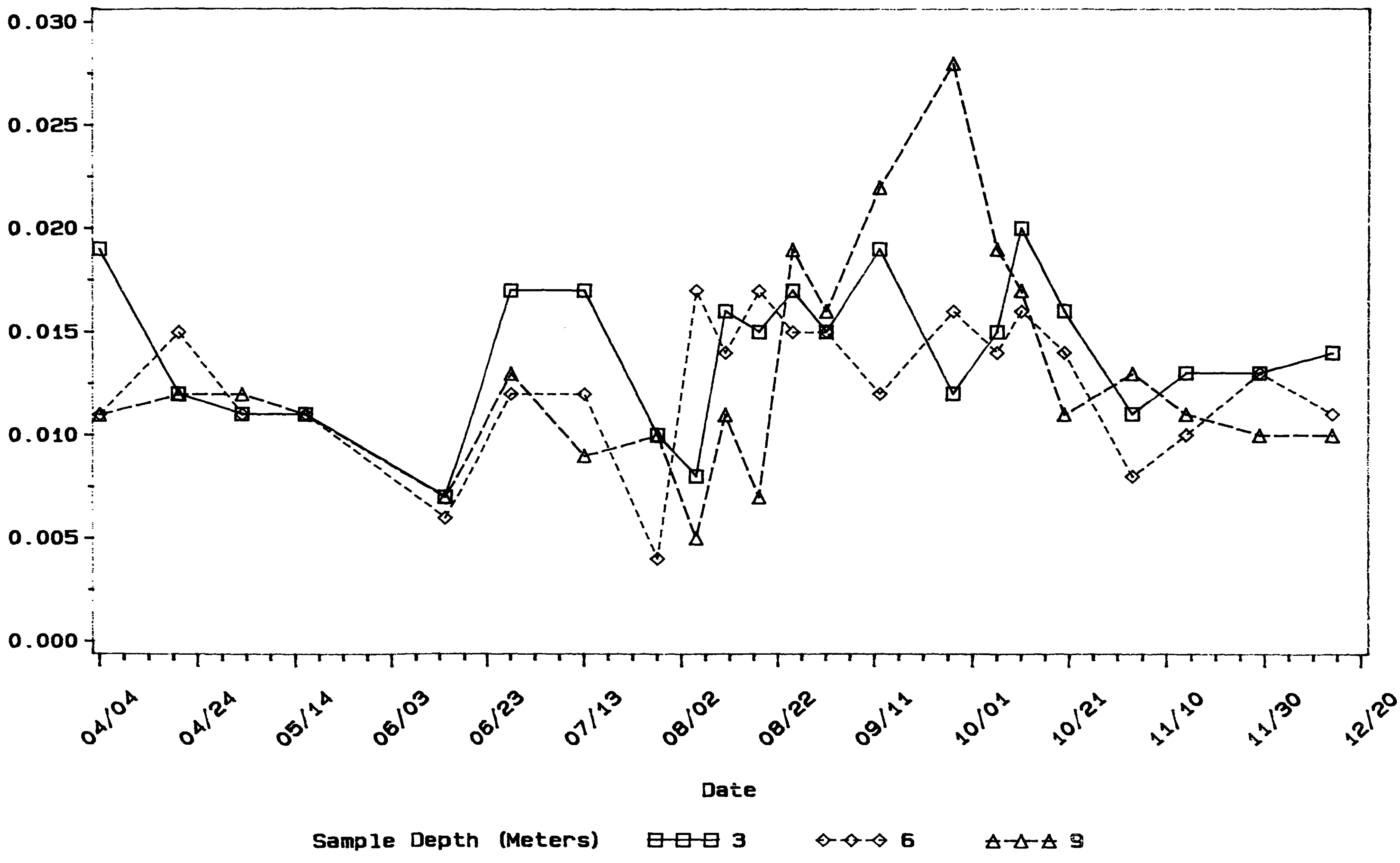




Particulate Nitrogen
(mg/L)
Bay Station
0.30
0.25
0.20
0.15
0.10
0.05
0.00
04/04
04/24
05/14
06/03
06/23
07/13
08/02
08/22
09/11
10/01
10/21
11/10
11/30
12/20
Date
Sample Depth (Meters) 3 6 9

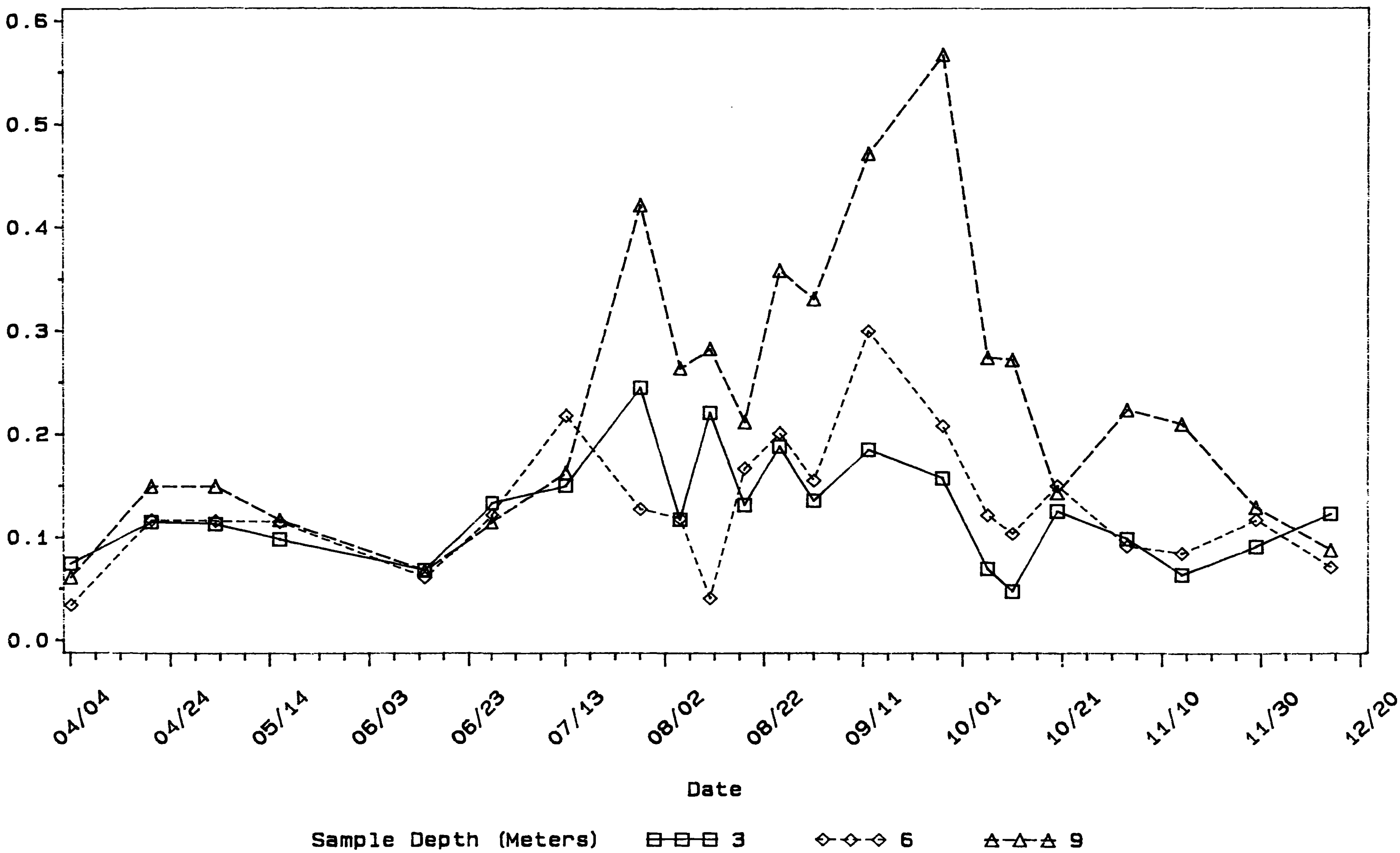
Particulate Phosphorus

(mg/L)
Bay Station



Biogenic Silica

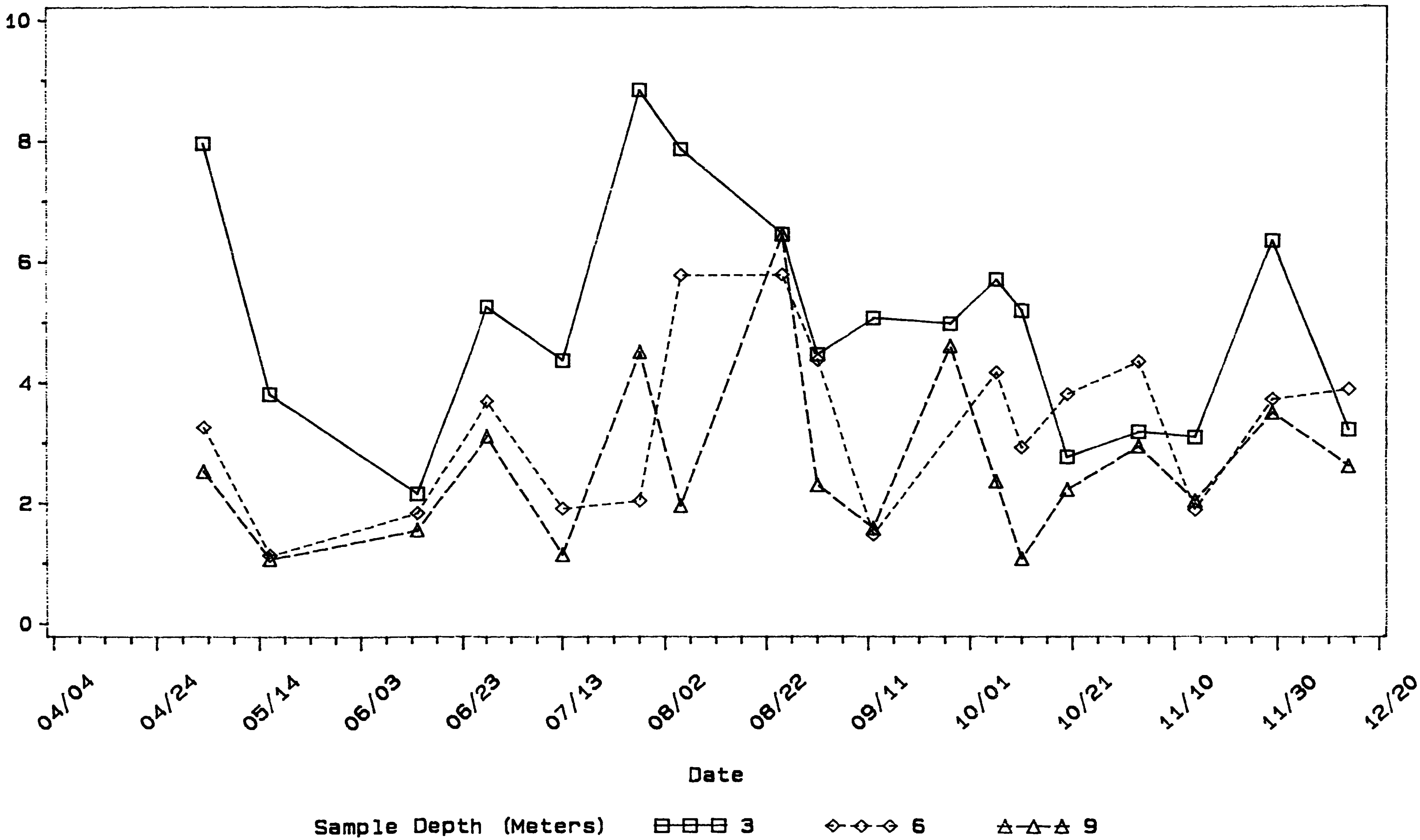
(mg/L)
Bay Station



Chlorophyll-A

(ug/L)

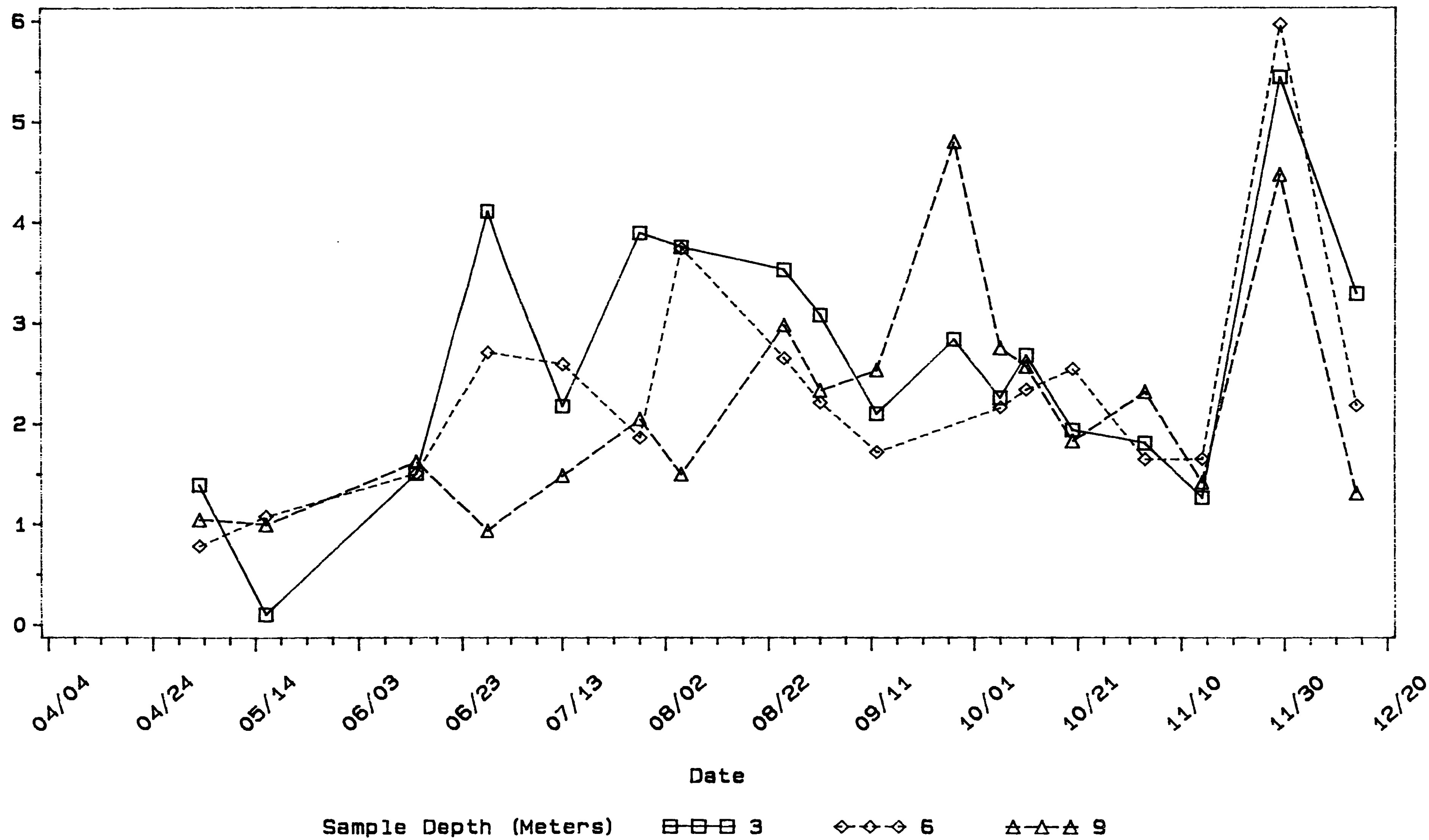
Bay Station



Pheophytin

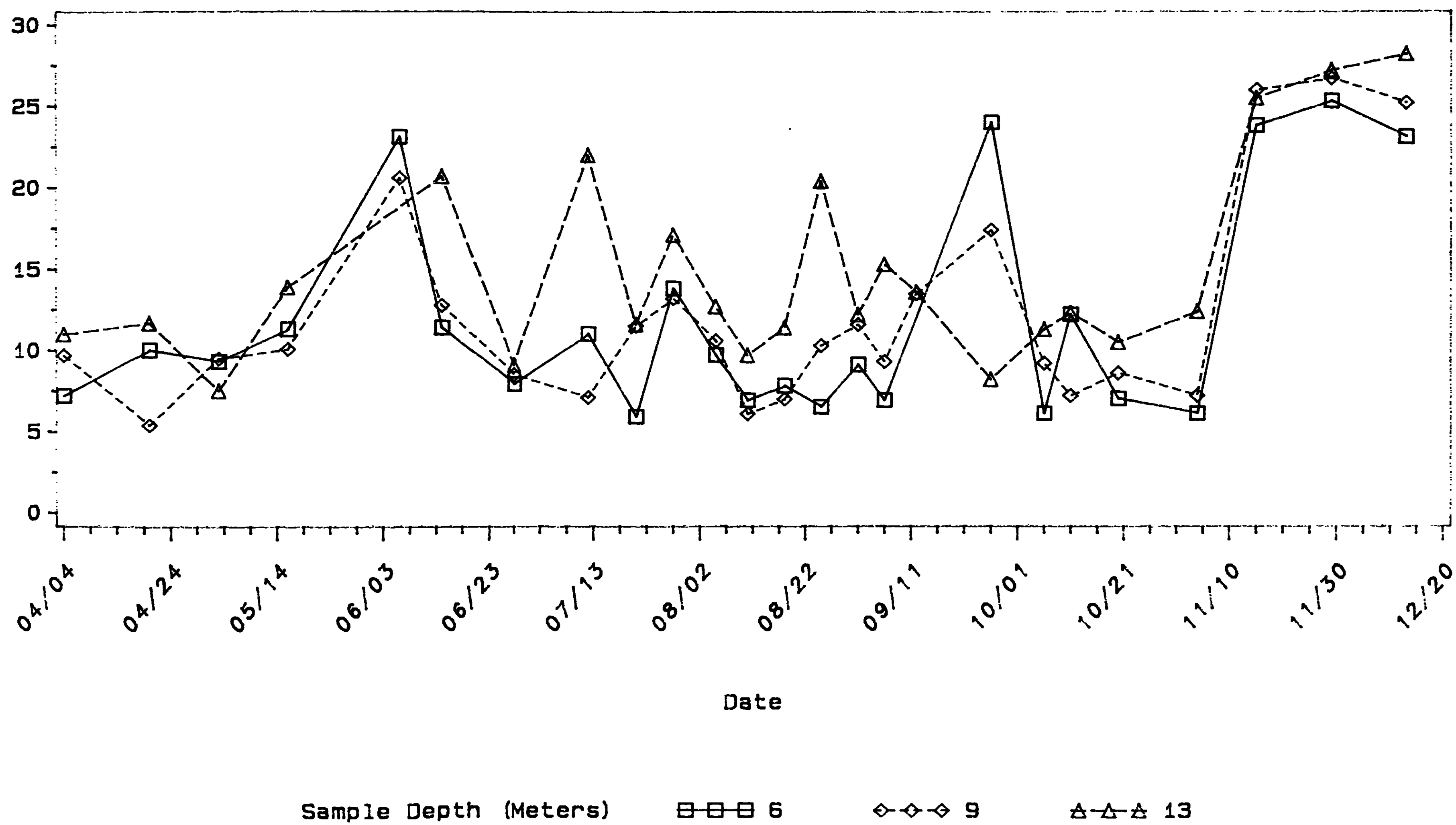
(ug/L)

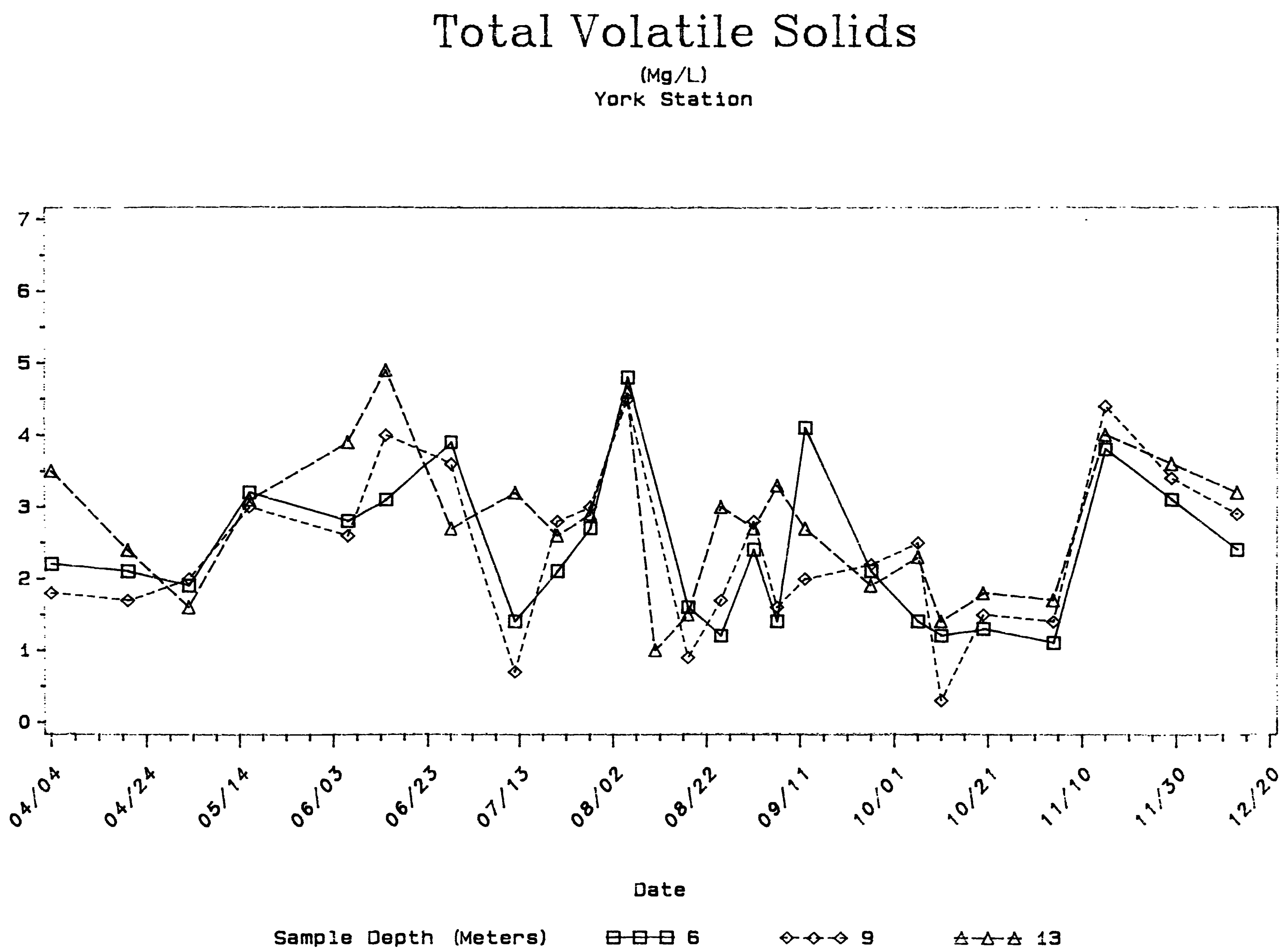
Bay Station



Total Suspended Solids

(Mg/L)
York Station

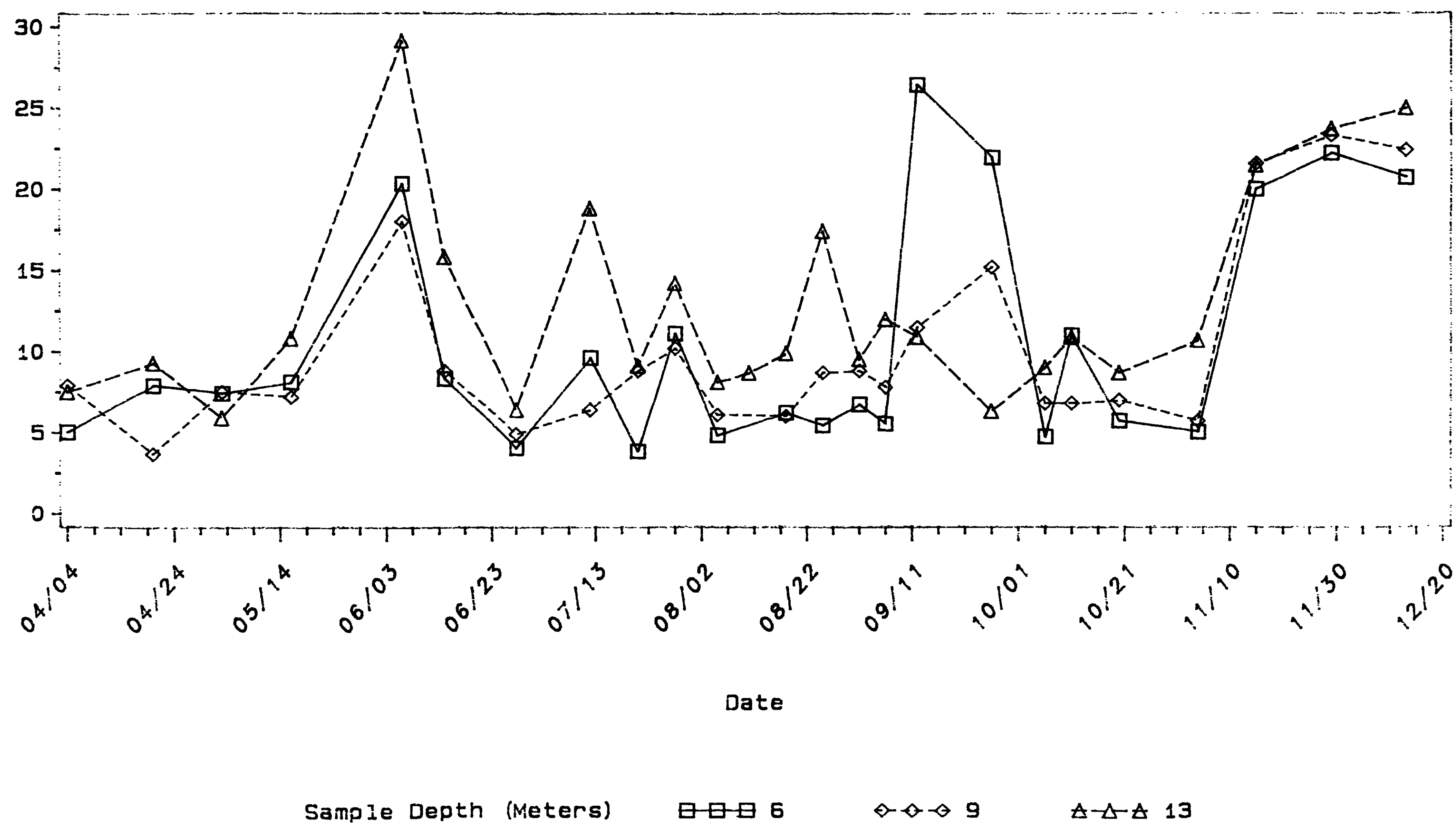




Total Volatile Solids
(Mg/L)
York Station
7
6
5
4
3
2
1
0
04/04
04/24
05/14
06/03
06/23
07/13
08/02
08/22
09/11
10/01
10/21
11/10
11/30
12/20
Date
Sample Depth (Meters)
6
9
13

