WATER AND NUTRIENT BUDGETS AND PHOSPHORUS MODELS FOR THE BIG EAU PLEINE RESERVOIR, WISCONSIN

by

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ABSTRACT

The Big Eau Pleine Reservoir, a eutrophic reservoir in central Wisconsin, was studied for a five year period, 1974-1978. Problems common to this reservoir are summer blue green algae blooms, water level fluctuation and winter fishkills. A series of computer data files were constructed and maintained for the students studing the Big Eau Pleine Reservoir. They contained the weather data, streamflow measurements, reservoir stage, evaporation rates, water quality data (semimonthly grab and continous sample data) and ice thickness measurements. Detailed water and nutrient budgets were calculated, by computer programs using these data files, for 1975 through 1978. These calculations provided a set of measured estimates of the location of mass in the reservoir and mass transfer rates between the reservoir segments. This study provides a backdrop of comparison, for the future application and predictions of more detailed digital ecological models.

A large percent, 97 percent, of the annual phosphorus load comes from the Big Eau Pleine Reservoir's agricultural watershed as surface runoff. Fifty four percent of the annual phosphorus load occurs during spring snowmelt. The reservoir's water is usually mixed, but forms a weak temperature and dissolved oxygen stratification early to midsummer. Low flow augmentation of the Wisconsin River and flood control were the major factors of the reservoir's water level management, during the study period. The action of a summer drawdown may have contributed to sustained algae bloom, primarily Aphanizomenon, in 1976. The spring flushing of excess runoff during the spring of 1976 contributed to an increase in the export of phosphorus from the reservoir.

Phosphorus was the primary limiting nutrient in the Big Eau Pleine Reservoir. Five phosphorus loading models were applied to the years that had the most accurate water and nutrient budgets (1975 and 1976). An attempt was made to locate a model that could predict the summer mean algae bloom chlorophyll a and steady state phosphorus concentration observed in the reservoir. The best prediction was obtained by using the Dillon and Rigler model applied to the reservoir divided into three segments. Two predictions were made. One was for a full reservoir management option, and the other was for reduction in the amount of surface runoff phosphorus load. The model predicted a slight improvement in reservoir water quality using a full reservoir management scheme. The largest predicted improvement was due to a reduction in phosphorus load to the reservoir. A 57 percent reduction of chlorophyll a was predicted by the model, when the phosphorus load from the watershed was decreased 50 percent.

ACKNOWLEDGEMENTS

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If it was not for all the special people who helped with keypunching data cards, programming, water sample collection and analysis, typing and providing ideas and support, this thesis would not have been completed. Special thanks to Tom Zeisler and Dr. Fred Hilpert of the Computer Center, Richard Stephens of the Environmental Task Force, Steve Bartelt, Jeff Boettcher, John Sullivan and all the other Graduate Students on the Eau Pleine Project.

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INTRODUCTION

The Big Eau Pleine Reservoir has been at the point of varying degrees of controversy since its construction in the thirties. It was built by the Wisconsin Valley Improvement company on the Big Eau Pleine River for the purpose of low flow augmentation of the Wisconsin River below Mosinee, Wisconsin and flood control. The reservoir became a resource for public recreational use because of the productive fishery caused by the fertility of the Big Eau Pleine's agricultural watershed. The magnitude and frequency of fish kills and algae blooms fueled public concern which sparked controversial ideas. This study was done because of this concern about the existing conditions and what could be done to improve the biological and physical water quality in the reservoir.

This paper discusses the data collected by the Big Eau Pleine Project and the structure of computer files designed to contain it. Detailed water and nutrient budget programs were developed to make calculations using the measured data. These detailed budgets provide background information to compare future computer modeling results against. The Big Eau Pleine Reservoir was treated as a whole and as three segments for the application of simple phosphorus loading models. Recommendations were developed for reservoir management options. Support for some of these recommendations were developed using descriptive data and nutrient budgets.

PHYSICAL FACTORS

Watershed

As a water manager, I view the Big Eau Pleine Reservoir 363 square mile or 940 km^2 watershed as five separate areas (Figure 1). The reservoir proper is the area of land covered by a liquid water body called the Big Eau Pleine Reservoir. Surface area of the reservoir ranges from 2770 ha to 170 ha or 6850 a to 420 a. The second area is the land surface 246.91 mi^2 or 639.5 km^2 above the State Highway 153 bridge near Stratford, Wisconsin and is called the Big Eau Pleine River Watershed. The third area is the Fenwood Creek Watershed (36.97 mi^2 or 95.75 km^2) and the fourth area is the Freeman Creek Watershed (21.73 mi^2 or 56.28 km^2). Both are above their respective State Highway 153 bridges. The final area (the assocated area) is the part of the Big Eau Pleine Watershed not in any of the other areas. The variable surface area of the water body affects the surface area of the associated area which ranges from 46.2 mi^2 to 56.9 mi^2 or 119.7 km^2 to 147.4 km^2. The subbasin areas change their surface areas too slowly to affect this study. The slow changes are dependent on factors such as the subbasin geology and soil erosion. The division of the reservoir's watershed down to these areas was made to facilitate calculations of the water and nutrient budgets. All the measured movements of water and nutrients are between the reservoir and these areas.

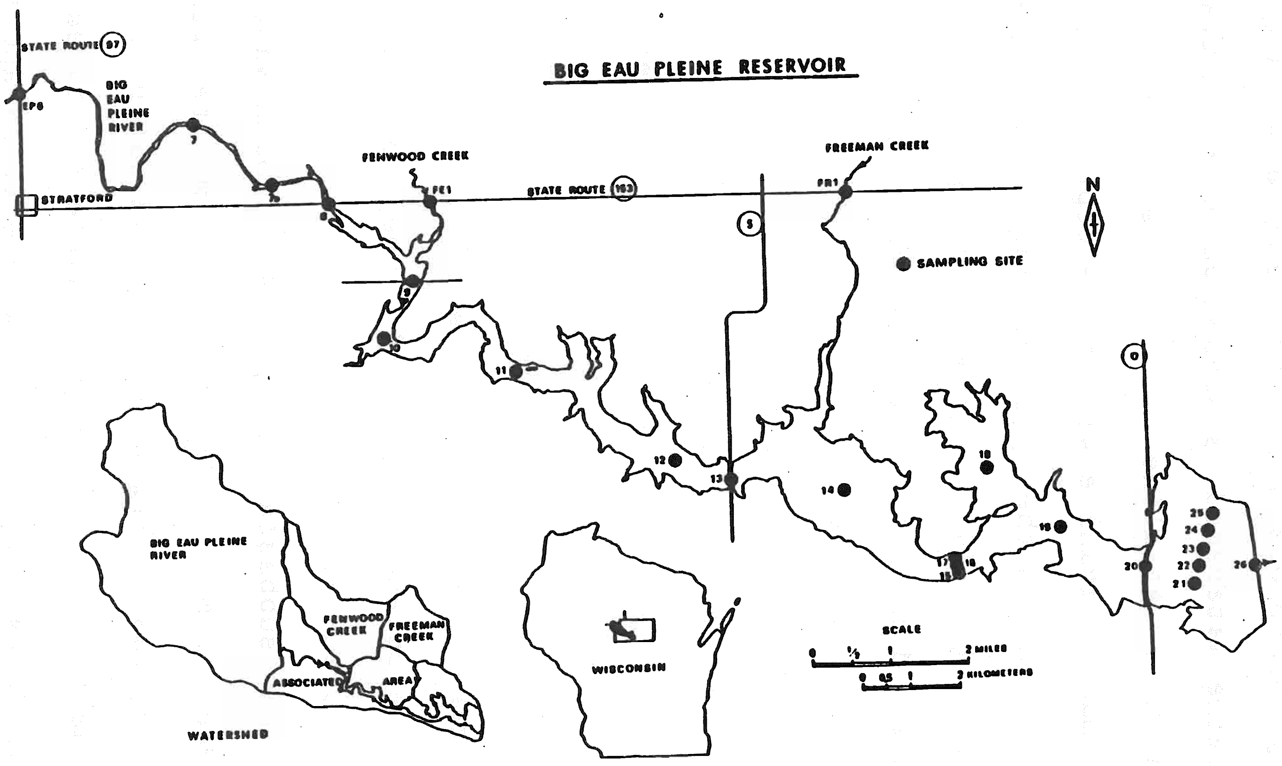


Figure 1. The Big Eau Pleine Reservoir, location and sampling stations.

Geology and Soils

The description of the watershed is on a subbasin basis because it is relevant to relating runoff quantity and quality from one subbasin to the others. All of the Big Eau Pleine Watershed is supported on a bedrock base of Precambrian age crystalline rock (Figure 2 and 3). This bedrock is primarily granite with the exception of some Cambrian age sandstone in the upper Big Eau Pleine River basin (Pell and Sherrill, 1974). The Big Eau Pleine River is a linear feature which might be a shear zone running north 120° east (LaBerge and Myers, 1972).

The Big Eau Pleine River subbasin is covered with 0 to 100 feet or 0 to 30.48 meters of Pleistocene till (Figure 4 and 6). Generally a band near the river in the lower one half of the subbasin is not covered with glacial material. The riverbed is generally alluvium, peat, or outwash in spots (Figure 4). The soils are loamy soils developed over glacial of the uplands (Figure 5). They were developed in residuum weathered from bedrock near the streams in the lower portion of this subbasin (USDA, 1979). Ground water availability ranges from 5 to 20 gallons per minute (gpm) in the lower end of the basin (Figure 7). Ground water pollution potential is highest in the lower basin where fractured bedrock is within 0 to 20 feet or 0 to 6.1 meters thick and the rate of infil-

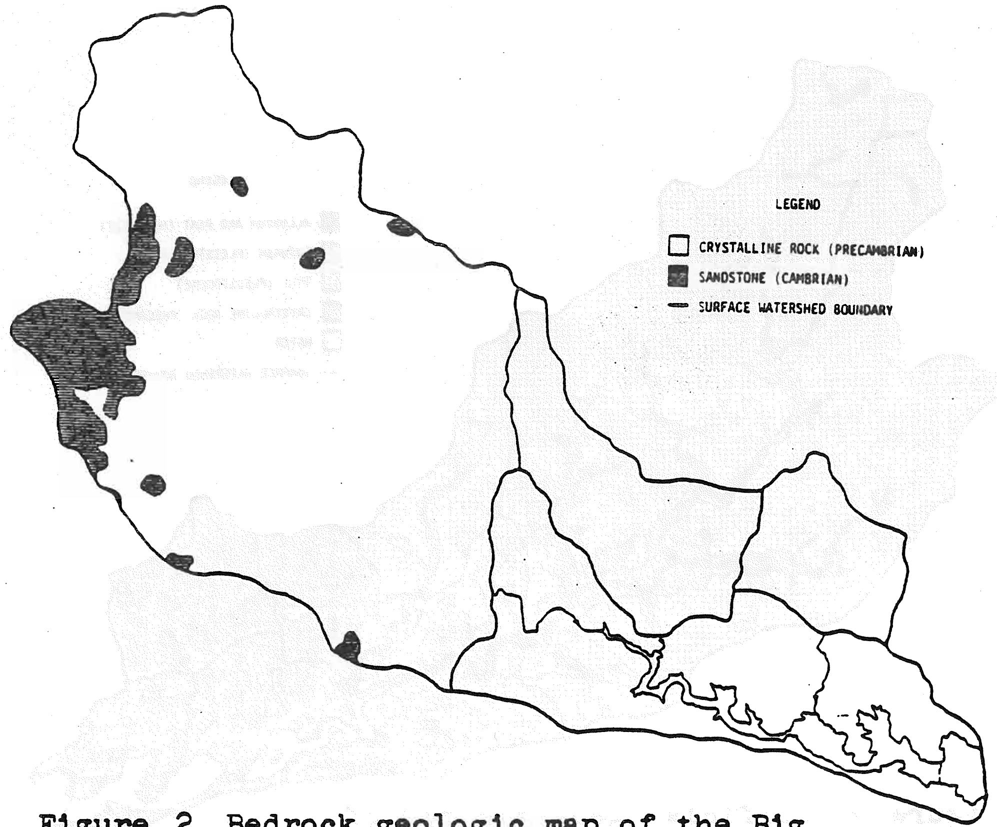


Figure 2. Bedrock geologic map of the Big Eau Pleine Watershed. (After Pell and Sherrill, 1974)

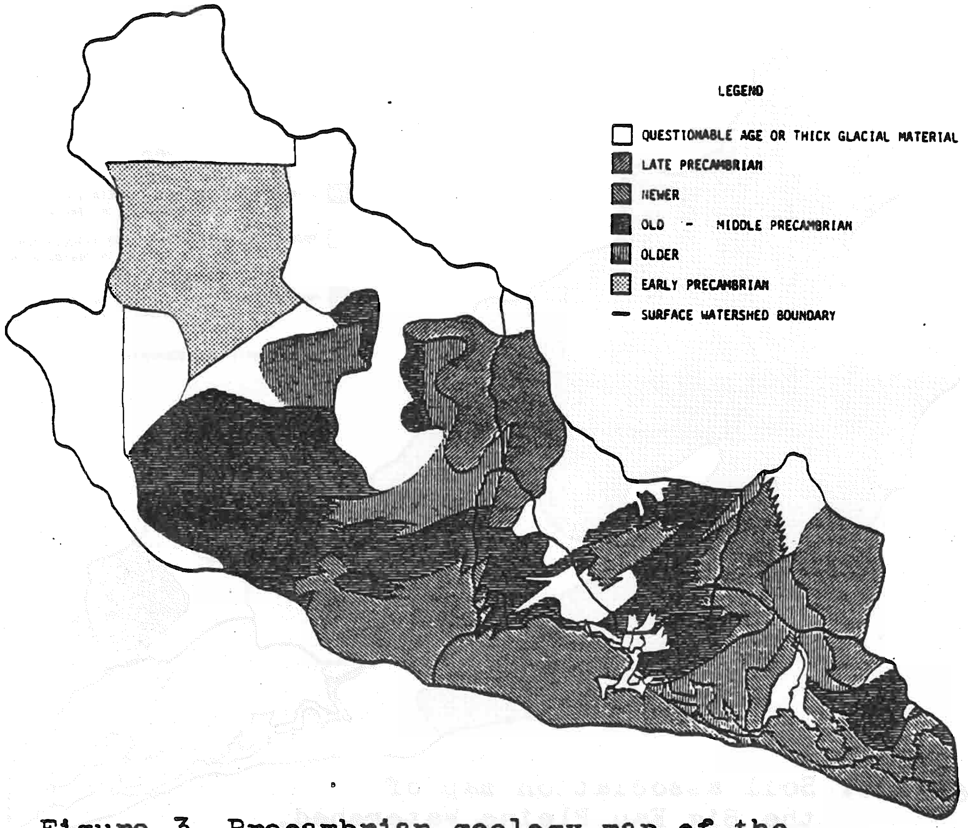


Figure 3. Precambrian geology map of the Big Eau Pleine Watershed. (Modified from LaBerge and Myers, Undated)

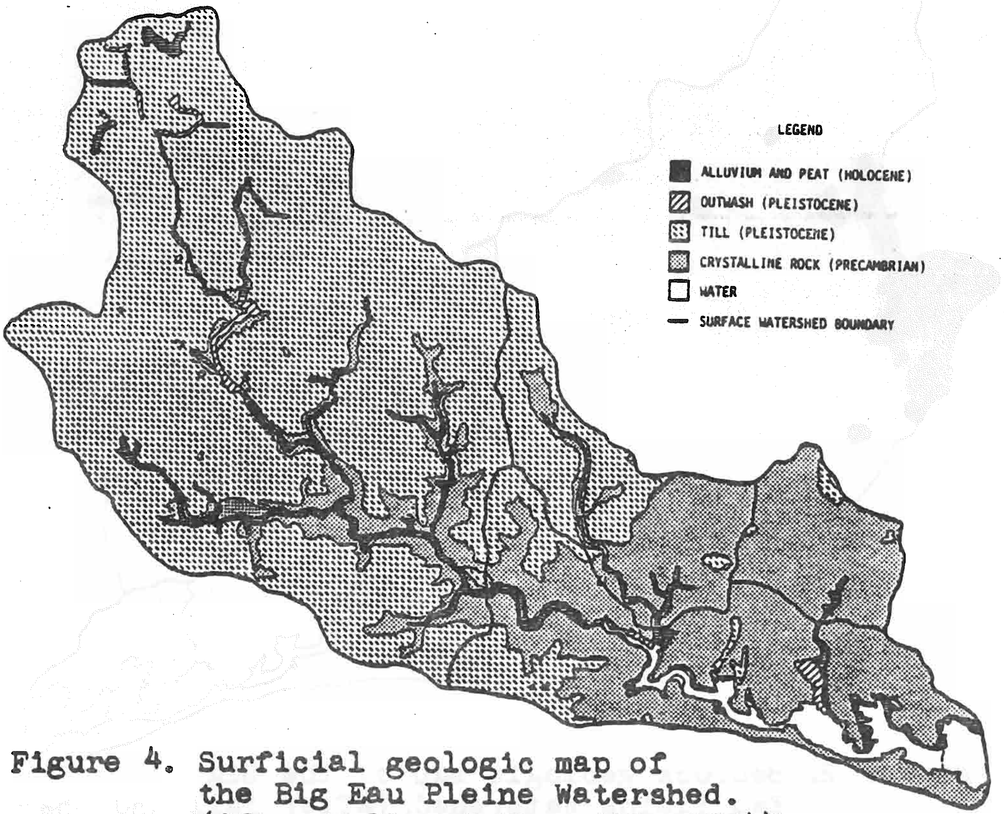


Figure 4. Surficial geologic map of the Big Eau Pleine Watershed. (After Pell and Sherrill, 1974)

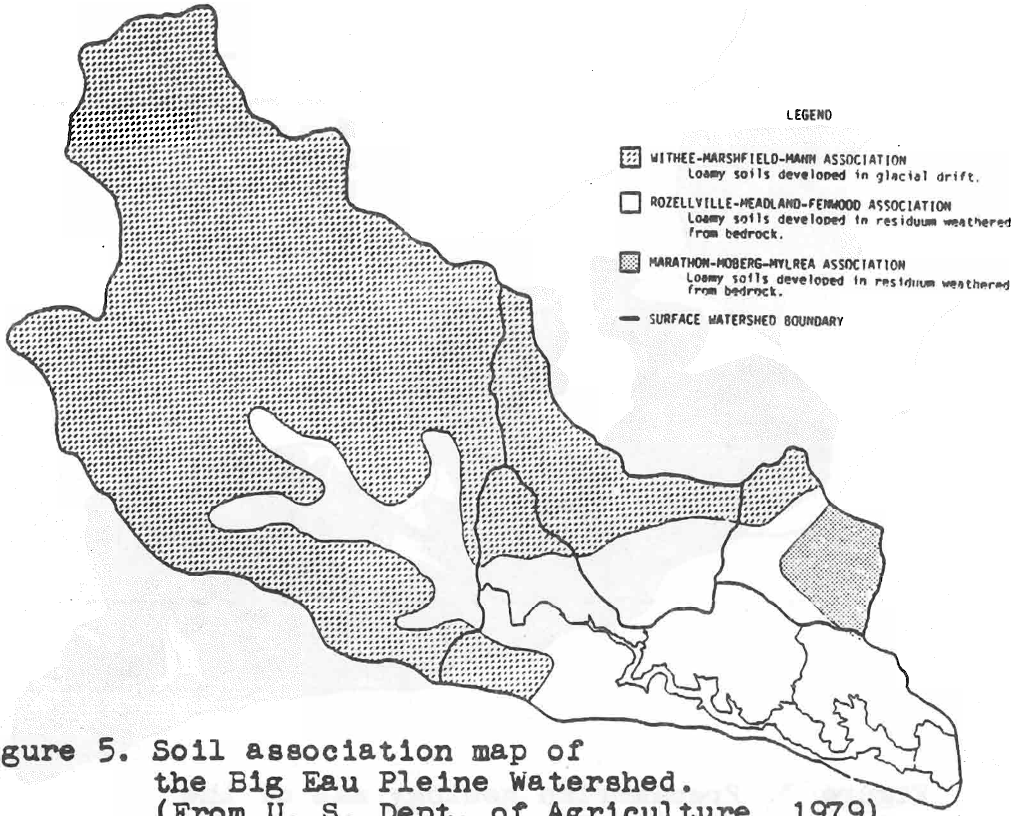


Figure 5. Soil association map of the Big Eau Pleine Watershed. (From U. S. Dept. of Agriculture, 1979)

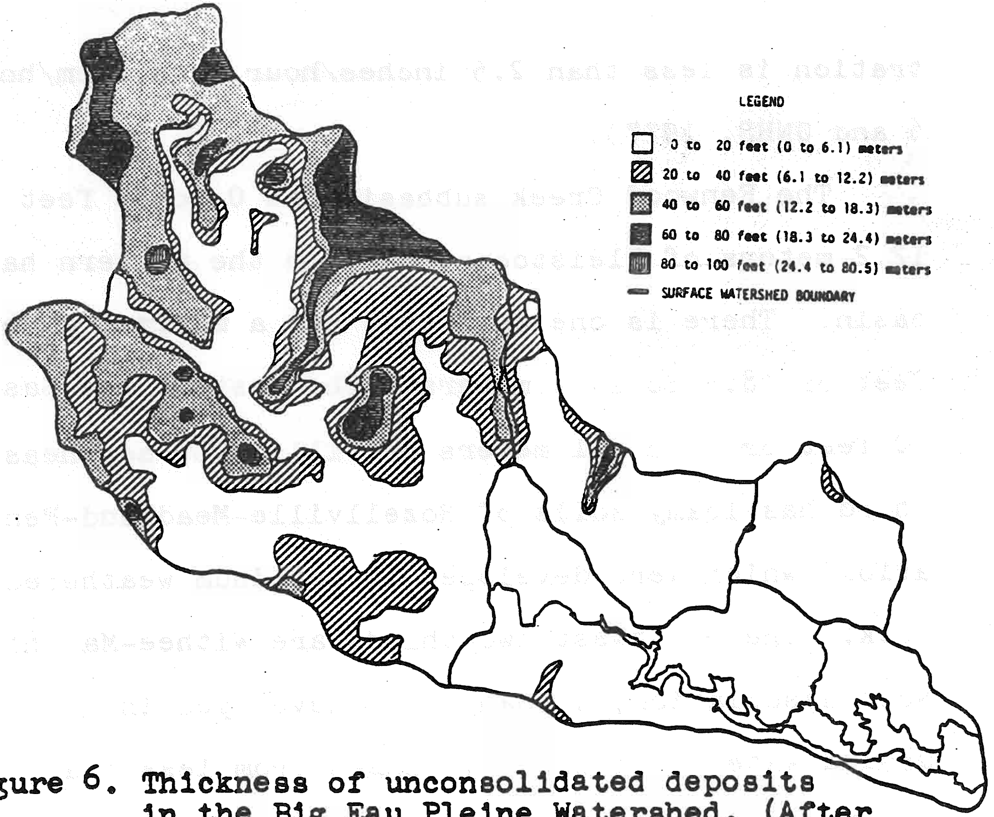


Figure 6. Thickness of unconsolidated deposits in the Big Eau Pleine Watershed. (After Pell and Sherrill, 1974)

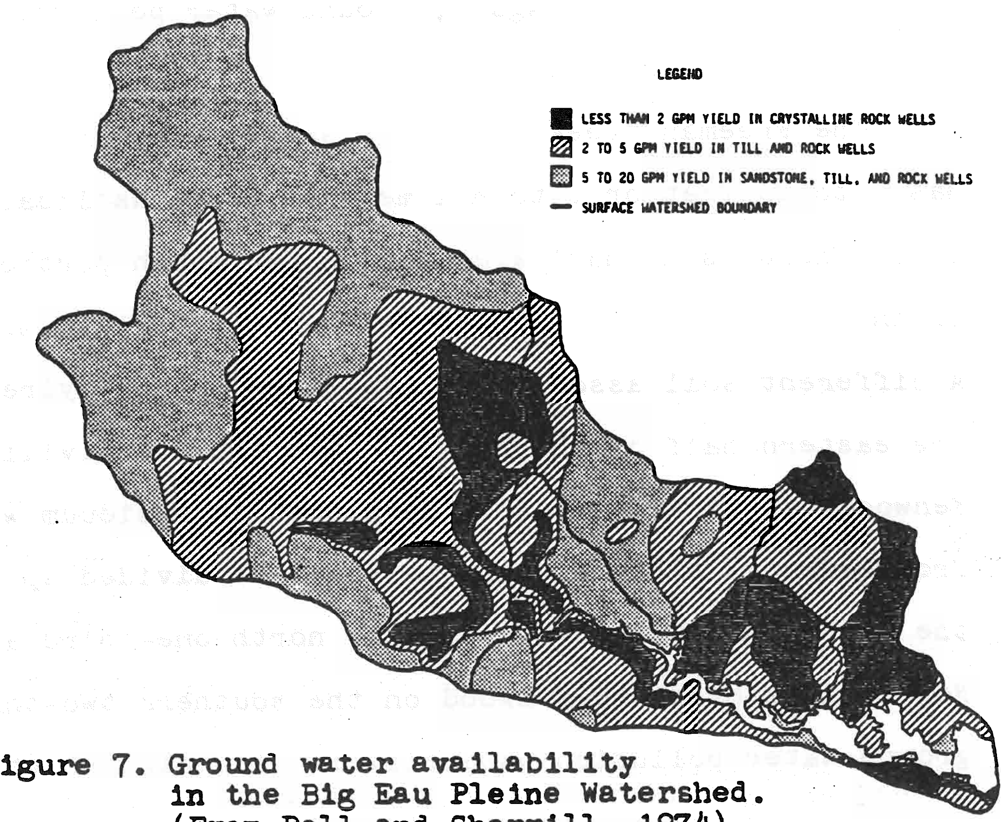


Figure 7. Ground water availability in the Big Eau Pleine Watershed. (From Pell and Sherrill, 1974)

tration is less than 2.5 inches/hour or 6.4 cm/hour (Figure 6 and GNHS, 1977).

The Fenwood Creek subbasin has 0 to 40 feet or 0 to 12.2 meters of Pleistocene till in the western half of the basin. There is one spot that has a maximum of 60 to 80 feet or 18.3 to 24.4 meters. The rest of the basin has 0 to 20 feet or 0 to 6.1 meters of till. The southeastern one third has loamy soils of Rozellville-Meadland-Fenwood association, which were developed in residuum weathered from bedrock. The northwest two-thirds are Withee-Marshfield-Mann soil association, a loamy soil developed in glacial drift. Ground water availability ranges from less than 2 gpm on the southeast and west sides of the basin to 5 to 20 gpm in the center of the basin. Again, ground water pollution potential is high in this basin.

The Freeman Creek subbasin, smallest of all the basins, has 0 to 20 feet or 0 to 6.1 meters of unconsolidated deposits. There is a small area in the far north portion of the basin that has till 20 to 40 feet or 6.1 to 12.2 meters thick. A different soil association, Marathon-Moberg-Mylrea, covers the eastern half of the basin. Like the Rozellville-Meadland-Fenwood, it is a loamy soil developed in residuum weathered from bedrock. The rest of the basin is divided up between the Withee-Marshfield-Mann on the north one-third and the Rozellville-Meadland-Fenwood on the southern two-thirds. The ground water pollution potential is also high in this basin.

The associated area is characterized by a mixture of till on the western end and residuum throughout this basin, generally from 0 to 20 feet or 0 to 6.1 meters thick. A small portion of the till in the southwest is 20 to 40 feet or 6.1 to 12.2 meters thick. The soils are almost exclusively Rozellville-Meadland-Fenwood with only a small portion in the north and southwest of Withee-Marshfield-Mann association. Ground water availability ranges from less than 2 to 20 gpm and generally has lower yields than higher yeilds. The higher yields are located along portions of the reservoir and in the uplands of the western half of the area.

Precipitation and Air Temperature

An evaluation of the available climatological weather stations was necessary to calculate a water budget and apply a water quality computer model to the Big Eau Pleine Reservoir. Figure 8 shows the location and distribution of stations that record precipitation and air temperature. The best station for precipitation input quantity to the reservoir was the Eau Pleine Reservoir station. Precipitation was recorded at this station with both daily and hourly gages. The following details of the weather stations describe the type of recording device, length of record, numeration, location, and station elevation.

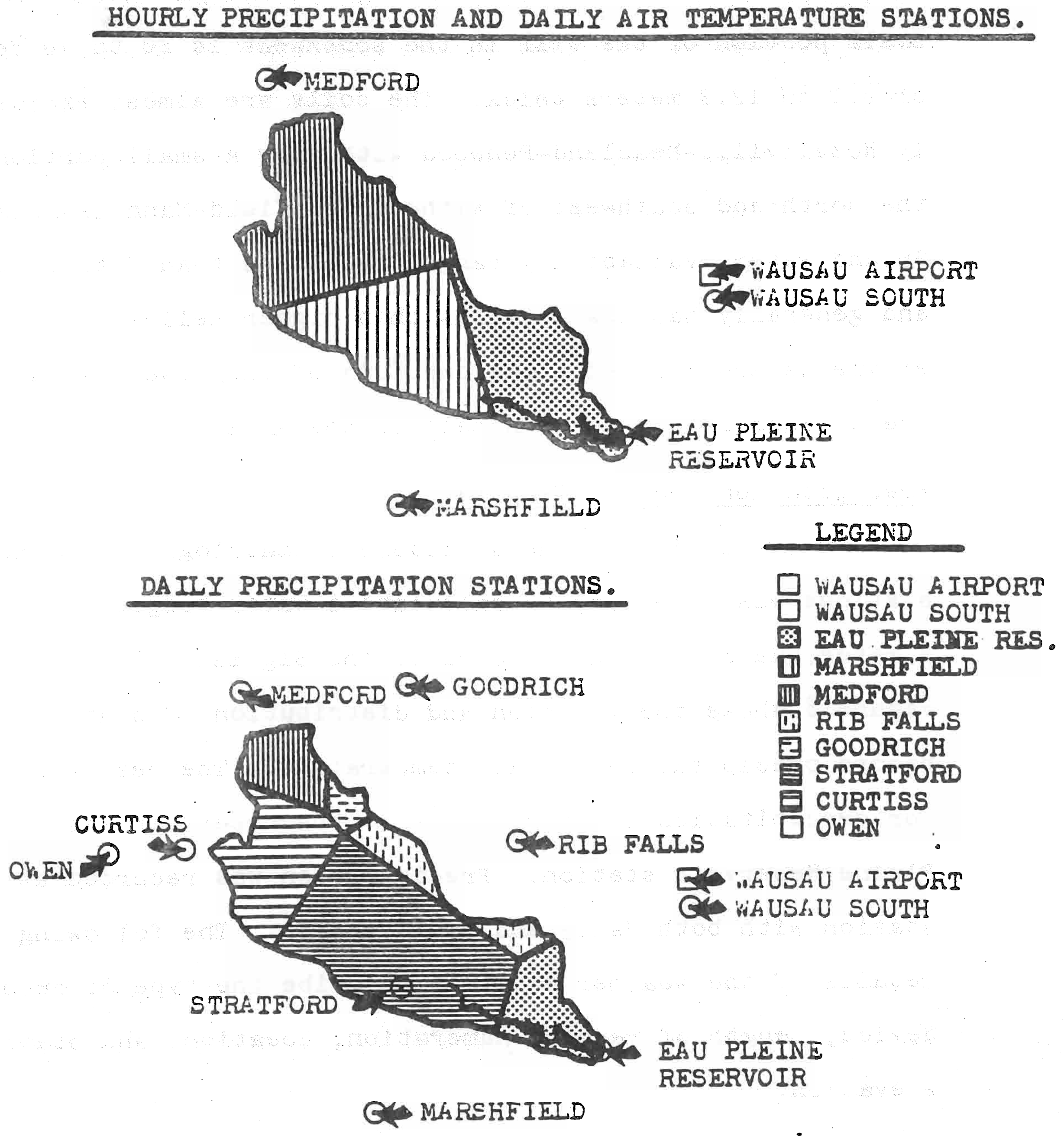


Figure 8. Precipitation Distribution By The Thiessen Polygon Method.

Precipitation Recording Stations (State Climatologist,1982):

1. Eau Pleine Reservoir- Wisconsin Valley Improvement Company (WVIC)- Wausau, WI.

    Recording Device- Standard rain gage and recording rain gage.

    Length of Record - December 16, 1946 to present.

    Recording rain gage April 8, 1954 to present.

    Numeration - 7 a.m. each day.

    Location - Latitude 44° 44', Longitude 89° 45'.

    Elevation- 1138 feet above mean sea level.

2. Marshfield Experimental Farm - University of Wisconsin

    Recording Device - Standard rain gage and recording rain gage.

    Length of Record - December 13, 1912 to present.

    Recording Rain gage April 15, 1941 to present.

    Numeration - 5 p.m. each day.

    Location - Latitude 44° 39' , Longitude 90°08'.

    Elevation - 1250 feet above mean sea level.

Air Temperature Recording Stations (State Climatologist,1982):

1. Eau Pleine Reservoir - WVIC - Wausau, WI.

    Recording Device - Hygro-thermograph in a standard weather shelter.

    Length of Record - November 8, 1974 to present.

    Quality - Holes in the 1974 and 1975 data, 1976 good.

    Numeration - Minimum and maximum evaluated from midnight to midnight.

Location - Latitude 44° 44', Longitude 89° 46'.

Elevation - 1138 feet above mean sea level.

2. Wausau FFA:

Recording Device - Maximum and minimum thermometers in a standard weather shelter. Read at 06:00, 12:00, 18:00, and 24:00.

Length of Record - December 1941 to present.

Quality - Good.

Numeration - Minimum and maximum evaluated from midnight to midnight.

Location - Latitude 44° 45', Longitude 89° 37'.

Elevation - 1200 feet above mean sea level.

3. Marshfield Experimental Farm - University of Wisconsin

Recording Device - Minimum and maximum thermometers in a standard wether shelter. Read at 17:00.

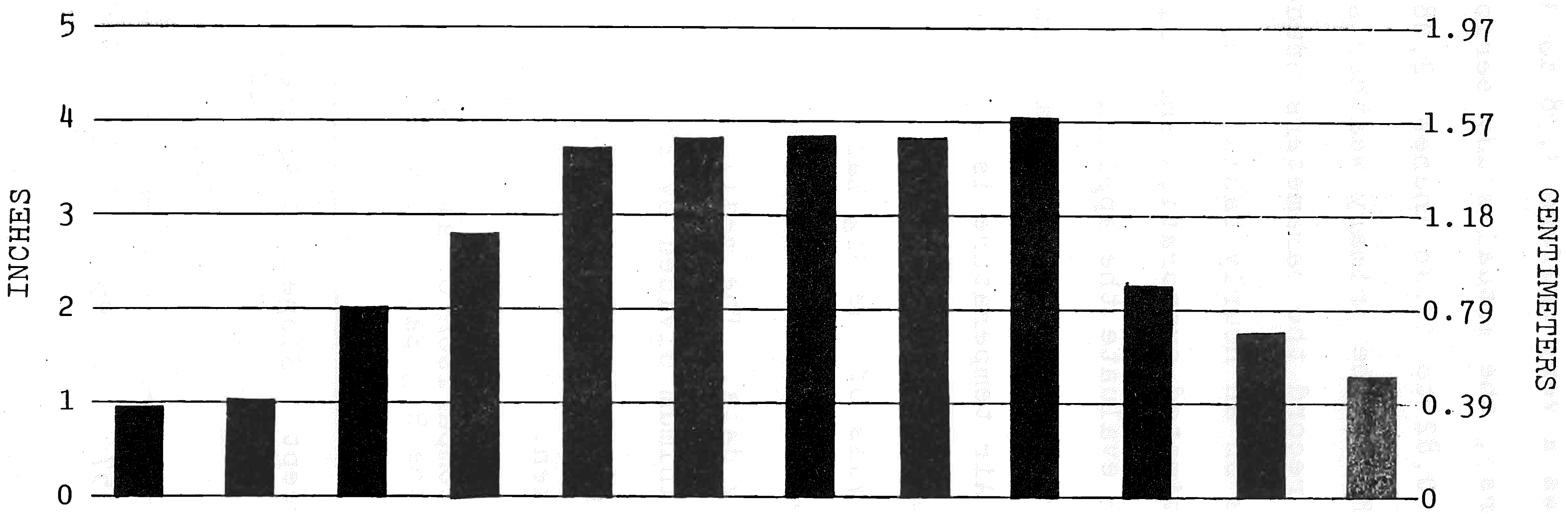
Length of Record - January 1913 to present.

Quality - Good.

Location - Latitude 44° 39', Longitude 90° 08'.

Elevation - 1250 feet above mean sea level.

Figure 9 is a plot of the 30 year mean monthly precipitation measured at the Big Eau Pleine Reservoir. The mean is 31.52 inches (80.06 centimeters). The month with the highest amount was September, with 4.03 inches (10.24 centimeters). The monthly data for the study period (1975-1978) was included to show the summer months, May thru August.



	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
X̄	.95	1.02	2.02	2.83	3.78	3.84	3.87	3.87	4.03	2.19	1.82	1.31	31.52
1975:	1.14	1.16	1.83	3.87	3.09	4.22	2.00	5.26	4.32	.91	4.11	1.97	33.88
1976:	1.24	1.23	3.30	5.76	2.87	.96	3.24	.82	.79	.55	.03	.45	21.24
1977:	.42	1.32	3.61	2.38	4.62	3.60	3.76	3.12	5.13	1.98	4.80	1.98	34.88
1978:	.54	.24	.27	3.68	5.30	3.87	10.46	4.95	4.02	1.85	2.39	1.05	37.94

Note: 1951 to 1980; Max. 38.28 - 1965, Min. 21.24 - 1976. (State Climatologist, 1982)

Figure 9. Thirty year mean monthly precipitation at Big Eau Pleine Reservoir.

While the mean data shows a very uniform 3.78 to 3.87 inches (9.60 to 9.83 centimeters), the actual study period data shows more variability, 0.82 to 10.46 inches (2.08 to 26.57 centimeters). Wausau FFA is the primary weather station for this study because they record the parameters needed to run the water quality models on an hourly basis. The computer water quality models estimated evaporation and solar radiation from this data. To evaluate the applicability of this station to the reservoir, a statistical comparison of air temperatures was done. Air temperature is a parameter that integrates many of the weather factors into one comparable number. Regression analysis of the Big Eau Pleine Reservoir, Wausau FFA, and Marshfield Experimental Farm air temperature was done on matched daily data. The median of the daily extremes (Maximum plus minimum divided by 2) was used. Table 1 shows the results of this analysis done on days when simultaneous readings were taken.

Table 1. A statistical comparison of air temperature recording stations with the Big Eau Pleine Reservoir Station.

Weather Station	Sample Size	Intercept	Slope	R-Squared (X 100)	St. Dev. of Y about Regression Line
Wausau FFA	855	-0.157	0.995	98.5	2.80
Marshfield Exp. Farm	848	-0.735	1.00	97.5	3.62

Based on this evaluation, the use of Wausau FFA as the primary weather station for the Big Eau Pleine Reservoir is adequate.

Tributary Flow

Big Eau Pleine River, near Stratford, is the name of the permanent gaging station operated by the U. S. Geological Survey - Water Resources Division (USGS). The gage is located 15 feet (4.6 m) upstream from the bridge of State Highway 97, north of Stratford, WI (USGS,1980). A number of factors combine to produce a river which has flashy flood flows and very low flows from a 224 mi^2 (580 km^2) watershed (Table 2). Extremes for the period of record include a maximum discharge of 41,000 ft^3/s (1,160 m^3/s) September 9, 1938 and no flow August 17, 1947 and January 22 to February 5,1961 (USGS, 1977). Records have been kept at this station from July 1912 to December 1925 and April 1937 to the present. Figure 10 is a plot of the average monthly flows for a 53 year period. The lowest flows occurred in February and the highest in April (spring runoff) with a secondary peak in September - November (fall rains). The 53 year average yearly discharge was 172 ft^3/s (4.871 m^3/s). Daily flow is reported as a mean value from midnight to midnight. Flow records at this station are reported as good (95 percent of the daily discharges were measured to within 10 percent) except for fair (95 percent of the measurements to within 15 percent) in the winter period.

Table 2. Mean monthly flow data of mean daily discharge for the Big Eau Pleine River near Stratford, WI. (USGS, 1976-1980).

Note: Table in CFS, to get m/s, multiply by 0.0283.

Month	1975	1976	1977	1978	$\bar{X}$(53 years)
Jan.	7.85	15.6	0.40	19.6	19.4
Feb	7.43	42.9	0.52	9.69	17.1
Mar.	66.4	1202.0	168.0	269.0	427.0
Apr.	918.0	535.0	153.0	564.0	641.0
May	113.0	84.4	15.8	173.0	257.0
June	90.2	7.14	10.0	131.0	205.0
July	13.3	5.82	57.6	642.0	67.0
Aug.	52.4	4.38	7.42	371.0	62.6
Sept.	97.4	3.56	144.0	391.0	141.0
Oct.	15.8	5.88	158.0	109.0	81.1
Nov.	227.0	4.89	146.0	38.6	107.0
Dec.	152.0	3.15	101.0	21.9	44.2
Daily mean total	146.0	160.0	80.4	230.0	172.0
Maximum	3130.	7650.	1090.	5770.	-
Minimum	0.36	0.30	0.33	8.6	-
Peak Discharge	4110.	9470.	1400.	9350.	41,000.
Date	Apr. 28	Mar. 30	Apr. 3	July 22	Sept. 9, 1938
Minimum Discharge	1.6	0.15	0.33	7.2	No flow
Date	July 7	Aug. 27	Jan. 13-23	Aug. 14	Aug. 17, 1947 & Jan. 22 to Feb. 5, 1961

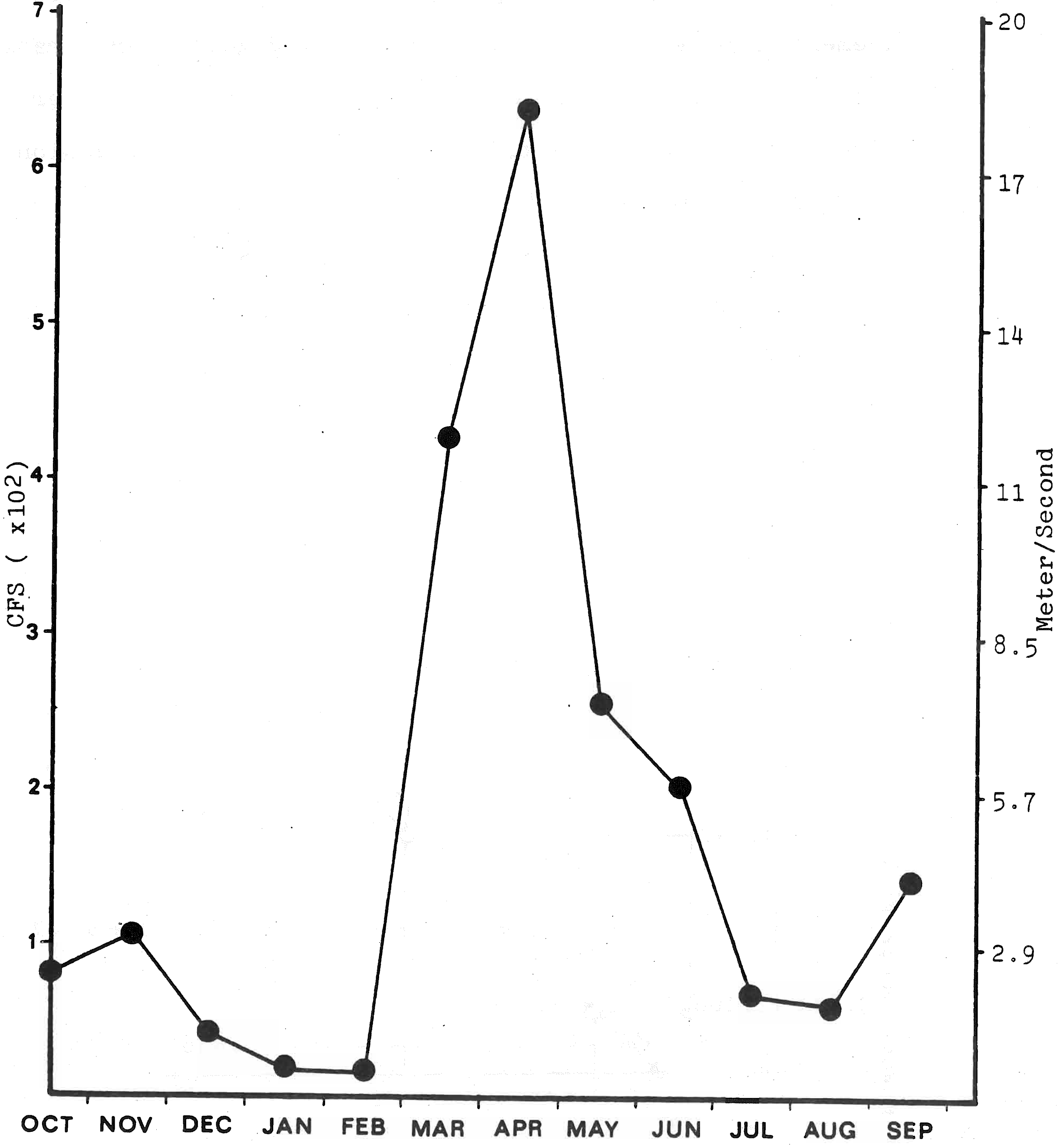
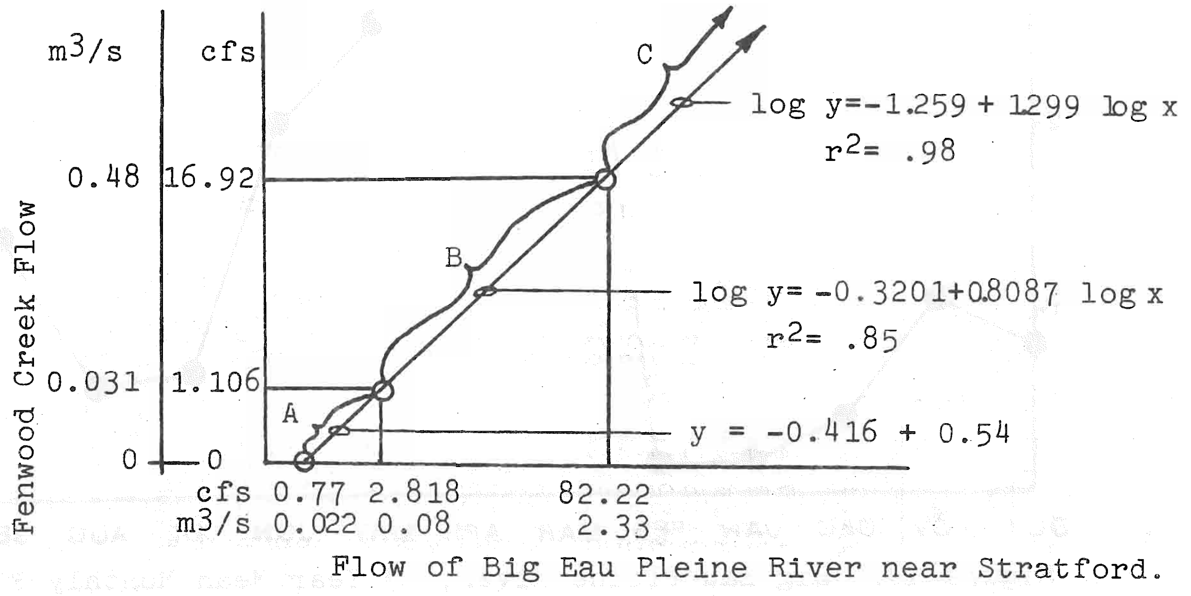


Figure 10. Big Eau Pleine River, 53 Year Mean Monthly Flow.

Flow relationships used in the reservoir's water budget for estimating the tributary flows, were based on stream flow measurements made by the U.S. Geological Survey. Flow in the tributary streams was compared with the mean daily flow measurement made at the Big Eau Pleine River gage near Stratford. Table 3 contains measurements from Big Eau Pleine River near Stratford, Fenwood Creek, and Freeman Creek. Regression equations derived from this data were used to predict daily discharge from the reservoir's tributaries.

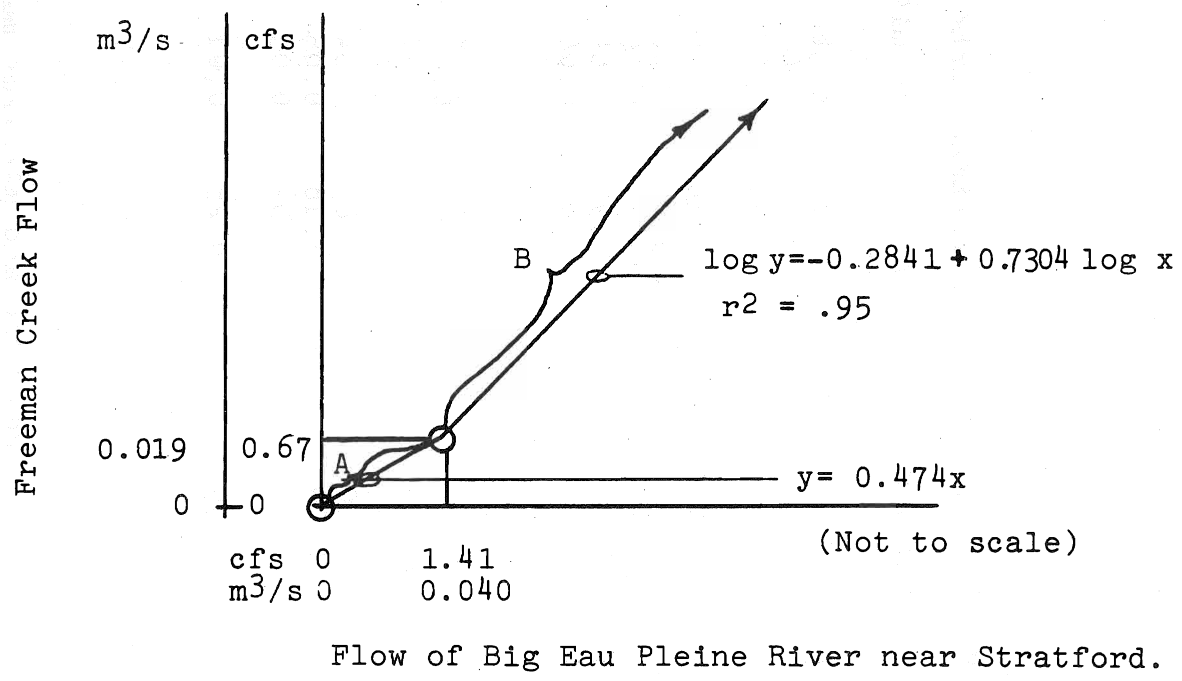
The best relationship for Fenwood Creek was developed as three line segments (A-C Figure 11) and a point of zero flow. The point was determined as 0.77 cubic feet per second (cfs) or 0.022 m^3/s by taking the average of the three dates when no flow was reported for Fenwood Creek.

Figure 11. Streamflow relationships between Big Eau Pleine River near Stratford and Fenwood Creek at Highway 153. Not to scale.



Freeman Creek's best relationship to the Big Eau Pleine River was a two part relationship (A and B, Figure 12).

Figure 12. Streamflow relationship between the Big Eau Pleine River near Stratford and Freeman Creek at Highway 153.



The Big Eau Pleine River's flow was estimated down to Site #8, Figure 1. This was done by assuming that the flow from EP6 (USGS Gaging station) to Site #8 is the same per unit of watershed surface area. Therefore the flow at EP6 was multiplied times the flow ratio of 226.91/224.32. This same kind of assumption was employed to obtain a daily flow from the associated area.

Reservoir Stage and Outflow

The Big Eau Pleine Dam is owned and operated by the Wisconsin Valley Improvement Company. They have developed a

	BIG EAU PLEINE RIVER		FENWOOD CREEK		FREEMAN CREEK	
DATE	cfs	cfs/mi^2	cfs	cfs/mi^2	cfs	cfs/mi^2
4/26/74	48.0	0.21	11.1	0.30	12.7	0.58
6/11/74	731.0	3.26	93.0	2.52	36.1	1.66
8/ 1/74	3.8	0.02	0.26	0.01	1.43	0.07
2/18/75	7.2	0.03	0.65	0.02	1.18	0.05
4/17/75	1600.0	7.14	204.0	5.52	109.0	5.02
5/22/75	24.0	0.11	8.2	0,22	14.3	0.66
7/30/75	1.4	0.01	0.17	0.00	0.97	0.04
8/22/75	5.4	0.02	0.78	0.02	1.41	0.06
9/30/75	21.0	0.09	1.14	0.03	3.54	0.16
2/19/76	92.0	0.41	12.4	0.34	14.9	0.69
3/16/76	35.0	0.16	11.1	0.30	13.6	0.63
3/25/76	4800.0	21.43	495.0	13.39	245.0	11.27
5/22/76	49.0	0.22	8.6	0.23	12.3	0.57
8/24/76	0.89	0.00	0.00	0.00	0.89	0.04
10/1/76	1.16	0.01	0.00	0.00	1.16	0.05
11/9/76	4.3	0.02	0.10	0.00	1.04	0.05
1/13/77	0.25	0.00	0.00	0.00	0.25	0.01
$\overline{X}$	436.73	1.95	49.79	1.35	27.63	1.27

Note: Units in the table are cfs and cfs/mi^2. To get m^3/s and m^3/s/km^2 multiply by 0.0283 and 0.0109 respectively.

Table 3. Flow measurements for some Big Eau Pleine Tributaries.

stage versus outflow relationship and record a daily stage and outflow rate. The reservoir is measured at 7:00 a.m. each day. The gage is a float activated tape in an open bottom pipe, read manually to a point of known elevation on the top. This type of gage is used to reduce the effects of summer waves and to prevent wintertime freezing when a layer of antifreeze or oil is placed in the pipe.

The reservoir's dam has four gates (Sheerar, 1976); three taintor and one sluice. Each taintor gate is opened from the bottom and can be raised to clear the water surface. They are 26 feet (7.92 meters) wide and have a sill elevation of 1129.93 feet (344.40 meters) above mean sea level.

Elevation of the sluice sill is 1112.93 feet (339.22 meters) above mean sea level. It opens from the bottom with a maximum opening of 10 feet (3.05 meters) by 6 feet (1.83 meters) high (Sheerar, 1976).

Reservoir Area and Volume

Figure 13, A through D, is a Bathymetric map of the reservoir which was determined by measurements with a recording sonar in June 1969 (DNR, 1969). The reservoir is physically segmented by the roads which cross it. In downstream order the first segment, which is defined for purposes of this study, is the portion of the reservoir from Highway 153 crossing (Figure 13-D) to County Road S (Figure 13-C). This segment has a maximum depth of 25 feet (7.6 meters).

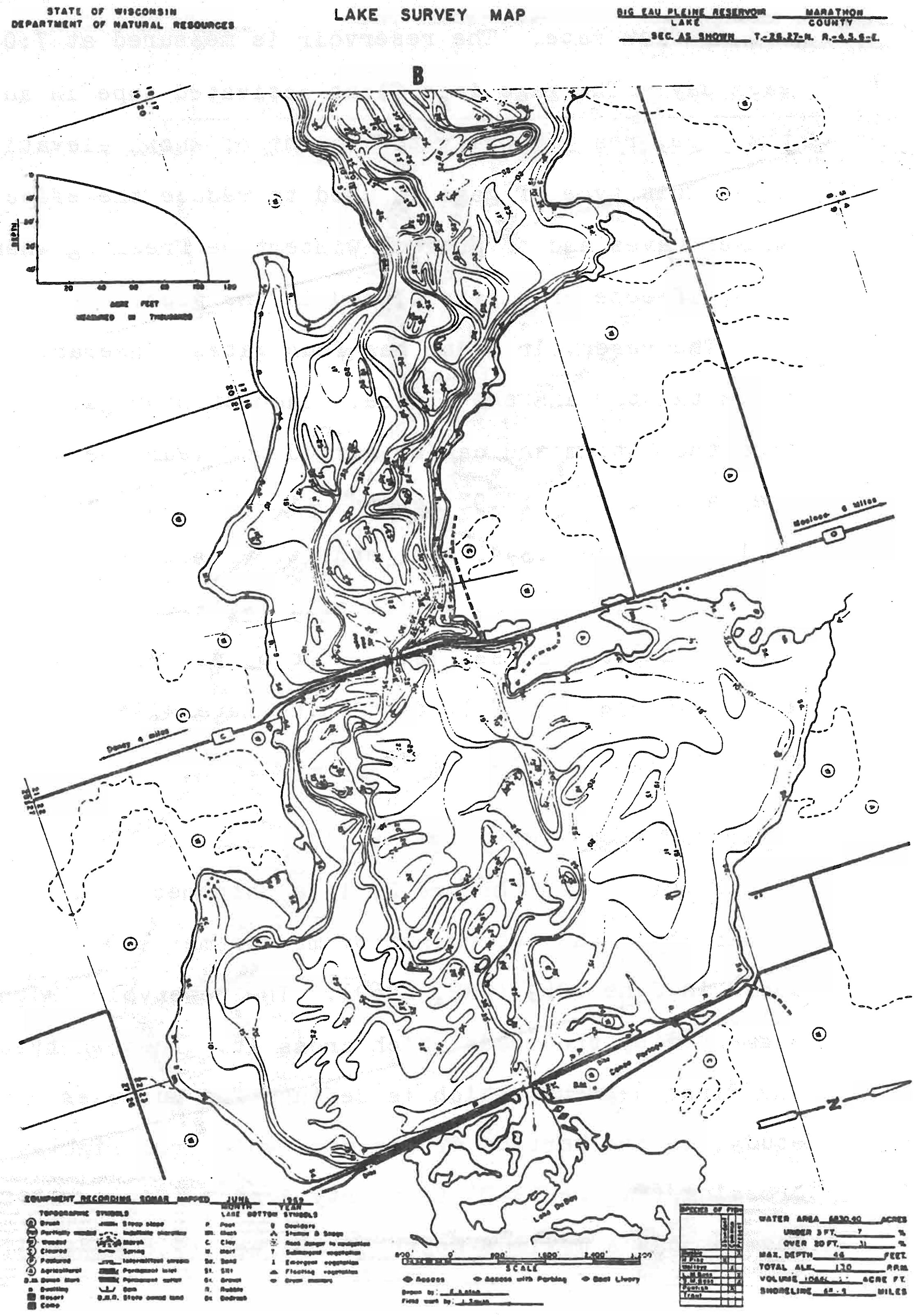


Figure 13-A Bathymetric map of the Big Eau Pleine Reservoir.

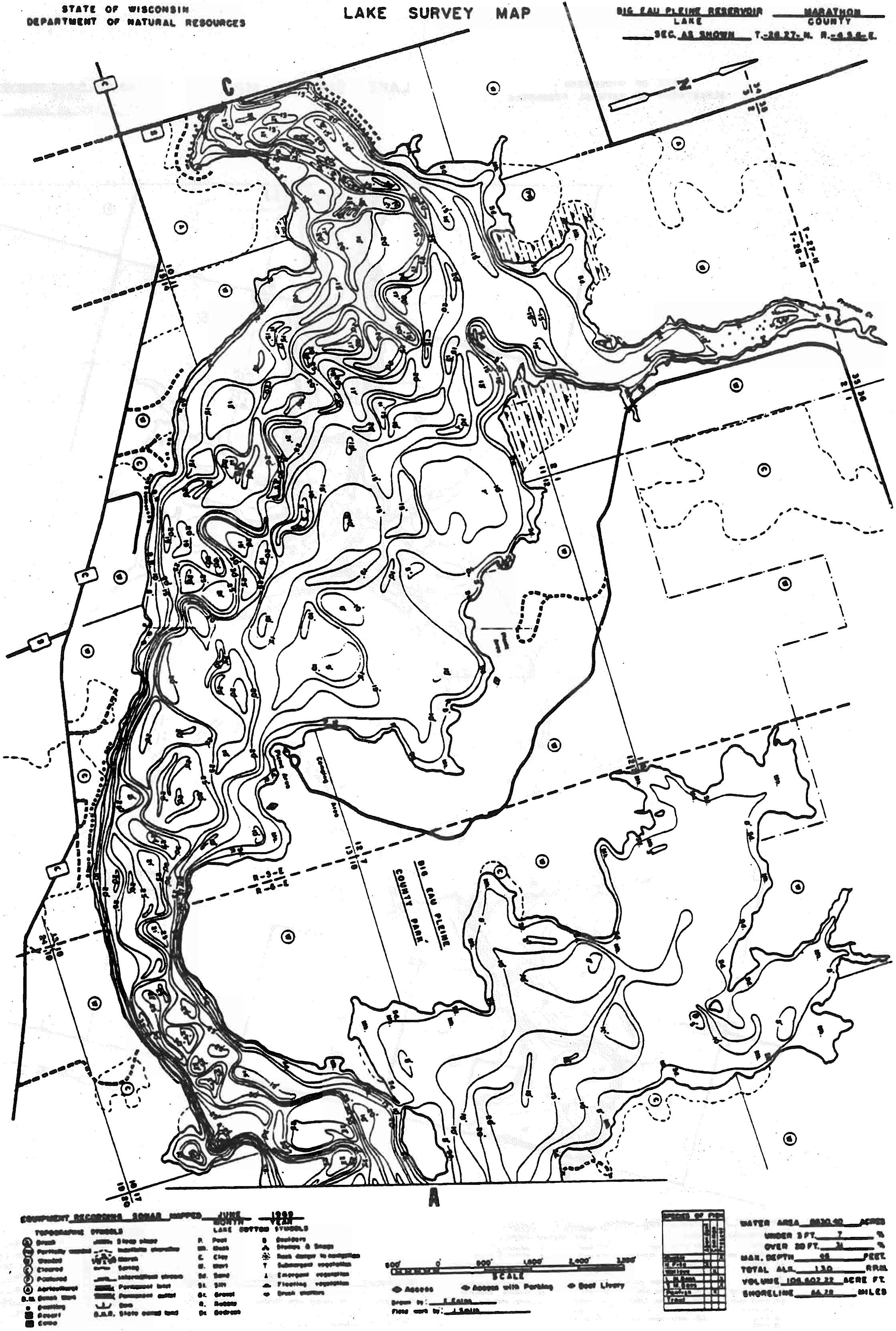


Figure 13-B Bathymetric Map of the Big Eau Pleine Reservoir.

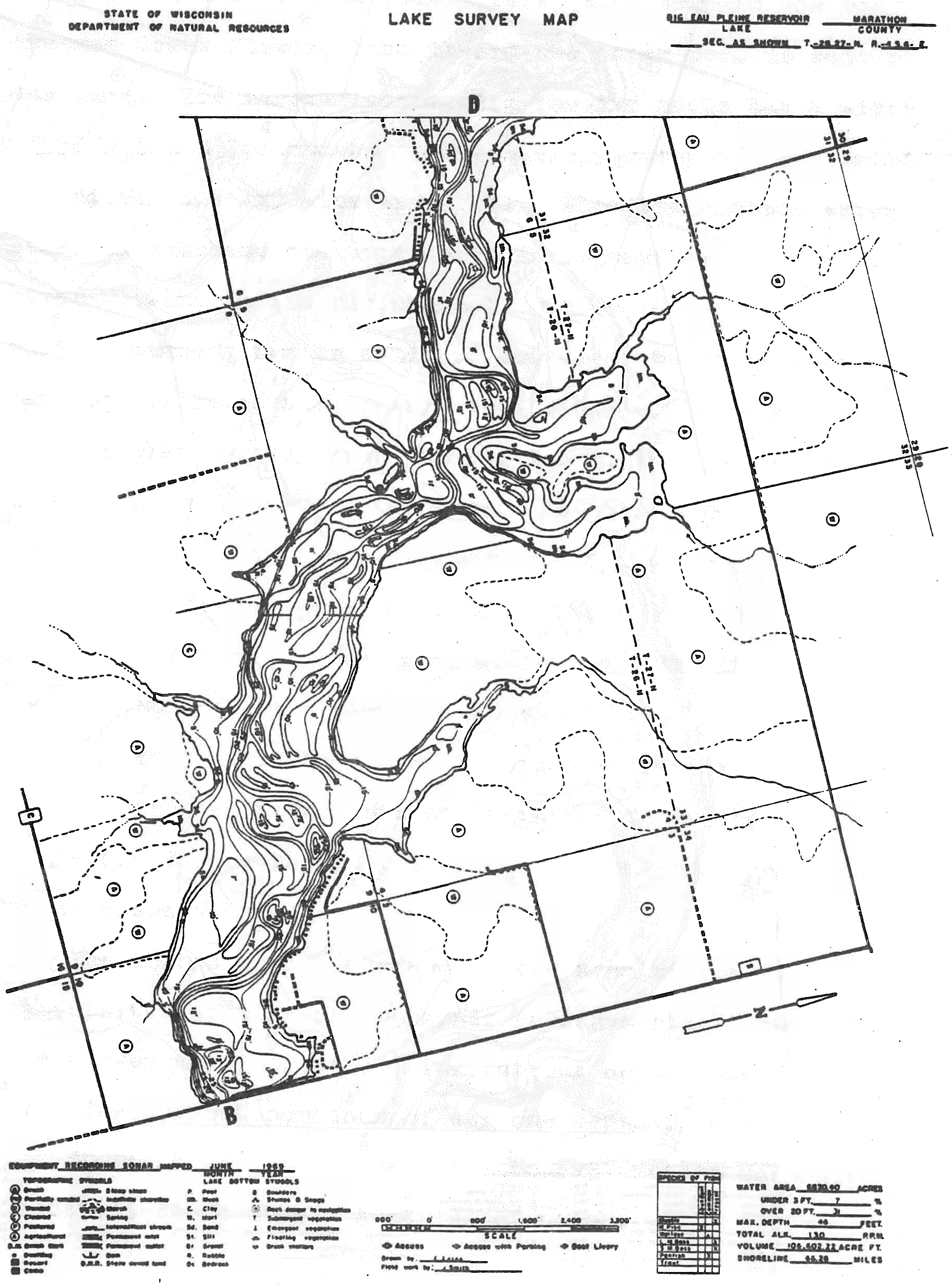


Figure 13-C Bathymetric Map of the Big Eau Pleine Reservoir.

