

SOUNDINGS

***100 years of the
Missouri River
Navigation
Project***

by John Ferrell

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SOUNDINGS

SOUNDINGS

***ONE HUNDRED YEARS OF THE
MISSOURI RIVER NAVIGATION PROJECT***

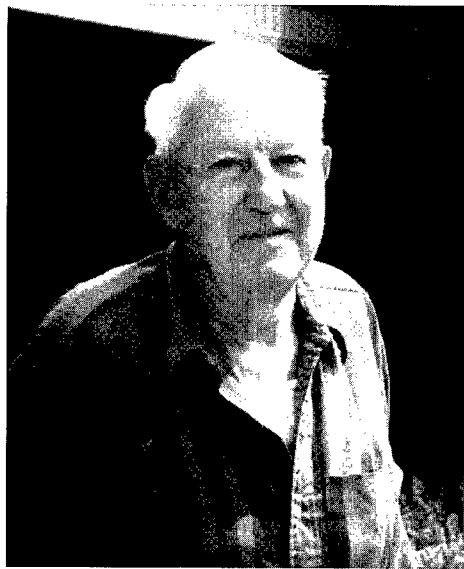
by John Ferrell

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Dedicated to

George Kishmar

who on September 6, 1948, caught the largest fish of his lifetime and was told by "Steamboat Bill" Heckmann that he was supposed to "find" the channel of the Missouri River and leave the catfish alone.



George Kishmar
in 1994

ACKNOWLEDGEMENTS

I am fortunate to have friends who are creative, talented, and dedicated. Their willingness to help me is a source of strength. Larry Crump responded to my unending pleas for help, clarifying obscure passages, and dealing efficiently with myriad details. Tom Hudson took my vague notions and translated them to satisfying images. He applied his talents to this publication by designing the layout, typesetting the manuscript, and offering valuable suggestions. Tom also created several drawings printed in this publication.

Charles Stegner willingly contributed his delightful original sketches to this volume, giving us an aesthetic uplift. Marilyn Hunter resolved publication challenges and salved my artistic wounds. Kathy Richardson edited the essay, saving me from some major embarrassments. I am privileged to work with this excellent team and enjoy the thought of doing so again.

Chuck Wyatt guided me on the Missouri River and through the bottomlands. He introduced me to fascinating places and interesting people. My interviews with a cadre of Corps of Engineers employees, active and retired, provided valuable information. George Kishmar was my primary mentor, contributing many hours patiently explaining channel developments and river navigation.

This project was conceived and executed by the U.S. Army Corps of Engineers, Kansas City District, Planning and Hydrologic Engineering Branch. Mary Lucido provided deft management of the project and was a pleasure to work with.

John Ferrell
Omaha, Nebraska
September 1995

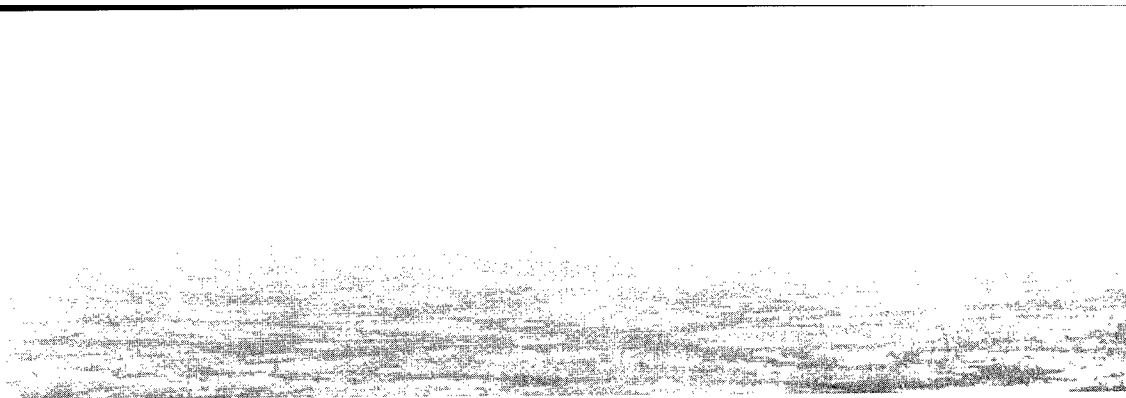
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SOUNDINGS:

ONE HUNDRED YEARS OF THE MISSOURI RIVER NAVIGATION PROJECT

INTRODUCTION

Mark Twain, that raconteur of river steamboat piloting, would be amazed at the Missouri River navigation channel. Piloting on the regulated channel is comparatively simple. Boaters are served by a clearly marked, obstruction-free channel. Man-made devices have compressed the river into a fixed channel.

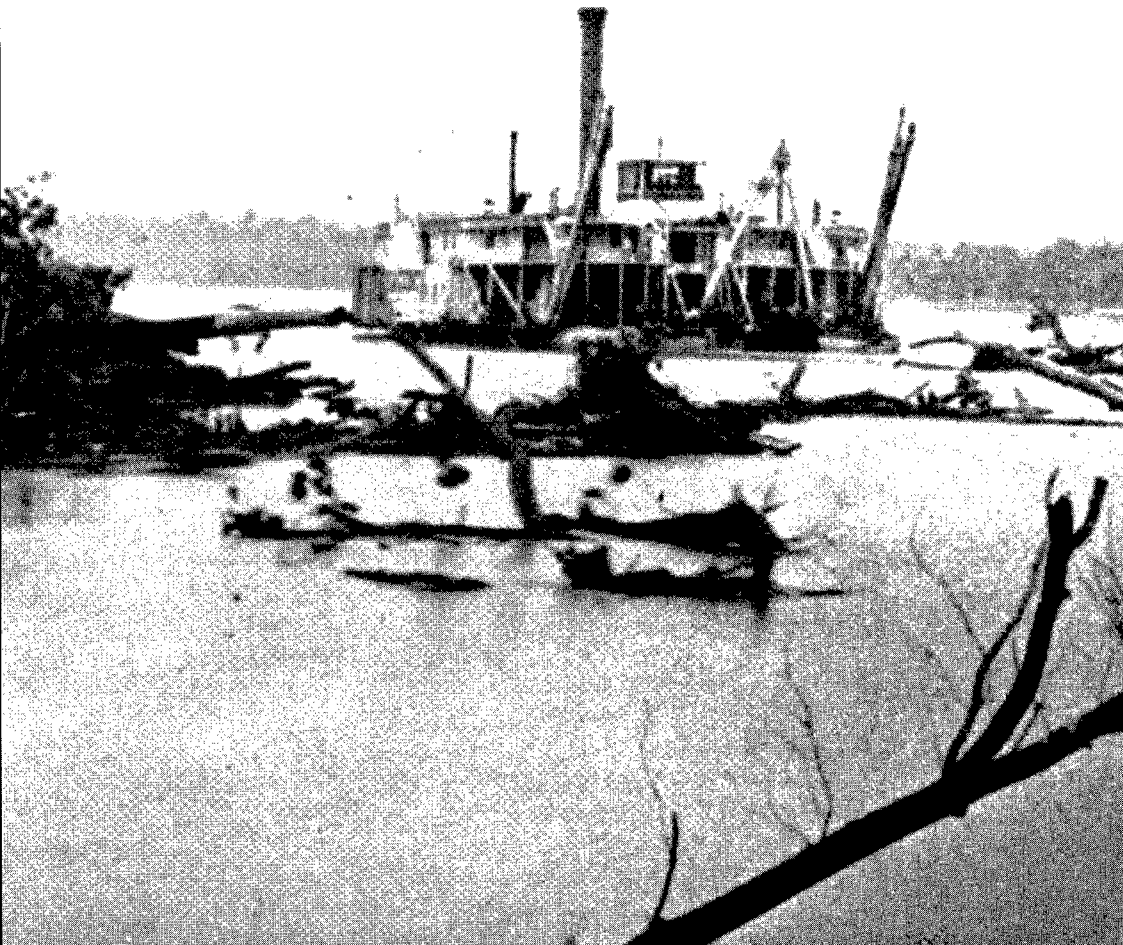
Before it was regulated, the river was a maze of arteries and series of snags. The Missouri riverboat pilot didn't necessarily rely on a channel, but was helped if he could find it. Piloting based on memory was a challenge because the channel shifted frequently across the broad floodplain.

Twain would be most perplexed by today's absence of traffic on the sinuous waterway. In his day, the Missouri was the major thoroughfare to the vast interior, and the river was the scene of abundant life. Now that it is "pegged down" and regulated, few boats are in evidence. The absence of life on the Missouri is one of its eerie aspects.

The enigma is that Missouri River navigation had almost ceased before the Corps of Engineers was assigned to improve the channel for navigation. The basin had rail communication, and commercial navigation was virtually nonexistent. By 1869, from Omaha, Nebraska, downstream to the mouth of the Missouri, the railway paralleled the waterway. As a river historian put it: "The past is gone . . . there now remains, on what was once the great commercial thoroughfare of the West, only the original navigator, the little blue-winged teal."

The editor of the *Kansas City Journal* tried to bring a barge line to Kansas City in 1872. His reasoning was simple: hauling grain by barges was cheaper than by using the railroad. The 1872 attempt failed as did another in 1877. In 1880, the Kansas City Board of Trade established a river service with a steamer and five barges. This line also eventually folded. The expanding network of trans-Mississippi railroads was making its mark felt.

Not only did the basin have rail service, but the river was simply a problem. Navigation was still dangerous. The marauding stream gnawed at soft alluvial soils. Public and private property caved into the river as the natural channel shifted to and fro through lush bottomlands. Man's goal to occupy the floodplain was in conflict with the river's natural movements.

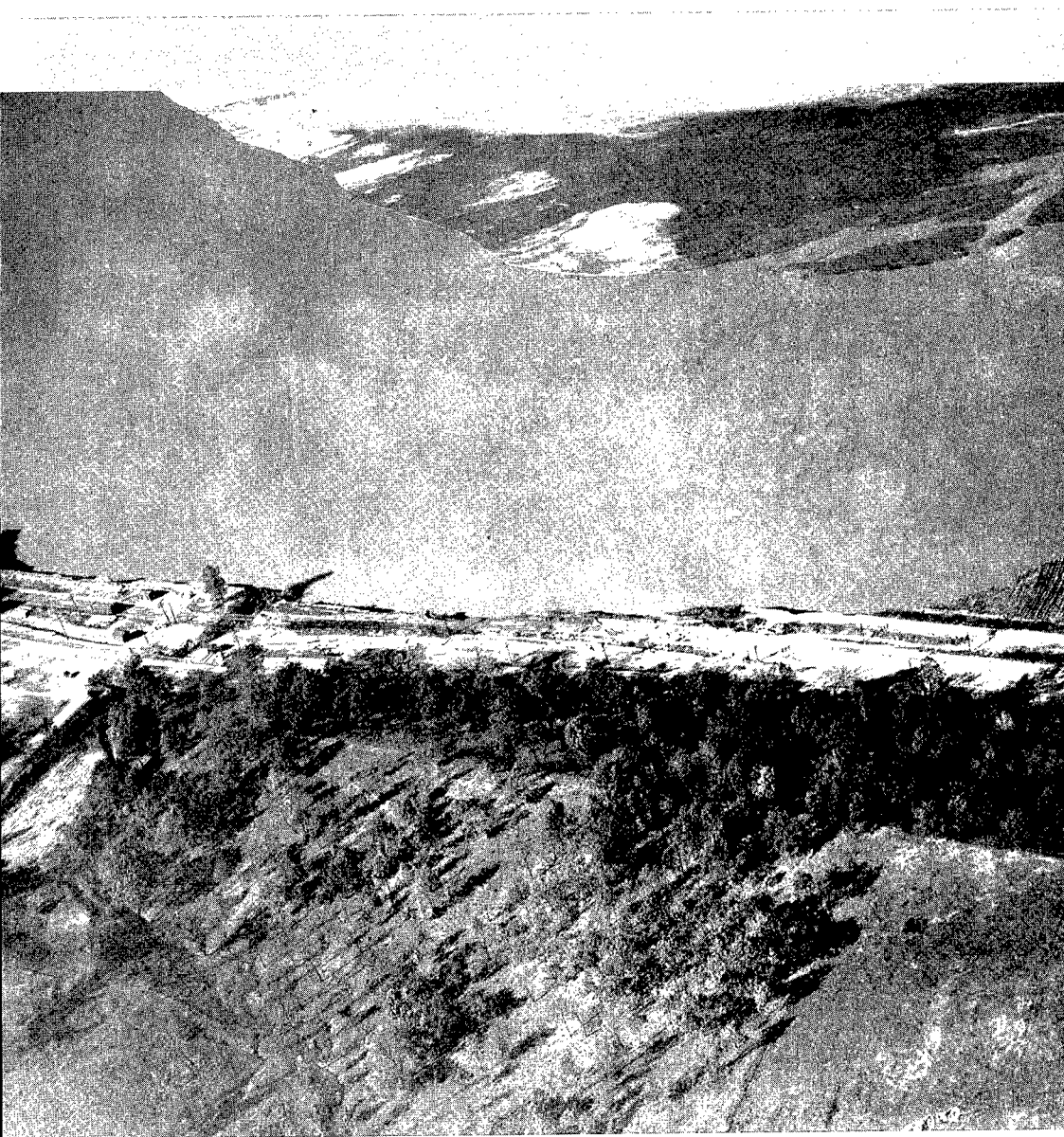


MISSOURI RIVER AUTHORIZATIONS BY CONGRESS, 1820-1871

As early as 1819, Congress recognized the importance of improving the Missouri River for navigation. In that year, and again in 1820, funds were appropriated for "a survey of the water courses tributary to, and west of, the Mississippi" (Acts of 15 February 1819, and 14 April 1820). In 1832, the President of the United States was authorized to extend the provisions of the original Rivers and Harbors Act of 24 May 1824 (an act to improve the navigation of the Ohio and Mississippi rivers) "so as to embrace in its operations the river Missouri, from its junction with the Mississippi River to the mouth of the Kansas River" (Act of 3 July 1832).

For several decades after the 1832 legislation, modest sums of money were appropriated at irregular intervals for work on the Missouri River. These funds were authorized for examinations, surveys, and reports; improvement of navigation through removal of bars, snags, wrecks, and other obstructions; the protection of banks at specified locations; and construction and repair of vessels, operating equipment and machinery required for the work. In 1871, a joint resolution of Congress authorized establishment of the first water-gauging station on the Missouri River, at Fort Leavenworth, Kansas, "with a view to obtaining information required for the protection of alluvial lands against overflow, and for the improvement of navigation" (Joint Resolution No. 40, 21 February 1871).





*Missouri River eroded through the main line of
the Missouri Pacific R.R.*





THE SUTER PLAN

*I*n 1881, Corps of Engineers Major Charles Suter said the wandering Missouri could be “pegged down” to a fixed alignment of curves. Suter noted that the power of Missouri River water “could produce tremendous effects and bring about the most astounding changes.” He wanted to use that natural force to produce benefits for basin residents.

Suter intended to turn the river on itself to create one fixed, curved main channel. He suggested a system of channel improvements to concentrate the flow of water. The scouring power created by the constricted and controlled channel would deepen the river and provide a navigable stream.

Suter thought the program would cost about \$10,000 per mile or \$8 million for the entire river to Sioux City. He wanted to start at the river’s mouth, where the Missouri flowed into the Mississippi, and work upstream. He thought that appropriations would cover reaches of at least 50 miles at a time. Above all, Suter wished to avoid a piecemeal approach: “If the money is to be frittered away at isolated points, and the improvement carried on in a disjointed and arbitrary manner, no estimate of the ultimate cost is possible.”

Suter presented his plan in the year of the historic flood of 1881. High water rolled down the Missouri repeatedly in March and April, inundating numerous communities. In some places, the river dumped five feet of sand. The channel changes were dramatic.

Raging waters swept away the Corps of Engineers' experimental works and demonstrated the power of the Missouri. Some in-channel works, for which Congress had appropriated money in 1876, were left standing. Surveys following the flood showed that the Engineers had to design light, yielding structures that allowed the river to flow along the length of the works. Suter reported on the principle of Missouri River improvement saying that "by utilizing the natural forces at work, we hope to avoid any direct conflict with the river, as in such a conflict we would in all probability be worsted."

THE MUDDY MO'

The Missouri River was the second muddiest river in the world before it was regulated and controlled. Scientists determined that it carried almost three times the silt of the Nile River in Egypt. Only the Colorado River had a heavier silt content.



The Missouri eroded its banks 2,000 feet a year in some places and deposited prodigious amounts of silt. Suter said the silt was the essential problem for basin residents who wanted to make the most use of the river and its floodplain. He estimated that 11 billion cubic feet of silt could have been carried past St. Charles, Missouri, during 1879 -- enough to cover a square mile of ground to a depth of 200 feet.



SEDIMENTS IN THE MISSOURI RIVER

Sediments in the Missouri River are a mixture of particles of different kinds and sizes. Sediments are carried by suspension or as bedload materials through drag, shear, or saltation actions. The riverbed exhibits a sequence of bed forms that can be correlated with velocity. These forms are called plan or flat, rippled, duned, plane and antidune and they can exist separately or together at any point along the river. Change from one form to another is always accompanied by an increase in velocity despite an increase in flow resistance.

An increase in roughness of the bed as dunes are formed results in an increase in physical resistance. At higher velocities, the dunes give way to a plane bed and are accompanied by a marked lowering in flow resistance and an increase in the rate at which sediment is transported. Movement of particles along the bed decreases the resistance to flow; and silts and clays act as a lubricant dampening turbulence, which increases the flow efficiency of the channel.

Silt caused great difficulties. It collected in lowland areas and on bars in the river, forcing the main channel to meander or diverting the current through many small channels. Channel changes increased erosion, added more silt to the river, and caused build-ups on downstream shoals. Stream changes became more pronounced during high-water stages, further hampering navigation and destroying the permanency of bottomland farms.

THE CROSSING AREA

The crossing area is the predominate problem area in designing the navigable section of the Missouri River. It is the transition zone from one bend alignment to adjacent reversing bend alignments. The energy required to transport the sediment load decreases through the crossing and allows mid-channel sand-bars to form.

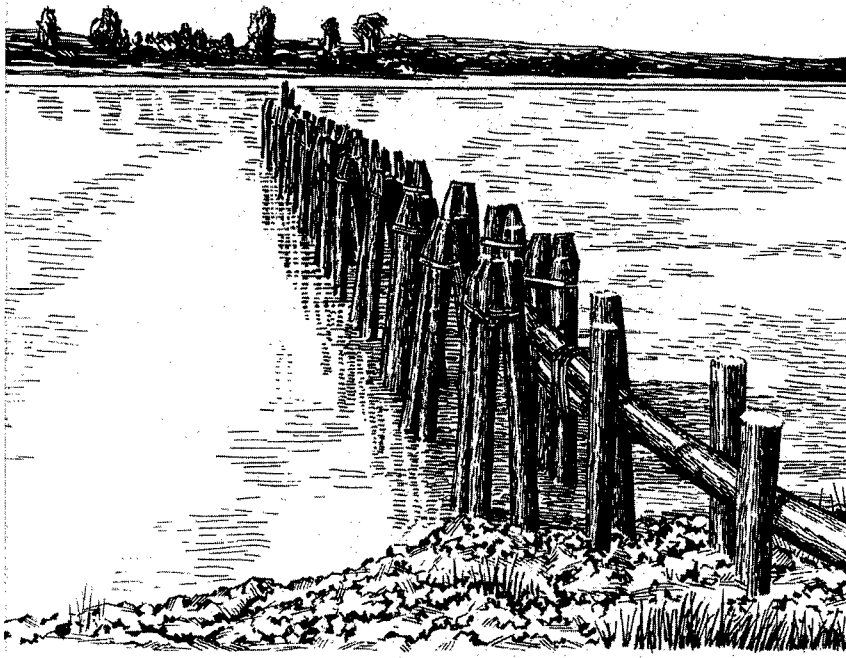
Another problem with the crossings is that they are transient, moving upstream and downstream, with fluctuations in the discharges. These problems require that the crossings be constricted to the minimum controlling width and that the adjoining curve alignments overlap by 500 to 1,000 feet. These measures maintain flow energy and allow the sediments to be transported through the crossing.



Suter and his assistants took up the challenge to design in-channel projects to combat the Missouri River silt load. They adopted such simple procedures as peeling the bark from piles to lessen friction and reduce the forces against these dike structures that extended into the stream. Suter's assistants mounted wire screens on pile tripods to reduce the capacity of the water that flowed through the dikes for carrying sand in suspension. As this action took place, accretions were formed by the silt that was dropped from suspension.

MISSOURI RIVER NAVIGATION CHANNEL AND BANK STABILIZATION PROJECT STRUCTURES

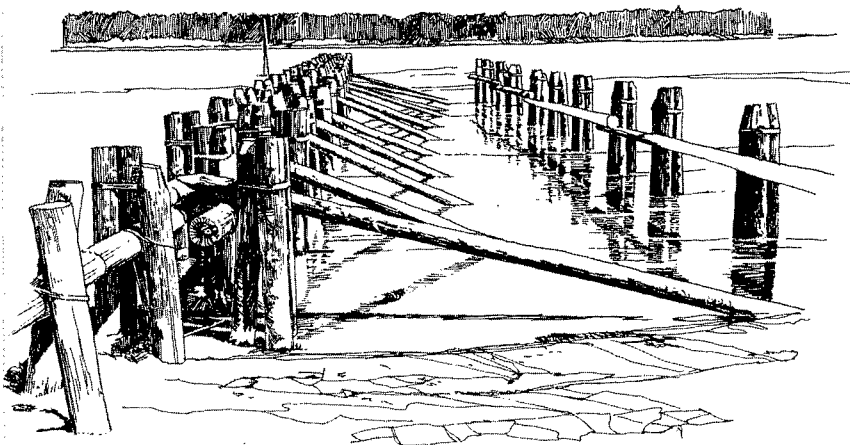
The project for improving the Missouri River channel consists of creating one stabilized channel from the numerous small channels of the natural river by concentrating the flow and shaping it in smooth easy bends so that the energy of the flowing water scours out a deeper, more efficient channel.





The Suter plan called for establishing the alignment of the channel to give the desired direction to the current by correcting the curvature of the bends and reducing the width of flow over cross-overs. This was accomplished mainly by the use of permeable dikes. "Permeable" meant a dike through which the water could flow but was retarded enough to cause a precipitation of a good part of the silt and sand carried in the water. By making these dike permeable the force of the attack of the current was greatly lessened.

In building these dikes three piles were driven into the ground to a depth of 20 to 30 feet below the river bed. The three piles were then drawn together at the top and securely clamped. This type of dike was known as a clump dike.

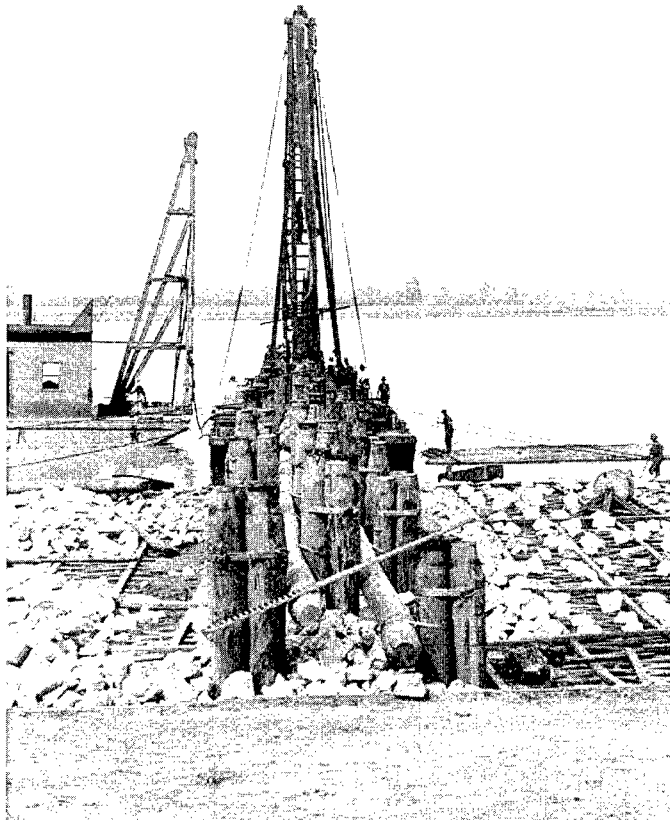


These clump dikes were built in one, two, or three rows depending upon the strength required in the dike to resist the attack of the water. The clumps were placed from 15 to 20 feet apart and were lashed together with stringers which were securely attached to the piling. While there were other types of dikes used, most of the diking constructed on the Missouri River was the clump piling type.

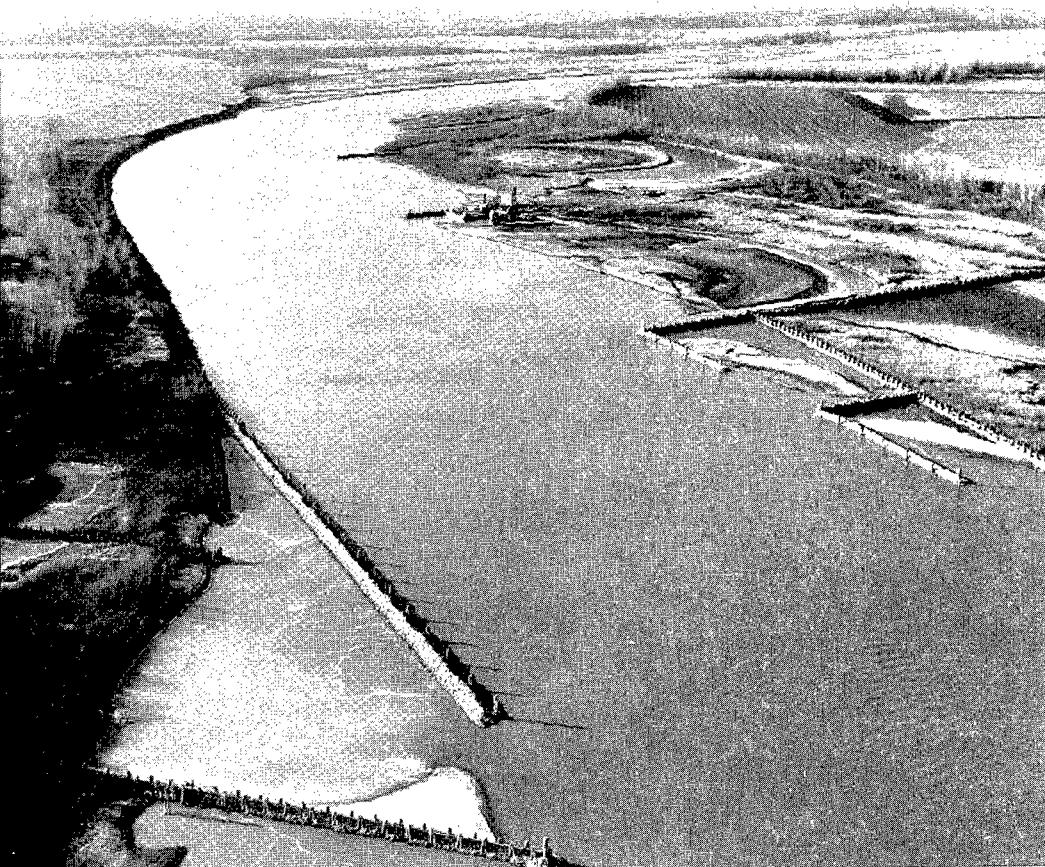
To prevent a scouring around the bottom of these dikes, a willow mattress was woven extending from the shore line to beyond the end of the dike. This mat was extended to the top of the graded slope on the river bank and was entirely covered with rip-rap, which consisted of stone.

In the mid-1940's, it was found that placing quarried stone around pile dikes greatly reduced the need for maintenance. Present-day structures consist almost entirely of stone fill with no wood pilings.

A "kicker structure" is a downstream extension of a revetment on the outside of a bend and is used to direct the flow from one bend into the next bend. It insures a reliable navigation channel in the crossing areas between two bends.



Dikes extend from the riverbank into the river, perpendicular or nearly perpendicular to the flow. They contract the river channel to the desired width and protect the bankline on their lee (downstream) sides from erosion. The illustration shows L-head dikes, which have short revetments attached to the riverward ends of the dike extending downstream parallel to the flow. They reduce the eddy action and turbulence off the end of straight-out dikes and direct the flow downstream.





Sills are low elevation extensions of dikes into the river channel. Sills are built approximately perpendicular to the flow at elevations that are always below the water level during the navigation season. Sills control the shape of the river cross section so that navigation depths can be maintained in the desired position within the section.

The channel is fixed into the design alignment by the construction of dikes along the convex side of the bend. The dikes are designed at a 10 to 22 degree downstream angle from normal to the current. The spacing of dikes depends on the function they are to perform and the degree of curvature through the bend. Spacing is then predicated on a rate of return flow of 1 on 4 or 1 on 5. That is, after the water flows around the riverward end of a dike, the flow begins to return toward the high bank at a rate of 1 foot landward to 4 feet downstream movement.

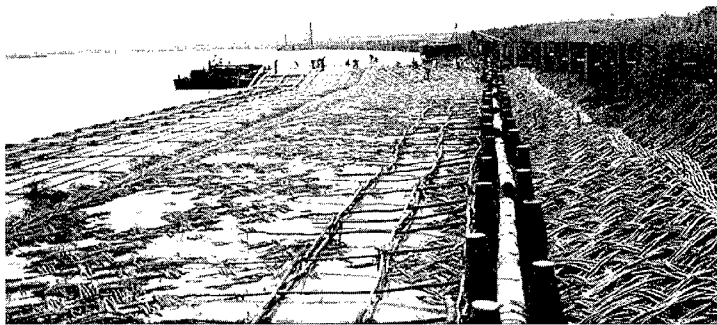
The revetment is the structural process used for protecting the bank from erosion. Revetments are built parallel to the river flow, either to establish and protect a desired bankline or to guide the flow along a desired alignment. In the earliest time of navigation channel and bank stabilization project work, after the bends had been rectified by reducing the curvature to the desired angle and the shoreline straightened, the bank was then graded back by hydraulic process to a slope of about one to three. After the grading of the bank had been done, mattresses were woven out of green willows. These mats were each about 80 to 90 feet in width and 12 inches thick. The mats were reinforced by 3/8 inch stranded cable and were anchored on top of the bank by cables attached to piles driven deep into the ground. The mattress was woven in a continuous length the entire distance of the particular stretch of revetment.

Workmen weighted the mat down by placing upon it one cubic yard of stone per hundred square feet of mat. This weighted the mat to the bottom and held it there. The shoreline edge of the mat was placed on the bank about three feet above standard low water so that practically all of the mat would be continuously submerged.

Modern revetments may be: (a) a layer of rock constructed directly on the original riverbank; (b) constructed in an excavated trench landward of the original riverbank; or (c) a rock fill along a desired alignment riverward of the original bankline. Today, little of the trench-type revetment is evident because the banks have eroded back to the constructed alignment. Much of the rock fill revetment originally placed riverward of the bank is now part of the bank because of build-ups of sediment deposits landward of the structure.

The basic channel width, formed by revetments and dikes, varies from 600 feet at Sioux City, Iowa, to 1,100 feet at the mouth of the river just above St. Louis, Missouri. Underwater sills extend into the channel an additional 100 to 200 feet.







SUTER PLAN IMPLEMENTED

River interests encouraged Congress to appropriate money for the Engineers' work. Concerned citizens met at Kansas City, Missouri, in 1880 and at St. Louis in 1881. At a major convention in St. Joseph, Missouri, later in 1881, delegates from Iowa, Kansas, Nebraska, and Missouri urged Congress to finance work on the river.

These conventions revealed why river interests wanted to change the natural, free-flowing river. The rationale was that navigation would lower regional shipping rates and boost economic activity. Stabilizing the banks and pegging down the river would create productive land, increase property values, and add real estate to the tax roles.

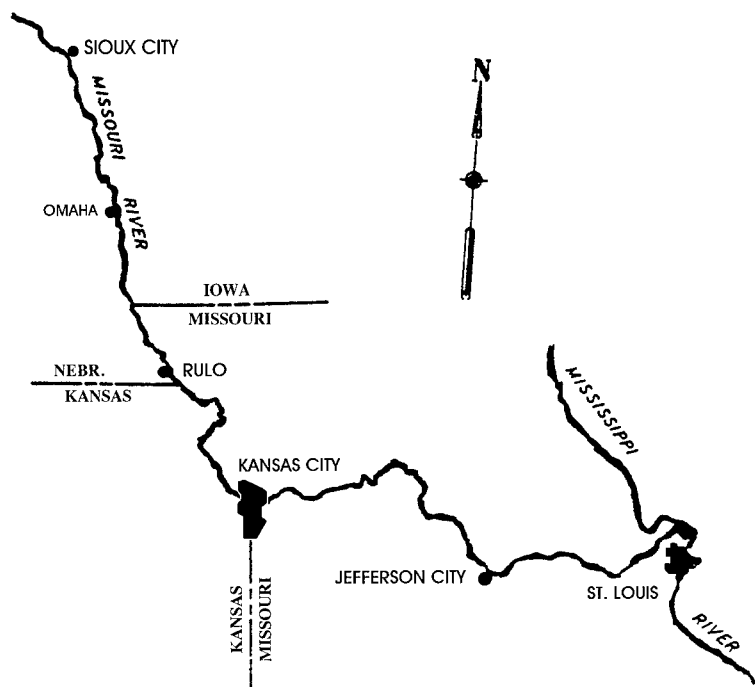
Congress responded favorably and in 1882 appropriated \$850,000 for Suter's work. Suter allocated about half of that to build new floating plant. His 188-vessel fleet included yawls, skiffs, quarter boats, barges, hydraulic pile drivers, and graders.

To simplify the administration and management of the river improvements, Suter divided the work area from Sioux City, Iowa, to the mouth into three divisions. The divisions were headquartered at St. Joseph and Kansas City, Missouri, and at Leavenworth, Kansas. The reach of the river from Charleston, Kansas, to Lexington, Missouri, was scheduled for systematic improvement.

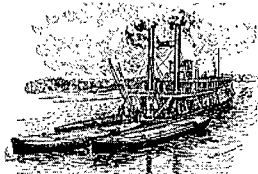
In this period of river work, the desire for local bank protection work interfered with Suter's desire for a "complete rectification of the river." By this he meant that Congress ought to adopt a systematic approach to be "carried on with no restrictions upon the judgment of the engineer as to time and place of expenditure."

For a time, the Suter ideal prevailed. The House of Representatives Committee on Commerce reported favorably on establishing the Missouri River Commission, modeled on the five-year-old Mississippi River Commission, to devise "the most effective and economical method of using the annual appropriation for this waterway." The committee said that "great natural advantages possessed by this waterway" made the Missouri River superior to the railroads for transporting bulk freight. With the establishment of a river commission, a government agency would view the Missouri as an integrated whole for the first time.

The House of Representatives centralized responsibility and accountability in 1883 when it created the Rivers and Harbors Committee. The newly formed committee recommended that Congress adopt the policy advocated by Suter and the Missouri River Improvement Convention of appropriating some money for improvements on the river to be used as the Corps of Engineers saw fit. In 1884 Congress adopted the policy.



PROCEEDINGS



OF THE

MISSOURI RIVER

IMPROVEMENT CONVENTION,

HELD AT

KANSAS CITY, MO.

DECEMBER 15TH AND 16TH, 1891.

REPORTED BY

WM. H. MILLER, SECRETARY.

2

Proceedings of Missouri River Commission

September 2, 1891.

Commission met at 2:15 P.M., present, all the members. When taken, the President was requested to designate committee to act as Secretary for this meeting and designated Major Ernst.

Major Ernst read the laws organizing the Commission, discussed.

Moved by Major Ernst that the Secretary of War be requested to detail an officer of the Engineer Corps to be Secretary of the Commission. Seconded by Mr. Breckinridge. Carried.

Moved by Mr. Breckinridge that St. Louis be established as headquarters of the Commission. Carried.

Moved by Mr. Breckinridge that the President of the Commission be requested to apply by telegraphic message to the Secretary of War for the detail of an Engineer officer as Secretary, mentioning the name of Kent Bingham, now in the City. Carried.

The following resolution was offered by Major Ernst. Seconded. That the Commission recommend to the Hon. Secretary of War that there be allotted for office expenses, traveling expenses and salaries of Commission members from the appropriation for the improvement of the Missouri River from Service only to the amount of \$25,000. The motion of Major Ernst the President of the Commission was requested to forward the resolution to-day with explanations as to why this allotment is needed separately. Carried.

Letter from J. L. Evans, Arkansas Mo., addressed to Mr. Breckinridge, read, and filed. (1)

A large number of applications for employment were presented and filed, without being read. Letter from Capt. S. M. Wilson presented and filed.

Letter from J. R. Hanson & Son, John A. Raymond, relative to construction of locks and channel of river between Hankins and mouth of Osage River presented and filed for future reference.

Program of work as decided. (1) to (10) will

1, 1891.

Mr. Ernst the President and for improvement of the river by the detail of a Secretary of the Commission.

1891.

