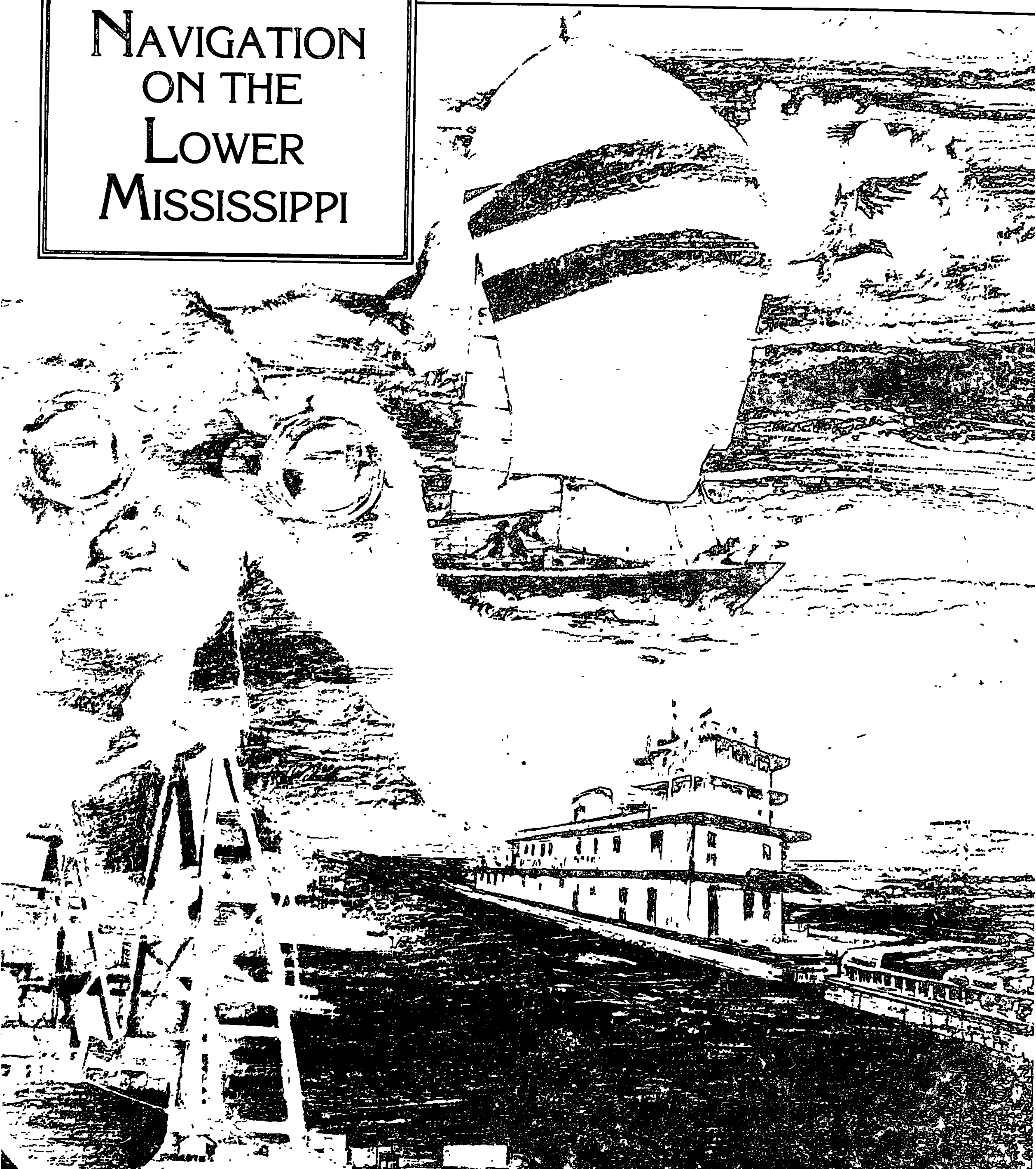
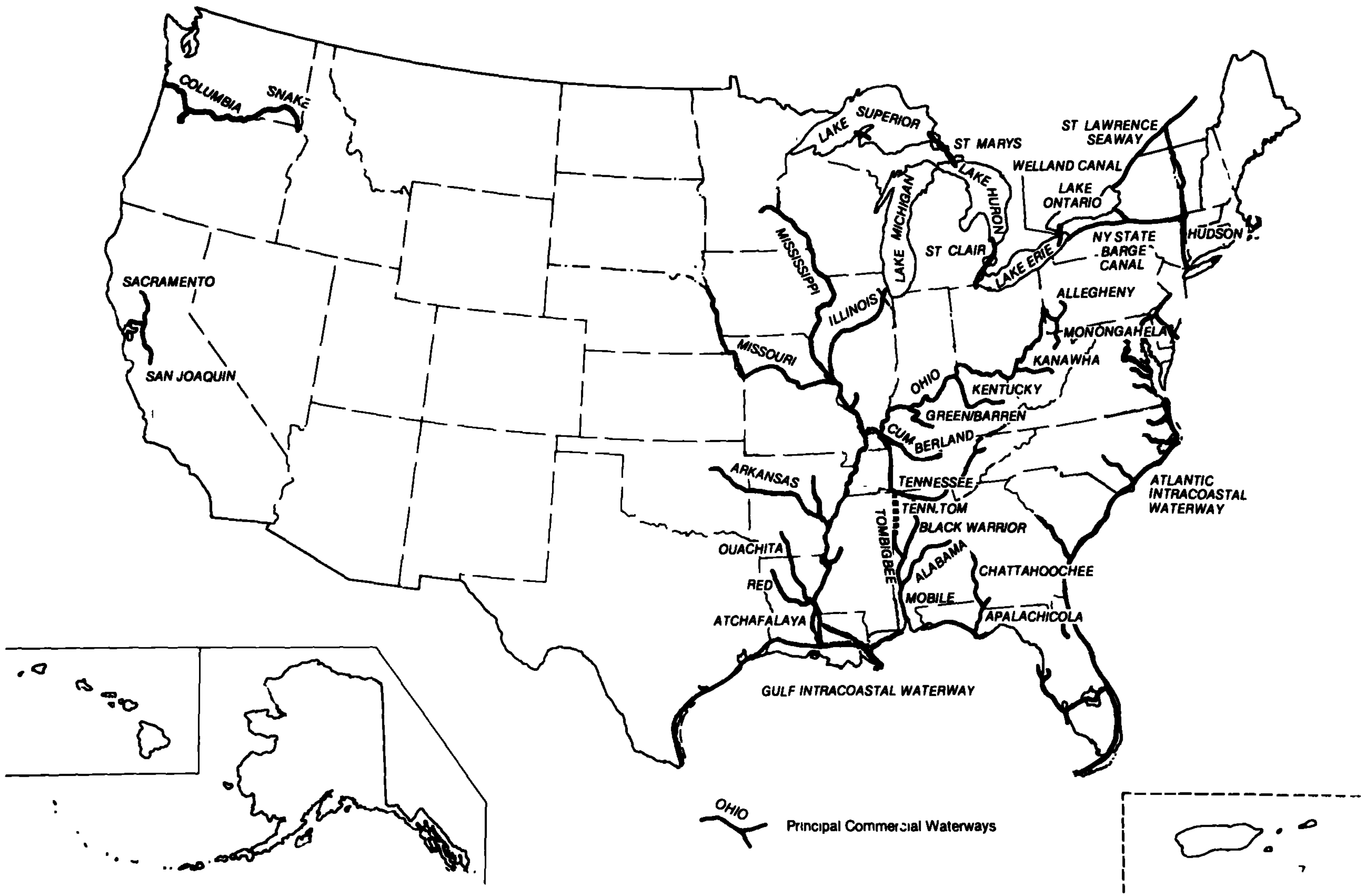
HISTORY OF NAVIGATION ON THE LOWER MISSISSIPPI



National Waterways Study □ U. S. Army Engineer Water Resources Support Center □ Institute for Water Resources

THE NATIONAL WATERWAYS
LOWER MISSISSIPPI RIVER



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Floyd M. Clay

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AUTHORITY FOR THE NATIONAL WATERWAYS STUDY

The Congress authorized the National Waterways Study (NWS) and provided the instructions for its conduct in Section 158 of the Water Resources Development Act of 1976 (Public Law 94-587):

> The Secretary of the Army, acting through the Chief of Engineers, is authorized and directed to make a comprehensive study and report on the system of waterway improvements under his jurisdiction. The study shall include a review of the existing system and its capability for meeting the national needs including emergency and defense requirements and an appraisal of additional improvements necessary to optimize the system and its intermodal characteristics. The Secretary of the Army, acting through the Chief of Engineers, shall submit a report to Congress on this study within three years after funds are first appropriated and made available for the study, together with his recommendations. The Secretary of the Army, acting through the Chief of Engineers, shall upon request, from time to time, make available to the National Transportation Policy Study Commission established by Section 154 of Public Law 94-280, the information and data developed as a result of the study.

PREFACE

This pamphlet is one of a series on the history of navigation done as part of the National Waterways Study, authorized by Congress in Public Law 94-587. The National Waterways Study is an intensive review by the Corps of Engineers' Institute for Water Resources of past, present, and future needs and capabilities of the United States water transportation network. The Historical Division of the Office of the Chief of Engineers supervised the development of this pamphlet, which is designed to present a succinct overview of the subject area.

John T. Greenwood

JOHN T. GREENWOOD
Chief, Historical Division

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Floyd M. Clay

Chapter I

EVOLUTION, DISCOVERY, AND EXPLORATION

The formation of the lower Mississippi dates from the end of the last Ice Age. As the climate warmed, the ice melted and runoff created rivers such as the Ohio and the Missouri. Those rivers, in turn, merged into one great shallow swamp, whose waters moved southward depositing rich topsoil in what came to be the Mississippi delta.[1] Slowly, a riverbed formed. The water, however, obeying geological principles, meandered throughout its length, as its own deposits and erosions constantly formed new routes to the sea. This process created land of modest elevation throughout the valley but swampy at the river's mouth, where the already ill-defined channel separated into several smaller flows, each seeking its own route to the Gulf. Today, the Mississippi continues to meander, causing man constantly to be on his guard against the shifting waters.

DISCOVERY AND EXPLORATION

In 1519 the Mississippi valley was bracketed by the Spanish explorers, with Juan Ponce de Leon exploring and mapping in Florida and Hernán Cortes beginning his plunder of Mexico. In that same year the Governor of Jamaica sent out Alonzo Alvarez de Pineda to explore and to chart the shores between Mexico and present-day Florida. Alvarez described the mouth of a large river which he named "Rio del Espiritu Santo," but it now seems that he was referring to the Mobile Bay outlet rather than the Mississippi. In 1582 a more reliable account by Cabeza de Vaca reported that he and the desperate remnants of his tragic expedition had been shipwrecked near the outlet of a major river, which from his description may have been the Mississippi.[2]

After the Spaniards had established a base in Florida a fully manned expedition, under Hernando de Soto, was dispatched into the interior of the Gulf coastal region. That 1541 expedition ranged through the interior until they encountered a large river, which they named the "Rio Grande." Their crossing of the Mississippi is assumed to have occurred somewhere between Memphis and Baton Rouge, perhaps at what is now Helena, Arkansas. Coincidentally, the expedition also recorded the first account of a major flood in the Mississippi valley.

Even though there was now clear proof of a major river leading to the center of North America, the Spaniards were still too preoccupied with Central and South America to divert their energies to securing the river. Thus interest in the Mississippi remained dormant for more than two centuries after de Soto's posthumous report.

It was not the Spaniards who capitalized on the existence of the river, but the French, who moved into the Great Lakes region via the St. Lawrence River. After hearing a report from trappers in 1655, the Governor at Quebec, the Compte de Frontenac, sent out Marquette and Jolliet to confirm the existence of a major river beyond the Great Lakes. On June 17, 1663, the little expedition entered the Mississippi headwaters. The explorers followed the downstream course as far as the mouth of the Arkansas River and then returned.

Unlike their Spanish counterparts, French authorities truly appreciated the value of the discovery, and prepared for a thorough exploration of the river. In August of 1678 Robert Cavelier, sieur de La Salle, led a well-equipped expedition which descended the river nearly to the Gulf. Near the Head of Passes, where the Mississippi divides into separate channels to the Gulf, he erected a cross and claimed the river and the entire valley. In honor of his king, Louis XIV, La Salle named the land Louisiana, and the river became "River St. Louis." Other names for the river included "Colbert," after Louis XIV's illustrious Finance Minister, and even "La Salle." All of these attempts to name the river came to nothing, however, for the quaint-sounding Indian name prevailed. The theory today is that the name "Mississippi" probably derives from the Chippewa term "mici zibi," meaning "large river." The French apparently understood the meaning to be "Father of Waters." That misinterpretation survives.[3]

To secure their claim the French erected outposts throughout the interior. In 1699 they established a colony at Biloxi, which they mistakenly believed to be near the mouth of the Mississippi. After the French found the actual outlets of the river, they despaired of establishing any settlement at the mouth at all; snakes, mud, mosquitoes, alligators, crawling insects, and oppressive heat and humidity proved too formidable obstacles. It was not until 1718, under pressure from authorities in France, that the Governor reluctantly chose an appropriate site. Workers cleared vines, brush, palmettoes, and other trees for the site, filled in some mud holes, and constructed a blockhouse so that a French flag could proclaim French presence near the outlets of the Mississippi. The New Orleans site was actually some 90 miles upriver, but was the only strategically located point from which both the Mississippi River and Lake Pontchartrain could be protected from foreign intrusion.

The establishment of New Orleans, however miserable the location, confirmed actual ownership and control of the river and lands claimed by La Salle.

