

25 Years Later

A History of the McClellan-Kerr Arkansas River Navigation System in Arkansas



*Arkansas River below
Little Rock before the
navigation project
(left) and after
(below)*

by
S. Charles
Bolton, Ph.D.



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McClellan-Kerr Arkansas River
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1995, U.S. Army Corps of Engineers, Little Rock District, P.O. Box 867, Little Rock, AR 72203

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Preface

In summer 1962, speaking about the Arkansas River project then under construction, Senator John L. McClellan said, “Nothing the federal government has ever done or could ever do will be as big a boon to our state as this.” (*Arkansas Gazette*, June 3, 1962, p. E3) The waterway was a boon—a gift, favor, or blessing—to Arkansas because of its potential to improve the economy of the state and the lives of its citizens. The following pages describe the condition of the Arkansas River and its effect on Arkansas, the process that led to legislative approval and funding of the waterway project, and the task of constructing the Arkansas River Navigation Project. They also discuss the operation of the waterway over the past 25 years, its impact on the environment, and its role as a recreational resource. Finally, this volume looks at the way in which the McClellan-Kerr System has promoted the economic development of Arkansas. My own belief is that Senator McClellan was right. The civil works project named for him and Senator Robert S. Kerr of Oklahoma has made, and continues to make, an important contribution to this state. I hope, however, that I have provided enough objective evidence so that readers may make up their own minds.

My credentials for this task include a Ph.D. from the University of Wisconsin and more than two decades of teaching American History at the University of Arkansas at Little Rock. I am also author of *Southern*

Anglicanism: The Church of England in Colonial South Carolina (1982) and *Territorial Ambition: Land and Society in Arkansas, 1800-1840* (1993). My previous experience with the Corps of Engineers includes history and oral history projects for the Vicksburg District as well as the Little Rock District.

Personnel of the Little Rock District, some of whom helped to build the Arkansas River Navigation Project, and all of whom assist in its operation and maintenance, have given generously of their time to assist the author in writing this book. Judy Bullwinkle, liaison between district and author, has done a great deal to make this project a pleasant as well as successful experience. Joe Clements and David Burroughs deserve special thanks for putting the history of the waterway into an overall perspective. The following people have given generously of their time and expertise to make this a better and more accurate volume:

Gordon Bartelt, Dianne B. Batson, Kit Carson, Laurie Driver, Doug Eggburn, Sheila Ellis, Bob Faletti, Clyde Gates, Fred Greenwood, Jerry Harris, Mark Hubbert, Dale Lassiter, Hal Lee, Dale Leggett, Dave McNully, Conrad Miller, Robert Moix, Major Stephen E. Muehlberg, Mack Osborn, Paul Revis, John Riggs, Chester Shaw, P.J. Spaul, Dearl Stone, Paul Weeks, Jack Woolfolk, and David Virden. Finally, Janice Drennan, visual information specialist, has devoted many hours to the layout and editing of this book.

—S. Charles Bolton, Ph.D.

Chronology of Events

Relating to the Construction of the McClellan-Kerr Arkansas River Navigation System in Arkansas

- | | |
|--|--|
| <p>1935 Corps of Engineers submits a comprehensive report on the Arkansas River and its tributaries that becomes known as House Document No. 308.</p> <p>1936 Flood Control Act recognizes a national responsibility for dealing with floods and authorizes the construction of reservoirs for that purpose.</p> <p>1943 Corps of Engineers submits report including recommendations for the multiple-purpose project on the Arkansas River.</p> <p>1946 Rivers and Harbors Act authorizes the multiple-purpose project.</p> <p>1957 Construction begins on Dardanelle Lock and Dam in June.</p> | <p>1960 Rivers and Harbors Act authorizes the incorporation of the multiple-purpose project and the flood control plan for the Arkansas River that had been authorized in the Flood Control Act of 1938 into one plan of development.</p> <p>1963 Construction begins on Norrell Lock and Dam in May.</p> <p>Construction begins on Lock No. 2 in May.</p> <p>Construction begins on Wilbur D. Mills Dam in May.</p> <p>Construction begins on Joe Hardin Lock and Dam in May.</p> <p>1964 Construction begins on Emmett Sanders Lock and Dam in May.</p> <p>Construction begins on Lock and Dam No. 5 in November.</p> <p>Construction begins on Murray Lock and Dam in November.</p> <p>Construction begins on Ozark-Jeta Taylor Lock and Dam in December.</p> |
|--|--|

Chronology of Events (continued)

- | | | | |
|------|--|------|--|
| 1965 | Construction begins on David D. Terry Lock and Dam in January.

Construction begins on Arthur V. Ormond Lock and Dam in April.

Construction begins on Toad Suck Ferry Lock and Dam in July.

Construction begins on J. W. Trimble Lock and Dam in October.

First Dardanelle Lock and Dam power unit goes on line in April. | 1969 | J. W. Trimble Lock and Dam is placed in operation in April.

Arthur V. Ormond Lock and Dam is placed in operation in July.

Murray Lock and Dam is placed in operation in October.

Toad Suck Ferry Lock and Dam is placed in operation in November.

Ozark-Jeta Taylor Lock and Dam is placed in operation in November.

Dardanelle Lock and Dam lock is placed in operation in December. |
| 1967 | Norrell Lock and Dam is placed in operation in June | | |
| 1968 | Wilbur D. Mills Dam is placed in operation in March.

David D. Terry Lock and Dam is placed in operation in August.

Joe Hardin Lock and Dam is placed in operation in December.

Lock and Dam No. 5 is placed in operation in December.

Emmett Sanders Lock and Dam is placed in operation in December. | 1970 | First commercial tow to navigate the entire channel arrives at Catoosa in December. |
| | | 1971 | President Richard M. Nixon dedicates the waterway June 5. |
| | | 1972 | First Ozark-Jeta Taylor Lock and Dam power unit goes on line in November. |

Names and Locations of Features in Arkansas

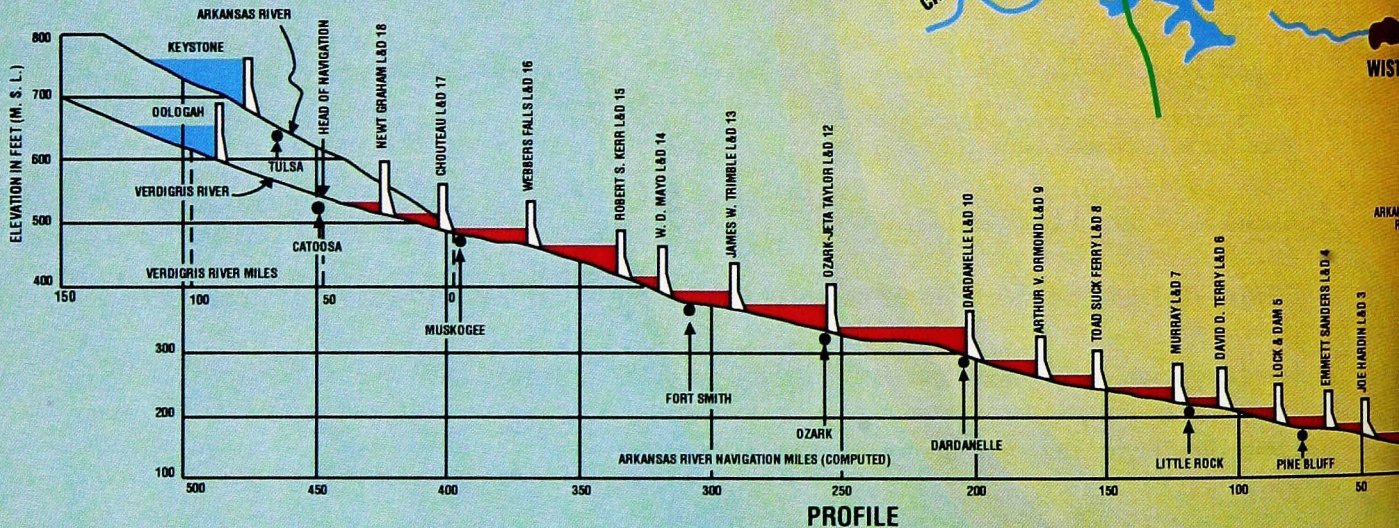
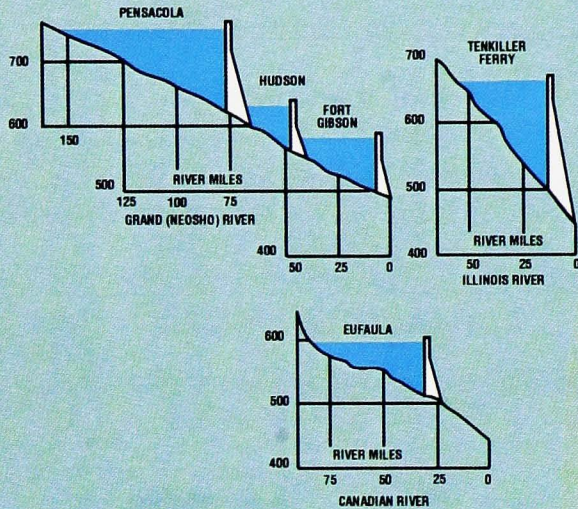
McClellan-Kerr Arkansas River Navigation System

Name	Miles Upstream from Mouth*	Miles from Nearest Town
Norrell Lock and Dam (No.1)	10.3	10.38 east of Arkansas Post
Lock No. 2	13.3	6 east of Arkansas Post
Wilbur D. Mills Dam (No. 2)	40.5	3 southeast of Arkansas Post
Joe Hardin Lock and Dam (No. 3)	50.2	5 north of Grady
Emmett Sanders Lock and Dam (No. 4)	66.0	7 east of Pine Bluff
Lock and Dam 5	86.3	4 southeast of Redfield
David D. Terry Lock and Dam (No. 6)	108.1	12 southeast of Little Rock
Murray Lock and Dam (No. 7)	125.4	6 northwest of Little Rock
Toad Suck Lock and Dam (No. 8)	155.9	6 west of Conway
Arthur V. Ormond Lock and Dam (No. 9)	176.9	3 southwest of Morrilton
Dardanelle Lock and Dam (No. 10)	205.5	2 northwest of Dardanelle
Lock and Dam 11 (deleted from project)		
Ozark-Jeta Taylor Lock and Dam (No. 12)	256.8	1 east of Ozark
J. W. Trimble Lock and Dam (No. 13)	292.8	7 east of Fort Smith

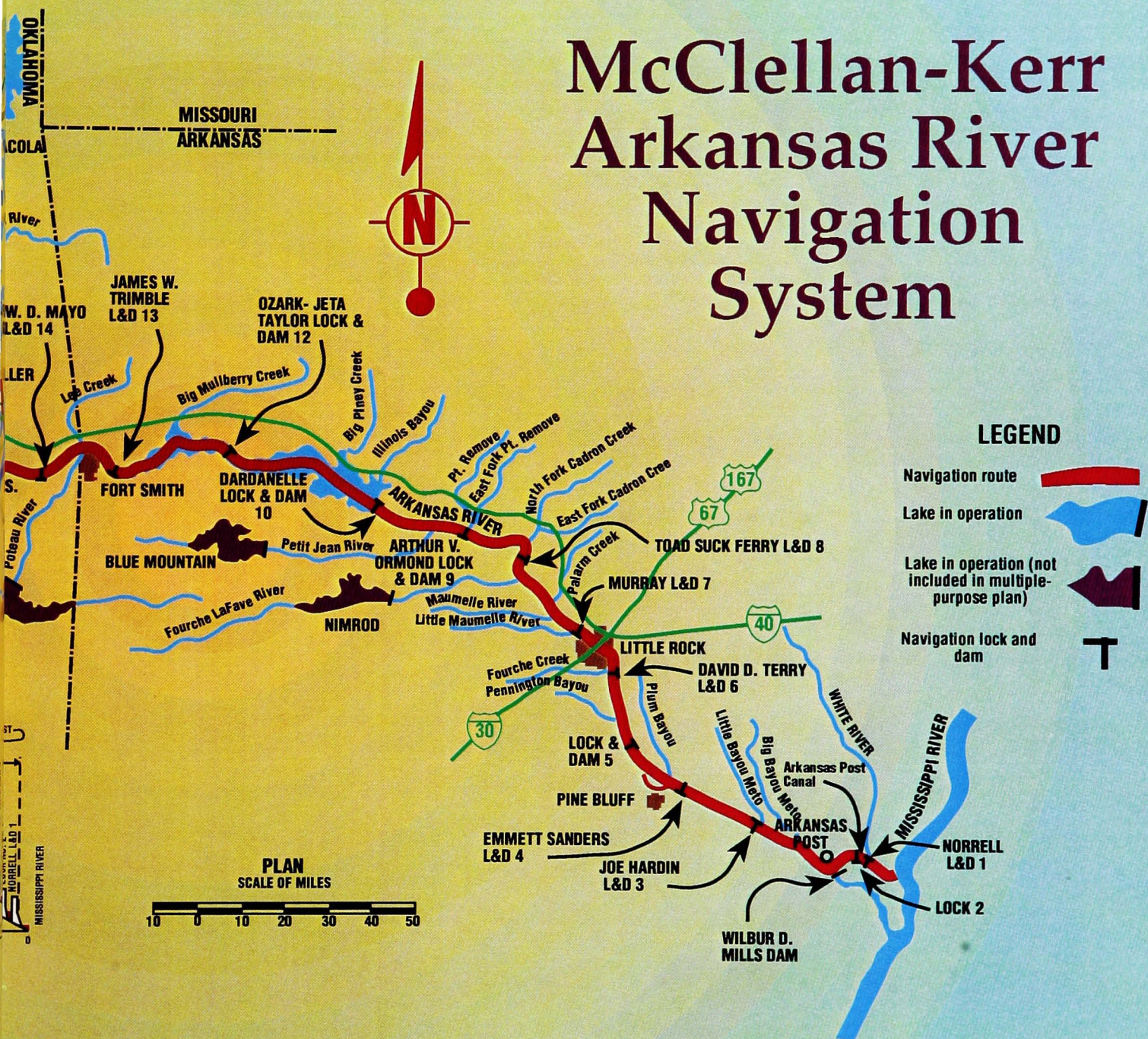
*Mileage is upstream from the mouth of the White River except for Wilbur D. Mills Dam, which is measured from the mouth of the Arkansas River.



US Army Corps
of Engineers



McClellan-Kerr Arkansas River Navigation System





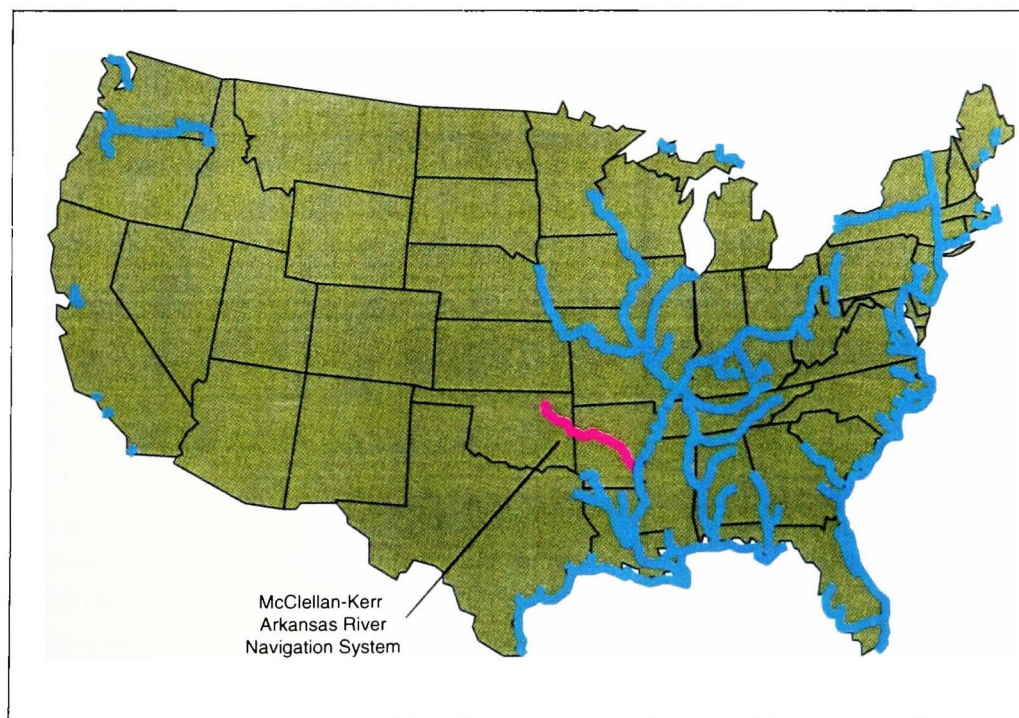
Chapter 1

A River and a Project

Since 1971 the lower 400 miles of the Arkansas River have been controlled by the McClellan-Kerr Arkansas River Navigation System, which has made the river fit for navigation, lessened the damage of its flooding, purified its water of much sand and dirt, and created permanent pools that are enjoyed by humans and wildlife alike. The purpose of this book is to present a history of the McClellan-Kerr System. In this chapter, we begin with a look back at the natural river and the people who have lived along it and then move forward to show why the idea of a waterway was developed and how it was enacted into law.

The River

A study completed in 1935 described the Arkansas River as it existed then and as it must have existed at least as long as human beings had lived along it. Melting snow that ran off the Rocky Mountains near Leadville, Colorado, flowed into a swift and cold stream that coursed rapidly down a mountain valley through the spectacular chasm known as Royal Gorge and on to Pueblo, Colorado, 125 miles to the south and east. More slowly the river moved across the flatter terrain of eastern Colorado and Kansas, taking a turn to the north below



*Major Inland
Waterway Systems*

Dodge City and then shifting south at Great Bend, where it ran through Wichita toward the Oklahoma line. Heading toward Tulsa, the Arkansas River began to erode its banks, which at this point were sandy, and meander into shorter and sharper bends. Tributaries such as the Salt Fork River and the Cimarron River carried in significant amounts of sediment. The fall of the river, which had been some 110 feet per mile near its source was only 2.5 feet per mile as it moved through Oklahoma.

Below Tulsa the river continued to get larger and flatter. In the vicinity of Muskogee, Oklahoma, it was joined first by the Verdigris River and then by the Grand River, both flowing in from the north; later came the Illinois River, Canadian River, and Poteau River. Between Fort Smith, Arkansas, and Little Rock, the Petit Jean River and Fourche La Pave River also emptied into the Arkansas. The effect of these and other augmentations was a flood channel capacity that was 18,000 cubic feet per second at Arkansas City, Kansas; 90,000 at Tulsa; 155,000 at Fort Smith; and 270,000 at Little Rock. Below Little Rock, the Arkansas River meandered still more as it flowed past Pine Bluff and received the waters of Bayou Meto before emptying into the Mississippi River. When its flows were high, part of the Arkansas reached the Mississippi through a natural cutoff that connected it with the White River. From Grand River to Little Rock, the fall of the river was .9 of a

foot (10.8 inches) per mile; and between Little Rock and the Mississippi River, it fell only .7 of a foot (8.4 inches) per mile.

From Leadville to the Mississippi, the Arkansas River traveled about 1,434 miles. It flowed through a river basin that was 870 miles long and averaged 185 miles in width, making up about 160,500 square miles or 12.8 percent of the Mississippi River basin of which it was a part. In addition to Colorado, Kansas, Oklahoma, and Arkansas, through which the river flowed, the Arkansas River drainage basin included portions of New Mexico, Texas, and Missouri. Only 7.6 percent of that basin was included in the state of Arkansas.¹

Arkansas, however, had a special relationship with the river that shares its name. The people along the 300 or so river miles between Fort Smith on the western border of the state and the Mississippi River on the east had been ravaged by floods from a swollen Arkansas River, and they had benefited from its capacity to be an avenue of transportation.

The People and the River

For thousands of years, human beings have lived along the Arkansas River in what is now the state of Arkansas. As early as 5,000 years ago, small bands of people appear to have sojourned there, hunting for the most part, gathering edible plants, and



Visitors at Toltec Mounds State Park, which is located on the Arkansas River along Plum Bayou (Courtesy of Arkansas Department of Parks and Tourism, C.H. Pierce, photographer)

Relatively few people lived at the Toltec site on a regular basis, but it appears to have been a regional center for governmental and religious activity.²

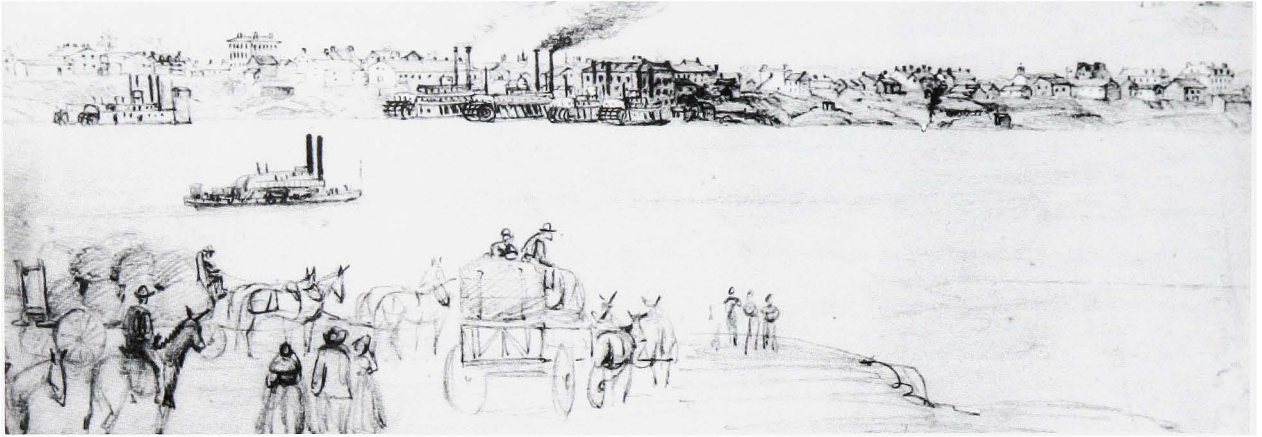
By the time Hernando De Soto and his Spanish army arrived in Arkansas in 1541, manifesting the

leaving projectile points and other stone tools. Twenty-five hundred years later, occupants of the valley were living more settled lives and probably learning to grow squash and other domestic foods that had been developed in Central America. Still they consumed large amounts of deer meat and gathered wild food, such as hickory nuts. Sometime over the next 2,500 years, in what archaeologists call the Woodland Period, cultural change became more rapid, probably because of the success of agriculture. Pottery, basketry, and the bow and arrow were part of the new way of life. Woodland people also built earthen mounds and used river transportation for long-distance trade.

One center of such activity is located along Plum Bayou, a few miles below Little Rock on the north side of the river, now the site of Toltec Mounds Archeological State Park. Three large mounds, the tallest of them rising 50 feet, overlook a watery access to the Arkansas River and dominate an area that covers nearly 100 acres. The site contains many smaller mounds and is protected by an earthen wall that once stood eight feet tall.

first presence of Europeans, the mounds were everywhere in disuse. Native Americans lived in large palisaded towns in northeast Arkansas and in smaller groups in all the river valleys. The most recent interpretation of De Soto's route through Arkansas claims that what the Spanish called the river of the Cayas was actually the Arkansas River and that the town of Autiumque, located on that river, where the conquistadors spent the winter of 1541-42, was somewhere below Little Rock. Wherever it actually happened, the prolonged contact between Europeans and Native Americans was a disaster for the indigenous people. Diseases carried by the Spanish conquistadors reduced the native population so drastically that the 75,000 people who probably lived in Arkansas when De Soto arrived had become only 15,000 by the time French explorers came more than a century later.³

The Quapaw Indians, perhaps survivors of the older culture or perhaps newcomers from the north, lived in villages located at the mouth of the Arkansas River. Upriver a few miles, the French built Arkansas Post to carry on trade and act as a way station between



Drawing of Little Rock by Alfred Rodolph Wand (1828-1891); view from opposite bank of Arkansas River (Courtesy of Historic New Orleans Collection, Acc. No. 1977.137.9.7.)

Louisiana and Canada. During the 18th century, European hunters and soldiers, a few traders and farmers, and an occasional administrator and cleric, traveled the lower Arkansas River, as did the Quapaws, although their numbers rapidly dwindled from disease and alcoholism. When the United States purchased Louisiana in 1803, Arkansas Post, then located about 36 miles from the mouth of the river, was a center of trade, government, and European culture, but it contained less than 500 people. The Arkansas River drained a land more empty than it had been in several thousand years.⁴

The repopulation of Arkansas by American settlers began slowly. In 1820, a year after the creation of Arkansas Territory, there were 14,000 inhabitants, most of whom had come down the Southwest Trail that began in southeastern Missouri and ran diagonally across Arkansas to the Red River. The Arkansas River floated a few dugout canoes, rafts, flatboats, and keelboats in the first decades of the century, but it became an important avenue of commerce largely because of Robert Fulton's steamboat, which reached western waters after the War of 1812.

The first steamboat to ply the waters of the Arkansas River was the *Comet*, which arrived at Arkansas Post on March 31, 1820, eight days out of New Orleans. Within a few years, steamboats had traveled to the new territorial capital at Little Rock, and by the 1830s they were a common sight on the Arkansas River. Flatboats continued to carry produce downstream to market on western rivers, but the two-way transportation provided by the steamboat integrated Arkansas and the entire Mississippi basin into the economy of the American republic, creating new opportunities for commercial agriculture and bringing up-to-date products and culture to the frontier.⁵

Steamboats also provided excitement and not a small amount of danger. William F. Pope, nephew of an Arkansas governor, boarded the *Reindeer*, an Arkansas River packet boat, at Louisville, Kentucky, on September 30, 1832. A heavy load of passengers and freight and low water on the Ohio meant that the vessel "hit every sandbar between Louisville and Paducah." At the latter city, Pope watched two men go ashore to settle an argument that ended when one

stabbed and killed the other. A storm on the Mississippi nearly capsized the *Reindeer*, and Pope observed two other vessels that were less fortunate: a cottonwood tree fell on one, killing five persons, and the other was burning on the shore as Pope's vessel steamed by. Arriving at Arkansas Post, Pope found the water level of the Arkansas River too low for navigation and rode a horse to Little Rock.⁶

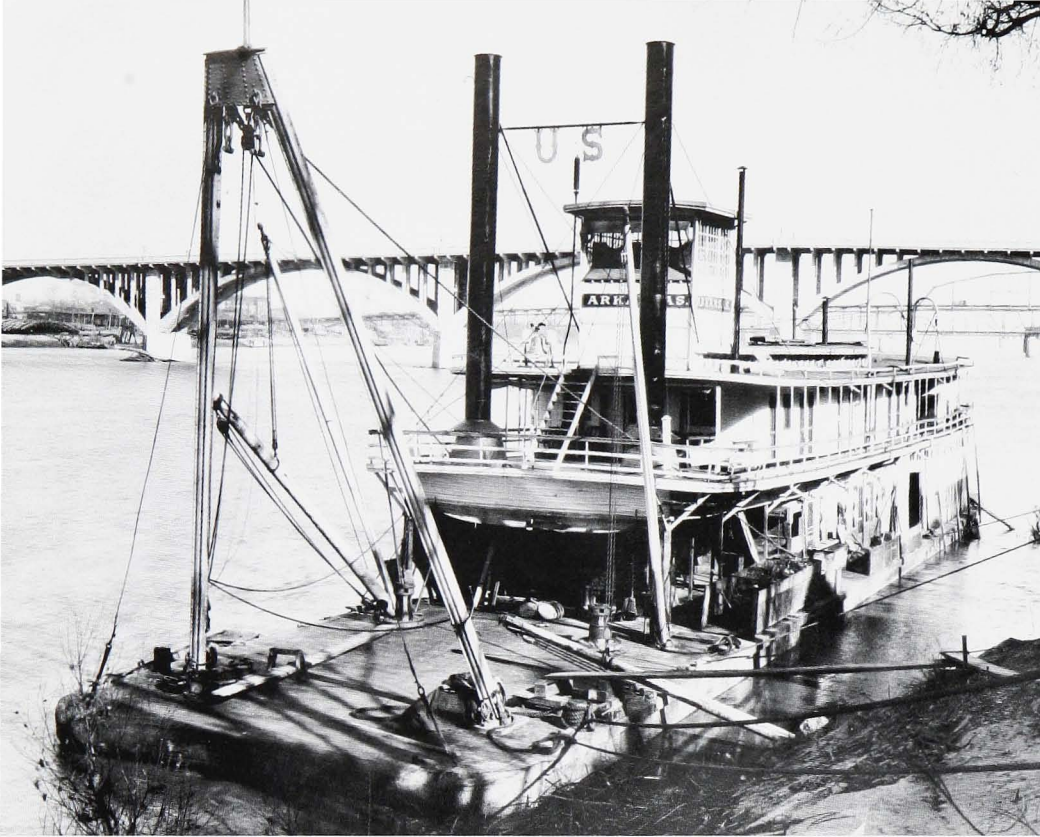
Friedrich Gerstäcker, a young German who visited Arkansas from 1838 to 1841 to partake of the marvelous hunting, earned money by working as a fireman on a steamboat, a job that entailed not only stoking the blaze but carrying large pieces of firewood down slippery river banks. Aside from its heavy work, Gerstäcker noted that the job also offered the "prospect of being blown up, no uncommon misfortune, thanks to the rashness of the American engineers." More often than fires or exploding boilers, steamboats fell prey to snags (logs or whole trees that fell into the river, lodged themselves in the sandy bottom, and projected upwards). At best snags were impediments that could be avoided by sharp-eyed pilots; at worst they caused nasty accidents and threatened to halt navigation.⁷

The low water that Pope experienced at Arkansas Post was an endemic problem that varied with the season of the year. Flows were highest in the spring and early summer and lowest in the late summer and fall. The

Arkansas River also increased its flow of water as it moved across Arkansas. A survey done in 1870 indicated that steamboats drawing five to six feet of water were used routinely from the mouth of the Arkansas up to Little Rock, but from there to Fort Smith a draft of three and one half feet was "more suitable," and from Fort Smith to Fort Gibson at the mouth of the Grand River in Oklahoma, only one foot would do. Around the middle of October, navigation usually ceased above Fort Smith and remained shut down for about two months. On the other hand, there were also floods, which interrupted navigation and had other serious consequences. William Pope witnessed a major flood in May and June of 1833, during which the swollen river cut across bends and separated farmhouses from farmlands, carrying away livestock, buildings, and land.⁸

The Government and the River

The uncertainties of navigating western rivers and the tremendous importance of transportation to the American economy encouraged the United States government to become involved in what were called "internal improvements," projects to improve the flow of people and goods across the vast and growing country. In 1824 President James Monroe signed into law the General Survey Act that authorized him to put the U.S. Army Corps of Engineers to



Snag boat Arkansas at Little Rock about 1923

this strange vessel was a steel-reinforced wooden ram, which was used to loosen obstructions that were then winched from the water. Shreve removed snags from the Mississippi River for several years and then attacked the

work considering routes for canals and roads that would be important for commerce and defense. Among the results of that piece of legislation would be a military road from Memphis to Little Rock and another from Little Rock to Fort Gibson, a military outpost located at the mouth of the Grand River in Indian Territory. Also passed in 1824 was the nation's first rivers and harbors act, which authorized the Corps of Engineers to become involved with the improvement of seaports and inland navigation. A few years later the Rivers and Harbors Act of 1828 authorized work to remove obstructions on the Red River, a project that was very important to settlers in southwest Arkansas.⁹

Henry M. Shreve, who became superintendent of western rivers for the Corps of Engineers in 1826, taught the nation how to deal with snags. He built the *Heliopolis*, a snag boat that was essentially two steamboats linked together at the hulls so that they could operate in tandem. Between the two bows of

Great Raft of the Red River, more than a hundred miles of tangled trees and other vegetation that made the river impassable. Using four snag boats and large work crews, Shreve assaulted the raft between 1833 and 1838, eventually opening the river to navigation from Natchitoches, Louisiana, to the newly founded town of Shreveport and giving a boost to land values in southwest Arkansas.