Mr. Ernst the President and for improvement of the river by the detail of a Secretary of the Commission. Letter from J. L. Evans, Arkansas Mo., addressed to Mr. Breckinridge, read, and filed. (1)

Congress created the Missouri River Commission to accomplish a continuous, progressive development of the river. Suter was made president of the five-member organization which was charged to make surveys and devise plans "to maintain a channel and depth of water . . . sufficient for . . . commerce" and to carry out plans of improvement the commission deemed necessary. As in the case of the parallel Mississippi River Commission, all facilities of the Corps of Engineers were made available to assist the Missouri River Commission in discharging its duties. In large measure, supervision of the Missouri River work remained under the control of Corps engineers.

The Missouri River Commission urged Congress to make an annual appropriation of \$1 million to pay for this systematic approach. In its initial report, the commission noted that five acts of Congress had appropriated money for work at 43 locations on the river with no useful results. The commission wanted policy changed so that expenditures would not be constrained.

Clearly, those with competing philosophies sought to direct the work of the Missouri River Commission. Local interests wanted the commission to protect private, corporate, and municipal property along the riverbank. The commission held that appropriations for the river were a capital investment. The money should be used to develop the river, make it a suitable transportation route, and eventually return revenues to the U.S. Treasury. These views were never reconciled.

Congress appropriated only \$375,000 of the \$1 million requested and specified nine projects. All of the projects varied from the commission's plans for systematic linked improvement, and all were to prevent bank erosion rather than channel rectification. Congressional appropriations to 1888 totaled less than the \$1 million requested by the commission for the first year. In 1888, Congress appropriated the desired amount, but it designated about \$775,000 to localities, leaving the commission with only \$225,000 to conduct its plan of systematic improvement.

George Vest, U.S. Senator from Missouri, railed against those special interests who continued to get funding for their local projects thus defeating the commission's more practical plan of systematic improvements. The money being spent for revetment work under the mantle of navigation improvements was clearly more for protection of private property. In despair, Senator Vest exclaimed that "If some Senator could invent a system by which the rivers and harbors of the country could be improved without the general appropriation bills," he would be of great service to the nation.

The Missouri River Commission also continued to urge Congress to reconsider its Missouri River appropriations procedures and break the bonds of constituency-oriented legislation. Congress had ordered the Commission to implement a plan to aid commerce and navigation on the Missouri, not to protect property on the river's banks. The commission repeatedly reminded Congress of that charge. Congressional action was hindering the Engineers' progress on the Missouri River. The commission lamented that it was "simply impossible to meet all these demands."

ADVOCACY FOR MISSOURI RIVER WORK

U.S. House of Representative Champ Clark of Missouri, spoke on the floor of the House, January 16, 1901, encouraging Congress to continue to support work on the Missouri River project:

"'The Missouri River is not navigable and the Mississippi ought not to be' is a saying which I have heard attributed to the Honorable Thomas Brackett Reed. . . . The Committee on Rivers and Harbors seems to have adopted this proposition as their own, notwithstanding the fact that there is no truth in the first half of it and no sense in the last half. . . . If another pound of freight is never carried upon either of those mighty streams, still it would be the part of wisdom to maintain their navigability as a regulator of freight rates; for the very fact that they can be navigated keeps freight rates from soaring sky high

Congress directed the Corps of Engineers to engage in work that thwarted the achievement of original goals. It diverted the commission from a purpose for which it was created: to affect the influence of special interests that lobbied for local project work on the banks of the river. Unfortunately, in the 1876 bill, Congress assigned the Corps of Engineers responsibility for protecting private property from bank erosion, a project purpose that Suter had candidly stated was "not to be thought of."

The Missouri River Commission became embroiled in an array of special-interest issues. Most of the problems related to the rapid municipal and industrial growth which was taking place on the lower river below Sioux City. Industry encroached on the floodplains in areas of rapid growth, such as at the confluence of the Kansas and Missouri rivers. The commission protested in vain.

In 1901, Lieutenant Colonel Amos Stickney, who succeeded Suter, wrote that the commission had received inadequate funds, achieved few useful results, and made few significant improvements. By 1902, the commission's efforts yielded a six-foot-deep channel for 45 miles and added 5,500 acres of reclaimed bottom land that added \$915,000 to the tax rolls.

The commission could do no better because money had been diverted to flood control, even though the Corps had no legislative mandate to engage in such work. As the commission stated, "A very large proportion of the total appropriations . . . has been

allotted by Congress to localities for the protection of private and corporate interests not wholly connected with navigation." The commission had been appropriated \$7,150,000 over 18 years, but only \$3,280,201 became available for the systematic improvement of the river.

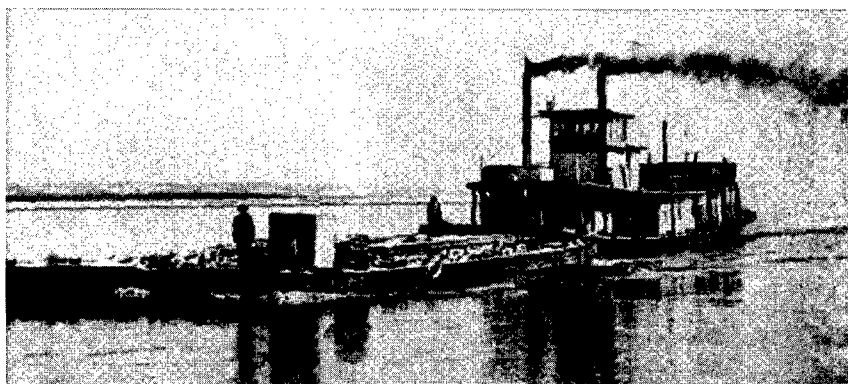
The commission's final words on the Missouri were that it: "makes no recommendation for any appropriation . . . unless it can be made in a manner to permit its application to a thorough systematic improvement of the river." The commission noted that "as Congress has not deemed it advisable to continue the work upon a scale and in a manner to make an effective general improvement, there is, of course, no longer necessity for the existence of the commission."

The Rivers and Harbors Committee Chairman Theodore E. Burton responded to the commissioners' lament. He called a hearing in 1900 to assess the views of members from the Missouri River districts. Fifteen congressmen appeared and none defended the navigation project per se. What they wanted were local projects that would protect riverbank property. Burton's committee responded with a report unfavorable to the Missouri River Commission and its systematic improvement project. No viable commerce existed on the river anyway.

After abolition of the commission, Captain Hiram M. Chittenden in the U.S. Engineer Office at Sioux City assumed responsibility for the improvement of the river. Like his predecessors, Chittenden managed upper and lower river projects, with the arbitrary dividing line at Sioux City. He sought lump sum appropriations, based on estimates for specific projects but disbursed as a whole. Only such a system, he argued, would permit flexible responses to the challenges the river presented.

A basinwide improvement program, carried out in the interest of navigation, would benefit the region in a variety of ways. Flood control, done in the interest of navigation because that was all the law allowed, could protect lives and property. Flood protection would bring security to riverfront communities and add usable acreage, raise and stabilize land values, and enhance the overall development and prosperity of the basin.

Chittenden sent his report to the Board of Engineers for Rivers and Harbors, which Congress had established in 1902 to examine proposals for navigation improvements. The board was not impressed. It made no recommendations for systematic improvements of the Missouri. Work on the river languished. Chittenden and his successors served as caretakers and custodians of the Missouri during their brief tenure.



MISSOURI RIVER COMMISSION WORK EVALUATED

Colonel D. W. Lockwood, senior member of the U.S. Board of Engineers, reported in 1908 on the work of the Missouri River Commission:

"The work done was principally confined to the upper 45 miles of the first reach, beginning at a point about 5 miles above Jefferson City, Missouri. This reach included the mouths of the Osage and Gasconade rivers and was reported to be the worst stretch of river then existing. The width between main banks was excessive, being as much as 3,000 to 4,000 feet in places, and the stream was obstructed by numerous sand and gravel bars and small islands which divided it into a number of small and tortuous channels with a low-water depth of only about 30 inches.

The effect of the works was to confine the stream to a single channel of easy curvature with a practically uniform width of 1,100 to 1,200 feet, the depth being increased to considerably over six feet at low water over a stretch of 45 miles, although the project was never carried to completion. Practically nothing in the way of repairs and maintenance has been done on this reach since the commission was abolished in 1902 Quite a large percent of it has been destroyed, but this is due in large measure to the entire abandonment of the work. The structures used are necessarily of a perishable nature and their integrity depends upon careful attention to maintenance. Notwithstanding the neglect of the river in recent years, and the consequent deterioration of the work, the results of the improvement of this stretch demonstrate beyond contention the entire feasibility of improving the Missouri River under a project similar to that adopted by the Commission."



KANSAS CITY DISTRICT INHERITS SUTER PLAN

In 1907, a new Kansas City District under Major Edward H. Schultz replaced the Sioux City office. The new headquarters managed the increasing activities related to Missouri River navigation improvement. Supporters were encouraged by President Theodore Roosevelt's advocacy of waterways development and by Burton's replacement by a more evocative chairman of the Rivers and Harbors Committee. De Alva S. Alexander was an ardent supporter of Missouri River improvement during his tenure as committee chairman.

GASCONADE BOATYARD

A new industry was introduced to the vine-growing agricultural valley of the Gasconade River in 1892, when the Missouri River Commission leased a parcel of farmland at the Gasconade's confluence with the Missouri. The federal government built a facility to construct, renovate, and repair riverboats at this ideal location. The farmer's barn was adjacent to the boatyard's office and a footbridge led from the Missouri Pacific Railroad tracks, past the pigpen and chicken yard to the boatyard's shops. The compact site was enlarged in 1910, when the government purchased the parcel. More land was added in 1929 as the workload increased on the Missouri River improvement project.

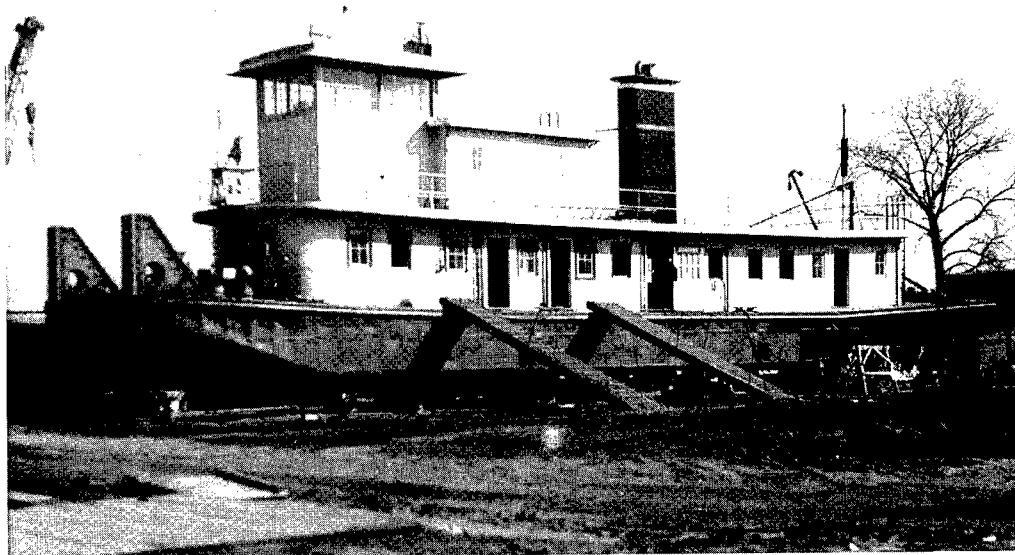
Use of the Gasconade Boatyard diminished as the Missouri River navigation channel and bank stabilization project neared completion. The Corps of Engineers decreased the number of permanent employees and increased its use of contract labor.

By 1966, the work force declined to 35 people, down from nearly 500 in 1935. The Kansas City District Engineer recommended in 1971 that the facilities be used only as a harbor. Gasconade Boatyard closed its doors in June 1972.

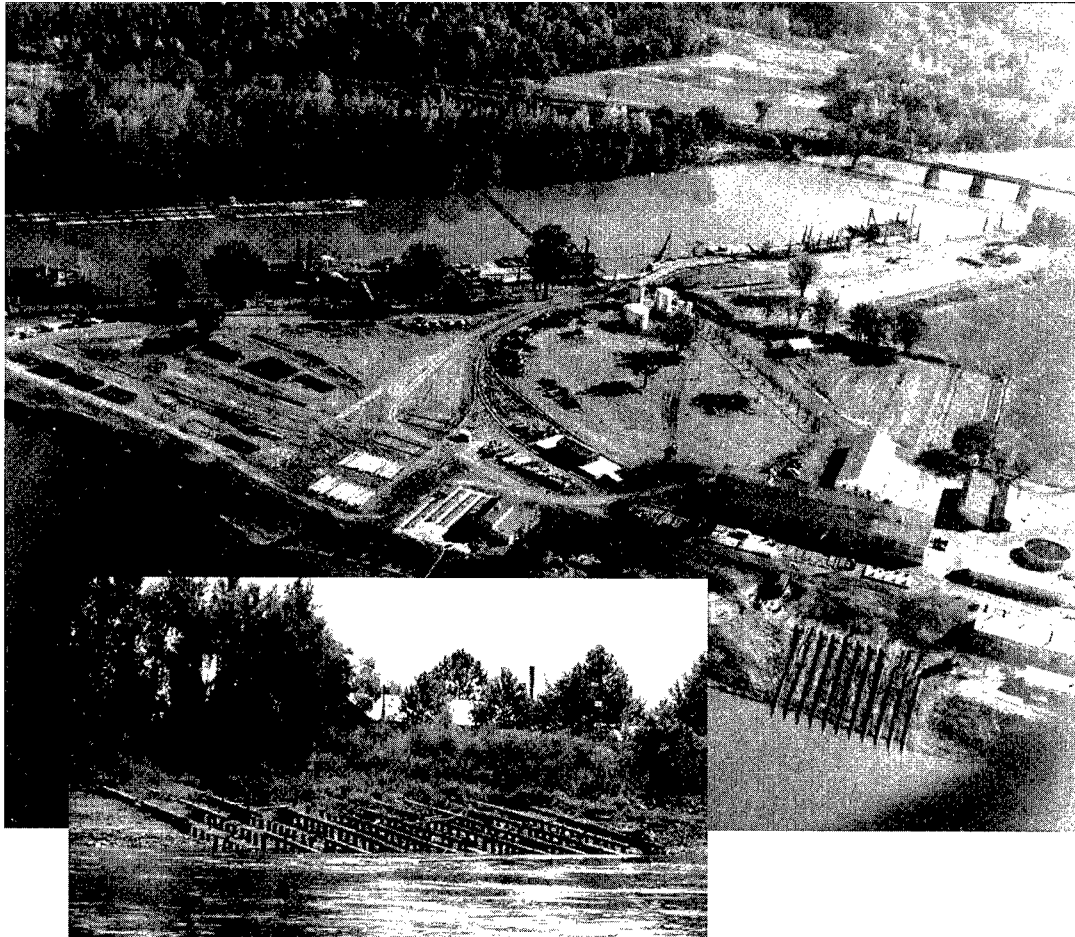
STERN DOCK at GASCONADE BOATYARD

The Corps of Engineers operated the Gasconade Boatyard efficiently and effectively. Facility personnel fabricated much of what was needed to make the yard useful at the lowest possible cost. They recycled items removed from boats and barges to use in the offices and shops or to reuse on river equipment and boats. They sought economical ways to repair vessels and equipment.

Gasconade personnel developed a "stern dock," a simple and economical substitute for a "dry dock." There is nothing about the bottom of a steel-hulled riverboat, except the rudder and propellers, that is likely to require any inspection or repairs. Drydocking a boat, which raises it out of the water, is time consuming and costly. The stern dock raised one end of the vessel out of water so that docking and repairing could be done expeditiously.



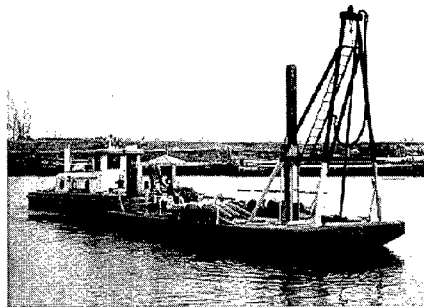
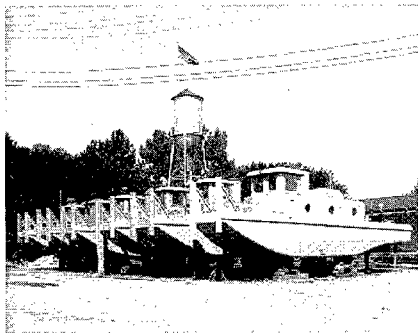
The stern dock was a wooden box 38 by 15 feet wide and 6 feet deep. Out of one side was cut a deep groove shaped like a cross-section of one of the boats at a point a few feet from the stern. This groove was covered with watertight packing. When the boat was ready to be docked, the box was sunk until it was nearly full of water and shoved under the boat so that the groove fit tightly around the hull. Then the water was pumped out and the box floated, lifting the end of the boat out of the water.



MARINE WAY AT GASCONADE BOATYARD

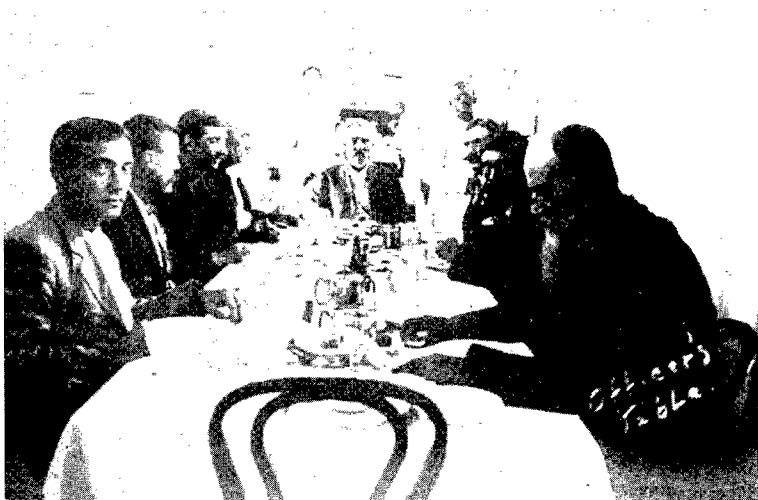
A marine way was built on the Missouri River side of the Gasconade Boatyard. It was built of long heavy timbers placed on top of a large piling set in the ground with the top about a foot above the graded ground level and a large metal pin to hold it in place. The pilings were set about five feet apart down the slope and as far into the river as possible. The timber slides were about 10 feet apart for a distance of about 100 feet.

The timbers continued on top of the bank for a distance of about 30 to 35 feet. These timbers could pivot so that they would be level with the ground. If a vessel was fabricated on them, the ends would be jacked up to the same slope as those under the bank. Then cables fastened to anchored pulleys near the water's edge and wrapped around the vessel would be pulled by steam winches set farther inland. Before the cables were pulled, the tops of the timbers were coated with tallow to make them more slippery. Then the vessel was pulled onto the sloping timbers and slid off the timbers and into the river. A person on the vessel would have a line fastened to a tree anchor. When the vessel was afloat, this person would slack off the line so that the boat would lodge against the bank below the marine ways, where a launch would tow it into the Gasconade harbor.



Intense lobbying by lower river improvement interests, who founded the Missouri Valley River Improvement Association in 1906, had a marked effect upon the Corps of Engineers' work on the lower Missouri River. Association president Lawrence Jones of Kansas City led a movement to get boats and freight on the river. The people of Kansas City organized the Kansas City Transportation and Steamship Company to reduce freight rates and to demonstrate to Congress that the Missouri was a navigable river.

The urban interests drew support from the lower basin's farmers. The railroads were unable to ship the burgeoning agricultural produce expeditiously, and the farmers felt that freight rates were too high. Jones claimed that had the river been improved "one congressional district in the state of Kansas would have received for its 1906 wheat crop over \$5 million more." Rural interests repeatedly declared their advocacy for river project work because it would protect and enhance their land values.



Officers and crew of the Kansas City Transportation and Steamship Company

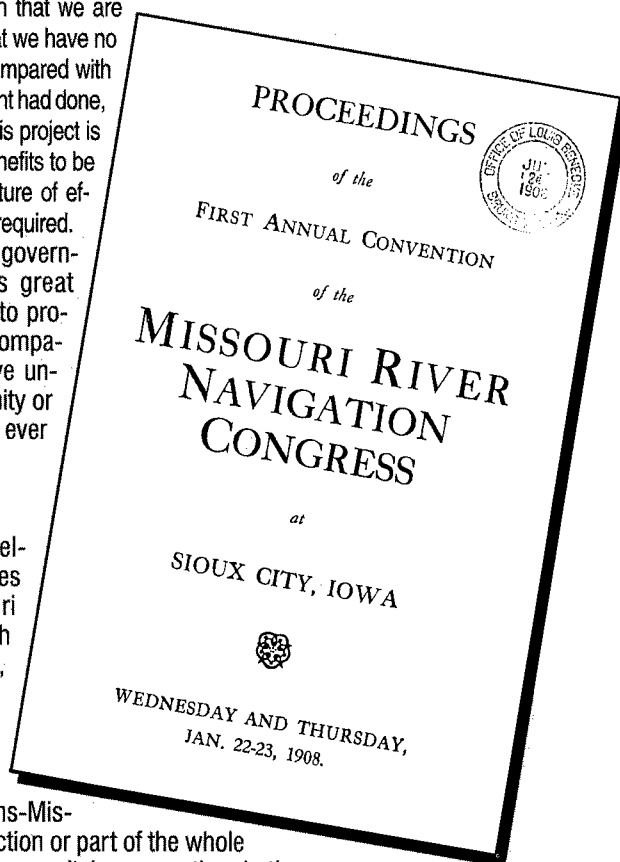
MISSOURI RIVER NAVIGATION CONGRESS

Edgar Ellis, U.S. House of Representatives member from Missouri, chaired a Missouri River navigation congress held in Sioux City, January 22-23, 1908:

"I desire simply to make plain that we are facing a great undertaking; that we have no precedent to guide us; that compared with other things that the government had done, is doing, or proposes to do, this project is unique, both in point of the benefits to be conferred and of the expenditure of effort and money which will be required. That to induce the national government to take hold of this great project, to approve it, and to provide the money for it, is incomparably the greatest legislative undertaking that any community or section of our country has ever attempted."

Ellis' committee reported:

"The gathering of 700 delegates out of the seven states bordering on the Missouri River from Montana, North Dakota, South Dakota, Iowa, Nebraska, Kansas and Missouri, attests a revival of faith in the great river as a prime factor in the industrial development of the trans-Mississippi west. . . . In no section or part of the whole country is the question of more vital concern than in the area represented in this convention. . . . Provision must be made by the national Congress, and money be authorized to undertake improvement of the Missouri River on a grand scale by treatment of long stretches; and work once begun be carried to completion and made permanent."



Congress responded to the “navigation fever” sweeping through the lower Missouri basin. It ordered the Corps of Engineers to perform a general survey from Sioux City to the Missouri’s confluence with the Mississippi River. The Kansas City District Engineer, Captain Edward H. Schultz, presented the Rivers and Harbors Committee with two development proposals. One involved the expenditure of \$3.5 million to increase navigable depths at existing crossings and bars between Kansas City and the river’s mouth. His second proposal involved the expenditure of \$20 million to permit continuous, permanent work to establish a channel of not less than six feet depth from Kansas City downstream. Schultz recommended that Congress adopt the larger plan as being more efficient and economical.

During the 1908 committee hearings on his recommendations, Schultz explained his rationale for the federal government’s spending \$20 million to obtain a six-foot navigation channel. Drawing almost entirely on information supplied by the Missouri River Improvement Association, he concluded that if the river were improved freight traffic would increase dramatically. The increase would result from the region’s phenomenal economic growth and more competitive shipping rates on the waterway. Even if the channel went unused, the potential for improved navigation would bring down freight rates in the region, he contended.

WATER-COMPELLED RATES

The price of shipping freight in a region that has railway, highway, and waterway alternatives is termed “water-compelled rates”.

The improvement work Schultz recommended also would bring benefits in the amount of land that would be made more productive and hence more valuable. The Rivers and Harbors Committee chairman, concerned with the authority of his jurisdiction, explained that of course the Rivers and Harbors Committee had “nothing to do with the protection of lands” except when it was absolutely in the interests of navigation. Yet, he asked Schultz to explain for the record his conclusions about land accretion and protection if Congress adopted the recommended plan. Schultz

said that between the bluffs bordering the stretch of river between Kansas City and the mouth lay 500,000 acres of land, including railway right-of-way and improvements, that would be protected by levee districts once the river was stabilized and the banks revetted.

COMMENTS ON CORPS' 1908 REPORT

Colonel D. W. Lockwood, senior member, Board of Engineers, in making the board report of Captain Schultz's examination and survey of the Missouri River in 1908 said:

"In the opinion of the board such continuous and systematic work on the lines proposed by the district officer may be expected to produce depths in excess of 6 feet and probably not less than 10 feet. . . . The river would then be comparable to the improved Rhine, to which the district officer refers."

These arguments of potential benefits were sufficient for Congress to adopt the Schultz recommendations for the larger plan of improvement. In 1910, it authorized \$1 million to be expended toward securing a permanent six-foot channel between Kansas City and the mouth: \$300,000 for improvement and maintenance from Kansas City to Fort Benton, Montana (2,285 miles upstream), and additional authorizations for tributary streams and specified locations.

U.S. Senator Champ Clark of Missouri rejoiced over the restoration of the river to the "granary." He exclaimed that the money was "well spent" if no shipping ever materialized from the project because "it fixes railroad rates." Railroad interests also might have joined the gleeful chorus because the money would be used for project work that protected railroad property.

Congress appointed an engineering board of three officers to report "upon the most economical and desirable plan of obtaining" the navigation channel. The board met in Kansas City in September 1910. It inspected the river to the mouth, and held public hearings on the proposition in November. The hearings were well attended by vigorous navigation interests and those who wanted land protection and accretion.

The three Engineer officers were impressed with what they saw and heard. The board advised Congress to choose Suter's original concept of systematic improvement and recommended bank stabilization by the "standard woven mat" process. Work should proceed downstream from Kansas City.

THE WOVEN MAT PROCESS

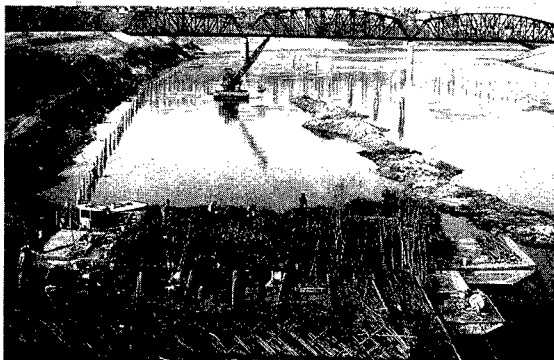
A Corps of Engineers employee, George Kishmar, whose first job on the Missouri River was working on a mattress barge, described the scene:

"The matt barge, about 100 feet long and 25 feet wide, and the willow barges about 100 feet long and 20 feet wide, were both made with two inch lumber. The matt barge had a rail of timber about three feet high set lengthwise in the middle of the barge. On top of the rail, spaced about ten feet apart, were 8-by-10 inch timbers that extended over the edge of the matt barge to the water's edge. These were called "fingers."

There was a clearance of ten feet from the ends of the rail to each end of the barge. In this clearance would be a manual capstan mounted about five feet from the ends of the barge. The capstan, a drum winch affair, had five three inch holes near its top which stood about 32 inches above the deck. The base was about 22 inches in diameter with cogs to prevent the drum, which was about 16 inches in diameter and about 18 inches tall, from slipping backwards. In the three inch holes, capstan bars made of hickory wood about three feet long, were inserted in the holes, usually two or three bars each with a man pushing on them. Ropes (lines) were fastened at one end to a clump of piling or some type of anchor, the other end was wrapped four or more turns around the drum.

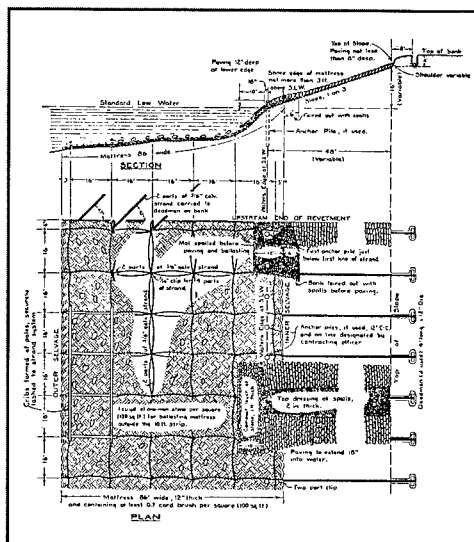
In operation, the men pushing on the bars with one man holding onto the end of the line to keep it from slipping, would wind the line onto the drum and pull the barge towards its anchor.

In weaving a mattress or matt as it was called, there were about eight men, called weavers. They started the process by placing willows in rolls about two feet in diameter some distance from the water's edge upon the bank. The best I remember, these rolls would be about 90 feet in length when built for a dike. Cable was wrapped around the roll. From near the top of the riverbank about four logs, about six feet long, with the ends of cable fastened to them, were buried several feet into the ground. These were spaced about 30 feet apart for the width of the matt. The cables came off spools under the rail of the matt barge and as the matt lengthened would unwind off the spool. Cables also attached to anchor piling above the dike line were fastened to those from the bank to hold the matt in place until it had been settled to the riverbed by placing rock on it to weight it down.



Getting back to the construction of the mattress. Weavers stuck the bottom ends of the willows into the roll, criss-crossed to its length and continued this pattern up on the fingers to the rail. Then the mattress barge would be pulled out into the river by the capstans until the edge of the amount of mattress constructed would be at the bottom edge of the fingers. The process was repeated until the length desired had been achieved. The cables from the bank and from the anchor pilings were fastened together with wire rope clamps the length of the dike.

As the mattress was being built, after a certain length, it would be sunk by throwing rock of various sizes, of which a man could handle, onto the floating mattress. This continued as the mattress was being built until it was completed. After enough mattress was sunk, a pile driver would start driving wood piling into the riverbed through the mattress. Two white painted 1-by-4 stakes about five feet long were driven into the ground, one near the top of the bank and the other about 100 feet inland, that when lined up would keep the dike being driven on a straight line.



Kishmar explained a pile driver and its function:

CORPS OF ENGINEERS

**MISSOURI RIVER IMPROVEMENT
KANSAS CITY DISTRICT
PILE DIKE
PLAN AND PROFILE**

Sheet No. 10 of 10
Scale: As Shown
Approved: [Signature]
Checked: [Signature]
Date: [Date]

GENERAL PLAN
Scale: 1"=20'

Number of rows and clump spacing in same row to be as directed by the Contracting Officer

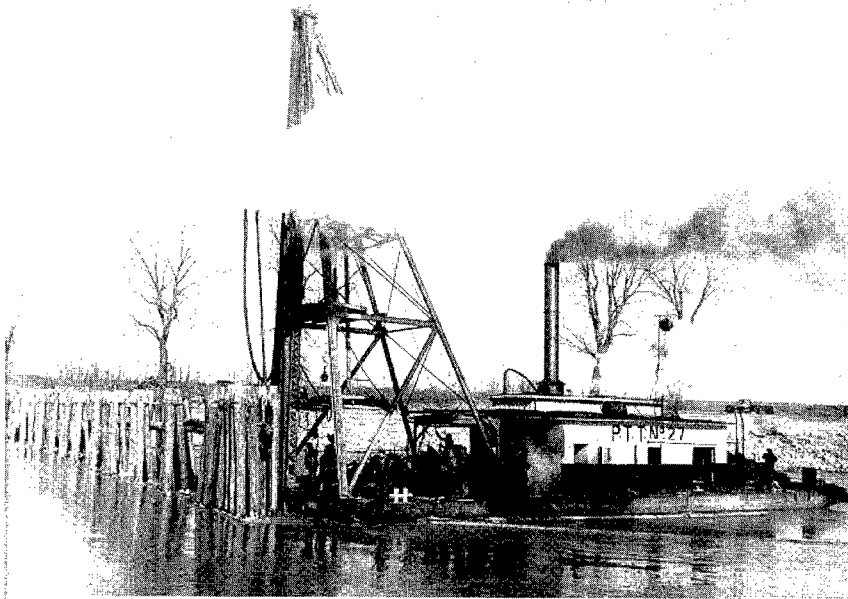
Marker clump
"C" Row
"D" Row
Dike terminal - see Detail of Dike Terminal, Sheet No. 4
Three row clump
Two row clump
Two row single pile with clump every 20'
Two row single pile
Two row single pile
Structure bench line
Raving (Note 1)
Top of bank
Intersection of Benchline and C&D line
Dike road
Spot material Short Note
Top of string (small end) (Note 1)
Trench
Elevation of bottom of pile to be as directed by Contracting Officer

GENERAL PROFILE
Scale: 1"=20'

For notes referred to on this drawing see Sheet No. 7

Marker clump
See Detail of Channelhead End of Dike, Sheet No. 4
Elevation of top of piles to be as directed by Contracting Officer
Safety cable (Note 1)
Back fill as directed by Contracting Officer
Construction Reference plane
Backfilling of dike (Note 1)
River end
Elevation of bottom of pile to be as directed by Contracting Officer

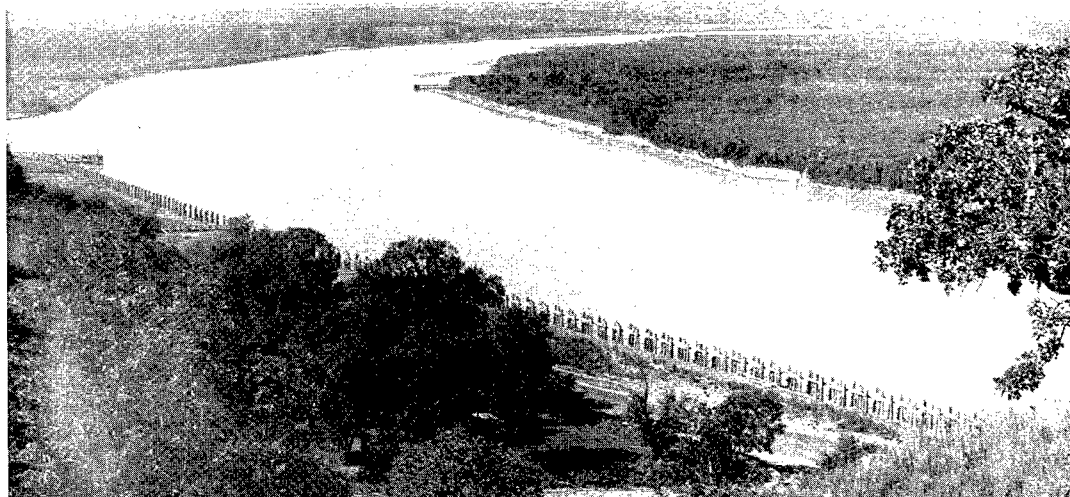
38



the top portion above the level of the top of the dike would be sawed off. In case of rock, shorter piling would be used. The length of the pilings varied from about 36 to 65 feet. The top elevation of the dike was determined by so many feet above a low water elevation, called construction reference plane. As best as I remember, it would be about 15 feet above low-water level.

The steam hammer, winch and the stern capstan of the driver, were supplied with steam from a boiler fueled by coal (later by crude oil). It was located near the center of the driver and was tended by a fireman. Besides the fireman, the crew consisted of the foreman, a leadsman, who positioned the piling in the leads, two deckhands to assist at the head end of the driver, and a deckhand at the stern to operate the lines on the capstan and to pull each piling from a raft of them at the stern, up to the head end of the driver as they were needed. Piling of different species of pine and some of cypress were shipped in by train. They were unloaded onto the bank near a river point, rolled into the river, and rafted and taken to the pile driver by a motor boat as they were needed.





TEN-YEAR PLAN

Congress was satisfied with the Corps of Engineers' responses and in 1912 adopted what came to be called the "Ten-Year Plan." The legislation's intent was to fund \$2 million a year. This approach heartened the navigation interests.

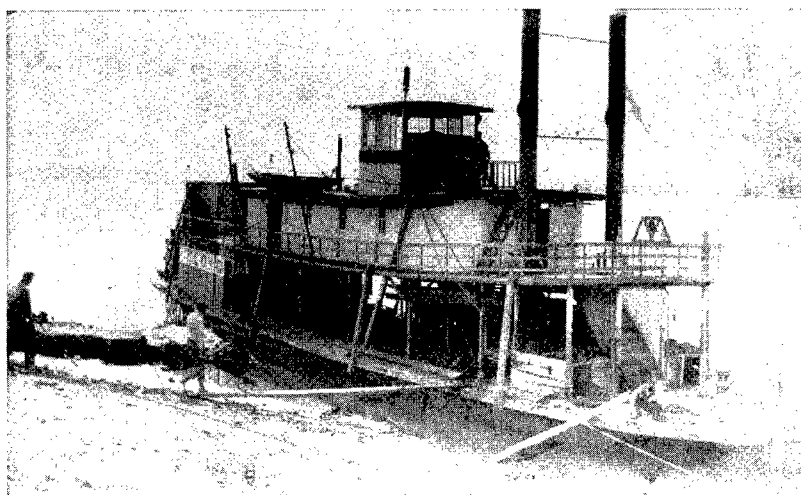
KANSAS CITY MISSOURI NAVIGATION COMPANY

Original shareholders of the Kansas City Missouri Navigation Company:

W. R. Nelson	A. H. Munger
W. S. Dickey	J. F. Richards
Leon Smith	J. T. Bird
L. M. Jones	J. J. Heim
R. A. Long	T. H. Swope
Charles Campbell	J. S. Loose
William Volker	

Walter S. Dickey, speaking for the group on September 8, 1909, said "Look at the men who have subscribed their names to these articles of incorporation. Note the sort of men they are. Recall what they have done and are still doing in Kansas City. . . . Kansas City is going ahead. It is going to build the boat line. Every dollar will be subscribed. We are going to navigate the Missouri River and make this a great and powerful city. . . . For a million dollars we are going to assure our industrial greatness and our commercial supremacy in this great Western empire."

