Harry S Truman Reservoir
1999 Water Quality Report

1. General.

a. **Project location**. Truman Dam is located approximately 1.5 miles northwest of Warsaw, Missouri, at river mile 175.1 on the Osage River, a tributary of the Missouri River. The Osage River watershed covers portions of west central Missouri and east central Kansas. Truman Dam is in the headwaters of the Lake of the Ozarks, 93.4 miles above Bagnell Dam. The drainage area upstream of Truman Dam is 11,500 square miles.

b. **Authorized project purposes**. Flood control and hydroelectric power are the primary project purposes; equally important, however, are its fish and wildlife resources and recreation benefits.

c. **Pertinent data**.

Pools	Surface Elevation (ft. above m.s.l.)	Current Capacity (1,000 A.F.)	Surface Area (acres)	Shoreline (miles)
Flood Control	739.6	4006.4	209,300	
Multipurpose	706.0	1,180.6	55,600	958
Inactive		221.6*		
Total		5,187.0		

Total Drainage Area: 11,500 sq. miles
Average Annual Inflow: 6,913,515 acre-feet

* Contained in multipurpose pool.

2. Activities and studies of the year.

The Water Quality Unit (PM-PR-W) conducted three surveys of Truman Reservoir in 1999. Surveillance monitoring was conducted on August 9-12 at 10 lake, 7 stream, and 9 beach or marina stations. Physical, chemical, biological, and bacteriological parameters were examined. *In situ* profiling of water temperature, dissolved oxygen (DO), conductivity, pH, and oxidation reduction potential (orp) or redox at 1-meter intervals, field measurements of secchi and photic zone depths, and water collections from surface, photic zone, and bottom strata were performed at the lake stations. Ambient measurements and surface water collections were obtained from the stream stations, and bacterial samples were obtained from beach or marina stations. The PM-PR-W performed the following analyses: chlorophyll a, turbidity, suspended solids, atrazine, alachlor, metolachlor, cyanazine, fecal coliform, and total alkalinity. Also in

support of the monitoring effort, the Chemical and Materials Quality Assurance Laboratory (CMQA), Omaha, performed ammonia, nitrite/nitrate nitrogen, total kjeldahl nitrogen, total phosphorus, and total orthophosphorus analyses.

At the request of Water Control Section (EC-HC), *in situ* profiling was also performed on June 23-24 at nine lake stations and the outlet to monitor the severity of thermal stratification prior to changes in the hydropower operations. And, at the request of Truman Project (OF-HT), bacterial sampling was conducted on June 30 at two beaches to verify results reported by an outside contractor.

The PM-PR-W also cooperated with OF-HT in monitoring downstream supersaturation levels during May and June flood control releases. Finally, OF-HT and EC-HC personnel continued to monitor and calibrate the continuous downstream water quality instrumentation to assure compliance with the State stream criteria.

3. **Existing Conditions**.

a. **Inflow**. The South Grand River near Urich (HT-18) exhibited a normal range of ambient conditions during the August 11 survey (Table 1). The DO concentration was slightly depressed at 5.7 mg/L, but still exceeded the State stream standard of 5 mg/L. Nutrient levels were moderately enriched with TN and TP concentrations of 2.32 mg/L and 0.08 mg/L, respectively. The latter was slightly below the generalized eutrophy criterion of 0.1 mg/L for streams. Under the low flow conditions, turbidity and TSS were reasonably low at 23 NTU and 24 mg/L, respectively. With the enriched conditions and moderately good water clarity, the chlorophyll concentration was high at 56.2 ug/L and indicative of a reasonably high algal biomass or standing crop. Herbicide concentrations under the low flow conditions were low, however, based on immunoassay analysis of four commonly detected products. No MCLs or MCLGs were exceeded. The Marais des Cygnes River near Amoret (HT-57) exhibited satisfactory DO (6.0 mg/L) given the warm water conditions (28.7^{o}C) on 10 August. The TN concentration of 0.41 mg/L was not high, but the TP concentration of 0.08 mg/L was slightly enriched. The stream was slightly turbid (44 NTU) and carried moderate TSS (40 mg/L) under the low flow summer conditions. The chlorophyll concentration of 4.4 ug/L indicated an extremely low algal standing crop was present. Herbicide concentrations were also very low. The highest concentration detected was 1.34 ug/L for atrazine. The Little Osage River near Stotesbury (HT-51) exhibited extremely depressed DO (2.3 mg/L) on 10 August. Nutrient levels were only slightly enriched (TN and TP of 0.3 mg/L and 0.07 mg/L, respectively). Moderate levels of turbidity (27 NTU) and TSS (35 mg/L) were present. Elevated total alkalinity (250 mg/L) and specific conductance (685 umhos/cm) together with the depressed DO suggest a possible wastewater source. The chlorophyll concentration of 19.7 ug/L was indicative of a slightly elevated algal biomass. Herbicide concentrations in the stream were very low. The Marmaton River north of Nevada (HT-43) also exhibited depressed DO concentrations (4.8 mg/L) on 10 August. Eutrophic nutrient levels were present (TN and TP concentrations were 1.34 mg/L and 0.1 mg/L, respectively). Turbidity and TSS were high at 52 NTU and 63 mg/L, respectively. The chlorophyll concentration of 13.8 ug/L slightly exceeded the generalized eutrophy criterion (10 ug/L). The highest herbicide concentration was 0.29 ug/L for atrazine. The Sac River at State Hwy 54 (HT-27) was well oxygenated (7.4 mg/L) during the August survey. Nutrient

levels were moderately low (TN, 0.21 mg/L and TP, 0.05 mg/L). Turbidity was slightly elevated (38 NTU) as a result of upstream power generation at Stockton Dam. Chlorophyll levels were very low (4.6 ug/L) in the stream. And no herbicides were detected. The Pomme de Terre River north of Hermitage (HT-9) exhibited slightly depressed DO (5.4 mg/L) on 10 August. All other ambient parameters were within normally expected ranges. Nutrient levels exceeded the generalized eutrophy criteria with TN and TP concentrations of 1.23 mg/L and 0.12 mg/L, respectively. Turbidity and TSS were very low at 7.6 NTU and 10 mg/L, respectively. However, algal populations were very low as evidenced by the chlorophyll concentration of 1.6 ug/L presumably because of the flow regime of the Pomme de Terre Dam several miles upstream. Herbicides were not detected in the stream. The Tebo Creek southeast of Calhoun (HT-32) was fairly well oxygenated (6.0 mg/L) in the August survey. Total nitrogen and TP concentrations were 1.24 mg/L and 0.04 mg/L, respectively. Turbidity and TSS were low at 15 NTU and 16 mg/L, respectively. Chlorophyll concentrations were very low (2.7 ug/L) indicating little algal biomass was present. Also, herbicides were present in very low concentrations.

Table 1. Truman Reservoir Water Quality Data, 1999

Station	Depth m	Date mm/dd/yy	Time hhmm	Atrazine ug/L	Alachlor ug/L	Metolachlor ug/L	Cyanazine ug/L	NH3 mg/L	NO3/NO2 mg/L	TKN mg/L	TN mg/L	T - Phos mg/L	T - Ortho-P mg/L	Turbidity NTU	TSS mg/L	Chlor A ug/L	Secchi m
HT-1A	0.1	8/11/99	1115	1.17	0.19	0.55	0.08	0.21	U	0.51	0.72	U	0.02	7.5	11	1.1	
HT-2	0.1	8/10/99	0930	1.51	0.21	0.57	0.07	0.18	0.07	0.35	0.6	0.03	0.01	4	4.1	15.4	1.22
HT-2	20	8/10/99	0950	0.97	0.06	0.37	0.06	0.99	1.26	U	2.25	0.51	0.03	69	61		
HT-3	0.1	8/11/99	0800	1.54	0.2	0.49	0.08	U	0.02	0.41	0.43	0.03	0.01	4.2	6.8	1.8	1.07
HT-3	19	8/11/99	0819	0.91	0.05	0.36	0.06	0.66	0.12	1.22	2	0.35	0.04	51	42		
HT-4	0.1	8/10/99	1300	1.55	0.28	0.67	0.06	U	0.3	0.29	0.59	0.01	0.01	6.6	6.3	16.3	1.16
HT-4	17	8/10/99	1317	1.02	0.08	0.48	0.08	0.91	U	1.1	2.01	0.36	0.05	44	34		
HT-5	0.1	8/11/99	0830	1.32	0.18	0.47	0.08	0.03	0.02	0.43	0.48	0.03	0.01	3.8	4.9	17.2	1.22
HT-5	15	8/11/99	0845	0.59	<0.05	0.19	<0.04	1.34	0.23	1.87	3.44	0.63	0.06	35	34		
HT-6	0.1	8/10/99	1200	1.32	0.27	0.69	0.09	U	0.34	0.24	0.58	0.02	0.01	12	7.8	3.8	0.76
HT-6	14	8/10/99	1214	0.92	0.06	0.39	0.06	0.96	U	1.17	2.13	0.35	0.04	46	37		
HT-9	0.1	8/10/99	1330	<0.05	<0.05	0.05	<0.04	0.86	0.13	0.24	1.23	0.12	0.07	7.6	10	1.6	
HT-14	0.1	8/12/99	1045	1.31	0.22	0.39	0.08	0.11	0.04	0.97	1.12	0.16	0.03	54	49	21.5	0.18
HT-14	4	8/12/99	1049	1.2	0.19	0.48	0.07	0.08	0.03	1	1.11	0.19	0.04	76	76		
HT-15	0.1	8/11/99	1330	0.95	0.18	0.44	0.07	U	U	0.32	0.32	0.04	0.05	5.6	6.1	11.7	1.16
HT-15	13	8/11/99	1343	0.96	0.09	0.38	0.07	0.68	U	0.86	1.54	0.27	0.04	52	44		
HT-18	0.1	8/11/99	0850	0.84	0.06	0.23	0.05	1.09	0.11	1.12	2.32	0.08	0.03	23	24	56.2	
HT-21	0.1	8/11/99	1130	<0.05	<0.05	0.08	<0.04	0.02	0.02	0.12	0.16	0.06	0.02	24	32	1.7	0.46
HT-21	8	8/11/99	1138	<0.05	<0.05	<0.05	<0.04	U	U	0.26	0.26	0.07	0.03	41	70		
HT-27	0.1	8/10/99	1200	<0.05	<0.05	<0.05	<0.04	0.04	0.06	0.11	0.21	0.05	0.01	38	127	4.6	
HT-28	0.1	8/10/99	1030	1.46	0.17	0.62	0.08	U	U	0.36	0.36	0.03	0.01	3.6	4.5	18	1.28
HT-28	15	8/10/99	1045	1.56	0.09	0.56	0.09	1.67	U	1.81	3.48	0.6	0.01	86	70		
HT-32	0.1	8/11/99	1020	0.1	<0.05	0.08	<0.04	0.8	U	0.44	1.24	0.04	0.01	15	16	2.7	
HT-43	0.1	8/10/99	1040	0.29	0.12	0.16	0.04	0.56	0.43	0.35	1.34	0.1	0.04	52	63	13.8	
HT-46	0.1	8/10/99	0830	1.55	0.21	0.58	0.09	U	U	0.28	0.28	0.02	0.01	3.6	8.2	17.4	1.22
HT-46	20	8/10/99	0850	1.11	0.08	0.44	0.07	0.76	U	0.99	1.75	0.34	0.05	54	48		
HT-51	0.1	8/10/99	1000	0.52	<0.05	0.12	<0.04	0.09	U	0.21	0.3	0.07	0.04	27	35	19.7	
HT-57	0.1	8/10/99	0910	1.34	0.11	0.39	0.08	0.03	0.22	0.16	0.41	0.08	0.04	44	40	4.4	