Arkansas grew rather rapidly in the 1830s, becoming a state in 1836 and reaching a population of 98,000 by the end of the decade. The Arkansas River that served the state was also an avenue of transportation to Indian Territory, and the Rivers and Harbors Act of 1832 called for the government to maintain a navigational channel from the Mississippi River to Fort Gibson, a distance of 465 miles. Using the *Heliopolis* and another snag boat called *Archimedes*, Shreve pulled more than 1,500 snags from the Arkansas River below Little Rock in 1834 and removed

twice as many logs and stumps from its exposed sandbars. Steamboats continued to ply the Arkansas during the antebellum period, and a number of light-draft models were built especially for that purpose. Tom Barrett of Little Rock built three vessels that the *Arkansas Gazette* bragged could travel “wherever the sand is moist.” Actually, unladen they needed about a foot of water and two feet when filled with cargo. During the Civil War, the Union used light-draft steamboats, now armed, armored, and sometimes ironclad. Some of them did service on the lower Arkansas and played a role in the January 1863 capture of Fort Hindman, the Confederate installation at Arkansas Post.¹⁰

After the war, the Corps of Engineers renewed its efforts to maintain the channels of western rivers. On the Arkansas, snag removal and dredging were the major activities. Until the 1890s, when hydraulic, suction dredges began to appear, dredging was done by draglines and steam-powered “dipper dredges,” which dug sand at critical places to deepen the channel. The engineers built stone and brush dikes supported by wooden piling that extended into the river to contract the channel and make it deeper. They also supported caving banks with fascine or mattress revetment woven out of willow saplings. One major project was the 1,700-foot dike constructed at Fort Smith in 1878 that forced the river to wash away a sandbar that had plagued the city. Still larger was the

effort authorized by Congress in 1879 to prevent the Arkansas River from eroding the high bank at Pine Bluff. After much planning and effort, a series of jetties was constructed along the shore, which led to the creation of a protective sandbar that pushed the current away from the city. After 1881 all these efforts were coordinated from a Little Rock office of the Corps of Engineers, which eventually grew into the Little Rock District.¹¹

For some time after the Civil War, the Arkansas River remained a vital avenue of commerce. A survey performed by the Corps of Engineers in 1870 indicated that 20 steamboats, “with an average burden of 300 tons,” were carrying freight from Fort Gibson, Fort Smith, and Little Rock and to New Orleans. At Fort Gibson, the boats loaded “robes, hides, and furs.” Further down the valley, 80,000 bales of cotton were shipped annually, along with unrecorded amounts of corn, tobacco, lead, and coal. In addition to New Orleans, merchandise came into the Arkansas River from New York, Philadelphia, Cincinnati, and St. Louis. Even as that optimistic account was being written, however, a railroad track was inching from Memphis to Little Rock, and the days of the steamboat were coming to a close. By 1900 almost all the freight on the Arkansas River consisted of forest products, and all the traffic was below Pine Bluff. Commerce continued to grow in the river towns, but it was not



Children play in flood water in the streets of North Little Rock, April 1927.

connected with navigation. The Arkansas River had been gradually abandoned “as the territory bordering it was supplied with railways.”¹²

The inland navigation of the nineteenth century, symbolized by steamboats filled with passengers and piled high with cotton bales, was no more, but the twentieth century would bring a new role for the Arkansas River. Already a new kind of navigation was coming into being. On some rivers, towboats were pushing freight-laden barges, making more efficient use of energy and challenging the dominance of the railroads. Locks and dams were also creating slack water channels that could be navigated at all seasons. The Davis Island Lock and Dam on the Ohio River, for example, which was completed in 1885, created a highly successful year-round harbor for Pittsburgh, but it also encouraged the construction of other movable dams and

established the 110-foot by 600-foot lock chamber dimensions that have been widely used ever since. Meanwhile the concept of multiple-purpose river basin development was gaining in popularity. Conservationists within the Progressive Movement, supported by President Teddy Roosevelt, argued that navigation was an important goal, but that controlling floods, generating electric power, irrigating arid lands, and supplying water to cities and industry were also significant. Conservationists felt that all these purposes should be considered when river basins were evaluated. An early example of this concept reached legislative fruition in the Reclamation Act of 1902, which led the Bureau of Reclamation to build reservoirs to irrigate arid areas of the West.¹³

For some time, the mission of the Corps of Engineers had been tied to navigation, and that organization opposed the multipurpose

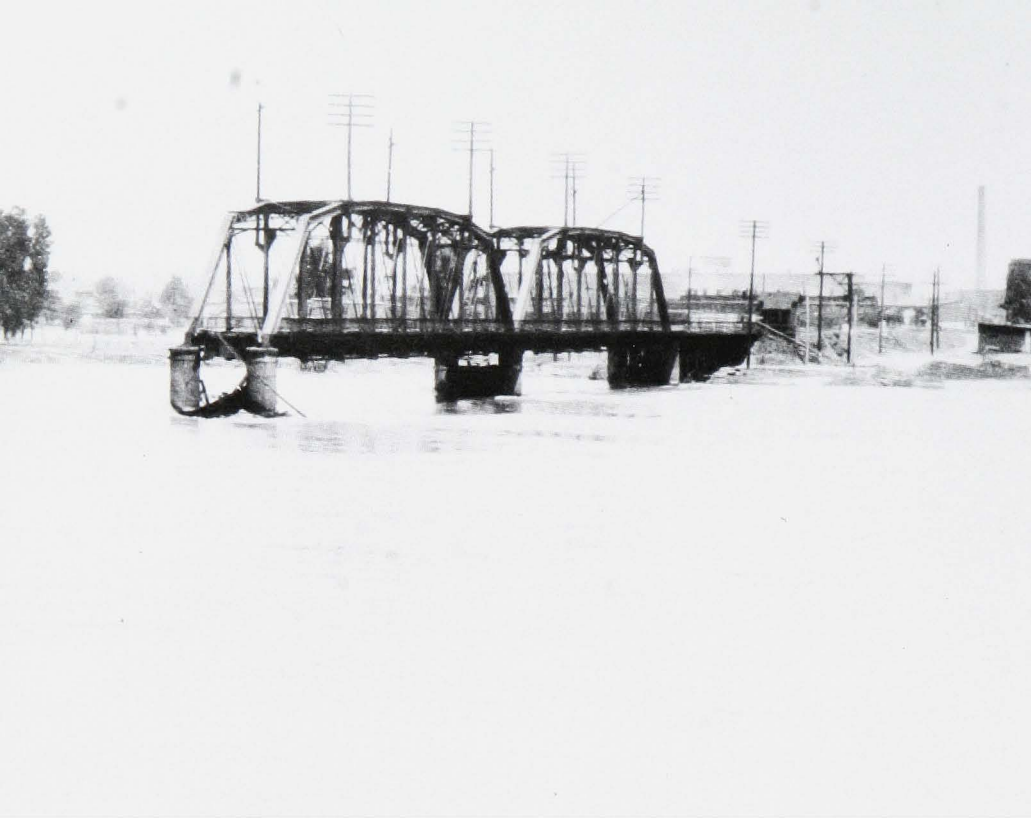


Flooded restaurant at North Little Rock, April 1927

approach to river development. However, the Rivers and Harbors Act of 1899 put the engineers in the regulatory business, requiring that individuals obtain a permit from them before dredging or filling in navigable waters or constructing docks, piers, or other structures in them. A decade later the Rivers and Harbors Act of 1909 directed the Corps of Engineers to consider non-navigation elements in planning its projects and to use anticipated benefits from these activities to offset the costs. Flood control, which had always been tied to navigation, became itself a federal concern in the Ransdell-Humphreys Flood Control Act of 1917, which provided \$45 million for flood works on the lower Mississippi River. Despite these developments, however, the Corps of Engineers was doing little on the Arkansas River, either with regard to navigation or flood control, and in 1921 it shut down the Little Rock District and gave

the Memphis District responsibility for the Arkansas and White river basins in Arkansas.¹⁴

A major disaster, however, was about to generate a new attitude on the part of the United States. The flood of 1927 inundated much of the lower Mississippi Valley, including more than 16 million acres in seven states. Its raging waters made 160,000 homes uninhabitable and destroyed 41,000 buildings. In Arkansas the Arkansas River tore away the Baring Cross railroad bridge at Little Rock and broke through the levee just below Pine Bluff, flooding rural areas, making the city a watery island, and leaving 2,000 people without homes. Further down the river, water poured through a crevasse in the levee at Pendleton, near Arkansas Post, and flooded much of southeastern Arkansas and northeastern Louisiana. The disaster put 140,000 Arkansans under the temporary care of the Red Cross. Congress responded with



*Washout of Baring Cross
railroad bridge at Little Rock
during flood of April 1927*

the Flood Control Act of 1928, which defined flooding on the Mississippi and its tributaries, including the Arkansas River, as a national problem and authorized a comprehensive program of flood works that would be paid for entirely by the federal government. It also adopted a flood control strategy developed by Chief of Engineers, Major General Edgar Jadwin, for the Mississippi River from the mouth of the Ohio River to the Head of Passes below New Orleans. The Jadwin Plan called for raising and strengthening the levees and supplementing them with a series of floodways designed to channel flood waters away from populated areas and valuable land and into places where it would do less damage. The law did not provide for flood control reservoirs because Jadwin did not believe that they were effective.¹⁵

The Project

Meanwhile the Corps of Engineers was involved in another very significant activity. Congress in

1924 had called upon the engineers and the Federal Power Commission to develop a list of some 200 rivers on which navigation and hydroelectric power might be developed. This list was published in House Document 308 in 1926, and in 1927 Congress authorized the Corps of Engineers to carry out the studies, which became known as the 308 Reports. The three volumes titled *Arkansas River and Tributaries* were researched and written by the Memphis District and published by Congress in 1936. They provided the first comprehensive examination of the Arkansas River with respect to navigation, hydroelectric power, irrigation, and flood control. Unfortunately for the growing number of Arkansans who wanted modern navigation on the Arkansas River, the report offered little promise of change.

The Arkansas River 308 Report examined in great detail the possibility of a nine-foot-deep navigational channel from the Mississippi River to the vicinity of Tulsa, Oklahoma. The navigation route would begin

at the mouth of the White River and follow the natural cutoff to the Arkansas River and then continue up the Arkansas to the Verdigris River and follow it to Catoosa, Oklahoma, a tiny community some 15 miles below Tulsa but 100 feet lower in elevation. This waterway would travel 537 miles and require 40 locks with an average lift of 11 feet. In addition to locks and dams, it was anticipated that a storage reservoir would be necessary to provide water for the system. The Arkansas would also require extensive bank protection work and regular dredging.

Chief of Engineers Major General E. M. Markham found the difficulties greater than the rewards. Because of “the considerable slope and the heavy movement of sand in its bed,” he declared that the improvement of the Arkansas River for navigation was “of doubtful feasibility” and unwarranted by any reasonable estimate of future traffic. Markham believed a large reservoir on the Arkansas River above Little Rock would be useful for both flood control and hydroelectric power, but that it would inundate land that was in productive use and would therefore be expensive to build. In sum, no new improvement of the Arkansas River was warranted.¹⁶

Again, however, disaster helped out. Another major flood beset the lower Mississippi Valley in the spring of 1935, and Arkansans once more lost property and were made homeless. In May of that year, a group of prominent citizens formed the Arkansas

Basin Association to lobby Congress on behalf of improvements for the Arkansas River. The early members represented different communities along the river: Clarence F. Byrns of Fort Smith, Reece Caudle of Russellville, Arthur V. Ormond of Morrilton, J.C. “Jack” Murray of Little Rock, and Emmett Sanders of Pine Bluff. They worked with like-minded individuals in Oklahoma, among whom Newt Graham of Tulsa was the acknowledged leader. For Sanders the devastation caused in Pine Bluff by the flood of 1927 provided motivation for improving the river. He had been in the business of providing supplies to farmers in the spring on the basis of payment to be made after cotton was ginned in the fall. In 1927 everything went under water and “many of the commissaries and small businesses which we supplied actually disappeared; they were simply washed away. I felt there must be a way to prevent this ever happening again.”¹⁷

The aspirations of the Arkansas Basin Association, and those of similar organizations in other river basins, received major support in 1936 when President Roosevelt signed the landmark Flood Control Act of 1936, which recognized flood control as a national responsibility and approved a large number of projects to implement that concept, many of them reservoirs of the sort that Jadwin had scorned. Under the 1936 Act the Corps of Engineers

was authorized to build more than 300 flood control reservoirs, many of which were multipurpose in nature. The fruits of this new federal commitment began to reach the Arkansas River valley in 1937 when the Little Rock District was reactivated, made part of a new Southwestern Division of the Corps of Engineers, and inundated, so to speak, with flood control projects. By 1940 the new district was beginning construction of four reservoirs, including Nimrod Dam and Reservoir on the Fourche La Pave River and Blue Mountain Dam and Reservoir on the Petit Jean River, both of these tributaries of the Arkansas River. Nimrod was completed in 1942, but Blue Mountain waited until 1947 when World War II was over.¹⁸

During the war, the Arkansas congressional delegation attempted to create a structure for the development of the Arkansas River basin, using two separate approaches to the problem. Senators John E. Miller and Hattie Caraway and Representative Clyde T. Ellis introduced the Arkansas Valley Authority Bill in 1941. This was modeled on the Tennessee Valley Authority and would have created a new agency to oversee navigation, flood control, and land reclamation in the valley. The authority would have controlled an area that was seven times larger than that under the jurisdiction of TVA. It drew opposition from the governor of Colorado on the grounds that it would infringe on the rights of states, was generally unpopular in the western parts of

the Arkansas basin, and did not come to a vote. Senator John McClellan introduced an Arkansas-White Basin Act in 1943, which emphasized the role of existing agencies. It placed navigation and flood control in the hands of the Corps of Engineers and defined procedures by which hydroelectricity could be marketed and decisions made about irrigation. This measure also did not pass, but the Flood Control Act of 1944 incorporated some of McClellan's ideas, allowing the Corps of Engineers to sell electricity generated at its hydroelectric installations and making provision for recreation facilities at flood control projects.¹⁹

In December of 1943, the Arkansas River Survey Board, a team from the Southwestern Division, submitted a new report that would become the basis for the McClellan-Kerr Arkansas River Navigation System. The Survey Board had been charged with investigating the feasibility of navigation and hydroelectric generation on the Arkansas system from the Tulsa area to the Mississippi River and developing appropriate plans for those purposes. The report was titled *Arkansas River and Tributaries: Arkansas and Oklahoma* and published in 1947 as House Document No. 758. It made extensive use of the 308 Report that had been published a decade earlier and also developed new information. In addition, it confronted new realities. In the intervening decade, Congress had approved no less than 20 flood control reservoirs on the



*Section 308
survey crew
at work in
Arkansas*

Arkansas and its tributaries, including 11 in Oklahoma and two in Arkansas. Basin development was under way.

Rethinking the possibility of navigation, the Survey Board was bothered by the “crooked and unstable” nature of the Arkansas River near its mouth. The engineers suggested cutting a 10.8-mile shortcut, known as the Pendleton Canal, which would leave the river at mile 25.3 and intersect it again at mile 53.8, thereby saving 28.5 miles and avoiding a particularly bad section of the river. They also called for only 34 locks, six less than in the 308 Report. The Survey Board also presented a plan for hydroelectric power that involved adding generators to the already approved reservoirs at Oologah on the Verdigris River and at Tenkiller Ferry on the Illinois River, both in Oklahoma. In addition, it called for the construction of a new reservoir at Eufaula on the Canadian River in Oklahoma and four reservoirs on the main stem of the Arkansas River, located at Short Mountain in Oklahoma, and at Ozark, Dardanelle, and Little Rock in Arkansas.²⁰

While the Arkansas River Survey Board presented a navigation plan and hydroelectric plan, what it really advocated was a multiple-purpose plan that would combine navigation with hydroelectric power and flood control and also provide recreational benefits and habitat for wildlife. The board recommended replacement of 11 low-head dams, those with a relatively short vertical drop from upper to

lower pool, with four higher-head dams that were capable of producing power. The Little Rock reservoir would be eliminated, but there would be two new reservoirs on the Arkansas River in Oklahoma, one at Blackburn and the other at Webbers Falls. The Blackburn Reservoir was designed to play a major role in trapping sediment that otherwise would enter the navigation channel, a function that would also be played by other flood control reservoirs, particularly the Mannford Reservoir on the Cimarron River. The Survey Board was less specific about the environmental aspects of the multiple-purpose plan, but it did claim that the permanent pools created by the Arkansas River dams would “be of value to the region as a whole for recreational purposes and wildlife refuges,” and it recommended constructing “such accessories as may be found desirable for these purposes.”²¹

The multiple-purpose plan for the Arkansas River was first evaluated by the Board of Engineers for Rivers and Harbors, an agency that had been providing expert and non-political reviews of Corps of Engineers projects since 1902. This board found little fault with the engineering proposed in the plan, but it worried about the economics of the project. The cost of constructing the facilities associated with the multiple-purpose plan was estimated at \$523 million in 1945 dollars. The annual cost of operating the system, including three percent interest on



*Chief of Engineers
Lieutenant General
Eugene Reybold, who also served
as Little Rock District chief
engineer and Southwestern District
engineer (b. 1884, d. 1961)*

money borrowed to carry out construction, was estimated at \$24.4 million, and annual benefits in terms of transportation savings, sale of electricity, flood control, and land rentals were estimated at \$26.4 million. The ratio of annual costs to annual benefits was thus 1 to 1.08. Moreover, 74 percent of the annual benefits were derived from a \$19.6 million transportation saving to accrue on the basis of an estimated nine million tons of commodities shipped on the waterway each year. The Board of Engineers for Rivers and Harbors recommended that construction of the flood control works go forward, and it endorsed the multiple-purpose plan as a guide for the future, but it suggested that “the navigation features be deferred until there is more definite assurance that the benefits will justify the expenditure.”²²

In a rare, indeed unprecedented, action, Chief of Engineers Lieutenant General Eugene Reybold overruled the negative recommendation of the Board of Engineers for Rivers and Harbors. Reybold believed that “an expansion of agriculture and industry” would follow the improvement of navigation and that “the tonnage for the waterway will exceed the amount now estimated,” and he recommended construction of the waterway. Reybold apparently felt that he knew more about the economic circumstances of the Arkansas River Valley than the board did, and he may have been right. He had directed surveys of the Arkansas River while a district

engineer at Memphis, had served as district engineer at Little Rock, and had been the Southwestern Division engineer who had created the Arkansas River Survey Board. Reybold was also a close friend of Newt Graham, the leading advocate of Arkansas River improvement in Oklahoma.²³

As a result of Reybold’s endorsement, the multiple-purpose plan for the Arkansas River was included in the rivers and harbors bill that came up for debate in May and June of 1946. Supporters of the measure from Arkansas and Oklahoma worked hard for its passage. An interstate committee created by Oklahoma Governor Robert S. Kerr and Arkansas Governor Ben Laney published a glossy brochure titled: *Neglected Riches in the Arkansas Basin Await a River at Work: A Pictorial Story of National Assets in a Great Southwestern Area*. Paid for with state funds and given to congressmen, this brochure argued that the economic potential of navigation was much greater than the Corps of Engineers had realized, and that the actual cost-to-benefit ratio should be \$1.00 to \$1.97. Testifying to Congress, Governor Kerr argued that cotton producers would save \$1.25 a bale by shipping their product on the waterway, that wheat shippers would save five cents a bushel on the 75 million bushels his state produced, and that the lowered cost of shipping mineral fertilizer would allow Oklahomans to use larger

*Robert S. Kerr, Oklahoma
governor at the time the river
project was proposed and senator
before its completion
(b. 1896, d. 1963)*



amounts as was done in eastern states. H. K. Thatcher of the Arkansas Resources and Development Commission claimed that a lack of transportation was one factor that prevented new industries from locating in his state. The main opposition to the project came from the Association of American Railroads, which supported the position that had been taken by the Board of Engineers for Rivers and Harbors. Pointing out that the cost-to-benefits ratio was only 1 to 1.01 when only navigation features of the plan were considered, it went on to argue that the navigation benefits used in the calculations were based on unrealistic estimates of future tonnage.²⁴

Congressional opposition to the project was led by Representative A. S. Monroney of Oklahoma, who authored an amendment to delete it from the rivers and harbors bill. The amendment was defeated by a two-to-one vote. While the House authorized the measure, however, it appropriated only \$55 million, all of it to be used for the construction of Eufaula Reservoir. The Senate, led by John L. McClellan of Arkansas, increased the amount to \$150 million, which would have allowed work on the navigation channel, but a conference committee restored the original amount. On that basis, the measure became part of the Rivers and Harbors Act of 1946. The multiple-purpose plan, including a navigable waterway, was approved; but as Emmett Sanders would later

write: "There was considerable difference between 'authorized' and 'appropriated.'" It would be more than a decade before money was available for actual construction.²⁵

The Arkansas project became caught up in a variety of issues. Beginning in 1945, the Truman administration began an extensive study of governmental reorganization that eventually called into question the nature and size of the Corps of Engineers' workload, which had greatly expanded in the last several decades. In 1948 Robert S. Kerr, the former governor of Oklahoma, was elected to the Senate. Believing that the river basins required more and broader planning, Kerr introduced a bill in 1949 to create a study commission for the Red, White, and Arkansas rivers that would be made up of a number of federal agencies and representatives from the states involved. Kerr's measure was associated with the concept of reorganization and opposed by supporters of the Corps of Engineers, including Senator McClellan. Defeated in the Senate, the Kerr Plan did influence President Truman's decision to create an Arkansas-White-Red Basins Interagency Committee. This was chaired by the Chief of Engineers and staffed by the Southwestern Division, but it included representatives from the departments of Agriculture, Labor, Commerce, and Interior, as well as the Federal Power Commission, Federal Security Agency, and Public Health Service. Hampered by internal bickering, the committee finally



*Senator John L. McClellan,
Democrat-Arkansas (b. 1896, d.
1977)*

issued a report in 1955 that provided much valuable information but did nothing to alter the logic of the Arkansas multiple-purpose plan.²⁶

Meanwhile the project made halting progress. The Flood Control Act of 1948 added bank protection work at Bradens Bend, Oklahoma, to the multiple-purpose project and appropriated \$1 million to do the work. The Flood Control Act of 1950 amended the plan by substituting the Keystone Reservoir on the Arkansas River for the Mannford Reservoir on the Cimarron River and dropping the Blackburn and Taft Reservoirs that would have been constructed on the Arkansas River. The Rivers and Harbors Act passed at the same time appropriated \$80 million for the project. Four years later, however, the ongoing review of Corps projects led to a decision that placed the Arkansas project in a deferred status. Responding to this, Southwestern Division officials reviewed the anticipated benefits in light of current economic information and raised the estimated annual return from \$23.6 million to \$64 million. This changed the cost-to-benefit ratio from 1 to 1.08 to 1 to 1.20. In 1955 at the request of Senator Kerr, now chairman of the Rivers and Harbors Subcommittee of the Public Works Committee and a member of the Senate Appropriations Committee, and Senator McClellan, Chief of Engineers Lieutenant General Samuel D. Sturgis removed the Arkansas River project from the

deferred list. Congress went on to appropriate funds to continue work on Oologah Reservoir, which had been started in 1950, and to begin work on Eufaula Dam, Keystone Dam, and Dardanelle Lock and Dam.²⁷

The rising hopes of those who supported the Arkansas River project fell in early 1956. Worried that these expenditures would commit the country to a billion-dollar navigation project, the need for which was dubious, President Eisenhower refused to release the funds for Eufaula and Dardanelle. Senator Kerr, however, was then chairman of the Senate Public Works Committee, which was considering the landmark interstate highway system that was favored by many senators and congressmen. The situation gave Kerr a great deal of temporary influence. The Oklahoma and Arkansas delegations visited the White House in February of 1956 to express their concerns about the waterway, and six weeks later the president sent a message that he would not block any new appropriations for the project. After passage of the highway bill, Congress passed a Public Works Appropriation that included \$1.25 million for the Eufaula Reservoir, \$1.5 million for Keystone Dam, and \$650,000 for Dardanelle Lock and Dam, and the president signed it into law. The Arkansas multiple-purpose plan was now in the construction phase.²⁸

Some evidence of how the project came into being is provided by the list of witnesses

before Senator Kerr's committee on March 26, 1956. Brooks Hays, James W. Trimble, and W. F. Morrell, all of Arkansas, were among the congressmen who spoke on behalf of the project. The public speakers were headed by Clarence F. Byrns of Fort Smith, editor of *Southwest American* and *Times Record*. He was chairman of the Arkansas-Oklahoma Interstate Committee for Arkansas Basin Development, a five-person group selected by the governors of Arkansas and Oklahoma to advance their joint interests. The Interstate Committee was created at the request of the Arkansas Basin Association, of which Byrns was a director. Other Arkansans included Jack Murray of Little Rock, an attorney dealing with transportation issues who was secretary of the Arkansas Basin Association; Emmett Sanders of Pine Bluff, president of the Arkansas Basin Association; and J. W. Hull, president of Arkansas Polytechnic College at Russellville, past president of the Arkansas Basin Association. Another speaker was Arthur V. Ormond of Morrilton, who claimed to "farm a little land there on the Arkansas River" and said that he had been in Washington "for 10 consecutive years" since the project was first authorized, speaking to subcommittees and committees of the Senate on behalf of the Arkansas River basin. T. A. Prewitt from Tillar in southeast Arkansas was a merchant and landowner whose main concern was "the losses occurring from floods, erosion, and caving banks." He praised the

bank stabilization work that had already been done and urged that it be continued.²⁹

The construction work at Dardanelle was only a starting point for the multiple-purpose plan, and completion was hardly assured. Still the project had entered a new phase, and navigation on the Arkansas was beginning to seem like a not-too-distant reality.