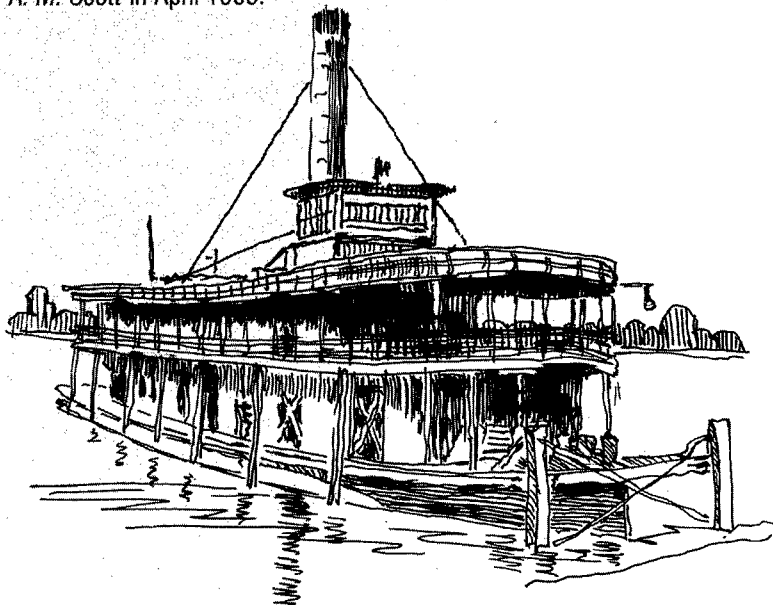
Commercial interests in Kansas City pledged \$1.2 million to capitalize a firm to engage in Missouri River shipping. The newly organized Kansas City Missouri River Navigation Company replaced stern-wheel river packets, which had a relatively small tonnage capacity and carried freight on the deck, and developed much more powerful twin-screw towboats and steel-hull cargo box barges.



Stern-wheel steamboat Floyd built at Bonnots Mill, Missouri.

COMMERCIAL TOWBOATS, 1909-1910

The Kansas City Missouri River Navigation Company purchased the towboat *A. M. Scott* in April 1909:



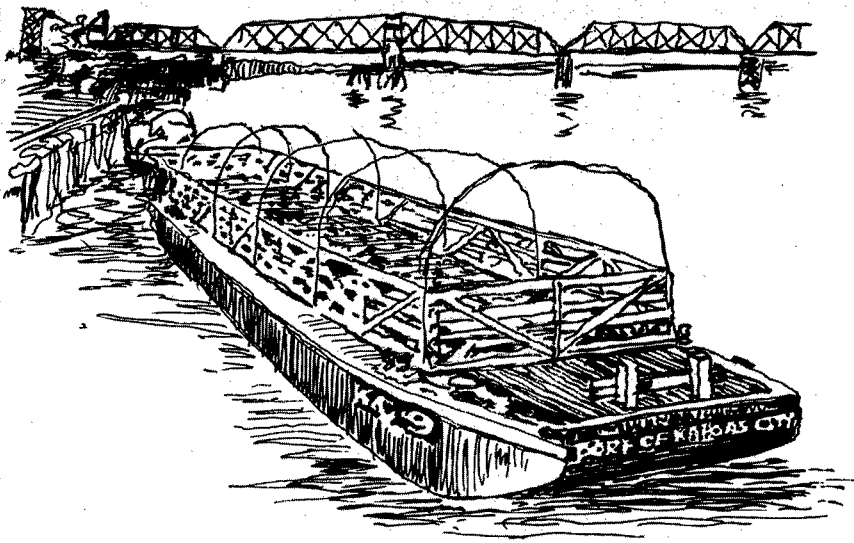
The *A. M. Scott* was a twin screw craft 150 feet long with a 28-foot beam. The boat had two triple expansion engines developing 700-horsepower. The propellers were five feet in diameter and 11 feet 6 inches apart from center to center. That space gave a wide leverage for quick turning. The boat would tow three to four barges.

In October, 1910, the Kansas City Navigation Company purchased the steamer *Pioneer*, which represented another advance in inland waterway boats. It was a steel-hulled, submerged-tunnel propeller towboat, driven by a combination of reciprocating and turbine engines, the first use of the latter type of engine on a river steamboat, developing 1,500-horsepower.

The propellers on the *Pioneer* were six feet in diameter, the tip of the blades being even with the bottom of the hull. Walter S. Dickey said the use of propellers in tunnels was not new (he had the design in his pleasure boat), but no commercial boat with that method of propulsion had been tried.

INNOVATIVE BARGE DESIGN

The Kansas City Missouri River Navigation Company's naval engineer, Maxmillan von Pagenhardt, designed a new type barge. Separate steel compartments or boxes, 40 feet long, 10 feet wide and 5 feet deep, were riveted and trussed together to make one barge at the Kansas City Structural Steel Company. The completed barge was two compartments wide and three long, giving a total dimension of 20-by-120 feet. The light draft of the barge was of particular advantage; when loaded with 200 tons of freight, it drew only four feet of water.



Kansas City voted \$75,000 in municipal bonds for terminal facilities with mechanical freight-handling devices and a rail link joining the river to overcome what had been a major weakness in the steamboat method of freight handling. The company leased property and built a terminal in East St. Louis, Illinois. No other modern docking facilities existed along the 391 miles of river between the two points.

The Kansas City residents' efforts to develop coordinated terminal facilities and adequate freight carriers for the Missouri resulted in increased shipping on the waterway. In 1911 the company reported 63 shippers and 1,084 tons of freight hauled. Three seasons later, it reported 221 shippers and 13,677 tons of freight hauled.

Those increases in commercial use of the Missouri were insufficient to justify the continuing expenditure of federal funds for river improvement, according to Kansas City District Engineer Lieutenant Colonel Herbert Deakyne. He said the engineering plan was adequate, but appropriations had lagged and the channel was only 14 percent complete in 1915. He found that the government was spending \$1.1 million a year to save shippers about \$10,000 a year. As for regulating railroads, Deakyne said that it was not necessary to spend \$20 million on the river to bring about a rail rate adjustment in the lower Missouri basin. He reported to the Rivers and Harbors Committee that the project ought to be abandoned because the engineering achievement and the federal expense was disproportionate to any possible national gains that might be realized.

MISSOURI CONGRESSMEN OPPOSE CORPS 1915 REPORT

Speaker of the House of Representatives, Champ Clark of Missouri, told the Rivers and Harbors Committee on December 8, 1915:

"Colonel Deakyne reported that from an engineering standpoint the improvement not only was feasible, but was being carried out successfully; that it is being done within the estimated cost and could be completed within the estimated time. He had no business to go further than that point. That is as far as he was called upon as an engineer to go.

"Whether there is commercial justification for the river improvement is a question for Congress to decide and the facts will be presented to this committee that will remove any doubt upon that score regardless of what may be the report of this engineer."

United States Senator James A. Reed of Missouri told the Committee:

"The proposition put up to Kansas City was one of the most absurd. . . . They told us to go out and navigate an unnavigable, unimproved stream and if you can show that it can be done, then we will improve the river and make it navigable. In other words, 'Yes, Mary, you may go out and swim, but don't go near the water.' Well, Kansas City has done that very thing. It has navigated and navigated successfully the Missouri River. . . . It has passed through the period of experimentation and has got the river proposition upon a tried and certain basis."

The Missouri basin citizens were aroused immediately by the Deakyne report. Kansas City hosted a conference of over 200 delegates in August, and in October a special Board of Review of the Board of Engineers for Rivers and Harbors held hearings in the city. The board heard the familiar arguments, including enhanced land values as well as reduced shipping rates. The board disagreed with Deakyne and recommended proceeding with the Ten-Year Plan.

SPECIAL INTERESTS OPPOSE CORPS' 1915 REPORT

Commercial Club, Washington, Missouri: "We have received Colonel Deakyne's unfavorable report on the Missouri River improvements with astonishment. You may be assured we will take immediate steps to oppose his report. It will be a fight to the finish as far as this city and the Commercial Club are concerned."

The Jefferson City Commercial Club: "Both Senator Stone and Congressman Shackleford are members of our organization and . . . will stand with us. Work already done on the river around Jefferson City has reclaimed several thousand acres valued at not less than \$100 an acre."

The Glasgow, Missouri, Commercial Club: "The business men of Glasgow are for river improvement and deplore the adverse recommendation made by Colonel Deakyne."

The Hermann, Missouri, Commercial Club adopted a resolution: "Resolved, that the Commercial Club of Hermann, Mo., enter its most emphatic protest to the intended abandonment of the improvement of the Missouri River between Kansas City and the mouth of the stream as recommended by Lieutenant Colonel Herbert Deakyne, United States Army Engineer, in Charge."

BOARD OF ENGINEERS FOR RIVERS AND HARBORS OPPOSES KANSAS CITY DISTRICT ENGINEER'S REPORT

Colonel W. M. Black, chairman of the Board of Engineers for Rivers and Harbors, reported April 6, 1916:

That the Kansas City interests were "making the most thorough attempt within the knowledge of the board to revive river traffic. . . . A continuance of the experiment under as favorable river conditions as can be secured is worth much to the United States and should go far towards showing the real possibilities in this important field of the transportation problem. A review of the agitation indicates that present grounds for continuance of this project are stronger than those which led to its adoption."

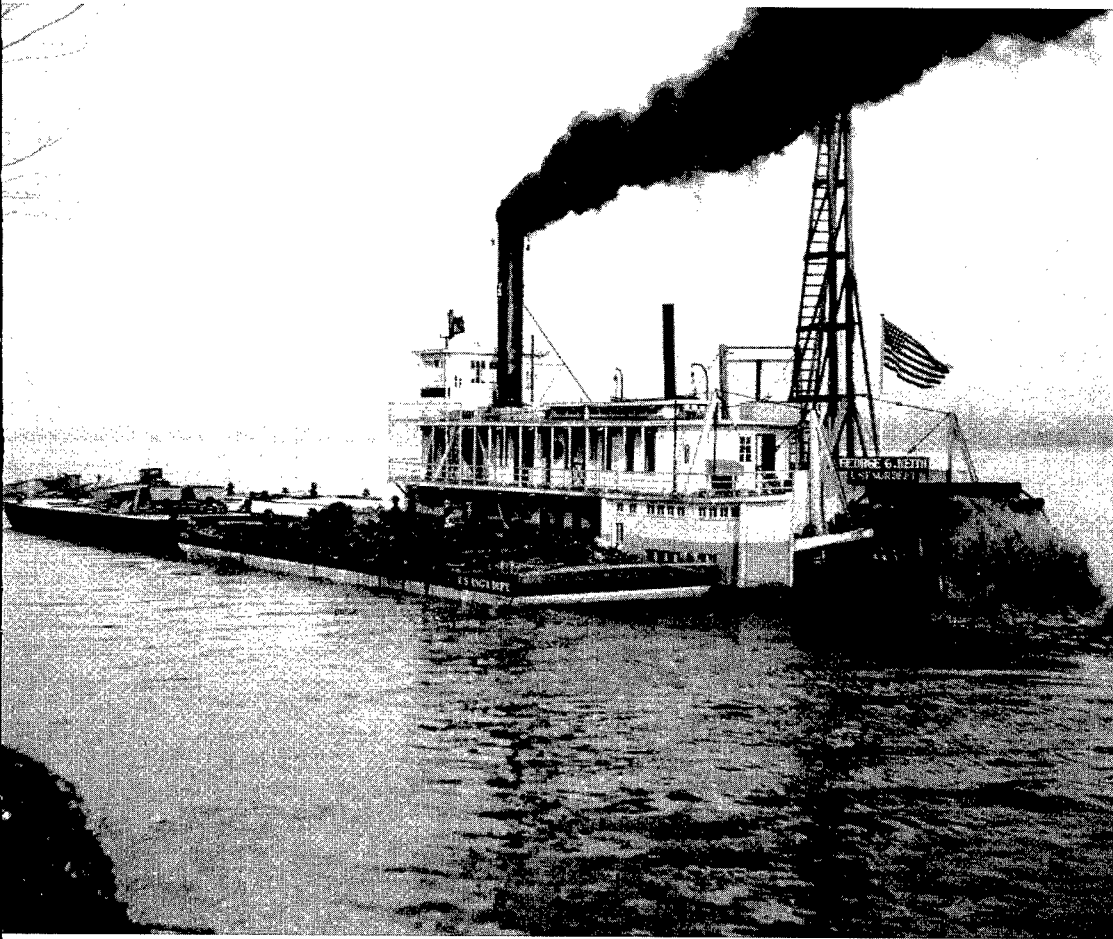
OPPOSITION TO MISSOURI RIVER WORK

Theodore E. Burton, former Senator of Ohio and former chairman of the House Rivers and Harbors committee, provided his views in Kansas City in November, 1915, saying:

"I have no apologies to make for opposing the \$20 million dollar expenditure on the Missouri River. The river appropriations had got to be a pork barrel -- a scandal."

U.S. House of Representatives member James Frear of Wisconsin, led a vigorous opposition against federal expenditures for the Missouri River waterway. He charged that the Missouri River lobby was one of the "worst in Washington and should be stopped." He wanted the Rivers and Harbors Appropriation Committee to "investigate the activities of the Missouri River lobby that is alleged to have active interest in securing appropriations for the reclaiming at government expense of half a million acres of private land . . . valued according to official reports at \$60 million."

The outbreak of war in Europe shifted the focus of the Army Engineers, legislators, and navigation interests away from the river. The world war halted almost all expenditures for inland waterways improvement. In 1918, the federal government, through the agency of the U.S. Railroad Administration, commandeered the Missouri River fleet for use with other equipment on the Mississippi River as a war measure. The Mississippi was seen as having a deeper channel on which greater tonnage could be carried effectively.



U.S. Engineer boat George G. Keith

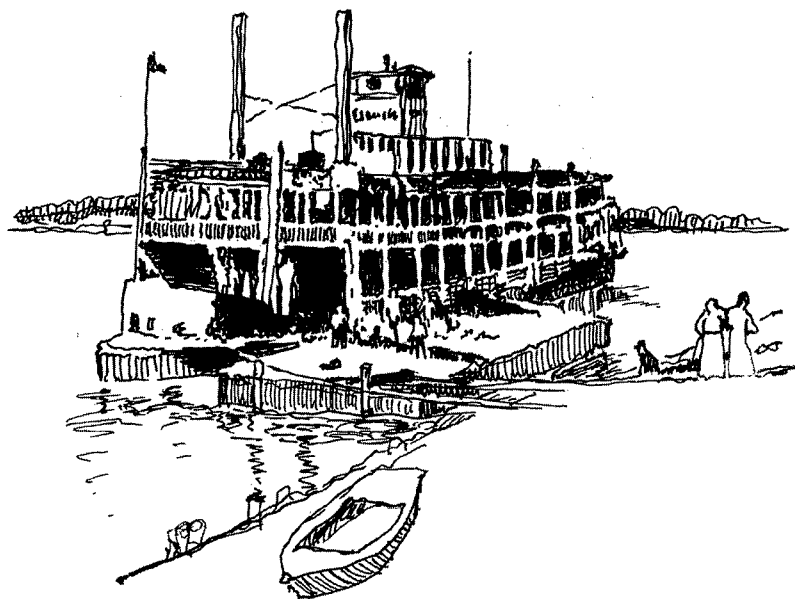


NADIR OF DEVELOPMENT

CROSSING LIGHTS TO AID NAVIGATION

The Corps of Engineers began putting up channel-crossing light structures where the channel crossed from one side of the river to the other in the 1920s. An oak post about 10 feet long had a half cross of 1-by-12 inch board near the top end. Opposite the bottom end was a small platform to hold a kerosene lantern, which was fastened to a nail in the post. A tree, properly located and of proper size, might substitute for the post. Lantern tenders were paid \$9.00 a month to add kerosene, clean globes, adjust and replace wicks.

The lanterns were not set up to illuminate the river. They were designed as steering beacons. The channel was located by sounding and inspection and then the lights were placed so that by steering toward them a pilot might be certain to be following the established channel.



COMMERCIAL NAVIGATION EFFORTS, 1888-1918

Some private-sector efforts to commercially navigate the Missouri River were the following: Macon Line, 1888-1893; Jones Line, 1900-1907; Kansas City and Missouri River Packet Company, 1890-1914; Kansas City Transportation and Steamship Company, 1907-1908; Kansas City Missouri River Navigation Company, 1910-1918.

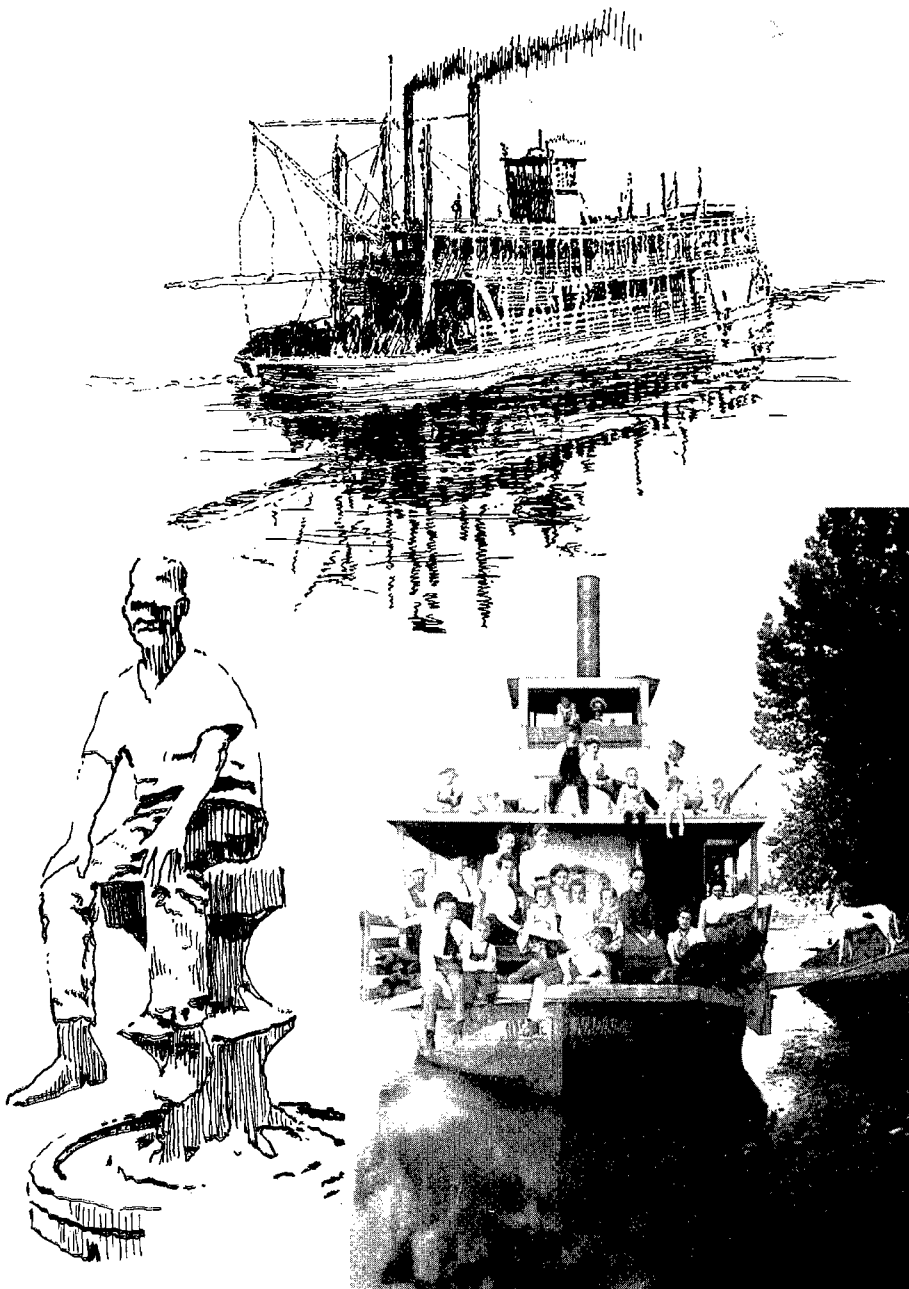
SHOWBOAT

In the early 1920s, a showboat, towed by a small steamboat, plied the river stopping at many river towns. The showboat was built on a barge and shaped like a long two-story house. The lower deck supported the stage, where vaudeville acts were performed. The upper level contained living quarters. According to George Kishmar, the showboat had a steam calliope which could be heard for at least three miles on a calm day. The man who played it had to wear asbestos gloves to keep from burning his fingers on the hot keys. "I attended several when they stopped at Chamois," said Kishmar.

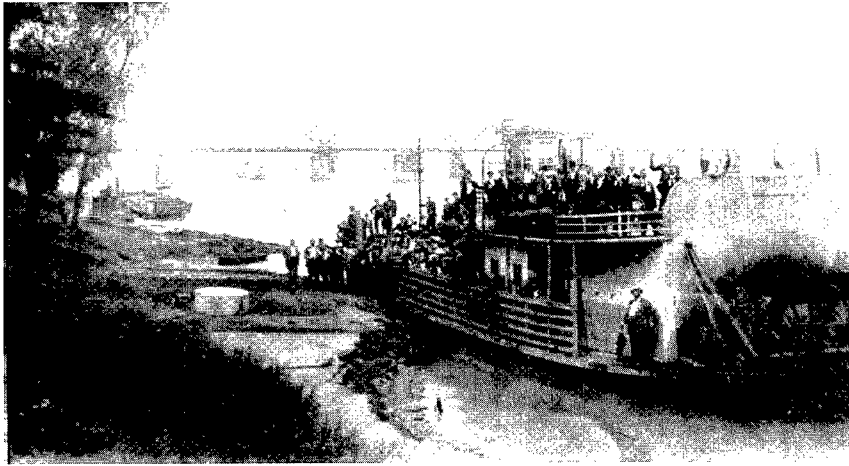


Captain W. L. Thompson





The Missouri River channel deteriorated. By 1921, only 35 percent of the six-foot-deep channel project was complete. The Kansas City District reported a dependable low-water depth of only 4-1/2 feet on the improved stretch from Kansas City downstream. District Engineer Major Gilbert Van B. Wilkes acknowledged "the necessity of curtailing all government expenditures" on the river except for maintenance.



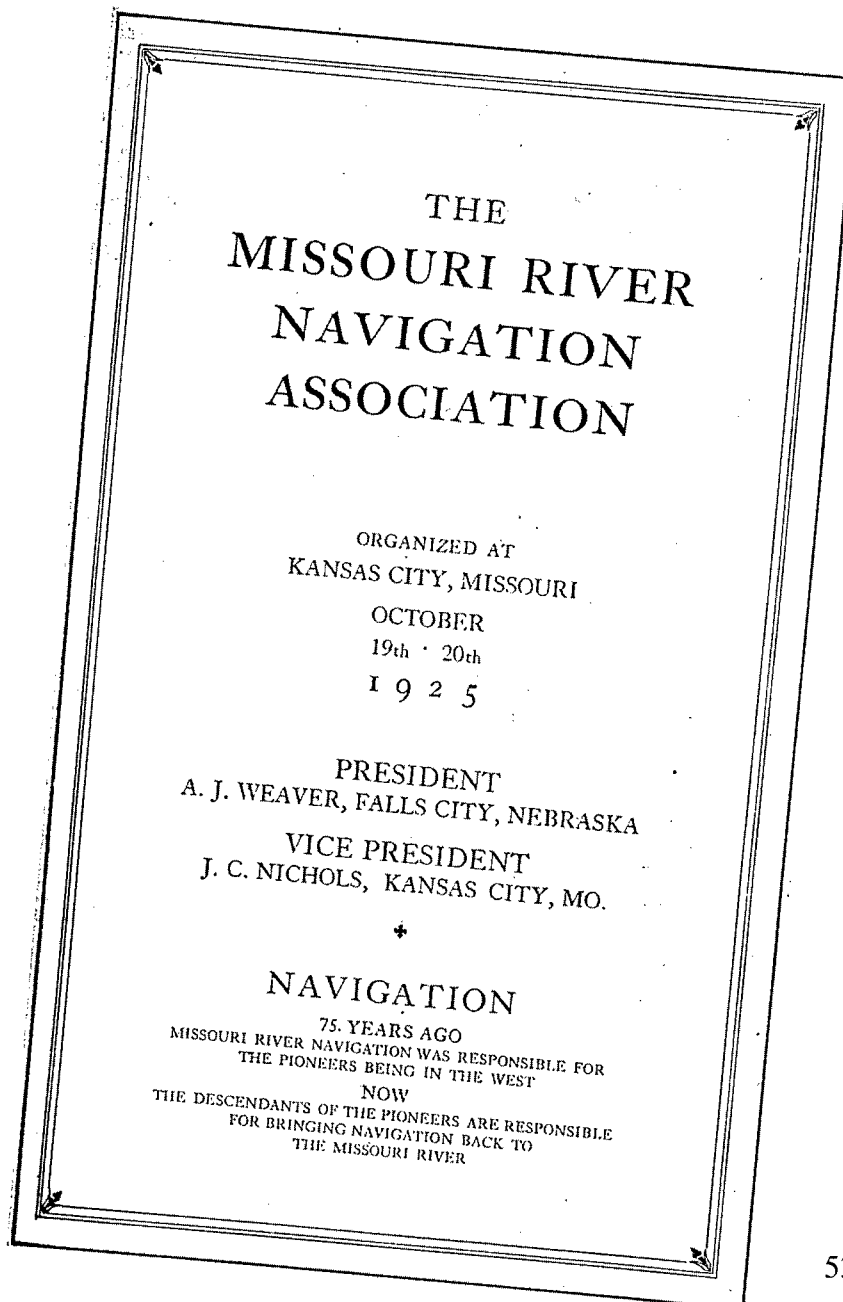
SOUNDING THE RIVER DEPTH

To see a river sailor taking soundings was a unique experience. The pilot clanged his bell and the deckhand standing in the prow of the boat thrust a 16-foot long, two-inch round pole into the stream. On the Missouri, the sounding rod had depth markings up to 12 feet in one-foot lengths. "No-o-o-o bottom," sang the deckhand when the water reached past the 12-foot mark. The pilot listened and the deckhand dipped again as the sounding vessel moved slowly forward. If the pole touched bottom at from 10-1/2 to 12 feet, he sang out "Ma-a-a-ark Twain." Lower readings meant calls of "Sca-a-ant Nine," and so on, in a sing-song cadence.

The views of the Kansas City District Engineer again differed from those of Missouri River navigation interests. The region's river development advocates mobilized forces under the broad-based Mississippi Valley Association and lobbied successfully to get \$1.2 million in appropriations in 1923. Under the direction of Major Cleveland C. Gee, the District resumed work on the lower channel project, which was mostly confined to repairing that which had deteriorated.

The river interests wanted more. In October 1925 they met in Kansas City and formed the Missouri River Navigation Association. At the initial meeting, they got Secretary of Commerce Herbert Hoover to be the keynote speaker. In a rousing speech on October 19, 1925, Hoover described his vision of a Mississippi valley system of inland waters that included a nine-foot-deep channel into the heartland with the navigation channel extending to Sioux City.

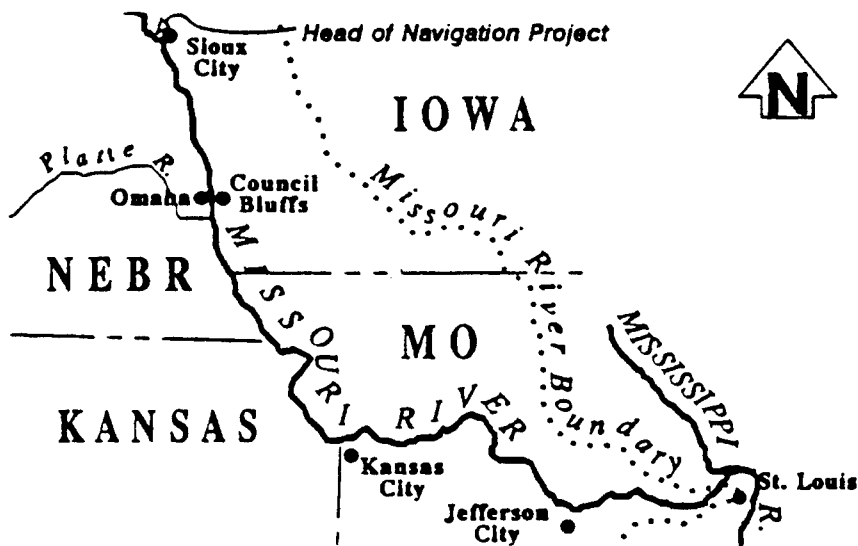
The next year, Gee recommended a less ambitious plan in a report based on a four-year study by the Kansas City District. The District studied the possibility of a channel upstream to Pierre, South Dakota. Gee thought a six-foot channel to Sioux City could be achieved. The Division Engineer preferred a still shorter channel project terminating at Omaha, and the Chief of Engineers rejected the entire project as unjustified from both the engineering and an economic standpoint.



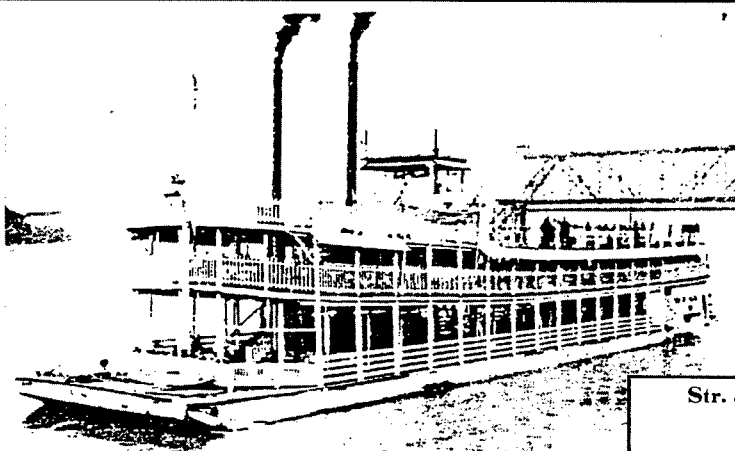
PLEA FOR RIVER WORK APPROPRIATIONS

Mayor Stewart Gilman of Sioux City testified June 15, 1926, before the Senate Commerce Committee on extending the channel project upstream: Answering a question from a committee member as to why the river was not navigated, Mayor Gilman said "About all the river is good for now is for a despondent farmer to commit suicide in." He said too many of them were in that condition and were "expecting the federal government to devote some attention to their condition."

Congress opted for Hoover's grandiose scheme. It approved extending the navigation channel upstream to Sioux City and "authorized to be appropriated" \$12 million for the project. Congress also requested a study to determine the feasibility of a nine-foot deep channel from Kansas City downstream. The river interests were ecstatic.



Missouri River Navigation Channel.



EXCURSION STEAMER JOHN HECKMANN

In 1927, Captain Edward Heckmann tramped his excursion steamer the *John Heckmann*, to Sioux City. His primary objective, he said, was to show that the Missouri River was navigable in fact as well as theory. The *John Heckmann* drew as much water as a freight steamer and had to overcome the same navigation obstacles. With dimensions of 163.6 by 30.5 feet and licensed to carry 1,200 passengers, it was the largest steamboat ever built with private funds to operate on the Missouri River.

Sir. John Heckmann



STEAMBOAT EXCURSIONS

2 Trips **SUNDAY, JUNE 10** 2 Trips

Boat leaves Hermann 1 p. m. sharp — Leaves northside, opposite courthouse at 1:30 p. m. — Arrives Gasconade 3 p. m.

See the ball game at Gasconade
Hermann vs. Gasconade.

See the big slide on Mo. Pacific — See the Gov. Boatyards.

Boat leaves Gasconade 5:30 p. m., arriving at Hermann at 6:30 p. m.

Fare Round Trip — Adults 75c Children 25c.

NIGHT TRIP

Boat leaves Hermann at 8:30 p. m. — Leaves northside at 9 p. m. — Arrive at Gasconade 10:30 p. m. — Leaves Gasconade 10:45 p. m. — Arrive Hermann 11:30 p. m. Fare Round Trip Adults 75c Children 50c.

Dancing Both Trips Free

EDW. HECKMANN, Master

NAVIGATION CHANNEL RECONNAISSANCE SURVEYS

In 1929, the Corps of Engineers began running reconnaissance surveys from Boonville to the mouth of the river. The crew consisted of three men. The chief of the party plotted the channel depths on maps provided by the office and wrote steering directions for the channel. The motorboat operator and the deckhand, besides untying and retying the launch, measured the depth of the river to locate the channel. They used the sounding pole, said George Kishmar.

During October 1929, Kansas City District Engineer Major Gordon R. Young presided over public meetings to obtain local opinion on the nine-foot channel. For four days he listened to development advocates, mostly sponsored under the umbrella of the Missouri River Navigation Association. They expressed overwhelming support for the nine-foot-deep channel. The transcript of the proceedings required 650 pages of print.

Major Young evaluated the information, juxtaposing the estimates of benefits from a six-foot channel and a nine-foot deep channel. He concluded that river traffic would benefit substantially from a nine-foot channel. The larger challenge was the engineering challenge to achieve the greater depth.

NAVIGATION CHANNEL INSPECTION, 1929

George Kishmar, youthful operator of the launch *Yellowstone*, talked about an inspection trip with Major Young on March 7-20, 1929:

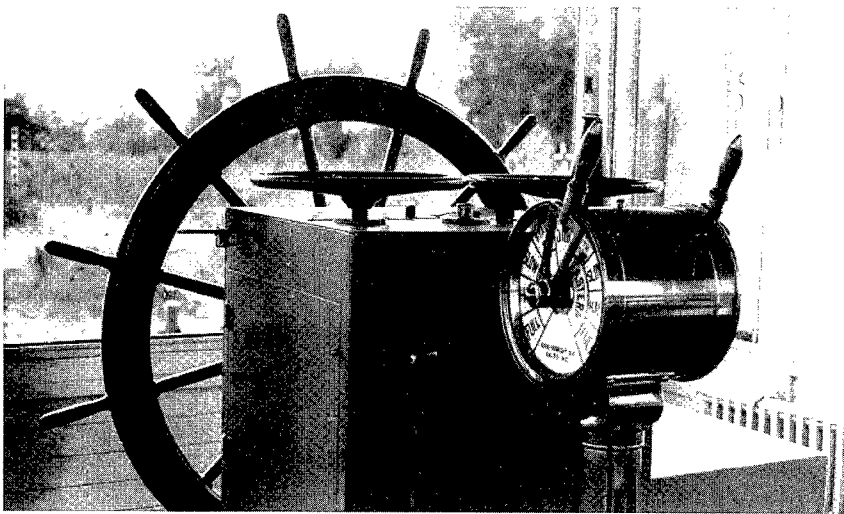
"My first trip down the Missouri from Gasconade began on March 7 in the launch *Yellowstone*. It was an inspection trip with Major Gordon R. Young, District Engineer; Captain Collins; Mr. Jackson; Mr. Kunz; Steamboat Captain Ramey Williams; Floyd Macklin; and William Worthington. (The last two were to be chiefs of the survey party.) We stopped at Hermann for lunch (dinner in those days; lunch was served between meals). Then we went on to Washington. Gasconade, mile 104. Washington Landing, 68.4. On the 8th we left Washington and went as far as St. Charles, mile 28, same party on board. On the 9th, leaving St. Charles, we stopped on Louis Bickle's construction Corps fleet, 3 miles below St. Charles, where we stayed till noon and ate dinner there. Afterward completed the trip to the mouth of the river. Returning upstream, those from Kansas City got off at mile 4.4 into waiting cars for the trip back to there. The two party chiefs and I continued back to St. Charles, where we stay overnight. The 10th and 11th we standby at St. Charles. Receive orders . . . to return to Gasconade, which we do on the 12th and 13th. On the 14th the three of us leave downstream in the same boat on a sounding trip."

