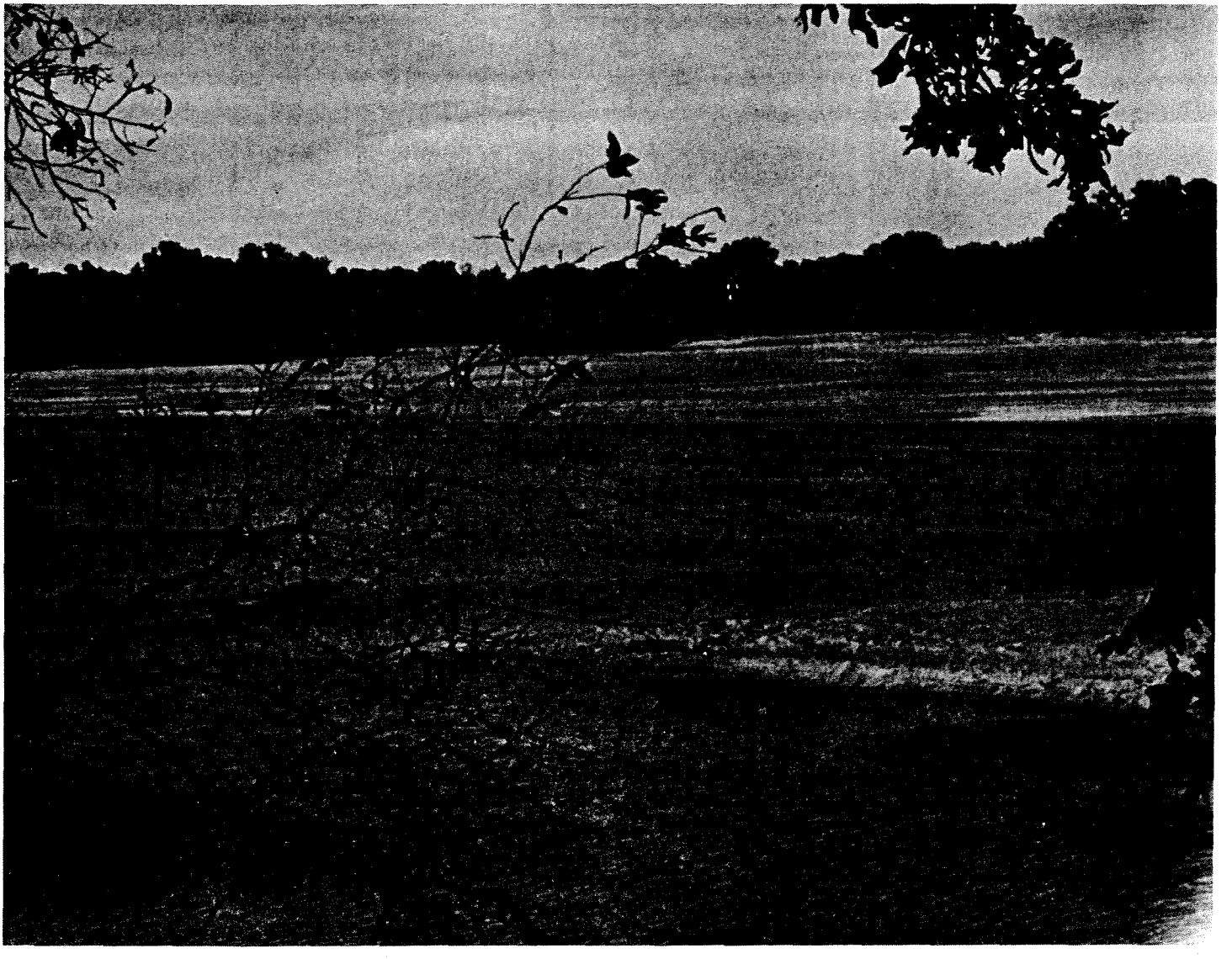
1979 THERMAL MONITORING ON THE ARKANSAS RIVER, OKLAHOMA: MAXIMUM WATER QUALITY TEMPERATURE STANDARD DEVELOPMENT EVALUATION



OKLAHOMA WATER RESOURCES BOARD

1979 THERMAL MONITORING ON THE ARKANSAS RIVER, OKLAHOMA: MAXIMUM WATER QUALITY TEMPERATURE STANDARD DEVELOPMENT EVALUATION

W. K. Morris

and

T. H. Maiello

State of Oklahoma

Oklahoma Water Resources Board

Water Quality Division

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CONCLUSIONS

1. At no time during the 1979 monitoring period did the Arkansas River main channel waters between Kaw Reservoir and monitoring Site 3 exceed 90°F (32.2°C).

2. A maximum water temperature of 88°F (31.1°C) occurred at Site 1 on July 14 and 16. The 1979 summer was abnormally cool as compared to the ambient air temperature average for the state and the maximum instream temperature experienced reflects this weather abnormality.

3. The OG&E Osage plant's thermal discharge adequately dissipated within 350 yards downstream of its effluent.

4. The main channel instream cross-sectional water temperatures indicated that, generally, isothermal conditions existed in the investigated river segment.

5. In summary, the OG&E Osage facility during this period of study did not violate the 1976 Oklahoma Water Quality Standard for temperature.

RECOMMENDATIONS

1. Prior to establishing a maximum instream temperature standard for this segment of the Arkansas River, further investigation is greatly warranted in light of the abnormal ambient air temperatures encountered during this study as compared to the 1955-1969 U.S. Weather service temperature average for this region of Oklahoma.

2. Site 2 should be relocated to increase the possibility for the probe to monitor the main channel of the Arkansas River and decrease the possibility of monitoring backwater areas.

3. Thorough mixing zone analysis of the OG&E Osage plant should avoid the use of nonconservative parameters such as temperature. A thorough analysis could be accomplished using fluorescent dye.

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SECTION I
INTRODUCTION

The Oklahoma Water Resources Board (OWRB) sets and revises water quality standards approximately every three years for the State of Oklahoma (1). This report will analyze the development of a temperature standard for a portion of the Arkansas River in north-central Oklahoma.

The Oklahoma Gas and Electric Company (OG&E) Osage Generating Station discharges into the Arkansas River, once - through non-contact, cooling water. The daily average permitted temperature of this discharge is 104°F (40.0°C) and the maximum allowable is 116°F (46.7°C) according to their U.S. Environmental Protection Agency National Pollutant Discharge Elimination System (NPDES) Permit. Considering the potential temperature of this discharge, concern surfaced among several Federal and State agencies regarding fish and wildlife propagation. In view of this concern an intensive survey was initiated to investigate the temperature in the Arkansas River.

The Sooner OG&E facility located in Noble County downstream of the Osage plant discharges into a 5400 acre cooling reservoir prior to discharging into the river. Due to the size of this lake the authors assumes this discharge should not have a significant effect on the natural river temperature.