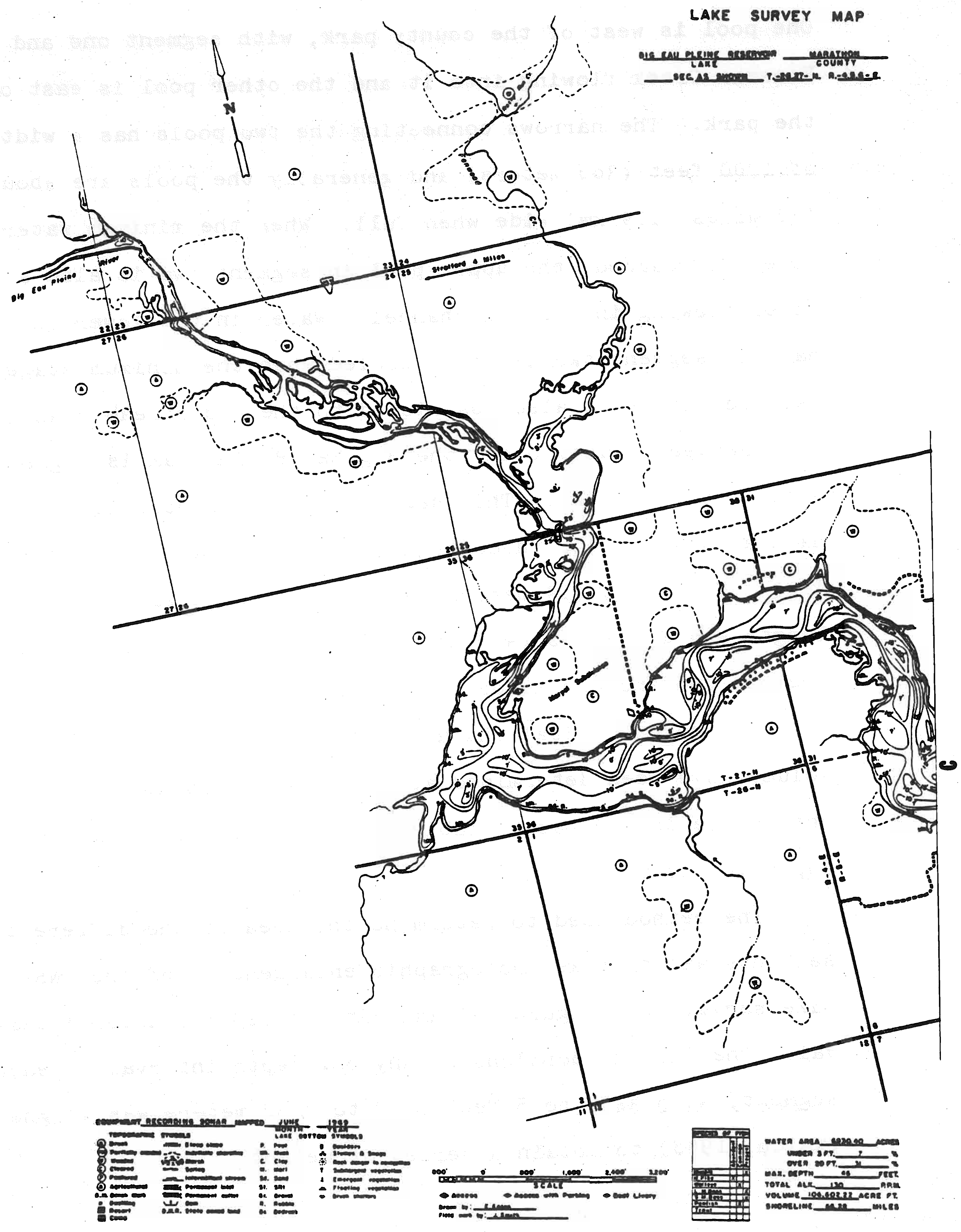


Figure 13-D Bathymetric Map of the Big Eau Pleine Reservoir.

One pool is west of the county park, with segment one and Freeman Creek flowing into it and the other pool is east of the park. The narrows connecting the two pools has a width of 1200 feet (366 meters) and generally the pools are about 1.2 miles (1.9 km) wide when full. When the minimum water level is reached, the upper pool in segment two is also a river flowing in its old channel. Water in the lower one half of segment two is still pooled when the minimum stage is reached but it is also restricted to the old stream channel.

Between County O and the Big Eau Pleine Dam is segment three (Figure 13-A). This segment is shaped most like a natural lake of the three segments. It contains the maximum depth of 46 feet (14 meters). Into its 1.5 miles (2.4 km) length and 2.5 miles (4.0 kim) width flows the outflow from segment two and one minor tributary.

The morphological characteristics of reservoir area and volume have been determined at different times and by different people in the past. Table 4 shows some measurements of depth versus volume curves.

The method used to determine the area of the different segments was to take photographic enlargements of the DNR's lake survey map (Figure 13) and cut out depth counter interval. The cut out portions of any one depth interval in each segment, such as 0 to 5 feet or 0 to 1.52 meters was weighed (Welch, 1948) to obtain a series of weight

Depth above bottom	Accumulative Volume			Elevation above Mean Sea Level	
	This study	DNR-(L. Andrews)	WVIC -(L.L. Sheerar)		
(m)	(m^3)	(m^3)	(m3)	(ft.)	(m)
0	0	0	0	1,100.43	335.41
1.52	22,000	36,400	-	1,105.43	336.94
3.05	368,000	428,000	-	1,110.43	338.46
4.57	2,222,000	2,389,000	2,507,000	1,115.43	339.98
6.10	7,658,000	7,976,000	8,686,000	1,120.43	341.51
7.62	18,141,000	18,651,000	18,925,000	1,125.43	343.03
9.14	34,999,000	35,734,000	34,089,000	1,130.43	343.56
10.67	59,380,000	60,361,000	56,198,000	1,135.43	344.56
12.19	91,952,000	93,142,000	87,633,000	1,140.43	346.08
13.72	131,488,000	132,878,000	127,934,000	1,145.43	349.13

Table 4. Depth versus volume data for the Big Eau Pleine Reservoir.

percentages that were used to divide the total reservoir area for each depth interval in the segments. Table 5 contains the depth versus area data used in the water budget calculations.

Volumes of the reservoir and the segments were calculated from the surface area and depth data. The area at the bottom (i.e. zero) is added to the surface area at 5 feet (1.52 meters) and divided by two, to get a average area. This area times the thickness of 5 feet (1.52 meters) yields a volume for the first layer. These volumes are accumulated from the bottom of the full lake surface and are tabulated in Table 6.

If the water body is sliced into layers one meter thick. The difference of the area on the top of the layer and the area on the bottom of each meter slice will give an estimate of the sediment area in contact with that meter slice (element). Divide it by the average area of the top and bottom of the element will produce a ratio called RA. The RA factor is useful to describe the physical characteristics of a lake or reservoir system. Figure 14 is a plot of the Big Eau Pleine's RA factor numbers versus depth in meters for the total reservoir and for its three segments. The inverse of the RA factor is the volume in cubic meters that is in contact with one square meter of bottom sediment per element. This is the logrithmic scale labeled on the right side of Figure 14.

A discussion of the characteristic volume, area, depth

Depth above lake bottom (m)	Area (m^2)			
	Total	Segment 1	Segment 2	Segment 3
0.0	0.	0.	0.	0.
1.5	28,790.	0.	2,476.	26,314.
3.0	425,567.	0.	157,034.	268,533.
4.6	2,006,988.	0.	852,974.	1,154,024.
6.1	5,126,720.	56,394.	2,558,234.	2,512,092.
7.6	8,630,731.	327,968.	5,074,870.	3,227,893.
9.1	13,492,786.	1,416,493.	7,879,787.	4,196,256.
10.7	18,502,712.	3,367,493	9,991,465.	5,143,754.
12.2	24,242,936.	5,672,847.	12,169,954.	6,400,135.
13.7	27,641,730.	7,352,700.	13,406,239.	6,882,791.

Table 5. Depth versus area data used to calculate the water budgets for the Big Eau Pleine Reservoir.

Depth Above Bottom (m)	Volume (m^3)			
	Total	Segment 1	Segment 2	Segment 3
0.0	0	0	0	0
1.5	22,000	0	1,857	19,736
3.0	368,000	0	121,490	240,871
4.6	2,222,000	0	929,496	1,378,916
6.1	7,658.000	42,296	3,487,902	4,128,503
7.6	18,141,000	330,567	9,212,730	8,433,492
9.1	34,999,000	1,639,100	18,928,723	14,001,604
10.7	59,380,000	5,466,489	33,225,724	21,473,612
12.2	91,952,000	12,246,744	49,846,788	30,131,529
13.7	131,488,000	22,015,904	69,028,933	40,093,723

Table 6. Depth versus volume used for calculating the water budgets for the Big Eau Pleine Reservoir.

and RA factor by segments helps to identify their differences and similarities. The segment with the largest area and volume when the reservoir is full is segment two. Segment one has a larger area than segment three, but, a smaller total volume when the reservoir is full. The area of segment one becomes smaller than segment three soon after any drawdown starts. With a mean depth of 2.99 meters (Table 7), segment one is the shallowest of the three segments. The RA factor of segment one is quite different than the other two segments. Because segment one is long and narrow rather than circular, it has less water volume per square meter of sediment contact area. The reversal of the RA factor between 6 and 7 meters corresponds to 19.7 and 23.3 feet on the Bathymetric map, Figure 13. This may be the steeper banks of the old river channel and the flatter portion of flood plain from 5 to 6 meters. Segment three's volume and area becomes larger than segment two near the 6.1 meter depth. In Table 7, the 6.1 meter depth corresponds to the 7.62 meter depth from the top on the RA plot, Figure 14, and 25 feet on the Bathymetric map Figure 13. With a full reservoir stage, segment three has greater than 4 cubic meters of lake water to one square meter of sediment contact area down to 7 meters (23 feet) as compared to only 5 meters (16.4 feet) in segment two. Below these points the RA factor in segment two and three increase at a rate similar to segment one. The

Table 7. Big Eau Pleine full reservoir mean depth and stage scales.

Mean Depths (m)

Total	Segment 1	Segment 2	Segment 3
4.76	2.99	5.15	5.83

Stage Scales

				----Elevation---	
	Meters	Meters	Feet	Feet	Meters
	13.72	0	0	1,145.43	349.13
Top	12.19	1.53	5	1,140.43	347.60
	10.67	3.05	10	1,135.43	346.08
	9.14	4.58	15	1,130.43	344.56
	7.62	6.10	20	1,125.43	343.03
	6.10	7.62	25	1,120.43	341.51
	4.57	9.15	30	1,115.43	339.98
	3.05	10.67	35	1,110.43	338.46
	1.52	12.20	40	1,105.43	336.94
Bottom	0	13.72	45	1,100.43	333.41

combination of a larger increase of RA per meter of depth followed by small increase may indicate a flood plain and then an old steep river bank. There are two such combinations in segment two at 6 to 7 meters (19.7 to 23 feet) and 9 to 10 meters (29.5 to 32.8 feet) and 11 to 12 meters (36.1 to 39.4 feet). An example cross-section through segment three,Figure 15, shows the old flood plains and stream channels in the reservoir.

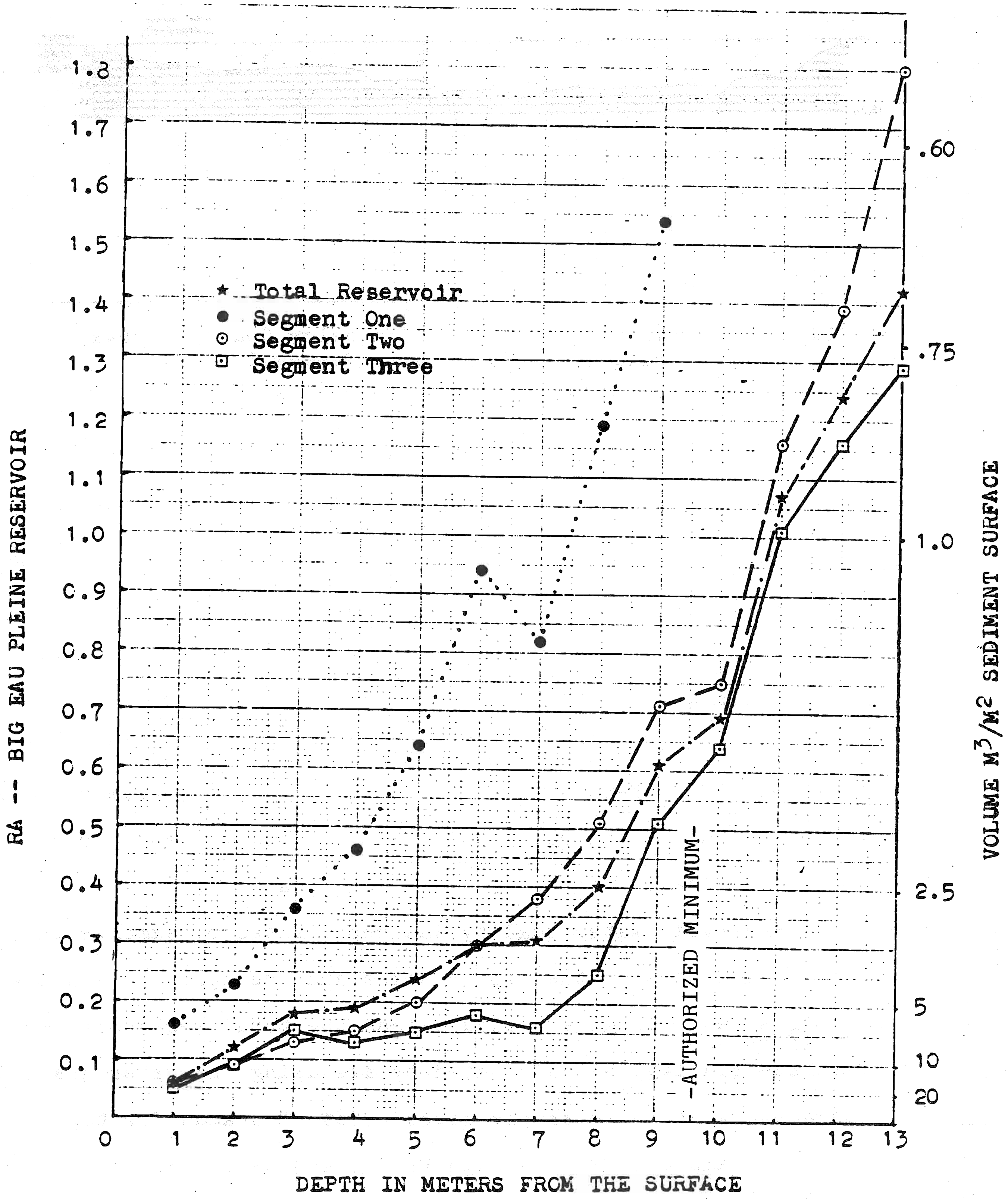


Figure 14. RA factor for the Big Eau Pleine Reservoir and its segments.

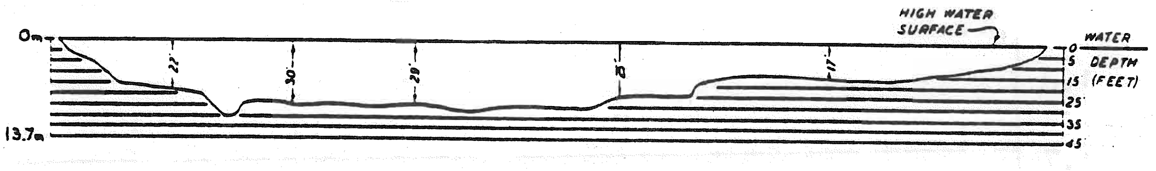


Figure 15. Sampling cross-section below County Highway O Bridge, Big Eau Pleine Reservoir.

WATER QUALITY

Methods

Figure 16 shows the water quality sampling sites in the Big Eau Pleine Watershed. Samples were collected from 39 sites in the watershed and 20 sites in the reservoir. Reservoir sites are labeled in Figure 1.

Inlet quality was sampled at sites Big Eau Pleine River Site #8 (EP8), Fenwood Creek Site #1 (FE1), and Freeman Creek Site #1 (FR1). The outlet site for the total reservoir and segment three is at the Big Eau Pleine Dam (EP26).

Reservoir water quality was represented by samples taken at three depths in the deeper sites and one depth in shallow water sites. In later calculations the total reservoir top average quality was calculated by averaging the water quality parameters at these sample sites: EP8T (T stands for top, surface sample), EP9T through EP17T, and EP20T through EP25T. Total reservoir average middle sites were EP12M through EP15M and EP20M through EP25M.

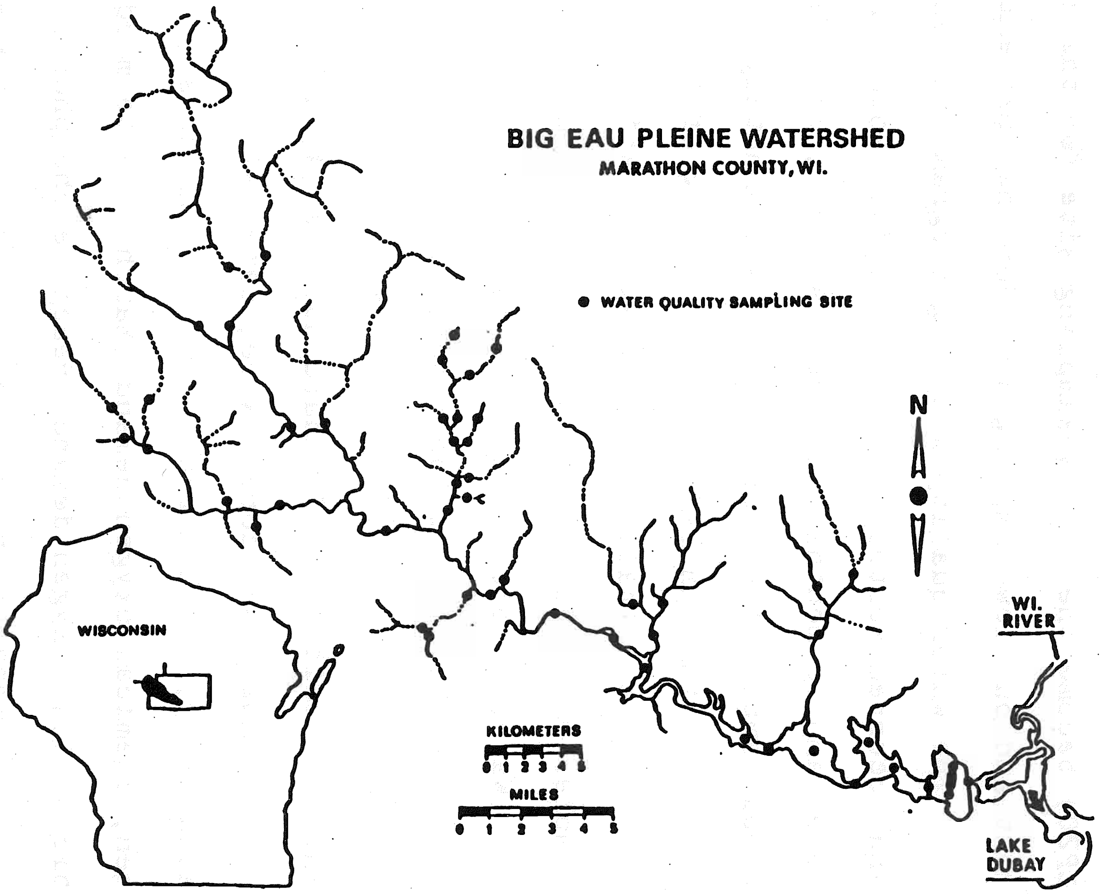


Figure 16. Water Quality Sampling Sites in the Big Eau Pleine Watershed.

Sites EP9B (B for bottom), EP12B through EP14B, EP16B, EP18B, and EP20B through EP25B were averaged to produce a total reservoir bottom average quality. When the reservoir is segmented, the sample sites at the county road bridges (EP13 and EP20) become the inflow sampling site for the downstream segment and outflow sampling site for the upstream segment.

The water quality sampling program started in March 1974 and occurred monthly until June 1974. Then, tributary sites were sampled monthly and the reservoir, Fenwood, and Freeman Creek sample sites were sampled semi-monthly. This sampling continued through 1978. In the spring of 1976 an automatic sampler was installed in the gaging station (site EP6). Samples were taken four times daily through 1979.

Water samples were collected and analyzed in the Environmental Task Force Laboratory at the University of Wisconsin - Stevens Point. Analysis methods were consistent with the 14th edition of Standard Methods (APHA, 1975).

Parameters recorded were; date, site, depth, Secchi disk, alkalinity, total hardness, calcium hardness, dissolved oxygen, chemical oxygen demand (March 1974 to middle of 1975), biochemical oxygen demand, reactive phosphorus, total phosphorus; ammonium, nitrate plus nitrite, and Kjeldahl nitrogen; volatile suspended solids, chlorophyll a, ice and snow thickness (Winter).

The tributary sampling differed in that occasional flow measurements were taken and depth, Secchi disk, ice and snow measurements were not collected. Analysis performed on samples collected by the ISCO automatic sampler were total and reactive phosphorus; Kjeldahl, ammonia, and nitrate plus nitrite nitrogen; chlorides; conductivity; and total and volatile suspended solids. The statistical program used to calculate site average quality was Minitab (Ryan, et. al., 1976).

Basic Description

This section contains a basic description of water quality in the Big Eau Pleine Reservoir from the samples collected of one site, EP23. This site had three depths where water samples were collected; top, middle, and bottom. It covers two years, 1975 and 1976, and provides a backdrop to compare the later loading calculations.

The water temperatures are plotted in the form of an isopleth plot in Figure 17. This plot shows the changes in the reservoir's water surface in the form of the water depth at the site. Ice cover thickness is also indicated. Winter water temperature stratification occurred in 1976 and not in 1975. The water depth at site 23 was deeper in March and April 1976. The Big Eau Pleine Reservoir is a polymictic body of water indicated by the uniform temperature from top to bottom in the spring and fall (i.e. vertical isopleth lines). A weak summer stratification

Figure 17.

Depth-time diagram of isotherms (°C) in the Big Eau Pleine Reservoir, Site 23. Ice cover to scale.

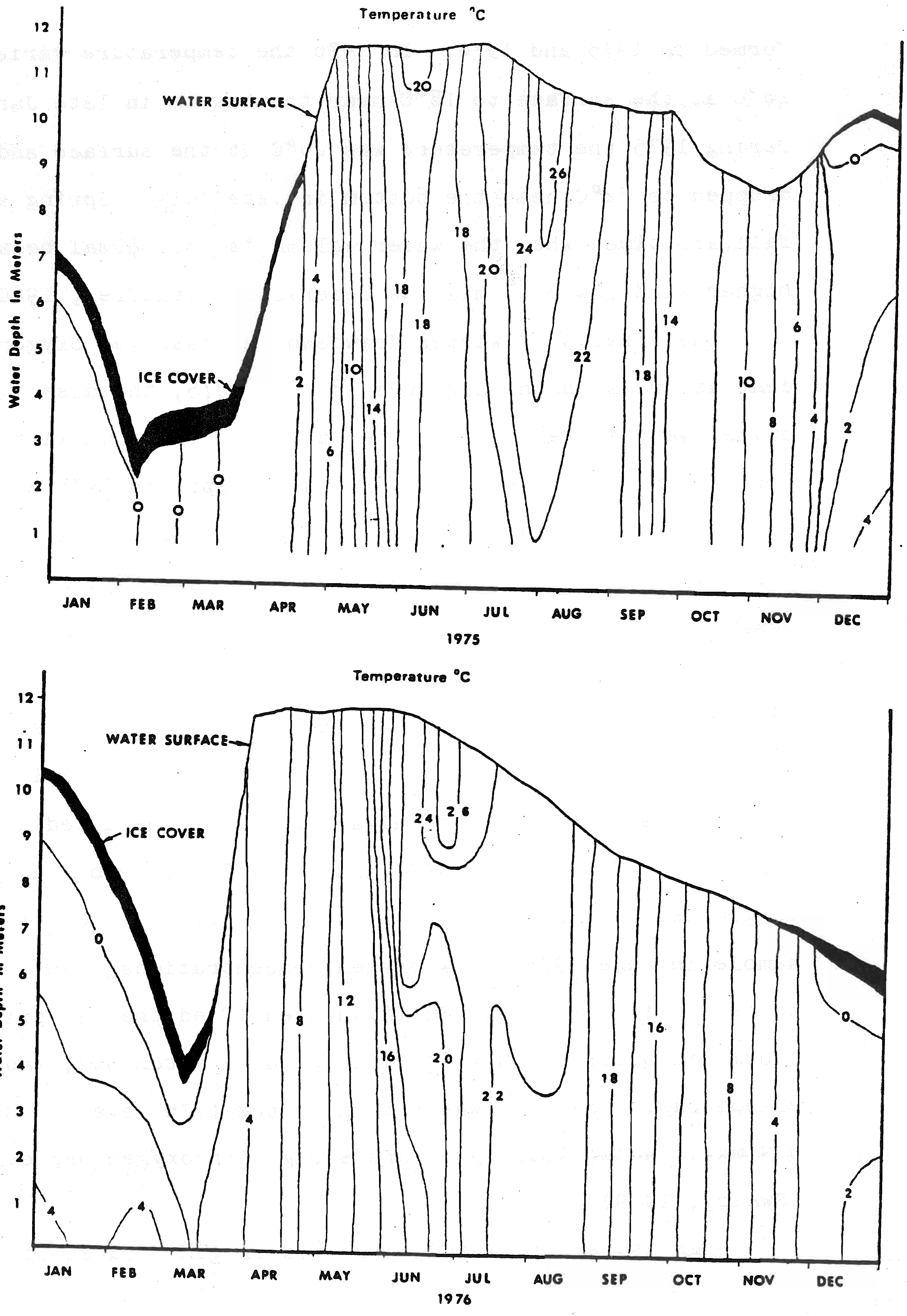

Temperature °C
WATER SURFACE
ICE COVER
Water Depth In Meters
1
2
3
4
5
6
7
8
9
10
11
12
0
0
0
2
4
6
10
14
18
18
20
18
20
24
26
22
18
14
10
8
6
4
2
0
4
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1975
Temperature °C
WATER SURFACE
ICE COVER
Water Depth In Meters
1
2
3
4
5
6
7
8
9
10
11
12
0
4
4
4
8
12
16
20
24
26
22
18
16
8
4
0
2
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1976

Figure 17.

formed in 1975 and 1976. In 1976 the temperature varied from 26°C at the surface to 18°C near the bottom in late June. During 1975 the temperature was 26°C at the surface and dropped to 22°C near the bottom in late July. Spring and fall are times when the water column is isothermal because of higher wind power to mix the reservoir (Stauffer, 1980b).

The effects of winter drawdown on dissolved oxygen concentration is shown on Figure 18. In 1975, the dissolved oxygen went to zero. A shorter duration drawdown with thinner ice and snow cover and more water depth in 1976 did not result in this site going to zero mg/l dissolved oxygen. There was generally an increase in dissolved oxygen, when the reservoir was filling, up to a spring value of 8 mg/l in April or May.

During May 1975, a time of mixed water and oxygen, there was a spring bloom of cyclotella and cryptomonas (Sullivan, 1978). The decline in the algae population resulted in an increased BOD (Swalby, 1979) and probably contributed to the oxygen demand and the zero dissolved oxygen in the bottom sample in June 1975. Low oxygen concentrations didn't occur in the spring of 1976. Sullivan identified that a spring bloom did occur in 1976 of cyclotella, cryptomonas, and stephanodiscus. The BOD_5 was not up to the 1975 level of 3.0 to 5.9 mg/l, which usually occurs along with oxygen depletion (Swalby, 1979).

High (supersaturated) dissolved oxygen occured at the

Figure 18.

Depth-time diagram of isopleths of dissolved oxygen concentrations in mg/l, Big Eau Pleine Reservoir, Site 23. Ice cover to scale.

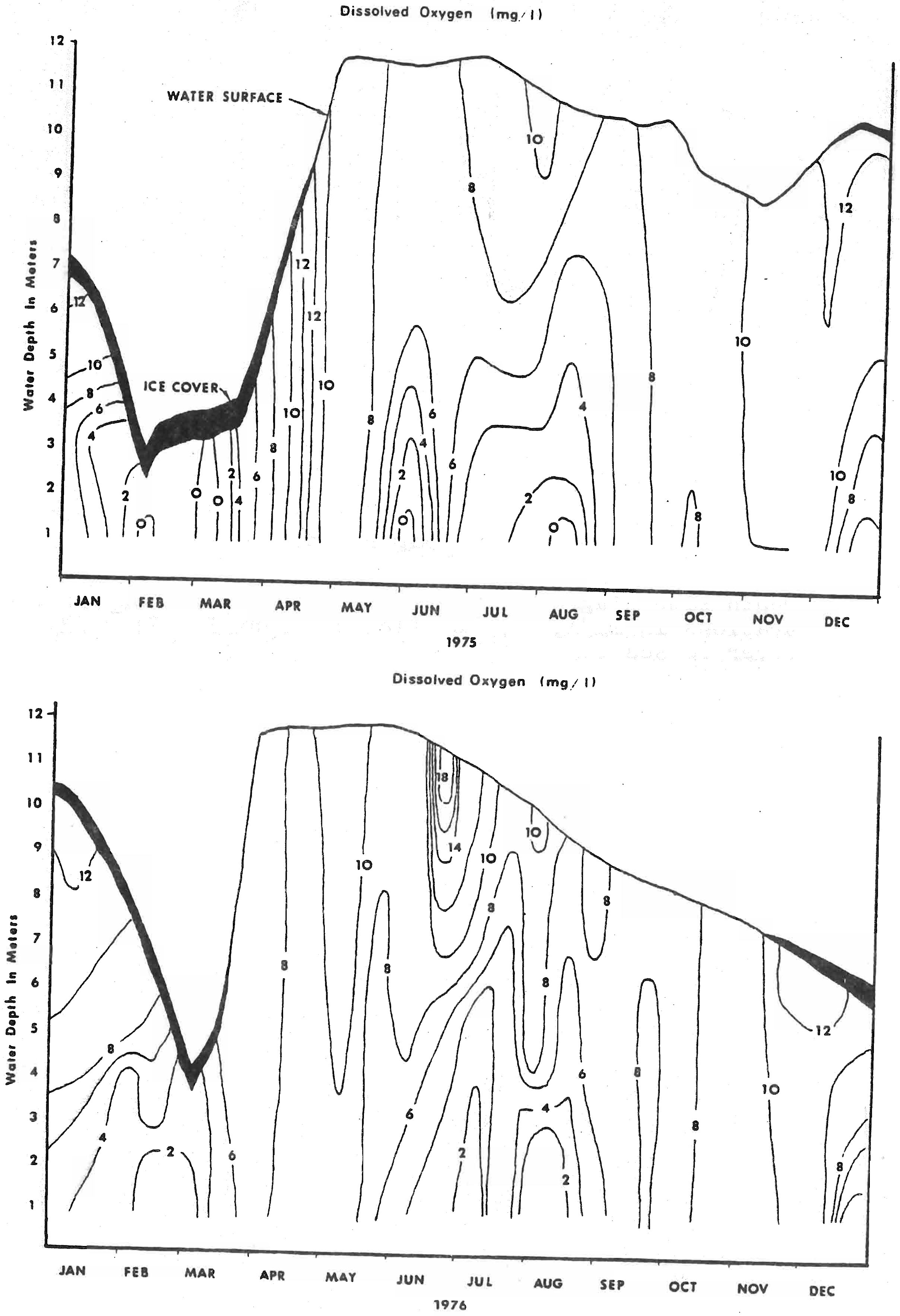

Dissolved Oxygen (mg/l)
Water Depth In Meters
WATER SURFACE
ICE COVER
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1975
Dissolved Oxygen (mg/l)
Water Depth In Meters
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1976

Figure 18.

reservoir surface at site 23. This occurred about a month after drawdown started. It is also the time when the water temperature reached its summer maximum (greater than 26 C). The high dissolved oxygen is explainable by the large blooms of blue-green algae, dominated by aphanizomenon in both years (Sullivan, 1978).

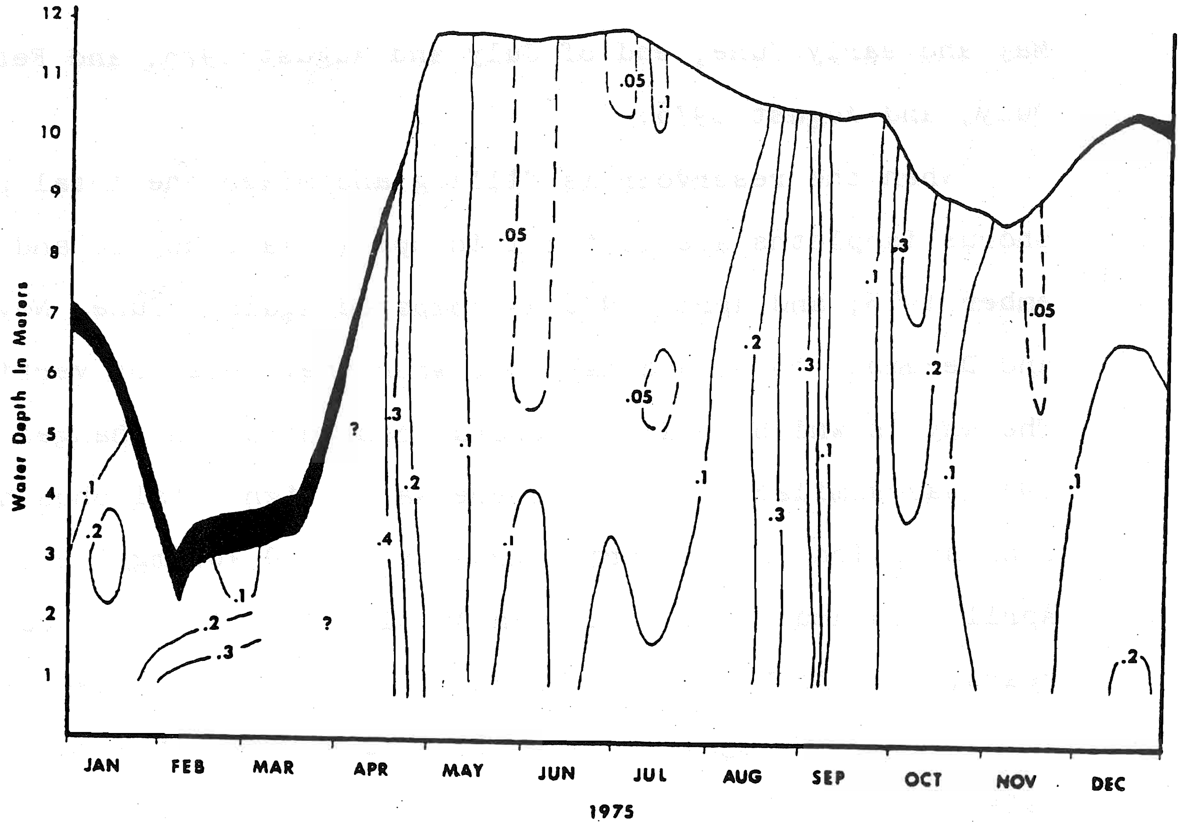
In the summer of 1975, the bottom water dissolved oxygen went to zero during early to mid August. The isopleths look less complicated than the summer of 1976. This relates well to the concentration of chlorophyll a concentration at site 23 of 110 μg/l in late July followed by a crash in August of the bloom to 18 μg/l in early September. A minor fall bloom to 68 μg/l occurred in mid-September, 1975. In 1976 there was a bloom in late June with a chlorophyll a concentration of 121 μg/l. It did not crash and was followed by two other blooms in late July and late September, 145 μg/l and 153 μg/l respectively, with a lower level bloom in mid-August at 50 μg/l.

The nutrient which will be discussed is phosphorus because it is the limiting nutrient for the blue-green algae in the Big Eau Pleine Reservoir (Sullivan, 1978). Figure 19 contains the isopleth diagram for total phosphorus at site 23 for 1975-1976. At times when the oxygen was two milligrams per liter or lower an increase of total phosphorus to 0.100 mg/l or greater was noted in the bottom samples. This situation occurred in late January and February; March; late

Figure 19.

Depth-time diagram of isopleths of total phosphorus concentrations in mg/l-p, Big Eau Pleine Reservoir, Site 23. Ice cover to scale. Dashed and dotted lines are intermediate contour to show details.

Total Phosphorus (mg/l-P)



Total Phosphorus (mg/l-P)

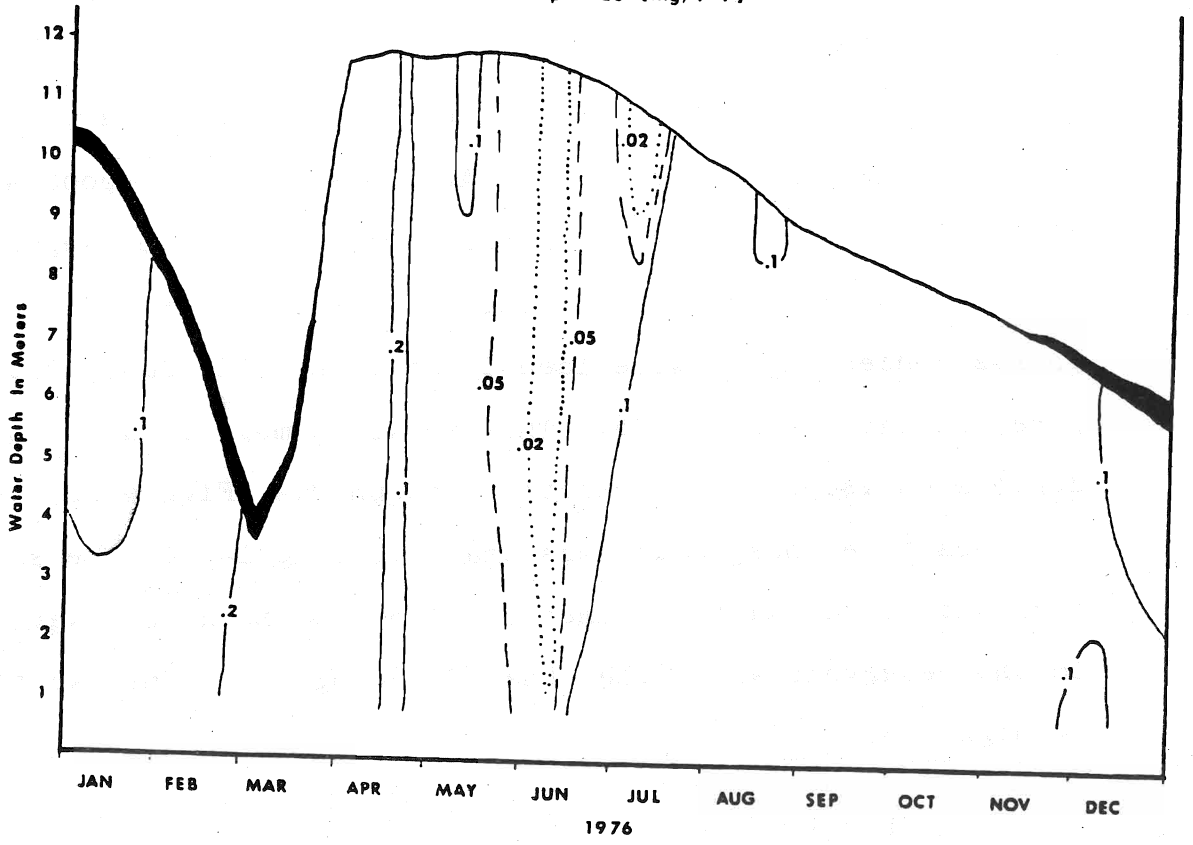


Figure 19.

May and early June; end of July and August 1975; and February, July, and August 1976.

When the reservoir is filling and mixed the total phosphorus isopleths are vertical in April, late August and September 1975; and April 1976 as compared against June, November, and December 1975; and May 1976 when they were not vertical. The way in which total phosphorus concentration changed in 1975 was similar to 1976. There was a high total phosphorus concentration in the spring greater than 0.400 mg/l-p in April 1975 and 0.200 mg/l-p in April 1976. Also, in both years, the mid-May total phosphorus concentration decreased to around 0.050 mg/l-p. Another similarity is the pockets of relatively higher and lower concentration that occur near or at the water's surface in the summer (May-August). These are associated with the spring algae bloom, May 1976, and the first blue-green algae blooms after the drawdown starts (mid-July 1975 and late June 1976). At times, when the populations of algae decreased from the surface water to deeper water or/and the lake sediments, pockets of lower total phosphorus concentration were identifiable in early June, late June and late August 1976. This shows up more clearly in the depth-area isopleths of reactive phosphorus (Figure 20).

Reactive phosphorus less than 0.020 mg/l-p in the surface waters during the summer of 1975 and the deeper waters in the reservoir was higher than 0.050 mg/l-p. The two times of higher reactive

Figure 20.

Depth-time diagram of isopleths of reactive phosphorus concentrations in mg/l-P, Big Eau Pleine Reservoir, Site 23. Ice cover to scale. Dashed and dotted lines are intermediate contour to show details.

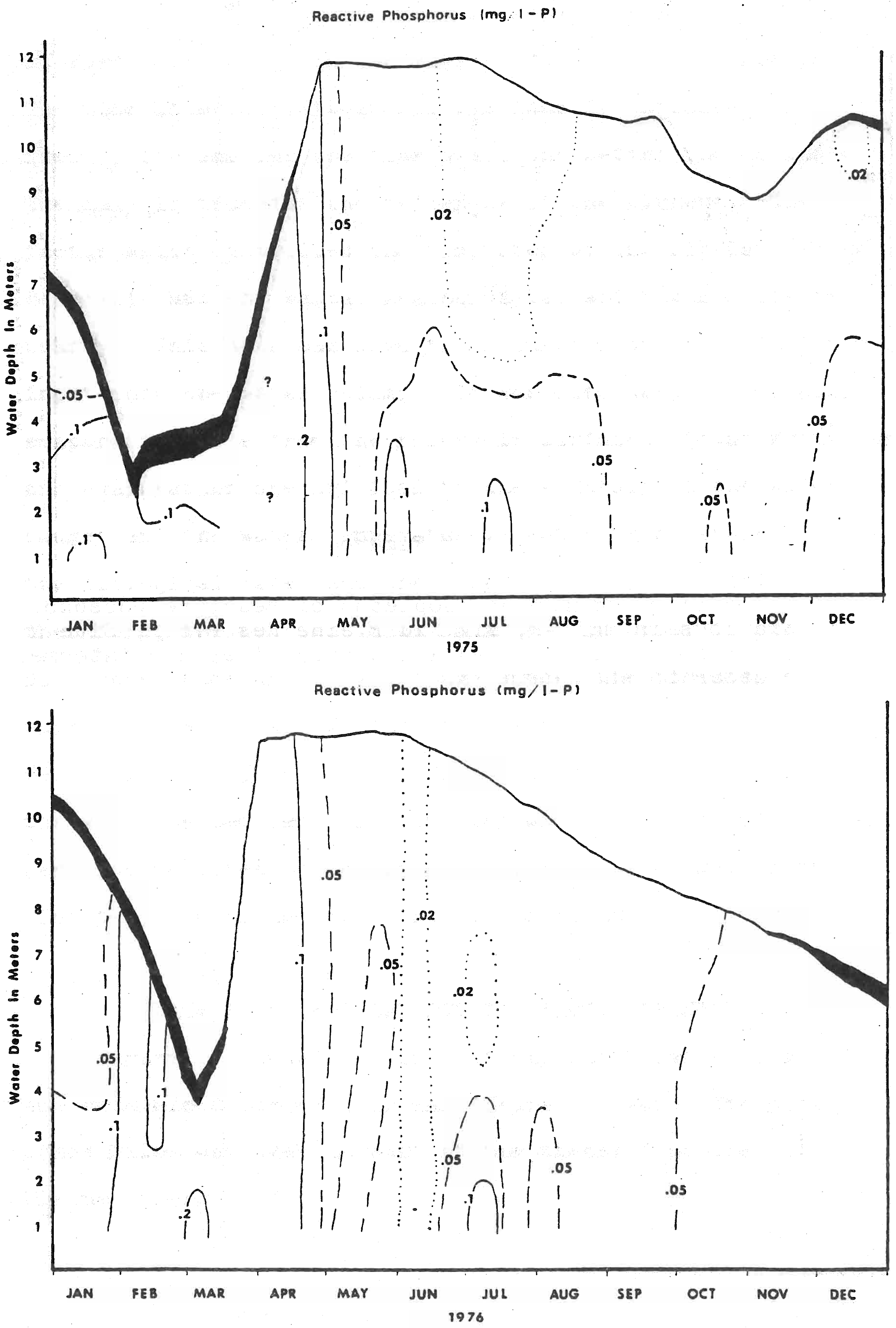

Reactive Phosphorus (mg/l-P)
Water Depth In Meters
12
11
10
9
8
7
6
5
4
3
2
1
.05
.1
.1
.1
?
?
.2
.1
.05
.02
.1
.1
.05
.05
.05
.02
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1975
Reactive Phosphorus (mg/l-P)
Water Depth In Meters
12
11
10
9
8
7
6
5
4
3
2
1
.05
.1
.1
.2
.1
.05
.05
.02
.02
.05
.1
.05
.05
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1976

Figure 20.

phosphorus in the bottom water corresponds with the spring and summer algae blooms. The 0.050 mg/l-p isopleth in the summer of 1975 is at a depth that corresponds to the 6 mg/l dissolved oxygen. In the summer of 1976, the pockets of 0.050 mg/l-p or greater, correspond with decreases in algae population peaks.

SUPPORTING EFFORT FOR COMPUTER MODELING

A digital computer model is a valuable tool to deal with the complexity of a water system like the Big Eau Pleine Reservoir. The amount of data needed to fit a model accurately to this reservoir requires a computer. Therefore, a system of data files and programs written in Fortran (Burroughs, 1974) were developed using a B6700 Burroughs computer at the University of Wisconsin - Stevens Point.

The use, of a lake or reservoir, one dimensional or quasi-two dimensional, digital water quality model (WRE,1974 and Baca, 1977), strongly influenced the type, frequency, and amount of data stored on the computer. These models divide the reservoir waterbody into elements (a horizontal slice of the whole waterbody of specified thickness usually one meter). Physical factors, chemistry, and biological factors are assumed to be constant in an element. The model calculates the vertical mixing and transport from one element to adjacent elements from the water's surface to the bottom. The time interval between calculations is variable. In theory, the smaller the time step, the better the estimate. The same is true for the thickness of the element. The factor which controlled the time step at the Big Eau Pleine Reservoir was the Wausau weather data, which was collected hourly. This data was used to estimate a solar radiation input into the water column. It was also used to calculate evaporation rate from the reservoir surface. Solar radiation and evaporation are critical to the accuracy of the water budget and the water temperature. Water temperature affects the biological rates and the rate of transport (mixing) and therefore, the nutrient mass balance. In order to conserve data entry time and data storage space, the timestep of three hours was chosen and weather data was input for 03:00, 06:00, 09:00, 12:00, 15:00, 18:00, 21:00, and 24:00. Another factor which helped set this timestep was the amount of computer time required to process the models. The smaller the timestep, the higher the cost for each computer program run.

DATA FILES FOR THE BIG EAU PLEINE PROJECT

Figure 21 contains a list of the basic data files built and maintained for the Big Eau Pleine Project. The data in these files was used in most of the theses from the Eau Pleine Project.

Figure 21. Data files for the Big Eau Pleine Project.

WATER QUALITY	WATER QUANTITY	ASSOCIATED ENVIRONMENTAL QUALITY
BIG EAU PLEINE RESERVOIR AND WATERSHED SAMPLING WATER QUALITY FILE 1974-1979	RESERVOIR DAILY STAGE AND OUTFLOW FILE 1974-1979	WAUSAU WEATHER DATA FILE 1974-1978: WINDSPEED WETBULB TEMP. DRYBULB TEMP. STATION PRESSURE DEWPOINT SKYCOVER
BOD AND OTHER ASSOCIATED WATER QUALITY FILE (SWALBY, 1979)	BIG EAU PLEINE RIVER NEAR STRATFORD -(EP6) MEAN DAILY DISCHARGE INFLOW FILE 1974-1978	PRECIPITATION QUALITY FILE ONESITE, HANCOCK, WI
CHLOROPHYLL - A SAMPLING FILE (SULLIVAN, 1978)	FREEMAN CREEK INFLOW FILE CALCULATED FROM EP6 FLOW FILE	MAXIMUM-MINIMUM AIR TEMPERATURE FILE THREE SITES
BIG EAU PLEINE RIVER AUTOMATIC SAMPLER DATA WATER QUALITY FILE 1976-1979	FENWOOD CREEK INFLOW FILE CALCULATED FROM EP6 FLOW FILE	AVERAGE DAILY ICE THICKNESS (MARANO, 1979)
SUSPENDED SEDIMENT AT BIG EAU PLEINE RIVER NEAR STRATFORD,WI LENGTH OF RECORD TWELVE YEARS (KAMINSKI, 1977)	COUNTY HIGHWAY O BRIDGE IN AND OUT FLOW FILE FROM WATER BUDGET	SHORTWAVE DATA FILE MADISON, WI (SULLIVAN,1978)
	COUNTY HIGHWAY S BRIDGE IN AND OUT FLOW FILE FROM WATER BUDGET	AVERAGE MONTHLY EVAPORATION RATE FILE MARSHFIELD,WI
	PRECIPITATION INFLOW FILE FROM WATER BUDGET	
	PRECIPITATION FILE - TEN SITES DAILY AND HOURLY DATA	

WATER BUDGET PROGRAM

There were four reasons why a water budget program (Appendix A) was written. First, water quality computer models such as EPARES (WRE, 1974) and LIMNOS (Baca, 1977) make the assumption that a water budget exists which has a minimum of errors in it. They are deterministic type models (Maki, 1973). Neither model checks to see if the data input is part of a balanced budget. Second, the Big Eau Pleine Reservoir changes just over nine meters in stage during a year (Figure 22). With small errors in the stage readings or the depth versus volume, comes large differences in water volume and mass in the reservoir relative to inflow or outflow. Third, winter conditions are important to the Big Eau Pleine's fish winterkill problem. Therefore, it was important to examine the mechanisms that controlled the wintertime liquid volume of the reservoir. Because the Eau Pleine is a low flow augmentation reservoir the maximum stage change and drawdown occurs in the winter. The amount of ice left high and dry by the receding water levels needed to be estimated. The final reason was the need to estimate the daily flow between segments in the reservoir.

The basic equation used is the hydrologic equation Inflow - Outflow = Change in Storage (Chow, 1964). The equation was expanded to this form:

$$I_{EP6} + I_{FE} + I_{FR} + I_A + I_P + I_I + I_R - (O_{EP26} + O_{EV} + O_{IO} + O_R) \pm \Delta S = 0.0$$

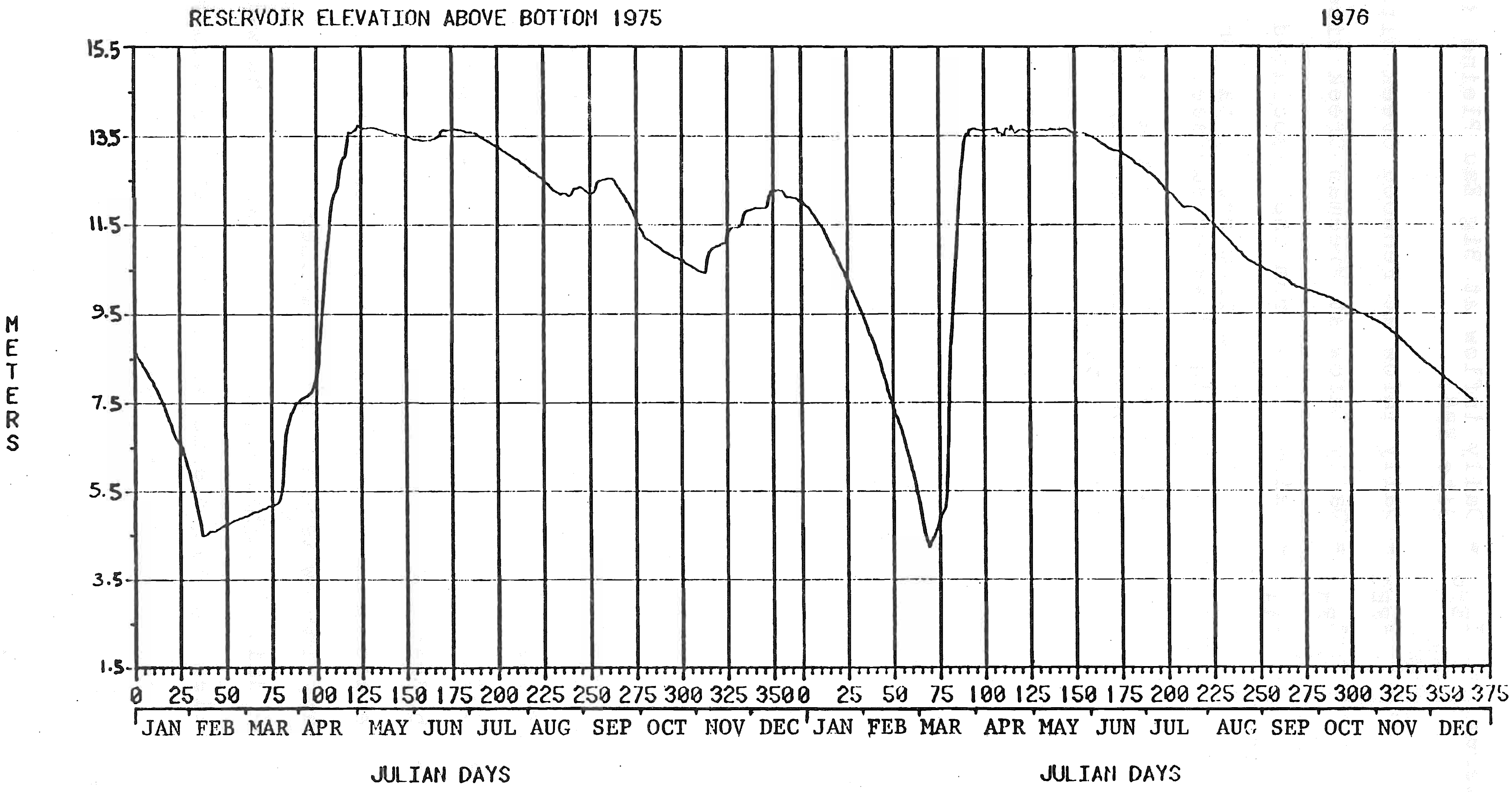


Figure 22. Water surface elevation above the bottom in the Big Eau Pleine Reservoir during 1975 and 1976.

Where: I_{EP6} = Daily inflow at Big Eau Pleine River, Site EP8.

I_{FE1} = Daily infow at Fenwood Creek site FE1.

I_{FR1} = Daily infow at Freeman Creek site FR1.

I_{AA} = Daily infow from the associated ara.

I_{PT} = Daily inflow from precipitation directly on the liquid water surface.

I_{I} = Daily inflow from ice that was stored on the banks of the reservoir due to a winter rise in stage.

I_{R} = Residual daily inflow necessary to balance the equation.

O_{EP26} = Daily outflow at the dam.

O_{EV} = Daily outflow due to evaporation off a liquid reservoir surface.

O_{IO} = Daily outflow of ice to the reservoir's banks due to a winter drop in stage.

O_{R} = Residual daily outflow necessary to balance the equation.

ΔS = Daily change in reservoir storage.

Due to the impermeable nature and shallow depth over bedrock of the soils near the Big Eau Pleine Reservoir, ground water inflow and outflow were considered insignificant to the water budget calculations.

The assumptions and relationships used in obtaining the tributary inflow were discussed earlier.

The daily precipitation station used in the water budget was called the Eau Pleine Reservoir. If the data was missing at that station, then the program referred to the Marshfield

Experimental Farm Station for the daily value. When both values were missing, then the person running the program would have to supply the daily precipitation value. The precipitation daily inflow rate was calculated by multiplying the lake daily surface area times the amount of rainfall in inches.

The change in storage was calculated by linear interpolation from the daily stage versus volume data in Table 6, from the volume on the prior day (Figure 23).

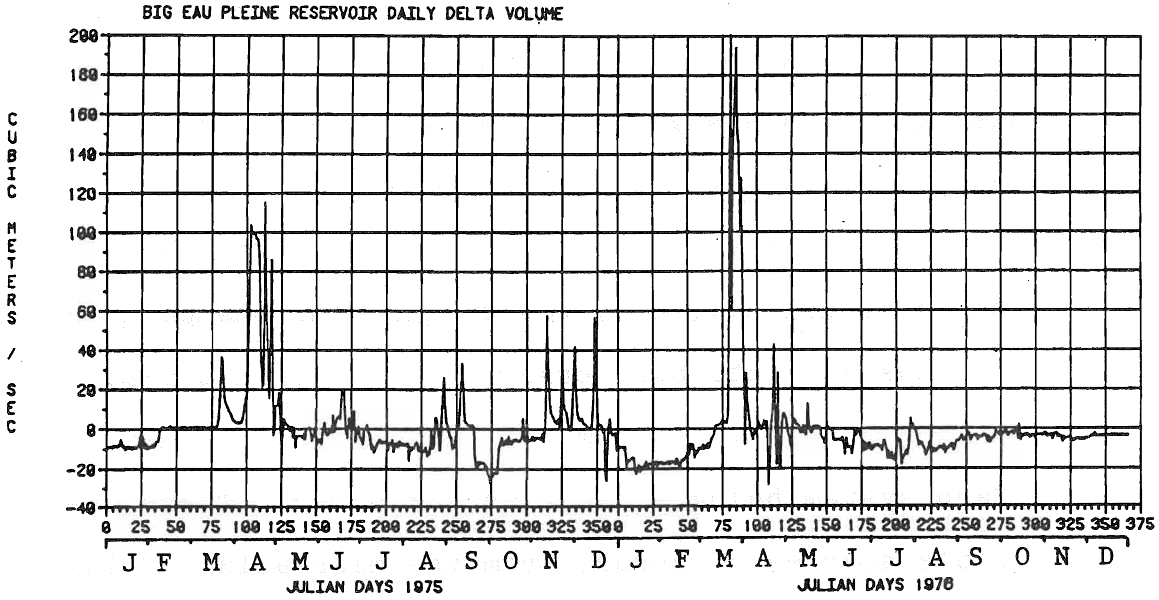


Figure 23. Daily change in volume of the Big Eau Pleine Reservoir during 1975 and 1976.

The calculation of an ice inflow and outflow in the winter was necessary due to the winter drawdowns. During these times, water stayed in the reservoir that was not a function of the reservoir stage. The average ice thickness between two consecutive days was multiplied by the change in reservoir surface area. Then, it was converted into a flow rate (Figure 24), subtracted from the daily budget and stored in a table as a function of stage. When the reservoir stage rose again to this level, that amount of water would become ice inflow (Figure 24).

Figure 25 is a plot of the outflow rate for the reservoir through its dam as estimated by WVIC for 1975 and 1976.

Evaporation estimates were made in this water budget using the same algorithm that was used in the water quality computer model (WRE, 1974)

If all the inflows and outflows were measured or estimated accurately, they would equal the change in storage. Inflows and outflows versus the change in storage could be looked at as two systems of measurement of the water budget. Each system being a check on the other. There are many possible sources of error; from the misreading of lake stage gage to precipitation which is not uniform over the lake or sub-watershed basins. When the hydrologic equation is not equal to zero, the difference is called the residual. If water needs to be added into the reservoir to balance the daily budget, then the residual is positive. While, if there was too much water and some had to exit from the reservoir to balance the

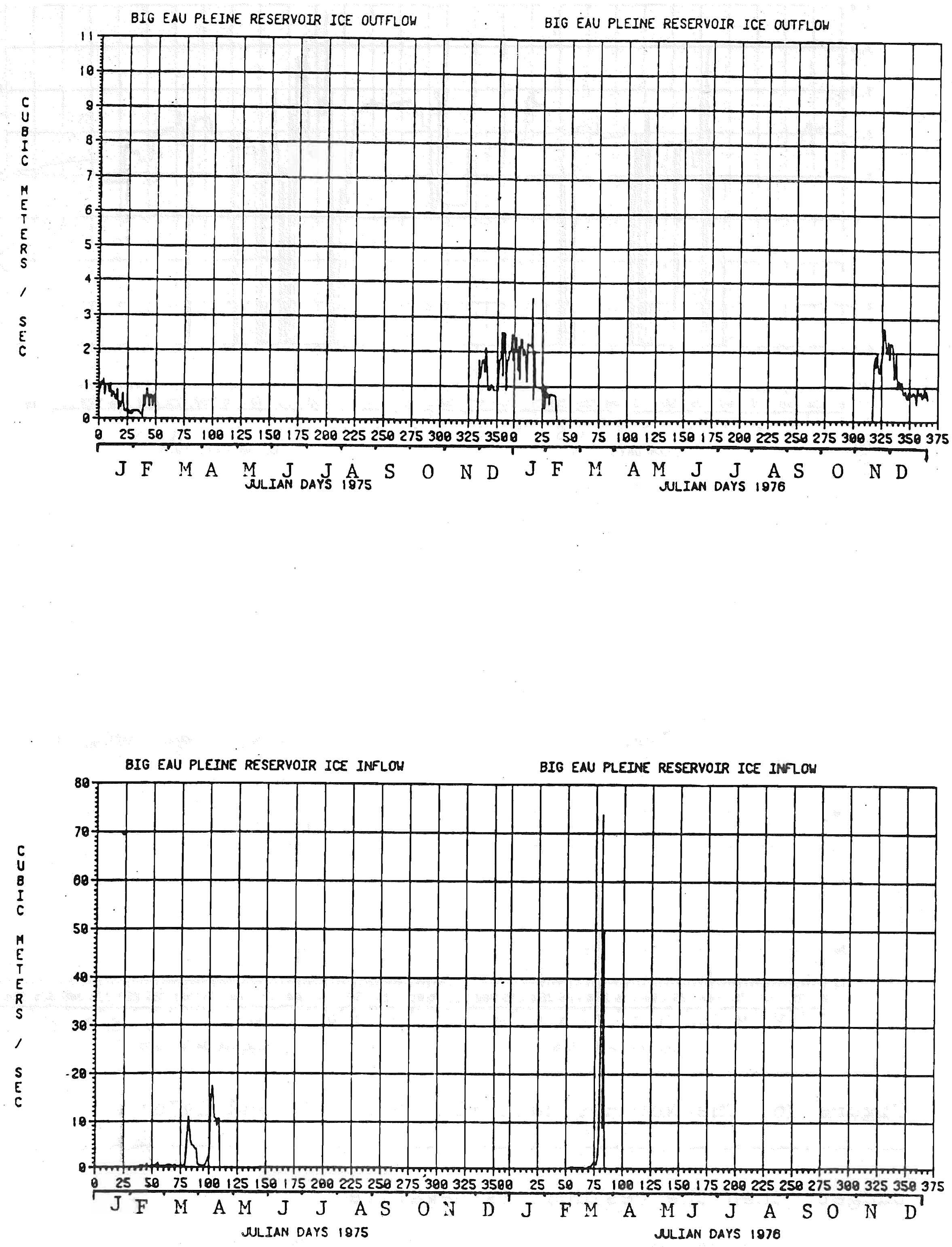


Figure 24. Ice outflow and inflow rates for 1975 and 1976 for the Big Eau Pleine Reservoir.

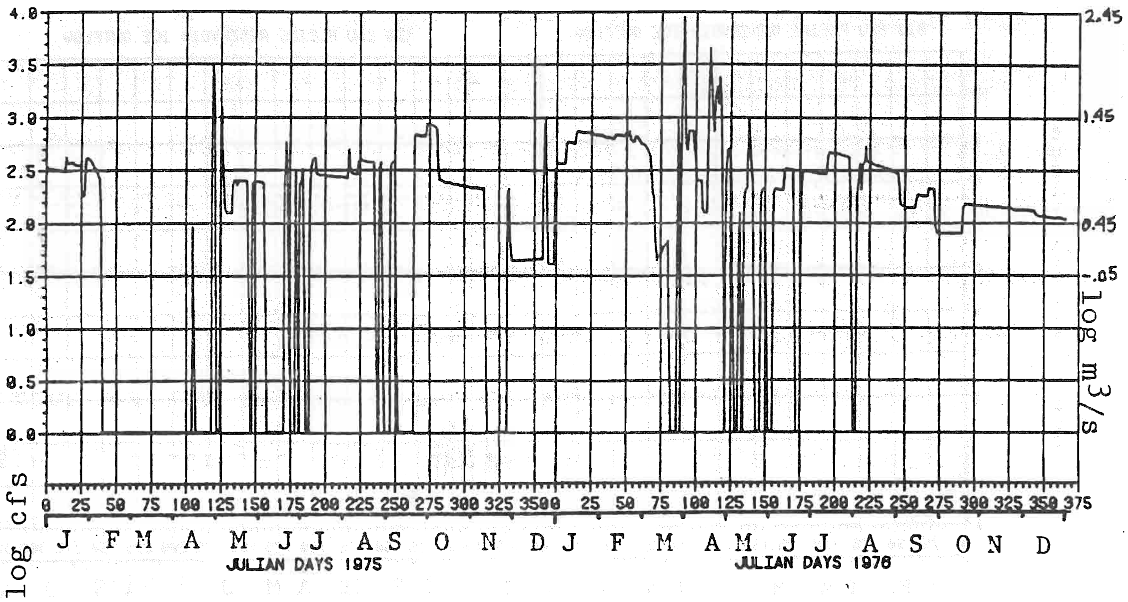


Figure 25. Big Eau Pleine Reservoir Outflow Rate during 1975 and 1976.