Bank Stabilization —

The lower Arkansas River, an alluvial stream, attacks its sandy banks and forms new channels, bars and cutoffs.

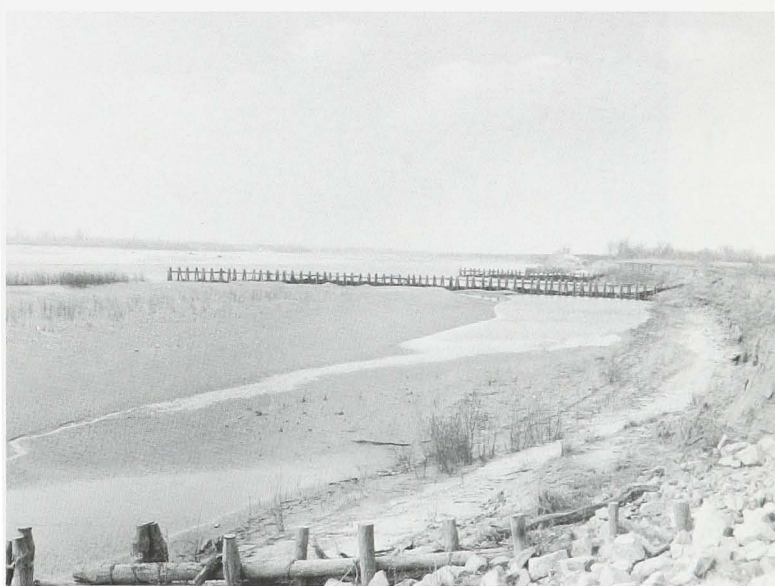
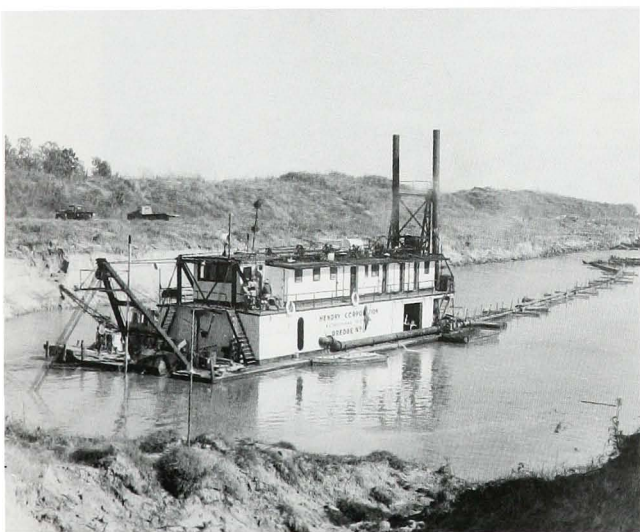
TOP: Line of caved bank above Little Rock, 1952; CENTER: Bank grading operations at Adamsburg Landing, 1950; BOTTOM: Rock dike at Hensley Bar, 1956. The process of bank stabilization includes revetment, which involves grading the bank and covering it with mattress-like material that will resist erosion; dikes, which train the current of the river away in ways that minimize danger to the banks; and cutoffs, which eliminate sharp bends to create a straighter, more stable channel.



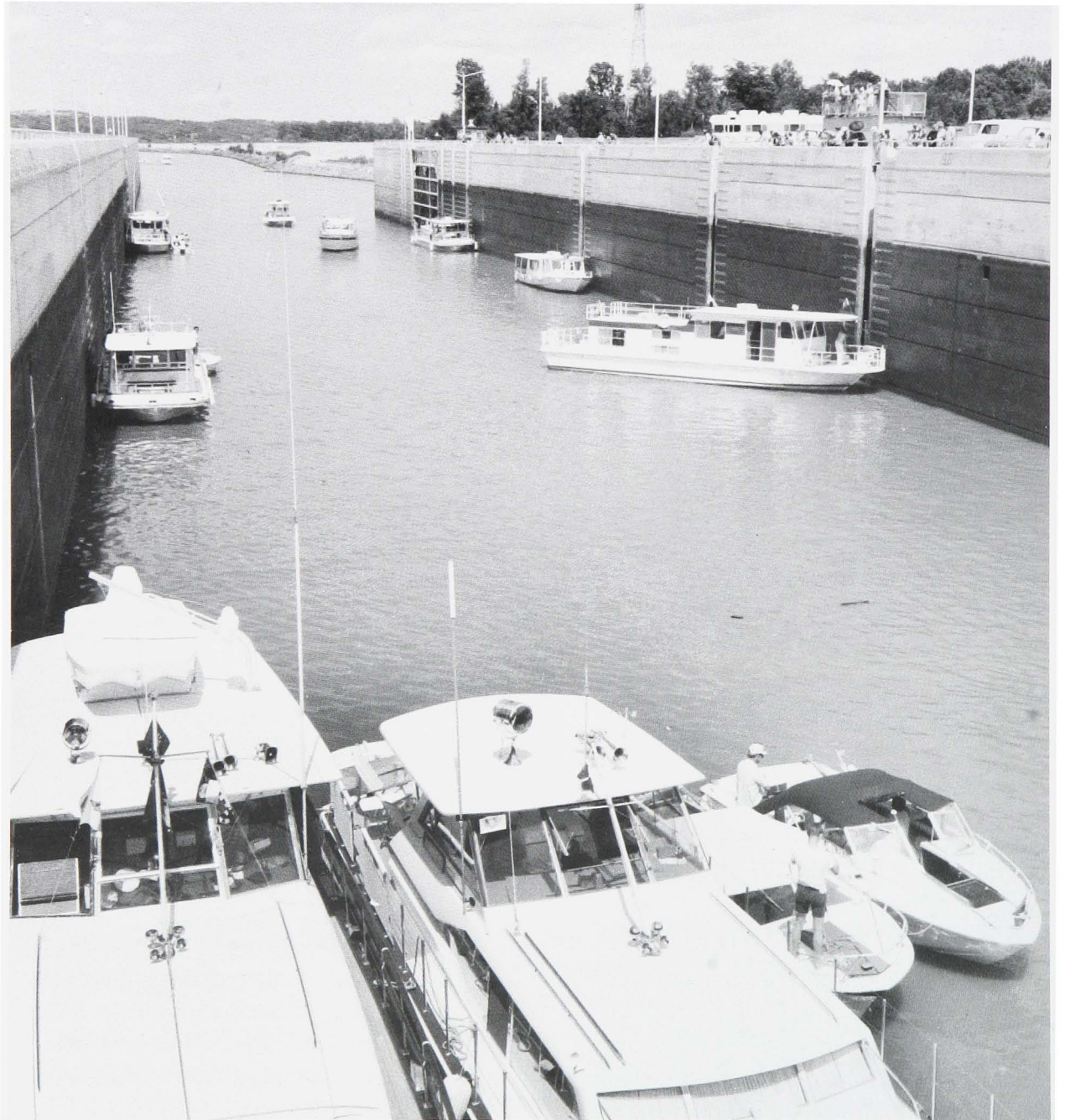


Revetment & Contraction Works—

ABOVE: Revetment mattress under construction at Adamsburg Landing, 1950; RIGHT: Pile dike at Estes Place, 1954; BELOW: Pilot channel construction to create a cutoff at Hensley Bar, 1951.



*Pleasure boats, bound for dedication ceremonies at the
Port of Catoosa, fill the lock chamber at Toad Suck
Ferry Lock and Dam near Conway, 1971.*



Chapter 2

Constructing a Waterway

While Congress and the White House struggled over funding of the Arkansas River project, the Corps of Engineers was planning how to bring it into being. The multiple-purpose plan developed in 1943 provided a logical approach, but it required a significant amount of engineering refinement before it could be constructed in an optimal manner. Then there was the construction process itself, a massive undertaking since the finished project would be the largest civil works project ever carried out by the Corps of Engineers. Finally there was the funding. More than once in the 1960s, the project's advocates would have reason to remember Emmett Sanders' emphasis on the distinction between approval and appropriation. Eventually, however, the engineers made final plans, Congress provided the funds, and the waterway became a reality.

Final Planning

One major change in the project increased the share of the work that would be done by the Little Rock District. In 1956, when the navigation portion of the plan received its first construction funds, three engineer districts were involved in the project. The Tulsa District was to construct everything in Oklahoma, including Webbers Falls Dam and Reservoir, Short Mountain Dam and Reservoir (later Robert S. Kerr Lock and

Dam), three locks and dams on the Verdigris River, and the western-most lock and dam on the Arkansas River. In addition, it was to dredge and perform bank stabilization and channel rectification on the Arkansas River west of Fort Smith. For this work, Tulsa was to receive 36 percent of the funds allocated for the navigation project. Little Rock District was to construct Ozark Dam and Reservoir, Dardanelle Dam and Reservoir, and nine locks and dams from Fort Smith to Pine Bluff. It would also stabilize the banks and improve the channel in that reach of the river. Little Rock was to receive 47 percent of the navigation funds. At Pine Bluff, responsibility shifted to the Vicksburg District, which was to construct all the locks and dams and do the bank and channel work between there and the Mississippi River. Its share of the money amounted to 17 percent.

In 1961 the Corps of Engineers changed this tripartite division of work, turning over the Vicksburg District portion to the Little Rock District and placing the entire project in the Southwestern Division. Under the new approach, Little Rock would construct all of the waterway from Fort Smith to the Mississippi River and spend 67 percent of the navigation project funds, while Tulsa District would do all the work in Oklahoma and spend 33 percent of the money.¹

The plan that the Little Rock District and Tulsa District would implement was based on a project design memorandum, completed in

1957, that followed rather closely the multiple-purpose plan that had been developed by the Arkansas River Survey Board in 1943. Two unresolved issues, however, had led to major changes. One involved dealing with the vast amount of sediment that was carried by the Arkansas River in its natural state, and the other had to do with the serpentine course it followed from Pine Bluff to the Mississippi River.

The Arkansas River ranked fourth among rivers in the United States in the sediment load that it carried, and most of that material was in the navigable portion of the river below Tulsa. An estimated 120 million tons of sediment, composed of about 25 percent sand, 55 percent silt, and 20 percent clay, passed by Little Rock every year, much of it originating from the Canadian and Cimarron rivers in Oklahoma. If this were not controlled, it would rapidly build up in the pools of the waterway and make them unusable. The magnitude of the problem caused Brigadier General William Whipple, who took command of the Southwestern Division in 1958, to hire private consultants and organize them into an Arkansas River Sediment Board to search for a solution to the problem.

Ultimately a variety of techniques was employed. Most important was the use of upstream reservoirs as silt traps, holding the sediment and purifying the water before it entered the navigation channel. The existing

flood control reservoirs, Pensacola, Markham Ferry, and Fort Gibson on the Grand River and Tenkiller Ferry on the Illinois River, would play a role in this. More important were the three reservoirs that would be directly involved in navigation: Keystone on the Arkansas River, Oologah on the Verdigris River, and Eufaula on the Canadian River. The relatively high-lift locks and dams, which included Webbers Falls and Robert S. Kerr Lock and Dam in Oklahoma and Ozark and Dardanelle in Arkansas were also expected to hold some sediment.

Bank stabilization also played an important role. Stone revetment would be used to support the bank at weak places to prevent the cave-ins that would produce more sediment. Other methods were designed to speed the flow of the river, so that sediment would be carried through rather than deposited. Cutoffs would widen bends in the river, and dikes would be used to make the current run deeper and faster. The new plans also called for raising the navigational lift at Robert S. Kerr Lock and Dam from 40 to 55 feet (later dropped to 48 feet) and that at Dardanelle Lock and Dam from 35 to 54 feet. The larger lift, combined with the narrower channel, would produce a degradation, or erosion, of the river bottom, reducing the buildup of sediment. All of these changes were tested at Waterways Experiment Station in Vicksburg, which one engineer later claimed

became a “second home” for him during this period. Test results not only indicated the best ways to control sediment but also led to modifications in the overall project. Their success at mastering sediment and deepening the channel led the engineers to eliminate two of the four locks and dams that had been planned between Robert S. Kerr and Ozark Reservoir and four of the six between Dardanelle and Little Rock.²

While it supported the development of the multiple-purpose project, the Arkansas River Survey Board had indicated its displeasure with the lower portion of the Arkansas River as a navigation route. Because it had been called upon to recommend a waterway that followed the Arkansas River, the board suggested the construction of the Pendleton Canal, a 10.8-mile waterway through the south bank of the Arkansas River that would leave the river at mile 25.3 and reenter it at mile 53.8, eliminating 28.5 “crooked and unstable” river miles. It pointed out, however, that below Little Rock the river followed a “tortuous course” and contained “unstable banks” and suggested avoiding it entirely. The board suggested that consideration be given to an alternative plan that involved leaving the Mississippi River at the mouth of the White River and following the White some 75 miles to the small town of Clarendon, Arkansas, from where a canal would be constructed to the

vicinity of Little Rock about 60 miles away. The survey board argued that the Little Rock-to-Clarendon canal route would be about as long as the Pendleton Canal route and less costly both to build and to maintain. It would, however, eliminate Pine Bluff from the waterway.³

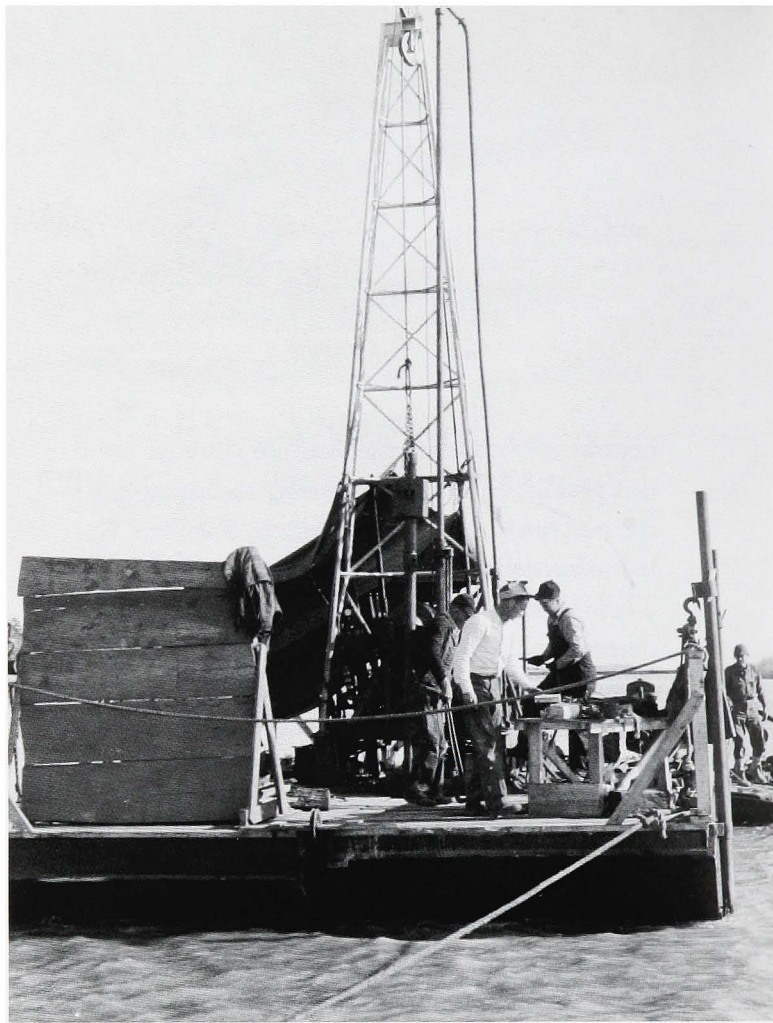
For more than 15 years, the Corps of Engineers studied the problem presented in the 1943 report, focusing most of its attention on alternative routes that would maintain the status of Pine Bluff as a river port. An Arkansas Post route was approved in 1950. This began at the mouth of the White River and followed that stream for about 10 miles to the mouth of Wild Goose Bayou, where another 10 miles of canal would connect with the Arkansas River in the vicinity of Arkansas Post. In 1954 the Arkansas Post route was supplanted by a North Bank Canal Route, which would also ascend the White River to Wild Goose Bayou, but from there it would follow a much longer canal that would not intersect with the Arkansas River until just below Pine Bluff. In 1960 the Corps returned to the Arkansas Post route, which was chosen because it would eliminate some of the difficult bends on the lower Arkansas River at reasonable cost and provide economic and reliable navigation. This route required one lock and dam at the lower end of the canal, a lock at the upper end, and a dam in the Arkansas River near the upper end of the canal.⁴

*Drilling with 3½-inch coring
equipment at Lake Dardanelle,
first construction site for the
river system in Arkansas, 1948*

Construction

The first large structure begun by the Little Rock District was Dardanelle Lock and Dam, located in Pope and Yell counties about two miles north of the town of Dardanelle, Arkansas. Designed for both navigation and hydroelectric power, Dardanelle was a relatively high-head dam that would rise to a height of 70 feet above the streambed and lift barges 54 feet, higher than any other lock and dam on the Arkansas River. The height of the dam was related to its placement in a narrow portion of the river valley where it was possible to create a reservoir without inundating too much productive land. This would be a “run of river” reservoir, meaning that water would flow in and out and would not be stored. The overall length of the structure was 2,569 feet, which included a 1,200-foot spillway equipped with 20 tainter gates, each of them 50 feet by 39 feet. The powerhouse located in the lock and dam would contain four generating units, each capable of producing 31,000 kilowatts of electricity.

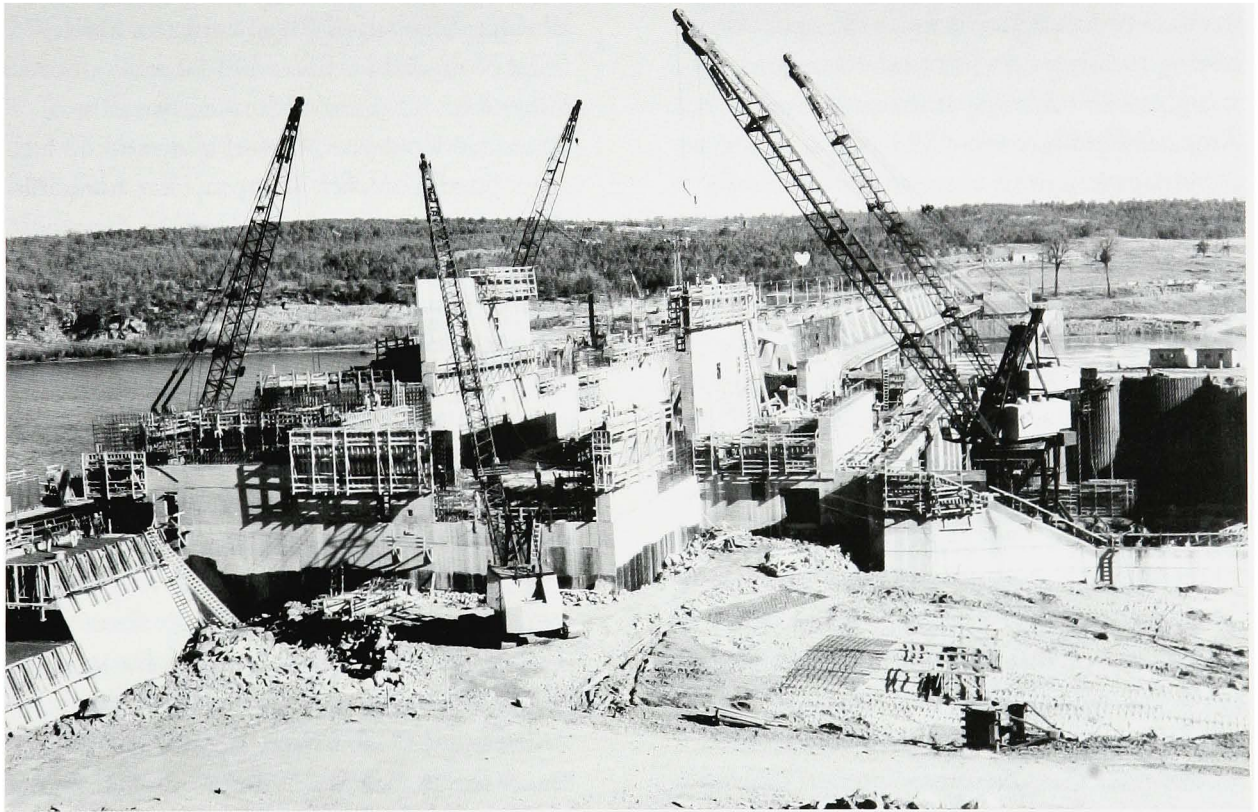
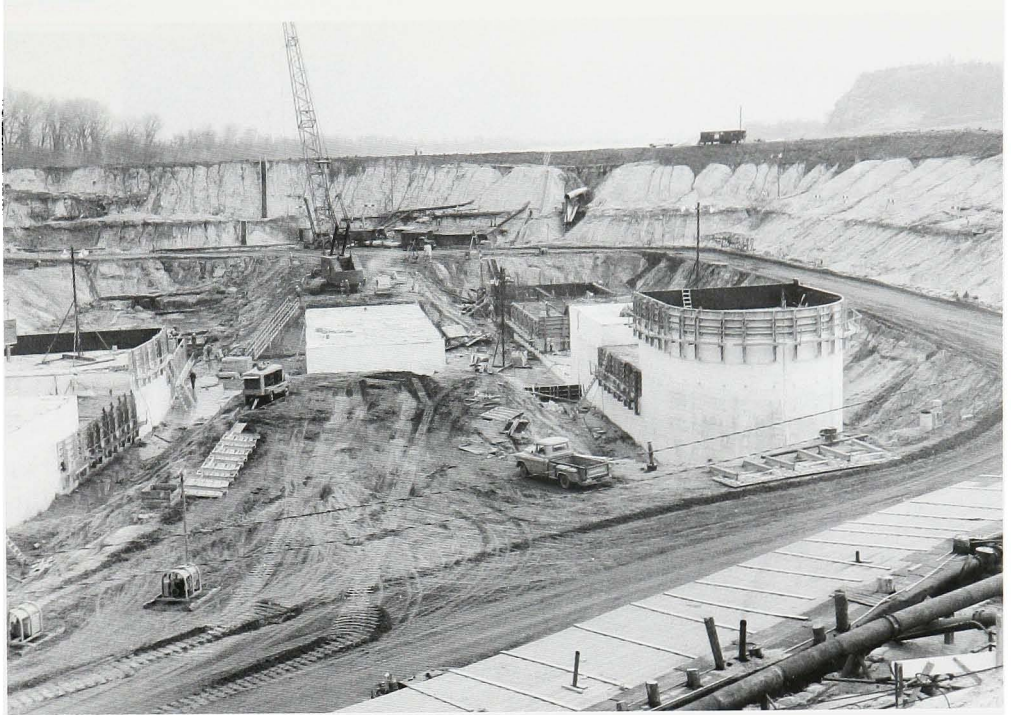
Dardanelle Lock and Dam was built first because the hydroelectric facilities meant that it could be productive before the navigation project was complete. In fact, the dam and powerhouse were constructed before most of the lock, and it was finished only when the locks and dams below were nearing completion. In addition, sedimentation was



an important concern in the timetable. Nearly three-quarters of the sediment passing through the site of the future Dardanelle Lock and Dam was estimated to have passed through the sites of the future Eufaula Dam and the future Keystone Dam. Those dams were under construction as work on Dardanelle began, and it was important that they be closed before Dardanelle so that the Arkansas dam would impound cleaner water. Similarly the closing of Dardanelle would trap some sediment that otherwise would clog the channel below it. It was estimated that the cleaner water coming over the spillway at Dardanelle would naturally recover its sediment and degrade the first few miles of the channel below as much as 11 feet over 10 years. Engineers were anxious to have that

RIGHT:
Construction of lock
and embankment at
Dardanelle, 1959

BELOW:
Construction of lock
powerhouse,
switchyard and non-
overflow section of
dam at Dardanelle,
1962



process begin as soon as possible.⁵

Work began at the Dardanelle site in the summer of 1957, and construction of the lock and dam commenced in May of 1959. Unlike the dams that would be built below Little

Rock, Dardanelle was constructed on a rock foundation. Dardanelle Lock and Dam was built in the river, as were all the dams on this system except for Wilbur Mills Dam.

Where possible, engineers prefer to



*White River Cutoff Closure
Structure*

and have a shoreline of 315 miles, touching five Arkansas counties.⁶

The central element in the Arkansas Post plan was the 10-mile Arkansas Post Canal, which

construct an actual lock and dam on dry land, often selecting a sharp bend in the river, so that when the project is finished, a cutoff can be dug to bring the river to the dam and straighten the channel at the same time. Because that was not possible at Dardanelle, a cofferdam had to be constructed to remove the water from the site. Huge steel sheets were placed in the river and formed into hollow shells that were filled with dirt. These were placed so as to create a protected area against the bank, which was then pumped dry to become the construction site for a part of the project. When that section was built, a new cofferdam was constructed, and the completed section was exposed to the water.

Including the purchase of land, Dardanelle Lock and Dam was estimated to cost \$87 million. In the summer of 1961, and the end of the government fiscal year, it was only 16 percent complete, but the pace increased rapidly after that. Two years later, in June of 1963, the project was 41 percent done, and two more years later it was 81 percent complete. Meanwhile, in October of 1963, the gates of the Dardanelle Dam were lowered, and it began to form a lake that would eventually extend 51 miles upstream

would cut through forest and swamp to connect the White River and Arkansas River, allowing Mississippi River traffic to travel 10 miles of the White River and 10 miles of canal rather than 40 miles of the Arkansas River. The canal would be 300 feet wide and 12 feet deep, lined with rock at appropriate points. On its north side and connected to the canal was Merrisach Lake, a haven for fish and wildlife that also acted as a sump or storage basin for water. The plan also called for an earthen closure structure that would block the Arkansas-White Cutoff, a natural connection between the two rivers, located some five miles below Wild Goose Bayou, which had been used by steamboats to avoid the extreme lower portion of the Arkansas River. The structure was designed to keep silt from flowing out of the Arkansas River into the White River and deteriorating its channel.

Lock and Dam 1 (later Norrell Lock and Dam) was to be located about one-half mile into the canal from the White River entrance. The lock would lift vessels a maximum of 30 feet into or out of the central pool of the canal when the water there was higher than that in the White River. The dam would be built in a fixed position without gates. It would

*Lock 2 in the
Arkansas Post Canal*



maintain a minimum water level in the canal; at higher levels, the canal water would flow over the dam into the White River. At still higher levels, river traffic would travel over the dam as well, bypassing the lock entirely. Lock 2 was to be located in the Arkansas Post Canal also, about three miles above Lock and Dam 1. Its purpose was to provide 20 to 28 feet of lift, which would provide a transition into or out of the pool created by Dam 2 (later Wilbur D. Mills Dam) that was to be located in the Arkansas River about three miles downstream of Arkansas Post.⁷

The pool created by Dam 2 would provide navigation depth in the Arkansas Post Canal and extend upriver some 30 miles to Lock and Dam 3. The precise site for this feature was determined by studies at the Waterways Experiment Station, which built a model of the lock and dam and 15 miles of the Arkansas River. Tests made on the basis of running water through the model allowed the engineers to provide valuable information not only on where structures should be located, but also on their size and shape and on the channel alignments that would work with them.

Lock and Dam 3 (later Joe Hardin Lock and Dam), like the structures below it and Lock and Dam 4, located 16 miles upriver, was built on a foundation of sand. Borings

done by the Vicksburg District indicated that the top stratum of river bed consisted of silt and clay that varied in depth from two to 30 feet. Below that was a layer of sand that ranged from 85 to 125 feet in depth. Creating a solid foundation meant driving steel and concrete pilings some 50 feet into the sand. Deciding on the composition of the pilings and their placement in the river was a critically important and highly sophisticated engineering problem. It was also relatively new to Little Rock engineers accustomed to the solid rock foundations that underlay dams built on the White River and the locks and dams on the upper Arkansas River. The complex calculations required by the pilings, however, were made much easier by the Bendix computer that the district had recently acquired.

