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 °C, and decreased thereafter through October to 12 °C (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 °C 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 °C in June (Figs. 3-3 through 3-5). In April and October, the temperature of the water column was lowest and averaged about 12 °C. In August, the temperature of the water column averaged 25 °C and peaked at 28 °C.

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.

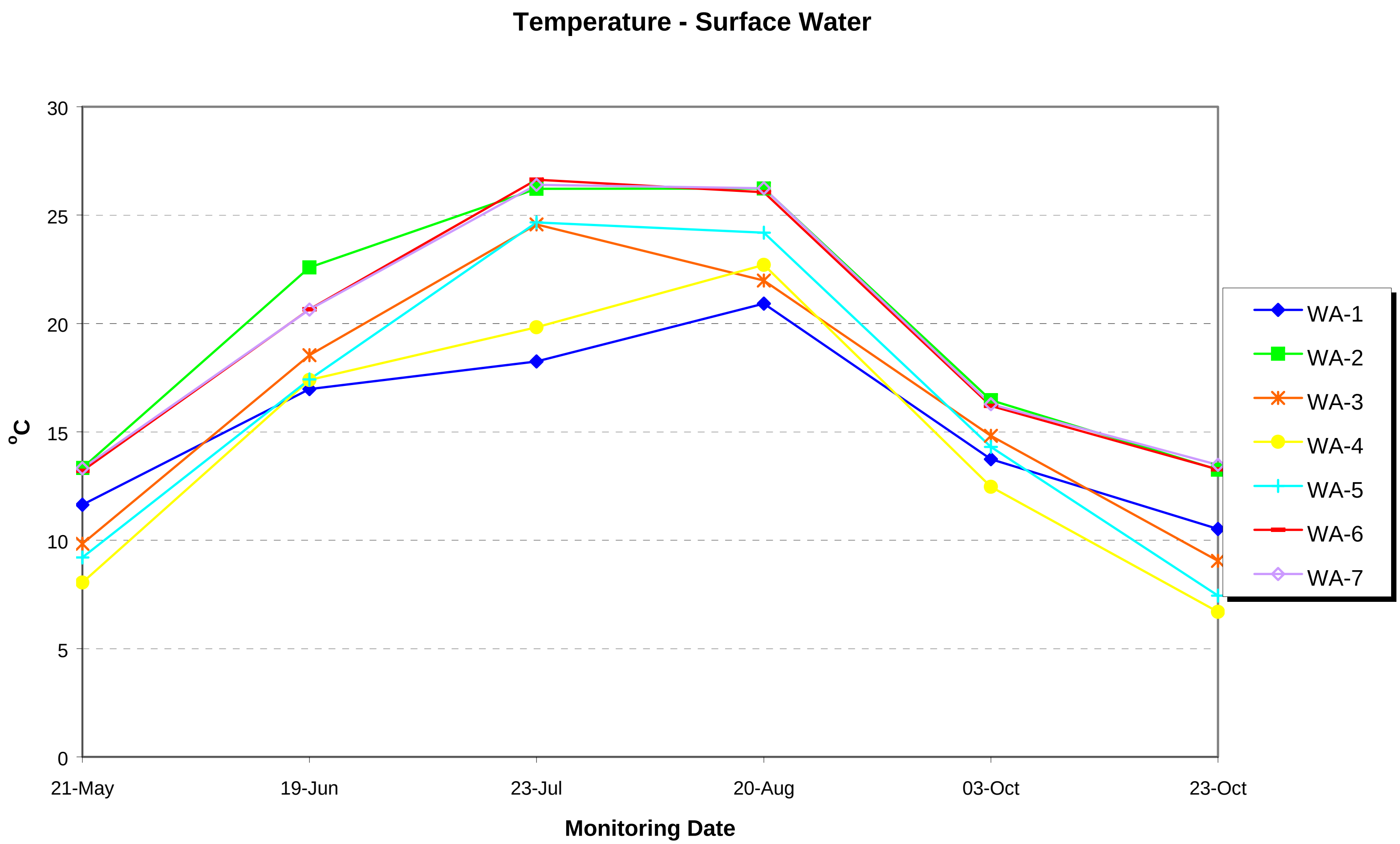


Figure 3-1. Temperature measured in surface waters of F.E. Walter Reservoir during 2002. See Appendix A for a summary of the plotted values.

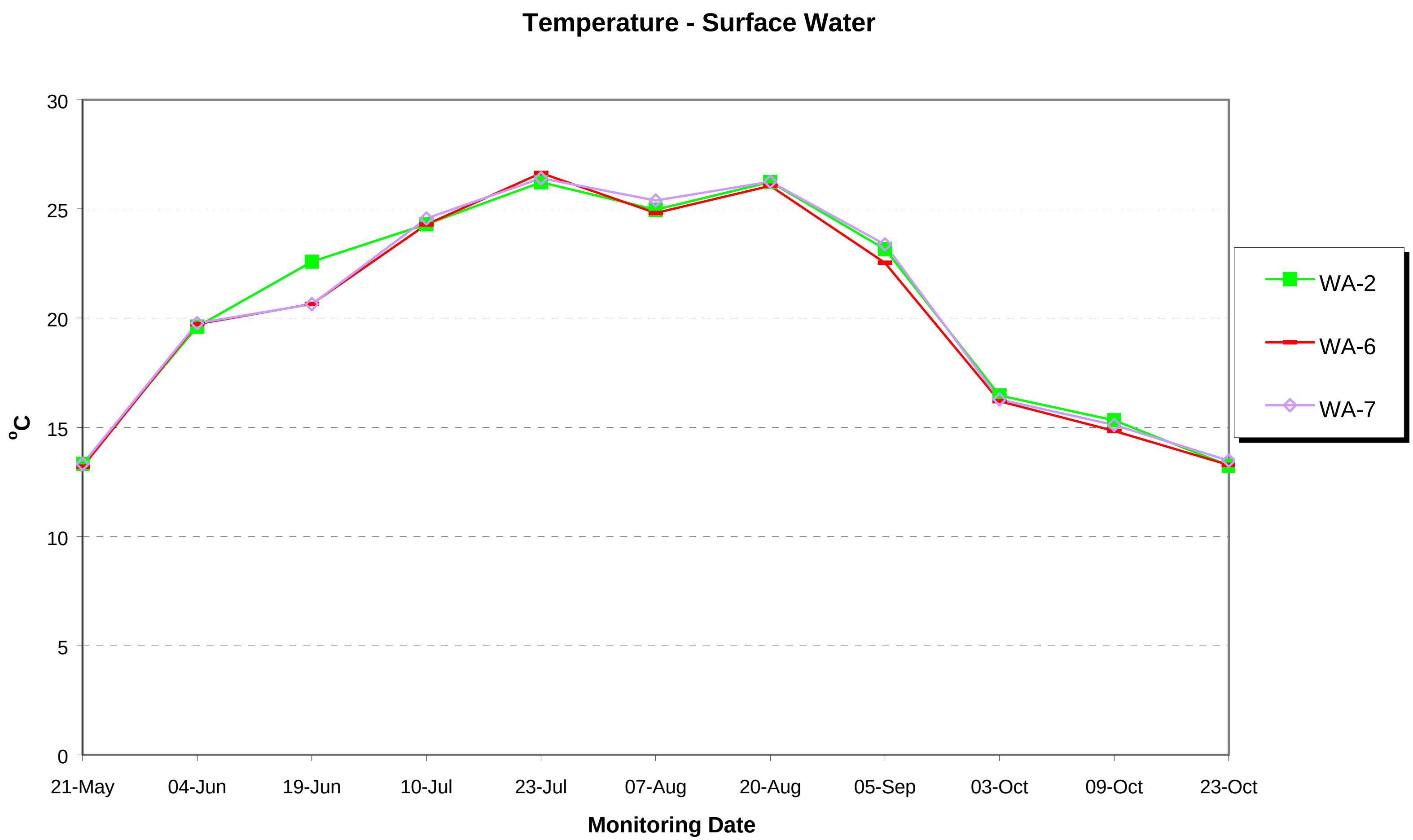


Figure 3-2. Temperature measured in surface waters of F.E. Walter Reservoir during 2002. See Appendix A for a summary of the plotted values.

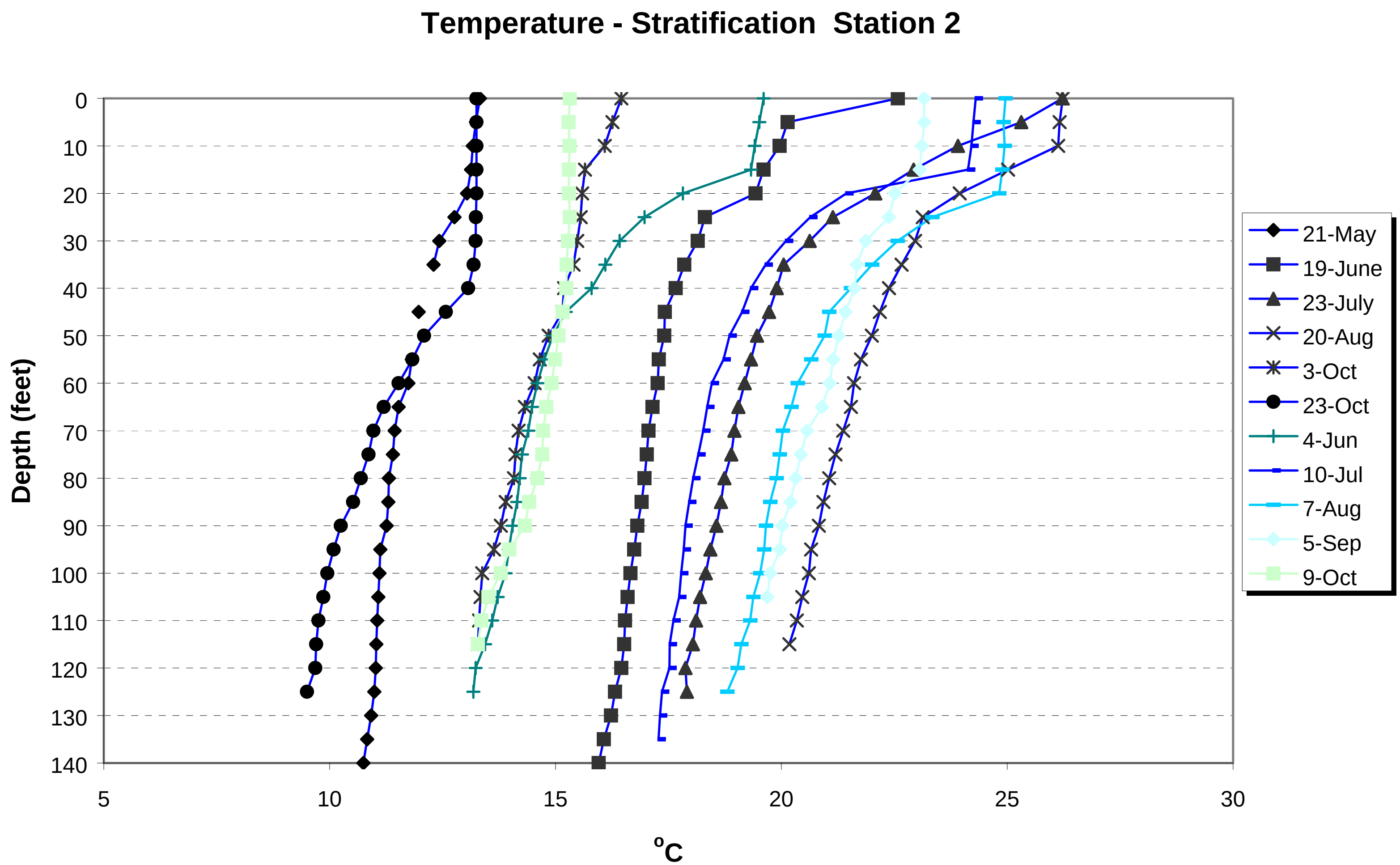


Figure 3-3. Stratification of temperature measured in the water column of F. E. Walter Reservoir at station WA-2 during 2002. See Appendix A for a summary of the plotted values.

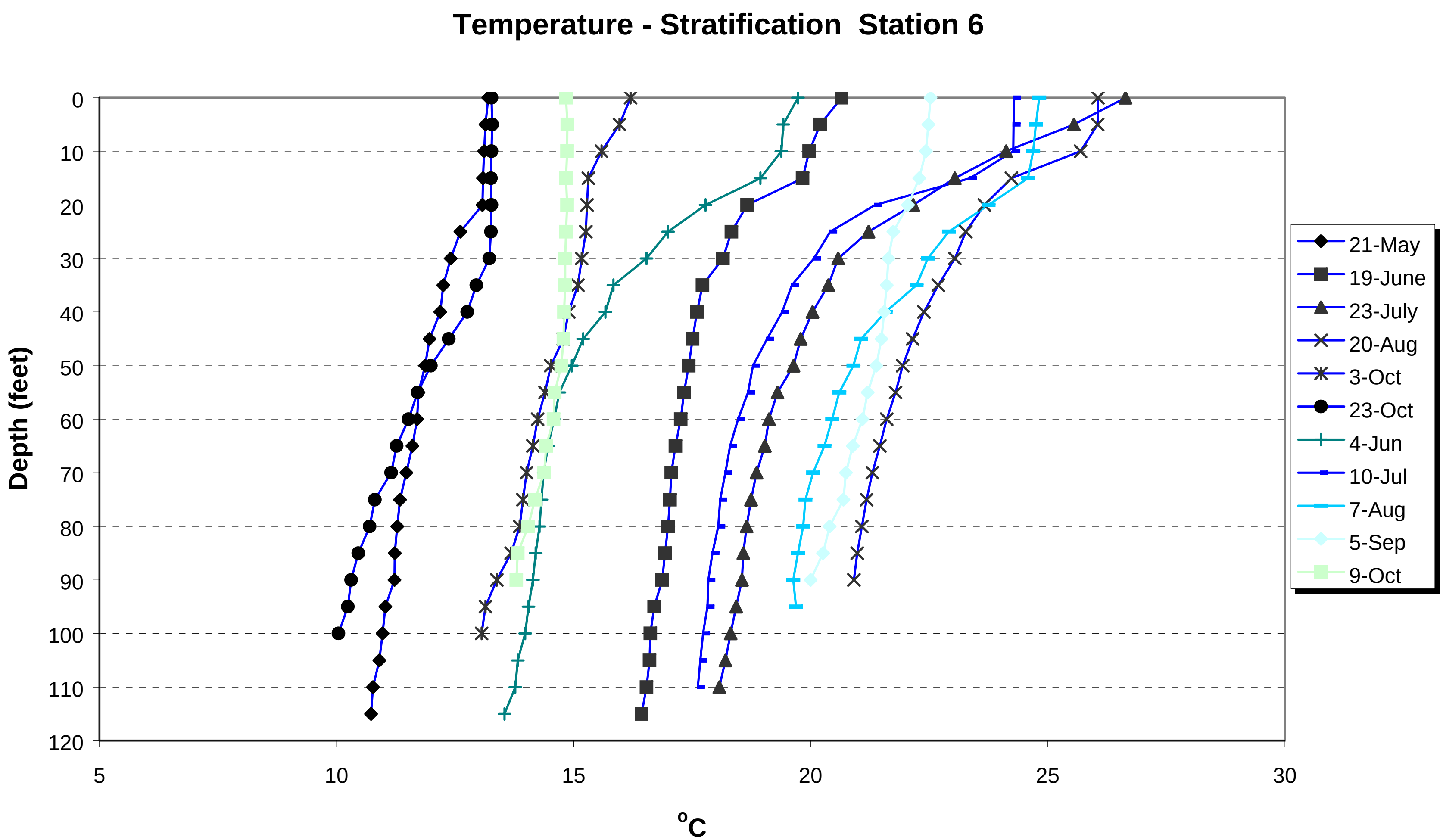


Figure 3-4. Stratification of temperature measured in the water column of F. E. Walter Reservoir at station WA-6 during 2002. See Appendix A for a summary of the plotted values.

Temperature - Stratification Station 7

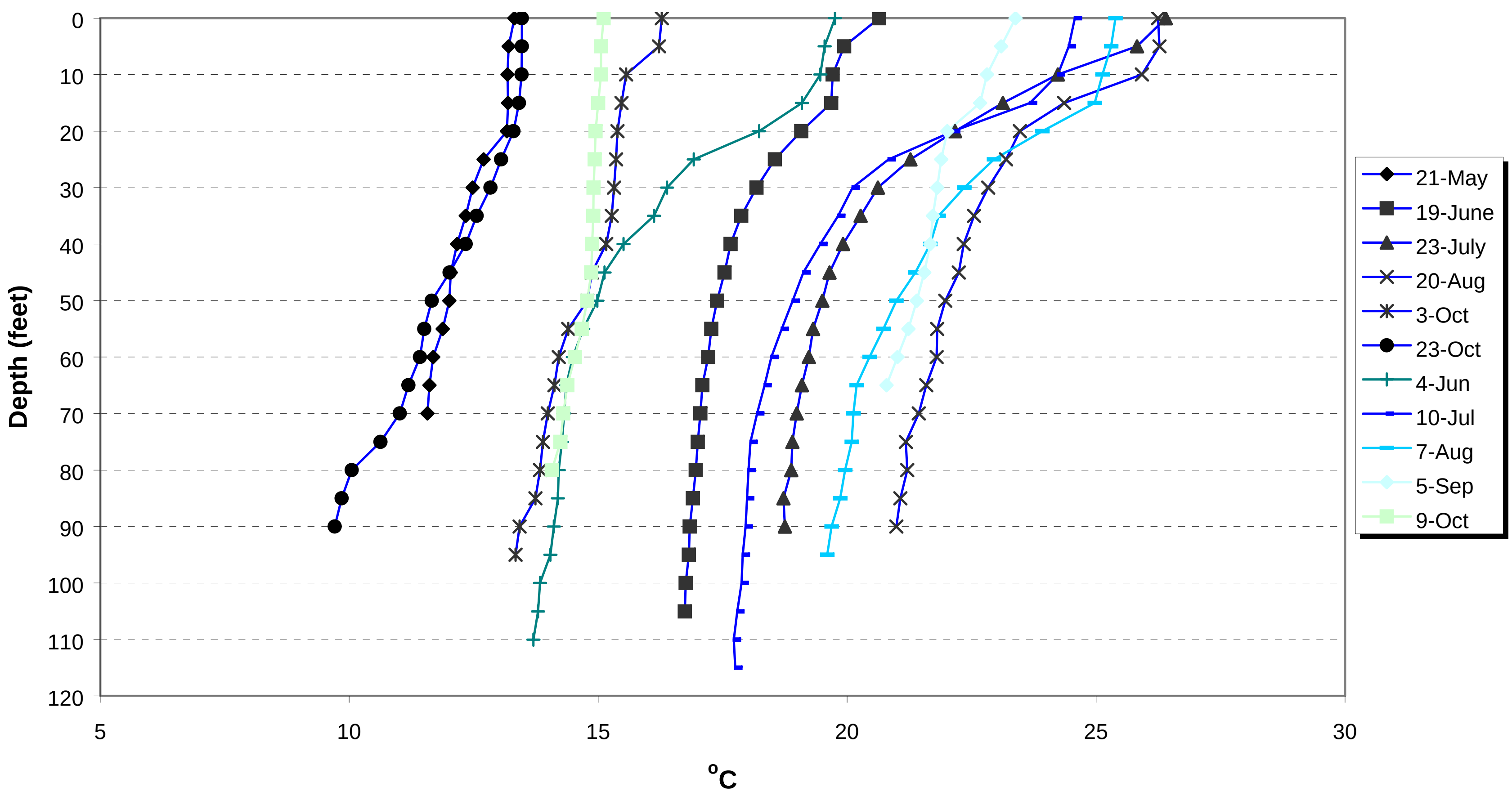


Figure 3-5. Stratification of temperature measured in the water column of F. E. Walter Reservoir at station WA-7 during 2002. See Appendix A for a summary of the plotted values.

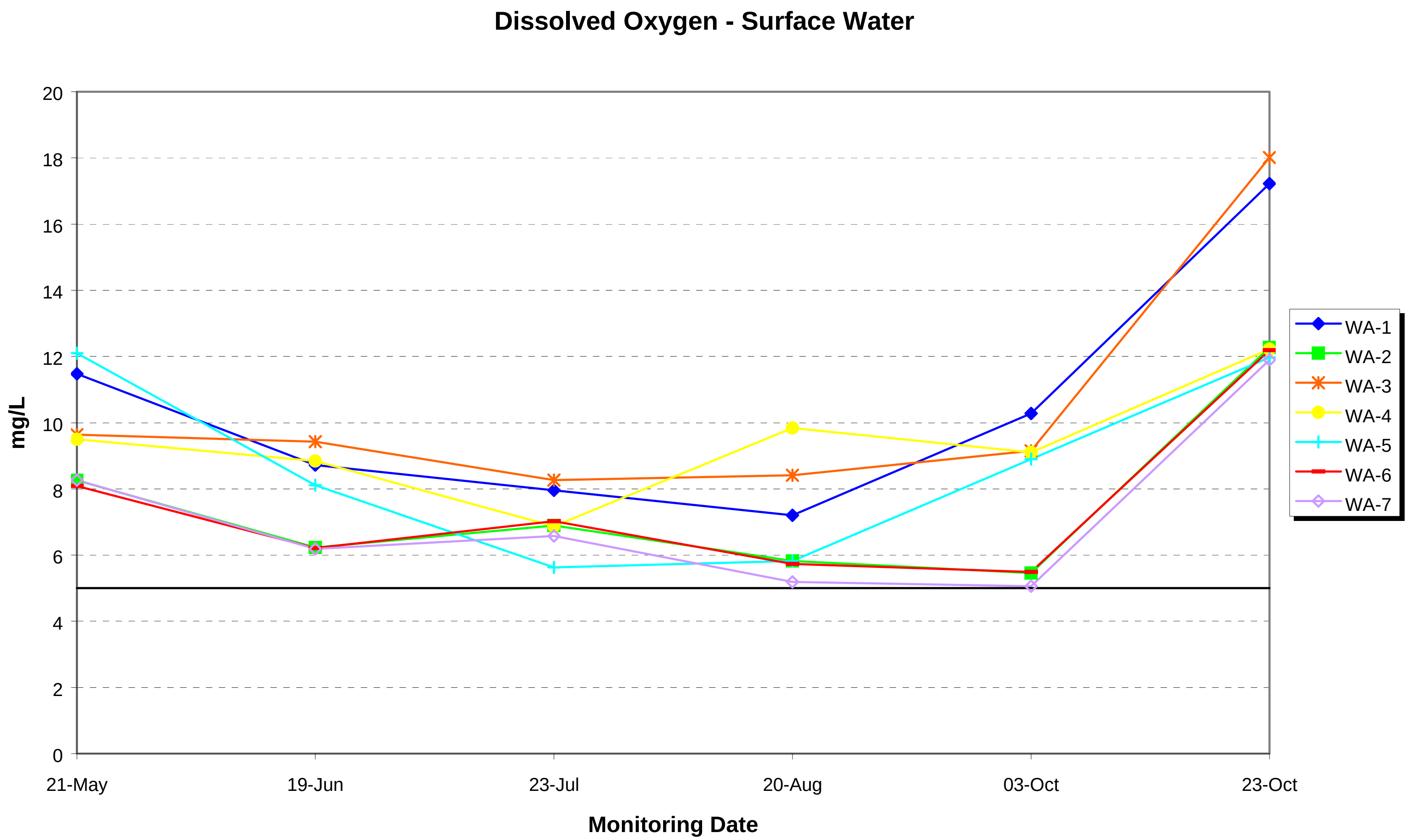


Figure 3-6. Percent saturation of dissolved oxygen measured in surface waters of F. E. Walter Reservoir during 2002. See Appendix A for a summary of the plotted values.

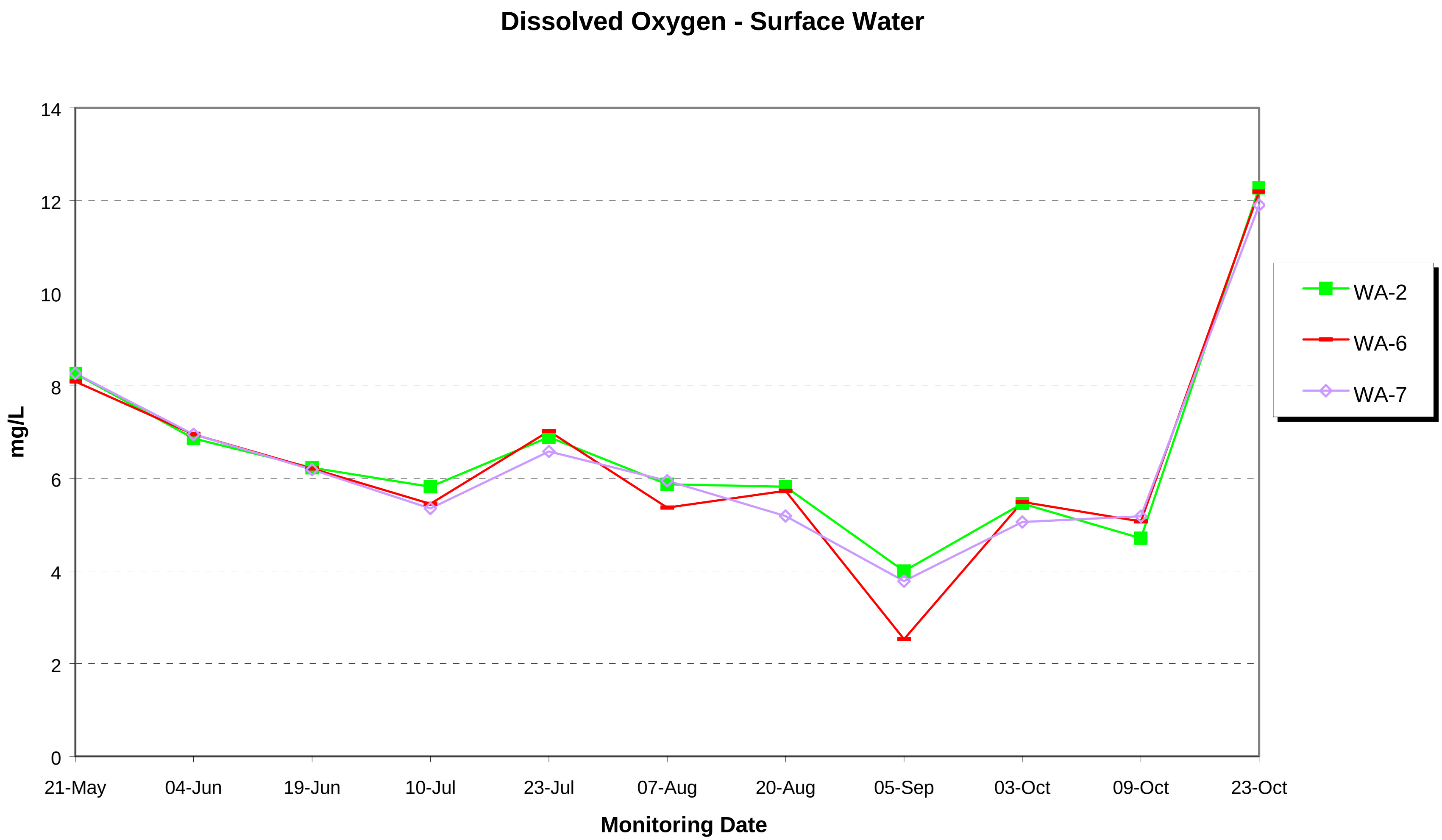


Figure 3-7. Percent saturation of dissolved oxygen measured in surface waters of F. E. Walter Reservoir during 2002. See Appendix A for a summary of the plotted values.