Early Mississippi Navigation

Commerce advanced. Even before New Orleans was established as a port of deposit and entry, trappers of the western Great Lakes area, as well as those of the Ohio and Illinois regions, used the Mississippi to ship goods to market. As early as 1705 the first recorded cargo, a load of 15,000 bear and deer hides, was rafted down the Mississippi, signalling what could become the opening of one of the major trade routes of the world.[4]

The passage of time confirmed the importance of the Mississippi. Along with its tributaries the Mississippi drained approximately 40 percent of the interior of the contiguous United States, and about 13 percent of Canada. The major tributaries of the Mississippi rank as major rivers in their own right--especially the Ohio, Missouri, and Arkansas. The statistics are impressive; the river empties into the Gulf of Mexico at the average rate of 785,000 million cubic yards a year, and delivers three times as much water as the majestic Rhine and a whopping 338 times as much as the Thames. The Mississippi is a breathtaking 2,340 miles long and has over 100,000 tributaries, large and small, throughout a watershed of about 1,245,000 square miles.[5] With its tributaries, the Mississippi ultimately provides over 15,000 miles of inland navigation. In addition to its critical role as a primary trade route, the Mississippi assumed increasing importance as a source of fresh water. It is said that enough fresh water flows past New Orleans daily to provide the entire United States with three days' supply. The great river accounts for about one-tenth of the world's daily supply of fresh water.[6]

The lower Mississippi begins at the point where the Ohio empties into the Mississippi at present-day Cairo, Illinois. Although the Ohio River delivers a relatively clean flow, the muddy Missouri dumps an excessively silt-laden load into the upper Mississippi. The Mississippi takes on its muddy character within a mile or two below Cairo. The silt burden of the Mississippi runs to about 50 pounds of mud for each 1,000 cubic feet of water, a fact early river travelers noticed. The muddy character of the Mississippi became part of the river's legend. It was considered almost unpatriotic not to assume that the river was the muddiest in the world: "too thick to drink and too thin to plow."[7] The legend is a fallacy, however, as the silt level cannot compare with that of certain other rivers, even those in the United States. Both the Missouri and the Colorado rivers carry about ten times more silt than does the Mississippi.[8]

With the establishment of French colonies in the Gulf region, river trade started not only for westerners, but for Indians as well. As early as 1706 English traders tried to undercut the incipient trade between the French and the Natchez Indians. They could make occasional forays upriver as long as the French had no settlements along the Mississippi itself. They tried to win the favor of the Natchez by giving them more presents than did the French, apparently the only real consideration of the time. After the French established their dominance in New Orleans, thus excluding the English, the Natchez began to cultivate tobacco on a commercial basis. By 1729 the Natchez were supplying a good portion of the 300,000-pound tobacco crop which was shipped from New Orleans that year.[9]

In the upper reaches of the Ohio the French found it almost impossible to stem the flow of English frontiersmen pushing into the valley. The French stoutly resisted this intrusion, but apparently raised no sustained objection to the use of the Ohio and the Mississippi for shipping goods downriver. That commerce, after all, would bring some prosperity to the thinly settled regions of the West, and especially to New Orleans. Thus New Orleans became the principal port of deposit for the English colonial frontier as well as for the French settlers in the western provinces.

Early River Craft

Several conveyances were suitable for taking bulk cargoes downriver. The canoe, adopted by fur trappers and traders, could be as large as 18 feet long and 3 feet in the beam, and might even use a crude sail to take advantage of favorable winds. The maneuverability of the canoe, and its cousin the pirogue, was especially suitable for the smaller tributaries. Once the cargo had been carried to the larger tributaries, or the Mississippi itself, it was practical to combine cargoes into one major shipment on a more stable craft.

The bullboat was the first of these major downriver carriers. Constructed of buffalo hide stretched over an oval sapling frame, it could carry a cargo of three tons while drawing only ten inches of draft. The bullboat was guided and aided by a crew of polemen.

Another similar conveyance was the Mackinaw, commonly used to transport fur pelts from the Missouri valley. The Mackinaw was constructed of hand-hewn planks pegged together. An average-sized craft was approximately 50 feet long and 12 feet in the beam. The Mackinaw was flat-bottomed and pointed at either end. A crew of four men could transport a load of 15 tons a distance of 75 to 150 miles in a time span of 15 to 18 hours.[10]

The flatboat was another common downstream conveyance found in the Mississippi valley. Flatboats, also known as broadhorns, carried passengers as well as cargo. Emigrants from the middle-state colonies came into the headwaters of the Ohio River, bought or constructed flatboats, and moved westward with provisions and homesteading essentials. Craftsmanship was not a major factor, for once these conveyances had fulfilled their function their owners dismantled them and either sold the lumber or used it to construct a homestead. The average flatboat was about 40 feet by 12 feet, and 8 feet deep. The cargo was solidly stowed except for a center aisle, and there was a cabin astern for the family. The cabin itself, a small house, contained the bare essentials--bunks, table, and a brick fireplace. The pilot steered the craft through vigorous control of a 40- to 50-foot sweep in the tiller.[11]

The more versatile keelboat allowed upstream movement, however laborious. Pointed at both ends, the keelboat averaged 60 to 70 feet in length, was about 18 feet wide, and had a slightly rounded bottom. These craft were distinguished by a heavy timber keel which served as a shock absorber in frequent encounters with floating trees or sandbars. Like the aforementioned craft, the keelboat floated downstream with the current, but it could be poled upstream by a crew of boatmen wielding iron-tipped poles. If the river bottom was too soft, or the current too swift, the keelboat could be winched forward by a method called cordelling. The crew tethered a rope to the craft, then carried the other end of the rope for a short distance upstream and anchored it to a tree on the bank. The craft could then be warped forward by hand or by means of a capstan. "Bushwacking" was a third way of moving against the current. This technique involved nothing more than moving the keelboat by means of grasping branches and pulling the boat forward. From all accounts, more muscle than skill was involved in moving a keelboat and its cargo upstream.

The sugar, molasses, and groceries carried into the hinterland represented the essential luxuries of the frontier, easily worth the four months or more that were necessary to get them from New Orleans to Pittsburgh. The riverboatmen rewarded themselves with fighting and debauchery at each opportunity along the way, and Natchez seemed to gain a reputation second only to that of New Orleans.[12]

Moving the cargo upstream on crude craft was an exercise in strength and endurance, but the alternative was even less attractive. Any attempt to punch through the wilderness with more than a backpack invited disaster by exhaustion, Indians, bandits, bears, or snakes. Those who were returning home by way of land usually traveled in heavily armed groups unencumbered by excess baggage. The primitive river craft were the least dangerous alternative, and up until the 1780s represented the best means of inland navigation despite being essentially one-way conveyances. Their major advantage was that they required neither deep water nor a cleared channel. Like the frontiersman themselves, the craft were rough and ready and got the job done with the fewest complications.

The Mississippi Becomes American

After the French and Indian War ended in 1763, defeated France deeded the Louisiana territory, including New Orleans, to Spain. The Mississippi became the dividing line between English and Spanish territory. Benevolent Spanish rule greatly enhanced commerce on the Mississippi. While the mother country had stringent and ill-devised commercial regulations regarding trade with foreign nations, the Spanish governors connived to violate those rules. This fact was particularly true after a major fire nearly wiped out New Orleans in 1788. In the interests of a quick recovery Governor Estevan Miro opened trade, not only to the Americans but to other nations which would trade through New Orleans. The venture was such a success in rebuilding the financial vitality of New Orleans that even the King of Spain congratulated the local governors on their violation of Spanish regulations.[13]

American deposits at New Orleans were significant, including expensive cargoes which often represented the sole cash crops of interior settlers. The warehouses at New Orleans bulged with tobacco, cider, and fur--and their quantities grew with each passing year.[14]

New Orleans had become too vital to the Americans to be left in foreign hands. Americans were dissatisfied with the status quo, for the privilege of navigating the western waters and of using New Orleans could be withdrawn. The situation became critical in 1800 with the news that Louisiana had been retroceded to France. Americans feared that France, under control of Napoleon Bonaparte, might capriciously withdraw the "Right of Deposit" which Spain had guaranteed. That prospect moved westerners to demand that New Orleans be secured for the United States. In that atmosphere American political leaders found it popular to advise westerners to "take redress into their own hands" if the foreigners dared try to close off New Orleans to American use. Secretary of State James Madison fairly well assessed the value of the Mississippi to western citizens when he said:

> The Mississippi to them is everything. It is the Hudson, the Delaware, the Potomac, and all navigable rivers of the Atlantic states, formed into one stream. The produce exported through

> that channel, last year (1802) amounted to $1,622,672 from the districts of Kentucky and Mississippi only, and will probably be 50 percent more this year, from the whole of the western country. Kentucky alone has exported, for the first half of this year, $591,432 in value, a great part which is now, or will shortly be, afloat for New Orleans and consequently exposed to the effects of this extraordinary exercise of power (possibility of cutting off a port vital to Americans).[15]

Senator Ross of Pennsylvania added, "To the free navigation of the Mississippi we had an undoubted right, from nature and from the position of our western country."[16]

The worst fear of the westerners was realized when France withdrew the Right of Deposit at New Orleans. Americans talked wildly of taking New Orleans by force. In 1803, President Thomas Jefferson responded by sending James Monroe to Paris to negotiate the purchase of New Orleans and its surroundings. Few anticipated that France would part easily with such a valuable possession, especially considering that the ministers were to offer only $2 million and to go no higher than $10 million.

However, events favored the Americans. Napoleon's ambitions suffered some disastrous setbacks, and he decided to divest himself of the more troublesome elements of the empire. "Damn sugar, damn coffee, damn colonies!"[17]

The American ministers approached Napoleon's infamous minister, Talleyrand, with some trepidation, being aware of his crafty reputation and their own modest financial proposal. Talleyrand dumbfounded the ministers by offering to sell all of Louisiana for little more than they had been authorized to pay for the New Orleans area. After a week of nervous haggling a deal was struck, and all of Louisiana belonged to the United States for the bargain price of $15 million, which included some debt write-offs. Now the Mississippi was truly an American river.[18]

Chapter II

NAVIGATION DURING THE STEAMBOAT ERA

The flood of new immigrants into the Mississippi valley assured that river commerce would grow as never before, but not necessarily that the river would be improved for navigation. The coming of the steamboat created the demand for improved channel conditions.

The first steamboat on the Mississippi, designed by Robert Fulton for Nicholas Roosevelt and built in Pittsburgh, was not well designed or suited for the shallow waters of the West, including the Mississippi. The ship was named for its destination, New Orleans. It was 148 feet long, sat deep in the water, had two auxiliary sail masts, a crew of 13, and looked more like an ocean-going vessel. Roosevelt, however, was a thorough man and had meticulously planned for the initial voyage. He arranged for fuel and supply stops along the route, picked a time when the river would be running high, and allowed time to stop at all major cities en route. At each of these stops he gave local dignitaries a short upriver ride to demonstrate the capabilities of his ship and to alert them to the steamship era about to begin.

The only major incident on the downriver trip occurred when the New Orleans was midstream during the famous New Madrid earthquake. As the river heaved and land sloughed away from the bluffs, the citizens of New Madrid spotted the strange, smoke-belching, fire-spitting contraption in the river. Roosevelt stopped and offered to take on the citizens for safety, but many apparently thought the apparition to be more of a menace than the earthquake. Perhaps, in their confusion the citizens even ascribed the earthquake to the presence of the strange craft.[1]

The drama of the first Mississippi steamboat was fully equal to the competition of an earthquake--and certainly of more consequence to the people of the Mississippi valley. The historic significance was not lost on the citizens of New Orleans, for they followed the news of the voyage with consuming curiosity. When the New Orleans landed in that city in January of 1812, it was greeted with a thunderous roar of cannon salutes, firework displays, and all the usual forms of public celebration. The trip from Pittsburgh had taken three and a half months, but when the New Orleans nosed upstream to begin its regular run to Natchez the steady three mph headway brought a gasp of approval. It was not the right ship, but it was the first ship. A new era had begun.[2]

The New Orleans provided the first steam-powered commercial route on the lower Mississippi, but within two years it also became the first steamship lost to the river, suffering what became the most common end of a steamboat, death by snagging. The incident emphasized that if steamboat navigation and commerce signalled a new era, then a more efficient steamboat was necessary--and river improvement was a fundamental requirement.

Within a few years of the arrival of the first steamboat there were hundreds and then thousands of steamboats operating on streams throughout the Mississippi valley. Their design differed radically from that of Fulton's New Orleans, due primarily to the innovative genius of Captain Henry Shreve.

A man of limitless energy, Shreve was "unencumbered by book learning, and ready to dare anything."[3] He learned his river craft in the hard school of keelboating, and quickly applied his logical mind and facile imagination to developing a steamboat more appropriate for western waters. While forming his ideas he became the captain of the Enterprise, launched just two years after the historic arrival of the New Orleans. The War of 1812 gave additional opportunity to Shreve. He ignored the monopoly on river traffic which Louisiana had granted to Robert Livingston and Robert Fulton. Transporting arms and supplies to Jackson, and defending New Orleans in an epic confrontation, gave Shreve the kind of publicity and contacts which served him well. After the war Shreve continued to defy the Fulton-Livingston monopoly and eventually broke its legal status.[4]

Shreve's new steamboat design quickly became the standard of western ship design and it was incorporated in his first boat, the Washington, launched in 1816. The hull, which was only a shallow barge, was a striking departure from conventional design. Shreve reasoned that there was no need to have the engine mounted below deck, as there would be no great waves or hurricane force winds to threaten the craft's stability. Rather, he mounted his engine on the deck and in the process created a craft requiring only one to 2 feet of water for navigation, as opposed to the customary 8- to 12-foot draft of conventional craft. Second, Shreve used a high-pressure engine which was both lighter and more powerful than the low-pressure model used in the Fulton-designed craft. Shreve's engines also had horizontal rather than vertical cylinders, contributing to better configuration of the ship. His new engines proved to be twice as fuel efficient as then-standard types.[5]

Shreve's new approach to river craft design resulted in a boat that drew less than two feet of water, carried a larger cargo, and was fuel and design efficient. Its shallow draft enabled it to float over sandbars and to travel shallow streams, bayous, and harbors. This highly successful design was as great a step in the growth of river commerce as the original steamboat. Combined with Shreve's successful challenge of the river monopolies, it brought a new surge of interest in river commerce. By 1818 there were as many steamboats built to the new design specifications as had been built in all the previous years.[6]

Improvements to Navigation

The steamboats brought a new era of prosperity into the valley. New settlements sprang up along the length of the river as trappers and farmers expanded their activities. The standard of living on the frontier leapt forward from the days when the most basic commodity was considered a luxury.