Currently the maximum temperature standard according to Oklahoma's Water Quality Standards (1), Section 6.7, reports the Arkansas River segment in question should not exceed 94°F (34.4°C) due to man-made causes.

In order for a justified temperature standard to be legally adopted many important factors must be considered. This investigation was directed at identifying these factors. The extreme summer temperatures of approximately 38 miles of Arkansas River below Kaw Reservoir were examined. This investigation should elucidate the natural 1979 summer temperatures in the Arkansas River. The objectives of this investigation regarding the river segment in question were:

(1) Compile list of the possible thermal perturbances that may affect the river:

    (a) man induced

    (b) natural

(2) Continuously monitor water temperature at a minimum of two sites by continuous recording monitors.

(3) Determine the temperature variation in the cross sections at each site and examine the Osage OG&E mixing zone.

(4) Determine percent of daily time river temperature exceeds 90°F (32.2°C).

(5) Identify maximum river temperature and when experienced.

(6) From the temperature data collected ascertain the development of a maximum river temperature standard for the river segment in question.

SECTION II
MATERIALS AND METHODS

The study area is located in north-central Oklahoma on the Arkansas River (Figure 1). Three continuous temperature monitoring sites were established on the Arkansas River; Site 1 at the Highway 11 bridge 72 miles below Kaw Reservoir in Section 35, Township 26N, Range 2E, Site 2 below the Osage OG&E plant mixing zone in Section 14, Township 25N, Range 2E, 11.7 miles below Kaw Reservoir, and Site 3 below the confluence of Greasy Creek with the Arkansas River 37.8 miles below Kaw Reservoir in Section 24, Township 23N, Range 4E.

A vacant wooden box on the Highway 11 bridge (Photo 1) made a convenient installation for the Site 1 thermograph. Specially designed steel boxes were fabricated for Sites 2 and 3. The thermograph at Site 2 was mounted in one of these boxes on a pole on the east bank of the river (Photos 2-4). The Site 3 thermograph was placed in the other steel box but mounted on an oil well drilling platform located in the river adjacent to the north bank (Photo 5). To prevent vandalism the leak proof wooden and metal boxes were locked.

The thermographs (T-12 Recorders) purchased for this study were made by Texas Gauge Company. The T-12 has 1% accuracy over the full scale from 0 to 120°F at 2°F intervals. Each recorder is operated by battery and has a 7 day chart drive rotation, therefore charts were changed about every 7 days.

In situ temperature monitoring was conducted at each station with a Hydrolab 6D Surveyor for cross-sectional data to determine temperature variation. Additional monitoring was performed between Site 2 and Osage OG&E to examine the plant's thermal mixing zone. Cross-sectional data at intervals of approximately 10 feet were taken at three transects; (1) 126 yards, (2) 350 yards, and (3) 550 yards downstream from the Osage OG&E facility as determined with a Rangematic Distance Finder. Generally a surface and bottom temperature were recorded as the flow was minimal and river depth varied usually from 6 inches to a maximum of approximately 3.5 feet. Transect data for Sites 1 and 3 were taken at various width intervals generally at the surface and bottom.

OWRB coordinated with the Corps of Engineers, Tulsa Division, to alter the discharge from Kaw Reservoir prior to and during the *in situ* cross-sectional monitoring during August because a general standard, such as a temperature maximum, applies "to all perennial streams of the State with the exception of when flow is less than the seven-day two-year low flow value," as stated in Oklahoma's Water Quality Standards, 1976. This coordination allowed this regulatory low flow condition to be approximated.

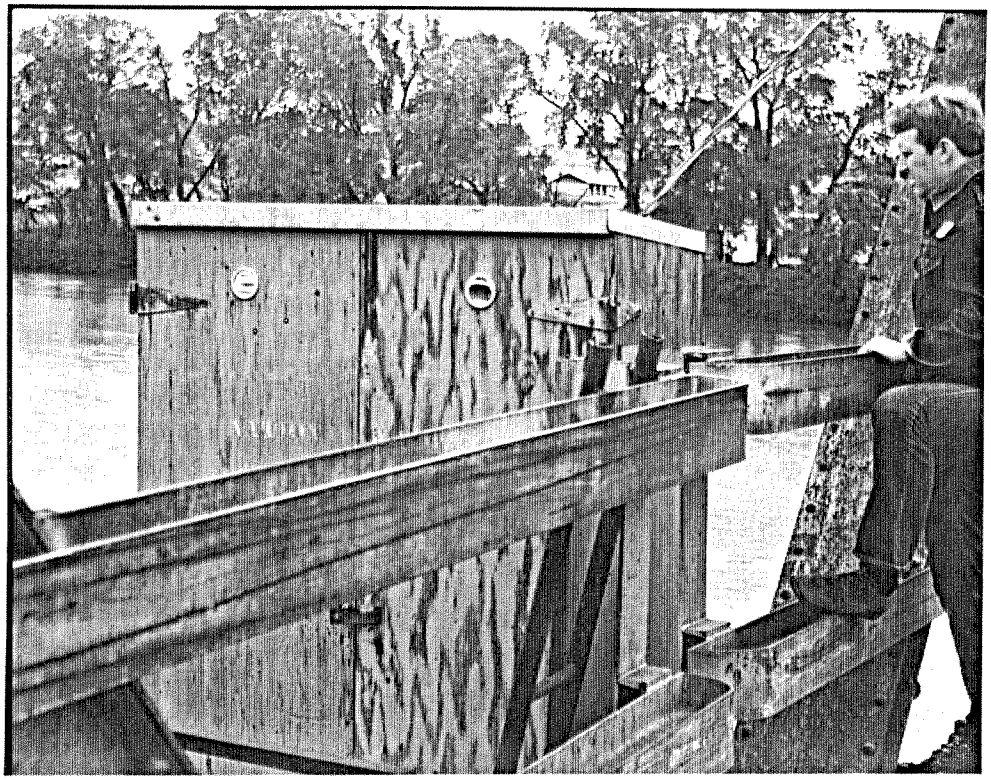


Photo 1. Wooden box for thermograph at Site 1 on the Arkansas River. Site 1 is located above the OG&E Osage facility on Highway 11 bridge.

