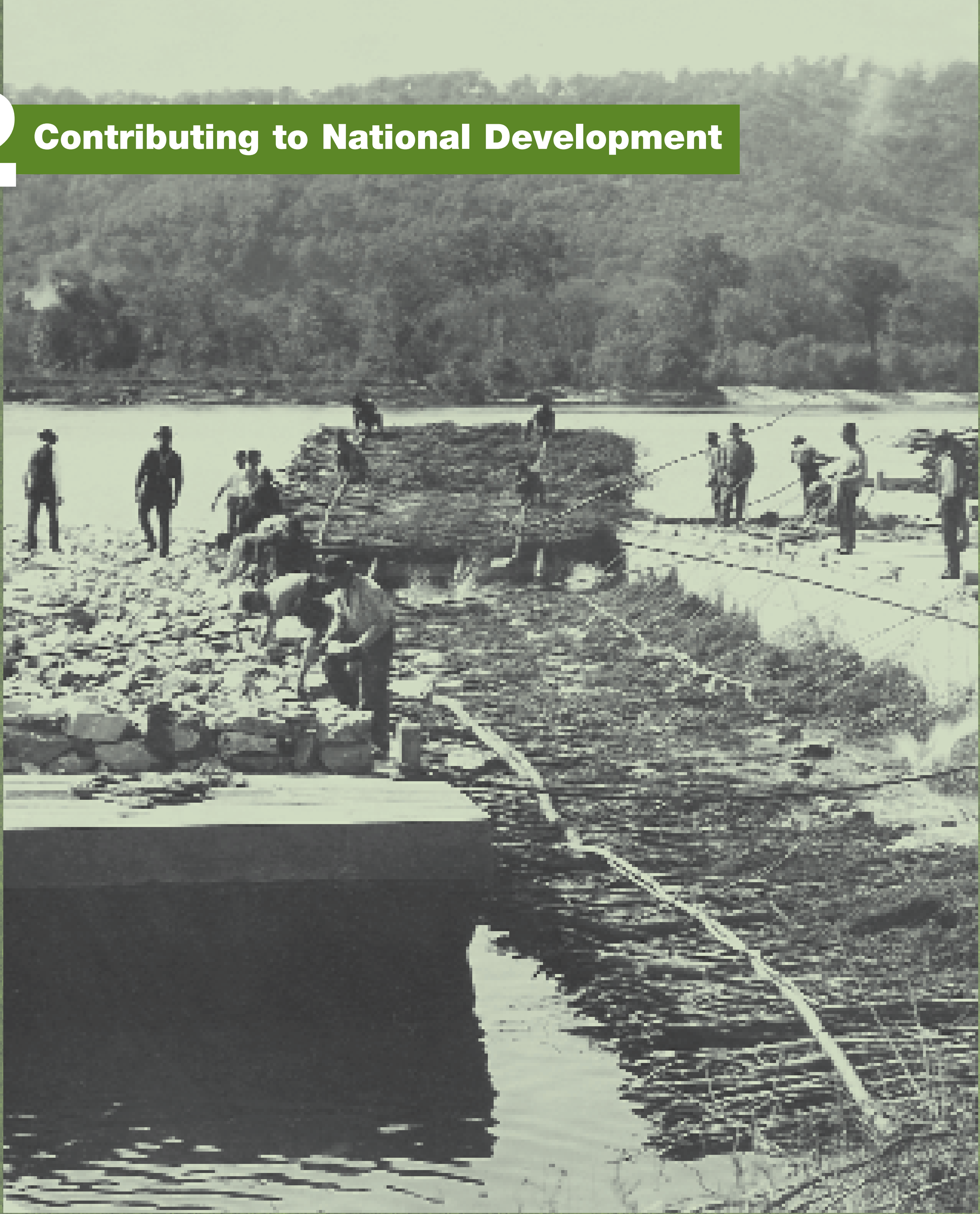
2 Contributing to National Development



Construction of rock and brush wing dams on the Mississippi River in 1891. The photographer, Henry Peter Bosse (1844–1903), worked as a civilian engineer and draughtsman for the Corps of Engineers during the reshaping of the Mississippi River for modern transportation. Rediscovered only in the early 1990s, Bosse's photographs have won international acclaim, earning him a place among the J. Paul Getty Museum's "38 Photographers of Genius."

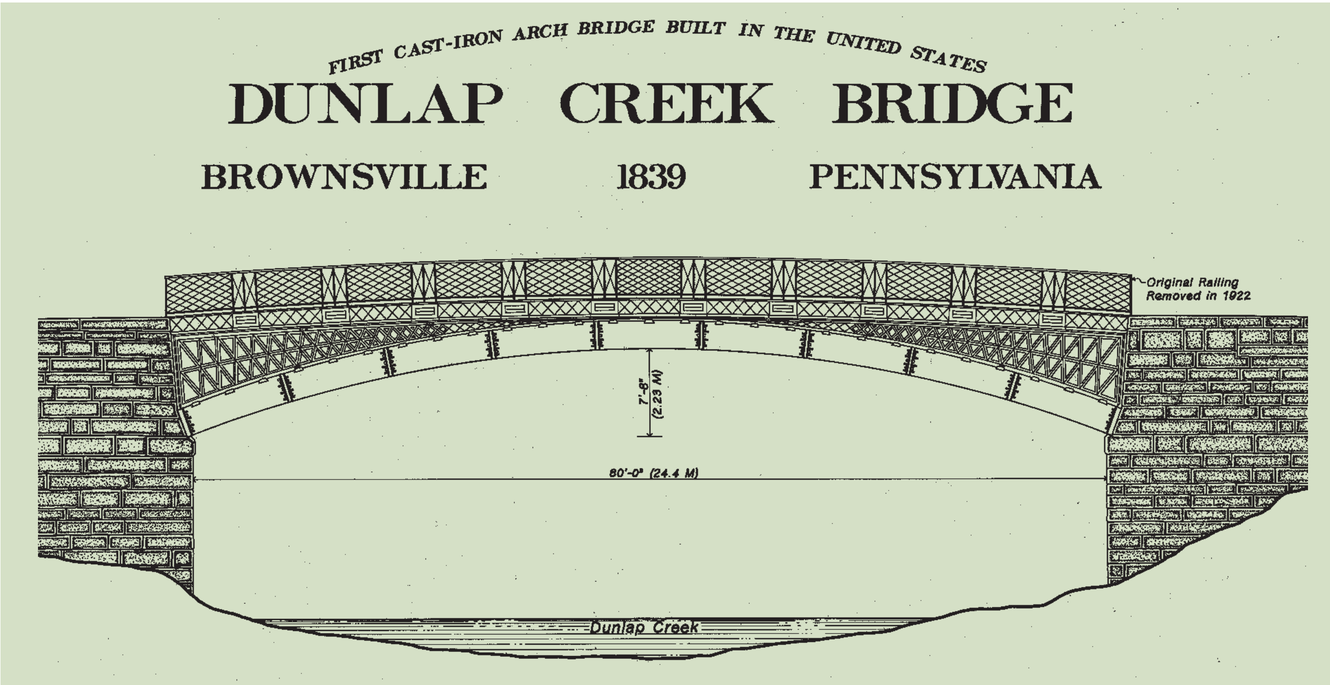
The National Road

As pioneers and immigrants settled west of the Appalachian Mountains, Americans felt a pressing need for reliable transportation routes to the newly formed states in the Ohio and Mississippi river basins. President Jefferson's Secretary of the Treasury, Albert Gallatin, and others proposed many road and river improvement projects to meet this need, but before 1840, only one project received substantial federal financial support. This was the National Road between Cumberland, Maryland, and Vandalia, Illinois, which the government built between 1811 and 1841 at a cost of more than $6 million.

Gallatin's Treasury Department supervised the construction of the first segment of the road, built between 1811 and 1818 between Cumberland on the Potomac River and Wheeling on the Ohio River. The U.S. Army Corps of Engineers assumed supervision of the road's construction in 1825, when Congress authorized the continuation of the road west of the Ohio River. The Secretary of War then ordered that the road be constructed using the method introduced in England by John McAdam. McAdam found that applying three successive three-inch layers of broken stone above ground level produced a well-compacted road surface that could bear the heaviest contemporary loads. Civilian superintendents reporting to the Engineer Department oversaw the road's construction until Congress, in 1832–1834, mandated that engineer officers be placed in immediate charge.

By then, the road east of the Ohio River had fallen into serious disrepair and Congress ordered that an engineer officer fix it and then turn it over for maintenance to the states through which it passed. That

Conestoga wagons crossing the Appalachian Mountains on the National Road. Carl Rakeman, an artist with the Bureau of Public Roads, painted this image in the mid-twentieth century.
Federal Highway Administration



North elevation of Dunlap Creek Bridge from drawings made in 1992 for the Historic American Engineering Record. After four other bridges failed at Dunlap Creek, Capt. Richard Delafield designed this cast-iron bridge in the mid-1830s. Construction began in 1836, but bad weather, labor shortages, and inadequate funding delayed completion until 1839.

