WATER QUALITY MONITORING

AT F.E. WALTER RESERVOIR

DURING 2002

Prepared for

U.S. Army Corps of Engineers
Philadelphia District
Philadelphia, PA 19107

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1.0 INTRODUCTION

1.1 PURPOSE OF THE MONITORING PROGRAM

The U.S. Army Corps of Engineers (USACE) manages F.E. Walter Reservoir located in northeastern Pennsylvania within the Delaware River Basin. Foremost, F.E. Walter Reservoir provides flood control and a dependable water supply to downstream communities on the Lehigh River. Additionally, the reservoir provides important habitat for fish, waterfowl, and other wildlife, and recreational opportunities through fishing, and boating. Due to the broad range of uses and demands F.E. Walter Reservoir serves, the USACE monitors water quality and other aspects related to reservoir health primarily to ensure public health safety. Water quality monitoring results are compared to state water quality standards and used to diagnose other problems that commonly effect reservoir health such as nutrient enrichment and toxic loadings. This report summarizes the results of water quality monitoring at F.E. Walter Reservoir from May through October 2002. This report also discusses the relevance of the water quality measures to the ecology of the reservoir and makes recommendations toward future water quality monitoring.

1.2 DESCRIPTION OF F.E. WALTER RESERVOIR

F.E. Walter Reservoir is an integral part of the Lehigh River Flood Control Program. The authorized purpose of this project is flood control. The reservoir project was authorized as a white water project as part of Public Law 100-676, Section 6, dated November 17, 1988. Located about 9 miles southeast of Wilkes-Barre, PA, the reservoir dams a drainage area of 288 square miles. The dam can impound up to 35.8 billion gallons of floodwater. The primary surface water input into the reservoir is the Lehigh River as it flows west between Luzerne and Carbon Counties. Bear Creek, a secondary surface water input, enters the reservoir from the north. Tobyhanna Creek drains an area to the southeast and joins the Lehigh River near the headwaters of the reservoir. The reservoir is approximately 3 miles long and usually about 50 feet deep behind the dam. This past year was exceptional, however, due to drought conditions in the region and reservoir depth increased substantially to about 140-ft. Average annual discharge from the dam into the Lehigh River is approximately 625 cubic feet per second (USGS 1993).

1.3 ELEMENTS OF THE STUDY

The USACE, Philadelphia District, has been monitoring the water quality of F.E. Walter Reservoir since 1975. Over this time, yearly monitoring program designs have evolved to address new areas of concern such as health aspects of public drinking water, sediment contaminants within the reservoir basin, and most recently, investigating a hydrogen sulfide smell near the tailwater of the dam. The 2002 monitoring program is similar to those in recent years and includes the following major elements:

- Monthly water quality and bacteria monitoring from May through October to evaluate compliance with the Pennsylvania state water quality standards;

- Meteorological monitoring of air temperature, relative humidity, solar radiation, wind speed and direction every ½ hour at the F. E. Walter Reservoir discharge tower;

- Sediment priority pollutant monitoring of PCB's, pesticides, and volatile organic compounds to evaluate sediment toxicity relative to identified screening concentrations;

- Drinking water monitoring to ensure public health safety by comparing water quality from a drinking water source to standards determined by the Safe Drinking Water Act (SDWA); and

- Hydrogen sulfide and dissolved metal sampling to address downstream hydrogen sulfide smell and further monitor the lake during anoxic conditions.

- Additional water quality monitoring at five stations along the Lehigh River below the reservoir including automated half-hour temperature recorders and physical water quality monitoring from July to October.

2.0 METHODS

2.1 PHYSICAL STRATIFICATION MONITORING

Physical stratification monitoring of the water column of F.E. Walter Reservoir was conducted eleven times between May and October 2002 (Table 2-1). Physical stratification parameters included temperature, dissolved oxygen (DO), percent of DO saturation (dependent on temperature), pH, and conductivity. Monitoring was conducted at seven fixed stations located throughout the reservoir watershed (Fig. 2-1). Surface water quality was monitored at stations downstream of the reservoir (WA-1), and upstream on Tobyhanna Creek (WA-3), the Lehigh River (WA-4), and Bear Creek (WA-5). Stratification monitoring was conducted at the reservoir-body station (WA-2), Bear Creek (WA-6), and Lehigh River (WA-7) with water quality measured at the surface to the bottom at 5-ft intervals. Three stations (WA-2, WA-6, WA-7) were conducted twice a month starting in June through October. All of the water quality monitoring was conducted with a calibrated Hydrolab water quality meter.

In this report, water quality data recorded from stratification monitoring were compared to water quality standards mandated by the Pennsylvania Department of Environmental Protection (PADEP Chapter 93). The standard for DO is a minimum concentration of 5 mg/L, and that for pH is an acceptable range from 6 to 9.

All of the water quality data collected during physical stratification monitoring are summarized in Appendix Table A-1.

2.2 WATER COLUMN CHEMISTRY MONITORING

Water column chemistry monitoring was conducted seven times at F.E. Walter Reservoir between May and October (Table 2-1). Water samples were collected at the seven fixed stations throughout the reservoir drainage area (Fig. 2-1). Surface water samples were collected at stations downstream of the reservoir (WA-1) and upstream on Tobyhanna Creek (WA-3), the Lehigh River (WA-4), and Bear Creek (WA-5). Surface, middle, and bottom water samples were collected at the reservoir-body station WA-2, WA-6, and WA-7. Surface water samples were collected by opening the sample containers approximately 1 foot below the water's surface. Middle and bottom samples were collected with a Van Dorn design horizontal water bottle.

Water samples collected from surface, middle, and bottom depths were analyzed for ammonia, nitrite, nitrate, total Kjeldahl nitrogen (TKN), total phosphorus, total dissolved phosphorus, dissolved phosphate, total dissolved solids (TDS), total suspended solids

Table 2-1. F.E. Walter Reservoir water quality monitoring schedule for 2002

Date of Sample Collection	Water Quality during anoxic conditions (WA-1, WA-2, WA-6, WA-7, LH-3)	Physical Stratification Monitoring (All Stations)**	Water Column Chemistry Monitoring (All Stations)	Trophic State Determination (WA-2)	Coliform Bacteria Monitoring (All Stations)	Sediment Priority Pollutant Monitoring (WA-2)	Lehigh Water Quality Monitoring	Drinking Water Monitoring*
21 May		X	X	X	X			
4 June		WA-2, WA-6, WA-7						
19 June		X	X	X	X			Set A and B
10 July		WA-2, WA-6, WA-7					X	
23 July		X	X	X	X	X		
7 August	X	WA-2, WA-6, WA-7					X	
20 August		X	X	X	X			Set A
5 September	X	WA-2, WA-6, WA-7					X	
3 October		X	X	X	X			
9 October		WA-2, WA-6, WA-7					X	
23 October		X	X	X	X		X	

* Set A – comprised analyses of nitrate, nitrite, and coliform bacteria contaminants.
  Set B – comprised analyses for primary and secondary contaminants.

**Stratification was done at all stations once a month and twice a month at stations WA-2, WA-6, and WA-7.

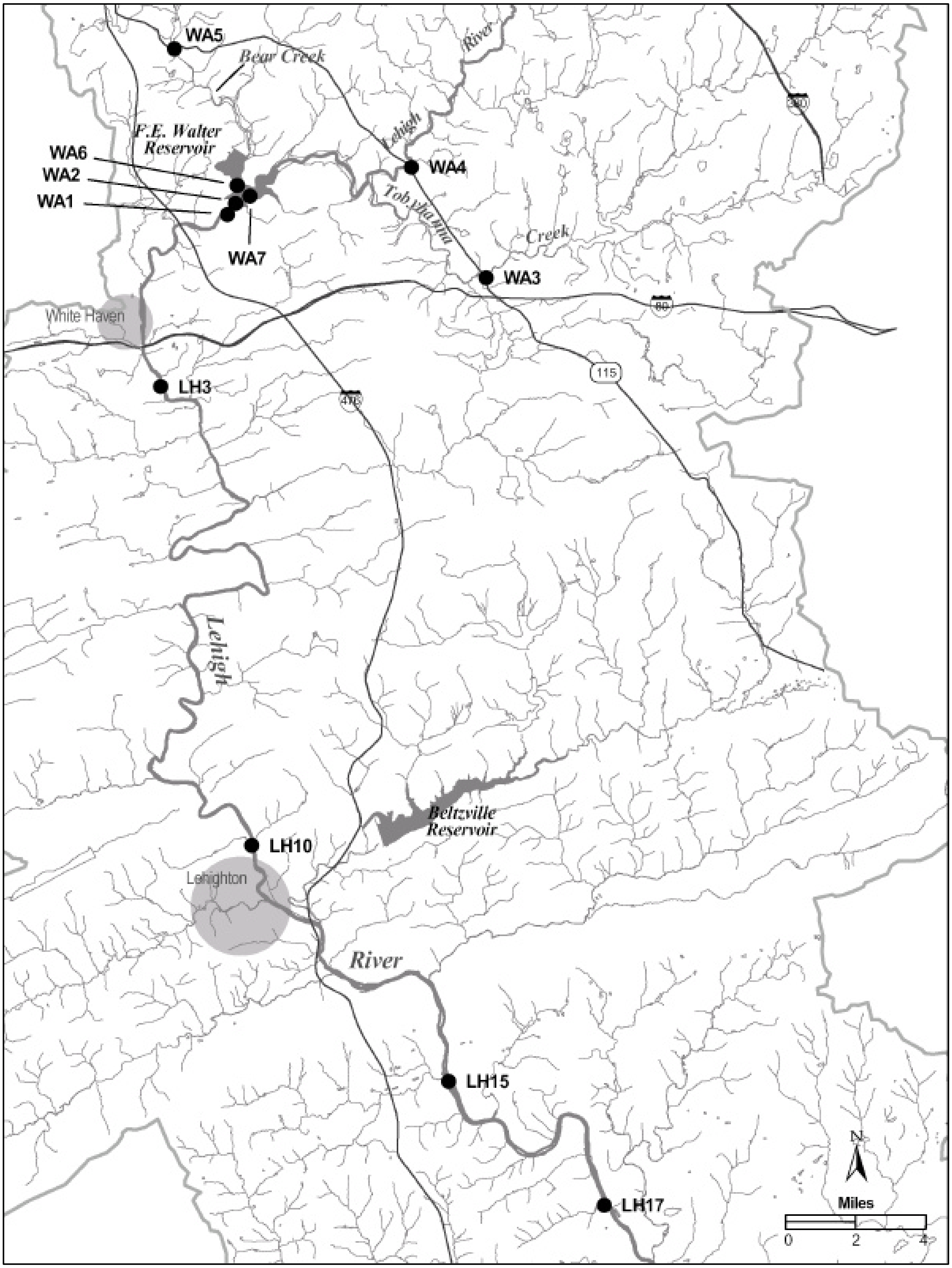

Figure 2-1. Location map for F.E. Walter Reservoir and water quality monitoring stations in 2002

(TSS), biochemical oxygen demand (BOD), alkalinity, total organic carbon (TOC), total inorganic carbon (TIC), total carbon, and chlorophyll *a*. Table 2-2 summarizes the water quality parameters; laboratory method detection limits, state water quality standards, and allowable and achieved maximum hold times for each.

Table 2-2. Water quality test methods, detection limits, state regulatory criteria, and sample holding times for water quality parameters monitored at F.E. Walter Reservoir in 2002

Parameter	**EPA Method**	**Detection Limit**	**PADEP Surface Water Quality Criteria**	**Allowable Hold Times (Days)**	**Maximum Hold Time Achieved (Days)**
Alkalinity	310.1	1 mg/L	minimum 20 mg/L $CaCO_3$	14	12
Biochemical Oxygen Demand (BOD)	SM5210B	2 mg/L	None	2	2
Total Phosphorus	365.2	0.01 mg/L	None	28	5
Total Dissolved Phosphorus	365.2	0.01mg/L	None	28	11
Dissolved Phosphate	365.2	0.01 mg/L	None	28	11
Total Organic Carbon	415.1	1 mg/L	None	14	2
Total Inorganic Carbon	415.1	1 mg/L	None	14	2
Total Carbon	415.1	1 mg/L	None	14	2
* Chlorophyll *a*			None		3
Total Kjeldahl Nitrogen	351.3	0.10 mg/L	None	28	14
Ammonia	350.3	0.05 mg/L	Temperature and pH dependent	28	13
Nitrate	353.2	0.1 mg/L	Maximum 10 mg/L (nitrate + nitrite)	2	2
Nitrite	354.1	0.01 mg/L		2	2
Total Dissolved Solids	160.1	10 mg/L	Maximum 500 mg/L	7	7
Total Suspended Solids	160.2	1 mg/L	None	7	7

* Chlorophyll *a* samples were calculated by averaging 10 readings per minute using a YSI 6600 with a chlorophyll sensor.

2.3 TROPHIC STATE DETERMINATION

The trophic state of F.E. Walter Reservoir was determined by methods outlined by Carlson (1977). In general, this method calculates trophic state indices (TSIs) independently for total phosphorus and chlorophyll *a* concentrations, and secchi disk depth. Surface water measures of total phosphorus and chlorophyll *a* from chemistry monitoring were averaged in determining monthly TSI values. Secchi disk depth was measured only in surface waters at the reservoir-body station (WA-2). Trophic state determinations were made using criteria defined by Carlson (1977) and EPA (1983).

2.4 RESERVOIR BACTERIA MONITORING

Monitoring for coliform bacteria contaminants was conducted six times between May and October at F.E. Walter Reservoir. Surface water samples were collected in the same manner as for chemical parameter samples, and analyzed for total and fecal coliform bacteria contamination. Table 2-3 presents the test methods, detection limits, PADEP standards, and sample holding times for the bacteria parameters monitored at F.E. Walter Reservoir in 2002. The bacteria analytical method was based on a membrane filtration technique. All of the samples were analyzed within their maximum allowable hold times. At the end of the monitoring period, streamflow data (CFS) collected from USGS gauging stations in the region (Blakeslee and Stoddartsville) and precipitation data collected at the dam were used to correlate rainfall patterns with measured bacteria levels (see Section 2.5).

Table 2-3. Water quality test methods, detection limits, PADEP water quality standards, and sample holding times for bacteria parameters monitored at F.E. Walter Reservoir in 2002

Parameter	Total coliform	Fecal coliform
Test method	SM 9222B	SM9222D
Detection limit	10 clns/100-mls	10 clns/100-ml
PADEP standard	-	Geometric mean less than 200 clns/100-ml (application of this standard is conservative because swimming is not permitted in the reservoir)
Maximum allowable holding time	30 hours	30 hours
Achieved holding time	< 30 hours	< 30 hours

Monthly coliform bacteria counts were compared to the PADEP water quality standard for bacteria. The standard is defined as a maximum geometric mean of 200 colonies/100-ml based on five samples collected on different days. Given our logistical limitations (all monthly sampling conducted on one day), we calculated the geometric mean based on all of the surface samples collected for each month. Although our sampling design does not fully meet PADEP guidelines, we feel that this interpretation of the coliform data meets the intent of the PADEP water quality standard for evaluating F.E. Walter Reservoir bacteria levels. Additionally, application of this standard is conservative because swimming and other human/water contact recreation is prohibited in the reservoir.

2.5 STREAMFLOW AND PRECIPITATION DATA

Streamflow and precipitation data for the principal monitoring months from May to October were compiled from USACE records (Figs. 2-2 through 2-7). Streamflow data were collected from the USGS stations located in Blakeslee and Stoddartsville and reflect rainfall patterns throughout the F.E. Walter Reservoir watershed. Precipitation data was collected by F.E. Walter Reservoir personnel and reflects a more local condition of rainfall pattern.

In May, streamflow was at its highest and peaked at approximately 2500-cfs. Monthly monitoring on 21 May was conducted at a streamflow of 930-cfs (Fig. 2-2). After the beginning of June, streamflow began to slowly decrease and continued to decrease throughout the summer. Monthly monitoring in June and July took place when streamflow ranged from 250 to 500-cfs (Figs. 2-3 and 2-4). In the later part of the summer the streamflow decreased to its lowest of approximately 60-cfs. Monthly monitoring in August was done at a streamflow between 90 to 147-cfs (Fig 2-5). Towards the middle of September there was a storm event that exceeded an inch of rain that increased the flow (Fig. 2-6). Monthly monitoring was conducted 3 October and 9 October the streamflow had decreased again to 71 and 85-cfs (Fig. 2-7). There were two storms in the middle of October that exceeded an inch of rain. These rain events increased the streamflow. Monthly monitoring 23 October was conducted at a streamflow of 210-cfs (Fig 2-7).

2.6 SEDIMENT PRIORITY POLLUTANT MONITORING

Sediment from F.E. Walter Reservoir was monitored for priority pollutant contaminants, Group 1 – PCB's, pesticides, and volatile organic compounds. Sediment was collected on 23 July at station WA-2 with a petite ponar grab-sampler. Sediment from the grab-sampler was emptied into a stainless steel mixing bowl and homogenized with a stainless steel spoon. Sediments were contained in appropriately labeled sample jars and stored on ice until shipment to the analytical laboratory. All field equipment used during the handling of reservoir sediments was decontaminated prior to sampling. Decontamination procedures were as follows: detergent wash, first deionized water rinse, 10% nitric acid rinse, second deionized water rinse, hexane rinse, and third deionized

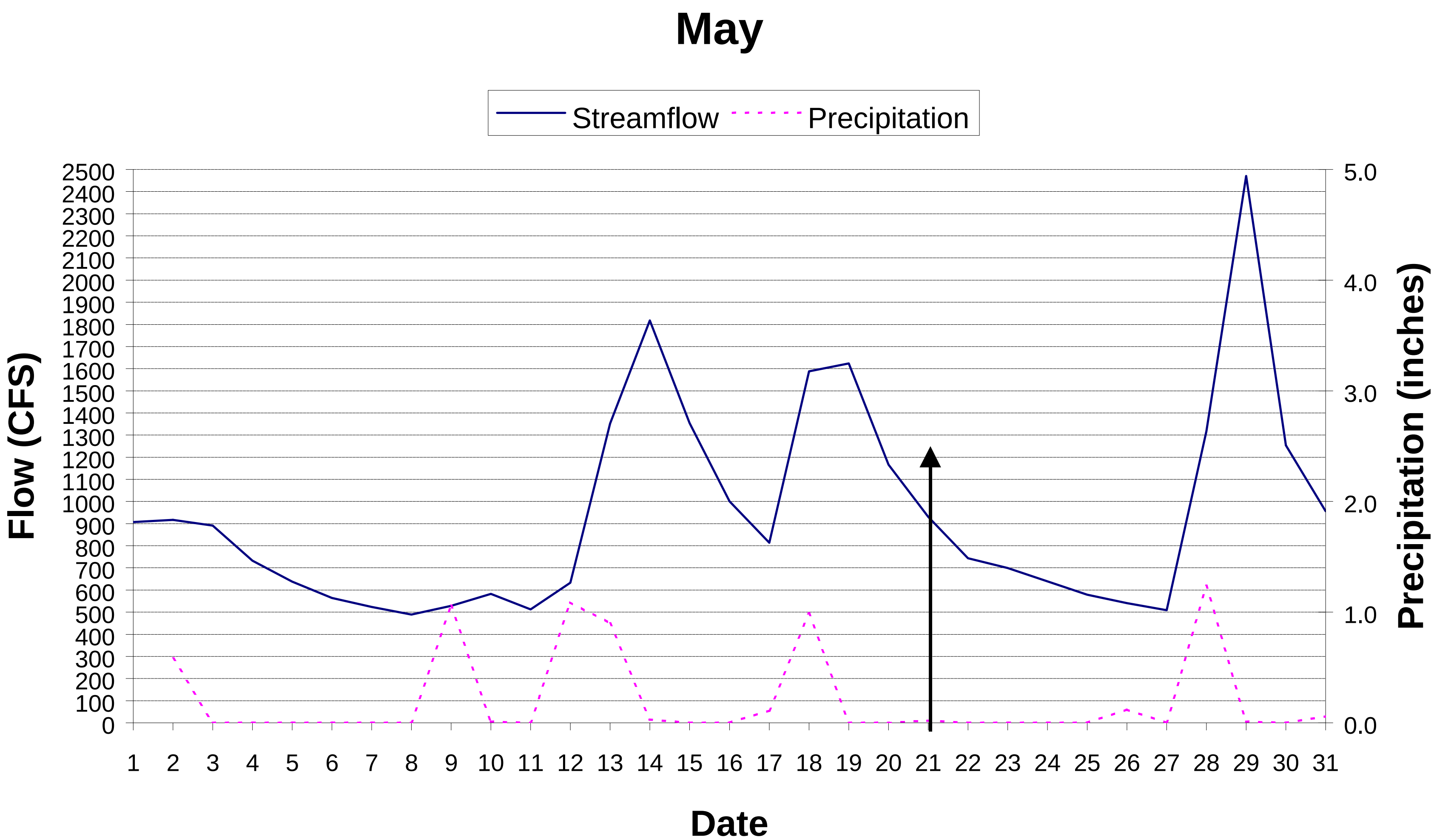

Figure 2-2. May streamflow and precipitation in the vicinity of F.E. Walter Reservoir in 2002

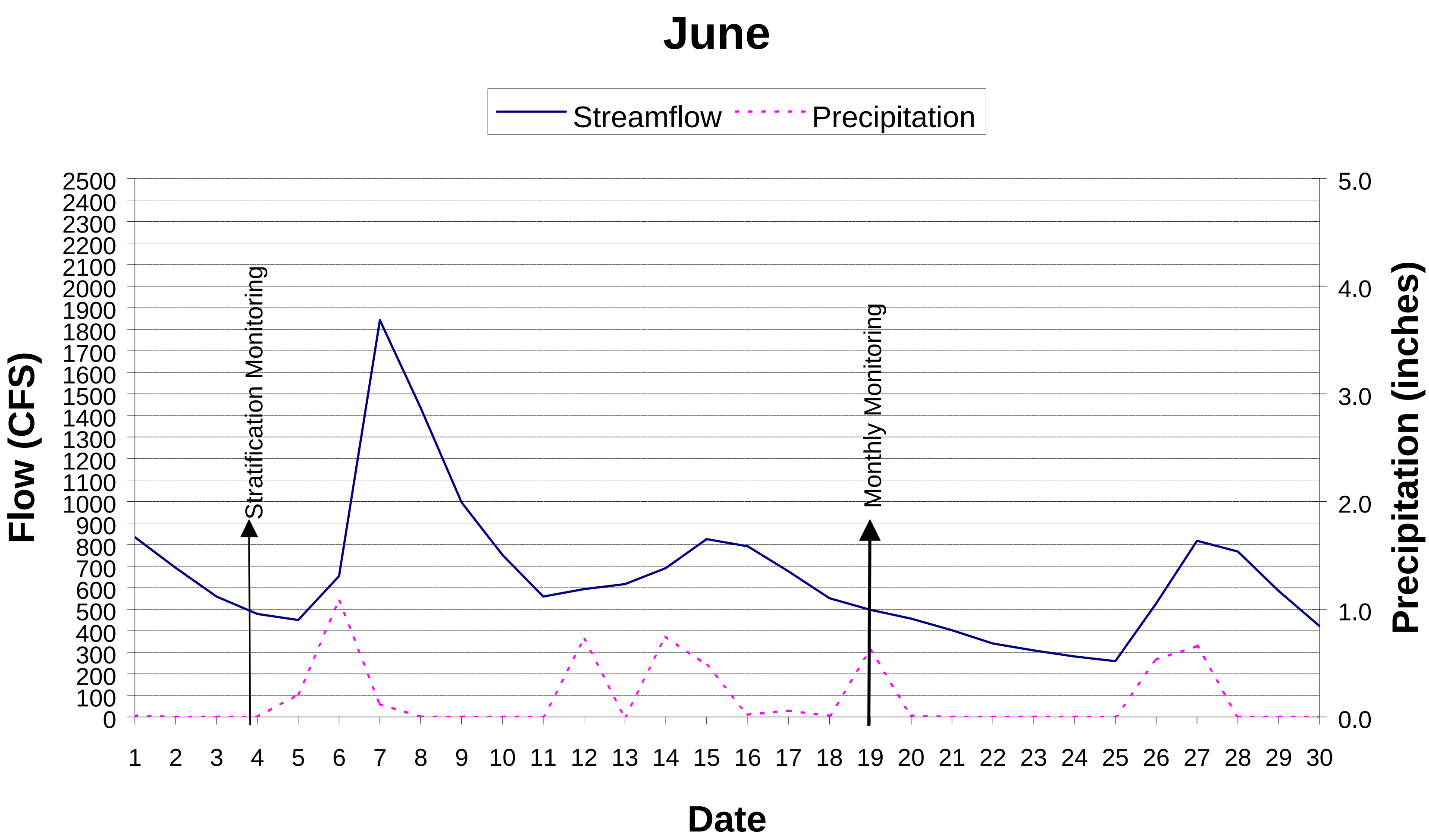

Figure 2-3. June streamflow and precipitation in the vicinity of F.E. Walter Reservoir in 2002

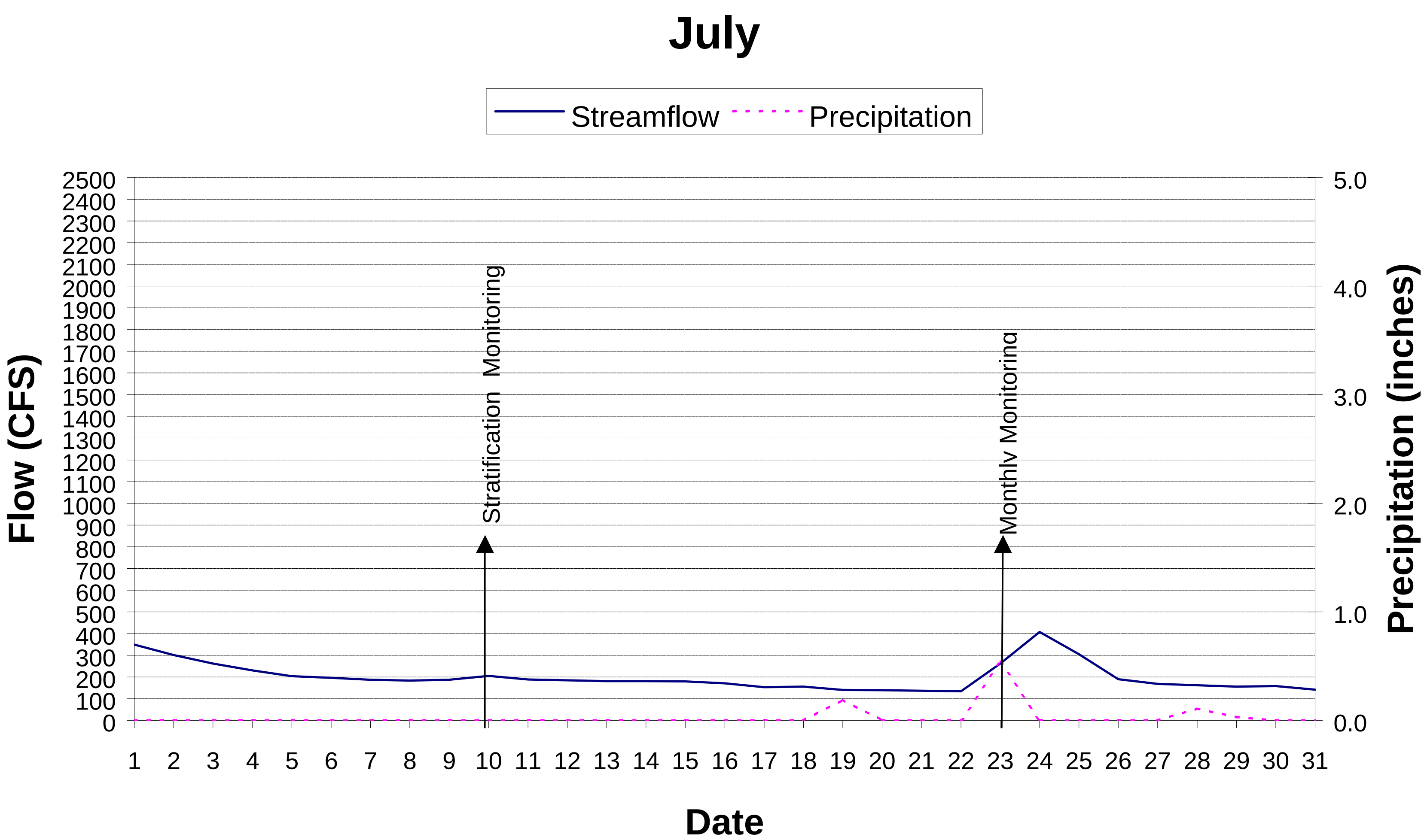

Figure 2-4. July streamflow and precipitation in the vicinity of F.E. Walter Reservoir in 2002

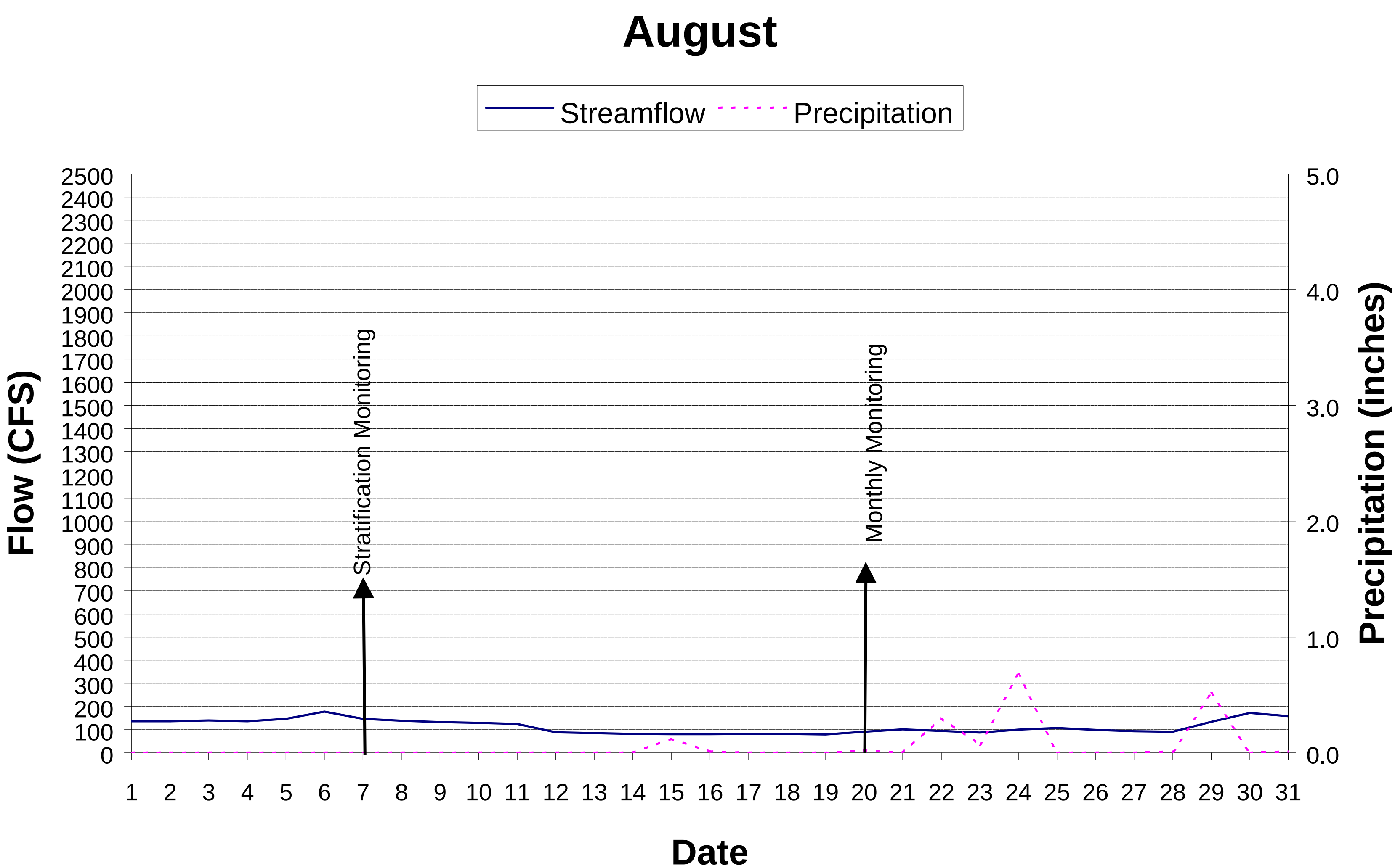

Figure 2-5. August streamflow and precipitation in the vicinity of F.E. Walter Reservoir during August 2002

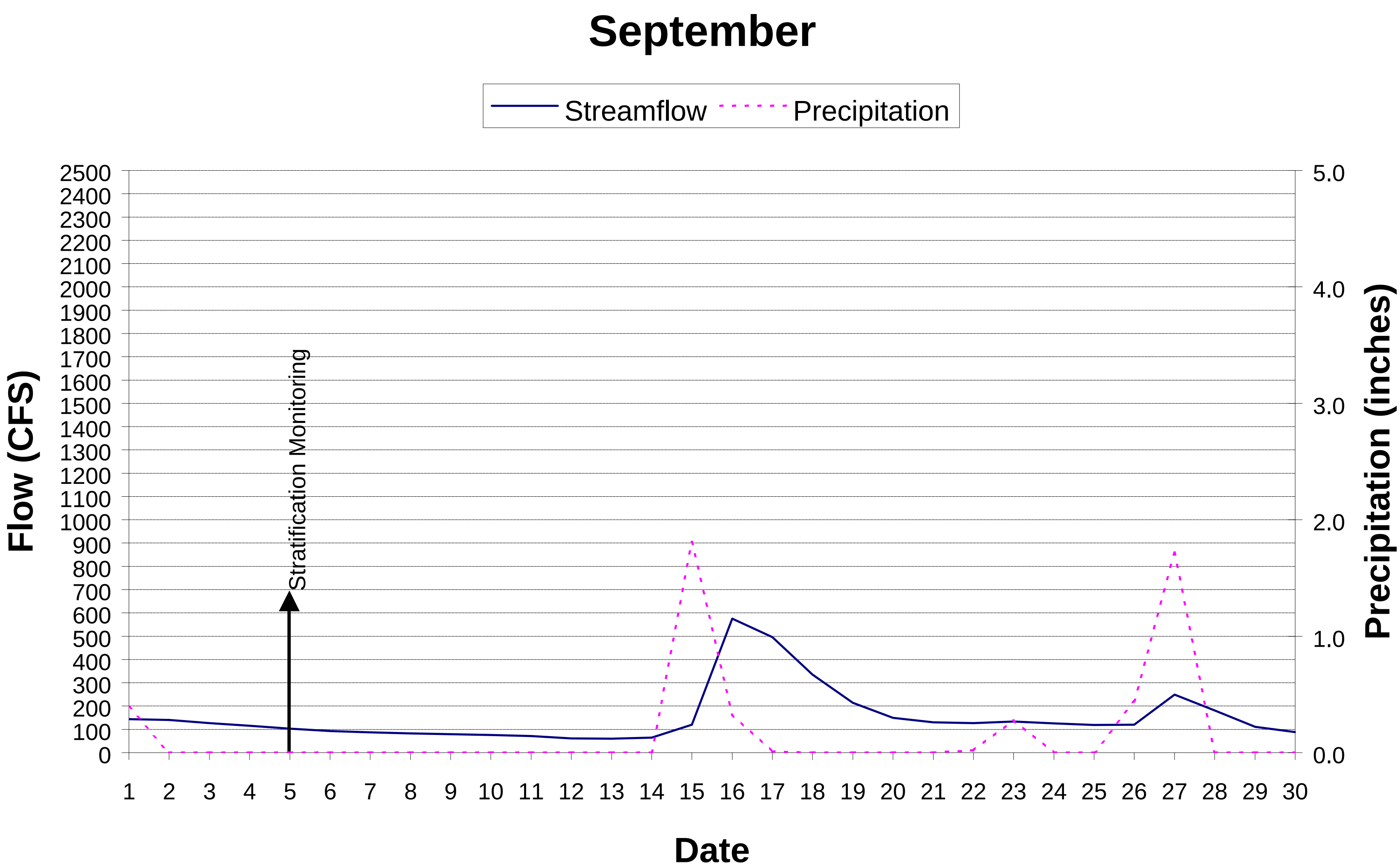

Figure 2-6. September streamflow and precipitation in the vicinity of F.E. Walter Reservoir during September 2002

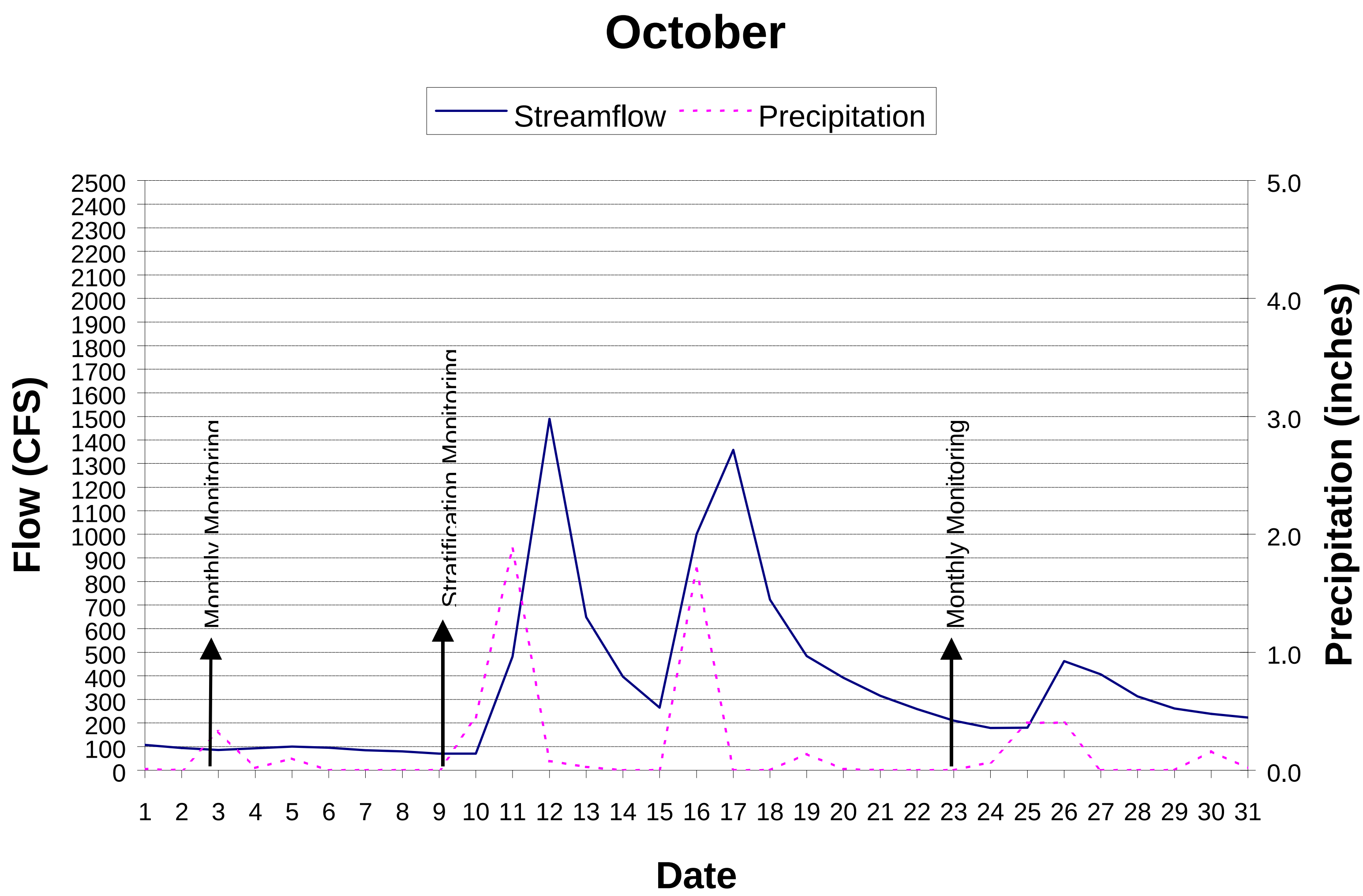

Figure 2-7. October streamflow and precipitation in the vicinity of F.E. Walter Reservoir in 2002

water rinse. Table 2-4 summarizes the parameters monitored, method detection limits, sample hold times, and the laboratory methods used in the analyses.

All sediment contaminant concentrations were reported on a dry weight basis, and were calculated as follows:

$$\text{Dry weight concentration (mg/kg)} = \frac{\text{Wet weight concentration (mg/kg)} \times 100}{\text{\% solid of sample}}$$

Sample-specific detection limits were calculated for the sediment tests because of matrix interference and the conversion from wet weight to dry weight.

Table 2-4. Sediment priority pollutants, Group 1 – volatile organic compounds, PCB's, and pesticides monitored at F. E. Walter Reservoir during 2002.

Parameter	Units	Method Detection Limit WA-2
PCBs - Method 8082		
Aroclor-1016	ppb	235
Aroclor-1221	ppb	235
Aroclor-1232	ppb	235
Aroclor-1242	ppb	235
Aroclor-1248	ppb	235
Aroclor-1254	ppb	235
Aroclor-1260	ppb	235
Pesticides - Method 8081A		
4,4'-DDD	ppb	9
4,4'-DDE	ppb	9
4,4'-DDT	ppb	9
alpha-BHC	ppb	9
a-Chlordane	ppb	9
Aldrin	ppb	9
beta-BHC	ppb	9
Chlordane, technical	ppb	94
delta-BHC	ppb	9
Dieldrin	ppb	9
Endosulfan I	ppb	9
Endosulfan II	ppb	9
Endrin	ppb	9
Endrin aldehyde	ppb	9
Endrin ketone	ppb	9
Endosulfan Sulfate	ppb	9
gamma-BHC (Lindane)	ppb	9
g-Chlordane	ppb	9
Heptachlor	ppb	9
Heptachlor epoxide	ppb	9

Table 2-4. (Continued)		
Parameter	**Units**	**Method Detection Limit WA-2**
Pesticides - Method 8081A (Continued)		
Methoxychlor	ppb	24
Toxaphene	ppb	9
Volatile Organic Compounds - Method 8260B		
1,1,1,2-Tetrachloroethane	ppb	178
1,1,1-Trichloroethane	ppb	178
1,1,2,2-Tetrachloroethane	ppb	178
1,1,2-Trichloroethane	ppb	178
1,1-Dichloroethane	ppb	178
1,1-Dichloroethene	ppb	178
1,1-Dichloropropene	ppb	178
1,2,3-Trichlorobenzene	ppb	178
1,2,3-Trichloropropane	ppb	178
1,2,4-Trichlorobenzene	ppb	178
1,2,4-Trimethylbenzene	ppb	178
1,2-Dibromo-3-chloropropane	ppb	178
1,2-Dichloroethane	ppb	178
1,2-Dichlorobenzene	ppb	178
1,2-Dichloropropane	ppb	178
1,2-Dibromoethane	ppb	178
1,3,5-Trimethylbenzene	ppb	178
1,3-Dichlorobenzene	ppb	178
1,3-Dichloropropane	ppb	178
1,4-Dichlorobenzene	ppb	178
2,2-Dichloropropane	ppb	178
2-Chlorotoluene	ppb	178
2-Hexanone	ppb	1778
4-Chlorotoluene	ppb	178
Acetone	ppb	1778
Benzene	ppb	178
Bromochloromethane	ppb	178
Bromodichloromethane	ppb	178
Bromobenzene	ppb	178
Bromoform	ppb	178
Bromomethane	ppb	178
c-1,2-Dichloroethene	ppb	178
c-1,3-Dichloropropene	ppb	178
Carbon Tetrachloride	ppb	178
Chlorobenzene	ppb	178
Chloroethane	ppb	178
Chloroform	ppb	178
Chloromethane	ppb	178
Methylene Chloride (DCM)	ppb	178

Table 2-4. (Continued)		
Parameter	**Units**	**Method Detection Limit WA-2**
Volatile Organic Compounds - Method 8260B (Continued)		
Dibromochloromethane	ppb	178
Dibromomethane	ppb	178
Dichlorofluoromethane	ppb	178
Ethylbenzene	ppb	178
Hexachloro1,3-butadiene	ppb	178
Isopropylbenzene (cumene)	ppb	178
m,p-Xylene	ppb	178
2-Butanone(MEK)	ppb	1778
4-Methyl-2-pentanone (MIBK)	ppb	1778
Methyl-tert-butylether (MTBE)	ppb	178
n-ButylBenzene	ppb	178
n-Propylbenzene	ppb	178
Naphthalene	ppb	178
o-Xylene	ppb	178
p-Isopropyltoluene	ppb	178
Tetrachloroethene	ppb	178
sec-Butylbenzene	ppb	178
Styrene	ppb	178
t-1,2-Dichloroethene	ppb	178
t-1,3-Dichloropropene	ppb	178
t-Butylalcohol	ppb	1778
Trichloroethene	ppb	178
Toluene	ppb	178
Trichlorofluoromethane	ppb	178
Vinyl chloride	ppb	178

2.7 TREND ANALYSIS METHODS

Annual water quality, sediment contaminant, and drinking water monitoring have been conducted at F.E. Walter Reservoir since 1975. Data collected over these years were compiled in to an electronic database by the USACE (Versar 1996). The compilation of historical data enables the use of statistical trend analysis, an important tool in determining if the water quality at F.E. Walter Reservoir has significantly changed. A number of different trend analysis methods are available; some more complicated than others. For the purpose of this report, we employed two general methods: regression analysis and the Mann-Kendall, or Seasonal Kendall, test.

2.7.1 Regression Analysis

The spatial and temporal distributions of the historical data were examined to determine which parameters had a sufficient time series to warrant meaningful trend analysis. Among the stations monitored for the major water quality parameters (e.g., nutrients, dissolved oxygen, total dissolved solids), downstream station WA-1 and reservoir station WA-2 were consistently sampled over the entire 23-year time series. Water quality trend analyses were limited to the spring (April through June) and summer (July through 15 October) periods. The "spring season" analyses were conceptualized as representing long-term trends associated with inputs to the reservoir during snow melt periods. The "summer season" analyses represented conditions during periods of maximum productivity and most severe low DO stress. Trends at station WA-1 were analyzed separately to evaluate conditions in the Lehigh River downstream of the reservoir. Regression analyses were used to determine if significant change in parameter concentrations occurred over the past two decades. The slope of the regression line was used to estimate the yearly rate of change. For this report, regression analysis was applied to the water quality parameters: total nitrogen, total phosphorus, total dissolved solids, biochemical oxygen demand, and fecal coliform bacteria.

2.7.2 Mann-Kendall Analysis

In addition to regression analysis, the non-parametric Mann-Kendall test was used to determine trends for individual stations over the time span of historical monitoring at F.E. Walter Reservoir. The Mann-Kendall (or Seasonal Kendall) test scores all combinations of yearly change for the tested parameter with a +1 or –1 depending on whether parameter increased or decreased over the time interval. All of the scores are then summed and compared to the chi-square distribution to determine if the parameter has a significant trend (increasing or decreasing) over the time series. For this report, the Mann-Kendall test was applied to the water quality parameters: dissolved oxygen, ammonia, total nitrogen, total phosphorus, total dissolved solids, biochemical oxygen demand, and total and fecal coliform bacteria.

2.8 DRINKING WATER MONITORING

Drinking water was monitored in the operations building of F.E. Walter Reservoir (Table 2-1). Drinking water parameters were divided into Sets A and B. Set A comprised bacteria parameters, total and fecal coliform (for analytical methods, see section 2.4), and nitrate and nitrite. Set A samples were collected 19 June and 20 August. Set B samples were analyzed for primary and secondary contaminants and were monitored 19 June. Table 2-5 summarizes the analytical methods, method detection limits, and sample hold times for each Set B parameter. All of the drinking water quality parameters were analyzed within their respective maximum allowable hold times during 2002.

