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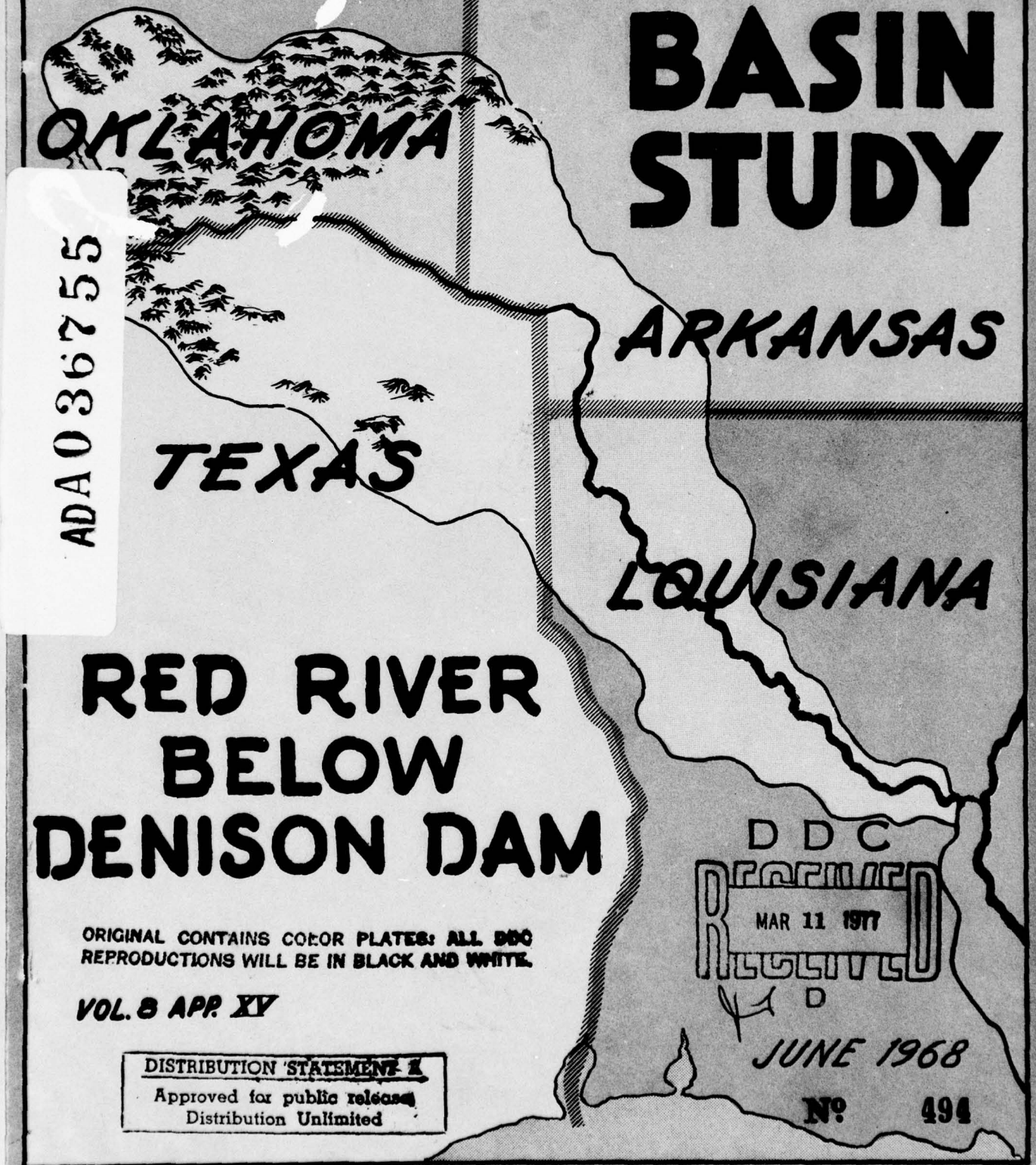
COMPREHENSIVE BASIN STUDY



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ORIGINAL CONTAINS COLOR PLATES: ALL DDC REPRODUCTIONS WILL BE IN BLACK AND WHITE.

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RED RIVER BELOW DENISON DAM
ARKANSAS, LOUISIANA, OKLAHOMA, AND TEXAS
COMPREHENSIVE BASIN STUDY

VOLUME INDEX

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Volume 2	-	Appendix I	- Economics
		Appendix II	- Climate and Meteorology
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Volume 7	-	Appendix XIV	- State Water Laws, Policies, and Programs
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(6) Comprehensive Basin Study.

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ARKANSAS, LOUISIANA, OKLAHOMA, AND TEXAS
~~COMPREHENSIVE BASIN STUDY~~

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Appendix XV.

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APPENDIX XV

PLAN FORMULATION

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Red River Basin Coordinating Committee

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PLAN FORMULATION

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APPENDIX XV

PLAN FORMULATION

INTRODUCTION

1. PURPOSE AND SCOPE

This appendix presents the proposed comprehensive plan of development for the basin and describes and analyzes the planning processes leading to its development. The plan is designed to meet existing and anticipated water and associated land resource needs of the Red River Basin below Denison Dam for the next 100 years. These needs include: water supply for municipal, industrial and irrigation uses; water quality control; flood control; drainage; watershed protection and flood prevention; navigation; bank stabilization; hydroelectric power, grazing and cropland improvements; forestry production; outdoor recreation; fish and wildlife enhancement; regional development; environmental preservation; and control of disease-bearing vectors. The plan is developed in sufficient detail to be used as a basis for obtaining Congressional authorization for projects required within the next 10-15 years, as well as providing a framework for future development of the basin's resources.

The formulation process recognized that increasing the national wealth, encouraging economic development in the Red River Basin, and preserving and enhancing the physical environment of the basin are all appropriate objectives of water resource development. In developing the plan, alternative projects and plans to satisfy the various needs of the basin were assembled. These alternative projects were then evaluated and compared to isolate those that would contribute most to the basin's economy. The basic yardstick utilized in comparing alternatives was the national efficiency objective. The use of this yardstick was, however, tempered by consideration of the less tangible economic and social impacts of the alternative projects.

2. RELATIONSHIP TO OTHER APPENDIXES

This appendix is the vehicle for summarizing and analyzing the physical and economic data generated throughout the study. It was

prepared subsequent to 14 appendixes representing the total interdisciplinary input for the study to this comprehensive report, since it draws on these other appendixes for basic data. In order to ensure the development of a fully coordinated comprehensive plan, this appendix was prepared by a Plan Formulation Task Force composed of representatives from all of the agencies participating in the study. Table 1 lists the Federal and State agencies that participated in formulation of the basic plan; table 2 lists the various appendixes and the agencies with primary responsibility for their preparation.

3. BASIN IMPROVEMENTS

Substantial progress has been made in the past 25-30 years by Federal and non-Federal interests in solving the water and related land resource problems of the Red River Basin below Denison Dam. Significant water resource projects that are existing, authorized, or under construction in the basin are described in the following paragraphs and are shown on figure 1. No attempt is made to list all of the projects in the basin; rather, coverage is limited to those projects which affect large areas of the basin and have a significant impact on the development of the area's water resources.

a. Existing and authorized Federal projects.

(1) Corps of Engineers.

(a) Navigation. In 1892, a Federal navigation project providing for the improvement of Red River for navigation from its mouth to Fulton, Arkansas, by snagging, dredging shoals, and other measures, was authorized. No channel dimensions were specified in the authorizing act, and at this time a dependable navigation channel exists only from the mouth of the Red River to its confluence with the Black River. The Caddo Dam was constructed in 1914 to provide a controlling depth of 4 feet in a project authorized in 1872, for navigation from the vicinity of Shreveport, La., to Jefferson, Tex. Use of this dimensionally inadequate channel has essentially disappeared and it is no longer maintained. Caddo Lake now serves as a source of water supply for communities and industries surrounding it. Incidental use of Caddo Lake for water supply, recreation, and marine servicing of oil wells has rendered the dam essential to the economy of the area, and it is being replaced under an authorized project. Construction of the replacement dam will begin early in July 1968. A 9- by 100-foot channel from the mouth of the Red River to Shreveport, La., was authorized in 1946. This project, known as the Overton-Red River Waterway, includes nine locks, a pumping plant, control structures, and appurtenant works. Construction of the lower 31 miles of this

TABLE 1

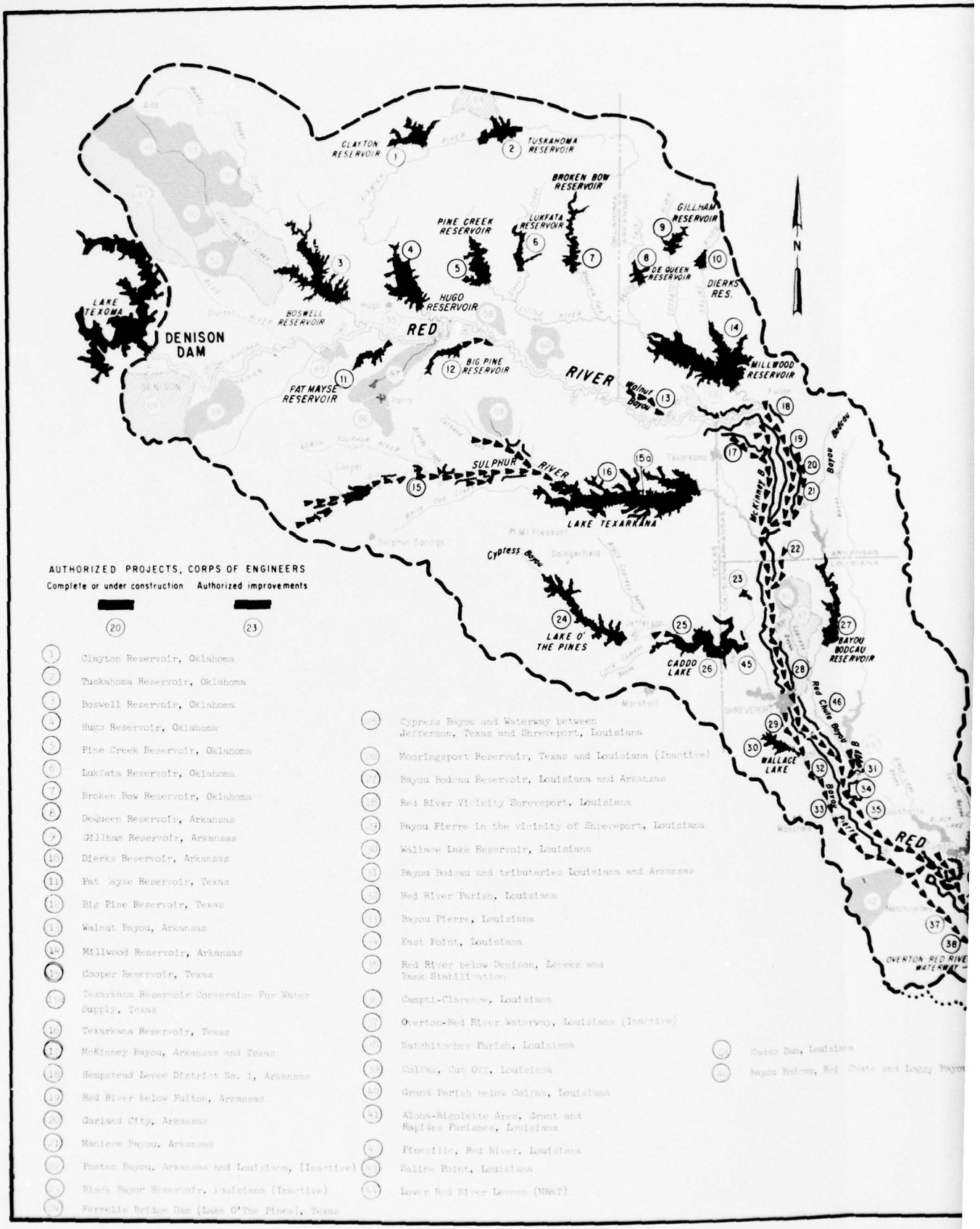
STUDY PARTICIPANTS

State or Federal Department	Field Agency	Abbreviation
Dept. of the Army (DA)	New Orleans Dist., Corps of Engineers	CE-NOD
	Tulsa Dist., Corps of Engineers	CE-TD
Dept. of Agriculture (USDA)	Soil Conservation Service	SCS
	Economic Research Service	ERS
	Forest Service	FS
Dept. of Commerce	Weather Bureau	ESSA
Dept. of the Interior	Bureau of Mines	BM
	Bureau of Outdoor Recreation	BOR
	Bureau of Reclamation	BR
	Bureau of Sport Fisheries and Wildlife	BSF&WL
	Federal Water Pollution Control Administration	FWPCA
	Southwestern Power Administration	SPA
	National Park Service	NPS
	U. S. Geological Survey	USGS
Dept. of Health, Education, and Welfare	Public Health Service	PHS
Federal Power Commission	Fort Worth Regional Office	FPC
State of Arkansas	Arkansas Soil and Water Conservation Commission	ASWCC
State of Louisiana	Department of Public Works	DPW
State of Oklahoma	Oklahoma Water Resources Board	OWRB
State of Texas	Texas Water Development Board	TWDB

TABLE 2

INTERAGENCY REPORT AND APPENDIXES

Appendix No.	Title	Prepared by
	Summary Report	Plan Form. Task Force
I	Economics	CE
II	Climate and Meteorology	ESSA
III	Hydrology, Surface and Ground Water, and Geology	CE & USGS
IV	Flood Control and Major Drainage	CE
V	Upstream Watershed Protection, Use, Management, and Development	USDA
VI	Irrigation	USDA & BR
VII	Drainage and Flood Prevention on Flatlands	USDA
VIII	Mineral Resources and Mineral Industry	BM
IX	Archaeological, Historical, and Natural Resources	NPS
X	Hydroelectric Power	FPC, SPA, & CE
XI	Water Supply and Water Quality Control	FWPCA
XII	Outdoor Recreation	BOR
XIII	Fish and Wildlife	BSF&WL
XIV	State Water Laws, Policies, and Programs	States of Ark., La., Okla. & Tex.
XV	Plan Formulation	Plan Form. Task Force



AUTHORIZED PROJECTS, CORPS OF ENGINEERS

Complete or under construction — Authorized improvements

(20) — (23)

1. Clayton Reservoir, Oklahoma
2. Tuskahoma Reservoir, Oklahoma
3. Boswell Reservoir, Oklahoma
4. Hugo Reservoir, Oklahoma
5. Pine Creek Reservoir, Oklahoma
6. Lukfata Reservoir, Oklahoma
7. Broken Bow Reservoir, Oklahoma
8. Dequeen Reservoir, Arkansas
9. Gillham Reservoir, Arkansas
10. Dierks Reservoir, Arkansas
11. Pat Mayse Reservoir, Texas
12. Big Pine Reservoir, Texas
13. Walnut Bayou, Arkansas
14. Millwood Reservoir, Arkansas
15. Cooper Reservoir, Texas
- Texarkana Reservoir Conversion For Water Supply, Texas
16. Texarkana Reservoir, Texas
17. McKinney Bayou, Arkansas and Texas
18. Hempstead Levee District No. 1, Arkansas
19. Red River below Fulton, Arkansas
20. Garland City, Arkansas
21. Maclene Bayou, Arkansas
- Foster Bayou, Arkansas and Louisiana, (Inactive)
- Black Bayou Reservoir, Louisiana (Inactive)
- Ferrells Bridge Dam (Lake O'The Pines), Texas
- Cypress Bayou and Waterway between Jefferson, Texas and Shreveport, Louisiana
- Mooringsport Reservoir, Texas and Louisiana (Inactive)
22. Bayou Bodcau Reservoir, Louisiana and Arkansas
- Red River Vicinity Shreveport, Louisiana
23. Bayou Pierre in the vicinity of Shreveport, Louisiana
24. Wallace Lake Reservoir, Louisiana
25. Bayou Bodcau and tributaries Louisiana and Arkansas
- Red River Parish, Louisiana
- Bayou Pierre, Louisiana
- East Point, Louisiana
26. Red River below Denison, Levees and Bank Stabilization
- Campti-Clarence, Louisiana
- Overton-Red River Waterway, Louisiana (Inactive)
- Natchitoches Parish, Louisiana
27. Colfax, Cut Off, Louisiana
28. Grand Parish below Colfax, Louisiana
29. Alpha-Bigolette Area, Grant and Rapides Parishes, Louisiana
- Pineville, Red River, Louisiana
30. Saline Point, Louisiana
31. Lower Red River Levees (MR&T)
- Caddo Dam, Louisiana
- Bayou Bodcau, Red Chute and Loggy Bayou

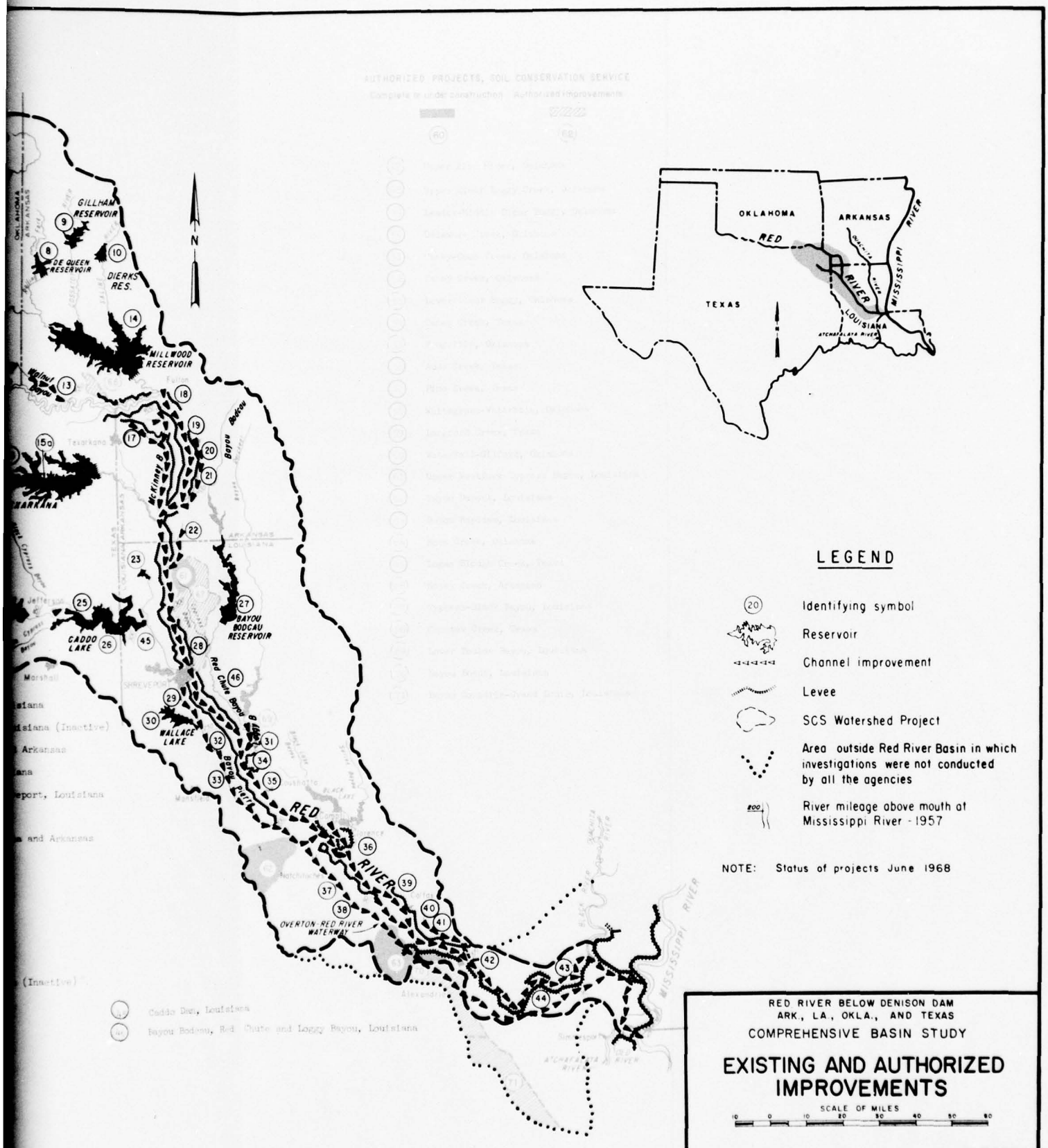

GILLHAM RESERVOIR
DE QUEEN RESERVOIR
DIERKS RES.
MILLWOOD RESERVOIR
Millwood Spillway
McKinney Bayou
Bayou Bodcau
MARKANA
CADDO LAKE
BAYOU BODCAU RESERVOIR
Red Chute Bayou
WALLACE LAKE
Bayou Pierre
RED RIVER
OVERTON-RED RIVER WATERWAY
MISSISSIPPI RIVER
N
OKLAHOMA
ARKANSAS
RED
RIVER
TEXAS
LOUISIANA
MISSISSIPPI RIVER
ATCHAFALAYA RIVER
LEGEND
20 Identifying symbol
Reservoir
Channel improvement
Levee
SCS Watershed Project
Area outside Red River Basin in which investigations were not conducted by all the agencies
800 River mileage above mouth at Mississippi River - 1957
NOTE: Status of projects June 1968
Caddo Dam, Louisiana
Bayou Bodcau, Red Chute and Loggy Bayou, Louisiana
RED RIVER BELOW DENISON DAM
ARK., LA., OKLA., AND TEXAS
COMPREHENSIVE BASIN STUDY
EXISTING AND AUTHORIZED IMPROVEMENTS
SCALE OF MILES
10 0 10 20 30 40 50 60
JUNE 1968
FILE NO. H-2-22654

FIGURE 1

project, which share a common alignment with the proposed Red River navigation project now pending authorization, will begin early in July 1968.

(b) Flood control. The Flood Control Act of July 24, 1946 approved a general plan for flood control on the Red River below Denison Dam which included, among other things, construction of six flood control reservoirs in combination with existing or authorized Federal and non-Federal levee improvements, modified as required, and construction of bank protection works at locations where levee setbacks were impossible or uneconomical. It further authorized incorporation into the project of several existing Federal projects for flood control along Red River below Denison Dam. Subsequent acts have amended this project to include a number of additional reservoirs on tributaries and other local protection works. Other smaller flood control projects have been authorized and constructed at various locations throughout the basin. The status of all specifically authorized Corps of Engineers flood control projects in the Red River Basin below Denison Dam is shown on tables 3 and 4.

(2) U. S. Department of Agriculture. Under the authority of the Soil Conservation Act of 1935 (Public Law 46), the USDA is providing technical assistance through Soil and Water Conservation Districts to the entire area in establishing farm conservation programs. Over 100,000 farm ponds have been constructed under the authority of this act.

As of December 31, 1962,twelve Public Law 566 watershed projects had been completed or approved for operations. These projects encompass about 1,316 square miles. They include 264 floodwater retarding and multiple-purpose reservoirs, 42 miles of channel improvement and irrigation delivery systems, and basic recreation facilities at one multiple-purpose reservoir. An additional 13 watershed projects in 14 CNI watersheds had been approved for operation through March 1968. These watersheds aggregate about 1,582 square miles. Improvements include 139 floodwater retarding and multiple-purpose reservoirs, 321 miles of stream channel improvement and irrigation delivery systems, and recreation facilities at five multiple-purpose reservoirs. Existing and authorized Upstream Watershed Projects are listed in table 5.

The National Forest System administers about 500,000 acres of land in the basin. These lands are managed for sustained timber production, watershed needs, range use, recreational use and fish and wildlife production. The National Grasslands program is similar but does not include commercial timber production. The State forestry agencies, in cooperation with the U. S. Forest Service, provide fire protection, timber management assistance, forest pest control, and forest planting stock for forest land owners in the basin.

TABLE 3

EXISTING, UNDER CONSTRUCTION, AND AUTHORIZED PROJECTS
U. S. ARMY ENGINEER DISTRICT, TULSA

Project	Stream	Total Storage (ac-ft)	Flood Control Storage (ac-ft)	Status	Estimated Cost	Purpose(1)
Boswell	Boggy Creek	1,130,000	1,100,000	Restudy	$ 24,100,000	FC, R, F&WL
Clayton	Jackfork Creek	290,500	104,000	Authorized	14,000,000	FC, R, F&WL
Tuskahoma	Kiamichi River	374,000	138,600	Authorized	17,600,000	FC, R, F&WL
Hugo	Kiamichi River	849,500	809,500	Under Const.	30,700,000	FC, R, F&WL, WQ
Pine Creek	Little River	465,800	388,000	Under Const.	21,200,000	FC, WS, WQ
Lukfata	Glover Creek	206,600	172,000	Authorized	13,400,000	FC, WS, WQ
Broken Bow	Mt. Fork River	1,368,800	450,000	Under Const.	39,600,000	FC, P, WS, WQ
De Queen	Rolling Fork	136,100	101,200	Under Const.	11,500,000	FC, WS, WQ
Gillham	Cossatot River	221,800	188,700	Under Const.	14,800,000	FC, WS, WQ
Dierks	Saline River	80,000	66,000	Under Const.	10,600,000	FC, WS
Millwood	Little River	1,858,000	1,651,400	Complete	43,077,000	FC, WS
Pat Mayse	Sanders Creek	189,100	64,600	Under Const.	7,700,000	FC, WS
Big Pine	Big Pine Creek	138,600	94,700	Authorized	9,200,000	FC, WS
Bank Stabilization	Red River	-	-	Complete	222,105(2)	FC
Walnut Bayou	Walnut Bayou	-	-	Complete	317,675(2)	FC
Total, U. S. Army Engineer District, Tulsa					$258,016,780	

(1)FC - Flood Control; P - Hydroelectric Power; WS - Water Supply; WQ - Water Quality Control; R - Recreation; F&WL - Fish and Wildlife.
(2)Actual cost.

TABLE 4

EXISTING, UNDER CONSTRUCTION, AND AUTHORIZED PROJECTS
U. S. ARMY ENGINEER DISTRICT, NEW ORLEANS

Project	Stream	Total Storage (ac-ft)	Flood Control Storage (ac-ft)	Status	Estimated Cost	Purpose(1)
Bayou Bodcau and Tributaries Ark. and La.	Bayou Bodcau, Red Chute and Loggy Bayous	-	-	Authorized	$ 2,110,000	FC
Campti-Clarence Area, La.	Red River	-	-	Under Const.	1,950,000	FC
Cooper Reservoir and Channels, Tex.	South Sulphur River	441,400	131,400	(2)	26,300,000	FC, WS
East Point, La.	Red River	-	-	Complete	479,000	FC
Ferrells Bridge Dam (Lake O' the Pines), Tex.	Cypress Creek	842,100	587,000	In Operation	14,382,000	FC, WS
Garland City, Ark.	Red River	-	-	Under Const.	1,280,000	FC
Mooringsport Reservoir, La. and Tex.	Cypress Creek	810,000	660,000	Inactive	11,200,000	FC
Texarkana Reservoir, Tex.	Sulphur River	2,654,300	2,509,000	In Operation	36,002,000	FC, WS(3)
Bayou Pierre in the vicinity of Shreveport, La.	Bayou Pierre	-	-	Complete	243,336	FC
Maniece Bayou, Ark.	Maniece and Field Bayous	-	-	Under Const.	1,179,500	FC
McKinney Bayou, Tex. and Ark.	McKinney Bayou	-	-	Complete(4)	1,456,700	FC
Red River below Denison Dam, levees and bank stabilization	Red River	-	-	Under Const.	15,800,000	FC
Bayou Pierre, La.	Bayou Pierre	-	-	Complete	299,529	FC
Wallace Lake Reservoir, La.	Cypress Bayou	96,100	88,300	Complete	1,219,371	FC
Bayou Bodcau Reservoir, La.	Bayou Bodcau	357,000	357,000	Complete	4,220,740	FC
Posten Bayou, Ark. and La.	Posten Bayou	-	-	Inactive	560,000	FC
Lower Red River Levees (Feature of Mississippi River and Tributaries Project)	Red River	-	-	Under Const.	8,990,000	FC
Hempstead County Levee Dist. No. 1, Ark.	Red River	-	-	Complete	88,006	FC
Red River Parish, La.	Red River	-	-	Complete	149,435	FC
Natchitoches Parish, La.	Red River	-	-	Complete	1,529,927	FC
Grant Parish below Colfax, La.	Red River	-	-	Complete	38,809	FC
Alpha-Rigolette Area, Grant and Rapides Parishes, La.	Bayou Rigolette	-	-	Complete	1,653,237	FC
Pineville, Red River, La.	Red River	-	-	Complete	232,426	FC
Colfax, Grant Parish, La.	Red River	-	-	Complete	70,348	FC
Saline Point, La.	Red River	-	-	Complete	124,111	FC
Red River in vicinity of Shreveport, La.	Red River	-	-	Complete	3,908,000	FC
Black Bayou Reservoir, La.	Black Bayou	33,800	33,800	Inactive	714,000	FC
Bayou Bodcau, Red Chute and Loggy Bayou, La.	Bayou Bodcau, Red Chute and Loggy Bayous	-	-	Complete	319,200	FC
Lower Red River, La.(5)	Red River	-	-	Under Const.	8,990,000	FC
Total, U. S. Army Engineer District, New Orleans					$145,489,675	

(1)FC - Flood Control; WS - Water Supply.
(2)Channels portion under construction, reservoir not started.
(3)To be provided by conversion of flood control storage space after completion of Cooper Reservoir.
(4)Modification authorized by Flood Control Act of 1960 is inactive.
(5)Feature of the Mississippi River and Tributaries project.

TABLE 5

EXISTING AND AUTHORIZED UPSTREAM WATERSHED PROJECTS
U. S. DEPARTMENT OF AGRICULTURE

	Watershed Project	Watershed Area (sq. mi.)	Structural Measures: Reservoirs (number)	Structural Measures: Channels (miles)	Storage: Flood Control (acre-feet)	Storage: Other(1) (acre-feet)	Storage: Total (acre-feet)	Status(1)
			PROJECTS AUTHORIZED THROUGH 1962					
3-21	Caney Creek	73.1	15	0	17,187	0	17,187	UC
3-36	Whitegrass Waterhole	46.2	9	19.5	9,264	0	9,264	C
3-23a	Upper Blue River	317.3	74	0	65,165	0	65,165	A
3h1-4	Delaware Creek	78.2	14	0	15,903	0	15,903	UC
3h1-5	Leader-Middle Clear Boggy	168.7	43	0	38,631	0	38,631	UC
3h1-6	Upper Clear Boggy	253.8	54	0	59,939	0	59,939	UC
3h2-5	Caney-Coon Creek	36.9	3	0	11,502	3,000 M	14,502	UC
3k-8	Langford Creek	39.1	12	0	5,876	1,118 M	6,994	C
3k-13	Auds Creek	49.5	14	0	7,352	0	7,352	C
3m2-4	Upper West Fork of Cypress Bayou	8.7	3	0	3,313	1,305 MF	4,618	C
3n-3	Bayou Dupont	90.0	22	2.9	16,559	0	16,559	UC
3-66	Bayou Jean de Jean)	91.4	1	20.0	652	24,348 IR	25,000	C
10-17	Bayou Rapides)	63.1						
	Subtotal	1,316.0	264	42.4	251,343	29,771	281,114	
			PROJECTS AUTHORIZED AFTER 1962					
3-19	Choctaw Creek	262.5	41	25.0	54,805	27,218 RIM	82,023	UC
3-27	Logan-Slough Creek	11.5	3	12.1	1,639	0	1,639	UC
3-33	Pine Creek	186.0	19	19.5	36,173	0	36,173	UC
3-39	Waterfall-Gilford	67.8	12	68.0	5,239	0	5,239	UC
3-46	Haney Creek	24.0	2	16.6	3,373	0	3,373	UC
3h1-2	Lower Clear Boggy	375.5	37	2.0	50,768	2,010 R	52,778	A
3h1-3	Caney Creek	47.7	14	0	10,288	0	10,288	UC
3i-2	Frogville	14.3	2	12.0	712	0	712	UC
3i-8	Rock Creek	59.4	4	0	10,368	2,600 M	12,968	UC
3m-1	Lower Toulon Bayou	13.4	1	3.0	1,273	0	1,273	C
3m2-3	Cypress-Black Bayou	232.0	2	55.5	1,590	30,010 MRI	31,600	A
10-11	Bayou Grand Louis)	103.4	0	83.4	0	0	0	A
10-12	Bayou Cocodrie)							
10-15	Bayou Boeuf	184.5	2	24.4	1,450	48,550 RI	50,000	A
	Subtotal	1,582.0	139	321.5	177,678	110,388	288,066	
TOTAL		2,898.0	403	363.9	429,021	140,159	569,180	

(1)Abbreviations: M - Municipal; F - Fish and Wildlife; I - Irrigation; R - Recreation; A - Authorized; UC - Under Construction; C - Complete

b. Non-Federal.

Local interests have constructed over 400 miles of main stem and backwater levees along both banks of the Red River. Many of these levees have subsequently been incorporated into the Federal levee system. Local political entities, railroads, and private interests have constructed protective works where caving banks threatened developed lands and improvements. The value of these works at current (1968) prices is in the category of $200 million. Numerous improvements for flood control, water supply, recreation, and other purposes have been constructed by local interests in tributary areas throughout the basin. Most of these works are of minor scope and their beneficial effects are realized in areas of rather limited extent.

PROBLEMS AND NEEDS

4. INTRODUCTION

An essential first step in river basin studies is the intelligent appraisal of the existing and potential needs or demands for the useful services which can be provided by the orderly and timely development of the basin water and related land resources. The short- and long-term basin needs for flood control, land resource problems, drainage, water supply, water quality control, irrigation, hydroelectric power, navigation, recreation, and fish and wildlife were developed by work groups composed of representatives of Federal and State agencies, considering the express wishes of local interests.

5. FLOOD CONTROL

The existing reservoirs and extensive levee system below Index, Arkansas, afford the Red River Basin good protection from the large devastating floods and additional improvements already authorized will further expand this protection. However, economic losses will continue to be caused yearly by four distinct types of flooding which are identified as follows:

a. Headwater flooding along the main stem: Lands adjacent to the Red River are flooded due to high stages in the river caused by excessive rainfall over a major portion of the Red River Basin.

b. Headwater flooding along tributary streams: Lands along tributary streams are flooded because of excessive rainfall in the particular tributary basin.

c. Backwater flooding: Where there is an uncontrolled connection of a tributary stream with the Red River, high stages in the river cause water to "back up" the tributary stream. Flooding of this nature is usually limited to the lower reaches of the tributary basin.

d. Ponding: Water may pond behind levees where drainage outlets are either inadequate or must be closed because of high stages on the Red River.

Flooding in the basin can result from any of these conditions occurring singly or in combination.

The basin is rural in character, moderately populated, and contains few large urban areas. Floods primarily affect agricultural enterprises and losses include damages to crops, pasture, and livestock. Other damage is inflicted on roads, railroads, farm improvements, urban developments, oilfield structures, bridges, and

utility lines. With all authorized projects in place, 2.5 million acres of land in the basin will remain subject to flooding. In addition, nearly 600,000 acres of land located in areas adjacent to the basin, which were included in the Soil Conservation Service studies, is also subject to flooding. The estimated average annual damages over the study period, considering future land conversions and increased crop yields that will occur without the installation of additional flood control projects, amount to about $11.6 million. Of the total damages about $1.0 million is in the adjacent areas studied by the Soil Conservation Service.

In addition to the losses sustained, threat of additional losses has restricted, to a marked degree, the utilization of the potentially highly productive alluvial bottom land in the area. These lands should be a prime source of the substantial increases in agricultural production necessary to meet future food demands. Future domestic demands and normal export trade will ultimately necessitate full utilization of productive bottom lands in this area. Details of flood damage and losses are included in appendix IV, "Flood Control and Major Drainage," and appendix V, "Upstream Watershed Protection, Use, Management, and Development."

In spite of decades of effort and the expenditure of more than $7 billion for flood control works, flood damages have taken an increasing toll. The increase is partially attributable to the construction of improvements in flood prone areas. The record makes it apparent that structural measures alone cannot prevent a continuing increase in flood losses.

The effectiveness of both structural and nonstructural measures for reducing flood damage will, in many cases, depend upon a timely notification of oncoming floods. While an effective flood forecast service is available in the basin, it should be expanded and strengthened by expanded use of electronic gear. Further, the application of automatic data processing techniques and procedures is required to accelerate formulation and dissemination of flood forecasts.

6. BANK STABILIZATION

The alluvial plain of Red River below Denison Dam is composed of sand and silt, and is highly susceptible to bank caving and erosion. Thousands of acres of highly productive agricultural land are lost to the river each year. The frequent wide fluctuations in stages of Red River, poor alignment of the stream, and the friable soils in the stream banks all contribute to the problem. The river meanders in a series of irregular curves. Bank recession takes place along the concave sides of the bends as the overall

configuration advances slowly downstream. Depending on the shape of the bend, composition of bank, slope of stream, stage of water, and other factors, the recession may be rapid or slow. In any single flood, one bend may move hundreds of feet, while another may undergo little or no change.

Practically all of the improvements situated on a caving bank, including levees, drainage systems, buildings, railroads, highways, bridge abutments, pipelines, and other utilities are lost or damaged as the bank recedes. About 2,100 acres of land are lost each year, on the average, in the reach below Index. Above Index, the rate is about 1,000 acres annually. The average annual loss to lands and improvements below Denison Dam under current conditions (1968) and prices is in excess of $4 million. Detailed information relative to bank stabilization is contained in the "Interim Report on Navigation and Bank Stabilization - Red River below Denison Dam," dated March 15, 1966.

7. LAND RESOURCE PROBLEMS

Erosion, soil limitation, and excess water problems. Land resource problems are classified into three general categories: soil erosion, excess water, and soil limitations in the root zone. Of the 17,333,300 acres in the study area,(1) about 16,559,800 acres have at least one of these problems. Soil erosion, the major problem, affects almost 51 percent of the entire acreage of the land resource problem area. Excess water and soil condition problems affect about 31 and 18 percent, respectively.

All scils in the acreage inventoried were classified according to their potentialities and limitations for sustained agricultural and forestry production. All soils of the study area are included in seven land capability classes, as follows:

Class I - Soils in this class have few limitations that restrict their use.

Class II - Soils in this class have some limitations that reduce the choice of plants or require moderate conservation practices.

Class III - Soils in this class have severe limitations that reduce the choice of plants or require special conservation practices, or both.

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(1) Area studied by Soil Conservation Service (SCS) includes two areas contiguous to the basin as shown on plate 1. The total area studied by SCS is referred to in this report as the "study area."

Class IV - Soils in this class have very severe limitations that restrict the choice of plants and require very careful management.

Class V - Soils in this class have little or no erosion hazard, but have other limitations, which are impractical to correct, that limit their use largely to pasture, range, woodland, and forest, or wildlife habitat.

Class VI - Soils in this class have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture or range, woodland and forest, or wildlife habitat.

Class VII - Soils in this class have very severe limitations that make them unsuited for cultivation and that restrict their use largely to grazing, woodland and forest, or wildlife.

The risk of soil damage or limitation in use becomes progressively greater from Class I to Class VII. Soils in the first four classes are capable of producing, under good management, adapted plants such as trees or range plants and the common cultivated field crops and pasture plants. Soils in the last three classes are best suited to the production of native vegetation. Some soils in Classes V and VI also are capable of producing specialized crops, such as certain fruits, ornamentals, field crops, and vegetable crops, under highly intensive management involving elaborate soil and water conservation practices.

Subclasses were not recognized in land capability Class I. All other land capability classes were divided into appropriate subclasses to identify the land resource problems. The dominant kind of soil problem or hazard that affects limitation in land use determined the subclass into which soils were placed. Subclass (e) includes soils that have limitations in use because erosion is the dominant problem or hazard. Soil erosion susceptibility and past erosion damage are the principal factors for placing soils into this subclass.

Subclass (w) includes soils that have limitations in use because excess water is the dominant problem or hazard. Soil wetness, high water table, overflow, and poor drainage are factors for placing soils into this subclass.

Soils with root zone limitations as the dominant hazard or limitation in use were included in subclass (s). Factors such as shallow soils, stoniness, low-moisture-holding capacity, low fertility that is difficult to correct, and salinity or alkalinity limit root zones in this subclass.

Major land use distribution by land capability subclasses is a primary factor in determining the scope and magnitude of land resource problems. An inventory of land capability subclasses by major land uses is shown in the following table:

LAND CAPABILITY SUBCLASS DISTRIBUTION BY MAJOR LAND USES,
RED RIVER BASIN STUDY AREA, 1962 CONDITIONS

Land Capability Class and Subclass	Cropland	Grazing Land	Woodland	Misc. Land	Total
	Thousand Acres				
Subclass IIe	765.7	435.7	754.0	85.5	2,040.9
Subclass IIIe	1,048.9	855.3	1,388.5	127.6	3,420.3
Subclass IVe	157.4	267.8	675.5	45.1	1,145.8
Subclass VIe	28.7	154.7	807.8	63.8	1,055.0
Subclass VIIe	64.5	138.3	533.5	5.0	741.3
Subtotal	2,065.2	1,851.8	4,159.3	327.0	8,403.3
Subclass IIs	343.7	111.4	126.8	8.2	590.1
Subclass IIIs	57.0	29.9	138.8	7.8	233.5
Subclass IVs	4.4	5.4	21.7	3.9	35.4
Subclass VIs	0.9	2.8	16.0	-	19.7
Subclass VIIs	0.1	204.8	1,949.7	5.7	2,160.3
Subtotal	406.1	354.3	2,253.0	25.6	3,039.0
Subclass IIw	190.6	162.2	319.6	21.7	694.1
Subclass IIIw	218.5	261.7	772.4	14.3	1,266.9
Subclass IVw	26.9	60.3	575.3	1.6	664.1
Subclass Vw	105.1	323.2	2,044.1	20.0	2,492.4
Subtotal	541.1	807.4	3,711.4	57.6	5,117.5
Total	3,012.4	3,013.5	10,123.7	410.2	16,559.8

Soil erosion problems are concentrated in land capability classes that are capable of producing cultivated field crops. About 79 percent of the erosion problems occur on soils in land capability Classes I to IV and only 21 percent occur on the land area that is best suited to native vegetation. Soil condition problems exist predominantly on land that is best suited to native vegetation. The excess water problems exist entirely on lands that are capable of producing field crops and pasture plants if the hazard were removed.

Agricultural and forest land use problems concern lack of conditions for adequate watershed management and loss of productivity for reasonable economic return.

Progress has been most evident in land use conversions and application of measures necessary to protect the land resource from erosion. Applied treatment practices consist of cropping systems that include rotation of legumes and grasses, contour and terrace farming, and grassed waterways. Treatment practices on pasture include pasture renovation, strategically located livestock watering places, and pasture and hayland establishment and management. Common conservation treatment practices for forest land include interplanting, grazing and harvesting control, release of desirable growing stock, and fire control.

The combined efforts of Federal, State, and local organizations, and of landowners and operators have played a major role in treating land resource problems. It is estimated that conservation measures, consisting of land use conversions and the common soil and water conservation practices, have been applied to about one-fourth of the study area.

Inadequate forest management. Forest land resource problems result on the large acreage of forest land with cover and soil conditions unsuitable for watershed management, and with timber productivity too low for economic return and support of desirable growth in basin industry. Treatment is needed on 40-50 percent of the commercial acreage for improved watershed protection. High-level, sustained-yield management is needed on 50-60 percent to realize needs in wood production.

With current (1967) producing acreage and management levels, supplies of factory hardwood logs are too low to adequately support established industry. High-level management of all remaining bottom land hardwood stands will be necessary to sustain established industry. The basin study indicates that, with current levels of management, future softwood supplies will not meet the needs of forest industry. The expected growth in manufacturing capacity will require an additional 110-135 million cubic feet of merchantable wood annually by the year 2010. High-level, sustained-yield management on an additional 2,250,000 acres of the most productive forest lands will be necessary to meet future needs. Detailed data on land resource problems are contained in appendix V, "Upstream Watershed Protection, Use, Management, and Development."

8. DRAINAGE

Excess water is the dominant problem on approximately 4,820,000 acres in the study area. Of this total, 400,000 have had improvements installed and 1,280,000 other acres of inadequately drained lands are feasible for drainage and flood prevention improvements. An inventory of acreage with combined drainage and flood problems as well as soils feasible for drainage and flood prevention improvements is broken down by land use and states as shown in the following table:

DRAINAGE AND FLOOD PROBLEM AREAS AND
SOILS FEASIBLE FOR DRAINAGE AND FLOOD IMPROVEMENTS

State	Soils with a drainage and flood problem				Soils feasible for drainage and flood prevention improvements			
	Cropland	Pasture	Woodland	Total	Cropland	Pasture	Woodland	Total
	(Acres - thousands)							
Arkansas	62.9	83.7	745.5	892.1	29.4	30.1	137.6	197.1
Louisiana	270.1	364.4	1,474.9	2,109.4	103.2	149.1	455.9	708.2
Oklahoma	38.6	100.9	305.1	444.6	23.9	33.2	31.4	88.5
Texas	274.2	237.1	865.0	1,376.3	83.7	82.4	119.6	285.7
Total	645.8	786.1	3,390.5	4,822.4	240.2	294.8	744.5	1,279.5

Many of the drainage problems are incidental to flooding and occur only as long as a flood persists. On flatlands the problems of inadequate drainage are considered inseparable from problems of flooding. Additional information relative to drainage is contained in appendix VII, "Drainage and Flood Prevention on Flatlands."

9. MUNICIPAL AND INDUSTRIAL WATER SUPPLY

In 1965, urban water use in the basin averaged about 84 million gallons per day (m.g.d.) for domestic service and commercial business, and small industrial water supply purposes. This quantity represented approximately 30 percent of the total water use in the basin for that year. The average per capita water use by urban areas throughout the basin was about 115 gallons per day (g.p.d.) in 1965. The major cities of the basin had a slightly higher average of about 124 g.p.d., which reflects concentrations of small industries normally supplied by public water supply systems.

Industries of the basin used approximately 137 m.g.d. in their manufacturing processes in 1965. About 12 percent is obtained from municipal water systems. The remainder is supplied from other public and private surface supplies and ground water sources. The heavy water using industries presently located in the basin can generally be classified under one of the following categories:

a. Thermal power generation

b. Petroleum refining

c. Petrochemical production

d. Pulp and paper manufacture

e. Primary metals (iron and steel)

f. Food and kindred products production

Estimates of future municipal water requirements were developed from population projections contained in appendix I, "Economics," and from studies of per capita water use in the lower Red River Basin and adjacent areas. The studies included an analysis of water-use records from municipalities, analyses of basin characteristics pertaining to precipitation and climate, and comparison of data with that of other agencies and municipalities.

In determining industrial water requirements, industries that have water needs in excess of those usually supplied by municipal water supply systems were selected for study. Water requirements for the food and kindred processing industries were determined on the basis of employment projections, which were developed by the Economic Work Group. Future thermal power water requirements were related to projected populations in the area. Future water requirements for the pulp and paper, petroleum, petrochemical, and iron and steel industries were related to a unit water use per unit of production. Growth rates for these industries were based on anticipated demands for the product and availability of raw materials. Location and description of these industries are presented in appendix I, "Economics"; appendix V, "Upstream Watershed Protection, Use, Management, and Development"; appendix VIII, "Mineral Resources and Mineral Industry"; and appendix X, "Hydroelectric Power." An analysis of water resources of the basin is presented in appendix XI, "Water Supply and Water Quality Control."

Rural water use within the basin for domestic and livestock purposes was approximately 27 m.g.d. in 1965, which represented about 10 percent of the average daily water use in the basin. It is estimated that rural water demands, exclusive of irrigation, will increase to about 63 m.g.d. by 1980. The higher demand will result from maintenance of higher living standards rather than any

anticipated population growth. At present, about 90 percent of the rural water supply is obtained from privately owned wells. Other sources are from farm ponds, cisterns, and streams.

Municipal and industrial water requirements are expected to increase to about 600 m.g.d. by 1980 and 1,300 m.g.d. by 2030. Reservoirs and facilities have been developed in the basin to supply approximately 400 m.g.d. from surface and ground water sources. However, certain areas have insufficient water supplies to meet projected demands or even immediate future demands because of inadequate surface water or ground water resources. Based on total basin water requirements, storage in Federal reservoirs and additional facilities will be needed to develop a total dependable yield of about 200 m.g.d. by 1980 and 600 m.g.d. by 2030. Projected municipal, industrial, and rural domestic water supply needs are listed in table 6 for basin areas shown on figure 2. A graphical presentation of the needs is shown on figure 3.

10. WATER QUALITY CONTROL

The chemical quality of surface waters of the main stem of the Red River below Denison Dam is generally poor because of high concentrations of dissolved solids, chlorides, and sulfates, and high carbonate hardness. Waters of the main stem are generally turbid, reflecting its high sediment load of sand and silt. However, the Red River improves in quality as it flows toward the Mississippi River. Large tributary rivers having high quality water empty into the Red River and significantly dilute the flows of the main stem, thus causing a sizable reduction in the concentration of dissolved solids. The waters of tributary basins, in general, are all of good quality and their chemical constituents are within the Public Health Service Drinking Water Standards.

The most extensive and serious pollution problem in the basin is from salt (sodium chloride). As a result of natural brine emissions and oilfield operations in the upper Red River Basin, water quality is seriously degraded and is unsuitable for general municipal, industrial, and agricultural use in the main stem of the lower Red River. In tributary basins, inadequate treatment and handling of waste flows by cities and industries have caused serious pollution problems in some areas, as indicated by fish kills, high chloride concentrations, high color, foaming, rapid temperature variations, and oxygen depletion. Approximately half the waste discharges in the basin are emptied into streams without adequate prior treatment.

Pollution problems of the basin, in general, present a detriment to existing and potential municipal, industrial, rural, domestic, and livestock water supply; to propagation of fish and wildlife; and to recreation use of the streams. The problems also result in degradation of aesthetics and the general environment.

TABLE 6

PROJECTED WATER REQUIREMENTS
(million gallons per day)

Year	Area	Municipal	Industrial	Municipal and Industrial	Rural, Domestic & Livestock
1980	1	4.6	2.0	6.6	4.0
	2	3.5	76.6	80.1	4.9
	3	18.6	20.0	38.6	7.1
	4	21.0	76.0	97.0	8.3
	5	18.5	61.0	79.5	8.0
	6	50.6	131.6	182.2	10.0
	7	5.8	28.0	33.8	7.4
	8	18.2	79.8	98.0	13.4
	Total	140.8	475.0	615.8	63.1
2000	1	8.1	27.7	35.8	4.0
	2	4.9	94.0	98.9	5.1
	3	29.0	23.9	52.9	6.9
	4	32.5	97.5	130.0	8.4
	5	27.9	110.0	137.9	7.8
	6	84.5	203.3	287.8	10.1
	7	10.8	29.4	40.2	7.5
	8	31.3	84.2	115.5	14.1
	Total	229.0	670.0	899.0	63.9
2030	1	14.1	52.7	66.8	3.8
	2	8.2	121.3	129.5	4.9
	3	46.7	31.1	77.8	6.8
	4	50.9	111.0	161.9	8.3
	5	43.6	149.0	192.6	7.3
	6	146.3	291.2	437.5	9.8
	7	19.5	34.0	53.5	7.3
	8	56.6	89.7	146.3	14.6
	Total	385.9	880.0	1,265.9	62.8
2080*	1	25.1	98.0	123.1	3.8
	2	11.2	122.0	133.2	4.9
	3	93.4	52.0	145.4	6.8
	4	102.2	145.0	247.2	8.3
	5	79.8	210.0	289.8	7.3
	6	358.9	415.0	773.9	9.8
	7	40.8	49.0	89.8	7.3
	8	133.0	109.0	242.0	14.6
	Total	844.4	1,200.0	2,044.4	62.8

*Extrapolated from projections for 2030.