Library of Congress

section of the road had been built with large foundation stones, and many of these had worked their way to the surface at dangerous angles. In return for subsequent state assumption of maintenance responsibilities, the federal government agreed to macadamize the road, to build a new route just west of Cumberland that avoided a steep mountain ridge, and to replace several decaying original bridges.

Engineer Captain Richard Delafield, a future Chief of Engineers, supervised most of the eastern repair work. His new solid masonry bridge over Will's Creek west of Cumberland had two elliptical arches, each spanning 59 feet and standing more than 26 feet above the water. With wing walls, its total length was 291 feet. Across Dunlap's Creek at Brownsville, Pennsylvania, Captain Delafield built the first bridge with a cast-iron superstructure in the United States, an 80-foot-long span that remains in use today. The Cumberland Road Project was an early example of the Corps providing imaginative and durable engineering work under challenging circumstances.

First cast-iron arch bridge built in the United States. Carl Rakeman painted this image of the Dunlap Creek Bridge.

Federal Highway Administration

The National Road at Clarysville, Md.

National Archives

The Corps Helped Construct Portions of Afghanistan's National Road

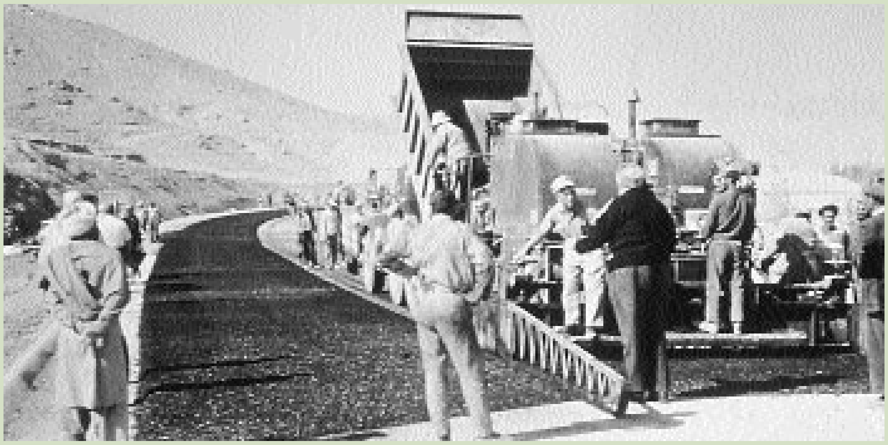
During the 1960s, the U.S. Army Corps of Engineers oversaw a program to improve Afghanistan s poor system of roads. At the time, Afghanistan s rudimentary highway system consisted of a 1,700-mile circle of rock-bed and dirt roads linking principal towns and cities. From Kandahar in the south, the roads ran both northeast to Kabul and northwest to Herat. The main road then looped across the northern tier of the country to connect Herat and Kabul. Spurs from this great elliptical route known as the ring road extended toward Iran to the west and Pakistan to the southeast. The Mediterranean Division s Gulf District established an Afghanistan Area Office at Kabul to tackle the construction challenge.

In 1961, the Corps initiated construction of one part of the highway system, a ninety-six-mile spur from Kandahar southeast to the border with Pakistan at Spin Baldak. Although this project had been completed in a relatively rapid manner, the major portion of the Afghanistan highway, the 300-mile road from Kabul to Kandahar, languished in the design stage. A border closing restricted construction operations for several years as the contractor had to develop alternate routes for transporting equipment and supplies principally through Iran to Meshed, across a primitive road to Herat, Afghanistan, and on to Kandahar. But modified specifications allowed the contractor to complete the initial segment in the north by 1964. Within two more years, the contractor turned over the final portion of the highway, along with a series of bridges and drainage ditches completed as ancillary projects.

The Mediterranean Division oversaw construction of a third highway segment running seventy-five miles west from Herat to the city of Islam Qala on the Iranian frontier, which was completed by late 1967. The total cost of constructing this road had risen to $9.5 million with the considerable repair and redesign necessitated by massive flooding.

The Herat-Islam Qala highway, the Kabul-Kandahar highway, and the Kandahar-Spin Baldak highway linked systematically with Russian-built roads. The total American contribution to this highway system consisted of more than $55 million for construction and another $25 million in related costs.

The Corps played a major role in providing Afghanistan with a modern highway system at the height of the Cold War. After the Soviet invasion of Afghanistan in 1979, the road network continued to degrade while it was used to facilitate occupation of the country. With the establishment of a new national government following the overthrow of the Taliban regime in 2001, the Corps resumed its role, constructing bridges and providing technical assistance to the Agency for International Development s transportation reconstruction program in Afghanistan.



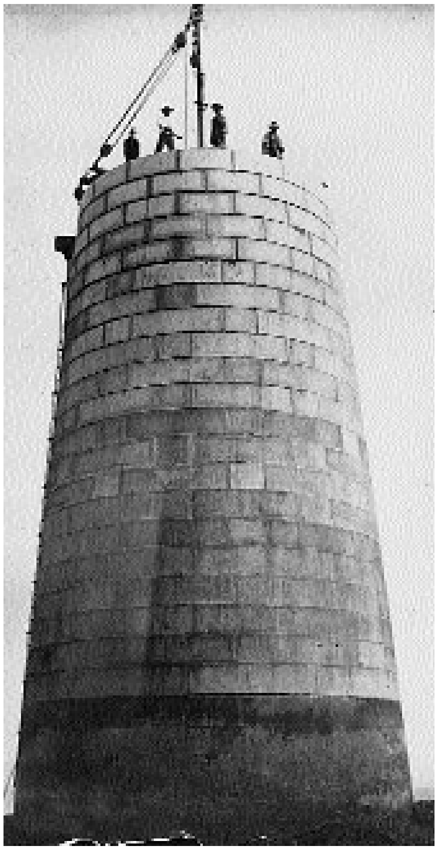
Laying highway asphalt along the ring road

Lighthouses

As early as 1716, private parties built lighthouses on the Atlantic Coast. U.S. Army engineers began supervising lighthouse construction in 1827. In 1831, the Treasury Department placed funds appropriated for lighthouses in the hands of the Chief Engineer of the U.S. Army Corps of Engineers. A federal Lighthouse Board, created in 1852, assumed responsibility for supervising lighthouse construction and inspection. Three engineer officers were members of the original Lighthouse Board, and U.S. Army engineers were assigned to each of the twelve lighthouse districts.

In the nineteenth century, engineer officers designed lighthouses to help mariners weather violent Atlantic storms. Adopting European technology, those officers often innovated to solve particular problems. Major Hartman Bache borrowed from British engineers the design for the first screw-pile lighthouse in the United States. This type of pile was ideal for the bottom of the Delaware Bay because it could be securely twisted into an unstable sea floor. To fend off the floating ice that threatened a structure at Brandywine Shoal, Delaware, Major Bache installed a fence of screw piles five inches in diameter around the lighthouse. He then added an outer fence and erected a platform over the space between the two fences. Tons of stone riprap were dumped around the structure to provide additional protection.