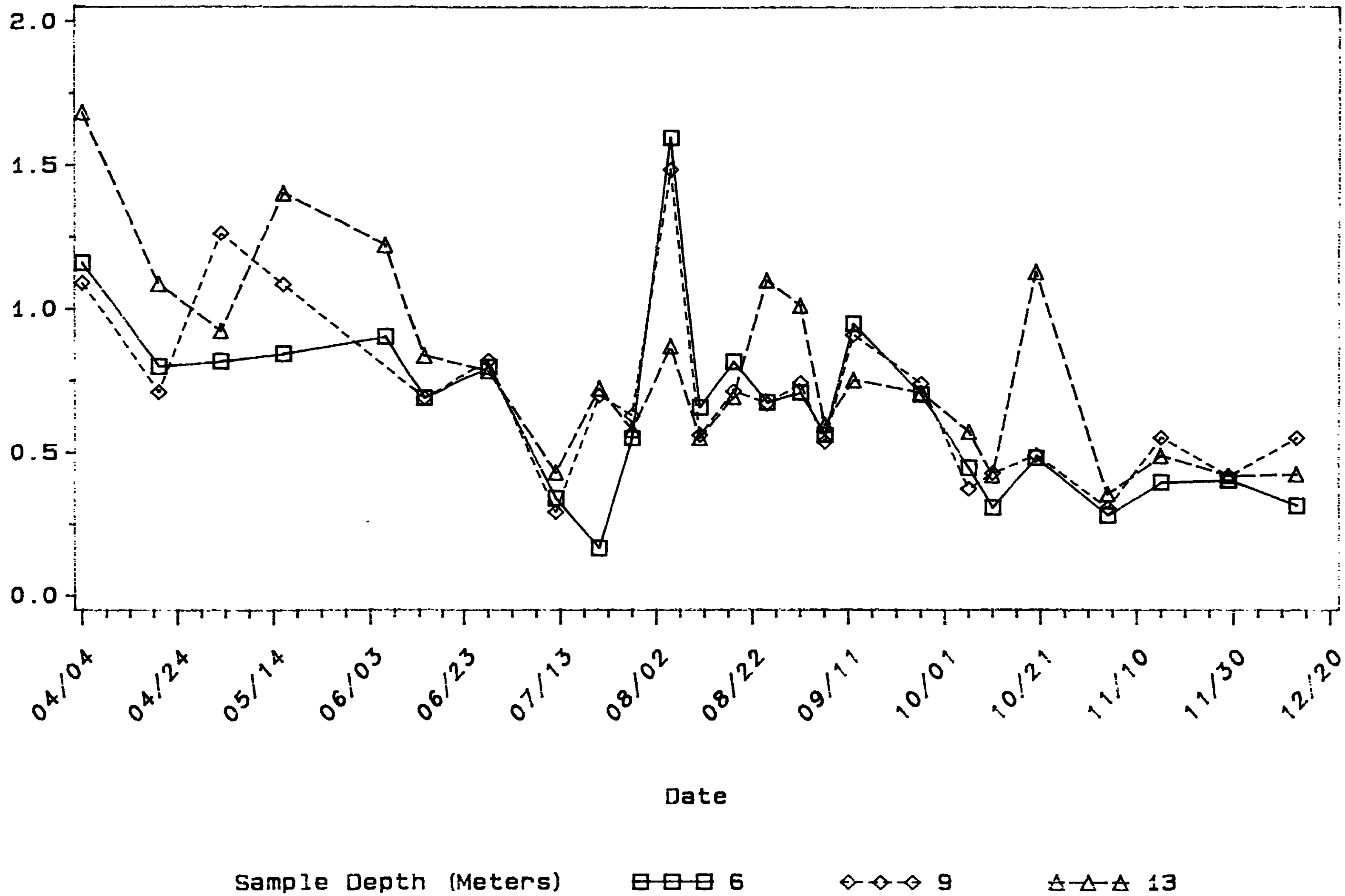
Total Non–Volatile Solids

(Mg/L)
York Station



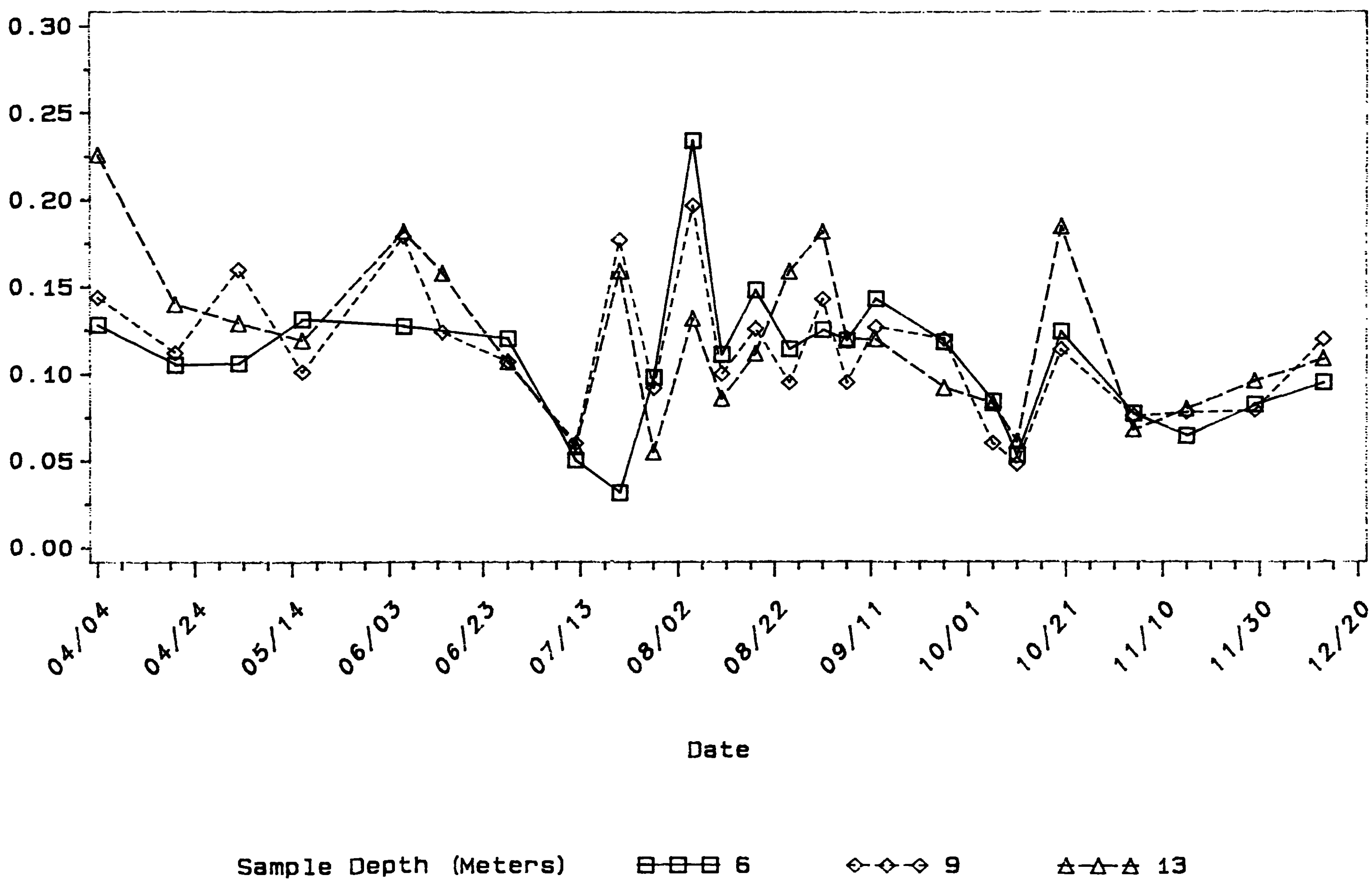
Particulate Carbon

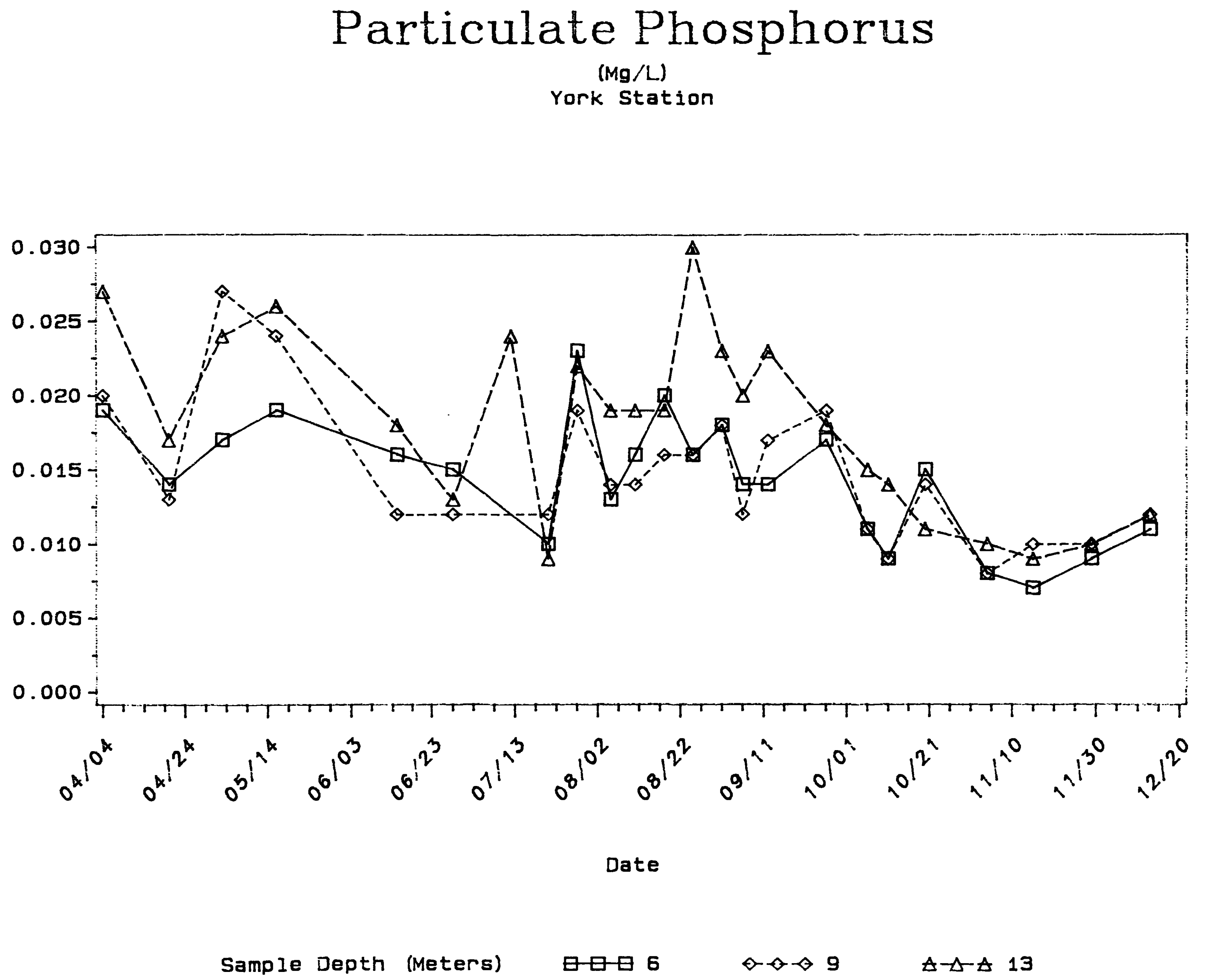
(Mg/L)
York Station



Particulate Nitrogen

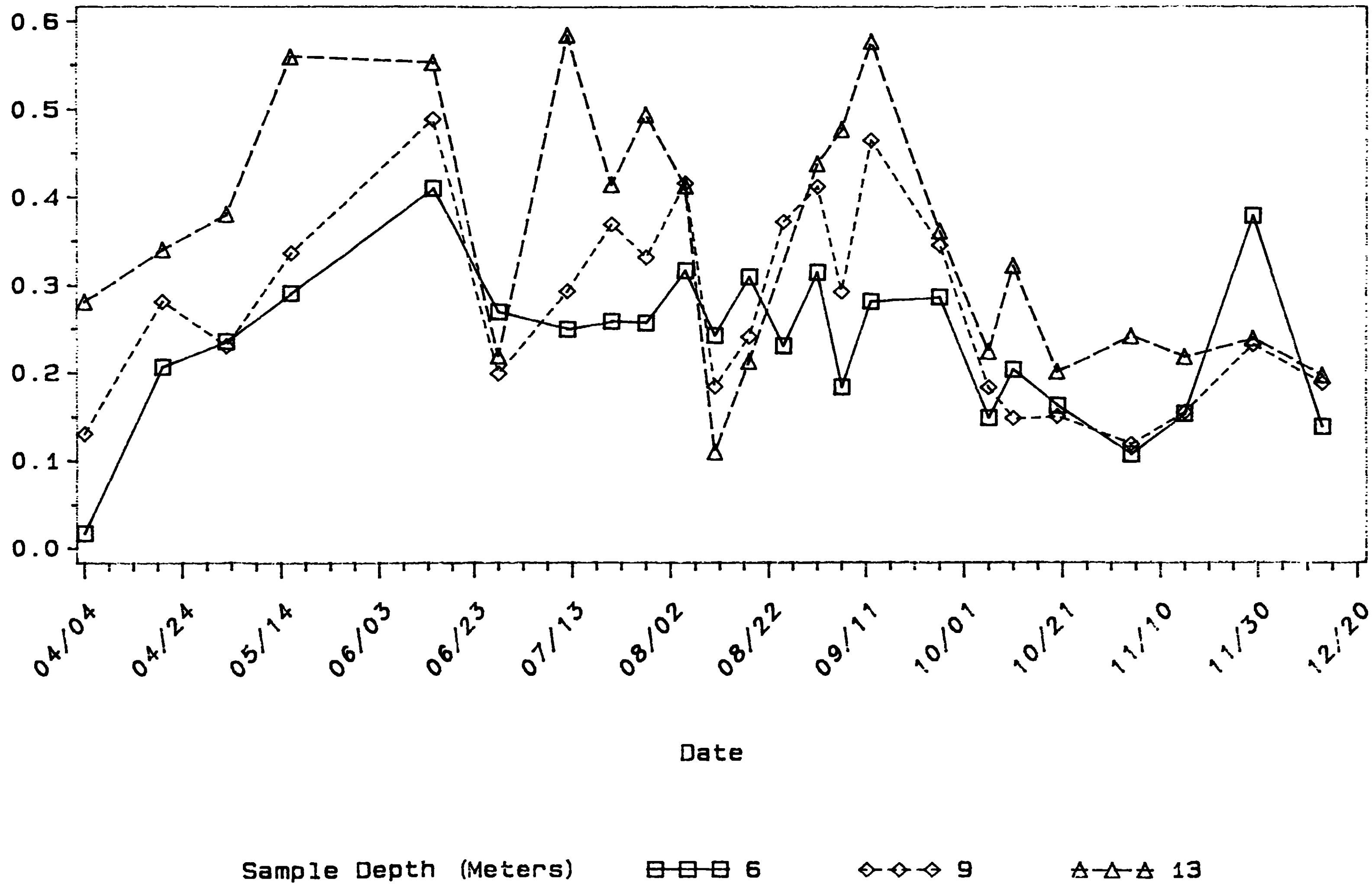
(Mg/L)
York Station




Particulate Phosphorus
(Mg/L)
York Station
0.030
0.025
0.020
0.015
0.010
0.005
0.000
04/04
04/24
05/14
06/03
06/23
07/13
08/02
08/22
09/11
10/01
10/21
11/10
11/30
12/20
Date
Sample Depth (Meters)
6
9
13

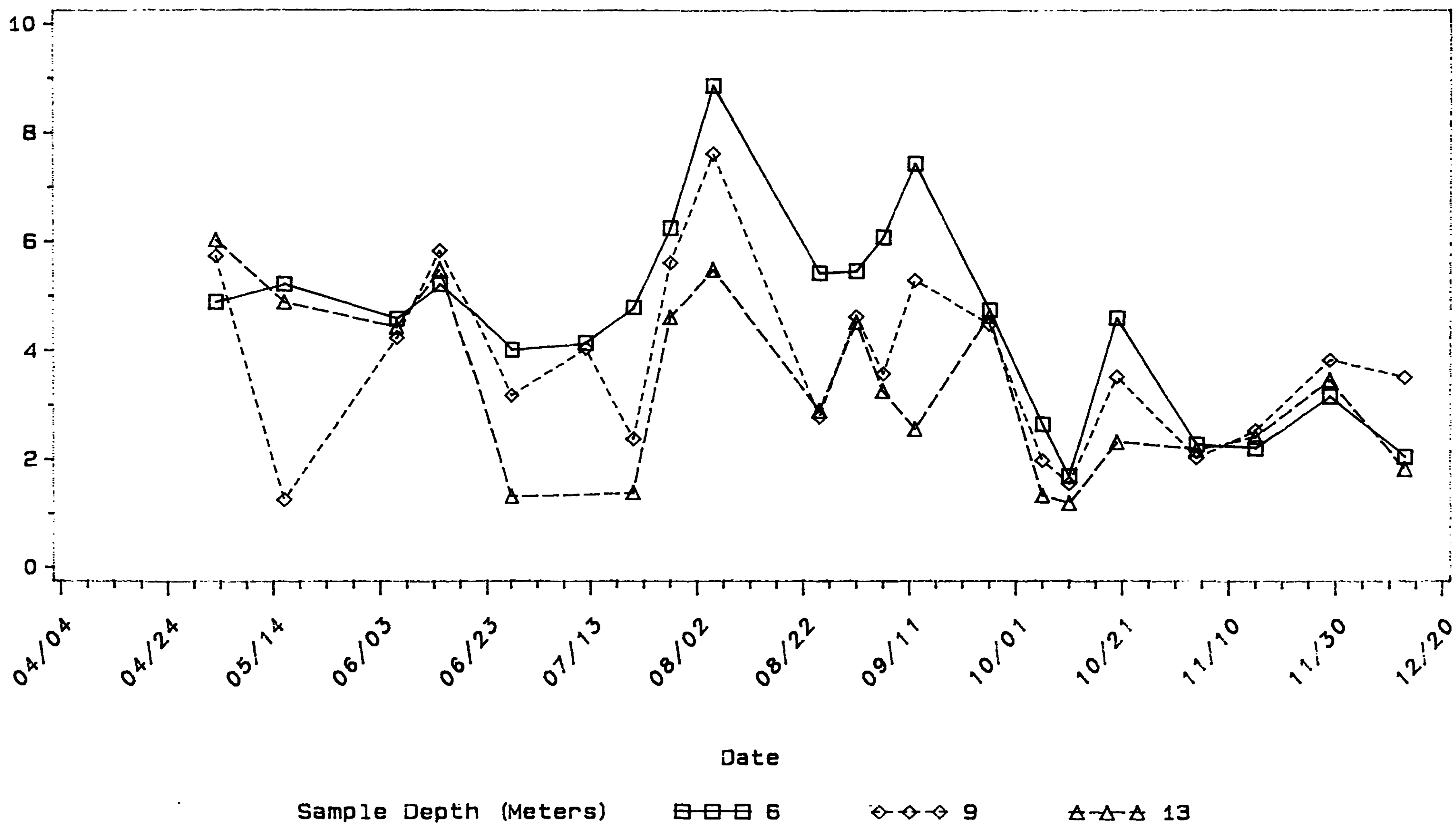
Biogenic Silica

(Mg/L)
York Station



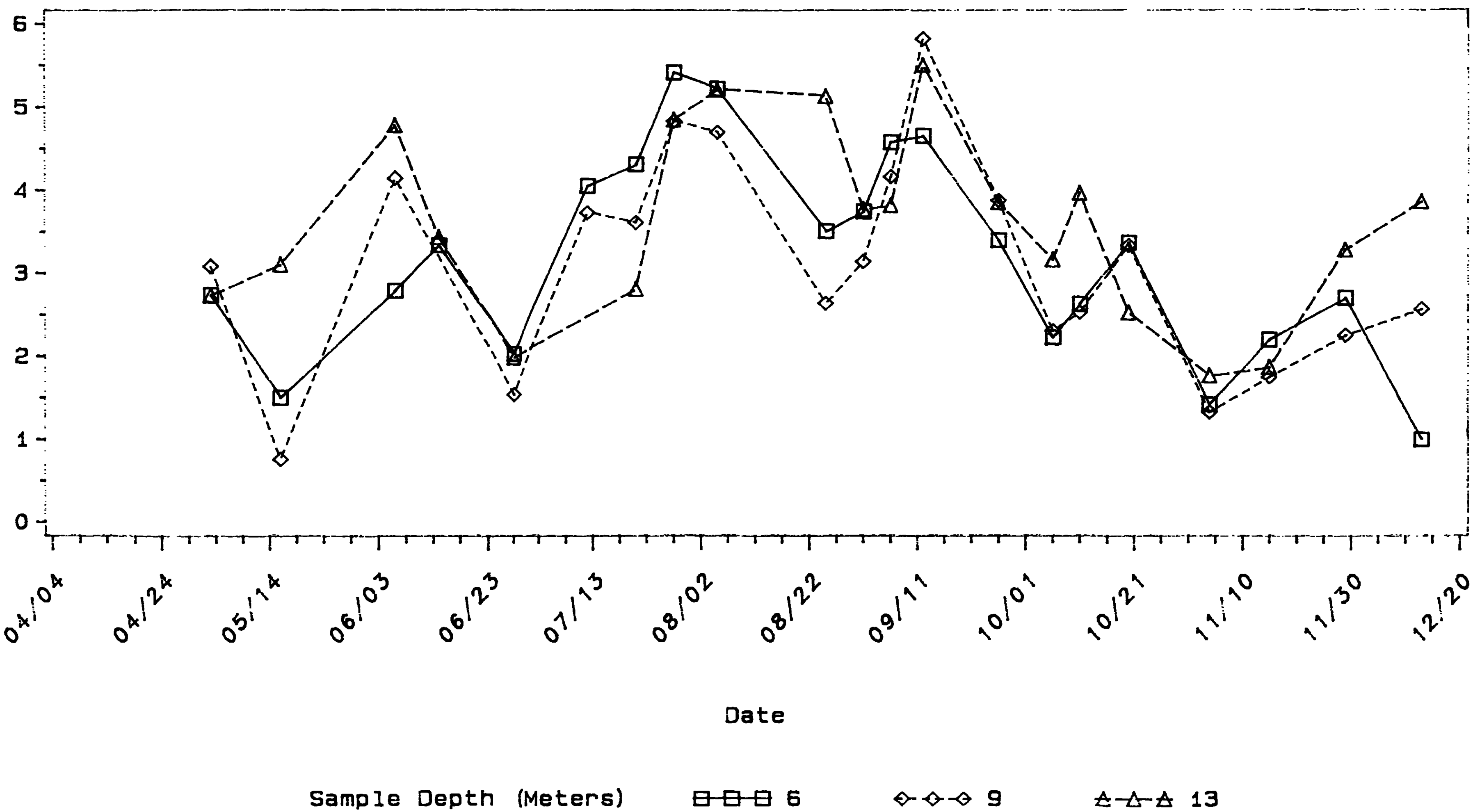
Chlorophyll-A

(Ug/L)
York Station



Pheophytin

(Ug/L)
York Station



APPENDIX II. SEDIMENT TRAP FLUXES

A. Summary Tables

B. Plots of Flux[@] versus Time
([@] Flux expressed in grams per square meter per day)

1. Lower Chesapeake Bay Station*
2. Lower York River Station*

* See main body of report for exact location and other information regarding the lower Chesapeake Bay station ("Bay station") and the lower York River station ("York station").

Total Suspended Solids Flux
April - December, 1988

Bay Station...........

Trap Depth (m)	Total Suspended Solids Flux		
	Mean	Minimum	Maximum
3..................	33.22	5.52	129.69
6..................	58.23	19.95	144.05
9..................	168.66	70.41	348.27

York Station..........

Trap Depth (m)	Total Suspended Solids Flux		
	Mean	Minimum	Maximum
6..................	61.78	21.69	115.60
9..................	88.24	30.66	139.53
13.................	175.32	90.25	307.06

Notes:

Flux as g/m**2/dy

Total Volatile Solids Flux
April - December, 1988

Bay Station...........

Trap Depth (m)	Total Volatile Solids Flux		
	Mean	Minimum	Maximum
3..................	2.76	0.60	9.51
6..................	4.15	1.00	9.97
9..................	10.51	4.77	18.03

York Station..........

Trap Depth (m)	Total Volatile Solids Flux		
	Mean	Minimum	Maximum
6..................	7.04	3.07	13.22
9..................	9.42	4.05	15.30
13.................	18.06	9.62	29.63

Notes:

Flux as g/m**2/dy

Total Non-Volatile Solids Flux
April - December, 1988

Bay Station..........

Trap Depth (m)	Total Non-Volatile Solids Flux		
	Mean	Minimum	Maximum
3..................	29.99	4.25	120.18
6..................	53.31	17.44	136.06
9..................	157.51	65.64	330.90

York Station..........

Trap Depth (m)	Total Non-Volatile Solids Flux		
	Mean	Minimum	Maximum
6..................	54.65	18.62	102.38
9..................	78.81	26.60	127.70
13.................	157.23	80.62	279.43

Notes:

Flux as g/m**2/dy

Particulate Carbon Flux
April - December, 1988

Bay Station..........

Trap Depth (m)	Particulate Carbon Flux		
	Mean	Minimum	Maximum
3..................	837.94	393.05	1,584.66
6..................	1,349.75	644.37	2,702.82
9..................	3,452.24	1,511.86	6,831.69

York Station..........

Trap Depth (m)	Particulate Carbon Flux		
	Mean	Minimum	Maximum
6..................	2,044.40	1,029.79	2,998.24
9..................	2,788.21	513.57	4,448.22
13.................	5,521.17	3,012.87	7,219.47

Notes:

Flux as mg/m**2/dy

Particulate Nitrogen Flux
April - December, 1988

Bay Station..........

Trap Depth (m)	Particulate Nitrogen Flux		
	Mean	Minimum	Maximum
3...................	112.70	48.63	186.95
6...................	167.92	73.49	387.06
9...................	396.74	151.87	1,021.67

York Station..........

Trap Depth (m)	Particulate Nitrogen Flux		
	Mean	Minimum	Maximum
6...................	266.23	77.80	507.05
9...................	357.80	109.20	793.02
13..................	674.53	295.55	1,091.27

Notes:

Flux as mg/m**2/dy

Particulate Phosphorus Flux
April - December, 1988

Bay Station..........

Trap Depth (m)	Particulate Phosphorus Flux		
	Mean	Minimum	Maximum
3..................	27.25	6.58	151.47
6..................	39.34	18.87	110.04
9..................	127.99	62.37	313.87

York Station..........

Trap Depth (m)	Particulate Phosphorus Flux		
	Mean	Minimum	Maximum
6..................	46.34	21.10	90.18
9..................	71.94	33.13	135.98
13.................	148.03	38.23	301.42

Notes:

Flux as mg/m**2/dy

Biogenic Silica Flux

Bay Station..........

Trap Depth (m)	Biogenic Silica Flux		
	Mean	Minimum	Maximum
3..................	387.18	22.36	1,006.14
6..................	670.81	81.42	2,097.50
9..................	2,124.15	708.86	5,952.38

York Station..........

Trap Depth (m)	Biogenic Silica Flux		
	Mean	Minimum	Maximum
6..................	1,535.88	599.02	5,764.99
9..................	2,077.70	1,026.13	3,345.46
13.................	3,909.08	1,595.32	7,147.26

Notes:

Flux as mg/m**2/dy

Chlorophyll-A Flux

Bay Station...........

Trap Depth (m)	Chlorophyll-A Flux		
	Mean	Minimum	Maximum
3...................	2,728.40	620.43	7,241.78
6...................	2,814.92	812.40	8,481.31
9...................	3,573.67	936.10	8,643.03

York Station..........

Trap Depth (m)	Chlorophyll-A Flux		
	Mean	Minimum	Maximum
6...................	4,235.60	1,980.52	9,884.31
9...................	4,585.03	1,828.57	9,012.97
13..................	5,866.90	1,507.73	13,466.65

Notes:

Flux as ug/m**2/dy

Pheophytin Flux

Bay Station...........

Trap Depth (m)	Pheophytin Flux		
	Mean	Minimum	Maximum
3..................	4,332.08	1,362.61	9,309.94
6..................	6,186.50	1,376.63	12,035.58
9..................	12,839.69	4,095.25	29,587.47

York Station..........