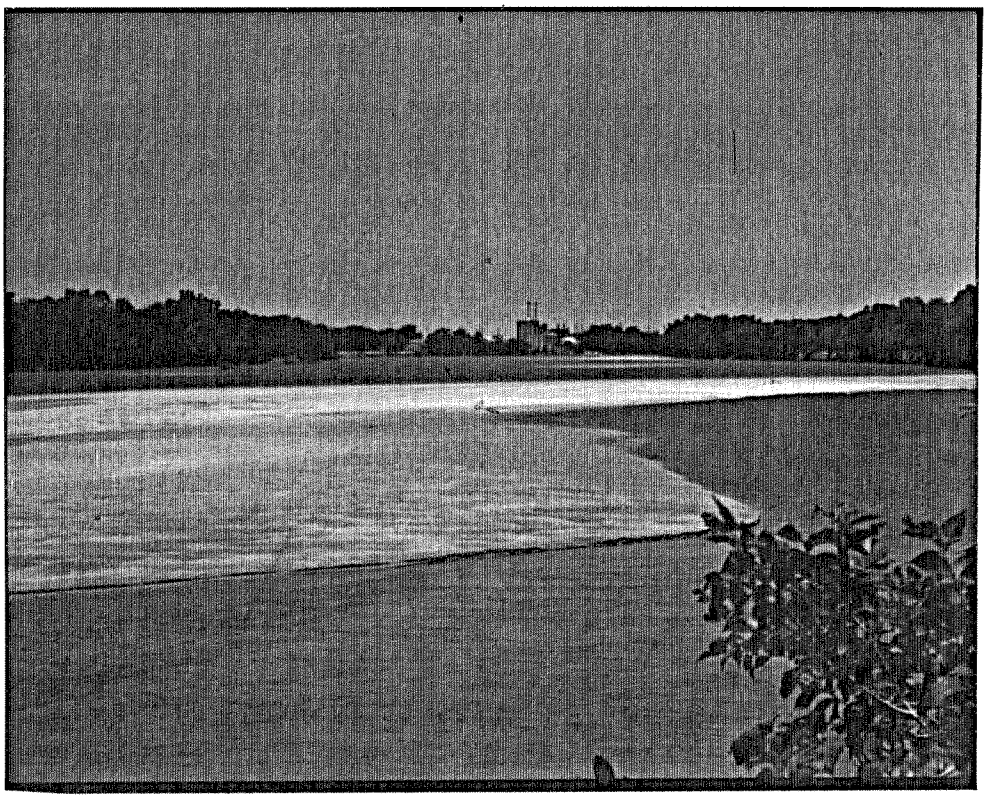
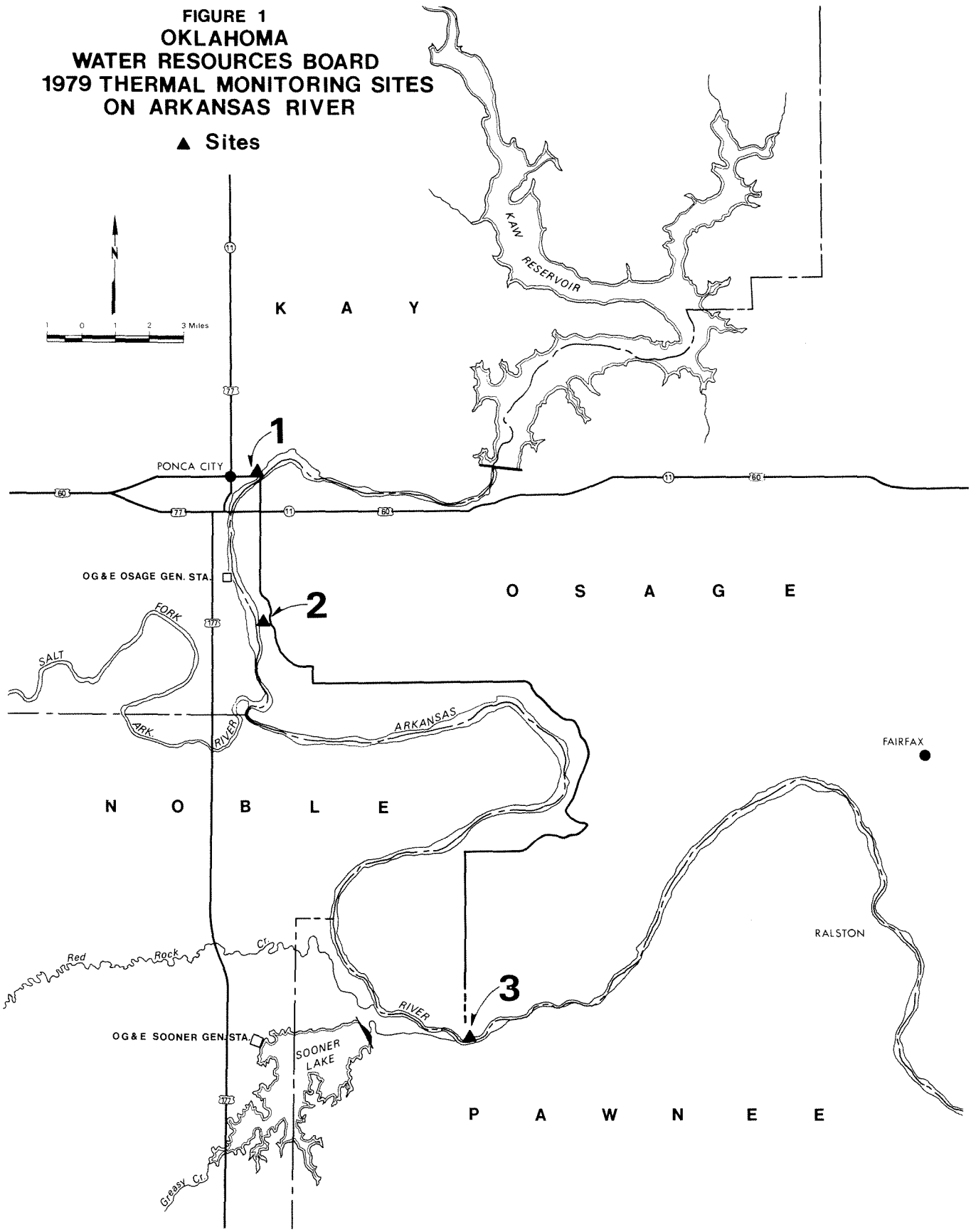
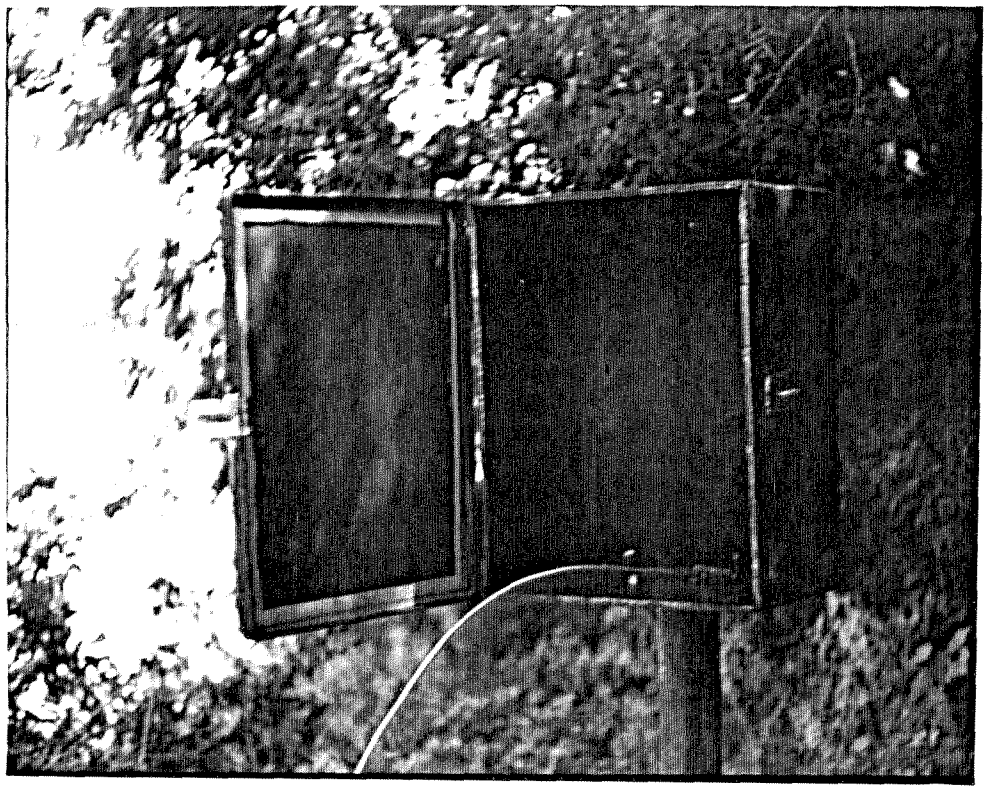