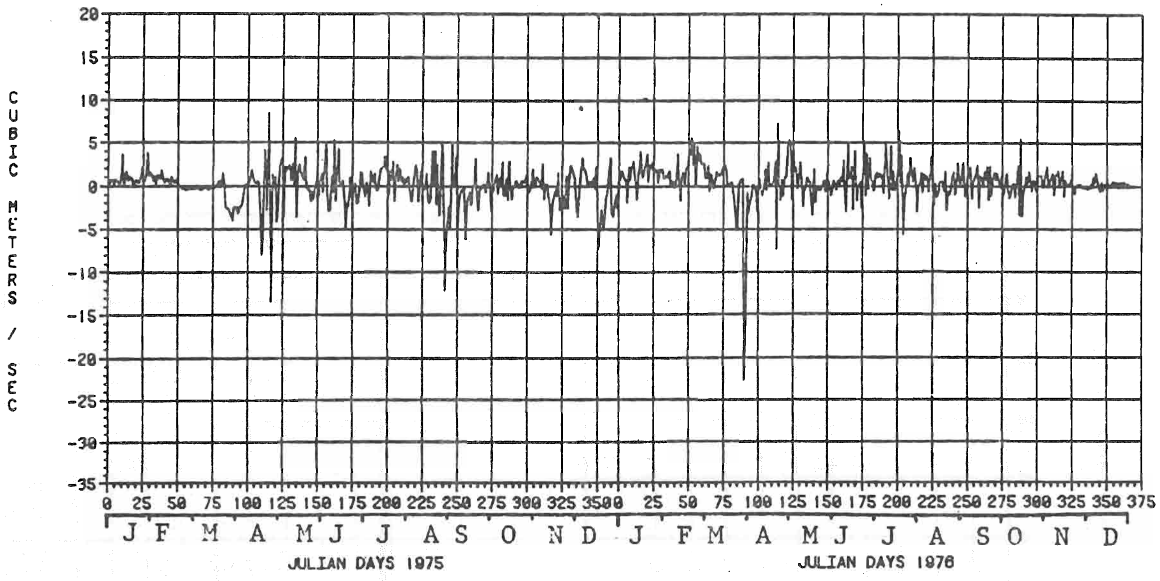


Figure 26. The Net Residual Flow for 1975 and 1976.

budget, then the residual is negative.

Figure 26 contains a plot of the net residual for 1975 and 1976. An accurate water budget was obtained by evaluating the days with large net residuals. A daily water budget was printed out for selected days, Figure 27. This type

```
******** **** ************************************************

DAY= 92  YR =76    UNIT=M3/SEC

              EVAP       PRECIP
              0.2855     0.4029    OLJ ICE THICKNESS:0.00 M
    ICEIN       *           *      NEW ICE THICKNESS:0.00 M
      0 .000   ***          *
                *           *
                *          ***
     INFLOW     *           *
      44.162******WATER SURFACE*****      13.5670 OLDER STAGE M
            *     28.0391DELTA VOL *      13.6550 NEWER STAGE M
            *                      *
            *BEGVOL    127384358.M3*
            *ENDVOL    129806937.M3*       ICEOUT       0.0000
            *                      *
            *                      *
            ************************
             *            *
             *           ***           OUTFLOW
             *            *           15.5176
            ***           *
             *            *
   RESIDUAL OUTFLOW  RESIDUAL INFLOW
          0.7229           0.0000

******** **** ************************************************
```

Figure 27. Output from program called to evaluate a daily water budget for potential errors.

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of evaluation identifies inconsistencies such as: key punching errors; errors in USGS estimated winter flow (when the river gage at Stratford was frozen); errors which resulted when the antifreeze left the lake gage and was not corrected; errors which resulted from rain storms that crossed the lower tributaries (that did not cause increased flow at EP6 and therefore were not accuratlely estimated); and timing errors where EP6 flow was a mean daily value from midnight to midnight (while the lake stage precipitation outflow was from 7:00 a.m. to 7:00 a.m. daily). Detailed error evaluations were made for 1975 and 1976. Data from 1977 and 1978 was also used to produce water budgets, but detailed evaluations were not done. The method used to correct these errors was to set up files of adjustments that combined a file of corrected daily values with a file of basic published data.

Table 8 shows all the input files required to run the water budget program (Appendix A). It also shows the output files produced to document and check the water budget and provides information for the nutrient budget and water quality models.

Table 8. Data files associated with the water budget program.

INPUT FILES	OUTPUT FILES
Remote (Terminal)	Remote (Terminal)
EP/EP17FLOW/ADJ	FILE/OUTFLOW
EP/PRECIP/EAUPLEINEDAM/ADJ	EP/PRECIPINFLOW
EP/AIRTEMP/EAUPLEINEDAM	EP/EP11INOUTFLOW
EP/WADPF	EP/INTCONDEPARES
EP/WAWSF	EP/EVAPORATION
EP/PRECIP/MFEXPFARM	EP/WATERBUDGET/DAILYOUTPUT
EP/ICETHICKNESS/ADJ	EP/WATERBUDGET/QUALITY
EP/EPGFLOW/ADJ	EP/WATERBUDGET/ACCUMULATIVE - OUTPUT
EP/MONTHLYEVAPRATES	
EP/WATERBUDGET/SPACETIME	EP/EP7INOUTFLOW
EP/FE1FLOW	EP/EP9INOUTFLOW
EP/FR1FLOW	EP/EP17INOUTFLOW
EP/EP18FLOW	FILE/RESELCK
EP/WATERBUDGET/DASIA	EP/WATERBUDGET/DAILYVOLOUTPUT
EP/AIRTEMP/MFEXPFARM	EP/WATERBUDGET/PICK
	FILE/ASSOCFLOW
	FILE/INFLOW
	FILE/FEFLOW
	FILE/FRELOW

Most of the file names describe the file contents. The unclear names are explained below:

EP/EP17FLOW/ADJ = The daily flow rate out of the dam and lake stage in feet above mean sea level adjusted for errors.

EP/WAWSP = Wausau weather station dewpoint data file.

EP/ PRECIP/MFEXPFARM = Daily precipitation data for Marshfield Experimental Farm.

EP/WATERBUDGET/SPACETIME = Is a file containing some of the program's required input data used to eliminate time spent on data input during program reruns.

EP/EP18FLOW = The stream flow estimate for site EP8 (Figure 1).

EP/WATERBUDGET/DASIA = The data file of reservoir depth versus area, slope, intercept, and accumulated volumes.

EP/EP11INOUTFLOW = Data file of daily flow rates from segment two to three.

EP/INTCONDEPARES = Sets up some initial conditions in a data file for the EPARES Water Quality Model.

EP/EP7INOUTFLOW = Data file of daily flow rates from segment one to two.

EP/EP9INOUTFLOW = Data file of daily flow at site 13 when the reservoir is divided into four segments.

EP/EP17INOUTFLOW = The daily flow at site EP26.

EP/WATERBUDGET/PICK = The daily ice inflow or outflow rates and the associated stages and dates when they occurred.

FILE/ = Files used to provide LIMNOS (Water Quality Model) with correct flow data and reservoir daily stage (RESELCK).

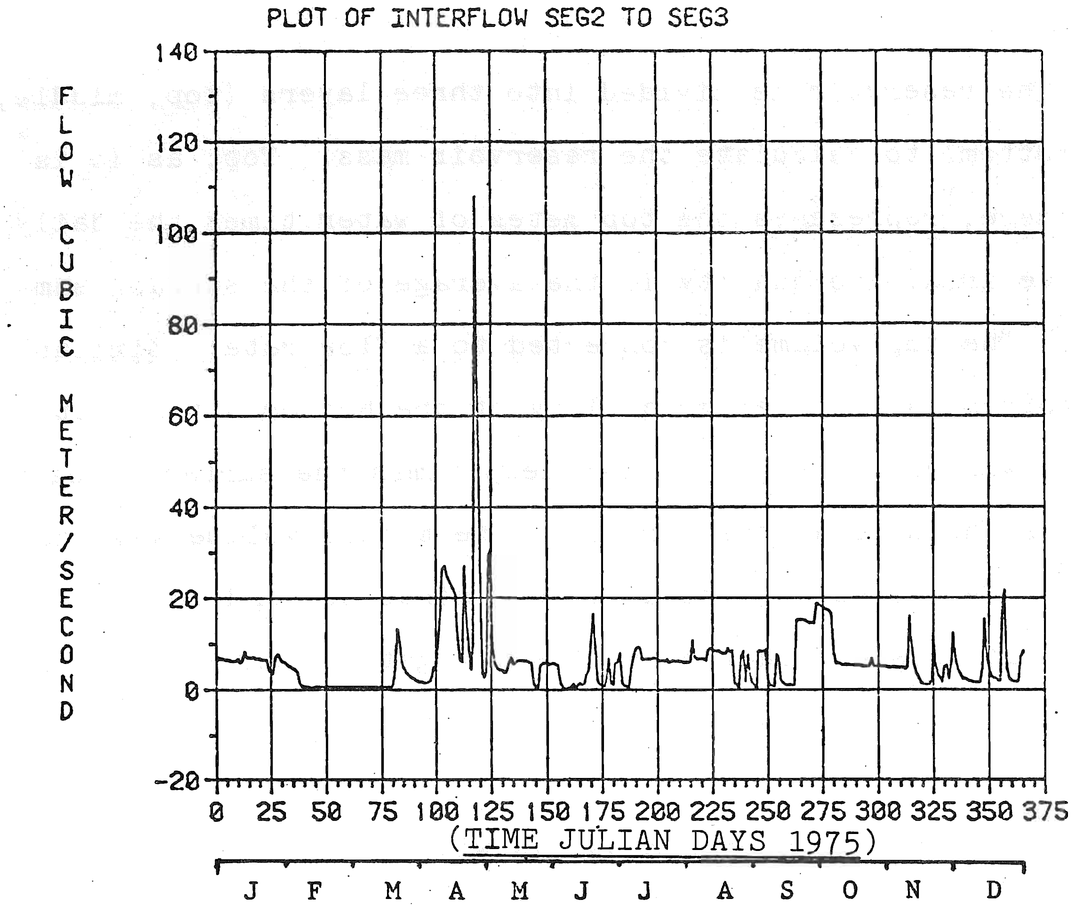
Figure 28 is the interflow rates between segments calculated by the water budget. The difference between the slug flow pattern, man's regulation at the dam,(in interflow segment

2 to 3) and the runoff peak flow pattern, from a natural tight soil watershed, (of interflow segment 1 and 2) is sizeable.

The water budget program can treat a reservoir as one segment or up to four segments.

CHEMICAL BUDGET PROGRAMS

Computer programs were written in FORTRAN that would compute chemical nutrient budgets on a daily basis and accumulate them over a definable time step. A program named QUAL/RES (Appendix B) took the water volume (Flows) calculated by the water budget program and combined them with the average inlake, inflow, and outflow measured concentrations. In the program, an array was established where each row represented one day and contained the daily flow. Quality parameters were also placed in the row with the same date that they were collected. Then, the unsampled days were assigned linear interpolated values between measured values. Each row in the file had the following: a year number, Julian day number, up to nine quality parameters, and a daily volume (expressed as a flow). By putting the data in the form of a time direct file, where each line is representing a day, the data could be plotted with relative ease. The resultant plots are in Appendix C. QUAL/LOADING, a program (Appendix D), calculated the daily chemical budget drawing on the direct time files of the inflow tributaries, precipitation, outflow, and the average in reservoir quality.


PLOT OF INTERFLOW SEG2 TO SEG3

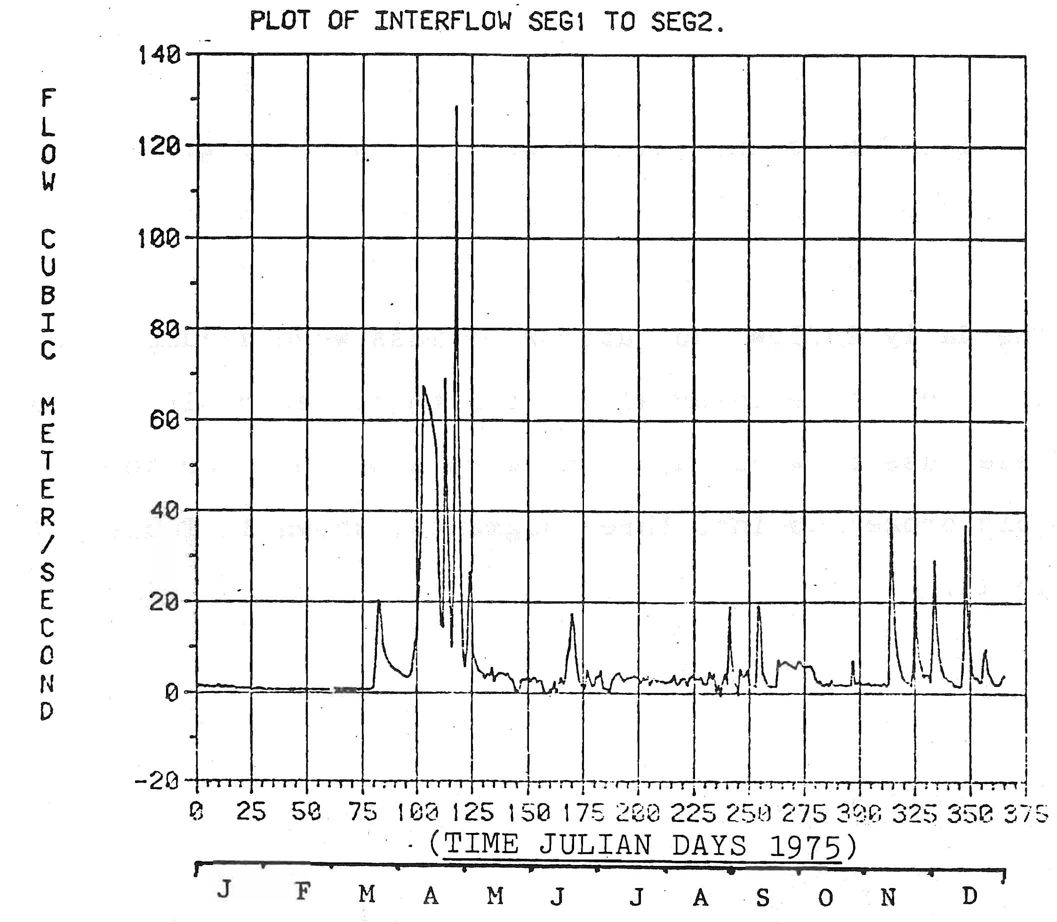
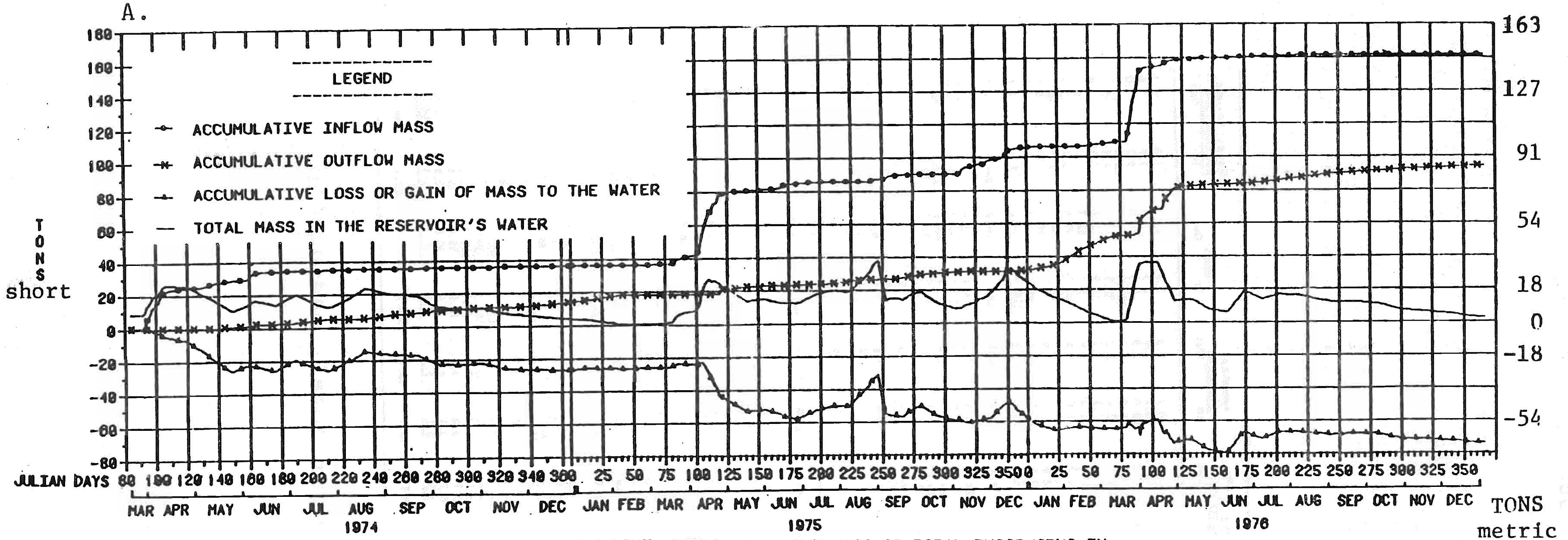

PLOT OF INTERFLOW SEG1 TO SEG2.

Figure 28. Calculated interflow between segments of the Big Eau Pleine Reservoir.

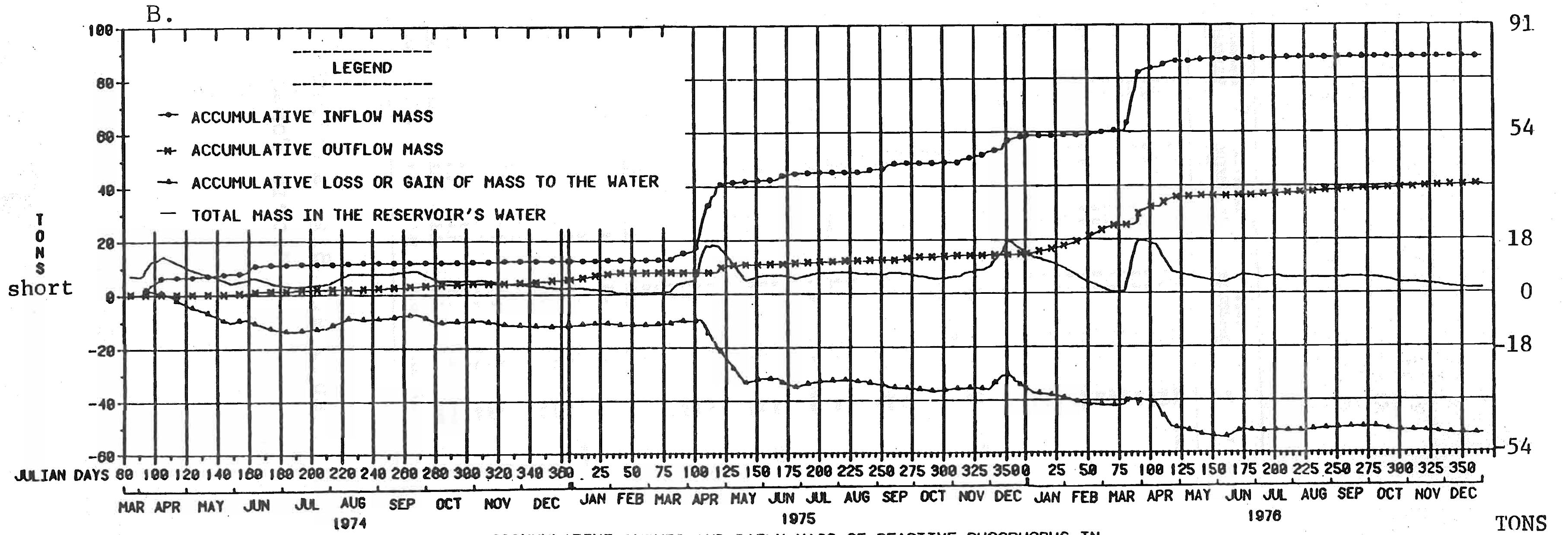
The reservoir is divided into three layers (top, middle, and bottom) to calculate the reservoir mass. Top, as it is used here, represents the top meter of water times the daily surface area. The quality is the average of the surface samples. The top volume is converted to a flow rate. Similarly, the bottom is the average quality of the bottom sites. Its volume was estimated one meter deep times the surface area, this is the same as the surface. The middle volume was the difference between the total volume minus top and bottom volumes. If this subtraction yields a negative number, then one half the difference was subtracted from both the top and bottom.

In order to conserve mass, as with the hydrologic equation, the inflow mass and the outflow mass should be equal to the change in reservoir mass. Differences in the residual mass were accumulated and plotted on the figures titled; Accumulative Curves and Daily Mass... (example:Figure 29). The unaccounted loss or gain of mass from the reservoir water column was negative, for a loss, and positive, for a gain, of mass.

The daily inflow and outflow of mass were accumulated during a month time interval for the total reservoir in Table 9. These mass flow calculations were also done for the reservoir broken up into three segments, shown in Tables 10 through 12.



ACCUMULATIVE CURVES AND DAILY MASS OF TOTAL PHOSPHORUS IN
THE BIG EAU PLEINE RESERVOIR.



ACCUMULATIVE CURVES AND DAILY MASS OF REACTIVE PHOSPHORUS IN
THE BIG EAU PLEINE RESERVOIR.

Figure 29.

Yr.	Mo.	Total Phosphorus		Reactive Phosphorus		Kjeldahl Nitrogen		$NO_3 + NO_2$ Nitrogen		Ammonia Nitrogen		BOD_5		Water Volume Hectometers ^{3}	
		In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
1975	Jan.	0.2	2.8	0.1	1.6	1.1	31.3	1.0	1.5	0.1	1.6	1.9	42.2	1.0	25.3
	Feb.	0.1	0.7	0.1	0.5	0.9	7.3	1.0	0.5	0.2	1.9	1.5	7.3	0.9	5.6
	Mar.	3.8	0.0	2.2	0.0	32.4	0.0	11.8	0.0	10.9	0.0	48.5	0.0	8.3	0.0
	Apr.	34.4	2.2	23.0	1.5	155.3	24.0	91.9	6.5	51.0	11.3	289.0	40.4	102.4	17.5
	May	2.4	2.3	1.6	1.3	15.5	28.7	11.9	12.1	2.4	11.2	21.9	47.1	13.8	20.1
	Jun.	3.3	0.5	2.2	0.4	18.3	7.5	3.4	2.1	2.3	2.2	21.9	12.8	10.6	6.8
	Jul.	0.9	1.0	0.6	0.6	3.9	18.1	1.1	3.0	1.0	2.4	3.7	62.7	1.7	19.1
	Aug.	1.1	1.7	0.8	0.4	5.8	33.0	2.6	1.5	1.8	1.8	10.7	93.6	6.2	21.4
	Sep.	2.4	1.6	2.1	0.6	17.0	29.2	5.1	1.0	2.0	2.1	29.5	98.5	11.5	20.7
	Oct.	0.4	2.4	0.2	0.7	3.1	40.2	0.8	2.6	0.5	3.8	4.2	69.0	2.0	28.1
	Nov.	6.7	0.4	3.4	0.3	38.5	8.3	19.6	0.8	2.6	0.5	98.9	16.2	26.8	6.5
	Dec.	7.7	0.6	5.4	0.5	20.4	13.8	18.7	2.4	4.2	1.6	118.4	14.2	19.3	8.6
	Total	63.4	16.2	41.7	8.4	312.2	241.4	168.9	34.2	79.0	40.4	650.1	504.0	204.5	179.7
1976	Jan.	0.4	5.4	0.4	2.5	2.4	48.3	3.6	21.2	0.6	7.1	6.4	52.5	2.0	46.4
	Feb.	1.5	10.5	0.9	5.1	14.7	49.2	7.0	37.0	4.8	26.9	12.2	84.2	4.9	44.9
	Mar.	39.8	10.6	20.3	5.6	320.9	82.7	132.5	14.5	79.5	31.4	267.9	146.9	130.5	20.5
	Apr.	5.9	18.2	3.9	5.6	96.8	141.7	45.2	15.6	22.3	26.2	87.5	201.8	69.5	97.5
	May	1.3	1.7	0.6	0.5	15.9	36.4	3.9	7.3	2.4	4.7	19.1	28.9	10.8	14.1
	Jun.	0.5	0.7	0.3	0.4	2.3	14.7	0.5	4.6	0.6	2.6	1.9	24.1	1.0	13.8
	Jul.	0.7	2.5	0.3	0.8	4.2	41.4	1.5	2.9	1.7	3.7	1.8	122.2	0.7	27.5
	Aug.	0.2	2.4	0.1	0.9	1.4	38.1	0.5	0.8	0.5	2.8	0.8	96.8	0.7	23.1
	Sep.	0.1	1.5	0.1	0.5	0.8	26.9	0.3	0.6	0.2	1.2	1.2	68.8	0.5	12.7
	Oct.	0.0	1.1	0.0	0.5	1.5	18.3	0.5	1.6	0.3	0.5	1.5	28.5	0.8	8.2
	Nov.	0.1	0.9	0.1	0.6	0.5	13.9	0.2	1.3	0.1	2.8	1.6	19.0	0.6	10.2
	Dec.	0.0	0.9	0.0	0.5	0.2	12.1	0.2	3.7	0.0	1.7	0.7	22.9	0.2	9.1
	Total	50.5	56.4	27.0	23.5	451.6	523.7	195.8	114.1	113.0	111.6	402.6	896.6	222.2	328.2
1977	Jan.	0.0	2.0	0.0	1.3	0.0	30.7	0.0	8.0	0.0	7.1	0.1	33.7	0.1	16.8
	Feb.	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.0	0.0	0.1	0.2	0.1	0.7	0.2
	Mar.	6.0	0.0	4.8	0.0	49.5	0.0	25.5	0.0	8.3	0.0	44.7	0.0	27.0	0.1
	Apr.	2.6	0.0	1.6	0.0	19.7	0.1	13.2	0.1	3.4	0.0	41.8	0.3	20.2	0.7
	May	0.3	1.4	0.2	0.4	2.1	10.7	0.3	5.4	0.3	5.7	3.5	29.3	3.0	10.6
	Jun.	0.1	0.0	0.1	0.0	1.2	0.0	0.1	0.1	0.1	0.0	1.8	0.1	1.6	2.6
	Jul.	1.3	0.6	1.1	0.3	10.0	6.3	0.9	0.0	1.0	0.5	2.7	16.9	8.5	6.2
	Aug.	0.1	0.2	0.1	0.1	0.5	2.0	0.1	0.1	0.1	0.1	1.1	7.6	2.2	2.5
	Sep.	4.0	0.0	2.5	0.0	30.0	0.0	2.7	0.0	1.9	0.0	27.8	0.0	18.9	1.2
	Oct.	4.3	0.0	2.6	0.0	22.3	0.0	5.6	0.0	1.3	0.0	17.1	0.0	17.4	1.6
	Nov.	4.2	0.0	3.1	0.0	18.3	0.3	13.5	0.0	1.4	0.0	25.9	0.4	19.6	4.3
	Dec.	3.5	0.6	2.9	0.2	14.7	16.0	15.4	2.2	2.5	1.6	18.1	19.2	13.4	16.8
	Total	26.4	4.8	19.0	2.3	168.4	66.3	77.4	15.9	20.3	15.1	184.8	107.6	132.6	63.6
1978	Jan.	0.6	2.5	0.5	1.7	2.3	46.7	3.7	8.0	0.5	7.8	4.1	36.8	2.7	44.9
	Feb.	0.3	4.9	0.3	4.4	0.6	59.1	1.7	19.6	0.2	10.8	1.3	71.1	1.1	49.0
	Mar.	14.6	7.8	7.9	5.0	156.3	59.1	56.1	31.5	62.9	11.5	1.1	90.3	57.2	41.2
	Apr.	11.8	0.0	7.4	0.0	108.8	0.0	81.4	0.0	14.4	0.0	139.9	0.0	66.7	1.3
	May	5.8	1.1	3.3	0.3	30.9	20.8	8.6	12.8	1.4	2.4	55.2	19.5	23.2	19.9
	Jun.	3.5	1.5	2.7	0.4	22.9	26.7	4.7	14.6	1.3	2.5	35.2	44.7	18.1	23.4
	Jul.	18.4	15.2	15.1	2.8	97.7	237.4	36.8	11.7	3.2	7.2	138.9	802.7	80.7	108.5
	Aug.	11.2	8.7	7.1	2.9	67.0	103.7	8.3	4.4	1.1	30.8	102.5	339.3	45.9	63.6
	Sep.	13.0	4.4	7.5	2.0	23.9	36.7	11.8	2.1	4.7	9.2	67.7	160.7	45.6	39.9
	Oct.	1.9	1.1	1.3	0.4	13.8	12.5	4.5	0.7	0.4	0.5	13.0	35.6	13.9	12.9
	Nov.	1.2	1.3	0.4	0.4	4.1	13.9	4.1	0.2	0.1	0.1	4.4	30.8	10.8	14.8
	Dec.	1.0	2.4	0.2	0.6	1.8	30.5	2.6	0.5	0.1	0.3	2.4	48.3	3.3	35.0
	Total	83.3	50.9	53.7	20.9	530.1	647.1	224.3	106.1	90.3	83.1	565.7	1697.8	369.2	454.4

Table 9. Big Eau Pleine Reservoir Total Loadings in Metric Tons.

Big Eau Pleine Reservoir - Segment One Loadings in Metric Tons

Yr.	Mo.	Total Phosphorus In	Total Phosphorus Out	Reactive Phosphorus In	Reactive Phosphorus Out	Kjeldahl Nitrogen In	Kjeldahl Nitrogen Out	$NO_3 + NO_2$ Nitrogen In	$NO_3 + NO_2$ Nitrogen Out	Ammonia Nitrogen In	Ammonia Nitrogen Out	BOD_5 In	BOD_5 Out	Water Volume Hectometers^3 In	Water Volume Hectometers^3 Out
1975	Jan.	0.1	0.5	0.1	0.4	0.7	3.9	0.6	0.5	0.0	1.8	1.4	2.6	0.79	2.19
	Feb.	0.1	0.2	0.1	0.1	0.7	1.1	0.6	0.4	0.2	0.8	1.2	1.5	0.70	0.74
	Mar.	3.5	4.0	2.1	2.2	30.8	37.5	10.1	10.3	10.9	16.5	46.9	55.9	9.77	9.31
	Apr.	30.9	21.5	21.8	13.7	140.3	172.6	80.8	93.6	46.6	55.6	269.2	269.1	106.42	84.55
	May	1.6	1.5	1.3	1.2	10.7	15.3	9.1	12.2	0.4	1.5	18.9	25.3	12.29	14.19
	Jun.	2.3	0.5	1.6	0.4	12.7	12.3	1.3	3.6	0.3	0.9	18.9	27.6	11.01	9.46
	Jul.	0.4	1.2	0.3	0.5	1.6	10.9	0.3	0.4	0.1	0.8	2.5	26.8	1.73	7.14
	Aug.	0.9	2.4	0.7	0.8	3.2	13.2	0.7	0.5	0.6	1.9	7.6	31.3	6.11	9.13
	Sep.	2.4	2.9	2.1	1.5	13.2	25.2	2.9	2.4	0.8	3.7	26.2	48.9	10.40	12.41
	Oct.	0.3	2.0	0.1	1.1	1.6	13.2	0.2	1.5	0.1	1.5	3.4	17.1	2.26	7.27
	Nov.	4.3	6.1	3.1	4.1	14.9	21.9	14.2	15.5	0.6	1.3	95.5	41.7	25.59	20.26
	Dec.	7.3	4.7	5.2	3.1	17.3	18.4	13.6	14.3	3.9	2.4	111.5	36.4	19.51	16.64
	Total	54.1	47.5	38.5	29.1	247.7	345.5	134.4	155.2	64.5	88.7	603.2	584.2	206.58	193.29
1976	Jan.	0.3	2.7	0.3	1.9	1.7	14.8	1.9	6.3	0.5	5.4	5.3	38.7	1.59	11.87
	Feb.	1.4	2.0	0.9	1.6	12.4	13.7	5.1	5.4	4.2	7.8	10.6	16.1	4.26	7.59
	Mar.	38.3	26.3	19.5	13.9	291.3	199.0	113.8	87.8	71.8	56.1	244.8	355.4	138.96	115.81
	Apr.	5.3	10.3	3.6	5.4	79.3	117.7	31.8	36.4	17.1	24.3	77.4	130.5	59.14	58.66
	May	0.9	1.0	0.6	0.5	11.6	15.1	1.5	4.6	0.5	2.1	16.5	23.3	10.62	11.60
	Jun.	0.2	0.6	0.0	0.4	0.6	12.3	0.1	0.6	0.1	1.2	1.0	11.0	0.85	5.34
	Jul.	0.1	1.3	0.1	0.5	0.7	14.0	0.2	0.5	0.2	1.8	0.9	24.6	1.14	7.62
	Aug.	0.1	1.5	0.1	0.8	0.5	12.8	0.1	0.1	0.1	1.4	0.5	27.1	0.58	6.01
	Sep.	0.1	0.9	0.0	0.5	0.4	7.6	0.0	0.3	0.0	0.5	0.4	11.0	0.39	2.84
	Oct.	0.0	0.5	0.0	0.3	0.7	4.4	0.2	0.5	0.1	0.5	0.8	5.4	0.67	2.31
	Nov.	0.0	0.3	0.0	0.2	0.3	3.2	0.0	0.4	0.0	0.5	0.9	8.3	0.46	1.96
	Dec.	0.0	0.1	0.0	0.0	0.1	1.4	0.0	0.1	0.1	0.2	0.4	3.4	0.13	0.92
	Total	46.7	47.5	25.1	26.0	399.6	416.0	154.7	143.0	94.7	101.8	359.5	654.8	218.79	232.53

Table 10. Big Eau Pleine Reservoir- Segment One Loadings in Metric Tons.

Big Eau Pleine Reservoir - Segment Two Loadings in Metric Tons

Yr.	Mo.	Total Phosphorus		Reactive Phosphorus		Kjeldahl Nitrogen		$NO_3 + NO_2$ Nitrogen		Ammonia Nitrogen		BOD_5		Water Volume Hectometers^3	
		In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
1975	Jan.	0.5	1.5	0.4	1.0	4.0	19.3	0.7	1.3	1.9	1.7	2.8	18.8	2.35	17.18
	Feb.	0.2	0.5	0.2	0.4	1.3	4.3	0.6	0.1	0.7	1.9	1.7	6.4	1.30	3.07
	Mar.	4.2	0.9	2.2	0.7	38.7	9.4	11.8	0.9	16.6	6.3	57.2	16.2	14.39	5.14
	Apr.	24.2	7.0	14.6	5.4	183.6	70.7	102.8	18.9	58.1	38.4	286.4	77.2	104.31	44.29
	May	1.9	2.3	1.4	1.3	16.9	30.5	13.4	9.9	1.8	9.2	27.2	34.3	16.33	18.50
	Jun.	0.9	1.1	0.5	0.5	13.9	10.0	4.3	3.9	1.1	3.5	29.9	16.4	11.64	9.33
	Jul.	1.3	2.4	0.6	1.2	11.3	27.6	0.7	1.8	0.9	2.9	27.3	50.4	7.15	16.45
	Aug.	2.5	5.4	0.9	2.9	14.3	54.6	1.5	1.7	2.1	7.0	33.6	121.5	10.97	17.90
	Sep.	3.3	3.3	1.7	0.8	27.7	33.6	3.9	2.0	4.1	2.5	51.8	68.5	14.91	20.57
	Oct.	2.0	5.1	1.2	1.2	13.7	34.8	1.9	1.2	1.5	1.5	17.9	56.0	7.75	20.66
	Nov.	6.4	1.2	4.3	0.6	25.0	13.7	18.7	1.8	1.4	0.7	44.6	25.7	24.92	12.31
	Dec.	5.0	1.6	3.3	0.7	21.0	8.8	18.6	2.1	2.6	0.8	41.8	16.4	19.11	14.57
	Total	52.4	32.2	31.3	16.7	371.4	317.3	178.9	45.6	92.8	76.4	622.2	507.8	235.13	199.97
1976	Jan.	2.7	4.1	1.9	2.4	15.1	24.2	7.0	19.1	5.5	8.3	39.1	50.4	11.49	37.00
	Feb.	2.1	6.5	1.7	4.8	14.7	44.3	6.5	21.8	8.1	18.8	16.9	56.8	8.50	32.36
	Mar.	27.4	17.8	14.6	11.5	225.0	132.5	104.0	34.4	61.8	51.2	376.5	211.4	141.88	76.67
	Apr.	10.6	10.3	5.6	5.4	129.2	108.2	45.8	34.9	26.6	29.8	139.5	154.5	67.58	66.17
	May	1.3	0.9	0.5	0.5	16.8	17.7	5.7	6.5	2.4	3.5	25.3	25.3	13.35	14.58
	Jun.	0.6	1.0	0.4	0.7	12.6	14.3	0.8	1.8	1.1	3.4	11.2	29.0	4.92	13.39
	Jul.	1.5	2.5	0.6	1.1	14.4	27.5	0.9	0.4	2.1	6.6	24.9	73.3	8.14	21.15
	Aug.	1.5	3.0	0.8	1.1	13.1	27.8	0.3	0.1	1.3	8.2	27.3	57.3	6.00	19.24
	Sep.	1.0	1.4	0.5	0.5	7.7	24.9	0.4	0.9	0.6	0.9	11.2	42.5	2.78	9.54
	Oct.	0.5	0.9	0.3	0.5	4.6	15.0	0.7	2.6	0.6	3.0	5.7	15.8	2.27	6.22
	Nov.	0.4	0.9	0.2	0.5	3.3	13.2	0.4	3.4	0.5	3.2	8.6	16.7	1.80	9.11
	Dec.	0.1	0.7	0.1	0.5	1.4	9.3	0.2	2.2	0.3	1.7	3.4	12.7	0.82	7.36
	Total	49.7	50.0	27.2	29.5	457.9	458.9	172.7	128.1	110.9	138.6	689.6	745.7	269.53	312.79

Table 11. Big Eau Pleine Reservoir-Segment Two Loadings in Metric Tons.

Big Eau Pleine Reservoir - Segment Three Loadings in Metric Tons

Yr.	Mo.	Total Phosphorus		Reactive Phosphorus		Kjeldahl Nitrogen		$NO_3 + NO_2$ Nitrogen		Ammonia Nitrogen		BOD_5		Water Volume Hectometers^3	
		In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
1975	Jan.	1.5	2.8	1.0	1.6	19.3	31.3	1.3	1.5	1.7	1.6	18.8	42.3	16.31	25.90
	Feb.	0.5	0.7	0.4	0.4	4.3	7.4	0.1	0.1	1.9	1.9	6.4	7.2	2.96	4.90
	Mar.	0.9	0.0	0.7	0.0	9.7	0.0	1.0	0.0	6.3	0.0	16.5	0.0	7.02	0.00
	Apr.	7.4	2.2	5.6	1.5	72.2	24.0	19.9	6.7	38.7	11.4	79.3	40.4	48.38	16.86
	May	2.4	2.3	1.4	1.3	30.7	28.7	10.0	12.1	9.3	11.2	34.5	47.2	17.68	18.71
	Jun.	1.1	0.5	0.5	0.3	10.3	7.4	4.1	2.5	3.5	2.1	16.6	12.8	8.60	7.50
	Jul.	2.4	1.0	1.2	0.6	27.7	18.1	2.0	3.0	3.0	2.5	50.4	62.6	14.93	20.16
	Aug.	5.4	1.7	2.9	0.4	54.9	33.1	2.0	1.5	7.1	1.8	121.4	93.6	17.60	21.33
	Sep.	3.4	1.6	0.8	0.6	33.9	29.1	2.2	1.0	2.5	2.0	68.7	98.4	20.39	23.33
	Oct.	5.1	2.4	1.3	0.8	34.9	40.4	1.3	2.6	1.6	3.9	55.9	69.0	20.14	26.84
	Nov.	1.3	0.4	0.6	0.3	14.2	8.2	2.2	0.9	0.7	0.4	25.9	16.2	12.87	6.25
	Dec.	1.7	0.6	0.7	0.5	9.0	13.9	2.4	2.3	0.8	1.7	17.3	14.2	12.77	10.52
	Total	33.1	16.2	17.1	8.3	321.1	241.6	48.5	34.2	77.1	40.5	511.7	503.9	199.65	182.30
1976	Jan.	4.1	5.4	2.4	2.5	24.2	47.5	19.2	21.2	8.4	7.1	50.5	52.5	34.94	48.21
	Feb.	6.5	10.5	4.8	5.1	44.5	49.8	21.9	37.0	18.8	26.9	56.9	84.2	32.27	46.05
	Mar.	17.9	10.6	11.6	5.6	135.8	82.8	35.9	14.5	52.0	31.4	214.0	146.9	82.62	47.57
	Apr.	10.3	18.4	5.5	5.6	109.4	141.6	35.8	15.6	30.0	26.3	155.2	201.7	66.77	65.99
	May	1.0	1.7	0.5	0.5	18.0	36.5	6.6	7.3	3.6	4.7	25.4	28.9	13.76	14.27
	Jun.	1.0	0.7	0.7	0.4	14.3	14.6	1.8	4.6	3.4	2.6	29.1	24.2	11.84	16.19
	Jul.	2.7	2.5	1.2	0.7	27.8	41.4	0.6	2.9	6.7	3.7	73.2	122.1	19.96	26.84
	Aug.	3.0	2.4	1.0	1.0	27.8	38.1	0.1	0.8	8.2	2.7	57.3	96.8	17.78	25.14
	Sep.	1.3	1.5	0.5	0.5	25.0	26.9	0.9	0.6	0.9	1.2	42.5	68.8	8.67	12.13
	Oct.	0.9	1.1	0.5	0.5	15.0	18.4	2.7	1.6	3.0	0.5	15.8	28.6	5.84	8.81
	Nov.	0.9	0.9	0.5	0.5	13.2	13.9	3.4	4.3	3.2	2.8	16.7	18.9	7.26	11.17
	Dec.	0.8	0.9	0.5	0.5	9.3	11.8	2.1	3.5	1.7	1.6	12.7	22.2	5.97	9.75
	Total	50.4	56.6	29.7	23.4	464.3	523.3	131.0	114.0	139.9	111.5	749.3	895.8	307.68	332.12

Table 12. Big Eau Pleine Reservoir- Segment Three Loadings in Metric Tons.

Phosphorus

Major peaks in the total phosphorus mass consistently occurred in the spring of each year (Figure 30A). Two more major peaks occurred in 1975. One, late in December, was associated with fall-winter rains and runoff from the watershed and some reservoir sediment contribution. The August-September peak was the highest with a total phosphorus mass of 35.3 metric tons. A comparison with the reactive phosphorus mass (Figure 30B) shows that this peak was not composed of reactive phosphorus. The accumulative curve of daily total-P mass (Figure 29A) indicates that it was not due to total phosphorus inflow, but was due to in-reservoir processes. Other total phosphorus peaks that occurred in the spring and fall had similar reactive phosphorus peaks, which may be associated with runoff. The in-reservoir increase of reactive phosphorus in the late fall of 1975 was greater in the reservoir than what the watershed inputted. Therefore, some reactive phosphorus was contributed by the sediment (Figure 29B).

The spring peaks contributed reactive and total phosphorus to the reservoir sediment. Following the spring peak in both years, within a 20 day period, 65% of the reactive phosphorus mass left the water column. In 1975, it went to the sediment and in 1976 some went to the sediment and, also, some went out at the dam. Figure 31 also exhibits the same trend for 1977, 1978, and 1979.

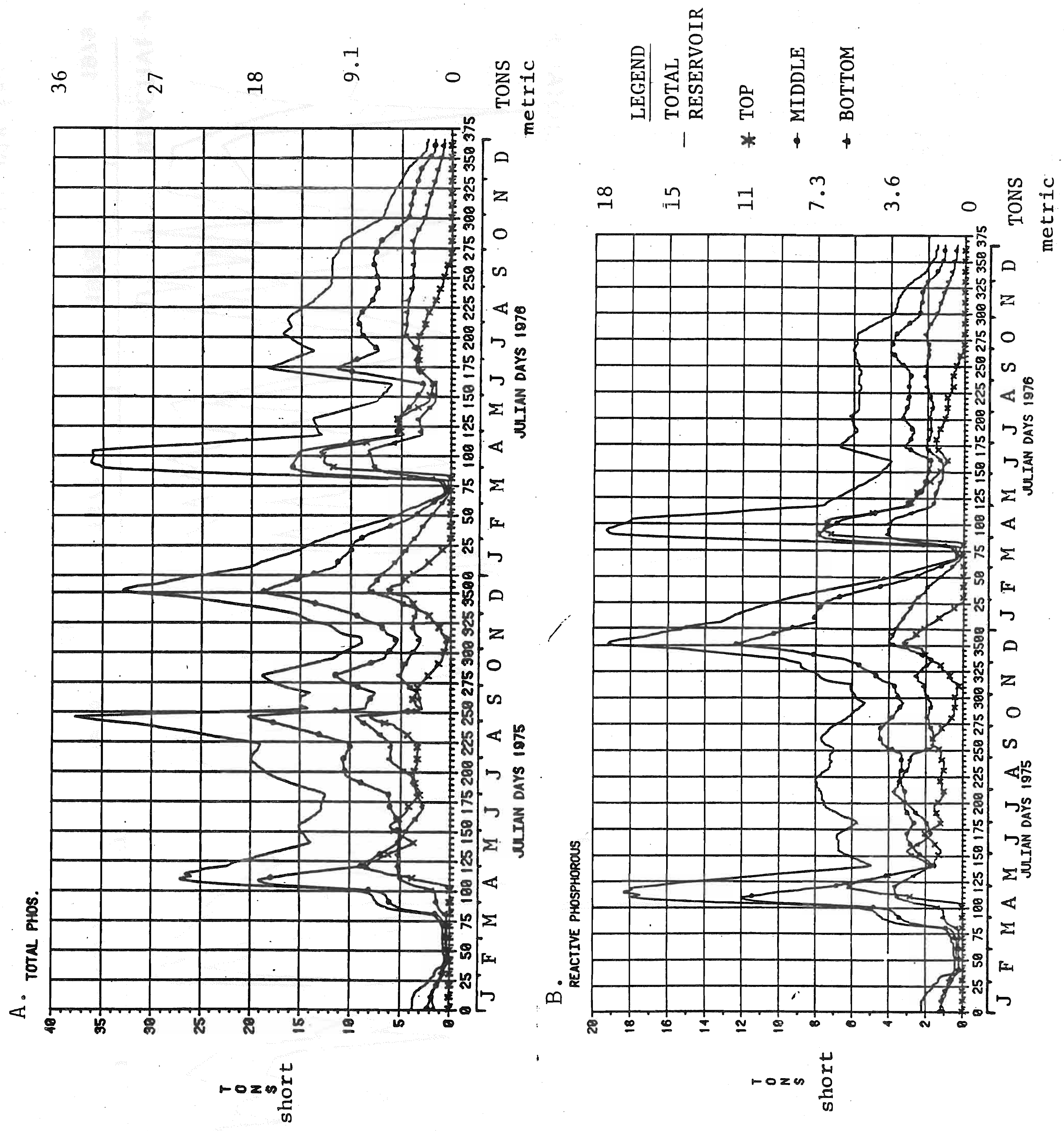


Figure 30. The total phosphorus and reactive phosphorus mass in the Big Eau Pleine Reservoir during 1975 and 1976.

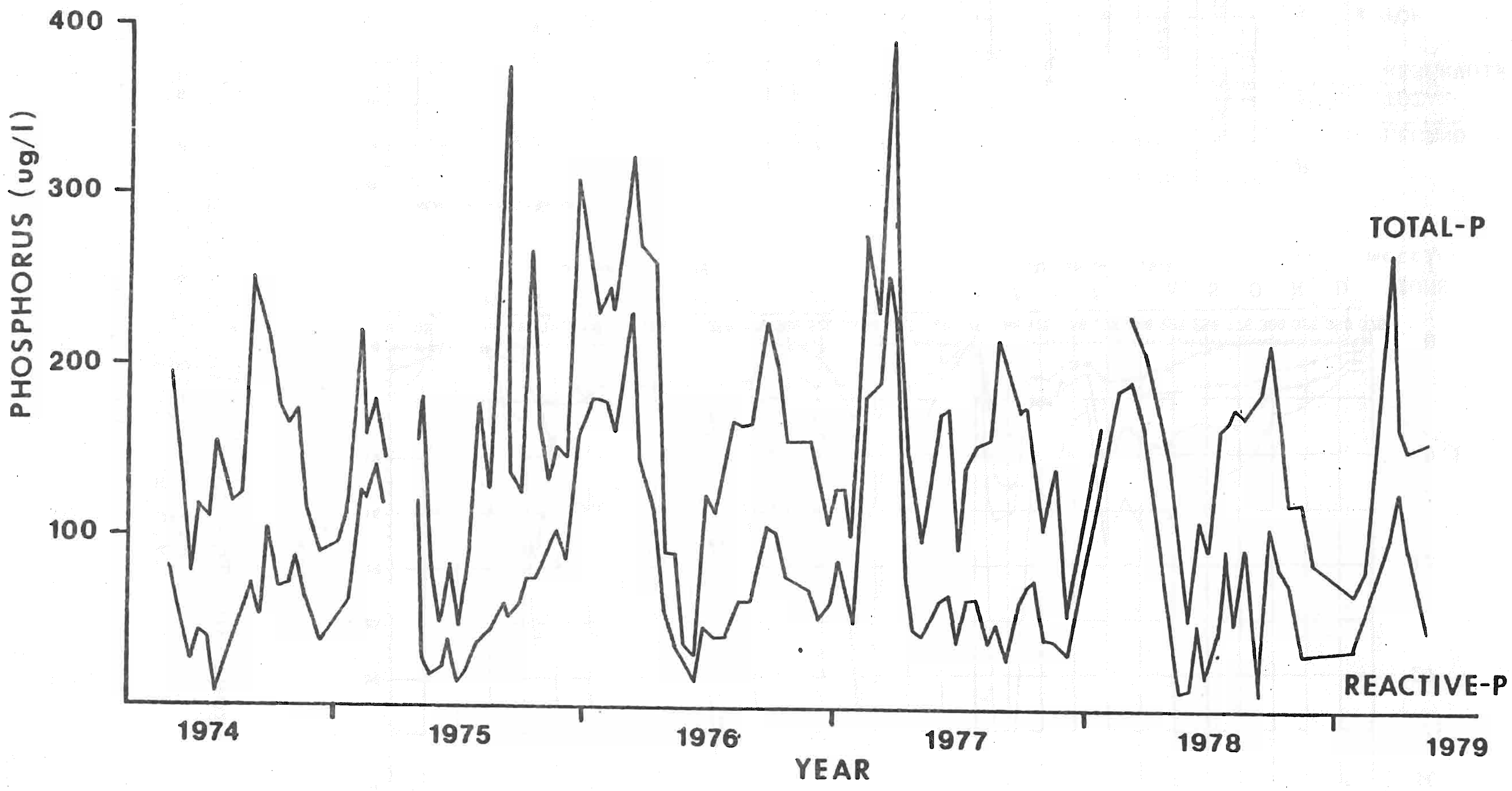


Figure 31. Average surface total reactive phosphorus concentrations in the Big Eau Pleine Reservoir.

The spring total mass phosphorus peak in the reservoir preceeded the water volume peak by (10, 5, and 10 days for segment 1, 2, and 3 in 1975) and (4, 1, and 9 days for segment 1, 2, and 3 in 1976). The lag occurs because the early flow has a higher phosphorus concentration than later flows, which have lower concentrations. Sedimentation is the probable cause for the decline of the total phosphorus mass in the reservoir in 1975. The value for segment 3 in 1976 was negative because the total phosphorus mass peak was after the water volume peak. This could have been a result of the dam being open to let excess spring runoff flow through the reservoir. Two factors that caused 1976 to have different lag periods were disturbance of the reservoir sediment, caused by excessive spring runoff flowing through the reservoir, and the speed that the reservoir filled.

Based on Figure 19, an estimate of the spring total phosphorus concentration would be between 0.1 and 0.2 mg/l-p. The average April concentration, calculated from the actual measured days, on the mass diagram (Figure 29) would yield 0.164 mg/l-p for 1975 and 0.175 mg/l-p for 1976.

The relative quantities of phosphorus flowing into the Big Eau Pleine Reservoir are identified by source in Table 13.

The largest sub-watershed, the Big Eau Pleine River, contributed the largest percentage both years. The total phosphorus export coefficient was 0.76 and 0.69 kg/ha/yr. for

Table 13. Percent inflow of total phosphorus mass to the Big Eau Pleine Reservoir.

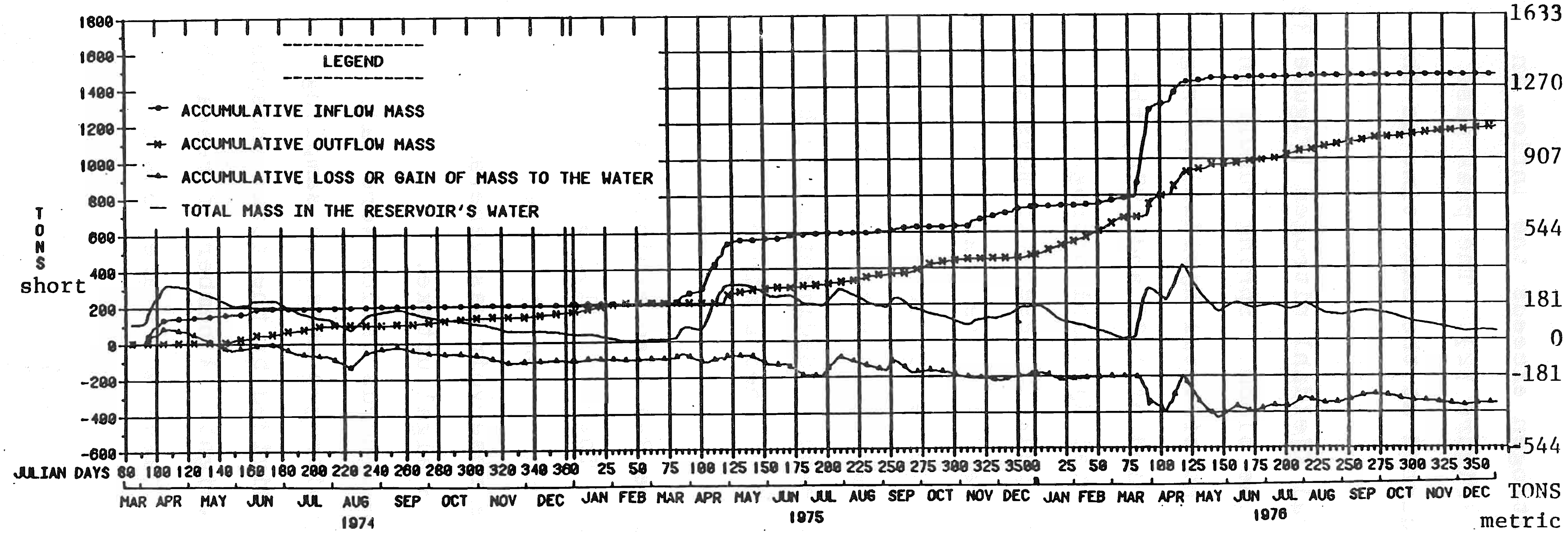
	1975 Percent	1976 Percent
Big Eau Pleine River	80	86
Stratford, Ditch (Sullivan, 1975)	2	3
Fenwood Creek	4	2
Freeman Creek	3	1
Associated Area	8	5
Septic Systems (EPA, 1974)	0.05	0.06
Precipitation	2	2

1975 and 1976. This compares well with other mixed agricultural yields (Rechow, 1980) and (Rasp and Lee,1978). Fenwood Creek's yields were 0.28 and 0.14 kg/ha/yr., and Freeman Creek's was 0.36 and 0.08 kg/ha/yr.. The Big Eau Pleine River had the highest yields and Freeman's Creek the lowest. Both Fenwood and Freeman Creeks' estimates were not as accurate,as the Big Eau Pleine River, because they were not sampled continously with an automatic sampler.

Nitrogen

Spring runoff is the time when total nitrogen reaches the maximum yearly mass in the reservoir (Figure 32).

Over the years, 1975 and 1976, there was a net loss of total nitrogen from the water column. This was similar to the net loss of total phosphorus.



ACCUMULATIVE CURVES AND DAILY MASS OF TOTAL NITROGEN IN THE BIG EAU PLEINE RESERVOIR.

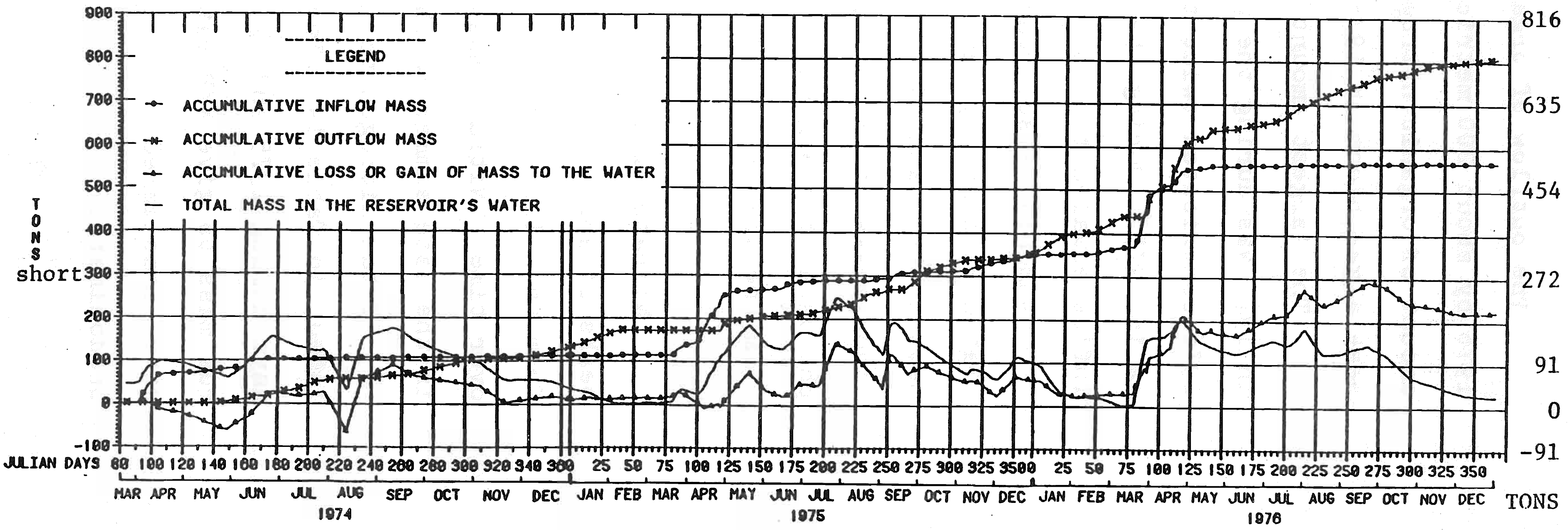


Figure 32. ACCUMULATIVE CURVES AND DAILY MASS OF ORGANIC NITROGEN IN THE BIG EAU PLEINE RESERVOIR.

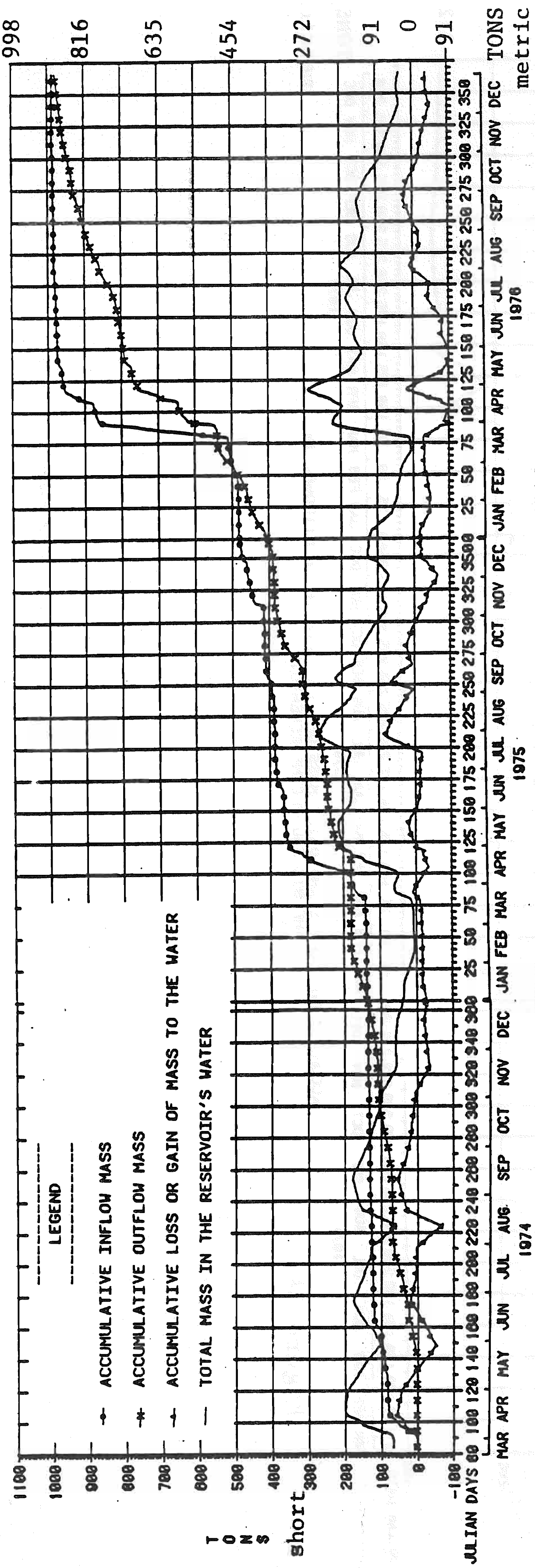
The outflow of organic nitrogen exceeds the inflow in 1976 by about 200 metric tons (Figure 32). The peak mass amount of organic nitrogen occurred at the same time as the peak algae bloom in 1975.

The largest amount of total Kjeldahl nitrogen (Figure 33) in 1975 was during the peak algae bloom. Spring runoff in 1976 contributed twice the amount of total Kjeldahl nitrogen as in 1975. During the time period of 1975 and 1976, the inflow equaled the outflow of total Kjeldahl nitrogen.

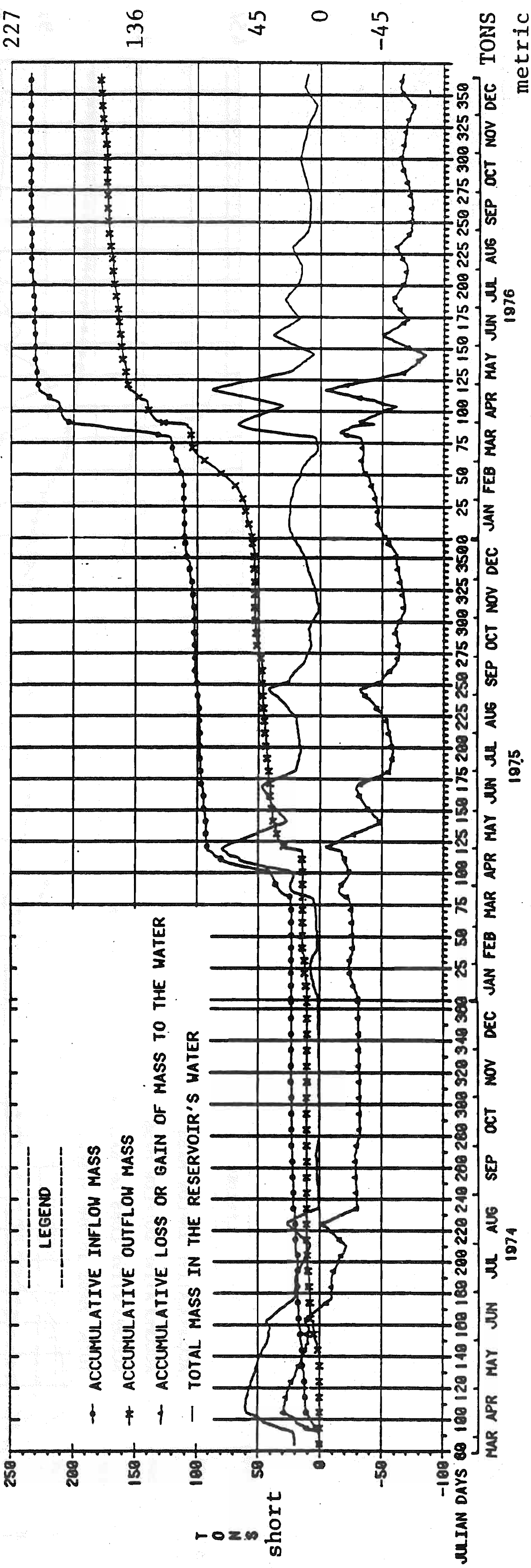
Ammonia, also, reached its peak in reservoir mass associated with spring runoff (Figure 33). The peak in reservoir mass in 1975 and 1976 was about 70 metric tons. One of the minor peaks of ammonia in 1975 was similar to the total phosphorus at the beginning of September. Sediment contribution from the winter of 1975 and 1976 reached a minor peak of 25 metric tons in January 1976.

Nitrate plus nitrite (Figure 34) also exhibits spring peaks of about 100 metric tons. There is also a net loss from this inorganic form of nitrogen from the water column over time. Nitrate mass in the reservoir was generally low in the late summer months due to algal uptake.

Total nitrogen to total phosphorus ratios were calculated, in Table 14. The total nitrogen mass, on sampling days during 1975 and 1976, was divided by the total phosphorus mass to give N/P ratio by weight. A number of researchers have established N/P ratios for lakes which are considered predominately

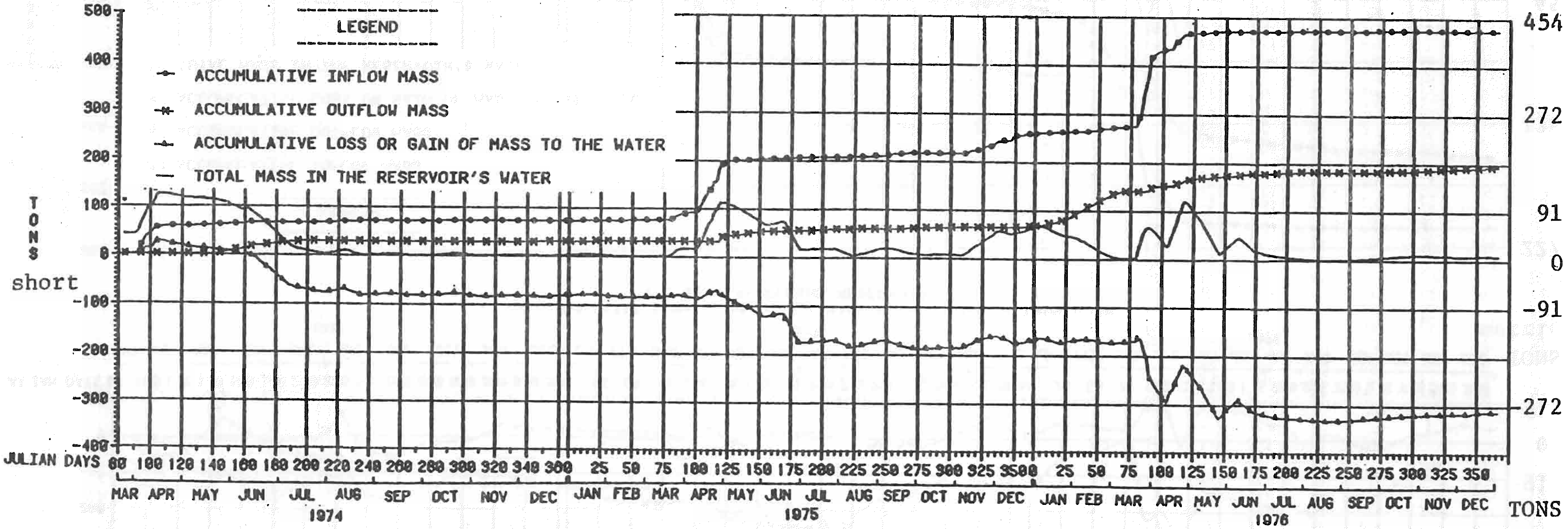


ACCUMULATIVE CURVES AND DAILY MASS OF KJELDAHL NITROGEN IN THE BIG EAU PLEINE RESERVOIR.



