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Hydrologic Engineering Center

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September 1996

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14. ABSTRACT
The purpose of this report was to evaluate water quality impacts associated with supplying whitewater releases on the Russell Fork of the Big Sandy River and a qualitative assessment of the water quality impact on the Ohio River at the confluence with the Big Sandy River. The tool used for this study was the Hydrologic Engineering Center's HEC-%Q computer model.

15. SUBJECT TERMS
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Prepared for:
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Huntington District
502 - 8th Street
Huntington, WV 25701-2070

Prepared by:
US Army Corps of Engineers
Institute for Water Resources
Hydrologic Engineering Center
609 Second Street
Davis, CA 95616

(530) 756-1104
(530) 756-8250 FAX
www.hec.usace.army.mil

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Preface

This study was performed at the request of Huntington District, U.S. Army Corps of Engineers. The purpose was to evaluate water quality impacts associated with supplying whitewater releases on the Russell Fork of the Big Sandy River, a tributary to the Ohio River at Kenova, West Virginia.

In March 1996, discussions between George Kincaid (Huntington District) and R.G. (Jerry) Willey from the Hydrologic Engineering Center (HEC) led to the opinion that the HEC-5Q computer model would be an appropriate tool for the objective of this project. In April, funds were provided in response to a scope of work prepared by HEC.

A study team was immediately formed with Jerry Willey as team leader. Vince Marchese, Tim Curran, Phillip Anderson, and George Kincaid, all of the Huntington District, were very generous in suppling the data required for input preparation. Advice and assistance on the input to and the results from the HEC-5 model were provided by Richard Hayes and Marilyn Hurst (HEC). Assistance with regression analysis and editing were provided by Cameron Ackerman (HEC). Graphics assistance was provided by Alfredo Montalvo and Anthony Novello (HEC). Field inspection assistance was provided by Vince Marchese and Rich Meyer (Huntington District).

The study was conducted under the general supervision of Arlen D. Feldman, Research Division Chief, and Darryl W. Davis, Director of HEC.

BIG SANDY RIVER
WATER CONSERVATION AND WATER QUALITY STUDY

1. Introduction

The Big Sandy River drains 4,283 square miles of watershed within portions of Kentucky, Virginia, and West Virginia. The Big Sandy River is formed by the junction of Tug and Levisa Forks at Louisa, Kentucky and flows in a generally northern direction for 26.8 miles to its junction with the Ohio River at Kenova, West Virginia. There are six Corps of Engineers' flood control lakes in the Levisa Fork drainage. There are none in the Tug Fork. The flood control lakes are North Fork of Pound River Lake (not included in this study other than as inflow to Flannagan), John W. Flannagan Reservoir, Fishtrap Lake, Dewey Lake, Paintsville Lake, and Yatesville Lake, in downstream order. Yatesville Lake was the latest flood control lake constructed and it started discharging flow in April 1991. The releases from the flood control lakes impact the water quality on the Pound River, Russell Fork of the Levisa Fork, Levisa Fork, Johns Creek, Paint Creek, Big Sandy River, and Blaine Creek, in downstream order. This stream system is shown in Figure 1.

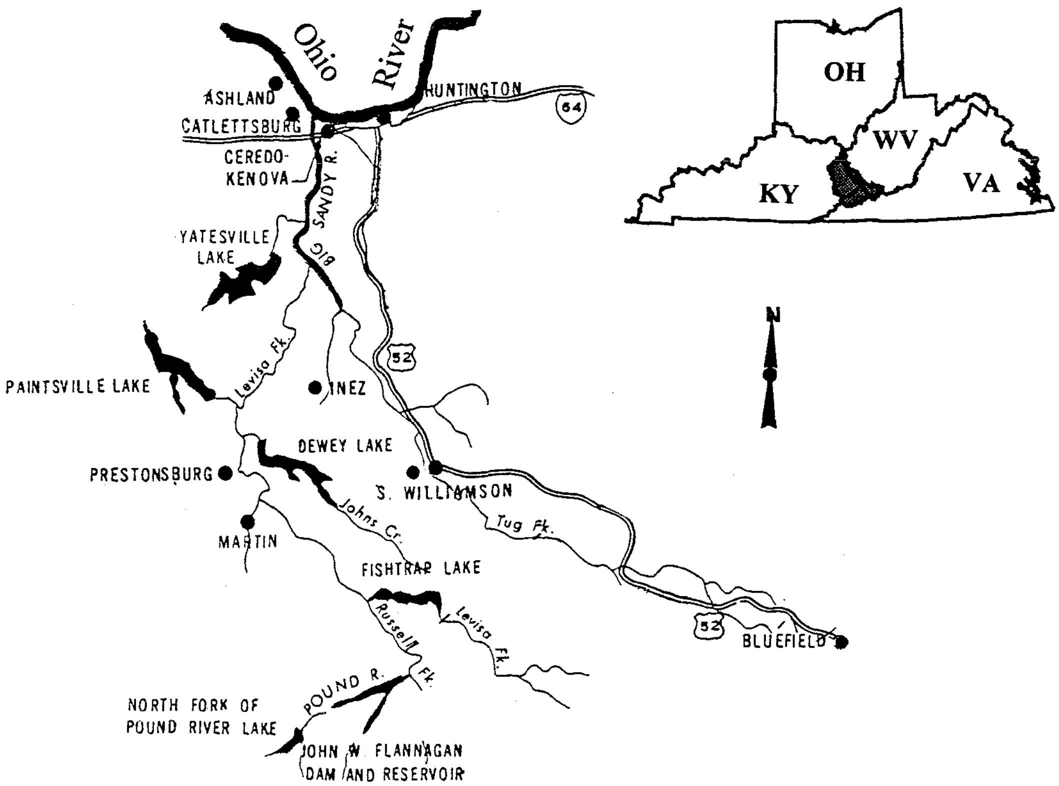

Figure 1. Big Sandy River Basin Map.

On April 1, 1996, the Hydrologic Engineering Center was requested by the U.S. Army Corps of Engineers Huntington District to apply the HEC-5Q computer model (HEC 1996) to the Big Sandy River basin described above.

2. Study Objective

The purpose of this study was to evaluate the Big Sandy basin-wide impact on water quality (water temperature and dissolved oxygen) due to providing whitewater releases to the Russell Fork from Flannagan Lake. In addition to the quantitative assessment of the Big Sandy River system, the District requested a qualitative assessment of the water quality impact on the Ohio River at the confluence with the Big Sandy River. It was decided that the scope of this study's dissolved oxygen (DO) calculations would include only the demand for oxygen from BOD (Biochemical Oxygen Demand). It was concluded that other parameters like algae and nutrients were beyond the scope of this study.

3. Physical Description Data

The physical description provided above and quantitative information from the pertinent data sheets in the five reservoir regulation manuals were used to define the river system control points and river mile identification. These were then used to develop the basin schematic shown in Figure 2 and for preparing the HEC-5Q input data.

Other data from the reservoir regulation manuals was used to prepare HEC-5Q input involving each reservoir's physical description including elevation/storage/surface area tables and elevation/outlet discharge capacity tables. Data on reservoir elevation/width near the dam and stream cross-section descriptions were provided by the Huntington District.

4. Time-Series Data

From an assessment based on Huntington District expertise involving historical meteorological and hydrological data, three study years were selected for use in the calibration of HEC-5Q. Two dry years (1987 and 1988) and one wet year (1994) were selected. The three years were selected based on the hydro/meteorological range of conditions provided for the calibration of the model but, also, for the amount of existing water quality data available within the reservoirs and at the stream control points.

The meteorological data were obtained from EarthInfo Inc. and is called NCDC Surface Airways Data (EarthInfo 1994/1995). The vendor provides the data for the period of record on a compact disc (CD) for a specified regional area. After a search of stations available in Virginia, West Virginia, and Kentucky, the closest stations to the Big Sandy River basin were determined to be Beckley and Huntington in West Virginia, and Jackson in Kentucky. Jackson was chosen as the most representative weather station for the Big Sandy River projects based on proximity to the upper basin reservoirs.

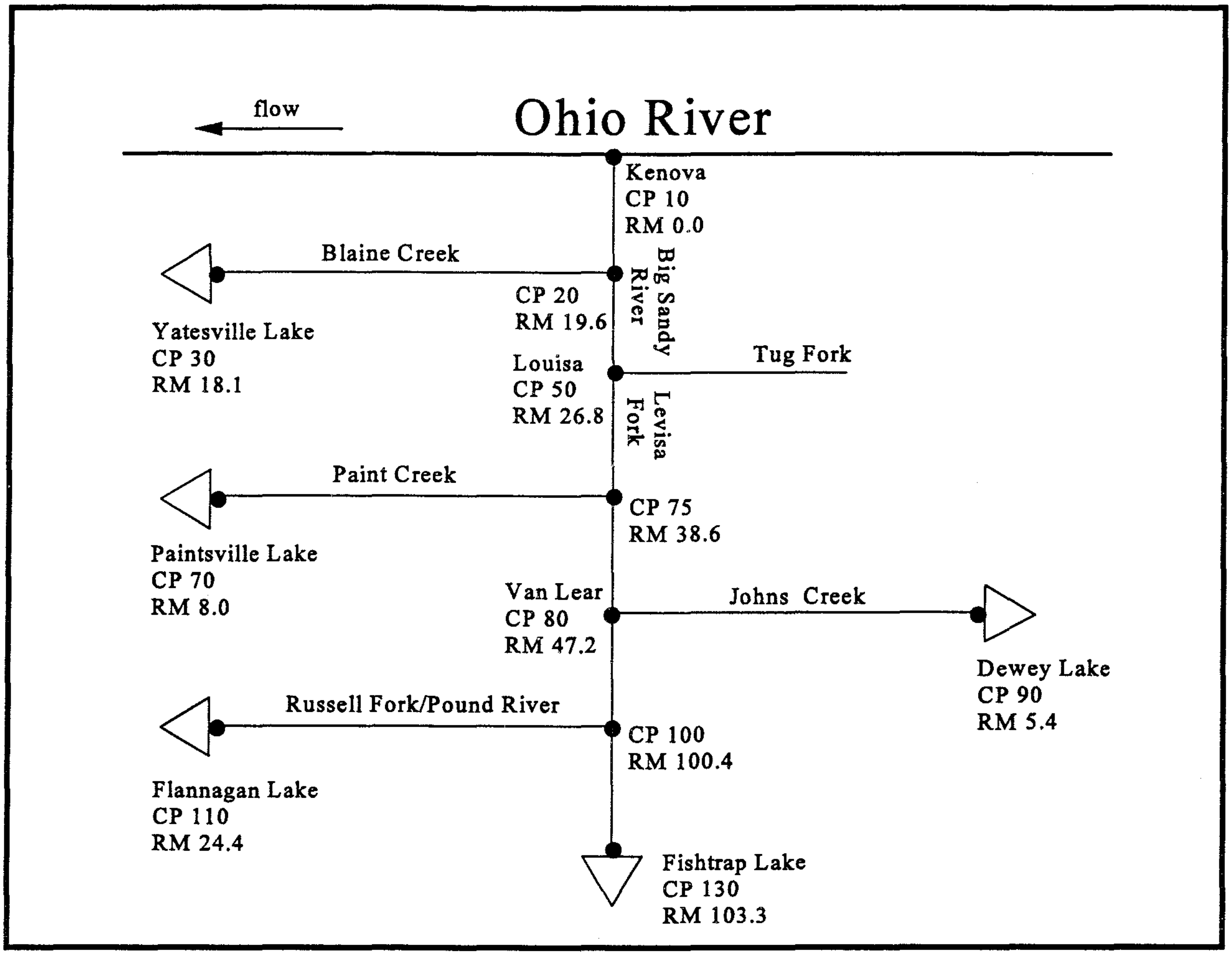

Figure 2. Schematic of the Big Sandy River Basin.

Hydrological data were provided by the Huntington District in the HEC-DSS database (HEC 1995). These data were available for reservoir inflows, releases, and pool elevations. Reservoir water quality inflow and release concentrations and reservoir water quality-depth profile data were also provided by the District.

5. Data Manipulation

The meteorological data were preprocessed by the HEC programs WEATHER and HEATX. WEATHER reads the hourly data exported from the EarthInfo CD in a CD144 format and modifies the format for input to the HEATX program. HEATX calculates the equilibrium temperature (shown in Figures 3 and 4 for the three study years), the heat exchange coefficient, and solar radiation. These results plus wind data are output for each time step in an appropriate format for HEC-5Q.

The other data that requires the use of a preprocessor is the cross-section data. The District provided the channel cross-sections in an HEC-2 format. These data were processed with GEDA to provide a physical description of the channels as horizontal layers including surface area, hydraulic radius, surface width, and a channel roughness coefficient (Manning's n) as a function of elevation. The program output is in the format required by HEC-5Q.

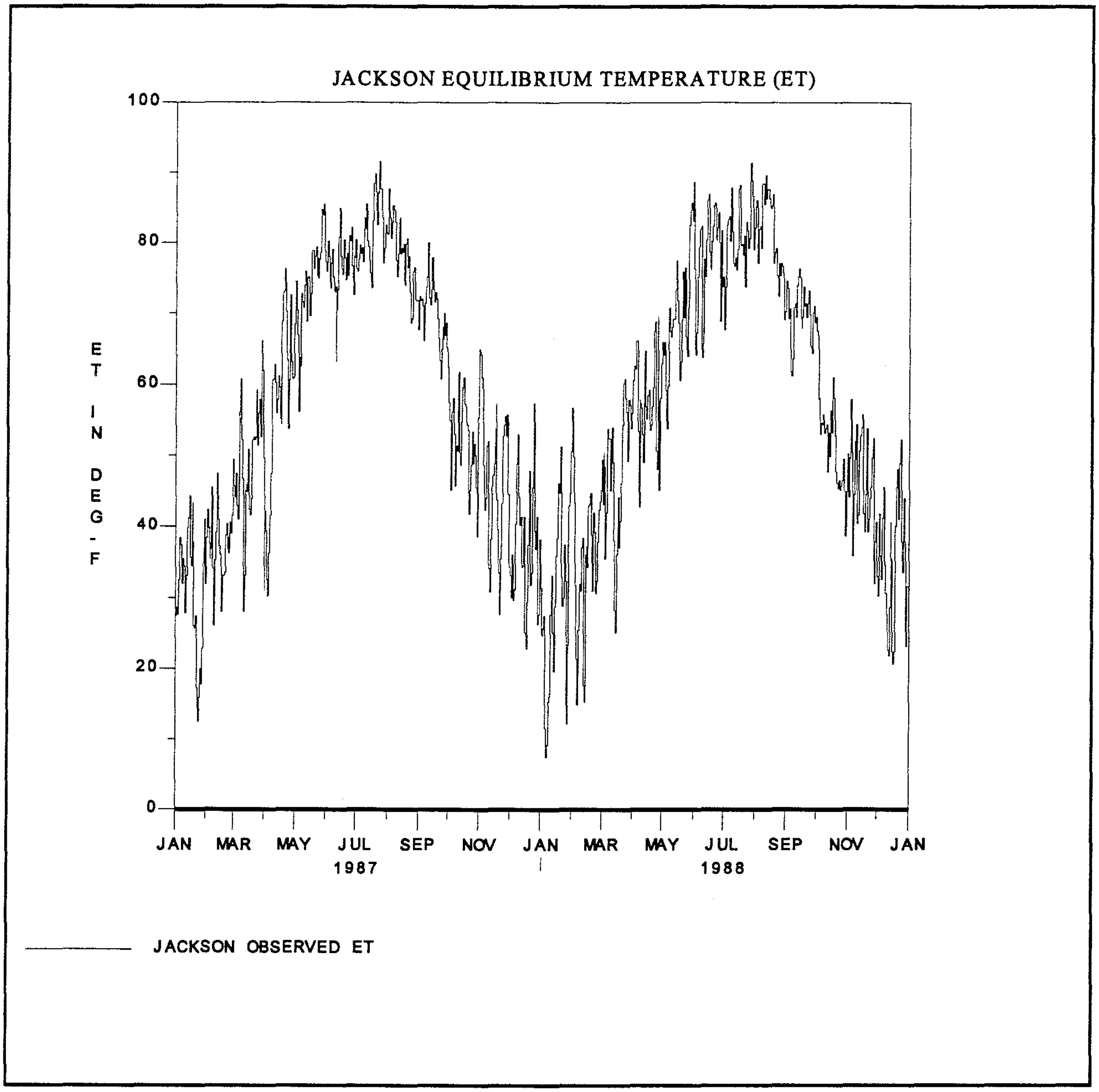

Figure 3. Jackson, Kentucky Equilibrium Temperatures for 1987 and 1988.

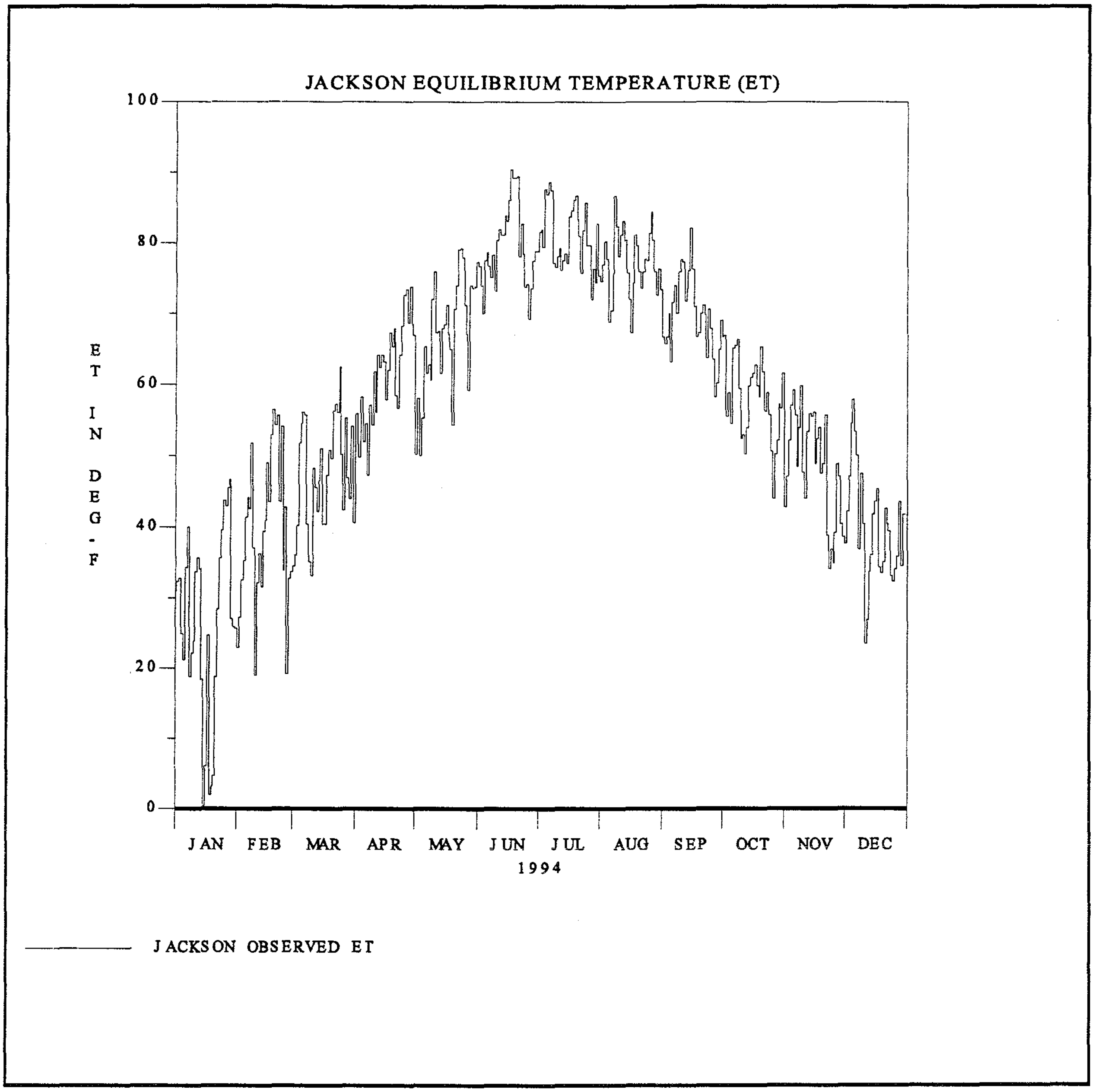

Figure 4. Jackson, Kentucky Equilibrium Temperatures for 1994.

The hydrological data provided in the HEC-DSS database were converted from hourly to mean daily using DSSMATH (HEC 1995). Other data provided by the District were entered into HEC-DSS using DSSITS (HEC 1995), for irregular time-series data or DSSPD (HEC 1995), for reservoir water quality profile data.

All the other HEC-5Q input data were gleaned from the resources mentioned above or by judgments based on experience with the application of HEC-5Q.

6. Model Calibration

The process of calibrating follows the preparation of the input data. It is always a necessary step for analysis of water quality in an existing reservoir. The purpose is to adjust several model coefficients in order to best reproduce measured water quality in the reservoir and at the discharge location. To accomplish this task, a comprehensive understanding of the exact operation of each project is necessary. Data is required for each project on the discharge quantity and quality, reservoir pool level, and reservoir water quality-depth profiles on several days during the year (especially during the summer stratification period).

The results of the calibration of the HEC-5 water quantity model are shown in Appendix A. The reservoir inflow, discharge, and reservoir storage were provided by the District. HEC-5 performs a hydrologic balance of continuity to calculate a release quantity. The computed release and the computed reservoir storage are compared to the observed values. The reproduction is satisfactory for water quality calculation purposes.

The calculation procedure was modified for Yatesville calibration. When the procedure described above was used, the Yatesville reservoir pool experienced wild variations in the calculated pool levels. It was assumed to be caused by the extremely small observed discharges (less than a few cfs). To maintain the observed pool, it was necessary to calculate a discharge that would reproduce that level. The result was to allow a significant difference between observed and calculated discharges in order to maintain the observed pool. The significance of solar radiation heating on the reservoir surface was considered to have a more important impact on the Big Sandy basin than the error in the discharge quantity. The channel flow routing is calibrated to best reproduce downstream flows at control points having gaged flow data.

A list of items (both input data and model coefficients) adjusted during the water quality calibration is shown in Table 1.

The HEC-5Q input requires inflow water temperatures and DO concentrations. The reservoir with the most measured data is Paintsville. Even at this site, measured data was available on only two of the three study years. Other reservoir's inflow water quality data were measured with less regularity. This shortage of regularly measured inflow data has required a quantitative method as an optional input in HEC-5Q for estimating the data on a daily basis.

Since daily meteorological data is required in a water quality model, the estimation technique is a numerical scheme relating Jackson's equilibrium temperature to each reservoir's inflow water temperature. Regression equations were developed with a spreadsheet between these two parameters at various sites with measured data. Where sufficient data did not exist at one site for a meaningful relationship, data from more than one site in a region were used in combination. The graphical results of these regression analyses are shown in Appendix B in the order discussed below. The numerical measure of correlation, R^2, ranges from 81-91%. The sensitivity of switching equations was found to be minimal. Therefore, the equation used at a given reservoir inflow site was chosen based on a combination of geographical location, elevation, and amount of available data.

Flannagan Lake inflow temperature is a function of the regression equation derived from data at Haysi, Virginia. Fishtrap Lake uses the equation derived from the data collected above the project on the Levisa Fork at Big Rock, Virginia. Dewey Lake uses the equation from the data collected at Meta, Kentucky. Paintsville Lake has three discrete inflow tributaries. The first and second use equations derived from data collected on two separate drainage channels into Little Paint Creek. The third uses an equation from data collected on the Open Fork channel combined with the data from the other two. Yatesville's data was sufficiently lacking in number of samples available. Therefore, Yatesville Lake uses an equation derived from data collected above the projects at Fishtrap, Dewey and Yatesville, and data collected at Meta, Kentucky. Tug Fork tributary temperatures use the equation derived from data at Fort Gay, West Virginia.

The resulting equation used for each reservoir is shown as TMPIN in a coded format in Table 1. The code for TMPIN consists of the regression constant (intercept) times 100 rounded to the nearest ten, plus the regression coefficient (slope) rounded to the nearest tenth. For example, a code of -060.75 is an intercept of -.060 and a slope of 0.75. The TMPIN value has been empirically adjusted by -2 to -3.7 degrees Celsius from the appropriate regression equation in Appendix B to best reproduce the amount of heat in the reservoir. For example, the equation from the Fishtrap inflow data has been adjusted to provide inflow temperatures that are cooler by 3.7 degrees Celsius. The adjustments for the other reservoirs are as follows: Flannagan is 3.0, Dewey is 3.5, Paintsville is 2.0 (all three tributaries), and Yatesville is 3.0.

The measured DO data, during 1987, 1988, and 1994, at these same sites was converted to percent saturation using the corresponding water temperature for each day of measurement and then averaged over the study periods. The DOIN is shown in Table 1. DOIN ranges from 93-98% at the three upstream reservoirs to 75% at the most downstream reservoir.

The BODIN shown in Table 1 was determined empirically by an interactive process to best reproduce both the DO-depth profile and the release DO from each reservoir. The necessary seasonal changes are shown vertically for a given calendar date. Interpolation between values is used within the model. Where more than one value is shown per date, each value represents a different study year in chronological order. Values used should not be compared exactly with what would be measured in the field but considered to be a surrogate of the demand required on the oxygen from all inorganic and organic compounds in the water. Derived values range from 0-15 mg/l at most locations and seasons, with the exception of 30 mg/l at Yatesville in the fall.

These three inputs (TMPIN, DOIN, and BODIN) are estimated due to lack of measured data. The three separate rows of values for Paintsville (CP70) are for the three main tributaries (CP70A, CP70B, and CP70C) sampled by the Huntington District.

TABLE 1

ESTIMATED LAKE INPUT DATA AND
MODEL CALIBRATION COEFFICIENTS

CP #	TMPIN code	DOIN % sat	BODIN mg/l	LIGHT %	SDISK feet	A1 E-4	GSWH E-6	A3 sq.m/sec	GMIN kg/cu. m/m	SOD mg/sq. m/day	REAIR % sat
130	-060.75	98	01/1- .4, .4, 15 04/1- .4, .4, 2 07/1- 2, 8, 2 08/1- 4, 0, 0	60	12	.2	.9	-.7	.030	3000, 2300, 2600	80, 80, 40
110	-040.72	93	01/1 - .9, 07/1 - 0, 09/1 - 15, 10/1 - 8	60	12	.2	1.	-.9	.015	2200, 1800, 1500	90
90	-090.79	97	01/1 - 1.5, 05/1 - 0, 07/15 - 7, 10/1 - 0	60	3	.05	1.	-.7	.035	600	80
70A	000.71	80	01/1 - 0, 0, 0 03/1 - 0, 2, 0 06/1 - 0, 0, 0 10/1 - 9, 0, 0	50	9	.07, .10, .09	6.	-.7	.025	1500, 1800, 1600	80
70B	-060.85	92	same as 70A								
70C	-030.78	85	same as 70A								
30	010.74	75	01/1 - 2, 05/1 - 0, 09/15 - 10, 10/15 - 3	70	18	.06	.03	-.8	.140	1500	95

LEGEND:

CP = Reservoir Control Point
TMPIN = Inflow Temperature Code
DOIN = Inflow Dissolved Oxygen
BODIN = Inflow Biochemical Oxygen Demand
LIGHT = Solar Radiation Absorbed in Top 3'
SDISK = Secchi Disk

A1 = Epilimnion & Hypolimnion Diffusion Coef.
GSWH = Reservoir Critical Stability
A3 = Coef. for Calculating Metalimnion Diffusion
GMIN = Reservoir Minimum Stability
SOD = Sediment Oxygen Demand
REAIR = Reservoir Release Rearation

The remainder of Table 1 contains model calibration coefficients. Each of the first six model calibration coefficients is determined empirically in combination with TEMPIN and each other. Each value is affected by all the others. LIGHT is the percent of solar radiation that is absorbed in the top layer (three feet) of the reservoir. The range is shown to be 50-70%, with most reservoirs using 60%. LIGHT has the tendency to locate most of the heat in the top reservoir layer. The remainder is transferred vertically with an exponential equation.

SDISK is a surrogate of the spring season secchi disk readings that are measured with a black and white target disk. It describes the ability to see beneath the surface and affects the depth of the calculated epilimnion zone. Values of 3-18 feet are shown in Table 1.

The A1, GSWH, A3, and GMIN coefficients are used in the diffusion computations. Effective diffusion is described as a combination of all energy transferred by eddy and molecular movement. This mixing concept is exclusive of the mixing caused by advective diffusion. Advective diffusion is the physical movement of energy caused by the water balance between layers as the inflow and release are processed. A more comprehensive description of effective diffusion is provided in the HEC-5Q User's Manual (HEC 1996). Where more than one value is shown for a given reservoir, the different values are for each study year, shown chronologically.

The SOD value in Table 1 is a time independent input. SOD is a sediment oxygen demand and impacts the DO profile, as do the DOIN and BODIN values. The SOD values obtained by calibration range from 5-1400 mg/sq. m/day. SOD has an impact on the use of oxygen in every layer of the reservoir.

The REAIR value is a correction applied to the oxygen being released from the dam to account for the combined reaeration at the discharge valve and in the turbulence associated with the tailwater area. During field inspection of the tailwater areas, significant reaeration was observed but the actual values used were derived by calibration.

The results of using the Table 1 values for the reproduction of the reservoir temperature and dissolved oxygen (DO) profiles are shown in Appendices C and D for each day that measured data was available at each reservoir. The error of reproduction of the thermal profiles is generally less than two degrees Celsius. The Paintsville profiles compare the best while the Yatesville profiles compare the worst. All of them are deemed adequate for the study purposes.

The DO profiles are not particularly good comparisons because the algal photosynthesis and respiration affect cannot be reproduced with only BOD. They are, however, sufficiently accurate to be used for the study purposes.

The results for the temperature and the DO release concentrations from each project are shown in Appendices E and F for all three study years. The reproduction of release temperatures is quite good. The observed data (those connected with a dotted line) are from short interval measurement and then averaged to obtain mean daily values. The other observed data points represented by a small circle are from spot samples taken sometime during the designated day. It is inappropriate to connect these discrete values. Also, these values represent the water quality only for the instant of measurement.

The release DO results are surprisingly adequate, if the several observed spot measurements less than eight mg/l are discounted. Release DO is usually very close to saturation. DO saturation is eight mg/l at 27 degrees Celsius. Warmer temperature water has lower saturation concentrations. DO below eight mg/l is assumed to be an anomaly.

Evaluation of the reproduction of both the profiles and the release quality, together, was used to determine a best set of Table 1 values.

The results at all tributary junction locations (CP's 100, 80, 75, 50, 20, and 10) are shown in Appendices G and H. Locations with measured data show the comparison between observed water quality and computed water quality. CP's without measured data show the computed results only. These reproductions are impacted by the routed release water quality and the input tributary water quality.

The tributary water quality is unmeasured and, therefore, estimated like the reservoir inflow water quality to best reproduce the measured data at the stream control points. The estimated tributary water quality data (TMPIN, DOIN, and BODIN) are shown at the bottom of Table 2 for each stream control point. The TMPIN values are warmed by zero to three degrees Celsius using an adiabatic lapse rate to account for the elevation difference from the elevation of the location associated with the most appropriate (geographical) regression equation.

The DOIN values are averages of the most appropriate (geographically) measured DO data. The BODIN values are arbitrarily low. The results from the estimated input of these three parameters are not particularly sensitive.

In general, the computed reservoir temperature profiles are to be construed as an average for the large portion of reservoir volume near the dam, not necessarily exactly where the observed profile was measured. With this in mind, the reproductions shown are of an acceptable level. The DO profiles have much more error than the temperature profiles. In most of the reservoirs, the observed DO profile shows all the characteristics of algal photosynthesis and respiration. It was beyond the scope of this study to analyze the nutrients and algae. The computed DO profiles appear to contain acceptable shape and magnitude to represent the DO affected by BOD only. Both the temperature profiles and the DO profiles are important only as they affect the release water quality since one-dimensional modeling cannot be used to represent the reservoir water quality much upstream of the dam.

The time-series plots of release water quality are within limits of acceptability as are the control point time-series graphs. The unavailability of any DO data at the control points make determination of their acceptability questionable. Some field samples were collected during a

TABLE 2

ESTIMATED STREAM SYSTEM INPUT DATA

CP \#	TMPIN code	DOIN % sat	BODIN mg/l
100	610.75	96	01/1 -.1
80	560.79	96	01/1 - .5
75	370.78	86	01/1 - .5
50	480.65	83	01/1 - 1
20	310.74	75	01/1 - 1
10	310.74	75	01/1 - 1

LEGEND:

CP = Stream Control Point
TMPIN = Tributary Water Temperature Code
DOIN = Tributary Dissolved Oxygen
BODIN = Tributary Biochemical Oxygen Demand

July 1995 field survey along the mainstem control points to provide some limited confidence in the general magnitude of summer temperature and DO at those points. This set of reproductions needs to be carefully interpreted and considered when drawing conclusions about the impact of the whitewater release on basin-wide water quality from the alternative analysis that follows.

7. Evaluation of Whitewater Alternative

The District's purpose for this modeling effort was to evaluate the water quality impacts of a proposed change in discharge operations. The revised release schedule involves discharges from Flannagan Lake of no more than 800 cfs on each of the first four weekends in October for whitewater recreation. The primary criterion is a streamflow at the Bartlick, Virginia USGS gage of between 1100 and 1300 cfs.

The HEC-5Q would normally be used in an operation mode, as opposed to a calibration mode, for this type of evaluation. The calibration mode requires input of specified discharges and other specific operation decisions. The operation mode uses the programmed operation rule curves to determine an appropriate discharge from each impoundment, instead of the actual release schedule.

Because the recently enhanced HEC-5Q model is still developmental, the operational aspects of the code are not completed. In lieu of this capability, the actual release schedule was simply modified to use the 800 cfs release on the first four weekends in October of each study year. This mean daily discharge is a very conservative value since whitewater releases are never continuous for 24 hours. The impacts associated with this conservative release should be considered extreme.

Appendix I shows the impact of the modified Flannagan releases on the reservoir storage for each study year. The drawdown associated with the increased releases (even the conservative mean daily 800 cfs) can be accommodated within the conservation (water quality) pool during the three study years. Since the study years were selected to include dry and wet periods, it is assumed that the proposed releases will not adversely impact the reservoir operation for authorized purposes in other years. The observed condition flow data was modified for the first four weekends in October of each year to reflect the Flannagan minimum release of 50 cfs instead of the flows actually released. The actual release was part of a pilot whitewater test. This change in observed data provides an appropriate comparison of conditions.

The graphical results showing the impact of this release on the Flannagan depth-temperature and depth-DO profiles are provided in Appendix J. The only observed profiles during the period of potential impact are on October 20, 1994. The profiles from this date show the cumulative impact of whitewater releases from the first three weekends. The thermal impact is less than one degree Celsius from 50 to 170 feet of depth with no measurable impact in the epilimnion. The DO impact is less than one mg/l except in the metalimnion. The DO impact in the metalimnion is difficult to evaluate numerically because of the algal problems discussed in the calibration section of this report.

Appendix K shows the impact of the modified Flannagan release on the discharge temperature and DO into the Pound River for each of the study years. The thermal impact for the 1987 operation is the release of water temperature about three degrees Celsius above the non-whitewater release on October 27 with less impact the remainder of the October 3 to mid-November period. The 1988 operations would have released warmer water of up to six degrees Celsius. The impact would have started on October 1 and peaked on October 25 with a gradual decrease in impact to early December. Thermal impact in the 1994 period would have been considerably reduced to slightly more than one degree Celsius around November 1 with less effect during the October 1 to mid-November period.

Also shown in Appendix K are the graphs of DO that result from the whitewater releases. The impact is insignificant (less than 0.2 mg/l).

The results of the impact of the thermally effected Flannagan releases on the rest of the basin are shown at each downstream control point in Appendix L. Those impacts are insignificant (less than 0.4 mg/l) for all three years at CP100 (near Pikeville, Kentucky) and all downstream locations including the confluence of the Ohio River. Although the changes in the Flannagan release DO were insignificant, some minor DO impacts at downstream locations can be seen due to changes in turbulence at the higher releases associated with the whitewater operation.

In general, the impacts of the whitewater releases on the water quality immediately below Flannagan are predicted to be minimal with no significant impacts more than a few miles below the dam.

8. Summary

The Big Sandy River Study was performed to evaluate the possible impacts associated with making whitewater releases from the Flannagan Lake conservation pool during the first four weekends in October. Three study years were selected to encompass dry and wet historical periods.

The amount of the maximum release, 800 cfs, was provided by Huntington District. The normal low-flow requirement is 50 cfs. The impact is to cause a significant drawdown on the reservoir pool in October. The drawdown does not impact the reservoir's authorized purposes. The reservoir water quality profiles (temperature and DO) are affected slightly and the water temperature of the release is modified a few degrees. The release water temperature has no significant impact downstream, except for a few miles, and no discernable impact at Pikeville. The release DO has no significant impact below the tailwater area.

9. References

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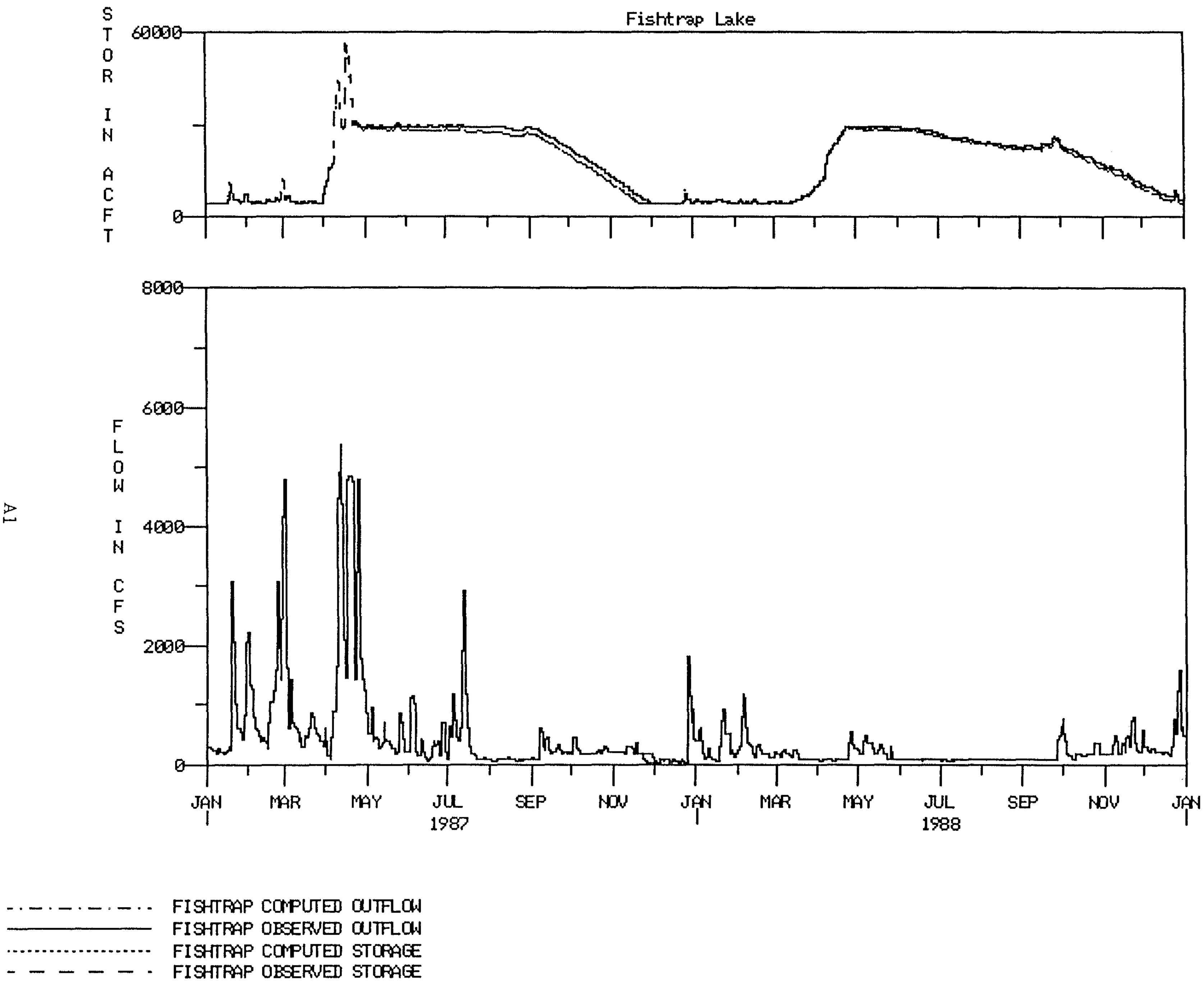
Hydrologic Engineering Center (HEC). (1995). "HEC-DSS, User's Guide and Utility Manuals," CPD-45 User's Manual, Davis, California.

Hydrologic Engineering Center (HEC). (1996). "HEC-5 Simulation of Flood Control and Conservation Systems, Appendix on Water Quality Analysis," CPD-5Q User's Manual, Davis, California.

Appendix A

Calibration of Discharge and Reservoir Storage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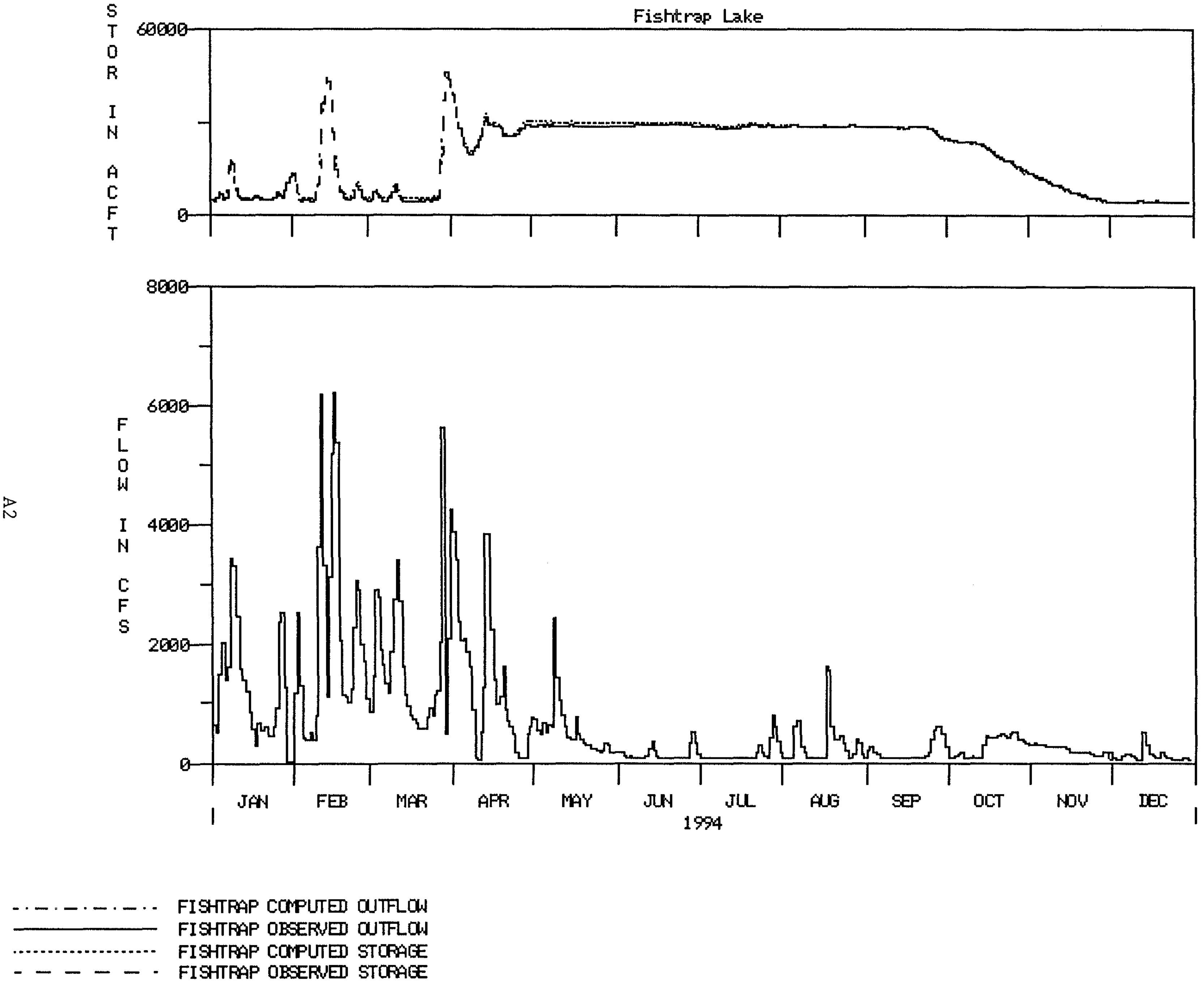
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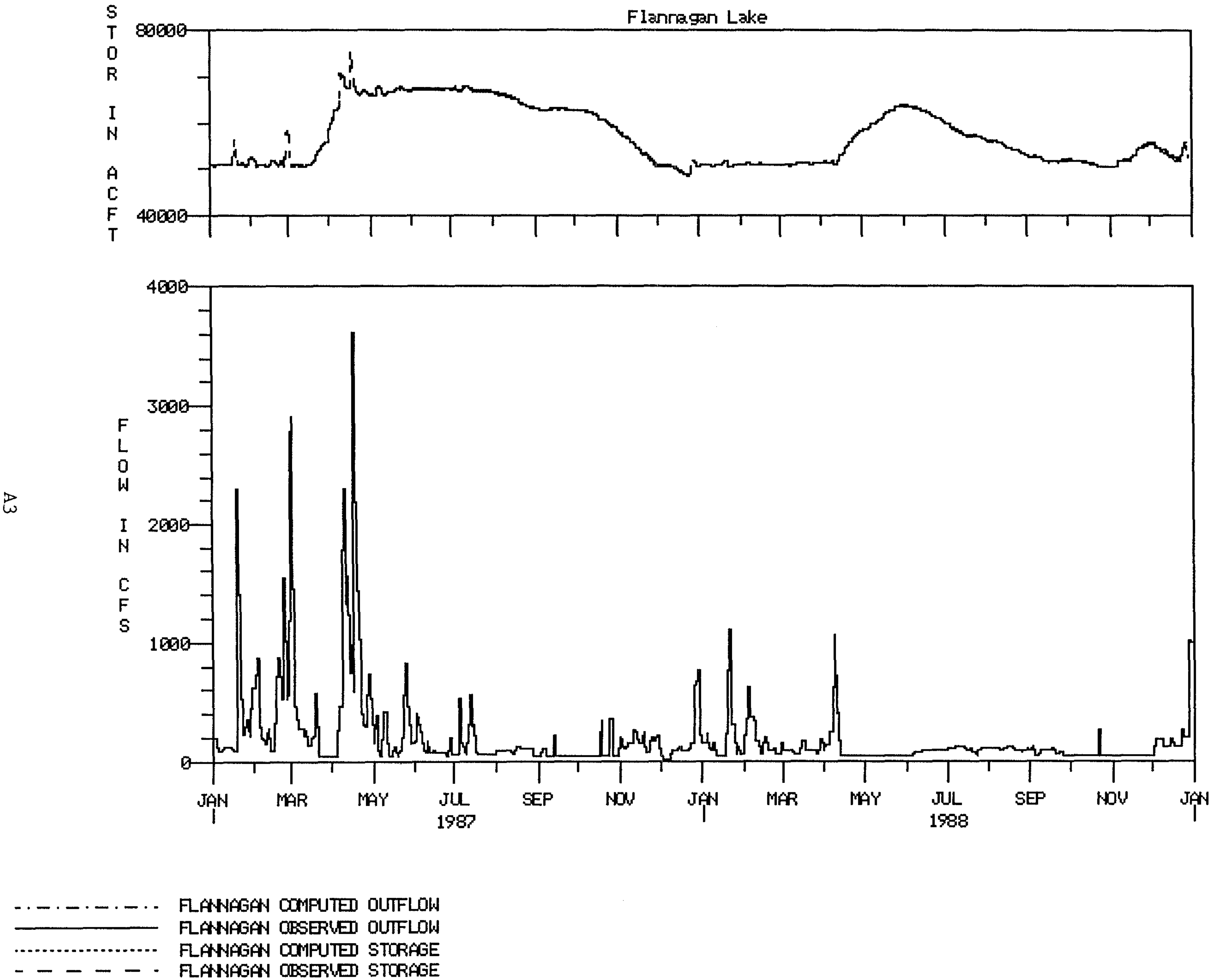

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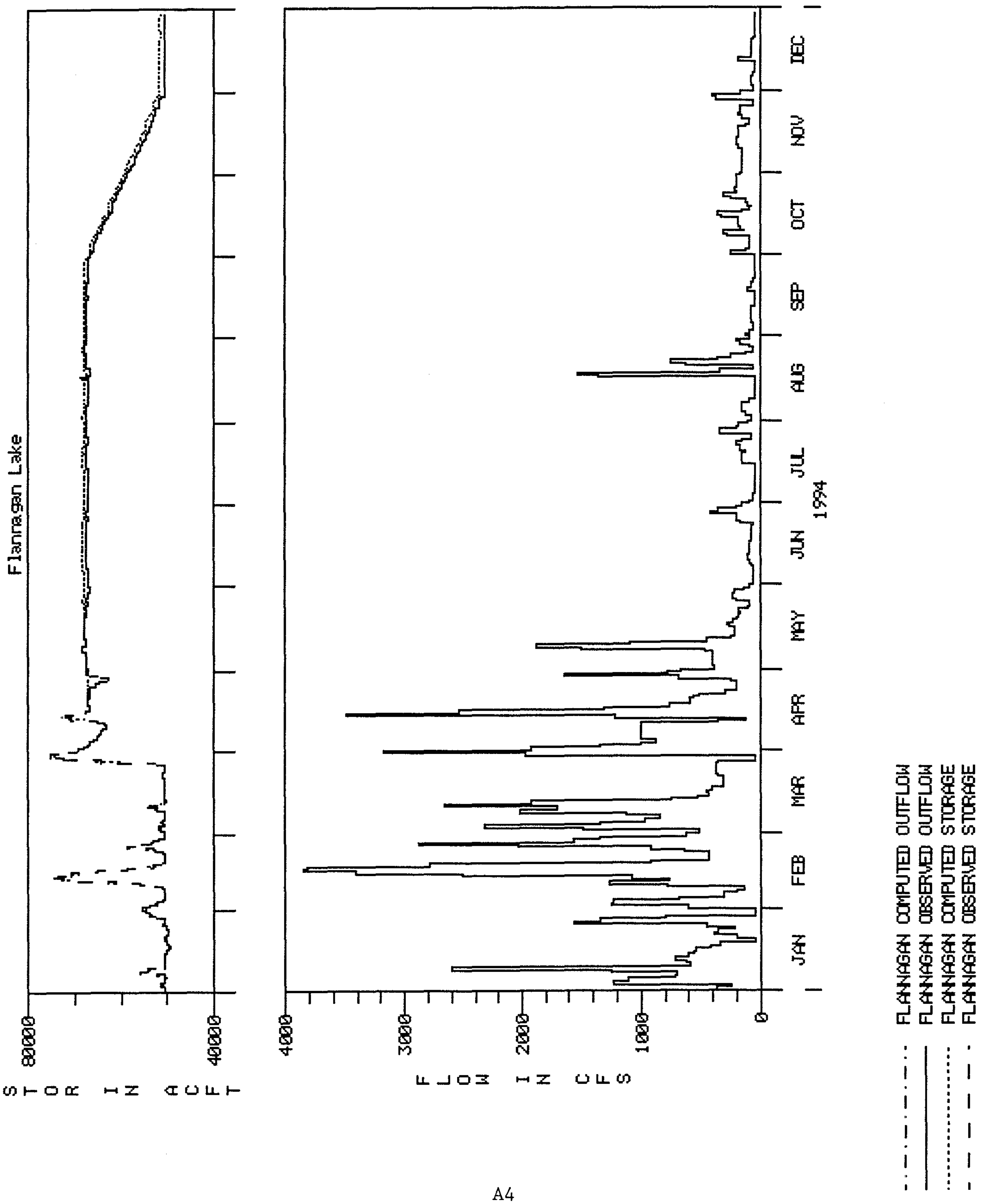
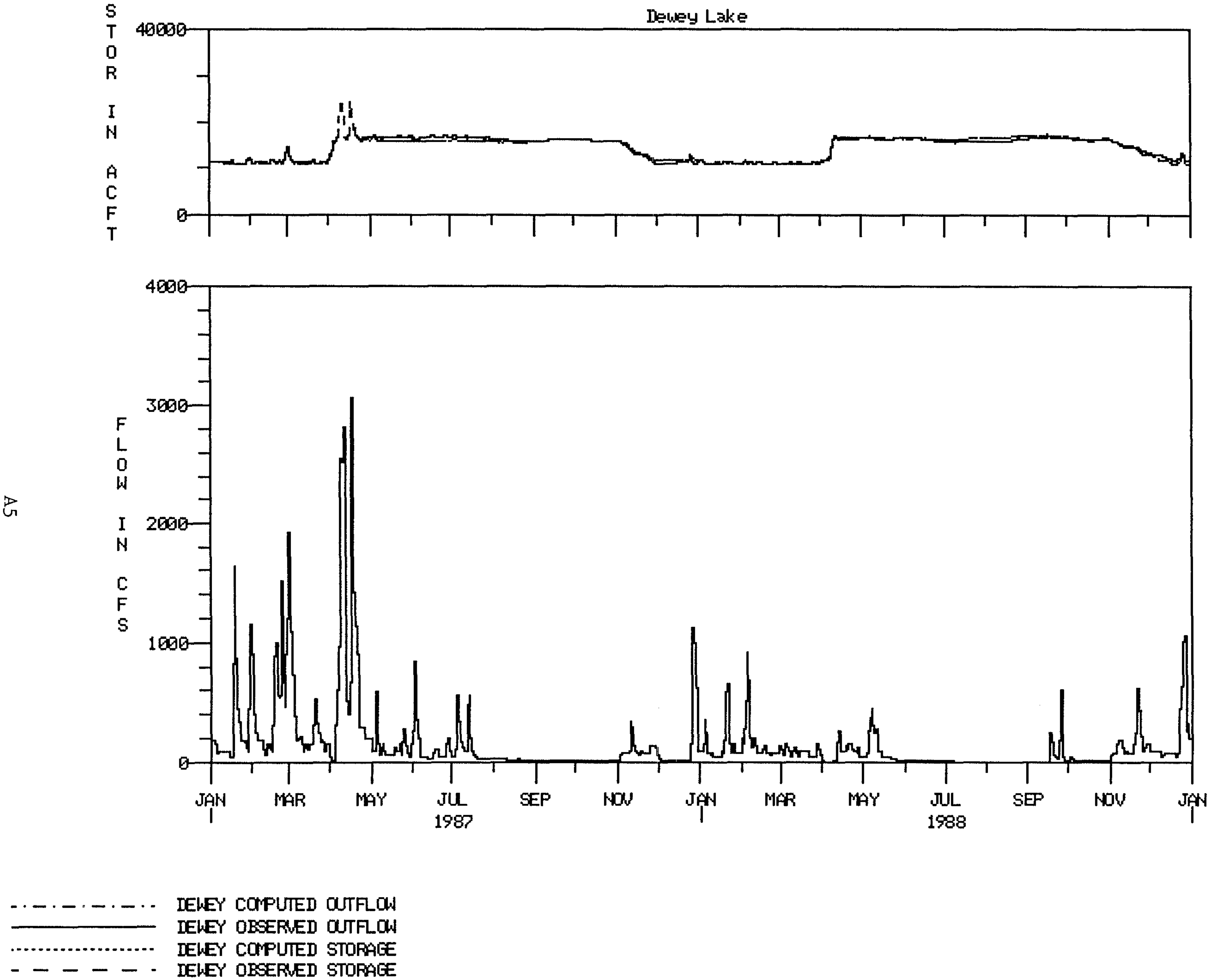
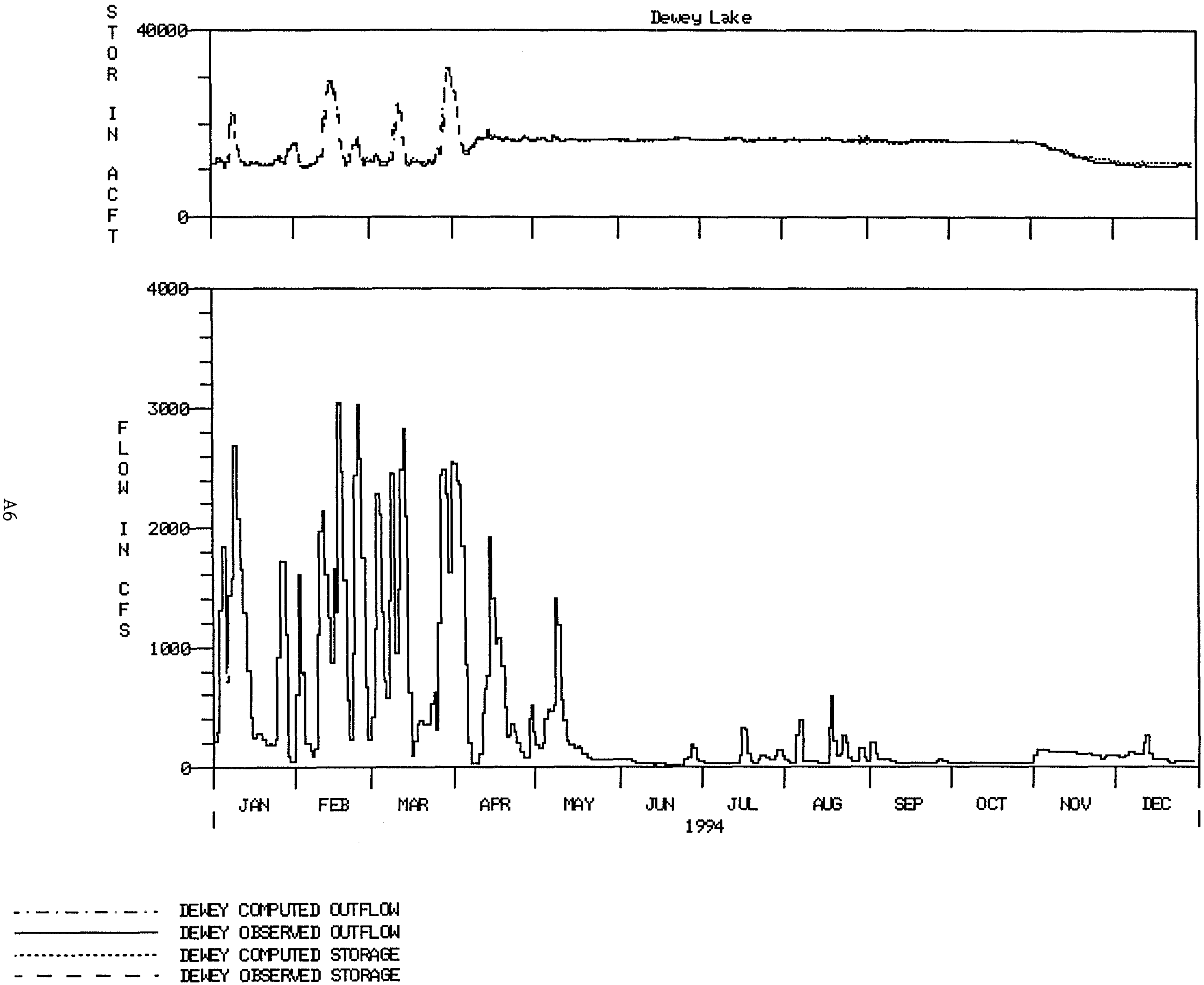
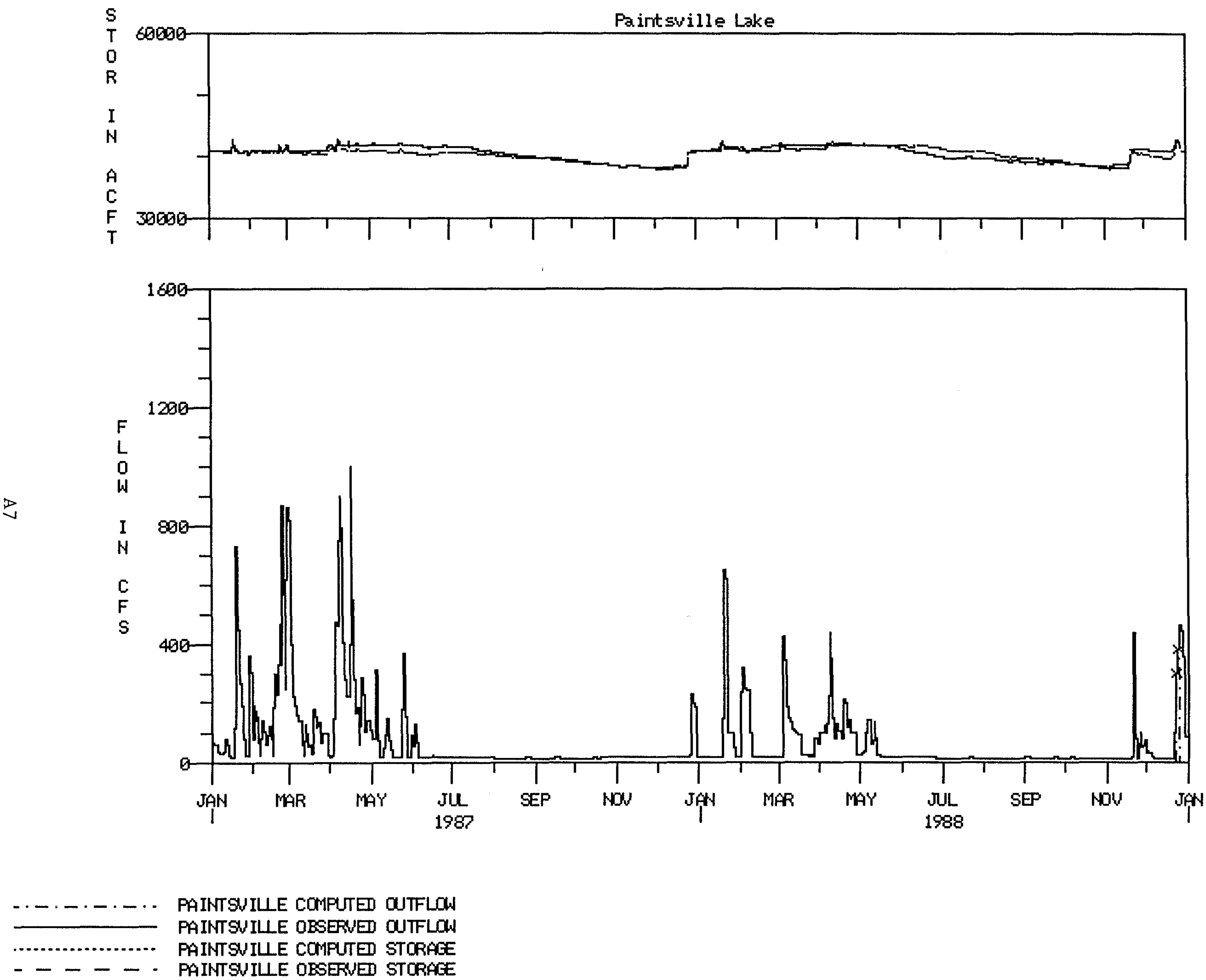
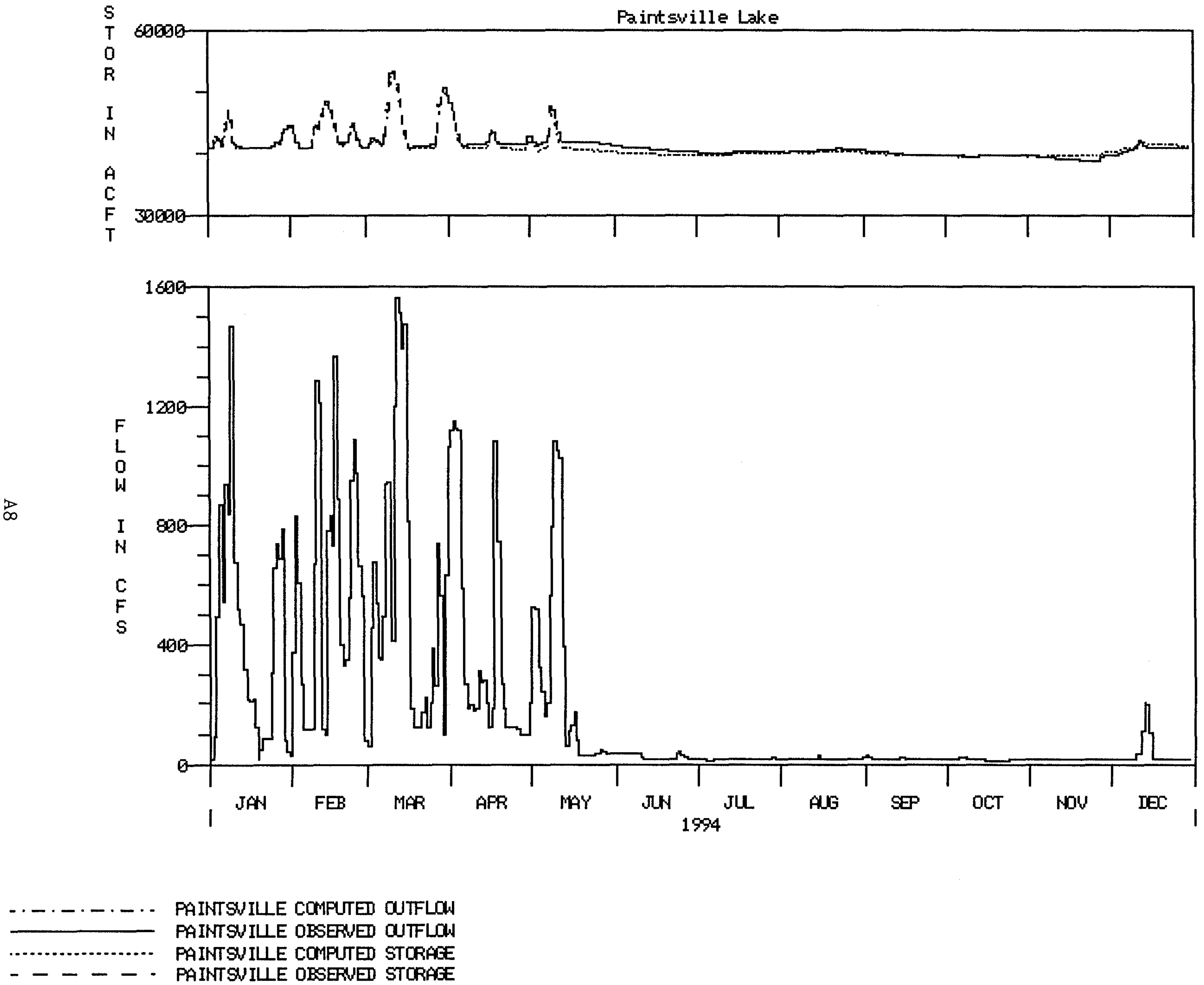
FLANNAGAN COMPUTED OUTFLOW
FLANNAGAN OBSERVED OUTFLOW
FLANNAGAN COMPUTED STORAGE
FLANNAGAN OBSERVED STORAGE


Flannagan Lake
STOR IN AC FT
80000
40000
FLOW IN CFS
4000
3000
2000
1000
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1994
FLANNAGAN COMPUTED OUTFLOW
FLANNAGAN OBSERVED OUTFLOW
FLANNAGAN COMPUTED STORAGE
FLANNAGAN OBSERVED STORAGE

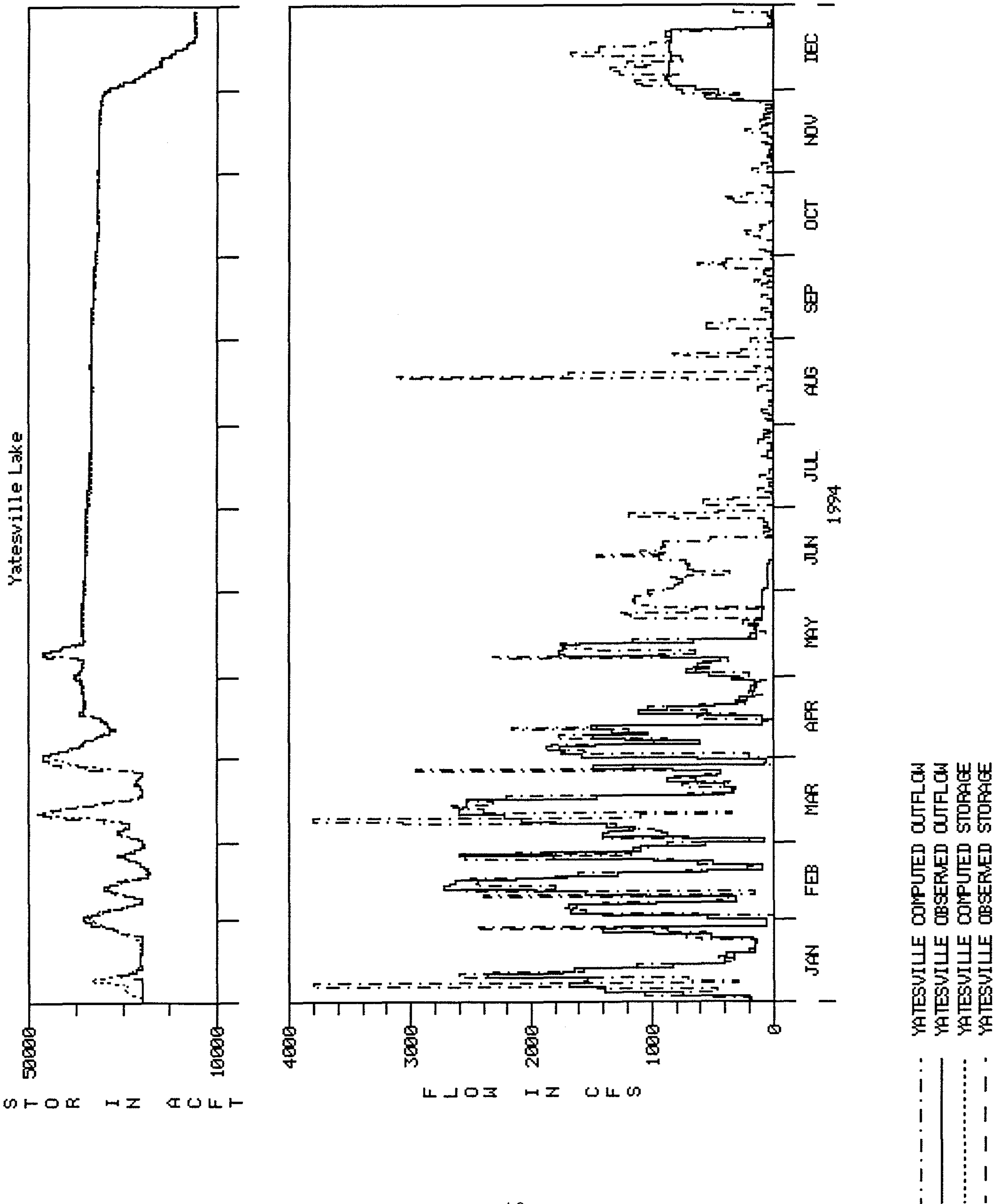

Dewey Lake
STOR IN ACFT
40000
0
FLOW IN CFS
4000
3000
2000
1000
0
JAN MAR MAY JUL SEP NOV JAN MAR MAY JUL SEP NOV JAN
1987
1988
DEWEY COMPUTED OUTFLOW
DEWEY OBSERVED OUTFLOW
DEWEY COMPUTED STORAGE
DEWEY OBSERVED STORAGE


Dewey Lake
STOR IN ACFT
40000
0
FLOW IN CFS
4000
3000
2000
1000
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1994
DEWEY COMPUTED OUTFLOW
DEWEY OBSERVED OUTFLOW
DEWEY COMPUTED STORAGE
DEWEY OBSERVED STORAGE


Paintsville Lake
STOR IN ACFT
60000
30000
FLOW IN CFS
1600
1200
800
400
0
JAN
MAR
MAY
JUL
SEP
NOV
JAN
MAR
MAY
JUL
SEP
NOV
JAN
1987
1988
PAINTSVILLE COMPUTED OUTFLOW
PAINTSVILLE OBSERVED OUTFLOW
PAINTSVILLE COMPUTED STORAGE
PAINTSVILLE OBSERVED STORAGE



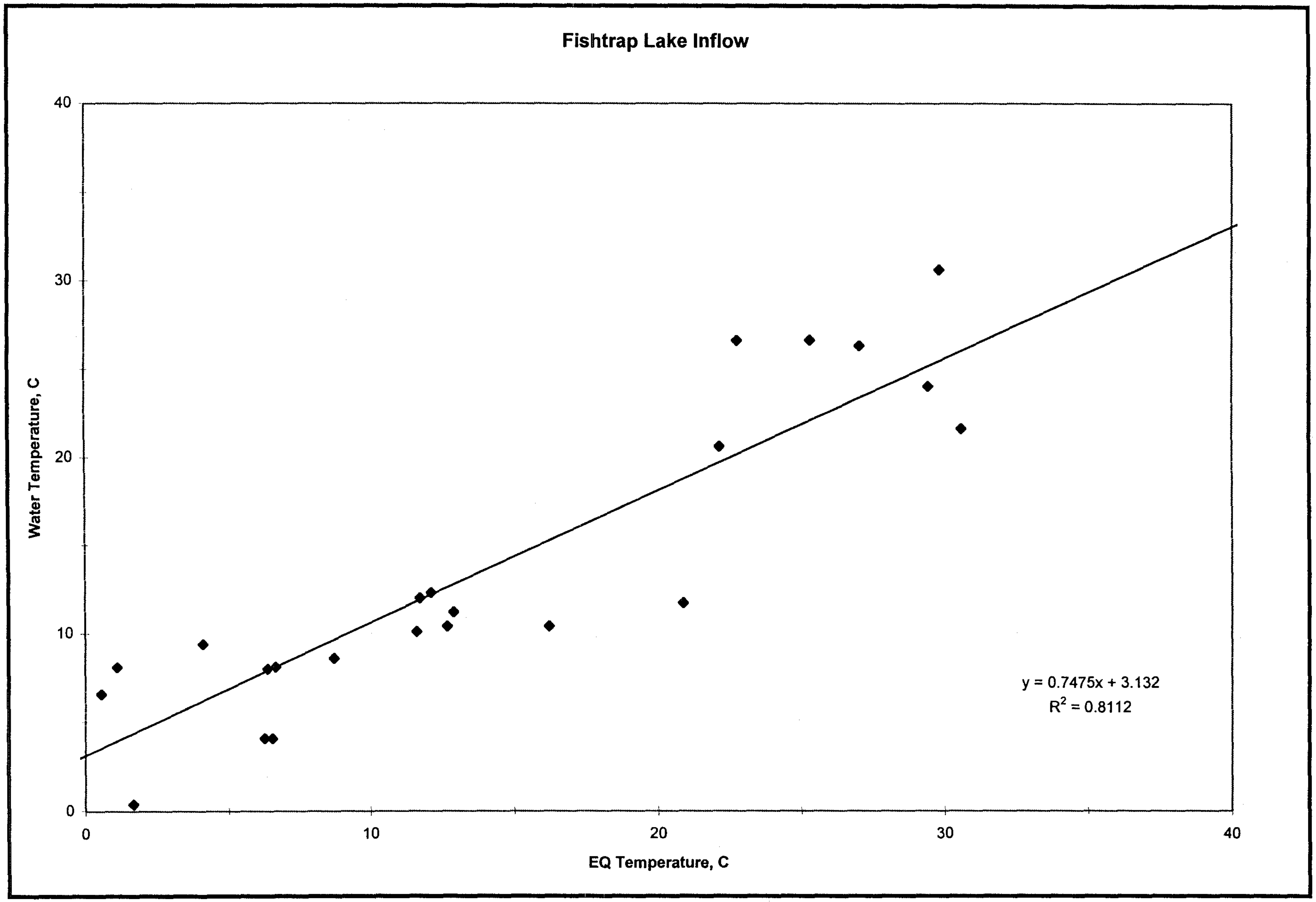
Paintsville Lake
STOR IN ACFT
60000
30000
FLOW IN CFS
1600
1200
800
400
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1994
PAINTSVILLE COMPUTED OUTFLOW
PAINTSVILLE OBSERVED OUTFLOW
PAINTSVILLE COMPUTED STORAGE
PAINTSVILLE OBSERVED STORAGE



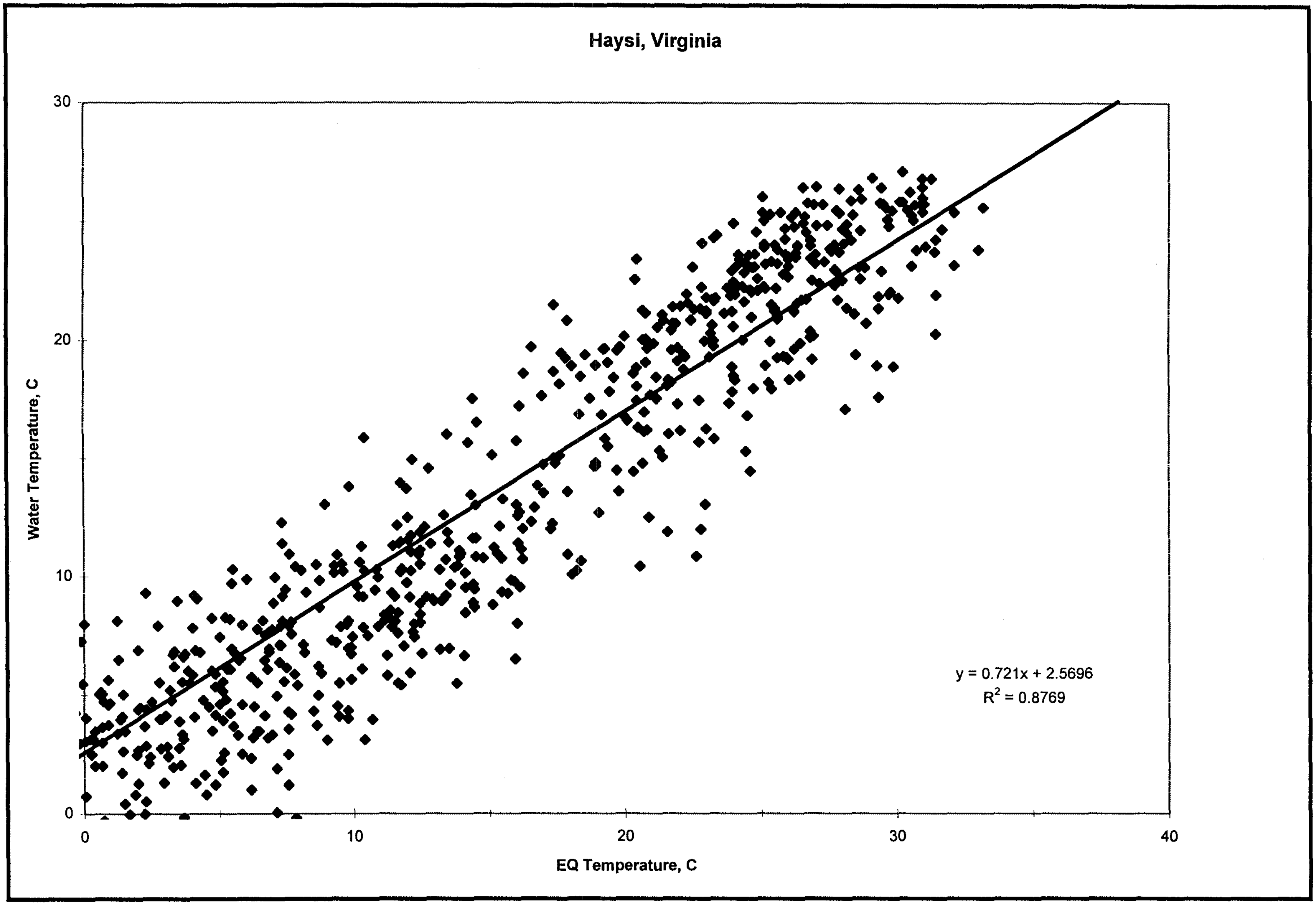
Yatesville Lake
STOR IN AC FT
50000
10000
FLOW IN CFS
4000
3000
2000
1000
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1994
YATESVILLE COMPUTED OUTFLOW
YATESVILLE OBSERVED OUTFLOW
YATESVILLE COMPUTED STORAGE
YATESVILLE OBSERVED STORAGE

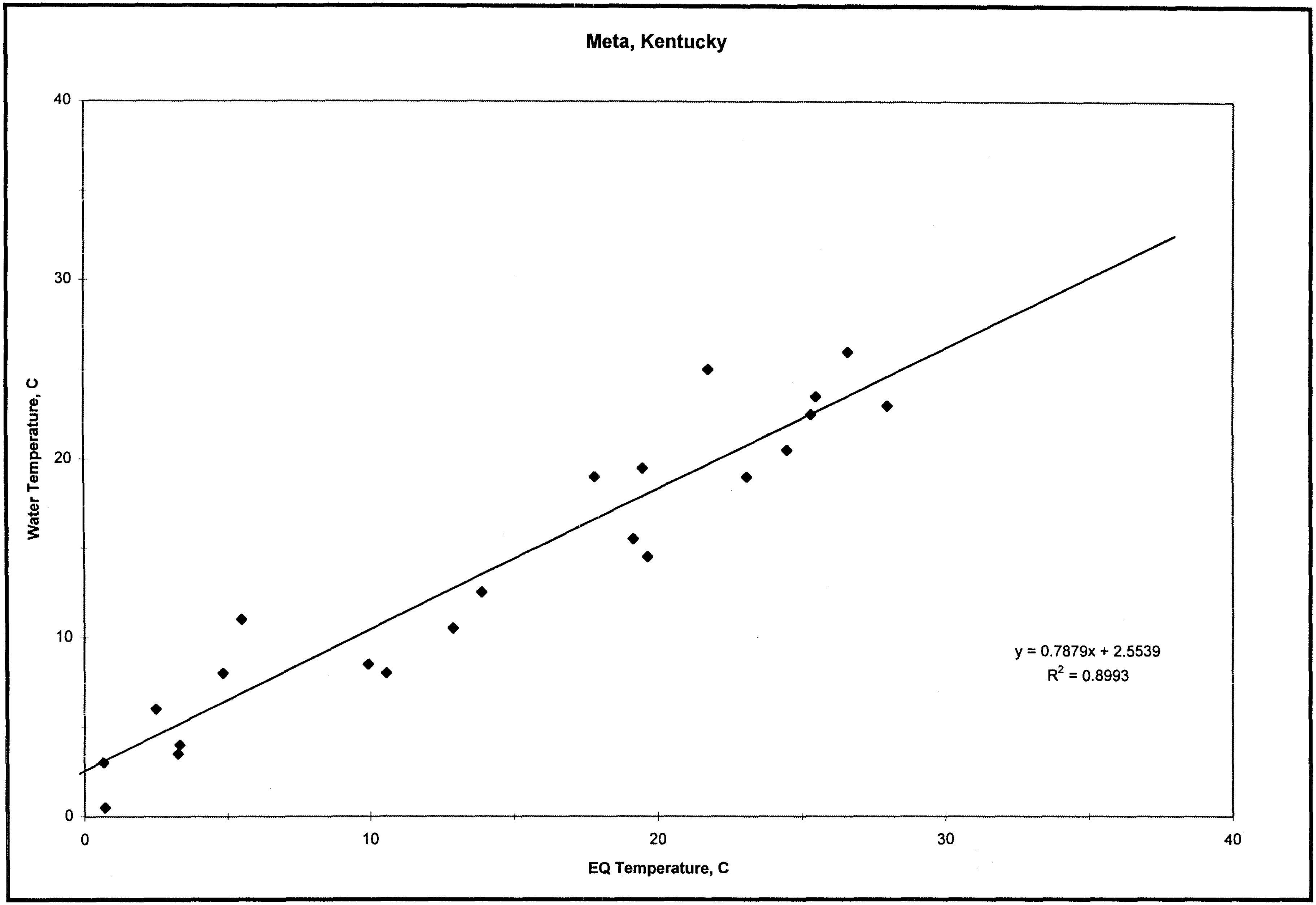
Appendix B

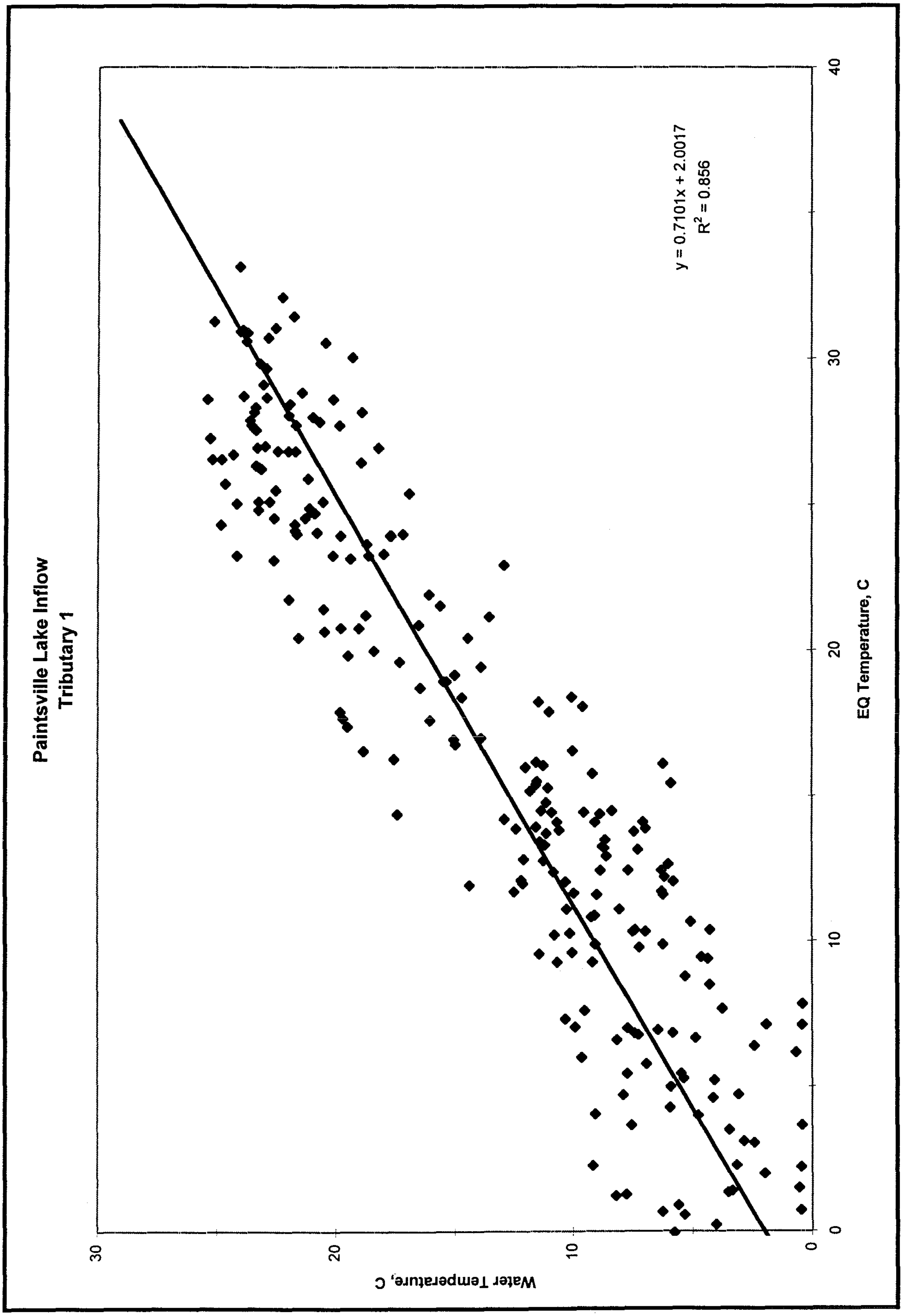
Regression Analysis of
Stream Temperature versus Equilibrium Temperature