b. **Lake**. *In situ* profiling on June 23-24 exhibited a fairly typical thermal regime for the early summer period. Up-lake areas were strongly influenced by the recent heavy inflows. The South Grand arm near State Hwy 13 Bridge (HT-14) exhibited only slight stratification with depressed DO concentrations in the lower half of the water column (Figure 1). The Osage arm at State Hwy 13 Bridge (HT-21) was essentially isothermal with slightly depressed DO concentrations throughout the water column (Figure 2). Mid-lake areas were strongly stratified with depressed surface DOs and anaerobic bottom conditions. The South Grand arm (HT-6) exhibited an 8^0C differential between surface and bottom waters in the 14-m water column (Figure 3). A thermocline existed between 10 and 11 meters. The DO concentrations ranged from 5.6 to 0.1 mg/L. The South Grand arm near State Hwy 7 Bridge (HT-4) exhibited almost identical conditions (Figure 4). The Osage arm (HT-15) exhibited a 10^0 C differential with DO concentrations ranging from 5.8 to 0.1 mg/L in the 14-m water column (Figure 5). A thermocline was present between 11 and 12 meters. Down-lake areas were as intensely stratified as mid-lake areas, but exhibited higher DO concentrations in the epilimnetic zone, presumably, as a result of higher water clarity. The Osage arm at State Hwy 7 (HT-3) exhibited a 10^0C differential between surface and bottom waters in the 21-m water column (Figure 6). The DO ranged from 8.6 to 0.1 mg/L. A thermocline and oxycline existed between 7 and 8 meters. The Osage arm near the mouth of the Grand arm (HT-46) also exhibited a 10^0C differential with a thermocline and oxycline between 7 and 8 meters in the 23-m water column (Figure 7). Below 8 meters the water column was essentially anaerobic. The Pomme de Terre arm near State Hwy 83 Bridge (HT-5) exhibited almost identical conditions with the exception that it contained even higher DO concentrations (10 mg/L) in the epilimnion (Figure 8). The latter was attributable to algal blooms within the higher clarity waters. The Tebo arm (HT-28), the other major clear water arm, also exhibited similar conditions (Figure 9). The final area of profiling in June, the area between the skimming weir and dam (HT-1), exhibited a 4^0C differential between surface and bottom waters in the 21-m water column (Figure 10). No thermocline was present, and DO concentrations, ranging from 6.7 to 1.6 mg/L, were very satisfactory at all depths except the bottom 2 meters.

During the August survey period, the upper South Grand arm (HT-14) exhibited isothermal conditions together with depressed DO concentrations throughout the 4-m water column (Figure 11). The upper Osage arm (HT-21) was also isothermal but contained very satisfactory DOs throughout the 8-m water column as a result of strong inflows (Figure 12). The middle reaches of the South Grand arm (HT-6) exhibited a 14^0C differential between surface and bottom waters in the 14-m water column (Figure 13). A thermocline existed between 7 and 8 meters and an oxycline was present between 5 and 6 meters. Below the oxycline the water column was essentially anaerobic. Further down lake the South Grand arm (HT-4) exhibited very similar conditions (Figure 14). The lower section of the South Grand (HT-2) exhibited a 14.5^0C differential in the 20-m water column (Figure 15). The upper 3 meters were supersaturated as a result of algal productivity. The thermocline and oxycline were present between 6-7 meters and 5-6 meters, respectively. The lower 14 meters were essentially anoxic. The middle portion of the Osage arm (HT-15) was also strongly stratified with a 13.5^0C differential and DO concentrations ranging from 9.3 to 0.1 mg/L in the 13-m water column (Figure 16). While the thermocline was fairly deep at 7-8 meters, the oxycline was very shallow at 1-2 meters. Below 3 meters, DO concentrations were inadequate to support most forms of

aquatic life. The Osage arm near Hwy 7 Bridge (HT-3) also exhibited a 14^0C differential in its 19-m water column (Figure 17). The thermocline and oxycline were present between 7- 8 meters and 4-5 meters, respectively. Anoxic conditions were present in 63 % of the water column. The Osage arm near the mouth of the Grand (HT-46) had a slightly shallower thermocline (6-7 meters) in its 20-m water column (Figure 18). While the epilimnion was well oxygenated with DO concentrations ranging from 9.4 - 2.8 mg/L, the 14-m hypolimnion was essentially anaerobic. The Pomme de Terre arm (HT-5) exhibited a 13^0C differential between surface and bottom waters in the 15-m water column (Figure 19). The upper 4 meters were supersaturated with DO concentrations ranging from 8.7 to 7.8 mg/L as a result of algal productivity in the higher water clarity conditions. The thermocline and oxycline were present between 7-8 meters and 5-6 meters, respectively. Anoxic conditions existed in the lower half of the water column. The Tebo arm (HT-28) also exhibited a 14^0C differential in the 15-m water column (Figure 20). The upper 2 meters were supersaturated with DOs ranging from 11.3 to 8.9 mg/L. The thermocline and oxycline were present between 8-9 meters and 3-4 meters, respectively. The lower 11 meters were essentially anoxic. Finally, the area between the weir and dam (HT-1) was essentially isothermal with DO concentrations ranging from 6.9 to 5.7 mg/L in the 20-m water column (Figure 21).