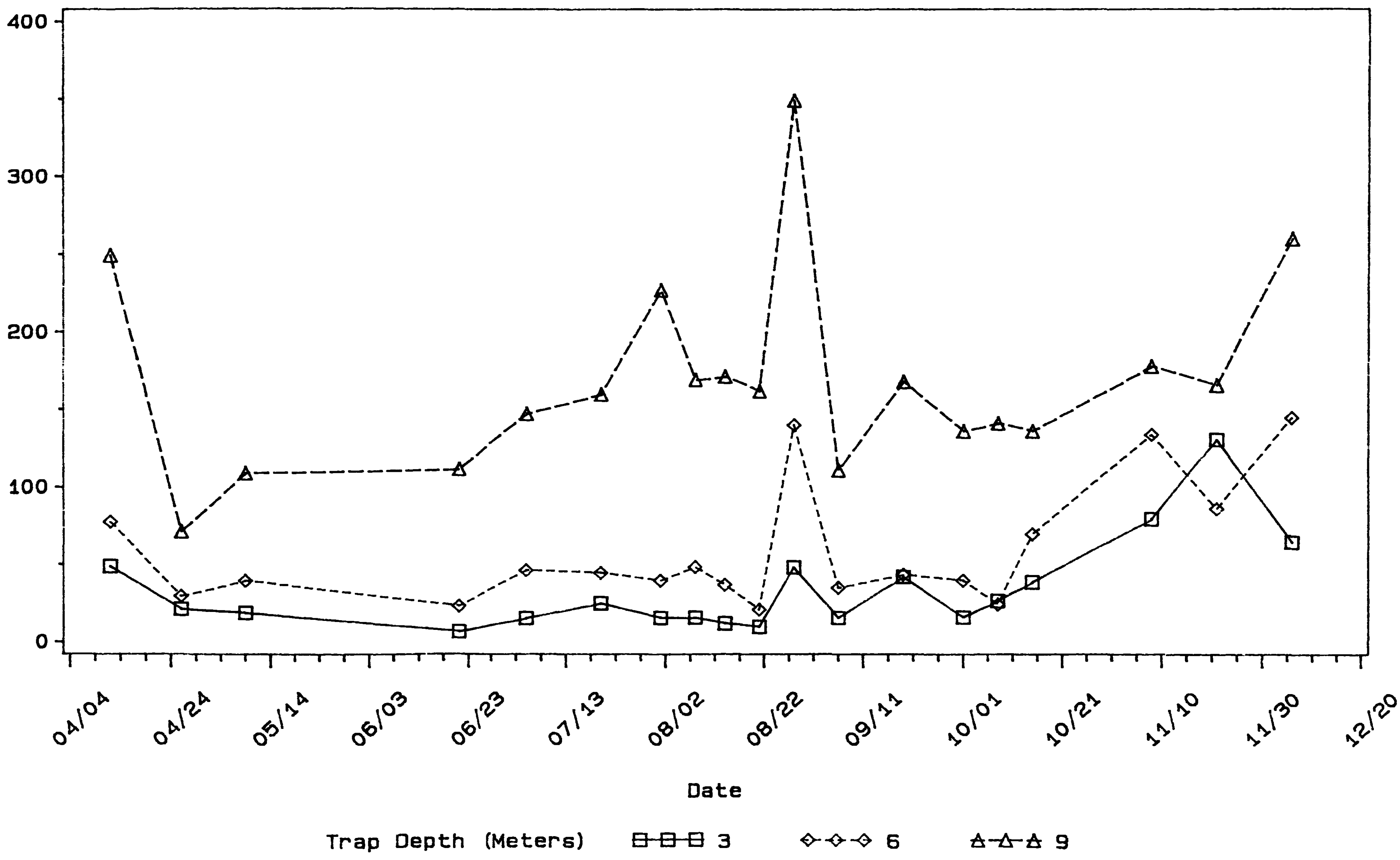
Trap Depth (m)	Pheophytin Flux		
	Mean	Minimum	Maximum
6..................	10,878.10	4,411.87	19,478.70
9..................	15,067.98	4,507.08	28,819.98
13..................	23,718.59	9,107.42	40,739.10

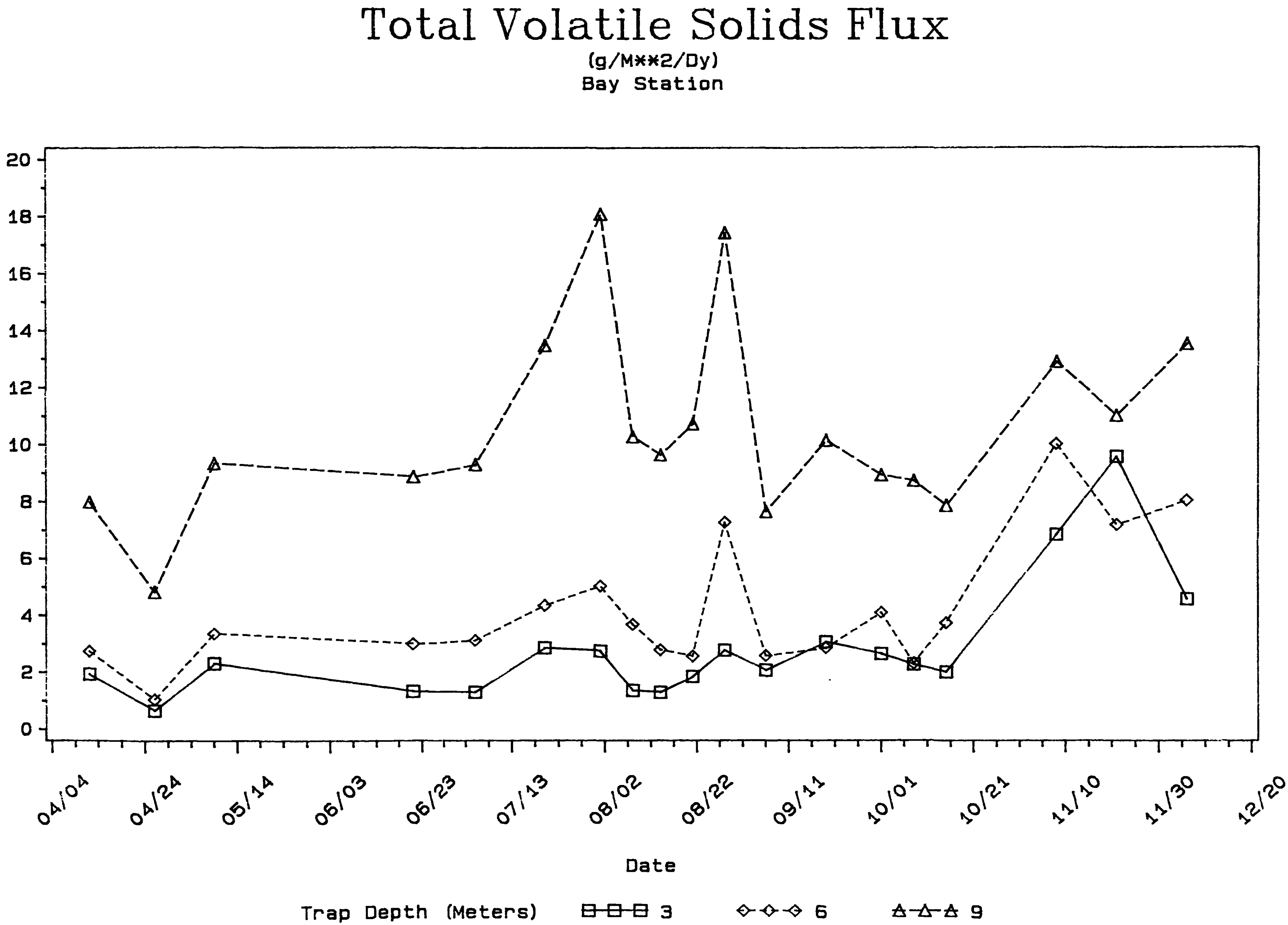
Notes:

Flux as ug/m**2/dy

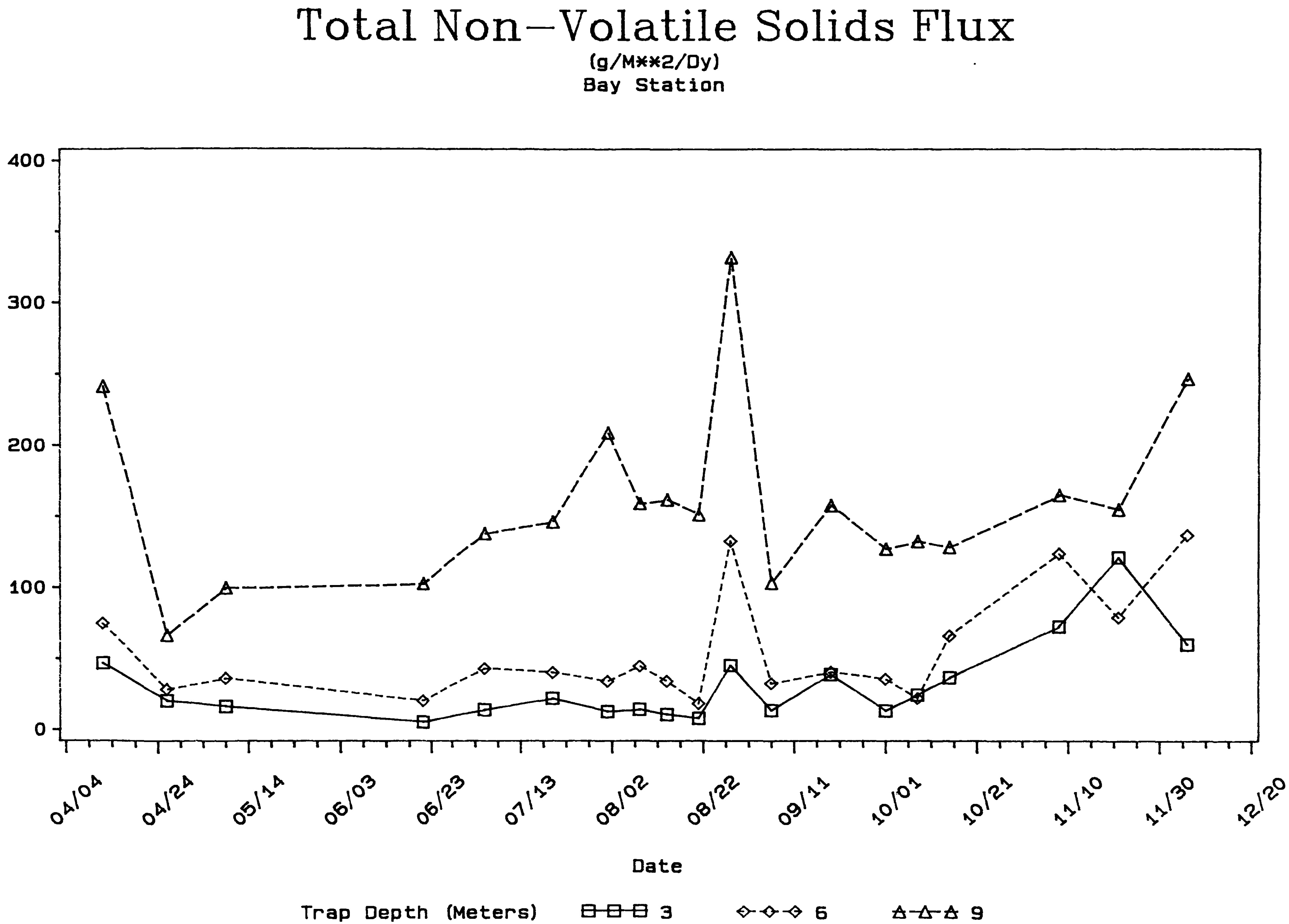
Total Suspended Solids Flux

(g/M**2/Dy)
Bay Station

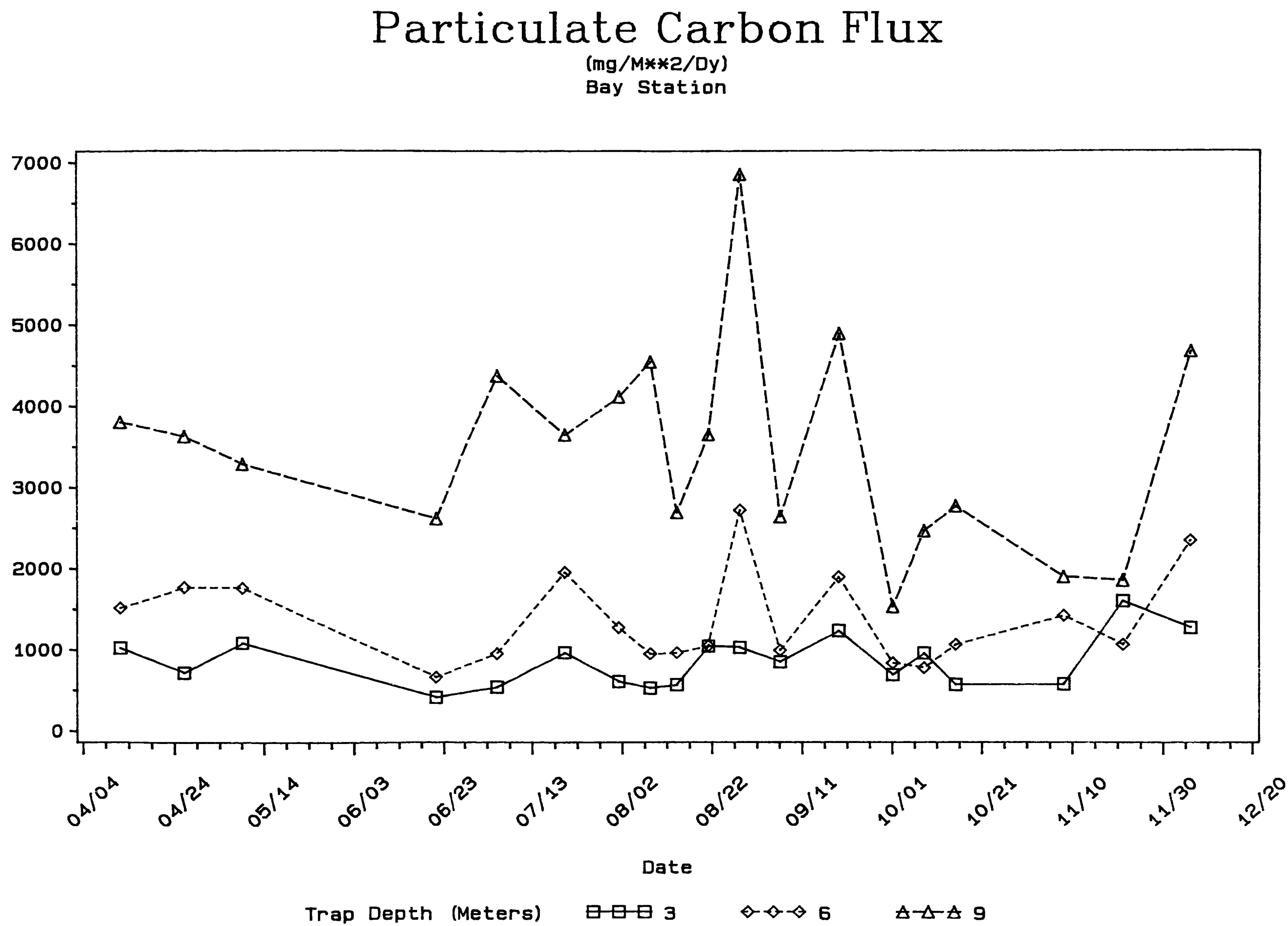




Total Volatile Solids Flux
(g/M**2/Dy)
Bay Station
0
2
4
6
8
10
12
14
16
18
20
04/04
04/24
05/14
06/03
06/23
07/13
08/02
08/22
09/11
10/01
10/21
11/10
11/30
12/20
Date
Trap Depth (Meters)
3
6
9

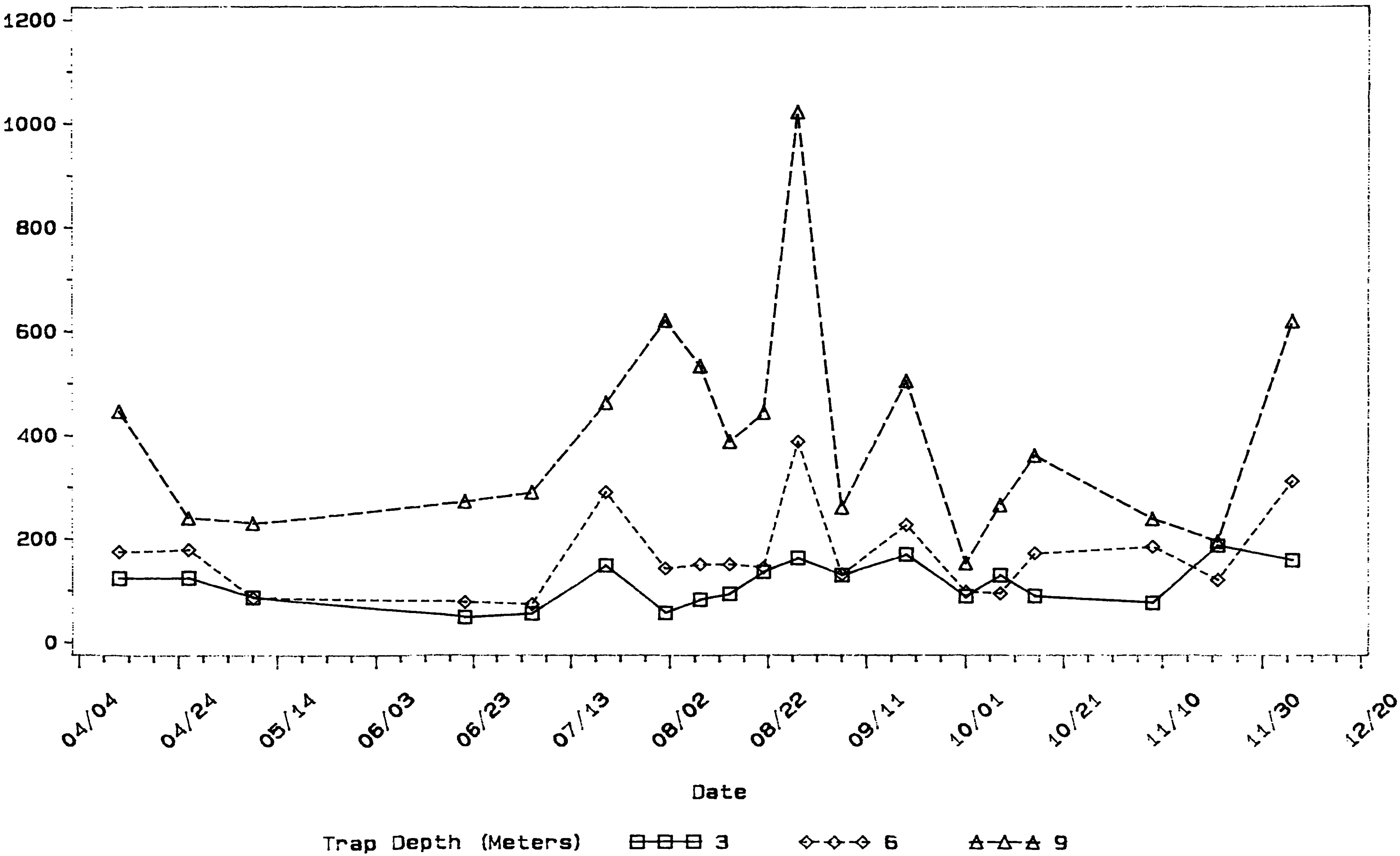


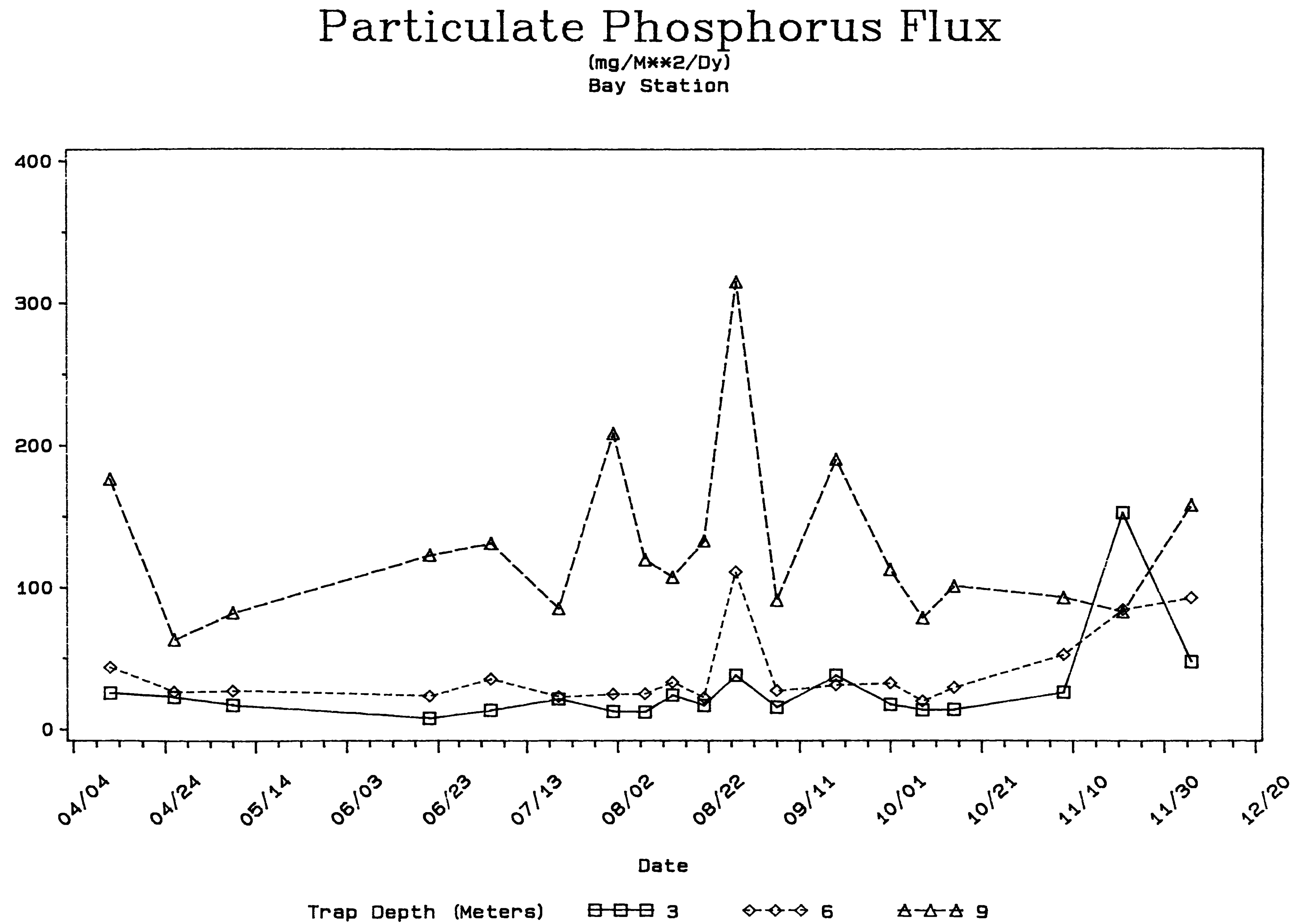
Total Non-Volatile Solids Flux
(g/M**2/Dy)
Bay Station
400
300
200
100
0
04/04
04/24
05/14
06/03
06/23
07/13
08/02
08/22
09/11
10/01
10/21
11/10
11/30
12/20
Date
Trap Depth (Meters)
3
6
9


Particulate Carbon Flux
(mg/M**2/Dy)
Bay Station
7000
6000
5000
4000
3000
2000
1000
0
04/04
04/24
05/14
06/03
06/23
07/13
08/02
08/22
09/11
10/01
10/21
11/10
11/30
12/20
Date
Trap Depth (Meters)
3
6
9

Particulate Nitrogen Flux

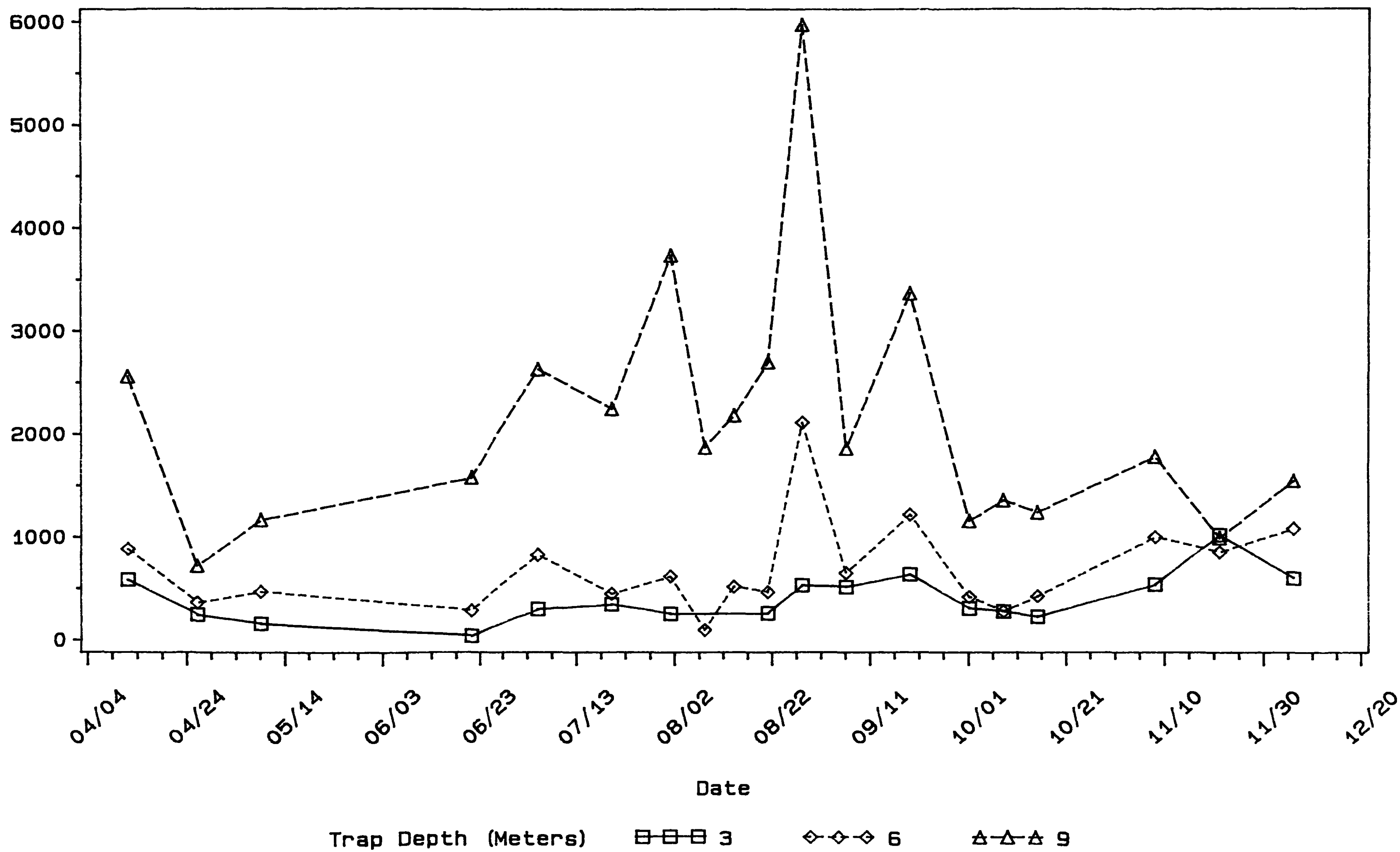
(mg/M**2/Dy)
Bay Station

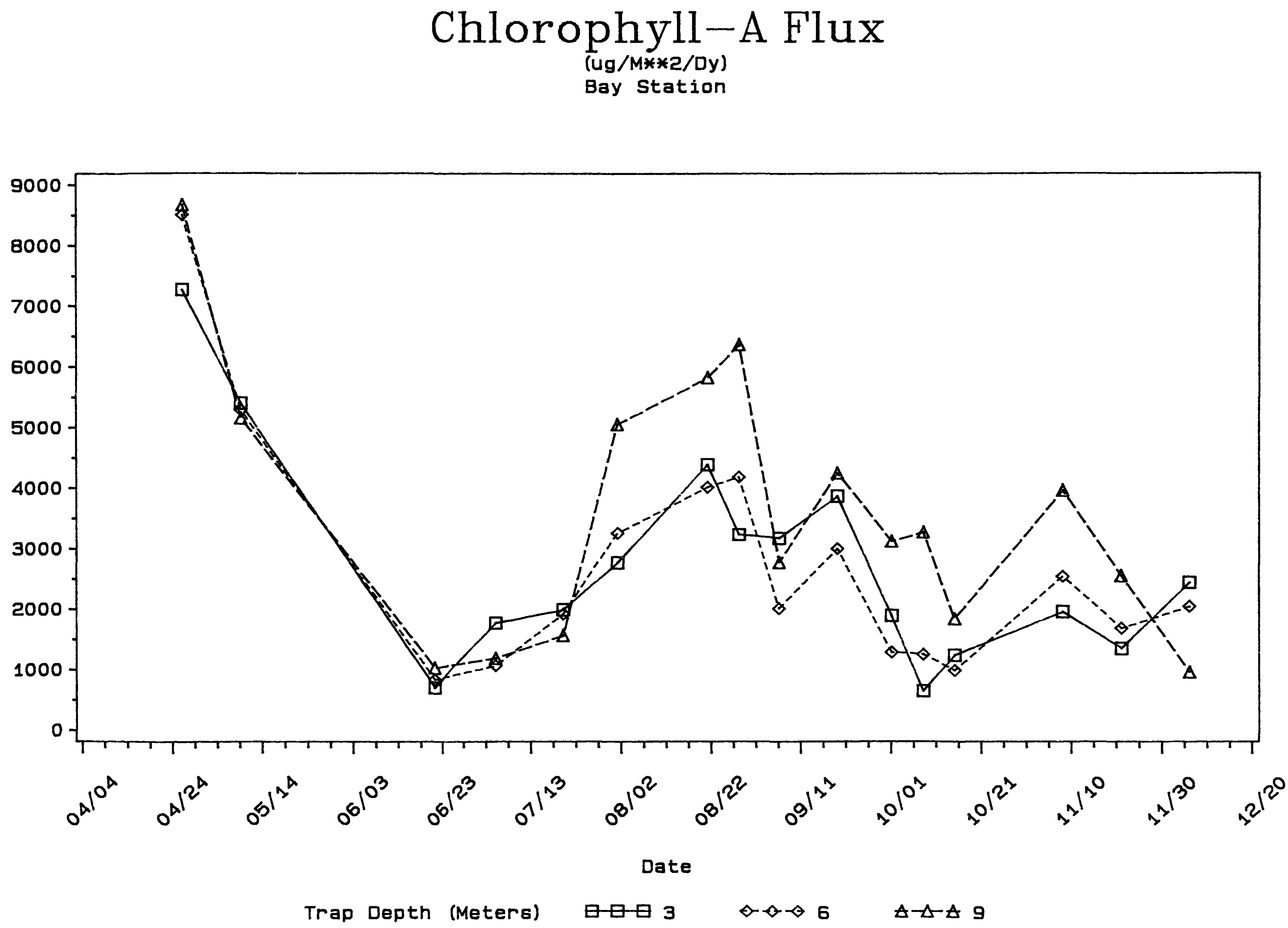



Particulate Phosphorus Flux
(mg/M**2/Dy)
Bay Station
400
300
200
100
0
04/04
04/24
05/14
06/03
06/23
07/13
08/02
08/22
09/11
10/01
10/21
11/10
11/30
12/20
Date
Trap Depth (Meters)
3
6
9

Biogenic Silica Flux

(mg/M**2/Dy)
Bay Station

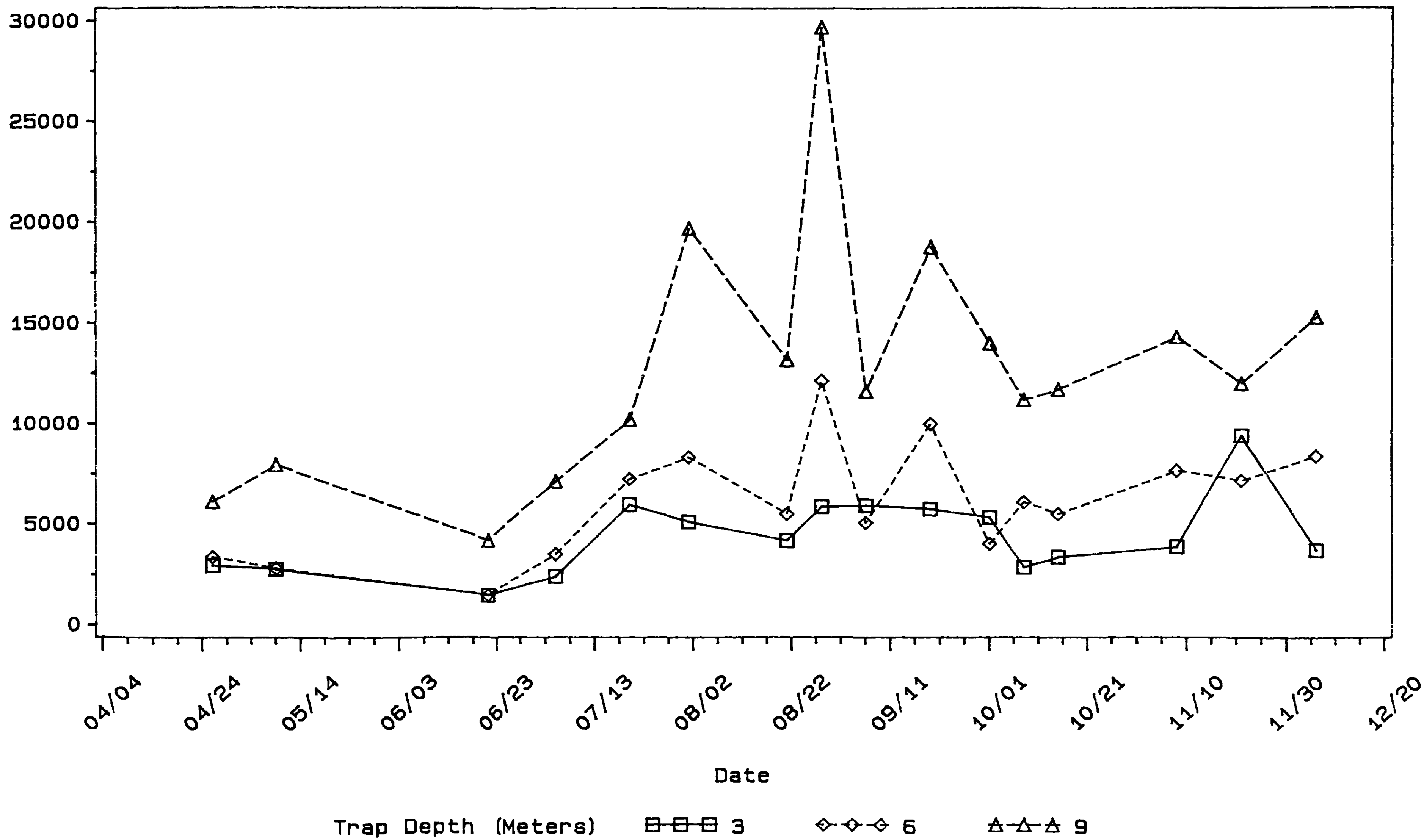




Chlorophyll-A Flux
(ug/M**2/Dy)
Bay Station
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
04/04
04/24
05/14
06/03
06/23
07/13
08/02
08/22
09/11
10/01
10/21
11/10
11/30
12/20
Date
Trap Depth (Meters)
3
6
9