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

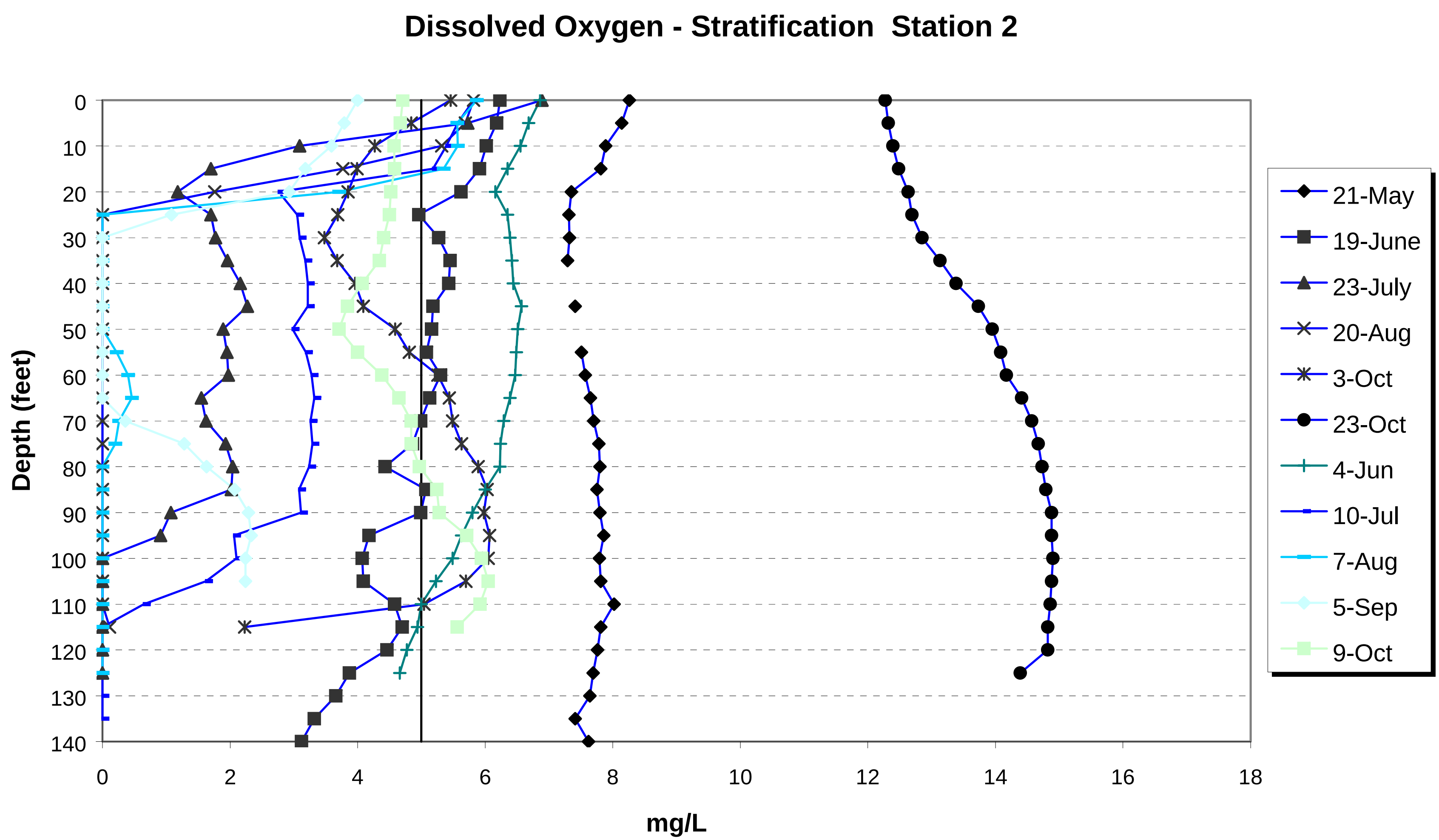


Figure 3-8. Dissolved oxygen measured in surface waters of F.E. Walter Reservoir at station WA-2 during 2002. The PADEP water quality standard for DO is a minimum concentration of 5 mg/L. See Appendix A for a summary of the plotted values.

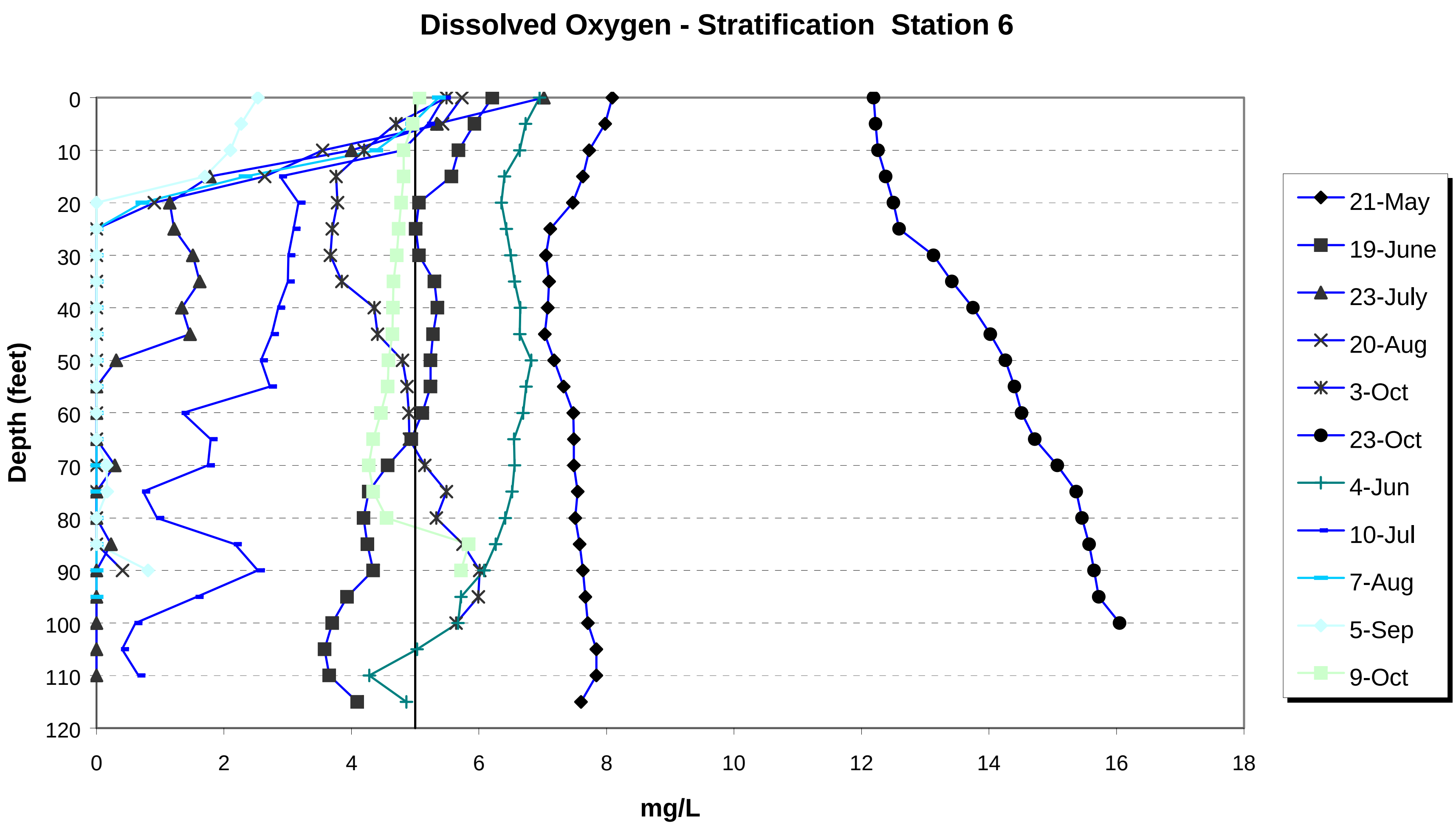


Figure 3-9. Dissolved oxygen measured in surface waters of F.E. Walter Reservoir at station WA-6 during 2002. The PADEP water quality standard for DO is a minimum concentration of 5 mg/L. See Appendix A for a summary of the plotted values.

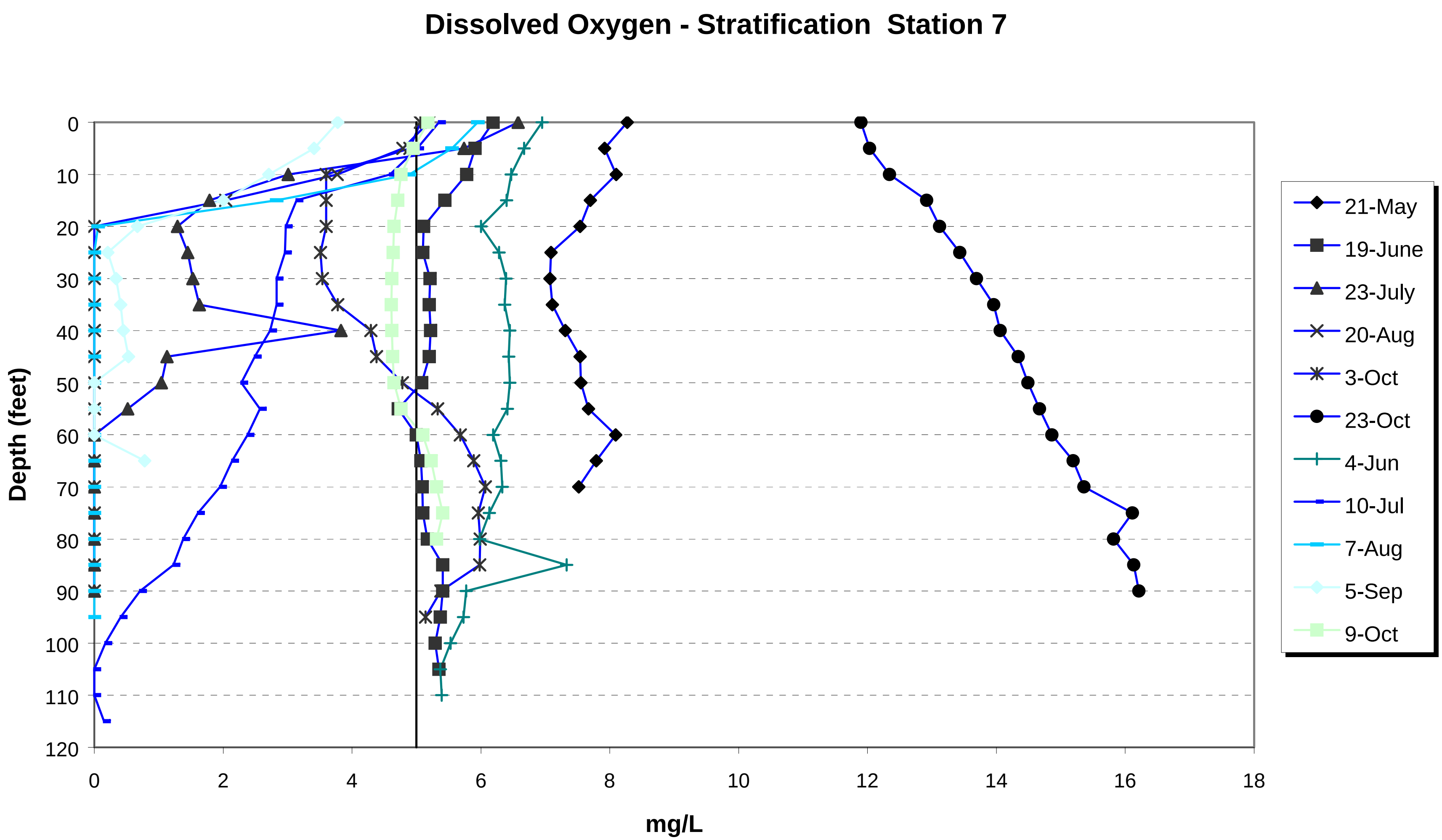


Figure 3-10. Dissolved oxygen measured in surface waters of F.E. Walter Reservoir at station WA-7 during 2002. The PADEP water quality standard for DO is a minimum concentration of 5 mg/L. See Appendix A for a summary of the plotted values.

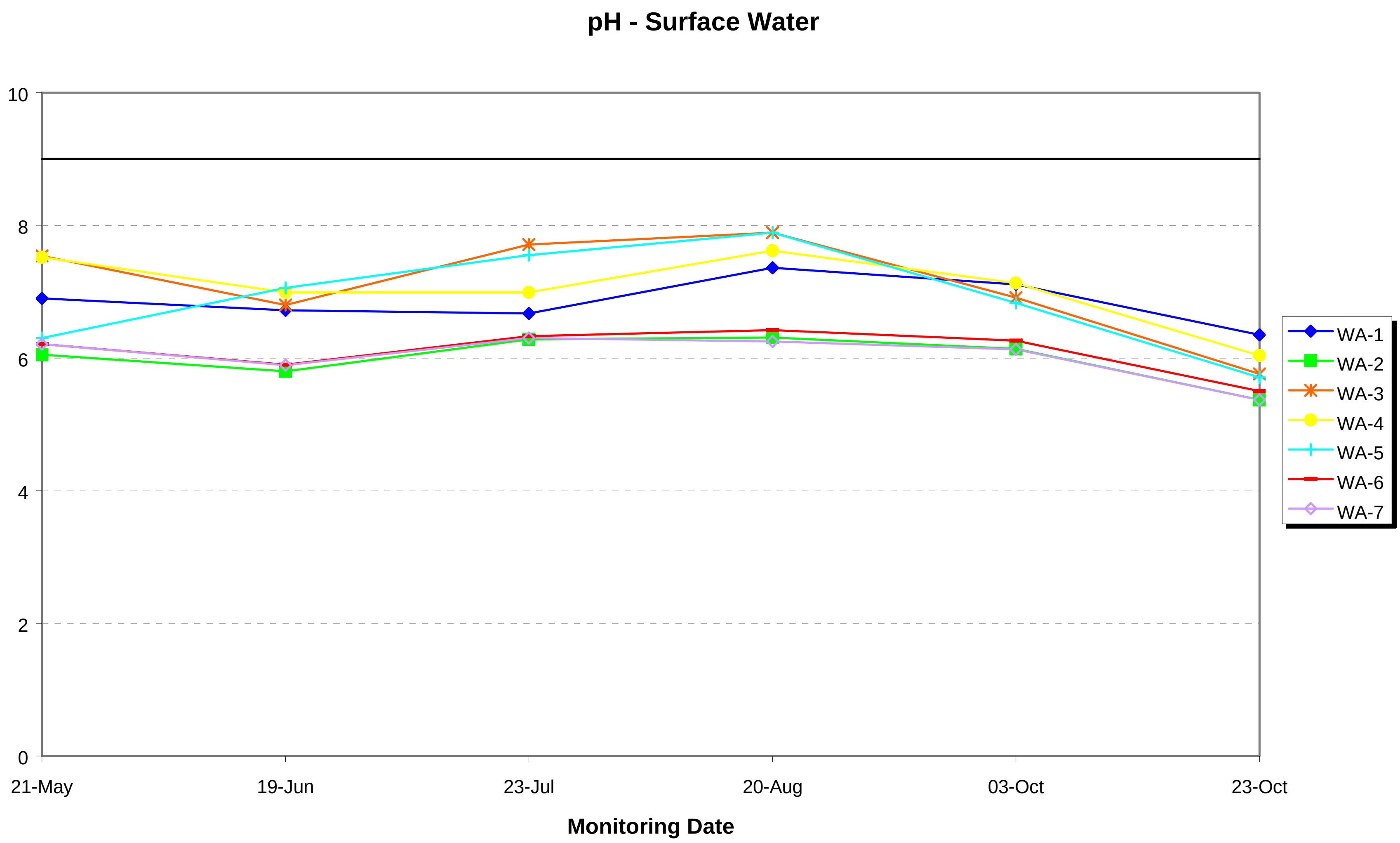


Figure 3-11. Measures of pH in surface waters of F.E. Walter Reservoir during 2002. The PADEP water quality standard for pH is an acceptable range from 6 to 9. See Appendix A for a summary of the plotted values.

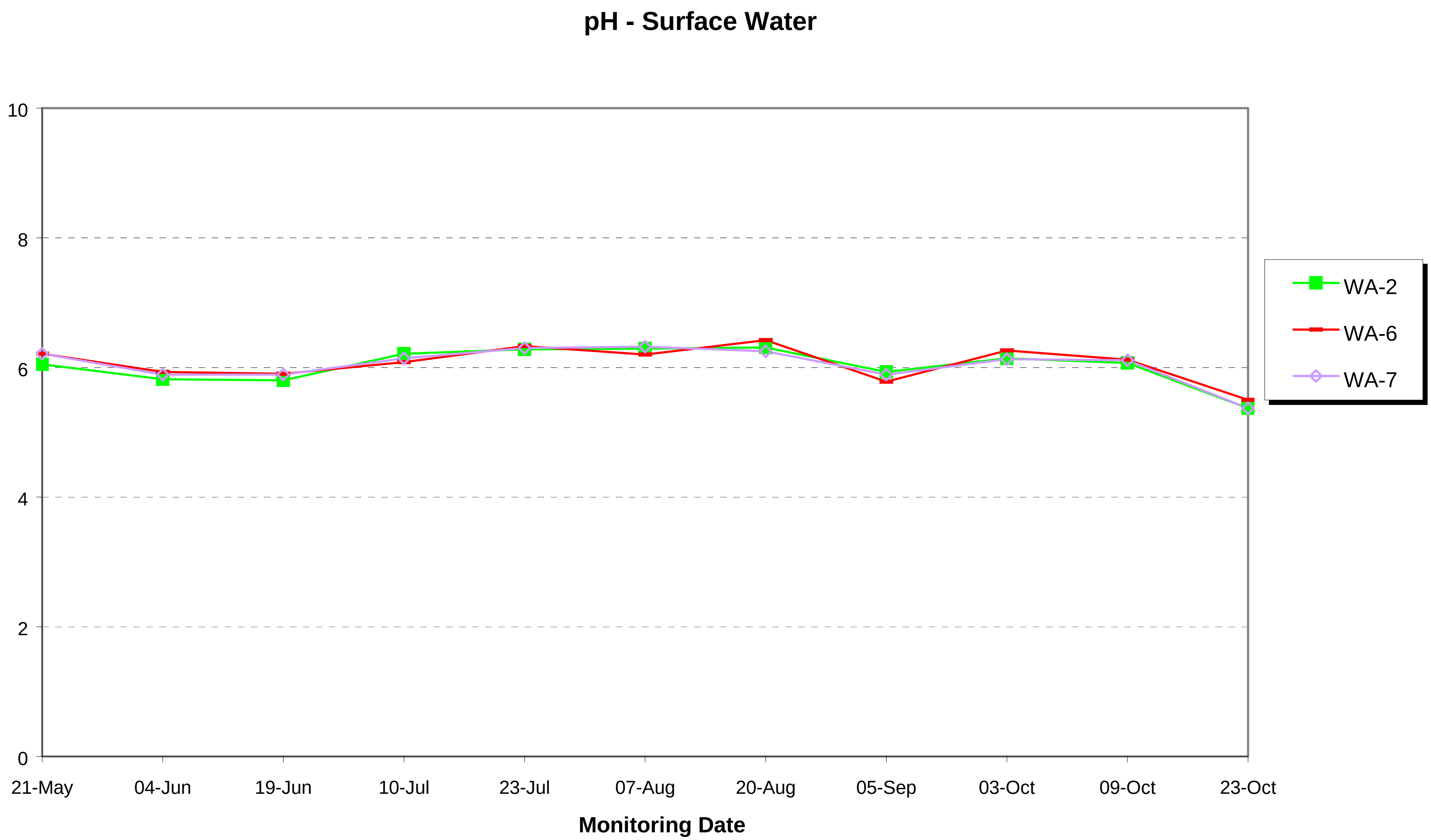


Figure 3-12. Measures of pH in surface waters of F.E. Walter Reservoir during 2002. The PADEP water quality standard for pH is an acceptable range from 6 to 9. See Appendix A for a summary of the plotted values.

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.

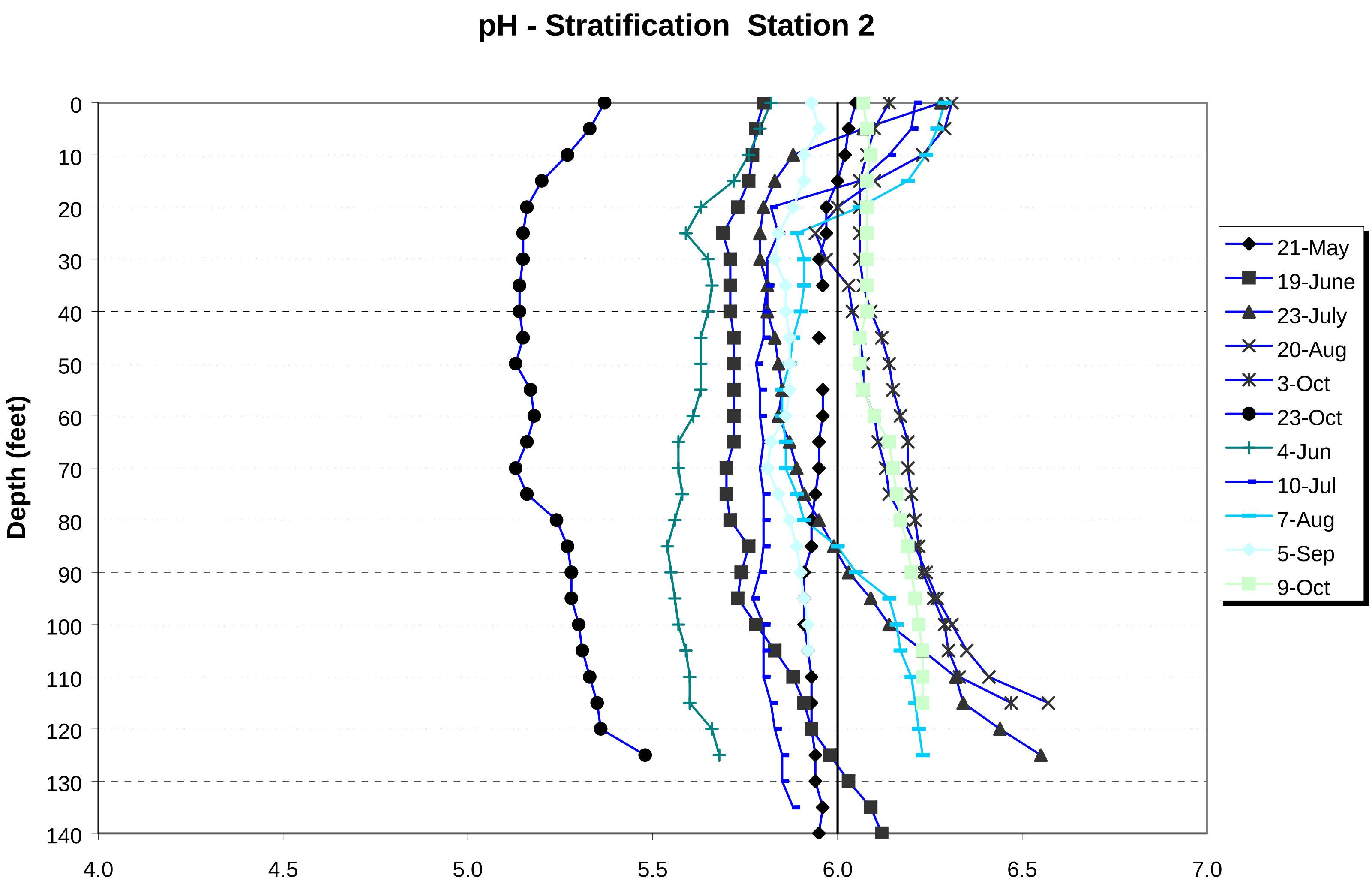


Figure 3-13. Stratification of pH measured in the water column of F.E. Walter Reservoir at station WA-2 during 2002. The PADEP water quality standard pH is an acceptable range from 6 to 9. See Appendix A for a summary of the plotted values.

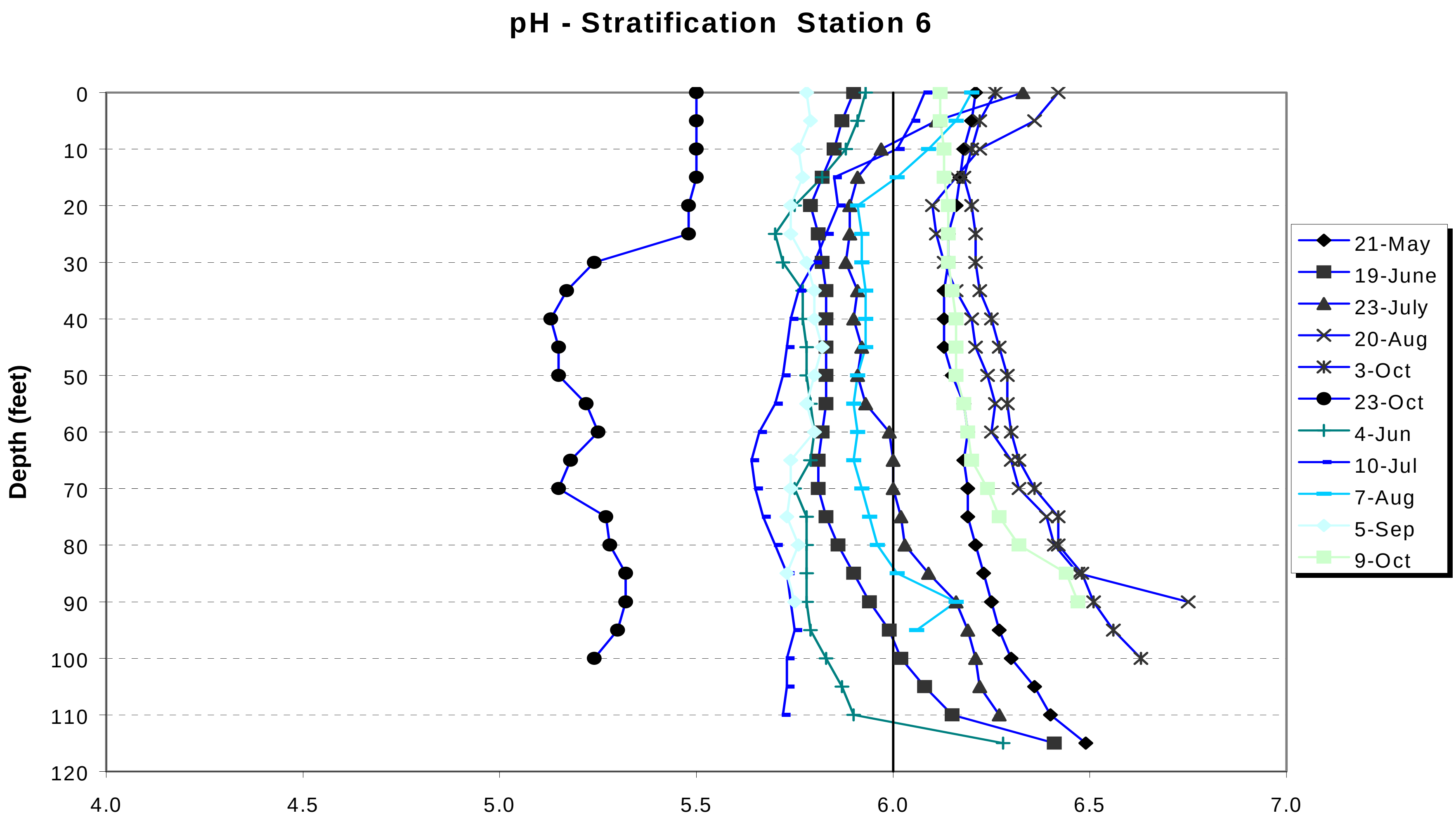


Figure 3-14. Stratification of pH measured in the water column of F.E. Walter Reservoir at station WA-6 during 2002. The PADEP water quality standard pH is an acceptable range from 6 to 9. See Appendix A for a summary of the plotted values.