Figure 1. HT-14 Profile, 6/23/99

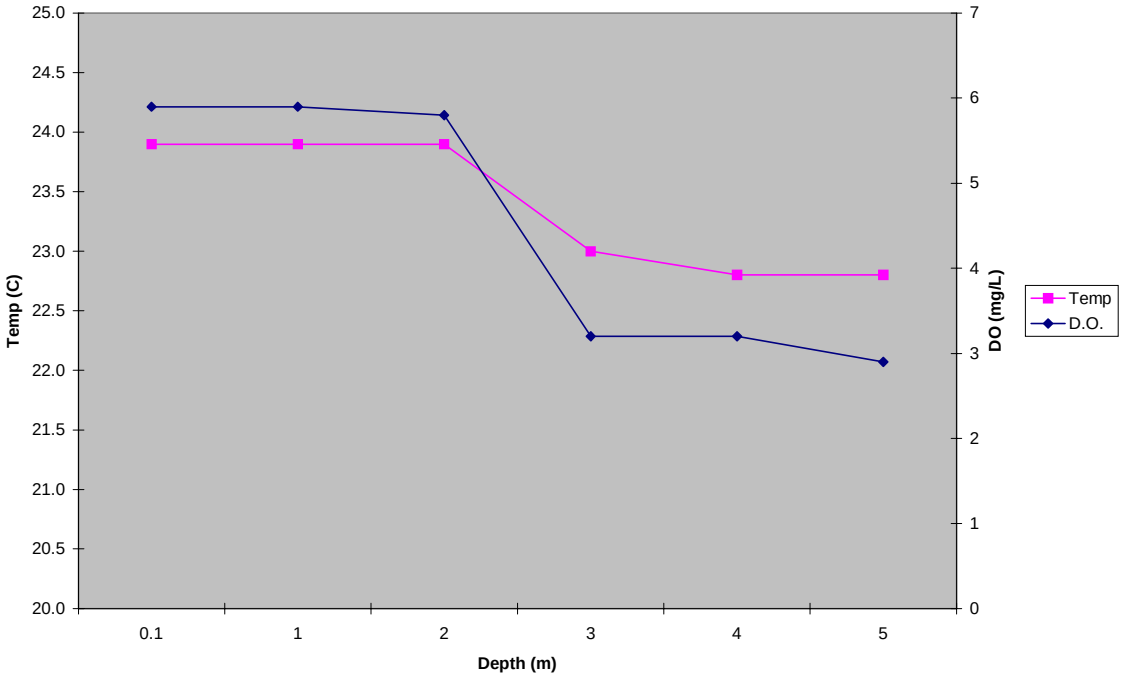


Figure 2. HT-21 Profile, 6/23/99

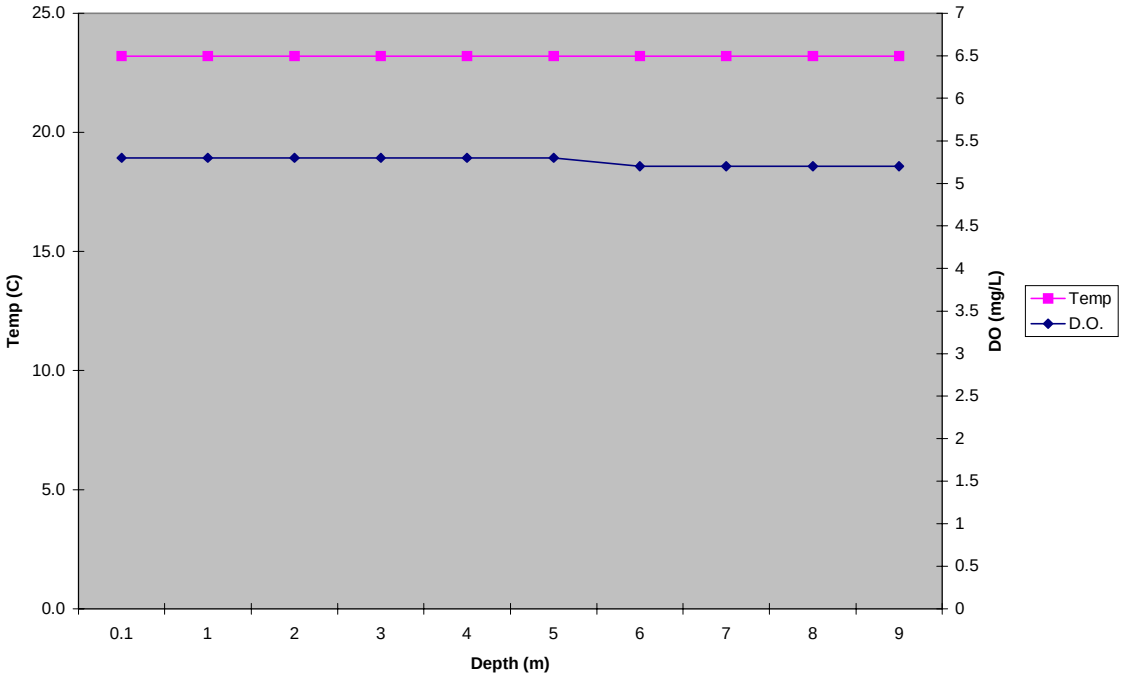


Figure 3. HT-6 Profile, 6/23/99

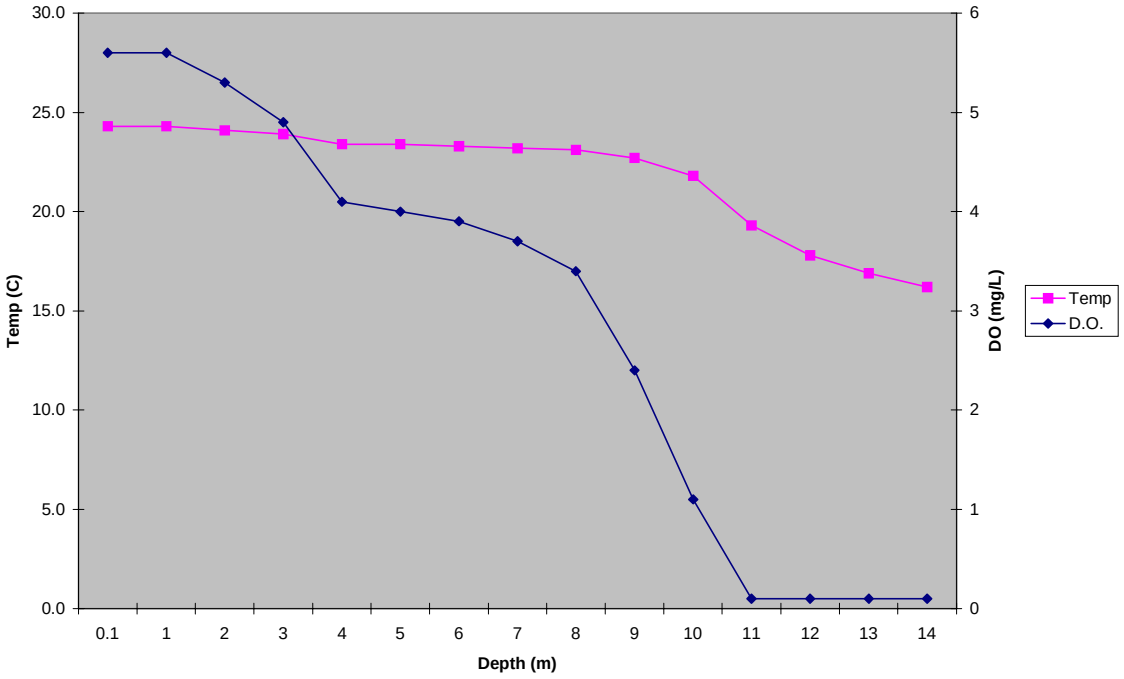


Figure 4. HT-4 Profile, 6/23/99

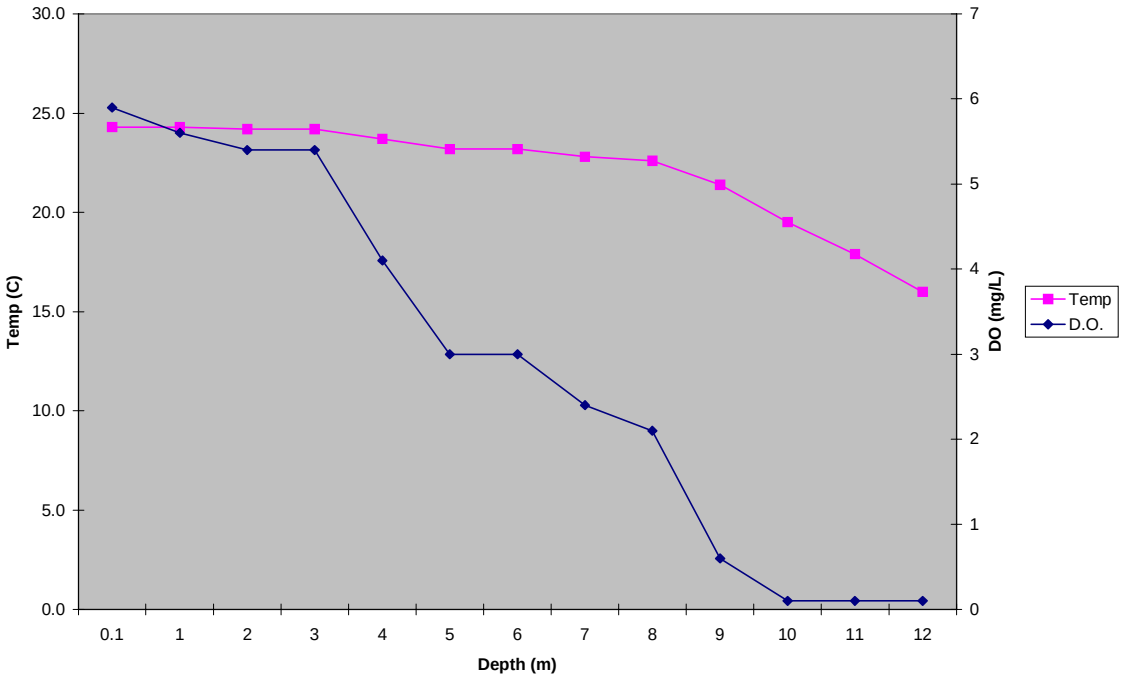