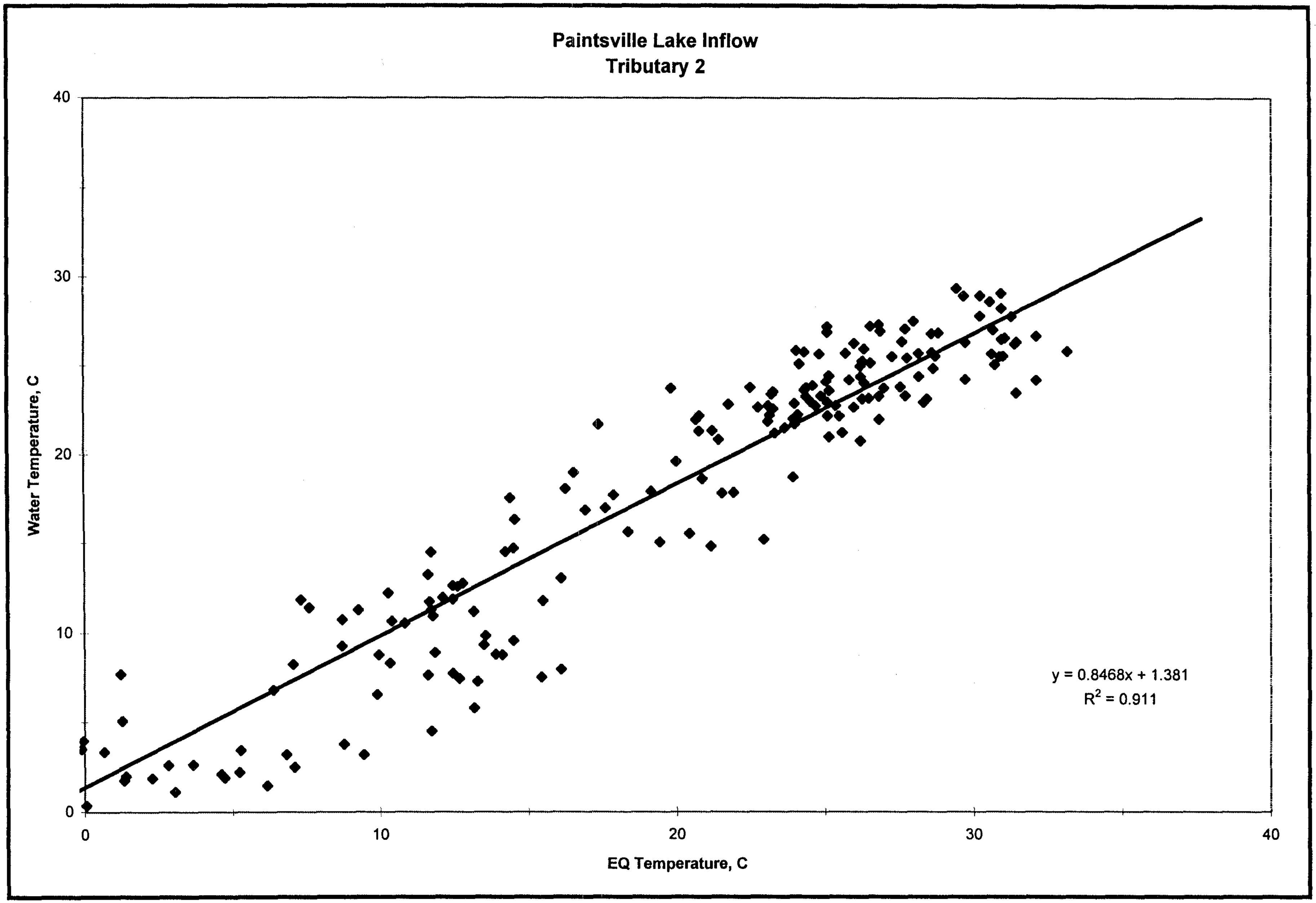


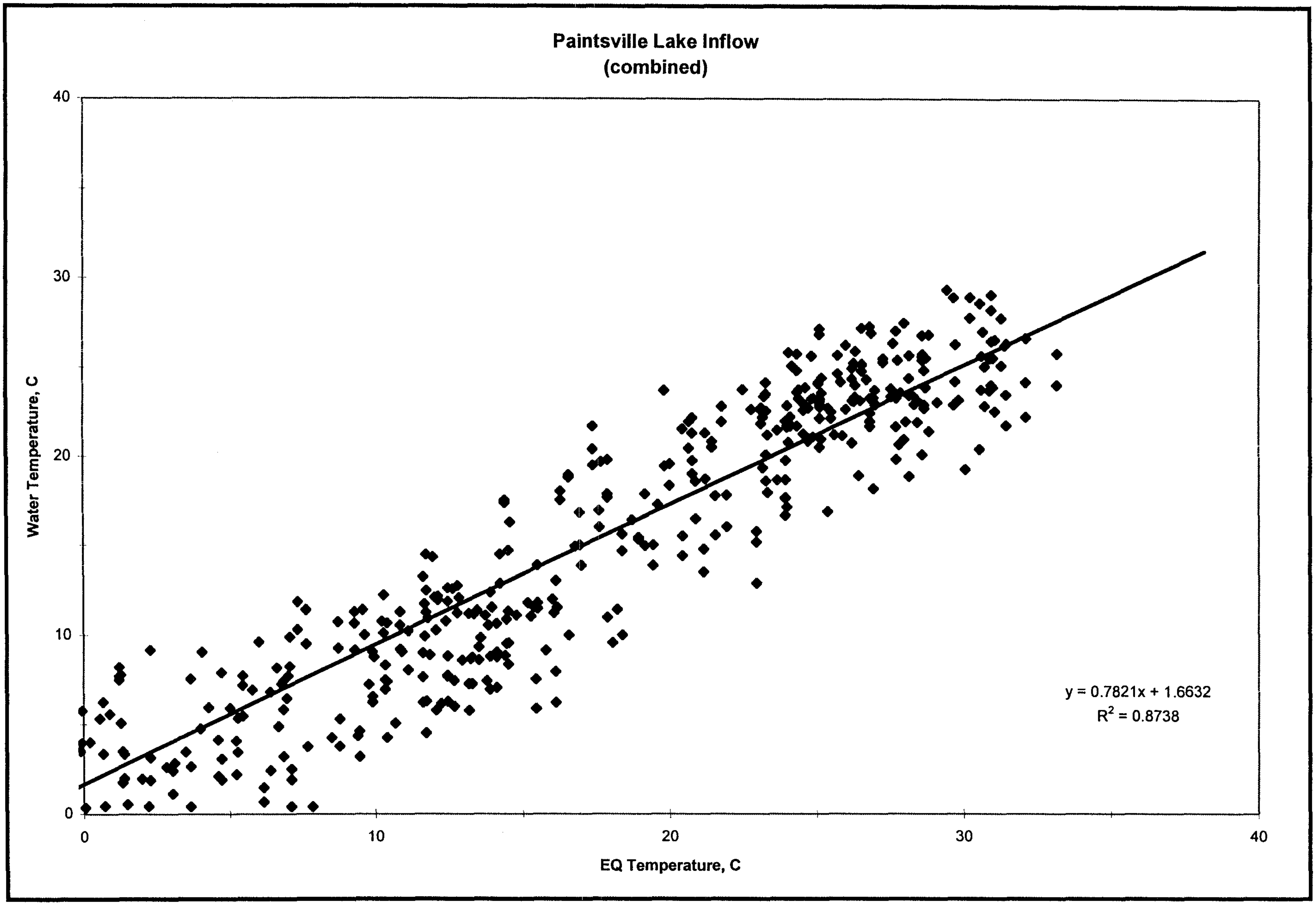
Fishtrap Lake Inflow
40
30
20
10
0
0
10
20
30
40
Water Temperature, C
EQ Temperature, C
y = 0.7475x + 3.132
R2 = 0.8112


Haysi, Virginia
Water Temperature, C
EQ Temperature, C
y = 0.721x + 2.5696
R2 = 0.8769
0
10
20
30
40

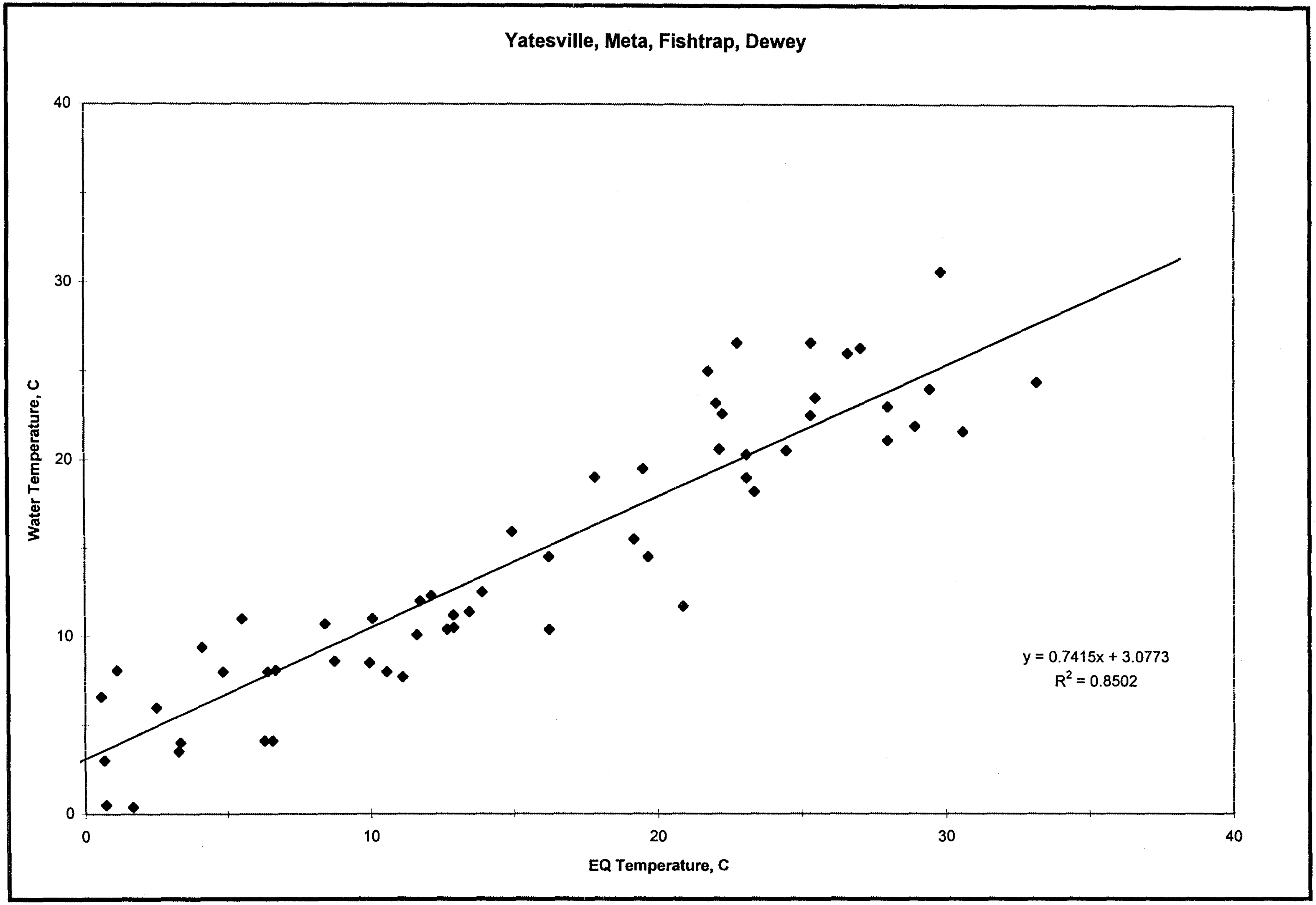

Meta, Kentucky
40
30
20
10
0
0
10
20
30
40
Water Temperature, C
EQ Temperature, C
y = 0.7879x + 2.5539
R^2 = 0.8993


Paintsville Lake Inflow
Tributary 1
y = 0.7101x + 2.0017
R2 = 0.856
Water Temperature, C
EQ Temperature, C
0
10
20
30
0
10
20
30
40

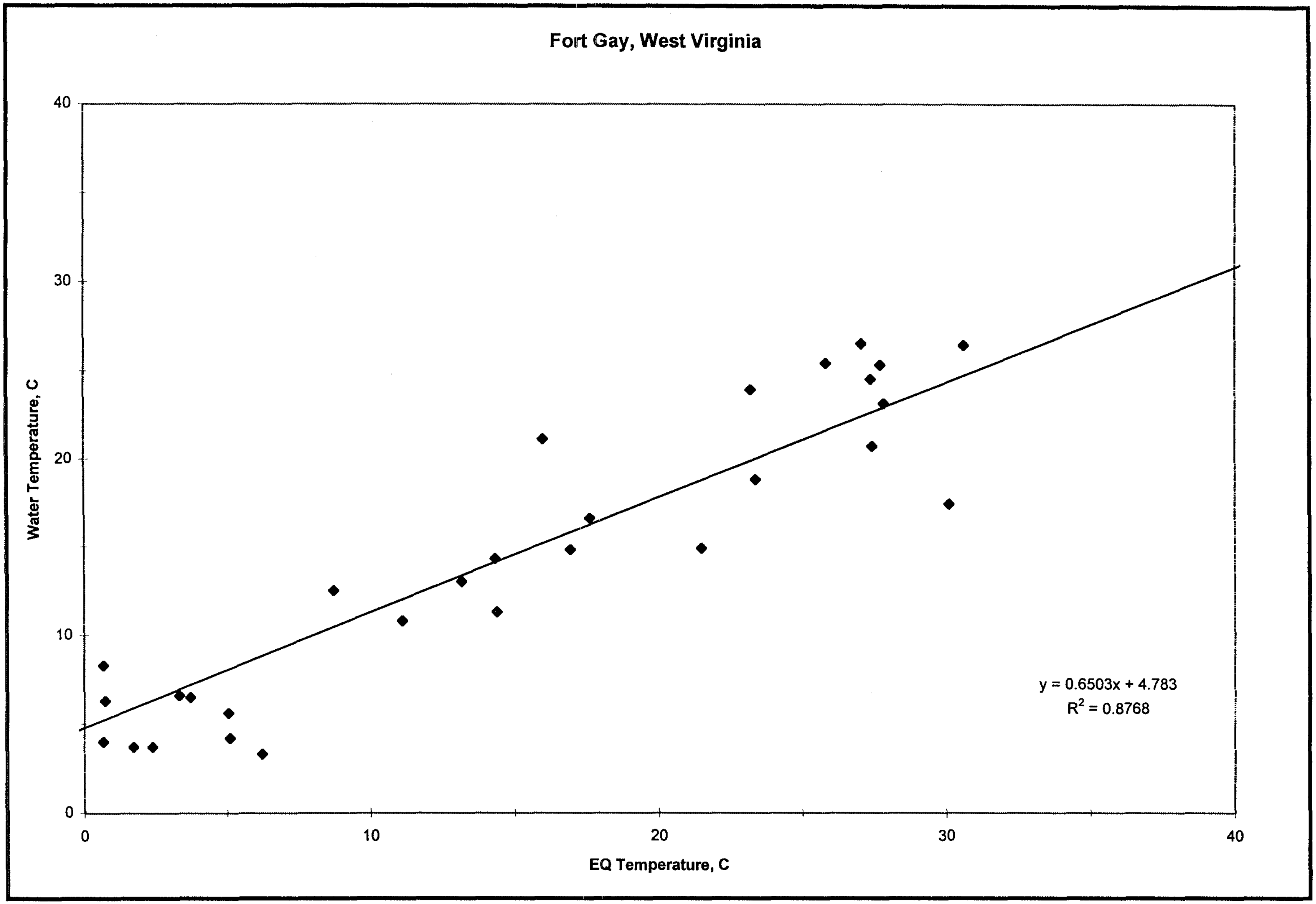

Paintsville Lake Inflow
Tributary 2
Water Temperature, C
EQ Temperature, C
0
10
20
30
40
0
10
20
30
40
y = 0.8468x + 1.381
R2 = 0.911



Paintsville Lake Inflow
(combined)
Water Temperature, C
EQ Temperature, C
0
10
20
30
40
y = 0.7821x + 1.6632
R^2 = 0.8738

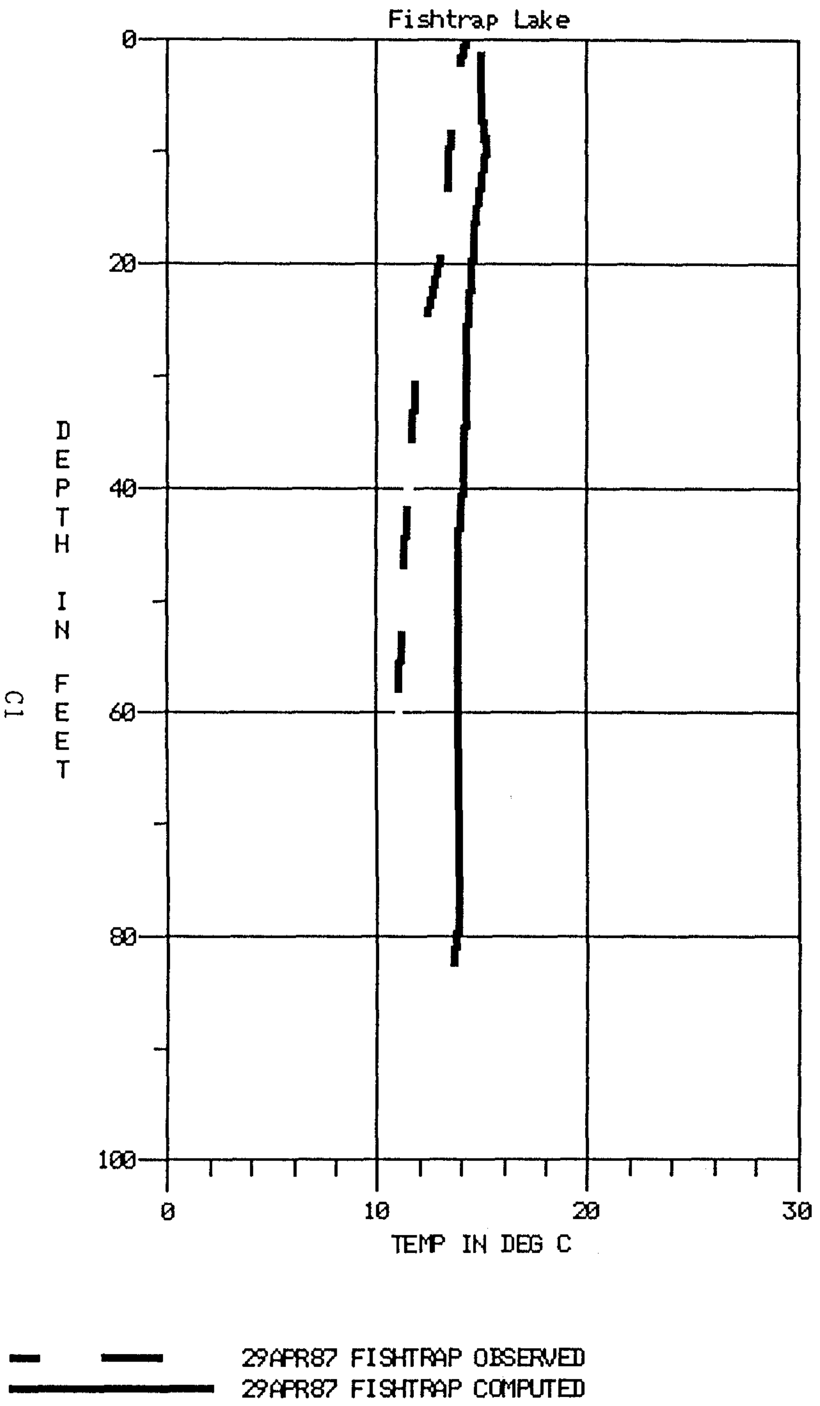


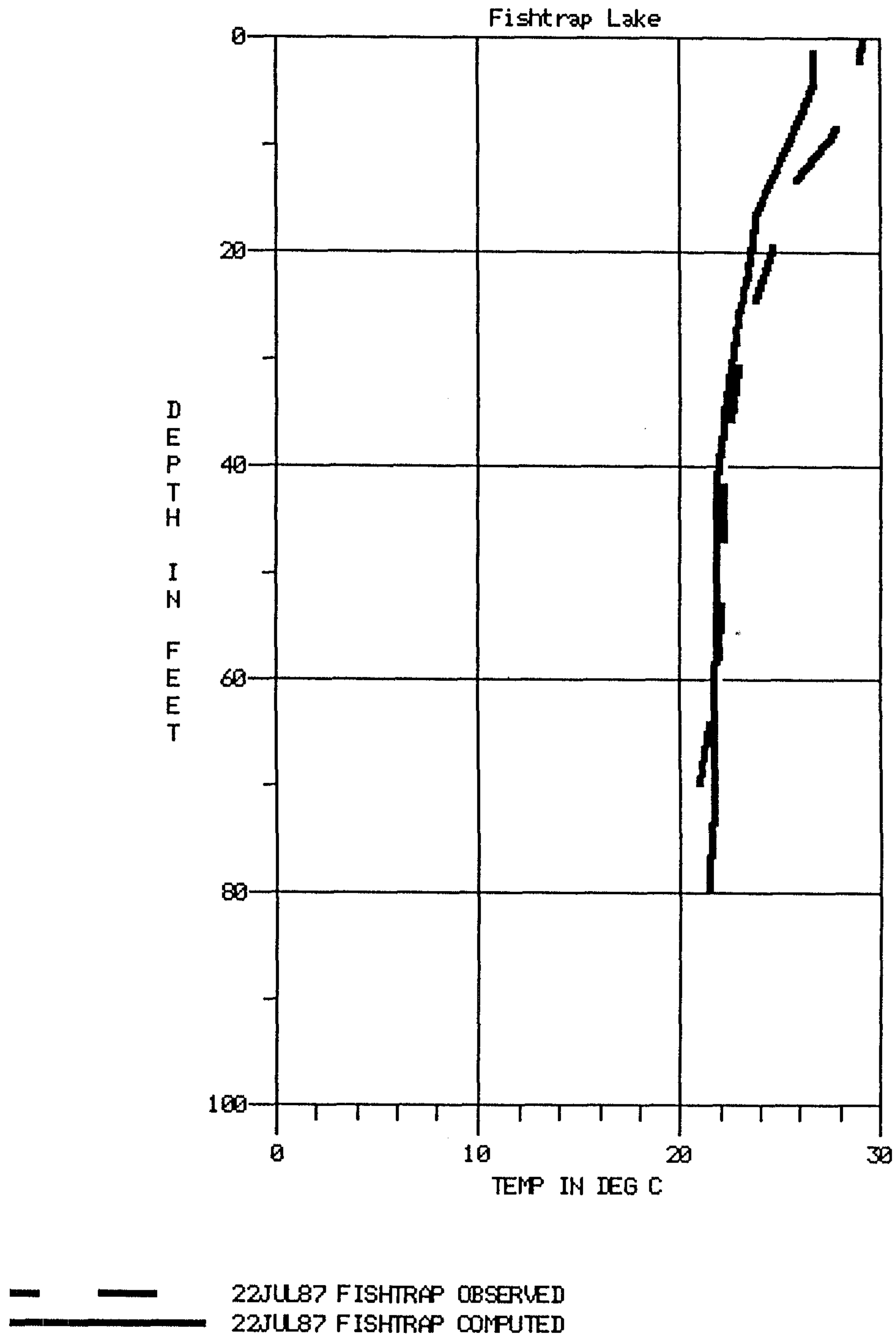
Yatesville, Meta, Fishtrap, Dewey
Water Temperature, C
EQ Temperature, C
0
10
20
30
40
y = 0.7415x + 3.0773
R^2 = 0.8502

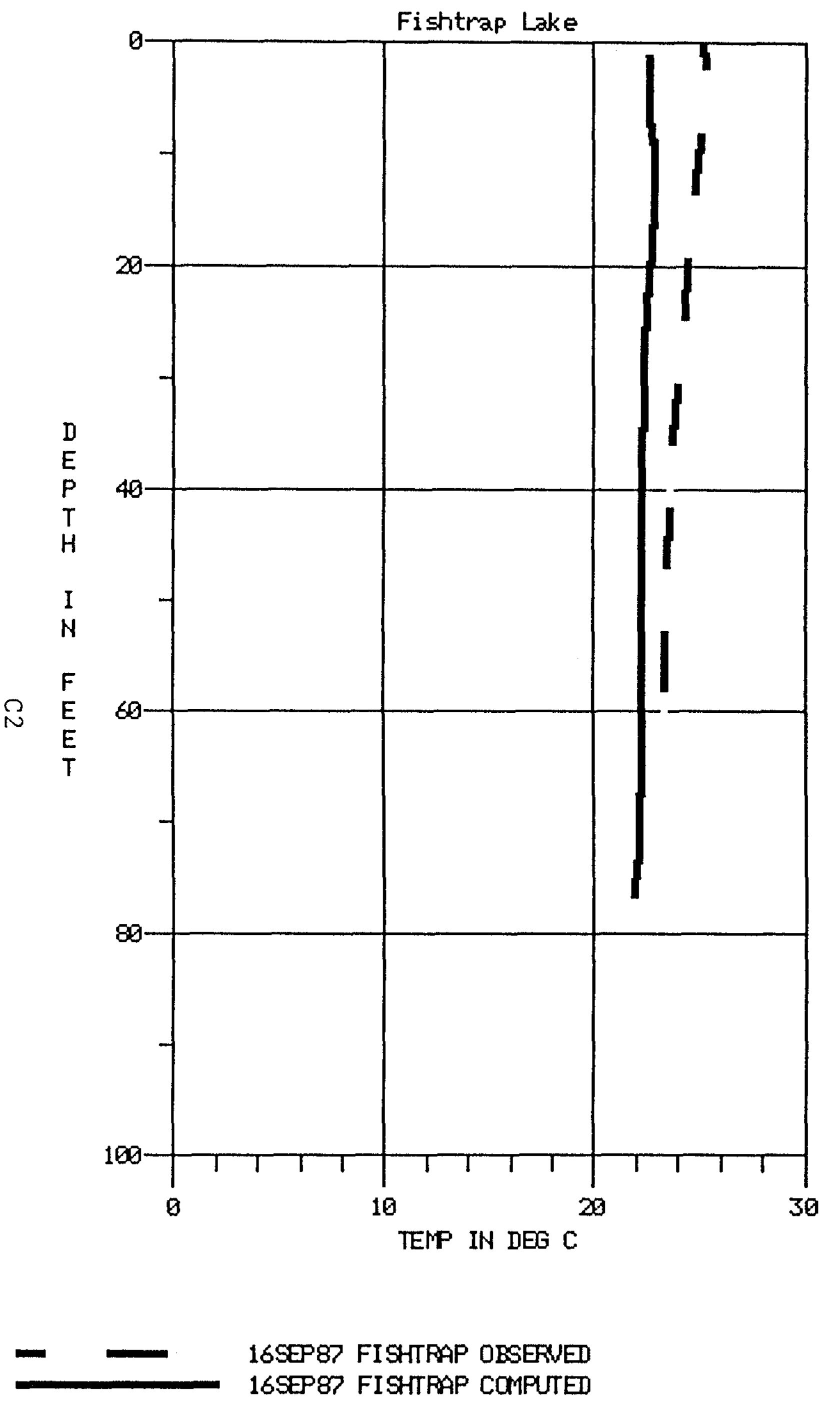

Fort Gay, West Virginia
Water Temperature, C
EQ Temperature, C
0
10
20
30
40
y = 0.6503x + 4.783
R2 = 0.8768

Appendix C

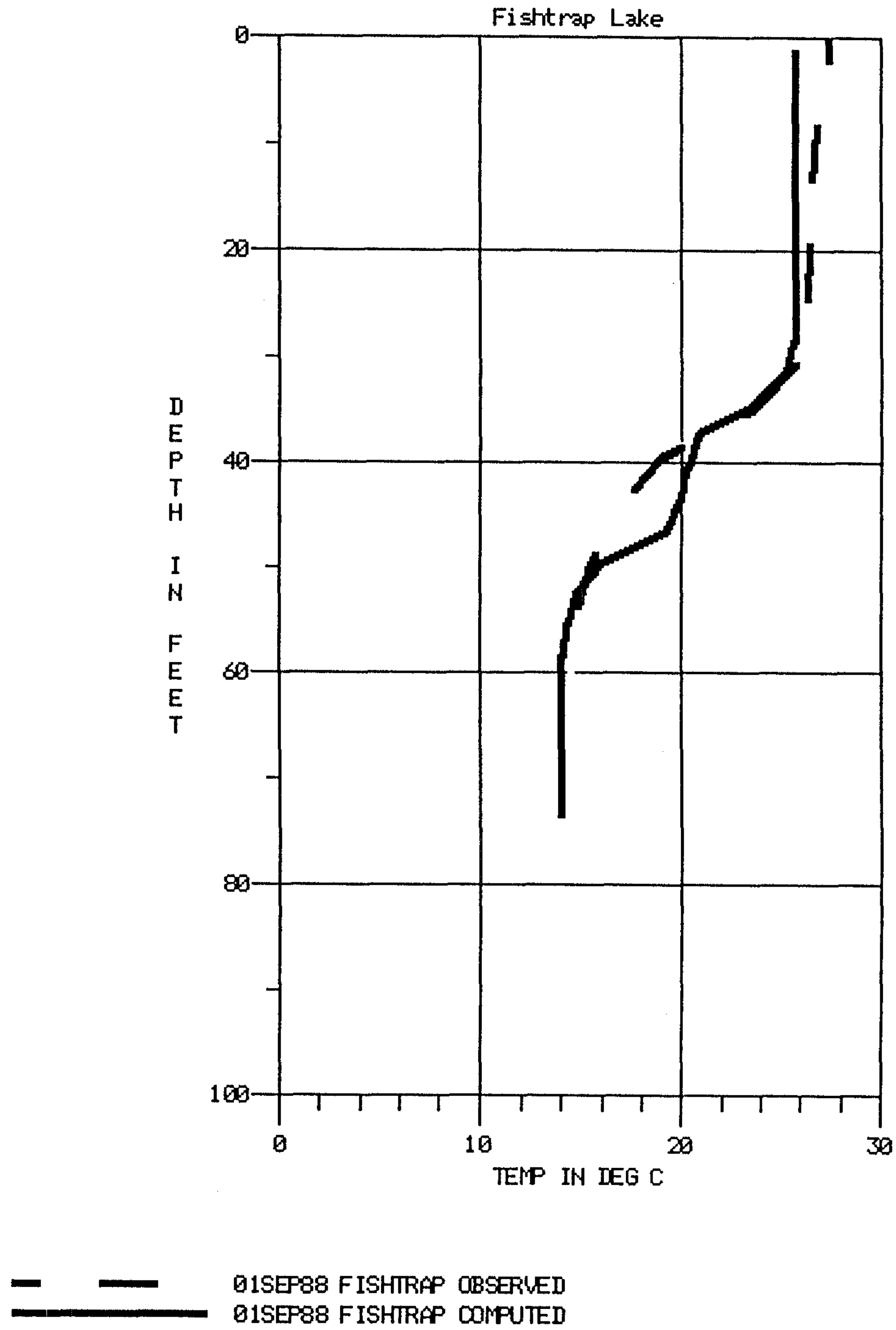
Calibration of Reservoir Temperature Profiles


Fishtrap Lake
DEPTH IN FEET
0
20
40
60
80
100
0
10
20
30
TEMP IN DEG C
29APR87 FISHTRAP OBSERVED
29APR87 FISHTRAP COMPUTED

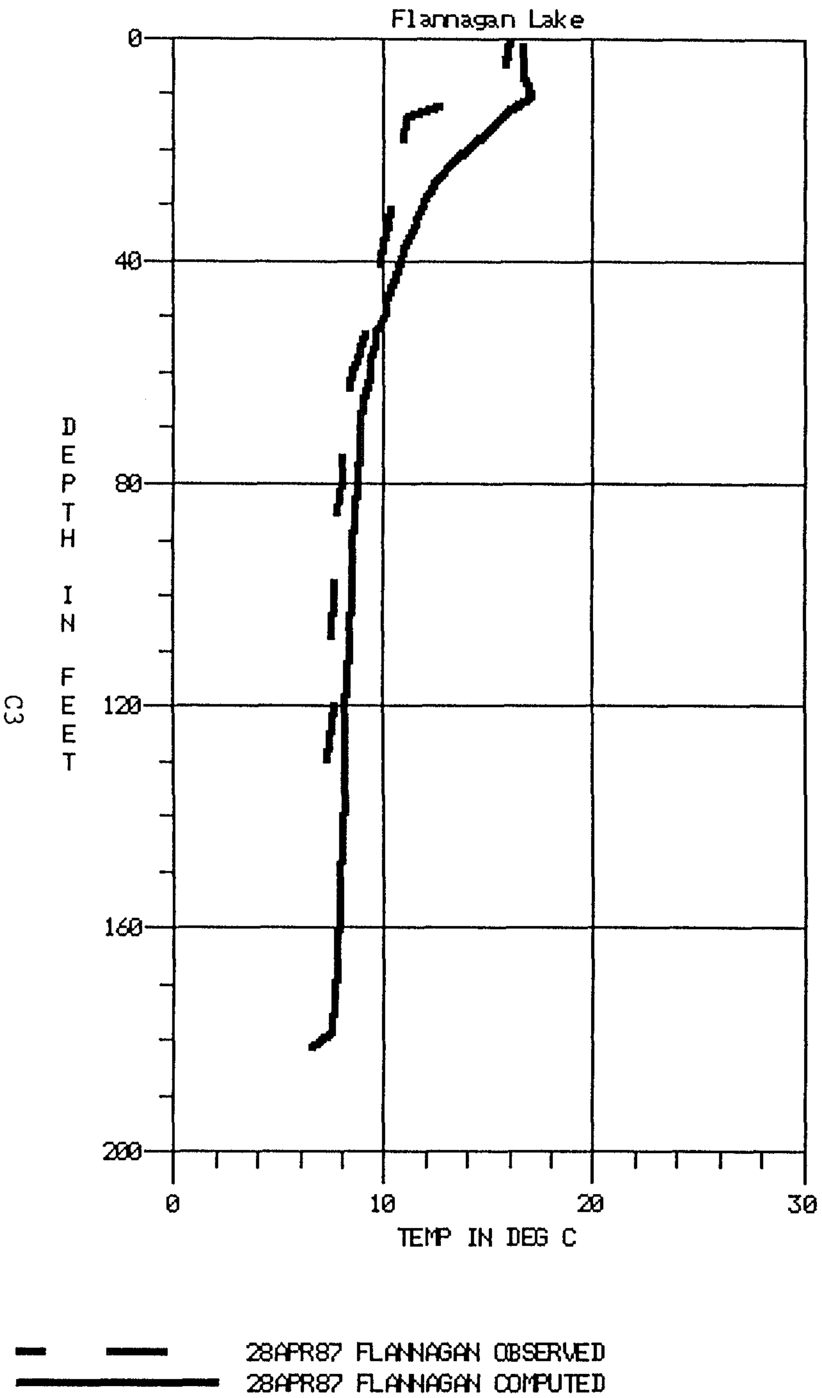

Fishtrap Lake
DEPTH IN FEET
0
20
40
60
80
100
0
10
20
30
TEMP IN DEG C
22JUL87 FISHTRAP OBSERVED
22JUL87 FISHTRAP COMPUTED

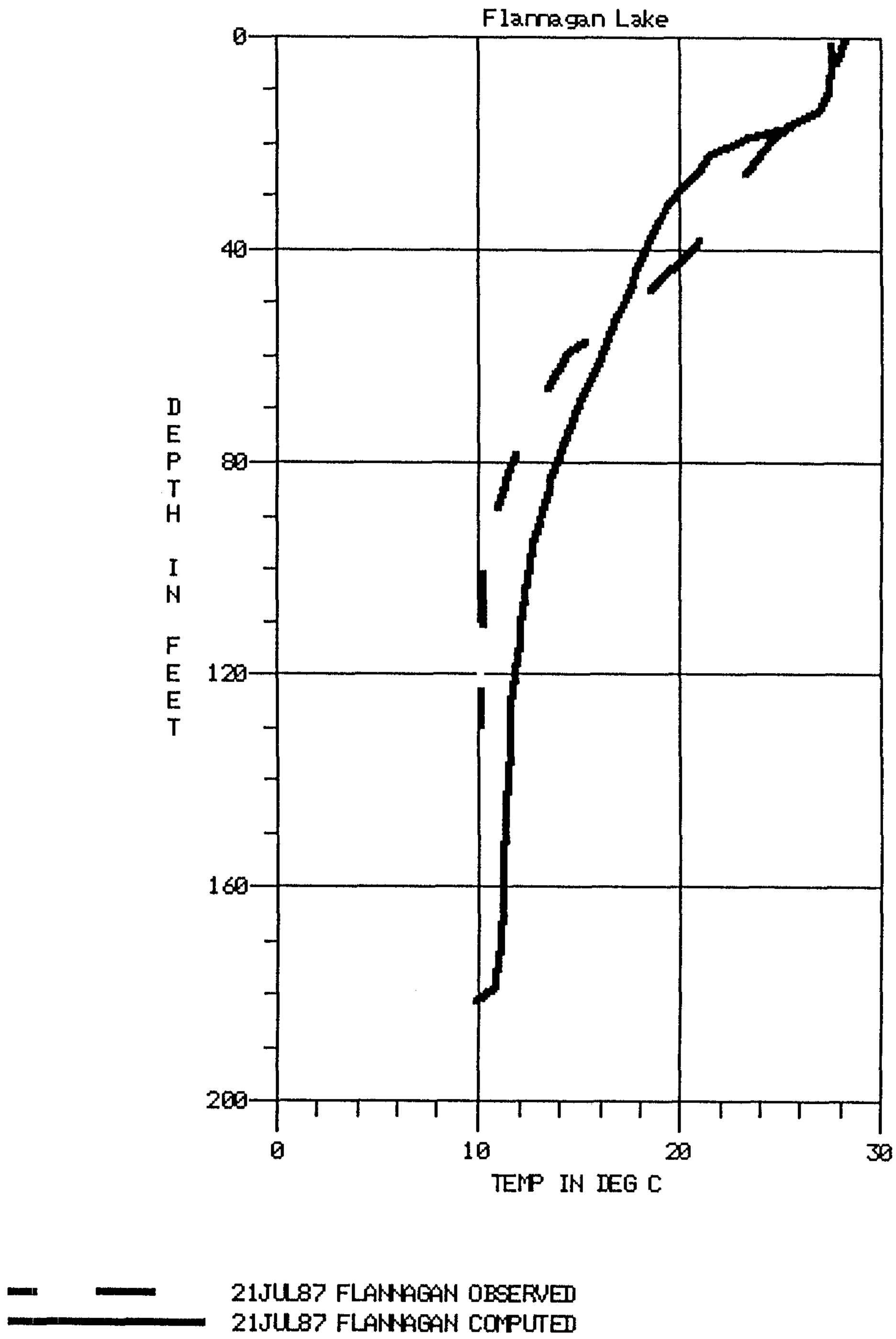


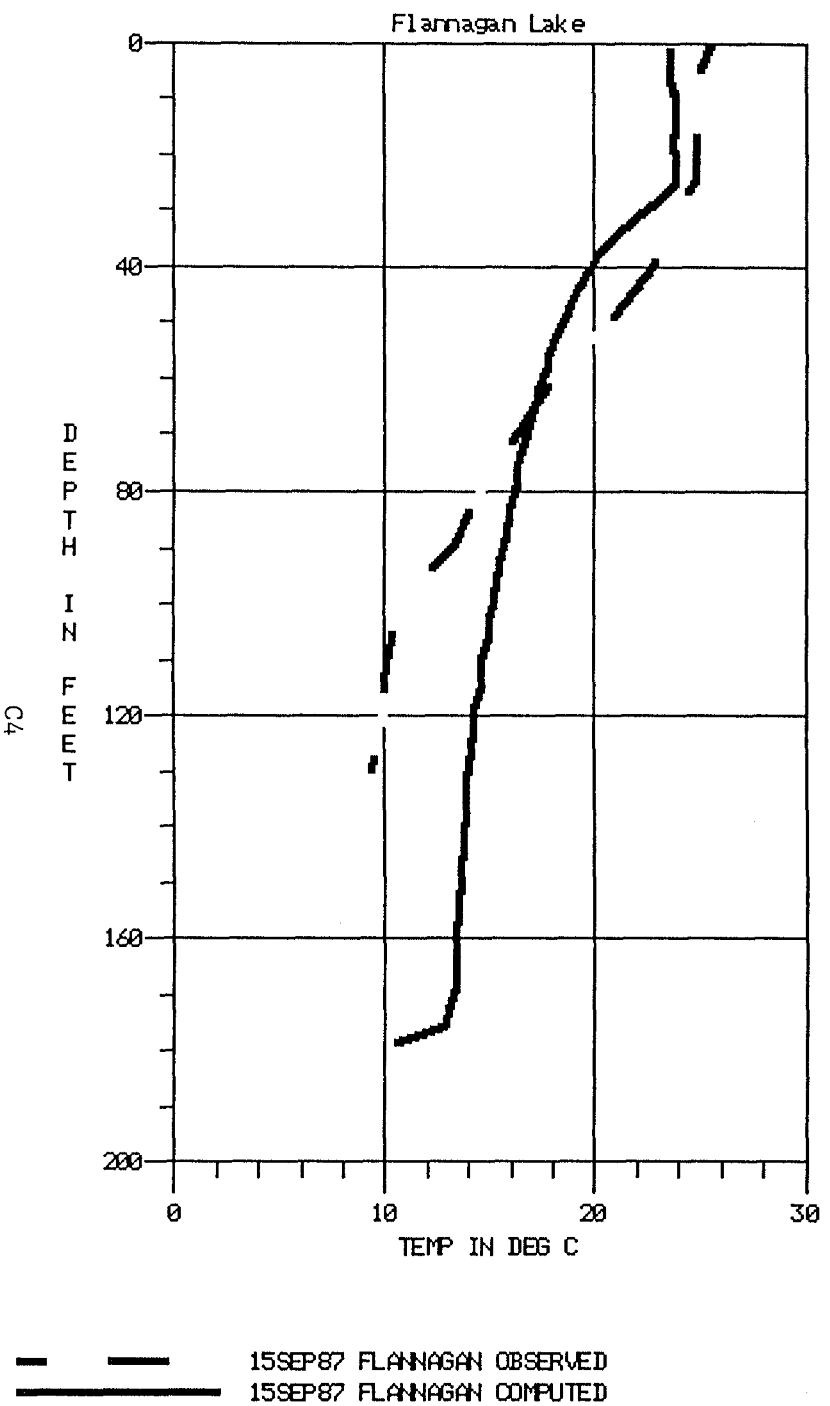
Fishtrap Lake
DEPTH IN FEET
0
20
40
60
80
100
0
10
20
30
TEMP IN DEG C
16SEP87 FISHTRAP OBSERVED
16SEP87 FISHTRAP COMPUTED

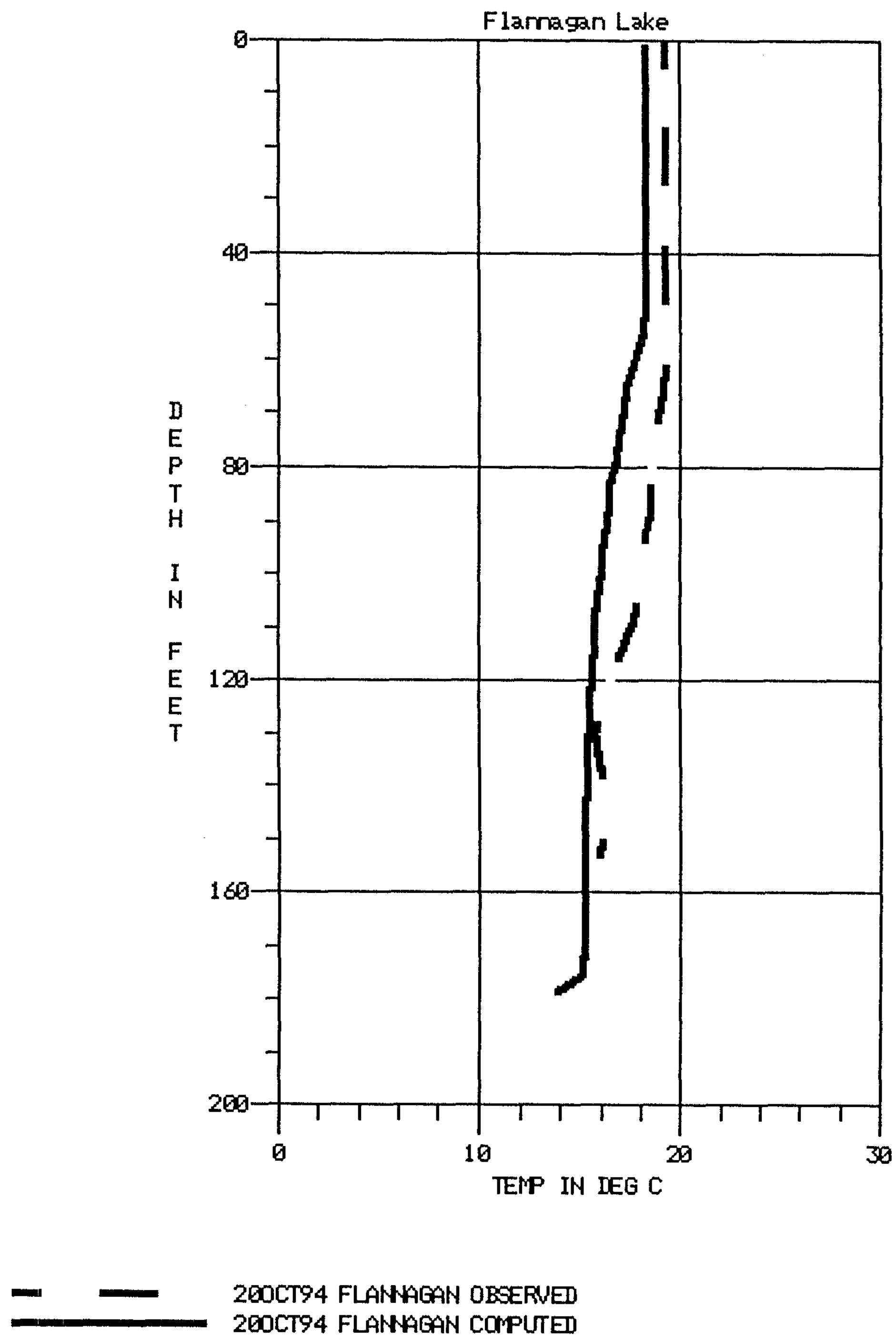


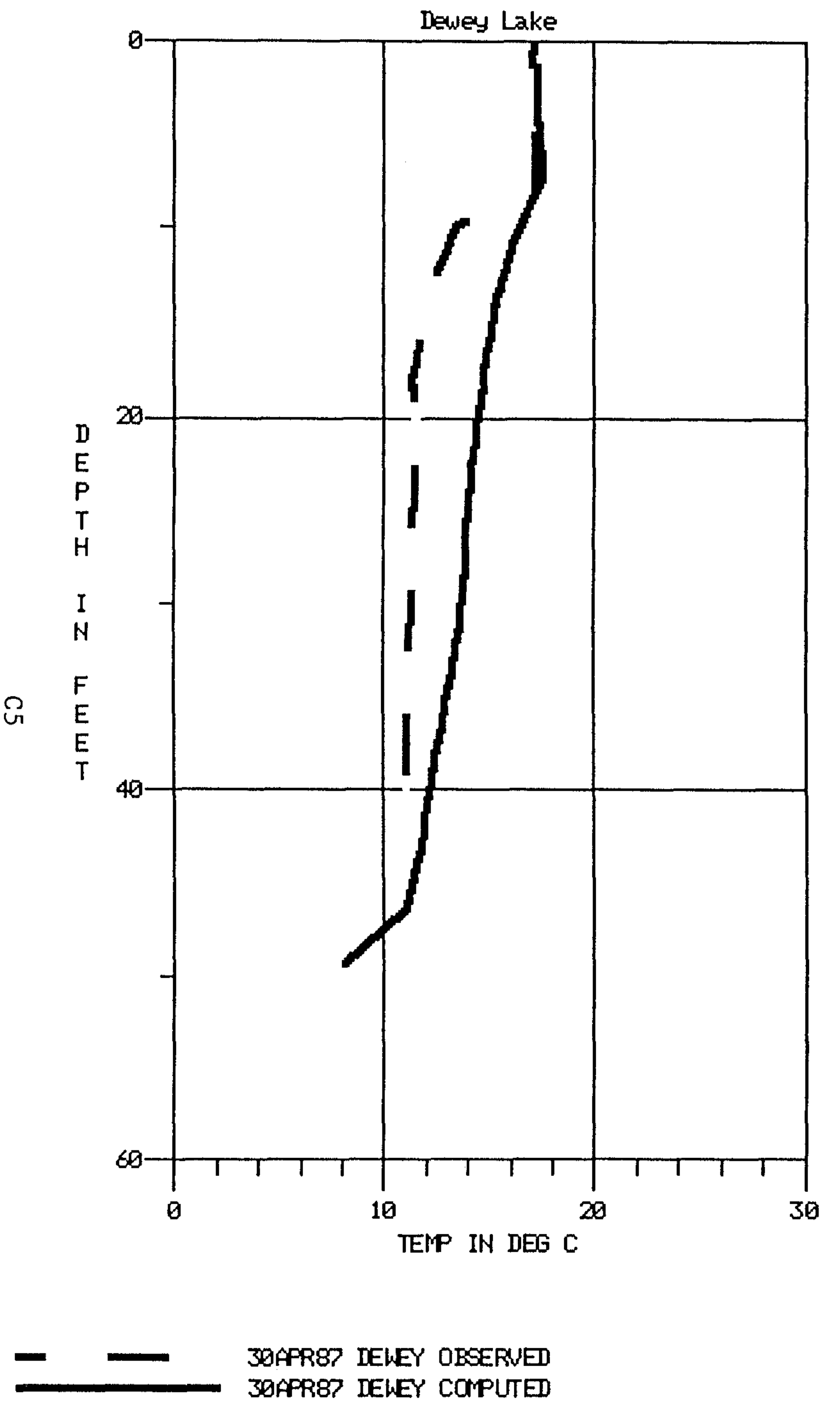
Fishtrap Lake
DEPTH IN FEET
0
20
40
60
80
100
0
10
20
30
TEMP IN DEG C
01SEP88 FISHTRAP OBSERVED
01SEP88 FISHTRAP COMPUTED

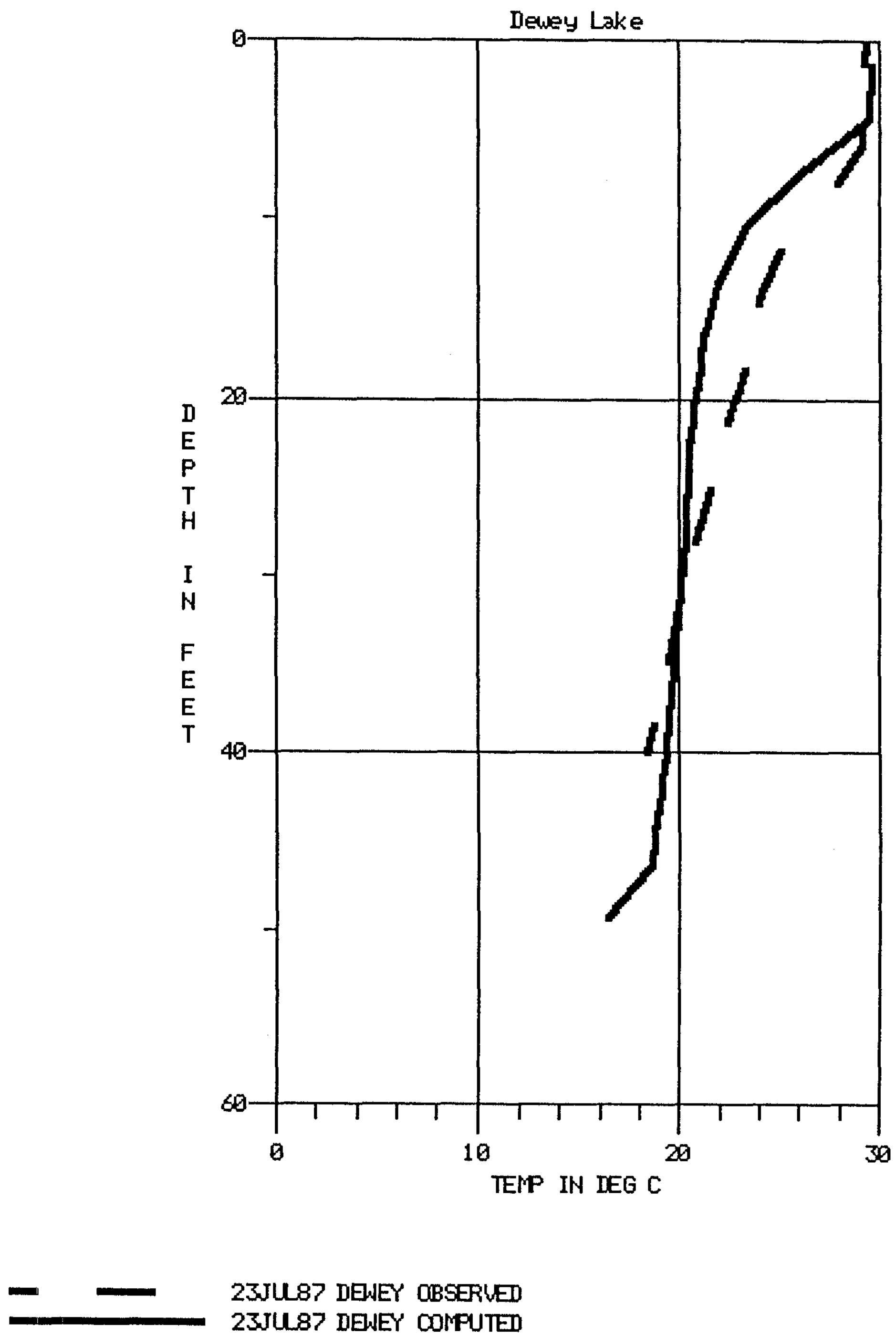

Flannagan Lake
DEPTH IN FEET
0
40
80
120
160
200
0
10
20
30
TEMP IN DEG C
28APR87 FLANNAGAN OBSERVED
28APR87 FLANNAGAN COMPUTED

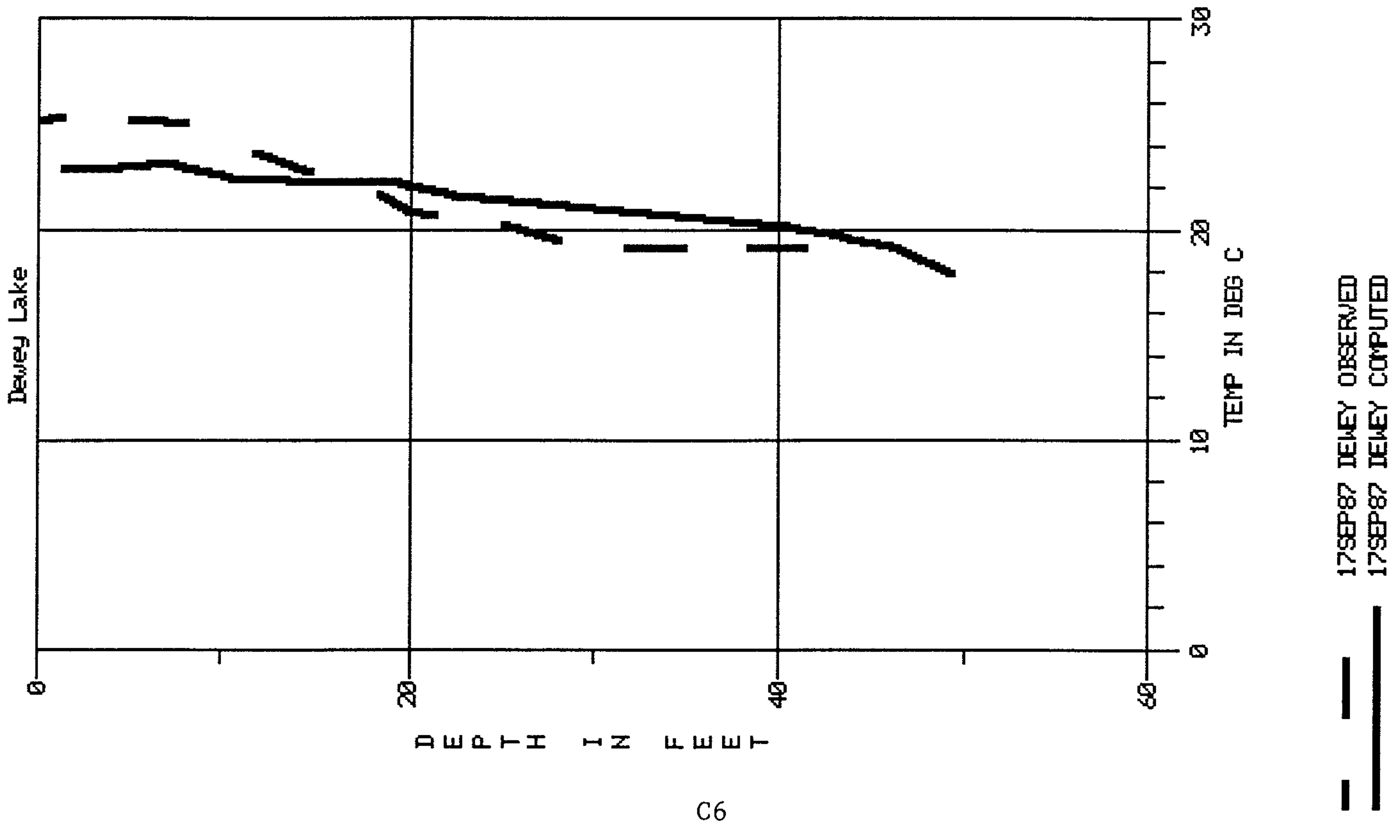

Flannagan Lake
DEPTH IN FEET
0
40
80
120
160
200
0
10
20
30
TEMP IN DEG C
21JUL87 FLANNAGAN OBSERVED
21JUL87 FLANNAGAN COMPUTED


Flannagan Lake
DEPTH IN FEET
0
40
80
120
160
200
0
10
20
30
TEMP IN DEG C
15SEP87 FLANNAGAN OBSERVED
15SEP87 FLANNAGAN COMPUTED

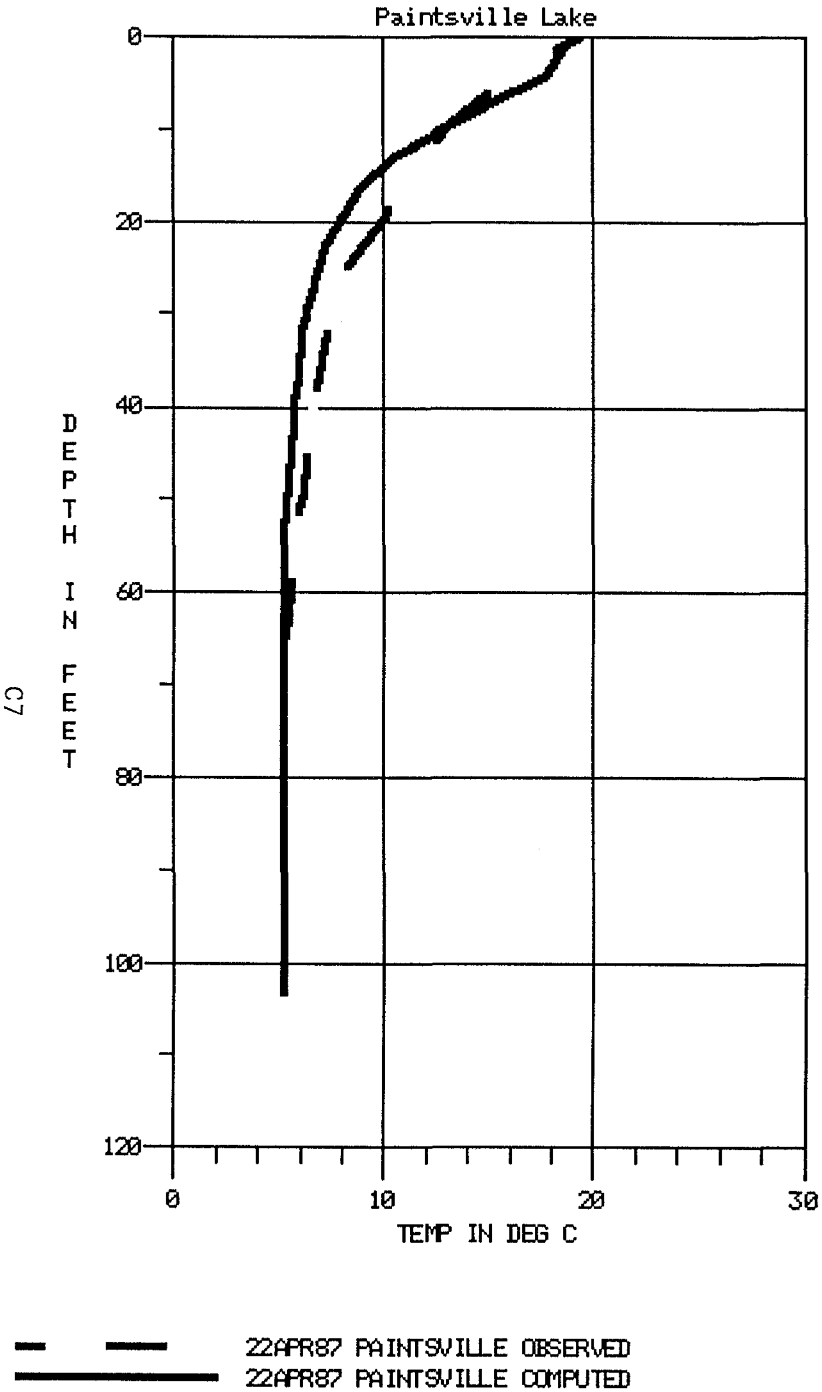

Flannagan Lake
DEPTH IN FEET
0
40
80
120
160
200
0
10
20
30
TEMP IN DEG C
20OCT94 FLANNAGAN OBSERVED
20OCT94 FLANNAGAN COMPUTED

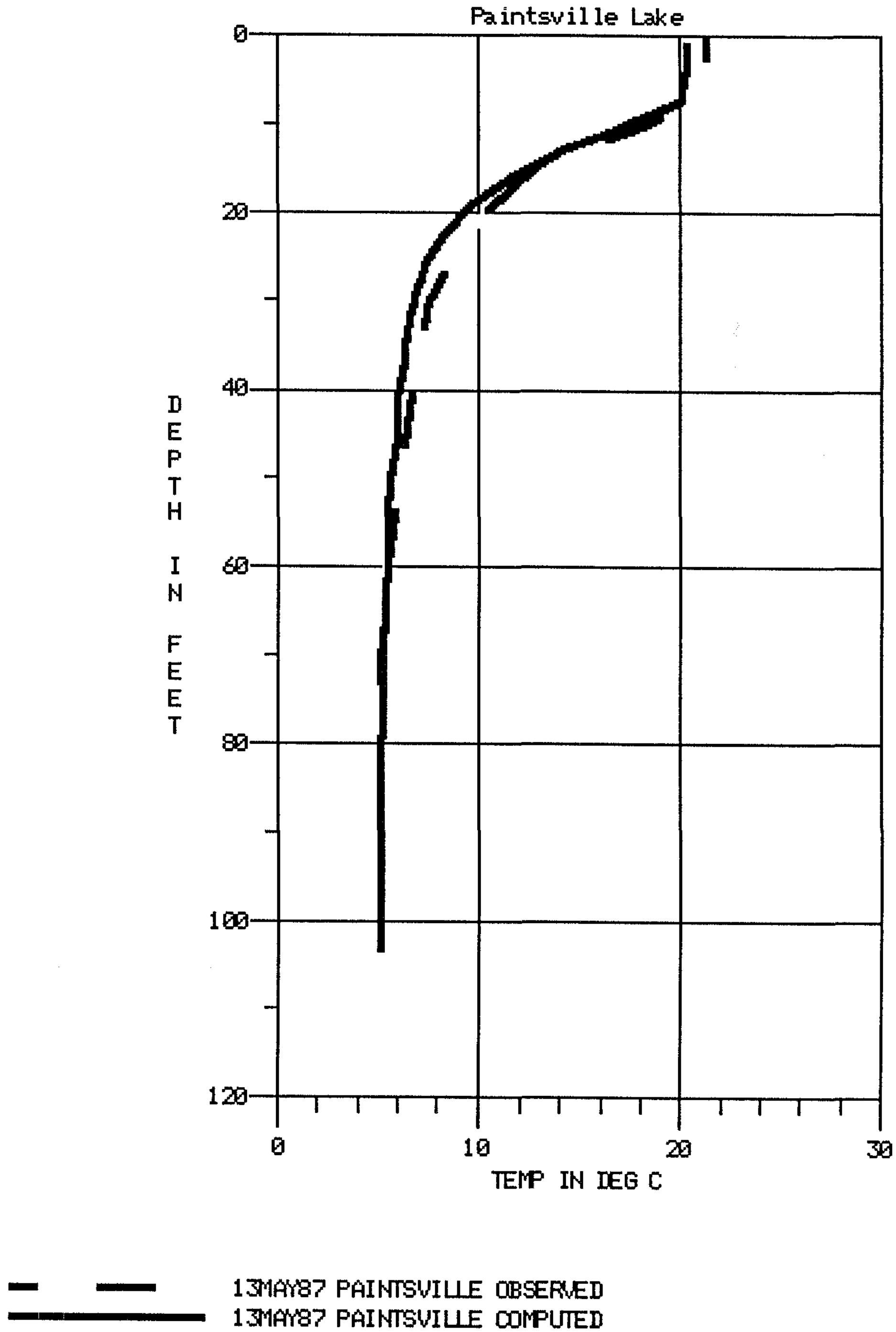

Dewey Lake
DEPTH IN FEET
0
20
40
60
0
10
20
30
TEMP IN DEG C
30APR87 DEWEY OBSERVED
30APR87 DEWEY COMPUTED

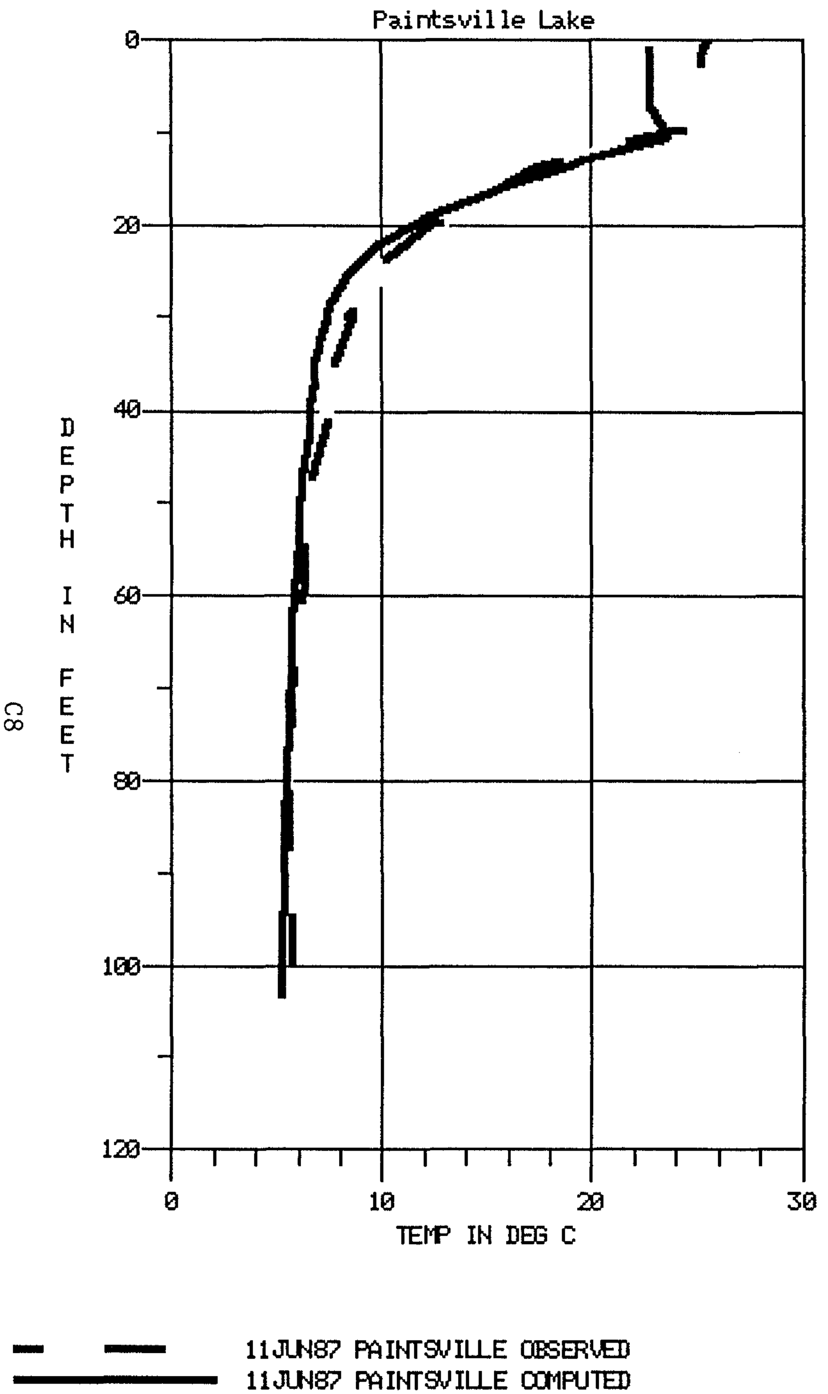

Dewey Lake
DEPTH IN FEET
0
20
40
60
0
10
20
30
TEMP IN DEG C
23JUL87 DEWEY OBSERVED
23JUL87 DEWEY COMPUTED

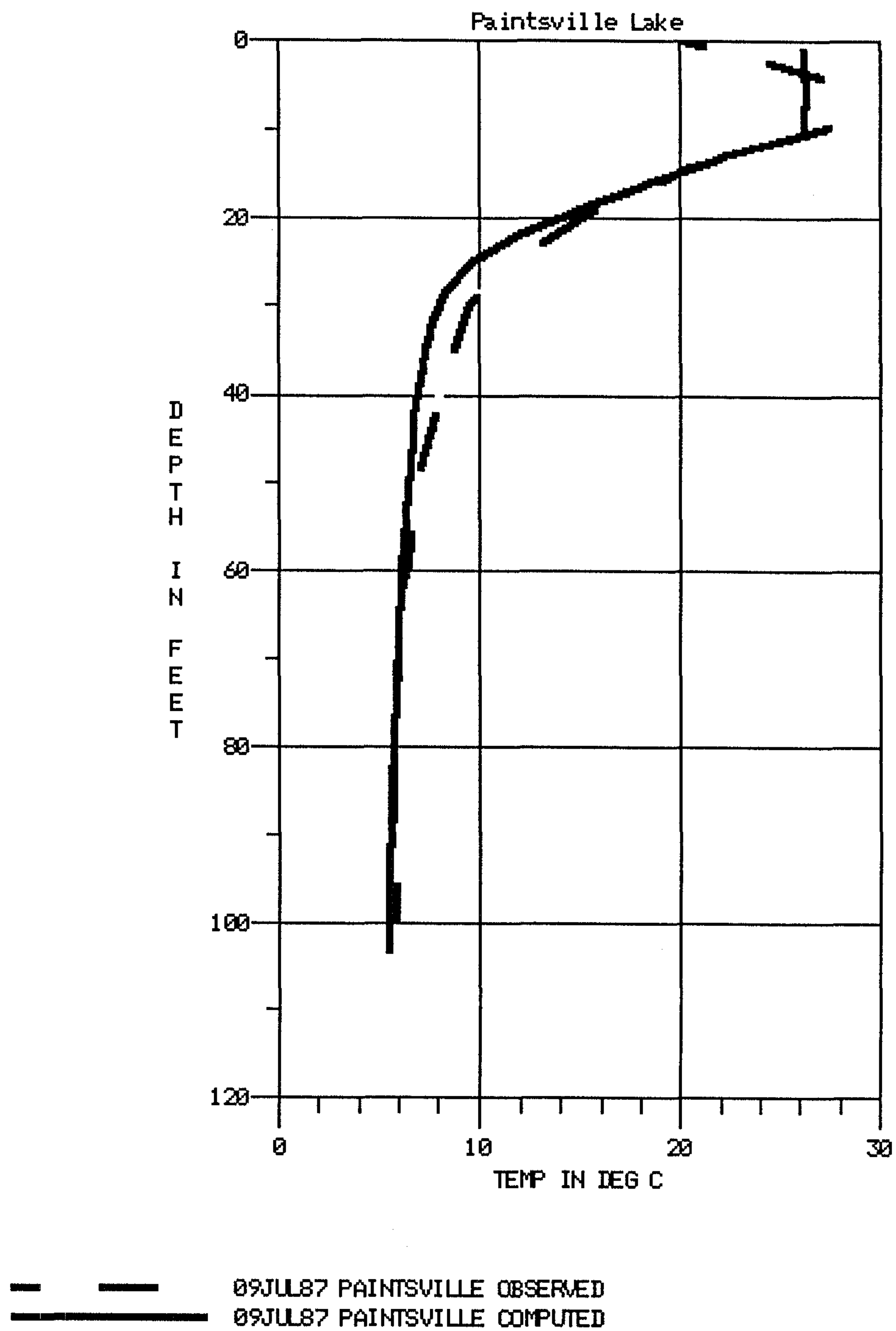


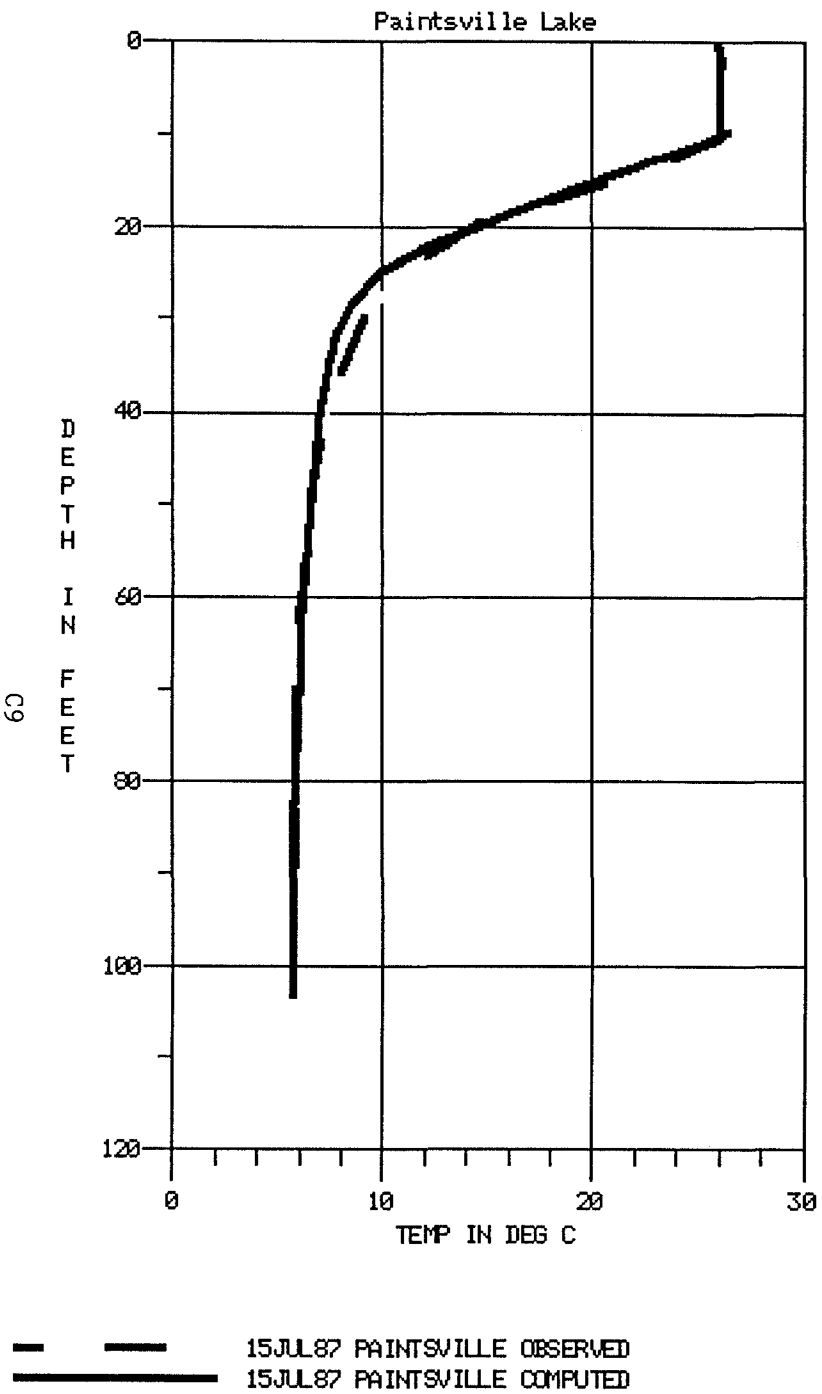
Dewey Lake
0
20
40
60
DEPTH IN FEET
0
10
20
30
TEMP IN DEG C
17SEP87 DEWEY OBSERVED
17SEP87 DEWEY COMPUTED


Paintsville Lake
DEPTH IN FEET
0
20
40
60
80
100
120
0
10
20
30
TEMP IN DEG C
22APR87 PAINTSVILLE OBSERVED
22APR87 PAINTSVILLE COMPUTED

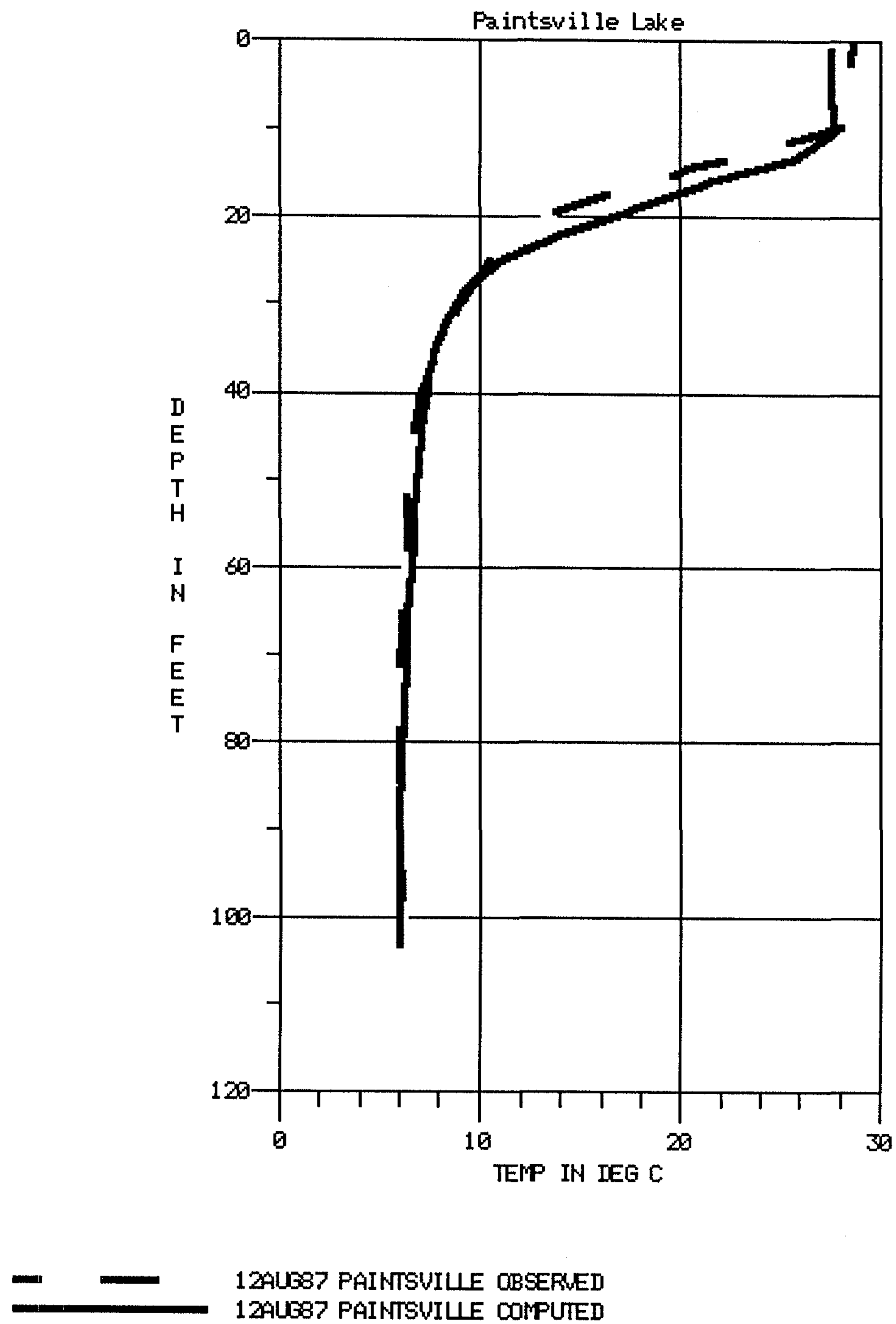

Paintsville Lake
DEPTH IN FEET
0
20
40
60
80
100
120
0
10
20
30
TEMP IN DEG C
13MAY87 PAINTSVILLE OBSERVED
13MAY87 PAINTSVILLE COMPUTED


Paintsville Lake
DEPTH IN FEET
TEMP IN DEG C
0
10
20
30
0
20
40
60
80
100
120
11JUN87 PAINTSVILLE OBSERVED
11JUN87 PAINTSVILLE COMPUTED

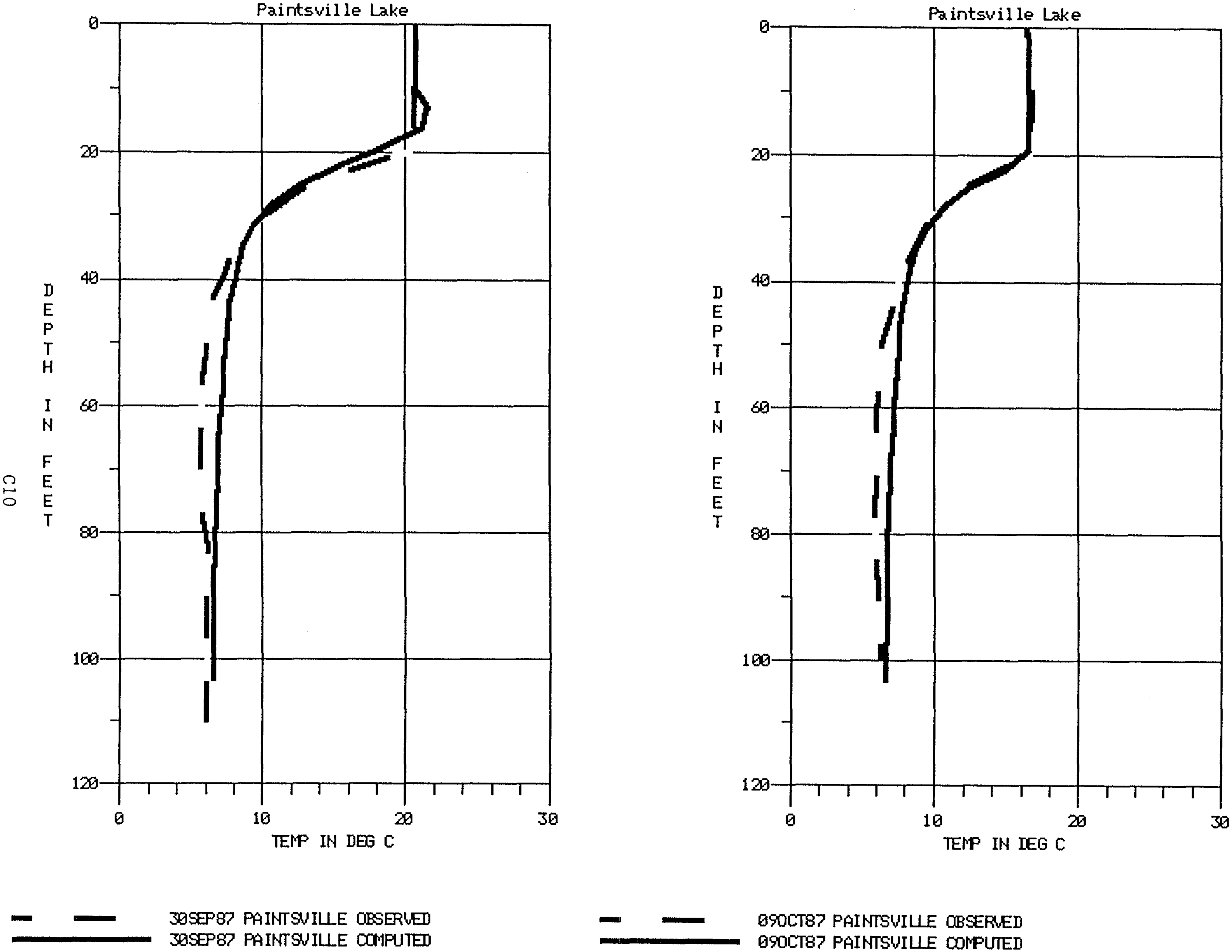

Paintsville Lake
DEPTH IN FEET
TEMP IN DEG C
0
10
20
30
0
20
40
60
80
100
120
09JUL87 PAINTSVILLE OBSERVED
09JUL87 PAINTSVILLE COMPUTED