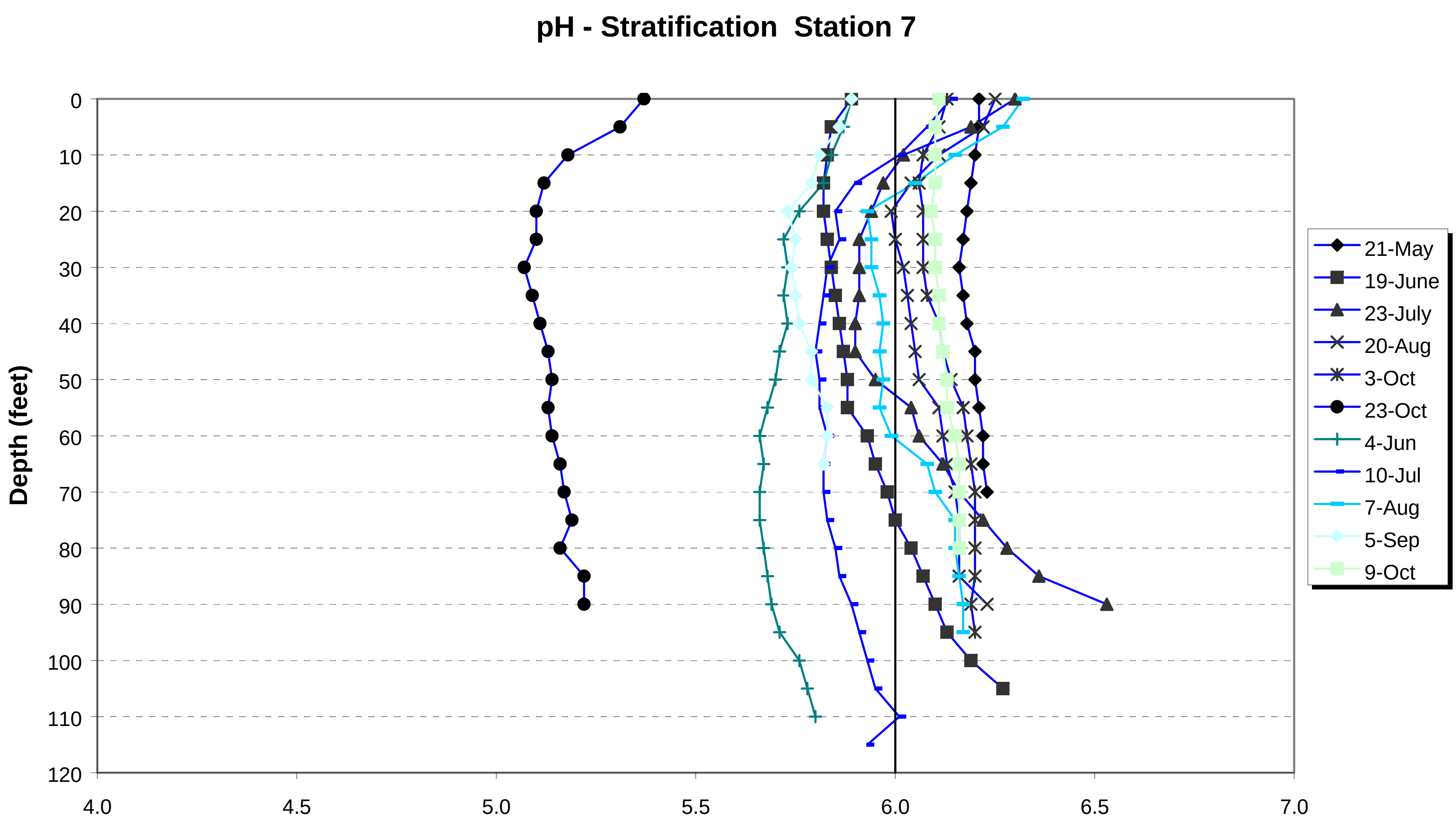


Figure 3-15. Stratification of pH measured in the water column of F.E. Walter Reservoir at station WA-7 during 2002. The PADEP water quality standard pH is an acceptable range from 6 to 9. See Appendix A for a summary of the plotted values.

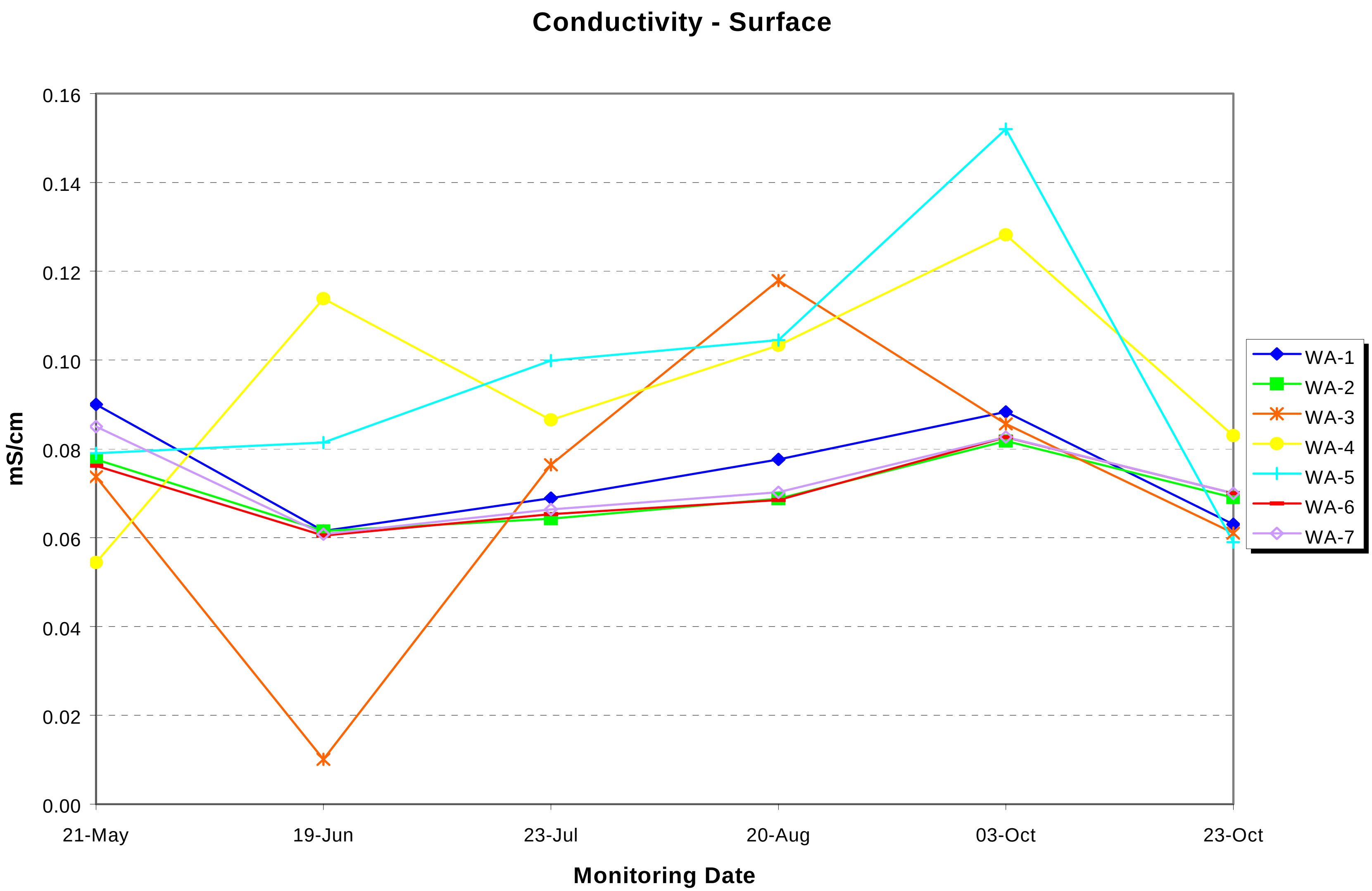


Figure 3-16. Conductivity measured in surface waters of F.E. Walter Reservoir during 2002. See Appendix A for a summary of the plotted values.

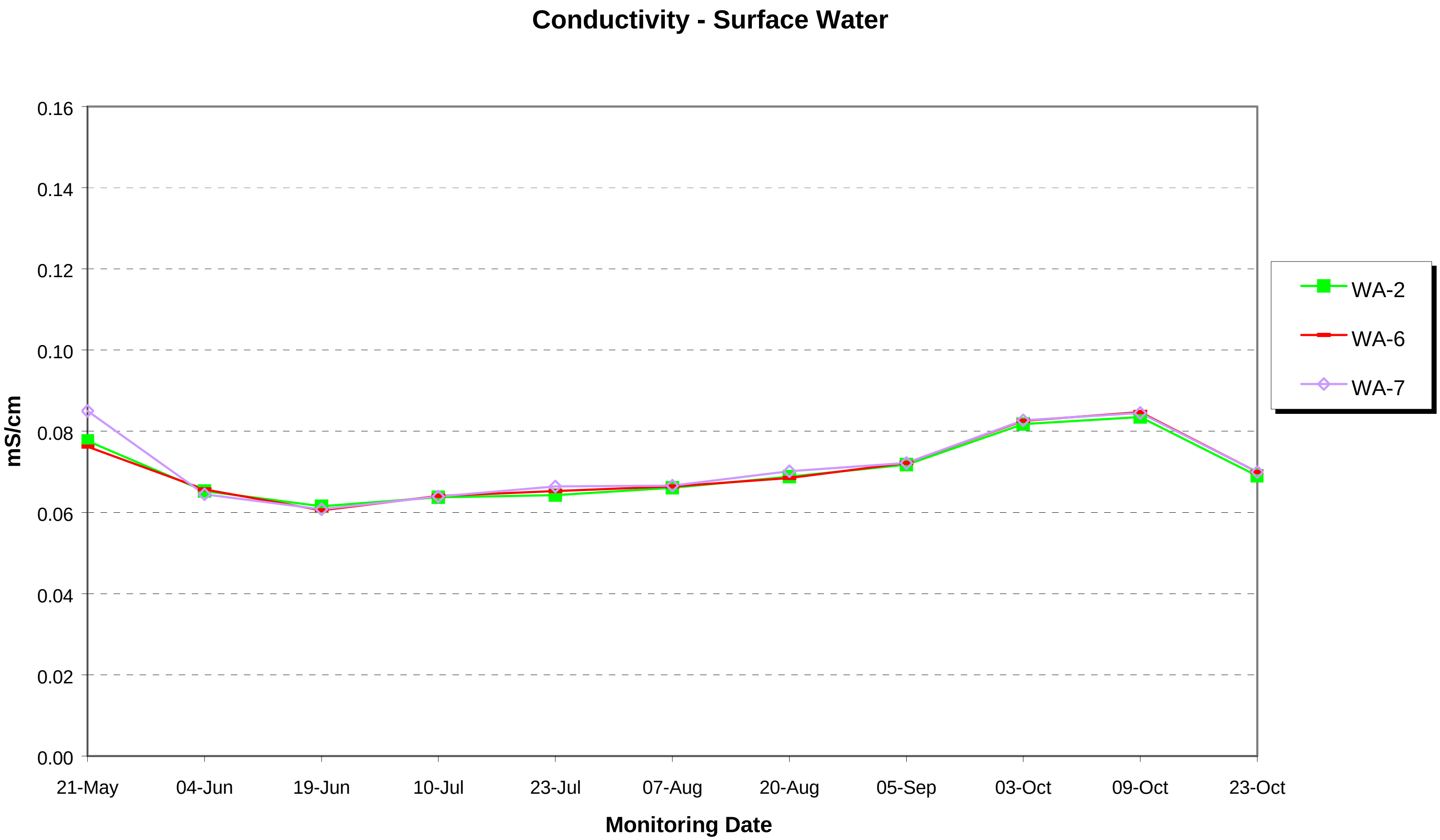


Figure 3-17. Conductivity measured in surface waters of F.E. Walter Reservoir during 2002. See Appendix A for a summary of the plotted values.

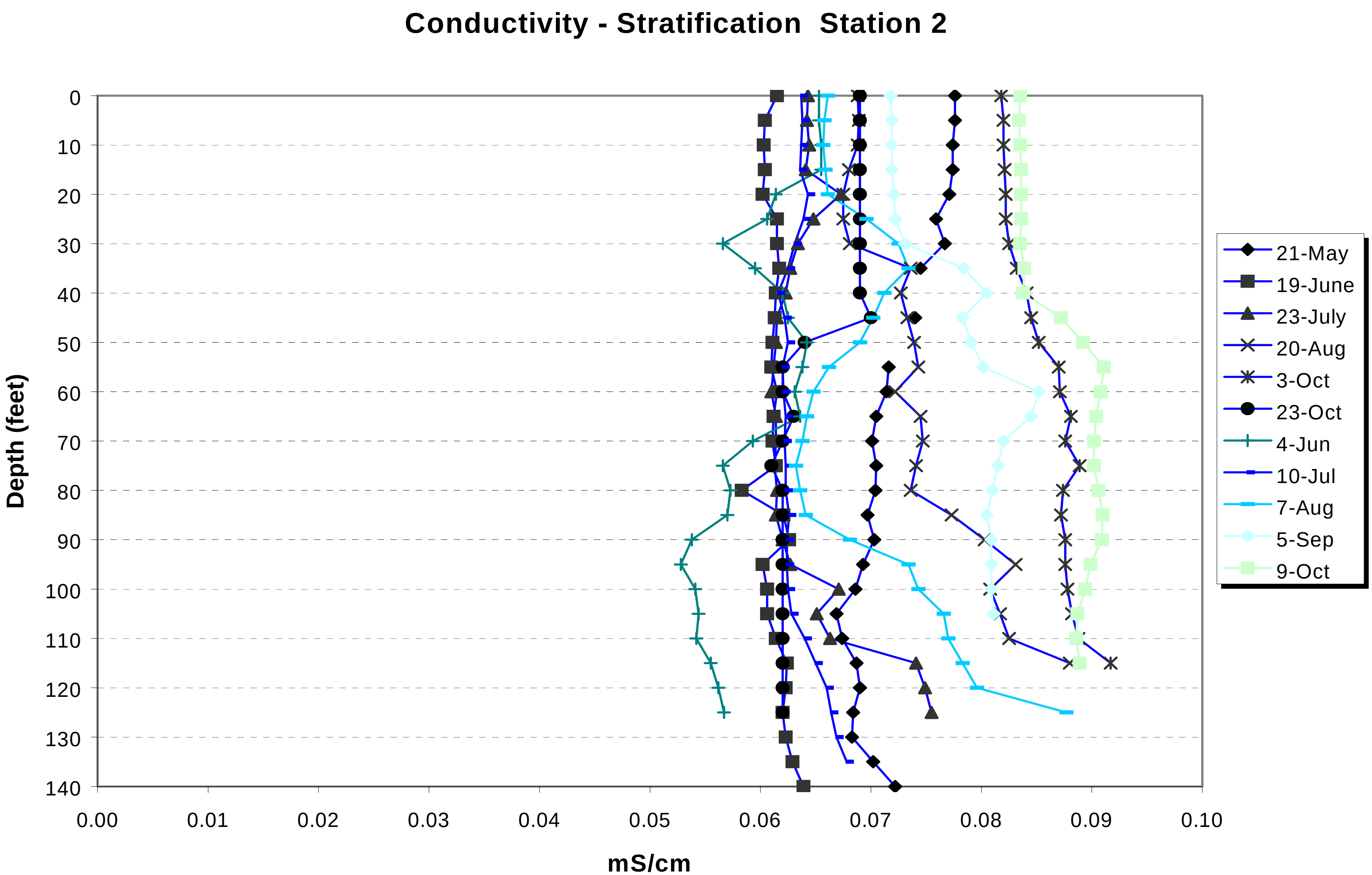


Figure 3-18. Stratification of conductivity measured in the water column of F. E. Walter Reservoir at station WA-2 during 2002. See Appendix A for a summary of the plotted values.

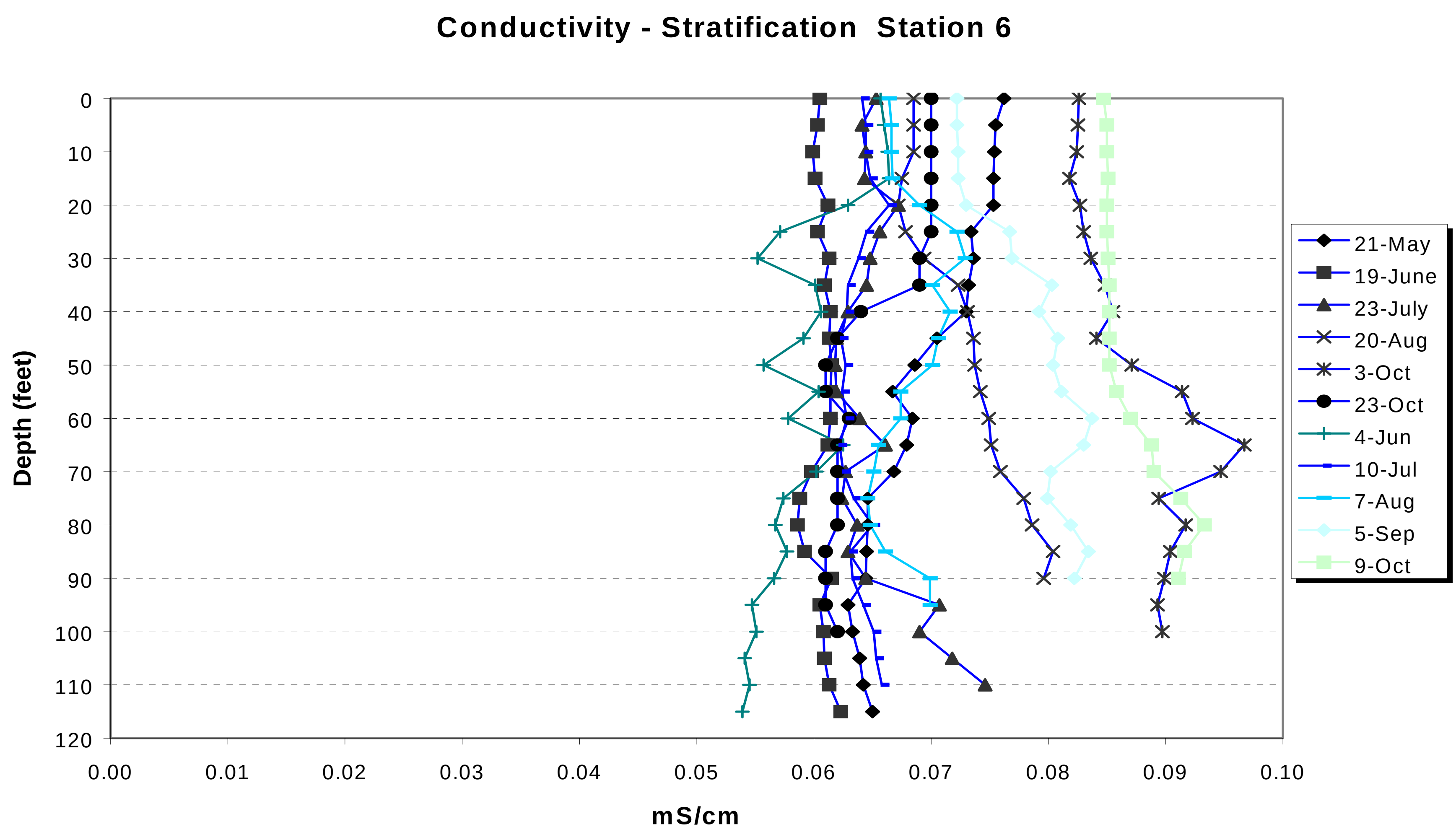


Figure 3-19. Stratification of conductivity measured in the water column of F. E. Walter Reservoir at station WA-6 during 2002. See Appendix A for a summary of the plotted values.

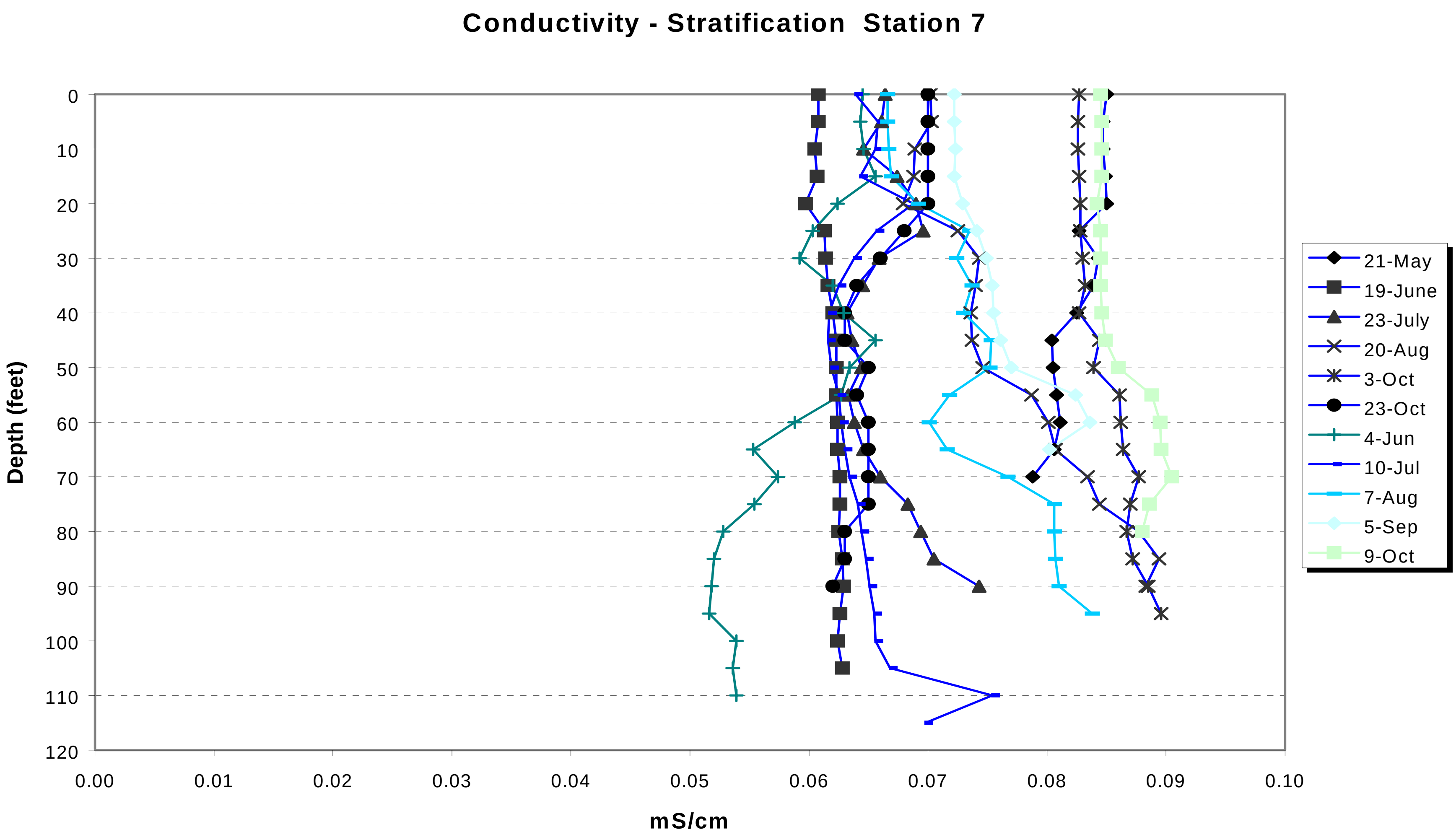


Figure 3-20. Stratification of conductivity measured in the water column of F. E. Walter Reservoir at station WA-7 during 2002. See Appendix A for a summary of the plotted values.

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

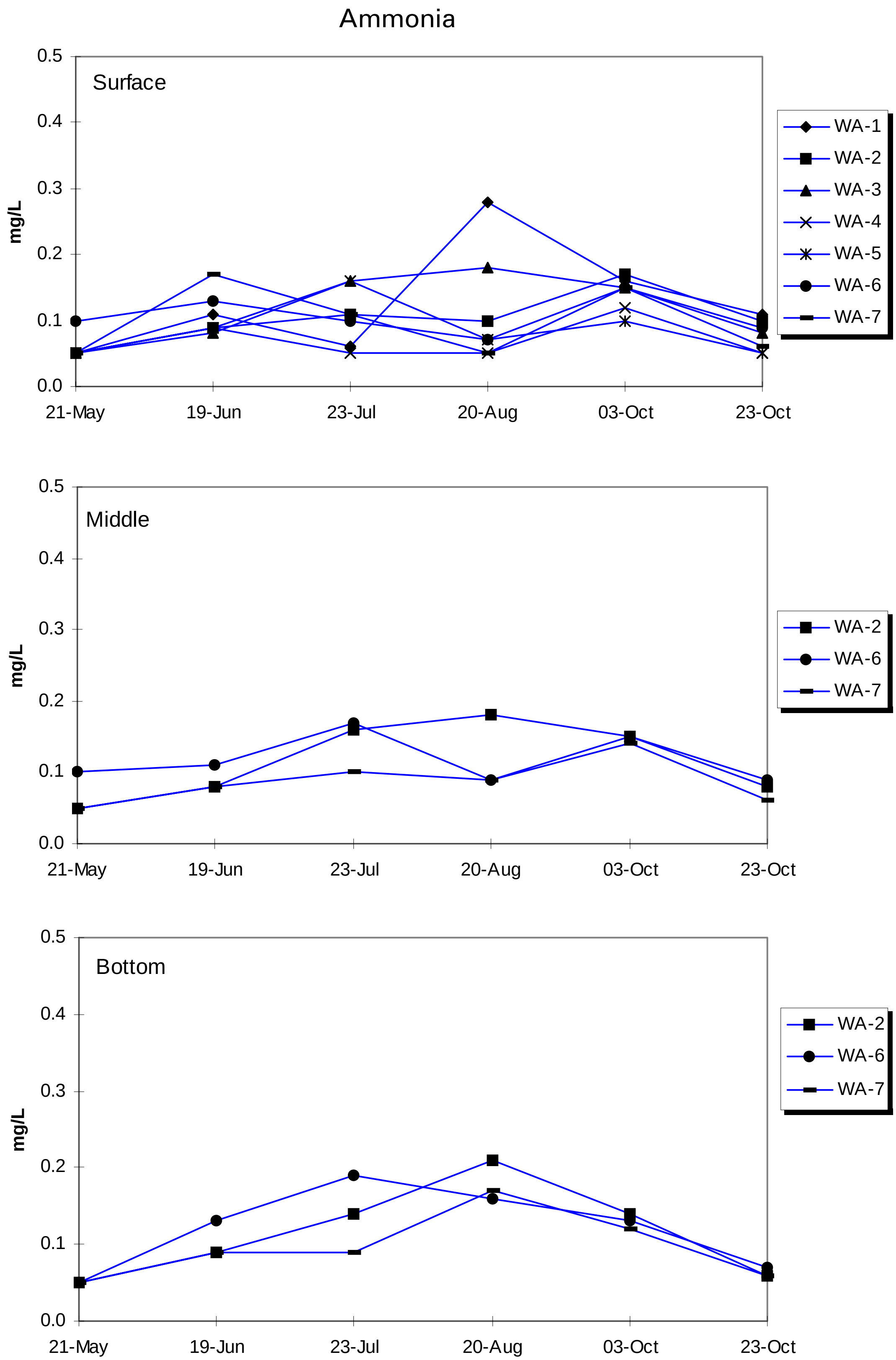


Figure 3-21. Ammonia measured in surface, middle, and bottom water of F. E. Walter Reservoir during 2002. The PADEP water quality standard for ammonia is dependent on temperature and pH.