Increasingly heavy traffic on the Mississippi caused greater losses because of navigational hazards. Profits were high enough that shipping interests could sustain the losses, but the better solution was to remove dangerous obstructions from the river.

Although a community might assume responsibility for eliminating obstructions from its own harbor, no private interest could undertake clearing the entire Mississippi. Thus commercial interests, shippers, local officials, and port authorities appealed to Congress for help in improving river conditions on this vital national artery. These demands occurred after the War of 1812, when interest heightened in improving the nation's road and waterway system. Congress, responding to a report by Secretary of War John C. Calhoun, finally agreed that maintaining inland navigation was in the national interest. Therefore in 1824 it enacted the first of many Rivers and Harbors bills. The 1824 bill authorized the President to spend $75,000 for the removal of trees which had lodged in the navigational streams of the Ohio River and the Mississippi. The Corps of Engineers was directed to carry out the congressional mandate.[7]

Snags

To the westerner, "river improvement" meant nothing more than removing dangerous obstructions from the main channel. Many of these obstructions were manmade, often the wreckage of a ship or other river craft. Other, and more common, obstructions were known as "snags," "sawyers," or "planters."[8]

A snag was a tree which had broken loose from an eroding bank and floated into the navigation line of the river. There, the base of the tree would settle to the bottom of the channel and the trunk would project above the water line. Within a few weeks the upper or exposed part of the tree would disappear, leaving only the shaft of the tree as a lethal spike capable of puncturing a moving craft without warning. Once the ship was caught, its weight and speed would impale the vessel on the tree trunk. So violent were these encounters that on many occasions the tree shaft penetrated not only the hull of the craft, but the upper decks and even the pilot's house as well.[9]

A sawyer was similar to a snag in that it was a displaced tree resting on the bottom of the navigational channel. But it differed from the snag in that it was less rigidly affixed at the base, and tended to bob up and down ("saw") with the action of the current or waves. The sawyer was just as dangerous as the snag, but a bit more capricious.[10]

A planter was usually a tree that remained as an obstacle when the river was cutting a new chute. The chute was the first indication that the river was going to cut across a bend, but often the process of cutting a new channel would occur so quickly that the better rooted trees would resist the attack of the new channel for many months. As they lost their protruding foliage and the channel became more navigable, the planters became a formidable obstacle to an unsuspecting pilot.[11]

The process of clearing all these obstructions, including old wrecks, was called "snagging." An onerous job, snagging involved attaching a rope or chain to the obstacle and jerking it out of the main channel. A process of jerking, dragging, and winching continued until the massive and ungainly object had been pulled off toward the bank. All too often the snag would refloat itself during the next high water and resume its guarding of the channel, and the same snag would have to be removed once again the following year. The task of clearing thousands of snags as thousands more drifted into the river was overwhelming, particularly when there was more river traffic on western waters than on the Great Lakes and the Atlantic Coast combined.[12]

The commercial interests along the lower Mississippi were understandably preoccupied with navigation. The 1840s and the 1850s marked frequent so-called river conventions, invariably held in one of the major cities benefiting from river trade. The conventions always culminated in a call for more federal concern (read: funding) for river improvements and occasionally voiced demands for flood control. The principal contention seemed to be that the river served the national interest, and that it would be unfair for the bordering states to assume the entire burden of its improvement. Accepting that argument, in 1844 President Tyler told Congress that the Mississippi River was a "unique highway" serving the commerce of the whole country, and that the United States should not expect the bordering states to bear the national burden any more than the bordering states should control commerce on the river.[13]

Congress was not impressed and several times failed to make necessary appropriations even for routine work. The strain of national tensions and sectionalism tended to make all else seem unimportant. The decade of the 1850s riveted national attention on the question of possible southern secession. In this mood of growing sectionalism it was not surprising that the lower Mississippi, flanked on both sides by slave states, would be neglected by Congress. In 1855 the government sold the snagboats and abandoned the lower Mississippi to nature; the only exception was a bill Congress passed in 1856, over a presidential veto, appropriating $330,000 to maintain ship channels at the Mississippi's mouth.[14]

Southerners undoubtedly thought the abandonment inexcusable, but northern legislators argued that further work must await the results of some major surveys. The 1850 Congress had authorized a complete survey of the lower Mississippi River, with a view toward a plan of improvement for navigation. The Secretary of War authorized both the Army Corps of Topographical Engineers and Charles Ellet, Jr., a well-known civil engineer, to make reports. Ellet's report gained attention because of its recommendation to build flood control reservoirs, a very controversial idea at the time. Captain A.A. Humphreys and Lieutenant Colonel Stephen H. Long of the Topographical Engineers began a separate report as part of a topographic and hydrographic survey of the Mississippi delta. Lieutenant Henry L. Abbot was later detailed as an assistant to Humphreys, while Long was assigned elsewhere. When the report was completed in 1861 it was known by either of two names; the Delta Survey or the Humphreys and Abbot Survey.[15]

Humphreys and Abbot suggested that navigation could be improved and floods minimized mainly by constructing levees. The report was a comprehensive examination of the Mississippi, employing both new research and new theory. Its impact on the development of river engineering in the United States can hardly be exaggerated. For the time being, however, the implementation of any new river engineering concepts was delayed by the Civil War.[16]

The Civil War

The Civil War not only postponed river improvement, it accelerated the deterioration of the channel. Frequent gunboat sinkings, mining of waterways, placing of manmade obstructions, and cutting of levees all made the waterway increasingly dangerous. At one point in the war General U.S. Grant attempted to divert the river so that it would bypass Vicksburg, but he found that more than pick and shovel would be required. Nearly ten years of neglect and five years of destruction negated previous gains.

Post-Civil War

Soon after the Civil War, Secretary of War Edwin Stanton sent Humphreys, then a brevet major general, to the lower Mississippi valley to inspect and repair the war-damaged levees. Though neither sufficient funds nor manpower were found to repair all the levees, Humphrey's report served as a guide to further action. Humphreys once more stressed the importance of levees for flood control; and, in the 1870s, Congress appropriated money for emergency levee repair, justifying the appropriation as an aid to navigation. Meanwhile, Corps of Engineers dredge boats cleared the channels at the Head of Passes of both manmade and natural obstructions.

The businessmen of the day were too impatient to await an "all clear" signal from the Corps, however. They put their ships back into operation as soon as they could be raised or refitted, launching their craft in snag-filled channels.

The steamboats of the period continued the romantic tradition of the prewar era. Luxurious passenger cabins equal to any fine hotel, elegantly appointed dining rooms, huge ballrooms with live entertainment, sumptuous food, and endless gambling were all part of river travel. To all this was added the exciting element of danger, the real fear that the ship might be lost for any number of reasons: snags, collisions, fires, sandbars, or exploding boilers. More than 500 steamboats and thousands of passengers had become casualties of river traffic in the ten years before the Civil War. The odds increased of accidents occurring on the neglected and debris-choked river of the postwar period.[17]

The historic 1871 steamboat race between the Robert E. Lee and the Natchez demonstrated the adventurous nature of steamboat captains. More important, the race refocused the nation's attention on the viability of river commerce. Steamboat captains tried to capture the record for cargo tonnage by stacking cargo as high as the pilot house. The Mary Belle temporarily captured that record with a cargo of 7,829 bales of cotton and 19,000 sacks of cotton seed, for a total cargo of 3,300 tons. These records were important for the shippers. They brought attention to the fact that cargoes could be transported efficiently and helped steamboat companies compete with the emerging railroad industry. The size cargo that the Mary Belle carried, for instance, would have required 110 cars on the trains of the period; and, of course, the expense would have been much greater.[18]

Heavy river traffic meant heavy commercial interests were lobbying in Washington. In June of 1874 Congress authorized a new survey of the lower Mississippi, with a view toward maintaining a guaranteed channel eight to ten feet deep. This work was greatly aided by new gages that had been set on the river in 1871, the beginning of systematic and continuous river gaging on the Mississippi. The new survey undertaken under the direction of Major Charles R. Suter, Corps of Engineers, was one of the most significant evaluations of the river. His reconnaissance resulted in a map, published on a scale of one inch to one mile, showing the bank lines, the river channel, sandbars, known wrecks, islands, bluffs, tributaries, and all known obstructions to navigation. Suter's survey updated previous knowledge of the river and was remarkably detailed. Even uninformed congressmen had to be impressed with the overwhelming problems of navigation on our nation's major waterway. Suter's map, depicting thousands of towheads, islands, drybars, wrecks, and chutes, clearly showed the problems of a twisting and convoluted channel.[19]

With these facts, Congress became convinced of the need to correlate all known information and develop a systematized approach to river improvement. The massive project required that a commission be created to investigate appropriate procedures and to oversee the efforts.

While Congress was studying the makeup of such a commission it authorized the formation of a Board of Engineers to help execute river improvements. More and varied information poured in, including new studies by Major C.B. Comstock to determine the amount of sediment in suspension. Congress became more convinced that river problems were too varied and complex to be approached piecemeal or to be handled by any one agency.[20] Therefore, in June 1879, Congress passed a bill authorizing the establishment of the Mississippi River Commission (MRC). Composed of seven presidential appointees, the Commission consisted of three officers from the Corps of Engineers, one from the U.S. Coast and Geodetic Survey, and three civilians, of whom two had to be civil engineers. The law specified that the President of the Commission be a Corps officer.[21] The MRC had a greater mass of accumulated river information than had ever previously existed, but funds were still scarce. The Commission clearly needed more congressional support if it ever was to fulfill its responsibilities to improve navigation and prevent disastrous flooding.

Chapter III

GETTING ORGANIZED

THE MISSISSIPPI RIVER COMMISSION

At first the Mississippi River Commission, headquartered in St. Louis, tried to do all--gather facts, develop plans, and hire the labor. The job was impossible. Thus in 1882 Congress relieved the MRC of the work detail. Thereafter the Commission would do the planning and the Army Corps of Engineers would do the work.

To facilitate the work on the river the MRC recommended and Congress authorized the establishment of Engineer Districts to handle projects within specific stretches of the river. The First District boundaries extended from Cairo southward to a point ten miles above Memphis. The Second District stretched from that point to the mouth of the White River. The Third District continued to about ten miles below Vicksburg, and the Fourth District reached from that point to the Head of Passes. These Districts were later supplemented by the creation of a Dredging District operating directly under the Commission.[1]

The original subdivision of the Engineer Districts was cumbersome, and by 1885 the First, Second, and Third Districts were all headquartered in Memphis, while New Orleans was the home of the Fourth District. After some interim adjustments, there was a major overhaul of the subdivisions in 1928. The lower Mississippi was divided into four districts: St. Louis District, containing part of the old First District; Memphis District, essentially comprising what had been part of the First and most of the Second Districts; Vicksburg District (formerly the Third District); and New Orleans District (the old Fourth District). At the same time Congress directed the MRC to implement the flood control plans for the lower Mississippi proposed by Major General Edgar Jadwin, the Chief of Engineers. The headquarters was relocated in Vicksburg in order to be central to its jurisdiction. In an efficiency move, the President of the MRC was later given additional responsibility, by being named the Mississippi Valley Division Engineer.

The act which created the Mississippi River Commission mandated the improvement of the river channel, but it also included a variety of other tasks and commitments. Commercial interests thought that the MRC was created to improve navigation on the river, but landowners hoped that the Commission might also provide flood protection. Many Congressmen, however, reinforced by public opinion, were firmly opposed to government-sponsored flood control, arguing that the Constitution forbade the use of federal funds to protect private property. Any flood protection measures were usually disguised as improvements to navigation. Not until 1917 did Congress authorize federal funds for flood protection.[2]

Coinciding with the creation of the Mississippi River Commission and partly because of the support of that agency, new hydraulic research and experimentation began. The results revolutionized the science of river engineering--remarkable progress was made in the areas of bank protection, regulation of the river, and dredging.

Bank Protection

The immediate need was to clear the river of hazardous obstructions (snags). Fortunately, the snagboat designed by Captain Shreve was up to the task, especially with the gradual introduction of steel hulls. Because the removal of snags was a routine matter, the Engineers were able to concentrate on the basic problem of snag prevention, that is, keeping trees and debris from collapsing into the river through bank decay and erosion.

Willow Mat

Bank protection was not a new idea. Man had long tried to keep the river from gnawing away at his property. By the nineteenth century the "science" of bank protection had evolved into a fairly routine system. The bank would be "prepared" by being cut to a slope of 45 degrees or less, then overlayed with some kind of protective covering extending above the high-water mark to well below the level of erosive turbulence. Up until the latter part of the nineteenth century there was only one abundant material for bank protection along the Mississippi banks--the ubiquitous willow tree saplings.