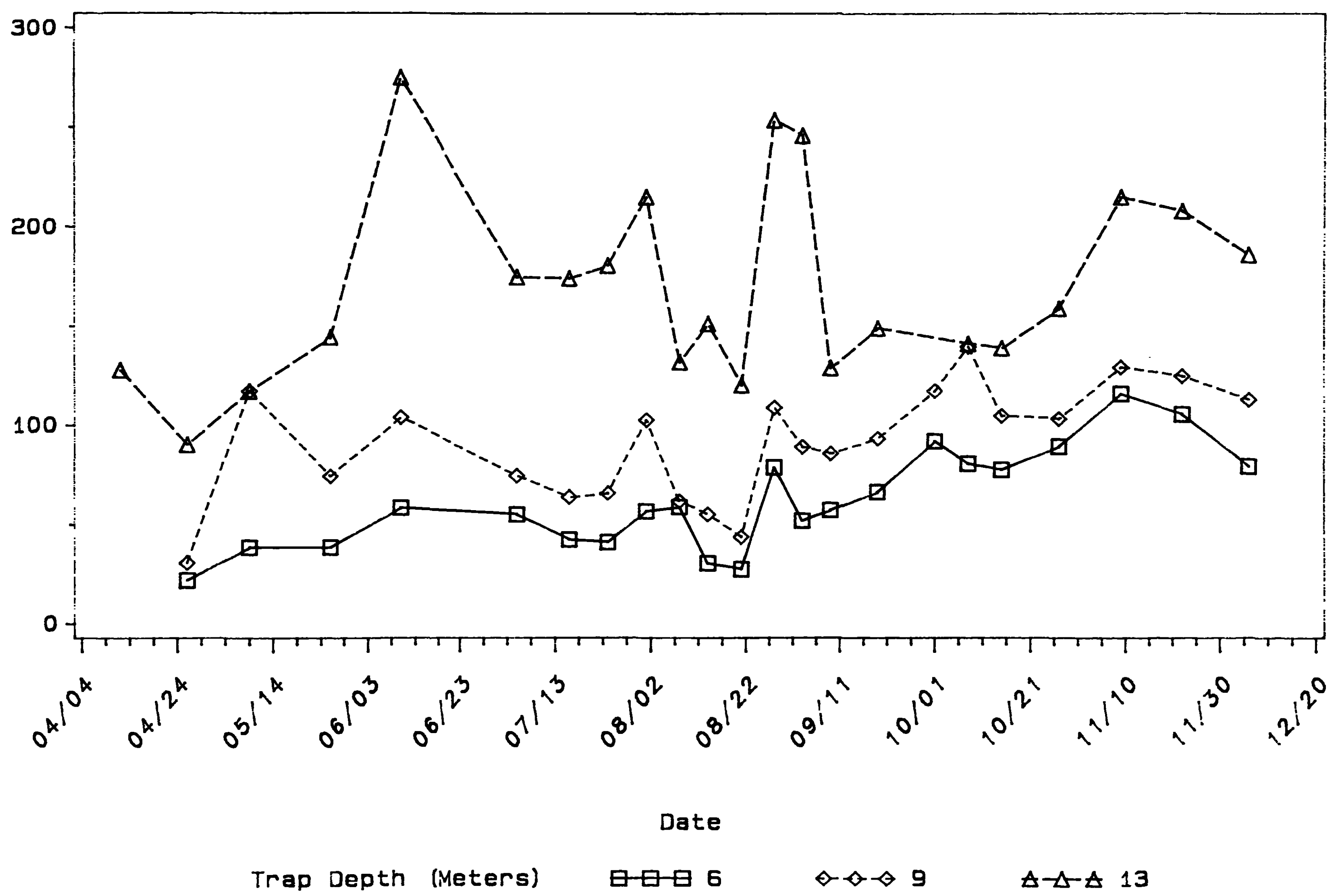
Pheophytin Flux

(ug/M**2/Dy)
Bay Station



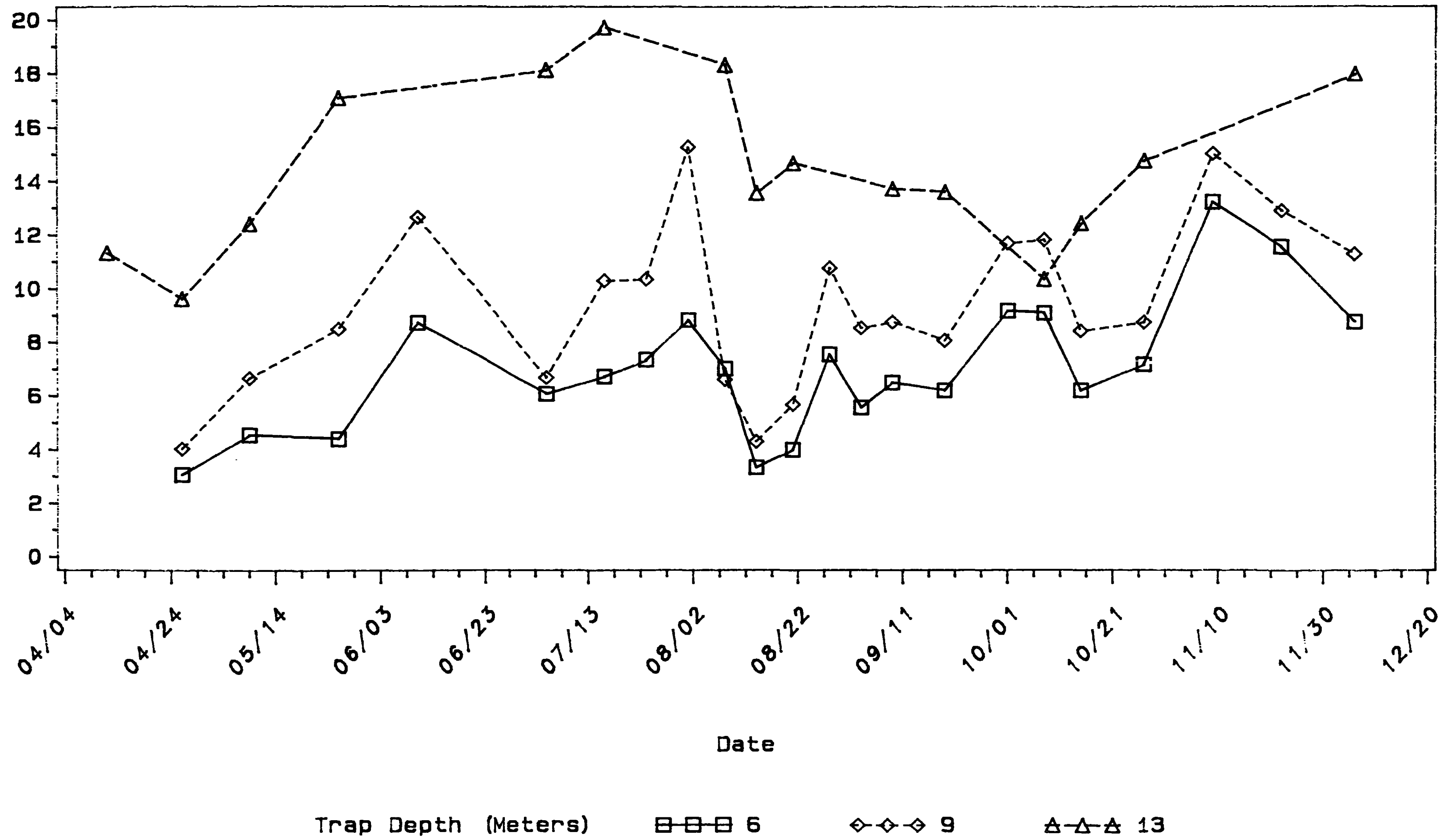
Total Suspended Solids Flux

(G/M**2/Dy)
York Station



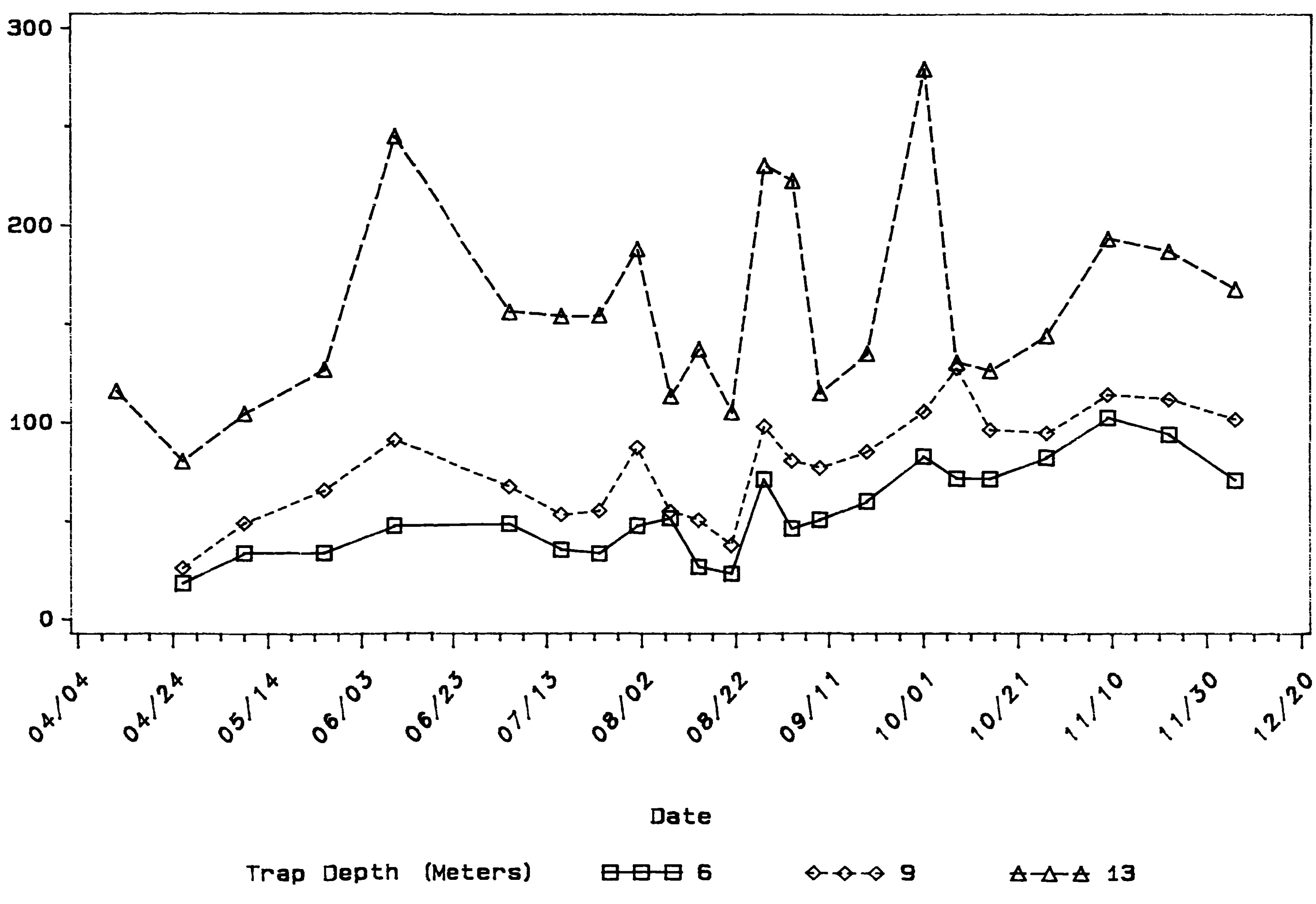
Total Volatile Solids Flux

(G/M**2/Dy)
York Station



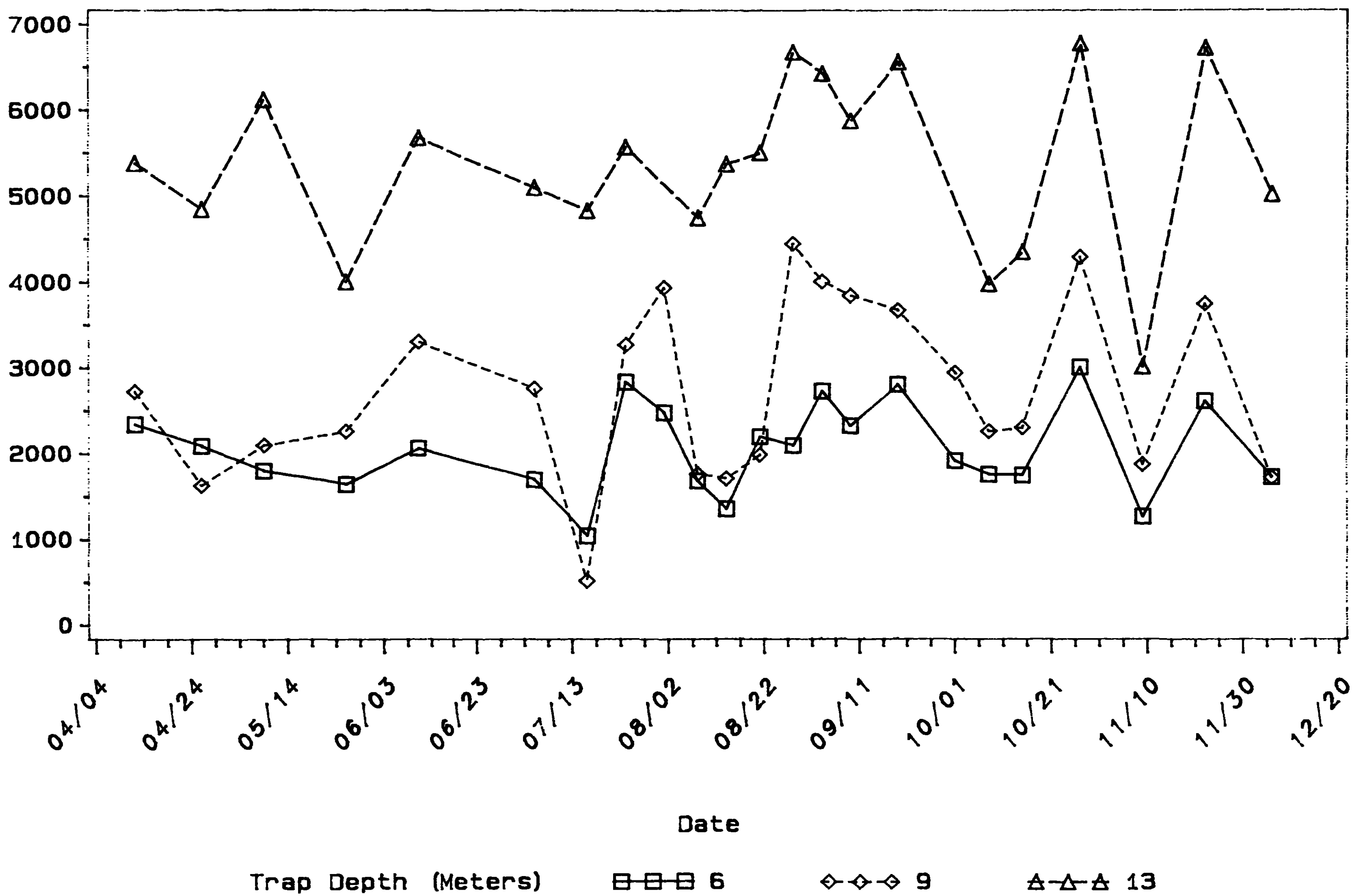
Total Non-Volatile Solids Flux

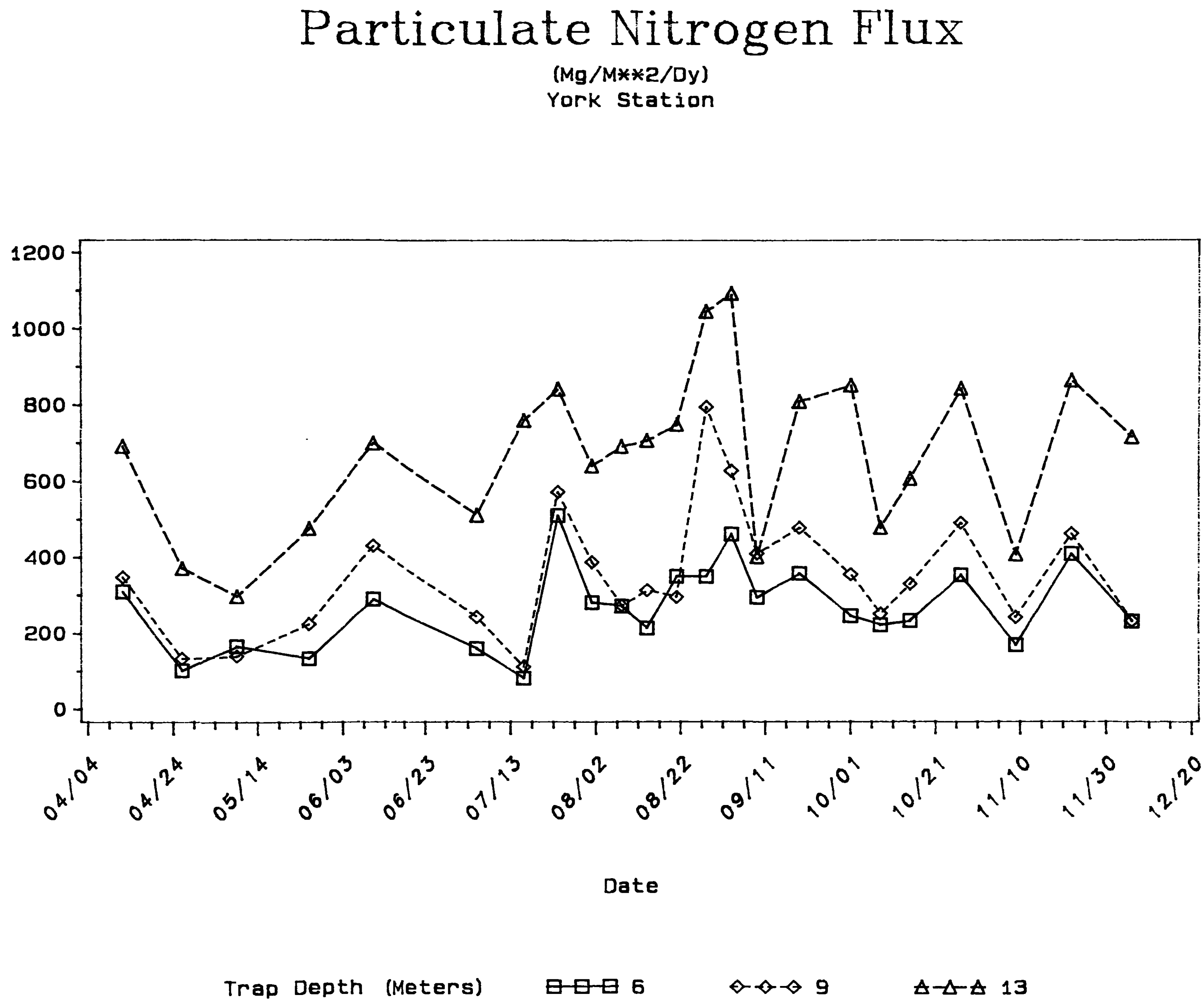
(G/M**2/Dy)
York Station

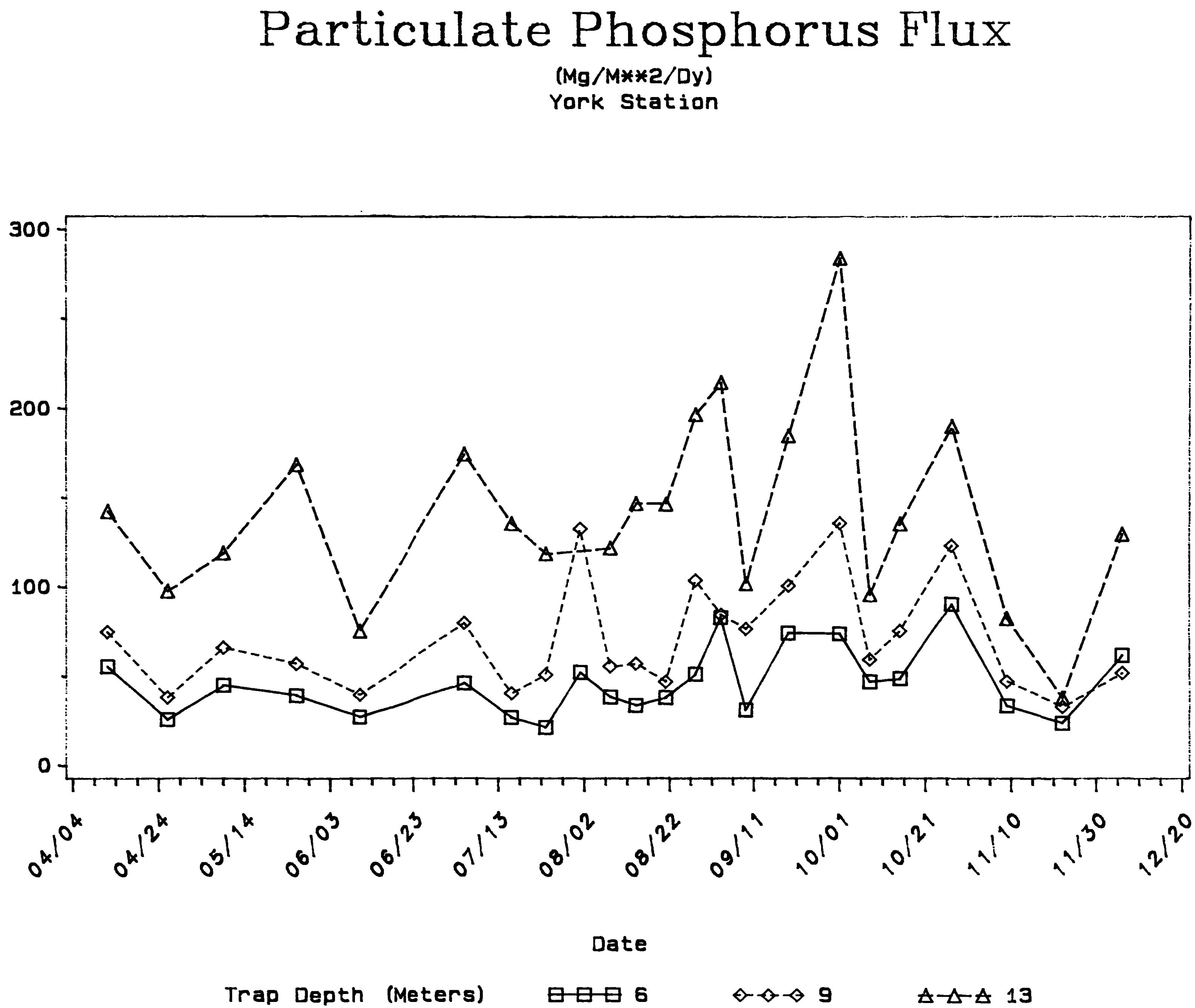


Particulate Carbon Flux

(Mg/M**2/Dy)
York Station

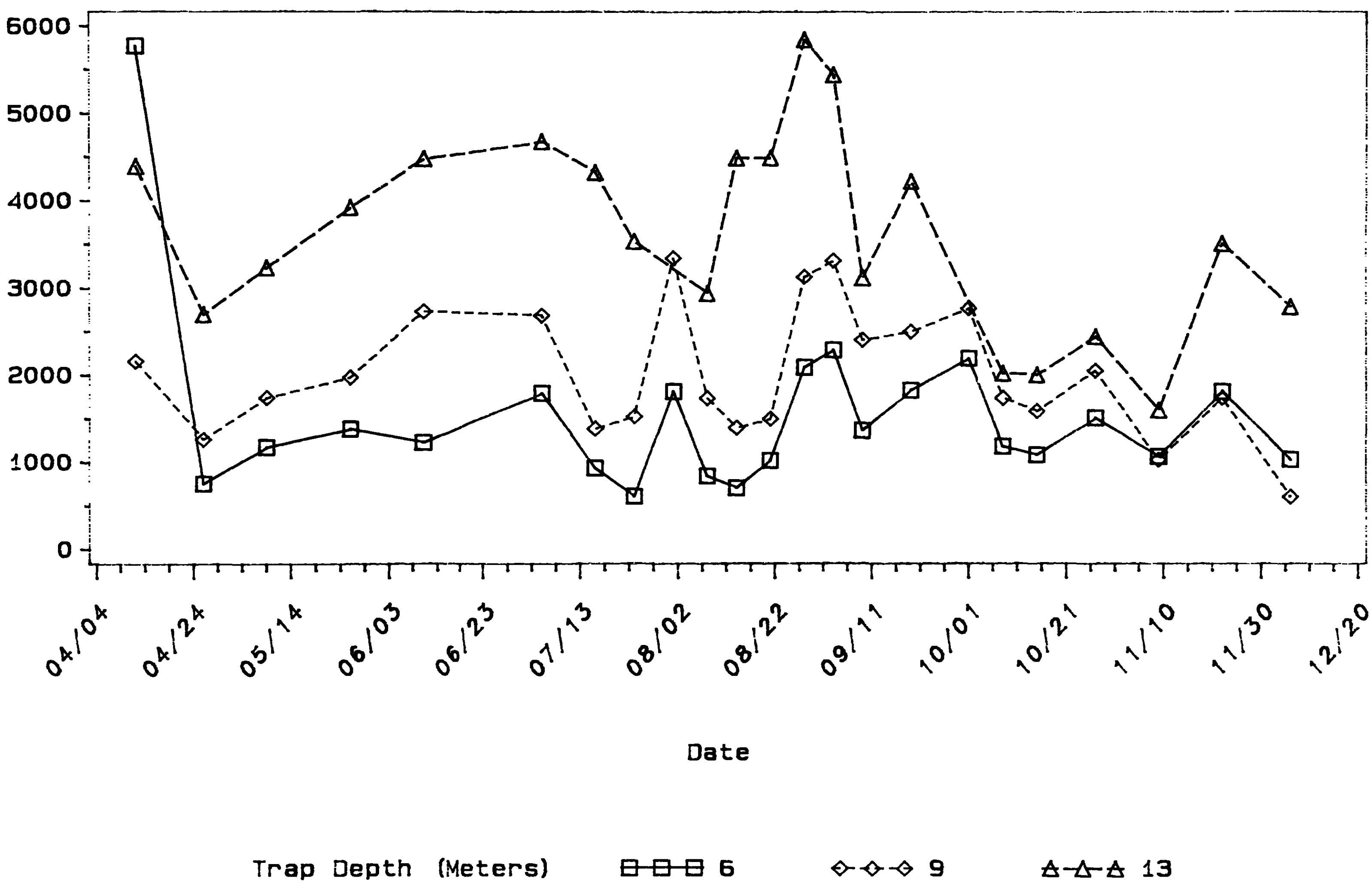



Particulate Nitrogen Flux
(Mg/M**2/Dy)
York Station
1200
1000
800
600
400
200
0
04/04
04/24
05/14
06/03
06/23
07/13
08/02
08/22
09/11
10/01
10/21
11/10
11/30
12/20
Date
Trap Depth (Meters)
6
9
13


Particulate Phosphorus Flux
(Mg/M**2/Dy)
York Station
300
200
100
0
04/04
04/24
05/14
06/03
06/23
07/13
08/02
08/22
09/11
10/01
10/21
11/10
11/30
12/20
Date
Trap Depth (Meters)
6
9
13