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

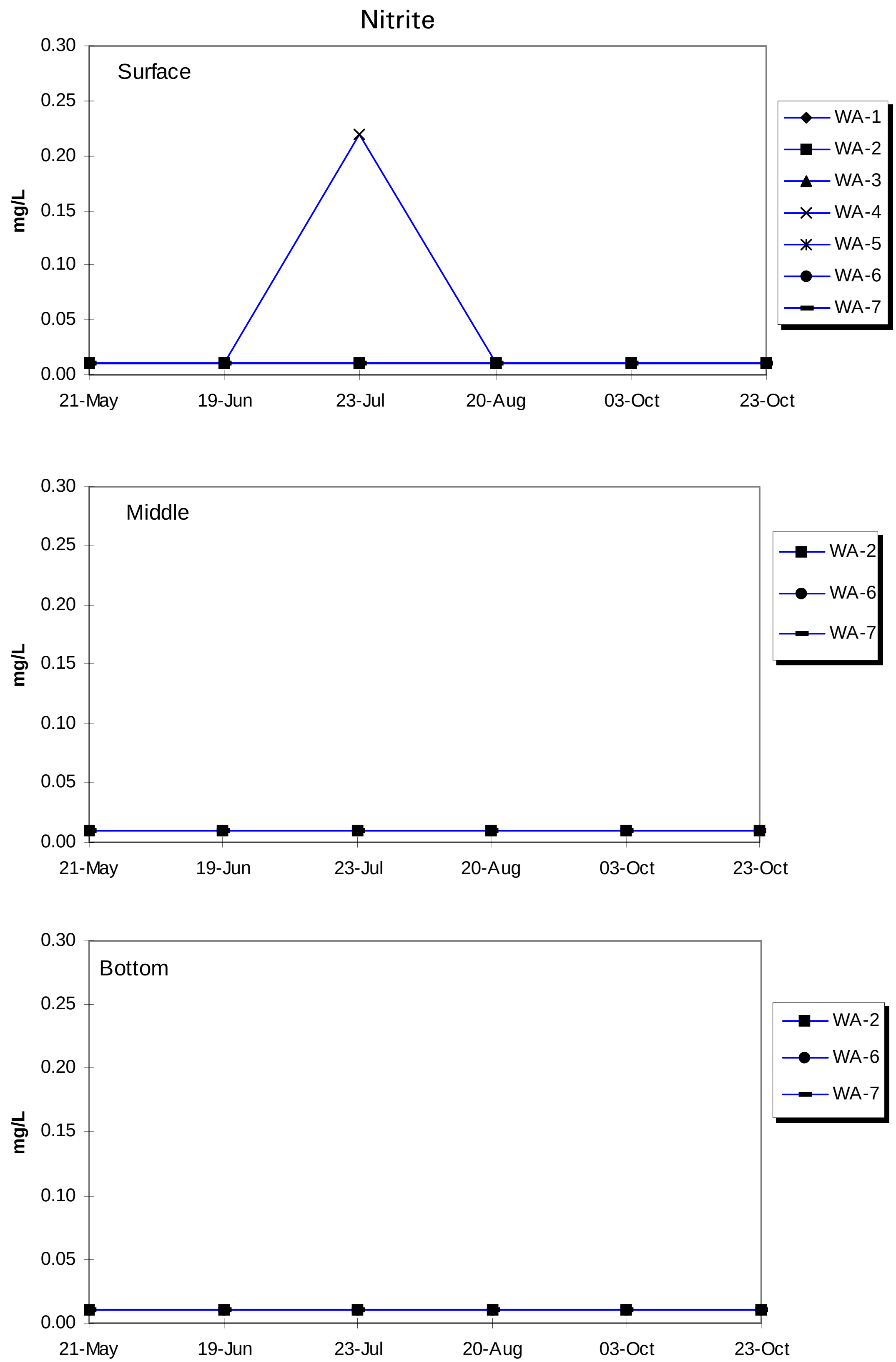


Figure 3-22. Nitrite measured in surface, middle, and bottom water of F. E. Walter Reservoir during 2002

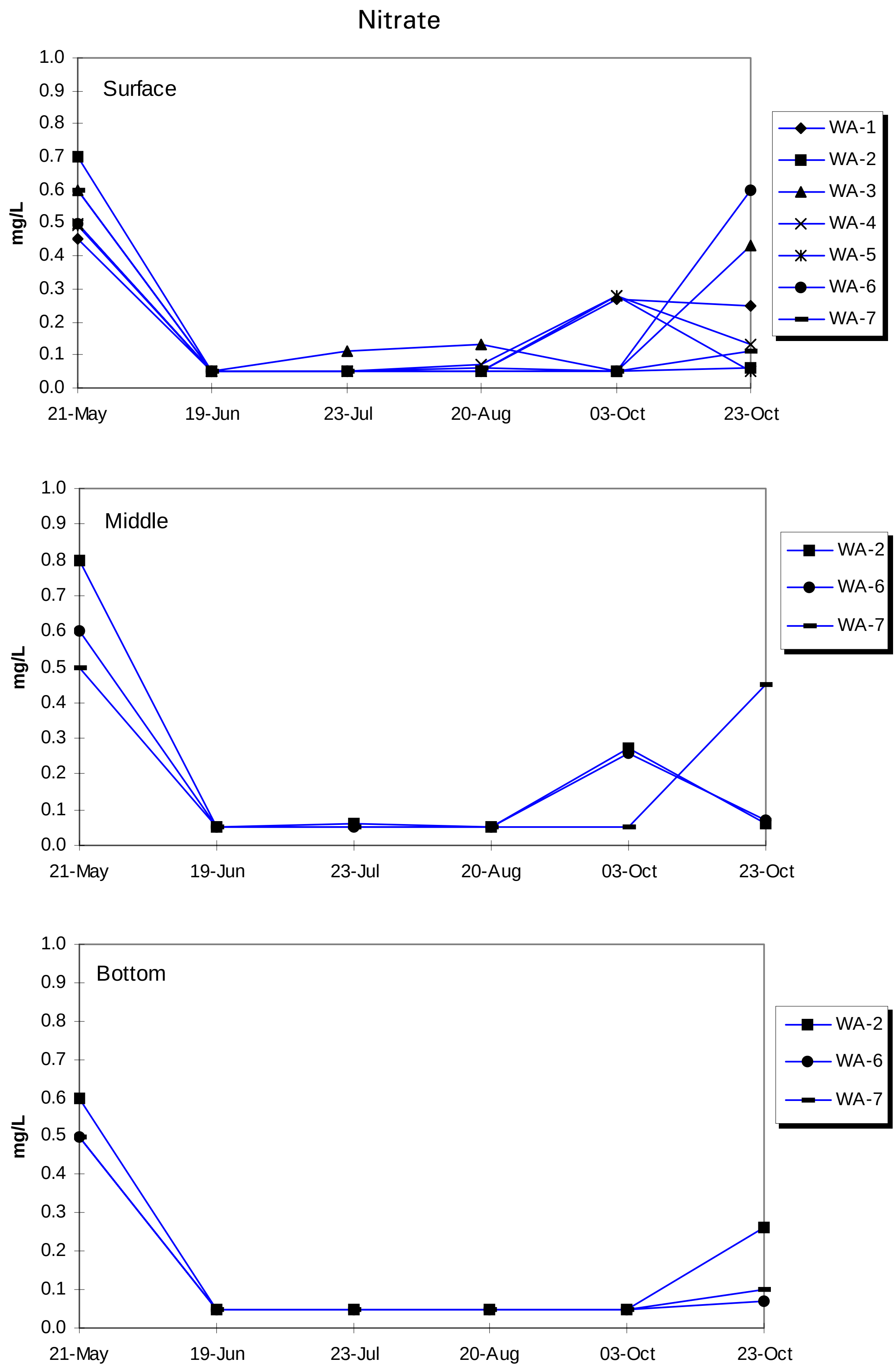


Figure 3-23. Nitrate measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002

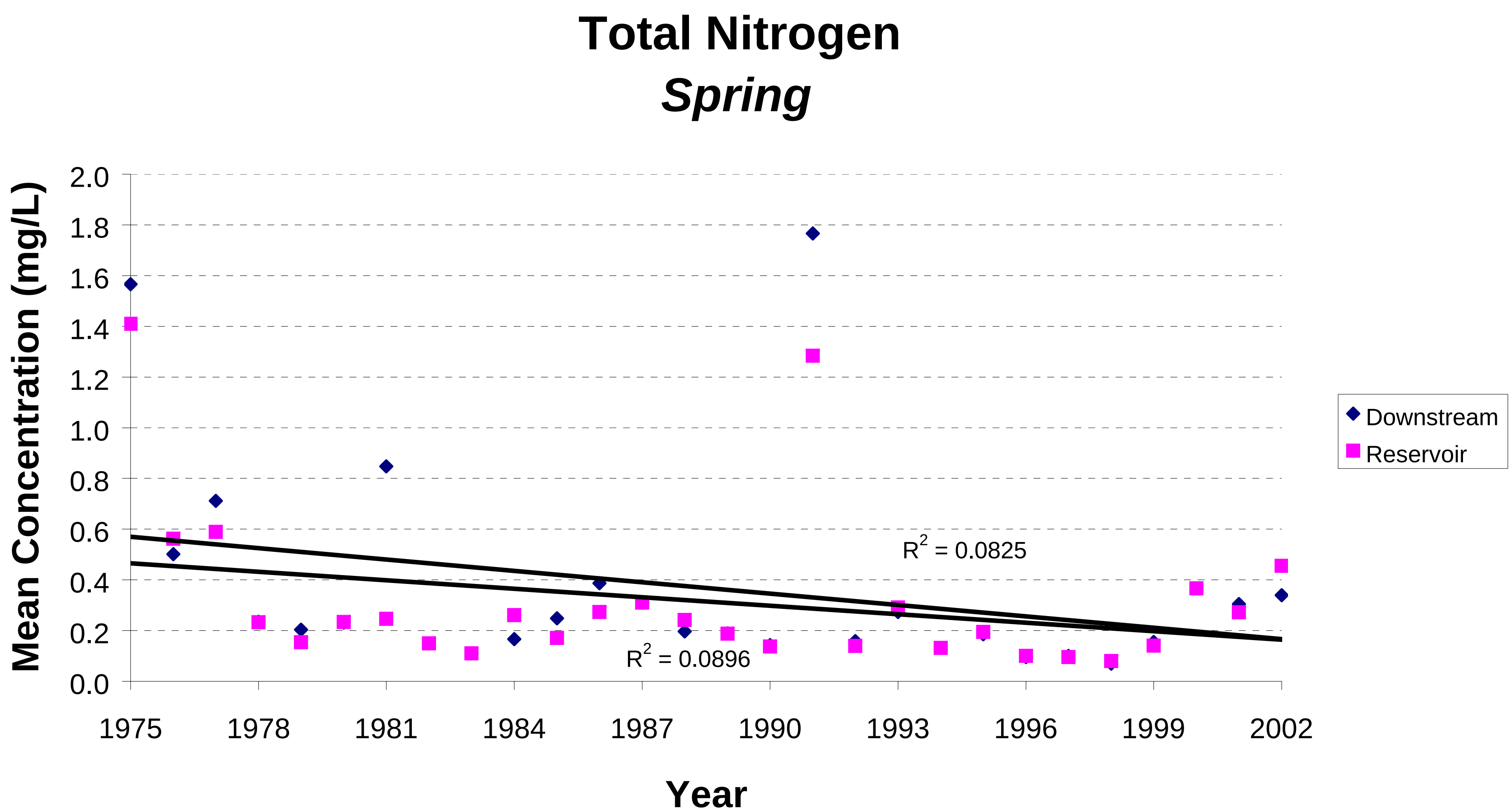


Figure 3-24. Seasonal trend analysis for total nitrogen (ammonia + nitrite + nitrate) measured during spring months (April, May, and June) at F. E. Walter Reservoir

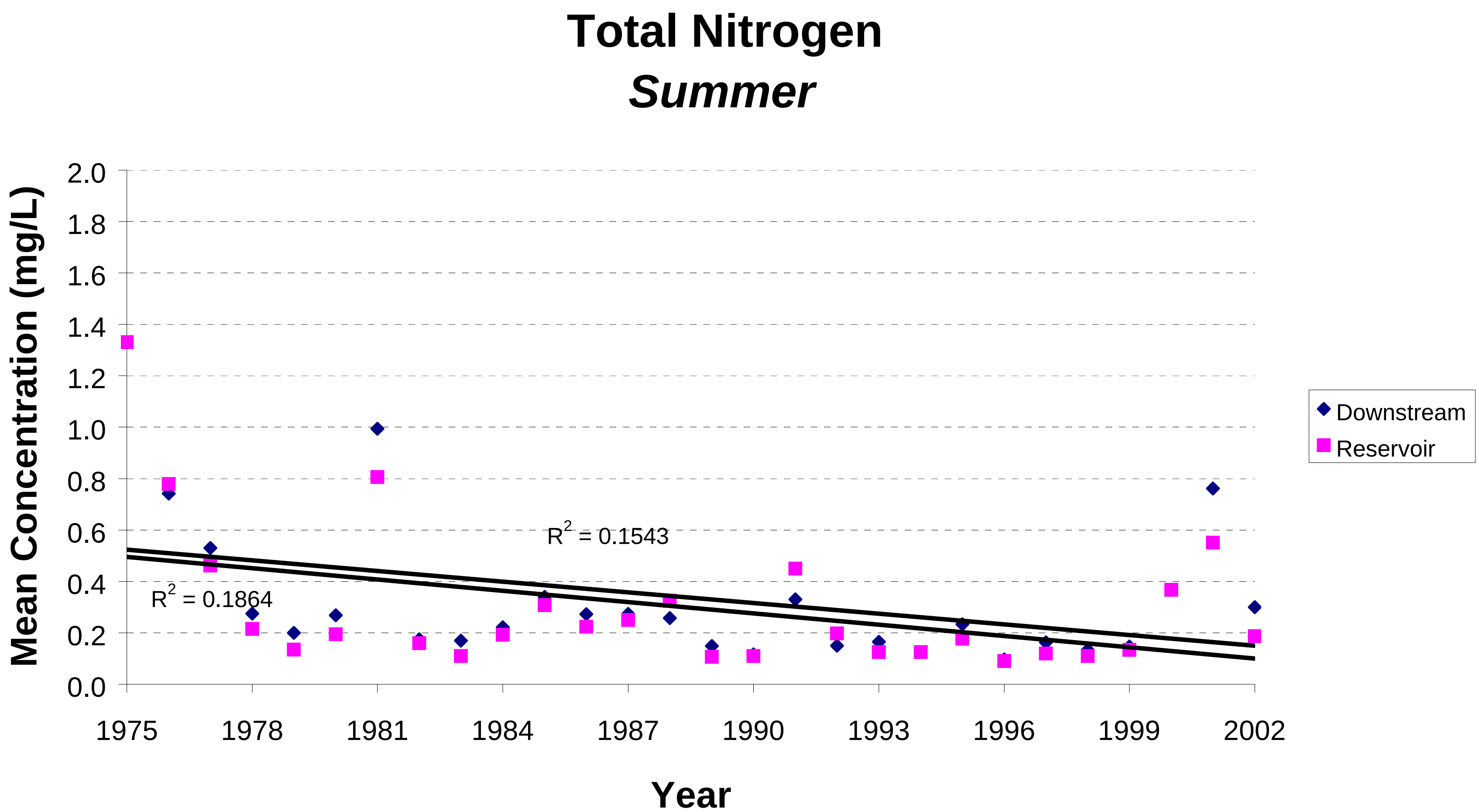


Figure 3-25. Seasonal trend analysis for total nitrogen (ammonia + nitrite + nitrate) measured during summer months (July, August, and October) at F.E. Walter Reservoir

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.

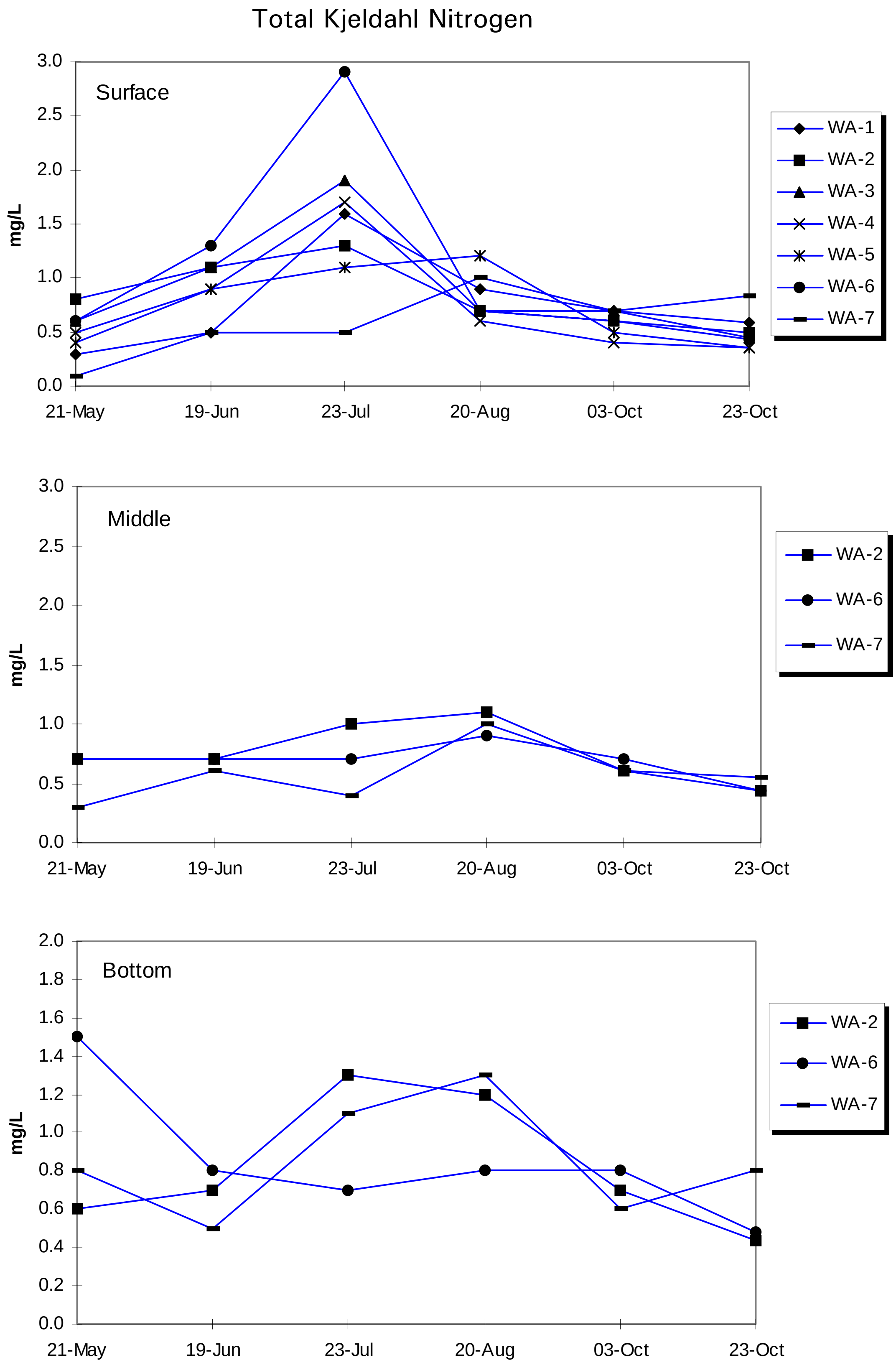


Figure 3-26. Total Kjeldahl nitrogen measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002

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.

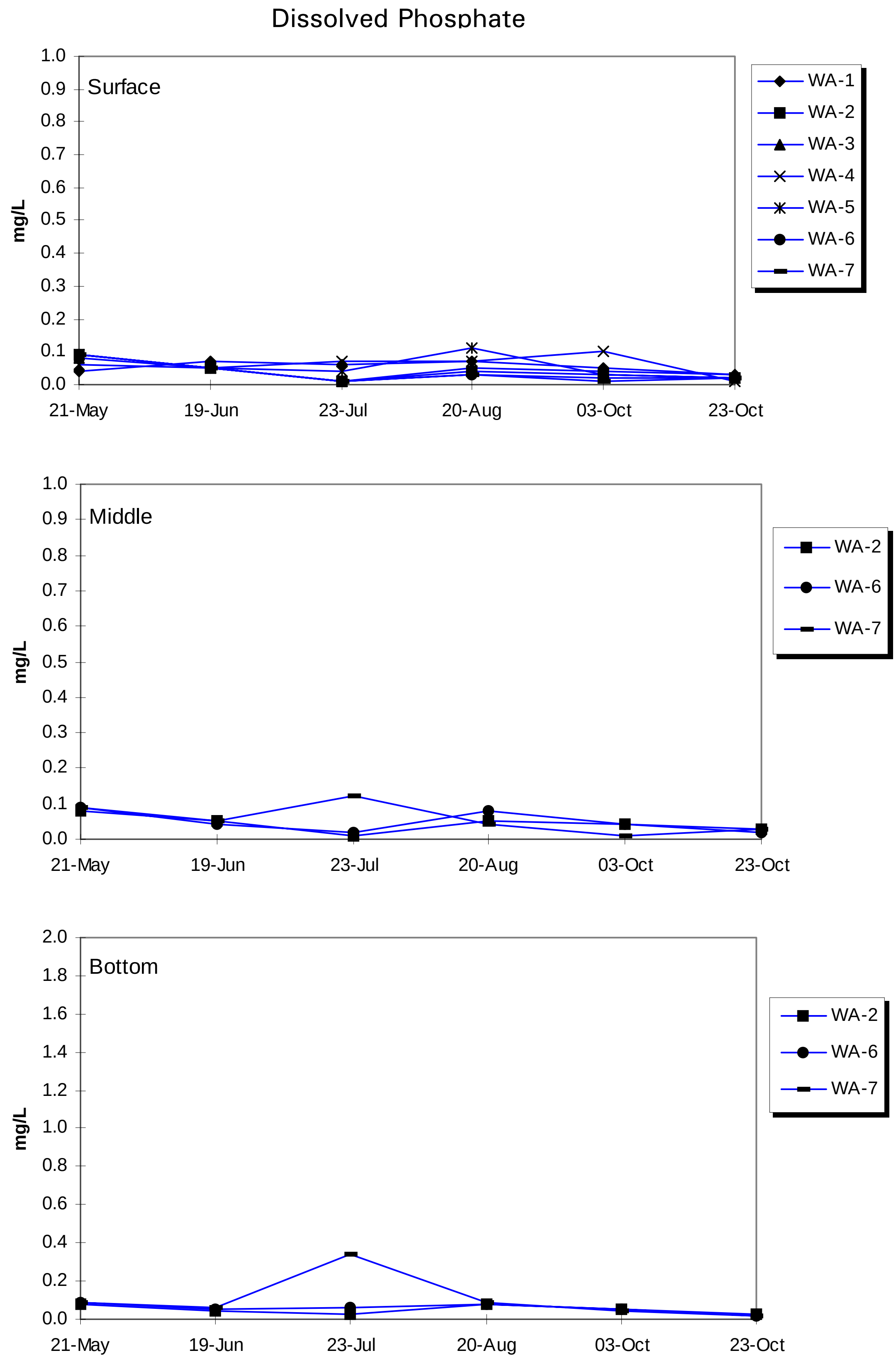


Figure 3-27. Total Phosphate measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002

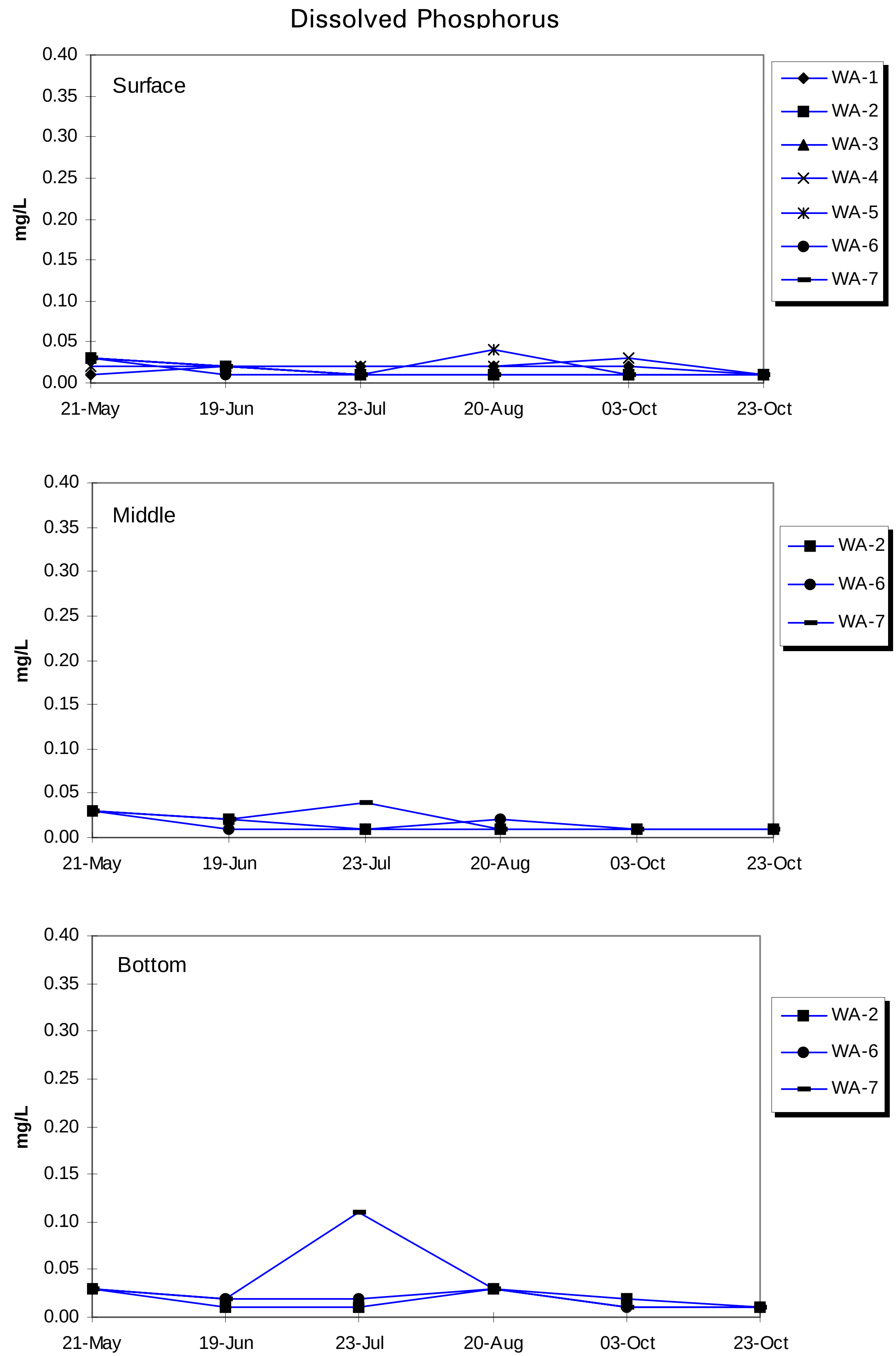


Figure 3-28. Total dissolved phosphorus measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002

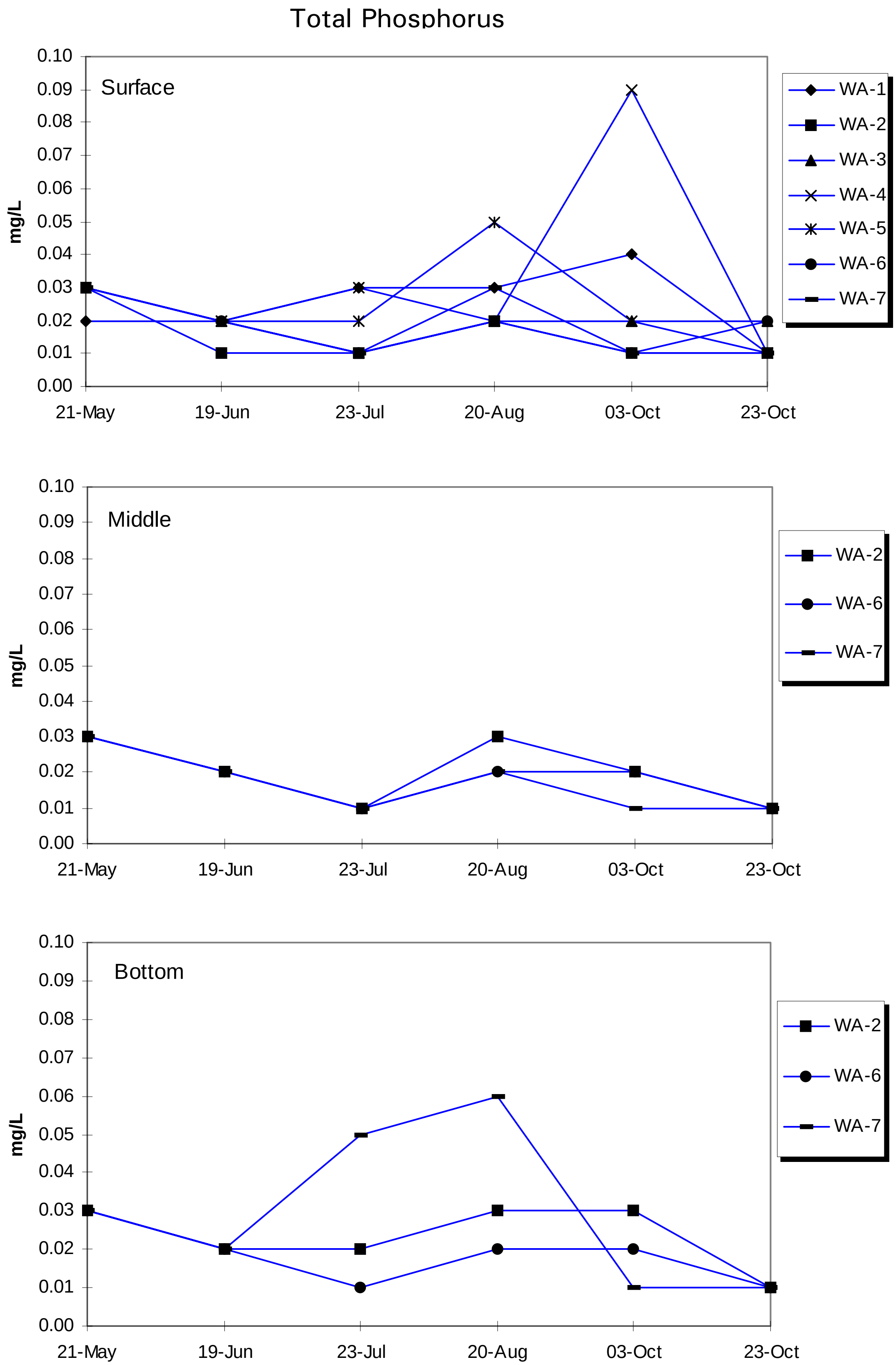


Figure 3-29. Total phosphorus measured in surface, middle, and bottom water of F.E.