Using a process brought over from Europe, workers cut the willow saplings into uniform lengths, cross-stacked them to a thickness of three to five feet, and then tied them together with wire. The mattress ("mat") was then securely anchored to the river bank. The mattress could be as long and as wide as needed, because the workers could build extensions both laterally and vertically.

The upper bank portion of the mat would be constructed in place, but the subaqueous (underwater) section required a special technique. The subaqueous mats were built on the deck of a "mat launching barge anchored tightly to the bank. As the mat sections were completed the barge was pulled out from uder the mattress, leaving the mat to float on the water. Laborers then loaded the mats with large stones (riprap) until the mattress sank into position.

The process was arduous and seemingly endless. Often the mattress would be swept away and destroyed by the next high water, or the river might change and move a hard-won revetment miles away. The key to survival of the willow mat lay in its being undisturbed for the first few months, when the saplings would actually send out roots and become an integral part of the river bank. Many of the willow forests along the river have their genesis in just such a development.

Bank revetment started with the protection of harbors, expanded to the protection of the most critical bends in the river, then on to protection of secondary reaches of the river. In the process, revetment spread from a few thousand feet to hundreds of miles of protection.

Concrete Mats

Certain districts assumed responsibility for experimentation and development of answers to specific river problems. The Engineers at Memphis took the lead in experimenting on better methods of revetment. The experimentation led them through several unusual concepts, beginning with the substitution of lumber for willow saplings. That concept was quickly abandoned because the lumber was vastly inferior for many reasons, including rot and drift. The search then turned to large, heavy slabs which would anchor themselves to the banks by their own weight. After a brief fling with cinder slabs (for reasons of economy), the Engineers turned to concrete. Overlapping concrete slabs were the beginning of the answer. However, the slabs were not the best answer since they were difficult to place, could be undermined by eddy currents or backwash, and would often slide off in the muck. Lap-slab paving pointed directly to the need to have smaller slabs tied together so that they could conform to bank erosion.

By 1916 the forerunner of today's standard articulated concrete mattress had evolved, and it was placed in Vicksburg harbor. The mat underwent some minor changes and it took a long time to develop the immensely complex mat-laying plant of today. Still, the basic concept of a flexible concrete mattress, consisting of small blocks of concrete preformed and wired together as units which could in turn be connected to other units, evolved as the best answer to the age-old problem of how to protect a bank from erosion, especially at the subaqueous stage.[3]

The present design of the articulated mat consists of a section of 20 blocks of concrete, linked together by a corrosion-resistant wire, and covering an area 4 feet by 25 feet (100 square feet). In the ultimate refinement of the placement process, the old method of derrick and crane has given way to a remarkably complex mat-laying plant (barge). This complex of machinery takes the units from the supply barges, lays them in proper juxtaposition, ties them together, and lays them on the slope of the bank. The plant was developed by the Vicksburg District Engineers and remains a marvel of technology, capable of laying 330,000 square feet of articulated mat in a ten-hour work day.[4]

The creation of a better mattress, plus the innovative technique for laying that mat, allowed the Engineers to plan for the protection of more and more segments of troublesome banks, as well as to repair those sections which were lost or bypassed by the river. No longer does one measure revetment by the miles, but rather by the hundreds of miles. At the end of 1980 the Memphis District had completed 85 percent of the authorized 340 miles of revetment within its district. The Vicksburg District had completed 241 miles of its authorized 289 miles (83 percent); and the New Orleans District had completed 206 miles of its authorized 325 miles (63 percent).[5]

Stabilizing the Channel

Just as the search for effective bank protection advanced through several stages of experiments and failures, so did the search for effective ways to control channel width and meander. The Rivers and Harbors Act of 1896 specified that the Engineers were to maintain a minimum depth of nine feet on the lower Mississippi, but that was not a goal easily attained.

The problem lay in the characteristics of the riverbed. The river worked itself through such a soft meander belt, easily eroded, that it tended to widen itself and run shallow in the process. Protecting the banks assured that there would be some limit as to the width of the river, but the natural banks permitted the river to spread over too large an area. Furthermore, the thalweg (a line representing the deepest part of a channel) could and would meander within the meander of the riverbed itself, creating shoals where none had been the day before. The problem was especially acute at places like Plum Point Reach, about 50 miles above Memphis. At that point the river seemed to be virtually unconfined within the low mud banks of the floodplain. There the river spread itself thin, flowed turgidly, dropped out sediment, and allowed snags to anchor themselves anywhere.

Because Plum Point was a particularly troublesome reach, the Engineers chose to fight the battle there, just as Shreve had chosen the same location to wage his war on snags. The solution for Plum Point, and for many other reaches of the Mississippi, was to constrict the water into a more manageable channel. Forcing the flow into a tighter, more confined channel would cause the water to scour away sandbars and to dig a deeper channel for itself--a task not easily accomplished.

Dikes

It would not be necessary to wall in the Mississippi in order to constrict the channel, but only to extend a dam-like structure from the bank to a proposed channel line. These structures were called dikes, or wing dams. The dikes would naturally stop the flow of water through its normal spread, and thus force the water to take the path that was unobstructed. Since the water would be slack between the dikes, sediment would continue to build up until those areas would become reclaimed land and, in turn, create a continuous bank for the constricted channel.

After much experimentation it appeared that a fundamental approach was best in constructing the dikes. A line of pilings (like telephone poles) would be driven along the line of the proposed dike, deep enough to assure stability. The pilings would be lashed together to form a continuous barrier. Willow mats were then lashed to the structure and anchored at the base by riprap. In theory, sediment would begin to accumulate between the dikes, displacing the water. So much for theory. More often than not the currents undermined the pilings and washed away the whole structure, no matter how deep the pilings or how well ballasted with stone.

In the continuous effort to create a more stable structure, single pilings gave way to multiple pilings driven deeper and lashed with greater rigidity. But all to no avail. The river seemed to have all the tools it needed to fight the best efforts of man. Even if the Engineers succeeded in creating a wing dam capable of withstanding the unrelenting force of the river, the next inspection would often show that the structure had been moved downstream while still intact.

The science of dike construction and placement has not undergone a technical revolution as happened with revetment, but it does benefit from the accrued knowledge of previous experience. The Engineers have developed better pilings and lashings, and have more knowledge of what it takes to produce a desired effect. The trend on the Mississippi for many years has been toward an increasing dependence on heavy stone dikes. The Engineers are aware that in a whim of fury nature is capable of undoing whatever has been done. Persistence and determination are the only answers, and as yet they are only temporary answers.

ATTACKING THE PROBLEM OF THE PASSES

The Problem

Beneath the muddy waters of the Mississippi, sand is constantly drifting along the riverbed. This sand, or sediment, tends to fall out and compact whenever the current is slowed or stopped, creating sandbars or shoals. The process is constant, and sandbars are one of the hazards of navigating the Mississippi, particularly where the river runs wide. Nowhere is the problem more critical, however, than at the outlets of the Mississippi. Because the Mississippi empties into the Gulf through several outlets, the distributed water slows in velocity as it is divided at the Head of Passes, and then slows even more at the outlets where it meets the waters of the Gulf. At minimum velocity (at the outlets), the Mississippi will drop its load of heavy sediment, creating a shoal which can reduce the depth of navigable water at the most crucial point of the whole river system. In the nineteenth century, the fall-out was so heavy that the passes were often clogged to the extent that only a few feet of water flowed above the bars.

The problem worried even the earliest settlers in the valley for even before the French established New Orleans they sometimes found that the passes were too shallow for their ocean-going craft. The old wooden-hulled sailing ships could wait for the next tide to float them free, but captains demanded that the French governor do something to alleviate the condition. In 1726, just a few years after the founding of New Orleans, French officials attempted to solve the problem by sending out ships that dragged iron harrows along the bottom of the outlets. The theory was that the harrows would break up the bars, and the river would carry the loosened material out into the Gulf. It was a good theory, and partially successful, but the sandbars quickly reformed. For the next few years emphasis was on piloting rather than on removal of the sandbars, with auxiliary vessels standing by to accept part of the cargo, and a winching process to warp across ships that became stuck on the bars.

The first dredging of an outlet occurred in 1729, using a machine supplied by the Company of the Indies. Even though a channel depth of 17 feet was achieved, there was some doubt about whether the dredge was responsible for that temporary condition. Balize Pass soon shoaled up again and was abandoned in favor of other passes. Once again the technique of scraping the bars was favored as the easiest and cheapest method of maintenance. Dredging was not resumed until 1838, when a Philadelphia-built, self-propelled ladder bucket dredge arrived on the scene. The Balize was a working machine, with a set of five 27-cubic-foot-capacity buckets on each side. However, the dredge was plagued with mechanical problems. After only a year the Balize was retired, but in the interim it dug a temporary channel 900 by 100 by 16 feet. Not until the 1850s would there be another attempt at channel improvement by dredging, but that decade produced many innovative concepts on removing the bars. The unusual ideas included a crude concept of a hydraulic dredge, several agitating screw dredges, the use of drydocks to carry ships across the bars, and a proposal that all but one of the outlets be sealed. Nevertheless, harrowing, scraping, blasting, and dipper dredging seemed to offer the most hope although some unique, experimental dredges were appealing in concept. The firm of Craig and Rightor received a government contract and began a short-lived experiment at constricting Southwest Pass through the construction of jetties, with the goal of providing a channel 20-feet deep. The jetties were too flimsy to work, were not accepted by the Corps, and were soon abandoned. To compound the problem, the work of Craig and Rightor seemed to accelerate the shoaling of the pass, and on the eve of the Civil War the outlet was in worse shape than ever.[6]

Improved Dredging

In 1866 a private engineer, Horace Tyler, developed a steamboat which featured forward thrusting conical propellers. When driven into a sandbar the propellers acted as gigantic drills, ripping and tearing apart the bar. The screws were amazingly successful at breaking up the bars, but the whole rig was improvised and prone to frequent failure. The lesson was not lost, however.

In 1867 the Corps of Engineers submitted plans for a much-improved version of the Tyler dredge. The new ship, called the Essayons (the Corps motto, meaning "Let Us Try"), started work in the summer of 1868 and was declared a success. Within a few years disappointment set in, for the bars reformed and again the machinery was prone to failure. No matter how successful such a craft might be, the river seemed even more successful in replenishing the dislodged sediment. The temporary advantage had to be weighed against the constant breakdown of equipment and the expense of repair.[7]

The Chief of Engineers, Brigadier General Andrew A. Humphreys, energetically supported the construction of a ship channel which would connect the Mississippi to the Gulf at a point near Fort St. Philip. His record, submitted to Congress in 1873, generally was favorably received, although some politicians worried about the high cost. There was an alternative, however, one which the Corps did not accept, and that was to construct jetties from one of the channels at the Head of Passes, past the sandbar, and into the Gulf. The idea was to constrict the channel, thereby increasing the velocity of the water. The faster current would take more sediment into the Gulf and prevent further sediment deposits. The man who turned this theory into reality was James B. Eads.

James B. Eads and the Jetties

James B. Eads, like Henry Shreve, was a colorful, willful, innovative genius, already famous for his ability to get things done no matter how difficult the task. He invented the diving bell, used to salvage so much cargo from sunken steamboats. He designed, built, and delivered armor-plated gunboats to the Union in just 65 days, thereby assuring Union control of the Mississippi during the Civil War. Finally, he built the first iron bridge across the Mississippi at St. Louis in 1874.[8]

It was obvious that Eads was not a man to be taken lightly. Yet when he stepped forward with an offer to open Southwest Pass to a guaranteed depth of 35 feet (for a payment of $10 million), he was met with skepticism, particularly from the Chief of Engineers, who was still advocating his own plan. Eads was determined, however, and brashly told Congress that he would "get results first and charge the government later."[9] He planned to constrict the pass by walling it in with a jetty system.

The concept of constricting the outlets, or at least one of the outlets, was an often proposed remedy. But the nation had always lacked the will and the funds to built a jetty system of sufficient durability. The failure of the Craig and Rightor jetties in the 1850s had proved nothing except their own inadequacy. Eads' plan, then, some considered theoretically good, but impractical for the passes.[10]

Eads' boundless self-confidence offended many, especially the conservative hierarchy of the Corps. However, Congress found his offer too irresistible to reject, especially after Congress lowered his price and insisted that the work be applied to the South Pass rather than the Southwest Pass. The Southwest Pass was the most naturally useable outlet, whereas the South Pass was "entirely worthless" as it stood.[11]

The genius of Eads prevailed over the ageless problem of South Pass. A parallel line of levee-like structures, consisting of laminations of willow mats and layers of stone capped by concrete and superimposed by a railroad bed on one of the extensions, created a new, narrower channel for South Pass. The current now had to pass through a channel that was but 350 feet wide, and thus began to scour a deeper bed for itself.

General Humphreys was sure the jetties would not work, at least in the long run, and awaited news of Eads' failure. By 1877, however, success seem assured as the largest ships were entering the river through South Pass, the smallest of the major passes. The project was certified a success two years later, and Eads began to receive incremental payments as certain channel depths were achieved. With the success of Eads' jetties, the viability of the Mississippi as a major inland waterway, and of New Orleans as a major world port, was secured.[12]

Using the same technique developed by Eads, the Engineers later opened Southwest Pass with a jetty system of much larger dimensions. Whereas South Pass had not contained a flow adequate for a larger system, it was possible for the Engineers to create a jettied channel 35 feet by 1,000 feet with the better natural conditions of Southwest Pass. Although authorized in 1902, the work was delayed by economic conditions and then by the war. It was not until 1932 that Southwest Pass had its jetty system.[13]

DREDGING ON THE MISSISSIPPI

If the Tyler dredge and its successor, the Essayons, had failed to deal adequately with the problem of the passes, they had at least demonstrated a new and promising solution to the dredging of shallow crossings in the river. By the early 1890s the science of dredging had progressed to the point where cutter heads eliminated bars, and giant hydraulic vacuums sucked up sediment which the dredge boats carried to dump sites Dredging had become such an efficient and effective method of maintaining a minimum channel that the Mississippi River Commission began to advocate that method above others.