Cape Lookout Lighthouse, N.C., completed by the Corps of Engineers in 1859

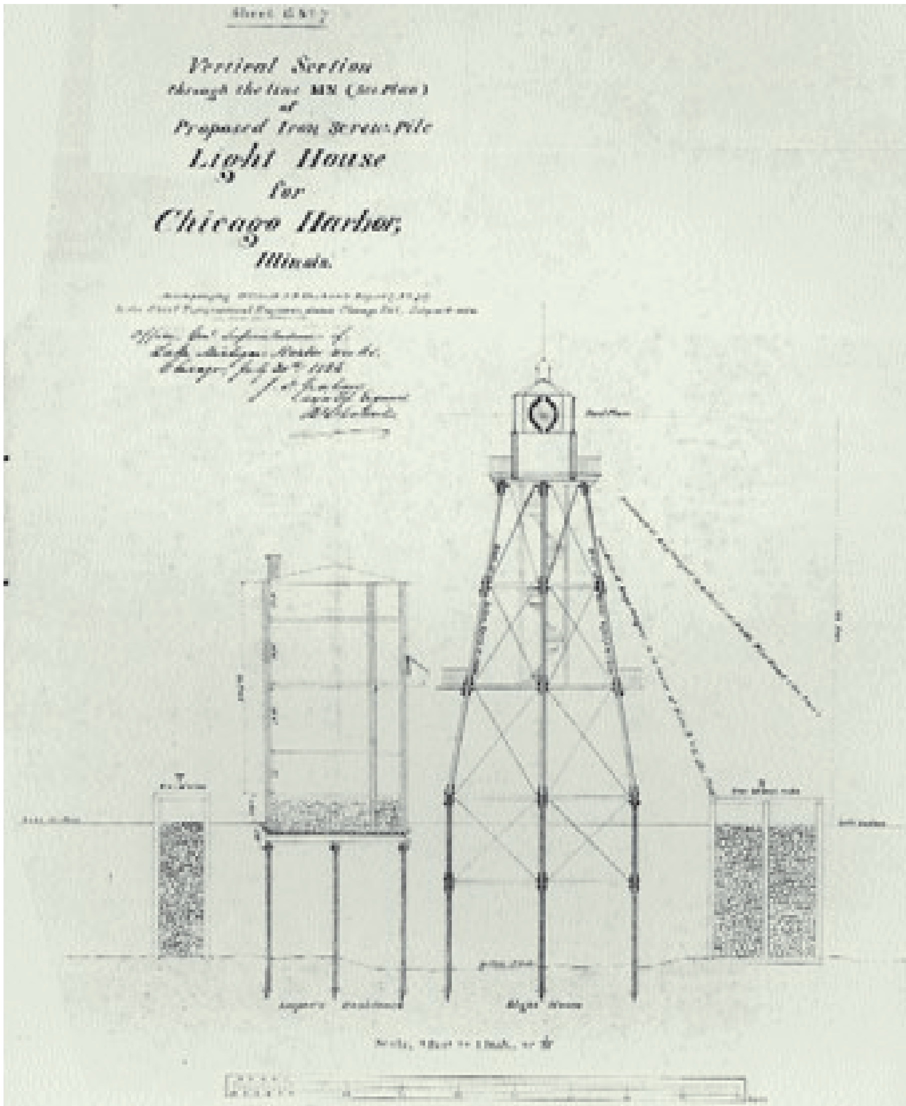


Minot's Ledge Lighthouse on the Mass. coast under construction in August 1859

National Archives

Sombrero Key Lighthouse designed and built by Lt. George G. Meade. Photograph taken 1971.
U.S. Coast Guard

Engineering advances later made it possible to erect sturdy lighthouses on the reefs around the Florida Keys. The most famous of these was the Sombrero Key Lighthouse, built by Lieutenant George G. Meade seven years before he met General Robert E. Lee at Gettysburg in July 1863. U.S. Army engineers also erected the first lighthouses on the Pacific Coast. By the Civil War, engineer officers



Lighthouse plan for Chicago Harbor
National Archives

had placed new Fresnel lenses in all lighthouses.

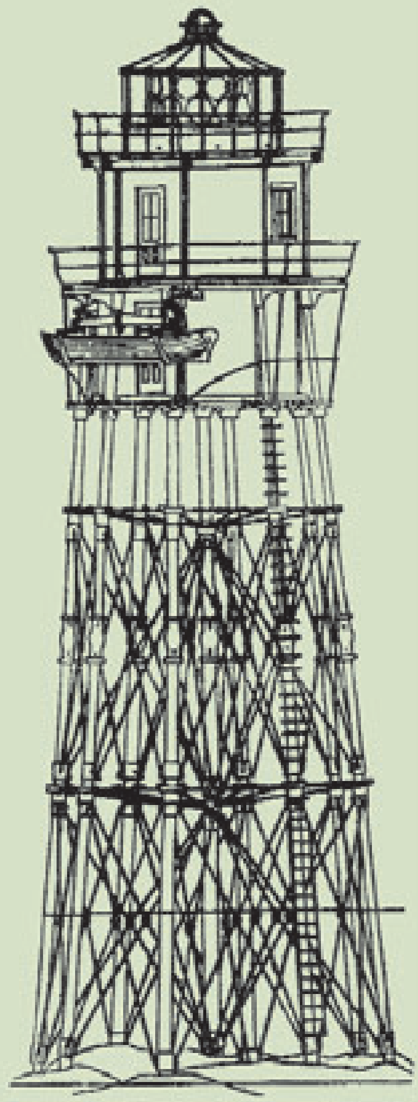
In addition to making design innovations, the Lighthouse Board oversaw significant advances in optics, sounding mechanisms, and mariner warnings. Engineers continued to serve as board members and as lighthouse district inspectors and engineers until Congress abolished the Lighthouse Board in 1910. The overall number of aids to navigation, including lighthouses, buoys, and fog signals, had grown from around four hundred at the inception of the board to just fewer than twelve thousand at its conclusion. After the board was abolished, U.S. Army engineer officers continued to work on intermittent lighthouse assignments.

Two Lighthouses at Minot's Ledge

Captain William H. Swift designed the screw pile iron lighthouse for Minot s Ledge outside Boston harbor and construction began in 1847. He studied examples of these new technologies in England and adapted them for American lighthouses. The Minot s Ledge location was a small, rocky island battered by the sea. Swift designed the lighthouse seventy feet high with a twenty-five-to-thirty-foot base. In 1849, after a violent storm, he began to add diagonal bracing to strengthen the structure, but, before this adaptation was complete, a tremendous gale in April 1851 destroyed the structure killing two lighthouse keepers. Accusations and recriminations began immediately with critics favoring a traditional heavy stone structure. Swift asserted that modifications made by the lighthouse keeper had weakened the iron structure. Congress eventually funded a stone lighthouse that exists today, but engineers continued to build iron lighthouses safely in other locations.

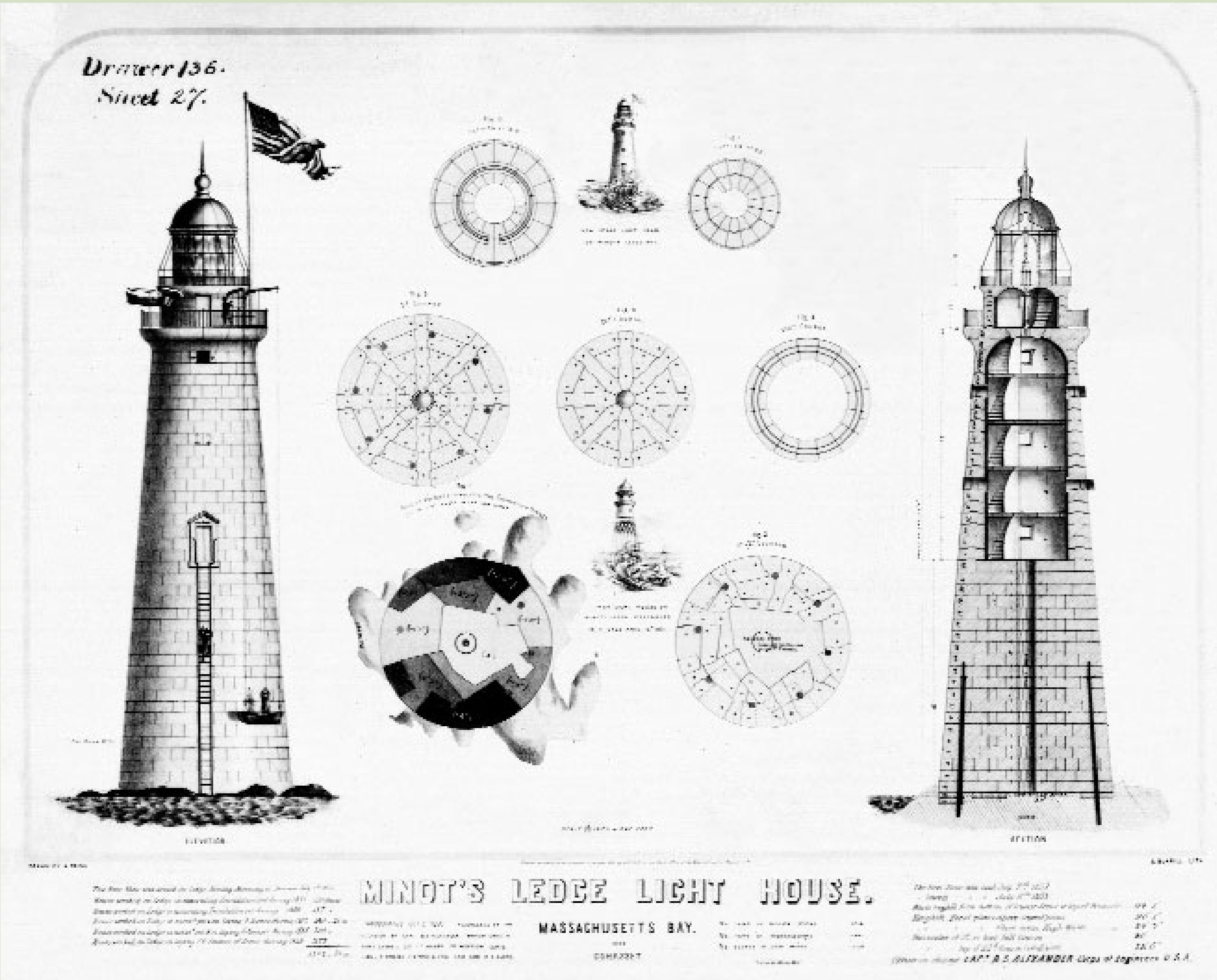
> The failure of Minot s Lighthouse did not stop work on the other [iron] lighthouses authorized by Congress in 1847 and had relatively little impact on their designs, apart from underscoring the importance of large bases relative to height and the need for diagonal bracing. An interesting feature of the early iron skeleton lighthouses is how unique each one was. Differences due to varying site features and requirements for the light such as height, type of foundation, and environmental conditions (breaking waves or harbor rollers) are understandable. But the towers varied in other ways, which indicated that the designers were experimenting. It also shows that Colonel [John J.] Abert [Chief of the Corps of Topographical Engineers] gave his officers latitude to experiment and to use their judgment in deciding the details of the lighthouses in their districts.