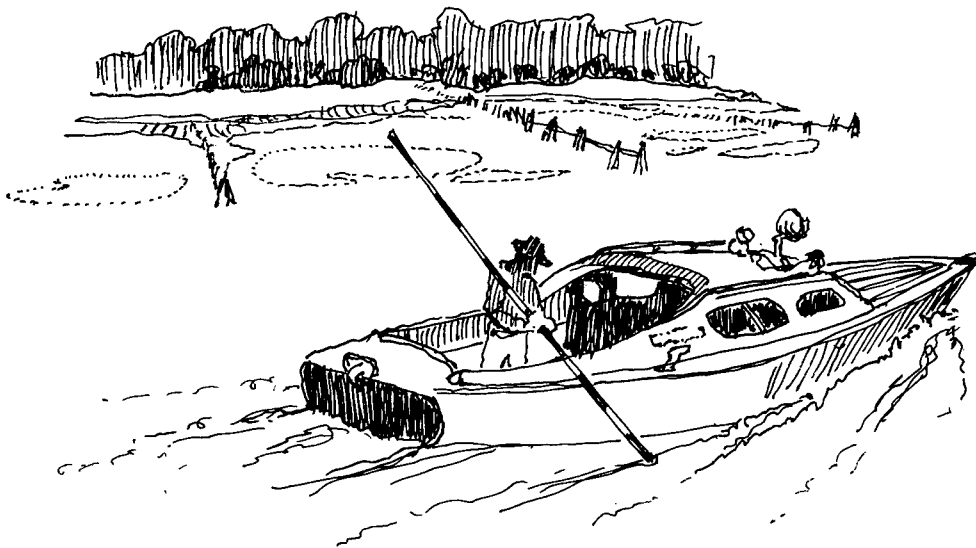
The Corps of Engineers considered alternative ways to achieve the nine-foot-deep channel. Dredging was inefficient and impermanent. Canalizing the Missouri was impracticable because of the heavy silt load. For similar reasons and because of the expense, low dams and locks were infeasible. High dams required the permanent flooding of too many acres of valuable agriculture land. The most feasible way to achieve a nine-foot channel depth was "not so much to 'regulate' the river in the . . . [European] sense, as to obtain a river to regulate."

Major Young echoed the earlier Suter report. He emphasized the importance of barring the river from its incessant meandering across the floodplain, pegging it down to a fixed alignment. "The great burden of sediment in the Missouri makes this an easy

(though expensive) task, since, if a stout permeable obstacle be interposed to the flow of the water, there is an immediate fill to approximately the height of the obstacle." He said all concave alluvial banks must be protected from the water's erosive cutting action.

Young said that he was uncertain whether it was even possible to obtain a nine-foot-deep channel. An extensive hydraulic survey would assist in that determination. In the interim, the Kansas City District would proceed with work to complete and maintain the authorized six-foot channel. Funding during the 1930s was provided through public works appropriations to create work for relief to unemployed people.





WORKIN' ON THE RIVER

HIRING A PERMANENT CORPS EMPLOYEE, 1927

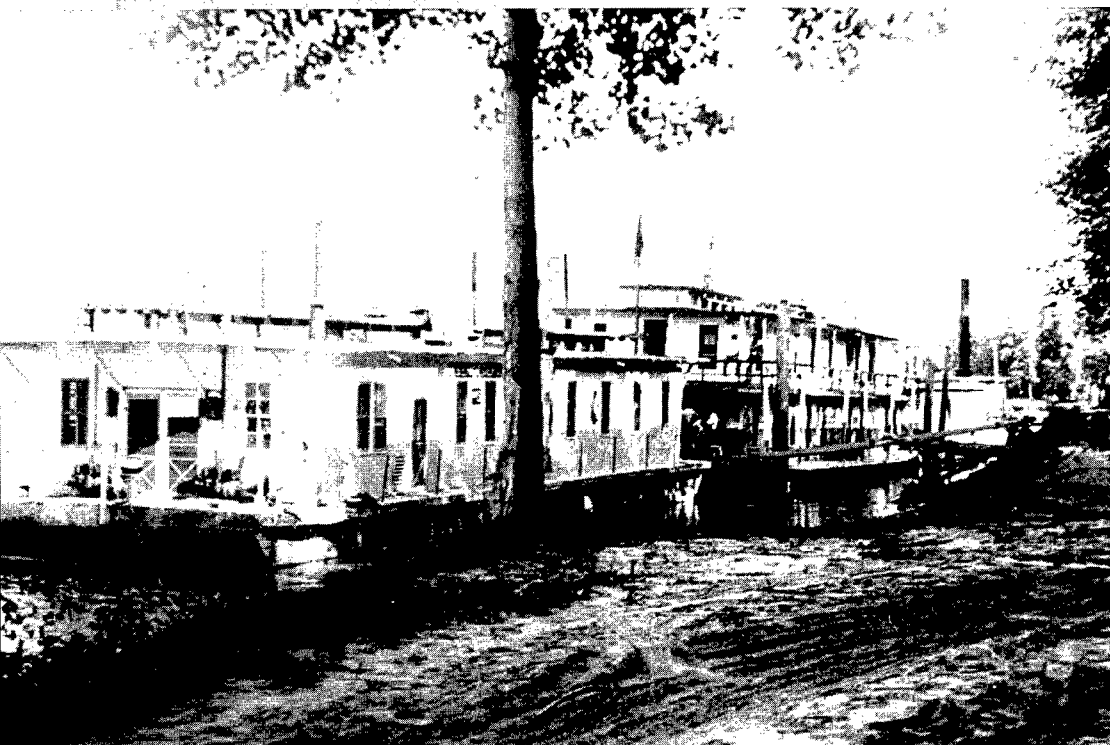
George Kishmar, 17 years of age, explained how he was hired:

"On July 19, 1927, a Corps of Engineers construction fleet was building dikes in the river just below Chamois. I asked for and was told to report for work the next day. I quit my job at the shoe factory and on the 20th I began my career on the river. My work consisted of throwing bundles of willow brush from the barge upon which they were loaded onto the mat barge. There would be 5 or 6 willows about an inch in diameter or 2 or 3 about 2 inches or larger in diameter about 12 to 14 feet long, tied in a bundle with thin wire.

I worked throwing down brush or passing it to the weavers to the end of the construction, the first of December, when I was laid off. I then went back to work in the shoe factory until about the middle of April 1928. The hours worked and the pay was the same as before, at 0.14 cents an hour. While I worked in the factory, I gave my parents \$1.00 a week for room and board out of the \$7.56 I made. While working on the river, I gave them \$1.00 each day when I boarded at home.

In mid-April, I quit my job at the shoe factory and went back on the river to work. This time on a pile driver, as the stern deckhand. I worked on the pile driver to the end of the season, the first part of December. Then the fleet, including all attendant plant, would be towed to the Corps boatyard harbor at the mouth of the Gasconade River by steamboat. There it was free of the floating ice and/or blockage of the ice in the Missouri River during the winter months.

On February 25, 1929, Mr. C. A. Kunz of the Navigation Section from the Kansas City office of the Corps of Engineers came to Chamois. He had been informed that my brother Tom had been a motor boat operator on a boat of the Corps on construction work the previous season. He might be available to operate a reconnaissance motor boat the Corps had decided to use to obtain channel information in the upcoming season. . . . After explaining the details of the job to my brother, he declined to accept it. . . . Arthur Harrison, a superintendent on a fleet on the upper river below Kansas City lived at Chamois and knew that I had operated my brother's own motor boat we used in fishing. Evidently he told Mr. Kunz about me.



They called me in and Mr. Kunz asked me several questions pertaining to the river and the operation of motor boats. After answering them, evidently he was satisfied with my qualifications. He told me to report to William Worthington, who was to be the chief of the party and was at the Gasconade Boatyard. I reported to him on the 26th. . . . My salary was to be \$100.00 a month plus \$2.00 a day expense money when out on a trip when meals and lodging had to be paid for.

Thousands of men labored along the riverbank in Missouri. They were working at the tasks of preventing the river from cutting its banks by placing revetment and then constricting it by diking. The goal was to put the river in place and hold it there. Quarter boats, where the workers slept and ate, lined the banks.

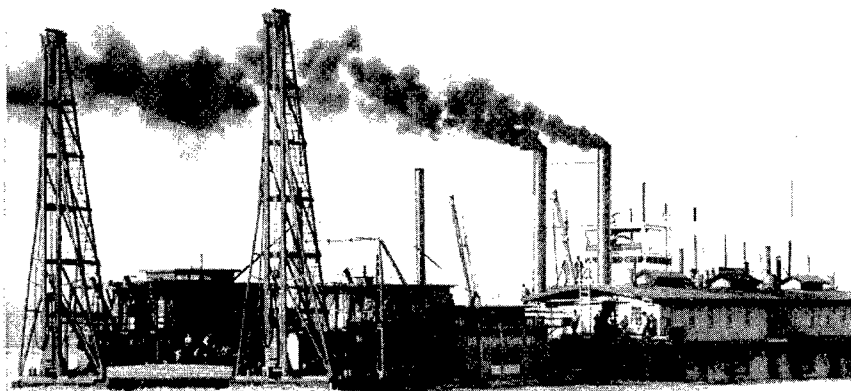
QUARTERBOAT LODGING

Kishmar explained Quarter Boat lodging:

"In 1927, when the fleet completed the job at Chamois and moved away to another site, lodging and board was provided on the quarter boat. The amount charged was taken out of our pay check.

A quarter boat was like a two-story building built on a barge. Most were about 90 feet long. The one with this fleet was 110 feet. They were then equipped with a coal-burning cook stove, a cook and two waiters. Civil Service employees sat at a separate table at one end of the lower deck, called a sharp end. Other employees had a dining room on the other end. It was called the "dull" or "gandy" dining room. Double or triple bunk beds were on the second deck, as was the office. The superintendent had a room of his own. Civil Service employees slept two to a room. Others slept in bunk beds on both sides of the room, which was almost one third the length of the boat. In cold weather, potbellied coal-fired stoves heated the sleeping quarters.

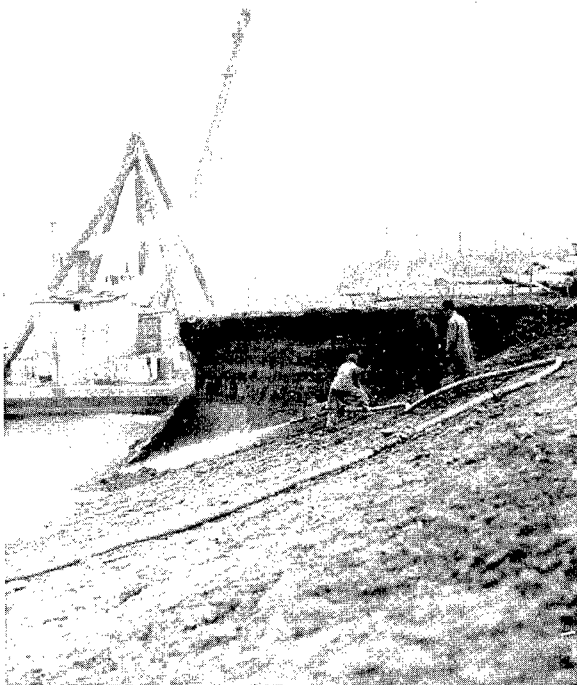
On each end was a hand-wound capstan by which lines fastened to trees on the bank would be tightened after spar poles were put out at each end of the



WORKIN' ON THE RIVER IN THE DEPRESSION THIRTIES

Near the historic village of Arrow Rock was a thriving center where workers blasted more than 800 yards of rock daily out of the hillsides. Fleets of trucks formed a constant parade to waiting barges, which were loaded and towed by government power boats to various points of activity.

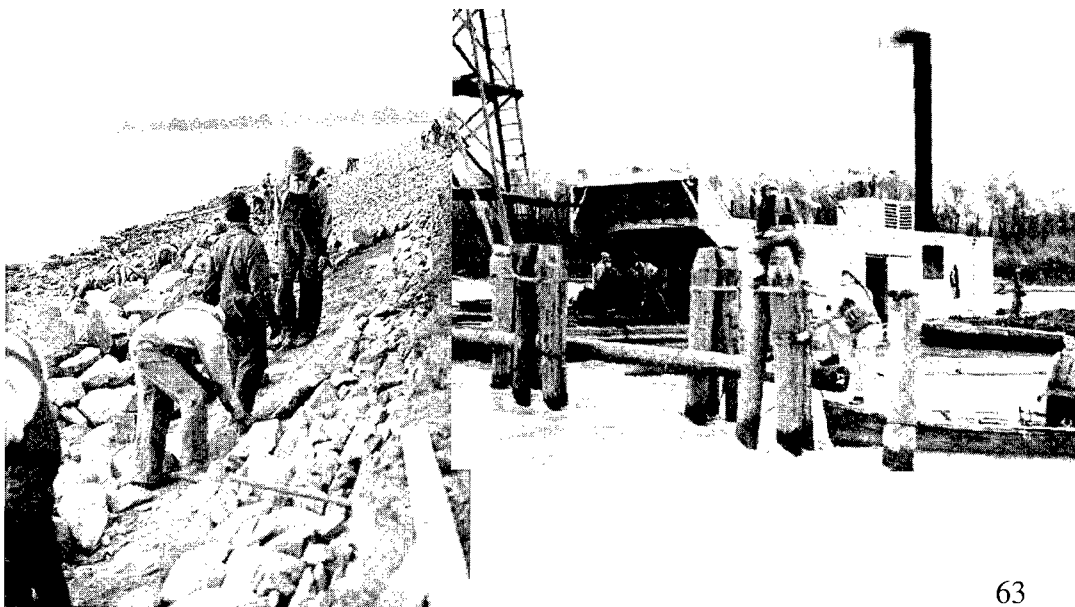
Along the banks, on the concave sides of the river bends, crews manned hydraulic hoses. They were cutting the banks into

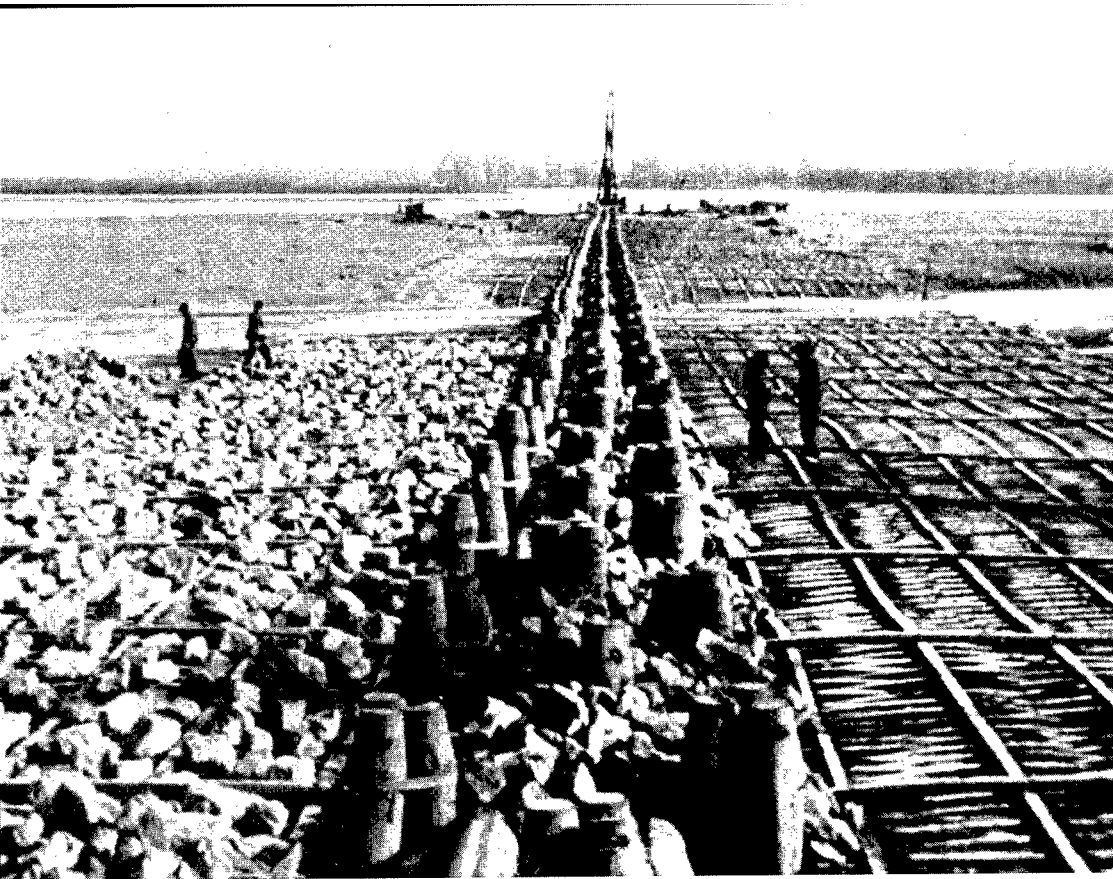


terraces with hydraulic pressure of from 125 to 200 pounds to the inch, creating a powerful jet stream from the river water. Great hunks of jagged shoreline dropped into the river as the smoothing process progressed in preparation for paving that was to follow.

The grading was followed by laying tons of rock on the smoothly sloped banks. From out on the river, the finished bank gave the impression of a receding concrete wall. The intent of the revetment was to defy the constant cutting action of the water at various stages, holding the banks in place.

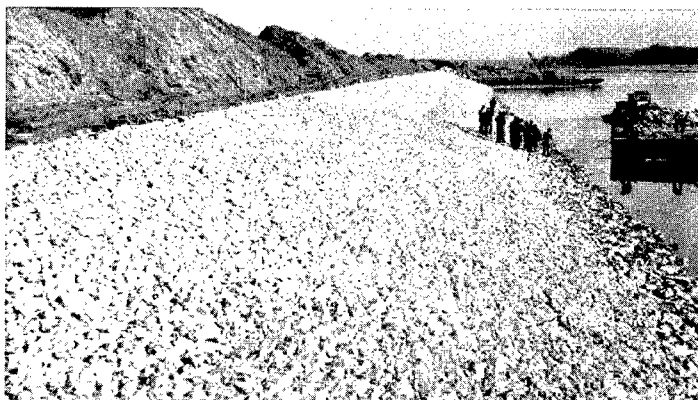
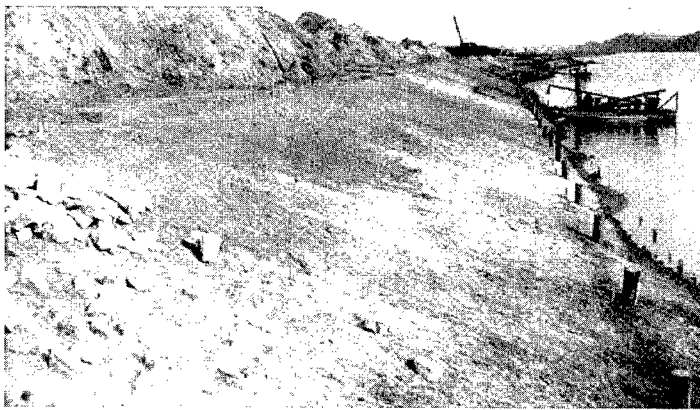
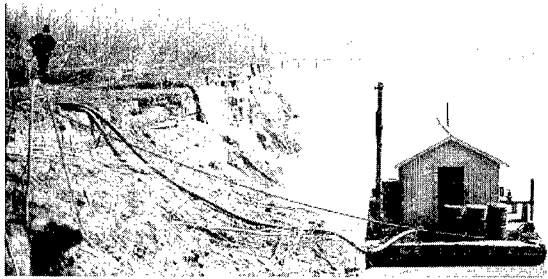
At other points along the river, on the convex sides of the curves, men were engaged in extending piling dikes into the stream. Giant steam-driven mechanical pile drivers were sinking rows of pine or cypress poles deep into the bed of the river and extending





at angles out into the stream. The intent was to narrow the wide channel, confining it to a single fixed place by using the force of the stream's velocity to scour out sediment and deepen the channel. The dikes would divert the force of the water away from the low-lying land and across to the bluff side. In 1930, between Kansas City and the mouth of the river 56 pile drivers were operating around the clock.

This simple principle is the touchstone of Missouri River navigation channel development. It was advanced by Corps engineers decades earlier and by 1930 was working out as theorized. The Missouri River was 200 to 1,500 feet wide around the curves, where once the stream divided into forks covering a half mile or more. Engineers, those who used the river, and riverine land owners were thrilled with the results.



The success of such work was already evident on other reaches of the Missouri River. In 1930, the river hugged the shore on the west side of the Kansas City airport. Tons of earth, vital for the east-west runway, were plunging into the water, undermined by the swift current.

Army Engineers used the same methods there as in other Missouri River reaches in preparing the stream for modern navigation tows. Willow mats, weighted by rocks, were put into the stream at right angles to the banks. Engineers drove piling through them. Row after row of such piling dikes were extended into the stream.

The dikes on the lowland side of the streambank retarded the current, which was heavily weighted with silt. The deposited sediment gradually built up the streambed until it became a mass of new land where once the channel flowed. The channel was shunted to the west side of the stream, as Corps engineers intended.

The airport property was protected from further erosion. The level of the new land would be raised as high water flowed over it, and eventually the dikes would be submerged. The new land could be used in the future to extend the runways over the former meandering channel. All along the lower Missouri, similar methods were being used to achieve similar results.



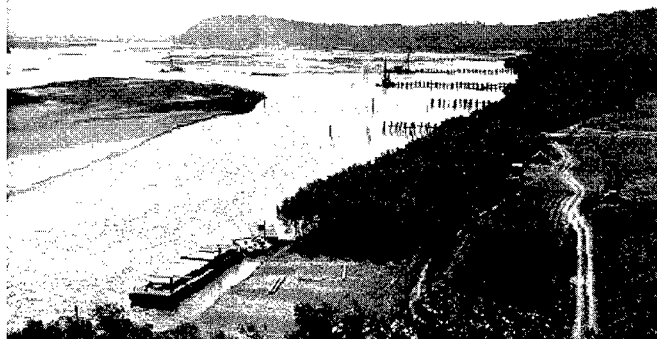
VESSELS OPERATED BY U.S. ENGINEER OFFICE, KANSAS CITY, as of September 1932:

Name of vessel	Type of Vessel	Kind of power	Horse power	Draft	
				Light	Loaded
General Chittenden	Towboat	Steam	250	2 0	2 6
Edwin M. Baldwin	do	do	250	2 8	3 11
Bixby	do	do	550	3 3	3 6
Daniel Boone	do	do	178	1 10	2 3
Geo. G. Keith	do	do	250	2 11	3 2
Suter	do	do	461.6	3 5	3 6
Wild Goose	do	Diesel	180	3" 1	3 8 ½
Robert McGregor	Dredge	Steam	900	3 6	— —
Captain Meriwether Lewis	do	do	1,400	3 11	4 1
Captain William Clark	do	do	1,400	3 11	4 1
Horatio G. Wright	Snagboat	do	600	4 6	4 6
Sergeant Floyd	Inspection boat	Diesel	600	— —	3 7½

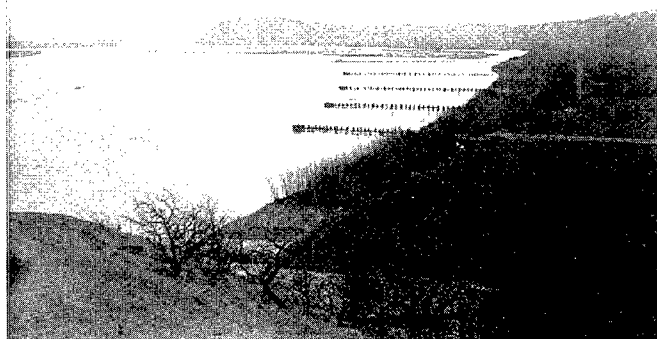
Name of Vessel	Registered net tonnage displacement	Length over all	Over-all width amidships	Type of Propulsion
General Chittenden	159.9	130 0	26 0	Stern wheel
Edwin M. Baldwin	143	139 0	24 0	Do.
Bixby	288	159 0	30 0	Do.
Daniel Boone	146	128 2	26 0	Do.
Geo. G. Keith	180	128 2	26 0	Do.
Suter	288	159 0	30 0	Do.
Wild Goose	140	100 0	22 0	Do.
Robert McGregor	769	207 11	44 4	Do.
Captain Meriwether Lewis	1,456	268 11	84 8	Side wheel
Captain William Clark	1,466	268 11	84 8	Do.
Horatio G. Wright	1,200	187 0	92 0	Do.
Sergeant Floyd	312	138 0	30 0	Twin screw.

The work done by the Corps of Engineers on the Lower Missouri River resulted in some dramatic changes. The following photos show the same bend of the river in different years:

1934



1935



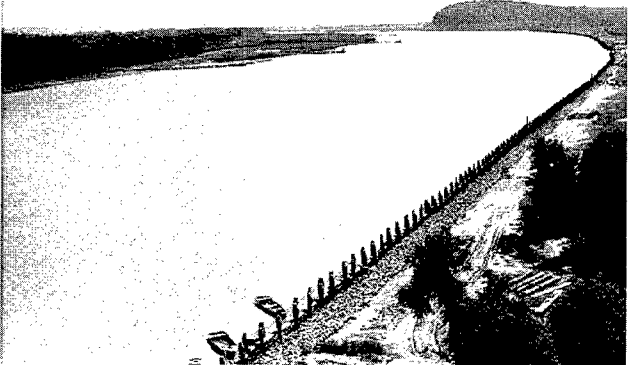
1936



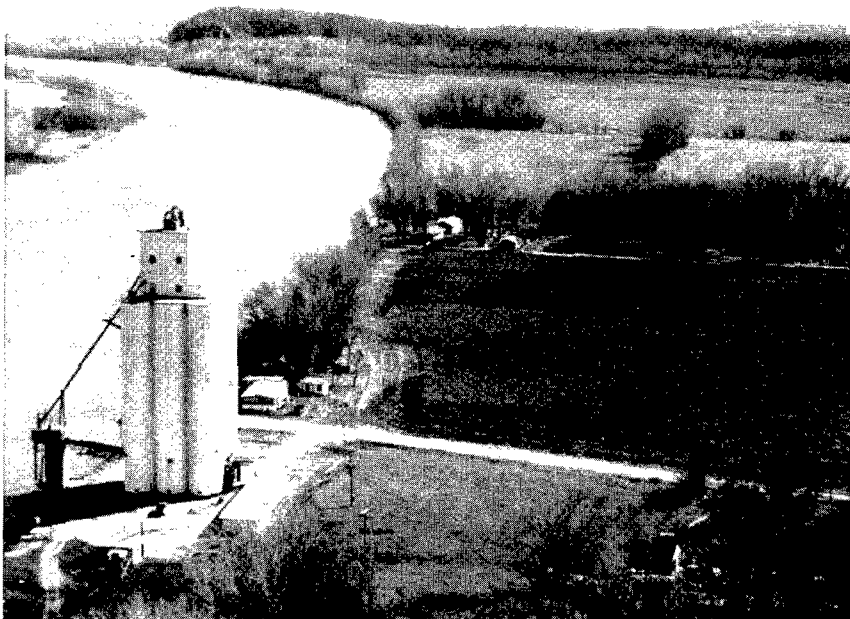
1939



1942



1983





ACHIEVING MINIMUM CHANNEL

MISSOURI RIVER PILOT'S REPORT, 1930

Pilot's Missouri River report, November 7-16, 1930:

"November 1. I leave Glasgow. 2nd. Arrive at Missouri City. Eat a steak supper, fried, with potatoes and gravy, at Fred Fancher's store. 0.75 cents. Then sleep at his house. \$1.00. 3rd. After breakfast of country ham and eggs at his store, we leave and arrive at Kansas City. Sunday at Kansas City.

4th. Leave, arrive at St. Joseph. On the 6th, Colonel Clarence Sturdevant, Broyles, Cecil Griffith, and Smith arrive from Kansas City. 7th. We leave early in the morning. Besides recording of depths by Griffith, Broyles wrote steering directions, which later turned out to be the first Pilot's Report ever recorded by the Corps on the Missouri.

As the stage of the river was very low, it took a lot of time finding the deepest channel. We eat dinner at Atchison, Kansas, mile 422.6. Then on to Leavenworth, mile 397.0.

8th. Leave and arrive at Kansas City. 9th. Sunday at Kansas City. 10th. Albert Manning joins the party as deckhand, which makes three. We leave, eat dinner at Missouri City, then on to Lexington for the night. 11th. We lose some time waiting for fog to lift. Sound to the mouth of Grand River, mile 250.0. Run up that river to Brunswick about 3 miles.

12th. Leave, eat dinner at Jefferson City, then on to Chamois. . .

14th. Leave, stop a while at the Boatyards. Eat dinner at Hermann, then on to Washington. 15th. Leave, eat sandwiches on the way, run to St. Charles. 16th. Leave, sound to the mouth, then run down the Mississippi River to St. Louis. All but Mayer and I return to Kansas City by train."

The Corps of Engineers estimated that as of 30 June 1932 the work for a controlled six-foot-deep channel to Sioux City was 92 percent completed. The Corps reported that the work accomplished included 680,566 feet of revetment for the purpose of permanently fixing the banks and 1,114,435 linear feet of dikes for shaping and stabilizing the navigation channel. The result was the control of the water flow to a single prism of water.

The Corps concluded that “both the river and the navigation channel [were] becoming fixed and there [was] a marked improvement of navigation channel depths.” Commercial shipping on the river in 1932 was, however, only about one-third the tonnage carried on the unimproved river in 1867. By the later date, the federal government had spent \$68 million on Missouri River channel improvements.

The Missouri River Navigation Association argued that the money was well spent: “An inventory of the property lying in the Missouri River bottoms, from the mouth to Sioux City, reveals an enormous property investment, all of which . . . with an unstabilized river, would be exposed to destruction by erosion or to flood damage” It estimated 1.9 million acres of bottomlands, 17 railroads, and 13 highways in the floodplain at a value of \$325,720,000.

The association claimed that the increase in taxable wealth from Corps of Engineers’ navigation work on the river would “amount to more than the entire cost of the Missouri River improvement.” The association emphasized the work was for the purpose of navigation and was not being advocated for the protection of property. It “merely” wanted “to show some incidental benefits of this work.”

This by-product of Missouri River improvement for navigation had been estimated earlier. Government documents recorded that losses caused by erosion averaged \$45,000 a river mile in a 10-year period. The cost to control the river was estimated at \$125,000 a mile. Within a few years, the economic savings on farmland alone would equal the cost of the river improvement and the river was being improved for another purpose entirely, proponents argued.



The Corps of Engineers in 1932 expressed confidence in the work completed on the lower Missouri River. It was, however, a time of drought and the Kansas City District Engineer noted the difficulties in maintaining a six-foot depth at Kansas City with a minimum of 20,000 cubic foot per second (cfs) of water flow in the channel. Only one-half of that flowed past the Kansas City neighborhoods of Armourdale and the Argentine. There was to be no escape from the drought that began in the Missouri basin in 1931 and lasted a decade.

REPORT ON LOW-WATER CONDITIONS

September 8, 1931. "Arrive at Kansas. Leave in the launch and arrive at St. Joseph the 10th. Broyles, Manning, Smith and Victor Flander, a mate from the dredge *McGregor*, to assist in the sounding, arrive from Kansas City. 11th. Leave. Arrive at Kansas City the 12th. Sunday, 13th at Kansas City. 14th. Leave, same party. Arrive at Lexington. 15th. Leave. Arriving at Sheep Nose Bend, mile 311.2, we find the channel and river diked off into only a one-foot depth. Since the *Catamount* drew two feet, we had to wade and carry the boat's anchor and line about 40 feet to the end of the dike. Then by putting the line around a kevel on the stern of the boat, it was maneuvered into position stern first, so that by using the propeller to wash a hole ahead at about eight feet at a time. Then the slack in the line would be taken up by the capstan on the bow of the boat and the washing continued. We lost five hours getting around the end of the dike and back into the channel on the lower side. We arrive at Waverly for the night. 16th-20th. Complete the trip. As the river was very low, we went aground at two different locations."

The Kansas City District Engineer, Captain Theodore Wyman, Jr., concluded that "the only feasible means" of ensuring minimum flows required for navigation was by means of reservoirs for headwater storage. "The reservoir site at Fort Peck, Montana, is the most suitable location to meet this condition," he said. Wyman reported to the Division Engineer of the Upper Mississippi Valley Division on 30 September 1932.

KANSAS CITY DISTRICT ENGINEER'S REPORT, 1932

Captain Wyman said the following: "The proposed plan for the ultimate development of the water resources of the Missouri River comprises improvement of the main stem from Yankton to the mouth to provide for 8-9 foot navigation by open channel regulation, supplemented by the Fort Peck Reservoir . . . to provide a minimum flow of 30,000 second-feet at Yankton during the navigation period, March 15 to November 15, and by the Topeka navigation flood control reservoir . . . , operated to supply all remaining deficiencies below 35,000 second-feet at Kansas City, 40,000 second-feet at Hermann, and 77,000 second-feet at St. Louis."

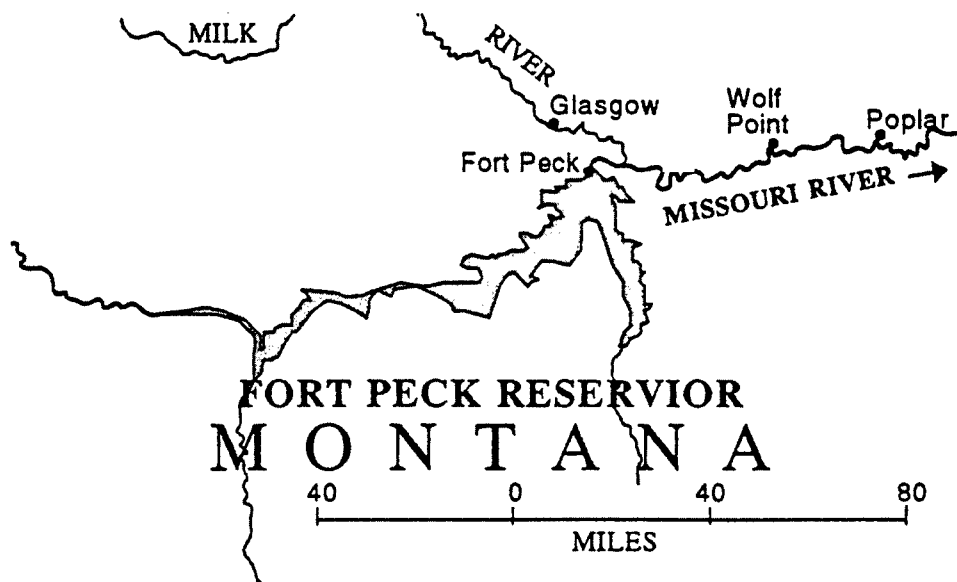
Colonel George R. Spalding, the Division Engineer, was not in complete agreement with Captain Wyman. He said that it seemed to those immediately responsible for the Missouri River navigation channel work that they were achieving "success in the attainment of the rather limited objective sought." But the subsequent drought revealed that the river's natural flow was "entirely inadequate" to attain project purposes.

Colonel Spalding questioned whether the channel would ever be adequate or dependable. The interests involved were so committed, however, that it would not be prudent to abandon the project work already authorized and accomplished. He believed the Corps of Engineers should defer any further decisions until it had more experience in the cost of maintenance and should study water-supply questions before it recommended storage reservoirs.

Captain Wyman did not address the adequacy or inadequacy of the existing project from the point of view of successful commercial navigation. The Division Engineer's quarter century on the Mississippi had shown him that significant volumes of shipping moved only on deep-water channels with slower currents than the Missouri's fast downstream pace. He said that: "Large incidental benefits in the way of protection of highways, railroads, communities, and farmland from caving banks, and also a benefit to Mississippi navigation . . . would arise from the full completion of such a navigation project but these additional benefits do not serve to justify the large cost involved."

The Board of Engineers for Rivers and Harbors concurred with the Division Engineer. The board said it thought the authorized project should be completed from the mouth to St. Joseph and a trial made through the operation of the Federal Barge Lines (FBL) to determine whether a substantial amount of commerce would move on the improved river before making expenditures for reservoir construction and additional improvement above St. Joseph.

The Chief of Engineers dissented from these views. He recommended the authorized six-foot channel project "be vigorously pressed to completion" to Sioux City. The Chief also wanted to see the Fort Peck site developed "to the maximum practicable capacity."



By the time the Chief of Engineers accepted Wyman's recommendations, the legendary hundred days of the first New Deal Congress had drawn to a close. Reacting to the nation's severe depression with a flurry of legislation, Congress had turned its attention to waterways. The National Industrial Recovery Act (NIRA) included authority for the president to act in the development of water resources projects as a means of addressing pressing unemployment. The act included, however, a clause constraining arbitrary presidential action. The NIRA provided that no federal river projects could be initiated without the recommendation of the Chief of Engineers.

Two weeks after the Chief's recommendation, President Franklin D. Roosevelt used his NIRA authority and the accompanying funds to approve the Fort Peck project. Within a week of Roosevelt's decision, Captain Wyman opened an area office of the Kansas City District in Glasgow, Montana, more than 1,500 river miles above the home office. A significant dimension was added to the viability of navigation on the Missouri River.