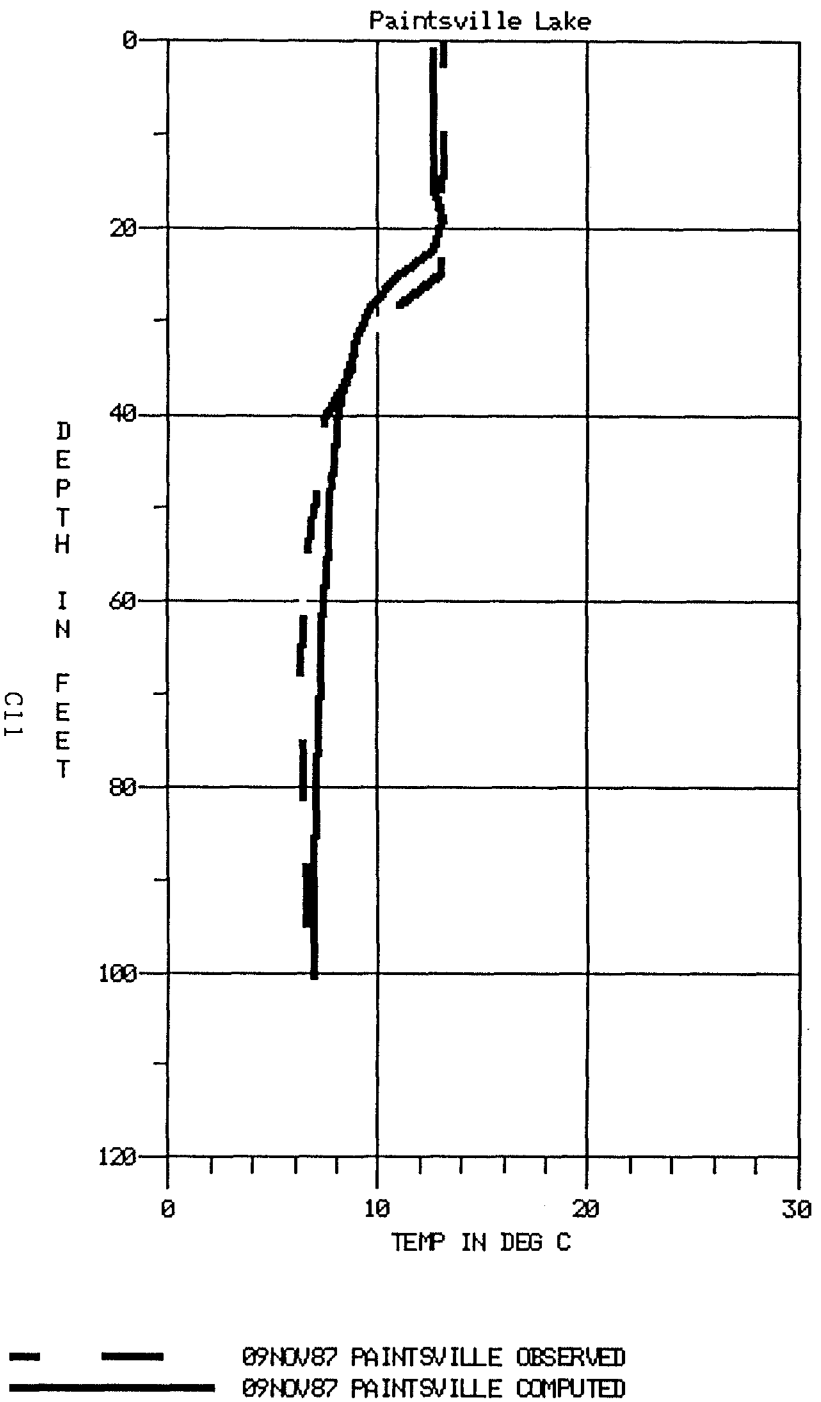


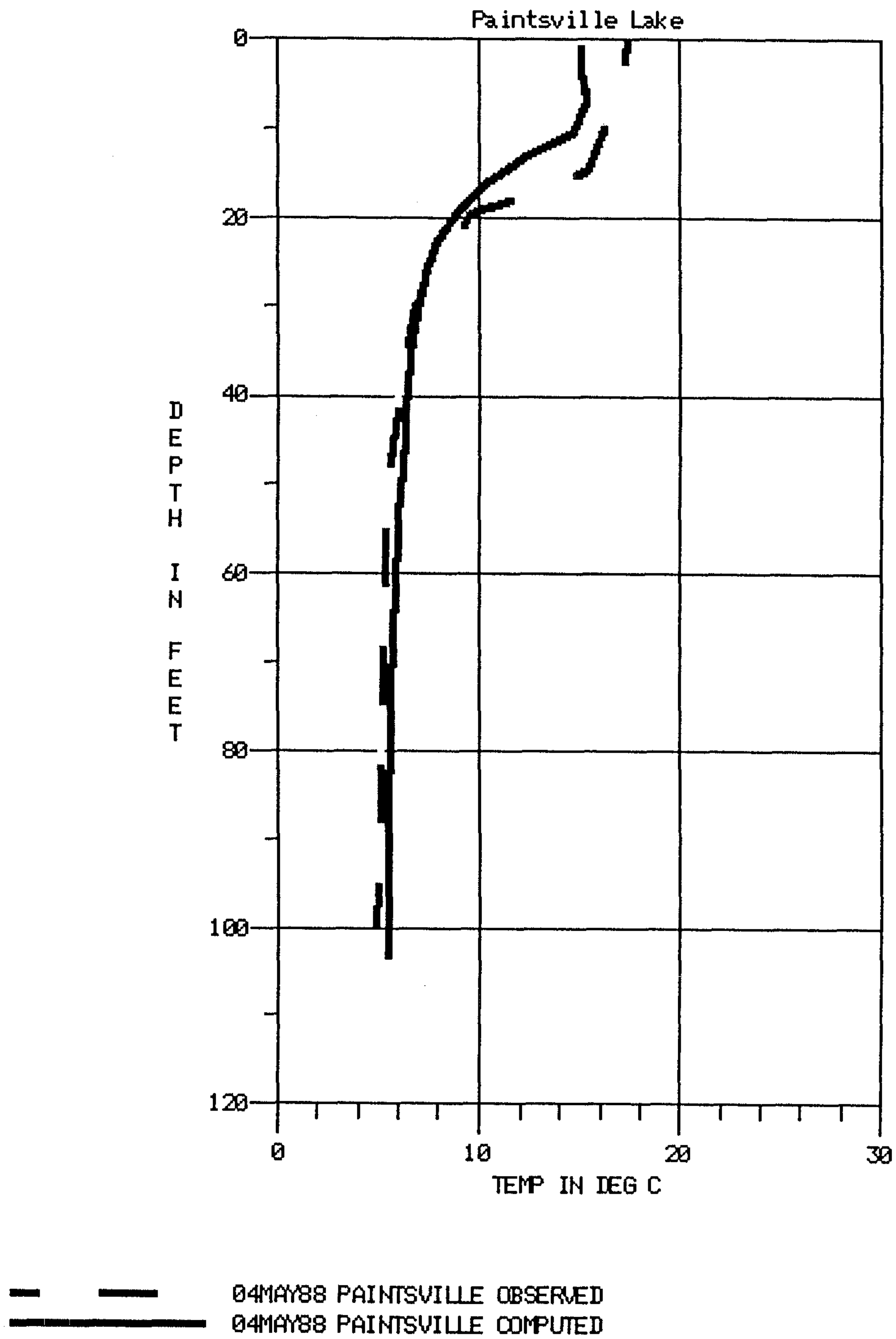
Paintsville Lake
DEPTH IN FEET
TEMP IN DEG C
0
20
40
60
80
100
120
0
10
20
30
15JUL87 PAINTSVILLE OBSERVED
15JUL87 PAINTSVILLE COMPUTED

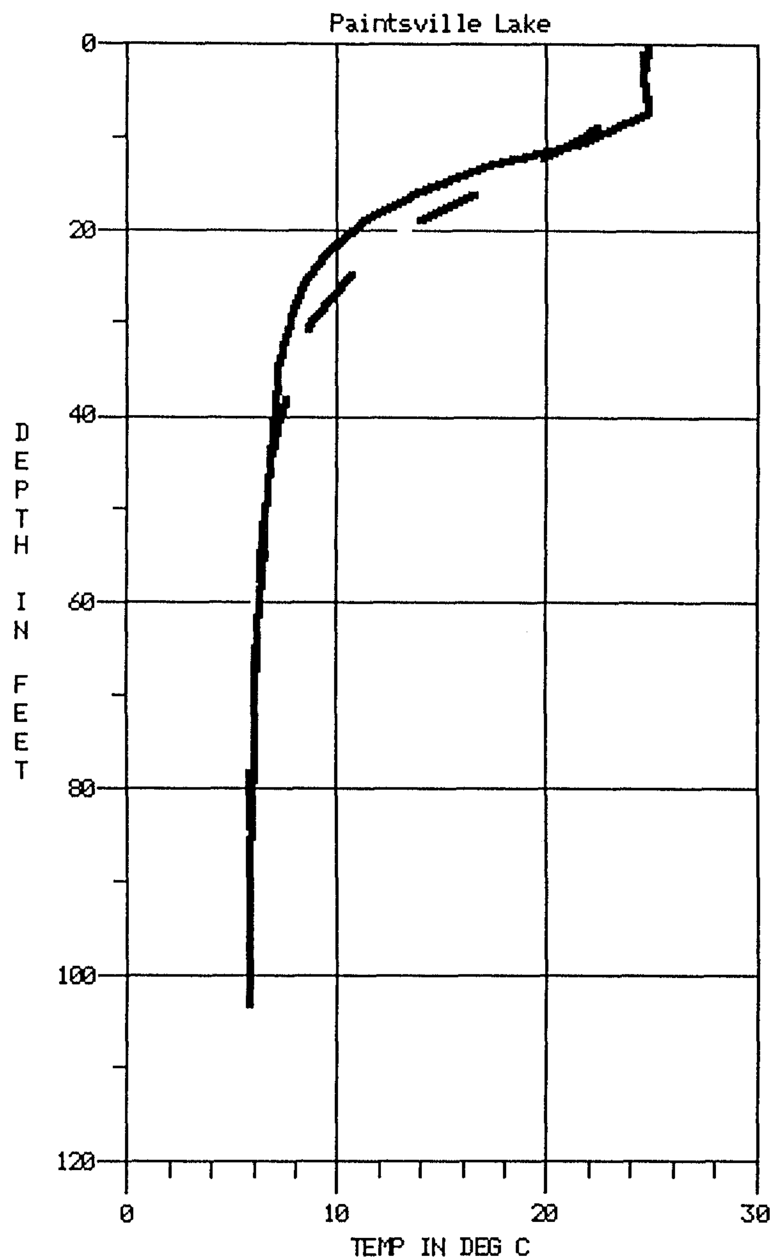


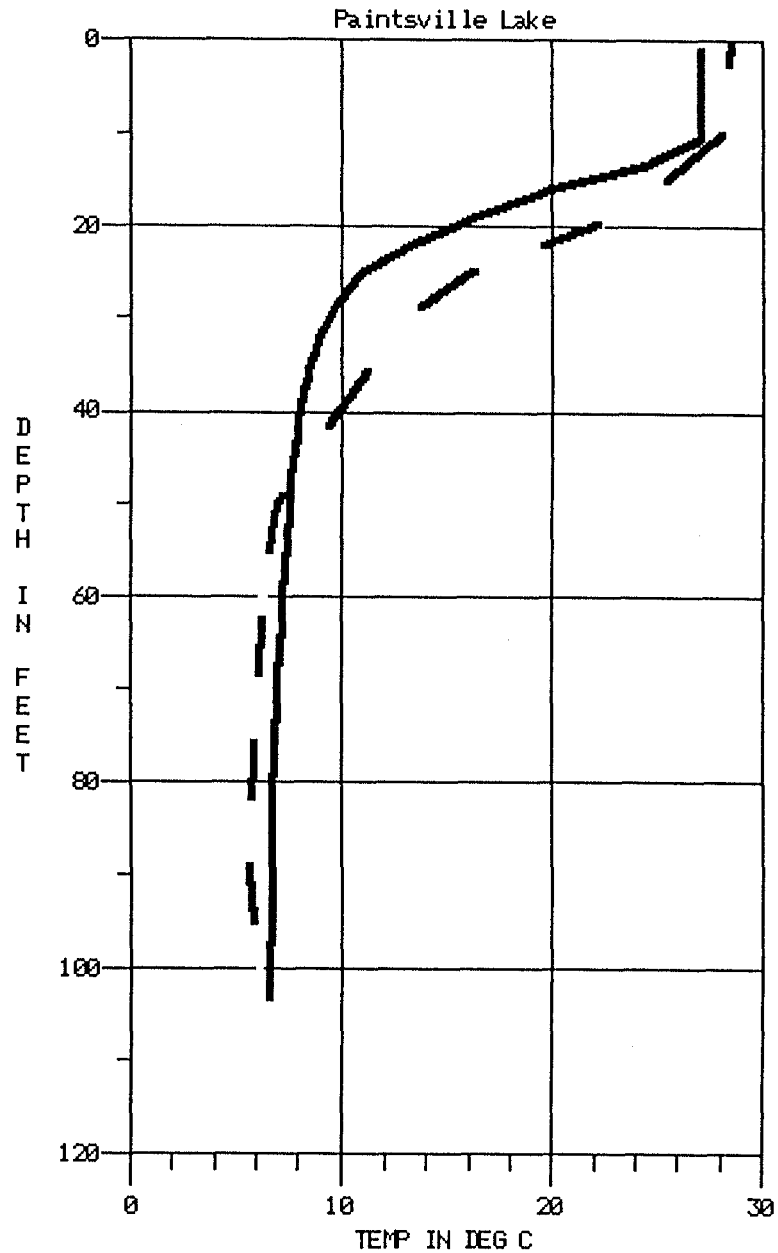
Paintsville Lake
DEPTH IN FEET
TEMP IN DEG C
0
20
40
60
80
100
120
0
10
20
30
12AUG87 PAINTSVILLE OBSERVED
12AUG87 PAINTSVILLE COMPUTED

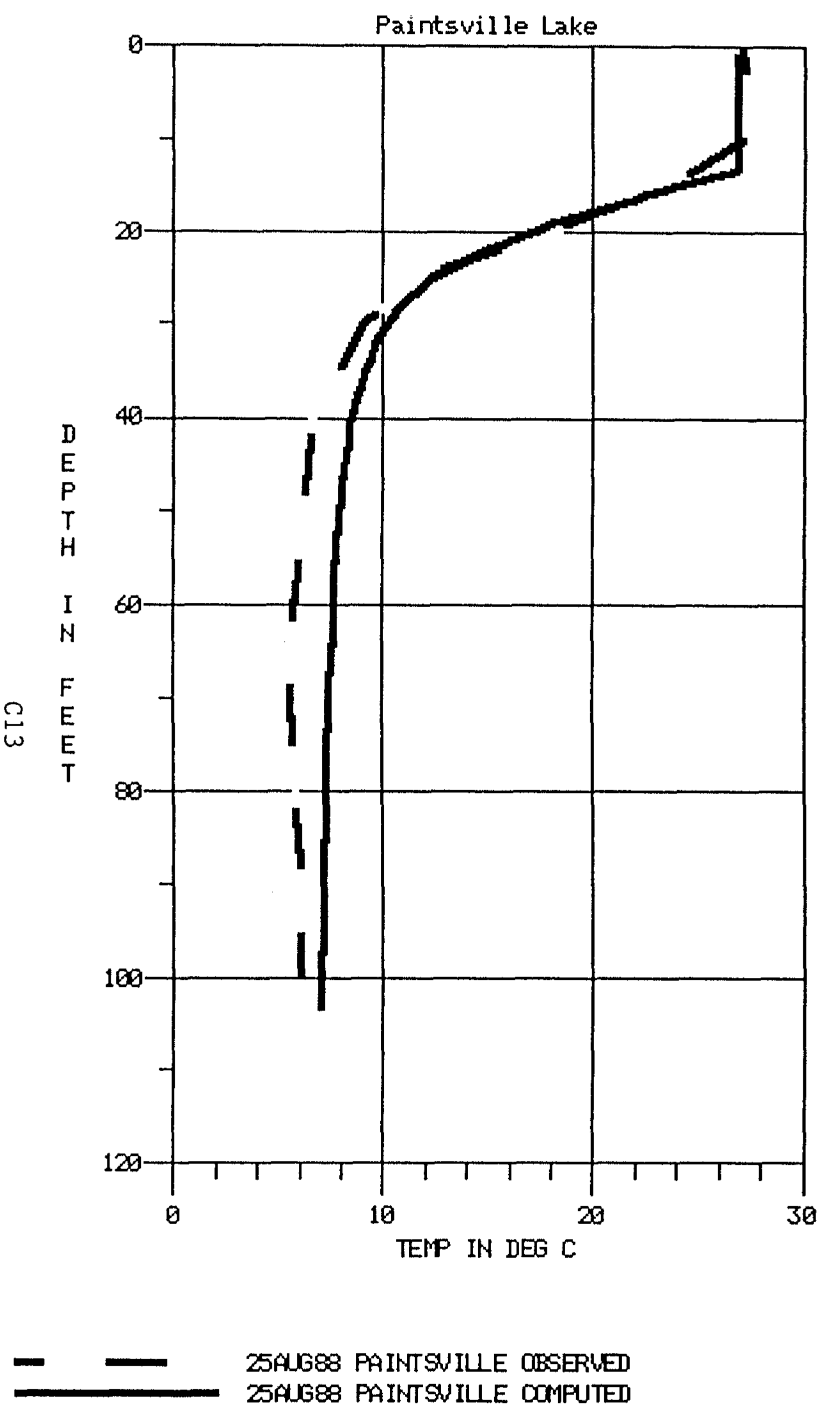

Paintsville Lake
DEPTH IN FEET
TEMP IN DEG C
30SEP87 PAINTSVILLE OBSERVED
30SEP87 PAINTSVILLE COMPUTED
Paintsville Lake
DEPTH IN FEET
TEMP IN DEG C
09OCT87 PAINTSVILLE OBSERVED
09OCT87 PAINTSVILLE COMPUTED

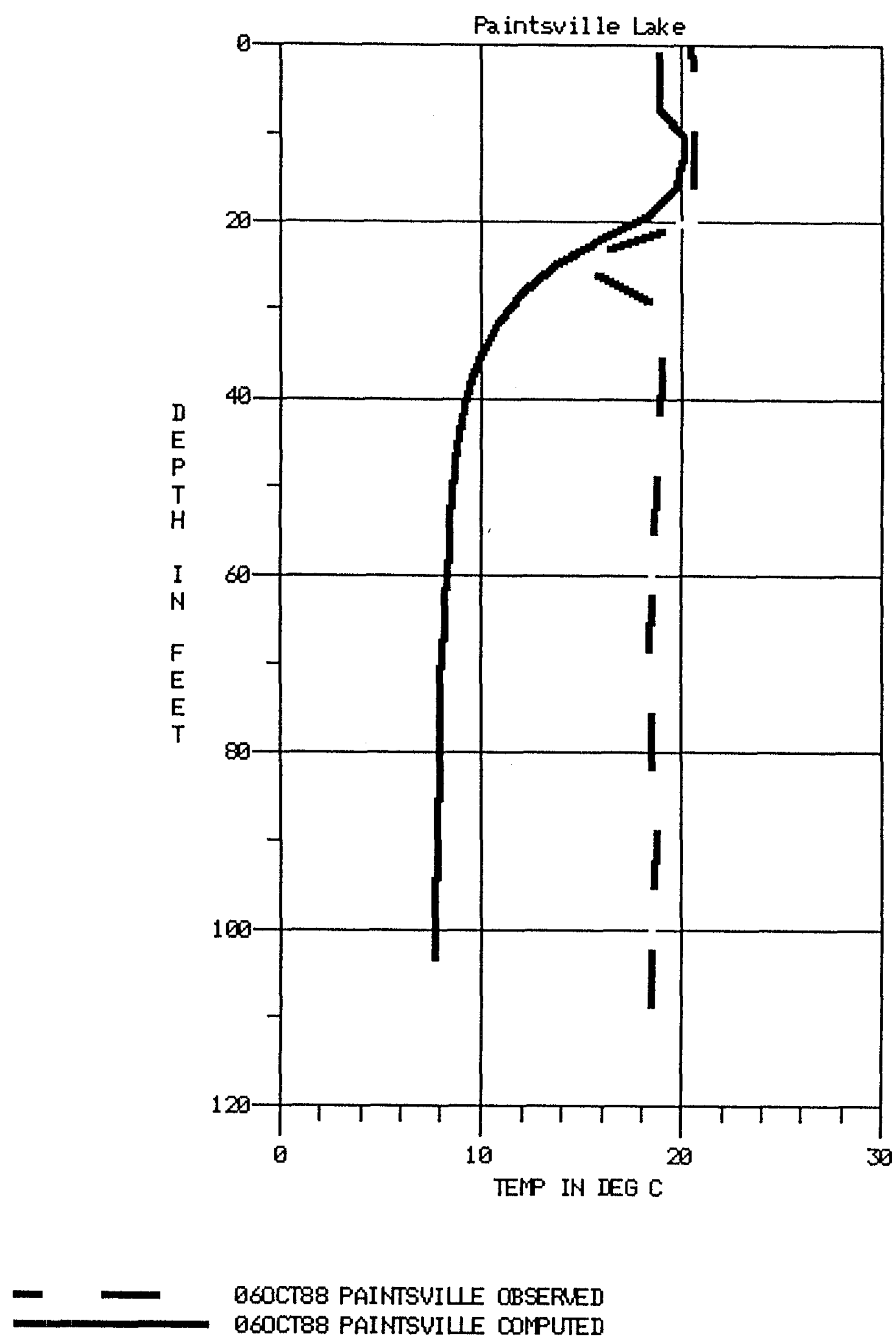

Paintsville Lake
DEPTH IN FEET
TEMP IN DEG C
0
20
40
60
80
100
120
0
10
20
30
09NOV87 PAINTSVILLE OBSERVED
09NOV87 PAINTSVILLE COMPUTED

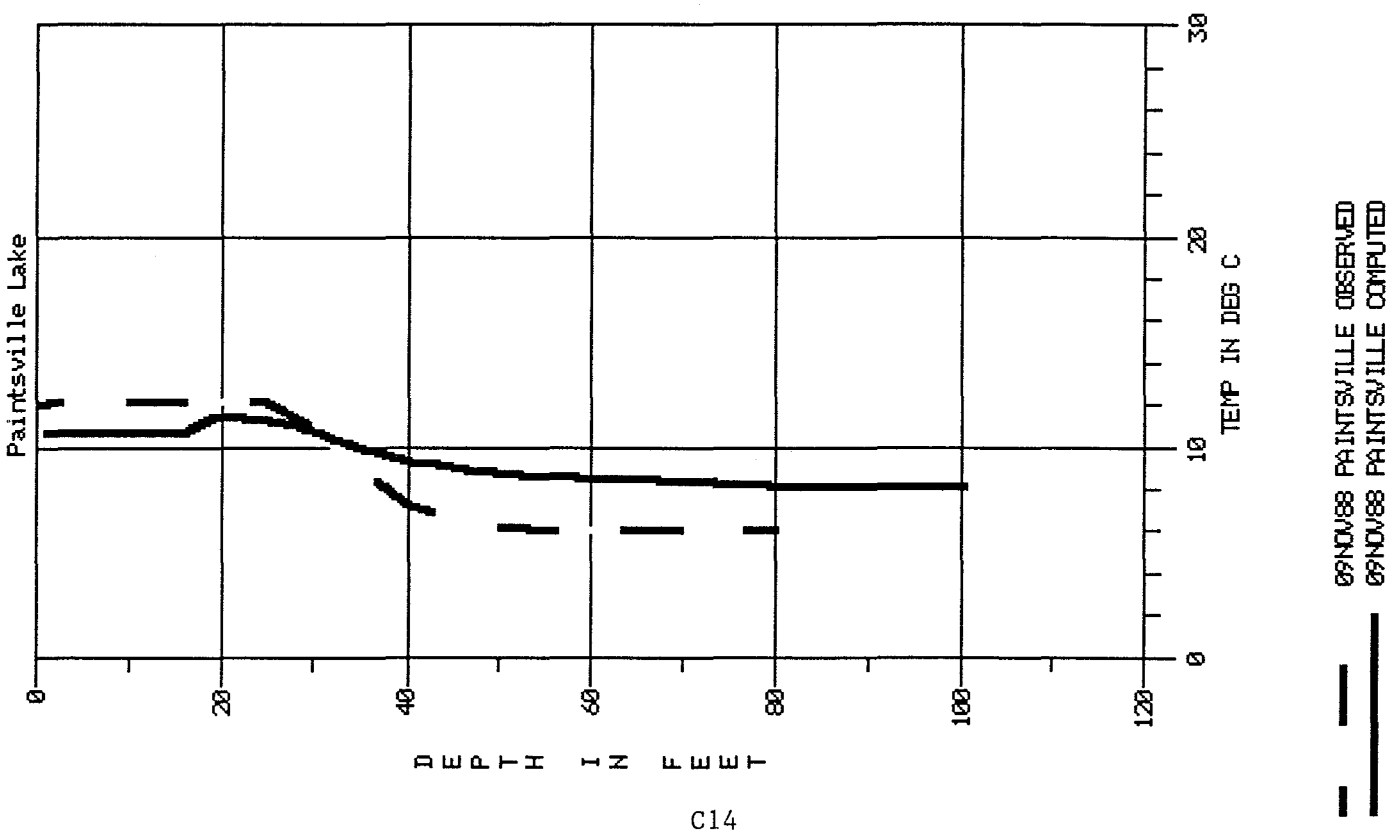

Paintsville Lake
DEPTH IN FEET
TEMP IN DEG C
0
20
40
60
80
100
120
0
10
20
30
04MAY88 PAINTSVILLE OBSERVED
04MAY88 PAINTSVILLE COMPUTED


Paintsville Lake
DEPTH IN FEET
TEMP IN DEG C
02JUN88 PAINTSVILLE OBSERVED
02JUN88 PAINTSVILLE COMPUTED

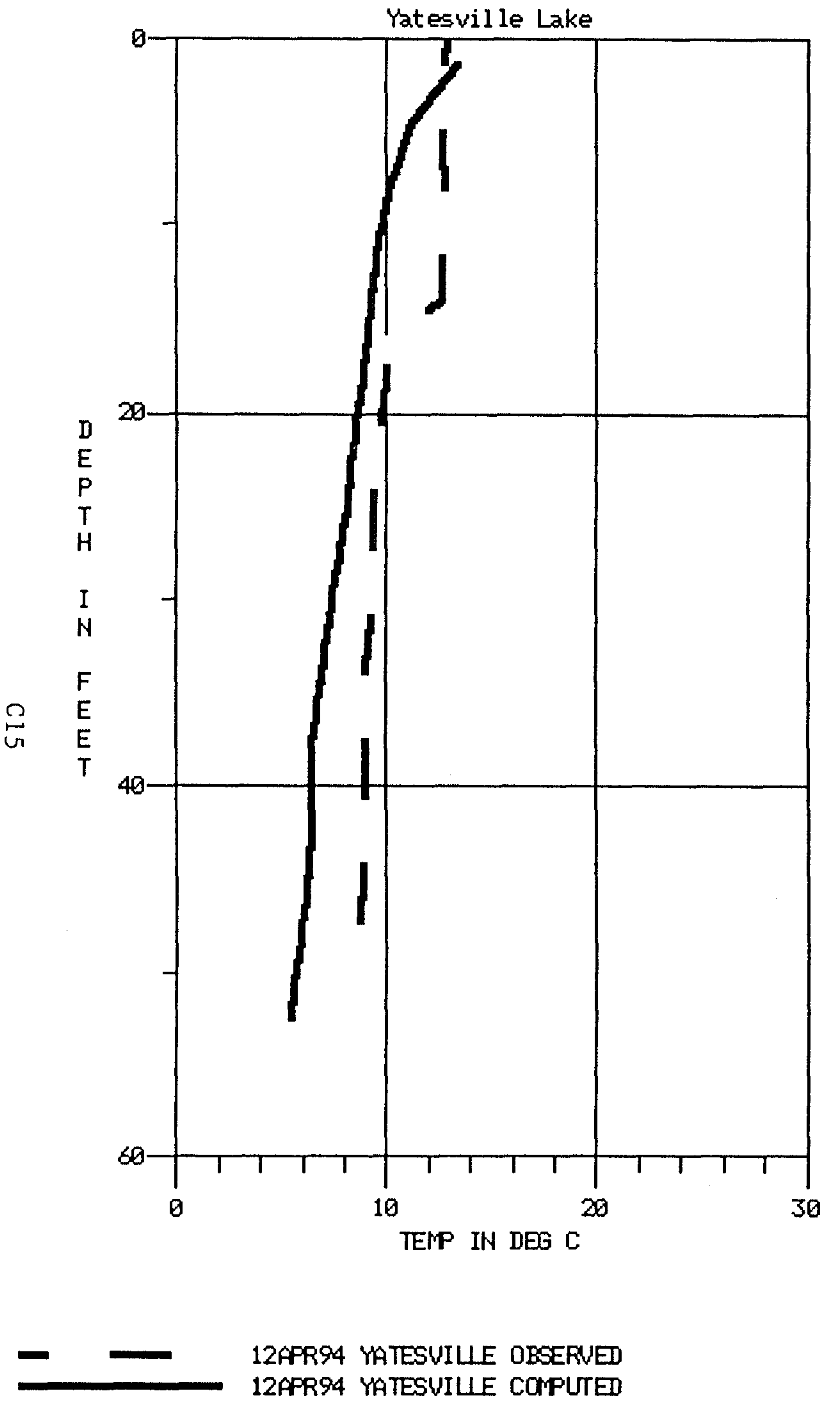

Paintsville Lake
DEPTH IN FEET
TEMP IN DEG C
27JUL88 PAINTSVILLE OBSERVED
27JUL88 PAINTSVILLE COMPUTED

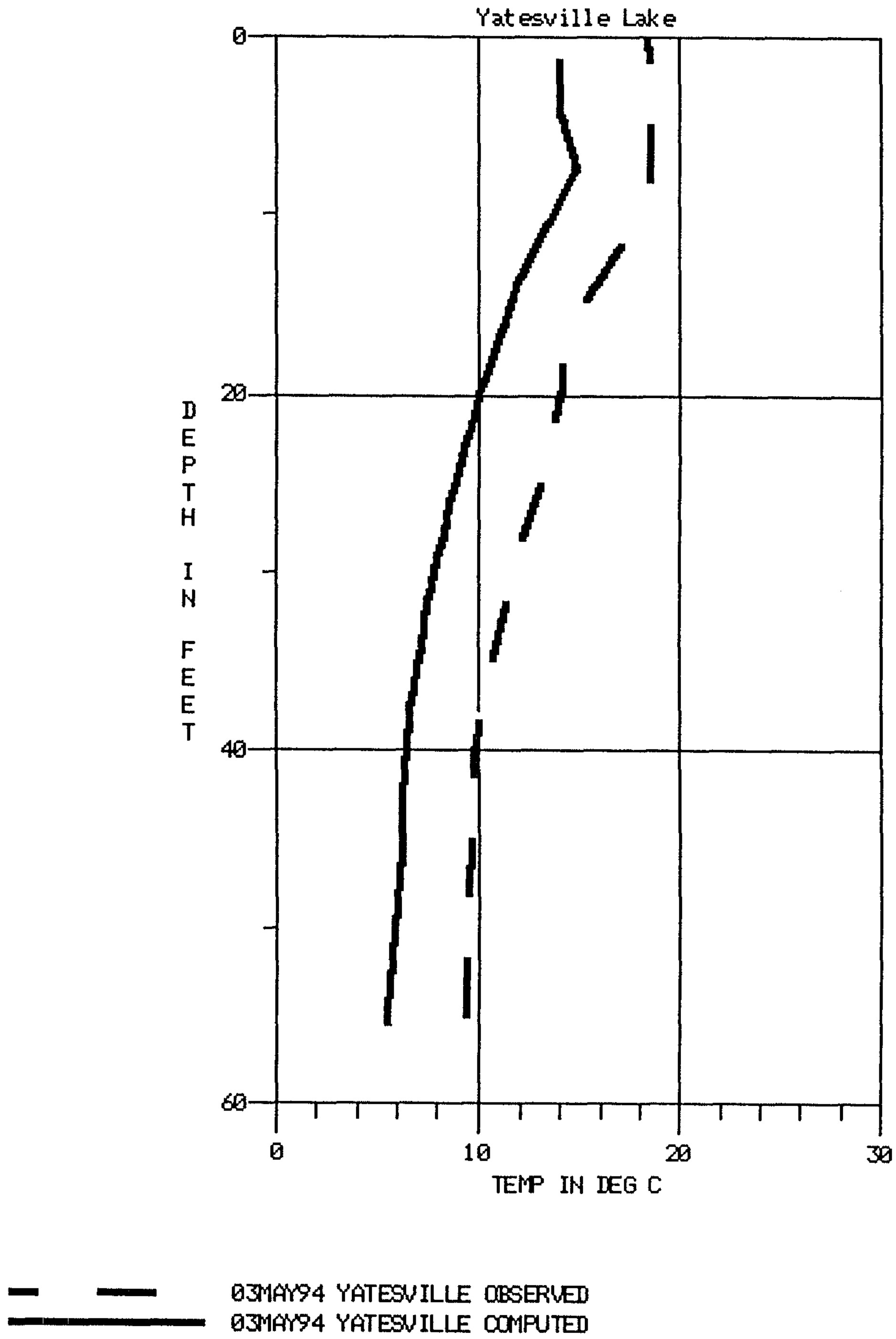

Paintsville Lake
DEPTH IN FEET
TEMP IN DEG C
0
20
40
60
80
100
120
0
10
20
30
25AUG88 PAINTSVILLE OBSERVED
25AUG88 PAINTSVILLE COMPUTED

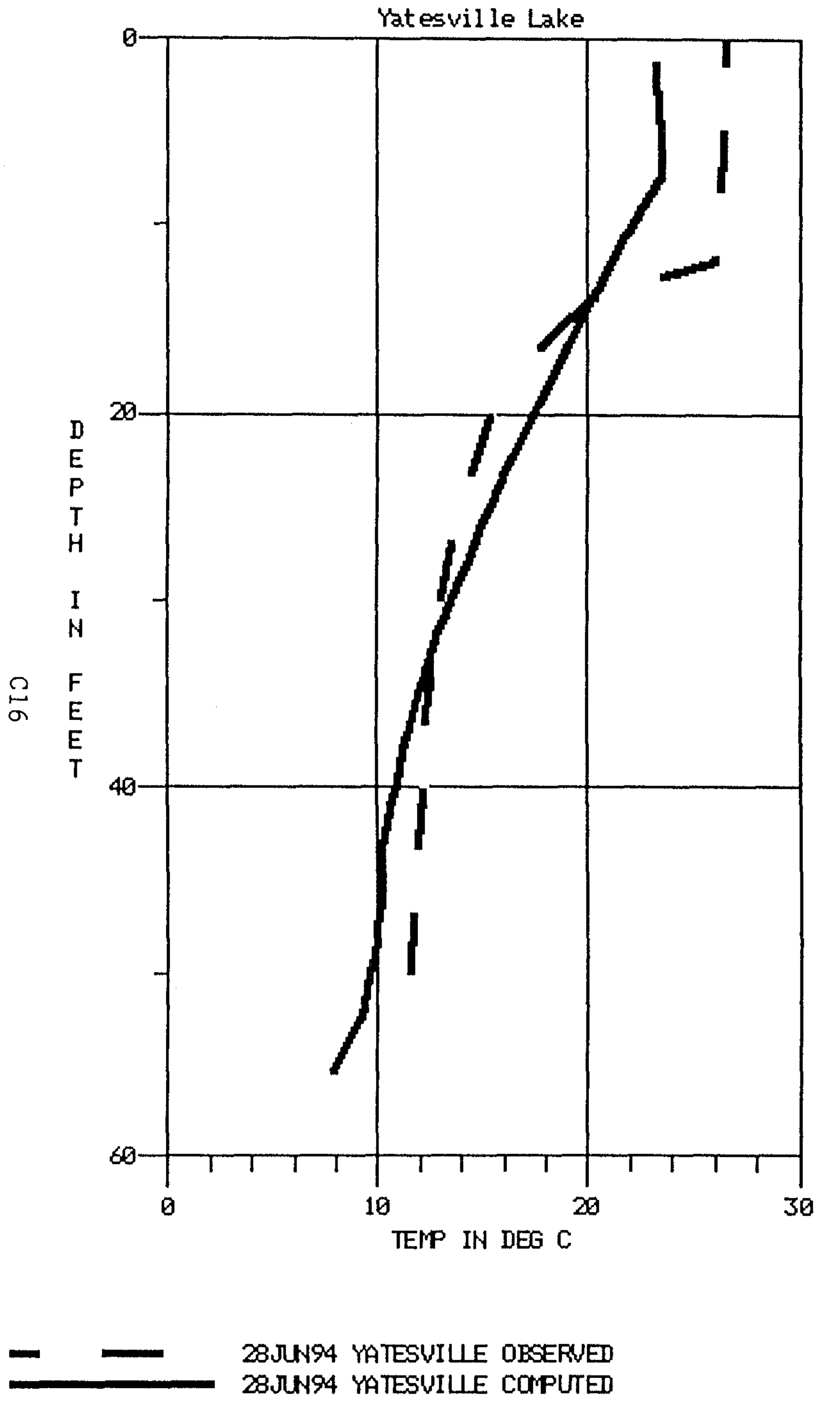

Paintsville Lake
DEPTH IN FEET
TEMP IN DEG C
0
20
40
60
80
100
120
0
10
20
30
06OCT88 PAINTSVILLE OBSERVED
06OCT88 PAINTSVILLE COMPUTED

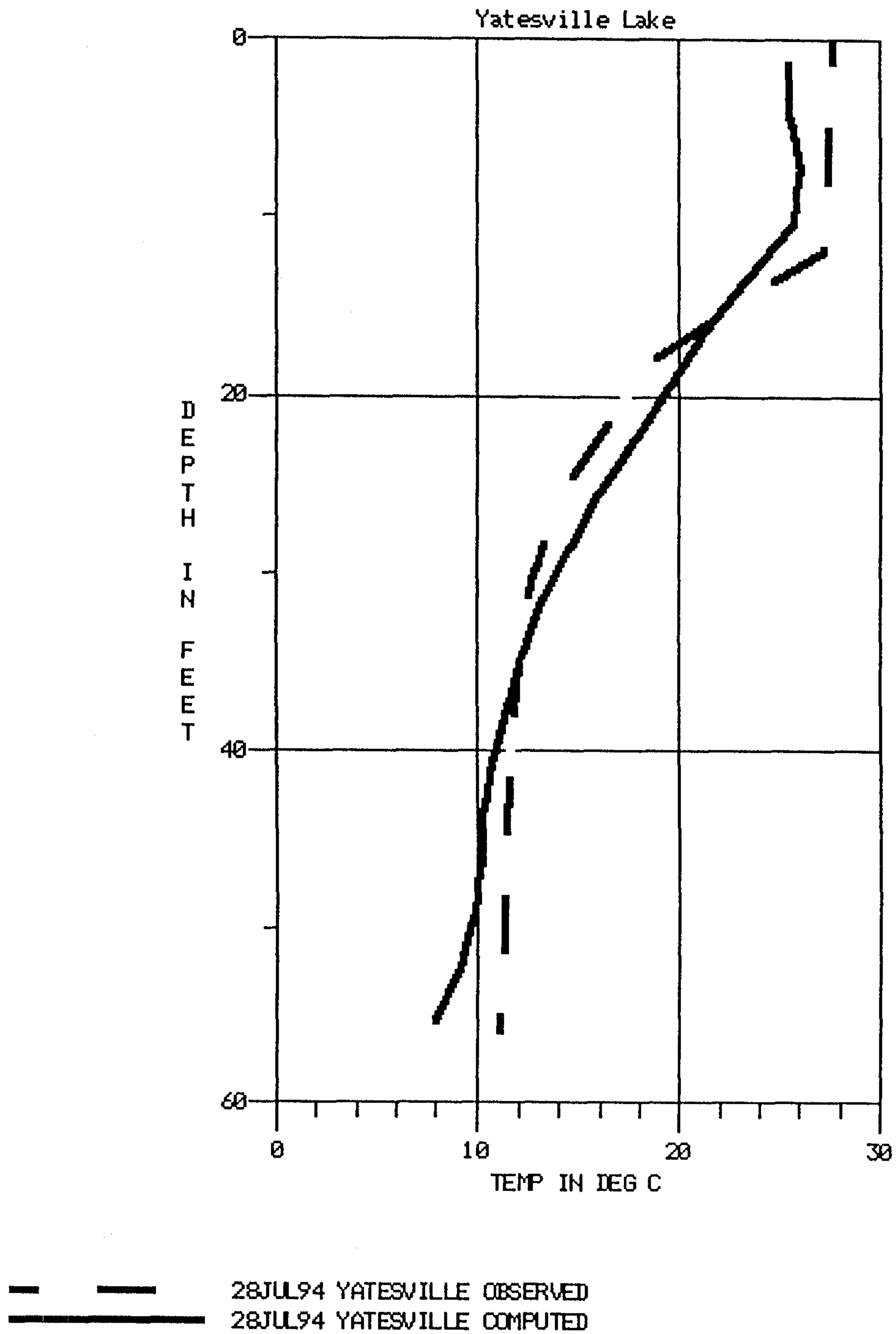


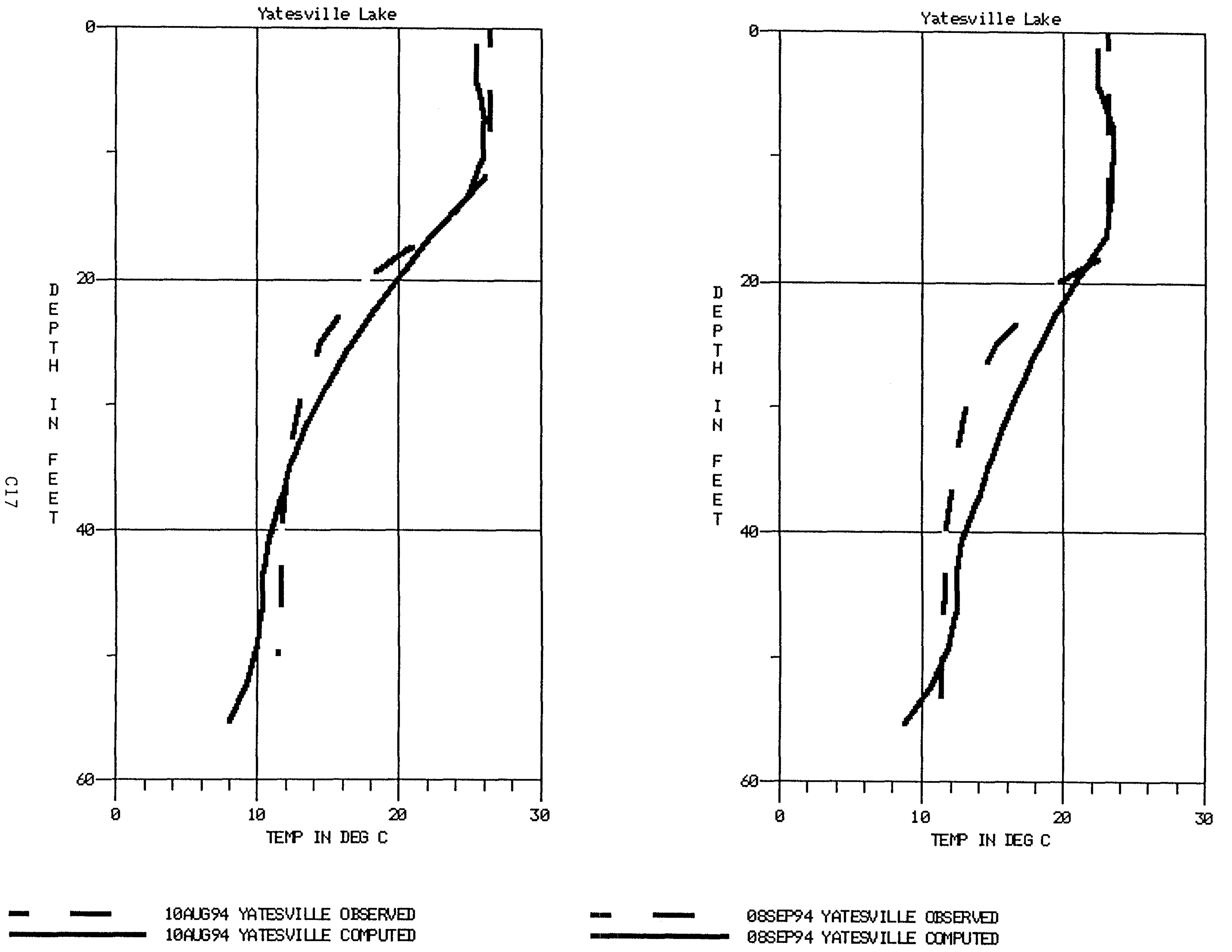
Paintsville Lake
TEMP IN DEG C
DEPTH IN FEET
0
10
20
30
0
20
40
60
80
100
120
09NOV88 PAINTSVILLE OBSERVED
09NOV88 PAINTSVILLE COMPUTED


Yatesville Lake
DEPTH IN FEET
0
20
40
60
0
10
20
30
TEMP IN DEG C
12APR94 YATESVILLE OBSERVED
12APR94 YATESVILLE COMPUTED

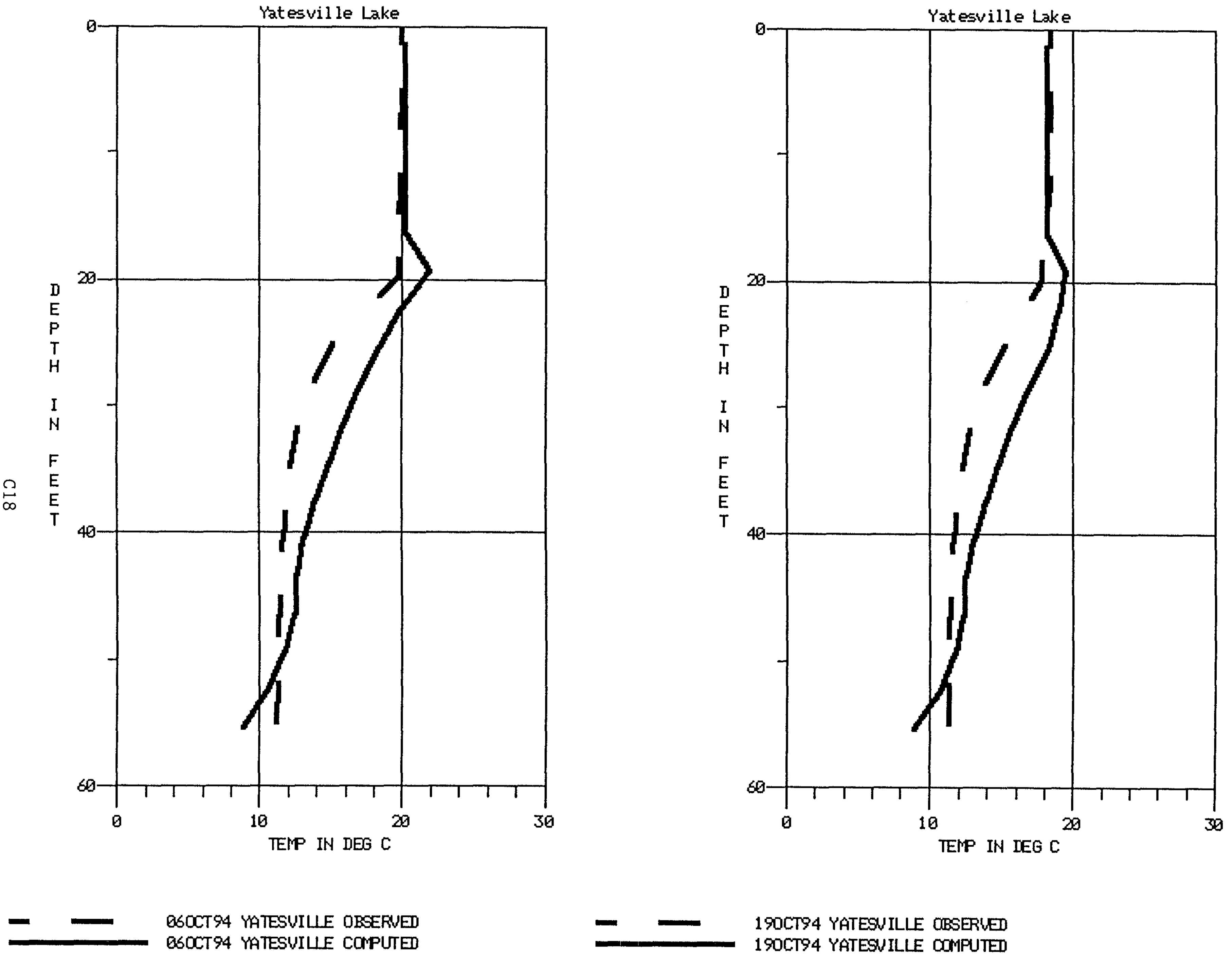

Yatesville Lake
DEPTH IN FEET
0
20
40
60
0
10
20
30
TEMP IN DEG C
03MAY94 YATESVILLE OBSERVED
03MAY94 YATESVILLE COMPUTED

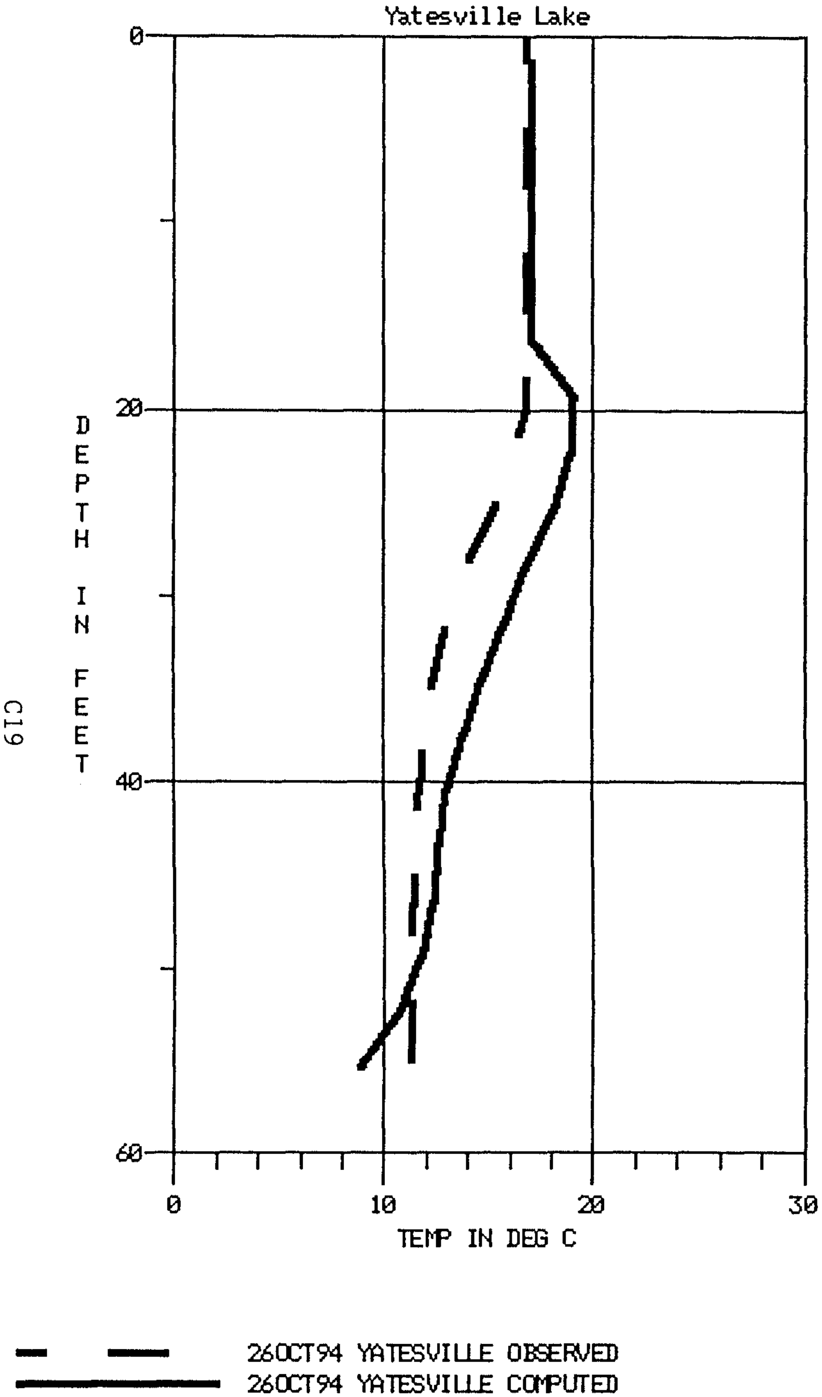

Yatesville Lake
DEPTH IN FEET
TEMP IN DEG C
0
20
40
60
0
10
20
30
28JUN94 YATESVILLE OBSERVED
28JUN94 YATESVILLE COMPUTED

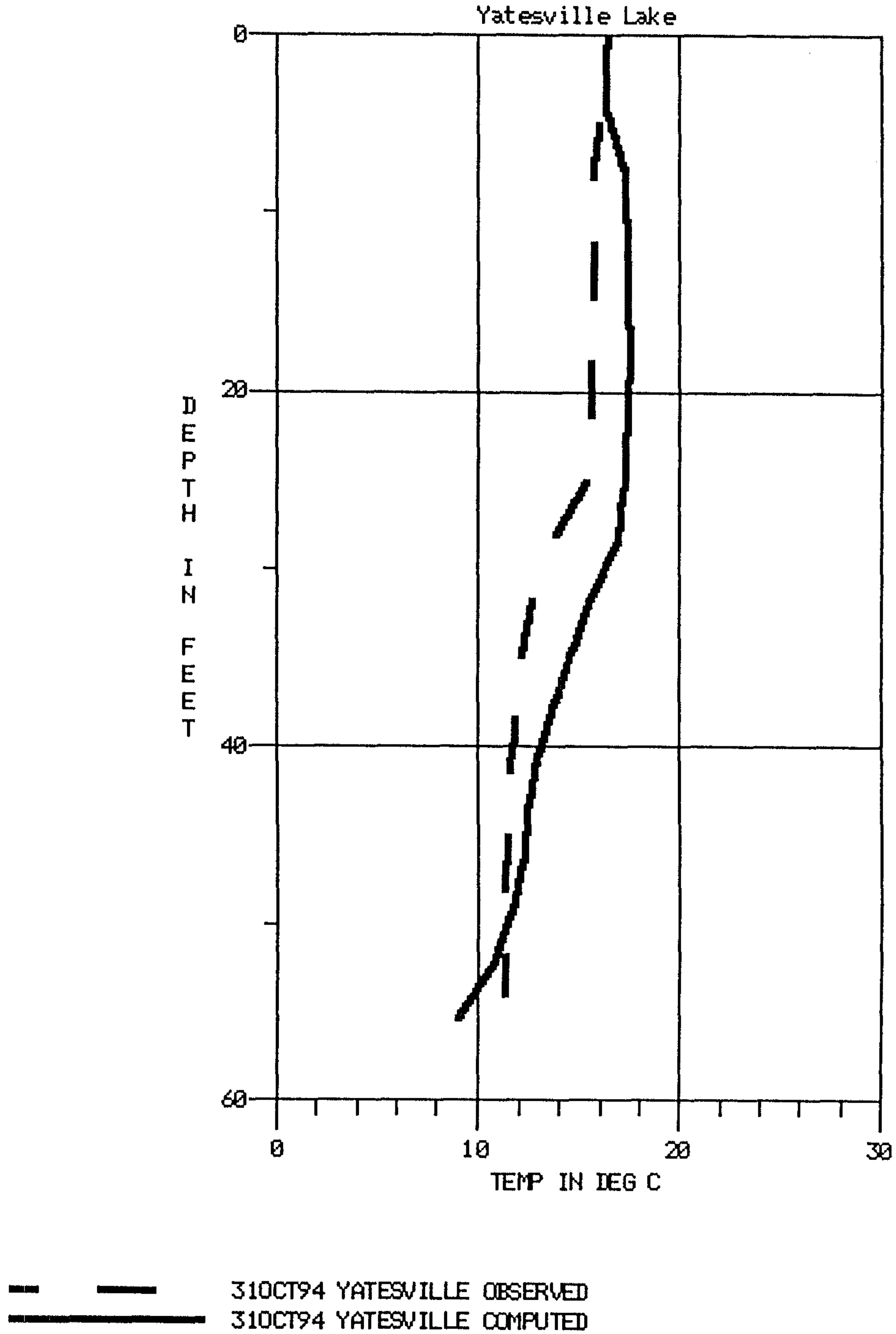

Yatesville Lake
DEPTH IN FEET
TEMP IN DEG C
0
20
40
60
0
10
20
30
28JUL94 YATESVILLE OBSERVED
28JUL94 YATESVILLE COMPUTED

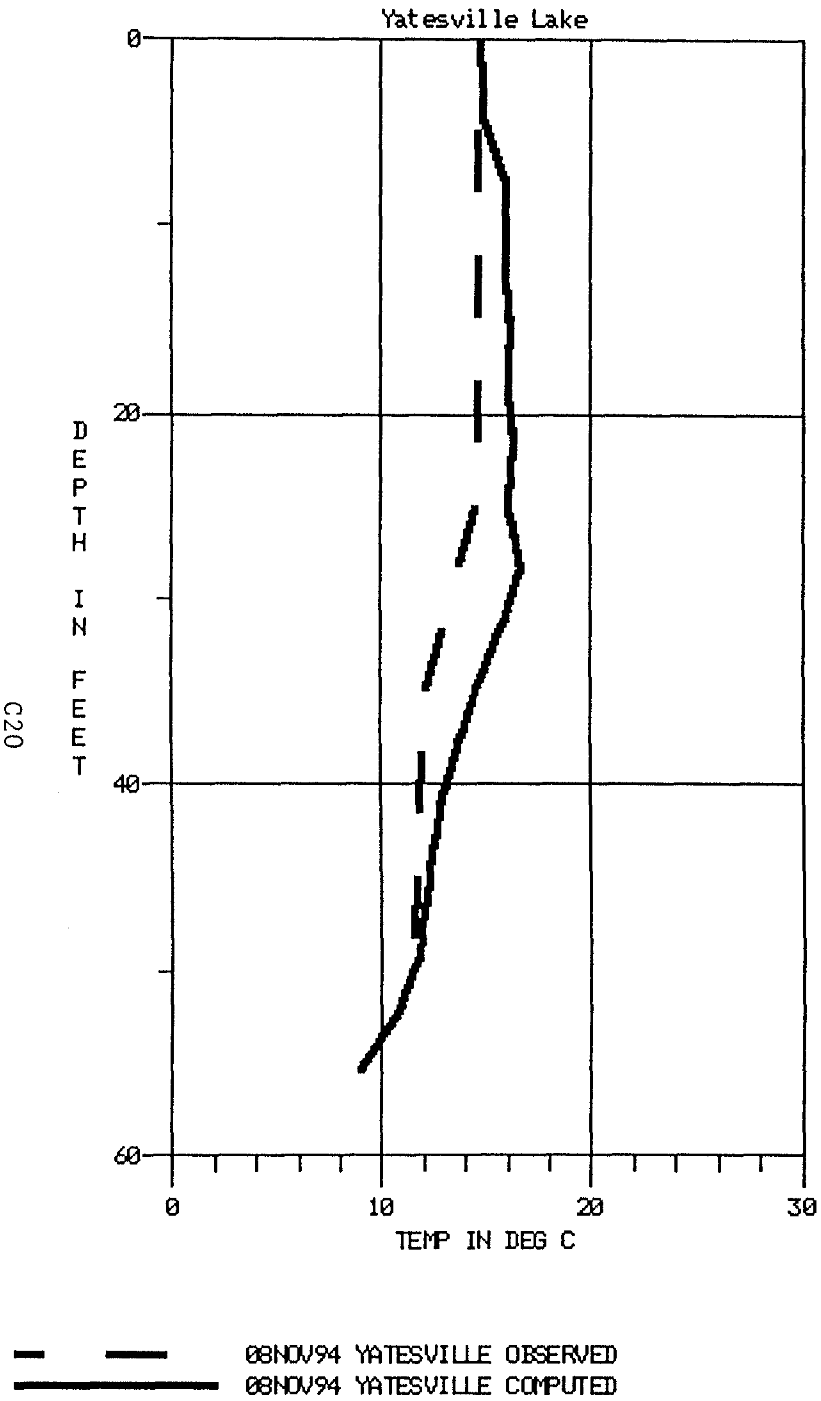


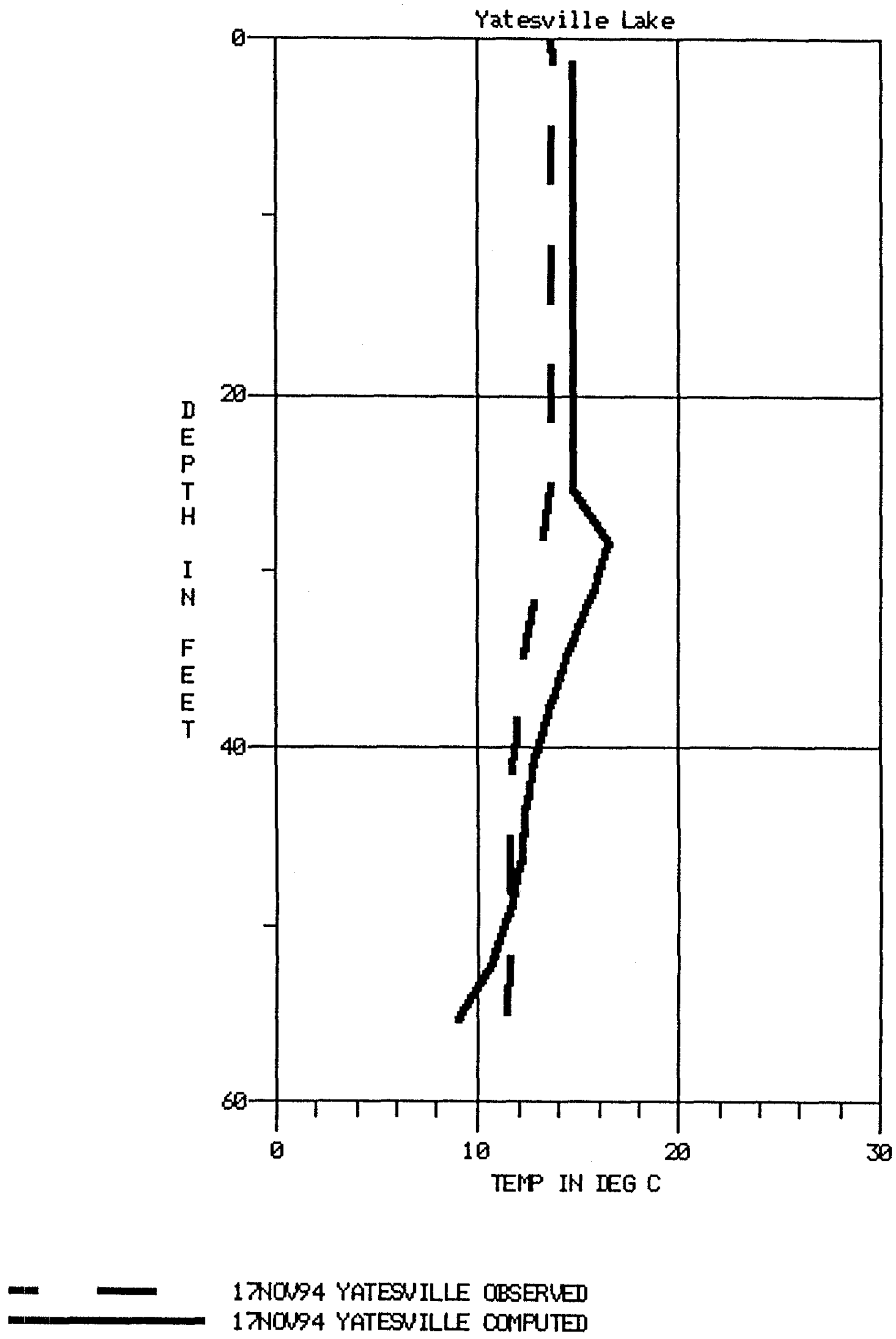
Yatesville Lake
DEPTH IN FEET
TEMP IN DEG C
0
20
40
60
0
10
20
30
10AUG94 YATESVILLE OBSERVED
10AUG94 YATESVILLE COMPUTED
Yatesville Lake
DEPTH IN FEET
TEMP IN DEG C
08SEP94 YATESVILLE OBSERVED
08SEP94 YATESVILLE COMPUTED

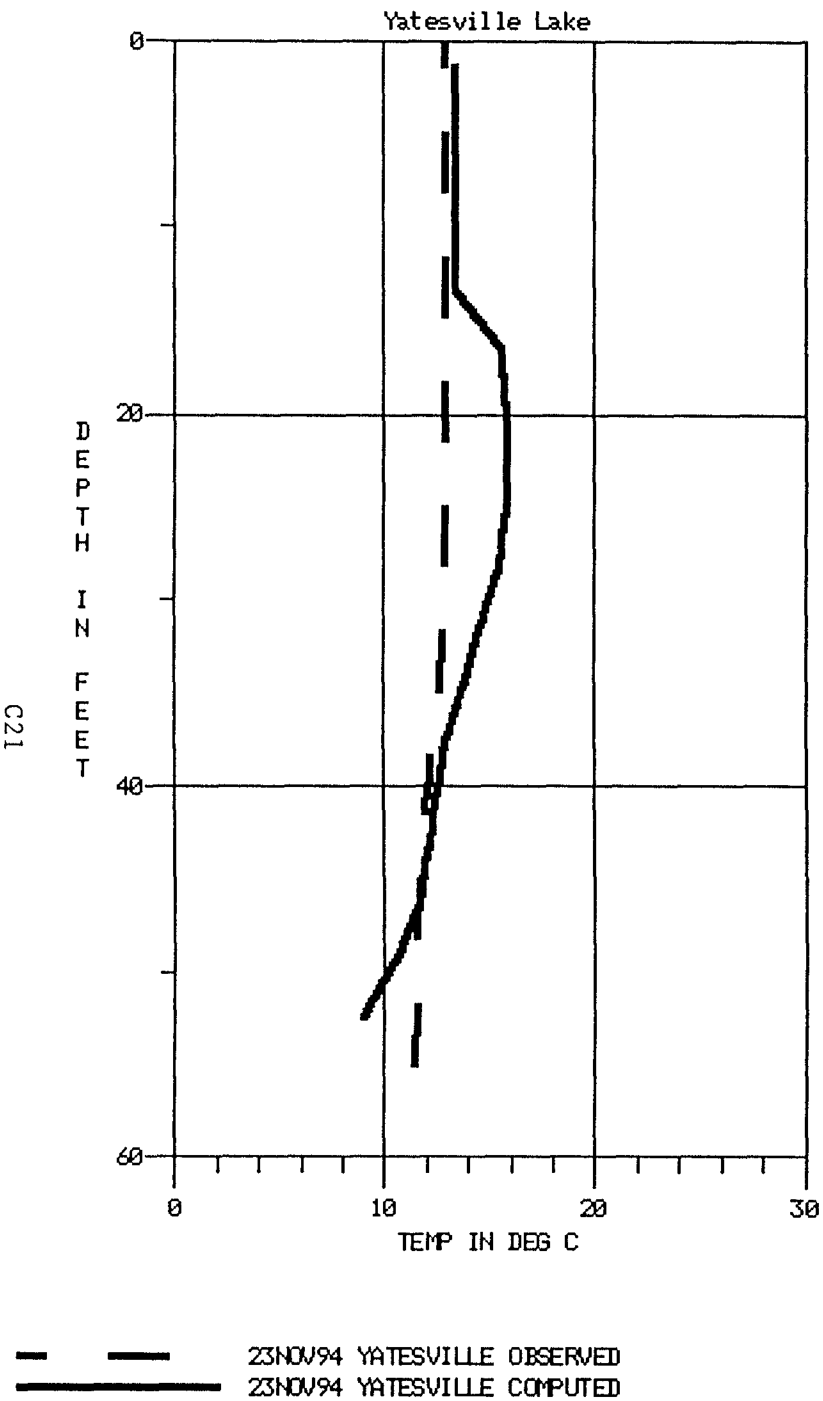

Yatesville Lake
0
20
40
60
D E P T H I N F E E T
0
10
20
30
TEMP IN DEG C
060CT94 YATESVILLE OBSERVED
060CT94 YATESVILLE COMPUTED
Yatesville Lake
0
20
40
60
D E P T H I N F E E T
0
10
20
30
TEMP IN DEG C
190CT94 YATESVILLE OBSERVED
190CT94 YATESVILLE COMPUTED

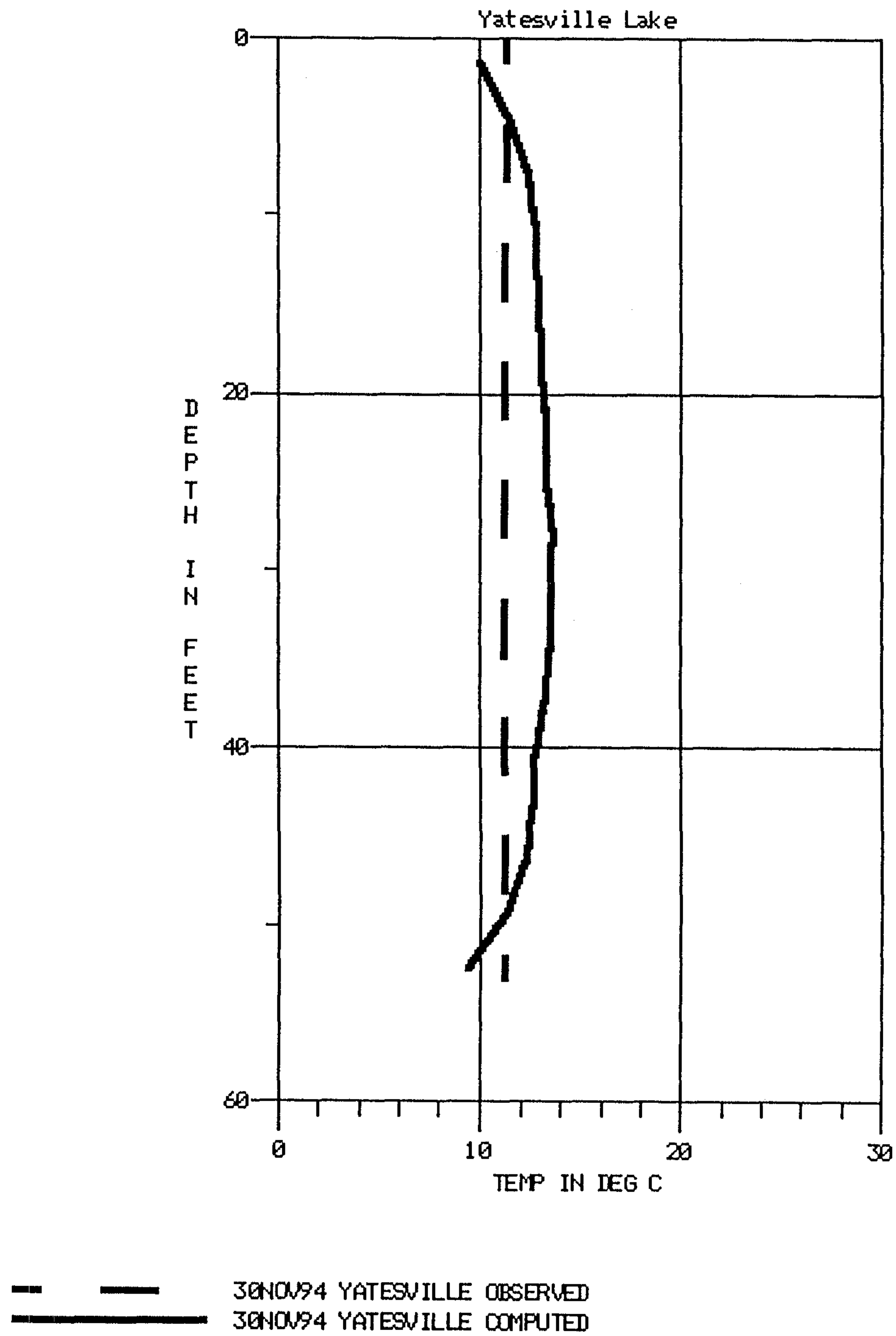

Yatesville Lake
DEPTH IN FEET
TEMP IN DEG C
0
20
40
60
0
10
20
30
260CT94 YATESVILLE OBSERVED
260CT94 YATESVILLE COMPUTED


Yatesville Lake
DEPTH IN FEET
TEMP IN DEG C
0
20
40
60
0
10
20
30
310CT94 YATESVILLE OBSERVED
310CT94 YATESVILLE COMPUTED


Yatesville Lake
DEPTH IN FEET
0
20
40
60
0
10
20
30
TEMP IN DEG C
08NOV94 YATESVILLE OBSERVED
08NOV94 YATESVILLE COMPUTED


Yatesville Lake
DEPTH IN FEET
0
20
40
60
0
10
20
30
TEMP IN DEG C
17NOV94 YATESVILLE OBSERVED
17NOV94 YATESVILLE COMPUTED

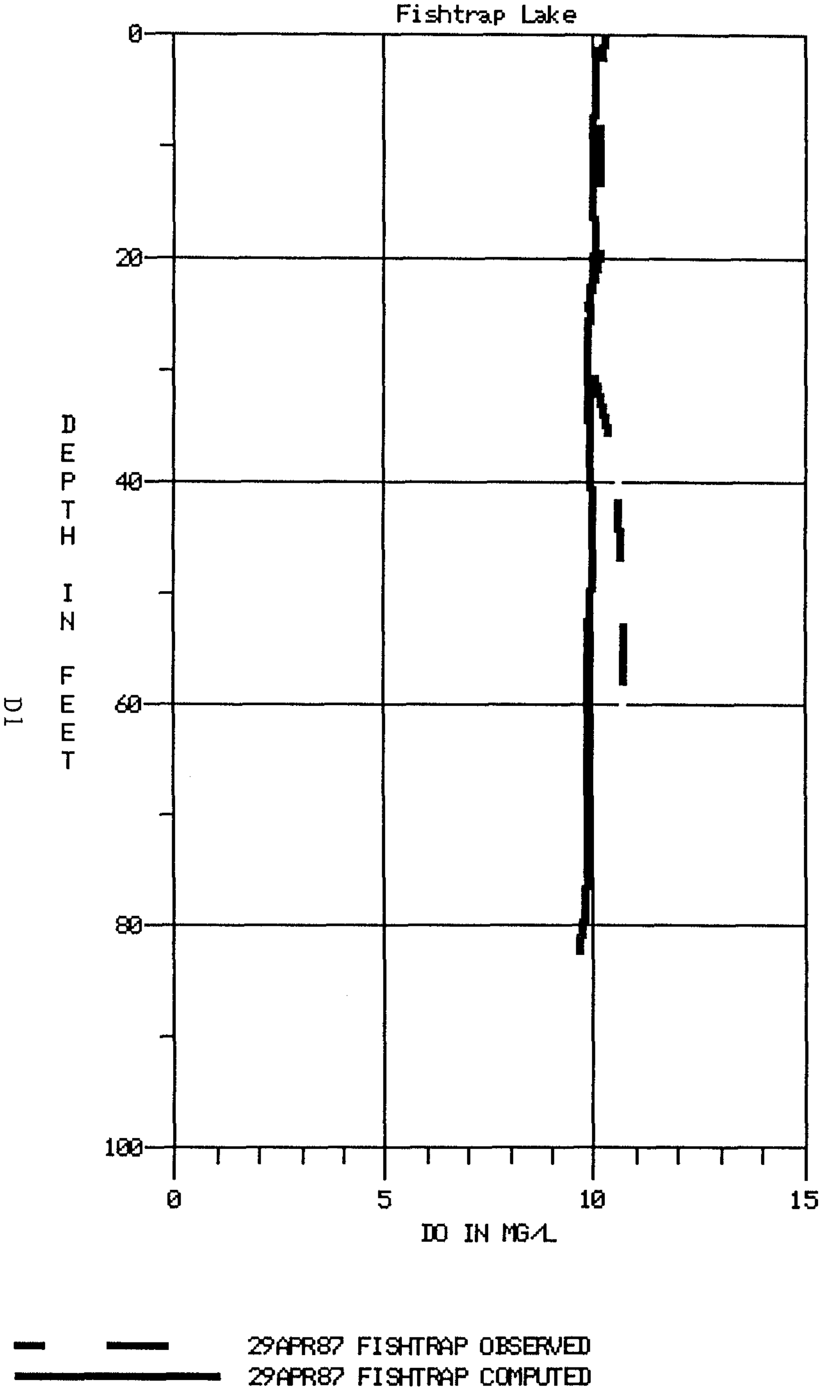

Yatesville Lake
DEPTH IN FEET
0
20
40
60
0
10
20
30
TEMP IN DEG C
23NOV94 YATESVILLE OBSERVED
23NOV94 YATESVILLE COMPUTED


Yatesville Lake
DEPTH IN FEET
0
20
40
60
0
10
20
30
TEMP IN DEG C
30NOV94 YATESVILLE OBSERVED
30NOV94 YATESVILLE COMPUTED

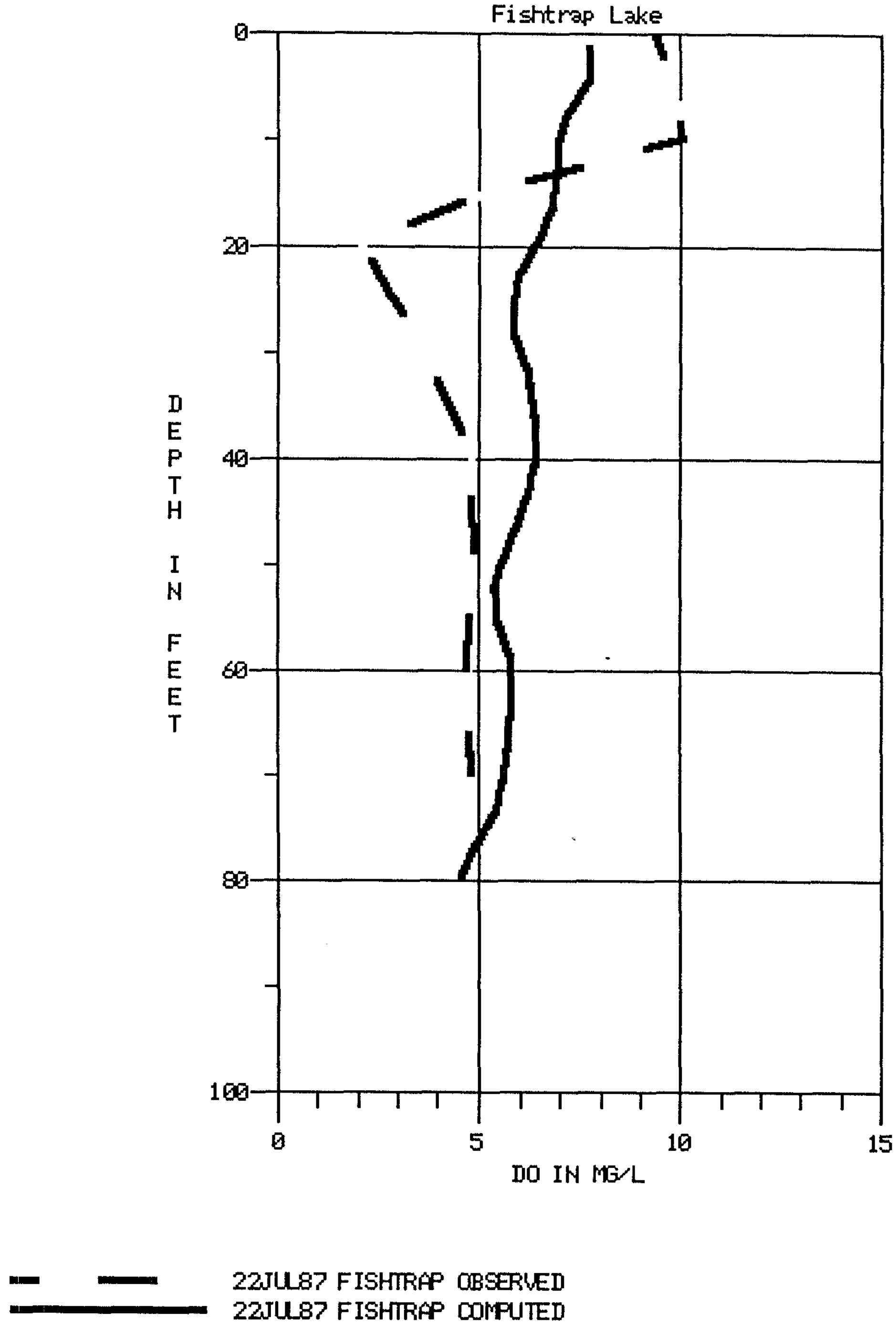
Appendix D

Calibration of Reservoir DO Profiles

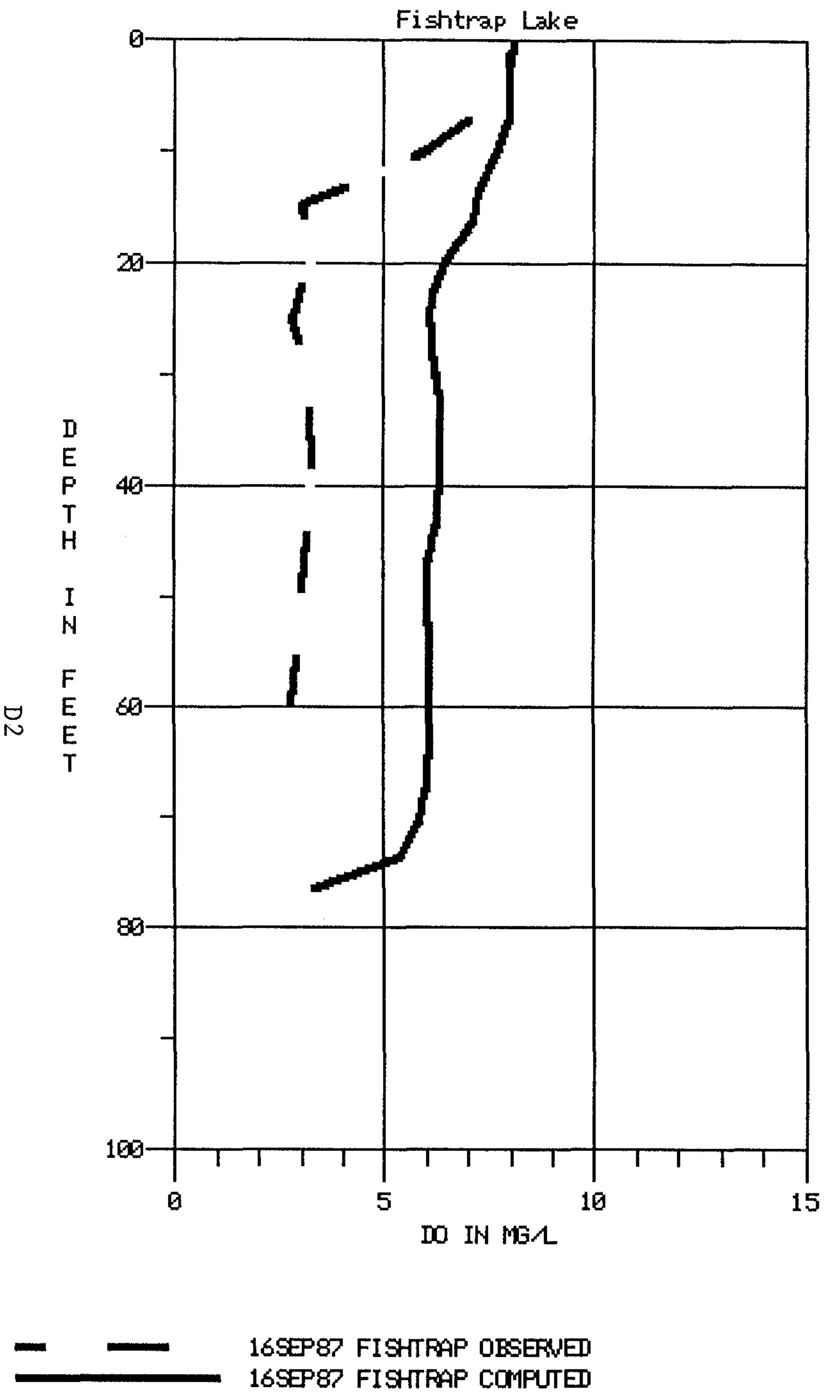
D1

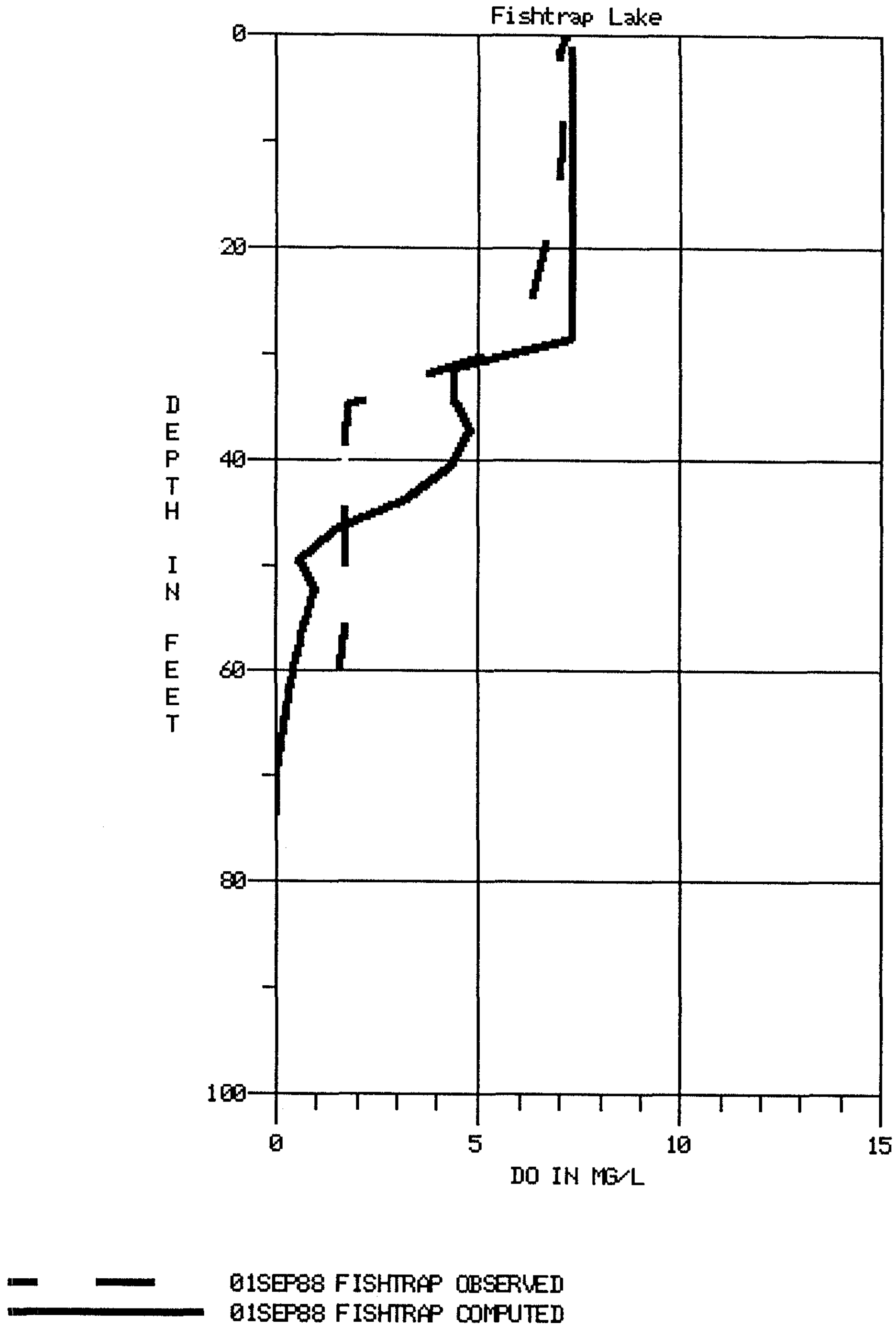


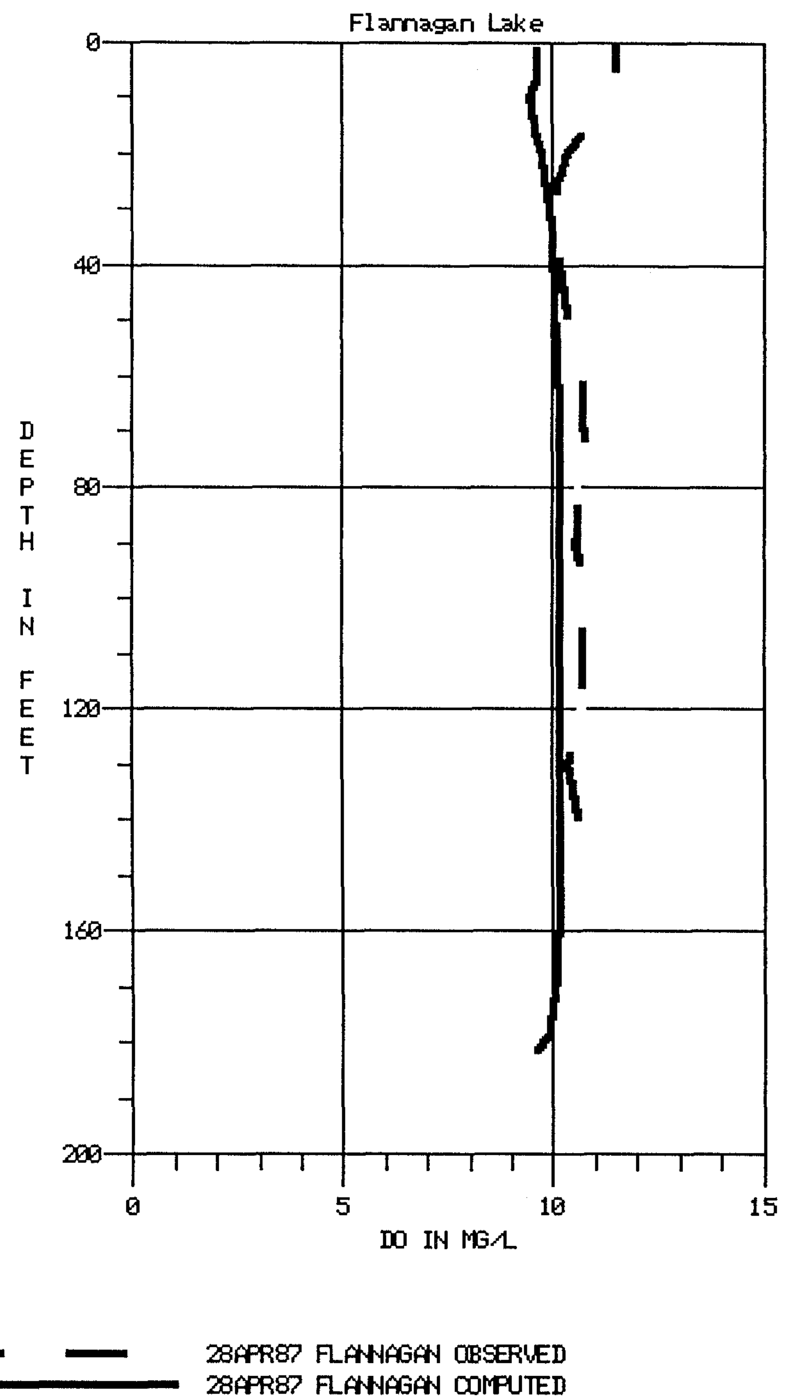
Fishtrap Lake
DEPTH IN FEET
0
20
40
60
80
100
0
5
10
15
DO IN MG/L
29APR87 FISHTRAP OBSERVED
29APR87 FISHTRAP COMPUTED