Lock and Dam 3, however, was typical of low-head lock and dam design. The Little Rock District used model studies to establish many of the common features of the locks and dams—for example, the 110-foot by 600-foot lock chamber; the 60-foot-wide tainter gates separated by a 10-foot wide pier; 40-foot-long stilling basins with four-foot vertical



Powerhouse at Dardanelle Lock and Dam, 1966

end sills; and a level crest on the dam set at the level of the anticipated river bed elevation. (The one exception to the level crest was at Lock and Dam 4, where the nine gates next to the lock were designed five feet lower than the other eight gates in the spillway.)

Each structure in Arkansas was site adapted by varying the number of gates from 14 to 18 and the height of the gates from 23 to 35 feet. An additional feature in the locks and dams downstream from Pine Bluff was the inclusion of a navigation pass in the overflow embankment. This navigation pass could be used by towboats, barges, and levee repair equipment during major floods to ensure the safety of the levees, which were part of the Mississippi River and tributaries flood control project. The two high-head locks and dams (Dardanelle and Ozark-Jeta Taylor) differed in that the spillway gates were only 50 feet wide. A primary objective at each lock and dam site was to have a spillway large enough to pass flood flows with the least interference and to have tainter gates that could be raised above the flood level and, in some cases, above the tops of nearby levees.⁸

Actual construction on the lower Arkansas began in May of 1963 when work started on Lock and Dam 1 and also on Lock 2 and Dam 2. That same summer tugboats pushed

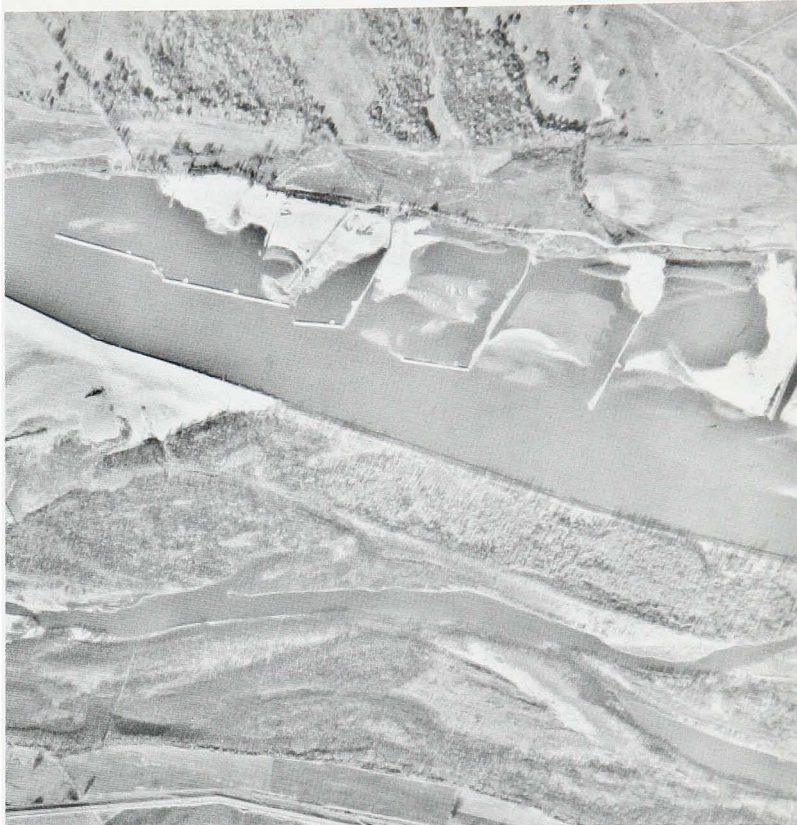
two giant dredges across the Intracoastal Waterway to New Orleans and then up the Mississippi River to the White River.

Arriving at the mouth of the cutoff that connected the White River with the Arkansas River, the dredges began to suction away silt, clay, and sand from the bottom of the White River and pile it into what would eventually become an earthen embankment some 7,000 feet long and up to 30 feet high, known as the White River Closure Structure. Construction of Lock and Dam 3 began in May of 1964.⁹

In September of 1966, the Little Rock District accepted Dam 2 from the contractor, making it the first of the Arkansas River waterway locks and dams to be completed. Located near a horseshoe bend in the Arkansas River two miles below Arkansas Post, Dam 2 was the only dam constructed apart from its lock, which was located in the Arkansas Post Canal. Early in 1967, Lock and Dam 1 and Lock 2 were close enough to completion so that drainage pumps were turned off, and the Arkansas Post Canal began to fill. On March 31, 1968, with Lock and Dam 3 also nearing completion, the Little Rock District lowered the gates at Dam 2 and began to create a navigation pool that would extend upstream to Lock and Dam 3. The initial 50 miles of the new waterway were then ready for traffic.¹⁰

The district moved steadily upriver. In October of 1965, it placed under construction Lock and Dam 13, located seven miles east of

*Dike field below
Lock and Dam 8*



Fort Smith and the last lock and dam in Arkansas. Early in April of 1966, the \$1.2 billion waterway reached a halfway point. Colonel Frank P. Bane, commander of the Little Rock District, and Harry Kraus of the Dravo Corporation in Pittsburgh celebrated by dumping a special bucket of concrete into Lock and Dam 6, already known as the David D. Terry Lock and Dam, which was under construction 12 miles east of Little Rock. Lock and Dam 11, which would have been located between Ozark Reservoir and Dardanelle Reservoir was eliminated in 1963 when the Ozark Lock and Dam was moved 10 miles downstream. The possibility that this might occur had been known as early as 1957, but the lock and dam was left in the plan until studies could be done to determine whether the water flowing through Ozark Lock and Dam would degrade the stream bed below it enough to make an additional pool unnecessary. Another change in plans involved the installation of hydroelectric power at Ozark Lock and Dam. The development of an inclined-axis tube turbine, which was substituted for the usual vertical-axis turbine, saved \$2 million and made it economically feasible to install a powerhouse.¹¹

The concrete structures emerging out of the river channel and spanning it from bank to bank justifiably received a great deal of attention, but effective navigation required other projects as well. "Bank Stabilization and Channel Rectification" accounted for 20

percent of the funds that the Little Rock District would spend on the waterway. Three types of activity were involved. Stone and pile revetment was used to line the bank of the waterway at critical points to prevent the river from altering its course. Groups of stone and pile dikes, known as dike fields, were built at right angles to the river to make the channel narrower, deeper, and self-cleaning. Finally, cutoffs were made to shorten and improve the channel. Draglines cut pilot channels across bends in the river, and the water poured through, enlarging the pilot channel and making a new, more navigable course for the river. By the summer of 1970, when the work was 89 percent complete, the Little Rock District had constructed 239 miles of revetment at different places, created dikes that would have stretched 150 miles if laid end to end, and moved 38 million cubic yards of earth and sand in the process of straightening the river.¹²

The 10 miles of the White River between



*Lock and Dam 4 foundation.
Note pile drivings in the sand.*



Lock and Dam 4 under construction



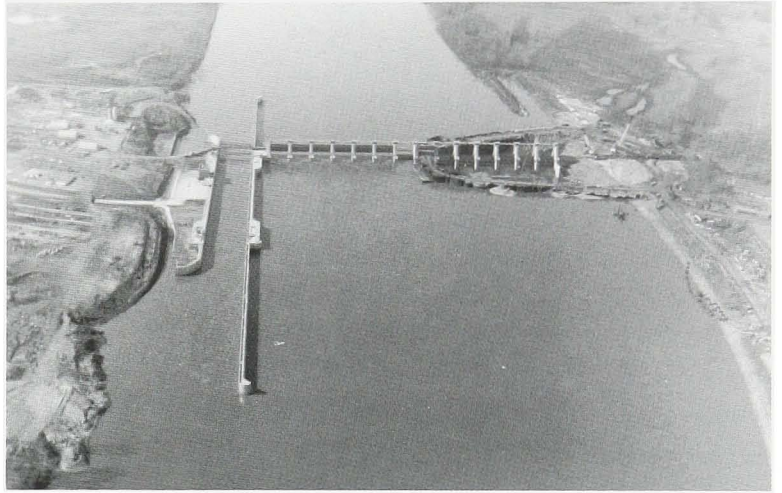
Lock and Dam 5 under construction



*Lock and Dam 6
under construction*

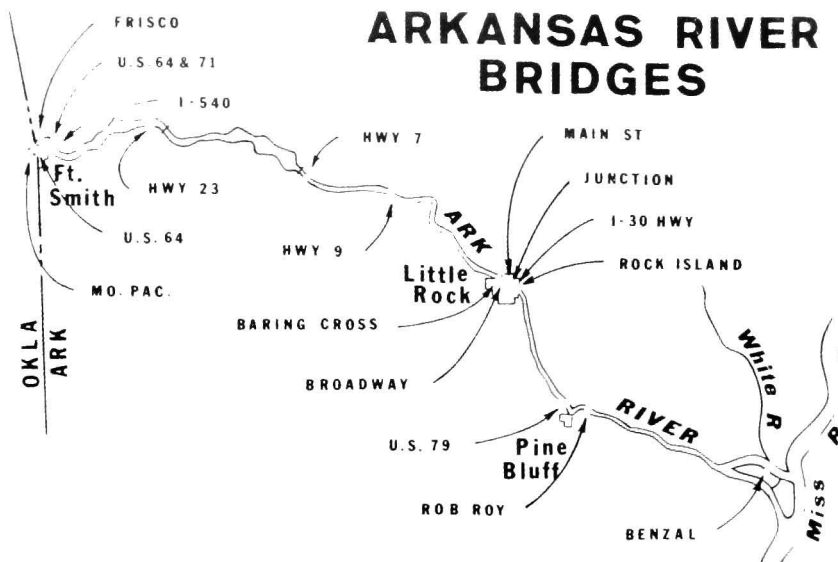


LEFT—First-stage diversion (cofferdam) at Lock and Dam 9, February 1968; BELOW—Second-stage diversion (cofferdam) at Lock and Dam 9, February 1969



Lock and Dam 13 bridge (near Fort Smith) under construction, January 25, 1977

ARKANSAS RIVER BRIDGES



Arkansas River bridges at time of construction of McClellan-Kerr Navigation System

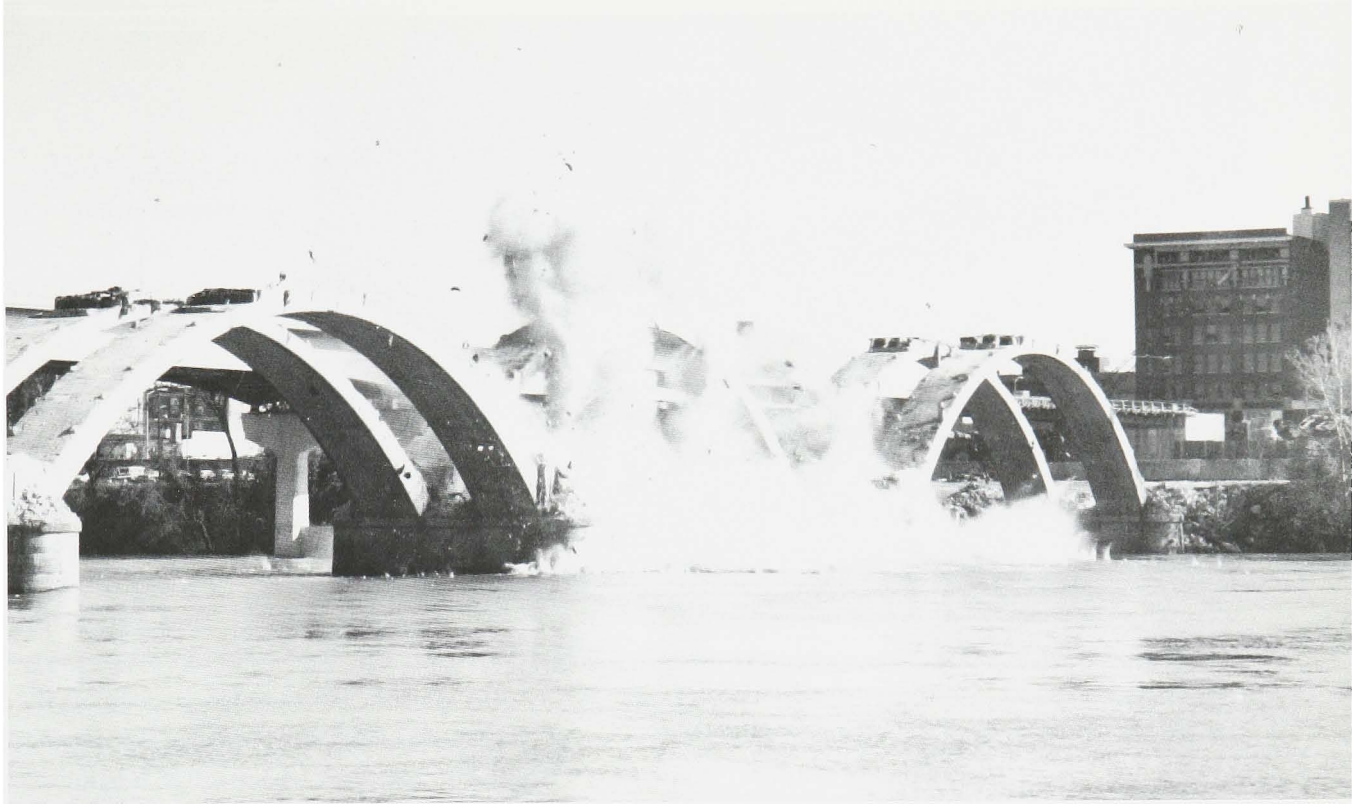
the Mississippi River and the Arkansas Post Canal received five miles of stone and pile revetment. During 12 months in late 1963 and early 1964, a total of 1.25 million tons of stone was hauled by train and truck to construction sites below Pine Bluff to be used in dikes and revetment. Much of it came from quarries along Highway 65, and residents of that area complained that stones sometimes fell from trucks to the peril of passing automobiles. Up and down the river, huge draglines dug cutoffs, taking 15 cubic yards of earth in each of their mouthfuls. At Fourche Place, six miles below Little Rock, a two-mile cutoff required 120,000 bites to create a ditch 30 feet deep, 135 feet wide at the bottom, and 320 feet across at the top. A dragline working on a sandbar near Wrightsville in the summer of 1961 was forced to protect itself from a sudden rise in the river that threatened while the machine was temporarily disabled. Operators built a five-foot mound of sand on the highest point of the bar and covered it with a layer of oak timbers. As the water rose, the dragline "walked" ponderously on its steel, pontoon-like legs over to the mound, climbed it, and remained safe from the flood.¹³

In addition to the construction of the White River Closure Structure, dredges were

used to widen and deepen the channel of the Arkansas River, which was required to be nine feet deep and 300 feet wide. To meet those specifications, all

the navigation pools except the one formed by Lock and Dam 3 required dredging, but most of the work took place above Little Rock, where the pools were shallower than at the lower end of the river. In problem areas, the Little Rock District required the contract dredges to create a channel that was 12 to 16 feet deep and as much as 400 feet wide. The extra space was known as "advance maintenance" because it postponed the day that more dredging would be required. About \$20 million was spent in this activity, and an estimated 60 million cubic yards of sand were moved, enough to fill five million large trucks. The cutter-head dredges that worked in the Arkansas River loosened the riverbed with an auger and then suctioned away the watery sand with a hydraulic pump, carrying it through as much as 2,500 feet of pipe before spewing it out on a selected site. Usually the material obtained from clearing the channel was deposited along the river bank, often between the dikes in a dike field.¹⁴

While the channel was being enlarged, the area overhead was also being cleared. Electric power lines, for example, were relocated to provide at least 72 feet of clearance above the water. More important, bridge openings were required to provide towboats with 300 feet of



Demolition of old Main Street bridge in Little Rock, 1973

horizontal clearance and 52 feet of vertical clearance above the two-percent flow line (a flow equalled or exceeded two percent of the time). In April of 1965, the Corps of Engineers announced that six of the 16 highway and railroad bridges that spanned the Arkansas River in Arkansas would have to be modified to meet these specifications. The proposed solution was to install on each bridge a 300-foot lift span that would raise vertically to allow the necessary clearance. The problem was more difficult at Little Rock because towboats would have to thread six bridges and because obstructions on the south bank caused cross-currents that could be dangerous in high flows. Again the Waterways Experiment Station built a model and ran a test. On the basis of the results, the Little Rock District decided that adding a lift span to the Missouri Pacific bridge, putting “protective cells” around the piers of other bridges to make them safer, and constructing a 1,600-foot dike parallel with the south bank

to eliminate the cross-current would create a safe channel. Towboat operators, however, argued that the situation would still be dangerous in high water when the current was strong. After more study, the district recommended to the Arkansas Highway Department that the Main Street bridge be replaced and the Broadway bridge be modified.¹⁵

Over the next year, the bridge plan changed, in part because of further study and in part because of local opposition. The Corps of Engineers decided that it was best to install lift spans on all seven railroad bridges over the Arkansas River, a change that would be paid for by the government and would inconvenience only trains. Lift spans on automobile bridges were a different story. Arkansans, led by Senator John McClellan, argued that causing traffic to wait while a bridge span was lifted for a tow was a serious inconvenience. In some cases, the Corps of Engineers felt that a new bridge could be



*Rob Roy railroad bridge
with elevated section,
1976*

justified on the basis of economic benefit. In other cases, however, the engineers believed the government could pay only the cost of a lift span, and the additional cost of a new bridge should be paid by state and local government. Wayne Hampton, chairman of the Arkansas Highway Commission, voiced the local view when he argued that “the Arkansas River navigation program [was] strictly a federal program” and should be paid for with federal funds. To resolve these concerns, Senator McClellan and other members of the Arkansas congressional delegation invited state and local leaders to Washington for a meeting with Chief of Engineers Lieutenant General William F. Cassidy. Within a week after the meeting, McClellan announced that the issue was resolved, and the Arkansans had gained almost everything they wanted. Six existing automobile bridges would be replaced with new bridges, and three would be modified; but none would have lift spans. McClellan estimated that the total cost would be \$36 million and that all but \$750,000 would be paid by the federal government.¹⁶

Funding

Senator McClellan’s leading role in the bridge controversy was an indication of his importance to the Arkansas River project as a whole. The Corps of Engineers was able to construct locks and dams, deepen the river’s channel, and stabilize its banks only because of a series of appropriations that would eventually total over \$1.2 billion. The entire Arkansas congressional delegation, as well as the Oklahoma delegation, played a role in securing those funds, and they were assisted by the Arkansas Basin Association and other local leaders; but McClellan was the acknowledged leader in Arkansas. As a member of the Senate Appropriations Committee and its Public Works Subcommittee, which considered the bills that appropriated money for the Corps of Engineers projects, McClellan played a major role on behalf of the navigation system. In January of 1963, when Senator Robert S. Kerr died, waterway backers in Oklahoma declared that McClellan was now the congressional leader for the project as a whole. That summer the Little Rock *Arkansas Gazette* called him “the hero of the River supporters.” The newspaper also declared, with some irony, that

the Senator was “a fiscal conservative except for spending on the Arkansas River.”¹⁷

Appropriations did not come easily in the early years of the 1960s. Brigadier General William Whipple, when he retired as Southwestern Division engineer, explained the hard facts to the Arkansas Basin Association in June of 1960. Getting the government to commit to the Arkansas River project was a big victory; but even though reservoirs were being built and bank protection was under way, each individual project would still need the approval of the Bureau of the Budget and of Congress. However, Whipple went on to provide an explanation for full and timely funding: “Except for the Oologah Reservoir . . . every remaining project unit in the system is dependent for its economic justification on the completion of all units in the system.” In other words, the economic benefits of the waterway would be realized only after it was complete; it was impossible to save money by delaying or stopping short of the goal. Whipple had also made it possible to use this argument with great precision. As division commander, he had instituted a planning tool known as Critical Path Method, which provided a comprehensive schedule of the Arkansas River project and made clear how much money was necessary to finish at a given time. Arkansas congressmen and river boosters would make use of this argument and this information many times in Washington over the next few years.¹⁸

President Eisenhower had not been very supportive of the Arkansas River project; but his final budget, presented in January 1961, provided funds to continue construction on Dardanelle Lock and Dam and also to do some bank stabilization work, although not all that had been requested. Explaining the good news, the *Arkansas Gazette* used an argument very similar to that of Whipple: “The projects have moved on to the point where the funds must be spent now or the projects will be more expensive in the long run.” The Arkansas River project did rather well in 1961 and 1962, in part because President Kennedy was more favorably inclined to it than Eisenhower had been. Despite the death of Senator Kerr, William H. Kennedy Jr., of Pine Bluff, president of the Arkansas Basin Association, told a Little Rock audience early in 1963 that the city should begin working on its port because navigation would be available in 1968.¹⁹

A public relations setback for the Arkansas River effort came in August of 1963 when *Life Magazine* published an article attacking wasteful government spending and calling the Arkansas River project “the most outrageous pork-barrel project in United States history.” The magazine referred to Senator Kerr as the “all-time king of the pork barrel,” and quoted an unnamed Army engineer who denounced the project because “the Arkansas is the most godawful, cantankerous river in the country!” Senator McClellan accused *Life* of distorting



McClellan speaking at Ozark dedication ceremonies, 1968

political facts and ignoring economic benefits associated with the development of natural resources. Governor Orval Faubus of Arkansas was less restrained. He claimed that the *Life* piece illustrated the “distorted, slanted, colored and even falsified literary practices of such periodicals” and added that the magazine disliked his state because “the projects in this area are too worthwhile [and] the people of the whole region too decent, honest, God-fearing and patriotic.”²⁰

Valid or not, the *Life* article came at a bad time. In the fall of 1963, the Kennedy

administration was preparing to cut the budget, and legislators from Arkansas and Oklahoma visited Budget Director Kermit Gordon to explain that any postponement of funding for the Arkansas River project “would add to the overall cost and nullify any savings a cutback next year would bring about.” They apparently received some assurance about future funding, but that support seemed problematical after President Kennedy’s assassination and his replacement by President Lyndon Johnson. Eventually Johnson’s budget provided \$84 million for the Arkansas River

First commercial tow (upper right) leaves Lock 2 moving upstream, 1968.

project instead of the \$123.9 million that the Corps of Engineers believed was necessary to keep it on schedule. The Arkansas Basin Association predicted that the reduction, if it continued, would result in postponing completion by four or five years and that each year would mean a loss of \$54 million in benefits. Members of the association, including Jeta Taylor of Ozark, Emmett Sanders of Pine Bluff, and E. S. Stephens of Fort Smith, went to Washington in February to secure an increase in funds, testifying, as they had many other times, before the House and Senate appropriations subcommittees on public works. Senator McClellan supported the Arkansas River project before his own subcommittee, arguing that the president's budget would delay it a year. Arkansas Senator J. William Fulbright also testified, as did Congressmen Trimble and Harris. Eventually they succeeded. President Lyndon B. Johnson increased the request to \$98 million, which was what the Corps of Engineers felt was necessary. Senator Fulbright summarized the politics succinctly, no doubt with an eye to the upcoming presidential election: "This is a good example of what the congressional delegation can accomplish with a Democratic administration."²¹



President Johnson attended the dedication of Eufaula Dam in Oklahoma in September of 1964 and announced his support for completing the Arkansas River project by 1970. The next month, at a ceremony marking the beginning of work on Ozark Lock and Dam, Senator McClellan said the president now understood that "delays in this program would be wasteful and imprudent," and there would be no further serious problem with funding. The project was 30-percent complete, and McClellan believed that Washington would provide at least \$150 million a year for the next six or eight years until the job was done. Jeta Taylor, president of the Arkansas Basin Association, echoed the same confidence. Looking back in 1968, McClellan made the same assessment, telling the Arkansas Bankers Association, that 1964 had been the critical year.²²



President Richard M. Nixon dedicates the McClellan-Kerr Arkansas River Navigation System at the Port of Catoosa, June 5, 1971.

Completion

In 1968 it all began to come together. Commercial navigation began on the waterway in April when the towboat *Charles Connor* pushed two barges, one filled with stone and one transporting a crane, up the Arkansas Post Canal and into the pool created by Dam 2. In October Senator McClellan officially inaugurated navigation to Little Rock by opening the lock at David D. Terry Lock and Dam and allowing a towboat and barge to proceed upstream toward the city. Addressing a crowd of 3,000 persons, the senator declared that “this project demonstrates once more the ingenuity of man in harnessing and transforming the destructive power of a mighty and turbulent river.” McClellan also paid tribute to individuals who had helped to bring the project in being who were no longer living, among them David D. Terry of Little Rock, for whom the lock and dam was named, Senator Robert S. Kerr, Representative William F. Norrell of Monticello, Clarence Byrns of Fort Smith, Newt Graham of Tulsa, and Jack Murray of Little Rock. At the end of

the year, the towboat *Arkansas Traveler* was being refitted in Paducah, Kentucky, in preparation for a trip to Arkansas, during which she would bring the first two barges to Little Rock.²³

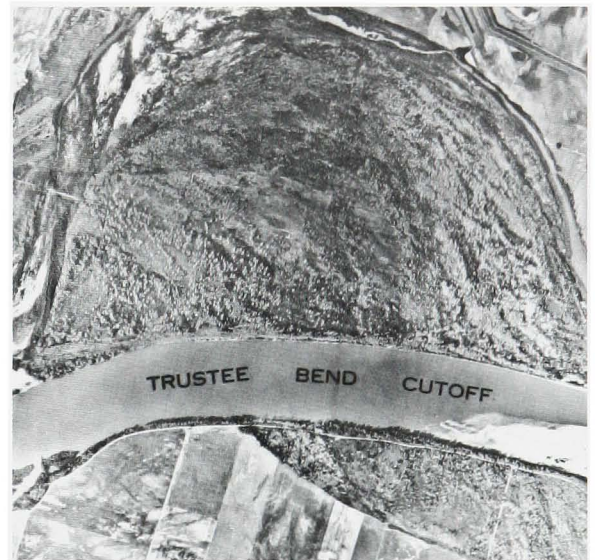
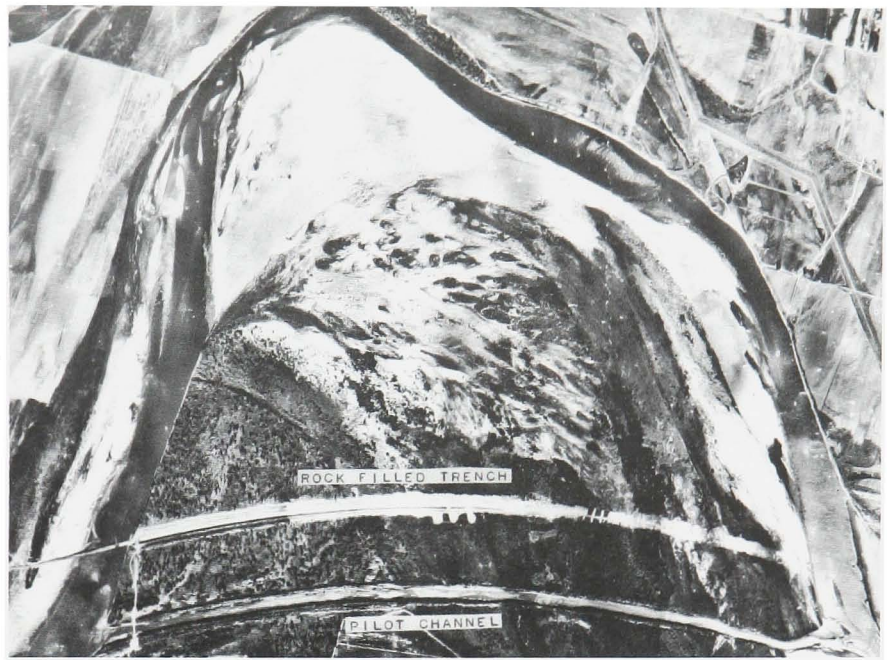
Two years later, on December 31, 1970, the waterway was officially declared open for navigation. A few days after that, President Richard M. Nixon signed a bill naming it the McClellan-Kerr Arkansas River Navigation System. On June 5, 1971, Nixon visited the Port of Catoosa and officially dedicated the new waterway. Speaking to a crowd of some 20,000 people, he said that the waterway would improve farm income and bring industrial development so that the migration of rural people to the cities could be reversed. He called the Arkansas River project a “monument in action,” honoring the “two senators whose names it bears,” and “the vision of many other leaders.” Speaking to them, Nixon said, “You have demonstrated once again the vitality of the American tradition of daring great things and achieving what we dare.”²⁴

By the time of its completion, the McClellan-Kerr Arkansas River Navigation

Cutoffs reduced the total navigation route by about 60 miles. They were constructed to avoid rectifying horseshoe bends in the meandering river.