The suction/cutter dredge provided several options. Sediment could be dumped in midstream to be carried off, it could be loaded onto barges and dumped elsewhere, or (as an expanded technique) it could be directly transported by huge discharge pipes to nearby lowlands.

The efficiency of the new suction dredges was phenomenal, especially compared to the old dipper dredges. Whereas the dipper dredge could usually handle a cubic yard per scoop, and about 1,000 yards per day, the 27-inch suction dredge could handle 1,500 cubic yards of material per hour, and could work day and night while programmed to move forward at a predetermined pace. Even so, improvements were made frequently. By 1900 most of the suction dredges were being built with 32-inch capacity and with much greater reliability. The dredge B.M. Harrod, with its 36-inch capacity, finally proved that a slightly lesser capacity was more practical in application.[14]

By 1901 the Mississippi River Commission had a total of nine dredges in its fleet, including cutter-head dredges capable of ripping through manmade debris as well as hardened and impacted bars.

DECLINE OF RIVER COMMERCE

Ironically, just as the river was being transformed into a more efficient commercial highway, river commerce started to decline. The principal cause was the accelerating expansion of the railroad systems. The railroads, celebrating a heyday, offered swift and direct service and could reach areas never before served by water commerce. Even in communities directly served by river traffic, commercial interests tended to use the faster railroads. The cost was greater, but commercial interests were willing to pay the price.

Commerce on the Mississippi did not suffer as much as commerce on lesser rivers. The Mississippi was a central artery and large enough to discourage bridge building. However, smaller rivers, streams, and bayous were drastically affected by low-level bridge crossings. Once a low bridge was in place, river commerce beyond that point was impossible. As the railroad network spread into sparsely settled areas, river interests were driven out. On the lower Mississippi many river towns depended on river commerce for continued prosperity, and they awaited the return of renewed interest in cost-efficient shipping. River conventions, usually held at Memphis because of its central location, called for federal help for navigational and harbor improvements.

In attempts to show good faith, many municipalities took the lead in improving their own harbor facilities. Usually these improvements involved building dikes, which would extend into the river and both protect the river frontage of the town and provide mooring facilities for steamboats. These dikes were usually constructed of huge wooden cribs which were floated into position and sunk in place by being filled with huge stones. Once in place the cribs were capped with additional stones, perhaps concrete, to create a "permanent" landing. These "citizen" dikes, as they were called in honor of their private funding, were often completed and maintained by the Corps. The dikes worked well and were easily replaced by the same technique.[15] Following the success of the citizen dikes at Memphis, other river towns above Memphis started their own harbor improvement programs.

Defying the trend of decline in river traffic, the giant sternwheeler _Sprague_ set all-time record tows in 1907 and again in 1908. In 1907 the _Sprague_ transported a tow of 60 barges of coal, with the tow covering a 6.5-acre area. In 1908 the _Sprague_ transported a lashed tow of 361 feet by 1,160 feet. "Big Mama" came to be a legend in her own time. She was later retired to show business, sank in Vicksburg harbor several years ago, was dry-docked, and is awaiting possible restoration as a river museum.[16]

Viewpoints

While flood control cannot be the focus of this short history of navigation on the lower Mississippi, it should be pointed out that major floods always drew attention to the river. On constitutional grounds, popular opinion still resisted the use of public funds to protect private property. Levees were a case in point. They obviously protected land from flooding. But they could also be justified as navigational aids in that they kept the water in the channel and sealed the river from runoffs which dumped snags and debris into the channel.

The period 1896-1927 witnessed the development of a "classical form of federal river policy."[17] That policy consisted of defining and elaborating existing policy rather than introducing new concepts. The District Engineers were to maintain and build levees to specifications. Dredging was to provide a nine-foot all-year channel. That abandonment occurred after the failure of the Plum Point experiments in the 1890s. For nearly three decades thereafter the Engineers relied almost entirely on the dredging fleet.[18]

Cutoffs Considered

In a search for channel improvement ideas, some people advocated cutting through the great bends of the Mississippi. The logic of the suggestion was that at least three benefits would accrue: (1) the commercial route would be shortened with each bypass, (2) the river would flow more swiftly, thereby scouring a better channel, and (3) floodwaters would move more quickly to the sea, thereby reducing both the size and duration of the inundations.

Cutoff was not an original idea. Nature itself had always cut through bends and loops in an effort to find a shorter route to the sea. Thus the idea of "assisting nature" was met with great favor by some river interests. The MRC, however did not approve the idea in the early twentieth century, since it erroneously argued that cutoffs would hinder a major navigational objective, that is, keeping enough water in the channel to assure a nine-foot channel during the low-water season. Because of this all-important consideration based on past hydraulic theory, the idea of creating cutoffs was temporarily abandoned. Every effort was made to prevent the river from forcing its own cutoffs by heavy reveting (paving) of bends where chutes were likely to occur.

World War I and a New View

Public opinion regarding the value of a river system underwent a drastic re-evaluation with the coming of World War I. The mobilization of resources and transportation put the river system back in the public eye. The need to get material and parts from the heartland of America to a major seaport, and vice versa, combined with the mounting expenses of the war, proved once again just how economical, advantageous, and vital a waterway system could be. Seizing the moment, river conventions again sprang to life, demanding governmental leadership in the maintenance and expansion of the underdeveloped system. River towns everywhere lobbied for specific goals. By this time there was a new demonstration of the viability of inland water commerce--the beginning of an east-west intracoastal canal system at New Orleans.

THE GULF INTRACOASTAL WATERWAY

The idea of creating a coastal waterway system of inland channels had long been considered. In the early days of the nation when a small navy was inadequate to protect our extensive coastline, much thought was given to the protection of coastal traffic. The War of 1812 revealed the vulnerability of coastal traffic to enemy warships. Therefore, by the 1820s military planners had designed a coastal route protected by natural features.

The Army Engineers believed that it would be practical to create a part natural, part manmade route extending from Florida to New Orleans. Throughout the antebellum period, coastal defense officers fought for the project. The Civil War brought a halt to such dreams. By the 1870s the idea was revived and expanded to include a western extension which would connect New Orleans with Texas coastal regions.

The project was partially authorized in 1905, and segments of the canal were completed by the time of World War I. The original authorization called for a channel only 5 feet deep by 40 feet wide. Immediate and heavy use of the route showed that those dimensions would be inadequate for the projected use. In time the channel dimensions were expanded to its present-day 12 feet by 125 feet. The digging of the manmade portions of the route was largely the work of dipper dredges, because the "gumbo" clay-mud of the coastal regions was too solid for suction dredges.

In its final form the Gulf Intracoastal Waterway is 1,300 miles of protected waterway stretching from the Mexican border at Brownsville, Texas, to St. Marks, Florida. Since the system intersects the Mississippi River at New Orleans, it has often been called the "Crossing of the T," with each system enhancing the other.

Most of this new water highway has been an unqualified success. The waterway has carried 42 percent as much cargo as the entire Mississippi River. Heavy use has created a demand that the canal dimensions be increased to 16 feet by 200 feet--the ultimate dimensions of the New Orleans District segment.[19]

Chapter IV

THE MASTER PLAN

With the passing of each decade of the twentieth century, congressional hostility toward federal flood control softened. The floods in the valley contributed to this gradual change, particularly the catastrophic flood of 1927. That flood created the demand for federal intervention, as well as for a major commitment to a comprehensive flood control system in the Mississippi valley.

The flood inundated parts of seven states; drove 600,000 men, women, and children from their homes; destroyed or damaged about 25,000 homes; killed hundreds of thousands of livestock; ripped away revetment and dikes; and created damage totaling $300 to $400 million. Secretary of Commerce Herbert Hoover, on inspecting the valley described the flood as "The greatest peace-time disaster in our history."[1]

Even before the 1927 floodwaters of the Mississippi had subsided, President Coolidge called for flood control measures to prevent such future disasters. Within a few months two plans were submitted, one by Major General Edgar Jadwin, the Chief of Engineers, and the other by the Mississippi River Commission. Both plans proposed abandoning the "levees only" policy of previous years, and suggested a mixture of levees, floodways, and spillways. While the two plans were similar, the plan suggested by the MRC included more tributaries, and thus was more expensive.[2]

Lobby groups seized the moment. Organizations such as the Chicago Flood Control Conference and the Mississippi River Flood Control Association formed. Civil and political parties favoring each one of the plans pressured Congress, but the President and uninvolved congressmen favored the Jadwin plan because of its lower costs.

By late 1927 President Coolidge submitted the Jadwin plan to Congress and recommended appropriate legislation. The President, however, believed that local interests should provide at least 20 percent of the costs because they would be receiving the primary benefit of flood control. At this hint of hesitance, the House Committee on Flood Control turned its attention to the MRC plan.[3]

General Jadwin was incensed by the committee's vacillation. In turn, the committee was offended by his attitude. Many southern congressmen pressured the committee to consider the more comprehensive plan submitted by the MRC, for it offered greater long-range benefits in the Mississippi valley. The stalemate was not broken until the bill was taken up and superficially amended by members of both the Senate and the House. As the Jones-Reid Bill, it was approved by the Senate and House in March and April of 1928. At last the salient points of the Jadwin plan were approved as the Flood Control Act of 1928.

The Jadwin plan called for raised levees, with all levees to be brought to grade and specifications. The plan also included lateral floodways and spillways which could be opened in times of high water. Navigation was to be improved through bank stabilization and training structures (dikes and wing dams), as well as improved dredging. The Jadwin plan represented a fundamental departure from past simplistic answers. Accordingly, it has to be recognized as a significant milestone in river engineering. Even though the original plan has not been completed, the success of the project has sparked constant demands that the plan be expanded to encompass areas and features not originally included.[4]

THE CUTOFF ERA

There was a reassessment during this period of the idea that cutoffs should be prevented. In 1933 the MRC entered a new era under the innovative guidance of the Commission President, Brigadier General Harley B. Ferguson. Basing his conclusions on test results from the Waterways Experiment Station (WES) at Vicksburg, General Ferguson felt that the turbulence of a newly opened cut might be minimized by dredging only a small pilot cut across the neck of a bend. He thought the small pilot cut would allow the river gradually to expand the cut to its full dimensions. This scheme would provide better regulation of the opening and allow the Engineers to make longer cuts to create better flow design.[5]

The concept of a pilot cut to help the river secure a better flow line was cost-efficient but not easy. Trees and other growth had to be removed from the designed channel path. Massive dredges had to excavate the cut line, each working at opposite ends of the proposed cut. Even in the depression years a pilot cut was an expensive undertaking; in 1933 the 3.8-mile cut at Worthington Point (mile 505-513) cost more than $303,000. Also, the amount of material removed, while only a portion of what the river itself would carry away, was still significant. The Jackson Point-Sunflower cutoffs required the removal of approximately 14 million cubic yards of material.[6]

Once the pilot cut was made, the Engineers awaited the proper time before removing the "plus," the last few feet of earth remaining at the center of the cut line. When river conditions were right, the plug would be blasted away with dynamite, and water would begin rushing through to scour away the rest of the plug and to start the process of eating away at the narrow pilot channel. It was a dramatic moment, but because the pilot channel was small and the water was turbulent it usually took several months before ships were able to use the new channel.[7]

By 1942, 16 bends in the river were eliminated through cutoffs. While the river had been shortened by more than 150 miles it was found that each new cut required attention (usually dredging or revetting), thus creating new problems as quickly as old ones were solved. The program had not been without its successes, but the advantages were often offset by the disadvantages.[8]

WORLD WAR II

The 1940s opened up yet another period of wartime testing of river capabilities. Improved navigation was evident despite a wartime curtailment of projects involving materials, men, and machinery. During this period the Engineers temporarily returned to the old willow mat for revetment purposes, and the process worked well. Contraction works (works constricting the width of the river) were suspended for the most part, and dredges kept the river at navigational depth. Some civilians were drafted into the military so that they could continue to do their essential work on the river, but the various Districts were heavily engaged in the construction of military airbases, camps, depots, coastal fortifications, and barges.

On several occasions the capabilities of the river were demonstrated with the passage of unusual craft. A fleet of 78 Army tugs, with 16-foot drafts, was muscled through, as were submarines and even a locking gate destined for the Panama Canal.[9]

During World War II the principal cargoes on the lower Mississippi were gasoline, oil, sulphur, and other products and materials vital to the war effort. The river served almost 4,000 Army and Navy craft and other vessels--destroyer escorts, fleet submarines, landing craft, freighters, tankers, and ocean-going tugs.[10]

The demonstrated utility of the river brought renewed demands that the government improve and extend the national river systems. Lower Mississippi interests urged Congress to authorize a deeper channel between Cairo and Baton Rouge. After almost a year of debate, the Flood Control Act of 1944 became law. The act authorized a channel of 12 feet in the Cairo-to-Baton Rouge reach. According to estimates, 600 miles of revetment, 100 miles of dikes, and 175 months of dredging were needed to accomplish the goal.[11] The project was enormous. Even the 9-foot channel required constant attention and massive application of supplies, men, and technology.

Changes in the demands on the river made the original 12-foot channel estimates invalid in terms of both time and material and the Engineers have not yet achieved the goal. Also, at present the existing river barges can be accommodated by the presently maintained channel. Increased shipping demands may create a fleet of new, larger barges, and at such time the 12-foot channel may be needed more urgently. In the meantime the 9-foot channel is serving the nation well.