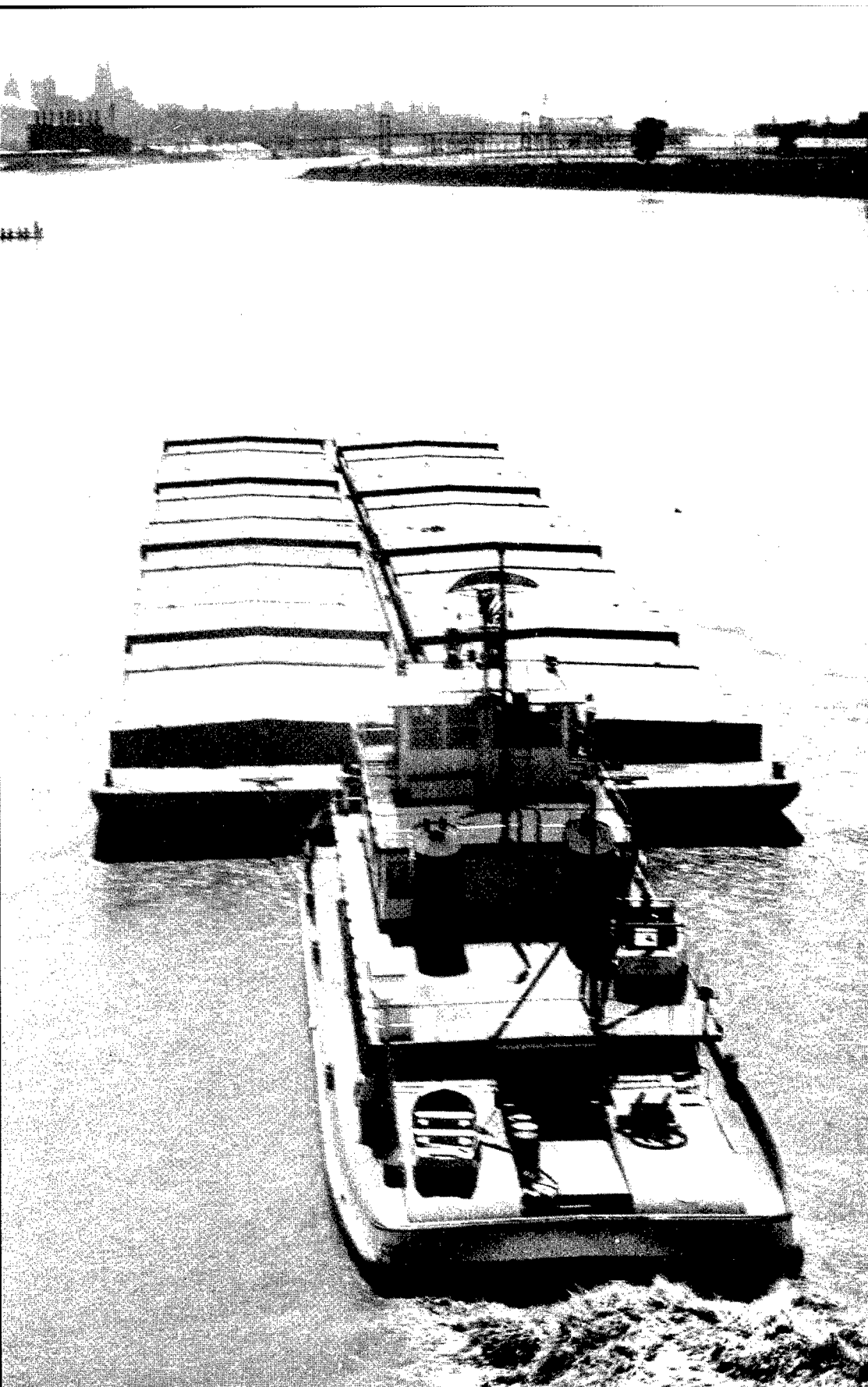
With so many dollars supporting efforts on the river reaches extending over such vast distances, the Corps of Engineers reorganized to more effectively and efficiently perform the extensive work that the Kansas City District had been assigned. On October 27, 1933, supervision of the river was withdrawn from the Upper Mississippi Valley Division and placed under a new Missouri River Division, which superintended three newly drawn Districts.



*Ft. Peck, the town
and dam project*



Initially, the Kansas City District's jurisdiction began at St. Joseph and extended only to Hermann, Missouri. The District's authority was soon extended upstream to Rulo, Nebraska, and downstream to the river's mouth.



COMMERCIAL NAVIGATION

INLAND WATERWAYS CORPORATION TO SERVICE MISSOURI RIVER

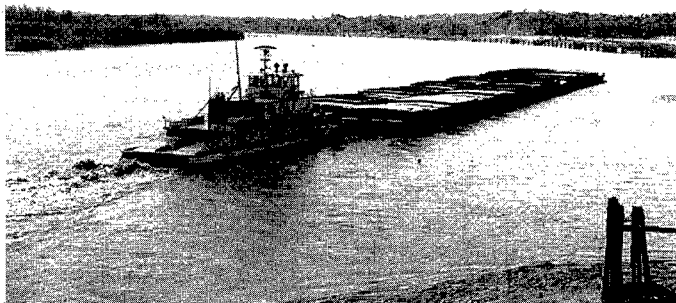
On September 28, 1933, Acting Secretary of War Harry H. Woodring, announced:

"The Chief of Engineers having certified that a sufficient and dependable channel will have been completed on the Missouri River from its mouth to Kansas City, Missouri, . . . by March 1, 1934, the Inland Waterways Corporation is directed to make a survey of traffic, tariff, arrangements, and terminal facilities of this waterway as required by law. The survey will be completed in such time so that the services of the Inland Waterways Corporation can be extended to this waterway during the spring of 1934."

While the Corps of Engineers pursued its work to completion on the authorized navigation channel, other interests began moving commerce on the river. Federal Barge Lines (FBL), a subsidiary of the government-owned Inland Waterway Corporation, in 1935 implemented an earlier recommendation of the Board of Engineers. During August and September, the FBL moved grain downstream from Leavenworth, Kansas. It ran the river from Kansas City to St. Louis with two towboats and added a third in 1938. During 1937, the FBL tows barged 60,000 tons of freight in regular runs in the section below Kansas City; in 1938 the tows transported 120,000 tons. No private lines had as yet attempted to begin regular service on the Missouri River.

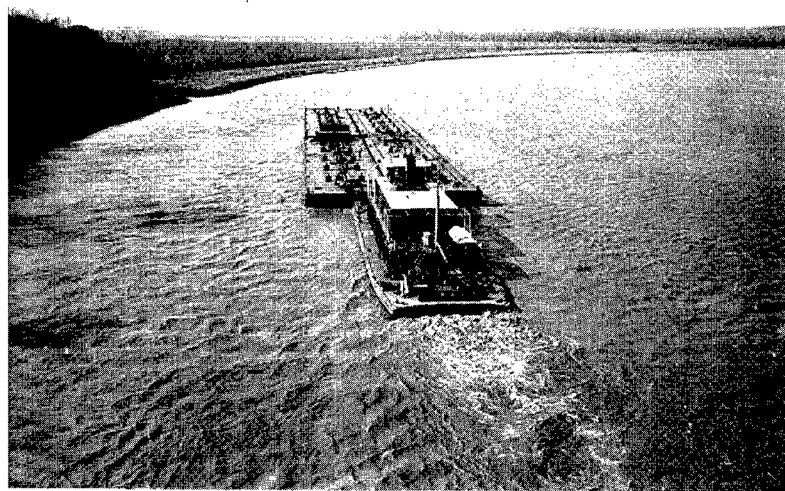
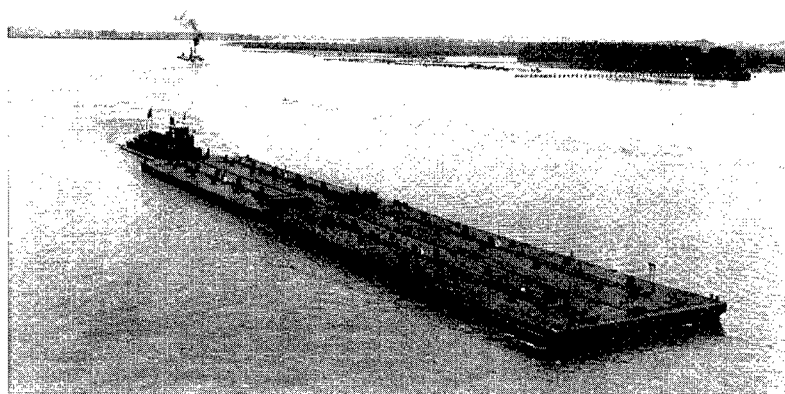
FEDERAL BARGE LINES' TRIAL RUN

Federal Barge Lines made a trial run from St. Louis to Kansas City in June 1932. The Corps of Engineers' launch *Catamount* with George Kishmar at the helm, escorted the Barge Line's towboats *Mark Twain* and *General Ashburn*, each with an empty barge. The purpose of the trip was to demon-



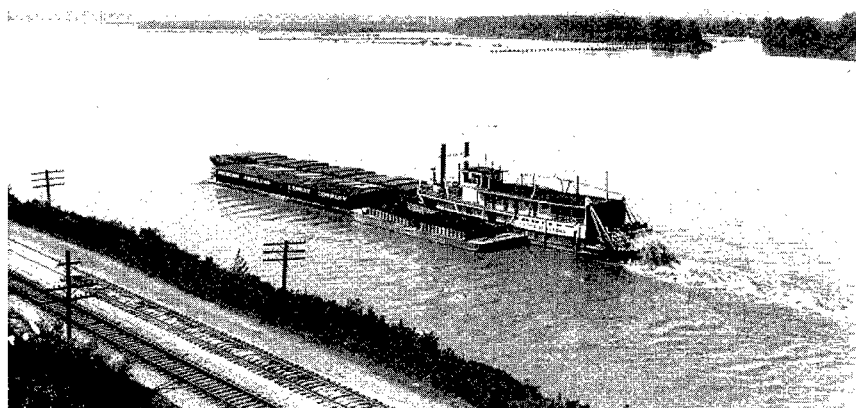
strate the navigability of the Missouri River channel. Upon arriving at Kansas City, the boats were greeted with a large celebration. The return of commercial navigation to the Missouri River seemed a reality.

The *Mark Twain* was one of the largest towboats built by the Inland Waterways Corporation and was designed especially for Missouri River navigation. The boat was 196 feet long with a 42-foot beam. It was equipped with two 500-horsepower compound condensing steam engines and could push eight barges up the Missouri current.



The Socony Vacuum Oil Company inaugurated a new era of barge navigation on the Missouri River in September 1937. The company began bargeline service for the transport of gasoline and other oil products from Kansas City to St. Louis; St. Paul, Minnesota; and other inland ports. Its barges had a capacity of 400,000 gallons, equivalent to 50 railroad cars at that time. The Corps sounded the channel ahead of the downbound company vessels, which were light loaded because of low-water conditions. The Socony Company also made runs to Omaha and Sioux City from 1939 to 1941.

In addition to this private commercial navigation activity, the Sioux City and New Orleans Barge Lines, Inc., of Sioux City was formed, and the first tow left its home port for Memphis on October 8, 1940. Of interest is that these two private shippers were operating out of home ports upstream on the Missouri River.



During this period, the Corps of Engineers assisted each of the towboats running the river. The Corps used its launches built at the Gasconade boatyard to sound the channel ahead of the commercial towboats. It set buoys to mark the channel, tended lights and daymarks, and wrote navigation steering directions. The Corps accompanied tows while they were on the river, both on board the tows or in the launches. It dredged shoals when the commercial tows required a deeper channel at specific river reaches.



CORPS OF ENGINEERS ASSISTS COMMERCIAL NAVIGATION

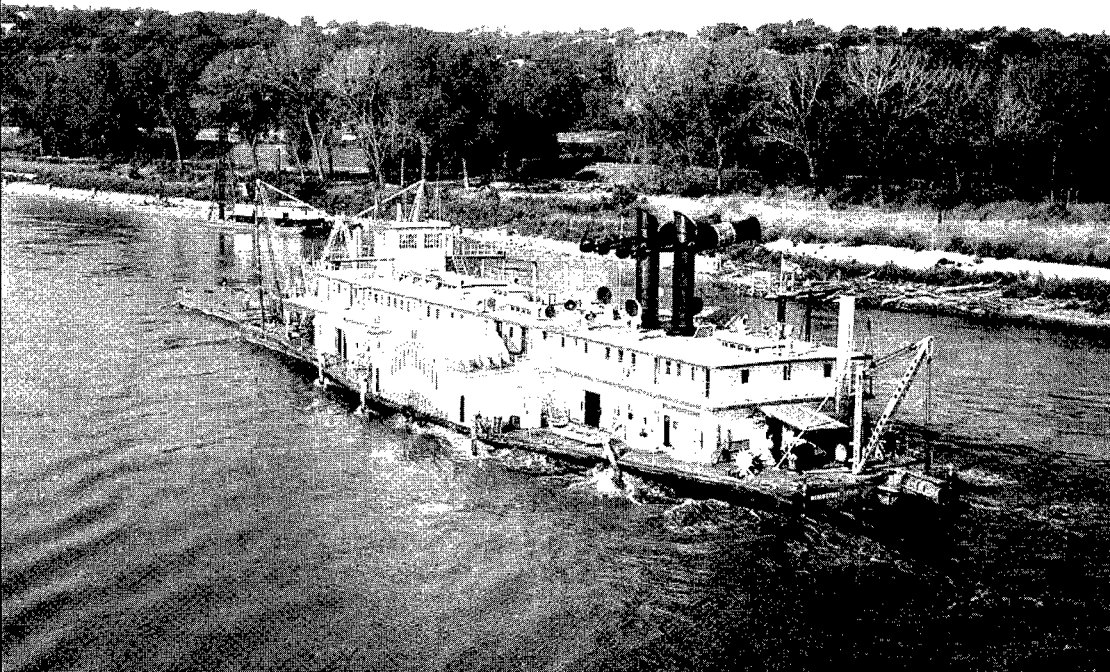
Kishmar discussed sounding and towboat accompanying activities in 1940:

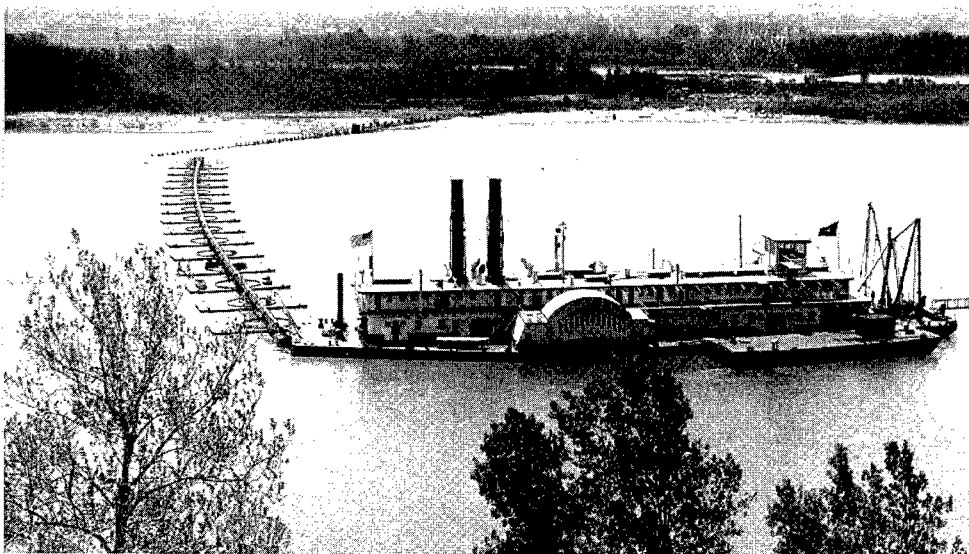
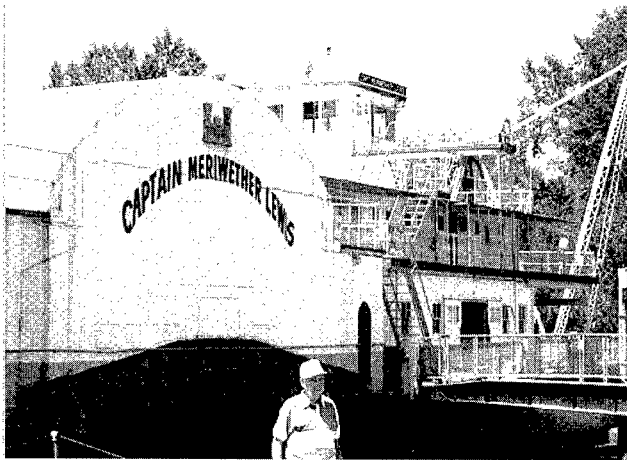
"July 8. Leave Boonville at 4:30 a.m. sounding ahead of towboat "Roosevelt" and three loaded barges. Arrive at Gasconade at 3:30 p.m. 9th. Leave, sound and plot on a map depths at Portland canal, mile 109 to 113.5. Arrive at Boonville on the 10th. 11th work on 0.1 inch = 2,000 foot maps of last recorded trip. 13th Saturday, leave. Sound down to four miles below Lupus. Meet towboat *Roosevelt* and tow upbound. I get aboard and furnish verbal channel information to three miles above Boonville, arriving there at 10:30 p.m. I then get on our launch and we return to Boonville. 14th and 15th. Sound ahead of *Kansas City Socony* to Gasconade. 16th and 17th. Return to Boonville. 18th. My thirtieth birthday. 19th. Sounding ahead of *Roosevelt* and two barges from three miles above Boonville. Grounded in shallow crossing one mile above town. Arrive at Gasconade the 21st. 22nd and 23rd. Return to Boonville. 24th-27th. Sound channel at mile 200, five miles above Boonville and at mile 171 and return. 28th. Leave. Sound and lead towboats *Kansas City Socony* and *St. Louis Socony* through shallow and crooked crossings to Gasconade. . . . August 1. Meet the *Roosevelt* and tow downbound half mile below Boonville. Lead them downstream. They double trip where necessary. Double trip means they tie off part of the barges above or below the shallow spot, depending on which way they are going. Take one part over the shoal, tie it off, return for the other part and work it over. Then make tow to all barges and resume the trip. It was necessary to double trip at two locations this trip. We arrive at Gasconade at 2:30 p.m. on the 2nd."

In 1932, the Kansas City District received its first of four new dredgeboats, the *Captain Meriwether Lewis*. Dredging was required in locations where the flow of the river lost its ability to transport sediments, or in areas where large amounts of sediments entered the river and where shoaling and deposition occurred. When sediments continued to build to such an extent that the navigation channel was encroached on, then dredging was required. This was usually done by using the launch to sound the shoal, then positioning the dredge; lowering the suction head into the material below the water; starting the suction pump, with each of the two paddle wheels turning slowly; cutting away the material creating the shoal; and blowing the material off to the side.

CORPS DREDGEBOATS *LEWIS* and *CLARK*

George Kishmar was sent to St. Louis on May 7, 1932, to lead the dredgeboat *Captain Meriwether Lewis* up the Missouri River. He used the Corps launch *Catamount* to lead the dredge through the shallow, crooked channel at Pelican Bend, miles 13.0-16.0. The crew arrived at St. Joseph on May 18. In June, Kishmar escorted the second new dredge for the Kansas City District,





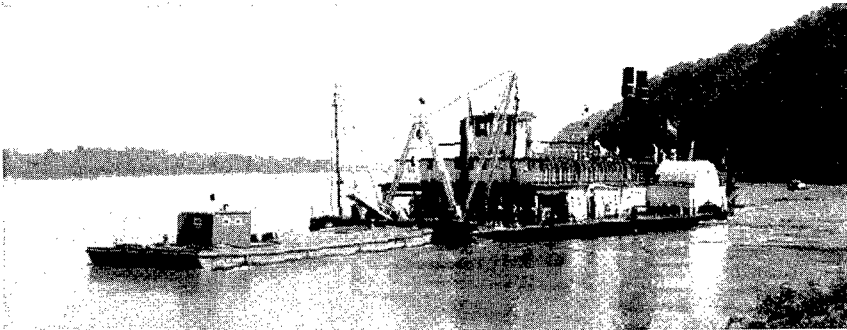
the *William Clark*. These dredgeboats were built at Point Pleasant, West Virginia. They each were 260 feet long with a string of pipes and pontoons trailing; their hulls were 50 feet wide, with an 85-foot width through the hull and twin sidewheel wheelhouses. They weighed 246 tons and had a four-foot draft. Each boat was capable of sucking and discharging 3,000 cubic yards of material a dredging hour.

CORPS DREDGEBOAT MITCHELL

Captain Royal Tate (1994)

Captain Royal Tate described dredgeboat *William S. Mitchell*, which he commanded for much of his Corps career:

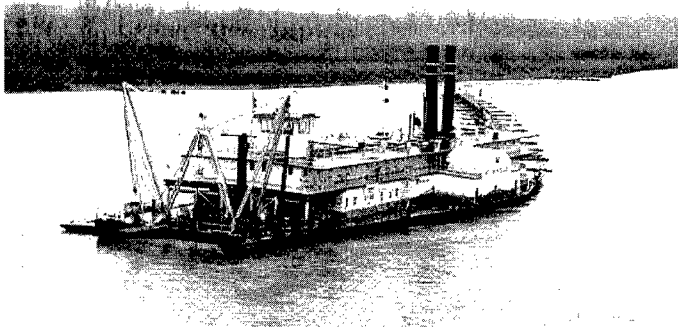
"She was gleaming white, 290 feet from stern to stern and 89 feet from wheelhouse to wheelhouse. Had twin smokestacks that rose 65 feet from the water to their tops, but could be lowered 15 feet for bridges thanks to special joints. Two 600-horsepower steam engines powered twin oak paddles on either side of the boat and would burn 6,500 gallons of number-six grade-oil; looked like tar. The *Mitchell* could 'round to' (that is, turn around in her



own length) by working the one wheel ahead while backing (reversing) the other. There was only one other boat like her, the *William M. Black*. It was exactly the same. Both were built at Point Pleasant, as had been earlier Corps dredges used on the Missouri River. The *Black* and *Mitchell* were built on specifications furnished by the people at Gasconade Boatyard and the Kansas City District Office.

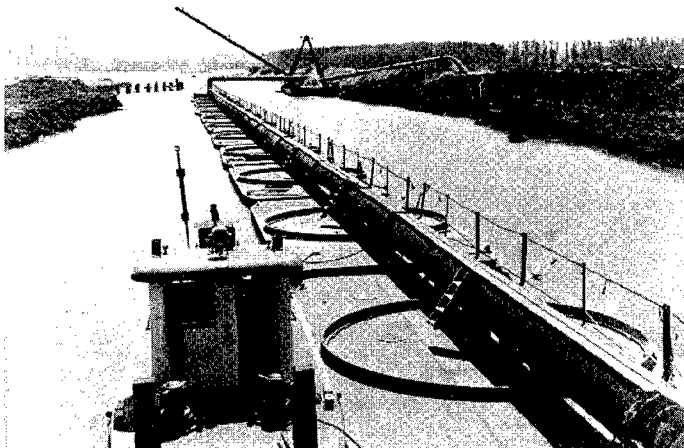
Fifty-four men made up the crew. Each had plenty to do. They ate, slept, and worked on board. Worked 8-hour shifts when times were good, longer if necessary. The captain's responsibility was 24 hours a day, 7 days a week. He had to see that the boat was properly located, the dredge pipes and suction head properly placed. Out in front of the boat was a dust pan suction pipe 60 feet wide, raised and lowered by derrick. It could be dropped down 20 feet

below the surface of the water and suck the silt out of a path 80 feet wide, moving forward about 1,300 feet in 24 hours. It took land that stood from 13 to 15 feet above the water surface and cut it down 27 feet so there was a channel depth of from 10 to 13 feet. While doing maintenance dredging, sucking up shoals, the dredge threw out about 4,000 cubic yards of sand an hour.



Separate engines operated the boat and the pumps. When the boat moved up to a sandbar, steel pipes were driven into the riverbed on the far side of the bar and cables run from them to two drums on the boat deck. The sweeper was dropped down into the silt, the pump started, and the boat rolled up the cable pulling itself forward as the sucker ate away the sand.

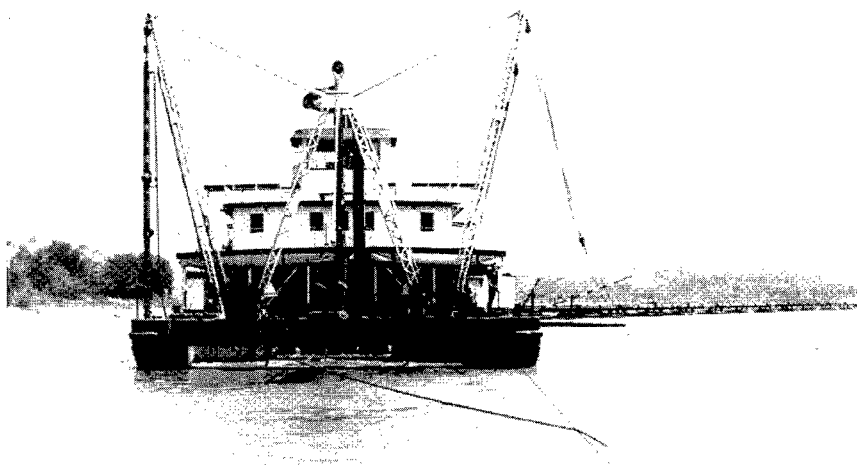
The dredged material was carried back through the pipes and the boat to a 36-inch pipe resting on pontoons. The pipe was hinged to the boat and had a deflector or rudder, a baffle plate, at the far end with which the pipe could be diverted from one side of the river to the other, discharging the silt wherever it was desired. Out at the end of the pipe and pontoon sat a small house, a dog house, with an operator to direct the flow of discharge.



In 1940, the channel was still difficult to navigate in certain reaches. Kishmar records that while on an inspection trip aboard the *Sgt. Floyd* with the District Engineer, Colonel A. M. Neilson, and others from the District office, they grounded in shallow water at mile 171.7, between Jefferson City and Boonville, for about two hours. The next morning they grounded a second time at the lower end of the Portland canal, mile 109.6, for three hours. These groundings occurred despite the assistance of a Corps reconnaissance launch that was sounding ahead of the *Sgt. Floyd*.

Dredging to support commercial navigation was necessary for many years. Kishmar noted that on July 13, 1942, he was sounding the Portland canal and found a seven-foot-deep channel. That depth was insufficient for the Federal Barge Lines *Roosevelt* which was coming downstream with four barges requiring a draft of eight feet. At the time, that was the most draft and tonnage to come down the Missouri River, he said.

Kishmar called the Kansas City District office and requested a dredge. He then went to a point above Chamois and waited for the *Roosevelt* to come downstream. "This gave them plenty of time to consider tying off at Chamois, to wait for the dredge to deepen the channel. They tied off at 9:45 p.m." The dredge worked overnight and radioed the next morning that it had made two cuts and could safely pass through the shoal.

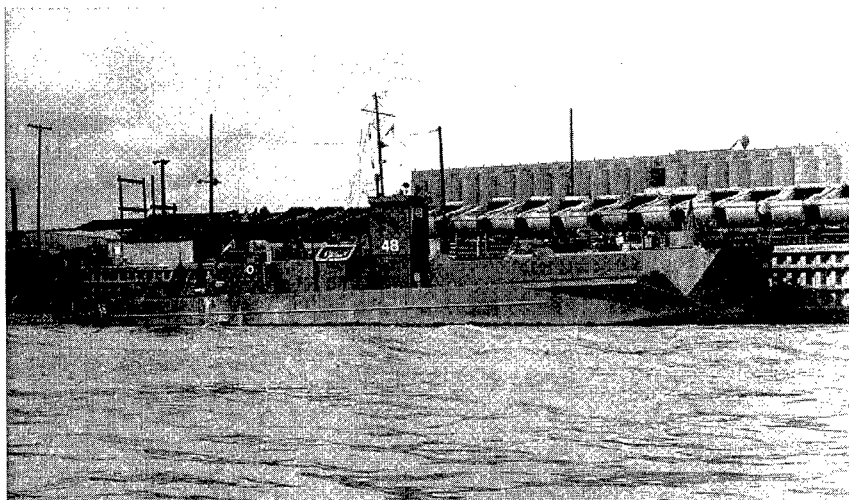






THE WORLD WAR II ERA

During the World War II years, the Missouri River channel and its Corps caretakers assumed an additional role. The Gasconade Boatyard and other facilities along the navigation channel built a variety of vessels used in the war effort. Navy Landing Craft Tanks (LCT's) were built at Leavenworth, Kansas; Blair, Nebraska; and Gasconade. Leavenworth boatyards also built Coast Guard cutters and ice plows. These craft were moved by Coast Guard pilots, who were often former Corps employees, or towed by Federal Barge Lines towboats. The Corps provided navigation support.

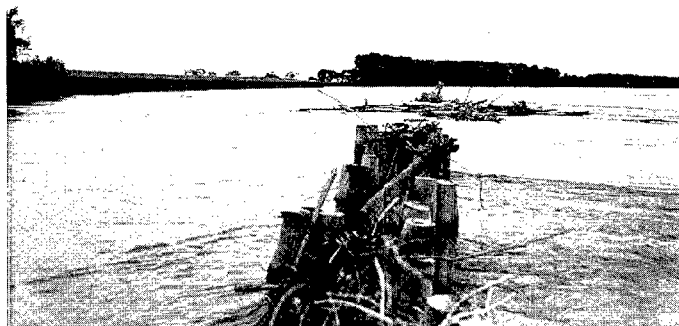


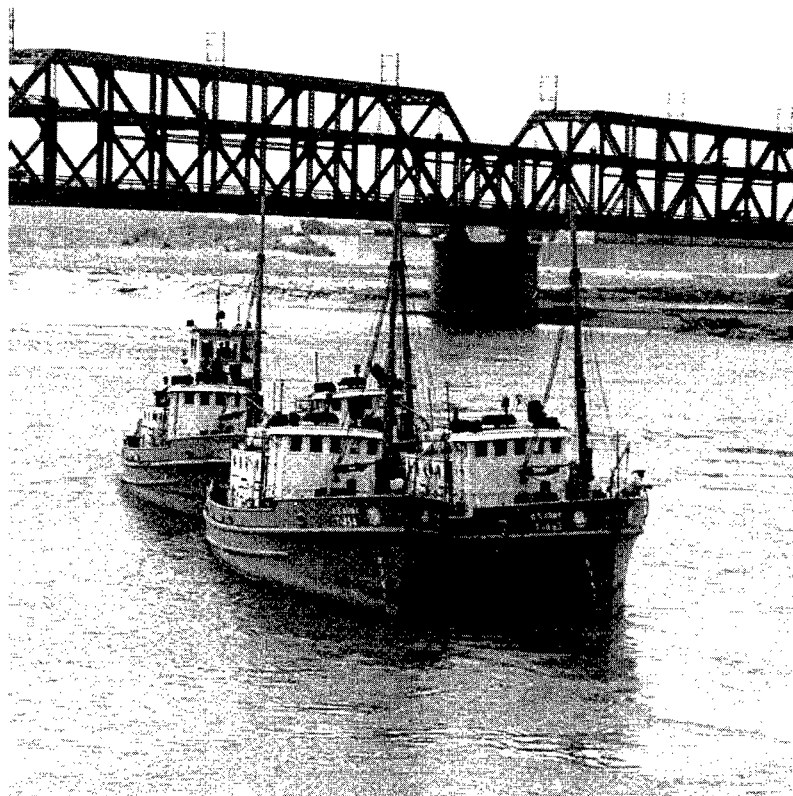
Navigational aids were especially necessary during the war years. The six-foot-deep channel was not completed and the nation's resources were directed to the war efforts. Project starts for river developments were suspended and many of the works in place deteriorated.

MISSOURI RIVER BOATYARDS' WORLD WAR II CONTRIBUTIONS

During the World War II period of 1942 to 1945, the boat yards located along the Missouri River channel constructed for war purposes and delivered over the waterway a total of 256 cargo and military craft: 86 Landing Craft Tanks 5' s (LCT's), 135 LCT-6's, 5 crane boats, 15 Coast Guard cutters, 6 dredge tenders, 8 launches, 4 towboats, and 8 barges.

Floods in 1942 and 1943 flanked and destroyed some completed structures. This destruction reduced the reliable depths in the navigation channel. In some reaches, especially above St. Joseph, channel alignment was completely lost and bank erosion was extensive. The river was returning to its natural state.





KISHMAR, CORPS OF ENGINEERS, AND WWII SUPPORT

Kishmar states in his log that on January 18, 1944, he left Gasconade on a sounding trip and wrote steering directions for Coast Guard pilots. He recorded the following:

"Hermann gage 3.3. I type 10 sets of steering directions. Leave at 1:45 p.m. Leading 8 LCT's. I give [each of the pilots, including Captains Martin Weith and Royal Tate] a set of steering directions. . . . The fleet tied up at Washington for the night. Leave 23rd. The launch *Richland* joins us, in case they are needed. We arrive at the mouth at 2:35 p.m. . . . We return to Gasconade. 28th, leave, sounding ahead of two LCT's. Arrive at St. Charles. 29th, I get aboard the lead LCT. Let the launch return to Gasconade. We arrive at St. Louis at noon. Return by train. February 1, make sounding trip, write steering directions, and lead 23 LCT's out of the river."



DEEPENING THE CHANNEL

The desire to get river work under way was urgently felt. Floods in 1943, and the perceived need for public works funding to combat an expected economic depression after the war, stimulated demands in the basin for federal project authorization to do more than repair the deteriorated channel stabilization structures. The navigation channel was linked with a more comprehensive water resources development plan for the Missouri River basin.

For several years, navigation interests had been urging Congress to increase the Missouri River navigation project channel depth to 9 feet with a 300-foot width. In 1938, the Missouri River Division Engineer, Colonel Clarence Sturdevant, had advised that the Corps could provide a nine-foot channel from Sioux City to the mouth of the Missouri "with relatively small expenditure for works additional to those now authorized." He said that, in fact, a major part of the total channel would, upon completion, have a depth of nine feet or greater, especially with the completion of the Fort Peck dam.

The Corps was concerned in 1938 with the legalities of expending funds for dredging to ensure nine feet on crossings where a six-foot depth was available. Under the authorized project, the Corps would be justified in dredging only those crossings likely to shoal to less than six feet. The controlling depth of the channel would still be limited to little more than six feet. The Corps believed that to remove this legal difficulty, and open up the entire river to Sioux City to nine-foot navigation, the deeper channel should be authorized.



Adding three feet to the authorized six-foot-deep channel project would add significant benefits to shippers. The cost of operating barges on a nine-foot channel was less than on a six-foot channel, according to the Federal Barge Lines. More traffic would be attracted to the deeper waterway because the nine-foot channel was the standard.



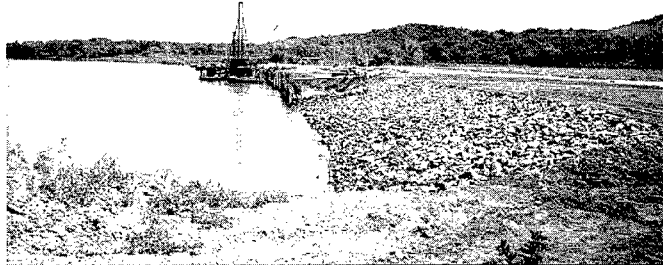
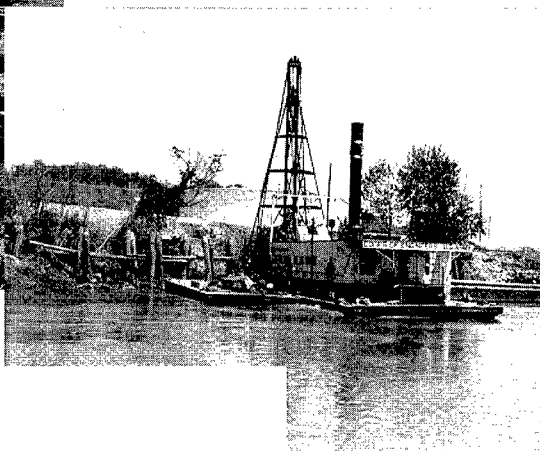
Discussions of the nine-foot channel were suspended during the early years of the war and taken up in Congress following the 1943 floods. The Flood Control Act of 1944 included provision for an extensive development of water resources in the Missouri River basin. Numerous dams were authorized to be built on the main stem and tributaries of the Missouri River, which would supply water for an enlarged navigation channel.

The multi-purpose regulatory reservoirs authorized in the 1944 act helped gain quick congressional approval,

in April 1945, of a nine-foot-deep navigation channel project from Sioux City to the river's confluence with the Mississippi River, a distance of 734.8 miles. This act modified earlier congressional authorizations in 1912 and 1927 that had provided for a 6-foot-deep, 200-foot-wide channel from the mouth to Sioux City. Work would continue on stabilizing the banks of the Missouri River and developing its channel for navigation.

The project would remain the open-river type, using the energy of the flowing water to develop and maintain a controlled and deepened navigation channel area. During the eight-month navigation season, the controlled channel depth would be provided water from the regulatory dams and reservoirs in the river's upper reaches and on its tributary streams.

In 1946, the Corps of Engineers launched a major effort to restore the deteriorated navigation channel and prepare for the deeper depth. For the fiscal year 1946, the Kansas City District, for example, spent twice as much money for maintenance as it did for new work on the river. Wooden-pile dikes driven to control the river before 1940 were rotting and collapsed when floodwaters and ice floes undermined the control structures.



Missouri River ice and floods destroyed the channel stabilization structures faster than the Corps could maintain them. In much of the section of the river from Sioux City to Omaha, the river had reverted to its natural state. Lost alignment had to be recaptured completely throughout most of this section of the river.

The section of river from Omaha to Kansas City also experienced severe damage. Advancement of the project in this reach from 1941 to 1950 had lagged because of the need to use available funds to correct the damage. In fact, during the years 1946 to 1954 the status of the Kansas City-Omaha reach of the project declined from 85 percent to 74 percent complete.