ACCUMULATIVE CURVES AND DAILY MASS OF AMMONIUM NITROGEN IN THE BIG EAU PLEINE RESERVOIR.

Figure 33.



ACCUMULATIVE CURVES AND DAILY MASS OF NITRATE+NITRITE NITROGEN IN THE BIG EAU PLEINE RESERVOIR.

Figure 34.

Table 14. The ratio of total nitrogen to total phosphorus in the Big Eau Pleine Reservoir during 1975 and 1976.

DATE	N/P RATIO BY WEIGHT			
1975	SEG 1	SEG 2	SEG 3	TOTAL RESERVOIR
Apr 30	15.7	13.8	13.7	14.0
May 20	10.6	17.7	26.5	18.6
Jun 3	8.9	24.4	31.4	21.8
Jun 18	13.4	19.3	23.8	19.3
Jun 30	11.1	17.7	18.0	15.3
Jul 15	6.6	19.3	19.5	14.1
Jul 28	11.1	23.0	14.1	17.4
Aug 11	7.9	20.3	8.8	12.9
Sep 3	5.7	4.0	5.9	4.8
Sep 9	8.3	16.2	28.4	15.9
Sep 23	8.3	11.8	19.7	12.6
Oct 7	7.0	9.4	11.8	9.7
Oct 21	7.1	10.4	13.9	10.9
Average	9.4	15.9	18.1	14.4
1976	SEG 1	SEG 2	SEG 3	TOTAL RESERVOIR
Apr 13	6.2	5.5	6.2	5.8
Apr 26	25.7	30.6	32.5	30.3
May 10	11.7	21.7	19.4	19.3
May 24	13.1	26.0	20.6	20.5
Jun 8	24.4	42.0	52.2	39.2
Jun 27	5.3	12.2	17.9	10.7
Jul 8	12.2	12.5	13.7	12.7
Jul 20	8.8	9.0	10.1	9.5
Aug 2	10.1	14.9	15.2	14.1
Aug 17	7.9	11.2	12.0	10.8
Aug 30	14.0	10.5	14.8	12.2
Sep 22	15.4	14.6	20.1	16.3
Oct 6	18.0	12.3	17.8	14.3
Oct 25	25.3	14.7	12.9	15.0
Average	14.2	17.0	19.0	16.5

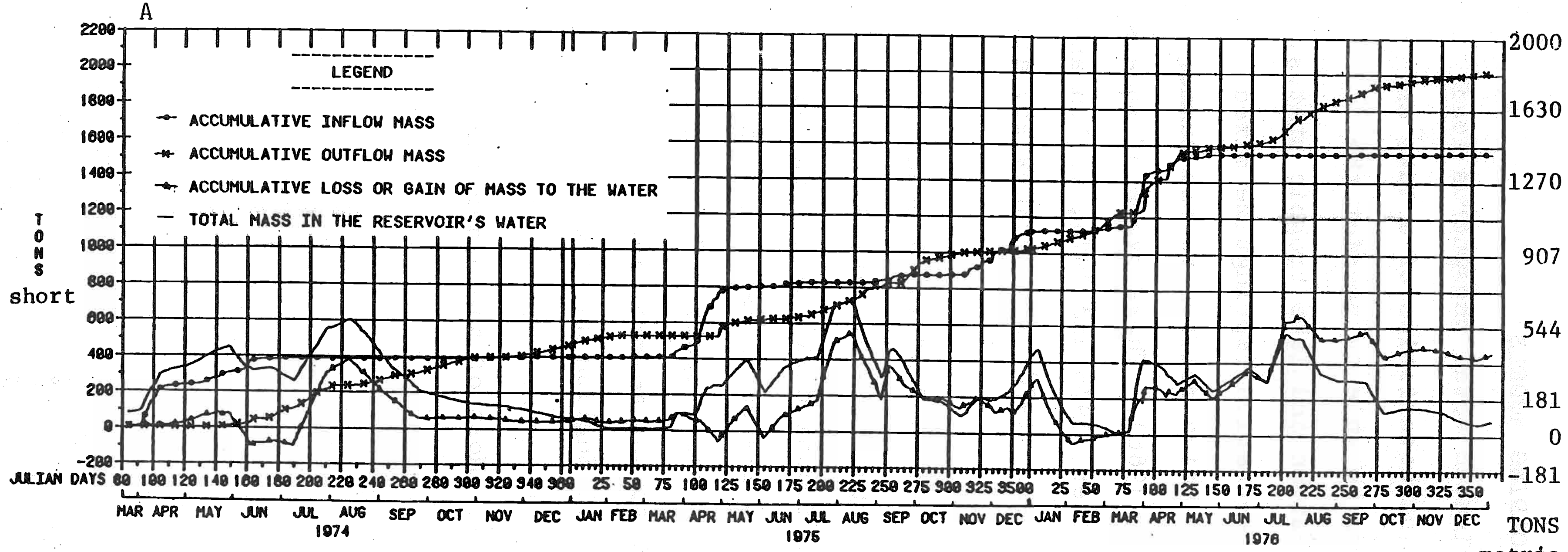
phosphorus limited. The ratios range from as low as 5:1 (Schindler, 1976) up to 15:1 (Baca, 1976). The Big Eau Pleine's N/P ratios range from 4:8 - 52:2 during the summer of 1975 and 1976. In both years, the ratio increased from segment one to segment three. The average N/P ratio was higher in 1976 than 1975. In the Big Eau Pleine Reservoir phosphorus is considered the controlling element because the blue green algae, composing the plankton flora, have the ability to fix nitrogen (Sullivan, 1978), and the nutrient budget's ratio of nitrogen to phosphorus was generally over 15:1 in the spring and summer.

BIOCHEMICAL OXYGEN DEMAND

The decline of blue green algae blooms in the Big Eau Pleine Reservoir corresponds to major peaks in BOD (Figure 35A). Runoff also produced minor peaks. In 1975, the inflow of BOD was nearly equal to the outflow. But in 1976, the outflow exceeded the inflow by about 200 metric tons. This shows the same trend as the organic nitrogen. 1976 was different because of the winter drawdown, scouring and spring flow that caused more transport of BOD out of the reservoir.

DISSOLVED OXYGEN

Maximum amounts of dissolved oxygen in the reservoir were associated with spring runoff and minimum amounts with low, late winter water volumes. The lower bottom water dissolved oxygen in Figure 35B did not show up very clearly on the mass curve because of the larger volume and mass of surface oxygenated water.



ACCUMULATIVE CURVES AND DAILY MASS OF FIVE DAY BOD IN THE BIG EAU PLEINE RESERVOIR.

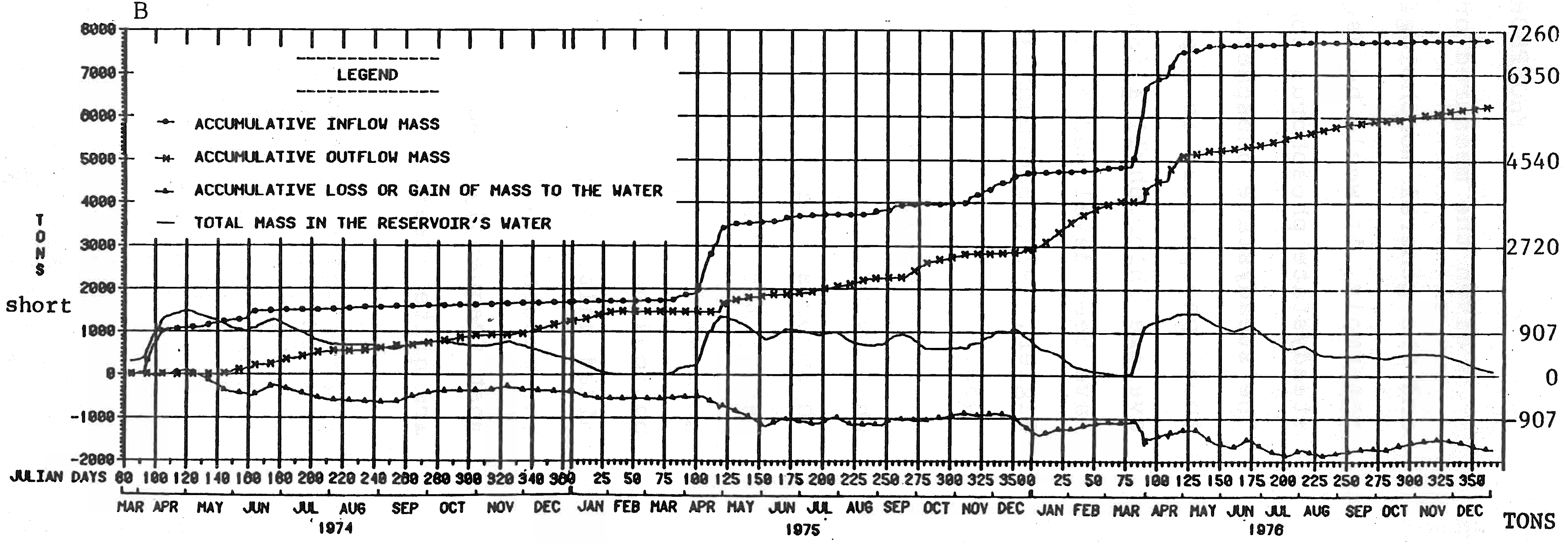


Figure 35.

ACCUMULATIVE CURVES AND DAILY MASS OF DISSOLVED OXYGEN IN THE BIG EAU PLEINE RESERVOIR.

PHOSPHORUS LOADING MODELS

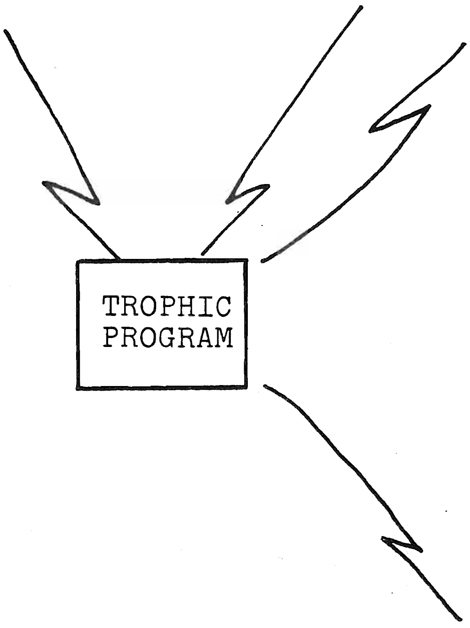
Given the measured or estimated total phosphorus load and the general morphological characteristics of a lake or reservoir, it would be useful to be able to predict the steadystate phosphorus concentration and lake trophic status. The steadystate phosphorus concentration (springtime mixed total phosphorus) is a parameter which relates to the summer average chlorophyll a (Sakamoto, 1966). These types of models have been developed by Vollenweider, 1975 and 1976; Dillon and Rigler, 1974; Bachmann and Canfield, 1978; and Reckhow et. al., 1980.

A program Trophic, was written in FORTRAN (Appendix E) which will calculate the lake trophic status (steadystate phosphorus, chlorophylla a, and Secchi disk) by several different methods. Given the inputs listed in Table 15, the program will printout some or all of the outputs. There are options built into this program to use metric, English, and mixed units. Mixed units have all English units except for the phosphorus load which is in kilograms. The time period most frequently used is 365 days. Most of the other inputs are quite clear.

Table 15. Input-output diagram of program (Trophic) operation.

INPUT

1. Lake Volume.
2. Outflow Rate.
3. Time Period.
4. Lake Surface Area.
5. Total Phosphorus Load.
6. Total Phosphorus Retention Coefficient or a Regressed Coefficient will be provided.
7. Initial Inlake Total Phosphorus Concentration - Required to do Predictions.
8. Steady State Phosphorus Concentration - Required to Back Calculate.



OUTPUT

1. Mean Depth.
2. Areal Water Loading.
3. Flushing Rate.
4. Hydraulic Residence Time.
5. Phosphorus Areal Loading.
6. Phosphorus Volumetric Loading.
7. Phosphorus Retention Coefficient.
8. Phosphorus Equilibrium Factor.
9. Half-Life of the Change in Phosphorus Concentration.
10. Predicted Phosphorus Steady-state Concentration Based On:
    - A - D.J. Dillon and F.H. Rigler, 1974.
    - B - R.A. Vollenweider, 1975.
    - C - R.A. Vollenweider, 1976.
    - D - R.W. Bachmann and D.E. Canfield, 1979.
    - E - K.H. Reckhow et al., 1980.
11. Acceptable Phosphorus Loading With A through C.
12. Excessive Phosphorus Loading With A through C.
13. Corresponding Chlorophyll a Conc. (Sakamoto, 1966) and Secchi Disk Depth (Lathrop, 1979) for A through E.
14. Predicted Recovery of the Phosphorus Conc. and Secchi Disk Depth After any Number of Years.
15. Mean Optimal Photosynthesis (Light Saturated).
16. Growing Season Mean Volumetric Rate of Photosynthesis.
17. Back Calculate the Phosphorus Loading for A through C.
18. List of Stored Input Variables.

If a regressed total phosphorus retnetion coefficient is requested, it will be calculated from this equation (Kirchner and Dillon, 1975):

$$Rp = 0.426 \exp(-.271 * A) + 0.574 * \exp(-.00949 * A)$$

Rp = Total phosphorus retention coefficient

A = Areal water loading = $\dfrac{\text{Outflow/Period}}{\text{Area of Lake Surface}}$

$*$ = Multiplication sign

The steadystate total phosphorus concentration can be calculated by one or any combination of five methods:

1. Dillon and Rigler, 1974.

$$P = \frac{L * (1-R)}{\bar{z} * \rho}$$

P = Inlake steadystate total phosphorus concentration

L = Specific areal phosphorus loading

$\bar{z}$ = Mean Depth

ρ = Flushing Rate

2. Vollenweider, 1975.

$$P = \frac{L}{10 + \bar{z} * \rho}$$

3. Vollenweider, 1976.

$$P = \frac{L}{\bar{z} * \rho} * \frac{\rho}{\sqrt{\rho} + \rho} = (P_o)\frac{\rho}{\sqrt{\rho} + \rho}$$

P_o = Inflow total phosphorus concentration

4. Rachmann and Canfield, 1979.

$$P = \frac{L}{\bar{z}\ (\sigma + p)}$$

σ = Phosphorus sedimentation rate

Lakes $\sigma = 0.162(L/\bar{z})^{0.458}$

Reservoir $\sigma = o.114(L/\bar{z})^{0.589}$

5. Reckhow, 1979.

$$P = \frac{L}{11.6 + 1.2A}$$

A = Areal water loading

Table 15. Minimum and maximum values for the data set used to develop the phosphorus loading model (from Reckhow, 1979).

Variable	Minimum	Maximum
P	0.004 mg/l	0.135 mg/l
L	0.07 $g/m^2.yr$	31.4 $g/m^2.yr$
A	1.23 m/yr	187.0 m/yr

The estimation of chlorophyll a concentration is calculated with the following relationship,

$$\text{CHL-}\underline{a} = 10 ** ((1.45 * \text{LOG } P) - 1.14) = mg/m^3$$

P = Total phosphorus steadystate concentration

** = To the power of

* = Multiplication sign

which was derived in Dillon & Rigler, 1974 from Sakamoto, 1966. One limitation of this relationship is that the algal growth must be phosphorus limited.

The relationship used by this program to estimate Secchi Disk depth in meters came from Lathrop, 1981. It was developed using Wisconsin lake data.

$$\text{Secchi Disk Depth (m)} = 5.19 * (\text{CHL-}\underline{a}\ (mg/m^3)) ** - .468)$$

These phosphorus loading models were applied to the total Big Eau Pleine Reservoir and its segments for 1975 and 1976.

Table 16 contains the input data applied to the Trophic program to predict steadystate phosphorus and chlorophyll a. The results of these calculations are listed in Table 17.

The first general conclusion drawn using all of the models is that, based on the annual phosphorus load, the Big Eau Pleine Reservoir is eutrophic. The measured chlorophyll a values were calculated from Appendix D of Sullivan, 1978. They represent the mean summer bloom chlorophyll a for the three segments and for the total reservoir. The spring total phosphorus was calculated by taking the total phosphorus mass in the segments and total reservoir, estimated by the nutrient budget for the two days sampled in April, and calculating an average concentration.

The Dillon and Rigler model predicted the chlorophyll a that was measured for 1975 in the segments. Under the title method in Table 17, the first Dillon and Rigler prediction uses a phosphorus retention coefficient estimated using the areal water load with the regression equation from Kirchner and Dillon. The second Dillon and Rigler prediction uses the phosphorus retention calculated from the nutrient budget. The Reckhow model was the second best fit for the 1975 Big Eau Pleine Reservoir data. In both models, the steadystate total phosphorus predictions did not match as good as the chlorophyll a data. This may be due to the way the measured value was obtained. The early and late April values were obtained before and

INPUT PARAMETERS	TOTAL	SEG 1	SEG 2	SEG 3
FULL LAKE VOLUME (m^3)	131,500,000	21,753,278	68,549,304	39,847,415
OUTFLOW RATE (m/s)	See Below	See Below	See Below	See Below
FULL LAKE SURFACE AREA (ha)	2,760	731.26	1,337.67	687.13
YEARLY AVERAGE LAKE VOLUME (n= 24) Meters				
YEAR	TOTAL	SEG 1	SEG 2	SEG 3
1975	75,634,735	10,458,131	40,450,579	24,726,025
1976	67,890,519	3,669,051	36,377,123	22,844,345
YEARLY OUTFLOW RATE (Meters/Sec.)				
YEAR	TOTAL	SEG 1	SEG 2	SEG 3
1975	5.71	6.12	6.34	5.77
1976	10.40	7.39	9.89	10.53
1977	2.03			
1978	14.40			
TOTAL PHOSPHORUS LOAD (kg/yr.)				
1975	63,400	54,100	52,400	33,100
1976	50,500	46,700	49,700	50,400
1977	26,400			
1978	83,300			

Table 16. Input data for trophic estimates of the Big Eau Pleine Reservoir; (Data cont. on next page).

INPUT PARAMETERS	TOTAL	SEG 1	SEG 2	SEG 3
YEARLY AVERAGE LAKE AREA (ha)				
YEAR	TOTAL	SEG 1	SEG 2	SEG 3
1975	1933	432.52	974.63	525.89
1976	1831.8	370.86	951.58	509.32
MEASURED PHOSPHORUS RETENTION COEFFICIENT				
1975	.74	.12	.39	.51
1976	-.12	-.02	-.01	-.12
1977	.82			
1978	.39			

Table 16. (cont'd). Input data for trophic estimates of the Big Eau Pleine Reservoir.

TOTAL RESERVOIR

		1975			1976	
Mean Depth		3.91			3.71	
Flushing Rate		2.38			4.83	
METHOD	PRC*	P(mg/m^3)	CHLa(mg/m^3)	PRC*	P(mg/m^3)	CHLa(mg/m^3)
Dillon & Rigler	.56	155	109	.49	79	41
Dillon & Rigler	.26	260	230	-.12	172	126
Vollenweider, 1975		170	124		99	57
Vollenweider, 1976		214	173		106	62
Bachmann & Canfield (artificial lakes)		352	355		154	108
Reckhow, 1980		144	98		83	44
Measured		164	98.7		175	120

* Phosphorus Retention Coefficient

SEGMENT ONE

		1975			1976	
Mean Depth		2.42			2.34	
Flushing Rate		18.5			26.9	
METHOD	PRC*	P(mg/m^3)	CHLa	PRC*	P(mg/m^3)	CHLa
Dillon & Rigler	.38	175	129	.32	137	91
Dillon & Rigler	.12	247	213	-.02	204	162
Vollenweider, 1975		229	191		173	127
Vollenweider, 1976		227	189		168	122
Bachmann & Canfield (artificial lakes)		280	256		200	158
Reckhow, 1980		192	148		144	98
Measured		186	129.4		156	121.0

Table 17. Mean yearly output data from the Trophic program.

SEGMENT TWO

		1975			1976	
Mean Depth		4.15			3.82	
Flushing Rate		4.94			8.57	
METHOD	PRC*	$P(mg/m^3)$	$CHL\underline{a}(mg/m^3)$	PRC*	$P(mg/m^3)$	$CHL\underline{a}(mg/m^3)$
Dillon & Rigler	.47	138	92	.42	92	51
Dillon & Rigler	.39	160	114	-.01	161	115
Vollenweider, 1975		176	131		122	77
Vollenweider, 1975		181	136		119	74
Bachmann & Canfield (artificial lakes)		262	233		159	113
Reckhow, 1980		148	102		193	60
Measured		142	98.7		179	131.7

* Phosphorus Retention Coefficient

SEGMENT THREE

		1975			1976	
Mean Depth		4.70			4.49	
Flushing Rate		7.36			14.54	
METHOD	PRC*	$P(mg/m^3)$	$CHL\underline{a}(mg/m^3)$	PRC*	$P(mg/m^3)$	$CHL\underline{a}(mg/m^3)$
Dillon & Rigler	.41	107	63	.31	105	62
Dillon & Rigler	.51	89	49	-.12	170	124
Vollenweider, 1975		141	95		132	86
Vollenweider, 1976		133	87		120	75
Bachmann & Canfield (artificial lakes)		182	137		152	105
Reckhow, 1980		118	73.6		110	66
Measured		193	67.9		179	106.9

Table 17 Cont'd. Mean yearly output data from the Trophic program.

after or during the spring loss of total phosphorus due to sedimentation. This caused the average to be of a large and small number, therefore much more variable than if they both had been similar.

In order to explain why the 1976 prediction did not fit the measured value, it is necessary to examine the assumptions of the Dillon and Rigler model:

> " 1) There are no seasonal changes in the input rate of total phosphorus to a lake; 2) the concentration of total phosphorus in the outflow is equal to the lake concentration; 3) the lake is completely mixed with respect to total phosphorus; and 4) the sedimentation rate of total phosphorus is proportional to the amount in the lake." (LaBaugh and Winter, 1981)

To evaluate the first assumption, refer to Figure 29A, during 1975, the accumulative inflow mass line kept increasing after the spring runoff contribution. While, in 1976 the line is flat after May. This is due to the record dry summer of 1976. For the second assumption refer to Appendix C, Figure C3-C6 and Figure C9-C11 to compare the segment three top, middle and bottom total phosphorus with the outflow concentrations. Generally, 1976 is similar and 1975 is about 5 mg/m^3 lower. The third assumption can be evaluated on Figure 19. It shows that the total phosphorus is generally completely mixed with respect to the water column in both years. Fourth, "is the sedimentation rate proportional to the amount in the lake," Figure 29A shows that the accumulative loss in mass during 1975 was about 36 metric tons and only about 10 metric tons in 1976, when both reached a mass of about 35 metric tons. A conclusion that can be drawn from this evaluation is that 1975 fits the assumptions of the model better than 1976.

Now that a model has been identified that predicts the conditions in the reservoir segments, a prediction of what the conditions would have been in the reservoir had it remained full during 1975 can be made. Table 18 contains the input data for a computer run of the Trophic program.

TOTAL RESERVOIR	1975
Full Lake Volume (m^3)	129,898,079
Outflow Rate (m/s)	3.99
Lake Surface Area (ha)	2,753.99
Total Phosphorus Load	63,400
SEGMENT ONE	
Full Lake Volume	21,686,459
Outflow Rate	5.76
Lake Surface Area	730.23
Total Phosphorus Load	54,100
SEGMENT TWO	
Full Lake Volume	68,427,022
Outflow Rate	5.45
Lake Surface Area	1,336.92
Total Phosphorus Load	48,522
SEGMENT THREE	
Full Lake Volume	39,784,598
Outflow Rate	5.29
Lake Surface Area	686.83
Total Phosphorus Load	31,445

Table 18. Full volume input data for the Trophic program.

The lake volume and area are the maximum observed during the spring of 1975. The annual outflow rate was reduced from the first estimate by the difference in the full volume and the actual yearly average volume. The loading to segment two and three was reduced by the percent difference in the regressed phosphorus retention coefficient. Predictions made using the Dillon and Rigler model are in Table 19.

	TOTAL	SEG 1	SEG 2	SEG 3
Mean Depth (m)	4.72	2.97	5.12	5.79
Flushing Rate (parts of lake/yr)	.97	8.38	2.51	4.19
Phosphorus Retention Coefficient	.67	.45	.52	.46
Steadystate Total Phosphorus (mg/m^3)	165	163	135	102
Chlorophyll a (mg/m^3)	119	117	89	60

Table 19. Full volume prediction using the Dillon and Rigler model for 1975.

Results of this prediction are comparable with the data in Table 17. The full volumes resulted in an increased mean depth and phosphorus retention coefficients. Similarly, the flushing rate was decreased. Steadystate phosphorus and chlorophyll a predictions for the segments indicated a slight improvement. While, treating the reservoir as a whole predicted slightly elevated levels of chlorophyll a and phosphorus. Because of the higher accuracy in predicting the segment quality, a full volume management of the reservoir should produce an improvement in reservoir quality.

The Dillon and Rigler model was also used to predict the effects of a reduced phosphorus load from the watershed. A reduction from the full 1975 phosphorus loads were made only on the portion that came from the watershed. Then, 20 and 50 percent reductions were calculated and added to the load from the other sources, to obtain the reduced loads in Table 20.

	TOTAL	SEG 1	SEG 2	SEG 3
Total Phosphorus Load	63,400	54,100	52,400	33,100
Steadystate Phosphorus	155	175	138	107
Chlorophyll a	109	129	92	63
Total Phosphorus Surface Runoff Reduced by 20%	52,240	44,580	43,180	27,270
Steadystate Phosphorus	128	144	114	88
Chlorophyll a	82	98	69	48
Total Phosphorus Surface Runoff Reduced by 50%	35,500	30,300	29,340	18,540
Steadystate Phosphorus	87	98	77	60
Chlorophyll a	47	56	40	27

Table 20. 1975 Phosphorus load reduction predictions using the Dillon and Rigler model for the Big Eau Pleine Reservoir.

Reduced phosphorus loads predicted a decreased phosphorus and chlorophyll a concentration. Even with the 50 percent reduction in segment three phosphorus load, the areal phosphorus load was still three times higher than an excessive load limit and seven times higher than the acceptable limit. That means the reservoir segment three would still be eutrophic. But the size of the algae blooms would be reduced.

CONCLUSION

The Big Eau Pleine is a polymictic reservoir that is eutrophic. It has an agricultural watershed that contributes an average of 54 percent of its phosphorus and 62 percent of its nitrogen annual load (4 year average) during spring runoff. Internal reservoir biology and chemistry is influenced by the changing of the water level up to 9 meters annually. The combination of spring runoff with reservoir flushing after the reservoir was full in 1976 contributed to a large outflow of total phosphorus from the reservoir.

When the reservoir was treated as three segments, it was possible to predict the summer bloom mean chlorophyll a concentration using the Dillon and Rigler model for 1975. A prediction was made using the phosphorus loading model for the reservoir with a full reservoir and segment volume. It resulted in a prediction of some slight improvements with the chlorophyll a in the segments and a slight higher level for the reservoir as a whole.

The major problems and potential management practices are summarized in Table 20. Biological problems in the Big Eau Pleine Reservoir are: algal blooms, winter dissolved oxygen depression, fishkills, and potential aquatic weeds. Possible management practices to deal with these problems include: maintianing a full reservoir; later drawdown of the reservoir (after the summer algae blooms); spring flushing of the reservoir prior to reservoir filling up; higher minimum volume; aeration; same management practices; and reducing the phosphorus load from the watershed.

Algae blooms have been a persistant problem in the Big Eau Pleine Reservoir. Some improvement in the magnitude of the bloom may be observed with implementation of these practices; full reservoir, later drawdown, or/and spring flush. But, the more positive solution is to reduce the phosphorus load from the watershed. If the full reservoir option is exercised then the aquatic weeds may be a problem in the Big Eau Pleine Reservoir.

The other problem area has been the winter dissolved oxygen depression and the resulting fishkill. Management practices that should help this problem are: full reservoir; later drawdown, if it is coupled with a higher minimum winter volume; and aeration combined with higher minimum winter volume. The spring flushing may result in a fishkill, unless the water level is raised to some higher stage than the minimum prior to flushing.

PROBLEMS PRACTICES	ALGAL BLOOMS	WINTER DISSOLVED OXYGEN DEPRESSION	FISHKILLS	AQUATIC WEEDS
FULL RESERVOIR	Some improvement but still will have blooms.	Should be eliminated.	Should be eliminated.	May become a problem.
LATER DRAWDOWN	Some improvement as with a full reservoir.	Some effect as in 1976.	Some effect as in 1976.	Should control some types of **macrophytes**.
SPRING FLUSH	Reduces the amount of phosphorus in the reservoir - improvement.	May have a slug of low D.O. and high BOD water.	May result in fishkill.	Little effect.
HIGHER MINIMUM VOLUME	Less flushing of phosphorus.	Less frequently a problem or eliminated at some stage.	Less frequently a problem or eliminated at some stage.	May become a problem depending on stage.
AERATION	Minimal effect.	Improve.	Improved.	No effect.
SAME MANAGEMENT PRACTICES	Remain about the same - more eutrophic with time.	With increased eutrophication - should occur more frequently.	More frequent with eutrophication.	Not a problem.
REDUCE PHOSPHORUS LOAD FROM WATERSHED	Potential for most dramatic effect.	A less eutrophic reservoir should improve D.O.	Improved.	Not a problem.

Table 21. Lake management of the Big Eau Pleine Reservoir.

The objective with these recommendations is not an oligotrophic reservoir. It is to address the problems voiced by the people, who do not seem to mind the algae blooms in a relatively water poor area, when compared to other Wisconsin glacial lake areas, but who are distressed with the fishkills in this productive fishery. Both watershed and reservoir practices will be required to eliminate fishkills in the Big Eau Pleine Reservoir.