Table 2-5. Analytical methods, method detection limits, and sample hold times for drinking water monitored at F.E. Walter Reservoir in 2002

Parameter	Detection Limits	EPA Method	Allowable Hold Times (Days)	Maximum Hold Time Achieved (Days)
Aluminum	0.003	200.7	183	9
Antimony	0.003	200.7	183	9
Arsenic	0.01	200.7	183	9
Barium	0.005	200.7	183	9
Cadmium	0.001	200.7	183	9
Chromium	0.001	200.7	183	9
Copper	0.001	200.7	183	9
Iron	0.002	200.7	183	9
Lead	0.003	200.7	183	9
Magnesium	0.001	200.7	183	9
Manganese	0.001	200.7	183	9
Mercury	0.0002	245.1	28	5
Nickel	0.001	200.7	183	9
Selenium	0.005	200.7	183	9
Silver	0.001	200.7	183	9
Sodium	0.02	200.7	183	9
Thallium	0.006	200.7	183	9
Zinc	0.003	200.7	183	9
Chloride	0.5	300	28	1
Cyanide, free	0.005	SM 4500CN-I	14	6
Fluoride	0.1	300	28	1
Foaming Agents	0.01	SM 5540C	2	1
Nitrate as N	0.05	300	2	2
Nitrite as N	0.01	300	2	2
PH	+/-0.01	150.1	N/A	0
Sulfate	1	300	28	1
Total Dissolved Solids	10.0	160.1	7	1

N/A – Not applicable

2.9 HYDROGEN SULFIDE AND DISSOLVED METALS WATER COLUMN TESTING

In December 2001 the Delaware River Basin Commission (DRBC) declared a drought emergency for the Delaware River Basin. In February 2002, the DRBC issued a Resolution authorizing the Executive Director to enter into a contract with the U.S. Army Corps of Engineers, relating to temporary storage of water at the F.E. Walter Reservoir during emergency drought periods. Due to the drought emergency, the storage of additional water at F.E. Walter Reservoir for the purpose of having that water available to augment low flows in the Delaware River, based on the Trenton Flow Objective, was considered urgent. In response to the drought emergency, the U.S. Army Corps of Engineers began storing water at F.E. Walter reservoir, raising the water level by approximately 70 feet. Personnel located at the F.E. Walter Dam reported the occurrence of a noxious, hydrogen sulfide odor in early August. Ongoing water quality studies indicated that the lake was thermally stratified and anoxic conditions existed throughout the deeper waters of the lake. In an effort to monitor water quality changes associated with the anoxic conditions seen at F. E. Walter Reservoir, the Corps initiated additional water quality sampling.

Hydrogen sulfide and dissolved metals samples were collected on 7 August and 5 September during the monitoring period of 2002 (Table 2-6). Water samples were collected from surface, middle, and bottom depths at stations WA-2, WA-6, and WA-7 (within the reservoir) and two surface stations WA-1 (below the damn) and WA-TB (Tannery Bridge). Table 2-6 summarizes the dissolved metals; laboratory detection limits, state water quality standards, allowable and achieved maximum hold times for each.

Table 2-6. Analytical methods, method detection limits, and sample hold times for dissolved metals and hydrogen sulfide monitored at F.E. Walter Reservoir in 2002

Parameter	Detection Limits	EPA Method	Allowable Hold Times (Days)	Maximum Hold Time Achieved (Days)
Aluminum	0.003	200.7/6010B	183	5
Antimony	0.003	200.7/6010B	183	5
Arsenic	0.010	200.7/6010B	183	5
Barium	0.005	200.7/6010B	183	5
Cadmium	0.001	200.7/6010B	183	5
Chromium	0.001	200.7/6010B	183	5
Copper	0.001	200.7/6010B	183	5
Hydrogen Sulfide	0.025	376.1	7	4
Iron	0.002	200.7/6010B	183	5
Silver	0.001	200.7/6010B	183	5
Manganese	0.001	200.7/6010B	183	5
Magnesium	0.001	200.7/6010B	183	5
Mercury	0.0002	245.1	183	6
Nickel	0.001	200.7/6010B	183	5
Selenium	0.005	200.7/6010B	183	5
Sodium	0.02	200.7/6010B	183	5
Thallium	0.006	200.7/6010B	183	5
Zinc	0.003	200.7/6010B	183	5

2.10 METEORLOGICAL MONITORING

Air temperature, relative humidity, solar radiation, wind speed and direction were monitored every ½ hour with a YSI 6200 meteorological station installed and maintained at the Beltzville Reservoir discharge tower. Local weather conditions were recorded with these units from May through October 2002 (Appendix E).

2.11 LEHIGH WATER QUALITY MONITORING

Ambient water temperature was recorded every ½ hour with Onset Computer Corporation TidbiT[tm] probes at four stations along the Lehigh River. The station locations were WA1 (just below the F. E. Walter dam outfall), mainstem station LH3 (several miles downstream of the dam), LH10 (Lehighton), LH15 (Walnutport), and LH17 (Northampton treatment plant intake).

Water quality monitoring of the Lehigh River was conducted five times during 2002, between July and October (Table 2-1). Monitoring was conducted at five stations WA1, LH3 (Tannery Bridge), LH10 (Lehighton), LH15 (Walnutport), and LH17 (Northampton treatment plant intake) (Fig. 2-1). Physical stratification parameters included temperature, dissolved oxygen (DO), pH, and conductivity. Turbidity and chlorophyll *a* were also monitored at these stations. All of the water quality monitoring was conducted with a calibrated YSI water quality meter.

3.0 RESULTS AND DISCUSSION

3.1 STRATIFICATION MONITORING

The following sections describe temporal and spatial patterns for the water quality parameters of temperature, dissolved oxygen (DO), percent saturation of DO, pH, and conductivity measured throughout the F.E. Walter Reservoir watershed during 2002. Additionally, patterns related to season and depths are described for stations WA-2, -6, and –7 located in the reservoir. All of the data collected during the 2002 monitoring period are presented in Appendix Table A-1.

3.1.1 Temperature

Temperature of the surface waters of the F.E. Walter Reservoir watershed generally followed a similar pattern throughout the monitoring period. Temperatures increased throughout the summer and peaked in August at approximately 24 ºC, and decreased thereafter through October to 12 ºC (Figs. 3-1 and 3-2). Temperatures in surface waters of the reservoir-body (station WA-2, -6, and -7) were generally warmer than in tributaries (stations WA-3, WA-4, and WA-5) and downstream of the dam (WA-1) and throughout the monitoring period averaged 3 ºC higher.

The water column of F.E. Walter Reservoir was weakly stratified during 2002. Temperatures throughout the water column in all months were somewhat uniform, and the greatest difference between surface and bottom was about 7 ºC in June (Figs. 3-3 through 3-5). In April and October, the temperature of the water column was lowest and averaged about 12 ºC. In August, the temperature of the water column averaged 25 ºC and peaked at 28 ºC.

3.1.2 Dissolved Oxygen

Dissolved oxygen (DO) in the surface waters of F.E. Walter Reservoir followed a consistent pattern during 2002. Concentrations among all stations generally averaged 8-mg/L over the monitoring period and ranged from 2.5 to 18-mg/L (Fig. 3-6 and 3-7). DO concentrations decreased slightly throughout the summer and rose in October, peaking on October 23 at about 12-mg/L. DO concentrations in surface waters of the reservoir-body (station WA-2, -6, and -7) were generally lower than in tributaries (stations WA-3, WA-4, and WA-5) and downstream of the dam (WA-1) and throughout the monitoring period averaged 3.4-mg/L less.

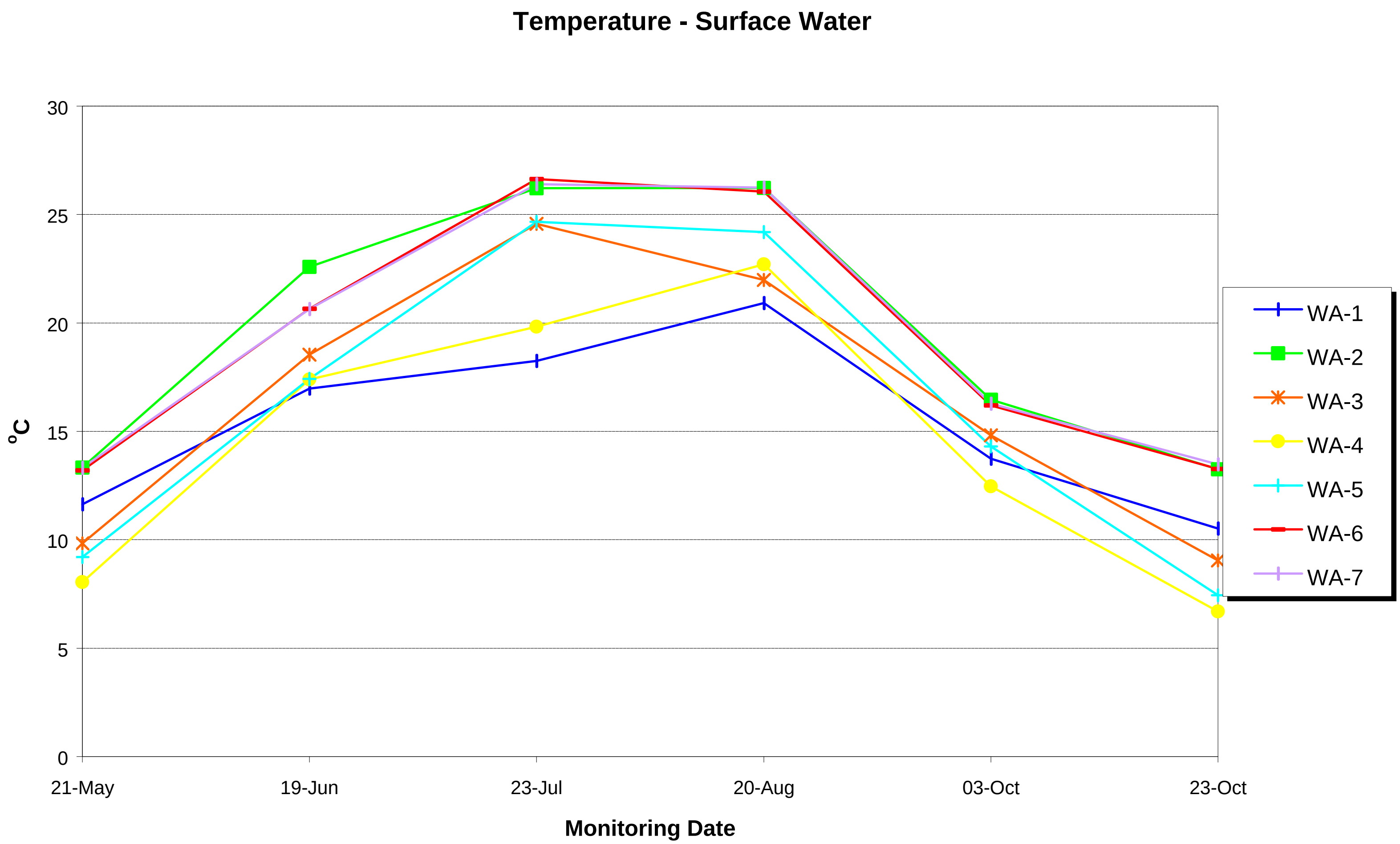

Figure 3-1. Temperature measured in surface waters of F.E. Walter Reservoir during 2002. See Appendix A for a summary of the plotted values.

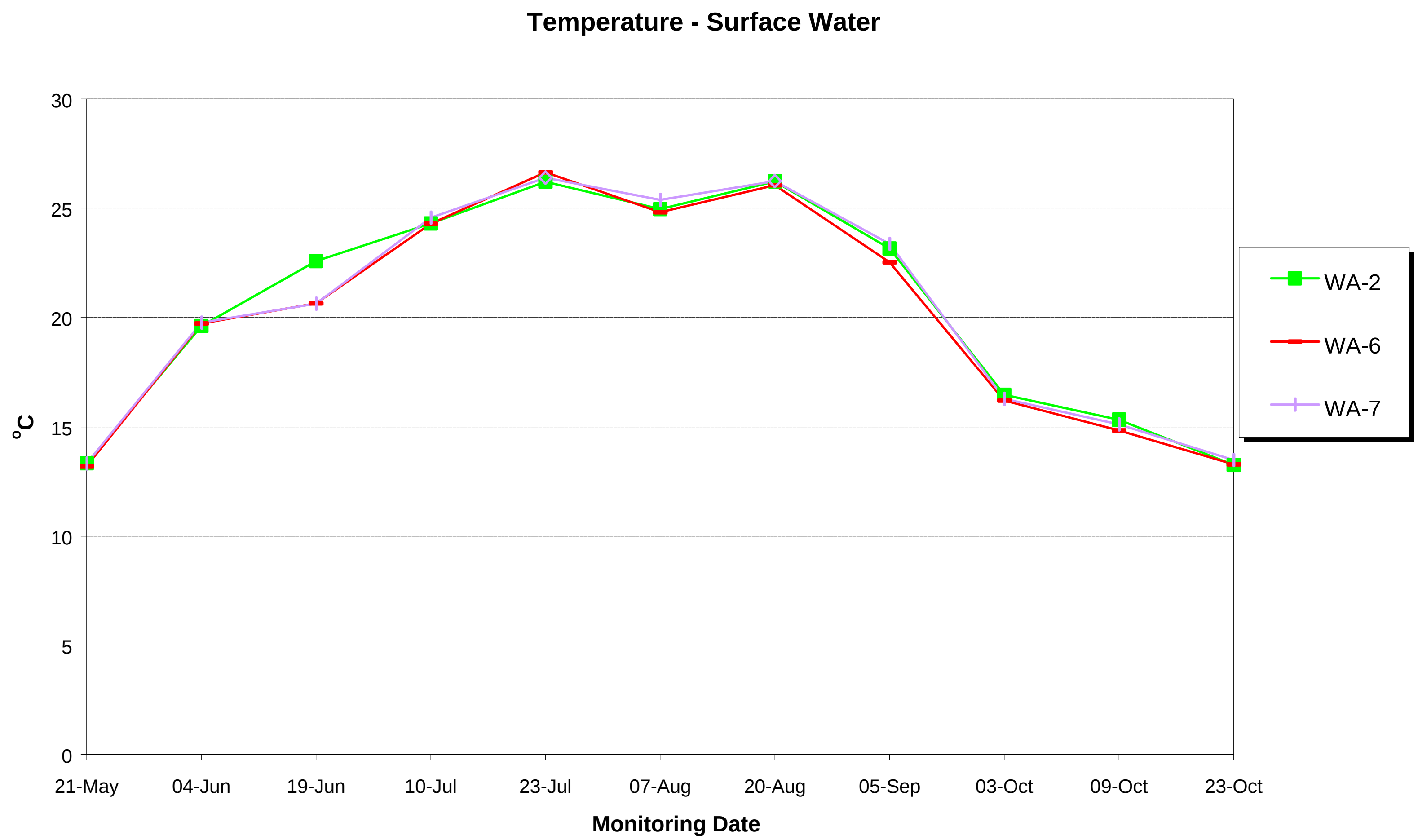

Figure 3-2. Temperature measured in surface waters of F.E. Walter Reservoir during 2002. See Appendix A for a summary of the plotted values.

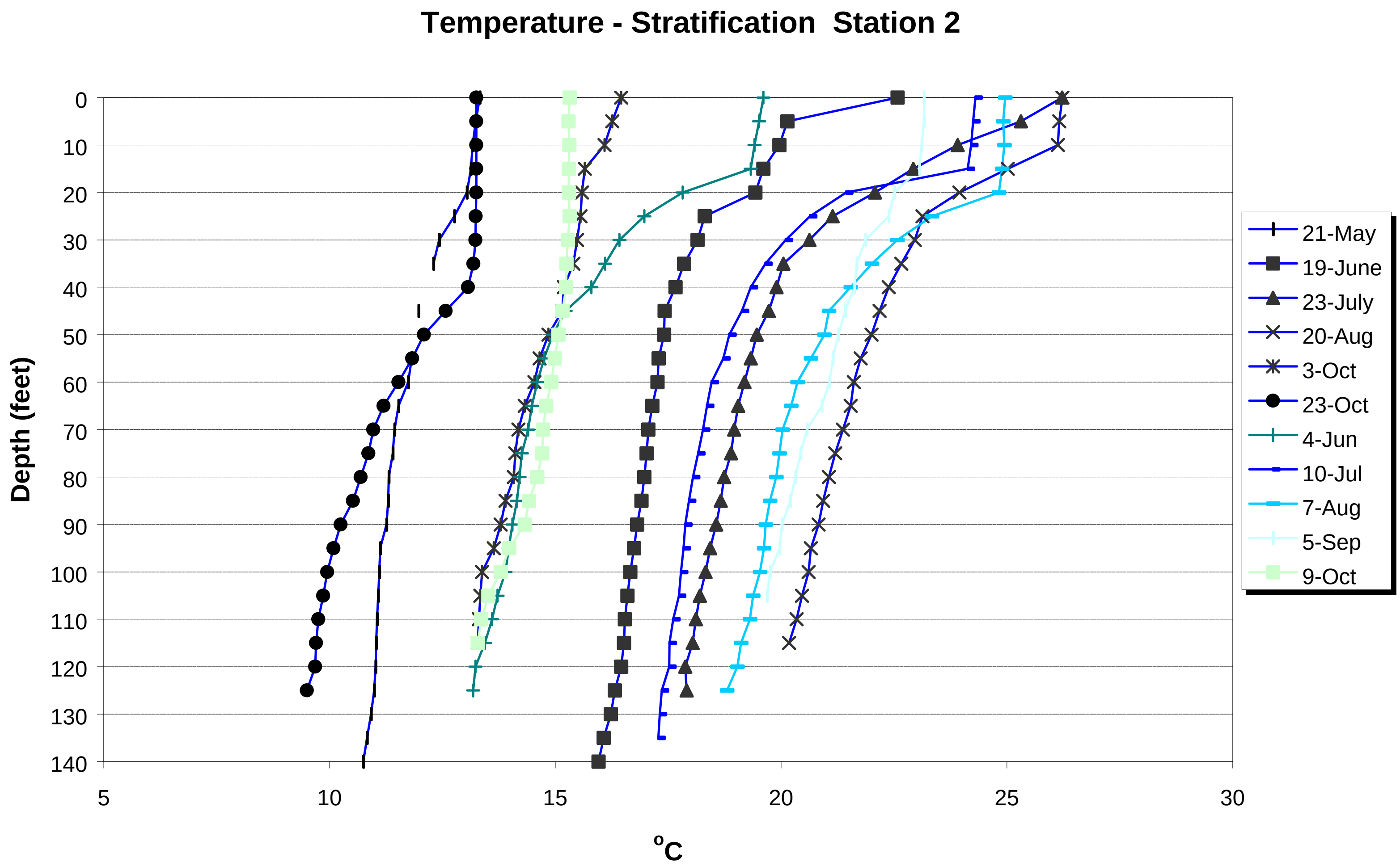

Figure 3-3. Stratification of temperature measured in the water column of F. E. Walter Reservoir at station WA-2 during 2002. See Appendix A for a summary of the plotted values.

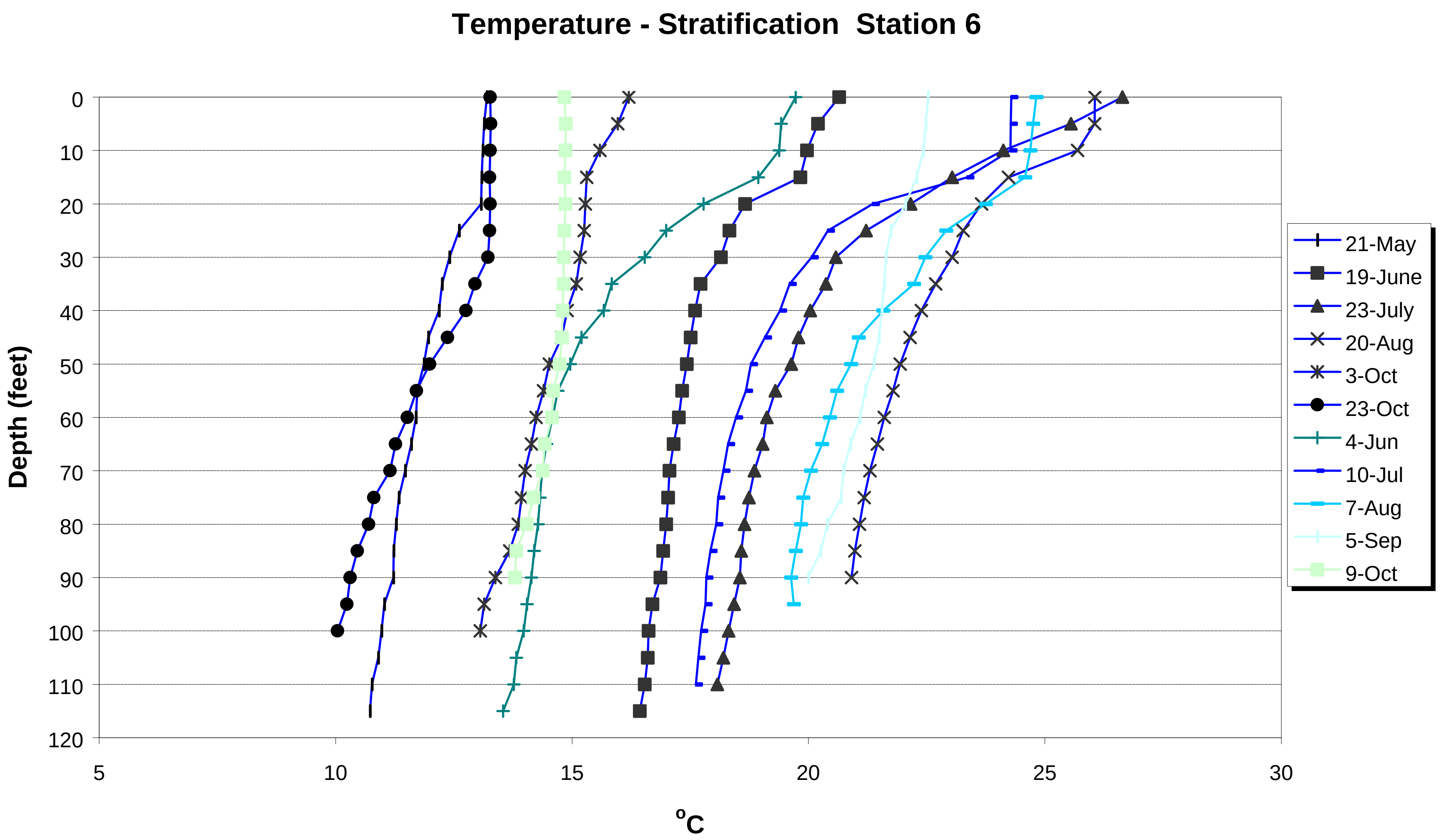

Figure 3-4. Stratification of temperature measured in the water column of F. E. Walter Reservoir at station WA-6 during 2002. See Appendix A for a summary of the plotted values.

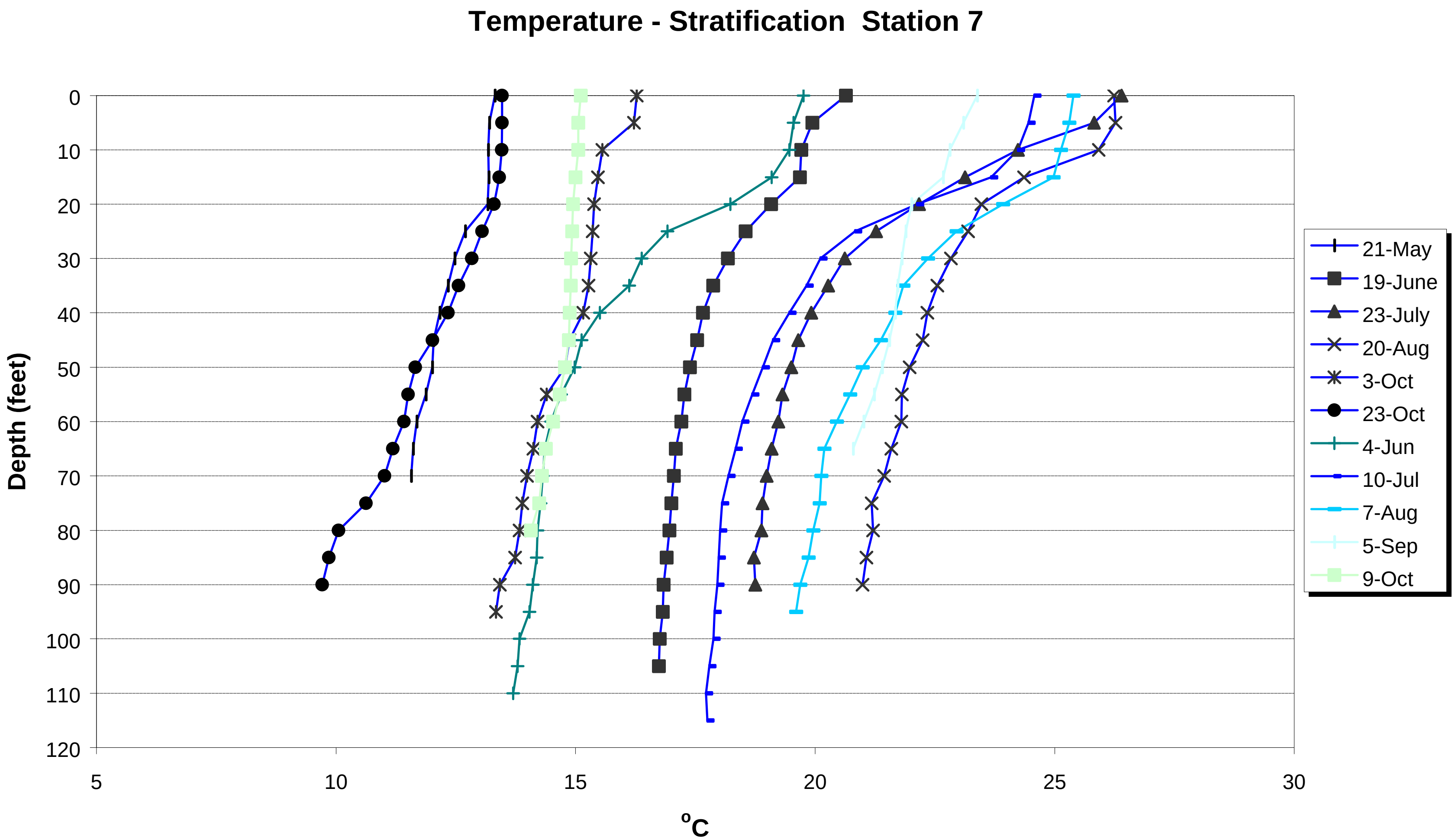

Figure 3-5. Stratification of temperature measured in the water column of F. E. Walter Reservoir at station WA-7 during 2002. See Appendix A for a summary of the plotted values.

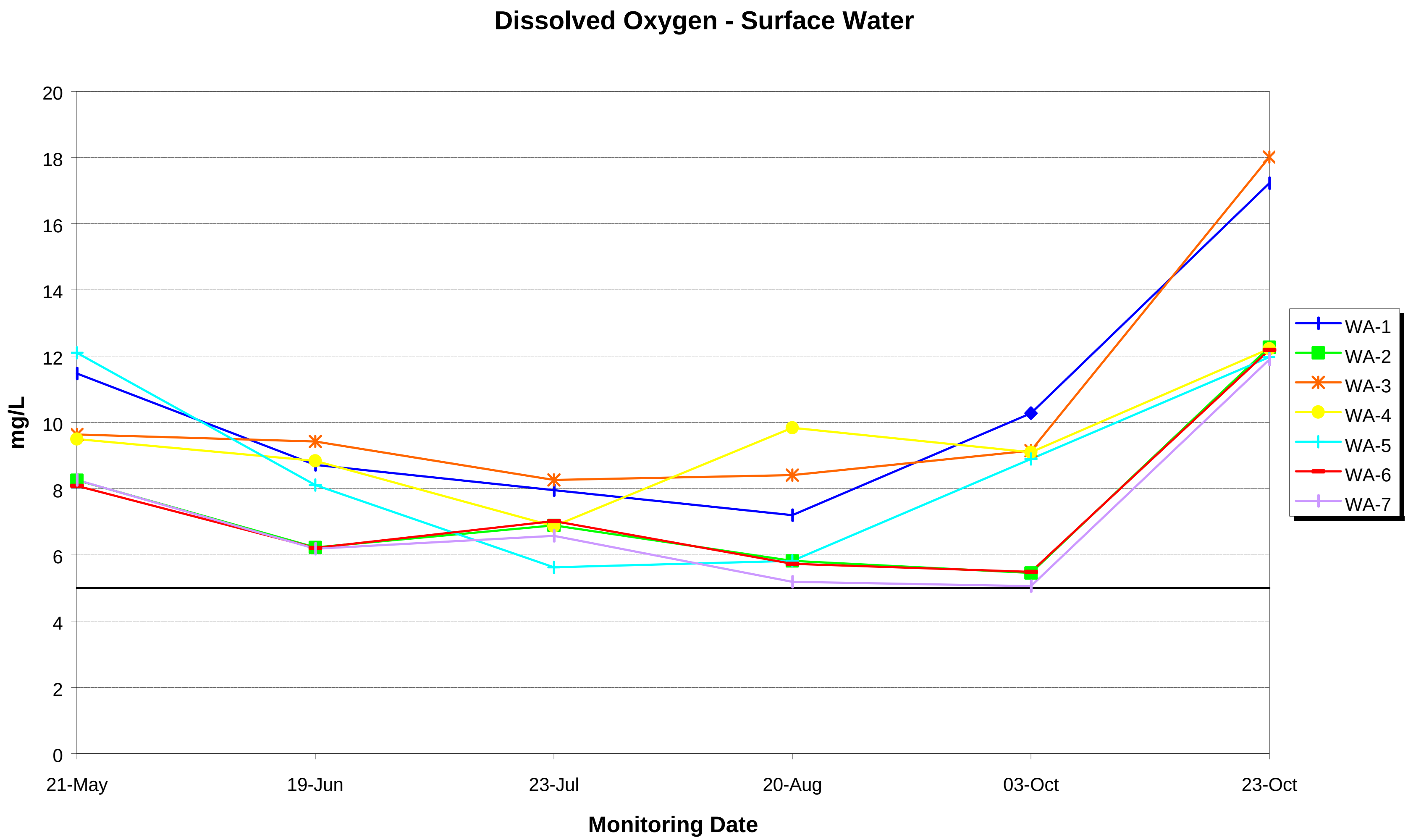

Figure 3-6. Percent saturation of dissolved oxygen measured in surface waters of F. E. Walter Reservoir during 2002. See Appendix A for a summary of the plotted values.

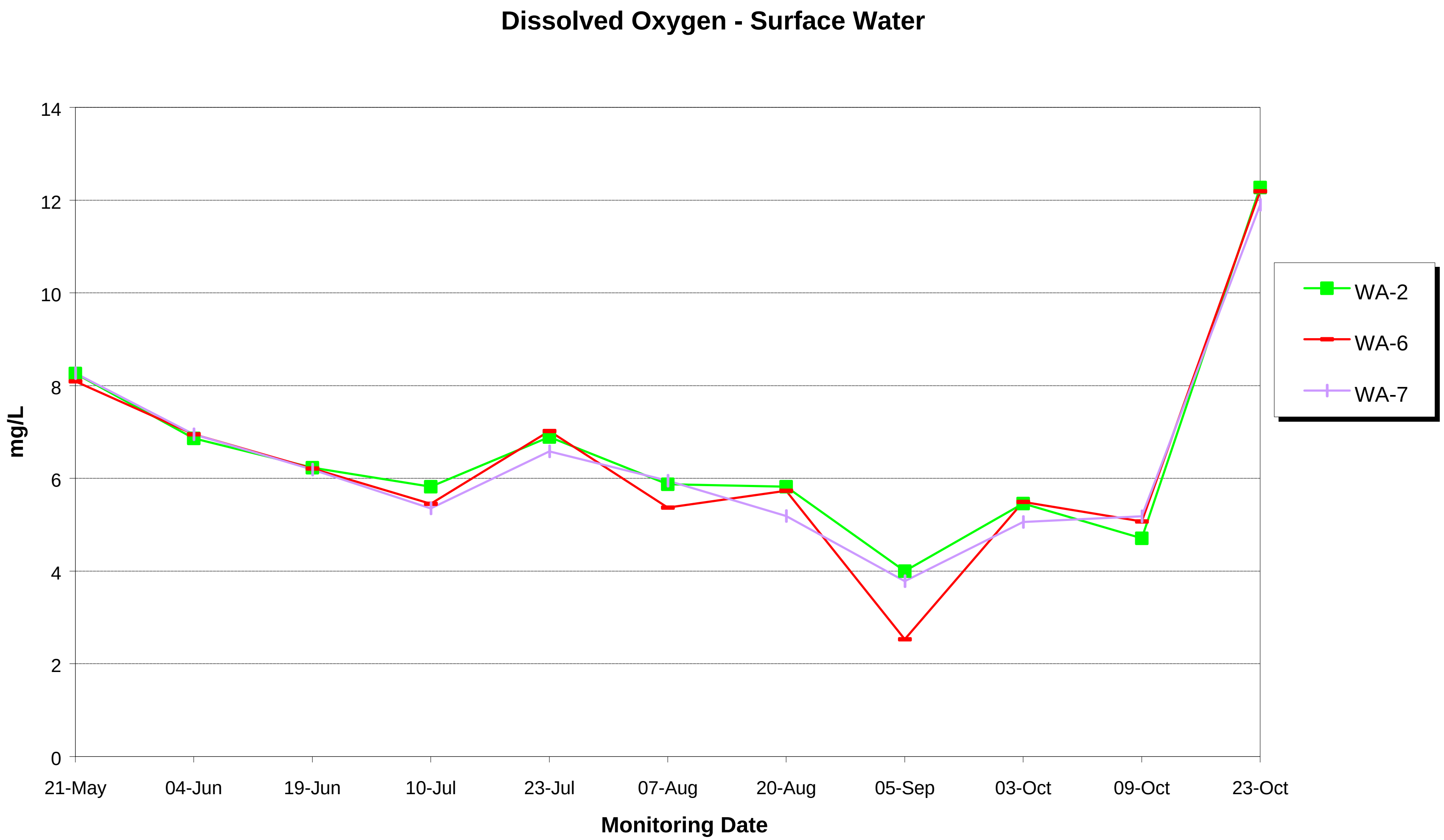

Figure 3-7. Percent saturation of dissolved oxygen measured in surface waters of F. E. Walter Reservoir during 2002. See Appendix A for a summary of the plotted values.

The water column of F.E. Walter Reservoir was stratified with respect to DO from July 10 through the October 3 sampling at stations WA-2, -6, -7 during 2002 (Figs. 3-8 through 3-10). During May, June, and October 9 the water column was relatively uniform with concentrations remaining fairly stable throughout the water column, averaging 5.9-mg/L. In July, August, September, and October 3 the DO in the water column was low with concentrations averaging 2-mg/L. DO concentrations on October 23 throughout the water column in the reservoir were higher, averaging 14-mg/L.

The health of aquatic ecosystems can be impaired by low DO concentrations in the water column. Hypoxia, or conditions of DO concentrations less than 2 mg/L, is generally accepted as the threshold at which the most severe effects on biota occur. In 2002, the lower water column of F.E. Walter Reservoir was severely affected by hypoxia (Figs. 3-8 through 3-10). Hypoxic water was encountered in the months from July to September and commonly occupied the more than half of the water column from 15 to 25-ft to the bottom. Hypoxia in the lower water column is a symptom of eutrophication. Nutrients in the water column feed explosive algal growth at the surface photic zone. Dead and decaying algae sink to lower levels of the water column and during the process of decay; oxygen is removed from the water column. The increased depth of the reservoir during 2002 and subsequent death of plants surrounding the reservoir may also have added to the hypoxia.

DO concentrations in the water column of F.E. Walter Reservoir were not in compliance with PADEP water quality standards from June 4 to October 9. The Pennsylvania water quality standard for DO is a minimum concentration of 5 mg/L. DO at stations WA-2 and WA-6 were below the criteria from June 4 through October 9. DO at station WA-7 was below criteria from June 19 through October 3.

A seasonal trend analysis of DO was conducted for individual stations of F.E. Walter Reservoir, combining 2002 and historical data. The Mann-Kendall statistic was applied to station data collected over the past 24 years or more, separately for spring (April to June) and summer (July to October 3) seasons. Stations included in the analysis were representative of locations downstream (WA-1), main reservoir (WA-2), and upstream sources on Tobyhanna Creek (WA-3), Lehigh River (WA-4), and Bear Creek (WA-5). Significant decreasing trends were determined from the analysis for station WA-2 in the spring and WA-5 in the summer (Table 3-1).

3.1.3 pH

Measures of pH in surface waters of F.E. Walter Reservoir generally followed a similar pattern during 2002; however, consistent differences were apparent between reservoir body and upstream and downstream waters (Figs. 3-11 and 3-12). Stations located in the reservoir body (WA-2, -6, and -7) averaged 6.0. Measures of pH

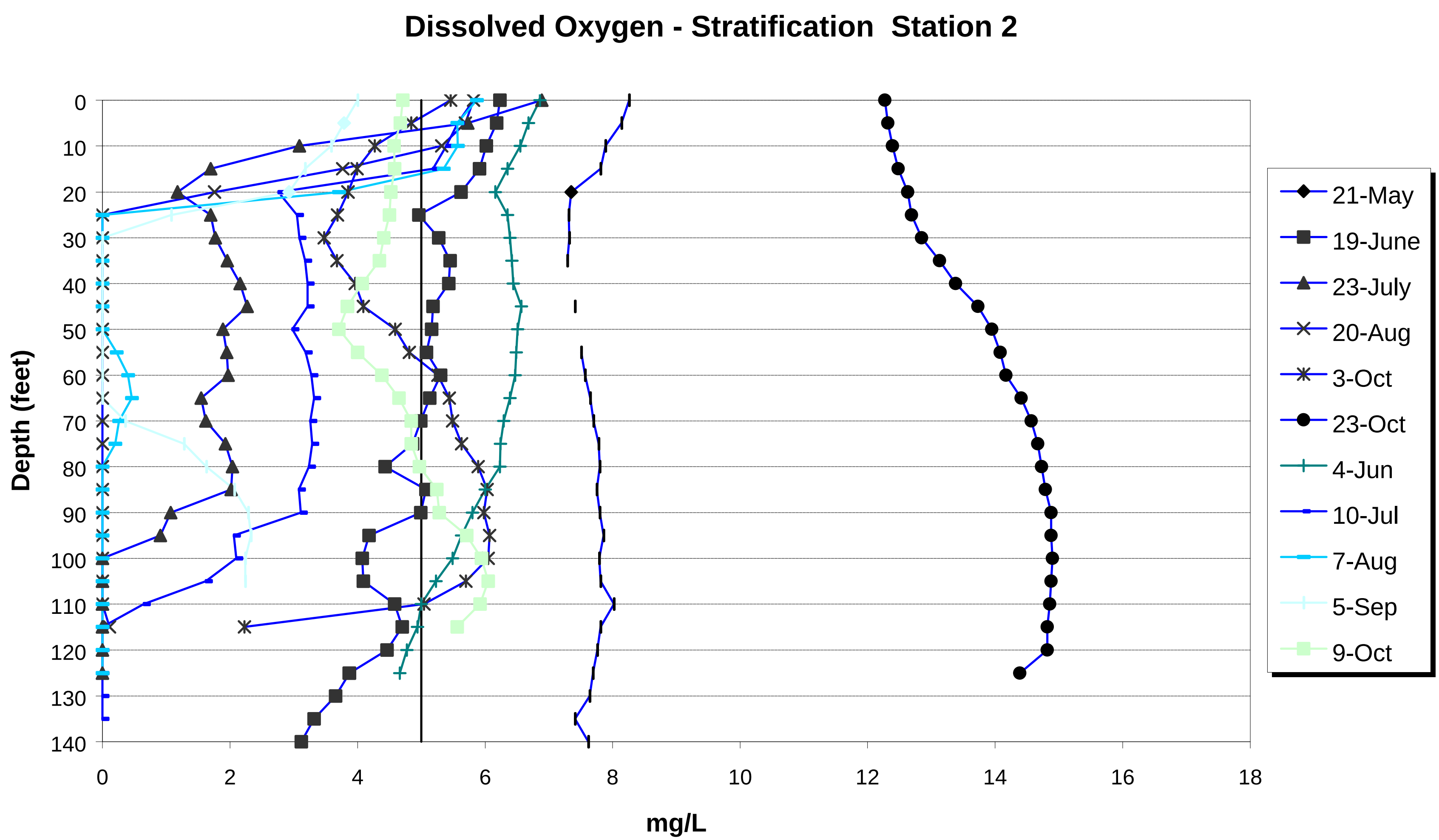

Figure 3-8. Dissolved oxygen measured in surface waters of F.E. Walter Reservoir at station WA-2 during 2002. The PADEP water quality standard for DO is a minimum concentration of 5 mg/L. See Appendix A for a summary of the plotted values.

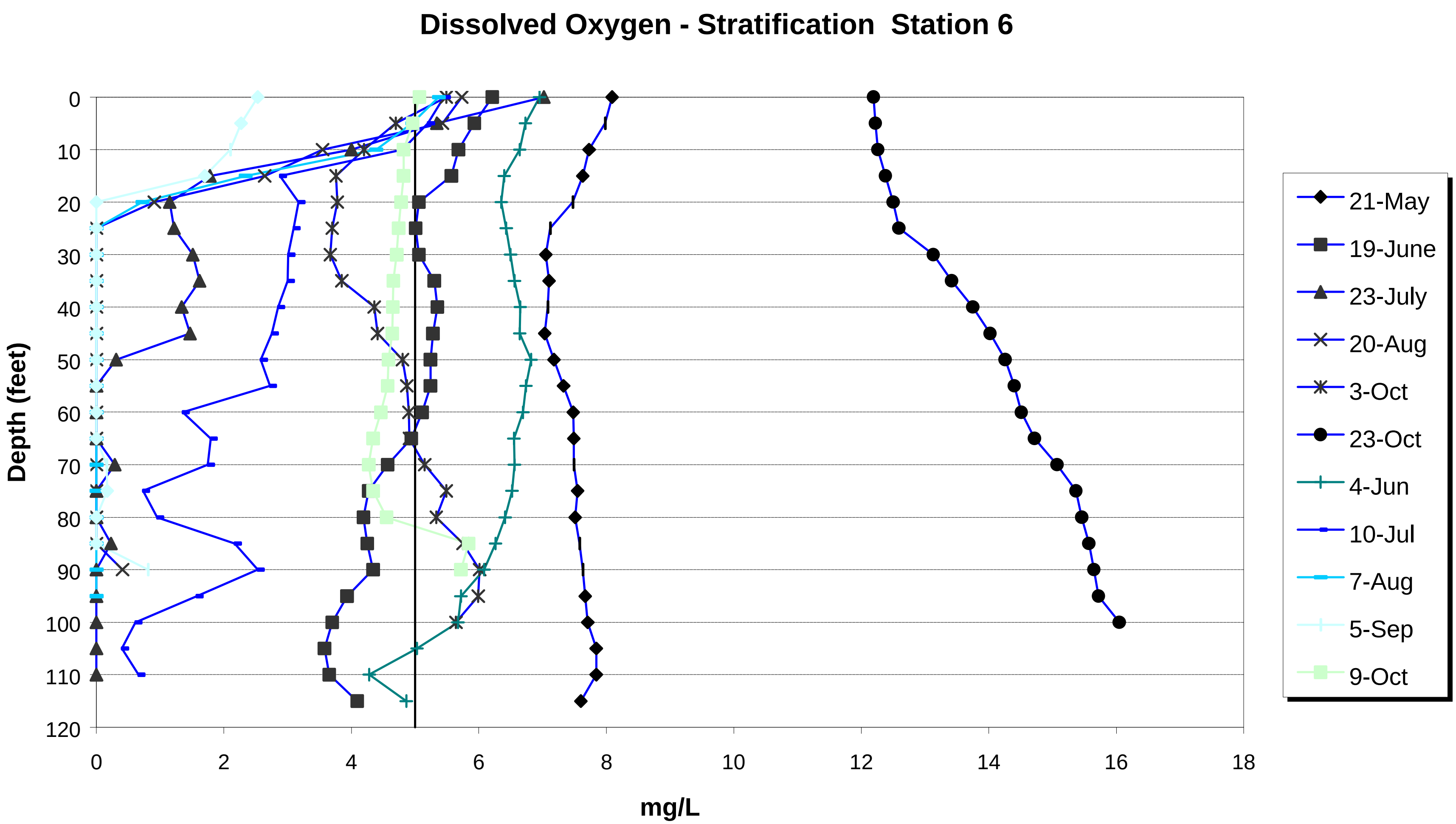

Figure 3-9. Dissolved oxygen measured in surface waters of F.E. Walter Reservoir at station WA-6 during 2002. The PADEP water quality standard for DO is a minimum concentration of 5 mg/L. See Appendix A for a summary of the plotted values.

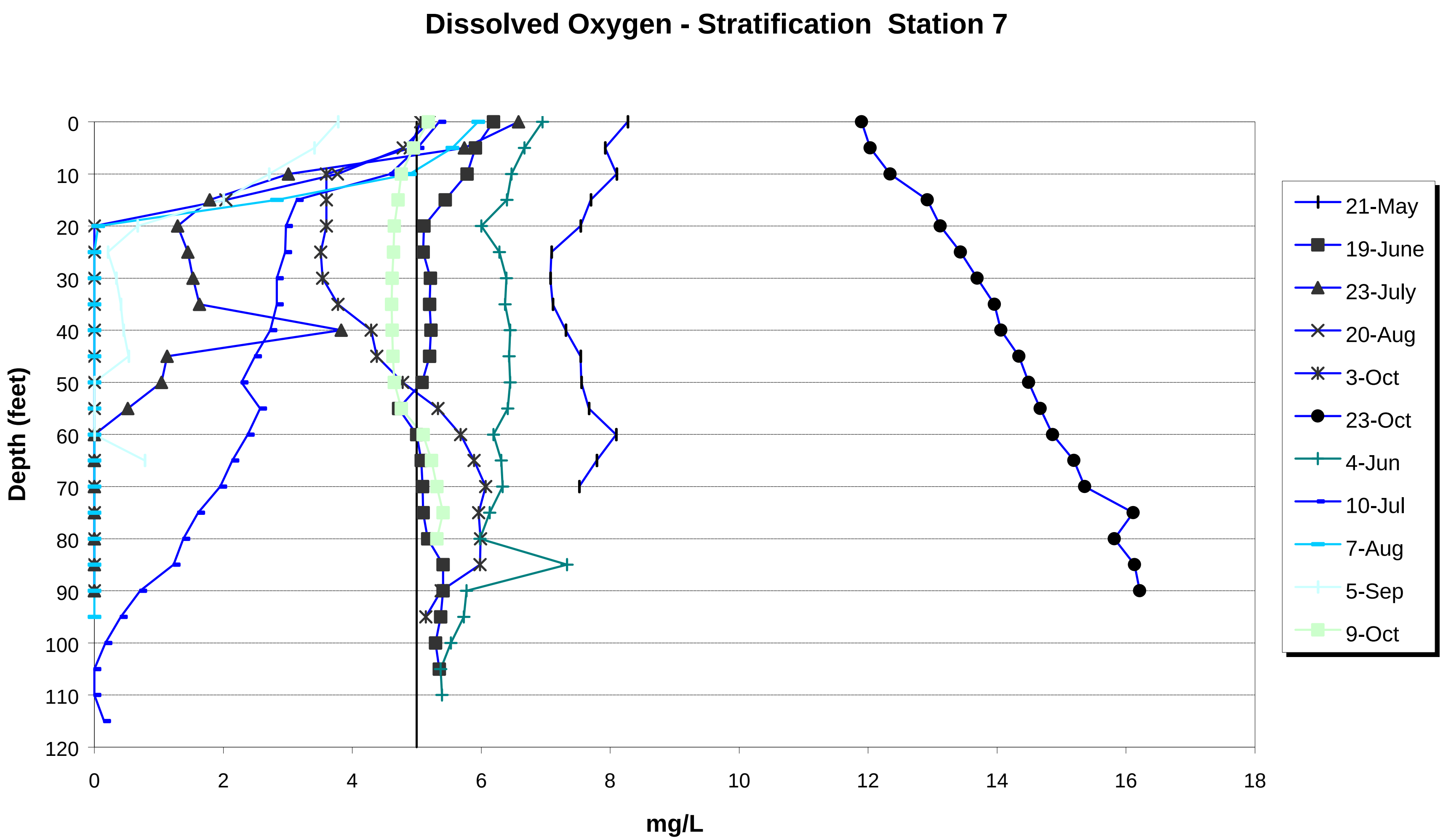

Figure 3-10. Dissolved oxygen measured in surface waters of F.E. Walter Reservoir at station WA-7 during 2002. The PADEP water quality standard for DO is a minimum concentration of 5 mg/L. See Appendix A for a summary of the plotted values.