The project from Kansas City to the mouth had progressed to the point where a fairly stable channel of between six and nine feet was available for navigation. Considerable work was still to be done, consisting mainly of stabilization of unprotected banks, correction of certain locations where the channel had deteriorated badly, and refinements to obtain full project depth. Shoals were still both a hardship and hazard to commercial barge navigation.

NAVIGATION DIFFICULTIES

George Kishmar describes in his log book some difficulties of commercial barges navigating in the lower river in 1948:

April 26. "Board the *Roosevelt* with three barges. Launch is along. One barge has 6-1/2-foot draft, the other two 5-1/2. Tie off at mile 65. Take the two 5-1/2-foot-draft barges and start washing them over 5 foot reef at mile 64.2. Over two hours later, tie them off at mile 50, at 8:30 p.m. Go back for 6-1/2-foot-draft barge.



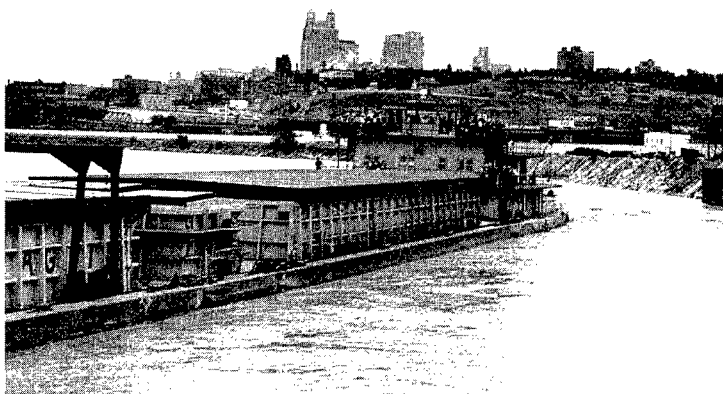
The river being at a high stage, a strong current was going down the chute, which had a rock trailer (longitudinal) dike, across the head. Because most of the current was going down the chute, the slacker current in the main river dropped sediment at the crossing in the channel, which caused the reef.

When the lead barges went aground, those in back were forced over the top of the rock dike, and the tow trailed. This was precarious. Had the river been a foot lower, the boat would have slammed into large rocks and no doubt in my mind, would have punctured a hole in the hull, causing it to sink.

After breaking the *Truman* out of the tow and turning it around on the back side of the dike, it was run back over the top of the rocks. Captain Ingersol made the remark: 'I couldn't dream of such a situation.' The launch in the meantime had found deeper water, near the middle of the main river. Then the boat went to the lower end, at the bow piece, made tow to it and worked it downstream and off the dike. Tied it up to get back on the other end. Made tow and left downstream. Arrived at St. Louis at 1:30 p.m."

April 27. Leave at 1 a.m. Grounded same place. Get off and arrive at mile 50 at 4 p.m. Tied off the barge and made tow to the other two and leave. Tied off at mile 45.5. With light boat (no barges), run down to mile 44.3, where the launch found only 5 feet. Returned to mile 45.5 and tied up for the night.

April 28. Returned to mile 44.3. Still only 5 feet. Returned and made tow to one barge and left. Washed it over, tied it up at mile 40, and went back for the second barge. Wash it over reef and tied off at first barge at 8 a.m. Leave up[stream] for 6-1/2-foot-draft barge. The river had risen about a foot overnight. Made tow, arrived at the other two barges at 11 a.m. Make all tow and leave at 11:45. Arrive at St. Louis at 7:10 p.m."



TOWBOAT *TRUMAN* and NAVIGATION HAZARD

Kishmar described a towboat in a hazardous situation, June 25, 1948:

"The new Federal Barge Lines' towboat *Harry Truman* enters the river with an integrated tow of four barges and a bow piece. The whole unit was as if one stern end of the bow piece. The barge ends were square, as was the bow of the

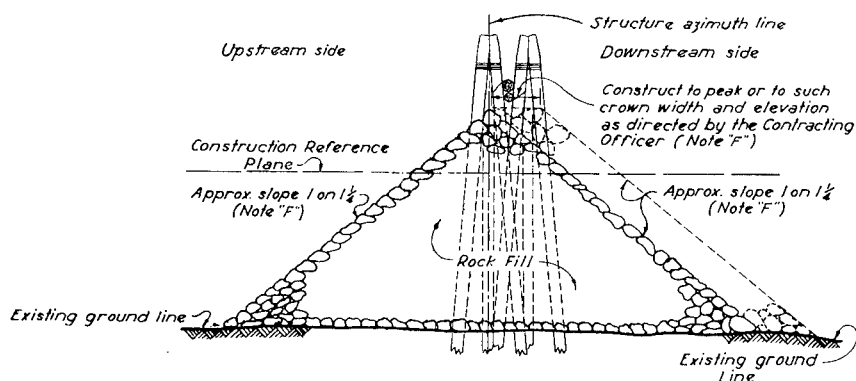
boat and the stern end of the bow piece, which had a rake front end. It had its advantages, but also a disadvantage in that whenever the boat had to maneuver around by itself, it was hard to steer. . . . We meet it at the mouth and I get aboard at 7:40 p.m. Captain Ingersol, President of the barge line, was also aboard. Captain Archie Howell was Master.

July 3. The *Truman* arrives from Kansas City with four barges loaded with grain. They tie up, break tow with the boat, run up to the bow piece and transfer fuel oil into the bunkers of the boat. Also take on fresh water from the boatyards [Gasconade]. Leave at 6:00 p.m. I am aboard the tow and the launch *Chariton* is running ahead sounding the channel. At 9:45 p.m., grounded at the upper end (head) of Centaur Chute, mile 49.8.

The Missouri River Division Engineer, Brigadier General S. D. Sturgis, Jr., said in 1950 that for ten years funds had been inadequate for proper maintenance of the channel stabilization and navigation project. In order to fully stabilize the control structures and permanently protect the accretions formed by them, more money was required not for maintenance but for new construction, he said. If the Corps of Engineers was to finish what Congress had assigned it to do, then the legislators would have to provide more money to enable the Engineers to catch up with deferred maintenance and to carry on new project construction in an orderly and systematic manner.

These construction methods saved money and were more permanent. Although some questions remained about the effectiveness of the use of rock in lieu of the standard timber piles and woven mattresses, the Office of the Chief of Engineers in 1949 approved the use of this quarry-run stone method as an alternative construction method for river-improvement structures.

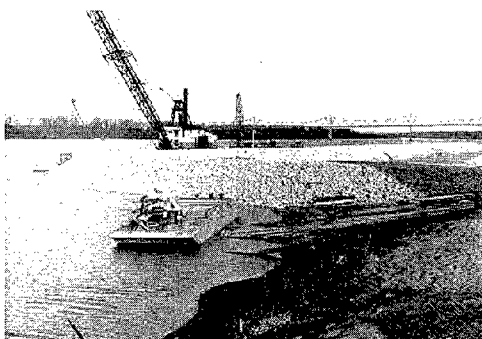
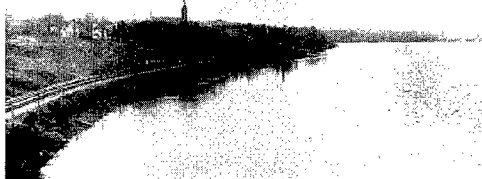
With 70 years of experience in controlling the Missouri River, the Corps Engineers were well aware of some special problems with previous construction. General Sturgis stated in 1950 that "The problems of stabilizing accreted banks through dike systems on the concave side of bends are of many classifications." At numerous locations, especially at flat bends, the pile dikes had proven very effective. In such cases, the cost of removing the structures and reconstructing the revetment had to be weighed against the cost of maintaining the dike system. Certain reaches were especially troubling to navigators, especially during floods.

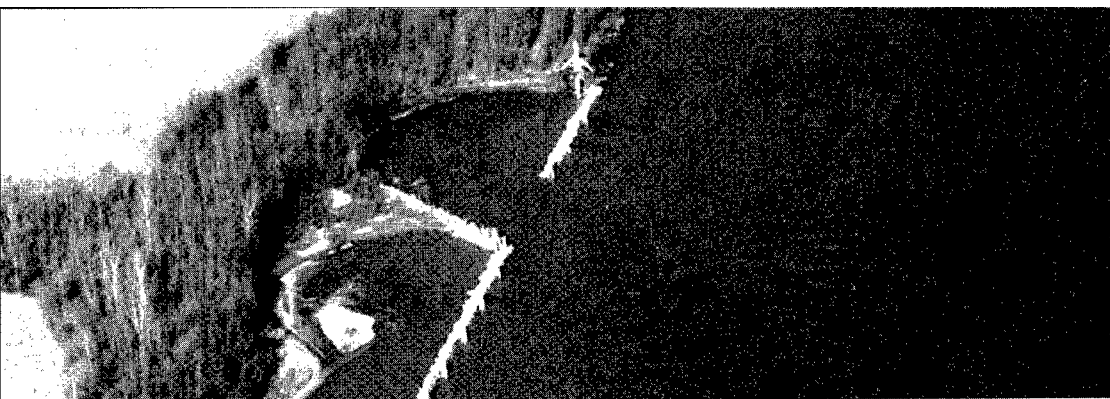


SPUR AND BAFFLE DIKES
GENERAL CROSS-SECTION
ROCK-FILL IN DIKE LINE
 No Scale



The Corps of Engineers sought more effective and efficient ways to construct the bank stabilization and channel works, while adhering to the Suter principles. For example, in 1941 a plan was developed for placing quarry-run stone up to a low-water elevation around timber piles to reduce maintenance during the development of accretion. In 1945, experimental work began on constructing standard revetments with an underwater rock toe in place of the standard foundation mattress. The quarry-run stone was handled by mechanical means in lieu of the formerly used hand-placed stone.



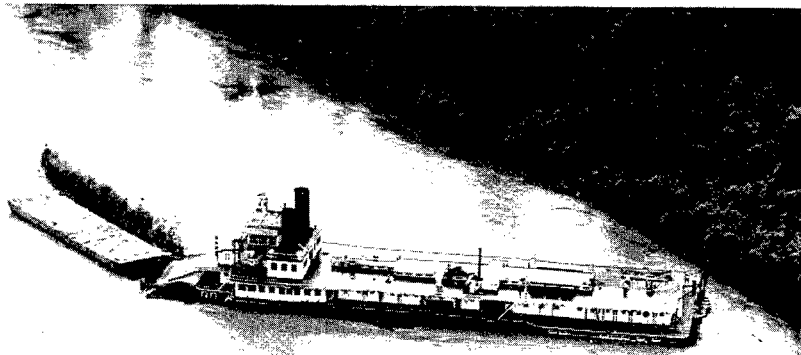


IMPROVING NAVIGATION

TOWBOAT "MINNESOTA" SANK

Krishmar explained the problems encountered by the commercial steamer *Minnesota*:

"June 21, 1951. High stage. Steamer *Minnesota*, with tow, sideswiped a rock pier of the railroad bridge at Sibley, Missouri, due to the swift current. On inspection it was found that the hull had been punctured badly. Captain Leonard Thompson, Master, who was on watch, was told of the damage by the mate. Knowing the boat could not be kept afloat with pumps he decided to work it across the river into shallow water, thinking it could be salvaged later. However the major flood shortly thereafter filled the hull and machinery with so much silt that it would have been too costly to salvage it. Everything that could be taken off it following the days after it sank was removed. It sank at approximately mile 334.0, Fishing River Bend, near the right bank."



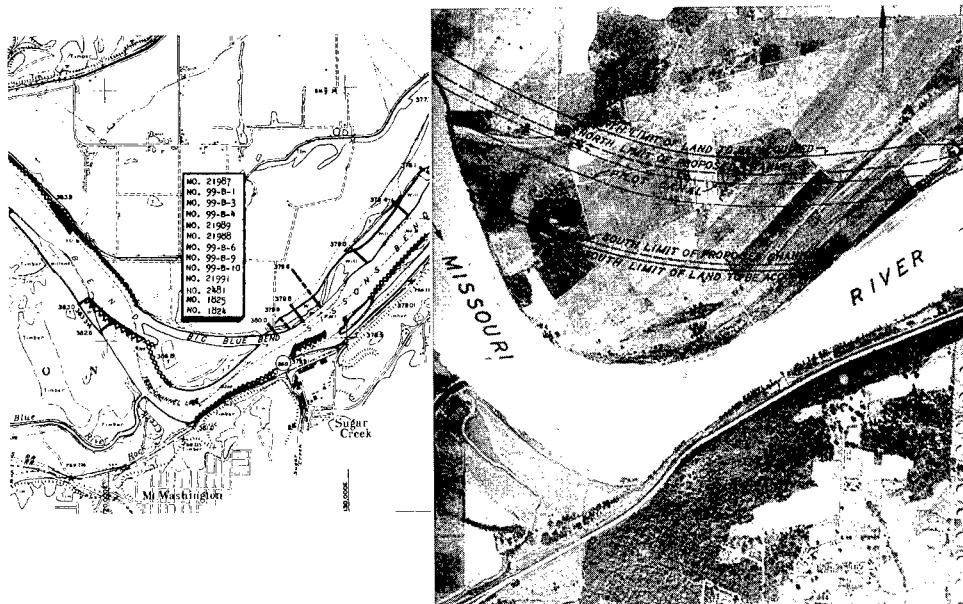
General Sturgis noted that many of the bends in the original design were too sharp to be efficiently maintained. Some of these had caused concern from a flood control and navigation standpoint. Lower maintenance costs and improved channel conditions could be gained at some locations by abandoning the original construction and realigning the sharp bends.

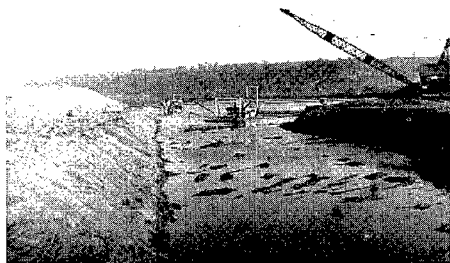
Before World War II, the Corps of Engineers implemented a plan of redesigning troublesome bends. Where a natural bend was so sharp that it was not practicable to adjust it to satisfactory curvature by building dikes and revetments, a cut-off might be incorporated into the realignment.

"CUT-OFF"

The term "cut-off" was defined as a new channel cut through the neck of a bend, which resulted in completely eliminating that bend and considerably shortening the channel. The alignment of the cut-off was designed to be symmetrical with the curvature of the channel upstream and downstream of the bend.

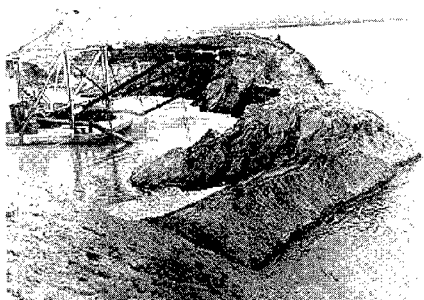
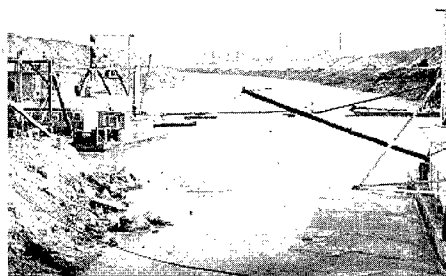
Just upstream from Kansas City, the Big Blue Bend was a 90 degree turn with unpredictable currents. A long gentle curve from Randolph to Sissons Bend would aid navigation, improve water flow, and facilitate bank stabilization. The Corps used dredges and land equipment to construct a river control structure that would form the new banks of the Missouri itself.





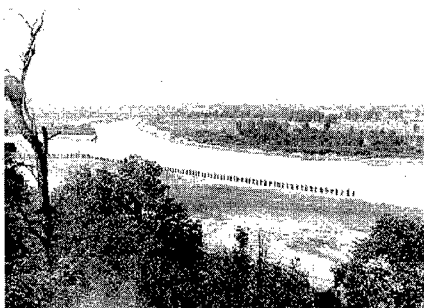
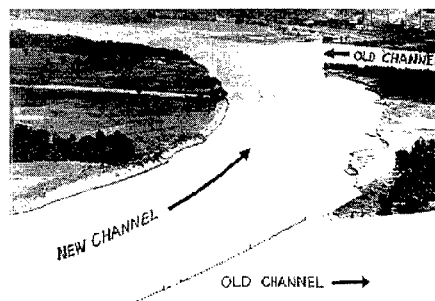
CONSTRUCTING A CUT-OFF

When a cut-off was to be constructed, the area was first cleared of trees, stumps, and brush. A construction canal was excavated by dragline or dredging along the designed concave bankline to the desired depth and to sufficient width to permit construction of a toe trench revetment along the concave bank. The construction canal was not opened at the upper end. A second or pilot canal was excavated near the convex bankline, leaving a plug at the upper end to hold back the river until the revetment had been completed. The general practice was to excavate the top portion of the canal by dragline in order to ensure removal of all roots and to excavate the underwater portion by hydraulic dredge.





Simultaneously, construction of upstream training structures was begun to direct the main current into the new channel at the proper time. When the revetment was completed and the pilot channel was prepared to receive the flow, the plug was removed and the upstream training structure was extended to divert the river into the cut-off and close off the old channel. The increased velocity through the shortened channel rapidly eroded the pilot channel to the previously constructed revetment and produced the necessary channel width.





In April 1947, the Kansas City District began construction on the Liberty Bend cut-off, just downstream from Kansas City. This project, studied before the war, involved constructing a long highway bridge over the location of a long new channel and making a shorter cut at the Blue Mills Bend to tie into the larger one. The channel cuts were about 10 feet wide and 15 feet deep. The Engineers expected the river to scour out a channel about 1,000 feet wide.

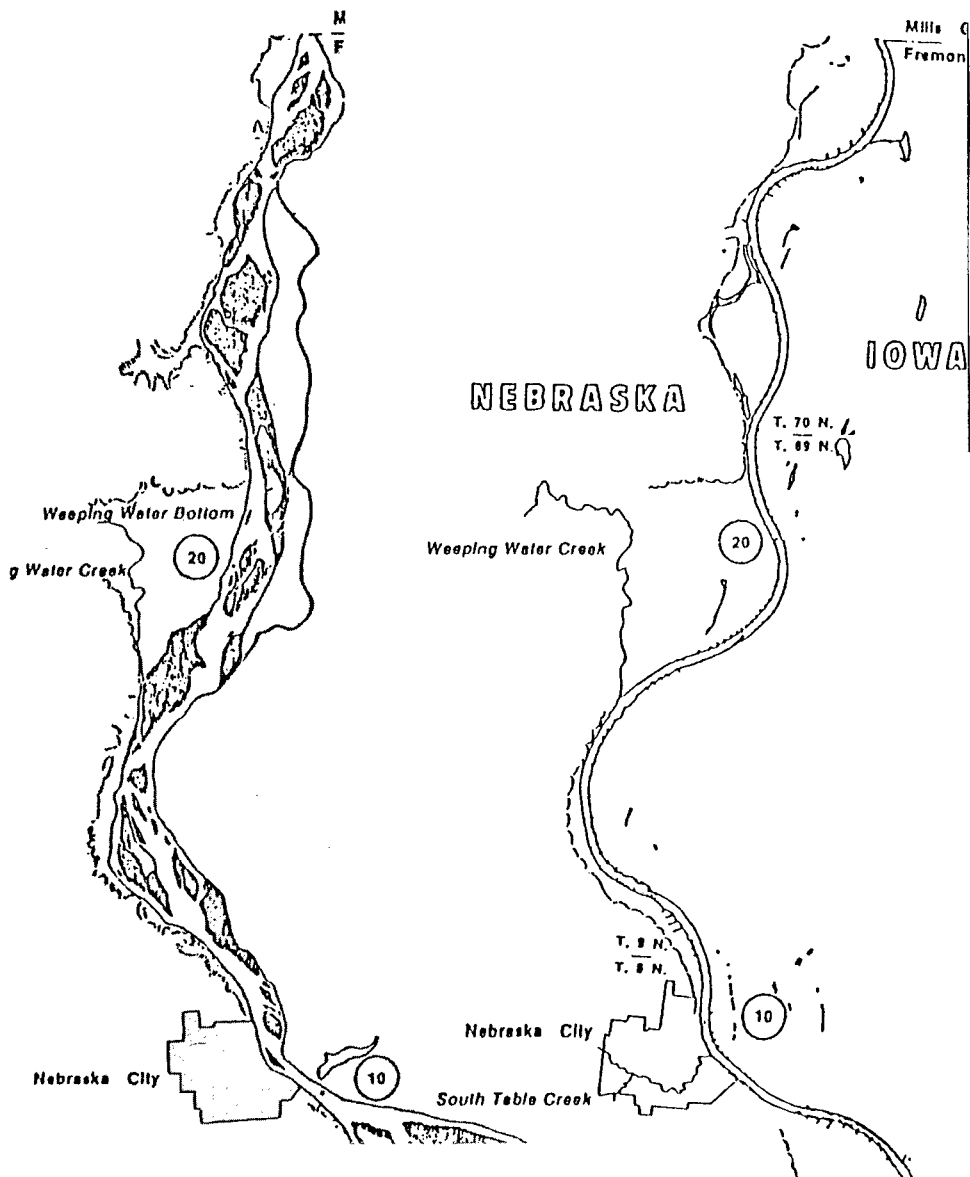
Another man-made gentle curve of river would replace a sharp "S" curve that hindered navigation and the evacuation of water during flood stages. When the Liberty Bend cut-off was opened in April 1949, diverting the Missouri into the new channel, the river was shortened by 4.7 miles.

The Corps was satisfied with its reshaping and stabilizing of the Missouri River. The improvement in channel conditions was reflected in the number of miles where depths and widths were already at 9 by 300 feet in 1949 when the cubic feet per second of flow at Kansas City was 32,000.

Total No. of Miles			
Year	Length of River in Miles	Where Channel 9' by 300' Obtained	
KC to Mouth:			
1939	386.2	155.0	(40.1%)
1949	386.2	310.6	(80.4%)
Rulo to KC:			
1939	128.3	64.7	(50.4%)
1949	128.3	106.2	(82.7%)

1890

1976



ANCILLARY BENEFITS AND TONNAGE ESTIMATES

The channel stabilization and navigation improvement works constructed up to 1949 had effectively prevented erosion. The project had reduced or eliminated major costs for erosion control incurred by public and private-sector entities located along the riverbanks.

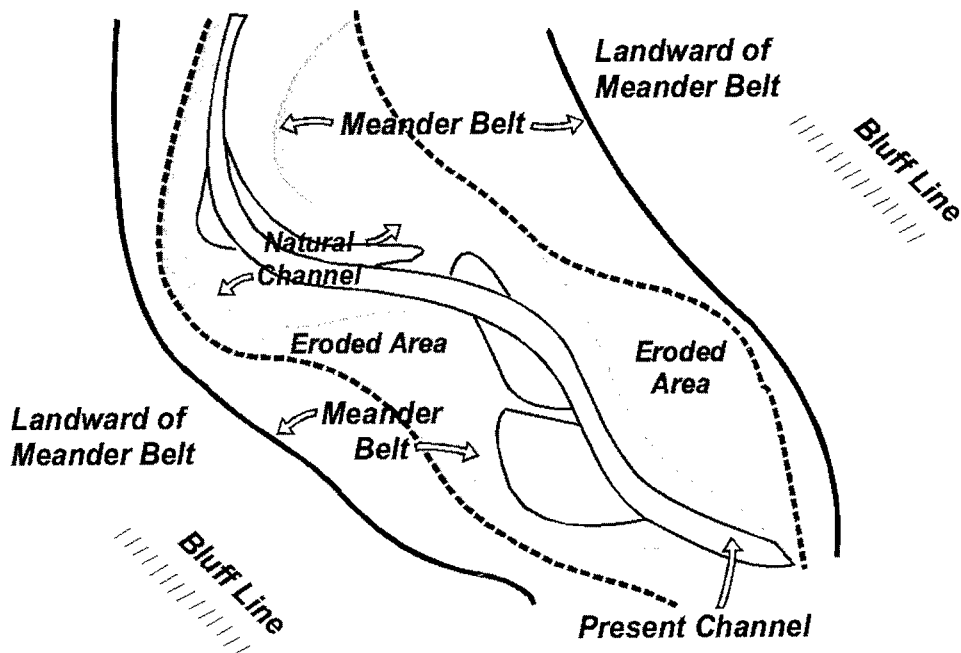
		Erosion		
	Annual Rate of Erosion	1890 To Date	Erosion Prevented To Date	Area in Meander Belt
KC to Mouth	4,634	176,000	102,000	291,100
KC to Rulo	1,538	67,000	25,300	107,600
Rulo to Sx. City	2,922	142,000	33,300	207,200
Totals	9,094	385,000	160,600	605,900

The annual rate of erosion under natural conditions was sufficient to move through the meander (calculated pattern of erosion) in about 70 years, the Corps of Engineers concluded. The bank stabilization and channel project had the net effect in 1949 of eliminating about 22 years of natural erosion from Kansas City to the mouth; 16.5 years from Kansas City to Rulo; and 11.5 years from Rulo to Sioux City.

Contracting and confining the river's flow into one channel created additional land suitable for a variety of uses. The Corps of Engineers provided information on the additional land created as of 1949 and estimated that which would be created in the future.

	High Ground Accreted to Date	Additional High Ground That Will Be Accreted	Total Acres
KC to Mouth	66,500	15,000	81,500
KC to Rulo	25,900	7,000	32,900
Rulo to SxCty	43,000	30,600	73,600
Totals	135,400	52,600	188,000

Missouri River Flood Plain



MISSOURI RIVER VALLEY AREA

Valley areas were segmented into four categories for the purpose of analysis and evaluation.

Meander Belt. An area of 605,900 acres located adjacent to the river, which included those areas being eroded and those subject to the most imminent threat of erosion.

Landward of Meander Belt. An area of 740,000 acres lying landward of the meander belt but within 3-1/2 miles of the river, where the threat of erosion was sufficient to preclude the full use of the land and to depress its value.

Creation of New Land. An area of 188,000 acres that had been or would be reclaimed from the natural river channel by accretion due to confinement of the river by the stabilization works.

Protection of Urban and Other High-Value Installations Against Erosion. The numerous municipal or urban areas and transportation infrastructure located in the flood plain of the Missouri River.

The Missouri River Division Engineer said in 1950 that the analysis of benefits showed that those accruing to the stabilization features of the project represented about two-thirds of the total benefits. The project was justified from the stabilization standpoint alone. But the project as then authorized was for providing a navigable channel.

It was necessary to estimate the amount of waterway commerce that could be expected if the nine-foot-deep channel were completed. Six surveys of probable commercial traffic on the Missouri River had been made between 1926 and 1939. The results of the surveys and estimated annual tonnages of traffic are as follows:

Estimated Tons		
Survey Made By	Year	Commercial Traffic
Omaha Chamber of Commerce	1926	14,255,140 (a)
U.S. Dept. of Commerce	1928	8,445,355 (b)
Mo. River Navig. Commission	1929	15,160,355 (c)
K.C. District Engineer	1929	4,793,000 (c)
K.C. District Engineer	1933	11,794,277 (b)
Mo. R. Division Engineer	1939	12,000,000 (b)

(a) Sioux City to Kansas City

(b) Sioux City to Mouth

(c) Kansas City to Mouth

The different estimates for the same portions of the river varied little. In fact, they were fairly consistent despite the different methods followed.

From the historical standpoint, the actual movements of commercial traffic along the Missouri River between Sioux City and the mouth have been quite small. The recorded movements stated in tons for the period from 1935 to 1949 were as follows:

Commercial Traffic Between

Year	Kansas City and the Mouth	Index(a)	Kansas City and Sioux City	Index(a)
1935	243,789	100	108,027	100
1936	215,138	87	15,400	14
1937	267,247	109	101,476	93
1938	375,334	153	64,163	59
1939	424,435	174	125,000	115
1940	349,563	143	102,110	94
1941	526,126	215	122,141	113
1942	514,038	210	92,020	85
1943	294,433	120	64,258	59
1944	241,759	99	2,620	2
1945	201,221	82	23,498	21
1946	528,534	216	57,662	53
1947	325,635	133	168,779	156
1948	251,987	103	278,962	258
1949	348,764	143	240,073	222
15yr. Average	340,534	139	104,420	96

(a) The table, in addition to showing the commercial tonnages, reflects index numbers for the respective years in relation to the year 1935, which was considered as 100.

Commercial traffic on the Missouri River between Kansas City and the mouth increased steadily from 1935 to 1942, when the United States entered World War II. Traffic upstream of Kansas City decreased in those years. From 1935 to 1948, commercial traffic between Kansas City and the mouth more than doubled in volume, while between Kansas City and Sioux City it decreased about 15 percent.

In 1950, the Corps of Engineers completed a major study of estimated future commerce on the river. In developing a basis on which to predicate an annual potential of barge-adaptable commerce, the study group canvassed the area along the Missouri River between Sioux City and the mouth for 75 miles back from the river. Contacts were made with 1,497 shippers considered to have barge-adaptable commerce. Of the tonnage developed, some was eliminated as not adaptable to barge transportation, some as of insufficient quantities to be practicable, and some as being inaccessible to the waterway.

For the remaining items of commerce, rail rates, barge rates, and rail-barge rates were compared. The study group worked closely with contracted commercial rate professionals on this portion of the study. This special segment of the study eliminated additional tonnage that showed no savings or insufficient savings to encourage shippers to change their modes of shipping.

The study group said that it would probably take twenty years for the estimated waterborne commerce to develop. An increase of about 25 percent was then added to the cumulative estimate to allow for future expansions of existing businesses and new industries that might develop and use the river for shipping.

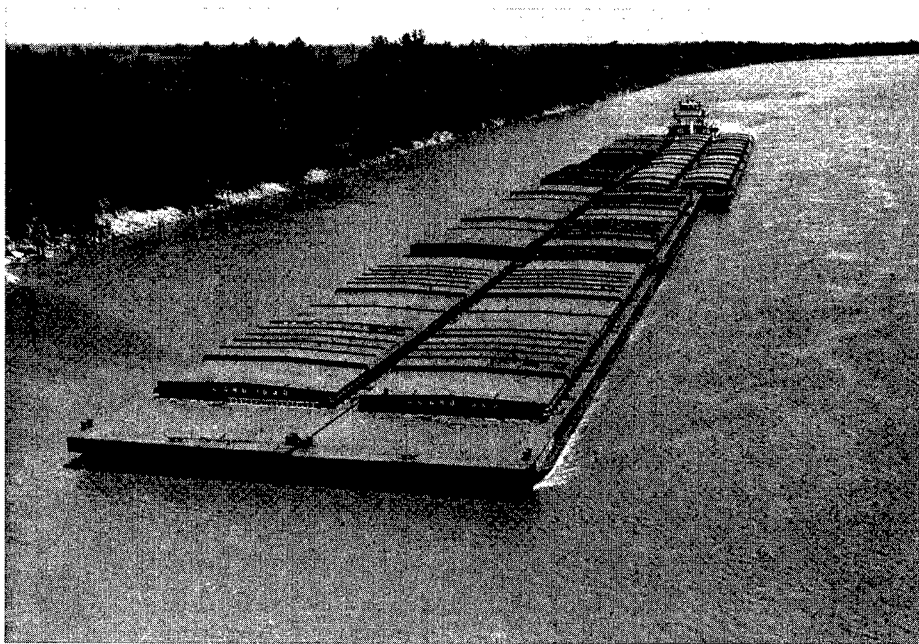
The Missouri River Division commercial traffic group projected that the following commerce would develop after completion of the project:

Annual	
<u>Year</u>	<u>Tonnage</u>
1955	430,000
1960	1,100,000
1965	2,430,000
1970	4,000,000
1975	4,750,000
1980	5,000,000

The final estimate of five million tons was calculated as follows:

	Tons
Total tons of commerce developed by field contact with shippers and receivers thereof	7,846,370
Tons eliminated because the commerce was inaccessible to the waterway	- 1,481,639
Balance of tonnage transformed to detailed analysis sheets for the purpose of determining probable transportation benefits	4,299,855
Estimated future potential commerce	5,000,000

The Division Engineer was more conservative. After carefully evaluating the data available to him, General Sturgis stated his belief that the maximum potential commerce on the completed Missouri River navigation channel was 4,074,000 tons.





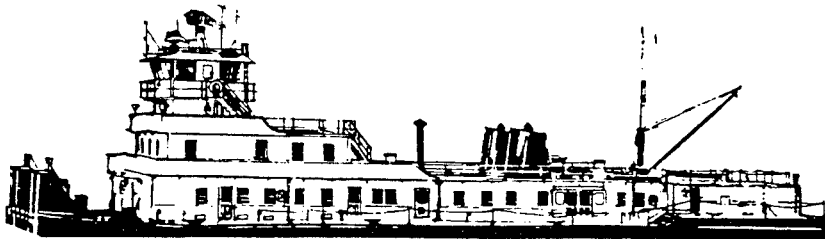
PROJECT PROGRESS

The Missouri River Division Engineer's conclusions regarding the benefits of the channel stabilization and navigation project resolved any doubts that Congress may have had and ensured that the work would not again be neglected because of a lack of continuing appropriations. As a result the Corps was able to accomplish new work and maintain existing structures. Work progressed steadily, with 5 to 8 percent completion of the project accomplished each year from about 1954.

A measure of the rate of success in Missouri River navigation, including channel conditions, was the activities of the Federal Barge Lines. In 1953, the FBL loaded to a six-foot-deep-draft to Kansas City, then the upstream terminus of such service. The next year it planned to load to a seven-foot draft to Kansas City and 6-1/2-feet to Omaha, the new terminus. Increasing the draft of a standard size barge from 6-1/2-feet to 7-feet meant an increase in capacity from 950 to 1050 tons.

Towboats typically travel approximately 4 miles per hour (m.p.h.) upstream on the lower and middle Missouri they move downstream at a pace of ten m.p.h. The trip from the mouth to Sioux City takes at least eight days, while the trip downstream takes about three days. Barges in use on the Missouri have a capacity of 1,500 tons, but are loaded with an average of 800 tons of cargo. Three barges make up a usual tow found on the river.

TYPICAL TOWBOATS AND BARGES



TOWBOATS

Length Feet	Breadth Feet	Draft Feet	Horsepower
117	30	7.6	1000 to 2000
142	34	8	2000 to 4000
160	40	8.6	4000 to 6000



OPEN HOPPER BARGES

Length Feet	Breadth Feet	Draft Feet	Capacity Tons
175	26	9	1000
195	35	9	1500
290	50	9	3000



COVERED DRY CARGO BARGES

Length Feet	Breadth Feet	Draft Feet	Capacity Tons
175	26	9	1000
195	35	9	1500



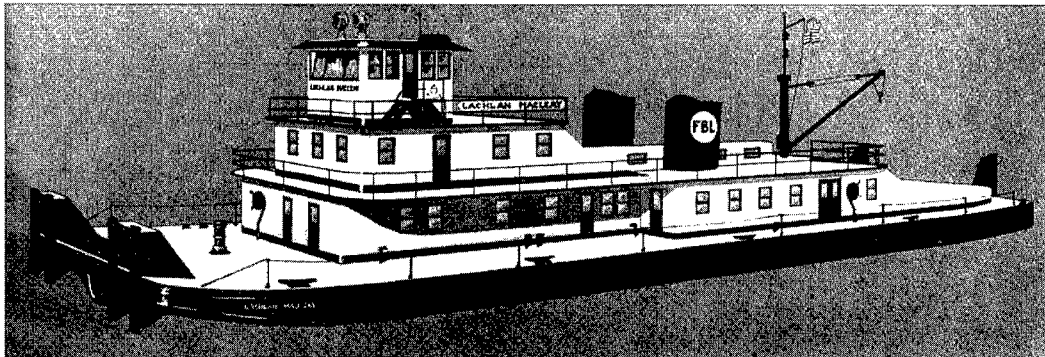
LIQUID CARGO (TANK) BARGES

Length Feet	Breadth Feet	Draft Feet	Capacity Tons	Capacity Gallons *
175	26	9	1000	302,000
195	35	9	1500	454,000
290	50	9	3000	907,200

* Based on an average of 7.2 barrels per ton and 42 gallons per barrel.

Source: The American Waterways Operators, Inc., Arlington, Virginia.

Another measure of success was the purchase of the government subsidized FBL by private enterprise, the St. Louis Shipbuilding and Steel Company. The new company built for introduction and use on the Missouri River in 1955, a specially designed tow boat. FBL had been operating two 1000-horsepower towboats on the Missouri. The new boat was to have 3600-horsepower, with important innovations in design to fit for her special assignment on the Missouri. Use of ten rudders would give the tow maximum maneuverability, a factor of great importance because of the swiftness of the current. Four propellers (quadruple screw) would provide great thrust for work in shallow water. The new 160-by-45-foot towboat, built by the private company FBL owners, was named the *Lachlan Macleay*.



The Missouri River States Committee, sometimes referred to as the "Governors Committee," passed a resolution on December 16, 1959, requesting that the 9-foot deep channel be completed to Sioux City within five years. Again, on December 15, 1960, the basin governors urged Congress to engage in a "vigorous prosecution of the bank stabilization and channelization" project. The governors target date was 1965 for completion of the project.