Quoted from Sara E. Wermiel, *Army Engineers' Contributions to the Development of Iron Construction in the Nineteenth Century,* Essays in Public Works History, #21 (Kansas City, Mo.: Public Works Historical Society, 2002), p. 18.



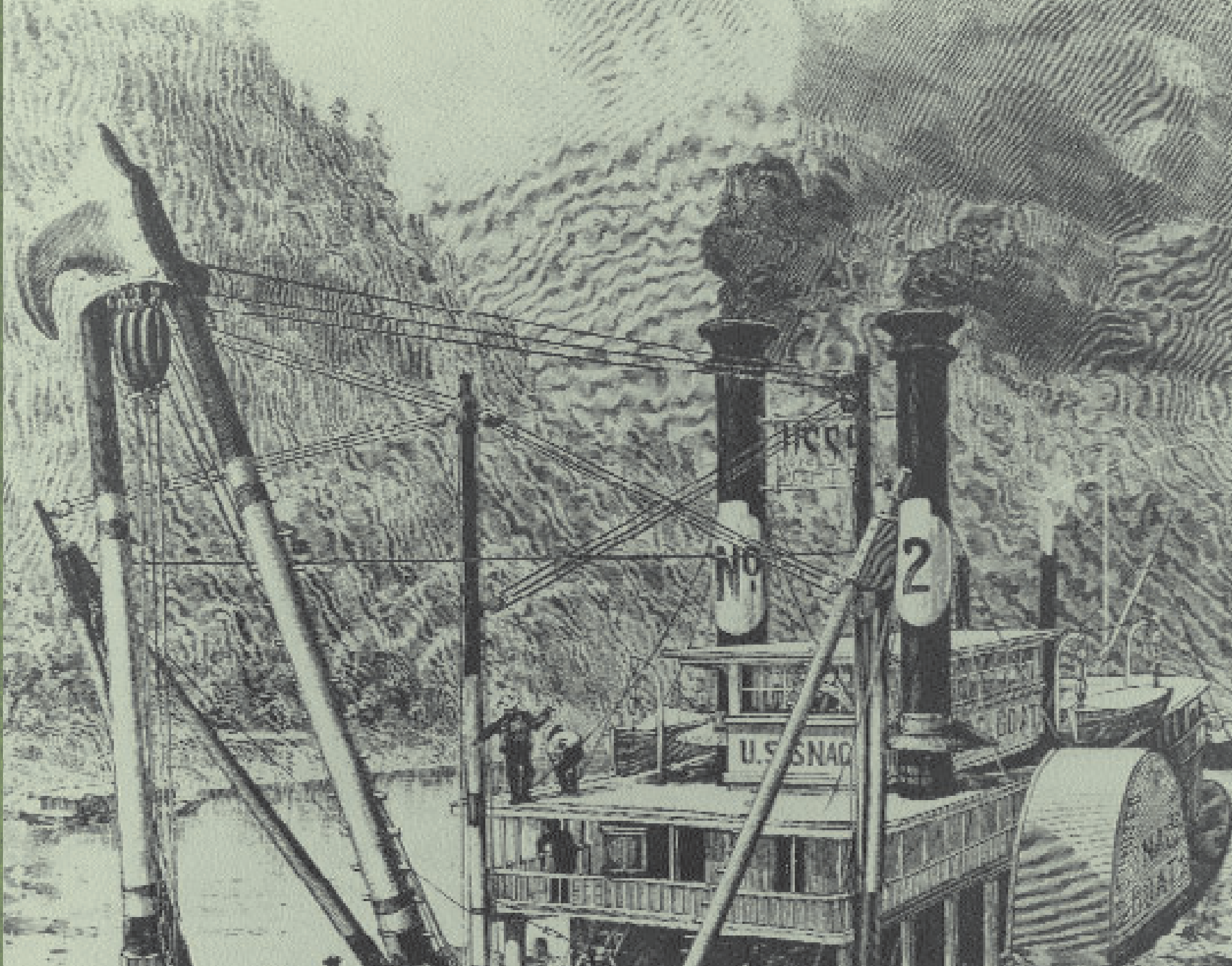
The iron lighthouse at Minot's Ledge, Cohasset, Mass.

Boston Journal, *April 21, 1851*



Plans for stone lighthouse at Minot's Ledge built after the destruction of the iron lighthouse in 1851

National Archives



U.S. Snagboat No. 2, *from* Harper's Weekly, *November 2, 1869*

Origins of Civil Works Missions

One of the major lessons of the War of 1812 was that the Nation needed an improved defense and transportation system. The British had invaded the United States from the north, from the south at New Orleans, and from the east, marching inland and even putting the capital to the torch. In the 1816 mobilization studies based on the lessons of the War of 1812, the U.S. Army Corps of Engineers reported that national defense should rest upon four pillars: a strong Navy at sea; a highly mobile regular Army supported by reserves and National Guard; invincible defenses on the seacoasts; and improved rivers, harbors, and transportation systems that would permit rapid armed concentration against an invading enemy, and swifter, more economical logistical lines.

In 1819, John C. Calhoun, then Secretary of War, recommended that the U.S. Army Corps of Engineers be directed to improve waterways navigation and other transportation systems because such civil works projects would facilitate the movement of the U.S. Army and its materials while contributing to national economic development. "It is in a state of war when a nation is compelled to put all of its resources … into requisition," said Calhoun, "that its Government realizes in its security the beneficial effects from a people made prosperous by a wise direction of its resources in peacetime."

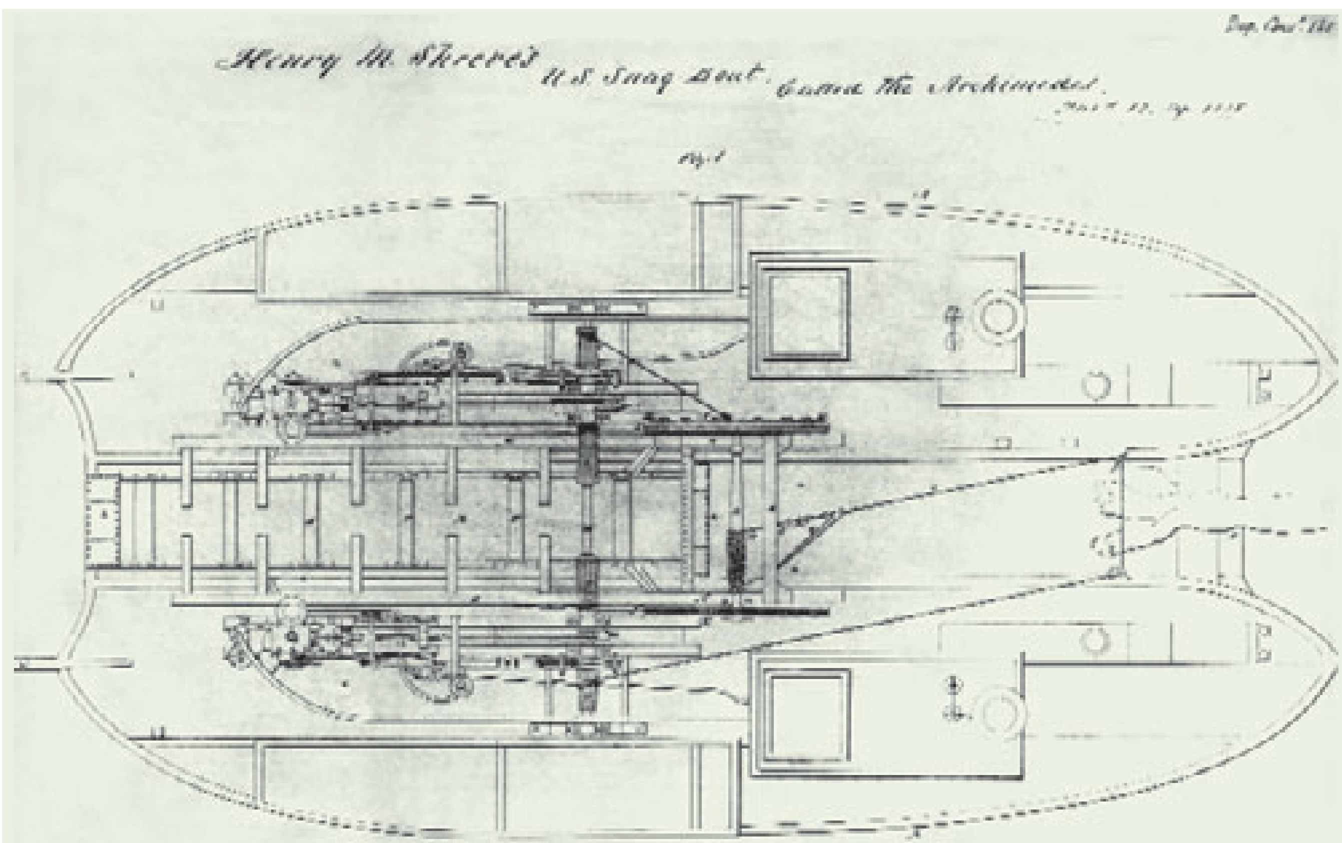
Congress finally accepted Calhoun's recommendations in 1824. It passed the General Survey Act on April 30, authorizing the president to use U.S. Army engineers to survey road and canal routes "of national importance, in a commercial or military point of view." A few weeks later, on May 24, Congress appropriated $75,000 for improving navigation on the Ohio and Mississippi rivers. This law allowed the president to employ "any of the engineers in the public service which he may deem proper" for the work. Also under this act, the Corps began to remove snags and floating trees from the Ohio and Mississippi rivers and to improve the Ohio's channel by attacking the sandbars that impeded river commerce.