Photo 2. OG&E Osage facility as seen upstream from temperature monitoring Site 2 on the Arkansas River.

FIGURE 1
OKLAHOMA
WATER RESOURCES BOARD
1979 THERMAL MONITORING SITES
ON ARKANSAS RIVER

▲ Sites





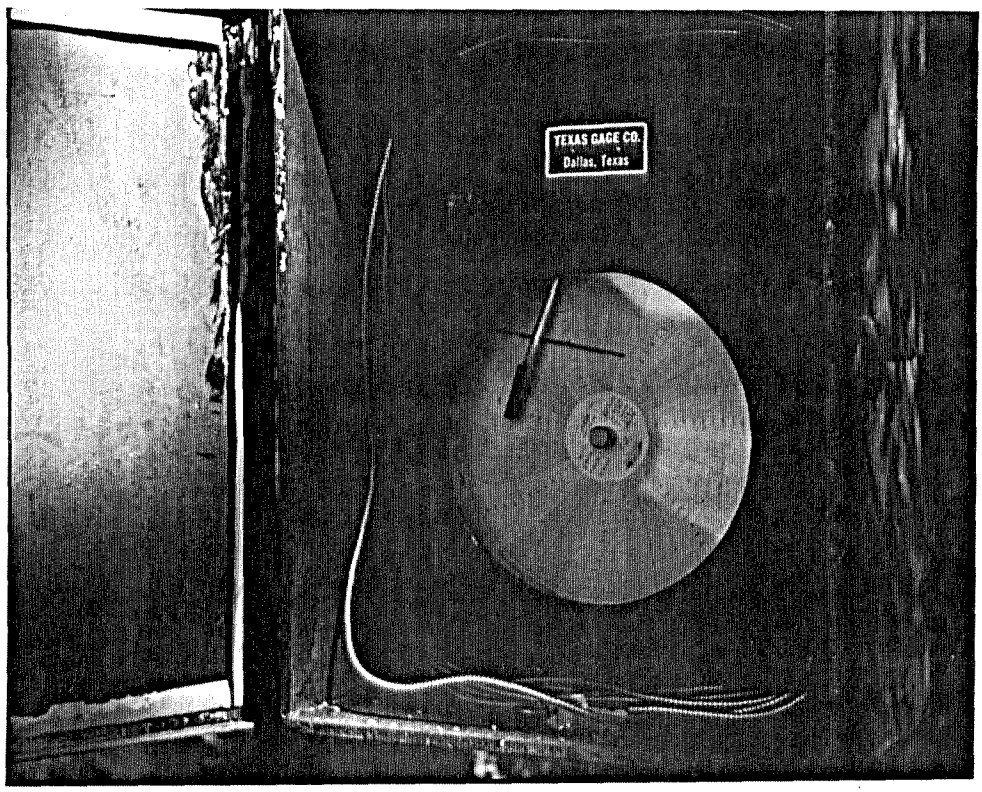
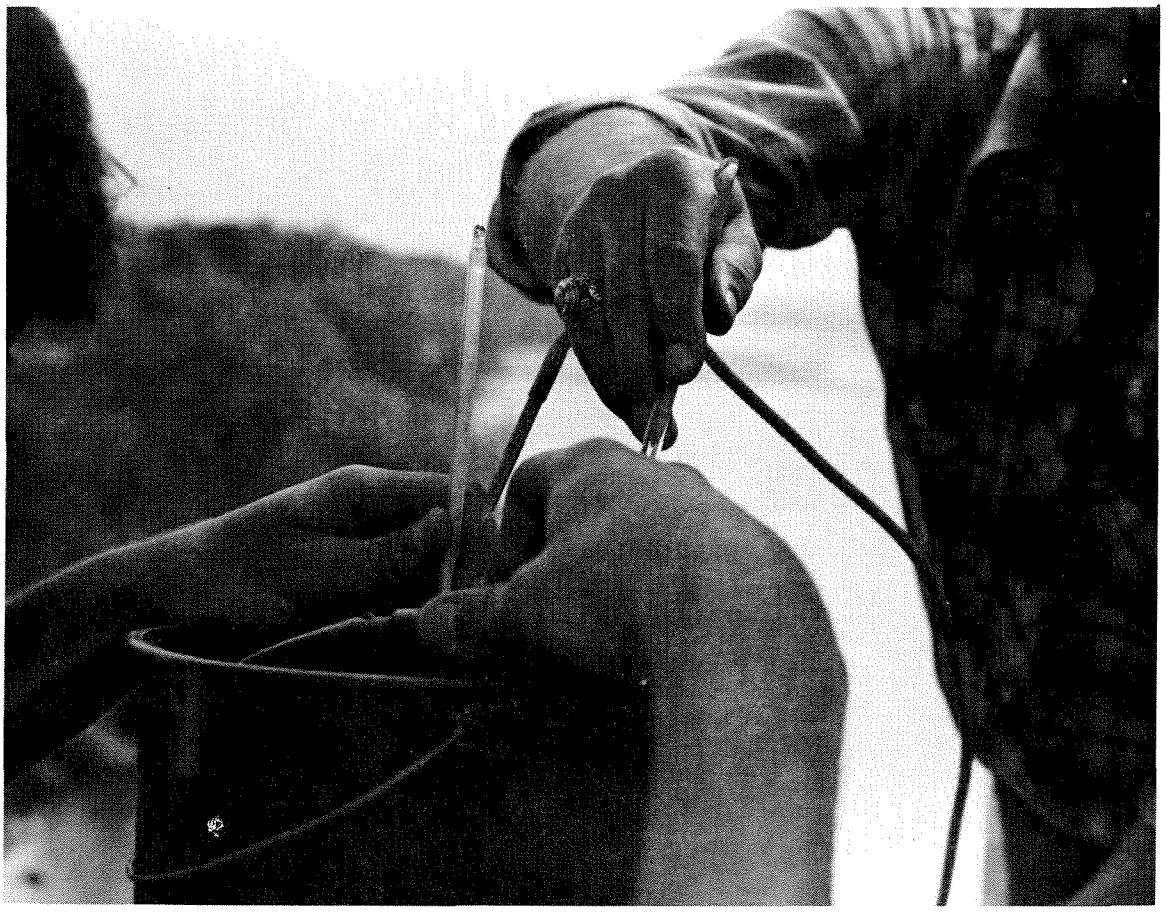