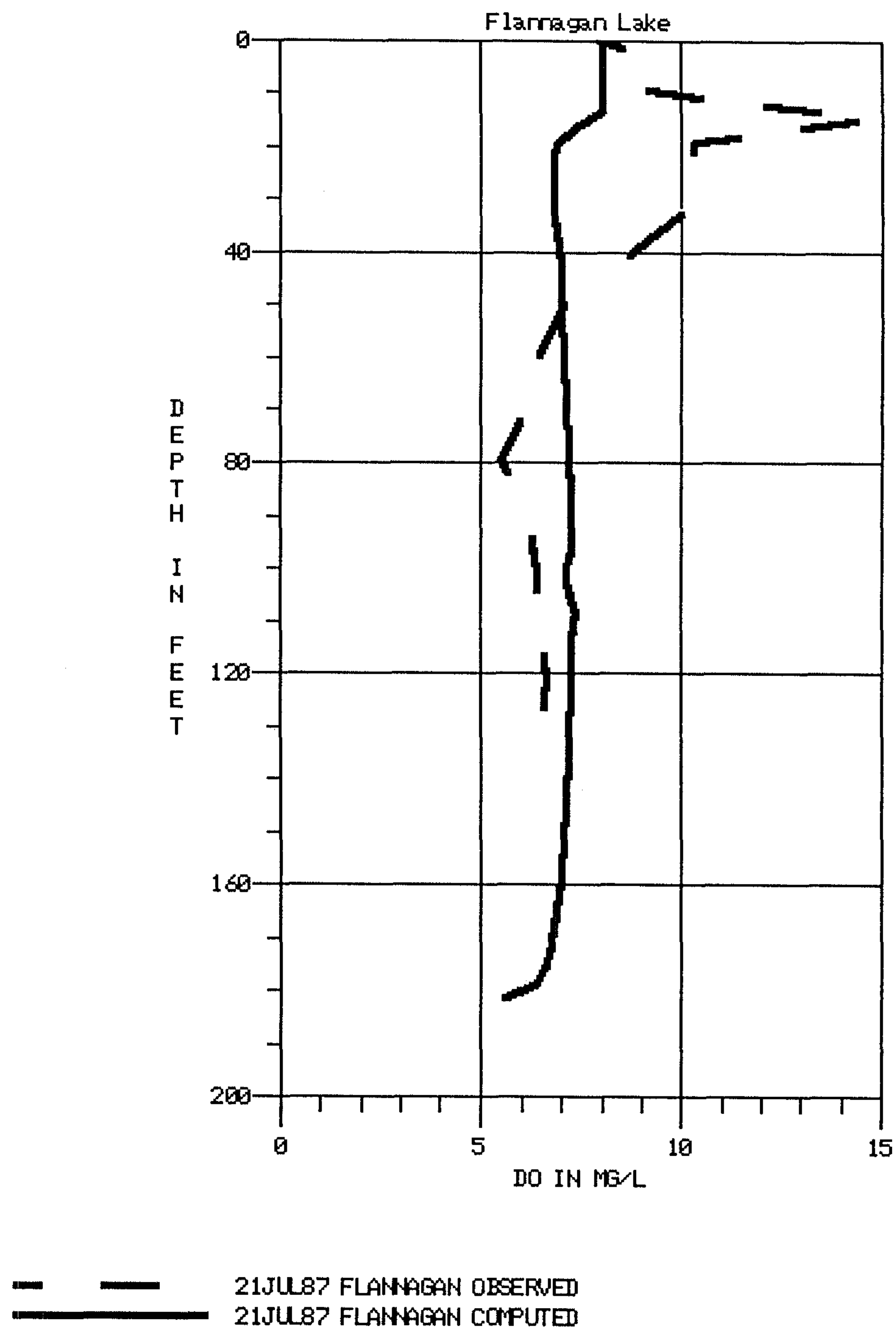


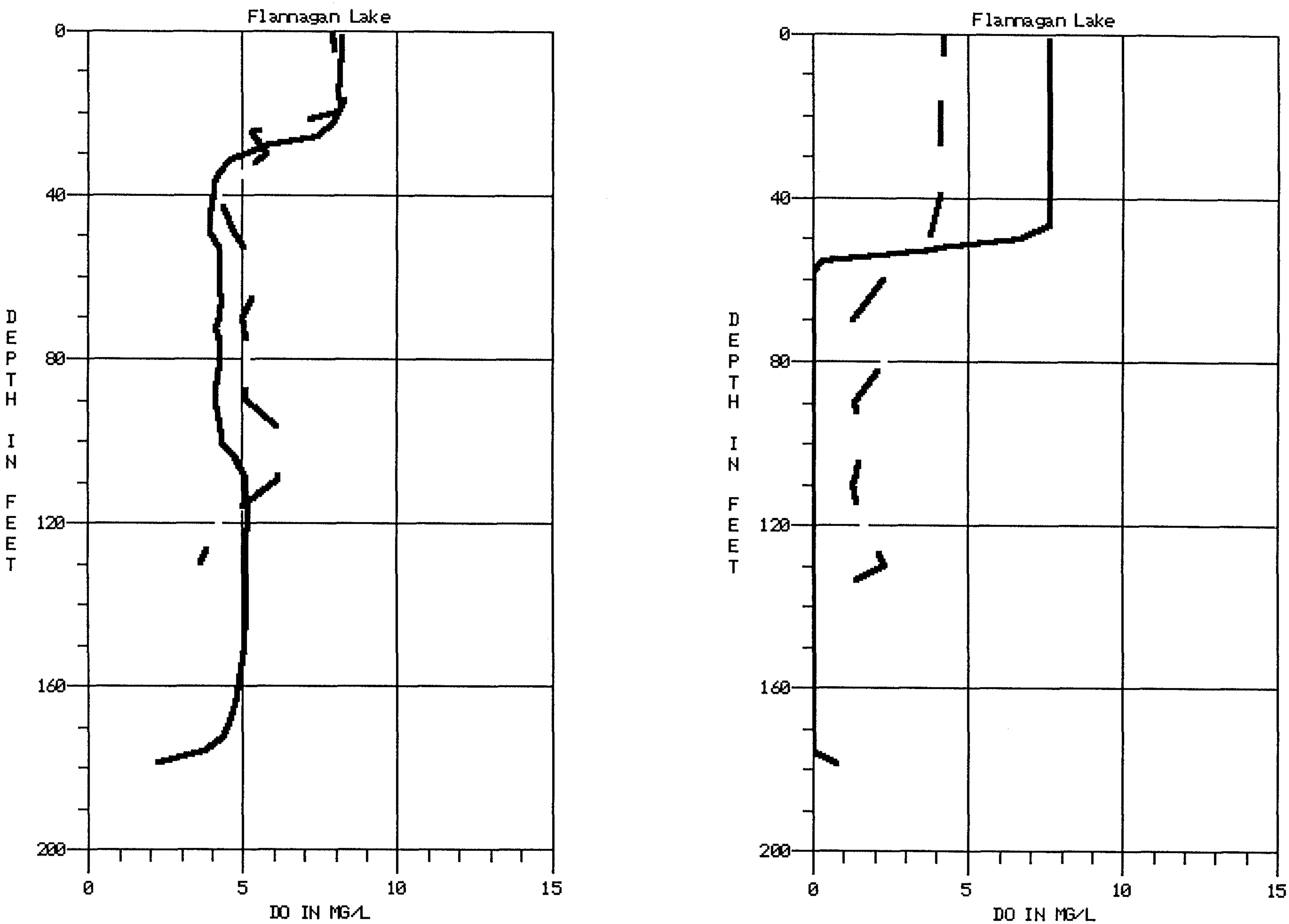
Fishtrap Lake
DEPTH IN FEET
0
20
40
60
80
100
0
5
10
15
DO IN MG/L
22JUL87 FISHTRAP OBSERVED
22JUL87 FISHTRAP COMPUTED


Fishtrap Lake
DEPTH IN FEET
0
20
40
60
80
100
0
5
10
15
DO IN MG/L
16SEP87 FISHTRAP OBSERVED
16SEP87 FISHTRAP COMPUTED


Fishtrap Lake
DEPTH IN FEET
0
20
40
60
80
100
0
5
10
15
DO IN MG/L
01SEP88 FISHTRAP OBSERVED
01SEP88 FISHTRAP COMPUTED


Flannagan Lake
DEPTH IN FEET
0
40
80
120
160
200
0
5
10
15
DO IN MG/L
28APR87 FLANNAGAN OBSERVED
28APR87 FLANNAGAN COMPUTED

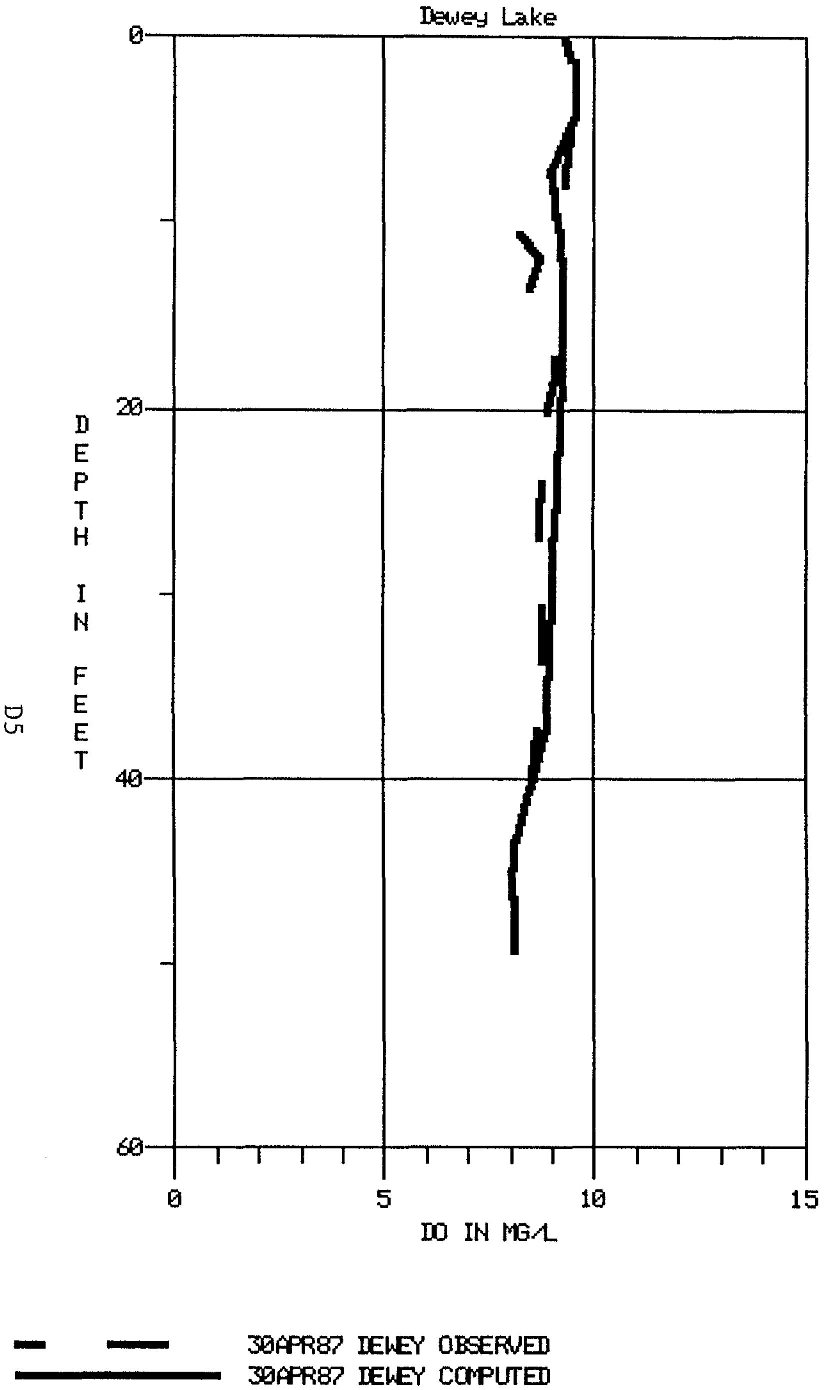

Flannagan Lake
DEPTH IN FEET
0
40
80
120
160
200
0
5
10
15
DO IN MG/L
21JUL87 FLANNAGAN OBSERVED
21JUL87 FLANNAGAN COMPUTED

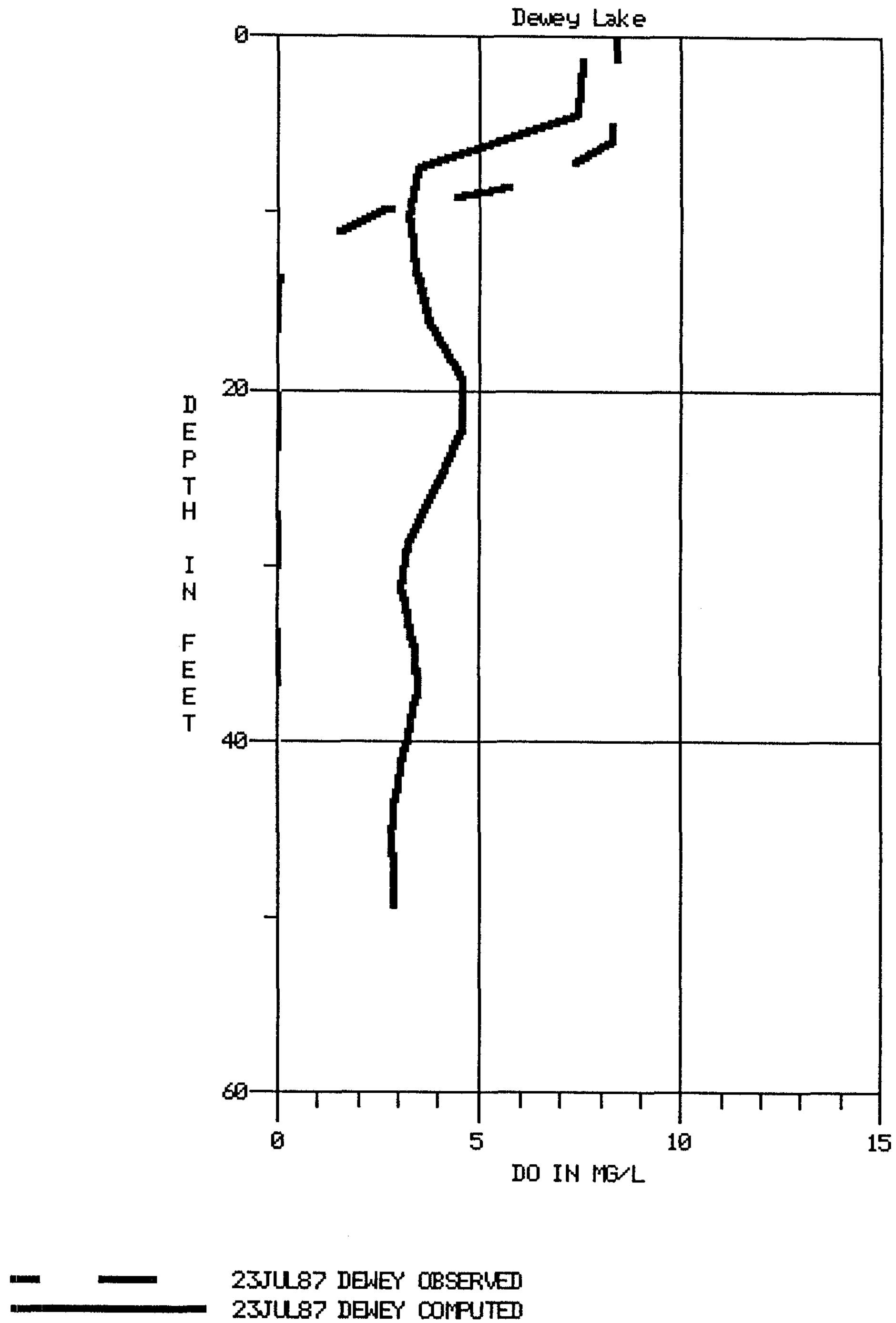


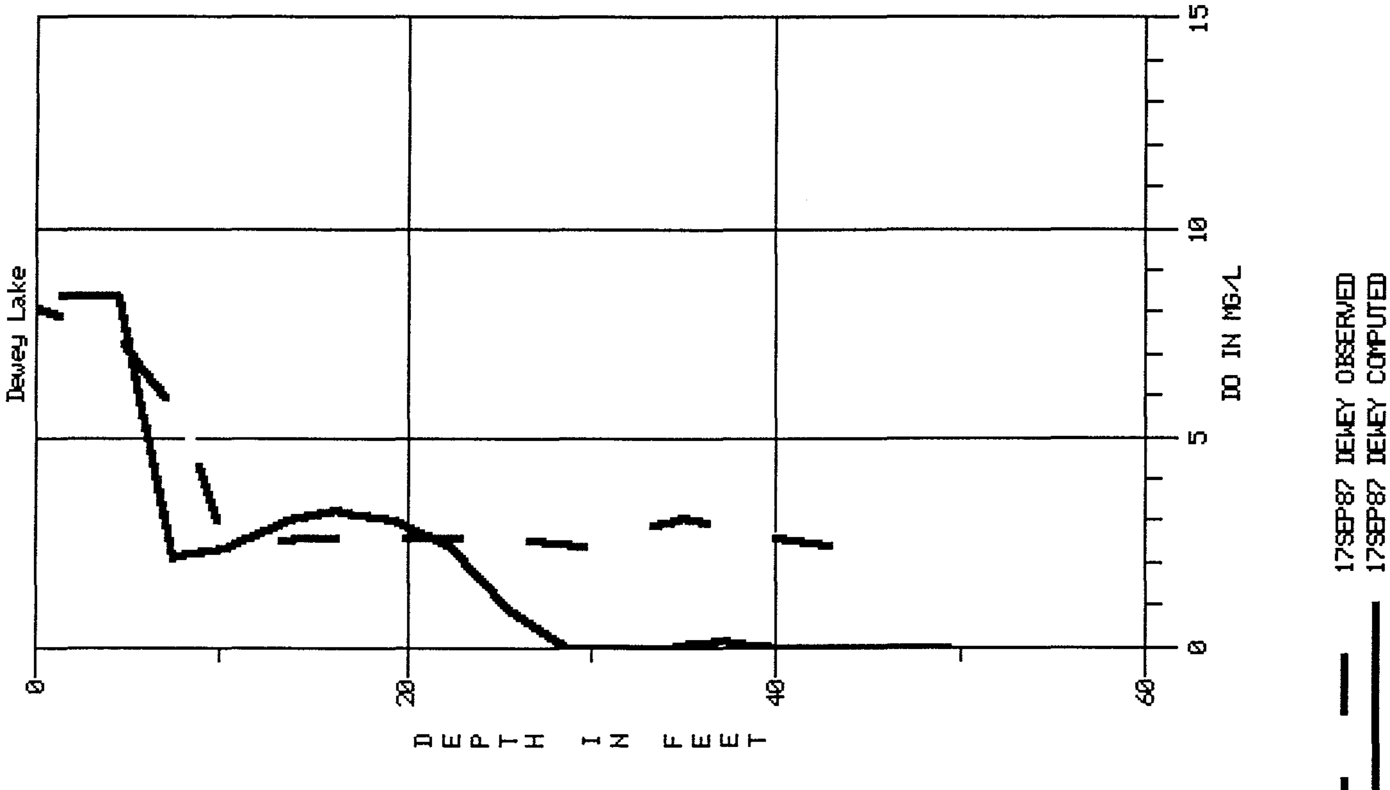
15SEP87 FLANNAGAN OBSERVED
15SEP87 FLANNAGAN COMPUTED

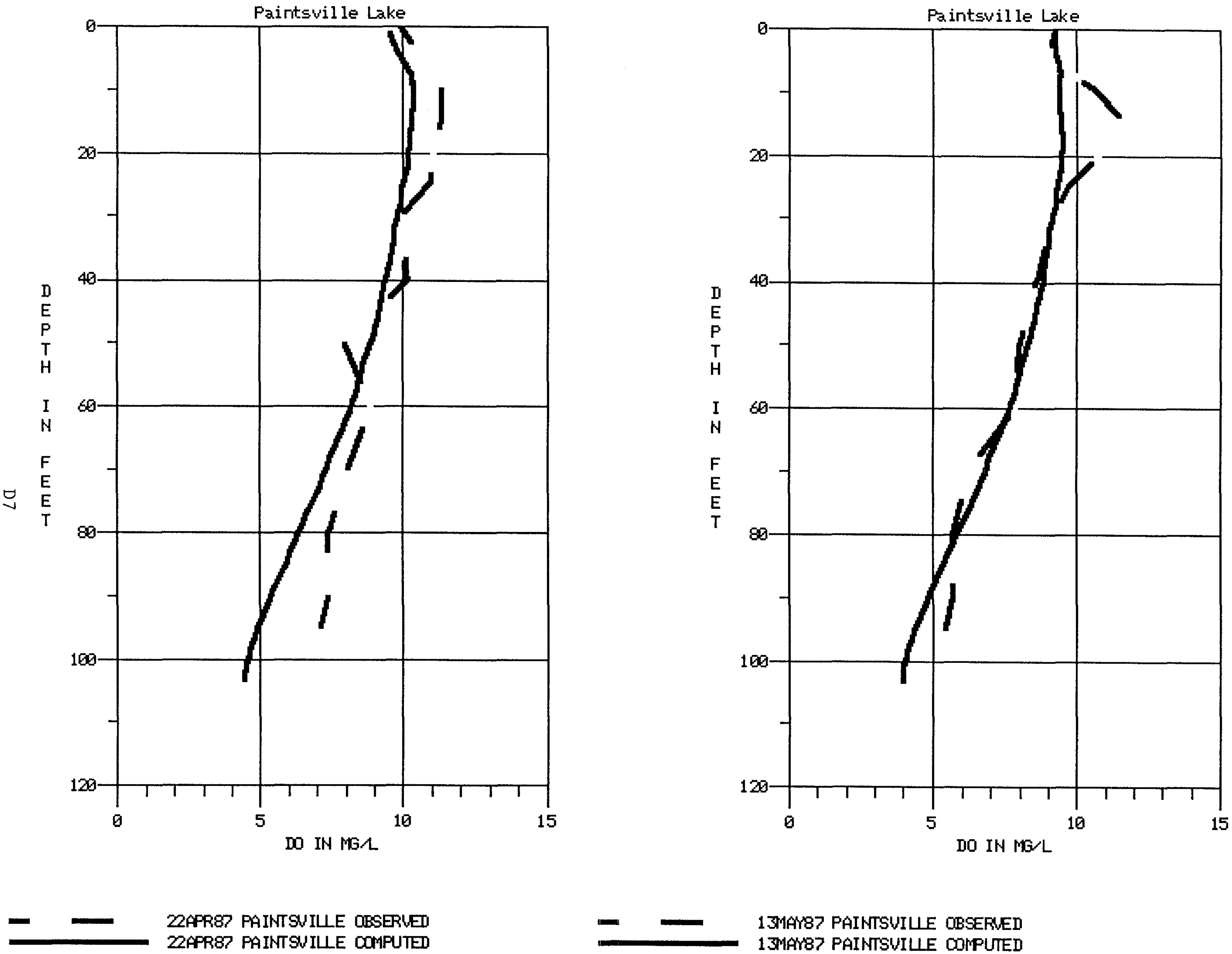
20OCT94 FLANNAGAN OBSERVED
20OCT94 FLANNAGAN COMPUTED

D4


Dewey Lake
DEPTH IN FEET
0
20
40
60
0
5
10
15
DO IN MG/L
30APR87 DEWEY OBSERVED
30APR87 DEWEY COMPUTED

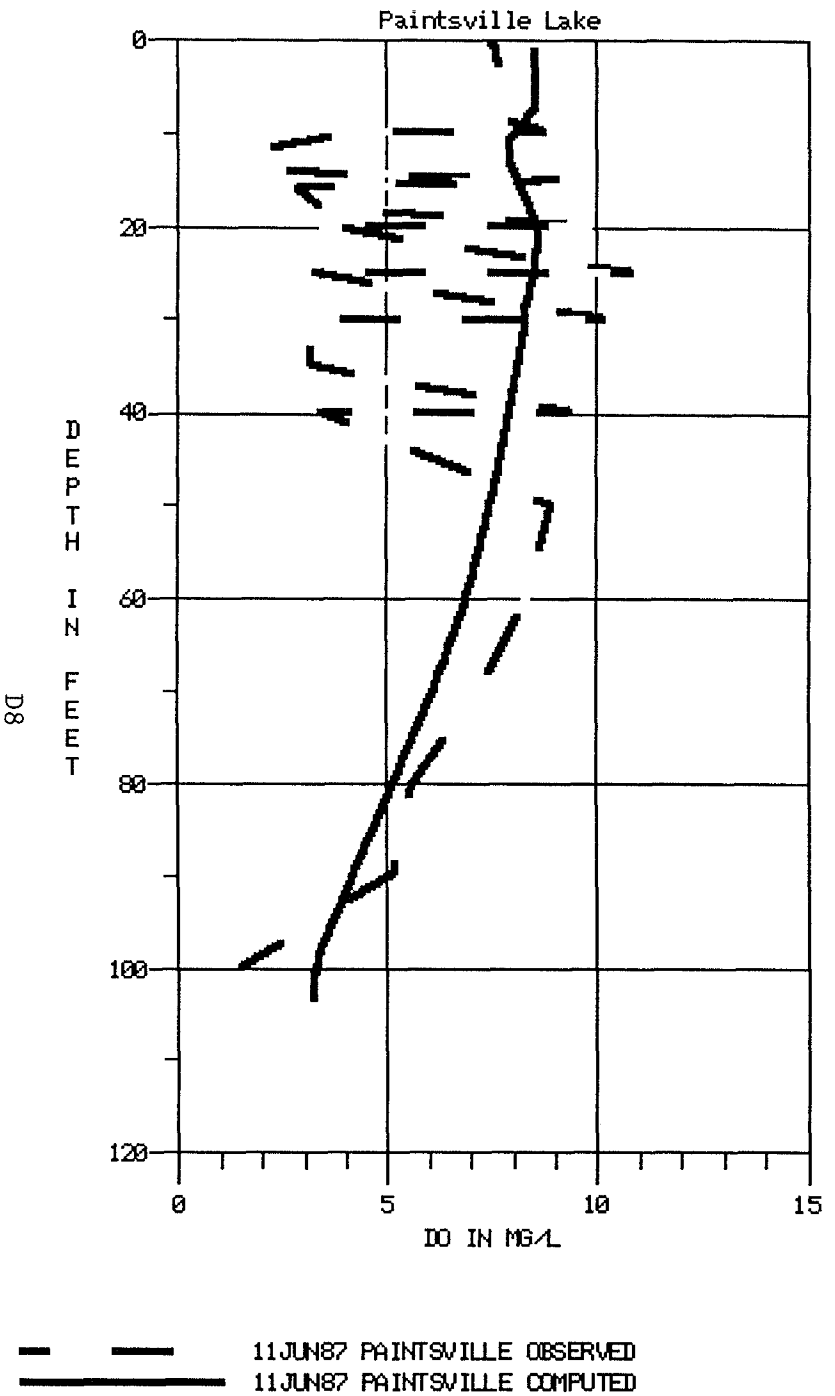

Dewey Lake
DEPTH IN FEET
0
20
40
60
0
5
10
15
DO IN MG/L
23JUL87 DEWEY OBSERVED
23JUL87 DEWEY COMPUTED

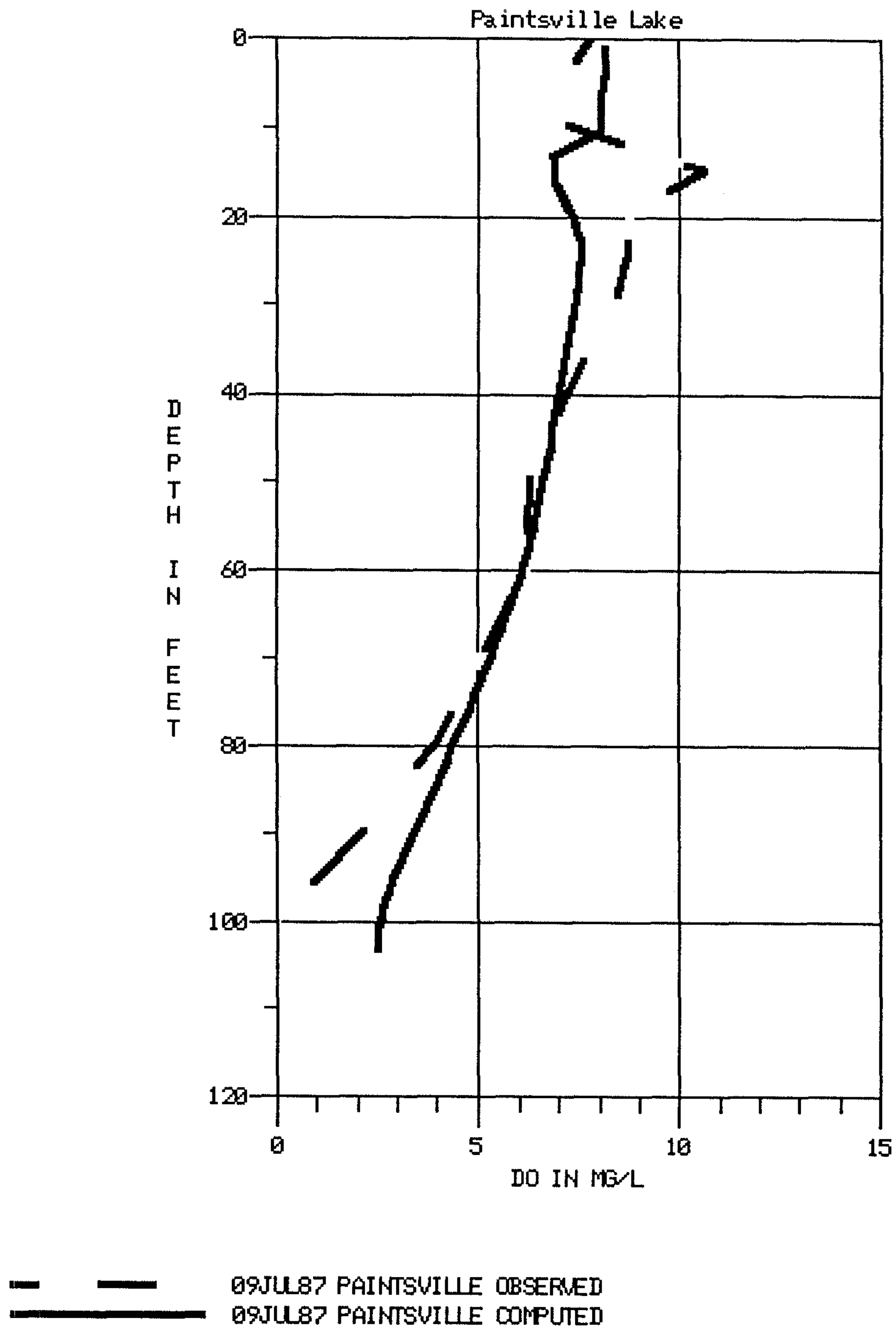

Dewey Lake
0
20
40
60
DEPTH IN FEET
0
5
10
15
DO IN MG/L
17SEP87 DEWEY OBSERVED
17SEP87 DEWEY COMPUTED

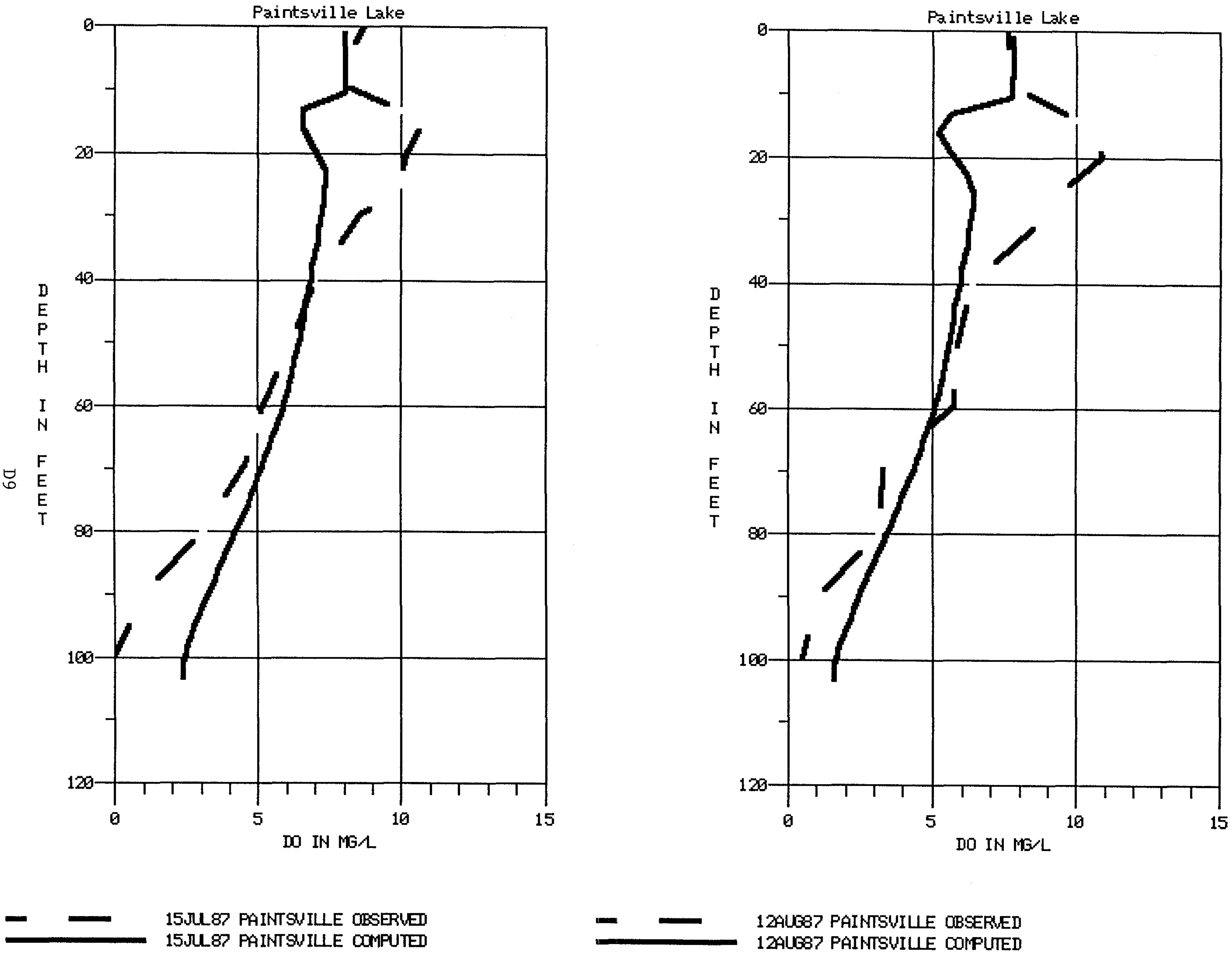


Paintsville Lake
DEPTH IN FEET
DO IN MG/L
Paintsville Lake
DEPTH IN FEET
DO IN MG/L
22APR87 PAINTSVILLE OBSERVED
22APR87 PAINTSVILLE COMPUTED
13MAY87 PAINTSVILLE OBSERVED
13MAY87 PAINTSVILLE COMPUTED

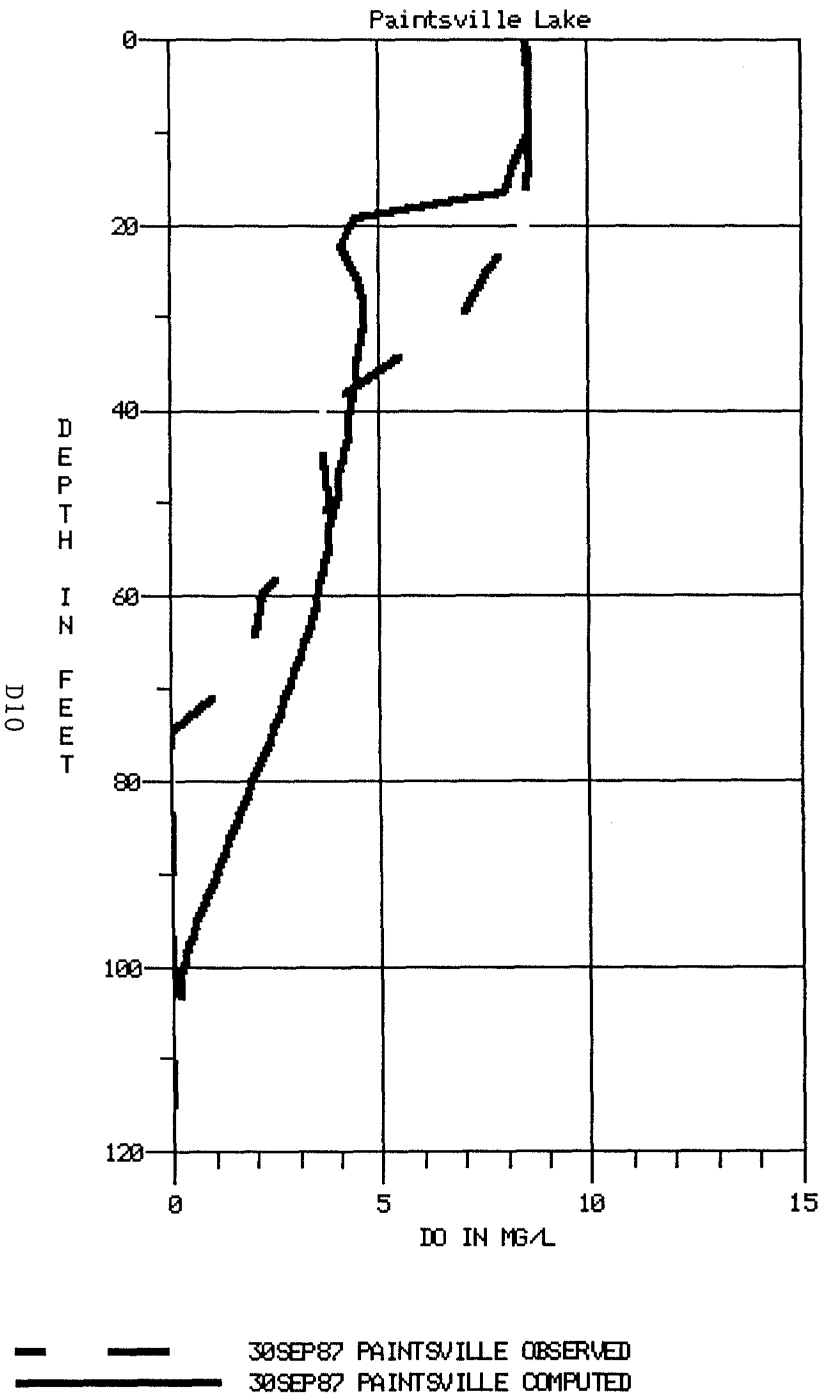
D8

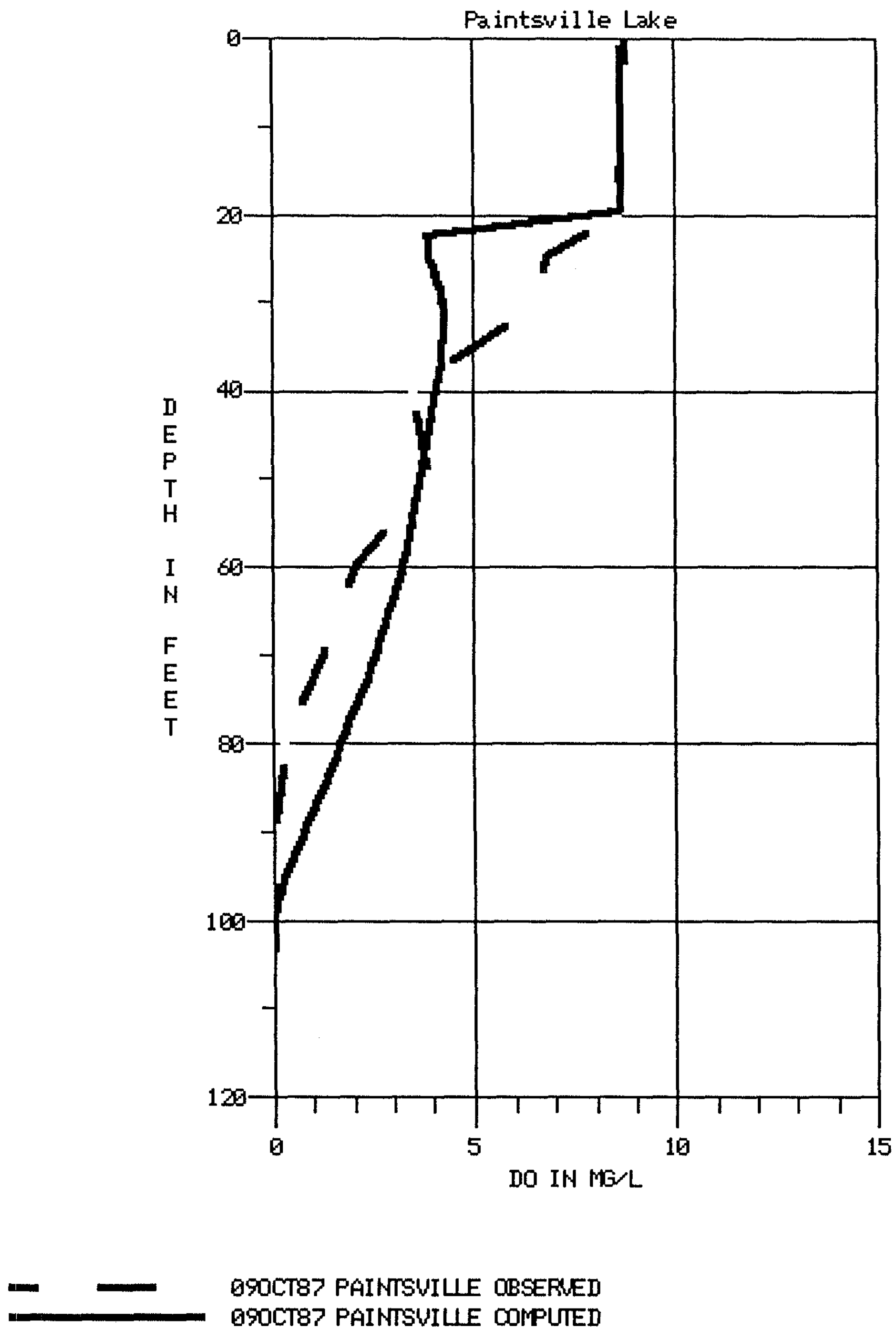

Paintsville Lake
DEPTH IN FEET
DO IN MG/L
11JUN87 PAINTSVILLE OBSERVED
11JUN87 PAINTSVILLE COMPUTED

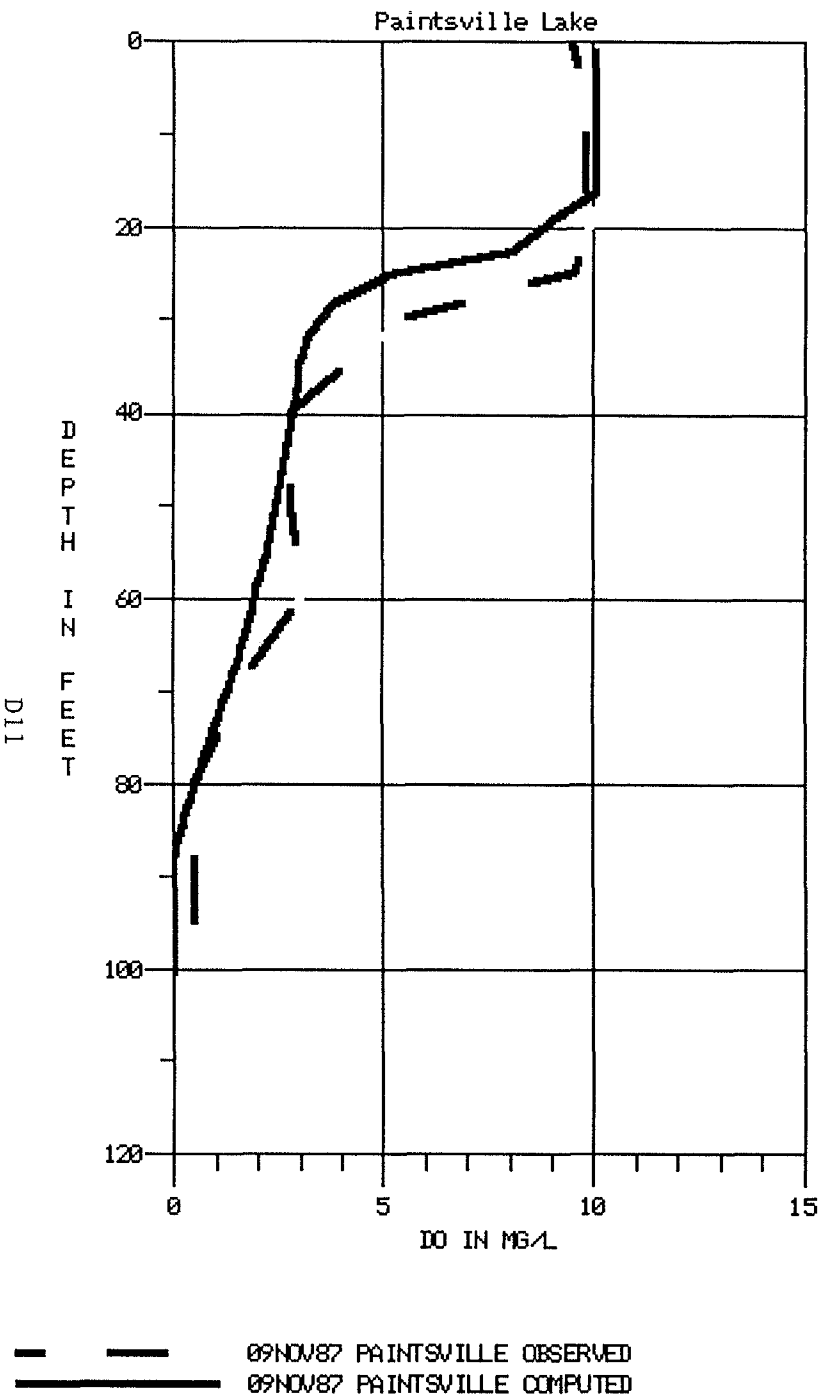

Paintsville Lake
DEPTH IN FEET
DO IN MG/L
09JUL87 PAINTSVILLE OBSERVED
09JUL87 PAINTSVILLE COMPUTED

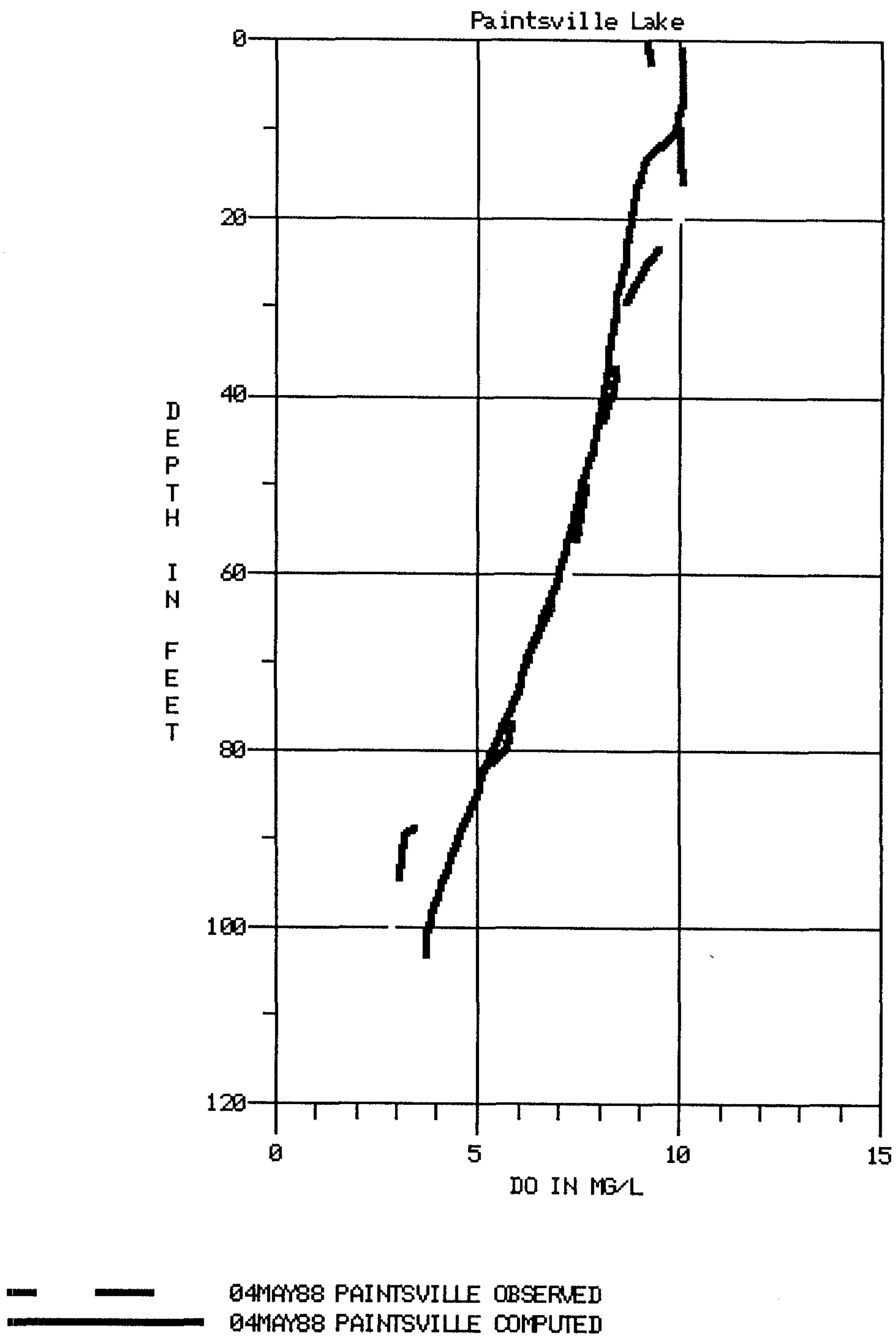

Paintsville Lake
DEPTH IN FEET
0
20
40
60
80
100
120
0
5
10
15
DO IN MG/L
15JUL87 PAINTSVILLE OBSERVED
15JUL87 PAINTSVILLE COMPUTED
Paintsville Lake
DEPTH IN FEET
0
20
40
60
80
100
120
0
5
10
15
DO IN MG/L
12AUG87 PAINTSVILLE OBSERVED
12AUG87 PAINTSVILLE COMPUTED

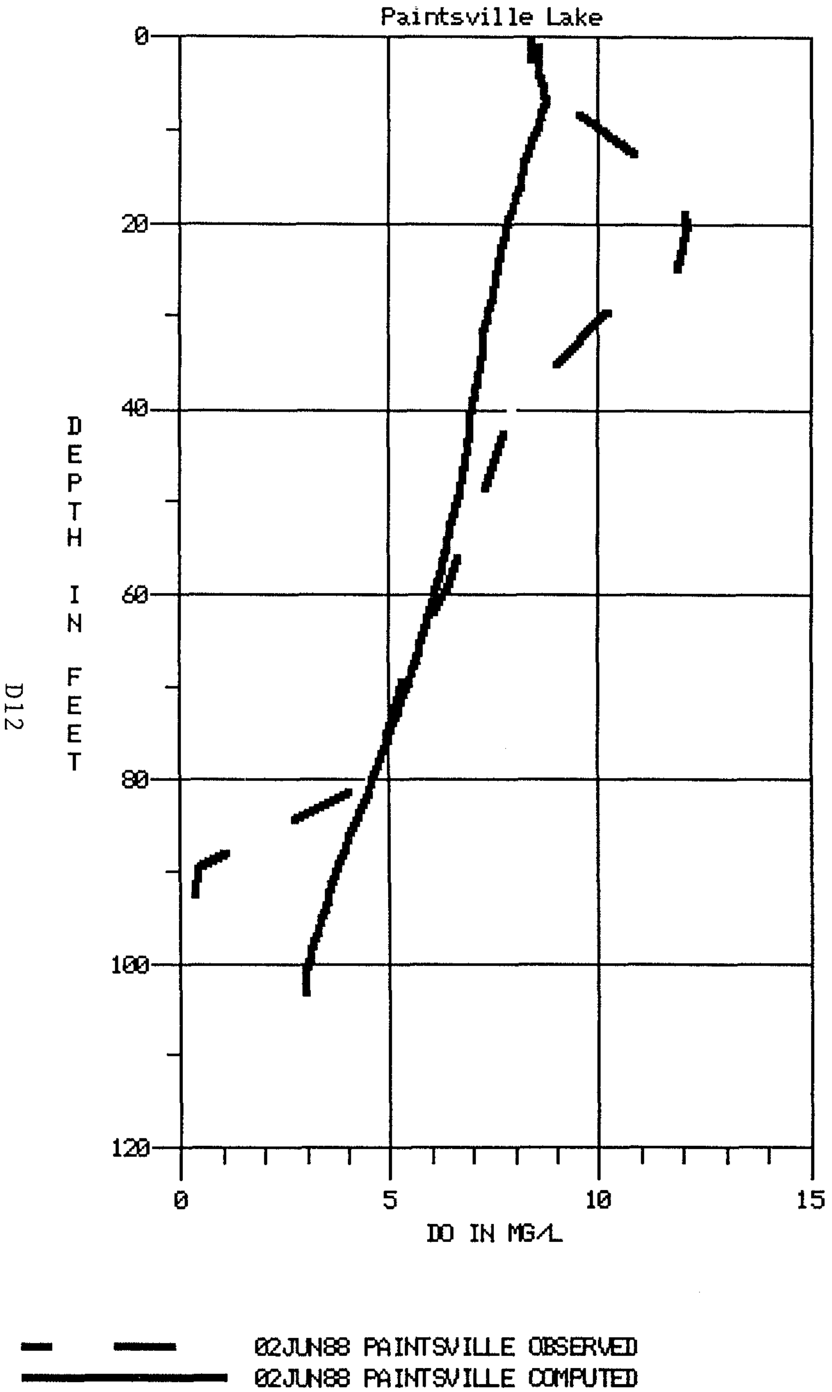
D10

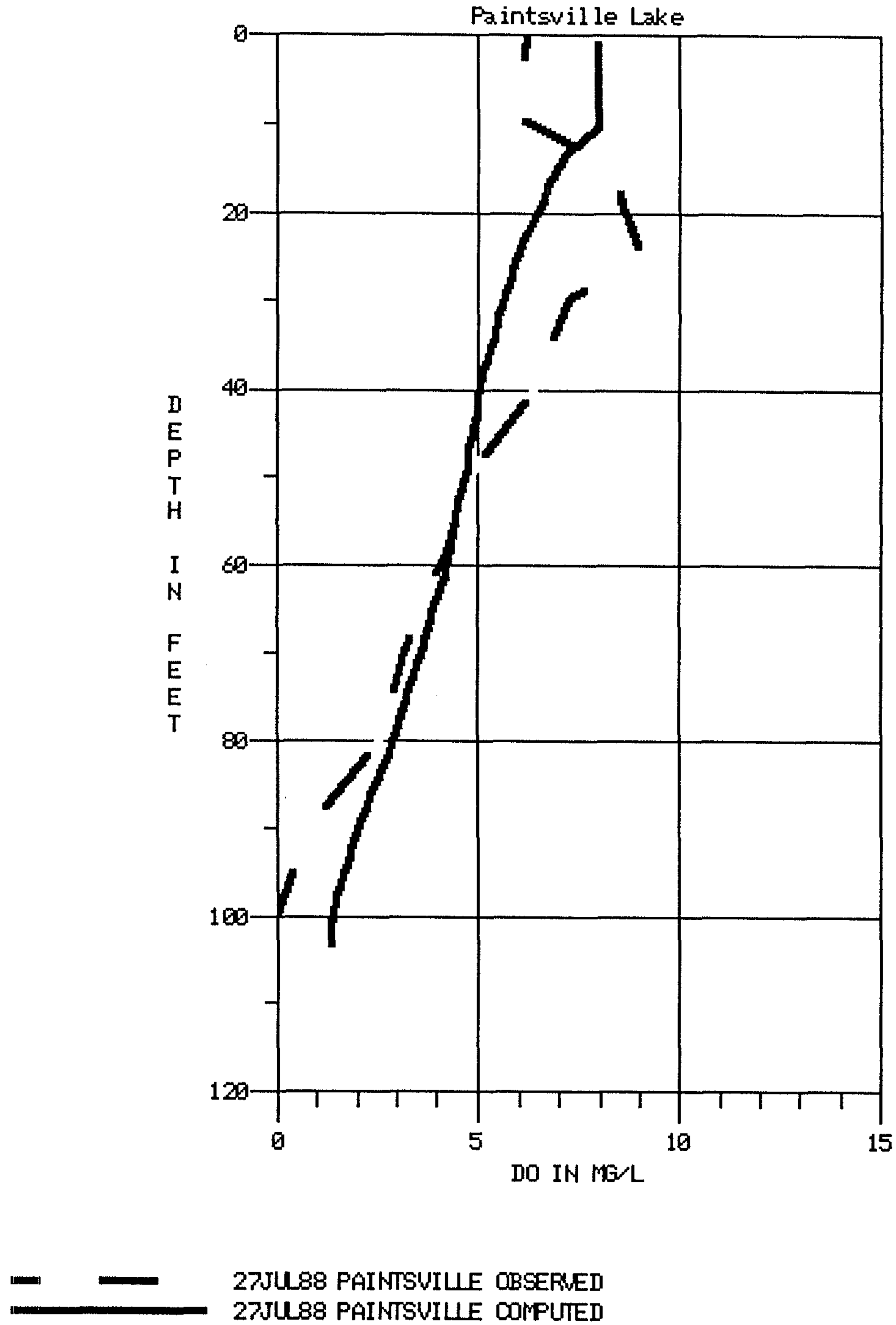

Paintsville Lake
DEPTH IN FEET
0
20
40
60
80
100
120
0
5
10
15
DO IN MG/L
30SEP87 PAINTSVILLE OBSERVED
30SEP87 PAINTSVILLE COMPUTED

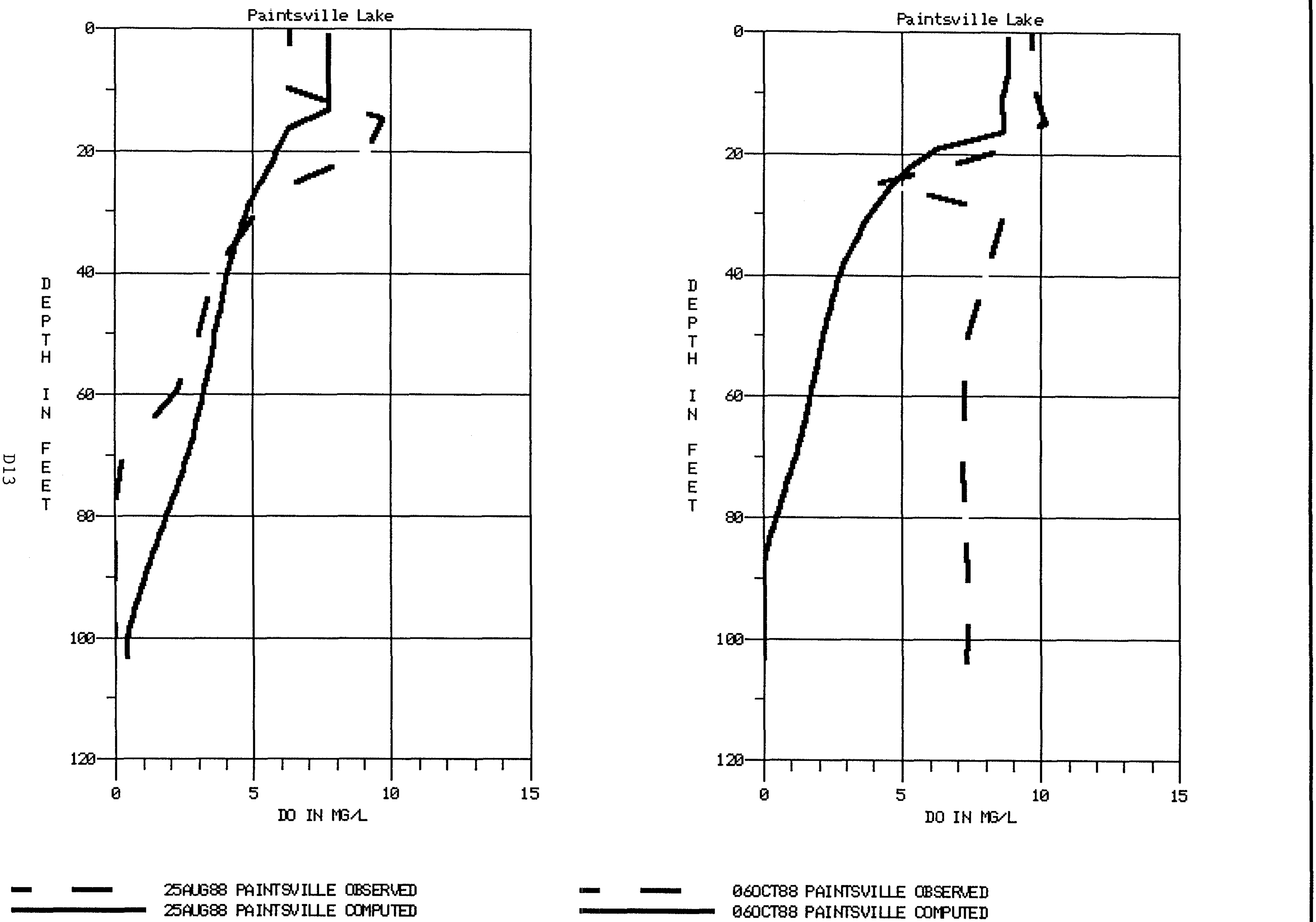

Paintsville Lake
DEPTH IN FEET
0
20
40
60
80
100
120
0
5
10
15
DO IN MG/L
09OCT87 PAINTSVILLE OBSERVED
09OCT87 PAINTSVILLE COMPUTED

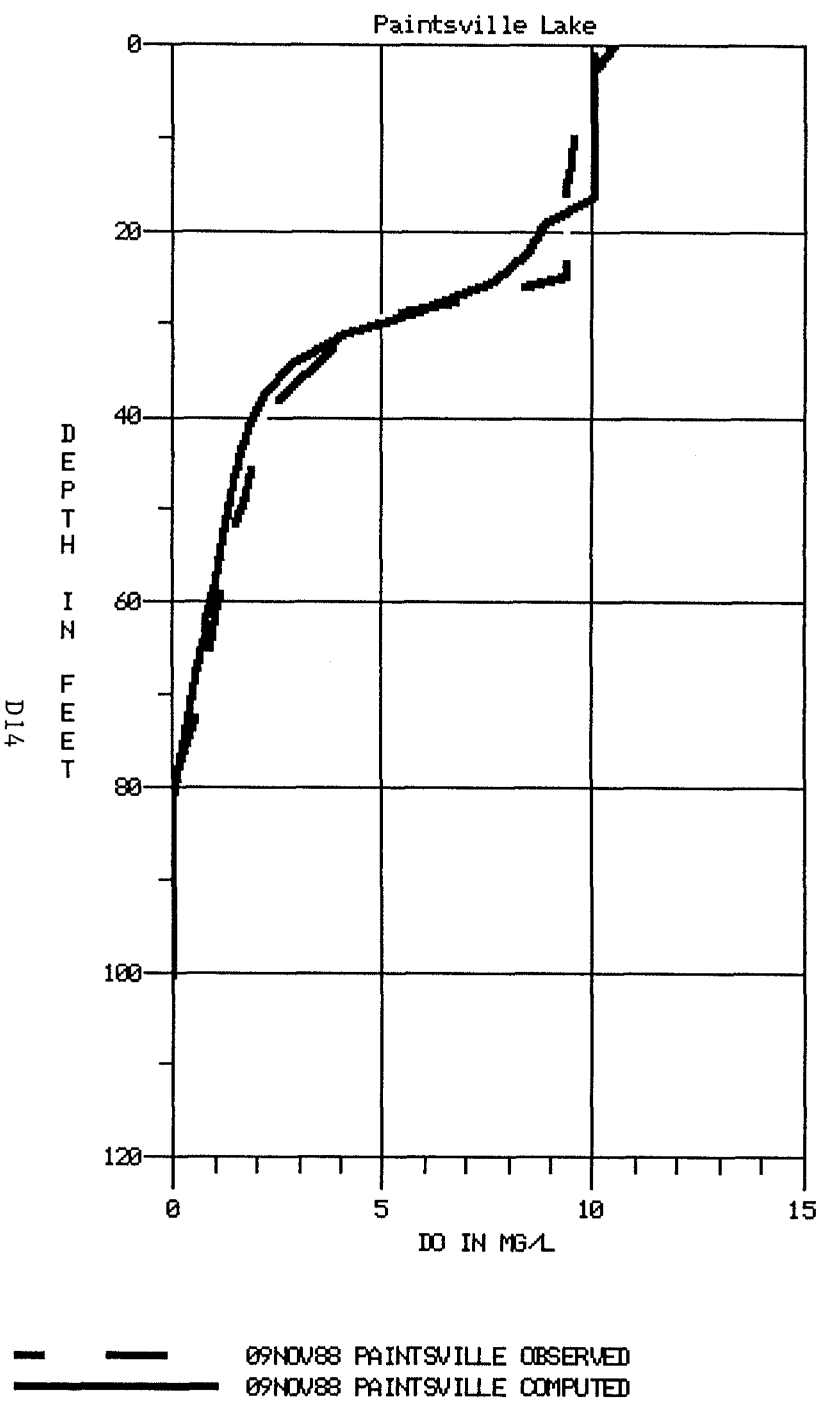

Paintsville Lake
DEPTH IN FEET
0
20
40
60
80
100
120
0
5
10
15
DO IN MG/L
09NOV87 PAINTSVILLE OBSERVED
09NOV87 PAINTSVILLE COMPUTED

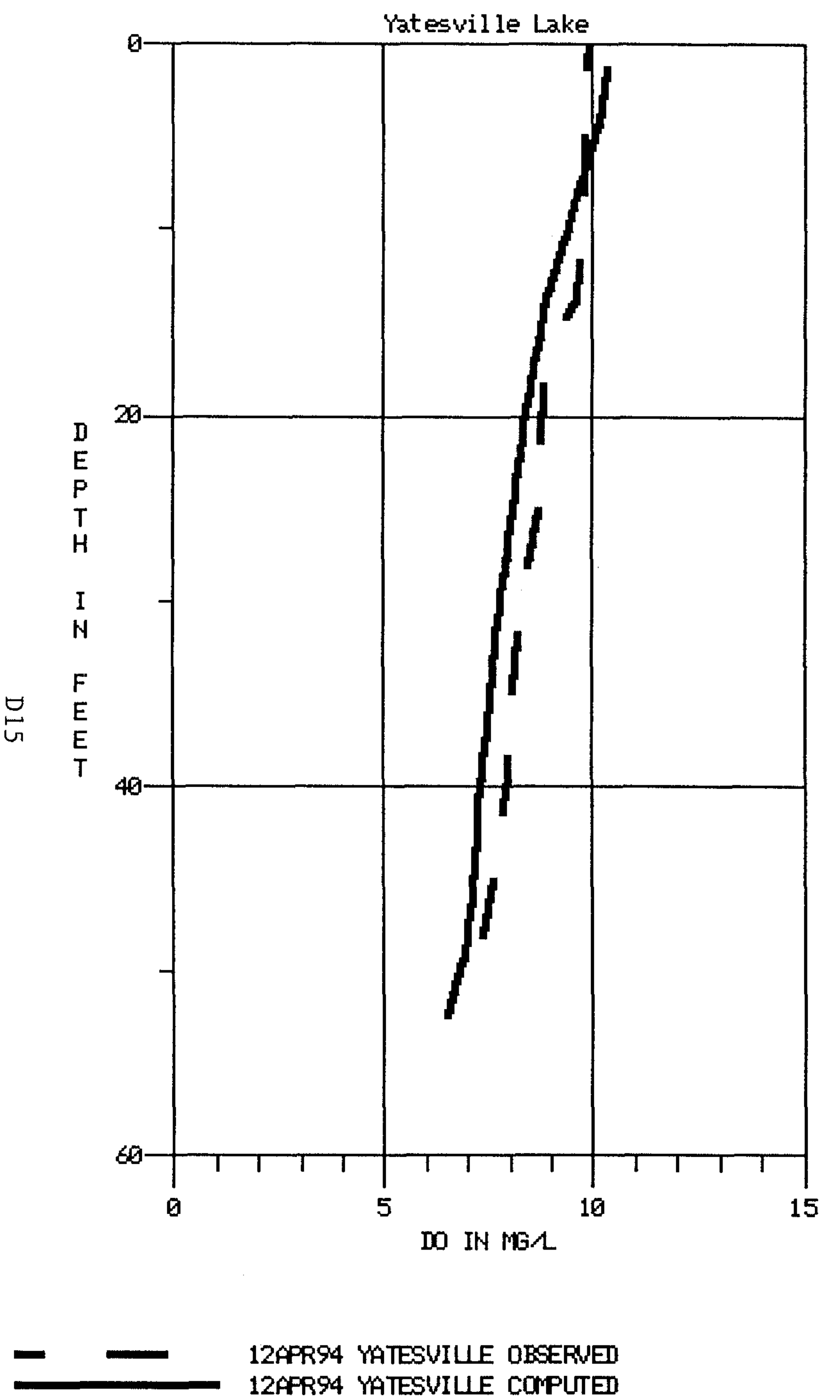

Paintsville Lake
DEPTH IN FEET
0
20
40
60
80
100
120
0
5
10
15
DO IN MG/L
04MAY88 PAINTSVILLE OBSERVED
04MAY88 PAINTSVILLE COMPUTED

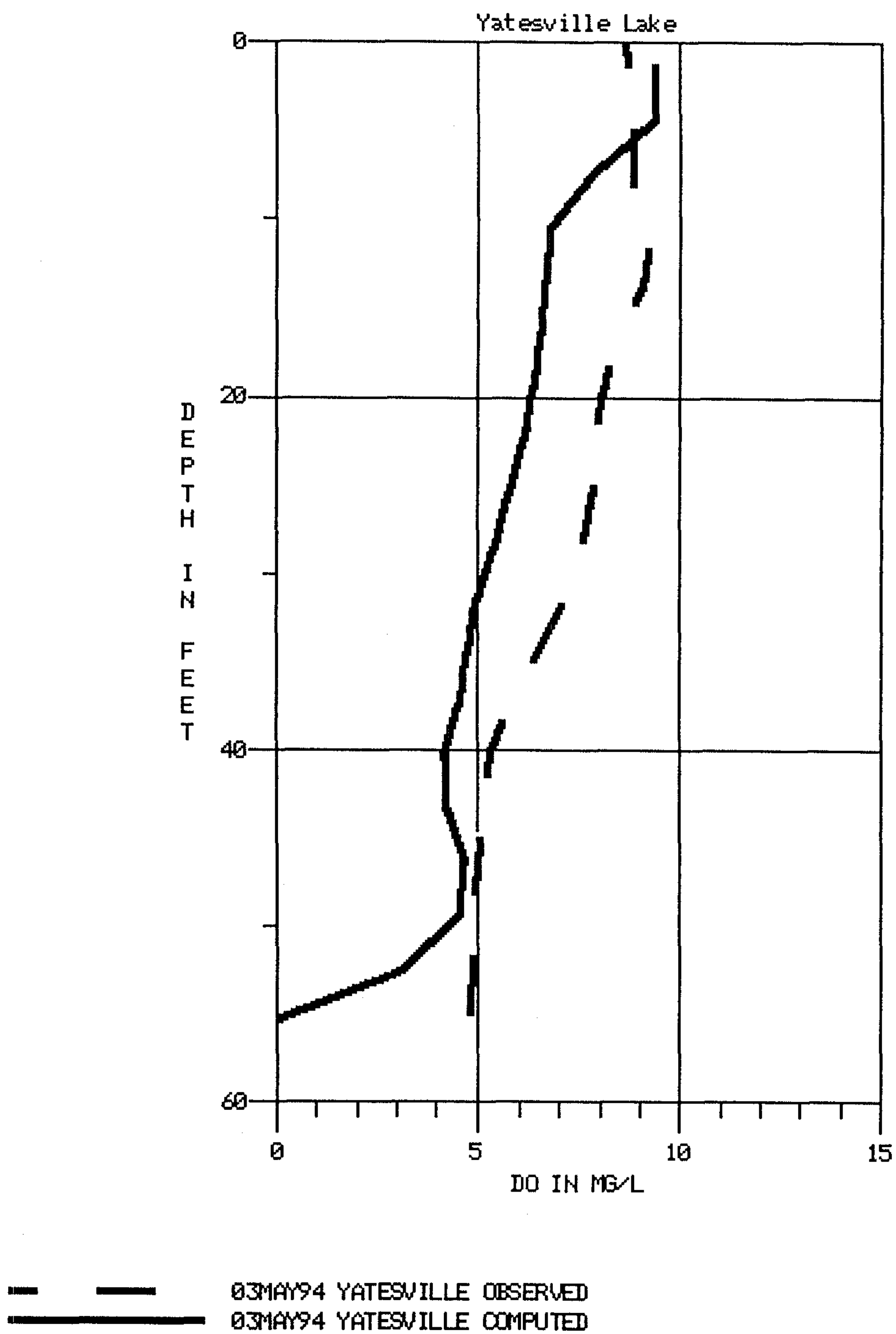

Paintsville Lake
DEPTH IN FEET
0
20
40
60
80
100
120
0
5
10
15
DO IN MG/L
02JUN88 PAINTSVILLE OBSERVED
02JUN88 PAINTSVILLE COMPUTED

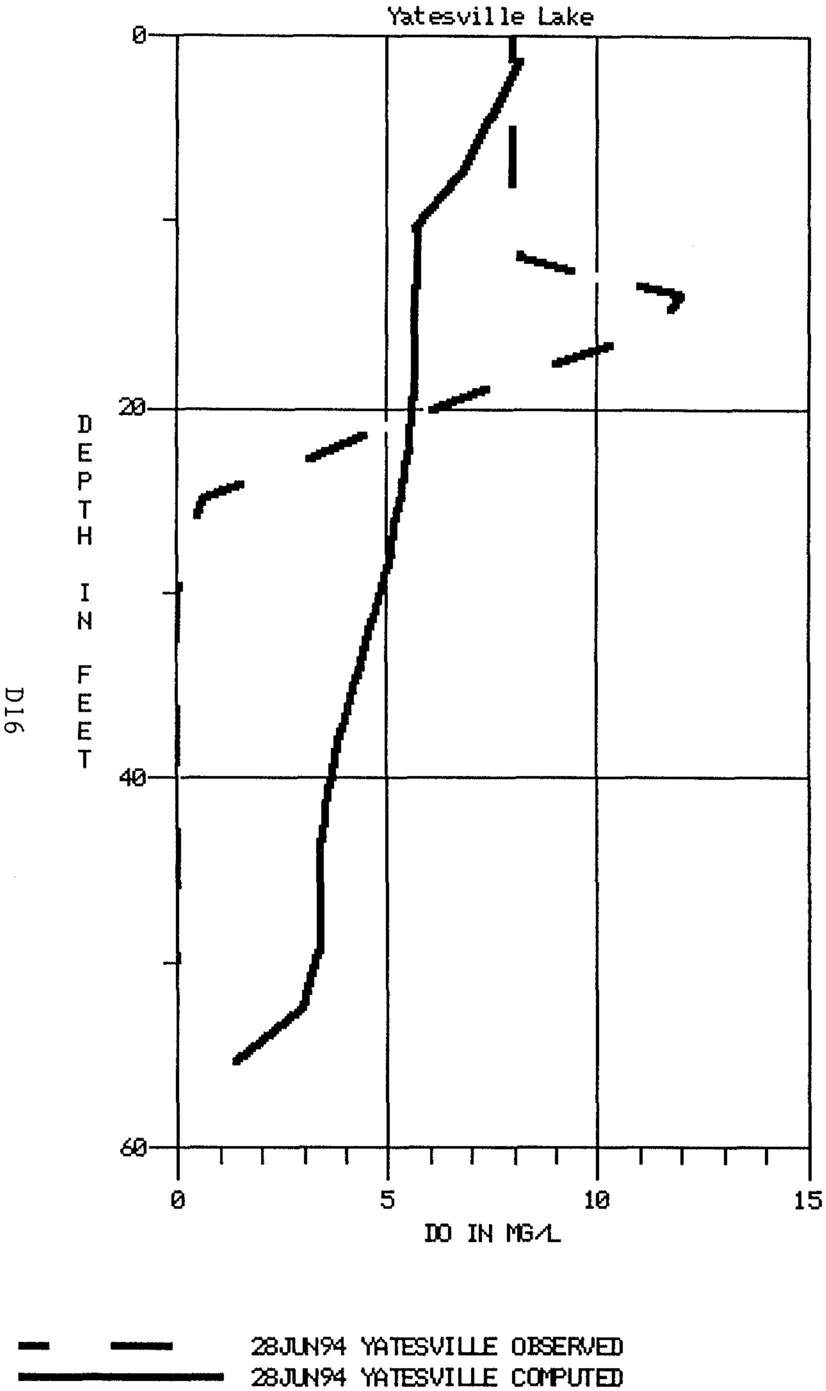

Paintsville Lake
DEPTH IN FEET
0
20
40
60
80
100
120
0
5
10
15
DO IN MG/L
27JUL88 PAINTSVILLE OBSERVED
27JUL88 PAINTSVILLE COMPUTED

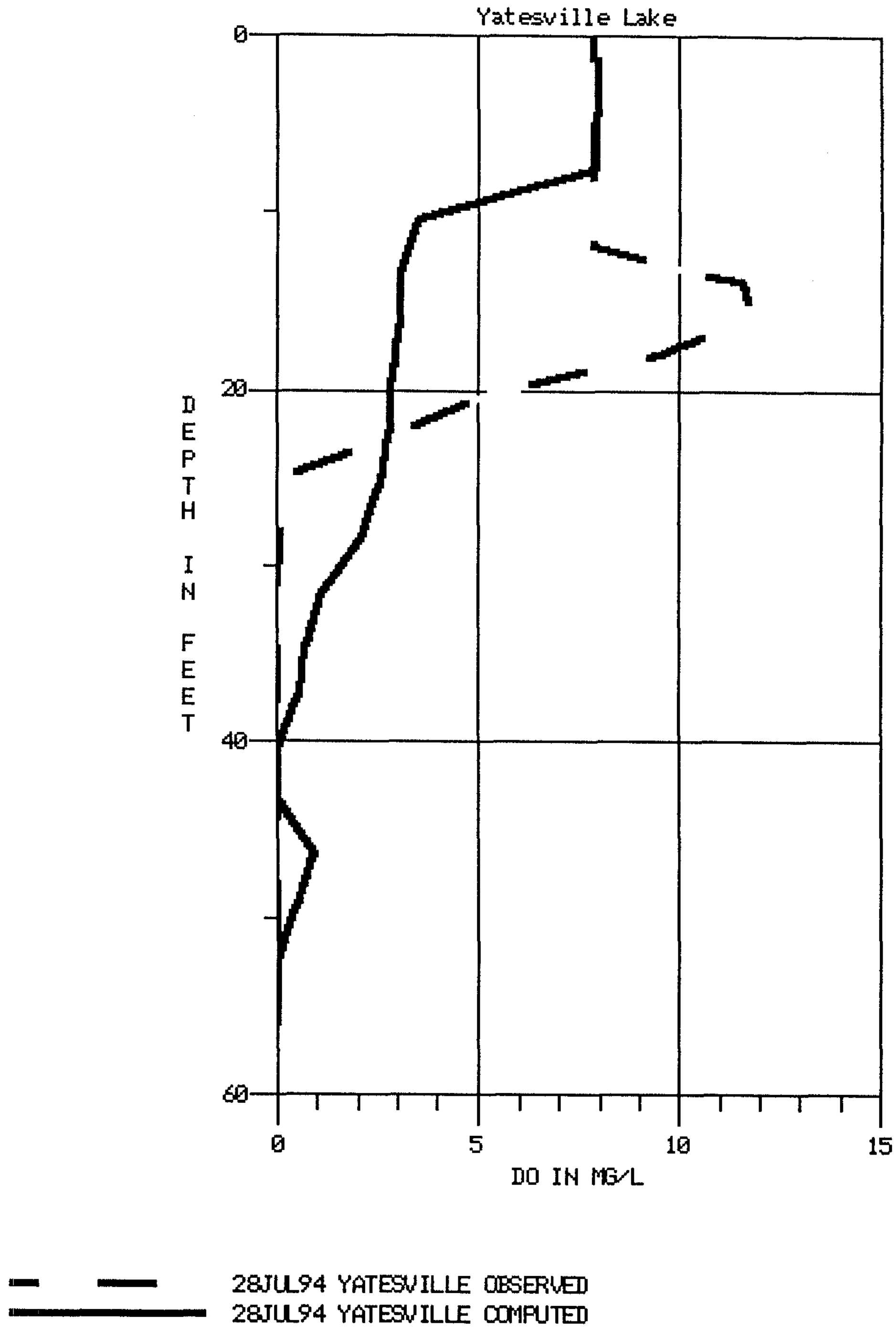

Paintsville Lake
DEPTH IN FEET
DO IN MG/L
25AUG88 PAINTSVILLE OBSERVED
25AUG88 PAINTSVILLE COMPUTED
Paintsville Lake
DEPTH IN FEET
DO IN MG/L
06OCT88 PAINTSVILLE OBSERVED
06OCT88 PAINTSVILLE COMPUTED

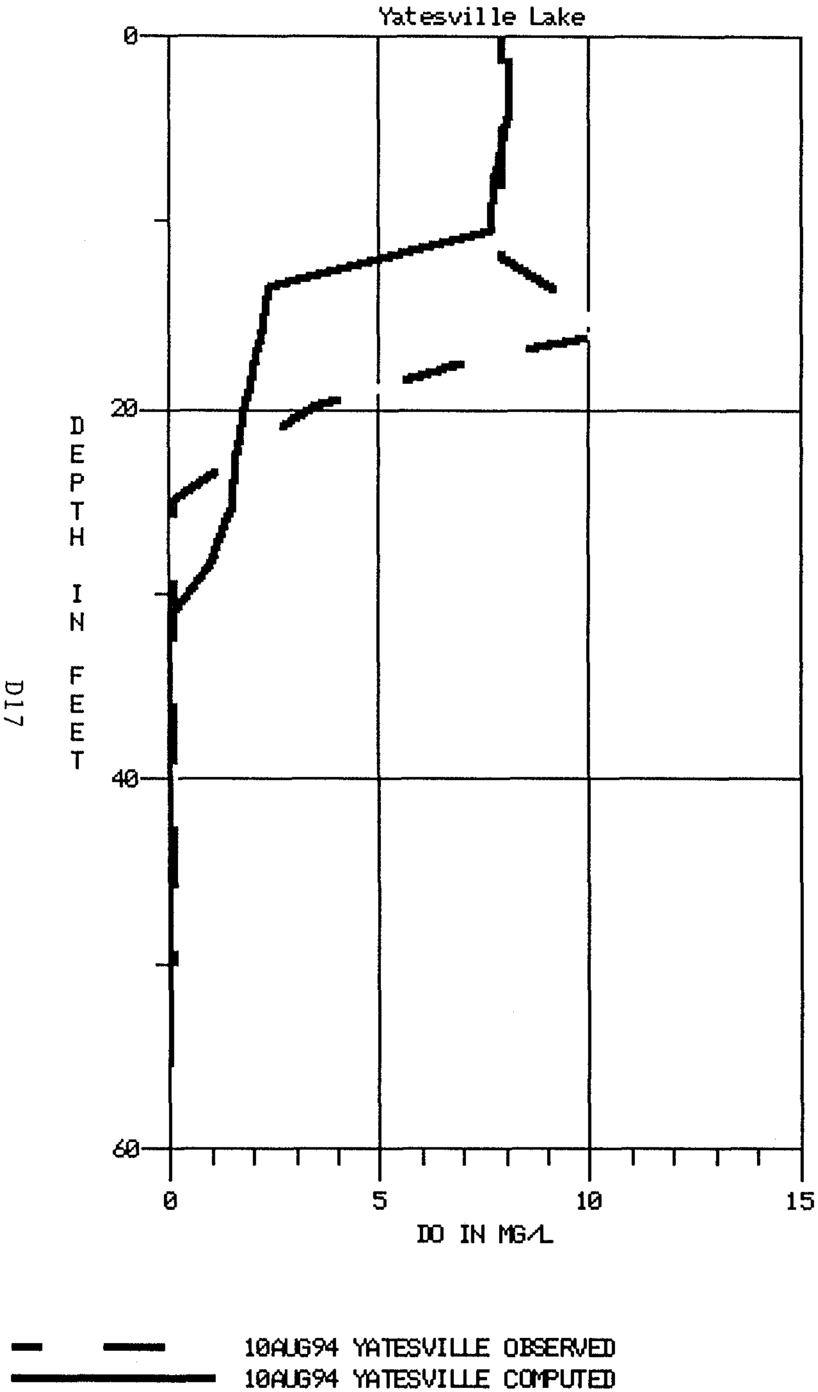

Paintsville Lake
DEPTH IN FEET
0
20
40
60
80
100
120
0
5
10
15
DO IN MG/L
09NOV88 PAINTSVILLE OBSERVED
09NOV88 PAINTSVILLE COMPUTED