John C. Calhoun, Secretary of War, 1817–1825, by John Wesley Jarvis
U.S. Army Collection

Captain Henry M. Shreve Clearing the Raft from Red River, 1833—38, *painted in 1969 by Lloyd Hawthorne*

Courtesy of the R. W. Norton Art Gallery, Shreveport, Louisiana

By 1829, U.S. Army engineers were using snagboats developed by the famous steamboat captain, Henry M. Shreve, to remove obstructions in river channels. Appointed by the secretary of war as superintendent of western rivers, Shreve realized that the use of a steam engine and other design techniques would cut the cost of snag removal in half. His first double-hulled snagboat, the *Heliopolis,* successfully removed extensive obstructions along the lower Mississippi and Red rivers (and later the Missouri, Ohio, and upper Mississippi rivers). An iron



Design plans for Shreve's snagboat Archimedes *(1838)* beam connecting the two hulls was used as a battering ram to dislodge a snag from the river bed. The vessel's lifting capability was provided by machinery instead of by hand, which made it a much more powerful snag remover. These Corps snagboats, which could lift a submerged tree weighing seventy-five tons lodged up to twenty feet deep, became known as "Uncle Sam's Toothpullers." Shreve, who eventually received a patent on his snagboat design, also began clearing riverbanks to prevent falling trees from becoming navigational hazards.

This early activity marked the beginning of the Corps' civil works mission—a dual role that emphasized a practical blending of civil works and military skills and fostered the development of a federal agency prepared to shoulder the engineering burden in the event of war or national emergency.

(right, top to bottom) Henry Bosse photo of the snagboat General Barnard *(1885), named after brevet Major General John Gross Barnard, chief engineer of the Washington, D.C., defenses during the Civil War*

Rock Island District, U.S. Army Corps of Engineers

U.S. Snagboat Chauncey B. Reese, *built in 1879*

Long's Steamboat

Major Stephen H. Long, an engineer officer famous for his exploration of the American West and for the survey and construction of early American railroads, also designed his own steamboat. In 1818, Long planned the building of the experimental craft, the *Western Engineer,* to transport himself and a task force of scientists, naturalists, and artists as far west as possible by water on their projected trip into the frontier.

The result was a steamboat designed to navigate narrow, shallow, snag-littered channels of inland rivers. It contained a particularly strong engine to provide increased power for pushing against swift currents. Another novel feature was a paddlewheel built into the stern to reduce the danger of damage from snags. The shallow-draft boat had a seventy-five-by-thirteen-foot hull with the weight of the machine carefully distributed to permit increased maneuverability in shallow channels.

The *Western Engineer* made an imposing debut when launched on the Ohio River in May 1819. To protect the vessel from Indian attack, Major Long installed a bulletproof pilot house. In addition, he had a cannon mounted on the bow, placed howitzers along the sides, and armed the crew with muskets and sabers. The boat had a serpent-like shape to frighten any would-be attackers. Drawing but nineteen inches of water compared to the five or six feet of most steamboats, the *Western Engineer* became the prototype of the Western river steam vessels.

At the beginning of that summer, the *Western Engineer* joined the Yellowstone Expedition of Colonel Henry W. Atkinson. In this vessel, Long and his crew explored the Ohio River, ascended the Mississippi River, then entered the Missouri River well into Nebraska. At this point, Long abandoned the *Western Engineer* and struck out overland for the Rocky Mountains in the spring of 1820, finally reaching the Arkansas River late that summer. Though plagued throughout the expedition by frequent breakdowns, Long s steamboat was the first such vessel to explore the territory of the Louisiana Purchase and had traveled further westward than any other steamboat.

Engineer Cantonment and Western Engineer *(1820) by Titian R. Peale*

American Philosophical Society Library

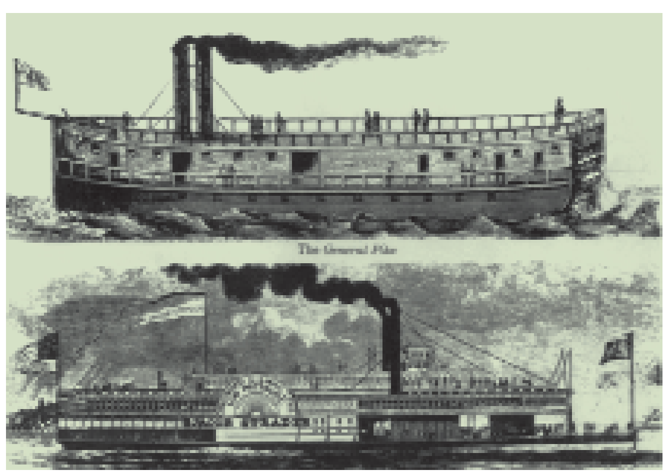
Waterway Development

Benjamin Henry Latrobe, a famous early nineteenth century engineer, once remarked that "nothing is so easily converted to a civil use as the science common both to the profession of a civil and military engineer." Few of Latrobe's contemporaries questioned this observation; engineers were also scientists, and navigation improvements required a scientific approach using principles developed mainly in Europe. At West Point, U.S. Army engineers learned the principles and applied them in their surveys of navigable rivers, often making their own significant contributions to river hydraulics in the process. In the early 1820s, U.S. Army Corps of Engineers officers surveyed both the Ohio and Lower Mississippi rivers. In the succeeding years, the Corps investigated a number of additional rivers. Many early navigation improvements resulted from trial and error, rather than from strict adherence to theory. If the obvious did not work, the less obvious was used until some method produced the desired result. A good example was the work on the Ohio River.

In 1824, Chief Engineer Alexander Macomb dispatched Major Stephen H. Long to the Ohio to initiate experiments on providing safer navigation. The main challenge was to deepen channels across sand and gravel bars. Major Long decided to perform experiments on a compacted gravel bar near Henderson, Kentucky, just below the mouth of the Green River. At low-river stage, this bar was covered by only fifteen inches of water. After preliminary studies, the major outfitted several flatboats with hand-powered pile drivers and

Topographical map of Henderson Island sandbar in the Ohio River, 1825

National Archives



Early steamers on the Ohio River, c. 1820

Up the Heights of Fame and Fortune, *Frederick B. Read, 1873* began to build a wing dam, so called because the structure extended from the bank of the river at a forty-five-degree angle. The dams decreased the width of the channel, thereby increasing the current's velocity and directing its force against the riverbed. Theoretically, this would cause the river to scour a deeper channel. Major Long built the dam to various widths, lengths, and heights. The final structure was 402 yards long and consisted of twin rows of 1,400 piles joined with stringers and filled with brush. Sediment gathered against the dam and helped anchor it to the riverbed. The project's total cost was less than $3,400.

Henry Bosse photo of wing dams below Nininger, Minn., on the Upper Mississippi River in 1891. These river structures were designed to constrict the river at shallow places, resulting in a narrowing and deepening of the channel.

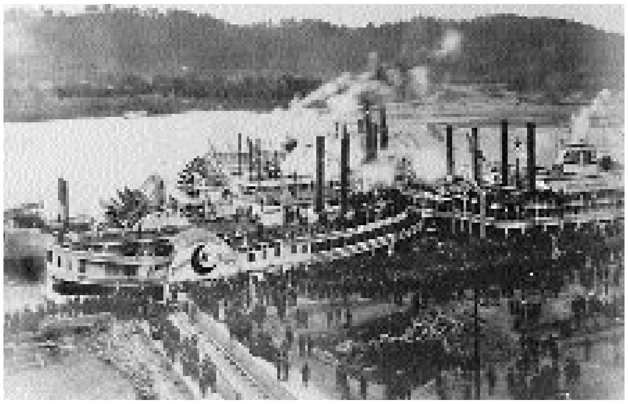
Wing dams such as Long's were used on the Ohio and other major rivers during most of the nineteenth century, but their effectiveness was always marginal. They were easily destroyed and did not always produce the desired results. After the Civil War, Corps officers grew increasingly skeptical about the dams. Brevet Major General Gouverneur K. Warren, a well-respected engineer officer, candidly wrote in 1867, "I do not believe the country will ever stand such a heavy continuous outlay as the wing-dam system of the Ohio has caused, and I believe that the extravagant and useless expenditure there, in the palmy days of western river improvements between 1830 and 1844, did more than anything else to bring the whole subject into disrepute."