Photo 3 & 4. Steel box and thermograph inplace at Site 2 on the Arkansas River.

Photo 5. The drilling platform at Site 3 in the Arkansas River below the OG&E Sooner facility. A thermograph was installed on this platform.

At each chart change the river temperature adjacent to the thermograph probe was checked with a pocket thermometer and compared to the recorded temperature as a means of checking calibration. If a large difference was noted, a calibration adjustment was made.

Prior to installation each thermograph was calibrated utilizing certified mercury filled thermometers. An *in situ* calibration check was made on the thermographs and Hydrolab at the end of the study with a National Bureau of Standards (NBS) certified mercury filled thermometer. This NBS thermometer was then compared in a laboratory to the certified thermometers used at the initiation of the study. These calibration checks were made by heating and cooling water appropriately.



SECTION III
RESULTS AND DISCUSSION

Initial calibration temperatures for the certified thermometers and thermographs are found in Table 1. Tagliabue Division of Marshalltown, Iowa, carefully compared these thermometers to an NBS certified standard. Appendix A contains the certificates for these certified thermometers. The thermographs were calibrated in the laboratory and then carefully transported to the study area for installation.

The calibration check at the end of the 1979 summer monitoring season indicated thermograph 2804 at Site 1 retained adequate calibration, but thermograph 2837 at Site 2 recorded a few degrees more than the 66.0 and 99.0°F certified readings (see Table 2). But in essence this data indicates that the thermographs did not substantially change from the initial calibration. However, thermograph 2837 at Site 2 needed calibration adjustment on August 3 (Table 4). The commencement and termination dates for this monitoring period are in Table 3. Thermograph 2836 at Site 3 malfunctioned during the study and therefore did not record temperature data past August 24.

Only three potential point source discharges were identified in the river segment studied (Table 5), however, only two of these actually discharged into the river, OG&E Osage and the Ponca City sewage treatment facility. OG&E Sooner cannot discharge into the river via Greasy Creek until the cooling reservoir is at the normal pool elevation. Of these three discharges, OG&E Osage has more potential to impact the aquatic environment due to once-through cooling. The largest tributaries of this segment of the Arkansas River are Red Rock Creek and the Salt Fork of the Arkansas.

During the 1979 monitoring period no temperatures of 90°F or higher were observed in the main channel of the Arkansas River. The maximum temperature recorded was 88°F (31.1°C) during low flow conditions in July at Site 1 (Tables 7 and 8). As this summer was rather mild this 88°F river maximum was not unreasonable (See Table 9).

Sites 2 and 3 could have possibly reached higher maximums if similar low flow/ambient air temperature conditions existed within their recording periods.

Table 1. Commencement calibration comparisons for the 1979 Arkansas River Temprature Survey (calibration certificates in Appendix).

Certified Thermometers* (Serial Nos.)			T-12 Thermographs (Meter Nos.)		
M693119	M692389	B692387	2804 (Site 1)	2836 (Site 3)	2837 (Site 2)
98.0°F					98°F
	31.7			32	32
98.1					98
	31.8			32	
	31.7			32	
97.6				98	97
		78.1		78	78
99.45			99.5		
		78.84	78.5		
		78.7	78.0		
		78.65	78.0		

* Tagliabue Division, Marshalltown, Iowa, carefully compared these thermometers to an NBS certified standard.

Table 2. Calibration verification for the 1979 Arkansas River Temperature Study season termination. Calibration checks were made on October 11 and 12.

Certified Thermometers Model Nos. °F				T-12 Thermographs Model Nos. °F		Hydrolab Model Nos. °C (°F)
NBS 96135	692387	M693119	692389	2804 (Site 1)	2837 (Site2)	373-12
99.0					102.0	
112.5				113.0		
66.0					68.0	
64.5				64.0		
32.5					32.0	
35.0				35.0		
100.4		100.4				38.0 (100.4)
77.9	78.0					25.5 (77.9)
32.0			32.0			0.25 (32.45)

Table 3. OWRB Arkansas River temperature monitoring periods for the 1979 summer season.

Site	Thermograph Model	Initiation	Termination
1	2804	June 15	October 12
2	2837	July 27	October 12
3	2836	July 26	August 20

Table 4. Recalibration data* for thermograph 2837 at Site 2 is presented. Certified thermometer 520629 had been previously verified to the primary certified thermometers of Table 1.

Certified Thermometer 520629	Thermograph 2837
96.0	97
85.2	85
31.6	26

* Once these values were obtained, no further adjustments were made.

Table 5. Arkansas River tributaries and associated potential point source discharges that may affect the river segment in question.

Pawnee County

Red Rock Creek
Greasy Creek*
OG&E Sooner**

Kay County

Ponca City Sewage Outfall**
OG&E Osage**

Osage County

Charley Creek
Pretty Hair Creek
Little Drum Creek
Simpkins Creek
Dry Creek
Big Drum Creek

*Major Tributary
**Point Source Discharge

Table 6. Arkansas Thermal Project daily water temperature data for Site 1 with maximum ambient air temperature (MAT) and discharge flow rate from the Corps of Engineers at Kaw Dam for June 1979.