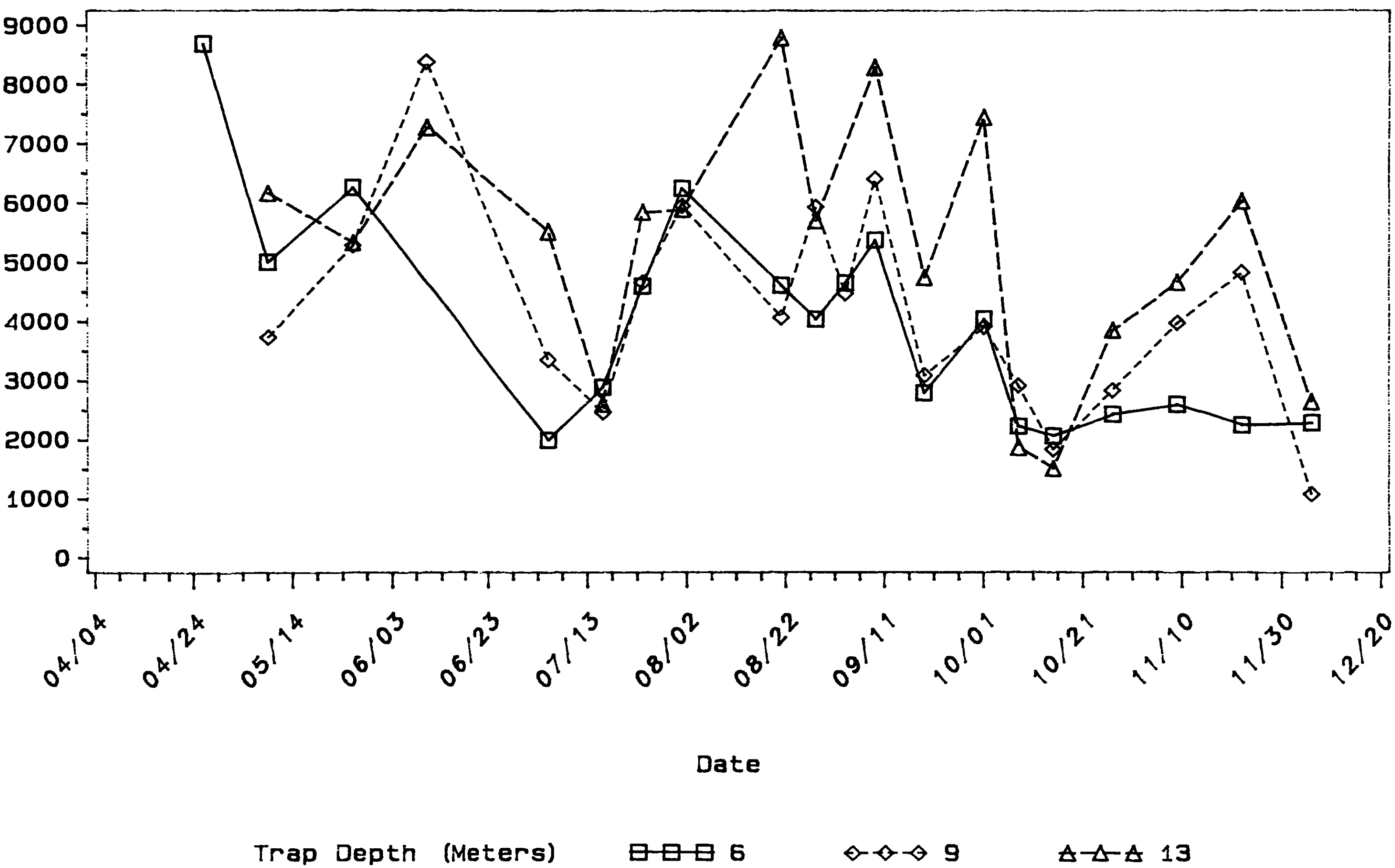
Biogenic Silica Flux

(Mg/M**2/Dy)
York Station



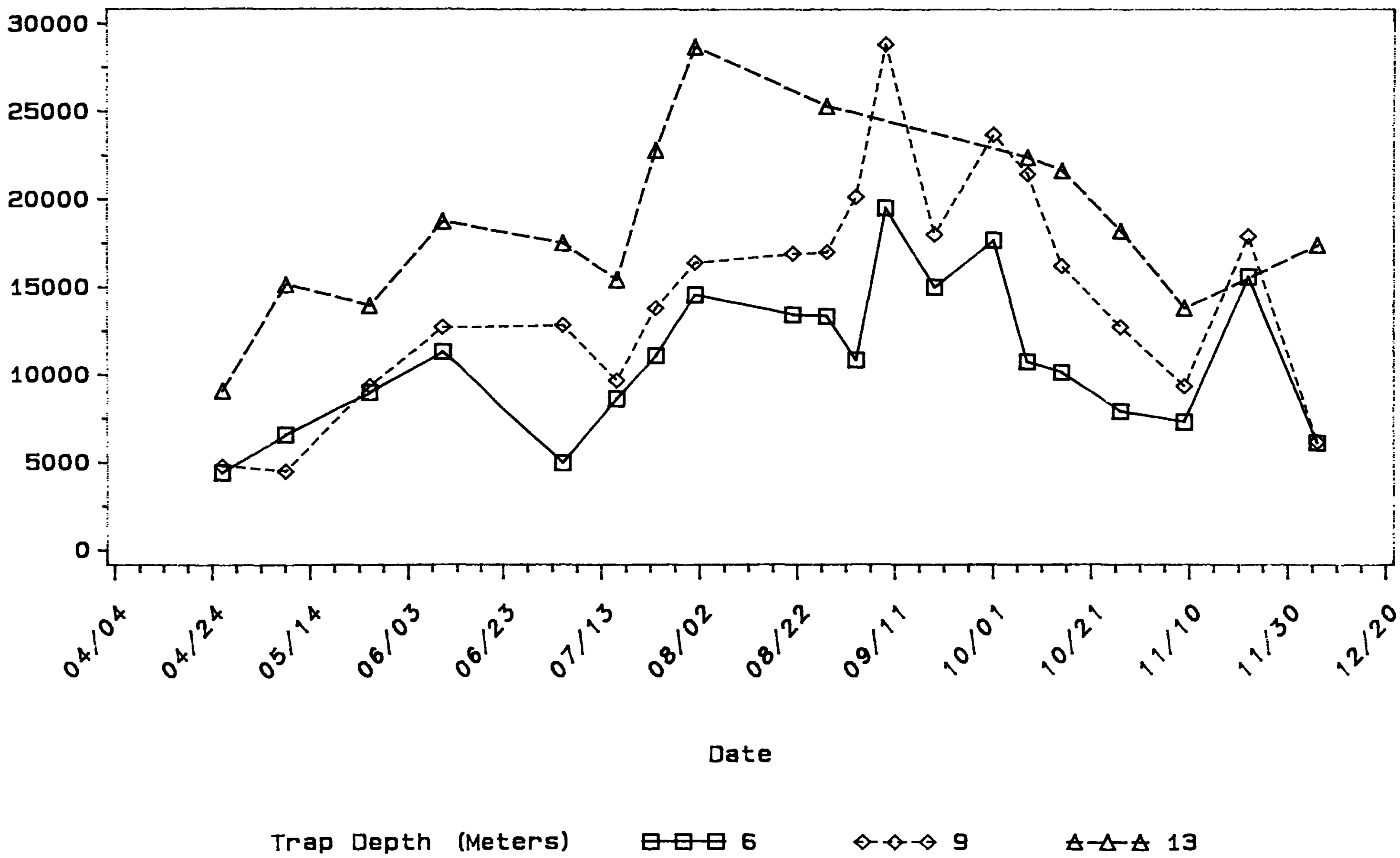
Chlorophyll-A Flux

(Ug/M**2/Dy)
York Station



Pheophytin Flux

(Ug/M**2/Dy)
York Station



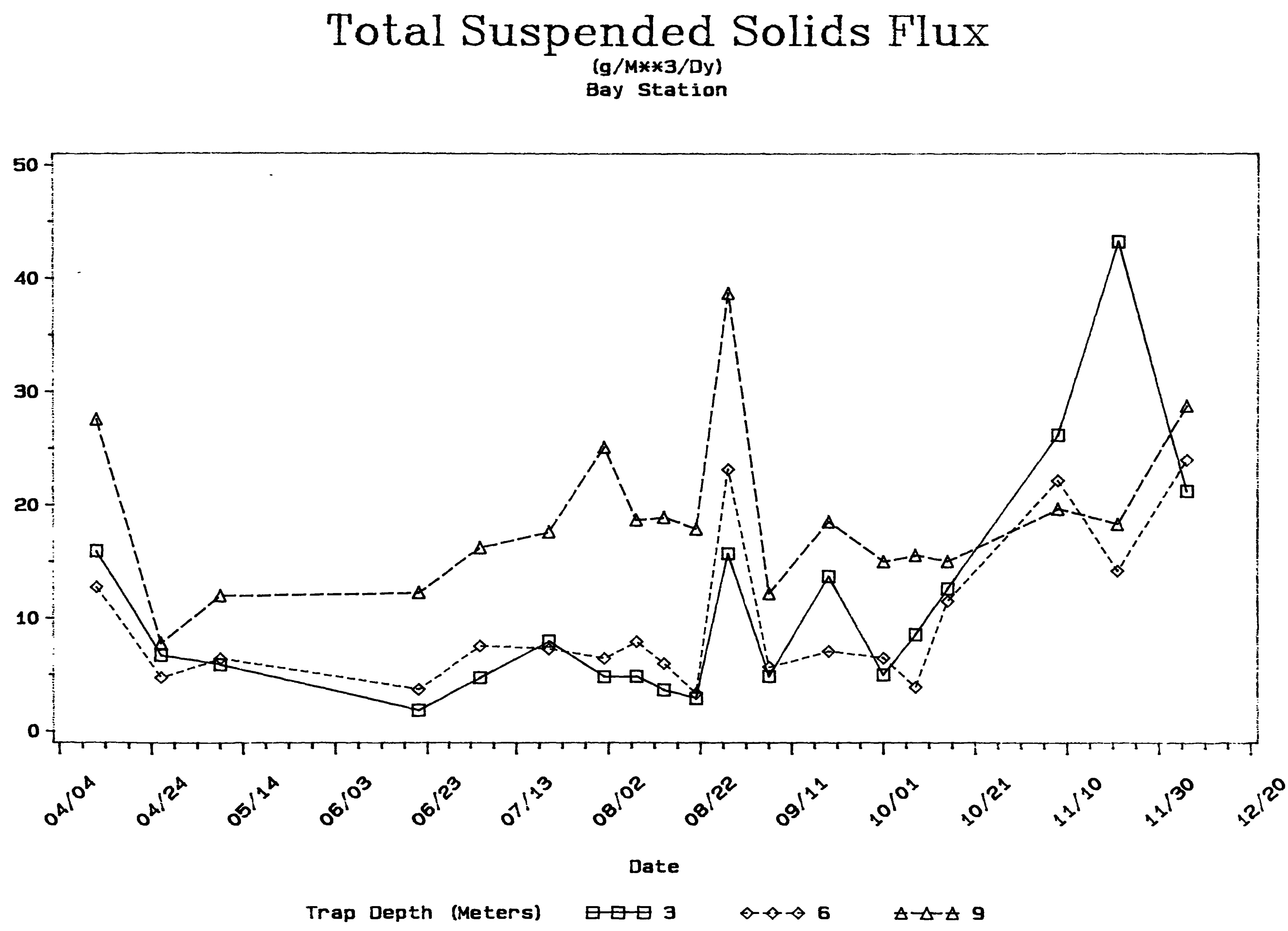
APPENDIX III. SEDIMENT TRAP FLUXES NORMALIZED FOR WATER DEPTH

A. Plots of Flux# versus Time
(#Flux expressed in grams per cubic meter per day)

1. Lower Chesapeake Bay Station*

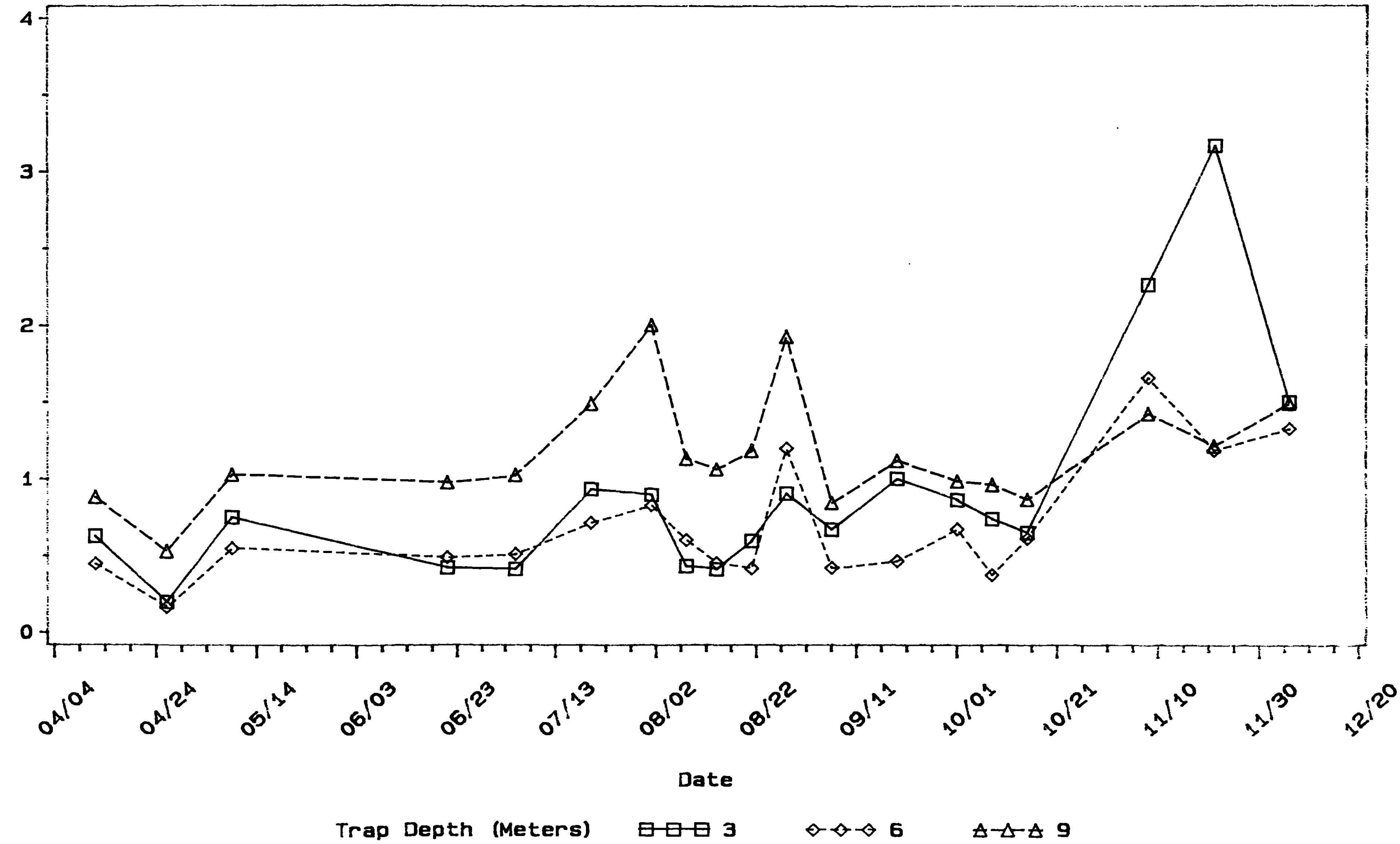
2. Lower York River Station*

* See main body of report for exact location and other information regarding the lower Chesapeake Bay station ("Bay station") and the lower York River station ("York station").


Total Suspended Solids Flux
(g/M**3/Dy)
Bay Station
50
40
30
20
10
0
04/04
04/24
05/14
06/03
06/23
07/13
08/02
08/22
09/11
10/01
10/21
11/10
11/30
12/20
Date
Trap Depth (Meters)
3
6
9

Total Volatile Solids Flux

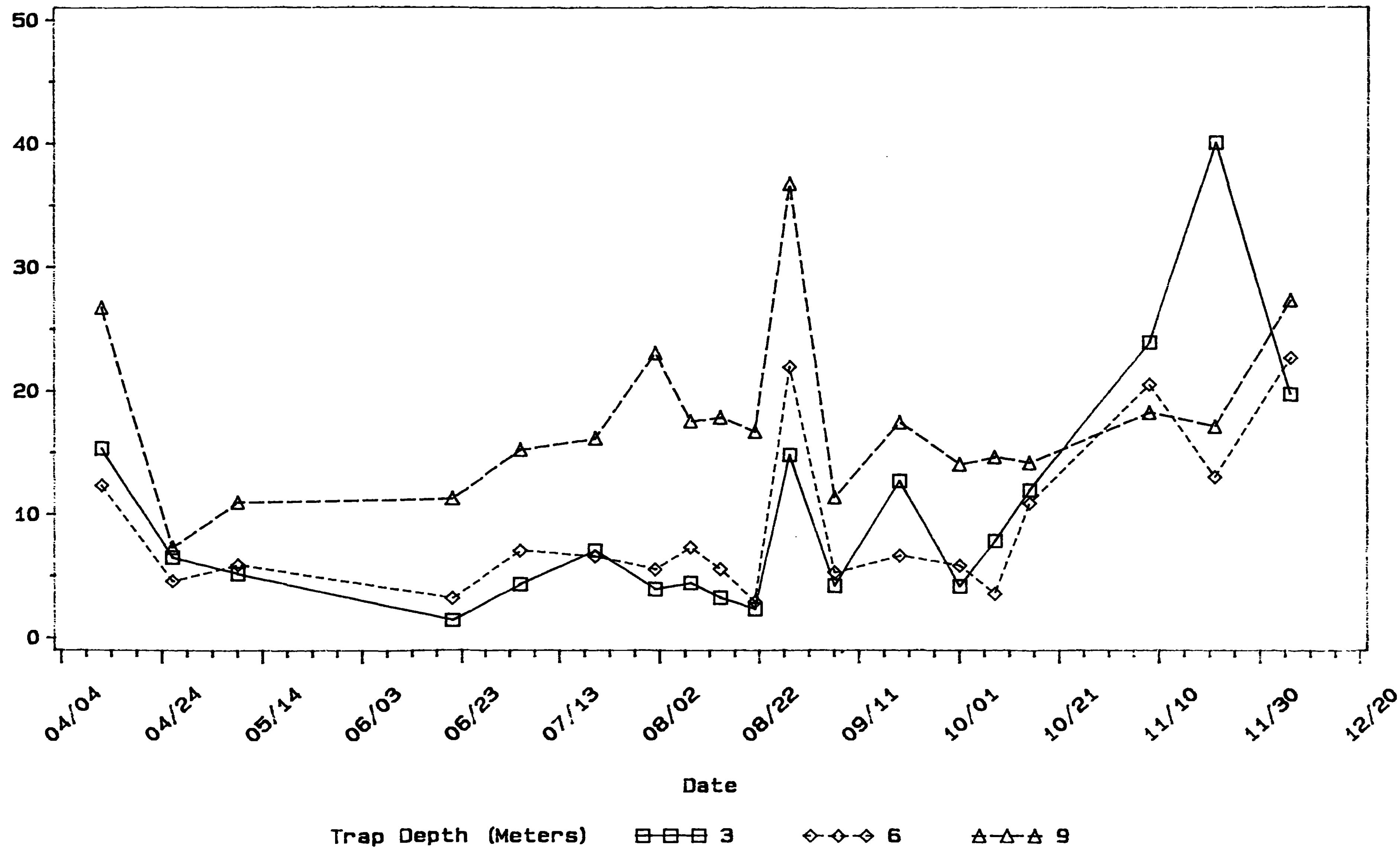
(g/M**3/Dy)
Bay Station



Total Non-Volatile Solids Flux

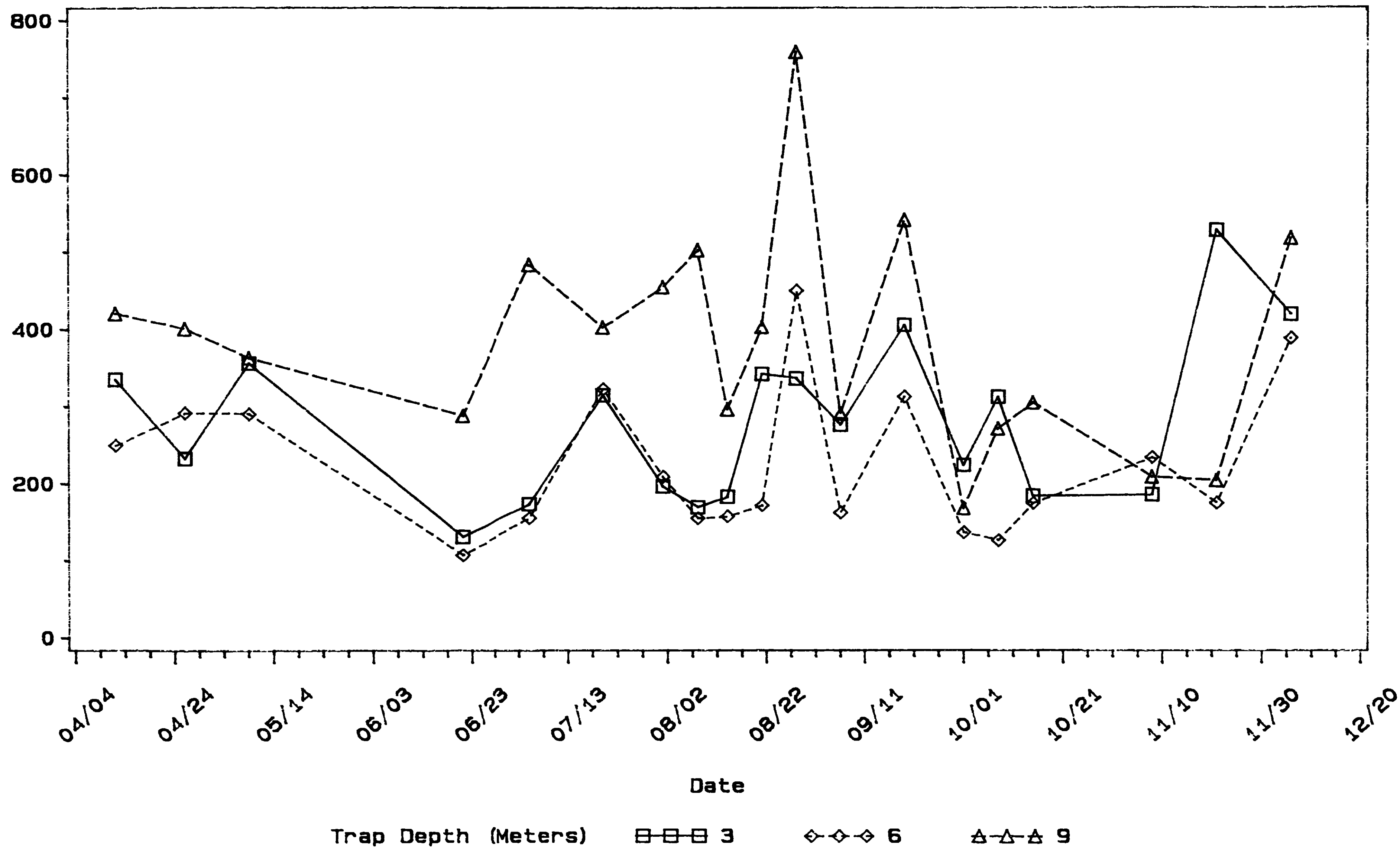
(g/M**3/Dy)