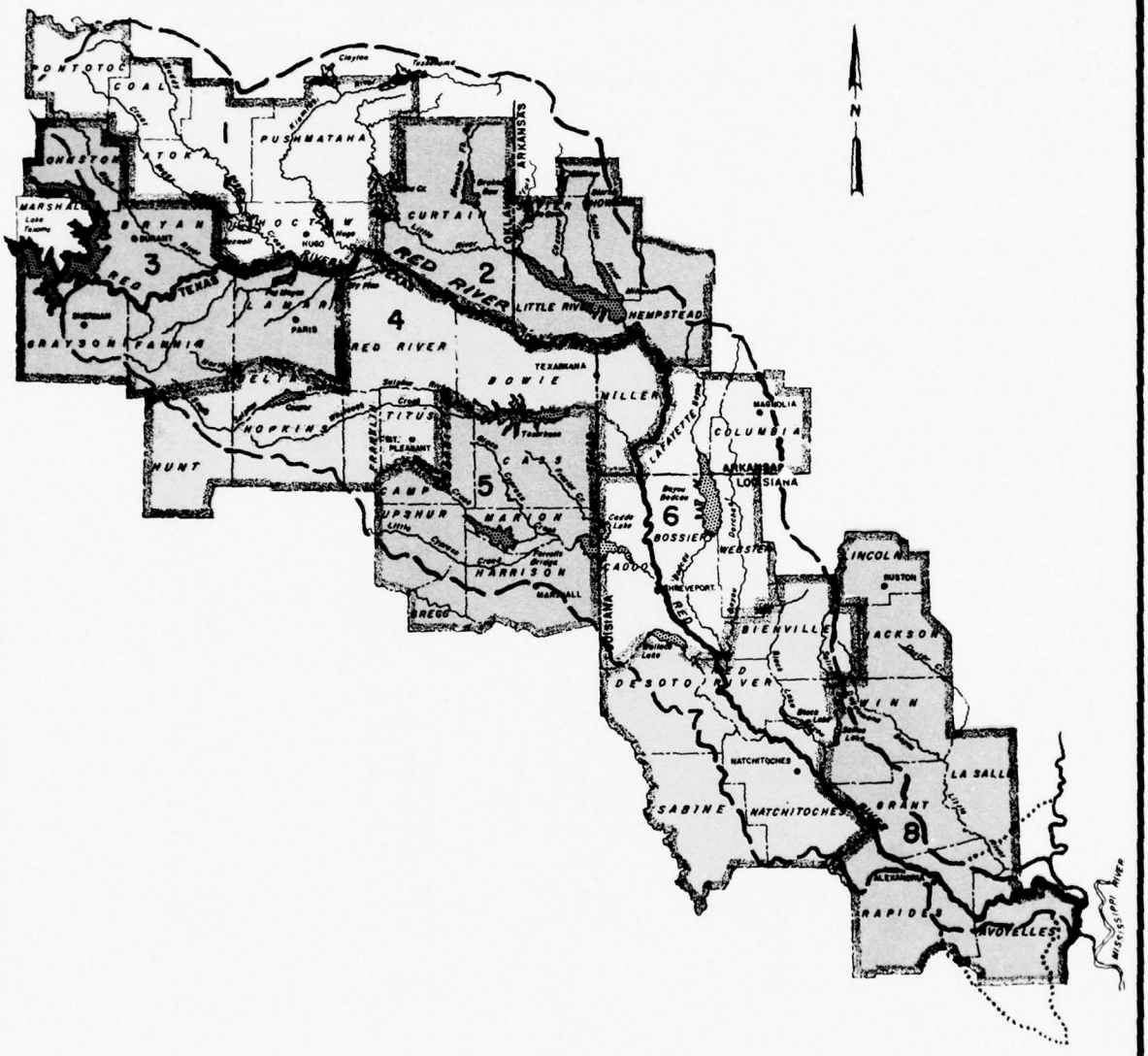


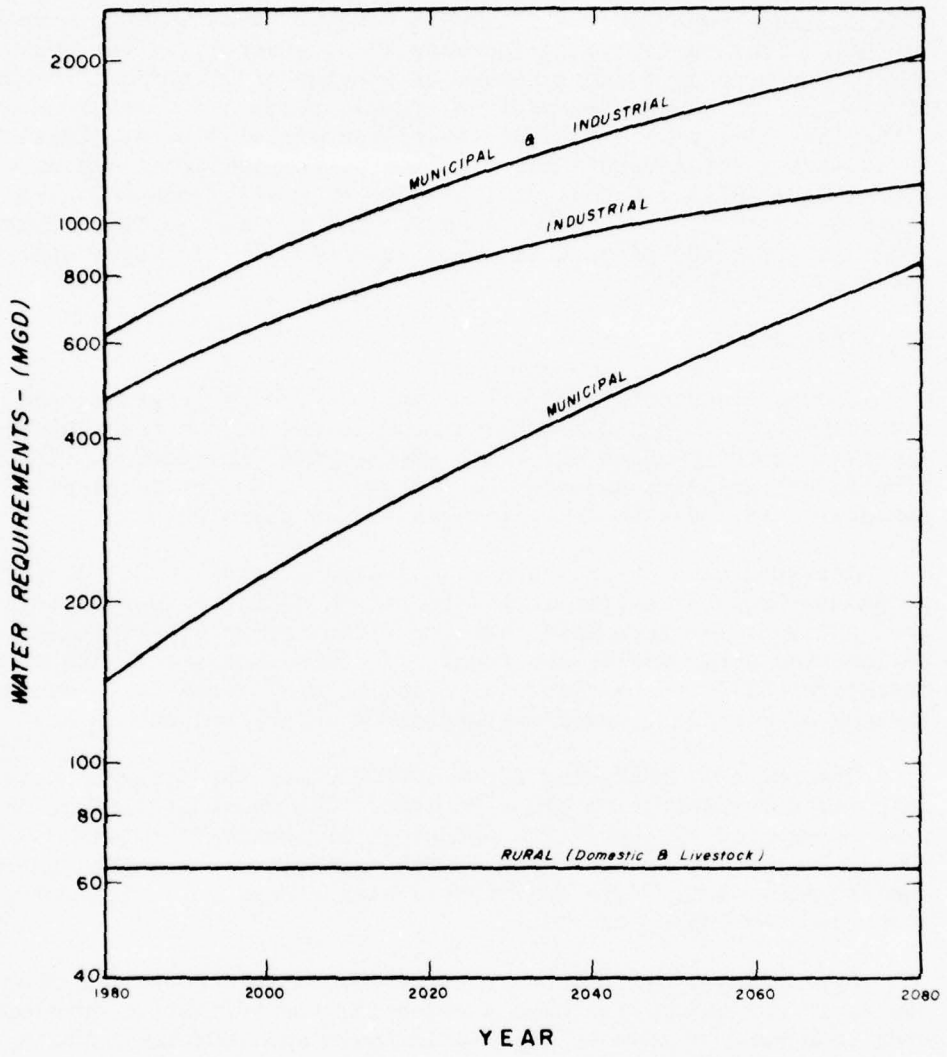
FIGURE 2

WATER SUPPLY STUDY AREAS

SCALE OF MILES

20 0 20 40 60

JUNE 1968



MUNICIPAL, INDUSTRIAL, AND
RURAL WATER REQUIREMENTS

JUNE 1968

FIGURE 3

To meet water quality objectives for the protection of future uses of the streams of the basin, highly advanced waste treatment or disposal measures, provision of supplemental flow, or a combination of these measures would be needed on not less than 13 streams by 1980. This number would increase to at least 17 by the year 2030. Based on an assumed basinwide average of 90 percent removal of biochemical oxygen demand from organic waste effluents from cities and an equivalent treatment of industrial wastes, streamflow deficiencies for adequate assimilation of the projected wastes will approximate 237 m.g.d. by 1980. Net water quality control needs are shown in table 7. A detailed description of water quality control needs is presented in appendix XI, "Water Supply and Water Quality Control."

11. IRRIGATION

Uneven distribution of precipitation greatly increases the risks involved in agricultural production and in the near future is expected to bring about extensive supplemental irrigation. Irrigation is an expensive undertaking and requires a high level of management in order to be profitable to the operator.

Although studies indicate that National needs do not justify proposing large areas for irrigation at this time, other factors are involved. Many farmers have installed irrigation equipment to increase their yields and to provide crop insurance. The twin incentives of increased production and insured income will encourage placing of more land under irrigation by owners and operators.

One project, including about 10,500 acres for irrigation, was authorized for operation prior to 1963. The value of irrigation has been recognized by owners and operators irrigating about 42,000 acres of cropland in the basin. With agriculture becoming increasingly competitive, it is anticipated that a real potential for increased irrigation exists.

Approximately 765,600 acres distributed throughout the four states in the study area have a potential for irrigation development. More than half of this acreage is in Louisiana. Of the total area, approximately 317,000 acres are suitable for project-type development and 448,600 acres could be developed individually by landowners and operators. Detailed data on irrigation are contained in appendix VI, "Irrigation."

12. HYDROELECTRIC POWER

Federal Power Commission Coordination Study Area K is the market area for power produced in the Red River Basin. It includes all of Arkansas and Louisiana, practically all of Kansas and Oklahoma, southern half of Missouri, western half of Mississippi, and a small area in east Texas as shown on figure 4.

TABLE 7

NET WATER QUALITY CONTROL NEEDS

Area No.	Stream	Supplemental Flow Needed With 90% Treatment (1) (m.g.d.) 1980	2030	% Treatment (1) For BOD Control Needed Without Supplemental Flow 1980	2030
1	Kiamichi River below Hugo Reservoir, Oklahoma	62.0(2)*	90.0(2)*	--	--
2	Mountain Fork and Little Rivers below Broken Bow Res., Okla.	65.3(3)*	110.0(3)*	--	--
2	Little River below Millwood Reservoir, Arkansas	60.0(3)*	100.0(3)*	--	--
2	Bois d'Arc Creek below Hope, Arkansas	18.5(3)	20.1(3)	--	--
2	Mine Creek below Nashville, Arkansas	0	0.1	--	92
3	Mineral Bayou below Durant, Oklahoma	0.2	0.7	94	96
3	Choctaw Creek below Sherman, Texas	1.9	5.9	94	96
3	Bois d'Arc Creek below Bonham, Texas	0.8	1.7	94	96
3	Pine Creek below Paris, Texas	13.8	35.4	97	98
4	South Sulphur River below Commerce, Texas	0.1	0.3	96	98
4	Sulphur River below Texarkana Reservoir	45.0*	35.0*	98	98
4	White Oak Creek below Sulphur Springs, Texas	0	1.5	--	96
5	Cypress Bayou below Mt. Pleasant, Texas	1.2	5.4	97	98
5	Little Cypress Bayou below Gilmer, Texas	0	0.7	--	94
6	Bodcau Bayou below Springhill, Louisiana	19.4	19.4	96	96
6	Dorcheat Bayou below Magnolia, Arkansas	1.4	9.8	94	96
6	Twelvemile Bayou below Caddo Lake, Louisiana	0	0.4	--	94
8	Dugdemona Bayou below Ruston, Louisiana	8.2	10.6	94	95

* Controlling parameter other than BOD.

(1) Percent removal of ultimate BOD.

(2) Needs developed in connection with the Public Health Service report on Southeastern Oklahoma - Southwestern Arkansas project. Authorized storage to develop a yield of 90 m.g.d. has been provided in the Hugo Reservoir to supply this need.

(3) Needs developed in connection with the Public Health Service report on Southeastern Oklahoma - Southwestern Arkansas project. Authorized storage to develop a yield of 110 m.g.d. has been provided in the Broken Bow Reservoir to supply this need.

NEBRASKA
IOWA
INDIANA
ILLINOIS
COLORADO
KANSAS
MISSOURI
KENTUCKY
OKLAHOMA
TENNESSEE
ARKANSAS
MISSISSIPPI
ALABAMA
TEXAS
LOUISIANA
0 100 200 300 400 miles
COORDINATION STUDY AREA K
JUNE 1968

FIGURE 4

Power supply areas as established by the Federal Power Commission for power market surveys, hydroelectric power need and utilization studies, and other analyses of power supply and requirements substantially represent the electrical service areas of major electric utilities. Usually a power supply area encompasses a combination of utilities that operate in close coordination under a common holding company or under other pooling arrangements. Study Area K in itself represents a logical market for determination of needs for future hydroelectric capacity that may be constructed in the Red River Basin below Denison Dam. Exports and imports of electric power made available by seasonal load diversity with TVA and by both seasonal load diversity and hydraulic diversity between the Missouri River and Arkansas-White-Red Basins are recognized in need and utilization studies. Other exports and imports affecting Study Area K are approximately offsetting.

The basin is located in the general service area of the Southwestern Electric Power Company, Louisiana Power and Light Company, Central Louisiana Electric Company, Arkansas Power and Light Company, Public Service Company of Oklahoma, Texas Power and Light Company, the City of Alexandria, and the Southwestern Power Administration.

Economic factors that affect the electric load growth in the designated market area are as follows:

a. Farm use of electric energy ranged from about 3,532 to 6,509 kilowatt-hours (kwh) per customer in 1965. Other residential use ranged from 3,909 to 5,261 kwh. Recent gains in residential consumption can be attributed to increasing acceptance of all types of refrigeration, air-conditioning, and heating equipment, as well as more extensive use of freezers, electric blankets, clothes dryers, lighting, and other electrical appliances. The electric energy consumption per commercial customer ranged from 20,998 to 26,392 kwh. This use is increasing as a result of air-conditioning, diversity of retail outlets, advent of shopping centers, expansion of electric cooking, and increased recreational activities.

b. The industrial development and associated electric growth in Study Area K has been principally affected by the phenomenal growth of the petrochemical industry along the Gulf Coast where plentiful raw materials, water, pipelines, low fuel costs, lower construction costs, lower labor costs, and water transportation are available. Petroleum refining is growing moderately but is substantially stable. The continued development and diversification in chemicals, petrochemicals, and plastics present a bright future, particularly in the southern portion of Study Area K.

c. No significant additional growth in electric load for light metal industries was considered in the studies made for this report.

d. The growing need for pulp and paper is expected to spur electric load growth due to the primary and secondary influences of the development of new paper processing industries in the forested regions of Study Area K. New processes are under continual development to utilize the types of forest reserves available.

e. The mineral industry in many areas provides a growing demand for power.

f. Growth is expected in the aircraft industry, space industry, and in food processing, cement, fertilizer, and small appliance industries.

There are presented in the following table historical and estimated future data on energy for load, peak demands, and annual load factors for Study Area K. It is to be noted that the peak demand for Area K increased from 2,890 megawatts (mw) in 1950 to 13,070 mw in 1965. Estimated future load growth as developed for the National Power Survey is expected to reach 35,900 mw by 1980. This estimate has been trended to the year 2020 for the Red River Basin below Denison Dam Comprehensive Study and the expected load at that time is estimated at 182,000 mw. The table also demonstrates the decrease in annual load factors between 1950 and 1965, due principally to the advent of residential and commercial air-conditioning. This trend appears to be reversing at this time and moderate increases in load factors are expected in the future due partly to load building activities of the electric utility industry.

HISTORICAL AND ESTIMATED FUTURE
POWER REQUIREMENTS

Date	Energy for load million kwh	Peak demand mw	Annual load factor %	Peak month(1)
1950	15,402	2,890	60.8	Aug., Sep., & Dec.
1955	27,519	5,347	58.8	July, Aug., & Sep.
1960	40,207	8,352	54.8	July & Aug.
1965	62,687	13,070	54.8	July
1970	93,270	19,300	55.2	Aug.
1980	178,900	35,900	56.7	Aug.
2000	462,000	93,000	56.7	Aug.
2020	904,000	182,000	56.7	Aug.

(1)Depending on subarea in Study Area K.

Existing utility generating plants in Study Area K in 1965 had a dependable capacity of approximately 15,731 mw; of this total, 84.6 percent, or 13,314 mw, is steam electric; 9.2 percent, or 1,449 mw, is hydroelectric; 4.9 percent is internal combustion; and 1.3 percent is gas turbine capacity. The largest generating plant in service as of December 31, 1965, was the Louisiana Power and Light Company's Little Gypsy No. 2 at 420,750 kw maximum nameplate rating; however, as a result of the development of Extra-High-Voltage (EHV) transmission facilities and growing loads, larger units are being planned and constructed.

Throughout Coordination Study Area K, a large number of industries own and operate their own generating plants. The installed capacity for industry-owned generation in the area as of December 31, 1965, amounted to 1,796 mw of steam-electric capacity, and 268 mw of diesel-electric capacity making a total of 2,064 mw. Total generation during 1965 was 13,995 million kwh. Industry-owned generation is not a part of the public power supply but is given consideration in projecting future electric utility load levels.

Some of the existing generating plants will be retired for various reasons, such as increased operation cost and need for building space. In general, retirement age for generating units is assumed to be 35 years. Retirement age subsequent to 1980 involving high-pressure high-temperature equipment may be lowered to 30 years. Additional capacity required to meet the power requirements of Study Area K is shown in the following table:

ADDITIONAL DEPENDABLE CAPACITY TO
SUPPLY ESTIMATED ELECTRIC UTILITY LOADS IN STUDY AREA K
(Megawatts)

	1965	1970	1980
Capacity requirements:			
Peak demand	13,070	19,300	35,900
Reserve requirement (12%)	1,568	2,316	4,310
Total capacity required	14,638	21,616	40,210
Capacity available:			
Existing fuel-electric 12-31-65	14,282	14,282	14,282
Less estimated retirements	0	934	1,460
Net fuel-electric	14,282	13,348	12,822
Existing hydroelectric 12-31-65	1,442	1,442	1,442
Scheduled additions to fuel-elec.	0	9,273	9,273
Scheduled additions to hydro	0	508	1,385
Imports of firm power	448	1,525(1)	2,525(2)
Total capacity available	16,172	26,096	27,447
Additional capacity required:	-1,534	-4,480	12,763

(1)SCEC-TVA Seasonal Capacity Agreement. Hydroelectric capacity diversity from NPS Study Areas I and L estimated to be 25 megawatts.

(2)SCEC-TVA capacity diversity estimated to increase to 2,500 megawatts by 1980. Hydroelectric capacity diversity from NPS Study Areas I and L estimated to be 25 megawatts.

Hydroelectric plants are admirably suited to supplementing base load thermal plants on high peak short duration loads. Hydroelectric projects have several important advantages over thermal plants, especially for peak generation, in that they do not consume water or fossil fuels, do not contribute to water or air pollution, have low operation and maintenance costs, have the ability to start quickly and meet load changes readily, and provide other corollary benefits. There is a growing need for peaking capacity throughout Study Area K.

The projected load curves indicate that, during the peak month of August, the hydroelectric power capacities shown in the table below, which are in excess of the capacity of existing and scheduled facilities, could be utilized on the load at a 20 percent plant factor. This is in the peak area of the load where hydroelectric generation is so advantageous and is the measure of the amount of hydroelectric capacity needed for a well-balanced electric power system for Study Area K.

HYDROELECTRIC POWER CAPACITY
(Megawatts)

Year	Total (conventional & pumped storage)	Max. Pumped Storage
1980	4,240	2,670
2000	14,240	6,920
2020	29,640	13,540

It is estimated that Federal facilities and the public bodies and cooperatives which have been given preference by Congress in the sale of power from Federally-developed hydroelectric power projects in the basin, could utilize the additional hydroelectric power capacities shown in the following table:

ADDITIONAL HYDROELECTRIC CAPACITY THAT CAN BE USED
IN SUPPLYING PREFERENCE USER LOAD
(Megawatts)

Year	Capacity
1980	460
2000	2,430
2020	5,990

13. RECREATION

The Red River Basin below Denison Dam has several problems of significant influence insofar as the outdoor recreation opportunities of the basin are concerned. A discussion of these problems follows:

The Red River above Lake Texoma has substantial natural pollution because of brine emissions. Below Lake Texoma, the main stem of Red River and some tributaries receive quantities of inadequately treated waste from cities, industries, and agricultural operations. This situation restricts water-contact recreation in many areas of the basin. If the Red River and affected tributaries are to offer significant additional recreational potential, established water quality standards must be enforced.

Many of the existing lakes and fishable and boatable streams in the basin are closed to the public because of limited or restricted access. Access refers to road or trails, as well as land and related facilities, needed to promote the utilization of resources. The interstate highway system, when completed, will give

good access into and through the basin, but the secondary and primary systems must be expanded to allow people to take full advantage of the recreational opportunities of the basin.

Planning and development of recreational resources have not kept pace with expanding demand. Most of the cities in the basin have experienced population growth far exceeding the rate at which parks and playgrounds have been developed. Continued growth of population, along with increasing demands for land because of industrial, agricultural, and urban expansion, will doubtless cause annual decreases in land available for outdoor recreation. Sound short- and long-range recreation plans can only be developed through coordinated effort at all levels of Government, but particularly at the State and local levels.

Outstanding outdoor recreation opportunities are available in the Red River Basin, but these opportunities simply have not been developed to their potential. Of 1.6 million acres of publicly-owned lands in the basin, only 9,000 acres are developed for outdoor recreation. In one area, over 90 percent of the existing facilities are located at two sites.

The demand for water-oriented recreational opportunities in the Red River Basin is increasing rapidly. It is estimated that the demand for recreational opportunities in excess of that which will be met by existing and programmed facilities will be 37,300,000 recreation days in 1980 and 300,000,000 in 2020. Detailed information relative to recreation is contained in appendix XII, "Outdoor Recreation."

14. FISH AND WILDLIFE

The expected population growth of the Red River Basin below Denison Dam would create a corresponding need for increased fishing and hunting opportunities. The area around the large urban centers would be affected first, but the need could extend to all parts of the basin in the foreseeable future. State lines are expected to continue to exert a controlling and restrictive influence on most of the basin's hunting and fishing populations and on plans to maintain a diversified supply of fish and wildlife resources. Various fish and wildlife needs, therefore, have been separated and are summarized below.

Indications are that the Arkansas and Oklahoma portions of the basin have ample supplies in all classes of sport fishing through 1980. Louisiana presently has adequate fishing waters to satisfy its resident demand, but by 1980 will exhibit unsatisfied needs in all classes of sport fishing. Pressing needs exist in Texas for all types of fishing, and projections indicate that these needs will become greater in future years.

At the available level of supply, each of the four states represented in this study will have unsatisfied hunting needs by 1980. By the year 2000, indications are that Louisiana resident hunting demands will surpass even the potential ability of the habitat to furnish quality hunting. By the end of the study period (2080), the Arkansas portion of the basin will face a similar situation. The potential supply for hunting in Oklahoma and Texas is apparently capable of satisfying hunting demands throughout the study period.

The Red River Basin's commercial fishery resource base appears to be capable of meeting intra-basin demands for freshwater commercial fishery products throughout the study period. A portion of the resource base is also capable of providing fish for interbasin demands of industrial fishery products, chiefly fish meal for the poultry feed industry. For more detailed information on fish and wildlife problems and needs, see appendix XIII, "Fish and Wildlife."

15. NAVIGATION

Navigation, specifically barge traffic, along Red River and its major tributaries is, for all practical purposes, nonexistent. Widely fluctuating stages, shifting beds and banks, and shoaling present conditions adverse to the interest of navigation. Controlling depths of the river from January to July are about 6 feet from the mouth to Alexandria, 5 feet to Shreveport, and 4 feet to Fulton. From August through December, controlling depths are 6.5 feet from the river mouth to the Black River, 4 feet to Alexandria, 1 to 2 feet to Shreveport, and less than 1 foot from Shreveport to Denison Dam.

In 1962, the lower 35 miles of Red River (up to the mouth of the Black River) carried about 400,000 tons of traffic. Three hundred thousand tons of this traffic originated or moved into the Ouachita-Black system, while the remainder originated or moved into Red River above mile 35.

Commercial traffic on the Jefferson-Shreveport Waterway, Cypress Creek, consists of local operators involved in oilfield operations (some 350 wells) on Caddo Lake. To all intents and purposes, other use of the authorized project has ceased and it is no longer maintained.

While the existing transportation service provided by air, truck, and railroad systems is excellent, anticipated economic growth of the basin will require extensions or addition to all transportation media. Future needs for low cost bulk transportation must be provided by rail, truck or a constructed water transport system. Many types of industry depend upon low cost bulk

transportation systems for their existence and, therefore, locate on waterways. This has been demonstrated repeatedly along the Ohio River, the Mississippi River, the Gulf Intracoastal Waterway, and other waterways. Each media has certain advantages over the others and all are required if the area is to enjoy a truly integrated mass transportation system.

If a navigation channel 9 feet deep were provided to move the commerce, it is estimated that by 1980 about 2.7 million tons of commerce suitable for waterway transportation would emanate from the area in and adjacent to the Red River Basin. This traffic would increase to about 24.3 million tons by 2030. Detailed information on navigation is contained in the "Interim Report on Navigation and Bank Stabilization - Red River below Denison Dam," dated March 15, 1966.

16. REGIONAL DEVELOPMENT

The effort to build a vigorous and expanding national economy is poorly served when regions of substantial geographical extent and population fail to achieve their full potential. The Red River Basin below Denison Dam is greatly in need of stimuli which would serve to relieve its economic disparity compared with other regions which are no more favorably endowed with economic potentials. At the last census, the average per capita income for the basin was about 60 percent of the national average - $1,380 as compared to $2,200. As of February 1968, the Economic Development Administration classified half of the counties in the basin as eligible for full financial assistance under the Public Works and Economic Development Act of 1965.

If the basin is to contribute to the economic well-being of the nation in accordance with its potentialities, intensive and extensive development of its water and related land resources will be required. Steps which must be taken to establish a physical environment conducive to vigorous economic growth include:

a. Elimination or reduction of flood problems. In urban areas, this would allow a more orderly and higher type of development than would otherwise take place. The reduction of overflow in rural areas, particularly along the fertile, alluvial plains, would provide the basin important gain in farm income.

b. Provision of adequate water supply for future population increases and for industrial uses.

c. Provision of a low cost, waterborne transportation system to accommodate existing industries and provide the incentive for the establishment of new ones, and enhance the competitive stance of the basin.

d. Protection against stream bank erosion and/or channel meandering to prevent irreparable losses of thousands of acres of highly productive alluvial lands each year. Benefits derived will include the prevention of the loss of agricultural production that otherwise would have occurred plus the prevention of damages to other improvements adjacent to the stream. Increased unit agricultural outputs over those presently anticipated will result from the improved farming practices and land conversions made possible.

e. Provision of adequate drainage in the agricultural producing areas to enhance yields on land presently in use and allow for the conversion of some woodland to higher uses.

f. Provision of low cost hydroelectric power to supplement other power sources and reduce the power cost to the consumers.

g. Provision of adequate outdoor recreation and fish and wildlife opportunities to enhance the overall environment and attract industries which consider this aspect an important factor in plant location.

17. ENVIRONMENTAL PRESERVATION.

The Red River Basin is endowed with natural values which constitute a rich heritage. The demands of progress have operated inexorably to reduce this heritage. The damages resulting from alteration of unique natural areas is quite different than most resource damages in that the loss inducing processes which stem from the alteration are usually irreversible. Numerous natural areas of the basin are sufficiently unique to warrant that expenditures be made for preservation, and that economic benefits be foregone, if necessary, to achieve such preservation. Such areas include, among many others, the Grassy Lake area in Arkansas and the Skyline Drive area in Oklahoma.

Preservation of certain types of land and water habitat is essential in maintaining a diversity of fish and wildlife in the basin study area. High quality fishing streams and certain types of bottom land forest are in short supply, and can be expected to decline in future years. Two species of endangered wildlife, the American Alligator and the Southern Bald Eagle, are occasionally found in the basin, while a third endangered species, the Red Wolf, is reported to exist in the more remote reaches of the study area. These wildlife species are at least partially dependent upon the preservation of certain habitat types.

The basin abounds in material of archaeological, historical, cultural, and scientific interest. Appropriate steps must be taken to explore these resources, and prevent their destruction.

18. HEALTH ASPECTS

Protecting the public from disease and injury and preserving water resources are basic to the objectives of comprehensive river basin planning. Health aspects involve water use and water quality, sanitary facilities at recreation areas, air pollution and solid waste control, injury control, and vector control.

Planning is not complete until the water reaches the point of use - the consumer. Therefore, the protection and safety of water supplies from the source through treatment, storage, and distribution are logical functions of planning and development of water resources. A program for development of adequate water treatment and distribution systems along with necessary quality and safety surveillance are needed to insure that each citizen in the basin area has drinking water that meets the Public Health Service Drinking Water Standards.

The vast growth in recreation facilities and their use will place more emphasis on water quality and safety for contact use, and provision of adequate sanitary facilities - potable water supply, toilet facilities, waste water disposal, and solid waste disposal. Programs of surveillance and monitoring these facilities will be needed.

The principal reasons for consideration of vector problems associated with the Red River Basin water resources and related land developments are: (1) to prevent conditions suitable for transmission of vector-borne diseases, and (2) to safeguard the comfort and well-being of the public.

Malaria formerly was an important disease in the 4-State area (Texas, Oklahoma, Arkansas, and Louisiana); but during recent years there has been no significant malaria transmission in these States or any other State of this country. Significant densities of the malaria mosquito (Anopheles quadrimaculatus) still exist throughout the Red River Basin. Therefore, a resurgence of malaria is an ever-present threat as long as travelers and military personnel bring malaria parasites into this country.

Mosquito-borne encephalitis has not been recognized as a public health problem in the Red River Basin, but the St. Louis stain of this disease (epidemics in Houston in 1964 and Dallas 1966) represents a threat in view of the prevalence of the vector -- Culex pipiens quinquefasciatus (southern house mosquito) -- in the area.

Two important tick vectors in the area are Amblyomma americanum (Lone-Star tick) and Dermacentor variabilis (American dog tick). These species are vectors of Rocky Mountain spotted fever and tularemia.

Annoyance problems are especially pertinent in connection with the development and utilization of outdoor recreational areas. Past experience has demonstrated that scourges of mosquitos such as floodwater species (e.g., Aedes vexans) and ricefield mosquitos (Psorophora confinnis) can be a real impediment to recreational developments. Other groups of vectors that may create serious nuisance problems in recreational areas include: deer flies, biting midges (Culicoides), wasps, ticks (especially Lone-Star), chiggers, and rodents.

PLANNING GOALS AND OBJECTIVES

19. PLANNING CONCEPTS AND CONSIDERATIONS

The fundamental purpose of this study is to produce a water and related land resources development program that will provide the basis for meeting the foreseeable basin needs, both short- and long-term. The program must provide for the development of specific projects to meet current and early prospective needs, and in addition, serve as a guide for the future orderly development of the basin's water and related land resources to meet needs over the next 100 years.

It is essential that the plan be truly responsive to all legitimate objectives for water resource development. Consideration must be given to the overall impacts of any feature which may be included in the program.

It is equally essential that all available and applicable alternatives be afforded adequate consideration, to the end that optimum solutions to water resource problems may be developed. In this connection, it is important to recognize that not all problems respond to structural measures, and that, in many cases, nonstructural measures alone, or in combination with structural measures, may be required to effect optimum solutions.

The formulation of the comprehensive plan has been approached, in this study, in general conformity with the above principles. Specific considerations applied in the formulation of individual projects are summarized in the following paragraphs:

a. General.

(1) That tangible benefits exceed project costs.

(2) That each separable segment or purpose provides benefits at least equal to its cost.

(3) That the scale of development is such as to provide the maximum excess benefits over costs insofar as practicable.

(4) That no more economical means, evaluated on a comparable basis, for accomplishing the same purpose or purposes, is available.

(5) That the scope and timing of selected projects and programs be responsive to the nature and urgency of the need.

b. Flood control.

(1) That the role of nonstructural measures for reducing flood damages, as alternatives or complements to structural works, be afforded full recognition.

(2) That flood protection be provided to agricultural flood plains against a recurrence of the 3-year flood as a minimum.

(3) That the effect of watershed land treatment measures, as they influence the hydrologic and economic aspects of the project, be considered.

c. Municipal and industrial water supply.

(1) That provision be made for optimum economical water supply storage in those reservoirs that are best suited to take care of the immediate and 100-year projected water needs of communities in each applicable watershed or subbasin.

(2) That maximum development be considered for each reservoir site with the objective of providing, after all foreseeable within-basin needs have been fully met, conservation storage for potential transbasin use where firm interest in such use is extant.

(3) That water supply development in the lower Red River Basin be coordinated with the plans of State planning agencies and municipalities.

(4) That full consideration be given to the use of ground water.

(5) That recognition be afforded to all local laws and policies relating to water and water rights.

d. Recreation and fish and wildlife.

(1) That the optimum recreational potential of each project, based on potential visitation to the project, be developed, recognizing the competition of other existing and proposed water projects within the zone of influence.

(2) That the preservation and protection of forests, wild areas and other areas of unique natural beauty and historical and scientific interest be provided for; and that full consideration be given to the preservation of areas likely to be of significance insofar as archaeological research is concerned.

(3) That non-Federal public interests be encouraged to develop short- and long-term recreational programs that will foster non-Federal management of project recreational areas and facilities.

(4) That maximum development at each reservoir site for the propagation of fish and wildlife be considered.

(5) That a short- and long-range fish and wildlife conservation program in consonance with each project under study be developed.

(6) That recreational developments at all major reservoir projects be sized for optimum contribution to the recreational resource. This will entail, in any such project to be presented for Federal authorization (except projects located within National Forests), local participation in accordance with the Federal Water Project Recreation Act of 1965 (Public Law 89-72). The desires of local interests as to the sizing of recreational development will be incorporated into reports seeking Federal authorization of such projects, and the required letters of intent included therein. Thus, the extent of recreational development at these projects, as presented in subsequent authorizing reports, may differ from that presented in this Comprehensive Report.

e. Hydropower.

(1) That all current and projected needs be considered in determining whether additional hydropower development would be utilized in the market area.

(2) That all sites considered to be feasible without exceeding the projected future power loads be developed to the optimum.

(3) That all Federal and non-Federal interests regarding the power development for both short- and long-range needs of the study area be considered.

f. Water quality control.

(1) That the need for supplemental streamflow or alternative pollution control measures to protect existing and projected uses of the streams, to protect the streams from further degradation, and to enhance water quality, be determined on the basis of the States' adopted Water Quality Standards.

(2) That needs for supplemental flow for water quality control be based initially on a waste treatment effectiveness of at least 90 percent, with recognition that a higher degree of treatment may, in the future, become generally feasible.

(3) That storage for water quality control be provided, where feasible, in areas where the need has been determined, and where provision of such storage is in accord with the desires of the respective States.

(4) That recognition be given to the propriety of releasing storages initially reserved for water quality control, should the need for such storages be obviated by a higher degree of treatment in the future.

SOLUTIONS CONSIDERED

20. GENERAL

After the basin needs or goals have been established, the next step in planning is to develop, analyze, and evaluate the practicable alternatives. For each specific problem, all practicable solutions were weighed and tested for applicability, effectiveness, relative economy, and total physical impact. The following paragraphs discuss the solution considered for each of the aspects of water resources development.

21. FLOOD CONTROL

The flood control problems and needs were analyzed independently by the Corps of Engineers and the Soil Conservation Service, U. S. Department of Agriculture. In general, the Corps of Engineers was responsible for large urban areas and watersheds with drainage areas larger than 250,000 acres. The Soil Conservation Service was responsible for upstream areas where the urban flood problems were less severe and watershed areas contained fewer than 250,000 acres. In areas where it was difficult to separate the responsibility, needs and solutions were considered jointly by the two construction agencies. Additional data on solutions considered for flood control are included in appendix IV, "Flood Control and Major Drainage," and appendix V, "Upstream Watershed Protection, Use, Management, and Development."

a. Red River Main Stem.

(1) With all authorized flood control works in place, most lands adjacent to the main stem will enjoy a high degree of protection; however, residual flood problems will remain on the batture lands between the river and the levees, the backwater areas, and lands along Red River above the levee system. A general lowering of the flow line in the river would essentially eliminate these problems and means for accomplishing this were investigated. The only practicable means available for accomplishing this lowering would be the construction of additional reservoirs with large flood storage capacities upstream either on the main stem or on major tributary streams. Available tributary reservoir sites proved to have only minor effects on the main stem flow line, and no suitable sites for a reservoir on the main stem were found. Improvements to lower the flow line were found to lack economic justification.

(2) Preliminary investigations were made for individual local protection projects as an alternative to general lowering of

the main stem flow line. Three areas along the main stem were found to suffer backwater flooding of a sufficient magnitude to warrant investigation of local protection projects and a discussion of each follows:

(a) Bayou Pierre, Louisiana. Two plans consisting of ring levees around the problem area with drainage structures and/or pumping plants to evacuate local runoff were investigated. Neither plan would produce benefits sufficient for economic justification at this time.

(b) Bayou Jean de Jean, Louisiana. Three plans consisting of levee and drainage structures or pumping plants in varying alignments as well as a plan incorporating loop levees around the larger areas of bottom land were studied. The cost of the most attractive plan, loop levees, is more than twice the anticipated benefits; hence, none of these features were included in the proposed basin plan.

(c) Black Lake-Saline Bayous, Louisiana. Several levee loop plans were investigated for isolated areas; however, project costs for all alternatives far outweighed benefits. Accordingly, studies were discontinued.

b. Tributaries.

(1) Choctaw Creek, Texas. Storage of flood flows in a multiple-purpose major reservoir; a system of upstream reservoirs conbined with channel improvement; and a project for a channel improvement alone were considered as means of reducing the flood problem on Choctaw Creek. The second plan was considered the best plan for the watershed since it would yield the greatest flood control benefits. This plan is included in the early action program.

(2) Brown Creek, Oklahoma. The sole feasible means of alleviating flooding on this stream consists of channel improvement throughout the length of the stream. An economically justified plan lacks local support at this time so improvement has been placed in the long-range plan of development.

(3) Island Bayou, Oklahoma. Alternative solutions considered include channel improvement along Island Bayou; a multiple-purpose major reservoir on Island Bayou at mile 6.5; a multiple-purpose major reservoir on Island Bayou at mile 15.4; and a system of seven upstream reservoirs. The major reservoir at mile 6.5 on Island Bayou was selected because this plan is most responsive to flood control and water supply needs.

(4) Blue River, Oklahoma. Studies were oriented toward meeting needs in the lower Blue River Basin because the needs of the upper Blue River Basin will be satisfied by a Soil Conservation Service plan which has been authorized for operations. Several systems of upstream reservoirs; multiple-purpose major reservoirs at river miles 13.0, 20.6, 30.2, 39.0, and 59.0; and a combined plan of 13 upstream reservoirs and a major multiple-purpose reservoir, were considered in planning studies. Discussions by the Coordinating Committee developed a concensus in favor of the combined plan. The Department of Agriculture detailed a number of objections to the combined plan, and expressed the opinion that local cooperation probably could not be obtained on the 13 upstream reservoirs. The Committee, accordingly, decided that the report would present, as an acceptable justified alternative to the combined plan, a system of 30 upstream reservoirs.

(5) Bois d'Arc Creek, Texas. Alternatives considered as a means of reducing flood damages include channel improvement; a system of upstream reservoirs combined with channel improvement; major multiple-purpose reservoirs at river miles 23.5, 24.8, 28.6, and 43.1 with associated flood release channels; and a combination of 22 upstream reservoirs, a large multiple-purpose reservoir at mile 43.1, and channel improvement. Local interests stated a preference for the combined plan.

(6) Boggy Creek, Oklahoma. Channel improvements; a system of upstream reservoirs; multiple-purpose reservoirs, both upstream and downstream of Highway 75 on Muddy Boggy Creek; and a combined plan of upstream reservoirs and a major multiple-purpose reservoir upstream of U. S. Highway 75 were considered as alternative solutions to the flood problem above the authorized Boswell Reservoir on the Muddy Boggy Creek arm of Boggy Creek. Channel improvements would not permit the full development of the water resources. A multiple-purpose reservoir in the upper portion of the basin, with flood control as a major purpose, would provide flood protection from its damsite downstream to the upper reaches of Boswell Reservoir without depleting the conservation potential of Boswell Reservoir. The combined plan would be most responsive to overall needs. The authorized Boswell Reservoir, in conjunction with a major reservoir on McGee Creek, will adequately meet the needs for flood protection in the lower reaches of Boggy Creek, and authorized upstream watershed projects will serve to protect Clear Boggy Creek watershed above Boswell Reservoir. Additional flood control structures on Clear Boggy Creek are not feasible at this time; however, Tupelo Reservoir has been placed in the long-range plan primarily to develop fully the water supply of the basin.

(7) Kiamichi River, Oklahoma. The only practicable means of providing flood control protection in this rugged, rocky terrain is through reservoir storage. Three multiple-purpose reservoirs were considered to supplement protection provided in the three

authorized major reservoirs - Hugo, Clayton, and Tuskahoma, and three upstream watershed projects. None of the additional reservoirs are economically feasible at this time.

(8) Little River and Tributaries, Arkansas-Oklahoma. The tributaries of Little River rise in the Kiamichi Mountains. The narrow valleys and rocky terrain of this area preclude consideration of any means to control flood flows other than storage in reservoirs. The control of flood waters on the tributary streams by authorized major reservoir projects will reduce but not completely abate the flood problem on Little River from Idabel to the upper reaches of Millwood Reservoir and on two tributary streams. Multiple-purpose reservoirs were considered at sites on Mine Creek, and Little, Cossatot, and Mountain Fork Rivers. Sherwood Reservoir on Mountain Fork River, which would provide transfer storage for flood control in combination with modification of the authorized Broken Bow Reservoir was justified for inclusion in the early-action plan of development. Caney Mountain on Little River, Hartley on Cossatot River, and Mena on Mountain Fork River reservoir projects offer excellent opportunities for future development and are included in the long-range plan. Upstream watershed projects would offer a means for reduction of flood damages in some tributaries.

(9) Colliers Creek, Texas. Backwater effects of Red River make channel improvements on Colliers Creek impracticable. A system of upstream reservoirs which would control flood flows and a major multiple-purpose reservoir were two alternatives considered. While neither alternative is feasible at this time, either would adequately protect the basin downstream on Colliers Creek. The latter alternative is included in the long-range plan.

(10) Pecan Bayou, Texas. Studies of means to control the flood flows on Pecan Bayou included a major multiple-purpose reservoir; a channel improvement project; and upstream watershed improvements. The multiple-purpose reservoir is feasible; however, studies are continuing as part of the investigation relating to the Texas Water Plan. Recommendations on this project will be developed in the current study of that plan.

(11) Mill and North Mill Creeks, Texas. Studies to control flood flows on Mill and North Mill Creeks considered major reservoir storage, channel improvement, and upstream watershed improvements. However, the projects were found to be not economically feasible at this time. A major reservoir was included in the long-range plan.

(12) Mud Creek, Texas. Backwater from flood stages in Red River in conjunction with Mud Creek runoff precluded realizing adequate flood control benefits to justify reservoir storage, channel improvements on Mud Creek, or upstream watershed improvements.

(13) Red Bayou, Texas. A channel improvement project, reservoir storage of flood flows, and upstream watershed improvements received consideration in the Red Bayou Basin. Low stream slopes, combined with backwater from flood flows on Red River, make channel improvements infeasible. Upstream watershed developments cannot be justified. Flood storage in a multiple-purpose reservoir would control floods on the lower reaches of Red Bayou, and although not economically feasible at this time, a major reservoir is included in the long-range plan.

(14) Barkman Creek, Texas-Arkansas. Channel improvement plans of various scopes were investigated. These plans involved drainage and flood prevention improvements in addition to existing channel improvement on Barkman Creek, and were to alleviate agricultural damages. A feasible plan was developed which would include 23 miles of multiple-purpose drainage and flood prevention channel improvement.

(15) Hempstead Levee District No. 1, Arkansas. The feasibility of supplementing the existing drainage system with the installation of pumping capacity was studied. However, the high annual cost associated with the operation of a pumping plant, and the relatively low flood damages experienced render this plan uneconomical.

(16) Bois d'Arc Creek, Arkansas. Channel improvements, levees, and upstream reservoirs were examined as means of reducing headwater and backwater flooding. None of the improvements are justified.

(17) Maniece Bayou, Arkansas. Channel improvement and upstream reservoirs providing greater protection than the plan now authorized were investigated; however, costs for the additional work outweigh the benefits which would accrue.

(18) McKinney Bayou, Texas-Arkansas. Modifications to the authorized plan including enlargement of the existing outlet, providing new outlets at Buzzard Bluff and the Louisiana-Arkansas State line, upstream reservoirs, and interior drainage improvements were considered. The improvements are economically justified and are included in the early-action plan of development.

(19) Sulphur River Basin, Texas-Arkansas.

(a) Streams above Lake Texarkana, Texas. The Sulphur River Basin is a major source area for out-of-basin supply under the Texas Water Plan. Some of the flood-prone area would be inundated by reservoirs proposed in the Plan. Since the Plan is still under study, however, investigations in this area were included in areas which might later be inundated by features of the Texas Water Plan.

Numerous alternative plans to reduce overall basin flooding were analyzed, including multiple-purpose reservoirs, channel improvements, loop levees and upstream reservoirs. Other than a plan for 78 upstream reservoirs, none of the solutions investigated were found to be economically feasible. This plan is included in the early-action plan of development, and would not be influenced by construction of any of the features proposed for the Texas Water Plan. Other improvements fall far short of justification.

(b) Days Creek, Arkansas-Texas. A channel improvement plan, involving an enlarged major outlet via Days Creek, to relieve flooding in the cities Texarkana, Texas and Arkansas, was examined. The improvements are feasible and included in the early-action plan.

(20) Posten Bayou, Arkansas-Louisiana. Modifications to the authorized plan including a diversion channel with control structure, upstream reservoirs, and interior drainage improvements were considered. A combined diversion channel with control structure and interior drainage improvements are included in the early-action plan and were recommended for construction in the "Interim Report on Posten Bayou, Arkansas," dated March 1968, prepared by the U. S. Army Engineer District, New Orleans, in cooperation with the Soil Conservation Service.

(21) Cypress Creek Basin, Texas-Arkansas-Louisiana. Upstream watershed projects were considered for all watersheds in the Cypress Creek Basin. No projects including flood control as a purpose were found to be economically feasible.

(a) Kelly-Black Bayous, Arkansas-Louisiana. Four alternative plans for reducing flood damage on Kelly Bayou were considered, including channel improvement, a diversion channel, upstream reservoirs, and the construction of the authorized Black Bayou Reservoir. None of the plans are economically justified at this time. The authorized Black Bayou Reservoir is included in the long-range plan of development.

(b) Frazier Creek, Texas. The only practicable solution to the flood problems along Frazier Creek is channel improvement. Channels of various sizes were studied to determine if benefits would support costs; however, none of the plans proved to be feasible.

(c) Black Cypress Creek, Texas. A flood control reservoir and channel improvement plan was studied. The channel improvement plan to provide protection from the 3-year frequency flood was found to be most practicable; however, even this plan is not economically feasible.

(d) Cypress Bayou, Texas. Flood control plans considered include channel improvement and the inclusion of flood control storage in the Titus County Reservoir. Neither of the plans was feasible.

(e) Little Cypress Creek, Texas. Two plans to reduce the flood damage along Little Cypress Creek were studied. The first involved placing flood control storage in a multiple-purpose reservoir, and the second consisted of enlarging the existing stream. Neither plan would produce sufficient benefits to justify its cost.

(f) Twelvemile Bayou, Louisiana. The area east of Twelvemile Bayou is presently protected from both Red River and Twelvemile Bayou overflow by levees; however, overflow due to ponding of interior runoff still exists. The only practicable solution to this problem would be the provision of pumping facilities to evacuate excess runoff. The cost of installation and operation of these facilities is very high and economic justification is lacking at this time. This project is included in the long-range plan of development.

(g) Middle Bayou-McCain Creek, Louisiana. The only practicable solution to the flood problems in this basin is the construction of levees. Improvements are not justified at this time, since flood losses have been confined to small acreages of native pasture. However, it appears that, in the future, urban expansion will necessitate development along the lower reaches of the stream. Consequently, a plan has been included in the long-range plan of development.

(22) Bayou Pierre, Louisiana. Information on measures designed to protect against Red River overflow is included in paragraph 21a.(2)(a). In addition to these measures, consideration was given to upstream watershed improvement plans, and an extension of the existing channel improvement project on Brush Bayou. One upstream watershed project is included in the early-action plan. The proposed improvement on Brush Bayou is included in the long-range plan; however, information only recently made available indicates that justification for early construction may exist, and studies to reevaluate the economics of the plan will be undertaken under the continuing authority of Section 205 of the Flood Control Act of 1962.

(23) Loggy Bayou Basin, Arkansas-Louisiana. Numerous plans of improvement were developed to reduce damages not provided for in authorized projects. These include single- and multiple-purpose reservoirs, channel enlargement along Bayou Dorcheat, several loop levee plans to protect the lower Loggy Bayou area from Red River backwater, and upstream watershed improvements. A major multiple-purpose reservoir, which does not, however, include flood control as a project purpose is included in the early-action

plan. Upstream watershed improvements are also included in the early-action plan to supplement authorized improvements in this basin. Two of the loop levee projects and additional upstream watershed improvement are included in the long-range plan.

(24) Campti-Clarence, Louisiana. The installation of pumping facilities to augment the authorized project was analyzed; however, present residual damages are minor and the proposal is not justified at this time. The plan is included in the long-range plan of development.

(25) Cane River-Kisatchie Bayou, Louisiana. Several alternative solutions to the flood control problems were investigated, including channel enlargement, levees, provision of flood control storage space in single- and multiple-purpose reservoirs on Kisatchie Bayou, and a system of upstream reservoirs and channel improvements. All plans are economically justified. A multiple-purpose reservoir with flood control storage is the solution favored by local interests. A system of eight upstream reservoirs as a supplement to the preferred plan was also studied. The eight reservoirs included three for flood prevention and five multiple-purpose reservoirs for flood prevention and municipal and industrial water supply. This system offers a potential for development if actual needs should exceed projections.

(26) Bayou Rapides, Louisiana. The only effective means of reducing flood overflow in this area, now protected from the Red River by levees, is through the use of pumping facilities. The project, which is not economically feasible now, is included in the long-range plan of development.

(27) Bayou Du Grappe-Rigolette, Louisiana. Several alternative methods of reducing flood damages were considered, including a multiple-purpose reservoir at Lake Iatt; a system of upstream reservoirs and channel improvements; channel improvements in Bayous Rigolette, Du Grappe, and Sugarhouse; and an additional outlet to convey runoff into Red River. The multiple-purpose reservoir is not economically justified; however, a plan consisting of channel improvements in Rigolette, Sugarhouse, and Du Grappe Bayous; installation of additional floodgates through the Red River levee, and 11 upstream reservoirs is justified and included in the early-action plan.

c. Other Upstream Watershed Projects considered by U. S. Department of Agriculture.

(1) Watersheds feasible for development. The USDA evaluated flood problems and formulated project plans in 55 watersheds which show urgent need for development. Thirteen upstream

watersheds were planned jointly with the Corps of Engineers; 42 projects plans were prepared primarily by USDA. These watershed projects are recommended for early-action development.

Six other watersheds investigated show damages attributable to flooding; however, these damages are relatively low in comparison to areas of more intensive use. These watershed projects are recommended for long-term development.

The details of watershed projects recommended by USDA for early-action and long-term development are presented in appendix V.

(2) Watersheds not feasible for development. A reconnaissance investigation and study was made in each Conservation Needs Inventory watershed in sufficient detail to determine feasibility for development. Watersheds in which it was apparent that floodwater erosion and sediment damages were such that projected benefits clearly would not exceed costs of structural measures in the future were classified as not feasible for development.

d. Flood plain management. The exercise of an intelligent selectivity in the use of flood plains and in the type of construction employed therein is essential to prevent the progressive growth of flood losses which cannot be economically dealt with by structural measures. The applicability of flood plain management was considered in each watershed and subbasin.

e. Flood forecasting. Regardless of the effectiveness of structural and nonstructural measures for the reduction of flood danger, the need for the expeditious collection, correlation, and dissemination of flood warning data will remain. Current programs may be improved by expansion of data collection networks and application, on a continuing basis, of more sophisticated equipment in the areas of electronic surveillance and automatic data processing.

22. BANK STABILIZATION

An exhaustive review was made of available data on design, construction, and maintenance experience of stabilization programs on Red River and on other rivers, principally the Arkansas, Missouri, and Mississippi. Types of protection measures considered included dredging for realignment in bends and cutoffs; pile dikes and pile revetments, with and without stone fill; board mattresses; articulated concrete mattresses; rock groins; and steel jetties. Additional information on solutions considered for bank stabilization is contained in the "Interim Report on Navigation and Bank Stabilization" dated March 15, 1966.

23. LAND RESOURCES

Land resource development is concerned with land and water uses that will yield continuing returns to the people of the study area and the Nation. A development program places emphasis on accelerating the land treatment measures that have a significant effect on reducing runoff, erosion, and sediment production. The measures are designed to protect and improve the agricultural lands and woodlands and increase overall farming efficiency. Thus, to meet the study area's share of the expanding National market demands, farmers will have to capitalize on the potential of land resource development. This can be accomplished by the adoption of improved crop, timber, and livestock production, and insofar as practical, use of land according to its capabilities.