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.

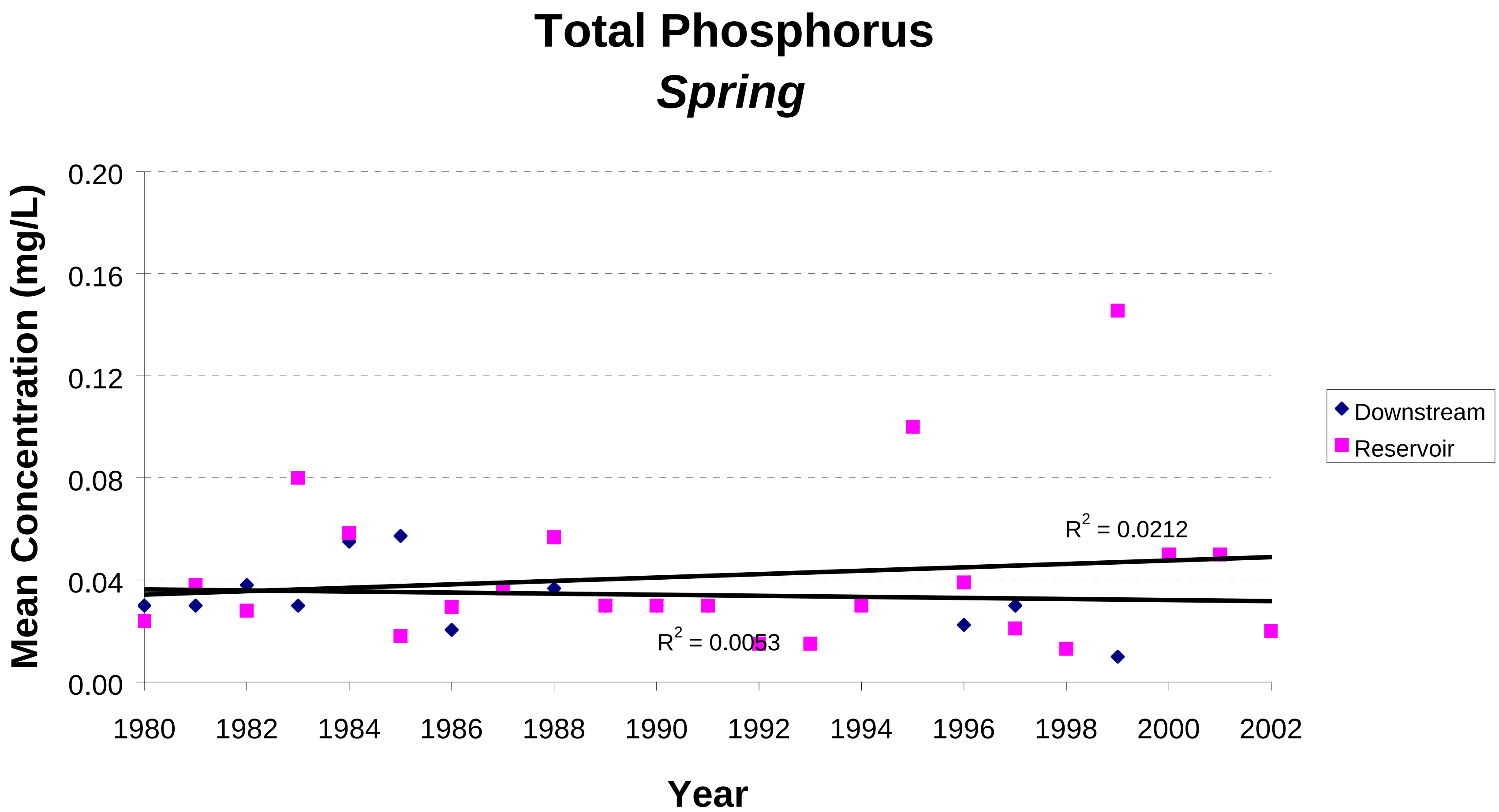


Figure 3-30. Seasonal trend analysis for total phosphorus measured during spring months (April, May, and June) at F.E. Walter Reservoir

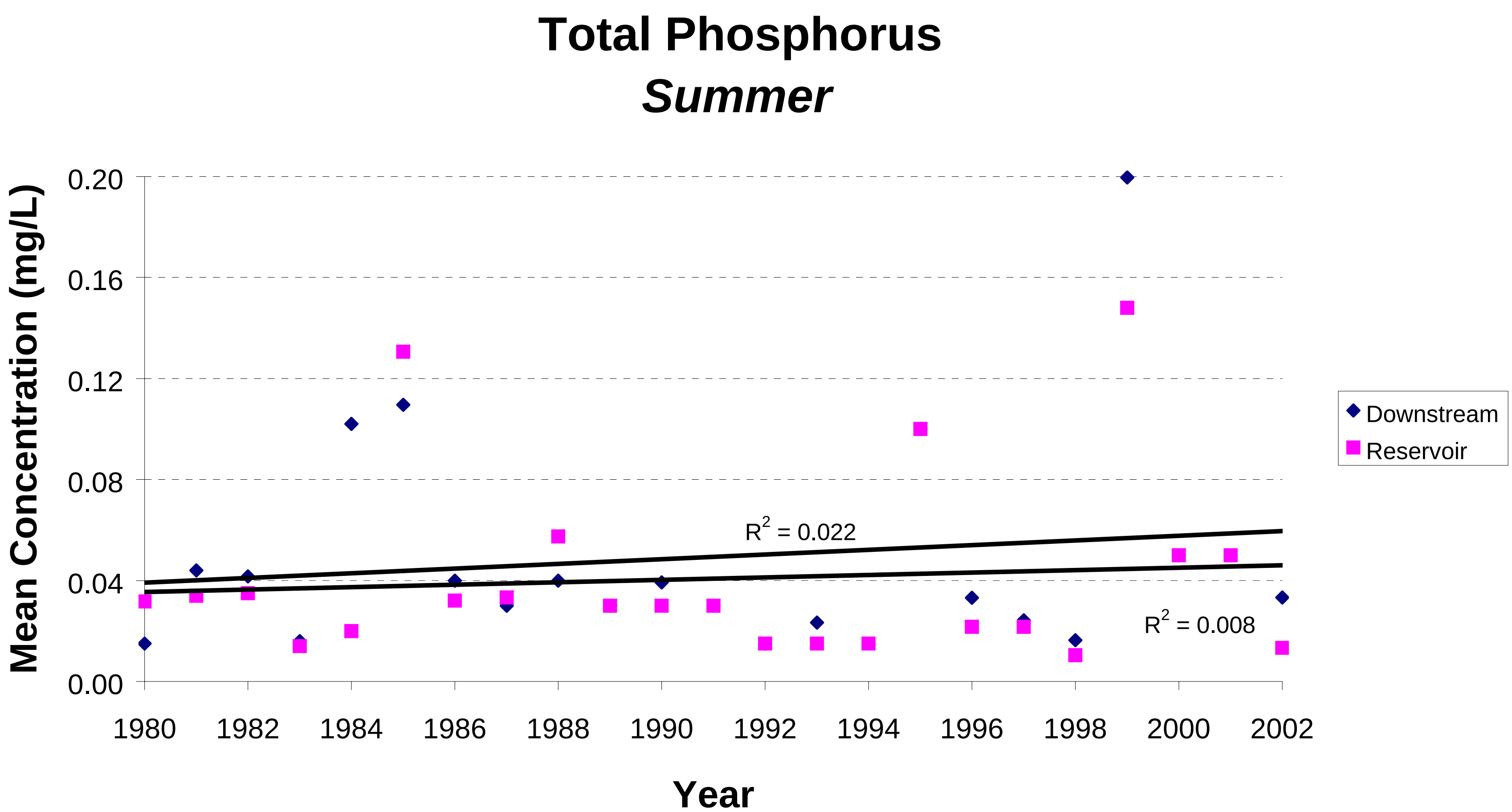


Figure 3-31. Seasonal trend analysis for total phosphorus measured during summer months (July, August, and October) at F.E. Walter Reservoir

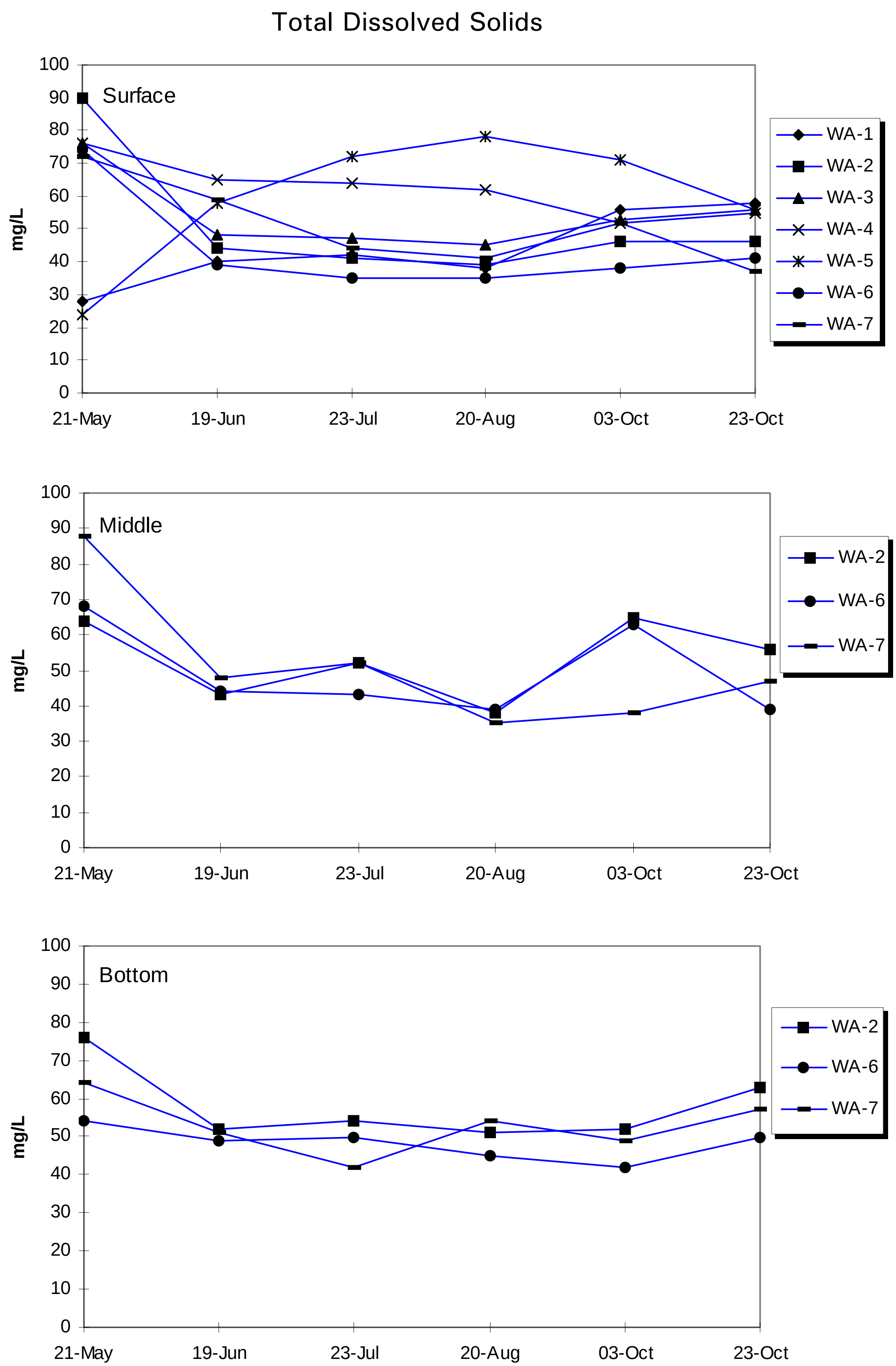


Figure 3-32. Total dissolved solids measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002. The PADEP water quality standard for TDS is a maximum concentration of 500 mg/L.

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).

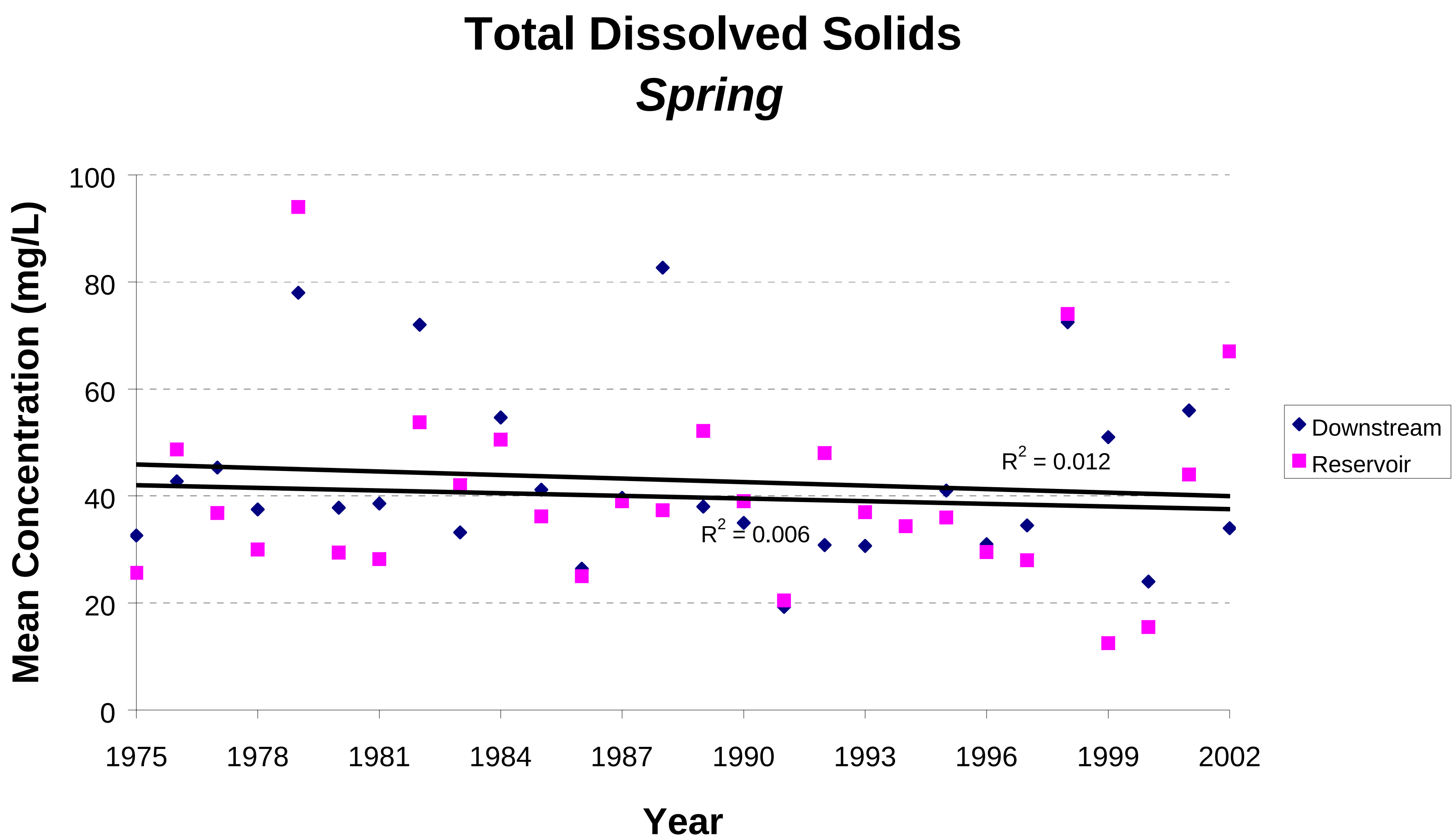


Figure 3-33. Seasonal trend analysis for total dissolved solids measured during spring months (April, May, and June) at F.E. Walter Reservoir

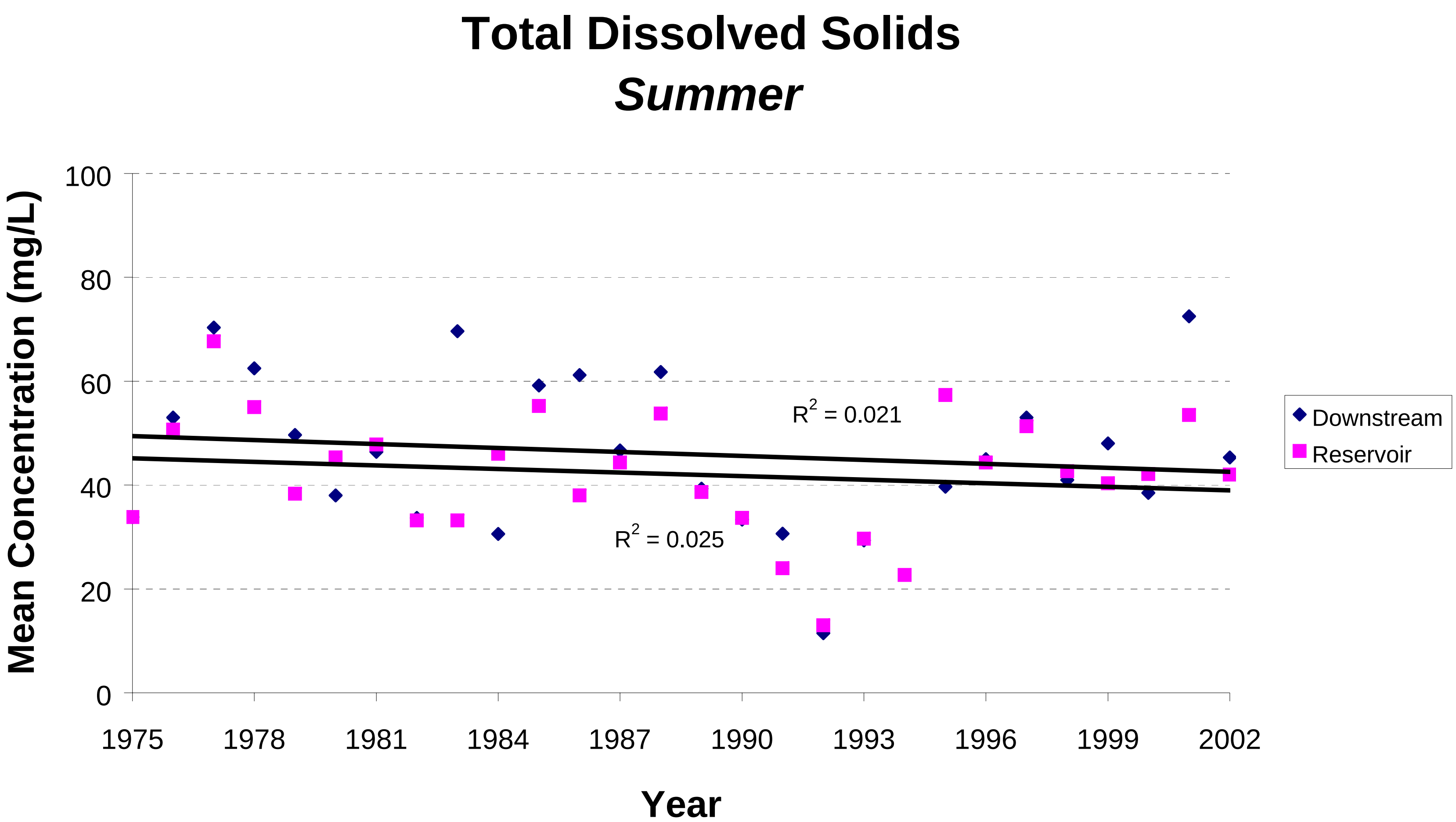


Figure 3-34. Seasonal trend analysis for total dissolved solids measured during summer months (July, August, and October 3) at F.E. Walter Reservoir

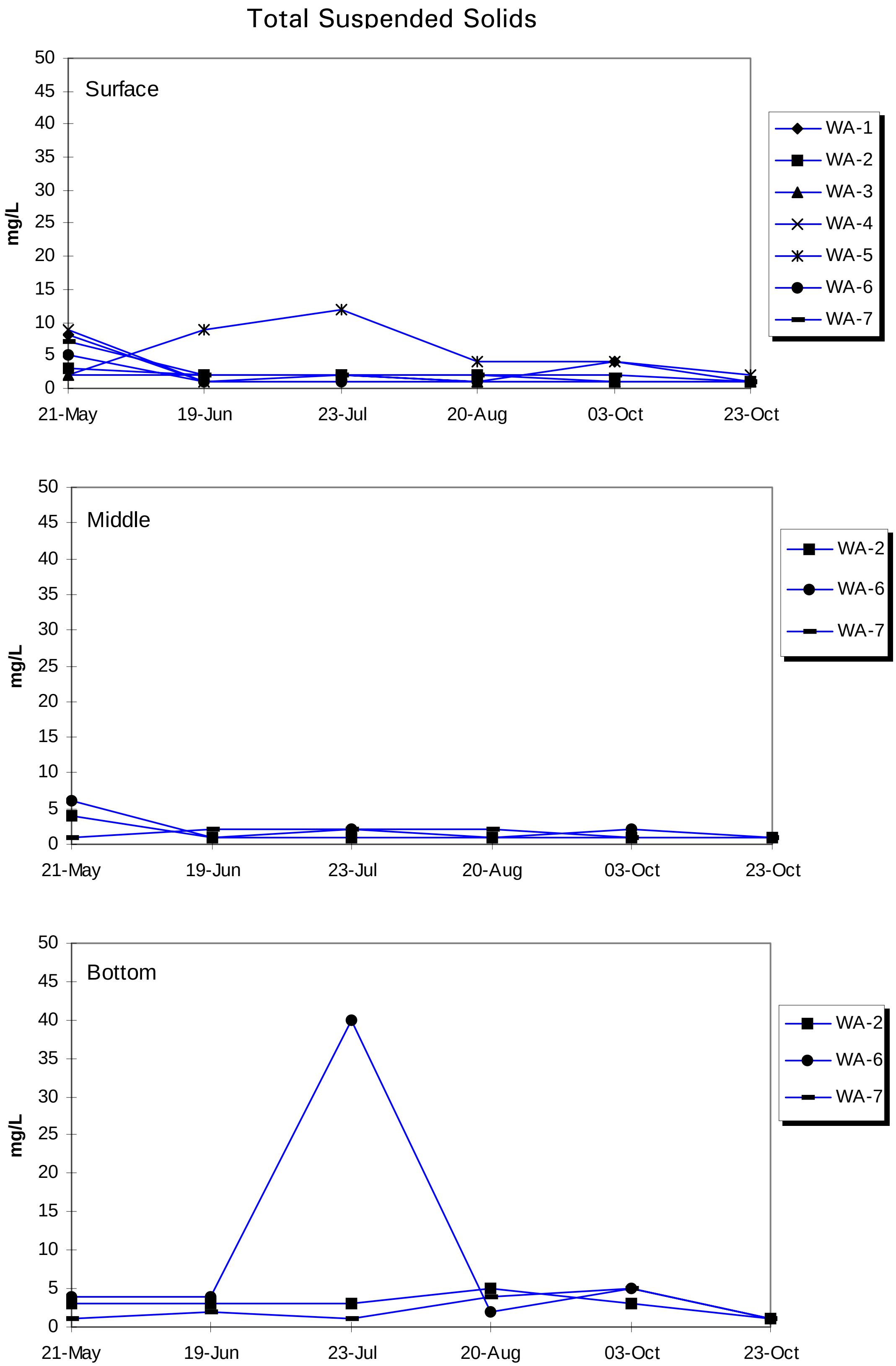


Figure 3-35. Total suspended solids measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002

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

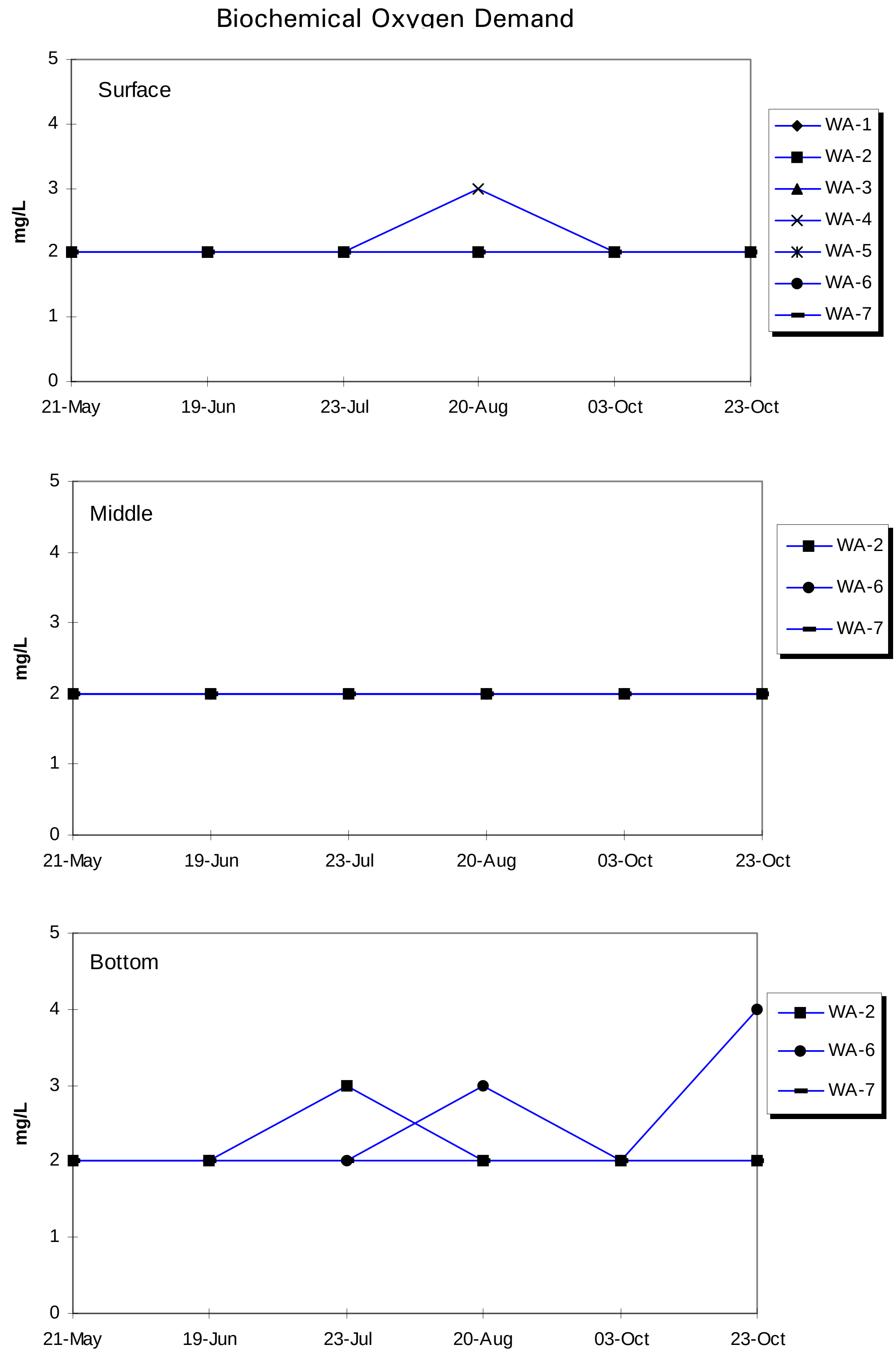


Figure 3-36. Biochemical oxygen demand (5-day) measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002