Figure 5. HT-15 Profile, 6/24/99

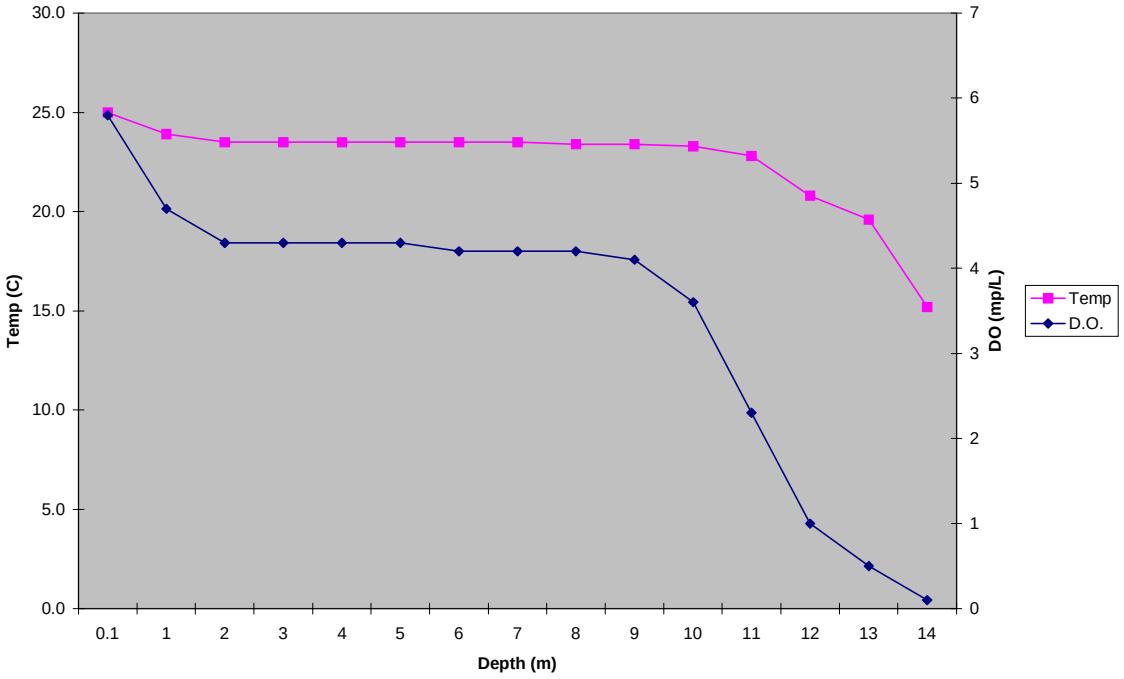


Figure 6. HT-3 Profile, 6/24/99

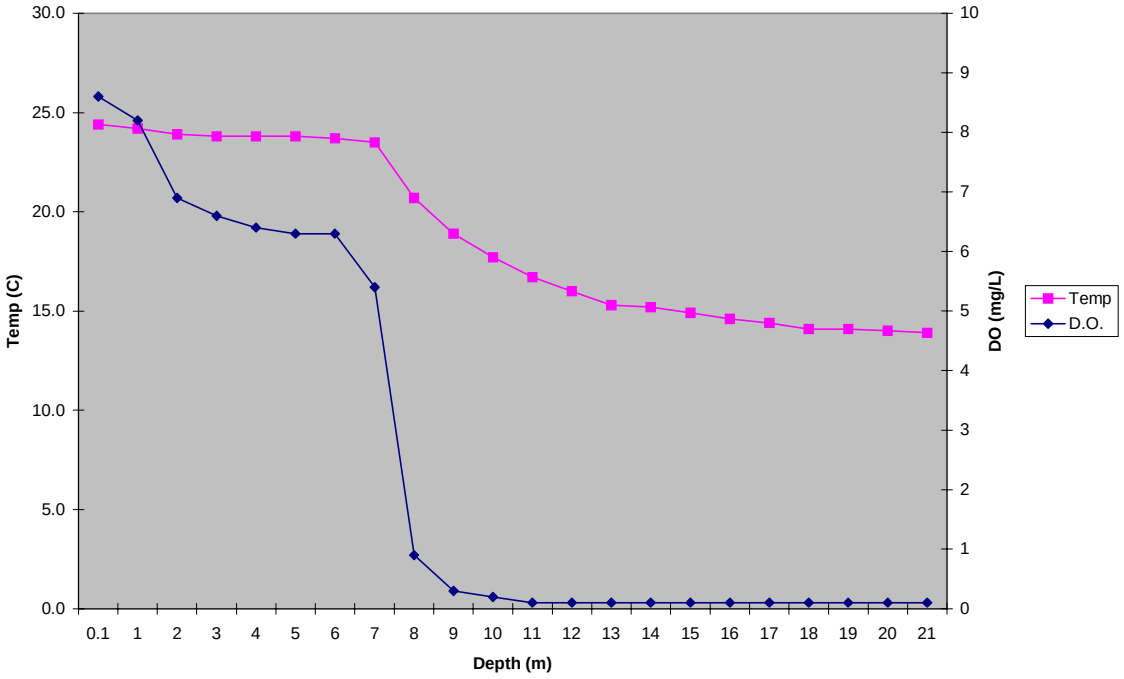


Figure 7. HT-46 Profile, 6/24/99

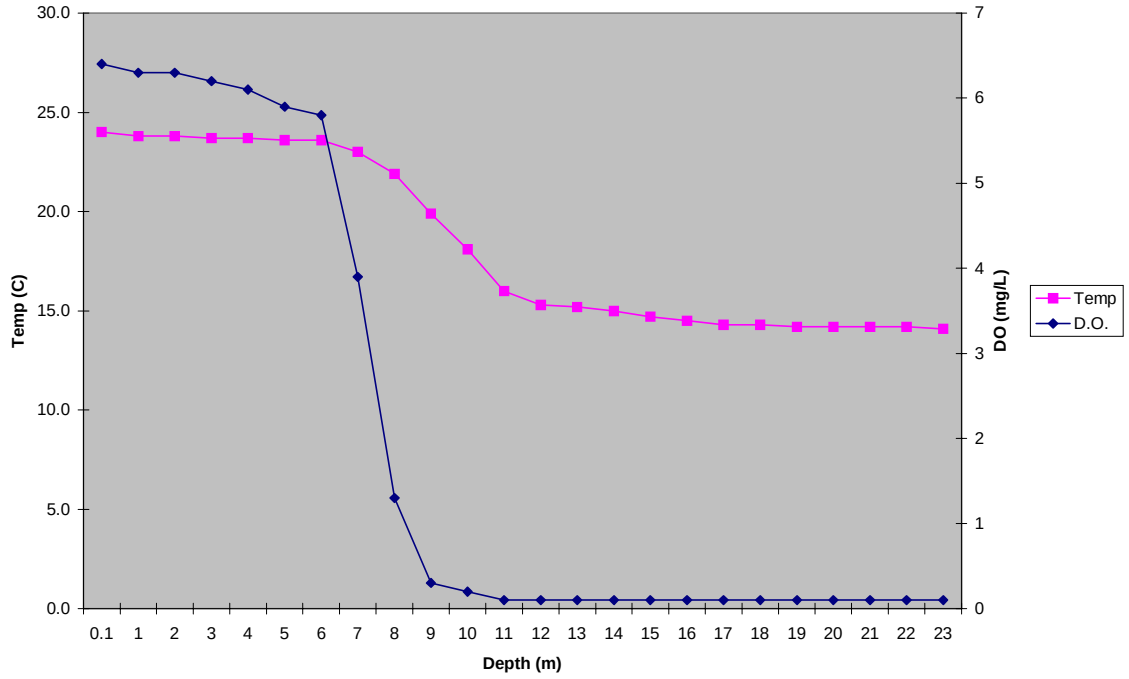


Figure 8. HT-5 Profile, 6/24/99

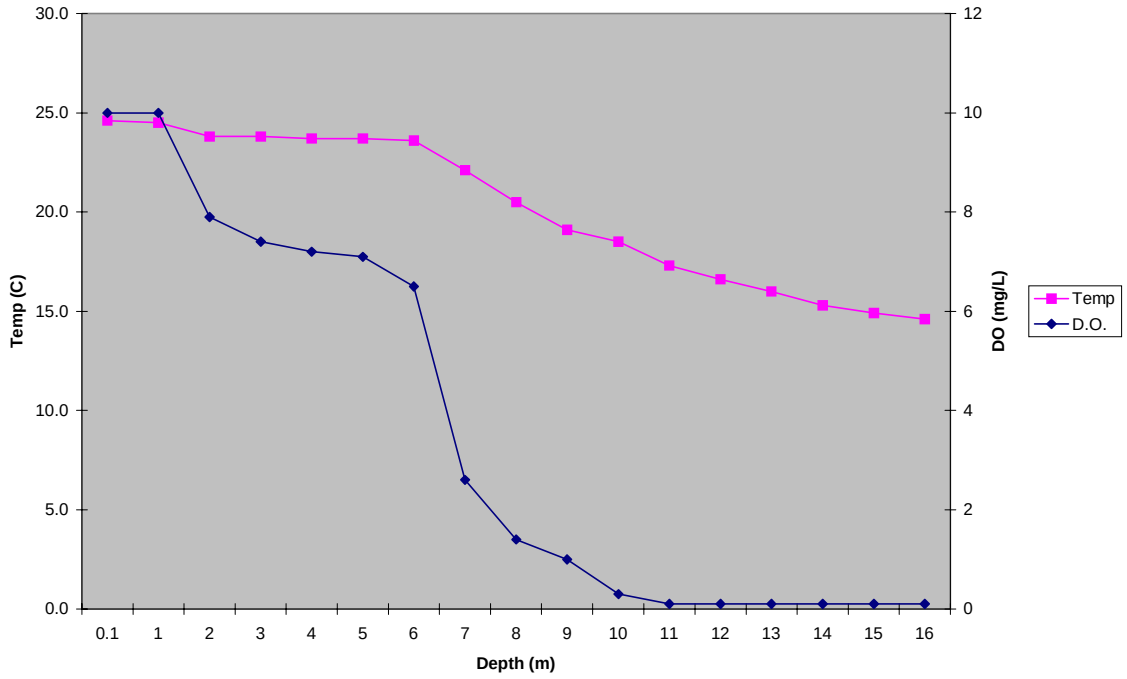


Figure 9. HT-28 Profile, 6/24/99