In addition, some adjustments in land use such as (1) clearing and draining wet land capable of profitable crop and pasture production, and (2) shifting idle land to crop or pasture uses will be required of farmers. On the other hand, some land now idle, in crops, or in pasture, could be better utilized through reforestation. Improved technology and its rate of acceptance and adaptation by farmers represents another potential for land resource development. Better communications, larger farms, and improved managerial techniques will accelerate the physical development of under-developed lands being used below their capabilities. As a result, a greater portion of the agricultural area will be utilized for production of the more intensive crops and improved pasture, the location of which will tend to shift to the more productive, less hazardous soils.

A major objective in the physical resource development program would be to control erosion on 1,972,000 acres of sloping cropland. The major land treatment practices to be applied include terraces, contour farming, grassed waterways, and special residue management. A cropping system designed to reduce erosion to a minimum is necessary to prevent resource deterioration.

About 95,500 acres, now classified as cropland, are too steep and eroded for cultivated crops. Generally, this land should be seeded to permanent grass and used for pasture. Some of it may be converted to woodland, wildlife land, or recreational areas.

Nearly 41 percent, or about 1,850,000 acres, of the grazing and pastureland has adequate cover to prevent soil erosion. However, for grazing and pasturelands to produce sufficient grazing to yield an economic return, at least 1,560,000 acres should be treated. High-level management of pastureland is accomplished by liming, fertilizing, reseeding improved pasture mixtures, and by fencing and developing additional water supplies for proper grazing control.

Treatment measures, including open land tree planting, forest interplanting, hydrologic stand improvement, fire protection, and grazing control are needed for forest lands of the study area. These measures will permit realization of full benefits in watershed management and wood productivity. Installation of the proposed measures would require that all private, nonforest industry lands be put under good forest management and sustained yield.

About 33 percent of the nearly 10,300,000 inventoried acreage of forest and woodland in the study area is on land-capability classes VI and VII. Lands in these capabilities are suited only to grass, tree production, and wildlife and recreational areas. Forty-eight percent is in capability classes I to IV. Capability class V accounts for the remaining 19 percent of the woodland area and is so classified because of a wetness problem. With land treatment measures applied, this land in capability classes I through V, or about 6,900,000 acres, could be used for cultivation to meet the future crop production needs.

24. DRAINAGE

The USDA made an inventory of drainage needs in the basin. Studies show that 1,279,500 acres of land are considered feasible for drainage and flood prevention improvement. Of this amount, 807,300 acres need group drainage and an additional 472,200 acres need drainage that can be accomplished by individual farmers. The Southern Mississippi Valley Alluvium and the Southern Mississippi Valley Silty Uplands Land Resource Areas have the greatest potential for drainage and flood prevention improvements.

Factors affecting feasibility of soils for drainage were based on the physical properties of the soils, projected land use changes, and the yield responses necessary to cover the cost of removing excess water limitations. Project-type drainage was not included for any land that was projected for woodland use. Solutions considered to alleviate drainage problems include multiple-purpose drainage and flood prevention channel improvement on flatland watersheds that would provide adequate outlets for on-farm drainage systems. Appurtenant structural measures would be included to complement channel efficiency. Pumping plants were not considered feasible for development in any of the watersheds with drainage needs.

25. MUNICIPAL AND INDUSTRIAL WATER SUPPLY

The projected basin requirements for municipal and industrial water supply are presented in paragraph 9 of this appendix and in appendix XI. The future water requirements, as outlined, represent gross needs based on economic and water-use projections. From the gross requirements, net needs were computed through use of the Public Health Service 1963 Inventory of Municipal Water Facilities and

other subsequent data available on reservoir projects completed, under construction, authorized, or in a definite planning stage. Data on ground water supply facilities, reflected in the 1963 Inventory, and data from the Geological Survey on 1965 water use were utilized in determination of net needs.

The net water requirements determined for this study represent basin needs for further water resource development prior to 1980, and reflect a trend of future basin needs for the next 50 to 100 years. In addition, substantial needs for additional water supply exist in a number of areas outside the basin. In formulating the plan, consideration was given to construction of reservoir projects to supply out-of-basin needs where firm and specific indications of interest in the water supply were in evidence. Such consideration was not, however, applied to certain specific projects in the Texas Water Plan, since such projects are being considered in the separate study of that plan now in progress.

Studies to determine practicable solutions to the municipal and industrial water supply problems included detailed investigations of potential ground water and surface water sources. For each area needing water, cost data and benefits were analyzed for all practicable alternative means of supplying water. The studies included both quantity of water available and the existing and projected quality of the potential water resources. Results of these studies are contained in appendix III, "Hydrology, Surface and Ground Water, and Geology"; and in appendix XI, "Water Supply and Water Quality Control."

26. WATER QUALITY CONTROL

Water quality control needs of the basin are described in detail in appendix XI, "Water Supply and Water Quality Control." Water quality control needs were projected for the 100-year period of study (1980-2080). The estimated supplemental flow requirements were based on projected waste discharges to streams from cities and industries in the basin expected to have extensive expansion and development in the future, as reflected in the Economic Base Study. Criteria for determining the streamflow requirements to maintain acceptable water quality were based on the water quality standards adopted by the respective States. The parameters used as a measure of existing and potential water quality included dissolved oxygen, biochemical oxygen demand, total dissolved solids, chlorides, sulfates, nutrients, color, temperature, turbidity, and other selected criteria for the protection of future uses of the streams - uses that have been designated by the States.

The water quality standards adopted by the States provide for a minimum treatment level of "secondary" for municipal wastes and its equivalent for industrial wastes. On this basis, an average

treatment level of 90 percent removal of biochemical oxygen demand has been used for computation of supplemental flow needs. In making this assumption, it is recognized that advancement in technology could greatly alter projected quality control methods and needs in the future. Quality control needs should be reexamined periodically in view of changed economic conditions, quality objectives, use of the streams, treatment practices, and treatment technology. Significant changes could alter or eliminate projected needs for supplemental flow for water quality control.

In studies to determine the need for and value of storage in reservoir projects for water quality control, alternative pollution control measures were considered. These included single-purpose (or least-costly alternative) reservoirs, advanced waste treatment, deep-well injection of wastes, pipelines to large receiving streams, and diversion of treated wastes for irrigation.

The Corps of Engineers and the USDA determined the feasibility of water quality control storage in major reservoirs and upstream watershed projects, respectively. Information on such storage in a major reservoir on Bayou Dorcheat is contained in a subsequent section of this appendix; information on major quality control storage in upstream reservoirs is included in appendix V, "Upstream Watershed Protection, Use, Management, and Development." None of the possible solutions for meeting water quality control needs involving storage for supplemental flow have been included in the Texas portion of the plan since that State has plans for other means of achieving satisfactory stream quality.

27. IRRIGATION

The irrigable lands along the Red River and its tributaries were investigated to determine their suitability for development of project-type irrigation. About 317,000 acres could be irrigated with water diverted from the Red River or its tributaries by means of streambank pumping plants to serve nearby lands. Reconnaissance reports for the Liberty Bottoms and Goodlands Projects covered the reach from Denison Dam to the Lamar-Red River county line and a feasibility report was prepared for the Liberty Bottoms project area in Bryan County, Oklahoma. Irrigation investigation summary reports were prepared for the remainder of the area along the Red River in Oklahoma and Texas, and a separate report covered the Arkansas-Louisiana portion of the basin. As a result of these studies it was concluded that there is not sufficient local interest in most areas of the basin to include irrigation project-type developments in the early-action plan of development.

In areas that did show an interest in irrigation, that purpose was included in the early-action plan. One major reservoir was formulated to include storage for irrigation. Irrigation has been considered as a purpose in six potential upstream projects.

28. HYDROELECTRIC POWER

The formulation studies gave consideration to the hydroelectric power potential at all reservoir sites. This investigation included authorized projects, projects under construction, projects in the framework plan, and a review of existing reservoirs. Preliminary factors that had a direct bearing on the scope of consideration were: the head that could be developed at each site; the flow available; the volume of storage available; and any restrictive operating criteria peculiar to the individual sites.

Single-purpose projects for generation of conventional, or run-of-the-river, hydroelectric power tend to be uneconomical. The variations of river flow during water deficient years make these sites, on many streams, marginally dependable at best. With adequate flow, the inclusion of conventional hydroelectric power as a project purpose in a multiple-purpose project may become feasible. Other factors to be weighed include the benefit-cost ratio and the costs compared with steam-electric plant costs.

Eleven reservoir sites met the preliminary investigation criteria of adequate flow, adequate storage available, and adequate head for conventional hydroelectric power development within multiple-purpose projects. Of these eleven sites, only Sherwood Reservoir had a benefit-cost ratio and a comparability ratio that was considered to be economically feasible for development at this time. This project is presented later in paragraph 40 of this appendix.

Since pumped storage hydroelectric power development is not dependent on quantity of river flow, and since storage requirements are less than the requirements for conventional hydropower development, pumped storage hydroelectric power generation may be feasible in areas that would not support a conventional installation. The extreme fluctuations of water levels in the forebay reservoirs of such projects usually preclude utilization of their pools for other purposes except in projects with a very large volume of storage.

Eight sites met the criteria for pumped storage hydroelectric power development. These criteria specified that: (1) a head of at least 150 feet be available between the upper and lower reservoirs; and (2) sufficient usable storage could be developed in the upper reservoir to allow at least a daily cycle of generating and pumping. All sites screened had preliminary benefit-cost ratios and comparability ratios that would indicate detailed studies were warranted; however, significantly higher heads could be developed at the Clayton Reservoir and the Tuskahoma Reservoir sites. The Tuskahoma pumped storage site proved to be economically feasible at this time. This project is presented in paragraph 40 also.

29. RECREATION

The lower Red River Basin offers a variety of opportunities for developing a basin recreation plan. Those available range from the development of large reservoirs to the preservation of free-flowing streams, and from the development of large amounts of forest land for recreation to the preservation of unique areas of outstanding natural beauty.

It is likely that water is one of the major factors that draw people to outdoor settings. A major consideration of the recreation plan, therefore, is water, either in the form of lakes or free-flowing streams.

The basin already has a number of large reservoirs supplying recreation opportunities. As recreation demand increases, facilities at existing reservoirs must be expanded to allow for the optimum recreation use of these resources. Additional reservoirs, both large and small, will be required in future years to meet the growing demand for water-dependent and water-enhanced outdoor recreation opportunities. A number of reservoir sites have been investigated and considered. Recreation was included as a project purpose in 11 of the 12 reservoir projects and in 21 upstream watersheds for early-action development.

Consideration was given to the possibility of developing adjacent river basins as a means of satisfying some of the recreational demands of this basin. A comprehensive river basin plan has been formulated for the Sabine River Basin which is adjacent to and drains a large area to the west and south of the subject basin. The data available on the Sabine do not indicate a substantial surplus of supply over the projected needs. These data do not present findings that additional demand could be satisfied more efficiently or effectively in the Sabine Basin than in the subject basin. However, Toledo Bend Reservoir should draw recreationists from the basin, particularly from the Shreveport Standard Metropolitan Statistical Area. Allowances for this were made in the demand calculation for the Louisiana and Texas subareas.

Stream preservation is of utmost importance for a balanced recreational resource. White-water canoeing and float fishing are highly prized recreational experiences. The Kiamichi, Blue, and Mountain Fork Rivers in Oklahoma; the Cossatot River in Arkansas; and the Saline Bayou and Bayou Dorcheat in Louisiana are examples of this nonrenewable resource that should be preserved.

Land resources in the basin range from the mountainous to the Mississippi Alluvial Plain. These lands offer opportunity to provide facilities for recreation activities such as driving for pleasure, sightseeing, hiking, camping, and many others. The development of trails, scenic roads, scenic areas, and wilderness areas

can provide opportunities to satisfy many of the recreation needs of modern America. Lands adjacent to existing and proposed reservoirs will be obtained for development of recreation facilities. Lands will also be required to preserve and utilize the free-flowing streams in the basin and to provide scenic drives and overlooks.

30. FISH AND WILDLIFE

The fish and wildlife plans presented in detail in appendix XIII were developed in cooperation with other Federal and State agencies. Certain planning items were developed for incorporation into water development project plans, while other items were designed to be accomplished independently. Measures considered as part of the plan to satisfy the fishing needs include stream preservation, low flow augmentation, development of public lakes for fishing, and water management structures for lakes and reservoirs. Measures considered in the plan to satisfy hunting needs included land acquisition, land development and management for wildlife, and provision of public access to these areas over all-weather roads. These plans, based on historical and present use of fish and wildlife resources, were developed to meet both short- and long-range public needs.

31. NAVIGATION

A detailed study of the basin was made with a view toward providing low cost bulk transportation to the commerce centers via a system of inland waterways. The characteristics of the river make open-river navigation impracticable; however, a usable waterway system can be developed through the use of locks and dams.

Main stem studies included provision of a navigation channel to extend from the Mississippi River via Old River and Red Rivers to Shreveport, La., and thence to Ogden, Ark., Arthur City, and Denison, Texas. Four tributary routes branching off the main stem were investigated. The first route extended from Red River in the vicinity of Shreveport, La., via Twelvemile and Cypress Bayous and Lake O' the Pines to the vicinity of Daingerfield, Texas, and northerly beyond, along existing streams and new land cuts to rejoin Red River near mile 510, thence to Denison Dam; the second extended from Red River via the Sulphur River to the vicinity of Texarkana, Texas-Arkansas; the third extended from Red River in the vicinity of Fulton, Ark., up Little River to Idabel, Okla., thence through a canal to Red River downstream from the mouth of the Kiamichi River; the fourth, up the Sulphur River to Texarkana Reservoir, thence north through a canal to Red River at mile 510 (existing mileage).

Detailed information relative to navigation is contained in the "Interim Report on Navigation and Bank Stabilization - Red River below Denison Dam," dated March 15, 1966. This report found that navigation on the main stem between Shreveport, La., and Denison, Texas, was not feasible even though substantial commerce would emanate from that portion of the basin. Subsequent to the release of the interim report, the feasibility of extending navigation above Shreveport was reviewed. In addition, an alternative tributary route extending from Red River, up Loggy Bayou and Bayou Dorcheat, to Springhill, La., was given consideration.

32. REGIONAL DEVELOPMENT

The role of water resources development in fostering regional development has not, as yet, been defined with precision. Further, means for quantitatively evaluating the benefits accruing from economic expansion, per se, are largely lacking. Thus, consideration of alternative solutions relating to regional development, in the same manner that alternative solutions for, say, flood problems are considered, is not possible. It would appear appropriate, for the present, to view the major contribution of water and related land resources development to regional enhancement as the establishment of a physical milieu favorable to economic expansion. Such a view was taken in the analyses made for this report.

33. ENVIRONMENTAL PRESERVATION

The goal of the comprehensive plan is to utilize all resources in meeting anticipated needs and to provide an equitable distribution of opportunity insofar as practicable. To gain this goal, consideration must be given to the preservation of a quality environment for human habitation.

For this comprehensive study, natural areas of value were inventoried, identified, and evaluated, and consideration given to various means through which their preservation could be effected. These included stream preservation, acquisition of lands for environmental enhancement, and consideration of the impact of structural measures on the environment in the formulation of plans for such measures with concommittant effort to minimize unfavorable impacts in this regard. Actually, environmental preservation is a relatively new concept, and specific measures for achieving it are generally not available. This report will have succeeded if it merely serves to identify and publicize this area of concern.

34. HEALTH ASPECTS

Important considerations involved in these planning studies include preimpoundment clearing, providing adequate depths in reservoirs to discourage aquatic growth, water level management in the interest

of vegetative and mosquito control, control of marshy and seep areas downstream from dams, proper location of recreational facilities with respect to the mosquito potential, provisions for proper disposal of waste and debris, and provisions for vector surveys at project sites. All of these factors have been considered in a general way; however, specific consideration must, in most cases, be deferred until detailed planning is undertaken.

COMPREHENSIVE PLAN OF DEVELOPMENT

35. GENERAL

In the formulation of a plan to meet the short- and long-term water and related land resource problems and needs of the basin, consideration was given to the authorized, under-construction, and existing projects. A comprehensive framework plan was developed to supplement those projects in order to fully utilize the water resources of the basin. Projects and programs were then selected from this framework plan, on the basis of need, which could be recommended for construction within the next 10 to 15 years. These projects and programs are described in paragraphs 39 through 45, "Early-Action Plan of Development." Those projects in the comprehensive plan that are not needed in the immediate future are included in the long-range plan of development.

36. DEVELOPMENT OF THE PLAN

The formulation of the comprehensive plan for developing the water and related land resources of the basin involved a process of testing and evaluating structural and nonstructural measures, systems of such measures, and programs, from different viewpoints and standards to achieve an overall design which would best serve the national and regional interest.

Existing, under-construction, and authorized Federal and State projects and programs for use and control of water and related land resources in the basin served as a base for the development of the comprehensive plan. Such projects and programs were evaluated and modifications were proposed where they could be justified on the basis of additional benefits. Additional projects and programs to meet the remaining immediate and long-range needs were developed and evaluated for inclusion in the comprehensive plan.

Because of urgent need and widespread interest, the identification of problems and needs associated with water transportation and bank caving along the main stem of Red River, and the development of plans for their solution were given first priority in the comprehensive study. Subsequently, the results of this study were published as an interim report by the Corps of Engineers in March 1966. The report recommends the construction of bank stabilization works on Red River from its mouth to Denison Dam, and construction of navigation projects by a series of locks and dams as far as Shreveport, Louisiana, on the Red River, and to the vicinity of Daingerfield, Texas, on the Twelvemile-Cypress Bayou tributary system. During this study, other problems and needs of the basin were considered to ensure the development of a plan which would be compatible with other projects or programs either in existence or

which would be identified as offering a potential for significant contribution to the economic welfare of the basin. The navigation and bank stabilization study was thoroughly coordinated among the Federal agencies and States involved in planning and the project was considered "in place" in planning for other improvements in the basin.

Plans for the control of damaging flood flows through reservoir storage or channel improvement were given priority according to the magnitude of the flood problem. As mentioned previously, sites for major reservoirs within the basin are limited and multiple-purpose use of such sites was always considered. Numerous main stem and major tributary sites were investigated for municipal and industrial water supply, water quality control, conventional and pumped-back hydroelectric power, irrigation, recreation, and fish and wildlife, as well as flood control.

Local protection works, including levees, channel improvements, diversion channels, drainage facilities, and pumping plants, are proposed, where feasible, for those areas sustaining flood damages which would not be protected by existing and proposed reservoirs.

Floodwater retardation structures are proposed in upstream areas where flood problems exist and suitable sites for such structures are available. Where a need exists, plans include storage for municipal and industrial water supply, water quality control, recreation, fish and wildlife, and irrigation. Land treatment measures are included where such measures are needed.

Various types of developments were considered to meet the needs for water-related recreational opportunities in the basin and area of influence. These included construction of main stem, major tributary, and upstream reservoirs; preservation of streams; development of additional recreation lakes and the acquisition of additional land within National Forests; construction of fish hatcheries; regulation of tailwater temperatures and provision of access to the tailwater below large reservoirs; provision of access to fish and wildlife habitat within leveed areas; construction of public lakes for fishing and hunting; provision of stream access, municipal impoundments, and farm ponds; and land acquisition for wildlife management.

In formulating the comprehensive plan for development of the land and water resources of the basin, projects and programs were screened to determine:

a. Those that are not qualified for inclusion in the plan by reason of unfavorable economics and/or lack of need.

b. Those that are economically feasible for construction within the next 10 to 15 years and are necessary to meet immediate and future needs. Such projects and programs are included in the early-action plan.

c. Those that are not economically feasible for construction in the next 10 to 15 years but are likely to be needed to meet future basin needs and are potentially feasible for development. Such projects and programs are included in the long-range plan.

Individual projects involving structural measures were developed by the Corps of Engineers and the Soil Conservation Service. Certain nonstructural measures were developed by other participants as well as by the two above agencies. Informal coordination was maintained throughout the formulation of all projects, not only between the two construction agencies, but among all study participants. In a number of cases, combined plans have been developed to accomplish a single purpose.

As might be expected in such a study, certain conflicts arose as to programs and methods. Most such conflicts were resolved by informal negotiation between the different agencies. When such negotiations failed to produce a mutually acceptable compromise, the problem was presented to the Plan Formulation Task Force in full session. In all cases, the Plan Formulation Task Force was able to develop recommendations for the Coordinating Committee which represented an adequate consensus.

When a tentative overall plan had been developed, it was presented to the Coordinating Committee for approval. After Coordinating Committee approval, the tentative plan was presented to the public at three public hearings - at Shreveport, Louisiana, on February 6, 1968; at Texarkana, Texas, on February 7, 1968; and at Lake Texoma Lodge, Oklahoma, on February 8, 1968. The hearings provided a final opportunity to elicit local views and preferences on a broad scale, and from them came the last of the inputs to the study. Thus, the hearings served to provide a means for all local interests to exert an appropriate influence on the final plan.

Subsequent to the public hearings, the tentative plan was adjusted in accordance with input data generated by the public hearings and presented, as the final plan, to the Coordinating Committee for approval. The plan and supporting report were then presented to the participating States and agencies for formal field-level review and comment. Agency and State comments are contained in Annex "A" to the Summary Report.

37. THE COMPREHENSIVE PLAN

The comprehensive plan of development includes both structural and nonstructural measures, categorized as early-action or long-range features, depending upon the urgency of the needs to which they are responsive. The comprehensive plan is divided into two sections with respect to status. The first section includes existing, under-construction, and authorized projects and programs. The second section comprises the additional features required to meet remaining needs. The projects and programs of the comprehensive plan are shown on plates 1 and 2, and discussed in subsequent paragraphs.

a. Existing, under-construction, and authorized improvements. These projects and programs include all of those presented in paragraph 3, with the following exceptions:

Project	Remarks
Mooringsport Reservoir	Deauthorization recommended in CE "Interim Report on Navigation and Bank Stabilization," dated March 15, 1966.
Red River below Fulton, Ark. (Overton Waterway)	Modification recommended in CE "Interim Report on Navigation and Bank Stabilization," dated March 15, 1966.
Cypress Bayou and Waterway between Jefferson, Texas, and Shreveport, La.	Same as above.
McKinney Bayou Modification authorized by Flood Control Act of 1960	Early-action plan includes a project of increased scope which encompasses all purposes of the authorized modification.
Posten Bayou	Deauthorization recommended in CE "Interim Report on Posten Bayou," dated March 1, 1968.

b. Additional improvements. Additional improvements are shown on plate 2. For the purposes of this report, all upstream watershed improvements authorized subsequent to December 31, 1962, regardless of their current state of completion, are included as features of the early-action plan, and are shown, in red, on plate 2.

The projects and programs of the early-action plan of improvement would satisfy the urgent needs for additional flood protection, water supply, recreation, fish and wildlife, and hydroelectric capacity in the Red River Basin below Denison Dam; stimulate the economic growth in the region; and provide for preservation of valuable environmental features. Flood protection and drainage benefits would be realized on 929,500 acres of rich agricultural land within the basin and on more than 363,000 acres in areas adjacent to the basin. The increase in the assured, dependable water supply would aid in satisfying a growing need and induce industries to locate in this region to develop the abundance of natural resources.

General recreation and fish and wildlife would be enhanced throughout the basin and opportunities for the establishment of associated service industries and trades would be increased. The hydroelectric capacity provided would satisfy a portion of the urgently needed peaking demands of the marketing area.

The projects and programs of the long-range plan of improvement would permit the full development of the basin's water and related land resources as the need arises. A résumé of the projects and programs included in the comprehensive plan follows:

(1) Structural measures.

(a) Early-action plan.

1. Multiple-purpose projects in 49 upstream watersheds as shown on table 31 of this appendix. Project plans include reservoirs and other measures for watershed protection, flood prevention, irrigation, drainage, water quality control, recreation, municipal and industrial water supply, and fish and wildlife purposes. Seven single-purpose reservoirs are included for municipal and industrial water supply, or recreation in six upstream watersheds.

2. Twelve major tributary reservoirs, as shown on table 8, which include 1 reservoir for flood control, municipal and industrial water supply, irrigation, recreation, and fish and wildlife; 4 reservoirs for flood control, municipal and industrial water supply, recreation, and fish and wildlife; 1 reservoir for flood control, hydropower, recreation, and fish and wildlife; 4 reservoirs for municipal and industrial water supply, recreation, and fish and wildlife; 1 reservoir for municipal and industrial water supply, water quality control, recreation, and fish and wildlife, and 1 single-purpose pumped-storage hydroelectric power project.

3. Three channel improvement projects, for local flood protection, as shown on table 9. These projects involve new channels, control structures, and improvement of existing channels. One of the projects, Posten Bayou, Arkansas, is the subject of an interim report prepared by the Corps of Engineers which was completed in March 1968.

4. The modification of a local interest levee to conform to Federal standards, and subsequent incorporation into the Federal project, "Red River below Denison Dam."

5. The construction of navigation improvements providing a 9- by 200-foot channel on the main stem of Red River, from the Mississippi River to Shreveport, Louisiana, a distance of 213 miles, including 5 locks and dams; navigation improvements providing a 9- by 200-foot channel extending 81 miles upstream from Shreveport to Daingerfield, Texas, via Twelvemile and Cypress

TABLE 8

MAJOR RESERVOIR IMPROVEMENTS IN EARLY-ACTION PLAN

Project	Stream Location	Purpose[1]
Albany Reservoir	Island Bayou, Okla.	FC, WS, R, F&WL
Durant Reservoir[2]	Blue River, Okla.	FC, WS, R, F&WL
Bonham Reservoir[2]	Bois d'Arc Creek, Tex.	FC, WS, R, F&WL
Parker Reservoir[2]	Muddy Boggy Creek, Okla.	FC, WS, R, F&Wl
Tuskahoma Pumped Storage Hydroelectric Project	Pushmataha County, Okla.	P
Sherwood Reservoir-Broken Bow Mod.	Mountain Fork River, Okla.	FC, P, R, F&WL
Liberty Hill Res.	Mud Creek, Tex.	WS, R, F&WL
McGee Creek Res.	McGee Creek, Okla.	FC, WS, R, F&WL
Titus County Res.	Cypress Creek, Tex.	WS, R, F&WL
Caddo Lake Enlgt.	Twelvemile Bayou, La.	WS, R, F&WL
Bayou Dorcheat Res.	Bayou Dorcheat, Ark.	WS, WQC, R, F&WL
Kisatchie Bayou Res.	Kisatchie Bayou, La.	FC, WS, I, R, F&WL

(1)Legend FC - Flood control
WS - Water supply
WQC - Water quality control
P - Hydroelectric power
I - Irrigation
R - Recreation
F&WL - Fish and wildlife

(2)Combined with upstream watershed improvements.

TABLE 9

IMPROVEMENTS FOR LOCAL FLOOD PROTECTION IN EARLY-ACTION PLAN

Project	Work	Purpose[1]
Days Creek, Tex.	Channel enlargement	FC & D
McKinney Bayou, Ark. & Tex.[2]	Channel enlargement, clearing and snagging, diversion channel and outlet structure	FC & D
Posten Bayou, Ark.[2]	Diversion channel and structure	FC & D
West Agurs Levee, La.	Modification of levee and incorporation into Federal System	FC

(1)Legend: FC - Flood control; D - Drainage

(2)Combined with upstream watershed improvements.

Bayous, including 4 locks and dams (2 dams existing); and bank stabilization improvements extending 520 miles along the main stem of Red River from Denison Dam to the Mississippi River.

6. Under multiple-use management on National Forest System lands, plans have been approved for construction (by 1980) of six additional impoundments with 465 acres of water for recreational development. Three impoundments would be managed as "green-tree" reservoirs for water fowl hunting. Thirteen new areas with 462 acres of land would be developed for other recreational use. Planning for sustained yield and other forest uses is completed and approved.

(b) Long-range plan.

1. Multiple-purpose projects in five upstream watersheds. Project plans include land treatment and structural measures for watershed protection, flood prevention, drainage, water supply, and recreation purposes. Single-purpose project plans are included in 40 upstream watersheds for irrigation, water supply, or recreation purposes. Pertinent data for these projects are included in table 33 of this appendix.

2. Fourteen new reservoirs, and twelve modifications to existing, authorized, or early-action reservoirs, on major tributaries or on streams emptying into the major tributaries. General information on these projects is presented in table 10. The authorized Black Bayou Reservoir, which is not economically justified at this time, is included in the 14 new reservoirs.

3. Local protection improvements, consisting of works, independently or in combination, for channel enlargement, diversion channels, pumping plants, and levees, on 14 streams in the basin are presented in table 11.

4. Navigation above Shreveport, Louisiana, along the main stem of Red River, to Denison Dam, to move the commerce expected to be generated in the upper portion of the basin by 2020.

(2) Nonstructural measures.

Full development of the water and related land resources cannot be attained through structural measures alone. The plan accordingly contains recommendations relative to implementation of the following nonstructural measures which are considered a vital part of the comprehensive plan and whose implementation will require the cooperation of Federal, State, and local interests. Implementation of these measures should begin at the earliest practicable date, and their application should be of a continuing nature.

TABLE 10

TRIBUTARY RESERVOIRS IN THE LONG-RANGE PLAN

Name and State	Stream	Mile	Project Purposes[1]
Tupelo Reservoir, Okla.	Clear Boggy Creek	73.5	FC, WS, R, F&WL
Chickasaw Reservoir, Okla.	Chickasaw Creek	2.0	FC, WS, R, F&WL
Kellond Reservoir, Okla.	Tenmile Creek	1.0	FC, WS, R, F&WL
Buck Reservoir, Okla.	Buck Creek	1.0	FC, WS, R, F&WL, P
Upper Antlers Reservoir, Okla.	Kiamichi River	66.2	FC, P, R, F&WL
Finley Reservoir, Okla.	Cedar Creek	1.0	FC, WS, R, F&WL
Caney Mountain Reservoir, Okla.	Little River	159.3	FC, WS, R, F&WL, P
Mena Reservoir, Ark.	Mountain Fork River	82.5	FC, WS, R, F&WL
Hartley Reservoir, Ark.	Cossatot River	70.0	FC, WS, R, P
Acworth Reservoir, Tex.	Colliers Creek	3.9	FC, WS, R, F&WL
Pine Springs Reservoir, Tex.	Mill Creek	12.7	FC, WS, R, F&WL
New Zion Reservoir, Tex.	Red Bayou	4.0	FC, WS, R, F&WL
Black Bayou, La.	Black Bayou	18.0	FC
Marshall Reservoir, Tex.	Little Cypress Creek	19.0	WS
Hugo Mod., Okla.	Kiamichi River	17.6	P
Durant Mod., Okla.	Blue River	13.0	P
Pine Creek Mod., Okla.	Little River	145.3	WS, P
Lukfata Mod., Okla.	Glover Creek	17.3	P
Dierks Mod., Ark.	Saline River	57.0	WS, P
DeQueen Mod., Ark.	Rolling Fork	22.8	WS, P
Gillham Mod., Ark.	Cossatot River	49.0	WS, P
Sherwood Mod., Okla.	Mountain Fork River	44.4	P
Clayton Mod., Okla.	Jackfork Creek	2.8	P
Broken Bow Mod., Okla.	Mountain Fork River	20.3	P
Millwood Mod., Ark.	Little River	16.0	WS
Bayou Bodcau Mod., La.	Bayou Bodcau	72.0	WS, WQC, R

[1]Legend: FC - Flood Control; WS - Water Supply; WQC - Water Quality Control; P - Hydroelectric Power; R - Recreation; F&WL - Fish and Wildlife.

TABLE 11

LOCAL PROTECTION PROJECTS IN THE LONG-RANGE PLAN

Subbasin	Stream	Type of Improvement
Cypress Creek, Tex., Ark., La.	Twelvemile Bayou	Pumping plant
	Middle Bayou	Levee and pumping plant
Bayou Pierre, La.	Brush Bayou	Channel improvement
	Bayou Pierre	Levee and pumping plant
Loggy Bayou, Ark., La.	Flat River	Channel improvement
	Loggy Bayou	Levee loops
		Pumping plants
East Point Area, La.	Coushatta Bayou	Pumping plant
Campti-Clarence Area, La.	Chevreuille Bayou	Pumping plant
Cane River, La.	Cane River Island	Pumping plant
Rapides Island, La.	Bayou Rapides	Pumping plant
McKinney Bayou, Tex., Ark.	McKinney Bayou	Channel improvement
		Diversion channel
		Pumping plants
Posten Bayou, Ark., La.	Posten Bayou	Channel improvements
		Pumping plant
Brown Creek, Okla.	Brown Creek	Channel improvement

(a) Development of more precise data relating to the flood hazard to the end that management programs for controlling and regulating the economic use of flood plains may be more effectively implemented.

(b) Action, at the State and local level, to fully utilize information relative to flood plain management in the development of plans to guide the utilization of flood plains. Such plans should be developed not only for areas in which flood damages cannot be eliminated or reduced economically by strucutral measures, but also for application in areas where structural measures for control of flood damage already exist or are proposed as features of the comprehensive plan.

(c) Continuation and expansion of current land management and conservation programs.

(d) Expansion of existing State-Federal cooperative forestry programs.

(e) Extension of organized fire protection to include 875,400 acres of forest land not now protected.

(f) Preservation of areas of unique natural beauty, and/or historical, archeological, scientific, and ecological importance.

(g) Recognition of the need for more extensive archeological surveys in the entire basin, and of the importance of avoiding destruction of archeological information.

(h) Preservation of streams or stream reaches as free-flowing streams.

(i) Protection of valuable habitat areas through pollution control and operation of reservoir projects to prevent adverse changes in stream discharge.

(j) Action at the Federal, State, and local level, as appropriate, to ensure that cognizance is given the respective official State comprehensive outdoor recreation plan as the focal point for all recreation planning and development activities.

(k) Licensing of lands obtained for mitigating wildlife losses to respective State game and fish agencies.

(l) Expansion of existing recreation areas in accordance with experienced visitation patterns.

(m) Consideration of the inclusion of recreation as a purpose in the formulation of all future water resource development projects.

(n) Continuing consideration of the protection of valuable wildlife habitat through pollution control and operation of reservoir projects.

(o) Continuing consideration of alternative approaches to the problems of evaluating the feasibility of providing mitigation measures in connection with construction of agency projects.

(p) Surveillance of water quality by Federal, State, and local agencies to assure safe and healthful utilization of water resources, and extension and expansion of the data collection network required to support such surveillance.

(q) Establishment of a systematic data collection program to provide a base for developing the ground water resource.

(r) Consideration in the detailed design of construction projects, to the needs for providing facilities for collecting hydrologic data.

(s) Expansion and improvement, on an expedited basis, of river and flood forecasting services.

(t) Further studies to determine the most feasible alternative means of improving the mineral quality of the main stem of Red River during the period while effective salt control measures in the upper basin are being implemented.

(u) Coordination of efforts of appropriate Federal agencies and States to ensure the protection of the public's health by establishing vector control programs, providing

adequate sanitary facilities at recreation sites, and providing surveillance programs to ensure proper operation and maintenance of such facilities.

(v) Action at the Federal, State, and local level, as appropriate, to ensure continuing review of water resource development laws, policies, and programs to maintain their relevance.

EARLY-ACTION PLAN OF DEVELOPMENT

38. GENERAL

The early-action plan has been formulated to satisfy existing and near-future water and related land resource needs in the basin. Major reservoirs to provide flood protection, water supply, water quality control, irrigation, recreation, fish and wildlife conservation, and hydroelectric power generation are contained in the plan. Navigation of the Red River from the Mississippi River to Shreveport, Louisiana, and of Twelvemile-Cypress Bayou system from Shreveport, Louisiana, to Daingerfield, Texas, was found to be economically feasible, as was bank stabilization on the Red River from its mouth to Denison Dam. Local flood protection projects at four locations are included in the plan. Upstream watershed projects in the plan comprise integrated systems of channel improvement, land treatment measures, and single- and multiple-purpose reservoirs for flood prevention, water supply, irrigation, water quality control, and recreation. Also contained in the plan are specific measures for environmental preservation, fish and wildlife enhancement, and recreation.

At all major reservoirs in the early-action plan, except Tuskahoma Forebay, public-use areas would be constructed to afford optimum recreational use of the projects. Those public recreation areas on the shores of the lakes would be provided with the following:

Roads and parking. Access roads, circulatory roads, and parking areas to provide public access to the recreation areas and to the lake shore.

Hiking trails. Routes permitting full opportunity for enjoyment of scenic areas.

Boat-launching ramps. Boat-launching ramps in protected areas to provide for launching of boats from trailers.

Picnic areas. Picnic areas for visitors on a 1-day outing. Facilities proposed in these areas include picnic tables, fireplaces, and refuse cans.

Campgrounds. Campgrounds for persons who stay overnight or longer. Facilities for a camping area would consist of an individual turnout for car and trailer, a graded tent site, a table, a fireplace, and a refuse can.

Swimming areas. Developed beach with safety and sanitary facilities.

Water and sanitary facilities. Water wells, toilets, marine sanitary station, and trailer sanitary disposal stations at all picnicking and camping areas.

Signs and navigation aids. Signs and navigation aids to give adequate information, protection, and directions.

Clearing, cleanup, erosion control, and reforestation. Clearing and cleanup of public-use areas would be the minimum required to provide pleasant, usable areas that can be maintained efficiently. Reforestation would be accomplished in those areas without trees. Trees, shrubs, and vines that are indigenous to the area would be planted for beautification. Open areas of poor ground cover and eroded areas would be fertilized, sprigged, and/or seeded.

Those public-use developments below the dams would consist of platforms to afford safe access to tailwater fishing areas and parking and sanitary facilities. At proposed projects other than major reservoirs, recreational development would be dependent upon the characteristics of the individual project and may include any or all of the facilities listed above. The scope of recreational development of each of the projects in the early-action plan is based on estimated demands and the potential of each project. Final determination of the recreational features to be provided at each project would be governed by the desires of the States at the time of project construction. At all major reservoirs except the Tuskahoma Pumped-Storage project, studies would be made during detailed planning to determine operational procedures to provide for flows to meet fish and wildlife needs.

Descriptions of the individual projects proposed for construction in the early-action program are contained in the following paragraphs.

39. MAJOR RESERVOIR IMPROVEMENTS

a. Albany Reservoir.

(1) Basin description. Island Bayou is a north bank tributary of the Red River. The stream flows from its source in an easterly direction about 37 miles to its confluence with the Red River. The watershed is composed of rolling hills that are covered with timber and grassland, and has a maximum width of about 11 miles. In the upper reaches of the basin the channel meanders, has intermittent bank lines, and is generally choked with timber and brush. At the proposed damsite (see Fig. 5), the channel is well defined and has a flow capacity of about 2,000 c.f.s. Principal crops grown in the basin are wheat, alfalfa, grain sorghums, cotton, corn, oats, and native pecans. The uncultivated areas are largely

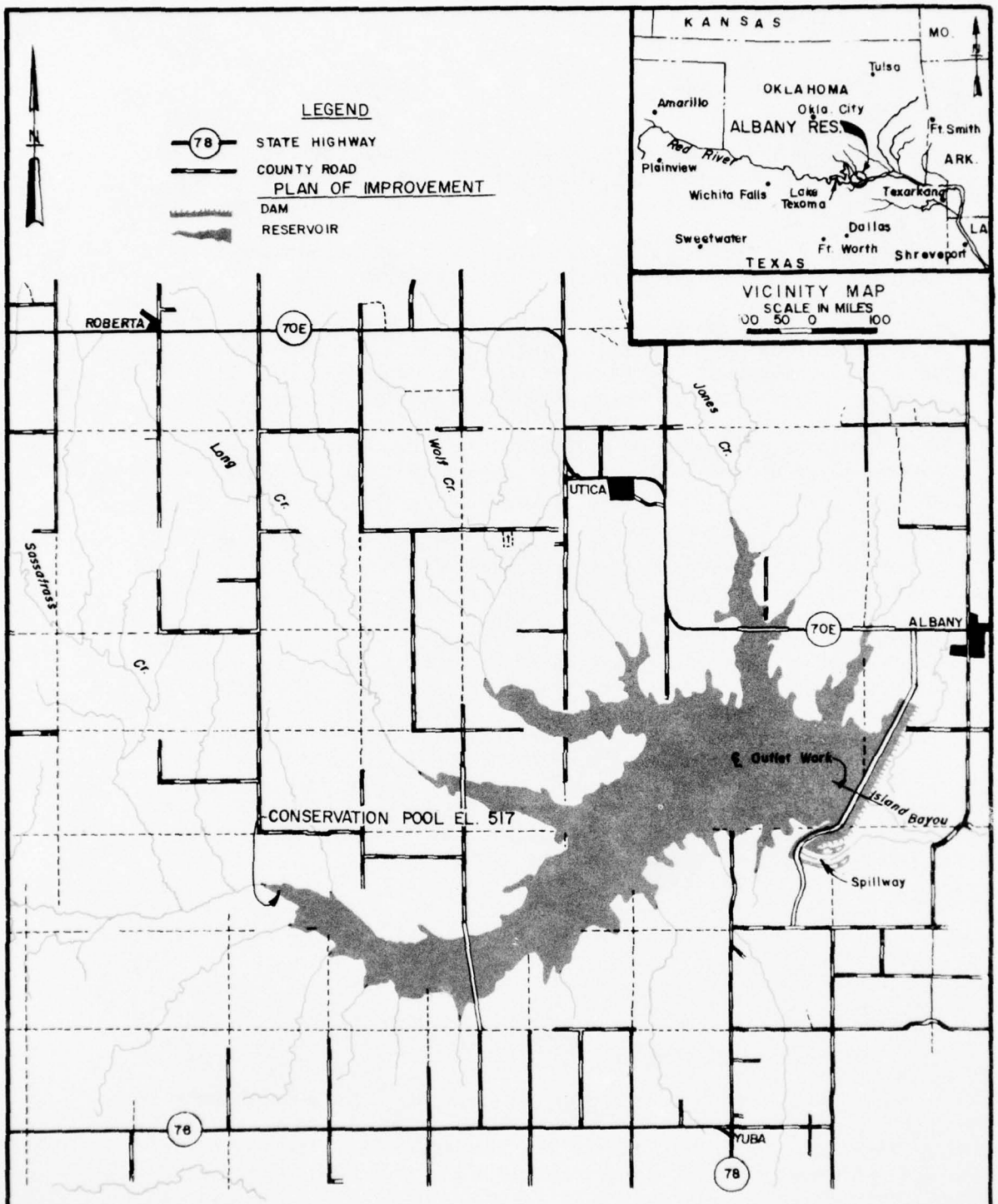


FIGURE 5
PLAN OF IMPROVEMENT
ALBANY RESERVOIR AREA, OKLA.

SCALE OF MILES

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devoted to pasture. The area is sparsely populated, and there are no towns of appreciable size within the basin. At present, no Public Law 566 programs are under way in the basin.

(2) Project formulation.

(a) Water and related land resource development needs in the Island Bayou Basin include flood control, municipal and industrial water supply, recreation, and fish and wildlife. Preliminary investigations demonstrated that flood control storage could provide a much higher degree of protection at a lower cost than channel improvement. In addition, the existence of needs in the municipal and industrial water supply, recreation, and fish and wildlife categories favors the reservoir solution. Two damsites on Island Bayou were considered in the preliminary phases of the study. These sites are located at river mile 6.5 and 15.4. It was found that the upper site would provide about the same flood control and recreation benefits but would yield 8 m.g.d. less water than the lower site. Cost studies indicate that the upper site would be more expensive. Since the lower site could provide more overall benefits at lower cost. it was selected for detailed studies.

(b) Flood control studies of Island Bayou at the Albany Reservoir site for ranges of 50- to 150-year frequency storage were considered. The 50-year frequency storage provided a slightly greater excess of benefits over costs. With the 50-year flood control storage held constant, increments of conservation storage were added. As the conservation storage increased, the water supply and recreation benefits also increased. Comparison of costs and benefits for the range of analysis showed that maximum benefits over costs would be obtained for the project having 85,200 acre-feet of net conservation storage, 6,800 acre-feet of sediment storage, and 45,200 acre-feet of flood control storage. This plan would provide 50-year flood protection and 32 m.g.d. dependable water supply yield for municipal and industrial purposes. Recreation facilities were considered for all scales of development. The minimum development would consist only of measures to protect the public as regards health and safety and would contain no recreation facilities as such. Recreation facilities were added until the maximum excess of benefits was obtained based on the number of people in the general area that could be expected to use the facilities. Albany Reservoir recreational facilities would be developed within the general recreation needs as described in appendix XII, "Outdoor Recreation." Four public-use areas on the reservoir and one area below the dam at the outlet works would provide optimum recreational use of the project. A commercial fish seining area would be cleared in the reservoir. Requests for lands for fish and wildlife developments would be fulfilled from project lands and additional lands

would not be purchased. The development and administration of the fish and wildlife facilities would be placed with the appropriate State agencies.

(3) Description of project. Pertinent data for the proposed plan of improvement are shown in table 12. The dam would consist of an earth embankment rising 79 feet above the streambed with a total length of about 10,300 feet. An uncontrolled limited service spillway would be located in a saddle near the right abutment. The outlet works would be located near the left abutment and would consist of a cut-and-cover conduit 7.25 feet in diameter with an uncontrolled morning glory inlet, wet well tower, a stilling basin, a 42-inch water supply conduit, and a 24-inch low flow release pipe. Total land requirements for the project would be about 13,000 acres, of which 12,200 acres would be for the dam and reservoir, and 800 acres for public use and access. Recreational facilities would be included for public use of the land and water areas. Construction of Albany Reservoir would require relocation of 1.25 miles of State highways, 1.6 miles of county roads, 6.1 miles of electrical power distribution lines, and 1 mile of telephone lines.

(4) Benefits. The flood control storage in Albany Reservoir would provide protection from damaging floods on lower Island Bayou and eliminate about 97 percent of the average annual damages in this reach. Annual flood control benefits would be $95,700. The conservation storage would develop the full yield potential of Island Bayou (32 m.g.d. of high quality water), for municipal and industrial uses. The estimated benefits would be $262,000 annually. The increase of water-oriented recreation opportunities at Albany Reservoir would produce about $290,000 in benefits per year, while annual benefits due to commercial fishing would be about $9,000.

(5) Costs. The first cost of construction of the reservoir and recreational facilities would be $11,000,000. The annual charges, including interest and amortization, operation and maintenance, major replacement, and engineering studies would be $486,300.

(6) Summary of benefits and costs. The total average annual benefits of $656,700, and the total annual charges of $486,300, yield a benefit-cost ratio of 1.4.

b. Durant Reservoir.

(1) Basin description. Blue River is a north bank tributary of the Red River with a drainage area of 676 square miles. (See Fig. 6.) The stream rises in Pontotoc County, Oklahoma, and flows in a southeasterly direction to its confluence with Red River at river mile 618.0. The basin is long and narrow, having a total length of about 118 miles and a maximum width of about 14 miles.

TABLE 12

ALBANY RESERVOIR

PERTINENT DATA

GENERAL	
Stream	Island Bayou
River mile	6.5
Drainage area, square miles	134
ELEVATION, FEET, m.s.l.	
Top of dam	549.0
Maximum pool	543.8
Top of flood control pool	525.0
Top of conservation pool	517.0
Top of inactive pool	489.0
50-year pool	525.0
Streambed	470.0
STORAGE, ACRE FEET	
Flood control	45,200
Conservation	85,200
Inactive	6,800
Total	137,200
AREA, ACRES	
Top of flood control pool	6,480
Top of conservation pool	4,960
50-year pool	6,480
SPILLWAY	
Location	Abutment
Type	Limited service
Width, feet	400
Crest elevation, feet, m.s.l.	533.0
Frequency of operation	Standard Project Flood
Discharge at maximum pool, c.f.s.	32,300
FLOOD CONTROL OUTLET WORKS	
Type	Morning glory
Size	1-7.25-foot conduit
WATER SUPPLY	
Yield, m.g.d. (M&I)	32
STATIC HEADPIPE (size)	1-42-inch

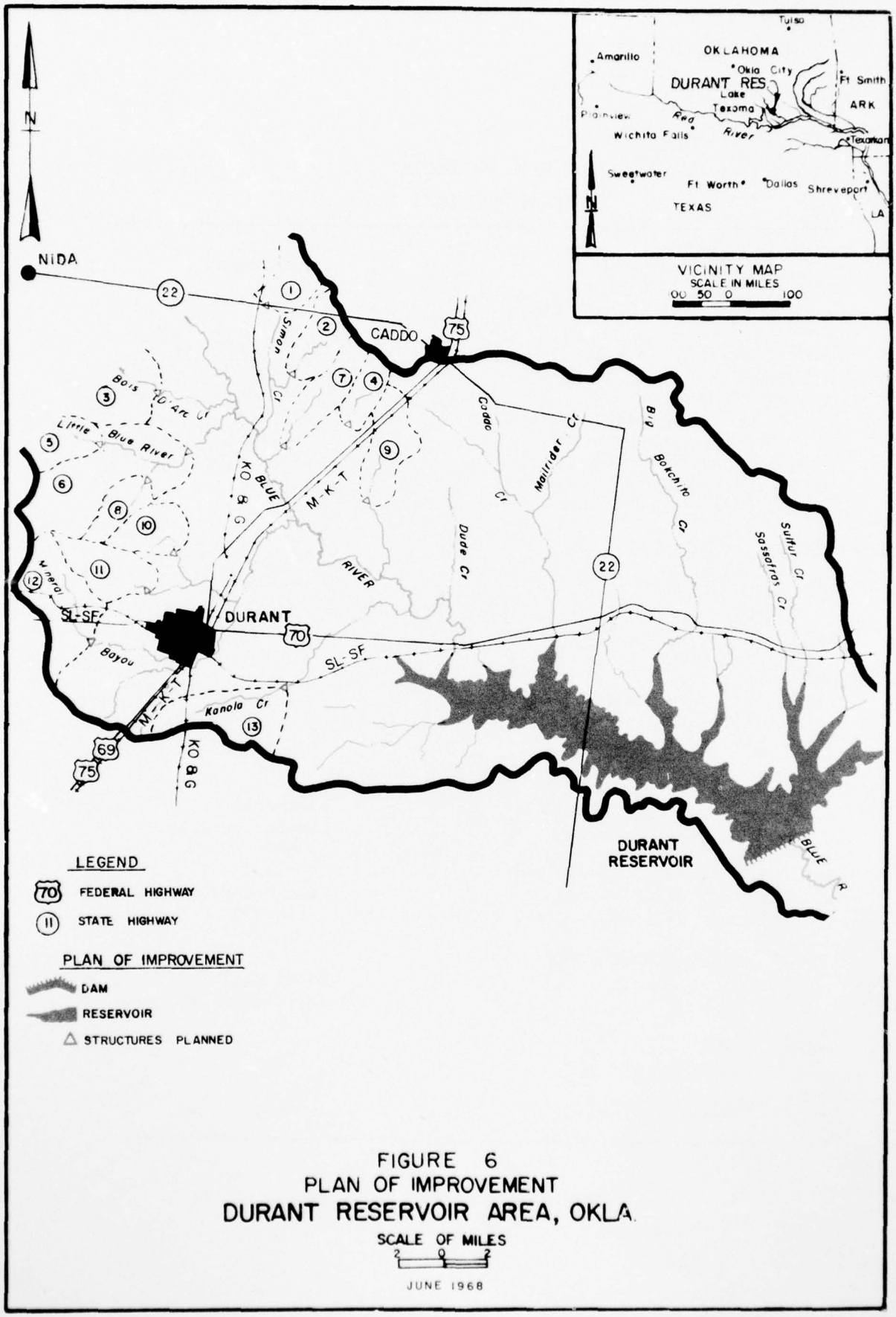

FIGURE 6
PLAN OF IMPROVEMENT
DURANT RESERVOIR AREA, OKLA.

SCALE OF MILES
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The channel is well-defined, but has considerable undergrowth and trees along the banks. Slope of the streambed varies from about 4.7 feet per mile at the proposed damsite to about 1.8 feet per mile near the mouth. Principal crops grown within the watershed include wheat, alfalfa, sorghum, cotton, corn, oats, soybeans, and pecans. The uncultivated areas are largely devoted to pasture. Durant, with a 1960 population of 10,467, is the only town of appreciable size in the basin. The principal industries located in Durant are manufacturing of truck and utility bodies, preparation of sausage and of other food products, and manufacturing plastic toys.

(2) Current Public Law 566 program. The Department of Agriculture, Soil Conservation Service, has a program for watershed treatment in the Blue River Basin under Public Law 566, 83d Congress, as amended. The Soil Conservation Service has divided the basin into an upper and a lower watershed with the drainage area above the bridge on Oklahoma State Highway No. 22, 6 miles east of Nida, Oklahoma, at approximate stream mile 59.0 in the upper watershed. Contracts with the Conservancy Districts in the upper watershed have been signed, and the Soil Conservation Service is proceeding with the development of land and water resources in this area. The Upper Blue River Watershed system, which has 74 reservoirs authorized or under construction, would affect runoff from about 206 square miles.