Bay Station



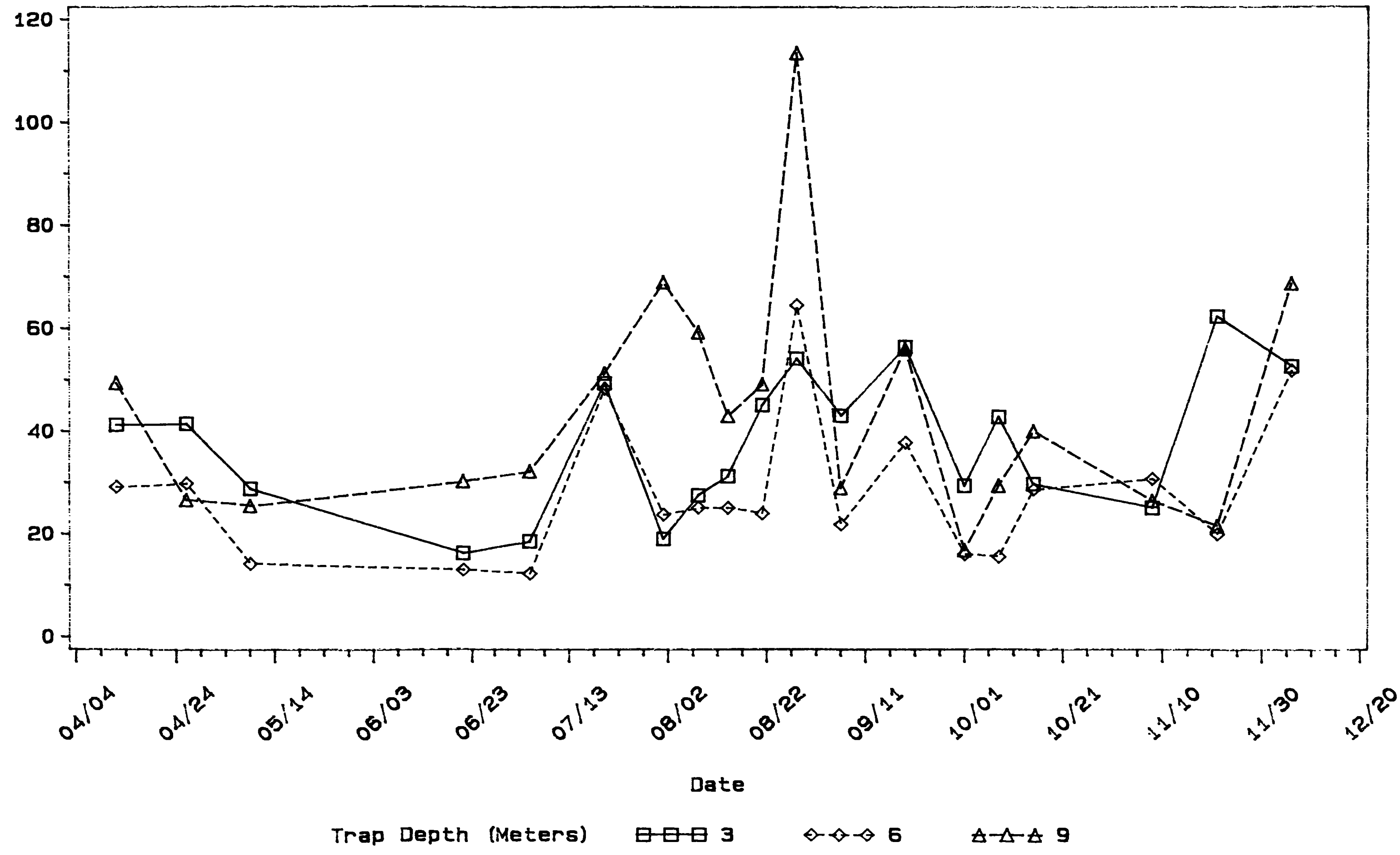
Particulate Carbon Flux

(mg/M**3/Dy)
Bay Station



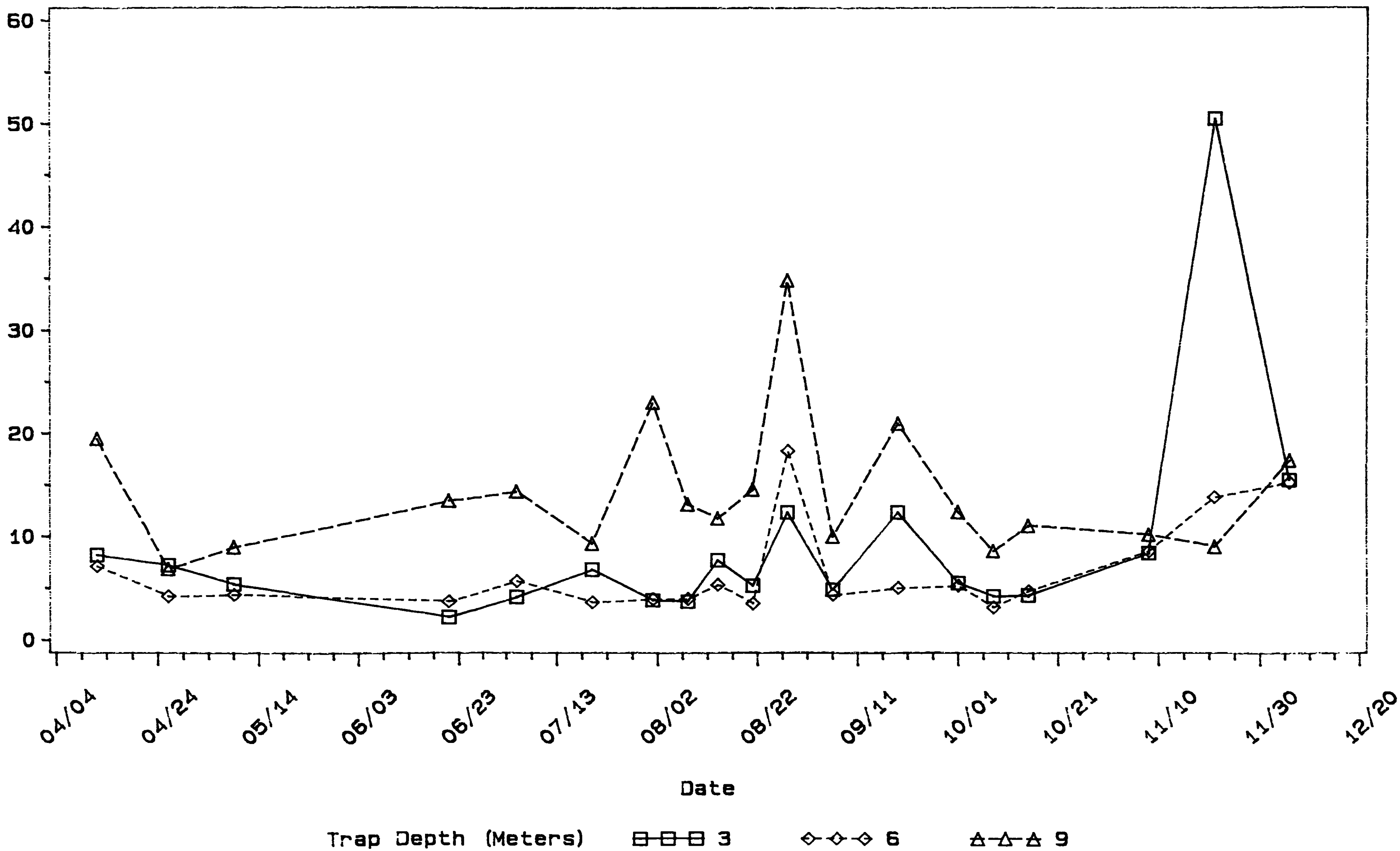
Particulate Nitrogen Flux

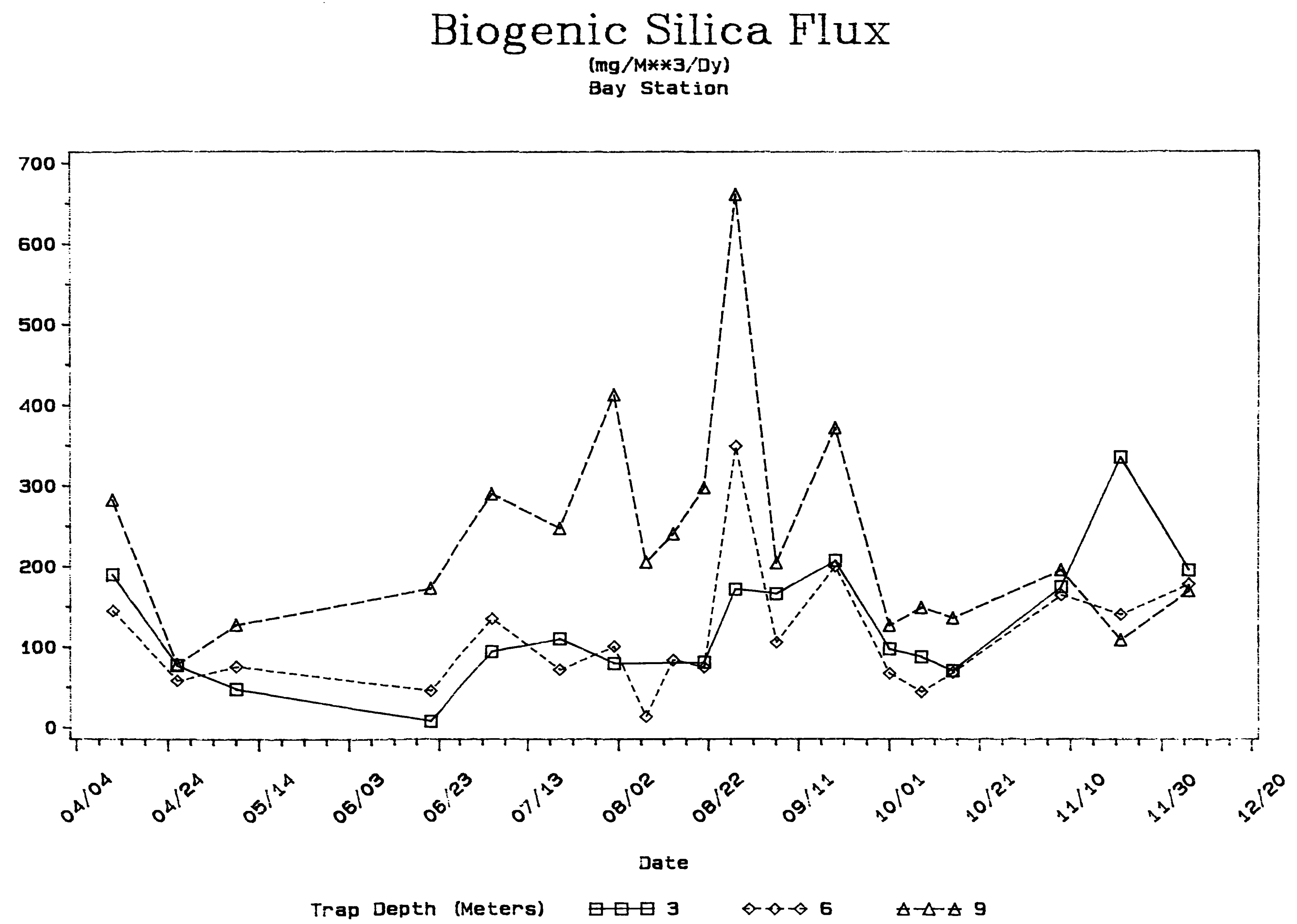
(mg/M**3/Dy)
Bay Station



Particulate Phosphorus Flux

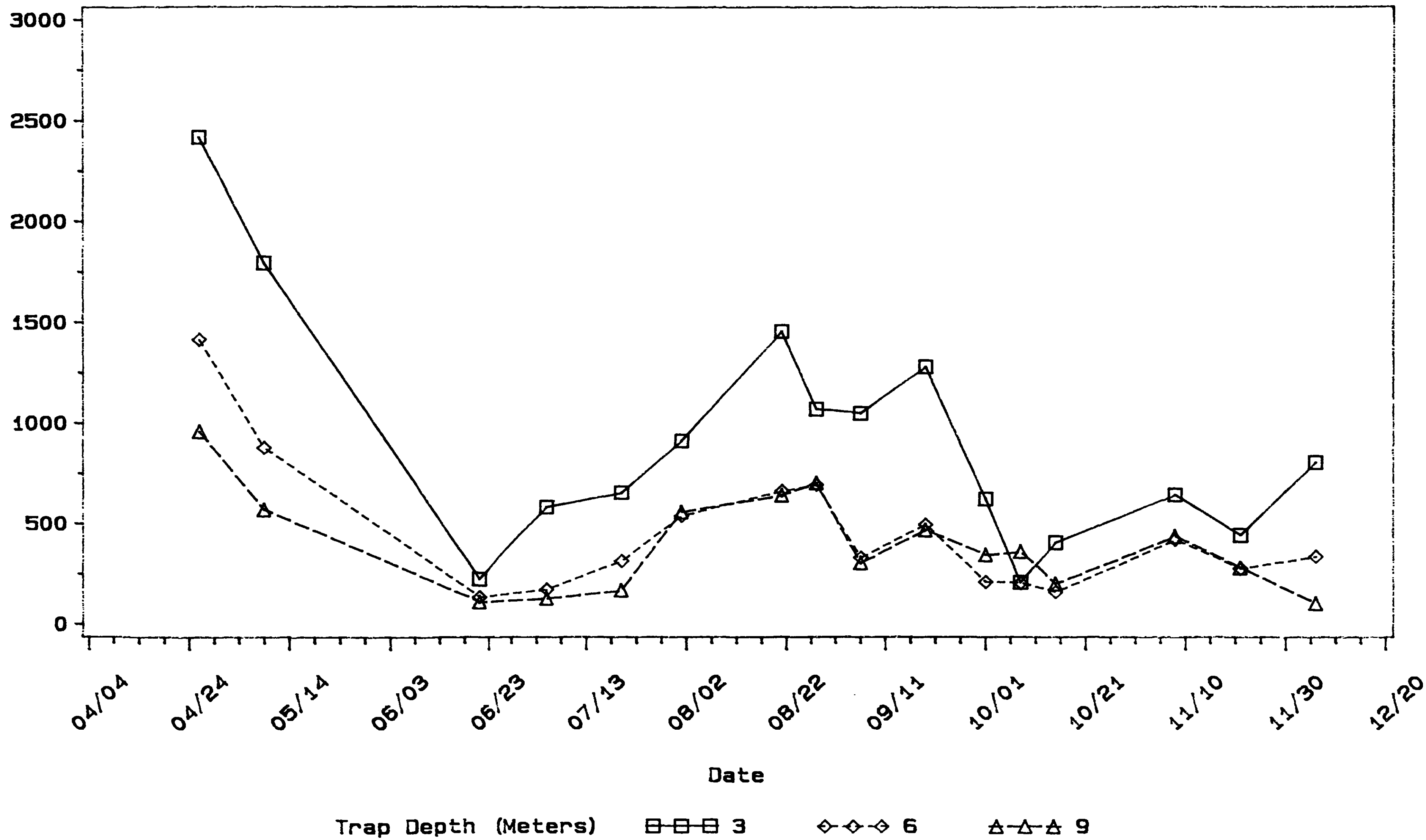
(mg/M**3/Dy)
Bay Station




Biogenic Silica Flux
(mg/M**3/Dy)
Bay Station
700
600
500
400
300
200
100
0
04/04
04/24
05/14
06/03
06/23
07/13
08/02
08/22
09/11
10/01
10/21
11/10
11/30
12/20
Date
Trap Depth (Meters) 3 6 9