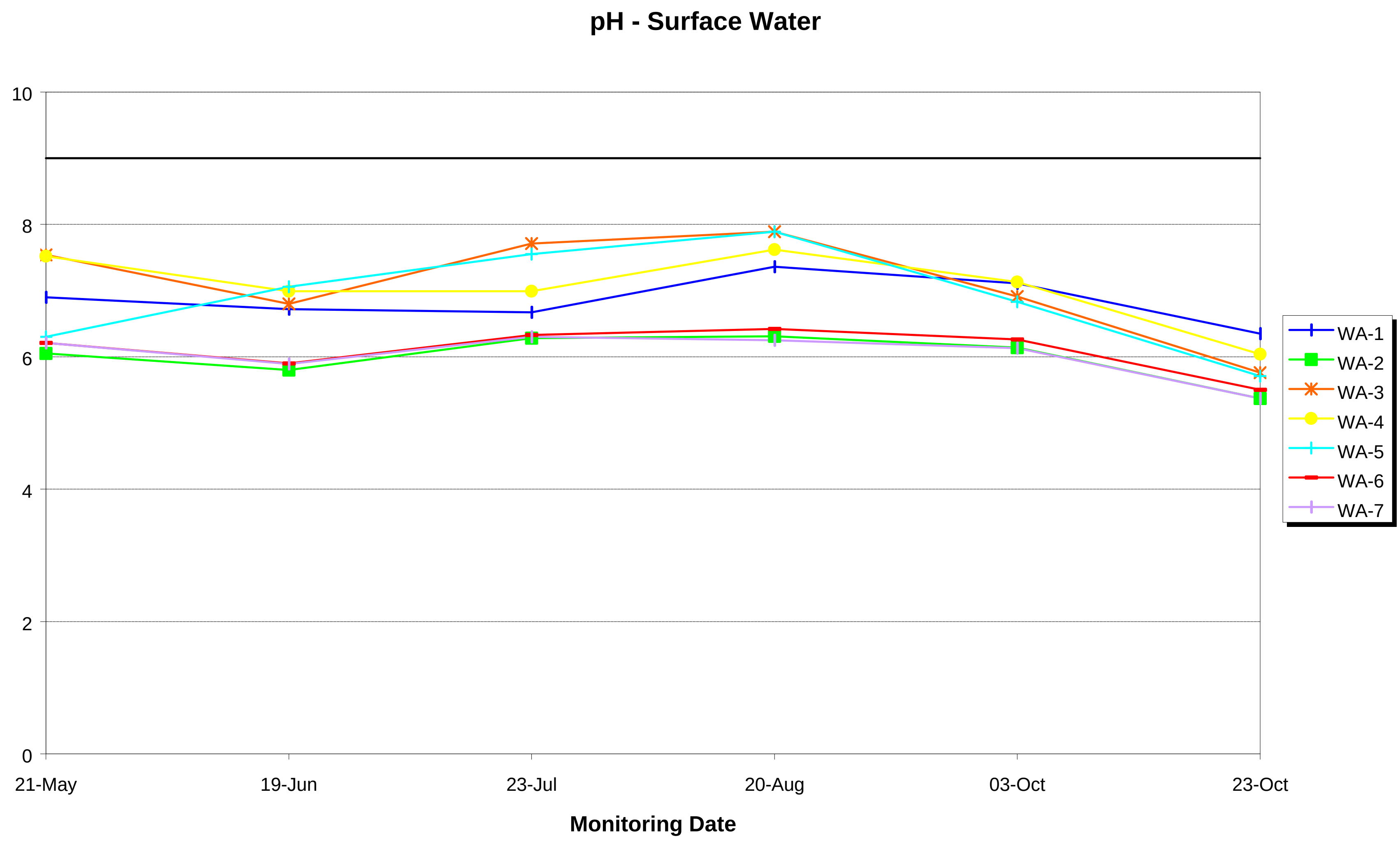

Figure 3-11. Measures of pH in surface waters of F.E. Walter Reservoir during 2002. The PADEP water quality standard for pH is an acceptable range from 6 to 9. See Appendix A for a summary of the plotted values.

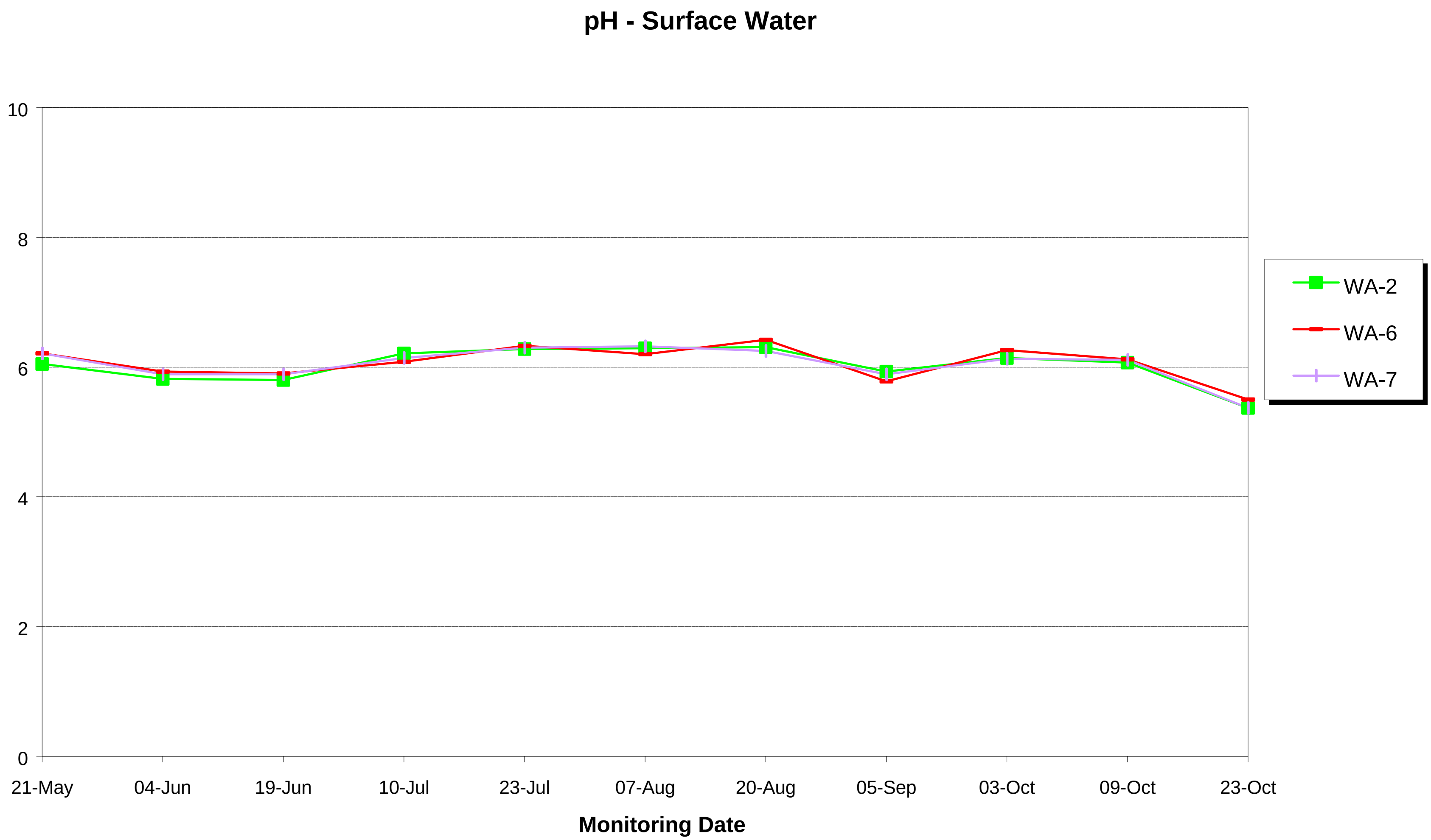

Figure 3-12. Measures of pH in surface waters of F.E. Walter Reservoir during 2002. The PADEP water quality standard for pH is an acceptable range from 6 to 9. See Appendix A for a summary of the plotted values.

downstream of the reservoir (WA-1) and the upstream stations (WA-3, -4, and –5) were consistently higher and averaged 7.0 (Fig. 3-11).

Table 3-1. Seasonal trends of dissolved oxygen concentration at individual stations of F.E. Walter Reservoir calculated with the Mann-Kendall Statistic.

Station	# of Years Spring/Summer	Spring		Summer	
		P Level	Rate (mg/L)	P Level	Rate (mg/L)
Surface Water					
WA-1	27	NS	0.0033	NS	-0.0411
WA-2	28	P < 0.05	-0.0466	NS	-0.0514
WA-3	27	NS	-0.0177	NS	-0.0251
WA-4	28	NS	-0.0237	NS	-0.0288
WA-5	24	NS	-0.0303	P < 0.05	-0.0895

The water column of F.E. Walter Reservoir was weakly stratified with respect to pH during 2002. On most monitoring dates, measures of pH were relatively uniform throughout the water column (Figs. 3-13 though 3-15). On October 3, pH was highest and averaged about 6.21. On October 23, pH was lowest averaging 5.2 and ranged from 5.1 to 5.5.

During 2002, all measures of pH in the water column of F.E. Walter Reservoir were not in compliance with PADEP water quality standards. The water quality standard for pH is a range of acceptable measures between 6 and 9. Stations WA-3 and WA-5 were below the standard on October 23. Stations WA-2, -6, and –7 were below the standard throughout the monitoring period with the exception of May 22 and August 20.

3.1.4 Conductivity

For the most part, conductivity among the surface waters of F.E. Walter Reservoir followed a fairly consistent pattern during 2002. Conductivity at all stations averaged 0.075-mS/cm throughout the monitoring period and ranged from 0.01 to 0.15-mS/cm (Figs. 3-15 and 3-16). Conductivity was typically higher upstream of the reservoir at stations WA-4 and WA-5. At these locations, conductivity averaged 0.095-mS/cm.

Conductivity in the water column of F.E. Walter Reservoir was weakly stratified during 2002. In most months, measures were generally uniform throughout, but followed a slight increasing trend as the season progressed (Figs. 3-17 through 3-19). On June 4, conductivity was lowest at approximately 0.06-mS/cm. Thereafter, through October 9, conductivity increased on each monitoring date to an average of 0.09-mS/cm. On October 23, conductivity decreased to an average of 0.065-mS/cm.

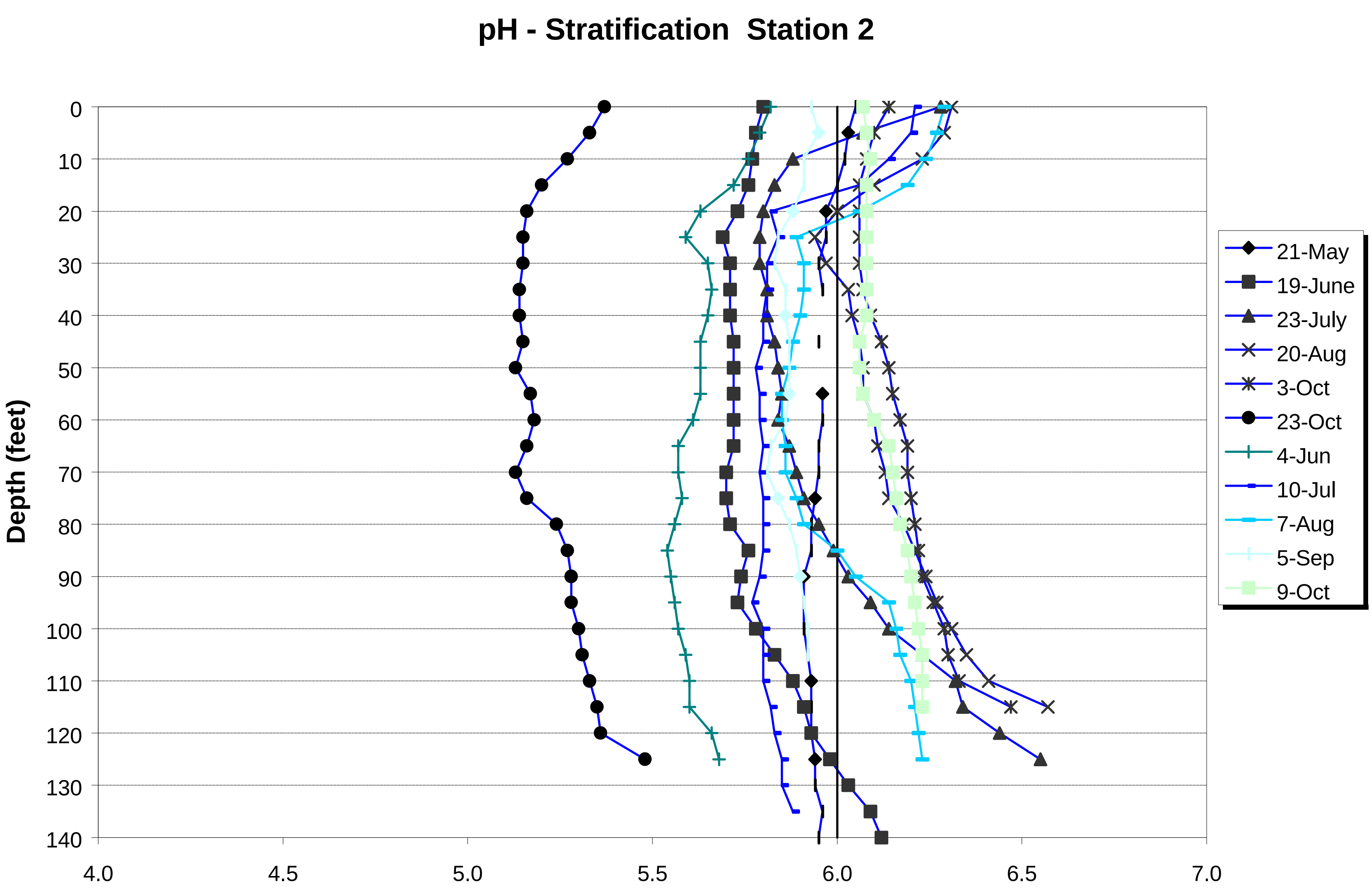

Figure 3-13. Stratification of pH measured in the water column of F.E. Walter Reservoir at station WA-2 during 2002. The PADEP water quality standard pH is an acceptable range from 6 to 9. See Appendix A for a summary of the plotted values.

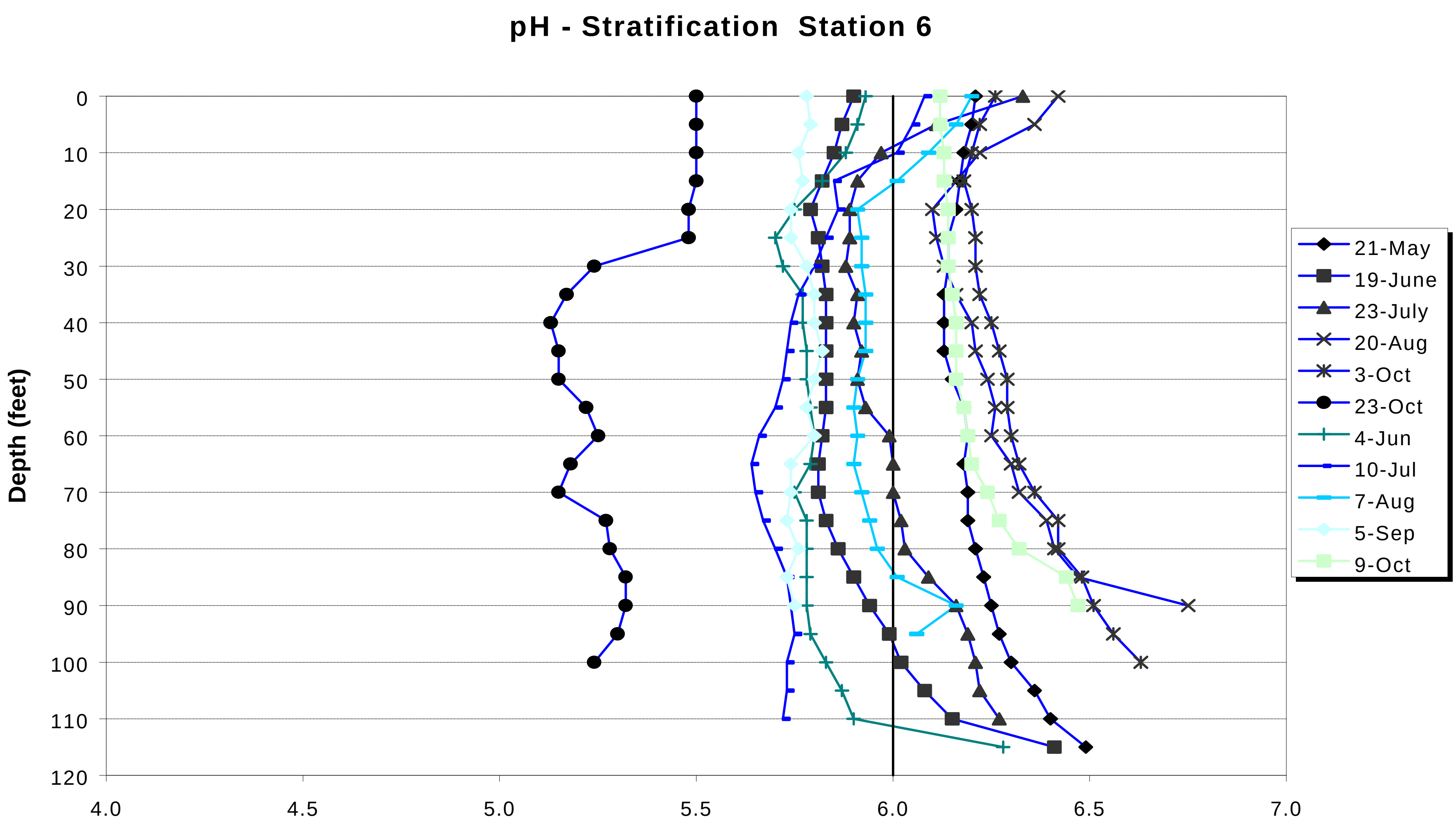

Figure 3-14. Stratification of pH measured in the water column of F.E. Walter Reservoir at station WA-6 during 2002. The PADEP water quality standard pH is an acceptable range from 6 to 9. See Appendix A for a summary of the plotted values.

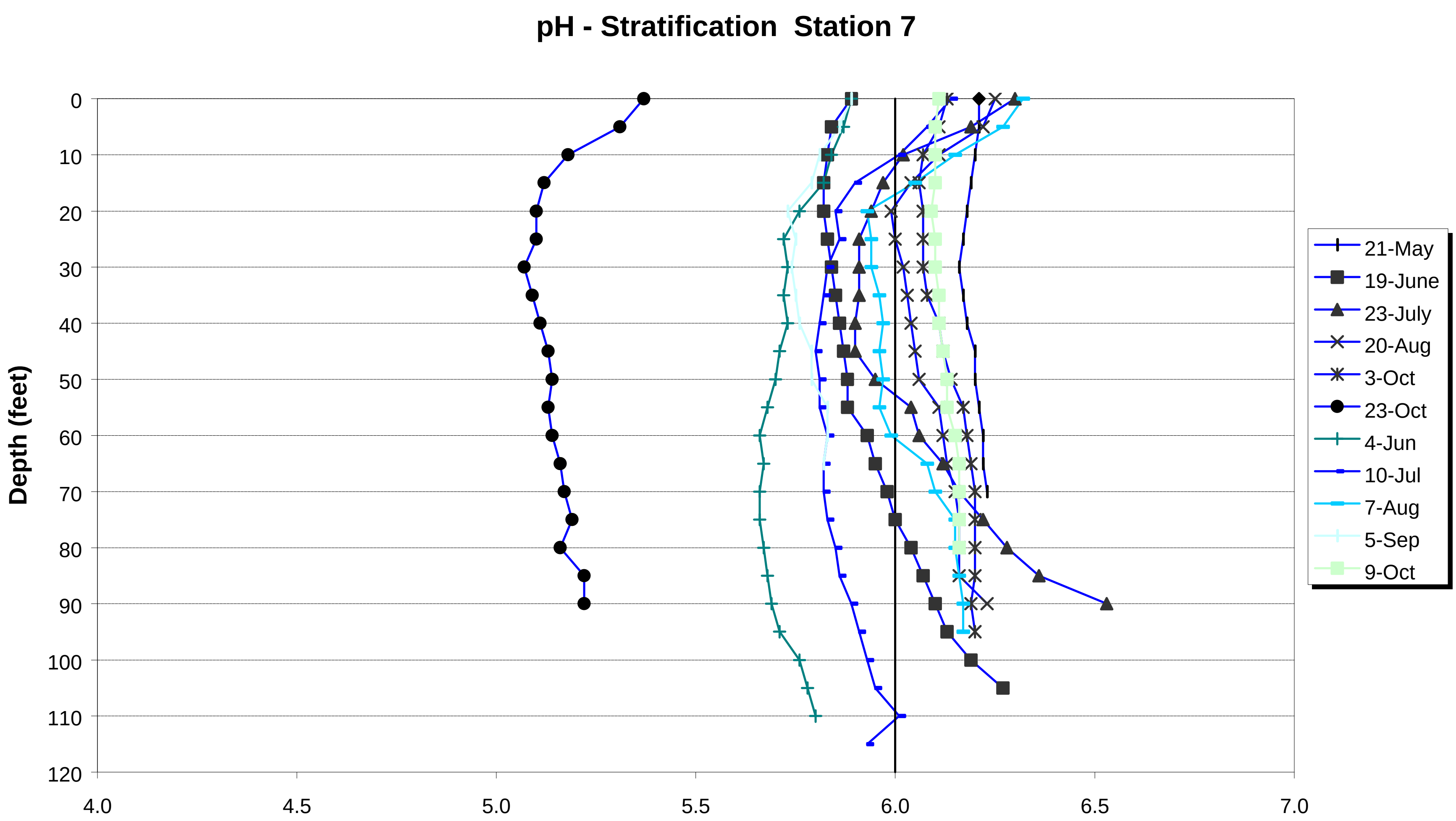

Figure 3-15. Stratification of pH measured in the water column of F.E. Walter Reservoir at station WA-7 during 2002. The PADEP water quality standard pH is an acceptable range from 6 to 9. See Appendix A for a summary of the plotted values.

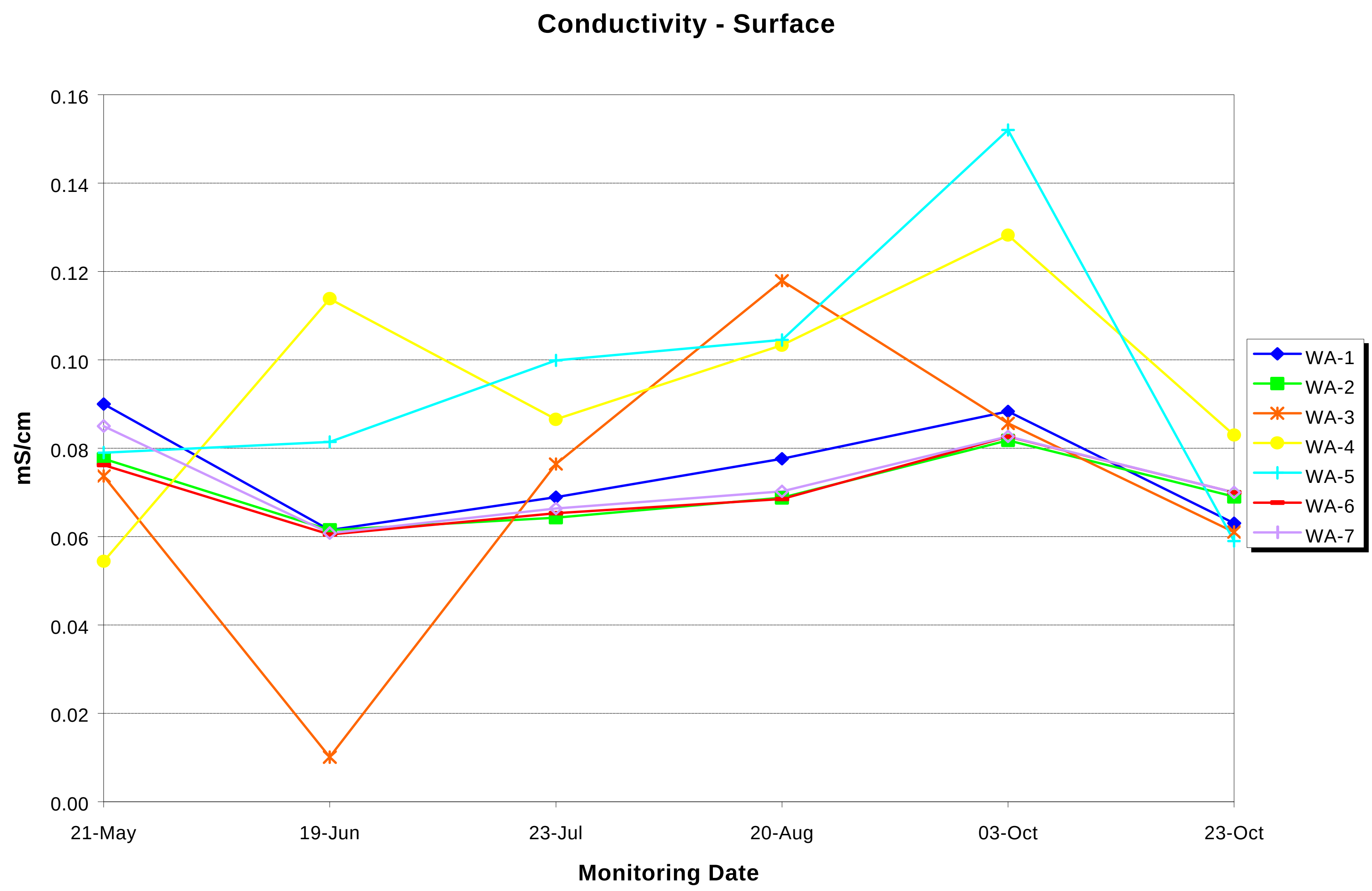

Figure 3-16. Conductivity measured in surface waters of F.E. Walter Reservoir during 2002. See Appendix A for a summary of the plotted values.

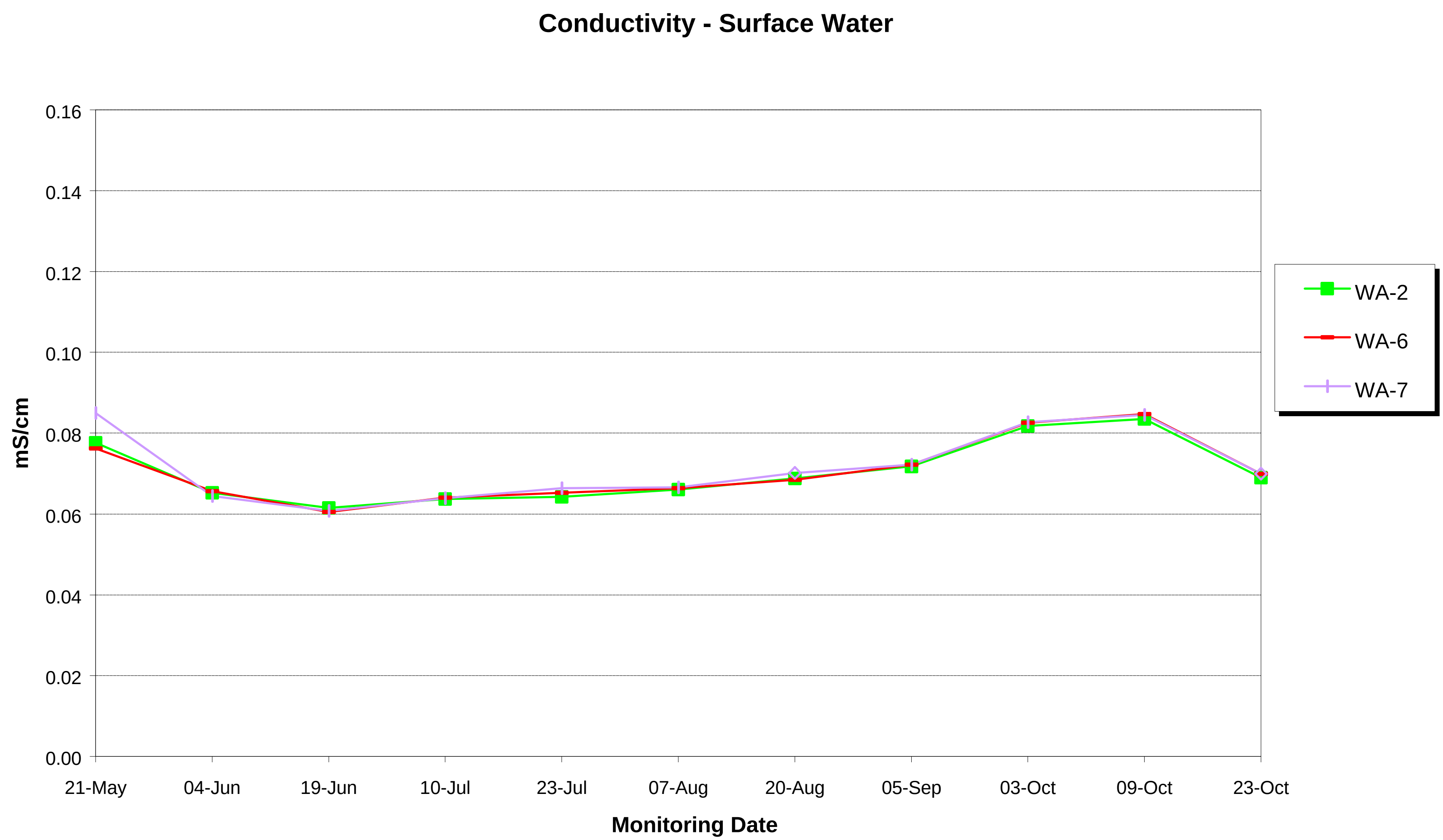

Figure 3-17. Conductivity measured in surface waters of F.E. Walter Reservoir during 2002. See Appendix A for a summary of the plotted values.

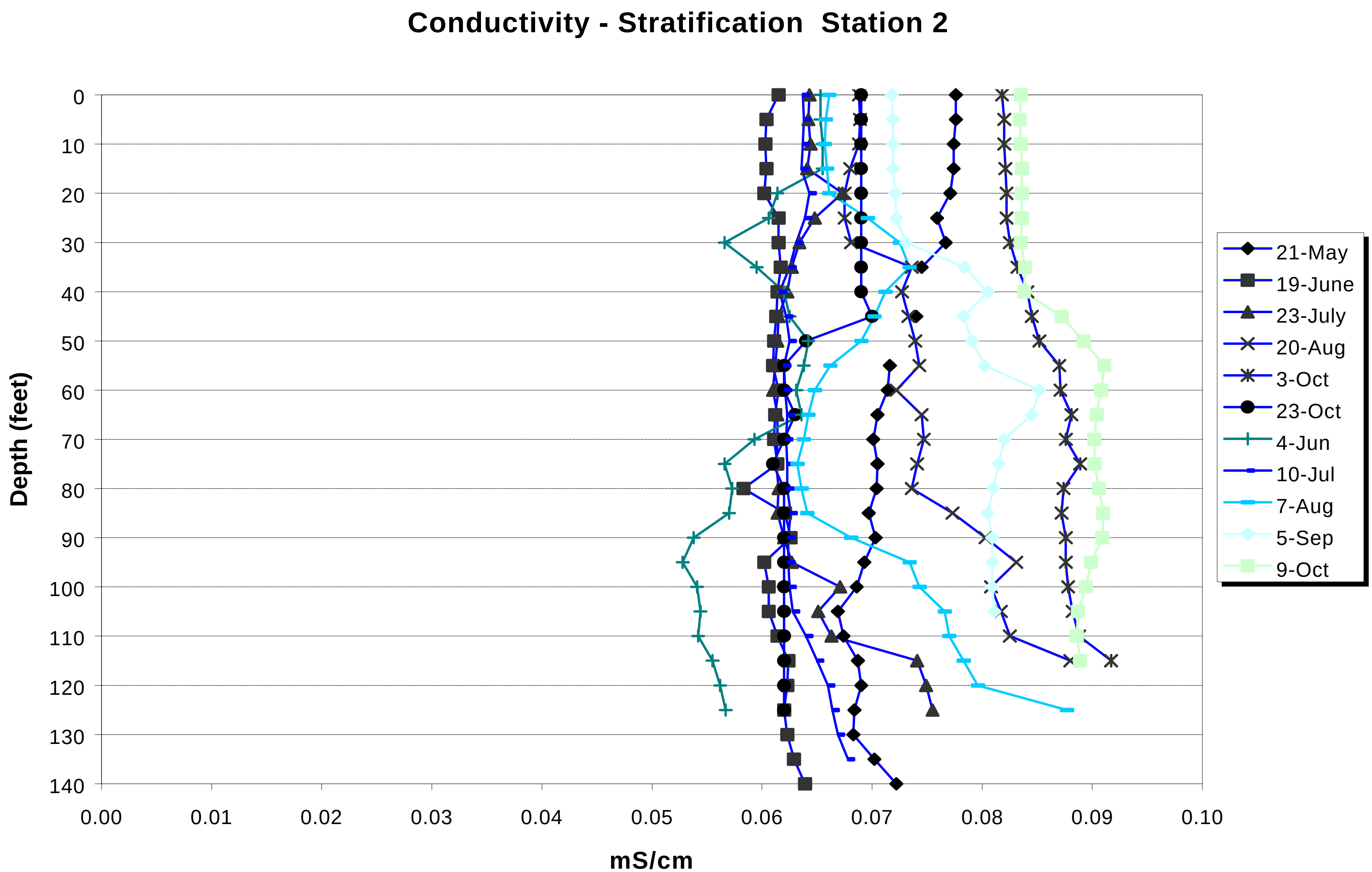

Figure 3-18. Stratification of conductivity measured in the water column of F. E. Walter Reservoir at station WA-2 during 2002. See Appendix A for a summary of the plotted values.

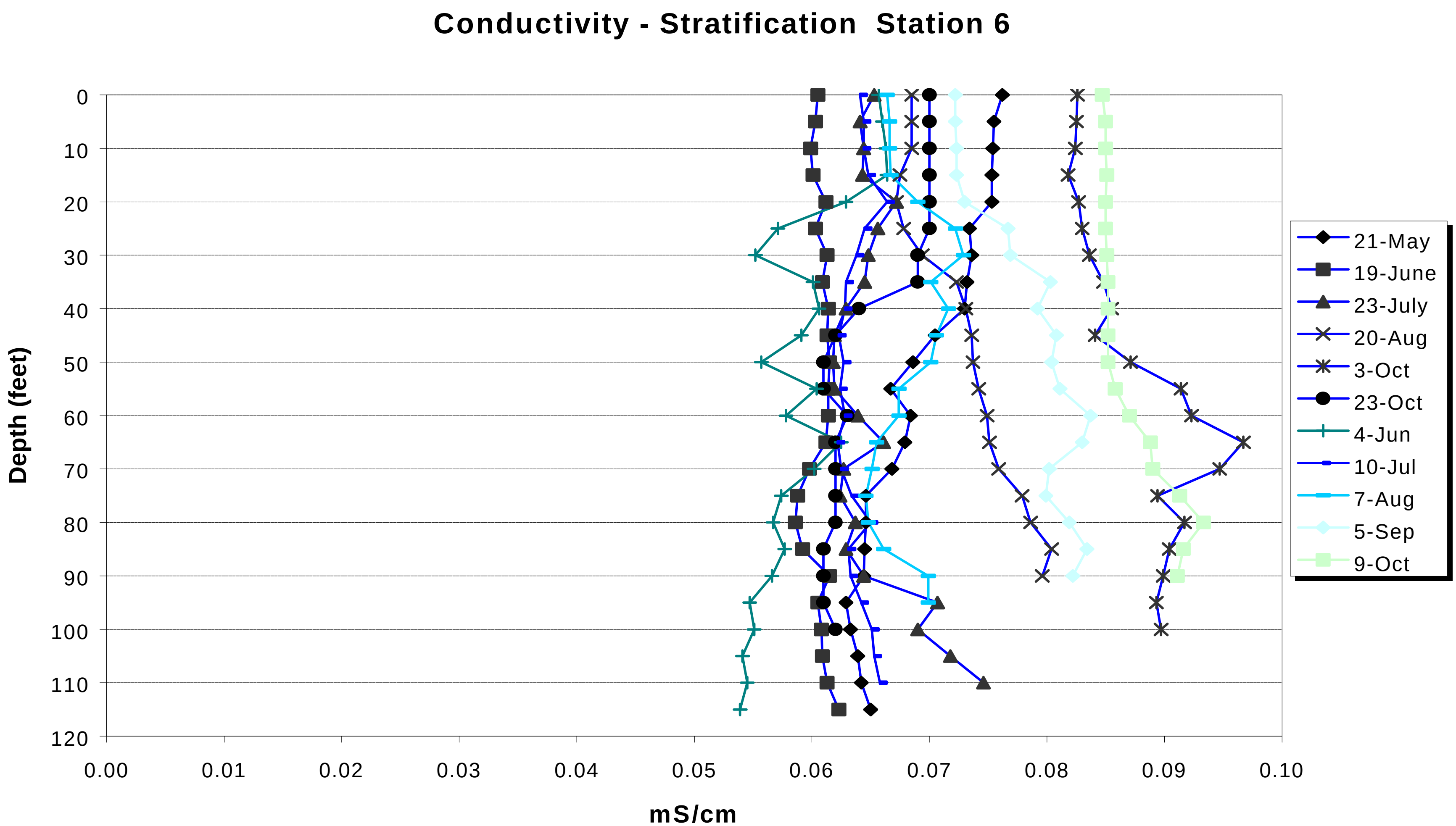

Figure 3-19. Stratification of conductivity measured in the water column of F. E. Walter Reservoir at station WA-6 during 2002. See Appendix A for a summary of the plotted values.

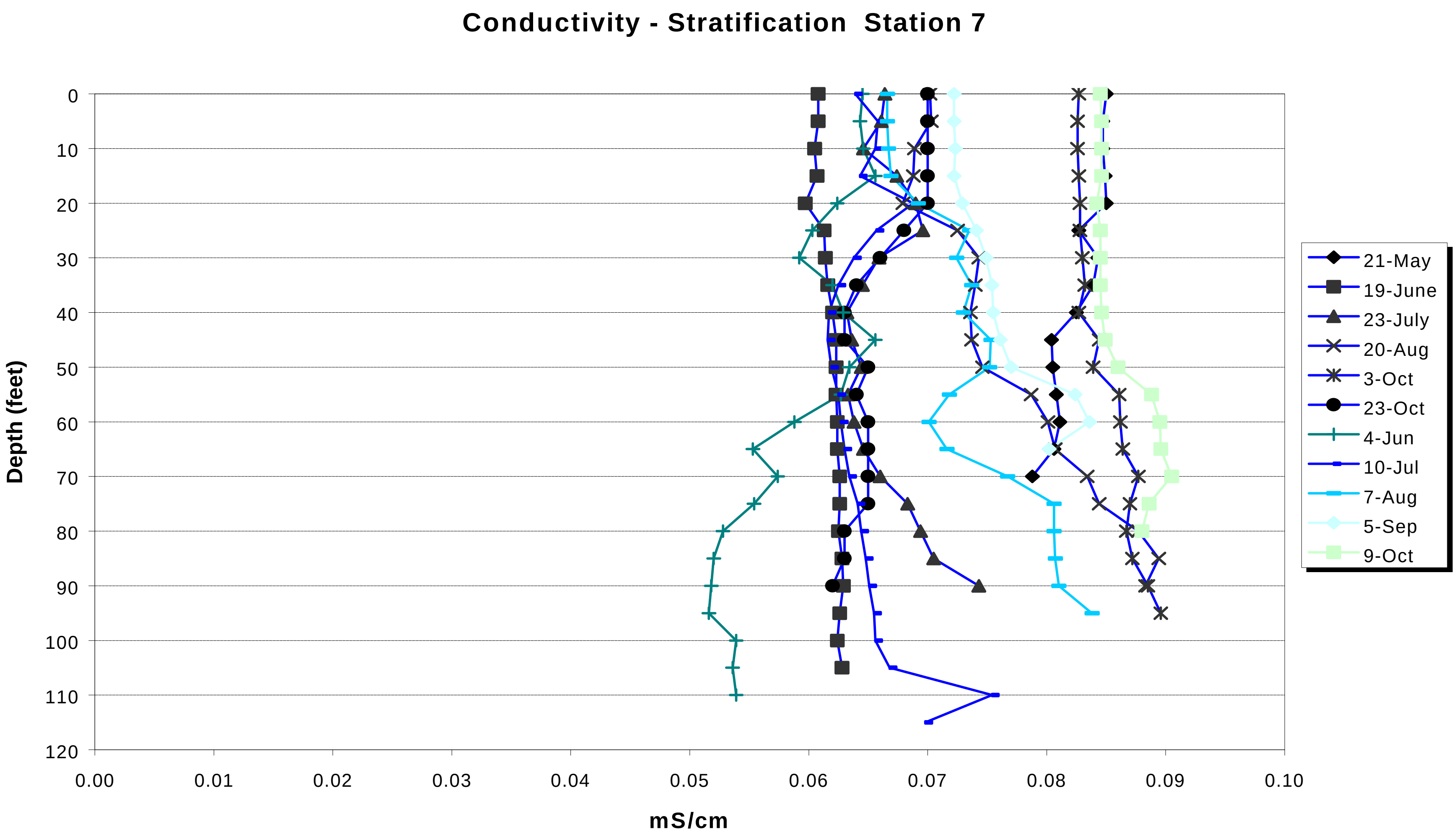

Figure 3-20. Stratification of conductivity measured in the water column of F. E. Walter Reservoir at station WA-7 during 2002. See Appendix A for a summary of the plotted values.

3.2 WATER COLUMN CHEMISTRY MONITORING

The following sections describe temporal, spatial, and depth related patterns for water quality measured in the water column of F.E. Walter Reservoir during 2002 (Table 3–2). Where appropriate, trends in surface water quality are discussed based on the regression and Mann-Kendall analysis of 2002 data and the F.E. Walter Reservoir water quality database.

3.2.1 Ammonia

Ammonia in the water column of F.E. Walter Reservoir was consistently low throughout the monitoring period (Fig. 3-21). Concentrations at most stations and depths averaged 0.1 mg/L. Measures of ammonia did not exceed 0.28-mg/L and ranged to less than the detection limit of 0.05-mg/L. In August the highest concentration was measured at downstream station WA-1. The concentration at WA-1 was 0.28-mg/L.

F.E. Walter Reservoir was in compliance with the PADEP water quality standard for ammonia during 2002. The water quality standard of ammonia is dependent on temperature and pH (Table 3-3). Throughout the monitoring period, all measures of ammonia were less than their respective criteria values.

A seasonal trend analysis of ammonia was conducted for individual stations of F.E. Walter Reservoir, combining 2002 and historical data. The Mann-Kendall statistic was applied to station data collected over the past 24 years or more, separately for spring (April to June) and summer (July to October 3) seasons. Stations included in the analysis represented locations downstream (WA-1), within the main reservoir (WA-2), and upstream sources on Tobyhanna Creek (WA-3), Lehigh River (WA-4), and Bear Creek (WA-5).

Ammonia concentrations appear to have decreased throughout the reservoir drainage area during both seasons. All but one of the stations, WA-5, had significant trends and reflected yearly decreases ranging from 0.001 to 0.006 mg/L (Table 3-4). In general, summer rates of decrease appeared to be slightly higher than for spring. The widespread trends appear to be driven by higher concentrations detected in the late 1970s; subsequently, most concentrations have been consistently lower at about 0.01 mg/L.