DATE	MAT	FLOW	MAXIMUM	MINIMUM
15	90	20500		
16	93	11700	73	69
17	91		79	69
18	92	7000		
19	88			
20	88	3100		
21	87			
22	73			
23	93		81	75
24	90	1600	79	71
25	87		80	73
26	77		79	72
27	82	6200	79	72
28	85		78	72
29	89		78	71
30	89	4100	80	71
31	92		78	71

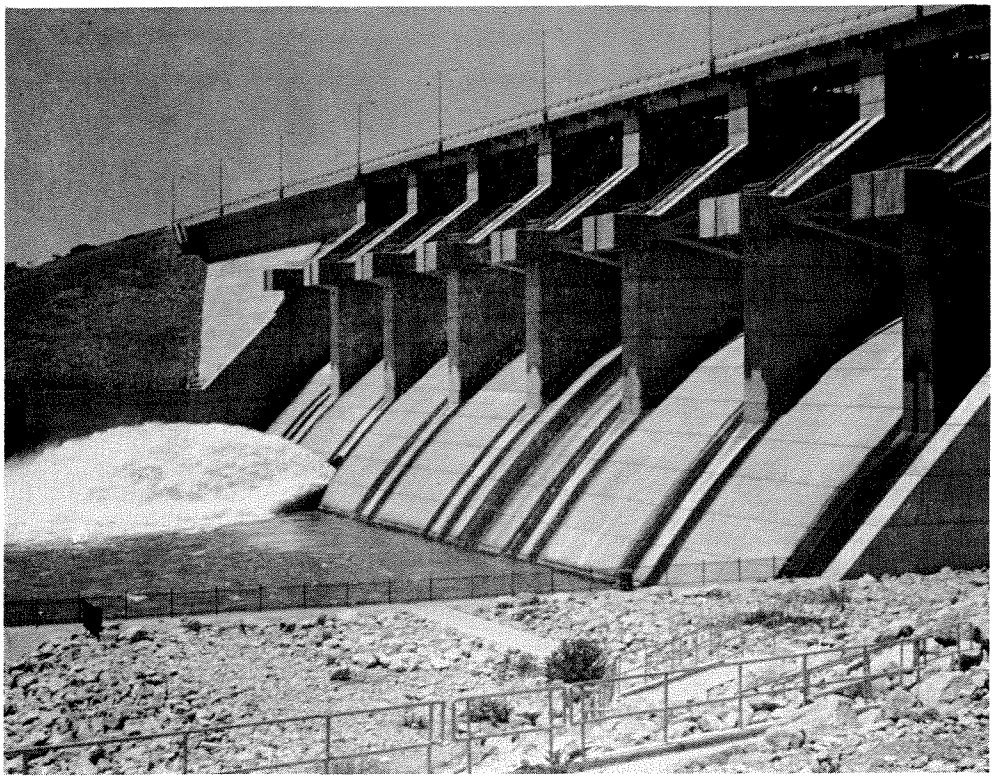


Table 6. Continued - Sites 1 and 3 for July 1979.

DATE	MAT	FLOW	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM
1	85	4100	77	71		
2	98		79	70		
3	95		81	71		
4		2000	82	71		
5	100		80	71		
6	100		79	72		
7	81		80	73		
8	83		83	72		
9	93		81	72		
10	97		83	72		
11	96		82	72		
12	94		82	72		
13	96		82	72		
14	97	300	88	72		
15	99		83	73		
16	93		88	73		
17	96		78	73		
18	81	3100	78	73		
19	84		79	73		
20	85	4460	81	74		
21	89		80	74		
22	83		79	74		
23	82		78	74		
24	77		81	75		
25	86		81	75		
26	83		80	74	80	74
27	84		80	74	81	79
28	82		81	75	81	79
29	89		81	74	81	79
30	93		80	74	81	79
31	92		78	74	80	77

Table 6. Continued - Sites 1, 2, and 3 for August 1979.

DATE	MAT	FLOW	SITE 1		SITE 2		SITE 3	
			MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM
1	92		82	75				
2	79		81	75			79	78
3	83		82	75			80	78
4	83		82	75	80	78		
5	86		81	75	79	78		
6	88		83	75	80	78		
7	88	2200	83	74	82	77		
8	87		83	74	82	77		
9	86		82	74	81	77		
10	84		83	74			83	77
11	88	300	81	79			80	74
12	71		84	68			79	71
13			84	69			80	70
14	83		83	73			82	74
15	96		78	68			79	72
16	96		84	70			79	72
17	93		85	72			82	74
18	95		84	72			81	74
19	95		83	72			82	73
20	98		81	70			79	72
21	89	1140	84	71				
22	95		85	71				
23	90		83	69				
24	87		84	73				
25			80	71				
26			81	76				
27	89		79	72				
28	86		84	72				
29	95		83	72				
30	95		84	72				
31	94		74	69				

Table 6. Continued - Site 1 for September 1979.

DATE	MAT	FLOW	MAXIMUM	MINIMUM
1	77	140	84	72
2	93		84	73
3	88		84	72
4	91		84	72
5	92	2280	82	73
6	92		79	73
7	86		80	73
8	85		80	71
9	88	1140	80	71
10	87		81	70
11	88		81	71
12	87		81	71
13	86		77	69
14	77	580	75	66
15			77	66
16			78	66
17	78		78	65
18	83		79	66
19	86	290	75	67
20	85		73	68
21	76		76	66
22			77	64
23			77	65
24			77	66
25			78	67
26			77	67
27			76	66
28			76	67
29			78	65
30			77	66
31				

Table 7. Number of days with maximum water temperature ranges per site for duration of Arkansas River Thermal Project from June 15 to September 30, 1979.

Site	Temperature Ranges (°F)				Total Days
	<70	≥70<80	≥80<85	≥85<90	
1	5	45	60	4	114
2	0	1	5	0	6
3	0	5	15	0	20

Table 8. Summary of maximum water temperatures per site for duration of Arkansas River temperature study, June 15 to August 24, 1979.

Site	Date	Time	Max. Water Temp. °F	Max. Water Temp. °C	Max. Amb. Temp. °F	Max. Amb. Temp. °C	Discharge Volume
1	7/14	1815	88	31.1	97	36.1	300
	7/16	1815	88	31.1	93	33.9	300
	8/17	1730	85	29.4	93	33.9	300
	8/22	1630	85	29.4	95	35.0	1140
2*	8/7	1800	82	27.8	88	31.1	2200
	8/8	1800	82	27.8	87	30.6	2200
3	8/10	1900	83	28.3	84	28.9	2200
	8/14	1930	82	27.8	83	28.3	300
	8/17	1500	82	27.8	93	33.9	300
	8/19	1530	82	27.8	95	35.0	300

* Site 2 developed into a backwater area shortly after installation of monitoring device. As a result only one week was monitored in the main channel.

The maximum water temperature for this study occurred at Site 1 on July 14 and 16 at 1815 hours with associated maximum ambient temperatures of 97°F (36.1°C) and 93°F (33.9°C) respectively at 300 cfs (the 2 year 7 day low flow for the Arkansas River below Kaw Reservoir is 500 cfs). Site 1 data spanned a 3.5 month period from June 15 to September 30 (Table 7).

Site 2 data reflects a 6 day period from August 4 to August 9 due to calibration complications prior to August 4 and an extended period of temperature fluctuations representative of a backwater area occurring after August 9 due to the low flow conditions. Maximum temperatures of 82°F (27.8°C) occurred on August 7 and 8 at 1800 hours during a 2200 cfs flow with maximum ambient temperatures of 88°F (31.1°C) and 87°F (30.6°C), respectively.

