DATA ANALYSIS OF DISSOLVED OXYGEN SAMPLING IN THE ARKANSAS RIVER, FT. SMITH TO DARDANELLE, ARKANSAS

ARKANSAS DEPARTMENT OF ENVIRONMENTAL QUALITY
Water Division

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INTRODUCTION

The Arkansas River originates in the Sangre de Cristo, Sawatch, and Front Ranges of the Southern Rocky Mountains in Colorado and New Mexico. The river meanders generally eastward, 1,460 miles across Colorado, Kansas, Oklahoma and Arkansas, and reaches its confluence with the Mississippi River approximately 152 miles downstream from Memphis, Tennessee. The drainage area at the Oklahoma-Arkansas state line is 149,977 square miles and 153,670 square miles at Dardanelle, Arkansas (USGS 1970).

The Ozark Plateaus north of the Arkansas River Valley and Ouachita Mountains to the south are rugged, with steep slopes and narrow valleys. Tributaries to the Arkansas River in western Arkansas are swift flowing streams. Principal tributaries to the Arkansas River between Ft. Smith and Dardanelle, Arkansas include the Poteau River, Lee Creek, Frog Bayou, Mulberry River, Big Piney Creek and Illinois Bayou.

Dams and reservoirs are found throughout a major portion of the Arkansas River's reach. In 1946, Congress authorized the Corps of Engineers to build the McClellan-Kerr Arkansas River Navigation System. This system consists of a series of locks and dams on the Arkansas River to help develop the river for navigation, flood control, and hydroelectric power generation. Construction of the dams began in 1957 and was completed in 1970. As part of this project, the Corps of Engineers built 11 dams on the Arkansas River in Arkansas and 3 dams in Oklahoma. Three dams are located between Ft. Smith and Dardanelle, Arkansas.

Objectives

Ten ambient water quality monitoring stations are located on the Arkansas River from Ft. Smith to Pendleton (Lock & Dam #2). These stations are typically sampled monthly. Minimum dissolved oxygen values at the stations exhibited a downward trend from 1988 to 2001. Minimum dissolved oxygen values declined substantially in the upper segment of the Arkansas River from Ft. Smith to Dardanelle in 1991 and have yet to recover to pre-1991 values. A similar, but less pronounced, decline occurred with maximum dissolved oxygen values at Ft. Smith and Dardanelle. Standard violations are typically occurring in these segments during the low flow periods from July through September. This downward trend and excessive number of standard violations prompted additional dissolved oxygen sampling in 2000 and 2001. Objectives include: 1) identify reaches on the Arkansas River between Ft. Smith and Dardanelle where D.O. standard violations are occurring during low flow conditions; 2) identify potential sources for sagging D.O. concentrations.

DISSOLVED OXYGEN SAMPLING

The data in this report has been compiled from historical data (1988 to present) collected at ADEQ ambient water quality monitoring stations and 12 special sampling events during 2000 and 2001. Sampling station locations are listed in Table 1. Ambient dissolved oxygen (D.O.) profiles were collected using a YSI Model 610 DM multi-sensor probe. Seventy-two hour D.O. profiles were collected using Hydrolab Datasondes® and Minisondes® in the Arkansas River at seven locations during 2000. Sampling generally occurred during mid-day (1100 to 1300). Sampling was conducted weekly beginning July 26, 2000 to September 12, 2000 and August 9, 2001 to September 6, 2001. On September 18, 2000, D.O. profiles were collected in the Ft. Smith vicinity from Trimble Lock and Dam to the Oklahoma-Arkansas state line (Table 2). D.O. utilization by sediment collected ¼ mile above Dardanelle Lock and Dam on September 12, 2000 was determined by a BOD (biochemical oxygen demand) type analysis.

Table 1. Location of D. O. sampling stations on the Arkansas River from Dardanelle to Ft. Smith.

Dardanelle WWTP – 75 yd downstream of effluent, river mile 201; left and right ¼ points, mid-channel
AR Highway 7 – 75 yd downstream of bridge; left and right ¼ points, mid-channel
Dardanelle L & D – ¼ mile downstream; left and right ¼ points, mid-channel
Lake Dardanelle – ¼ mile upstream of Dardanelle L & D; thalweg
Ozark Lake – ¼ mile upstream of Ozark-Jetta L & D; thalweg
Ozark-Jetta L & D – ¾ mile downstream of Ozark-Jetta Lock and Dam
Trimble L & D – ¾ mile upstream of Trimble Lock and Dam
P Street – ½ mile downstream of "P" Street STP effluent, Ft. Smith

RESULTS

Historical Data

Minimum dissolved oxygen (D.O.) values declined substantially in the Arkansas River from Ft. Smith to Ozark since 1991 (Figure 1). In the Ft. Smith and Ozark pools, values remained unusually low from 1991 to 1998. D.O. concentrations showed signs of recovering to pre-1991 values from 1999-2001. However, minimum D.O. values have steadily declined below Dardanelle Lock and Dam since 1988. Minimum D.O. concentrations generally have remained above the standard, 5 mg/L, downstream of Morrilton (Figure 1 and 2).

Between 1995 and 1998, 14% of D.O. values violated standards at Ft. Smith, 12% of samples violated standards at Ozark and 13% of samples violated standards at Dardanelle (Figure 1). There were no standard violations observed at Ft. Smith and Ozark between 1999 and 2001. Seven percent of samples violated standards at Dardanelle between 1999 to 2001. Historical data identified low flow conditions during the months of July, August and September to be the primary months that D.O. values were likely to violate standards.

Lake Profiles

No thermal stratification occurred in either Dardanelle or Ozark lakes during the 2000 and 2001 sampling period (Figures 3 and 4). D.O. concentrations generally were greater,

Table 2. Dissolved oxygen, pH, temperature and depth for the Arkansas River, Ft. Smith to Lake Dardanelle on September 18-19, 2000.