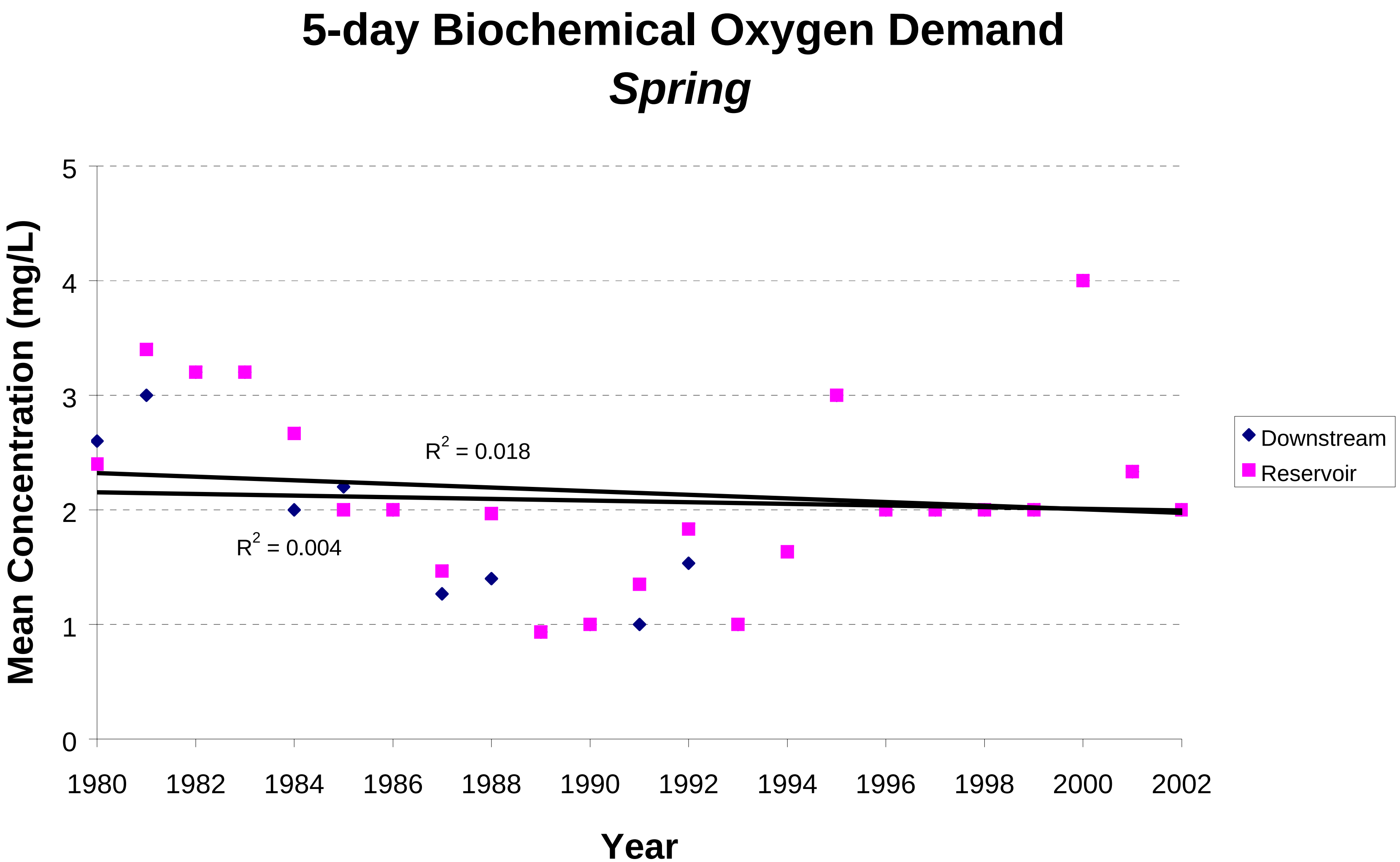


Figure 3-37. Seasonal trend analysis for biochemical oxygen demand (5-day) measured during spring months (April, May, and June) at F.E. Walter Reservoir

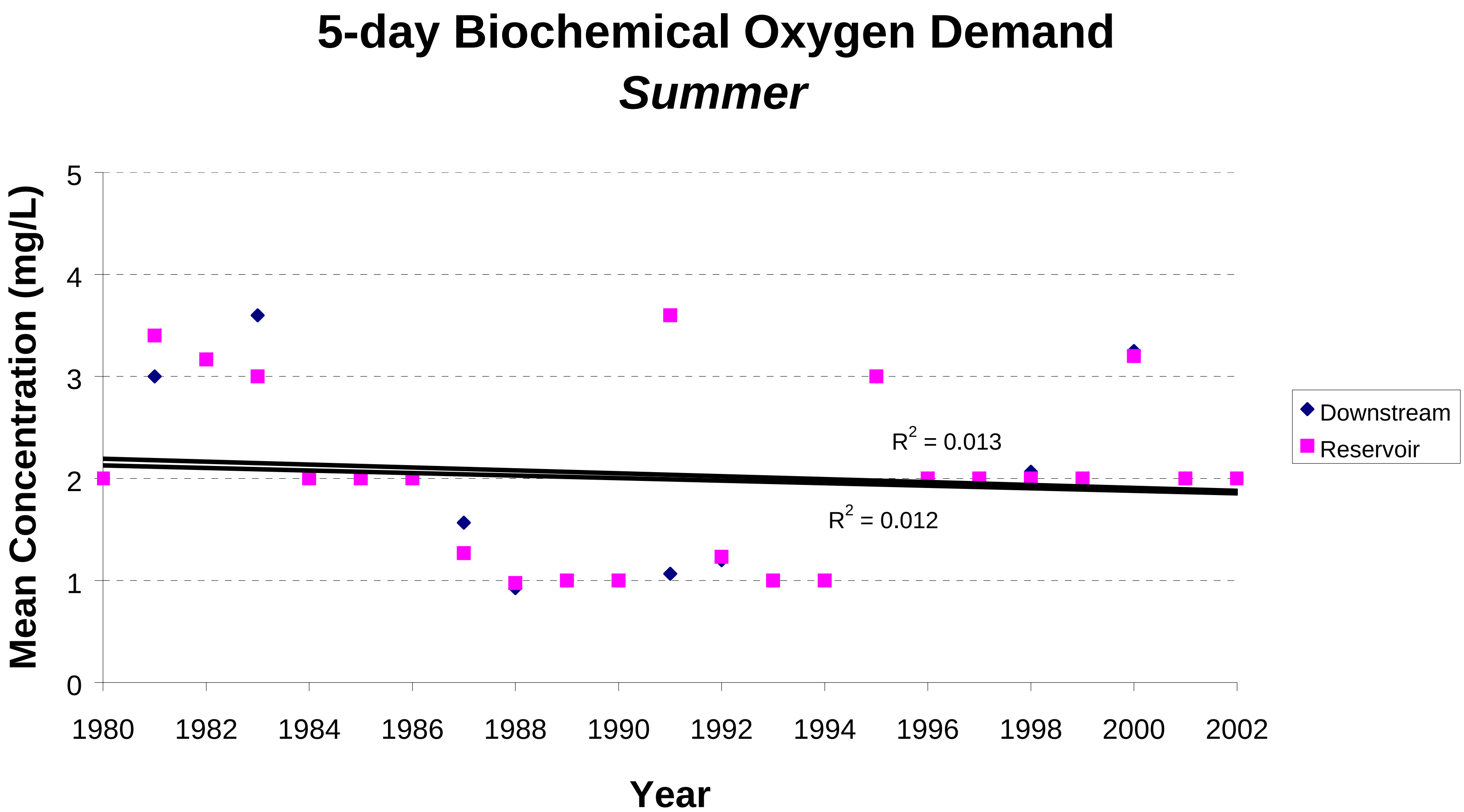


Figure 3-38. Seasonal trend analysis for biochemical oxygen demand (5-day) measured during summer months (July, August, and October 3) at F.E. Walter Reservoir

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).

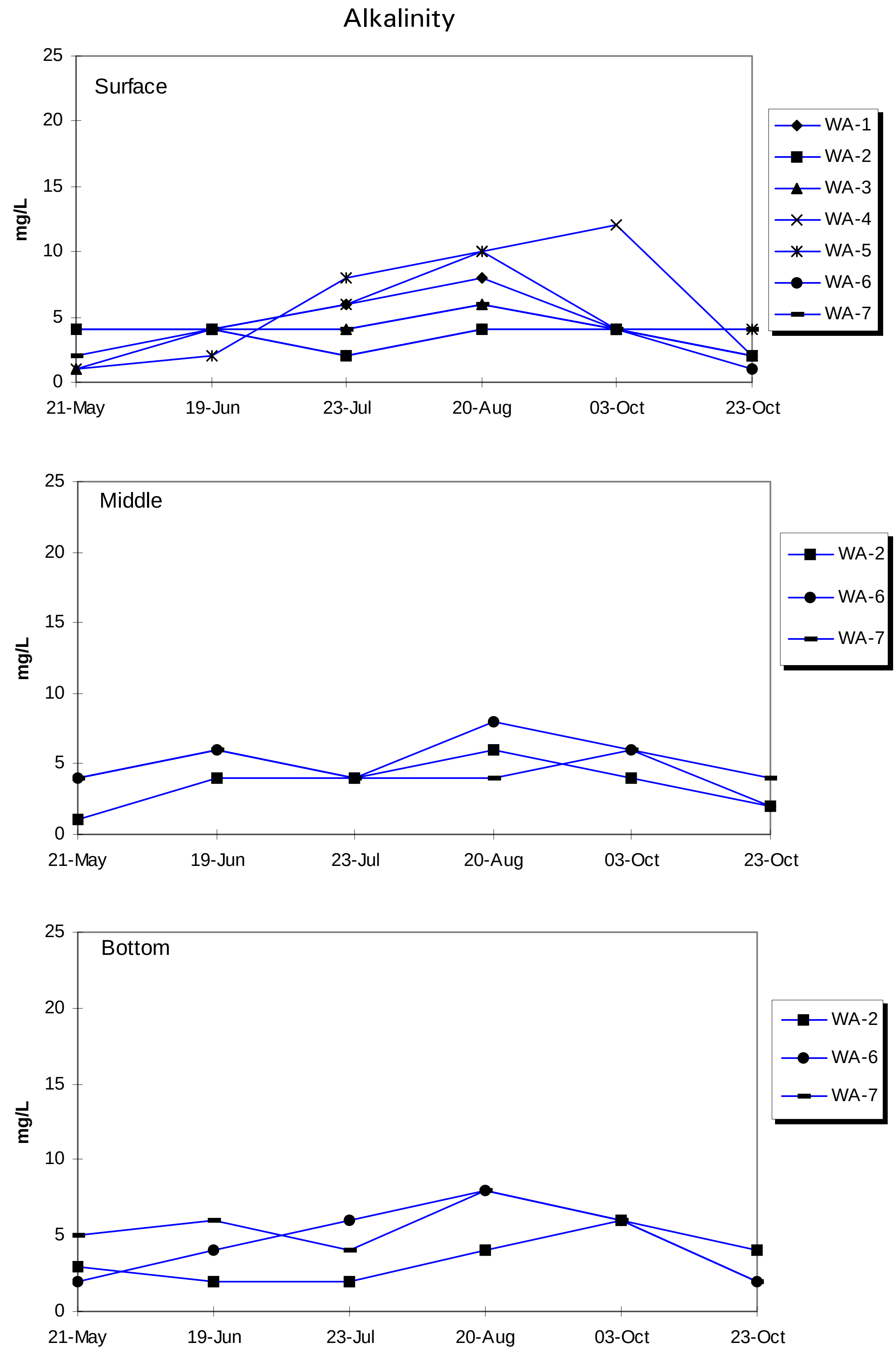


Figure 3-39. Alkalinity measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002. The PADEP water quality standard for alkalinity is a minimum concentration of 20 mg/L.

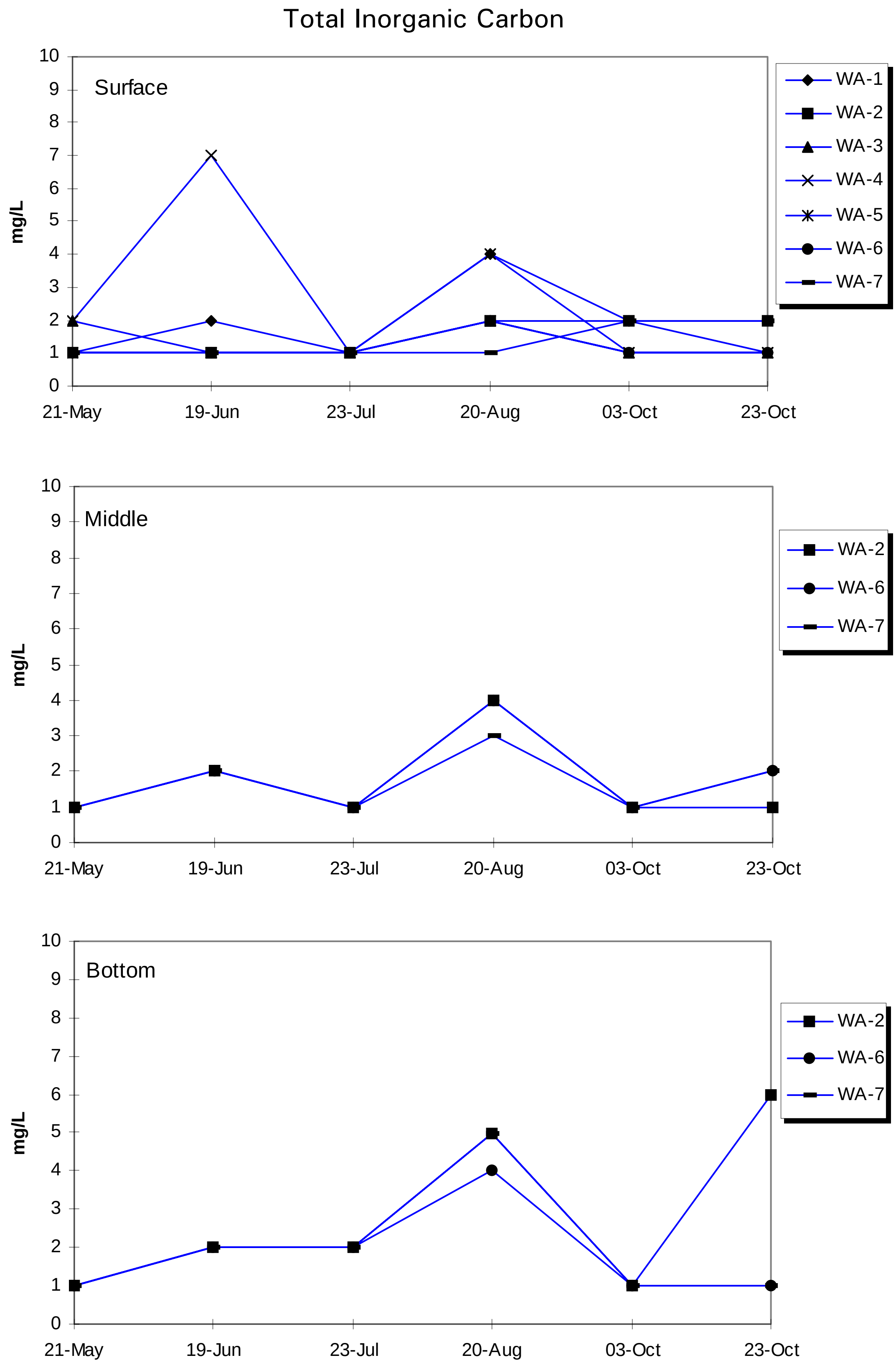
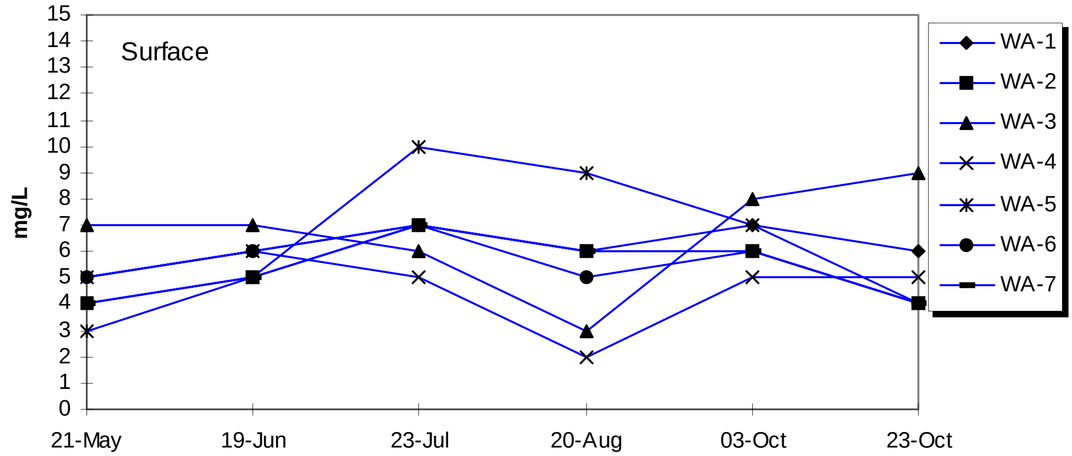
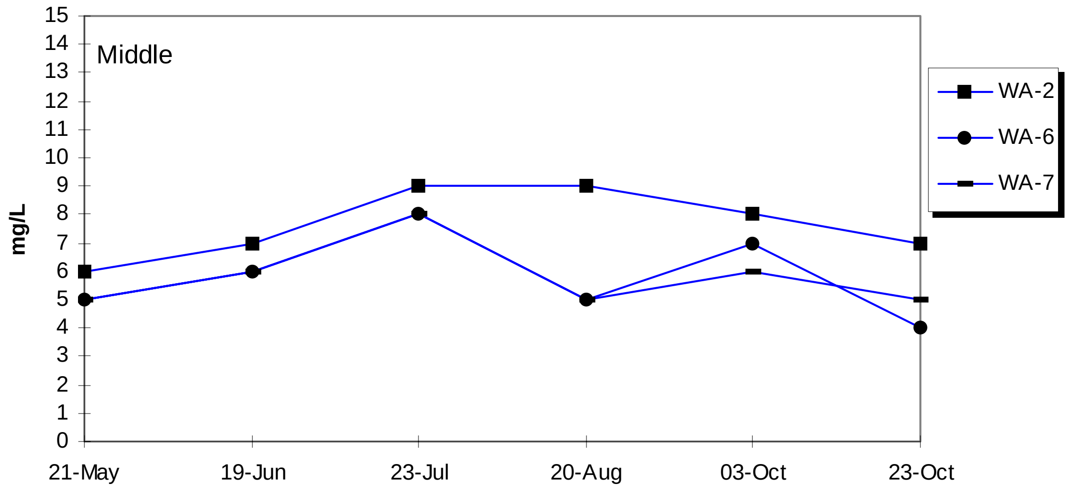


Figure 3-40. Total inorganic carbon measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002.

Total Organic Carbon





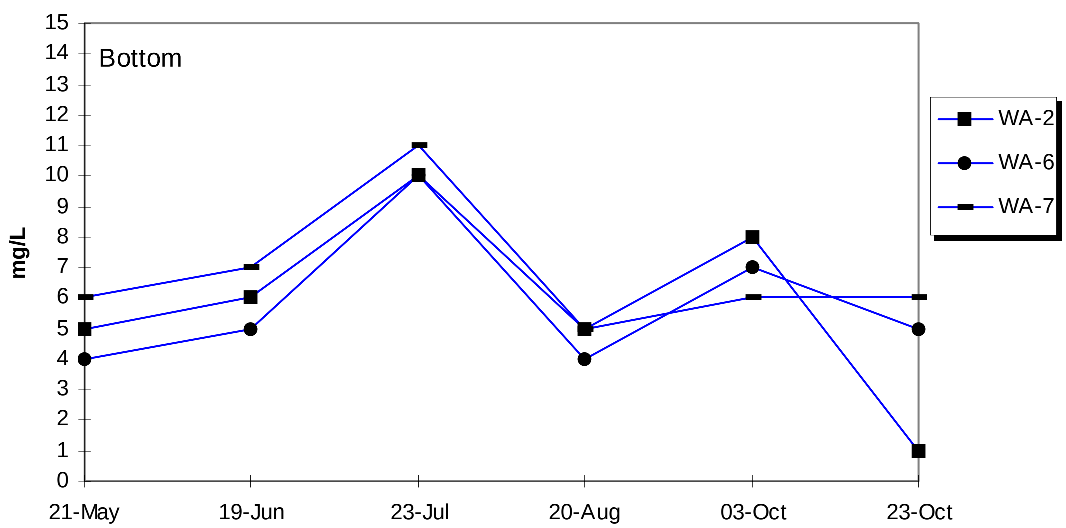


Figure 3-41. Total organic carbon measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002

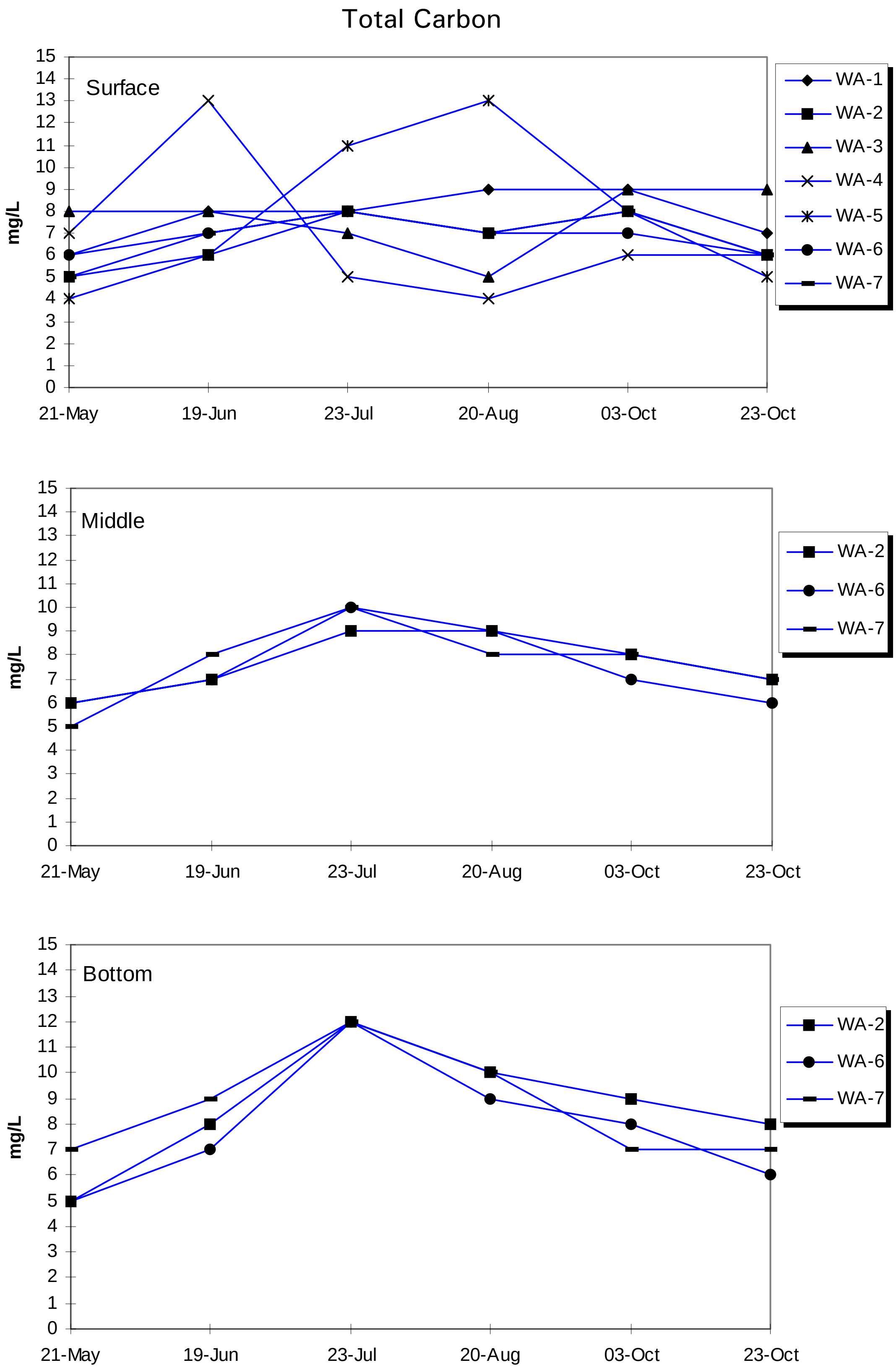


Figure 3-42. Total carbon measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002