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APPENDIX A

Listing of the computer program called EP/WATERBUDGET/FLOWPROG.

```
$FILE (10084)EP/WATERBUDGET/FLOWPROG ON ACAD
100 $SET LINEINFO
~~200 $RESET FREE~~
300 FILE  1(TITLE="(10084)EP/EP17FLOW/ADJ",KIND=PACK,MAXRECSIZE=14,
400       -BLOCKSIZE=420)
~~500 FILE  2(TITLE="(10084)EP/PRECIP/EAUPLEINEDAM/ADJ",KIND=PACK,MAXRECSIZE=~~
600      -14,BLOCKSIZE=420)
700 FILE  3(TITLE="(10084)EP/AIRTEMP/EAUPLEINEDAM",KIND=PACK,MAXRECSIZE=14,
~~800       -BLOCKSIZE=420)~~
900 FILE  4(TITLE="(10007)EP/WADPF",KIND=PACK,MAXRECSIZE=14,
1000      -BLOCKSIZE=420)
~~1100 FILE  5(KIND=REMOTE,MAXRECSIZE=22)~~
1200 FILE  6(KIND=REMOTE,MAXRECSIZE=22)
1300 FILE  7(TITLE="(10084)FILE/OUTFLOW",KIND=PACK,MAXRECSIZE=14,
~~1400      -BLOCKSIZE=420)~~
1500 FILE  8(TITLE="(10084)EP/PRECIPINFLOW",KIND=PACK,MAXRECSIZE=14,
1600      -BLOCKSIZE=420)
~~1700 FILE  9(TITLE="(10084)EP/EP11INOUTFLOW",KIND=PACK,MAXRECSIZE=14,~~
1800      -BLOCKSIZE=420)
1900 FILE  10(TITLE="(10084)EP/INTCONDEPARES",KIND=PACK,MAXRECSIZE=14,
~~2000      -BLOCKSIZE=420)~~
2100 FILE  11(TITLE="(10007)EP/WAWSF",KIND=PACK,MAXRECSIZE=14,
2200      -BLOCKSIZE=420)
~~2300 FILE  12(TITLE="(10084)EP/PRECIP/MFEXPFARM",KIND=PACK,MAXRECSIZE=14,~~
2400      -BLOCKSIZE=420)
2500 FILE  13(TITLE="(10084)EP/AIRTEMP/MFEXPFARM",KIND=PACK,MAXRECSIZE=14,
~~2600      -BLOCKSIZE=420)~~
~~2700 FILE  14(TITLE="(10084)EP/EVAPORATION",KIND=PACK,MAXRECSIZE=14,~~
2800      -BLOCKSIZE=420)
2900 FILE  15(TITLE="(10084)EP/ICETHICKNESS/ADJ",KIND=PACK,MAXRECSIZE=14,
3000      -BLOCKSIZE=420)
3100 FILE  16(TITLE="(10084)EP/EP6FLOW/ADJ",KIND=PACK,MAXRECSIZE=14,
~~3200      -BLOCKSIZE=420)~~
3300 FILE  17(TITLE="(10084)EP/WATERBUDGET/DAILYOUTPUT",KIND=PACK,MAXRECSIZE=
3400      -14,BLOCKSIZE=420)
~~3500 FILE  18(TITLE="(10084)EP/WATERBUDGET/QUALITY",KIND=PACK,MAXRECSIZE=14,~~
3600      -BLOCKSIZE=420)
3700 FILE  19(TITLE="(10084)EP/MONTHLYEVAPRATES",KIND=PACK,MAXRECSIZE=14,
~~3800      -BLOCKSIZE=420)~~
3900 FILE  20(TITLE="(10084)EP/WATERBUDGET/SPACETIME",KIND=PACK,MAXRECSIZE=14
4000      -,BLOCKSIZE=420)
~~4100 FILE  21(TITLE="(10084)EP/WATERBUDGET/ACCUMLATIVEOUTPUT",KIND=PACK,~~
4200      -MAXRECSIZE=14,BLOCKSIZE=420)
4300 FILE  22(TITLE="(10084)EP/FE1FLOW",KIND=PACK,MAXRECSIZE=14,
~~4400      -BLOCKSIZE=420)~~
4500 FILE  23(TITLE="(10084)EP/FR1FLOW",KIND=PACK,MAXRECSIZE=14,
4600      -BLOCKSIZE=420)
~~4700 FILE  24(TITLE="(10084)EP/EP18FLOW",KIND=PACK,MAXRECSIZE=14,~~
4800      -BLOCKSIZE=420)
4900 FILE  25(TITLE="(10084)EP/WATERBUDGET/DASIA",KIND=PACK,MAXRECSIZE=14,
~~5000      -BLOCKSIZE=420)~~
5100 FILE  31(TITLE="(10084)EP/EP7INOUTFLOW",KIND=PACK,MAXRECSIZE=14,
5200      -BLOCKSIZE=420)
~~5300 FILE  32(TITLE="(10084)EP/EP9INOUTFLOW",KIND=PACK,MAXRECSIZE=14,~~
5400      -BLOCKSIZE=420)
5500 FILE  33(TITLE="(10084)EP/EP17INOUTFLOW",KIND=PACK,MAXRECSIZE=14,
~~5600      -BLOCKSIZE=420)~~
5700 FILE  34(TITLE="(10084)FILE/RESELCK",KIND=PACK,MAXRECSIZE=14,
5800      -BLOCKSIZE=420)
~~5900 FILE  35(TITLE="(10084)EP/WATERBUDGET/DAILYVOLOUTPUT",KIND=PACK,~~
6000      -MAXRECSIZE=14,BLOCKSIZE=420)
6100 FILE  39(TITLE="(10084)EP/WATERBUDGET/PICK",KIND=PACK,MAXRECSIZE=14,
~~6200      -BLOCKSIZE=420)~~
6300 FILE  40(TITLE="(10084)FILE/ASSOCFLOW",KIND=PACK,MAXRECSIZE=14,
6400      -BLOCKSIZE=420)
~~6450 FILE  41(TITLE="(10084)FILE/INFLOW",KIND=PACK,MAXRECSIZE=14,~~
6460      -BLOCKSIZE=420)
6463 FILE  42(TITLE="(10084)FILE/FEFLOW",KIND=PACK,MAXRECSIZE=14,
~~6465      -BLOCKSIZE=420)~~
6467 FILE  43(TITLE="(10084)FILE/FRFLOW",KIND=PACK,MAXRECSIZE=14,
6469      -BLOCKSIZE=420)
~~6500 C*~~
6600 C*
6700        COMMON/NVS/ NS,SW(4),SL(4),SEG(5,20,2),DASI(70,5,5),IDP(5),CNL
~~6800        COMMON/ERR/ IREGNO(25)~~
6900        COMMON/EVA/ BB,A,EVSUM,KEYEVP,EVAPM(12),EVAPYR
7000        COMMON/TIME/ NDAY,IYR
~~7100        DIMENSION NT(4),MD(12),MONTH(13),OFAA(4),ITFN(4,5),PI(150,3,5)~~
7200        DIMENSION ALPHA(70),DATA(20),ALABEL(20)
7300        DIMENSION IDO(14),TRBFLO(4),AREAI(5)
```

```
7350          DATA AREAI/5*0.0/
7400          DATA END/'END'/,IPI/0/
7500          DATA IRECNO/25*0/
7600          DATA MD/31,28,31,30,31,30,31,31,30,31,30,31/
7700          DATA MONTH/1,32,60,91,121,152,182,213,224,274,305,335,366/
7800          DATA ALABEL /'UPSIN','TRIB ','ASSFL','PREC ','ICEIN','RSIN ',
7900         -'NETRS','RSOUT ','ICEOT ','     ','EVAP ','DVOL ','NVOL ',
8000         -'DVOL ','OSURA','NSURA','DSURA','OUTFL','PASSA','TASSA'/
8100          DATA NCLDAY,NCLYR /4,77/
8200          LOGICAL ERCK
8300 C*
8400 C*
8500          PRINT//,'ENTER A FOURTEEN DIGIT NUMBER:EACH DIGIT WILL'
8600          PRINT//,'BE EITHER A ZERO OR A ONE.A ONE INDICATES TO THE'
8700          PRINT//,'PROGRAM TO MAKE A FILE. A ZERO INDICATES DO NOT PRINT'
8800          PRINT//,'THIS FILE. THE FOURTEEN FILES FROM LEFT TO RIGHT ARE:'
8900          PRINT//,'(10084)FILE/OUTFLOW'
9000          PRINT//,'(10084)EP/PRECIPINFLOW'
9100          PRINT//,'(10084)EP/EP11INOUTFLOW'
9200          PRINT//,'(10084)EP/EVAPORATION'
9300          PRINT//,'(10084)EP/WATERBUDGET/DAILYOUTPUT'
9400          PRINT//,'(10084)EP/WATERBUDGET/QUALITY'
9500          PRINT//,'(10084)EP/WATERBUDGET/ACCUMULATIVEOUTPUT'
9600          PRINT//,'(10084)EP/EP7INOUTFLOW'
9700          PRINT//,'(10084)EP/EP9INOUTFLOW'
9800          PRINT//,'(10084)EP/EP17INOUTFLOW'
9900          PRINT//,'(10084)FILE/RESELK'
10000          PRINT//,'(10084)EP/WATERBUDGET/DAILYVOLOUTPUT'
10100          PRINT//,'(10084)EP/WATERBUDGET/PICK'
10150          PRINT//,'(10084)FILE/INFLOW'
10200          READ(5,8321)IDO
10300   8321  FORMAT(15I1)
10400          IF(IDO(1).EQ.1)PRINT//,'(10084)FILE/OUTFLOW WILL BE PRINTED'
10600          IF(IDO(2).EQ.1)PRINT//,'(10084)EP/PRECIPINFLOW WILL BE PRINTED.'
10700          IF (IDO(3).EQ.1)PRINT//,'(10084)EP/EP11INOUTFLOW WILL BE PRINTED.'
10800          IF(IDO(4).EQ.1)PRINT//,'(10084)EP/EVAPORATION WILL BE PRINTED.'
10900          IF(IDO(5).EQ.1)PRINT//,'(10084)EP/WATERBUDGET/DAILYOUTPUT'
11000        -,'WILL BE PRINTED.'
11100          IF(IDO(6).EQ.1)PRINT//,'(10084)EP/WATERBUDGET/QUALITY WILL'
11200        -,'BE PRINTED.'
11300          IF(IDO(7).EQ.1)PRINT//,'(10084)EP/WATERBUDGET/ACCUMULATIVEOUTPUT'
11400        -,'WILL BE PRINTED.'
11500          IF(IDO(8).EQ.1)PRINT//,'(10084)EP/EP7INOUTFLOW WILL BE PRINTED.'
11600          IF(IDO(9).EQ.1)PRINT//,'(10084)EP/EP9INOUTFLOW WILL BE PRINTED.'
11700          IF(IDO(10).EQ.1)PRINT//,'(10084)EP/EP17INOUTFLOW WILL BE PRINTED.'
11800          IF(IDO(11).EQ.1)PRINT//,'(10084)FILE/RESELCK WILL BE PRINTED.'
11900          IF(IDO(12).EQ.1)PRINT//,'(10084)EP/WATERBUDGET/DAILYVOLOUTPUT'
12000        -,'WILL BE PRINTED.'
12100          IF(IDO(13).EQ.1)PRINT//,'(10084)EP/WATERBUDGET/PICK WILL'
12200        -,'BE PRINTED.'
12250          IF(IDO(14).EQ.1)PRINT//,'(10084)FILE/INFLOW WILL BE PRINTED.'
12300          PRINT//,'THIS PROGRAM IS RUNABLE FROM A FILE OR TERMINAL.'
12400   3      PRINT//,'ENTER THE MODE OF THIS RUN ("FILE" OR "TERMINAL").'
12500          PRINT//,'---->'
12600          READ(5,5)RUN
12700 5        FORMAT(A4)
12800          IF(RUN.EQ.'FILE'.OR.RUN.EQ.'TERM')GO TO 4
12900          GO TO 3
13000 C*      RUN=A VARIABLE TO DEFINE IF THE DATA INPUT IS FROM A FILE OR TERM.
13100 4        IF(RUN.EQ.'FILE')GO TO 10
13200          PRINT//,'DO YOU WANT TO SEE THE PROGRAM DESCRIPTION?'
13300          PRINT//,'ENTER ("YES" OR "NO ").'
13400          PRINT//,'--->'
13500          READ(5,2)YES
13600 2        FORMAT(A3)
13700          IF(YES.EQ.'NO ')GO TO 1
13800 C*
13900 C*
14000          PRINT//,'PROGRAM DESCRIPTION.'
14100          PRINT//,'WATER BUDGET PROGRAM'
14200          PRINT//,'BY MIKE MARANO AND JIM VENNIE'
14300          PRINT//,'    '
14400          PRINT//,'     THIS PROGRAM IS ABLE TO CALCULATE THE DAILY WATER'
14500          PRINT//,'BUDGET FOR A SEGMENTED RESERVOIR.  THE REPORTS OF THE '
14600          PRINT//,'BUDGET CAN BE ACCUMLATED FOR DAYS, MONTHS, OR YEARS.'
14700          PRINT//,'A SMALLER SUBDIVISION OF THE SEGMENTS INTO CELLS IS'
14800          PRINT//,'DONE USING THE ASSUMPTION THAT THE RESERVOIR IS IN THE '
14900          PRINT//,'SHAPE OF A FIX LENGTH MAJOR AXIS ELLIPSE.'
15000          PRINT//,'                                JUNE 1977'
15100 C*
15200 C*      PARAMETERS DEFINED ABOUT SPACE.
15300 C*
```

```
1      PRINT//,'ENTER THESE VARIABLES IN ONE LINE SEPARATED WITH COMMAS.'
       PRINT//,' 1.  NUMBER OF SEGMENTS (MAXIMUM=4)'
       PRINT//,' 2.  THE LENGTH OF THE NORMAL CELL,ENTER ZERO IF THE CELL
      - IS NOT USED.'
       PRINT//,' 3.  LENGTH OF EACH SEGMENT (METERS).'
       PRINT//,' 4.  NUMBER OF THE MINOR TRIBUTARY INPUTS TO EACH SEGMENT
      -(MAXIMUM=5)'
       PRINT//,' 5.  OVERLAND FLOW AREA PER SEGMENT (SQ. MILES).'
3015   PRINT//,'--->'
       READ(5,3000)ALPHA
3000   FORMAT(70C1)
       CALL CONVRT(70,ALPHA,20,DATA,ERCK)
       IF(.NOT.ERCK) GO TO 3010
       PRINT //,'ERROR IN DATA ENTRY REENTER THE DATA.'
       GO TO 3015
3010   NS=DATA(1)
       CNL=DATA(2)
       DO 3001 J=1,NS
3001   SL(J)=DATA(2+J)
       ICCNT=2+NS
       DO 3002 J=1,NS
3002   NT(J)=DATA(ICCNT+J)
       ICCNT=ICCNT+NS
       DO 3003 J=1,NS
3003   OFAA(J)=DATA(ICCNT+J)
       WRITE(20,6)NS,CNL,NS,(SL(J),J=1,NS),NS,(NT(J),J=1,NS),NS,(OFAA(J),
      -J=1,NS)
6      FORMAT(I5,F10.2,/,*(F8.0),/*(I3/),/*(F8.2))
       J=1
       IDI=0
       DO 15 J=1,NS
       IF(J.EQ.NS.AND.NT(J).EQ.0)GO TO 15
       PRINT//,'ENTER THE FILE NUMBERS FOR SEGMENT',J,', AND ITS MINOR TR
      -IBUTARIES (MAXIMUM = 5), IN ONE LINE SEPARATED BY COMMAS,'
       PRINT//,'  WITH',NT(J),' ENTRIES, FOLLOWED BY THE INTERFLOW FILE #
      -.'
17     PRINT//,'--->'
       READ(5,3000)ALPHA
       CALL CONVRT(50,ALPHA,20,DATA,ERCK)
       IF(.NOT.ERCK)GO TO 3335
       PRINT//,'ERROR IN DATA ENTRY REENTER THE LAST DATA LINE.'
       GO TO 17
3335   DO 3033 JI=1,NT(J)+1
3033   ITFN(J,JI)=DATA(JI)
       WRITE(20,7)(ITFN(J,K),K=1,(NT(J)+1))
7      FORMAT(6I3)
 15    CONTINUE
       DO 20 J=1,NS
       IWRT=0
       DI=0.0
       AI=0.0
       IMYR=0
       GO TO 8
888    DO 882 JW=1,IWRT
       IF(IWRT.EQ.0)GO TO 8
882    BACKSPACE 20
8      PRINT//,'ENTER THE DEPTH AND AREA PROFILE FOR SEGMENT NUMBER',J
       IF(J.EQ.1)
      -PRINT//,'ENTER A DEPTH IN METERS ABOVE BASELINE AND AREA IN SQ. ME
      -TERS',
      -' OR THE WORD "END",USING COMMAS TO SEPARATE NUMBERS.'
       IF(J.EQ.1)
      -PRINT//,'THE FIRST DATA SET MUST BE (0,0) OR ZERO DEPTH AND ZERO A
      -REA.'
       DO 30 JJ=1,71
9      PRINT//,'--->'
       READ(5,3036)ALPHA,ENDCK
3036   FORMAT(70C1,T1,A6)
       IREDO=0
       CALL CONVRT(50,ALPHA,20,DATA,ERCK)
       IF(ENDCK.EQ.'END   ') GO TO 25
       IF(.NOT.ERCK) GO TO 3333
       PRINT//,'REENTER LAST STRING OF DATA'
       GO TO 9
3333   DO 3337 K=1,2
3337   DASI(JJ,K,J)=DATA(K)
       IF(JJ.EQ.1.AND.DATA(1).EQ.0.0.AND.DATA(2).EQ.0.0)GO TO 3334
       IF(DASI(JJ,1,J)-DASI((JJ-1),1,J).LT.0.0.OR.DASI(JJ,2,J)
      --DASI(JJ-1,2,J).LT.0.0)IREDO=1
```

```
      IF(IREDO.EQ.1)PRINT//,'REENTER THE LAST DATA STRING WITH',
     -'SMALLEST VALUES FIRST'
      IF(IREDO.EQ.1.AND.JJ.EQ.2)GO TO 888
      IF(IREDO.EQ.1)GO TO 9
3334  WRITE(20,35)(DASI(JJ,K,J),K=1,2)
35    FORMAT(2F15.5)
      IWRT=IWRT+1
30    CONTINUE
65    PRINT//,'ERROR IN SIZE OF DASI ARRAY, INCREASE ITS DIMENSION TO MO
     -RE THAN 70.'
      STOP
25    IDP(J)=JJ-1
      WRITE(20,40) END
40    FORMAT(A3)
20    CONTINUE
      PRINT//,'ENTER THE BASELINE ELEVATION AS FEET ABOVE MEAN SEA LEVEL
     -,(F8.0)'
      PRINT//,'--->'
      READ(5,67)BASELV
      WRITE(20,67)BASELV
67    FORMAT(F8.2)
      GO TO 66
C*
C***   INPUT READ FROM FILE (20)
C*
10    READ(20,6)NS,CNL,NS,(SL(J),J=1,NS),NS,(NT(J),J=1,NS),NS,(OFAA(J),J
     -=1,NS)
      DO 45 J=1,NS
C*    IF(J.EQ.NS.AND.NT(J).EQ.0)GO TO 45
      READ(20,7)(ITFN(J,K),K=1,NT(J)+2)
 45   CONTINUE
      DO 50 J=1,NS
      DO 55 JJ=1,70
55    READ(20,35,DATA=50)(DASI(JJ,K,J),K=1,2)
      GO TO 65
50    IDP(J)=JJ-1
      READ(20,67)BASELV
C*
C*** ECHO PRINT SPACE INPUT DATA
C*
66    PRINT//,'NUMBER OF SEGMENTS =',NS
      PRINT//,'THE CELLS NORMAL LENGTH=',CNL
      PRINT//,'SEGMENT NUMBER.          1    2    3    4    '
      PRINT//,'NUMBER OF TRIBS/SEGMENT,',NT
      PRINT//,'SEGMENT LENGTH',SL
      PRINT//,'OVERLAND FLOW ASSOC AREA',OFAA
      PRINT//,'FILE NUMBERS OF TRIBS. PER SEGMENT'
      PRINT//,'SEGMENT          TRIBS.          INTERFLOW'
      DO 68 J=1,NS
      INTFLN=NT(J)+1
      IF(NT(J).EQ.0)INTFLN=2
68    PRINT//,J,'WITH FILES',(ITFN(J,K),K=1,(NT(J))),
     -'            ',ITFN(J,INTFLN)
      DO 70 J=1,NS
      PRINT//,'   '
      PRINT//,'DEPTH AREA PROFILE FOR SEGMENT',J
      DO 70 JI=1,IDP(J)
70    PRINT//,'DEPTH',DASI(JI,1,J),'AREA',DASI(JI,2,J)
      PRINT//,'THE BASE LINE ELEVATION=',BASELV
C*
C*** ENTER THE PARAMETERS DEFINED IN TIME.
C*
 47   PRINT//,'  '
      PRINT//,'ENTER THE MODE OF THE TIME ENTRIES'
      PRINT//,'("FILE" OR "TERMINAL")'
      PRINT//,'--->'
      READ(5,5)RUN
      IF(RUN.EQ.'FILE'.OR.RUN.EQ.'TERM')GO TO 44
      GO TO 47
44    IF(RUN.EQ.'FILE')GO TO 46
      PRINT//,'ENTER IN THE TIME DATA IN ONE LINE SEPARATED WITH COMMAS,
     - IN THIS ORDER.'
      PRINT//,' 1.  FIRST DATE OF CALCULATION(MONTH,DAY,YEAR) AS (1-12,1
     --31,74-76)'
      PRINT//,' 2.  LAST DATE OF THE CALCULATION MONTH, DAY, YEAR.'
      PRINT//,' 3.  THE TIME INCREMENT IN DAYS.'
      PRINT//,'     OR ENTER A ZERO TO USE THE MONTH OR YEAR'
902   PRINT//,'--->'
```

```
30900          READ(5,3000)ALPHA
~~31000          CALL CONVRT(50,ALPHA,20,DATA,ERCK)~~
31100          IF(.NOT.ERCK)GO TO 901
31200          PRINT//,'ERROR IN DATA ENTRY REENTER THE DATA STRING'
~~31300          GO TO 902~~
31400 901      IFM=DATA(1)
31500          IFD=DATA(2)
~~31600          IFYR=DATA(3)~~
31700          ILM=DATA(4)
31800          ILD=DATA(5)
~~31900          ILYR=DATA(6)~~
32000          IDT=DATA(7)
32100          IJFD=JULIA(IFM,IFD,IFYR)
~~32200          IJLD=JULIA(ILM,ILD,ILYR)~~
32300          WRITE(20,80)IJFD,IFYR,IJLD,ILYR,IDT
32400 80       FORMAT(5I3)
~~32500 C*~~
32600 C*** THE MONTH OR YEAR OPTION.
32700 C*
~~32800          IF(IDT.NE.0)GO TO 83~~
32900          PRINT//,'ENTER IN THE WORD "MONTH" OR "YEAR".'
33000          READ(5,81)AYR
~~33100 81       FORMAT(A5)~~
33200          WRITE(20,81)AYR
33300          IMYR=1
~~33400          IF(AYR.EQ.'YEAR ')IMYR=2~~
33500          GO TO 83
33600 C*
~~33700 C***     INPUT READ FROM FILE (20)~~
33800 C*
33900 46       READ(20,80,END=3030)IJFD,IFYR,IJLD,ILYR,IDT
~~34000          IF(IDT.EQ.0)READ(20,81,END=3030)AYR~~
34100          IF(AYR.EQ.'YEAR ')IMYR=2
34200          IF(AYR.EQ.'MONTH')IMYR=1
~~34300          GO TO 83~~
34400 3030     CALL ERROR(20)
34500 C*
34600 C***     ECHO ~~PRINT TIME INPUT~~ DATA.
34700 C*
34800 83       PRINT//,'FIRST DATE = DAY',IJFD,'YEAR',IFYR
34900          LOCK 20
35000          PRINT//,'LAST DATE = DAY',IJLD,'YEAR',ILYR
35100          IF(IDT.GT.0)PRINT//,'THE DAYS FOR ACC. BUDGET INCREMENT IS=',IDT
~~35200          IF(IDT.EQ.0)WRITE(6,88)AYR~~
35300 88       FORMAT(' THE WATER BUDGET TIME INCREMENT IS BY ',A5,'.')
35400          PRINT//,'    '
~~35600 C*~~
35700 C***     CALCULATE THE SLOPES AND AREAS OF THE DEPTH AREA PROFILES
35800 C***      OF ALL THE SEGMENTS
~~35900 C*~~
36000          CALL CURFIT
36100 C*
~~36200 C** ADJUST POINTERS IN ALL FILES TO FIRST DAY~~
36300 C*
36400          NDAY=IJFD
~~36500          IYR=IFYR~~
36600          CALL DAYONE(IJFD,IFYR)
36700 C*
~~36800 C***     CALULATE THE SURFACE AREA AND VOLUMES.~~
36900 C*
37000          IER=NS
~~37100          IFRN=IRECNO(1)~~
37200          READ(15=IRECNO(15),101,END=97)IIYR,IIDY,ZICE
37300 C*       CLOSE 15
~~37400 101      FORMAT(I2,I3,F6.0)~~
37500          IRECNO(15)=IRECNO(15)+1
37600          ZICE=ZICE/100.0
~~37700          IF(ZICE.GT.0.0)PRINT//,'ERROR-- THE ICE IS GREATER THAN ZERO',~~
37800         -'ON THE FIRST DAY.  RESTART BEFORE ICE UP.'
37900          IF(ZICE.GT.0.0)STOP
~~38000          CALL STGVOL(13,13,1,IER,IJFD,RESEL,OUTFL,ZICE,BASELV)~~
38100          IRECNO(1)=IFRN
38200          CALL STGVOL(16,16,1,IER,IJFD,RESEL,OUTFL,ZICE,BASELV)
~~38300 C*~~
38400 C***     FILL IN THE ASSOCATED AREAS INTO THE SEG ARRAY.
38500 C*
~~38600          DO 673 JZ=1,NS~~
38700 673      SEG(JZ,20,1)=OFAA(JZ)
38800 C*
```

```
C***   START THE LOOPS FOR THE TIME RUN.
C*
84     IT=0
       NECNT=0
       DO 85 IAMYR=IFYR,ILYR
       IYR=IAMYR
       IF(IYR.EQ.ILYR)LIMIT=IJLD
       IF(ILYR.GT.IYR)LIMIT=365
       IF(ILYR.GT.IYR.AND.MOD(IYR,4).EQ.0)LIMIT=366
       IF(NECNT.EQ.0)ISTART=1
       IF(NECNT.GT.0)ISTART=NECNT+1
       IF(IT.EQ.0)ISTART=IJFD
       IDTM=IDT
       NECNT=0
       DO 90 IDAY=ISTART,LIMIT,IDTM
C*     PRINT*//,IYR,IDAY,ISTART,LIMIT,IDTM
       IF(ISTART.GE.LIMIT) GO TO 91
       ISTART=IDAY
       IF(IDT.GT.0)GO TO 305
C*
C*** IF MONTH OPTION USED.
C*
       IF(IMYR.EQ.2)GO TO 312
       ICFAC=0
       IF(MOD(IYR,4).EQ.0.AND.ISTART.GT.59)ICFAC=1
       DO 310 J=1,12
310    IF((IDAY-ICFAC).LT.MONTH(J))GO TO 311
311    J=J-1
       PRINT*//,'MONTH INDEX',J,'YEAR INDEX',IAMYR
       IDTM=MD(J)
       IF(MOD(IYR,4).EQ.0.AND.J.EQ.2)IDTM=29
       IF(IYR.EQ.IFYR.AND.IDAY.EQ.IJFD)IDTM=MONTH(J+1)-IDAY+ICFAC
       GO TO 305
C*
C***   THE YEAR OPTION.
C*
312    IDTM=(LIMIT-ISTART)+1
  305  DO 95 ODAY=ISTART,(ISTART+IDTM-1)
       NDAY =ODAY
       IT=IT+1
       IF(NDAY.GT.LIMIT.AND.IYR.EQ.ILYR)GO TO 91
       IF(ODAY.GT.LIMIT)NECNT=NECNT+1
       IF(NDAY.GT.LIMIT)IYR=IYR+1
       IF(NDAY.GT.LIMIT)NDAY=NECNT
       N1DAY=NDAY+1
       IF(NDAY.EQ.366.OR.(MOD(IYR,4).NE.0.AND.NDAY.EQ.365))N1DAY=1
       ORESEL=RESEL
       ZOICE=ZICE
       IF(ODAY.EQ.ISTART)FRESEL=ORESEL
       IF(ODAY.EQ.ISTART)ZFICE=ZOICE
       READ(15=IRECNO(15),101,END=955)IIYR,IIDY,ZICE
C*     CLOSE 15
       IRECNO(15)=IRECNO(15)+1
       ZICE=ZICE/100.0
C*
C*
C****     CHECK ICE DEPTH ARRAY
C*     IF(NDAY.EQ.45)PRINT*//,NDAY,IYR,IPI,((PI(NIT,NAT,1),NIT=1,IPI),
C*    -NAT=2,3)
C****
C*
       CALL STGVOL(12,17,1,IER,N1DAY,RESEL,OUTFL,ZICE,BASELV)
C*
C*
C***   WRITE RESEL TO RESEL CHECK FILE.
C*
       IF (IDO(11).EQ.0) GO TO 8325
       WRITE(34,4037)NDAY,IYR,RESEL
 8325  CONTINUE
C*
C*     LOOP TO MOVE THE FIRST AREA AND VOL. TO THE ACCUMLATIVE BUDGET.
C*
       IF(ODAY.NE.ISTART)GO TO 7007
       TOTVOL=0.0
       TOAREA=0.0
       DO 4002 IDB=1,NS
       SEG(IDB,12,2)=SEG(IDB,12,1)
       TOTVOL=TOTVOL+SEG(IDB,12,1)
       TOAREA=TOAREA+SEG(IDB,15,1)
```

```
 4002 SEG(IDB,15,2)=SEG(IDB,15,1)
      SEG(NS+1,12,2)=TOTVOL
      SEG(NS+1,15,2)=TOAREA
C*
C*** CHECK TO SEE IF ANY SEGMENTS HAVE ZERO VOLUME.
C*
 7007  ISN=1
      INSMO=0
      NERR=0
      DO 1061 J=1,NS
      IF(SEG(J,12,1).LE.0.0)INSMO=INSMO+1
      IF(INSMO.GT.0.AND.SEG(J,12,1).GT.0.0)NERR=1
      IF(NERR.GT.0.AND.SEG(J,12,1).LE.0.0)PRINT//,'ERROR ON DAY',
     -NDAY,'SEGMENT',J,'HAS ZERO VOLUME.'
 1061 IF(SEG(J,12,1).LE.0.0)PRINT//,'VOLUME IN SEGMENT',J,'IS ZERO',
     -'ON DAY',NDAY,'YR=',IAMYR
      IF(INSMO.EQ.0)GO TO 1063
      ISN=INSMO+1
C*
C***  MOVE OUTFLOW TO SEG ARRAY
C*
 1063 SEG(NS,18,1)=OUTFL*0.3048**3.0
C*
      CALL PRECIP(ZICE,ZOICE)
C*
C*    PRINT*//,NDAY,IYR,ZICE,ZOICE
      IF(ZICE.EQ.0.0.OR.ZOICE.EQ.0.0)CALL EVAP
      IF(ZICE.EQ.0.AND.IPI.GT.0)GO TO 3775
      GO TO 3778
 3775 DO 3776 J=ISN,NS
      ACCICE=0.0
      DO 3777 IDX=1,IPI
      ACCICE=ACCICE+PI(IDX,3,J)
      PI(IDX,1,J)=0.0
      PI(IDX,2,J)=0.0
      PI(IDX,3,J)=0.0
 3777 CONTINUE
      SEG(J,5,1)=ACCICE
 3776 CONTINUE
      IPI=0
      PRINT//,' PERCHED ICE WAS DUMPED INTO THE SYSTEM ON DAY',NDAY,
     -'BECAUSE ICE THICKNESS EQUALS ZERO.'
 3778 IF(ZICE.EQ.0.0.AND.ZOICE.EQ.0.0)GO TO 117
      IF(ORESEL-RESEL)102,103,105
C*
C***  CASE OF DRAWDOWN THEREFORE CALC. PERCHED ICE VOLUME.
C*
  105 IPI=IPI+1
      IF(ID.GT.150) PRINT//,'PI LIMIT (150) EXCEEDED REDIMENSION PI.'
      IF(IPI.GT.150)CALL ERROR(0)
      DO 100 J=ISN,NS
      IF(ZOICE.EQ.ZICE) GO TO 6113
      IF(ZOICE-ZICE.LT.0.0) SEG(J,9,1)=(ZICE-ZOICE)*SEG(J,16,1)
     -/86400.0*0.9
      IF(ZOICE-ZICE.GT.0.0) SEG(J,5,1)=(ZOICE-ZICE)*SEG(J,16,1)
     -/86400.0*0.9
 6113 TICEO=(((SEG(J,15,1)-SEG(J,16,1))*(ZICE+ZOICE)/2.0)/86400.0)*.9
      PI(IPI,1,J)=ORESEL
      PI(IPI,2,J)=RESEL
      PI(IPI,3,J)=TICEO
      TIVOL=TICEO*86400.0
      IF (IDO(13).EQ.0) GO TO 8327
  100 WRITE (39,6112) IYR,NDAY,ORESEL,RESEL,TICEO,TIVOL
 6112 FORMAT(' IYR=',I2,'NDAY=',I3,'OWS=',F7.4,'WS=',F7.4,
     -'TOTAL ICE PERCHED=',F7.4,1X,F9.0)
 8327 CONTINUE
      GO TO 117
C*
C***  CASE OF RISE IN STAGE THEREFORE CALC. INPUT OF ICE.
C*
  102 IF(IPI.EQ.0)GO TO 103
      IMO=0
      DO 1031 J=ISN,NS
      ACCICE=0.0
      DO 113 K=1,IPI
      I=(IPI+1)-K
      IF(RESEL.GE.PI(I,1,J))ACCICE=ACCICE+PI(I,3,J)
      IF(RESEL.GE.PI(I,1,J))IMO=IMO+1
      IF(RESEL.GE.PI(I,2,J).AND.RESEL.LE.PI(I,1,J))
     -ACCICE=((RESEL-PI(I,2,J))/(PI(I,1,J)-PI(I,2,J)))*PI(I,3,J)+ACC
```

```
       -ICE
        SEG(J,5,1)=ACCICE
        IF(SEG(J,5,1).LT.0.0)SEG(J,5,1)=0.0
        ~~IF(RESEL.GE.PI(I,2,J).AND.RESEL.LE.PI(I,1,J)) PI(I,3,J)=(PI(I,1,J)~~
       --RESEL)/(PI(I,1,J)-PI(I,2,J))*PI(I,3,J)
        IF(RESEL.GE.PI(I,2,J).AND.RESEL.LE.PI(I,1,J))PI(I,2,J)=RESEL
        ~~IF(RESEL.GE.PI(I,1,J))PI(I,3,J)=0.0~~
        IF(RESEL.GE.PI(I,1,J))PI(I,2,J)=0.0
        IF(RESEL.GE.PI(I,1,J))PI(I,1,J)=0.0
~~113     CONTINUE~~
        IMODC=IMO
        IMO=0
~~1031    CONTINUE~~
        IPI=IPI-IMODC
C*
~~C***    STAGE RISED OR IT REMAINED THE SAME CALCULATE ICE GROWTH OR LOSS~~
C*
  103   DO 1973 J=ISN,NS
        ~~IF(SEG(J,17,1).GE.0.0.AND.AREAI(J).EQ.0.0)AREAI(J)=SEG(J,16,1)~~
1973    IF(SEG(J,17,1).LT.0.0)AREAI(J)=SEG(J,16,1)
        IF(ZOICE-ZICE)115,117,119
~~115     DO 114 J=ISN,NS~~
    114 SEG(J,9,1)=AREAI(J)*(ZICE-ZOICE)/86400.0*0.9
        GO TO 117
~~119     DO 116 J=ISN,NS~~
        RMELT=((AREAI(J)*(ZOICE-ZICE))/86400.0)*0.9
        SEG(J,5,1)=SEG(J,5,1)+RMELT
~~ 116    CONTINUE~~
C*
C***    FILL IN UPSTREAM INFLOW TO THE SEGMENT
~~C*~~
117     READ(24=IRECNO(24),127,END=907)IIYR,IIDY,FLOWUP
C*      CLOSE 24
        ~~IF(IIDY.NE.NDAY.OR.IIYR.NE.IAMYR)CALL ERROR(24)~~
        SEG(1,1,1)=FLOWUP*0.3048**3.0
        IRECNO(24)=IRECNO(24)+1
~~C*~~
C*** READ IN THE FLOW AT EP 6.
C*
        ~~READ(16=IRECNO(16),120,END=301)IM,ID,IIYR,FLOWEP~~
C*      CLOSE 16
120     FORMAT(3X,3I2,F8.0)
        ~~IIDY=JULIA(IM,ID,IIYR)~~
        IF(IIDY.NE.NDAY.OR.IIYR.NE.IYR)CALL ERROR(16)
        IRECNO(16)=IRECNO(16)+1
~~C*~~
C***    CALCULATE CURRENT ASSOCATED AREA PER SEGMENT AND INFLOW.
C*
        ~~DO 121 J=1,NS~~
        IF(ZICE.GT.0.0)SEG(J,19,1)=SEG(J,20,1)
        IF(ZICE.EQ.0.0)SEG(J,19,1)=SEG(J,20,1)-((SEG(J,15,1)+(SEG(J,17,1)/
       ~~-2.0))/2589988.1)~~
121     SEG(J,3,1)=FLOWEP*(SEG(J,19,1)/224.32)*0.3048**3.0
C*
~~C***    READ IN TRIBUTARY INFLOWS.~~
C*
        DO 123 J=1,NS
        ~~DO 123 K=1,NT(J)~~
        IF(NT(J).EQ.0) GO TO 123
        READ(ITFN(J,K)=IRECNO(ITFN(J,K)),127,END=129)IIYR,IIDY,TINFL
~~C*      CLOSE ITFN(J,K)~~
127     FORMAT(I2,I3,F8.0)
        IF(IIYR.NE.IYR.OR.IIDY.NE.NDAY)CALL ERROR(ITFN(J,K))
        IRECNO(ITFN(J,K))=IRECNO(ITFN(J,K))+1
        SEG(J,2,1)=SEG(J,2,1)+TINFL*0.3048**3.0
 123    CONTINUE
C*
C***    CALC. MAIN TRIBUTARY INFLOW TO A SEGMENT BELOW A ZERO VOL SEG.
C*
        ~~IF(ISN.EQ.1)GO TO 1067~~
        DO 1066 J=1,ISN-1
1066    SEG(J+1,1,1)=SEG(J,1,1)+SEG(J,2,1)+SEG(J,3,1)
~~1067    CONTINUE~~
C*
C***    TOTAL UP THE DAILY SEG. BUDGET INPUTS IN THE SEG ARRAY
~~C*~~
        DO 130 I=1,5
        TOTAL=0.0
        ~~DO 133 J=ISN,NS~~
133     TOTAL=SEG(J,I,1)+TOTAL
```

```
 130    SEG(NS+1,I,1)=TOTAL
        DO 135 I=9,18
        TOTAL=0.0
        DO 137 J=ISN,NS
 137    TOTAL=TOTAL+SEG(J,I,1)
 135    SEG(NS+1,I,1)=TOTAL
C*
C***    CALC. TOTAL INFLOW AND TOTAL OUTFLOW
C*
        TNFLOW=0.0
        DO 139 J=1,5
 139    TNFLOW=TNFLOW+SEG(NS+1,J,1)
        TOFLOW=0.0
        DO 141 J=9,11
 141    TOFLOW = TOFLOW+SEG(NS+1,J,1)
        TOFLOW=TOFLOW+SEG(NS+1,18,1)
C*
C***    CASES TO BE NOTED FOR SPECIAL CHECKING.
C*
        DRC=SEG(NS+1,14,1)/86400.0
C*      IF(SEG(NS+1,14,1).GT.0.0.AND.TNFLOW.LT.(SEG(NS+1,14,1)/86400.))
C*     -PRINT//,'CHECK DAY',NDAY, 'YR=',IAMYR,'BECAUSE THE TOTAL INFLOW RA
C*     -TE(',TNFLOW,
C*     -') IS LESS THAN THE RATE OF INCREASED VOLUME (',DRC,').'
C*      IF(SEG(NS+1,14,1).LT.0.0.AND.TOFLOW.LT.(SEG(NS+1,14,1)/86400.))
C*     -PRINT//,'CHECK DAY',NDAY,'YR=',IAMYR,'BECAUSE THE TOTAL OUTFLOW RA
C*     -TE (',TOFLOW,
C*     -') IS LESS THAN THE RATE OF DECREASED VOLUME (',DRC,').'
C*
C*** CALC. RESIDUAL WATER COMPONENT.
C*
C*************** DEFINTIONS ******
C*
C*        AN INCEASE IN STAGE OVER TIME CAUSES DELTA VOL. TO BE POS.
C*
C*        A DECREASE IN STAGE OVER TIME CAUSES DELTA VOL TO BE NEG.
C*
C*        RESIDUAL WATER ENTRY INTO THE SYSTEM IS POSITIVE.
C*
C*        RESIDUAL WATER EXIT FROM THE SYSTEM IS NEGITIVE.
C*
C**********************************
C*
        RS=TOFLOW-TNFLOW+(SEG(NS+1,14,1)/86400)
        IF(RS.EQ.0.0)GO TO 200
        IF(RS.LT.0.0)IFN=8
        IF(RS.GT.0.0)IFN=6
        RSV=RS
        RS=ABS(RS)
C*
C***    DISTRIBUTE NET RESIDUAL IN THE SEG ARRAY
C*
        SEG(NS+1,IFN,1)=RS
        SEG(NS+1,7,1)=RSV
        DO 143 J=ISN,NS
C*      IF(J.EQ.ISN.AND.SEG(NS+1,17,1).EQ.0.0)PRINT//,"DELTA SURFACE AREA
C*     -IS ZERO,",
C*     -'RESIDUAL WATER WAS DISTRIBUTED BY THE NUMBER THAT IS A FRACTION O
C*     -F NS,',
C*     -'ON DAY',NDAY,'YR=',IAMYR
        IF(SEG(NS+1,17,1).EQ.0.0)GO TO 144
        SEG(J,IFN,1)=RS*(SEG(J,17,1)/SEG(NS+1,17,1))
        SEG(J,7,1)=RSV*(SEG(J,17,1)/SEG(NS+1,17,1))
        GO TO 143
 144    SEG(J,IFN,1)=RS*(1.0/(NS+1-ISN))
        SEG(J,7,1)=RSV*(1.0/(NS+1-ISN))
 143    CONTINUE
C*
C***    ACCUMLATE THE TOTALS IN THE ACCUMLATIVE PORTION OF THE SEG ARRAY.
C*
 200    DO 145 I=1,11
        DO 145 J=ISN,NS+1
 145    SEG(J,I,2)=SEG(J,I,2)+SEG(J,I,1)
        DO 147 I=18,20
        DO 147 J=ISN,NS+1
 147    SEG(J,I,2)=SEG(J,I,2)+SEG(J,I,1)
C*
C*** CALCULATE THE INTERFLOWS
C*
```

```
~~      DO 149 J=ISN,NS~~
      TN=0.0
      IF(J.GT.ISN)SEG(J,1,1)=SEG(J-1,18,1)
~~      DO 150 K=1,6~~
 150  TN=SEG(J,K,1)+TN
      TO=0.0
~~      DO 153 K=8,11~~
 153  TO=TO+SEG(J,K,1)
      IF(J.EQ.NS)OUTFLM=SEG(NS,18,1)
~~      SEG(J,18,1)=TN-TO-(SEG(J,14,1)/86400)~~
C*    TRBFLO(J)=TN
C*    IF(TRBFLO(J).LT.0.0) TRBFLO(J)=0.0
~~      OUTADJ=((SEG(J,8,1)+SEG(J,9,1)+SEG(J,18,1))*35.31)~~
C*
C***  WRITE INTERFLOW DATA TO APPROPATE FILES.
~~C*~~
      INTFLN=NT(J)+1
      IF(NT(J).EQ.0)INTFLN=2
~~      IF(ITFN(J,INTFLN).EQ.9.AND.IDO(3).EQ.0)GO TO 149~~
      IF(ITFN(J,INTFLN).EQ.31.AND.IDO(8).EQ.0)GO TO 149
      IF(ITFN(J,INTFLN).EQ.32.AND.IDO(9).EQ.0)GO TO 149
~~      IF(ITFN(J,INTFLN).EQ.33.AND.IDO(10).EQ.0)GO TO 149~~
      IF(J.LT.NS.AND.ITFN(J,INTFLN).NE.0)WRITE(ITFN(J,INTFLN),4037)NDAY
     -,IYR,SEG(J,18,1)
~~  149 CONTINUE~~
C*
C***  WRITE OUTFLOW TO DISK FILE
~~C*~~
      STAGEA=((RESEL+ZICE)/0.3048)+BASELV
      IF (IDO(1).EQ.0)GO TO 8322
~~      WRITE(7,4037)NDAY,IYR,STAGEA,OUTADJ~~
 8322 CONTINUE
 4037 FORMAT(3X,I3,3X,'19',I2,4X,F8.2,3X,F6.0)
~~C*~~
C*** WRITE OUT THE TOTAL INFLOWS TO TRIB/INFLOW.
C*
C*      ITAB=NS-ISN+1
C*      IF(IDO(14).EQ.1)WRITE(41,9005)IYR,NDAY,ITAB,(TRBFLO(J),J=ISN,NS)
C*9005 FORMAT(I2,I4,*E10.4)
      TRBFLO(1)=(SEG(1,1,1)+SEG(1,4,1)+SEG(1,5,1)+(SEG(1,6,1)*0.6811))*3
     -5.31
      IF(IDO(14).EQ.1)WRITE(41,9005)IYR,NDAY,TRBFLO(1)
~~ 9005 FORMAT(I2,I3,F8.2)~~
      IF(ABS(OUTFLM-SEG(NS,18,1)).GT.0.0001)
     -PRINT//,'ERROR : CALC. OUTFLOW',
~~     -SEG(NS,18,1),'IS NOT EQUAL TO THE MEASURED OUTFLOW',OUTFLM~~
     -,'ON DAY',NDAY
      FEFLOW=((SEG(1,2,1)+(SEG(1,6,1)*.1020))*35.31)-TINFL
~~      FRFLOW=((SEG(1,6,1)*.0599)*35.31)+TINFL~~
      IF(IDO(14).EQ.1)WRITE(42,9005)IYR,NDAY,FEFLOW
      IF(IDO(14).EQ.1)WRITE(43,9005)IYR,NDAY,FRFLOW
~~C*~~
C*** WRITE OUT THE ACCOC FLOW INTO A DISK FILE (ONE SEG ONLY)...
C*
~~      SEGFLW=(SEG(1,3,1)+(SEG(1,6,1)*0.157))*35.31~~
      WRITE(40,6182)IYR,NDAY,SEGFLW
 6182 FORMAT(I2,I3,F8.2)
~~C*~~
C*** OUTPUT DAILY VALUES IF REQUESTED
C*
~~      DO 4553 J=1,NS+1~~
 4553 SEG(J,14,1)=SEG(J,14,1)/86400.0
      IF (IDO(5).EQ.0)GO TO 8323
~~      WRITE(17,4551)IAMYR,NDAY,IT,ORESEL,RESEL,ZOICE,ZICE,TNFLOW,TOFLOW~~
 4551 FORMAT('YR=',I2,'DY=',I3,'CNT=',I4,'OWS=',F6.3,'WS=',
     -F6.3,'OICE=',F5.3,'ICE=',F5.3,'TIN=',F7.3,'TOUT=',F7.3)
~~      DO 155 J=1,20~~
 155  WRITE(17,156)ALABEL(J),(SEG(K,J,1),K=1,NS+1)
 156  FORMAT(A5,5F15.4)
~~ 8323 CONTINUE~~
C*
C***  CONVERT THE RATES IN THE SEG ARRAY TO VOLUMES.
~~C*~~
      DO 4555 J=1,NS+1
 4555 SEG(J,14,1)=SEG(J,14,1)*86400.0
~~      DO 4008 I=1,11~~
      DO 4008 J=1,NS+1
 4008 SEG(J,I,1)=SEG(J,I,1)*86400.0
~~      DO 4327 J=1,NS+1~~
 4327 SEG(J,18,1)=SEG(J,18,1)*86400.0
C*
```

```
C***-CHECK-TO-SEE IF THE-CELL BREAKDOWN IS CALC?
C*
           IF(CNL.LE.0.0) GO TO 4004
C*         IF(NDAY.EQ.NCLDAY.AND.IYR.EQ.NCLYR)CALL GELINT(RESEL,ORESEL)
C*         IF(NDAY.GT.NCLDAY.AND.IYR.EQ.NCLYR)CALL CMAIN(RESEL,ORESEL)
C*
C***-PRINT OUT-THE DAILY OUTPUT-IN-VOLUMES TO A DISK FILE.
C*
4004       IF(IDO(12).EQ.0) GO TO 8326
           WRITE(35,4551)IAMYR,NDAY,IT,ORESEL,RESEL,ZOICE,ZICE,TNFLOW,TOFLOW
           DO 1555 J=1,20
1555       WRITE(35,156)ALABEL(J),(SEG(K,J,1),K=1,NS+1)
8326       CONTINUE
C*
C*** ZERO PARTS OF THE SEGMENT ARRAY
C*
           DO 157 J=1,NS+1
           DO 157 K=1,11
157        SEG(J,K,1)=0.0
           DO 159 J=1,NS+1
           DO 159 K=18,19
159        SEG(J,K,1)=0.0
95         CONTINUE
C*
C*** ACCUMLATE WATER BUDGET - CALC. DELTA VOL AND DELTA AREA.
C*
91         DO 161 K=14,17,3
           DO 161 J=ISN,NS+1
           SEG(J,K-1,2)=SEG(J,K-1,1)
           SEG(J,K,2)=SEG(J,K-1,2)-SEG(J,K-2,2)
161        IF(K.EQ.14)SEG(J,14,2)=SEG(J,14,2)/(86400.0*IDTM)
C*
C***       CALCULATE THE AVERAGE RATE FOR THE PERIOD.
C*
           DO 1450 I=1,11
           DO 1450 J=1,NS+1
1450       IF(IDT.GE.0)SEG(J,I,2)=SEG(J,I,2)/IDTM
           DO 1451 I=18,20
           DO 1451 J=1,NS+1
1451       IF(IDT.GE.0)SEG(J,I,2)=SEG(J,I,2)/IDTM
C*
C*** PRINTOUT THE SEG ACC ARRAY
C*
           TNFLOW=0.0
           TOFLOW=0.0
           DO 5514 K=1,5
5514       TNFLOW=TNFLOW+SEG(NS+1,K,2)
           DO 5515 K=9,11
5515       TOFLOW=TOFLOW+SEG(NS+1,K,2)
           TOFLOW=TOFLOW+SEG(NS+1,18,2)
           IF (IDO(7).EQ.0)GO TO 8324
           WRITE(21,4551)IAMYR,NDAY,IT,FRESEL,RESEL,ZFICE,ZICE,TNFLOW,TOFLOW
           DO 165 J=1,20
165        WRITE(21,156)ALABEL(J),(SEG(K,J,2),K=1,NS+1)
8324       CONTINUE
C*
C*** ZERO PARTS OF THE SEG ARRAY
C*
           DO 167 J=1,NS+1
           DO 167 K=1,20
167        SEG(J,K,2)=0.0
90         CONTINUE
85         CONTINUE
           CALL ERROR(0)
97         CALL ERROR(15)
301        CALL ERROR(16)
129        CALL ERROR(ITFN(J,K))
907        CALL ERROR(24)
 955       CALL ERROR(15)
           END
C*
C*
C*
           SUBROUTINE CURFIT
           COMMON/NVS/ NS,SW(4),SL(4),SEG(5,20,2),DASI(70,5,5),IDP(5),CNL
           DO 63 ID=1,IDP(1)
           TOTAL=0.0
           DO 60 JD=1,NS
60         TOTAL=TOTAL+DASI(ID,2,JD)
           DASI(ID,2,NS+1)=TOTAL
```

```
63      DASI(ID,1,NS+1)=DASI(ID,1,1)
        DO 3 IN=1,NS+1
        ACCVOL=0.0
        DO 5 J=1,IDP(IN)-1
        IF(DASI(J,2,IN).EQ.0.0)GO TO 10
        GO TO 10
C*
C***    CALCULATION USING THE LOG - - LOG ASSUMPTION.
C*
C***SLOPE
C*
C*       DASI(J,3,IN)=(ALOG10(DASI(J+1,2,IN))-ALOG10(DASI(J,2,IN)))/(ALOG10
C*      -(DASI(J+1,1,IN))-ALOG10(DASI(J,1,IN)))
C*
C***     INTERCEPT
C*
C*       DASI(J,4,IN)=ALOG10(DASI(J,2,IN))-(DASI(J,3,IN)*ALOG10(DASI(J,1,IN
C*      -)))
C*
C***     ACCUMLATIVE VOLUME.
C*
C*       ACCVOL=ACCVOL+(((10**DASI(J,4,IN))/(DASI(J,3,IN)+1.0))*((DASI(J+1,
C*      -1,IN)**(DASI(J,3,IN)+1.0))-(DASI(J,1,IN)**(DASI(J,3,IN)+1.0))))
C*       GO TO 30
C*
C***     CALCULATIONS USING THE LINEAR ASSUMPTION
C*
C*
C*       SLOPE
C*
10       DASI(J,3,IN)=(DASI(J+1,2,IN)-DASI(J,2,IN))/(DASI(J+1,1,IN)-DASI(J,
        -1,IN))
C*
C*       INTERCEPT
C*
         DASI(J,4,IN)=DASI(J,2,IN)-(DASI(J,3,IN)*DASI(J,1,IN))
C*
C*       ACC VOLUME
C*
C*       ACCVOL=ACCVOL+(((DASI(J,3,IN)/2.0)*DASI(J+1,1,IN)**2.0)+DASI(J,4,I
C*       N)*DASI(J+1,1,IN))-(((DASI(J,3,IN)/2.0)*DASI(J,1,IN)**2.0)+DASI(J,
C*      -4,IN)*DASI(J,1,IN))
         ACCVOL=ACCVOL+(((DASI(J,2,IN)+DASI(J+1,2,IN))/2.0)*(DASI(J+1,1,IN)
        -DASI(J,1,IN)))
30       DASI(J,5,IN)=ACCVOL
5        CONTINUE
3        CONTINUE
         DO 77 II=1,NS+1
         DO 77 IT=1,70
  77     WRITE(25,76)(DASI(IT,K,II),K=1,5)
76       FORMAT(5F15.4)
         LOCK  25
         RETURN
         END
C*
C*
C*
         FUNCTION JULIA(MONTH,IDAY,IYEAR)
C***
C        ROUTINE TO CONVERT CONVENTIONAL DATE TO JULIAN DATE
C**
         DIMENSION IADD(12)
         DATA IADD/0,31,59,90,120,151,181,212,243,273,304,334/
         LEAP=0
         IF((FLOAT(IYEAR)/4.0)-FLOAT(IYEAR/4)).EQ.0.000) LEAP=1
         IF(MONTH.EQ.1) JULIA=IDAY
         IF(MONTH.EQ.2) JULIA=IDAY+31
         DO 20 I=3,12
         IF(MONTH.EQ.I) JULIA=IDAY +IADD(I)+LEAP
     20  CONTINUE
         RETURN
         END
C*
C*
C*
         SUBROUTINE DAYONE(IFTDAY,IFTYR)
         COMMON/ERR/ IRECNO(25)
         COMMON/EVA/BB,A,EVSUM,KEYEVP,EVAPM(12),EVAPYR
C***
```

```
~~C***  SEARCH FILES FOR THE FIRST DATE~~
C***
5       IRECNO(1)=IRECNO(1)+1
~~      READ(1=IRECNO(1),3,END=91)IIDY,IIYR~~
3       FORMAT(3X,I3,5X,I2)
        IF(IFTYR.NE.IIYR) GO TO 5
~~      IF(IFTDAY.NE.IIDY) GO TO 5~~
        CLOSE 1
15      IRECNO(2)=IRECNO(2)+1
~~      READ(2=IRECNO(2),30,END=92)IIM,IID,IIYR~~
30      FORMAT(3I2)
        IF(IFTYR.NE.IIYR) GO TO 15
~~      IIDY=JULIA(IIM,IID,IIYR)~~
        IF(IFTDAY.NE.IIDY) GO TO 15
        CLOSE 2
~~C*    PRINT*//,IRECNO(2),IIM,IID,IIYR,IIDY~~
35      IRECNO(3)=IRECNO(3)+1
        READ(3=IRECNO(3),40,END=293)IIYR,IIWK
~~40    FORMAT(2X,2I2)~~
        IF(IFTYR.NE.IIYR) GO TO 35
        IF(IIWK.LE.8)ICOFAC=0
~~      IF(IIWK.GE.9)ICOFAC=1~~
        IF(IIWK.GE.10.AND.(IYR.EQ.IFIX(FLOAT(IYR)/4.0)*4))ICOFAC=2
        IDYLMT=7
~~      IF(IIWK.GE.10.AND.(IIYR.EQ.IFIX(FLOAT(IIYR)/4.0)*4))~~
       -IDYLMT=7
        IF(IIWK.EQ.8.OR.(IIWK.EQ.9.AND.(IIYR.EQ.IFIX(FLOAT(IIYR)/4.0)
~~     -*4)))IDYLMT=8~~
C*      PRINT*//,IIYR,IIWK,IFTYR,IFTDAY,ICOFAC,IDYLMT
        DO 43 JIT=1,IDYLMT
~~      IIDY=((IIWK-1)*7)+JIT+ICOFAC~~
C*      PRINT*//,IIDY,JIT
43      IF(IFTDAY.EQ.IIDY) GO TO 44
~~      GO TO 35~~
44      CONTINUE
        CLOSE 3
~~C*    PRINT*//,IRECNO(8),IIYR,IIWK,IIDY~~
67      IRECNO(13)=IRECNO(13)+1
        READ(13=IRECNO(13),40,END=97)IIYR,IIWK
~~C*    PRINT*//,IIYR,IIWK,IFTDAY,IFTYR,IRECNO~~
        IF(IFTYR.NE.IIYR) GO TO 67
        IF(IIWK.LE.8)ICOFAC=0
~~      IF(IIWK.GE.9)ICOFAC=1~~
        IF(IIWK.GE.10.AND.(IIYR.EQ.IFIX(FLOAT(IIYR)/4.0)*4))ICOFAC=2
        IDYLMT=7
~~      IF(IIWK.GE.8.OR.(IIWK.EQ.9.AND.(IIYR.EQ.IFIX(FLOAT(IIYR)/4.0)*4)))~~
       -IDYLMT=8
        DO 433 JIT=1,IDYLMT
~~      IIDY=((IIWK-1)*7)+JIT+ICOFAC~~
C*      PRINT*//,IFTDAY,IIDY,IIYR,IIWK,ICOFAC
 433    IF(IFTDAY.EQ.IIDY)GO TO 68
~~      GO TO 67~~
 68     CONTINUE
        CLOSE 13
~~C*    PRINT*//,IRECNO(13),IIYR,IIWK,IIDY~~
        KEYEVP=0
 45     IRECNO(4)=IRECNO(4)+1
~~      READ(4=IRECNO(4),50,END=94)IIYR,IIDY~~
 50     FORMAT(I2,1X,I3)
        IF(IFTYR.LT.IIYR.OR.(IFTYR.LT.IIYR.AND.IFTDAY.LT.IIDY))KEYEVP=
       -IIDY+(IIYR*1000)
C*      PRINT*//,IFTYR,IIYR,IFTDAY,IIDY,KEYEVP
        IF(KEYEVP.GT.0)IRECNO(4)=1
        IF(KEYEVP.GT.0)IRECNO(11)=1
        IF(KEYEVP.GT.0)GO TO 62
        IF(IFTYR.NE.IIYR)GO TO 45
~~      IF(IFTDAY.NE.IIDY)GO TO 45~~
        CLOSE 4
C*      PRINT*//,IRECNO(4),IIYR,IIDY
~~ 55   IRECNO(11)=IRECNO(11)+1~~
        READ(11=IRECNO(11),60,END=95)IIYR,IIDY
 60     FORMAT(I2,1X,I3)
~~      IF(IFTYR.NE.IIYR)GO TO 55~~
        IF(IFTDAY.NE.IIDY)GO TO 55
        CLOSE 11
~~C*    PRINT*//,IRECNO(11),IIYR,IIDY~~
        GO TO 66
62      IRECNO(19)=IRECNO(19)+1
~~      READ(19=IRECNO(19),19,END=99)EVAPYR,EVAPM~~
```

```
99300   19    FORMAT(I2,4X,12F6.2)
99400         IF(IFTYR.NE.EVAPYR)GO TO 62
~~99500         CLOSE 19~~
99600   66    IRECNO(12)=IRECNO(12)+1
99700         READ(12=IRECNO(12),30,END=96)IIM,IID,IIYR
~~99800         IF(IIYR.NE.IFTYR)GO TO 66~~
99900         IIDY=JULIA(IIM,IID,IIYR)
100000         IF(IIDY.NE.IFTDAY)GO TO 66
~~100100         CLOSE 12~~
100200 100     IRECNO(15)=IRECNO(15)+1
100300         READ(15=IRECNO(15),102,END=105)IIYR,IIDY
~~100400 102     FORMAT(I2,I3)~~
100500         IF(IIYR.NE.IFTYR) GO TO 100
100600         IF(IIDY.NE.IFTDAY) GO TO 100
~~100700         CLOSE 15~~
100800 106     IRECNO(16)=IRECNO(16)+1
100900         READ(16=IRECNO(16),120,END=107)IM,ID,IIYR
~~101000 120     FORMAT(3X,3I2)~~
101100         IF(IIYR.NE.IFTYR)GO TO 106
101200         IIDY=JULIA(IM,ID,IIYR)
~~101300         IF(IIDY.NE.IFTDAY)GO TO 106~~
101400         CLOSE 16
101500 108     IRECNO(22)=IRECNO(22)+1
~~101600         READ(22=IRECNO(22),102,END=109)IIYR,IIDY~~
101700         IF(IIYR.NE.IFTYR)GO TO 108
101800         IF(IIDY.NE.IFTDAY)GO TO 108
~~101900         CLOSE 22~~
102000 110     IRECNO(23)=IRECNO(23)+1
102100         READ(23=IRECNO(23),102,END=111)IIYR,IIDY
~~102200         IF(IIYR.NE.IFTYR)GO TO 110~~
102300         IF(IIDY.NE.IFTDAY)GO TO 110
102400         CLOSE 23
~~102500 113     IRECNO(24)=IRECNO(24)+1~~
102600         READ(24=IRECNO(24),102,END=202)IIYR,IIDY
102700         IF(IIYR.NE.IFTYR)GO TO 113
~~102800         IF(IIDY.NE.IFTDAY)GO TO 113~~
102900         CLOSE 24
103000 C*      PRINT*//,IRECNO,IIM,IID,IIYR,IIDY
~~103100         PRINT*//,IRECNO~~
103200         RETURN
103300 91      CALL ERROR(1)
~~103400 92      CALL ERROR(2)~~
103500 293     CALL ERROR(3)
103600 94      CALL ERROR(4)
~~103700 95      CALL ERROR(11)~~
103800 96      CALL ERROR(12)
103900 97      CALL ERROR(13)
~~104000 99      CALL ERROR(19)~~
~~104100 105     CALL ERROR(15)~~
104200 107     CALL ERROR(16)
104300 109     CALL ERROR(22)
104400 111     CALL ERROR(23)
104500 202     CALL ERROR(24)
~~104600         RETURN~~
104700         END
104800 C*
~~104900 C*~~
105000 C*
105100         SUBROUTINE ERROR(IEF)
~~105200         COMMON/TIME/ NDAY,IYR~~
105300         COMMON/ERR/ IRECNO(25)
105400         IF(IEF.EQ.0)GO TO 10
~~105500         PRINT//,'ERROR - WAS UNABLE TO FIND DAY',NDAY,'FOR YEAR',~~
105600        -IYR,'IN THE FILE NUMBER',IEF
105700         PRINT//,'THE RECORD NUMBER AT THE TIME WAS IRECNO(',IEF,
~~105800        -')=',IRECNO(IEF)~~
105900         PRINT*//,IRECNO
106000 10      LOCK 7
~~106100         LOCK 8~~
106200         LOCK 9
106300         LOCK 14
~~106400         LOCK 17~~
106500         LOCK 18
106600         LOCK 20
~~106700         LOCK 21~~
106800         LOCK 25
106900         LOCK 26
~~107000         LOCK 27~~
107100         LOCK 28
```

```
      LOCK 29
      LOCK 30
      LOCK 31
      LOCK 32
      LOCK 33
      LOCK 34
      LOCK 35
      LOCK 39
      LOCK 40
      LOCK 41
      LOCK 42
      LOCK 43
      STOP
      END
C*
C*
C*
      SUBROUTINE STGVOL(IBC,IEC,IBR,IER,IDCK,RESEL,OUTFL,ZICE,BASELV)
      COMMON/ERR/ IRECNO(25)
      COMMON/NVS/ NS,SW(4),SL(4),SEG(5,20,2),DASI(70,5,5),IDP(5),CNL
C*
C***  READ A RECORD FROM THE STAGE OUTFLOW FILE.
C*
      READ(1=IRECNO(1),1,END=100)IIDY,IIYR,STAGE,OUTFL
C*    CLOSE 1
1     FORMAT(3X,I3,5X,I2,4X,F8.0,3X,F6.0)
      IF(IIDY.NE.IDCK)CALL ERROR(1)
      IRECNO(1)=IRECNO(1)+1
      RESEL=((STAGE-BASELV)*0.3048)-ZICE
      DO 3 K=IBC,IEC
      IF(K.EQ.12.OR.K.EQ.15)GO TO 3
      IF(K.EQ.13)GO TO 5
      IF(K.EQ.16)GO TO 15
      IF(K.EQ.14.OR.K.EQ.17)GO TO 30
      PRINT//,'ERROR-- IN THE ARGUMENT LIST OF THE STGVOL SUBROUTINE'
     -,',  WITH K=',K
      CALL ERROR(0)
100   CALL ERROR(1)
3     CONTINUE
      RETURN
C*
C***  CALCULATE NEW VOLUMES FOR SEGMENTS.
C*
5     DO 7 J=IBR,IER
      SEG(J,K-1,1)=SEG(J,K,1)
      ACCVOL=0.0
      DO 9 I=1,IDP(J)
      IF(DASI(I,1,J).GT.RESEL)GO TO 11
 9    CONTINUE
      I=IDP(J)
 11   I=I-1
      ACCVOL=DASI(I-1,5,J)
      IF(DASI(I,2,J).EQ.0.0)GO TO 13
      GO TO 13
C*
C***  CALCULATE THE VOLUME USING THE LOG.- LOG. ASSUMPTION.
C*
C*    ACCVOL=ACCVOL+((10**DASI(I,4,J))/(DASI(I,3,J)+1))*((
C*   -RESEL**(DASI(I,3,J)+1))-(DASI(I,1,J)**(DASI(I,3,J)+1)))
C*    GO TO 8
C*
C***  CALCULATE VOLUME USING THE ARITHMATIC ASSUMPTION.
C*
13    ACCVOL=ACCVOL+(((DASI(I,3,J)/2.0)*RESEL**2.0)+DASI(I,4,J)
     -*RESEL)-(((DASI(I,3,J)/2.0)*DASI(I,1,J)**2)+DASI(I,4,J)*
     -DASI(I,1,J))
8     SEG(J,13,1)=ACCVOL
7     CONTINUE
      GO TO 3
C*
C***  CALCULATE THE SURFACE AREA OLD AND NEW.
C*
15    DO 16 J=IBR,IER
      SEG(J,K-1,1)=SEG(J,K,1)
      DO 17 KZ=1,IDP(J)
17    IF(DASI(KZ,1,J).GT.RESEL)GO TO 19
      KZ=IDP(J)
 19   KZ=KZ-1
      IF(DASI(KZ,2,J).EQ.0.0)GO TO 23
      GO TO 23
```

```
C*
C*** CALCULATED SURFACE AREA USING LOG-LOG ASSUMPTION.
C*
C*     SEG(J,16,1)=10.0**(DASI(KZ,3,J)*ALOG10(RESEL)+DASI(KZ,4,J))
C*     GO TO 16
C*
C***   CALCULATE THE SURFACE AREA USING THE ARITHMATIC ASSUMPTION.
C*
23     SEG(J,16,1)=DASI(KZ,3,J)*RESEL+DASI(KZ,4,J)
16     CONTINUE
       GO TO 3
C*
C***   CALCULATE THE DELTA VOLUME OR DELTA SURFACE AREA.
C*
30     DO 31 J=IBR,IER
31     SEG(J,K,1)=SEG(J,K-1,1)-SEG(J,K-2,1)
       GO TO 3
       END
C*
C*
C*
       SUBROUTINE EVAP
       COMMON/ERR/ IRECNO(25)
       COMMON/EVA/ BB,A,EVSUM,KEYEVP,EVAPM(12),EVAPYR
       COMMON/NVS/ NS,SW(4),SL(4),SEG(5,20,2),DASI(70,5,5),IDP(5),CNL
       COMMON/TIME/ NDAY,IYR
       COMMON/AIRTP/IAVGAT
       DIMENSION DEWPTS(8),WINDS(8),ALPHA(6),BET(6),MONTH(12)
       DIMENSION MD(12)
       DATA ALPHA/5.70,4.00,0.757,-5.41,-15.29,-30.45/
       DATA BET/0.620,0.842,1.107,1.459,1.898,2.449/
       DATA MONTH/32,60,91,121,152,182,213,224,274,305,335,366/
       DATA MD/31,28,31,30,31,30,31,31,30,31,30,31/
C*     IF(KEYEVP.LE.(NDAY+(IYR*1000))) GO TO 10
C*
C***   USE THE MONTH'S EVAPORATION RATE TO CALCULATE LOSS DUE TO EVAP.
C*
17     IF(EVAPYR.EQ.IYR)GO TO 15
       PRINT*//,EVAPYR,IYR,IRECNO(19),EVAPM
       READ(19=IRECNO(19),19,END=99)EVAPYR,EVAPM
C*     CLOSE 19
19     FORMAT(I2,4X,12F6.2)
       IF(EVAPYR.LT.IYR)IRECNO(19)=IRECNO(19)+1
       GO TO 17
99     CALL ERROR(19)
       RETURN
15     ICOFAC=0
       IDM=0
       IF(MOD(IYR,4).EQ.0.0.AND.NDAY.GT.60)ICOFAC=1
       DO 23 IMN=1,12
       IF((NDAY-ICOFAC).LT.MONTH(IMN))GO TO 27
23     CONTINUE
27     IF(MOD(IYR,4).EQ.0.0.AND.IMN.EQ.2)IDM=1
       EV=EVAPM(IMN)*0.77*0.0245/((MD(IMN)+IDM)*86400)
       EVPD=EV*86400
       EVSUM=EVSUM+EVPD
       GO TO 155
C*
C***   USE WIND SPEED, DEWPOINT, AND AIRTEMP TO CALCULATE DAILY EVAP.
C*
10     AVGDPT=0.0
 3     READ(4=IRECNO(4),50,END=94)IIYR,IIDY,DEWPTS
50     FORMAT(I2,1X,I3,8F5.0)
       IRECNO(4)=IRECNO(4)+1
       IF(IIYR.NE.IYR.OR.IIDY.NE.NDAY)GO TO 3
C*     CLOSE 4
       DO 126 JJ=1,8
  126  AVGDPT=AVGDPT+DEWPTS(JJ)
       XDPT=((AVGDPT/8.0)-32.0)*5.0/9.0
       AVGWD=0.0
4      READ(11=IRECNO(11),60,END=95)IIYR,IIDY,WINDS
 60    FORMAT(I2,1X,I3,8F5.0)
       IRECNO(11)=IRECNO(11)+1
       IF(IIYR.NE.IYR.OR.IIDY.NE.NDAY)GO TO 4
C*     CLOSE 11
       DO 127 JJ=1,8
  127  AVGWD=AVGWD+WINDS(JJ)
       XWIND=(AVGWD/8.0)*0.5144
C*     PRINT//,IIDY,WINDS,AVGWD,XWIND
```

```
      IF(IIDY.LT.1.OR.IIDY.GT.366)PRINT*//,'JULIAN DAY OUT OF BOUNDS',II
     -DY
      IF(IIDY.LT.1.OR.IIDY.GT.366)STOP
      IF(IIDY.LE.183.AND.IIDY.GE.1)TW=-16.09+0.4221*IAVGAT+0.1772*IIDY
      IF(IIDY.LE.366.AND.IIDY.GE.184)TW=0.605+0.2454*IAVGAT+0.1125*(366-
     -IIDY)
C*    PRINT*//,IAVGAT,IIDY,TW
      IF(TW.LT.0.0)TW=0.0
      EA=2.1718E+08*EXP(-4157.0/(XDPT+239.09))
      NN=TW/5.0+1.0
      IF(NN.GT.6)PRINT//,"THE WATER TEMP. WAS OVER 35 ON",IIDY,IIYR
      IF(NN.GT.6)NN=6
      ES=ALPHA(NN)+BET(NN)*TW
      IF(EA.GT.ES) EA=ES
      IF(BB.NE.0.0)GO TO 310
      PRINT//,'ENTER IN THE COEFFICENT FOR THE RATE OF EVAPORATION'
C*    READ(10=17,504) (TITLE(L),L=1,5),A,(TITLE(L),L=6,10),BB
C*    CLOSE 10
  504 FORMAT(5A4,E10.0,10X,5A4,E10.0)
C*    BB=1.64E-09
      BB=1.56E-09
C*    BB=1.42E-09
C*    BB=2.45E-09
C*    A=1.250E-09
      PRINT*//,BB,A
  310 EV=(XWIND*BB+A)*(ES-EA)
      EVPD=EV*86400
      EVSUM=EVSUM+EVPD
C*
C**** WRITE OUT THE ACCUMLATED EVAP. IN METERS AND EVAP. RATE M/S.
C*
  155 DO 154 K=1,NS
      SEG(K,11,1)=EV*(SEG(K,15,1)+(SEG(K,17,1)/2))
      IRECNO(14)=IRECNO(14)+1
      WTERLT=EVPD*((SEG(K,15,1)+SEG(K,16,1))/2.0)
  154 WRITE(14=IRECNO(14),152,END=98)IIYR,IIDY,K,SEG(K,11,1),EVSUM,EVPD,
     -IAVGAT,WTERLT
  152 FORMAT(I2,I3,I1,E10.4,2F8.3,I3,F8.0)
      RETURN
   94 CALL ERROR(4)
   95 CALL ERROR(11)
   98 CALL ERROR(14)
      RETURN
      END
C*
C*
C*
      SUBROUTINE PRECIP(ZICE,ZOICE)
      COMMON/ERR/ IRECNO(25)
      COMMON/NVS/ NS,SW(4),SL(4),SEG(5,20,2),DASI(70,5,5),IDP(5),CNL
      COMMON/TIME/ NDAY,IYR
      COMMON/AIRTP/IAVGAT
      DIMENSION TYPE(4),IAIRTX(8),IAIRTM(8)
      DIMENSION SDO(36)
      DATA DASH,ISNOW,AIRDO/'-',0,0.0/
      DATA SDO/14.16,13.77,13.40,13.05,12.70,12.37,12.06,11.76,11.47,
     -11.19,10.92,10.67,10.43,10.20,9.98,9.76,9.56,9.37,9.18,9.01,8.84,
     -8.68,8.53,8.38,8.25,8.11,7.99,7.86,7.75,7.64,7.53,7.42,7.32,7.22,
     -7.13,7.04/
C*
C***  FIND A VALUE FOR TODAY'S PRECIPITATION.
C*
      IF(ZICE.GT.0.0.OR.ZOICE.GT.0.0)CLOSE 2
      IF(ZICE.GT.0.0.OR.ZOICE.GT.0.0)CLOSE 12
      IF(ZICE.GT.0.0.OR.ZOICE.GT.0.0)GO TO 300
      READ(2=IRECNO(2),30,END=192)IIM,IID,IIYR,PRECP,TYPE
C*    CLOSE 2
   30 FORMAT(3I2,3X,F5.2,4G1)
      DO 201 IKK=1,4
      IF(TYPE(IKK).EQ.96.0)GO TO 102
  201 CONTINUE
      GO TO 103
  107 PRINT//,'RAINFALL IS DISCONTINUOUS ON,',NDAY,' DAY ',IYR,
     -' YEAR IN BOTH PRECIP FILES.  ENTER IN A REAL VALUE'
      PRINT//,'F4.2 FOR PRECIPITATION ON THAT DAY OR A NEGATIVE',
     -' NUMBER WILL STOP THE PROGRAM.'
      PRINT//,'------>'
      READ(5,110)PRECP
  110 FORMAT(F4.2)
```

```
        PRINT*//,PRECP
        IF(PRECP.GE.0.0)GO TO 103
        PRINT*//,'ERROR IN ENTRY',PRECP
        CALL ERROR(0)
 102    READ(12=IRECNO(12),30,END=96)IIM,IID,IIYR,PRECP,TYPE
 C*     CLOSE 12
        DO 202 IKK=1,4
        IF(TYPE(IKK).EQ.96.0)GO TO 107
 202    CONTINUE
 103    IIDY=JULIA(IIM,IID,IIYR)
  300   IRECNO(2)=IRECNO(2)+1
        IRECNO(12)=IRECNO(12)+1
 C*
 C***   FINDING A DAILY AVERAGE AIR TEMP.
 C*
        IAVGAT=0.0
        READ(3=IRECNO(3),40,END=93)IIYR,IIWK,((IAIRTX(JT),IAIRTM(JT)),
       -JT=1,8)
 C*     CLOSE 3
   40   FORMAT(2X,2I2,16I3)
        IF(IIWK.LE.8)ICOFAC=0
        IF(IIWK.GE.9)ICOFAC=1
        IF(IIWK.GE.10.AND.(IYR.EQ.(IFIX(FLOAT(IYR)/4.0)*4)))ICOFAC=2
        IDYWK=(NDAY-(((IIWK-1)*7)+ICOFAC))
        IF(IAIRTM(IDYWK).EQ.999.OR.IAIRTX(IDYWK).EQ.999)GO TO 112
        IAIRMT=IAIRTM(IDYWK)
        IAIRXT=IAIRTX(IDYWK)
 C*     PRINT*//,'FILE 3',IYR,IIWK,IAIRTX,IAIRTM,IDYWK,ICOFAC
 C*     PRINT*//,IAIRXT,IAIRMT
        GO TO 113
  115   PRINT//,'MAXIMUM AIR TEMP =',IAIRTX(IDYWK)
        PRINT//,'MINIMUM AIR TEMP =',IAIRTM(IDYWK)
        PRINT//,'MISSING A MINIMUM AIR TEMP. OR MAXIMUM AIR TEMP.',
       -' ON DAY ',NDAY,' YEAR ',IYR,'.  ENTER IN TWO INTEGERS'
        PRINT//,'TEMPERATURES ARE IN DEGREES F.'
        PRINT//,'IN THE FORMAT (2I3), MAX AND THEN MIN AIR TEMP.'
        PRINT//,'FOR THAT DAY OR A (-99,-99) TO END THE PROGRAM'
        PRINT//,'------>'
        READ(5,600)IAIRXT,IAIRMT
  600   FORMAT(2I3)
        IF(IAIRXT.EQ.-99)CALL ERROR(5)
        PRINT//,IAIRXT,'AND',IAIRMT,'WERE THE ENTERED TEMPS.'
        GO TO 113
  112   READ(13=IRECNO(13),40,END=97)IYR,IIWK,((IAIRTX(JT),IAIRTM(JT)),
       -JT=1,8)
 C*     CLOSE 13
        IF(IIWK.LE.8)ICOFAC=0
        IF(IIWK.GE.9)ICOFAC=1
        IF(IIWK.GE.10.AND.(IYR.EQ.(IFIX(FLOAT(IYR)/4.0)*4)))ICOFAC=2
        IDYWK=(NDAY-(((IIWK-1)*7)+ICOFAC))
        IF(IAIRTM(IDYWK).EQ.999.OR.IAIRTX(IDYWK).EQ.999)GO TO 115
        IAIRMT=IAIRTM(IDYWK)
        IAIRXT=IAIRTX(IDYWK)
 C*     PRINT*//,'FILE 13',IYR,IIWK,IAIRTX,IAIRTM,IDYWK,ICOFAC
    113 IF(IDYWK.EQ.8)IRECNO(3)=IRECNO(3)+1
        IF(IDYWK.EQ.8)IRECNO(13)=IRECNO(13)+1
        IF((IIWK.NE.8.AND.IIWK.NE.9).AND.IDYWK.EQ.7)IRECNO(3)=IRECNO(3)+1
        IF((IIWK.NE.8.AND.IIWK.NE.9).AND.IDYWK.EQ.7)IRECNO(13)=IRECNO(13)+
       -1
        IF((IIWK.EQ.9.AND.(IYR.NE.IFIX(FLOAT(IYR)/4.0)*4)).AND.IDYWK.EQ.
       -7)IRECNO(3)=IRECNO(3)+1
        IF((IIWK.EQ.9.AND.(IYR.NE.IFIX(FLOAT(IYR)/4.0)*4)).AND.IDYWK.EQ.
       -7)IRECNO(13)=IRECNO(13)+1
        IAVGAT=FLOAT(IAIRXT+IAIRMT)/2.0
        IAVGAT=(IAVGAT-32.0)*5.0/9.0
        IF(IAVGAT.LE.0)ISNOW=1
        IF(ZICE.GT.0.0.AND.ZOICE.GT.0.0)GO TO 124
        IF(PRECP.LE.0.0)GO TO 123
        IF(IAVGAT.LE.0.0)AIRDO=0.0
        IF(IAVGAT.LE.0.0)GO TO 123
        AIRDO=SDO(IAVGAT)
 123    DO 127 J=1,NS
        SEG(J,4,1)=(SEG(J,15,1)+(SEG(J,17,1)/2.0))*PRECP*0.0254/86400.0
        DELTPC=SEG(J,4,1)
 127    WRITE(8,125)IYR,NDAY,DELTPC,IAVGAT,AIRDO,ISNOW
 125    FORMAT(I2,I3,E10.4,I3,F5.2,I1)
        RETURN
 124    ISNOW=0
        DELTPC=0.0
        AIRDO=0.0
```

```
          DO 128 J=1,NS
    128   WRITE(8,125)IYR,NDAY,DELTPC,IAVGAT,AIRDO,ISNOW
          RETURN
    93    CALL ERROR(3)
    96    CALL ERROR(12)
    97    CALL ERROR(13)
    192   CALL ERROR(2)
          RETURN
          END
C*
C*
C*
$SET FREE
         SUBROUTINE CONVRT (IN,ALPHA,JN,NUMBER,EFLAG)
DIMENSION ALPHA(IN)
REAL NUMBER(JN)
 DATA NEG/Z60/
REAL NUMB
LOGICAL DFLAG,EFLAG
DATA PERIOD/Z4B/,COMMA/Z6B/,BLANK/Z40/,DASH/Z60/
REAL NUM(10)/ZF0,ZF1,ZF2,ZF3,ZF4,ZF5,ZF6,ZF7,ZF8,ZF9/
 EFLAG=.FALSE.
DFLAG=.FALSE.
INDEX=0
DCOUNT=1
 NEGONE=1
 NUMB=0
 IF(IN.EQ.80)GO TO 102
        DO 25 J=1,JN
25      NUMBER(J)=0.0
102 DO 100 I=1,IN
        IF(ALPHA(I).EQ.DASH)GO TO 1000
IF(ALPHA(I).EQ.BLANK.AND.I.EQ.IN) GO TO 50
       IF(ALPHA(I).EQ.BLANK) GO TO 100
       IF(ALPHA(I).EQ.COMMA) GO TO 50
        IF(ALPHA(I).NE.NEG) GO TO 20
        NEGONE=-1
        GO TO 100
20     IF(ALPHA(I).NE.PERIOD) GO TO 30
            DFLAG=.TRUE.
            GO TO 100
30     IF(DFLAG) DCOUNT=DCOUNT+1
       NFLAG=99
       DO 40 K=1,10
40     IF(ALPHA(I).EQ.NUM(K)) NFLAG=K
       IF(NFLAG.GT.10) GO TO 1000
       NUMB=NUMB+(NFLAG-1)
       NUMB=NUMB*10
   GO TO 100
50     INDEX=INDEX+1
       IF(INDEX.GT.JN) RETURN
       NUMB=NUMB/10**DCOUNT
       NUMBER(INDEX)=NUMB*NEGONE
       IF(I.EQ.IN) RETURN
       NUMB=0
 NEGONE=1
DFLAG=.FALSE.
DCOUNT=1
100 CONTINUE
1000 EFLAG=.TRUE.
RETURN
END
#
```

APPENDIX B

Listing of the computer program called QUAL/RES.

```
$FILE (10084)QUAL/RES ON PACK
100 $RESET FREE
200 $SET LINEINFO
300 C*CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
400 C*
500 C*      THIS PROGRAM TAKES A SITE WITH ITS QUALITY AND
600 C*      QUANITY DAILY FLOW DATA AND INTERPOLATES DAILY QUALITY
700 C*      WHICH IS USED TO CALCULATE LOADING ON A SAMPLE DATE,
800 C*      MONTHLY, SEASONALLY, AND ANNUAL BASIS.
900 C*                                FEB. 77 J. VENNIE
1000 C*CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
1100 FILE  1(TITLE="(10007)AVG/TOP/QUALITY",KIND=PACK,MAXRECSIZE=14,
1200      -BLOCKSIZE=420)
1300 FILE  2(TITLE="(10007)AVG/TOP/DATES",KIND=PACK,MAXRECSIZE=14,
1400      -BLOCKSIZE=420)
1500 FILE  6(KIND=REMOTE,MAXRECSIZE=22)
1600 FILE  7(TITLE="QUAL/DIRECTLOAD",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
1700 FILE  8(TITLE="(10084)STAGEVOLUMEOUTPUT",KIND=PACK,MAXRECSIZE=14,BLOCKSI
1800      -ZE=420)
1900 C*FILE  9(TITLE="EP/SAMPDATESUMMARY",KIND=PACK,MAXRECSIZE=14,
2000 C*      1BLOCKSIZE=420)
2100 C*FILE  9(KIND=PRINTER)
2200 FILE  10(TITLE="EP/MONTHLYSUMMARY",KIND=PACK,MAXRECSIZE=14,
2300      1BLOCKSIZE=420)
2400 C*FILE  10(KIND=PRINTER)
2500 C*FILE  11(TITLE="EP/SEASONSUMMARY",KIND=PACK,MAXRECSIZE=14,
2600 C*      1BLOCKSIZE=420)
2700 C*FILE  11(KIND=PRINTER)
2800 C*FILE  12(TITLE="EP/ANNUALSUMMARY",KIND=PACK,MAXRECSIZE=14,
2900 C*      1BLOCKSIZE=420)
3000 C*FILE  12(KIND=PRINTER)
3100 FILE  13(TITLE="MINTAPE/LOAD",KIND=PACK,MAXRECSIZE=14,
3200      -BLOCKSIZE=420)
3300 C*FILE  14(KIND=PRINTER)
3400 FILE  15(TITLE="QUAL/POINTER",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
3500 FILE  16(TITLE="EP/LOADING/DAYRATES",KIND=PACK,MAXRECSIZE=14,
3600      -BLOCKSIZE=420)
3700 FILE  17(TITLE="EP/AUTODATA/DAILY",KIND=PACK,MAXRECSIZE=14,
3800      -BLOCKSIZE=420)
3900 C***
4000 C***  FUNCTION SUBPROGRAM
4100 C     ROUTINE TO CONVERT CONVENTIONAL DATE TO JULIAN DATE
4200 C***
4300       FUNCTION JULIA(MONTH,IDAY,IYEAR)
4400       DIMENSION IADD(12)
4500       DATA IADD/0,31,59,90,120,151,181,212,243,273,304,334/
4600       LEAP=0
4700       IF((FLOAT(IYEAR)/4.0)-FLOAT(IYEAR/4).EQ.0.000) LEAP=1
4800       IF(MONTH.EQ.1) JULIA=IDAY
4900       IF(MONTH.EQ.2)JULIA=IDAY+31
5000       DO 20 I=3,12
5100       IF(MONTH.EQ.I) JULIA=IDAY +IADD(I)+LEAP
5200    20 CONTINUE
5300       RETURN
5400       END
5500 C***
5600 C***  MAINLINE EP/LOADING
5700 C***
5800       DIMENSION SPOT(3),IDATA(3),DATA(11),ID(7),VALUE(7),PRINT(20)
5900       DIMENSION SITE(3),WQDATA(100,17),DATA1(18)
6000       DIMENSION DIRECT(1500,22),ISAMP(3,12), AMSEAM(4,12,3),ABLKLN(20)
6100       DIMENSION ZDATE(2),RATE(11),ILIM(11),WHATBD(20),SAMPLE(3,12)
6200       DIMENSION ANNUAL(4,12,3), SEASON(4),AMONTH(12),SEANAM(5)
6300       DIMENSION AMNAME(13),AYNAME(4),JIDAY(13),IDO(6)
6400       DIMENSION AMONTL(12),SEASOL(4),NZERO(3)
6500       DIMENSION PTD(10),ZVOL(3)
6600       INTEGER DAY,YR,TIME,W1,W2,CLOUD
6700       REAL ICE,NH4,NN,KN
6800       EQUIVALENCE (IDATA(1),MO)
6900       EQUIVALENCE(IDATA(2),DAY)
7000       EQUIVALENCE (IDATA(3),YR)
7100       EQUIVALENCE (DATA(1),DO)
7200       EQUIVALENCE (DATA(2),COND)
7300       EQUIVALENCE (DATA(3),BOD5)
7400       EQUIVALENCE(DATA(4),OPO4)
7500       EQUIVALENCE (DATA(5),TPO4)
7600       EQUIVALENCE (DATA(6),ORGP)
7700       EQUIVALENCE (DATA(7),NH4)
7800       EQUIVALENCE (DATA(8),NN)
7900       EQUIVALENCE (DATA(9),KN)
```

```
      EQUIVALENCE (DATA(10),TIN)
      EQUIVALENCE (DATA(11),TON)
      DATA JIDAY/0,31,59,90,120,151,181,212,243,273,304,334,366/
      DATA AYNAME/'1974','1975','1976','1977'/
      DATA  ABLKLN/20*'    '/
      DATA AMNAME/'JAN.','FEB.','MAR.','APR.','MAY','JUNE','JULY',
     -  'AUG.','SEPT.','OCT.','NOV.','DEC.','END.'/
      DATA AMONTL/31,60,91,121,152,182,213,244,274,305,335,366/
      DATA SEASOL/60,121,274,335/
      DATA AMONTH/31,59,90,120,151,181,212,243,273,304,334,365/
      DATA SEASON/59,120,273,334/
      DATA SEANAM/'WINTER','SPRING','SUMMER','FALL','END   '/
      PRINT//,' ENTER THE SITE AT WHICH THE LOADING IS TO BE'
      PRINT//,' CALCULATED.  DID YOU REMEMBER TO SET UP AN'
      PRINT//,' ASSOCATED DAILY FLOW FILE?'
      PRINT//,' ENTER THE SITE WITH AN (2A2,A1) FORMAT.'
      READ(5,1) SITE
 1    FORMAT(A2,A2,A1)
      IDO(1)=1
      PRINT//,'   '
  9251 PRINT//,'ENTER THE VOLUME YOU WILL BE USING "TOP","MID","BOT"'
       READ(5,9250)IWV
  9250 FORMAT(A3)
       IF(IWV.EQ."TOP".OR.IWV.EQ."MID".OR.IWV.EQ."BOT")GO TO 9252
       GO TO 9251
  9252 IF(IWV.EQ."TOP")IWNV=1
       IF(IWV.EQ,"MID")IWNV=2
       IF(IWV.EQ."BOT")IWNV=3
       ASDT='NO '
       IFILE = 1
       IJ = 0
       IRECNO = 0
C***
C   READ A WATER QUALITY SAMPLE RECORD...
C***
  100  IRECNO=IRECNO+1
       READ(2=IRECNO,160,END=900)(IDATA(K),K=1,3)
       READ(1=IRECNO,161,END=162)(DATA(K),K=1,11)
  160  FORMAT(3I2)
  161  FORMAT(11F7.3)
       GO TO 163
  162  PRINT//,'ERROR IN THE INPUT DATA FILES. MAKE SURE THE DATES OK.'
       STOP
  163  CONTINUE
C***
C   WRITE THE DATA INTO THE WQDATA ARRAY
C***
       IJ=IJ+1
       DO 6 J=1,3
       INDX=J+3
6      WQDATA(IJ,INDX)=IDATA(J)
       DO 7 J=1,11
       INDX=J+6
7      WQDATA(IJ,INDX)=DATA(J)
       GO TO 100
C***
C   WRITE OUT A LINE IF THERE IS AN ERROR IN IT...
C***
800    BACKSPACE IFILE
       READ(IFILE,825)PRINT
   825 FORMAT(20A4)
       WRITE(6,850)PRINT
   850 FORMAT(1H0,'EXECUTION ERROR ENCOUNTERED ON THE FOLLOWING CARD'/
      F 1H0,20A4)
       GO TO 100
C***
C   GO ON TO THE NEXT WQ FILE
C***
C*900   IFILE=IFILE+1
C*      IRECNO=0
C*      IF(IFILE.LT.4)GO TO 100
900    CONTINUE
       CLOSE 1
       CLOSE 2
C***
C*** CHECK WQDATA FOR FIRST DATE
C***
       PRINT//,'THE NUMBER OF SAMPLES FOUND FOR THIS SITE =',IJ
       JDAYFT=JULIA(WQDATA(1,4),WQDATA(1,5),WQDATA(1,6))
       JDAYLT=JULIA(WQDATA(IJ,4),WQDATA(IJ,5),WQDATA(IJ,6))
       ICNT=0
C*     PRINT/,'  WQDATA=',WQDATA
```

```
C***
C*** FIND LENGTH IN DAYS OF DIRECT ARRAY.
C***
      IF(WQDATA(IJ,6).EQ.WQDATA(1,6))LIMIT=(JDAYLT - JDAYFT)+1
      IF(LIMIT.GT.1300)STOP
      IF(WQDATA(IJ,6)-WQDATA(1,6).EQ.1.0) GO TO 405
      IF(WQDATA(IJ,6)-WQDATA(1,6).EQ.2.0) GO TO 405
      IF(WQDATA(IJ,6)-WQDATA(1,6).EQ.3.0) GO TO 405
      IF(WQDATA(IJ,6)-WQDATA(1,6).LT.0.0.OR. WQDATA(IJ,6)-WQDATA(1,6)
     -  .GT.3.0) GO TO 409
      YEAR=365
      IF(MOD(IFIX(WQDATA(1,6)),4).EQ.0)YEAR=366
      GO TO 505
  409 WRITE(6,499)
  499 FORMAT(' ','STOP..BECAUSE COULD NOT DETERMINE THE PROPER LIMIT FOR
     - DIRECT ARRAY')
C***
      STOP
C***
  405 CK=IFIX(1900.0+WQDATA(1,6)/4.0)*4.0
      YEAR=365
      IF(CK.EQ.(WQDATA(1,6)+1900))YEAR=366
      CK=IFIX((1900.0+WQDATA(1,6)+1.0)/4.0)*4.0
      SDYEAR=365
      IF(CK.EQ.(WQDATA(1,6)+1901))SDYEAR=366
      CK=IFIX((1900.0+WQDATA(1,6)+2.0)/4.0)*4.0
      TDYEAR=365
      IF(CK.EQ.(WQDATA(1,6)+1902)) TDYEAR=366
      IF(WQDATA(IJ,6)-WQDATA(1,6).EQ.1.0)LIMIT=((YEAR-JDAYFT) +
     -JDAYLT)+1
      IF(WQDATA(IJ,6)-WQDATA(1,6).EQ.2.0)LIMIT=((YEAR-JDAYFT) +
     -SDYEAR+JDAYLT)+1
      IF(WQDATA(IJ,6)-WQDATA(1,6).EQ.3.0) LIMIT=((YEAR-JDAYFT) +
     -SDYEAR + TDYEAR + JDAYLT) + 1
C***
C*** LABEL THE DATES IN DIRECT ARRAY
C***
  505  CONTINUE
       PRINT//,' COUNTER FOR THE TIME DIRECT ARRAY =',ICNT
       PRINT//,' FIRST DATE IN THE TIME DIRECT ARRAY =',JDAYFT,'YR=',WQDA
     -TA(1,6)
       PRINT//,' NUMBER OF DAYS IN THE FIRST YEAR =',YEAR
       PRINT//,' NUMBER OF DAYS IN THE TIME DIRECT ARRAY =',LIMIT
       DO 411 KI=JDAYFT,YEAR
       ICNT=ICNT+1
       DIRECT(ICNT,1)=WQDATA(1,6)
       DIRECT(ICNT,2)=KI
  411  CONTINUE
       IF(ICNT.EQ.LIMIT) GO TO 500
       PRINT//,' NUMBER OF DAYS IN THE SECOND YEAR =',SDYEAR
       DO 413 KI=1,SDYEAR
       ICNT=ICNT+1
       IF(ICNT.GT.LIMIT) GO TO 500
       DIRECT(ICNT,1)=WQDATA(1,6)+1.0
  413  DIRECT(ICNT,2)=KI
       PRINT/,' JDAYLT=',JDAYLT,'ICNT=',ICNT
       PRINT*//,TDYEAR,WQDATA(IJ,6)
       IF(TDYEAR.EQ.0.0) GO TO 7000
       DO 414 KI=1,TDYEAR
       ICNT=ICNT+1
       IF(ICNT.GT.LIMIT) GO TO 500
       DIRECT(ICNT,1)=WQDATA(1,6)+2.0
  414  DIRECT(ICNT,2)=KI
7000   DO 415 KI=1,JDAYLT
       ICNT=ICNT+1
       IF(ICNT.GT.LIMIT)GO TO 500
       DIRECT(ICNT,1)=WQDATA(IJ,6)
  415  DIRECT(ICNT,2)=KI
C***
C*
C*** MOVE ALL THE MEASURED DATA POINTS IN THE WQDATA ARRAY INTO DIRECT A
C*
C*** INDICATOR:  0=SIMULATED    1=MEASURED  (COLUMNS 13-22)
C***
  500   DO 525 IK=1,IJ
        ADAY=JULIA(WQDATA(IK,4),WQDATA(IK,5),WQDATA(IK,6))
        DO 506 IZ=1,LIMIT
        IF(DIRECT(IZ,1).NE.WQDATA(IK,6)) GO TO 506
        IF(DIRECT(IZ,2).NE.ADAY) GO TO 506
C***
C*** MOVE DATA
C*** WHERE IY=1=DO, 2=COND, 3=BOD5, 4=OPO4, 5=TPO4, 6=ORGP, 7=NH4,
C***          8=NN, 9=KN, 10=TIN, 11=TON
C***
```

```
      DO 507 IX=3,11
      IF(IX.EQ.3)IY=1
      IF(IX.EQ.4)IY=3
      IF(IX.EQ.5)IY=4
      IF(IX.EQ.6)IY=5
      IF(IX.EQ.7)IY=6
      IF(IX.EQ.8)IY=7
      IF(IX.EQ.9)IY=8
      IF(IX.EQ.10)IY=9
      IF(IX.EQ.11)IY=11
      IF(WQDATA(IK,IY+6).EQ.0.0)WQDATA(IK,IY+6)=0.000001
      DIRECT(IZ,IX)=WQDATA(IK,IY+6)
      IF(WQDATA(IK,IY+6).EQ.-88.888)DIRECT(IZ,IX)=0.0
  507 IF(WQDATA(IK,IY+6).NE.-88.888)DIRECT(IZ,IX+10)=1.0
      GO TO 525
  506  CONTINUE
      WRITE(6,509)ADAY,WQDATA(IK,6),(WQDATA(IK,IKKX),IKKX=4,6)
  509 FORMAT(' ERROR, DID NOT FIND THE JULIAN DATE IN THE DIRECT ARRAY
     - TO ENTER QUALITY FROM WQDATA ARRAY',/,10X,'WQDATA DATE=',F4.0,
     -'YEAR=',F5.0,3(3X,F3.0))
C***
      STOP
C***
  525 CONTINUE
C*
C***  MOVE AUTOMATIC SAMPLER DATA INTO TIME DIRECT ARRAY.
C*
      IF(ASDT.EQ.'NO')GO TO 9270
      IASCT=0
9265  IASCT=IASCT+1
      READ(17=IASCT,160,END=9264)SPOT,NUM,IDATA,DATA,NOADD
C*      PRINT*//,SPOT,NUM,IDATA,DATA,NOADD
      ITDAY=JULIA(IDATA(1),IDATA(2),IDATA(3))
      DO 9266 IZ=1,LIMIT
      IF(DIRECT(IZ,1).NE.IDATA(3))GO TO 9266
      IF(DIRECT(IZ,2).NE.ITDAY)GO TO 9266
      GO TO 9267
9266  CONTINUE
      PRINT//,' ERROR****** COULD NOT FIND AUTOMATIC SAMPLE DAY,'
      PRINT*//,IDATA(1),IDATA(2),IDATA(3),ITDAY,'IN THE DIRECT ARRAY'
      GO TO 9265
 9267 ZMAX=AMAX1(DIRECT(IZ,13),DIRECT(IZ,14),DIRECT(IZ,15),DIRECT(IZ,
     -16),DIRECT(IZ,17),DIRECT(IZ,18),DIRECT(IZ,19),DIRECT(IZ,20),
     -DIRECT(IZ,21))
      IF(ZMAX.GT.0.0)GO TO 9265
      DO 9268 IX=3,11
      IF(IX.EQ.3)IY=12
      IF(IX.EQ.4)IY=13
      IF(IX.EQ.5)IY=14
      IF(IX.EQ.6)IY=15
      IF(IX.EQ.7)IY=16
      IF(IX.EQ.8)IY=10
      IF(IX.EQ.9)IY=17
      IF(IX.EQ.10)IY=18
      IF(IX.EQ.11)IY=15
      IF(DATA(IY).EQ.0.0)DATA(IY)=0.000001
      DIRECT(IZ,IX)=DATA(IY)
      IF(DIRECT(IZ,IX).NE.-8.0)DIRECT(IZ,IX+10)=1.0
      IF(DIRECT(IZ,IX).EQ.-8.0)DIRECT(IZ,IX)=0.0
 9268 CONTINUE
      DO 9269 IX=3,4
      IF(DIRECT(IZ,IX).EQ.-0.8)DIRECT(IZ,IX+10)=0.0
9269  IF(DIRECT(IZ,IX).EQ.-0.8)DIRECT(IZ,IX)=0.0
C*      PRINT*//,DIRECT(IZ,11),DIRECT(IZ,6),DIRECT(IZ,21),DIRECT(IZ,16),
C*     -DIRECT(IZ,15),DIRECT(IZ,5)
      IF(DIRECT(IZ,21).EQ.0.0)GO TO 9265
      IF(DIRECT(IZ,21).EQ.1.0.AND.DIRECT(IZ,11).LT.0.0)DIRECT(IZ,11)
     -=DIRECT(IZ,11)*(-1.0)
      IF(DIRECT(IZ,6).LT.0.0)DIRECT(IZ,16)=0.0
      IF(DIRECT(IZ,6).LT.0.0)DIRECT(IZ,6)=0.0
      IF(DIRECT(IZ,16).EQ.0.0)GO TO 9265
      IF(DIRECT(IZ,21).EQ.1.0.AND.DIRECT(IZ,15).EQ.1.0)DIRECT(IZ,11)=
     -DIRECT(IZ,11)+DIRECT(IZ,5)
      IF(DIRECT(IZ,15).EQ.0.0.AND.DIRECT(IZ,21).EQ.1.0)DIRECT(IZ,11)=
     -0.0
      IF(DIRECT(IZ,15).EQ.0.0.AND.DIRECT(IZ,21).EQ.1.0)DIRECT(IZ,21)=
     -0.0
      GO TO 9265
9264  PRINT//,' EP 6 AUTOMATIC SAMPLER DATA INSERTED INTO DIRECT ARRAY'
9270  CONTINUE
      CLOSE 17
C*    PRINT/,'  DIRECT=',DIRECT
C***
```

```
C*** ALL QUALITY IS TRANSFERED...START INTERPOLATION
C*** IROW= THE ROW OF MEASURED VALUES FROM WHICH INTERPOLATED DATA
C***       WILL BE FILLED IN FROM.
C*** ODTBLK=EQUALS ZERO UNLESS DATA IN IROW EQUALS ZERO.
C*** RATE= EQUALS AN ARRAY WITH THE RATE OF CHANGE IN EACH COLUMN.
C*** ILIM=THE LIMIT WHICH THE RATE IS APPLICABLE.
C***
      PRINT/,'  STARTING INTERPOLATION OF THE DIRECT ARRAY'
      IROW=1
  531 DO 530 ICL=3,11
      IDTBLK=0
      IF(DIRECT(IROW,ICL).EQ.0.0)IDTBLK=1
      INXROW=IROW+1
      DO 533 ICKNW=INXROW,LIMIT
      IF(DIRECT(ICKNW,ICL).NE.0.0)GO TO 536
  533 CONTINUE
      IF(IDTBLK.EQ.1)GO TO 537
      IF(IDTBLK.EQ.2) GO TO 538
      ILIM(ICL)=LIMIT
      GO TO 530
  538 DIRECT(IROW,ICL)=DIRECT(ILIM(ICL),ICL)
      RATE(ICL)=0.0
      GO TO 530
  537 ILIM(ICL)=LIMIT
      GO TO 530
  536 IF(IDTCLK.EQ.1) GO TO 540
      IF(IDTBLK.EQ.2) GO TO 543
      RATE(ICL)=((DIRECT(ICKNW,ICL)-DIRECT(IROW,ICL))/(ICKNW-IROW))
      ILIM(ICL)=ICKNW
      GO TO 530
  540 IDTBLK=2
      HDVAL=DIRECT(ICKNW,ICL)
      ILIM(ICL)=ICKNW
      GO TO 533
  543 RATE(ICL)=((DIRECT(ICKNW,ICL)-HDVAL)/(ICKNW-ILIM(ICL)))
      DIRECT(IROW,ICL)=HDVAL-(RATE(ICL)*(ILIM(ICL)-IROW))
 530  CONTINUE
C*    PRINT/,'IROW=',IROW,'ILIM=',ILIM,'RATE=',RATE
      ITPEND=MIN0(ILIM(3),ILIM(4),
     -ILIM(5),ILIM(6),ILIM(7),ILIM(8),ILIM(9),ILIM(10),ILIM(11))
C*    PRINT/,'ITPEND=',ITPEND,'INXROW=',INXROW
      DO 545 IDROW=INXROW,ITPEND
      DO 546 ICL=3,11
  546 DIRECT(IDROW,ICL)=DIRECT(IDROW-1,ICL)+RATE(ICL)
C*
C*** WRITE OUT TO A DAILY RATE FILE.
C*
      IF(IDO(6).EQ.0)GO TO 9272
      WRITE(16,9271)DIRECT(IDROW,1),DIRECT(IDROW,2),RATE
9271  FORMAT(F3.0,F4.0,11F6.3)
9272  CONTINUE
  545 CONTINUE
      IROW=ITPEND
      IF(ITPEND.EQ.LIMIT) GO TO 547
      GO TO 531
C***
C*** DIRECT ARRAY FILLED WITH THE FLOW DATA
C***
  547 IHCNT=1
      IF(IDO(6).EQ.1)LOCK 16
      PRINT/,' FILLING IN FLOW NOW.....'
 3004 READ(8,555,END=3003)LYR,LD
  555 FORMAT(F3.0,F4.0)
      LDAY=LD
      LSTYR=LYR
      GO TO 3004
 3003 PRINT*//,LDAY,LSTYR,'FLOW FILE'
      REWIND 8
      WRITE (7,2837)SITE
2837  FORMAT(' ','DIRECTLOAD WORKSHEET FOR SITE ',2A2,A1)
      WRITE(7,9912)SITE
 9912 FORMAT(' DATE  DO  BOD5  OPO4  TP  ORGP  NH4  NN  KN '
     -,' TON VOLUME (M3/S) ',2A2,A1)
      WRITE(15,2837)SITE
      WRITE(15,9912)SITE
C*
C***   ENTER THE FLOW DATA FROM A DISK FILE
C*
C*    PRINT*//,IWNV
 550  READ(8,551,END=561,DATA=560)ZDATE,ZSTAGE,ZVOL
 551  FORMAT(F3.0,F4.0,F6.0,3F10.0)
```

```
C*    PRINT*//,IWNV,ZDATE,ZVOL
      IF(ZDATE(1).NE.DIRECT(IHCNT,1)) GO TO 550
      IF(ZDATE(2).NE.DIRECT(IHCNT,2)) GO TO 550
      ZFLOW=ZVOL(IWNV)/86400.0
      DIRECT(IHCNT,12)=ZFLOW
      DIRECT(IHCNT,22)=1.0
C*    PRINT*//,ZDATE,ZVOL,IWNV,ZFLOW,DIRECT(IHCNT,12)
C***
C***  WRITE THE DIRECTLOAD ARRAY OUT TO A DISK FILE.
C***
      IF(IDO(1).EQ.0) GO TO 941
      WRITE(7,553)(DIRECT(IHCNT,J),J=1,12)
 553  FORMAT(' ',I2,I3,2F5.2,3F7.3,4F5.2,F10.3)
      WRITE(15,554)(DIRECT(IHCNT,J),J=1,2),(DIRECT(IHCNT,K),K=13,22)
 554  FORMAT(' ',I2,I3,10F2.0)
941   IF(IHCNT.EQ.LIMIT) GO TO 872
      IF(DIRECT(IHCNT,1).EQ.LSTYR.AND.DIRECT(IHCNT,2).EQ.LDAY)
     -GO TO 5650
      IHCNT=IHCNT+1
      GO TO 550
  560 BACKSPACE 8
      READ(8,562) WHATBD
  562 FORMAT(20A4)
      PRINT//,'  FLOW FILE MISSREAD THIS CARD'
      WRITE(6,563)WHATBD
  563 FORMAT(5X,20A4)
C***
      STOP
C***
 561  PRINT//,'  WENT OFF THE END OF THE FLOW FILE DIRECT FILE DATE=',
     -     DIRECT(IHCNT,2),'YR',DIRECT(IHCNT,1),'CHECK FLOW FILE'
C***
C*    STOP
C***
 5650 LIMIT=IHCNT
      PRINT//,' LIMIT OF THE TIME DIRECT ARRAY RESET TO =',LIMIT,' BECAU
     -SE;'
      PRINT//,' THE LAST DATE IN THE FLOW FILE =',DIRECT(LIMIT,2)
     -,'  YEAR=',DIRECT(LIMIT,1)
C***
 872  LOCK 9
      LOCK 7
      LOCK 15
      PRINT/,' PROGRAM COMPLETED LOADING THE SAMPLE SUMMARY FILE!!!'
      STOP
      END
```

APPENDIX C

Average reservoir (total and segmented), inlets, outlet measured water chemical concentration data for the Big Eau Pleine Reservoir.