Site 3 became operative on July 26 and functioned until August 20. A maximum temperature of 83°F (28.3°C) occurred on August 10 at 1900 hours during 2200 cfs flow with a maximum ambient temperature of 84°F (28.9°C). Secondary high readings of 82°F (27.8°C) occurred on August 14, 17, and 19 between 1500 hours and 1930 hours during low flow conditions of 300 cfs with maximum ambient temperatures of 83°F (28.3°C), 93°F (33.9°C), and 95°F (35.0°C), respectively.

Table 10 displays the cross-section data monitored below the OG&E Osage Power Plant. A thermal variance of 3°C (5.4°F)* was observed in transect 2a with a high temperature of 29°C (84.2°F) obtained on the west shore, 126 yards below the Osage facility. In transect 2b (350 yards below the plant) a 1°C (1.8°F) variance was observed also with the warmer water near the shore, and transect 2c (550 yards below the plant) the variation across the river was 0.5°C (0.9°F).

Transect data at sites 1 and 3 (Table 11) repeatedly showed isothermal conditions across the river with maximum variations of 0.5°C (0.9°F), The non-isothermal conditions exhibited at sites 2a, 2b, 2c, and 2 appear to result from two thermal influences; 1) the thermal effluent from the OG&E Osage Power Plant, and 2) solar radiation accompanied by low flow conditions (300 cfs) and the presence of sand bars. At transect 2a, a 3°C (5.4°F) increase occurs along the west shore below the OG&E thermal discharge. This increase identifies the presence of OG&E's thermal plume mixing zone. At transect 2b, the 1°C (1.8°F) variance indicates that the mixing zone has become dispersed across a large portion of the river. Problems allowing clear definition of this mixing zone arise primarily due to solar radiation, low flow conditions, and the presence of sand bars in this portion of the river. Overall temperature increases from transect 2b to 2c and 2c to 2 can be partially explained by caloric uptake due to solar radiation (Table 10). Sand bars within each transect tend to channelize separate currents with resulting isothermal conditions per channel. Accompanying low flow conditions tend to create sand bar isolated backwater areas of fluctuating temperatures.

* Transect temperatures were recorded using a Hydrolab which utilizes the centigrade scale (°F are shown in parenthesis).

Table 9. Mean number of days with observed ambient air temperature 100°F or greater for fifteen year period compared to 1979. Fifteen year data from U.S. Weather Bureau remote reading indicator #206279ESSA at the FAA Flight Service Station at Ponca City, Oklahoma.

	Mean Number of days with Ambient Air Temperature ≥100°F (from U.S. Weather Service, 1955-1969)	Recorded Number of days with Ambient Air Temperature ≥100°F for 1979
May	<0.5	0
June	1	0
July	7	2
August	6	0
September	1	0
October	0	0
Annual mean 15 days		*1979 - 2

* 1978 extreme ambient air temperatures from the Corps of Engineers Kaw Project of July 10 - 106°F and August 19 - 103°F.

Table 10. 1979 Arkansas River Thermal Project Cross Section Data at 300 cfs. Transect temperature recorded in °C at ten foot intervals from the west shore to the east shore.

Interval West to East shore	Site 1 August 17		Site 2a August 16		Site 2b August 16		Site 2c August 16		Site 2 August 16		Site 3* August 17	
	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
0	26.5		29.0	28.5	28.5	28.5	28.5	28.5	29.5	29.0	29.5	29.5
10	26.75	26.75	28.5	28.5	28.5	28.5		28.5	29.5	29.5	29.5	29.5
20	26.75	26.75	27.5	27.5	28.0	28.0		28.5	Sand bar		29.5	29.5
30	26.75	26.75	26.5	26.5	28.0	28.0		28.5	29.0	29.0	29.5	29.5
40	27.0	27.0	26.0	26.0	28.0	27.5		28.5	29.0	29.0	29.5	29.5
50	27.0	27.0	26.0	26.0	27.5	27.5		28.0	29.0	29.0	29.5	29.5
60	27.0	27.0	26.0	26.0	27.5	27.5			29.0	29.0	Sand bar	
70			26.0	26.0	27.5	27.5		28.0	28.5		29.5	29.5
80			Sand bar		27.5	27.5			Sand bar		29.5	29.5
90			26.5					28.0	30.0		29.0	29.5
100			26.5						28.5		29.5	29.5
110			26.5					28.0	28.5		29.0	
120			26.5					28.0			29.0	
130			26.5								29.5	29.5
140			26.5				28.0	28.0			29.5	
150			26.5								30.0	30.0
160			26.5				28.0	28.0			30.0	30.0
170			Sand bar				28.0	28.0			29.5	30.0
180			26.0								30.0	
190			26.5									

* Site 3 transect data taken from south to north shore as river meanders.

Table 11. 1979 Arkansas River Thermal Project Cross Section Data at 300 cfs. Transect temperature recorded in °C at ten foot intervals from the west shore to the east shore.

INTERVAL WEST TO EAST SHORE	AUGUST 3				AUGUST 10			
	SITE 1		SITE 3		SITE 1		SITE 3	
	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM	SURFACE	BOTTOM
0	28.0	28.0	31.0	31.0	29.5		27.5	27.5
10	28.0	28.0	31.0	31.0	29.5	29.5	27.5	27.5
20	28.0	28.0	31.0	31.0	29.0	29.0	27.5	27.0
30	28.0	28.0	31.0	31.0	29.0	29.0	27.0	27.0
40	28.0	28.0	31.0	31.0	29.0	29.0	27.0	27.0
50	28.0	28.0	31.0	31.0	29.0	29.0	27.5	27.5
60	28.0	28.0	31.0	31.0	29.0	29.0	27.0	27.0
70	28.0	28.0	31.0	31.0	29.0	29.0		
80	28.0	28.0	31.0	31.0	29.0			
90	28.0	28.0	31.0	31.0	29.0			
100	28.0	28.0	31.0	31.0	29.0	29.0		
110	28.0	28.0	31.0	31.0	29.0	29.0		
120	28.0	28.0	31.0	31.0	29.0	29.0		
130	28.0	28.0	31.0	31.0	29.0	29.0		
140	28.0	28.0	31.0	31.0	29.0	29.0		
150	28.0	28.0	31.0	31.0	29.0	29.0		
160	28.0	28.0	31.0	31.0	29.0	29.0		
170	28.0	28.0	31.0	31.0	29.0	29.0		
180	28.0	28.0	31.0	31.0	29.0	29.0		
190	28.0	28.0	31.0	31.0	29.0	29.0		
200	28.0	28.0	31.0	31.0	29.0	29.0		
210	28.0	28.0	31.0	31.0	29.0	29.0		
220			31.0	31.0	29.0	29.0		
230			31.0	31.0	29.0	29.0		
240			31.0	31.0				
250			31.0	31.0				
260			31.0	31.0				
270			31.0	31.0				
280			31.0	31.0				
290			31.0	31.0				

* Site 3 transect data taken from south to north shore as river meanders.