RENAISSANCE OF RIVER TOWNS

The wartime attention to the importance of river traffic was naturally shared by the old river towns. Petitioners besieged Congress for aid in either establishing or re-establishing ports. The anticipation of a 12- or even 14-foot channel from Cairo to Baton Rouge, and deep-port facilities from that point through the passes, encouraged commercial interests to develop inland port facilities as soon as possible. Some former river towns were lost to commerce forever, of course, being abandoned by the river in one of its frequent meanderings. Towns like Tiptonville, Tennessee; Grand Gulf, Mississippi; and St. Joseph and Port Hudson, Louisiana, could only look back on the days of being river ports. Others were more fortunate.

Memphis

At Memphis, river traffic had never been extinguished, but the average yearly tonnage of 1.5 to 2 million in the prewar era had not satisfied city fathers. Port facilities were strained by the wartime burden of nearly 4 million tons per year. The existing 36 port terminals simply were inadequate in view of the anticipated growth of river traffic, and there was no logical way to extend the terminals without future problems.

General Max Tyler, President of the Mississippi River Commission, presented a plan which was not only feasible, but a forerunner of developments for other communities. The "Tyler plan" suggested that a chute winding around President's Island, just south of Memphis, be blocked off at the upper end, and that the chute be dredged out as a slackwater harbor for Memphis. The enlarged chute could be designed for maximum convenience, with port facilities situated for optimum efficiency. The cost of the port facilities would be borne by city and private interests.[12]

The project was authorized in 1946 and started in 1948. Work was slow because of budgetary cutbacks by various administrations and the Memphis Harbor Project was not completed until 1967. But the project's effectiveness was proved even before its completion. By 1960 Memphis harbor was handling more than 6 million tons of cargo per year on a regular basis. With completion, harbor tonnage was up to 8 million by 1969. Ten years later tonnage was up to almost 15 million.

Memphis harbor was enhanced when the Engineers diverted Wolf River through Mud Island (a bar of longstanding contention in front of Memphis). The flow of Wolf River scoured out a natural channel between the riverfront and Mud Island, creating a natural harbor with obvious benefit to local citizens. The lower 3.5 miles of channel, parallel to the Mississippi River, became a slackwater harbor that was naturally maintained as part of Wolf River's inclusion in the flood control program. While local citizens still call it Mud Island harbor, it is within the reach called Memphis harbor. The channel is maintained at 9 feet with a bottom width of at least 200 feet upriver as far as mile 3. Mud Island harbor is heavily used by private craft, and the island itself is being developed by Memphis as a recreational and cultural center.[13]

Baton Rouge

Another major project was the Baton Rouge harbor, better known as Devil's Swamp harbor, named for the area out of which it was carved. Because Baton Rouge represented the upper end of a concentration of heavy industry flanking the river south to a few miles below New Orleans, developers correctly assumed that Baton Rouge should be an inland deepwater port, with harbor facilities to match.

Devil's Swamp, just above Baton Rouge and a former chute of the Mississippi, was a logical site. The harbor, authorized in 1948, called for an eventual 5 miles of dredged channel, to be accomplished in two increments of 2.5 miles each. Construction of the first 2.5 miles of the channel started in January of 1958, and was completed in July of 1959. Approximately 7.5 million cubic yards of material was excavated for that portion of the project.

Building the harbor was easily justified, for within ten years harbor tonnage went from about 26 million annually to almost 41 million, and in another ten years tonnage reached almost 77 million. Baton Rouge now ranks as the nation's seventh largest port. Despite the considerable increase in tonnage the remainder of the proposed five miles will not be dredged until justified by development of the existing 2.5 miles of channel.[14]

Hickman, Kentucky

As part of the Rivers and Harbors Act of 1960, the Army Corps of Engineers completed a harbor project at Hickman, Kentucky, in 1963. The harbor was created by using the former city waterfront for a 1.1-mile reach, and dredging to specifications. Local interests created an industrial port of about 130 acres, including terminal facilities to handle grain, sand and gravel, and petroleum products.[15]

Osceola, Arkansas

Authorized under the Rivers and Harbors Act of 1960, the Osceola harbor project was not recommended by the Chief of Engineers until 1971. In creating the harbor, the Engineers used the old chute of Island Number 30. The new harbor was 6,500 feet long, with a 250-foot-radius turning basin at the upstream end of the harbor channel. The material excavated for the channel was placed on the top bank to form a flood-free industrial park which will be developed by local interests. The engineering aspects of the project are complete, but further dredging is required.[16]

New Madrid, Missouri

New Madrid originated as an entrepreneur's dream to create a vast personal empire under Spanish sponsorship. The scheme failed in all respects except to establish the name of the proposed settlement. Misfortune seemed to plague the community. During the colonial period large chunks of the village periodically caved into the river to the extent that some buildings were built on wheels or sleds so they could be pulled back as the bluff sloughed off. On one spectacular occasion New Madrid was the center of an epic earthquake. At times it seemed that the town would be overcome by misfortune, and little of the original settlement remains. However, the town survived and is even enjoying something of a revival.

The Rivers and Harbors Act of 1960 called for the creation of a harbor channel along the city waterfront downstream for a distance of 9,400 feet. Work began in 1968, and the project was completed in 1970. Local interests have created a 200-acre industrial park. Three terminals handle petroleum products, grain, and sand and gravel.[17]

Helena, Arkansas

Helena, which was plundered by Union troops during the Civil War, found its harbor being blocked by a relentless accretion of sand. For several decades the Engineers tried to protect the harbor with dikes and revetment, but finally accepted the inevitable. The old harbor was allowed to fill in as the Engineers created a new harbor to the south.

The Rivers and Harbors Act of 1960 approved the construction of the Helena harbor, and the project has since been completed. Local interests have set up industries and have built ten terminals to serve the harbor. The terminals handle petroleum, grain, and chemicals used in both agriculture and industry. Local initiative, combined with the harbor, has brought a new vitality to an old, major river port.[18]

Greenville, Mississippi

The first attempt to establish a town in the area failed because of the strong river current. Old Greenville was abandoned and the citizens moved a few miles up the river to a location that was considered safer. The new town was burned by the Union troops during the Civil War, but determined settlers rebuilt it.

It seemed that the Engineers condemned Greenville to oblivion when one of General Ferguson's cutoffs bypassed Bachelor Bend, where the town was located. Leland cutoff, as it was known, left Greenville on an oxbow lake, appropriately called Lake Ferguson. Normally the ends of Lake Ferguson would have silted over to the extent that river traffic would be eliminated. But what the Engineers took away they gave back with the Greenville Harbor Project. The project restored Greenville's status as a river town, with a much better harbor than before.

Completed in April of 1963, Greenville harbor has since enjoyed steady growth. By 1969 the harbor accounted for over 1.5 million tons of shipping. In 1979 that figure had almost doubled.[19]

Lake Providence, Louisiana

An old river town, Lake Providence was a center of brisk trade in cotton and plantation supplies before the Civil War. During the War General Grant attempted to reconnect the adjacent oxbow lake with the Mississippi, as a means of bypassing the devastating Confederate batteries at Vicksburg. The effort failed, and Grant's canal remained half-completed well into the twentieth century. After the Civil War the town gradually declined, as portions of it eroded into the river. By the twentieth century the community had spread away from the old location.

The 1953 Rivers and Harbors Act authorized a new harbor at Lake Providence as part of commercial renewal on the Mississippi. The new harbor was created through the use of the former Hagaman Chute. Local interests dredged Hagaman Chute and built terminals and a 248-acre industrial park. In 1969 the Port of Lake Providence handled almost 624,000 tons of merchandise, mostly corn, soybeans, iron, steel, wood, paper, lime, and sand and gravel. Annual tonnage has leveled out at around 500,000 tons per year.

Vicksburg, Mississippi

One of the oldest settlements on the Mississippi, Vicksburg was the site of a port and fortress predating even New Orleans. A thriving steamboat river town, Vicksburg suffered heavy damage during the Civil War. The town seemed doomed as a river port when the 1876 Centennial Cutoff left the old harbor area out of the mainstream of the river. Vicksburg, however, was far from through, especially after 1928. The little city became headquarters for both the Mississippi River Commission, Vicksburg District, as well as the site of the U.S. Army Corps of Engineers Waterways Experiment Station.

Vicksburg harbor was included in those post-World War II projects designed to restore commercial viability to the river. The Corps of Engineers designed and built a first-rate slackwater harbor, which opened in 1960. The 245-acre industrial park, combined with the harbor, has contributed to a steady growth of river-based commerce.

Before the creation of the harbor, Vicksburg handled 300,000 to 400,000 tons of cargo per year. In 1960 that figure rocketed to more than 925,000 tons. By 1978 tonnage was reported at almost 3,500,000.[21]

Natchez, Mississippi

The citizens of Natchez can boast that the first steamboat on the Mississippi stopped at Natchez before proceeding to New Orleans. The city was further distinguished by being designated the original port of call for the regular run of that first steamer, the New Orleans.

In 1968 the Corps of Engineers installed facilities to protect the port areas from flooding. The port is served by an industrial park which, like the port, was established by local interests.

In 1960 the port handled 615,000 tons of cargo, and in 1978 tonnage was almost 912,000.[22]

Some Results of The Renaissance

By 1980 the other Mississippi ports were all reporting dramatic increases over the 1960s. New Orleans, as expected, was the leading port on the river, handling more than 167 million tons in 1979 (as compared to 113 million tons in 1959). The other harbors, aside from those already mentioned, averaged from just under a million tons to about 3.5 million tons annually.[23]

Other than normally evolving economic conditions, one of the reasons why the lower Mississippi has developed so rapidly in the post-World War II era is the careful long-range planning to accommodate new shipping patterns. Nowhere is the point better illustrated than in the 1945 decision to create an ocean-going channel all the way to Baton Rouge.

The combination of projects authorized in March of 1945 included Baton Rouge to New Orleans, the Harbor of New Orleans, New Orleans to Head of Passes, South Pass, and Southwest Pass. The single project was called "Mississippi River, Baton Rouge to the Gulf of Mexico." The plan was to enlarge the channel and outlets to dimensions which would allow all ocean-going vessels to use the river all the way to Baton Rouge. The original channel dimensions were dredged to 33 by 500 feet from Baton Rouge to New Orleans, 35 by 1,500 feet through New Orleans, 40 by 1,000 feet from New Orleans to the Head of Passes, 40 by 800 feet through Southwest Pass, and 30 by 450 feet through South Pass. The project was so successful, however, that in 1962 the original act was amended to provide that the Baton Rouge to New Orleans channel dimensions be increased to 40 by 500 feet. There is at present a growing demand for even greater guarantees. As a result of this project the United States has what is in effect the single, largest deep-water port in the world, capable of handling the needs of the nation for generations to come--and the backbone of an industrial heartland.[24]

Chapter V

NEW DEVELOPMENTS

THE ATCHAFALAYA

The Problem

In the post-World War II period the Atchafalaya River has occupied a unique and ominous position in the future of navigation on the lower Mississippi. Simply put, the Mississippi, following normal river patterns, threatened to divert its main flow into the Atchafalaya, thus cutting a shorter channel to the Gulf.

At the time of the Louisiana Purchase the Atchafalaya was no more than a log-choked distributary of the Red River, and only occasionally a natural spillway for the Mississippi when in flood. Not only was the Atchafalaya choked, but the two rivers which fed it, the Red and the Ouachita, were also clogged. Therefore, turbid water fed the system. These conditions revealed no threat of the Atchafalaya "capturing" the Mississippi.

Shortly after the War of 1812, settlers at the upper end of the Atchafalaya observed that a river would be a much shorter route to the Gulf. Therefore, they began trying to clear the river of its obstructions. In 1831, however, the irrepressible Captain Henry Shreve cut off Turnbull Bend as a way of straightening out the Mississippi. The abandoned bend began to silt up in both the upper and lower reaches. It appeared that the Mississippi would no longer dump its overload into the Atchafalaya--at least not on a regular basis.

In 1839 confident settlers, determined to have a navigable river, set fire to the log raft on the upper reach of the Atchafalaya, and burned it to the waterline. Later the state of Louisiana cleared out the remainder with snagboats. It seemed that the Atchafalaya, with its direct route to the Gulf, was just too attractive a possibility to leave untried.[1]

The log raft periodically reformed and was just as frequently dislodged, until by 1880 the Atchafalaya was permanently clear and rapidly enlarging because of the increased flow from the Mississippi. Unfortunately, the enlargement of the Atchafalaya brought misery to the people at the lower end of the system, because it created floodwaters in an area which measured "dry" land by an elevation of one or two feet.

LOWER MISSISSIPPI RIVER

The natural development from that time dictated that the Red-Atchafalaya would form a single river running parallel to the Mississippi. But man again intervened by dredging the lower arm of the old Turnbull Bend as a way of maintaining a navigation link between the two systems.

For several decades there seemed to be no major problem, for the lower Old River, as it came to be known popularly, acted as both a navigation channel and a water diversion system in which the current flowed west or east according to the relative stages on the Mississippi and on the Red. In 1881 it was recorded that the current flowed eastward for 56 days, westward for 56 days, and was still for 13 days.[2]

The possibility of the Atchafalaya capturing the Mississippi was discussed periodically throughout the nineteenth century, and Congress even solicited expert testimony about it after the disastrous Mississippi floods in 1912 and 1913. However, it was only in the 1928 Jadwin plan that the Atchafalaya became a major flood control component. The Jadwin plan assumed protection for a "project flood" 20 percent greater than the record flood of 1927. This "project flood" could carry a flow of 3,000,000 cubic feet per second (cfs) at Red River Landing, the point at which the Mississippi connects with the Atchafalaya system. Under this plan, the Atchafalaya would be used to divert exactly half, or 1,500,000 cfs, of that "project flood" into its system.