Table 3-2. Summary of surface, middle, and bottom water quality monitoring data for F.E. Walter Reservoir in 2002

STATION	DATE	NH3	NO2	NO3	PO4	TKN	TP	TDS	TSS	BOD 5	ALK	DISS P	TOC	TIC	TC	CHLA
WA-1S	21-May	0.05	< 0.01	0.45	0.04	0.3	0.02	28	8	2	4	0.01	5	1	6	1.9
	19-Jun	0.11	< 0.01	<0.05	0.07	0.5	0.02	40	< 1	<2	4	0.02	6	2	8	1.95
	23-Jul	0.06	< 0.01	<0.05	0.06	1.6	0.03	42	1	2	6	0.02	7	<1	8	0.61
	20-Aug	0.28	< 0.01	<0.05	0.07	0.9	0.03	38	< 1	2	8	0.02	6	4	9	2.97
	03-Oct	0.16	< 0.01	0.27	0.05	0.7	0.04	56	4	<2	4	0.02	7	2	9	3.3
	23-Oct	0.11	< 0.01	0.25	0.03	0.58	0.01	58	< 1	2	2	0.01	6	1	7	2.28
Mean		0.13	0.010	0.19	0.05	0.76	0.03	43.7	2.7	2.0	4.7	0.0	6.2	1.8	7.8	2.2
Maximum		0.28	0.010	0.45	0.07	1.60	0.04	58.0	8.0	2.0	8.0	0.0	7.0	4.0	9.0	3.3
Minimum		0.05	0.010	0.05	0.03	0.30	0.01	28.0	1.0	2.0	2.0	0.0	5.0	1.0	6.0	0.6
Std. Dev		0.08	0.000	0.17	0.02	0.46	0.01	11.4	2.9	0.0	2.1	0.0	0.8	1.2	1.2	0.9
No. of D		6	0	3	6	6	6	6	3	4	6	6	6	5	6	6
WA-2S	21-May	<0.05	< 0.01	0.7	0.09	0.8	0.03	90	3	<2	4	0.03	4	<1	5	1.69
	19-Jun	0.09	< 0.01	<0.05	0.05	1.1	0.01	44	2	<2	4	0.02	5	1	6	3.88
	23-Jul	0.11	< 0.01	<0.05	< 0.01	1.3	0.01	41	2	<2	2	<0.01	7	<1	8	1.48
	20-Aug	0.1	< 0.01	<0.05	0.04	0.7	0.02	39	2	<2	4	0.01	6	2	7	6.97
	03-Oct	0.17	< 0.01	<0.05	0.03	0.6	0.01	46	< 1	<2	4	0.01	6	2	8	1.82
	23-Oct	0.1	< 0.01	0.06	0.02	0.49	0.01	46	< 1	<2	2	0.01	4	2	6	3.3
Mean		0.10	0.010	0.16	0.04	0.83	0.02	51.0	1.8	2.0	3.3	0.0	5.3	1.5	6.7	3.2
Maximum		0.17	0.010	0.70	0.09	1.30	0.03	90.0	3.0	2.0	4.0	0.0	7.0	2.0	8.0	7.0
Minimum		0.05	0.010	0.05	0.01	0.49	0.01	39.0	1.0	2.0	2.0	0.0	4.0	1.0	5.0	1.5
Std. Dev		0.04	0.000	0.26	0.03	0.31	0.01	19.3	0.8	0.0	1.0	0.0	1.2	0.5	1.2	2.1
No. of D		5	0	2	5	6	6	6	4	0	6	4	6	4	6	6
WA-2M	21-May	<0.05	< 0.01	0.8	0.08	0.7	0.03	64	4	<2	1	0.03	5	<1	6	1.4
	19-Jun	0.08	< 0.01	<0.05	0.05	0.7	0.02	43	< 1	<2	4	0.02	6	2	7	8.8
	23-Jul	0.16	< 0.01	0.06	< 0.01	1	<0.01	52	< 1	<2	4	<0.01	8	1	9	3.95
	20-Aug	0.18	< 0.01	<0.05	0.05	1.1	0.03	38	< 1	2	6	0.01	5	4	9	1.4
	03-Oct	0.15	< 0.01	0.27	0.04	0.6	0.02	65	1	<2	4	0.01	7	<1	8	1.7
	23-Oct	0.08	< 0.01	0.06	0.03	0.44	0.01	56	1	<2	2	0.01	5	1	7	4.78
Mean		0.12	0.010	0.22	0.04	0.76	0.02	53.0	1.5	2.0	3.5	0.02	6.0	1.7	7.7	3.7
Maximum		0.18	0.010	0.80	0.08	1.10	0.03	65.0	4.0	2.0	6.0	0.03	8.0	4.0	9.0	8.8
Minimum		0.05	0.010	0.05	0.01	0.44	0.01	38.0	1.0	2.0	1.0	0.01	5.0	1.0	6.0	1.4
Std. Dev		0.05	0.000	0.30	0.02	0.25	0.01	11.0	1.2	0	1.8	0.01	1.3	1.2	1.2	2.9
No. of D		5	0	4	5	6	5	6	3	1	6	4	6	4	6	6
WA-2B	21-May	<0.05	< 0.01	0.6	0.08	0.6	0.03	76	3	<2	3	0.03	5	<1	5	2.45
	19-Jun	0.09	< 0.01	<0.05	0.04	0.7	0.02	52	3	<2	2	0.01	6	2	8	4.15
	23-Jul	0.14	< 0.01	<0.05	0.03	1.3	0.02	54	3	3	2	0.01	10	2	12	4.74
	20-Aug	0.21	< 0.01	<0.05	0.08	1.2	0.03	51	5	2	4	0.03	5	5	10	4.1
	03-Oct	0.14	< 0.01	<0.05	0.05	0.7	0.03	52	3	<2	6	0.02	8	<1	9	5.38
	23-Oct	0.06	< 0.01	0.26	0.03	0.44	0.01	63	1	<2	4	0.01	1	6	8	1.79
Mean		0.12	0.010	0.18	0.05	0.82	0.02	58.0	3.0	2.2	3.5	0.02	5.8	2.8	8.7	3.8
Maximum		0.21	0.010	0.60	0.08	1.30	0.03	76.0	5.0	3.0	6.0	0.03	10.0	6.0	12.0	5.4
Minimum		0.05	0.010	0.05	0.03	0.44	0.01	51.0	1.0	2.0	2.0	0.01	1.0	1.0	5.0	1.8
Std. Dev		0.06	0.000	0.22	0.02	0.35	0.01	9.9	1.3	0.4	1.5	0.01	3.1	2.1	2.3	1.4
No. of D		5	0	2	6	6	6	6	6	2	6	5	6	4	6	6
WA-3S	21-May	<0.05	< 0.01	0.6	0.09	0.6	0.03	76	2	<2	3	0.03	7	2	8	5.24
	19-Jun	0.07	< 0.01	<0.05	0.04	1.1	0.02	48	2	<2	6	0.01	7	1	8	2.59
	23-Jul	0.11	< 0.01	0.11	0.03	1.9	0.01	47	2	2	6	0.01	6	<1	7	3.3
	20-Aug	0.1	< 0.01	0.13	0.05	0.7	0.02	45	< 1	2	6	0.02	3	2	5	2.67
	03-Oct	0.13	< 0.01	<0.05	0.02	0.7	0.02	53	1	<2	4	0.01	8	1	9	0.82
	23-Oct	0.05	< 0.01	0.43	0.03	0.45	0.02	56	< 1	<2	2	0.01	9	<1	9	1.77
Mean		0.09	0.010	0.23	0.04	0.91	0.02	54.2	1.5	2.0	4.5	0.02	6.7	1.3	7.7	2.7
Maximum		0.13	0.010	0.60	0.09	1.90	0.03	76.0	2.0	2.0	6.0	0.03	9.0	2.0	9.0	5.2
Minimum		0.05	0.010	0.05	0.02	0.45	0.01	45.0	1.0	2.0	2.0	0.01	3.0	1.0	5.0	0.8
Std. Dev		0.03	0.000	0.23	0.03	0.53	0.01	11.4	0.5	0.0	1.8	0.01	2.1	0.5	1.5	1.5
No. of D		5	0	4	6	6	6	6	4	2	6	5	6	4	6	6

Table 3-2. (Continued)																
STATION	**DATE**	**NH3**	**NO2**	**NO3**	**PO4**	**TKN**	**TP**	**TDS**	**TSS**	**BOD 5**	**ALK**	**DISS P**	**TOC**	**TIC**	**TC**	**CHLA**
WA-4S	21-May	<0.05	< 0.01	0.5	0.09	0.5	0.03	76	9	2	4	0.03	5	2	7	1.1
	19-Jun	0.09	< 0.01	< 0.05	0.05	0.9	0.02	65	1	<2	4	0.02	6	7	13	1.8
	23-Jul	<0.05	0.22	< 0.05	0.07	1.7	0.03	64	2	<2	6	0.02	5	<1	5	0.85
	20-Aug	<0.05	< 0.01	0.07	0.07	0.6	0.02	62	< 1	3	10	0.02	2	2	4	3.92
	03-Oct	0.12	< 0.01	0.28	0.1	0.4	0.09	52	< 1	<2	12	0.03	5	1	6	0.83
	23-Oct	0.05	< 0.01	0.13	0.01	0.36	0.01	55	< 1	<2	2	<0.01	5	<1	6	3.79
Mean		0.07	0.045	0.18	0.07	0.74	0.03	62.3	2.5	2.2	6.3	0.02	4.7	2.3	6.8	2.0
Maximum		0.12	0.220	0.50	0.10	1.70	0.09	76.0	9.0	3.0	12.0	0.03	6.0	7.0	13.0	3.9
Minimum		0.05	0.010	0.05	0.01	0.36	0.01	52.0	1.0	2.0	2.0	0.01	2.0	1.0	4.0	0.8
Std. Dev		0.03	0.086	0.18	0.03	0.51	0.03	8.5	3.2	0.4	3.9	0.01	1.4	2.3	3.2	1.4
No. of D		3	1	4	6	6	6	6	3	2	6	4	6	4	6	6
WA-5S	21-May	<0.05	< 0.01	0.49	0.06	0.4	0.03	24	2	<2	<1	0.02	3	<1	4	1.7
	19-Jun	0.09	< 0.01	< 0.05	0.05	0.9	0.02	58	9	<2	2	0.02	5	1	6	3.08
	23-Jul	0.16	< 0.01	< 0.05	0.04	1.1	0.02	72	12	2	8	0.01	10	1	11	0.51
	20-Aug	0.07	< 0.01	< 0.05	0.11	1.2	0.05	78	4	2	10	0.04	9	4	13	5.01
	03-Oct	0.1	< 0.01	0.28	0.03	0.5	0.02	71	4	<2	4	0.01	7	1	8	9.76
	23-Oct	<0.05	< 0.01	< 0.05	0.02	0.35	0.01	56	2	<2	4	0.01	4	<1	5	1.82
Mean		0.09	0.010	0.16	0.05	0.74	0.03	59.8	5.5	2.0	4.8	0.02	6.3	1.5	7.8	3.6
Maximum		0.16	0.010	0.49	0.11	1.20	0.05	78.0	12.0	2.0	10.0	0.04	10.0	4.0	13.0	9.8
Minimum		0.05	0.010	0.05	0.02	0.35	0.01	24.0	2.0	2.0	1.0	0.01	3.0	1.0	4.0	0.5
Std. Dev		0.04	0.000	0.19	0.03	0.37	0.01	19.5	4.1	0.0	3.5	0.01	2.8	1.2	3.5	3.4
No. of D		4	0	2	6	6	6	6	6	2	5	6	6	4	6	6
WA-6S	21-May	0.1	< 0.01	0.5	0.09	0.6	0.03	74	5	<2	4	0.03	5	1	6	0.5
	19-Jun	0.13	< 0.01	< 0.05	0.05	1.3	0.02	39	1	2	4	0.01	6	<1	7	0.81
	23-Jul	0.1	< 0.01	< 0.05	< 0.01	2.9	0.01	35	< 1	<2	2	<0.01	7	<1	8	2
	20-Aug	0.07	< 0.01	< 0.05	0.94	0.7	0.02	35	< 1	2	4	0.31	5	2	7	18.45
	03-Oct	0.15	< 0.01	< 0.05	0.02	0.6	0.01	38	1	<2	4	0.01	6	1	7	1.62
	23-Oct	0.09	< 0.01	0.6	0.02	0.43	0.02	41	1	<2	<1	0.01	4	1	6	2.8
Mean		0.11	0.010	0.22	0.19	1.09	0.02	43.7	1.7	2.0	3.2	0.1	5.5	1.2	6.8	4.4
Maximum		0.15	0.010	0.60	0.94	2.90	0.03	74.0	5.0	2.0	4.0	0.3	7.0	2.0	8.0	18.5
Minimum		0.07	0.010	0.05	0.01	0.43	0.01	35.0	1.0	2.0	1.0	0.0	4.0	1.0	6.0	0.5
Std. Dev		0.03	0.000	0.26	0.37	0.94	0.01	15.0	1.6	0.0	1.3	0.1	1.0	0.4	0.8	7.0
No. of D		6	0	2	5	6	6	6	4	2	5	4	6	4	6	6
WA-6M	21-May	0.1	< 0.01	0.6	0.09	0.7	0.03	68	6	<2	4	0.03	5	1	6	0.95
	19-Jun	0.11	< 0.01	< 0.05	0.04	0.7	0.02	44	1	<2	6	0.01	6	2	7	1.19
	23-Jul	0.17	< 0.01	< 0.05	0.02	0.7	0.01	43	2	<2	4	<0.01	8	1	10	2.21
	20-Aug	0.09	< 0.01	< 0.05	0.08	0.9	0.02	39	< 1	<2	8	0.02	5	4	9	1.81
	03-Oct	0.15	< 0.01	0.26	0.04	0.7	0.02	63	2	<2	6	0.01	7	<1	7	5
	23-Oct	0.09	< 0.01	0.07	0.02	0.44	0.01	39	< 1	<2	2	0.01	4	2	6	1.15
Mean		0.12	0.010	0.18	0.05	0.69	0.02	49.3	2.2	2.0	5.0	0.02	5.8	1.8	7.5	2.1
Maximum		0.17	0.010	0.60	0.09	0.90	0.03	68.0	6.0	2.0	8.0	0.03	8.0	4.0	10.0	5.0
Minimum		0.09	0.010	0.05	0.02	0.44	0.01	39.0	1.0	2.0	2.0	0.01	4.0	1.0	6.0	1.0
Std. Dev		0.03	0.000	0.22	0.03	0.15	0.01	12.8	1.9	0.0	2.1	0.0	1.5	1.2	1.6	1.5
No. of D		6	0	3	6	6	6	6	4	0	6	4	6	5	6	6
WA-6B	21-May	<0.05	< 0.01	0.5	0.09	1.5	0.03	54	4	<2	2	0.03	4	1	5	0.52
	19-Jun	0.13	< 0.01	< 0.05	0.05	0.8	0.02	49	4	<2	4	0.02	5	2	7	5.71
	23-Jul	0.19	< 0.01	< 0.05	0.06	0.7	0.03	50	40	2	6	0.02	10	2	12	1.8
	20-Aug	0.16	< 0.01	< 0.05	0.08	0.8	0.02	45	2	3	8	0.03	4	4	9	1.7
	03-Oct	0.13	< 0.01	< 0.05	0.05	0.8	0.02	42	5	<2	6	0.01	7	<1	8	2.5
	23-Oct	0.07	< 0.01	0.07	0.02	0.48	0.01	50	1	4	2	0.01	5	1	6	0.79
Mean		0.12	0.010	0.13	0.06	0.85	0.02	48.3	9.3	2.5	4.7	0.02	5.8	1.8	7.8	2.2
Maximum		0.19	0.010	0.50	0.09	1.50	0.03	54.0	40.0	4.0	8.0	0.03	10.0	4.0	12.0	5.7
Minimum		0.05	0.010	0.05	0.02	0.48	0.01	42.0	1.0	2.0	2.0	0.01	4.0	1.0	5.0	0.5
Std. Dev		0.05	0.000	0.18	0.02	0.34	0.01	4.2	15.1	0.8	2.4	0.01	2.3	1.2	2.5	1.9
No. of D		5	0	2	6	6	6	6	6	3	6	5	6	5	6	6

Table 3-2. (Continued)

STATION	DATE	NH3	NO2	NO3	PO4	TKN	TP	TDS	TSS	BOD5	ALK	DISS P	TOC	TIC	TC	CHLA
WA-7S	21-May	<0.05	< 0.01	0.6	0.09	0.1	0.03	72	7	<2	2	0.03	4	<1	5	1.91
	19-Jun	0.17	< 0.01	< 0.05	0.05	0.5	0.02	59	2	<2	4	0.02	5	1	7	2.34
	23-Jul	0.11	< 0.01	< 0.05	< 0.01	0.5	0.01	44	2	2	4	<0.01	7	<1	8	1.8
	20-Aug	<0.05	< 0.01	0.06	0.03	1	0.03	41	2	<2	6	0.01	6	1	7	1.39
	03-Oct	0.15	< 0.01	< 0.05	0.01	0.7	0.01	52	2	<2	4	<0.01	6	2	8	4.17
	23-Oct	0.06	< 0.01	0.11	0.02	0.83	0.01	37	< 1	<2	4	0.01	4	2	6	1.52
Mean		0.10	0.010	0.15	0.04	0.61	0.02	50.8	2.7	2.0	4.0	0.02	5.3	1.3	6.8	2.2
Maximum		0.17	0.010	0.60	0.09	1.00	0.03	72.0	7.0	2.0	6.0	0.03	7.0	2.0	8.0	4.2
Minimum		0.05	0.010	0.05	0.01	0.10	0.01	37.0	1.0	2.0	2.0	0.01	4.0	1.0	5.0	1.4
Std. Dev		0.05	0.000	0.22	0.03	0.31	0.01	13.0	2.2	0.0	1.3	0.01	1.2	0.5	1.2	1.0
No. of D		4	0	3	5	6	6	6	5	1	6	3	6	4	6	6
WA-7M	21-May	<0.05	< 0.01	0.5	0.09	0.3	0.03	88	< 1	<2	4	0.03	5	<1	5	1.35
	19-Jun	0.08	< 0.01	< 0.05	0.05	0.6	0.02	48	2	2	6	0.02	6	2	8	1.4
	23-Jul	0.1	< 0.01	0.05	0.12	0.4	0.01	52	2	<2	4	0.04	8	1	10	0.98
	20-Aug	0.09	< 0.01	< 0.05	0.04	1	0.02	35	2	<2	4	0.01	5	3	8	2.91
	03-Oct	0.14	< 0.01	< 0.05	0.01	0.6	0.01	38	1	<2	6	<0.01	6	1	8	3.33
	23-Oct	0.06	< 0.01	0.45	0.03	0.55	0.01	47	< 1	<2	4	0.01	5	2	7	3.99
Mean		0.09	0.010	0.19	0.06	0.58	0.02	51.3	1.5	2.0	4.7	0.02	5.8	1.7	7.7	2.3
Maximum		0.14	0.010	0.50	0.12	1.00	0.03	88.0	2.0	2.0	6.0	0.04	8.0	3.0	10.0	4.0
Minimum		0.05	0.010	0.05	0.01	0.30	0.01	35.0	1.0	2.0	4.0	0.01	5.0	1.0	5.0	1.0
Std. Dev		0.03	0.000	0.22	0.04	0.24	0.01	19.1	0.5	0.0	1.0	0.01	1.2	0.8	1.6	1.2
No. of D		5	0	3	6	6	6	6	4	1	6	4	6	5	6	6
WA-7B	21-May	<0.05	< 0.01	0.5	0.09	0.8	0.03	64	1	<2	5	0.03	6	1	7	5.9
	19-Jun	0.09	< 0.01	< 0.05	0.06	0.5	0.02	51	2	<2	6	0.02	7	2	9	0.71
	23-Jul	0.09	< 0.01	< 0.05	0.34	1.1	0.05	42	< 1	<2	4	0.11	11	2	12	1.34
	20-Aug	0.17	< 0.01	< 0.05	0.09	1.3	0.06	54	4	2	8	0.03	5	5	10	2.22
	03-Oct	0.12	< 0.01	< 0.05	0.04	0.6	0.01	49	5	<2	6	0.01	6	1	7	3.01
	23-Oct	0.06	< 0.01	0.1	0.02	0.8	0.01	57	< 1	<2	2	0.01	6	1	7	3.7
Mean		0.10	0.010	0.13	0.11	0.85	0.03	52.8	2.3	2.0	5.2	0.04	6.8	2.0	8.7	2.8
Maximum		0.17	0.010	0.50	0.34	1.30	0.06	64.0	5.0	2.0	8.0	0.11	11.0	5.0	12.0	5.9
Minimum		0.05	0.010	0.05	0.02	0.50	0.01	42.0	1.0	2.0	2.0	0.01	5.0	1.0	7.0	0.7
Std. Dev		0.04	0.000	0.18	0.12	0.30	0.02	7.5	1.8	0.0	2.0	0.04	2.1	1.5	2.1	1.9
No. of D		5	0	2	6	6	6	6	4	1	6	6	6	6	6	6

Table 3-3. PADEP ammonia nitrogen criteria (Pennsylvania Code, Title 25 1984). Specific ammonia criteria dependent on temperature and pH.

PH	0 °C	5 °C	10 °C	15 °C	20 °C	25 °C	30 °C
6.50	25.5	25.5	25.5	17.4	12.0	8.4	5.9
6.75	23.6	23.6	23.6	16.0	11.1	7.7	5.5
7.00	20.6	20.6	20.6	14.0	9.7	6.8	4.8
7.25	16.7	16.7	16.7	11.4	7.8	5.5	3.9
7.50	12.4	12.4	12.4	8.5	5.9	4.1	2.9
7.75	8.5	8.5	8.5	5.8	4.0	2.8	2.0
8.00	5.5	5.5	5.5	5.8	4.0	2.8	2.0
8.25	3.4	3.4	3.4	2.3	1.6	1.2	0.9
8.50	2.0	2.0	2.0	1.4	1.0	0.7	0.6
8.75	1.2	1.2	1.2	0.9	0.6	0.5	0.4
9.00	0.8	0.8	0.8	0.5	0.4	0.3	0.3

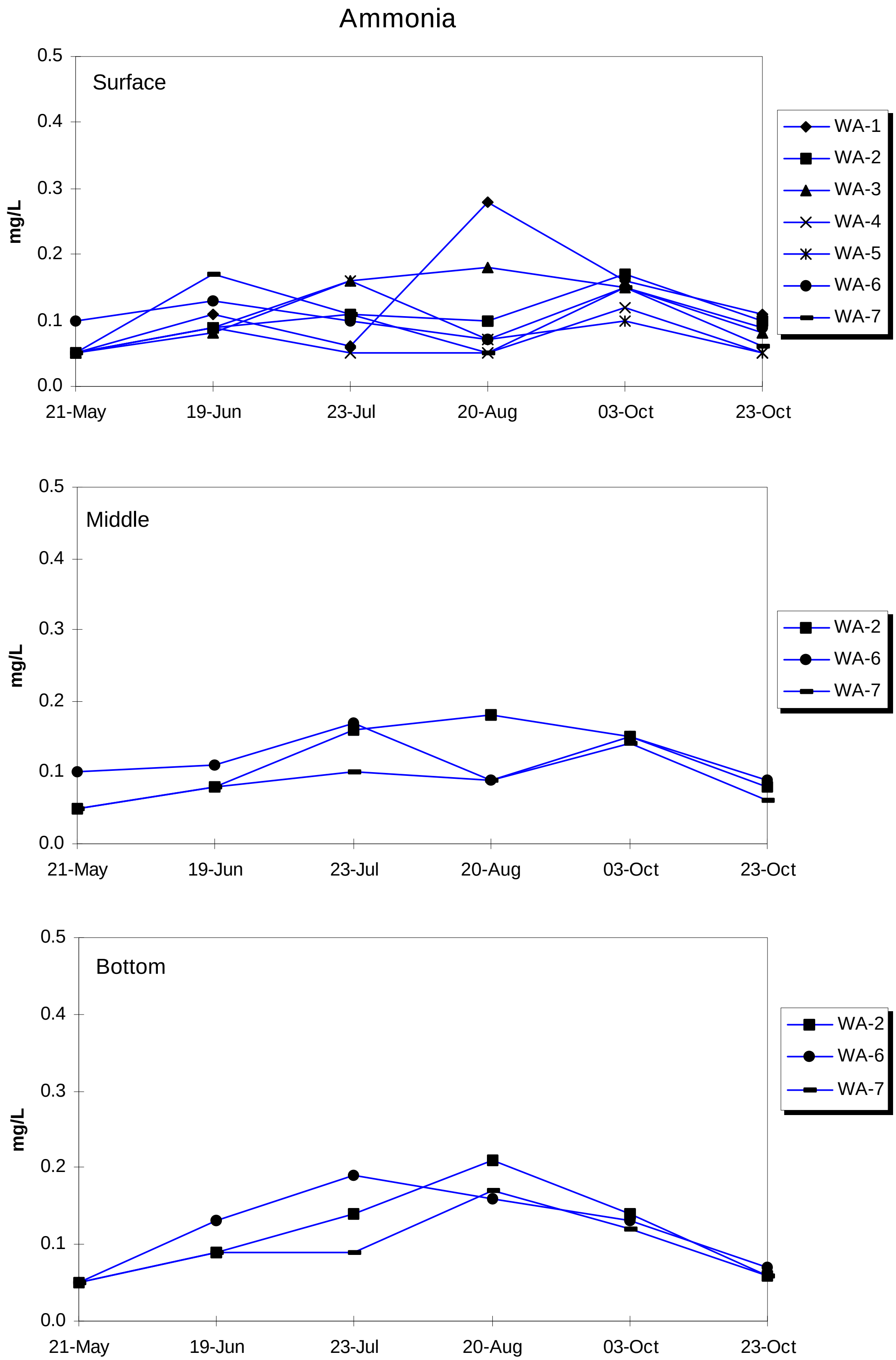

Figure 3-21. Ammonia measured in surface, middle, and bottom water of F. E. Walter Reservoir during 2002. The PADEP water quality standard for ammonia is dependent on temperature and pH.

Table 3-4. Seasonal trends of ammonia concentration at individual stations of F.E. Walter Reservoir calculated with the Mann-Kendall Statistic. Shaded values are significant (at least P < 0.05).					
Station	# of Years Spring/Summer	Spring		Summer	
		P Level	Rate (mg/)	P Level	Rate (mg/L)
Surface Water					
WA-1	27	< 0.05	-0.002	< 0.001	-0.006
WA-2	28	< 0.01	-0.003	< 0.01	-0.003
WA-3	27	< 0.01	-0.002	< 0.01	-0.002
WA-4	28	< 0.05	-0.001	< 0.001	-0.002
WA-5	24	NS	-0.001	NS	-0.0002

3.2.2 Nitrite and Nitrate

Concentrations of nitrite in the water column of F.E. Walter Reservoir were consistently low during 2002. With the exception of one sample, concentrations of nitrite measured at all stations and all depths were less than method detection limits (0.01-mg/L) throughout the monitoring period (Fig. 3-22). Station WA-4 in the surface waters had a nitrite concentration of 0.22-mg/L in July.

Nitrate was distributed uniformly in the water column of F.E. Walter Reservoir during 2002 (Fig. 3-23). At most stations and depths, concentrations ranged from less than the method detection limit (0.05-mg/L) to 0.8-mg/L. Overall, concentrations averaged 0.18-mg/L throughout the monitoring period. Concentrations of nitrate were higher in May and October averaging 0.3-mg/L and ranging from 0.05 to 0.8-mg/L.

In 2002, F.E. Walter Reservoir was in compliance with the PADEP water quality standard for nitrogen. The water quality standard for nitrogen is a summed concentration of nitrite and nitrate of less than 10-mg/L. Throughout the monitoring period, the summed concentrations for each station were less than 0.81-mg/L.

3.2.3 Total Inorganic Nitrogen

Concentrations of total inorganic nitrogen measured in 2002 and historical data collected from over the past 28 years were analyzed for seasonal trends (Figs. 3-24 and 3-25). The trend analysis was conducted for spring (April through June) and summer (July through October 3) periods, separately for stations representative of the reservoir and downstream. Concentrations of nitrogen have decreased in the reservoir and downstream during the summer (Fig. 3-25). Both regression lines were significant ($R^2 = 0.19$ and 0.15, respectively; $P < 0.05$), and corresponded to an average 10-year decrease of approximately

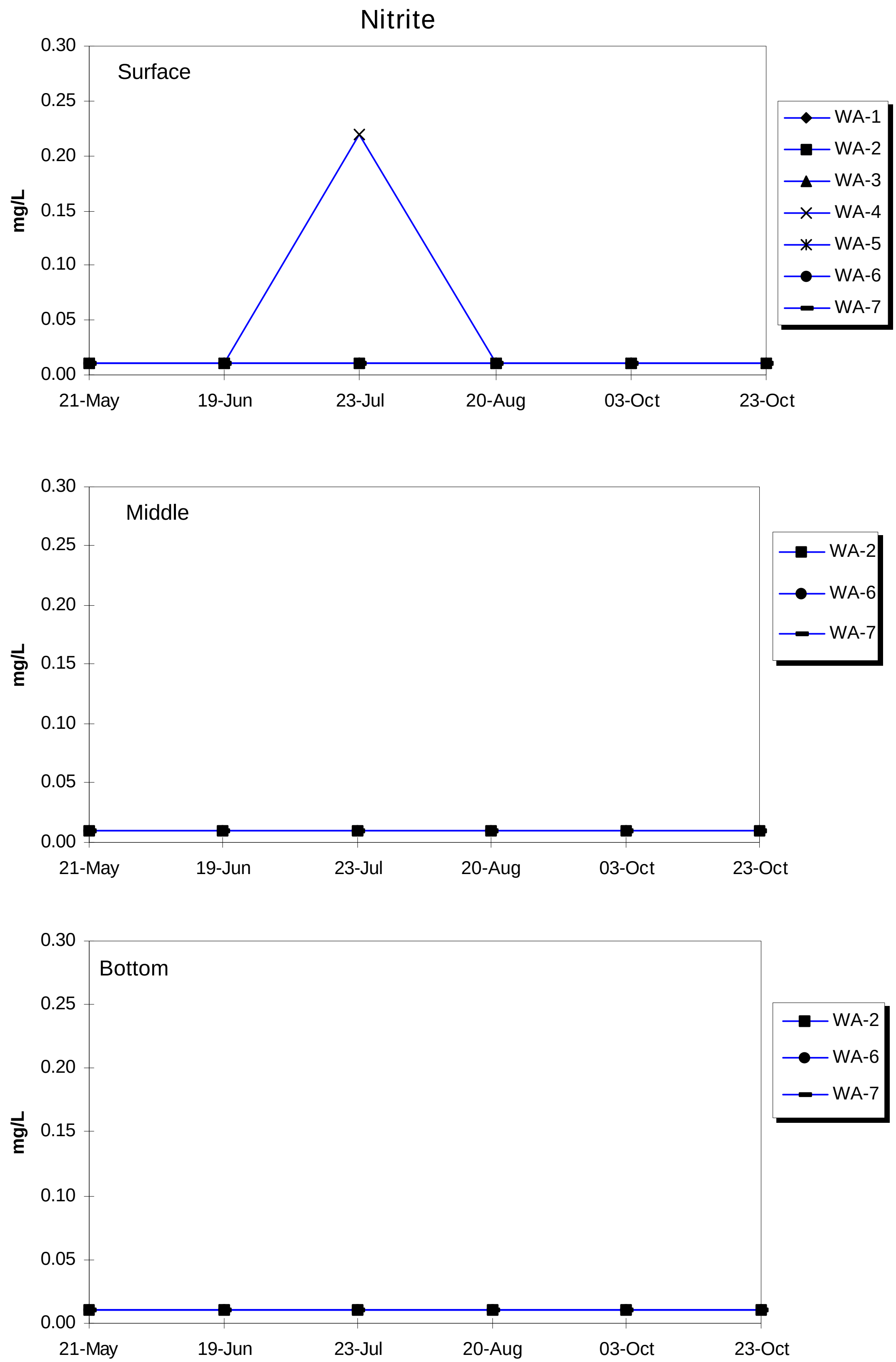

Figure 3-22. Nitrite measured in surface, middle, and bottom water of F. E. Walter Reservoir during 2002

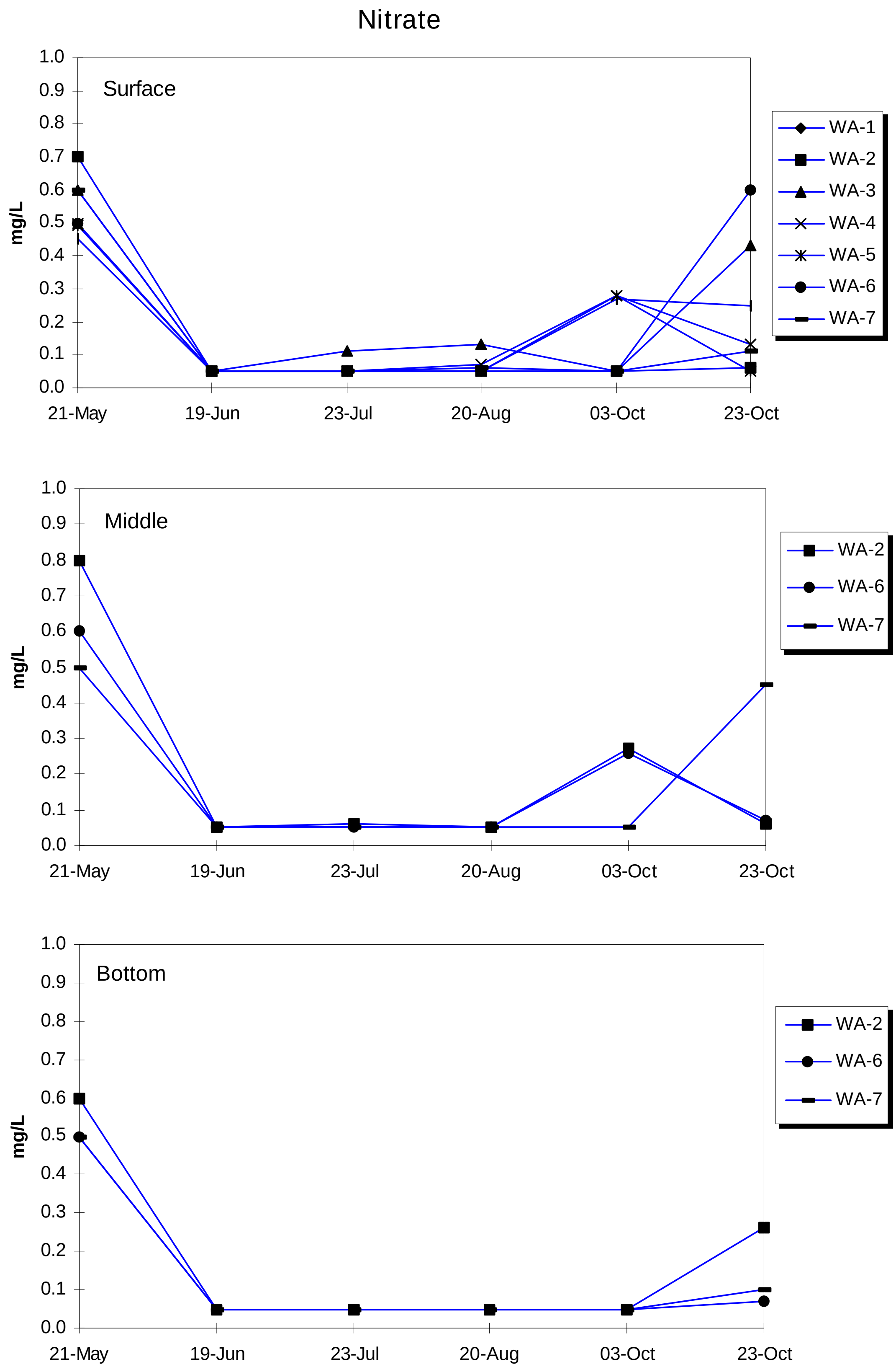

Figure 3-23. Nitrate measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002

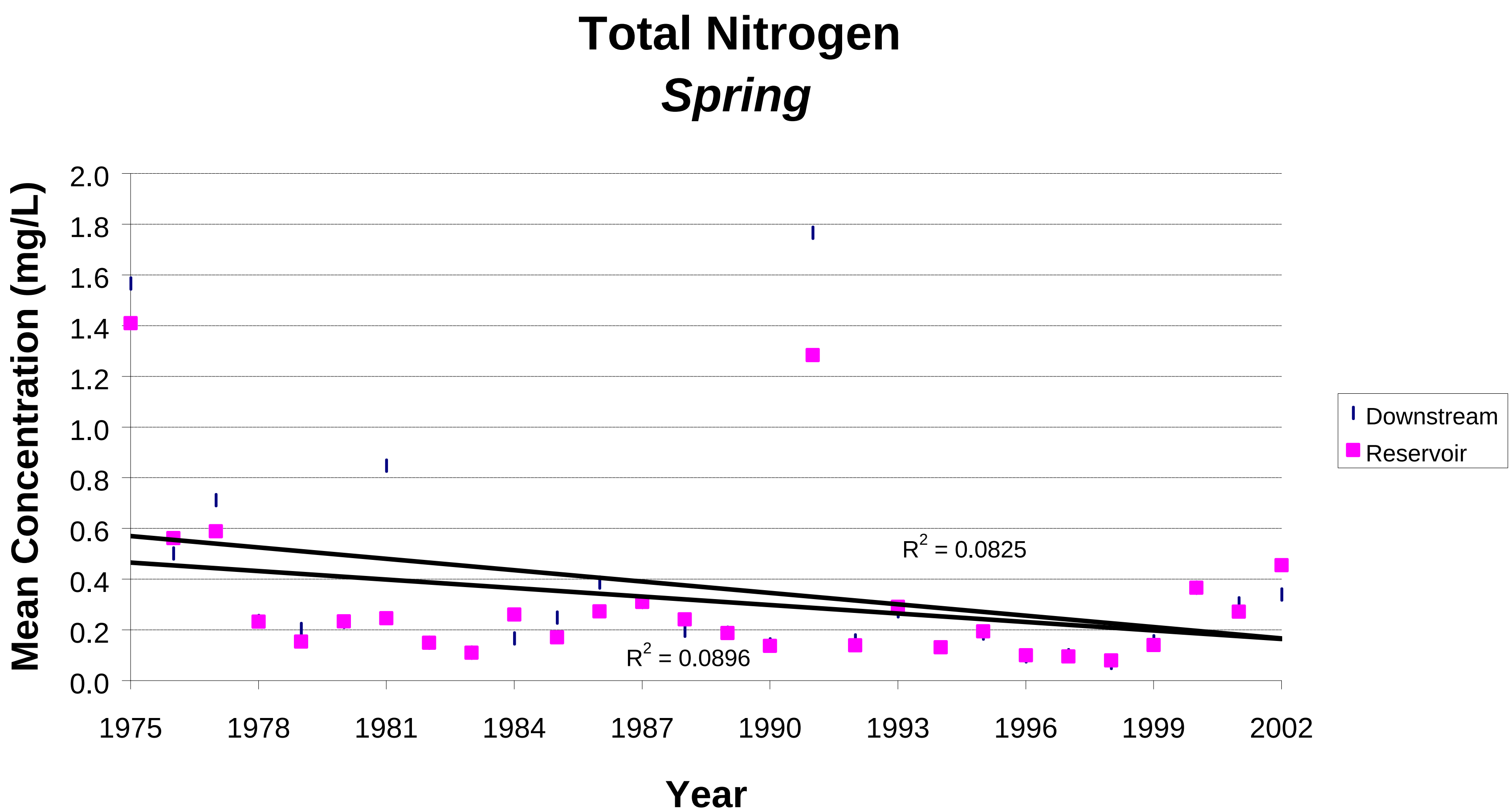

Figure 3-24. Seasonal trend analysis for total nitrogen (ammonia + nitrite + nitrate) measured during spring months (April, May, and June) at F. E. Walter Reservoir

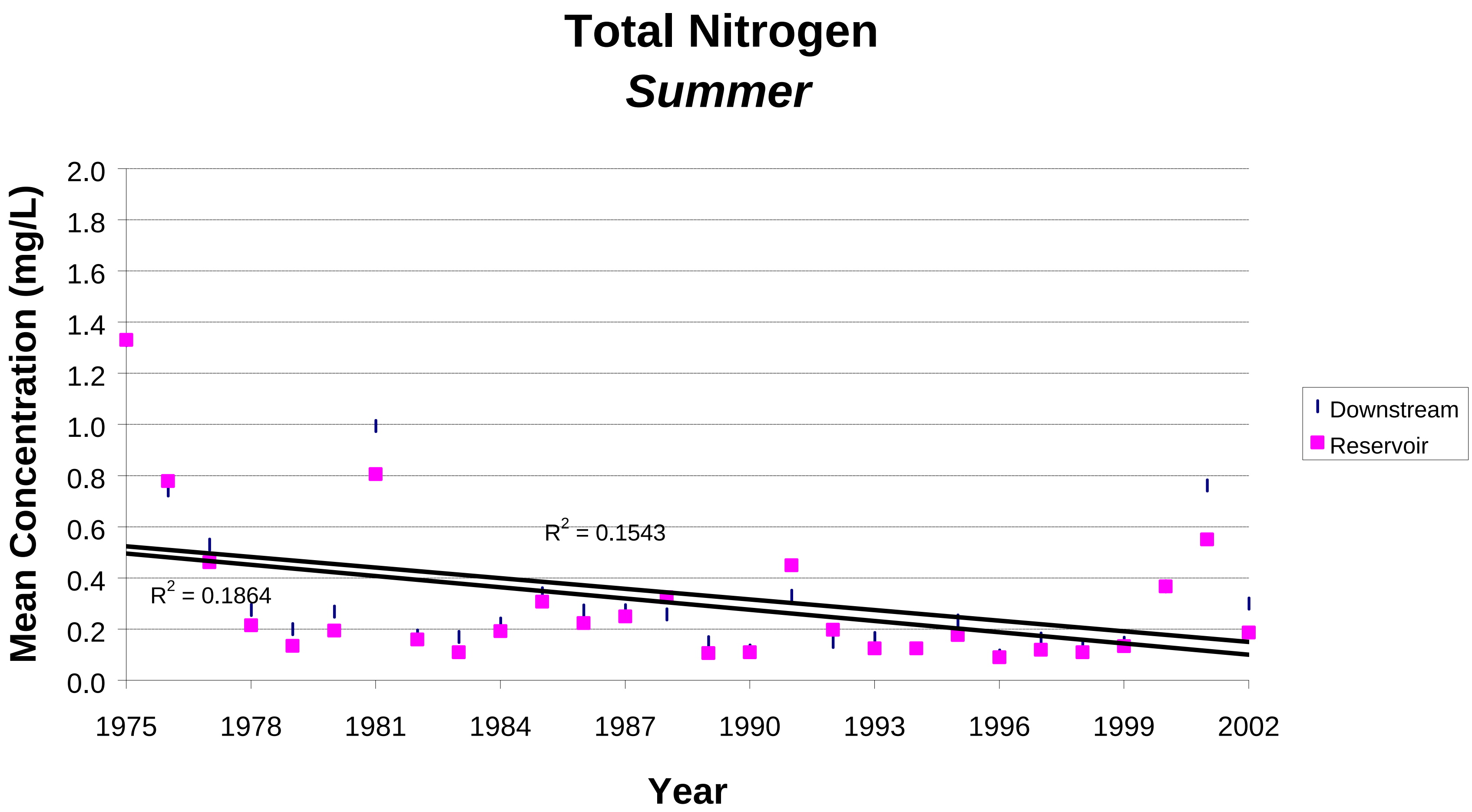

Figure 3-25. Seasonal trend analysis for total nitrogen (ammonia + nitrite + nitrate) measured during summer months (July, August, and October) at F.E. Walter Reservoir

0.15-mg/L. The trend analyses conducted for reservoir and downstream stations in the spring season were not significant (Fig. 3-24).

A seasonal trend analysis of total nitrogen was conducted for individual stations of F.E. Walter Reservoir, combining 2002 and historical data. The Mann-Kendall statistic was applied to station data collected over the past 23 years or more, separately for spring (April to June) and summer (July to October 3) seasons. Stations included in the analysis represented locations downstream (WA-1), within the main reservoir (WA-2), and upstream sources on Tobyhanna Creek (WA-3), Lehigh River (WA-4), and Bear Creek (WA-5).

Table 3-5. Seasonal trends of total nitrogen concentration at individual stations of F.E. Walter Reservoir calculated with the Mann-Kendall Statistic. Shaded values are significant (at least $P < 0.05$).

Station	**# of Years Spring/Summer**	**Spring**		**Summer**	
		P Level	**Rate (mg/L)**	**P Level**	**Rate (mg/L)**
Surface Water					
WA-1	26/27	NS	-0.007	< 0.05	-0.008
WA-2	27/28	NS	-0.006	NS	-0.005
WA-3	26/27	NS	-0.004	NS	-0.005
WA-4	27/28	NS	-0.005	NS	-0.005
WA-5	23/24	NS	-0.003	NS	-0.0004

Nitrogen concentrations have decreased at the downstream station (WA-1) in the summer season (Table 3-5). The Summer trend was significant ($p < 0.05$) and reflected an average annual decrease of 0.008-mg/L. None of the other seasonal trends were significant.

3.2.4 Total Kjeldahl Nitrogen

Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen that includes ammonia. TKN in the water column of F.E. Walter Reservoir was generally low during 2002 (Fig. 3-26). Concentrations measured at most stations and depths averaged 0.8-mg/L throughout the monitoring period. The highest concentrations were measured in July and ranged to 2.9-mg/L in surface water at station WA-6 and 1.9-mg/L in at station WA-3.

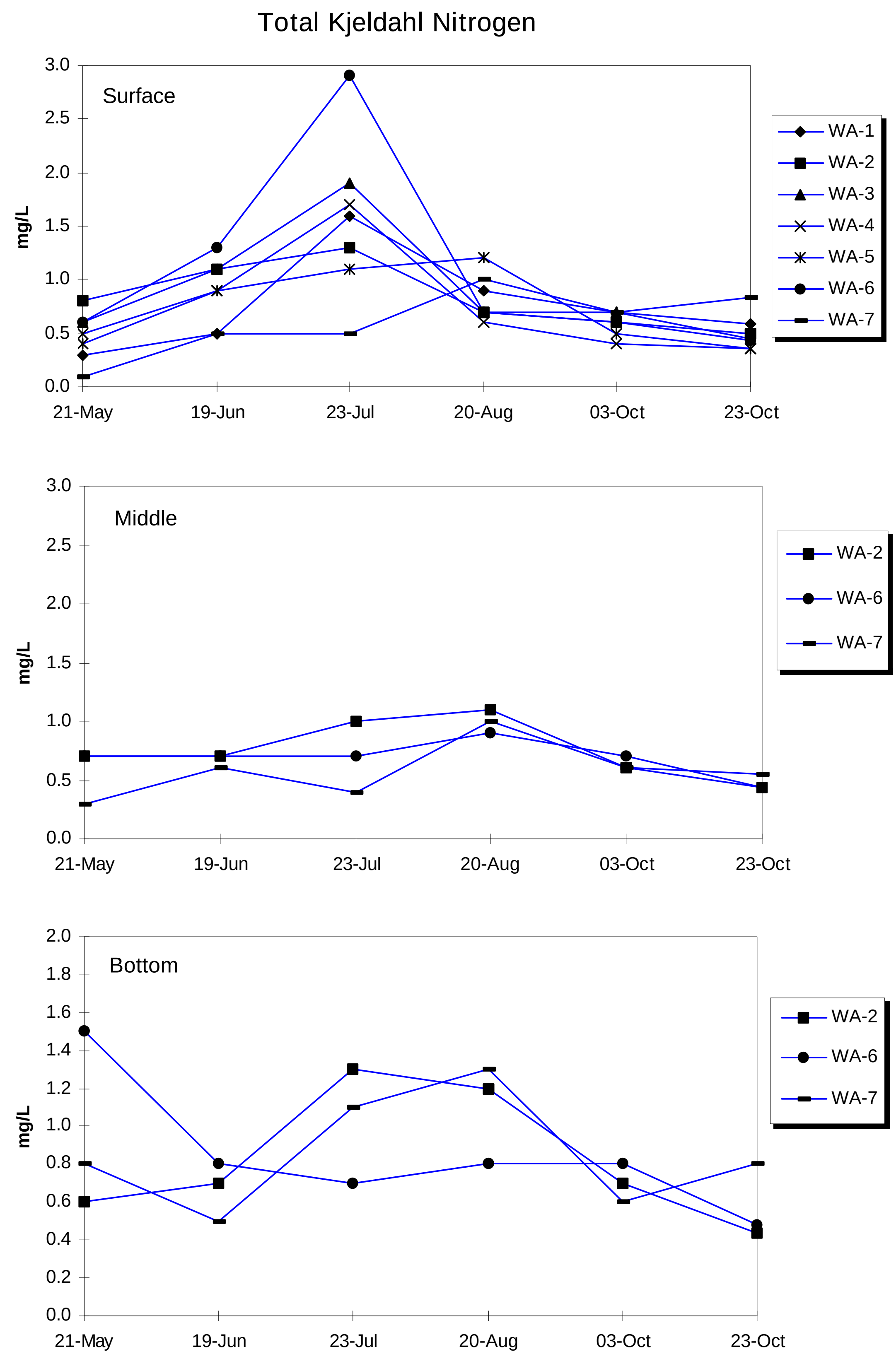

Figure 3-26. Total Kjeldahl nitrogen measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002

3.2.5 Dissolved Phosphate

Dissolved phosphate in the water column of F.E. Walter Reservoir was consistently low during 2002. Concentrations measured at all stations and depths averaged 0.06-mg/L throughout the monitoring period (Fig. 3-27). The highest concentration of dissolved phosphate (0.34-mg/L) was measured in the bottom waters of the reservoir (WA-7) in July. In freshwater environments, dissolved phosphate is usually a limiting nutrient and is readily taken up by freshwater plants and algae.

3.2.6 Dissolved Phosphorus

Dissolved phosphorus was not a significant nutrient parameter at F.E. Walter Reservoir in 2002 (Fig. 3-28) Concentrations of dissolved phosphate were generally at or below the detection limit of 0.01-mg/L and averaged 0.02-mg/L at most stations and depths. One isolated instance of high values was recorded, in July at WA-7 in the bottom water. This concentration was 0.11-mg/L.

3.2.7 Total Phosphorus

Total phosphorus in the water column of F.E. Walter Reservoir was measured at moderate concentrations during 2002 (Fig. 3-29). EPA guidance for nutrient criteria in lakes and reservoirs suggests a minimum concentration for total phosphorus of 0.01-mg/L (EPA 2000). Lakes and reservoirs exceeding this concentration are more likely to experience algal bloom problems during the growing season. Overall, 69% of the measures for total phosphorus were greater than the EPA guideline averaging 0.03-mg/L. The remaining 24 results were equal to or less than a detection limit of 0.01-mg/L, which is equal to the guideline.

Concentrations of total phosphorus were fairly uniform throughout the reservoir and generally less than 0.05-mg/L (Fig. 3-29). The average total phosphorus level throughout the reservoir was 0.02 mg/L; however, a high concentration of 0.09-mg/L resulted at WA-4 at the surface on October 3.