Temperature is a nonconservative parameter, i.e., a parameter whose values change with downstream flow and diffusion. Therefore, the combination of the nonconservative nature of temperature with the effects of diffusion and solar heating greatly clouds the defining of a mixing zone pertaining to temperature. However, the thermal discharge of the OG&E Osage Power Plant appeared effectively dissipated within 350 yards downstream of its source in this mixing zone evaluation.

LITERATURE CITED

1. Oklahoma Water Resources Board. Oklahoma's Water Quality Standards 1976. Publication 79, Oklahoma City, Oklahoma.

2. Huntzinger, Thomas L., 1978. Low-Flow Characteristics of Oklahoma Streams. U.S. Department of the Interior, Geological Survey, Open-File Report 78-166.

APPENDIX

THERMOMETER CERTIFICATES

Certificate
for
LIQUID-IN-GLASS THERMOMETER

erial No. B692387 Immersion TOTAL
ange 74.5/79.5F Graduated 0.1

The thermometer bearing the above identification as carefully compared with a National Bureau of tandards certified Standard in accordance with methods ecommended by that institution. The following readings ere observed:

Standard Temperature	Thermometer Reading	Correction To Reading
32.00	32.02	-0.02
77.00	77.02	-0.02
79.00	79.03	-0.03

Date: 2-27-69
ests supervised by D.F.W

TAGLIABUE DIVISION
MARSHALLTOWN MANUFACTURING INC.
MARSHALLTOWN, IOWA, U.S.A.

FORM 63 A

Certificate
for
LIQUID-IN-GLASS THERMOMETER

Serial No. B692119 Immersion TOTAL
Range 97.5/102.5F Graduated 0.1

The thermometer bearing the above identification was carefully compared with a National Bureau of Standards certified Standard in accordance with methods recommended by that institution. The following readings were observed:

Standard Temperature	Thermometer Reading	Correction To Reading
32.00	31.98	+0.02
100.00	100.03	-0.03
102.00	102.03	-0.03

Date: 1-15-70
Tests supervised by D.F.W

TAGLIABUE DIVISION
MARSHALLTOWN MANUFACTURING INC.
MARSHALLTOWN, IOWA, U.S.A.

FORM 63 A

Certificate
for
LIQUID-IN-GLASS THERMOMETER

erial No. B692389 Immersion TOTAL
ange 74.5/79.5F Graduated 0.1

The thermometer bearing the above identification as carefully compared with a National Bureau of tandards certified Standard in accordance with methods ecommended by that institution. The following readings ere observed:

Standard Temperature	Thermometer Reading	Correction To Reading
32.00	32.03	-0.03
77.00	77.03	-0.03
79.00	79.02	-0.02

Date: 2-27-69 D.F.W
Tests supervised by

TAGLIABUE DIVISION
MARSHALLTOWN MANUFACTURING INC.
MARSHALLTOWN, IOWA, U.S.A.

FORM 63 A

UNITED STATES DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, D.C. 20234

August 22, 1979

In reply refer to:
522/221332

Labco Scientific Division
3 East Main
Oklahoma City, Oklahoma 73104

Attention: Dean Porter

Subject : Thermometric Test
Order No: 9136

Gentlemen:

Enclosed are results of the test which you requested in the above reference. Please refer to the above file number in any later communication, and if you have any questions concerning this test, contact Jacquelyn A. Wise, telephone number (301) 921-2087.

Sincerely yours,

James F. Schooley

James F. Schooley
Chief, Temperature Measurements
and Standards Division
Center for Absolute Physical Quantities

Material tested:

1 Thermometer

Enclosure:

1 Report of Calibration

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
NATIONAL MEASUREMENT LABORATORY
WASHINGTON, D.C. 20234

REPORT OF CALIBRATION

LIQUID-IN-GLASS THERMOMETER

TESTED FOR: LABCO SCIENTIFIC DIVISION

MARKED: TCA 96135
RANGE: -31 TO +124 DEGREES F IN 1 DEGREE

THERMOMETER READING	CORRECTION (IPTS-68)**
85.00 F	-.42 F
90.00	-.39
95.00	-.44
100.00	-.40

**ALL TEMPERATURES IN THIS REPORT ARE BASED ON THE INTERNATIONAL PRACTICAL TEMPERATURE SCALE OF 1968, IPTS-68. THIS TEMPERATURE SCALE WAS ADOPTED BY THE INTERNATIONAL COMMITTEE OF WEIGHTS AND MEASURES AT ITS MEETING IN OCTOBER, 1968, AND IS DESCRIBED IN "THE INTERNATIONAL PRACTICAL TEMPERATURE SCALE OF 1968 AMENDED EDITION OF 1975," METROLOGIA 12, NO. 1, 7-17 (1976).

ESTIMATED UNCERTAINTIES IN THE ABOVE CORRECTIONS DO NOT EXCEED 0.5 DEGREE UP TO 124 DEGREES F .

FOR A DISCUSSION OF ACCURACIES ATTAINABLE WITH SUCH THERMOMETERS SEE NATIONAL BUREAU OF STANDARDS MONOGRAPH 150, LIQUID-IN-GLASS THERMOMETRY.

IF NO SIGN IS GIVEN ON THE CORRECTION, THE TRUE TEMPERATURE IS HIGHER THAN THE INDICATED TEMPERATURE; IF THE SIGN GIVEN IS NEGATIVE, THE TRUE TEMPERATURE IS LOWER THAN THE INDICATED TEMPERATURE. TO USE THE CORRECTIONS PROPERLY, REFERENCE SHOULD BE MADE TO THE NOTES GIVEN BELOW.

THE THERMOMETER WAS TESTED IN A LARGE, CLOSED-TOP, ELECTRICALLY HEATED, LIQUID BATH AT AN IMMERSION OF 76 MM . THE TEMPERATURE OF THE ROOM WAS ABOUT 23 DEGREES C (73 DEGREES F). IF THE THERMOMETER IS USED UNDER CONDITIONS WHICH WOULD CAUSE THE AVERAGE TEMPERATURE OF THE EMERGENT LIQUID COLUMN TO DIFFER MARKEDLY FROM THAT PREVAILING IN THE TEST, APPRECIABLE DIFFERENCES IN THE INDICATIONS OF THE THERMOMETER WOULD RESULT.

NOT TESTED OVER THE ENTIRE RANGE OF SCALE.

FOR THE DIRECTOR,
NATIONAL MEASUREMENT LABORATORY

TEST NUMBER 221332
COMPLETED 8-21-79

JAMES F. SCHOOLEY
CHIEF, TEMPERATURE MEASUREMENTS
AND STANDARDS DIVISION
CENTER FOR ABSOLUTE PHYSICAL QUANTITIES