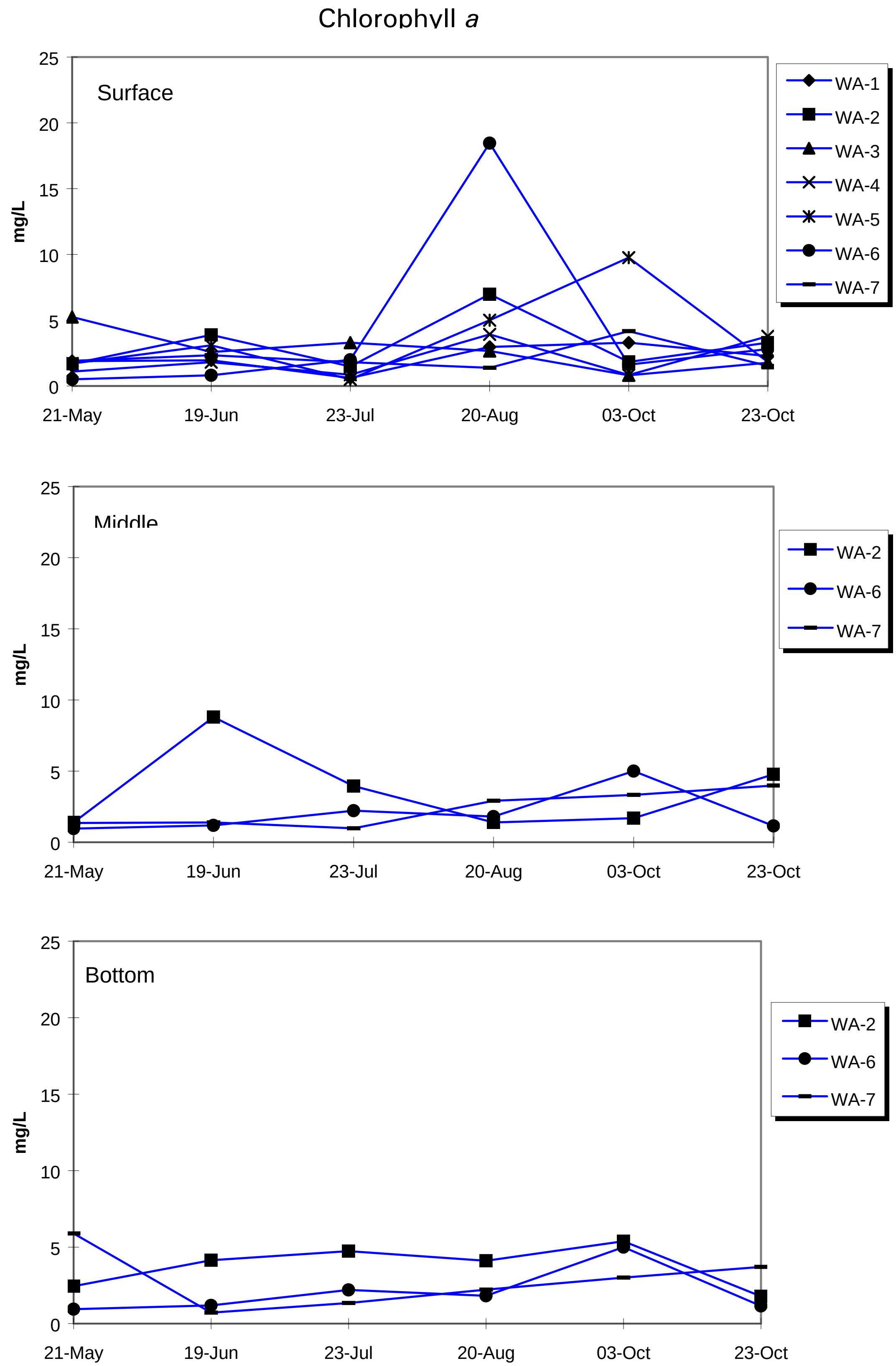


Figure 3-43. Chlorophyll *a* measured in surface, middle, and bottom water of F.E. Walter Reservoir during 2002

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

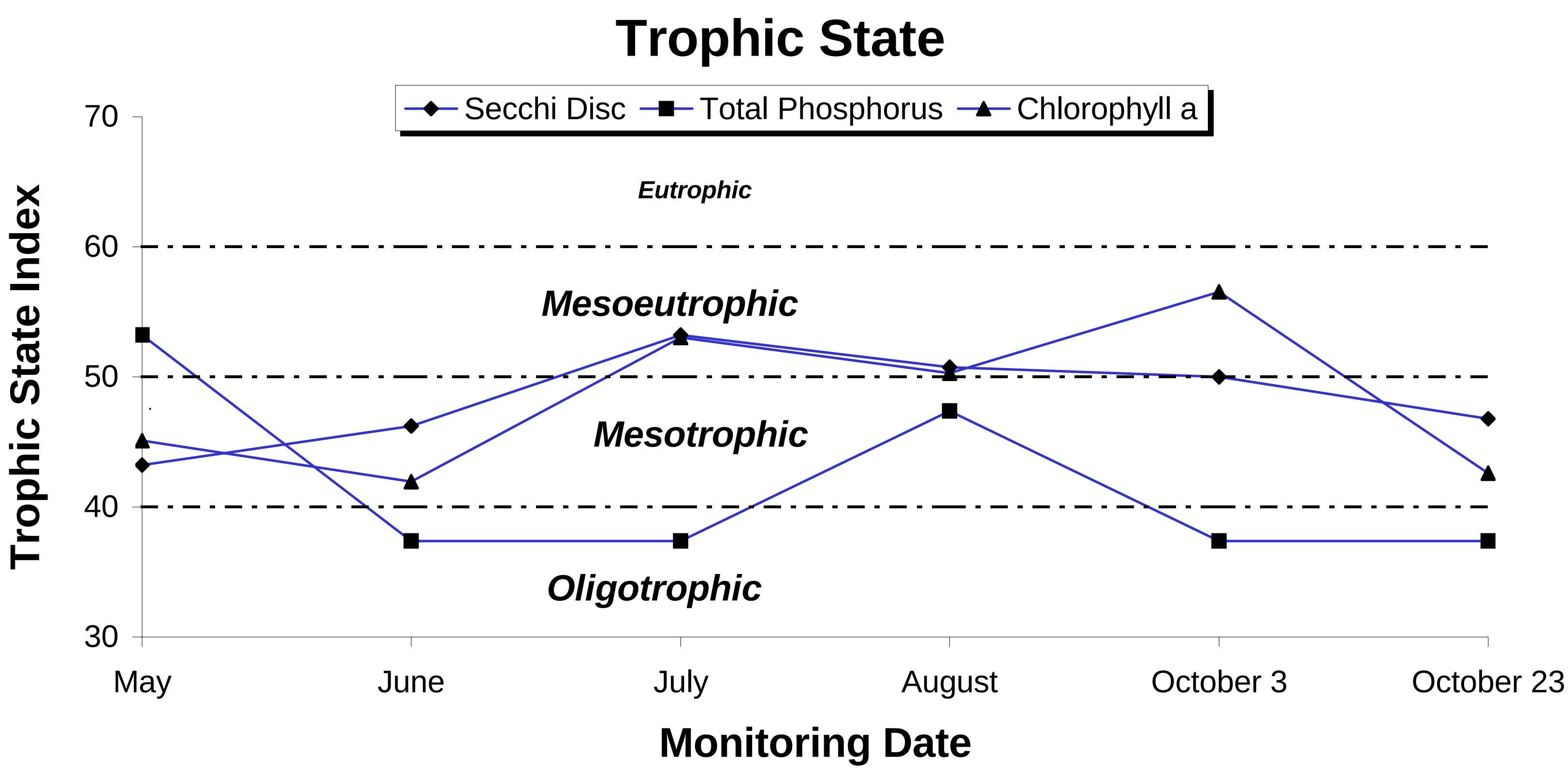


Figure 3-44. Trophic state indices calculated from secchi disk depth and concentrations of chlorophyll *a* and total phosphorus measured in surface water of F.E. Walter Reservoir during 2002

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

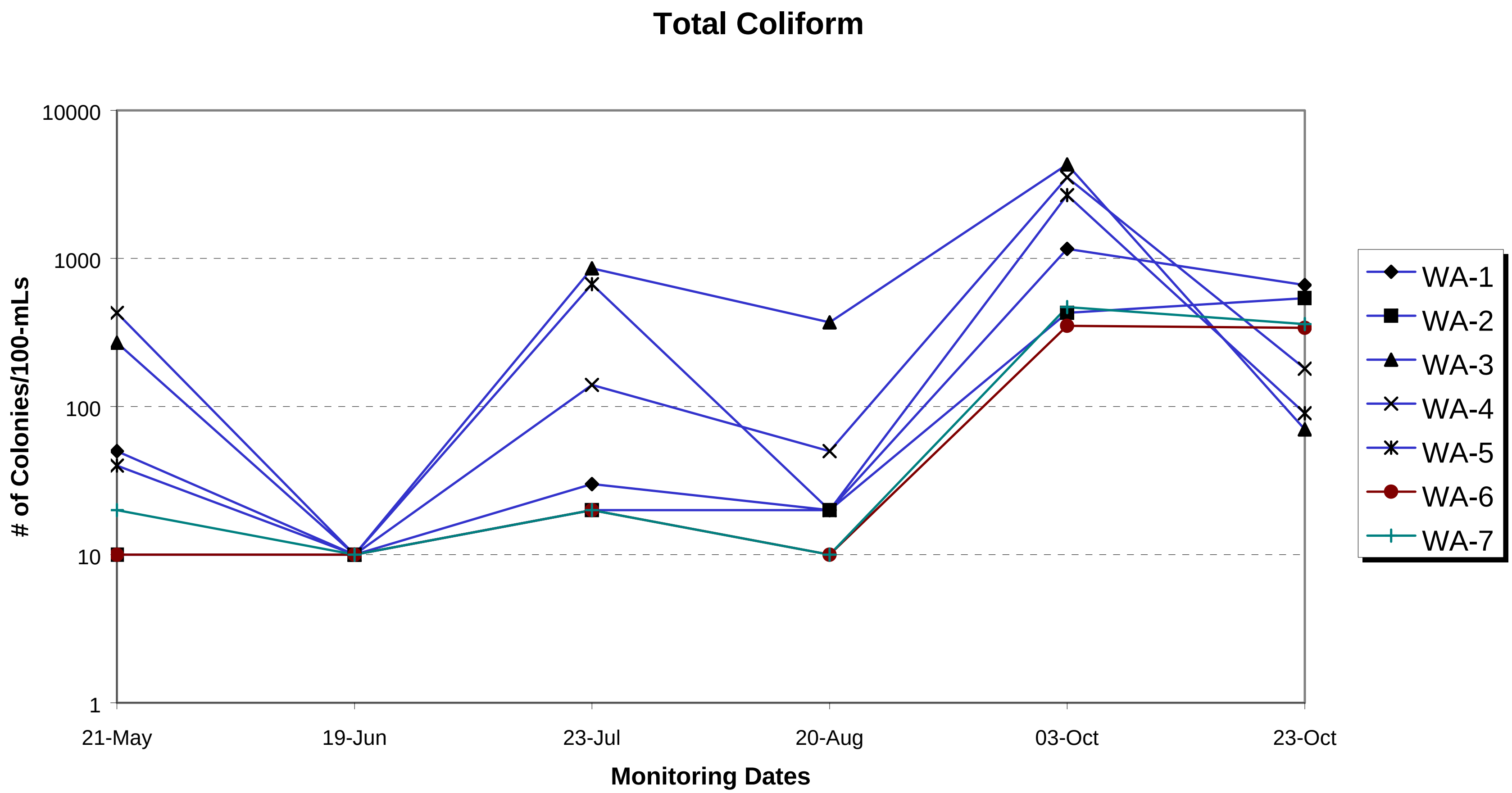


Figure 3-45. Counts of total coliform bacteria in surface waters of F.E. Walter Reservoir during 2002

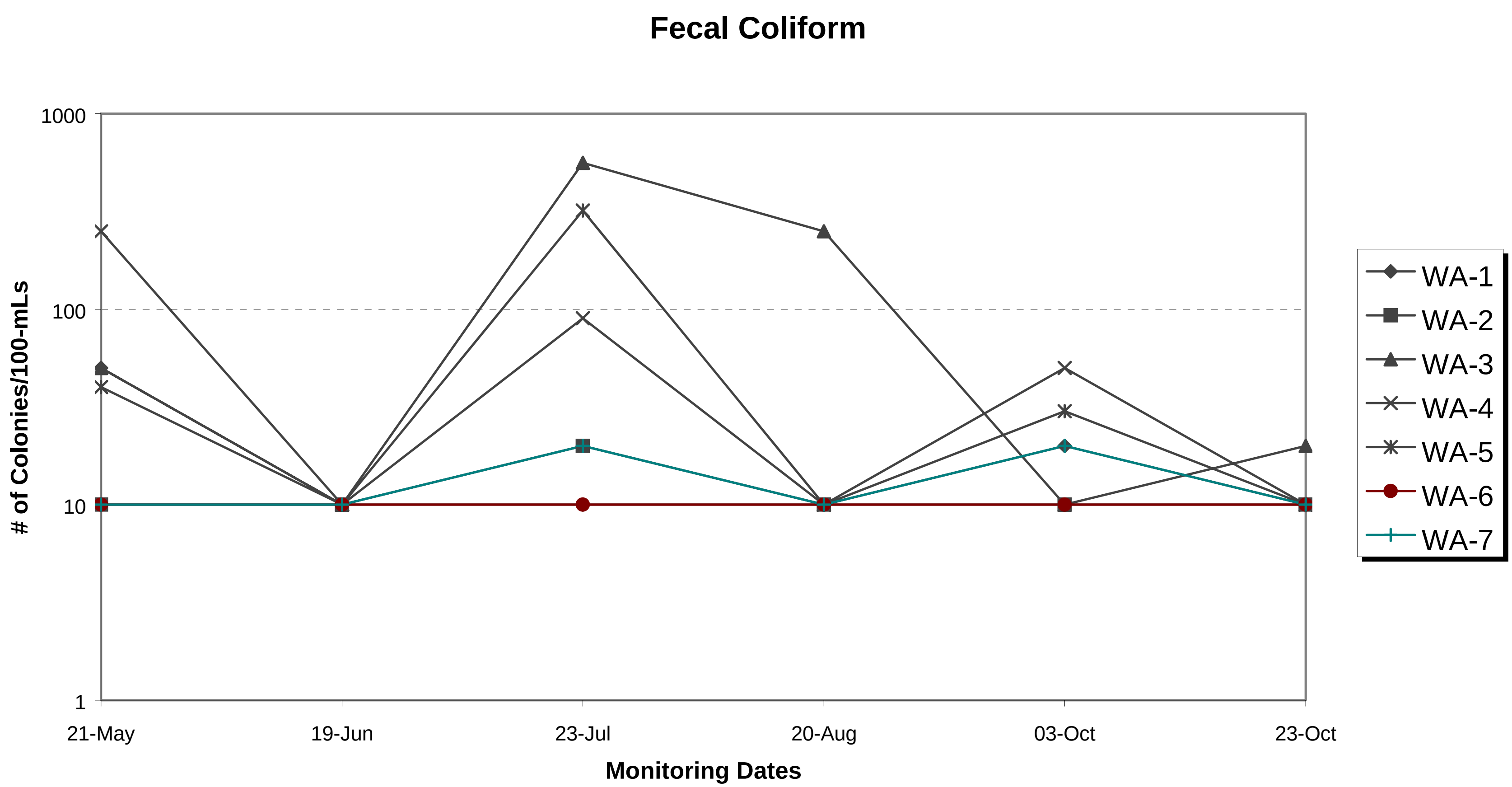


Figure 3-46. Counts of fecal coliform bacteria in surface waters of F.E. Walter Reservoir during 2002

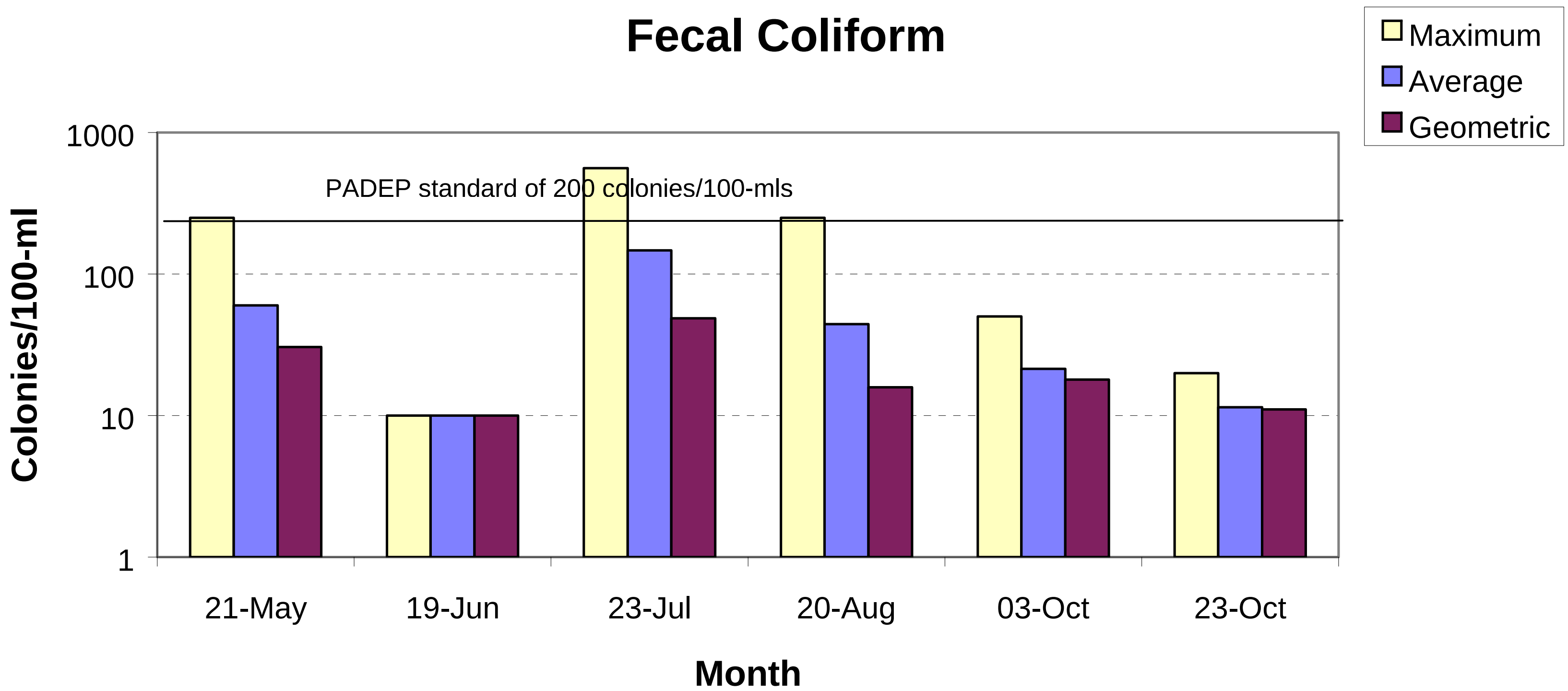


Figure 3-47. Maximum average, and geometric mean of fecal coliform counts (colonies/100-ml) for all stations monitored at F.E. Walter Reservoir in 2002

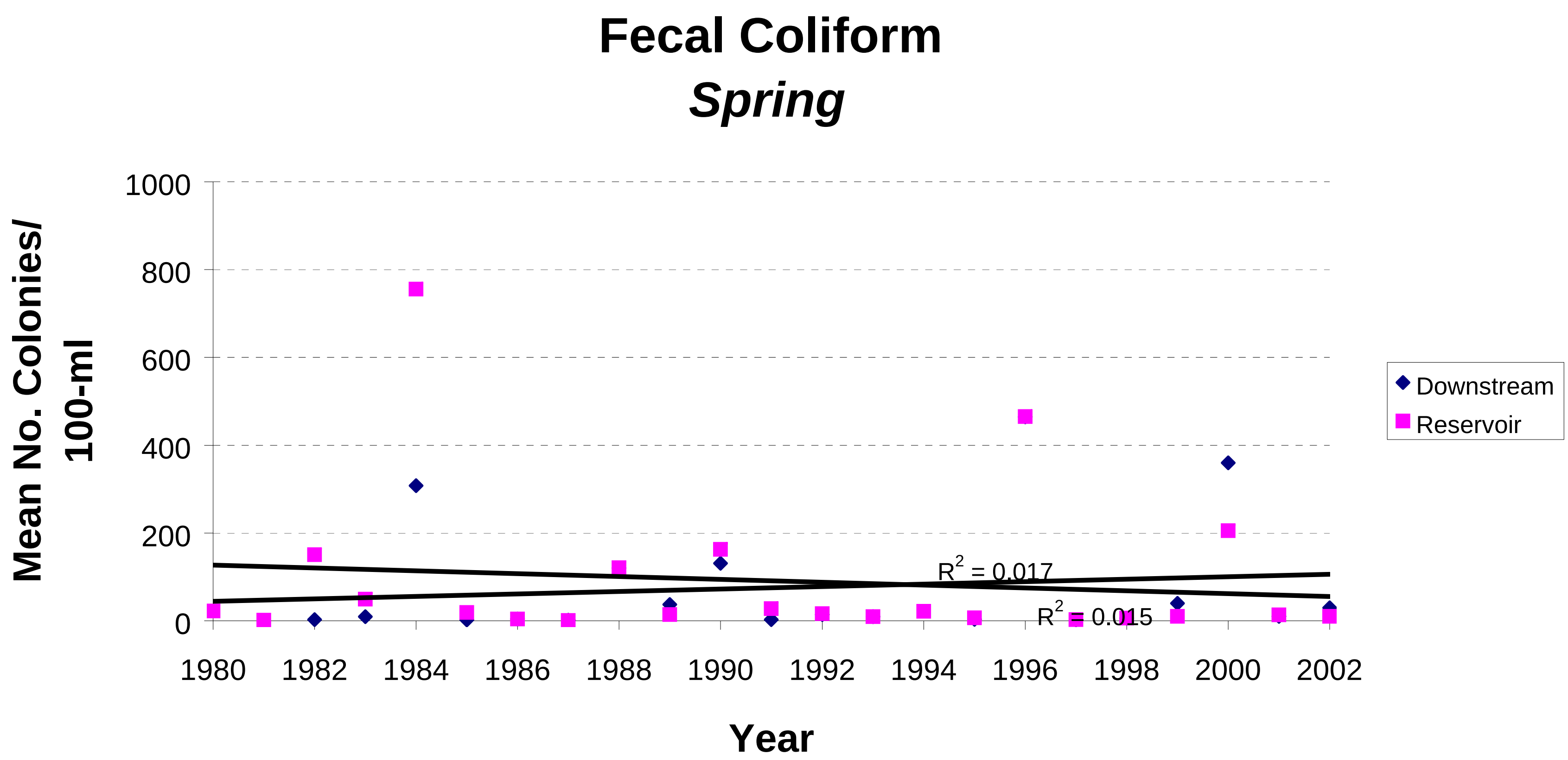


Figure 3-48. Seasonal trend analysis for counts of fecal coliform bacteria during spring months (Apirl, May, and June) at F.E. Walter Reservoir

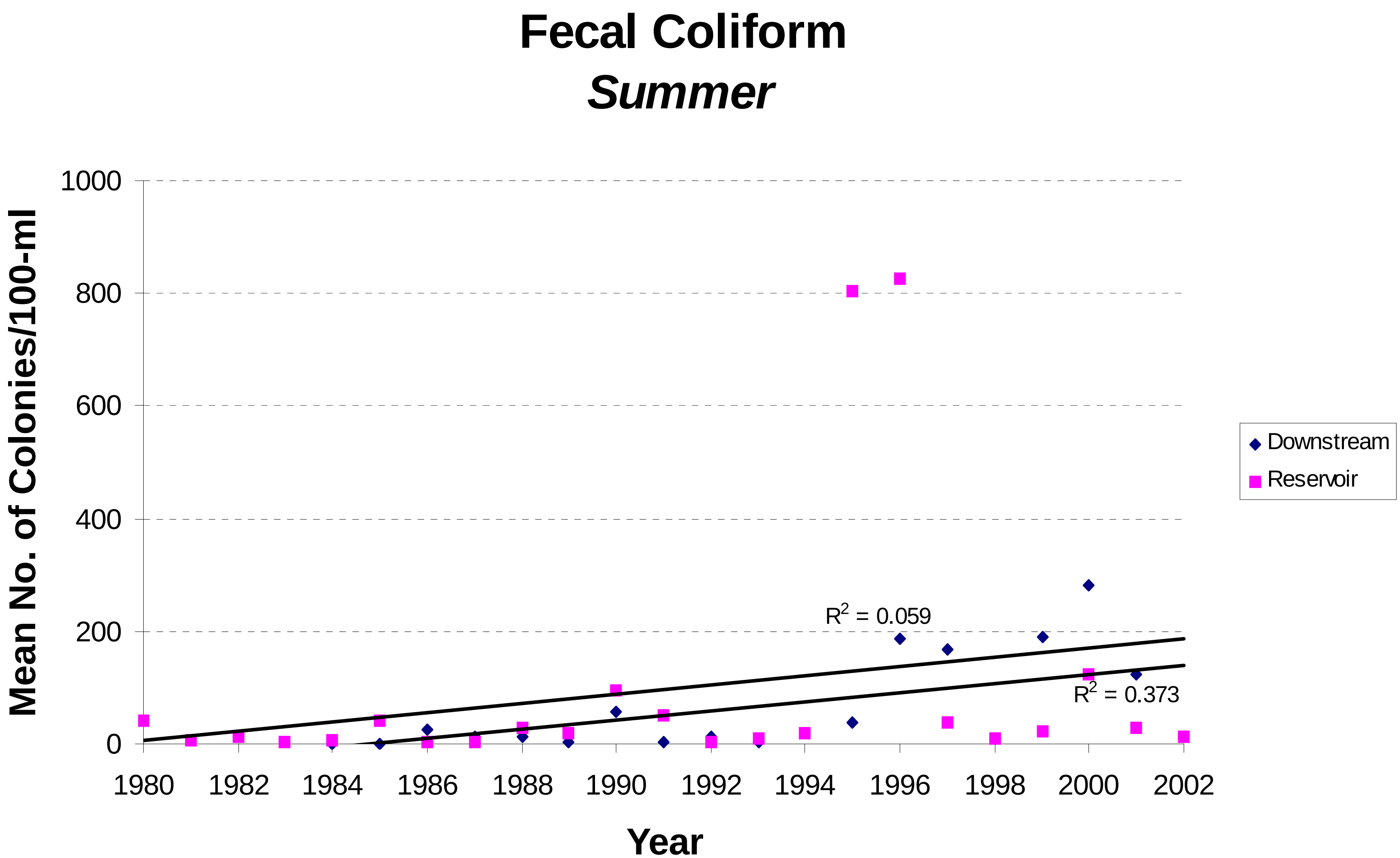


Figure 3-49. Seasonal trend analysis for counts of fecal coliform bacteria during summer months (July, August, and October 3) at F.E. Walter Reservoir

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 °C 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 °C on 22 October (Fig. 3-50).

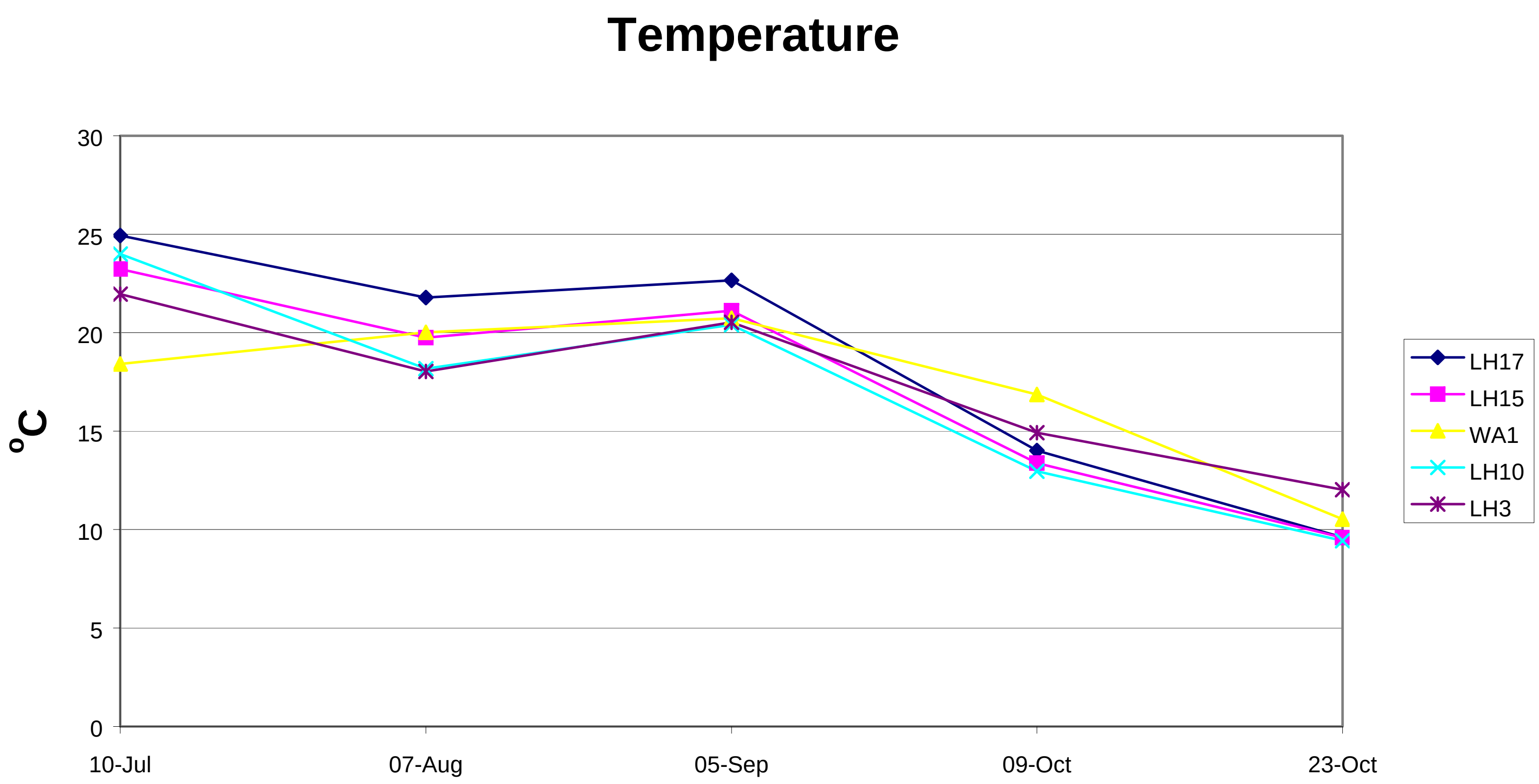


Figure 3-50. Temperature measured in surface waters of Lehigh River during 2002.