RIGHT : Cutoff at Trustee Bend, 1956, showing the cutoff with some water flowing through the pilot channel. The rock-filled trench was designed to limit the cutting of the river.

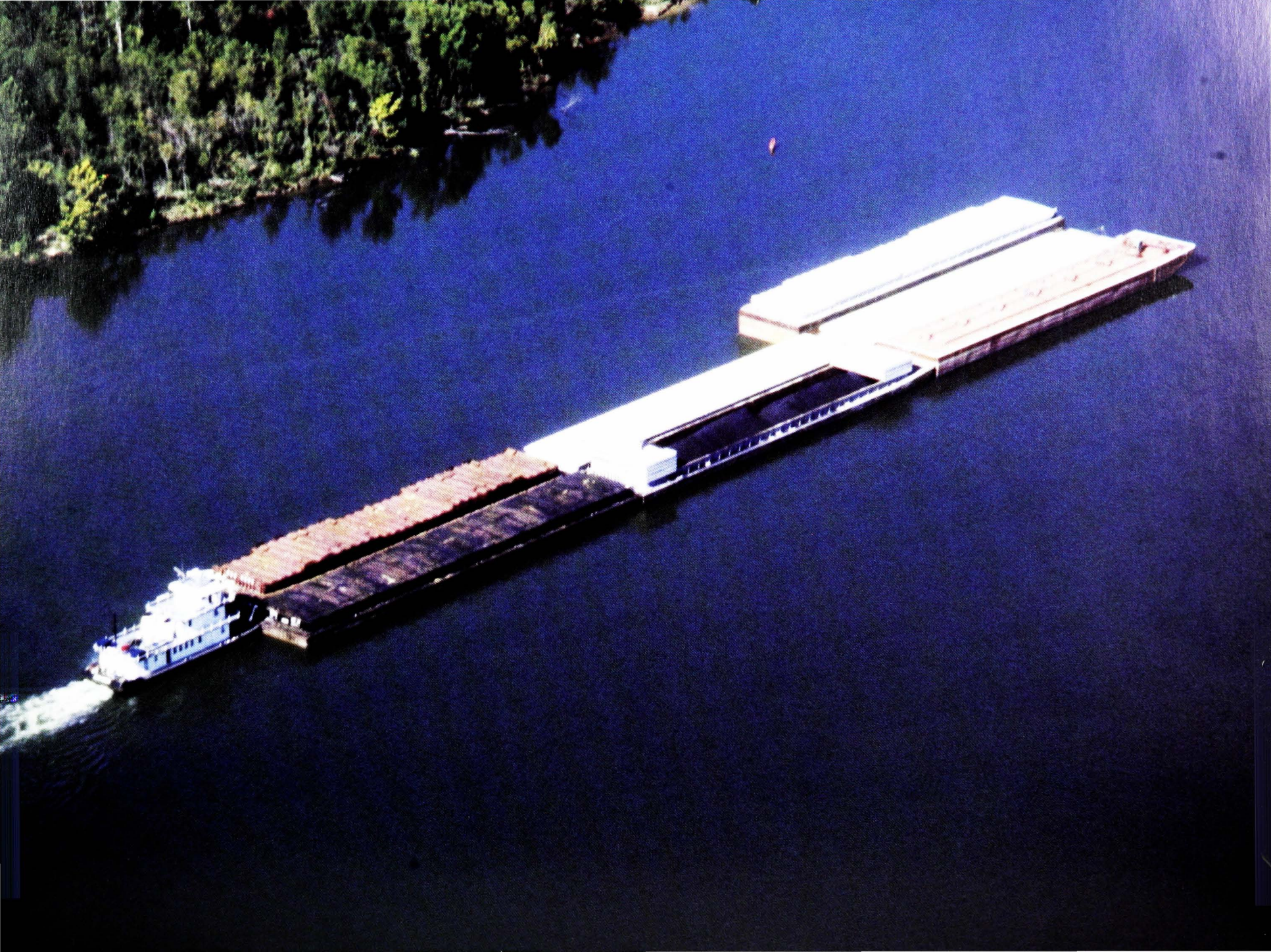
BELOW RIGHT: Cutoff at Trustee Bend, 1969, showing that the current of the river has cut the balance of the channel.



System was already beginning to lose its pork barrel image. Reporting on the dedication of David D. Terry Lock and Dam, the *New York Times* declared that the waterway would cost more than the St. Lawrence Seaway and four times what the United States paid for the Panama Canal, but that it would return a profit for every dollar spent. Moreover, the newspaper quoted Senator J. William Fulbright, whose speech at the ceremony pointed out that the \$1.2 billion price tag [which later would become \$1.3 billion] would finance only two weeks of the Vietnam War. On another occasion, the *Times* cited the dictum of Will Rogers, the Oklahoma humorist, that “it would be easier and cheaper to pave the Arkansas than to develop it,” but it went on to point out that the project had already tamed a river that often “went on a rampage, destroying towns, tearing up ranches and killing thousands of head of valuable cattle.”²⁵

It was also true that even if Will Rogers had been right about the cost, paving the Arkansas River would only have produced a road, while the waterway provided much more than transportation. On the day after President

Nixon dedicated the system, the *Times* discussed the numerous benefits of the multiple-purpose project: low-cost water transportation that would save shippers an estimated \$40 million each year, flood control, hydroelectric plants that would produce more than three billion kilowatt-hours of electricity, the attraction of new industry that would generate 20,000 new jobs in the next five years, and recreation at the lakes and parks developed in conjunction with the reservoirs and waterways.²⁶



Chapter 3

Operating a Waterway

The opening of the McClellan-Kerr Arkansas River Navigation System marked the end of a long process of planning and construction and the beginning of a longer period in which the waterway would function as an important artery of inland navigation. Seventeen locks and dams and 445 miles of channel allowed barges to travel from the Mississippi River to the Port of Catoosa, but each structure and every mile would require some attention by the Corps of Engineers.

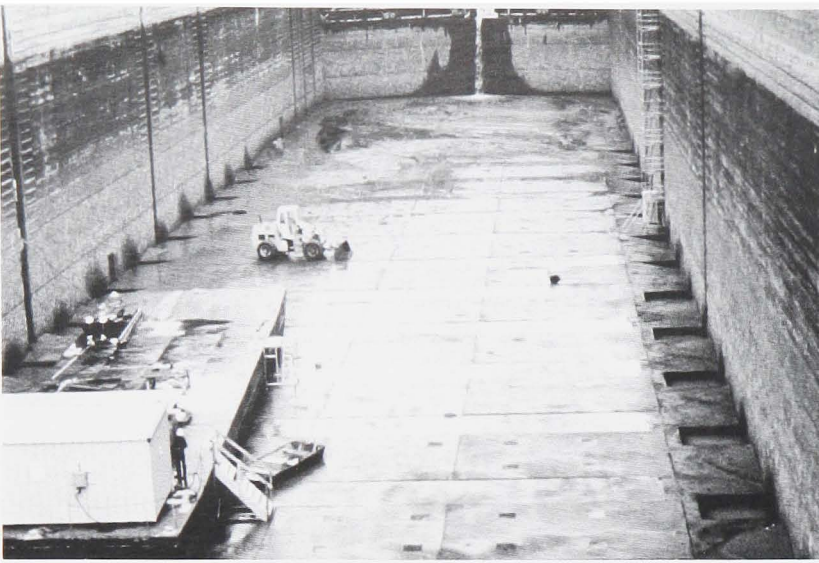
The Little Rock District is responsible for the 12 locks and dams and more than 300 miles of waterway located in Arkansas. Within the district, day-to-day operations and maintenance of the system are carried out by resident offices, often working under the direction of district headquarters. The Pine Bluff Resident Office handles the portion from the Mississippi River to Little Rock, and the Russellville Resident Office is responsible for everything from Little Rock to the Oklahoma line. The McClellan-Kerr System is a complex thing, “a big machine,” as one engineer has called it.¹ All of the components of this system, from the reservoirs to the river channel, to the locks and the dams, to the hydroelectric powerhouses, are interrelated.

The Navigation Mission

The McClellan-Kerr Arkansas River Navigation System is part of the nation’s inland waterway system, which includes approximately 11,000 miles of channel at least nine feet deep. Each year more than a half billion tons of commodities are shipped over the system. The Arkansas River is part of the Mississippi River system, along with other tributary rivers such as the Ohio, Illinois, Tennessee, and Missouri. Together with the main stem Mississippi River, these waterways make up 85 percent of the nine-foot navigation in the United States. The lower Mississippi River, the portion below the Ohio River and above the deep-water, ocean-vessel channel that begins at Baton Rouge, has no locks and can accommodate tows with 40 or more barges, a set of circumstances that makes transportation very inexpensive. In 1993, 184 million tons of commodities traveled on the lower Mississippi, moving back and forth from the tributary rivers to ports on the Gulf Coast. Farm products were more than half of that total; and coal was a third, while petroleum and petrochemicals were also important.²

The primary goal of operations on the McClellan-Kerr System is to ensure reliable, year-round navigation on the Verdigris River, Arkansas River, and White River so that commercial shippers can have access to and from the Mississippi River. Barges moving

OPPOSITE PAGE—Towboat pushing barges along the Arkansas River



Unwatering Lock 1, 1980

downstream carry large amounts of wheat and lesser quantities of soybeans and rice. Traffic coming from the Mississippi brings agricultural and industrial chemicals and significant amounts of industrial metals. Commercial shippers use private ports as well as public ports that have been developed by the river cities of Catoosa and Muskogee in Oklahoma and Fort Smith, Little Rock, and Pine Bluff in Arkansas.³

Recreational navigation is also important on the waterway. The navigation pools above each dam make ideal sites for boating and fishing, and the operation of the system has made the Arkansas a much cleaner river than it was. Parks and campsites located along the waterway have enhanced its use by boaters. Pleasure boats are allowed to go through the locks free, but commercial vessels are always given preference.⁴

Locks, Dams, and Pools

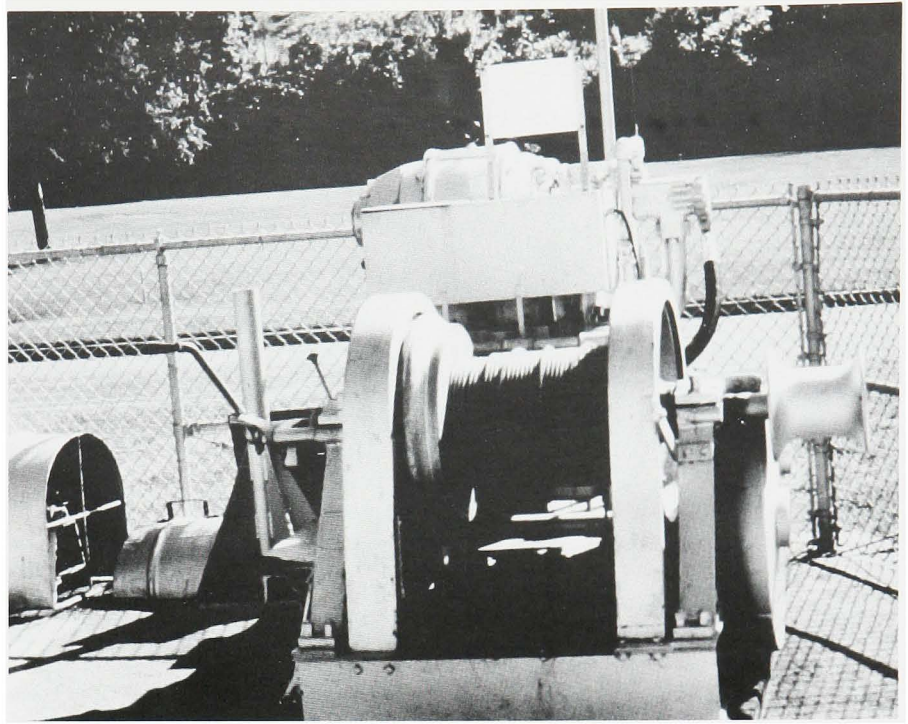
Navigation on the Arkansas River in its natural state was hampered by a shortage of rainfall at certain times of the year and by the fall of the river, which is close to a foot per mile between Tulsa and the Mississippi River. The 11 dams on the Arkansas River in Arkansas create pools in

which a navigation channel with a minimum depth of nine feet can be maintained.

Together they create a stepped series of pools, a staircase of water as it has been called, that replaces the gradual fall of the natural river. The locks, of course, lift or lower vessels from one pool or stair step to another. The pool-to-pool height, or the lift of the lock, as it is called, varies greatly. The Emmett Sanders Lock and Dam has a lift of only 14 feet, while the lift at Dardanelle Lock and Dam is 54 feet.

Locks and dams vary in size, but lock chambers are uniformly 600 feet long and 110 feet wide. They can accept the variety of barges used by towboat companies as well as all sorts of recreational vessels. Indeed, in 1986 a 300-foot, ocean-going cargo ship registered in Germany made its way up and down the McClellan-Kerr System. A normal lockage requires about 30 minutes. Locks can accommodate a towboat and eight jumbo barges, each 35 feet by 195 feet, which are known collectively as a "single cut." Sometimes a towboat will push a "double cut," 12 or more jumbo barges, which situation requires the tow to be divided in half and locked through in two operations. An important recent development is the installation of tow haulage equipment at locks on the lower river. This allows a tow to move through the lock without its towboat, controlled instead by a permanently installed

Tow haulage equipment, which allows cargo to move through the lock independent of its tow



cable and winch system that “hauls” the barges out of the lock and allows them to be moored. A towboat pushing a “double cut” can send half of it through the lock and organize the second half

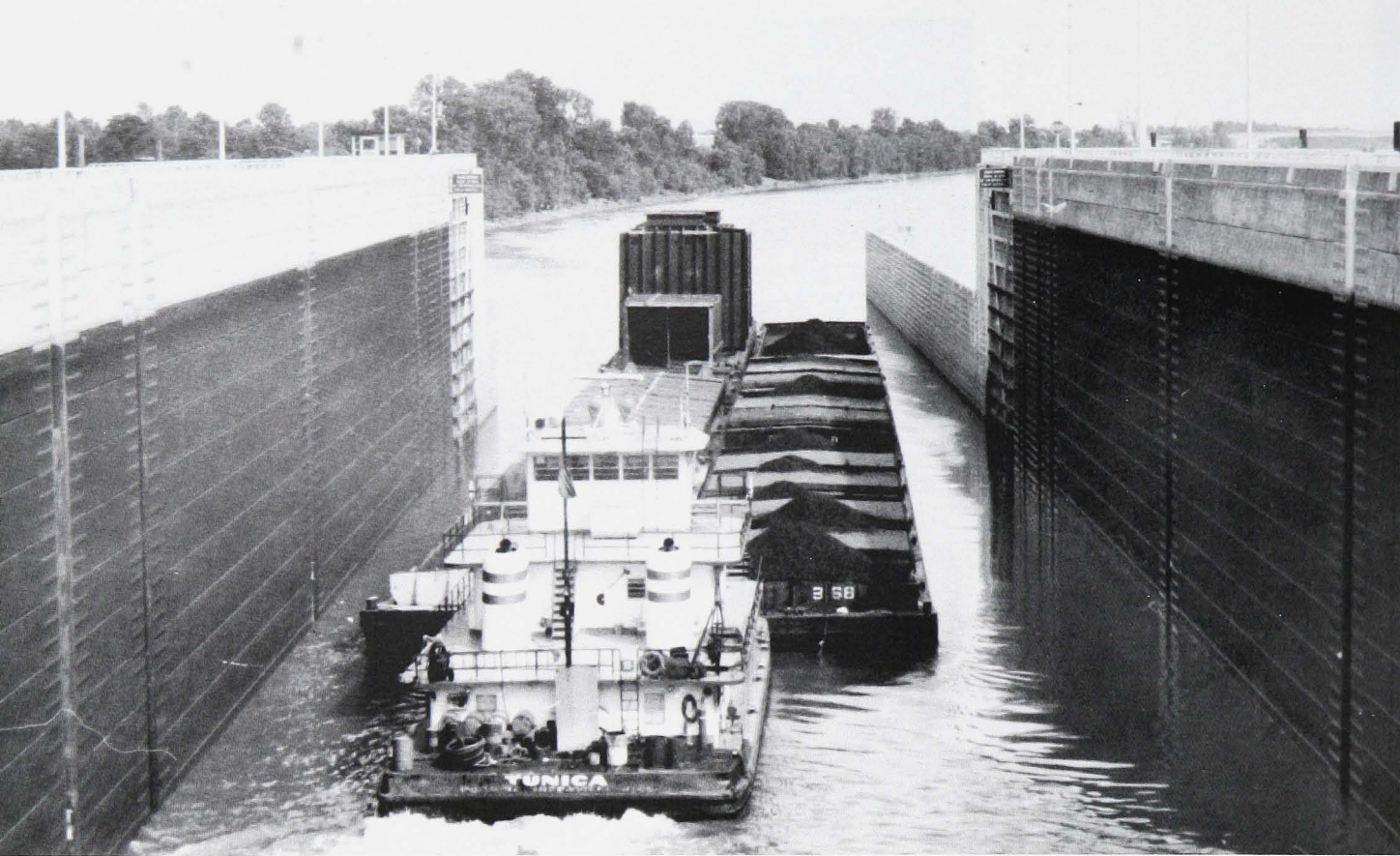
while the first is moving. Tow haulage equipment is gradually being installed on all the locks and dams below Little Rock.⁵

Like other forms of equipment, locks require routine maintenance. Some of this can be done during normal operations, which go on 24 hours a day and 365 days a year, but other maintenance and repair operations require access to the underwater portions of the lock. The Little Rock District has instituted a long-range maintenance schedule for locks that involves unwatering two of them each year for a thorough examination and the making of any necessary repairs. The entire process takes about two weeks. Shippers, port managers, and towboat operators are alerted to this schedule to minimize inconvenience.⁶

While vessels move from pool to pool through the locks, water travels downstream through the spillways of the dams. These vary in length according to the terrain, ranging from about 1,000 feet to about 1,200 feet. Each spillway consists of a series of concrete piers and bays with hinged gates. Dardanelle Lock and Dam and Ozark Lock and Dam

have gates that are 50 feet wide, while other dams have 60-foot gates. The height and number of the gates vary from dam to dam. Wilbur D. Mills Dam has 16 gates, while Dardanelle Lock and Dam has 20 gates. Emmett Sanders Lock and Dam (formerly Lock and Dam 4) has gates of two different heights. Various gate configurations reflect engineering calculations as to how best to control the flow of water within the limitations of streambed and banks. Below the spillway and out of sight under water, each dam also has a stilling basin, a concrete apron that extends for 40 to 80 feet, depending on the dam, and keeps the flowing water from undermining the structure.

By raising and lowering the gates of a dam, lockmasters regulate the level of water in the pool above it and maintain conditions for navigation. The Corps of Engineers has an approved operating plan for each of the district’s dams and uses it to tell lockmasters how to set their gates. Only in emergency situations, when confronted with debris or with a loose barge, for example, do the operators at the dam depart from the plan to



Eight-barge tow loaded with coal and fabricated steel, 1978

deal with the immediate problem. Rarely does the flow of water on the system increase or decrease to such a level that it halts commercial navigation. When flows are low, the velocity of the river is low, creating ideal navigational conditions. The pools in the system maintain their channel even when the flow is nearly zero. During extremely high flows, however, dam gates are raised out of the water to let it pass as quickly as possible. Under this condition, known as open river, the river reverts to its natural state without pools.

Dams also manage the flow of water from pool to pool to assist in maintaining an optimal channel for navigation. Three techniques are used in the process—the hinged pool, elevated pool, and navigation taper. When a navigation channel is created, the long upper portion of the pool may be sloped, while the area closer to a dam is

flattened. Because of this, sediment is frequently deposited at the intersection of the sloped and flat portions of the pool. To remove sediment from this point, dam operators hinge a pool during high flows by dropping the water level at the dam as much as five feet. The increased water velocity extends the sloped portion in the upper end of the pool and creates a scouring action that will flush out the intersection between the sloped and the flat channel and move the sediment downstream into deeper water. Hinging does not take the place of dredging, but it reduces the amount of dredging that has to be done.

To elevate a pool is to raise the water level by lowering the tainter gates and allowing less water to flow through. During high-flow periods, shoals build up in the upper, shallower end of a pool. It is sometimes necessary to elevate the pool to increase the

*Barge accident, Wilbur
D. Mills Dam, 1982*



depth over these shoals until they are removed. In like manner, a gradual buildup of a shoal during a prolonged low-flow period may require raising the pool to maintain navigation depths.

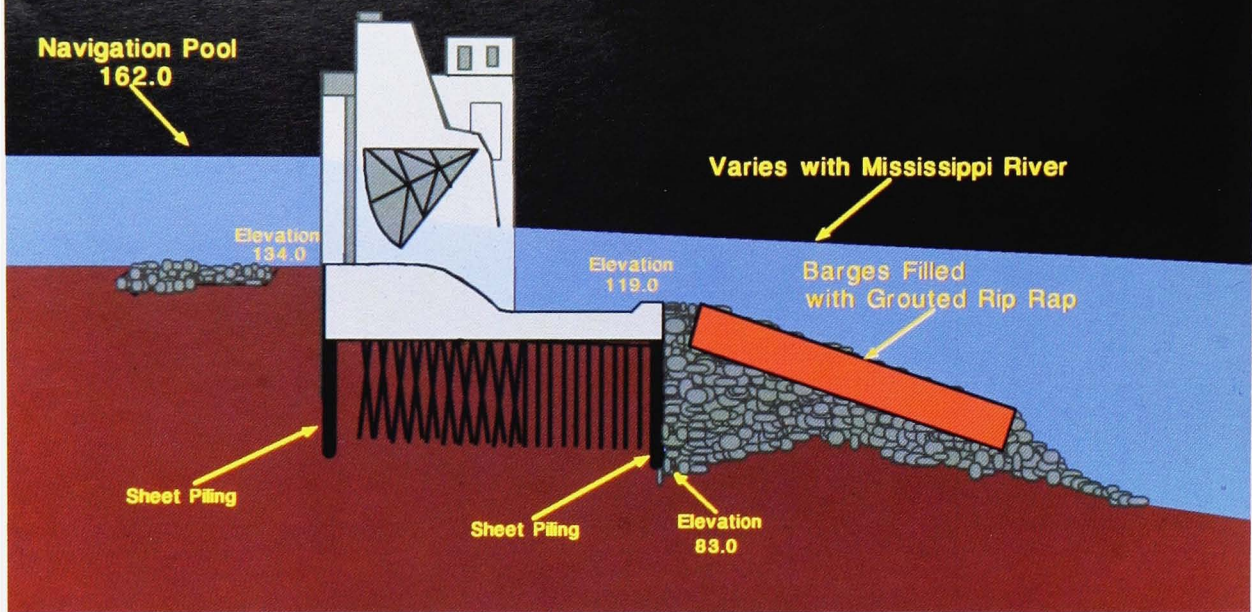
A navigation taper is created by changing the release rate of flood waters stored in the upstream projects. This is accomplished by reserving a minimum amount of flood waters to be released over a longer period of time. These releases are great enough to maintain navigation depths over shoals, but not long enough to jeopardize the flood control capacity of the storage projects. This additional time is used to locate the shoals and remove them before the navigation pools are lowered back to their low-flood levels.

Inland waterways are not the high seas, but accidents do happen and sometimes create dangerous circumstances. Fishing boats occasionally get too close to the lower end of a spillway and capsize in the turbulent water. Barges sometimes break loose from their tows and crash into the upstream side of a dam. Large and heavily loaded barges are difficult to remove, and these accidents sometimes close dams for several hours. In the summer of 1982, an oil barge broke loose in a high flow, lodged against Emmett Sanders Lock and Dam, and eventually submerged. Oil began to

leak from ruptured tanks in irregular “burps” and was quickly spread by the 10-mile-an-hour current. Over the next several days, an estimated 378,000 gallons of heavy grade oil, out of 880,000 gallons carried by the barge, leaked into the river, closing it to traffic. The Environmental Protection Agency established a command post in Pine Bluff to deal with the accident and hired private firms to contain the oil and clean up the river. Booms were placed at the head of the Arkansas Post Canal to prevent the oil from entering it. Not until two weeks after the accident was a private salvage firm able to raise the barge.⁸

Six months later a much more dangerous incident occurred. On December 4, during the flood of December 1982, 38 barges broke loose from a fleeting area above Wilbur D. Mills Dam and were carried downstream. Thirteen barges struck the dam, some sinking while others blocked the entrances to gates or became lodged in gate openings. The weight of the barges and the force of the water behind them actually pushed the dam a half inch out of alignment for a time. A more important threat to the dam was the greatly increased flow of water through the open

Wilbur D. Mills Dam Stilling Basin Enlargement



gates, which caused a dangerous scouring beyond the stilling basin that could have jeopardized the integrity of the dam itself. A potential existed for what one member of the Little Rock District called the “worst accident on the inland waterway system.”⁹

District officials called on the U.S. Navy supervisor of salvage to organize a team of private contractors to remove the barges. Eventually the operation required a 32-member salvage team, working over a 60-day period and using a variety of heavy lift cranes and derricks as well as the services of many towboats. The entire salvage operation cost \$3 million. On the first of day operations, a Pine Bluff Sand and Gravel Company towboat sank in the water below the dam, its crew members rescued by a safety boat that had been put on station the same morning of the accident.¹⁰

Removing the barges, however, turned out to be inexpensive compared with repairing the damage below the dam and ensuring its future stability. A study by Waterways Experiment

Station suggested that the best method was to extend the stilling basin by sinking hopper barges filled with concrete and stone. Eventually 26 barges were used, creating a floor on the bottom of the river that was 1,000 feet wide, 200 feet long, and 13 feet deep. The process began in 1990 and was completed in 1993 at a cost of \$19 million. The repair was a highly innovative solution. The traditional engineering approach would have called for the construction of cofferdams so that Wilbur D. Mills could be unwatered and the stilling basin repaired under dry conditions, a process that would have been much more expensive.¹¹

Banks and Channel

Construction of the McClellan-Kerr System included extensive bank stabilization efforts. These involved stone revetment to hold the bank in place at critical points and stone and pile dikes to deepen the current and push it into desired

*Dredging at Pine
Bluff Port, 1968*

alignments. In addition to creating a navigation channel, these works were intended to make the river run faster and deposit less

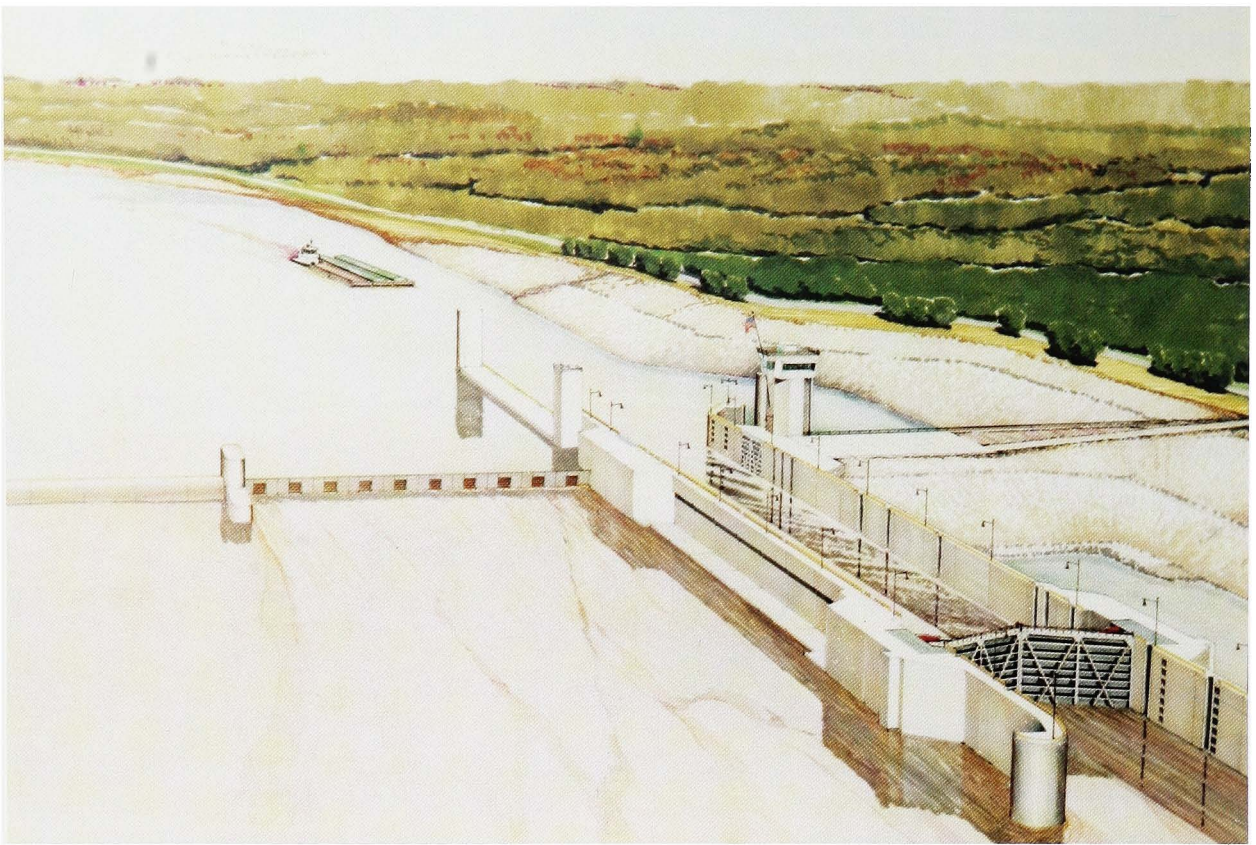
sediment. Since completion of the system, a process of fine-tuning has gone on. Additional revetment has been put in place, dikes added, and piles of stone installed at strategic locations. As a result of these efforts, the need for dredging has decreased over time in many parts of the river. Still, it has not been eliminated.