River Mile	Date	Time	pH	D.O.	Temp	Sample Depth	Max Depth	Remarks
303 RL1/4	9/18/2000	11:45	8.02	8.33	25.95	5.5	22.0	3/8 mi above Lee Cr
303 RL1/4	9/18/2000	11:49	8.15	8.89	25.78	20.2	22.0	3/8 mi above Lee Cr
303 Mid pt	9/18/2000	11:53	8.32	9.92	26.07	5.0	27.0	3/8 mi above Lee Cr
303 Mid pt	9/18/2000	11:55	8.24	8.97	25.8	26.1	27.0	3/8 mi above Lee Cr
303 RR1/4	9/18/2000	11:59	8.32	9.74	26.02	5.0	10.0	3/8 mi above Lee Cr
303 RR1/4	9/18/2000	12:00	8.29	9.7	25.92	9.0	10.0	3/8 mi above Lee Cr
301 RL1/4	9/18/2000	12:53	8.29	9.58	26.16	5.0	19.0	at Power line by Ft. Smith
301 RL1/4	9/18/2000	12:55	8.24	9.24	25.99	17.0	19.0	at Power line by Ft. Smith
301 Mid pt	9/18/2000	12:47	8.35	10.56	26.4	5.0	30.0	at Power line by Ft. Smith
301 Mid pt	9/18/2000	12:50	8.27	9.24	25.9	28.0	30.0	at Power line by Ft. Smith
301 RR1/4	9/18/2000	12:42	8.12	9.38	26.01	5.0	8.0	at Power line by Ft. Smith
300 RL1/4	9/18/2000	13:20	8.3	9.52	26.6	5.0	25.0	3/4 way dwnstrm btwn 64/
300 RL1/4	9/18/2000	13:20	8.37	9.89	25.9	24.0	25.0	3/4 way dwnstrm btwn 64/
300 Mid pt	9/18/2000	13:15	8.3	9.53	26.9	5.0	20.0	3/4 way dwnstrm btwn 64/
300 Mid pt	9/18/2000	13:15	8.31	9.57	26.01	18.0	20.0	3/4 way dwnstrm btwn 64/
300 RR1/4	9/18/2000	13:10	8.51	11.09	26.26	5.0	10.0	3/4 way dwnstrm btwn 64/
297 RL1/4	9/18/2000	13:55	8.65	12.13	26.47	5.0	9.0	
297 Mid pt	9/18/2000	13:48	8.33	9.55	26.19	5.0	25.0	
297 Mid pt	9/18/2000	13:51	8.26	8.93	26.02	23.0	25.0	
297 RR1/4	9/18/2000	13:38	8.41	11.05	26.31	5.0	13.0	Ponar - Sand
297 RR1/4	9/18/2000	13:39	8.39	10.47	26.17	10.0	13.0	
293 RL1/4	9/18/2000	14:30	8.31	8.46	26.45	5.0	28.0	~550' above L&D @ uppe
293 RL1/4	9/18/2000	14:32	8.16	7.78	26.28	24.0	28.0	~550' above L&D @ uppe
293 RR1/4	9/18/2000	14:19	8.54	10.78	27.22	5.0	14.0	Submerged outfall out fro
293 RR1/4	9/18/2000	14:22	8.3	8.71	26.42	11.5	14.0	Submerged outfall out fro
293 Deepest pt	9/18/2000	14:35	8.52	10.99	27.83	1.0	37.0	Profile - Above L&D #13
293 Deepest pt	9/18/2000	14:35	8.38	9.56	26.53	5.0	37.0	Profile - Above L&D #13
293 Deepest pt	9/18/2000	14:35	8.3	8.92	26.44	10.0	37.0	Profile - Above L&D #13
293 Deepest pt	9/18/2000	14:35	8.28	8.75	26.42	15.0	37.0	Profile - Above L&D #13
293 Deepest pt	9/18/2000	14:35	8.29	8.51	26.36	20.0	37.0	Profile - Above L&D #13
293 Deepest pt	9/18/2000	14:35	8.21	8.43	26.21	25.0	37.0	Profile - Above L&D #13
293 Deepest pt	9/18/2000	14:35	8.22	8.35	26.18	30.0	37.0	Profile - Above L&D #13
293 Deepest pt	9/18/2000	14:35	7.88	8.18	25.89	35.0	37.0	Profile - Above L&D #13
307.2 P St inlet	9/18/2000	16:00	7.33	6.26	27.7	1.0	2.0	100' below outfall pipe
307.2 P St inlet	9/18/2000	16:00		5.69		1.0	2.5	100 yds below outfall pipe
307.2 P St inlet	9/18/2000	16:00		3.57		1.0	2.5	150 yds below outfall pipe
307.25 RL1/4	9/18/2000	16:49	8.27	10.38	25.85	6.0	10.0	200' above P St outfall can
307.25 Mid pt	9/18/2000	16:44	8.24	9.84	25.82	5.0	18.0	200' above P St outfall can
307.25 Mid pt	9/18/2000	16:44	8.13	9.24	25.68	15.0	18.0	200' above P St outfall can
307.25 RR1/4	9/18/2000	16:37	8.15	9.56	25.76	5.0	28.0	200' above P St outfall can
307.25 RR1/4	9/18/2000	16:37	7.97	9.05	25.63	20.0	28.0	200' above P St outfall can
306.8 RL1/4	9/18/2000	16:55	8.45	11.12	25.96	5.0	13.0	Effluent hugging Right Ba
306.8 RL1/4	9/18/2000	16:58	8.43	11.1	25.94	10.0	13.0	
306.8 Mid pt	9/18/2000	16:59	8.25	9.67	25.85	5.0	18.0	
306.8 Mid pt	9/18/2000	17:02	8.21	9.57	25.73	16.0	18.0	
306.8 RR1/4	9/18/2000	17:05	8.33	10.14	26.15	5.0	18.0	Ponar - Clean Sand/gravel
306.8 RR1/4	9/18/2000	17:07	8.29	10.05	26.15	14.0	18.0	
291 RL1/4	9/19/2000	9:12	8.33	9.02	25.78	5.0	8.0	Below Trimble L&D
291 Mid pt	9/19/2000	9:08	8.3	8.85	25.96	5.0	13.0	Below Trimble L&D
291 Mid pt	9/19/2000	9:09	8.3	8.8	25.88	11.0	13.0	Below Trimble L&D
291 RR1/4	9/19/2000	9:00	8.19	8.88	25.97	5.0	16.0	Below Trimble L&D
291 RR1/4	9/19/2000	9:04	8.25	8.75	25.95	14.0	16.0	Below Trimble L&D
287 RL1/4	9/19/2000	9:42	8.32	8.9	26.18	5.0	13.0	Below Vache Grasse
287 RL1/4	9/19/2000	9:43	8.32	9.02	26.16	10.0	13.0	Below Vache Grasse
287 Mid pt	9/19/2000	9:37	8.36	9.2	26.19	5.0	19.0	Below Vache Grasse
287 Mid pt	9/19/2000	9:37	8.28	8.62	26.04	17.0	19.0	Below Vache Grasse
287 RR1/4	9/19/2000	9:31	8.31	8.92	26.21	5.0	17.0	Below Vache Grasse
287 RR1/4	9/19/2000	9:35	8.33	8.77	26.14	15.0	17.0	Below Vache Grasse
276.2 RL1/4	9/19/2000	10:54	8.54	9.69	25.76	5.0	21.0	Below Frog Bayou
276.2 RL1/4	9/19/2000	10:56	8.45	8.91	25.65	19.0	21.0	Below Frog Bayou
276.2 Mid pt	9/19/2000	11:01	8.5	9.81	25.78	5.0	8.0	Below Frog Bayou
276.2 RR1/4	9/19/2000	11:04	8.61	10.87	25.39	3.0	4.2	Below Frog Bayou
270.5 RL1/4	9/19/2000	11:35	8.51	9.76	25.98	5.0	28.0	Below Mulberry River
270.5 RL1/4	9/19/2000	11:35	8.44	9.04	25.85	26.0	28.0	Below Mulberry River
270.5 Mid pt	9/19/2000	11:30	8.53	9.77	25.97	5.0	31.0	Below Mulberry River
270.5 Mid pt	9/19/2000	11:30	8.47	9.21	25.86	28.0	31.0	Below Mulberry River
270.5 RR1/4	9/19/2000	11:25	8.55	9.81	25.98	5.0	15.0	Below Mulberry River

Table 2. Continued.

River Mile	Date	Time	pH	D.O.	Temp	Sample Depth	Max Depth	Remarks
255.2 RL1/4	9/19/2000	14:00	8.49	8.81	27.32	5.0	19.0	In barge wake - Below Ozark L
255.2 RL1/4	9/19/2000	14:03	8.29	8.08	26.91	14.0	19.0	In barge wake - Below Ozark L
255.2 RL1/4	9/19/2000	13:50	8.28	7.79	27.04	5.0	15.0	Below Ozark L&D
255.2 RL1/4	9/19/2000	13:52	8.24	7.68	26.91	10.0	15.0	Below Ozark L&D
255.2 RL1/4	9/19/2000	13:47	8.52	9.55	27.43	5.0	8.0	Below Ozark L&D
235.2 RL1/4	9/19/2000	16:16	8.53	10.08	27.25	5.0	34.0	
235.2 RL1/4	9/19/2000	16:18	8.37	8.19	26.25	28.0	34.0	Below Horsehead Cr - L. Darda
235.2 Mid pt	9/19/2000	16:11	8.51	9.72	26.8	5.0	28.0	Below Horsehead Cr - L. Darda
235.2 Mid pt	9/19/2000	16:13	8.36	8.33	26.22	24.0	28.0	Below Horsehead Cr - L. Darda
235.2 RR1/4	9/19/2000	16:07	8.41	8.59	26.26	5.0	8.0	Below Horsehead Cr - L. Darda

by 2 to 3 mg/L, in Ozark Lake when compared to those of Lake Dardanelle. Ozark Lake typically was mixed well from surface to bottom. This resulted in D.O. profiles that were similar from surface to bottom. D.O. concentrations in Lake Dardanelle, while well mixed on a couple of sampling events, generally declined 3 to 4 mg/L in the upper 10 feet and continued to steadily decline at deeper depths.

On July 26, 2000, D.O. concentrations in Lake Dardanelle remained relatively constant only dropping 1 mg/L from surface to bottom. All values on this date remained above the D.O. standard of 5 mg/L. During August 2000, dissolved oxygen (D.O.) concentrations in Lake Dardanelle showed sharp declines of 3 to 4 mg/L in the upper 10 feet of the water column. D. O. concentrations steadily declined at deeper depths. By September 12, 2000, D.O. concentrations were beginning to increase in response to cooler temperatures.

Lake Dardanelle D.O. profiles in 2001 showed similar trends to 2000 profiles, 2 to 4 mg/L declines in the upper 12 feet and then gradually declining concentrations or concentrations that remained constant. D.O. profiles in Ozark Lake remained constant or gradually declined from surface to bottom. All surface D.O. concentrations were greater in Ozark Lake when compared to those of Lake Dardanelle. In Ozark Lake, bottom D.O. concentrations generally were greater than those of Lake Dardanelle. Exceptions occurred on August 16, 21 and 28, 2001. On these dates, bottom D.O. concentrations were similar in both lakes.

River Profiles

Figure 5 and 6 illustrate D.O. concentrations at 1-foot depth for three transects on the Arkansas River below Dardanelle Lock and Dam. Several interesting trends emerged from the river profiles. First, D.O. concentrations generally are lower in the river channel (thalweg) and increase downstream of Arkansas Highway 7. D.O. concentrations are the lowest immediately below Dardanelle Lock and Dam. During periods of no generation and sunlight, the lack of photosynthesis, is the primary determining factor of D.O. concentrations. During initial releases (power up phase) and sustained generation, D.O. concentrations appear to be controlled more by hydropower releases. This is most apparent in Figure 6 on August 9, 2001, which illustrates profiles taken during a power up phase. Likewise, there are no releases to continue aerating the water when turbines