Major General Warren's pessimism was unjustified, for both Congress and commercial interests continued to support waterway improvements after the Civil War. Indeed, the support increased. River and harbor work jumped from about $3.5 million for 49 projects and 26 surveys in 1866 to nearly $19 million for 371 projects and 135 surveys in 1882. Nevertheless, Warren's frustration was shared by other engineers. W. Milnor Roberts, a well-known civil engineer, concluded in 1870 that existing navigation facilities on the Ohio, while certainly of public benefit, were no better than an "amelioration of the present difficulty." He proposed instead to canalize the river through the construction of 66 locks and dams. This project would offer six-foot slackwater navigation from Pittsburgh, Pennsylvania, to Cairo, Illinois.

Chief of Engineers Andrew A. Humphreys organized an Army Engineer Board of Inquiry, composed of Majors William E. Merrill and Godfrey Weitzel, to examine the question of canalizing the Ohio. The officers agreed with Roberts that a system of locks and dams would best provide for future navigation. Somewhat surprisingly, the recommendation met resistance from the very group that would most profit from its implementation. Coal shippers, in Major Merrill's words, were "absolutely opposed to a slack-water system, unless arrangements can be made to pass their fleets through without stopping and separating for the passage of locks."

The resistance forced Merrill, who was in charge of Ohio River improvements, to look for alternative solutions. He thought the wicket dam design, developed by Jacques Chanoine in France in 1852, might be adapted for use on the Ohio. The structure used a number of large folding boards called wickets, which were hinged to a concrete base at

Gouverneur K. Warren as a Bvt. Maj. Gen.



The Davis Island Lock dedication, October 7, 1885

the bottom of the river. Each wicket was about 3.75 feet wide and 12 feet long. When the wickets were raised, the water behind them rose high enough to permit navigation. During high water, they could be lowered to allow boats to pass unimpeded. In this way, the delays the coal shippers feared would be avoided.

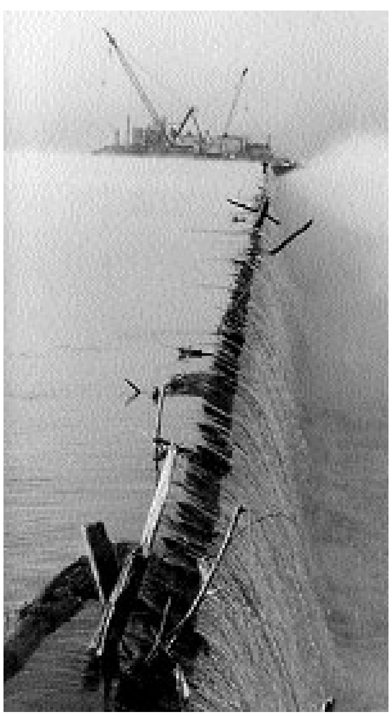
In 1874, Merrill proposed that a series of movable dams, employing Chanoine wickets, be constructed on the Ohio. For the first step he recommended that a 110-by-600-foot lock and movable dam be built at Davis Island, five miles below Pittsburgh. In 1877, Congress approved Merrill's plan. A year later the Corps began construction of the Davis Island Project, completing it in seven years. The 110-by-600-foot lock was the largest in the world, as was the 1,223-foot-long dam. The dam was actually composed of 305 separate Chanoine wickets and three weirs.

Impressed by the early success of the Davis Island Project, in 1888 Congress authorized the extension of the Six-foot Navigation Project down the Ohio. By 1904, two locks and dams had been completed, seven were under construction, and five more were funded. At this time, before further work was done, Chief of Engineers Alexander Mackenzie decided to conduct another complete review of the project. The basic question was whether the project should be extended down the Lower Ohio River, particularly in view of generally declining commerce on inland waterways.

Pursuant to congressional authorization, Mackenzie appointed a board headed by Colonel Daniel W. Lockwood. The Lockwood Board's review of the Ohio River Project led to recommendations for a nine-foot project for the entire course of the Ohio. This conclusion rested on the finding that the probable cost per ton-mile for a six-foot project would be nearly 50 percent greater than for the nine-foot project. In the 1910 Rivers and Harbors Act, Congress authorized the construction of a nine-foot Ohio River canalization project. The Corps of Engineers completed the $125 million project in 1929.

Meanwhile, the Corps had been busy in other parts of the country developing a reliable internal waterway system. One of the key projects, going back to the mid-nineteenth

Wicket dam at Lock and Dam 52 on the Ohio River, 1996



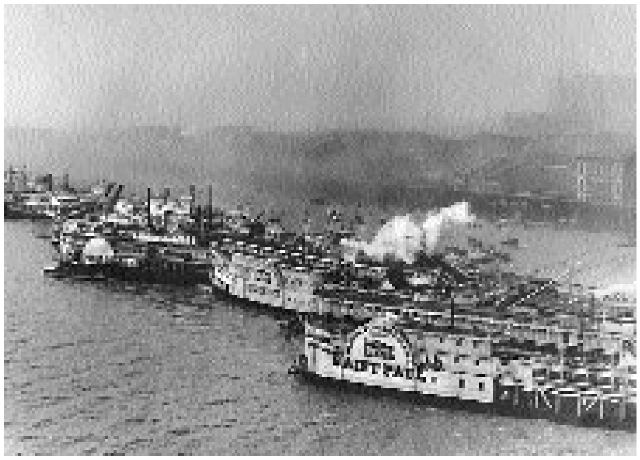
Excavating the Illinois and Mississippi Canal, 1904

National Archives

century, was the Soo Locks at Sault St. Marie, Michigan. These locks were instrumental in securing a navigable route from the copper and iron mines on the shores of Lake Superior to the industrial plants of the East. In 1852, Congress agreed to help private interests finance the cost of building a canal at St. Marys Falls to replace a structure on the Canadian side that had been destroyed during the War of 1812. Congress granted 750,000 acres of land to the state of Michigan. Captain Augustus Canfield of the Topographical Engineers was assigned as chief engineer and superintendent of the project for the state of Michigan. Captain Canfield's design for the canal conformed to the congressional stipulation that the passage be not less than 100 feet wide and 12 feet deep, with two locks not less than 250 feet long and 60 feet wide.

Within two decades, burgeoning traffic and larger vessels made the original canal inadequate to serve commercial needs, so Congress authorized the deepening of the St. Marys River Channel and the construction of a new facility—the Weitzel Lock. Corps work began on July 11, 1870, with an appropriation of $150,000. The original canal was

Mixing plant on the Illinois and Mississippi Canal, 1900



Steamboats on the St. Louis waterfront, 1909
National Archives

widened, and the depth was increased from 12 to 16 feet. The Corps constructed a lock 515 feet long by 80 feet wide with a lift of 17 feet.

At the time of its construction, the Weitzel Lock was considered the latest in lock technology. Its culvert valves, of the butterfly type, were operated by a single stroke hydraulic engine directly connected to the valves. Hydraulic turbines generated the power that operated the lock

Dredging a cut-off to shorten the river at Jackson Point, Miss., 1940

Barge and articulated concrete revetment along the Arkansas River, 1940

gates. A movable dam was also introduced to shut off the flow of water during maintenance operations.

The U.S. Army's success in providing a passage to Lake Superior and Canada's commitment to canal building whetted the desires of shippers and industrialists for a deep-water route through the Great Lakes—a dream eventually realized in the twentieth century with the completion of the St. Lawrence Seaway.

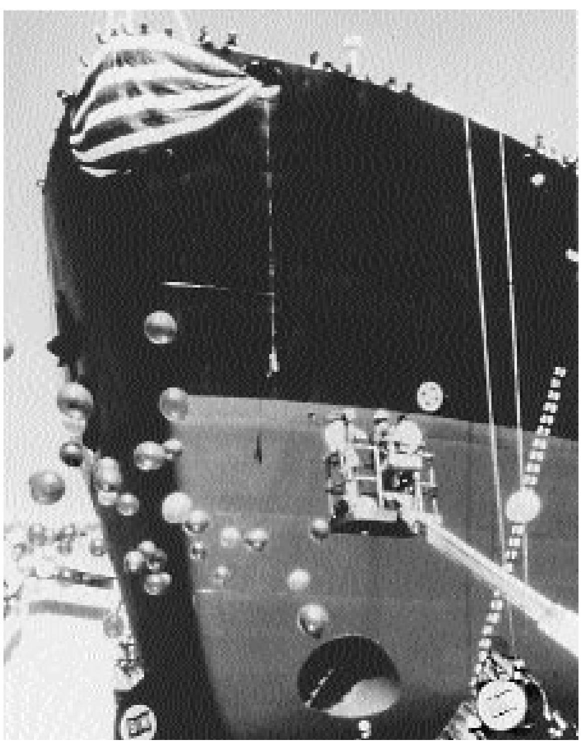
It was the turn of the century when Congress responded to the renewed interest in water transportation by authorizing navigation projects designed to create an integrated system connecting inland areas with coastal harbors. Sandbars and rapids along the Ohio, Missouri, Arkansas, and other major rivers posed significant obstacles to the maintenance of year-round navigation channels. Eventually, with the advancement of lock-and-dam technology and more efficient dredging equipment, a nine-foot channel depth was ensured in the Mississippi and its major tributaries.