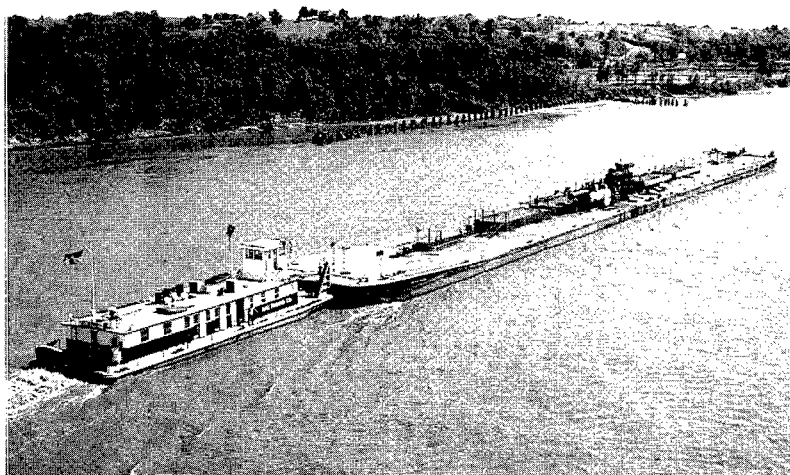
NAVIGATING THE MISSOURI RIVER, 1954

Kishmar described piloting activity in the summer navigation season of 1954: "May. Make three round trips, sounding. Ride the steamer *Missouri* with seven barges out of the river three times. Dusty Rhoades, Master; Homer (Red) Howard, Pilot. Ride the *Roosevelt* out twice. The launch was along each trip, sounding ahead for possible channel changes.

June. Make three round trips writing steering directions. . . . Ride the steamer *Missouri* with eight loaded barges upstream once. . . . Ride the *Bull Durham* twice upstream with two barges of molasses, draft of six feet. . . .

July. Towboats and tows increasing. Make two round trips. Ride Motor Vessel (MV) *Harriet M* twice with two barges of molasses, 7-1/2-foot-draft, upstream once. . . . On the 8th, Parker Brothers Towing Company, of Houston, Texas, under the name of Sioux City Barge Lines, had their first boat, *Sioux City* with two barges of aviation fuel enter, bound for Parkville, Missouri. I rode it upstream twice. Captain Stringer, Master; Delmar Ruediger, of Hermann, Pilot. Ride the steamer *Missouri* with tow upstream once and downstream once. Ride the MV *Delivery* with one barge down. (It was owned by the Leavenworth, Kansas, shipyards). . . . Although the *Bixby* rebuoys the channel about every 10 days, there are frequent changes. That is why we have to make our trips and or have the launch sounding ahead of the tows.

Several groundings. Lost time, six hours and up to 10 hours in the shallow channel."

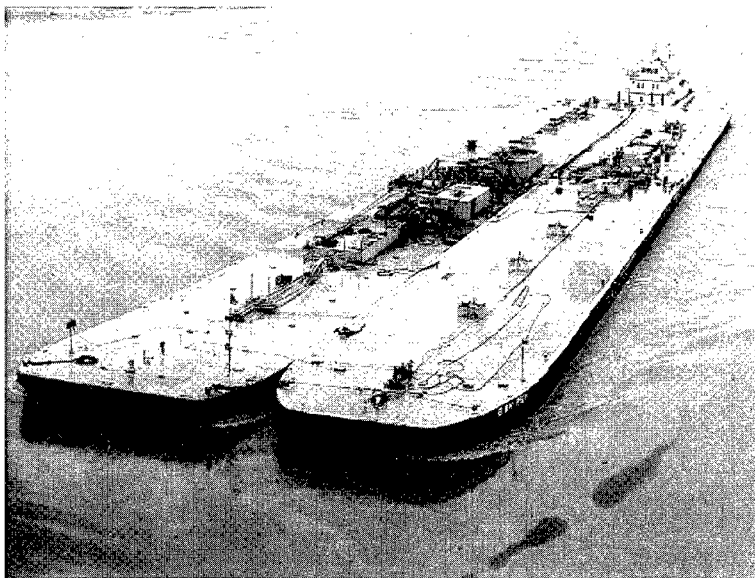


Even with the usual progress that led toward completion, the goal of reaching a continuous nine-foot channel depth was elusive. In 1960, a draft of 6.5 to 7 feet was available during ordinary river stages as far upstream as Omaha. When the controlling depth between Sioux City and Omaha stood at 5.5 feet in 1964, commercial traffic in this reach resumed. By that time, releases of water from the large main stem dams assured shippers of a flow at Kansas City of 35,000 cfs.

DEPTH SOUNDER REPLACES POLE

In 1957, the Corps of Engineers began installing at the Gasconade Boatyard "depth sounders" on its Missouri River launches, replacing the sounding pole. The sounder was a gauge installed on the inspection vessel dashboard. A crew member sat at a small table reading the gauge and marked the depths read from the gauge. Crew members still occasionally extended a sounding pole from the deck of the inspection boat to the river bottom to test the accuracy of the depth sounder. Over time they found the sounder was remarkably accurate.

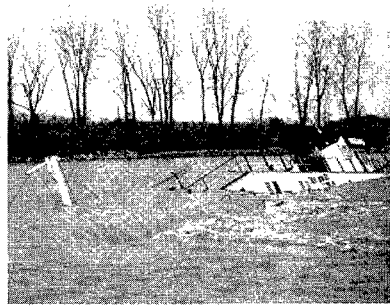
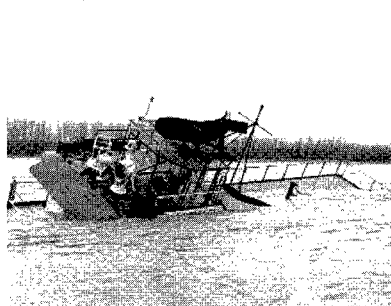
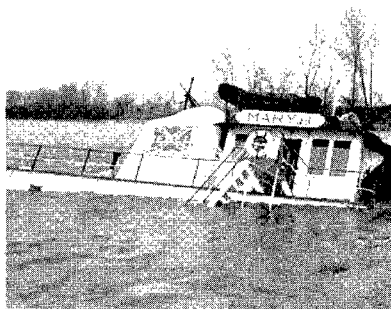
The major problem navigators had on the Missouri was the historic one of shoaling. The crossings still resulted in sharp changes in the speed of the current and often led to settling of silt that rapidly formed reefs.



"MARY B" SANK

Kishmar noted in his log dated April 19, 1961, while on a sounding trip that he passed the *Mary B*, with three loaded barges and two empties.

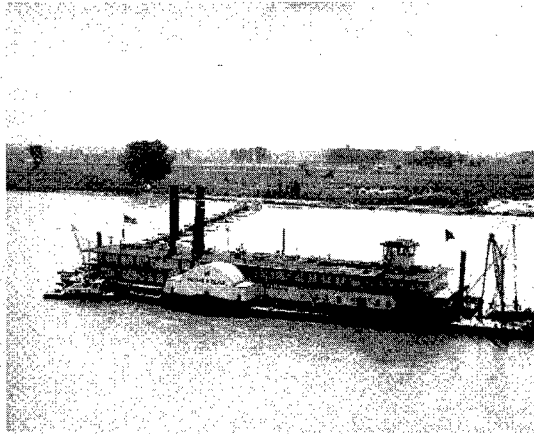
"This is the last time I will see this beautiful towboat. On the 20th at mile 151.2, near Hartsburg Landing, aground the boat got broadside of the current. Why it was not straightened out is a mystery to me. After a certain length of time in this position the sand on the upper side scoured out, leaving a deeper hole, while the sand piled up on the lower side. As the upper hole got deeper, the boat began to tilt. Eventually, after tilting so far, water began to run over the deck and into the open deck of the engine room which caused it to tip over on its side. I believe the crew had plenty of time to get their belongings onto the barges, which eventually broke loose and floated downstream with all persons aboard. . . . The river stage then became high and with the boat on its side, it was impossible to raise it upright. Later a dredge dug a hole about 50 feet deep and the boat slid into it. The silt covered it completely.



Corps Engineers developed techniques to provide better flow patterns over identified difficult crossings. Corps channel inspectors reported in 1963 that the river was getting deeper and barges were carrying heavier loads. In 1964, barges were loading to a draft of 6 to 6-1/2-feet.

MAINTENANCE DREDGING

Maintenance dredging was performed regularly during the navigation season. The average annual dredging from 1963 through 1973 was 3.7 million cubic yards, varying from a maximum of 7.8 million

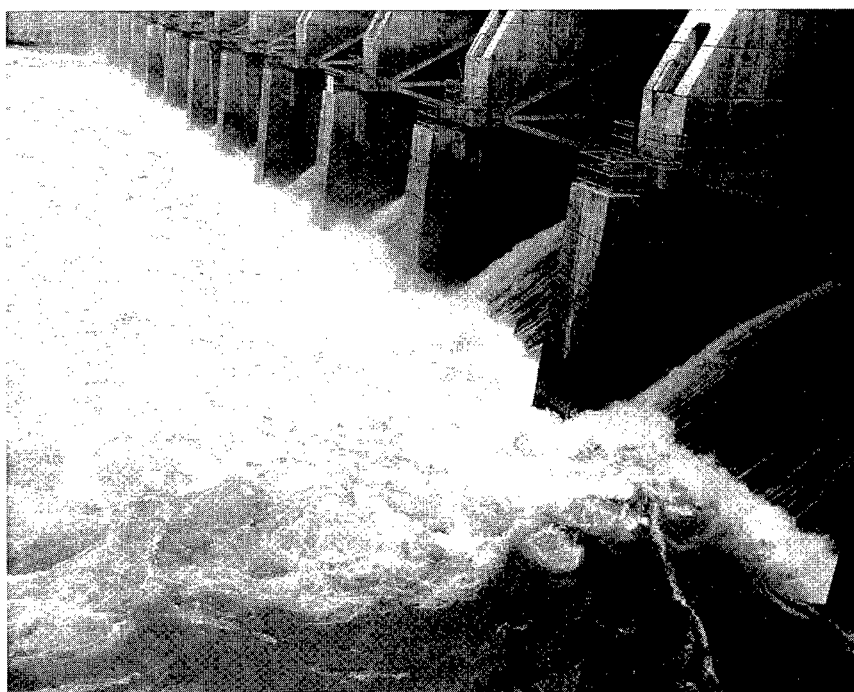
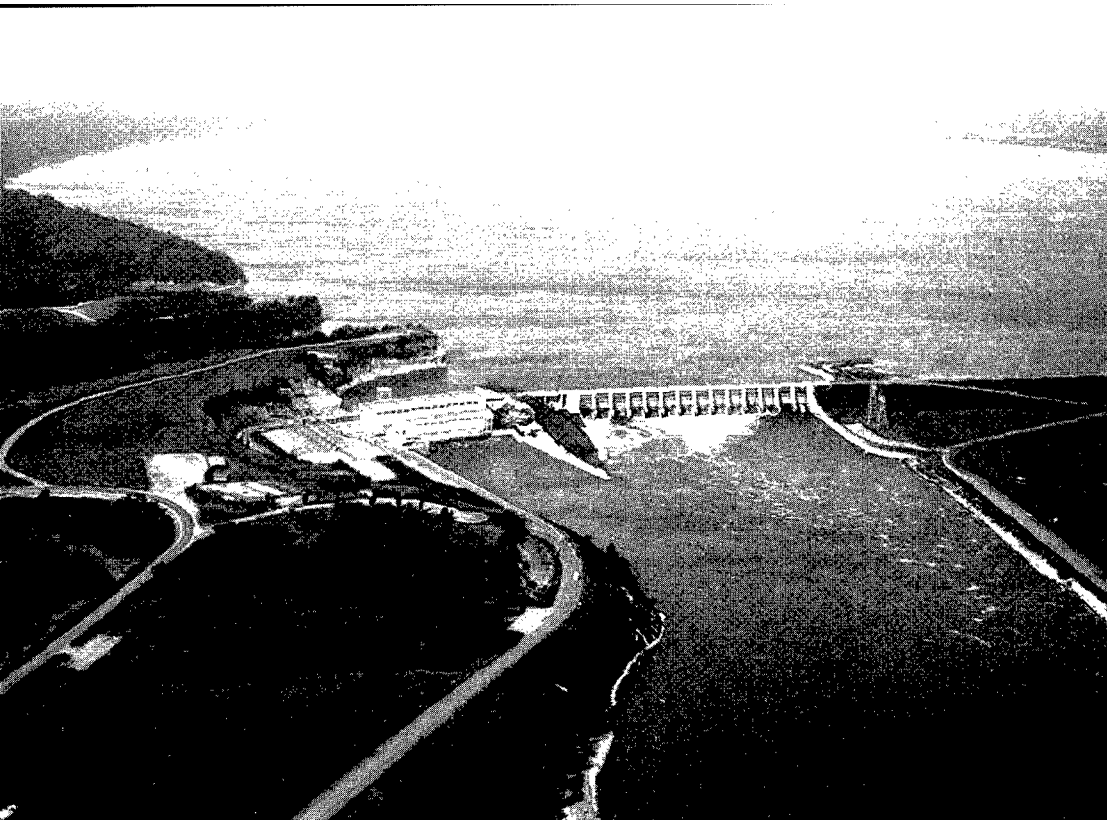


cubic yards during 1963 to a minimum of 220,000 cubic yards in 1969. Disposal of dredged materials was usually in open-water areas of the river between channel control structures.

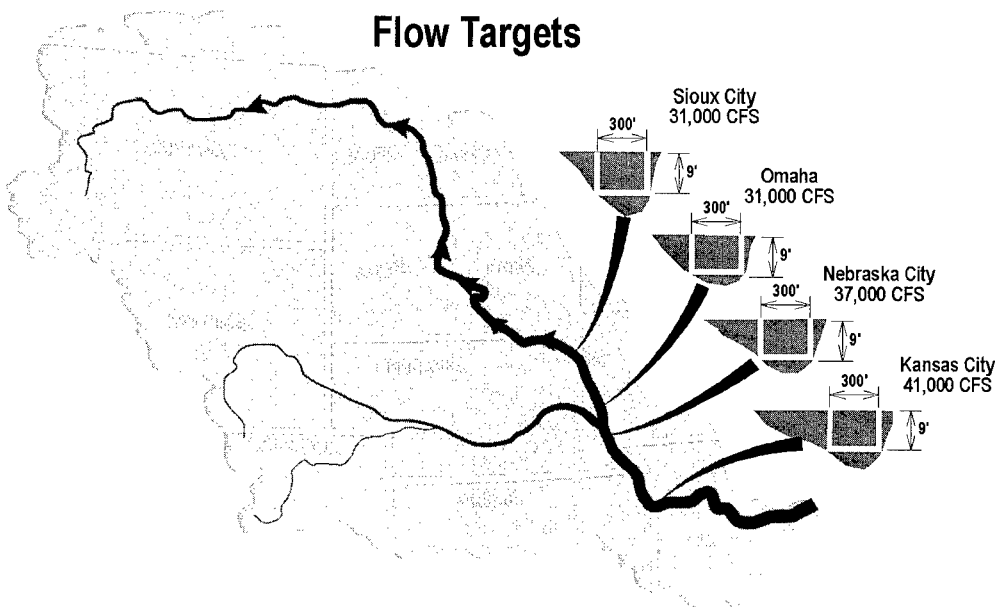
In the early 1970s, the river generally was well over nine feet deep in most reaches, while a number of crossings stayed a foot or so lower. The need for dredging dropped sharply because stabilization had made the river generally self-scouring. The river was evidencing that it was permanently "pegged down" in the sense that Suter had explained the concept in 1881.

Corps of Engineers Dredging - Rulo to the Mouth

Year	Cubic Yards
1964	7,235,145
1965	1,839,320
1966	7,645,740
1967	2,778,795
1968	2,954,210
1969	219,993
1970	2,820,043
1971	2,276,131
1972	1,503,370
1973	155,350



Missouri River Main Stem Flow Targets



NAVIGATION CHANNEL, REGULATORY DAMS AND RESERVOIRS, AND TARGET FLOWS

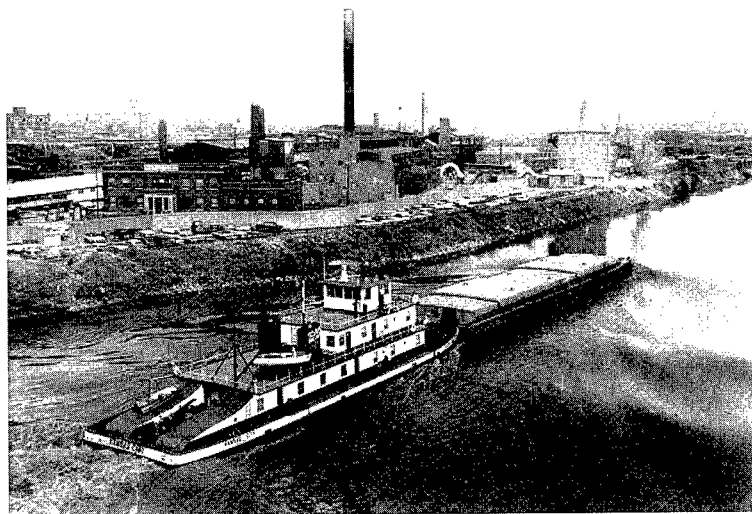
Regulatory dams and reservoirs are elements of the channel stabilization and navigation project. The level of navigation provided is determined by the amount of water in storage in March and July of each year. On 15 March, if main stem reservoir storage totals more than 54.6 million acre feet (MAF), full service is provided by releases from Gavins Point Dam, which is located above Sioux City, the nominal head of navigation. On 1 July, full service is provided if 59 MAF or more water is in storage. Navigation service flows are reduced in proportion to lesser quantities of water in storage.

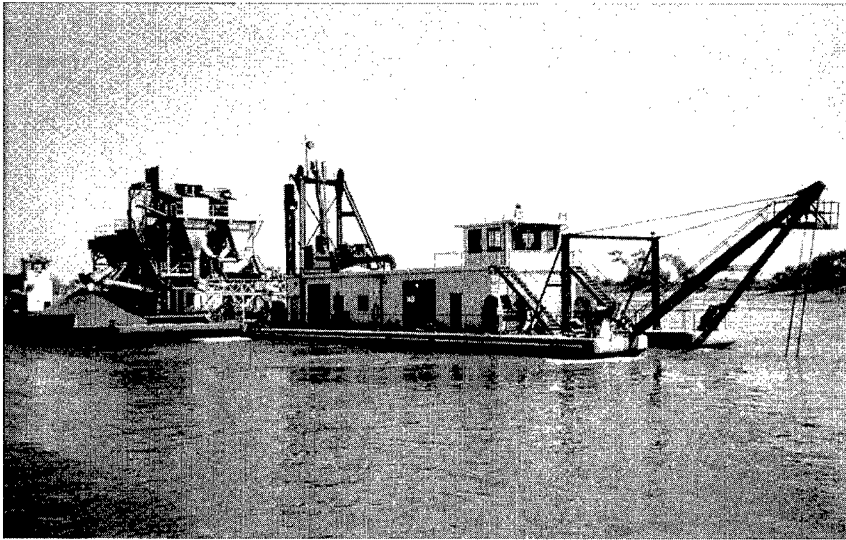
Operating experience had demonstrated that the flows for full service were 31,000 cubic feet per second at Sioux City and 41,000 cfs at Kansas City. These full-service flows generally provided a 9-foot navigation channel and the capability to load barges to an 8-1/2-foot draft.

TAMPICO SANK

The Missouri River was still a difficult stream to navigate. On July 3, 1965, the towboat *Tampico* sank at mile 11.6. Kishmar said: "the *Tampico* was "downbound with a tow at about mile 21.0, entangled drifting logs locked the rudders and propellers causing loss of control. The boat hit a rock dike and metal pipe at the St. Louis County water intake at mile 20.4, right bank, punching holes in the hull. Evidently, the pilot did not realize the extent of the damage until it was too late. As I understood what happened, when the crew knew the boat was going to sink, they put their belongings on the barges. They broke loose as the boat sank, the crew and barges drifted into dikes from where the crew walked to shore. The boat was never salvaged, but was buried deeper.

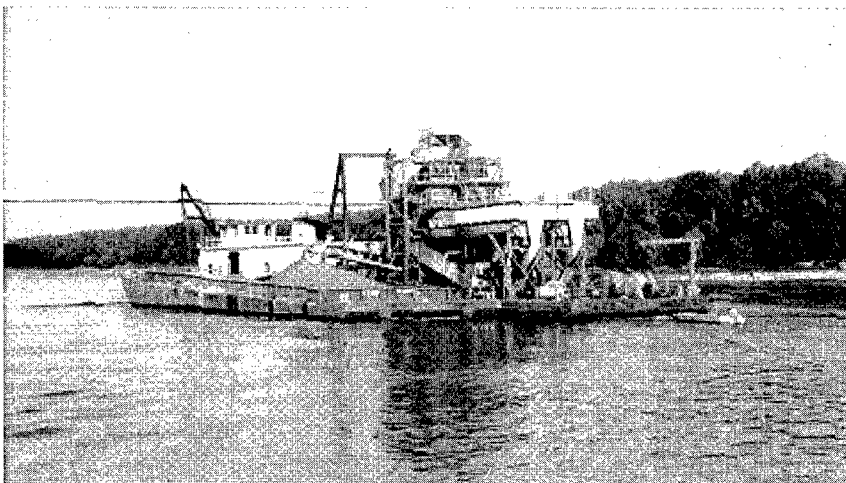
By 1970, Missouri River navigation seemed to be meeting the expectations river development advocates had set decades earlier. Riverborne commerce was expanding. Total commercial tonnage was 4,696,479 in 1970. Over one million tons of grain moved downstream out of the basin. More than 460,000 tons of fertilizer and 60,000 tons of metal products and other bulky items were shipped upstream. Still, sand and gravel from the river and its shoreline constituted the largest bulk products, attaining more than 2.25 million tons in 1970. Sand and gravel operations used loading facilities built and operated exclusively for this important short-haul activity.





In 1977, over 3.3 million commercial tons were shipped, excluding sand and gravel and waterway materials used to maintain the project. That record still stood when the Corps of Engineers declared the bank stabilization and navigation project complete in September 1981. In a full eight-month navigation season, the Corps estimated that the Missouri River navigation channel could accommodate 20 million tons of cargo per year.

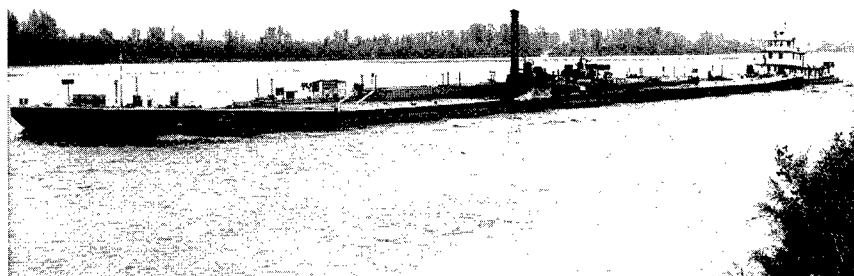
Commercial shipping averaged about 2.5 million tons per year until 1986, when a severe drought set upon the watershed region. During the drought years until 1993, the normal eight-month navigation season was shortened, and navigators loaded barges to lighter drafts and lost revenues. Tonnage fell from 2.30 million in



1986 to 1.33 million in 1990.

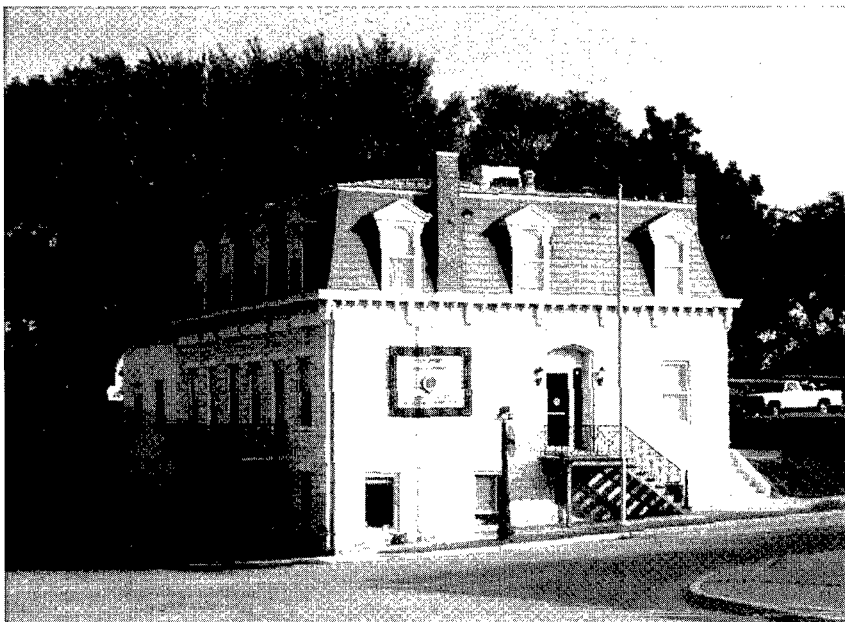
Commercial Tonnage Moved on the Missouri River, 1953-1974.

Year	Upstream	Downstream	Total
1953	108,432	43,569	152,000
1954	200,306	86,843	297,149
1955	288,683	146,772	435,455
1956	157,974	161,,102	319,076
1957	136,641	137,254	273,895
1958	289,616	300-,500	596,116
1959	299,526	543,286	842,812
1960	282,826	1,158,159	1,440,985
1961	381,018	1,185,853	1,566,871
1962	437,709	1,772,149	2,209,858
1963	455,705	1,861,429	2,317,134
1964	447,879	2,104,020	2,551,899
1965	588,672	1,682,891	2,271,563
1966	765,284	1,798,366	2,563,650
1967	845,574	1,720,970	2,566,544
1968	1,015,780	1,273,065	2,288,845
1969	1,070,495	1,003,434	2,073,929
1970	1,238,657	1,327,339	2,565,996
1971	1,240,846	1,570,105	2,810,951
1972	1,200,00	1,500,030	2,700,000
1973	850,000	1,010,000	1,860,000
1974	1,045,707	1,527,933	2,573,640

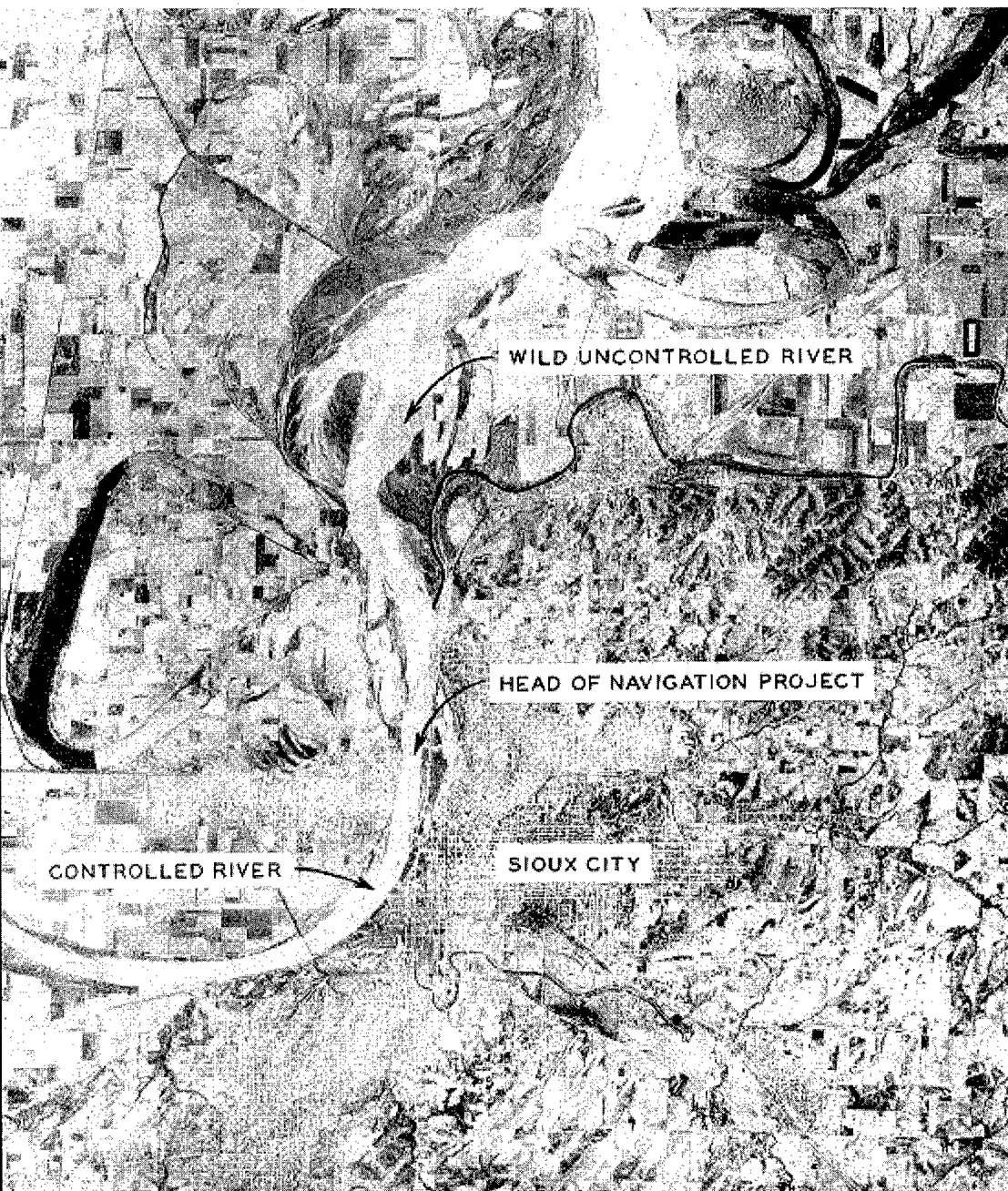




High flows also can disrupt navigation. Service was interrupted for seven weeks in 1993 by severe flooding in the region. The river generally is closed to navigation when stages become sufficiently high that tow boat prop wash can damage on shore developments.



Corps of Engineers Office at Jefferson City, Missouri.



CONCLUSIONS

In 1879, the federal government began to experiment with channel work for contracting the Missouri River. The policy was officially adopted in 1881 and was kept up in ever increasing measure. No more boats have been put into the river, however, than if the work had not been done. Total commercial tonnage has not even matched the amount of rock used to stabilize the channel.

This was hardly what project boosters had in mind when Congress, in 1912, first authorized development of a 6-foot- deep, 200-foot-wide navigation channel from St.Louis to Kansas City. In 1927, Congress extended the project to Sioux City. The Chief of Engineers told the legislators of the risk and urged them to wait until the river work was complete to Kansas City. Time would reveal whether the great waterway to the West could resurge.

Boosters and lawmakers were anxious. The work progressed upstream; boats didn't. In 1937, total commercial tonnage had still not matched the estimated half-million tons in 1867. From 1935 to 1945, in fact, the predominant tonnage that moved on the river consisted of locally hauled sand and gravel or construction materials used for the project.

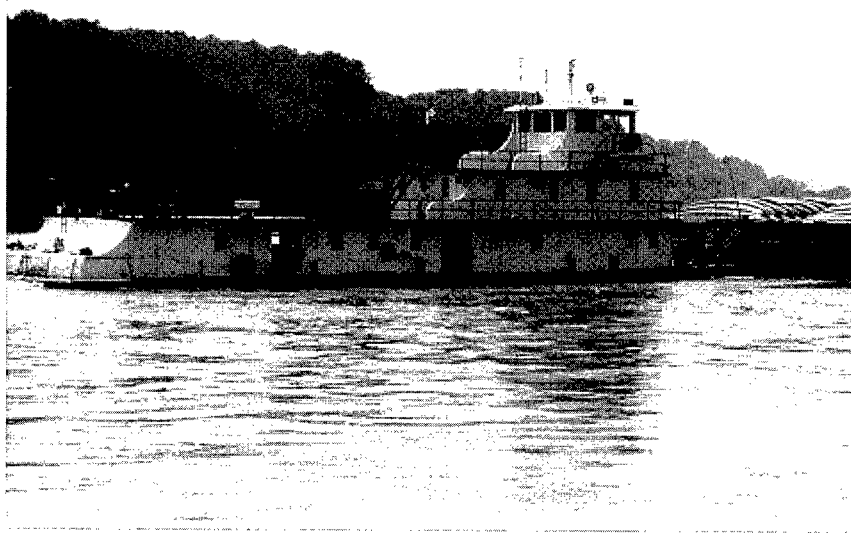
In 1945, waterborne commerce was still negligible and the channel had deteriorated because of wartime neglect. Boosters lobbied for a renovated and bigger navigation channel. Congress authorized expansion of the channel to a 9-foot depth and 300-foot width. The Corps of Engineers accomplished that task officially in 1981, but the Missouri River was not converted into a bustling waterway of commerce.

**MISSOURI RIVER NAVIGATION TONNAGE
AVERAGE 1984-1988**

FARM PRODUCTS	TONS	PERCENT
CORN	128,0031	7.9%
OATS	2,030	0.3%
SORGHUM	72,582	10.1%
WHEAT	303,343	42.4%
SOYBEANS	203,638	28.5%
OTHER	5,754	0.8%
TOTAL	715,350	100.0%
FOOD PRODUCTS		
TALLOW	25,352	7.6%
ANIMAL FEED	114,882	34.4%
GRAIN MILL PRODUCTS	72,915	21.8%
MOLASSES	82,122	24.6%
VEGETABLE OIL	36,673	11.0%
OTHER	1,815	0.5%
TOTAL	333,759	100.0%
CHEMICALS		
SODIUM HYDROXIDE	16,643	2.5%
ALCOHOLS	20,812	3.1%
BASIC CHEMICALS NEC	10,607	1.6%
NITROGEN FERTILIZER	244,552	36.7%
PHOSPHATE FERTILIZER	40,246	6.0%
FERTILIZERS NEC	318,888	47.9%
OTHER	13,851	2.1%
TOTAL	665,599	100.0%
BUILDING PRODUCTS	233,291	100.0%
PETROLEUM PRODUCTS		
KEROSENE	1,339	0.4%
RESIDUAL FUEL OIL	1,180	0.4%
ASPHALT	278,605	85.9%
COKE	43,099	13.3%
OTHER	263	0.1%
TOTAL	324,486	100.0%
OTHER		
MANGANESE ORES	2,686	1.3%
COAL	35,170	17.1%
LIMESTONE	2,404	1.2%
CLAY	4,466	2.2%
NON METALLIC MINERALS NEC	53,858	26.2%
NEWSPRINT	5,998	2.9%
SLAG	13,496	6.6%
IRON & STEEL INGOTS	22,885	11.1%
IRON & STEEL PLATES	23,591	11.5%
FERROALLOYS	9,082	4.4%
IRON & STEEL PDS NEC	4,023	2.0%
MACHINERY	2,229	1.1%
SCRAP	13,365	6.5%
MISCELLANEOUS	12,219	5.9%
TOTAL	205,472	100.0%
TOTAL COMMERCIAL		
- Excluding Sand & Gravel	12,477,957	
SAND & GRAVEL	3,848,172	
WATERWAY IMPROVEMENT MATERIAL	326,742	
TOTAL	6,652,871	

Source: Waterborne Commerce of the United States

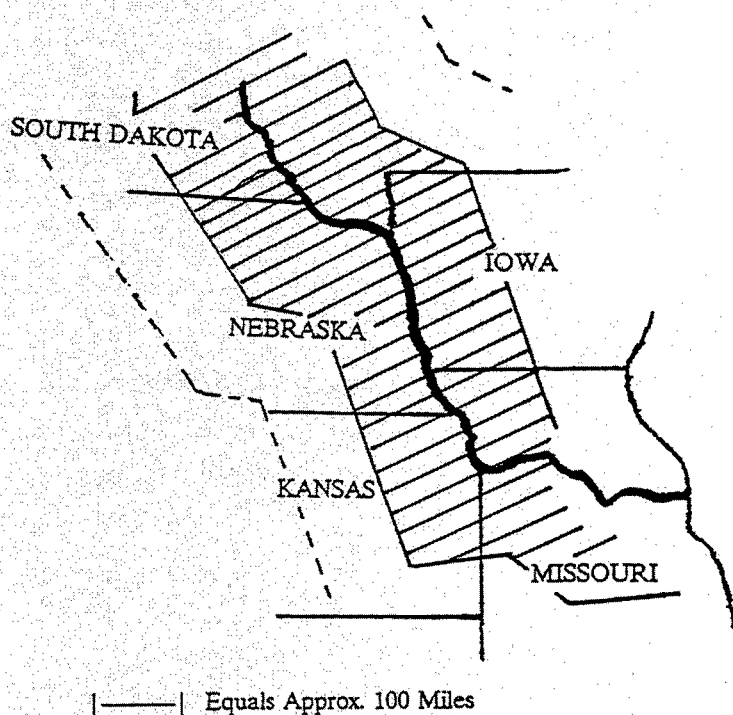
One of the problems hindering the extensive use of tows and barges on the Missouri River is the wide disparity between upbound and downbound movements. The channelized river's swift current discourages upstream operation. Upbound rates for tow operation between Sioux City and the mouth are from 1.3 to 2.4 times those for downstream operations, dependent on river stages. Upbound and downbound traffic needs to be similar in volume. The shipping balance has not developed in the Missouri basin.