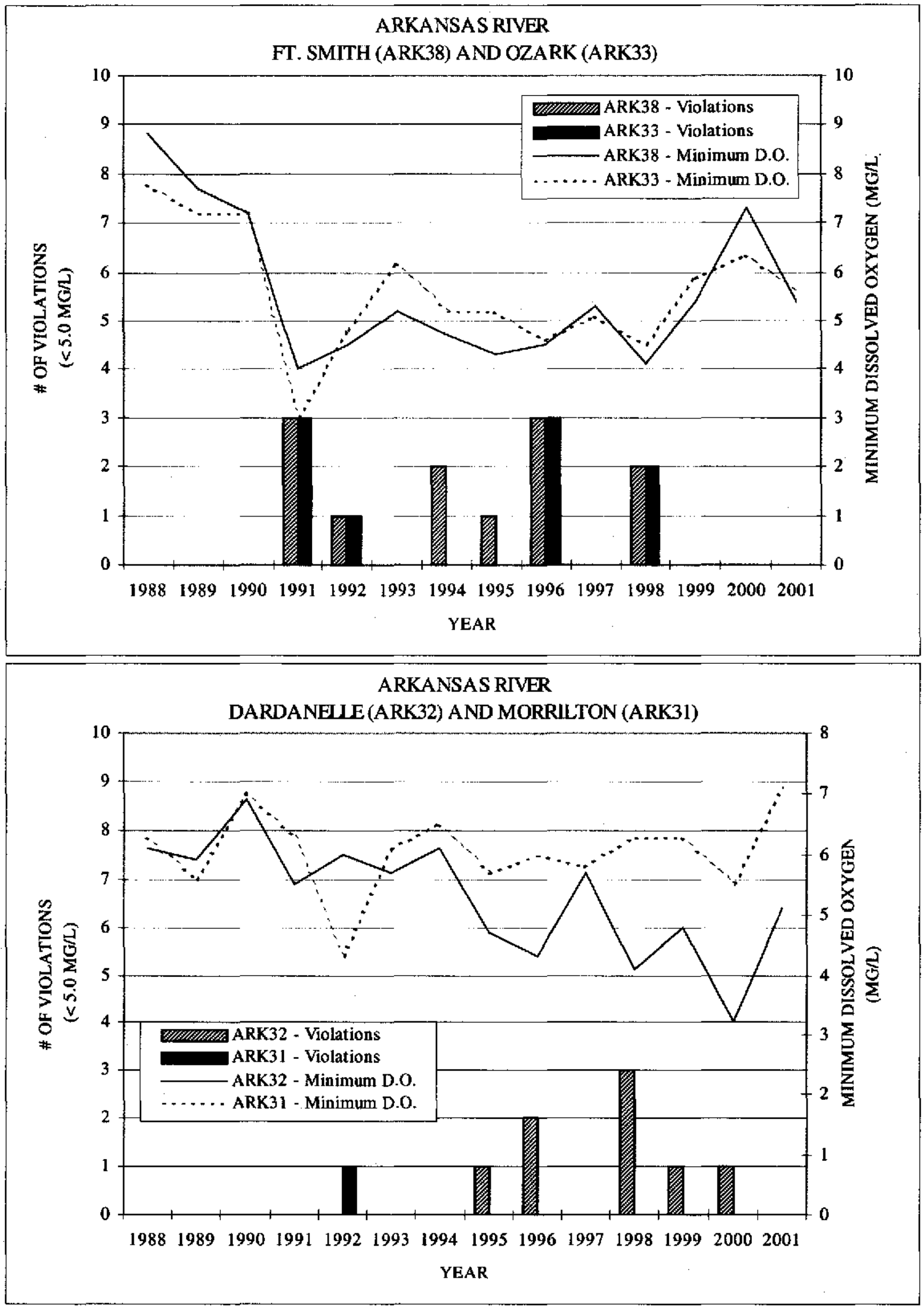


Figure 1. Minimum values for dissolved oxygen and number of standard violations in the Arkansas River from Ft. Smith to Morrilton.

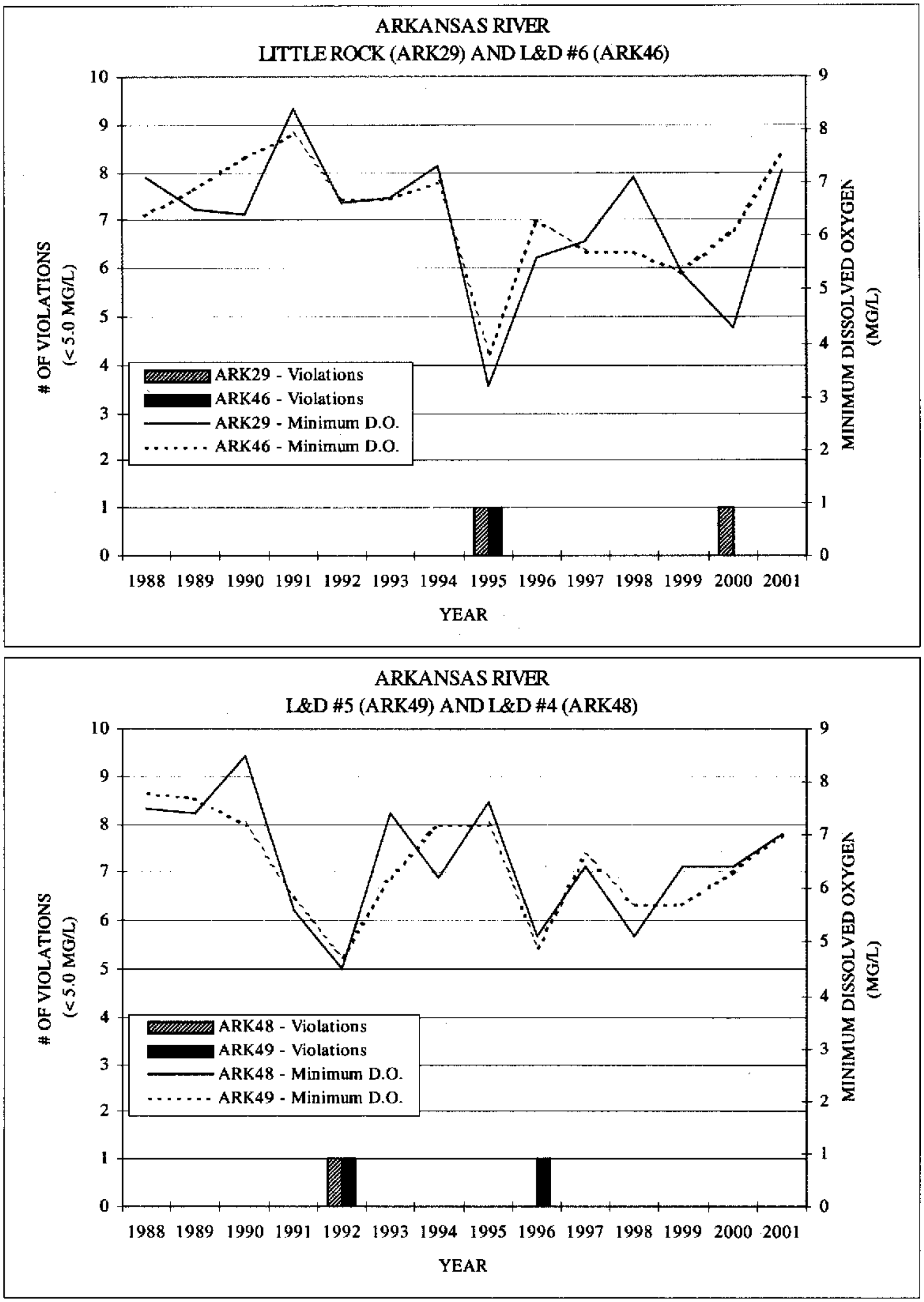


Figure 2. Minimum values for dissolved oxygen and number of standard violations in the Arkansas River from Little Rock to Lock and Dam #4.

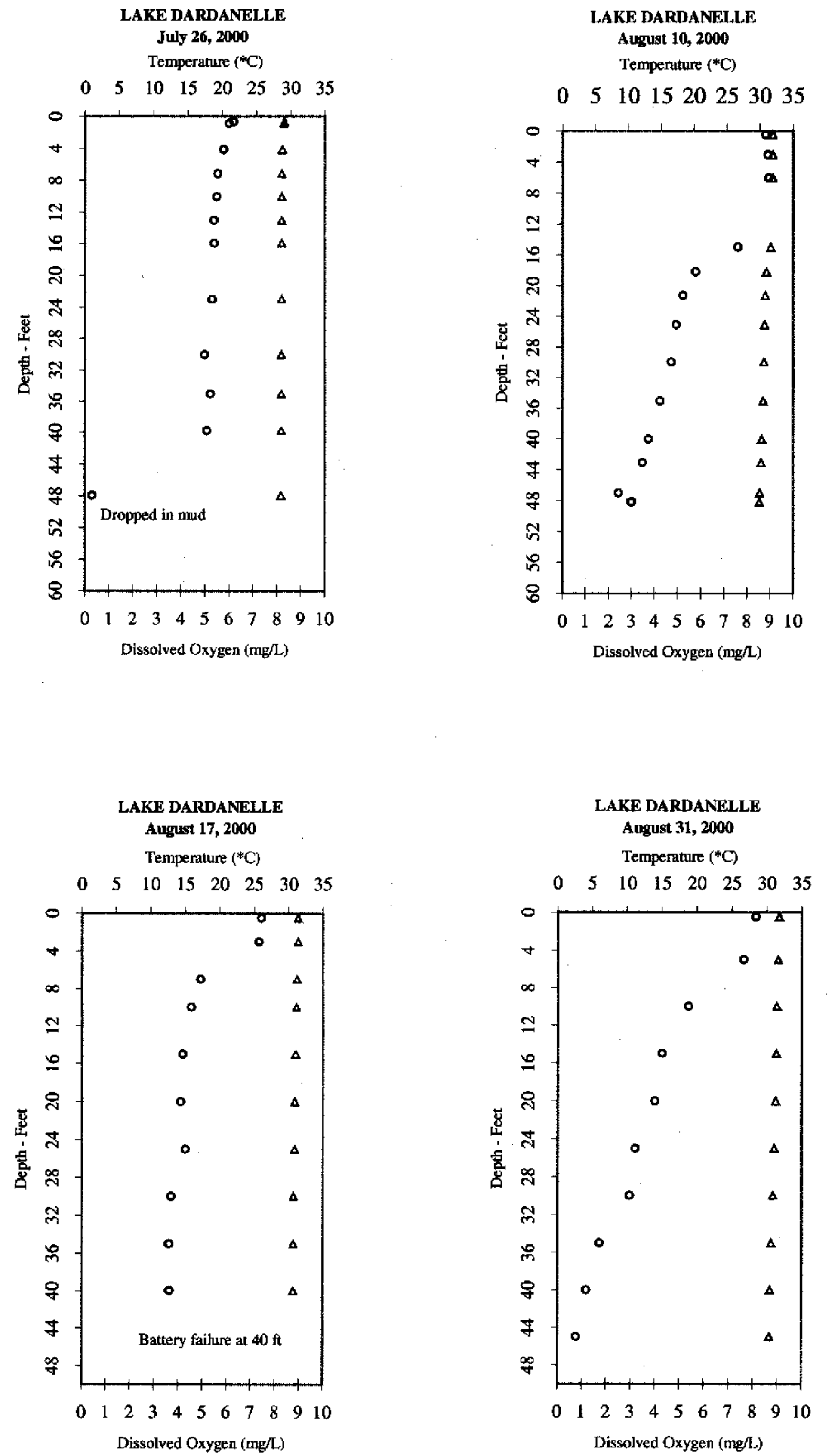


Figure 3. Dissolved oxygen profiles for Ozark and Dardanelle lakes. Profiles taken approximately ¼ mile upstream of Ozark-Jetta and Dardanelle Lock and Dams, 2000.