To assure the proper functioning of the Atchafalaya as a floodway, the design called for dredging and straightening the river in order that it could accommodate its design flow without needlessly overflowing surrounding land. Within a decade the Atchafalaya was adjusting its own channel, always seeking the shortest route to the sea. The Atchafalaya's route to the Gulf was not only about 75 miles shorter than the Mississippi's, it had a 3-to-1 advantage in slope. Unchecked, the main flow of the Mississippi would have shifted from its own channel to that of the Atchafalaya. The Atchafalaya would "capture" the main flow of the Mississippi, a potential disaster to the heavily industrialized Mississippi valley south of Baton Rouge. In order to prevent that radical change in the behavior of the river, Congress in 1954 authorized the Engineers to construct a control system to mechanically divert water from the Mississippi to the Atchafalaya. The Corps' plans called for utilizing both the upper and lower arms of the old Turnbull Bend, the upper arm to control water flow and the lower arm (Old River) to accommodate navigation.

Old River Control Structures

The Corps decided to use the old channels, but not exactly where they had been. Thus the dredging considerably realigned the channel to improve design conditions. Construction began in September of 1955, with building of the low-sill structure, which was designed to maintain the flow considered normal at the time the structure was completed in June 1959. The overbank structure, added to take care of excess water in times of major floods, was finished in October 1959. The inflow and outflow channels were completed two years later.

The Corps finished the navigation lock in December 1962. It is of "U"-frame construction, reinforced concrete with steel miter gates, and has a useable length of 1,185 feet and a width of 75 feet. Sill elevation is minus 11 feet (-11 ft.) mean sea level.[3]

Once these structures were operating, Old River was closed by an earthen dam 1,500 feet wide and 60 feet high. Finally, the Mississippi levees between Shaw and Torras were strengthened, and the banks were reinforced and stabilized along the Atchafalaya and Red rivers from the outflow channel to Simmesport, Louisiana.[4]

Almost from the opening of the navigation lock, annual tonnage has averaged three million tons, with a high of more than six million tons recorded in 1971. The navigation feature enables traffic to move from the Mississippi to either the Red River or the Atchafalaya River, and vice versa, creating an unusual triple water connection.

From the juncture at the Mississippi, the Atchafalaya is a significantly shorter route for those barges moving between the Mississippi and the westbound Intracoastal Waterway, but there are problems. Because the Atchafalaya is a shorter route with a steeper slope, the water flows more swiftly and with great turbulence. Those problems, combined with the fact that there are few port facilities or industries along the route, have limited the growth of traffic on that stretch.

New Problems

For about ten years after the Old River control structures were in place there were no unusual flood conditions to test them. The hiatus came to an abrupt end in 1973. Prolonged, extremely heavy rainfalls in the fall of 1972 and the winter and spring of 1973 saturated the central plains and the Mississippi and Ohio valleys, and caused many tributaries of the Mississippi to exceed flood stage. The Mississippi crested several times that spring, and a prolonged battle with the flood raged up and down the big river, its tributaries, and its distributaries.

The most significant gage on the lower Mississippi is that at the confluence of the Ohio, for it (the Cairo gage) reflects not only the water entering the lower Mississippi from the Ohio, but also the water entering from the upper Mississippi and Missouri rivers and their tributaries. The Cairo gage gave early warning that a situation was developing similar to that which led to the flood of 1927.[5]

As the floodwaters crested again and again the sheer volume of water passing through both Old River structures was awesome, but it was the low-sill structure that bore the brunt. The flood itself revealed changes in the behavior of the river, and the Mississippi could not handle as much water as it had in the last major flood. The Atchafalaya, on the other hand, had been deepening and flowing faster, thus demanding even more water. The low-sill structure was designed to curb that flow, and it did so, but was taking a terrible battering in the process. As the Engineers watched apprehensively, they saw a wing wall groan, tear loose, and tilt out of position. The force of the water can be gaged by the fact that it moved a massive concrete wall which was 80 feet high, 80 feet wide, and 100 feet wide at the base.

With the loss of the wing wall, the entire structure began to shudder and shake not only because of the absence of the wall, but from the new turbulence created by the displaced wall. Here, it seemed, was the event that would signal the victory of the river in its effort to divert into the Atchafalaya basin. The crisis had come.

The Engineers responded to the emergency with speed and skill. The New Orleans District Engineer received permission from the MRC President, Major General Charles C. Noble, to reduce the river head by opening the overbank structure and the Morganza Floodway (another feature of the Jadwin plan located to the south of the Old River structures). The decision not to close the low-sill structure was, in view of postflood observations, fortunate. Inspection showed the whole south side of the structure had been undermined and was supported on the telephone pole-type piles which formed the foundation. The poles, which had originally been driven 100 feet deep, were now anchored only on the bottom 30 feet of their length. The closing of the structure would have created more pressure than could be sustained, threatening disaster. Although the structure was seriously impaired, it did not collapse.[6]

After the flood crisis the scour hold under the low-sill structure was filled in by anchoring an "upper set" barge several hundred feet upstream. Seven-ton quarry stone was bulldozed from the barge into the stream, with the force of the current carrying this heavy stone to its intended point of placement. Eventually some 115,000 tons of stone were required to fill in the scour which had been eaten out under the structure. Additionally, holes were drilled through the cement top of the structure, and a special grout-like mixture was pumped in under pressure to fill the cavity now closed off by the stone. Further investigations revealed still more scours in front of the structure, and they were filled in as well. The crisis was even greater than thought, but the structure had held and the battle was won, at least for the time being.

In order to handle such future crises the Corps has recommended installing an auxiliary structure, with the new inflow channel to be built near the present ones. The Chief of Engineers has approved, construction has started, and the structure is expected to be operating sometime in 1985. The new structure will operate in conjunction with the previous ones, and will reduce significantly the water flow through the low sill. Water pressure and current and, in turn, destructive turbulence, will be reduced. Furthermore, in case of accident, either the auxiliary structure or the low-sill structure can be closed.[7]

NEW FLOWLINE

During the high-water crisis of 1973 a serious flaw in the project flowline was discovered. The flowline is, as the name implies, an assumed characteristic of the flow of the river, from which calculations and computations regarding navigation and flood control are made. Despite the existence and use of a highly sophisticated research facility such as the Waterways Experiment Station at Vicksburg, and information from hundreds of river gages, it is only during times of flood that one can gather absolutely accurate data on flood conditions. Since there had been no major flood for over two decades it could be presumed that the flowline had undergone some changes, but where and how much?

General Noble of the MRC had already reported that the river functioned more efficiently after completion of the projects. However, transporting greater volumes of water through one reach was likely to create additional siltation problems in other reaches. Furthermore, the projects did not necessarily stabilize the river. Indeed, they could accelerate changes. A flow of 900,000 cfs passed Vicksburg at a stage of 39.4 feet in December of 1972; in 1970 1,800,000 cfs passed with a stage of 43.7 feet; and in December of 1972 a flow of 1,100,000 cfs passed at a stage of only 34.2 feet. In April of 1973, the 1950 discharge rate was creating a stage of 50.6 feet, illustrating the problem and proving that the flowline would have to be revised upward.

The 1973 flood also revealed that the river was not rising in a steady and predictable stage-discharge curve, but recorded new crests with each new rise, even though the discharge rate remained the same. Engineers knew that a rising river could carry more water at a lower stage than it could carry when it was falling, but the rating curve loop was now not as predictable as it had been before the flood.

The revised flowline was from 1 to 6 feet higher than the flowline on which the Mississippi River and Tributaries Project had been based. For the Mississippi River Commission the course of action was clear: locate those levees which did not meet new flowline specifications and rectify their deficiencies as quickly as possible. The work is well under way.[8]

LOCKS ON THE MISSISSIPPI

Most of the structures locking into the Mississippi are related to the Intracoastal Waterway. Some are related directly such as the Inner Harbor Navigation Canal Lock and the Harvey Lock, which together route canal traffic across the Mississippi at New Orleans. Additionally, in 1956 an alternate lock was placed in the New Orleans vicinity on the west bank; the Algiers Lock serves to divert westside canal traffic to the south of New Orleans.

The Atchafalaya Lock has already been noted. But in addition there has been an important lock constructed at Port Allen, just across the river from Baton Rouge. The Port Allen Lock and Canal was built to update and replace the obsolete Plaquemine Lock (1909-1961), one of the oldest locks in the vicinity.

The Plaquemine Bayou was one of the original distributaries of the Mississippi, and an important navigational tie. The lock was a way of maintaining that navigational link while at the same time preventing the unchecked flow of water from the Mississippi into the lowlands behind the Mississippi levees. With the deep-channel "Mississippi River, Baton Rouge to the Gulf" project, however, there was the feeling that barge traffic would be better served by a river entry closer to Baton Rouge. Congress approved a Corps recommendation not to replace the Plaquemine Lock but to construct a new lock at Port Allen and link it to the old Plaquemine system by a manmade canal.

The Port Allen Lock and Canal was built in the years 1955 to 1961. With a lift of 45 feet, a cross-section of 12 feet by 125 feet, and a 1,200-foot useable length, the canal had an immediate impact on barge traffic and on the Mississippi. By using the Port Allen Lock and Canal, shippers cut the distance from the Mississippi to the western segment of the Gulf Intracoastal Waterway by approximately 160 miles. With the new route the distance to Morgan City is now only 64 miles.

In 1974 traffic through the Port Allen Lock totaled 16.3 million tons, far greater than many harbors handle.[9]

THE MISSISSIPPI-GULF OUTLET

The Louisiana inland waterway system of locks across the Mississippi through New Orleans was a significant achievement in its own right. Without federal assistance, the Dock Board of New Orleans had constructed a canal connecting the Mississippi to Lake Pontchartrain. The Inner Harbor Navigation Canal, better known as the Industrial Canal, was added to the Intracoastal Waterway after World War I.

In 1942, concerned with the menace of German submarine activity in the Gulf, Congress eliminated the Pontchartrain segment of the waterway system by providing for a land cut from the Rigolets (the outlet of Lake Pontchartrain) to the inner harbor. Having created a new dimension in commercial routine, engineers and politicians reopened the question of developing a direct, deep-water ship channel connection between New Orleans and the Gulf of Mexico.[10]

A direct connection between the Mississippi at New Orleans and the Gulf was an old dream. To reach the Gulf via the Mississippi it was necessary to cover approximately 95 miles of main stem to the Head of Passes, plus 15 to 20 miles of outlet to the Gulf. Many commercial entrepreneurs had projected a route that would be shorter and easier to maintain--a channel directly to the Gulf from New Orleans.

Because New Orleans was so close to sea level, the idea of constructing a sea-level channel was quite feasible. The area southeast of New Orleans presented a likely site for such a project, with largely uninhabited marshes, bayous, inlets, and estuaries.

Funding, as always, was the major obstacle, even though investigation showed the practicality of the venture. Congressional response seemed to focus on the undeniable fact that the immediate and tangible benefits of the projects would accrue to local interests. The Louisiana congressional delegation argued that New Orleans served the vast interior of the nation, and that the systematic development of the Mississippi and its tributaries logically demanded that the system's outlet be fully developed.[11]

Gradually, political support developed. Authorization finally came with the Rivers and Harbors Act of 1956. Funding was to be a joint venture, however, considering the local benefits, and it was up to local interests to generate the financial support needed to win federal participation. Those commitments, along with the original assurances, were made. The project was set.[12]

The project design resembled older concepts. The slackwater canal would provide a direct water route from the Gulf to the "back door" of New Orleans, the inner harbor. That juncture would represent another new commercial crossroad, joining the Mississippi, the Intracoastal Waterway, the inner harbor, and the new direct link to the Gulf.[13]

Dredging was started in March of 1958. The canal was to be 36 feet deep and 500 feet wide, expanding to 38 by 600 feet in the Gulf. The completed project would be a 76-mile land-and-water cut.

The partially completed channel opened to navigation in July of 1963 and was completed in July of 1968. The canal dimensions are being maintained through systematic dredging. While the canal is still in a stage of evolving use, additional inner harbor facilities will bring dramatic increases in tonnage. As the channel develops economically, there is a provision for constructing a lock to connect the channel to the Mississippi River in the vicinity of Meraux, Louisiana. In 1979 annual tonnage on the Mississippi-Gulf outlet was approximately 8,200,000.[14]

RIVER COMMERCE TODAY

The proven efficiency of river transport, as compared to railroad or truck transportation, would have been enough to assure the steady growth of the river system. The energy crisis of the 1970s, therefore, only added emphasis to the movement. Grain shippers benefited most in terms of the new growth. In 1950 the nation had exported only 15 million tons of grain, but by 1980 the figure rose to more than 119 million tons. In fact, the United States has reached the point where it cannot only feed itself, it can export more than 60 percent of its wheat, 50 percent of its soybeans and rice, and about 33 percent of its corn. The key grain export region of the world is that segment of the Mississippi from Baton Rouge to the outlets. Within that reach of the river, actually one deep harbor, there are ten grain elevators, with another under construction. Those facilities alone move about 40 percent of the nation's grain exports.[15]

Reflecting a common procedure, grain shipping on the Mississippi entails two stages. The grain must reach the Baton Rouge-New Orleans area by barge, because the river above Baton Rouge is too shallow for ocean-going vessels. Barges not only require less river depth, they can be lashed together to create "tows" that are immense in both surface area and tonnage. Barge traffic is practical, efficient, and profitable on all inland river and waterway systems. Overseas transport, on the other hand, demands ocean-going craft; when the barged product reaches a deep harbor it must be transferred. Sometimes a product can be transferred directly from the barge to the ship, but most frequently the product must be unloaded, stored briefly in a warehouse, then reloaded onto the ship.