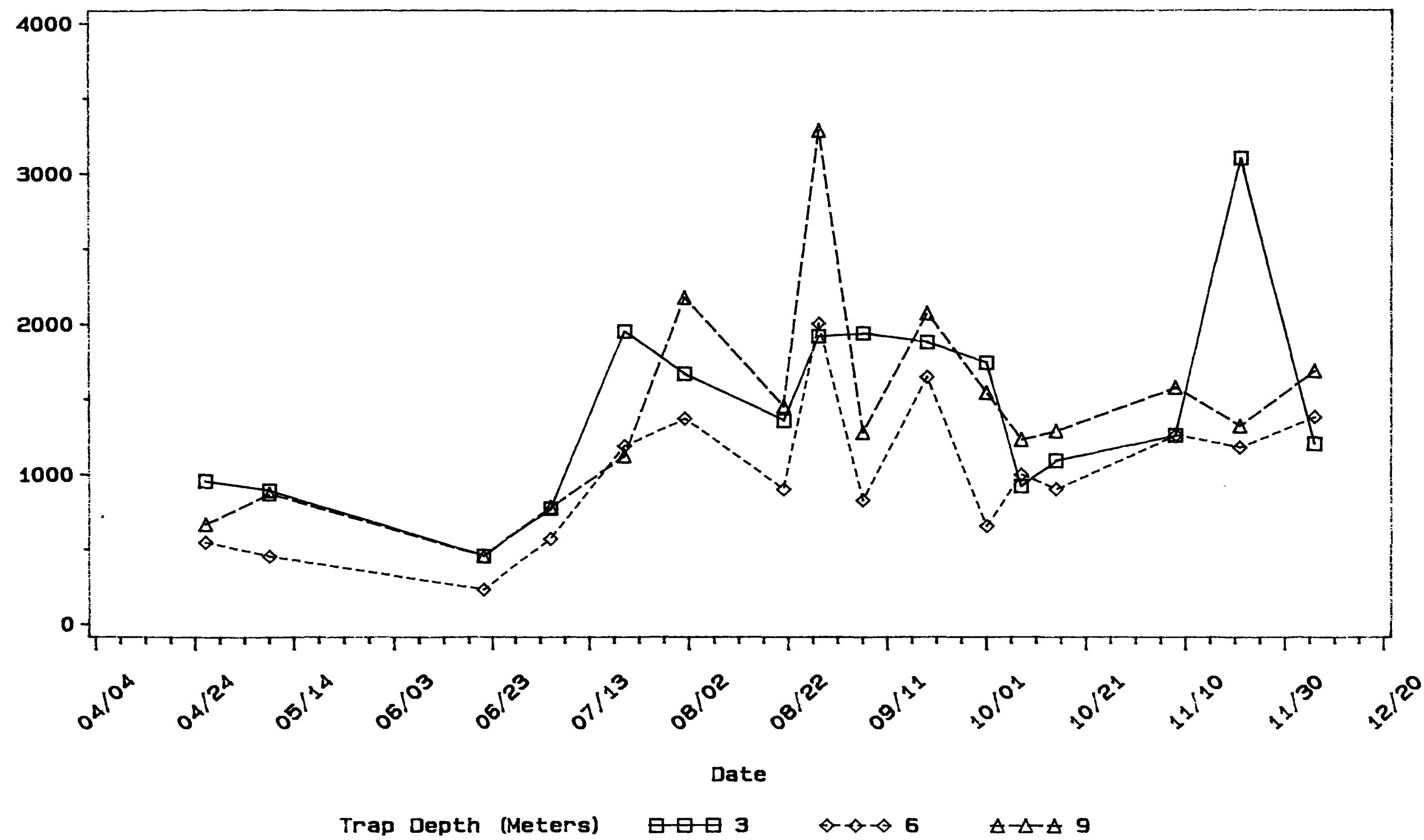
Chlorophyll-A Flux

(ug/M**3/Dy)
Bay Station



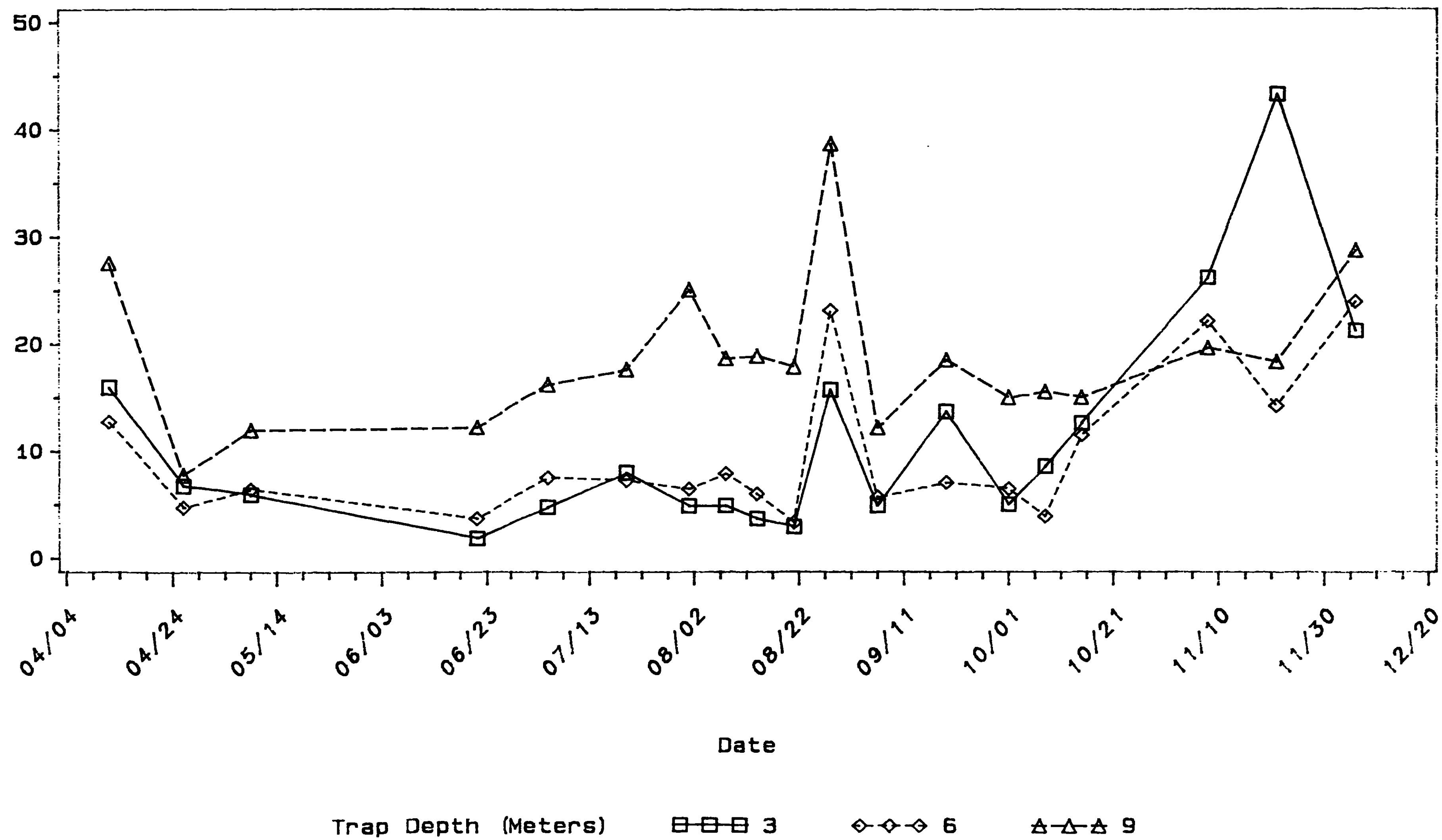
Pheophytin Flux

(ug/M**3/Dy)
Bay Station



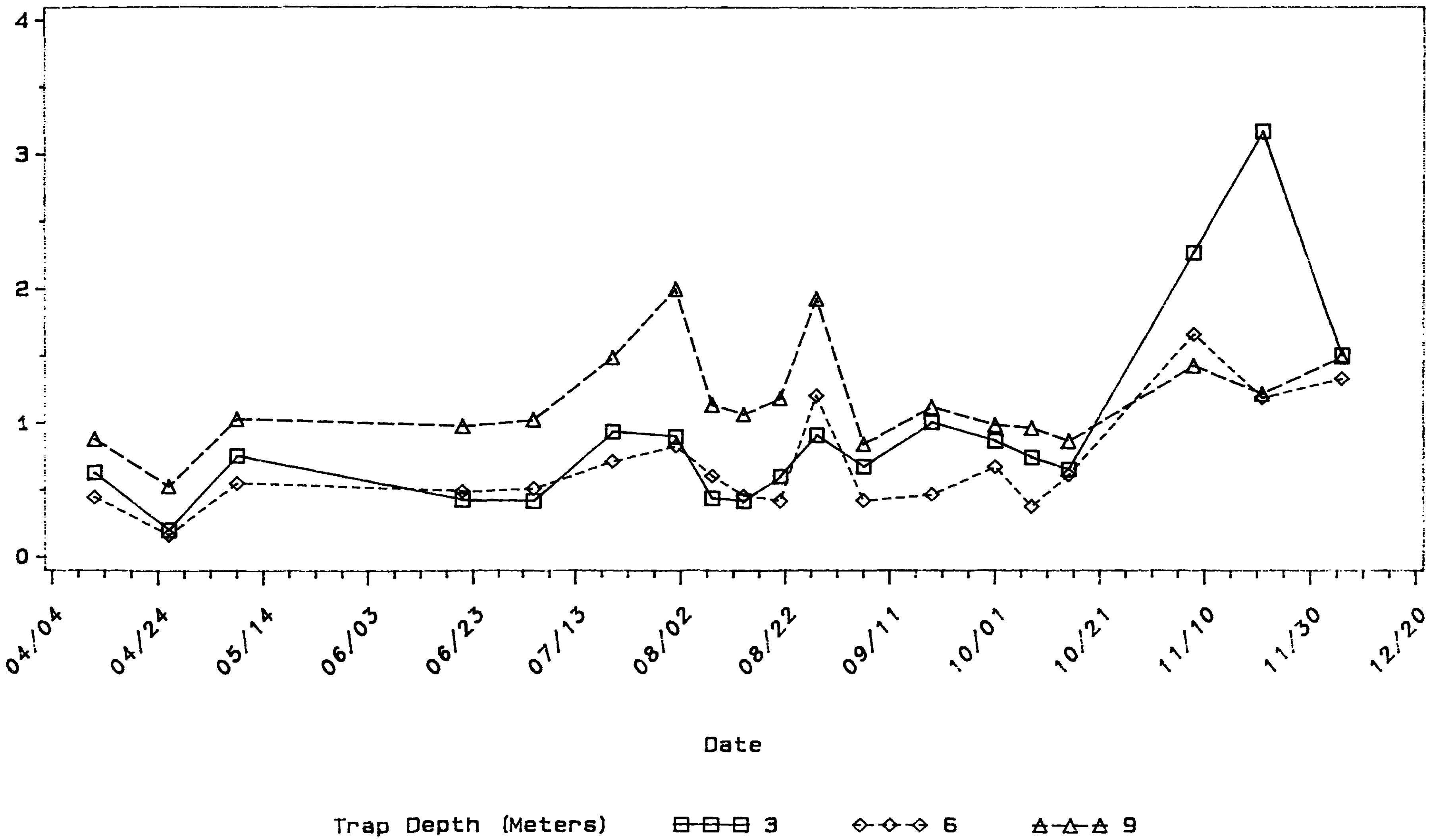
Total Suspended Solids Flux

(G/M**3/Dy)
York Station



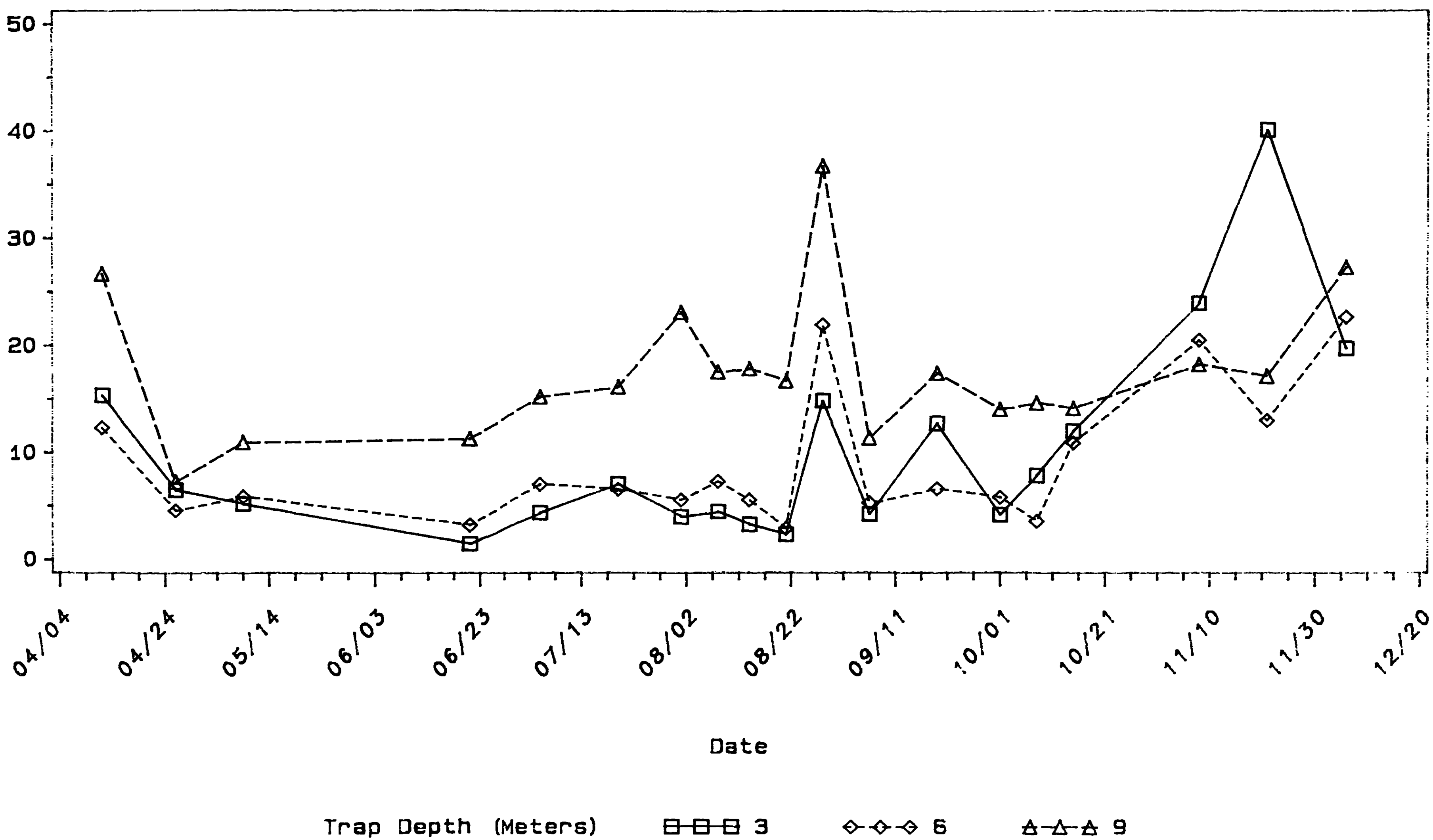
Total Volatile Solids Flux

(G/M**3/Dy)
York Station



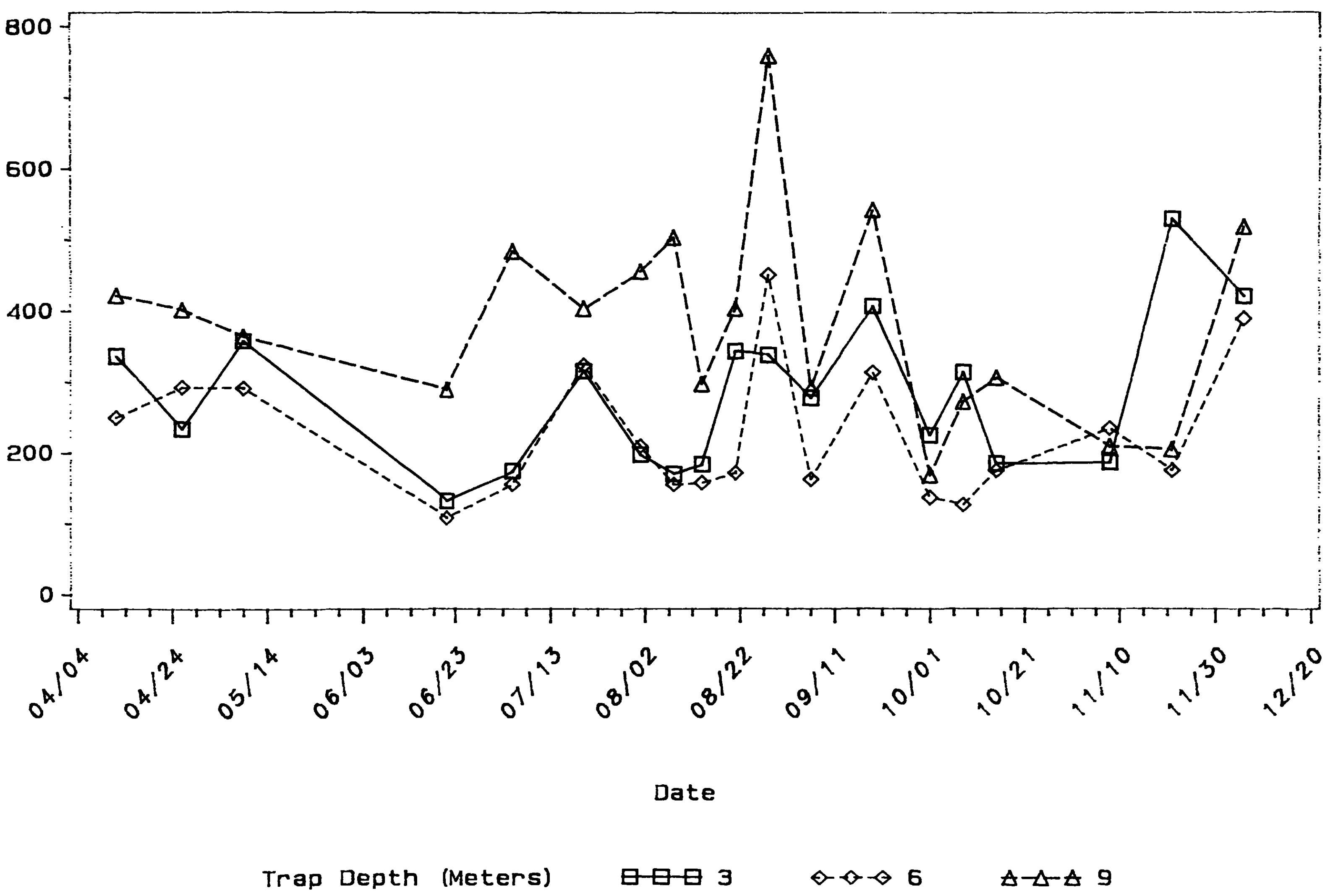
Total Non-Volatile Solids Flux

(G/M**3/Dy)
York Station



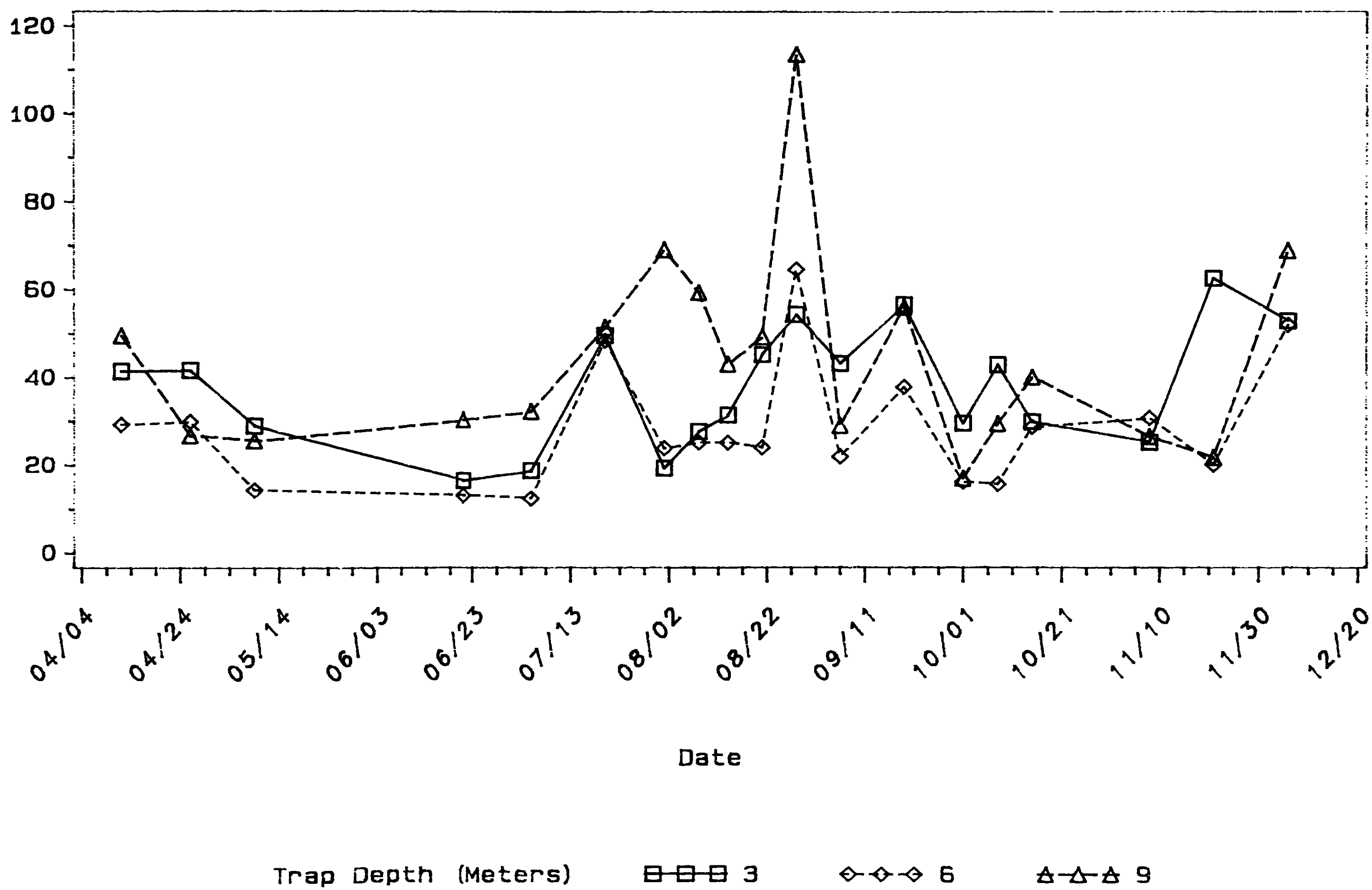
Particulate Carbon Flux

(Mg/M**3/Dy)
York Station



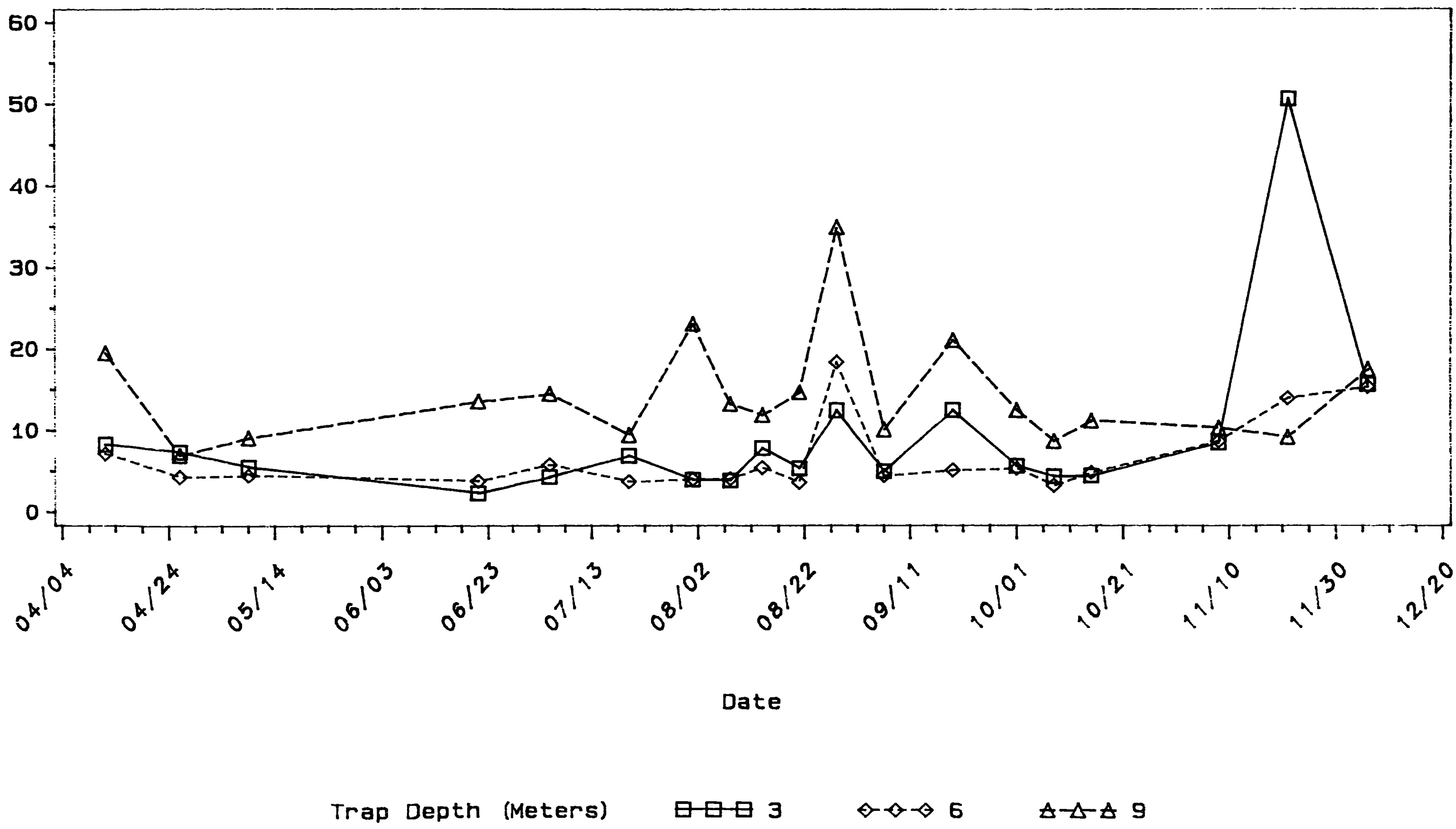
Particulate Nitrogen Flux

(Mg/M**3/Dy)
York Station



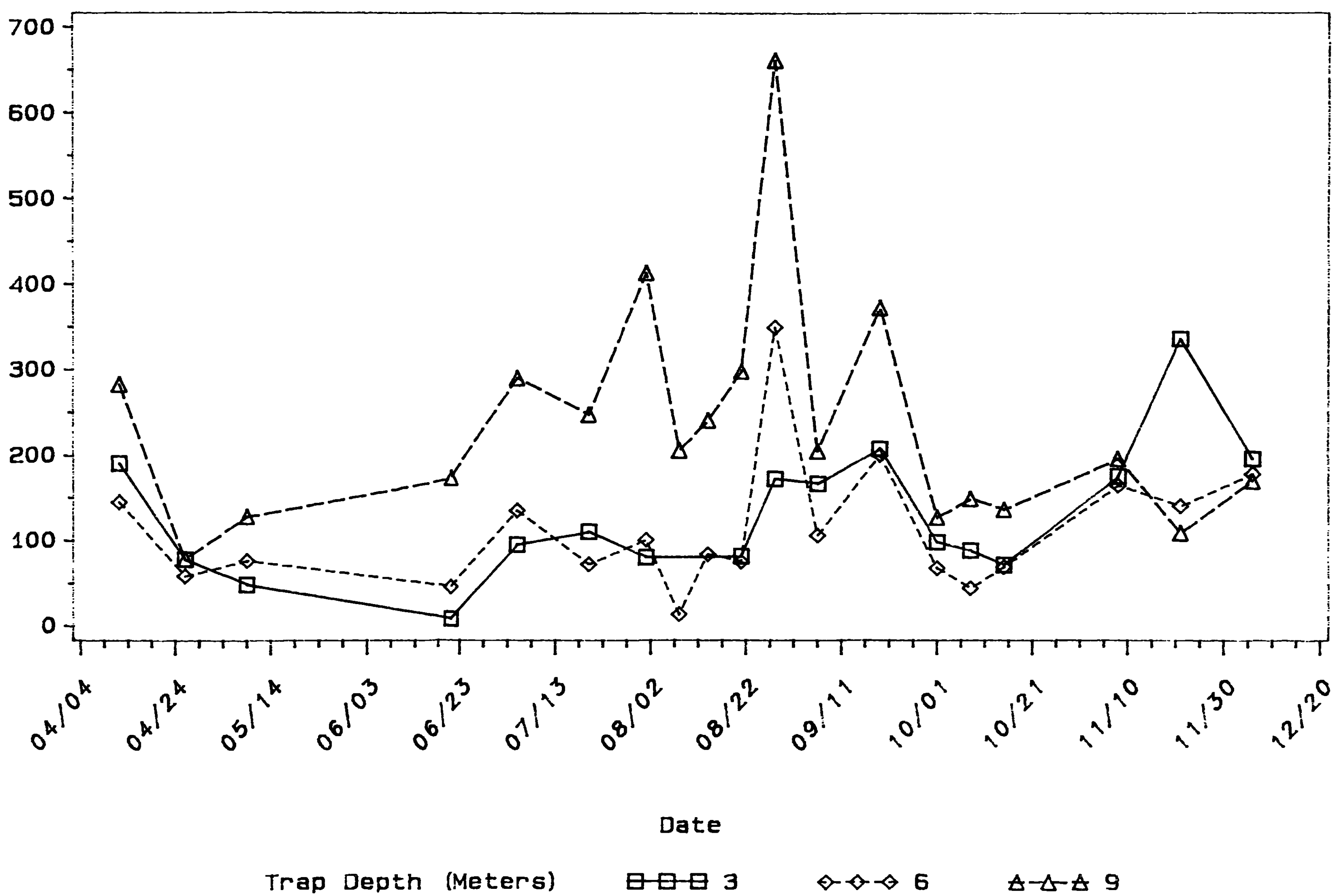
Particulate Phosphorus Flux

(Mg/M**3/Dy)
York Station



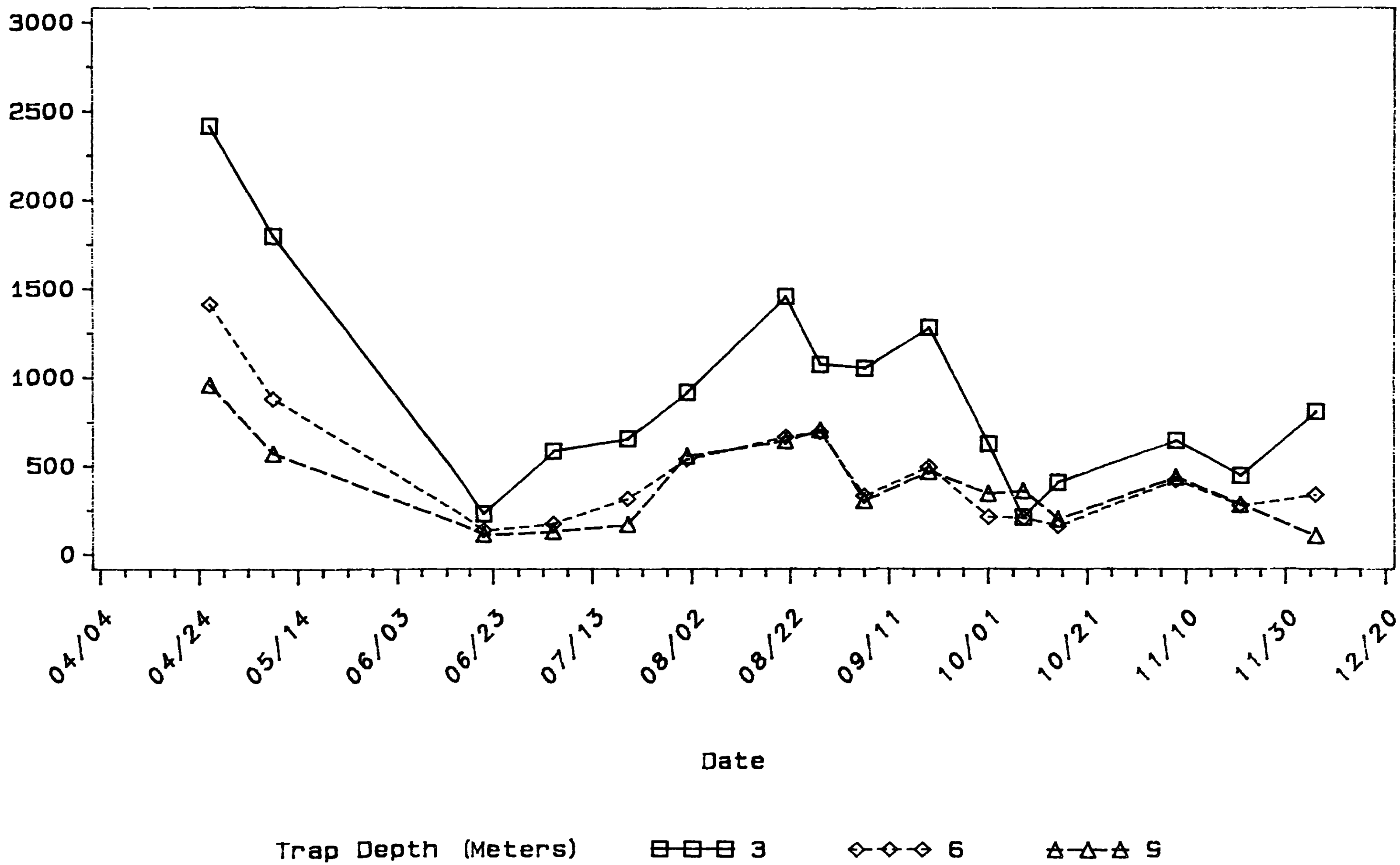
Biogenic Silica Flux

(Mg/M**3/Dy)
York Station



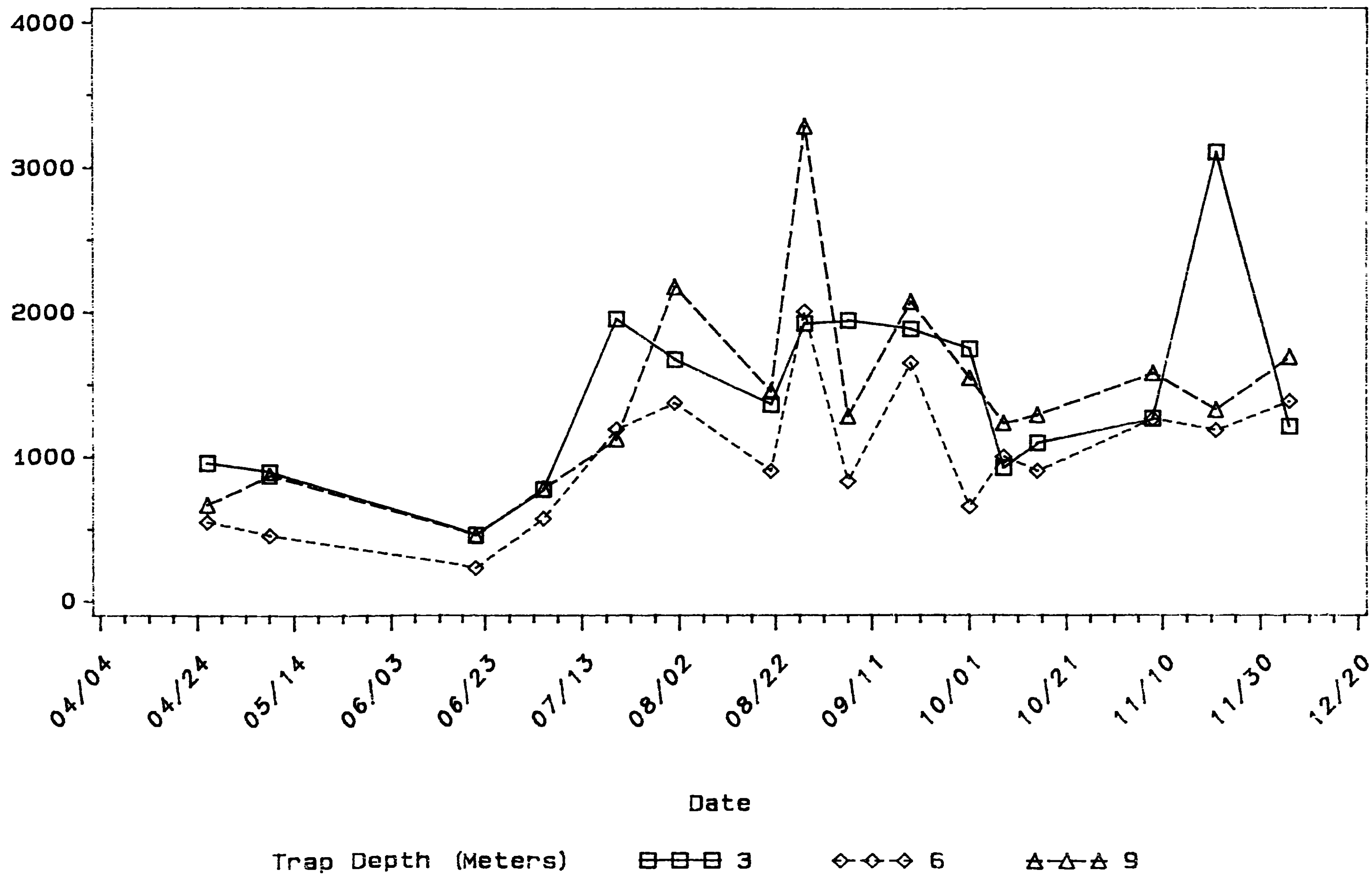
Chlorophyll-A Flux

(Ug/M**3/Dy)
York Station



Pheophytin Flux

(Ug/M**3/Dy)
York Station



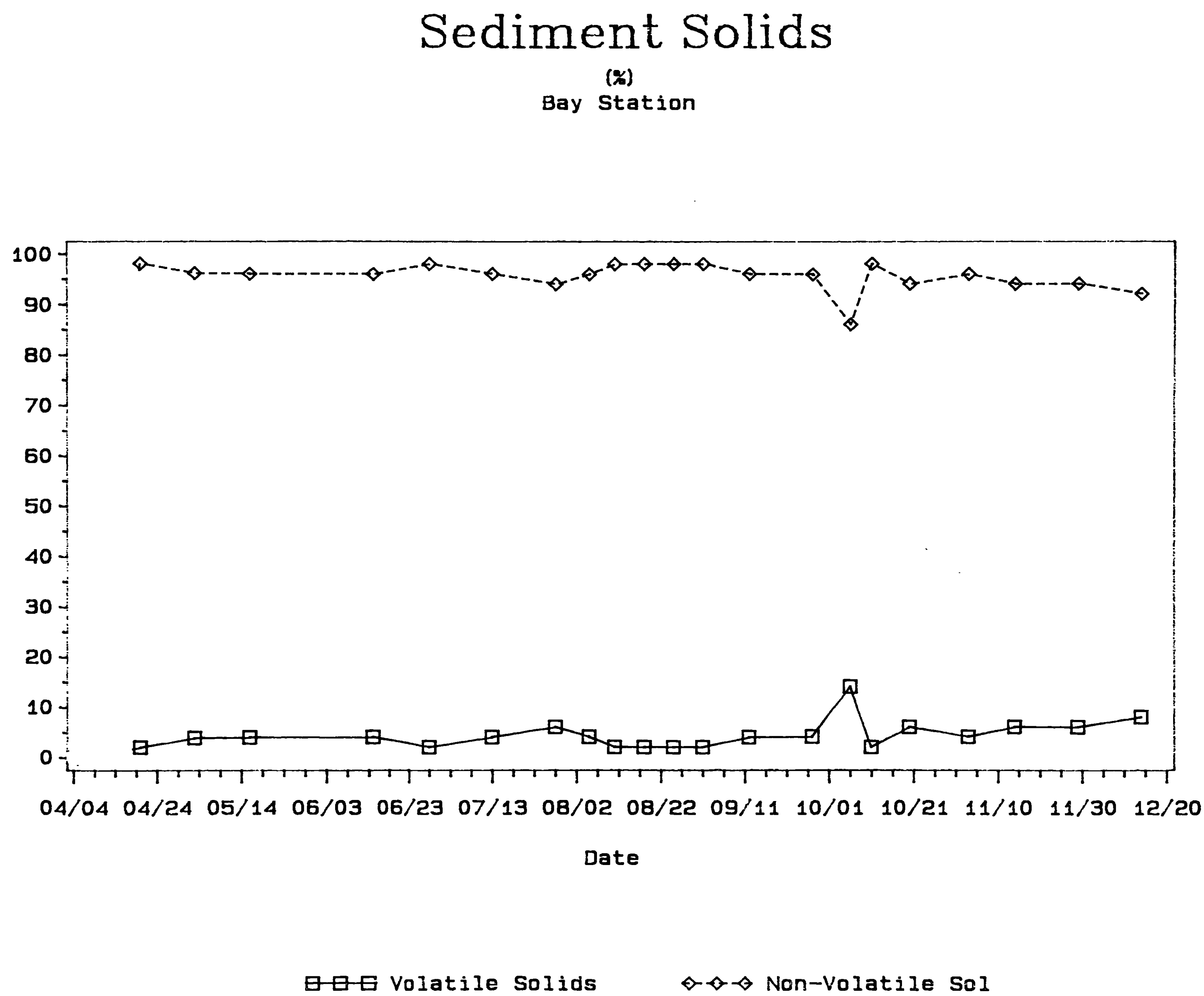
APPENDIX IV. BOTTOM SEDIMENT CHARACTERISTICS

A. Plots of Composition versus Time

1. Lower Chesapeake Bay Station*

2. Lower York River Station*

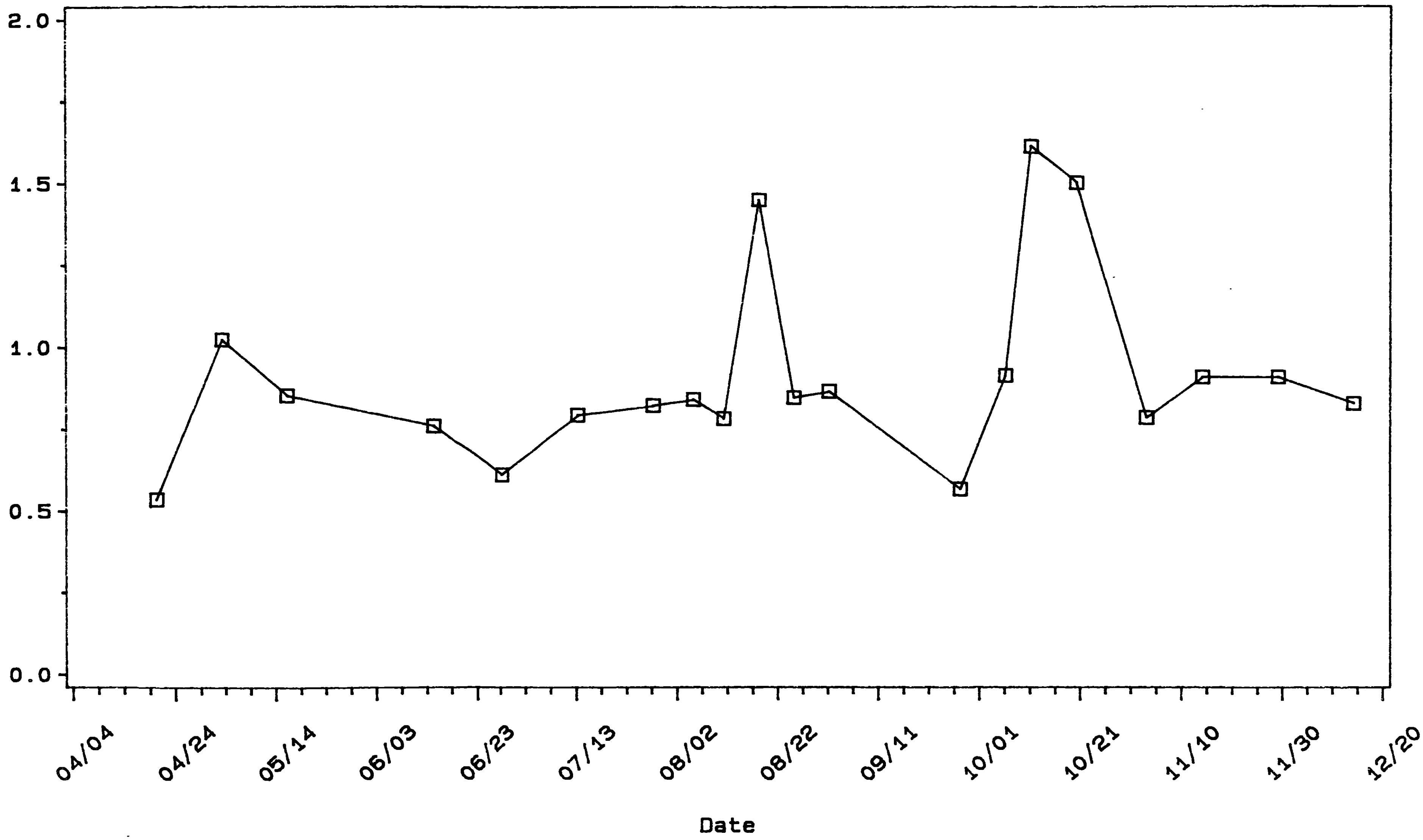
* See main body of report for exact location and other information regarding the lower Chesapeake Bay station ("Bay station") and the lower York River station ("York station").

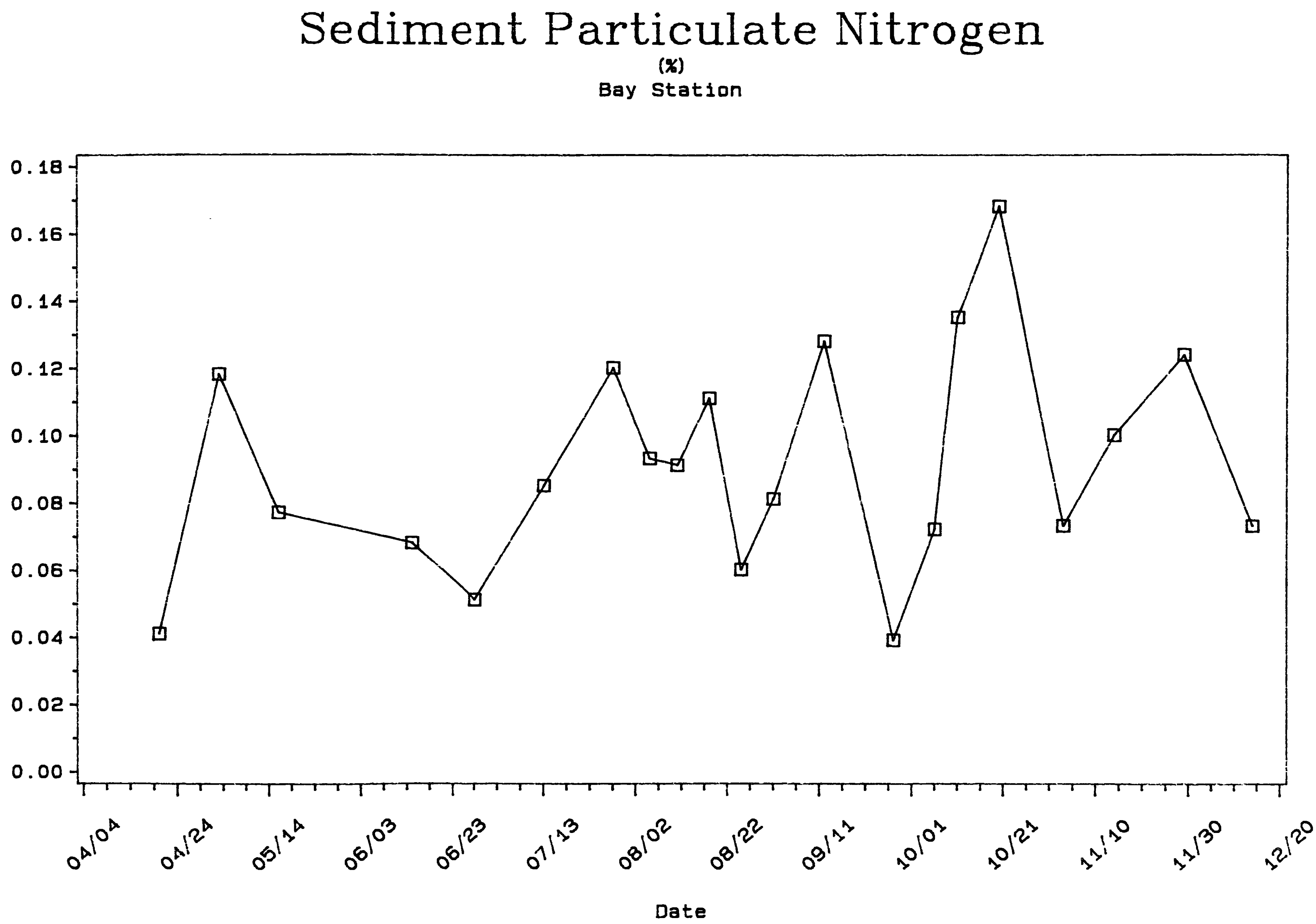


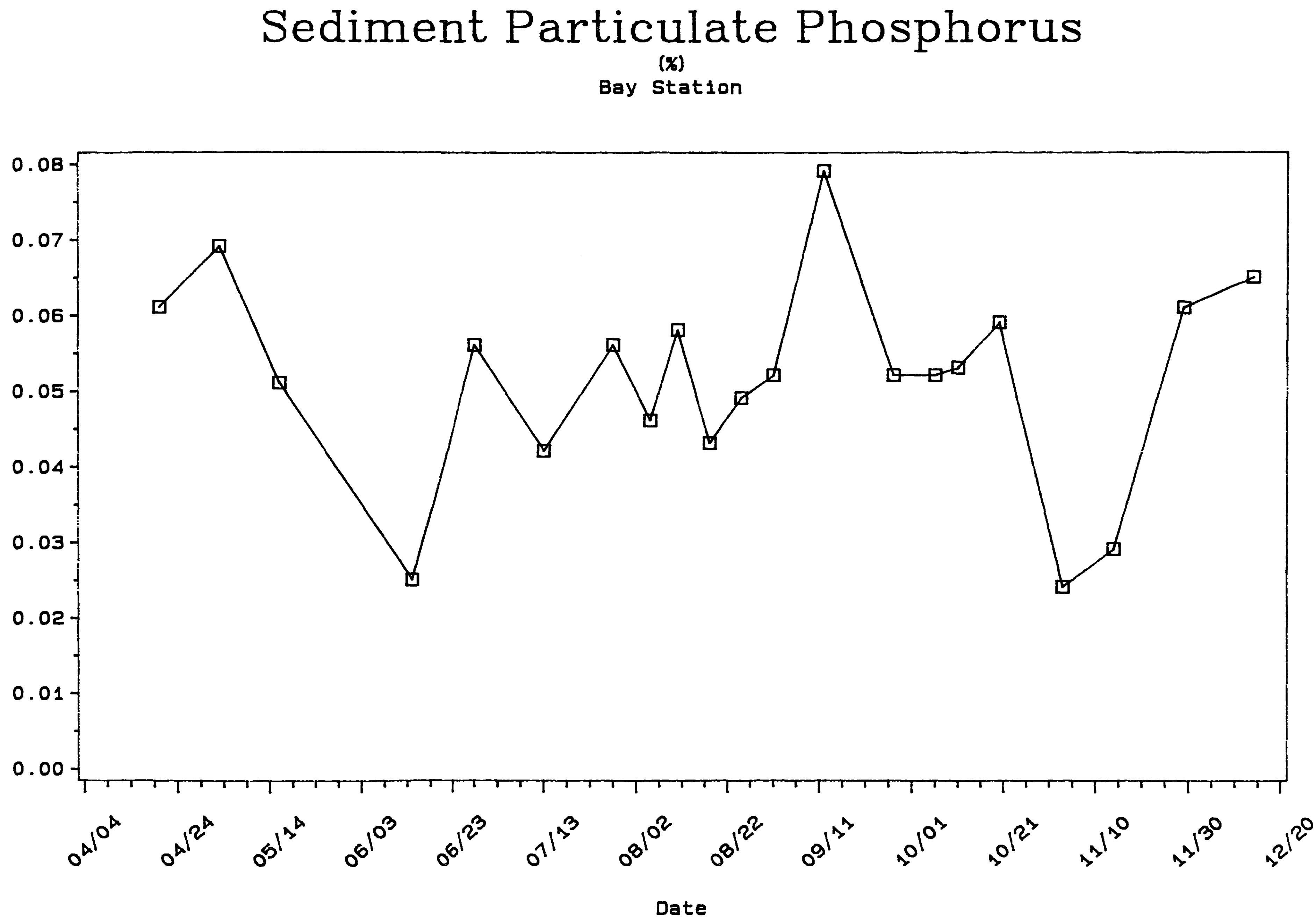
Sediment Solids
(%)
Bay Station
100
90
80
70
60
50
40
30
20
10
0
04/04 04/24 05/14 06/03 06/23 07/13 08/02 08/22 09/11 10/01 10/21 11/10 11/30 12/20
Date
Volatile Solids
Non-Volatile Sol