(3) Project formulation.

(a) Water and related land resource development needs in the lower Blue River Basin exist in the flood control and drainage, municipal and industrial water supply, recreation, and fish and wildlife categories. Preliminary investigations demonstrated that flood control storage in a major reservoir, combined with a system of detention reservoirs and land treatment measures upstream from the major reservoir would best provide for the needs of the basin. Since the SCS has an authorized plan of development for the upper Blue River Watershed, the Corps of Engineers studies were oriented toward the lower Blue River Basin. Major reservoir sites at river miles 59.0, 39.0, 30.2, and 20.6 were studied in addition to the Durant site at river mile 13.0. Preliminary studies showed that reservoirs at only three of these sites would provide benefits in excess of costs. The site at river mile 39.0 (Blue Damsite) was marginal because of relocation problems. This narrowed the selection down to the site at river mile 20.6 (Cherokee Lake site) and the Durant site. The Durant site was selected because of greater excess benefits and good physical characteristics. A reservoir at the Durant site would provide more flood control protection on the Red River and has a potential conservation yield over twice that of the Cherokee Lake site. The Durant Damsite is located about 19 miles southeast of Durant, Oklahoma, as shown on

figure 6. The reservoir would control 649 square miles, or about 96 percent, of the total Blue River Watershed. The project would control damaging floods on the lower Blue River and provide municipal and industrial water supply for the town of Durant and surrounding industrial areas. The City of Durant, Oklahoma, has requested immediate construction of Durant Reservoir and has given assurances to the Corps of Engineers of participation in the costs of storage for 30 m.g.d. of water supply. The State of Oklahoma has also expressed an interest in Durant Reservoir and has stated that the State would participate in the cost of storage for water supply.

(b) A system of small detention reservoirs in the upper reaches of the watershed would not adequately control runoff from the long duration storms that occur in this area and could present a possibility of delayed floodflows from the tributaries augmenting flood waters on the main stream. Flood routing studies show, however, that such a system would serve to lessen the requirements for sediment and flood control storage in Durant Reservoir in addition to providing other benefits. The upstream watershed improvement increment of the combined plan was formulated in accordance with standard Soil Conservation Service practices. This plan comprises 13 small detention reservoirs above Durant Reservoir, which control 77 square miles of drainage area, and land treatment measures, which will reduce erosion. The 13 detention reservoirs will detain an average of 8.3 inches of runoff from the area they would control. The locations of the detention reservoirs are shown on figure 6 and pertinent data are shown on table 13.

(c) Flood control studies for the Durant Reservoir were made on the basis of multiple-purpose plans with varying amounts of flood control storage combined with conservation storage for municipal and industrial water supply. The upstream watershed increment of the plan was assumed to be in place. Flood control storages varying from 50- to 150-year frequency were considered. However, maximum excess benefits were obtained for the 50-year frequency storage. Since the estimated water supply needs of the Durant industrial area are 30 m.g.d., storage to provide this yield was held constant and storage for recreation was varied to compute maximum benefits over costs. The recreational storage, which would yield an additional 55 m.g.d., may be converted to other uses when needed. The potential yield of the stream at the damsite is 137 m.g.d. and could be realized as a second stage modification. Recreation facilities were considered for all scales of development. The minimum development would consist of only measures to protect the public as regards health and safety and would contain no recreation facilities as such. Recreation facilities were added until the maximum excess benefits were obtained considering the limiting factor as the amount of people in the general area that could be expected to use the facilities. Durant Reservoir recreational facilities would be developed within the general recreation

TABLE 13

COMBINED PLAN OF IMPROVEMENT FOR THE LOWER BLUE RIVER BASIN

PERTINENT DATA

Site No.	Estimated Height of Dam (feet)	Maximum Surface Area-Emergency Spillway Level (acres)	Drainage Area (sq. mi.)	Storage Capacity Planned (acre-feet)				
				Sediment	Flood Control	Recreation	Water Supply	Total
USDA - P.L. 566								
1	37	130	3.6	290	1,570	-	-	1,860
2	43	225	6.2	510	2,710	-	-	3,220
3	47	510(2)	11.8	630	5,100	2,000	-	7,730
4	35	105	2.9	240	970	-	-	1,210
5	37	127	3.5	280	1,530	-	-	1,810
6	52	415	13.7	1,080	5,920	-	-	7,000
7	50	175	4.9	400	2,140	-	-	2,540
8	36	110	3.1	250	1,370	-	-	1,620
9	47	230	6.3	500	2,760	-	-	3,260
10	34	394	2.6	220	1,150	-	-	1,370
11	39	150	4.1	360	1,790	-	-	2,150
12	46	462(3)	8.7	750	4,550	-	2,050(1)	7,350
13	34	228	5.4	500	2,360	-	-	2,860
USDA TOTAL	-	3,261	76.8	6,010	33,920	2,000	2,050	43,980
DURANT RES.	104	13,430(4)	649.0	14,480	232,200	89,750	57,300	393,700
GRAND TOTAL	-	16,691	725.8	20,490	266,120	91,720	59,350	437,680

(1) Water quality control.
(2) Surface area of recreational pool - 235 acres.
(3) Surface area of water quality control pool - 238 acres.
(4) Surface area of conservation pool - 8,980 acres.

needs as described in appendix XII, "Outdoor Recreation." Five public-use areas on the reservoir and one area below the dam at the outlet works would provide optimum recreational use of the project. A commercial fish seining area would be cleared in the reservoir. Requests for lands for fish and wildlife developments would be fulfilled from project lands and additional lands would not be purchased. The development and administration of the fish and wildlife facilities would be operated and maintained by the Oklahoma Department of Wildlife Conservation. Benefit-cost analysis of Durant Reservoir show that maximum benefits over costs may be obtained with 232,200 acre-feet flood control storage, 147,020 acre-feet conservation storage, and 14,480 acre-feet sediment storage. Pertinent data for the proposed plan of improvement are shown in table 14. The dam would consist of an earth embankment about 10,700 feet long rising 104 feet above the streambed and an uncontrolled limited service spillway in a saddle near the left abutment. The outlet works would be a cut-and-cover conduit with a gated inlet. Approximately 25,000 acres would be required for construction of the dam and operation of the reservoir. An additional 1,000 acres would be required for public use and access. Recreation facilities would be included for public use of the land and water areas. Construction of Durant Reservoir would include alterations of one State highway and numerous county roads and utility facilities. About 100 graves located in the reservoir area would require relocation also.

(4) Benefits. The flood control storage in Durant Reservoir, operating in conjunction with the SCS program of 13 detention reservoirs, would provide protection from damaging floods on the lower Blue River and eliminate about 94 percent of the average annual damages in this reach. Flood control benefits would also be realized on the main stem of the Red River. The annual flood control benefits attributable to the combined plan would be $479,500. Durant Reservoir would yield 30 m.g.d. of water initially and would have provisions for developing about 85 m.g.d. The water supply benefits, based on the yield of 30 m.g.d., would be $275,400 annually. The increase of water-oriented recreation opportunities at Durant Reservoir would produce about $493,200 in benefits per year while annual benefits from commercial fishing in Durant Reservoir would be about $19,000. Recreation benefits of $75,750 annually would be produced by the SCS increment of the combined plan, and that plan would also produce a water quality control benefit of $10,000 annually. Reduction in the Durant Dam height due to the 13 SCS reservoirs would produce a benefit of $5,200. Commercial fishing benefit produced by the SCS increment of the plan is estimated at $10,400 annually. The total annual benefit for the combined plan would be $1,368,450. The total benefit attributable to the Durant Reservoir would be $1,161,400 annually.

TABLE 14

DURANT RESERVOIR

PERTINENT DATA

GENERAL	
Stream	Blue River
River mile	13.0
Drainage area, square miles	649
ELEVATION, FEET, m.s.l.	
Top of dam	562.0
Maximum pool	556.6
Top of flood control pool	530.0
Top of conservation pool	511.0
Top of inactive pool	481.0
50-year pool	530.0
10-year drawdown pool	506.0
Streambed	458.0
STORAGE, ACRE-FEET	
Flood control	232,200
Conservation(1)	147,020
Inactive	14,480
Total	393,700
AREA, ACRES	
Top of flood control pool	15,430
Top of conservation pool	8,980
50-year pool	15,430
SPILLWAY	
Location	Saddle
Type	Limited service
Side slopes (horizontal/vertical)	3/1
Width, feet	500
Crest elevation, feet, m.s.l.	539.5
Frequency of operation	Standard Project Flood
Discharge at maximum pool, c.f.s	105,000
FLOOD CONTROL OUTLET WORKS	
Type	Gated conduit
Number and size	1-12-foot
WATER SUPPLY	
Yield, m.g.d. (M&I)	30
STATIC HEADPIPE	
Size	1-42-inch

(1) Contains approximately 57,300 acre-feet for water supply and 89,700 acre-feet for recreation.

(5) Costs. The first cost of construction for the combined plan would be $22,571,250. The total annual charge, including interest and amortization, operation and maintenance, major replacement, and engineering studies, would be $964,430. The corresponding figures for the Durant Reservoir are $20,100,000 and $869,000, respectively.

(6) Summary of benefits and costs. The total average annual benefits of $1,368,450, and the total annual charge of $964,430 result in a benefit-cost ratio, for the combined plan, of 1.4. The average annual benefit of $1,161,400 and the annual charge of $869,000 yield a benefit-cost ratio, for the Durant Reservoir, of 1.3.

(7) A system of upstream reservoirs was developed as an alternative to the combined plan approved by the Coordinating Committee for the Lower Blue River. This alternative plan consists of a system of 30 upstream reservoirs, including four multiple-purpose reservoirs for flood prevention, municipal and industrial water supply, water quality control, recreation and fish and wildlife water supply, and 26 single-purpose flood prevention reservoirs. The municipal and industrial water supply storage included in two of the multiple-purpose reservoirs would yield 5 m.g.d. for the use of the City of Durant. The total installation cost of the alternative plan would be $5,623,330 with an annual cost of $201,500. The plan would yield benefits of $519,200, and the benefit-cost ratio would be 2.6.

c. Bonham Reservoir.

(1) Basin description. Bois d'Arc Creek, a south bank tributary of the Red River at mile 611.0, has its source near Whitewright, Texas. (See Fig. 7.) The stream flows in a northeasterly direction about 58 miles to its confluence with the Red River. The watershed is composed of gently rolling prairie and has a maximum width of about 18 miles. The upstream portion of the basin reaches an elevation of about 760 feet,[1] and the stream descends at an average rate of about 6 feet per mile to elevation 430 at its confluence with Red River. The average annual rainfall over the basin is about 42 inches. About 40 percent of the watershed is cultivated, the principal crops being cotton and corn, with lesser amounts of oats, grain sorghums, alfalfa, and pecans. The uncultivated areas in the watershed are largely devoted to pasture. The only towns of appreciable size within the basin are Whitewright and Bonham with 1960 populations of 1,315 and 7,357, respectively.

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[1] Unless otherwise specified, all elevations in this appendix are in feet and referred to mean sea level.

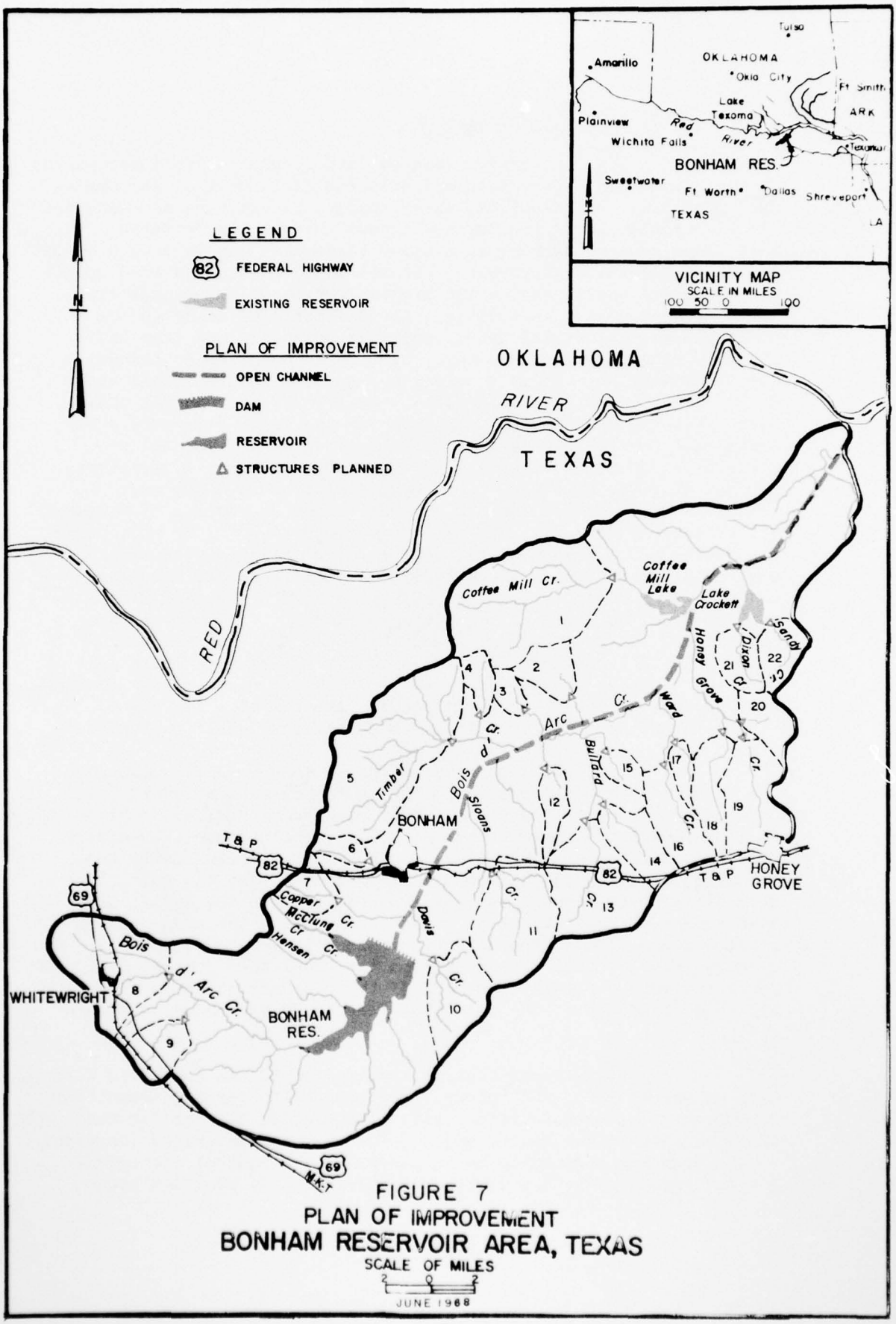

FIGURE 7
PLAN OF IMPROVEMENT
BONHAM RESERVOIR AREA, TEXAS
SCALE OF MILES
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(2) Project formulation.

(a) Water and related land resource development needs in the Bois d'Arc Creek Basin exist in the flood control and drainage, municipal and industrial water supply, recreation, and fish and wildlife categories. Preliminary investigations demonstrated that flood control storage in a major reservoir, combined with a system of detention reservoirs, channel improvement, and land treatment measures would provide the highest degree of flood protection at the lowest cost. In addition, the existence of needs in the municipal and industrial water supply, recreation, and fish and wildlife categories, favors this solution as compared to channel improvement alone. While a multiple-purpose major reservoir alone would be justified, it would yield a smaller excess benefit than the combined plan. Several damsites for the major reservoir were considered in preliminary studies. These sites are located at river miles 23.5, 24.8, 28.6, and 43.1. Of the three lower sites, the one at river mile 23.5 (Coffee Mill site) showed the most promise. This site is located just below the confluence of Coffee Mill Creek and Bois d'Arc Creek. When compared with the site at river mile 43.1 (Bonham site), however, the Coffee Mill site has several disadvantages. A reservoir at this site would inundate an existing Forest Service lake on Coffee Mill Creek, and flood control benefits would be reduced by backwater effects from the Red River. The City of Bonham and the State of Texas have indicated that they prefer the Bonham site, mainly because it is in a more advantageous location for water supply and recreation. Preliminary studies indicate that the Bonham site has slightly higher excess benefits; therefore, it was selected for detailed studies.

(b) The upstream watershed improvement increment of the combined plan was formulated in accordance with standard Soil Conservation Service practices. This plan comprises two small detention reservoirs above Bonham Reservoir, which control 20 square miles of drainage area; 20 detention reservoirs below Bonham Reservoir controlling 155 square miles; improvement of the channel of Bois d'Arc Creek from Bonham Reservoir damsite to the mouth; and land treatment measures to alleviate erosion and the sediment load in Bois d'Arc Creek. The detention reservoirs would detain an average of 7.1 inches of runoff from the areas they control. Pertinent data for this increment of the plan are shown on table 15. The locations of the detention reservoirs are shown on figure 7.

(c) Flood control studies for Bonham Reservoir were made on the basis of multiple-purpose plans with varying amounts of flood control storage combined with conservation storage for municipal and industrial water supply. The upstream watershed increment of the plan was assumed to be in place. Flood control storage of 50-year frequency with a limited service spillway provides higher

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COMPREHENSIVE BASIN STUDY. RED RIVER BELOW DENISON DAM, ARKANSA--ETC(U)
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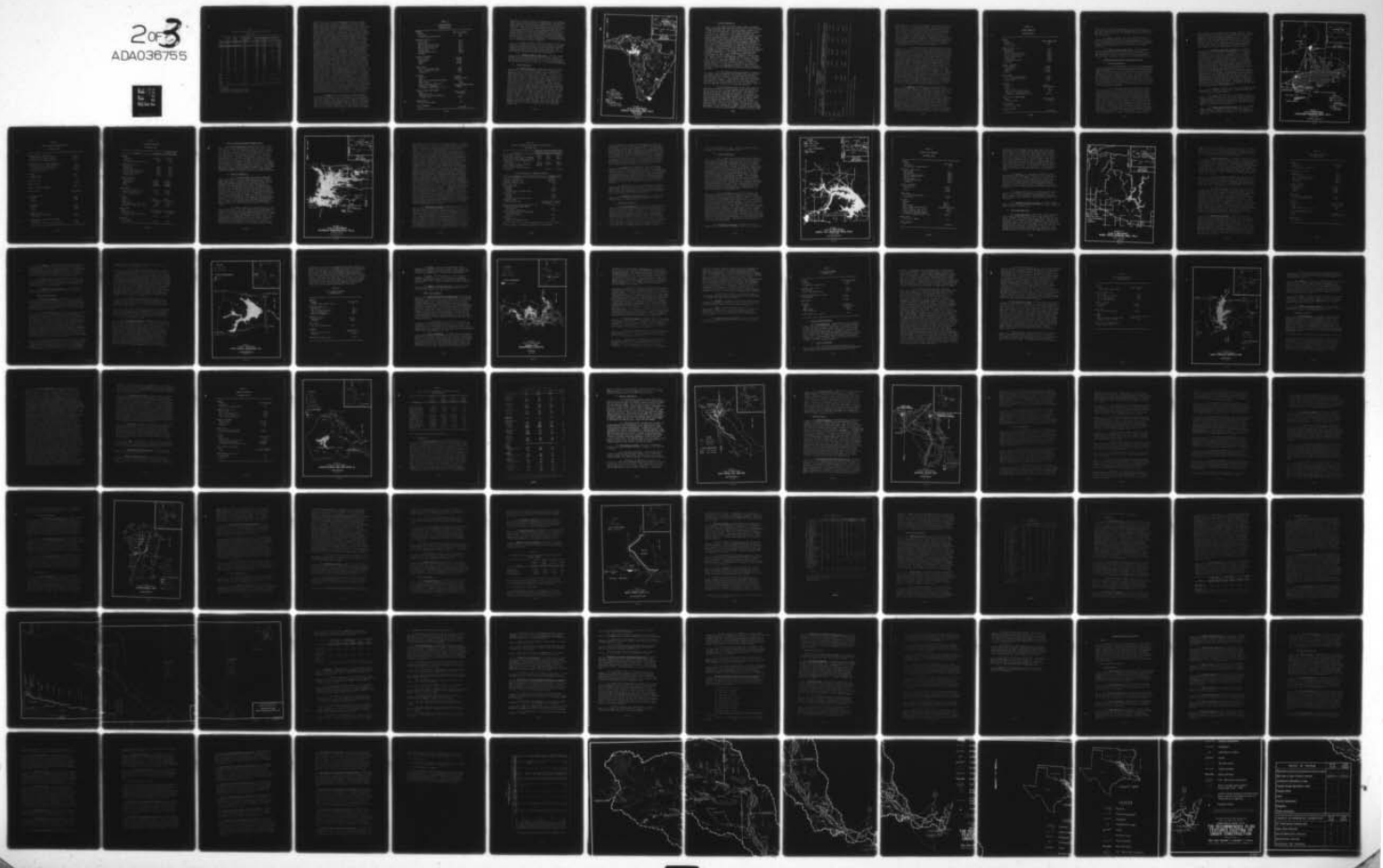

TABLE 15

COMBINED PLAN OF IMPROVEMENT FOR THE BOIS D'ARC CREEK BASIN

PERTINENT DATA

Site No.	Drainage Area (sq.mi.)	Est. Height of Dam (feet)	Max. Surface Area-Emergency Spillway Level (acres)	Storage Capacity Planned (acre-feet)			
				Sediment	Flood Control	Other	Total
USDA-PL 566 above Bonham Reservoir							
8	15.7	41	540	1,010	6,870	-	7,880
9	4.5	32	210	410	1,370	-	1,780
USDA-PL 566 below Bonham Reservoir							
1	24.8	38	840	660	8,470	-	9,130
2	5.4	25	200	230	1,380	-	1,610
3	2.3	29	100	150	700	-	850
4	3.7	33	140	360	970	-	1,330
5	25.6	52	1,450(3)	960	10,100	10,400(1)	21,460
6	3.7	33	210	360	1,930	-	2,290
7	4.2	30	130	390	1,280	-	1,670
10	8.2	39	310	1,000	3,400	-	4,400
11	13.8	36	770(4)	1,330	6,990	1,580(2)	9,900
12	3.4	34	160	470	1,050	-	1,520
13	13.4	37	670	1,290	5,430	-	6,720
14	5.6	28	240	750	1,700	-	2,450
15	2.5	34	120	360	1,050	-	1,410
16	9.5	35	410	1,570	2,840	-	4,410
17	2.0	22	100	300	620	-	920
18	5.3	41	220	680	1,600	-	2,280
19	11.4	40	650	1,220	4,680	-	5,900
20	4.0	30	180	560	1,220	-	1,780
21	2.9	32	120	170	760	-	930
22	3.6	30	160	1,500	1,110	-	1,610
TOTAL USDA	175.5	-	7,930	14,730	65,520	11,980	92,230
BONHAM RES.	108.0	86	8,170(5)	6,960	48,500	82,040(1)	137,500
GRAND TOTAL	283.5	-	16,100	21,690	114,020	94,020	229,730

(1)Water Supply.
(2)Recreation.
(3)Surface area of Municipal pool - 840 acres.
(4)Surface area of Recreation pool - 340 acres.
(5)Surface area of Conservation pool - 5,280.

excess benefits over costs and was adopted for use in further project formulation studies to determine the optimum conservation storage. The flood control benefits used in the project formulation studies represent Bonham Reservoir's share of the benefits for the combined plan. Conservation storage was varied to compute maximum benefits over costs. Recreation facilities were considered for all scales of development. The minimum development would consist of measures to protect the public as regards health and safety and would contain no recreation facilities as such. Recreation facilities were added until the maximum excess benefits were obtained considering the limiting factor as the number of people in the general area that could be expected to use the facilities. Recreational facilities were developed within the general recreation needs as described in appendix XII, "Outdoor Recreation." Three public-use areas on the reservoir and one area below the dam at the outlet works would provide optimum recreational use of the project. A commercial fish seining area would be cleared in the reservoir. Requests for lands for fish and wildlife developments would be fulfilled from project lands and additional lands would not be purchased. The development and administration of the fish and wildlife facilities would be placed with the appropriate Texas State agency. Benefit-cost analyses demonstrated that maximum benefits over costs would be obtained with 48,500 acre-feet storage for flood control, 82,040 acre-feet conservation storage, and 6,960 acre-feet sediment storage. This plan would provide 50-year flood control protection and 24 m.g.d. water supply yield. Pertinent data for Bonham Reservoir are contained in table 16, and the reservoir area is shown on figure 7. The dam would consist of an earth embankment about 10,500 feet long rising 86 feet above the streambed, and an uncontrolled limited service spillway in a saddle near the right abutment. The outlet works would consist of a cut-and-cover conduit 8 feet in diameter with a gated intake structure, a stilling basin, a 42-inch water supply conduit and a 48-inch low-flow release pipe. Approximately 12,000 acres of land would be required for construction of the dam and operation of the reservoir. An additional 500 acres would be required for public use and access. Recreation facilities would be included for public use of the land and water areas. Construction of Bonham Reservoir would require relocation of 5 miles of State highways, 1.8 miles of county roads, 16.5 miles of electrical power and distribution lines, and 5.4 miles of telephone lines. About 50 graves in the reservoir area would require relocation.

(3) Benefits. The flood control storage in Bonham Reservoir, operating with the SCS program of detention reservoirs and channel improvement, would provide protection from damaging floods on lower Bois d'Arc Creek and would eliminate about 97 percent of the average annual damages below the damsite. The annual flood control benefits attributed to the combined plan would be $665,230. The conservation storage in Bonham Reservoir would develop the full stream potential of Bois d'Arc Creek at the damsite

TABLE 16

BONHAM RESERVOIR

PERTINENT DATA

GENERAL	
Stream	Bois d'Arc Creek
River mile	43.1
Drainage area, square miles	108
ELEVATION, FEET, m.s.l.	
Top of dam	630.0
Maximum pool	624.7
Top of flood control pool	611.0
Top of conservation pool	603.0
Top of inactive pool	575.0
50-year pool	611.0
10-year drawdown pool	590.0
Streambed	544.0
STORAGE, ACRE-FEET	
Flood control	48,500
Conservation	82,040
Inactive	6,960
Total	137,500
AREA, ACRES	
Top of flood control pool	7,200
Top of conservation pool	5,280
50-year pool	7,200
SPILLWAY	
Location	Abutment
Type	Limited service
Side slopes (horizontal/vertical)	3/1
Width, feet	400
Crest elevation, feet, m.s.l.	614.0
Frequency of operation	Standard Project Flood
Discharge at maximum pool, c.f.s.	36,900
FLOOD CONTROL OUTLET WORKS	
Type	Gated conduit
Number and size	1-8-foot
Discharge at top conservation pool, c.f.s.	1,950
WATER SUPPLY	
Yield, m.g.d. (M&I)	24
STATIC HEADPIPE	
Size	1-42-inch

(24 m.g.d.). The water would be of high quality. The estimated annual benefit would be $378,700. Storage space included in the small detention reservoirs for municipal and industrial water supply will yield an additional 6.2 m.g.d., with an annual benefit of $19,410. The increase of water-oriented recreational opportunities in Bonham Reservoir would produce about $251,000 in annual benefits, while recreation development in connection with small detention reservoirs would generate an additional annual benefit of $71,100. Annual benefits from commercial fishing in Bonham Reservoir would be about $14,000. The total annual benefit for the combined plan would be $1,399,440. The benefit attributable to Bonham Reservoir would be $845,200.

(4) Cost. The first cost of construction for the combined plan would be $21,909,520. The annual charges, including interest and amortization, operation and maintenance, major replacement and engineering studies, would be $961,200. The corresponding figures for the Bonham Reservoir increment of the plan would be $14,200,000 and $612,300, respectively.

(5) Summary of benefits and costs. The total average annual benefits of $1,399,440 and the total annual charges of $961,200 yield a benefit-cost ratio of 1.5 for the combined plan. The average annual benefit of $845,200, and the annual charge of $612,300 yield a benefit-cost ratio of 1.4 for the Bonham Reservoir.

d. Parker Reservoir.

(1) Basin description. Muddy Boggy Creek rises near Ada, Oklahoma, and flows about 131 miles in a southeasterly direction to its confluence with Boggy Creek at river mile 24.4. Boggy Creek enters the Red River at mile 591.5. (See Fig. 8.) Total drainage area of Boggy Creek is 2,429 square miles, 1,218 square miles of which is in the Muddy Boggy Creek Watershed. The other major tributary of Boggy Creek is Clear Boggy Creek. The only existing major reservoir in the Boggy Creek Basin is the Atoka Reservoir located on North Boggy Creek. Boswell Reservoir, authorized by the Flood Control Act of 1946, will be located at river mile 19.6. The upper portion of the Muddy Boggy Creek Basin is located in rugged terrain largely covered by timber. The lower portion is in gently rolling hills and flat plain areas with much of the land being in cultivation or grass. Maximum width of the basin is about 20 miles. The channel is well-defined above and below the damsite. The channel slope above the damsite is approximately 4.4 feet per mile, and channel capacity below the damsite is about 3,000 c.f.s. Principal crops grown on the basin are alfalfa, corn, grain sorghum, and hay. The uncultivated areas are largely devoted to pasture. Principal towns in the basin are Coalgate and Atoka, with 1960 populations of 1,689 and 2,877, respectively.

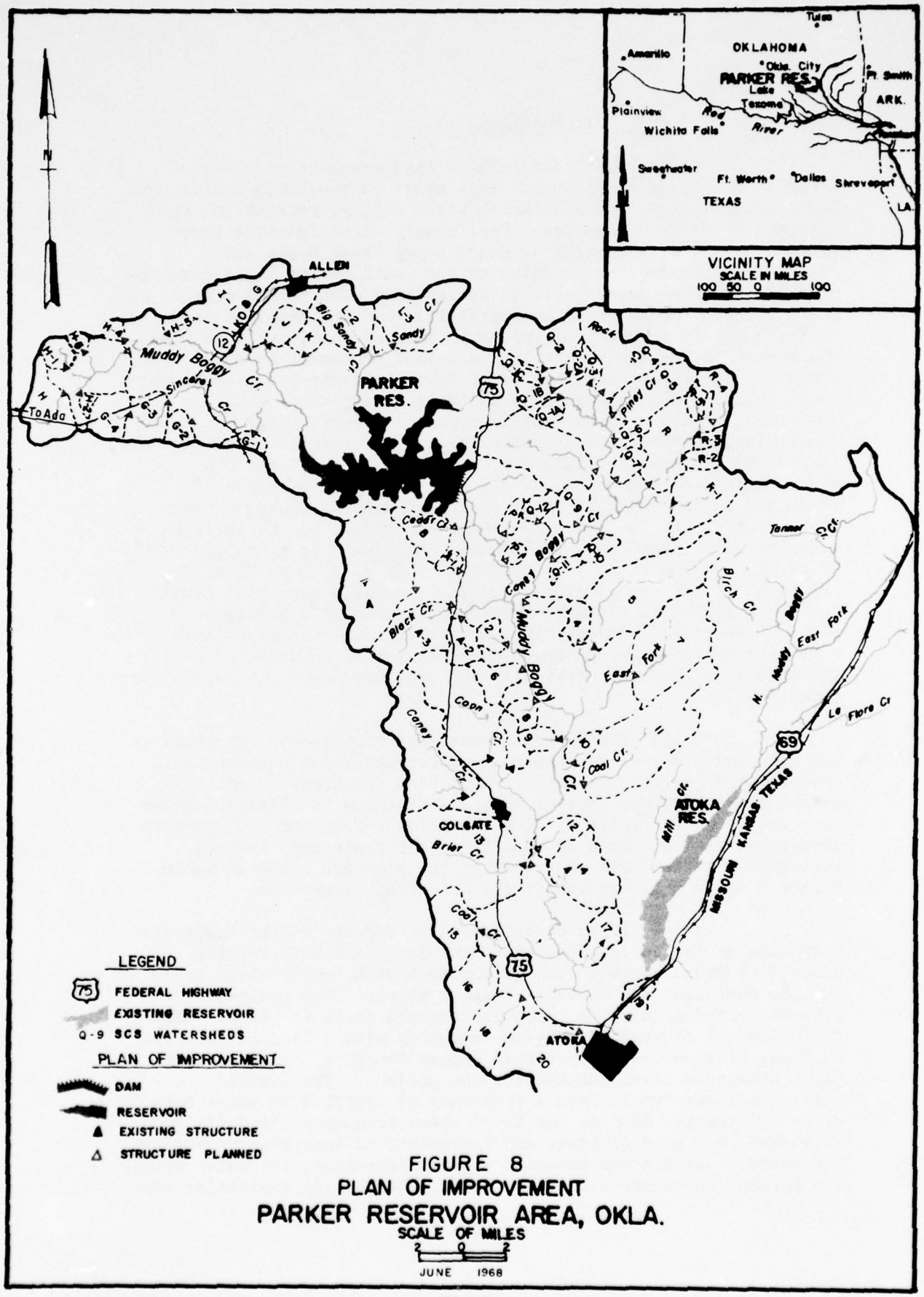

FIGURE 8
PLAN OF IMPROVEMENT
PARKER RESERVOIR AREA, OKLA.

(2) Project formulation.

(a) Water and related land resource development needs in the Muddy Boggy Creek Basin exist in the flood control and drainage, municipal and industrial water supply, recreation, and fish and wildlife categories. Preliminary investigations demonstrated that the topography of Muddy Boggy Creek Basin was adaptable to the reservoir solution and would permit ample development of its water resources. Investigations also showed single-purpose improvements would be impractical and uneconomical, and that storage in a major multiple-purpose reservoir, combined with a system of detention reservoirs, and land treatment measures would provide the highest degree of flood protection at the lowest cost. While a multiple-purpose major reservoir alone would be justified, it would yield a smaller excess benefit than the combined plan. Several damsites for the major reservoir were considered in preliminary studies. These sites included locations both upstream and downstream of U. S. Highway 75. These sites were evaluated on the bases of their effectiveness with respect to flood control and water supply yield. Proximity to the existing water pipeline from Atoka to Oklahoma City was also a consideration. The Parker site, just upstream of U. S. Highway 75 bridge, proved to be far enough above Boswell Reservoir to provide flood control benefits sufficient to warrant studies of a multiple-purpose reservoir. In addition, a reservoir at the Parker site would not deplete the conservation potential of Boswell Reservoir. The site is a good one physically and provides excellent recreation potential.

(b) The upstream watershed improvement increment of the combined plan was formulated in accordance with standard Soil Conservation Service practices. This plan comprises 69 small detention reservoirs, some above and some below the Parker Reservoir, as shown on figure 8. The detention reservoirs would detain an average of 7.1 inches of runoff for the areas they control. Pertinent data for this increment of the plan are shown on table 17. Figure 8 shows the location of the detention reservoirs.

(c) Flood control studies for the Parker Reservoir were made on the basis of multiple-purpose plans with varying amounts of flood control storage combined with conservation storage for municipal and industrial water supply. The upstream watershed increment of the plan was assumed to be in place. The flood control storage of 50-year frequency with a limited service spillway provides slightly higher excess benefits than the other plans studied and was adopted for the project. The limited service spillway would have a frequency of overflow of about once every 100 years. Storage for the 50-year frequency flood (75,200 acre-feet) was held constant and increments of conservation storage were added. As the conservation storage increased, the water supply and recreation benefits also increased. Recreation facilities were

TABLE 17

COMBINED PLAN OF IMPROVEMENT FOR THE UPPER MUDDY BOGGY CREEK BASIN

PERTINENT DATA

Site No.	Number of Structures	Drainage Area (sq. mi.)	Maximum Surface Area-Emergency Spillway Level (acres)	Storage Capacity Planned (acre-feet)			
				Sediment	Flood Control	Water supply	Total
USDA - P.L. 566							
3h2-6	44	158	-	8,400	50,500	3,000(2)	61,900
3h2-4	25	155	-	8,250	49,250	2,000	59,500
USDA TOTAL	69	313	6,725	16,650	99,750	5,000	121,400
PARKER RES.	1	172(1)	8,290	6,970	75,200	114,630	196,800
GRAND TOTAL	70	-	15,015	23,620	174,950	119,630	318,200

(1) Includes 66 square miles above SCS sites.

(2) Includes 1,000 acre-feet of recreation storage.

considered for all scales of development. The minimum development would consist of only measures to protect the public as regards health and safety and would contain no recreation facilities as such. Recreation facilities were added until the maximum excess benefits were obtained considering the limiting factor was the number of people in the general area that could be expected to use the facilities. Parker Reservoir recreational facilities would be developed within the general recreation needs as described in appendix XII, "Outdoor Recreation." Four public-use areas on the reservoir and one area below the dam at the outlet works would provide optimum recreational use of the project. A commercial fish seining area would be cleared in the reservoir.

Requests for lands for fish and wildlife developments would be fulfilled from project lands and additional lands would not be purchased. The development and administration of the fish and wildlife facilities would be placed with the Oklahoma Department of Wildlife Conservation. Benefit-cost analysis of Parker Reservoir show that maximum benefits over costs would be obtained with 75,200 acre-feet of flood control storage, 114,630 acre-feet conservation storage, and 6,970 acre-feet sediment storage. This plan would provide 50-year flood control protection and 47 m.g.d. water supply yield. Pertinent data for the Parker Reservoir are contained in table 18, and its location is shown on figure 8. The dam would consist of an earth embankment about 1,800 feet long, rising 97.5 feet above the streambed and an uncontrolled limited service spillway in a saddle near the right abutment. The outlet works would be a cut-and-cover conduit with a gated inlet. Approximately 13,500 acres of land would be required for construction of the dam and operation of the reservoir. An additional 1,200 acres of land would be required for public use and access. Recreation facilities would be included for public use of the land and water areas. Construction of Parker Reservoir would include alterations to several county roads and numerous utility facilities. About 100 graves in the reservoir area would require relocation.

(3) Benefits. The flood control storage in Parker Reservoir, operating with the SCS program, would provide protection from damaging floods between the damsite and the upper limits of Boswell Reservoir and would eliminate about 97 percent of the average annual damages in this reach. The annual flood control benefits credited to the combined plan would be $472,700. The conservation storage in Parker Reservoir would produce a dependable yield of 47 m.g.d. which is essentially the full stream potential at the site. The estimated overall water supply benefits would be $245,000 annually. Yield from 4,000 acre-feet of storage space included in the detention reservoirs would produce an additional benefit of $13,500 annually. The increase in water-oriented recreation opportunities at Parker Reservoir would produce $571,000 in benefits annually, while the detention reservoirs would produce an additional recreation benefit of $51,600 annually. Annual fish

TABLE 18

PARKER RESERVOIR

PERTINENT DATA

GENERAL	
Stream	Muddy Boggy Creek
River mile	127.4
Drainage area	172
ELEVATION, FEET, m.s.l.	
Top of dam	720.5
Maximum pool	715.1
Top of flood control pool	700.5
Top of conservation pool	690.0
Top of inactive pool	652.5
50-year pool	700.5
10-year drawdown pool	673.0
Streambed	623.0
STORAGE, ACRE-FEET	
Flood control	75,200
Conservation	114,630
Inactive	6,970
Total	196,800
AREA, ACRES	
Top of flood control pool	8,290
Top of conservation pool	6,110
50-year pool	8,290
SPILLWAY	
Location	Abutment
Type	Limited service
Width, feet	400
Crest elevation, feet, m.s.l.	703.0
Frequency of operation, years	100
Discharge at maximum pool, c.f.s.	43,300
FLOOD CONTROL OUTLET WORKS	
Type	Gated conduit
Number and size	1-10-foot
WATER SUPPLY	
Yield, m.g.d. (M&I)	47
STATIC HEADPIPE	
Size	1-54-inch

and wildlife benefits from commercial fishing would be $13,000. The total annual benefits for the combined plan would be $1,366,800. The total benefit attributable to the Parker Reservoir only would be $982,800 annually.

(4) Cost. The first cost of construction for the combined plan would be $16,366,000. The annual charges, including interest and amortization, operation and maintenance, major replacement, and engineering studies, would be $710,230. The corresponding figures for the Parker Reservoir are $9,930,000 and $476,900, respectively.

(5) Summary of benefits and costs. The total average annual benefits of $1,366,800 and the total annual charges of $710,230 yield a benefit-cost ratio, for the combined plan, of 1.9. The average annual benefits of $982,800 and the annual charge of $476,900 yield a benefit-cost ratio of 2.1 for the Parker Reservoir.

e. Tuskahoma pumped-storage hydroelectric project.

(1) Project formulation.

(a) Pumped hydropower storage is unique among methods of electric generation. It functions as an energy accumulator which stores energy by using low-cost off-peak energy to pump water from a lower to a higher reservoir. The stored water can then be returned through its turbines to generate power during peak periods when it has capacity as well as higher energy values. Prerequisites for such development are available water supply, high power head, and the availability of low incremental cost of peak energy. Two watersheds, the Little River and Kiamichi River, located in the lower Red River Basin, satisfy these prerequisites. The two watersheds possess several sites that have potential for pumped-storage as well as conventional hydropower development.

(b) In executing feasibility studies, the Federal Power Commission and the Southwestern Power Administration were consulted for data relative to existing power supply, a forecast of future hydropower needs, estimates of power and energy values, transmission, and marketing for potential hydropower development. It was concluded that planning for the Tuskahoma pumped-storage project should be limited to development of 1,000,000 kw at this time. This decision was based, in part, on the geographical area covered by "Study Area K." The Arkansas River, White River, and Ouachita River Basins also lie in "Study Area K" and possess sites with excellent potential for pumped-storage hydroelectric power development. The proposed project is an adjoining-type development which would use the authorized Tuskahoma Dam and Reservoir project as the afterbay reservoir. The forebay reservoir would be located near the headwaters of a canyon in the Kiamichi Mountain range

which parallels the south bank of the Tuskahoma Reservoir. The forebay reservoir would have sufficient storage capacity, including seepage and evaporation losses, to furnish 16 hours of continuous generation should loads require greater than 6 hours' daily generation. The upper and lower reservoirs would be connected by means of a vertical shaft and tunnel. The power plant would be located at the foot of the Kiamichi Mountains and a trapezoidal waterway would connect the powerhouse to Tuskahoma Reservoir. The location of the plan of improvement is shown on figure 9.

(2) Description and scale of project. The proposed Tuskahoma pumped-storage project is located on the left bank of the Kiamichi River, at river mile 118.5 adjacent to the authorized Tuskahoma Dam and Reservoir, Pushmataha County, Oklahoma. The installed power-generating capacity of the project will be 1,000 megawatts. The proposed facilities consist of a 19,000 acre-foot capacity operating forebay reservoir, a power-intake canal, a 115-foot-high power-intake, a 27-foot I.D. steel-lined power tunnel and shaft 5,820 feet in length, a power plant with four 250,000 kw capacity reversible Francis pump-turbines each connected mechanically to a reversible motor-generator, a switchyard, a power discharge canal, and an afterbay reservoir. The authorized Tuskahoma Dam and Reservoir, with some modification, would be used as the afterbay. No relocations would be required. Pertinent data on the Tuskahoma pumped-storage forebay reservoir power plant, and adjoining facilities are included in table 19. Pertinent Data on the authorized and proposed modification to the Tuskahoma multiple-purpose reservoir are included in table 20. Approximately 800 acres of land would be required for construction and operation of the forebay reservoir. The enlarged Tuskahoma Reservoir would require approximately 1,800 acres of land over and above that required for the document plan.

(3) Benefits. Benefits credited to the Tuskahoma Pumped-Storage Project would be for generation of hydropower only, and would amount to $17,996,900 annually.

(4) Costs. The first cost of construction for the project, including necessary revisions to the authorized Tuskahoma Reservoir, would be $108,700,000. The annual charges, based on a 50-year amortization period, including interest and amortization, operation and maintenance, major replacements, pumping costs, and engineering studies, would be $8,174,400.

(5) Summary of benefits and costs. The total average annual benefits of $17,996,900 and the total annual charges of $8,174,400 yield a benefit-cost ratio of 2.2. The alternative annual cost for power would be $9,496,900 and the comparability ratio 1.16.

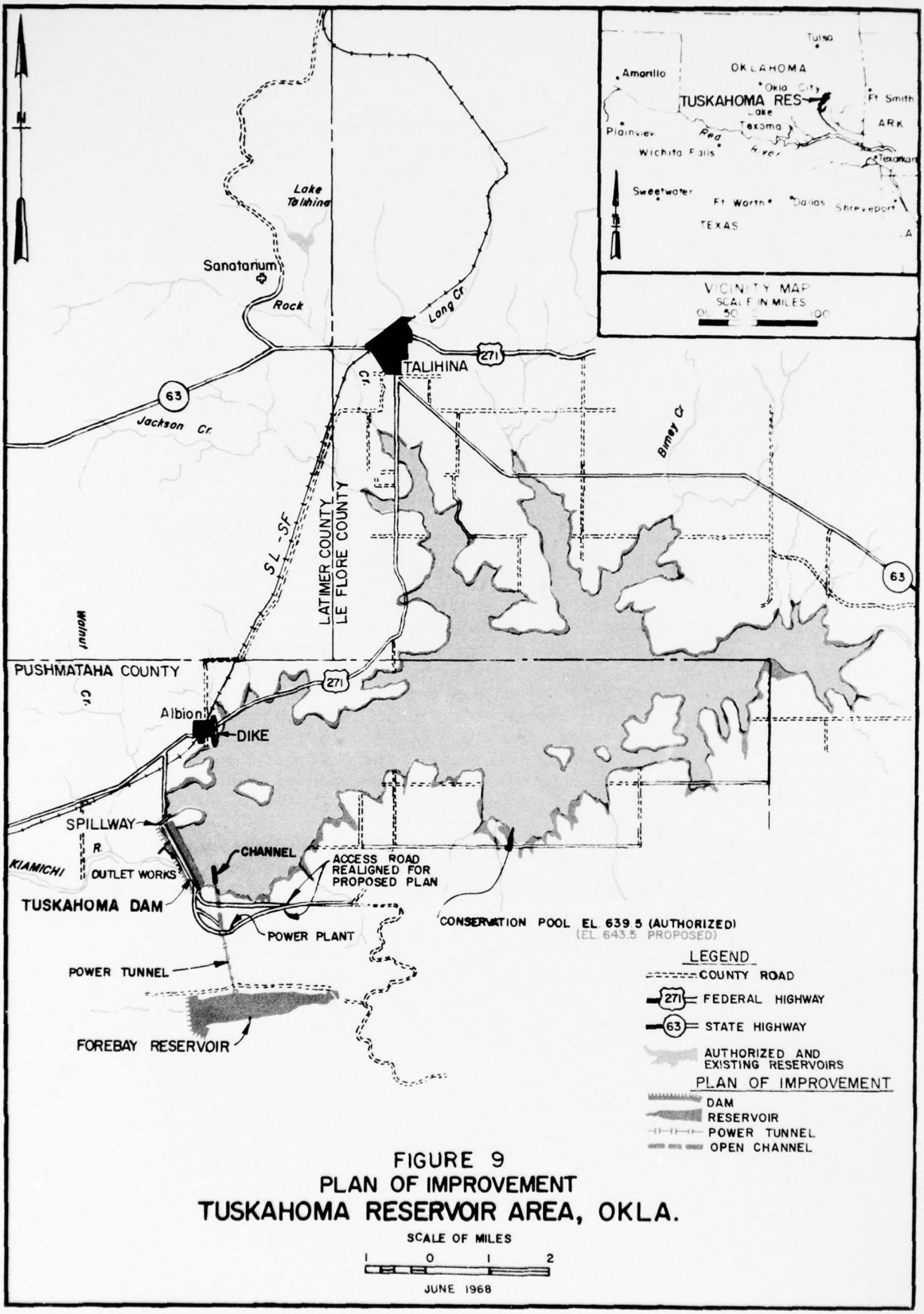

FIGURE 9
PLAN OF IMPROVEMENT
TUSKAHOMA RESERVOIR AREA, OKLA.

SCALE OF MILES
1 0 1 2

JUNE 1968

TABLE 19

TUSKAHOMA PUMPED-STORAGE PROJECT

PERTINENT DATA

Forebay Reservoir - Hilltop	
Maximum water surface elevation	1,750.0
Minimum water surface elevation	1,710.0
Capacity (1,700-1,750) acre-feet	19,000
Afterbay Reservoir - Tuskahoma Reservoir	
Top flood control pool, elevation	653.0
Top conservation pool, elevation	643.5
Top inactive pool, elevation	610.0
Tailwater, elevation	611.0
Penstock	
Length, feet	5,820
Diameter, feet	27
Head loss, feet	40.0
Type of turbine	Francis
Station capacity, megawatts	1,000
Number of units	4 (250,000 kw)
Gross heads, feet	
Maximum	1,139
Rated	1,089
Minimum	1,046
Net heads, feet	
Maximum	1,099
Rated	1,049
Minimum	1,006
Discharge, c.f.s.	
Maximum through turbines	15,700
Rated head	13,100
Average annual energy (12% L-F), kmwh	
Generation	1,051
Pumping (75% overall plant efficiency)	1,401

TABLE 20

TUSKAHOMA RESERVOIR

PERTINENT DATA

Feature	Authorized	Proposed with Pumped-Storage
GENERAL		
Stream	Kiamichi	Kiamichi
River mile	118.5	118.5
Drainage area, square miles	347	347
ELEVATION, FEET, m.s.l.		
Top of dam	674.0	676.5
Maximum pool	669.0	671.3
Top of flood control pool	649.5	653.0
Top of conservation pool	639.5	643.5
Top of inactive pool	587.0	610.0
50-year pool	649.5	653.0
STORAGE, ACRE-FEET		
Flood control	138,600	140,000
Conservation	231,000	251,500
Inactive	4,400	35,500
Total	374,000	427,000
AREA, ACRES		
Top of flood control pool	15,400	16,780
Top of conservation pool	11,600	13,000
Top of inactive pool	355	2,540
SPILLWAY		
Location	Saddle	Saddle
Type	Uncontrolled	Uncontrolled
Width, feet	200	200
Crest elevation, feet, m.s.l.	649.5	653.0
Discharge at max. pool, c.f.s.	55,800	63,800
OUTLET WORKS		
Type	Gated conduit	Gated conduit
Number and size	1-16-foot	1-16-foot
Discharge at top conservation pool, c.f.s.	7,000	7,000
WATER SUPPLY		
Yield, m.g.d.	200	200

f. Sherwood Reservoir-Broken Bow Modification.

(1) Basin description. Mountain Fork River, a tributary of Little River, drains an area of 842 square miles. From its source in the Kiamichi Mountains in LeFlore County, Oklahoma, the river flows in an easterly direction into Arkansas to form a loop around Round Mountain, then in a southwesterly direction into Oklahoma, then in a southerly direction to its confluence with Little River. The basin is mountainous, varying in elevation from about 310 feet at the mouth of the stream to about 2,400 feet in the headwater. The banks are quite stable and the average slope of the streambed is about 9 feet per mile. Numerous small tributaries and springs contribute to the flow, but neither the river nor its tributaries carries much sediment. Uncultivated area in the basin is mostly woodlands and pasture with small tracts developed for gardens and production of crops. Broken Bow Dam, located on Mountain Fork River at mile 20.3, is under construction.

(2) Project formulation.

(a) Water and related land resource development needs in the Mountain Fork River Basin include flood control, hydroelectric power, recreation, and fish and wildlife. Preliminary investigations indicated that a reservoir located near the headwaters of Broken Bow Reservoir would provide the best solution to the hydroelectric power needs. In addition, this reservoir would satisfy recreation and fish and wildlife needs. There are excellent damsites at river miles 42.6, 44.4, and 46.8. At these locations, Mountain Fork River cuts through mountainous ridges and the river valley is narrow. Preliminary cost estimates were made to determine the indicated cost of developing each of the three prospective damsites. Each estimate recognized the relocation of U. S. Highway 259, State Highway 21, and protection or relocation of the town of Smithville, Oklahoma (1960 population 110). Comparison of estimates indicated a cost advantage for the damsite at mile 44.4. This damsite was selected for detailed studies.