The bed of the Arkansas River is constantly in motion. The river moves sediment as the flow increases and deposits it as the flow decreases. During high flows, the river carries large amounts of sand and dumps it at places where its velocity lessens, causing shoals, sandbars that can affect navigation. To deal with these, the Little Rock District employs privately-owned, cutter-head dredges that chop the sediment and suction it away to be deposited elsewhere. In the same manner as other public or private parties, the Army Corps of Engineers is obligated to obtain permits ensuring that environmental standards are being met before depositing dredged materials along the river. Dredging operations within the Little Rock District normally amount to the removal of about two



million cubic yards of sediment each year. Over time the Little Rock District has located areas that must be dredged on an annual basis, but shoals still arise in unexpected places. The majority of all dredging is conducted below Pine Bluff, and the greatest need for it is in the White River below Norrell Lock and Dam.

Reconnaissance boats check channel depths every week or two to locate shoals and other impediments to navigation. After a shoal is located, a survey vessel makes a detailed hydrographic chart. Both boats use the Global Position System, which is based on satellite navigation, to determine the position of shoals and debris. The survey vessel also has side-scan sonar that records a three-dimensional chart of the river bottom. Reconnaissance boats disseminate information to lock masters even as they collect it, not only reporting on shoals and other obstructions to navigation but providing a written summary of system conditions, including channel depths and the status of navigation aids. Summaries of these reports are given to towboat pilots to inform them of



Artist's rendering of Montgomery Point Lock and Dam

conditions on the river.

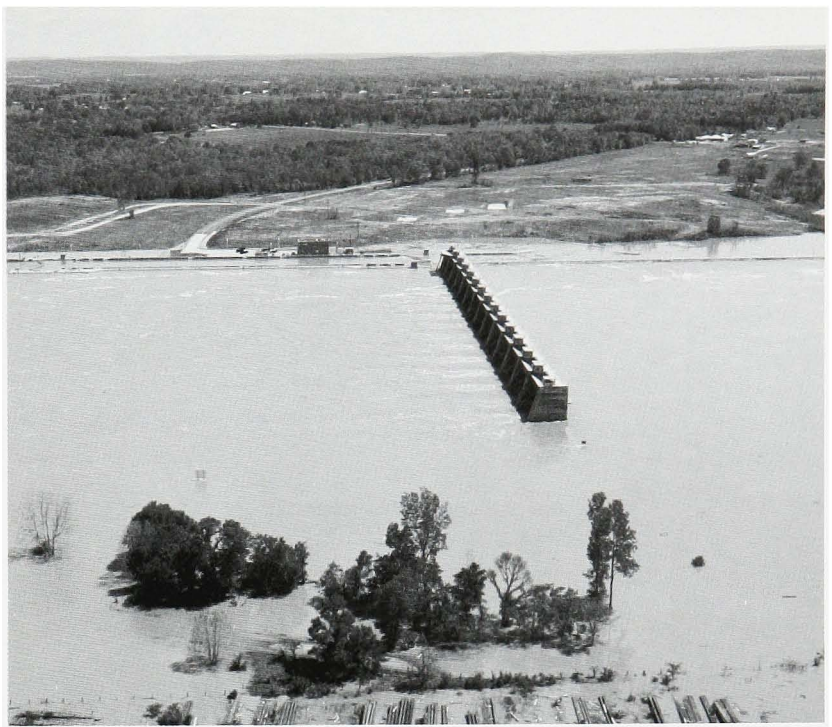
The United States Coast Guard installs and maintains navigational aids on the Arkansas River Navigation System. These permanent channel markers are noted on maritime charts that are available to both private and commercial waterway users. The Coast Guard regularly inspects navigation markers and replaces damaged or missing markers. Daily marine radio bulletins are available to help waterway users be fully informed on conditions and significant changes.¹²

Montgomery Point Lock and Dam

In recent years, the biggest operations and maintenance problem for the Little Rock District has been in the White River Entrance Channel. Vessels entering the McClellan-Kerr System from the Mississippi River travel 10 miles up the White River before encountering

Norrell Lock and Dam, which provides access to the Arkansas Post Canal. The depth of the channel in the White River is not controlled by any structure and is determined largely by the stages, or water level, of the Mississippi River. A major problem for the McClellan-Kerr System is that Mississippi River stages have been falling. When the system was designed, the lowest known elevation of the Mississippi at the mouth of the White River was 110 feet NGVD (National Geodetic Vertical Datum). In recent years, however, elevations below 110 feet have occurred a number of times; and during the drought conditions in the summer of 1988, the elevation of the Mississippi River at the White River was only 104.2 feet. Restrictions on navigation usually begin when the Mississippi drops below 112 feet and average over 44 days per year. During 1988 restrictions were imposed on navigation for more than six months.

*High water nearly
inundates Authur V.
Ormond Lock and
Dam, April 1973*



Dredging is one way to keep a channel open in times of low water, but it is an expensive process that produces only limited results. Because of the cost, the entire channel is not dredged, and dredging is combined with restrictions on the size or number of tows that can use the channel. Dredges also hinder river traffic while they work, and a number of them are usually required in the White River channel, creating a formidable obstacle. Limitations such as these cause significant expenses to waterway shippers and make other forms of transportation more attractive.

Furthermore, dredging alone will not solve the navigation problem in this area because the concrete sill elevation at Norrell Lock and Dam is set at 97 feet NGVD. No matter how low the Mississippi River stages fall, there is no need to dredge below 98 feet at Norrell Lock and Dam because at any lower level, commercial navigation traffic would not be able to pass over the concrete sill.

Another concern about dredging is that the channel flows through an environmentally sensitive area of wetlands and bottomland hardwoods with a large and varied wildlife population. Available sites to dispose of dredged material are becoming filled, and future disposal may place a unacceptable burden on the environment.

In light of these and other considerations

and after analyzing a number of other solutions, the Little Rock District has proposed the construction of Montgomery Point Lock and Dam. This lock and dam would be located six-tenths of a mile upstream from the mouth of the White River and serve as the “doorway” or entrance to the navigation system. The dam portion would be submerged at normal stages, and navigation would pass over its gates, which would be laid on the channel bottom in a horizontal position, with the tops of the gates at 102 feet NGVD. This bypass situation is estimated to occur about three-quarters of the time with existing stages on the Mississippi River but less than two-thirds of the time as the river continues to fall. At low stages, the gates in the navigable pass would be raised, rotated vertically, to a maximum of 115 feet to form a pool that would extend upriver to Norrell Lock and Dam. Under these conditions, river traffic would move through the lock.

Montgomery Point Lock and Dam is estimated to reduce substantially the dredging now being done at the mouth of the White River and allow commercial navigation to take



Livestock trapped by Arkansas River during flood of 1990

place on a year-round and unrestricted basis. It is estimated to cost \$163.5 million and to yield a 1.16 to 1 benefit-to-cost ratio over 70 years of service. The project is authorized and presently under consideration for construction funding by Congress.¹³

Flood Control

Flood control has always been an important goal for those interested in improving the Arkansas River, and it was a project purpose in the Corps of Engineers' multiple-purpose plan in 1943. On the other hand, that plan stated clearly that "flood-control reservoirs in the Arkansas River Basin will . . . result in a considerable reduction in flood heights and frequencies; however, the direct and indirect flood losses along the main stem of the Arkansas River will still be large after this system of reservoirs

is in operation." Ten years later, when the Little Rock District developed project design memoranda to implement the plan, engineers estimated that flood control benefits associated with the system would total \$6.6 million on an annual basis, 10 percent of total benefits derived from the system. The flood control benefits were principally associated with three reservoirs in Oklahoma that were being built as part of the new waterway—Keystone Reservoir on the Arkansas River, Oologah Reservoir on the Verdigris River, and Eufaula Reservoir on the Canadian River.¹⁴ Other large reservoirs in Oklahoma and two smaller ones in Arkansas, Blue Mountain Lake on the Petit Jean River and Nimrod Lake on the Fourche La Fave River, would also contribute to lessening peak flows on the Arkansas. The locks and dams on the Arkansas River, however, would do nothing to ease the destructive force of floods. Indeed, as we have

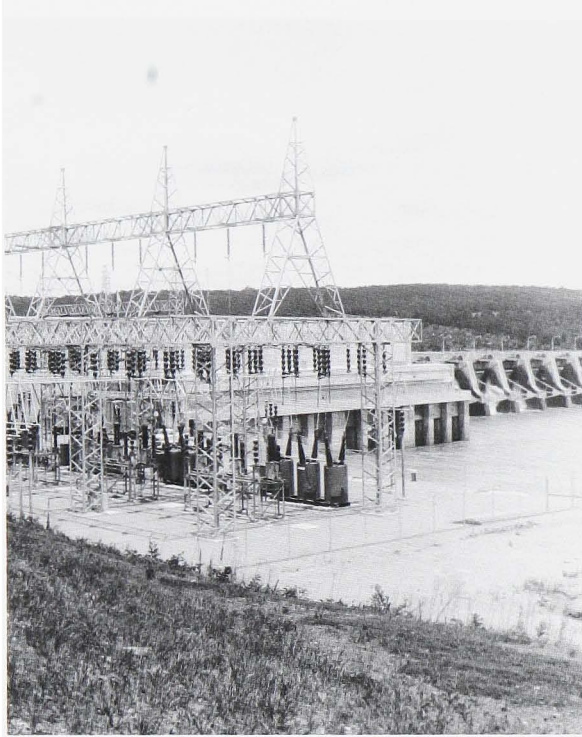
seen, when flows are extremely high, the dams lift their gates out of the water and go to open river.

Several years after the McClellan-Kerr System opened, Colonel Donald G. Weinert, Little Rock District Engineer, explained the realities of flood control. Speaking to the Little Rock Chamber of Commerce in March of 1973, he claimed that there was “a common misconception” that the McClellan-Kerr System would prevent flooding. He pointed out that the Oklahoma reservoirs could lower stages on the river but that flooding would still occur. He also made clear that the locks and dams were designed for navigation purposes and did not store flood water. On the other hand, Weinert denied that a recent series of high-water episodes were related to the operation of the waterway. Two weeks later Weinert wrote a letter to the editor of the *Arkansas Gazette* reacting to an editorial expressing “disillusionment” at his flood control talk. Elaborating on his early comments, the colonel pointed out that one cause of flooding was the rainfall that fell downstream from the reservoirs. Yet the reservoirs did make a difference. The Arkansas River had crested recently at 21.1 feet at Little Rock, just a small amount below flood stage. The Corps of Engineers estimated that without the storage capacity of the reservoirs, the crest would have been at 30 feet, and parts of the city would have flooded. Summing up, the colonel wrote that the Arkansas River

basin did not have “absolute flood control” but it had a “significant amount.” Two very wet months later, Weinert provided an illustration of how significant the amount really was. He reported that the reservoirs of the Arkansas River system had prevented \$18 million of damage in March and another \$18 million in April.¹⁵

Flood control is a major purpose of the reservoirs in the McClellan-Kerr System, but they are also used to produce hydroelectric power and serve a large and growing recreational industry. Water for these latter purposes is contained in the lower portion of the reservoir, known as the conservation pool. The difference between the conservation pool and the capacity of the reservoir is known as the flood control pool; it is this area that stores excess rainfall to prevent flooding downstream. Flood waters are released from those reservoirs according to an approved release plan.¹⁶

The McClellan-Kerr System has experienced a number of floods in the last 25 years, but none as severe as the flood of 1990. After a very wet spring and several severe rainstorms in April, intense rainfall in western Arkansas and eastern Oklahoma between May 2 and May 4 created a severe flood in the Tulsa and Little Rock Districts. The Arkansas River experienced its highest stages since 1945. Murray Hydroelectric Generating Plant, an almost new facility located at Murray Lock and Dam and owned by the



Dardanelle switchyard and powerhouse, 1968

City of North Little Rock was nearly covered with water. Despite extensive sandbagging and pumping, six homes in the exclusive Riverlyn Addition of Fort Smith were flooded. Flood fighters were more successful in the Crockett Addition of North Little Rock, another lowlying area. River Park and Island Harbor, both on the river side of the levee in Pine Bluff, suffered serious flooding. A private levee in disrepair in Perry County was overtopped, generating a furious flood fight that staved off serious damage. Up and down the river, livestock and croplands on the river side of the levee were hard hit. Flood damages amounted to an estimated \$34.2 million in the Arkansas River basin; but flood control structures, including the 223 miles of levees between Fort Smith and Pine Bluff, prevented an estimated \$142.3 million in damages.¹⁷

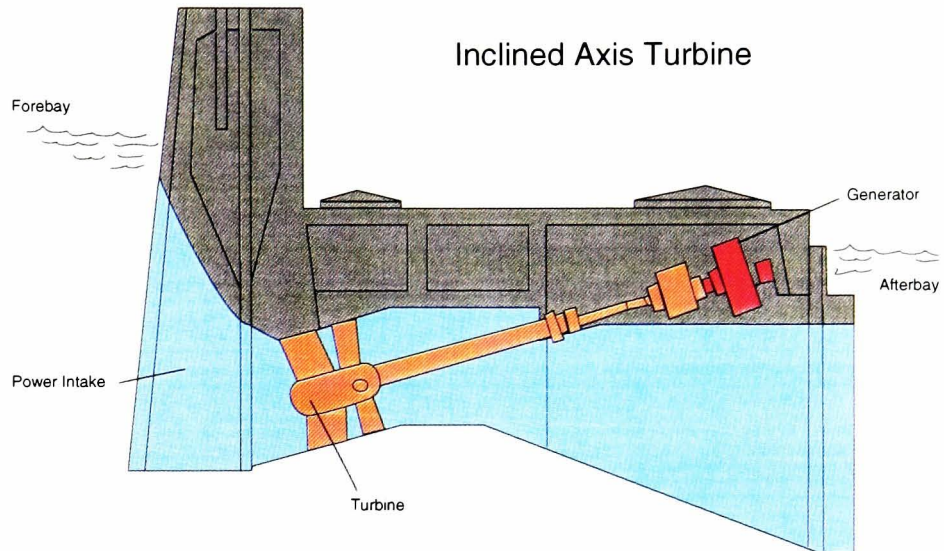
Hydroelectric Power

A project design memorandum completed in 1957 estimated that hydroelectric power would provide about 15 percent of the annual economic benefits of the waterway. This was

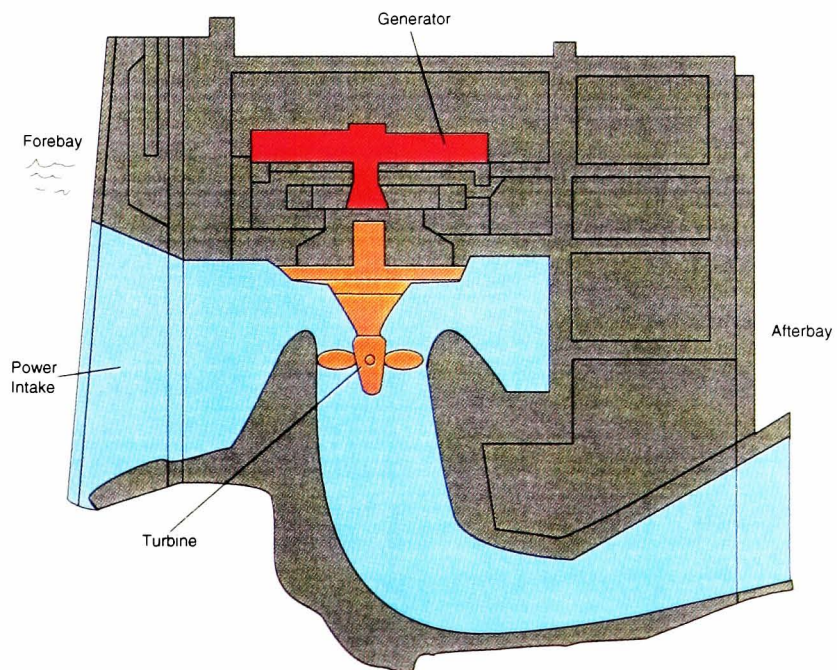
based on the assumption that generating equipment would be installed at Dardanelle Lock and Dam in Arkansas and at Keystone Dam and Robert S. Kerr Lock and Dam in Oklahoma. Today, however, the sale of electrical power accounts for nearly 20 percent of the annual benefits, and it is produced at Ozark-Jeta Taylor Lock and Dam (formerly Ozark Lock and Dam) in Arkansas and Webbers Falls Lock and Dam in Oklahoma in addition to the original three locations. The hydroelectric projects on the Arkansas River are among 70 operated by the Corps of Engineers in different parts of the United States. Together these facilities have the capacity of about 20 medium nuclear plants and generate electricity at less than 10 percent of the cost of nuclear or fossil-fuel plants.¹⁸

The additional two power plants came about because of innovative engineering at the Hydroelectric Design Branch of the Southwestern Division. The original hydroelectric facilities on the McClellan-Kerr System were all of the conventional vertical axis Kaplan-type, which worked well on high dams but was less effective on low ones. To allow the generation of electricity at Ozark and Webbers Falls, engineers adapted an inclined-axis turbine that had been used in Europe. Because it required a smaller powerhouse, saving space that would have been carved out of rock, the inclined-axis turbine represented a considerable savings in construction that made hydropower

Inclined Axis Turbine



Kaplan Turbine



production feasible. Since the European models were smaller in size than what was needed on the Arkansas River, it was necessary to adapt the concept to a larger form. The five inclined-axis turbine shafts at Ozark-Jeta Taylor are 55 feet long and five feet in diameter, as were those at Webbers Falls.¹⁹

While the inclined-axis turbines were the best design solution for the Ozark-Jeta Taylor site, by 1975 extended operations revealed significant problems. Routine inspections revealed such problems as cracks in coupling bolts and turbine shafts resulting from the force of gravity operating on the long shafts. Three of the inclined-axis shafts at Ozark-Jeta Taylor exhibited cracking after only about 10,000 hours of use. District engineers collaborated with Allis-Chalmers personnel to redesign the shafts and bolts but experienced great difficulties in removing the shafts within the powerhouses. Several of the Ozark-Jeta Taylor turbines have been rebuilt more than once. David R. Rippey, former chief of the Engineering Division, Little Rock District, said, "Perhaps our choice of turbine style at Ozark would have been different had we known then what we know now about the type of turbine that was employed there. But it was new and it was probably the [only] type hydroelectric turbine that would have been functional under the limited head there."²⁰

The Kaplan shafts utilized at Dardanelle have been very reliable, but maintenance is an important concern there. Part of the of the

problem at both powerhouses is the sand that is still carried by the Arkansas River. More important for Dardanelle, however, is the fact that it is used for "load control," producing electricity for short periods of high demand that occur particularly during the summer months. This uneven output places a strain on the turbines. The conventional turbines at Dardanelle are scheduled to be rehabilitated in the near future and their capacity increased.²¹

The four generating units at Dardanelle Lock and Dam have a capacity of 124,000 kilowatts, and the five inclined-axis turbines at Ozark-Jeta Taylor Lock and Dam have a capacity of 100,000 kilowatts. From 1990 to 1994, the net annual generation was 717,890 megawatts at Dardanelle and 390,356 at Ozark-Jeta Taylor. This electricity is distributed by the Southwest Power Administration of the U.S. Department of Energy, which sells it at cost to public bodies, electric cooperatives, and private utilities to lower the rates paid by consumers.²²

There are also non-federal hydroelectric power plants on the McClellan-Kerr Arkansas River Navigation System. The Arkansas Electric Cooperative Corporation operates hydroelectric units at James W. Trimble Lock and Dam adjacent to Fort Smith and at Arthur V. Ormond Lock and Dam at Morrilton. Construction is under way for a power house at Wilbur D. Mills Dam. In addition, the City of North Little Rock has generating units at Murray Lock and Dam

*Barges moored on
Mississippi backwater,
awaiting access to White
River Entrance Channel
during low-water stages*



that provide electricity for urban use. In these cases, the non-federal agency is required to have a license from the Federal Energy Regulatory Commission. The Corps of Engineers also reviews all plans and specifications to ensure the structural integrity of the lock and dam.²³

Summary

After a quarter of a century, the McClellan-Kerr Arkansas River Navigation System is functioning much as its early supporters had hoped. Commercial barges make their way up and down the river, connecting Tulsa, Muskogee, Fort Smith, Little Rock, and Pine Bluff with

Mississippi ports and world markets. Within the Little Rock District, the 12 locks and dams have operated efficiently and effectively and with relatively few problems. For the most part, the channel of the river seems to have become more efficient as a result of continued placement of stone revetment and dikes. Flooding poses a special problem both in terms of personal and property losses and with respect to dangers associated with navigation. High water, however, is not so much a problem to be solved as a challenge to be faced. The single biggest problem for the district is the White River Entrance Channel, where the falling water stages of the Mississippi threaten year-round navigation.



Chapter 4

An Altered Environment

Over the past 30 years, the people of the United States and their government have become sensitive to environmental change. The National Environmental Policy Act of 1969, known as NEPA, declared “a national policy which will encourage productive and enjoyable harmony between man and his environment.” It called for the “widest range of beneficial uses of the environment,” but only those that could occur without the “degradation” of nature. It also required the preservation of “historic” and “cultural” as well as “natural” aspects of the “national heritage.”¹

Water resource projects can have a significant impact on the natural environment. Rivers are altered, land is inundated, borrow pits make holes in the landscape, dredged materials create unnatural piles of sand, and concrete structures intrude on nature. In this chapter, we look at the environmental changes associated with building and operating the McClellan-Kerr System. We shall be concerned with what may have been lost as the natural river became a waterway and also what may have been gained. One significant benefit has to do with the use of the river for recreational purposes. Before the waterway was built, the Arkansas River was salty, muddy, and filled with untreated sewage. For significant parts of the year, water stages were too low to support most species of fish or wildlife. Today the water is much cleaner, and the river is an

excellent habitat for game fish and waterfowl. Camping, fishing, boating, and other recreation activities are now common along the river.

Environmental Changes

During the 1970s, the U.S. Army Institute for Water Resources commissioned researchers at the University of Arkansas at Fayetteville to produce a series of studies analyzing the environmental effects of the McClellan-Kerr System.² This research provides a good analysis of how the construction process impacted the natural river and how the infant waterway was developing within its environment.

One issue is visual. Did the waterway look different from the river? One major visual change was a new stability with respect to the width of the river and the creation of semi-permanent edges as it stayed within a relatively fixed channel. The natural river, by contrast, had been a changeable thing that widened and narrowed frequently as it flooded its bottom land and then receded. It had occasionally meandered into new courses, creating oxbows and then cutting them off.

The creation of the navigation pools did widen the Arkansas River upstream from each dam on a permanent basis. The amount of widening and the length within each pool were directly related to the height of the dam



Arkansas River downstream from Ozark-Jeta Taylor Lock and Dam, 1976

with respect to the height of the natural banks. Most of the pools for the low-head locks and dams were within the confines of the natural banks. However, the high-head projects, such as Dardanelle and Ozark-Jeta Taylor, created lakes that permanently covered the natural banks and adjoining lands. This process inundated sandbars and islands that were in the natural river, as well as wetlands that existed along its edges. A much different look was created as the new water level rose to the level of the trees, and forest replaced wetlands as the visual edge of the water.

The physical structures associated with the navigation system, including locks and dams, revetment, dikes, and levees, also altered the appearance of the river. The researchers, however, found that much of the river did not seem to have greatly changed from its natural state. Dredged material and other byproducts

of construction were disposed of in a non-obtrusive manner. Even the parks that had been built by the Corps of Engineers for public recreation purposes were mostly hidden from the view of river travelers.³

Perhaps the biggest environmental gain associated with the McClellan-Kerr System was the reduction of turbidity (the opaque or muddy quality of the river). Through 1965 the sediment load of the Arkansas River had ranged between 62 and 97 million tons; after 1965 it dropped to around 10 million tons per year. Part of the change was due to the storage reservoirs in Oklahoma that acted as silt traps, but a University of Arkansas study argued that bank stabilization was the major factor. After Little Rock District engineers had eased bendways, reveted banks, and built dike fields, the river was less subject to bank cavings and less likely to pick up sediment

*Bass Masters tournament
contestants leave lock
at Pine Bluff.*



from its bed. The Arkansas River ran much clearer as a waterway than it did in its natural state.⁴

The quality of water has improved in other ways. The Arkansas River traditionally carried a high amount of dissolved chlorides picked up from natural salt deposits in western Oklahoma and southwestern Kansas. The saline content of the river had been going down since 1945, however, apparently because of natural causes. Additional improvement came from the upstream reservoirs of the McClellan-Kerr System that allowed rainwater to mix with the river water before it flowed through Arkansas. The Clean Water Act of 1972 led to significant reductions in the industrial and human waste that was dumped in the river. The river cities of Arkansas built sewage treatment plants that greatly reduced the fecal coliform count in the river. Yet a quarter of a century after the waterway was completed, the Arkansas Department of Health still warns against "body contact" water recreation such as wading or swimming in the river below Little Rock because treated sewage is still flushed into the river. The Department of Health has not approved the Arkansas River as a source for public drinking water supply, in part because other sources are available. The water, however, is neither so saline nor so toxic that treatment could not make it suitable for drinking. The Department of Health does

allow use of river water for drinking on an emergency basis.⁵

Improvement in water quality has helped to change the nature of the fish population. Two fish common to silt-filled rivers, the plains shiner and the Arkansas River shiner, were no longer found in the river after the waterway was constructed. The general fish population, however, greatly increased; and the number of species probably more than doubled, although the limited nature of pre-construction surveys makes it impossible to measure the increase with precision. The development of fish communities was aided by the fact that the Arkansas Game and Fish Commission stocked each reservoir and pool with sport fish. The impounded water in the lakes and pools of the waterway created a positive habitat for fish. The decrease in turbidity also encouraged the development of a larger and more diverse fish population.⁶

Sport fish, in fact, became one of the great success stories of the lower Arkansas River. In 1984 and again in 1985, the Bass Angler's Sportsmen Society held its annual Bass Masters Classic at Pine Bluff. Contestants fished Pools 2 through 6 of the waterway, ranging from Arkansas Post to Little Rock; and in the 1984 contest, they broke almost all

previous tournament records. That success and a warm reception in the area brought the tournament back for a second year. Other bass-fishing tournaments have followed.⁷

While sport fish established themselves, at the bottom of the river, among what biologists call the benthic communities, a less happy change took place. There was less stability in this environment than in a natural river, in part because of dredging activities. This instability created ideal conditions for an Asian clam, *Corbicula*, (also called “zebra mussel”) that first appeared in the United States in the Columbia River. It arrived in Arkansas probably about 1965, perhaps when a vessel from the Gulf Coast pumped water from its bilge into the McClellan-Kerr System. Chances are that the clam would have spread to the Arkansas River anyway from other parts of the United States.