CONTENTS OF APPENDIX C

Note: The individual data points are located at bends in the plotted lines. Symbols on each line only label the line types.

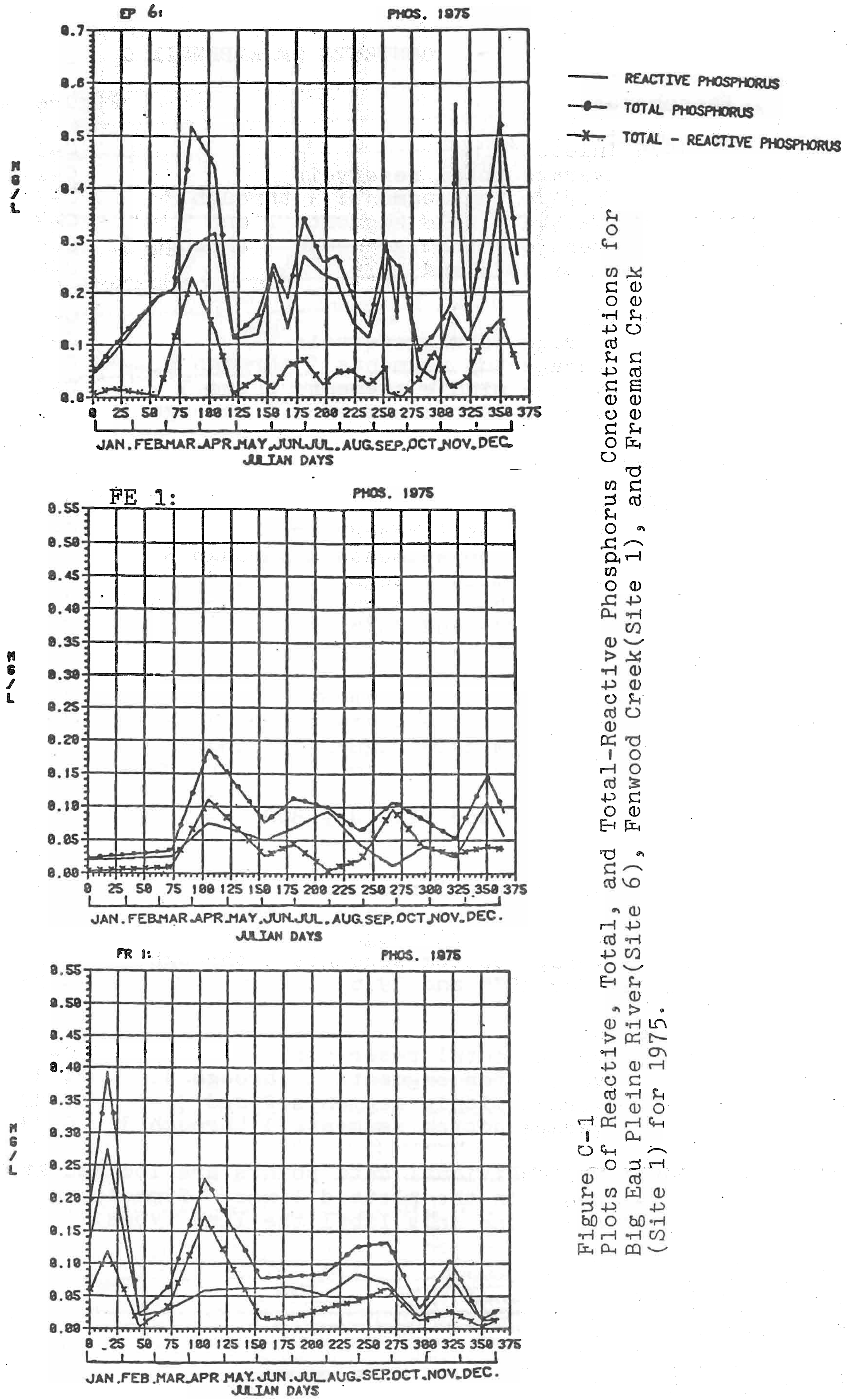


Figure C-1
Plots of Reactive, Total, and Total-Reactive Phosphorus Concentrations for Big Eau Pleine River(Site 6), Fenwood Creek(Site 1), and Freeman Creek (Site 1) for 1975.

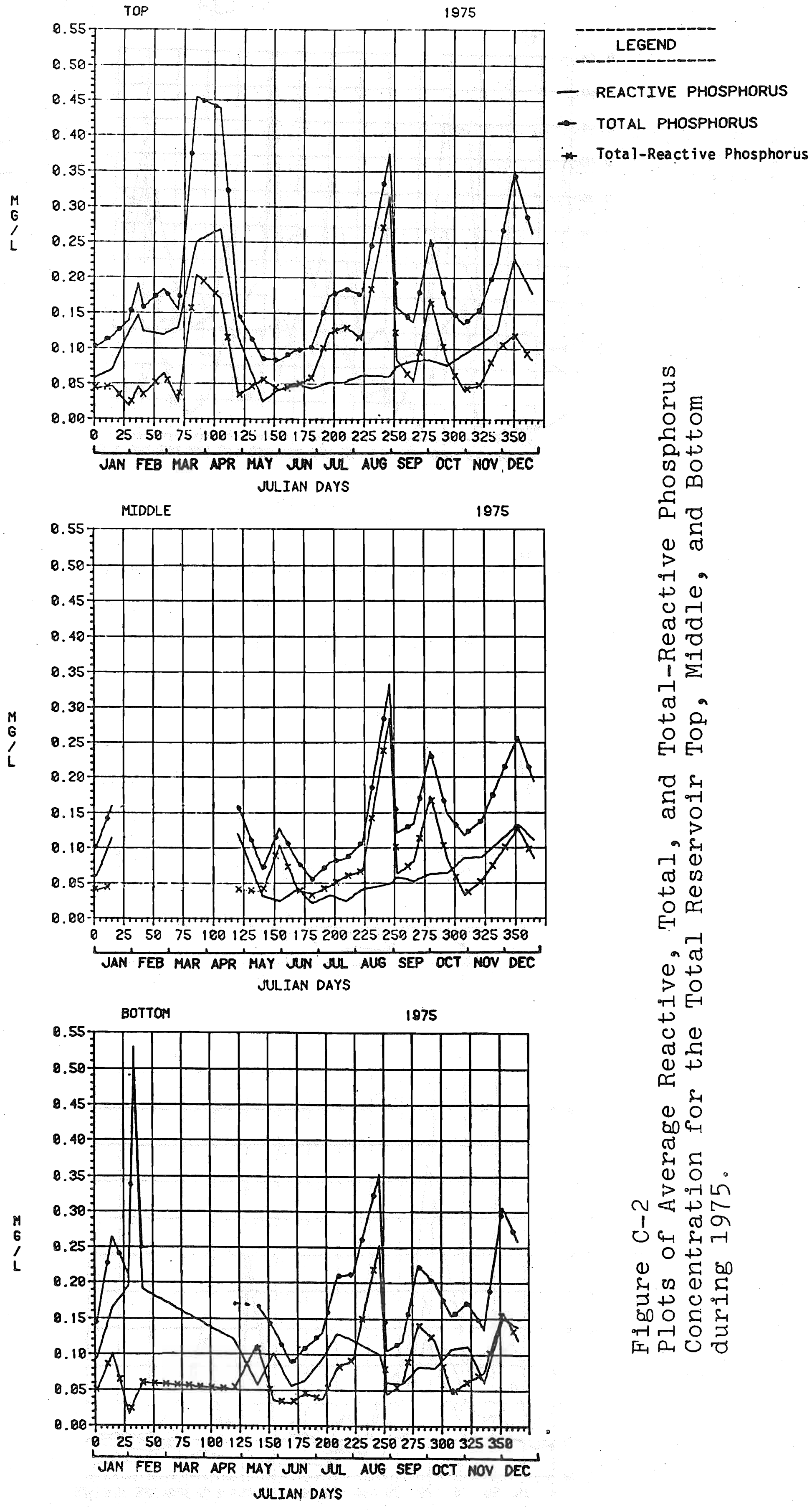


Figure C-2
Plots of Average Reactive, Total, and Total-Reactive Phosphorus Concentration for the Total Reservoir Top, Middle, and Bottom during 1975.

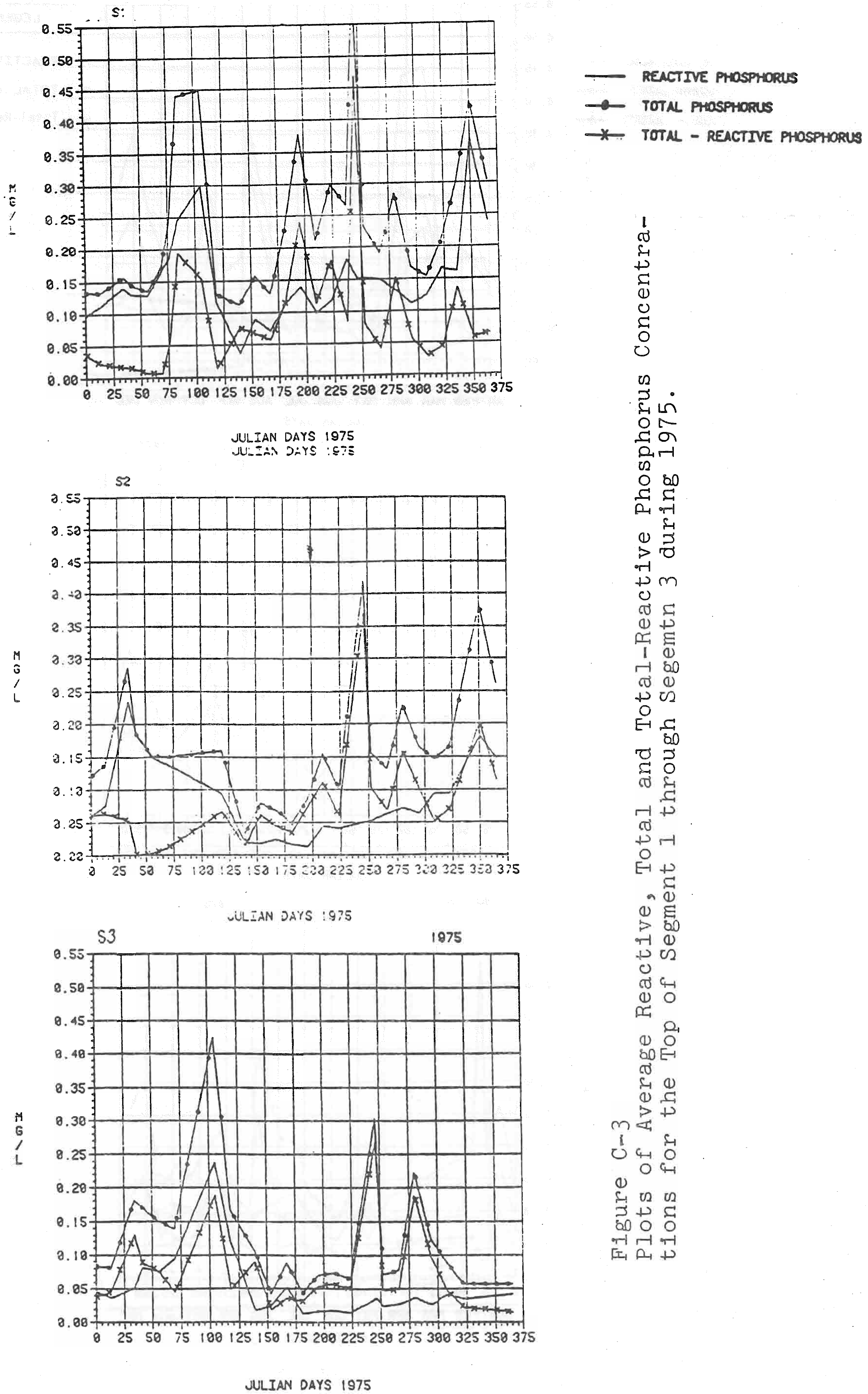


Figure C-3
Plots of Average Reactive, Total and Total-Reactive Phosphorus Concentrations for the Top of Segment 1 through Segemtn 3 during 1975.

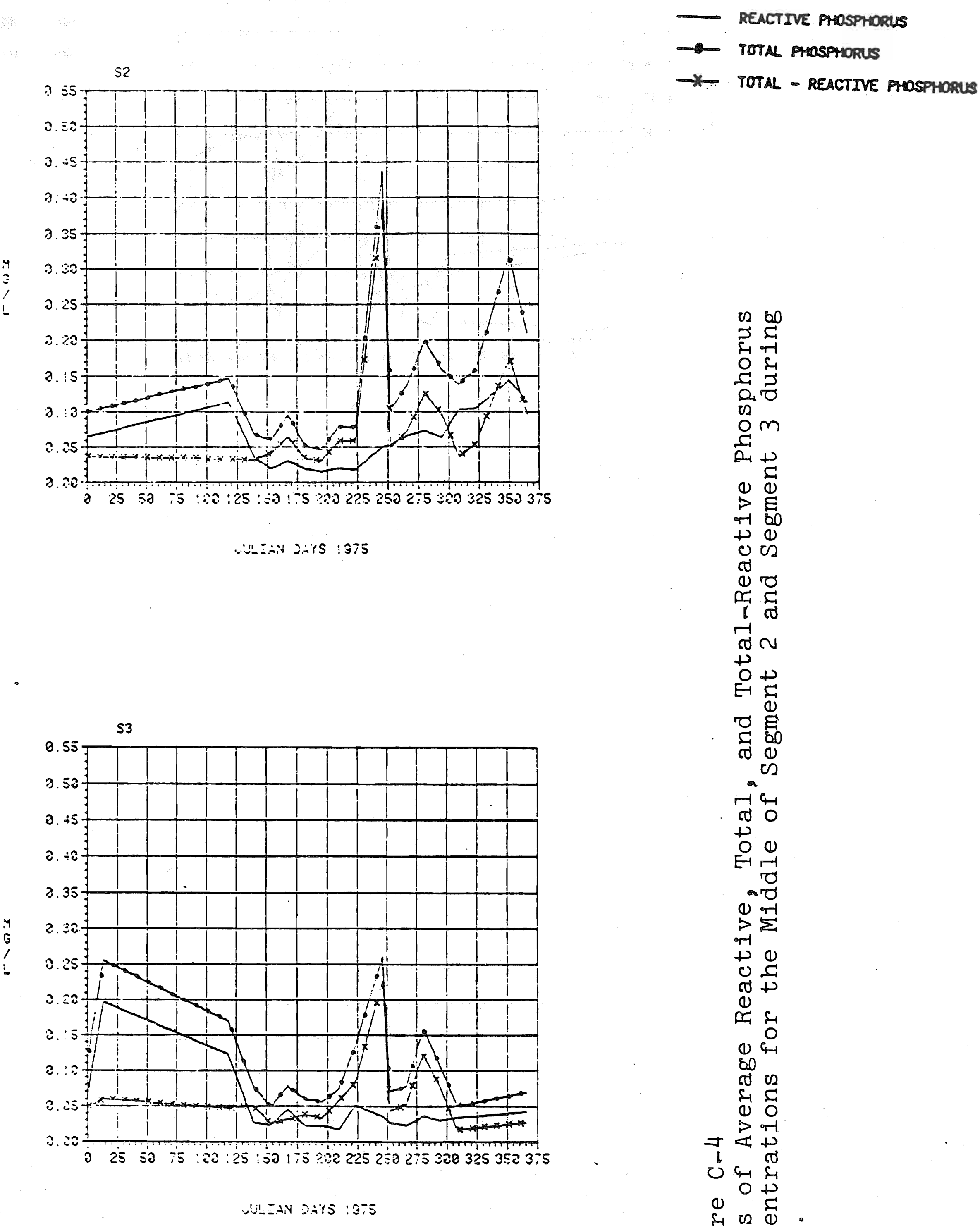


Figure C-4
Plots of Average Reactive, Total, and Total-Reactive Phosphorus Concentrations for the Middle of Segment 2 and Segment 3 during 1975.

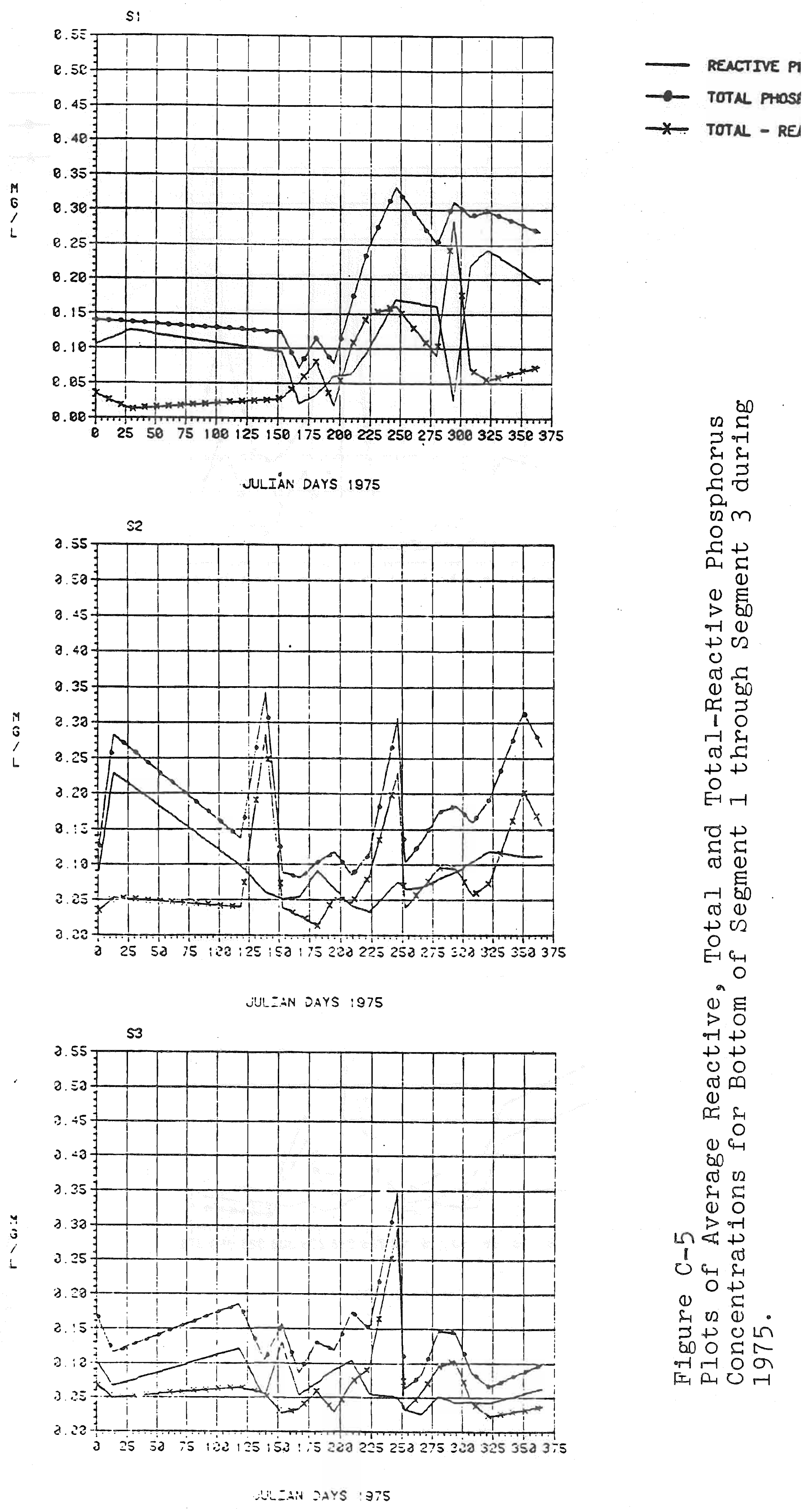
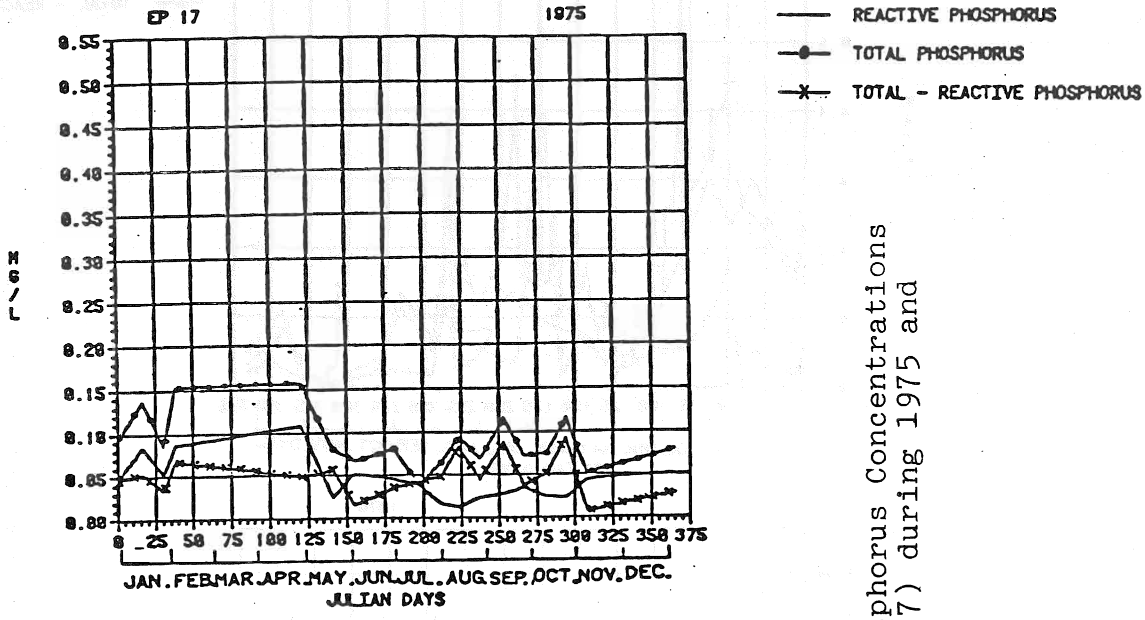


Figure C-5
Plots of Average Reactive, Total and Total-Reactive Phosphorus Concentrations for Bottom of Segment 1 through Segment 3 during 1975.



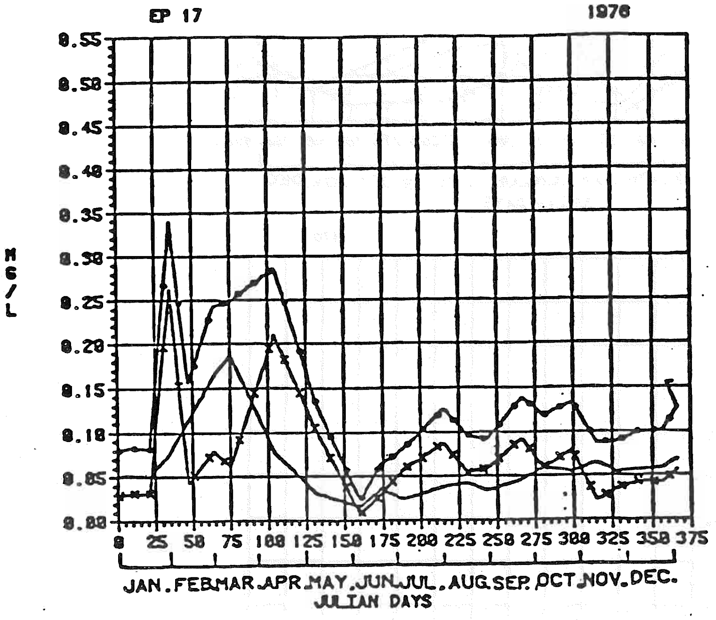


Figure C-6
Plots of Reactive, Total, and Total-Reactive Phosphorus Concentrations for the Big Eau Pleine Reservoir outlet (site EP17) during 1975 and 1976.

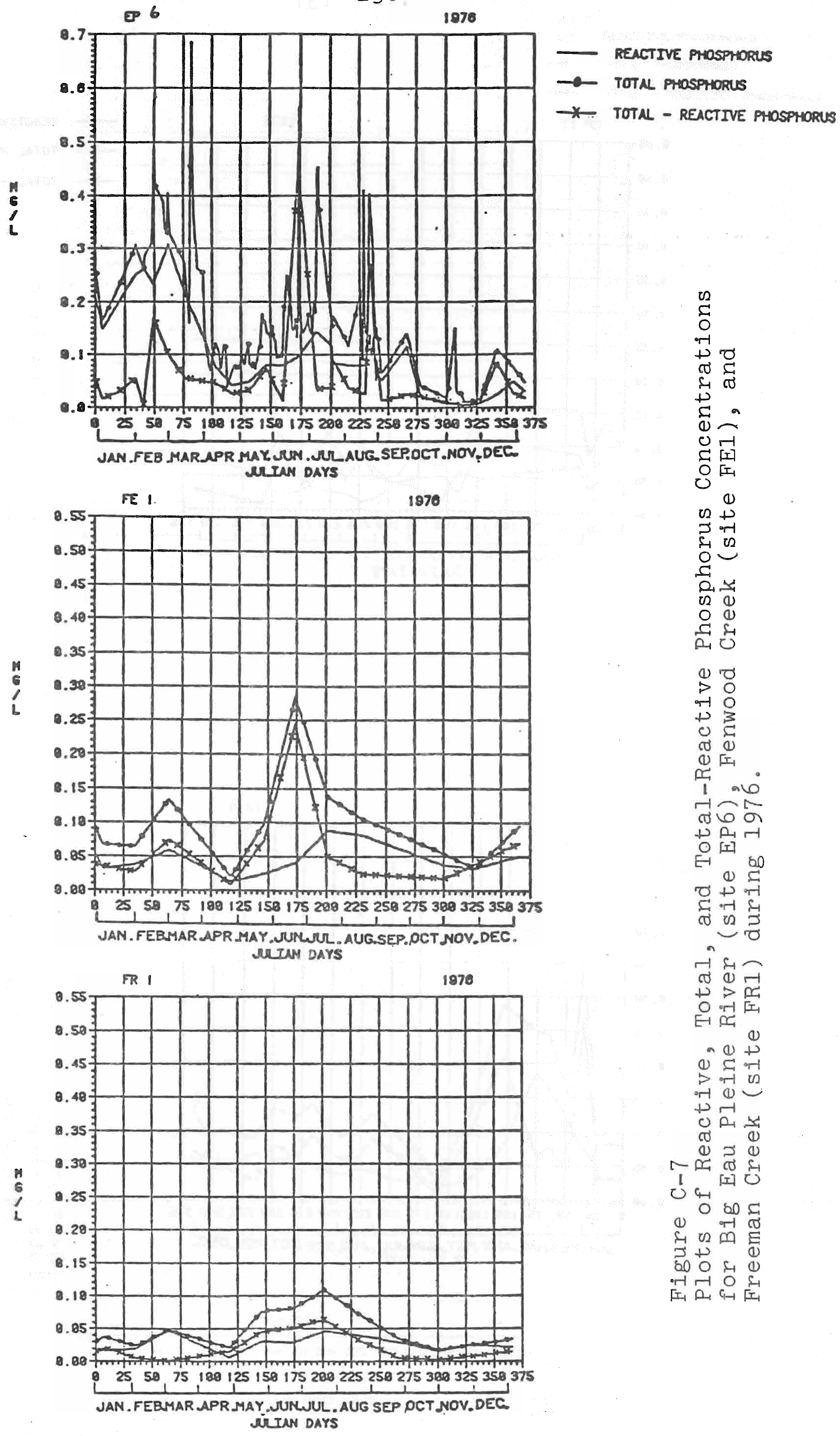


Figure C-7
Plots of Reactive, Total, and Total-Reactive Phosphorus Concentrations for Big Eau Pleine River (site EP6), Fenwood Creek (site FE1), and Freeman Creek (site FR1) during 1976.

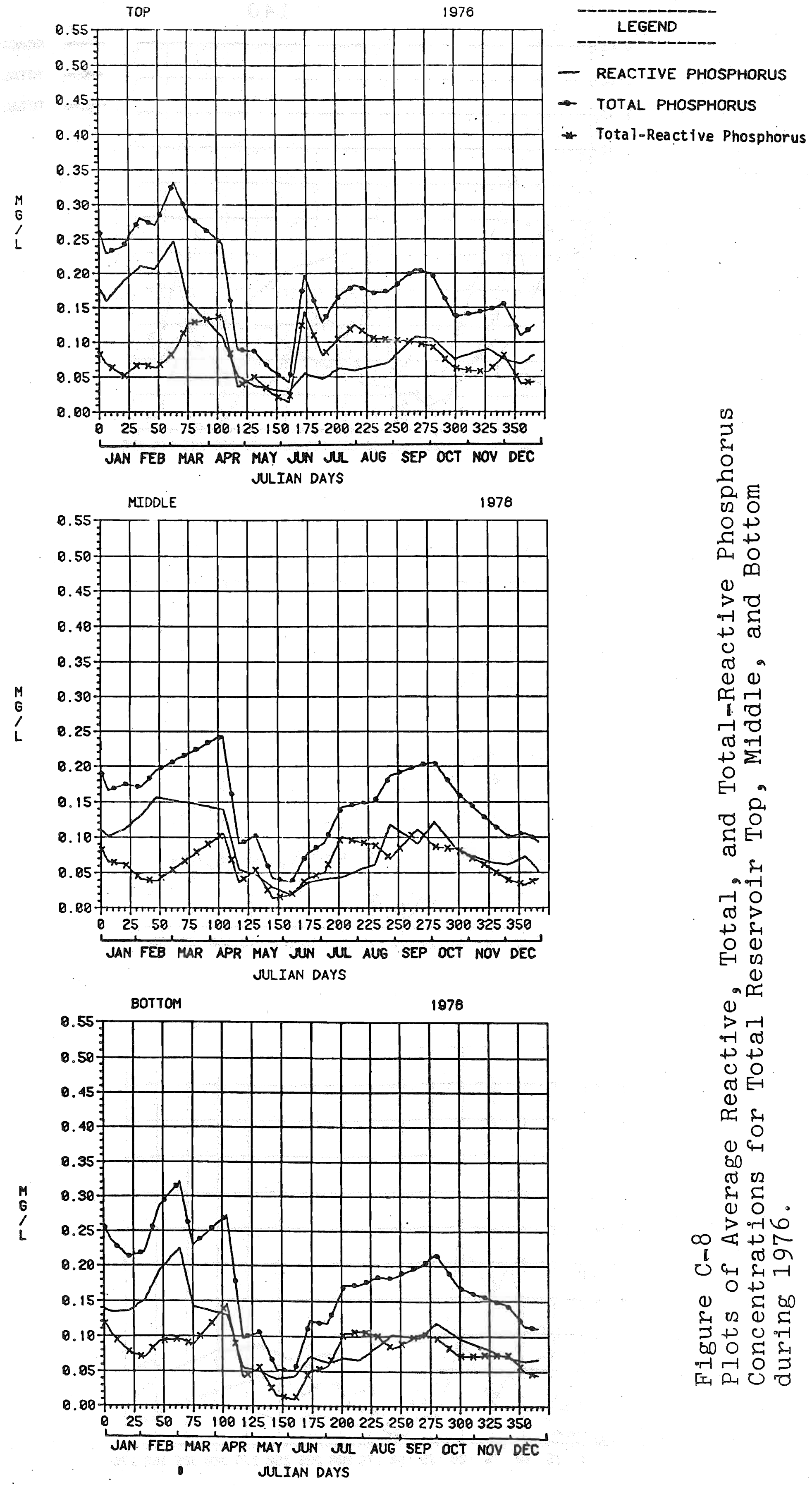


Figure C-8
Plots of Average Reactive, Total, and Total-Reactive Phosphorus Concentrations for Total Reservoir Top, Middle, and Bottom during 1976.

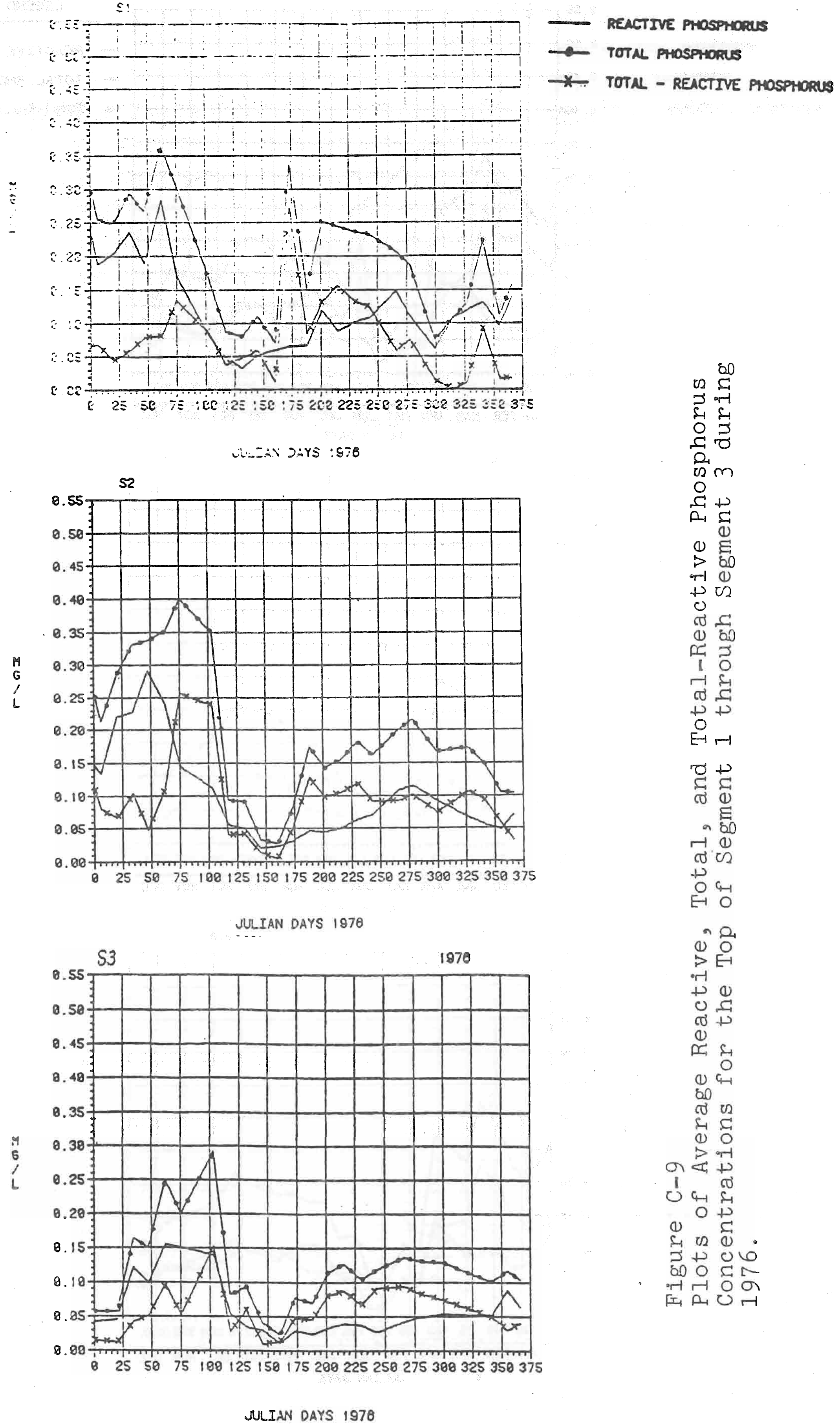
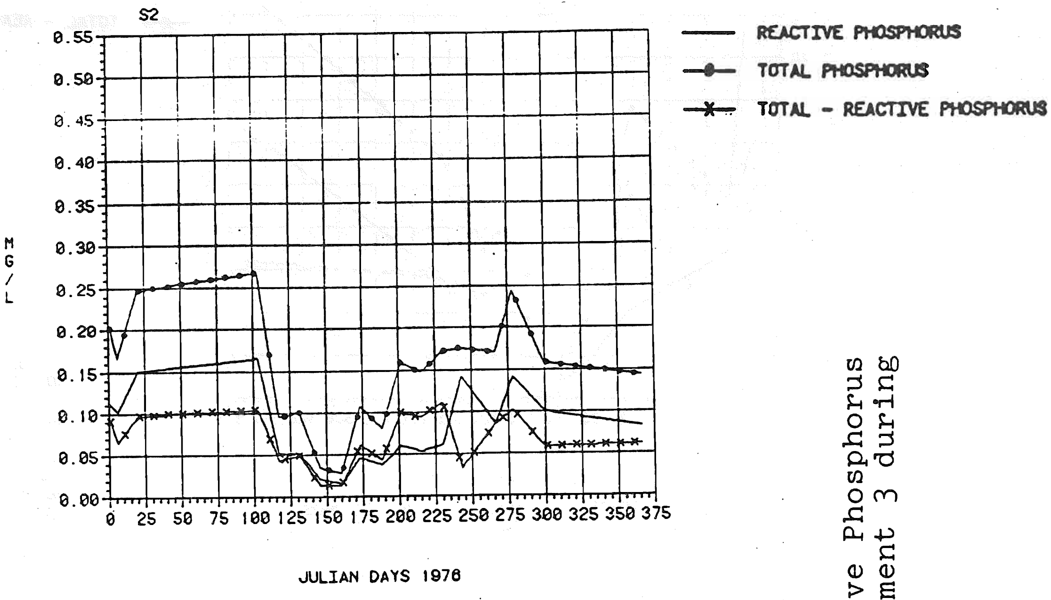


Figure C-9
Plots of Average Reactive, Total, and Total-Reactive Phosphorus Concentrations for the Top of Segment 1 through Segment 3 during 1976.



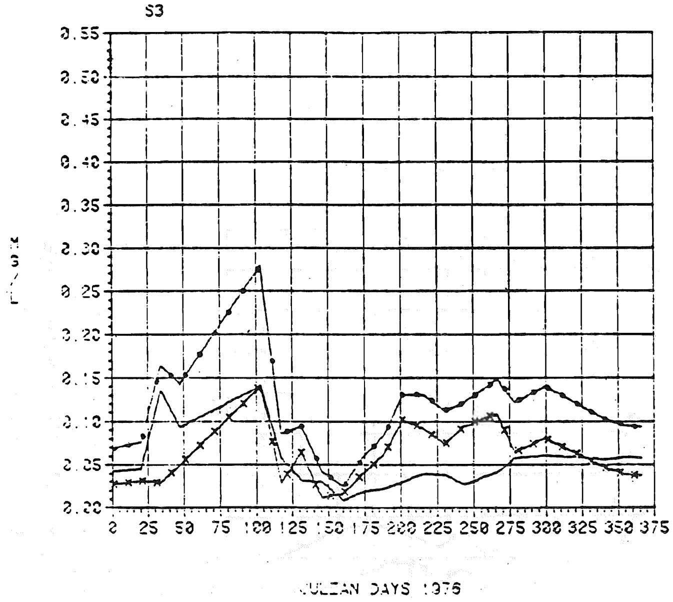


Figure C-10
Plots of Average Reactive, Total, and Total-Reactive Phosphorus Concentrations for the Middle of Segment 2 and Segment 3 during 1976.

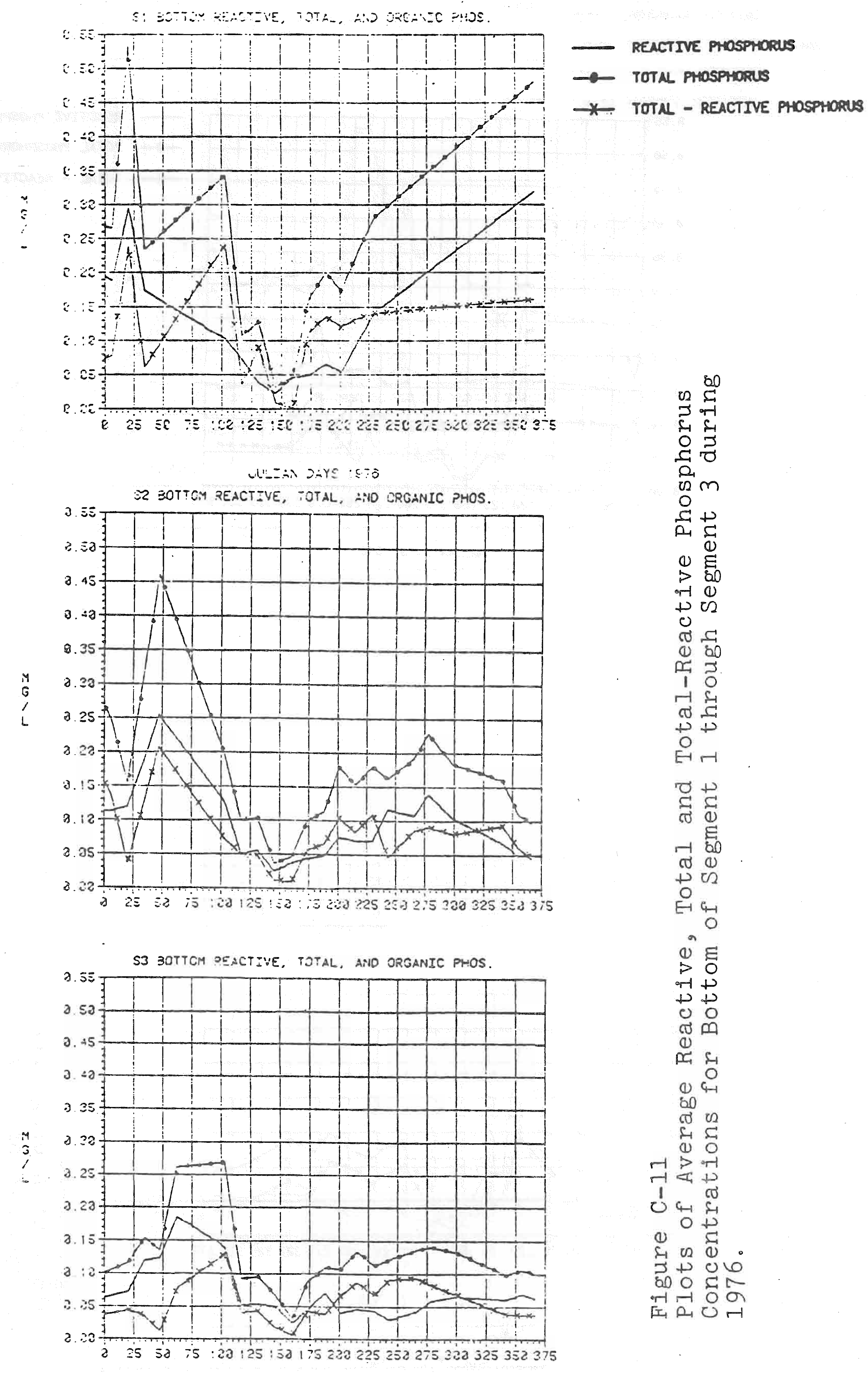


Figure C-11
Plots of Average Reactive, Total and Total-Reactive Phosphorus Concentrations for Bottom of Segment 1 through Segment 3 during 1976.

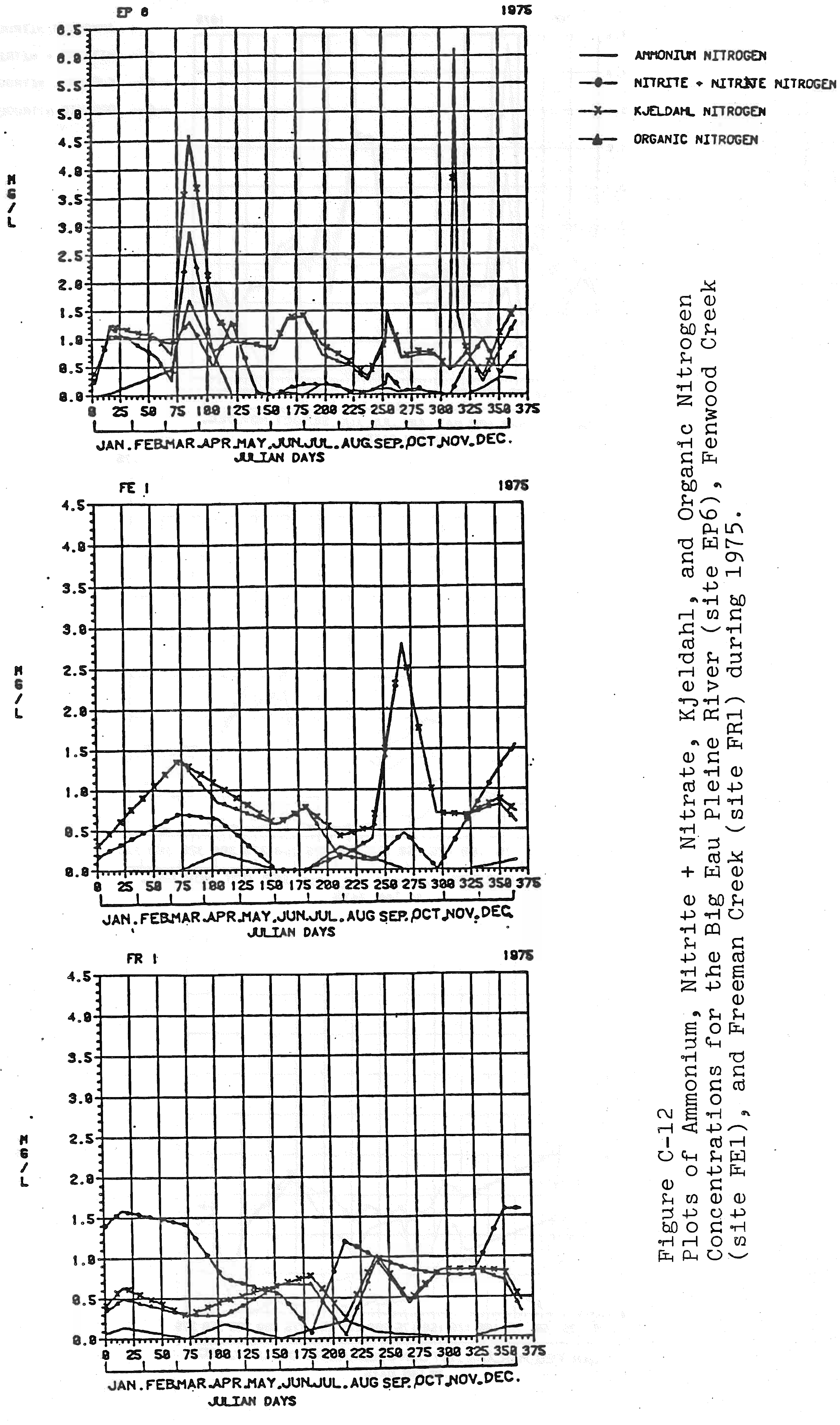


Figure C-12
Plots of Ammonium, Nitrite + Nitrate, Kjeldahl, and Organic Nitrogen Concentrations for the Big Eau Pleine River (site EP6), Fenwood Creek (site FE1), and Freeman Creek (site FR1) during 1975.

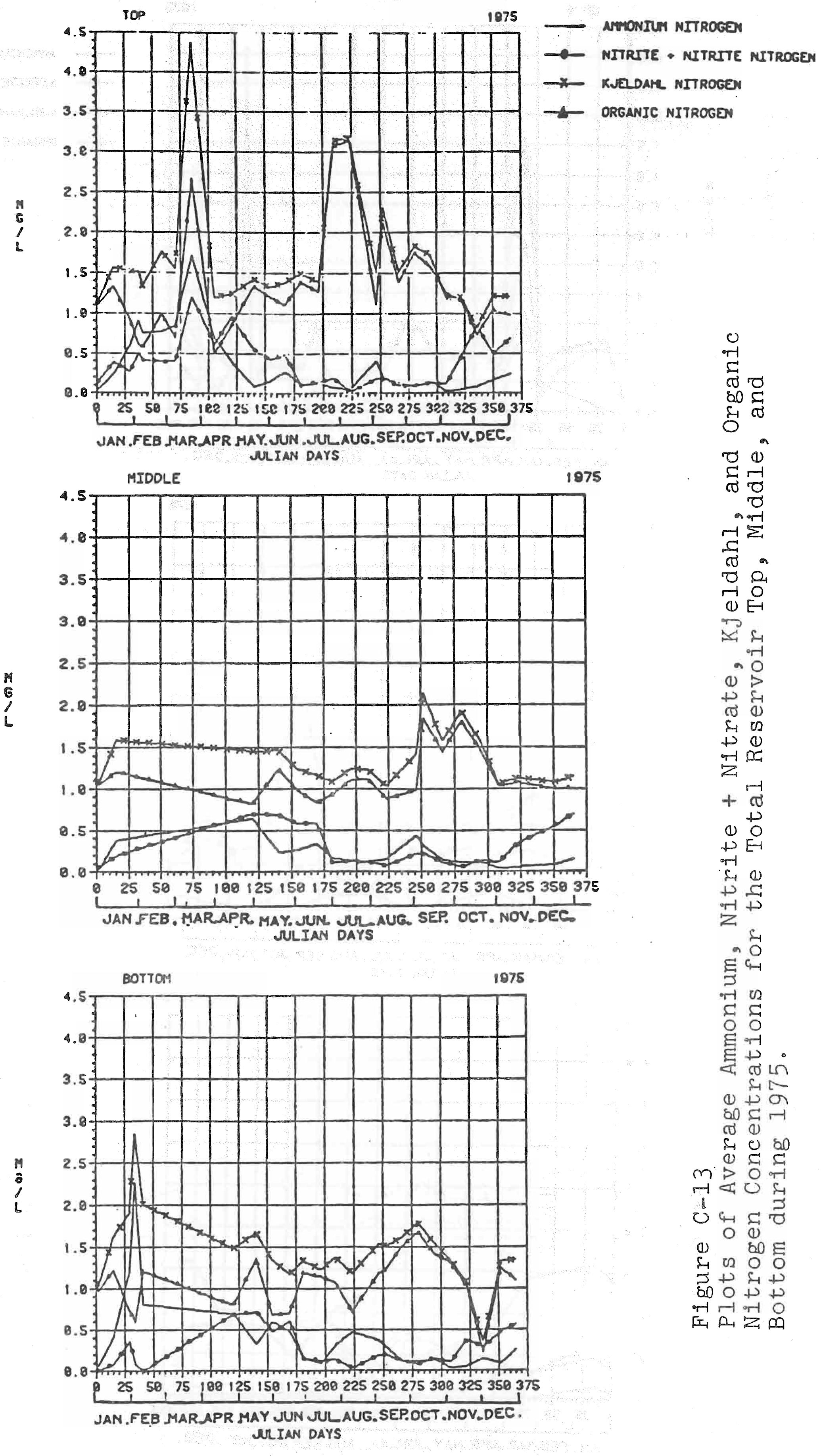
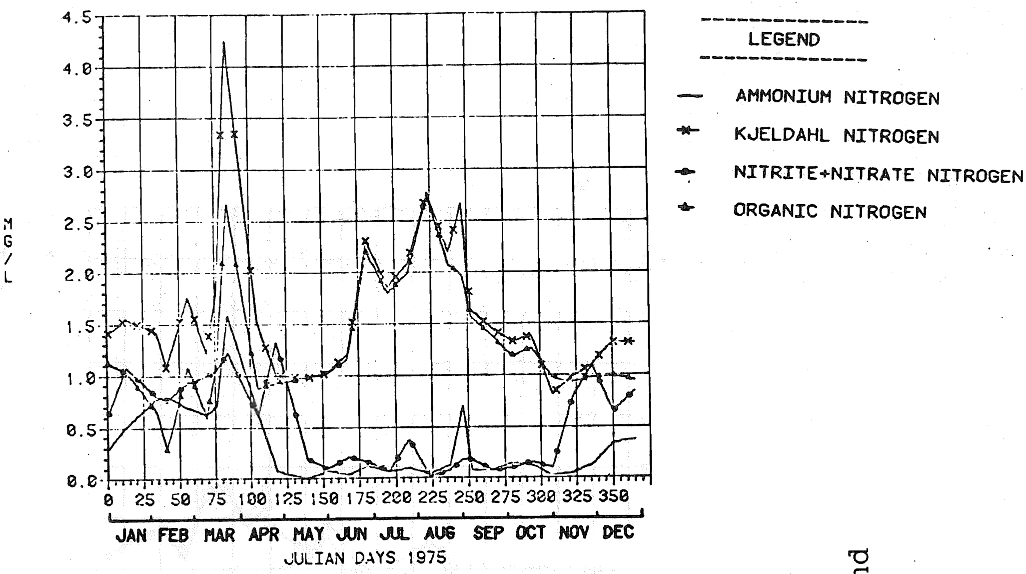
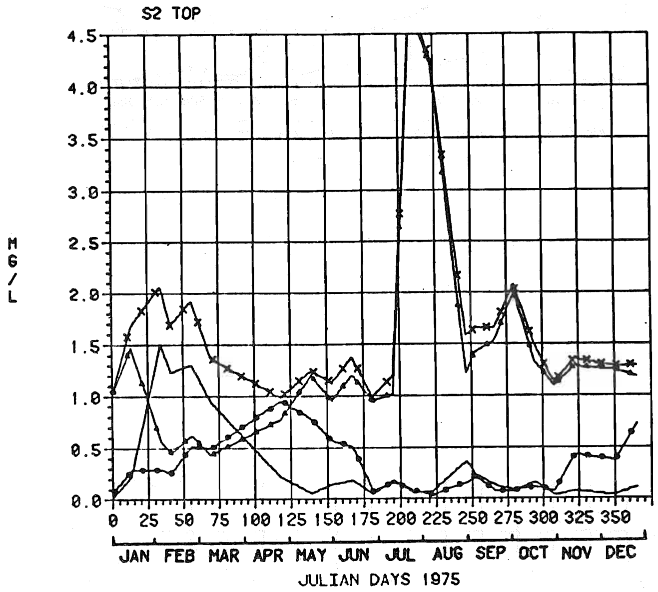


Figure C-13
Plots of Average Ammonium, Nitrite + Nitrate, Kjeldahl, and Organic Nitrogen Concentrations for the Total Reservoir Top, Middle, and Bottom during 1975.





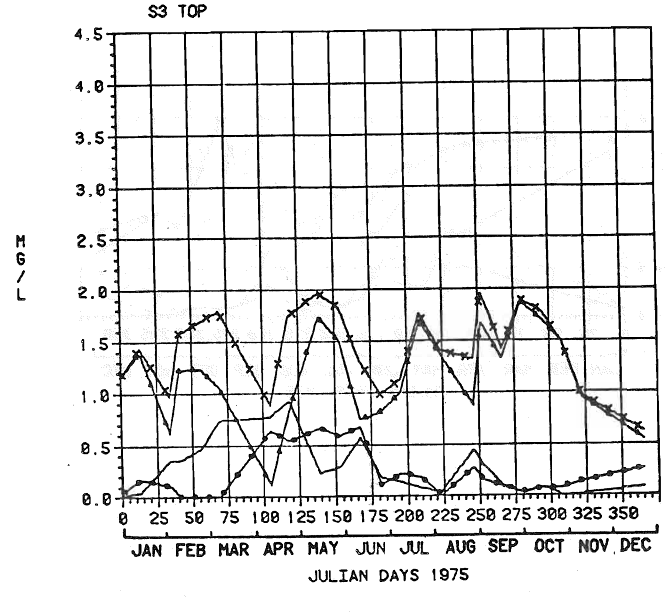


Figure C-14
Plots of Average Ammonium, Nitrite + Nitrate, Kjeldahl, and Organic Nitrogen Concentration for the Top of Segment 1 through Segment 3 during 1975.

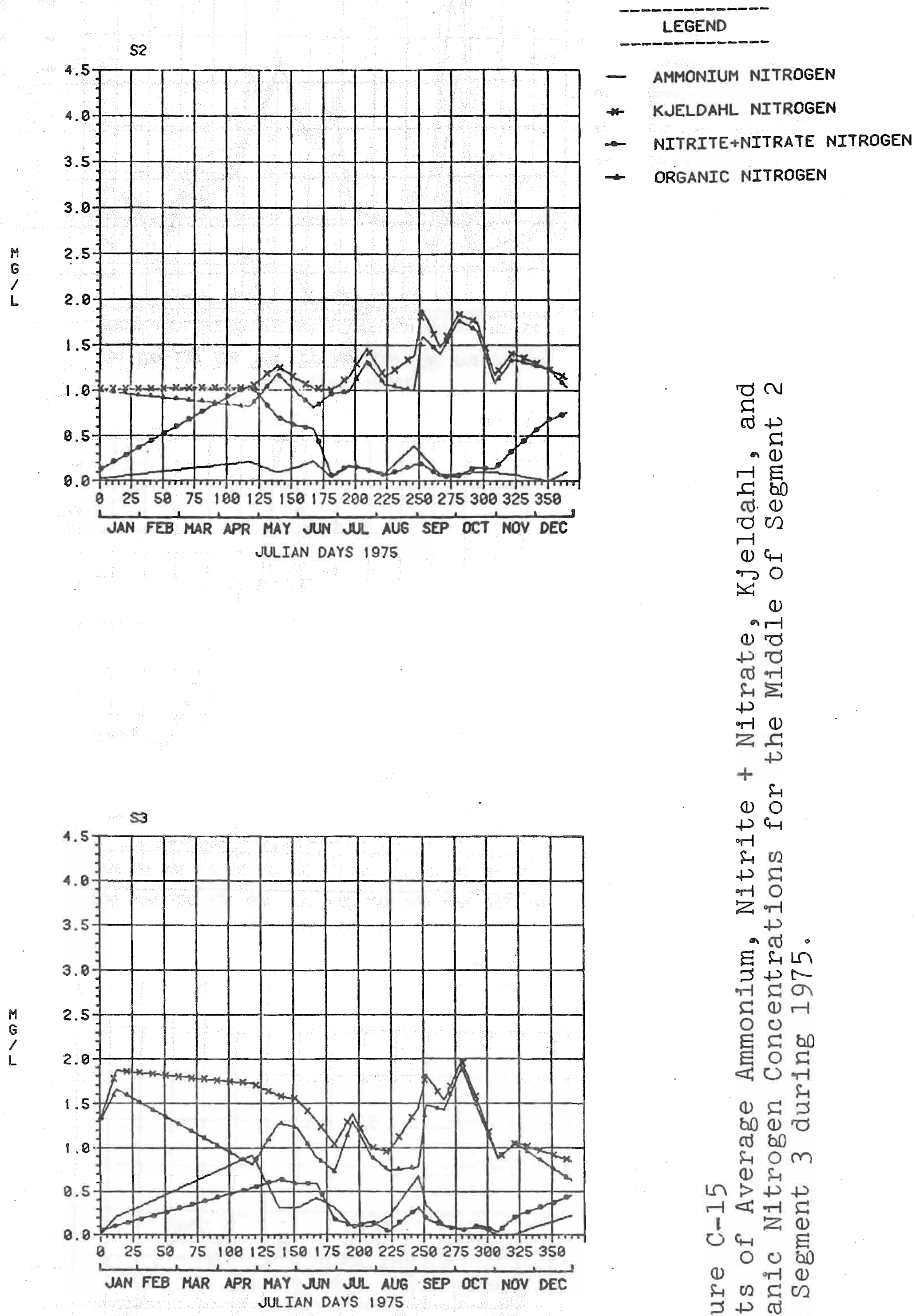


Figure C-15
Plots of Average Ammonium, Nitrite + Nitrate, Kjeldahl, and Organic Nitrogen Concentrations for the Middle of Segment 2 and Segment 3 during 1975.