(b) Sherwood damsite is located at river mile 44.4, about 22 miles north of the city of Broken Bow, Oklahoma, and about 4.5 miles southwest of the city of Watson, Oklahoma, as shown on figure 10. The proposed Sherwood Reservoir would control 601 square miles of the total basin drainage area of 842 square miles. Its location near the headwaters of Broken Bow Reservoir would permit installation of pump-back hydroelectric facilities, using Broken Bow Reservoir as an afterbay. Reallocation of flood control storage from Broken Bow Reservoir will provide storage for power generation and flood protection. Project purposes would include

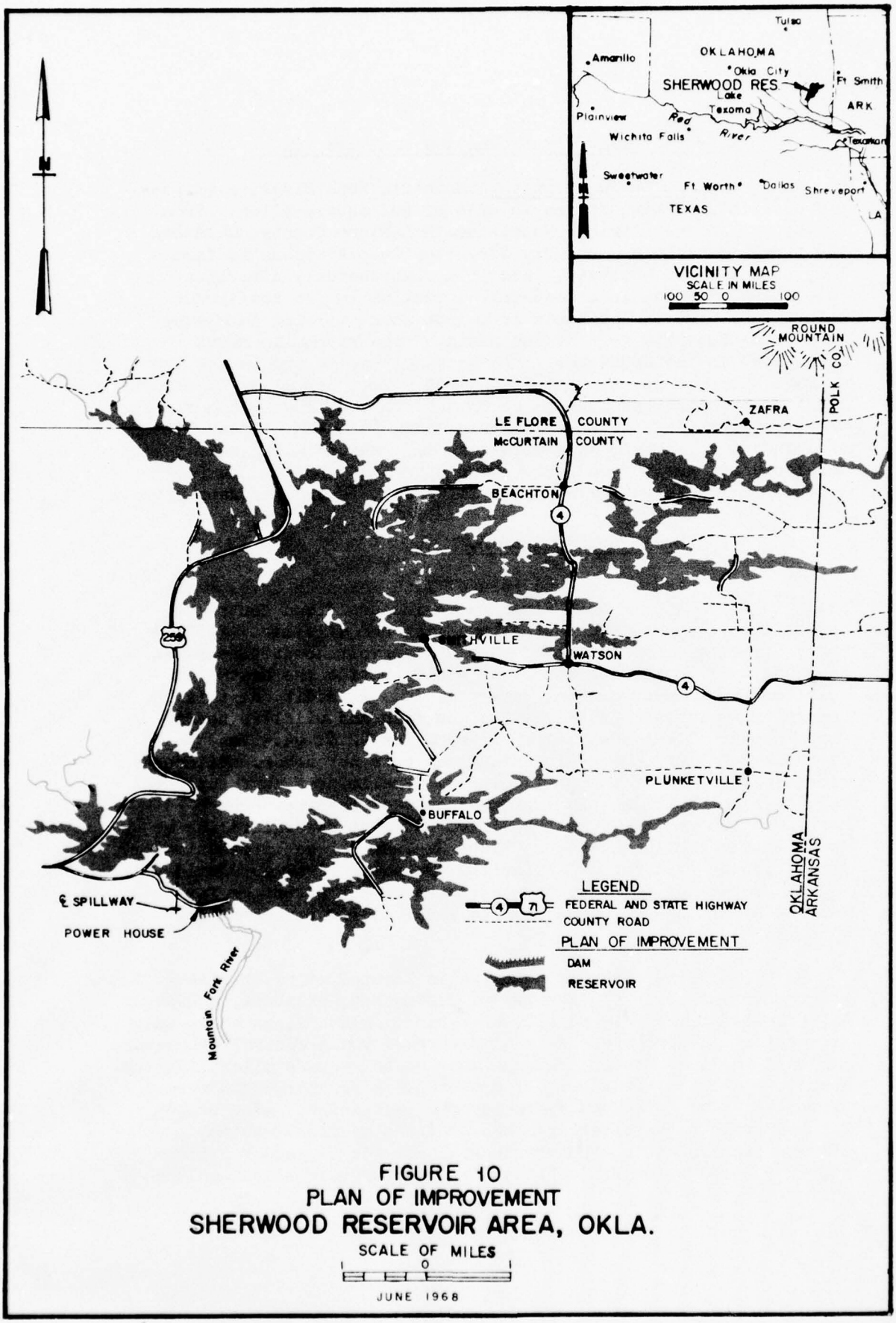

FIGURE 10
PLAN OF IMPROVEMENT
SHERWOOD RESERVOIR AREA, OKLA.

SCALE OF MILES
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JUNE 1968

hydroelectric power, recreation, and fish and wildlife. Sherwood and Broken Bow Reservoirs would be in tandem and their operation would be coordinated. Therefore, reservoir system benefits were used to evaluate flood storage distribution between the two projects. The formulation studies showed that inclusion of 109,700 acre-feet flood control storage in Sherwood and the reallocation of storage in Broken Bow for more dependable power capacity effected a maximum in net benefits for the system. The storage reallocated in Broken Bow to power would be equivalent to the 109,700 acre-feet flood control storage proposed for the Sherwood project. Therefore, as proposed, the reservoir system would provide the same degree of flood protection and flood storage (450,000 acre-feet) as the single project, Broken Bow. Dependable power capacity of Broken Bow would be increased from 86,000 kw to 100,000 kw. Recreation facilities were considered for all scales of development. The minimum development would consist of measures to protect the public as regards health and safety and would contain no recreation facilities. Recreation facilities were added until the maximum excess benefits were obtained, considering the limiting factor as the number of people in the general area who could be expected to use the facilities. Sherwood Reservoir recreational facilities would be developed to be within the general recreation needs as described in appendix XII, "Outdoor Recreation." Seven public-use areas on the reservoir and one area below the dam at the outlet works would provide optimum recreational use of the project. A commercial fish seining area would be cleared in the reservoir. Requests for lands for fish and wildlife developments would be fulfilled from project lands and additional lands would not be purchased. The development and administration of the fish and wildlife facilities would be placed with the Oklahoma Department of Wildlife Conservation. Detailed design studies will consider design of a variable level intake structure to provide releases most beneficial for downstream fish habitat. Preliminary studies indicate that with waters of suitable temperatures a beneficial trout fishery could be established downstream from the reservoir.

(3) Description of project. Pertinent data for the proposed plan of improvement are shown in table 21. Sherwood Dam would consist of a rock-fill and earth structure about 2,200 feet long, rising about 238 feet above the streambed. A 600-foot long uncontrolled spillway would be located in a saddle 1/4 mile west of the right abutment of the dam. Two tunnels, each 41.5 feet in diameter, would lead to the powerhouse at the foot of the dam and supply water under a gross average head during the critical period of about 164 feet to one conventional generating turbine and five reversible pump-turbines for power generation. Each unit would generate 115,000 kw of power. Recreation facilities would be included for public use of the land and water areas. Construction of Sherwood Reservoir would require relocation of 12.3 miles

TABLE 21

SHERWOOD RESERVOIR WITH BROKEN BOW MODIFICATION

PERTINENT DATA

Feature	Sherwood Reservoir	Broken Bow Authorized	Broken Bow Modified
Top of dam, elevation	819.0	645.0	645.0
Top of flood control pool, elevation	798.5	627.5	627.5
Top power or water supply pool, elev.	795.0	599.5	606.0
Bottom power or water supply pool, elevation	761.0	559.0	590.0
Flood control storage, acre-feet	109,700	450,000	350,000
Power storage, acre-feet	844,000	-	-
Power and water supply storage, acre-feet	-	470,000	223,200

POWER DEVELOPMENT AT SHERWOOD RESERVOIR

Feature	Amount
Installed capacity, kw	600,000
Dependable capacity, kw	690,000(1)
Tailwater elevation, feet	614.0
Head loss, feet	5.0
Gross heads, feet:	
Maximum	181.0
Minimum	147.0
Average during critical period	164.0
Net heads, feet:	
Maximum	176.0
Minimum	142.0
Average during critical period	159.0
Generating units:	
Type and size (kw)	1-Conventional 100,000 5-Reversible 500,000
Maximum discharge through turbines, c.f.s.	58,000
Average annual generation kmwh:	
Conventional	110.0
Reversible @ 12% L.F.	620.2
Average annual pumping energy, kmwh: (75% efficiency)	
Reversible @ 12% L.F.	826.9
Penstocks:	
Length, feet	700
Number and diameter, feet	2 - 41.5

(1)Units capable of continuous generation at 15% overload.

of Federal highway, 12.3 miles of State highway, 9.5 miles of county roads, 27 miles of electric power and distribution lines, 48.2 miles of telephone lines, and 400 graves. Land, properties, and structures in the town of Smithville, Oklahoma, which will be inundated, would be acquired. Approximately 42,300 acres of land would be required for construction and operation of the project. An additional 1,600 acres of land would be required to mitigate fish and wildlife losses. It is proposed to acquire these lands as a part of a 5,000-acre tract to be developed for wildlife propagation and public hunting. The developed tract would mitigate wildlife damages attributable to both the Sherwood project and the bank stabilization project for Red River.

(4) Benefits. The conventional and pumped storage hydropower capability would help meet the needs of the general area as outlined by the Federal Power Commission. The annual benefits from generation of hydropower would be $12,463,100. Based on a systems analysis, flood control and water supply storages would not produce benefits in excess of those at the authorized Broken Bow Reservoir. The water-oriented recreational opportunities at Sherwood Reservoir would total $1,681,000 in benefits annually, while annual benefits from commercial fishing would be about $19,000.

(5) Costs. The first cost of construction of Sherwood Dam and Reservoir, including recreational facilities, would be $154,400,000. The annual charge, including interest and amortization, operation and maintenance, major replacements, engineering studies, and pumping cost, would be $8,884,900.

(6) Summary of benefits and costs. The total average annual benefits of $14,163,100 and the total annual charge of $8,884,900 yield a benefit-cost ratio of 1.6.

g. Liberty Hill Reservoir.

(1) Basin description. Mud Creek, a south bank tributary to the Red River, has its source near DeKalb, Texas, and flows in a generally easterly direction to its confluence with the Red River at river mile 470.0. (See Fig. 11.) The basin is 22 miles long and has a maximum width of 9 miles. The Mud Creek drainage area is moderately flat and fairly well drained except in the lower reaches where the channel is small and choked with brush. The slope of the channel in the lower reaches is about 1.2 feet per mile. Principal crops grown in the basin are alfalfa, corn, oats, grain sorghums, and hay. The uncultivated areas in the watershed are largely devoted to pasture. DeKalb, Texas, is the only town of any appreciable size within the basin.

It had a 1960 population of 2,042. There are no Public Law 566 programs in the basin at the present time.

(2) Project formulation.

(a) The water and related land resource development needs in the Mud Creek Basin include flood control, municipal and industrial water supply, recreation, and fish and wildlife. Preliminary investigations demonstrated that storage for flood control was not economically justified in Liberty Hill Reservoir due to the backwater effects of floods on Red River. However, the reservoir would provide municipal and industrial water supply and would enhance the recreation opportunities of the area. Three damsites were considered in the screening process. One site is located about half a mile upstream of the proposed site, just below the confluence of Mud and Holly Creeks. Cost of storage at this site would be approximately the same as at the proposed site, but the potential water yield would be considerably less (about 80 percent as much). The third site is located on Daniels Creek just upstream of the confluence of that stream and Mud Creek. The drainage area of this site is only 15 square miles, and the potential development is quite limited. The selected site for detailed study provides more opportunity for maximum water resources development at a reasonable cost.

(b) To determine the size of the reservoir that would provide maximum net benefits, increments of conservation storage were added and the costs and benefits compared. Results of this study show that maximum excess benefits would be obtained with a reservoir containing about 90,000 acre-feet of conservation storage and 8,000 acre-feet of sediment storage. Recreation facilities were considered for all scales of development. The amount of recreation facilities was increased until the maximum excess recreation benefits were obtained. Four public-use areas on the reservoir and one area below the dam at the spillway would provide optimum recreational use of the project. Three commercial fish seining areas would be cleared in the reservoir. Requests for land for fish and wildlife developments would be fulfilled from project lands and additional lands would not be purchased. The development and administration of the fish and wildlife facilities would be placed with the appropriate Texas State agency. This plan would also provide 30 m.g.d. of water supply yield.

(3) Description of project. Pertinent data for the proposed plan of improvement are shown on table 22. The dam would

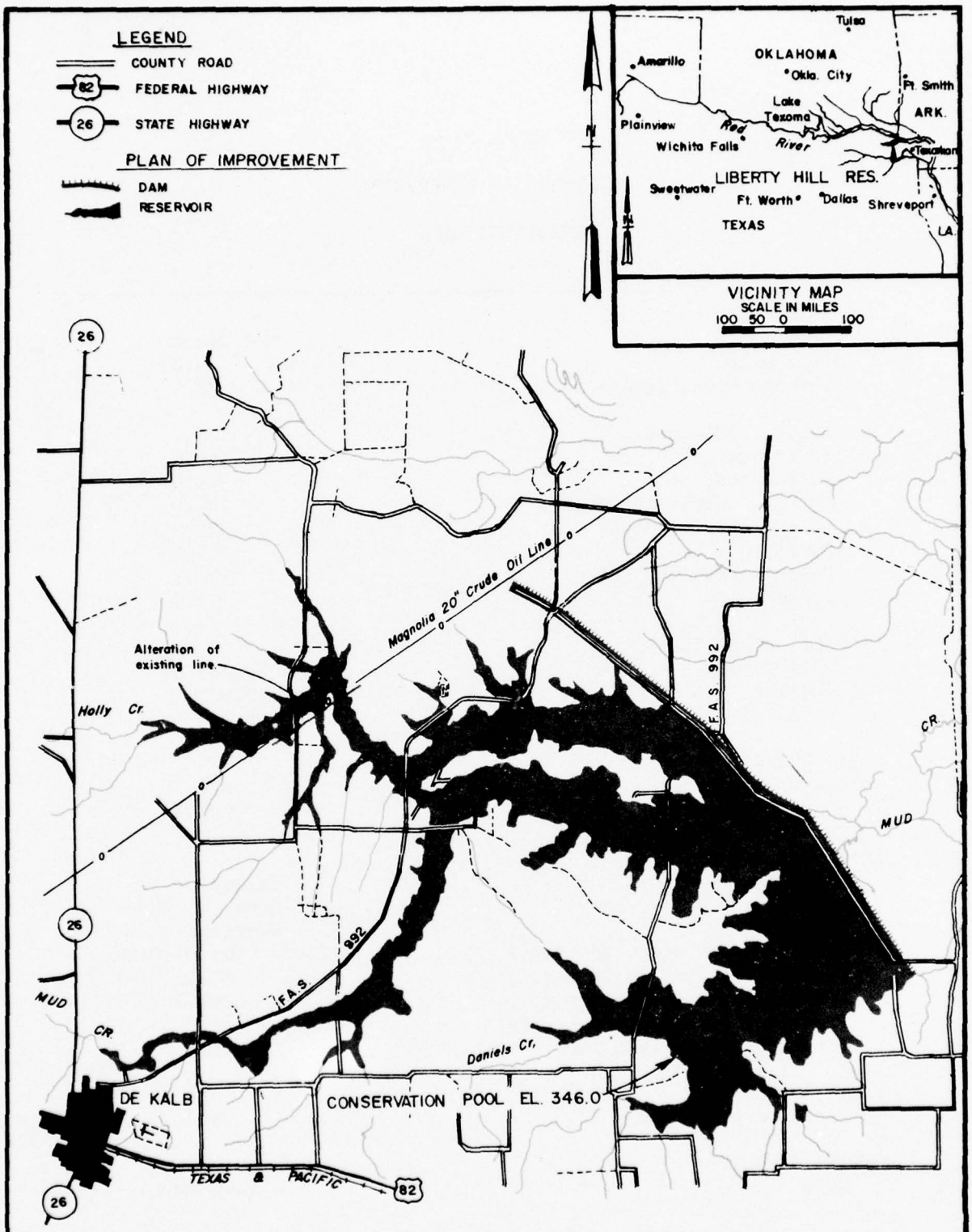

FIGURE 11
PLAN OF IMPROVEMENT
LIBERTY HILL RESERVOIR AREA, TEXAS
SCALE OF MILES
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JUNE 1968

TABLE 22

LIBERTY HILL RESERVOIR

PERTINENT DATA

GENERAL	
Stream	Mud Creek
River mile	9.0
Drainage area, square miles	73
ELEVATION, FEET, m.s.l.	
Top of dam	358.0
Maximum pool	353.0
Top of conservation pool	346.0
Top of inactive pool	320.0
50-year pool	346.3
10-year drawdown pool	334.0
Streambed	297.0
STORAGE, ACRE-FEET	
Conservation	89,840
Inactive	7,900
Total	97,740
AREA, ACRES	
Top of conservation pool	7,070
50-year pool	7,200
SPILLWAY	
Location	Valley
Type	Ogee
Side slopes	Vertical
Gates, number and size (feet)	3-20-foot by 20-foot
Crest elevation, feet, m.s.l.	326.0
Apron elevation, feet, m.s.l.	297.0
Frequency of operation (years)	1
Discharge at maximum pool, c.f.s.	27,900
WATER SUPPLY	
Yield, m.g.d. (M&I)	30
STATIC HEADPIPE	
Size	1-42-inch

consist of an earth embankment about 19,500 feet long rising 61 feet above the streambed. The spillway would be a concrete ogee weir with three 20-foot by 20-foot tainter gates located in the valley on the right bank of Mud Creek. Construction of Liberty Hill Reservoir would include alterations of 3.3 miles of Texas F.A.S. Highway No. 992, 1.1 miles of Bowie County roads, 12.3 miles of powerlines, 10.0 miles of telephone lines, 1.0 mile of pipelines, and about 150 graves. Approximately 12,000 acres of land would be required for construction of the dam and operation of the reservoir. An additional 400 acres of land would be required for public use and access. Recreation facilities would be included for public use of the land and water areas.

(4) Benefits. The conservation storage in Liberty Hill Reservoir would essentially develop the full stream potential of Mud Creek at the damsite. The yield of 30 m.g.d. of water would satisfy most of the projected water supply demand of the area. Water supply benefits would be $361,200 annually. The increase of water-oriented recreational opportunities at Liberty Hill Reservoir would produce about $308,000 in annual benefits, and annual commercial fisheries benefits would be about $19,000.

(5) Costs. The first cost of construction of the reservoir and recreational facilities would be $14,200,000. The annual charges, including interest and amortization, operation and maintenance, major replacement, and engineering studies would be $599,700.

(6) Summary of benefits and costs. The total average annual benefits of $688,200 and the total annual charges of $599,700 yield a benefit-cost ratio of 1.1.

h. McGee Creek Reservoir.

(1) Basin description. McGee Creek, a north bank tributary to Muddy Boggy Creek, has its source near Chockie, Atoka County, Oklahoma. The stream flows in a southerly direction about 37 miles to its confluence with Muddy Boggy Creek. (See Fig. 12.) The upper portion of the watershed is characterized by long narrow ridges and valleys with steep side slopes. The ridge lines in the middle and lower portion of the watershed are not well defined. The watershed is about 25 miles long and about 10 miles wide. The stream is well defined, has a rambling route, and has an average gradient of about 7 feet per mile. The largest industry in the

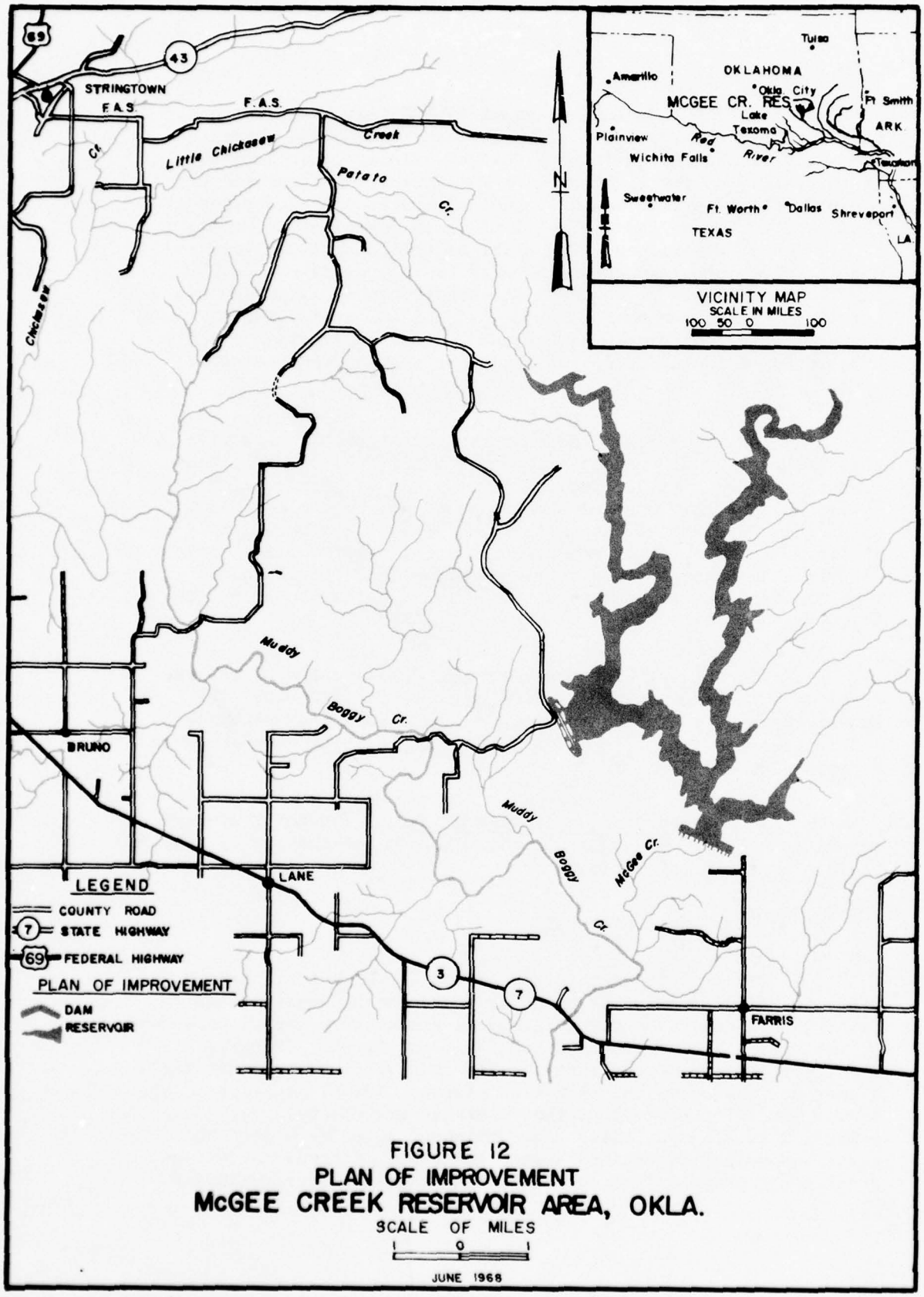

FIGURE 12
PLAN OF IMPROVEMENT
McGEE CREEK RESERVOIR AREA, OKLA.
SCALE OF MILES
1 0 1
JUNE 1968

watershed is the lumber business. Agriculture is limited; however, some dairy products, beef cattle, sheep, goats and hogs are produced. The area is sparsely populated with the towns of Redden and Wesley being the only communities within the basin. At present, there are no Public Law 566 programs under way in the basin.

(2) Project formulation. As a result of data presented at the public hearing, held on February 8, 1968, officials for Oklahoma City asked that McGee Creek Reservoir be placed in the early-action plan instead of the long-range plan. Since projects proposed for the long-range plan were not studied in detail, the project data presented are preliminary. The reservoir would contain storage for flood control and municipal and industrial water supply. The flood control storage was based on providing protection for a 50-year event. The conservation storage was based on providing the maximum practicable yield of the stream.

In order to design a reservoir that would produce the maximum yield possible from McGee Creek, the damsite would have to be located between the mouth of this stream and its confluence with Patapo Creek. A study of available topographic maps indicated the best site to be at river mile 3.4. The preliminary studies for this report were based on designing a dam at this site.

The McGee Creek damsite is located at river mile 3.4, 3.5 miles north of Farris, Oklahoma, as shown on figure 11. The proposed reservoir would control 168 square miles of the total basin drainage area of 175 square miles. The flood control storage included in the reservoir would be in lieu of an equivalent amount now included in the authorized Boswell Reservoir, which is located downstream on Muddy Boggy Creek. The project would provide protection from a 50-year flood event and provide storage for municipal and industrial water supply. Preliminary flood control benefits were determined on the basis of transfer of flood control storage from Boswell Reservoir, by assigning to McGee Reservoir a portion of the Boswell flood control benefits based on the storage space transferred. Detail studies will further explore the matter of flood control benefits. It would also enhance the recreational opportunities of the area by providing facilities for that purpose.

(3) Description of project. Pertinent data for the proposed plan of improvement are shown in table 23. The dam would consist of an earth embankment rising 128 feet above the streambed and would be approximately 3,900 feet in length and have an uncontrolled limited service spillway near the right abutment. The outlet works would be a cut-and-cover gated conduit. Construction of McGee Creek Reservoir would include alterations to county roads and relocation of two cemeteries. Approximately 7,000 acres of land would be required for construction of the dam and operation of the reservoir. An additional 200 acres would be required for public use and access. Recreation facilities for the use of land and water areas would be included.

TABLE 23

McGEE CREEK RESERVOIR
PERTINENT DATA

GENERAL	
Stream	McGee Creek
River mile	3.4
Drainage area, square miles	168
ELEVATION, FEET, m.s.l.	
Top of dam	612.0
Maximum pool	604.0
Top of flood control pool	596.0
Top of conservation pool	579.0
Top of inactive pool	498.0
Streambed	460.0
STORAGE, ACRE-FEET	
Flood control	80,500
Conservation	131,000
Inactive	3,000
Total	214,500
AREA, ACRES	
Top of flood control pool	5,500
Top of conservation pool	3,500
SPILLWAY	
Location	Right abutment
Type	Uncontrolled
Width, feet	300
Crest elevation, feet, m.s.l.	596
FLOOD CONTROL OUTLET WORKS	
Type	Controlled
Size	1 - 12-foot conduit
WATER SUPPLY	
Yield, m.g.d.	60

(4) Benefits. The flood control benefits are $107,500. The conservation storage would develop the full yield potential of McGee Creek of 60 m.g.d. of good quality water. The preliminary water supply benefits would be $358,000 annually. The increase of water-oriented recreation opportunities at McGee Creek Reservoir would produce about $257,500 in benefits annually, and the annual benefit to the commercial fisheries would be about $10,000.

(5) Costs. Based on the preliminary studies the first cost of construction of the reservoir and recreational facilities would be $15,600,000. The annual charges, including interest and amortization, operation and maintenance, major replacement, and engineering studies, would be $682,000.

(6) Summary of benefits and costs. The total annual benefits of $733,000 and the total annual charges of $682,000 yield a benefit-cost ratio of 1.1.

i. Titus County Reservoir.

(1) Project formulation. This project has been formulated to meet municipal and industrial water supply, recreation, and fish and wildlife development needs in the Cypress Bayou Watershed. While some flood control needs which could be satisfied by inclusion of flood control storage space in the reservoir do exist, preliminary investigations disclosed that this solution fell far short of economic justification.

The formulation of the reservoir was based on recognition of the fact that the Texas Water Plan may be implemented in the future. This plan envisions that, ultimately, flood control storage will be required at the Titus County site in order to permit conversion of a portion of the flood control storage space in the existing Lake O' the Pines Reservoir to municipal and industrial use. In sizing the reservoir for municipal and industrial water supply, it was considered that sufficient yield would have to be provided to meet the 2080 needs of Mount Pleasant, Texas, and, in addition, to make available a release for the purpose of maintaining the yield of existing municipal and industrial water supply space in Lake O' the Pines Reservoir. The total yield required for both of the above purposes in 2080 would be 84 m.g.d. The impact of the Texas Water Plan was also considered in estimating recreation demands to be satisfied by the Titus County Reservoir.

Since the city of Mount Pleasant would be the primary user of water from the reservoir, a general area for the damsite was selected so as to place the reservoir as close to that city as was consistent with overall yield requirements and valley topography. A number of possible damsites within the general area selected were investigated, and the most favorable location, economically, was

determined to be on Big Cypress Creek about 6 miles south of Mount Pleasant, as shown on figure 13.

The full yield potential of this site in the worst drought of record is 107 m.g.d., or some 23 m.g.d. in excess of the currently foreseeable needs in 2080. Several factors support construction to full potential. The Cypress Bayou Basin is a main supply area for the Texas Water Plan, and the State of Texas favors development of the site to full potential. There is little question but that the additional space would find a ready market for purchase for municipal and industrial use; in fact, the Texas Water Development Board has indicated that they will purchase the space if other interests do not. It must be remembered also that policy regarding the control of the quality of water in the streams of Texas is evolving in the direction of making such control a direct responsibility of that State, to be met by treatment or diversions from M&I water supply, at the option of the State. Thus, generous development of the capabilities for municipal and industrial water supply in Texas sites is only prudent.

Development of the reservoir for recreation and fish and wildlife has been based on meeting such needs, as they develop, to the year 2080. This will involve development of the reservoir to about 40 percent of its full potential in 2020, and about 75 percent in 2080.

If, prior to construction of the Titus County Reservoir, the current studies of the Texas Water Plan are completed and result in a recommendation that the transfer of storage between Titus County Reservoir and Lake O' the Pines be accomplished, the plan for the Titus County Reservoir which follows should be modified to include this transfer storage.

(2) Description of project. Pertinent data for the proposed reservoir are given in table 24. The earthfill dam would be about 13,000 feet long and would rise some 77 feet above the streambed. The spillway structure would consist of an uncontrolled section 40 feet long with weir crest at elevation 343.2 and a controlled section containing 4 tainter gates, each 40 feet long and 29 feet high with a crest at elevation 326.0. The outlet works would consist of one 7-foot diameter culvert with invert elevation of 294.0. Eleven public-use areas are included in the plan. In addition, about 50 percent of the area of the water supply pool would be cleared including boat lanes as required to provide access for hunting and fishing throughout the lake. Construction of the reservoir would require relocation of two farm-to-market roads and the modification of about 13,800 feet of pipelines. About 17,000 acres of land, including 1,200 acres for recreational

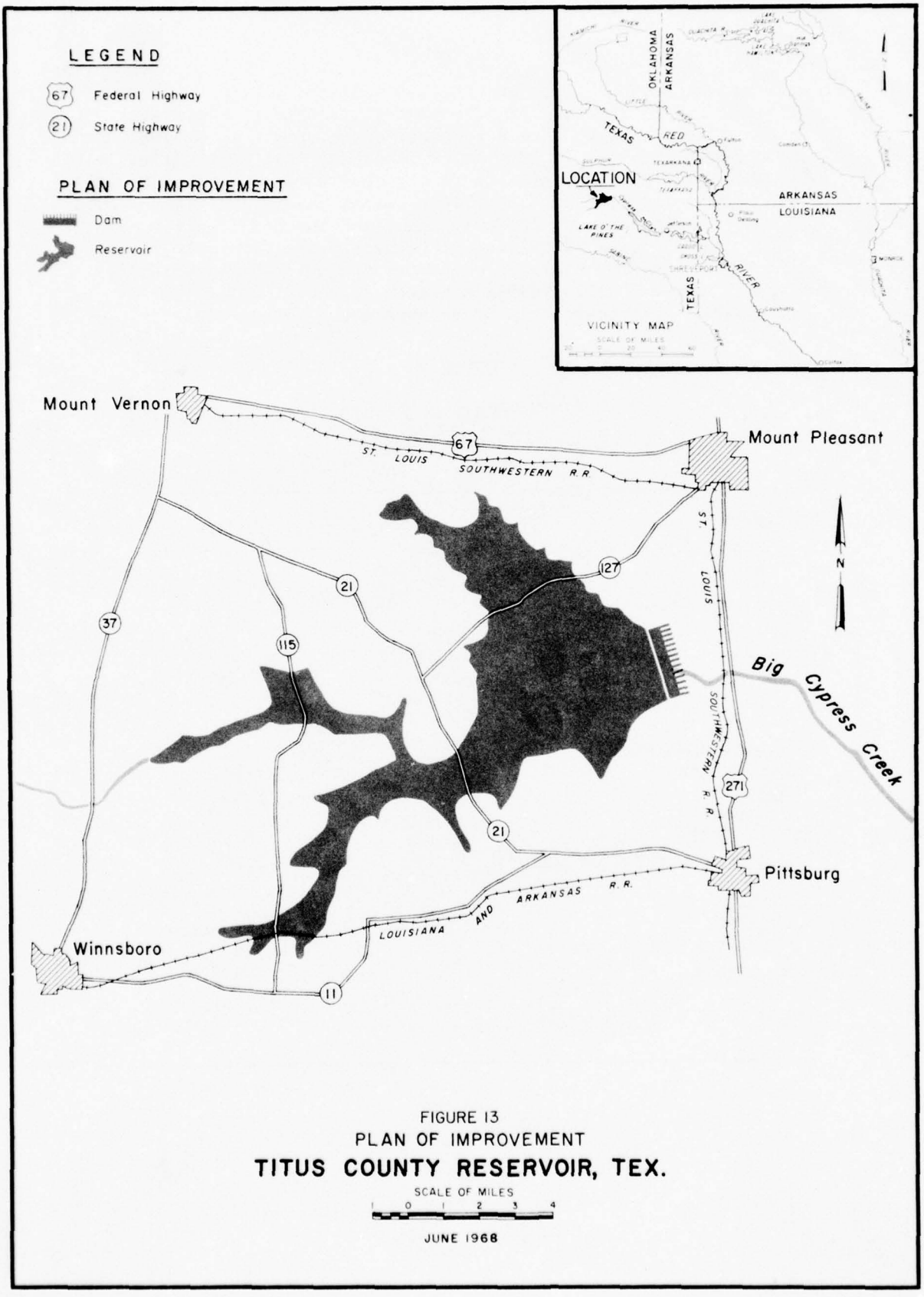

FIGURE 13

PLAN OF IMPROVEMENT

TITUS COUNTY RESERVOIR, TEX.

SCALE OF MILES

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development and 820 acres to mitigate wildlife losses would be required for the project. It is proposed to acquire this latter acreage as a part of a greentree reservoir development in the Sulphur River bottoms in Texas, just below Texarkana Dam, aggregating 2,000 acres; the total area to be acquired to meet needs for mitigation in connection with the Titus County Reservoir, the Texas portion of the enlargement of Caddo Lake, and the Texas portion of the navigation and bank stabilization project. The single development is proximate to the areas in which the project-occasioned losses would occur, and will provide a higher degree of mitigation at lower total cost than would three separate developments.

TABLE 24

TITUS COUNTY RESERVOIR
PERTINENT DATA

GENERAL	
Stream	Cypress Bayou
Drainage area, square miles	273
ELEVATION, FEET, m.s.l.	
Top of dam	362.0
Top of conservation pool	343.2
Top of inactive pool	294.0
Top of surcharge pool	356.3
STORAGE, ACRE-FEET	
Conservation	314,000
Inactive	2,800
AREA, ACRES	
Top of conservation pool	12,200
SPILLWAY	
Type	Tainter gates
Number and size (feet)	4 (40 x 29)
Elevation	326.0
WATER SUPPLY YIELD, m.g.d.	107.0

(3) Benefits. The total average annual benefits accruing to the project would be $1,735,000. These consist of $871,000 for municipal and industrial water supply; $606,000 for recreation; and $258,000 for fish and wildlife enhancement.

(4) Costs. The total first cost of the project is estimated to be $23,100,000. The annual charges, including interest, amortization, operation, maintenance, major replacements, economic losses on land, and engineering studies, would be $1,116,000.

(5) Summary of benefits and costs. The project would produce annual benefits of $1,735,000 at an annual cost of $1,116,000 for a benefit-cost ratio of 1.6.

j. Caddo Lake Enlargement.

(1) Location and history of existing dam. The existing Caddo Dam is located at the head of Twelvemile Bayou in the Cypress Bayou Basin about 20 miles northwest of Shreveport, Louisiana, and is shown on figure 14. It was constructed in 1914 to maintain navigable depths in the Jefferson-Shreveport Waterway; however, because of the inadequate depths provided--4 feet--this waterway is not used for through traffic. The only navigation associated with the project at this time is that necessary to service the numerous oil wells in Caddo Lake. While its use for navigation was never realized, other uses in the lake have grown to the point that it is now a necessary adjunct to the economy of the area. The lake is the prime source of water supply for many industries and towns in both Louisiana and Texas, and provides abundant opportunities for outdoor recreation.

The existing dam is structurally obsolete and its replacement has been authorized by Congress. It is expected that construction of the replacement dam will begin in mid-1968. The replacement dam is so designed as to simplify modification that will permit raising the controlled lake level about 4 feet to provide additional water supply storage in the lake.

(2) Project formulation. The project has been designed to meet municipal and industrial water supply, recreation, and fish and wildlife development needs of the area. Previous investigations made in connection with the replacement dam indicated that raising the dam to elevation 172.0 was the maximum enlargement that could be economically justified. Pool levels above that elevation would inundate much of the extensive private and commercial development on the shores of the lake. Raising the conservation pool to

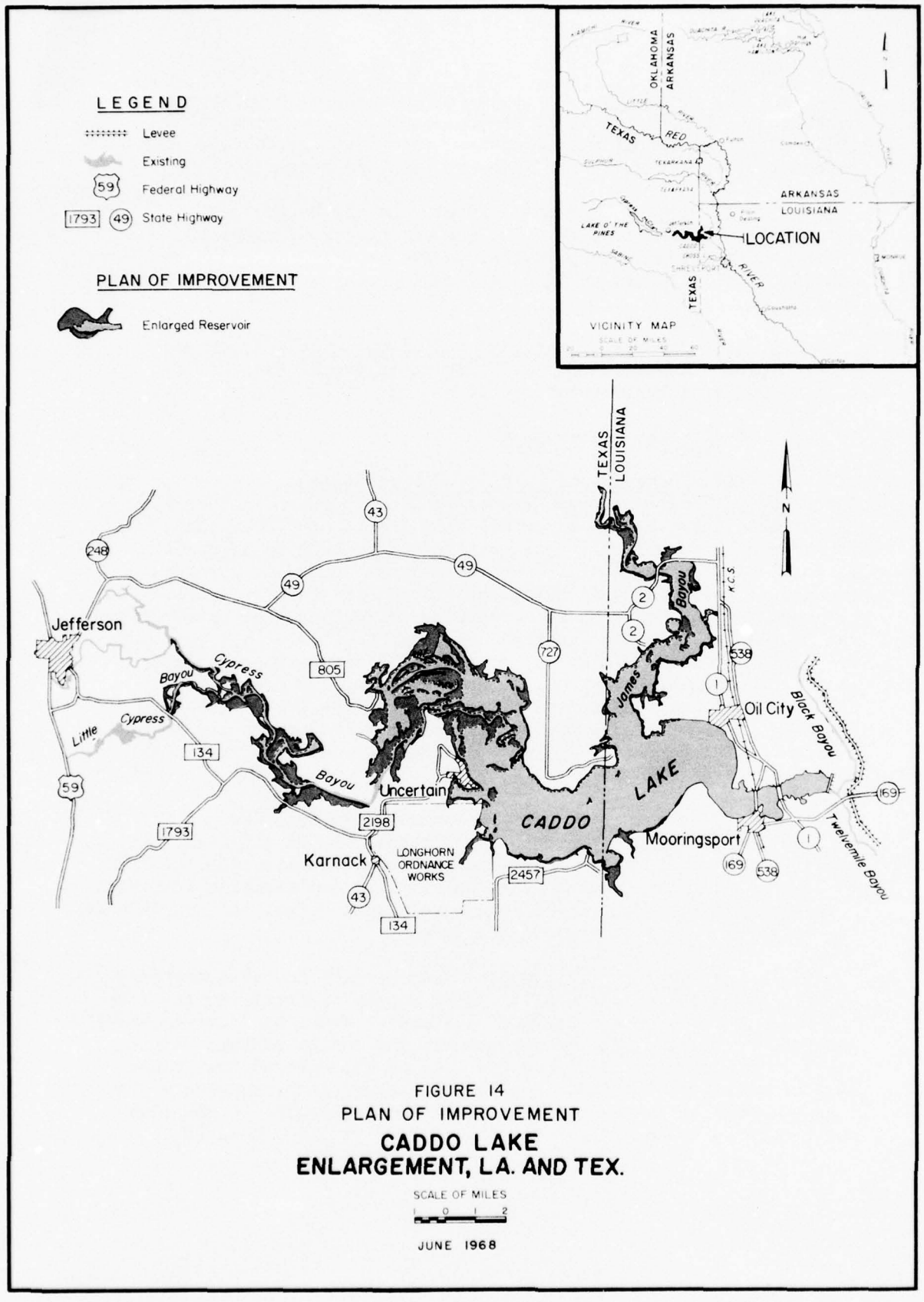

FIGURE 14

PLAN OF IMPROVEMENT

CADDO LAKE
ENLARGEMENT, LA. AND TEX.

SCALE OF MILES
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elevation 172.5 would provide a dependable yield of 107 m.g.d., all of which would be available to satisfy water supply needs in Louisiana and Texas. For planning purposes, this yield has been distributed between the two States in accordance with provisions of the preliminary draft of the Red River Compact relating to distribution of excess water in the existing lake. Final determination of the distribution of water between the two States will depend upon the terms of the compact when accepted by the four States involved and the U. S. Congress; and the existence of specific prospective purchasers.

As previously alluded to, considerable recreational development has taken place on the existing lake. The private, private commercial, and public sectors are represented in the existing development. Continued expansion of private and private commercial development is indicated, and additional public development is planned in connection with the replacement of the existing dam, but a quantitative evaluation of these contributions cannot be made with confidence at this time. Accordingly, it is proposed to formulate the project with sufficient recreational development to meet early prospective recreational needs. Accordingly, the recreational development included in the plan is that required to achieve 15% of the full potential of the added water area. On this basis, about 50% of the project cost would be allocated to the recreation purpose. Development to meet future recreational demands not satisfied by expansion in the private and private commercial sectors would be accomplished as required. A number of existing cost-sharing programs could be applied to such development.

(3) Project description. Pertinent data for the proposed reservoir are shown on table 25. Enlargement of the reservoir would be accomplished by raising the 2,400-foot long, uncontrolled spillway of the replacement dam to elevation 172.5. Construction of one bridge and modification of one bridge and about 450 oil well structures in the lake would be required.

The project would include provisions for developing two public-use sites on the shores of the lake to satisfy the future recreation needs. A fishing platform and parking area at the outlet works also would be included.

Enlargement of the existing lake would result in the inundation and destruction of valuable wildlife habitat. To mitigate the resulting loss, a total of 990 acres would be acquired, in two sites, as parts of two greentree reservoir developments. The two developments would provide for mitigation

of project occasioned losses in connection with the enlargement of Caddo Lake, the Titus County Reservoir, and the navigation and bank stabilization project. The first development would be in the Sulphur River bottom lands in Texas just below the existing Texarkana Dam. This development would include a total of 2,000 acres, of which 920 acres would be acquired to mitigate the losses in Texas attributable to the enlargement of Caddo Lake. The second development would be located as an extension of the Soda Lake Game Management Area, immediately downstream from the Caddo Dam. This development of 530 acres would include 70 acres for mitigation of losses in Louisiana attributable to the enlargement of Caddo Lake. The two developments are proximate to the areas in which the project occasioned losses could occur, and would provide a higher degree of mitigation at a lower cost than would three independent developments.

The total lands required for the project amount to 21,590 acres, including 600 acres for recreational development, and the aforementioned 990 acres for mitigation.

(4) Benefits. The project would provide annual benefits of $714,300, consisting of $339,300 for water supply, $240,000 for recreation, and $135,000 for fish and wildlife enhancement.

(5) Costs. The total estimated first cost of the improvements is $10,500,000. The annual charges for interest and amortization, operation and maintenance, major replacements, economic losses on lands, and engineering studies are estimated to be $492,500.

(6) Summary of benefits and costs. With annual benefits of $714,300 and annual costs of $492,500, the benefit-cost ratio of the proposed project is 1.5.

TABLE 25

CADDO LAKE ENLARGEMENT
PERTINENT DATA

GENERAL	
Stream	Twelvemile Bayou
River mile	23.8
Drainage area, square miles	2,700
ELEVATION, FEET, m.s.l.	
Top of dam	176.0
Top of conservation pool	172.5
STORAGE (ADDITIONAL), ACRE-FEET	
Conservation	183,000
AREA, ACRES	35,600
SPILLWAY	
Location	Existing
Type	Uncontrolled
Width, feet	2,400
Crest elevation	172.5
WATER SUPPLY YIELD, m.g.d.	107

k. Bayou Dorcheat Reservoir.

(1) Basin description. Bayou Dorcheat rises in Nevada County, Arkansas, and flows about 47 miles in a southerly direction to empty into Lake Bistineau. Loggy Bayou is the outlet for Lake Bistineau and flows 17 miles south to enter the Red River through the left descending bank at mile 237. Between the lake and Red River, flows from the Bayou Bodcau system enter Loggy Bayou. The Bayou Dorcheat Basin is composed of alluvial bottom lands flanked by rolling hills. The major urban areas of the basin are Magnolia, Arkansas, and Minden, Louisiana. Most of the agricultural land in the basin is devoted to native pasture.

(2) Project formulation.

Water and related land resource needs in the Bayou Dorcheat Basin include flood control, municipal and industrial water supply, water quality control, recreation, and fish and

wildlife. Preliminary studies indicated that no single-purpose flood control projects on the main stem of Bayou Dorcheat were economically justified. Further studies demonstrated that inclusion of flood control storage in major multiple-purpose reservoirs also lacked economic justification. Upstream watershed improvements were, however, found justified in the Big Creek Tributary Watershed, and the early-action plan for that watershed includes nine upstream reservoirs. Space included in certain of these reservoirs will provide yields of 8.9 m.g.d. and 3.8 m.g.d., respectively, for municipal and industrial water supply, and water quality control.

The estimated 2080 municipal and industrial water supply needs for the Dorcheat Basin, above those which would be met from storage to be provided in upstream reservoirs are 40.3 m.g.d. for Columbia County, Arkansas, and 23.8 m.g.d. for Webster Parish, Louisiana. In addition to these needs, it is estimated that, based on the current level of treatment technology, a yield of 16.7 m.g.d., in addition to the yield of storage to be included in upstream reservoirs, would be required to meet 2080 needs for supplemental flows. In addition to these needs, an immediate need exists in the adjacent Bayou Bodcau Basin for a yield of 19.4 m.g.d. for supplemental flow on that stream below the Arkansas-Louisiana State line. This need is not expected to increase in the future. Favorable reservoir sites which might supply this latter need are lacking in the Bayou Bodcau Basin, necessitating consideration of transfer of water from the Bayou Dorcheat Basin. Surface impoundment in a major reservoir is the only practicable means of providing additional water supply of the magnitude described above. Numerous reservoir sites on Bayou Dorcheat both above and below Magnolia, Arkansas, were investigated. Developed to its full potential, a reservoir with a dam at mile 105 would yield 80 m.g.d. in the worst drought of record. This yield would meet all foreseeable needs for water quality control in the Bayou Bodcau Basin, and, in addition, would meet all municipal and industrial and water quality control needs in the Bayou Dorcheat Basin through the year 2060. By that year, advances in treatment technology may well have operated to reduce supplemental flow requirements, thus permitting the transfer of space from water quality control use to use for municipal and industrial water supply, if this should be desirable. An additional yield of about 20 m.g.d. could be obtained by shifting the damsite downstream to a point just below the mouth of Big Creek. Such action would, however, destroy the valuable potential for upstream watershed development in the Big Creek watershed and is clearly undesirable.

The Dorcheat Reservoir would be located in an area with a severe shortage of the types of outdoor recreational opportunities which reservoir development provides. By 1980, the demand in the general area could absorb about 50% of the maximum potential of the Dorcheat Reservoir. It is proposed to develop the reservoir to meet this demand. Such development would result in approximately 50% of the project costs being allocated to the recreation purpose. Additional demand could be provided for by future development as determined by the growth in demand. A number of existing cost sharing programs might be applicable to such development. Construction of the reservoir would damage valuable wildlife habitat. To mitigate the resulting loss, 1,660 acres of land would be acquired as part of a 2,000-acre greentree reservoir development in the Sulphur River bottoms in Arkansas. This development would provide mitigation for damages resulting from construction of the navigation and bank stabilization project in Arkansas. The development is located proximate to the areas in which the project-occasioned damages would occur, and will provide a higher degree of mitigation, at a lower cost, than would two separate developments.

(3) Description of project. Pertinent data on the Bayou Dorcheat Reservoir are given in table 26. The proposed reservoir area is shown on figure 15. The earth dam would rise 50 feet above the valley floor and be about 8,500 feet long. The spillway would consist of a concrete ogee weir with a crest elevation of 237.0. Six tainter gates, each 40 feet wide and 22 feet high, would control flows over the weir. A 7-foot conduit, with an invert elevation of 215.0, along with a stilling basin and the necessary inlet and discharge channel, would function to release flows into Bayou Dorcheat. Eight public-use sites are included in the plan. Seven of these would be located on the shores of the lake and one below the dam at the outlet works. To insure ready access to fishing areas in the lake about 50 percent of the area of the conservation pool would be cleared. Construction of the dam and reservoir would require raising one railroad and one highway bridge, constructing 8 new highway bridges, raising about 3.7 miles of roads, and modifying 30 oil wells and 20,000 feet of powerlines.

Works necessary to convey the water quality control flows to the Bayou Bodcau Basin consist of a 60-c.f.s. pumping plant, 1,700 linear feet of 36-inch concrete pipe, 25,000 linear feet of transmission channel, and the modification of three bridges, two culverts, and one siphon. The proposed plan is shown on figure 12.

TABLE 26

BAYOU DORCHEAT RESERVOIR
PERTINENT DATA

GENERAL	
Stream	Bayou Dorcheat
Drainage area, square miles	239
ELEVATION, FEET, M.S.L.	
Top of dam	265.0
Top of conservation pool	257.0
Top of inactive pool	221.4
Top of surcharge pool	259.0
STORAGE, ACRE-FEET	
Conservation	285,200
Inactive	6,800
AREA, ACRES	
Top of conservation pool	18,000
SPILLWAY	
Type	Tainter gated ogee weir
Number and size of gates (feet)	6 (40 x 22)
Elevation, crest of weir	237.0
WATER SUPPLY AND WATER QUALITY CONTROL YIELD, M.G.D.	80

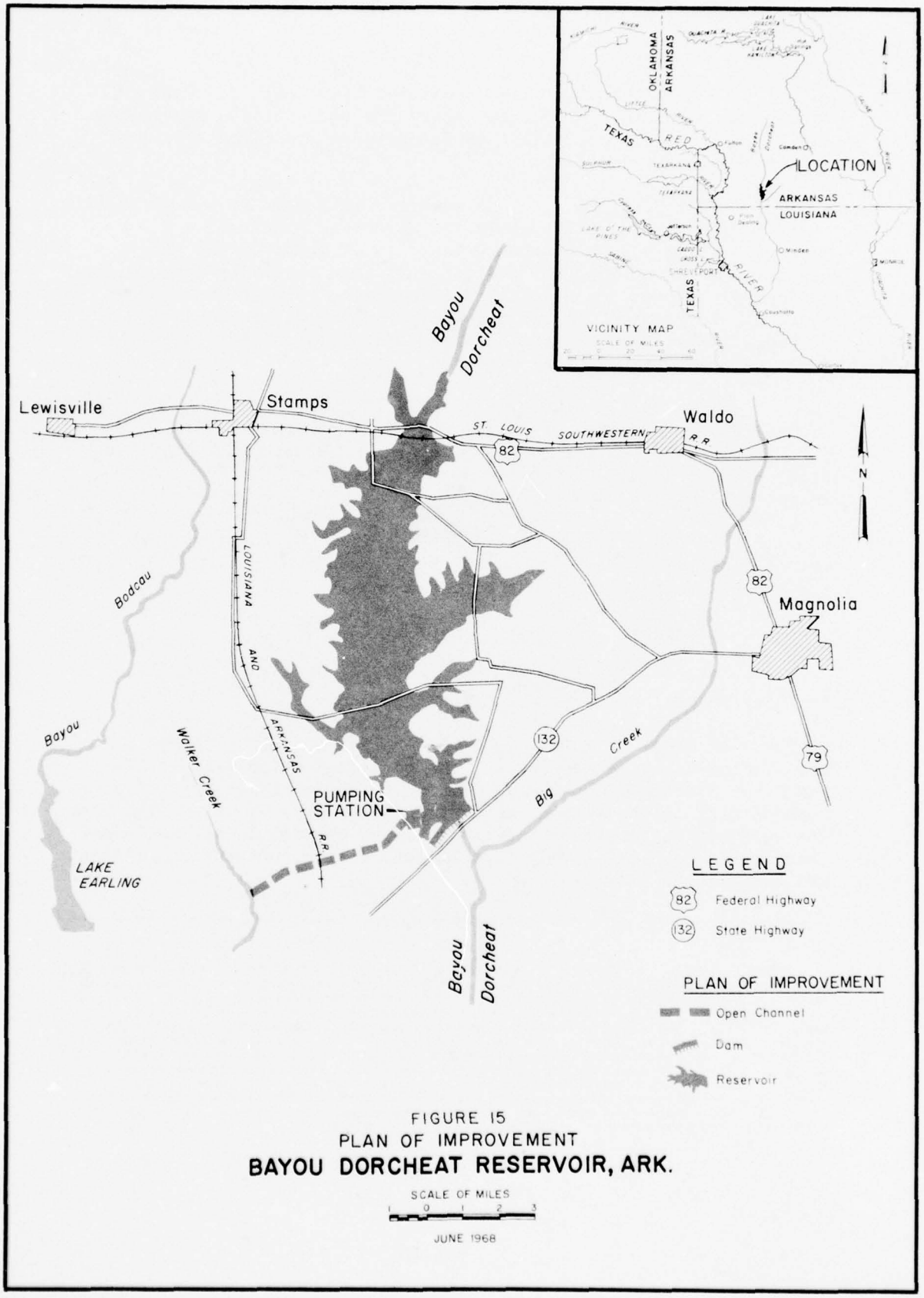

FIGURE 15

PLAN OF IMPROVEMENT

BAYOU DORCHEAT RESERVOIR, ARK.