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.

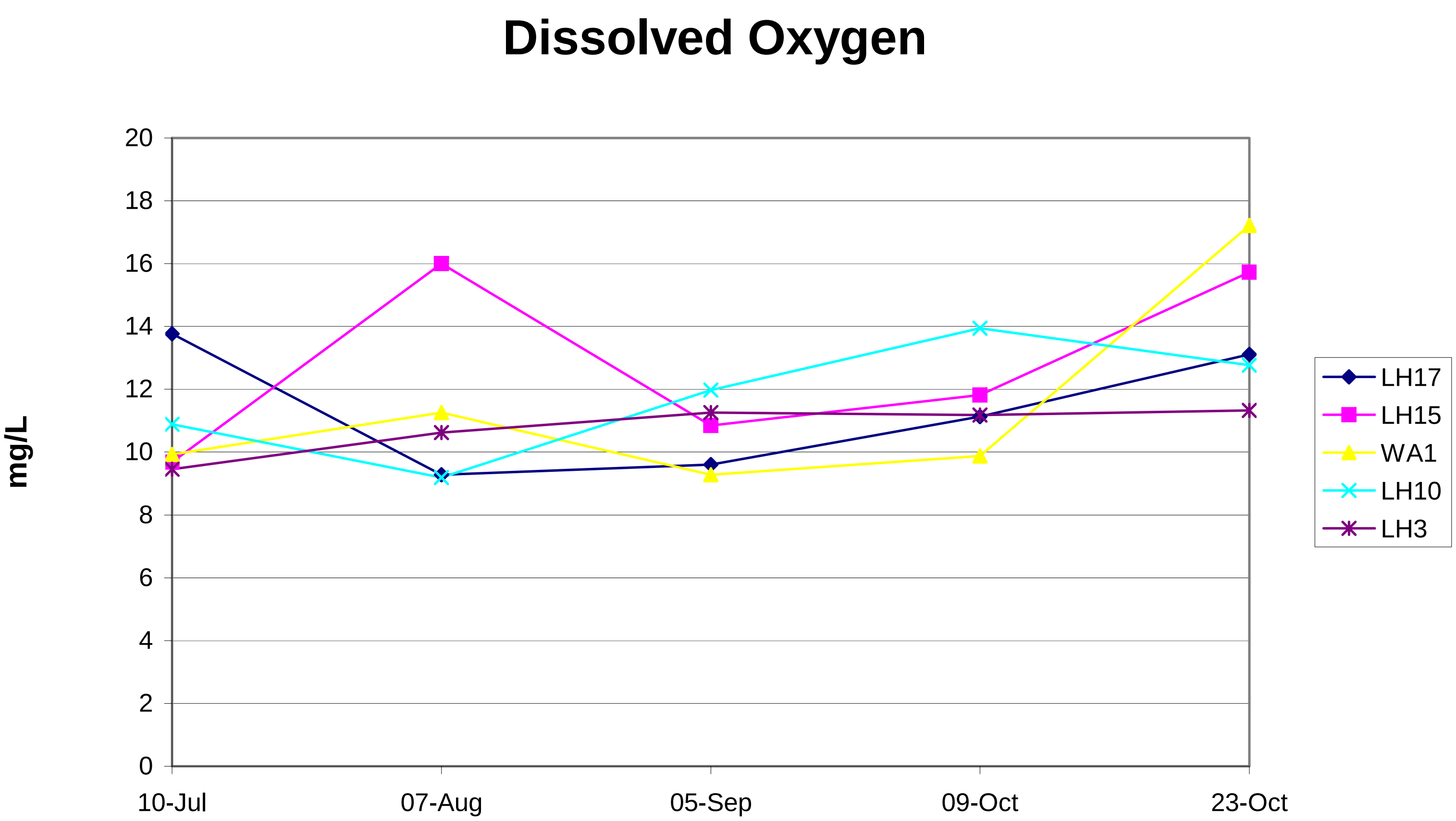


Figure 3-51. Dissolved oxygen measured in surface waters of Lehigh River during 2002.

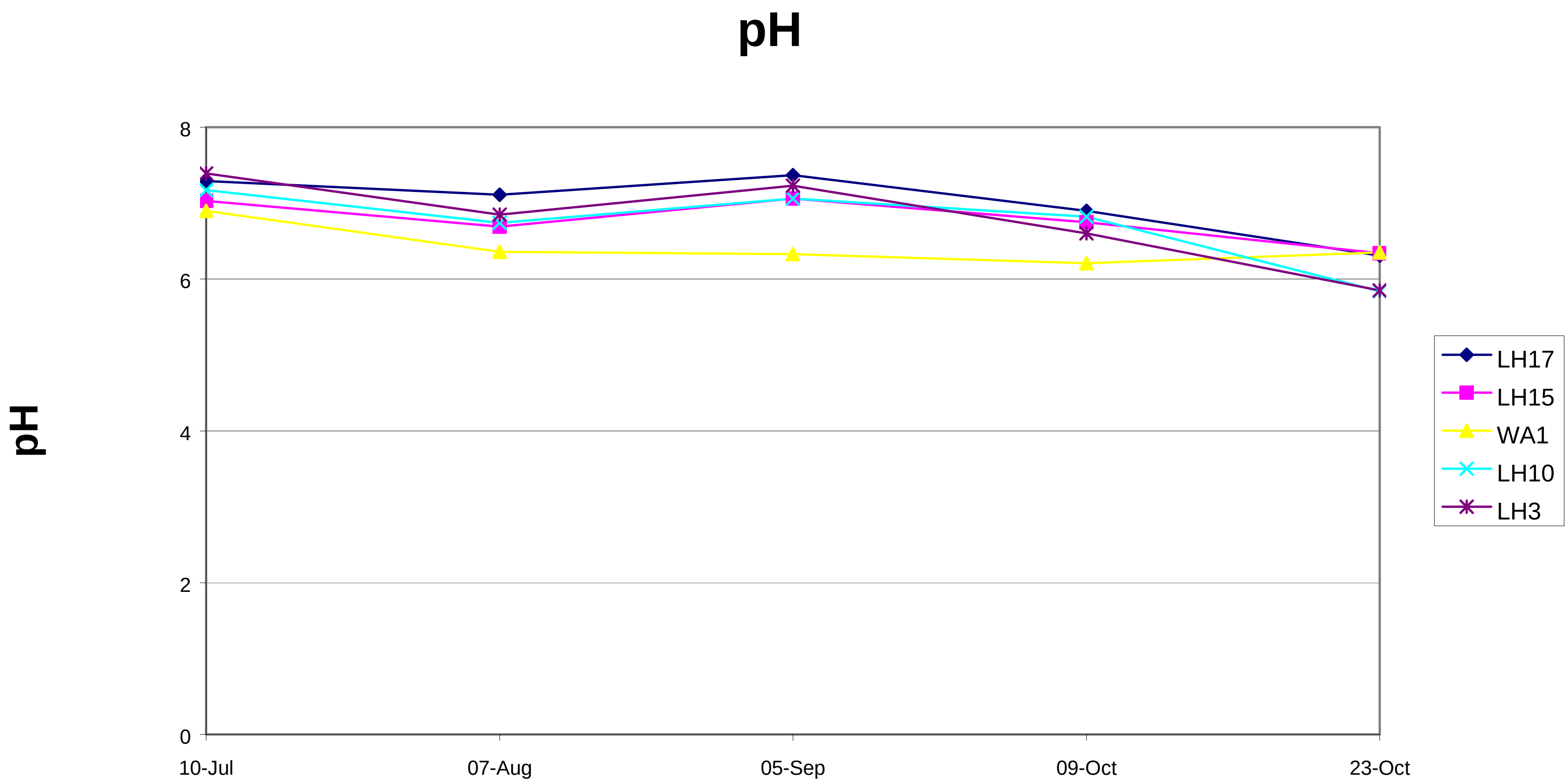


Figure 3-52. pH measured in surface waters of Lehigh River during 2002.

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

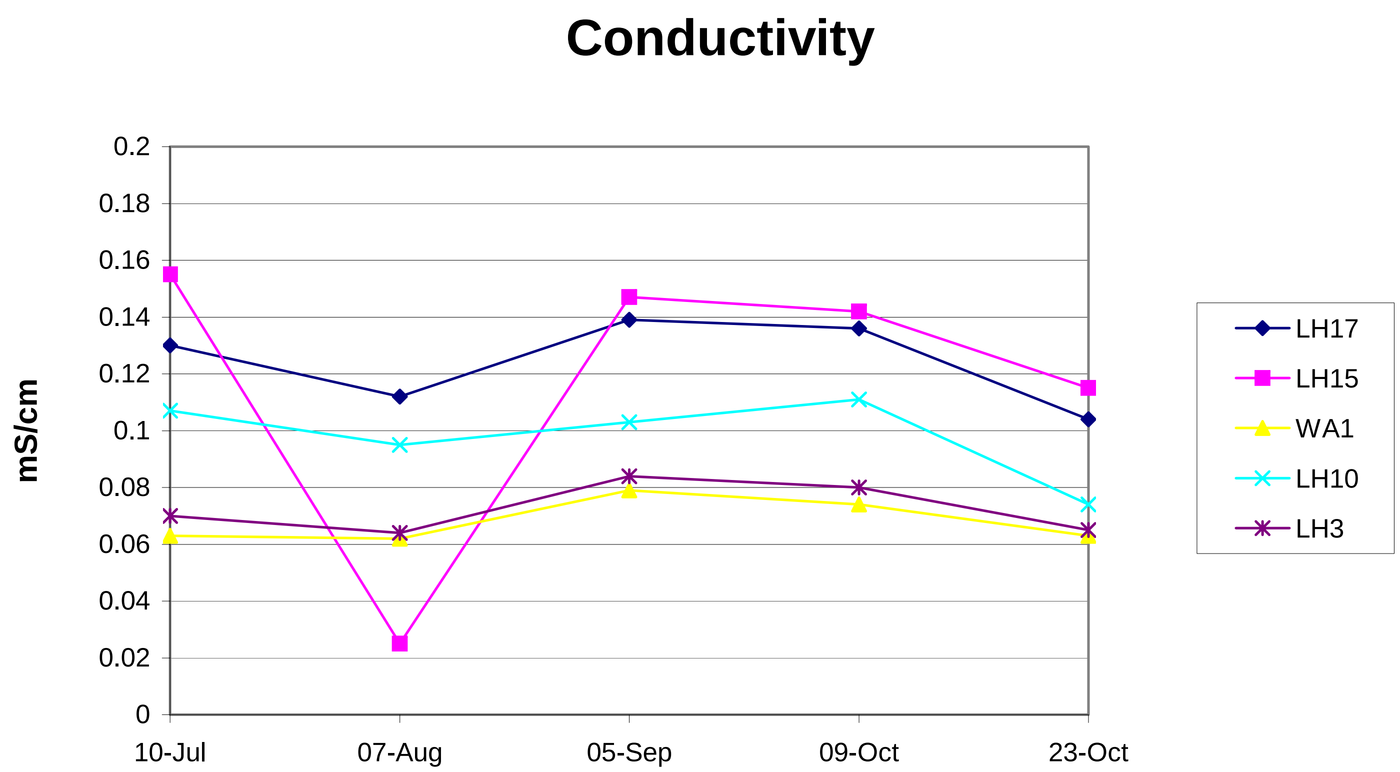


Figure 3-53. Conductivity measured in surface waters of Lehigh River during 2002.

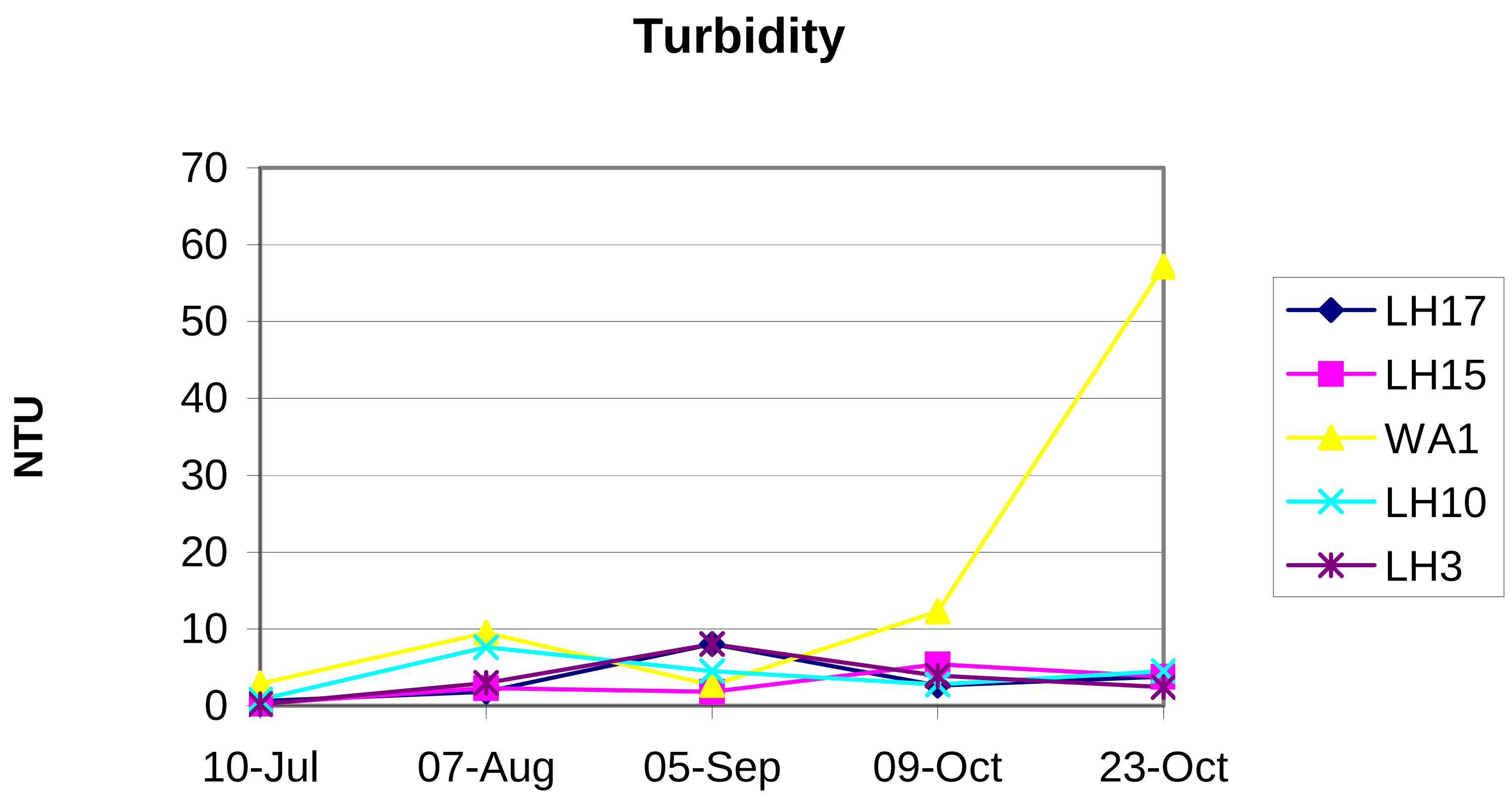


Figure 3-54. Turbidity measured in surface waters of Lehigh River during 2002

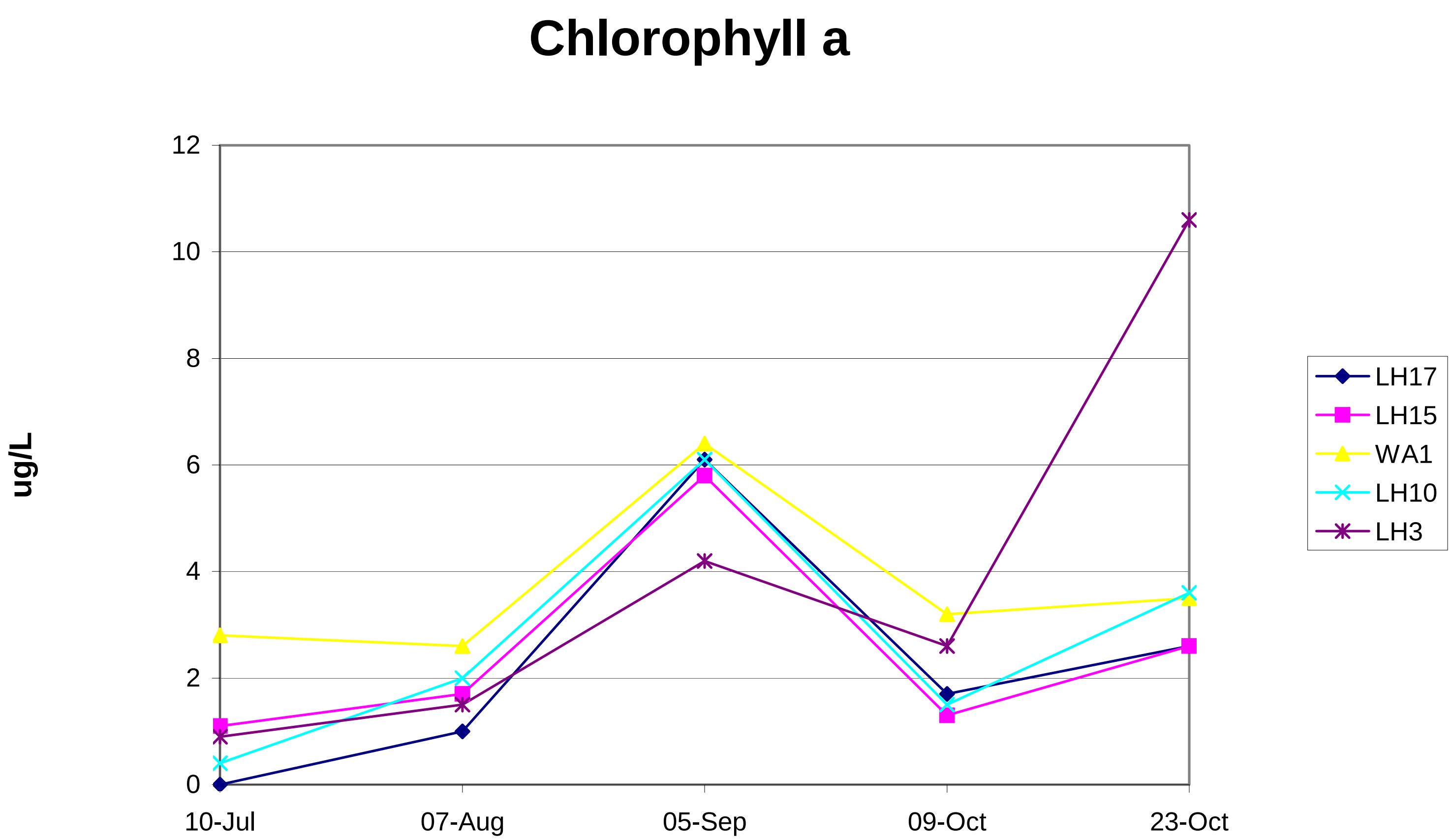


Figure 3-55. Chlorophyll a measured in surface waters of Lehigh River during 2002.

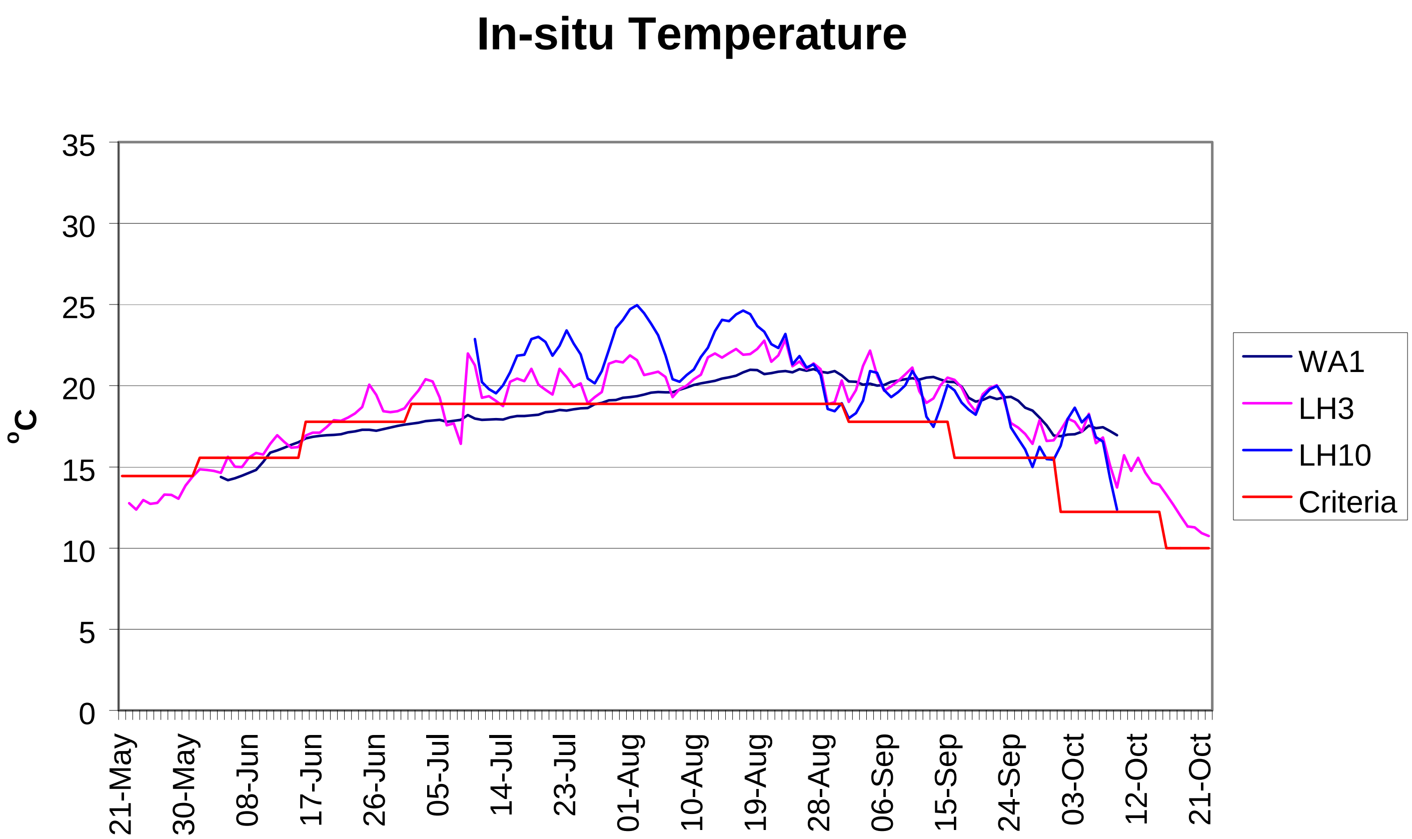


Figure 3-56. In-situ temperature measured in surface waters of Lehigh River during 2002.

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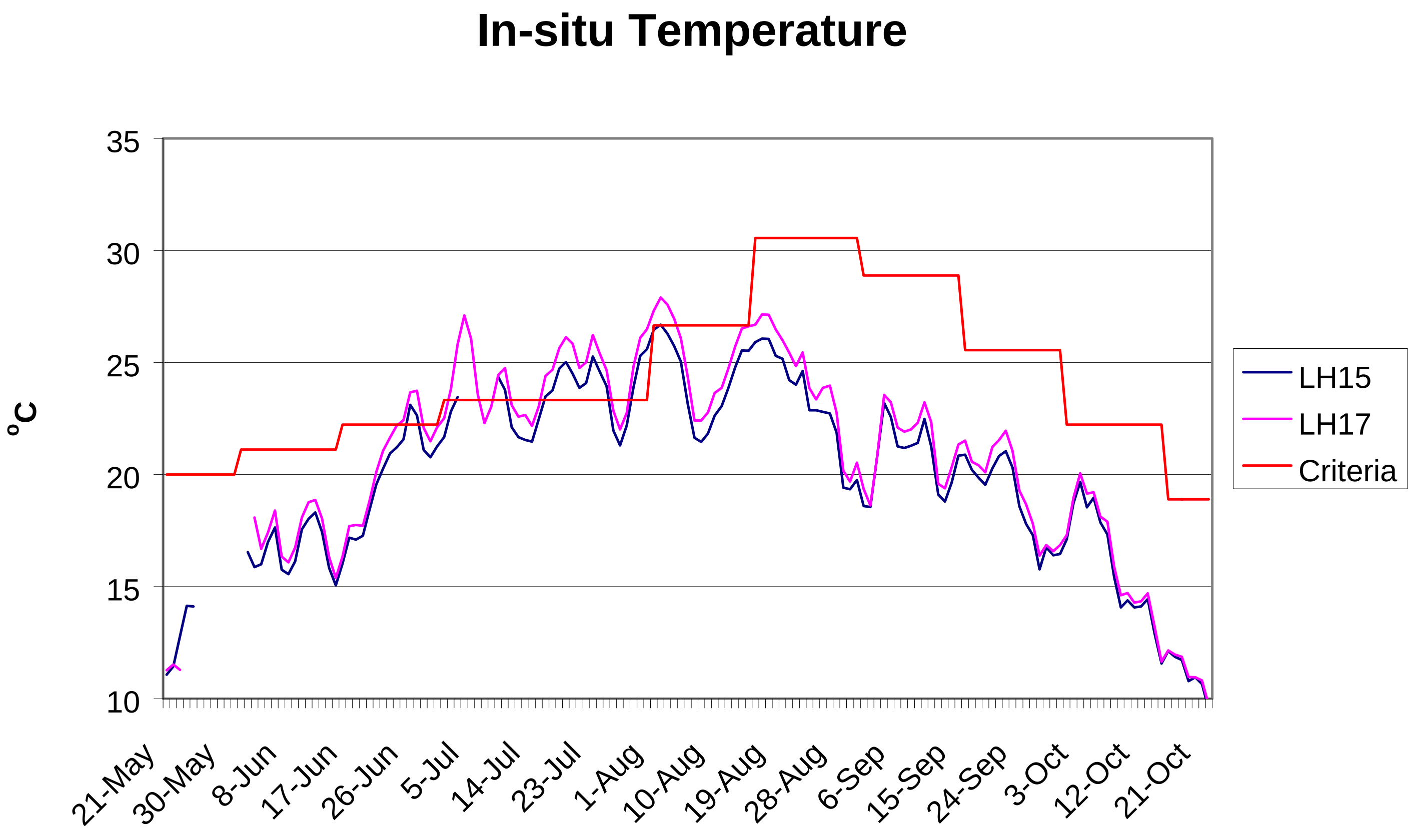

Figure 3-57.In-situ temperature measured in surface waters of Lehigh River during 2002.

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