Yatesville Lake
DEPTH IN FEET
0
20
40
60
0
5
10
15
DO IN MG/L
12APR94 YATESVILLE OBSERVED
12APR94 YATESVILLE COMPUTED

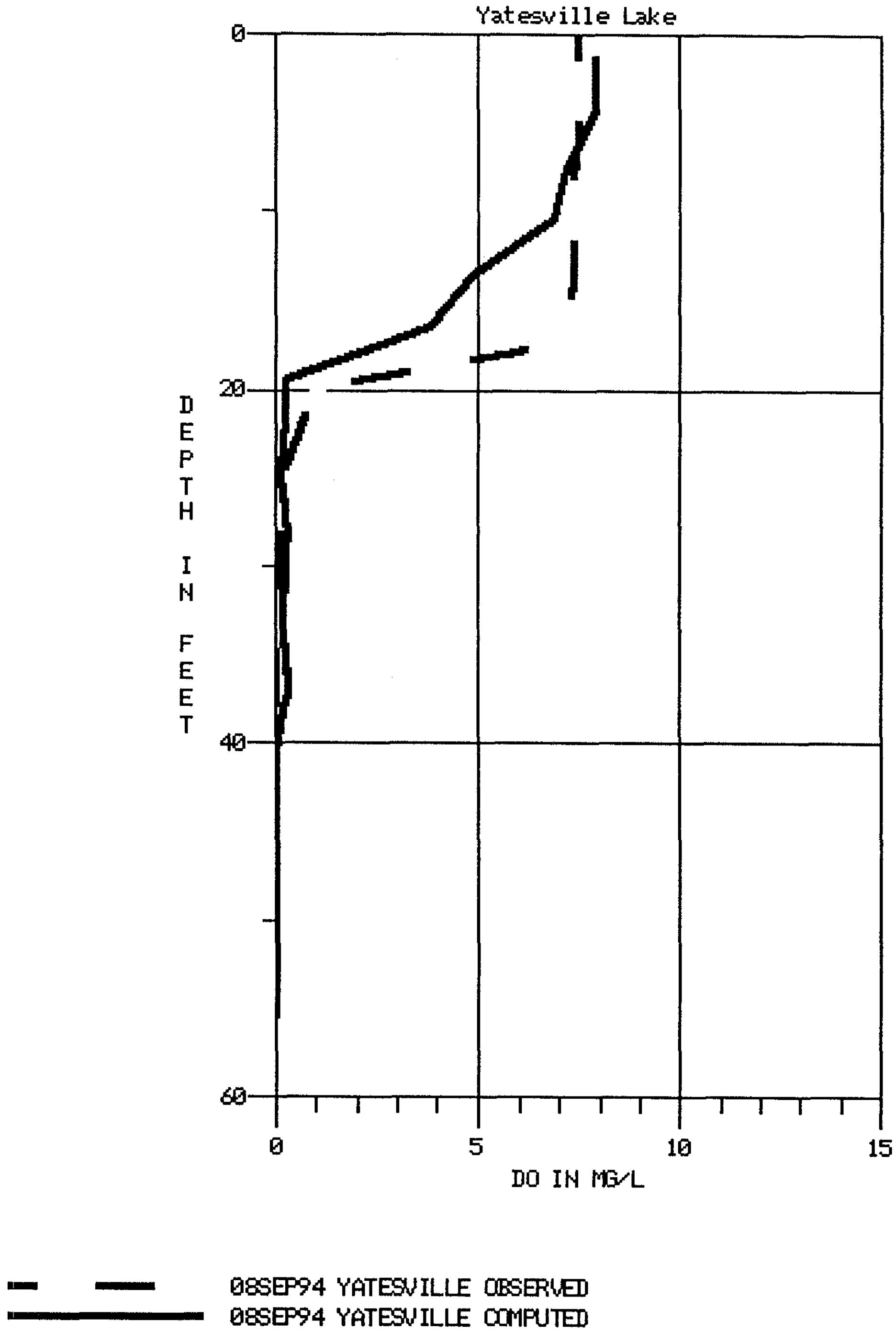

Yatesville Lake
DEPTH IN FEET
0
20
40
60
0
5
10
15
DO IN MG/L
03MAY94 YATESVILLE OBSERVED
03MAY94 YATESVILLE COMPUTED


Yatesville Lake
DEPTH IN FEET
0
20
40
60
0
5
10
15
DO IN MG/L
28JUN94 YATESVILLE OBSERVED
28JUN94 YATESVILLE COMPUTED


Yatesville Lake
DEPTH IN FEET
0
20
40
60
0
5
10
15
DO IN MG/L
28JUL94 YATESVILLE OBSERVED
28JUL94 YATESVILLE COMPUTED

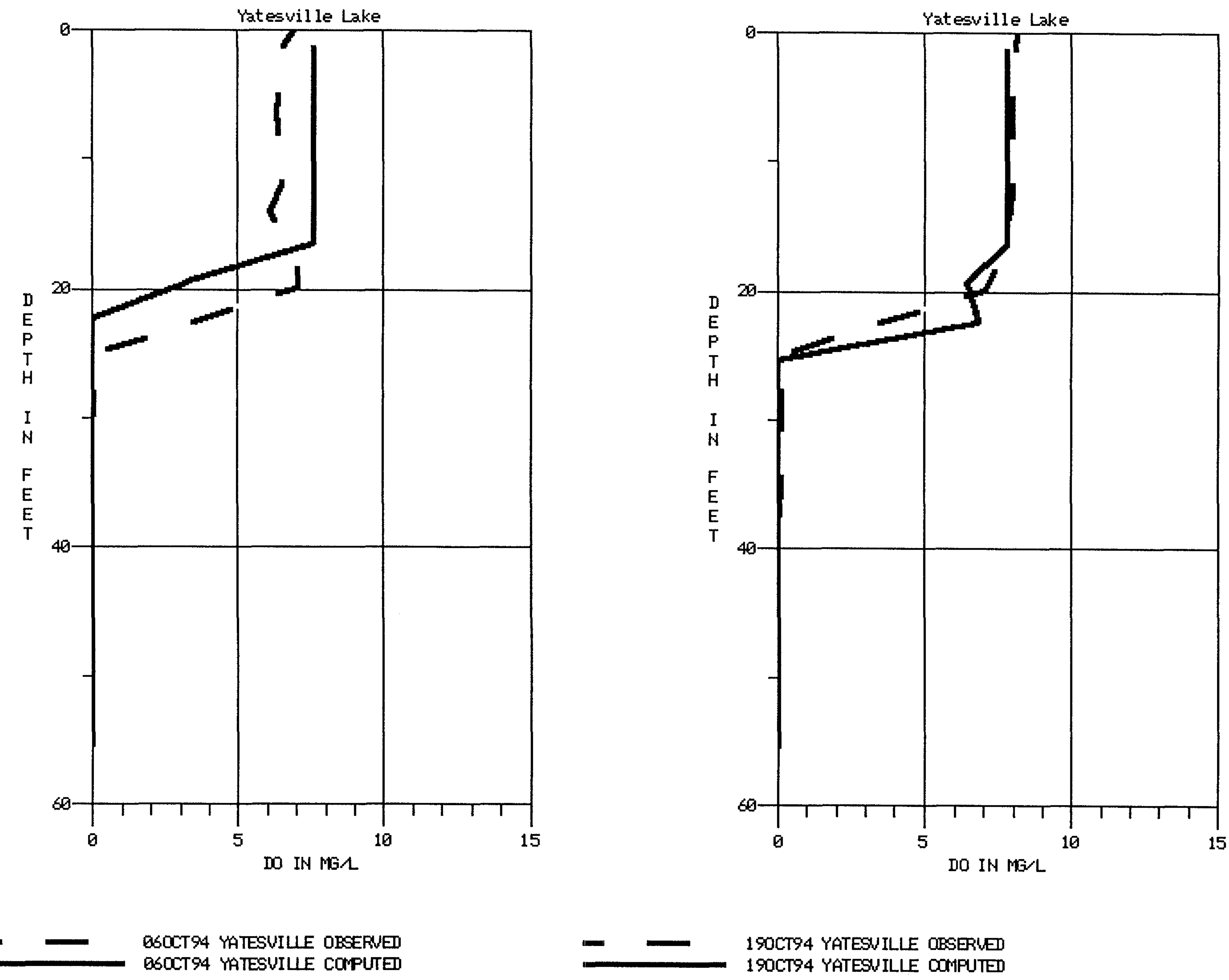


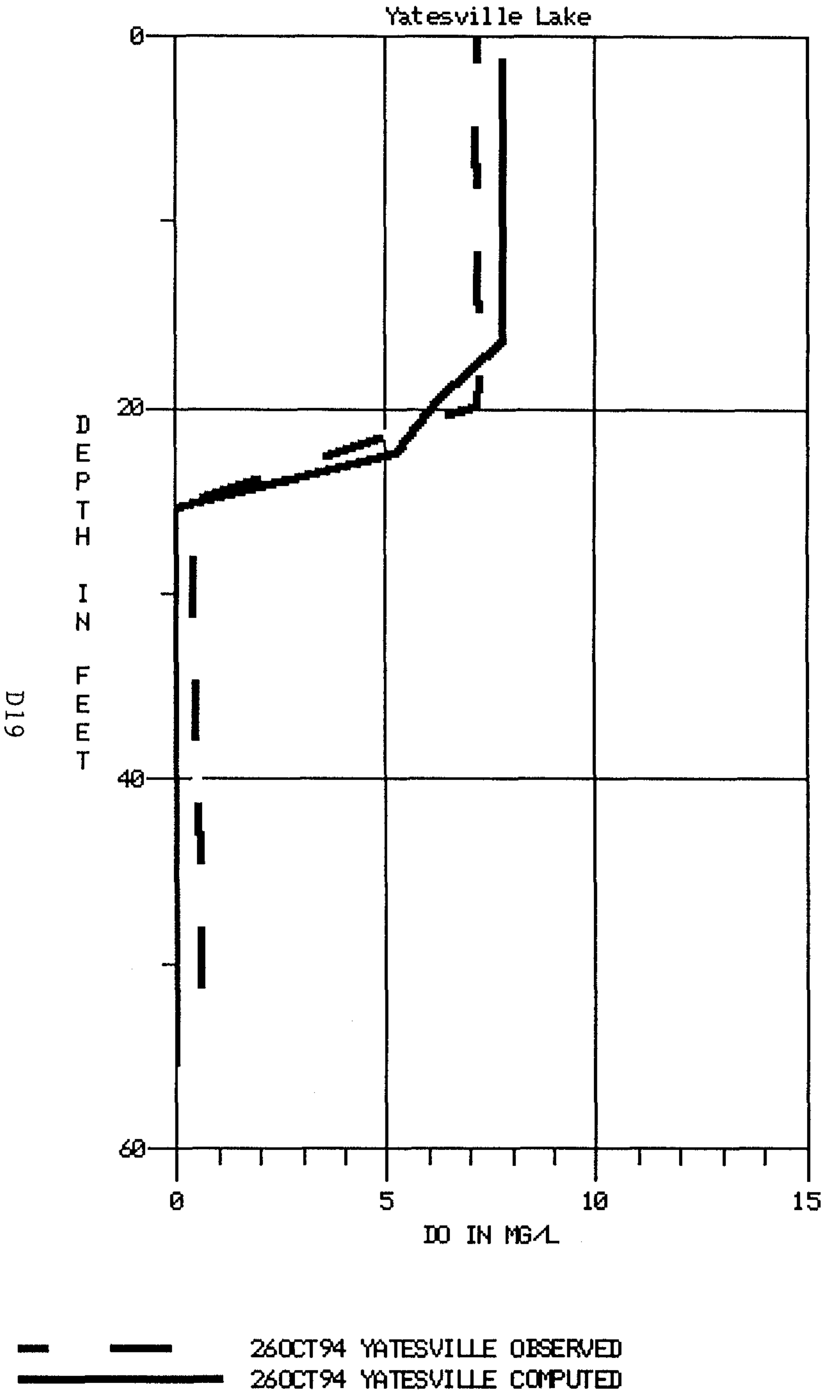
Yatesville Lake
DEPTH IN FEET
0
20
40
60
0
5
10
15
DO IN MG/L
10AUG94 YATESVILLE OBSERVED
10AUG94 YATESVILLE COMPUTED

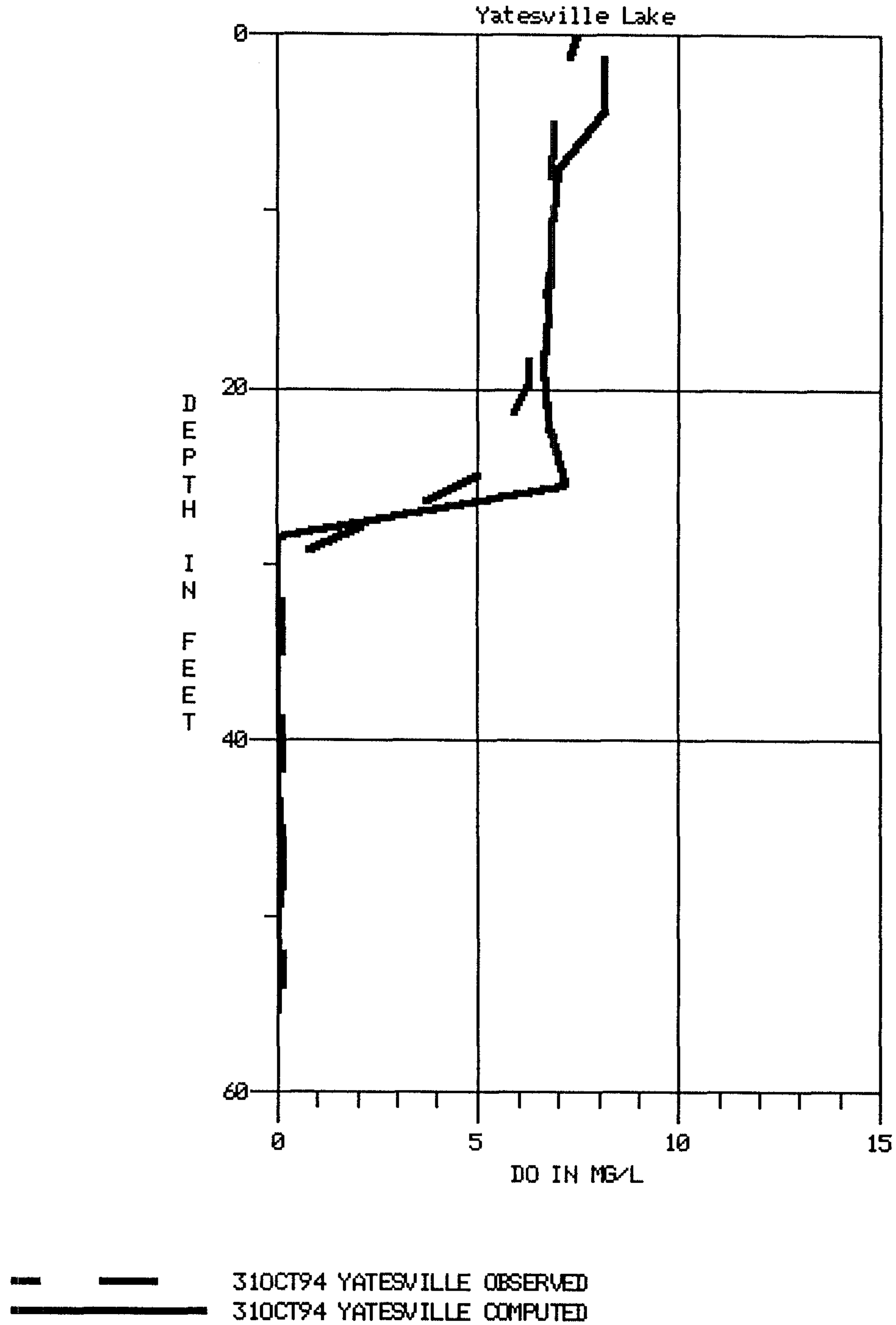


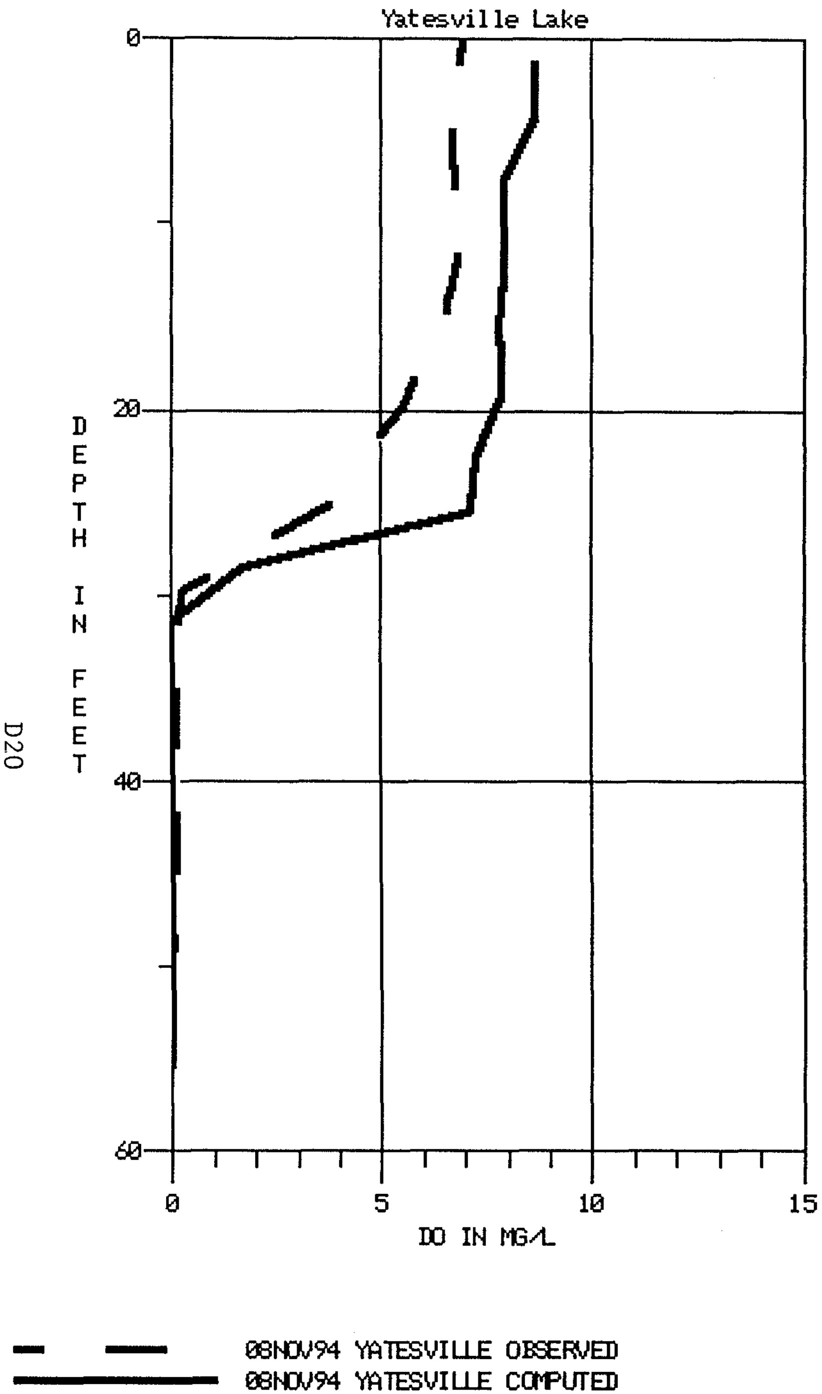
Yatesville Lake
DEPTH IN FEET
0
20
40
60
0
5
10
15
DO IN MG/L
08SEP94 YATESVILLE OBSERVED
08SEP94 YATESVILLE COMPUTED

D17

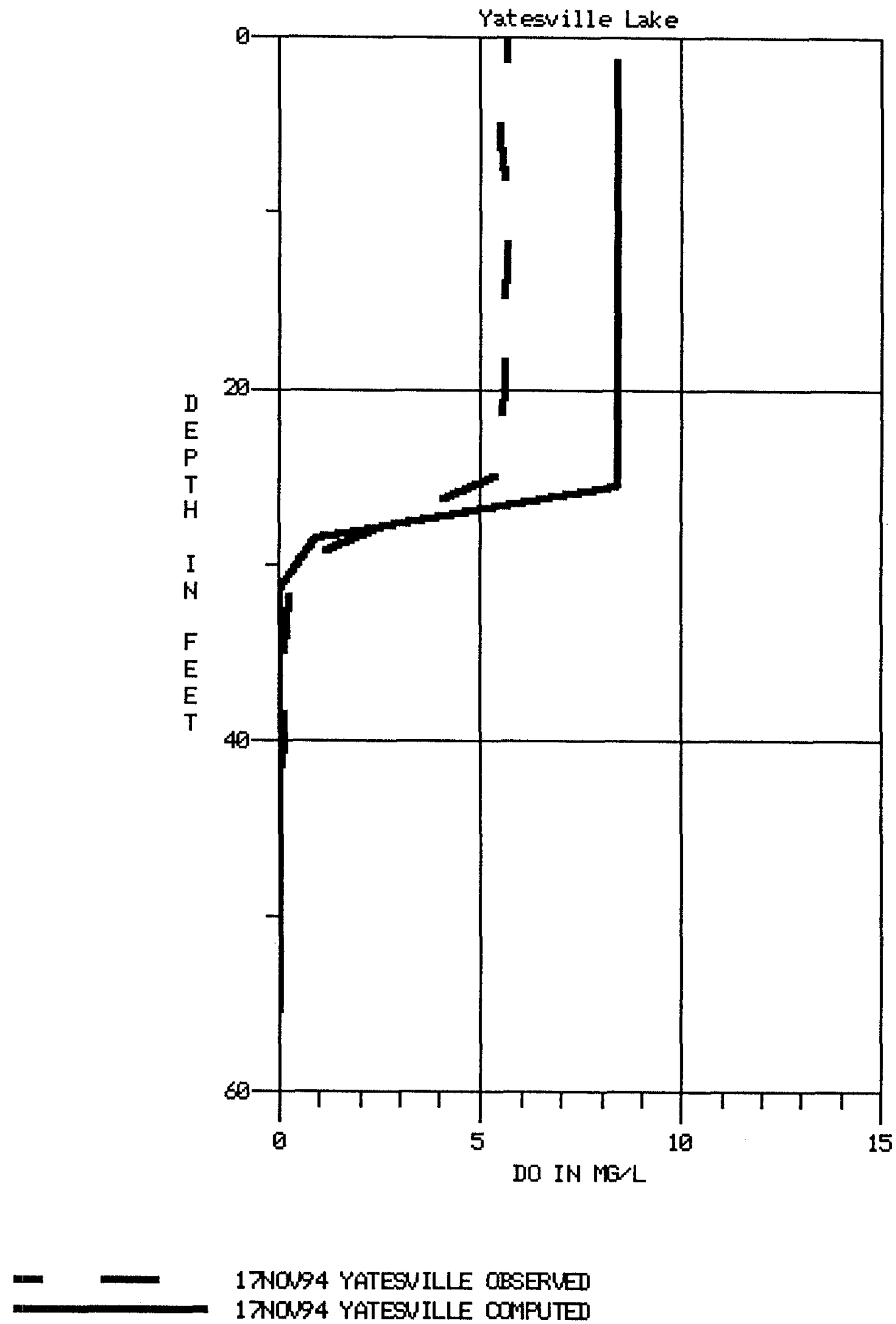

Yatesville Lake
DEPTH IN FEET
0
20
40
60
0
5
10
15
DO IN MG/L
Yatesville Lake
DEPTH IN FEET
0
20
40
60
0
5
10
15
DO IN MG/L
06OCT94 YATESVILLE OBSERVED
06OCT94 YATESVILLE COMPUTED
19OCT94 YATESVILLE OBSERVED
19OCT94 YATESVILLE COMPUTED


Yatesville Lake
DEPTH IN FEET
0
20
40
60
0
5
10
15
DO IN MG/L
26OCT94 YATESVILLE OBSERVED
26OCT94 YATESVILLE COMPUTED


Yatesville Lake
DEPTH IN FEET
0
20
40
60
0
5
10
15
DO IN MG/L
31OCT94 YATESVILLE OBSERVED
31OCT94 YATESVILLE COMPUTED

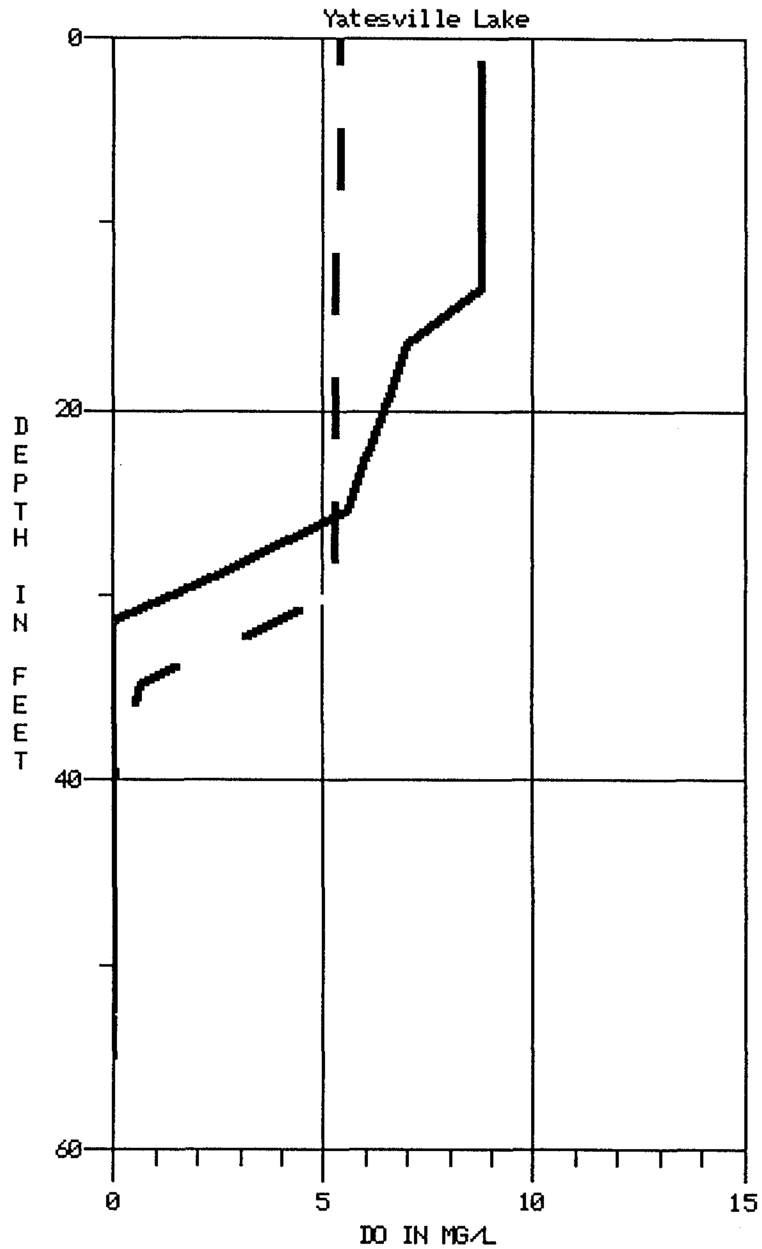


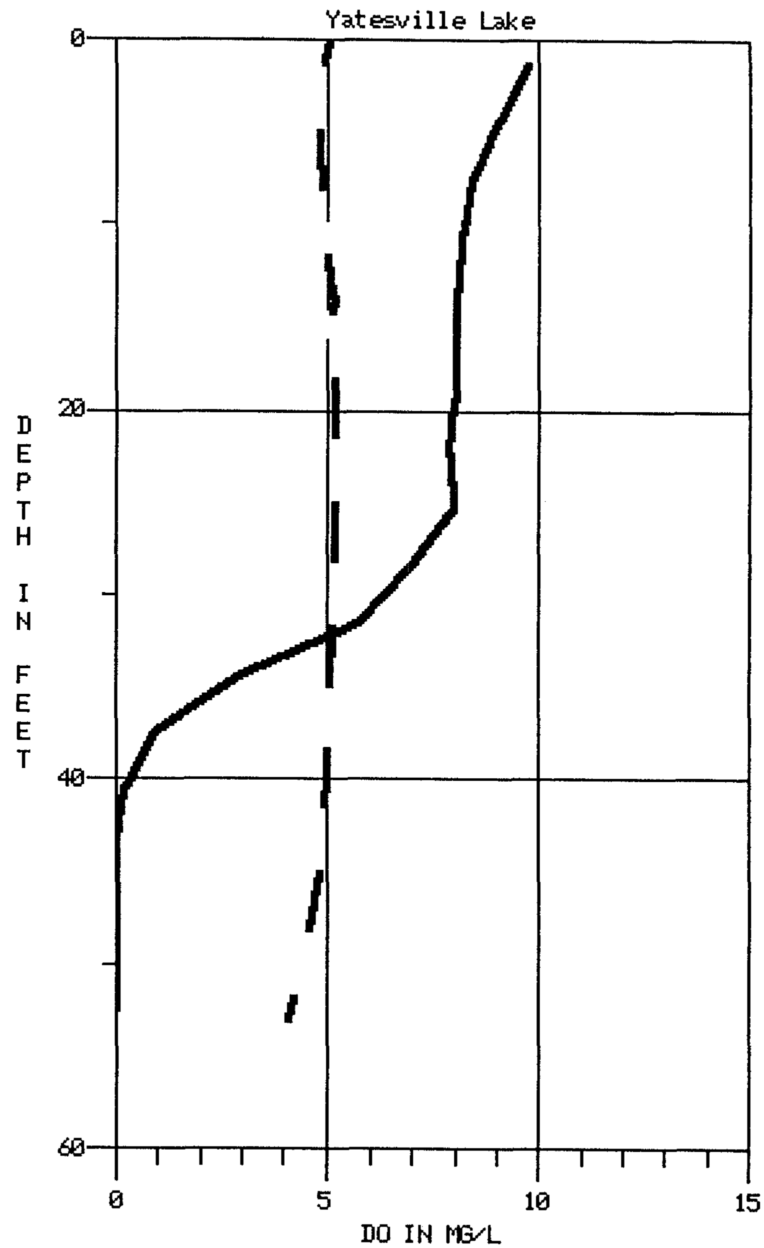
Yatesville Lake
DEPTH IN FEET
0
20
40
60
0
5
10
15
DO IN MG/L
08NOV94 YATESVILLE OBSERVED
08NOV94 YATESVILLE COMPUTED



Yatesville Lake
DEPTH IN FEET
0
20
40
60
0
5
10
15
DO IN MG/L
17NOV94 YATESVILLE OBSERVED
17NOV94 YATESVILLE COMPUTED

D20



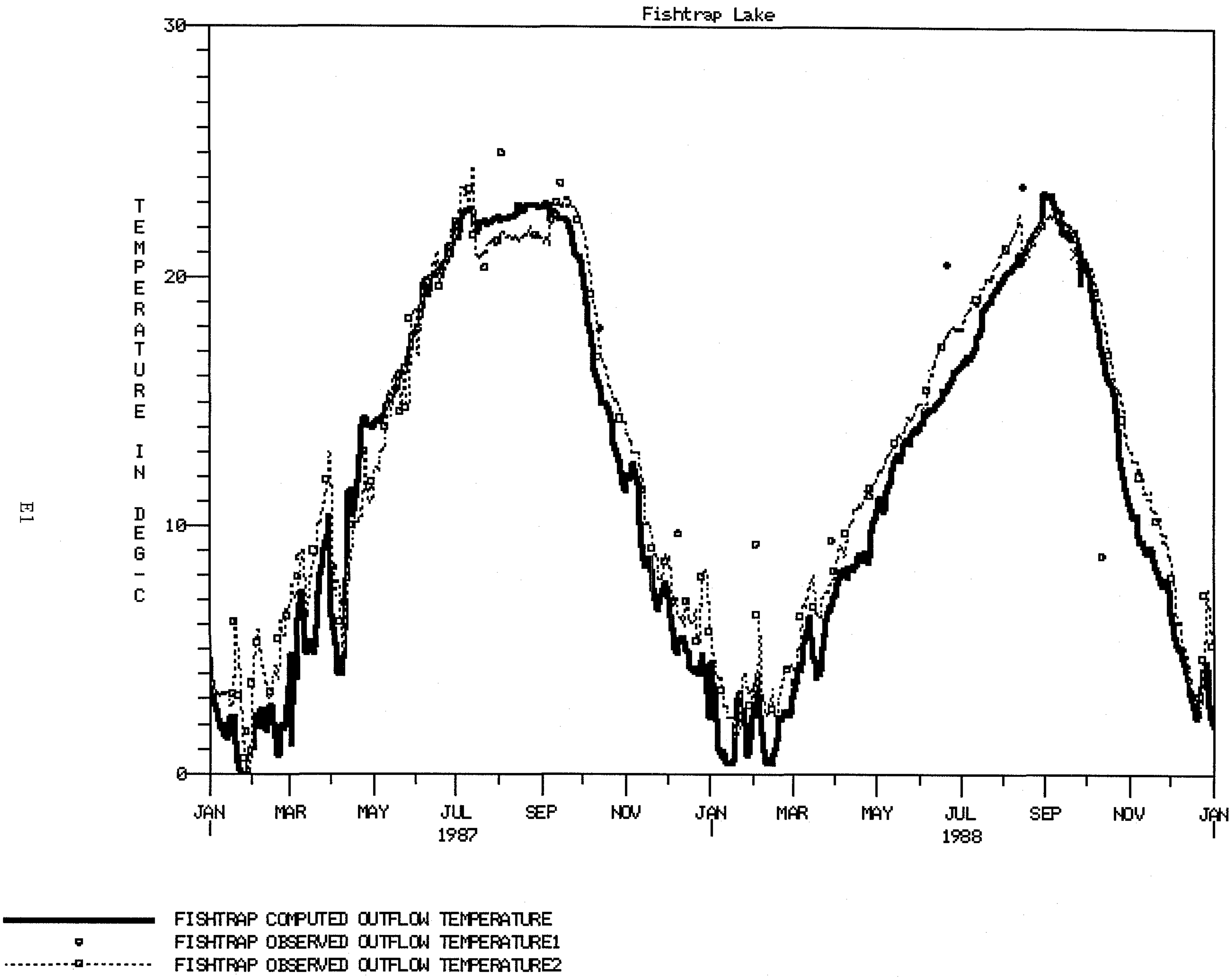


23NOV94 YATESVILLE OBSERVED
23NOV94 YATESVILLE COMPUTED

30NOV94 YATESVILLE OBSERVED
30NOV94 YATESVILLE COMPUTED

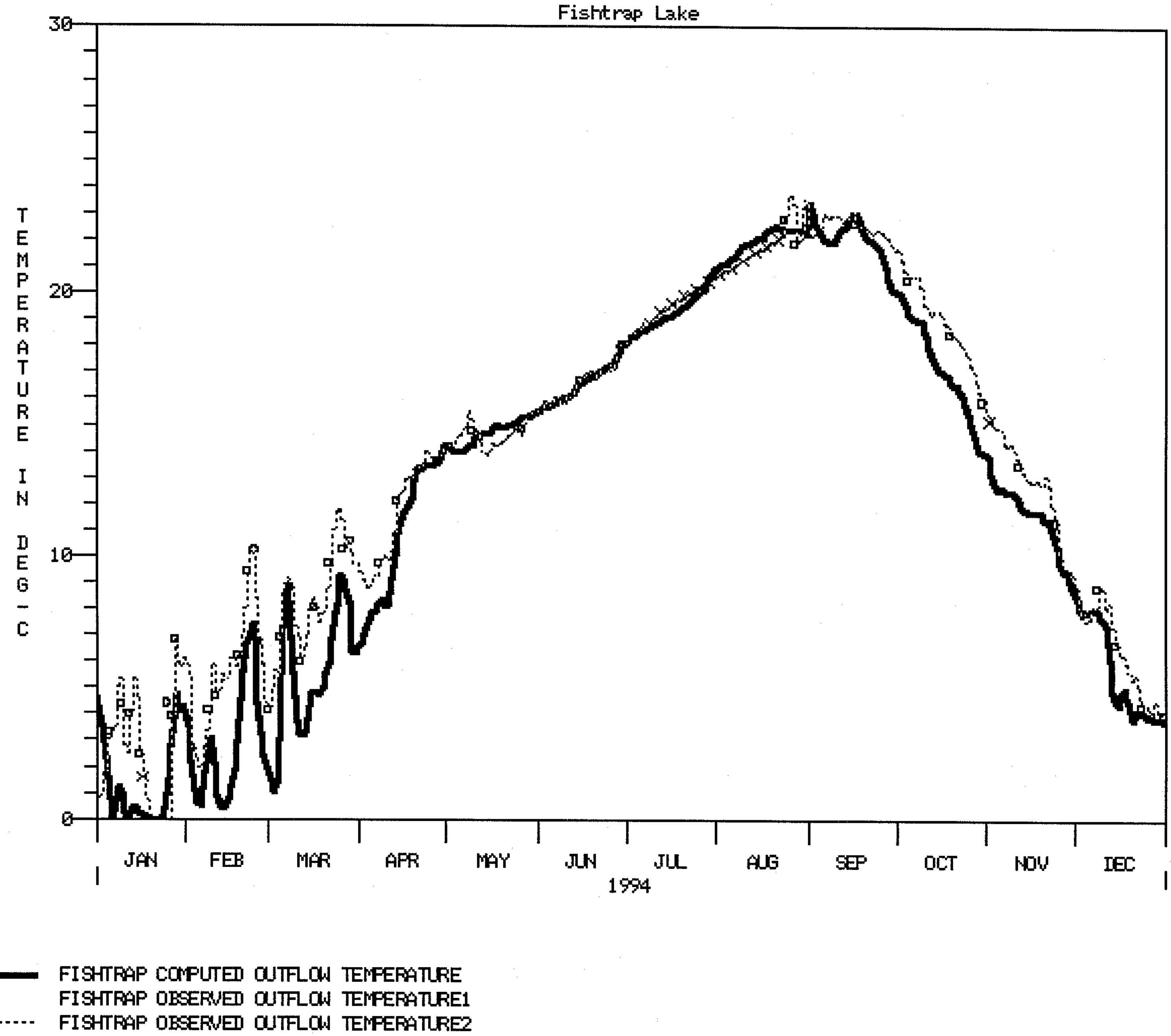
Appendix E

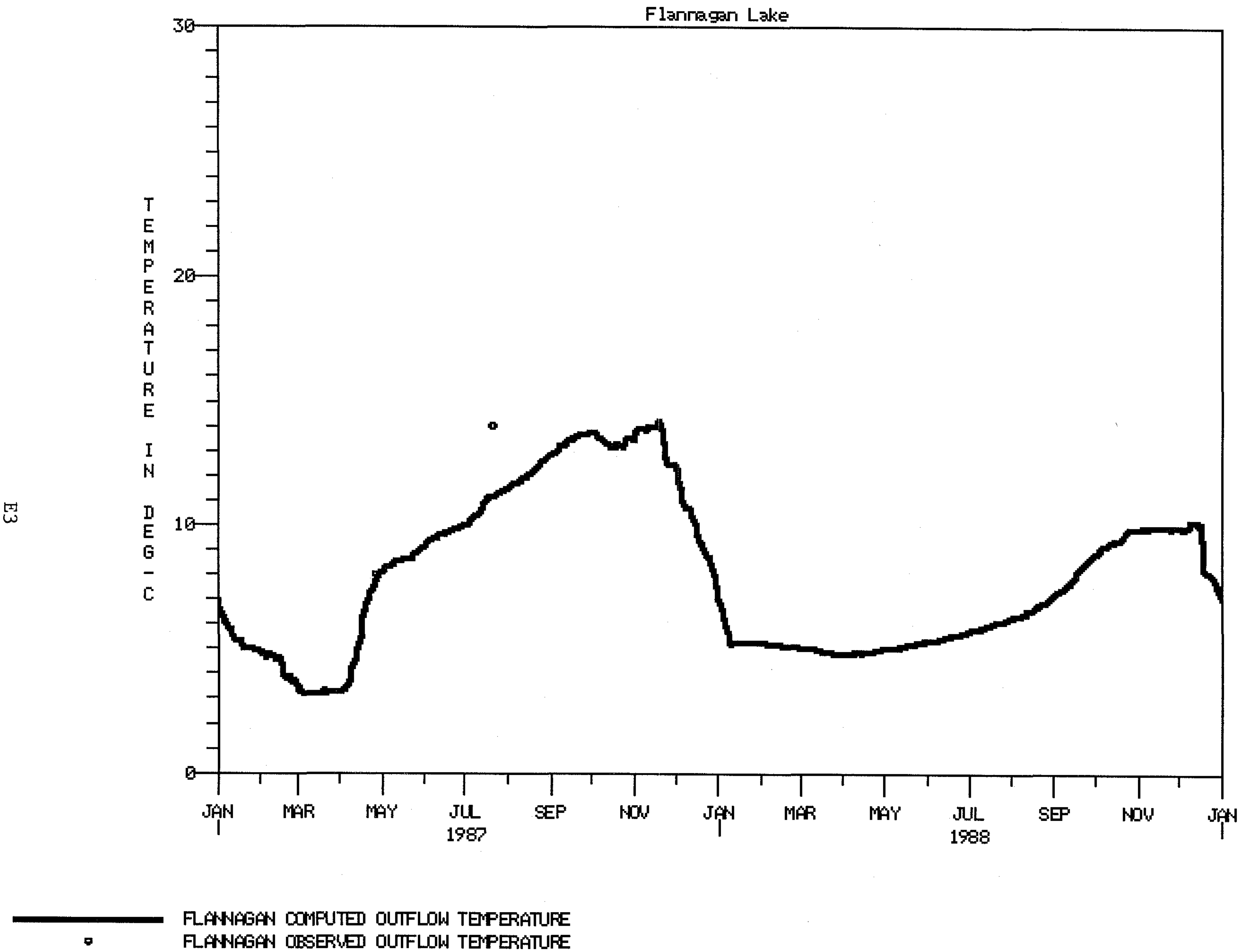
Calibration of
Reservoir Temperature Releases

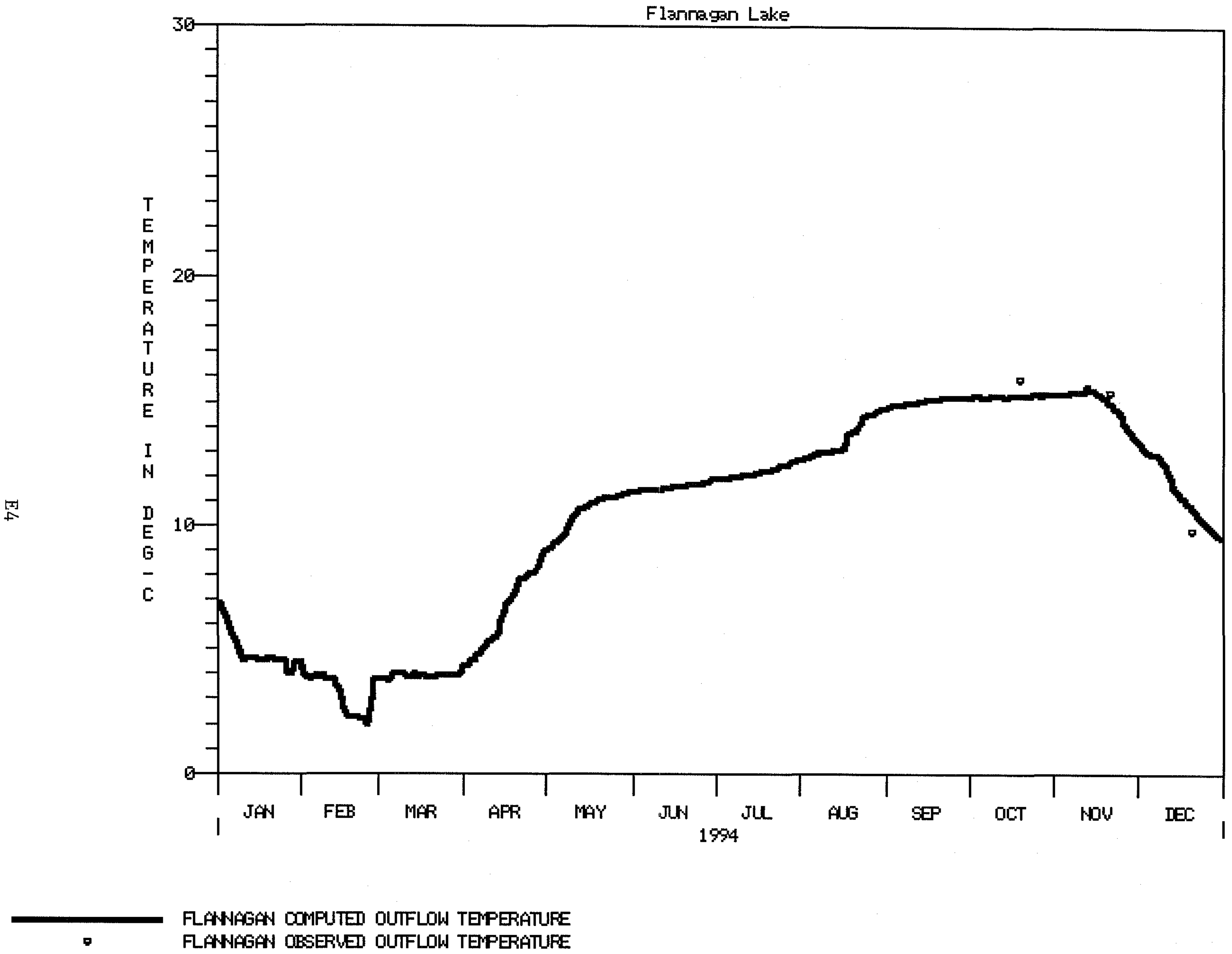

Fishtrap Lake
TEMPERATURE IN DEG-C
30
20
10
0
JAN
MAR
MAY
JUL
SEP
NOV
JAN
MAR
MAY
JUL
SEP
NOV
JAN
1987
1988
FISHTRAP COMPUTED OUTFLOW TEMPERATURE
FISHTRAP OBSERVED OUTFLOW TEMPERATURE1
FISHTRAP OBSERVED OUTFLOW TEMPERATURE2

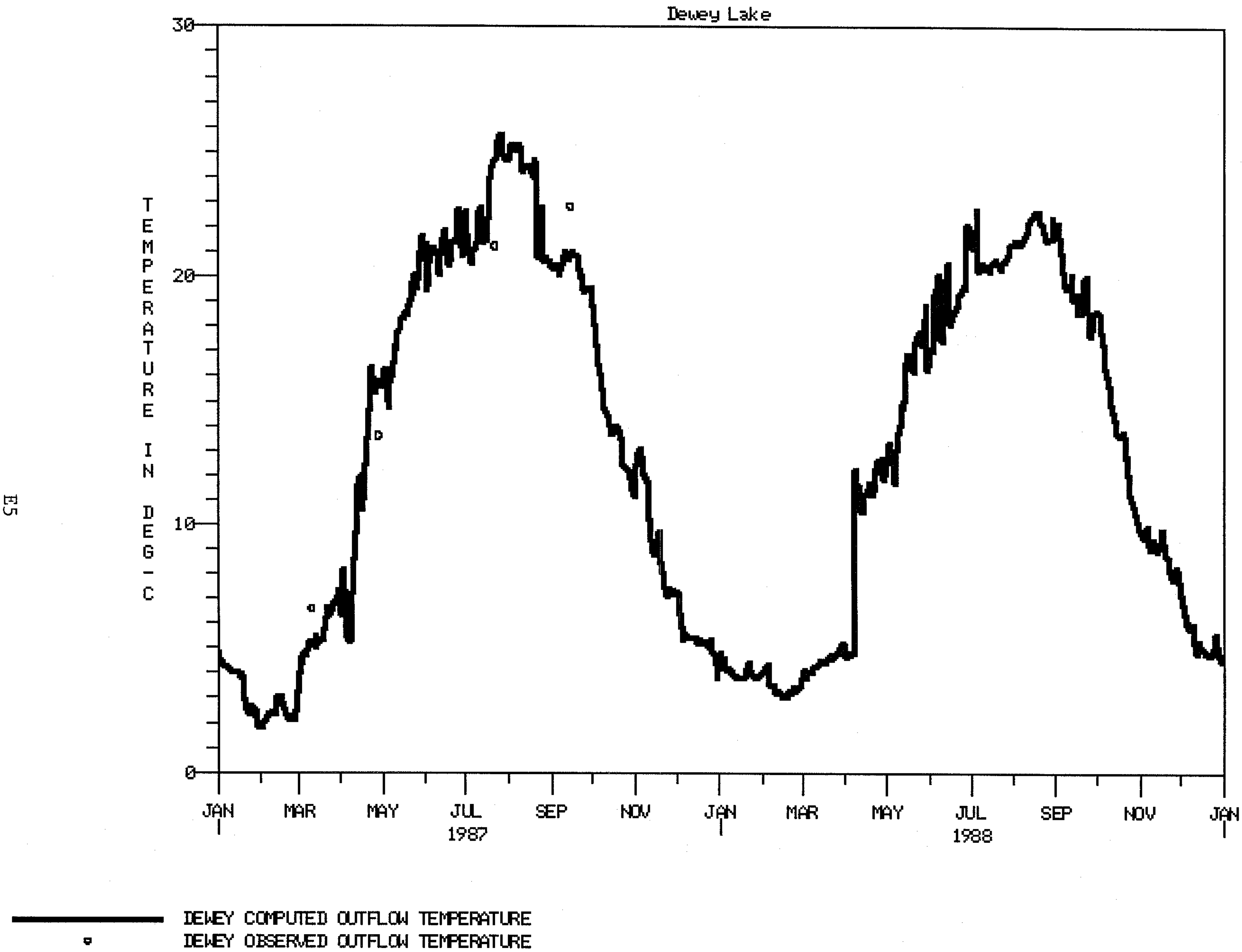
E1

E2

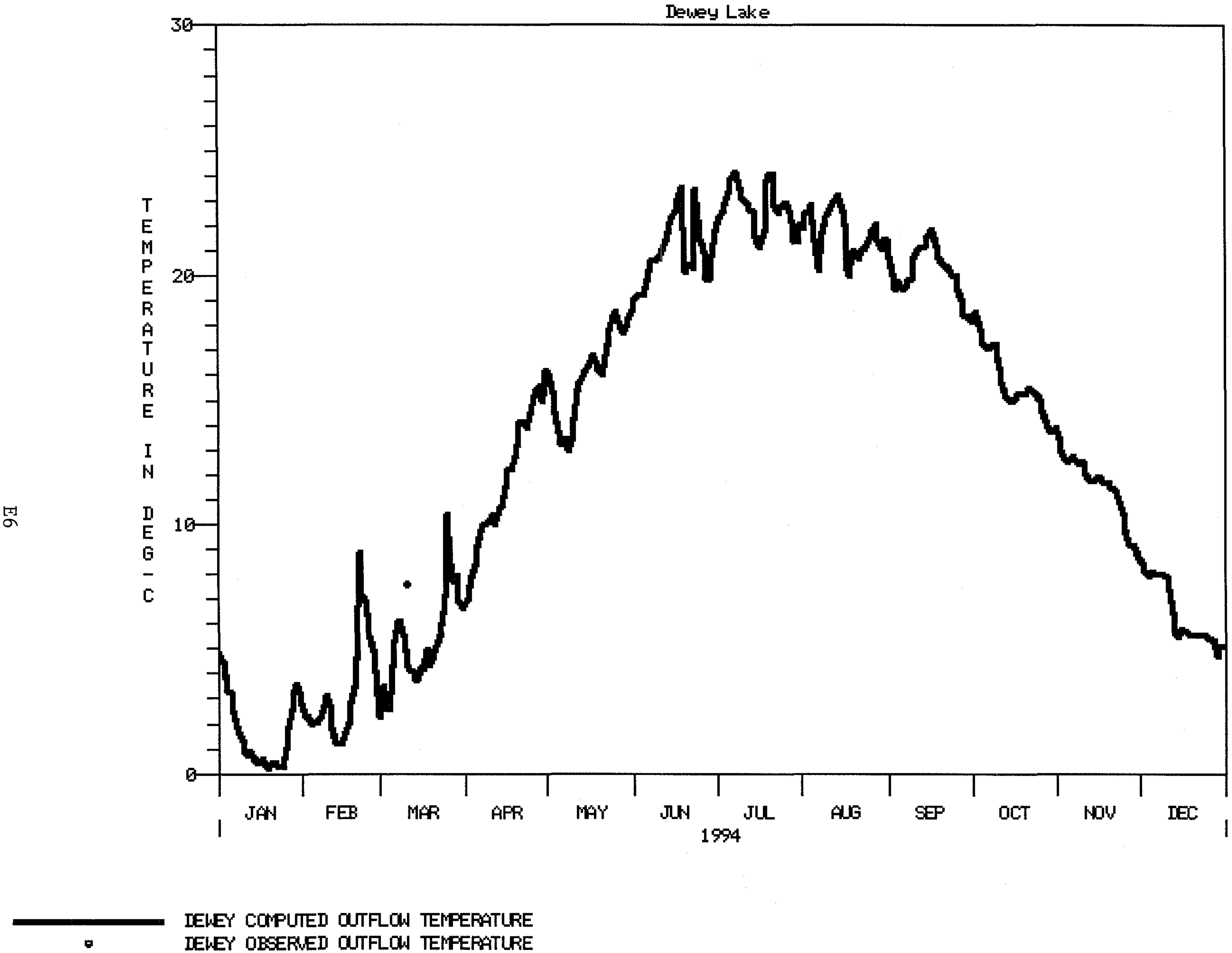

Fishtrap Lake
TEMPERATURE IN DEG-C
30
20
10
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1994
FISHTRAP COMPUTED OUTFLOW TEMPERATURE
FISHTRAP OBSERVED OUTFLOW TEMPERATURE1
FISHTRAP OBSERVED OUTFLOW TEMPERATURE2

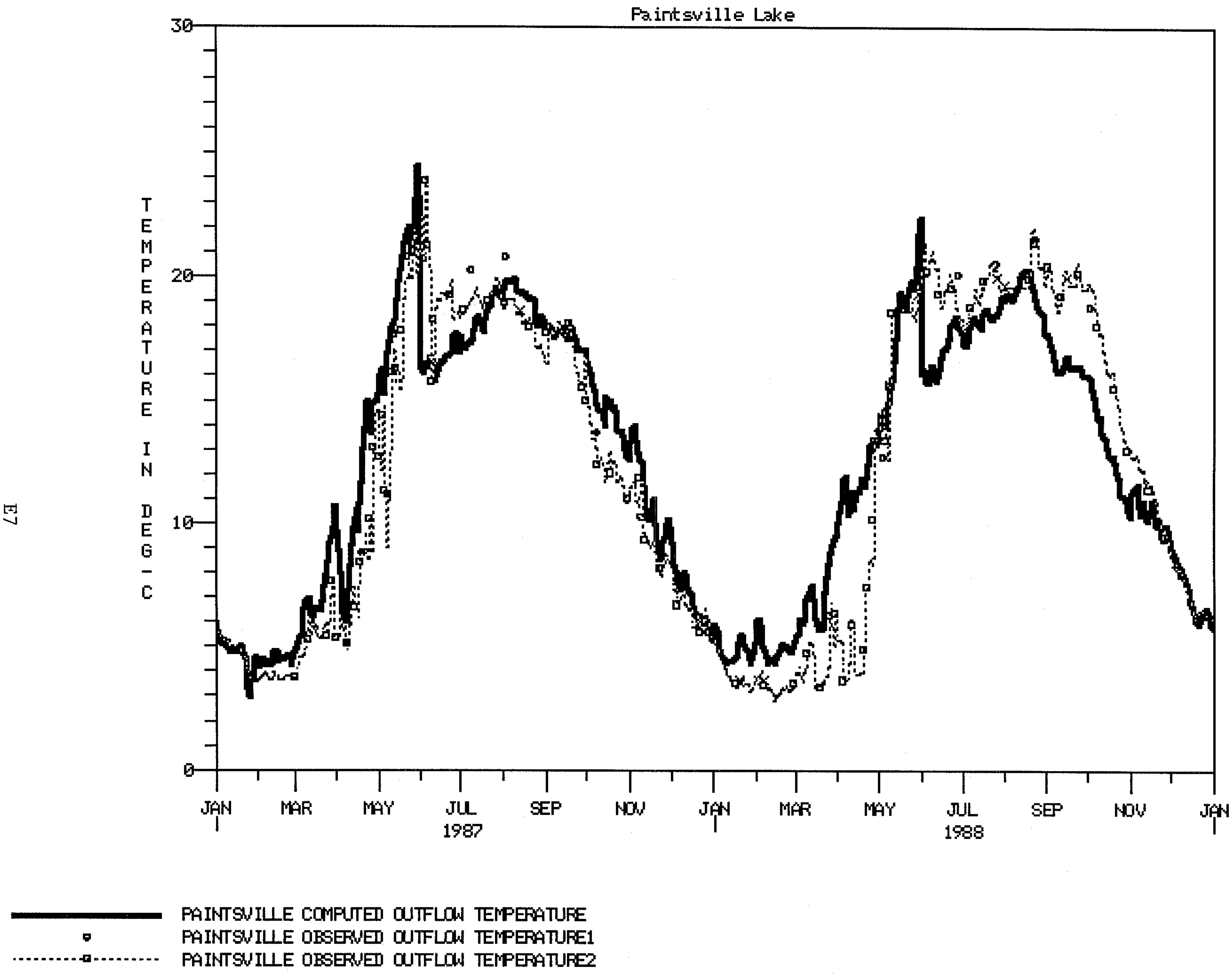

Flannagan Lake
30
20
10
0
TEMPERATURE IN DEG-C
JAN
MAR
MAY
JUL
SEP
NOV
JAN
MAR
MAY
JUL
SEP
NOV
JAN
1987
1988
FLANNAGAN COMPUTED OUTFLOW TEMPERATURE
FLANNAGAN OBSERVED OUTFLOW TEMPERATURE

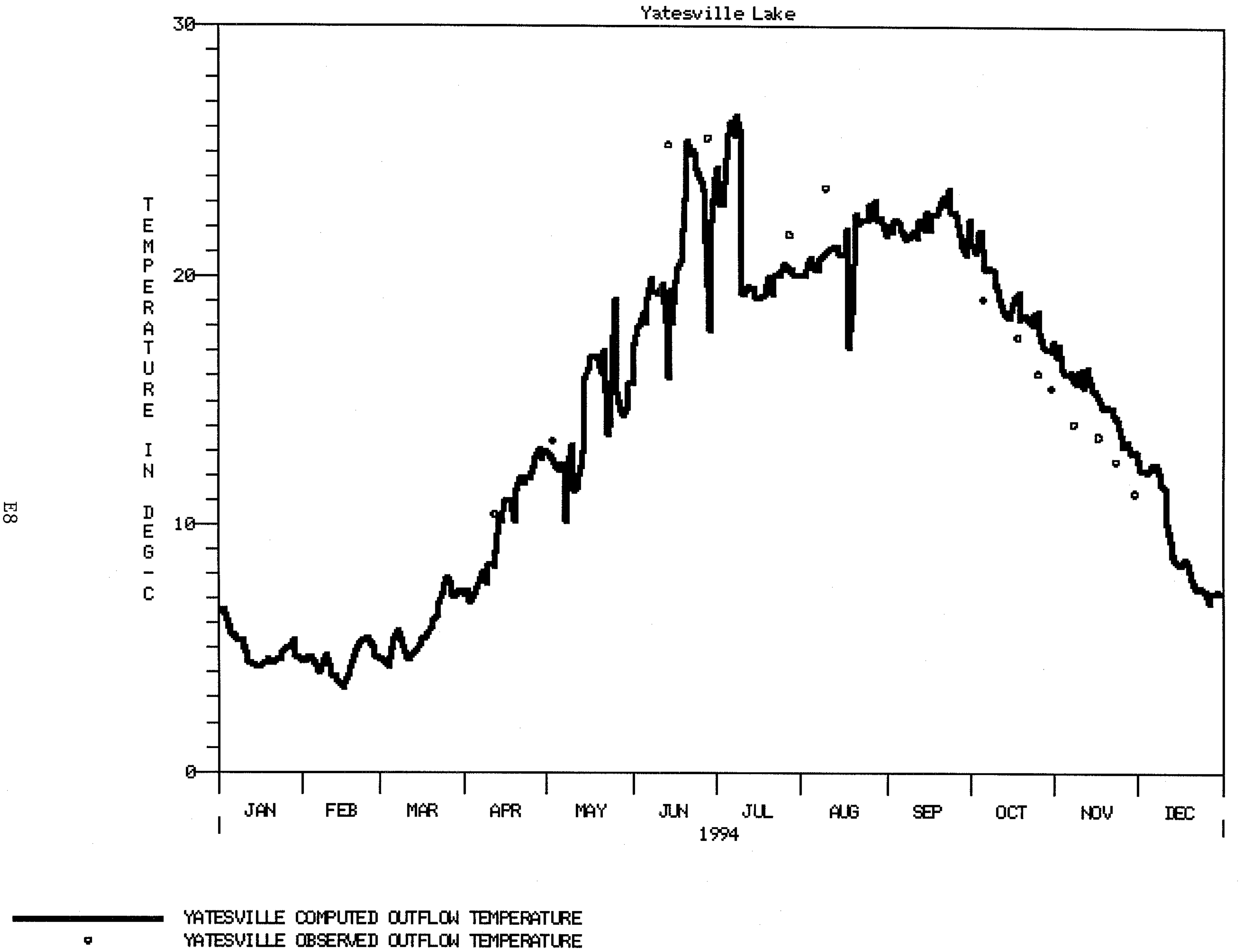

Flannagan Lake
TEMPERATURE IN DEG-C
30
20
10
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1994
FLANNAGAN COMPUTED OUTFLOW TEMPERATURE
FLANNAGAN OBSERVED OUTFLOW TEMPERATURE

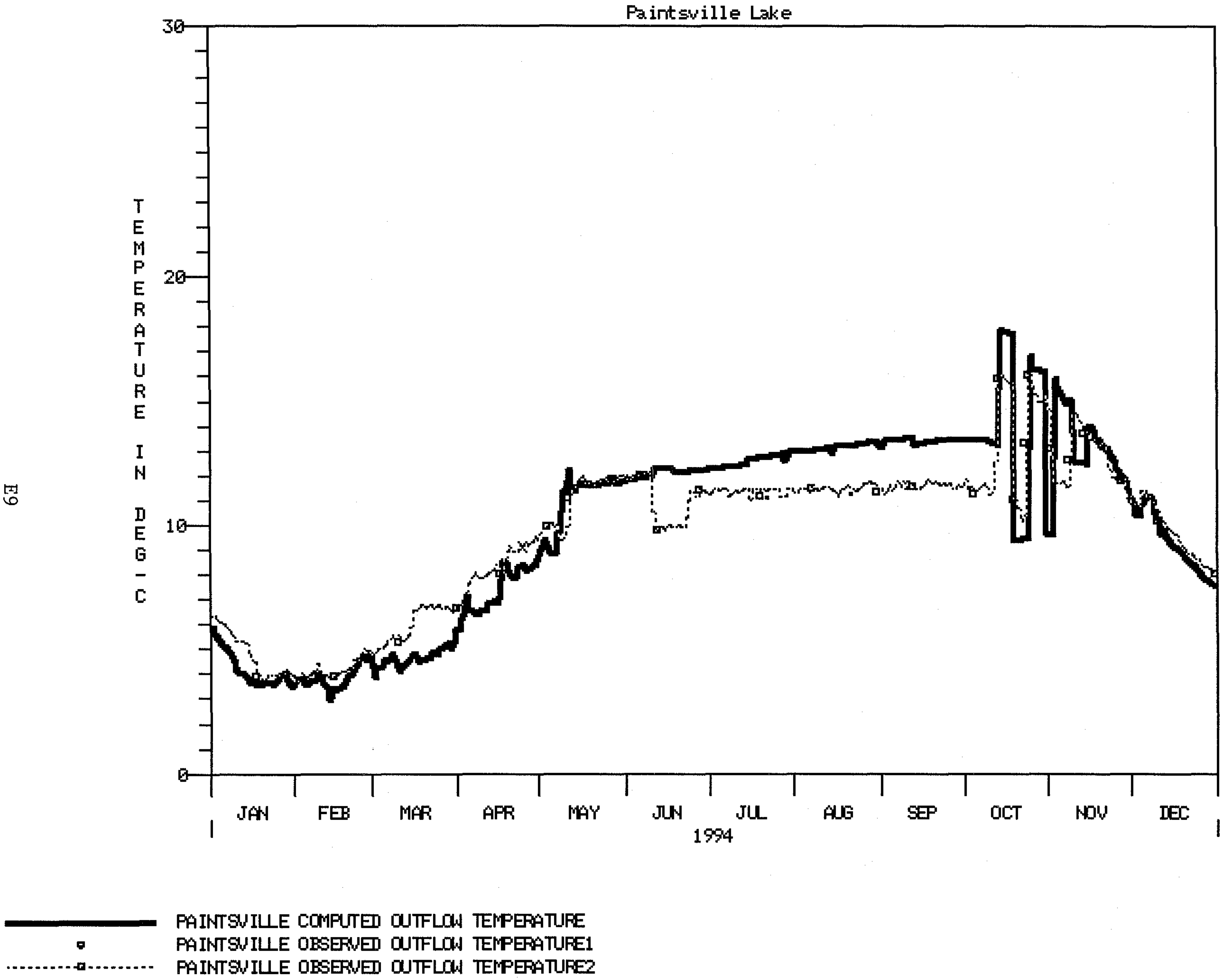

Dewey Lake
TEMPERATURE IN DEG-C
30
20
10
0
JAN
MAR
MAY
JUL
SEP
NOV
JAN
MAR
MAY
JUL
SEP
NOV
JAN
1987
1988
DEWEY COMPUTED OUTFLOW TEMPERATURE
DEWEY OBSERVED OUTFLOW TEMPERATURE

E5


Dewey Lake
TEMPERATURE IN DEG-C
30
20
10
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1994
DEWEY COMPUTED OUTFLOW TEMPERATURE
DEWEY OBSERVED OUTFLOW TEMPERATURE

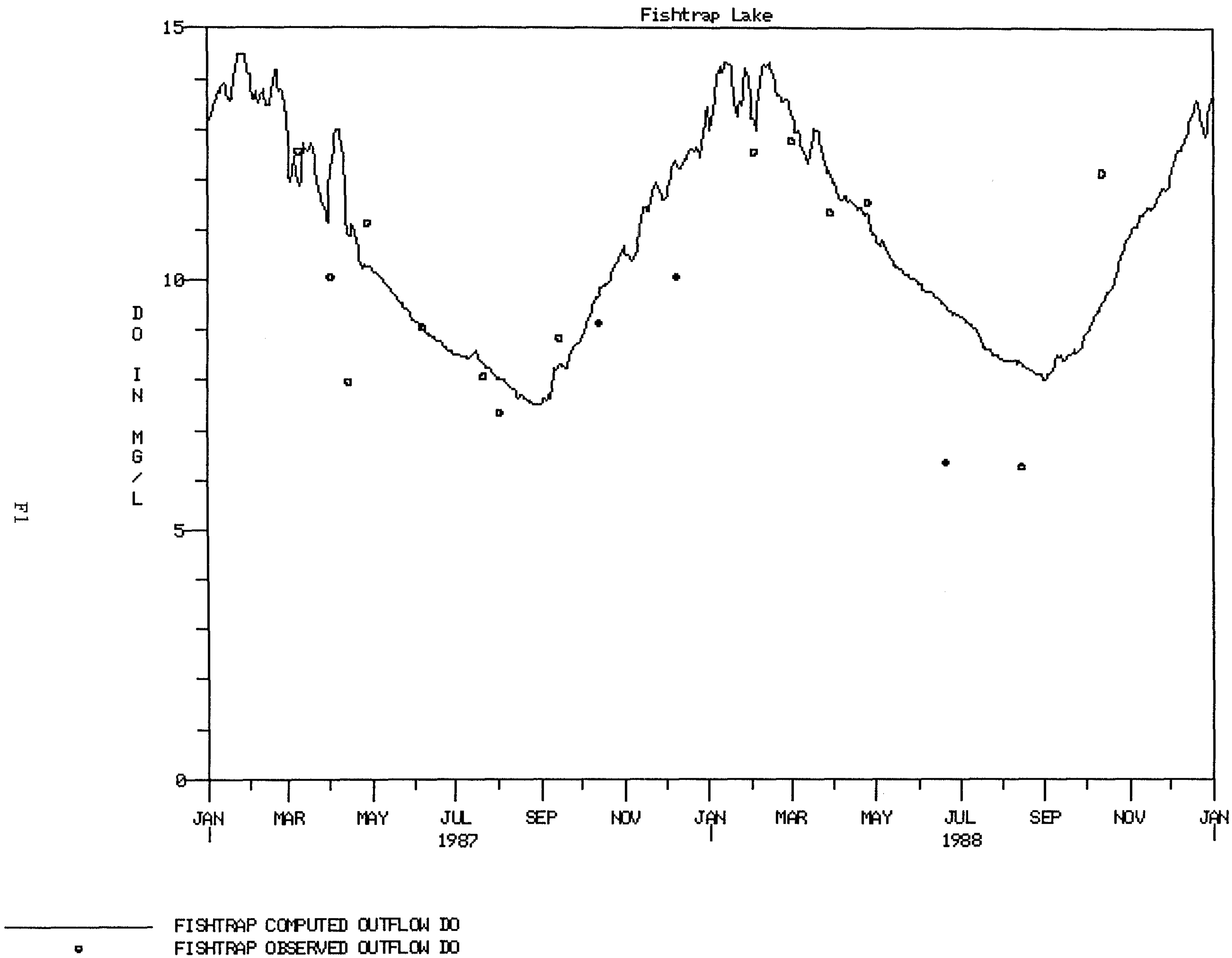

Paintsville Lake
TEMPERATURE IN DEG-C
30
20
10
0
JAN
MAR
MAY
JUL
SEP
NOV
JAN
MAR
MAY
JUL
SEP
NOV
JAN
1987
1988
PAINTSVILLE COMPUTED OUTFLOW TEMPERATURE
PAINTSVILLE OBSERVED OUTFLOW TEMPERATURE1
PAINTSVILLE OBSERVED OUTFLOW TEMPERATURE2

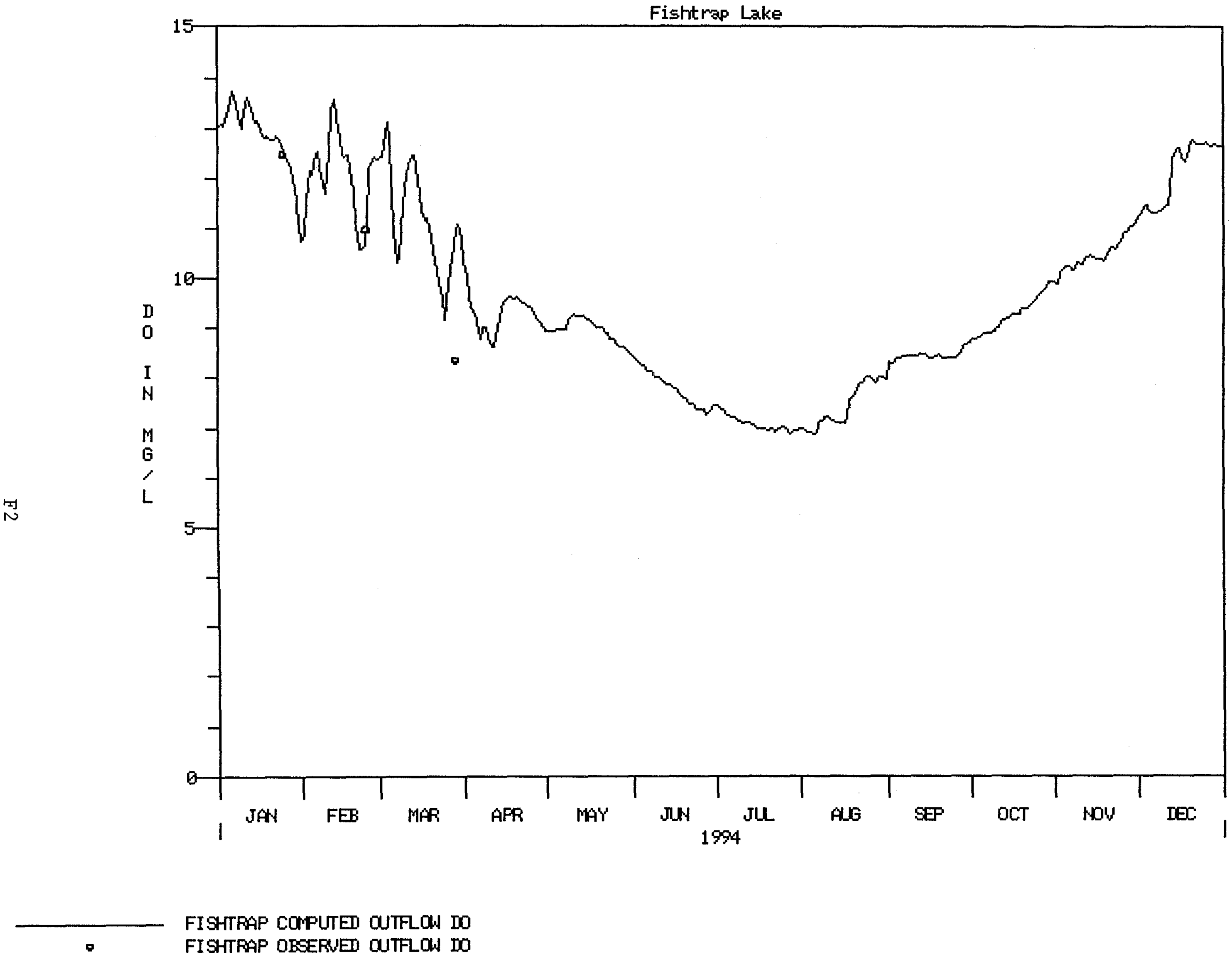

Yatesville Lake
TEMPERATURE IN DEG-C
30
20
10
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1994
YATESVILLE COMPUTED OUTFLOW TEMPERATURE
YATESVILLE OBSERVED OUTFLOW TEMPERATURE

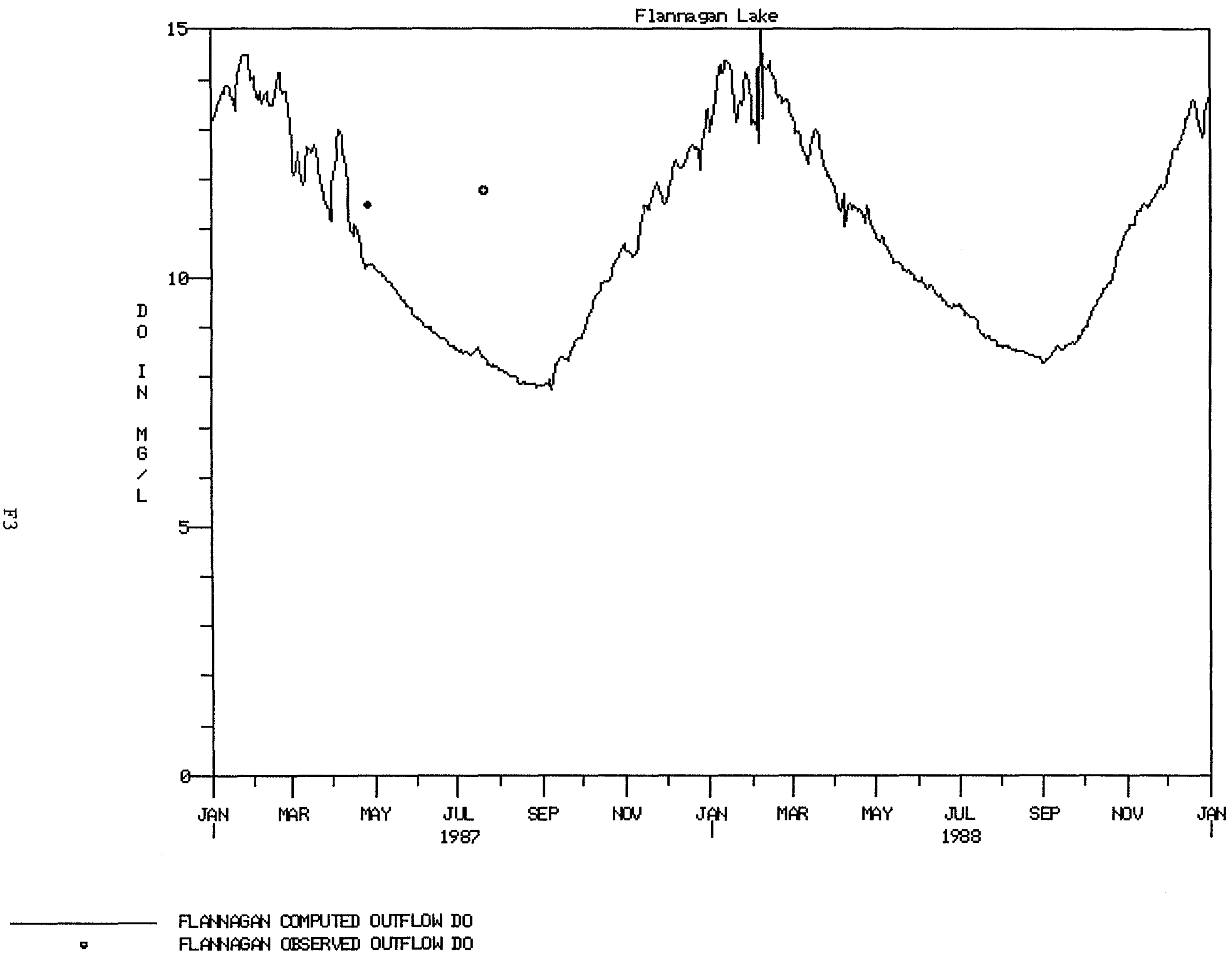

Paintsville Lake
30
20
10
0
TEMPERATURE IN DEG-C
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1994
PAINTSVILLE COMPUTED OUTFLOW TEMPERATURE
PAINTSVILLE OBSERVED OUTFLOW TEMPERATURE1
PAINTSVILLE OBSERVED OUTFLOW TEMPERATURE2

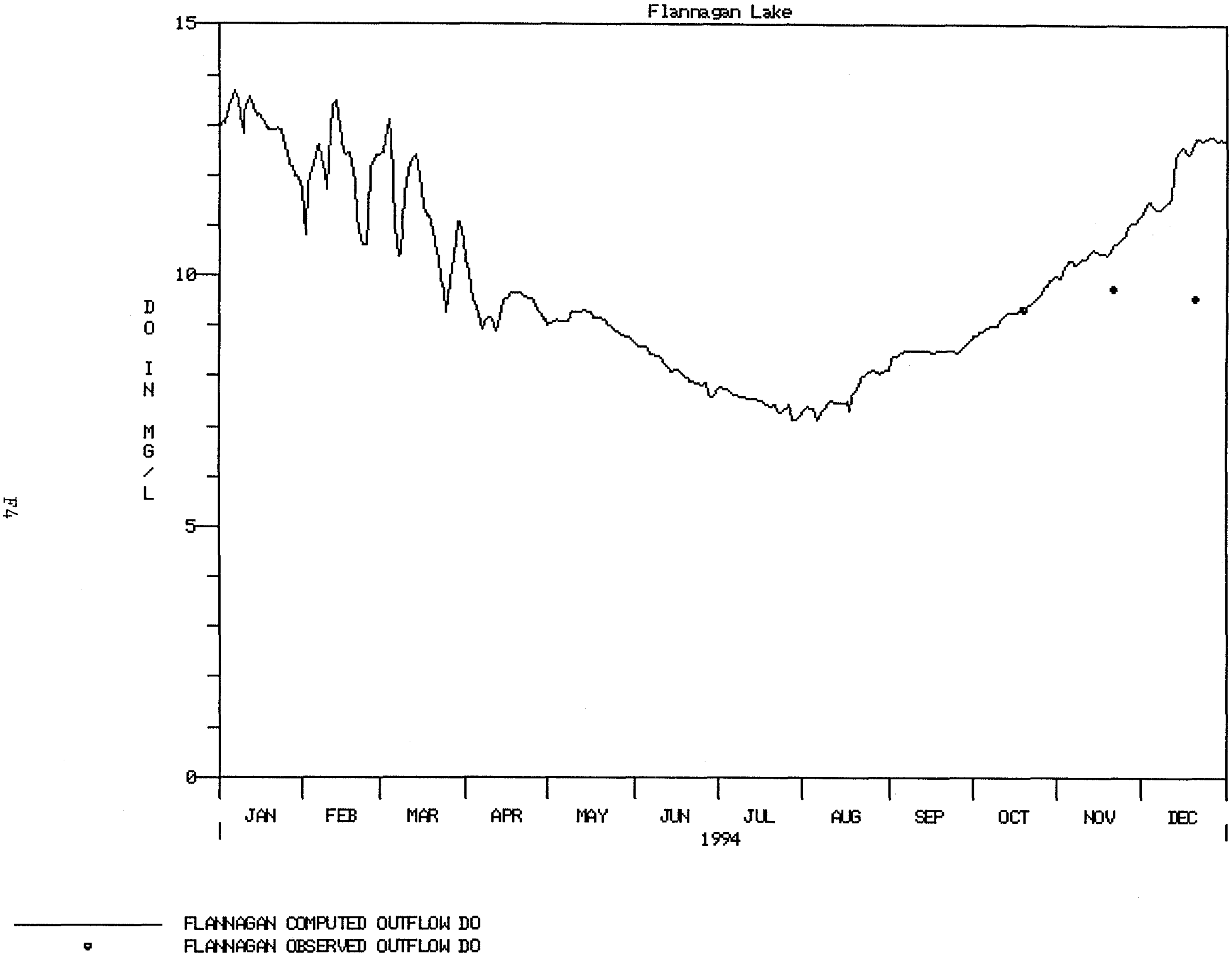
Appendix F

Calibration of Reservoir DO Releases

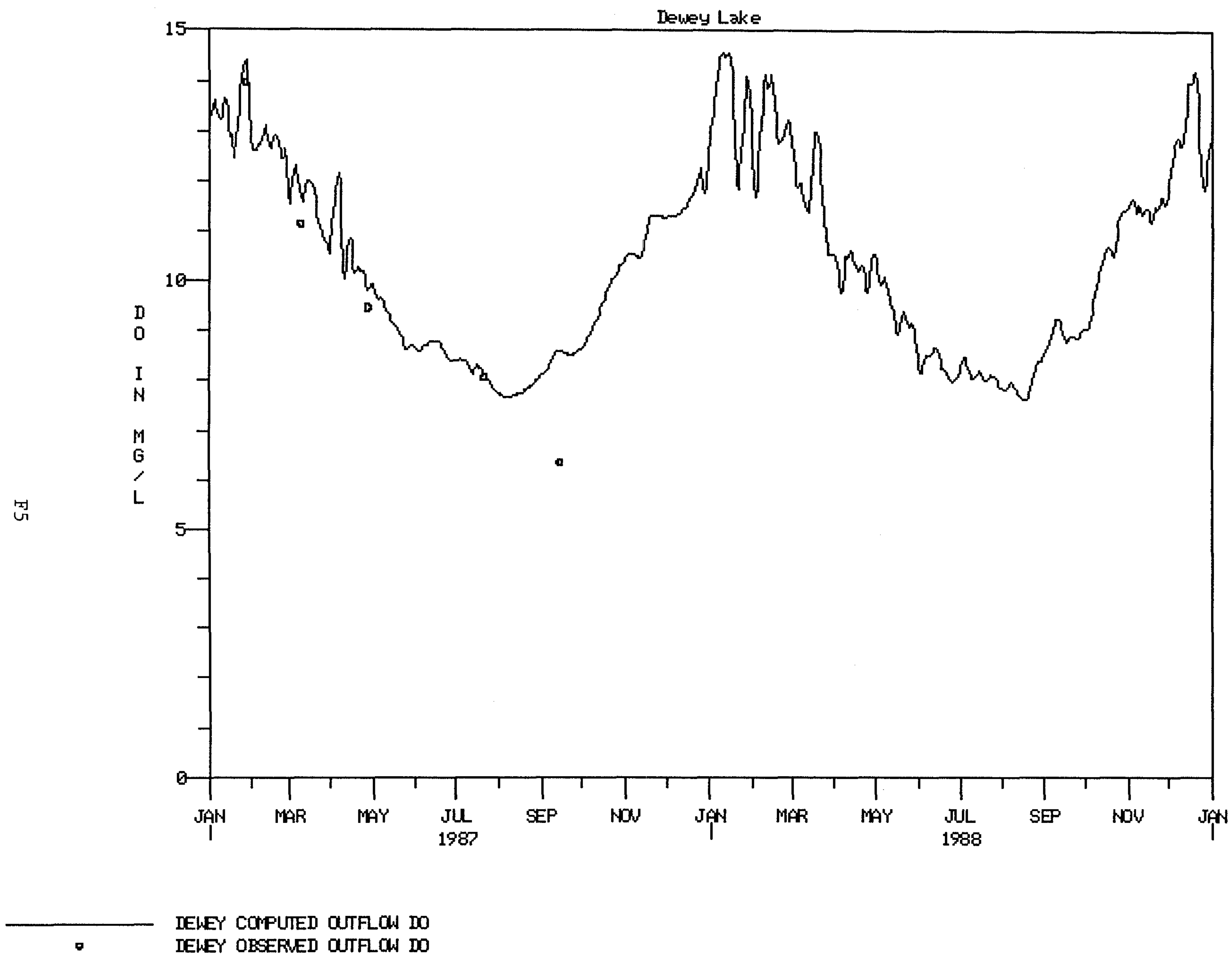

Fishtrap Lake
15
10
5
0
DO IN MG/L
JAN
MAR
MAY
JUL
1987
SEP
NOV
JAN
MAR
MAY
JUL
1988
SEP
NOV
JAN
FISHTRAP COMPUTED OUTFLOW DO
FISHTRAP OBSERVED OUTFLOW DO


Fishtrap Lake
15
10
5
0
DO IN MG/L
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1994
FISHTRAP COMPUTED OUTFLOW DO
FISHTRAP OBSERVED OUTFLOW DO

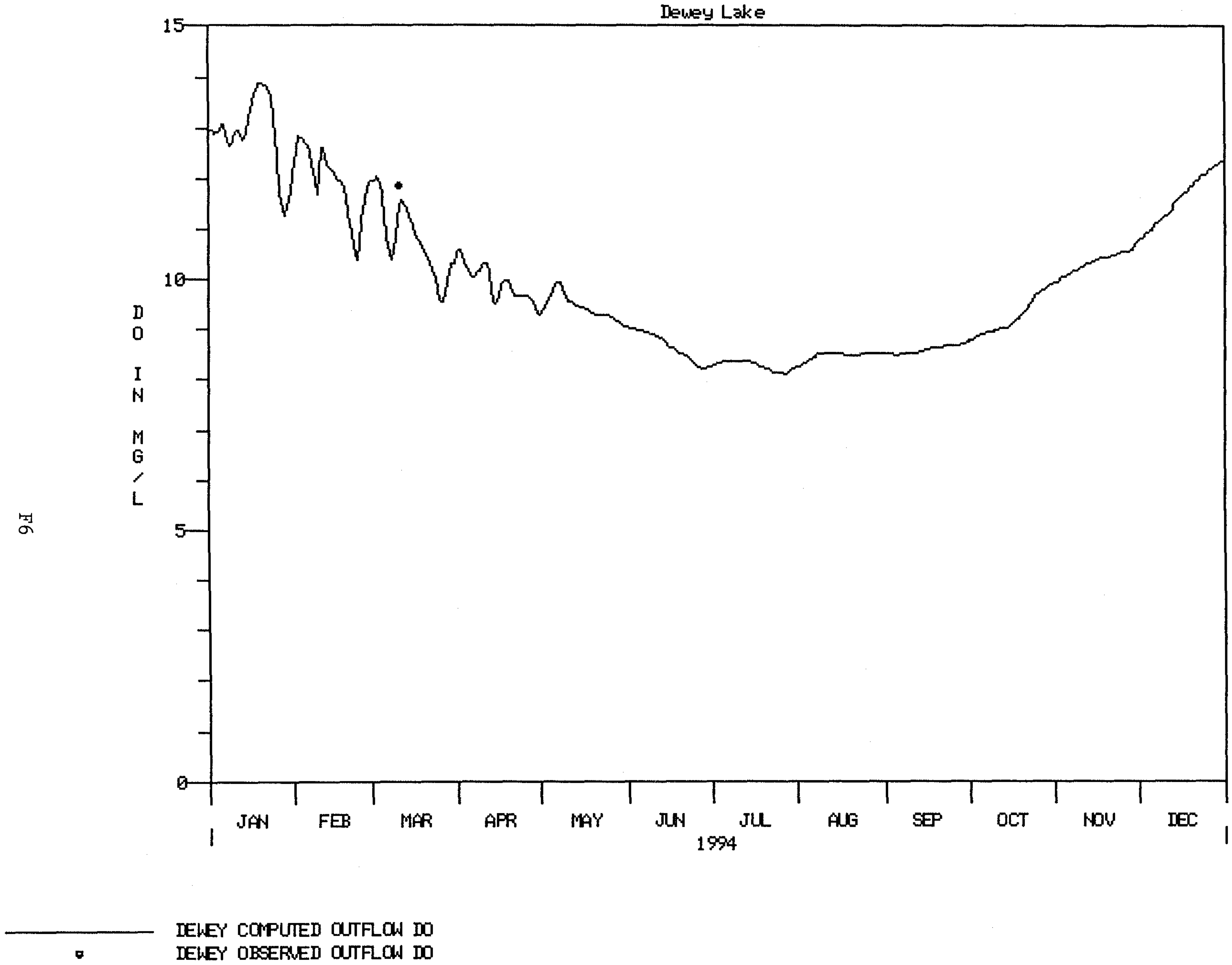

Flannagan Lake
15
10
5
0
DO IN MG/L
JAN
MAR
MAY
JUL
SEP
NOV
JAN
MAR
MAY
JUL
SEP
NOV
JAN
1987
1988
FLANNAGAN COMPUTED OUTFLOW DO
FLANNAGAN OBSERVED OUTFLOW DO