SCALE OF MILES

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A total of 22,960 acres of land would be required for the project, including 1,800 acres for recreational development and 1,660 acres for mitigation of project-occasioned damages to fish and wildlife habitat.

(4) Benefits. [1] The project would provide annual benefits of $2,783,000. The water supply for Magnolia, Arkansas, and Minden, Louisiana, would produce benefits of $499,000 per year. Annual benefits of $509,000 would result from improving the quality of Bayous Dorcheat and Bodcau. The increased recreational opportunities afforded by the project would yield benefits amounting to $1,650,000 annually, while fish and wildlife enhancement benefits would be about $125,000 per year.

(5) Costs. The total estimated first cost of the project, including the recreation facilities and the conveyance works, is $27,100,000. The estimated annual charges for interest, amortization, operation, maintenance, major replacements, and economic losses on lands are $1,546,500.

(6) Summary of costs and benefits. Based on average annual benefits of $2,783,000 and average annual costs of $1,546,500, the benefit-cost ratio of the proposed project is 1.8.

1. Kisatchie Reservoir.

(1) Basin description. The Kisatchie Bayou-Cane River Basin extends along the right descending bank of Red River from the city of Natchitoches to the hills opposite Colfax, a river distance of about 40 miles. The western portion of the basin is hilly with elevations up to 400; the eastern portion lies in the Red River flood plain and is generally below elevation 100. The largest city in the area is Natchitoches, Louisiana, which lies near the northern extremity of the basin. Most streams in the basin are characterized by relatively flat slopes, follow tortuous courses and are sluggish in flow.

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[1] The Department of the Interior has recently altered its policy for computing water quality control benefits. The Secretary has directed the Federal Water Pollution Control Administration and other Interior agencies to develop benefits based on more direct methods than alternative costs, in instances where it is considered practicable. Guidelines state that new methods should be directed toward specific use of the streams. Benefits would accrue from increased usage of the clean stream as compared to the use of the polluted stream. These benefits have been determined for the inclusive use of the stream for recreation and fish and wildlife purposes and amount to $222,100. The benefits were developed by the Bureau of Outdoor Recreation and the Bureau of Sport Fisheries and Wildlife, in cooperation with the Federal Water Pollution Control Administration. It is evident that the entire approach to the evaluation of storage for streamflow regulation, both as to needs and benefits, is in a period of continuing change. Under the circumstances, it was considered proper in this report to utilize the least-costly alternative method of evaluating water quality control benefits.

(2) Project formulation. Water and related resource development needs in the basin include irrigation, municipal and industrial water supply, flood control, recreation, and fish and wildlife. Several alternative methods for satisfying the flood control needs were considered. These included channel improvement and single- and multiple-purpose reservoirs. None of the single-purpose solutions were found to be economically justified. Since the other water resource needs could be satisfied from surface impoundments, multiple-purpose reservoirs at various locations were studied. It was determined that, ideally, the reservoir should contain sufficient storage to yield 52 m.g.d. of municipal and industrial water supply for the city of Natchitoches, and 34 m.g.d. for irrigation, and provide the maximum practicable flood control. Preliminary studies narrowed the list of possible damsites to those at miles 3.7, 5.7, and 8.3. Further studies showed that the site at mile 3.7 could be eliminated from further investigation because of economic considerations and that the site at mile 8.3 could be eliminated because storage characteristics at that location are not as favorable as those at mile 5.7. Since the site at mile 5.7 could furnish the required yields more economically than any of the others, it was selected for detailed study. These studies showed that a flood control pool at elevation 143.5 would provide protection from a flood having a recurrence interval of once in 40 years. Topographical conditions at the selected site dictate the use of a natural saddle spillway at about elevation 147.5 which is 4 feet above the top of the flood control pool and would preclude spillway operation except at very infrequent intervals. Lowering the amount of flood control storage was considered. It was found that only a small savings in cost would be realized at a great sacrifice in benefits. The reservoir, with the spillway at elevation 147.5, would develop the full water supply yield of the site. It would contain 170,000 acre-feet of flood control storage, 119,000 acre-feet for conservation, and 8,000 acre-feet of inactive storage. The recommended plan would protect downstream areas from a flood with a return frequency of once in 40 years, and yield 52 m.g.d. for municipal and industrial water supply and 34 m.g.d. for irrigation. The conservation pool area of 9,200 acres could, if fully developed, support 1,770,000 man-days of general recreation per year, and the demand, in 1990, would be sufficient to utilize this capacity. It is proposed, however, to limit the recreational development to the scope which would result in approximately one-half of the total allocation to all project purposes being assigned to recreation. Under this limitation, the recreational development would be about 65% of the full potential. Depending upon further growth in the demand, additional development could be provided under a number of current programs. Construction of the reservoir would result in the inundation of valuable wildlife

habitat. To mitigate this loss, the acquisition of 1,000 acres of land adjacent to the reservoir is proposed for inclusion in the project. This land would be developed and operated as a game management area and would provide opportunities for hunting waterfowl, squirrel, deer, and other upland game.

(3) Description of project. Pertinent data for the proposed Kisatchie Reservoir are shown on table 27. The proposed reservoir is shown on figure 16. The dam would consist of an earth embankment about 28,500 feet long, rising some 71 feet above the streambed. The broad-crested spillway would have a crest elevation of 147.5 and a length of about 7,000 feet. The outlet works would consist of two gated culverts, each 7.5 feet in diameter, approach and discharge channels, and a stilling basin. A 170-c.f.s. pumping plant and about 1,000 feet of 48-inch pipe are included to convey the irrigation releases to the Cane River Lake Area. Six public-use areas would be included for recreational use of the land and water areas. Construction of three new bridges and modifications of two existing bridges, 2 miles of State roads, and one 20-inch pipeline would be required. A total of 21,100 acres of land would be required for the project, including 900 acres for recreation and 1,000 acres for mitigating project-induced wildlife damages.

(4) Benefits. Reduction of flooding below the dam would result in average annual benefits of $502,000 for flood control. The conservation storage would provide $235,000 for irrigation benefits and $332,000 of municipal and industrial water supply benefits annually. The increase in water-oriented recreational opportunities would produce $1,450,000 in benefits per year, while annual fish and wildlife enhancement benefits would be $175,000. The total average annual benefits that would accrue to the project are $2,694,000.

(5) Costs. The first cost of constructing the plan would be $20,500,000. The annual charges, including interest and amortization, operation and maintenance, major replacements, economic loss on lands, and engineering studies would be $1,321,100.

(6) Summary of costs and benefits. The average annual benefits of $2,694,000 and average annual cost of $1,321,100 would yield a benefit-cost ratio of 2.0.

m. Summary of costs and benefits. The first cost, annual charges, annual benefits, and benefit-cost ratio of all major reservoirs included in the early-action plan are shown on table 28. Data on allocation of costs and benefits are summarized on table 29, page XV-132.

TABLE 27

KISATCHIE RESERVOIR

PERTINENT DATA

GENERAL	
Stream	Kisatchie Bayou
River mile	5.7
Drainage area, square miles	277
ELEVATION, FEET, m.s.l.	
Top of dam	158.5
Top of surcharge pool	152.1
Top of flood control pool	143.5
Top of conservation pool	129.8
STORAGE, ACRE-FEET	
Flood control	170,000
Conservation	119,000
Inactive	8,000
AREA, ACRES	
Top of flood control pool	14,750
Top of conservation pool	9,200
SPILLWAY	
Type	Broad crested
Width, feet	7,000
Crest elevation, feet, m.s.l.	147.5
Frequency of operation	100 years
Discharge at maximum pool, c.f.s.	126,000
FLOOD CONTROL OUTLET WORKS	
Type	Gated conduit
Size	2-7.5-foot diameter
CONSERVATION YIELD, m.g.d.	
Water supply	52
Irrigation	34
Total	86

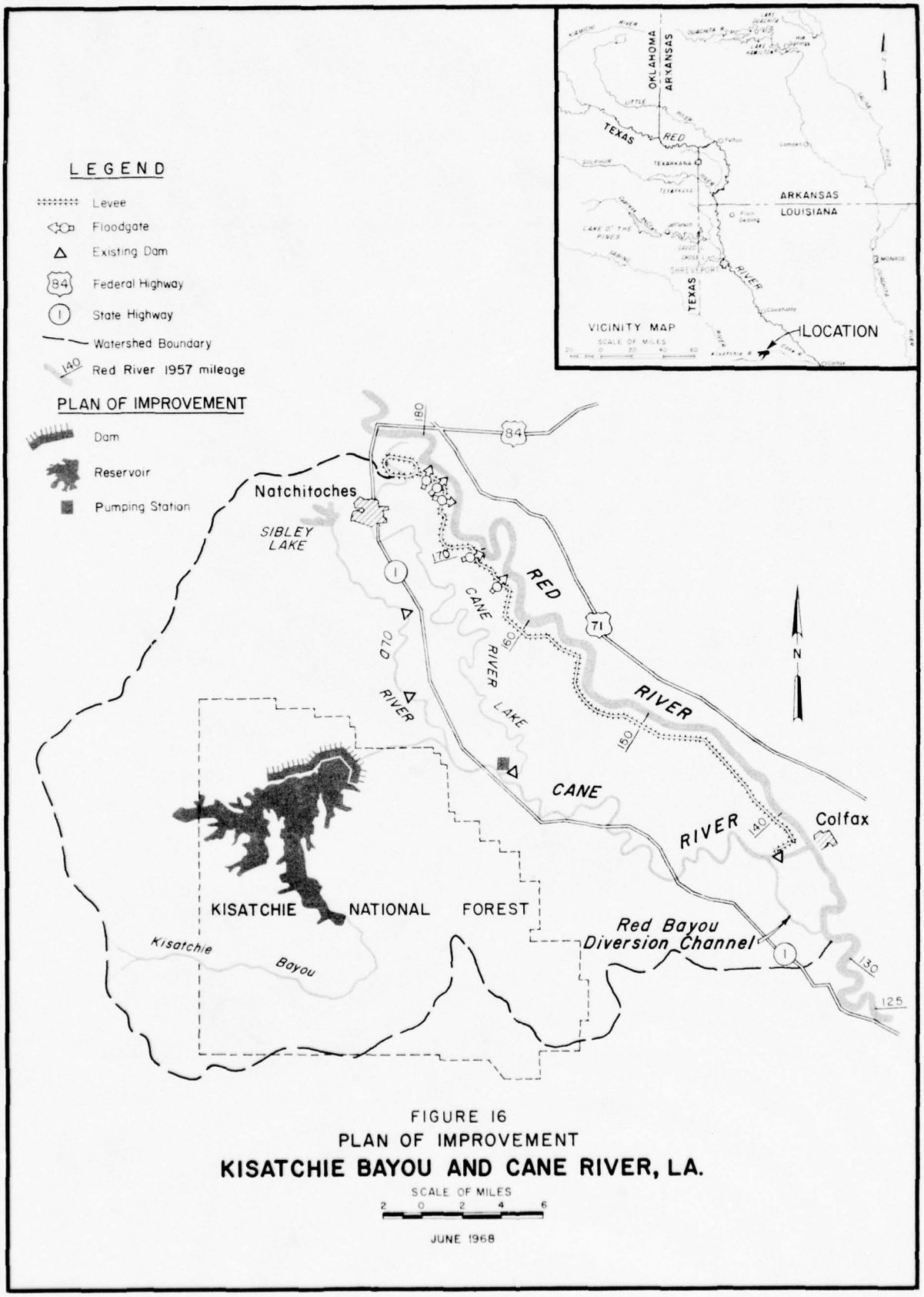

FIGURE 16

PLAN OF IMPROVEMENT

KISATCHIE BAYOU AND CANE RIVER, LA.

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TABLE 28

MAJOR RESERVOIR IMPROVEMENTS IN EARLY-ACTION PLAN
ECONOMIC SUMMARY

Project	Project Total Cost (1000's) $	Total Annual Charges (1000's) $	Total Annual Benefits (1000's) $	Benefit/ Cost Ratio
Albany Reservoir	11,000.0	486.3	656.7	1.4
Durant Reservoir	20,100 0	869.3	1,161.4	1.3
Bonham Reservoir	14,200.0	612.3	845.2	1.4
Parker Reservoir	9,930.0	476.9	982.8	2.1
Tuskahoma Pumped Storage Project	108,700.0	8,174.4	17,996.0	2.2
Sherwood Res.	154,400.0	8,884.9	14,163.1	1.6
Liberty Hill Res.	14,200.0	599.7	688.2	1.1
McGee Creek Res.	15,600.0	682.0	733.0	1.1
Titus County Res.	23,100.0	1,116.0	1,735.0	1.6
Caddo Lake Enlgt.	10,500.0	492.5	714.3	1.5
Bayou Dorcheat Res.	27,100.0	1,546.5	2,783.0	1.8
Kisatchie Res.	20,500.0	1,321.1	2,694.0	2.0

40. IMPROVEMENTS FOR LOCAL FLOOD PROTECTION

a. Days Creek.

(1) Basin description. The Days Creek Watershed is located in southwestern Arkansas and northeastern Texas and includes the cities of Texarkana, Arkansas, and Texas. The watershed covers an area of 101 square miles, and is characterized by a narrow valley extending through rolling to hilly uplands. Elevations in the watershed vary from about 400 in the north to about 200 in the valley in the south. Days Creek rises within the Texarkana city limits at the confluence of Nix and Swampoodle Creeks. The watershed above this point totals some 10,900 acres, practically all of which is urban. Days Creek runs in a southerly direction about 1 mile where it is joined by the right descending bank tributary, Wagner Creek, which contributes runoff from an urban area of some 15,100 acres. A mile below this point Days Creek is joined by Howard Creek (right bank) and a smaller unnamed Creek (left bank). These two creeks drain an area of about 4,900 acres. Days Creek continues in a southeasterly direction some 17 miles to a confluence with the Sulphur River. In this reach Days Creek is joined by a number of left bank tributaries: Rocky Creek at mile 14.3; Hooker Branch at

TABLE 29

ALLOCATION SUMMARY - MAJOR RESERVOIR PROJECTS IN EARLY-ACTION PLAN(1)

Project and Purpose	Allocable First Cost ($1,000)	Total Annual Charges ($1,000)	Total Annual Benefits ($1,000)	Benefit-Cost Ratio
Albany Reservoir (200)(1)				
Flood Control	1,131.0	62.3	95.7	1.5
Water Supply	4,941.0	198.5	262.0	1.3
Recreation	4,581.0	219.5	290.5	1.3
Fish & Wildlife	147.0	6.0	9.0	1.5
Total	10,800.0(1)	486.3	656.7	1.4
Durant Reservoir (400)(1)				
Flood Control	6,069.0	270.0	373.8	1.4
Water Supply	4,234.0	187.1	275.4	1.5
Recreation	9,120.0	399.5	493.2	1.2
Fish & Wildlife	277.0	12.4	19.0	1.5
Total	19,700.0(1)	869.0	1,161.4	1.3
Parker Reservoir (180)(1)				
Flood Control	2,122.0	106.5	153.8	1.4
Water Supply	2,935.0	130.1	245.0	1.9
Recreation	4,556.0	233.8	571.0	2.4
Fish & Wildlife	137.0	6.5	13.0	2.0
Total	9,750.0(1)	476.9	982.8	2.0
Tuskahoma Pumped Storage Project				
Hydropower	108,700.0	8,174.4	17,996.9	2.2
Sherwood Reservoir - Broken Bow Mod. (200)(1)(2)				
Flood Control	4,816.0	214.2	509.6	2.4
Hydropower	127,618.0	7,680.5	14,127.2	1.8
Water Supply	3,369.0	126.2	163.2	1.3
Water Quality	4,359.0	168.3	185.0	1.1
Recreation	52,619.0	2,399.4	2,601.0	1.1
Fish & Wildlife	1,019.0	39.8	44.0	1.1
Total	193,800.0	10,628.4	17,630.0	1.7
Bonham Reservoir (300)(1)				
Flood Control	3,248.0	145.8	201.5	1.4
Water Supply	6,596.0	272.1	378.7	1.4
Recreation	3,910.0	188.3	251.0	1.3
Fish & Wildlife	146.0	6.1	9.0	1.5
Total	13,900.0(1)	612.3	840.2	1.4
Liberty Hill Reservoir (243)(1)				
Water Supply	7,869.0	319.3	361.2	1.1
Recreation	5,826.0	269.5	308.0	1.1
Fish & Wildlife	262.0	10.9	13.0	1.2
Total	13,957.0	599.7	682.2	1.1
McGee Creek Reservoir	Allocation data not available [see page XV-109, paragraph 39.h.(2)]			
Titus County Reservoir				
Water Supply	13,900.0	561.5	871.0	1.6
Recreation, Fish and Wildlife	9,200.0	475.5	864.0	1.8
Economic Loss	-	79.0	-	-
Total	23,100.0	1,116.0	1,735.0	1.6
Caddo Lake Enlargement				
Water Supply	5,630.0	194.3	339.3	1.7
Recreation, Fish and Wildlife	4,870.0	194.2	375.0	1.9
Economic Loss	-	104.0	-	-
Total	10,500.0	492.5	714.3	1.5
Dorcheat Reservoir				
Water Supply	10,500.0	433.7	499.0	1.2
Water Quality	9,500.0	417.0	509.0	1.2
Recreation, Fish & Wildlife	7,100.0	621.8	1,775.0	2.9
Economic Loss	-	74.0	-	-
Total	27,100.0	1,546.5	2,783.0	1.8
Kisatchie Reservoir				
Flood Control	6,830.0	278.2	502.0	1.8
Water Supply	3,440.0	147.2	332.0	2.3
Irrigation	2,730.0	198.8	235.0	1.2
Recreation, Fish and Wildlife	7,500.0	596.9	1,625.0	2.7
Economic Loss	-	100.0	-	-
Total	20,500.0	1,321.1	2,694.0	2.0

(1)Amount, in thousands of dollars, excluded for relocation of roads above replacement in kind standards.

(2)Sherwood and Broken Bow Reservoirs would operate as a system, separate cost allocations were not considered appropriate. The Sherwood-Broken Bow Modifications were added to the cost of Broken Bow Reservoir and the total allocable cost of $193,800,000 was allocated to each project purpose by the SCRB method.

mile 11.0; Fourmile Creek at mile 8.7; Caney Branch at mile 7.6; Spring Branch at mile 5.5; and Boggy Creek at mile 4.5. The areas drained by these tributaries are practically all rural.

(2) Project formulation.

(a) Under present conditions, urban lands in the lower limits of the cities of Texarkana, and rural lands downstream from the cities totaling 5,700 acres are subject to periodic flooding and consequent damage. Days Creek serves as the main outlet for five tributary creeks: Howard, Wagner, Cowhorn, Swampoodle, and Nix, which collect runoff from the cities of Texarkana. These creeks are crossed at more than 50 locations by streets, railroads, and various utilities, many of which provide only restricted openings for flood flows. The problem has been aggravated by increased runoff produced by the growth of the urban area. The cities have increased 73 percent in size between 1940 and 1960 and are expected to double between 1960 and 1990. The average annual flood damage is estimated to be $65,100, all of which is urban damage.

(b) Preliminary studies indicated that suitable upstream reservoir sites do not exist in the area, and solutions involving levees and/or floodwalls are not practicable by reason of the pattern of existing development. Alternative solutions investigated were limited to enlargement, in varying degrees, of Days Creek below the city, in combination with tributary and other drainage improvements within the city. The plan of improvements best suited to the needs of the area consists of extensive improvement of the city drainage system and enlargement of Days Creek from mile 7.6 to mile 18.6. The enlarged channel would be capable of conveying, without serious overflow, the peak flows generated by a 25-year frequency storm centered over the urban area.

(3) Description of project. The plan of improvement consists of two major elements as shown on figure 17, and described as follows:

(a) Extensive improvement of city drainage system including enlarging and paving the channels of Nix, Swampoodle, Cowhorn, Wagner, and Howard Creeks, and modification of the many railroad, street, and utility crossings to provide adequate openings.

(b) Enlargement of Days Creek from mile 7.6 to mile 18.6. Depths of the enlarged channel would vary from 18.5 feet at mile 7.6 to 17 feet at mile 18.6. The bottom width would vary from 80 feet at mile 7.6 to 110 feet at mile 18.6. The sides of the enlarged channel would be sloped 1 vertical to 3 horizontal.

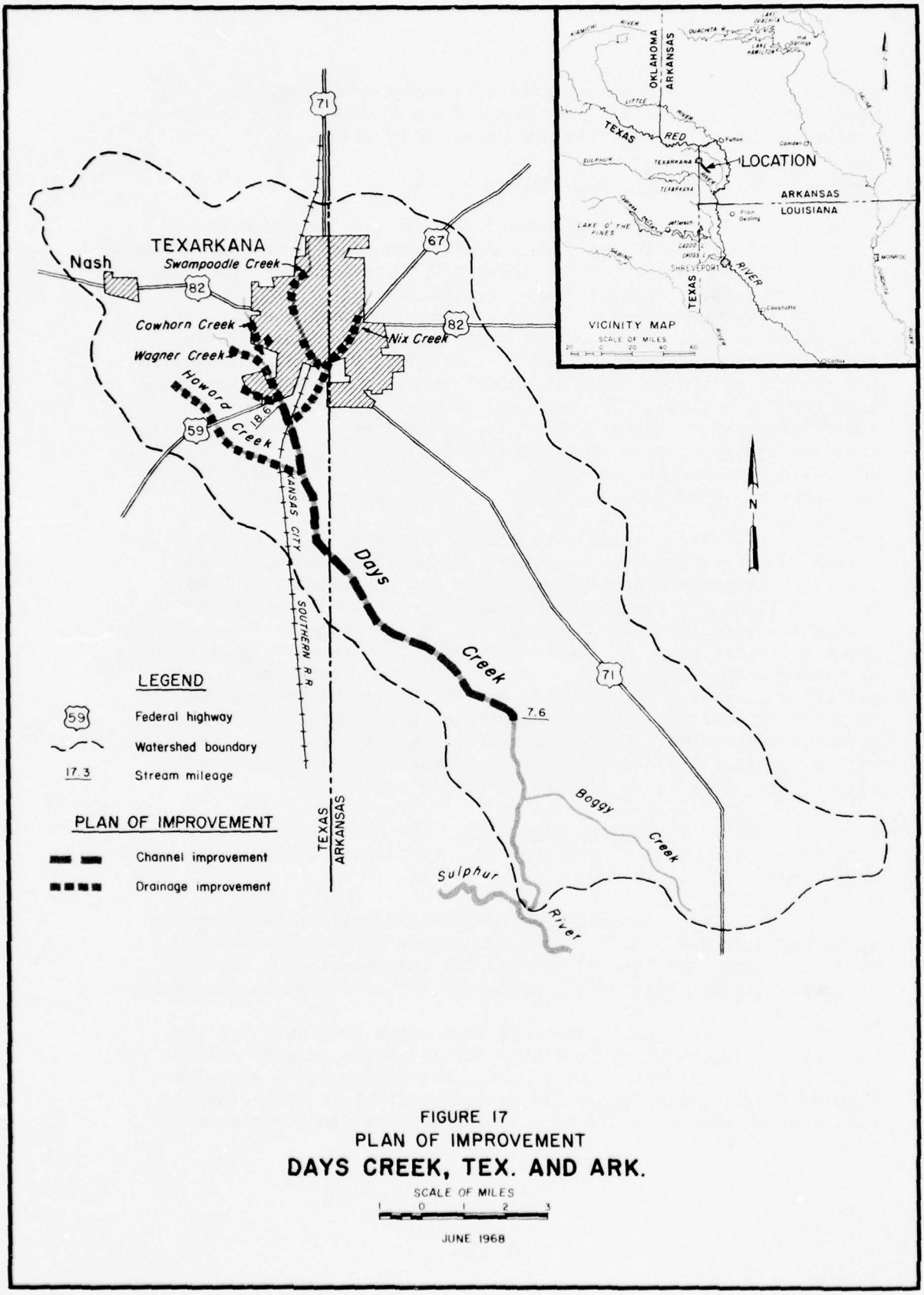

FIGURE 17

PLAN OF IMPROVEMENT

DAYS CREEK, TEX. AND ARK.

SCALE OF MILES

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(4) Benefits and costs. Construction of channel improvements along Days Creek and its tributaries: Nix, Swampoodle, Cowhorn, Wager, and Howard Creeks would effectively reduce flood stages on approximately 3,700 acres, including improvements within and adjacent to the Texarkana cities limits, resulting in average annual benefits of $56,700. Enhancements on an estimated 1,100 acres of commercial and industrial land plus 1,070 acres of residential will amount to $213,600 annually. Total benefits are $270,300. The estimated first cost of the improvements, including the drainage improvements within the cities and channel enlargement on Days Creek, is $5,580,000. The total annual charge would be $252,000, including maintenance and operation. Comparison of total annual benefits of $270,300 with annual cost of $252,000 indicates a benefit-cost ratio of 1.1.

b. McKinney Bayou.

(1) Basin description. The McKinney Bayou watershed is located in southwestern Arkansas and northeastern Texas in the vicinity of Texarkana, Arkansas, and Texas. The crescent-shaped watershed, with a total area of 360 square miles, is adjacent to the Red River and comprises 66 percent alluvial lands of the Red River flood plain and 34 percent hilly uplands (see Fig. 18). McKinney Bayou rises in Texas about 5 miles northwest of Texarkana. The meandering channel runs eastward along the toe of the foothills for several miles to enter Arkansas. In Arkansas, the bayou changes course to a southeasterly direction and proceeds some 20 miles to a junction with Red Chute Bayou. McKinney Bayou then flows south some 22 miles to enter the Red River at mile 339 (1957). The area is protected from direct overflow from Red River by a levee on the right descending bank of the river, which is a feature of the project "Red River below Denison Dam, Okla., Tex., Ark., and La." Runoff from within the watershed area enters McKinney Bayou through numerous hill tributaries on the right descending bank; from a meandering, poorly defined system of natural channels within the Red River bottom lands above Red Chute Bayou; and, through gated culverts, from two leveed drainage districts below Red Chute Bayou. The natural streams within the alluvial plain are characterized by tortuous alignments, relatively flat slopes, and sluggish flow.

(2) Existing and authorized Federal projects. The Flood Control Act of 1955 authorized the construction of improvements for flood control in the McKinney Bayou area consisting of channel improvement and realignment of McKinney Bayou from its junction with Red River at mile 386 (1938) to the headwaters, a distance of about 47 miles; minor repair of an existing levee on the left descending bank of McKinney Bayou from Red River to about mile 13.5 of McKinney Bayou; construction of a new levee on the left descending bank of McKinney Bayou from mile 13.5 to Red Chute Bayou; construction of a

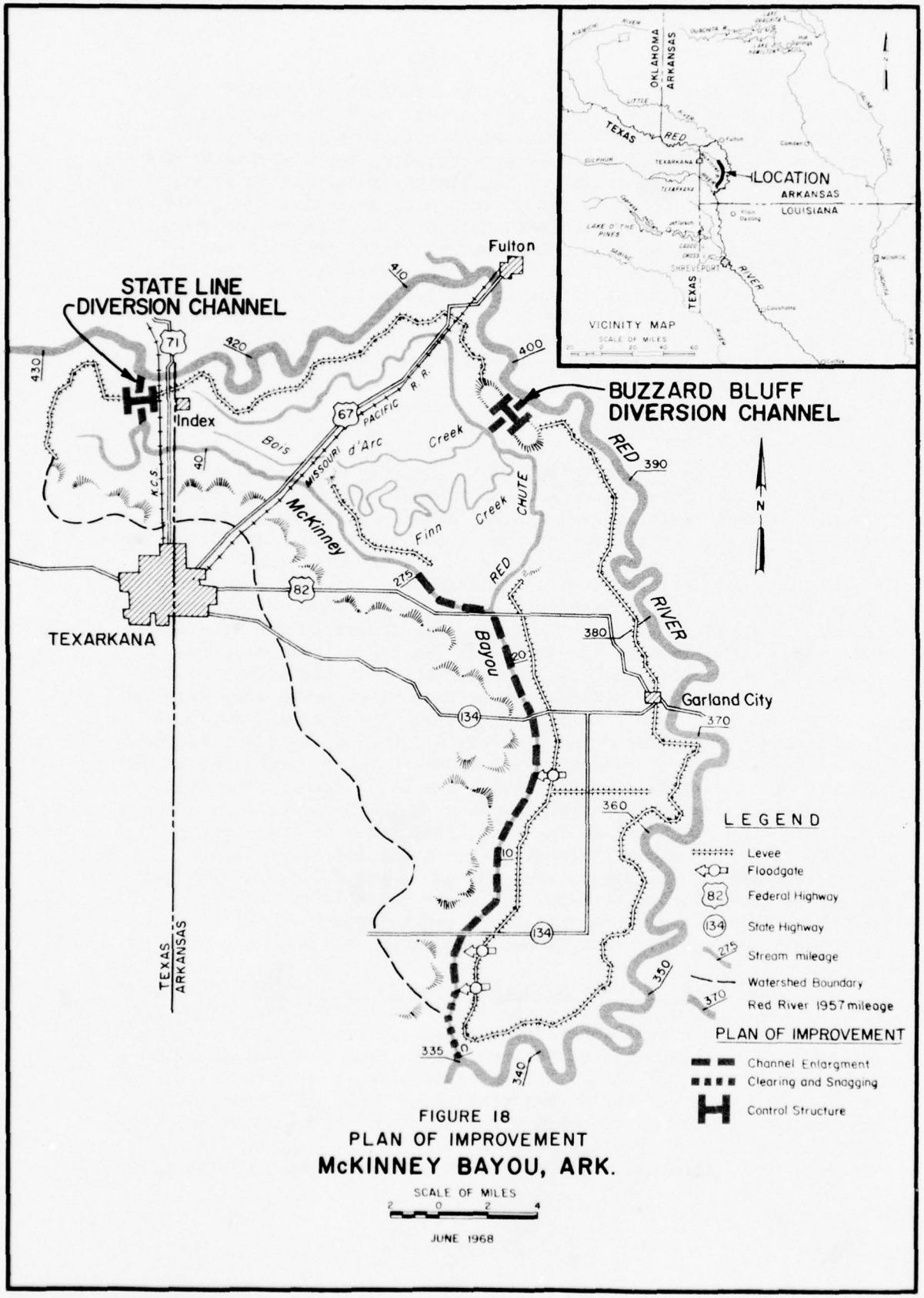


FIGURE 18
PLAN OF IMPROVEMENT
McKINNEY BAYOU, ARK.

new levee on the left descending bank of McKinney Bayou from mile 27.5 to a point about 2 miles below the Arkansas-Texas State line; and a gated drainage structure in the levee at mile 13.5 of McKinney Bayou. In the detailed planning of the project it was found that levee work would not be required above mile 33.7 and this work was deleted from the project. All work located in Texas was deleted from the project as a result of the failure of local interests to provide the required assurances of local cooperation within the statutory time limit. The project, as modified above, was completed in July 1961.

The Flood Control Act of 1960 provided for further improvement in the McKinney Bayou area, consisting of about 8.6 miles of new channel construction to provide an improved outlet to McKinney Bayou for the Finn Bayou and Bois d'Arc Creek (Ark.) areas, and additional new levee construction with appurtenant drainage structures between Red Chute Bayou and mile 27.5 of McKinney Bayou. Local interests objected to the plan of improvement and requested that the authorized project be classified as inactive. The Chief of Engineers so classified the project on October 27, 1964.

(3) Project formulation.

(a) The principal flood problem in the watershed is associated with headwater overflow. Some 69,000 acres of Red River bottom lands in Texas and Arkansas, 41,600 acres of which are cleared, are subject to damage. An additional 11,000 acres, 9,000 acres of which are cleared, are without adequate drainage. The existing Federal levee system along Red River and the local backwater levee along McKinney Bayou protect the entire area from Red River overflow. The existing Federal flood control project on McKinney Bayou offers partial protection to an estimated 17,400 acres of cleared lands.

The watershed is divided into six distinct subareas by manmade and natural barriers. Starting at the mouth of McKinney Bayou, the first area, the McKinney Bayou Drainage District, is located on the left descending bank of the bayou, and extends to mile 13.5. Federal and local levees inclose this area, which drains into McKinney Bayou through floodgates located at about miles 2.4 and 4.5. Problems in the area are caused by inadequate interior drainage. Damages are experienced on 17,500 acres of land, of which 11,700 acres are cleared.

The second area is just north of the first and due west of Garland City, Arkansas. Inclosed on the east, west, and south sides by levees, and the Red Chute Bayou on the north, the area is drained by a floodgate consisting of five 6-foot diameter corrugated metal pipe culverts equipped with flap gates. The floodgate is located in the southwest corner of the area and discharges into

McKinney Bayou at mile 13.5. During periods of heavy rainfall, high stages in McKinney Bayou prevent outflow from the protected area, and runoff is ponded until receding stages in the bayou permit the evacuation of stored water through the floodgate. An area of 16,600 acres, including 9,700 acres which are cleared, is subject to flooding.

The third area is located between Red Chute and Finn Bayous and the hill line on the south. The unleveed reach of McKinney Bayou in this area was not enlarged under the existing project and, during most storms of consequence, overflow of the lowlands upstream of Red Chute Bayou occurs. Some 5,900 acres, 4,300 of which are cleared, experienced frequent flooding.

The fourth area is bounded by Finn Bayou, the Arkansas-Texas State line, and Red River. The outlet for drainage of this area is poorly defined. Runoff which collects in the area moves slowly south through the upper reach of Red Chute, thence down through local drainage ditches, low areas, and old lakes, to flow finally into McKinney Bayou through the floodgate at mile 13.5. Approximately 19,300 acres of land experience flooding, of which 12,000 acres are cleared.

The fifth area is located upstream and west of Highway 71 and is entirely within the State of Texas. The unimproved channel of McKinney Bayou in this area cannot accommodate even moderate flood flows. Some 2,800 acres, 1,700 of which are cleared, experience flood problems.

The last area comprises the lands along McKinney Bayou between the bluff line on the right descending bank and the levees on the left descending bank, or the area called the "floodway." Some 6,900 acres within the floodway, including 2,200 acres of cleared land, are flooded frequently.

The average annual crop damages for the entire watershed are estimated to be $140,500. Noncrop damages are estimated at $44,400.

(b) Preliminary investigation clearly demonstrated that the flood problem was of a dual nature, resulting from inadequacy of the existing outlet, and the lack of a suitable interior drainage system. Thus, the solution of choice necessarily involved the establishment of an adequate system for interior drainage, and augmentation of the existing outlet capacity.

Solutions were considered for the first five problem areas described above. Specific improvements within the sixth or "floodway" area are clearly impracticable. Incidental benefits will be experienced in this area, however, as a result of the works provided.

In the first area, the floodgate and outlet to Red River are adequate, but the existing interior drainage system is not. The construction of a drainage plan recommended by the Soil Conservation Service would essentially correct the unsatisfactory conditions which now obtain in the area. This system consists of 33 miles of major drainage improvements.

Alternatives investigated for the second and third areas included a number of plans for enlargement of McKinney Bayou from mile 27.5 to Red River, both with and without enlargement of the existing floodgate at mile 13.5, combined with appropriate drainage improvements in the protected area. The improved channel would effect lowerings of 5 feet and 3 feet, respectively, in the 3-year stages, at mile 13.5 and mile 27.5.

As previously mentioned, local interests objected to the plan of improvement on which the authorized Federal project is based. This plan involved major drainage channels to convey runoff to the existing outlet via McKinney Bayou, combined with levees, to prevent the overflow of the lower lands. In view of this objection, the only acceptable alternative for solution of flood and drainage problems in the fourth area is to reroute the flow directly to Red River at Buzzard Bluff. Additional drainage improvements are required to insure proper functioning of such an outlet. The improvement works would essentially eliminate all overflow for floods occurring more frequently than once in 3 years.

In the fifth area, alternatives investigated included enlargement of the existing outlet via McKinney Bayou throughout its entire length, and provision of a new outlet to Red River just above the Arkansas-Texas State line. Interior drainage improvements are required to produce a viable plan under either alternative. The improvement works would essentially eliminate all overflow for floods occurring more frequently than once in 3 years.

As previously indicated, no specific plans for improving conditions in the floodway were studied; however, the alternatives considered for other areas would effect stage reductions within the floodway, and incidental benefits would be realized from such reductions.

In these evaluations, it was developed that flood damage reduction benefits were influenced by the improvements to a much lesser degree than the land enhancement benefits. Accordingly, features of the plan of improvement were sized to achieve the full land enhancement potential, and thus maximize the excess of benefits over costs.

(c) Wildlife losses attributable to features of McKinney Bayou amount to 700 man-days. These losses could be

mitigated by acquisition and development of an area as a green tree reservoir. Similar mitigation is required for another project included in the early-action plan - the Posten Bayou project. The two project areas very nearly abut one another, and a single greentree development will better serve the needs of both areas, at a lower total cost, than would two smaller developments. Accordingly, a single greentree development of 350 acres in the Sulphur River bottoms of Arkansas should be provided.

(4) Description of project. The plan of improvement consists of three major elements as shown on figure 18, and as described below. The purposes served by the project described herein would encompass all intended functions of the authorized project for the improvement of McKinney Bayou on which construction has not been initiated. That project would, accordingly, be deauthorized upon approval of the plan developed herein.

(a) Improvement of McKinney Bayou from Red River to mile 27.5. The first 2.2 miles of McKinney Bayou would be improved by clearing and snagging. From mile 2.2 up to mile 27.5, the channel would be enlarged. Depths would vary from 18 feet at mile 2.2 to 8 feet at mile 27.5, and bottom widths would vary from 40 feet at mile 2.2 to 95 feet at mile 27.5. In addition to the above improvement, some 54 miles of major drainage improvement, plus four floodflow retarding structures, formulated by the U. S. Department of Agriculture, Soil Conservation Service, would be installed.

(b) Provision of a new outlet to Red River at Buzzard Bluff, to alleviate overflow problems in areas lying north and west of Finn Bayou to the Arkansas-Texas State line. The outlet would consist of a gated control structure with 300 square feet of clear opening, an inlet channel connecting to Finn Bayou and Bois d'Arc Creek, and an outlet channel to Red River. The inlet and outlet channels would both be about 15 feet deep with bottom widths of 30 feet. Some 71 miles of drainage improvements, formulated by the Soil Conservation Service, also would be provided.

(c) Provision of a new outlet to Red River west of the Arkansas-Texas State line. The new outlet would consist of a gated control structure with a clear opening of 200 square feet, an inlet channel to McKinney Bayou, and an outlet channel to Red River. The inlet channel would be approximately 20 feet deep and have a bottom width of 40 feet; the outlet channel would be the same depth and would have a bottom width of 30 feet. The existing outlet via McKinney Bayou would remain open to carry a portion of the outflow during normal and moderately high stages on Red River, and to serve as the sole outlet on the rare occasions when stages

in Red River preclude outflow through the new outlet. Twenty-four miles of interior drainage works formulated by the Soil Conservation Service would be included in the plan.

(5) Benefits and costs.

(a) Improvement of McKinney Bayou. Damages prevented by the combined Corps and SCS plans are estimated to be $54,000 annually, comprised of $24,300 in crop damages and $29,700 in non-crop damages. Enhancement benefits would total $344,100 annually resulting from improved crop distribution, increased crop yields and woodland conversions. Recreation benefits would be $61,800. The first cost of the combined improvements is $3,501,000. Total annual charge, including operation and maintenance and on-farm drainage costs, would be $226,900. The total annual benefits of $459,900 and the annual charges of $226,900 yield a benefit-cost ratio of 2.0.

(b) Buzzard Bluff Diversion. Damages prevented by the combined Corps and SCS plan are estimated to be $52,400 annually, comprised of $46,700 crop damages and $5,700 noncrop damages. Total enhancement due to higher utilization of lands is estimated at $227,400. The estimated first cost of the combined plan is $2,016,000. Annual charges including operation and maintenance and on-farm drainage cost would be $138,500. The total annual benefits of $279,800 and the annual charges of $138,500 result in a benefit-cost ratio of 2.0.

(c) State Line Diversion. Flood damages prevented by the combined Corps and SCS plan, all to crops, are estimated to be $8,300 annually. Annual benefits attributable to land enhancement would be $85,000. The first cost of the combined plan is estimated at $1,038,000. The total annual charge, including interest and amortization, operation and maintenance, and on-farm drainage cost, would be $63,800. The total annual benefit of $93,300 and the annual charge of $63,800 yield a benefit-cost ratio of 1.5.

c. Posten Bayou.

(1) Basin description. The Posten Bayou Watershed is located in southwestern Arkansas and northwestern Louisiana. Posten Bayou rises in Lafayette County, Arkansas, on the left descending bank of Red River and follows a southerly course for about 18 miles to enter Red River at mile 319, as shown on figure 19. The watershed covers an area of 114 square miles. The drainage area within Arkansas aggregates about 73 square miles, of which 48 square miles are alluvial plain and 25 square miles are rolling hills. In Louisiana, the drainage area of 41 square miles is comprised of 24 square miles of alluvial plain and 17

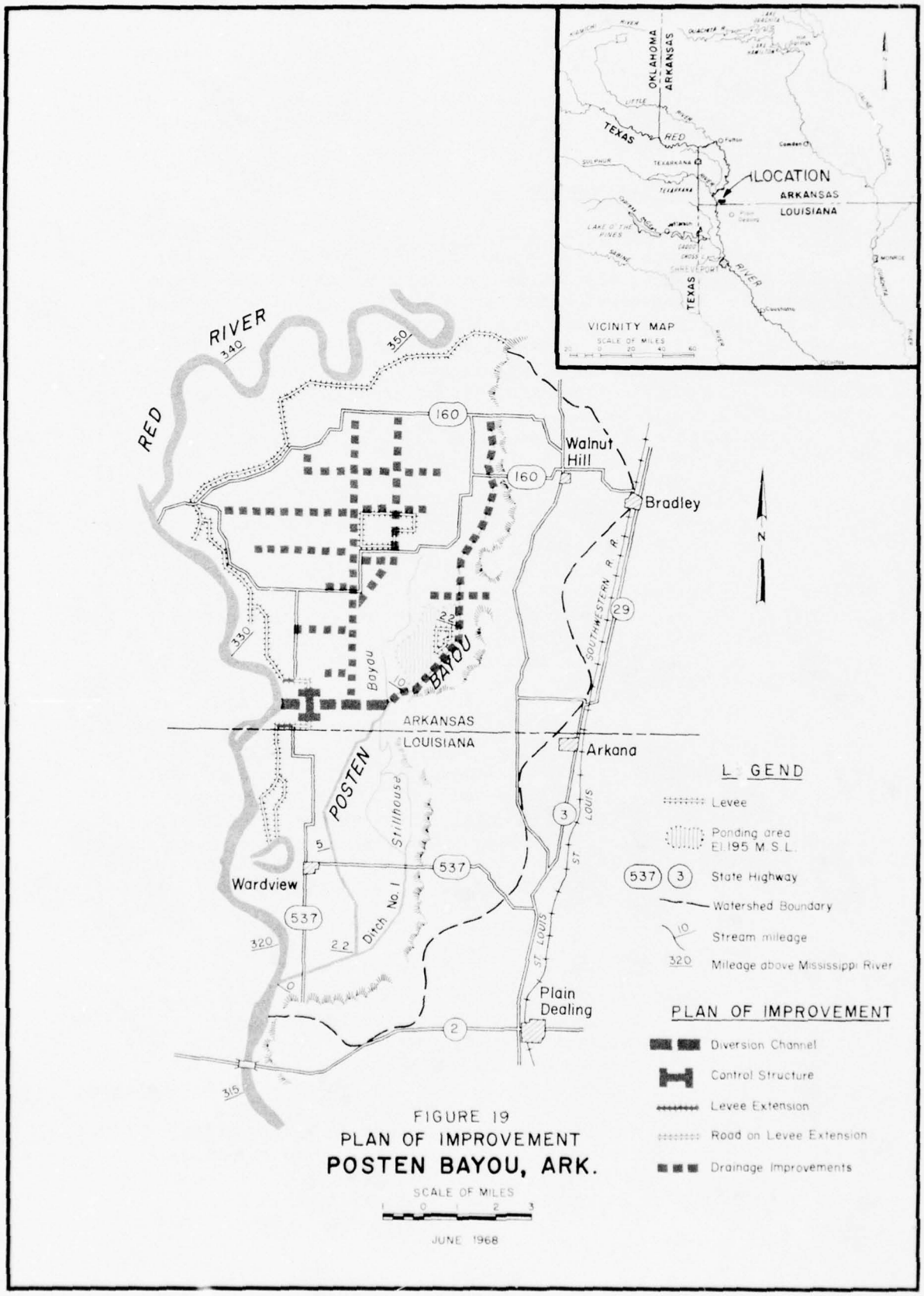


FIGURE 19
PLAN OF IMPROVEMENT
POSTEN BAYOU, ARK.

JUNE 1968

square miles of rolling hills. Drainage of most of the alluvial lands in Arkansas is provided by two main north-south drainage ditches and numerous connecting laterals; the remaining alluvial lands to the east, and all of the hill lands, are drained by Posten Bayou. In Louisiana, the hill lands to the east and a portion of the alluvial lands adjacent thereto, are drained by Stillhouse Bayou, a tributary of Posten Bayou; the remaining alluvial lands along Red River are drained by Posten Bayou.

(2) Existing and authorized improvements. In 1951 the channel of Posten Bayou was enlarged between miles 2.2 and 4.6 and between miles 7.4 and 8.8, and cleared and snagged between miles 8.8 and 12.2. These improvements were accomplished under the authority of Section 2 of the Flood Control Act of August 28, 1937, as amended. Local interests have assumed responsibility for the maintenance of this work.

The Flood Control Act of July 24, 1946 authorized a comprehensive plan for flood control on Red River below Denison Dam. Included in this plan were upstream reservoirs in combination with existing or previously authorized Federal or non-Federal levee improvements, modified as required, and construction of bank protection works where levee setbacks were impossible or uneconomical. The major flood control reservoirs have been completed, thus substantially reducing backwater flooding in the lower Posten Bayou watershed. About 90 percent of the levee and bank stabilization works, including enlargement of the levee along the left descending bank of Red River between miles 361 and 333, which protects the Posten Bayou Watershed from direct overflow from Red River, are complete.

Another modification of the comprehensive plan, authorized by the Flood Control Act of August 3, 1955, provides for the enlargement and realignment of the lower 10 miles of Posten Bayou. This plan of improvement is only partially responsive to the needs of the area and lacks local support. Construction has not been initiated, and the project is inactive.

(3) Project formulation.

(a) The principal problem in the basin is periodic flooding due to the restricted capacity of Posten and Stillhouse Bayous. Some 16,000 acres of land in Arkansas, 12,500 of which are cleared, are subject to damage from overflow.

(b) Preliminary investigations revealed that potential reservoirs could control only a small portion of the drainage area and effect only minor reductions in storm runoff. Solutions involving levees were investigated; however, the problem area is saucer-shaped with channels spread like fingers to drain the area,

a topographical configuration not conducive to a levee-type solution. Since the area is rural, solutions such as flood plain zoning and evacuation are not applicable. The sole practicable approach to the solution of the problem is the provision of a larger outlet combined with appropriate improvements to the interior drainage system. Three alternative plans were developed which would provide an equivalent degree of protection. The first plan consisted of enlargement and realignments of Posten Bayou from mile 10 to Red River, and improvement in the existing drainage network in Arkansas. This plan is an updating of a plan previously studied but not recommended because required local support in Louisiana was lacking. The second plan retained the interior drainage improvements included in the first plan but substituted a diversion channel located wholly within the State of Arkansas for the outlet improvement. The floodgate of this plan would be located in the diversion channel about 0.6 mile from Red River. The third plan was similar to the second, except that the floodgate would be located in the existing Red River levee alignment. Based on an analysis of costs and benefits, it was concluded that the second plan represents the most efficient approach to the solution of the problem. Numerous sizes of diversion channel and control structure were then evaluated economically. In these evaluations, it was developed that flood damage reduction benefits were influenced by diversion channel and control structure sizes to a much lesser degree than were the land enhancement benefits. These features were accordingly sized to achieve the full land enhancement potential.

(c) Wildlife losses attributed to features of Posten Bayou amount to 600 man-days. A 350-acre greentree reservoir development would provide for mitigation of these losses, and those of the McKinney Bayou project as well.

(4) Description of project. The plan of improvement provides for construction of an outlet from Posten Bayou, at approximately mile 9.5, into Red River and interior drainage improvements, as shown on figure 19. The major outlet is to be constructed by the Corps of Engineers, while the interior drainage improvements are to be accomplished by local interests either in cooperation with the Soil Conservation Service, or through some local means.

The major outlet consists of three salient features: a diversion channel approximately 2.5 miles in length; a gated control structure; and about 1.2 miles of tie-in levees to retain the protection against overflow from Red River afforded by the existing levee.

(a) That portion of the diversion channel on the river side of the structure will have a bottom width of 70 feet at

elevation 174. Side slopes will be 1 on 4 up to elevation 185, thence 1 on 3 to natural ground. The portion of the diversion channel upstream of the structure will have a bottom width of 60 feet at elevation 174. Side slopes will be 1 on 3.

(b) The control structure will consist of three 10- by 13-foot concrete culverts with invert elevation of 174, service and emergency gates, a stilling basin, and a control tower.

(c) Tie-in levees, at elevation 213.3, will extend from the existing system along Red River down one side of the diversion channel to the structure, thence across the structure and up the other side of the diversion channel to connect back to the Red River system. The levees will be constructed from channel spoil. Channel spoil surplus to levee requirements will be placed landward of the levee cross section in such a manner as to produce a single embankment. Surplus spoil will be dressed but not compacted.

(5) The interior drainage improvements consist of extension and rehabilitation of the existing main, lateral, and on-farm drainage systems. The Soil Conservation Service developed the plan for major drainage which includes construction or improvement of 39 miles of main and lateral drainage ditches.

Further details on this project are contained in the report entitled "Comprehensive Basin Study, Red River below Denison Dam, Louisiana, Arkansas, Oklahoma, and Texas - Interim Report on Posten Bayou, Arkansas," dated March 1968.

(6) Benefits and costs. Flood damages prevented by the combined Corps and SCS plans are estimated to be $74,600 annually. Annual benefits attributable to land enhancement would be $313,900. The first cost of the combined plan is estimated at $2,503,000. The total annual charge, including interest and amortization, operation and maintenance, economic losses on lands, and on-farm drainage costs, would be $164,000. The total annual benefit of $388,500 and the annual charge of $164,000 yield a benefit-cost ratio of 2.4.

d. West Agurs Levee.

(1) Project formulation. This levee, which lies along the east bank of Twelvemile Bayou and extends from the existing Texas and Pacific Railroad embankment near Shreveport to about 3 miles upstream, protects about 770 acres of land located between U. S. Highway 71 and Twelvemile Bayou. The levee was constructed by local interests. They have requested its incorporation into the Federal levee system. Investigations disclosed that the levee grade met requirements of the Federal project "Red River below

Denison Dam," but an analysis of the soil boring logs indicates that the thickness of the clay layer under the existing borrow pit does not provide an adequate safety factor against seepage and uplift.

(2) Description of project. Improvements required to prevent seepage and uplift pressure consist of refilling the borrow pit with material excavated from the landward bank of the pit, as shown on figure 20. The new borrow area would provide adequate cross section for interior drainage needs.