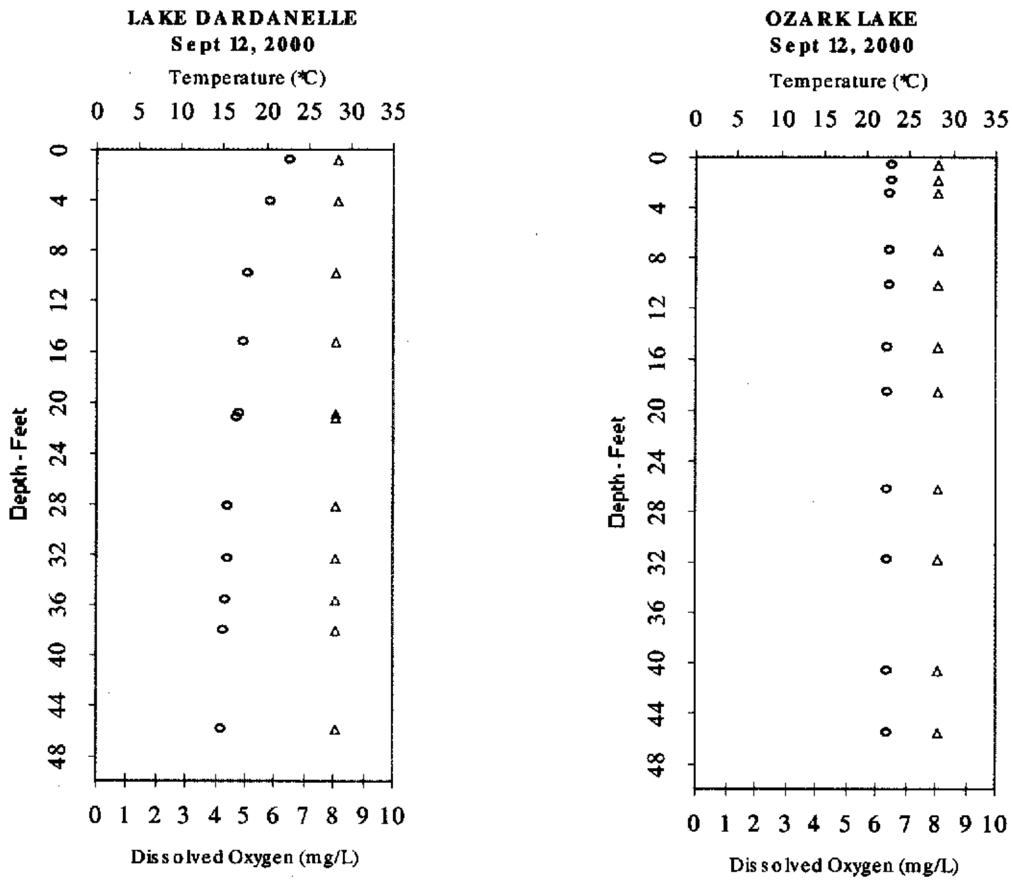


Figure 3. Continued

are shut-off. At this point, low D.O. water seems to remain in the vicinity of Dardanelle Lock and Dam. Photosynthesis appears to have a greater influence from Arkansas Highway 7 downstream during periods of no generation. However, on August 21, 2001, D.O. values were consistently around 4 mg/L at all stations below the dam. These data were collected during a non-generation period at 7:00 a.m., which is after the maximum respiration period for planktonic organisms and before peak photosynthesis takes place. This probably represents the minimum diel D.O. values.

The 2000 river profiles were generally lower than the 2001 river profiles. It is important to note that 2000 sampling occurred during power up phases, whereas 2001 sampling occurred during periods of no generation and increased photosynthetic influences. In both years, the lowest D.O. values in the Arkansas River below Dardanelle Lock and Dam occurred during the hottest month (August). D.O. values began to rise in September as temperatures decreased.

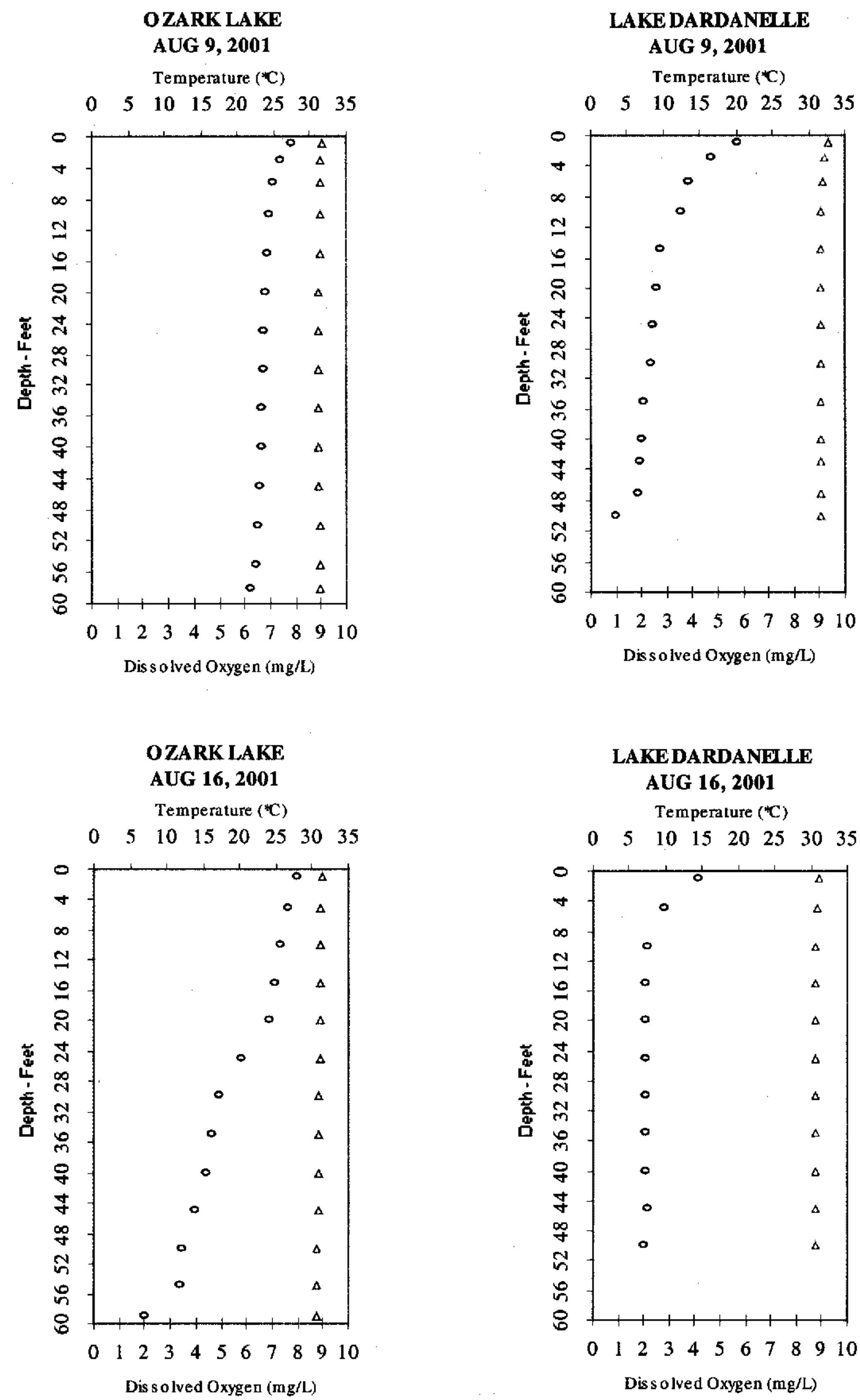


Figure 4. Dissolved oxygen profiles for Ozark and Dardanelle lakes. Profiles taken approximately ¼ mile upstream of Ozark-Jetta and Dardanelle Lock and Dams, 2001