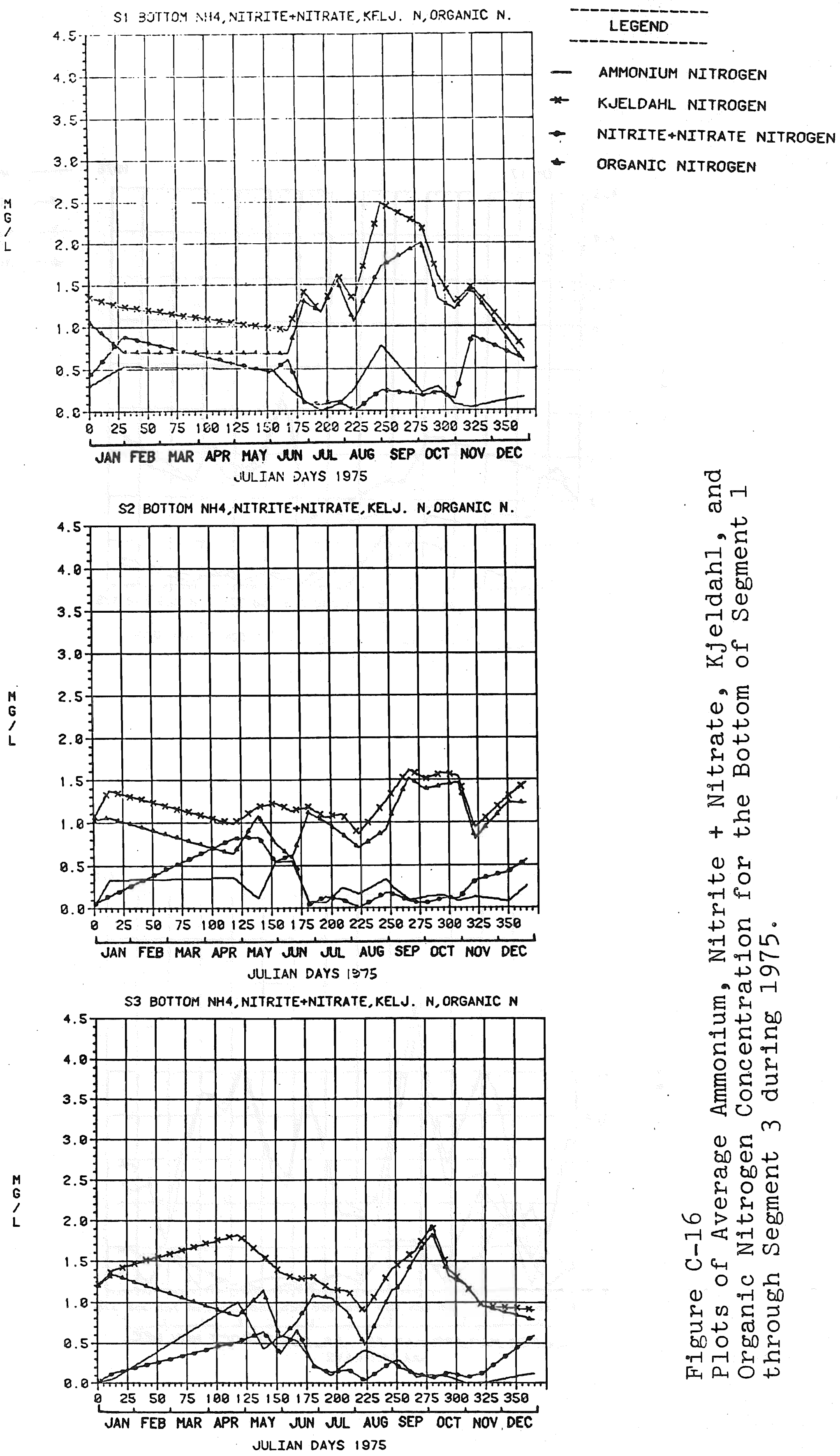


Figure C-16
Plots of Average Ammonium, Nitrite + Nitrate, Kjeldahl, and Organic Nitrogen Concentration for the Bottom of Segment 1 through Segment 3 during 1975.

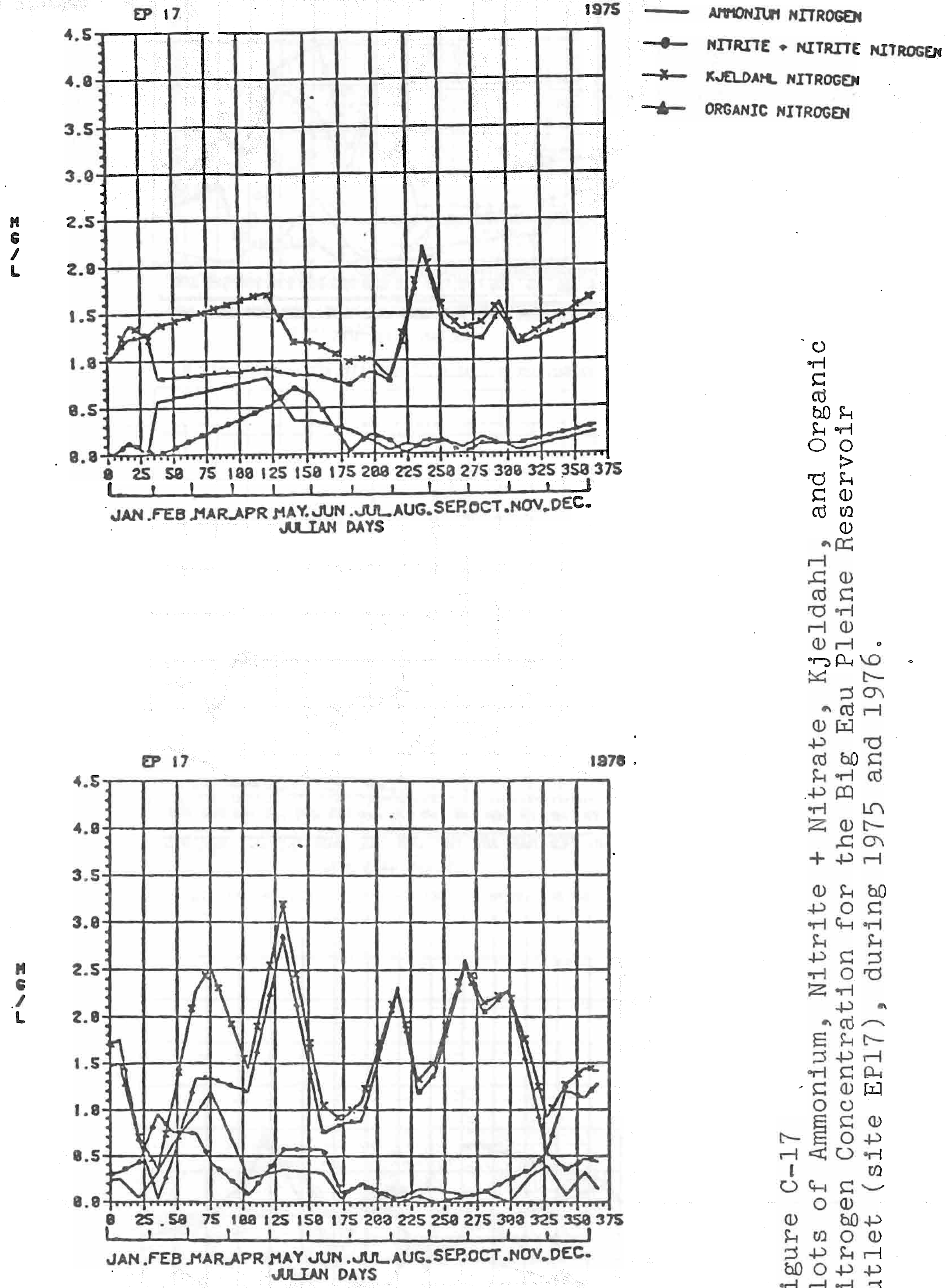
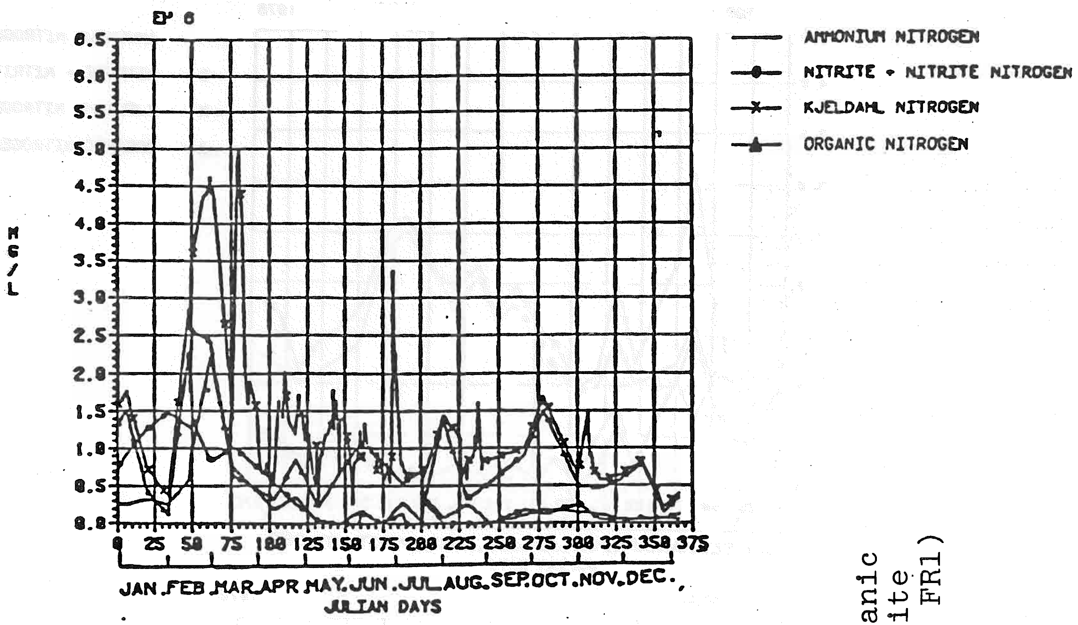
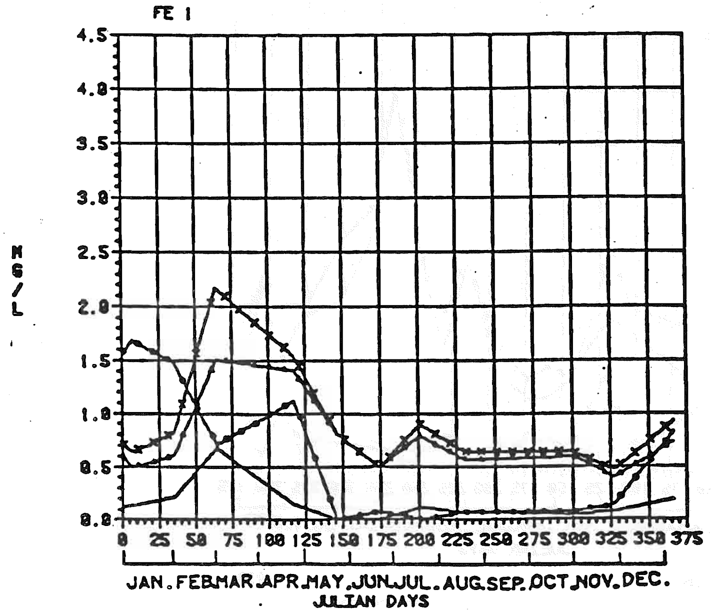


Figure C-17
Plots of Ammonium, Nitrite + Nitrate, Kjeldahl, and Organic Nitrogen Concentration for the Big Eau Pleine Reservoir outlet (site EP17), during 1975 and 1976.





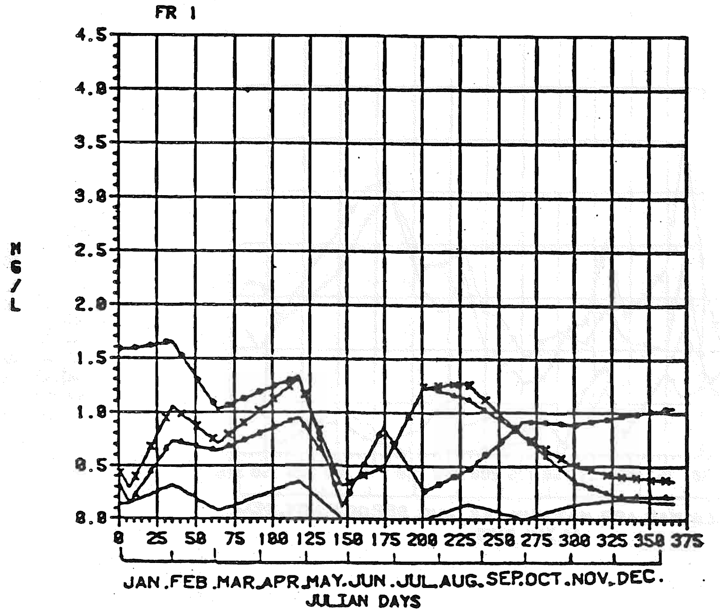


Figure C-18
Plots of Ammonium, Nitrite + Nitrate, Kjeldahl, and Organic Nitrogen Concentrations for the Big Eau Pleine River (site EP6), Fenwood Creek (site FE1), and Freeman Creek (site FR1) during 1976.

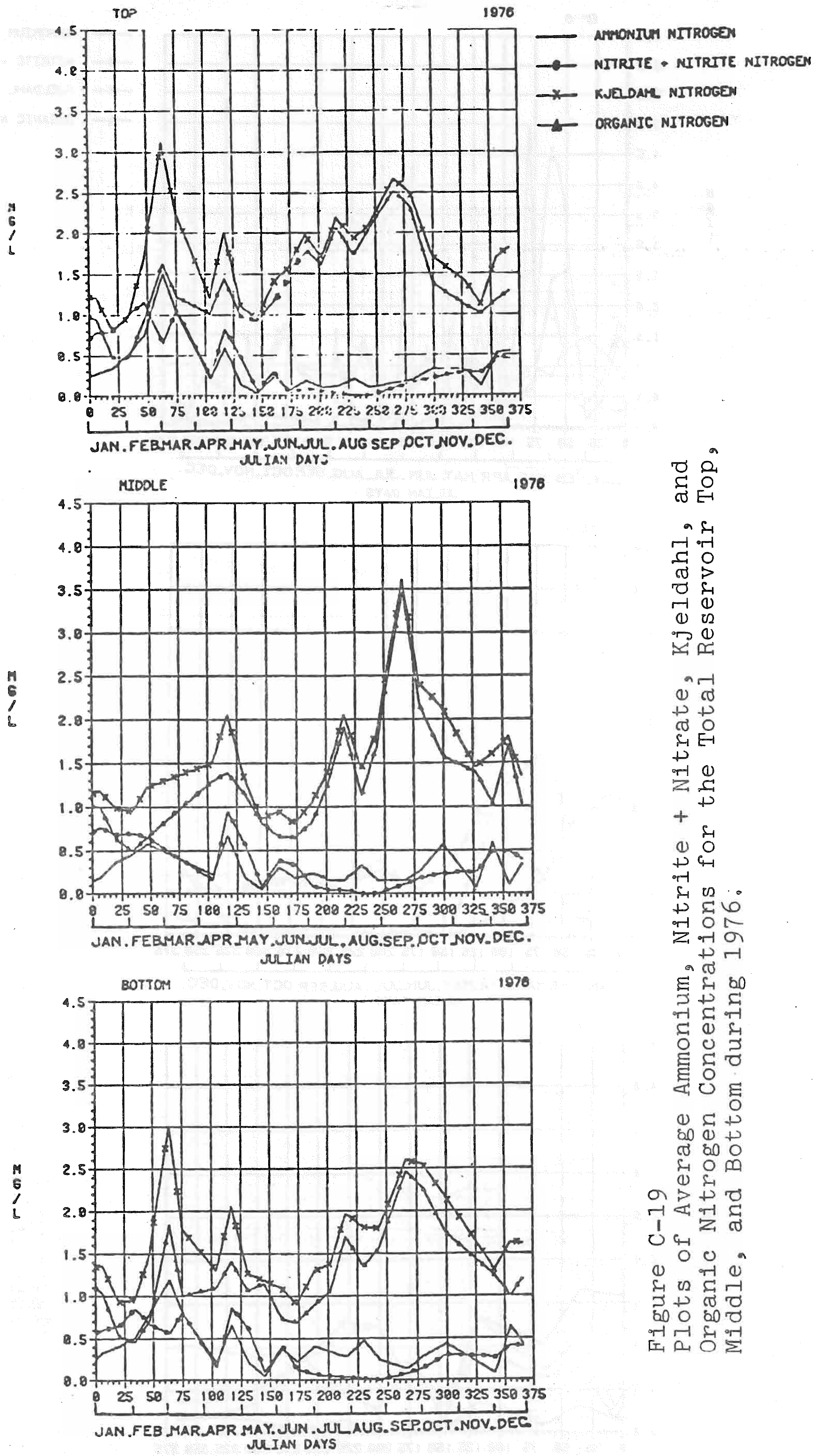


Figure C-19
Plots of Average Ammonium, Nitrite + Nitrate, Kjeldahl, and Organic Nitrogen Concentrations for the Total Reservoir Top, Middle, and Bottom during 1976.

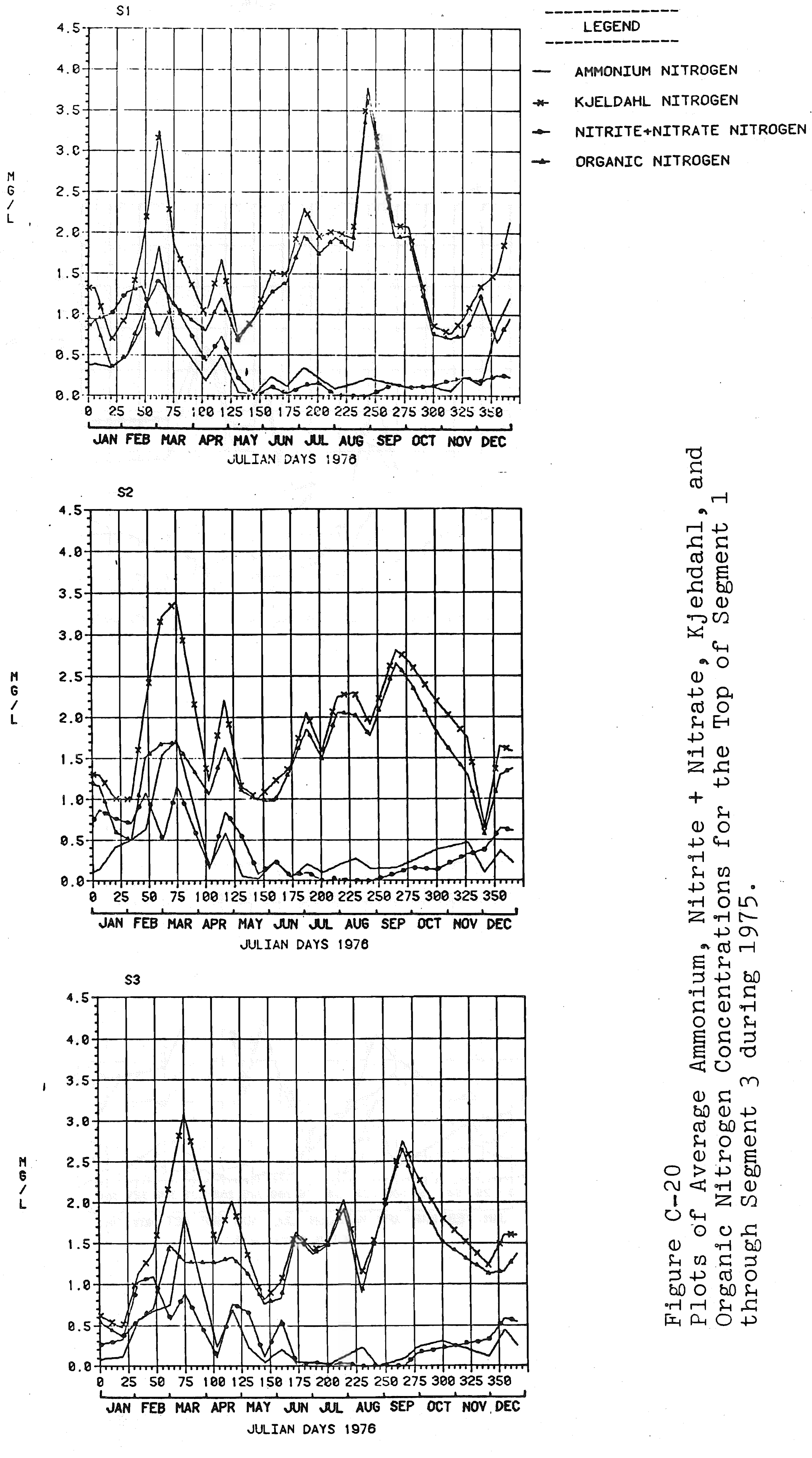


Figure C-20
Plots of Average Ammonium, Nitrite + Nitrate, Kjehdahl, and Organic Nitrogen Concentrations for the Top of Segment 1 through Segment 3 during 1975.

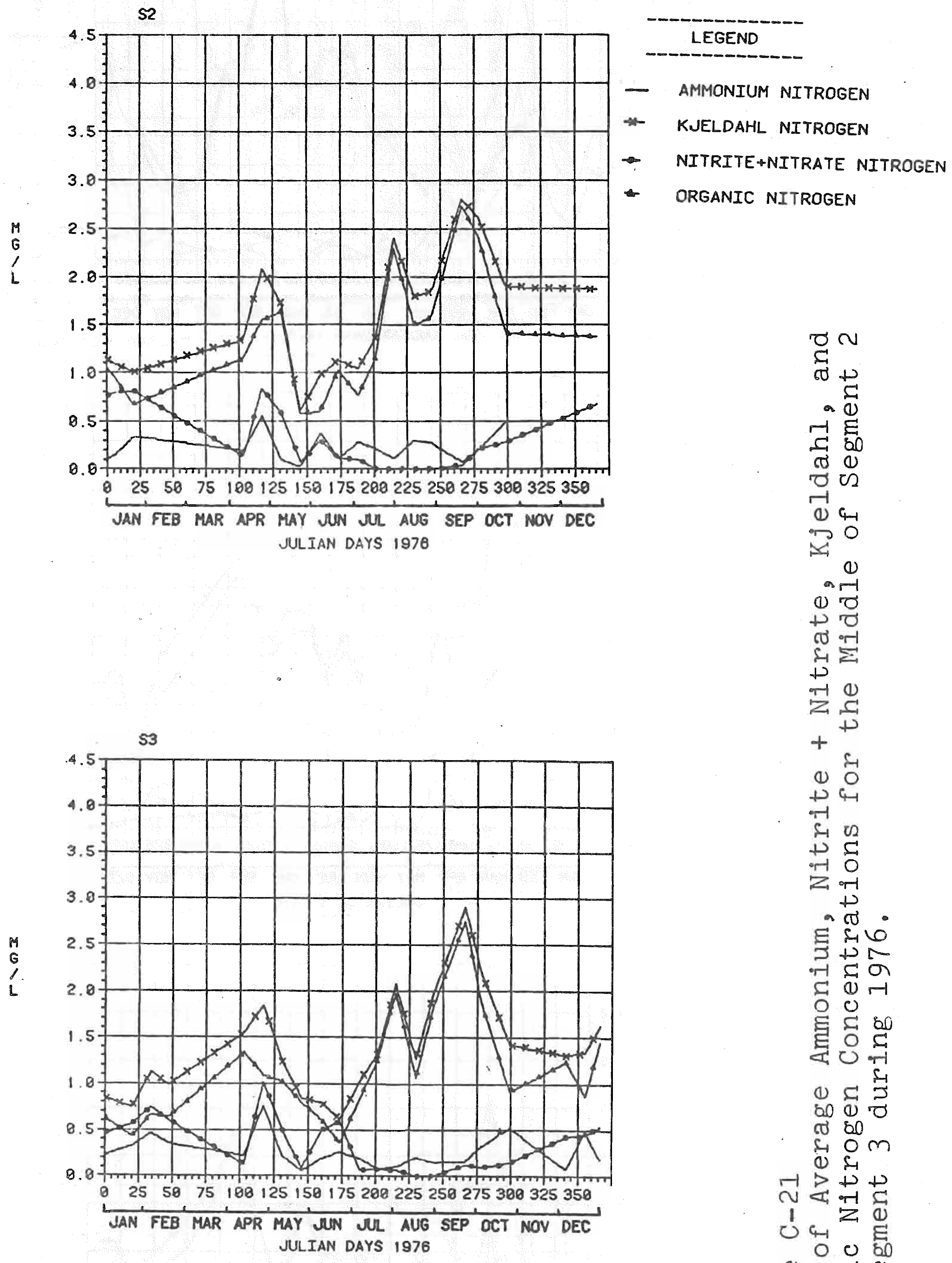


Figure C-21
Plots of Average Ammonium, Nitrite + Nitrate, Kjeldahl, and Organic Nitrogen Concentrations for the Middle of Segment 2 and Segment 3 during 1976.

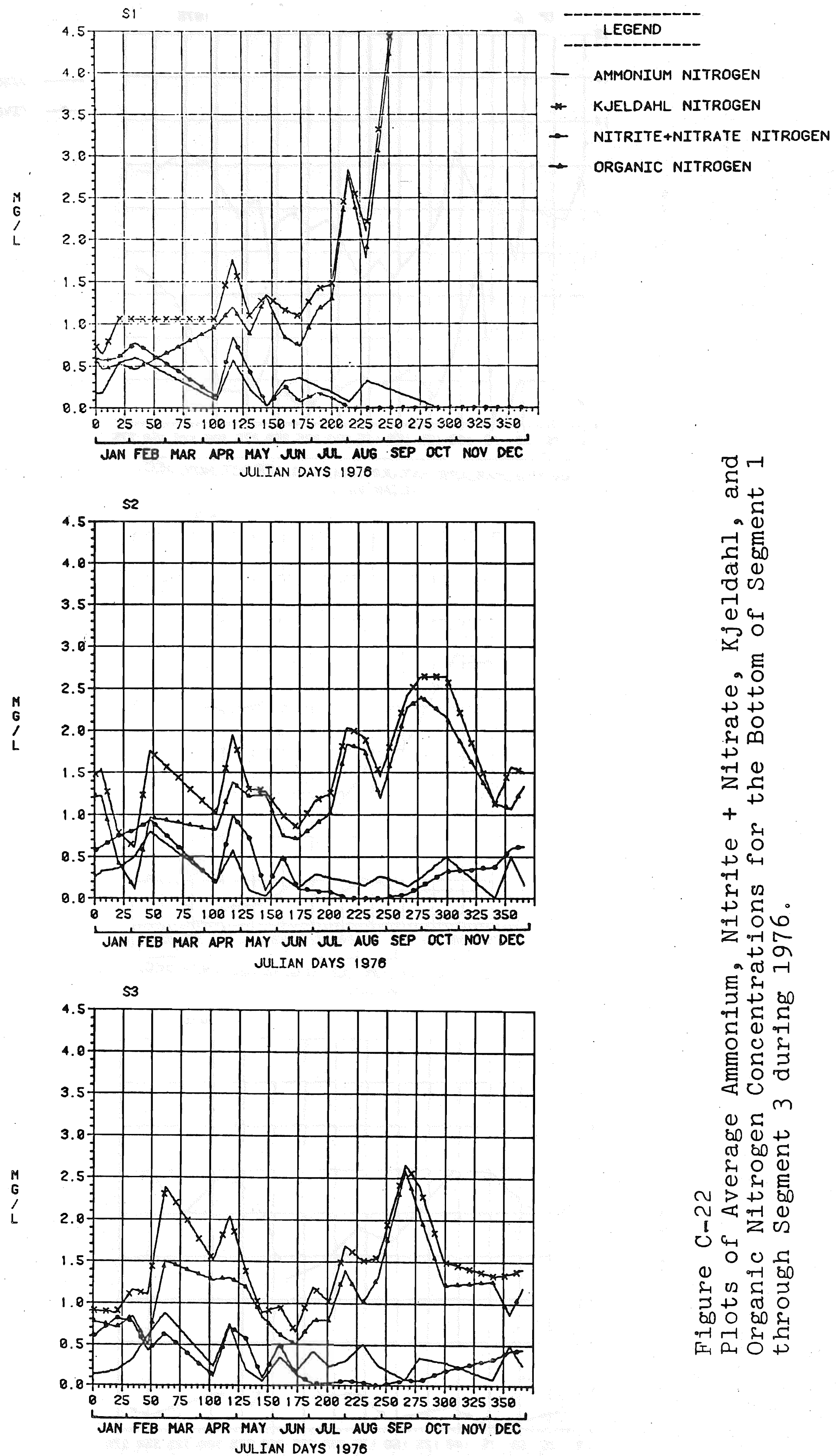


Figure C-22
Plots of Average Ammonium, Nitrite + Nitrate, Kjeldahl, and Organic Nitrogen Concentrations for the Bottom of Segment 1 through Segment 3 during 1976.

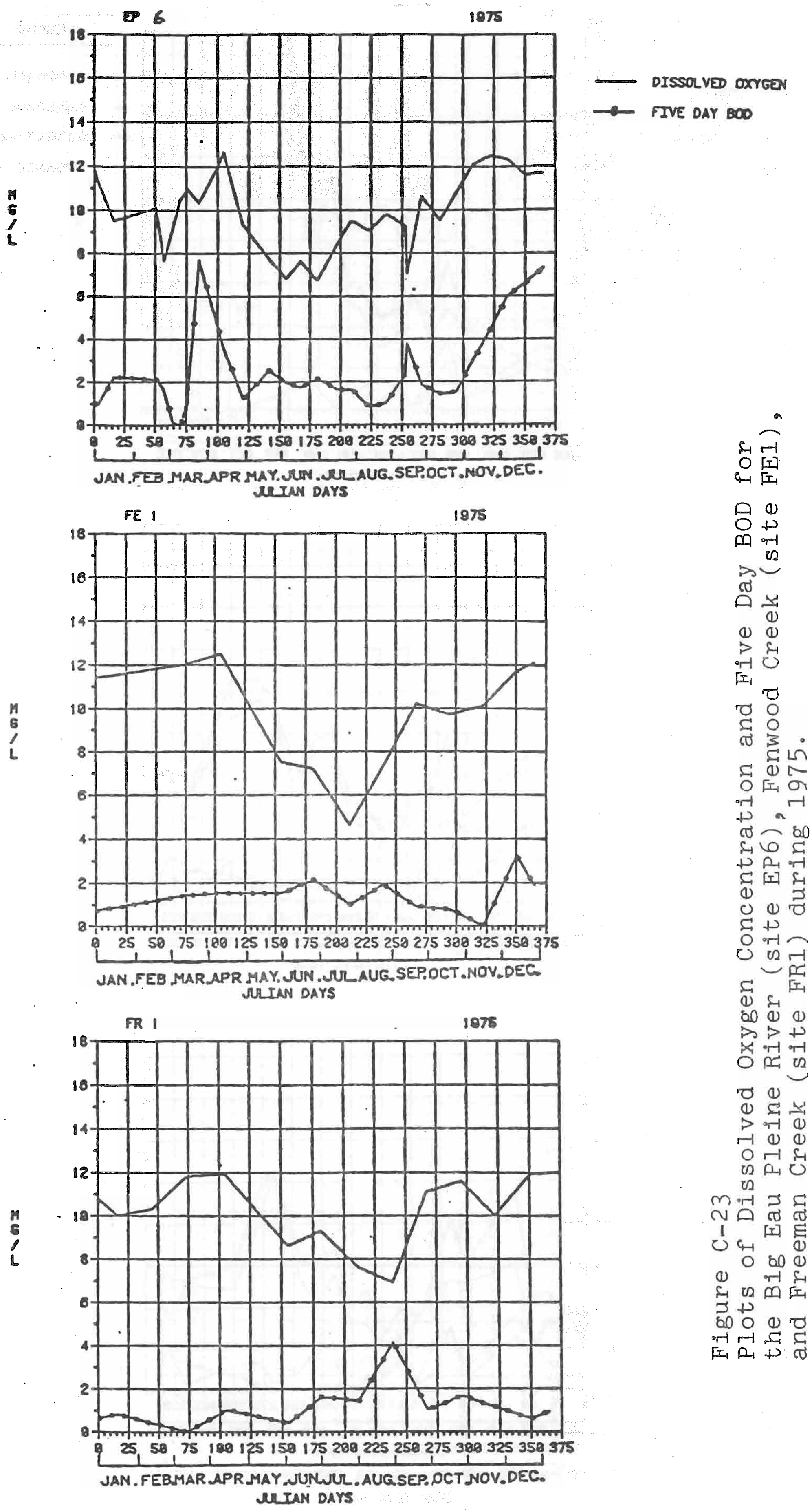


Figure C-23
Plots of Dissolved Oxygen Concentration and Five Day BOD for the Big Eau Pleine River (site EP6), Fenwood Creek (site FE1), and Freeman Creek (site FR1) during 1975.

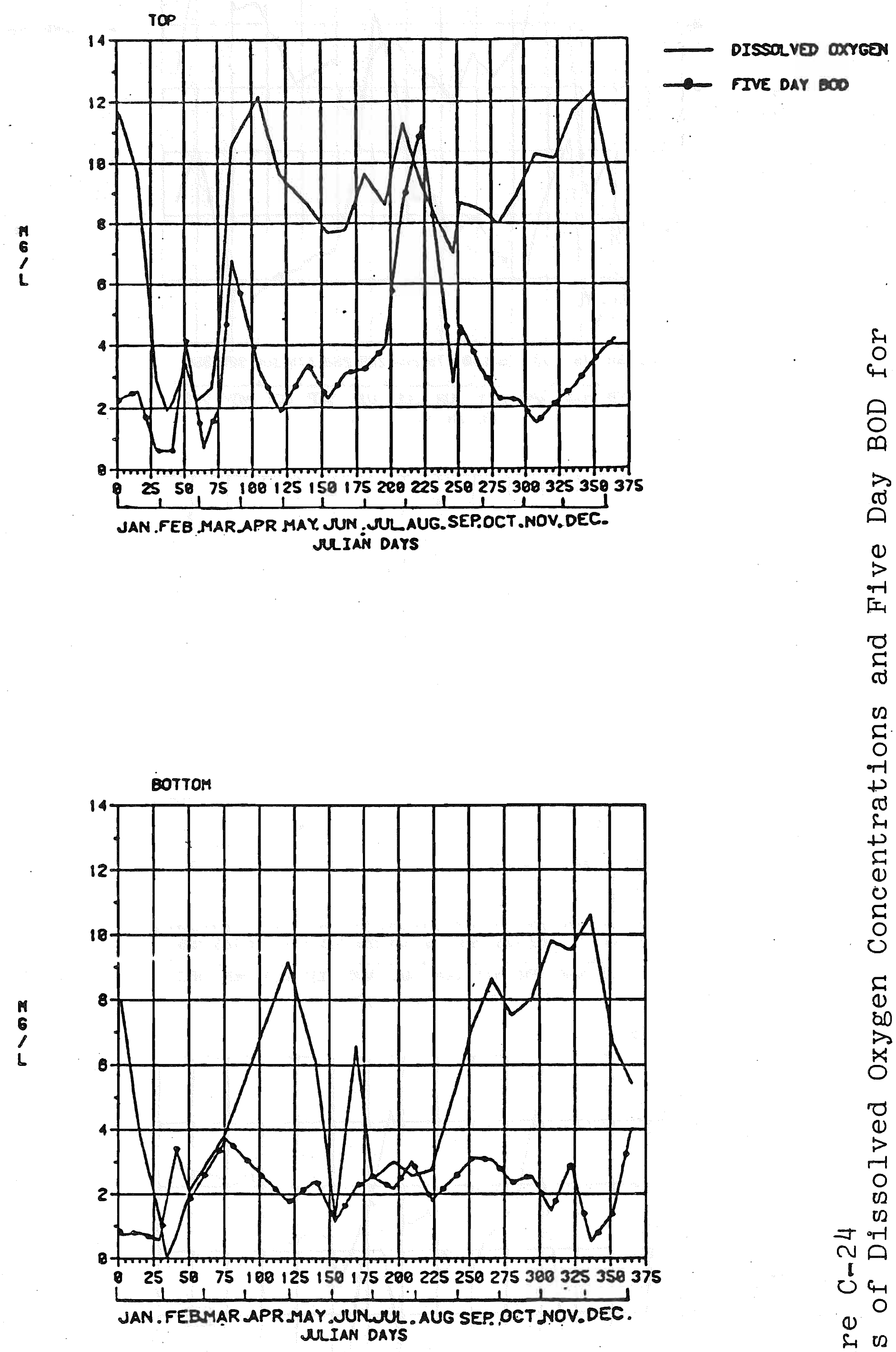


Figure C-24
Plots of Dissolved Oxygen Concentrations and Five Day BOD for the Total Reservoir Top and Bottom during 1975.

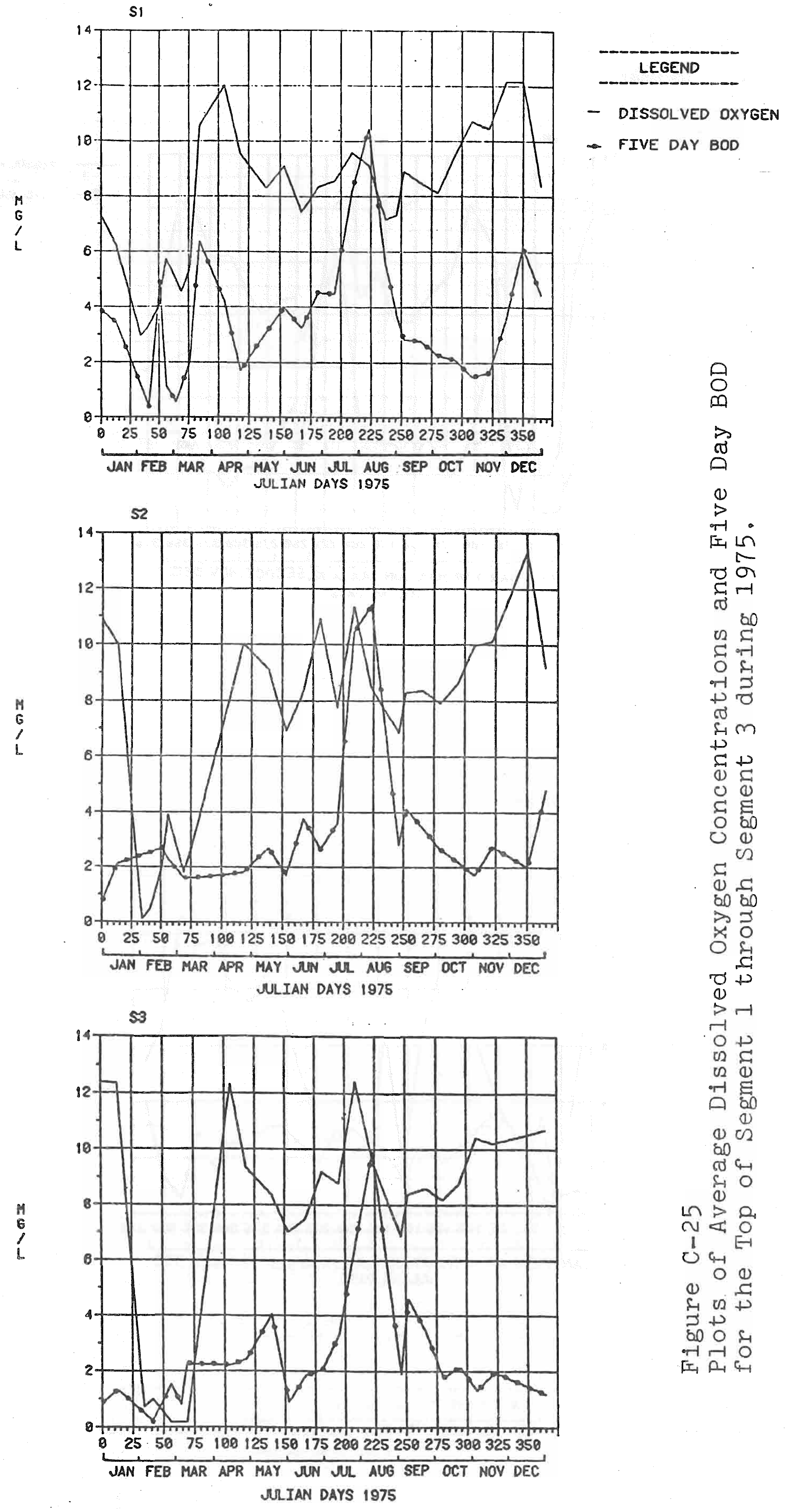


Figure C-25
Plots of Average Dissolved Oxygen Concentrations and Five Day BOD for the Top of Segment 1 through Segment 3 during 1975.

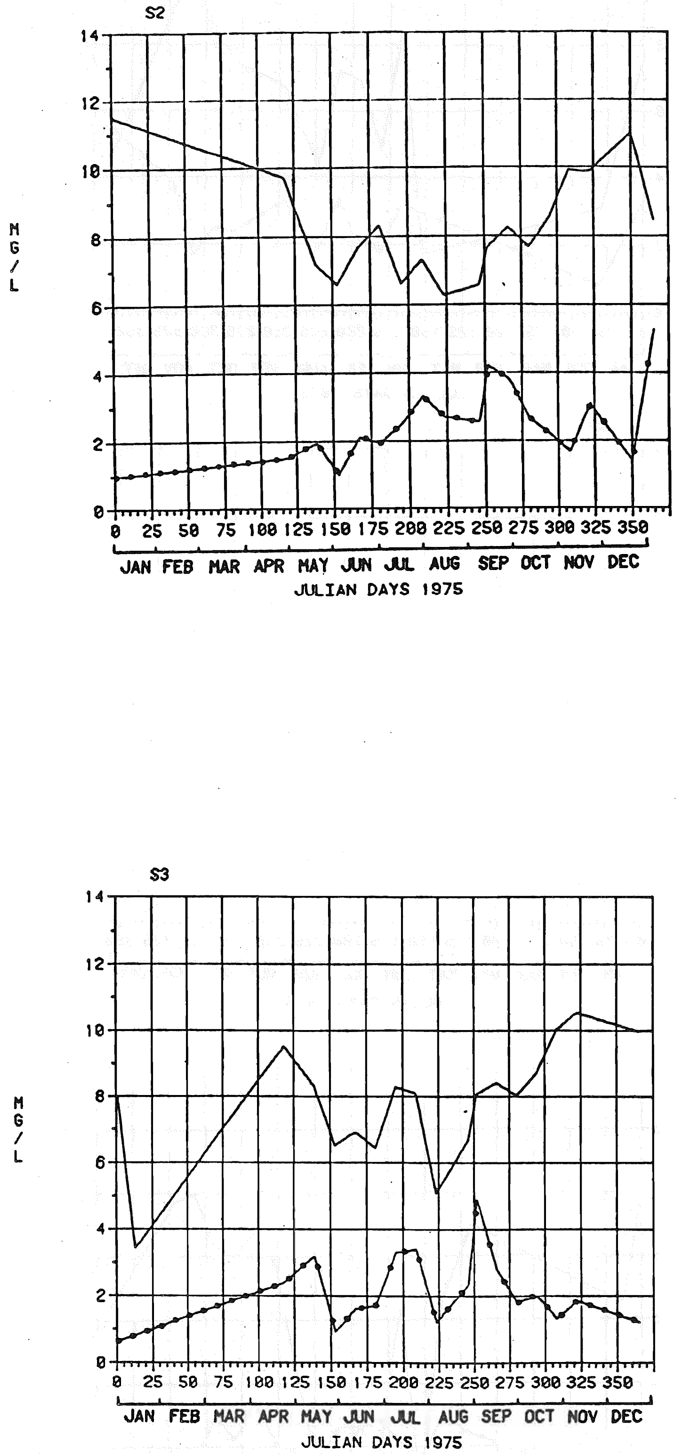


Figure C-26
Plots of Average Dissolved Oxygen Concentrations and Five Day BOD for the Middle of Segment 2 and Segment 3 during 1975.

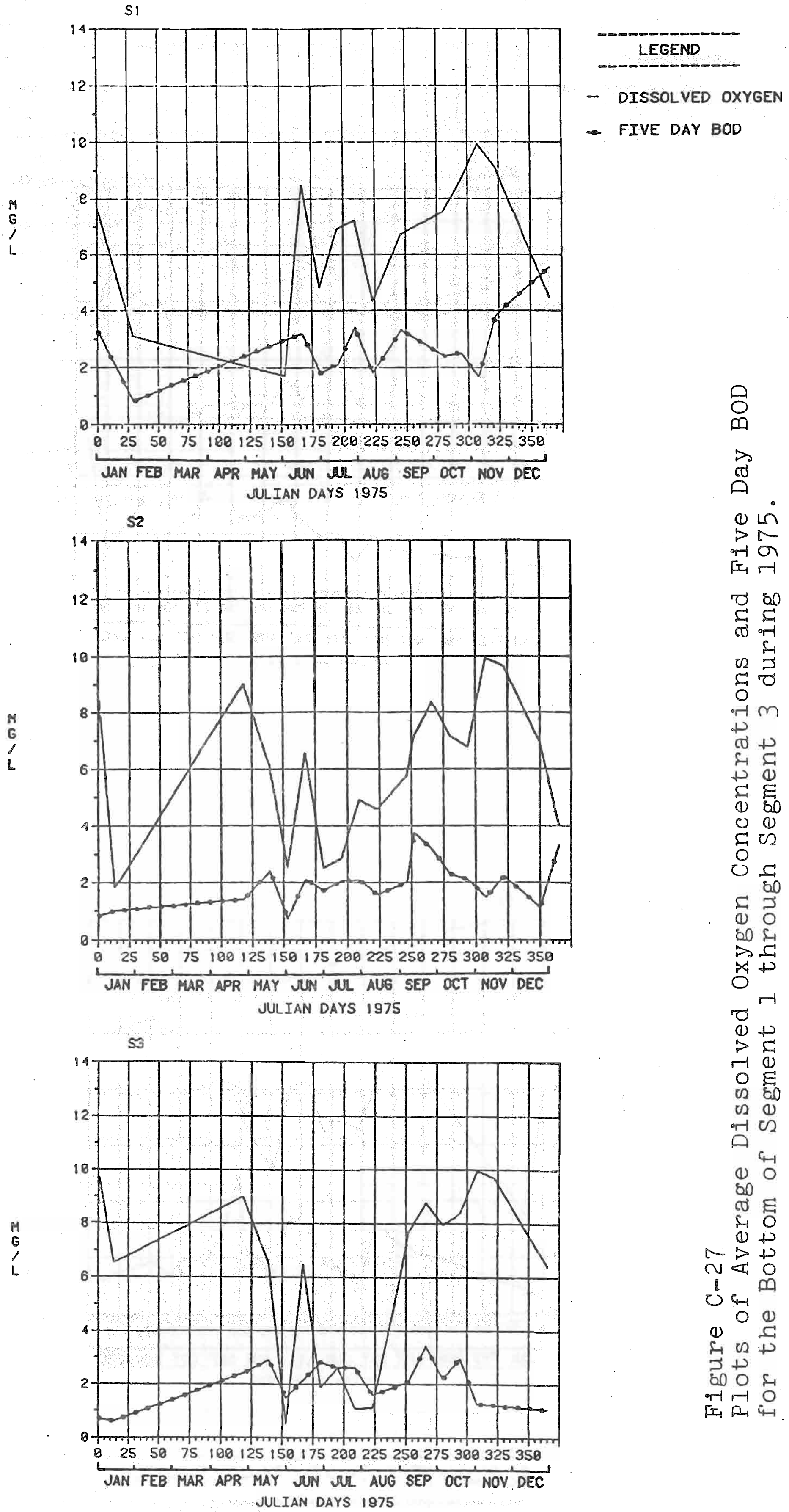


Figure C-27
Plots of Average Dissolved Oxygen Concentrations and Five Day BOD for the Bottom of Segment 1 through Segment 3 during 1975.

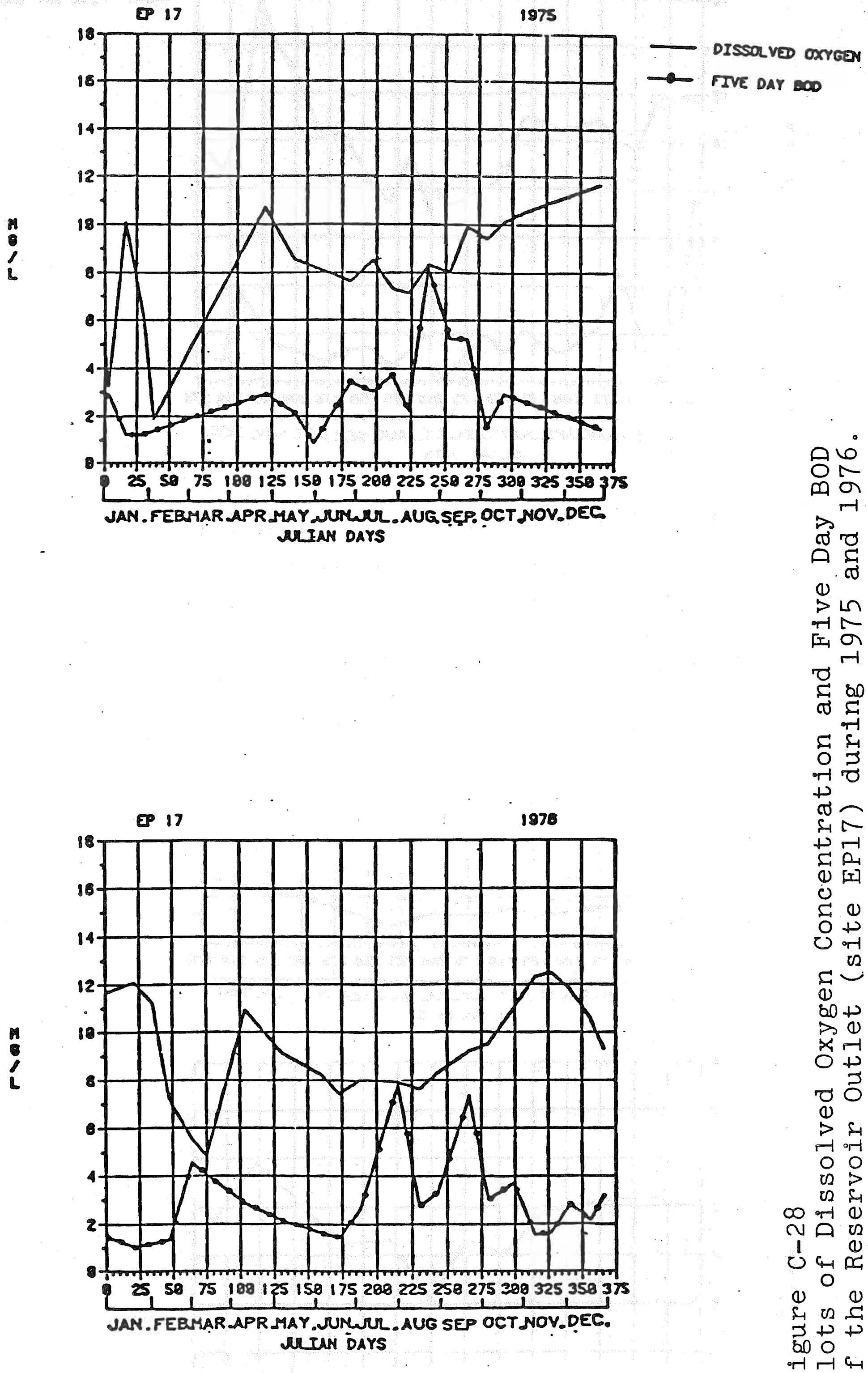


Figure C-28
Plots of Dissolved Oxygen Concentration and Five Day BOD of the Reservoir Outlet (site EP17) during 1975 and 1976.

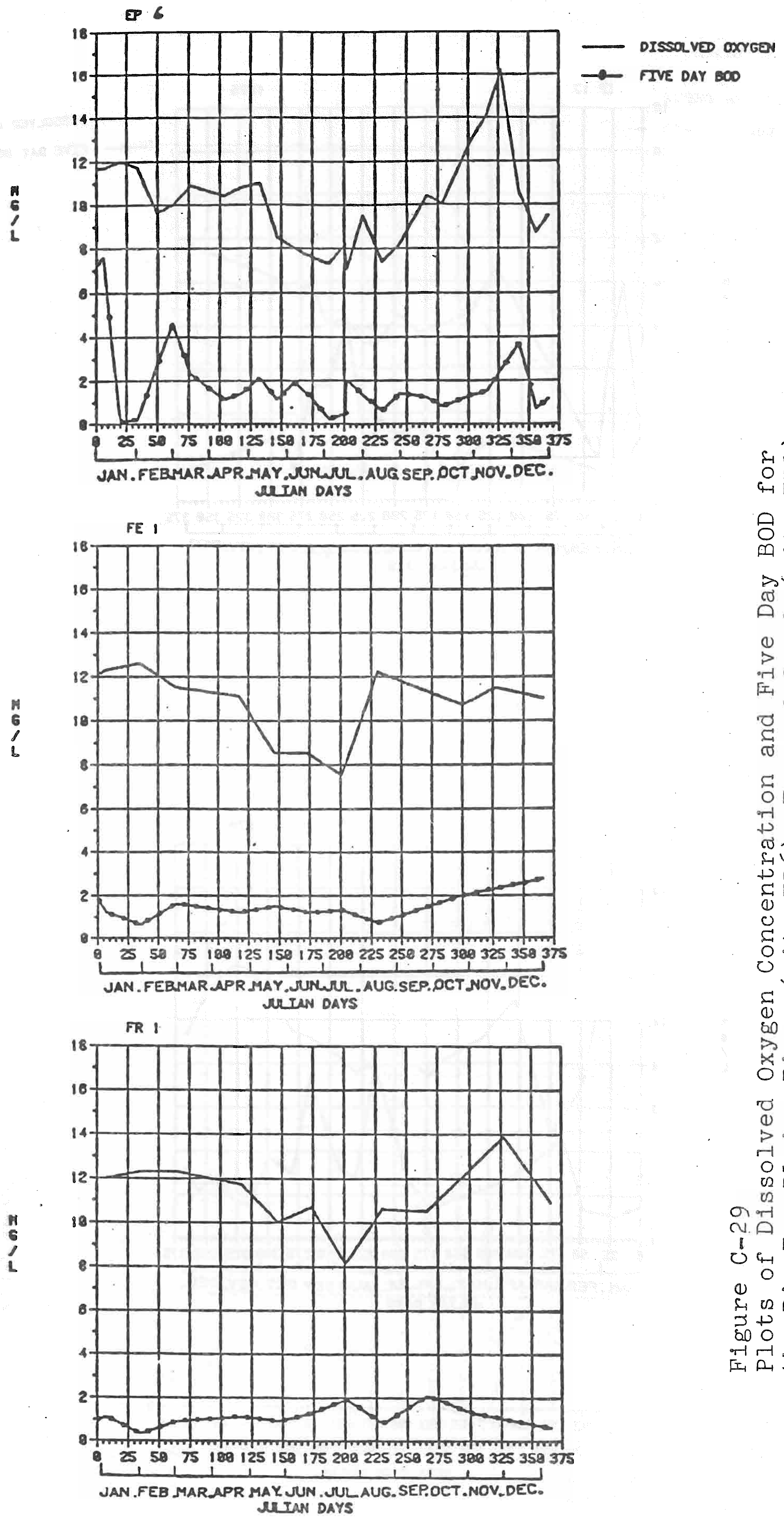


Figure C-29
Plots of Dissolved Oxygen Concentration and Five Day BOD for the Big Eau Pleine River (site EP6), Fenwood Creek (site FE1), and Freeman Creek (site FR1) during 1976.

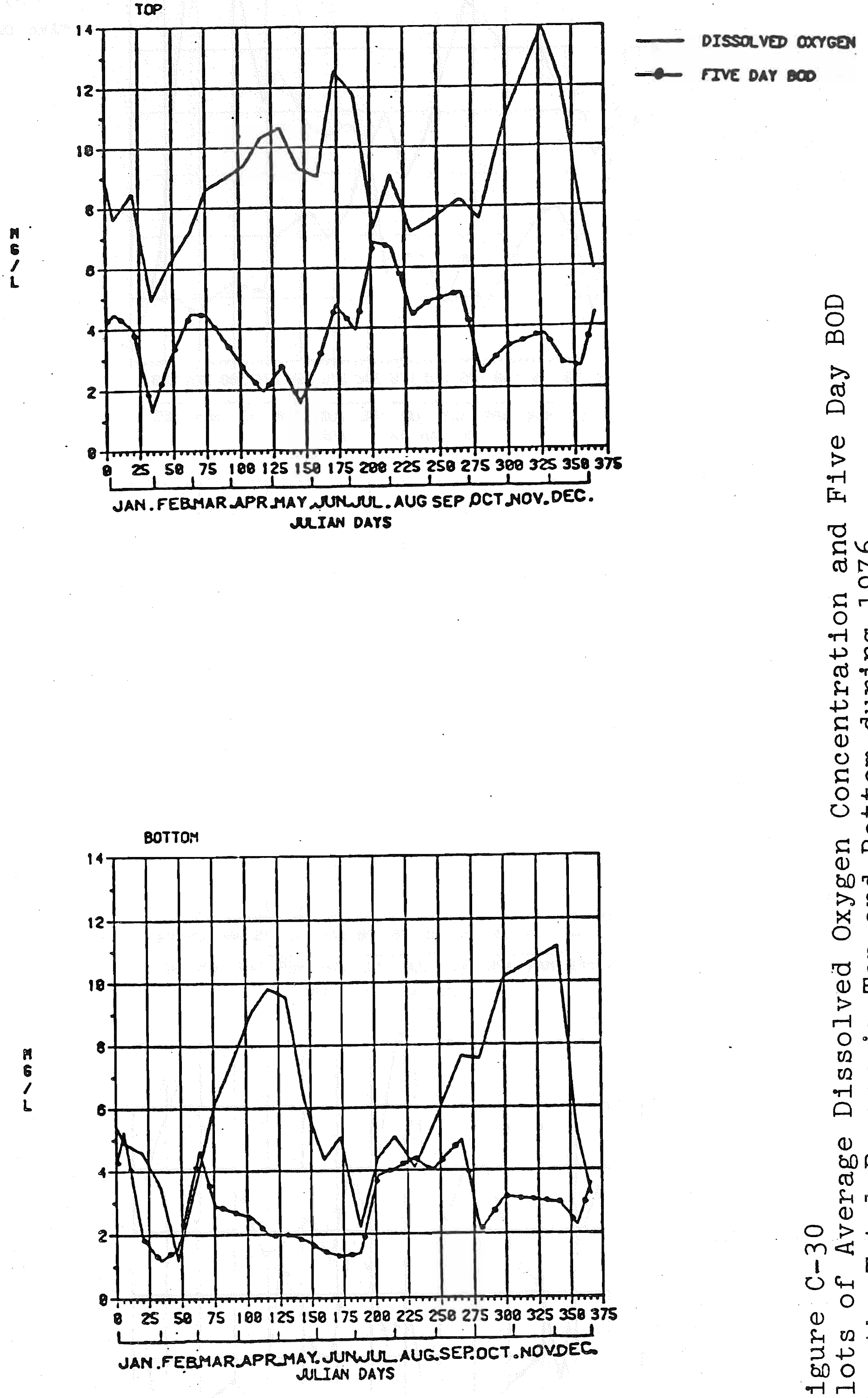


Figure C-30
Plots of Average Dissolved Oxygen Concentration and Five Day BOD for the Total Reservoir Top and Bottom during 1976.

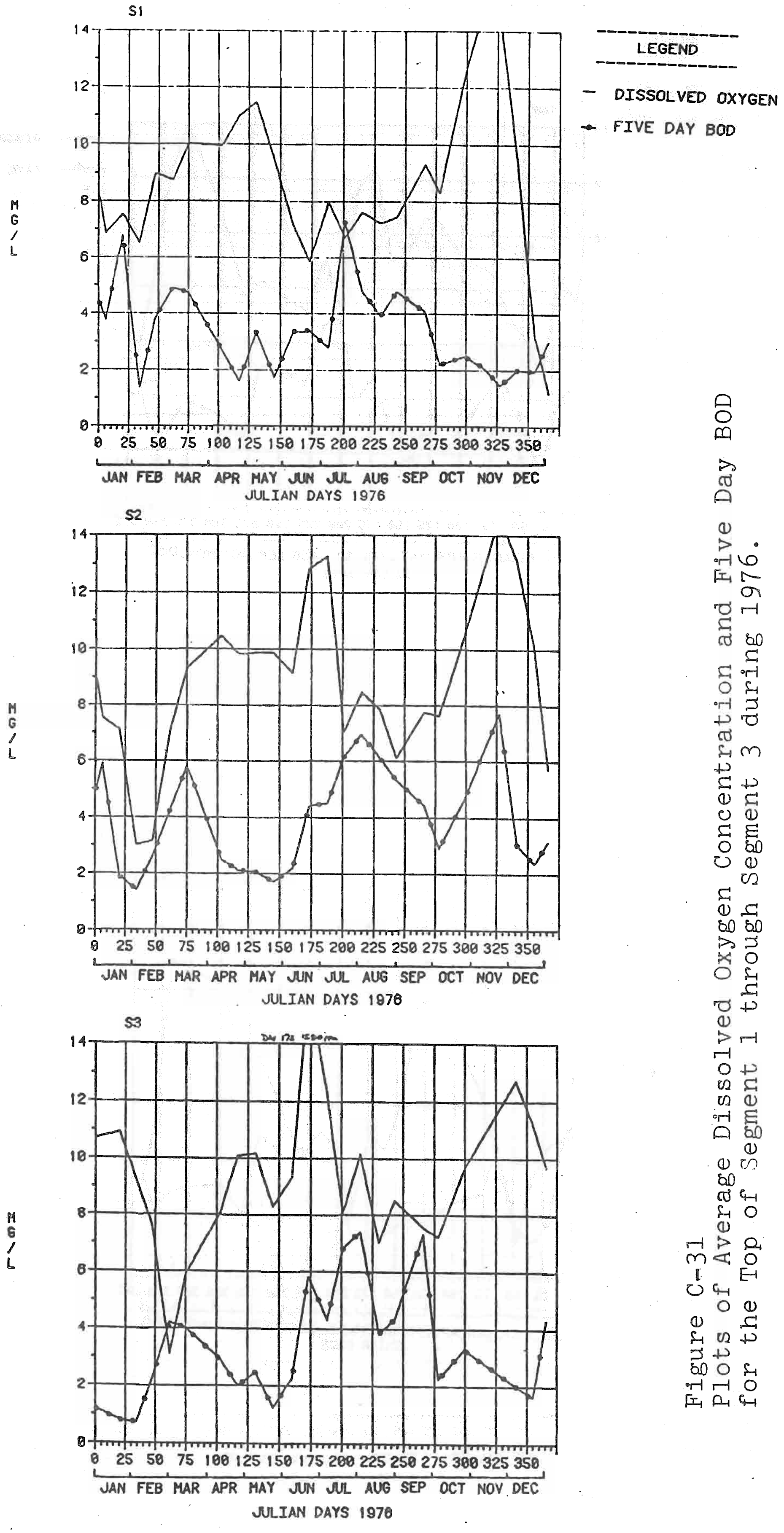


Figure C-31
Plots of Average Dissolved Oxygen Concentration and Five Day BOD for the Top of Segment 1 through Segment 3 during 1976.