Completion of the dewatering of the cofferdam at the Olmstead Locks and Dam in Illinois, which took forty days, August 8, 1995

U.S. Army Corps of Engineers navigation projects continue to play an important role in support of America's economic well-being. Commercial use of the twelve thousand miles of inland and intracoastal waterways has increased: approximately one-sixth of all intercity cargo is transported by water. Waterborne commerce, recognized by experts to be the least expensive and least energy-consumptive means of transportation, is the logical choice for shippers of energy-producing commodities. Petroleum and coal together constitute more than half of all waterborne freight on the federally maintained waterways.

This expansion of commercial water transport has been facilitated by the Corps' work on major waterways, including locks and dams. The Corps dredges more than 300 million cubic yards of material annually to maintain authorized channel depths and constructs bank stabilization projects in its traditional role as the primary developer of the Nation's waterways. Also, as of 2005, engineer districts and divisions owned 257 lock chambers at 212 sites, although only 240 chambers at 195 sites received funding and were operational. The oldest operating locks are Locks 1 and 2, which were built on the Kentucky River in 1839. The Nation's newest lock, opened in July 2004, is Montgomery Point Lock located on the White River in Arkansas. An efficient system of interconnected waterways not only provides vital commercial links, it has proven to be a key factor in America's ability to mobilize in the event of war.

John T. Myers Lock and Dam, Ky.



Launching the new dredge Essayons, *1982*

Lieutenant Eugene A. Woodruff: "A Model for All Similar Undertakings"

The can-do spirit of U.S. Army engineers often manifests in unexpected contributions to the public well-being. Such devotion is exhibited in an anecdote arising from work on an early Corps navigation project. In 1873, Captain Charles W. Howell, District Engineer at New Orleans, assigned his deputy, Lieutenant Eugene A. Woodruff, to the Red River of Louisiana as supervisor of the project to clear the river of the great log raft, a formidable obstruction to navigation.

Captain Charles W. Howell

In September of that year, Lieutenant Woodruff left his workboats and crew on the Red River to visit Shreveport and recruit a survey party. When he arrived in Shreveport, he found the city in the grip of a yellow fever epidemic. Fearing that he might

The U.S. Steamer Aid *battles Raft Number 5 on the Red River*

U.S. Military Academy Library

carry the disease to his workmen if he returned to camp, Woodruff elected to remain in Shreveport and tend to the sick. Volunteering his services to the Howard Association, a Louisiana disaster relief charity, he traveled from house to house in his carriage, delivering food, medicine, and good cheer to the sick and dying. He contracted the disease and died of it in Shreveport on September 30.

Captain Howell effectively captured this spirit in his eulogy to Woodruff: He died because too brave to abandon his post even in the face of a fearful pestilence and too humane to let his fellow beings perish without giving all the aid in his power to save them. His name should be cherished, not only by his many personal friends, but by the Army, as of one who lived purely, labored faithfully, and died in the path of duty . His conduct of the great work on which he was engaged at the time of his death will be a model for all similar undertakings and the completion of the work a monument to his memory.

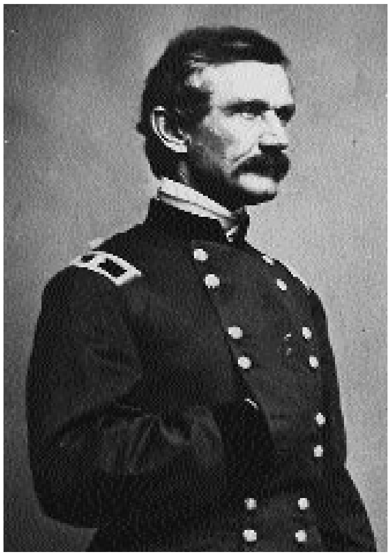
Captain Howell then assigned the task of completing the work on the Red River to Assistant Engineer George Woodruff, the lieutenant s brother. On November 27, 1873, the engineers broke through the raft, finally clearing the Red River for navigation.

Flood refugees flee to the levees at Hickman, Ky., 1912.

Flood Control

Congress did not authorize a comprehensive topographic and hydrographic study of a major river basin until 1850, when floods along the Mississippi River drew congressional attention to the need for a practical plan for flood control and navigation improvements at the river's mouth. The Secretary of War, Charles M. Conrad, sent Lieutenant Colonel Stephen H. Long and Captain Andrew A. Humphreys, two officers of the Corps of Topographical Engineers, to the Mississippi Basin to conduct the survey. Charles S. Ellet, Jr., one of the best-known engineers of the day, also applied to make the delta survey. Conrad suggested that Ellet work with Long and Humphreys, but Ellet preferred to work independently. Under pressure from some congressmen and after seeing President Millard Fillmore, Conrad relented, dividing the $50,000 congressional appropriation between the U.S. Army's survey and Ellet's.

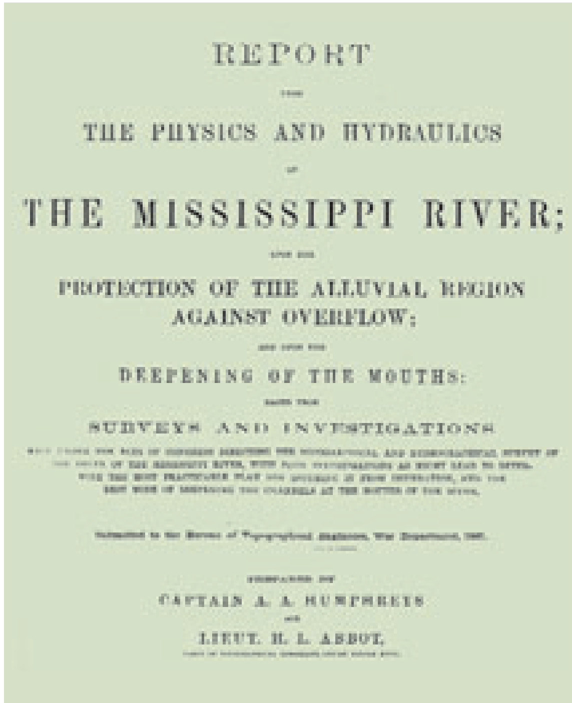
Before the U.S. Army survey was complete, Captain Humphreys became quite ill and took an extended leave of absence. Lieutenant Colonel Long drafted a report based on Humphreys' notes, but he confined it simply to an exposition of what had been done without offering any specific recommendations. Therefore, Ellet's essay became the first comprehensive study of flood control on the Mississippi. Both reports were sent to Congress in January 1852. What distinguished Ellet's submission was the author's insistence on both the practicability and value of building reservoirs on the Mississippi's tributaries to reduce flooding. That recommendation prompted Colonel John J.



Bvt. Maj. Gen. Andrew Atkinson Humphreys during the Civil War

Early levee construction

The Humphreys-Abbot Report (1861) represented the most thorough analysis of the Mississippi River ever completed and decidedly influenced the development of river engineering in America.


REPORT

THE PHYSICS AND HYDRAULICS

THE MISSISSIPPI RIVER;

PROTECTION OF THE ALLUVIAL REGION AGAINST OVERFLOW;

DEEPENING OF THE MOUTHS:

SURVEYS AND INVESTIGATIONS

CAPTAIN A. A. HUMPHREYS

LIEUT. H. L. ABBOT.

Abert, Chief of the Corps of Topographical Engineers, to write, "While I willingly admit that all the speculations of a man of intellect are full of interest and deserving of careful thought, yet I cannot agree with him that these reservoirs would have any good or preventive effects upon the pernicious inundations of this river."

Nine years later, Humphreys elevated Abert's comment to official Corps policy. After a long convalescence and subsequent work on the Pacific Railroad Surveys, Humphreys took up his task once more in 1857, this time with the assistance of Lieutenant Henry L. Abbot. The

Flood victims on a Mississippi River levee at Arkansas City, Ark., 1927. Note flooding behind the levee from the Arkansas River.