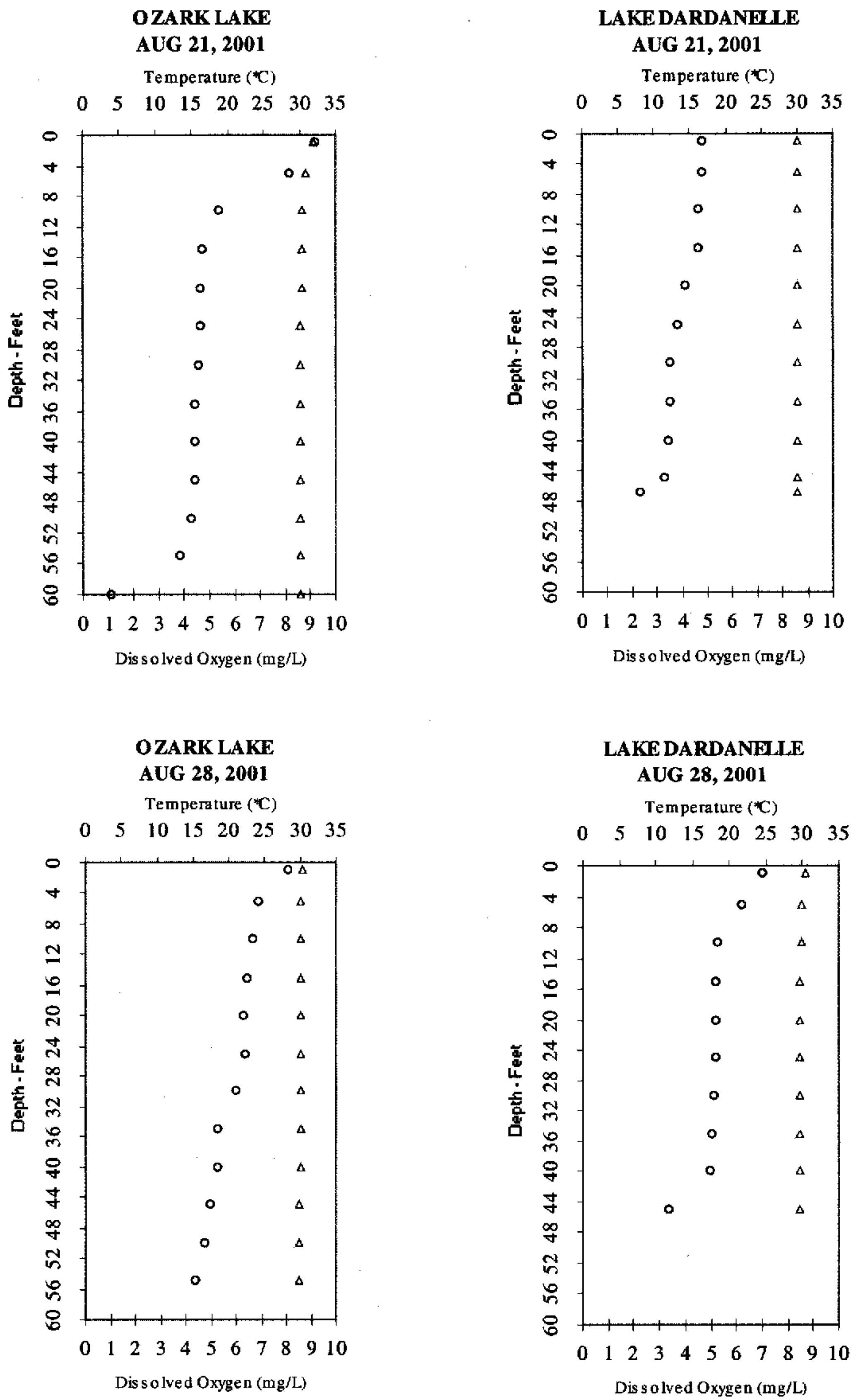


Figure 4. Continued

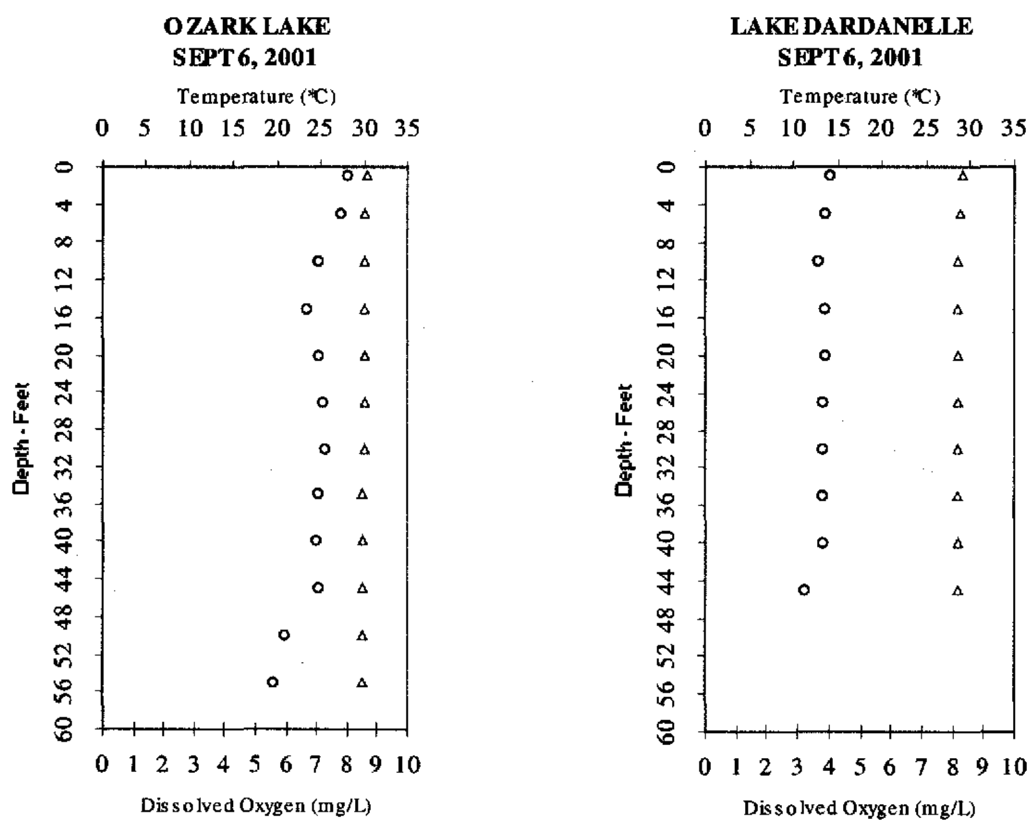


Figure 4. Continued

One sampling event occurred in the vicinity of Trimble Lock and Dam to the Arkansas-Oklahoma state line in mid-September after flows increased and temperature decreased. Data from this sampling event is shown in Table 2. The only D.O. standard violations found in this segment of the Arkansas River occurred in the city of Ft. Smith's "P" Street sewage treatment plant outfall channel. All other D.O. values were > 3 mg/L above the D.O. standard.

Hydrolab 72-Hour River Profiles

Seventy-two hour D.O. profiles below Dardanelle Lock and Dam support results from ambient sampling. Generation influences on D.O. values are greater close to the dam (Figure 7). D.O. concentrations decline during initial periods of generation below Dardanelle Lock and Dam. This decline was not observed in the Ozark and Ft. Smith vicinities and concentrations were 2 to 3 mg/L higher than at Dardanelle.

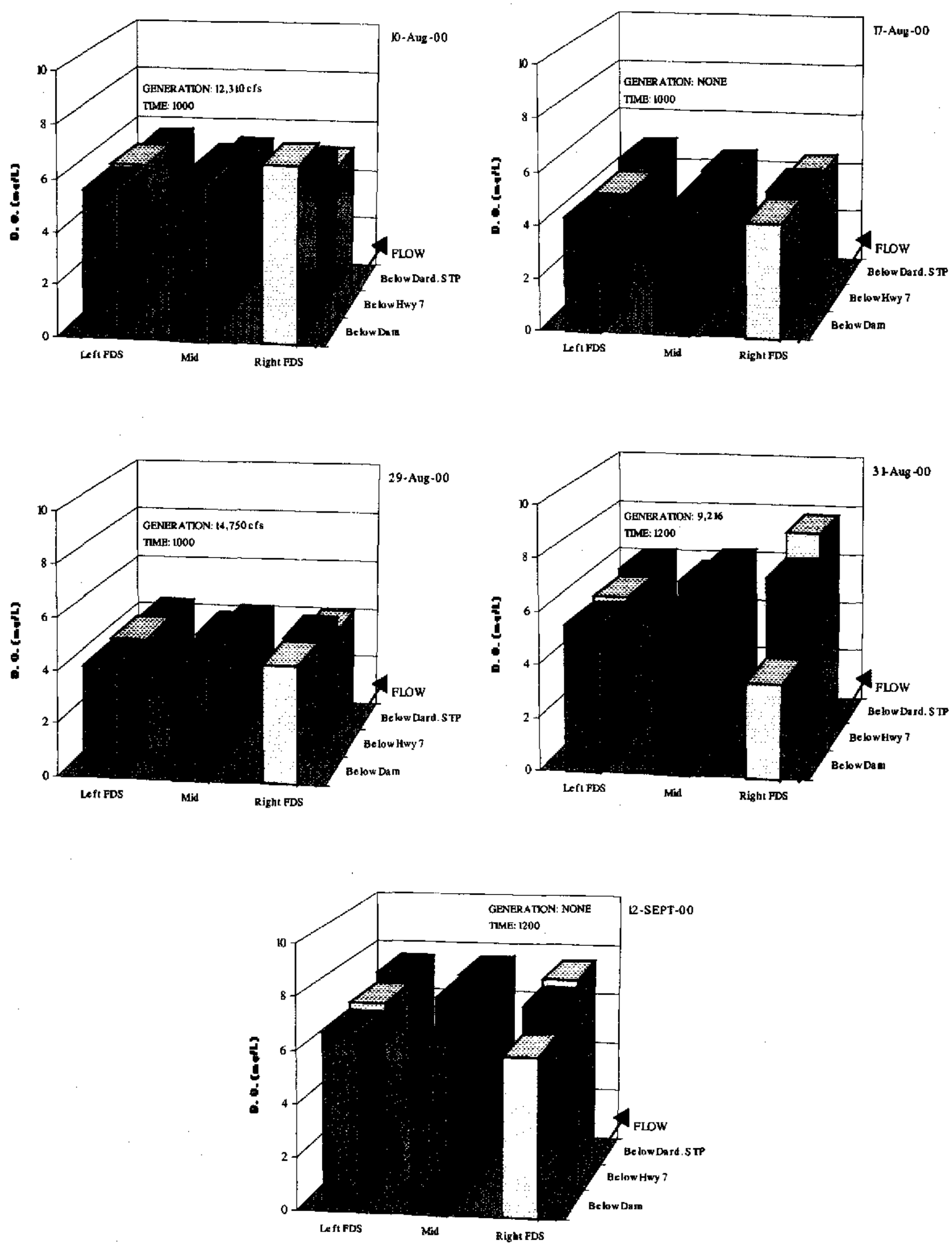


Figure 5. Dissolved oxygen concentrations at 1-foot depth for the Arkansas River downstream of Dardanelle Lock and Dam, 2000