One interesting development in eliminating a significant part of expensive and time-consuming cargo handling is a system whereby special barges are floated to the ships, then hoisted aboard directly and intact. The vessels are called LASH craft, an acronym for "Lighter Aboard Ships." Designed by Jerome L. Goldman, the 859-foot freighters carry their own cranes for hoisting these special river barges, or lighters, aboard. Filled with cargo, the barges weigh up to one million pounds each, and are stacked 4 deep in the hold and 2 deep on deck, up to a total of 80. This system not only makes shipping more efficient, the reversal of the process at the destination allows shipments to many developing nations which have few or inadeq ate port facilities.[16]

The increasing growth of river traffic may be traced to many interdependent factors; improvement of the river, new port facilities, innovative handling techniques and, not the least, the improvement in barges and towboats themselves. Modern steel barges have a capacity of three to four times that of a turn-of-the-century packet. A single barge usually holds as much grain as 15 railroad cars, or 57 trucks, and a modern steam or diesel towboat may push as many as 40 of these huge barges. Furthermore, the idea of integrated tows is no longer considered unusual. Assembled as a bowpiece, a number of square-end barges, and a towboat, the entire unit is lashed together to form one streamlined vessel.

An integrated tow may be as much as 1,200 feet long--longer than the largest ocean liner afloat. With today's increasing concern for efficient use of energy, it is significant that a single tow can carry some 200,000 barrels of petroleum products to their destination in the most efficient and economical way.[17]

Towboats have kept pace with barge technology. Whereas the older towboats operated with about 500-horsepower plants, the modern towboat average is more like 3,000 horsepower, and some towboats operate with more than 10,500 hp. Such towboats are needed to work the great tows which are found on the sometimes treacherous reaches of the lower Mississippi and the Atchafalaya. In a search for maximum efficiency it is becoming customary to lash together even those large barges with heavy cargoes of steel, ores, grain, petroleum products, and chemicals.[18]

Because of their increasing efficiency, barge shipments are expected to recapture their share of the transport that was being lost to the rails before the energy crunch. The traditional barge share of grain shipment was once approximately 60 percent, but dropped to about 50 percent in the

1970s before beginning to reclaim its dominance. In 1977 calculations indicated that transportation of corn from Minnesota to the Gulf cost only 17.5 cents per bushel, as compared to 54.5 cents by rail. The figure is somewhat misleading, however, because one has to consider the overland cost of getting the grain to the river. An interesting comparison can be made with the pre-Civil War era freight rates on the Mississippi of 37.5 cents per hundredweight downstream and 62.5 cents upstream.[19]

Navigation on the lower Mississippi reaches a new high with each passing year, both in number of vessels and in tonnage. In 1980 there was a record-breaking tonnage for agricultural exports despite an embargo against increased shipments to the Soviet Union.[20] The evolution of larger ocean-going vessels is a natural corollary to increased emphasis on river commerce. Subsequently, there is demand for deeper channel access to the seaport segment of the Mississippi. Grain and coal are the major exports contributing to this situation.

Grain, as a growing commodity item has resulted in bulk cargoes of 150,000 pennyweight. But because of the energy crisis, the United States has become a major coal exporter with harbors inadequate to the anticipated demands for coal. On the Mississippi the present 40-foot harbor depths no longer seem capable of handling some of the major ocean-going ships which are evolving to handle the international coal trade. To meet specifications demanded by the great ships, there is at present a demand for a minimum 55-foot depth through the passes to Baton Rouge, or at least to New Orleans as an interim goal. One report shows that for every $1 invested in a deeper channel, approximately $9 in benefits will return. In support of the demand, shippers point out that the export of coal alone has increased 142 percent from the 1979 volume of 1,367,000 tons to 3,313,000 tons in 1980. They also point out that this rapid increase in coal shipments has helped mitigate the gradual decline in foreign imports. In New Orleans the trend was more than offset by the fact that exports climbed to 24.1 million tons in 1980 over 1979's total of 18.6 million tons, an increase of 30 percent. It is estimated that coal may be providing as much as 66 percent of the world's energy needs by the year 2000. Thus an annual export goal of 100 million tons by 1990 is realistic. Even that figure could double by the year 2000. In the same period, grain exports are expected to reach 150 million tons.[21]

Navigation on the Mississippi was always feasible and profitable, even in the era of rafts and keelboats. But increasing use of the Mississippi in the nineteenth century created a demand for federal assistance in improving navigation and in guaranteeing a channel depth throughout the year. The success of that assistance spurred the growth of river traffic, the importance of which has been affirmed by national emergencies.[22]

The importance of the lower Mississippi cannot be overestimated. It is the main stem of a network of inland navigable waterways serving 40 percent of the nation's interior. The prospect is that the river will be ever more important to the nation. Its potential is greater than ever.

CHRONOLOGY

1519 - Spanish expeditionary leader, Alonzo Alvarez be Pineda, sights the mouth of a great river, which he names "Rio del Espiritu Santo."

1541 - Spanish explorer Hernando de Soto, while on an inland expedition, reaches the Mississippi somewhere below present-day Memphis.

1655 - The French Governor at Quebec, the Compte de Frontenac, hears report of a great river to the west, and sends out an exploration team to confirm that report.

1673 - French team of Marquette and Jolliet follow the downstream course of the Mississippi as far as the mouth of the Arkansas River.

1678 - Under Governor Frontenac's orders to follow the river to its mouth, Robert Cavelier, sieur de La Salle, descends the length of the river to the Head of Passes, claiming for the King of France the river and all the lands drained by the river.

1699 - French settlers arrive by ship to establish a colony showing French presence and control of the river. The settlers are unable to locate the mouth of the Mississippi, and a colony is established at Biloxi.

1705 - The first recorded cargo is floated down the Mississippi by westerners. The cargo consists of bear and deer hides.

1706 - English traders, ignoring French claim, attempt to set up trade with the Natchez Indians.

1718 - In order to secure their claim to the Mississippi, the French establish New Orleans at a spot calculated to control both the Mississippi and Lake Pontchartrain.

1763 - The Spaniards take control of the Louisiana territory, relaxing trade restrictions and encouraging Americans to use the Mississippi.

1800 - France, under Napoleon Bonaparte, reclaims Louisiana, arousing fears that France may cut off use of the river to the Americans.

1803 - The Louisiana territory is purchased from the French to assure permanent American control of the Mississippi.

1812 - The first Mississippi steamboat arrives at New Orleans, ending a downriver trip from Pittsburgh. The New Orleans then starts the first regular steam-powered service in the valley, with Natchez as its northern terminus.

1816 - Captain Henry Shreve unveils his new design for steamboats better suited to the shallow waters of the interior. The Washington, with its shallow hull and improved steam engines, is so successful that it establishes a new standard for steamboats.

1819 - Congress, recognizing the importance of rivers in the West, approves a law calling for a survey of the Mississippi River and its tributaries, to be undertaken by the Corps of Engineers.

1824 - Congress enacts the first of the Rivers and Harbors acts, which authorize the Corps of Engineers to clear certain important rivers of navigational obstructions.

1844 - President Tyler asks Congress to accept responsibility for improving navigation on the Mississippi, considering its unique importance to the nation.

1850 - Congress appropriates $50 thousand for a survey of the Mississippi delta.

1852 - Pursuant to the 1850 congressional authorization, the Corps of Topographical Engineers submits two reports to Congress. Charles Ellet, Jr., a civil engineer, recommends flood control reservoirs. Lieutenant Colonel Stephen H. Long submits only a preliminary report because Captain Andrew A. Humphreys' sickness has delayed completion of the work.

1855 - In fear of a possible war, Congress sells its river equipment and craft, allowing the river to return to nature.

1861 - Humphreys and Lieutenant Henry L. Abbot publish their Report upon the Physics and Hydraulics of the Mississippi River; Protection of the Alluvial Region Against Overflow; and upon the Deepening of the Mouths. The study is immediately recognized as a significant contribution to hydraulic engineering, and it influences the Corps of Engineers for years to come.

1865 - The end of the Civil War finds the lower Mississippi clogged with wrecks, snags, and shallow sandbars.

1871 - The historic steamboat race between the Robert E. Lee and the Natchez serves to refocus national attention on the river and its usefulness.

1874 - Congress authorizes a new survey of the lower Mississippi. Colonel Suter's survey and maps update previous knowledge of the river, and pinpoint major problems.

1877 - South Pass is opened to the largest ships as a result of the jetty system devised and constructed by James B. Eads.

1879 - The Mississippi River Commission is created, signaling federal commitment to a systematic effort to solve the problems of the river.

1895 - MRC decides to maintain the navigation channel depth principally through use of suction dredges rather than training works.

1908 - The giant sternwheeler Sprague breaks its own 1907 record with an even larger tow.

1912 - In both years disastrous floods inundate the lower Mississippi
1913 valley. Congress hears many pleas for financial aid to relieve the distress and for revised plans to contain the floodwaters more effectively.

1918 - The crisis of World War I having affirmed the value of a waterway system, the federal government creates a barge line as an example for the private sector. The Federal Barge Lines demonstrates the practicality of combining the advantages of river transport with the rail system.

1927 - The record flood of 1927 proves the need for a comprehensive flood control system, as well as a comprehensive navigational program.

1928 - The Jadwin plan is accepted.

1933 - The era of the cutoffs begins under the leadership of General Harley B. Ferguson. By 1942, 16 bends in the river are eliminated, with mixed results.

1944 - The Flood Control Act of 1944 approves a 12-foot channel, but a 9-foot channel proves to be adequate for existing barges.

1945 - "Mississippi River, Baton Rouge to the Gulf of Mexico" deep-water channel is approved.

1946 - The Memphis Harbor Project is authorized.

1948 - "Devil's Swamp" Harbor (Baton Rouge) is authorized.

1959 - Low-sill and overbank control structures at Old River are completed.

1960 - Rivers and Harbors Act of 1960 authorizes federal assistance in the creation and maintenance of several additional harbor projects on the lower Mississippi.

1961 - Port Allen Lock and Canal is completed.

1962 - The deep-water channel from Baton Rouge to the Gulf is modified to provide for a channel depth increase from 35 feet to 40 feet.

1963 - Navigation lock is completed at Old River, to provide for traffic between the Atchafalaya-Red rivers and the Mississippi.

1963 - Mississippi-Gulf outlet is opened.

1973 - The massive flood of 1973 threatens to take out the low-sill structure at Old River, with possible diversion of the Mississippi main flow into the Atchafalaya channel.

1973 - The flood of 1973 reveals that the river has undergone a transformation and has a new flowline.

1980 - Shipping interests intensify their lobbying for a deeper channel through the passes to Baton Rouge to accommodate the new, giant ships being built to transport grain and coal.

1981 - Work starts on an auxiliary control structure at Old River.

FOOTNOTES

Chapter I

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2. Edwin A. Davis, Louisiana (Baton Rouge, 1971), p. 27.

3. Thomas H. Johnson (ed.), The Oxford Companion to American History (New York, 1966), p. 535; Joseph Tregle, Jr., "The Lower Mississippi," The Rivers and Bayous of Louisiana (Baton Rouge, 1968), p. 146; Major D.O. Elliott, The Improvement of the Lower Mississippi for Flood Control and Navigation (Vicksburg, 1932), I, pp. 1-4.

4. Mississippi River Commission (MRC), Mississippi River Navigation (Vicksburg, 1971), p. 3; Willard Price, The Amazing Mississippi (New York, 1963), pp. 3-6. The length proclaimed on a marker at Lake Itasca, Minnesota. Actual length today is approximately 2,400 miles.

5. Elliott, Improvement of the Lower Mississippi, I, p. 93; Price, Ibid.; A Water Policy for the American People (GPO, 1950). Interpolating from the statement that the total daily supply is 4,300 billion gallons daily, "about 10 times the average flow of the Mississippi River," p. 109.

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Chapter II

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2. Ibid.

3. Albert E. Cowdrey, The Delta Engineers: A History of the United States Army Corps of Engineers in the New Orleans District (New Orleans, 1971), pp. 16, 17.

4. n.a., "Ship Sinkings"; Emerson W. Gould, Fifty Years on the Mississippi (Columbus, Ohio, 1880), p. 156; Quick and Quick, Mississippi Steamboatin', p. 89; Harry Drago, The Steamboaters (New York, 1967), p. 12.

5. Ibid.

6. Louis C. Hunter, Steamboats of the Western Rivers (Cambridge, Mass., 1949), p. 14.

7. Elliott, The Improvement of the Lower Mississippi, I, pp. 7, 27; Clay, A Century on the Mississippi, p. 8.

8. Ibid., pp. 8-10.

9. Ray Samuel, et al., Tales of the Mississippi (New York, 1955), p. 49.

10. Ibid.; Hunter, Steamboats, p. 102; Donovan, River Boats of America, p. 104; Clay, A Century on the Mississippi, p. 10; "Ship Sinkings," pp. 47, 48.

11. Donovan, River Boats of America, p. 104.

12. Robert R. McCormick, "Steamboat Years," reprint of an address given over the Mutual Broadcasting System, November 13, 1948; Andrist, Steamboats, p. 57.

13. U.S. House of Representatives, Floods and Levees, 1914; Clay, A Century on the Mississippi, p. 11.

14. Cowdrey, The Delta Engineers, p. 14.

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20. Ibid.

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4. Ibid.

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6. Cowdrey, Delta Engineers, p. 37.

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13. Elliott, Improvement of the Lower Mississippi, I, p. 12.

14. Clay, A Century on the Mississippi, pp. 39, 50, 106; Clay, A History of the Little Rock District, U.S. Army Corps of Engineers, 1881-1979, 2d edition (Little Rock, 1979), p. 75.

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2. Ibid., H. Fisk, Geological Investigation of the Atchafalaya Basin and the Problem of Mississippi River Diversion (Vicksburg, MRC, 1952), p. 122.

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