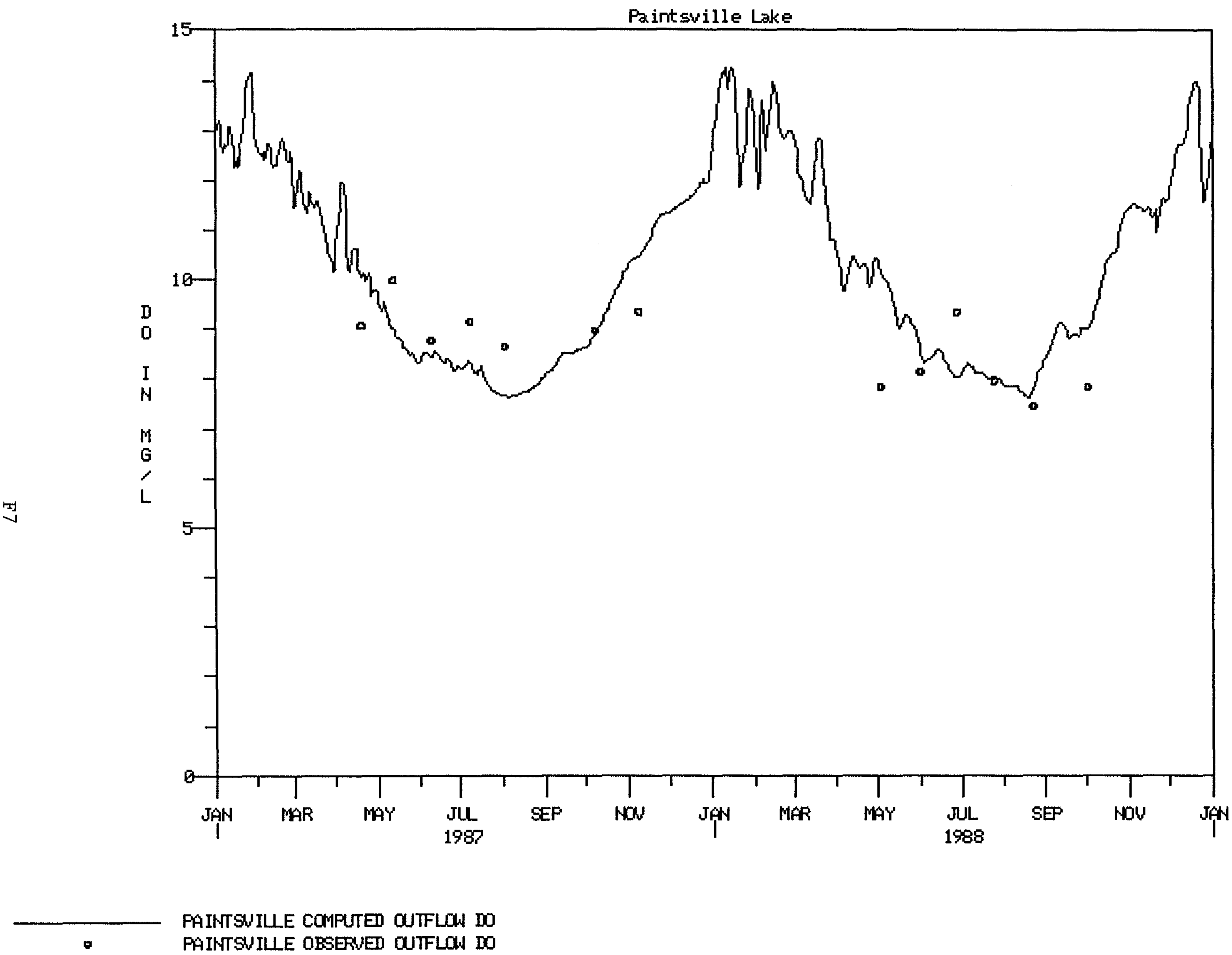
Flannagan Lake
15
10
5
0
DO IN MG/L
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1994
FLANNAGAN COMPUTED OUTFLOW DO
FLANNAGAN OBSERVED OUTFLOW DO



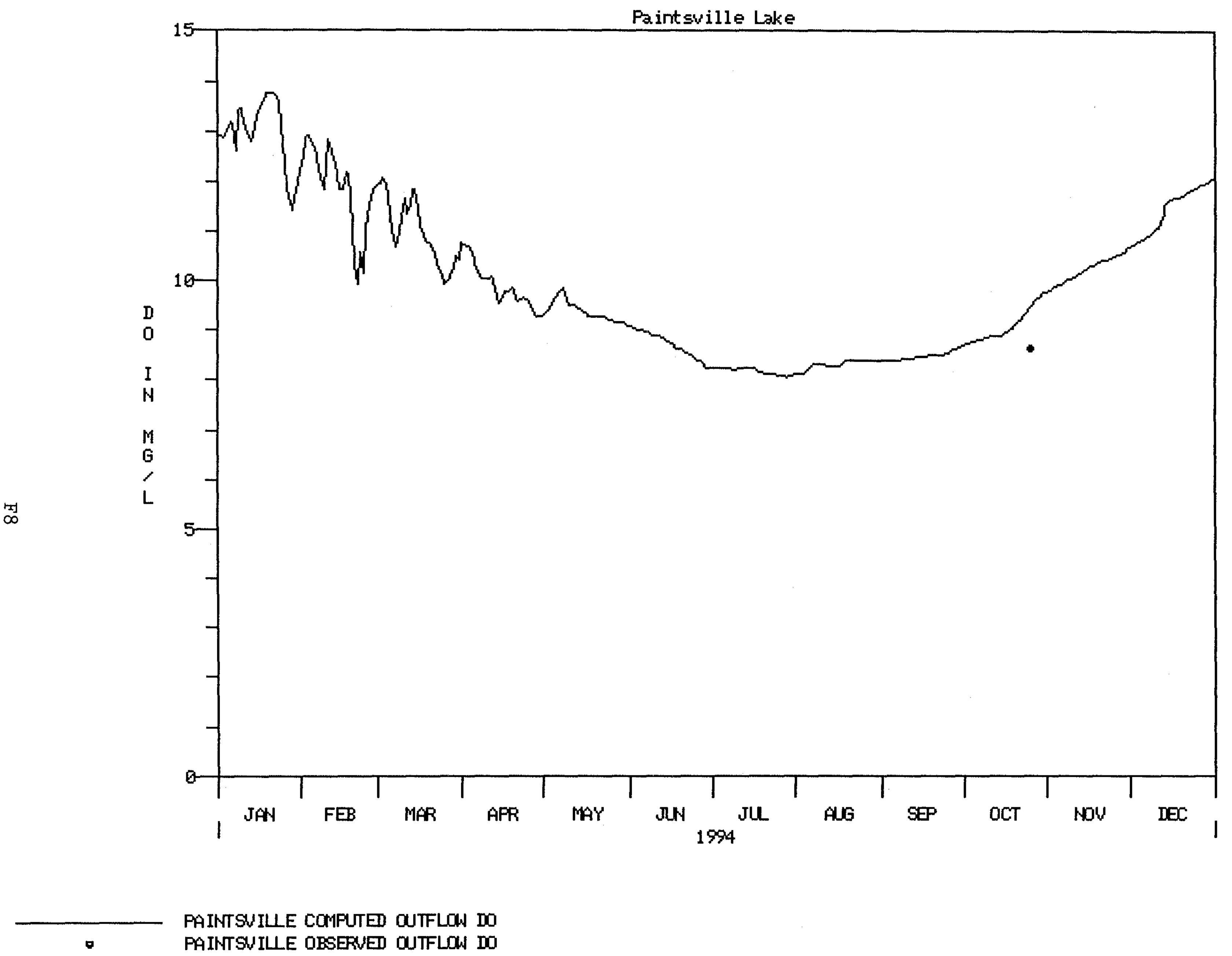
Dewey Lake
DO IN MG/L
15
10
5
0
JAN
MAR
MAY
JUL
1987
SEP
NOV
JAN
MAR
MAY
JUL
1988
SEP
NOV
JAN
DEWEY COMPUTED OUTFLOW DO
DEWEY OBSERVED OUTFLOW DO



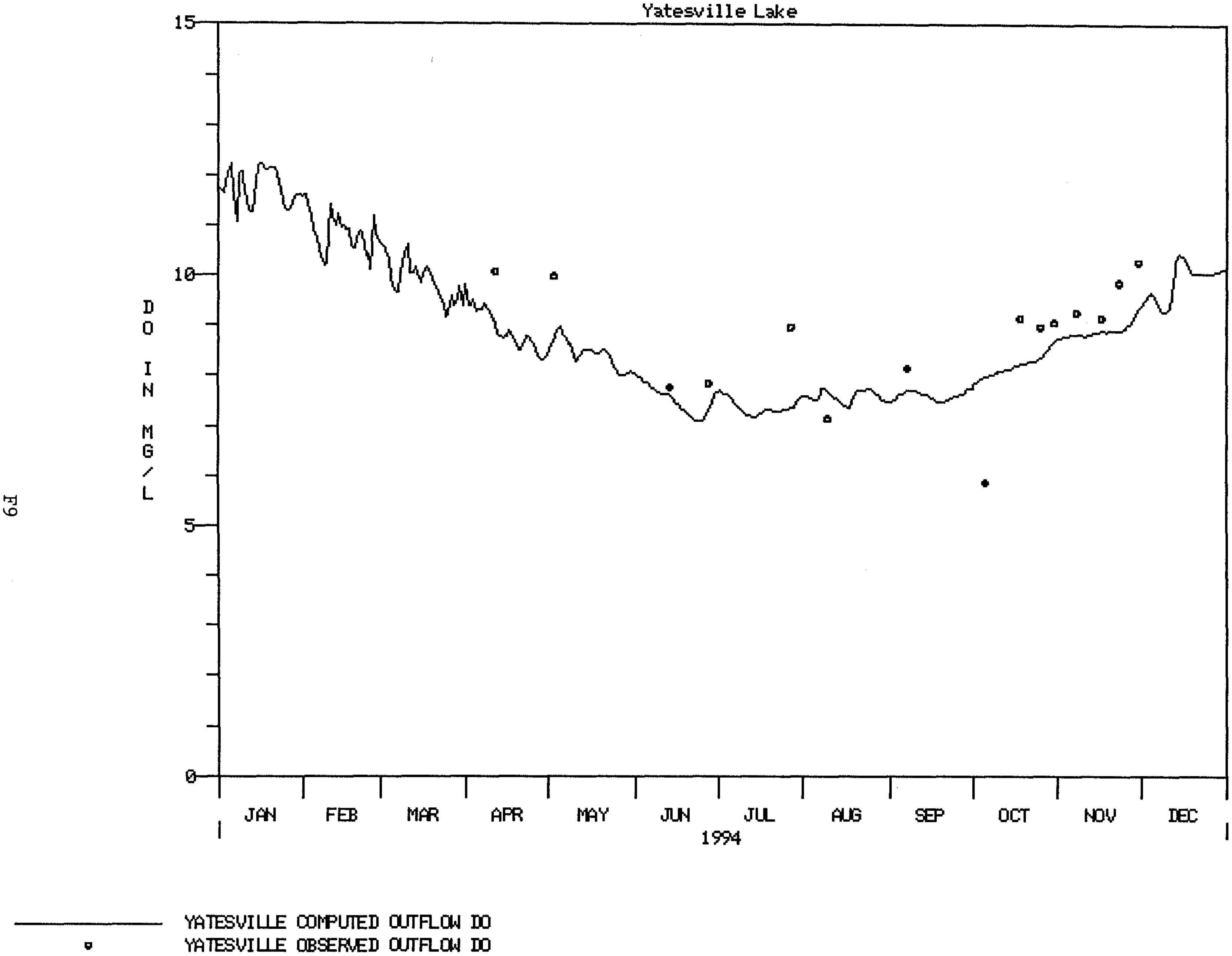
Dewey Lake
15
10
5
0
DO IN MG/L
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1994
DEWEY COMPUTED OUTFLOW DO
DEWEY OBSERVED OUTFLOW DO



Paintsville Lake
15
10
5
0
DO IN MG/L
JAN
MAR
MAY
JUL
SEP
NOV
JAN
MAR
MAY
JUL
SEP
NOV
JAN
1987
1988
PAINTSVILLE COMPUTED OUTFLOW DO
PAINTSVILLE OBSERVED OUTFLOW DO



Paintsville Lake
15
10
5
0
DO IN MG/L
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1994
PAINTSVILLE COMPUTED OUTFLOW DO
PAINTSVILLE OBSERVED OUTFLOW DO

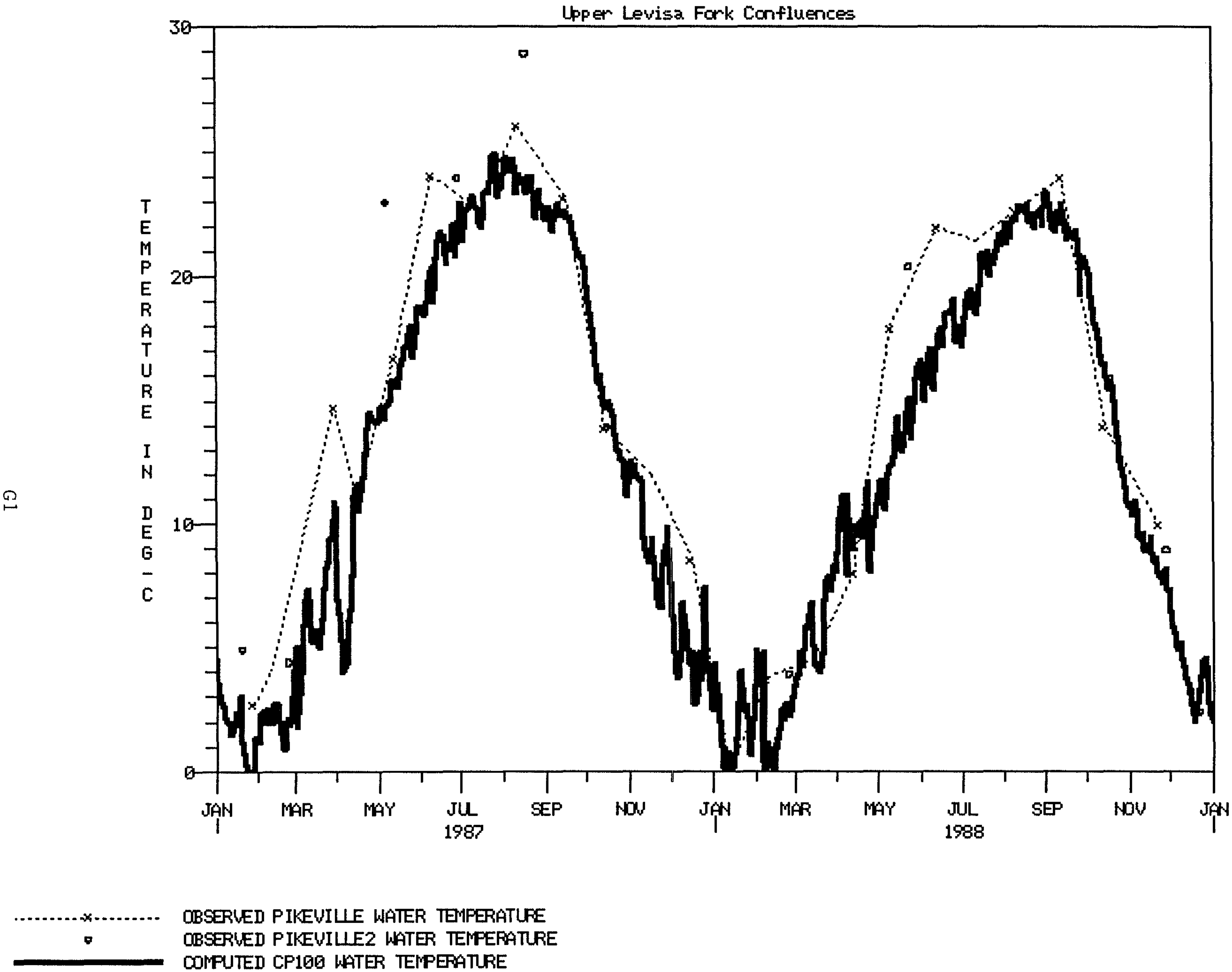


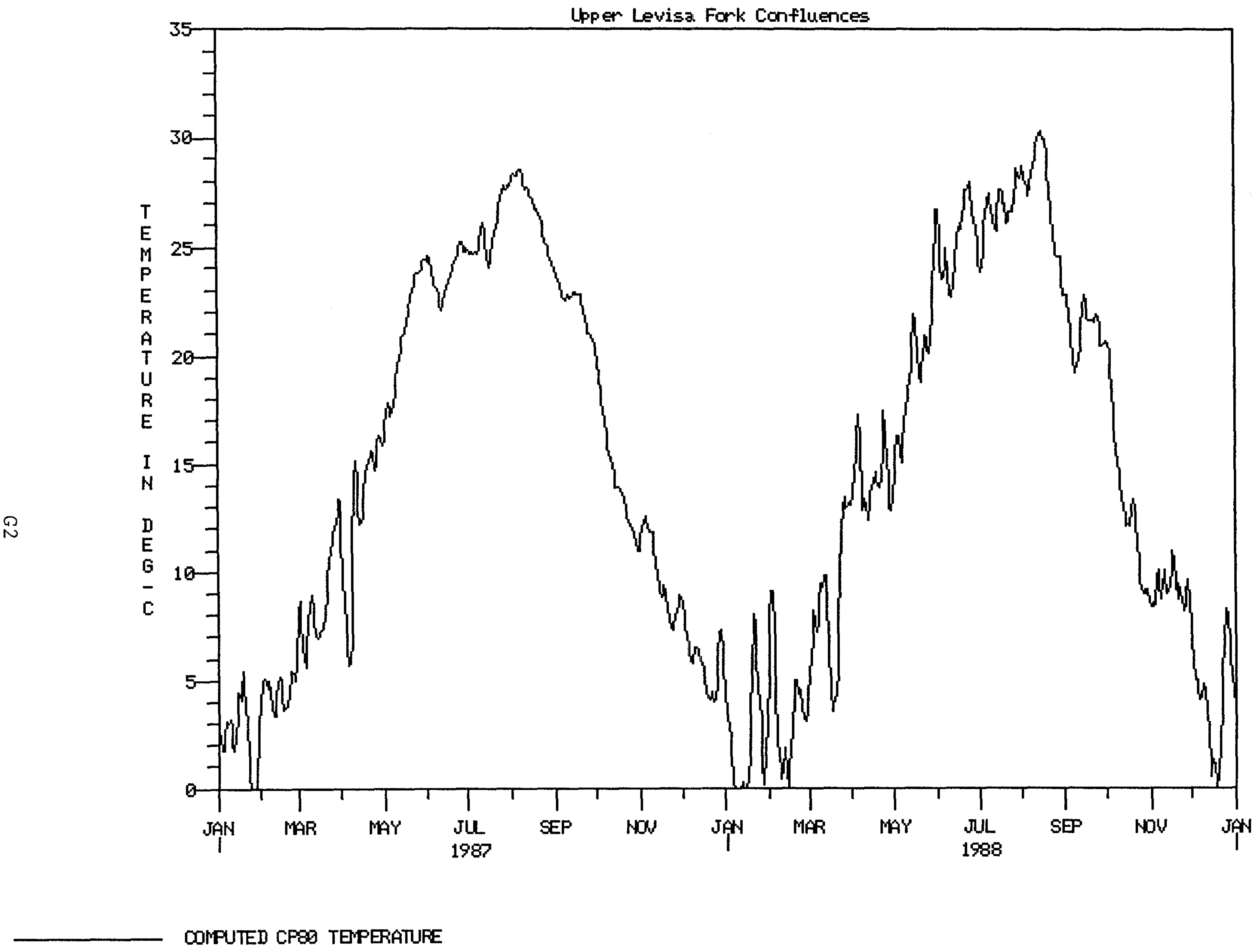
Yatesville Lake
15
10
5
0
DO IN MG/L
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1994
YATESVILLE COMPUTED OUTFLOW DO
YATESVILLE OBSERVED OUTFLOW DO

Appendix G

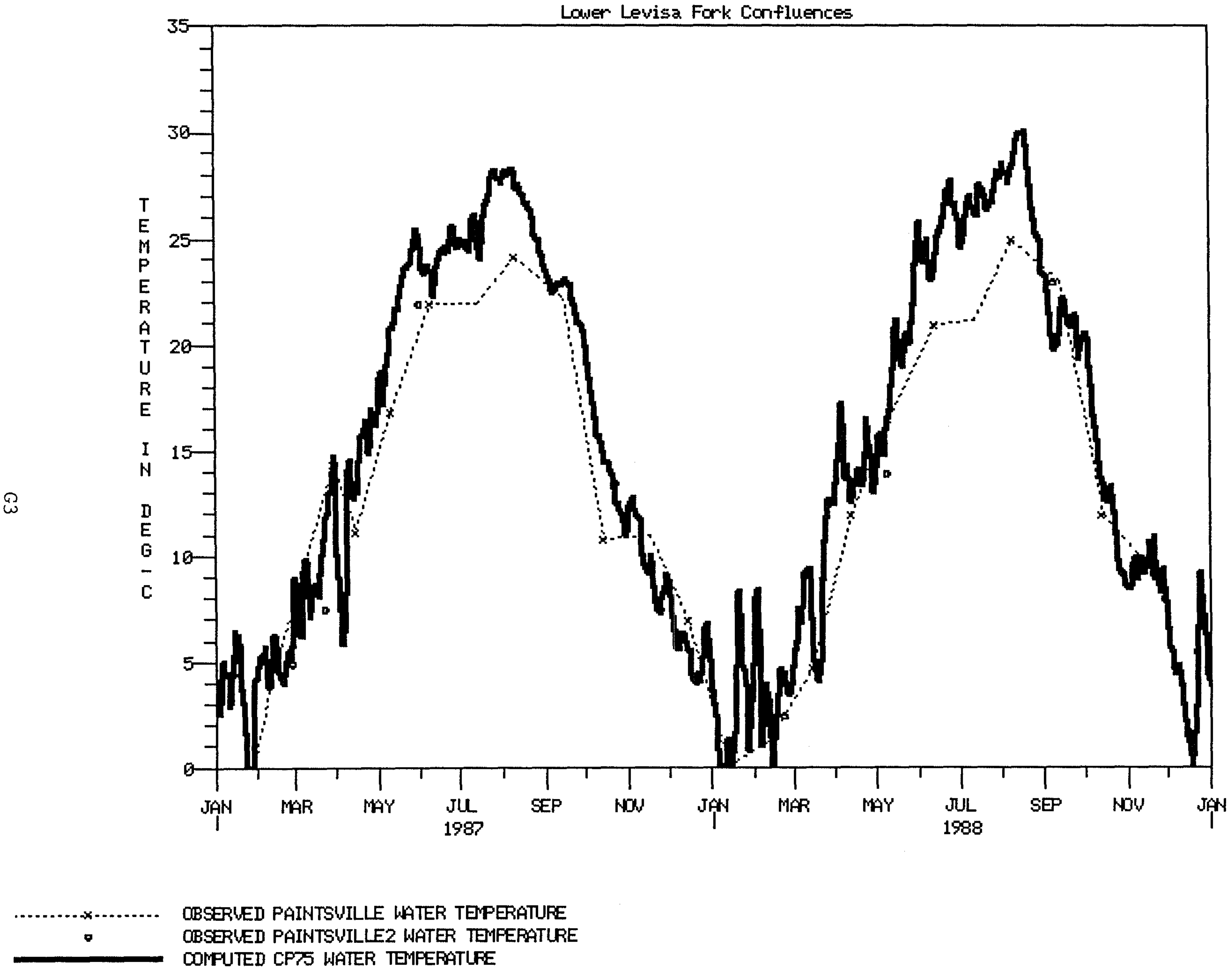
Calibration of
Temperature at River Control Points

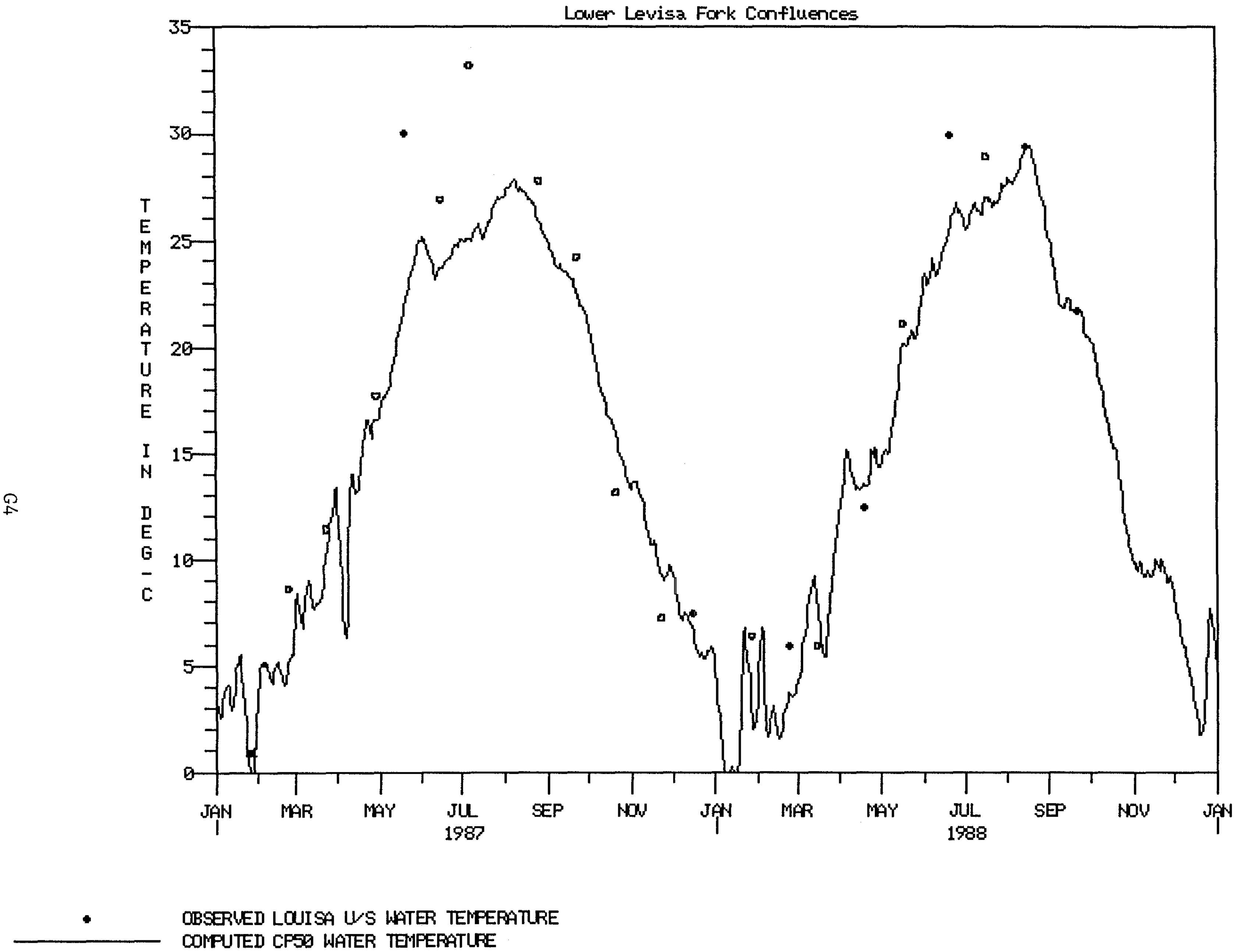
G1


Upper Levisa Fork Confluences
TEMPERATURE IN DEG-C
30
20
10
0
JAN
MAR
MAY
JUL
SEP
NOV
JAN
MAR
MAY
JUL
SEP
NOV
JAN
1987
1988
OBSERVED PIKEVILLE WATER TEMPERATURE
OBSERVED PIKEVILLE2 WATER TEMPERATURE
COMPUTED CP100 WATER TEMPERATURE

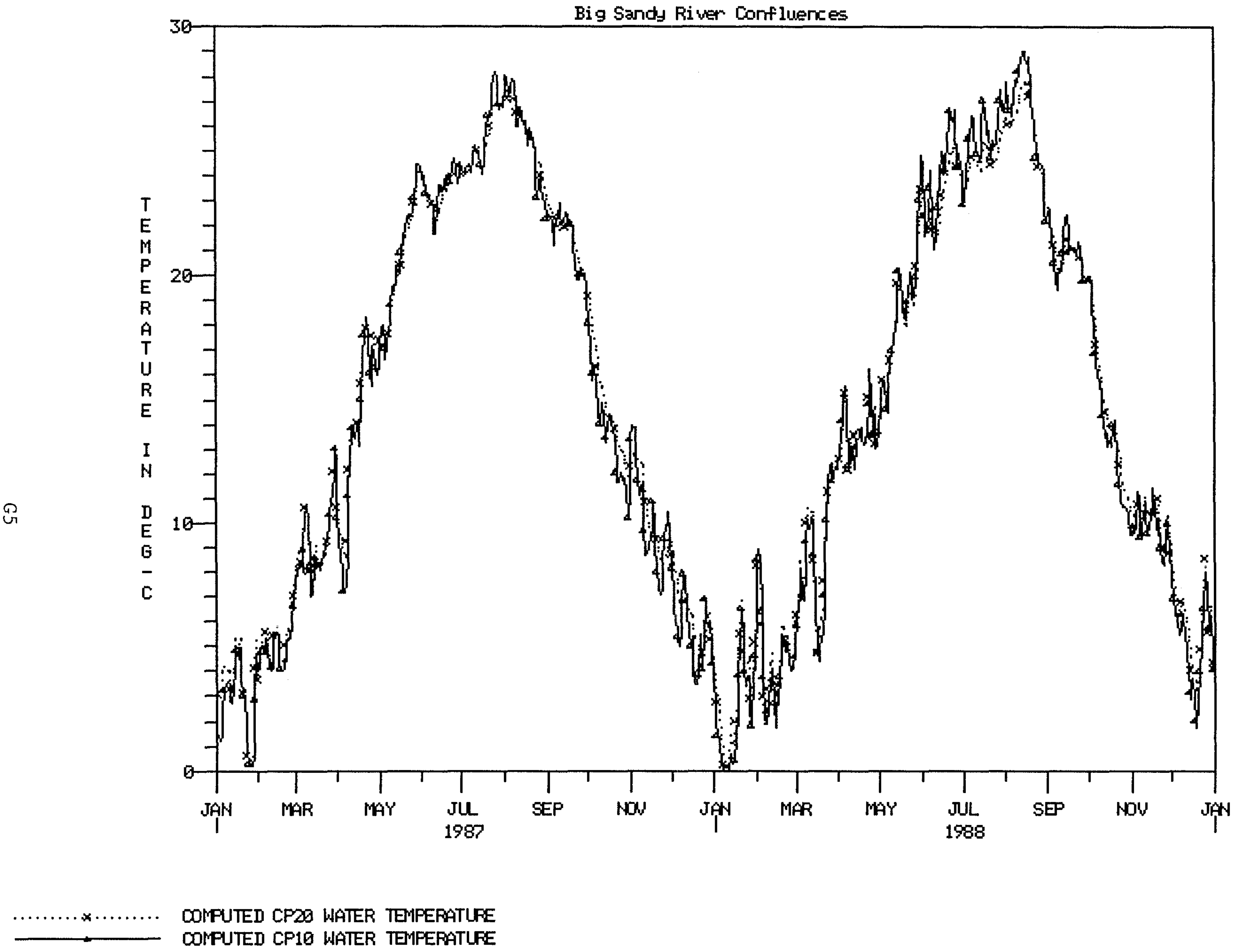


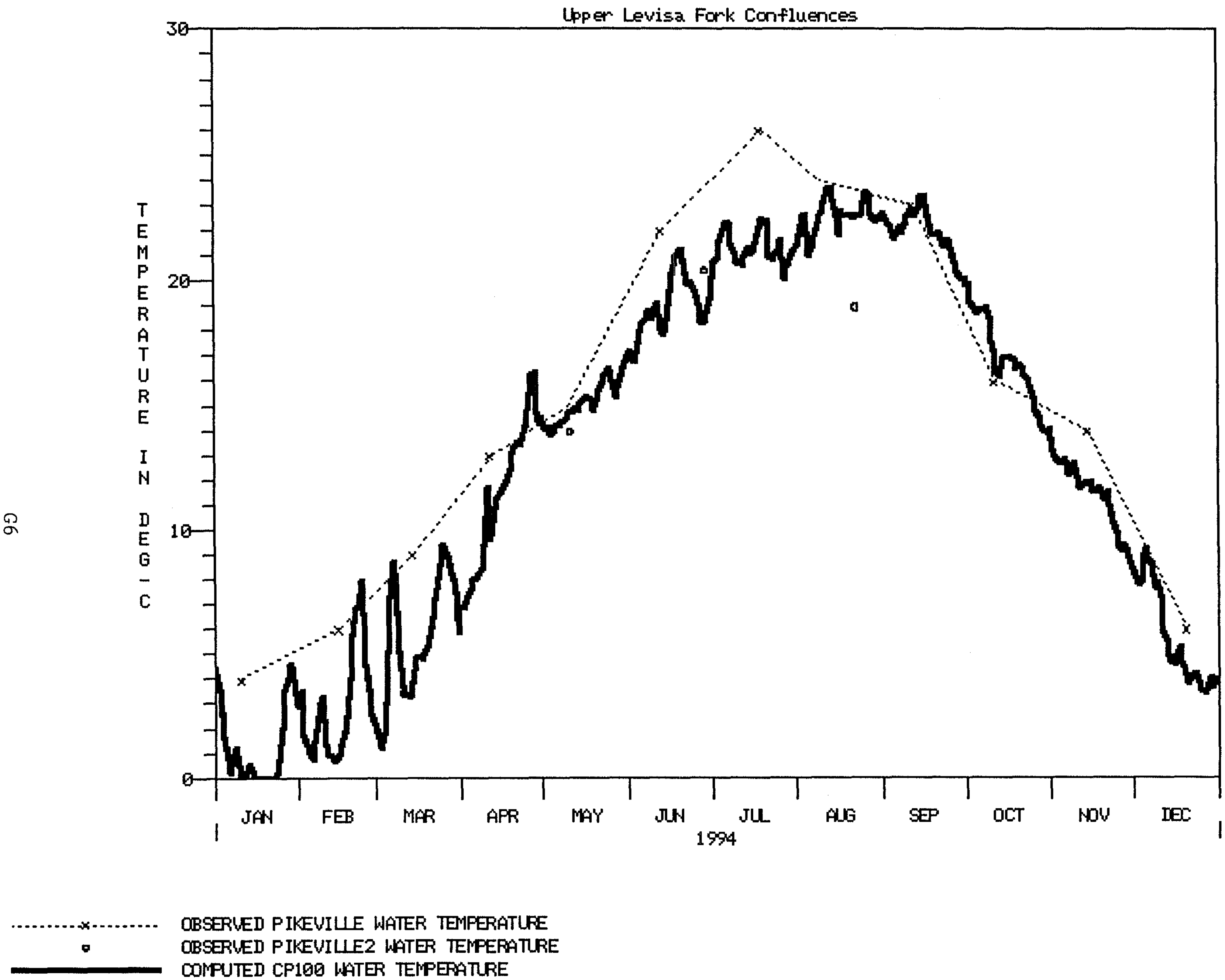
Upper Levisa Fork Confluences
TEMPERATURE IN DEG-C
35
30
25
20
15
10
5
0
JAN
MAR
MAY
JUL
SEP
NOV
JAN
MAR
MAY
JUL
SEP
NOV
JAN
1987
1988
COMPUTED CP80 TEMPERATURE

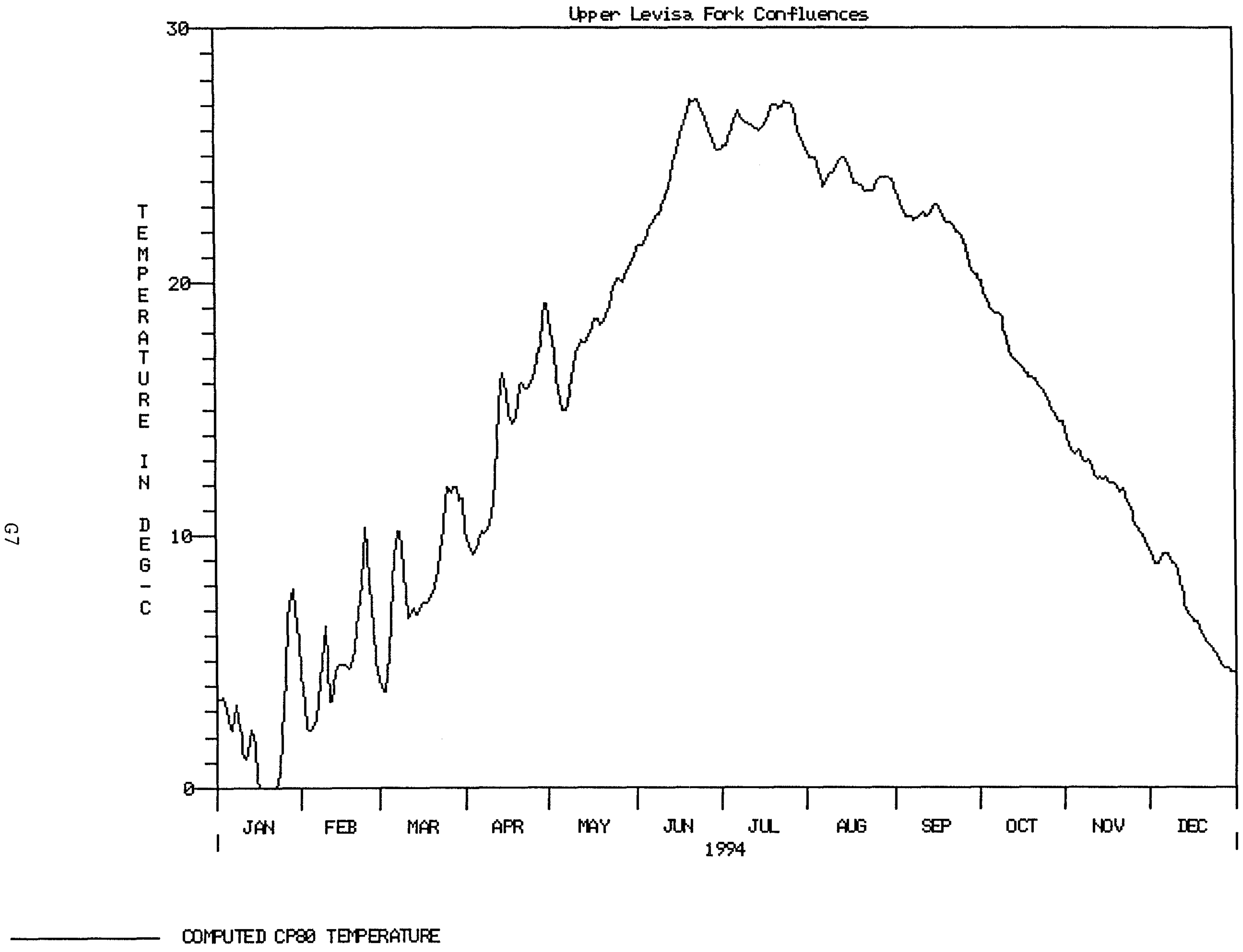

Lower Levisa Fork Confluences
TEMPERATURE IN DEG-C
35
30
25
20
15
10
5
0
JAN
MAR
MAY
JUL
SEP
NOV
JAN
MAR
MAY
JUL
SEP
NOV
JAN
1987
1988
OBSERVED PAINTSVILLE WATER TEMPERATURE
OBSERVED PAINTSVILLE2 WATER TEMPERATURE
COMPUTED CP75 WATER TEMPERATURE



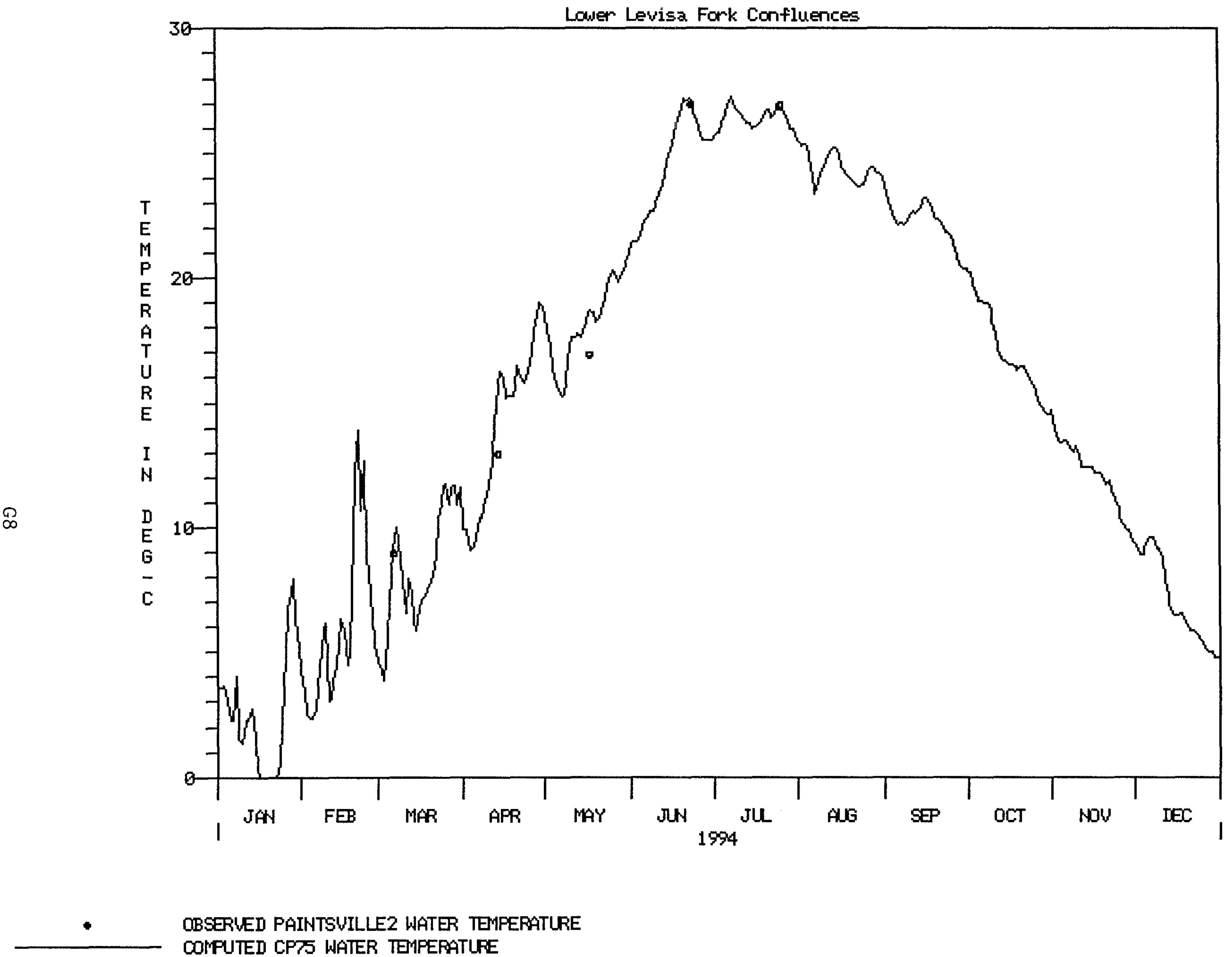
Lower Levisa Fork Confluences
TEMPERATURE IN DEG-C
35
30
25
20
15
10
5
0
JAN
MAR
MAY
JUL
SEP
NOV
JAN
MAR
MAY
JUL
SEP
NOV
JAN
1987
1988
OBSERVED LOUISA U/S WATER TEMPERATURE
COMPUTED CP50 WATER TEMPERATURE

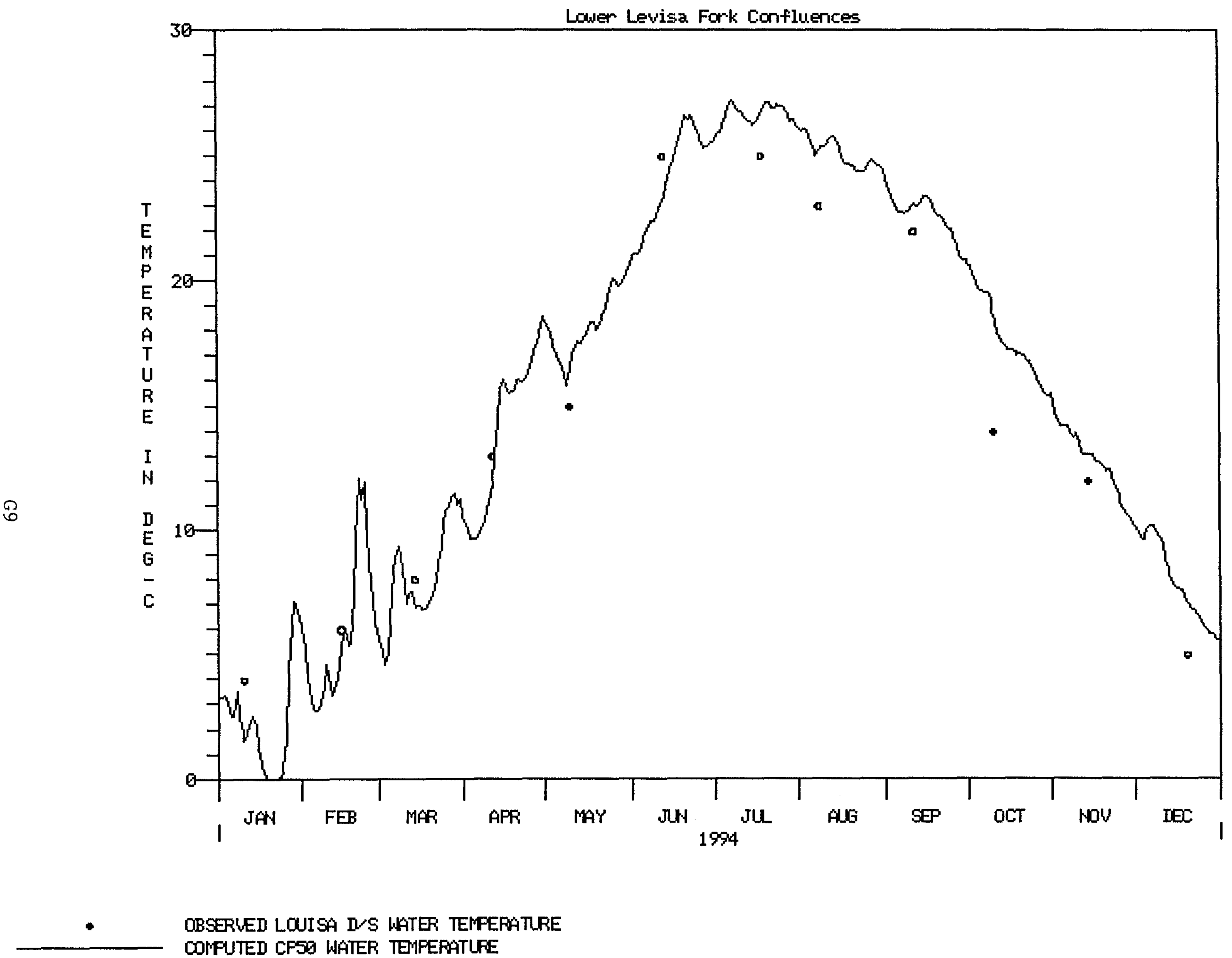

Big Sandy River Confluences
TEMPERATURE IN DEG-C
30
20
10
0
JAN
MAR
MAY
JUL
SEP
NOV
JAN
MAR
MAY
JUL
SEP
NOV
JAN
1987
1988
COMPUTED CP20 WATER TEMPERATURE
COMPUTED CP10 WATER TEMPERATURE

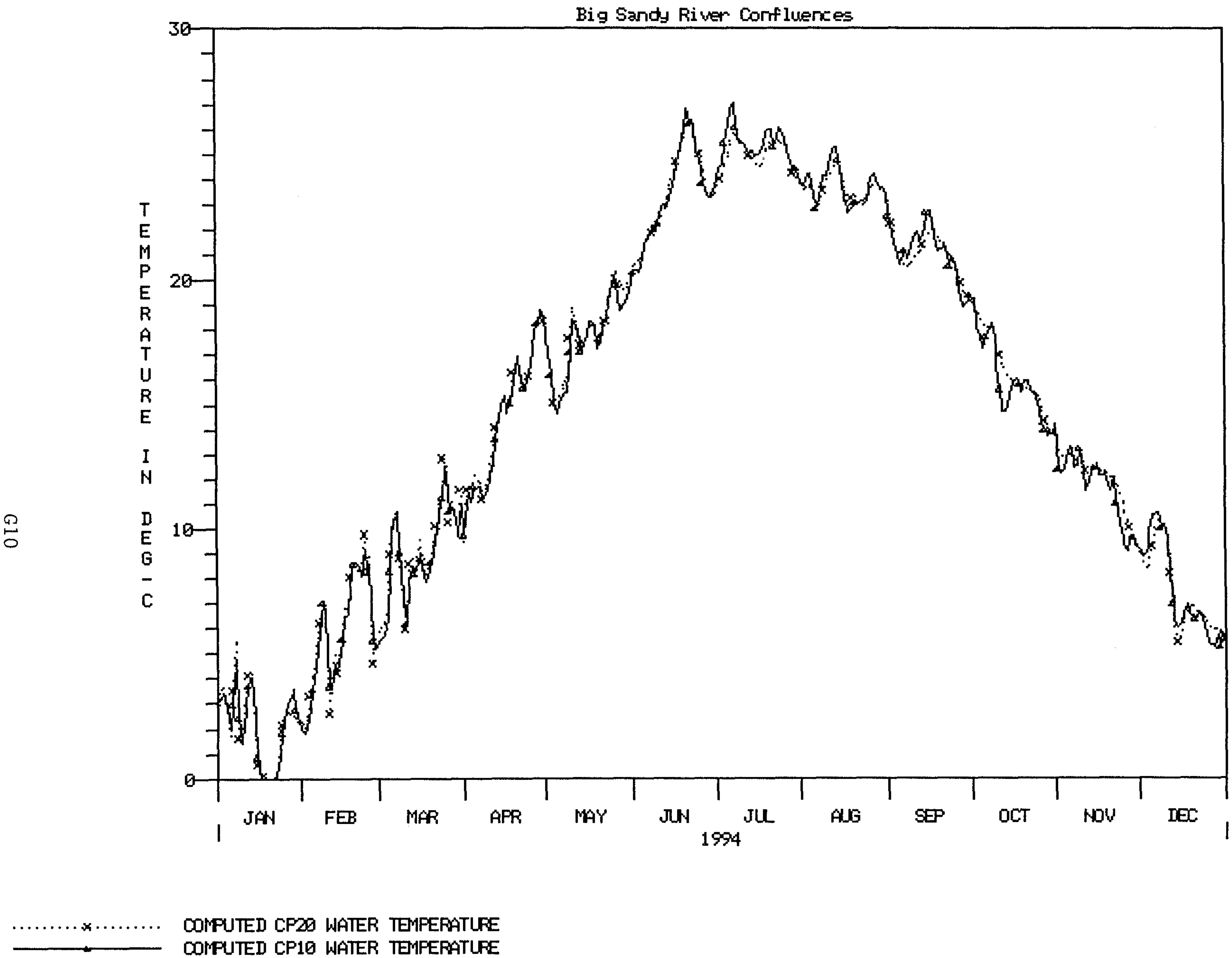

Upper Levisa Fork Confluences
TEMPERATURE IN DEG C
30
20
10
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1994
OBSERVED PIKEVILLE WATER TEMPERATURE
OBSERVED PIKEVILLE2 WATER TEMPERATURE
COMPUTED CP100 WATER TEMPERATURE



Upper Levisa Fork Confluences
30
20
10
0
TEMPERATURE IN DEG-C
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1994
COMPUTED CP80 TEMPERATURE


Lower Levisa Fork Confluences
30
20
10
0
TEMPERATURE IN DEG-C
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1994
OBSERVED PAINTSVILLE2 WATER TEMPERATURE
COMPUTED CP75 WATER TEMPERATURE


Lower Levisa Fork Confluences
30
20
10
0
TEMPERATURE IN DEG-C
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1994
OBSERVED LOUISA D/S WATER TEMPERATURE
COMPUTED CP50 WATER TEMPERATURE

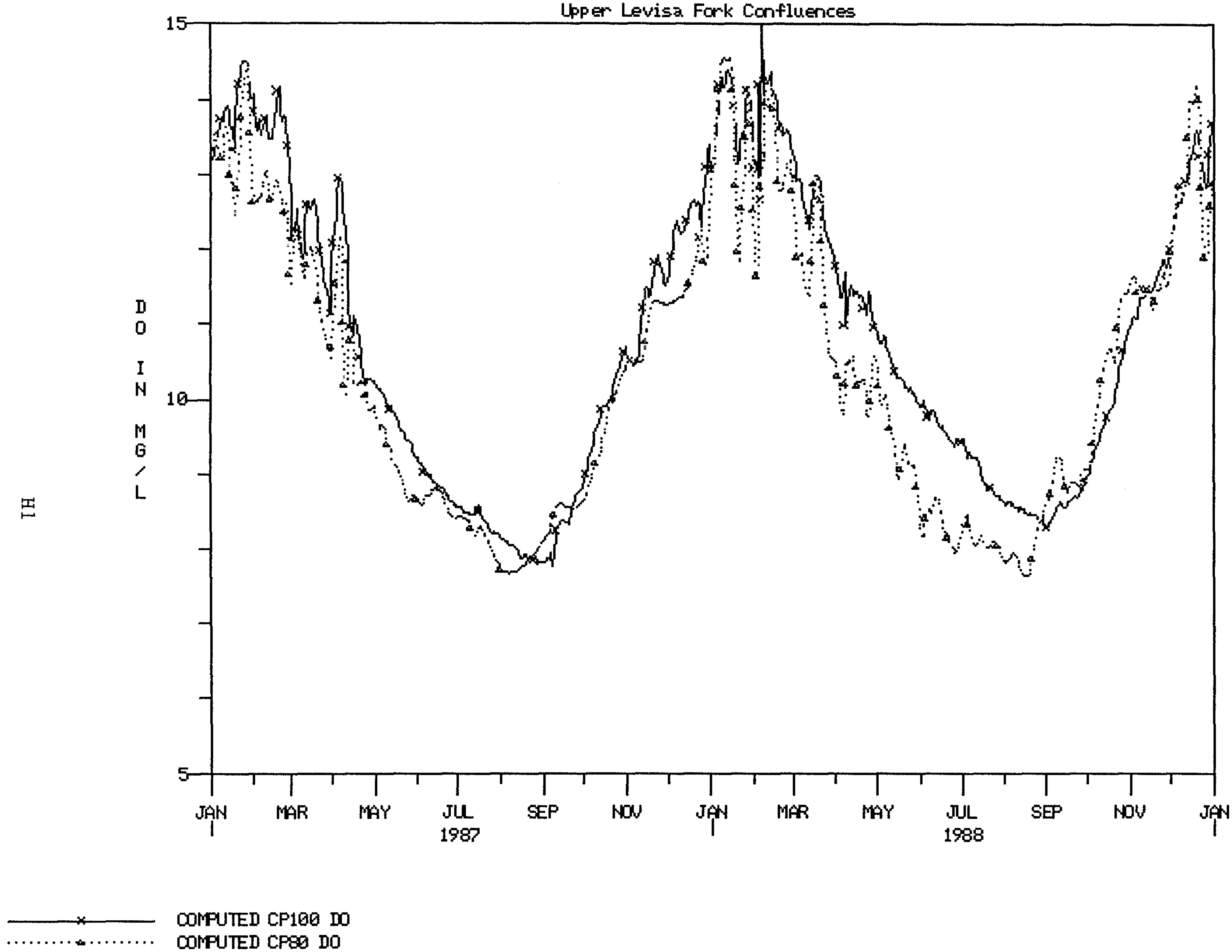


Big Sandy River Confluences
TEMPERATURE IN DEG-C
30
20
10
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1994
COMPUTED CP20 WATER TEMPERATURE
COMPUTED CP10 WATER TEMPERATURE

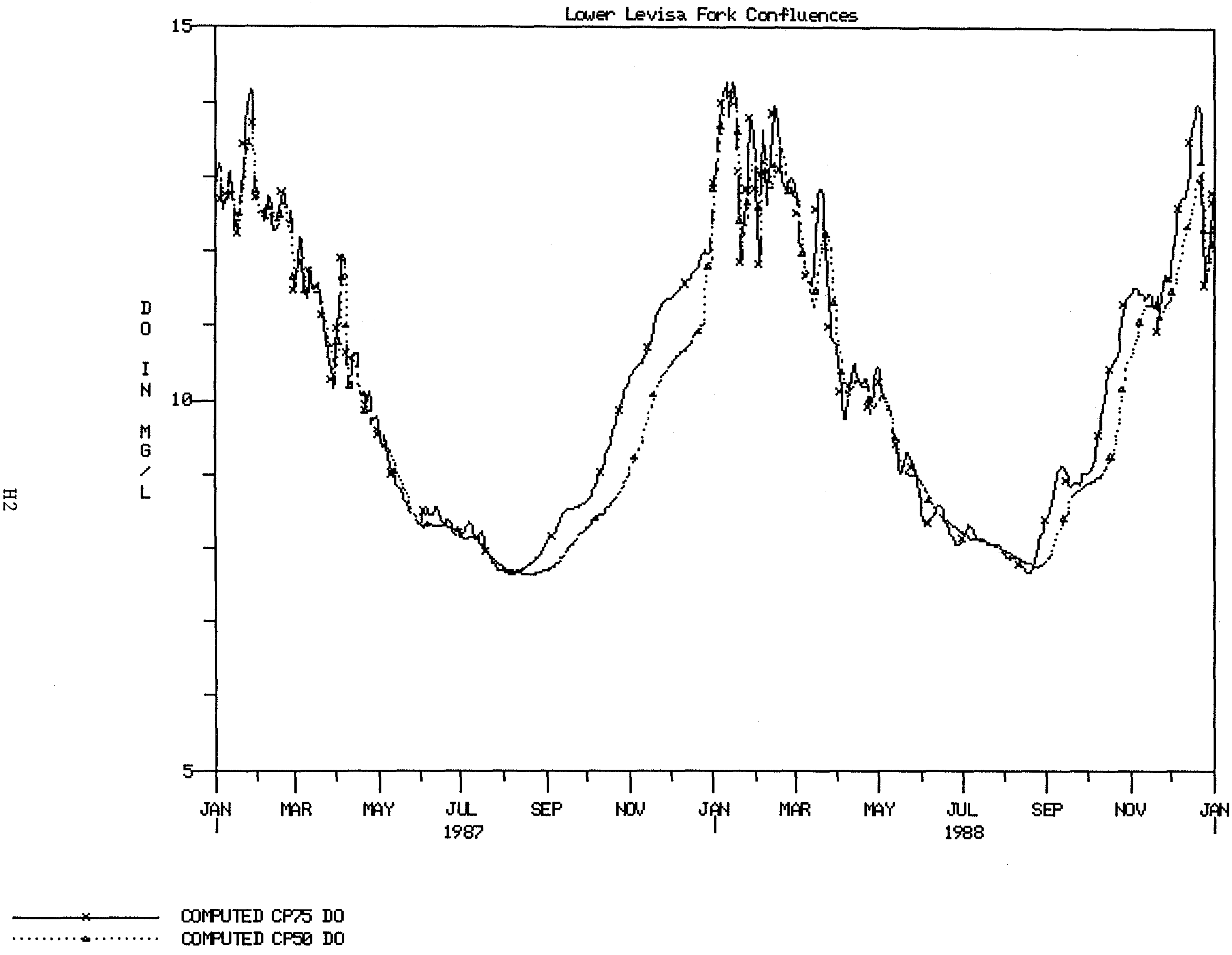
G10

Appendix H

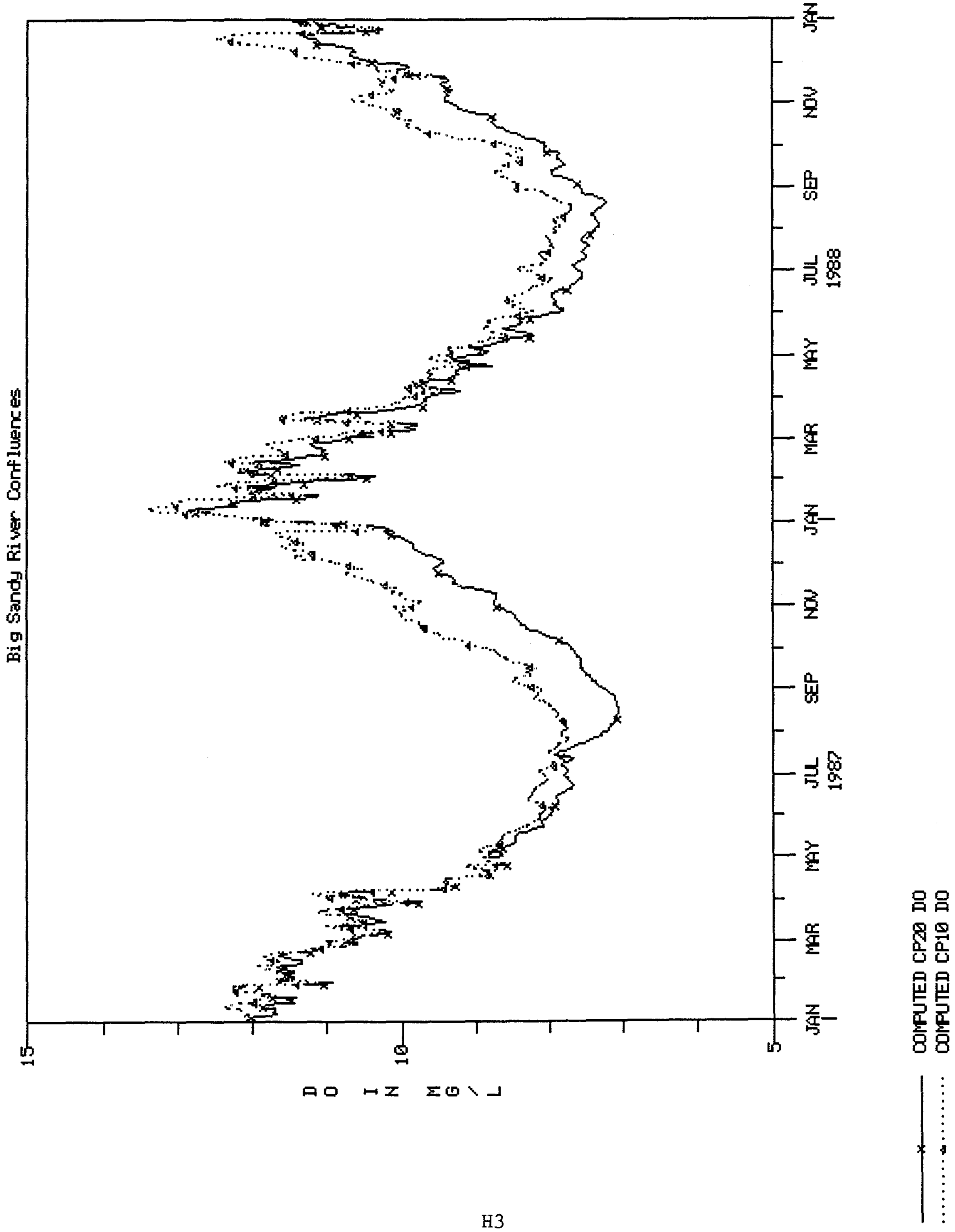
Calibration of
DO at River Control Points

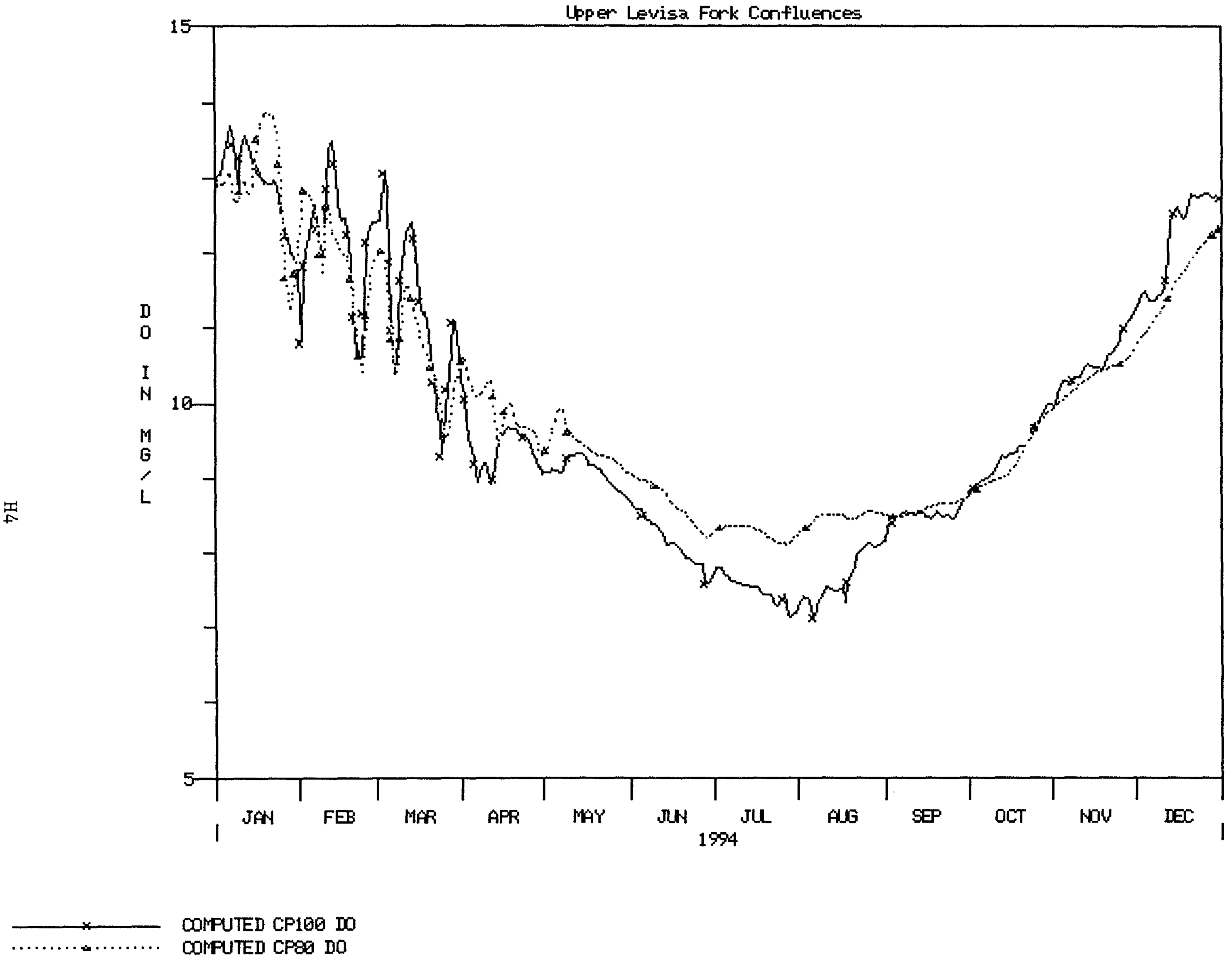

Upper Levisa Fork Confluences
15
10
5
DO IN MG/L
JAN
MAR
MAY
JUL
SEP
NOV
JAN
MAR
MAY
JUL
SEP
NOV
JAN
1987
1988
COMPUTED CP100 DO
COMPUTED CP80 DO

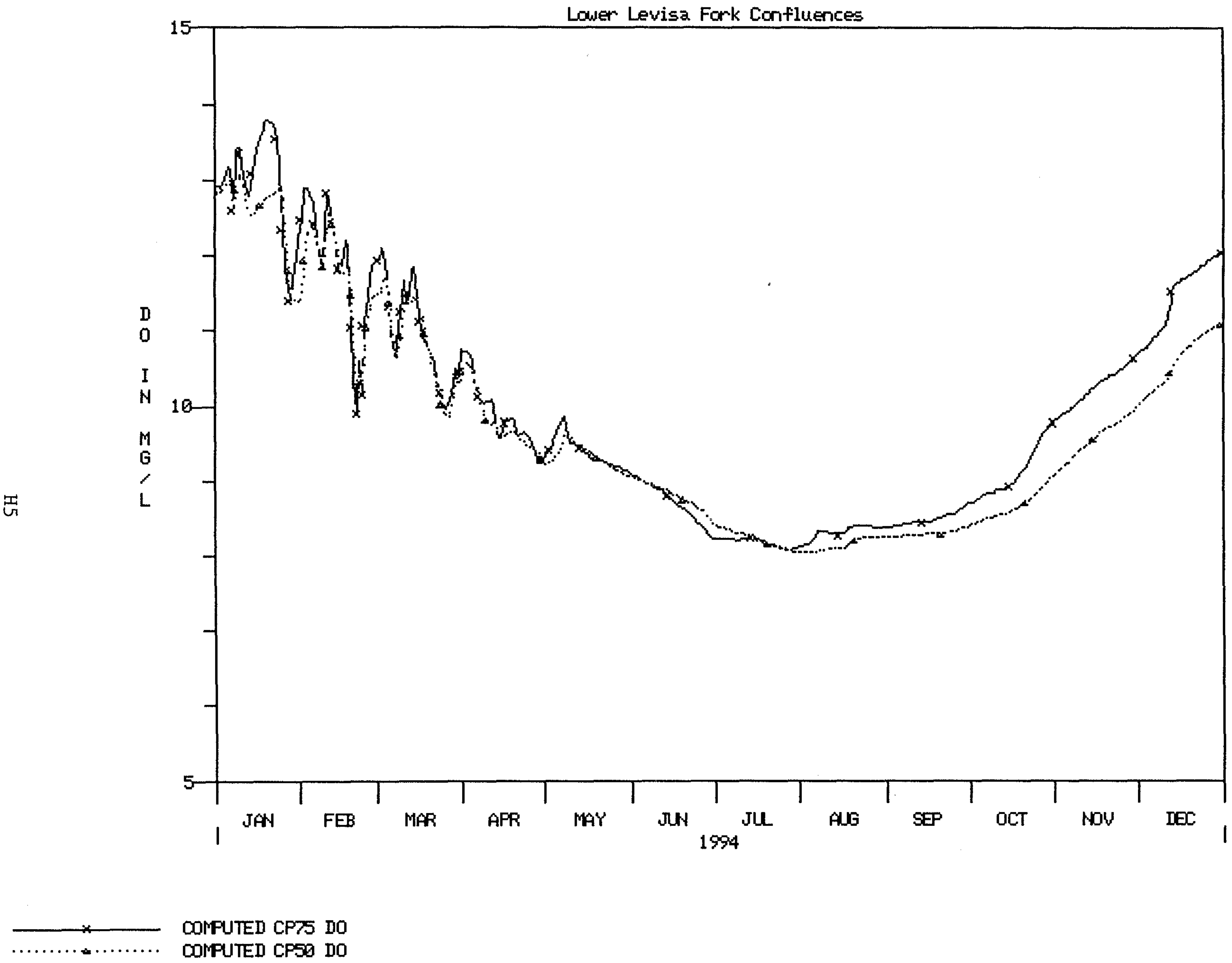
IH



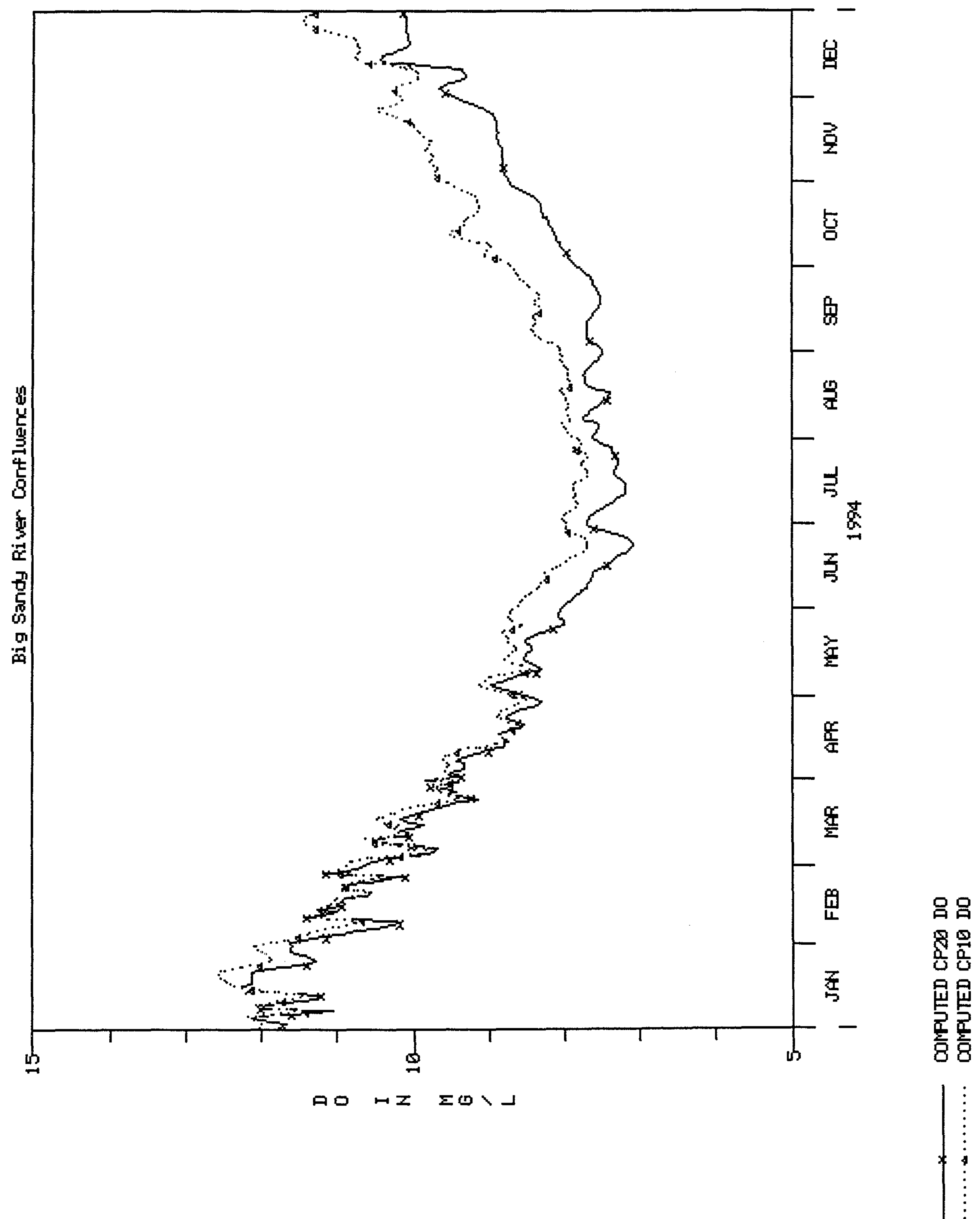
Lower Levisa Fork Confluences
15
10
5
DO IN MG/L
JAN
MAR
MAY
JUL
1987
SEP
NOV
JAN
MAR
MAY
JUL
1988
SEP
NOV
JAN
COMPUTED CP75 DO
COMPUTED CP50 DO


Big Sandy River Confluences
DO IN MG/L
15
10
5
JAN
MAR
MAY
JUL
1987
SEP
NOV
JAN
MAR
MAY
JUL
1988
SEP
NOV
JAN
COMPUTED CP20 DO
COMPUTED CP10 DO


Upper Levisa Fork Confluences
15
10
5
DO IN MG/L
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1994
COMPUTED CP100 DO
COMPUTED CP80 DO


Lower Levisa Fork Confluences
15
10
5
DO IN MG/L
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1994
COMPUTED CP75 DO
COMPUTED CP50 DO

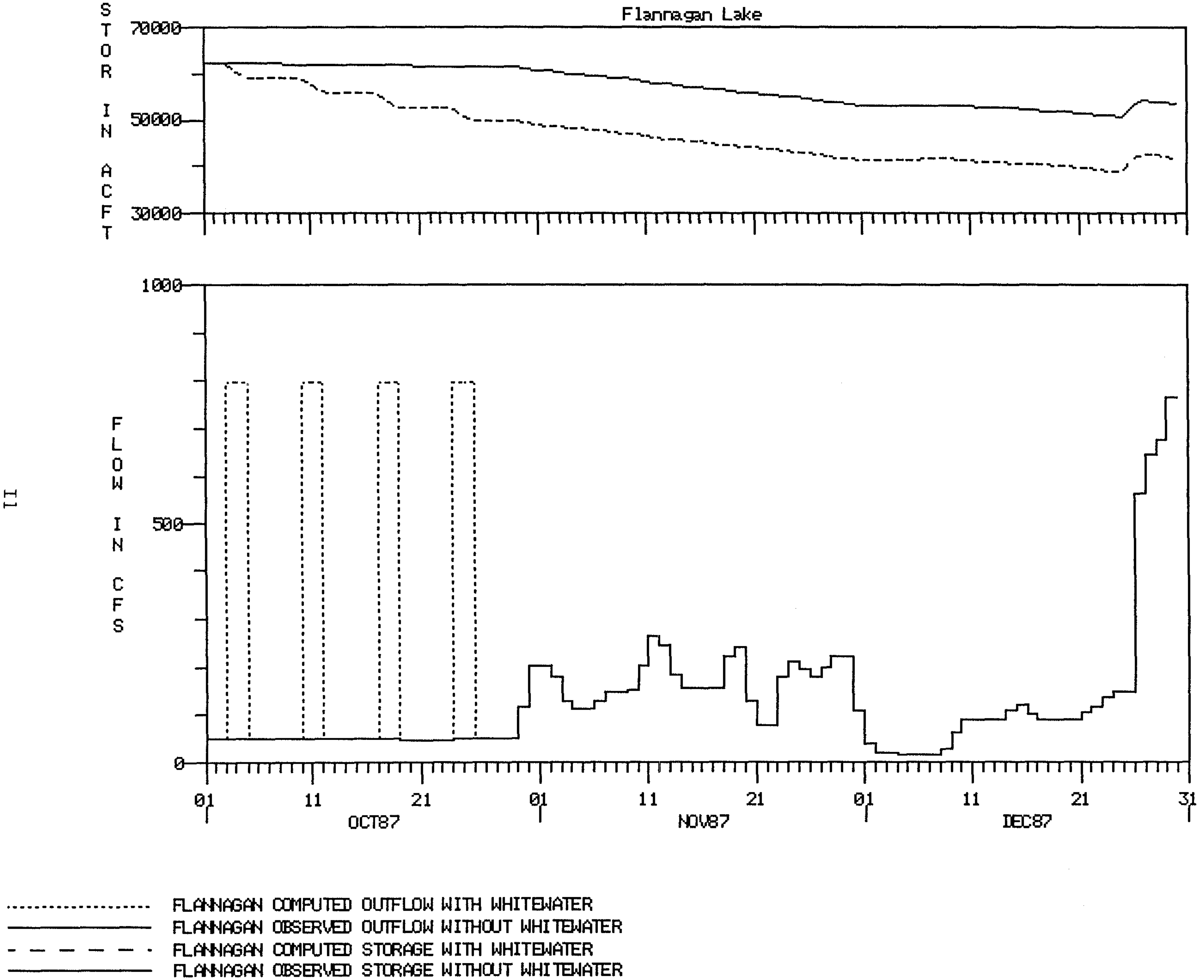
H5

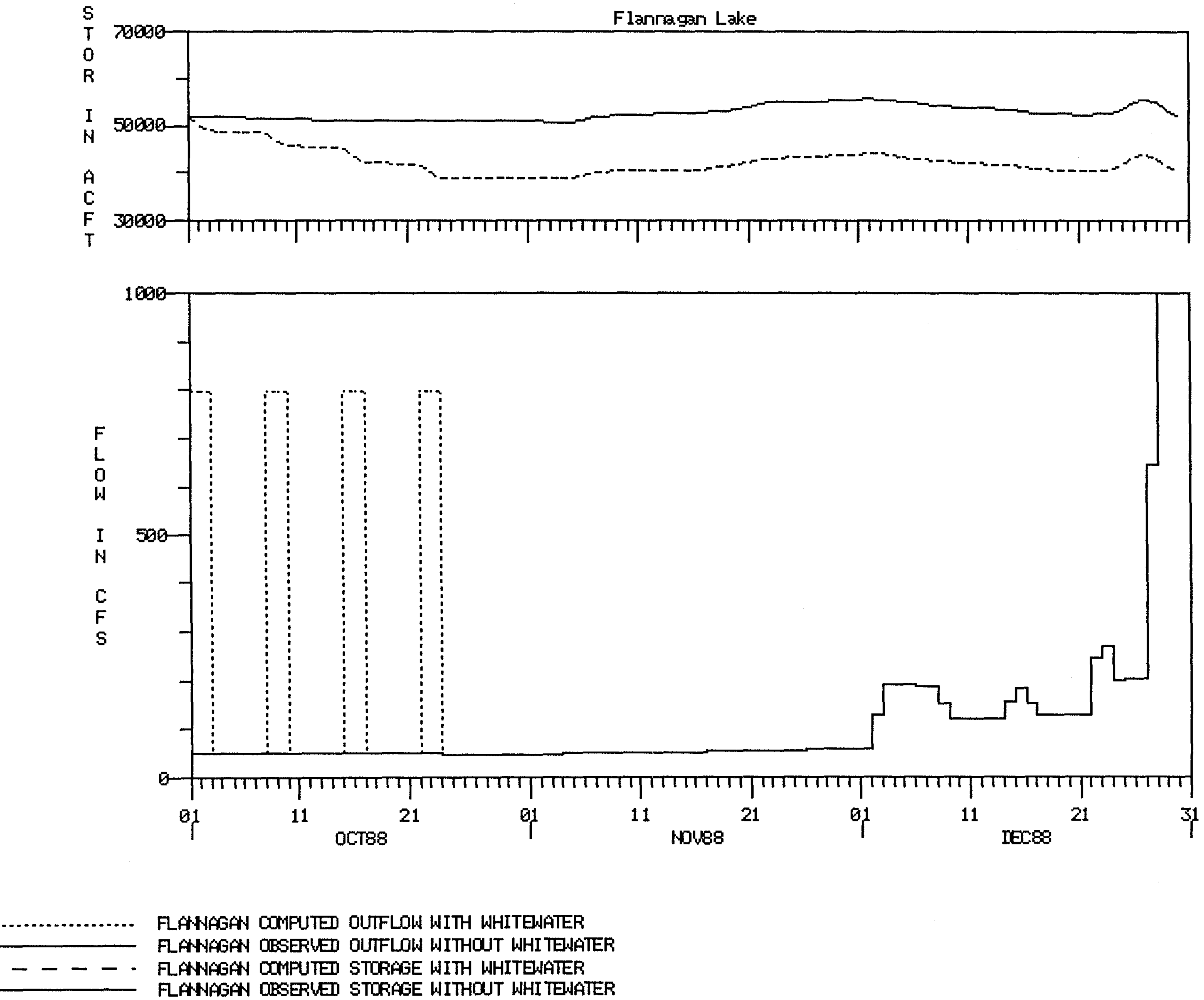


Big Sandy River Confluences
DO IN MG/L
15
10
5
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1994
COMPUTED CP20 DO
COMPUTED CP10 DO

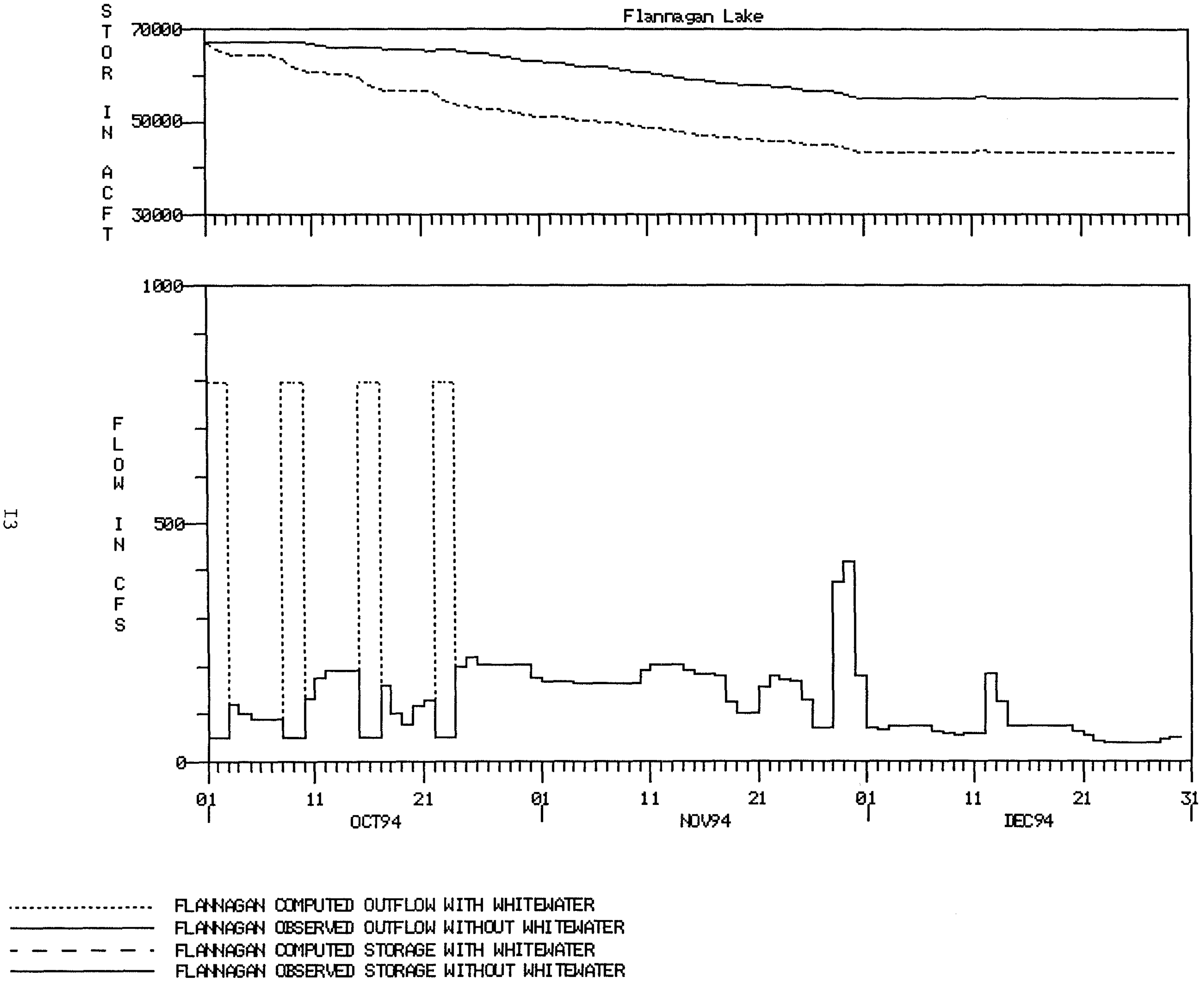
Appendix I

Whitewater Alternative - Flannagan Discharge and Reservoir Storage


Flannagan Lake
STOR IN ACFT
70000
50000
30000
FLOW IN CFS
1000
500
0
01
11
21
01
11
21
01
11
21
31
OCT87
NOV87
DEC87
FLANNAGAN COMPUTED OUTFLOW WITH WHITEWATER
FLANNAGAN OBSERVED OUTFLOW WITHOUT WHITEWATER
FLANNAGAN COMPUTED STORAGE WITH WHITEWATER
FLANNAGAN OBSERVED STORAGE WITHOUT WHITEWATER