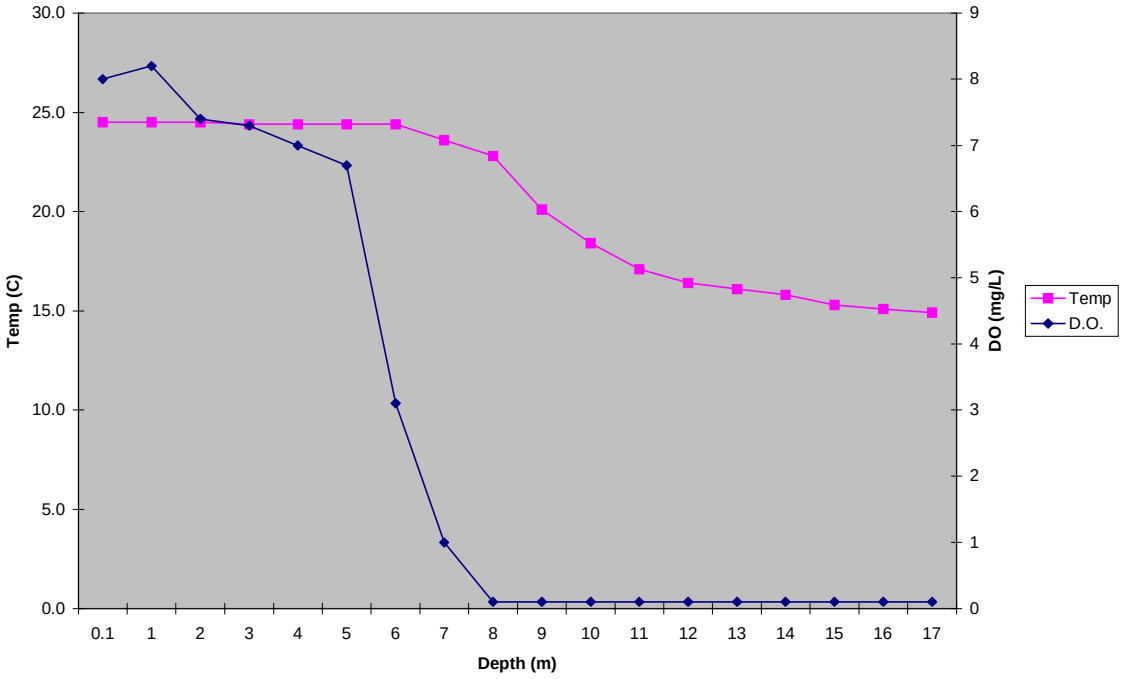


Figure 10. HT-1 Profile, 6/24/99

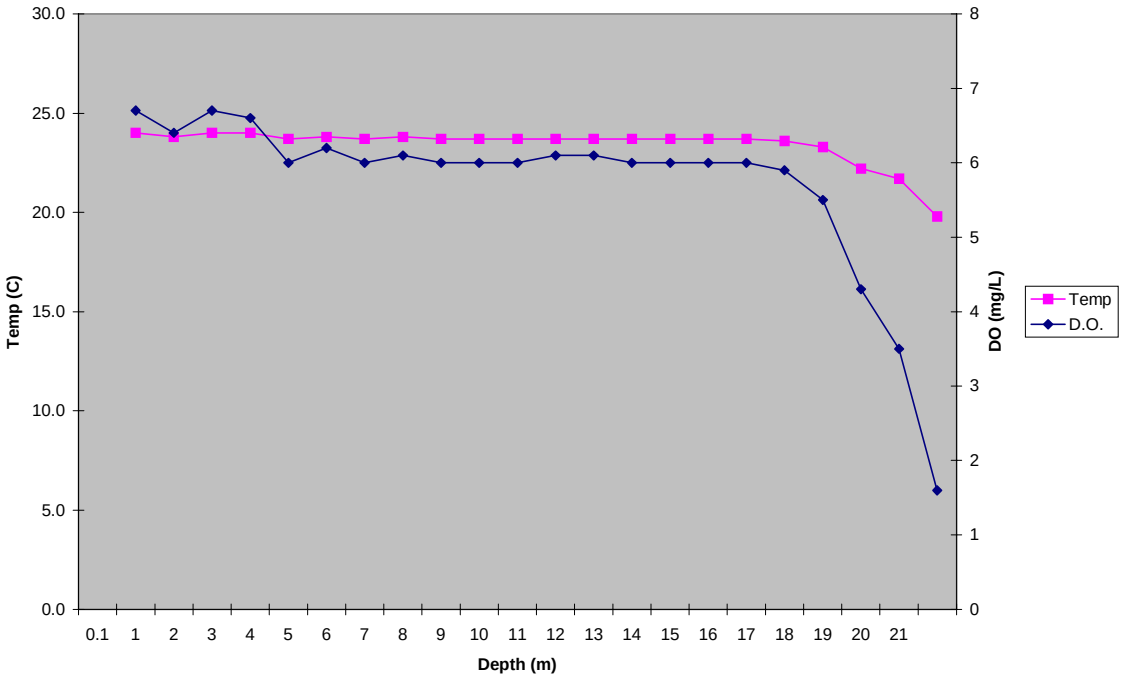


Figure 11. HT-14 Profile, 8/12/99

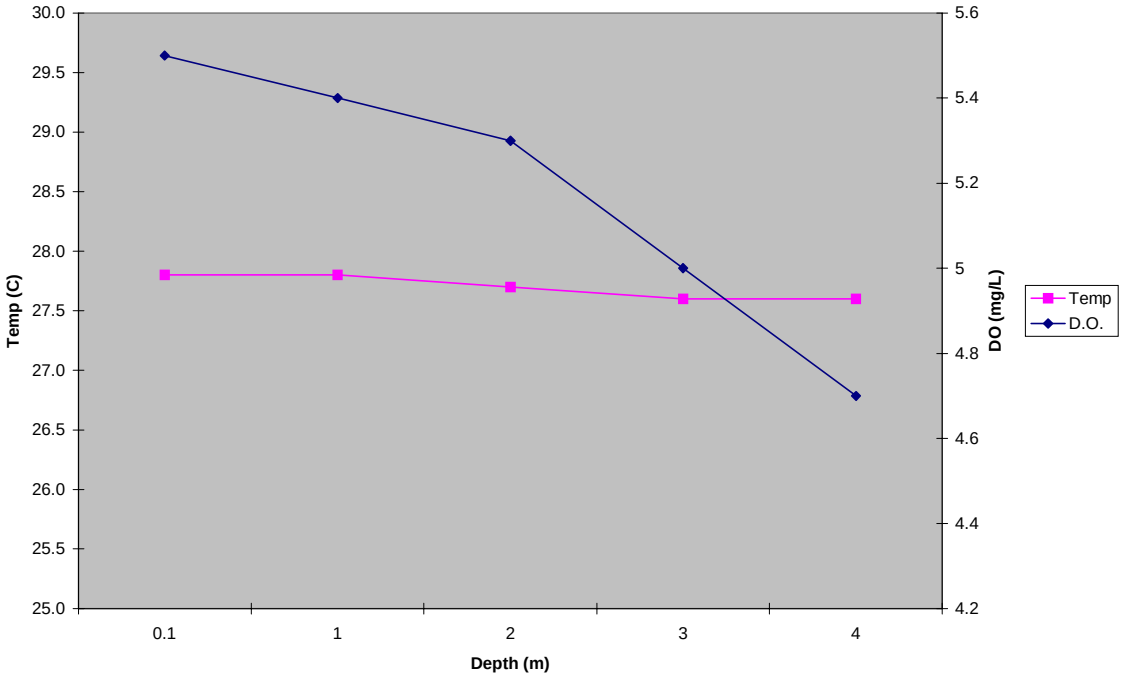


Figure 12. HT-21 Profile, 8/11/99

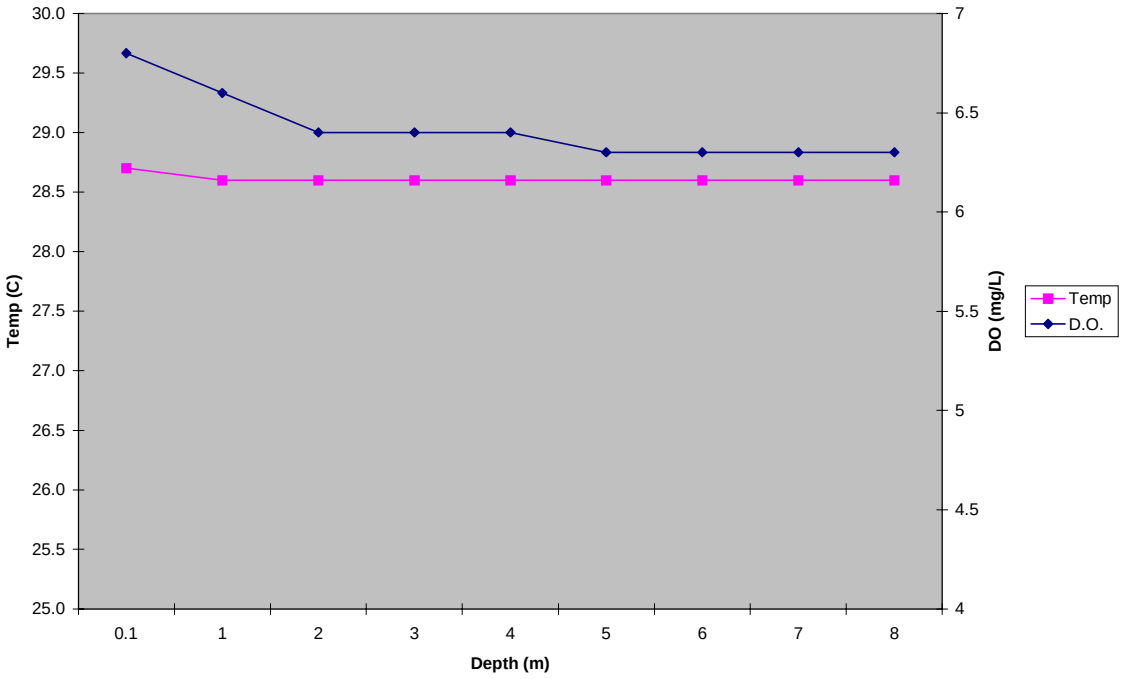


Figure 13. HT-6 Profile, 8/10/99