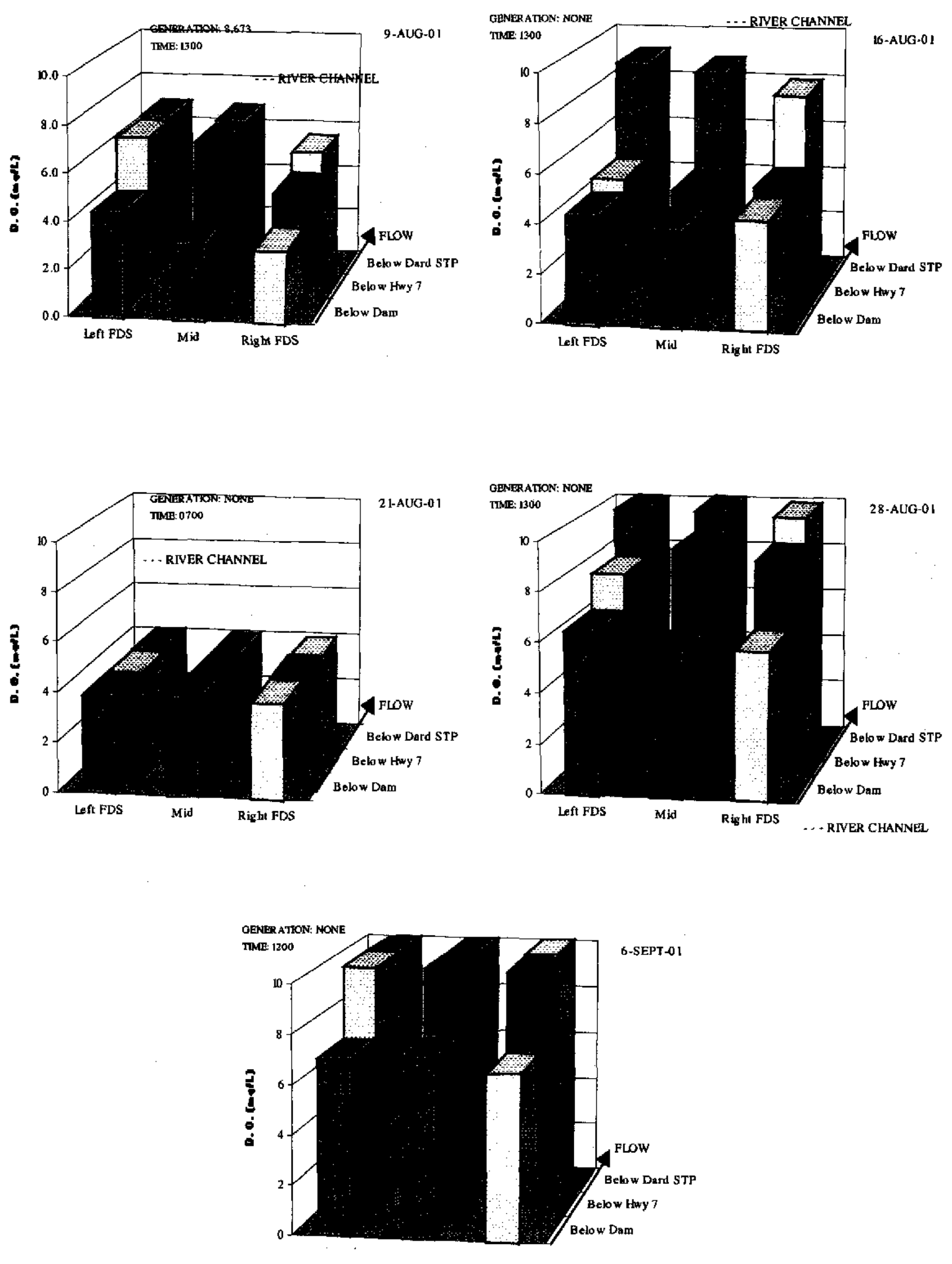


Figure 6. Dissolved oxygen concentrations at 1-foot depth for the Arkansas River downstream of Dardanelle Lock and Dam, 2001

Table 3. D.O. depletion rates for Lake Dardanelle sediment, September 12, 2000.

Trial One			Trial Two		
Time	D.O.	Temp	Time	D.O.	Temp
10:28 am	6.05	23.10	9:54 am	7.50	22.80
10:33 am	3.95	22.97	9:59 am	5.30	
10:38 am	3.07	22.91	10:04 am	4.41	
10:43 am	2.52	22.89	10:09 am	3.77	22.89
10:48 am	2.11	22.91	10:14 am	3.24	22.91
10:53 am	1.80	22.90	10:19 am	2.86	22.93
			10:23 am	2.57	22.96
25 min	4.25 mg/L		29 min	4.93 mg/L	
At this rate, depletion would be 10.2 mg/L per hour			At this rate, depletion would be 10.2 mg/L per hour		
Actual per hour rate would be somewhat less.					
K rate/day = 80			K rate/day = 60		

Sediment sample

D.O. depletion rates derived from sediment samples using 20 ml of sediment in a 300 ml BOD bottle and read every 5 minutes are shown in Table 3. The amount of organic material in the sediment was approximately 3% as determined by volatilizing the organic matter in a muffle furnace.

DISCUSSION

Results presented in this report suggest that the primary areas of concern for the Arkansas River are in Lake Dardanelle and immediately below Dardanelle Lock and Dam. D.O. profiles collected from Ozark and Dardanelle lakes have shown that values immediately above and below Dardanelle Lock and Dam often fall below 5 mg/L during August. The most plausible theory for the differences observed between the two lakes seems to point to sediment oxygen demand.

Sediment oxygen demand (SOD) is the rate that D.O. is removed from the water column due to decomposition of organic material in the bottom sediments and/or by chemical depletion due to the presence of reduced minerals such as iron and manganese. SOD is a component of the benthic oxygen demand that includes the removal of D.O. from the water column by all benthic processes. SOD is fueled by a continuous but seasonally variable supply of organic material settling from the water column. The organic material in the water column is contributed by several sources including wastewater discharges, stormwater runoff, non-point sources and natural occurrences such as leaf fall.

By locating sample sites below known wastewater effluents (i.e. Dardanelle STP, Tyson effluent), we have discounted these sources as major contributors to low D.O. values below Dardanelle Lock and Dam. Lake Dardanelle is the only major lake on the Arkansas River in Arkansas. The numerous bays in Lake Dardanelle act as a sediment trap, not only trapping sediments from major and minor tributaries that drain directly into the lake but also trapping sediments from approximately 150,000 square miles of watershed above the lake that are being transported downstream by the Arkansas River. Since the river does not widen to the extent that it does in Lake Dardanelle anywhere else in Arkansas, the vast majority of sediments are transported downstream rather than being deposited in these segments of the river. Reduced sediment deposition equates to a lower SOD and higher D.O. concentrations.

ADEQ (1999) conducted an intensive non-point source study of the Big Piney Creek watershed in the late 1990's. Big Piney Creek is the largest tributary draining directly into Lake Dardanelle. This study identified numerous bank erosion areas that were contributing sediment to the river, and thus being transported to the lake. In addition, numerous confined animal operations and pastures exist in the Big Piney Creek watershed. Pastures are common throughout the Arkansas River Valley in Arkansas.

Hydropower intakes at Dardanelle Lock and Dam extend from about 8-foot below the lake surface to the lake bottom. This allows withdrawals to easily come from 42-feet of the 50-feet depth of the lake, as discharges increase the withdrawal zone moves closer to the surface.

Recommendations

D.O. concentrations appear to be improving in the Ft. Smith and Ozark reaches during the past 3 years. The decline in D.O. concentrations in these two reaches from 1988 to 1998 can not be explained. Efforts should be made to closely monitor these reaches in the future to identify any possible declines that may occur.

Reducing sediment deposition in Lake Dardanelle will be extremely difficult and costly. Best management practices should be implemented in Arkansas tributaries that lie within the Lake Dardanelle watershed. Practices to better manage nutrient runoff, increase riparian vegetation on pasture lands, reduce water runoff from pasture lands and reduce livestock access to streams would all help to reduce the sediment load to Lake Dardanelle. In addition, reducing soil runoff from unpaved roads and from the areas of the watershed with little or no vegetative cover would also help reduce the sediment load. Furthermore, efforts should continue to address the streambank erosion problems and increasing the quality of the vegetative cover in the riparian zones along the eroded stream channels.

The U. S. Army Corps of Engineers should investigate modifications of the hydropower structures that would increase aeration of water passing through the dam. While costly, such modifications may be the least expensive and most productive remedy to increasing D.O. concentrations below Dardanelle Lock and Dam. However, dam modifications are an indirect, short-term solution to the problem. State, federal and private entities need to work together to improve water quality in Lake Dardanelle by reducing sediment deposition in the lake.