Sediment Particulate Carbon

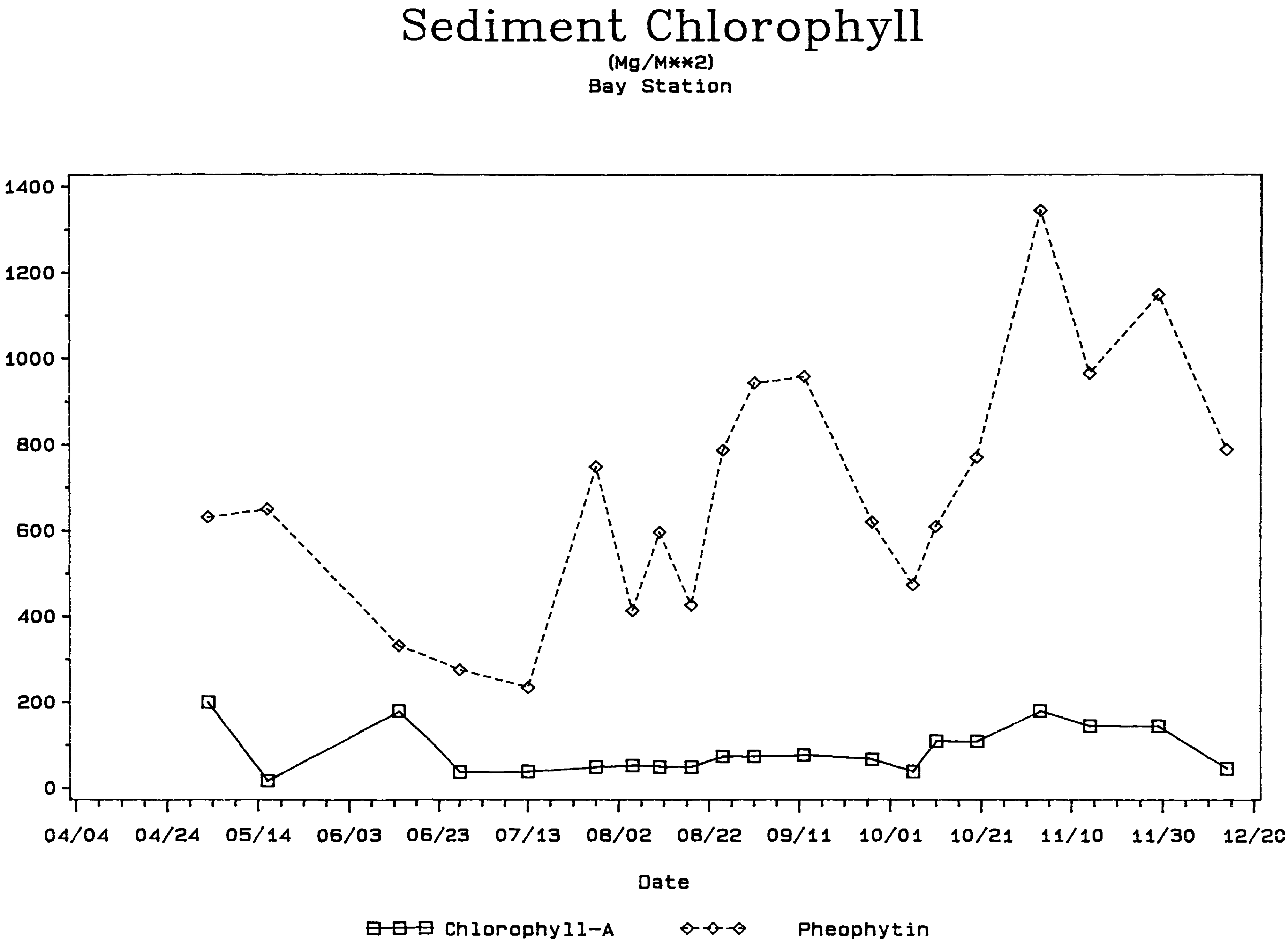
(%)
Bay Station




Sediment Particulate Nitrogen
(%)
Bay Station
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
04/04
04/24
05/14
06/03
06/23
07/13
08/02
08/22
09/11
10/01
10/21
11/10
11/30
12/20
Date

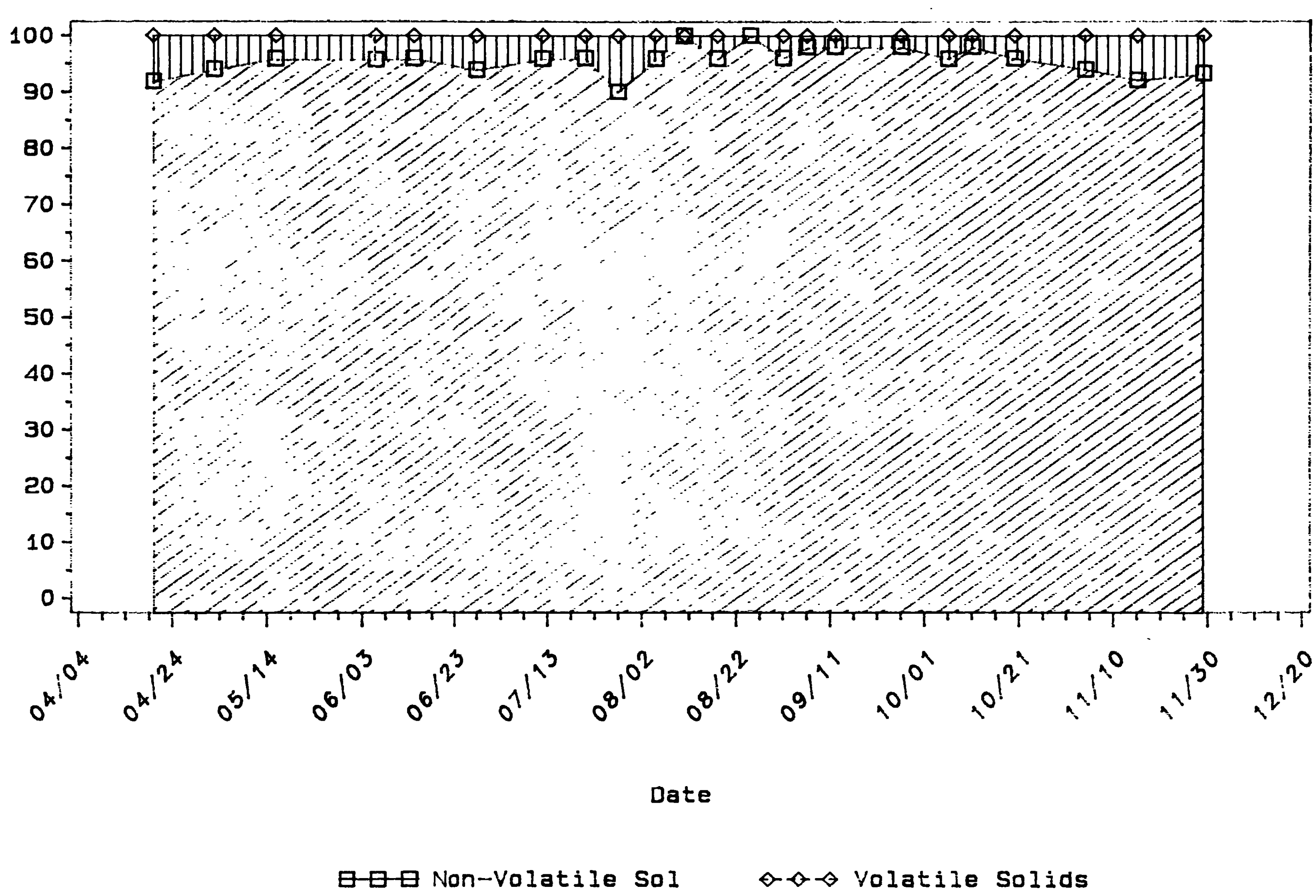


Sediment Particulate Phosphorus
(%)
Bay Station
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
04/04
04/24
05/14
06/03
06/23
07/13
08/02
08/22
09/11
10/01
10/21
11/10
11/30
12/20
Date


Sediment Chlorophyll
(Mg/M**2)
Bay Station
1400
1200
1000
800
600
400
200
0
04/04
04/24
05/14
06/03
06/23
07/13
08/02
08/22
09/11
10/01
10/21
11/10
11/30
12/20
Date
Chlorophyll-A
Pheophytin

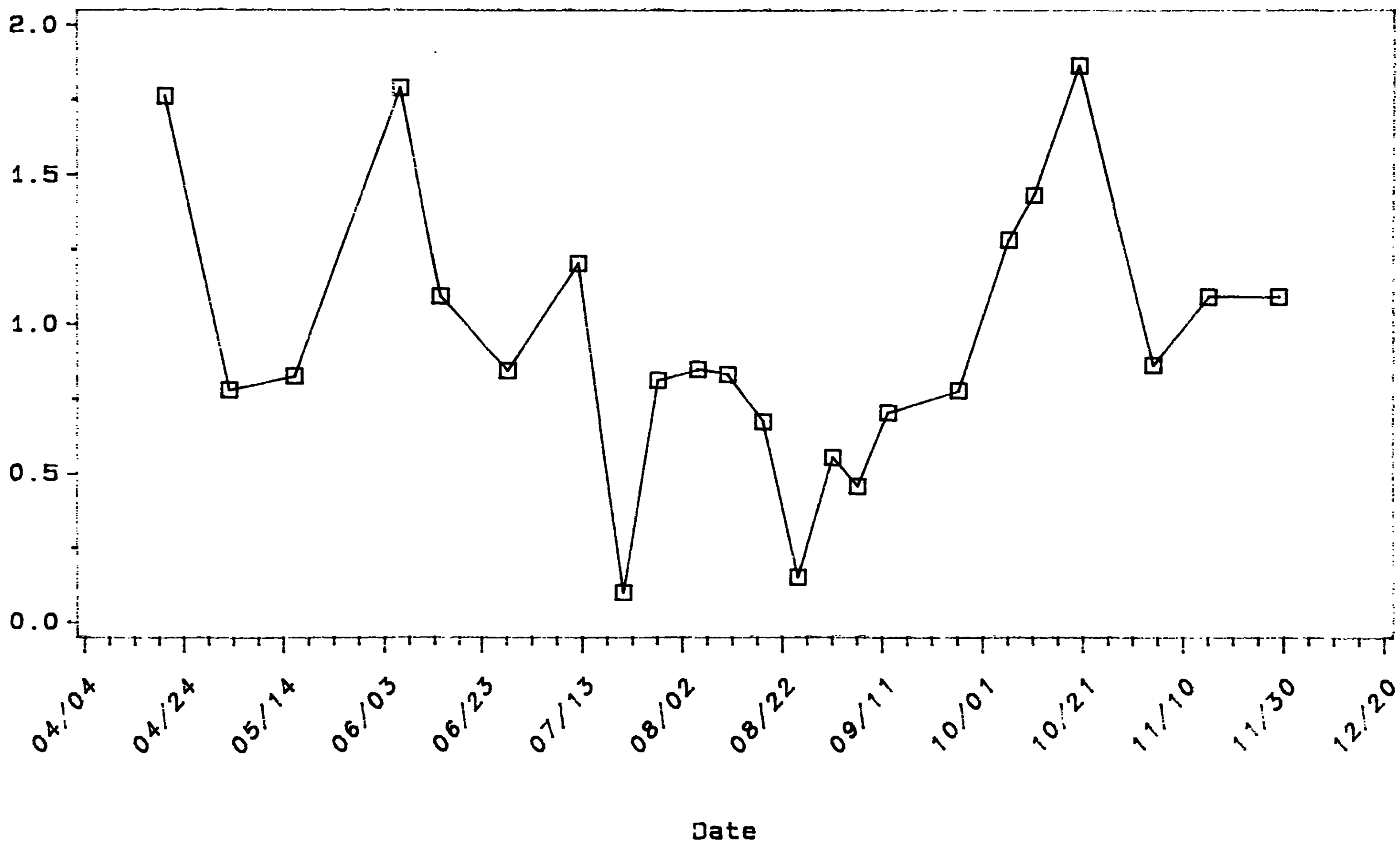
Sediment Solids

(%)
York Station



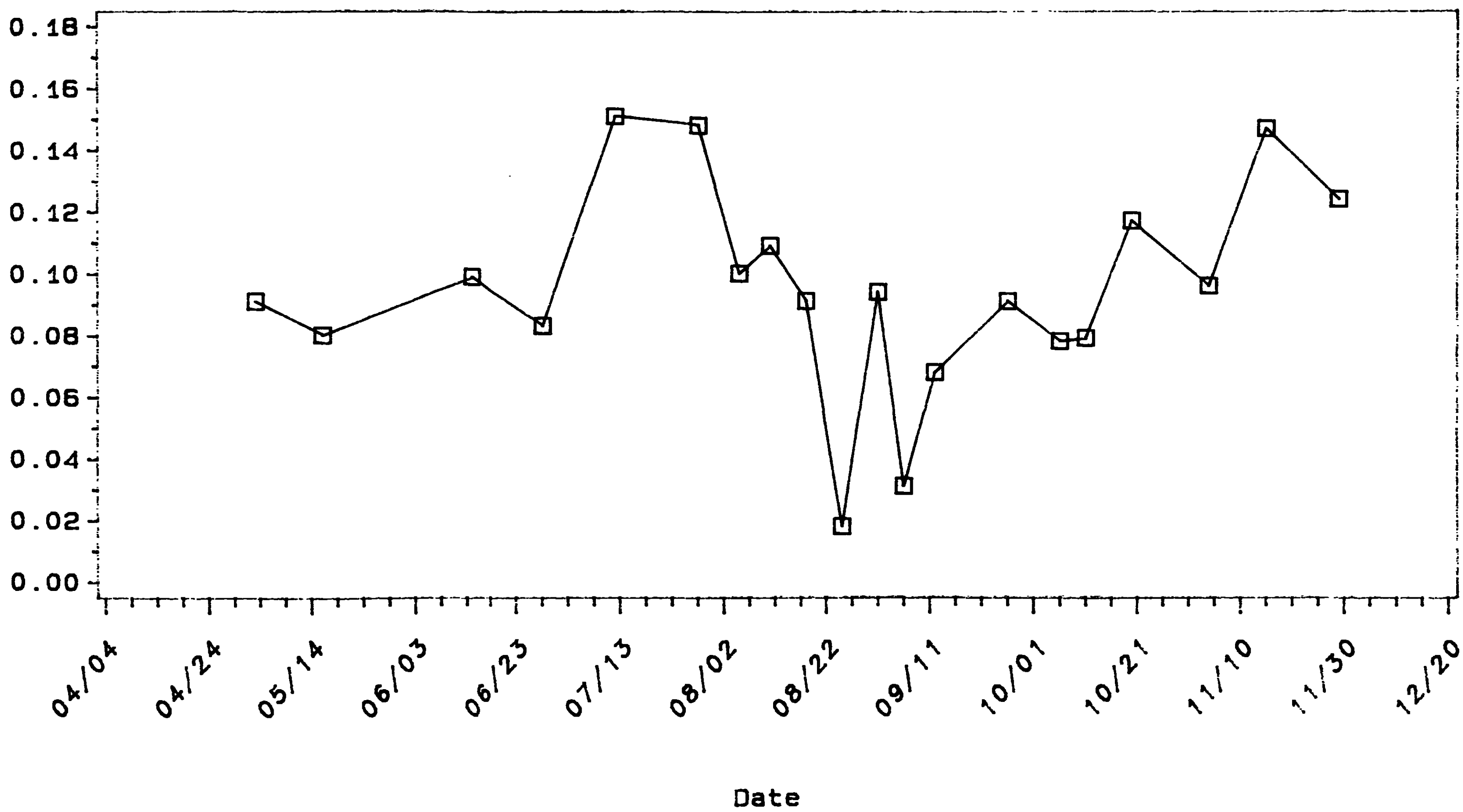
Sediment Particulate Carbon

(%)
York Station



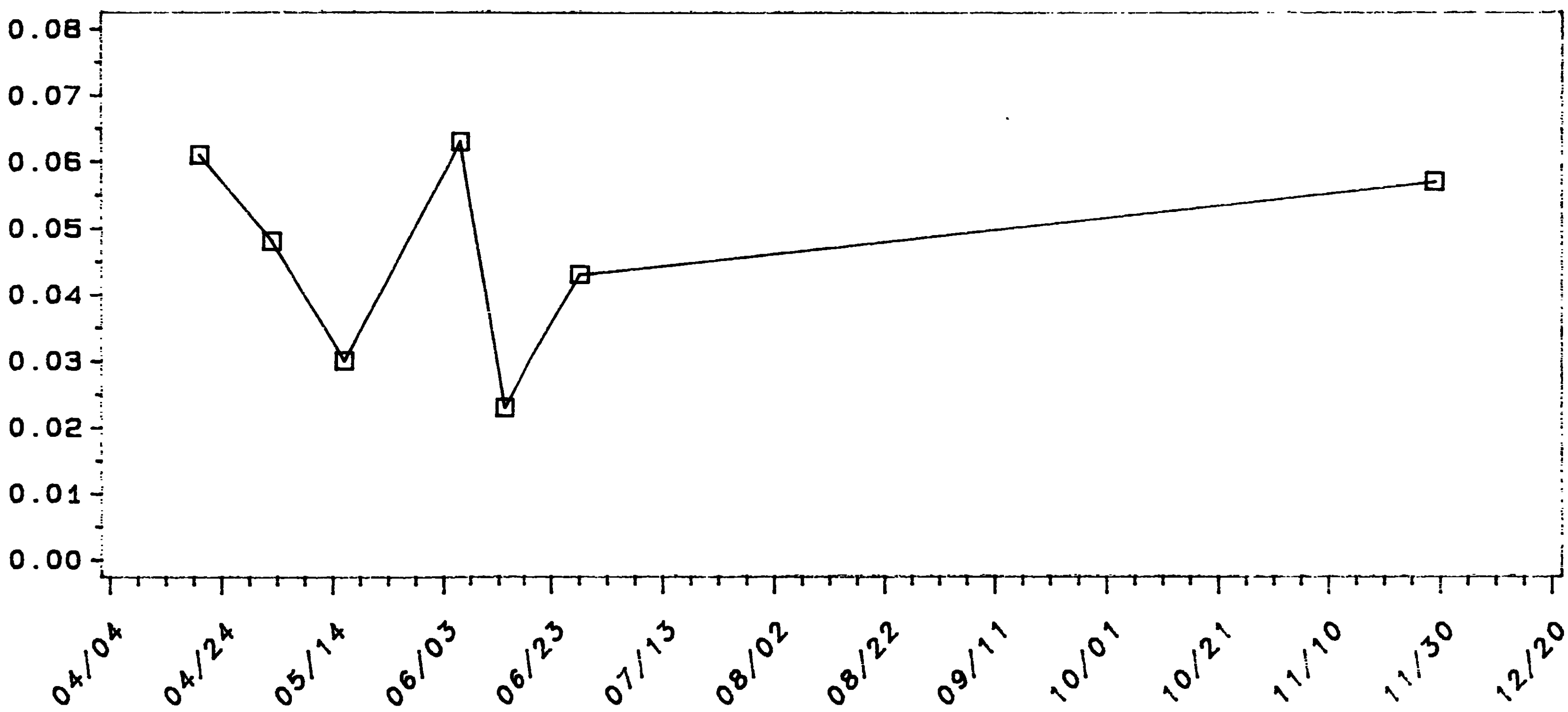
Sediment Particulate Nitrogen

(%)
York Station



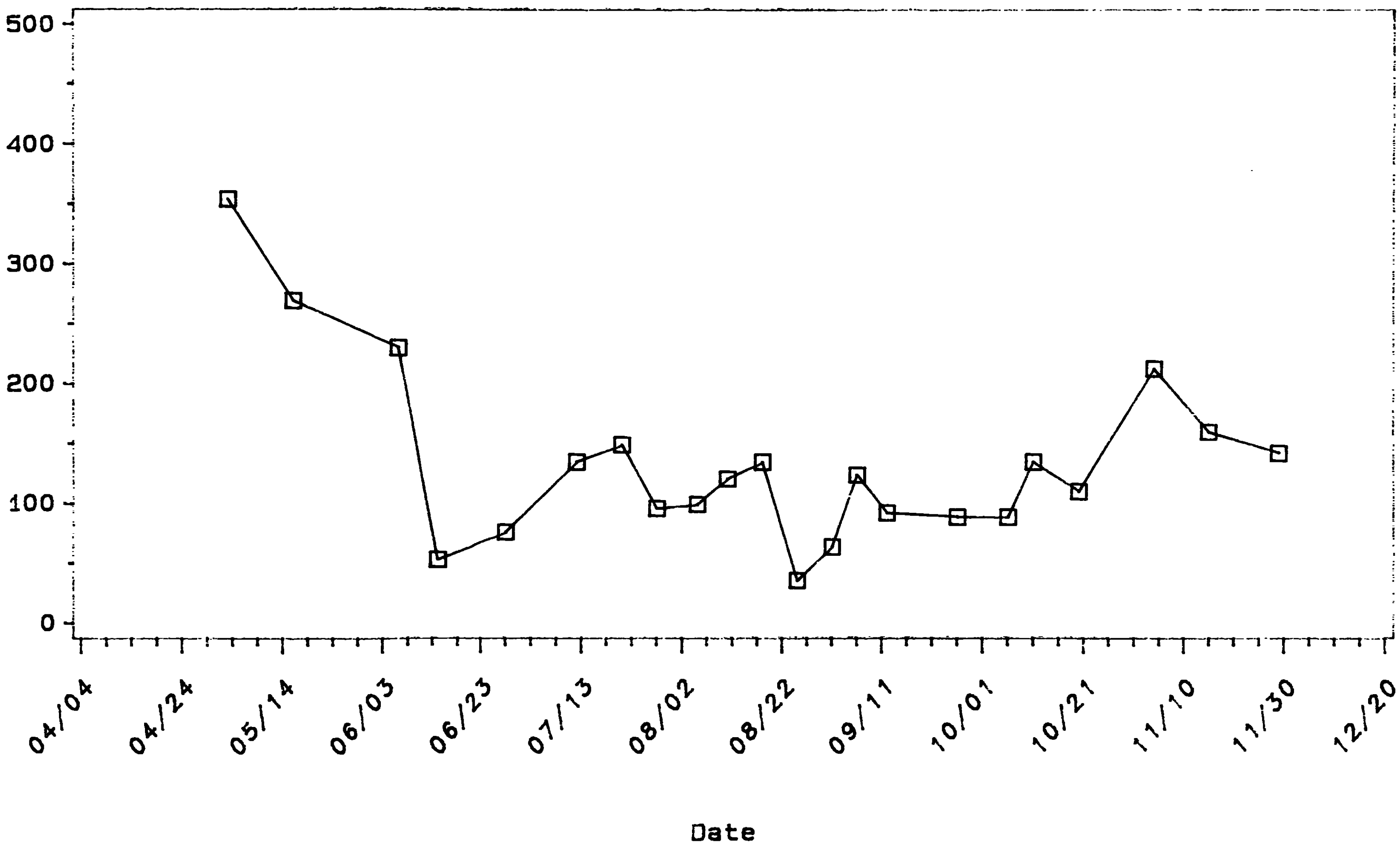
Sediment Particulate Phosphorus

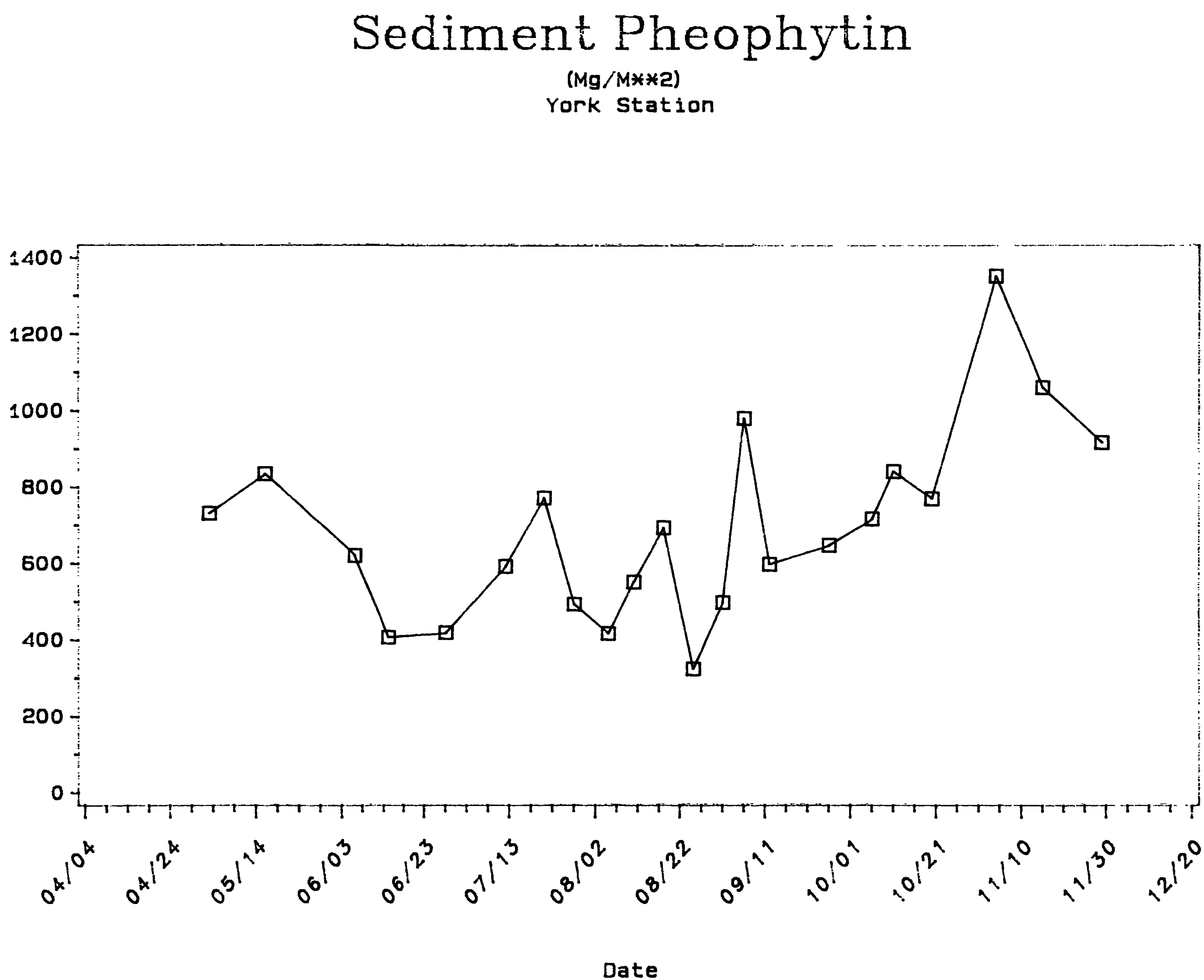
(%)
York Station



Sediment Chlorophyll-A

(Mg/M**2)
York Station




Sediment Pheophytin
(Mg/M**2)
York Station
1400
1200
1000
800
600
400
200
0
04/04
04/24
05/14
06/03
06/23
07/13
08/02
08/22
09/11
10/01
10/21
11/10
11/30
12/20
Date