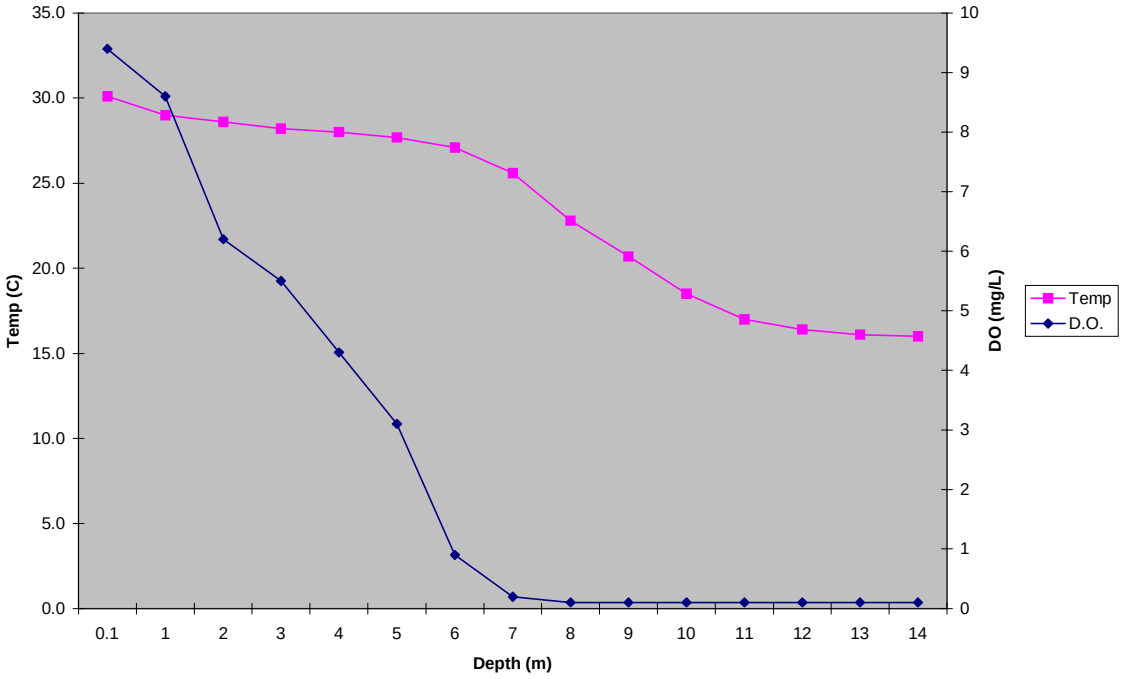


Figure 14. HT-4 Profile, 8/10/99

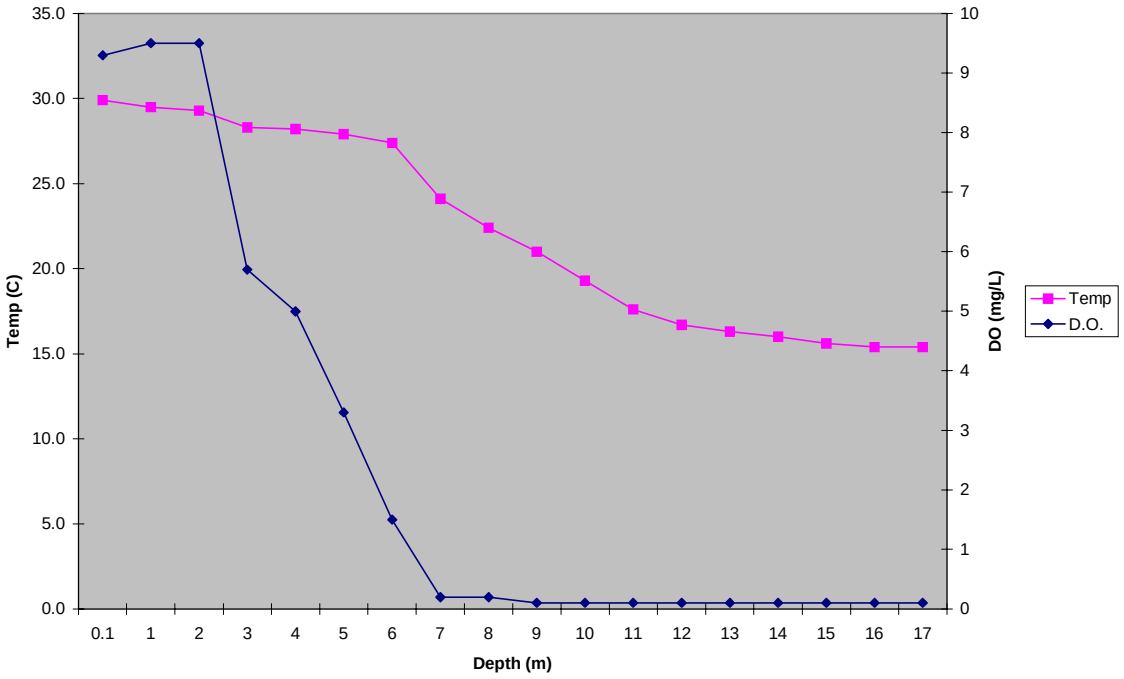


Figure 15. HT-2 Profile, 8/10/99

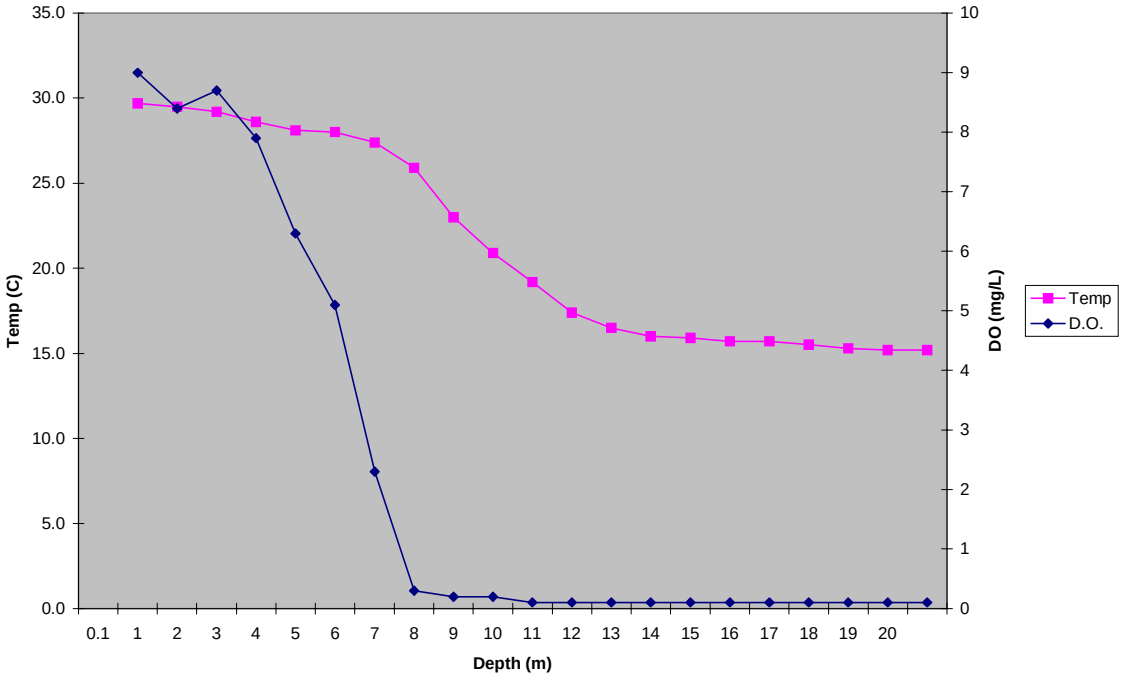


Figure 16. HT-15 Profile, 8/11/99

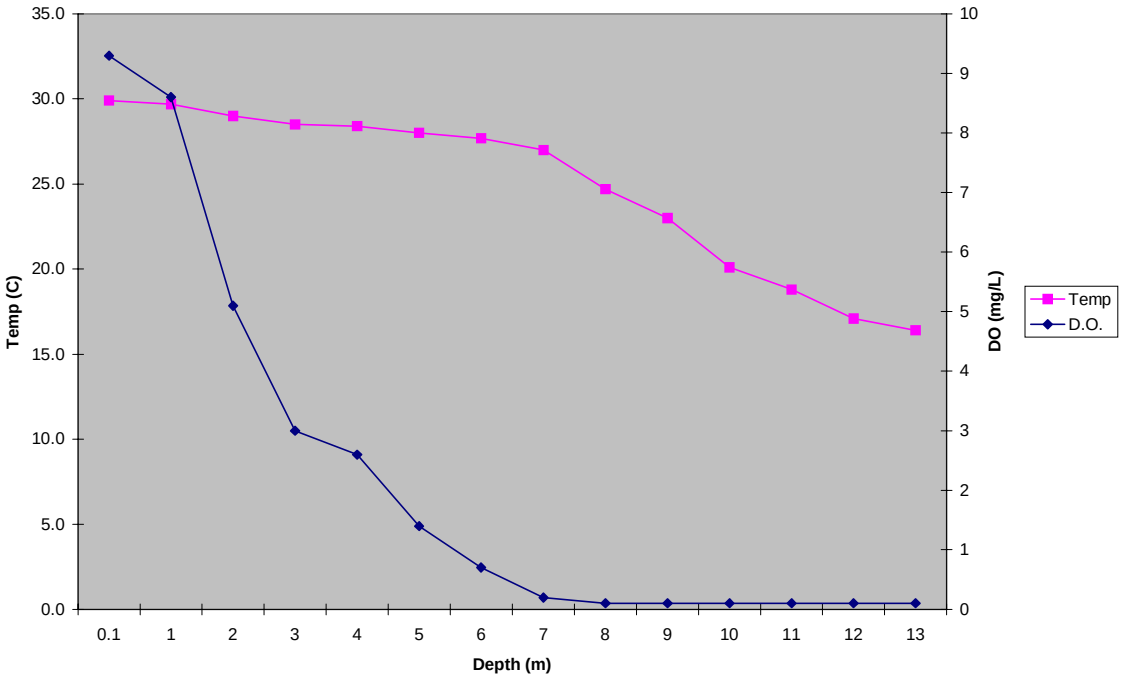


Figure 17. HT-3 Profile, 8/11/99