(3) Benefits and costs. Improvement of the levee would provide a higher degree of flood protection to about 770 acres of land resulting in annual benefits of $170,000. The first cost of modifications to the levee is estimated at $282,000. Annual charges for the plan would total $13,300, including $1,000 for operation and maintenance. The benefit-cost ratio is 12.8.

e. Summary of costs and benefits. The first cost, annual charges, annual benefits, and benefit-cost ratios of all improvements for local flood protection included in the early-action plan are shown in table 30.

TABLE 30

IMPROVEMENTS FOR LOCAL FLOOD PROTECTION IN EARLY-ACTION PLAN
ECONOMIC SUMMARY

Project	Total Project Cost ($1,000's)	Total annual charges ($1,000's)	Total annual benefits ($1,000's)	Benefit/ cost ratio
Days Creek	5,580.0	252.0	270.3	1.1
McKinney Bayou	6,555.0	429.2	833.0	1.9
Posten Bayou	2,503.0	164.0*	388.5	2.4
West Agurs Levee	282.0	13.3	170.0	12.8

*Includes $600 for wildlife damages as shown in "Interim Report on Posten Bayou" dated March 1968. The comprehensive plan includes a recommendation for acquisition of lands for mitigation.

41. UPSTREAM WATERSHED IMPROVEMENTS

The USDA recommends projects in 55 watersheds. Multiple-purpose watershed protection and flood prevention projects are recommended in 49 upstream watersheds, and single-purpose reservoir projects are recommended in six upstream watersheds. The

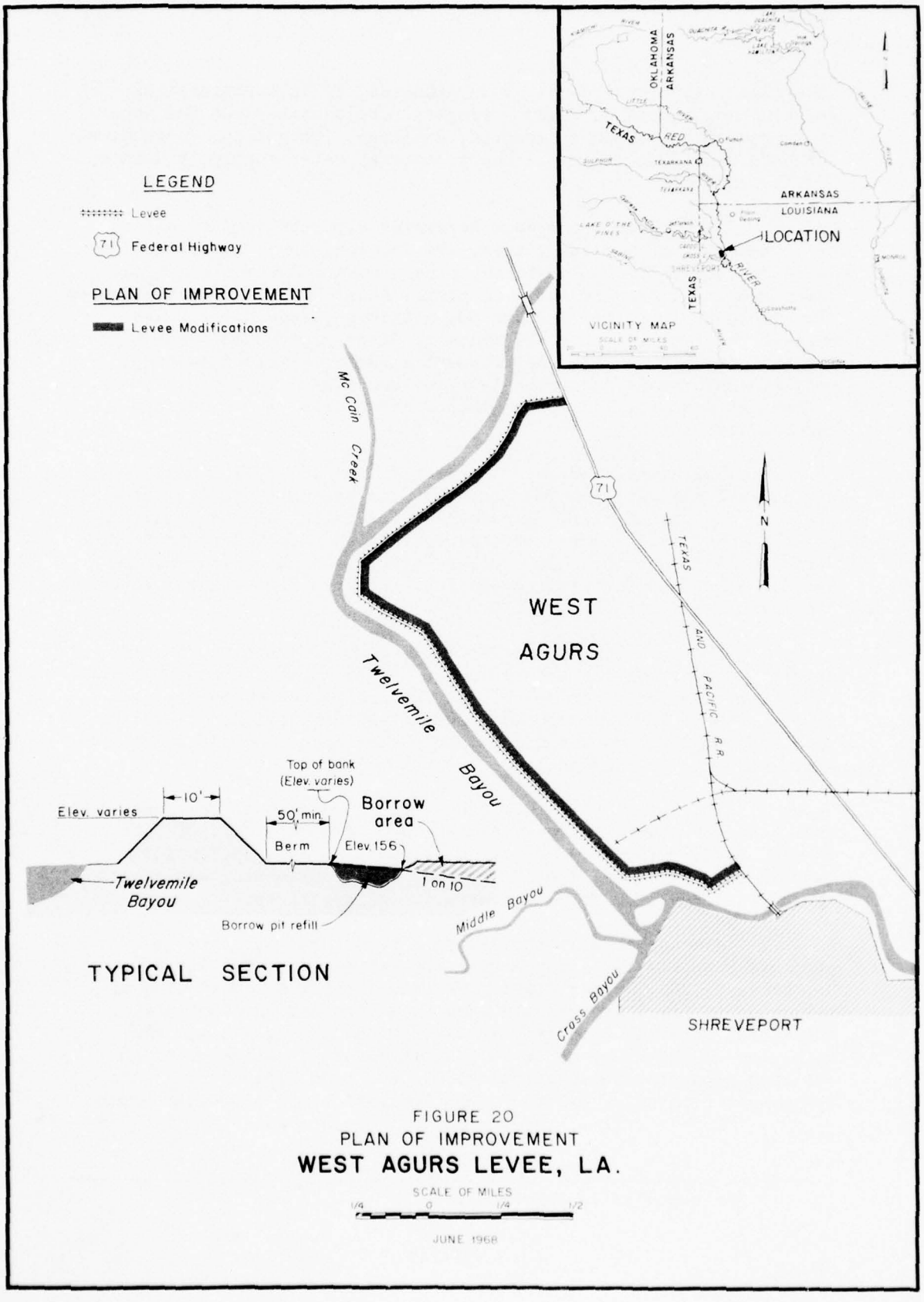


FIGURE 20
PLAN OF IMPROVEMENT
WEST AGURS LEVEE, LA.

JUNE 1968

watersheds are distributed: 8 in Arkansas, 21 in Louisiana, 12 in Oklahoma, and 14 in Texas. Projects include measures for watershed protection, flood prevention, drainage, irrigation, recreation, fish and wildlife, municipal and industrial water supply, and water quality control.

a. Structural measures. Approximately 7,500 square miles, or 25 percent, of the study area, are included in the Conservation Needs Inventory (CNI)(1) watersheds recommended for early action. Watershed locations are shown on plates 1 and 2. Structural measures that would be installed include 381 multiple-purpose or single-purpose reservoirs, and 1,426 miles of flood prevention, drainage, and irrigation channels. Appurtenant structures needed to complement the reservoirs and channel improvement would include 15 water control structures, 7 erosion control structures, and 1 sediment control structure.

Potential storage of the reservoirs is 984,182 acre-feet divided as follows: 111,363 acre-feet for sediment, 81,278 acre-feet for recreation, 122,131 acre-feet for municipal and industrial water supply, 62,541 acre-feet for irrigation, 8,050 acre-feet for water quality control, 1,000 acre-feet for fish and wildlife, and 597,819 acre-feet for flood detention. Reservoir structural data are summarized on table 31.

The upstream watershed development programs would offer excellent opportunities for recreational development through inclusion of recreation water storage in favorably located multiple-purpose reservoirs. Recreation facilities for picnicking, boating, fishing, camping, and swimming would be included in conjunction with reservoir site development.

The total installation cost for the proposed upstream watershed structural improvements would be $98,847,300. Of this amount, $64,983,700 would be for construction, $17,195,700 for installation services, $16,171,200 for land, easements, and rights-of-way, and $497,300 for administration of contracts.

Average annual benefits from structural measures in projects proposed for early action are estimated at $11,768,700. Of these, $5,282,000 are flood prevention benefits, consisting of reduction in flood damages and more intensive use of flood plain. Additional benefits estimated at $24,500 would accrue along the main stem of Red River above Fulton, Arkansas, from the combined upstream projects. Benefits of $2,697,200 from agricultural water management consist of $495,700 from irrigation and $2,201,500 from

(1) See appendix V, page V-13.

TABLE 31

UPSTREAM WATERSHED PROJECTS IN EARLY-ACTION PLAN

PERTINENT STRUCTURAL DATA

	Watershed Projects	Watershed Area (sq. mi.)	Drainage Area Controlled (sq. mi.)	Structural Reservoirs (number)	Measures Channels (miles)	Reservoir Pool Capacity(1) Detention (acre-feet)	Sediment (acre-feet)	Recreation (acre-feet)	M&I (acre-feet)	Other (acre-feet)	Surface Area Perm. Pool (acres)
3-19	Choctaw Creek*	262.5	112.6	41	25.0	43,106	11,699	2,990	24,127	101 I	2,508
3-25	Lower Bois D' Arc Creek	208.4	96.0	14	22.2	32,610	8,910	0	0	0	1,385
3-25a	Upper Bois D' Arc Creek	222.6	79.0	8	8.1	32,910	5,820	1,580	10,400	0	1,629
3-27	Logan-Slough Creek*	11.5	4.0	3	12.1	1,336	303	0	0	0	61
3-29	Chicota	22.8	1.5	2	28.6	490	140	480	0	0	98
3-33	Pine Creek*	186.0	84.0	19	19.5	31,793	4,380	0	0	0	670
3-35	McKinney-Buzzard	26.0	12.0	1	8.5	4,925	576	394	0	0	65
3-39	Waterfall-Gilford*	67.8	18.4	12	68.0	4,537	702	0	0	0	167
3-40	Norwood Creek	86.4	28.0	3	21.2	8,634	1,350	0	0	0	164
3-41	Walnut Bayou	89.8	32.0	11	27.0	10,940	1,950	450	0	0	463
3-46	Haney Creek*	24.0	8.4	2	16.6	3,080	293	0	0	0	71
3-23	Lower Blue River	360.4	77.0	13	0	33,920	6,120	3,000(3)	0	2,050 W	1,155
3h1-2	Lower Clear Boggy*	375.5	161.8	37	2.0	43,811	6,957	2,010	0	0	1,662
3h1-3	Caney Creek*	47.7	32.2	14	0	8,865	1,423	0	0	0	286
3h2-4	Middle Muddy Boggy Creek	225.4	155.0	25	0	49,250	8,250	0	2,000	0	NA
3h2-6	Upper Muddy Boggy Creek	322.2	158.0	44	0	50,500	8,400	1,000	2,000	0	NA
3i-2	Progville*	14.3	2.0	2	12.0	609	103	0	0	0	24
3i-4	Dumpling-Beaver	62.0	37.8	10	8.5	12,288	2,142	1,350	3,000	0	873
3i-8	Rock Creek*	59.4	24.9	4	0	9,285	1,083	0	2,600(4)	0	70
3-47	Ash Slough	4.0	-	-	4.1	-	-	-	-	-	-
3-48	Barkman Creek	69.0	-	-	15.0	-	-	-	-	-	-
3j-4	Mine Creek	147.0	47.0	14	0	21,120	3,390	320	0	0	580
3-52	Upper McKinney Bayou	195.8	31.0	4	78.0	14,870	800	1,410	0	0	408
3-53	Buzzard Bluff	86.3	-	-	71.0	-	-	-	-	-	-
3-54	McKinney Bayou	45.1	-	-	33.0	-	-	-	-	-	-
3-55	Beech Creek	57.3	8.0(2)	1	0	0	300	7,500	-	-	550
3k-9	Bruton Creek	98.0	46.0	7	0	18,320	7,624	0	0	0	610
3k-11	Deport Creek	6.0	5.0	1	0	3,065	540	324	354	0	240
3k-12	Click Creek	30.0	11.3	3	0	4,870	970	0	0	0	154
3k-14	Upper North Sulphur River	319.7	12.7	1	0	5,690	1,860	7,550	0	0	306
3k-17	South Sulphur River, Middle Sulphur River, Pecan Creek	211.0	49.2	21	16.0	17,280	4,090	0	0	0	880
3k-18	Upper South Sulphur River	121.0	61.0	23	0	21,140	5,950	0	0	0	1,190
3-57	Upper Posten Bayou	95.8	0	1	39.2	0	130	500	0	0	120
3-60	East Point	37.6	-	-	9.0	-	-	-	-	-	-
3m-1	Lower Toulon Bayou*	13.4	3.8	1	3.0	1,175	98	0	0	0	20
3m1-7	Big Creek	140.2	54.4	9	21.8	25,010	1,090	820	23,300	6,000 W	2,813
3m2-3	Cypress-Black Bayou*	232.0	-	2	55.5	0	1,990	6,010	4,350	19,650 I	3,850
3n-2	Johnson Chute	144.1	63.9	9	12.0	27,450	2,080	7,540	0	5,100 I	2,659
3n-5	Wallace Bayou	357.0	65.0(2)	2	-	-	2,430	21,990	-	-	2,040
3o1-3	Black Lake Bayou Laterals	292.6	5.5(2)	1	-	-	240	-	3,100	-	340
3o1-4	Upper Black Lake Bayou	337.5	3.8(2)	1	-	-	170	-	5,000	-	460
3-68	Bayou Jean de Jean	91.4	33.8(2)	1	-	-	1,500	-	23,500	-	1,600
10-17	Bayou Rapides	63.1	11.8(2)	1	-	-	500	-	21,400	-	1,470
3-69	Bayou Du Grappe	31.5	-	-	18.0	-	-	-	-	-	-
3-70	Bayou Rigolette	386.2	116.8	11	63.0	54,940	3,440	3,200	0	0	986
3-73	Vick to Saline Bayou	60.8	-	-	29.0	-	-	-	-	-	-
3-75	Jonesville to Larto Lake	173.5	-	-	70.0	-	-	-	-	-	-
3-76	Saline Bayou to Black River	37.0	-	-	28.0	-	-	-	-	-	-
10-10	Washasha-Courtableau	169.3	-	-	80.0	-	-	-	-	-	-
10-11	Bayou Grand Louis*	103.4	-	-	83.4	-	-	-	-	-	-
10-12	Bayou Cocodrie*										
10-13	Bayou Rouge	375.8	-	-	249.0	-	-	-	-	-	-
10-14	Bayou Des Glaises										
10-15	Bayou Boeuf*	184.5	-	2	24.4	-	1,450	10,860	-	37,690 I	4,170
10-16	Chatlin Lake	71.6	-	-	135.0	-	-	-	-	-	-
	TOTAL	7,463.2	1,754.6	381	1,420.6	597,819	111,363	81,278	122,131	70,591	NA
3-23	Lower Blue River-Alternate Plan(5)	360.4	167.3	30	0	66,510	13,570	2,000	8,010	3,050 FW	2,520

*Watershed projects approved for operations.

(1)Abbreviations for pool capacities: I - Irrigation, W - Water Quality Control, F - Fish and Wildlife, M&I - Municipal and Industrial.

(2)Drainage area above structure.

(3)Includes 1,000 acre-feet of Fish and Wildlife storage.

(4)Existing municipal water supply.

(5)See page XV-84, para. 39 b.(7)

drainage. Nonagricultural water management benefits amounting to $2,534,600 consist of $395,900 from municipal and industrial water supply, $36,200 from water quality control, $2,092,100 from recreation, and $10,400 from storage for fish and wildlife. Redevelopment benefits of $33,100 and secondary benefits estimated at $1,221,800 would also accrue from the proposed projects. Annual charges for the upstream improvements total $4,521,200, including $927,100 for operation and maintenance. The resultant benefit-cost ratio is 2.6 to 1. An economic summary of all upstream watershed projects included in the early-action plan is given in table 32.

b. Land treatment measures.

(1) Agricultural lands. Approximately 16,600 square miles of land are included in the projects recommended for early action. Land treatment needed on these lands is included. Treatment needs include measures that have a significant effect on reducing runoff, erosion, and sediment production, and measures that help to provide maximum benefits from drainage improvements and irrigation development. Treatment measures are designed to improve the woodland and agricultural lands and increase overall farming efficiency. Land treatment needs have been developed, and it was determined that going programs will not accomplish the needs for project development. Approximately 501,600 acres of land included in the USDA projects recommended for early action require acceleration of the installation of land treatment measures. These treatment measures include practices essential to the proper functioning of structural measures and to the realization of full benefits from structural improvements. Accelerated land treatment is included for 436,800 acres of cropland and pasture. Treatment practices include conservation cropping systems, diversion and terrace construction, land shaping, and drainage on croplands, and pasture planting, pasture renovation, and farm ponds on pasture.

(2) Forest lands. Accelerated treatment is planned for 63,440 acres of forest land, and open land with erosion problems. Tree planting, stand conversion, release of desirable growing stock, and grazing control will be utilized on poorly protected and depleted project forest lands. Measures to improve fire protection are planned for installation during the watershed programs on six projects. Additional suppression units are planned to increase fire protection now available in these areas.

Going forestry programs on the early-action watershed projects in the commercial forest area are expected to treat an additional 97,935 acres of forest land. State and Federal cooperative programs and high-level, sustained-yield management programs on National Forest and forest-industry lands will provide most of this activity. The measures to be installed will improve watershed protection and help meet basin wood supply needs.

TABLE 32

UPSTREAM WATERSHED PROJECTS IN EARLY-ACTION PLAN

ECONOMIC EVALUATION SUMMARY

	Watershed Projects	First Cost	Annual cost: Amortized Installation Cost	Annual cost: Operation and Maintenance Cost	Annual cost: Total	Annual Benefits	Benefit-Cost Ratio
		(thousand dollars)					
3-19	Choctaw Creek*	8,717.4	285.6	28.6	314.2	476.4	1.5
3-25	Lower Bois d'Arc Creek	4,944.4)					
3-25a	Upper Bois d'Arc Creek	2,637.0)	248.4	94.3	342.7	554.2	1.6
3-27	Logan-Slough Creek*	420.0	17.9	2.9	20.8	76.5	3.7
3-29	Chicota	309.2	11.4	13.6	29.0	150.8	6.0
3-33	Pine Creek*	3,059.9	100.7	8.3	109.0	242.3	2.2
3-35	McKinney-Buzzard	682.3	24.1	12.7	36.8	72.6	2.0
3-39	Waterfall-Dilford*	1,730.4	106.2	14.8	121.0	330.9	2.7
3-40	Norwood Creek	609.2	25.8	7.9	33.7	99.0	2.9
3-41	Walnut Bayou	1,608.8	52.7	27.7	80.4	315.8	3.9
3-46	Haney Creek*	659.7	30.7	6.4	37.1	48.1	1.3
3-23	Lower Blue River	2,471.3	60.4	14.9	75.4	207.0	2.2
3h1-2	Lower Clear Boggy*	4,160.0	103.7	3.9	107.6	290.9	1.6
3h1-3	Caney Creek*	636.3	24.2	1.2	25.4	48.3	1.7
3h2-4	Middle Muddy Boggy Creek	2,888.5)					
3h2-6	Upper Muddy Boggy Creek	3,547.1)	210.8	22.5	233.3	384.1	1.5
3i-2	Frogville*	482.0	15.8	11.8	27.6	97.3	3.6
3i-4	Dumpling-Beaver	1,540.8	50.5	20.2	70.7	136.6	1.9
3i-8	Rock Creek*	1,232.1	40.4	1.1	41.4	85.6	2.1
3-47	Ash Slough	62.9	2.5	1.8	4.3	24.6	5.7
3-48	Barkman Creek	404.2	16.0	11.8	27.8	117.5	4.2
3j-4	Mine Creek	3,061.9	100.3	14.5	114.8	166.5	1.5
3-52	Upper McKinney Bayou	1,757.3	122.9	49.6	172.5	408.4	2.4
3-53	Buzzard Bluff	999.4	47.8	28.6	76.4	449.2	5.9
3-54	McKinney Bayou	339.7	44.6	14.3	58.9	197.	3.4
3-55	Beech Creek	590.5	19.3	12.8	32.1	181.9	5.6
3k-9	Bruton Creek	860.4	25.2	1.2	26.4	37.1	1.3
3k-11	Deport Creek	298.1	7.8	9.5	17.3	53.5	2.8
3k-12	Click Creek	372.3	12.2	0.5	12.7	16.8	1.3
3k-14	Upper North Sulphur River	742.2	24.3	12.4	36.7	53.8	1.5
3k-17	South Sulphur River, Middle Sulphur River, Pecan Creek	1,744.4	57.3	10.2	67.3	106.5	1.6
3k-18	Upper South Sulphur River	1,756.4	57.5	3.9	61.4	85.1	1.4
3-57	Posten Bayou	1,338.2	118.6	42.9	161.5	450.8	2.8
3-60	East Point	79.7	4.6	2.4	7.0	66.5	9.5
3m-1	Lower Toulon Bayou*	138.0	4.5	0.4	4.9	8.9	1.8
3m1-7	Big Creek	4,608.7	151.0	55.6	206.6	337.2	1.6
3m2-3	Cypress-Black Bayou*	8,384.9	274.7	94.9	369.6	671.8	1.8
3n-2	Johnson Chute	2,888.5	91.5	21.0	112.5	197.4	1.8
3n-5	Wallace Bayou	1,980.2	64.9	35.6	90.5	673.2	7.4
3o1-3	Black Lake Bayou Laterals	273.0	8.9	0.2	9.1	9.1	1.0
3o1-4	Upper Black Lake Bayou	300.9	9.9	0.2	10.1	10.1	1.0
3-68	Bayou Jean de Jean	1,887.2	61.8	0.2	62.0	62.0	1.0
10-17	Bayou Rapides	1,175.2	38.5	0.2	38.7	38.7	1.0
3-69	Bayou DuGrappe	212.8	7.0	10.6	17.6	141.5	8.1
3-70	Bayou Rigolette	6,759.6	221.4	77.3	298.7	519.1	1.7
3-73	Vick to Saline Bayou	212.7	12.4	5.2	17.6	234.7	13.3
3-75	Jonesville to Larto Lake	515.0	30.0	12.6	42.6	448.5	10.5
3-76	Saline Bayou to Black River	1,760.5	102.5	12.0	114.5	392.9	3.4
10-10	Waukasha-Courtableau	307.0	23.7	20.7	44.4	210.5	4.7
10-11	Bayou Grand Louis)*						
10-12	Bayou Cocodrie)*	1,292.7	61.3	8.4	69.6	101.4	1.5
10-13	Bayou Rouge)						
10-14	Bayou des Glaises)	2,490.9	99.1	34.7	129.8	746.4	5.8
10-15	Bayou Boeuf*	5,816.5	184.0	23.3	207.3	434.0	2.1
10-16	Chatlin Lake	1,399.0	55.7	15.2	70.9	500.5	7.1
	Total	96,847.3	3,594.9	527.1	4,121.9	11,760.7	2.8
3-23	Lower Blue River-Alternate Plan**	5,623.3	184.2	17.3	201.5	519.2	2.6

*Watershed projects approved for operations.

**See page XV-84, para. 39 b.(7)

42. NAVIGATION AND BANK STABILIZATION IMPROVEMENTS

a. Navigation.

(1) Project formulation. Studies were made of a navigation channel to extend from the Mississippi River via Old and Red Rivers to Shreveport, La., and thence to Ogden, Ark., Arthur City and Denison, Texas. Five tributary routes branching off the main stem were investigated. The first route extended from Red River in the vicinity of Shreveport, La., via Twelvemile and Cypress Bayous and Lake O' the Pines to the vicinity of Daingerfield, Texas, and northerly beyond, along existing streams and new land cuts to rejoin Red River near mile 510, thence to Denison Dam; the second extended from Red River via the Sulphur River to the vicinity of Texarkana, Texas-Arkansas; the third extended from Red River in the vicinity of Fulton, Ark., up Little River to Idabel, Okla., thence through a canal to Red River downstream from the mouth of the Kiamichi River; the fourth, up the Sulphur River to Texarkana Reservoir, thence north through a canal to Red River at mile 510; the fifth extended from the main stem up Loggy and Bayou Dorcheat to Springhill, La. The authorized Overton-Red River Waterway was studied as an alternative route by which navigation could be provided to Shreveport, La. Revised to modern standards and updated to current conditions and prices, this route proved to be most costly than main stem improvements. Moreover, the river improvement plan affords added benefits to bank stabilization, recreation, fish and wildlife, and other purposes.

In formulating the navigation plan, studies were made in incremental steps, by analysis of potential traffic to various destinations along the river and its tributaries, by comparison of savings in use of different size channels and tows, and by comparison of the number, size, and design of locks. Preliminary studies demonstrated that improvements for navigation other than on the main stem of Red River from the Mississippi River to Shreveport, and on a route following Twelvemile and Cypress Bayous from Shreveport to the vicinity of Daingerfield, Texas, were clearly not justified.

Analyses were made of channel sizes for depths of 9 and 12 feet and widths of 150 and 200 feet. Taking into consideration traffic patterns, prospective commerce and transportation savings, the effect of recently authorized waterway improvements not yet completed, alternative routes, and the latest information relating to the expected growth of the region, the 9- by 200-foot channel provided the greatest excess of benefits over costs.

(2) Description of project. The navigation project provides for construction of a waterway extending from the Mississippi River through Old River (7 miles) and Red River (212 miles), thence through Twelvemile and Cypress Bayous (75 miles) to a turning basin

in Lake O' the Pines downstream of U. S. Highway 259 bridge, near Daingerfield, Texas. Traffic from the Mississippi River will enter the route through the existing Old River Lock. Minimum channel dimensions will be 9 feet by 200 feet. Navigation depths will be secured by construction of a series of five locks in combination with spillway dams on Red River to reach Shreveport and four locks to reach Daingerfield. The navigation plan is shown on figure 21. Two of the locks on the tributary route will be constructed in combination with the existing dams; namely, Caddo Lake Dam and the Ferrells Bridge Dam (forming Lake O' the pines). The other lock will be constructed near Jefferson, Texas, in combination with a small gated dam. All locks will have usable dimensions of 84 feet width and 600 feet length with minimum depth over the sill of 14 feet. The dams on the main stem will be constructed adjacent to the lock structures and will be of the controlled spillway type. To provide water for lockages for the Twelvemile-Cypress Bayou reach, where minimum flows will be insufficient, the plan includes a single-purpose reservoir, with a storage capacity of 104,000 acre-feet, on Cypress Creek in the vicinity of Harvard, Texas. Later studies in the post-authorization phase will consider other means of satisfying the need for lockage water. The plan provides access for recreation, fishing, and hunting at the site of each lock and dam, at selected points along the navigation channel and bendway lakes formed by cutoffs. Design criteria, pertinent data, and various other details are presented in the Corps of Engineers "Interim Report on Navigation and Bank Stabilization," dated March 15, 1966.

(3) Costs and benefits. The navigation improvements are estimated to have a total first cost of $294,032,200, including $279,063,800 Federal cost, and $14,968,400 non-Federal cost. Annual charges are $14,776,300 Federal, and $966,200 non-Federal, a total of $15,742,500. Total annual benefits are estimated at $19,688,100. The following tabulation gives the first cost, annual cost, and annual benefits for the Mississippi River to Shreveport reach and the Shreveport to Daingerfield reach.

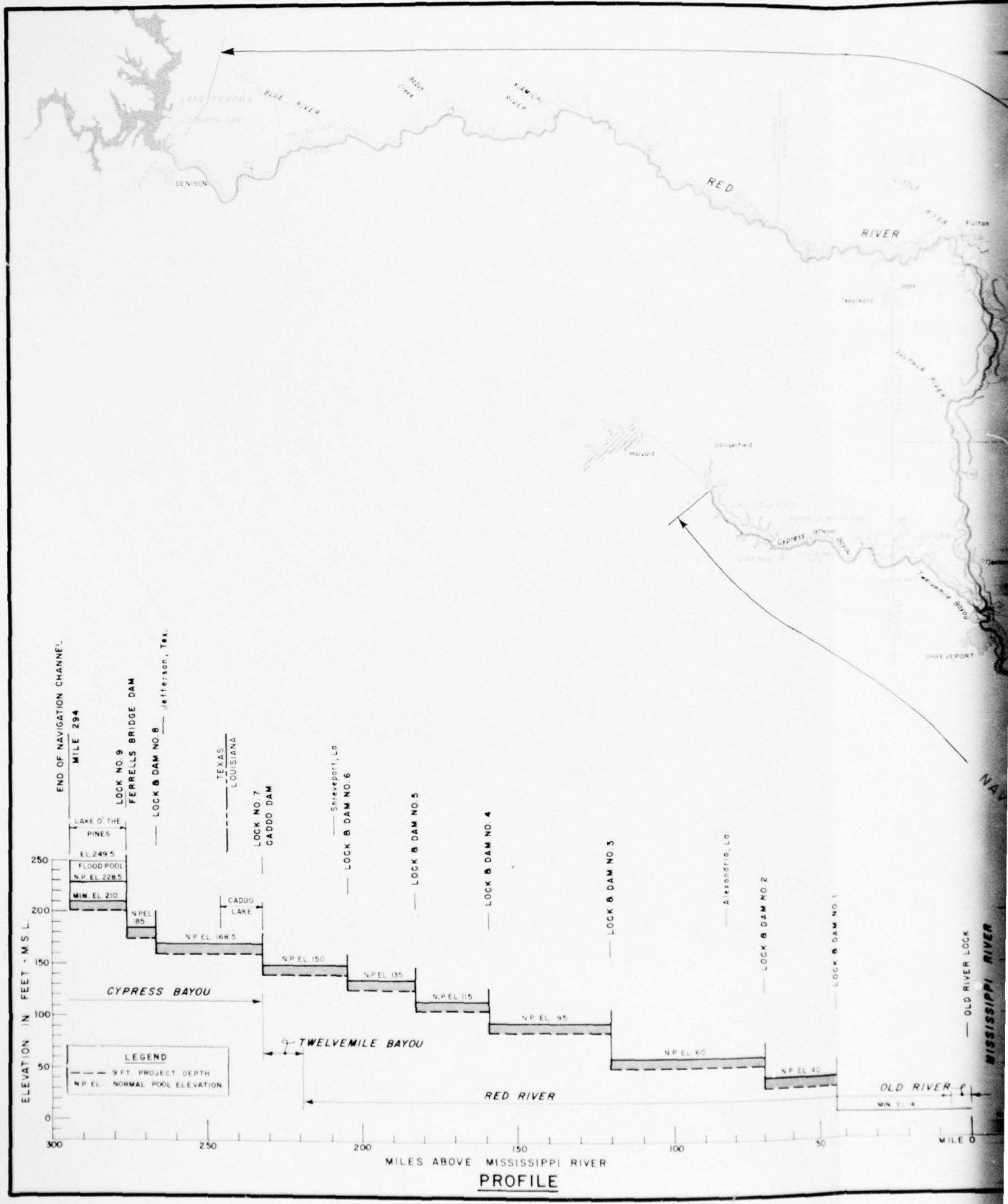
Reach	First cost		Annual cost		Annual benefits	Benefit/cost ratio
	Federal	Non-Federal	Federal	Non-Federal		
	($1,000)	($1,000)	($1,000)	($1,000)	($1,000)	
Miss. River to Shreveport, La.	150,016.3	7,825.7	8,309.7	425.1	12,471.5	1.4
Shreveport, La. to Daingerfield, Tex.	129,047.5	7,142.7	6,466.6	541.1	7,216.6	1.0

b. Bank stabilization.

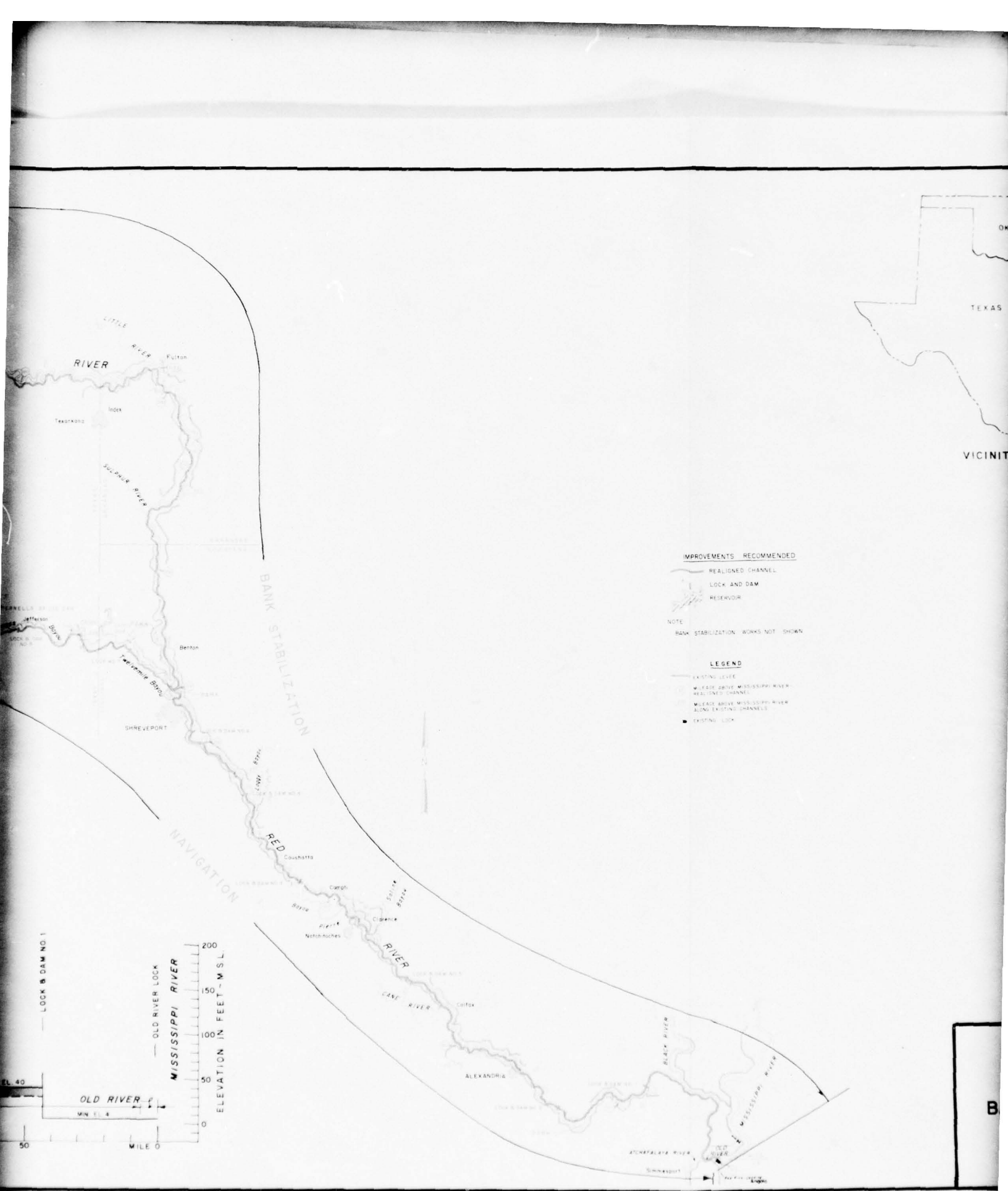
(1) Project formulation. A review was made of available data on design, construction, and maintenance experience of stabilization programs on Red River and on other rivers, principally the Arkansas, Missouri, and Mississippi. It was concluded that, in providing dependable stabilization on the Red River from the Mississippi River to Denison Dam at minimum cost for construction and maintenance, several factors were salient: the development of a favorable channel alignment, the type of works selected to accomplish the purpose, and continuity of the stabilization work throughout the length of a stream or at least from one stable point to another. Types of protection works considered included pile dikes and pile revetments, with and without stone fill, board mattresses, articulated concrete mattresses, rock groins, and steel jetties. Alternatives were considered in the selection of the types of stabilization or protective works, the location and limits of coverage, the degree of channel alignment, and methods of construction and maintenance. Recreation facilities were provided in the plan to increase net benefits beyond those afforded incidental to the construction of bank stabilization improvements.

(2) Description of project. The bank stabilization project provides for channel realignment and stabilization of Red River from the Mississippi River to Denison Dam. Realignment of the channel will be attained through dredging, cutoffs, and training works. The type of protection works to be employed will vary according to the nature of the problem in a specific locality or reach and will include pile dikes and pile revetments, some with stone fill, board mattresses, articulated concrete mattresses, rock groins, and steel jetties. The realigned length of the river from the Mississippi River to Denison Dam is 528.5 miles and represents a reduction of 146 miles in the river length. Public access for recreation, fishing, and hunting will be developed at selected cutoff bendway lakes which will be created between the Mississippi River and Denison Dam. The bank stabilization plan is shown on figure 21. Design criteria, pertinent data, and a full analysis of the plan are presented in the Corps of Engineers "Interim Report on Navigation and Bank Stabilization," dated March 15, 1966.

(3) Costs and benefits. The estimated total first cost of construction of the bank stabilization plan is $229,966,000, including $193,125,000 Federal cost, and $36,841,000 non-Federal cost. Annual charges are $7,720,900 Federal, and $3,737,500 non-Federal, a total of $11,458,400. Total annual benefits are estimated at $13,352,500. The benefit-to-cost ratio is 1.2 to 1. The following tabulation gives the first cost, annual cost, and annual benefits for the Mississippi River to Shreveport reach,


BLUE RIVER
RED
RIVER
DENISON
Jefferson, Tex.
TEXAS
LOUISIANA
Shreveport, La
Alexandria, La
SHREVEPORT
END OF NAVIGATION CHANNEL
MILE 294
LAKE O' THE PINES
EL. 249.5
FLOOD POOL
N.P. EL. 228.5
MIN. EL. 210
LOCK NO. 9
FERRELLS BRIDGE DAM
LOCK & DAM NO. 8
LOCK NO. 7
CADDO DAM
CADDO LAKE
LOCK & DAM NO. 6
LOCK & DAM NO. 5
LOCK & DAM NO. 4
LOCK & DAM NO. 3
LOCK & DAM NO. 2
LOCK & DAM NO. 1
OLD RIVER LOCK
N.P. EL. 185
N.P. EL. 168.5
N.P. EL. 150
N.P. EL. 135
N.P. EL. 115
N.P. EL. 95
N.P. EL. 60
N.P. EL. 40
MIN. EL. 4
CYPRESS BAYOU
TWELVEMILE BAYOU
RED RIVER
OLD RIVER
MISSISSIPPI RIVER
LEGEND
9 FT. PROJECT DEPTH
N.P. EL. NORMAL POOL ELEVATION
ELEVATION IN FEET - M.S.L.
250
200
150
100
50
0
300
250
200
150
100
50
MILE 0
MILES ABOVE MISSISSIPPI RIVER

PROFILE


LITTLE RIVER
Fulton
Index
Texarkana
SULPHUR RIVER
Jefferson
Bayou
Benton
Tallahatchie Bayou
SHREVEPORT
Lower Bayou
RED
Coushatta
Campti
Bayou
Pierre
Natchitoches
Clarence
RIVER
CANE RIVER
Colfax
ALEXANDRIA
BLACK RIVER
MISSISSIPPI RIVER
ATCHAFALAYA RIVER
OLD RIVER
Simmesport
BANK STABILIZATION
NAVIGATION
TEXAS
VICINIT
IMPROVEMENTS RECOMMENDED
REALIGNED CHANNEL
LOCK AND DAM
RESERVOIR
NOTE
BANK STABILIZATION WORKS NOT SHOWN
LEGEND
EXISTING LEVEE
MILEAGE ABOVE MISSISSIPPI RIVER REALIGNED CHANNEL
MILEAGE ABOVE MISSISSIPPI RIVER ALONG EXISTING CHANNELS
EXISTING LOCK
LOCK & DAM NO. 1
OLD RIVER LOCK
MISSISSIPPI RIVER
ELEVATION IN FEET - M.S.L.
200
150
100
50
0
EL. 40
OLD RIVER
MIN. EL. 4
50
MILE 0

VICINITY MAP

IMPROVEMENTS RECOMMENDED

- REALIGNED CHANNEL
- LOCK AND DAM
- RESERVOIR

NOTE:
BANK STABILIZATION WORKS NOT SHOWN

LEGEND

- EXISTING LEVEE
- MILEAGE ABOVE MISSISSIPPI RIVER REALIGNED CHANNEL
- MILEAGE ABOVE MISSISSIPPI RIVER ALONG EXISTING CHANNELS
- EXISTING LOCK

RED RIVER BELOW DENISON DAM
ARK., LA., OKLA., AND TEXAS
COMPREHENSIVE BASIN STUDY

NAVIGATION AND BANK STABILIZATION PLAN

JUNE 1968

FIGURE 21

3

which corresponds with the reach recommended for navigation improvements; the Shreveport to head of the levee system reach; and the unleveed reach of the river to Denison Dam.

Reach	First cost: Federal ($1,000)	First cost: Non Federal ($1,000)	Annual cost: Federal ($1,000)	Annual cost: Non-Federal ($1,000)	Annual benefits ($1,000)	Benefit/cost ratio
Miss. River to Shreveport, La.	86,241.0	7,712.0	4,099.6	422.2	5,319.7	1.2
Shreveport, La. to head of levee system	49,900.0	5,749.0	1,690.7	1,066.3	3,562.7	1.3
Head of levee system to Denison Dam	56,984.0	23,380.0	1,930.6	2,249.0	4,470.1	1.1

c. Mitigation. Combined losses to fish and wildlife attributable to all features of the navigation and bank stabilization plan amount to 14,300 man-days annually. Lands should be acquired in mitigation as follows:

(1) Thirty-four hundred acres in Oklahoma for the 10,000-man-day loss above Fulton, Arkansas, as part of a 5,000-acre tract for mitigating project-occasioned wildlife damages for the proposed Sherwood Reservoir as well.

(2) Three hundred and forty acres for the 1,400-man-day loss in Arkansas below Fulton, as part of a 2,000-acre greentree reservoir development in the Sulphur River bottoms in Arkansas. The entire tract would mitigate project-induced wildlife damage for both this project and the Bayou Dorcheat Reservoir.

(3) Four hundred and sixty acres at Soda Lake Game Management Area for the 2,100-man-day loss in Louisiana, as part of a 530-acre development for mitigation of wildlife losses for this project and the replacement of Caddo Dam.

(4) Two hundred and sixty acres for the 800-man-day loss in Texas, as part of a 2,000-acre greentree reservoir development in the Sulphur River bottoms just below Texarkana Dam which will mitigate project-induced losses for the proposed Titus County Reservoir and Caddo Lake Enlargement as well.

As presented in the referenced interim report, the plan does not include the mitigation measures listed above. Action should be taken to obtain necessary authority for these measures.

43. IMPROVEMENTS FOR FISH AND WILDLIFE AND RECREATION

The improvements listed below are included specifically for fish and wildlife and recreation and are in addition to features to be realized in connection with construction of the various structural measures included in the plan. These proposed improvements can be accomplished by the respective State conservation agencies through current State-Federal cost-sharing programs.

a. Stream preservation. To perpetuate high quality stream fishing and to maintain diversity in the type of fishing waters in the basin study area, it is important that certain streams be preserved in their natural state. Streams provide species of fish, such as smallmouth bass and rock bass, that may not be adaptable to impounded waters. Streams provide opportunities for float fishing and wade fishing in areas of great natural beauty. To insure the continuation of stream fishing in the future, the following stream segments are proposed for preservation (see plate 2):

(1) Mountain Fork River in Polk County, Arkansas - about 15 miles of stream; and, on the same river below Broken Bow re-regulating dam downstream to Little River in McCurtain County, about 11 miles for a total of about 26 miles.

(2) Cossatot River in Howard and Polk Counties, Arkansas, upstream from Gillham Reservoir - about 60 miles of stream.

(3) Little River in Sevier County, Arkansas, and McCurtain and Pushmåtaha Counties, Oklahoma, upstream from Millwood Reservoir - about 138 miles of stream.

(4) Rolling Fork River above DeQueen Reservoir in Polk County - about 25 miles of stream.

(5) Saline River in Howard and Polk Counties, Arkansas, upstream from Dierks Reservoir - about 25 miles of streams.

(6) Bayou Bodcau in Lafayette County, Arkansas, and Bossier-Webster Parishes in Louisiana upstream from the Bodcau Reservoir damsite - about 57 miles of stream.

(7) Bayou Dorcheat in Webster Parish, Louisiana, and Columbia County, Arkansas, upstream from Lake Bistineau to the Dorcheat Reservoir damsite - about 55 miles of stream.

(8) Saline Bayou in Bienville, Winn, and Natchitoches Parishes, Louisiana, upstream from Saline Lake - about 60 miles of stream.

(9) Black Lake Bayou in Red River, Natchitoches, and Bienville Parishes, Louisiana, upstream from Black Lake - about 70 miles of stream.

(10) Muddy Boggy Creek in Choctaw County, Oklahoma, from the mouth of Red River upstream to near Unger, Oklahoma - 16 miles of stream.

(11) Kiamichi River in Choctaw and Pushmataha Counties, Oklahoma, from the mouth at Red River upstream to near Sawyer, Oklahoma (20 miles) and from near Tushahoma Reservoir downstream to near Antlers (29 miles) - total of 49 miles.

(12) Blue River in Johnston County, Oklahoma, from near Milburn upstream for 20 miles.

(13) Glover Creek in McCurtain County, Oklahoma, from State Highway 3 downstream to its confluence with Little River for a distance of 10 stream miles.

(14) Black Fork Creek in Pushmataha County, Oklahoma, from its junction with Little River upstream for 21 miles.

b. Stream access developments. To provide for full utilization of the Red River main stem and tributary streams, including the stream segments designated for preservation, a program of access developments is proposed for the basin study area. The type of access developments on Red River and the flatland tributaries would consist of parking areas, boat-launching ramps, and other appropriate facilities. In the upland areas, parking facilities and provisions for stream-fishermen access are planned.

The number of access sites planned is as follows: 11 sites on the Red River main stem, 90 sites on streams designated for preservation, and 9 sites on other tributary streams in the basin.

c. Land acquisition and associated developments for wildlife. The proposed acquisition and development of additional wildlife lands would supplement existing public hunting areas in the Red River Basin. Management of these areas by respective State conservation agencies and the Bureau of Sport Fisheries and Wildlife would insure the preservation and proper utilization of the wildlife resources involved. The following developments are planned:

(1) Acquisition of 1,000 acres in Sevier County and 1,000 acres in Howard County, adjacent to Millwood Reservoir. This acreage would be developed for both big game and upland game management and hunting.

(2) Acquisition and management of 2,000 acres of land as an addition to Bois d'Arc Game Management Area in Arkansas.

(3) Acquisition and management of the 30,000 acres of land comprising the Corps of Engineers flood easement on Sulphur River between the Arkansas-Texas State line and the Red River in Arkansas.

(4) A 13,000-acre public hunting area on Red River below Shreveport, Louisiana.

(5) A 500-acre greentree reservoir area on Savage and Iatt Creeks in Grant Parish, Louisiana.

(6) Two 500-acre greentree developments on the existing Saline Game Management Area in LaSalle and Catahoula Parishes, Louisiana.

(7) Acquisition and development of a 30,000-acre wildlife management and public hunting area between Saline Lake and Red River in Avoyelles Parish, Louisiana.

(8) The construction of an earthen dam and water-control gate above the present waterfowl-management dam on Bayou Bodcau to develop an additional 2,000-acre greentree area.

(9) The construction of three low-water weirs in Bayou Pierre - one each in Caddo, DeSoto, and Natchitoches Parishes.

d. Preservation of unique fish and wildlife habitat. Several species of fish and wildlife in the Red River Basin are at least partially dependent upon the preservation of certain habitat types. The type of habitat involved is now in short supply in the basin and can be expected to decline further in future years. In addition to protecting certain species of fish and wildlife, the areas also have high esthetic values. The following areas are proposed for preservation:

(1) The "Shutins" area on the upper Cossatot River in Arkansas: This remote area of primative character contains steep bluffs that provide views of falls and rapids in the stream below. Fish and wildlife thrive in a sylvan setting of natural beauty. This area borders, and would compliment, the segment of the Cossatot River designated for preservation in the comprehensive plan.

(2) Grassy Lake in Hempstead County, Arkansas: This lake, having a surface area of about 3,000 acres, harbors a native population of alligators, various waterfowl, and many other forms of aquatic fauna and flora. Prior to construction of Denison Dam, on the Red River, this lake frequently received overflow or floodwaters of a turbid nature from the Red River. This turbid water prevented sunlight penetration and therefore retarded growth of aquatic vegetation in the lake. With Denison Dam in place, the frequency of flooding, or provision of overflow water, has been significantly reduced. The waters supplied to the lake are also much less turbid than floodwaters. Vegetation has started to grow in the lake, and if permitted to continue, will alter the ecology of the lake and result in loss of many aquatic forms of fauna and flora.

Diversion of waters from nearby streams into Grassy Lake has been ineffective in preserving the ecology of the lake because these waters have lacked the needed turbidity.

Studies are needed to determine if naturally turbid floodwaters from Millwood Reservoir, Yellow Creek, or other drainage areas could be introduced into Grassy Lake to restore and maintain the ecology of the lake. These studies should include investigation of the alternative of producing turbidity in water by addition of clays or other substances. Additionally these studies should determine the optimum timing, magnitude, and duration of waters needed.

(3) The Beavers Bend State Park area in Oklahoma: This 1,260-acre park and the surrounding terrain are vegetated with stands of virgin pine and hardwoods. The Mountain Fork River flows through this area. Access to the many unique opportunities for wildlife-oriented recreation is excellent.

(4) The McCurtain County Game Refuge in Oklahoma: This area, containing more than 14,000 acres and including 10 surface acres of water, provides unusual opportunities for nature study, wildlife observation and study, and sightseeing.

(5) Lands bordering the Blue River from Milburn, Oklahoma, upstream for 20 miles: The preservation of these lands would compliment the Blue River Fishing Project sponsored by the Oklahoma Department of Wildlife Conservation. This scenic reach of river recently provided more than 500 man-days of fishing in a single mile.

e. Access developments on existing lakes and reservoirs. Additional access and related facilities on existing water areas in Louisiana are needed to insure optimum utilization by fishermen and hunters. The developments would consist of parking areas, boat-launching ramps, and appropriate facilities, except on Bayou Pierre where bank access is anticipated.

(1) Saline Lake - 6 sites;

(2) Black Lake - 8 sites;

(3) Clear Lake - 6 sites;

(4) Iatt Lake - 8 sites;

(5) Nantachie Lake - 6 sites;

(6) Cotile Lake - 5 sites;

(7) Valentine Lake - 6 sites;

(8) Sibley Lake - 6 sites;

(9) Larto Lake - 2 sites;

(10) Grassy Lake - 1 site;

(11) Several small lakes along Red River below Pineville - 1 site each;

(12) Access to each of the three weirs proposed in Bayou Pierre.

f. Expansion of existing recreation facilities. Existing parks and recreational areas should be expanded to meet needs as indicated by visitation. Emphasis should be directed toward full utilization of the resources, without detracting from the natural beauty. Additional city-park type recreational areas are needed to satisfy existing and estimated future urban demands. Basin municipalities should be alert to the opportunities which will be offered by certain of the structural measures included in the comprehensive plan.

44. NONSTRUCTURAL MEASURES

In addition to the nonstructural measures in the interest of recreation and fish and wildlife, as described in the preceding paragraph, the early-action plan includes the following:

a. Flood plain management. Flood plain information reports are currently being prepared by the Corps of Engineers for Sulphur Springs, Texas, and Sherman, Texas. Preparation of such reports for other areas where significant flood hazards exist should be accomplished as rapidly as practicable. The comprehensive plan recognizes the essential need to exploit the opportunities for reducing flood losses offered by full utilization of information on flood hazard, and the application of sound management principles, including regulation of use and flood proofing, in areas with significant flood hazards. The plan encourages local action in this regard.

b. Area preservation. Aspects of the comprehensive plan relating to fish and wildlife habitat and outdoor recreation are covered in paragraph 43 of this appendix. The need for preservation encompasses other aspects, however, and the plan must be addressed to the preservation of areas of historical, cultural, or scientific interest. The plan accordingly identifies the following additional areas for preservation, either permanently, or pending completion of archeological or other scientific studies.

(1) The Rich Mountain Area in Polk County, Arkansas. This area receives in excess of 60 inches of rain per year and qualifies as a true rain forest. It harbors one of the richest floral associations in temperate North America, and is the home of two species of salamanders which do not occur anywhere else.

(2) An area of 4,000 acres of short-leafed, mostly virgin timber, pine hardwood in the Ouachita Mountains in the Mena Ranger District, Ouachita National Forest, Polk County, Arkansas. The area is roadless and is currently being maintained in an undisturbed condition except for the provision of necessary protection against insect epidemic and fire.

(3) An area of 80 acres in the Winn Ranger District, Kisatchie National Forest, Louisiana. The area supports a stand of very old second growth loblolly pine of 30,000 board feet per acre, and is, in all, a most unique vegetative complex. It is being maintained in an undisturbed condition.

(4) Numerous other sites in the State of Louisiana. Other sites warranting preservation in Louisiana are catalogued in a report entitled "The Comprehensive Plan for the State of Louisiana." The report is available in the offices of the Department of Public Works of that State.

(5) The Skyline or Talimena Drive located within the Ouachita National Forest in LeFlore County, Oklahoma, and the area contiguous thereto. The hard-surfaced road (State Route 98) traverses the Winding Stair Mountains and offers panoramic views from many locations.

(6) La Harpe's 1719 Trading Post in Bowie County, Texas. The site's general vicinity is known; however, the trading post itself has not been located. The site has tremendous potential for historians of French trading in Texas, for archeologists, and should yield a wealth of valuable information. The post could be reconstructed and with appropriate interpretive exhibits would be a fine tourist attraction.