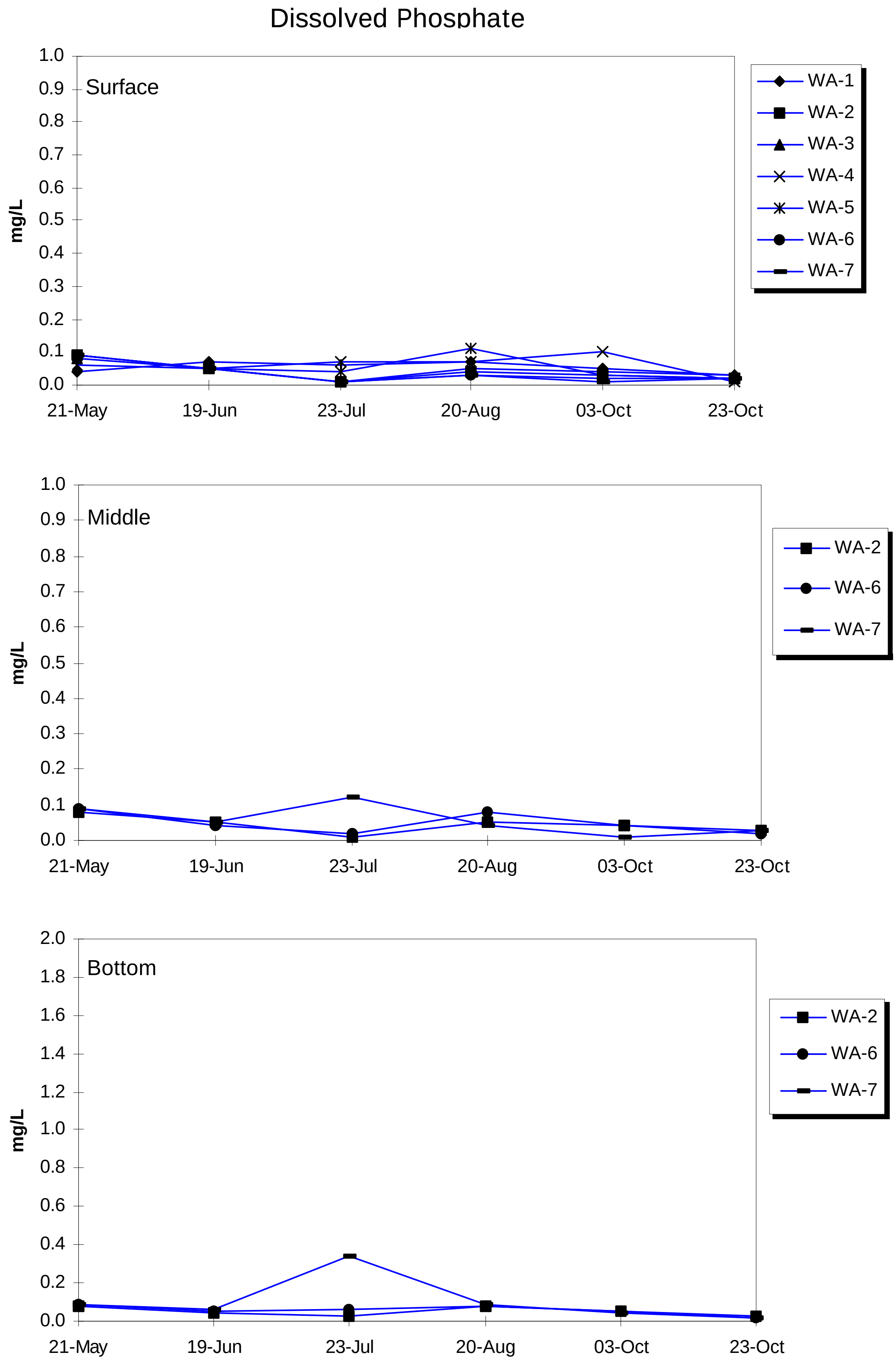

Figure 3-27. Total Phosphate measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002

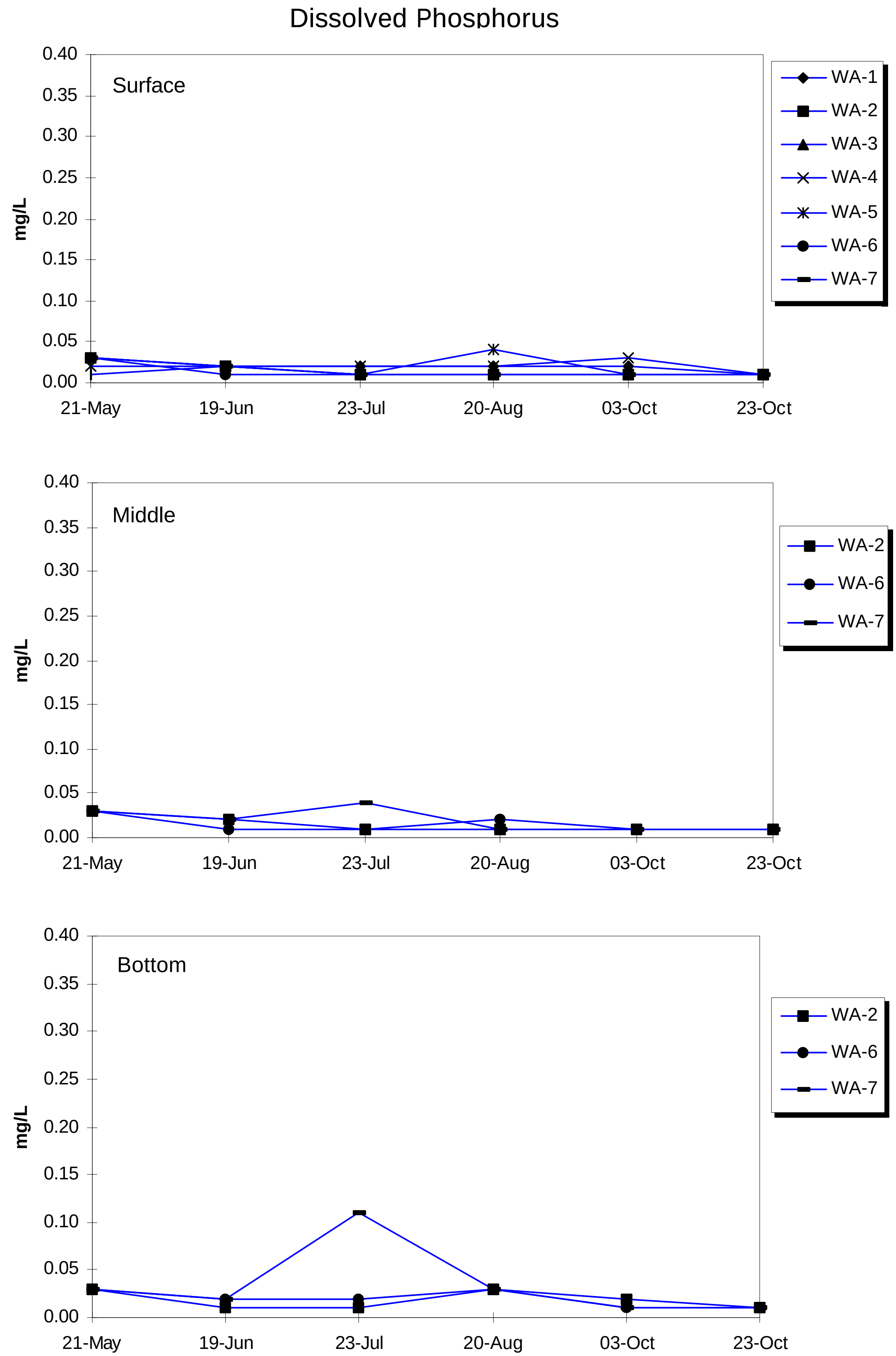

Figure 3-28. Total dissolved phosphorus measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002

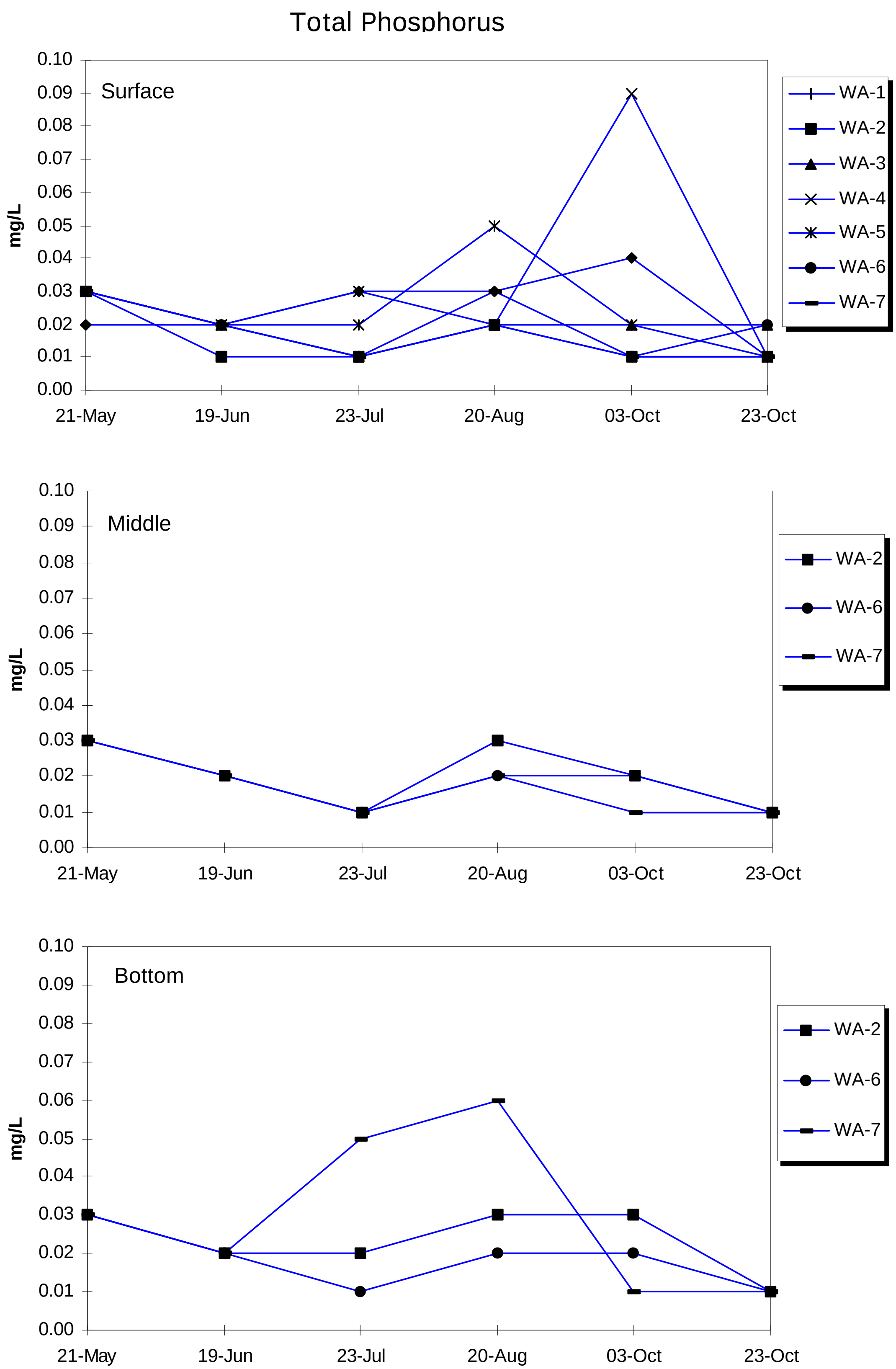

Figure 3-29. Total phosphorus measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002

Concentrations of total phosphorus measured in 2002 and historical data collected over the past 22 years were analyzed for seasonal trends using regression. The trend analysis was conducted for spring and summer periods, separately for stations representative of the reservoir and downstream. No trends were determined for either of the reservoir or downstream locations (Figs. 3-30 and 3-31). None of the regressions were significant ($P > 0.05$).

A seasonal trend analysis of total phosphorus was also conducted for individual stations of F.E. Walter Reservoir, combining 2002 and historical data. The Mann-Kendall statistic was applied to station data collected over the past 22 years or more, separately for spring (April to June) and summer (July to October 3) seasons. Stations included in the analysis were representative of locations downstream (WA-1), within the main reservoir (WA-2), and upstream sources on Tobyhanna Creek (WA-3), Lehigh River (WA-4), and Bear Creek (WA-5). Based on this analysis, no significant trends were apparent for individual stations (Table 3-6).

Table 3-6. Seasonal trends of total phosphorus concentration at individual stations of F.E. Walter Reservoir calculated with the Mann-Kendall Statistic.

Station	# of Years	Spring		Summer	
		P Level	Rate (mg/L)	P Level	Rate (mg/L)
Surface Water					
WA-1	22	NS	-0.0008	NS	0.0002
WA-2	23	NS	-0.0004	NS	-0.0003
WA-3	22	NS	-0.0004	NS	0.0001
WA-4	23	NS	-0.0001	NS	-0.0002
WA-5	23	NS	0.0001	NS	0.0001

3.2.8 Total Dissolved Solids

Total dissolved solids (TDS) in the water column of F.E. Walter Reservoir throughout, followed a similar pattern during 2002. Concentrations at all stations and depths averaged 52-mg/L over the monitoring period while ranging from 24 to 90-mg/L (Fig. 3-32). Concentrations at upstream stations (WA-4 and WA-5) averaged slightly higher concentrations. Concentrations at WA-4 and WA-5 averaged 61-mg/L.

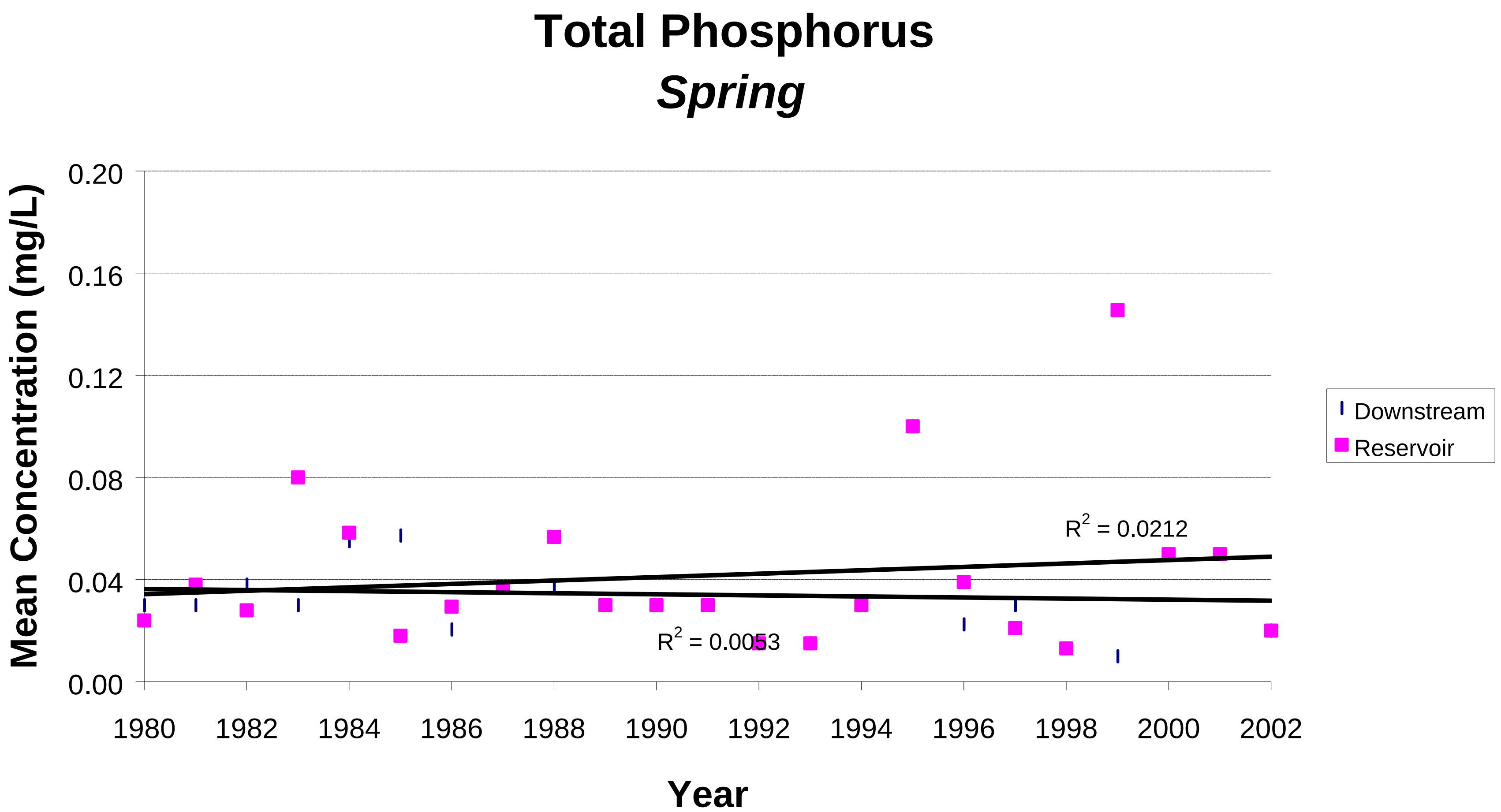

Figure 3-30. Seasonal trend analysis for total phosphorus measured during spring months (April, May, and June) at F.E. Walter Reservoir

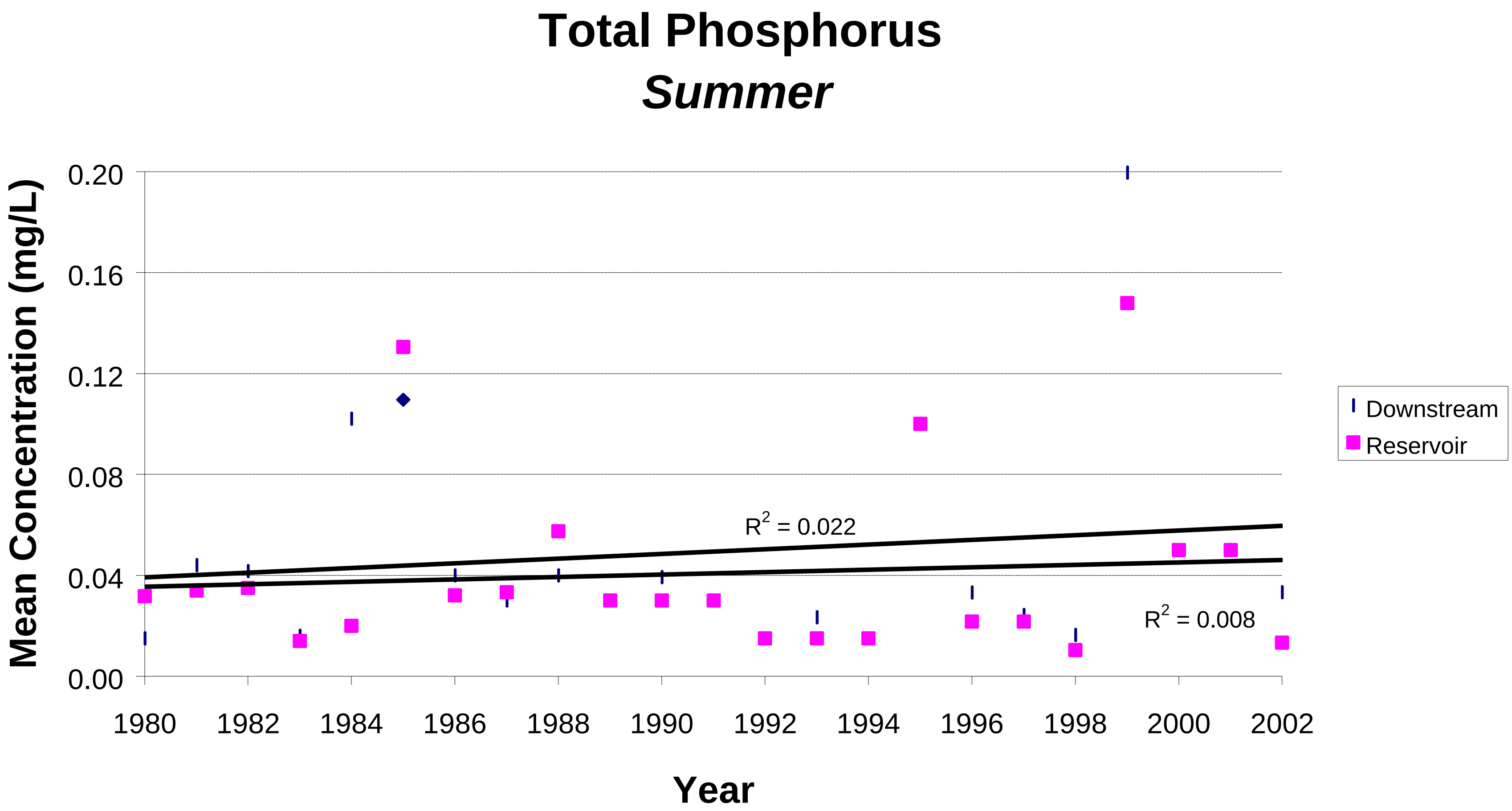

Figure 3-31. Seasonal trend analysis for total phosphorus measured during summer months (July, August, and October) at F.E. Walter Reservoir

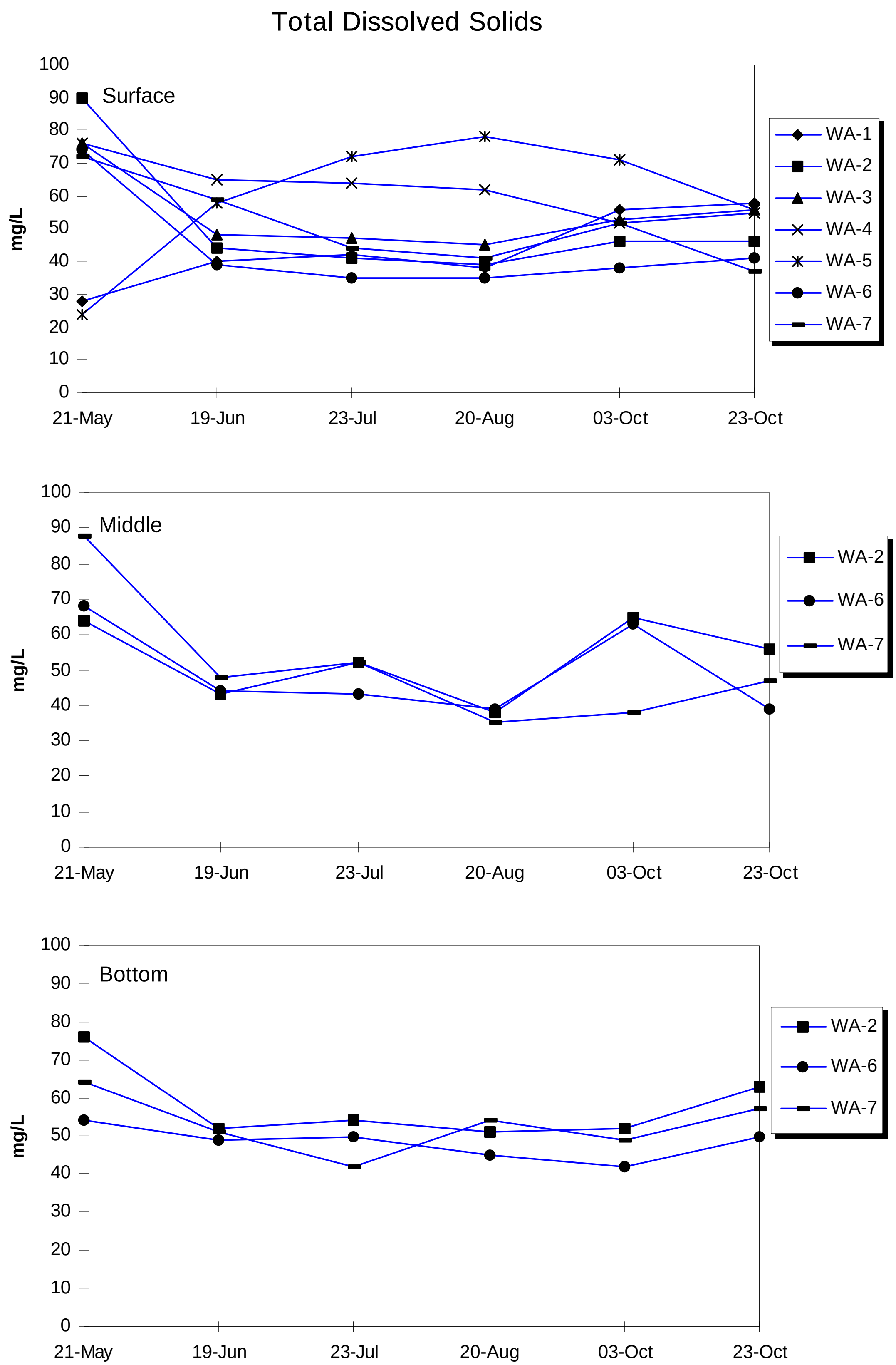

Figure 3-32. Total dissolved solids measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002. The PADEP water quality standard for TDS is a maximum concentration of 500 mg/L.

F.E. Walter Reservoir was in compliance with the PADEP water quality standard for total dissolved solids during 2002. The water quality standard is a maximum concentration of 500-mg/L. Throughout the monitoring period, concentrations measured at all stations were always at least five times less than the standard.

Concentrations of total dissolved solids measured in 2002 and historical data collected over the past 26 years were analyzed for seasonal trends. The trend analysis was conducted for spring and summer periods, separately for stations representative of the reservoir and downstream. TDS concentrations at F.E. Walter Reservoir have not changed consistently over the time series (Fig. 3-33 and 3-34). No significant trends were identified by the regression analyses ($P > 0.05$) for either season at reservoir and downstream stations.

A seasonal trend analysis of TDS was also conducted for individual stations of F.E. Walter Reservoir combining 2002 and historical data. The Mann-Kendall statistic was applied to station data collected over the past 24 years or more, separately for spring (April to June) and summer (July to October 3) seasons. Stations included in the analysis represented: downstream (WA-1), main reservoir (WA-2), and upstream sources on Tobyhanna Creek (WA-3), Lehigh River (WA-4), and Bear Creek (WA-5). Based on this analysis, no significant trends were apparent for individual stations (Table 3-7).

Table 3-7. Seasonal trends of total dissolved solids concentration at individual stations of F.E. Walter Reservoir calculated with the Mann-Kendall Statistic.

Station	# of Years Spring/Summer	Spring		Summer	
		P Level	Rate (mg/L)	P Level	Rate (mg/L)
Surface Water					
WA-1	27	NS	-0.25	NS	-0.27
WA-2	28	NS	-0.27	NS	-0.27
WA-3	27	NS	0.53	NS	0.00
WA-4	28	NS	0.34	NS	0.26
WA-5	24	NS	-0.32	NS	0.81

3.2.9 Total Suspended Solids

Total suspended solids (TSS) in the water column of F.E. Walter Reservoir were consistently low in 2002. For the most part, concentrations measured throughout the reservoir ranged less than 10 mg/L (Fig. 3-35). Overall concentrations at stations and all depths averaged 2.9-mg/L and ranged from 1 to 40-mg/L (Fig. 3-35).

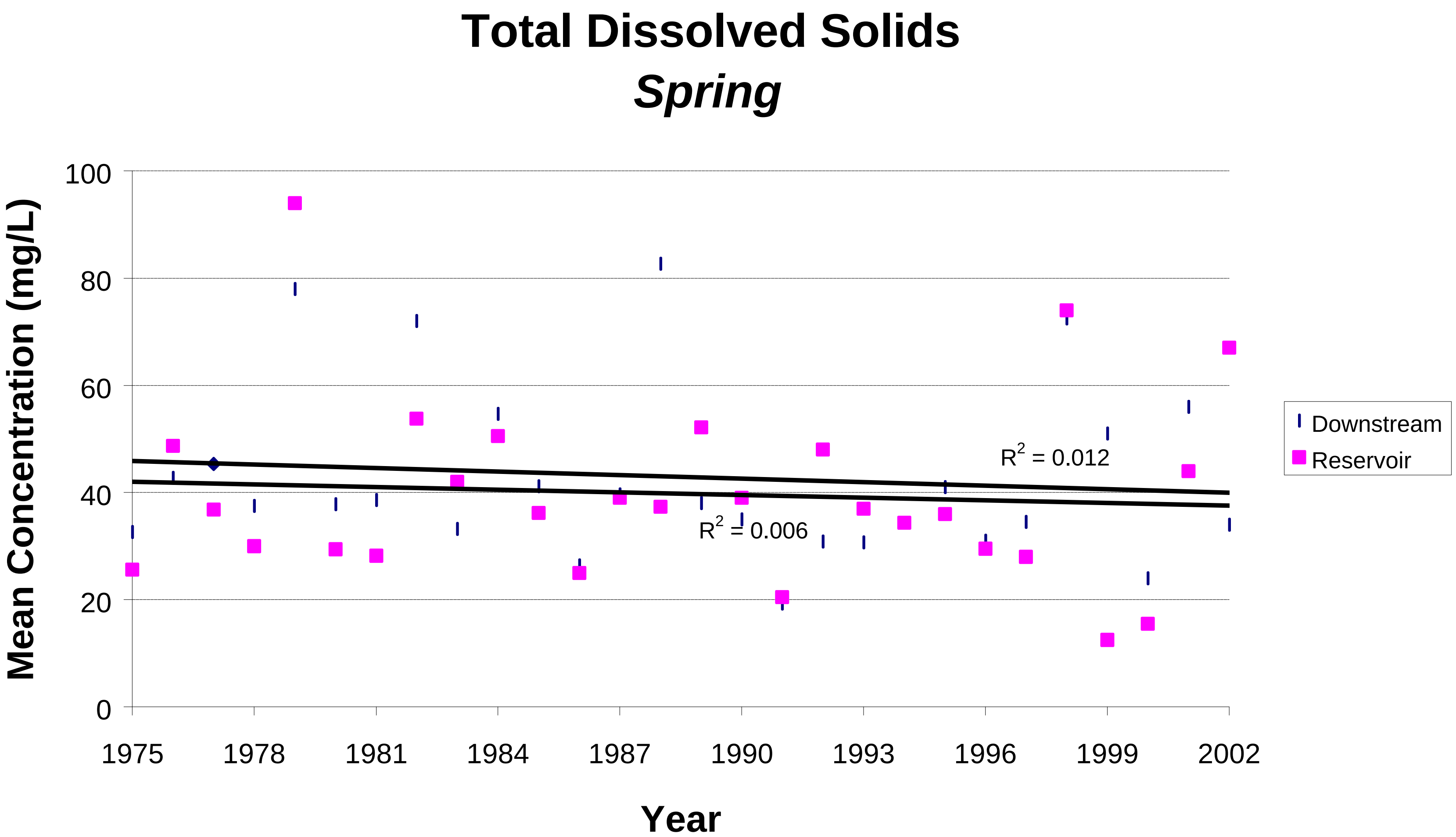

Figure 3-33. Seasonal trend analysis for total dissolved solids measured during spring months (April, May, and June) at F.E. Walter Reservoir

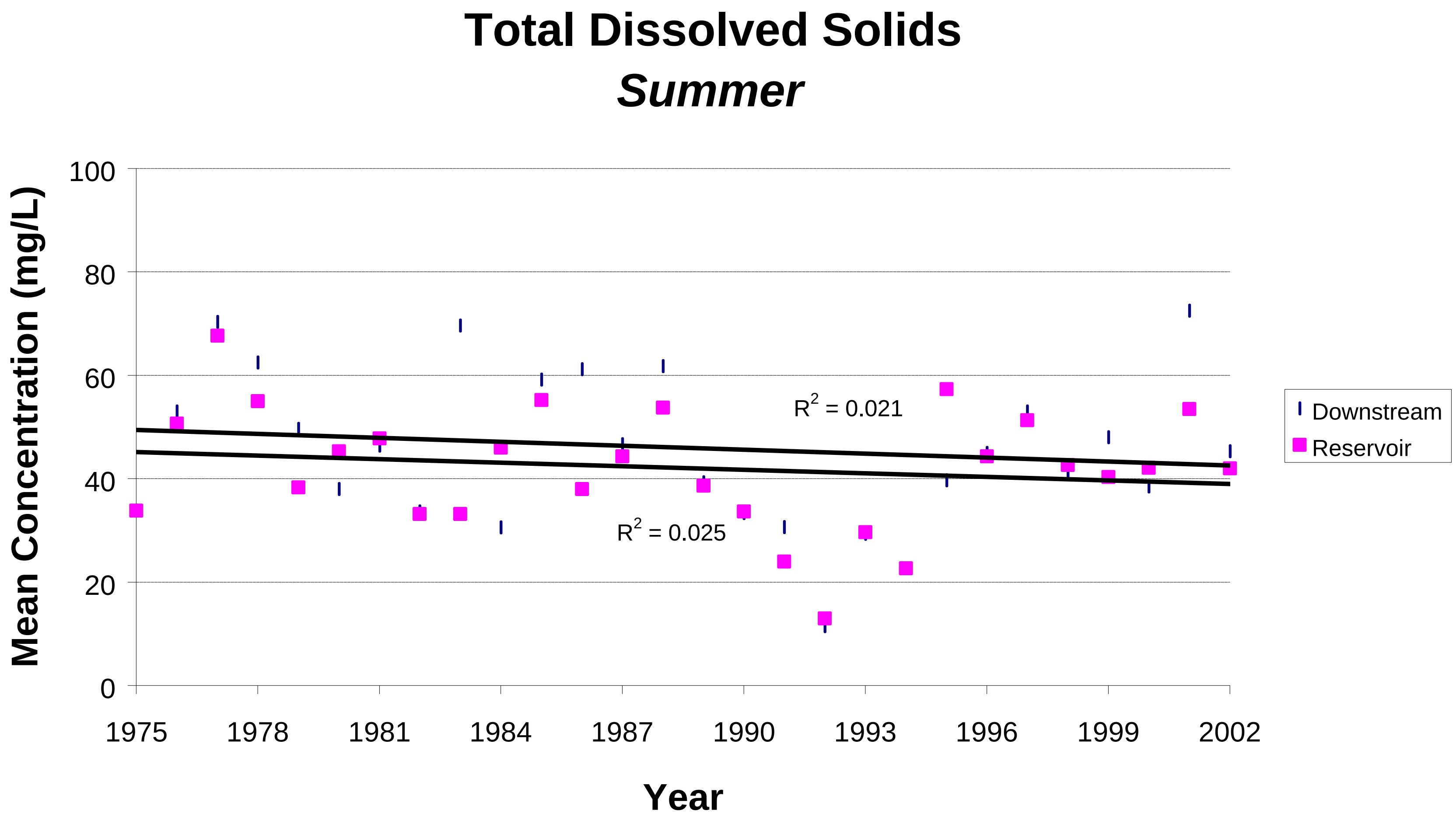

Figure 3-34. Seasonal trend analysis for total dissolved solids measured during summer months (July, August, and October 3) at F.E. Walter Reservoir

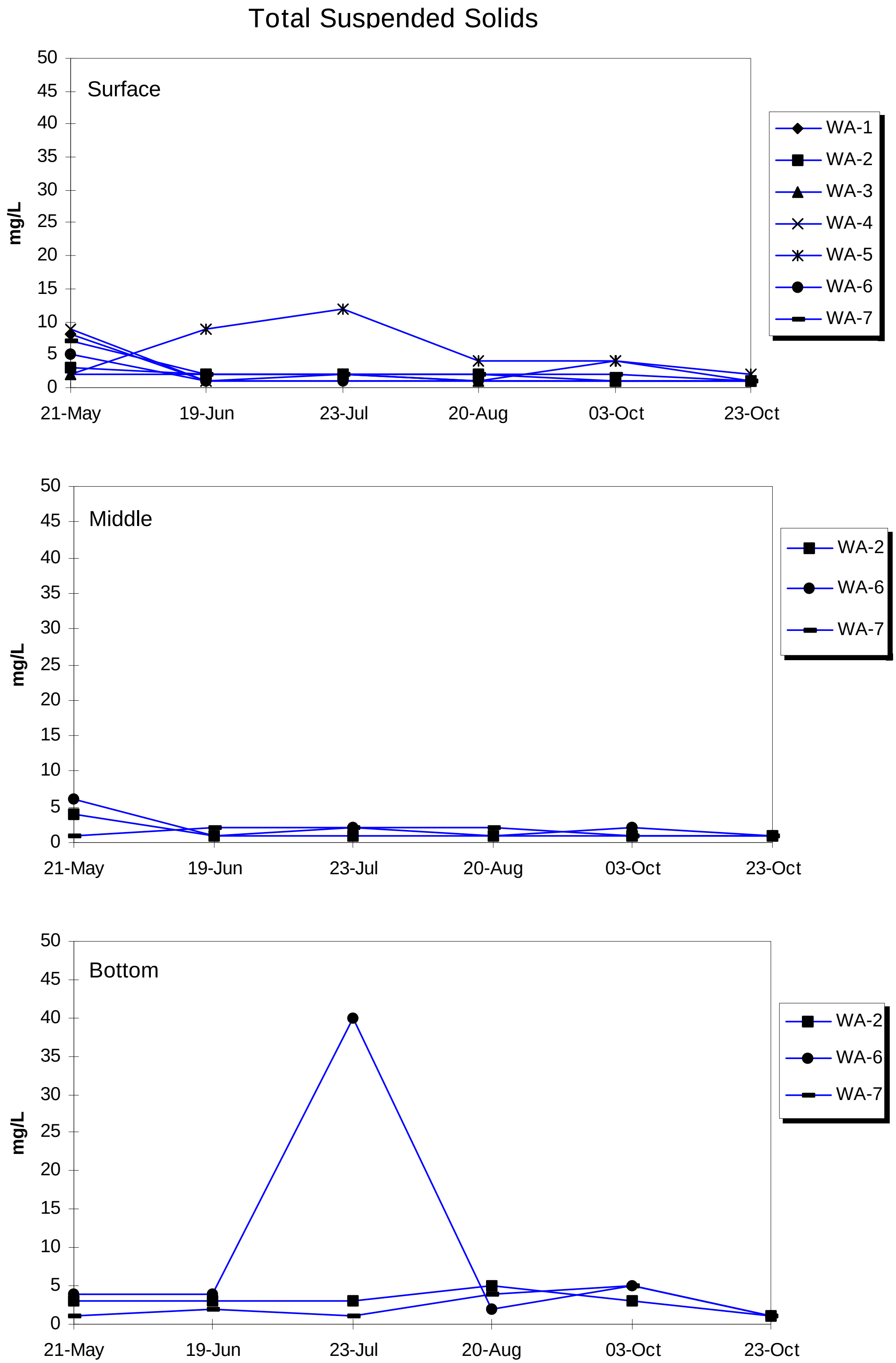

Figure 3-35. Total suspended solids measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002

3.2.10 Biochemical Oxygen Demand

Biochemical oxygen demand (BOD) in the water column of F.E. Walter Reservoir was consistently low during 2002. With several exceptions, concentrations measured at all stations and depths were always less than or equal to the method detection limit (2-mg/L) throughout the monitoring period (Fig. 3-36). Concentrations of BOD in the surface waters at station WA-4 during August and the bottoms waters of WA-2 in July and WA-6 in August were 3-mg/L. Additionally, concentrations of BOD in the bottom waters of WA-6 on October 23 were 4-mg/L.

Concentrations of BOD measured in 2002 and historical data collected from over the past 22 years were analyzed for seasonal trends. The trend analysis was conducted for spring and summer periods, separately, for stations representative of the reservoir and downstream. No seasonal trends were determined for either of the reservoir and downstream locations (Fig. 3-37 and 3-38). None of the regressions were significant ($P > 0.05$). The analyses; however, has probably been confounded by low concentrations measured in recent years. Since 1995, the seasonal averages at both locations have been near or less than the method detection limits which ranged from 2 to 4-mg/L.

A seasonal trend analysis of BOD was also conducted for individual stations of F.E. Walter Reservoir combining 2002 and historical data. The Mann-Kendall statistic was applied to station data collected over the past 22 years or more, separately, for spring (April to June) and summer (July to October 3) seasons. Stations included in the analysis were representative of locations downstream (WA-1), within the reservoir (WA-2), and upstream sources on Tobyhanna Creek (WA-3), Lehigh River (WA-4), and Bear Creek (WA-5). Based on this analysis, no significant trends were identified for individual stations (Table 3-8).

Table 3-8. Seasonal trends of BOD concentration at individual stations of F.E. Walter Reservoir calculated with the Mann-Kendall Statistic.

Station	**# of Years Spring/Summer**	**Spring**		**Summer**	
		P Level	**Rate (mg/L)**	**P Level**	**Rate (mg/L)**
Surface Water					
WA-1	22	NS	-0.0146	NS	0.0000
WA-2	23	NS	-0.0424	NS	-0.0154
WA-3	22	NS	-0.0175	NS	0
WA-4	23	NS	-0.0111	NS	0
WA-5	23	NS	0	NS	0

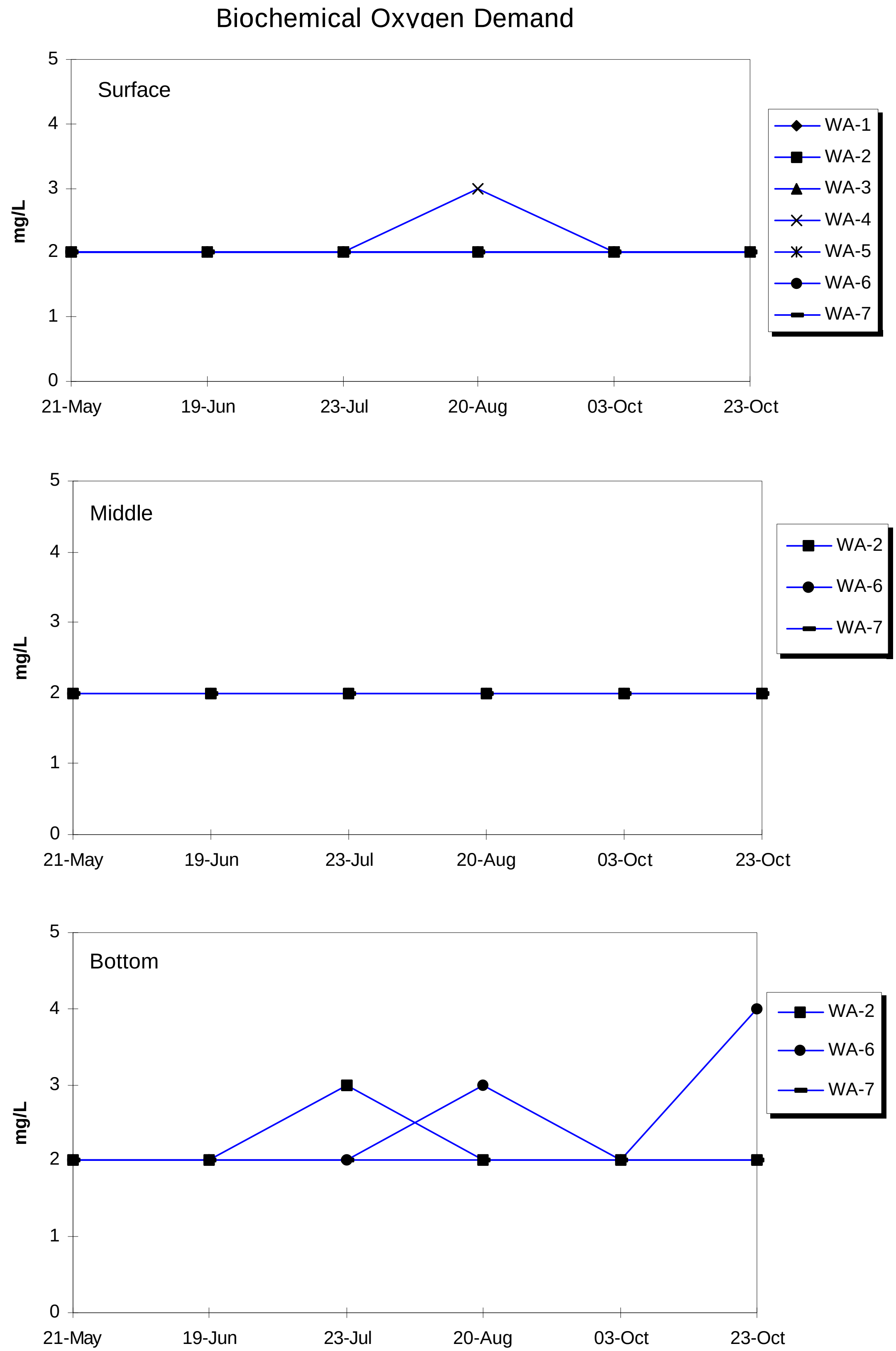

Figure 3-36. Biochemical oxygen demand (5-day) measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002

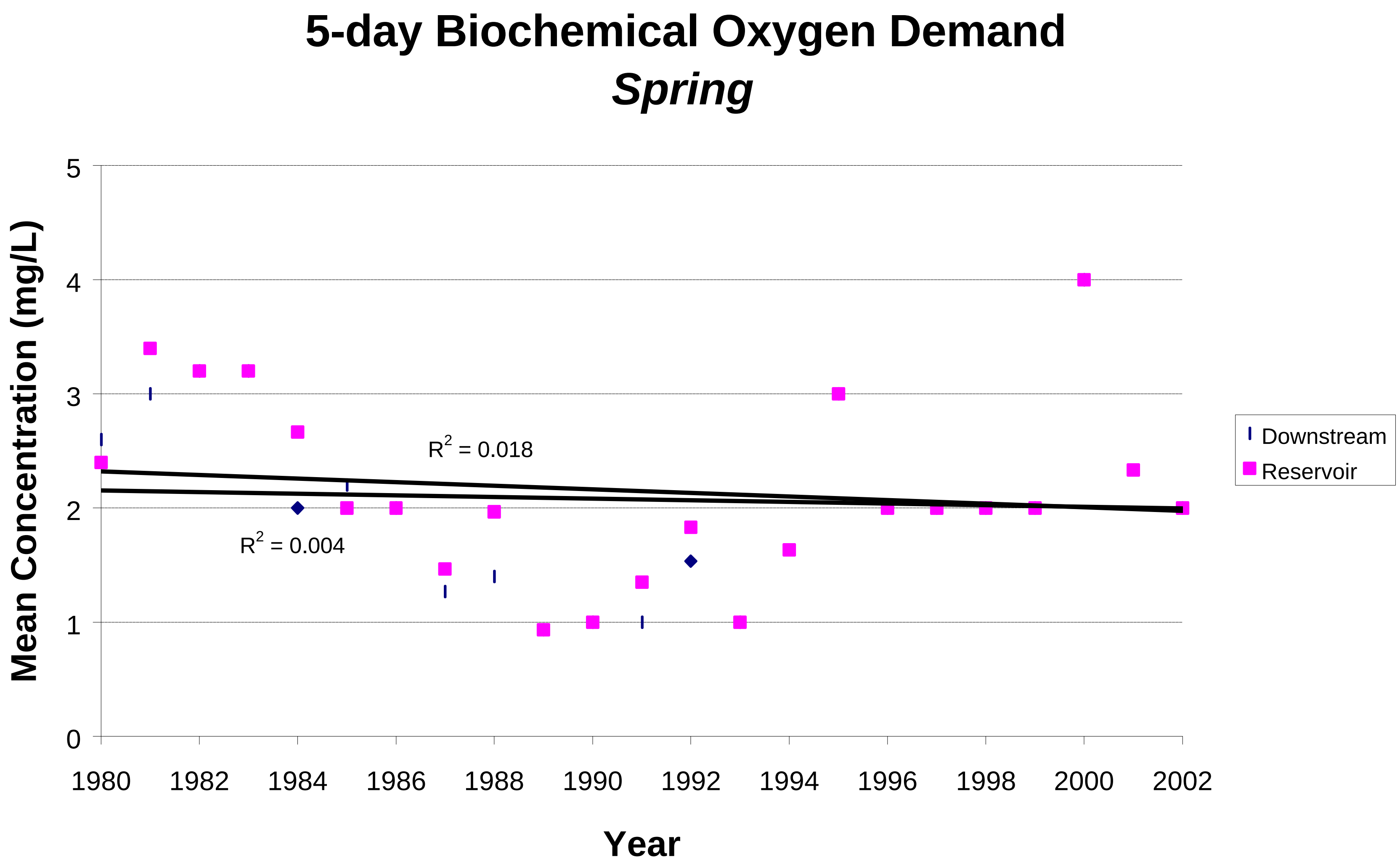

Figure 3-37. Seasonal trend analysis for biochemical oxygen demand (5-day) measured during spring months (April, May, and June) at F.E. Walter Reservoir

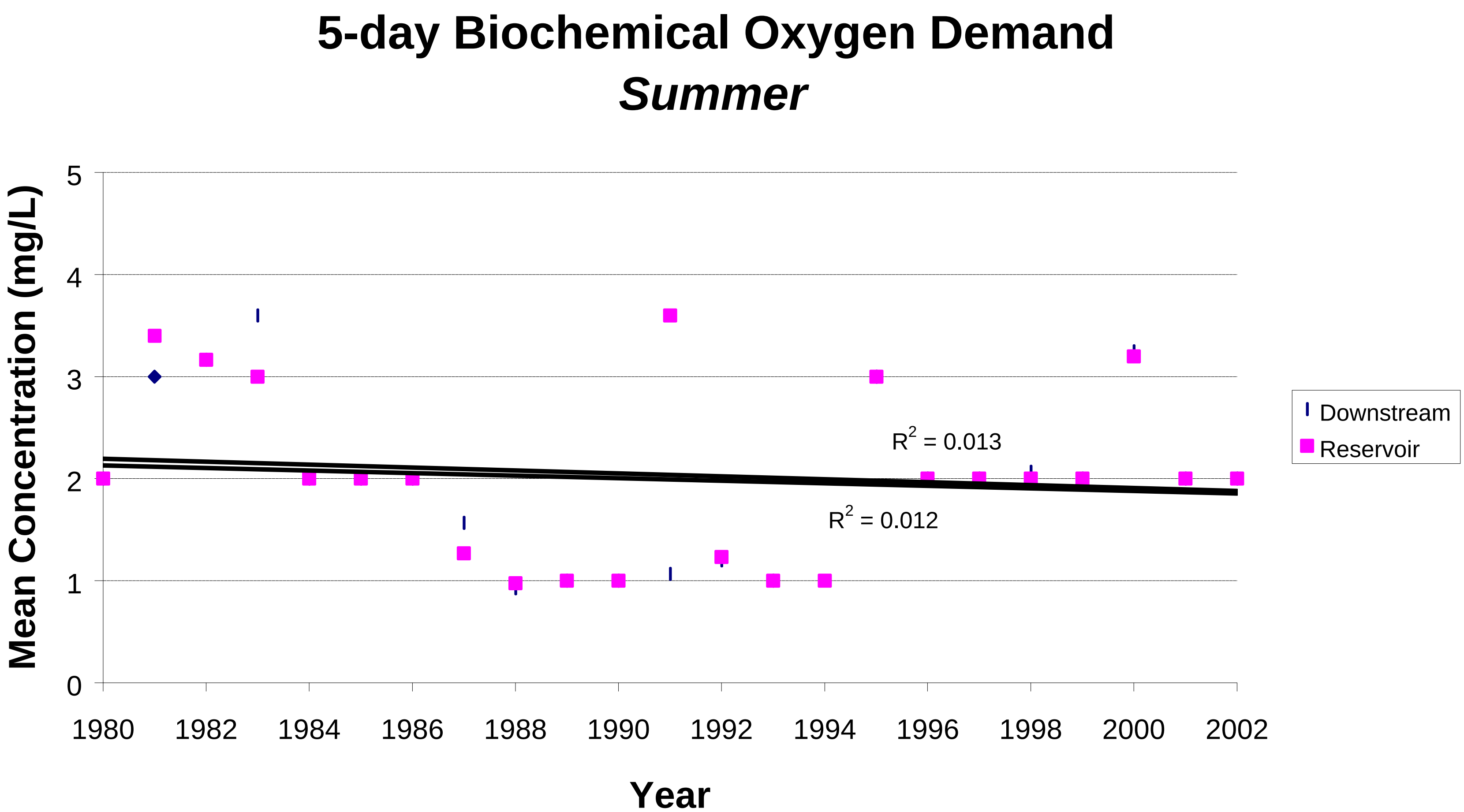

Figure 3-38. Seasonal trend analysis for biochemical oxygen demand (5-day) measured during summer months (July, August, and October 3) at F.E. Walter Reservoir

3.2.11 Alkalinity

Alkalinity in the waters of F.E. Walter Reservoir was very low during 2002. Concentrations measured at all stations and depths averaged 4.4-mg/L and ranged less than 12-mg/L throughout the monitoring period (Fig. 3-39). Alkalinity is a measure of the acid-neutralizing capacity of water. The PADEP standard is a minimum concentration of 20-mg/L $CaCO_3$ except where natural conditions are less. The natural alkalinity of water is largely dependent on the underlying geology and soils within the surrounding watershed. The low alkalinity measured at F.E. Walter Reservoir probably results from the regional geology, which is primarily sandstone and shale (Van Diver 1990).