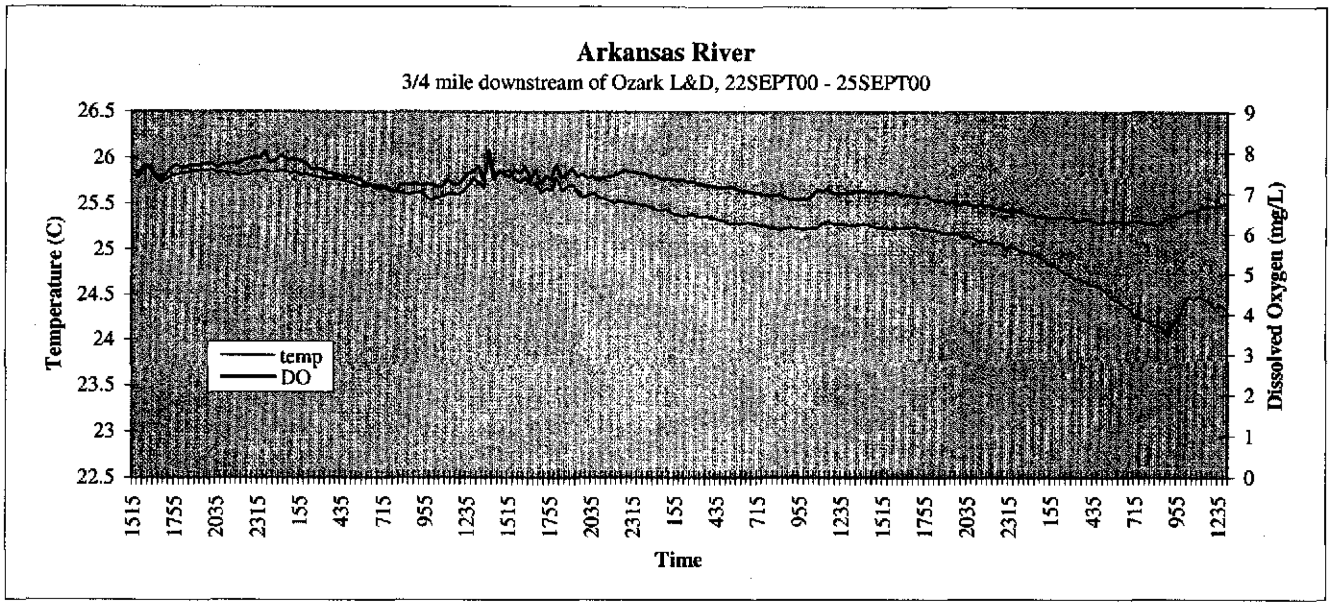
LITERATURE CITED

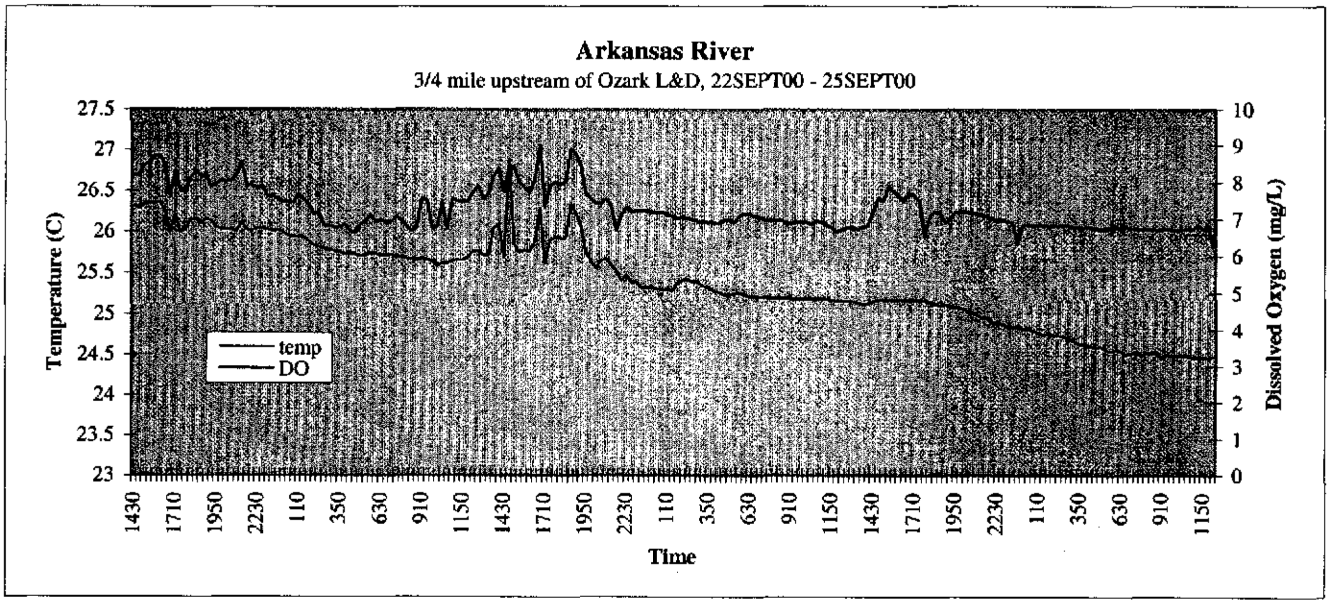
ADEQ. 1999. Physical, chemical and biological assessment of the Piney Creek Watershed, Johnson, Newton and Pope counties, Arkansas. Arkansas Department of Environmental Quality, Water Division. Report #WQ-99-07-01.

USGS. 1970. Drainage area of streams in Arkansas. Arkansas River Basin. Open file report, Little Rock, Arkansas.