Since it has no native predators, *Corbicula* has spread rapidly in the McClellan-Kerr waterway. The clam poses some danger for facilities that take in water from the river because it can attach itself to intake pipes, where its shell can impede normal operations.⁸

Another aspect of environmental change was the change in the nature of wetlands along the river. Bank stabilization and the building of levees led to the draining of some wetlands, and others were inundated permanently when the water level was raised in navigation pools. Before the navigation system was constructed, wetlands would flood

intermittently and then become dry. By stabilizing water levels, the navigation system actually has created more acres of wetlands.

Researchers have found that the biological communities associated with the wetlands of the natural river remain only in a few areas, such as the lower end of Merrisach Lake on the Arkansas Post Canal and in oxbows, such as that at Holla Bend near Dardanelle. One loss in the process has been the black willow, a tree that is intolerant of prolonged flooding. By the mid-1970s, black willows and similar trees were beginning to grow in new wetlands created by navigation pools, but these environments were poorer habitats than those that had existed because of their tendency to remain flooded.⁹

In a number of respects, the environment of the Arkansas River appears to have rejuvenated itself. Testimony on that point comes from the interior least tern (*Sterna antillarum*) a grey and white, black-capped bird that is eight to 10 inches long and has a wingspread of 19 to 20 inches. Typically found on sandbars of large rivers in this region, the least tern was placed on the Endangered Species List in 1985 by the Department of the Interior’s Fish and Wildlife Service because much of its habitat had been lost in recent years. In fact, the terns were absent from the Arkansas River for some time after the creation of the navigation system, probably because the pools of the waterway inundated existing islands of sand or dirt on

Interior least tern



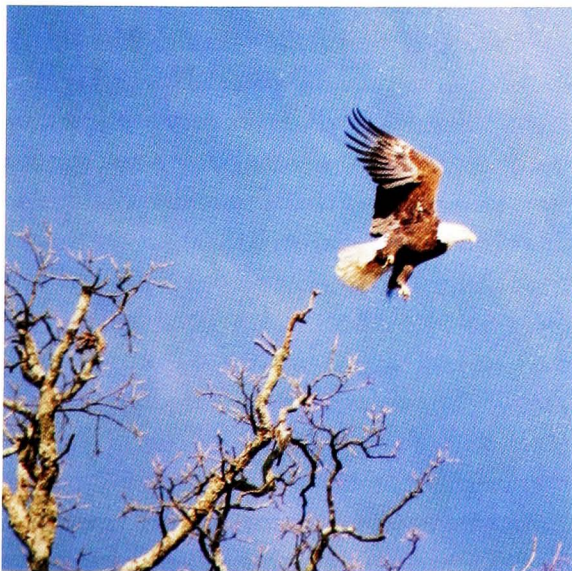
which the terns had nested. Gradually, however, the buildup of sediment in slack water areas and the deposit of dredged materials in the same

places created new sandbars and islands that provide excellent breeding habitat for the birds.

Since 1986 the Little Rock District has been following a management plan designed to encourage the return of the least tern. It calls for dredged material to be used to create habitat for terns and for nesting areas to be left undisturbed. District personnel make an annual helicopter flight up the river to document the existence and location of the

interior least tern. More than a hundred of the birds now inhabit the river.¹⁰

Bald eagles now also live on the bountiful fish provided by the Arkansas River. The mid-winter bald eagle count for 1994 found a total of 1,020 eagles in Arkansas. Separate observations taken at Arkansas Post National Park, at the lower end of the McClellan-Kerr System, indicated an average of 11 birds at that location between 1990 and 1993. Along the massive shoreline of Lake Dardanelle and Pool 9, an average of 129 bald eagles were sighted in the same four-year period. Since 1990 there is evidence that the eagles are not only visiting the Arkansas River but nesting along it as well.¹¹



Bald eagle, Dardanelle

As we have seen, the environmental policy of the United States is concerned with protecting historic and cultural resources as well natural ones. One historical site was an early victim of the McClellan-Kerr System. The place along the bank of the Illinois Bayou, near modern Russellville, where the Rev. Cephus Washburn established the Timothy Dwight Mission in 1820 and where Sequoyah devised an alphabet for the Cherokee people was covered by the waters of

*Fishing gets results on Lake
Dardanelle, 1978*



Lake Dardanelle. Before its inundation, however, the site contained only a historical marker, and that was later set up some distance from the lake.¹²

History enthusiasts feared a serious loss on the lower Arkansas River where the Arkansas Post National Memorial now commemorates the first European settlement in Arkansas and first territorial capital. In January of 1962, John L. Ferguson, executive secretary of the Arkansas History Commission, wrote a letter to the *Arkansas Gazette* protesting the fact that a “large part” of the proposed memorial would be “permanently flooded” by the dam located just below it. Fearing that the park might be moved, Ferguson argued that “history cannot be relocated.” Senator John McClellan received a number of similar letters, and the senator wrote to the Office of the Chief of Engineers for clarification. As it turned out, approximately 440 of the 720 acres chosen for the Arkansas Post national park were to be flooded by the pool created by Dam 2. On the other hand, this land lay at or below 162 feet above NGVD and flooded frequently anyway. It was not intended for development in the memorial. The developed portion of the park was to be at 170 feet or above, and it would be less prone to flooding as a result of the McClellan-Kerr System. Two years later Arkansas Post National Memorial was opened to the public on 389 acres of land at its original location. It has coexisted with the

waterway ever since.¹³

In addition to the cultural remnants of European settlement and of the western movement of the United States, the Arkansas River valley contains a large number of archaeological sites arising from the thousands of years it was occupied by Native Americans and early Euro-Americans. The immediate effect of the McClellan-Kerr System on these cultural resources was mixed. Studies by the Smithsonian Institute and the University of Arkansas had already identified potential archaeological sites along the river. The flooding of some areas, particularly at Lake Dardanelle and Ozark Lake, prevented further study of these sites; on the other hand, the stabilization of the river prevented it from destroying sites along its banks as it meandered into new courses. Following the dictates of NEPA and subsequent legislation, the Corps of Engineers has sponsored a number of studies devoted to finding and inventorying archaeological resources along the river.¹⁴

In one recent case, action by the Little Rock District was instrumental in bringing about both the study and preservation of an

*Children on dock at Lake
Dardanelle, 1978*

important archaeological resource. The Greer Mound Site, as archaeologists know it, overlooks Brodie Bend, a horseshoe lake on the Arkansas River created by the Brodie Bend cutoff channel near Plum Bayou. Plum Bayou, which flows by the Toltec Mounds, empties into Brodie Bend. On the Greer Site is an Indian mound that had long interested archaeologists but had never been investigated. High water in the fall of 1986 caused erosion along Brodie Bend that included damage to Greer Mound and the threat of its future destruction. Informed of the problem, however, the Little Rock District and other elements of the Corps of Engineers worked with the Arkansas Archeological Survey to develop a plan to preserve the site and study the mound. The first step was to establish the significance of the mound, making it possible for the government to assist in its preservation even though the site itself was on private property. With that done, a "limited data recovery program" was carried out in the summer of 1987. Working in the eroded portion of the mound, archaeologists found pieces of pottery and other artifacts. They were able to determine that the earthwork was constructed in the period between A.D. 1400 and 1700 and that it was originally a low earthen platform with a wattle and daub building on it. Later a smaller mound was constructed on top of the first. When this preliminary study was complete, the Little Rock District stabilized the river



bank near the Greer Mound Site so that the mound would be protected for later scholars.¹⁵

Recreation

Just as attitudes toward the environment were changing as the McClellan-Kerr System was coming into being, so also was the Corps of Engineers taking on new responsibilities with respect to recreation. The Flood Control Act of 1944 had authorized the engineers to make their flood control reservoirs available for recreation. In the years after World War II, as Americans enjoyed new affluence, camping and water sports became increasingly popular, and the manmade lakes constructed for flood control purposes became the playgrounds of a leisure-oriented society. Recreation became a big business, and the Army was a part of it. As a Little Rock District recreation specialist would later put it: "The Corps of Engineers wasn't supposed to be in the recreation business, but we found ourselves before long with a greater visitation



Bank fishing at Murray Park, Little Rock

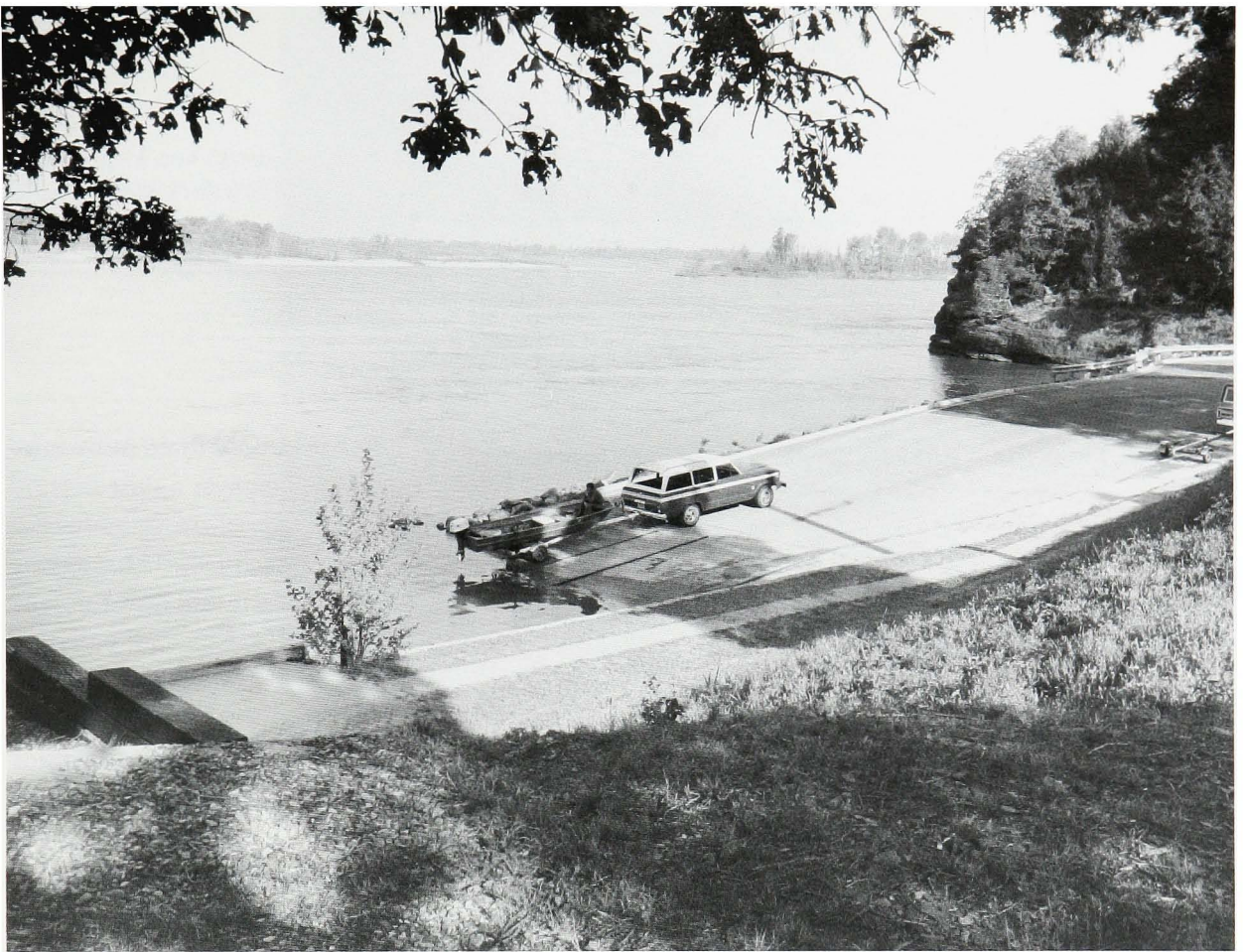
economic justification for new projects.¹⁸

than the National Parks Service.”¹⁶

Recreation was only a minor part of the original Arkansas River project, but it gained increasing importance over time. House Document 758, published in 1947, which used nearly 300 pages of text, prefatory materials, tables, plates, and appendices to describe what would become the McClellan-Kerr Arkansas River Navigation System devoted less than a paragraph to recreation. The same paragraph discussed both “recreational purposes and wildlife refuges,” saying that “it would be advisable to construct such accessories as may be found desirable for these purposes” at the same times as other features of the waterway. Neither in this document, nor in the project design memorandum written for the waterway in 1957, was the future income from recreational activities used as economic justification for the project.¹⁷ Still the times were changing. Major General E. C. Itschner, chief of engineers, spoke to the Arkansas Basin Development Association at Sequoyah State Park in Oklahoma in October of 1956, and recreation was much on his mind. “Flood control and navigation,” said the general, were the primary purposes for water resources projects, “but the recreational benefits are becoming increasingly important and recognized.” He called for legislation that would allow recreational benefits to be part of the

While General Itschner was speaking, Little Rock District engineers were working on a “Preliminary Master Plan” for recreational facilities on the McClellan-Kerr System. This document noted that “a growing demand for a large variety of outdoor sports such as boating, water sports, hunting, and fishing is evident throughout the project area.” The planners believed that the new recreation areas associated with the waterway would “have a further stimulating interest in the public use of all projects.” Individual plans were developed on the basis of map studies, aerial photographs, and on-site inspections. Access by the public to the facility was a major consideration in picking sites; other issues included scenic appeal, proper terrain, and access to water. Public hearings were held to ensure that the right choices were made.¹⁹

In the early 1970s, with the locks and dams in place, the Little Rock District began to construct its recreational facilities. Joel Callaway, a former reservoir manager at Dardanelle Resident Office, remembers the rapid development of some 43 parks between Little Rock and Fort Smith. Roads were built, picnic and camping areas laid out, and restrooms and other facilities constructed. In the beginning, neither running water nor electricity was provided to the camp sites. Over the years, however, the district has upgraded its facilities. Callaway explains the



Boat ramp at Cadron Settlement Park, February 1977

change: "Camping has changed. The way it used to be, you had one vehicle and a tent and your kids, and you went camping. It's not that way any more, believe me. They go out, and they've got big campers. They want water. They want electricity. They want a place to park about two or three vehicles and a boat."²⁰

The public wanted recreational facilities, and it used them. In 1971, the first year that Corps of Engineers parks were open at all the pools and lakes of the McClellan-Kerr System, estimated visitation was 4.6 million—that is, an estimated 4.6 million individuals spent a day or part of a day at a recreational facility. By the early 1980s, annual visitation along the river had climbed to about 12 million visits, and it has remained in that vicinity ever since. Lake Dardanelle, which has nine parks with a total of 387 campsites, 255 of them with

electricity and 123 with running water, receives more than a quarter of all the visits. The pool formed by David D. Terry Lock and Dam, known as David D. Terry Lake, and Pool 7, formed by Murray Lock and Dam, both at Little Rock, receive another quarter. Slightly behind each of those areas is John Paul Hammerschmidt Lake, which is formed by J. W. Trimble Lock and Dam and winds around Fort Smith. In 1994 fees from Arkansas River parks amounted to \$634,000, most of it arising from camping.²¹

Pleasure boats in large numbers use the pools and lakes of the system. The 12 locks of the McClellan-Kerr System in Arkansas had more than 10,000 lockages involving recreational vessels in 1994. Seventy-two percent of these occurred in June, July, August, and September. Thirty-nine percent



Merrisach Park

occurred at David D. Terry Lock and Dam and Murray Lock and Dam, both of which serve the Little Rock area.²² Moreover, anglers and other boaters often put in at the pool they want to use and avoid the locks altogether.

While boat trips are often day excursions only, a captain who wishes can travel from the Mississippi River to the vicinity of Tulsa.²³ The journey up the McClellan-Kerr Arkansas River Navigation System begins for pleasure craft, as it does for towboats, just above Greenville, Mississippi, at Mississippi River Mile 599, where the White River enters the Mississippi River from the west. The 10-mile trip on the White River passes through a heavily forested region that is a resting place for millions of migrating waterfowl and home to a variety of other birds and mammals, including white-tailed deer and black bear. Approaching Norrell Lock and Dam, the White River National Wildlife Refuge borders the river on the north, and it is possible to stop and view the area from Wild Goose Bayou Park. On the south side is the state-owned Trusten Holder Wildlife Management Area. When the river is above 154 feet NGVD, boats may ignore Norrell Lock and pass over the dam into the Arkansas Post Canal, a manmade waterway that carries vessels from the White River to the Arkansas.

Lock 2 is located three miles into the canal. Just over a mile later, the north side of the canal opens onto Merrisach Lake. Throughout

this area, fishing enthusiasts will find bass, crappie, and bream.

Emerging from the Arkansas Post Canal, the recreational boater will find a number of places of interest. Downstream where Wilbur Mills Dam forms the first pool on the Arkansas River portion of the waterway is Notrebes Bend Park, named for a one-time officer in Napoleon's army who became wealthy trading in cotton at Arkansas Post. (The park is not, however, directly accessible from the river. Access is below Dam 2.) Pendleton Bend Park, on the right side of the river, is another large recreational area. The Pendleton Marina is the first such facility encountered after leaving the Mississippi River. Just upstream of the mouth of the canal is Arkansas Post Park and National Monument. The Arkansas Post, where the French and later the Spanish traded with the Quapaws and other Indians, was located at three different sites. This one was occupied from 1749 to 1756 and from 1779 on. It was the first territorial capital of Arkansas in 1819. A museum is now located at the monument.

Leaving the Arkansas Post area, pleasure boaters encounter fewer parks and a more cultivated landscape. On both sides of the river are farmlands that produce rich harvests of rice, soybeans, and cotton. Only an

*Murray Lock and Dam
with Pinnacle
Mountain in
background*

occasional stand of bottomland hardwood gives evidence of the environment that preceded the development of intensive agriculture. Small parks exist where Big Bayou Meto and later Little Bayou Meto flow south into the Arkansas. Huffs Island Park is located at Lock and Dam 3, near Swan Lake, and Rising Star Park is a few miles upriver. After the Emmett Sanders Lock and Dam, a vessel passes by the Port of Pine Bluff and the city itself, which provides two marinas and several parks. Above Lock and Dam 5, 15 miles beyond Pine Bluff, the landscape regains its pastoral quality except for occasional signs of industrial development, such as the coal-fired, electrical generating unit at White Bluff. Tar Camp Park is a popular recreational area in this reach of the river.

David D. Terry Lock and Dam lifts boats into David D. Terry Lake, which divides the Little Rock and North Little Rock areas. Willow Beach Park, on the north side of the river, offers recreational opportunities. Moving into the downtown area, water travelers pass Riverfront Park, a facility that is used regularly for walking and sitting and occasionally for outdoor concerts and other



special events. The river offers an ideal way to view the commercial architecture that has given Little Rock a big-city skyline in the last two decades. One can also see the back of the Old State Capitol that was built in 1836. Upriver boaters pass Burns Park on the north shore, which covers 1,575 acres, belongs to the city of North Little Rock, and is the second largest municipally-owned park in the nation. Murray Park, on the Little Rock side of the river, offers an excellent view of Murray Lock and Dam and provides urbanites with a place to play volleyball, cook out, or wet a line.

From the Mississippi River to Little Rock, boats pass through a lowland area, part of the Mississippi Alluvial Plain known locally as the Delta. Above Little Rock, westward-moving vessels enter a highland region known as the Arkansas River Valley, which cuts through the Ouachita Mountains and Ozark Plateaus. The change is noticeable just below and across the river from Murray Park where the mass of Big



Petit Jean Mountain looms above the Arkansas River.

Rock still dominates the north side just as it did when French voyagers recognized it as the first large outcropping on the river. (Below it on the other side of the river, the Little Rock for which the capital city is named is partially hidden by the base of a railroad bridge.)

Upriver Pinnacle Mountain comes into view, a small but sharp, partially wooded, projection into the sky, which is a state park. Another 25 miles upriver is Toad Suck Ferry Lock and Dam. This is the site of the Toad Suck Ferry that used to carry people and vehicles across the river, a job now done by Arkansas State Highway 60, which runs over the lock and dam. A few miles above Toad Suck Lock and Dam, there is a park at the Cadron Settlement, a community that originated around 1810 when American pioneers first came into Arkansas. Another 20 miles up the river, past the city of Morrilton, is Point Remove Park. Shortly after vessels lock through Arthur V. Ormond Lock and

Dam and pass into Winthrop Rockefeller Lake, Petit Jean Mountain comes into view to the west. This flat-topped edifice rises more than 1,000 feet above the river and covers 3,500 acres. Arkansas Governor Winthrop Rockefeller made his home here, and it is the present site of Winrock Farms, Petit Jean State Park, and a variety of camps and retreats. After passing Petit Jean Mountain, boats go by Holla Bend National Wildlife Refuge, an oxbow of the Arkansas River created by the Holla Bend cutoff and now a resting place for geese, quail, dove, bald eagles, and other wildlife.

Ten miles above Holla Bend, Dardanelle Lock and Dam lifts boats as high as 54 feet and places them into a new environment. The high sides of the river valley above Russellville allow Dardanelle Lock and Dam to create Lake Dardanelle, a pool that is more than 50 miles long and contains 315 miles of shoreline along its 34,300 acres. The Corps of

*Ozark-Jeta Taylor
Lock and Dam*



Engineers operates 14 parks along the shore of Lake Dardanelle, including one at Spadra, where the United States had a trading post in 1817. At the north end of Dardanelle Lake, a pleasure boat enters Ozark-Jeta Taylor Lock and Dam and emerges into Ozark Lake, which is about 35 miles long, has 173 miles of shoreline, and contains 10,600 acres of surface area. Seven parks are located at scenic points along the lake. At the eastern edge of Fort Smith, James W. Trimble Lock and Dam carries vessels into John Paul Hammerschmidt Lake, the final pool in Arkansas, and they proceed around a large bend that contains the city of Fort Smith. It was known as Belle Point in 1818 when the original army fort was constructed and has seen a lot of history since, including the stern justice decreed by Judge Isaac Parker. On the west side of Fort Smith at about river mile 308, boats heading upstream enter Oklahoma, passing from the waters of the Little Rock District into those of the Tulsa

District of the Corps of Engineers.

The McClellan-Kerr Arkansas River Navigation System altered the environment of the Arkansas River. Whether the change was good or bad depends on one's values. The Arkansas River is no longer a natural river. The natural Arkansas River, however, was salty, muddy, and experienced drastic changes in flow. Man had contaminated it with human waste. It provided habitat for a large amount of plants, fish, and wildlife, particularly in its lower region, but it was of only limited use for recreation. The waterway now may be considered an improved habitat and is certainly a very significant recreational resource. Nature has been changed, but few would argue that it has been degraded.



Chapter 5

The Bottom Line

The McClellan-Kerr Arkansas River Navigation System cost \$1.3 billion to construct and has served Arkansas and Oklahoma for a quarter of a century. Has the operation of the waterway been enough of an economic boon to the region to justify those expenditures, or was it, as some have suggested, a pork barrel project that used federal tax dollars to benefit a local area without adequate result? In this chapter, we attempt to answer that question by looking at two different kinds of economic analyses. One of them is the ratio of annual benefits to annual costs, which is the way that Corps of Engineers water projects are justified for legislative approval. A second issue is economic development. To what extent did the McClellan-Kerr System promote the development of agriculture and industry in Arkansas and Oklahoma? The role of the waterway in bringing economic progress was less critical to Congress than was the benefit-to-cost ratio, but development was a constant theme of those who supported the project. With the McClellan-Kerr System funded and constructed, its role in bringing about positive economic change would seem to be the most important issue—the bottom line.

Annual Benefits and Costs

While many things enter into congressional discussion of a civil works project, one important

element is the ratio of its estimated annual economic benefits to their estimated annual costs. Projects are not normally constructed unless the ratio is at least 1 to 1.0. The mathematics of the ratio, however, may imply a precision that overstates what is possible. Estimating the annual cost of a multi-million dollar project over its useful life is a difficult task but one that can be grounded in present-day economic reality. Estimating the future benefits of a project, on the other hand, requires making predictions about a variety of complex factors over a lengthy period of time. Estimating the tonnage that will be carried by a waterway, for example, means making assumptions about future economic conditions and the transportation needs that will be associated with them. While it involves some estimation, the benefit-to-cost ratio is a valuable tool because it attempts to indicate the cost effectiveness of a federal project.

The earliest benefit-to-cost estimates for the McClellan-Kerr System were contained in the 1943 Corps of Engineers study that was published as House Document No. 758. It provided a separate analysis for a navigation-only project from the mouth of the Arkansas River to the Port of Catoosa near Tulsa, Oklahoma. After a detailed study that included sending questionnaires to both shippers and receivers of freight, Corps of Engineers planners determined that an Arkansas River waterway could be expected to carry nine million tons of commerce annually,



Towboat near Conway, 1970, with a bargeload of stone – The dikes in the background constrict the river flow into a narrower channel.

that each ton would save an average of \$2.17 per ton over other forms of transportation, and thus that the annual transportation benefit would be \$19.6 million. The annual cost of the navigation project included the amortization of its construction costs, three percent interest on those costs, and an estimate of the yearly charges for operating and maintaining the system. These were estimated at a total of \$19.5 million. The benefit-to-cost ratio was thus \$19.6 million to \$19.5 million or 1.01 to 1.0 in 1943 dollars.¹

The multiple-purpose plan in the same document added flood control and hydroelectric power to the navigation features of the waterway and increased the annual cost of the project to \$24.4 million. Estimated transportation benefits remained the same, but they were supplemented by benefits associated with the additional functions. Planners estimated that the sale of electricity would benefit the economy an annual \$5.6 million, flood control features of the system would prevent an annual \$0.9 million in damage, and \$0.3 million in benefits would arise from renting land near the reservoirs. The total benefits were \$26.4 million, making

the benefit-to-cost ratio for this plan 1.08 to 1.0 in 1943 dollars.²

The approval of the plan within the Corps of Engineers involved a shift in emphasis from its benefit-to-cost ratio to its potential for economic

development. The Board of Engineers for Rivers and Harbors “was not convinced that the benefits to be derived from the navigation project warrant its construction at this time.” It recommended that the multiple-purpose plan be a model for the future, but that only flood control facilities be constructed at present. Chief of Engineers Lieutenant General Eugene Reybold, a former Little Rock district engineer, took a different view. He argued “that expansion of agriculture and industry will follow the completion of such an important link in our inland waterway system” and claimed that “it is reasonably certain that the tonnage for the waterway will exceed the amount now estimated.” In effect, Reybold believed that the benefits of the waterway would increase as a result of the economic activity it would generate. For him the 1943 ratio was less important than future ratios that would come about as navigation on the Arkansas River generated economic development in the river valley.³

When the Arkansas River project was restudied in 1954, the benefit-to-cost ratio was increased from 1.08 to 1 to 1.19 to 1. The original tonnage estimates had been done in

Table 1
The Changing Nature of Benefits

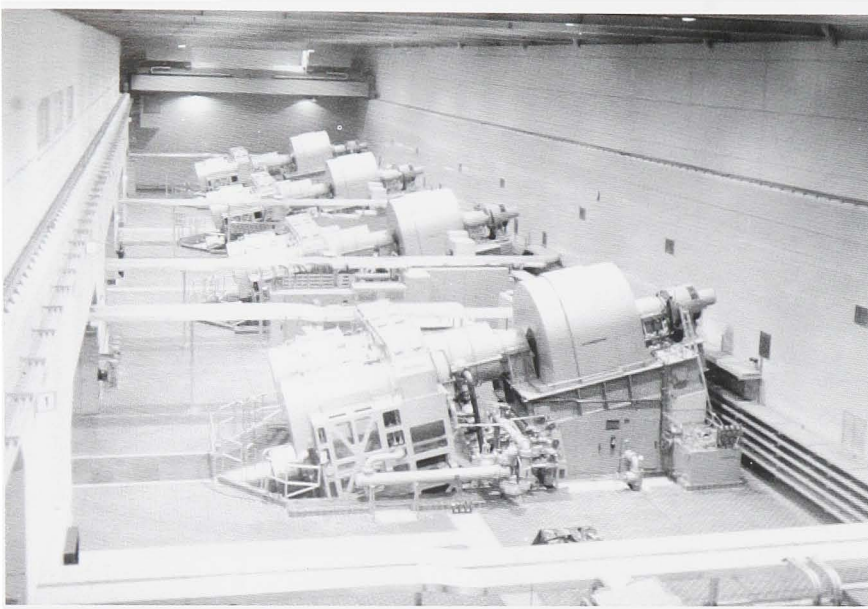
ESTIMATED ANNUAL BENEFITS			
	1945	1954	1968
Transportation Charges	\$19,606,000	\$40,470,000	\$40,470,000
Value of Power	5,586,500	9,599,000	14,838,900
Flood Control Benefits	912,800	6,688,000	6,602,600
Value of Land Rentals	260,900	227,000	
Channel Stabilization		6,575,000	6,575,000
Water Supply		1,114,000	828,900
Fish and Wildlife			312,000
Recreation			2,297,000
Redevelopment			3,355,800
Totals	\$26,366,200	\$64,673,000	\$75,280,200

1939, and they were reevaluated in light of the economic growth that had taken place since that time. The new estimate raised the estimated annual tonnage from nine million tons to 13.2 million tons. The savings to the economy associated with the new figure were estimated at \$40.5 million, a figure that had been developed in 1949 and was simply applied to the new tonnage figures. On that basis, each of the 13.2 million tons of commerce was assumed to represent a transportation savings of \$3.06 in 1954 dollars. The new benefits figures also featured larger numbers for hydroelectric power and flood control. In addition, economic benefits were associated with bank stabilization and the supply of water for municipal and industrial purposes.