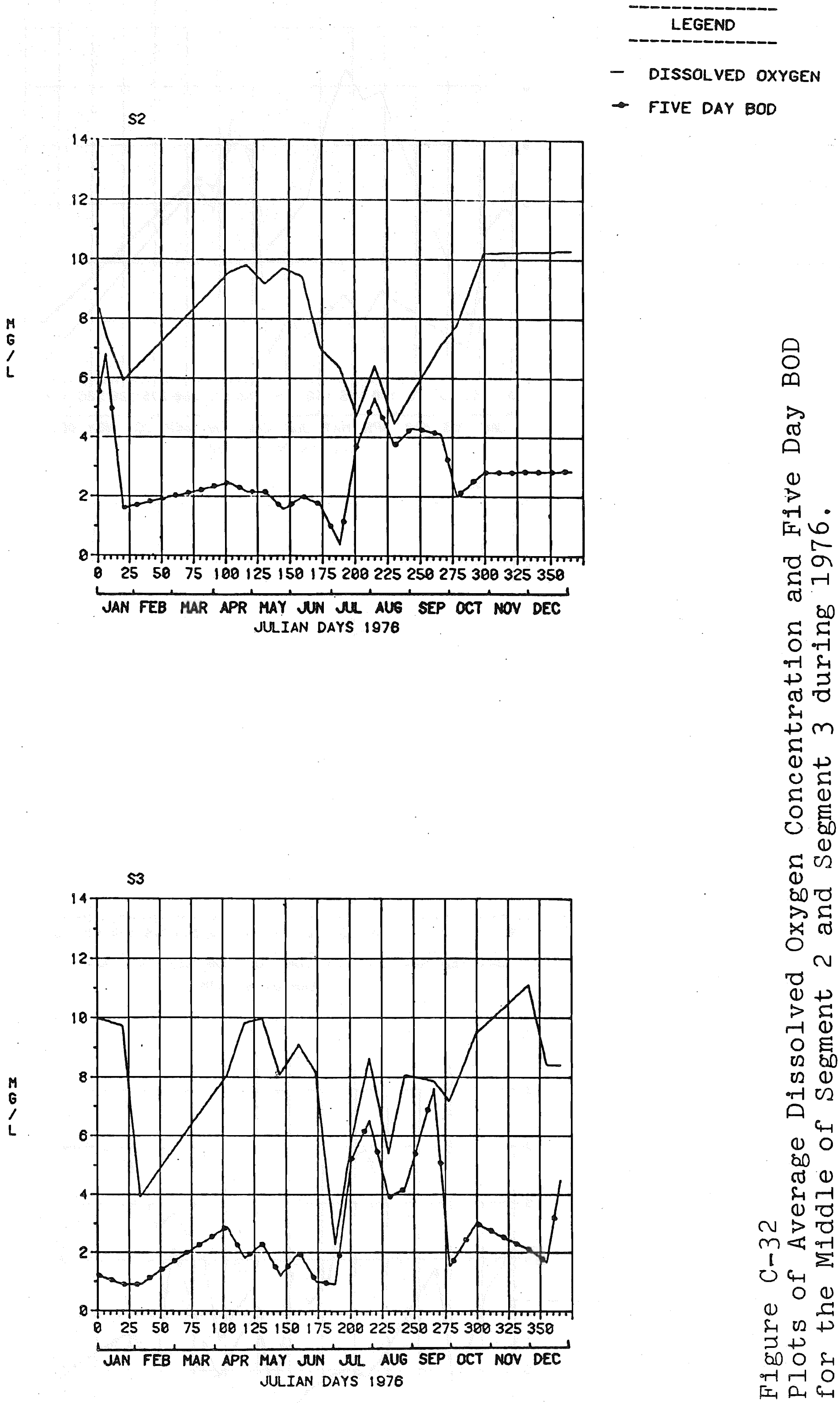


Figure C-32
Plots of Average Dissolved Oxygen Concentration and Five Day BOD
for the Middle of Segment 2 and Segment 3 during 1976.

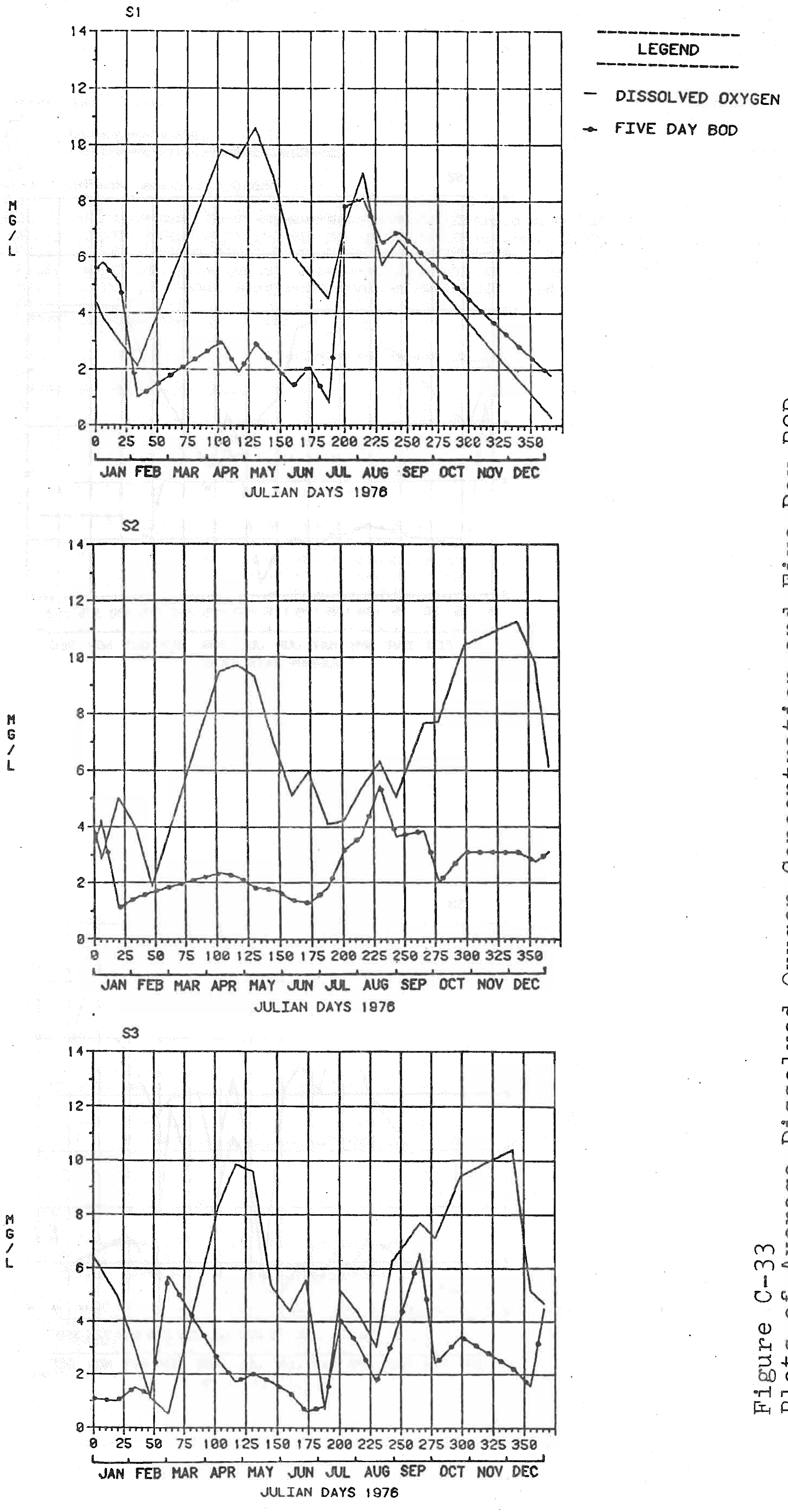


Figure C-33
Plots of Average Dissolved Oxygen Concentration and Five Day BOD for the Bottom of Segment 1 through Segment 3 during 1976.

APPENDIX D

Listing of the computer program called QUAL/LOADING

```
C**** DISK FILES
C*
FILE  5(KIND=REMOTE)
FILE  6(KIND=REMOTE,MAXRECSIZE=22)
C*
C**** INFLOW QUALITY FILES
C*
FILE  7(TITLE="QUAL/EP6",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
FILE  8(TITLE="QUAL/FE1",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
FILE  9(TITLE="QUAL/FR1",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
FILE  10(TITLE="QUAL/ASSOC",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
FILE  11(TITLE="QUAL/RAIN",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
C*
C**** OUTFLOW QUALITY FILES
C*
FILE  12(TITLE="QUAL/EP17",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
C*
C**** IN RESERVOIR QUALITY
C*
FILE  13(TITLE="QUAL/TOP",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
FILE  14(TITLE="QUAL/MID",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
FILE  15(TITLE="QUAL/BOT",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
C*
C**** OUTPUT OF DAILY OR PERIOD MASS
C*
FILE  20(TITLE="QL/DO",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
FILE  21(TITLE="QL/BOD",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
FILE  22(TITLE="QL/RP",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
FILE  23(TITLE="QL/TP",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
FILE  24(TITLE="QL/OP",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
FILE  25(TITLE="QL/NH4",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
FILE  26(TITLE="QL/NN",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
FILE  27(TITLE="QL/KN",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
FILE  28(TITLE="QL/ON",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
C*
C**** OUTPUT OF ACCUMLATIVE MASS PER DAY OR PERIOD
C*
FILE  30(TITLE="QUALITY/DO",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
FILE  31(TITLE="QUALITY/BOD",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
FILE  32(TITLE="QUALITY/RP",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
FILE  33(TITLE="QUALITY/TP",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
FILE  34(TITLE="QUALITY/OP",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
FILE  35(TITLE="QUALITY/NH4",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
FILE  36(TITLE="QUALITY/NN",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
FILE  37(TITLE="QUALITY/KN",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
FILE  38(TITLE="QUALITY/ON",KIND=PACK,MAXRECSIZE=14,BLOCKSIZE=420)
C*
C*     PROGRAM TO CALC. LOADING IN A RESERVOIR USING THE DIRECTLOAD
C*     ARRYS.
C*          FEB 78, FEB 80 JIM VENNIE
C*
C***********
C*
C**** MAINLINE
C*
C*** INTILIZE SOME VARIABLES
C*
      DIMENSION AMONTH(12),AMONTL(12),MTHLDY(12),MTHDAY(12)
      DATA AMONTL/31,60,91,121,152,182,213,244,274,305,335,366/
      DATA AMONTH/31,59,90,120,151,181,212,243,273,304,334,365/
      DATA MTHLDY/31,29,31,30,31,30,31,31,30,31,30,31/
      DATA MTHDAY/31,28,31,30,31,30,31,31,30,31,30,31/
      IEND=0
      IIFL=5
      IOFL=1
      IRFL=3
C*
C**** TERMINAL INPUT OF THE RUN OPTIONS.
C*
      CALL OPTION(IYR,IDAY,OPT,IOPDY)
C*
C**** MOVE THE POINTERS IN ALL INPUT FILES TO THE FIRST DAY.
C*
      CALL SETFLS(IYR,IDAY,IIFL,IOFL,IRFL)
C*
C**** SET UP THE LOOP OPTION FOR ACCUM. LOAD BY DAYS OR MONTHS.
C*
      INDAY=IDAY
      INYR=IYR
      ICKDAY=INDAY
```

```
      ICKYR=INYR
      ID=1
      LOOP=0
      IF(OPT.EQ.'DAYS')ICNT=IOPDY
5     IF(OPT.EQ.'DAYS')GO TO 10
      IF(MOD(ICKYR,4).NE.0)GO TO 20
      DO 22 I=1,12
      IF(ICKDAY.LT.AMONTL(I))GO TO 24
22    CONTINUE
29    PRINT//,'ERROR - NOT ABLE TO LOCATE THE NUMBER OF DAYS IN',
     -'THE MONTH',ICKYR,ICKDAY
      STOP
24    ICNT=MTHLDY(I)
      GO TO 10
20    DO 26 I=1,12
      IF(ICKDAY.LT.AMONTH(I))GO TO 28
26    CONTINUE
      GO TO 29
28    ICNT=MTHDAY(I)
10    CONTINUE
C*
C**** READ IN THE PERIOD'S CONC. AND FLOWS FROM THE IN AND OUTFLOW FILES
C*
      CALL INOUT(INYR,INDAY,IIFL,IOFL,IRFL,ICNT,IEND,ICKYR,ICKDAY,
     -IODAY,IOYR,ID)
      IF(IEND.GT.0)GO TO 30
C*
C**** READ THE RESERVOIR'S CONC. AND VOLUME AS FLOWS FROM THE FILES
C*
      CALL RES(INYR,INDAY,IIFL,IOFL,IRFL,ICNT,IEND,ICKYR,ICKDAY,
     -IODAY,IOYR,ID)
      IF(IEND.GT.0)GO TO 30
      ID=0
C*
C**** DO THE CALC.(ACCUMLATIVE MASSES)AND WRITE OUT THE FILE FOR PLOTS
C*
      LOOP=LOOP+1
      CALL CALC(ICKYR,ICKDAY,LOOP,ICNT)
      INDAY=ICKDAY
      INYR=ICKYR
      GO TO 5
C*
C**** CLOSE THE OUTPUT FILES
C*
30    CONTINUE
      DO 35 I=20,28
35    CLOSE(I,DISP=CRUNCH)
      DO 40 I=30,38
40    CLOSE(I,DISP=CRUNCH)
      STOP
      END
C*
C**** DEFINITIONS
C*
C*    IEND       = END OF FILE LABEL NULL=0, POSITIVE=1,2,3
C*    IIFL       = NUMBER OF INFLOW FILES
C*    IOFL       = NUMBER OF OUTFLOW FILES
C*    IRFL       = NUMBER OF RESERVOIR FILES
C*    OPTION     = SUBROUTINE FOR TERMINAL INPUT OF RUN OPTIONS
C*    IYR        = FIRST YEAR OF THE LOADING CALCULATIONS
C*    IDAY       = FIRST DAY OF THE LOADING CALCULATIONS
C*    SETFLS     = SUBROUTINE FOR MOVING POINTERS IN ALL INPUT FILES TO
C*                 IDAY AND IYR
C*    INDAY      = DAY CLOCK FOR CALCULATIONS
C*    INYR       = YEAR CLOCK FOR CALCULATIONS
C*    OPT        = A4 - LABEL FOR LOADING CALCULATIONS 'DAYS','MONTH'
C*    IOPDY      = NUMBER OF DAYS PER PERIOD
C*    ICNT       = THE NUMBER OF DAYS IN THE CURRENT PERIOD
C*    ICKYR      = CURRENT YEAR IN THE LOOP
C*    ICKDAY     = CURRENT DAY IN THE LOOP
C*    AMONTH     = END OF THE MONTH'S JULIAN DAY NUMBER REGULAR YEAR
C*    AMONTL     = END OF THE MONTH'S JULIAN DAY NUMBER LEAP YEAR
C*    MTHDAY     = THE NUMBER OF DAYS IN EACH MONTH REG. YEAR
C*    MTHLDY     = THE NUMBER OF DAYS IN EACH MONTH LEAP YEAR
C*    IODAY      = INTEGER NUMBER OF THE PRIOR DAY'S NUMBER
C*    IOYR       = INTEGER NUMBER OF THE PRIOR DAY'S YEAR NUMBER
C*    INOUT      = SUBROUTINE TO READ IN AND OUTFLOW CONC. AND FLOWS
C*    ID         = INDEX NUMBER '1' MEANS FIRST DAY OF THE CALCULATION
C*                               '0' MEANS ITS NOT THE FIRST DAY
C*    RES        = SUBROUTINE TO READ IN THE RESERVOIR'S CONC. AND VOL.
C*                 AS FLOW
```

```
C*     CALC        = SUBROUTINE TO DO CALCULATIONS AND WRITE OUT THE
C*                   ACCUMLATIVE MASS DATA FOR PLOTTING
C*     QL          = FILE LABEL WHICH MEANS IT CONTAINS DAILY TOTAL IN AND
C*                   OUTFLOW DAILY MASSES
C*     QUALITY     = FILE LABEL WHICH MEANS IT CONTAINS ACCUMLATIVE TOTAL
C*                   IN, OUFLOW, AND RESERVOIR DAILY MASSES
C*     LOOP        = THE RECORD NUMBER USED TO WRITE OUT THE QUALITY FILES
C*
C**********
C**********
C**********
C*
       SUBROUTINE OPTION (IYR,IDAY,OPT,IOPDY)
C*
C***   OBJECTIVE -- SET OPTIONS
C*
2      WRITE(6,1)
1      FORMAT(' ','ENTER THE STARTING YEAR AND DAY,(I2,I3).')
       READ(5,4)IYR,IDAY
4      FORMAT(I2,I3)
       IF((IYR.LT.70.OR.IYR.GT.85).OR.(IDAY.LT.1.OR.IDAY.GT.366))GO TO 2
7      WRITE(6,3)
3      FORMAT(' ','ENTER THE OPTION INTERVAL IN "DAYS" OR "MONTHS".--->')
       READ(5,6)OPT
6      FORMAT(A4)
       IF(OPT.EQ.'DAYS'.OR.OPT.EQ.'MONT')GO TO 8
       GO TO 7
8      IF(OPT.EQ.'MONT')GO TO 11
13     WRITE(6,9)
9      FORMAT(' ','ENTER THE NUMBER OF DAYS IN THE INTERVAL. (1-32)(I2).
      --->')
       READ(5,12)IOPDY
12     FORMAT(I2)
       IF(IOPDY.LT.1.OR.IOPDY.GT.32)GO TO 13
11     CONTINUE
       RETURN
       END
C*
C****  DEFINITIONS
C*
C*     IYR         = FIRST YEAR OF THE LOADING CALC. LIMITS 70-85
C*     IDAY        = FIRST DAY OF THE LOADING CALC. LIMITS 1-366
C*     OPT         = WORD "DAY " OR "MONTHS" FOR ACCUMLATION OF THE
C*                   LOADING OVER A PERIOD.
C*     IOPDY       = THE NUMBER OF DAYS IN THE INTERVAL IF OPT= DAYS
C*                   IS SPECIFIED.
C*
C**********
C**********
C**********
C*
       SUBROUTINE SETFLS(IYR,IDAY,IIFL,IOFL,IRFL)
C*
C****  OBJECTIVE -- TO READY THE INPUT FILES TO READ THE FIRST DAY.
C*
C*              AN ASSUMPTION WAS MADE THAT ALL INPUT FILES WOULD BE
C*         ORDERED WITH THE INFLOW FILES FIRST.  FOLLOWED BY OUTPUT
C*         AND IN RESERVOIR QUALITY STARTING WITH FILE NUMBER SEVEN.
C*
       ITFL=IIFL+IRFL+IOFL
       DO 1 J=7,ITFL+6
3      READ(J,2,END=10)NYR,NDAY
2      FORMAT(2I3)
       IF(NYR.GT.IYR)GO TO 10
       IF(NYR.EQ.IYR.AND.IDAY.EQ.NDAY)GO TO 13
       GO TO 3
13     BACKSPACE J
1      CONTINUE
       PRINT//,'FILES HAVE POINTERS AT FIRST DAY.'
       CLOSE 5
       RETURN
10     PRINT*//,'ERROR IN FILE.',J,IYR,IDAY,IIFL,IOFL,IRFL,ITFL,NYR,NDAY
       STOP
       END
C*
C****  DEFINITIONS
C*
C*     IYR         = FIRST YEAT OF THE LOADING CALC. LIMITS 70-85
C*     IDAY        = FIRST DAY OF THE LOADING CALC. LIMITS 1-366
C*     IIFL        = NUMBER OF INFLOW FILES
```

```
C*    IOFL       = NUMBER OF OUTFLOW FILES
C*    IRFL       = NUMBER OF RESERVOIR FILES
C*    ITFL       = NUMBER OF TOTAL INPUT FILES
C*    J          = INDEX FOR FILE NUMBERS
C*    NYR        = FILE YEAR FOR COMPARSION FROM INPUT FILE
C*    NDAY       = FILE DAY FOR COMPARSION FROM INPUT FILE
C*
C*********
C*********
C*********
C*
      SUBROUTINE INOUT(INYR,INDAY,IIFL,IOFL,IRFL,ICNT,IEND,ICKYR,
     -ICKDAY,IODAY,IOYR,ID)
C*
C**** OBJECTIVE -- READ AND WRITE INFLOW AND OUTFLOW CONC. AND FLOWS.
C*
      COMMON/BLK1/ TISUM(9),TOSUM(9),TOP(9,2),AMID(9,2),BOT(9,2),RMASS(3
     -,9)
      DIMENSION   HOLD(10),AMASS(6,9),OMASS(2,9)
C*
C**** ZERO AND INITIALIZE VARIABLES
C*
      DO 1 I=1,9
      DO 2 II=1,6
      IF(II.LT.3)OMASS(II,I)=0.0
2     AMASS(II,I)=0.0
      TISUM(I)=0.0
1     TOSUM(I)=0.0
      ICKDY=INDAY
      ICKYR=INYR
C*
C**** READ IN THE FILE DATA
C*
      DO 5 I=1,ICNT
      IODAY=ICKDAY
      IOYR=ICKYR
      IF(ID.EQ.1)GO TO 9
      IF(ICKDAY.EQ.366)ICKDAY=0
      IF(ICKDAY.EQ.365.AND.(MOD(ICKYR,4).NE.0))ICKDAY=0
      IF(ICKDAY.EQ.0)ICKYR=ICKYR+1
      ICKDAY=ICKDAY+1
C*
C**** INFLOWS
C*
9     DO 10 K=7,IIFL+6
      READ(K,3,END=39)NYR,NDAY,HOLD
3     FORMAT(2I3,2F5.2,3F7.3,2F5.2,F6.2,F5.2,F10.3)
      IF(NYR.NE.ICKYR.OR.NDAY.NE.ICKDAY)PRINT*//,'ERROR--INFLOW--',
     -'FILE NO.',K,IIFL,NDAY,ICKDAY,NYR,ICKYR
      HOLD(10)=HOLD(10)*0.3048**3.0
      DO 10 L=1,9
C*
C**** CONVERSION FACTOR SEC/LITERS/M3 gm/lb lb/ton
C*    0.095256=(86400/1000)*(2.205/2000)
C*
      AMASS(K-6,L)=AMASS(K-6,L)+(HOLD(L)*HOLD(10)*0.095256)
10    CONTINUE
      GO TO 15
39    IEND=1
      GO TO 41
C*
C**** OUTFLOWS
C*
15    DO 20 M=7+IIFL,IIFL+IOFL+6
      READ(M,3,END=42)JYR,JDAY,HOLD
      IF(JYR.NE.ICKYR.OR.JDAY.NE.ICKDAY)PRINT*//,'ERROR--OUTFLOW--FILE N
     -O.',M,IIFL,IOFL,JDAY,ICKDAY,JYR,ICKYR
      HOLD(10)=HOLD(10)*0.3048**3.0
      DO 20 N=1,9
      OMASS(M-6-IIFL,N)=OMASS(M-6-IIFL,N)+(HOLD(N)*HOLD(10)*0.095256)
20    CONTINUE
      IF(IEND.GT.0)GO TO 41
5     CONTINUE
      GO TO 25
42    IEND=IEND+1
      PRINT//,'ERROR UNMATCHED FILES LOOK AT THE LAST DATES OF THE INFLO
     -W OR OUTFLOW FILES.'
41    CONTINUE
      IF(I.EQ.1)RETURN
C*
```

```
C**** PRINT OUT THE INFLOW AND OUTFLOW MASSES FOR PLOTTING
C*
25    DO 22 I=1,9
      DO 23 K=1,IIFL
23    TISUM(I)=TISUM(I)+AMASS(K,I)
C*
C**** WRITING OUT THE QL FILES.
C*
      WRITE(I+19,24)ICKYR,ICKDAY,TISUM(I),(AMASS(J,I),J=1,IIFL),OMASS(1
     -,I)
24    FORMAT(2I3,7F10.4)
      DO 26 J=1,IOFL
26    TOSUM(I)=TOSUM(I)+OMASS(J,I)
22    CONTINUE
      RETURN
      END
C*
C**** DEFINITIONS
C*
C*    J           = INDEX COUNTER
C*    N           = INDEX COUNTER
C*    HOLD        = ARRAY HOLDING THE DAILY PARAMETERS OF QUALITY
C*                  AND QUANITY.
C*    INOUT       = SUBROUTINE TO READ IN THE INFLOW AND OUTFLOW
C*                  CONC. AND FLOWS AND CALC. MASSES.
C*    INYR        = YEAR CLOCK FOR CURRENT CALCULATION
C*    INDAY       = DAY CLOCK FOR CURRENT CALCULATION
C*    IIFL        = NUMBER OF INFLOW FILES
C*    IOFL        = NUMBER OF OUTFLOW FILES
C*    IRFL        = NUMBER OF RESERVOIR FILES
C*    ICNT        = THE NUMBER OF DAYS IN THE CURRENT PERIOD
C*    IEND        = END OF FILE LABEL NULL=0 POS.=1,2,3
C*    ICKYR       = CURRENT YEAR IN THE LOOP.
C*    ICKDAY      = CURRENT DAY IN THE LOOP.
C*    IODAY       = INTEGER NUMBER OF THE PRIOR DAY
C*    IOYR        = INTEGER NUMBER OF THE PRIOR YEAR
C*    ID          = INDEX NUMBER '1'=FIRST DAY '0'=NOT
C*    BLK1        = COMMON BLOCK NAME
C*    TISUM       = TOTAL INFLOW SUM (DAILY)
C*    TOSUM       = TOTAL OUTFLOW SUM (DAILY)
C*    TOP         = TOP RESERVOIR QUALITY MASSES
C*    AMID        = MIDDLE RESERVOIR QUALITY MASSES
C*    BOT         = BOTTOM RESERVOIR QUALITY MASSES
C*    JYR         = YEAR NUMBER FROM OUTFLOW FILE
C*    AMASS       = ARRAY OF INFLOW MASSES
C*    OMASS       = ARRAY OF OUTFLOW MASSES
C*    I           = INDEX COUNTER
C*    II          = INDEX COUNTER
C*    K           = INDEX COUNTER
C*    NYR         = YEAR NUMBER READ FROM AN INFLOW FILE
C*    NDAY        = DAY NUMBER READ FROM AN INFLOW FILE
C*    L           = INDEX COUNTER
C*    M           = INDEX COUNTER
C*    JDAY        = DAY NUMBER READ FROM AN OUTFLOW FILE
C*
C***********
C***********
C***********
C*
      SUBROUTINE RES(INYR,INDAY,IIFL,IOFL,IRFL,ICNT,IEND,ICKYR,
     -               ICKDAY,IODAY,IOYR,ID)
C*
C**** OBJECTIVE -- READ IN RESERVOIR QUALITY AND CALC. MASS.
C*
      COMMON/BLK1/ TISUM(9),TOSUM(9),TOP(9,2),AMID(9,2),BOT(9,2)
     -,RMASS(3,9)
      COMMON/BLK2/ TRSUM(9),TRLG(9),TIASUM(9),TOASUM(9),TRALG(9),
     -             XBTOP(9),XBMID(9),XBBOT(9)
      DIMENSION HOLD(10)
C*
C**** ZERO AND INITIALIZE VARIABLES
C*
      DO 1 I=1,9
      DO 2 II=1,3
2     RMASS(II,I)=0.0
      HOLD(I)=0.0
C*
C**** IF NOT THE FIRST DAY, THEN MOVE THE PRIOR DAY'S MASS TO COL. 1
C*
      IF(ID.EQ.0)TOP(I,1)=TOP(I,2)
```

```
      IF(ID.EQ.0)AMID(I,1)=AMID(I,2)
      IF(ID.EQ.0)BOT(I,1)=BOT(I,2)
1     CONTINUE
      IST=IIFL+IOFL+7
C*
C**** READ IN RESERVOIR FILE DATA
C*
      DO 5 I=1,ICNT
      DO 5 J=IST,IST+(IRFL-1)
      READ(J,111,END=33)IYR,IDAY,HOLD
111   FORMAT(1X,I2,I3,2F5.2,3F7.3,4F5.2,F10.3)
      IF((IYR.EQ.INYR.AND.IDAY.EQ.INDAY).AND.ID.EQ.1)GO TO 7
      IF((IYR.EQ.ICKYR.AND.IDAY.EQ.ICKDAY).AND.IEND.EQ.0)GO TO 9
      IF((IYR.EQ.IOYR.AND.IDAY.EQ.IODAY).AND.IEND.GT.0)GO TO 9
      PRINT*//,'CANNOT DETERMINE AN INDEX VALUE SUB. RES',IYR,INYR,ICKYR
     -,IOYR,IDAY,INDAY,ICKDAY,IODAY,ID,IEND
      GO TO 10
7     INDEX=1
      GO TO 11
9     INDEX=2
11    DO 15 K=1,9
      IF(J.EQ.IST)TOP(K,INDEX)=HOLD(K)*HOLD(10)*0.095256
      IF(J.EQ.IST+1.AND.IRFL.EQ.3)AMID(K,INDEX)=HOLD(K)*HOLD(10)*
     -0.095256
      IF(J.EQ.IST+2.OR.(J.EQ.IST+1.AND.IRFL.EQ.2))BOT(K,INDEX)=
     -HOLD(K)*HOLD(10)*0.095256
      RMASS(1,K)=RMASS(1,K)+TOP(K,INDEX)
      RMASS(2,K)=RMASS(2,K)+AMID(K,INDEX)
15    RMASS(3,K)=RMASS(3,K)+BOT(K,INDEX)
      IF(ID.EQ.1.AND.INDEX.EQ.2)GO TO 5
      IF(ID.EQ.1)INDEX=2
      IF(ID.EQ.1)GO TO 11
5     CONTINUE
      GO TO 50
33    PRINT*//,'HIT THE END OF THE RESERVOIR QUALITY FILE --',
     -INYR,INDAY,IYR,IDAY
10    IEND=IEND+1
50    CONTINUE
      RETURN
      END
C*
C**** DEFINITIONS
C*
C*    RES        = SUBROUTINE TO READ IN THE RESERVOIR MASSES
C*    INYR       = YEAR CLOCK FOR THE CALCULATION
C*    INDAY      = DAY CLOCK FOR THE CALCULATION
C*    IIFL       = NUMBER OF INFLOW FILES
C*    IOFL       = NUMBER OF OUTFLOW FILES
C*    IRFL       = NUMBER OF RESERVOIR FILES
C*    ICNT       = NUMBER OF DAYS IN THE CURRENT PERIOD
C*    IEND       = END OF FILE LABEL NULL=0 POS.=1,2,3
C*    ICKYR      = CURRENT YEAR IN THE LOOP
C*    ICKDAY     = CURRENT DAY IN THE LOOP
C*    IODAY      = INTERGER # OF THE PRIOR DAY'S #
C*    IOYR       = INTERGER # OF THE PRIOR YEAR'S #
C*    ID         = INDEX # '1'=FIRST DAY,'0'=NOT
C*    BLK1       = BLOCK COMMON NAME
C*    BLK2       = BLOCK COMMON NAME
C*    TISUM      = TOTAL INFLOW SUM (DAILY)
C*    TOSUM      = TOTAL OUTFLOW SUM (DAILY)
C*    TOP        = TOP RESERVOIR QUALITY MASSES
C*    AMID       = MIDDLE RESERVOIR QUALITY MASSES
C*    BOT        = BOTTOM RESERVOIR QUALITY MASSES
C*    TRSUM      = TOTAL RESERVOIR MASSES
C*    TRLG       = TOTAL RESERVOIR LOSS OF GAIN OF MASS PER PERIOD
C*    TIASUM     = TOTAL INFLOW ACCUMLATIVE SUM OF MASS
C*    TOASUM     = TOTAL OUTFLOW ACCUMLATIVE SUM OF MASS
C*    TRALG      = TOTAL RESIDUAL ACCUMLATIVE LOSS OF GAIN OF MASS
C*    XBTOP      = MEAN MASS IN THE TOP LEVEL OF THE RESERVOIR
C*    XBMID      = MEAN MASS IN THE MIDDLE LEVEL OF THE RESERVOIR
C*    XBBOT      = MEAN MASS IN THE BOTTOM LEVEL OF THE RESERVOIR
C*    HOLD       = ARRAY THAT HOLDS THE DAILY QUALITY AND FLOWS
C*    RMASS      = ARRAY OF ACCUMLATIVE DAILY RESERVOIR MASS FOR THE
C*                 MEAN RESERVOIR LOAD CALCULATION
C*    I          = INDEX COUNTER
C*    II         = INDEX COUNTER
C*    IST        = FIRST RESERVOIR FILE NUMBER
C*    IYR        = YEAR DATE READ IN FROM THE RES. FILE
C*    IDAY       = DAY DATE READ IN FROM THE RES. FILE
C*    J          = INDEX COUNTER
```

```
C*    INDEX       = "1"MEANS PRIOR DAY, "2"MEANS CURRENT DAY'S LOAD
C*                  FOR THE DELTA MASS CALCULATION
C*    NP          = 1=TOP 2=MID 3=BOT
C*
C**********
C**********
C**********
C*
      SUBROUTINE CALC(ICKYR,ICKDAY,LOOP,ICNT)
C*
C**** OBJECTIVE -- CALC. THE MASS BUDGET AND PRINT OUT THE PARAMETERS.
C*
      COMMON/BLK1/ TISUM(9),TOSUM(9),TOP(9,2),AMID(9,2),BOT(9,20),
     -RMASS(3,9)
      COMMON/BLK2/ TRSUM(9),TRLG(9),TIASUM(9),TOASUM(9),TRALG(9),
     -             XBTOP(9),XBMID(9),XBBOT(9)
      DIMENSION DMTOP(9),DMMID(9),DMBOT(9),DMRES(9)
C*
C**** ZERO AND INITIALIZE VARIABLES
C*
      DO 1 I=1,9
      TRSUM(I)=0.0
      TRLG(I)=0.0
      XBTOP(I)=0.0
      XBMID(I)=0.0
      XBBOT(I)=0.0
      DMTOP(I)=0.0
      DMMID(I)=0.0
      DMBOT(I)=0.0
      DMRES(I)=0.0
      TRLG(I)=0.0
1     CONTINUE
      CNT=ICNT
C*
C**** FIND MEAN MASS, CHANGE IN MASS, AND SUM UP MASS IN THE RES.
C*
      DO 2 I=1,9
      XBTOP(I)=(TOP(I,1)+TOP(I,2))/2.0
      XBMID(I)=(AMID(I,1)+AMID(I,2))/2.0
      XBBOT(I)=(BOT(I,1)+BOT(I,2))/2.0
      TRSUM(I)=XBTOP(I)+XBMID(I)+XBBOT(I)
      DMTOP(I)=TOP(I,2)-TOP(I,1)
      DMMID(I)=AMID(I,2)-AMID(I,1)
      DMBOT(I)=BOT(I,2)-BOT(I,1)
      DMTOP(I)=RMASS(1,I)/CNT
      DMMID(I)=RMASS(2,I)/CNT
      DMBOT(I)=RMASS(3,I)/CNT
      DMRES(I)=DMTOP(I)+DMMID(I)+DMBOT(I)
      TIASUM(I)=TIASUM(I)+TISUM(I)
      TOASUM(I)=TOASUM(I)+TOSUM(I)
      TRLG(I)=TOSUM(I)-TISUM(I)+DMRES(I)
      TRALG(I)=TRALG(I)+TRLG(9)
2     CONTINUE
C*
C**** WRITE OUT THE DATA FOR PLOTING
C*
      DO 3 I=1,9
      IFL=29+I
      WRITE(IFL=LOOP,10)ICKYR,ICKDAY,TISUM(I),TOSUM(I),TRSUM(I),TRLG(I),
     -                  TIASUM(I),TOASUM(I),TRALG(I),XBTOP(I),XBMID(I),
     -                  XBBOT(I)
10    FORMAT(2I3,2F7.2,F8.1,F7.2,3F8.1,3F7.2)
3     CONTINUE
      RETURN
      END
C*
C**** DEFINITIONS
C*
C*    AMID        = ARRAY OF THE BEGINNING AND ENDING MASSES OF THE RES.
C*                  PER PERIOD
C*    BOT         = ARRAY OF THE BEGINNING AND ENDING BOTTOM MASSES OF
C*                  RESERVOIR PER PERIOD
C*    BLK1        = COMMON BLOCK ONE
C*    BLK2        = COMMON BLOCK TWO
C*    CALC        = SUBROUTINE THAT CALCULATES THE MASS BUDGET
C*    CNT         = REAL NUMBER FOR THE # OF DAYS IN THE PERIOD
C*    DMBOT       = MEAN MASS IN THE RESERVOIR BOTTOM DURING THE PERIOD
C*    DMMID       = MEAN MASS IN THE RESERVOIR MIDDLE DURING THE PERIOD
C*    DMRES       = MEAN MASS IN THE RESERVOIR TOTAL DURING THE PERIOD
```

```
56000 C*    DMTOP      = MEAN MASS IN THE RESERVOIR TOP DURING THE PERIOD
56100 C*    I          = INDEX COUNTER
56200 C*    ICKDAY     = CURRENT DAY IN THE LOOP
56300 C*    ICKYR      = CURRENT YEAR IN THE LOOP
56400 C*    ICNT       = NUMBER OF DAYS IN THE CURRENT PERIOD
56500 C*    IFL        = FILE NUMBER OF THE OUTPUT FILE, VARIABLE DEPENDENT
56600 C*                 ON THE NUMBER OF PARAMETERS
56700 C*    LOOP       = RECORD # USED TO WRITE OUT THE QUALITY FILES
56800 C*    RMASS      = ARRAY OF ACCUMLATIVE RESERVOIR MASS FOR MEAN
56900 C*                 RESERVOIR LOAD CALCULATION
57000 C*    TIASUM     = TOTAL INFLOW ACCUMLATIVE SUM OF MASS
57100 C*    TISUM      = TOTAL INFLOW SUM OF MASS PER THE CURRENT PERIOD
57200 C*    TOASUM     = TOTAL OUTFLOW ACCUMLATIVE SUM OF MASS
57300 C*    TOP        = ARRAY OF BEGINNING AND ENDING MASSES OF THE TOP
57400 C*                 PER PERIOD
57500 C*    TOSUM      = TOTAL OUTFLOW SUM OF MASS PER CURRENT PERIOD
57600 C*    TRALG      = TOTAL RESERVOIR ACCUMLATIVE LOSS OR GAIN NET
57700 C*                 RESIDUAL MASSES
57800 C*    TRLG       = TOTAL RESERVOIR CURRENT PERIOD LOSS OR GAIN NET
57900 C*                 RESIDUAL MASSES
58000 C*    TRSUM      = TOTAL RESERVOIR CURRENT PERIOD MASS
58100 C*    XBBOT      = MEAN BOTTOM RESERVOIR MASS DURING CURRENT PERIOD
58200 C*    XBMID      = MEAN MIDDLE RESERVOIR MASS DURING CURRENT PERIOD
58300 C*    XBTOP      = MEAN TOP RESERVOIR MASS DURING CURRENT PERIOD
58400 C*
58500 C*********
58600 C*********
58700 C*********
#
```

APPENDIX E

Listing of the computer program called TROPHIC

```
TROPHIC
 C
 C************************************************************
 C
 C
 C     THE FOLLOWING INFORMATION IS NEEDED AS INPUT:
 C
 C       1. TIME PERIOD (DAYS) MAX. 1095 DAYS
 C       2. LAKE VOLUME
 C       3. OUTFLOW RATE
 C       4. LAKE SURFACE AREA
 C       5. TOTAL PHOSPHORUS LOAD
 C       6. RETENTION COEFFICIENT (INPUT OR ONE IS PROVIDED)
 C       7. INITIAL PHOSPHORUS CONCENTRATION INLAKE
 C
 C************************************************************
 C
 C     THE FOLLOWING INFORMATION WILL BE CALCULATED:
 C
 C       1. MEAN DEPTH
 C       2. AREAL WATER LOADING
 C       3. FLUSHING RATE
 C       4. HYDRAULIC RESIDENCE TIME
 C       5. PHOSPHORUS AREAL LOADING
 C       6. PHOSPHORUS VOLUMETRIC LOADING
 C       7. PHOSPHORUS RETENTION COEFFICIENT
 C       8. PHOSPHORUS EQUILIBRIUM FACTOR
 C       9. HALF-LIFE OF THE CHANGE IN CONCENTRATION
 C      10. PREDICTED PHOSPHORUS STEADY STATE CONCENTRATION,
 C           BASED ON P. J. DILLON AND F. H. RIGLER,1974.
 C      10A. MEAN OPTIMAL PHOTOSYNTHESIS (LIGHT SATURATED)
 C      10B. GROWING SEASON MEAN VOLUMETRIC RATES OF
 C            PHOTOSYNTHESIS BASED ON SMITH, V.H., 1979.
 C      11. PREDICTED PHOSPHORUS STEADY STATE CONCENTRATION,
 C           BASED ON VOLLENWEIDER, 1975.
 C      12. PREDICTED PHOSPHORUS STEADY STATE CONCENTRATION,
 C           BASED ON VOLLENWEIDER, 1976.
 C      13. PREDICTED PHOSPHORUS STEADY STATE CONCENTRATION,
 C           BASED ON BACHMAN AND CANFIELD, 1979
 C           FOR: NATURAL IOWA LAKES
 C                ARTIFICIAL IOWA LAKES
 C      14. PREDICTED PHOSPHORUS STEADY STATE CONCENTRATION,
 C           BASED ON RECKHOW ET. AL., 1980.
 C      15. CALCULATE CORRESPONDING CHLOROPHYLL-A CONCENTRATION
 C           AND SECCHI DISC DEPTH.
 C      16. PREDICTED PHOSPHORUS CONCENTRATION, CHLOROPHYLL-A
 C           CONCENTRATION AND SECCHI DISC DEPTH AFTER ANY
 C           NUMBER OF YEARS.
 C      17. BACK CALCULATE WITH METHODS 1-3.
 C
 C************************************************************
 C
 C     FORMULAE USED:
 C
 C       1. ZM = V/A
 C       2. QS = Q/A
 C       3. F = Q/V
 C       4. RW = V/Q
 C       5. PA = J/A
 C       6. PV = J/V
 C       7. KIRCHNER AND DILLON, 1975
 C          R = .426*EXP(-.271QS)+.574*EXP(-.00949QS)
 C       8. PEF = (1-R)/F
 C       9. HL = LOGE(2)*((1-R)/F)
 C      10. DILLON AND RIGLER, 1974B
 C          PST=(J/A)*(1-R)/(ZM*F)
 C          SMITH,V.H.,1979
 C      10A. MOP=(19.2(J/A)*(1-R)/(ZM*F))-77.
 C      10B. MVP=(10.1(J/A)*(1-R)/ZM*F)-79.
 C      11. VOLLENWEIDER, 1975
 C          PST = (J/A)/(10.+(ZM*F))
 C      12. VOLLENWEIDER, 1976
 C          PST = (J/A)*F)/(ZM*F*(SQRT(F)+F))
 C      13. BACHMAN AND CANFIELD,1979 - IOWA LAKES
 C          NATURAL LAKES  PST=PA/ZM(.162((PA/ZM)**.458)+F)
 C          ARTIFICAL LAKES PST=PA/ZM(.114((PA/ZM)**.589)+F)
 C      13. DILLON AND RIGLER,1974A
 C          LOG10(CH-A) = 1.45*LOG10(P)-1.14   MG/M**3
 C      14. REGRESSED-'LAKE STANDARDS TASK FORCE' DICK LATHROP
 C          SECCHI(METER)=5.19((CHLA)**-.468)
 C
```

```
C************************************************************
C
C
C     GET INPUT
C
C
C************************************************************
C
      INTEGER UNIT
      REAL MOP,MVF
      WRITE(6,10)
10    FORMAT(1H0,'  THIS PROGRAM ESTIMATES LAKE TROPHIC STATUS')
20    WRITE(6,30)
30    FORMAT(1H0,'   TYPE IN A 0 FOR METRIC UNITS (DAYS,M3,M3/S,HA, AND'
     -,' KG)',/,
     -14X,'1 FOR MIXED ENGLISH AND METRIC (DAYS,AC.FT.,CFS,ACRES, ',
     -    'AND KG)',/,
     -14X,'2 FOR ENGLISH (DAYS,AC.FT.,CFS,ACRES, AND LB.)')
      READ(5,40) UNIT
40    FORMAT()
      IF (UNIT.LT.0.OR.UNIT.GT.2)GO TO 20
      IJUMP=0
      IOPT=0
50    WRITE(6,60)
60    FORMAT(1H0,'   TYPE IN THE NUMBER DAYS IN THE LOADING PERIOD',/
     -,'             (365 FOR A YEAR)')
      READ(5,70)DAYS
70    FORMAT()
      IF(DAYS.LT.1.0.OR.DAYS.GT.1095)GO TO 50
      IF(UNIT.LT..001) GO TO 80
90    WRITE(6,100)
100   FORMAT(1H0,'   TYPE LAKE VOLUME IN ACRE FEET')
      READ(5,110) AVOLUM
110   FORMAT( )
      AVOLMM=AVOLUM*(0.3048**3.)*43560.
      IF(AVOLUM.LT.0.) GO TO 90
      IF(IJUMP.GT.0)GO TO 120
130   WRITE(6,140)
140   FORMAT(1H0,'   TYPE OUTFLOW IN CFS')
      READ(5,150) AFLOW
150   FORMAT( )
      AFLOWM=AFLOW*(0.3048**3)
      IF(AFLOW.LT.0.) GO TO 130
      IF(IJUMP.GT.0)GO TO 160
170   WRITE(6,180)
180   FORMAT(1H0,'   TYPE LAKE SURFACE AREA IN ACRES')
      READ(5,190) AREA
190   FORMAT( )
      AREAM=AREA*.4047
      IF(AREA.LT.0.) GO TO 170
      IF(IJUMP.GT.0)GO TO 160
      GO TO 200
80    WRITE(6,210)
210   FORMAT(1H0,'   TYPE IN LAKE VOLUME IN CUBIC METERS')
      READ(5,110)AVOLMM
      AVOLUM=AVOLMM/((0.3048**3.)*43560.)
      IF(AVOLUM.LT.0.)GO TO 80
      IF(IJUMP.GT.0)GO TO 120
220   WRITE(6,230)
230   FORMAT(1H0,'   TYPE IN OUTFLOW IN CUBIC METERS PER SECOND')
      READ(5,150)AFLOWM
      IF(AFLOW.LT.0.)GO TO 220
      AFLOW=AFLOWM/(0.3048**3)
      IF(IJUMP.GT.0)GO TO 160
240   WRITE(6,250)
250   FORMAT(1H0,'   TYPE IN LAKE SURFACE AREA IN HECTARES')
      READ(5,190)AREAM
      IF(AREA.LT.0.)GO TO 240
      AREA=AREAM/.4047
      IF(IJUMP.GT.0)GO TO 160
200   IF (UNIT.LT.2)GO TO 260
      WRITE(6,270)
270   FORMAT(1H0,'TYPE IN THE PHOSPHORUS LOAD IN LBS/PERIOD')
      READ(5,280)APHOLE
280   FORMAT()
      APHOLO=APHOLE*0.4535
      IF(APHOLO.LT.0)GO TO 200
      GO TO 160
```

```
260   WRITE(6,290)
290   FORMAT(1H0,'TYPE IN THE PHOSPHORUS LOAD IN KG/PERIOD')
      READ(5,300) APHOLO
300   FORMAT( )
      APHOLE=APHOLO*2.205
      IF(APHOLO.LT.0.) GO TO 260
      IF(IJUMP.GT.0)GO TO 120
160   WRITE(6,310)
310   FORMAT(1H0,'   TYPE PHOSPHORUS RETENTION COEFFICIENT',
     -/,'    IF YOU TYPED 0, A REGRESSED ONE WILL BE PROVIDED')
      READ(5,320) RETCOE
320   FORMAT( )
      AWLOAD =(220.665124*AFLOW/AREA)*DAYS/365.
      IF(RETCOE.GT..000001) GO TO 330
C
C*************************************************************
C
C     CALCULATE THE RETENTION COEFFICIENT
C
C*************************************************************
C
      A = AWLOAD
C      SOURCE: KIRCHNER AND DILLON,1975
      RETCOE = .426*EXP(-.271*A)+.574*EXP(-.00949*A)
330   IF(RETCOE.GT.1.0) RETCOE=1.0
      IF(RETCOE.LT.0.) RETCOE=.0
C
C*************************************************************
C
C     CALCULATE PHOSPHORUS STEADY STATE CONCENTRATION
C     AND THE RELATED OUTPUT
C
C*************************************************************
C
120   ZM=(AVOLUM/AREA)*.3048
      FLUSH =(723.9669421*AFLOW/AVOLUM)*DAYS/365.
      RETIME = 1./FLUSH
      PALOAD = .2471*APHOLO/AREA
      PVLOAD = 810.7132*APHOLO/AVOLUM
      EQUFAC = (1.-RETCOE)*RETIME
      HALFLI = LOG(2.)*EQUFAC
C
C*************************************************************
C
C     CALCULATE TOTAL PHOSPHORUS STEADY STATE CONCENTRATION
C     BY ONE OF THREE METHODS.
C
C*************************************************************
C
      REDO = 0.0
      IF(IOPT.EQ.5)GO TO 340
350   WRITE(6,360)
360   FORMAT(1H0,'   TYPE IN A NUMBER              ',/,
     -             5X, '1  DILLON AND RIGLER, 1974B',/,
     -             5X, '2  VOLLENWEIDER, 1975',/,
     -             5X, '3  VOLLENWEIDER, 1976',/,
     -             5X, '4  ALL THE METHODS ABOVE.',/,
     -             5X, '   BACHMAN AND CANFIELD, 1979',/,
     -             5X, '5     NATURAL LAKES',/,
     -             5X, '6     ARTIFICIAL LAKES',/,
     -             5X, '7  RECKHOW AND ET.AL., 1980',/,
     -             5X, '8  ALL THE METHODS ABOVE.')
      READ(5,370)ID
370   FORMAT(I1)
      IF(ID.LT.1.OR.ID.GT.8)GO TO 350
      LS=0
      LSS=0
      GO TO(340,380,390,440,410,420,430,440),ID
C
C     DILLON AND RIGLER, 1974B
C
340   ID=1
      PHOSTE = PALOAD*1000.*EQUFAC/ZM
C      SOURCE: UTTORMARK AND HUTCHINS, 1978
      ACCLD = (.01*ZM*FLUSH)/(1.-RETCOE)
      EXCLD = (.02*ZM*FLUSH)/(1.-RETCOE)
C       SOURCE:SMITH, V. H., 1979
      MOP=((19.2*PALOAD*1000.*EQUFAC)/ZM)-77.
      MVP=((10.1*PALOAD*1000.*EQUFAC)/ZM)-79.
      GO TO 450
```

```
C
C    VOLLENWEIDER, 1975
C
380    PHOSTE = PALOAD*1000./(10.+(ZM*FLUSH))
C      SOURCE: UTTORMARK AND HUTCHINS, 1978
       ACCLD = .01*(10.+(ZM*FLUSH))
       EXCLD = .02*(10.+(ZM*FLUSH))
       GO TO 450
C
C    VOLLENWEIDER, 1976
C
390    PHOSTE=(PALOAD*1000.*FLUSH)/(ZM*FLUSH*(SQRT(FLUSH)+FLUSH))
C      SOURCE: UTTORMARK AND HUTCHINS, 1978
       ASSSI = .01*(1.+(1./SQRT(FLUSH)))
       EXCCI = .02*(1.+(1./SQRT(FLUSH)))
       ACCLD=ASSSI*ZM*FLUSH
       EXCLD=EXCCI*ZM*FLUSH
       TPIC=PALOAD/(ZM*FLUSH)
       GO TO 450
C
C    BACHMAN AND CANFIELD, 1979 - NATURAL LAKES
C
410    SED=0.162*(((PALOAD/1000.)/ZM)**0.458)
       GO TO 460
C
C    BACHMAN AND CANFIELD, 1979 - ARTIFICAL LAKES
C
420    SED=0.114*(((PALOAD/1000.)/ZM)**0.589)
460    PHOSTE=(PALOAD*1000.)/(ZM*(SED+FLUSH))
       GO TO 450
C
C    RECKHOW AND ET.AL., 1980
C
430    PHOSTE=(PALOAD*1000.)/(11.6+(1.2*AWLOAD))
C
C    SOURCE: DILLON AND RIGLER, 1974 FROM SAKOMOTO,1966
C
450    CHLORA = 10.**(1.45*LOG10(PHOSTE)-1.14)
C
C    SOURCE: 'LAKE STANDARDS TASK FORCE' - DICK LATHROP
C
       SECCHI = 5.19*((CHLORA)**-.468)
C
       IF(REDO.GT.0.0001)GO TO 470
       IF(IOPT.EQ.5)GO TO 480
C***********************************************************
C
C      PRINT OUT STEADY STATE CONCENTRATIONS
C
C***********************************************************
C
       WRITE(6,490)ZM
490    FORMAT(1H0,'    MEAN DEPTH (METERS)',T50,F20.2)
       WRITE(6,500) AWLOAD
500    FORMAT(1H0,'    AREAL WATER LOADING (METER/PERIOD)',T50,F20.2)
       WRITE(6,510) FLUSH
510    FORMAT(1H0,'    FLUSHING RATE (PARTS OF LAKE/PERIOD)',T50,F20.3)
       WRITE(6,520) RETIME
520    FORMAT(1H0,'    HYDRAULIC RESIDENCE TIME (PERIOD)',T50,F20.3)
       WRITE(6,530) PALOAD
530    FORMAT(1H0,'    PHOSPHORUS AREAL LOAD (GM/SQ.M/PERIOD)',T50,F20.4)
       WRITE(6,540) PVLOAD
540    FORMAT(1H0,'    PHOSPHORUS VOLUMETRIC LOAD (MG/CU.M/PERIOD)',
     -T50,F20.2)
       WRITE(6,550) RETCOE
550    FORMAT(1H0,'    PHOSPHORUS RETENTION COEFFICIENT',T50,F20.3)
       WRITE(6,560) EQUFAC
560    FORMAT(1H0,'    PHOSPHORUS EQULIBRIUM FACTOR (PERIOD)',T50,F20.4)
       WRITE(6,570) HALFLI
570    FORMAT(1H0,'    HALF-LIFE OF THE CHANGE IN CONCENTRATION ',
     -'(PERIOD)',T60,F10.2)
480    REDO = 1.0
470    CONTINUE
       IOPT=0
       GO TO(580,590,600,440,610,620,630,440),ID
580    WRITE(6,640)
640    FORMAT(1H0,'    ***',/,'    BASED ON DILLON AND RIGLER, 1974B',/,
     -'    ***')
       GO TO 650
```

```
 590   WRITE(6,660)
 660   FORMAT(1HO,'    ***',/,'    BASED ON VOLLENWEIDER,1975',/,'    ***')
       GO TO 650
 600   WRITE(6,670)TPIC
 670   FORMAT(1HO,'    ***',/,'    VOLLENWEIDER, 1976 FIGURE 3',/,'    ***',
      -//,'   INFLOW TOTAL PHOSPHORUS CONCENTRATION (GM/M3)',T60,F10.3)
       WRITE(6,680)ASSSI,EXCCI
 680   FORMAT(1HO,'   ACCEPTABLE INFLOW TOTAL PHOSPHORUS CONCENTRATION',
      -' (GM/M3)',T61,F9.3,//,'    EXCESSIVE INFLOW TOTAL PHOSPHORUS',
      -' CONCENTRATION (GM/M3)',T61,F9.3)
 650   WRITE(6,690)PALOAD
 690   FORMAT(1HO,'   CURRENT TOTAL AREAL PHOSPHORUS LOAD (GM/M2/PERIOD)'
      -,T57,F13.4)
       WRITE(6,700)ACCLD,EXCLD
 700   FORMAT(1HO,'   ACCEPTABLE TOTAL AREAL PHOSPHORUS LOADING (GM/M2/P'
      -,'ERIOD)',T60,F10.4,//,'    EXCESSIVE TOTAL PHOSPHORUS AREAL LOAD'
      -,'ING (GM/M2/PERIOD)',T60,F10.4)
       GO TO 710
 610   WRITE(6,720)
 720   FORMAT(1HO,'    ***',/,'    BASED ON BACHMAN AND CANFIELD,1979 -',
      -' FOR NATURAL LAKES',/,'    ***')
       GO TO 710
 620   WRITE(6,730)
 730   FORMAT(1HO,'    ***',/,'    BASED ON BACHMAN AND CANFIELD,1979 -',
      -' FOR ARTIFICIAL LAKES',/,'    ***')
       GO TO 710
 630   WRITE(6,740)
 740   FORMAT(1HO,'    ***',/,'    BASED ON RECKHOW, ET. AL., 1980',
      -/,'    ***')
 710   WRITE(6,750) PHOSTE
 750   FORMAT(1HO,'   PHOSPHORUS STEADY STATE CONCENTRATION (MG/CU.M)',
      -T60,F10.5)
       WRITE(6,760) CHLORA
 760   FORMAT(1HO,'   CHLOROPHYLL-A CONCENTRATION (MG/CU.M)',T50,F20.3)
       WRITE(6,770) SECCHI
 770   FORMAT(1HO,'   SECCHI DISC DEPTH (METERS)',T50,F20.3)
       IF(ID.GT.1)GO TO 440
       WRITE(6,780)MOP
 780   FORMAT(1HO,'   MEAN OPTIMAL PHOTOSYNTHESIS, LIGHT SATURATED',
      -/,'    (MG CARBON/CU.M/DAY)',T50,F20.4)
       WRITE(6,790)MVP
 790   FORMAT(1HO,'   GROWING SEASON MEAN VOLUMETRIC RATES OF',/,
      -'    PHOTOSYNTHESIS (MG CARBON/CU.M/DAY)',
      -T50,F20.4)
 440   IF(ID.EQ.4.OR.ID.EQ.8)GO TO 400
       IF(LSS.GT.0)GO TO 400
       GO TO 800
 400   IF(ID.EQ.4.OR.ID.EQ.8)LSS=ID
       LS=LS+1
       IF(LS.GT.3.AND.LSS.EQ.4)GO TO 810
       IF(LS.GT.3.AND.LSS.EQ.8)GO TO 820
       ID=LS
       GO TO (340,380,390),LS
 820   IF(LS.EQ.4)LS=5
       IF(LS.GT.7)GO TO 810
       ID=LS
       GO TO (810,810,810,810,410,420,430),LS
 810   LSS=0
       LS=0
       ID=3
 800   WRITE(6,830)
 830   FORMAT(1HO,'   ENTER A NUMBER 1-12',/,
      -'    CHANGE  VOLUME  OUTFLOW  AREA  LOAD  P-RETENTION,'/
      -'    NUMBER     1        2       3     4          5     ,'/
      -5X,'6 - RETURN THE CHANGED VALUE BACK',/
      -5X,'7 - RECALCULATE A STEADY STATE P BY A DIFFERENT',
      -' METHOD',/
      -5X,'8 - START OVER',/
      -5X,'9 - QUIT',/
      -5X,'10 - PREDICT THE RECOVERY OF THE LAKE',/
      -5X,'11 - BACK CALCULATE THE PHOSPHORUS LOADING.',/,
      -5X,'12 - LIST STORED INPUT VARIABLES.')
 840   READ(5,850)IOPT
 850   FORMAT( )
       IF(IOPT.GT.12.OR.IOPT.LT.1)GO TO 800
       IJUMP=1
       IF(IOPT.GT.5)GO TO 860
       HVOLM=AVOLMM
       HFLOWM=AFLOWM
```

```
      HAREAM=AREAM
      HPHOLO=APHOLO
      HVOLUM=AVOLUM
      HFLOW=AFLOW
      HAREA=AREA
      HPHOLE=APHOLE
      HRETCO=RETCOE
      IF(UNIT.EQ.0)GO TO 870
860   GO TO (90,130,170,200,160,880,350,20,890,900,910,920),IOPT
870   GO TO (80,220,240,200,160,880,350,20,890,900,910,920),IOPT
C
C*******************************************************************
C
C     LIST STORED VARIABLES
C
C*******************************************************************
C
920   WRITE(6,930)AVOLMM,AFLOWM,AREAM,APHOLD,RETCOE,AVOLUM,AFLOW,
     -AREA,APHOLE,RETCOE
930   FORMAT(1HO,T13,'VOLUME',T25,'OUTFLOW',T38,'AREA',T48,'P-LOAD',
     -T56,'P-RETENTION',/,' METRIC',T9,F12.0,2F12.2,F12.1,F10.3,/,
     -' ENGLISH',T9,3F12.2,F12.0,F10.3)
      WRITE(6,940)
940   FORMAT(' ENTER A NUMBER 1-12')
      GO TO 840
C
C********************************************************
C
C   CHANGE THE VALUES BACK TO THEIR VALUE BEFORE LAST CHANGE.
C
C********************************************************
C
880   AVOLMM=HVOLM
      AFLOWM=HFLOWM
      AREAM=HAREAM
      APHOLO=HPHOLO
      AVOLUM=HVOLUM
      AFLOW=HFLOW
      AREA=HAREA
      APHOLE=HPHOLE
      RETCOE=HRETCO
      AWLOAD=(220.665124*AFLOW/AREA)*DAYS/365.
      ZM=(AVOLUM/AREA)*.3048
      FLUSH =( 723.9669421*AFLOW/AVOLUM)*DAYS/365.
      RETIME = 1./FLUSH
      PALOAD = .2471*APHOLO/AREA
      PVLOAD = 810.7132*APHOLO/AVOLUM
      EQUFAC = (1.-RETCOE)*RETIME
      HALFLI = LOG(2.)*EQUFAC
      WRITE(6,940)
      GO TO 840
C
C***********************************************************
C
C     PREDICT THE RECOVERY OF THE LAKE
C
C***********************************************************
C
C
C     SOURCE: SONZOGNI, UTTORMARK, AND LEE, 1976
C
900   WRITE(6,950)
950   FORMAT(1HO,'TYPE INITIAL PHOSPHORUS CONCENTRATION IN MG/CU.M',
     -' - MAX 10000')
      READ(5,960)AINPHO
960   FORMAT( )
      IF(AINPHO.GT.10000.0.OR.AINPHO.LT.0)GO TO 900
970   WRITE(6,980)
980   FORMAT(1HO'  TYPE THE NUMBER OF YEARS FROM INITIAL TIME')
      READ(5,990)TIME
990   FORMAT( )
      IF(TIME.LE.0)GO TO 970
      ARG=-(TIME/EQUFAC)
      PHOCON = PHOSTE+(AINPHO-PHOSTE)*EXP(ARG)
      CHLA = 10.**(1.45*LOG10(PHOCON)-1.14)
      SEC = 5.19*((CHLA)**-.468)
      WRITE(6,1000) TIME
1000  FORMAT(1HO,'   AT THE END OF',F7.2,' YEARS,'
     -/,' THE CONDITION IN THE LAKE IS PREDICTED TO BE :')
```

```
      WRITE(6,1010) PHOCON
 1010 FORMAT(1H0,'   PHOSPHORUS CONCENTRATION (MG/CU.M)',
     -T50,F20.3)
      WRITE(6,1020) CHLA
 1020 FORMAT(1H0,'   CHLOROPHYLL-A CONCENTRATION (MG/CU.M)',T50,F20.3)
      WRITE(6,1030) SEC
 1030 FORMAT(1H0,'   SECCHI DISC DEPTH (METERS)',T50,F20.3)
      WRITE(6,1040)PHOSTE
 1040 FORMAT(1H0,'   THE STEADY STATE PHOSPHORUS CONC. (MG/CU.M) IS ',
     -F10.5)
 1050 WRITE(6,1060)
 1060 FORMAT(1H0,'   ENTER 1,2,3,OR 4.'/
     -5X,'  1=NEW TIME PERIOD,'/
     -5X,'  2=NEW INITIAL CONC. AND TIME PERIOD,'/
     -5X,'  3=CONTINUE,'/
     -5X,'  4=QUIT.')
      READ(5,1070)INDEX
 1070 FORMAT( )
      IF(INDEX.LT.1.OR.INDEX.GT.4)GO TO 1050
      GO TO (970,900,800,890),INDEX
C
C***********************************************************
C
C      BACK CALCULATE A PHOSPHORUS CONCENTRATION
C
C********************************************************
C
910   WRITE(6,1080)
 1080 FORMAT(1H0'TYPE IN THE OBSERVED SPRING TOTAL PHOSPHORUS',
     -' CONCENTRATION IN MG/CU.M')
      READ(5,1090)AEPHOS
 1090 FORMAT( )
      IF(AEPHOS.LT.0.0.OR.AEPHOS.GT.10000.)GO TO 910
 1100  WRITE (6,1110)
 1110 FORMAT(1H0,'  ENTER A NUMBER 1-4',/,
     -5X,'1 DILLON AND RIGLER, 1974B',/,
     -5X,'2 VOLLENWEIDER, 1975',/,
     -5X,'3 VOLLENWEIDER, 1976',/,
     -5X,'4 ALL THE METHODS ABOVE.')
      READ(5,1090)IGO
      IF(IGO.LT.1.OR.IGO.GT.4)GO TO 1100
      LR=0
      GO TO(1120,1130,1140,1150),IGO
 1120 WRITE(6,1160)RETCOE
 1160 FORMAT(1H0,'   ENTER A NEW PHOSPHORUS RETENTION COEFFICIENT',
     -/,'   IT CURRENTLY IS,',F10.3,/,
     -/,'    IF YOU TYPE 0, A REGRESSED ONE WILL BE CALC.')
      ID=1
      READ(5,1170)RETCOE
 1170 FORMAT( )
      IF(RETCOE.GT..000001)GO TO 1180
C
C***********************************************************
C
C   CALCULATE THE RETENTION COEFFICIENT
C
C**********************************************************
C
      A=AWLOAD
C
C   SOURCE: KIRCHNER AND DILLON, 1975
C
      RETCOE=.426*EXP(-.271*A)+.574*EXP(-.00949*A)
 1180 IF(RETCOE.GT.1.)RETCOE=1.0
      IF(RETCOE.LT.0)RETCOE=.0
      EPLOAD=(AEPHOS*ZM*FLUSH)/(1-RETCOE)
      GO TO 1190
 1130 EPLOAD=AEPHOS*(10.+(ZM*FLUSH))
      ID=2
      GO TO 1190
 1140 EPLOAD=AEPHOS*ZM*((FLUSH**0.5)+FLUSH)
      ID=3
 1190 EPLOAD=EPLOAD*AREAM/100.
      EELOAD=EPLOAD*2.205
 1200 WRITE(6,1210)ID,EPLOAD,EELOAD
 1210 FORMAT(1H0,'THE ESTIMATED PHOSPHORUS LOAD BY METHOD  ',I2,' IS ',
     -F10.2,' KG/YR'/,T34,F10.2,' LBS/YR')
      CHLORA=10.**(1.45*LOG10(AEPHOS)-1.14)
      SECCHI=5.19*((CHLORA)**-.468)
```

```
       WRITE(6,1220)CHLORA,SECCHI
 1220  FORMAT(1H0,T15,'CHLOROPHYLL-A CONC. (MG/CU. M)',F10.3,/,
      -T15,'SECCHI DISC DEPTH (METERS)',F10.3,//)
       IF(LR.EQ.0)GO TO 1230
 1150  LR=LR+1
       GO TO (1120,1130,1140,1230),LR
 1230  WRITE(6,1240)
 1240  FORMAT(1H0,'   ENTER A NUMBER 1-4',/,
      -5X,'1= ANOTHER METHOD',/
      -5X,'2= ANOTHER PHOSPHORUS CONCENTRATION,'/
      -5X,'3= CONTINUE',/
      -5X,'4= QUIT')
       READ(5,1250)IEGO
 1250  FORMAT()
       IF(IEGO.LT.1.OR.IEGO.GT.4)GO TO 1230
       GO TO(1100,910,800,890),IEGO
 890   WRITE(6,1260)
 1260  FORMAT(1H0,'************* LATER *************')
       STOP
       END
```