Figure7. Arkansas River Dissolved Oxygen Profiles

Hydrolab 72-Hour Profiles





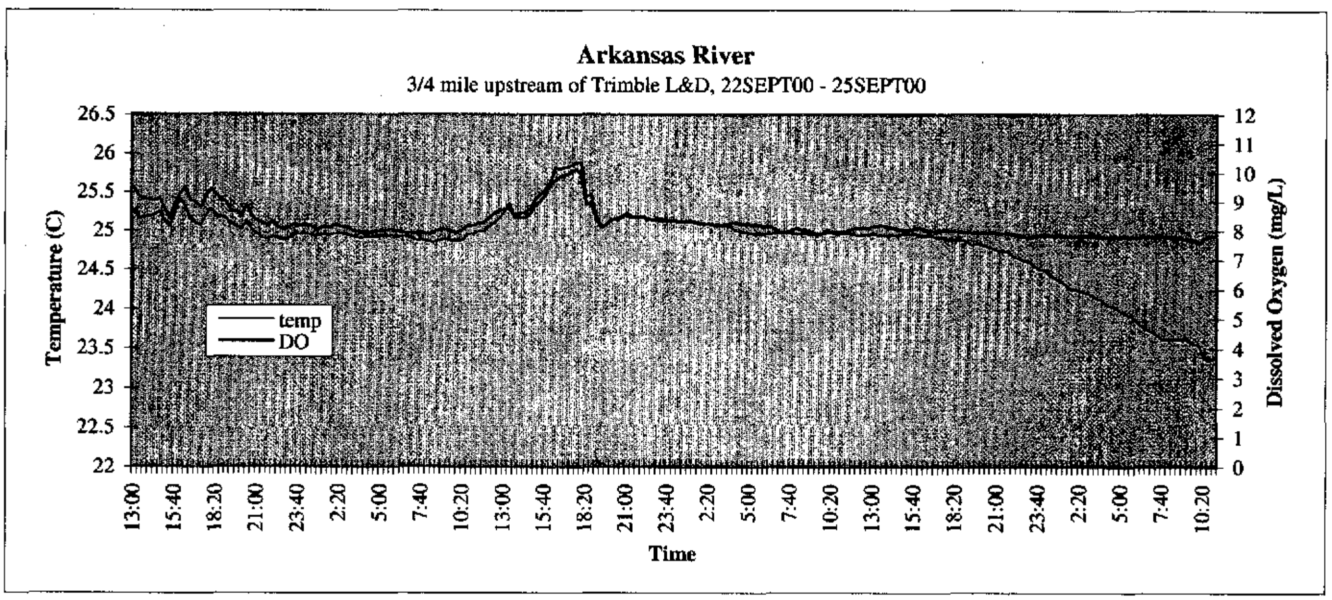
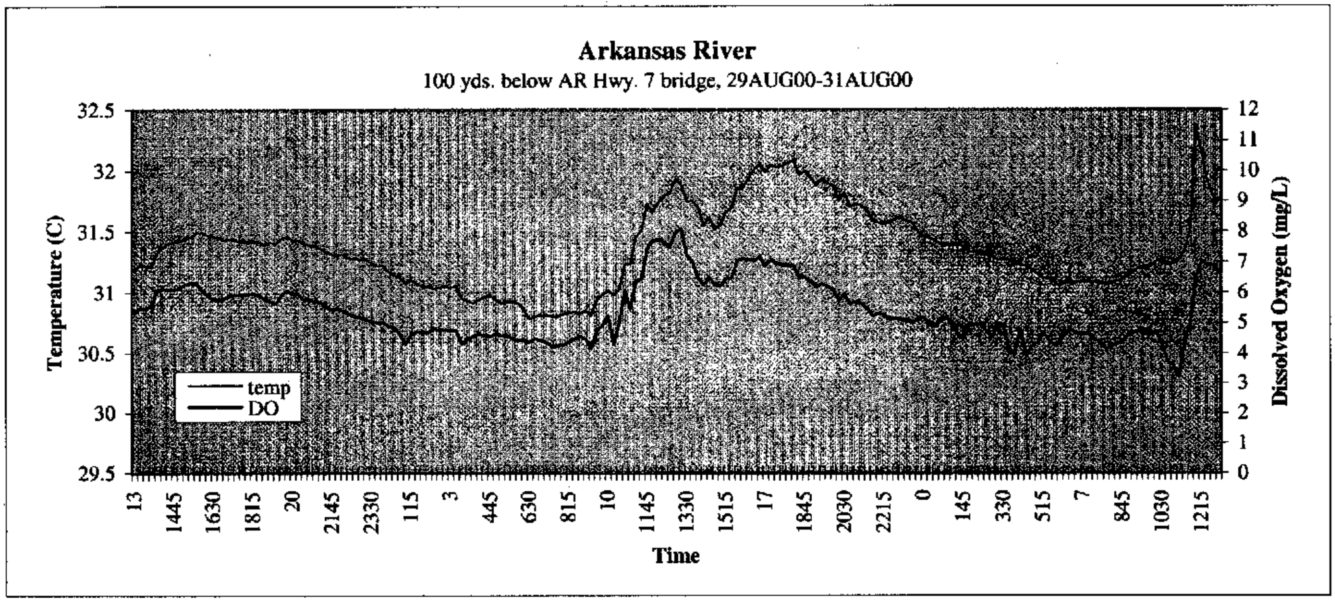
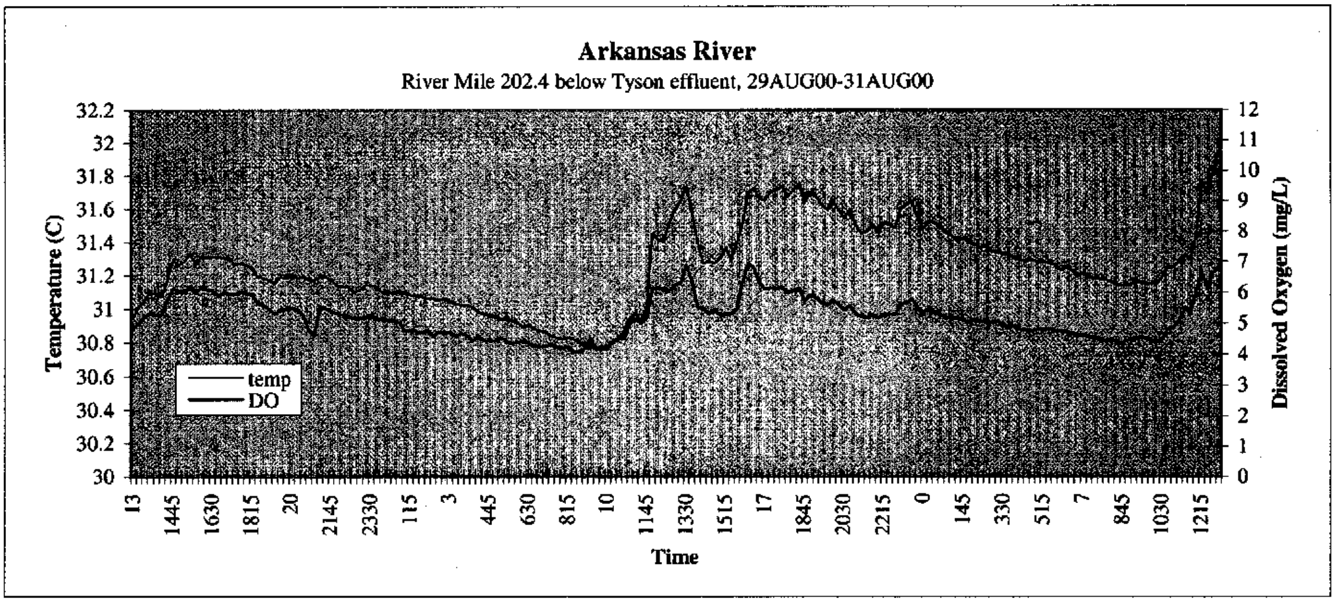
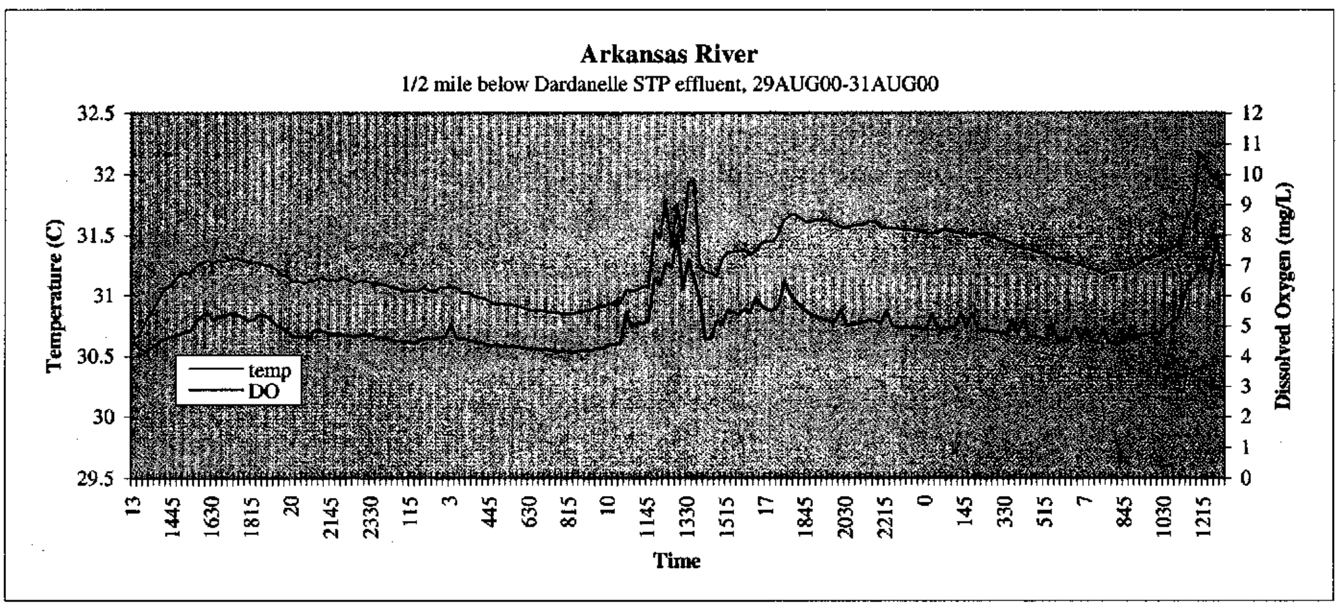


Figure7. Arkansas River Dissolved Oxygen Profiles

Hydrolab 72-Hour Profiles







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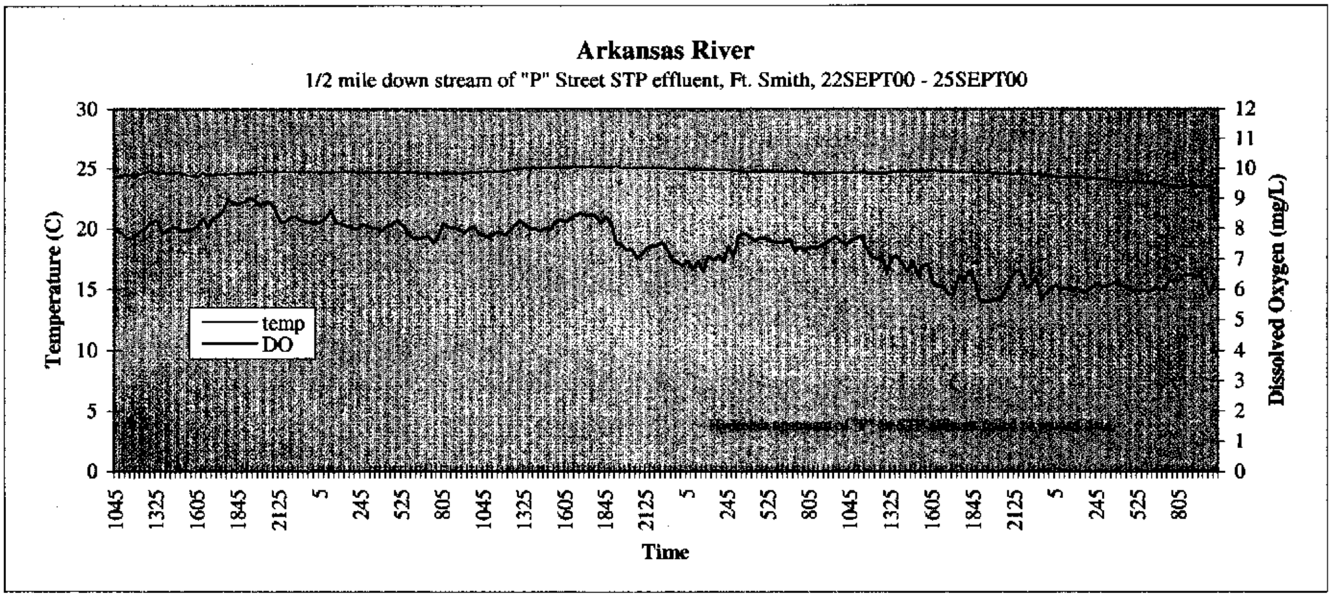
Hydrolab 72-Hour Profiles



Generation Periods for Dardanelle L&D (#11)

8/29/2000	12:30 AM	All units off
8/29/2000	7:00 AM	Unit 1 on
8/29/2000	8:30 AM	Unit 2 on
8/29/2000	12:00 PM	Unit 3 on
8/29/2000	2:00 PM	Unit 4 on
8/29/2000	10:00 PM	one unit off
8/29/2000	10:47 PM	two more units off
8/30/2000	12:30 AM	All units off
8/30/2000	1:00 PM	three units on
8/30/2000	7:00 PM	one unit off
8/30/2000	10:00 PM	All units off
8/31/2000	12:00 PM	Unit 1 on
8/31/2000	1:00 PM	Unit 2 on
8/31/2000	4:00 PM	Unit 3 on
8/31/2000	7:14 PM	one unit off
8/31/2000	7:20 PM	second unit of
8/31/2000	10:30 PM	All units off