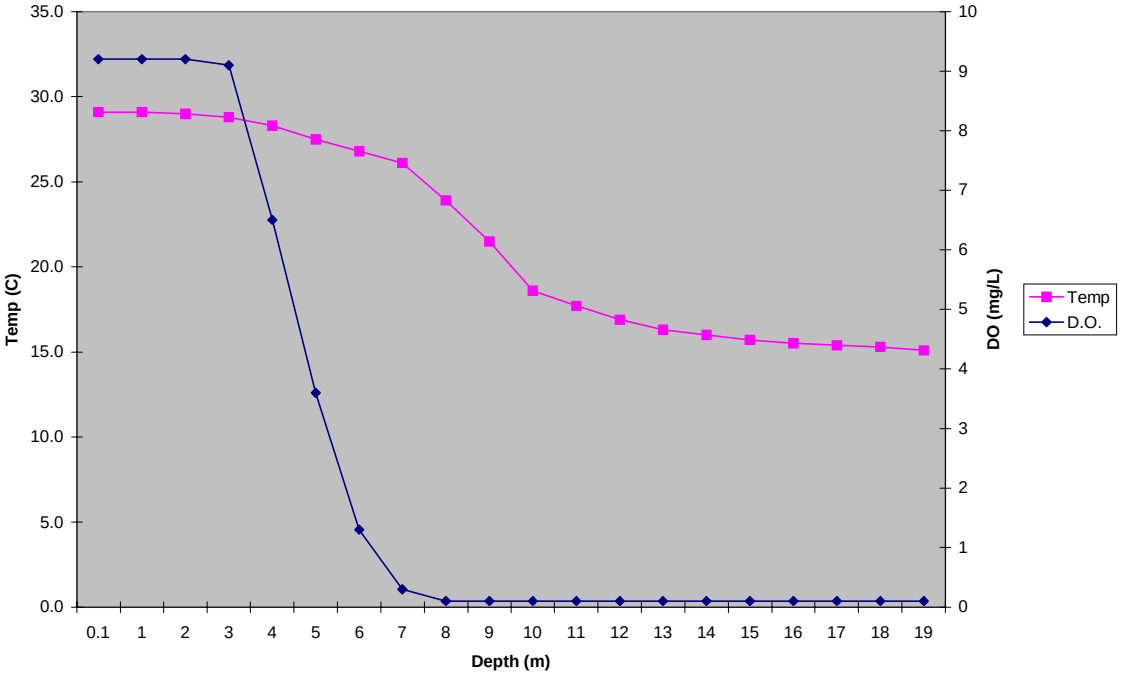


Figure 18. HT-46 Profile, 8/10/99

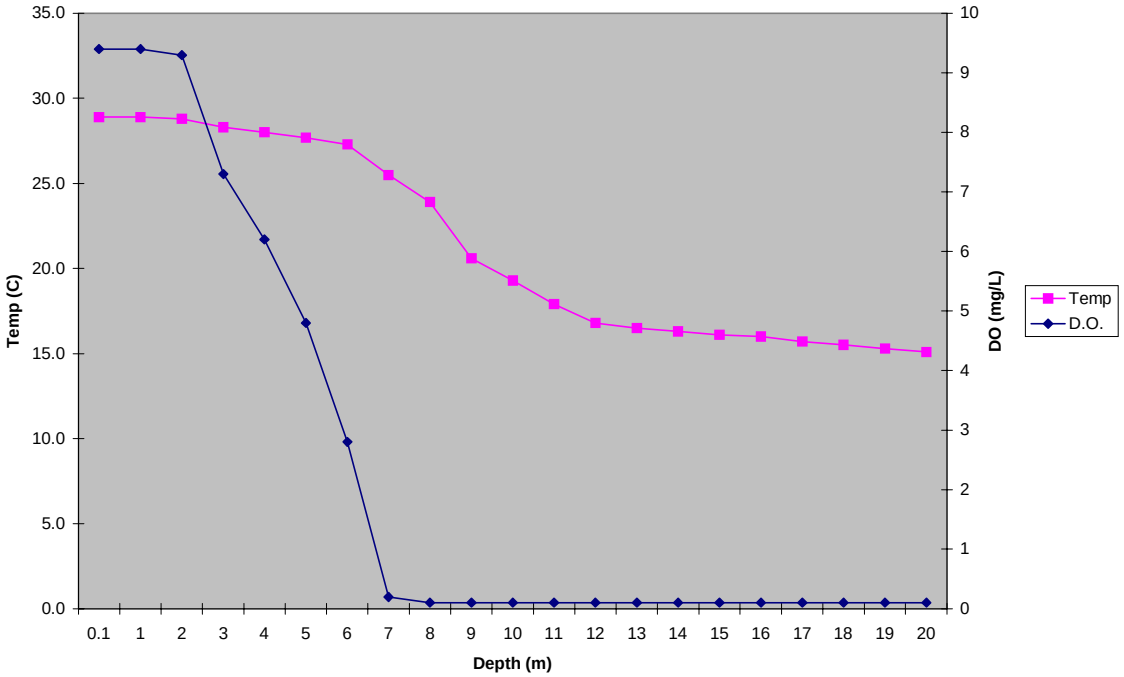


Figure 19. HT-5 Profile, 8/11/99

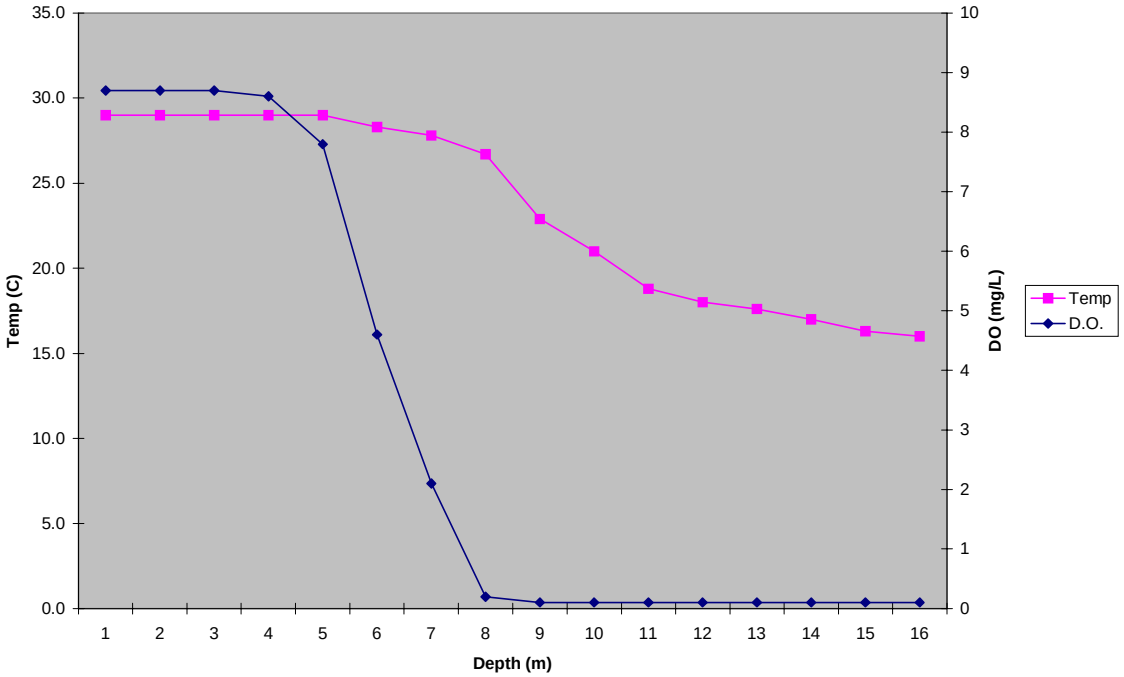


Figure 20. HT-28 Profile, 8/10/99

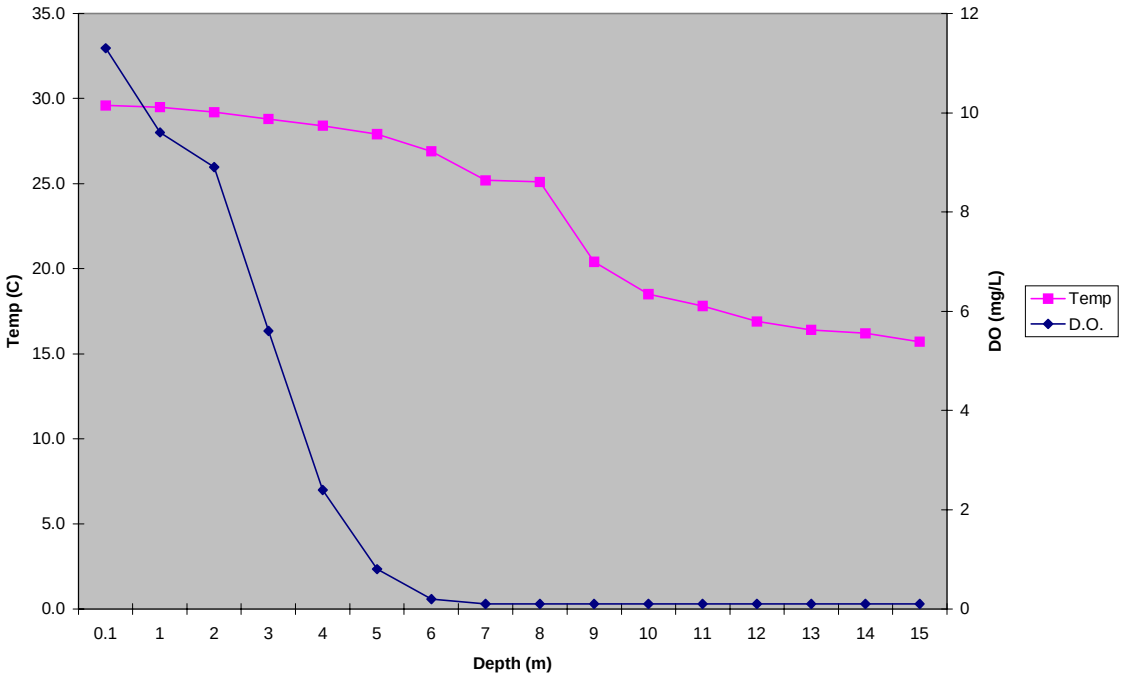
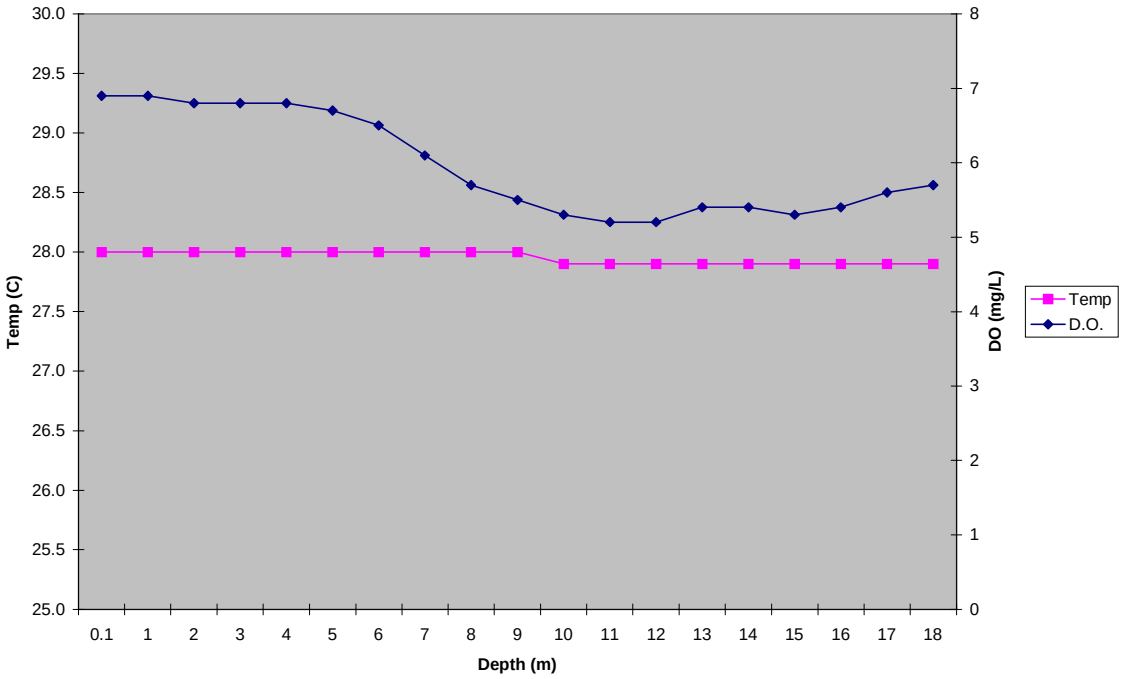