3.2.12 Total Inorganic and Organic Carbon

Total inorganic carbon (TIC) and total organic carbon (TOC) in the water column of F.E. Walter Reservoir were present in low concentrations during 2002 (Fig. 3-40 and Fig. 3-41). Concentrations of TIC at all stations and depths ranged from 7-mg/L to less than the method detection limit of 1-mg/L and averaged 1.76-mg/L. Additionally, concentrations of TOC at all stations and depths ranged from 11-mg/L to less than the method detection limit of 1-mg/L and averaged 5.86-mg/L.

Total carbon is the sum of TIC and TOC. Total carbon in the water column of Walter Reservoir at all stations and depths averaged 7.58-mg/L and ranged from 4-mg/L to 13-mg/L (Fig. 3-42).

3.2.13 Chlorophyll *a*

For the most part, chlorophyll *a* was low in the water column of F.E. Walter Reservoir during 2002 (Fig. 3-43). Concentrations at all stations and depths averaged 2.86-mg/m^3 and generally ranged up to 18.45-mg/m^3 throughout the monitoring period.

3.3 TROPHIC STATE DETERMINATION

Carlson's (1977) trophic state index (TSI) is a method of expressing the extent of eutrophication of a lake, quantitatively. The trophic state analysis calculates separate indices for eutrophication based on measures of total phosphorus, chlorophyll *a*, and secchi disk depth. Index values for each parameter range on the same scale from 0 (least enriched) to 100 (most enriched). The resulting indices can also be compared to qualitative threshold values that correspond to levels of eutrophication: mesotrophic (TSI $<$ 40), mesoeutrophic (TSI's from 50 to 60), and eutrophic (TSI $>$ 60).

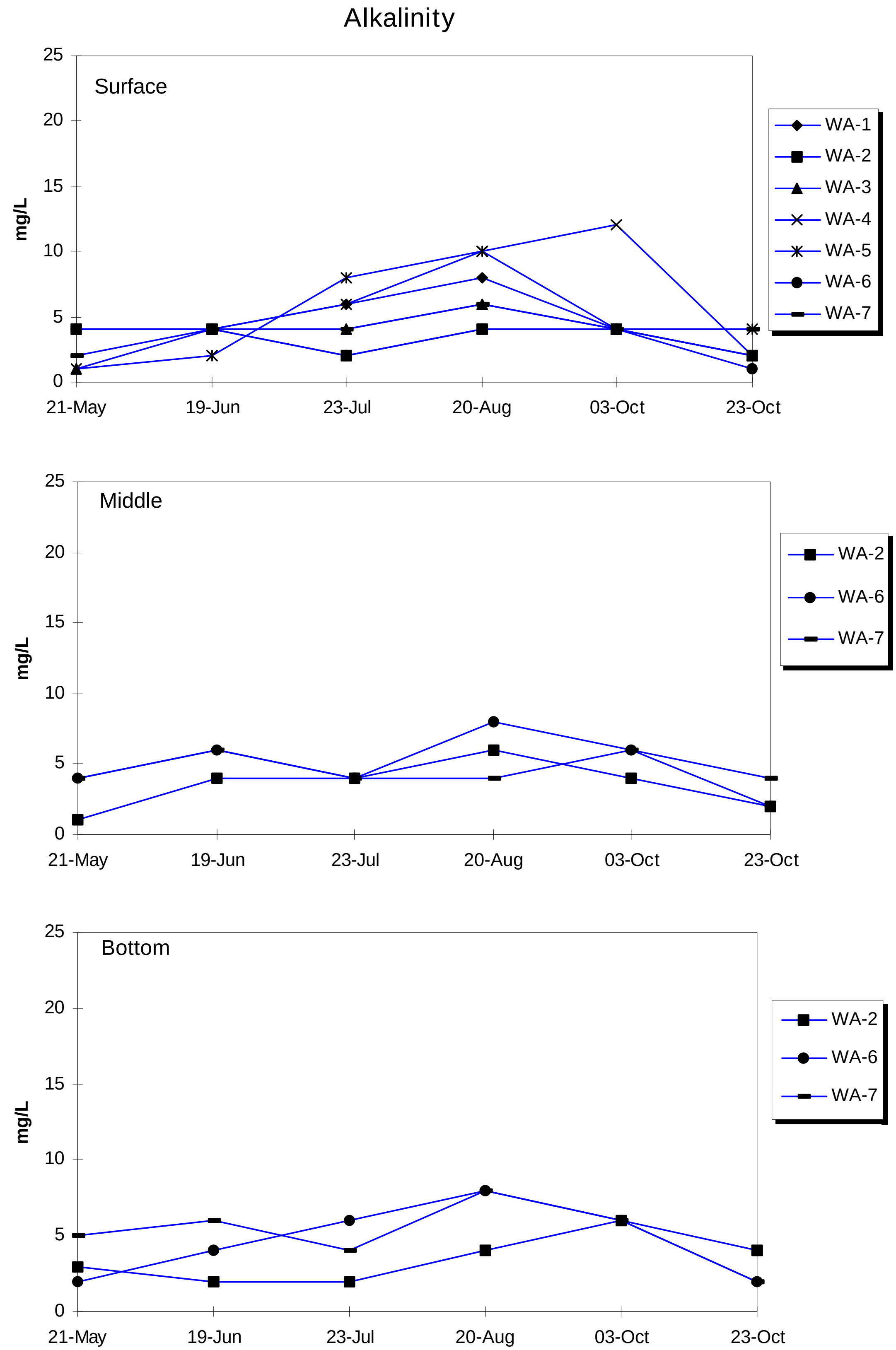

Figure 3-39. Alkalinity measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002. The PADEP water quality standard for alkalinity is a minimum concentration of 20 mg/L.

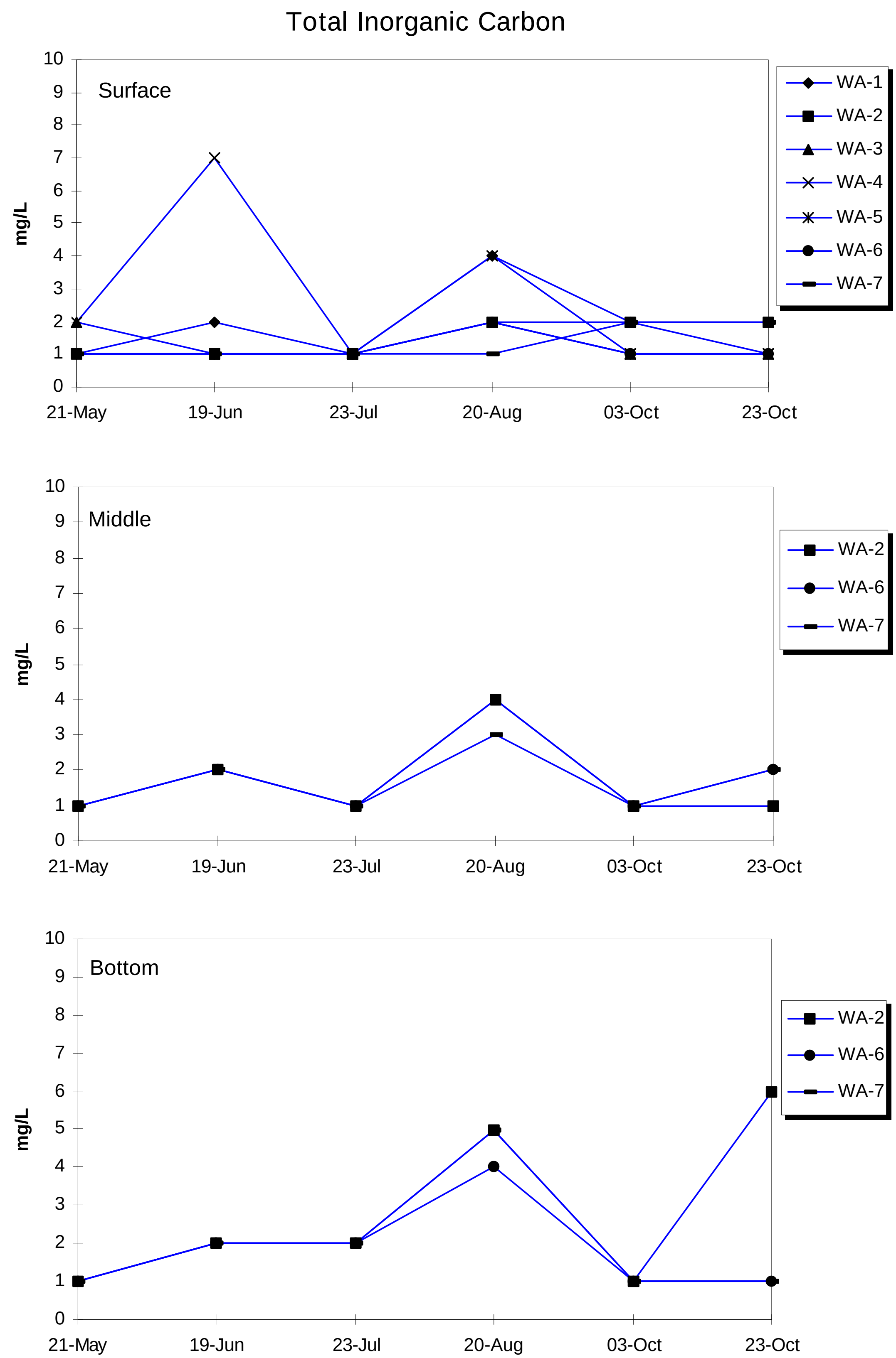

Figure 3-40. Total inorganic carbon measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002.

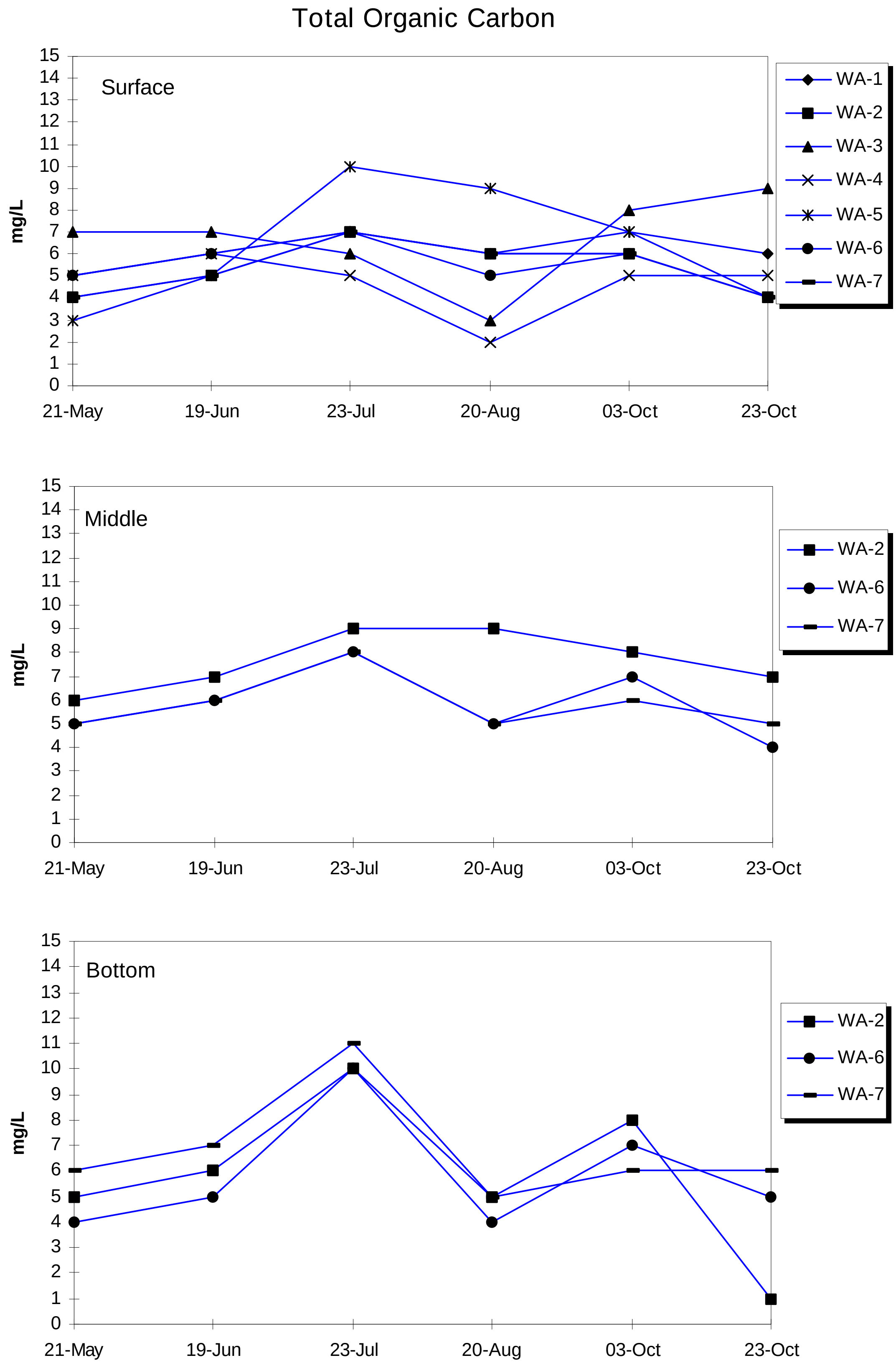

Figure 3-41. Total organic carbon measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002

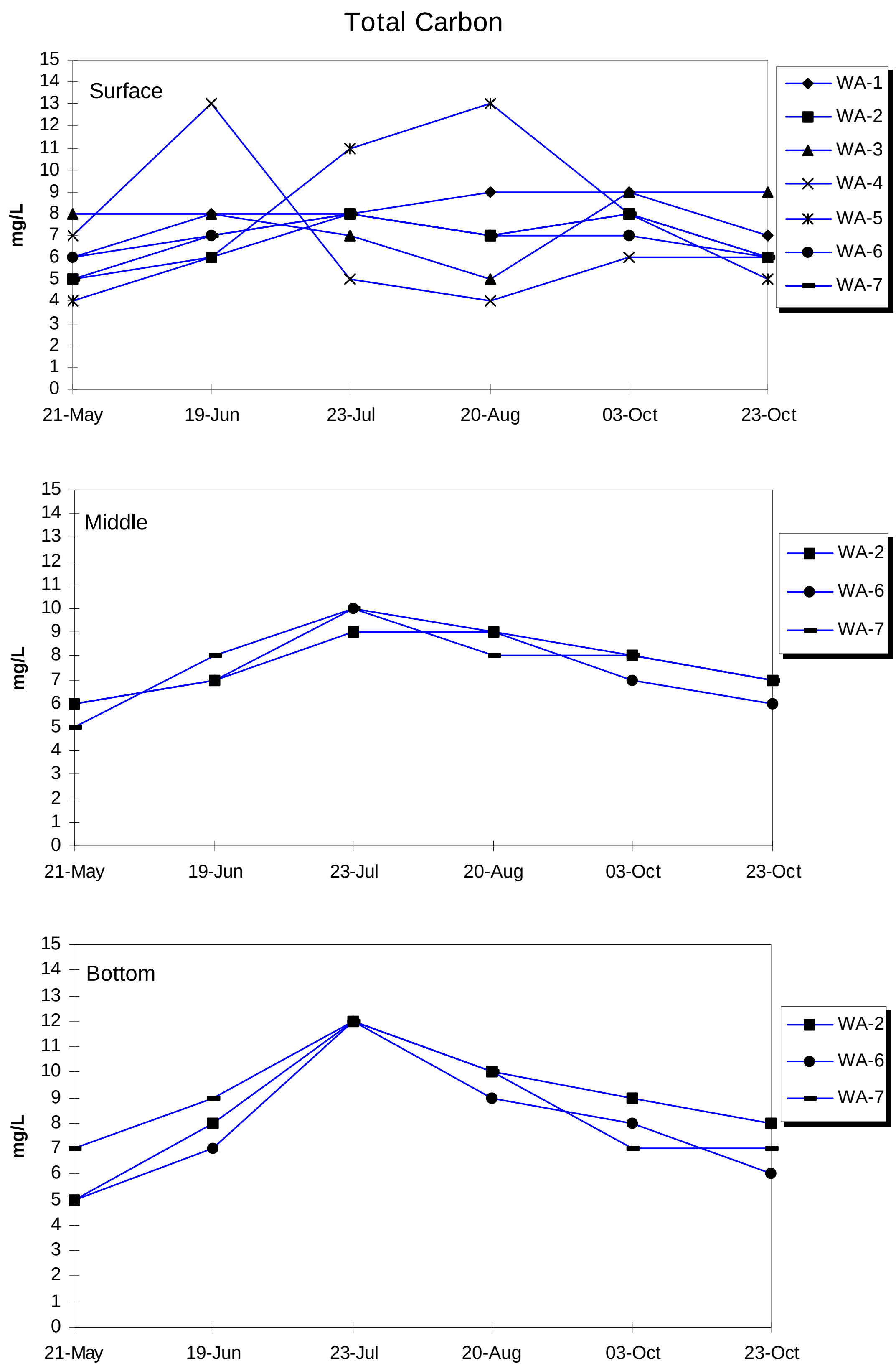

Figure 3-42. Total carbon measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002

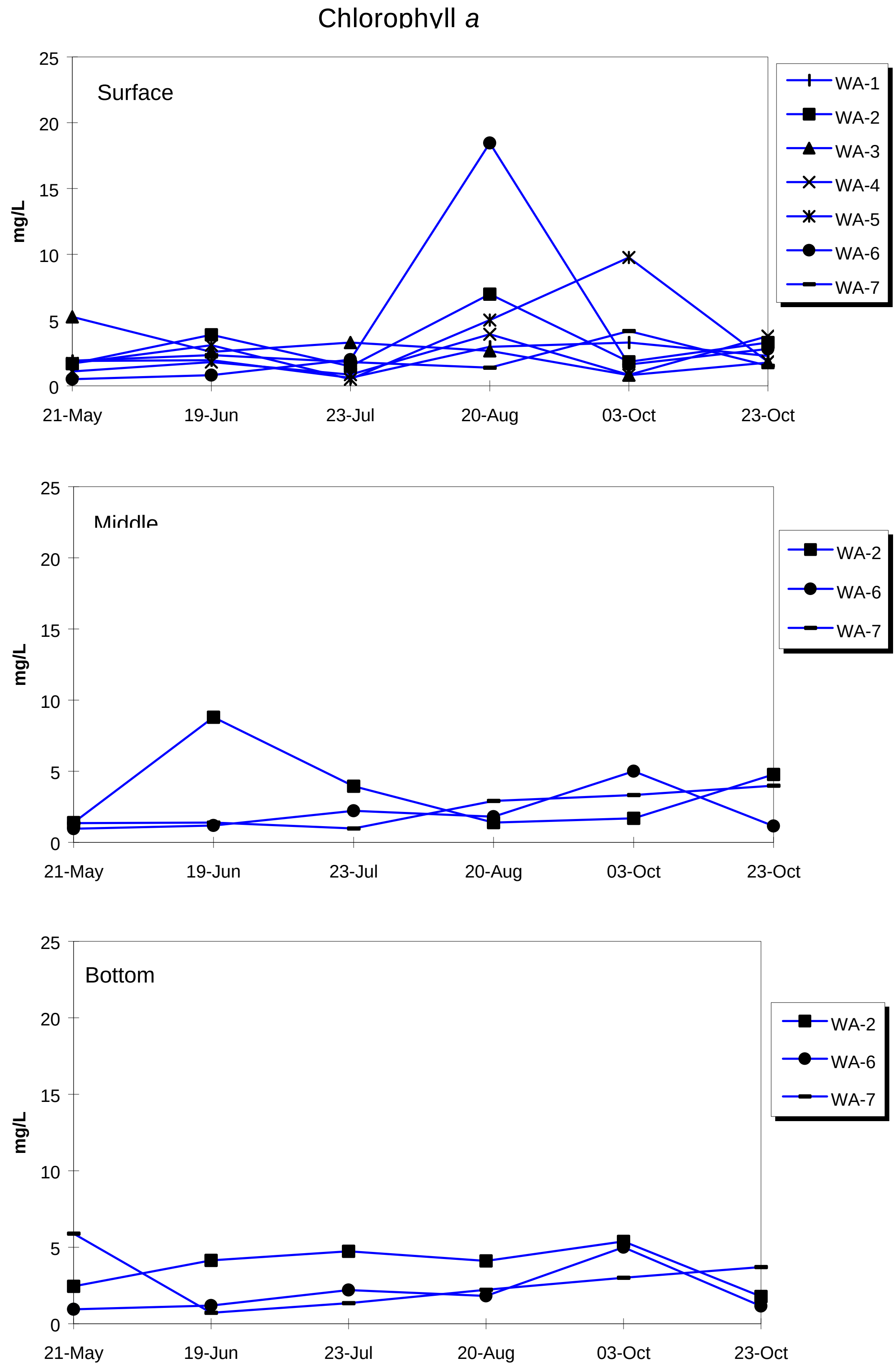

Figure 3-43. Chlorophyll *a* measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002

TSIs calculated for measures of secchi disk depth classified F.E. Walter Reservoir as mesotrophic with values ranging from 43 to 47 in May, June, and on October 23. In July, August, and on October 3 the trophic state is classified as mesoeutrophic with values of 50 to 53 (Fig. 3-44).

TSIs calculated for measures of total phosphorus classified F.E. Walter Reservoir as mesoeutrophic in the beginning of the summer with a TSI value of 53 (Fig. 3-44). The TSI values decreased to 37 (oligotrophic) for the remainder of the monitoring period with the exception of August when the TSI value rose to 47 (mesotrophic).

TSIs calculated for measures of chlorophyll *a* classified F.E. Walter Reservoir as mesotrophic in May and June with TSI values of 45 and 42 (Fig. 3-44). TSIs calculated for measures of chlorophyll *a* rose in July, August, and on October 3, ranging from 50 to 57. The calculated TSI for October 23 returned to 43, a mesotrophic classification.

Carlson (1977) warned against averaging TSI values estimated for different parameters, and instead suggested giving priority to chlorophyll *a* during the summer and to phosphorus in the spring, fall, and winter. With this in mind, and the general agreement in pattern between TSI values for secchi disk depth and chlorophyll *a*, it is our estimation that the reservoir was mesotrophic/mesoeutrophic during 2002.

The EPA (1983) also provides criteria for classifying the trophic conditions of lakes of the North Temperate Zone based on concentrations of total phosphorus, chlorophyll *a*, and secchi disk depth (Table 3-9). Concentrations of total phosphorus generally classified the lake as mesotrophic. Concentrations of chlorophyll *a* ranged from oligotrophic (June and October 23) to eutrophic (October 3). In May, July, and August the lake was classified as mesotrophic. Secchi disk depth classified the lake as eutrophic in July and August and mesotrophic the remainder of the monitoring period. Taking into account the general agreement between the EPA classifications with that of the TSIs, the trophic condition of F.E. Walter Reservoir was mesotrophic borderline eutrophic.

Table 3-9. EPA trophic classification criteria and average monthly measures for F.E. Walter Reservoir in 2002

Water Quality Variable	Oligo-trophic	Meso-trophic	Eutrophic	May	Jun	Jul	Aug	Oct 3	Oct 23
Total phos. (µg/l)	< 10	10-20	> 20	30	10	10	20	10	10
Chlorophyll (mg/m^3)	< 4	4-10	> 10	4.4	3.2	9.9	7.5	14.1	3.4
Secchi depth (m)	> 4	2-4	< 2	3.2	2.6	1.6	1.9	2.0	2.5

NM = not measured

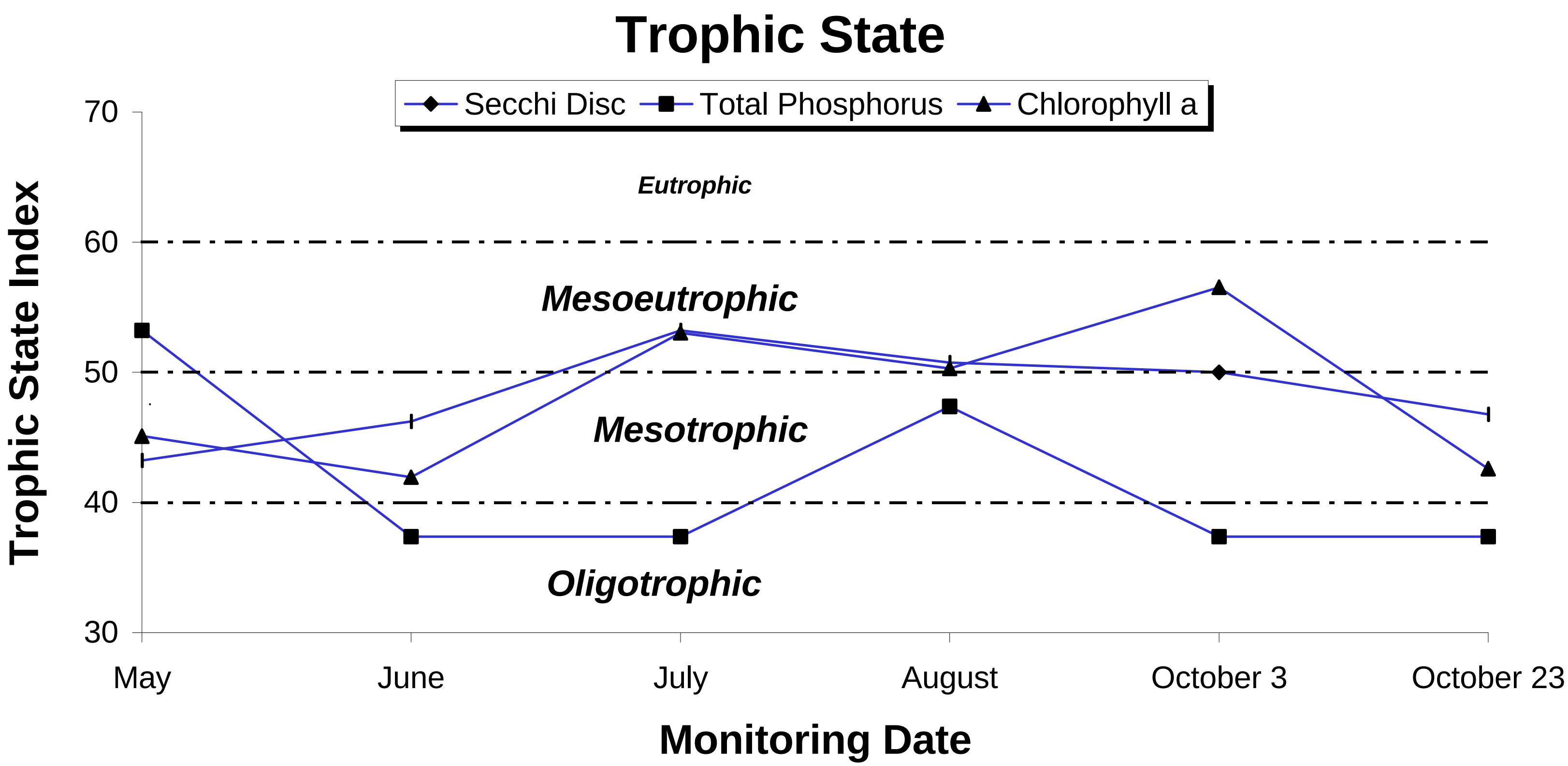

Figure 3-44. Trophic state indices calculated from secchi disk depth and concentrations of chlorophyll *a* and total phosphorus measured in surface water of F.E. Walter Reservoir during 2002

3.4 RESERVOIR BACTERIA MONITORING

Two forms of coliform bacteria contamination were monitored at F.E. Walter Reservoir during 2002 including total and fecal coliform (Table 3-10). Total coliform includes *Escherica coli* (*E. coli*) and related bacteria that are associated with fecal discharges. Fecal coliform bacteria are a subgroup of the total coliform and are normally associated with waste derived from human and other warm-blooded animals.

Total coliform contamination was variable at F.E. Walter Reservoir during 2002. With the exception of October 3, most counts among all stations ranged from less than the detection limit of 10 to 860-clns/100-ml throughout the monitoring period and averaged 154-clns/100-ml (Table 3-10; Fig. 3-45). Total coliform measures on October 3 ranged from 350 to 4320-clns/100-ml and averaged 1847-clns/100-ml. Total coliforms were not present in detectable amounts in June at all stations except WA-4 where it was detected at the method detection limit of 10-clns/100-ml.

Fecal coliform contamination at F.E. Walter Reservoir during 2002 ranged from less than the detection limit of 10 to 560-clns/100-ml throughout the monitoring period and averaged 49-clns/100-ml (Table 3-10; Fig. 3-46). The highest fecal coliform levels were observed in July, averaging 147-clns/100/ml.

Coliform bacteria contamination was for the most part low at F.E. Walter Reservoir with respect to PADEP water quality standards throughout the monitoring period. The water quality standard for bacteria contamination is a geometric mean among fecal coliform samples less than 200 colonies/100-ml. The geometric means among all stations and dates were at least four times less than the PADEP standard (Table 3-11; Fig. 3-47).

Flow data from USGS gauging stations within the F. E. Walter Reservoir watershed (Stoddartsville and Blakeslee) were analyzed to qualitatively correlate precipitation events with coliform bacteria data (Fig 2-2 through 2-8). Precipitation does not appear to have contributed to elevated coliform levels in the reservoir. On 19 June, a storm event with approximately 0.5 inches of precipitation resulted in very low coliform levels and on October 3 a storm event with approximately 0.33 inches of precipitation resulted in the highest values of total coliform recorded for the monitoring period.

Fecal coliform counts for 2002 and historical data from the past 20 years or more were analyzed for seasonal trends. The trend analysis was conducted for spring and summer seasons separately for stations representative of the reservoir and downstream (Figs. 3-48 and 3-49). From the analysis, fecal coliform contamination appears to have increased downstream of the reservoir during the summer season. The increasing trend was significant ($R^2 = 0.37$; $P < 0.005$), and appeared to be driven by higher average counts (about 200 colonies/100-ml) from 1996 to present (Fig. 3-49). Significant trends were not determined for the reservoir in either season, or downstream of the reservoir for the spring.

Table 3-10. Bacteria counts (colonies/100 ml) at F.E. Walter Reservoir during 2002.

STATION	DATE	Total Coliform (TC)	Fecal Coliform (FC)
WA-1S	21-May	50	50
	19-Jun	< 10	< 10
	23-Jul	30	10
	20-Aug	20	< 10
	3-Oct	1160	20
	23-Oct	660	10
WA-2S	21-May	10	10
	19-Jun	< 10	< 10
	23-Jul	20	20
	20-Aug	20	< 10
	3-Oct	430	10
	23-Oct	540	< 10
WA-3S	21-May	270	50
	19-Jun	< 10	< 10
	23-Jul	860	560
	20-Aug	370	250
	3-Oct	4320	< 10
	23-Oct	70	20
WA-4S	21-May	430	250
	19-Jun	10	10
	23-Jul	140	90
	20-Aug	50	< 10
	3-Oct	3520	50
	23-Oct	180	< 10
WA-5S	21-May	40	40
	19-Jun	< 10	< 10
	23-Jul	670	320
	20-Aug	20	< 10
	3-Oct	2680	30
	23-Oct	90	10
WA-6S	21-May	10	< 10
	19-Jun	< 10	< 10
	23-Jul	20	10
	20-Aug	< 10	< 10
	3-Oct	350	< 10
	23-Oct	340	10
WA-7S	21-May	20	10
	19-Jun	< 10	< 10
	23-Jul	20	20
	20-Aug	< 10	< 10
	3-Oct	470	20
	23-Oct	360	10

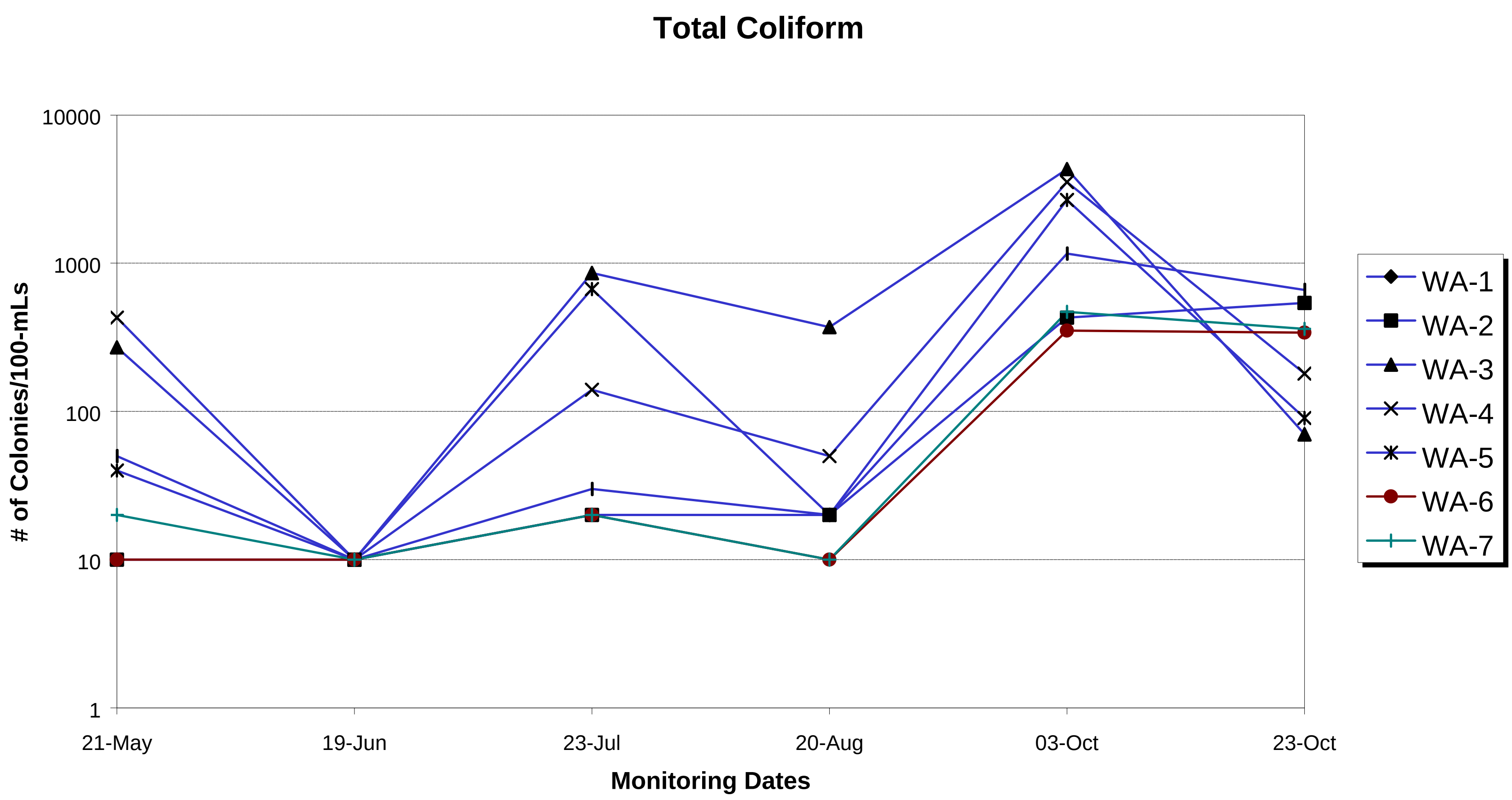

Figure 3-45. Counts of total coliform bacteria in surface waters of F.E. Walter Reservoir during 2002

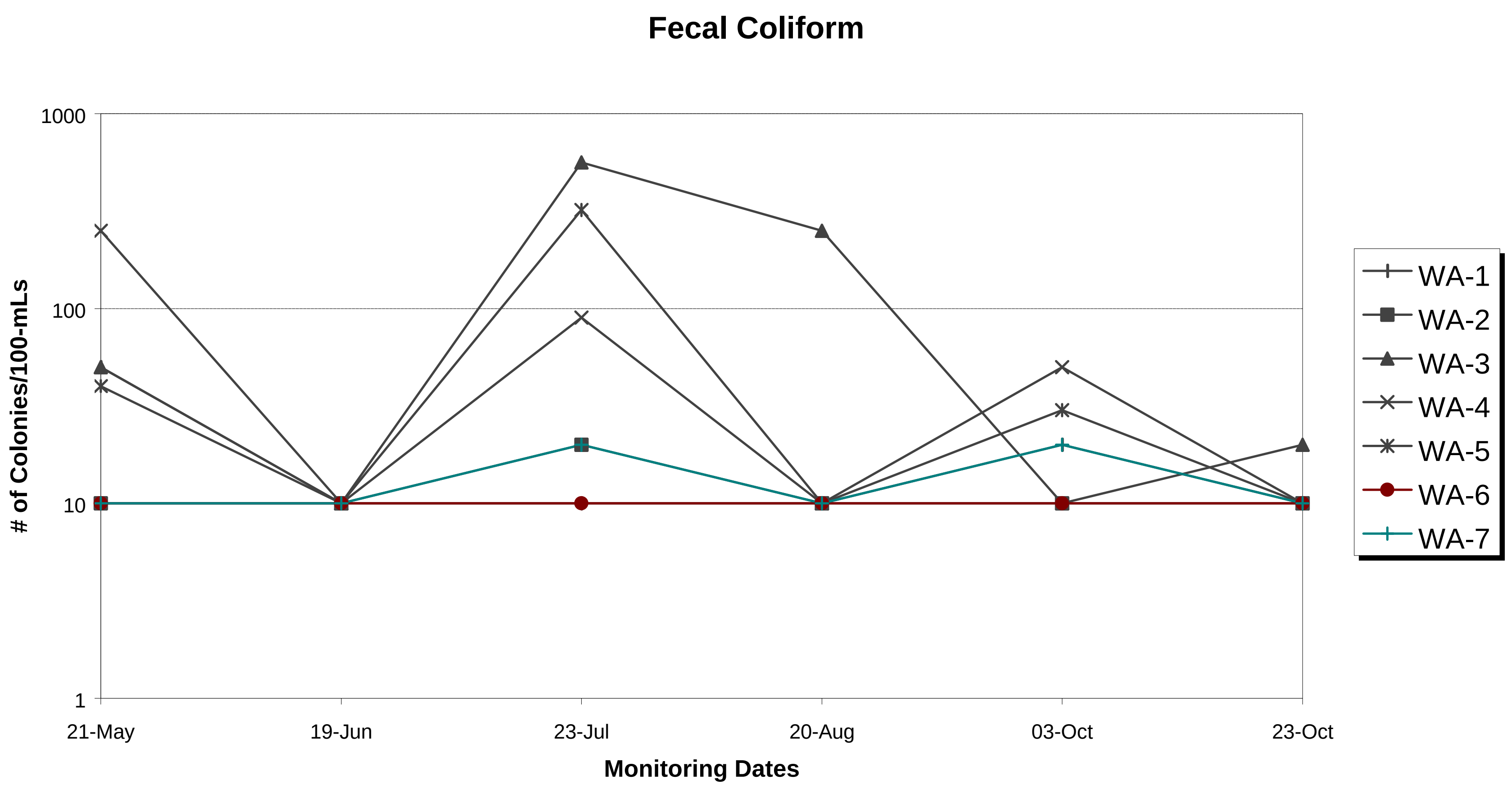

Figure 3-46. Counts of fecal coliform bacteria in surface waters of F.E. Walter Reservoir during 2002

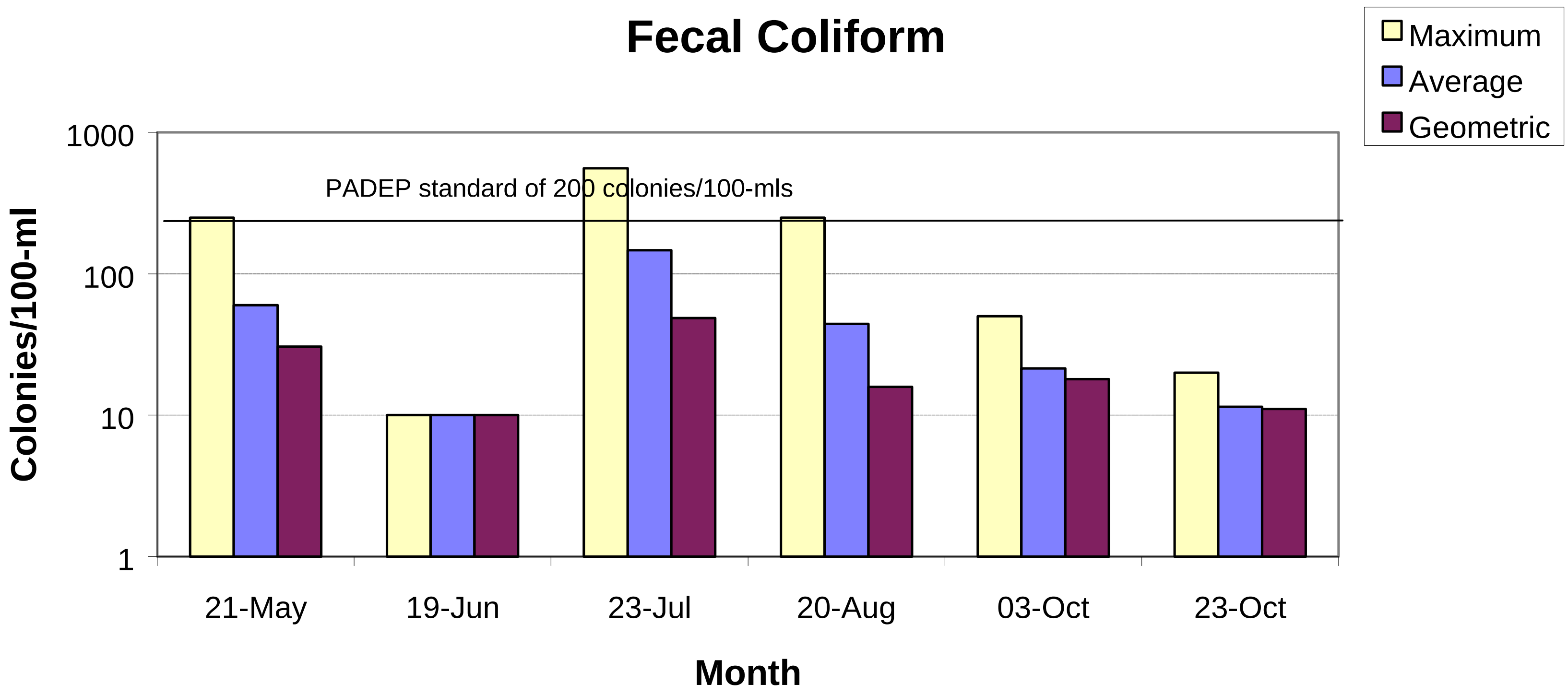

Figure 3-47. Maximum average, and geometric mean of fecal coliform counts (colonies/100-ml) for all stations monitored at F.E. Walter Reservoir in 2002

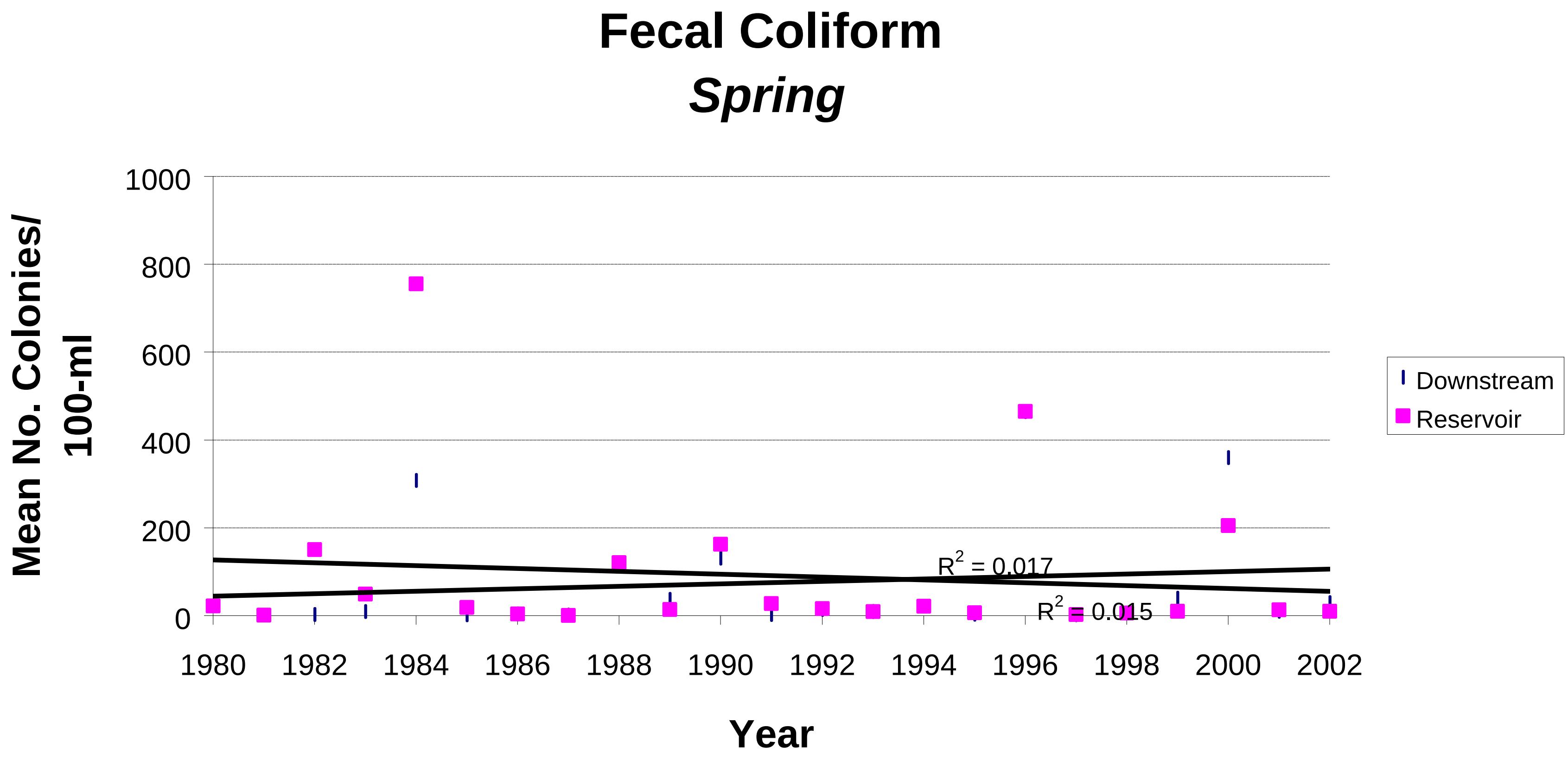

Figure 3-48. Seasonal trend analysis for counts of fecal coliform bacteria during spring months (Apirl, May, and June) at F.E. Walter Reservoir

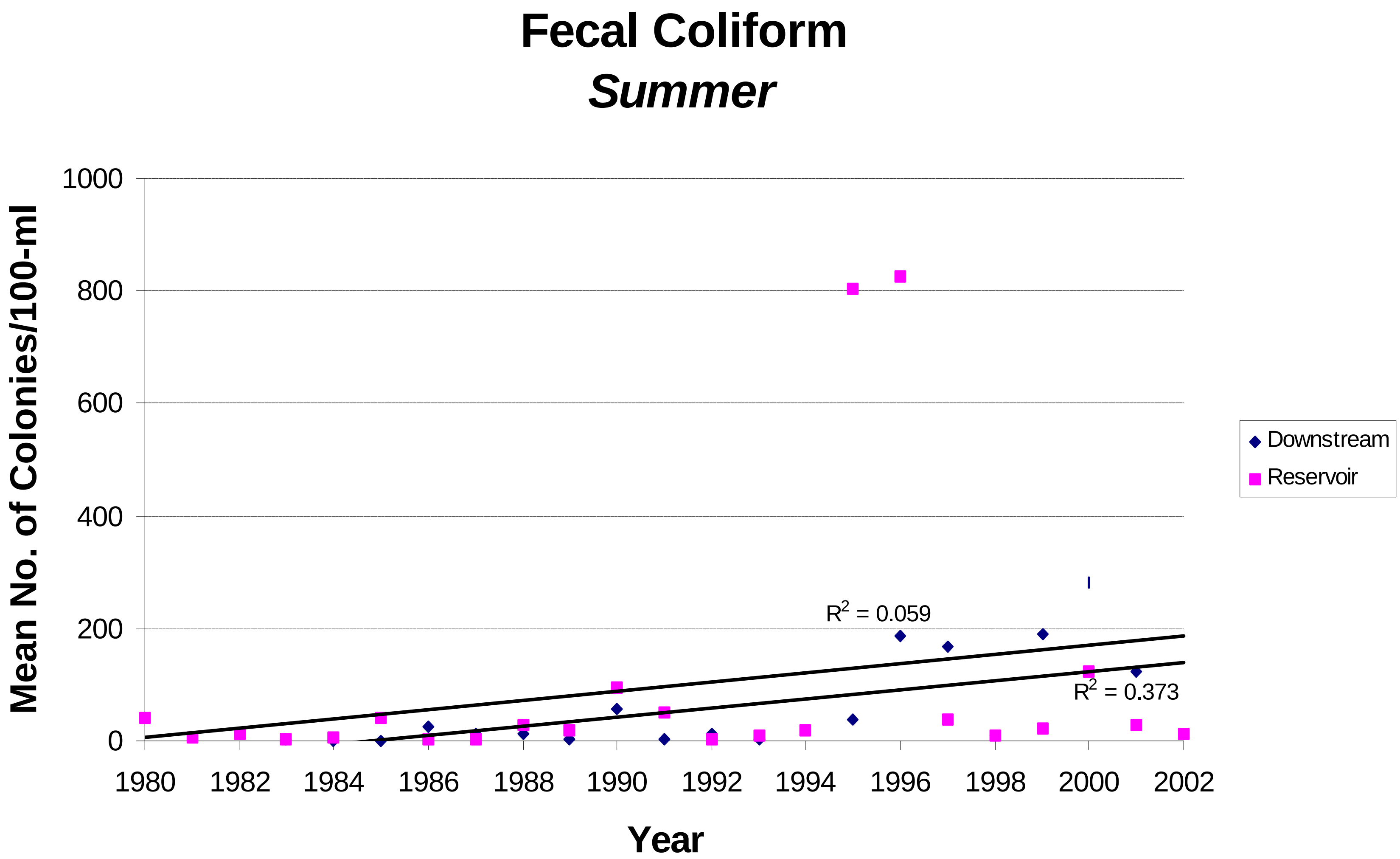

Figure 3-49. Seasonal trend analysis for counts of fecal coliform bacteria during summer months (July, August, and October 3) at F.E. Walter Reservoir

Table 3-11. Summary statistics of fecal coliform counts (colonies/100-ml) among all stations of F.E. Walter Reservoir during 2002. (PADEP water quality standard for fecal coliforms is a geometric mean not greater than 200 colonies/100-ml.)