From the point of view of commercial tonnage, the engineering accomplishment has been wasted effort. From another perspective, the navigation channel has sustaining value. Under contract with the Corps of Engineers, the Tennessee Valley Authority (TVA) examined freight rates in the Missouri basin. Reporting in December 1991, the analysts concluded that water competition does indeed affect railroad transportation rates. The study said that "the possibility of the barge alternative significantly affects rates for the movement of grain up to a distance of at least 100 miles" from terminal locations.

WATER COMPELLED RATES (1994)

"It is postulated that the mere existence of the Missouri River navigation channel reduces transportation costs by damping rates charged by alternative modes, principally railroads, for the region tributary to the Missouri River.

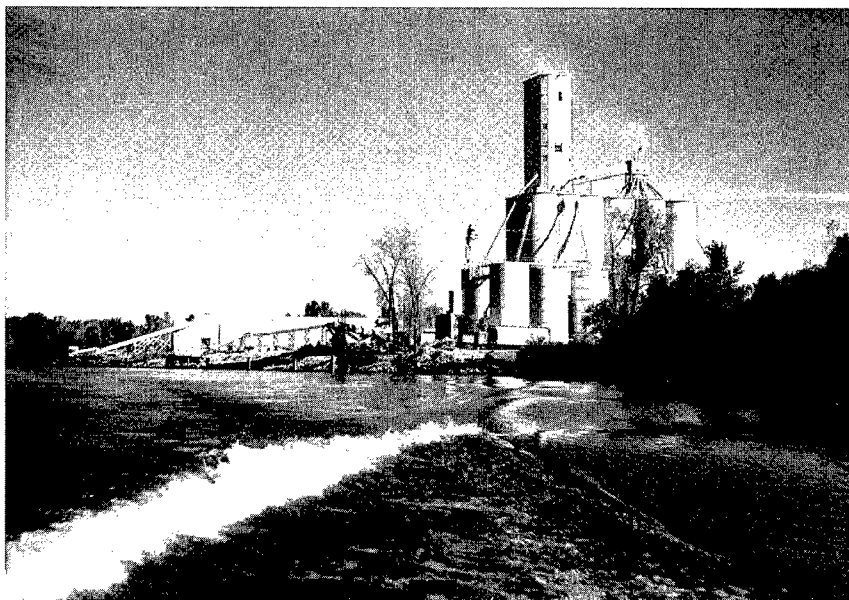


The principal beneficiaries are shippers and users of bulk products, primarily agricultural commodities, that are, or could be shipped by barge located within an area economically influenced by the Missouri River. . . . Existence of reduced rail rates in the Missouri River basin in response to competitive barge transportation had been reported by numerous shippers. . . . Water competition does have an impact on railroad transportation rates in the study area. Study results suggest that, for the movement of grain and other bulk commodities, rail rates would be higher than they currently are."

*Missouri River Master Water Control Manual
River and Update Study (1994)*

The region enjoys some advantage with water-compelled rates, although the project's purpose to entice barge commerce went unfulfilled. This latter was through no fault of the Corps engineers, their design or work. In its natural state, the Missouri River was unstable and presented almost insurmountable problems in making it suitable for navigation. It is an alluvial stream characterized by a meandering habit. Carrying a heavy sediment load and subject to wide and frequent fluctuations, the river could switch its course and destroy improvements along its banks. The river was difficult to navigate and it iced over during the winter months. Railways, built adjacent to the waterway and beyond it, were more reliable and captured the commercial traffic of the region.

The Corps of Engineers' bank stabilization and navigation project did not even get underway until the railways had won the hauling competition. The Corps, directed by Congress to continue the channel development, successfully fulfilled its assignment to establish a stable navigation channel for the 734 miles to Sioux City. This channel, with the timely releases of water from the upstream and tributary dams and reservoirs, provided dependable water depths and predictable flows for the commercial waterway and municipal and industrial water intakes. Allowing the river to flow in its natural uncontrolled state would not permit such beneficial uses.



Bank stabilization and channel rectification has had a substantial impact upon water quality parameters. The project has reduced the supply of sediment material the river obtained from the banks. Sediment storage in the reservoirs has also decreased the supply of material to the river. Within the stabilized channel, the river now obtains most of its load from the bottom. The material from the bottom of the river is heavier and cleaner. The flushed out flowing water in the stabilized channel is less turbid with a significant reduction in suspended sediment loads than the natural stream. The project focused attention on water quality indicators, and many programs have combined to greatly improve the basic quality of the riverine system.

Corps engineers curbed the river's capricious nature of eating away its own banks. Large areas of productive farmland were lost each year when the river flowed in its natural state. Banks would erode 200 to 300 feet during a single rise.

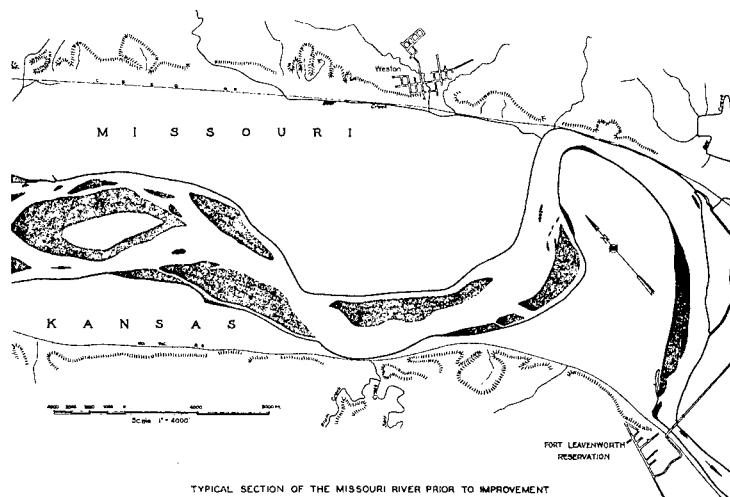


Caving banks destroyed flood control levees. The stabilized channel prevents the loss of levees from this cause as well as preventing damages and threats to the safety of bridges, powerlines, pipelines, and water intakes along the river.

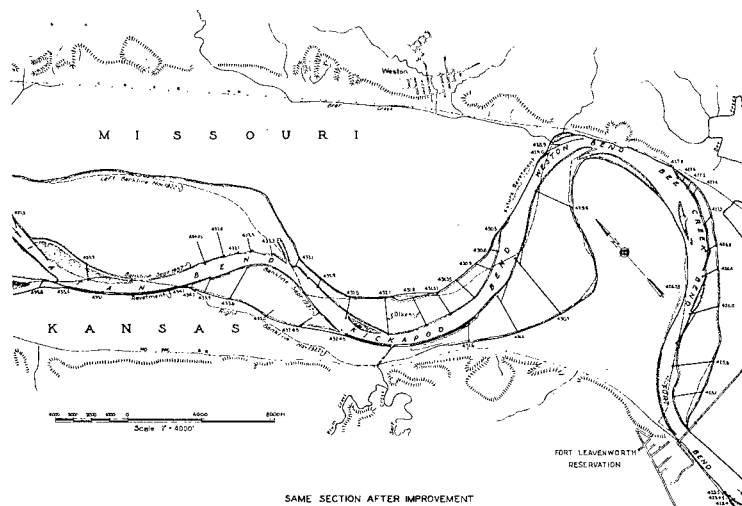
The Corps of Engineers considered erosion control and related benefits from the project as more important than the navigation aspects. Of the total estimated annual benefits attributable to

channel stabilization, about 25 percent was credited to navigation and about 75 percent to bank erosion control and land enhancement. Myron Levin, writing for the *Kansas City Star*, said that the Corps engineers had made the Missouri River "yield up new land in a feat perhaps unmatched since the Creation."

Using early maps and other data, the Corps of Engineers concluded that the Missouri River in its natural state would erode an average of 9,094 acres each year. At this rate all the land in the meander belt (that area of 605,900 acres located next to the natural channel) would erode once in 70 years. As erosion occurred, an equal area of land was formed by deposition elsewhere in the floodplain. Under natural conditions the newly deposited land passed through a recovery cycle and attained the approximate elevation of the high banks in 40 years.



TYPICAL SECTION OF THE MISSOURI RIVER PRIOR TO IMPROVEMENT



SAME SECTION AFTER IMPROVEMENT

John W. Robinson, a fishery biologist of the state of Missouri Department of Conservation, compared river conditions in 1879 with those of 1967. He measured the acreage of water and wetlands and the percent lost in five areas. His findings show that along 71 miles of the river which he planimetered, 19,363 total acres, an average of 273 acres per mile, or 63 percent of water acreage and wetlands, had been lost in the 88 year period.

**ACREAGE OF WATER AND WETLANDS LOST FROM FIVE LOCATIONS,
1879 to 1967**

River Location	Acreage Mile	Percent		Miles Loss	Measured
		1879	1967		
Mouth	0-17	10,500	2,100	80	17
Jefferson City	142-152	2,972	1,313	56	10
Rocheport	173-188	6,377	2,193	66	15
Glasgow	220-231	3,730	1,541	59	11
Miami	242-260	5,222	2,291	56	18
Totals		28,801	9,438	63	71

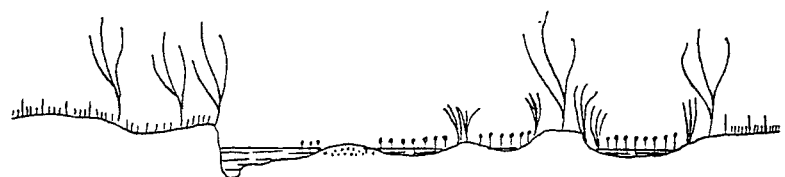
The Corps estimated that the river occupied in its natural state 300,000 acres between Sioux City and the mouth. Under controlled conditions the river area was 112,000 acres. This 63 percent reduction in the original river acreage, attributable to the channel stabilization program, would result in the accretion of 188,000 acres of new land which otherwise would not have existed, according to Corps of Engineers estimates.

The benefits accruing to agricultural lands have been substantial. Progress and improvement in farming the bottomlands is apparent through more intensive use of and higher yields on floodplain lands. With labor and capital invested in it, the accreted land is productive and adds to the tax base.

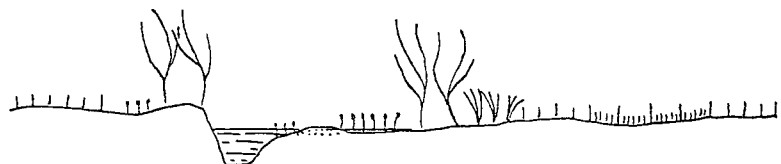
Accreted land and land protected from erosion benefits urban and high-value installations located along the channel stabilization project. The federal project replaced work which public and private sector entities would have been required to do to protect an array of bottomland developments. One study showed that about one-fifth of the total cost of the bank stabilization and navigation project may be charged just to protective works for high-value

installations. The project has encouraged location of facilities adjacent to the river and more intensive developments on the floodplain.

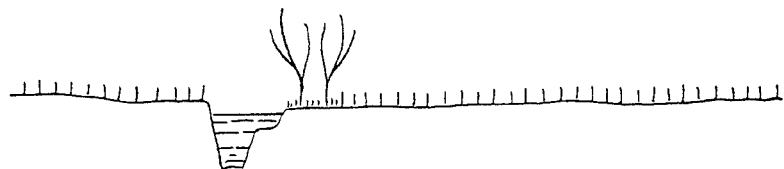
MISSOURI RIVER, SIOUX CITY TO MOUTH Schematic - Channel Accretion



Without Bank Stabilization and Navigation Project



Midway through Construction of the Project



Ultimate effect of the Project

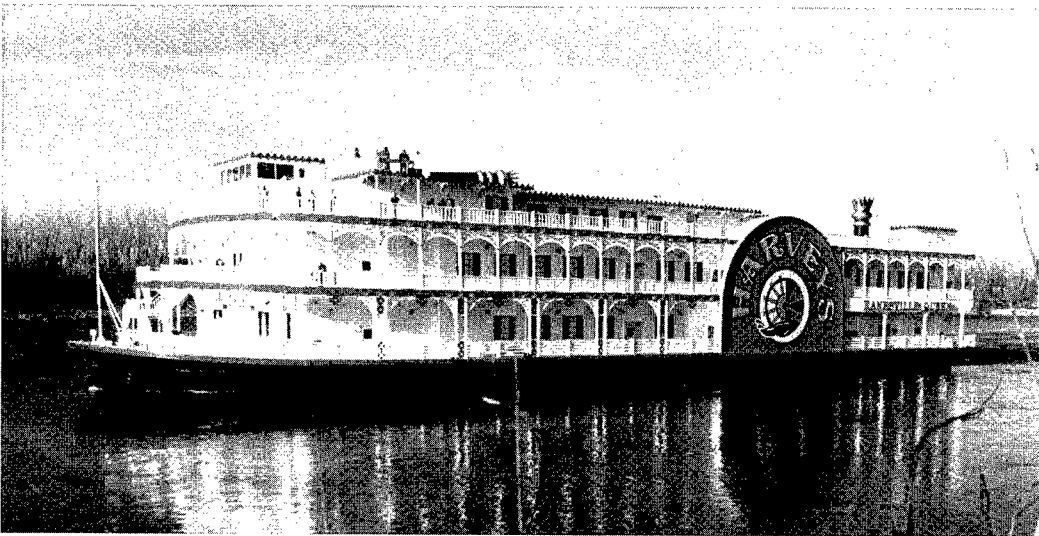
Legend:					
Channel		Timber		Grass	
Sand Bar				Cropland	
				(Low Productivity	
Willow				Cropland	
		Wetland		(High Productivity)	

The gambling industry, absent on the river since steamboat days, has returned. The new gambling activity is a striking revival, dwarfing its historic counterpart. Along the navigation channel in the states of Missouri and Iowa, multimillion dollar on-shore and boat casinos are operating or planned. For example, in 1995 a capital investment of \$200 million was being spent on a pair of riverboat gambling projects on the banks of the Missouri River at Council Bluffs, Iowa. The complexes at Council Bluffs include three hotels, five restaurants, a convention center, and two magnificent riverboats.

The new riverboats are awesome compared to the historic passenger vessels on the Missouri. As examples, two of the boats accommodate 1,700 to 1,800 passengers and feature from 26,328 to 27,500 square feet of casino area. The triple-deck *Kanesville Queen* is a 272- by 78-foot vessel powered by four diesel engines driving 1,440 kilowatt generators at 1,800 revolutions per minute to provide propulsion and electrical service. This \$18 million riverboat will cruise a minimum of 100 days a season on the stabilized and controlled channel.

The navigation project, with its attendant attractive developments on the floodplain and levees for protection of bottomlands, cause





higher flood stages for an equal discharge. Other factors, too, probably have had a bearing upon increased flooding. Rating curves show, however, a reduction in discharge capacity at flood stages.

Dr. Charles B. Belt of the Department of Earth and Atmospheric Sciences at St. Louis University made these observations after substantial flooding in 1973 in the lower Missouri River. Belt said that while flood control dams and reservoirs and levees had a positive effect on reducing flood dangers in the Kansas City area, downstream flood hazards had been intensified by the bank stabilization and navigation project. Citing U.S. Geological Survey figures, Belt said that a volume of water of 618,000 cubic feet per second raised the river at Hermann, Missouri, to a gauge height of 33.3 feet in July 1951. But with the channel area decreased through the work of the Corps, a volume of only about 500,000 cubic feet per second produced a higher gauge reading of 33.7 feet in April 1973.

The Corps acknowledged in a 1979 report that the stabilization and navigation project contributed "to river flood stages as they exist today." To this extent, the study stated the project could be "viewed as an adverse impact." Flood stages are, however, reduced by holdouts of water at Missouri River basin dam and reservoir projects. During several recent flood events, the flow of water has been reduced because upstream flood control projects functioned as designed.

The Corps of Engineers has studied another post-project impact associated with increased flooding. The stabilization project has lowered the bed of the Missouri River. Degradation along the bottom of the channel has not been great enough to compensate for the reduction in the width. A smaller channel capacity for flood discharge in fact is a logical consequence of channel restriction.

Riverbed degradation causes numerous problems. The lowered surface can affect port facilities and water intakes. It can erode bridge foundations and river channelization structures. The lowered water also has been blamed for the drainage of backwater and oxbow lakes adjacent to the river and for contributing to the decline of the groundwater table in the river valley.



The Missouri River bank stabilization and navigation project was authorized, planned, and constructed at a time when environmental values, fish and wildlife conservation, and recreation were issues that ranked lower than economic development. Recreation was recognized as a legitimate project purpose in 1962. Environmental quality with special regard for natural systems and the biogeographic region were not considered until Congress passed the National Environmental Quality Act of 1969.

The Corps of Engineers reported on some environmental impacts of the bank stabilization and navigation project. The Corps estimated that 522,000 acres of aquatic and terrestrial habitat would be eliminated from the natural channel and meander belt by the year 2003. In addition, large numbers of fish and wildlife would be reduced because of the variety of habitats lost. The table following shows a breakdown of the habitat losses in each affected state.

**HABITAT CHANGES IN ACRES BY STATE,
1912-2003**

State	Natural Channel Aquatic	Natural Channel Terrestrial	Meander Belt Terrestrial	Total
Missouri	55,800	27,700	221,400	304,900
Iowa	17,100	18,700	29,600	65,400
Kansas	9,100	2,000	44,000	5,100
Nebraska	18,200	19,400	59,000	96,600
Totals	100,200	67,800	354,000	522,000

The Fish and Wildlife Coordination Act of 1958 gave the Corps of Engineers authority to study and prepare a Missouri River Bank Stabilization and Navigation Project Final Feasibility Report and Final Environmental Impact Statement for Fish and Wildlife Mitigation. The Feasibility Report recommended that the Corps be authorized to acquire, restore, preserve, or otherwise develop certain lands and waters in the project area.

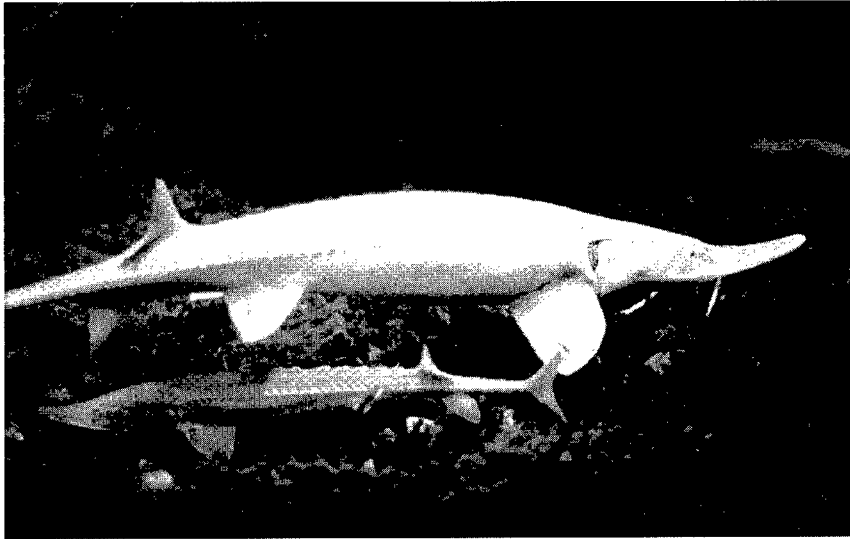
The Water Resources Development Act of 1986 authorized a fish and wildlife mitigation program in the states of Iowa, Nebraska, Kansas, and Missouri. The authorized mitigation project was designed to restore, develop, and preserve 48,100 acres or approximately 10 percent of the habitat that was lost due to the bank stabilization and navigation project.

Many environmental concerns are rooted in the past decisions that were made when plans for the Missouri River were authorized. The Rivers and Harbors Acts of 1912, 1917, 1925, 1927, 1930, 1935, and 1945 each affirmed the desire of the occupants of the floodplain, the basin's elected officials, and the federal government to control the natural river and develop a viable navigation channel. Appropriations measures through the subsequent decades reaffirmed this desire.

THE MISSOURI RIVER, A MASTERPIECE

"It was Carlyle -- was it not? -- who said that all great works produce an unpleasant impression on first acquaintance. It is so with the Missouri River. Carlyle was not, I think, speaking of rivers; but he was speaking of masterpieces -- and so am I."

John G. Neihardt, *The River and I*



Man-made structures altered the natural river and bottomlands landscapes. Natural ecosystems, closely resembling original conditions, are present today only as small relict communities. A vista of erosion-cut banks, mid-channel islands, side-channel chutes, and extensive sandbars has been replaced by one of rock-lined banks and man-made stabilization structures on each side of a comparatively narrow, geometrically curving sinuosity of alignment. Aesthetic appreciation associated with the visual impacts of the bank stabilization and navigation project, and its harmony or dissonance with the natural landscape, is an individual matter.

AN AESTHETIC POINT OF VIEW

"From an aesthetic point of view, the Missouri River has an unenviable reputation. People who never see it except in crossing . . . bridges, from which they look down into a mass of muddy, eddying water, are liable to compare it unfavorably with other important streams.

"But to him who is fortunate enough to travel upon it, and study it in all its phases, it is not only an attractive stream, but one of great scenic beauty."

Hiram Martin Chittenden,
*History of Early Steamboat
Navigation on the Missouri River*

After more than 100 years of work on the Missouri River channel, an array of interests questioned the value of the effort. Comingling of past policies with contemporary issues is appropriate. Like the hydrologic cycle, which is ultimately a system of rebirth, human beings, too, come around to new ideas and understanding. Once, pegging down the bully river, creating the sinuous navigation channel, was the ideal feat. Building dams too became the focus of achievement. Now the center of activity is on environmental restoration.

MISSOURI RIVER FUTURE

"What of the future? . . . Is its great history a closed book? The river is still there -- a fact, a thing to be reckoned with in some way or other. It will not let its presence be forgotten."

Chittenden,
History of Steamboat Navigation

Water and related land management issues in the vast Missouri River basin have become much more complex than was envisioned in the heady development days. Water is more than a commodity to which rules of capture and control apply. The mighty Missouri is a life line, a vital link on which we depend for essentials and many benefits. Once the pathway of Indians, explorers, and pioneers -- the trail of dreams -- our river is still a sustaining image of what is possible and valuable. The Missouri River is vast in its unrealized potential.

SELECTED REFERENCES

Laws of the United States Relating to the Improvement of Rivers and Harbors.

U.S. Army Corps of Engineers. Annual Report, Chief of Engineers. Various years.

U.S. Army Corps of Engineers, Kansas City District. 1938. *Improvements on the Missouri River for Navigation.*

U.S. Army Corps of Engineers, Missouri River Division. 1950. Report on Missouri River Channel Stabilization and Navigation Project, Sioux City to Mouth. Appendix III, Benefits.

U.S. Army Corps of Engineers, Omaha District. 1969. Missouri River Channel Regime Studies, MRD Sediment Series No. 13B.

U.S. Army Corps of Engineers, Omaha District. 1971. Velocity Trends, Missouri River Navigation Channel.

U.S. Army Corps of Engineers, Missouri River Division Task Force Group. 1974. Missouri River Bank Stabilization and Navigation Project Working Papers.

U.S. Army Corps of Engineers, Missouri River Division Task Force Group. 1975. Missouri River Bank Stabilization-Navigation Project, Sioux City, Iowa to Mouth.

U.S. Army Corps of Engineers, Missouri River Division. 1976. Missouri River Bank Stabilization and Navigation Project, Final Environmental Statement Continuing Construction and Maintenance.

U. S. Army Corps of Engineers, Omaha District. 1980. Missouri River Recreation Master Plan. Nebraska, Iowa, Missouri and South Dakota.

U.S. Army Corps of Engineers, Missouri River Division. 1980. Missouri River Bank Stabilization and Navigation Project Economics.

U.S. Army Corps of Engineers, Missouri River Division. 1981. Missouri River Bank Stabilization and Navigation Project, Final Feasibility Report and Final Environmental Impact Statement for the Fish and Wildlife Mitigation Plan.

U.S. Army Corps of Engineers, Missouri River Division. 1981. Missouri River Bank Stabilization and Navigation Project, Management Plan.

U. S. Army Corps of Engineers, Kansas City and Omaha Districts. 1981. Final Report and Final Environmental Impact Statement for Fish and Wildlife Mitigation for the Missouri River Bank Stabilization and Navigation Project. Appendixes A through G.

Harrison, A. S. and W. J. Mellema. 1984. Aggradation and Degradation Aspects of the Missouri River Main Stem Dams. Missouri River Division Sediment Series. Number 34.

Sayre, W. W. and J. F. Kennedy. 1978. Degradation and Aggradation of the Missouri River. The University of Iowa, Iowa Institute of Hydraulic Research.

U.S. Army Corps of Engineers, Missouri River Division. 1994. Master Water Control Manual, Missouri River Review and Update. Volume 6A: Economic Studies, Navigation Economics.

Missouri River Commission, Minutes of the Meetings, 1884-1901.

Board of U.S. Army Engineers, Hearings, October 19 and 20, 1915.

U.S. Senate, Senate Report 307, 43rd Congress, 1st session, 1872.

U.S. Senate, Committee on Commerce, Hearings, 61st Congress, 2d session, March 2, 1910.

U.S. Senate, Committee on Commerce, Hearings, 64th Congress, 1st session, November 12, 1915.

U.S. Senate Document 741, 61st Congress, 3rd session, 1911.

U.S. House of Representatives, House Miscellaneous Document 63, 42d Congress, 3d session, 1871.

U. S. House Executive Document 92, 46th Congress, 3d session, 1881.

U.S. House Document 441, 58th Congress, 2d session, 1904.

U.S. House Document 1120, 60th Congress, 1st session, 1908.

U. S. House Document 913, 63rd Congress, 2d session, 1913.

U.S. House Document 1287, 61st Congress, 3rd session, 1911.

U.S. House Document 463, 64th Congress, 1st session, 1915.

U.S. House Document 594, 69th Congress, 2d session, 1926.

U.S. House Document 238, 73rd Congress, 1st session 1935.

U.S. House Document 214, 76th Congress, 1st session, 1939.

U.S. House Document 821, 76th Congress, 3rd, 194

U.S. House Report 1488, 51st Congress, 1st session, 1890.

U.S. House Report 1826, 55th Congress, 3rd session, 1899.

U.S. House Report 1543, 56th Congress, 1st session, 1900.

U.S. House, Committee on Rivers and Harbors, Hearings, 61st Congress, 2d session, January 21, 1910.

U.S. House, Committee on Rivers and Harbors, Hearings, 75th Congress, 1st session, 1937.

U.S. House, Committee on Rivers and Harbors, Hearings, 75th Congress, 3rd session, 1938.

U.S. House, Committee on Appropriations, Hearings, 82nd Congress, 2nd session, 1952.

U.S. Congressional Record. Various volumes, 1883-1981.

Missouri River Improvement Convention. 1881. Proceedings.

Missouri Valley River Improvement Association. 1891. Proceedings.

Missouri Valley River Improvement Association. 1907. The Missouri A Deep Waterway

Missouri Valley River Improvement Association. 1908. The Work of the Missouri Valley River Improvement Association.

Missouri River Navigation Congress. 1908. Proceedings.

Missouri River Navigation Association. 1925. Proceedings.

Hoover, H. October 19, 1925. *"The Need of Inland Waterway Transportation for Agriculture and Industry."* Address before the Missouri River navigation congress..

Missouri River Navigation Association. 1927. *Missouri River Navigation and the Railroads*.

Missouri River Navigation Association. 1931. *Railways and Waterways*.

Pross, E. L. A History of Rivers and Harbors Appropriation Bills, 1866-1933. Ph. D. Dissertation, Ohio State University.

Sharpe, M. Q., Governor of South Dakota. October 18, 1945. Aspect "Navigation s on Missouri River." Missouri Basin Inter-Agency Committee.

Hill, Hibbert, et al.. 1955. *Report on Effects of Channel Stabilization and Navigation Project Upon Missouri River Levels*.

Potter, W. E., Colonel, Kansas City District Engineer. March 23, 1946. "Missouri River Navigation Project." Missouri Basin Inter-Agency Committee.

"Steamboat Days Returning." 1906 (October). Nation, Volume 82.

Jones, L. M. 1908 (January). "The Improvement of the Missouri River and Its Usefulness as a Traffic Route." Annals of the American Academy of Political and Social Science, Volume 31.

Neff, D. R. 1940 (September). "Missouri -- Development and Maintenance of a Navigable Channel in the River." Civil Engineering.

Whipple, W., Jr. 1942. "Missouri River Slope and Sediment." American Society of Civil Engineers, Transactions. Vol. 107.

Ingersoll, A. G., Jr., Inland Waterways Corporation. September 9, 1948. "Past History of the Inland Waterways Corporation." Missouri Basin Inter-Agency Committee.

Ingersoll, A. G., Jr. September 17, 1957. "Commercial Navigation on the Missouri River." Missouri Basin Inter-Agency Committee.

The Kansas City Star. 1909-1945. Various issues.

The Kansas City Times. 1894- 1981. Various issues.

The Kansas City Post. 1907-1909. Various issues.

The Kansas City Journal. 1907-1910. Various issues.

Sturgis, S. D., Jr., Brigadier General, Missouri River Division Engineer. May 18, 1950. "*Navigation Development on the Missouri River.*" Missouri Basin Inter-Agency Committee.

Berrigan, P. D., Colonel, Kansas City District Engineer. May 18, 1950. "*Early Day Activities and Improvements on the Missouri River.*" Missouri Basin Inter-Agency Committee.

Hoeffer, H. J., Colonel, Omaha District Engineer. May 18, 1950. "*Progress of Channel Stabilization Works.*" Missouri Basin Inter-Agency Committee.

John Ferrell. 1993. *Big Dam Era.*

John Ferrell. 1991. *Heartland Engineers.*

John Ferrell. 1989. *Developing the Missouri.*

John Ferrell. 1986. *Agricultural Legacies.*

Bragg, T. B. and A. K. Tatschi. 1977. *Changes in Flood-Plain Vegetation and Land Use Along the Missouri River from 1826 to 1972. Environmental Management. Vol. I.*

Parker, D. D., Captain, President, Sioux City-New Orleans Barge Lines. January 27, 1954. "*Prospects for Navigation on the Missouri River.*" Missouri Basin Inter-Agency Committee.

Kemp, W. E., Council, Federal Barge Lines. April 21, 1955. "*Growth of Traffic on the Missouri River.*" Missouri Basin Inter-Agency Committee.

Kemp, W. E. February 18, 1959. "*Navigation on the Missouri River Today and Tomorrow.*" Missouri Basin Inter-Agency Committee.

Funk, J. L. and Robinson, J. W. 1974. *Changes in the Channel of the Lower Missouri River and Effects on Fish and Wildlife.* Missouri Department of Conservation.

Dodson, J. A., Farmers Union. December 14, 1961. "*Importance of Missouri River navigation to Agriculture in the High Plains Area.*" Missouri Basin Inter-Agency Committee.

Young, Gordon. 1971 (September). "*That Damned Missouri River.*" *National Geographic. Volume 140, No. 3.*

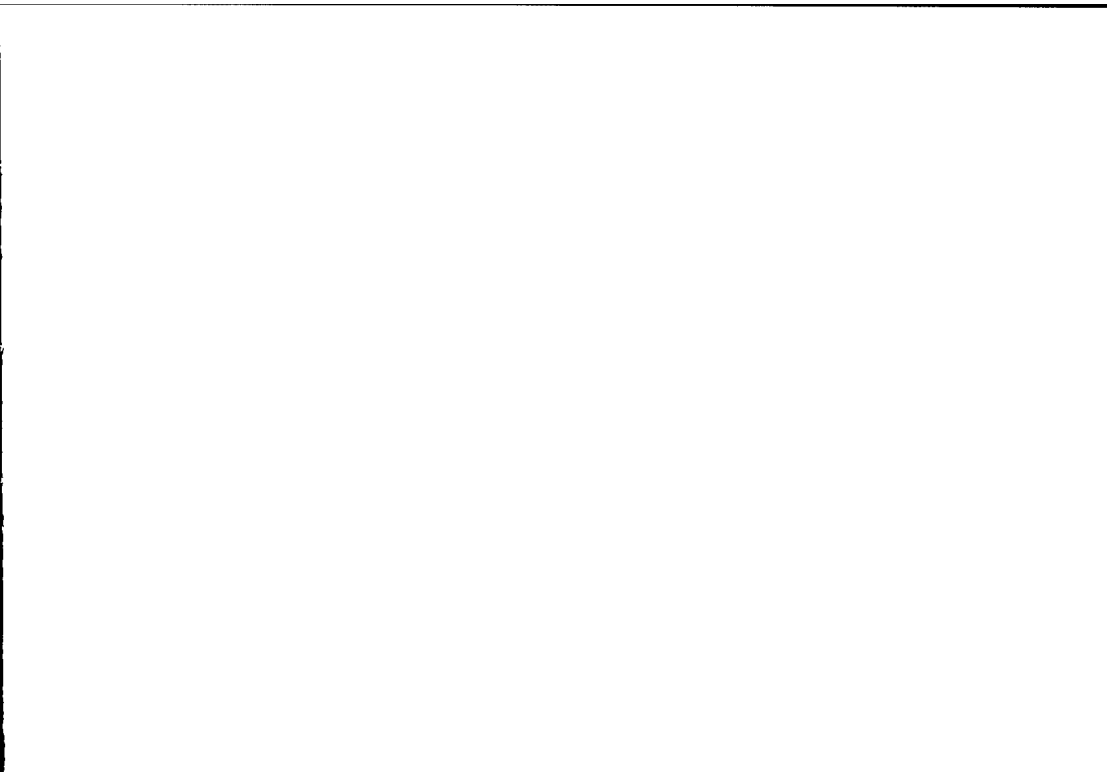




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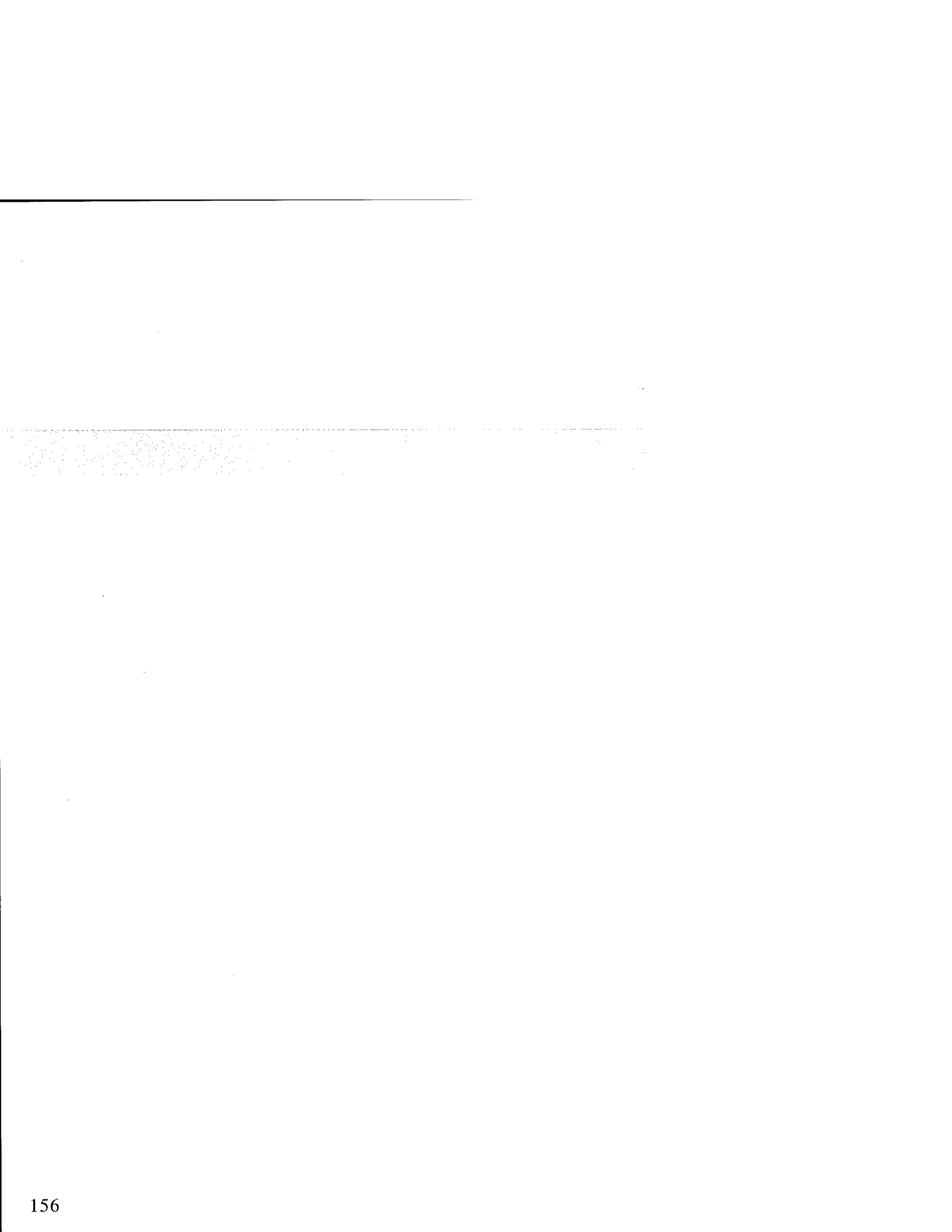
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