Figure 21. HT-1 Profile, 8/10/99



As noted over the period of record, nutrient levels were higher in the bottom depths than in the surface waters in the stratified areas of the reservoir (Table 1). And, in most instances, the bottom concentrations exceeded the generalized eutrophy criteria for lakes (1 mg/L TN and 0.05 mg/L TP). However, during the intense summer stratification, algal productivity was dependent on the nutrient concentrations in the upper-lighted strata (photic zone) and on water clarity (light limitation). In the shallower, upper reaches of the reservoir, inflow from storm runoff not only prevented the development of stratification, but also created a water column with uniform nutrient concentrations. The latter was noted in the upper South Grand arm (HT-14) with surface and bottom TN concentrations of 1.12 and 1.11 mg/L and surface and bottom TP concentrations of 0.16 and 0.19 mg/L, respectively. The surface TP concentration was the highest surface concentration observed in the August survey and was one of only two surface samples exceeding the TP eutrophy criterion. Similarly, in the upper Osage arm (HT-21), surface and bottom strata contained TN concentrations of 0.16 and 0.26 mg/L and TP concentrations of 0.06 and 0.07 mg/L, respectively. In the middle reaches of the reservoir typified by stations HT-6 and HT-15, nutrient levels were substantially different between depths. The South Grand arm (HT-6) exhibited surface and bottom TN concentrations of 0.58 and 2.13 mg/L and surface and bottom TP concentrations of 0.02 and 0.35 mg/L, respectively. And the surface and bottom strata of the Osage arm (HT-15) contained TN concentrations of 0.32 and 1.54 mg/L and TP concentrations of 0.04 and 0.27 mg/L, respectively. The Osage arm near the Hwy 7 Bridge (HT-3) contained TN concentrations of 0.43 and 2 mg/L and TP concentrations of 0.03 and 0.35 mg/L in its surface and bottom waters, respectively. The middle reach of the Pomme de Terre arm (HT-5) contained TN concentrations of 0.43 and 1.87 mg/L and TP concentrations of 0.03 and 0.63 mg/L in the surface and bottom waters, respectively. The middle reach of the Tebo arm (HT-28) contained TN concentrations of 0.36 and 3.48 mg/L and TP concentrations of 0.03 and 0.6 mg/L in its surface and bottom waters, respectively. Down-lake reaches represented by HT-2 and HT-46 were also very similar. The South Grand arm (HT-2) exhibited surface and bottom strata with TN concentrations of 0.6 and 2.25 mg/L and TP concentrations of 0.03 and 0.51 mg/L, respectively. The Osage arm at the mouth of the Grand arm (HT-46) exhibited surface and bottom strata with TN concentrations of 0.28 and 1.75 mg/L and TP concentrations of 0.02 and 0.34 mg/L, respectively.

Turbidity and total suspended solids (TSS) were also substantially higher in the bottom depths as a result of settling and sedimentation within the reservoir. Since the primary interest of this report is their effect on algal productivity, only surface concentrations will be discussed; however, all data are presented in Table 1. Highest turbidities and TSS were present in the upper South Grand arm (HT-14) with surface concentrations of 54 NTU and 49 mg/L, respectively. Two factors influence water clarity in the up-lake reach, inflow contributions and wind driven resuspension of sediment on the shallow flats. The upper Osage arm (HT-21) exhibited surface turbidities and TSS of 24 NTU and 32 mg/L, respectively. Water clarity improved substantially at the more down-lake stations. In the middle reach of the South Grand arm (HT-6), turbidity and TSS were 12 NTU and 7.8 mg/L, respectively. Further down lake at HT-4 the South Grand exhibited still lower concentrations (6.6 NTU and 6.3 mg/L). In the middle reach of the Osage arm (HT-15), surface turbidity and TSS were 5.6 NTU and 6.1 mg/L, respectively. Further down lake at HT-3 the Osage was even clearer with turbidities and TSS of 4.2 NTU and 6.8 mg/L, respectively. The middle portion of the Pomme de Terre arm (HT-5) was extremely clear during

the August survey with turbidities and TSS of 3.8 NTU and 4.9 mg/L, respectively. The middle section of the Tebo arm (HT-28) also exhibited its characteristically clear conditions with turbidities and TSS of 3.6 NTU and 4.5 mg/L, respectively. The lower sections of the Grand (HT-2) and Osage (HT-46) arms were equally clear with turbidities and TSS of 4 NTU and 4.1 mg/L and 3.6 NTU and 8.2 mg/L, respectively.

Two measurements of water transparency, secchi depth and photic zone depth, were taken; the latter is the depth that 1 % of the surface light remains and defines the maximum useful depth for algal photosynthesis. Secchi depths ranged from 0.18 m in the upper South Grand arm to 1.28 m in the middle section of the Tebo arm. The upper Osage and the middle South Grand reaches exhibited limited secchi depths (0.46 m and 0.76 m, respectively), while the remaining areas of the reservoir exhibited secchi depths of more than 1 m. Similarly, photic zone depths ranged from 0.61 m in the upper South Grand to 2.99 m in the lower lake sections of the South Grand and Osage arms. Photic zone depths of 1.16 m and 1.83 m were present in the upper Osage and middle South Grand sections, respectively. The remaining areas of the reservoir exhibited photic zone depths of more than 2.4 m.

The algal response to the available nutrient and water clarity conditions was within an expected range based on historical data. Chlorophyll *a* concentrations, which are commonly used to estimate algal biomass, ranged from 1.7 ug/L in the upper Osage arm to 21.5 ug/L in the upper South Grand arm. Higher concentrations were present in the middle Tebo (18 ug/L), lower Osage (17.4 ug/L), middle Pomme de Terre (17.2 ug/L), middle South Grand (16.3 ug/L), and lower South Grand (15.4 ug/L). The mean chlorophyll concentration for the August survey was 12.5 ug/L, which is slightly above the generalized eutrophy criterion for lakes (a mean growing season concentration of 10 ug/L). Concentrations ranging between 10 and 20 ug/L are indicative of moderately enriched conditions, but not excessive or hypereutrophic levels.

Prior to reopening the recreation area beaches following flood pool operations, PM-PR-W performed additional bacterial analyses to confirm results reported by an outside contractor. Fecal coliform densities at the Berry Bend and Shawnee Bend beaches on 30 June were below the primary contact standard (200 colonies/100 mL). Berry Bend Beach (HT-75) and Shawnee Bend Beach (HT-58) had mean concentrations of 42 and 55 colonies/100 mL, respectively. Fecal coliform densities at the nine sampling stations on 9 and 12 August were also satisfactory for primary contact. Low concentrations were present at Sparrowfoot Beach (HT-48), 5/100 mL; Bucksaw Beach (HT-68), 5/100 mL; Shawnee Bend Beach, 10/100 mL; Long Shoal Marina (HT-73), 17/100 mL; Bucksaw Marina (HT-67), 20/100 mL; and Windsor Crossing Beach (HT-56), 30/100 mL. Moderate concentrations were present at Osage Bluff Marina (HT-69), 70/100 mL; Long Shoal Beach (HT-52), 100/100 mL; and Sterett Creek Marina (HT-64), 170/100 mL.

c. **Outlet**. During May and June, total discharges ranged from 32,000-53,000 cfs in the outlet as a result of flood control releases from Truman Dam. Spillway releases represented 10,000-18,000 cfs of the total discharge. As in past years, total dissolved gas percentages were monitored to avoid supersaturation problems. Percentages ranged from 104-109 %, which did exceed the national criterion of 110 % to avoid fish mortalities. Periodic inspections of creeled

fish taken in the outlet did not reveal the presence of gas bubble disease, and no fish kills attributable to supersaturation were noted.

4. **Future conditions**.

Despite periodic low dissolved oxygen levels, the general water quality of Truman Lake has been good as evidenced by the development of an excellent, warm water fishery. Nutrient levels, which support a strong forage base, the abundance of cover, and the lake's shallow average depth, are other major qualities contributing to the excellent fishery. Since it is unlikely that soil conservation practices in the Osage River and Grand River watersheds will improve significantly in the near term, turbidities, suspended solids, and nutrient levels in the upper arms of the reservoir will remain high.

The eventual loss of standing timber and brush, which have reduced or trapped the alluvial material, will require implementation of modified operational procedures to attenuate the lower water quality conditions. Once the Osage Basin model is running, management of water quantity and quality for optimal conditions should be attainable, particularly at Truman Reservoir. Probably, the most beneficial change in operations from a water quality standpoint would be stepped down discharges, which would not pull the extremely turbid water throughout the entire length of the reservoir. Lower discharge rates would also benefit the fishery, since spring spawning could be carried out without large stage fluctuations, which in the past have been very detrimental and resulted in poor, sport fish year classes. And unless a strong year class is produced at least every three years, the fishery will decline. Benefits would also accrue downstream of the dam; elimination of large tainter gate releases in the spring would reduce total dissolved gas percentages and the fish losses associated with supersaturation. The sport fishery in the upper Lake of the Ozarks would also benefit from lowered discharges, more stable stages, and reduced turbidities and bank erosion through better spawning, rearing, and food production conditions.

5. **Recommendations**.

Because of the concerns for low oxygen, as well as supersaturated, conditions, the PM-PR-W recommends that past monitoring efforts continue in 2000. During high releases, summer stratification, and initial destratification, monitoring should be conducted to provide real time data for hydropower operations. The continuous downstream monitor is critical in meeting State water quality standards for dissolved oxygen in the tail water and should be maintained. To continue the efforts to define long-term water quality trends, PM-PR-W recommends conducting two surveys, which include in-situ monitoring, bacterial analysis, field chemistry, and laboratory analyses for approximately 30 parameters.