Date	Geometric Mean	Arithmetic mean	Maximum Count
21-May	30.6	60.0	250
19-Jun	10.0	10.0	10
23-Jul	48.7	147.1	560
20-Aug	15.8	44.3	250
3-Oct	17.9	21.4	50
23-Oct	11.0	11.4	20

Seasonal trend analyses of total and fecal coliform bacteria were conducted for individual stations of F. E. Walter Reservoir, combining 2002 and historical data (Tables 3-12 and 3-13). The Mann-Kendall statistic was applied to station data collected over the past 20 years or more, separately for spring (April to June) and summer (July to October 3) seasons. Stations included in the analysis were representative of downstream (WA-1), within the main reservoir (WA-2), and upstream sources on Tobyhanna Creek (WA-3), Lehigh River (WA-4), and Bear Creek (WA-5).

Table 3-12. Seasonal trends of fecal coliforms/100-ml at individual stations of F.E. Walter Reservoir calculated with the Mann-Kendall Statistic. Shaded values are significant at P=0.05.

Station	# of Years Spring/Summer	Spring		Summer	
		P Level	Rate (mg/L)	P Level	Rate
Surface Water					
WA-1	20	NS	0.336	< 0.05	0.821
WA-2	23	NS	-0.892	NS	0.531
WA-3	23	NS	0.514	< 0.05	4.052
WA-4	22	NS	2.857	< 0.01	3.167
WA-5	22	NS	0.107	< 0.05	3.000

Table 3-13. Seasonal trends of total coliforms/100-ml at individual stations of F.E. Walter Reservoir calculated with the Mann-Kendall Statistic.

Station	# of Years Spring/Summer	Spring		Summer	
		P Level	Rate (mg/L)	P Level	Rate
Surface Water					
WA-1	20	NS	-19.712	NS	3.990
WA-2	23	< 0.05	-11.667	NS	-2.424
WA-3	23/22	NS	-9.250	NS	12.464
WA-4	22	NS	8.433	NS	3.222
WA-5	22	NS	-4.441	NS	12.576

Fecal coliform bacteria appeared to have increased during the summer season at four locations within the F. E. Walter Reservoir drainage area. Significant trends were determined for stations downstream (WA-1), upstream on Tobyhanna Creek (WA-3), the Lehigh River (WA-4), and Bear Creek (WA-5). The yearly rates of increase ranged from 0.8 to 4 colonies/100-ml (Table 3-12). Significant trends of total coliform contaminants were not indicated at any of the stations in either season.

3.5 SEDIMENT PRIORITY POLLUTANT MONITORING

Sediment samples were collected at station WA-2 and analyzed for priority pollutant contaminants, Group 1 – PCB's, pesticides, and volatile organic compounds. Resulting concentrations were compared to New Jersey Soil Cleanup Criteria (NJDEP 1999; Table 3-14). The NJDEP criteria are human health based with categories addressing residential and non-residential settings, and impacts to groundwater. For our comparison, we reported the most conservative of the two criteria.

Of the 93 priority pollutant contaminants analyzed in F.E. Walter Reservoir sediments, none were detected and all parameters were measured at levels below sediment screening levels (Table 3-14).

3.6 ADDITIONAL WATER QUALITY MONITORING ALONG THE LEHIGH RIVER

The following sections describe temporal and spatial patterns for the water quality parameters of temperature, dissolved oxygen (DO), pH, conductivity, turbidity, and chlorophyll a measured at the five stations throughout the Lehigh River during 2002.

3.6.1 Temperature

Temperature of the surface waters of the Lehigh River generally followed a similar pattern throughout the monitoring period. Temperatures remained high throughout the summer at all of the stations. The highest temperature was 25 ºC at LH-17 (Northampton) on 9 July. The temperatures began to decrease after September. At station LH-10 (Lehighton Water Plant), the temperature decreased to 9.4 ºC on 22 October (Fig. 3-50).

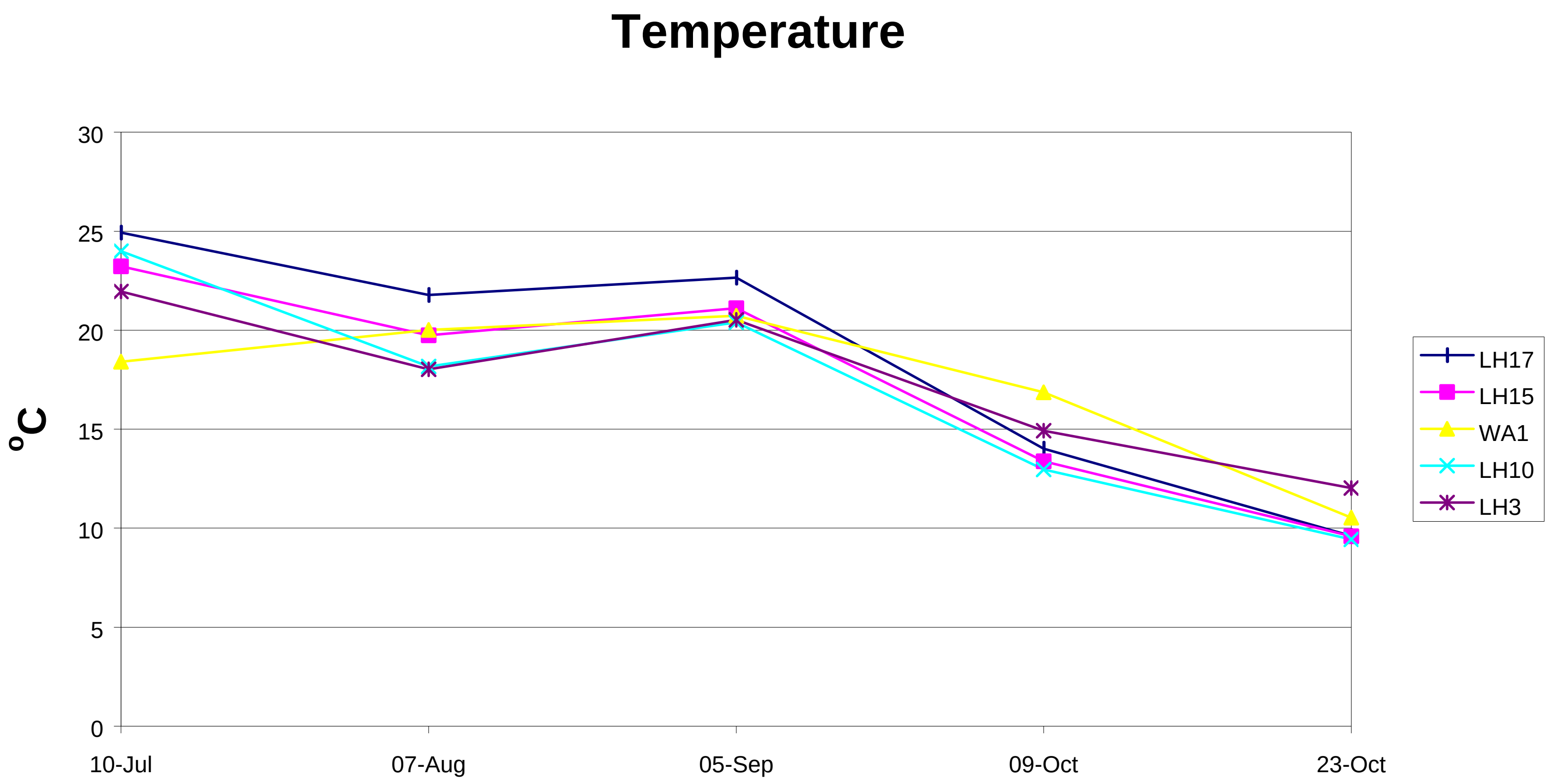

Figure 3-50. Temperature measured in surface waters of Lehigh River during 2002.

Table 3-14. PCB's, pesticides, and volatile organic compounds (Group I) concentrations measured in sediments of F.E. Walter Reservoir in 2002.

	Residential Direct Contact Soil Cleanup Criteria	Non-Residential Direct Contact Soil Cleanup Criteria	Units	Method Detection Limit	WA-2
Percent Solids			ppb	0.1	27
PCBs - Method 8082					
Aroclor-1016			ppb	100	ND
Aroclor-1221			ppb	100	ND
Aroclor-1232			ppb	100	ND
Aroclor-1242			ppb	100	ND
Aroclor-1248			ppb	100	ND
Aroclor-1254			ppb	100	ND
Aroclor-1260			ppb	100	ND
Pesticides - Method 8081A					
4,4'-DDD	3000	12000	ppb	5	ND
4,4'-DDE	2000	9000	ppb	5	ND
4,4'-DDT	2000	9000	ppb	5	ND
alpha-BHC			ppb	5	ND
a-Chlordane			ppb	5	ND
Aldrin	40	170	ppb	5	ND
beta-BHC			ppb	5	ND
Chlordane, technical			ppb	25	ND
delta-BHC			ppb	5	ND
Dieldrin	42	180	ppb	5	ND
Endosulfan I	340000	6200000	ppb	5	ND
Endosulfan II	340000	6200000	ppb	5	ND
Endrin	17000	310000	ppb	5	ND
Endrin aldehyde			ppb	5	ND
Endrin ketone			ppb	5	ND
Endosulfan Sulfate			ppb	5	ND
Gamma-BHC (Lindane)	520	2200	ppb	5	ND
g-Chlordane			ppb	5	ND
Heptachlor	150	650	ppb	5	ND
Heptachlor epoxide			ppb	5	ND
Methoxychlor	280000	5200000	ppb	25	ND
Toxaphene	100	200	ppb	25	ND
Volatile Organic Compounds - Method 8260B					
1,1,1,2-Tetrachloroethane	170000	310000	ppb	1	ND
1,1,1-Trichloroethane	210000	1000000	ppb	1	ND
1,1,2,2-Tetrachloroethane	34000	70000	ppb	1	ND
1,1,2-Trichloroethane	22000	420000	ppb	1	ND
1,1-Dichloroethane	570000	1000000	ppb	1	ND
1,1-Dichloroethene	8000	150000	ppb	1	ND
1,1-Dichloropropene			ppb	1	ND

Table 3-14. (Continued)					
	Residential Direct Contact Soil Cleanup Criteria	**Non-Residential Direct Contact Soil Cleanup Criteria**	**Units**	**Method Detection Limit**	**WA-2**
Volatile Organic Compounds - Method 8260B (Con't)					
1,2,3-Trichlorobenzene			ppb	1	ND
1,2,3-Trichloropropane			ppb	1	ND
1,2,4-Trichlorobenzene	68000	1200000	ppb	1	ND
1,2,4-Trimethylbenzene			ppb	1	ND
1,2-Dibromo-3-chloropropane			ppb	1	ND
1,2-Dichloroethane	6000	24000	ppb	1	ND
1,2-Dichlorobenzene	5100000	10000000	ppb	1	ND
1,2-Dichloropropane	10000	43000	ppb	1	ND
1,2-Dibromoethane			ppb	1	ND
1,3,5-Trimethylbenzene			ppb	1	ND
1,3-Dichlorobenzene	5100000	10000000	ppb	1	ND
1,3-Dichloropropane			ppb	1	ND
1,4-Dichlorobenzene	570000	10000000	ppb	1	ND
2,2-Dichloropropane			ppb	1	ND
2-Chlorotoluene			ppb	1	ND
2-Hexanone			ppb	10	ND
4-Chlorotoluene			ppb	1	ND
Acetone	1000000	1000000	ppb	10	ND
Benzene	3000	13000	ppb	1	ND
Bromochloromethane			ppb	1	ND
Bromodichloromethane	11000	46000	ppb	1	ND
Bromobenzene			ppb	1	ND
Bromoform	86000	370000	ppb	1	ND
Bromomethane	79000	1000000	ppb	1	ND
c-1,2-Dichloroethene	79000	1000000	ppb	1	ND
c-1,3-Dichloropropene	4000	5000	ppb	1	ND
Carbon Tetrachloride	2000	4000	ppb	1	ND
Chlorobenzene	37000	680000	ppb	1	ND
Chloroethane			ppb	1	ND
Chloroform	19000	28000	ppb	1	ND
Chloromethane	520000	1000000	ppb	1	ND
Methylene Chloride (DCM)	49000	210000	ppb	1	ND
Dibromochloromethane	110000	1000000	ppb	1	ND
Dibromomethane			ppb	1	ND
Dichlorofluoromethane			ppb	1	ND
Ethylbenzene	1000000	1000000	ppb	1	ND
Hexachloro1,3-butadiene	1000	21000	ppb	1	ND
Isopropylbenzene (cumene)			ppb	1	ND
M,p-Xylene			ppb	1	ND
2-Butanone(MEK)	1000000	1000000	ppb	10	ND
4-Methyl-2-pentanone (MIBK)	1000000	1000000	ppb	10	ND
Methyl-tert-butylether (MTBE)			ppb	1	ND

Table 3-14. (Continued)	Residential Direct Contact Soil Cleanup Criteria	Non-Residential Direct Contact Soil Cleanup Criteria	Units	Method Detection Limit	WA-2
Volatile Organic Compounds - Method 8260B (Con't)					
n-ButylBenzene			ppb	1	ND
n-Propylbenzene			ppb	1	ND
Naphthalene	230000	4200000	ppb	1	ND
o-Xylene			ppb	1	ND
p-Isopropyltoluene			ppb	1	ND
Tetrachloroethene	4000	6000	ppb	1	ND
sec-Butylbenzene			ppb	1	ND
Styrene	23000	97000	ppb	1	ND
trans-1,2-dichloroethene	1000000	1000000	ppb	1	ND
t-1,3-Dichloropropene	4000	5000	ppb	1	ND
t-Butylalcohol			ppb	10	ND
Trichloroethene	23000	54000	ppb	1	ND
Toluene	1000000	1000000	ppb	1	ND
Trichlorofluoromethane			ppb	1	ND
Vinyl chloride	2000	7000	ppb	1	ND

3.6.2 Dissolved Oxygen

Dissolved oxygen (DO) in the surface waters of the Lehigh River did not follow a consistent pattern during 2002. Concentrations among all stations generally averaged 11-mg/L over the monitoring period and ranged from 9.19 to 17-mg/L (Fig. 3-51). The highest DO concentration (17-mg/L) was on 23 October at WA-1 (F. E. Walter Dam). The DO concentrations were high at all of the stations during 23 October sampling event. DO concentrations at the Lehigh River stations were in compliance with PADEP water quality standards.

3.6.3 pH

Measures of pH in surface waters of the Lehigh River generally followed a similar pattern during 2002 (Fig. 3-52). At all five stations pH generally averaged 7 and ranged from 5.84 to 7.39. Throughout the monitoring period only two measures of pH in the Lehigh River were not in compliance with PADEP water quality standards. The water quality standard for pH is a range of acceptable measures between 6 and 9. Stations LH-3 and LH-10 were below the standard on 22 October with measures of 5.85 and 5.84 respectively.

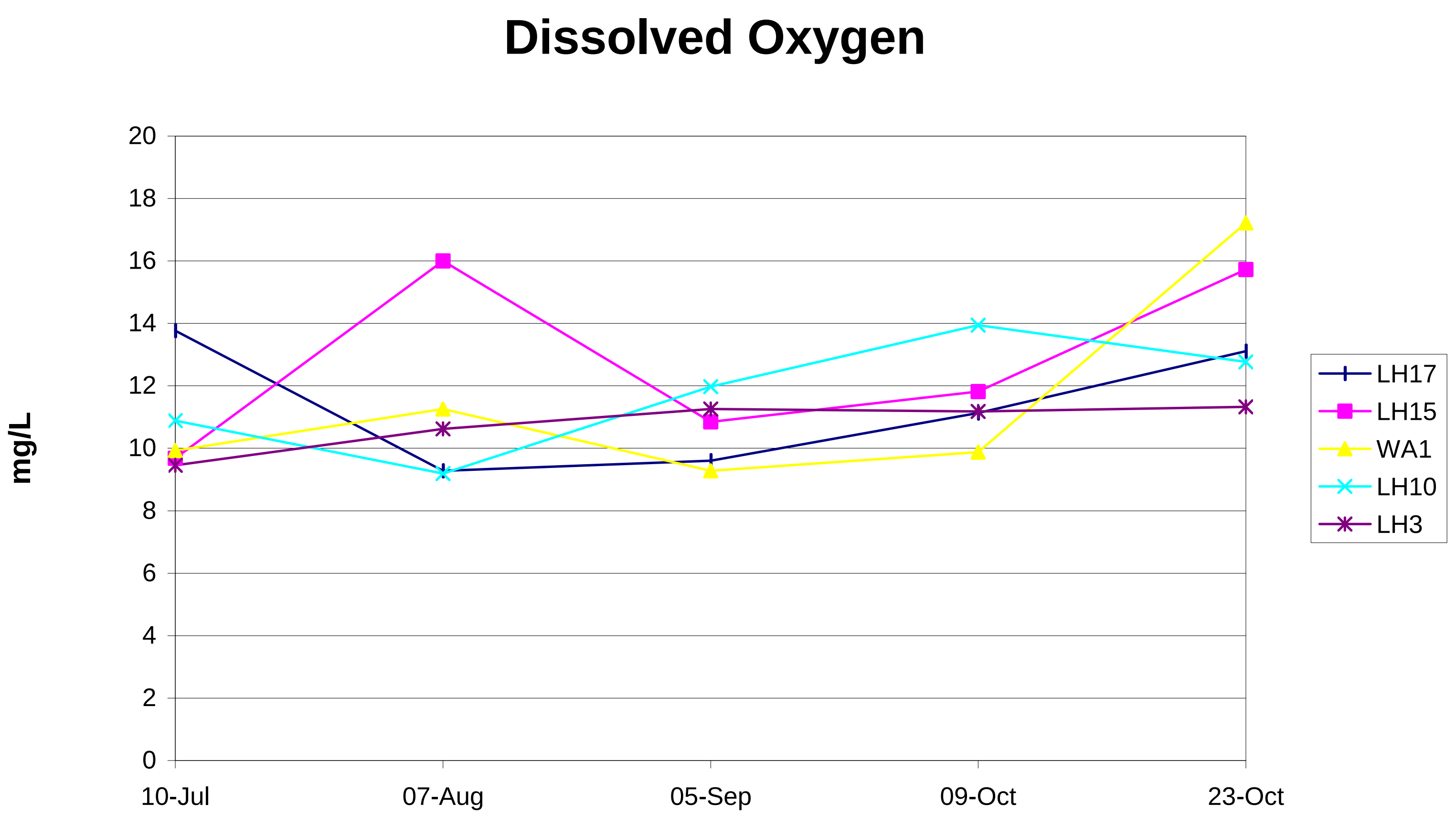

Figure 3-51. Dissolved oxygen measured in surface waters of Lehigh River during 2002.

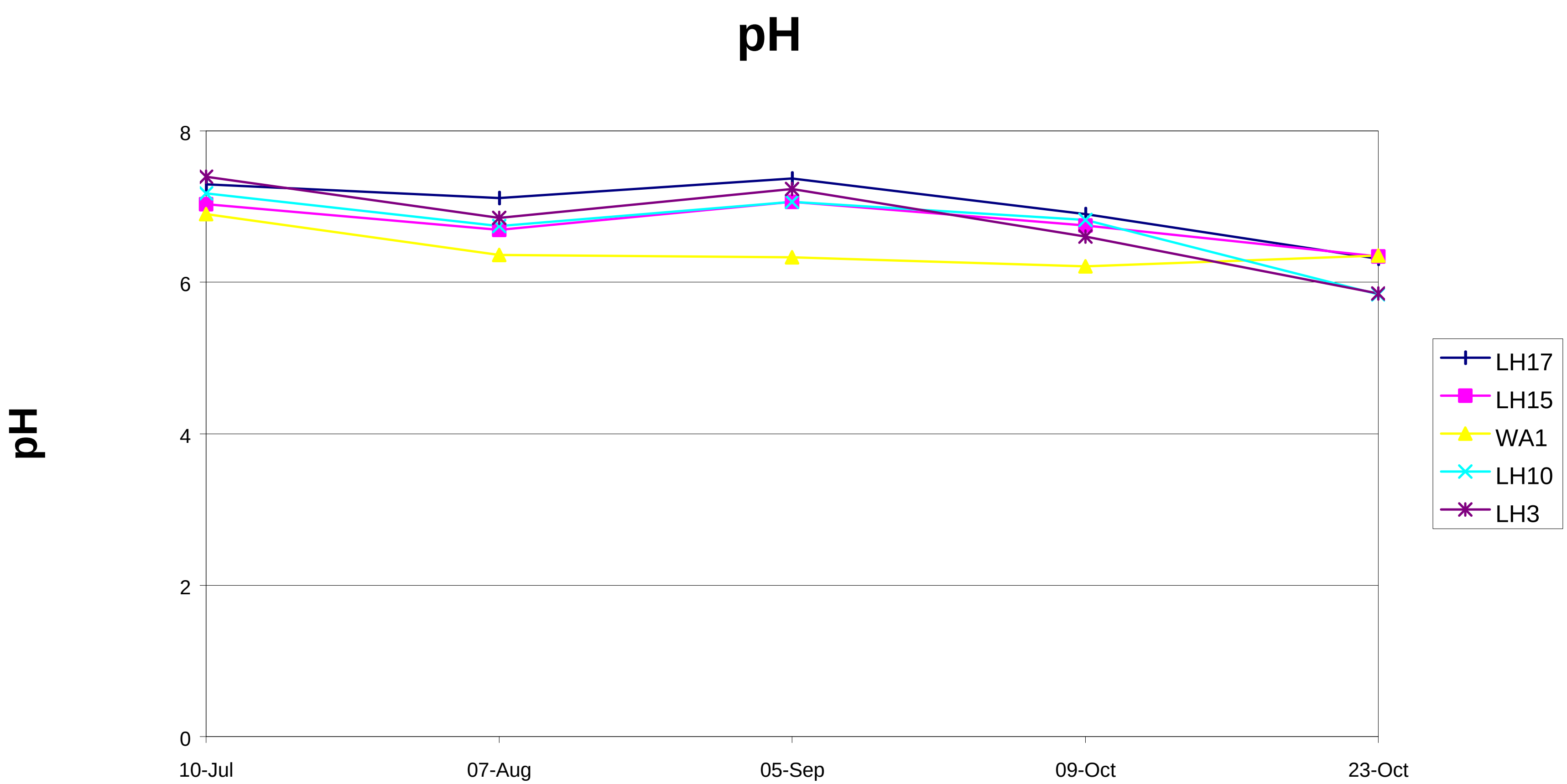

Figure 3-52. pH measured in surface waters of Lehigh River during 2002.

3.6.4 Conductivity

For the most part, conductivity among the surface waters the Lehigh River followed a fairly consistent pattern during 2002. Conductivity at all stations averaged 0.096-mS/cm throughout the monitoring period and ranged from 0.025 to 0.155-mS/cm (Fig. 3-53). Conductivity was typically higher further downstream of the reservoir at stations LH-15 and LH-17. At these locations, conductivity averaged 0.12-mS/cm.

3.6.5 Turbidity

Turbidity in the surface waters of the Lehigh River did not follow a consistent pattern during 2002 (Fig. 3-54). Stations LH-17, -15, -10, and -3 averaged 4-NTU throughout the monitoring period. Station WA-1, just below F.E. Walter Dam, averaged slightly higher at 17-NTU throughout the monitoring period. On 23 October, turbidity at WA-1 ranged to 57.2-NTU. This may have been caused by elevated flow on this day.

3.6.6 Chlorophyll a

For the most part, chlorophyll *a* was low along the Lehigh River during 2002 (Fig. 3-55). Concentrations at all stations averaged 3-mg/m^3 and ranged up to 10.6-mg/m^3 throughout the monitoring period.

3.6.7 Temperature Probe Monitoring

Daily mean temperatures calculated from the data recorded by the TidbiT^{tm} probes deployed at five Lehigh River monitoring stations were examined and compared to PADEP water use criteria for temperature. Stations WA1 (just below the F. E. Walter dam outfall), LH3 (Tannery Bridge), and LH10 (Lehighton) were plotted together along with the season specific temperature criteria for High Quality Cold Water Fisheries (HQ-CWF; Fig. 3-56). Stations LH15 (Walnutport Gauge) and LH17 (Northampton) are classified as either a Trout Stocking Fishery (TSF) or a Cold Water Fishery (CW) and observed water temperatures relative to seasonal specific temperature criteria are presented in Figure 3-57. This analysis indicated that stations WA1, LH3, and LH10 were not in compliance with temperature requirements for a cold water fishery for most of monitoring period (Fig. 3-56).

The sampling stations at LH15 and downstream at LH17 were either categorized as a Trout Stocking Fishery or a Cold Water Fishery by the PADEP. Figure 3-57 compares the season water temperature requirements to those observed from the in-situ temperature

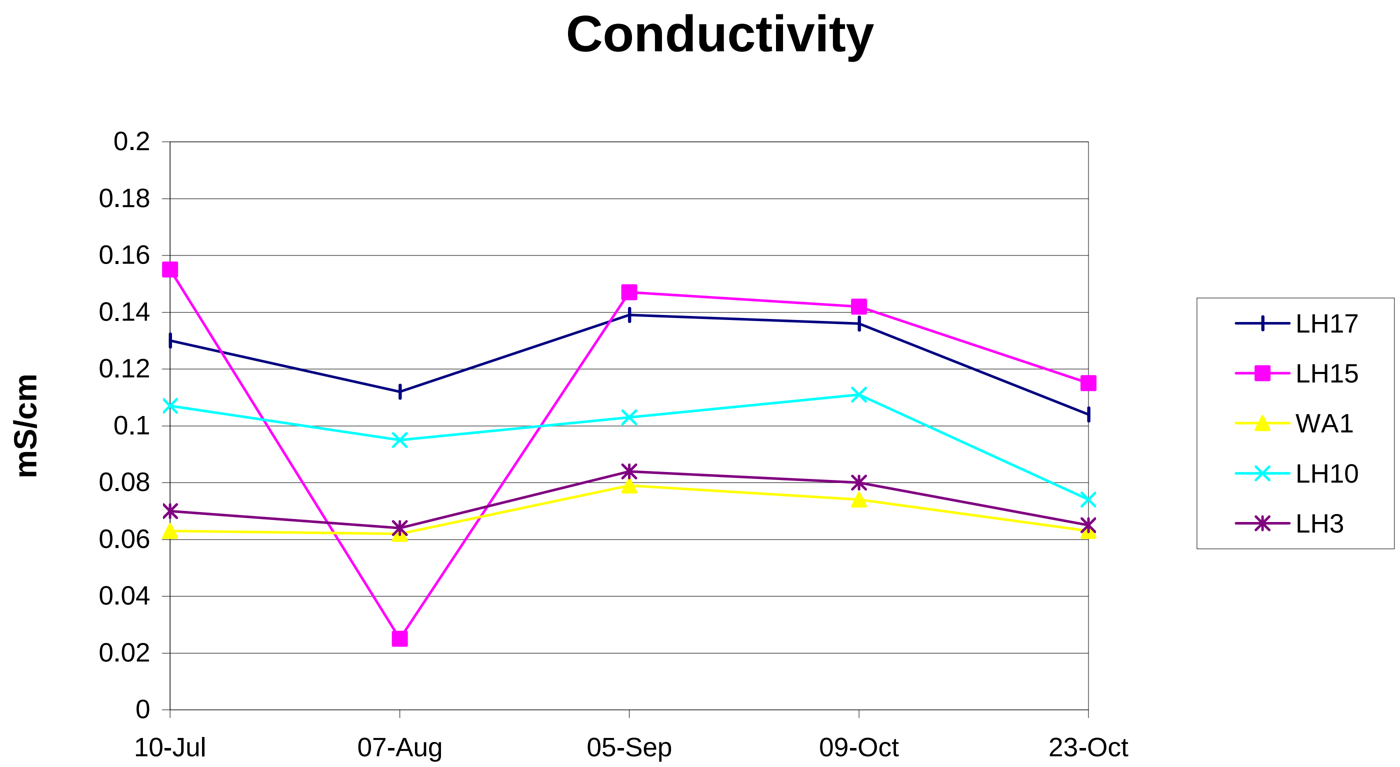

Figure 3-53. Conductivity measured in surface waters of Lehigh River during 2002.

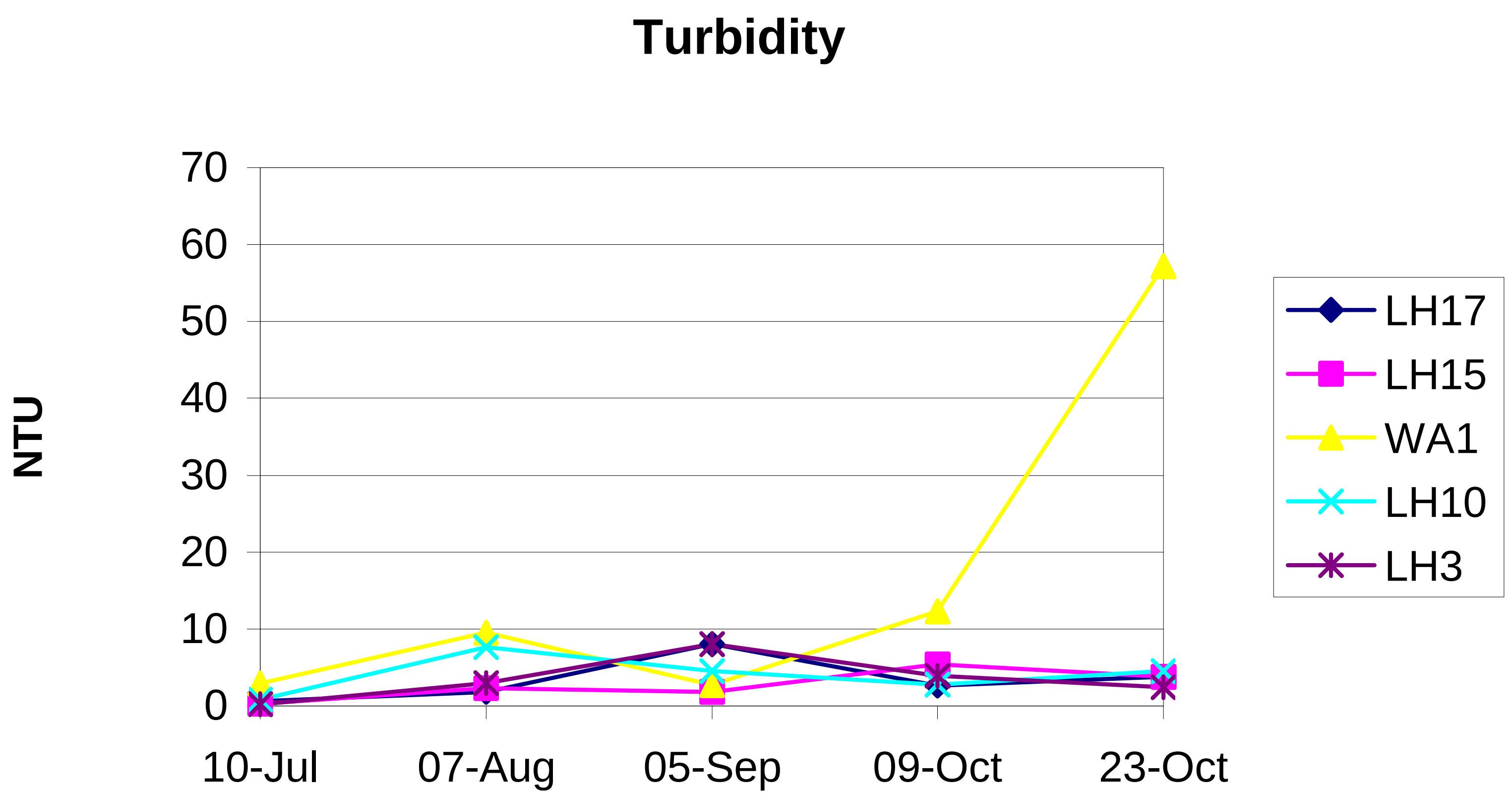

Figure 3-54. Turbidity measured in surface waters of Lehigh River during 2002

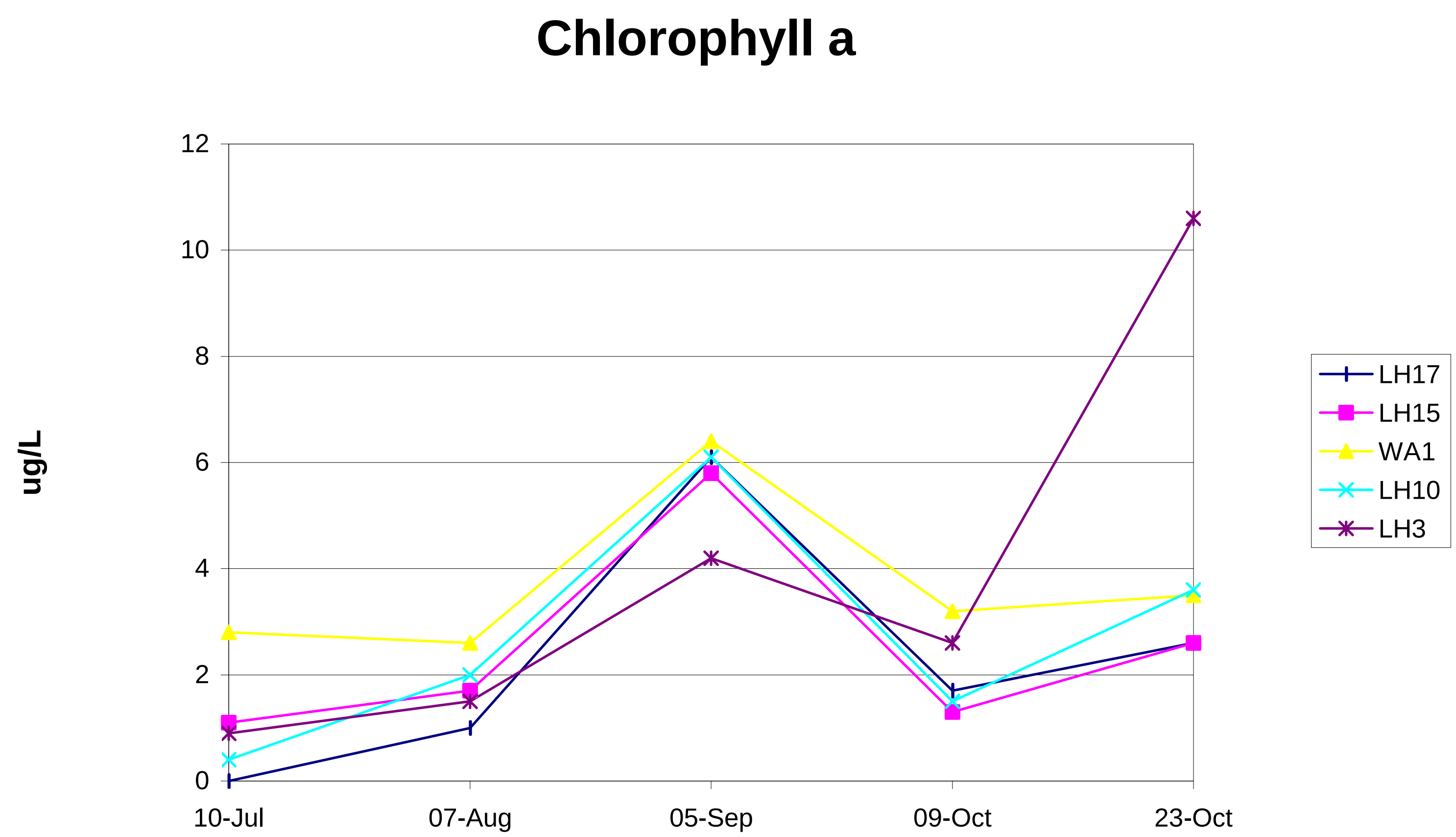

Figure 3-55. Chlorophyll a measured in surface waters of Lehigh River during 2002.

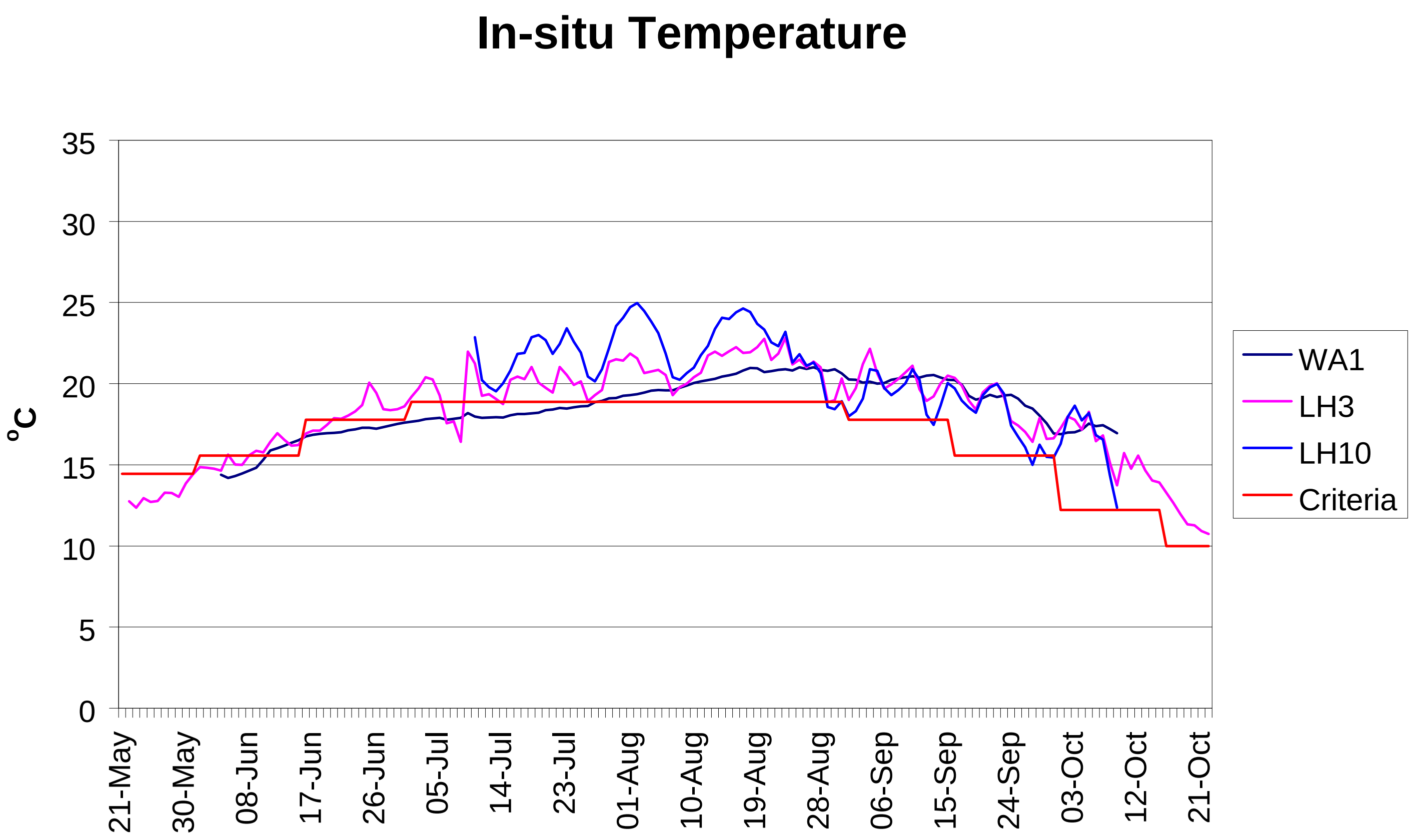

Figure 3-56. In-situ temperature measured in surface waters of Lehigh River during 2002.

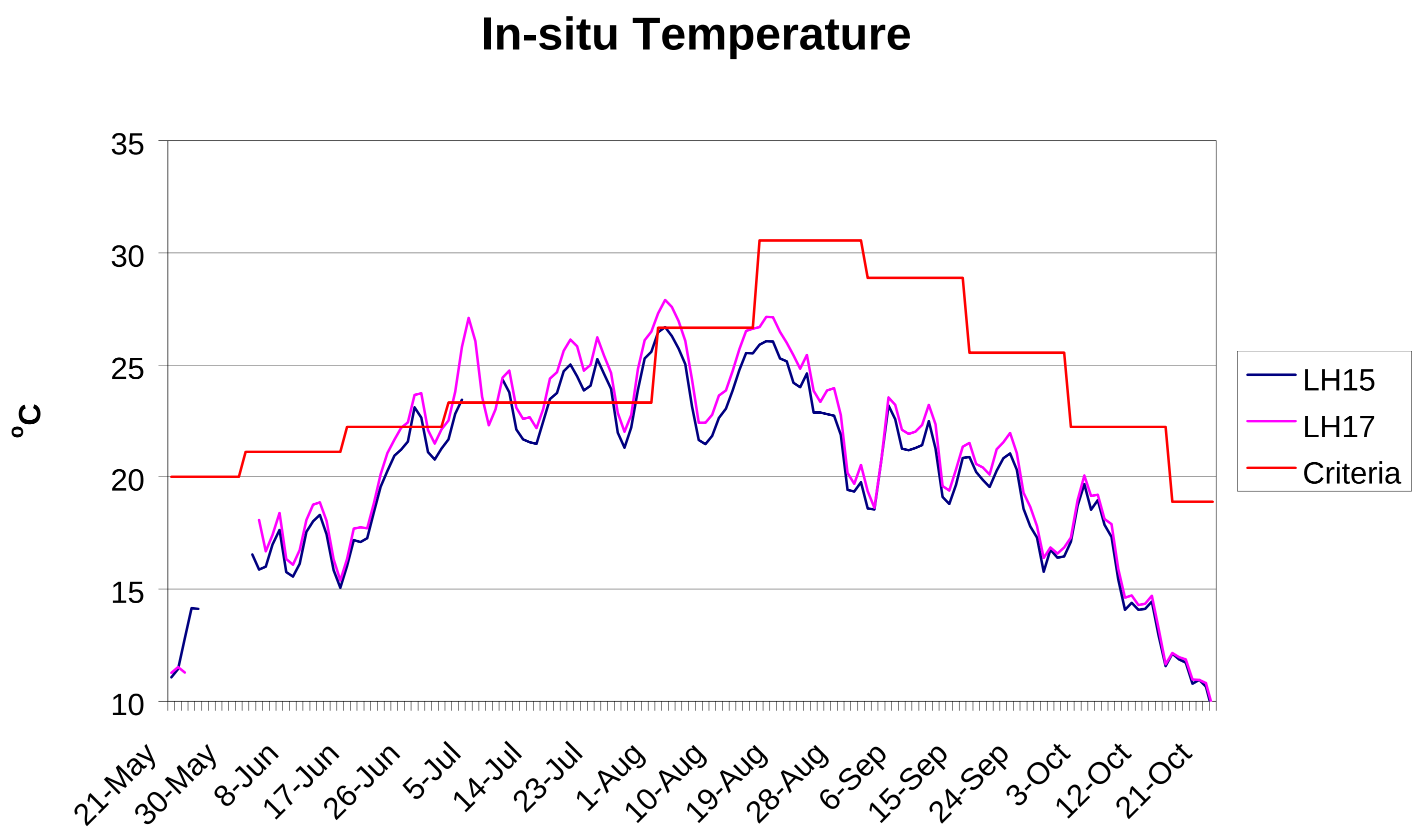

Figure 3-57.In-situ temperature measured in surface waters of Lehigh River during 2002.

monitors. These data show that, with a few exceptions in the summer months, these stations met the PADEP requirements.