(7) Hatchel Mound in Bowie County, Texas. The site has an impcsing mound over 25 feet high. Excavations nearby in a cemetery have produced a great deal of important archeological material. The mound could be stabilized; more work could be done in the cemetery; opened graves could be roofed over and protected; and with appropriate interpretive data could offer an attractive tourist spot.

(8) First Townsite of Paris in Red River County, Texas. Abandoned in 1844, this site has a great potential for yielding important historical and archeological data. A period reconstruction of the townsite with museum and appropriate concessions would have tremendous tourist potential.

(9) Jonesborough and Pecan Point in Red River County, Texas. Both are early Anglo-American settlements in north Texas. They should be treated similarly to Old Parish and have the same archeological and tourist potential.

(10) Kiomatia Site in Red River County, Texas. A large Caddoan mound site north of Kiomatia. Four large rectangular mounds are present and in a good state of preservation. Adjacent cemeteries and burial areas are in cultivation. The site comprises several hundred acres and has a vast archeological potential. A "mound park" would also be appropriate here.

(11) Sam Kaufman Site in Red River County, Texas. At present, two mounds are being excavated at the site. One has a shaft burial pit which contained 11 burials and a large quantity of important archeological material and information. There are 375 known sites in Red River County, and a number of large mound sites with a similar potential are scattered along the river and as far as 2 miles from it.

(12) Womac Site in Lamar County, Texas. An important historic Wichita Indian village. Limited archeological work here has brought to light important information about Indian trade. A number of European trade items were recovered. There is much more to be done at the Womac Site to fill gaps in our knowledge of Indian-early European trade relationships in north Texas.

(13) Sanders Site in Lamar County, Texas. An important early Caddoan mound (2), burial, and village site. While some excavation has taken place at the site, much more needs to be done. Because of its archeological potential and the size of the mounds, a "mound park" would also be appropriate here.

c. Other. Other nonstructural features included in the comprehensive plan, not requiring elucidation in this section, are listed in paragraph 37.

LONG-RANGE PLAN OF DEVELOPMENT

45. GENERAL

As previously mentioned, the Framework Plan includes all existing, authorized, and proposed projects for water and related land resource development in the basin. The existing, authorized, and proposed early-action projects have been outlined in previous paragraphs of this appendix. The remaining projects in the Framework Plan are those that would be needed in the future (to 2080) to satisfy water and land resource development needs. This section presents the structural features of the long-range plan of development. Nonstructural measures previously described are of a continuing nature and are equally pertinent to the early-action and long-range programs.

46. MAJOR RESERVOIR IMPROVEMENTS

a. New reservoirs.

(1) Tupelo Reservoir on Clear Boggy Creek, Oklahoma, would include storage for flood control and water supply. This site offers a good potential for recreation as well as full development of the stream yield. The Soil Conservation Service has an authorized program which will meet most of the present flood control needs of the basin. This reservoir could be developed in conjunction with a reallocation of storage in Boswell Reservoir.

(2) Chickasaw Reservoir on Chickasaw Creek, Oklahoma, would include water supply and flood control storage. The water in this stream is of excellent quality. Recreation and fish and wildlife would also be enhanced.

(3) Buck Creek Reservoir in Oklahoma would include storage for flood control, hydropower, and water supply. The reservoir has excellent recreational and fish and wildlife potential and would aid in obtaining the maximum yield of the Kiamichi River Basin.

(4) Kellond Reservoir on Tenmile Creek in Oklahoma would include flood control, water supply, and recreation. This project would be a part of the basin development to attain the maximum yield of the Kiamichi River Basin.

(5) Finley Reservoir on Cedar Creek in Oklahoma would include flood control and conservation storage. The water of Cedar Creek is of excellent quality. This project offers excellent recreational and fish and wildlife potential. Finley Reservoir also would aid in developing the maximum water resources of the Kiamichi River.

(6) Upper Antlers Reservoir on Kiamichi River in Oklahoma would provide for maximum development of hydropower and would include flood control as a project purpose. Recreation and fish and wildlife would be developed. Upper Antlers Reservoir would aid in developing the maximum hydropower potential of the Kiamichi River Basin.

(7) Caney Mountain Reservoir on Little River in Oklahoma was studied to develop, in conjunction with the Pine Creek Reservoir, the maximum potential yield of the upper Little River. The Caney Mountain Reservoir and the Pine Creek Reservoir, with a reallocation of storages, would provide the present authorized flood protection and would also provide for future water supply and hydropower development. The water in the Little River is of excellent quality. The Caney Mountain Reservoir also offers excellent recreational and fish and wildlife potential.

(8) Mena Reservoir on Mountain Fork River in Arkansas would have flood control, municipal and industrial water supply, recreation, and fish and wildlife as project purposes. The water in Mountain Fork River is excellent for municipal and industrial use.

(9) Hartley Reservoir on Cossatot River in Arkansas, in conjunction with Gillham Reservoir, would fully develop the water resources of the basin. Flood control, recreation, and conservation storages for water supply would be provided. Hartley and Gillham Reservoirs in combination could provide the same flood protection downstream of Gillham on the Cossatot River as in the authorized project.

(10) Acworth Reservoir on Collier Creek in Texas would provide for the major purposes of flood control, water supply, recreation, and fish and wildlife.

(11) Pine Springs Reservoir on Mill Creek in Texas offers an excellent potential for flood control, water supply, recreation, and fish and wildlife. The water is of good to excellent quality.

(12) New Zion Reservoir site on Red Bayou in Texas provides excellent potential for water supply storage. Flood control storage would also be used to protect crop lands downstream to the mouth of Red Bayou. Recreation and fish and wildlife would be enhanced.

(13) Marshall Reservoir on Little Cypress Creek in Texas has excellent storage characteristics and could yield as much as 300 m.g.d. if developed to full potential. This reservoir is included in the Texas Water Plan as a source of water for the Marshall, Texas, area.

(14) Black Bayou Reservoir. The authorized Black Bayou Reservoir has never been constructed and, at this time, it lacks economic justification. As flood control requirements increase in the future, this reservoir is expected to become economically justified. The single-purpose reservoir would contain 33,800 acre-feet of storage for flood control. If future development of this reservoir should prove infeasible, the channel enlargement and diversion channel plans discussed in paragraph 21.b.(21)(a) could be substituted for it.

b. Reservoir modifications.

(1) Hugo Reservoir. The abundance of flow in Kiamichi River and the physical setting of Hugo Dam offers potential for the installation of a conventional hydroelectric power plant. Preliminary studies indicated that 50,000 kw installed capacity at an average net head of 74.5 feet could be supported at this site. The flood control storage in Hugo Reservoir would be reallocated to the Kiamichi River system of reservoirs to provide power storage. In addition, construction of a forebay providing storage of 16,000 acre-feet would permit the installation of a pumped-storage hydroelectric project of 850 mw capacity. The net rated generating head would be 368 feet and the existing Hugo Reservoir would be utilized as an afterbay. This project would help meet a portion of the peaking power demand of the marketing area.

(2) Durant Reservoir. Both flow and head characteristics of the Durant damsite make this a potential site for the installation of a conventional hydroelectric power plant of 7,500 kw capacity. The benefit-cost ratio and the comparability ratio are less than unity at the present time, but the projected need of electrical capacity warrants the inclusion of hydroelectric power at Durant Dam in the long-range plan.

(3) Pine Creek Reservoir. The Pine Creek Dam and Reservoir is under construction on the Little River in McCurtain County, Oklahoma. Sufficient conservation storage has been provided in the project to furnish a dependable yield of 120 m.g.d. for the initial water supply needs of the area. In the future, the conservation storage could be increased to yield 160 m.g.d. for water supply by the addition of gates on the crest of the uncontrolled spillway while maintaining the same flood control storage. Conventional hydroelectric power development at the reservoir is warranted by the ample head available and the quantity of flow in Little River. The Pine Creek Dam could support an installation of 86,000 kw capacity.

(4) Lukfata Reservoir. Glover Creek has adequate flow and the physical characteristics of Lukfata damsite would permit a conventional hydroelectric installation of 32,000 kw capacity

at 185 feet maximum net head. The comparability ratio does not warrant installation of power generating facilities at this time.

(5) Dierks Reservoir. Dierks Dam and Reservoir is presently under construction on the Saline River in Sevier and Howard Counties, Arkansas. Storage for water supply would yield 19 m.g.d. for the area needs as presently planned in the project. By future modification of the spillway, the conservation storage could be enlarged to provide storage for water supply that would yield 40 m.g.d. The maximum net head of 132 feet and adequate flow at the Dierks damsite would support a conventional hydroelectric plant of 13,500 kw capacity.

(6) De Queen Reservoir. The De Queen Dam and Reservoir is under construction on the Rolling Fork River in Sevier County, Arkansas. The project as presently planned will provide storage for water supply yielding 32 m.g.d. By future modification of the spillway, the conservation storage of the project could be enlarged to provide additional storage for water supply yielding 75 m.g.d. Adequate flow and available head at De Queen damsite offer the potential for installation of a conventional hydroelectric plant.

(7) Gillham Reservoir. Gillham Dam and Reservoir is under construction on the Cossatot River in Howard and Polk Counties, Arkansas, and contains conservation storage that would provide a dependable yield of 60 m.g.d. for water supply. The project could be modified in the future by a reallocation of storages, giving less storage to flood control and more to water supply. The loss in flood control storage could be compensated for by channel improvement on the Cossatot River or by transfer of flood control storage to the upstream Hartley Reservoir. The project would be adaptable to the installation of a conventional power plant. Pumped storage, with the authorized Gillham Reservoir as an afterbay, also is feasible at this site. Installed capacity could be 380 mw at a net rated generating head of 327 feet.

(8) Sherwood Reservoir. A 10,000 acre-foot forebay reservoir adjoining Sherwood Reservoir would permit an installed capacity of 1,000 mw at a net rated generating head of 718 feet. Sherwood heservoir would be utilized as an afterbay.

(9) Clayton Reservoir. Installed capacity of 1,000 mw at a net rated generating head of 915 feet would be feasible at the Clayton Pumped-Storage Hydroelectric Plant. Maximum storage in the forebay would be 8,900 acre-feet, and Clayton Reservoir would be utilized as an afterbay. Six hours generation, with an approximate 10 percent reserve, would be possible.

(10) Broken Bow Reservoir. A forebay storing 10,400 acre-feet would permit an installed capacity of 700 mw at a rated

net generating head of 465 feet. The afterbay would be the authorized Broken Bow Reservoir.

(11) Millwood Reservoir. This completed project has storage yielding 265 m.g.d. for water supply purposes. In the future, additional flood control structures may be constructed upstream on the Little River. At that time, the conservation storage could be increased by using a part of the flood control storage. Preliminary studies indicate that the conservation yield could be increased from 265 m.g.d. to 466 m.g.d. without reducing the flood protection downstream of Millwood Reservoir.

(12) Bayou Bodcau Reservoir. This existing project is for flood control only and has no permanent pool. Future water development needs in the Bayou Bodcau Basin include water supply, water quality control, and recreation. The existing reservoir could be enlarged to provide sufficient water to satisfy these needs.

47. LOCAL FLOOD PROTECTION PROJECTS

Certain proposed local flood protection projects on numerous streams in the basin would not produce sufficient benefits to warrant their construction at this time. However, due to the anticipated increase in agricultural development and expansion of urban areas it is expected that many of these projects would become economically justified over the 100-year study period. They are, therefore, included in the long-range plan of development and are outlined below. Additional information on these projects can be found in appendix IV, "Flood Control and Major Drainage."

a. Brown Creek Channel Improvement, Oklahoma. Channel improvement was authorized for Brown Creek, a north bank tributary of Red River at mile 492, in 1955; however, local interests would not furnish the required rights-of-way for diversion to the Red River and the project was subsequently deauthorized in 1962. Local people state that the flood problem still exists and they would like to see the problem solved by enlargement of the existing Brown Creek channel.

b. Brush Bayou Channel Improvement, Louisiana. Continued expansion of the City of Shreveport, Louisiana, is expected to necessitate enlarging the Brush Bayou channel to reduce the flood hazard. Information which indicates that this project may be justified for inclusion in the early-action program has recently become available. Studies are now being made under the continuing authority of Section 205 of the Flood Control Act of 1962 to determine if this project should be constructed within the next 10-15 years.

c. Cane River Island Pumping Plant, Louisiana. Interior drainage on Cane River Island discharges into Cane River through gated gravity drainage structures. During periods of high stages on Cane River, these gates must be closed and flooding due to impounded local runoff results. The most practicable solution to this flood problem would be the installation of pumping facilities to evacuate this impounded runoff.

d. Campti-Clarence Area Pumping Plant, Louisiana. Flood problems along Bayou Chevreuille are small at this time. However, pressures for additional agricultural development in the alluvial bottom lands in the area are great and are expected to result in the conversion of about 2,000 acres of woodland over the 100-year study period. To maximize the productivity of these lands, it will be necessary to install pumping facilities to discharge the interior drainage into the Red River when river stages do not permit use of the existing gravity drainage structures.

e. East Point Area Pumping Plant, Louisiana. Flood problems in this area are similar in nature to those of Cane River Island and the Campti-Clarence Area and result from high stages on Red River precluding the use of existing drainage works. Intensified agricultural cultivation of the fertile alluvial bottom lands along Coushatta Bayou should be sufficient to require construction of this project within the 100-year study period.

f. Flat River Pumping Plant, Louisiana. This improvement would be located on Flat River adjacent to Bossier City, Louisiana, It is expected that the increasing population of the city will require improved local drainage and installation of pumping facilities to protect this area. Possible alternatives to the pumping plant would include extensive channel improvement or upstream floodwater retarding structures.

g. Loggy Bayou-Red Chute Bayou Levees, Louisiana. The highly fertile lands along Loggy Bayou and the lower reaches of Bayou Bodcau will probably be brought into production in the future. The necessary protection could be furnished by loop levees along the west side of both Loggy Bayou and Bayou Bodcau.

h. McKinney Bayou Channel Improvement, Arkansas. Completed and proposed Federal projects will provide a high degree of flood protection to much of the land in the McKinney Bayou Basin. It is estimated, however, that additional protection will be needed on about 29,000 acres over the 100-year study period. Lowering stages on the Red River will provide partial relief to some of this land. Further protection could be accomplished by enlarging the existing outlet to the Red River. Other possible future projects include additional outlets to the Red River and the installation of pumping facilities.

i. Middle Bayou Levee, Louisiana. Flooding in this area results from headwater flows in Middle Bayou and McCain Creek, together with backwater from Twelvemile Bayou and Red River. Studies showed the most feasible means of protecting the area would be construction of about 10 miles of levees. Initial investigations determined that justification for the project was marginal at this time. Recently received information, however, indicates that the project may be economically justified for inclusion in the early-action plan. It is anticipated that further studies will be made under the authority of Section 205 of the Flood Control Act of 1962 to determine if this project is justified for early construction.

j. Bayou Pierre Levee and Pumping Plant, Louisiana. Lands along the lower reaches of this stream are flooded by backwater from the Red River. The most suitable plan to protect the area would consist of ring levees with gravity drainage structures to evacuate the local runoff. These improvements are expected to become economically justified before the middle of the 100-year study period. Subsequent development is anticipated to be sufficient to justify adding pumping facilities to the plan near the end of the study period.

k. Posten Bayou Channel Improvement, Louisiana. Existing and proposed early-action projects will offer protection to large areas of this basin. Some flood damages will continue to be experienced along the lower reaches of the stream. The stage lowering which would be produced by the recommended navigation and bank stabilization project will likely make it economically feasible to construct additional improvements to eliminate or reduce the residual damages. The most favorable plan appears to be the enlargement of the existing channel. Pumping facilities, headwater detention reservoirs, and a diversion channel all are considered as possible alternatives to the long-range channel improvement plan.

l. Rapides Island Pumping Plant, Louisiana. Drainage of the island is effected by two means: pumping into Red River and diversion into the Bayou Cocodrie system. The latter method can be used only when flows in the Bayou Cocodrie system are not high. When this system cannot be utilized, the presently installed pumping facilities are of insufficient capacity to prevent flooding on the island. The only effective method to eliminate this flooding is the installation of additional pumps. Although not justified at this time, it is expected that increased residential development will support construction of these improvements early in the study period.

m. Twelvemile Bayou Pumping Plant, Louisiana. Flood problems in the upper Caddo Levee District along Twelvemile Bayou derive from both headwater floodflows and from high backwater stages from the Red River. This area is located near the City of Shreveport, Louisiana, and urban development toward this area is anticipated. The

only practicable solution to the flood problem would be the installation of pumps to drain the runoff impounded when floodgates must be closed due to high stages in the Red River.

48. NAVIGATION PROJECT

By 2020 basin development will warrant the extension of navigation on Red River from Shreveport to Denison Dam.

49. UPSTREAM WATERSHED IMPROVEMENTS

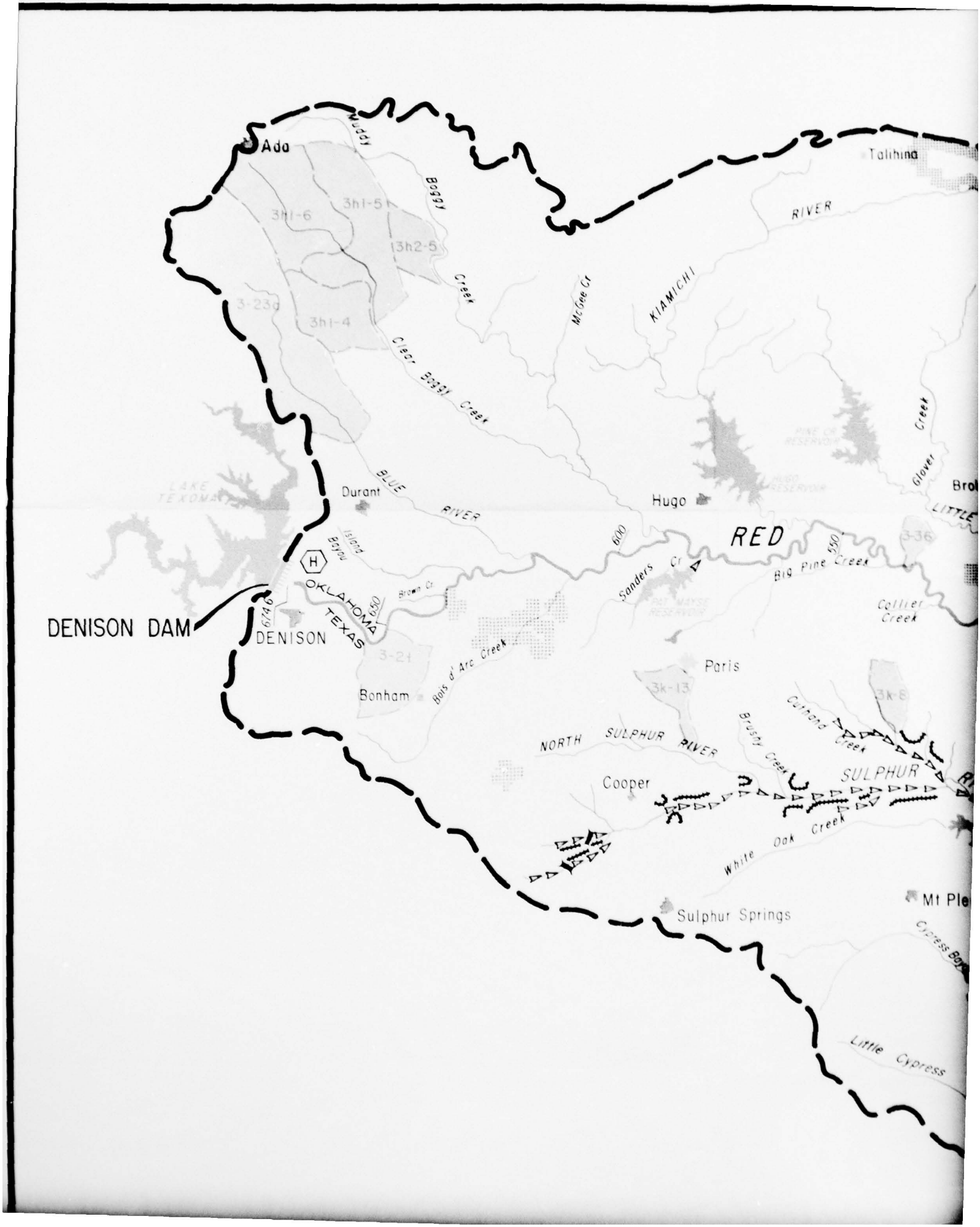
Structural measures in upstream watersheds proposed for long-range development would include 78 upstream reservoirs and 30 miles of channel improvement. Five upstream watersheds would include flood prevention as a project purpose. Single-purpose reservoirs located in 40 upstream watersheds would include recreation, municipal and industrial water supply, and irrigation. Pertinent structural data for this program are summarized in table 33.

TABLE 33

UPSTREAM WATERSHED PROJECTS IN LONG-RANGE PLAN
PERTINENT STRUCTURAL SUMMARY DATA

	Watershed Projects	Watershed Area (sq. mi.)	Drainage Area above Structure (sq. mi.)	Structural Measures: Reservoirs (number)	Structural Measures: Channels (miles)	Reservoir Pool Capacity (acre-feet): Detention	Sediment	Recreation	Mun. & Ind.	Irrigation	Surface Area (acres)
3-30	Sanders Creek	184	53.0	12	6.3	18,120	10,780	18,000	0	0	2,090
3-33	Pine Creek	186	5.6	1	0	0	300	5,970	0	0	500
3-22	Island Bayou	334	49.9	5	0	0	4,000	0	0	30,500	2,030
3-26	Whitegrass Creek	113	34.0	5	0	11,390	1,860	0	0	0	220
3j-2	Lower Little River Laterals	116	0	0	8.0	0	0	0	0	0	0
3k-15	Morgan Creek	15	11.0	4	0	3,800	2,280	0	0	0	220
3k-17	South Sulphur Rv. Mid. & Pecan Creeks	211	9.5	1	0	0	510	3,450	0	0	510
3-57a	Lower Posten Bayou	69	10.4	2	16.0	1,950	410	280	0	10,000	
3-24	Fannin Laterals	113	6.0	1	0	0	320	3,450	0	0	320
3-27a	Upper Slough Creek	50	14.6	1	0	0	790	0	0	11,400	760
3-42	Pecan Bayou	381	115.3	4	0	0	4,200	9,600	0	67,900	5,800
3-32	Choctaw Laterals	116	11.2	1	0	0	910	0	0	8,700	650
3-37	Perry Creek	37	21.0	1	0	0	730	0	0	23,100	1,680
3i-1	Lower Kiamichi	440	7.1	1	0	0	380	2,570	0	0	250
3j-15	Lower Rolling Fork	192	10.6	1	0	0	450	12,100	0	0	900
3j1-4	Upper Mountain	121	16.5	1	0	0	700	4,800	0	0	410
3-55	Beech Creek	57	35.3	1	0	0	1,940	0	0	21,900	1,680
3k-16	South Sulphur Laterals	132	11.8	1	0	0	630	4,010	0	0	380
3k-1	Lower Sulphur River	285	33.5	1	0	0	1,430	23,000	0	0	1,600
3k-4	Anderson Creek	386	4.6	1	0	0	250	4,000	0	0	370
3k1-1	Lower White Oak Bayou	389	6.0	1	0	0	320	5,800	0	0	480
3k1-2a	White Oak Bayou	216	56.5	2	0	0	3,020	20,130	0	0	1,520
3L-3	Kelly-Black Bayous	178	26.6	1	0	0	1,460	0	0	22,400	1,680
3L-4	Black Bayou	208	28.5	1	0	0	1,520	23,480	0	0	1,680
3L-8	Upper Frazier Creek	140	44.8	1	0	0	2,390	22,610	0	0	1,680
3L1-1	Little Cypress	386	29.5	2	0	0	2,100	18,800	0	0	1,400
3L1-2	Lilly Creek	388	38.8	2	0	0	2,010	23,200	0	0	1,740
3L1-3	Black Cypress	377	9.1	1	0	0	500	9,300	0	0	720
3L1-5	Middle Cypress	380	21.6	1	0	0	1,200	8,600	0	0	670
3L1-6	Upper Cypress	389	33.2	1	0	0	1,800	13,500	0	0	1,000
3m1-2	Middle Bayou Dorcheat Laterals	230	37.3	1	0	0	1,590	23,410	0	0	1,680
3m1-3	Cypress Creek	200	31.1	1	0	0	1,330	23,670	0	0	1,680
3m2(a)-2	Martin Creek	85	80.6	1	0	0	4,300	0	15,500	0	2,310
3m2(a)-5	Middle Bayou Bodcau	90	2.8	1	0	0	150	0	500	0	70
3m2(a)-7	Bodcau Creek	105	25.6	2	0	0	1,100	30,800	0	0	2,280
3-56	Maniece Bayou	115	5.8	1	0	0	250	5,250	0	0	440
3n-1	Jims River	230	87.5	4	0	0	3,700	80,500	0	0	5,860
3n-4	Bayou Pierre Laterals	371	42.0	2	0	0	1,810	13,000	8,440	0	2,330
3n-5	Wallace Bayou	357	54.0	2	0	0	2,300	39,700	0	0	2,830
3o1-2	Grand Bayou	174	42.0	2	0	0	1,810	23,470	1,700	0	1,850
3o-3	Upper Saline Bayou	212	10.4	1	0	0	300	17,200	0	0	1,210
3o1-4	Upper Black Lake Bayou	337	25.7	1	0	0	1,100	23,900	0	0	1,680
3-63	Wantachie Creek	84	7.3	1	0	0	320	0	1,000	0	130
	Total	9,153	1,207.6	78	30.3	35,260	69,310	517,550	27,140	195,900	58,150

XV-173


Ada
Muddy
Boggy
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3h1-5
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Clear Boggy Creek
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RIVER
Talihina
Creek
Glover
Durant
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RIVER
Hugo
RED
600
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Sanders Cr
Big Pine Creek
3-36
Collier Creek
Island Bayou
Brown Cr
OKLAHOMA
TEXAS
DENISON DAM
DENISON
3-21
Bois d'Arc Creek
Bonham
Paris
3k-13
3k-6
Cuthand Creek
NORTH SULPHUR RIVER
Brushy Creek
SULPHUR
Cooper
White Oak Creek
Sulphur Springs
Mt Ple
Cypress Bayou
Little Cypress

Talihina
RIVER
OKLAHOMA
ARKANSAS
Fork
Creek
Glover
Broken Bow
Mountain Fork
Rolling
COSSATOT
SALINE
RIVER
LITTLE RIVER
RED
RIVER
Big Pine Creek
Collier Creek
Walnut Bayou
Mill Creek
Mud Cr.
Red Bayou
Barkman Cr
Paris
Fulton
New Boston
Texarkana
Cuthand Creek
Brushy Creek
SULPHUR RIVER
White Oak Creek
Days Cr.
McKinney B
Maniece B
Bayou Bodcau
B Dorcheat
TEXAS
LOUISIANA
ARKANSAS
LOUISIANA
Posten B
Black Bayou
Cypress Bayou
Twelvemile Bayou
McCain Creek
Red Chute Bayou
LAKE BISTINEAU
Bayou Loggy
Black Lake Bayou
East Point
Coushatta
Mt Pleasant
Sulphur Springs
Daingerfield
Cypress Bayou
Black Cypress Bayou
Little Cypress Bayou
Jefferson
Marshall
SHREVEPORT
LAKE TEXARKANA
LAKE O' THE PINES
PINE CR. RESERVOIR
HUGO RESERVOIR
BROKEN BOW RESERVOIR
GILLHAM RESERVOIR
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DIERKS RESERVOIR
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BODCAU RESERVOIR
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Loggy Bayou
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Bayou Pierre
East Point
Black Lake
Bayou
Saline Bayou
Coushatta
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LAKE
Mansfield
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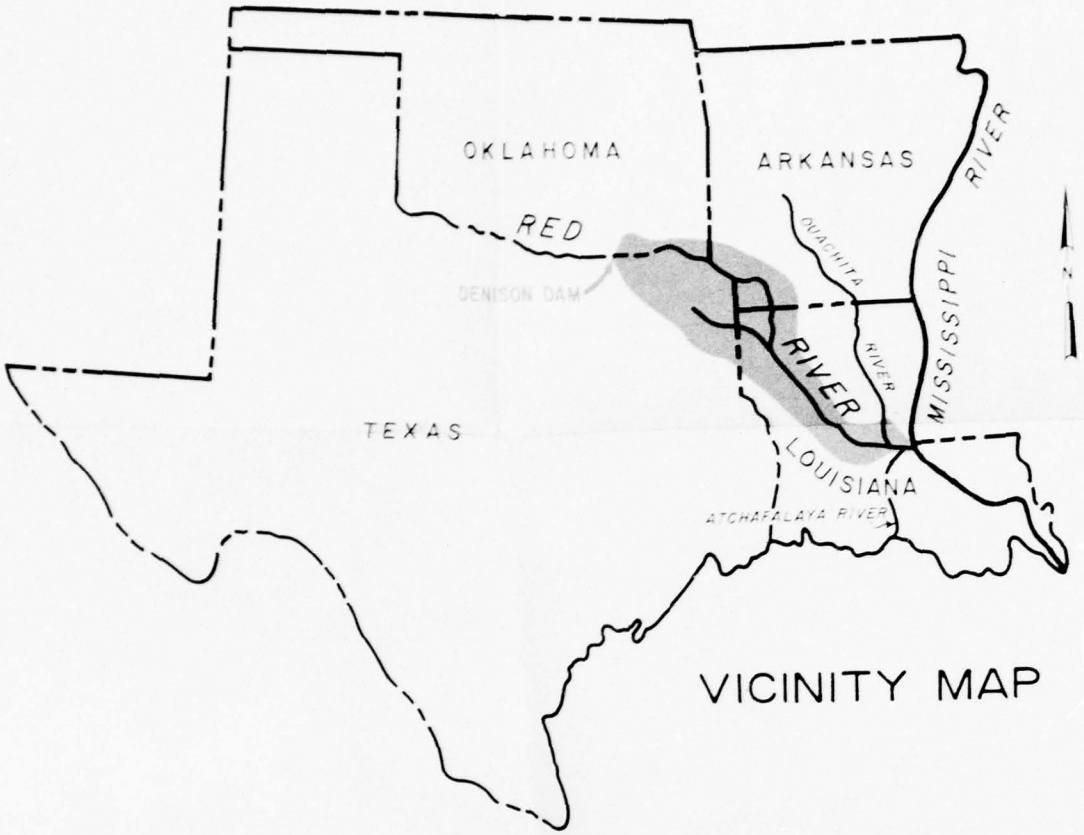
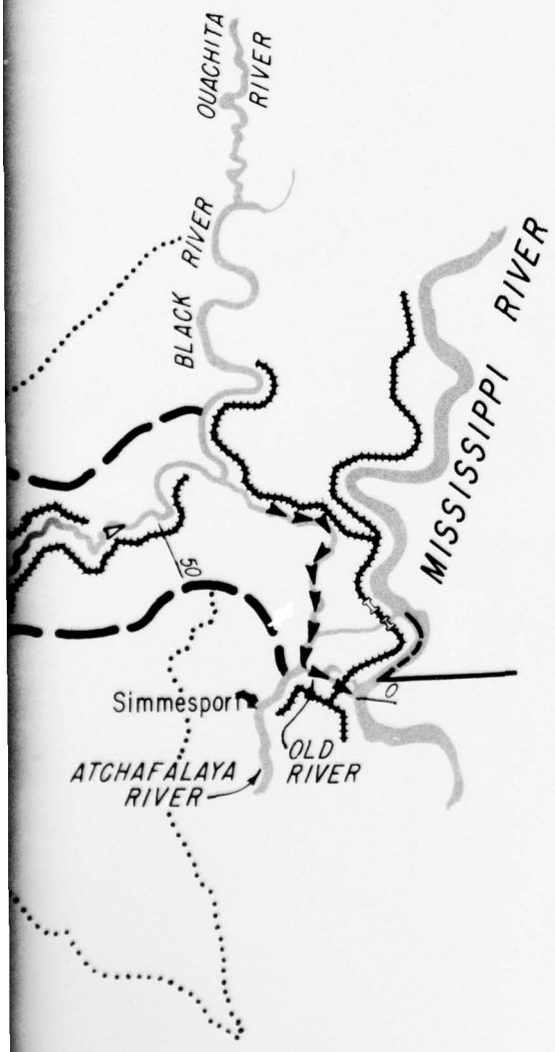


VICINITY MAP

LEGEND

- Reservoir
- Channel improvement
- Navigation
- (H) Hydroelectric power
- Levee
- National forest
- State boundary
- Basin boundary
- (2m2-1) CNI Watershed boundaries



Channel improvement

Navigation

Hydroelectric power

Levee

National forest

State boundary

Basin boundary

2m2-1 CNI Watershed boundaries

200 River mileage above mouth at Mississippi River - 1957

Limits of area external to the Red River Basin in which investigations were not conducted by all agencies.

Pumping station

NOTE: For the purposes of this report, all upstream watershed improvements authorized subsequent to 31 December 1962, regardless of their current state of completion, are considered to be features of the early action plan and are shown in red on plate 2.

RED RIVER BASIN BELOW DENISON DAM
ARK., LA., OKLA., AND TEXAS

COMPREHENSIVE BASIN STUDY

THE RECOMMENDED PLAN FEATURES EXISTING OR UNDER CONSTRUCTION

SCALE OF MILES

10 0 10 20 30 40 50 60

RED RIVER BASIN COORDINATING COMMITTEE

JUNE 1968

PROJECT OR PROGRAM	10-15 YEAR	LONG RANGE
Watershed protection, flood prevention and development		
Main stem or major tributary reservoir		
Conventional hydroelectric power	H	H
Pumped storage hydroelectric power	P	P
Pumping station		
Levee		
Channel improvement		
Navigation		
Stream preservation		

PROJECTS OR PROGRAM NOT SHOWN ON MAP	10-15 YEAR	LONG RANGE
U.S. Forest service recreation sites	X	–
Upper Antlers Reservoir	–	X
Fish and Wildlife Non-structural	X	X
Recreation Non-structural	X	X
Preservation Non-Structural	X	X

AD-A036 755 RED RIVER BASIN COORDINATING COMMITTEE NEW ORLEANS LA F/G 8/6
COMPREHENSIVE BASIN STUDY. RED RIVER BELOW DENISON DAM, ARKANSA--ETC(U)
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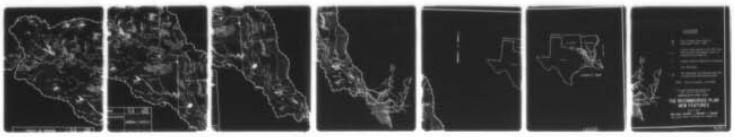

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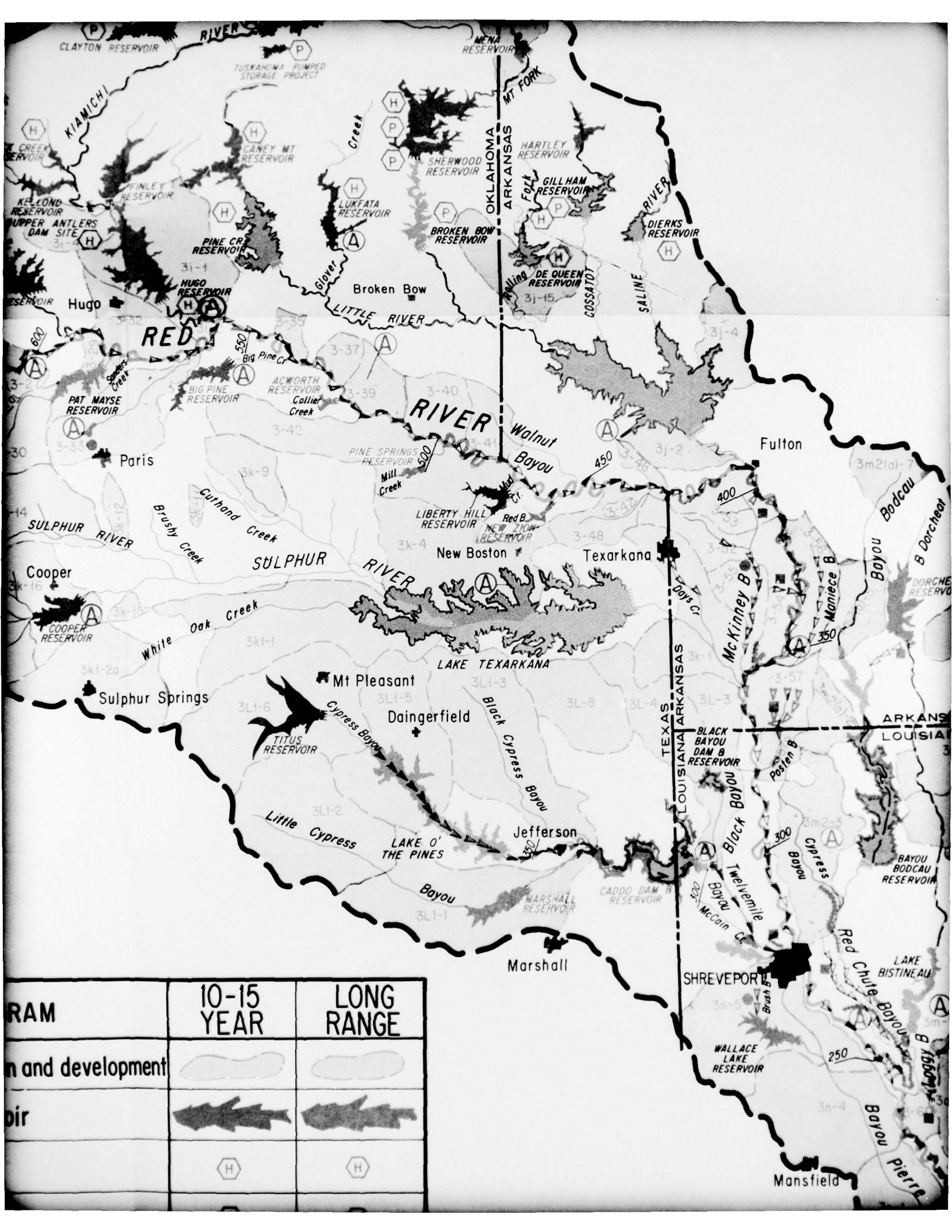
PROJECT OR PROGRAM	10-15 YEAR	LONG RANGE



RAM	10-15 YEAR	LONG RANGE
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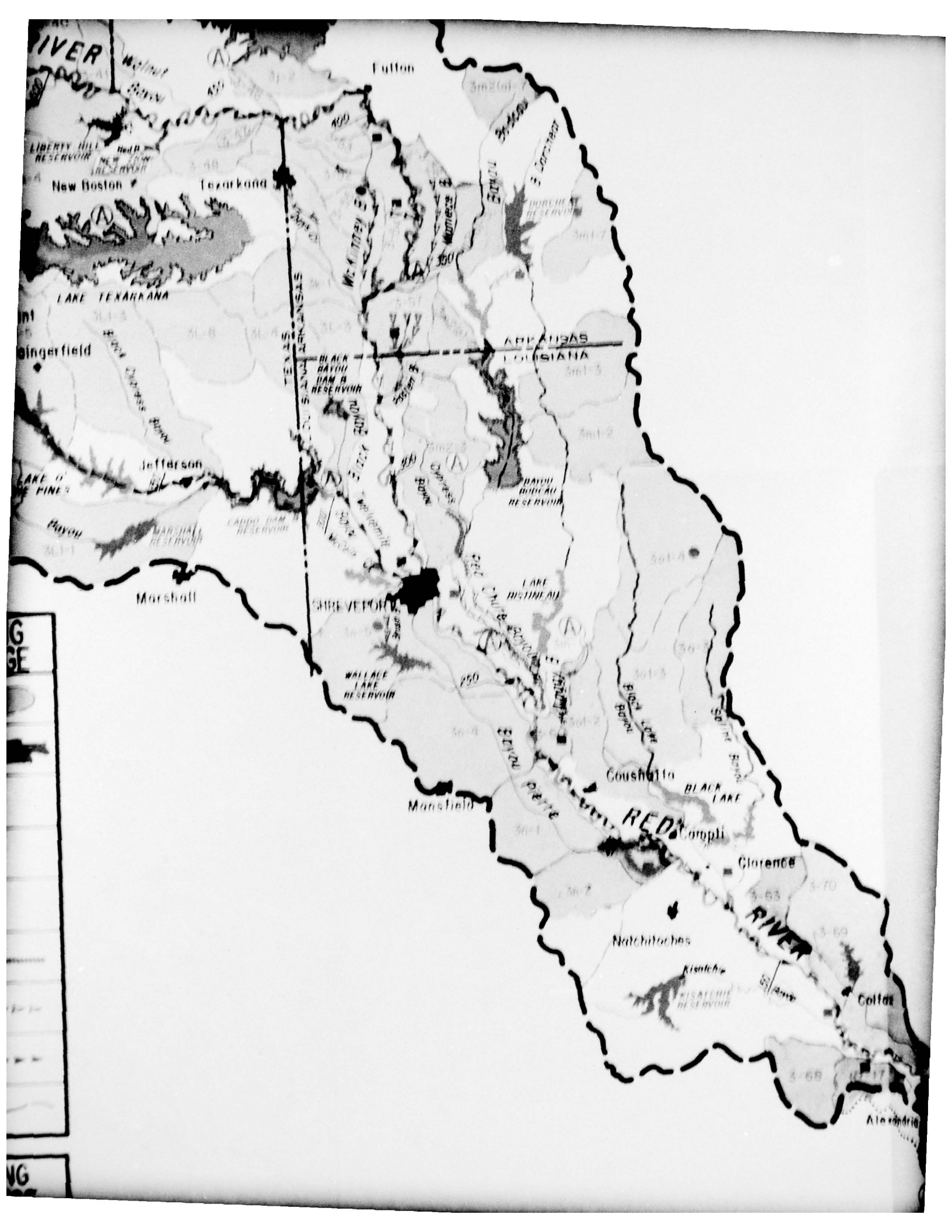
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Jefferson
Marshall
SHREVEPORT
Coushatta
Mansfield
Campti
Clarence
Natchitoches
Colfax
RED RIVER
ARKANSAS
LOUISIANA
LIBERTY HILL RESERVOIR
BLACK BAYOU DAM B RESERVOIR
BAYOU BODCAU RESERVOIR
LAKE BISTINEAU
WALLACE LAKE RESERVOIR
CADDO DAM B RESERVOIR
MARSHALL RESERVOIR
KISATCHIE RESERVOIR
BLACK LAKE
Alexandria

ARKANSAS
LOUISIANA
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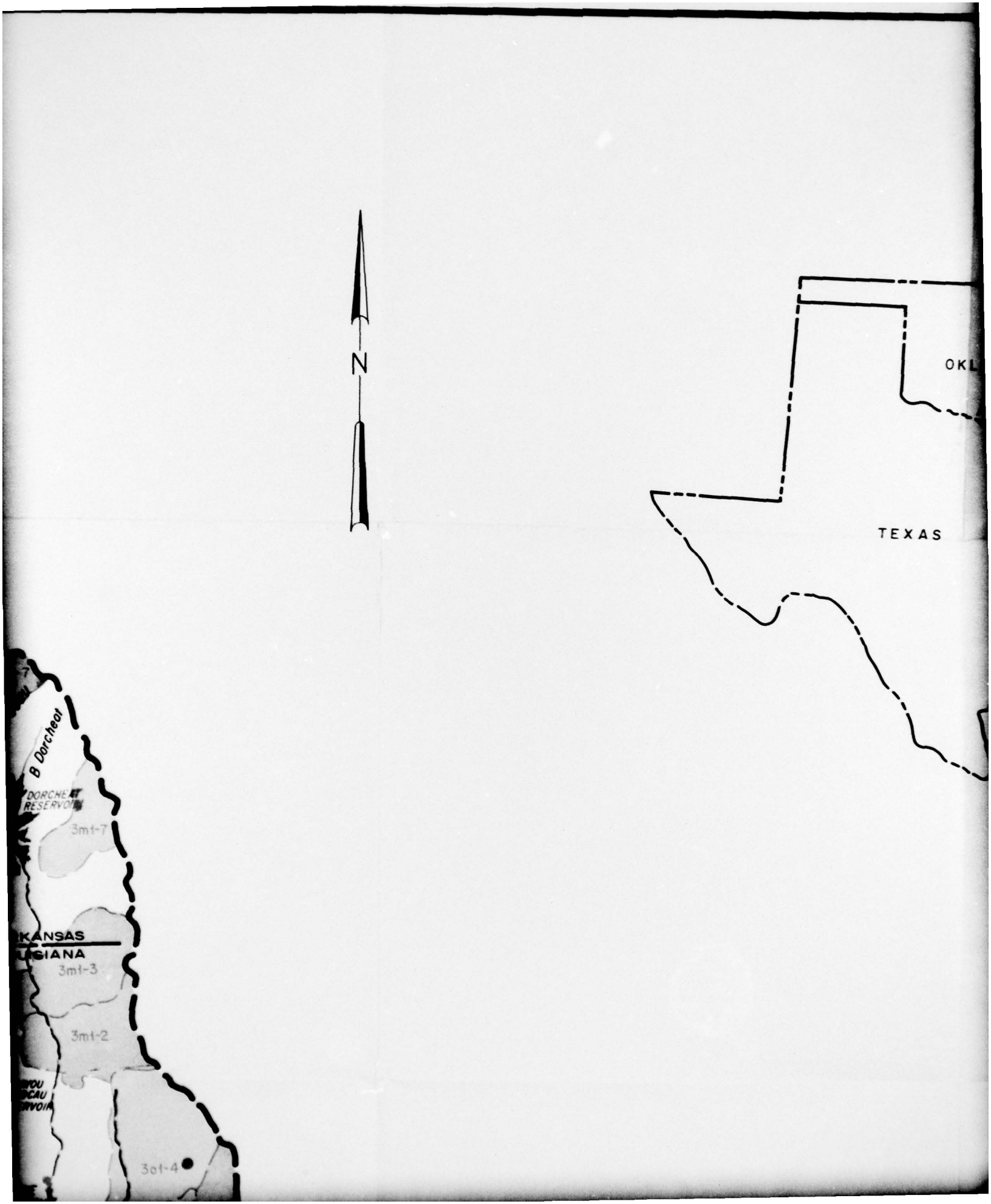
3m1-2
BAYOU BODCAU RESERVOIR
3o1-4
LAKE BISTINEAU
Red Chute Bayou
3m-1
3o-3
3o1-3
Black Lake Bayou
Saline Bayou
250
3n-4
3o1-2
Bayou Pierre
Coushatta
BLACK LAKE
RED
Campti
3n-1
Clarence
3n-2
3-63
3-70
RIVER
3-69
Natchitoches
Kisatchie
KISATCHIE RESERVOIR
Bayou
Colfax
3-75
BLACK RIVER
OUACHITA RIVER
3-68
10-17
100
Alexandria
3-73
10-16
10-14
10-15
Simmesport
10-13
ATCHAFALAYA RIVER
OLD RIVER
10-12
10-11
10-10
MISSISSIPPI RIVER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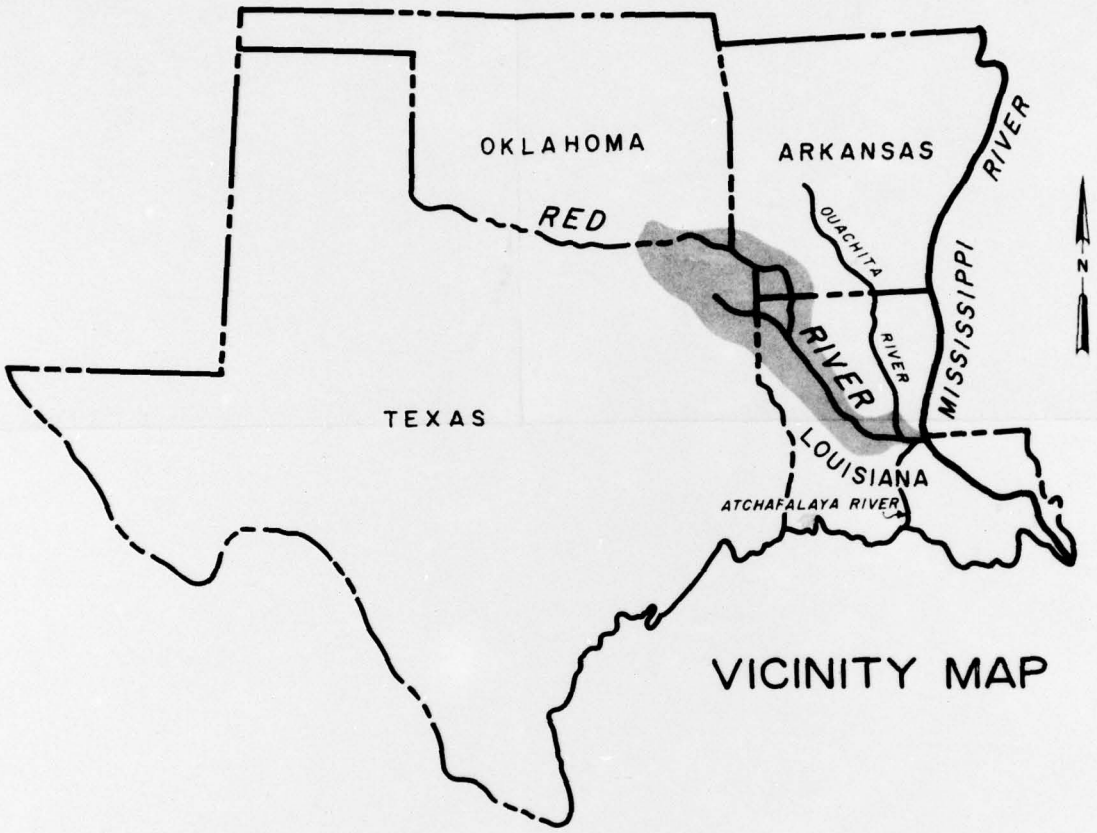
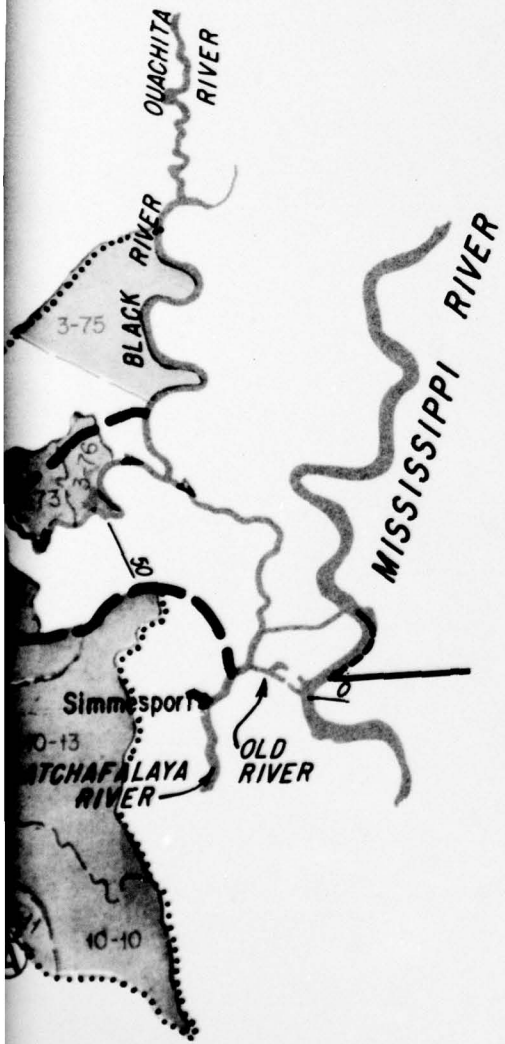


VICINITY MAP

LEGEND



LEGEND

200 — River mileage above mouth at Mississippi River - 1957

Limits of area external to the Red River Basin in which investigations were not conducted by all agencies.

Ⓐ — Denotes projects authorized for construction

3m1-7 — CNI Watershed

3k-17 ● — CNI watershed to be improved under both the early action and long range plans

NOTE: Status of projects, June 1968

RED RIVER BASIN BELOW DENISON DAM
ARK., LA., OKLA., AND TEXAS

COMPREHENSIVE BASIN STUDY

THE RECOMMENDED PLAN NEW FEATURES

SCALE OF MILES

10 0 10 20 30 40 50 60

RED RIVER BASIN COORDINATING COMMITTEE

JUNE 1968