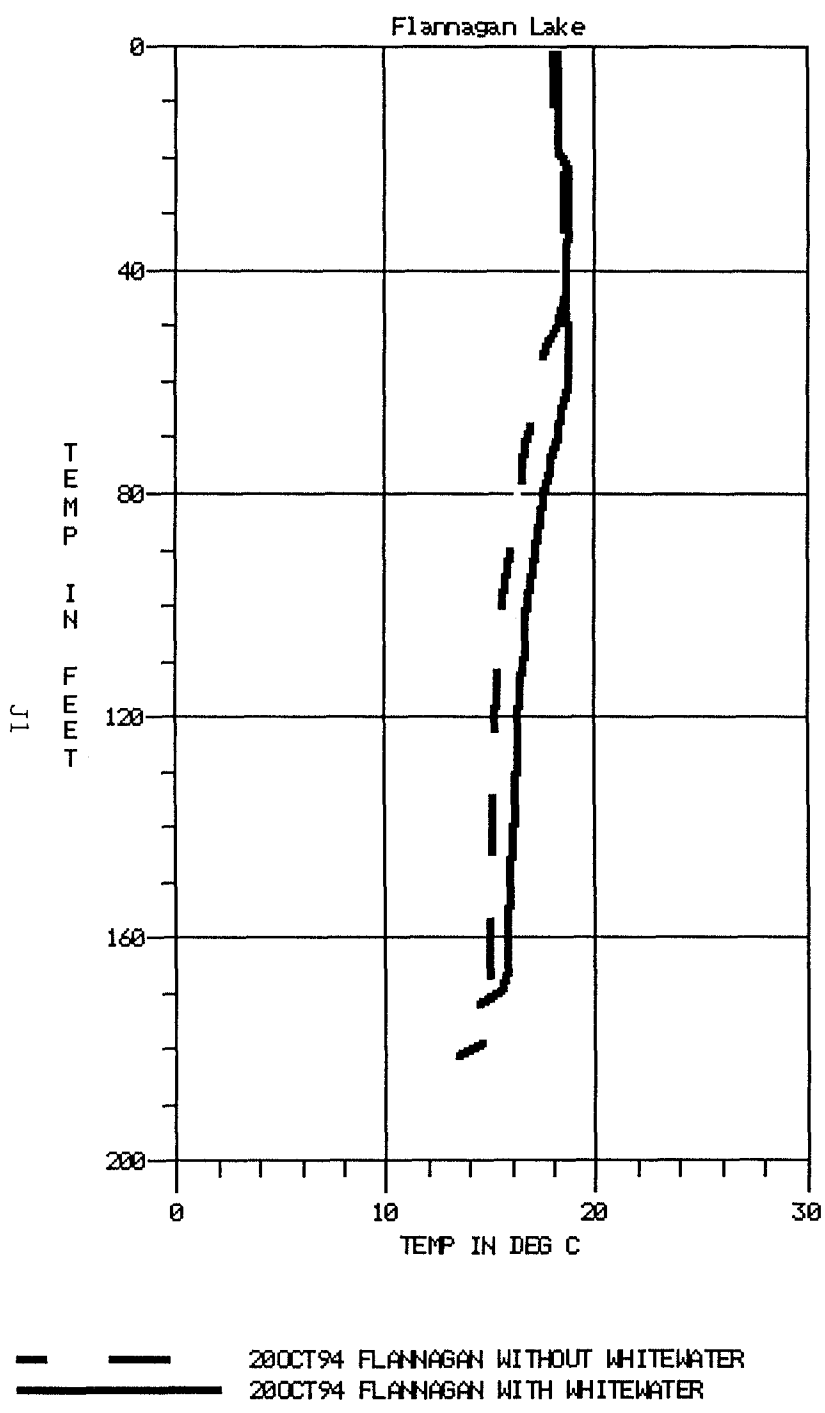
Flannagan Lake
STOR IN ACFT
70000
50000
30000
FLOW IN CFS
1000
500
0
01
11
21
01
11
21
01
11
21
31
OCT88
NOV88
DEC88
FLANNAGAN COMPUTED OUTFLOW WITH WHITEWATER
FLANNAGAN OBSERVED OUTFLOW WITHOUT WHITEWATER
FLANNAGAN COMPUTED STORAGE WITH WHITEWATER
FLANNAGAN OBSERVED STORAGE WITHOUT WHITEWATER

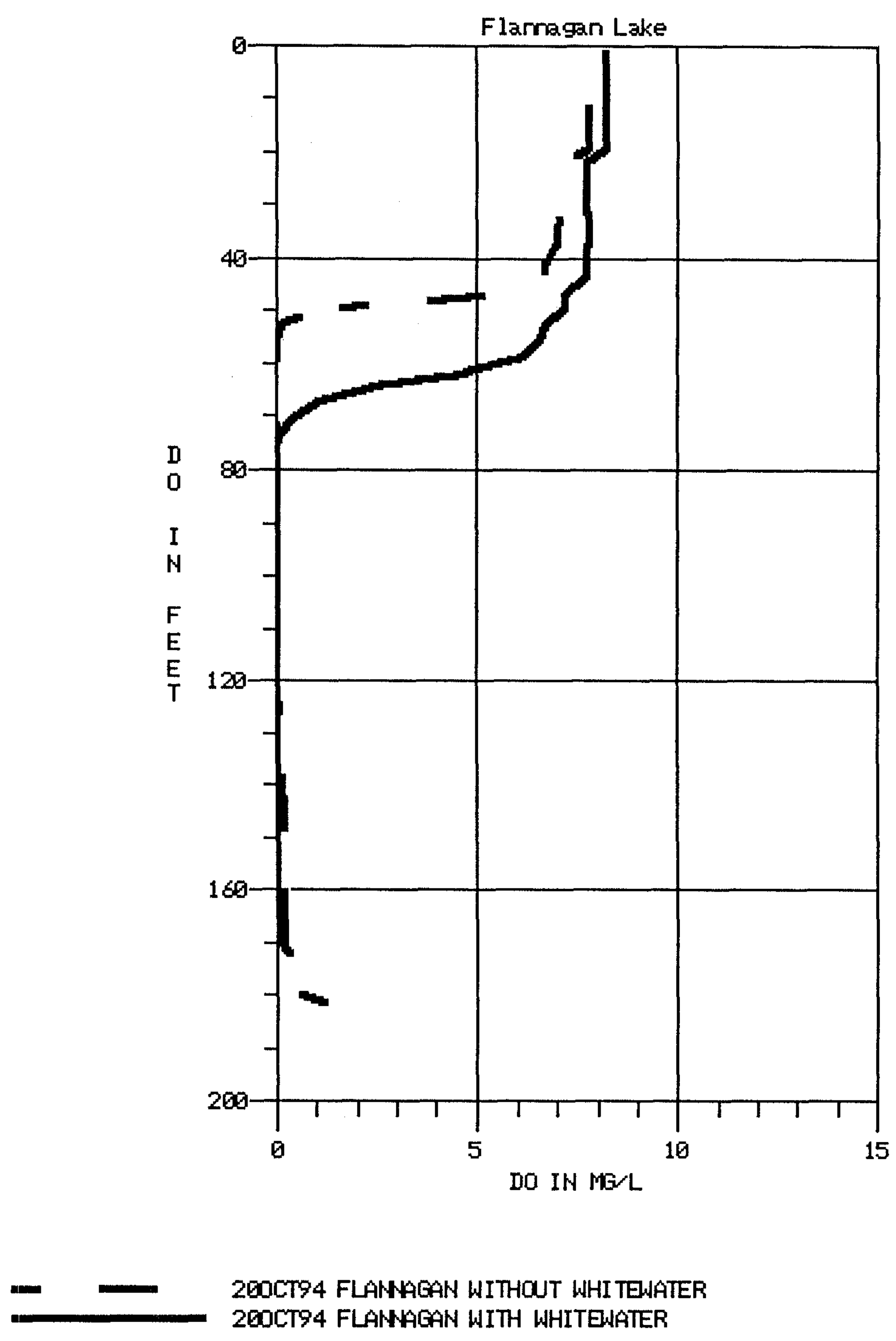


Flannagan Lake
STOR IN ACFT
70000
50000
30000
FLOW IN CFS
1000
500
0
01
11
21
01
11
21
01
11
21
31
OCT94
NOV94
DEC94
FLANNAGAN COMPUTED OUTFLOW WITH WHITEWATER
FLANNAGAN OBSERVED OUTFLOW WITHOUT WHITEWATER
FLANNAGAN COMPUTED STORAGE WITH WHITEWATER
FLANNAGAN OBSERVED STORAGE WITHOUT WHITEWATER

Appendix J

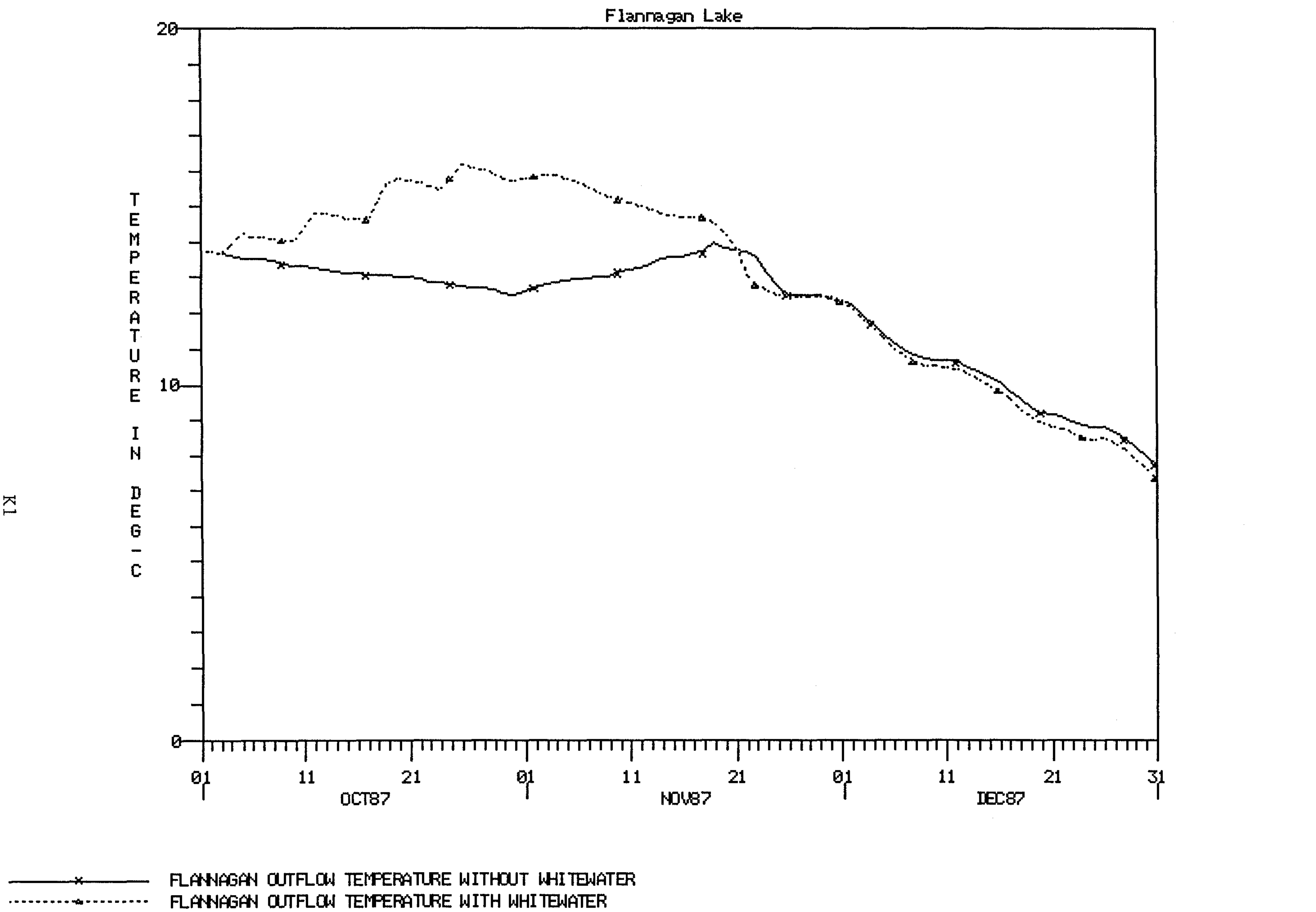
Whitewater Alternative -
Flannagan Temperature and DO Profiles

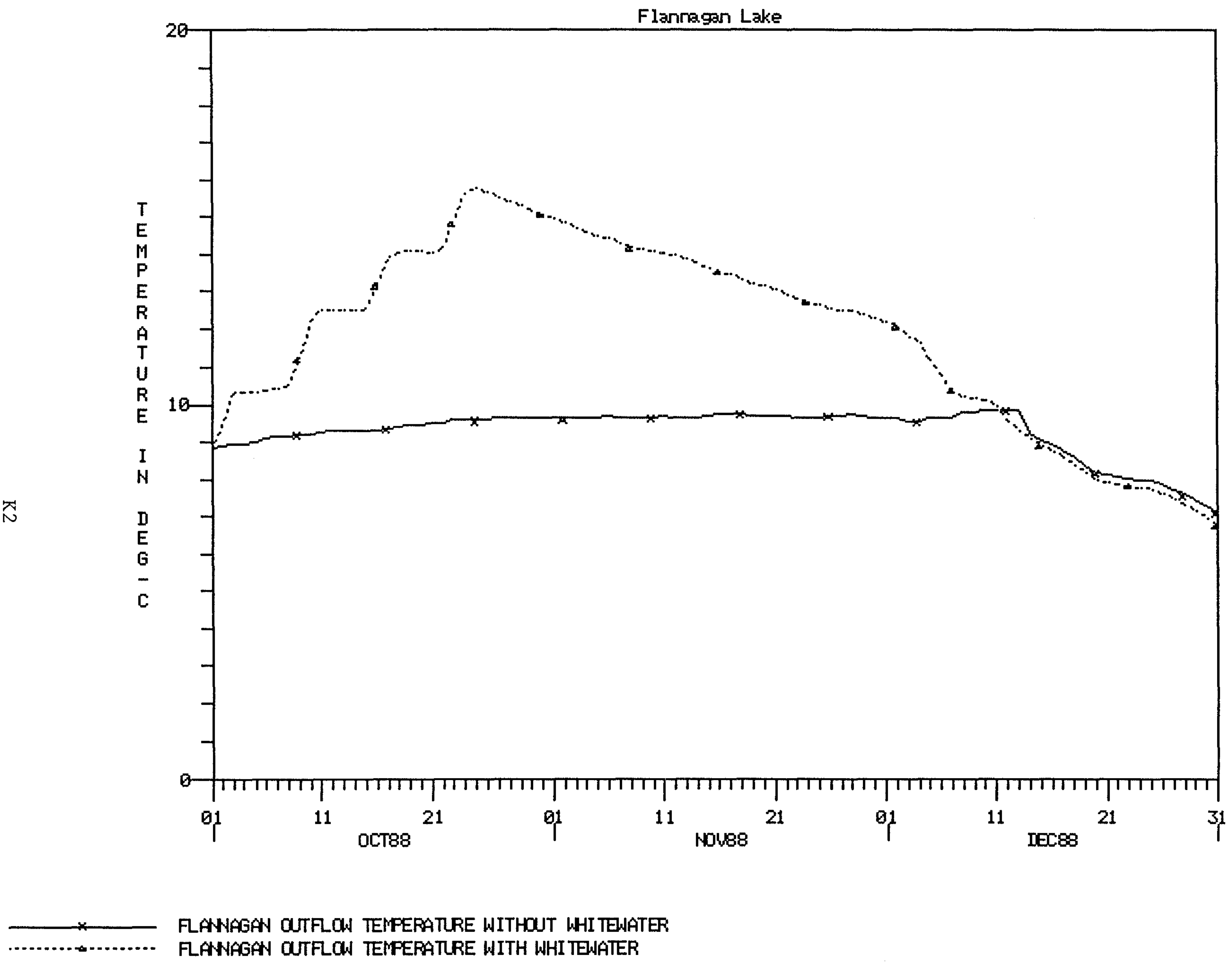

Flannagan Lake
TEMP IN FEET
TEMP IN DEG C
0
40
80
120
160
200
0
10
20
30
J1
200CT94 FLANNAGAN WITHOUT WHITEWATER
200CT94 FLANNAGAN WITH WHITEWATER


Flannagan Lake
DO IN FEET
DO IN MG/L
0
40
80
120
160
200
0
5
10
15
200CT94 FLANNAGAN WITHOUT WHITEWATER
200CT94 FLANNAGAN WITH WHITEWATER

Appendix K

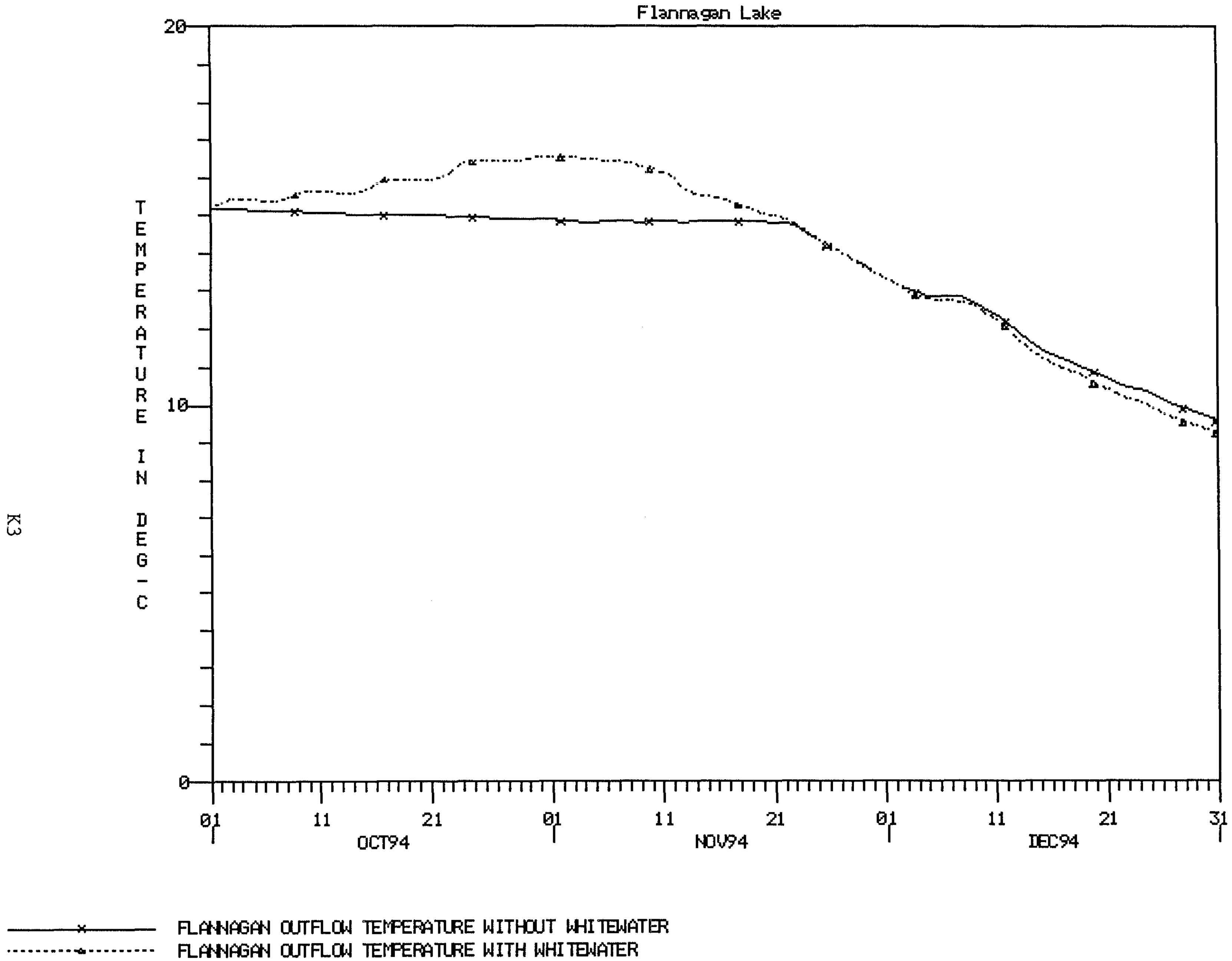
Whitewater Alternative -
Flannagan Temperature and DO Releases

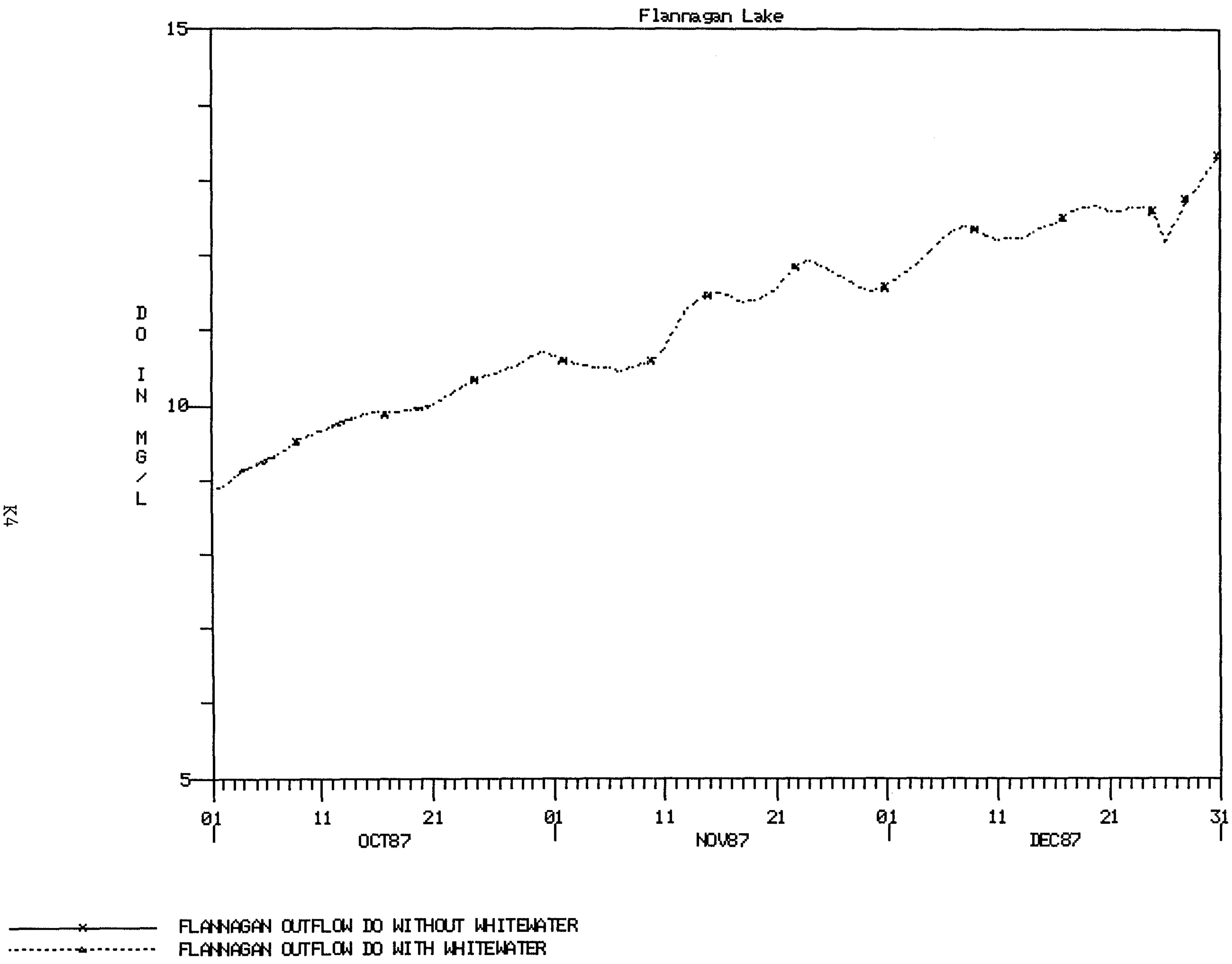

Flannagan Lake
TEMPERATURE IN DEG-C
20
10
0
01
11
21
01
11
21
01
11
21
31
OCT87
NOV87
DEC87
FLANNAGAN OUTFLOW TEMPERATURE WITHOUT WHITEWATER
FLANNAGAN OUTFLOW TEMPERATURE WITH WHITEWATER



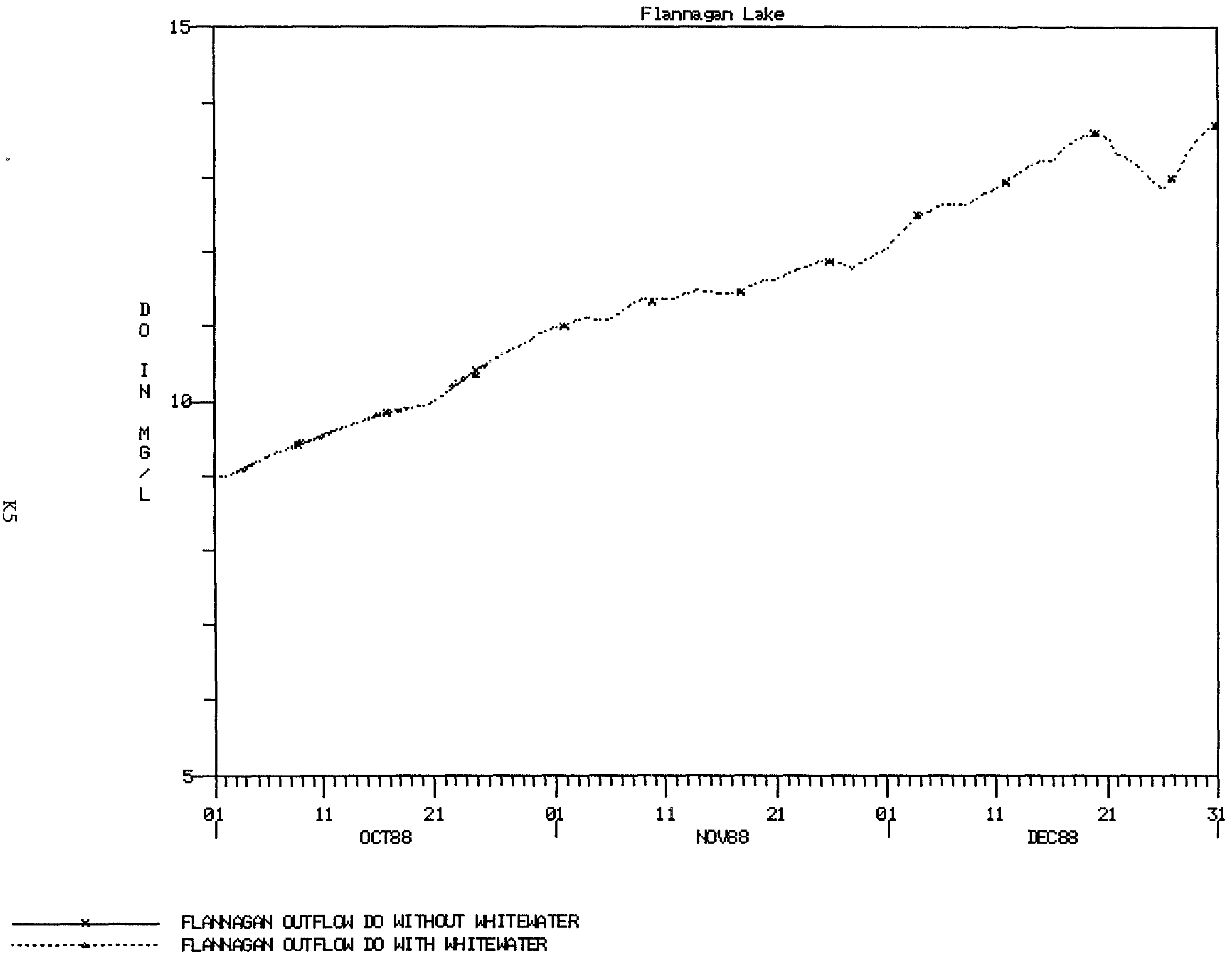
Flannagan Lake
20
10
0
TEMPERATURE IN DEG-C
01
11
21
01
11
21
01
11
21
31
OCT88
NOV88
DEC88
FLANNAGAN OUTFLOW TEMPERATURE WITHOUT WHITEWATER
FLANNAGAN OUTFLOW TEMPERATURE WITH WHITEWATER

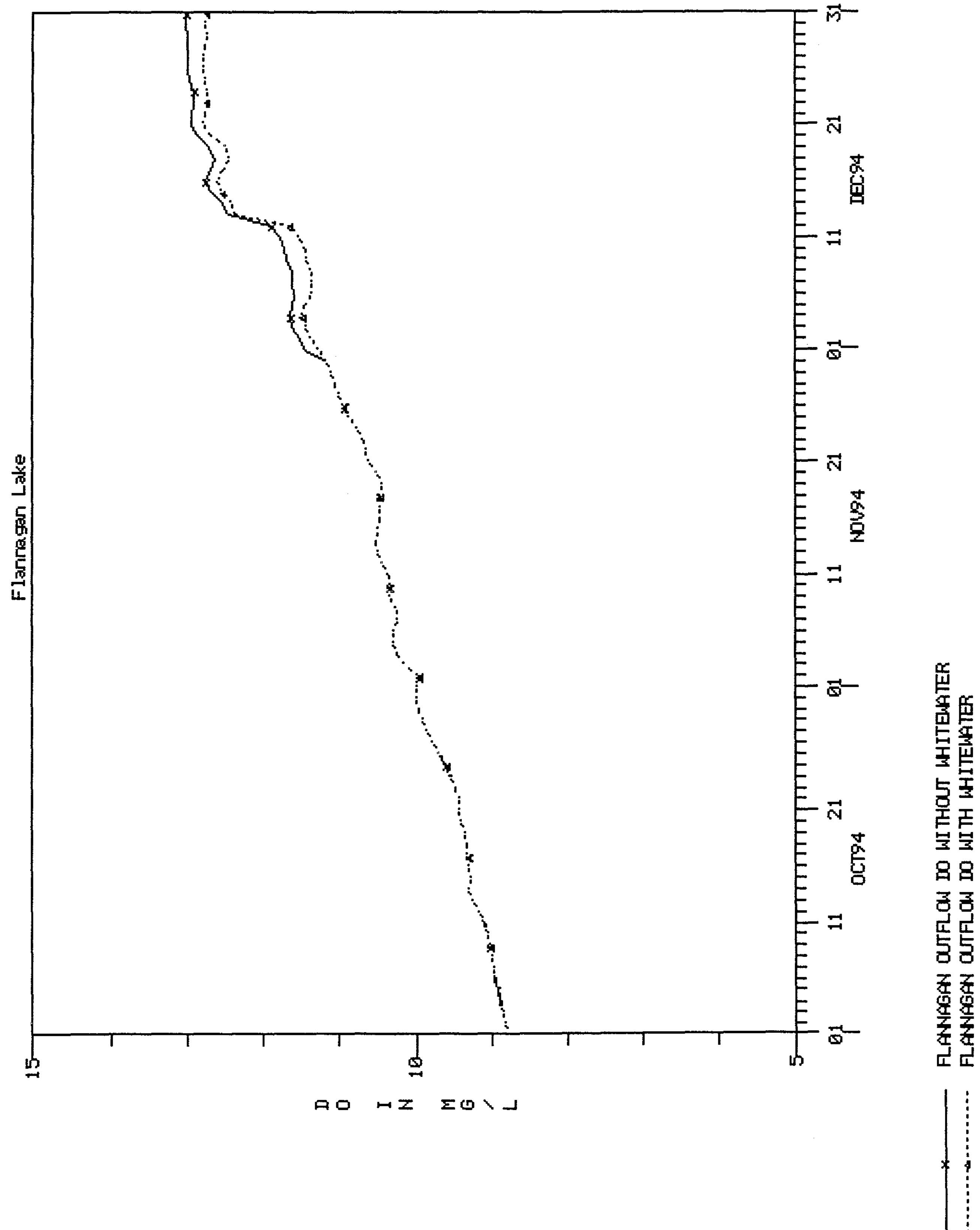
K2


Flannagan Lake
20
10
0
TEMPERATURE IN DEG-C
01
11
21
01
11
21
01
11
21
31
OCT94
NOV94
DEC94
FLANNAGAN OUTFLOW TEMPERATURE WITHOUT WHITEWATER
FLANNAGAN OUTFLOW TEMPERATURE WITH WHITEWATER



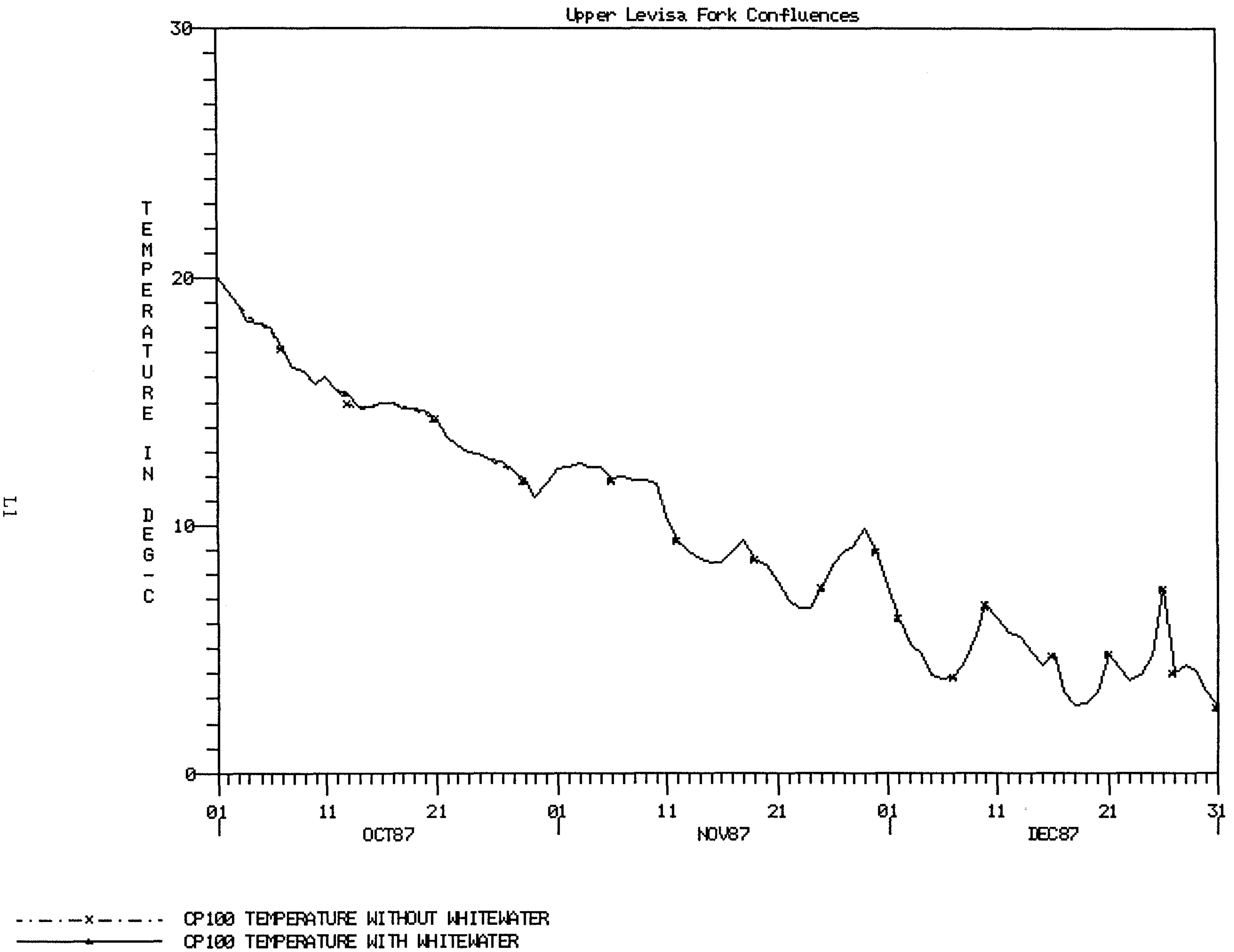
Flannagan Lake
15
10
5
DO IN MG/L
01
11
21
OCT87
01
11
21
NOV87
01
11
21
DEC87
31
FLANNAGAN OUTFLOW DO WITHOUT WHITEWATER
FLANNAGAN OUTFLOW DO WITH WHITEWATER

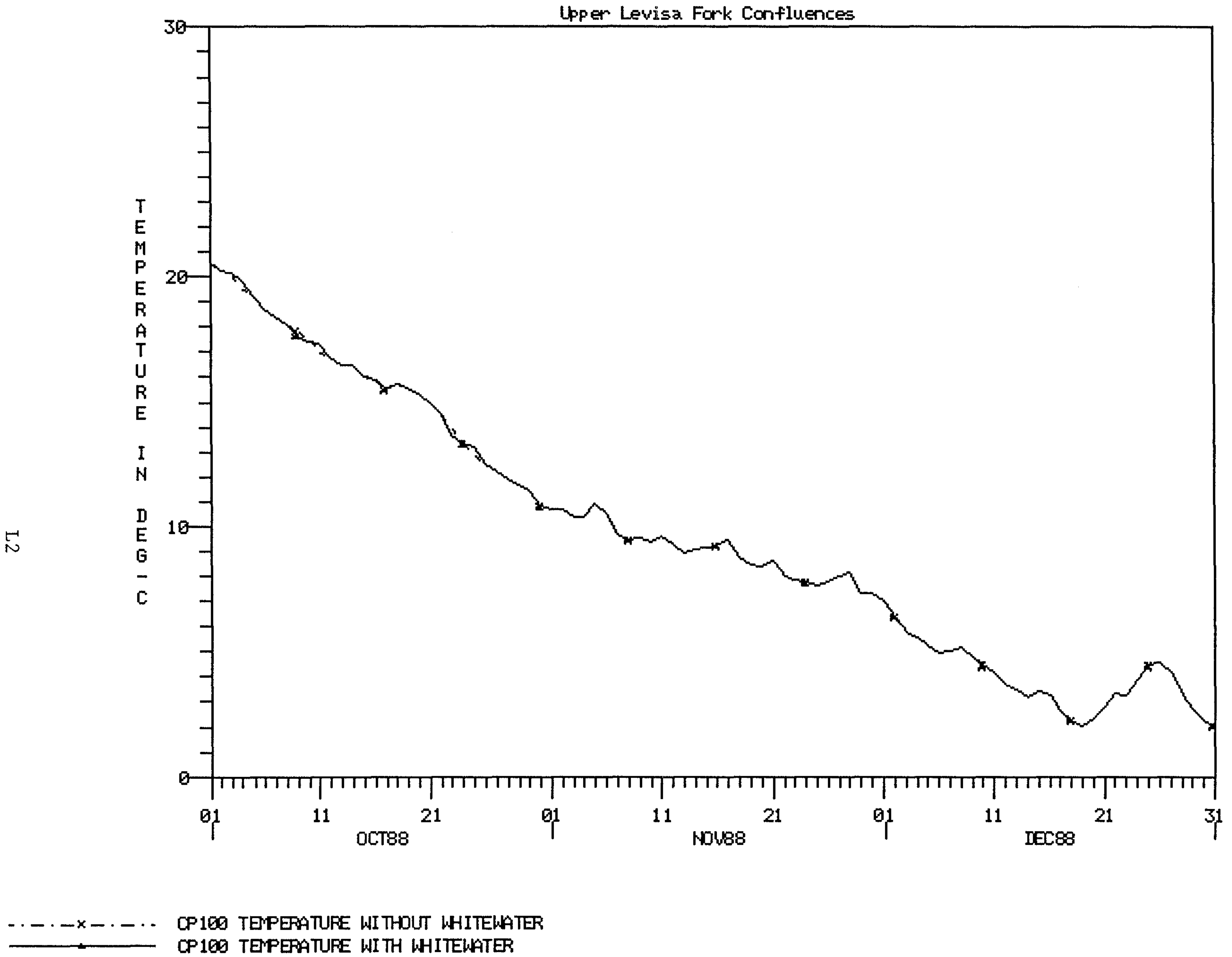

Flannagan Lake
15
10
5
DO IN MG/L
01
11
21
01
11
21
01
11
21
31
OCT88
NOV88
DEC88
FLANNAGAN OUTFLOW DO WITHOUT WHITEWATER
FLANNAGAN OUTFLOW DO WITH WHITEWATER

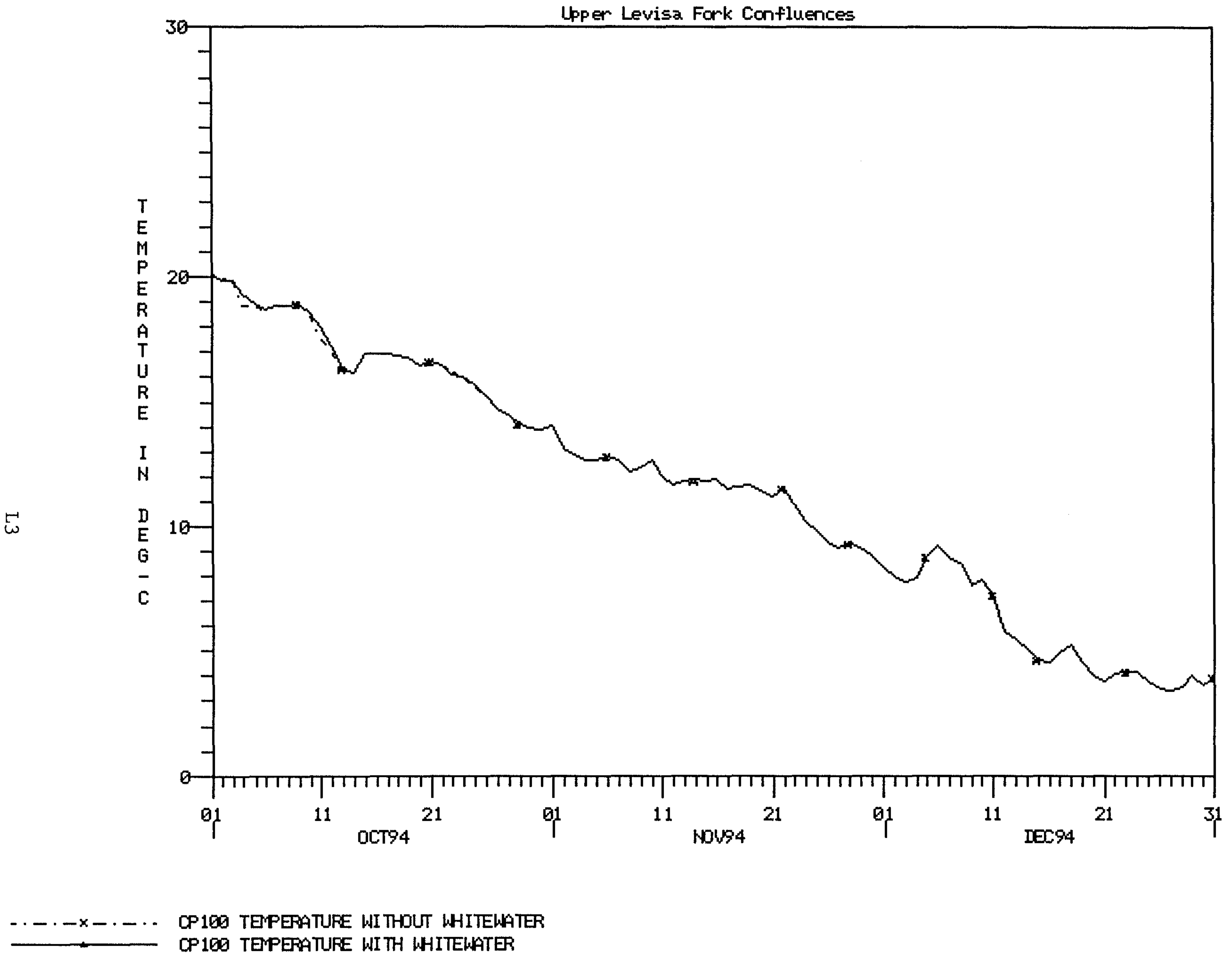

Flannagan Lake
DO IN MG/L
15
10
5
01
11
21
OCT94
01
11
21
NOV94
01
11
21
31
DEC94
FLANNAGAN OUTFLOW DO WITHOUT WHITEWATER
FLANNAGAN OUTFLOW DO WITH WHITEWATER

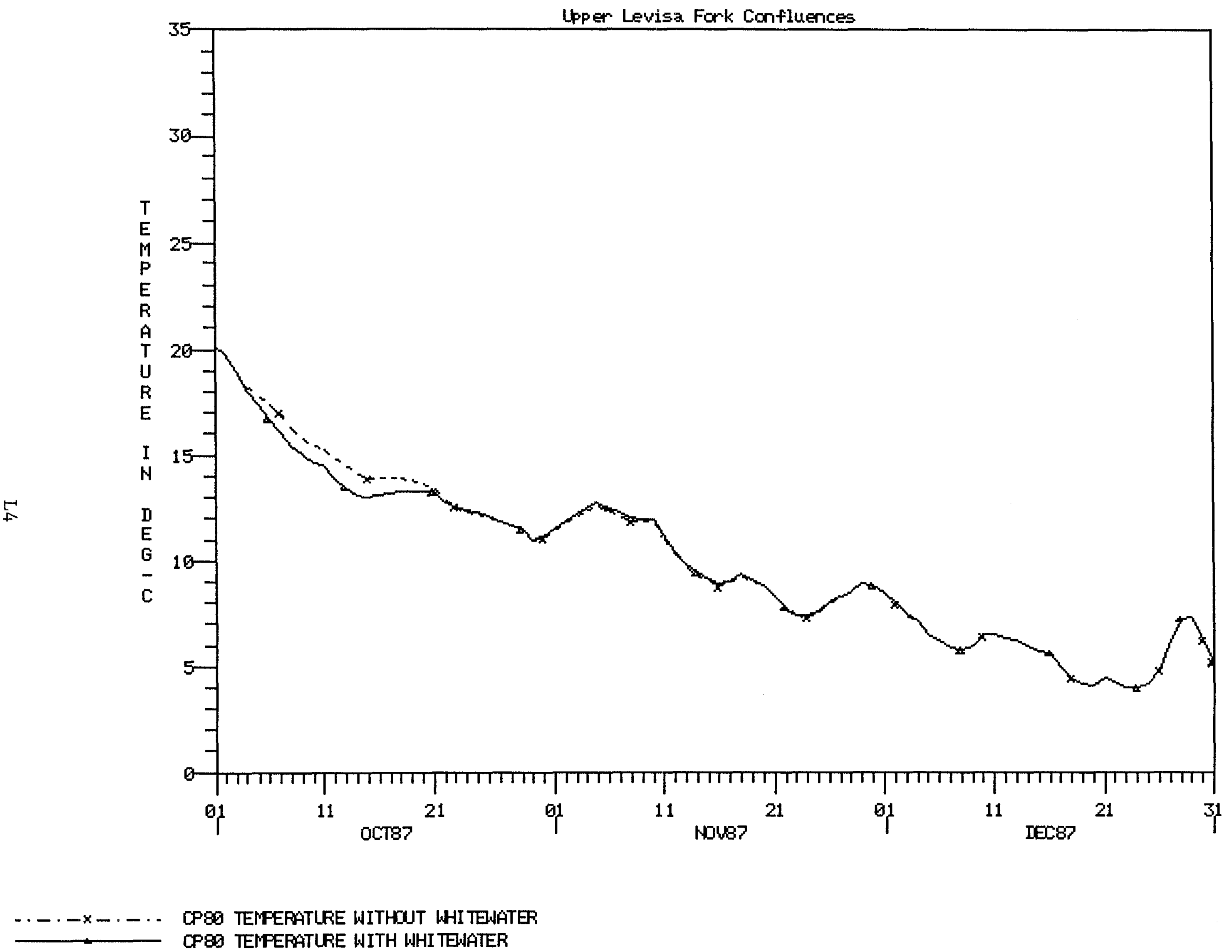
Appendix L

Whitewater Alternative - Temperature and DO at River Control Points

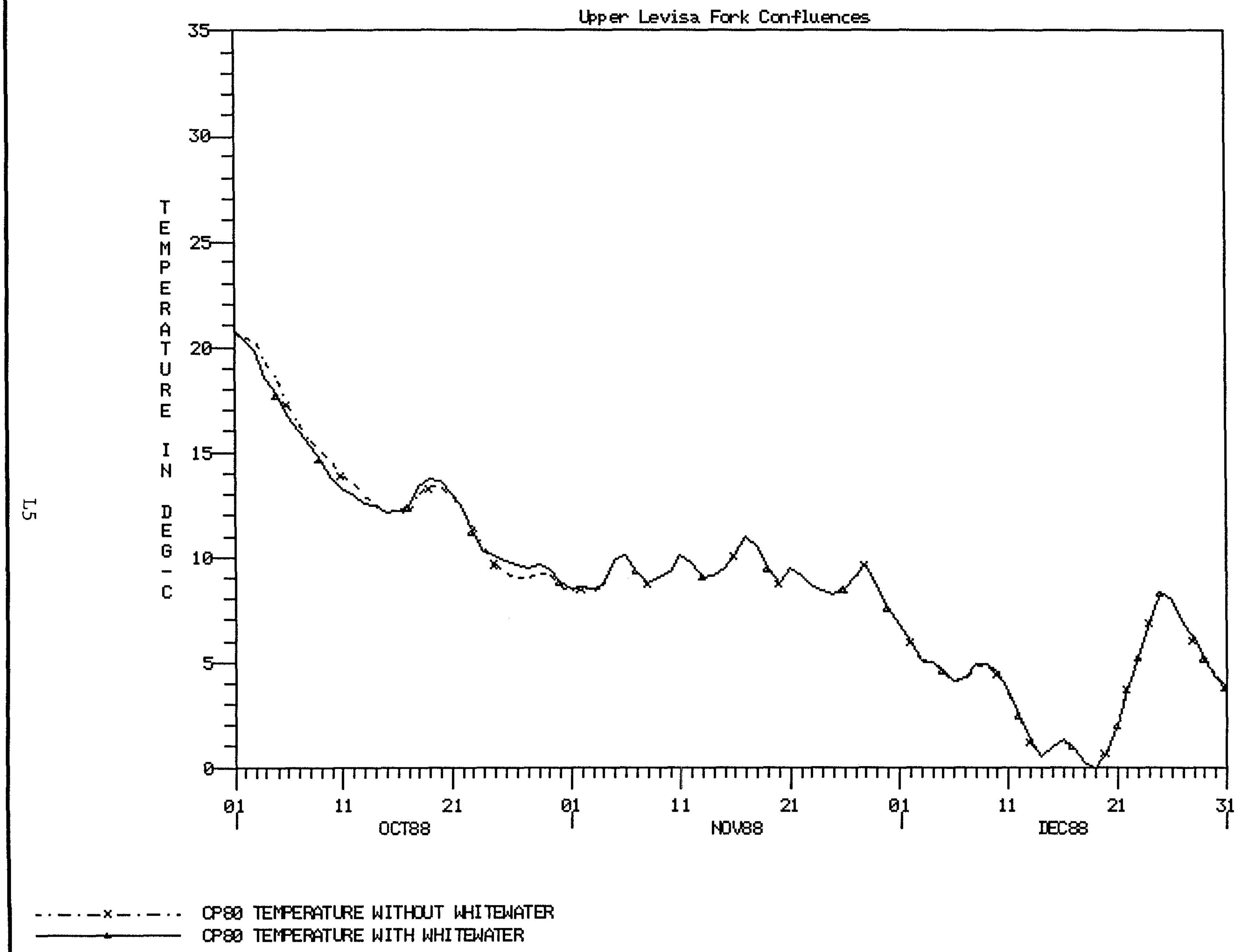

Upper Levisa Fork Confluences
TEMPERATURE IN DEG-C
30
20
10
0
01
11
21
01
11
21
01
11
21
31
OCT87
NOV87
DEC87
CP100 TEMPERATURE WITHOUT WHITEWATER
CP100 TEMPERATURE WITH WHITEWATER


Upper Levisa Fork Confluences
TEMPERATURE IN DEG-C
30
20
10
0
01
11
21
01
11
21
01
11
21
31
OCT88
NOV88
DEC88
CP100 TEMPERATURE WITHOUT WHITEWATER
CP100 TEMPERATURE WITH WHITEWATER

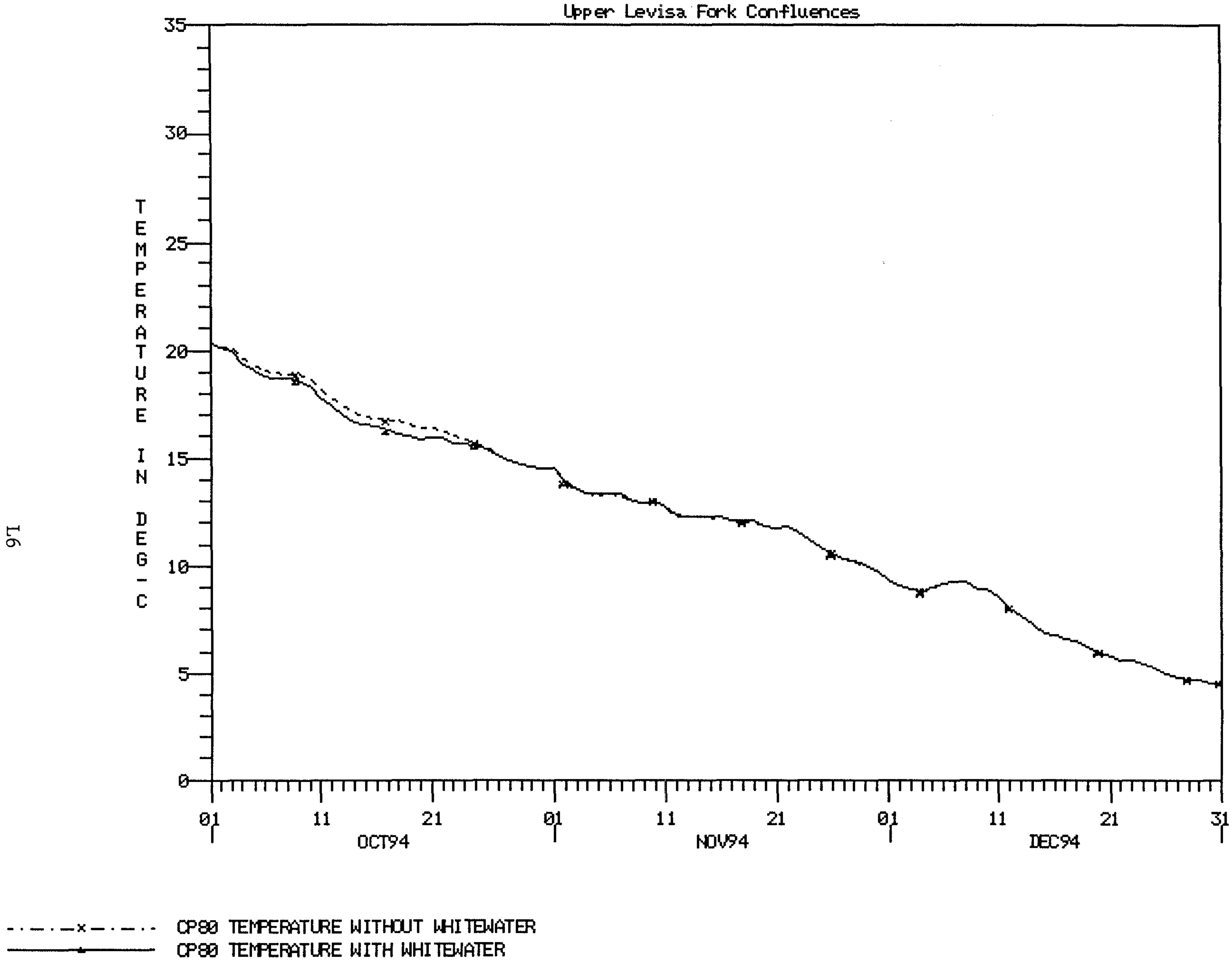

Upper Levisa Fork Confluences
TEMPERATURE IN DEG-C
30
20
10
0
01
11
21
01
11
21
01
11
21
31
OCT94
NOV94
DEC94
CP100 TEMPERATURE WITHOUT WHITEWATER
CP100 TEMPERATURE WITH WHITEWATER



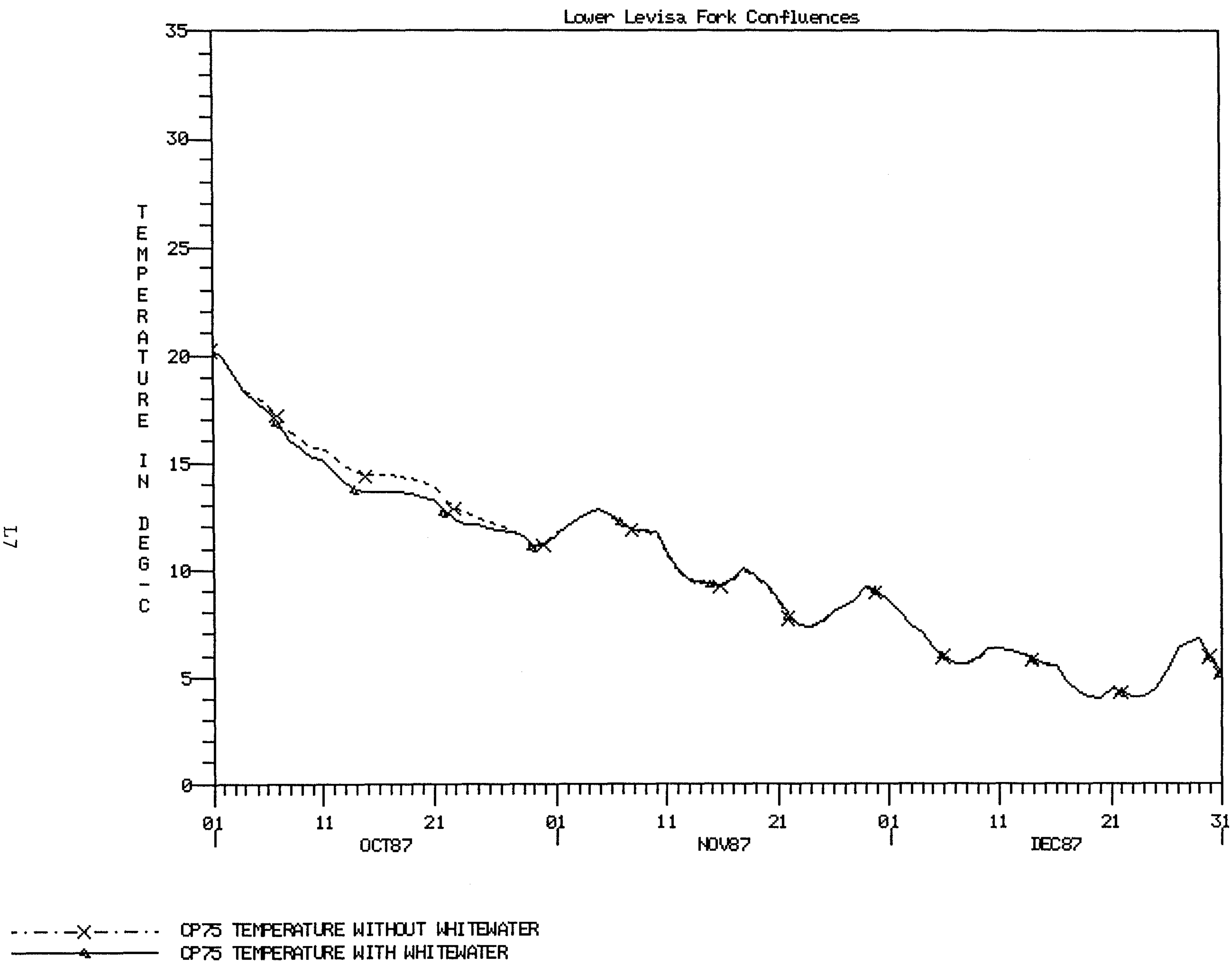
Upper Levisa Fork Confluences
TEMPERATURE IN DEG-C
35
30
25
20
15
10
5
0
01 11 21 01 11 21 01 11 21 31
OCT87
NOV87
DEC87
CP80 TEMPERATURE WITHOUT WHITEWATER
CP80 TEMPERATURE WITH WHITEWATER



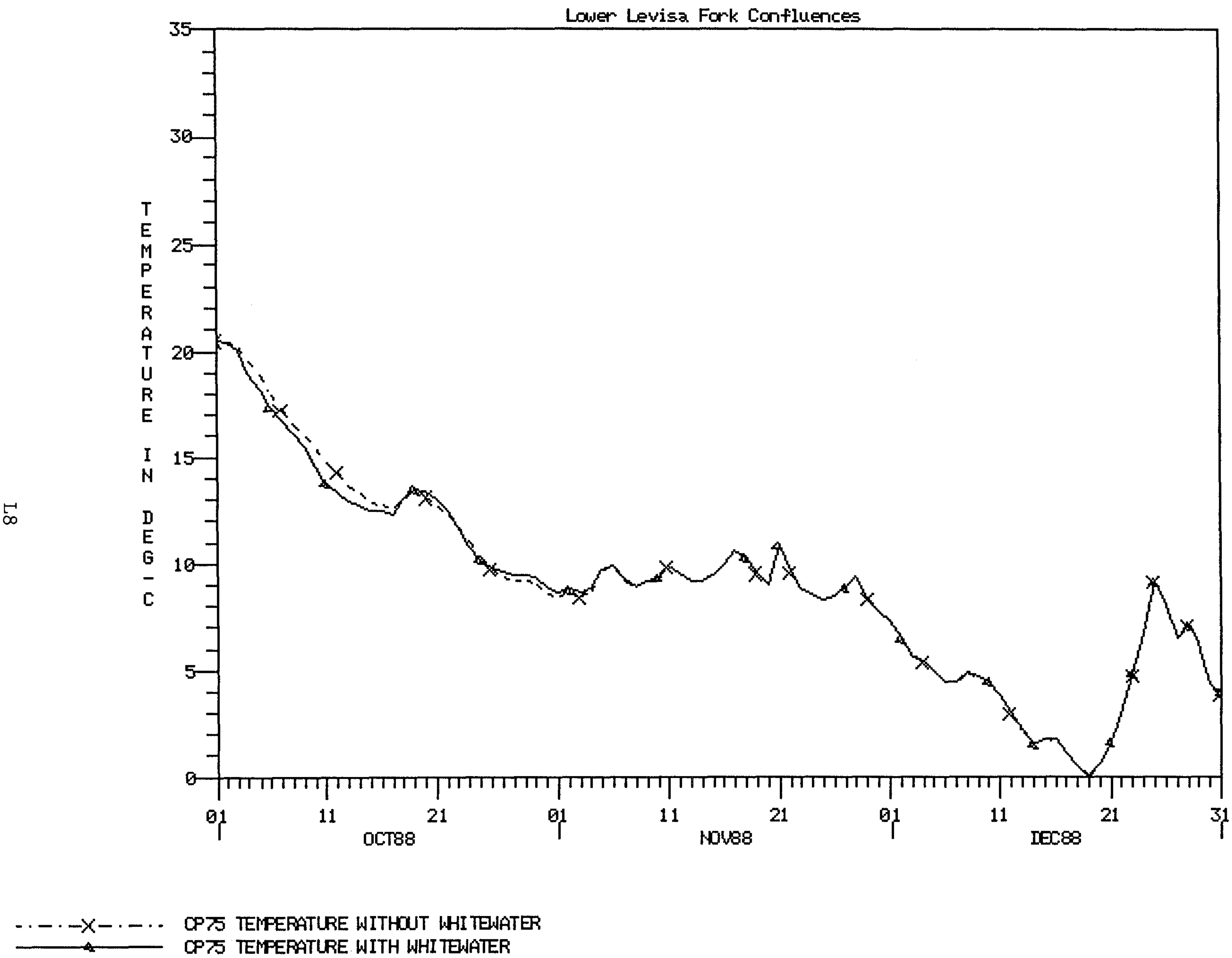
Upper Levisa Fork Confluences
TEMPERATURE IN DEG-C
35
30
25
20
15
10
5
0
01
11
21
01
11
21
01
11
21
31
OCT88
NOV88
DEC88
CP80 TEMPERATURE WITHOUT WHITEWATER
CP80 TEMPERATURE WITH WHITEWATER

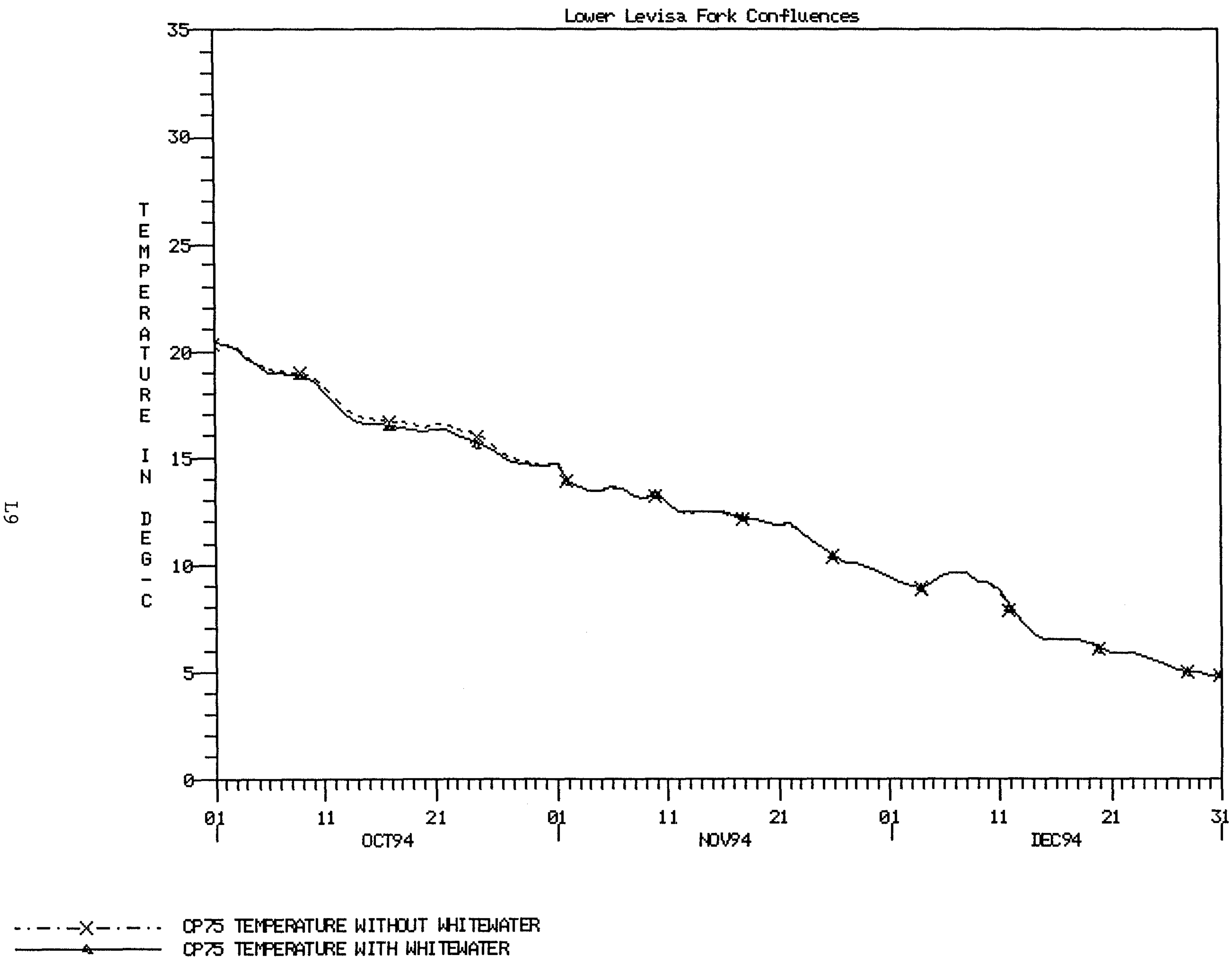


Upper Levisa Fork Confluences
TEMPERATURE IN DEG-C
35
30
25
20
15
10
5
0
01
11
21
01
11
21
01
11
21
31
OCT94
NOV94
DEC94
CP80 TEMPERATURE WITHOUT WHITEWATER
CP80 TEMPERATURE WITH WHITEWATER

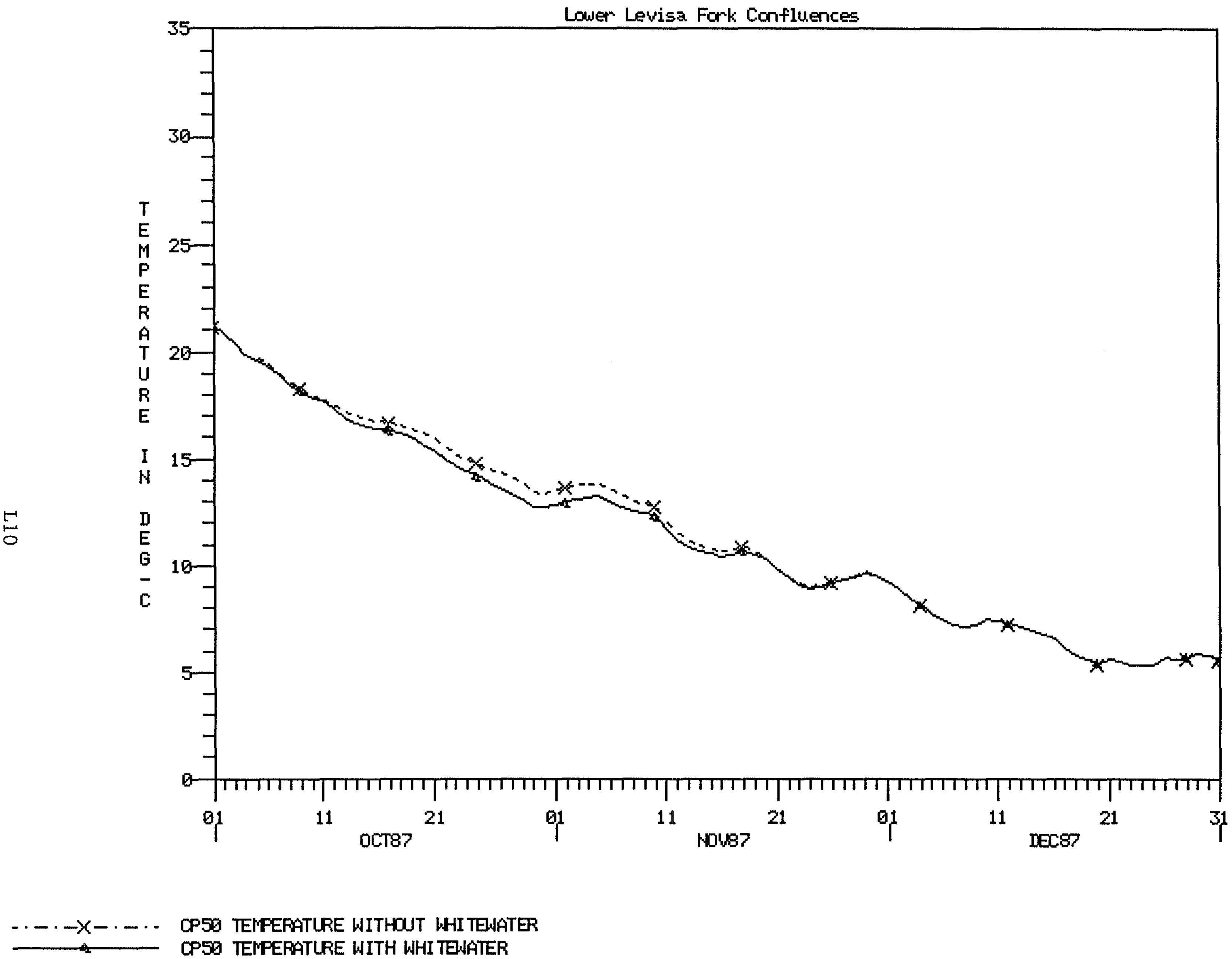


Lower Levisa Fork Confluences
TEMPERATURE IN DEG-C
35
30
25
20
15
10
5
0
01
11
21
01
11
21
01
11
21
31
OCT87
NOV87
DEC87
CP75 TEMPERATURE WITHOUT WHITEWATER
CP75 TEMPERATURE WITH WHITEWATER

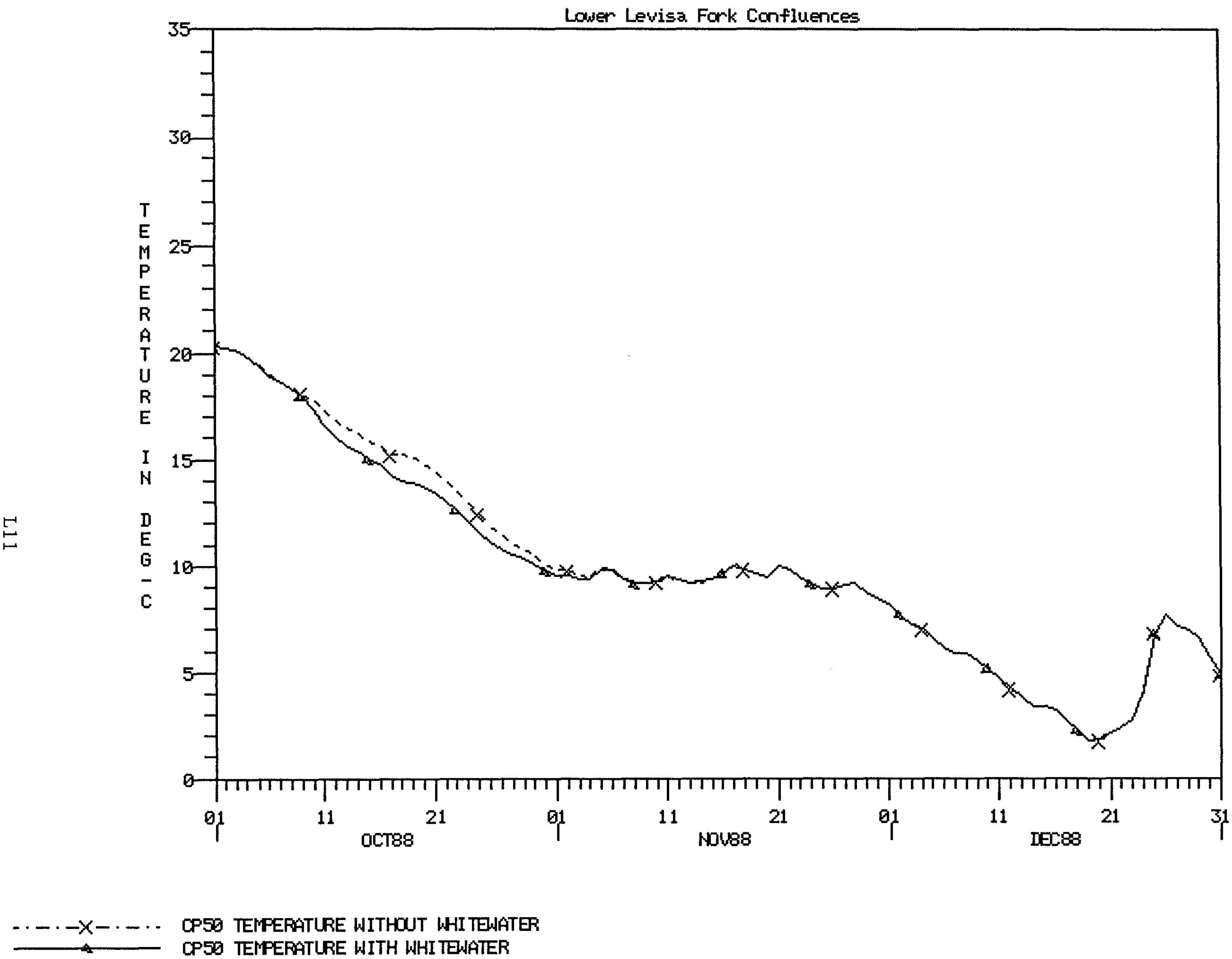

Lower Levisa Fork Confluences
TEMPERATURE IN DEG-C
35
30
25
20
15
10
5
0
01
11
21
01
11
21
01
11
21
31
OCT88
NOV88
DEC88
CP75 TEMPERATURE WITHOUT WHITEWATER
CP75 TEMPERATURE WITH WHITEWATER



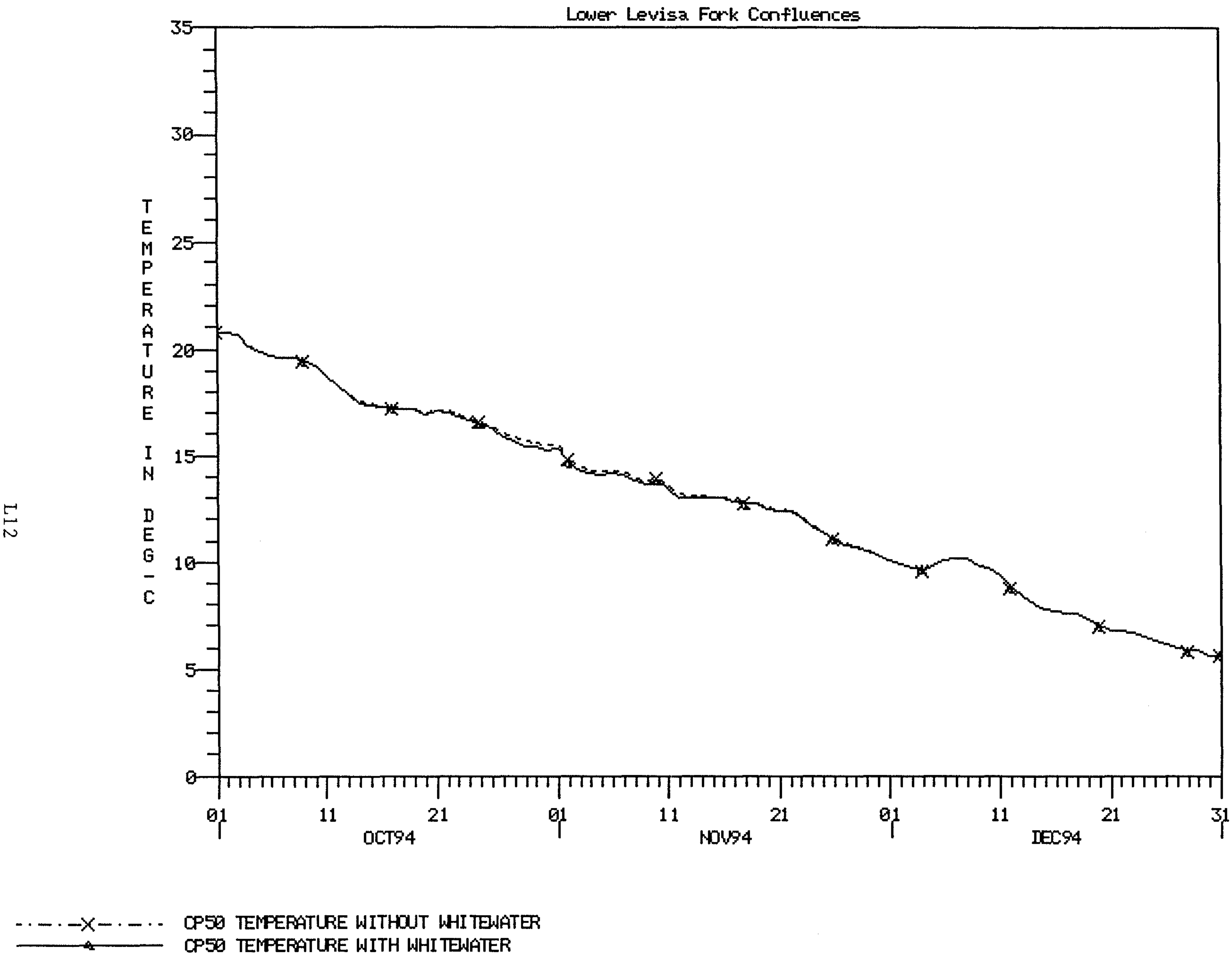
Lower Levisa Fork Confluences
TEMPERATURE IN DEG-C
35
30
25
20
15
10
5
0
01
11
21
01
11
21
01
11
21
31
OCT94
NOV94
DEC94
CP75 TEMPERATURE WITHOUT WHITEWATER
CP75 TEMPERATURE WITH WHITEWATER

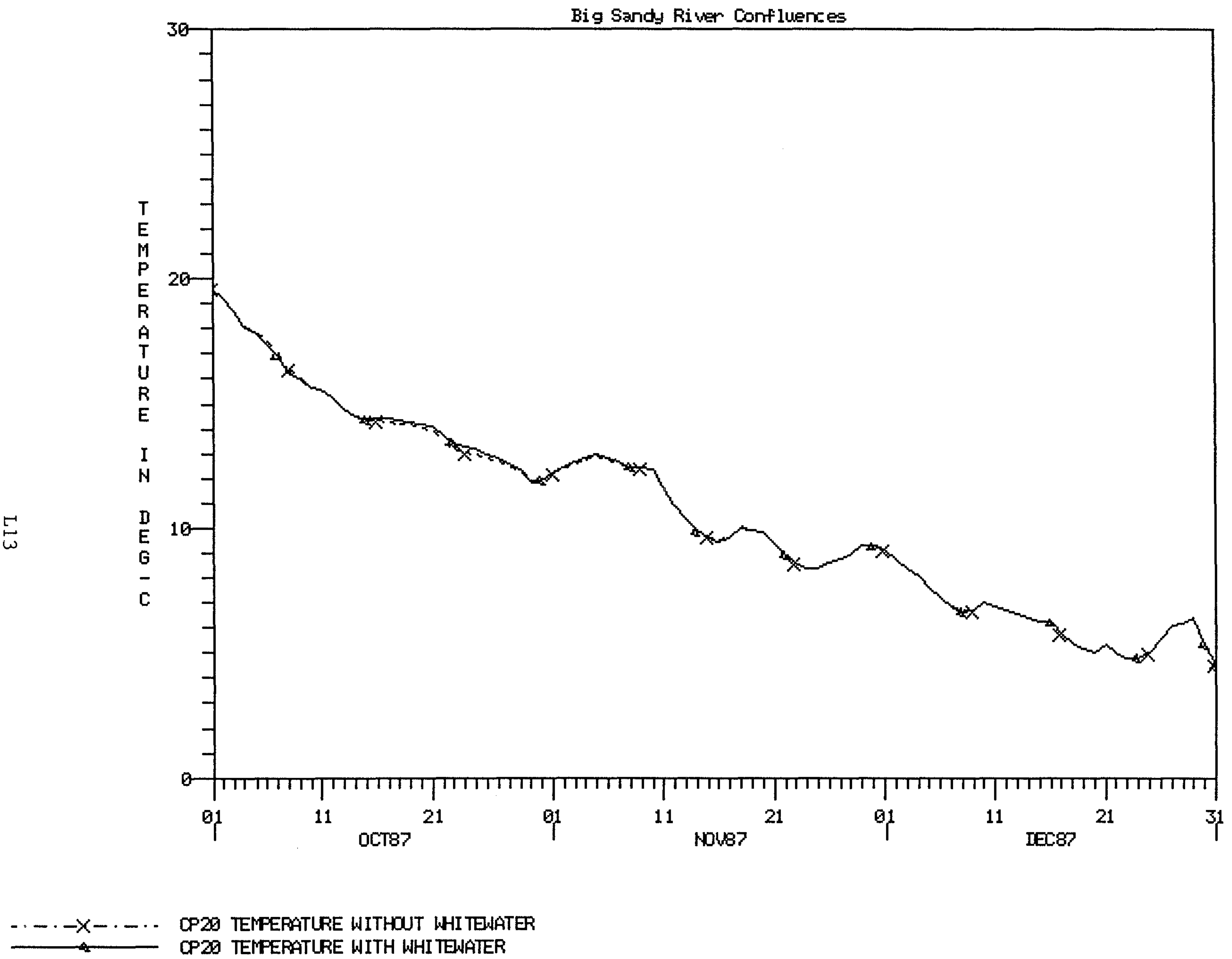


Lower Levisa Fork Confluences
TEMPERATURE IN DEG-C
35
30
25
20
15
10
5
0
01
11
21
01
11
21
01
11
21
31
OCT87
NOV87
DEC87
CP50 TEMPERATURE WITHOUT WHITEWATER
CP50 TEMPERATURE WITH WHITEWATER