3.7 HYDROGEN SULFIDE AND DISSOLVED METALS WATER COLUMN TESTING

Hydrogen sulfide was monitored at reservoir stations WA-2, -6, and -7 and down stream at two stations (WA-1 and LH-3) this year due to concern that elevated levels of hydrogen sulfide from the reservoir were being transported downstream. During early August personnel at the F.E. Walter dam reported a rotten egg odor in the vicinity of the reservoir. Subsequently hydrogen sulfide was sampled on August 7 and September 5. The odor of water with a concentration as little as 0.5-mg/L of hydrogen sulfide is detectable by most people. Concentrations less than 1-mg/L give the water a "musty" or "swampy" odor. A 1-2 mg/L hydrogen sulfide concentration gives water a "rotten egg" odor. Hydrogen sulfide was only detected in August and ranged from less than the detection limit of 0.025-mg/L to 1.6-mg/L (Table 3-15).

During periods of low DO the reducing conditions of the hypoxic environment present in the lower water column enables more metals to be mobilized from bottom sediments. Therefore dissolved metals were also collected at reservoir stations WA-2, -6, and -7 and down stream at two stations (WA-1 and LH-3) during early August and September. None of the dissolved metals exceeded the PADEP Fish and Aquatic Life Continuous or Maximum Concentration criteria (Table 3-15).

3.8 DRINKING WATER

Drinking water from the utility sink located in the maintenance building of F. E. Walter Reservoir was monitored for compliance with PADEP water quality standards for primary and secondary contaminants, and inorganic nitrogen (nitrate and nitrite) and coliform bacteria contaminants during 2002. Drinking water samples were analyzed in duplicate, comprising initial and confirmation samples. For matters of reporting, only if the result of the initial sample was not in compliance with water quality standards, the result of the confirmation sample was also reported.

3.8.1 Primary and Secondary Contaminants

F. E. Walter Reservoir drinking water was in compliance with PADEP water quality standards for all the primary and secondary contaminants with the exception of pH and manganese (Table 3-16). The initial and secondary samples for pH measurements were less than the standard range (6.5 to 8.5). The initial was 4.76 and the secondary was 4.62. The initial and secondary samples for manganese were greater than the standard (0.05-mg/L). The initial was 0.057-mg/L and the secondary was 0.061-mg/L. As part of

Table 3-15. Dissolved inorganic concentrations in the water samples collected from the F.E. Walter Reservoir and Tannery Bridge (LH3) in mg/L.

		WA-1S	WA-1S	WA-2S	WA-2S	WA-2M	WA-2M	WA-2B	WA-2B	WA-6S	WA-6S	WA-6M	WA-6M
Parameter	Criteria	07-Aug	05-Sep	07-Aug	05-Sep	07-Aug	05-Sep	07-Aug	05-Sep	07-Aug	05-Sep	07-Aug	05-Sep
Aluminum	NL	0.014	0.004	< 0.003	0.027	0.038	< 0.003	0.017	0.018	0.011	0.007	0.004	0.034
Antimony	NL	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.005	< 0.003	< 0.005	< 0.003	< 0.005
Arsenic	NL	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Barium	NL	0.028	0.023	0.019	0.022	0.088	< 0.005	0.03	0.024	0.095	0.02	0.023	0.03
Cadmium		0.001	0.003	< 0.001	0.002	< 0.001	0.002	< 0.001	0.001	< 0.001	0.001	< 0.001	< 0.001
	C*	0.089	0.094	0.080	0.083	0.095	0.104	0.089	0.093	0.080	0.083	0.086	0.089
	M*	0.954	1.038	0.826	0.866	1.057	1.201	0.957	1.031	0.828	0.866	0.915	0.957
Chromium		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	C	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	M	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Copper		0.02	0.002	0.008	0.004	0.008	< 0.001	0.006	0.003	0.005	0.002	0.003	< 0.001
	C*	0.653	0.698	0.582	0.604	0.709	0.785	0.655	0.695	0.583	0.605	0.632	0.655
	M*	1.522	1.638	1.341	1.397	1.666	1.864	1.526	1.630	1.343	1.398	1.467	1.526
Iron	NL	0.147	0.05	< 0.002	0.24	0.078	0.196	0.435	0.21	0.053	0.03	< 0.002	0.8
Magnesium	NL	0.91	1.21	0.876	1.02	0.913	1.425	0.934	1.2	0.89	1.03	0.927	1.08
Manganese	NL	0.597	0.2	0.002	0.26	0.072	0.313	0.614	0.21	0.019	0.28	0.128	0.5
Mercury		< 0.0002	< 0.0002	< 0.0002	0.0003	< 0.0002	< 0.0002	< 0.0002	0.0008	< 0.0002	< 0.0002	< 0.0002	< 0.0002
	C**	770	770	770	770	770	770	770	770	770	770	770	770
	M**	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400
Nickel		< 0.001	< 0.001	< 0.001	0.002	0.001	< 0.001	0.001	0.001	0.001	0.001	0.001	0.002
	C*	3.633	3.883	3.243	3.366	3.941	4.359	3.643	3.864	3.248	3.367	3.515	3.644
	M*	32.711	34.957	29.201	30.304	35.480	39.244	32.801	34.792	29.239	30.311	31.649	32.804
Selenium		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
	C	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Silver		0.004	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	M*	19.38	22.18	15.38	16.59	22.86	28.06	19.49	21.97	15.43	16.60	18.12	19.49
Sodium	NL	4.16	4.70	3.94	4.18	5.11	3.16	3.86	4.72	5.26	4.30	3.97	4.24
Thallium	NL	< 0.006	< 0.005	0.008	< 0.005	< 0.006	< 0.005	< 0.006	< 0.005	< 0.006	< 0.005	< 0.006	< 0.005
Zinc		< 0.003	0.008	< 0.003	0.009	0.053	0.1	< 0.003	0.007	0.023	0.006	< 0.003	< 0.003
	C*	8.307	8.878	7.415	7.695	9.012	9.969	8.330	8.837	7.424	7.697	8.037	8.331
	M*	8.307	8.878	7.415	7.695	9.012	9.969	8.330	8.837	7.424	7.697	8.037	8.331
Hydrogen Sulfide	NL	< 0.025	< 0.025	0.4	< 0.025	1.2	< 0.025	0.4	< 0.025	0.4	< 0.025	< 0.025	< 0.025

		WA-6B	WA-6B	WA-7S	WA-7S	WA-7M	WA-7M	WA-7B	WA-7B	LH-3	LH-3		
		07-Aug	05-Sep	07-Aug	05-Sep	07-Aug	05-Sep	07-Aug	05-Sep	07-Aug	05-Sep		
Aluminum	NL	0.014	0.007	0.008	0.03	0.007	0.017	0.037	0.016	0.025	< 0.02		
Antimony	NL	< 0.003	< 0.005	< 0.003	< 0.003	< 0.003	< 0.005	< 0.003	< 0.005	< 0.003	< 0.02		
Arsenic	NL	< 0.01	0.022	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05		
Barium	NL	0.024	0.024	0.019	0.02	0.025	0.024	0.115	0.03	0.089	0.012		
Cadmium		< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.005		
	C*	0.087	0.093	0.080	0.083	0.084	0.085	0.089	0.092	0.093	0.099		
	M*	0.931	1.025	0.828	0.866	0.884	0.896	0.957	1.008	1.026	1.117		
Chromium		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.005		
	C	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01		
	M	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016		
Copper		0.001	< 0.001	< 0.001	0.002	< 0.001	0.002	< 0.001	0.001	< 0.001	< 0.005		
	C*	0.640	0.691	0.583	0.604	0.614	0.621	0.655	0.682	0.692	0.740		
	M*	1.489	1.620	1.343	1.397	1.423	1.441	1.526	1.597	1.622	1.748		
Iron	NL	0.003	0.006	< 0.002	0.25	0.004	0.1	0.709	0.05	0.156	0.04		
Magnesium	NL	0.864	1.2	0.873	1.01	0.985	1.03	1.018	1.2	0.926	1.25		
Manganese	NL	0.196	0.22	0.002	0.26	0.123	0.29	0.693	0.4	0.03	0.011		
Mercury		< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002		
	C**	770	770	770	770	770	770	770	770	770	770		
	M**	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400		
Nickel		0.001	0.002	< 0.001	0.002	< 0.001	0.001	0.001	0.002	0.001	< 0.001		
	C*	3.564	3.844	3.249	3.365	3.421	3.459	3.642	3.794	3.848	4.115		
	M*	32.090	34.611	29.248	30.297	30.800	31.142	32.794	34.159	34.648	37.048		
Selenium		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		
	C	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005		
Silver		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		
	M*	18.64	21.74	15.43	16.58	17.15	17.54	19.48	21.16	21.78	24.96		
Sodium	NL	3.74	4.63	3.88	4.13	4.12	4.13	5.54	4.64	5.30	5.35		
Thallium	NL	0.008	< 0.005	< 0.006	< 0.005	< 0.006	< 0.005	< 0.006	< 0.05	< 0.006	< 0.005		
Zinc		< 0.003	< 0.003	< 0.003	0.007	< 0.003	0.006	0.067	< 0.005	0.021	< 0.003		
	C*	8.149	8.791	7.426	7.693	7.821	7.908	8.328	8.675	8.800	9.410		
	M*	8.149	8.791	7.426	7.693	7.821	7.908	8.328	8.675	8.800	9.410		

Table 3-15. (Continued)

		WA-1S	WA-1S	WA-2S	WA-2S	WA-2M	WA-2M	WA-2B	WA-2B	WA-6S	WA-6S	WA-6M	WA-6M
Hydrogen Sulfide	NL	0.4	<0.025	0.4	<0.025	0.8	<0.025	1.6	<0.025	1.2	<0.025		

NL - No PADEP criteria listed
C - PADEP Fish and Aquatic Life Criteria Continuous Concentrations
M - PADEP Fish and Aquatic Life Criteria Maximum Concentrations
(*) Water quality standards for these chemicals are hardness dependent and were calculated based on ambient river conditions.
(**) The lower of the water quality standards for chromium III, which is hardness dependent, and chromium VI were used – chromium VI was lower under these conditions.

Table 3-16. Concentrations of primary and secondary contaminants in drinking water at F.E. Walter Reservoir in 2002. Shaded values indicate results that exceeded Pennsylvania State drinking water standards; in these instances the result of a second sample is also reported.

Parameter	**Sampling Date 19 June**	**PADEP Regulatory Level**	**Detection Limits (mg/L)**	**EPA Method**
Aluminum	0.042	0.2	0.003	200.7
Antimony	< 0.003	0.006	0.003	200.7
Arsenic	< 0.01	0.05	0.010	200.7
Barium	0.012	2.0	0.005	200.7
Cadmium	< 0.001	0.005	0.001	200.7
Chromium	< 0.001	0.1	0.001	200.7
Copper	0.292	1.3	0.001	200.7
Iron	0.066	0.3	0.002	200.7
Lead	0.006	0.015	0.003	200.7
Magnesium	0.721	NL	0.001	200.7
Manganese	0.057 / 0.061	0.05	0.001	200.7
Mercury	< 0.0002	0.002	0.0002	245.1
Nickel	0.004	0.1	0.001	200.7
Selenium	< 0.005	0.05	0.005	200.7
Silver	< 0.001	0.1	0.001	200.7
Sodium	0.206	NL	0.020	200.7
Thallium	< 0.006	0.002	0.006	200.7
Zinc	0.034	5.0	0.003	200.7
Chloride	0.6	250	0.5	300
Cyanide	< 0.005	0.2	0.005	SM 4500CN-C&E
Fluoride	0.8	2.0	0.1	300
Foaming Agents	< 0.01	0.5	0.01	SM 5540C
PH	4.76 / 4.62	6.5-8.5	+/- 0.01	150.1
Sulfate	2	250.0	1	300
Total Dissolved Solids	34	500.0	10	160.1

All results, criteria and detection limits are expressed in mg/L except pH which is expressed in positive/negative
ND – Not Detected
NL – Not Listed

drinking water compliance monitoring, Safe Drinking Water Act (SDWA) forms 4 for the reporting of results of primary and secondary drinking water contaminants were submitted to appropriate state environmental agencies.

3.8.2 Inorganic Nitrogen and Coliform Bacteria

F. E. Walter Reservoir drinking water was in compliance with PADEP criteria for inorganic nitrogen contaminants, nitrate and nitrite, and coliform bacteria contaminants (Table 3-17). None of these contaminants were found in the drinking waters samples at F.E. Walter Reservoir. Following laboratory testing, drinking water monitoring results were recorded on Safe Drinking Water Act (SDWA-S and SDWA-4) forms and submitted to the appropriate state environmental agencies.

Table 3-17. Concentrations of nitrate and nitrite, and results of coliform bacteria monitoring of drinking water sampled from the public water fountain located in the overlook building at F.E. Walter Reservoir during 2002

Parameter	Sampling Dates		PADEP Regulatory Level	Detection Limits	Method
	19 June	20 August			
Nitrate as N (mg/L)	< 0.05	< 0.05	10.0	0.05	300
Nitrite as N (mg/L)	< 0.05	< 0.05	1.0	0.01	300
E. coli (CFU)	Absence	Absence	Presence	1	SM 9223
Total Coliform (CFU)	Absence	Absence	Presence	1	SM 9223

3.8.3 Historical Drinking Water Quality

Drinking water quality has been monitored at Walter Reservoir over the past 20 years. Versar (1996) compiled the results from all of the previous years into a single database to facilitate water quality comparisons. Historical data from drinking water quality parameters were compared to their respective PADEP standards. Of 26 parameters summarized, 5 had incidences of noncompliance with drinking water standards from 1983 to present (Table 3-18). Cadmium, Copper, pH, manganese, and corrosivity were most often not in compliance with PADEP criteria. During 2002 monitoring period, manganese and pH were out of compliance.

Table 3-18. Drinking water parameters exceeding PADEP criteria at F.E. Walter Reservoir from 1983 to 2002

Parameter	Monitoring Date	Result	Criteria
Cadmium (mg/L)	15 June 1987	0.006	0.005
	26 July 1988	0.008	0.005
	4 April 1991	0.007	0.005
	27 July 1994	0.040	0.005
Copper (mg/L)	10 June 1998	2.83	1.3
	20 June 2000	2.03	1.3
Corrosivity	10 June 1998	-1.80	Non-negative
	22 June 1999	NEG	Non-negative
	20 June 2000	-5.3	Non-negative
pH	10 June 1998	5.9	6.5-8.5
	22 June 1999	5.6	6.5-8.5
	20 June 2000	5.5	6.5-8.5
	14 June 2001	5.4	6.5-8.5
	19 June 2002	4.76 / 4.62	6.5-8.5
Manganese	14 June 2001	0.053	0.05
	19 June 2002	0.057 / 0.061	0.05

4.0 SUMMARY

The USACE implements a yearly monitoring program at F. E. Walter Reservoir to evaluate potential public health concerns. In general, the monitoring programs emphasize measuring water quality and sediment contamination. Monitoring results are compared to state and federal criteria to evaluate the condition of F. E. Walter Reservoir. The 2002 monitoring program of F. E. Walter Reservoir comprised seven major elements:

- Monthly water quality and bacteria monitoring from May through October to evaluate compliance with the Pennsylvania state water quality standards;
- Meteorological monitoring of air temperature, relative humidity, solar radiation, wind speed and direction every ½ hour at the F. E. Walter Reservoir discharge tower;
- Sediment priority pollutant monitoring of PCB's, pesticides, and volatile organic compounds to evaluate sediment toxicity relative to identified screening concentrations;
- Drinking water monitoring to ensure public health safety by comparing water quality from a drinking water source to standards determined by the Safe Drinking Water Act (SDWA);
- Hydrogen sulfide and dissolved metal samples were collected on 7 August and 5 September to further monitor the lake during anoxic conditions;
- Ambient water temperature was recorded every ½ hour with Onset Computer Corporation TidbiT^{tm} probes at five stations along the Lehigh River; and
- Physical water quality monitoring at five stations along the Lehigh River.

4.1 WATER QUALITY MONITORING

Water quality monitoring at F. E. Walter Reservoir generally indicated the presence of acceptable conditions during 2002. In general surface and downstream water quality were in compliance with the PADEP water quality standards. However, dissolved oxygen (DO) in more than half the water column of the reservoir (WA-2, -6, and –7) was below standard (a minimum concentration of 5-mg/L) from June through October. Measures of pH were not in compliance with the PADEP water quality standard range, the range is from 6 to 9. Stations WA-3 and WA-5 were below the standard on October 23. Stations WA-2, -6, and –7 were below the standard throughout the monitoring period with the exception of May 22 and August 20. F. E. Walter Reservoir contained acceptable levels of nutrients during 2002. Measures for total phosphorus with results greater than the detection limit exceed the EPA guideline in 69% of the samples. Ammonia, nitrate +

nitrite, TDS, and alkalinity were in compliance with state water quality standards throughout the reservoir watershed.

4.2 MONITORING PROGRAM TRENDS

Trends computed for individual stations using the Mann-Kendall test indicated significant water quality changes at several locations in the F. E. Walter Reservoir drainage. DO was decreasing in the spring at WA-2 and the summer at station WA-5. Ammonia was decreasing in the reservoir watershed except at WA-5 in both spring and summer seasons. Station WA-1 had a decreasing trend for total nitrogen during the summer. Trends for fecal coliform were increasing during the summer at upstream stations, WA-3, -4 and -5, as well as downstream of the reservoir at station WA-1. Trends for total phosphorus, TDS, BOD, and total coliform were not significant.

4.3 TROPHIC STATE CLASSIFICATION

The trophic condition of F.E. Walter Reservoir was characterized as mesotrophic in 2002. The trophic status was defined independently by Carlson's trophic state indices and EPA criteria. Both classifications were based on concentrations of total phosphorus, chlorophyll *a* and secchi disk depths.

4.4 COLIFORM BACTERIA MONITORING

Coliform bacteria contamination at F. E. Walter Reservoir was in compliance with the PADEP water quality standard for bacteria contamination during 2002. The geometric means among samples collected each month were always less than 200 colonies/100-ml. Both regression and Mann-Kendall analyses indicated an increasing trend for fecal coliform downstream of the reservoir during summer. The Mann-Kendall also determined an increasing trend upstream on the Lehigh River (WA-3, -4, and -5) for fecal coliform during the summer.

4.5 SEDIMENT PRIORITY POLLUTANT MONITORING

F.E. Walter Reservoir was in compliance with NJDEP soil guidelines in 2002. Of the 93 priority pollutant contaminants analyzed in F.E. Walter Reservoir sediments, none were detected and all parameters were measured at levels below sediment screening levels.

4.6 DRINKING WATER MONITORING

F. E. Walter Reservoir drinking water was in compliance with PADEP drinking water standards for primary and secondary and bacteria with the exception of pH and manganese. Manganese concentration of 0.053 mg/L exceeded the PADEP drinking water standards by 0.007 and 0.011-mg/L. Measures of pH were less than the standard range of 6.5 to 8.5.

4.7 ADDITIONAL WATER QUALITY MONITORING ALONG THE LEHIGH RIVER

Water quality monitoring at five Lehigh River monitoring stations were examined and compared to PADEP water use criteria for temperature, DO, pH, and turbidity. Stations along the Lehigh were WA1 (just below the F. E. Walter dam outfall), LH3 (Tannery Bridge), LH10 (Lehighton), LH15 (Walnutport Gauge), and LH17 (Northampton). Stations LH-3 and LH-10 were below the standard on 22 October with measures of 5.85 and 5.84 respectively

4.8 HYDROGEN SULFIDE AND DISSOLVED METAL MONITORING

Hydrogen Sulfide and dissolved metals were monitored in F.E. Walter Reservoir and at two downstream stations on 7 August and 5 September. Hydrogen sulfide was only detected in August and ranged from less than the detection limit of 0.025-mg/L to 1.6-mg/L. None of the dissolved metals exceeded the PADEP Fish and Aquatic Life Continuous or Maximum Concentration criteria.

4.9 TEMPERATURE PROBE MONITORING

Daily mean temperatures calculated from the data recorded by the TidbiT^{tm} probes deployed at five Lehigh River monitoring stations were examined and compared to PADEP water use criteria for temperature. The analysis indicated that stations WA1, LH3, and LH10 were not in compliance with temperature requirements for a High Quality Cold Water Fisheries for most of monitoring period. Additionally, stations LH15 and LH17, with a few exceptions in the summer months, met the PADEP requirements for a Cold Water Fishery.

5.0 RECOMMENDATIONS

The USACE intends to continue monitoring of the F.E. Walter Reservoir in future years to evaluate trends and to identify potential environmental problems related to human development within the watershed. The USACE is continually seeking to improve the quality and cost-effectiveness of the information gathered as part of this effort. Below, we present three recommendations for improving the monitoring program:

Recommendation 1: Add a monitoring component to assess relative loadings of nutrients, toxic chemicals and sediment from each of the major watersheds draining into the F.E. Walter Reservoir.

The F.E. Walter Reservoir contains several feeder streams, which drain different watersheds. Each of these watersheds has different land use characteristics (e.g., residential, agricultural, forested ecosystems) each of which may contribute a different suite of chemical loadings to the reservoir. Management of water quality problems in the reservoir will require an understanding of the relative loadings of nutrients, toxics, and sediment from each watershed, and in which watersheds these loadings are changing most rapidly. Developing this information could be accomplished by deploying automatic samplers into the major feeder streams to obtain composite samples over randomly selected 24-hour periods, stratified by season, and by conducting special sampling during storm events.

Recommendation 2: Adjust nutrient concentration to account for yearly differences in flow.

The trends presented in this report have not taken into account the effects of flow volume on parameter concentrations. Further analyses using concentrations weighted for stream flow (from USGS gauging stations) would provide a better estimate of trends within the system. These data could be used to calculate total nutrient loadings (kg/day) and could form the basis for creating a nutrient budget for the system. The observed trends should be correlated to management practices in the watershed (e.g., sewage treatment plant construction or upgrades, changes in agricultural activities) to help explain water quality improvements or degradations observed during the monitoring period.

Recommendation 3: Conduct a watershed modeling effort.

A survey of all nutrient and pollutant sources (point source and non-point source) within the F.E. Walter Reservoir watershed could be conducted and presented in a GIS format. Using predicted loadings from the various pollutant sources identified within the watershed, a simple nutrient/DO prediction model could be constructed and verified with the long-term data set. This model could be used to predict the degree of improvement in reservoir water quality that could be obtained through various nutrient control measures such as sewage treatment upgrades and reduced fertilizer application to farmlands.

6.0 REFERENCES

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APPENDIX A

STRATIFICATION MONITORING

Table A-1. Summary of stratification monitoring at F. E. Walter Reservoir in 2002

Station	Date	Depth (F)	Temp °C	pH	DO (mg/L)	DO (%)	Cond (ms/cm)
WA1	22-May	0	11.63	6.9	11.47	105.4	0.09
	19-Jun	0	16.97	6.72	8.72	90.1	0.0615
	23-Jul	0	18.25	6.67	7.96	84.5	0.0689
	20-Aug	0	20.91	7.36	7.2	80.6	0.0776
	03-Oct	0	13.74	7.11	10.28	99.1	0.0883
WA2	22-May	138	10.75	5.95	7.62	68.7	0.0722
		135	10.83	5.96	7.41	66.9	0.0702
		130	10.92	5.94	7.64	69.1	0.0683
		125	10.99	5.94	7.69	69.8	0.0684
		120	11.02	5.93	7.76	70.4	0.069
		115	11.03	5.93	7.81	70.9	0.0687
		110	11.05	5.93	8.02	72.8	0.0674
		105	11.08	5.92	7.81	71	0.0669
		100	11.1	5.91	7.79	70.8	0.0686
		95	11.12	5.91	7.86	71.5	0.0693
		90	11.26	5.91	7.8	71.2	0.0703
		85	11.3	5.93	7.75	70.8	0.0697
		80	11.31	5.93	7.8	71.2	0.0704
		75	11.4	5.94	7.78	71.2	0.0705
		70	11.44	5.95	7.7	70.6	0.0701
		65	11.53	5.95	7.65	70.3	0.0705
		60	11.74	5.96	7.57	69.8	0.0714
		55	11.82	5.96	7.51	69.4	0.0716
		50					
		45	11.97	5.95	7.41	68.7	0.074
		40					
		35	12.3	5.96	7.29	68.1	0.0745
		30	12.43	5.95	7.32	68.6	0.0767
		25	12.76	5.97	7.31	69	0.0759
		20	13.04	5.97	7.35	69.9	0.0771
		15	13.13	6	7.81	74.4	0.0774
		10	13.17	6.02	7.89	75.2	0.0774
		5	13.24	6.03	8.14	77.7	0.0776
		0	13.33	6.05	8.26	79	0.0776
	19-Jun	138	15.96	6.12	3.12	31.6	0.0639
		135	16.07	6.09	3.32	33.7	0.0629
		130	16.23	6.03	3.66	37.3	0.0623
		125	16.32	5.98	3.87	39.5	0.062
		120	16.46	5.93	4.46	45.7	0.0623
		115	16.52	5.91	4.7	48.1	0.0624
		110	16.54	5.88	4.58	46.9	0.0614
		105	16.6	5.83	4.09	42	0.0606
		100	16.66	5.78	4.07	41.8	0.0606
		95	16.74	5.73	4.18	43	0.0602
		90	16.81	5.74	4.99	51.4	0.0626
		85	16.91	5.76	5.07	52.4	0.0621

Table A-1. (Continued)

Station	Date	Depth (F)	Temp °C	pH	DO (mg/L)	DO (%)	Cond (ms/cm)
WA2 (Con't)	19 Jun (Con't)	80	16.97	5.71	4.43	45.8	0.0583
		75	17.02	5.7	4.86	50.3	0.0614
		70	17.06	5.7	4.99	51.7	0.0611
		65	17.15	5.72	5.13	53.3	0.0612
		60	17.26	5.72	5.3	55.2	0.0615
		55	17.29	5.72	5.08	52.9	0.061
		50	17.41	5.72	5.16	53.9	0.0611
		45	17.42	5.72	5.18	54.1	0.0613
		40	17.66	5.71	5.43	57	0.0614
		35	17.85	5.71	5.45	57.4	0.0617
		30	18.15	5.71	5.27	55.9	0.0615
		25	18.31	5.69	4.96	52.7	0.0615
		20	19.43	5.73	5.62	61.1	0.0602
		15	19.61	5.76	5.91	64.5	0.0604
		10	19.96	5.77	6.02	66.1	0.0603
		5	20.14	5.78	6.18	68.2	0.0604
		0	22.58	5.8	6.23	72.1	0.0615
	23-Jul	125	17.91	6.55	0	0	0.0755
		120	17.88	6.44	0	0	0.0749
		115	18.04	6.34	0	0	0.0741
		110	18.11	6.32	0	0	0.0663
		105	18.2	6.23	0	0	0.0651
		100	18.33	6.14	0	0	0.0671
		95	18.43	6.09	0.91	9.7	0.0627
		90	18.56	6.03	1.07	11.5	0.062
		85	18.66	5.99	2.02	21.6	0.0614
		80	18.74	5.95	2.04	21.8	0.0615
		75	18.89	5.91	1.93	20.8	0.0613
		70	18.96	5.89	1.62	17.4	0.0614
		65	19.05	5.87	1.55	16.7	0.0614
		60	19.19	5.84	1.97	21.3	0.061
		55	19.33	5.85	1.95	21.1	0.0612
		50	19.46	5.84	1.89	20.6	0.0614
		45	19.73	5.83	2.27	24.8	0.0615
		40	19.9	5.81	2.16	23.7	0.0623
		35	20.05	5.81	1.96	21.6	0.0627
		30	20.63	5.79	1.77	19.8	0.0634
		25	21.14	5.79	1.7	19.1	0.0648
		20	22.08	5.8	1.18	13.5	0.0673
		15	22.93	5.83	1.7	19.8	0.0641
		10	23.91	5.88	3.09	36.7	0.0644
		5	25.31	6.07	5.73	69.8	0.0642
		0	26.22	6.28	6.89	85.3	0.0643

Table A-1. (Continued)

Station	Date	Depth (F)	Temp °C	pH	DO (mg/L)	DO (%)	Cond (ms/cm)
WA2 (**Con't)**	20-Aug	115	20.18	6.57	0.11	1.2	0.088
		110	20.34	6.41	0	0	0.0825
		105	20.46	6.35	0	0	0.0817
		100	20.61	6.31	0	0	0.0808
		95	20.66	6.27	0	0	0.0831
		90	20.83	6.24	0	0	0.0803
		85	20.93	6.21	0	0	0.0773
		80	21.06	6.18	0	0	0.0736
		75	21.2	6.14	0	0	0.0741
		70	21.37	6.13	0	0	0.0747
		65	21.54	6.11	0	0	0.0745
		60	21.61	6.1	0	0	0.0722
		55	21.76	6.07	0	0	0.0743
		50	22	6.07	0	0	0.0739
		45	22.18	6.06	0	0	0.0733
		40	22.38	6.04	0	0	0.0727
		35	22.66	6.03	0	0	0.0736
		30	22.96	5.97	0	0	0.0681
		25	23.13	5.94	0	0	0.0675
		20	23.95	6	1.76	20.9	0.0675
		15	25.02	6.1	3.77	45.6	0.068
		10	26.13	6.23	5.32	65.7	0.0688
		5	26.16	6.29	5.69	70.4	0.0689
		0	26.23	6.31	5.82	72.1	0.0688
	03-Oct	115	13.28	6.47	2.23	21.3	0.0917
		110	13.31	6.33	5.04	48.2	0.0888
		105	13.34	6.3	5.7	54.5	0.0882
		100	13.38	6.29	6.05	58	0.0878
		95	13.64	6.26	6.07	58.4	0.0876
		90	13.79	6.23	5.98	57.7	0.0876
		85	13.9	6.22	6.03	58.4	0.0872
		80	14.08	6.21	5.89	57.3	0.0874
		75	14.11	6.2	5.63	54.8	0.0889
		70	14.18	6.19	5.49	53.5	0.0876
		65	14.32	6.19	5.44	53.2	0.0881
		60	14.54	6.17	5.26	51.6	0.0871
		55	14.65	6.15	4.81	47.3	0.087
		50	14.85	6.14	4.59	45.4	0.0852
		45	15.15	6.12	4.09	40.7	0.0845
		40	15.19	6.09	3.96	39.4	0.0841
		35	15.4	6.07	3.68	36.8	0.0832
		30	15.48	6.06	3.48	34.9	0.0825
		25	15.56	6.06	3.69	37	0.0822
		20	15.59	6.06	3.85	38.6	0.0822
		15	15.65	6.06	3.99	40.1	0.0821
		10	16.09	6.08	4.27	43.4	0.082

Table A-1. (Continued)

Station	Date	Depth (F)	Temp °C	pH	DO (mg/L)	DO (%)	Cond (ms/cm)	
WA2 (Con't)	3 Oct (Con't)	5	16.26	6.1	4.84	49.3	0.082	
		0	16.46	6.14	5.46	55.8	0.0818	
WA3	22-May	0	9.84	7.54	9.64	85.1	0.0737	
	19-Jun	0	18.54	6.8	9.43	100.7	0.0101	
	23-Jul	0	24.57	7.71	8.27	99.3	0.0764	
	20-Aug	0	21.98	7.89	8.41	96.2	0.1179	
	03-Oct	0	14.82	6.91	9.15	90.4	0.0856	
WA4	22-May	0	8.04	7.52	9.5	80.3	0.0544	
	19-Jun	0	17.39	6.99	8.84	92.2	0.1138	
	23-Jul	0	19.82	6.99	6.87	75.4	0.0865	
	20-Aug	0	22.71	7.62	9.84	114.1	0.1033	
	03-Oct	0	12.46	7.13	9.1	85.3	0.1282	
WA5	22-May	0	9.2	6.3	12.1	104.6	0.079	
	19-Jun	0	17.42	7.06	8.11	84.7	0.0814	
	23-Jul	0	24.66	7.55	5.63	67.7	0.0999	
	20-Aug	0	24.19	7.89	5.82	69.4	0.1045	
	03-Oct	0	14.3	6.83	8.9	87	0.152	
WA6	22-May	115	10.73	6.49	7.6	68.5	0.065	
		110	10.77	6.4	7.84	70.8	0.0642	
		105	10.9	6.36	7.84	70.9	0.0639	
		100	10.97	6.3	7.71	69.9	0.0633	
		95	11.03	6.27	7.67	69.6	0.0629	
		90	11.22	6.25	7.63	69.6	0.0644	
		85	11.23	6.23	7.58	69.2	0.0645	
		80	11.28	6.21	7.51	68.6	0.0646	
		75	11.34	6.19	7.55	69	0.0646	
		70	11.47	6.19	7.49	68.6	0.0668	
		65	11.6	6.18	7.49	68.9	0.0679	
		60	11.7	6.19	7.48	68.9	0.0684	
		55	11.73	6.18	7.33	67.6	0.0667	
		50	11.87	6.15	7.18	66.4	0.0686	
		45	11.96	6.13	7.03	65.2	0.0705	
		40	12.19	6.13	7.08	66	0.073	
		35	12.25	6.13	7.1	66.3	0.0732	
		30	12.41	6.14	7.05	66.1	0.0736	
		25	12.61	6.14	7.12	67	0.0734	
		20	13.08	6.16	7.47	71	0.0753	
		15	13.09	6.17	7.63	72.6	0.0753	
		10	13.11	6.18	7.73	73.6	0.0754	
		5	13.14	6.2	7.98	76	0.0755	
		0	13.2	6.21	8.09	77.1	0.0762	

Table A-1. (Continued)

Station	Date	Depth (F)	Temp °C	pH	DO (mg/L)	DO (%)	Cond (ms/cm)
WA6 (Con't)	19-Jun	113	16.43	6.41	4.09	41.9	0.0623
		110	16.54	6.15	3.65	37.4	0.0613
		105	16.6	6.08	3.58	36.7	0.0609
		100	16.62	6.02	3.7	38	0.0608
		95	16.7	5.99	3.93	40.4	0.0605
		90	16.87	5.94	4.34	44.8	0.0615
		85	16.93	5.9	4.25	43.9	0.0592
		80	16.99	5.86	4.19	43.3	0.0586
		75	17.03	5.83	4.27	44.2	0.0588
		70	17.06	5.81	4.57	47.3	0.0598
		65	17.15	5.81	4.94	51.3	0.0612
		60	17.26	5.82	5.11	53.2	0.0614
		55	17.33	5.83	5.24	54.6	0.0614
		50	17.43	5.83	5.24	54.7	0.0615
		45	17.51	5.83	5.28	55.2	0.0613
		40	17.6	5.83	5.35	56	0.0614
		35	17.72	5.83	5.3	55.7	0.0609
		30	18.15	5.82	5.06	53.6	0.0613
		25	18.33	5.81	5.01	53.3	0.0603
		20	18.66	5.79	5.06	54.2	0.0612
		15	19.83	5.82	5.57	61.1	0.0601
		10	19.97	5.85	5.68	62.5	0.0599
		5	20.2	5.87	5.93	65.5	0.0603
		0	20.65	5.9	6.21	69.1	0.0605
	23-Jul	110	18.07	6.27	0	0	0.0746
		105	18.2	6.22	0	0	0.0718
		100	18.31	6.21	0	0	0.069
		95	18.43	6.19	0	0	0.0707
		90	18.55	6.16	0	0	0.0644
		85	18.58	6.09	0.23	2.5	0.0629
		80	18.65	6.03	0	0	0.0637
		75	18.74	6.02	0	0	0.0624
		70	18.86	6	0.29	3.1	0.0627
		65	19.03	6	0	0	0.0661
		60	19.12	5.99	0	0	0.0639
		55	19.3	5.93	0	0	0.0619
		50	19.64	5.91	0.31	3.3	0.0618
		45	19.79	5.92	1.47	16.1	0.0619
		40	20.04	5.9	1.34	14.8	0.0629
		35	20.37	5.91	1.62	17.9	0.0645
		30	20.58	5.88	1.51	16.8	0.0648
		25	21.22	5.89	1.22	13.7	0.0656
		20	22.16	5.89	1.15	13.1	0.0672
		15	23.04	5.91	1.78	20.8	0.0643
		10	24.12	5.97	4	47.7	0.0644

Table A-1. (Continued)								
Station	**Date**	**Depth (F)**	**Temp °C**	**pH**	**DO (mg/L)**	**DO (%)**	**Cond (ms/cm)**	
WA6 (Con't)	23 Jul (Con't)	5	25.55	6.11	5.34	65.3	0.0641	
		0	26.64	6.33	7.02	87.6	0.0653	
	20-Aug	90	20.91	6.75	0.41	4.6	0.0796	
		85	20.98	6.47	0	0	0.0804	
		80	21.08	6.41	0	0	0.0786	
		75	21.18	6.39	0	0	0.0779	
		70	21.3	6.32	0	0	0.0759	
		65	21.46	6.3	0	0	0.0751	
		60	21.6	6.25	0	0	0.0749	
		55	21.79	6.26	0	0	0.0742	
		50	21.94	6.24	0	0	0.0737	
		45	22.15	6.21	0	0	0.0736	
		40	22.39	6.2	0	0	0.0731	
		35	22.69	6.16	0	0	0.0723	
		30	23.04	6.13	0	0	0.0694	
		25	23.27	6.11	0	0	0.0678	
		20	23.66	6.1	0.91	10.7	0.0672	
		15	24.23	6.16	2.64	31.5	0.0675	
		10	25.69	6.22	3.55	43.6	0.0685	
		5	26.05	6.36	5.43	67	0.0685	
		0	26.06	6.42	5.73	70.8	0.0685	
	03-Oct	100	13.06	6.63	5.64	53.6	0.0897	
		95	13.14	6.56	5.99	57	0.0893	
		90	13.38	6.51	6.01	57.6	0.0899	
		85	13.68	6.48	5.75	55.5	0.0904	
		80	13.86	6.42	5.33	51.6	0.0917	
		75	13.93	6.42	5.49	53.2	0.0894	
		70	14.01	6.36	5.15	50	0.0947	
		65	14.14	6.32	4.91	47.8	0.0967	
		60	14.24	6.3	4.9	47.8	0.0923	
		55	14.4	6.29	4.87	47.7	0.0914	
		50	14.52	6.29	4.8	47.1	0.0871	
		45	14.78	6.27	4.41	43.5	0.0841	
		40	14.9	6.25	4.36	43.2	0.0855	
		35	15.09	6.22	3.85	38.2	0.0848	
		30	15.17	6.21	3.67	36.6	0.0836	
		25	15.26	6.21	3.7	36.9	0.083	
		20	15.28	6.2	3.78	37.7	0.0827	
		15	15.31	6.18	3.76	37.5	0.0818	
		10	15.59	6.2	4.2	42.2	0.0824	
		5	15.97	6.22	4.7	47.6	0.0825	
		0	16.2	6.26	5.49	55.8	0.0826	

Table A-1. (Continued)

Station	Date	Depth (F)	Temp °C	pH	DO (mg/L)	DO (%)	Cond (ms/cm)
WA7	22-May	70	11.57	6.23	7.52	69.1	0.0788
		65	11.61	6.22	7.79	71.7	0.0806
		60	11.69	6.22	8.09	74.5	0.0811
		55	11.88	6.21	7.67	71	0.0808
		50	12.01	6.2	7.55	70.1	0.0805
		45	12.04	6.2	7.54	70	0.0804
		40	12.17	6.18	7.31	68.1	0.0825
		35	12.34	6.17	7.11	66.5	0.0839
		30	12.48	6.16	7.07	66.4	0.0843
		25	12.7	6.17	7.09	66.8	0.0827
		20	13.17	6.18	7.54	71.9	0.085
		15	13.19	6.19	7.7	73.4	0.0849
		10	13.18	6.2	8.1	77.2	0.0847
		5	13.2	6.21	7.92	75.5	0.0847
		0	13.32	6.21	8.27	79.1	0.085
	19-Jun	105	16.74	6.27	5.35	55.1	0.0628
		100	16.76	6.19	5.29	54.5	0.0624
		95	16.82	6.13	5.37	55.4	0.0626
		90	16.84	6.1	5.41	55.8	0.0629
		85	16.9	6.07	5.41	55.8	0.0628
		80	16.96	6.04	5.17	53.5	0.0625
		75	17	6	5.1	52.7	0.0626
		70	17.05	5.98	5.09	52.7	0.0626
		65	17.09	5.95	5.07	52.5	0.0624
		60	17.21	5.93	5	52	0.0624
		55	17.27	5.88	4.72	49.1	0.0623
		50	17.39	5.88	5.08	53	0.0623
		45	17.54	5.87	5.2	54.4	0.0623
		40	17.66	5.86	5.22	54.8	0.062
		35	17.87	5.85	5.2	54.8	0.0616
		30	18.18	5.84	5.21	55.3	0.0614
		25	18.55	5.83	5.1	54.5	0.0613
		20	19.08	5.82	5.11	55.1	0.0597
		15	19.68	5.82	5.44	59.5	0.0607
		10	19.71	5.83	5.78	63.3	0.0605
		5	19.94	5.84	5.91	64.9	0.0608
		0	20.64	5.89	6.19	69	0.0608
	23-Jul	90	18.75	6.53	0	0	0.0743
		85	18.72	6.36	0	0	0.0705
		80	18.88	6.28	0	0	0.0694
		75	18.9	6.22	0	0	0.0683
		70	18.99	6.16	0	0	0.066
		65	19.09	6.12	0	0	0.0646
		60	19.23	6.06	0	0	0.0638
		55	19.32	6.04	0.52	5.6	0.0633
		50	19.5	5.95	1.04	11.3	0.0644

Table A-1. (Continued)

Station	Date	Depth (F)	Temp °C	pH	DO (mg/L)	DO (%)	Cond (ms/cm)	
WA7 (Con't)	23 Jul (Con't)	45	19.65	5.9	1.13	12.3	0.0636	
		40	19.92	5.9	3.83	42.1	0.0632	
		35	20.27	5.91	1.63	18.1	0.0645	
		30	20.62	5.91	1.53	17.1	0.0659	
		25	21.27	5.91	1.45	16.4	0.0696	
		20	22.17	5.94	1.29	14.8	0.069	
		15	23.13	5.97	1.79	20.9	0.0674	
		10	24.23	6.02	3.01	36	0.0646	
		5	25.82	6.19	5.74	70.5	0.0661	
		0	26.4	6.3	6.58	81.7	0.0664	
	20-Aug	88	20.99	6.23	0	0	0.0883	
		85	21.07	6.16	0	0	0.0894	
		80	21.21	6.16	0	0	0.0877	
		75	21.18	6.16	0	0	0.0844	
		70	21.44	6.15	0	0	0.0834	
		65	21.59	6.13	0	0	0.0807	
		60	21.8	6.12	0	0	0.0801	
		55	21.81	6.11	0	0	0.0787	
		50	21.97	6.06	0	0	0.0746	
		45	22.24	6.05	0	0	0.0737	
		40	22.34	6.04	0	0	0.0736	
		35	22.55	6.03	0	0	0.074	
		30	22.83	6.02	0	0	0.0743	
		25	23.19	6	0	0	0.0725	
		20	23.47	5.99	0	0	0.0679	
		15	24.36	6.04	2.04	24.4	0.0688	
		10	25.92	6.11	3.77	46.4	0.0689	
		5	26.27	6.22	4.79	59.4	0.0703	
		0	26.24	6.25	5.19	64.3	0.0702	
	03-Oct	93	13.34	6.2	5.14	49.2	0.0896	
		90	13.42	6.19	5.38	51.5	0.0885	
		85	13.74	6.2	5.98	57.7	0.0872	
		80	13.83	6.2	5.99	57.9	0.0867	
		75	13.89	6.2	5.96	57.7	0.087	
		70	13.99	6.2	6.07	58.9	0.0877	
		65	14.12	6.19	5.89	57.3	0.0864	
		60	14.21	6.18	5.68	55.4	0.0862	
		55	14.4	6.17	5.33	52.2	0.0861	
		50	14.78	6.14	4.78	47.2	0.0839	
		45	14.87	6.12	4.38	43.4	0.0844	
		40	15.16	6.11	4.29	42.7	0.0827	
		35	15.27	6.08	3.78	37.7	0.0832	
		30	15.32	6.07	3.54	35.4	0.083	
		25	15.36	6.07	3.51	35.1	0.0828	
		20	15.39	6.07	3.6	36	0.0828	

Table A-1. (Continued)								
Station	**Date**	**Depth (F)**	**Temp °C**	**pH**	**DO (mg/L)**	**DO (%)**	**Cond (ms/cm)**	
WA7 (Con't)	3 Oct (Con't)	15	15.47	6.06	3.6	36	0.0827	
		10	15.56	6.07	3.6	36.2	0.0826	
		5	16.22	6.11	4.9	49.8	0.0826	
		0	16.28	6.13	5.06	51.6	0.0827	
Northampton LH17								
Date	**Time**	**Temp °C**	**SpCond mS/cm**	**DO% %**	**DO Conc mg/L**	**pH**	**Turbidity NTU**	**Chlorophyll µg/L**
10-Jul	11:22	24.94	0.13	166.5	13.77	7.29	0.6	0
07-Aug	9:37	21.78	0.112	105.7	9.28	7.11	1.8	1
05-Sep	9:31	22.66	0.139	111.2	9.6	7.37	8	6.1
09-Oct	9:47	14.02	0.136	108.1	11.13	6.9	2.6	1.7
23-Oct	9:56	9.6	0.104	115	13.11	6.31	3.8	2.6
Walnutport LH15								
10-Jul	11:55	23.23	0.155	113.4	9.68	7.03	0.3	1.1
07-Aug	10:03	19.74	0.025	175.1	16	6.69	2.3	1.7
05-Sep	9:52	21.12	0.147	122.1	10.85	7.06	1.8	5.8
09-Oct	10:12	13.37	0.142	113.1	11.82	6.75	5.4	1.3
23-Oct	10:37	9.58	0.115	138	15.73	6.34	3.8	2.6
Lehighton Water Plant LH10								
10-Jul	13:45	24	0.107	129.4	10.89	7.17	0.8	0.4
07-Aug	6:50	18.17	0.095	97.5	9.19	6.74	7.6	2
05-Sep	10:56	20.4	0.103	132.7	11.97	7.06	4.5	6.1
09-Oct	10:53	12.96	0.111	132.2	13.94	6.82	2.8	1.5
23-Oct	11:17	9.43	0.074	111.6	12.77	5.84	4.5	3.6
Tannery Bridge LH3								
10-Jul	15:17	21.96	0.07	108.1	9.46	7.39	0.2	0.9
07-Aug	11:03	18.03	0.064	112.2	10.62	6.85	3	1.5
05-Sep	12:47	20.52	0.084	125.2	11.26	7.23	8	4.2
09-Oct	13:49	14.92	0.08	110.7	11.18	6.6	3.9	2.6
23-Oct	13:55	12.02	0.065	105.2	11.33	5.85	2.4	10.6
F.E. Walter Dam WA1								
10-Jul	11:00	18.4	0.063	105.7	9.93	6.9	2.9	2.8
07-Aug	12:41	20.02	0.062	123.9	11.26	6.36	9.5	2.6
05-Sep	15:59	20.73	0.079	103.6	9.28	6.33	2.7	6.4
09-Oct	15:16	16.87	0.074	102	9.88	6.21	12.3	3.2
23-Oct	11:21	10.52	0.063	154.4	17.22	6.35	57.2	3.5

APPENDIX B

WATER COLUMN CHEMISTRY MONITORING LABORATORY ANALYSIS CERTIFICATES

APPENDIX C

SEDIMENT PRIORITY POLLUTANT
LABORATORY ANALYSIS CERTIFICATES

APPENDIX D

DRINKING WATER MONITORING LABORATORY ANALYSIS CERTIFICATES

APPENDIX E

METEOROLOGICAL DATA
(See CD for file)

APPENDIX F

SCOPE OF WORK