By the time of its completion, the McClellan-Kerr Arkansas River Navigation System was being assigned a benefit-to-cost

ratio of 1.5 to 1. Transportation benefits remained the same, and flood control benefits were lowered slightly. The value of power increased more than \$5 million, however, presumably as a result of the new hydroelectric capability at Ozark Lock and Dam. In addition, the planners assigned dollar figures to benefits involving the creation of fish and wildlife habitat and of recreation facilities. Redevelopment, which involved employing people who would otherwise not have jobs, also was part of the benefits. The higher benefit ratio was also the result of lowering the annual charges from the figure of \$54,449,000 used in 1954 to \$51,019,800, a change that resulted in part from lengthening the life of some aspects of the project from 50 to 100 years.⁴ (Table 1)

Despite General Reybold's emphasis on economic development, both supporters of the McClellan-Kerr System and detractors



Ozark powerhouse

tended to focus on the benefits-to-cost aspect of its justification and in particular on the role of navigation in producing economic benefits. The railroad industry questioned the amount of commerce that would be carried by the Arkansas River and the degree to which it would represent a savings over other forms of transportation. Six railroads presented an analysis to the House Subcommittee on Appropriations in 1956, attacking the navigation estimates that were used in the 1943 study. After a detailed analysis of their own for each category of freight, both with respect to estimated tonnage and estimated savings, and including a 30-percent increase for economic growth, the railroads determined that the navigation portion of the project had a benefit-to-cost ratio of only .05 to 1. Their recommendation was that the Arkansas River project should be confined to "water supply, flood control, and power, and that appropriations for the navigation features should be deferred indefinitely." In 1960 a study done by the Waterways Projects of the Association of American Railroads argued that only two million tons of commerce would be carried on the Arkansas River.⁵

The arguments over benefits and costs were largely concerned with congressional approval

and funding of the waterway, and in that sense they were moot by 1971 when the McClellan-Kerr System became a reality.

Still it is important to examine the development of navigation over the last 25 years to see how well the system has fulfilled the promises that were made for it.

Commerce on the Waterway, 1971-1995

Actual tonnage on the McClellan-Kerr Arkansas River Navigation System has been much less than the estimate made by the Corps of Engineers but much more than the prediction made by the railroads. The official figures from *Waterborne Commerce of the United States* indicate that from 1971 to 1993 the average annual tonnage carried on the waterway was 7.6 million tons. As Table 2 indicates, the average in the first five years was 5.1 million tons; but from 1976 to 1980, commerce increased to an annual 8.5 million tons. In the next two five-year periods, the average was 7.9 million tons. The growth of the navigation project appeared to be over.

Based on movements in 1994-95, however, the commerce appears to have entered a new growth period. Hidden in the average figure for 1986-90 is the fact that 8.8 million tons



Bunge Grain Elevator near Pine Bluff, 1978

moved on the waterway in 1990, nearly a million tons more than the average for that five years. And the increase appears to be sustaining. Between 1991 and 1994, the average annual commerce was 9.4 million tons.⁶

Table 2
Average Annual Commerce
on McClellan-Kerr System
for Selected Periods

Years	Millions of Tons
1971-75	5.1
1976-80	8.5
1981-85	7.9
1986-90	7.9
1971-90	7.6
1991-94	9.4

The current annual average, therefore, is 19

percent above the annual average of the previous five years and 24 percent above the annual average between 1971 and 1990. A record 10.6 million tons of commerce were carried in 1994, and unpublished reports kept by the Little Rock District indicate that the increase is continuing in 1995.⁷

It may be that the 1980s will turn out to have been an anomaly. During the 1970s, the system achieved a level of growth that encouraged some economists to predict an annual increase of about 8.9 percent for the next 25 years.⁸ Instead almost no growth occurred for the next decade. The upsurge that began in 1990 suggests that the system, belatedly, is coming into its own.

The nature of commerce on the McClellan-Kerr System is illustrated in Tables 3 and 4. The largest quantity of material shipped on the waterway has been sand, gravel, and rock, which is relatively low in value. Moreover, most of this material moves internally, from one port on the system to another, and much of it is used for the maintenance and improvement of the

Tow near Pendleton, 1980



waterway itself. Much more important economically are the commodities shipped out of and into the system.

The most significant group of outbound commodities is agricultural products, principally wheat, soybeans, and rice from Arkansas. From 1971 to 1994, these commodities made up about 21 percent of all shipping on the waterway, and they were nearly 25 percent in 1994. Wheat, the single largest agricultural commodity, comes from Oklahoma and Kansas and is shipped from the Port of Catoosa to New Orleans. Soybeans and rice are Arkansas products, for the most part. Agricultural products from the upper White River also pass through the last 10 miles of the McClellan-Kerr System.

Petroleum products have been an important part of commerce on the McClellan-Kerr System, but they are less significant at present. In 1980 nearly two million tons of petroleum products moved on the waterway, but the amount declined to one million over the next several years and then continued to fall to less than one-half million tons. Oil production in Oklahoma lessened after the energy crisis of the late 1970s, and it has not recovered. Should market conditions change, however, petroleum products could become much more significant for the waterway. Coal shipments, which have amounted to nearly seven percent of annual traffic over the life of the waterway, are also

volatile in response to world market conditions.

Inbound towboats carry a great deal of agricultural fertilizer from the lower Mississippi valley that is off-loaded at all of the ports along the system. Iron, steel, and other primary metals have made up nearly seven percent of the annual traffic, much of it coming from the upper Mississippi River area and the Ohio River valley. Industrial chemicals are significant as well, among them caustic soda being shipped from Baton Rouge to Pine Bluff and Little Rock, methanol from Louisiana and Texas to the Tulsa area, alumina from Matagorda, Texas, to Little Rock, and benzene and toluene from Pittsburgh to Tulsa.

Among the more interesting items of miscellaneous traffic on the McClellan-Kerr System are military movements. Since 1986 the government has been using the waterway as a means of transporting military equipment to and from Fort Chaffee, Arkansas, and Camp Gruber, Oklahoma. Inland water transportation not only reduces costs, but it also provides an alternative mode of transportation that might be useful in the event of a disaster.⁹ (Table 3)

The movement of cargo on the McClellan-

Pine Bluff Sand and Gravel Company, just off the Arkansas River at Pine Bluff Harbor



Kerr System is facilitated by an extensive system of public and private ports. In 1946, when the Corps of Engineers was investigating a canal route below Little Rock that would have bypassed Pine Bluff, the latter city made a commitment to “provide adequate terminal and transfer facilities to meet the demands of river transportation” if it became a port. When the waterway was built, Pine Bluff responded quickly by constructing a Harbor Industrial District on Lake Langhoffer, a natural slack water harbor. The Port of Pine Bluff Public Terminal today includes two 40,000-square-foot warehouses. A 75-ton crane, a 50-ton crane, and a 25-ton covered gantry crane assist in the transfer of grain, lumber, paper, and steel. Liquid transfer facilities are also available.

The Port of Little Rock Public Terminal began operation in 1969 but was greatly improved by the addition of a 4,800-foot slack water harbor that opened in 1987. It has a 33,000-square-foot warehouse, crawler cranes, rail-mounted container cranes, a gantry crane, and pipelines for both molasses and petroleum. Other commodities handled by the port include steel, hardboard, lumber, bulk liquids, riprap and rock products, agricultural chemicals, grains, and forest products. A Foreign Trade Zone is available. The Little Rock Port Railroad makes connections with the Cotton Belt and Missouri Pacific railroads.

A third public port is available at Fort Smith at a site on the Poteau River. It handles large amounts of steel as well as coal, grain, lumber, and other commodities.

Private firms also have established terminals along the waterway in Arkansas. The Bunge Corporation ships grain out of Linwood and also Pine Bluff. Century Tube loads and unloads steel coil, pipe, and conduit at its own facility in Pine Bluff; and Pine Bluff Sand & Gravel operates out of that city as well. Bruce Oakley, Inc., loads and unloads grain and fertilizer at North Little Rock and Morrilton. About 40 other firms operate terminals from Dumas to Fort Smith.¹⁰

Economic Development

In 1968 Senator John McClellan believed that the Arkansas waterway under construction would bring much larger returns than those suggested by a benefits-to-cost analysis of 1.5 to 1. Speaking at the David D. Terry Lock and Dam and dedicating the navigation channel that now reached to Little Rock, McClellan argued that the waterway would make the Arkansas River Valley “the valley of promise, progress, and prosperity.” President Richard M. Nixon also

took a broad view of the waterway's promise, stating in his dedication speech at Tulsa that the McClellan-Kerr System would make "this region . . . a magnet for people seeking the good life" and reverse the movement of people off the farms and into the city.¹¹

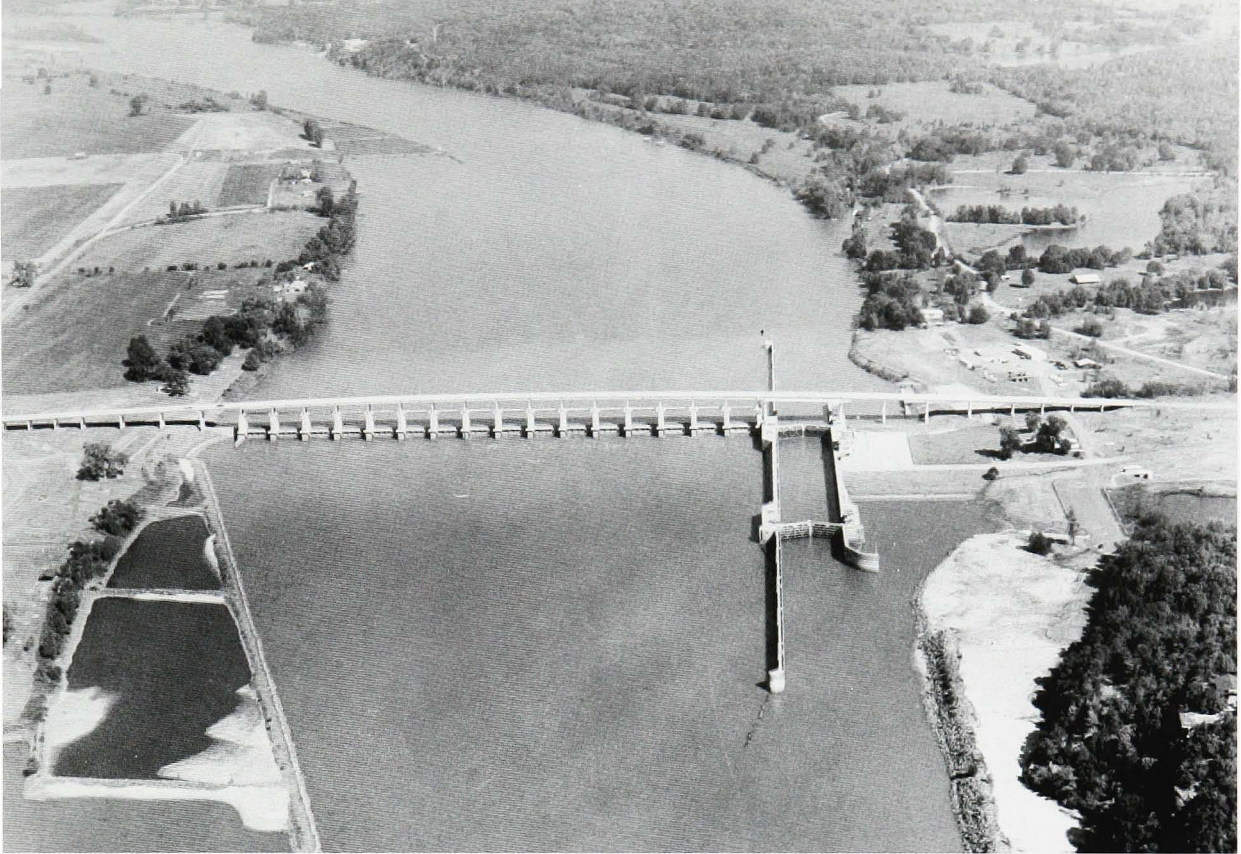
Table 3
Commodities Shipped
by Percentages
1971-1994 and 1994

Commodities	1971-1994	1994
Sand, gravel and rock	33.6	38.0
Petroleum products	12.0	4.3
Chemical fertilizers	10.7	15.2
Wheat	9.2	13.2
Coal and coke	6.7	3.1
Iron and steel	6.7	7.3
Soybeans	6.2	4.8
Other grains	5.4	6.5
Other chemicals	2.7	1.5
Miscellaneous	6.7	6.1
Total	99.9	100.0

In 1977 *New York Times* writer Roy Reed found evidence to support the idea that the waterway had already brought considerable

progress. He started with the water, which "if not quite blue, is a most appealing clear green instead of the muddy brown it once was." Reed found that navigation had brought the benefits that McClellan and Nixon had predicted. It "induced industry to build new plants in the Arkansas Valley, industry that provides thousands of jobs for country and small-town people who no longer rely on the land for a living." Recreation also was booming. There were 39 parks along the river and 21 more under construction, most of them equipped with boat ramps, camp sites, and various other amenities. The big story for those who fished was that the Arkansas River that once contained large amounts of "sewage, chicken entrails, and industrial waste" had become "the best fishing water in the state."¹²

As Reed's description suggests, the benefits-to-cost ratio is simply too narrow a concept to measure the impact of the waterway on the region it serves. Take recreation for example. According to the benefits and costs statement of 1968, recreation is supposed to produce \$2.3 million in benefits, an amount that roughly corresponds to the amount of user fees collected at recreational sites along the entire system. But the economic value of the McClellan-Kerr System goes far beyond fee revenue. A study commissioned by the U.S. Army Institute for Water Resources and carried out by scholars at Oklahoma State University indicates that almost immediately the benefits were much greater. In 1975



Toad Suck Ferry Lock and Dam and bridge across Arkansas River near Conway, 1977

people using recreational sites along the Arkansas River in Arkansas were spending an average of \$8.20 for each daily visit. This included \$5.30 for daily or trip expenditures, such as food and lodging, and \$2.90 for annual expenditures, such as the purchase of fishing or boating equipment. The total amount was a little higher at sites above Little Rock, probably because of the exceptional boating opportunities at Lake Dardanelle and Ozark Lake. The average figure of \$8.20 multiplied by the official visitor day estimate for 1975 indicates a total expenditure of \$54.8 million dollars. Thus the recreational facilities of the McClellan-Kerr System in Arkansas alone were producing economic activity that was nearly 24 times the \$2.3 million that had been predicted as benefits for the system as a whole.¹³ (Table 4)

A later study of recreation businesses along

the McClellan-Kerr System demonstrated the importance of recreation spending to the local economy. In 1978 waterway recreation was supporting full and part-time jobs that equaled an estimated 268 full-time equivalent positions, and it had generated 193 proprietors with their own establishments. The estimated annual income from this activity was \$3.9 million. The economic effect of each dollar earned was multiplied, however, depending on the amount of business activity in an area. Using different multipliers based on the characteristics of each county, researchers estimated that the full impact of income generated from recreation was \$7.6 million dollars in the Arkansas waterway counties in 1978.¹⁴ (Table 5)

Table 4
Estimated Expenditures Per Visitor Day at Arkansas River
Recreation Sites in Arkansas in 1975

	Trip	Annual	Total	Days	Expenditures/Yr.
Below Little Rock	\$4.94	\$2.41	\$7.35	2,349,000	\$17,265,150
Above Little Rock	\$5.50	\$3.17	\$8.67	4,330,000	\$37,541,100
All Arkansas	\$5.30	\$2.90	\$8.20	6,679,000	\$54,806,250

Table 5
Impact of Recreation Business on Jobs and Income in 1978,
in Arkansas River Counties in Arkansas

	NUMBER	INCOME
Full-Time Equivalent Jobs	268	\$1,939,251
Proprietors	193	\$1,969,654
Total for Recreation Industry	461	\$3,908,905
Multiplied Impact	486	\$3,679,177
TOTAL	947	\$7,588,082

Just as recreation benefits have a broad effect on the economy, so also do the benefits of navigation. The waterway reduces transportation costs, which lowers the sales price of commodities shipped by water; the lowered price then creates a larger market, and the growth of the market stimulates more production, more employment, and more income. A careful study by economists at the University of Oklahoma indicates that

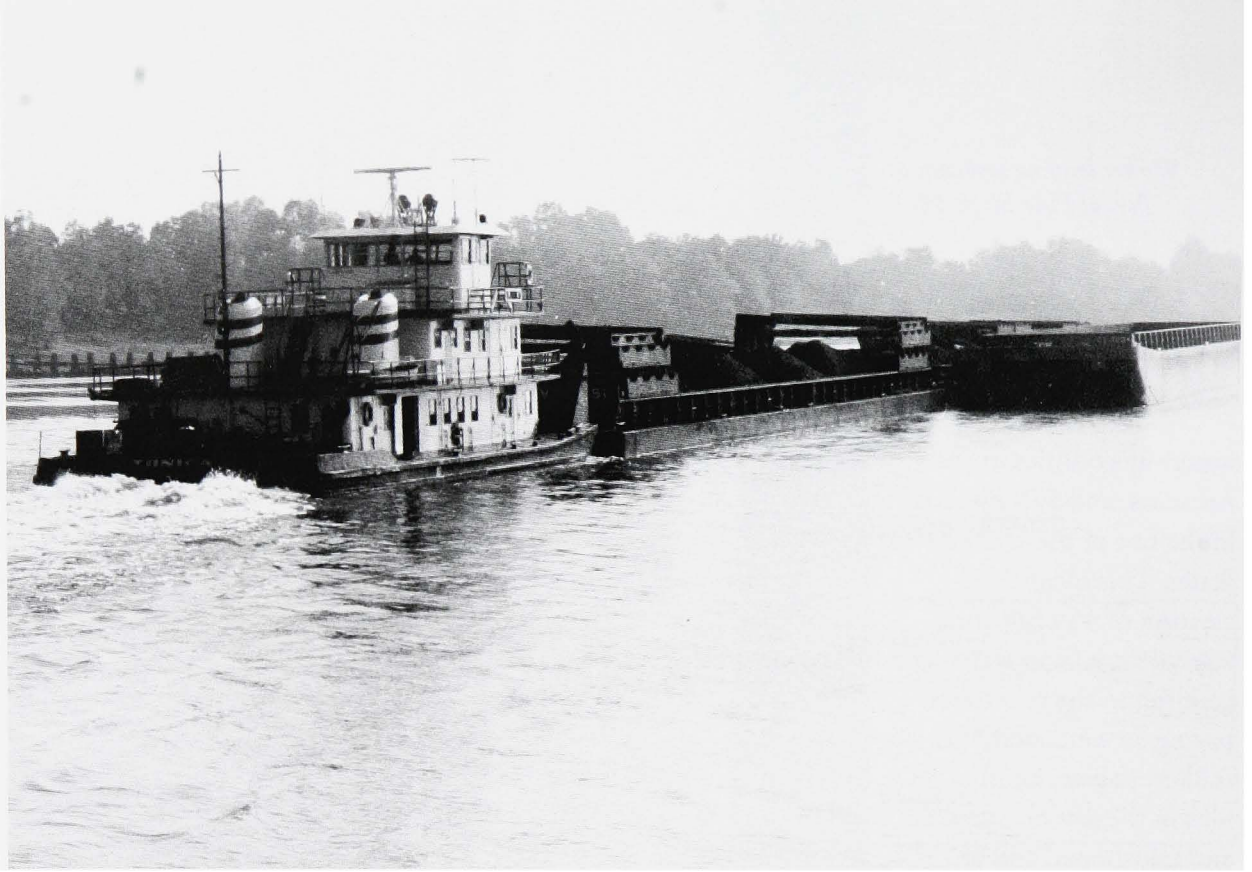
between 1974 and 1978 the McClellan-Kerr System lowered transportation costs by \$38 million dollars a year, which would be \$5.17 for each ton of cargo shipped. Using a complex model to describe the relationship between transportation costs and industrial output, this study argues that the \$38 million in cost savings produced \$119 million in industrial output, \$20 million along waterway counties in Oklahoma, \$20 million along the

*Worker loading soybeans at
Port of Pine Bluff, 1969*

waterway counties in Arkansas, and \$79 million in the rest of the United States. This meant the creation of 454 full-time equivalent jobs in waterway counties in the two states, paying an estimated \$6.2 million dollars, another 337 jobs in the rest of Arkansas and Oklahoma, and an additional 1,929 jobs in the remainder of the United States.¹⁵

These studies dealing with recreation and navigation are important because they suggest that the McClellan-Kerr System has had an impact on the economic health of Arkansas that goes beyond the benefits predicted by its planners. The lives of Arkansans have been improved by the recreational facilities provided by the waterway; and as they enjoyed themselves, people also spent money that had positive benefits for the economy. Less commerce moved on the Arkansas River than planners had predicted, but the tonnage that was carried seems to have had a larger impact than was anticipated.





A towboat pushing barges loaded with coal on the Arkansas River

Conclusion

The McClellan-Kerr Arkansas River Navigation System has delivered many benefits to the Arkansas River Valley. Waterborne transportation, flood protection, hydroelectric power, recreational facilities, fish and wildlife habitat, and usable water are the major products of the McClellan-Kerr System. In addition, the waterway has created jobs and encouraged economic growth. Moreover, after 25 years of service, it stands ready to meet the needs of the state into the 21st century. Senator McClellan seems to have been right when he claimed that nothing the federal government could do would “be as big a boon to our state as this.”



The Shorty Baird, Little Rock District workboat, at Toad Suck Ferry Lock and Dam, 1978

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Glossary

308 Reports: Series of nationwide river basin studies conducted by the Corps in the late 1920s and 1930s.

Alluvial: Pertaining to or composed of earth deposited by water.

Appropriation: The setting aside of money by Congress, through legislation, for a specific use.

Bank and channel stabilization: The process of preventing bank erosion and channel meandering.

Bar: A ridge-like deposit of sand, gravel, or other material in a river that obstructs navigation.

Basin: (1) Drainage area of a lake or stream, such as a river basin; (2) naturally or artificially enclosed harbor for a small craft (example: a turning basin for tows, or a yacht basin).

Channel: Deeper part of a river, a navigable route through which river traffic passes.

Closure structure: A movable part or section located along low points of a levee or floodway, such as a street or railroad intersection, to prevent floodwaters from flooding the area protected by the levee or floodway.

Crevasse: Break in a levee that enables flood waters to inundate a large area of land.

Cutoff: A natural or artificial shortening of the river by cutting across the neck or narrow portion of a meander in a river.

Dam: Barrier constructed across a valley for impounding water or creating a reservoir,

usually with facilities to control the release of impounded waters.

Dike: Rock structure built perpendicular to the river bank to direct and confine the channel into desirable, stable alignment.

Diversion channel: (1) An artificial channel constructed around a town or other point of high potential flood damages, to divert floodwaters from the main channel to minimize flood damages; (2) a channel carrying water from a diversion dam.

Habitat: Total environmental conditions affecting the life of plants and animals.

Draft: Vertical distance from the waterline to the bottom of a floating vessel.

Dredge: (1) An apparatus for scooping up mud, sand, etc., as in the deepening or clearing of channels, harbors, etc.; (2) to enlarge or clean out a river channel, harbor, or the like.

Fascine: Bundles of willow brush used to fabricate bank revetments during the late nineteenth and early twentieth centuries.

Flood: An overflowing of water onto usually dry land.

Floodway: Area dedicated to the passage of excess floodflows past critical reaches of a river.

Flood crest: The highest or peak elevation of the water level during a flood.

Flood control: The protection of land from floods by various measures.

Flow line: An observed or computed longitudinal water surface profile that depicts

an actual event or computed event. It is used as a vertical reference line for establishing clearances for navigational features and structures crossing the waterway.

Hydroelectric: Producing, or relating to the production of, electricity by water power.

Hydraulics: The branch of engineering dealing primarily with the flow of water and other fluids.

Jadwin, Edgar, Maj. Gen. (1865-1931): Chief of engineers (1927-1929).

Left bank of a river: The left-hand bank of a river when observed facing downstream.

Levee: Dike or embankment, generally constructed close to the banks of the river, stream or other body of water, and intended to protect the land side from inundation or to confine the flow of the stream to its regular channel.

Lift: Difference in elevation between upstream and downstream water surface levels in a lock and dam system.

Lock: Enclosed part of a waterway equipped with gates that allow water levels to change to raise or lower boats.

Lock operation: Locks fill and empty by gravity, with no pumps needed to raise or lower the water level. To raise water level, valves are opened above the upper gates and water flows into the lock through tunnels in both lock walls. This process is reversed to lower water in the lock. Valves are opened below the lower gates and water drains out of the lock through tunnels. Gates at both ends

of the lock open and close electrically after proper water level is reached.

Main stem: The principal course of a river or stream.

Miter gate: The closure gates at the upstream or downstream end of a lock chamber. Each section is shaped so it will meet the other in the center of the lock chamber and form a self-sealing water barrier.

Mouth of river: Exit or point of discharge of a river into another river, stream, lake, gulf or the sea.

NGVD: National Geodetic Vertical Datum; formerly Mean Sea Level (msl). Name changed in 1978 in accordance with instructions of the National Ocean Survey, Washington, D.C.

Ox bow: A remnant of a former river channel that has been separated from the river by a natural or artificial cutoff of a meander of the river.

Pilot channel: A manmade cut across the neck of a meander to create an artificial cutoff in the river.

Pool: Rather deep body of quiet water, as that formed behind a dam. On the Arkansas River, pools formed behind dams provide for the navigation channel.

Project: Large or major undertaking, especially one involving a considerable amount of money, personnel, and equipment.

Reach: Length, distance, or leg of a channel or other watercourse.

Recreation day of use: Attendance of one

person at a project engaging in one or more recreational activities for one day or a fraction thereof.

Reservoir: Pond, lake, basin, or other space, either natural or created in whole or in part by building of a structure such as a dam that is used for storage, regulation, and control of water for power navigation, recreation, etc.

Revetment: (1) A facing of stone, concrete, sandbags, etc., extending into the streambed to protect a bank of earth from erosion; (2) a retaining wall.

Right bank of river The right-hand bank of a river when observed facing downstream.

Riprap: A layer, facing, or protective mound of stones to prevent erosion, scour, or sloughing of a structure or embankment. The stone used for this purpose also is called riprap.

River basin: A portion of a water resource region, defined by a hydrological boundary, that is usually the drainage area of one of the lesser streams in the region. Examples are the Arkansas, Ouachita, Red, Tensas, White, and St. Francis River Basins.

River region: A major hydrologic area consisting of either the drainage area of a major river, such as the Arkansas River, or the combined drainage areas of a series of streams.

Rock dike: Embankment built principally of rock.

Shoal area: Patches of sand, gravel, or other hard bottom lying at shallow depths.

Shreve, Henry Miller (1785-1851): Pioneer

steamboat inventor who devised snagboats to remove obstructions from the Arkansas, Mississippi, Red, and other rivers.

Sill: (1) Horizontal beam forming the bottom of the entrance to a lock; (2) low, submerged dam-like structure built to control riverbed scour and current velocities.

Spillway: Waterway, dam, or other structure used to discharge excess water to avoid overtopping of a dam or permit diversion of flow from one waterway to another.

Stage: Elevation of water surface above or below an arbitrary figure.

Tainter gate: A water control gate in which the skin plate forms an arc of circle and the gate is rotated about the center of a circle. Tainter gates control the opening for the passage of water either between piers or conduits.

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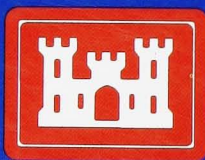
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