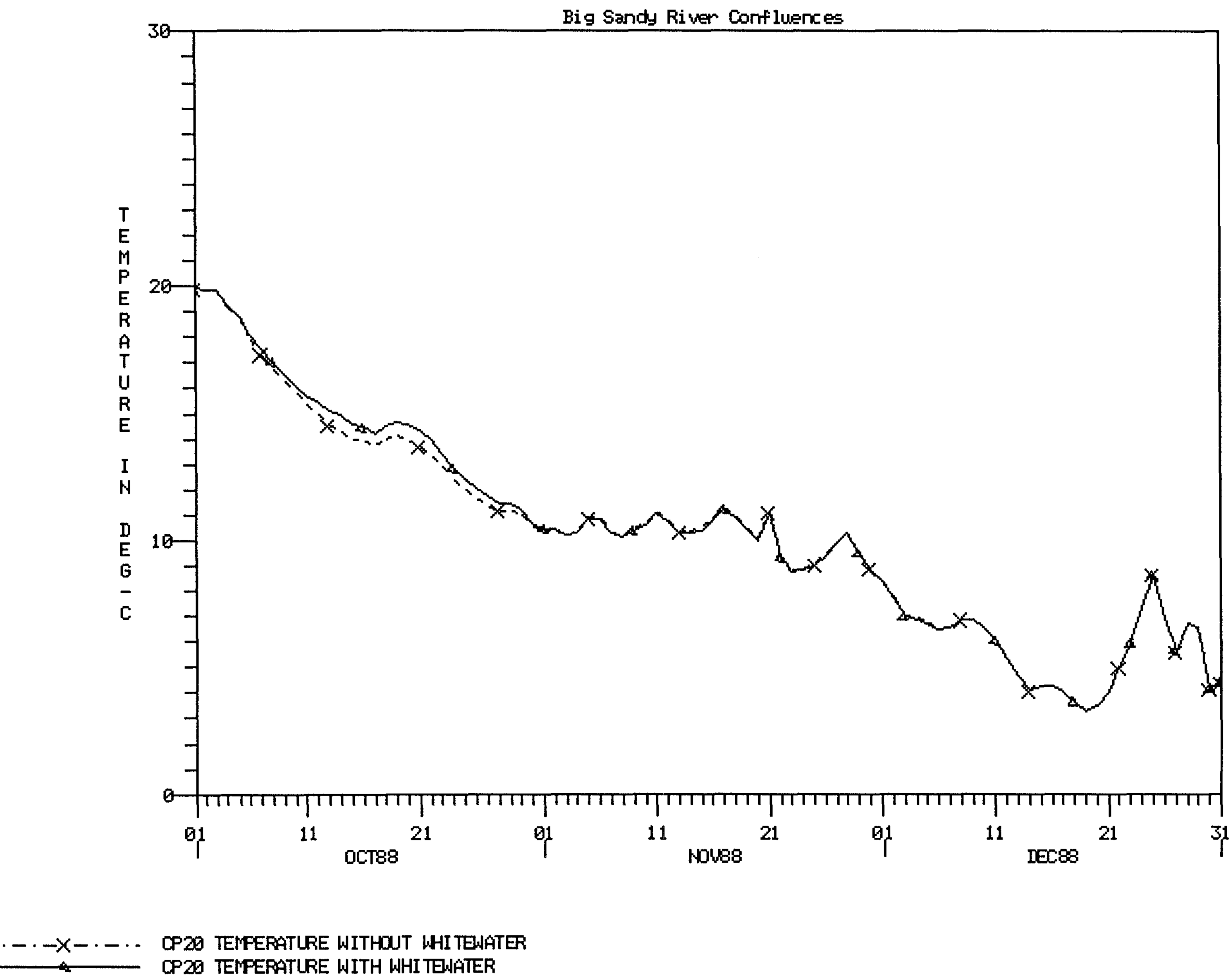


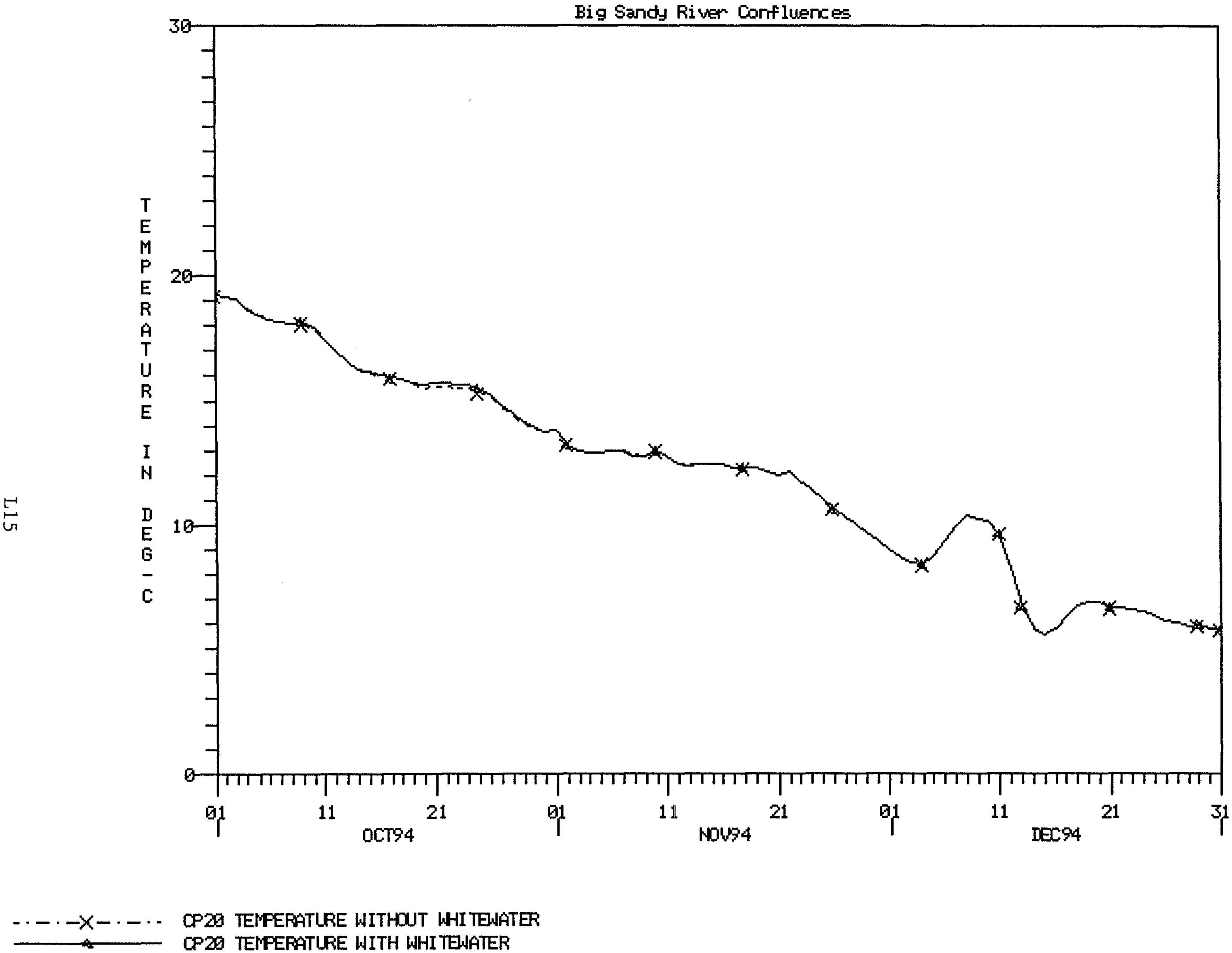
Lower Levisa Fork Confluences
TEMPERATURE IN DEG-C
35
30
25
20
15
10
5
0
01
11
21
01
11
21
01
11
21
31
OCT88
NOV88
DEC88
CP50 TEMPERATURE WITHOUT WHITEWATER
CP50 TEMPERATURE WITH WHITEWATER


Lower Levisa Fork Confluences
TEMPERATURE IN DEG-C
35
30
25
20
15
10
5
0
01
11
21
01
11
21
01
11
21
31
OCT94
NOV94
DEC94
CP50 TEMPERATURE WITHOUT WHITEWATER
CP50 TEMPERATURE WITH WHITEWATER

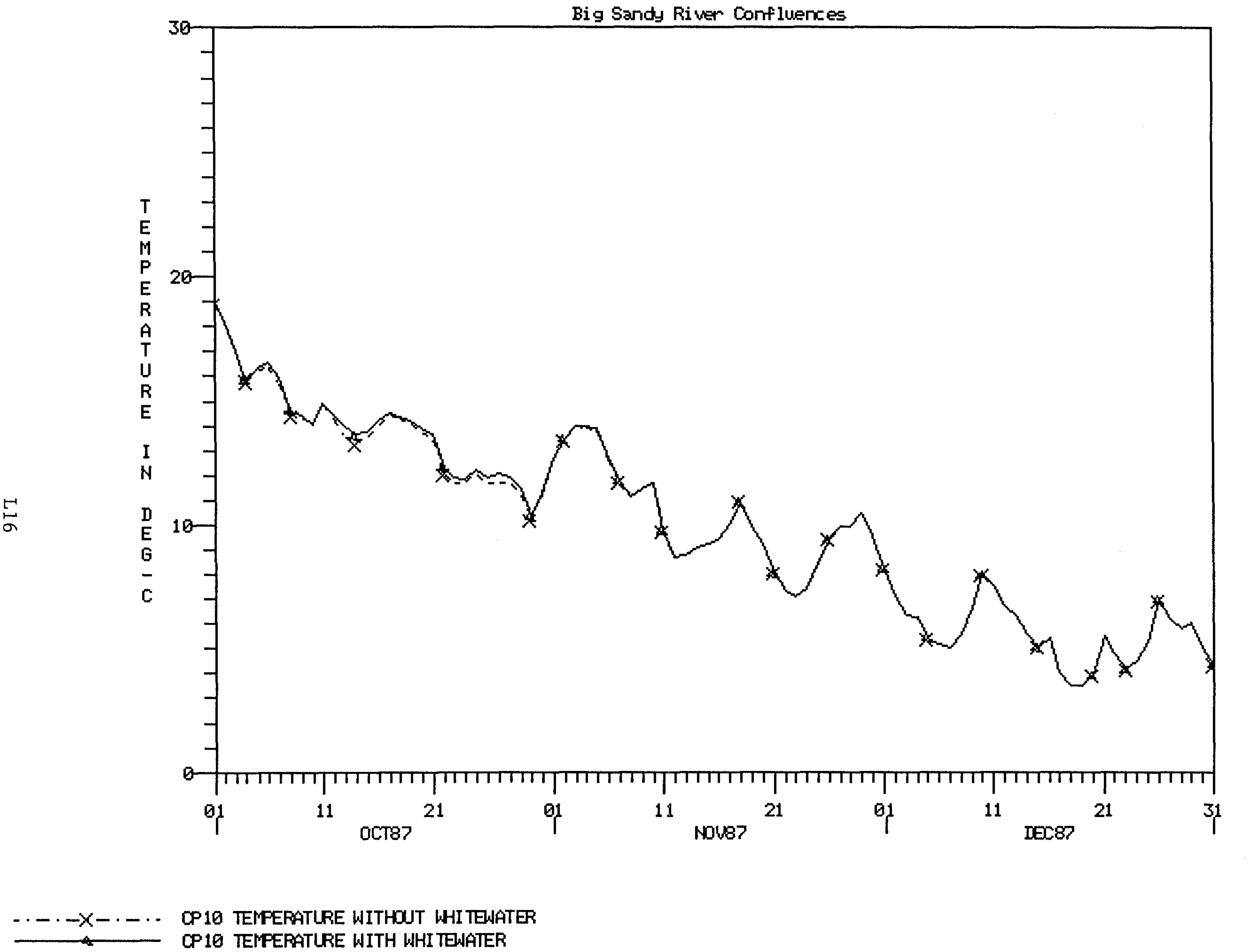


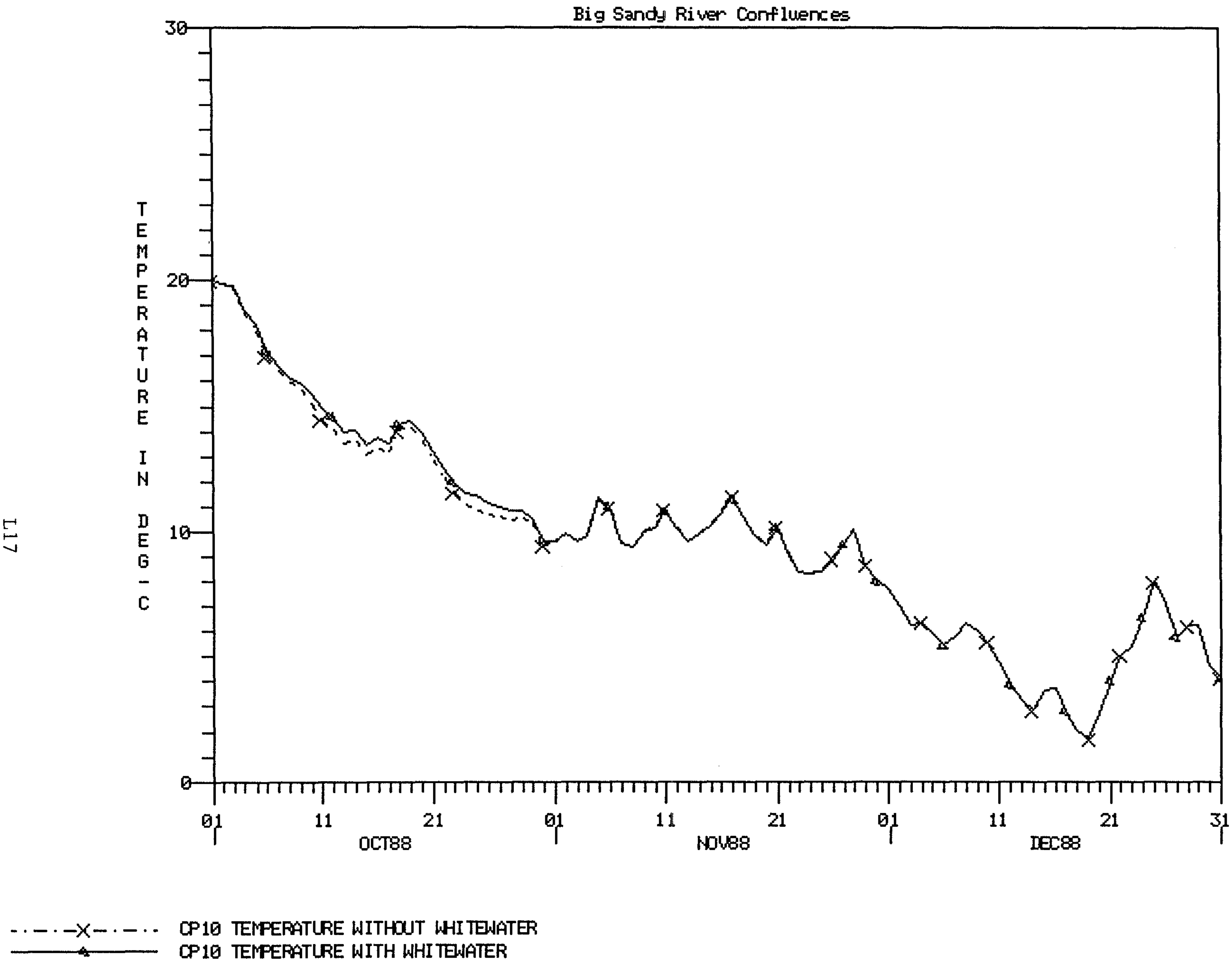
Big Sandy River Confluences
TEMPERATURE IN DEG-C
30
20
10
0
01
11
21
01
11
21
01
11
21
31
OCT87
NOV87
DEC87
CP20 TEMPERATURE WITHOUT WHITEWATER
CP20 TEMPERATURE WITH WHITEWATER

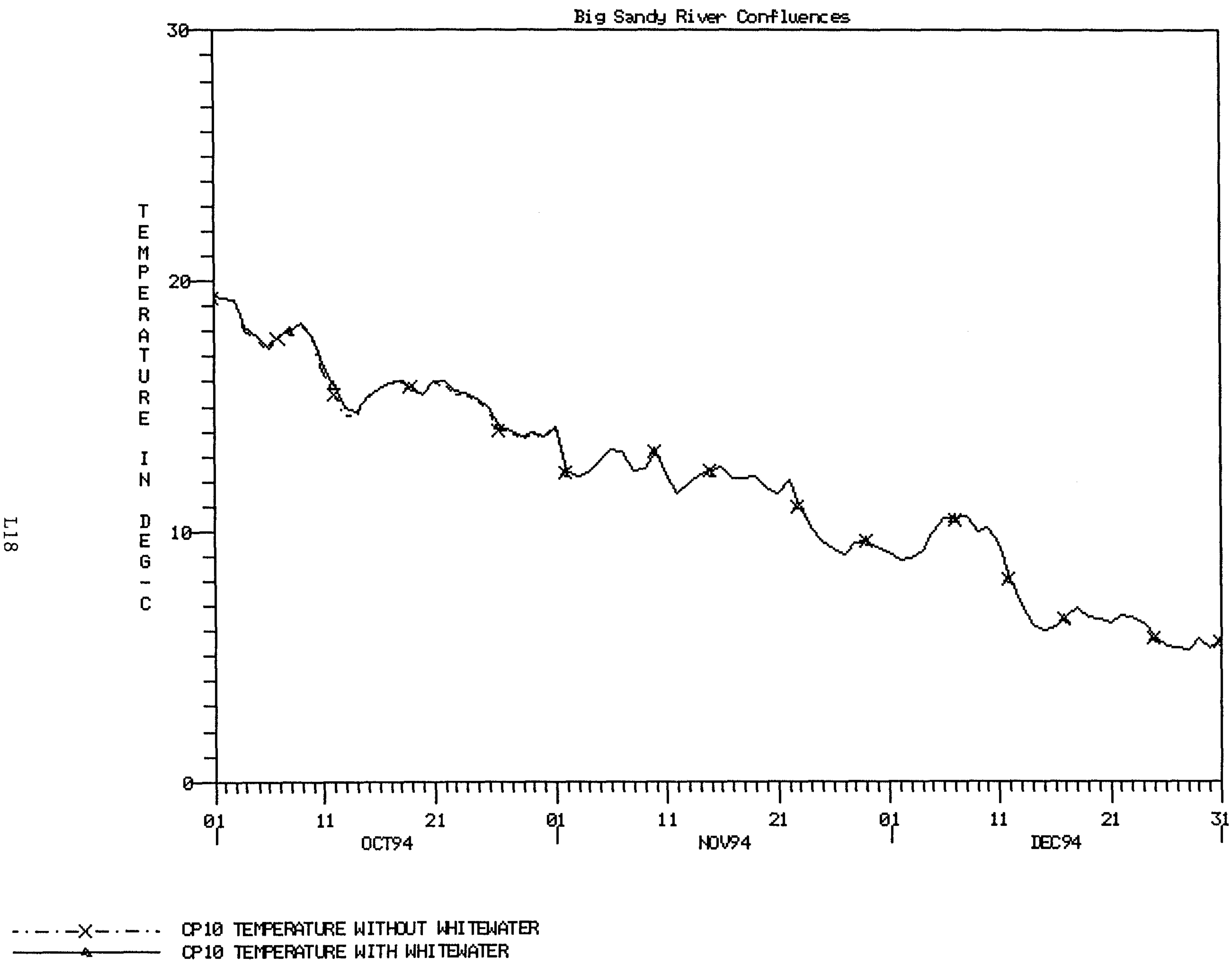

Big Sandy River Confluences
TEMPERATURE IN DEG-C
30
20
10
0
01
11
21
01
11
21
01
11
21
31
OCT88
NOV88
DEC88
CP20 TEMPERATURE WITHOUT WHITEWATER
CP20 TEMPERATURE WITH WHITEWATER



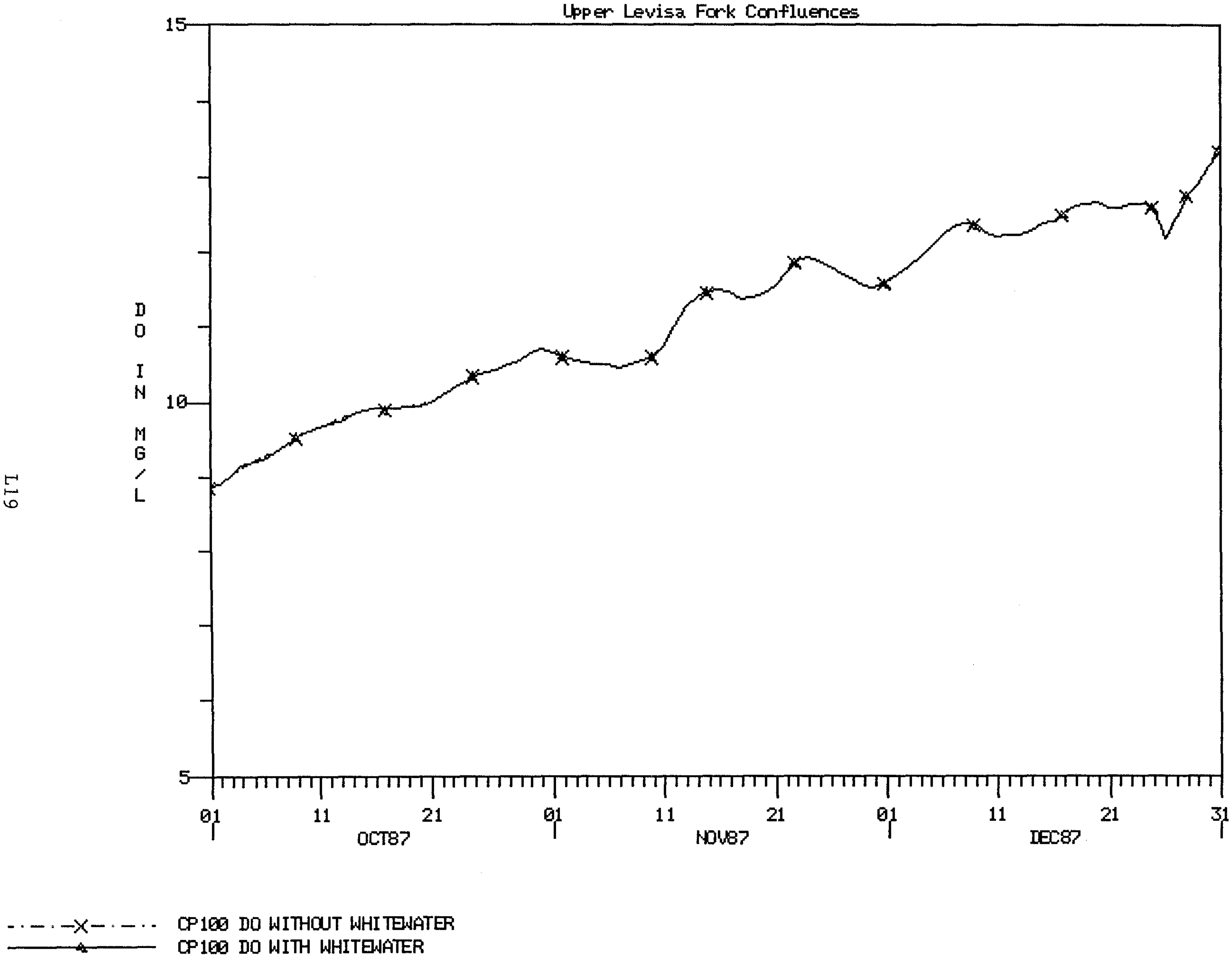
Big Sandy River Confluences
TEMPERATURE IN DEG-C
30
20
10
0
01
11
21
01
11
21
01
11
21
31
OCT94
NOV94
DEC94
CP20 TEMPERATURE WITHOUT WHITEWATER
CP20 TEMPERATURE WITH WHITEWATER

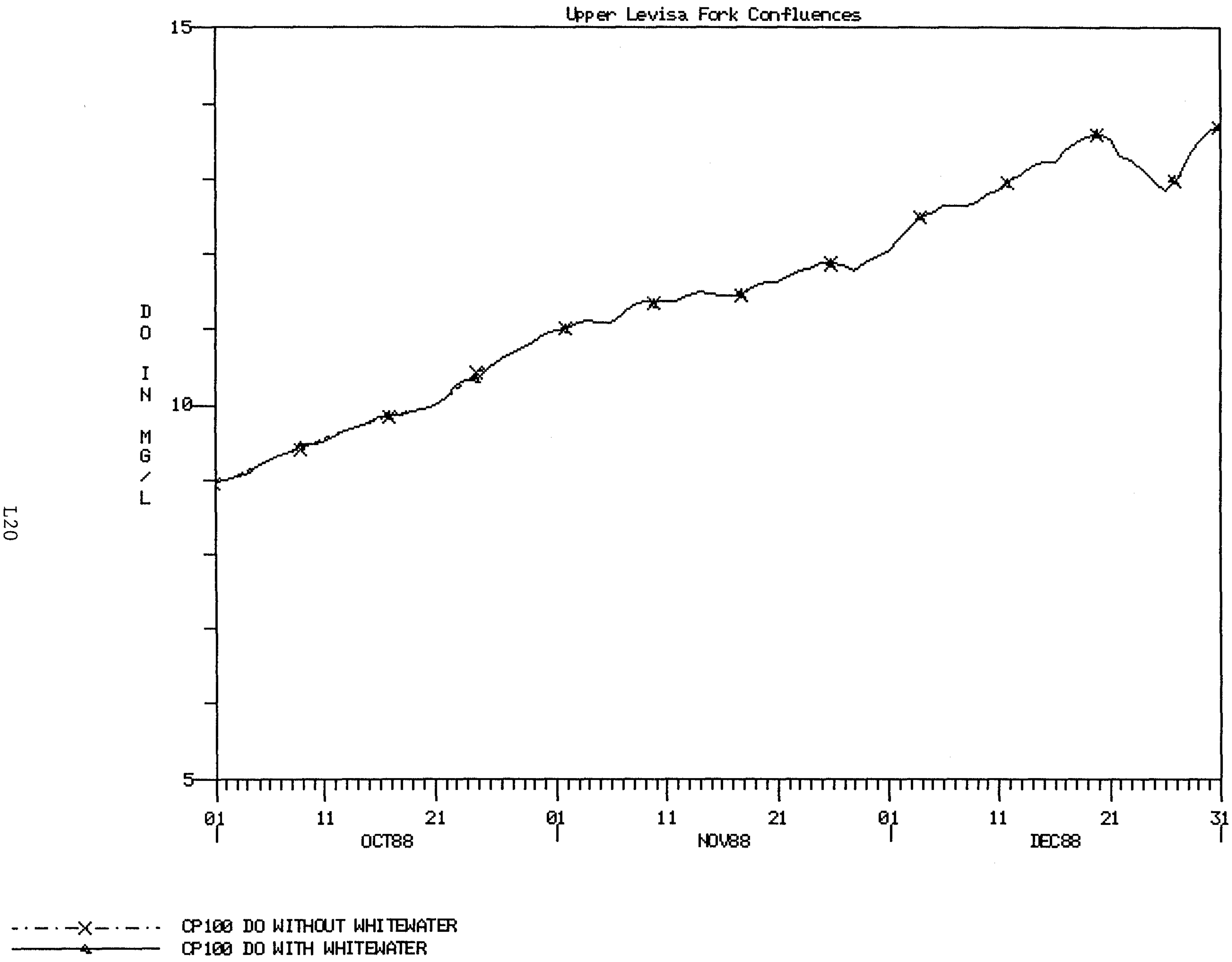

Big Sandy River Confluences
TEMPERATURE IN DEG-C
0
10
20
30
01
11
21
01
11
21
01
11
21
31
OCT87
NOV87
DEC87
CP10 TEMPERATURE WITHOUT WHITEWATER
CP10 TEMPERATURE WITH WHITEWATER


Big Sandy River Confluences
TEMPERATURE IN DEG-C
30
20
10
0
01
11
21
01
11
21
01
11
21
31
OCT88
NOV88
DEC88
CP10 TEMPERATURE WITHOUT WHITEWATER
CP10 TEMPERATURE WITH WHITEWATER

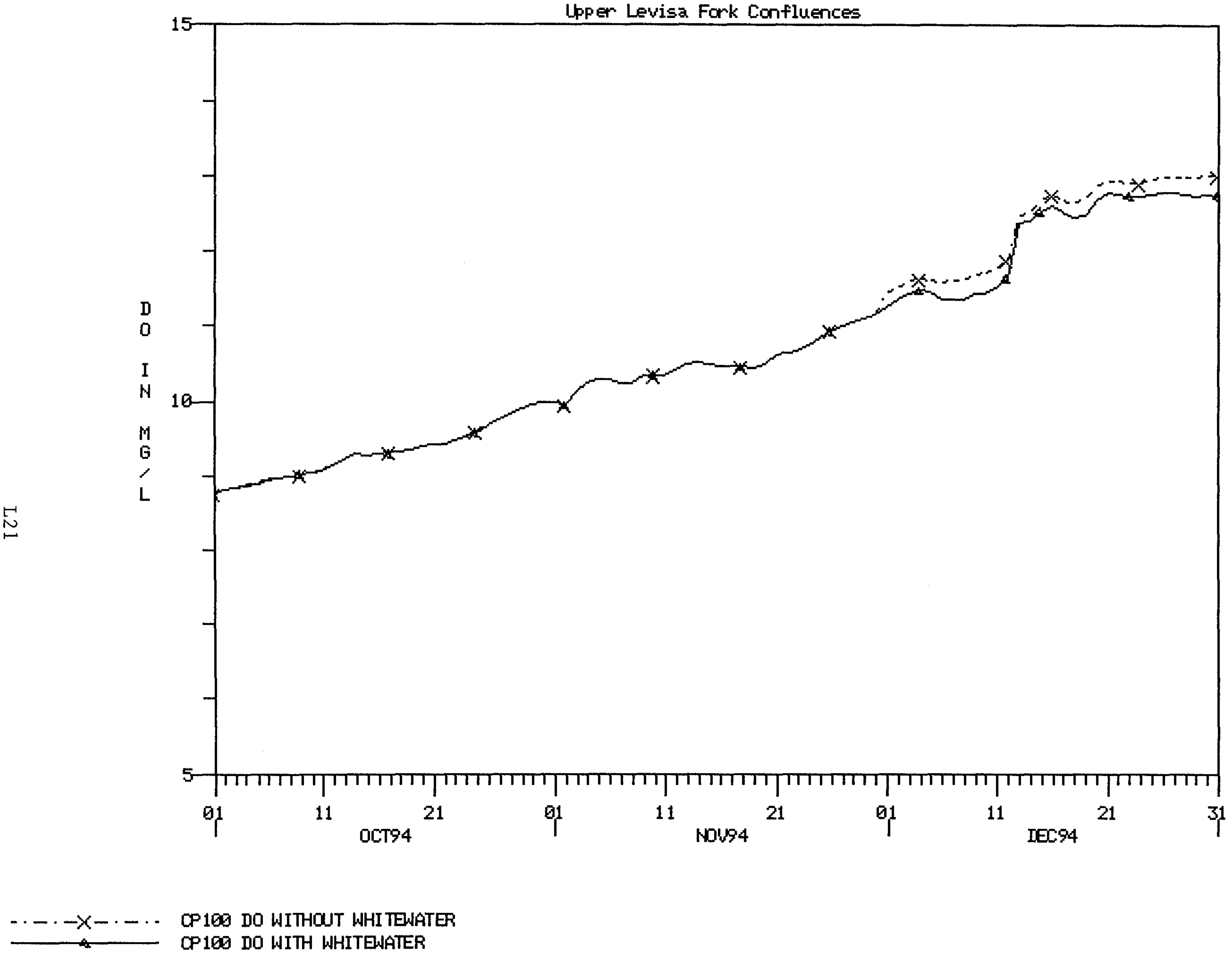


Big Sandy River Confluences
TEMPERATURE IN DEG-C
30
20
10
0
01
11
21
01
11
21
01
11
21
31
OCT94
NOV94
DEC94
CP10 TEMPERATURE WITHOUT WHITEWATER
CP10 TEMPERATURE WITH WHITEWATER

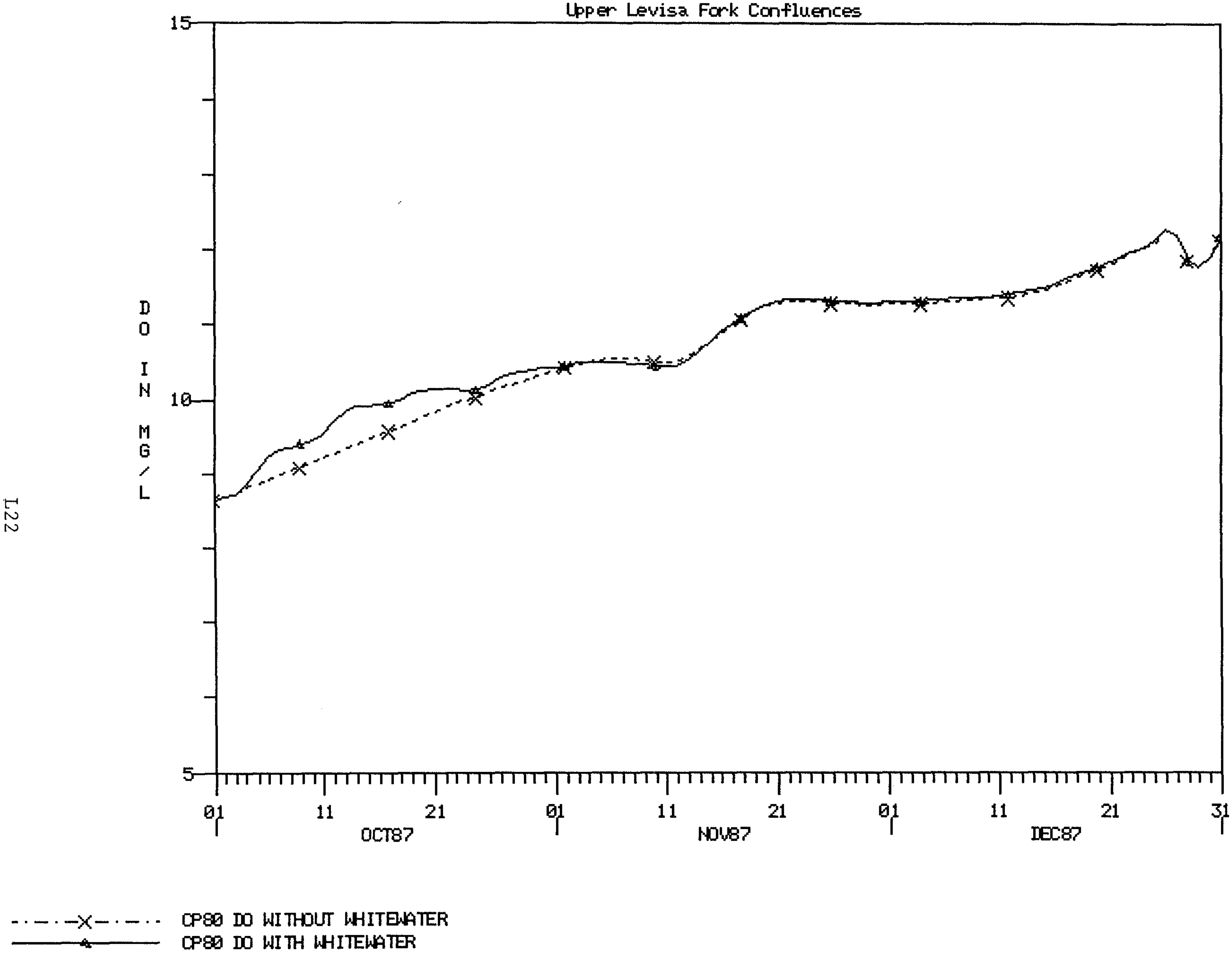

Upper Levisa Fork Confluences
DO IN MG/L
15
10
5
01
11
21
01
11
21
01
11
21
31
OCT87
NOV87
DEC87
CP100 DO WITHOUT WHITEWATER
CP100 DO WITH WHITEWATER

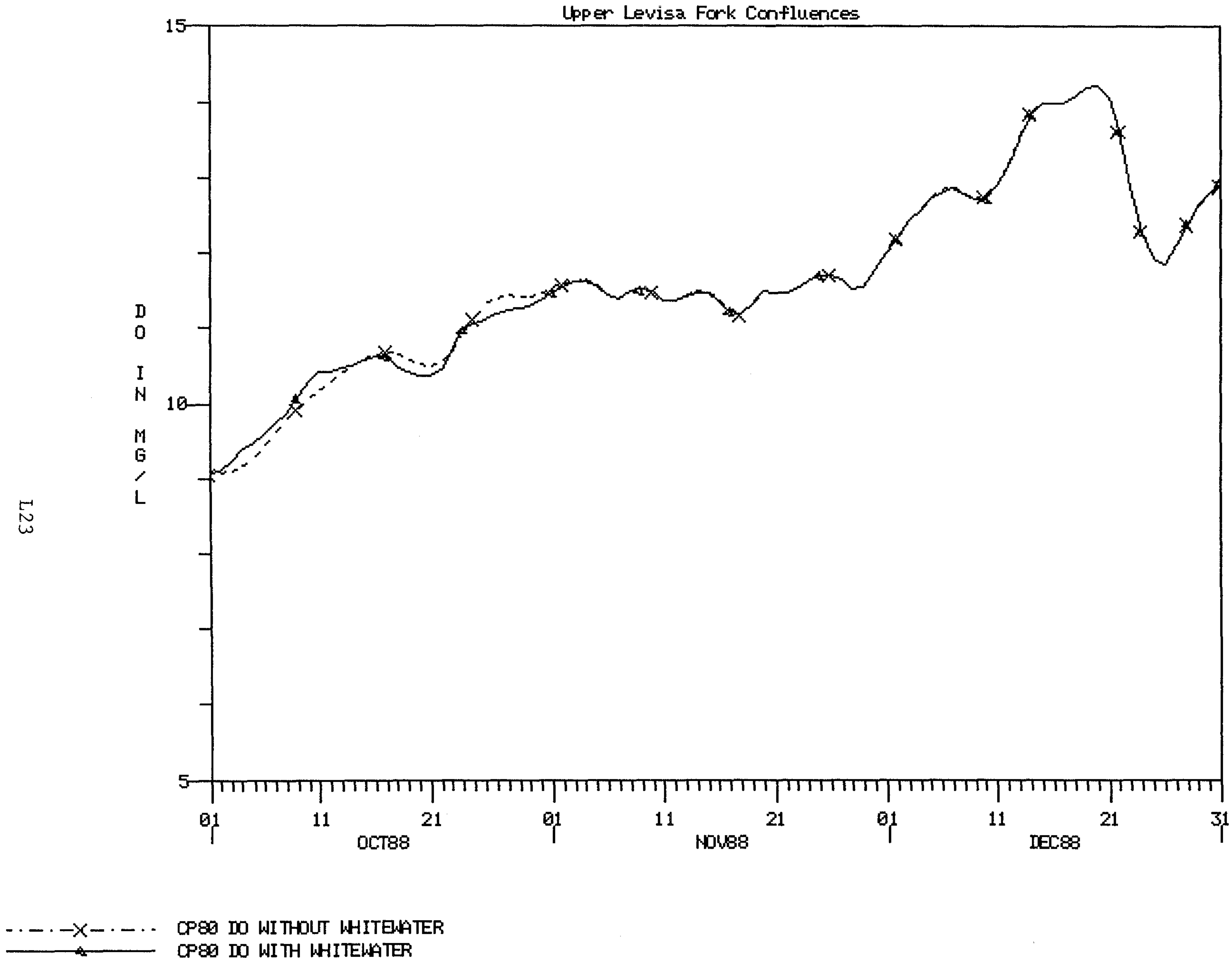


Upper Levisa Fork Confluences
15
10
5
DO IN MG/L
01
11
21
01
11
21
01
11
21
31
OCT88
NOV88
DEC88
CP100 DO WITHOUT WHITEWATER
CP100 DO WITH WHITEWATER

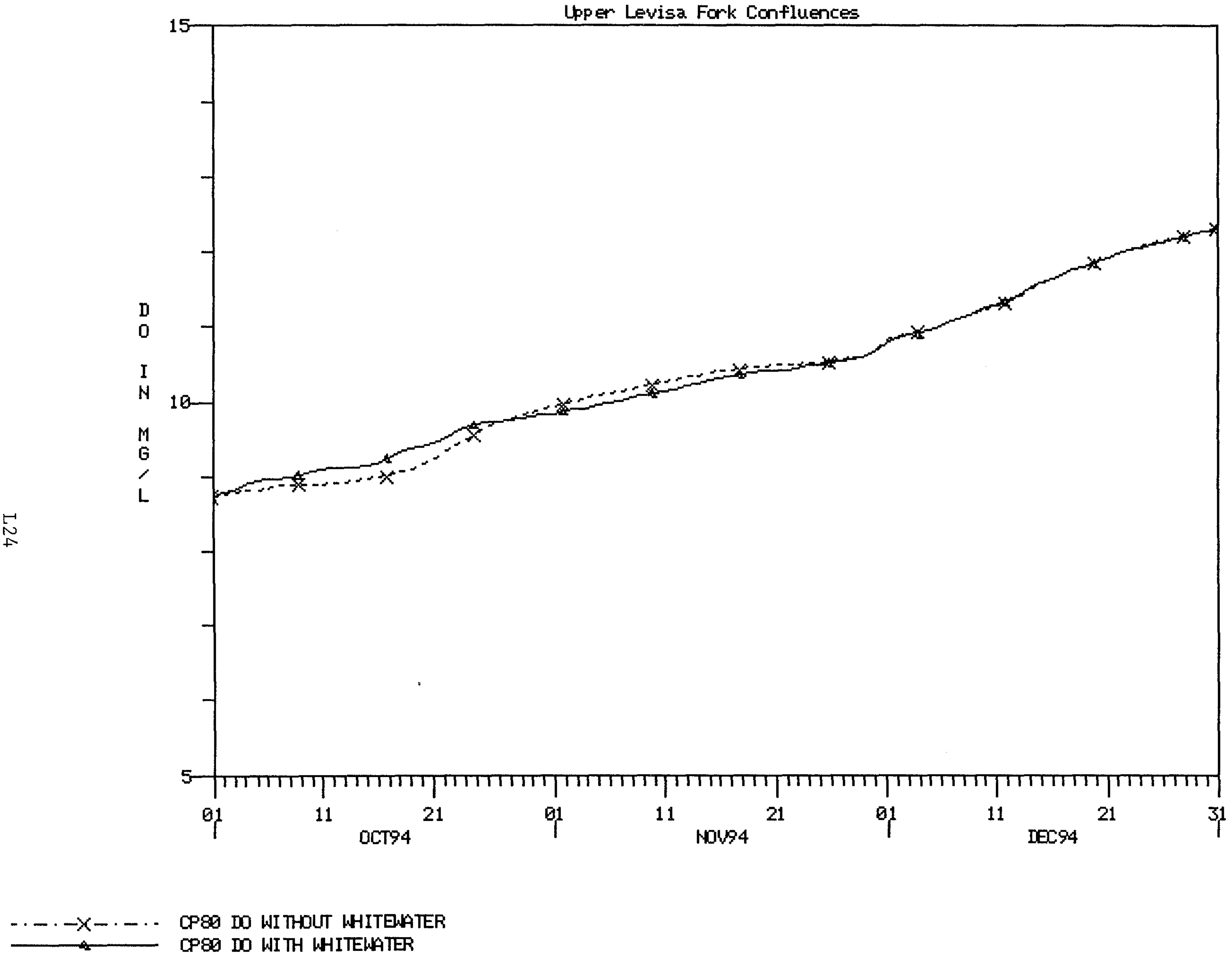


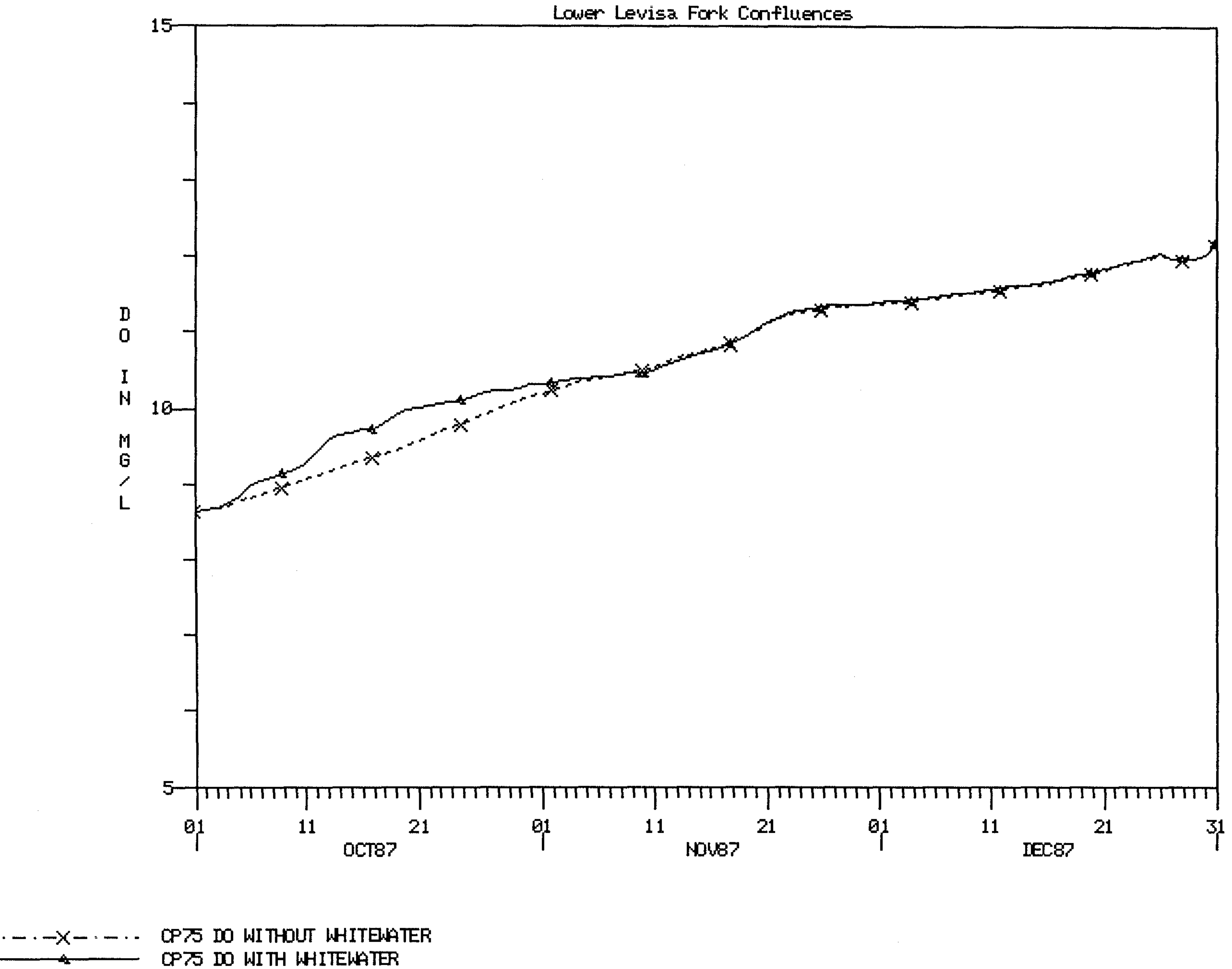
Upper Levisa Fork Confluences
DO IN MG/L
15
10
5
01
11
21
01
11
21
01
11
21
31
OCT94
NOV94
DEC94
CP100 DO WITHOUT WHITEWATER
CP100 DO WITH WHITEWATER


Upper Levisa Fork Confluences
D O IN MG/L
15
10
5
01
11
21
01
11
21
01
11
21
31
OCT87
NOV87
DEC87
CP80 DO WITHOUT WHITEWATER
CP80 DO WITH WHITEWATER

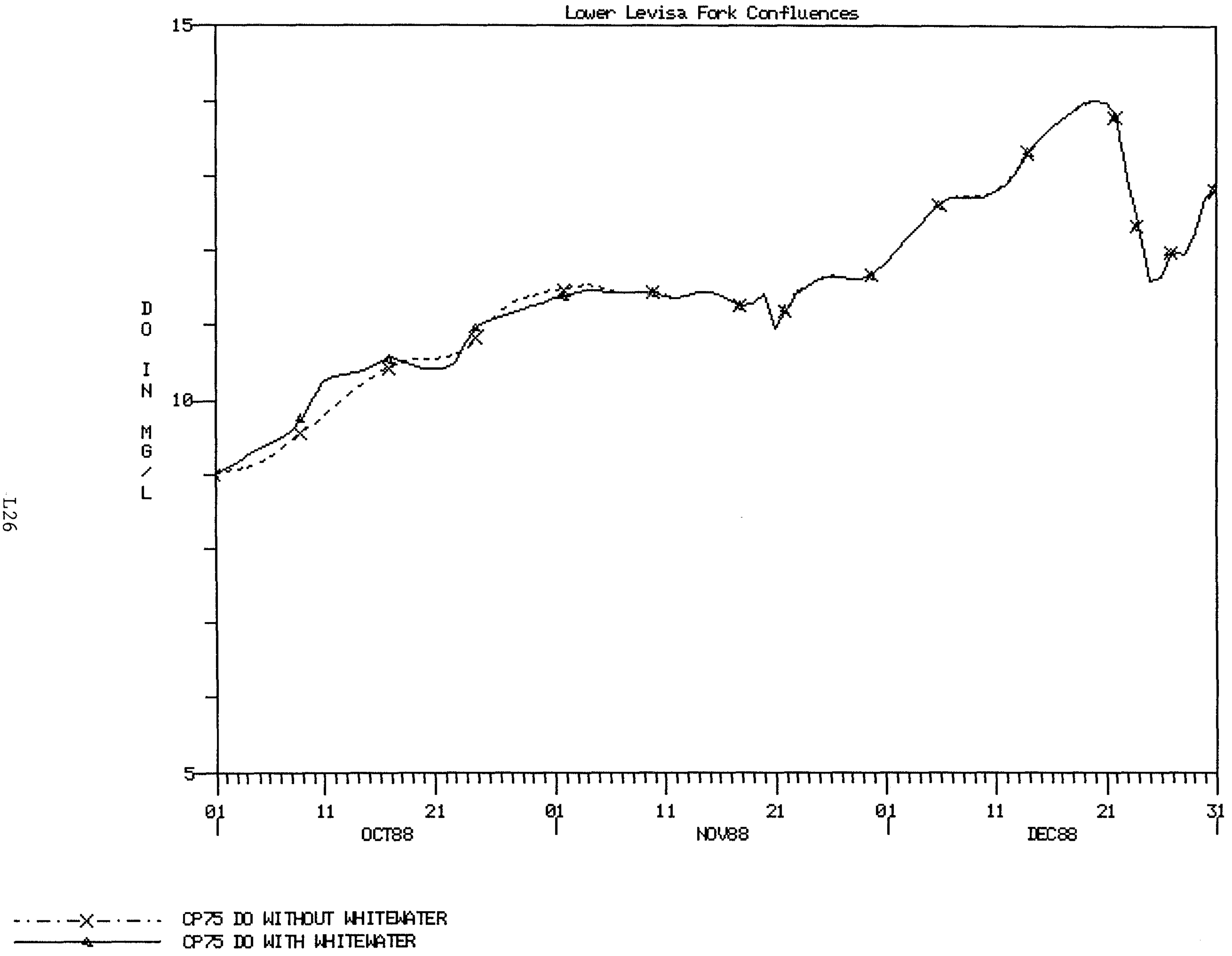

Upper Levisa Fork Confluences
DO IN MG/L
15
10
5
01
11
21
01
11
21
01
11
21
31
OCT88
NOV88
DEC88
CP80 DO WITHOUT WHITEWATER
CP80 DO WITH WHITEWATER

L23

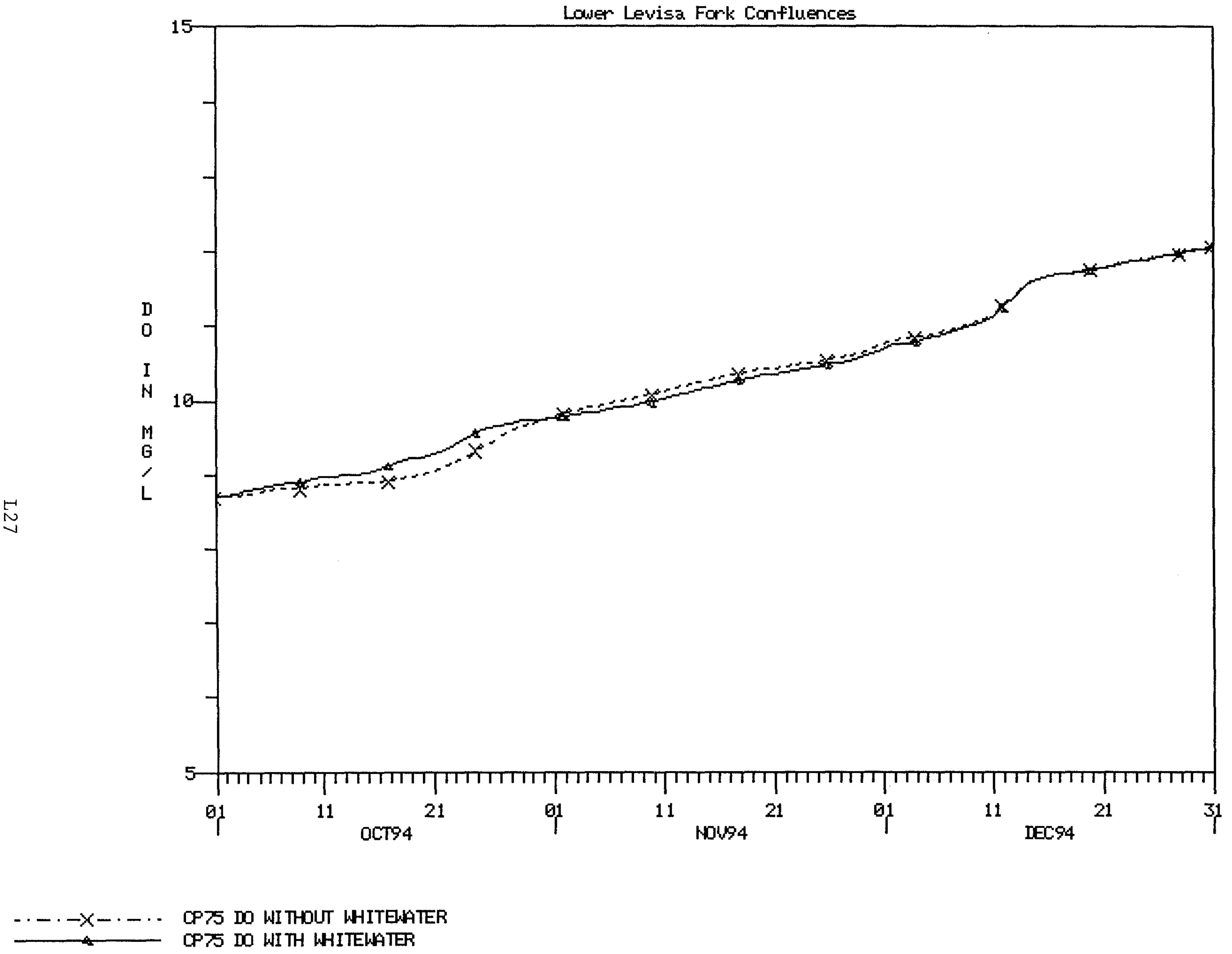

Upper Levisa Fork Confluences
15
10
5
DO IN MG/L
01
11
21
01
11
21
01
11
21
31
OCT94
NOV94
DEC94
CP80 DO WITHOUT WHITEWATER
CP80 DO WITH WHITEWATER

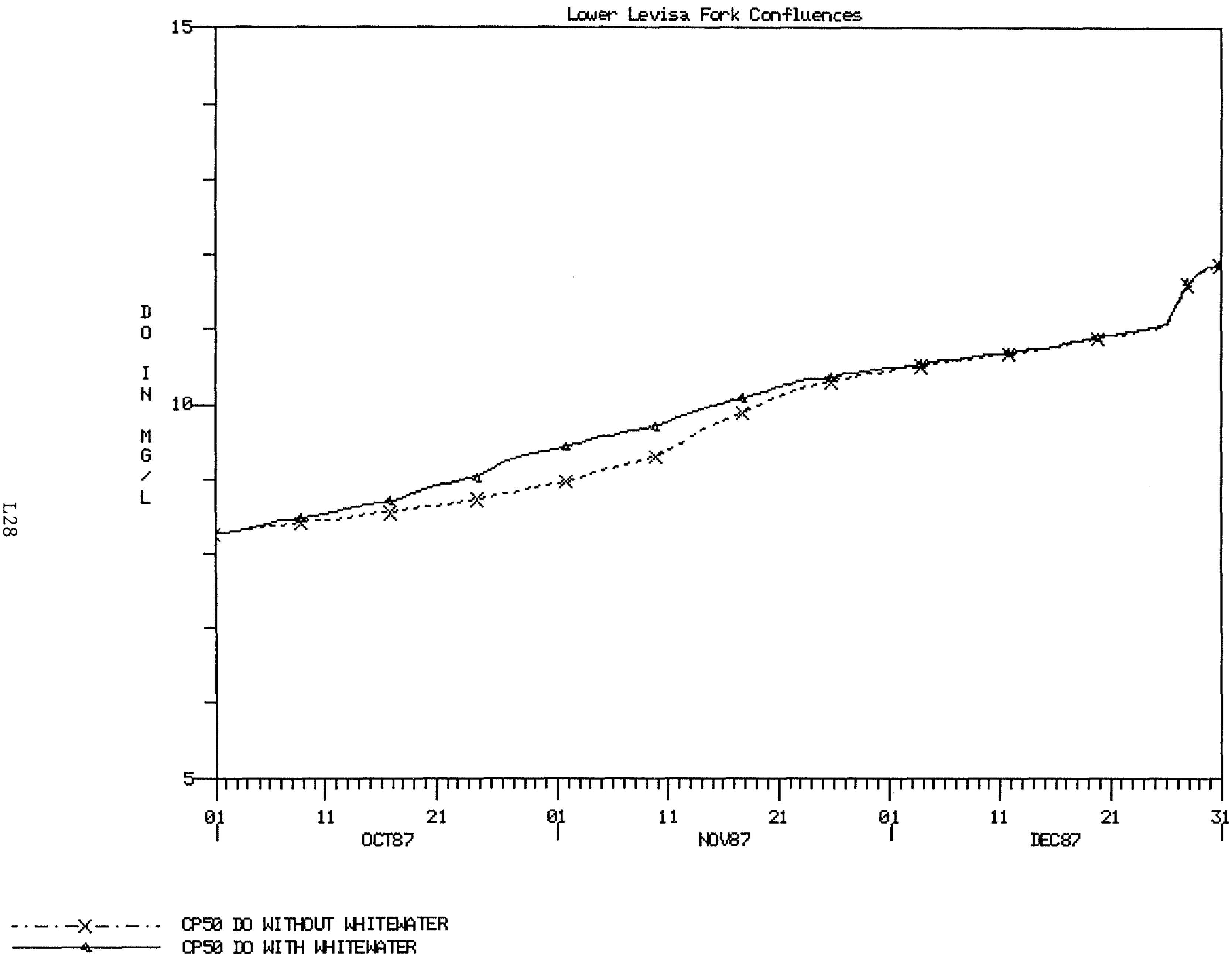


Lower Levisa Fork Confluences
15
10
5
D O IN MG/L
01
11
21
01
11
21
01
11
21
31
OCT87
NOV87
DEC87
CP75 DO WITHOUT WHITEWATER
CP75 DO WITH WHITEWATER

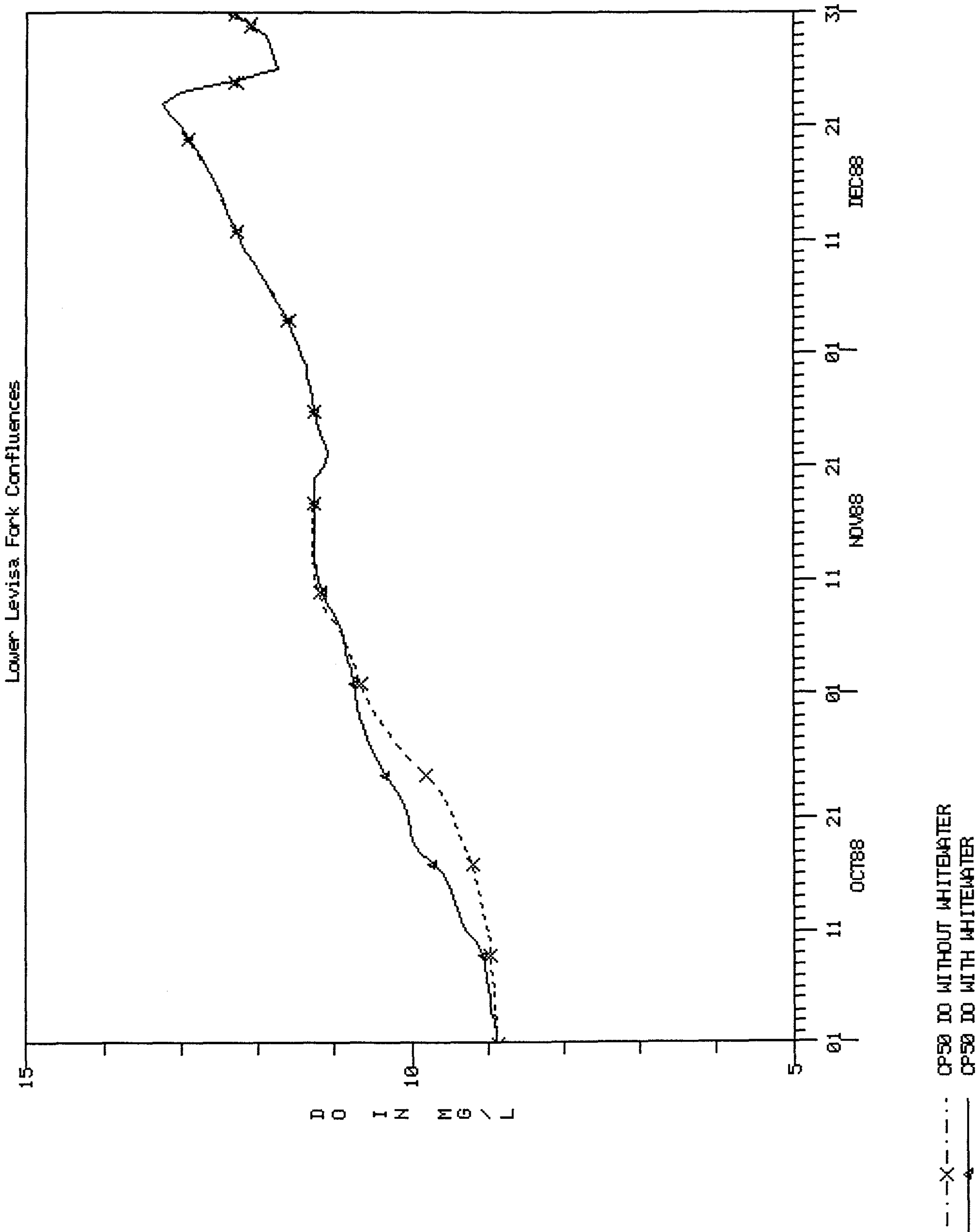


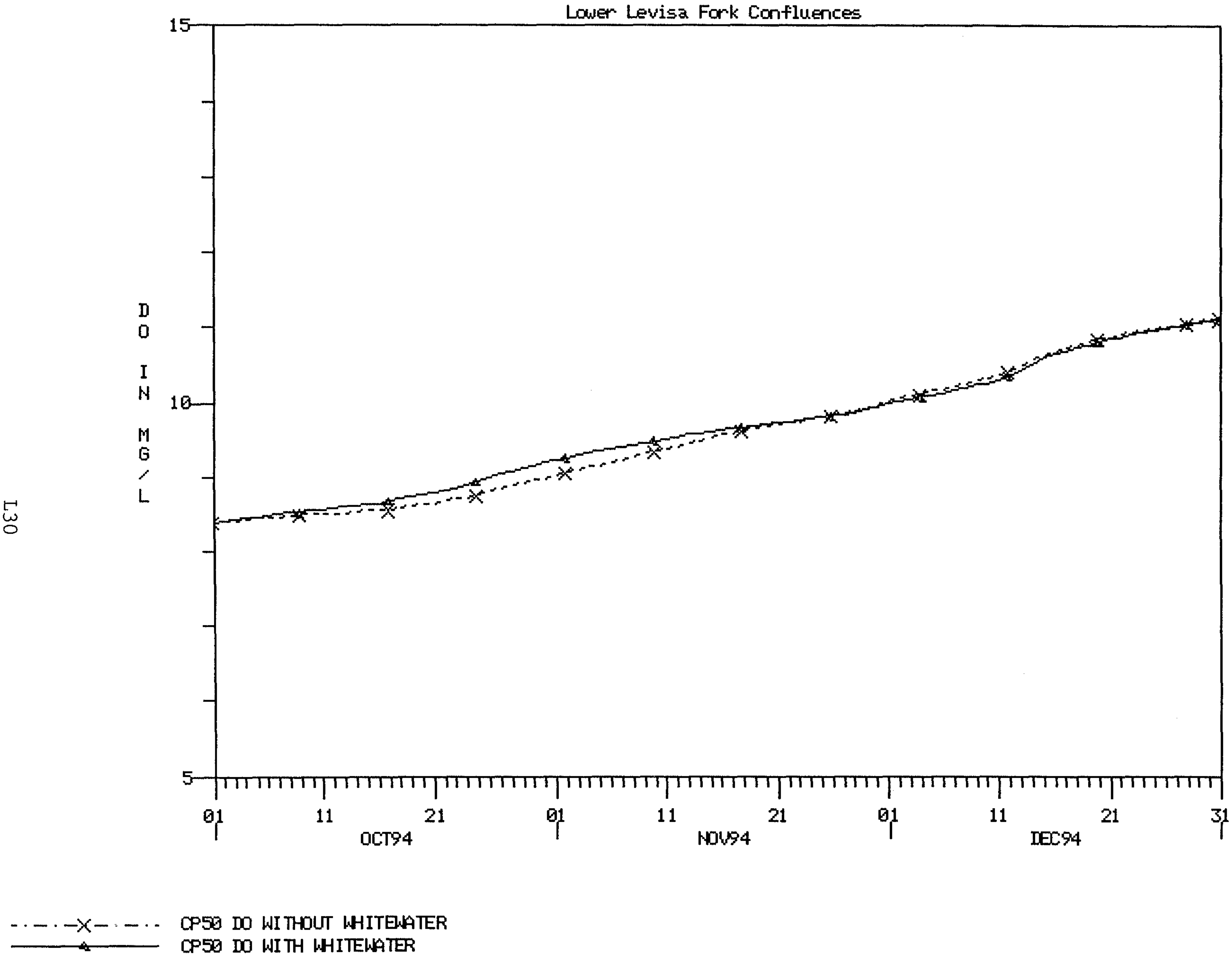
Lower Levisa Fork Confluences
15
10
5
D O IN MG/L
01
11
21
01
11
21
01
11
21
31
OCT88
NOV88
DEC88
CP75 DO WITHOUT WHITEWATER
CP75 DO WITH WHITEWATER

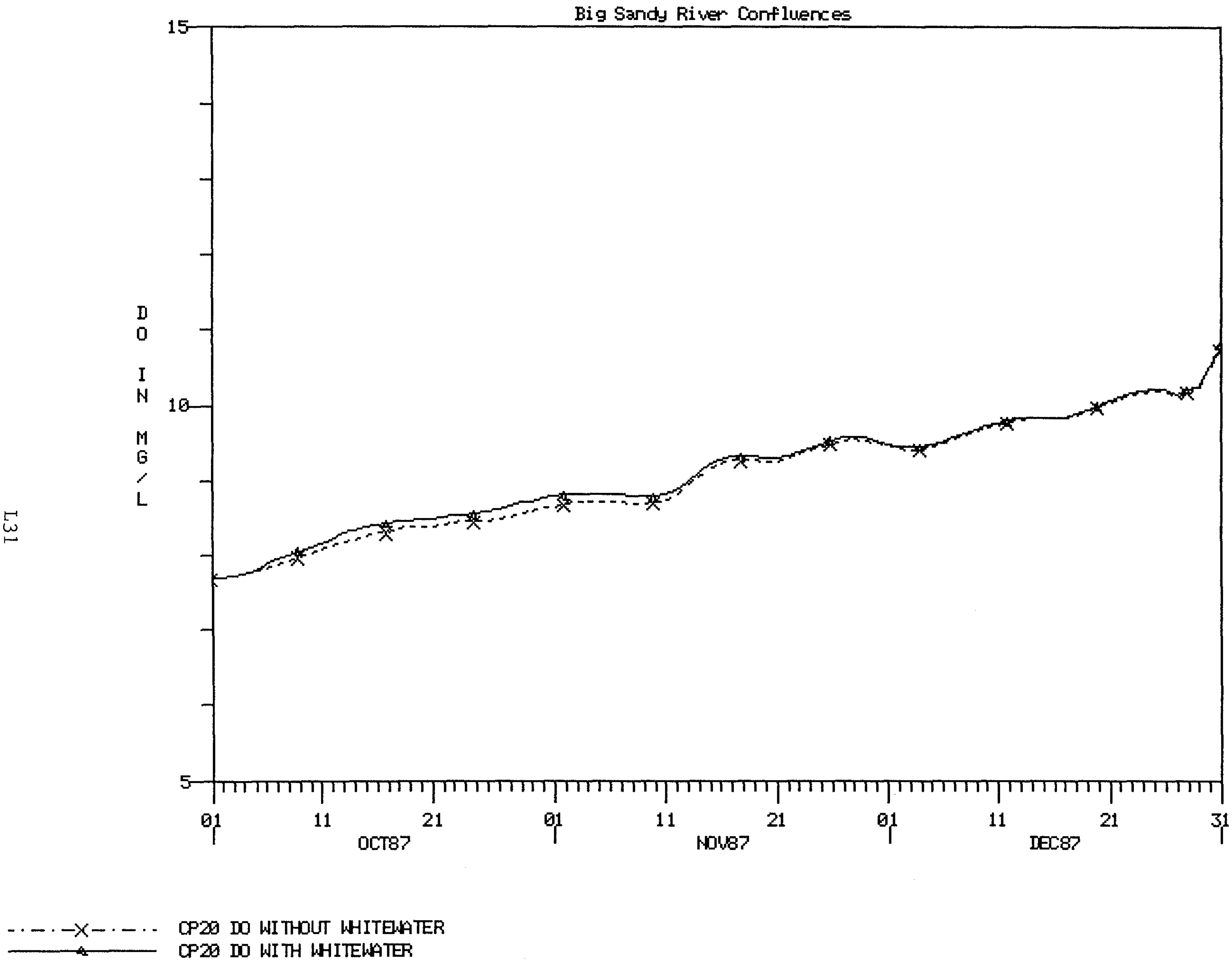

Lower Levisa Fork Confluences
15
10
5
DO IN MG/L
01
11
21
01
11
21
01
11
21
31
OCT94
NOV94
DEC94
CP75 DO WITHOUT WHITEWATER
CP75 DO WITH WHITEWATER



Lower Levisa Fork Confluences
DO IN MG/L
15
10
5
01
11
21
OCT87
01
11
21
NOV87
01
11
21
DEC87
31
CP50 DO WITHOUT WHITEWATER
CP50 DO WITH WHITEWATER

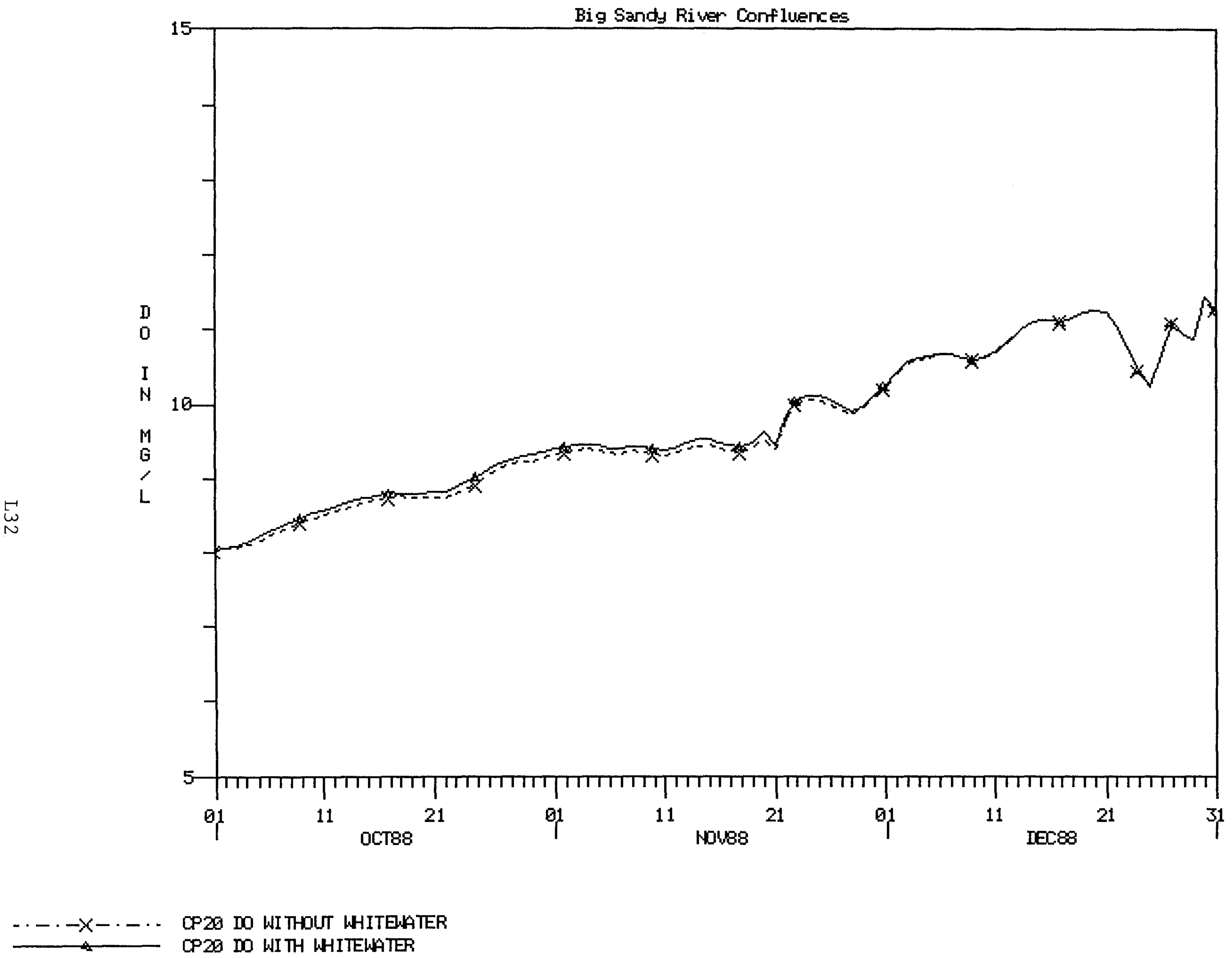

Lower Levisa Fork Confluences
DO IN MG/L
15
10
5
01
11
21
OCT88
01
11
21
NOV88
01
11
21
DEC88
31
CP50 DO WITHOUT WHITEWATER
CP50 DO WITH WHITEWATER


Lower Levisa Fork Confluences
D O IN MG/L
15
10
5
01
11
21
OCT94
01
11
21
NOV94
01
11
21
31
DEC94
CP50 DO WITHOUT WHITEWATER
CP50 DO WITH WHITEWATER

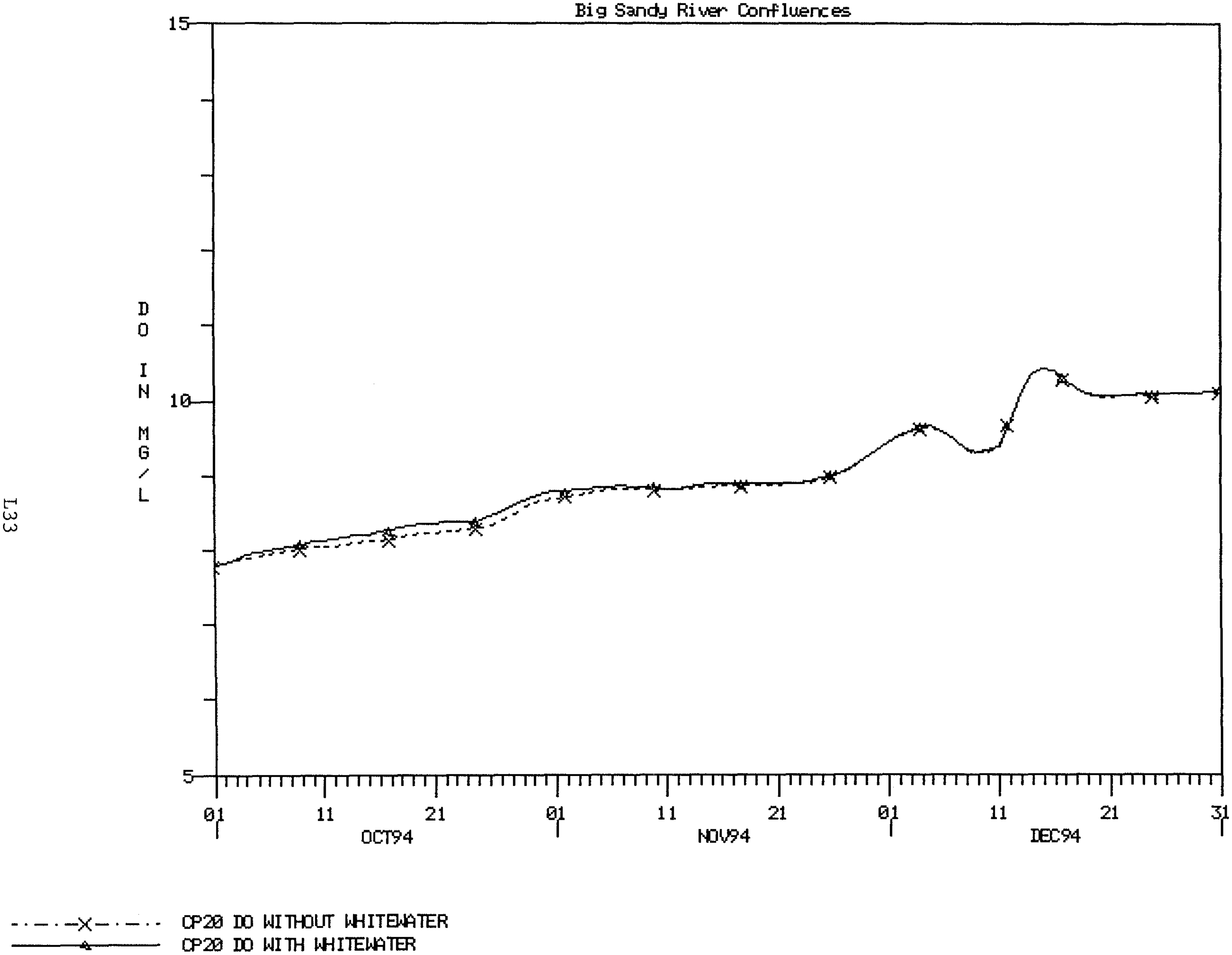


Big Sandy River Confluences
DO IN MG/L
15
10
5
01
11
21
01
11
21
01
11
21
31
OCT87
NOV87
DEC87
CP20 DO WITHOUT WHITEWATER
CP20 DO WITH WHITEWATER

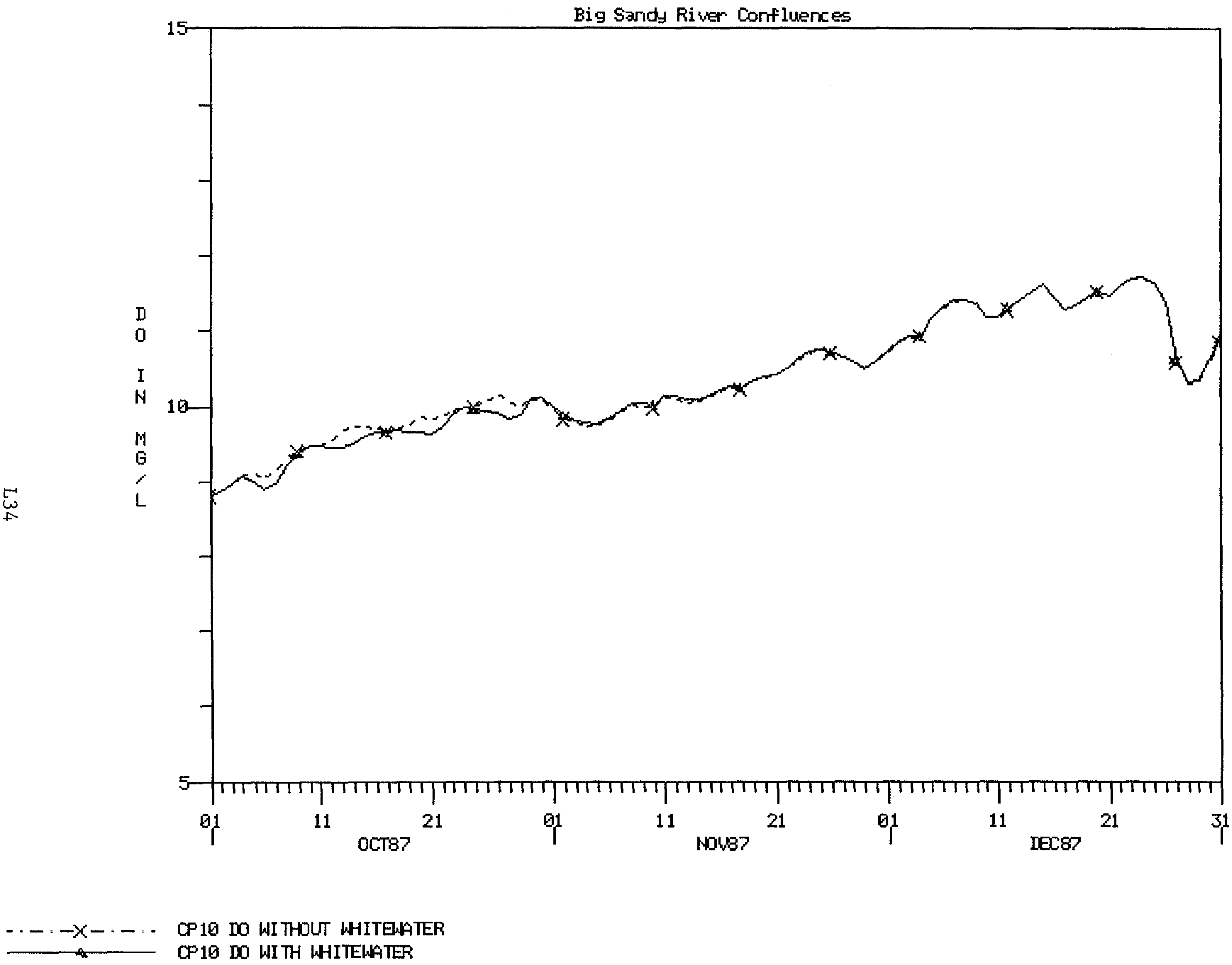
L31

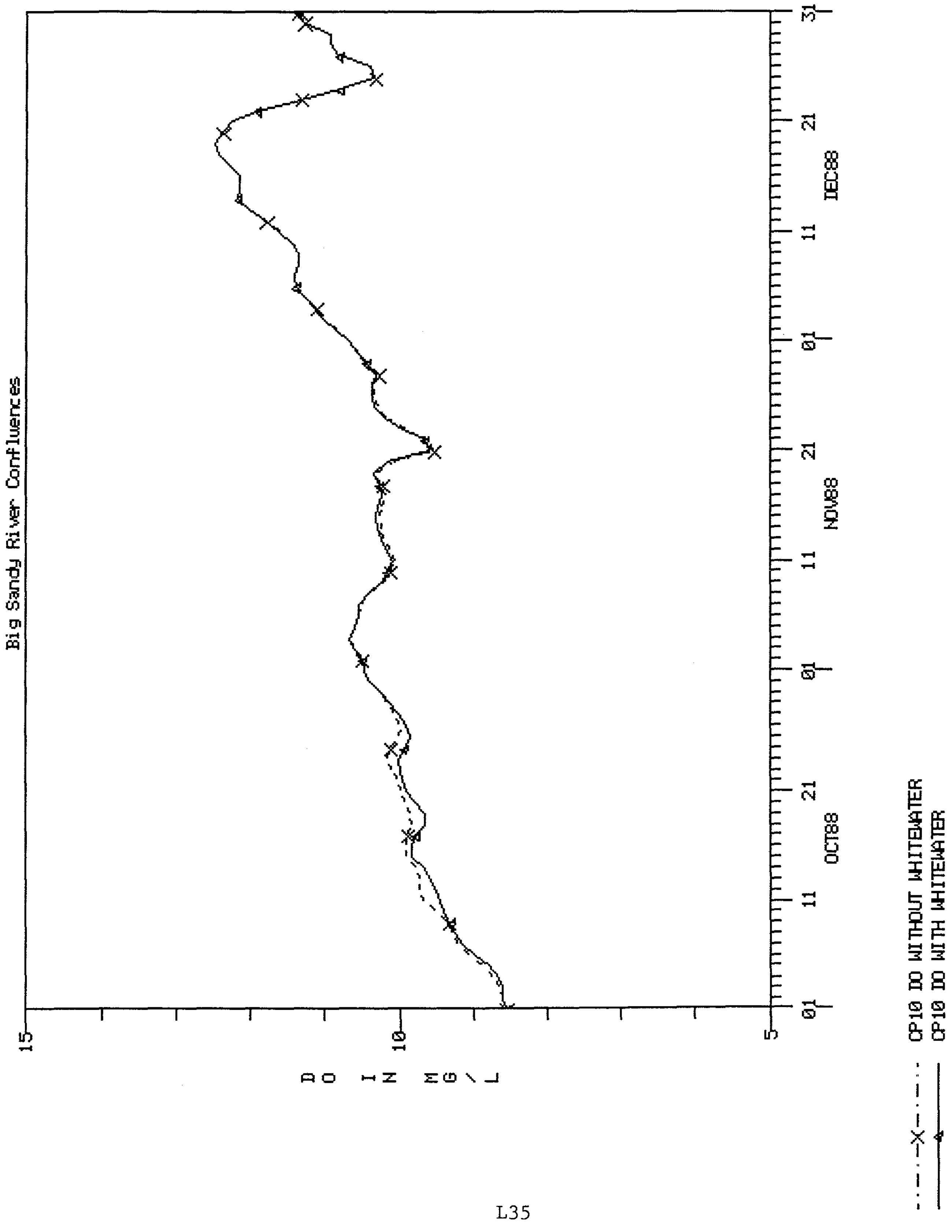


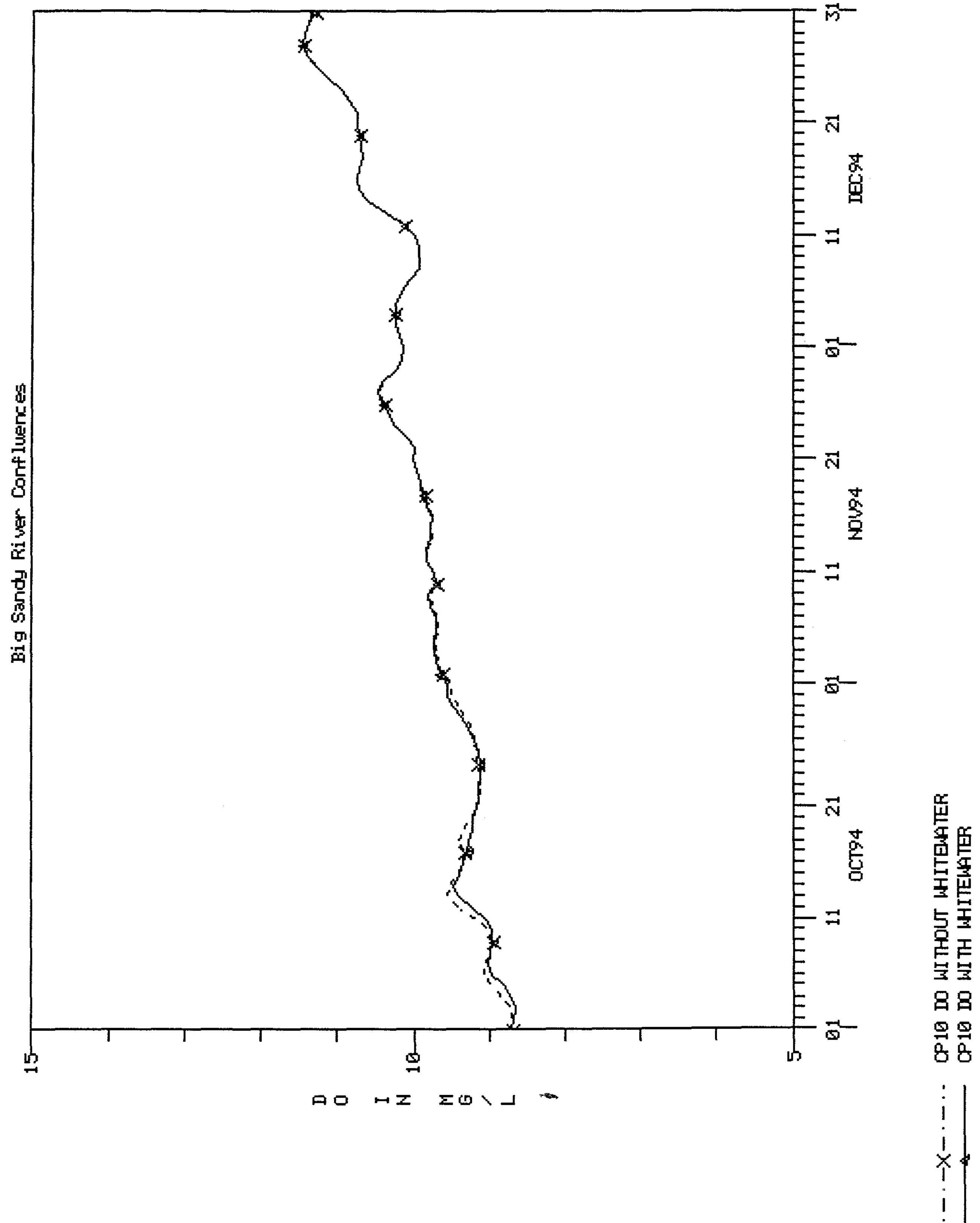
Big Sandy River Confluences
15
10
5
D O IN MG/L
01
11
21
01
11
21
01
11
21
31
OCT88
NOV88
DEC88
CP20 DO WITHOUT WHITEWATER
CP20 DO WITH WHITEWATER



Big Sandy River Confluences
15
10
5
D O IN MG/L
01
11
21
01
11
21
01
11
21
31
OCT94
NOV94
DEC94
CP20 DO WITHOUT WHITEWATER
CP20 DO WITH WHITEWATER


Big Sandy River Confluences
DO IN MG/L
15
10
5
01
11
21
01
11
21
01
11
21
31
OCT87
NOV87
DEC87
CP10 DO WITHOUT WHITEWATER
CP10 DO WITH WHITEWATER


Big Sandy River Confluences
DO IN MG/L
15
10
5
01
11
21
OCT88
01
11
21
NOV88
01
11
21
DEC88
31
CP10 DO WITHOUT WHITEWATER
CP10 DO WITH WHITEWATER


Big Sandy River Confluences
DO IN MG/L
15
10
5
01
11
21
OCT94
01
11
21
NOV94
01
11
21
DEC94
31
CP10 DO WITHOUT WHITEWATER
CP10 DO WITH WHITEWATER