Shoring up a levee near Memphis, Tenn., 1927

young lieutenant supervised a party that took gauge readings, determined discharges at various points, measured cross-sections, and reported on the state of various river improvements. When possible, he compared his data with that obtained by earlier survey parties. "In a word," Abbot later wrote, "the finger was to be firmly placed on the pulse of the great river, and every symptom of its annual paroxysm was to be noted." It was in the shadow of the Civil War that Humphreys and Abbot finally put their five hundred-page report together. They submitted it to the Chief of Topographical Engineers in August 1861, a few months after the firing on Fort Sumter. Humphreys was technically the report's author, but he insisted on listing Abbot as coauthor in recognition of his diligence and skill.

Humphreys's and Abbot's *Report Upon the Physics and Hydraulics of the Mississippi River* not only contained much new data about the Mississippi, it also analyzed other alluvial rivers around the world. The authors introduced entirely new formulations to explain river flow and sediment resistance and concluded that Ellet's calculations and assumptions were erroneous. Their own position, based on significantly more information, was that "levees only" could prevent flooding on the Mississippi. Neither reservoirs nor cut-offs were needed. Already a member of the American Philosophical Society, Humphreys received numerous honors for his work on hydraulics. He was made an honorary member of the Imperial Royal Geological Institute of Vienna in 1862 and the following year a corporator of the National Academy of Sciences and a fellow of the American Academy of Arts and Sciences. In 1864 he was elected an honorary member of the Royal Institute of Science and Arts of Lombardy, and in 1868, Harvard College conferred upon him the degree of Doctor of Laws.

In considering navigation and flood control as interrelated problems, Humphreys, Abbot, Ellet, and other engineers in the United States and many in Europe were ahead of their time. By 1879, growing pressures for navigation improvements and flood control prompted Congress to establish the Mississippi River Commission, a seven-member organization responsible for executing a comprehensive plan for flood control and navigation works on the Lower Mississippi. This permanent body of experts included three members from the U.S. Army Corps of Engineers, one from the Coast and Geodetic Survey, and three civilians, two of whom had to be civil engineers. The creation of this river basin authority marked the federal government's growing commitment to the development of a reliable inland waterway system. Initially, Congress authorized the commission to build and repair levees only if the work was part of a general navigation improvement plan. Monumental floods in 1912 and 1913, however, drew national attention to the need for federal flood relief legislation. Finally in 1917, Congress passed the first Flood Control Act. This legislation appropriated $45 million for flood control on the Lower Mississippi and $5.6 million for work on the Sacramento River.

Flood at Greenville, Miss., 1927

High water at Pine Bluff, Ark., 1927

The 1861 report of Humphreys and Abbot enormously influenced river engineering in the United States. Until 1927, when a catastrophic flood hit the Lower Mississippi, the Corps' position was that "levees only" could control flooding on the river. The Corps was not unalterably opposed to reservoirs, however. Several were built on the Upper Mississippi, but principally to aid navigation.

Advocates of reservoir construction also received support in 1897 from Captain Hiram S. Chittenden of the U.S. Army Corps of Engineers. Chittenden's essay, *Preliminary Examination of Reservoir Sites in Wyoming and Colorado,* submitted in response to a congressional directive, was a comprehensive and lucid presentation of engineering, physiographic, and economic data. In it Chittenden declared that reservoir construction in the arid regions of the West was "an indispensable condition to the highest development of that section." He also warned, "The function of reservoirs will always be primarily the promotion of industrial ends; secondarily only, a possible amelioration of flood conditions in the rivers." So far as the Mississippi was concerned, "the difficulty was not so much a physical as a financial

Capt. Hiram M. Chittenden

Floodwall at Cairo, Ill., 1936

one." He identified a few potential reservoir sites in the Mississippi Basin but thought that flood control alone would never justify construction. He also examined the various methods of constructing reservoirs, noting that the arched dam, first constructed in France in the 1860s, showed promise for use in the West. Finally, Chittenden boldly proposed that public agencies, mainly federal, be charged with the responsibility for reservoir development.

With the passage of the second major Flood Control Act in 1928, the federal government became firmly committed to flood control on the Mississippi. This act resulted from public response to the flooding the year before, which had taken between 250 and 500 lives in the Lower Mississippi Basin, had flooded more

A willow mattress for bank protection along the Arkansas River, 1938 than sixteen million acres, and had left more than half a million people requiring temporary shelter. Two reports were submitted to Congress recommending ways to prevent future disasters of this magnitude, one by the Mississippi River Commission and the other by the Chief of Engineers, Major General Edgar Jadwin.

Principally because Major General Jadwin promised equal protection for less than half the money, Congress accepted his plan. This time, there was no dispute about levees. The 1927 flood demonstrated the bankruptcy of the "levees only" policy. In addition to levees, Jadwin proposed a mix of floodways and spillways, including the much discussed Bonnet Carré Spillway connecting the Mississippi with Lake Pontchartrain. Also included in the plan was the controversial idea of sending about half of the Mississippi's flood waters down the Atchafalaya River into the Gulf of

Floodwater over Bonnet Carré Spillway

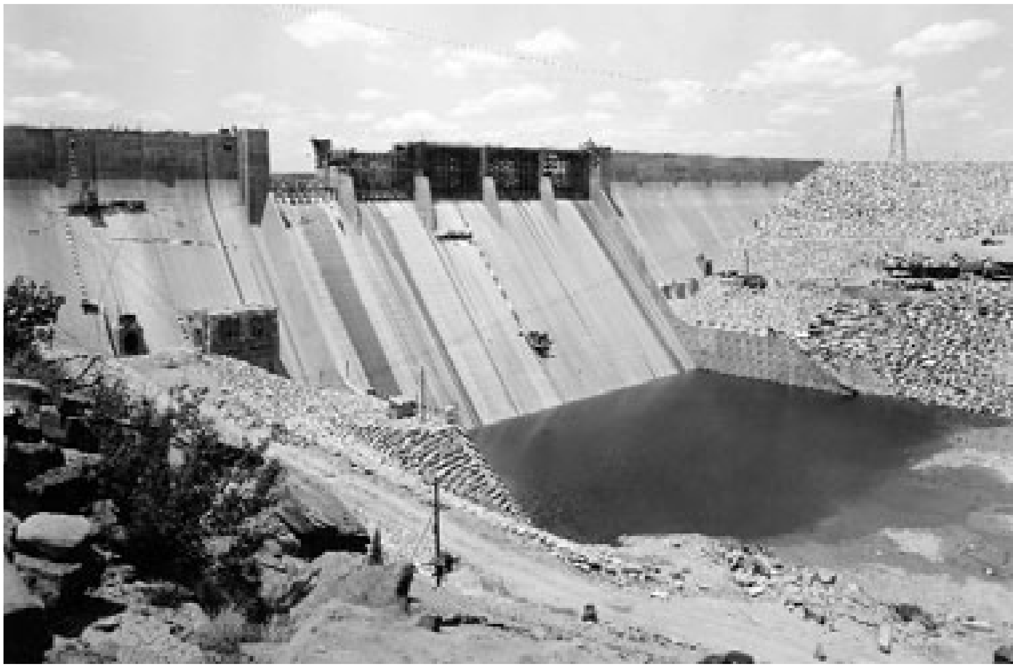
Wappapello Dam on the St. Francis River, Mo., 1941. Wappapello is a vital component of the flood control system for the Lower Mississippi River.

Mexico. This was an idea that Humphreys and Abbot had deemed "virtually impracticable," but the Atchafalaya had greatly enlarged over the years so that most engineers now considered the proposal workable. On the other hand, Major General Jadwin stood firmly in the tradition of his predecessor in opposing reservoirs. He had established a special Reservoir Board of engineer officers to examine the subject, and the board had concluded that Jadwin's plan was "far cheaper than any method the board has been able to devise for accomplishing the same result by any combination of reservoirs."

Nevertheless, the idea of locating reservoirs on the Lower Mississippi was far from dead. In fact, the Corps' own work stimulated interest in the subject. In 1927, Congress authorized the Corps to survey the country's navigable streams to formulate plans

Soldiers sandbagging a levee during the Mississippi River Flood, 1944 for the improvement of navigation, water power, flood control, and irrigation. The surveys came to be called "308 Reports," named after Congressional Document 308, in which the Corps and the Federal Power Commission had jointly presented to Congress the estimated cost for the surveys. Soon after funds were appropriated, Corps district offices around the country proceeded with the work. Having dispensed with the main stem of the Mississippi in the Jadwin plan, district engineers along the Lower Mississippi directed their attention to the major tributaries. Not surprisingly, engineers concluded that construction of reservoirs along such streams as the Yazoo and St. Francis, while contributing to local flood control, would not be cost effective. This position proved politically unpopular in the midst of growing unemployment resulting from the Great Depression. Public works projects, once considered uneconomical, began looking very attractive as a means of employment. Moreover, many politicians felt that flood control was essential to protect human life, no matter what the economists said. Mainly reacting to this political interest, the Corps reversed its position on a number of flood control projects. Revised reports concluded that the necessity for "public-work relief" and the suffering caused by recurring floods provided grounds for construction.

A flood control levee just below Medora Crossing on the Mississippi River at Mile 210

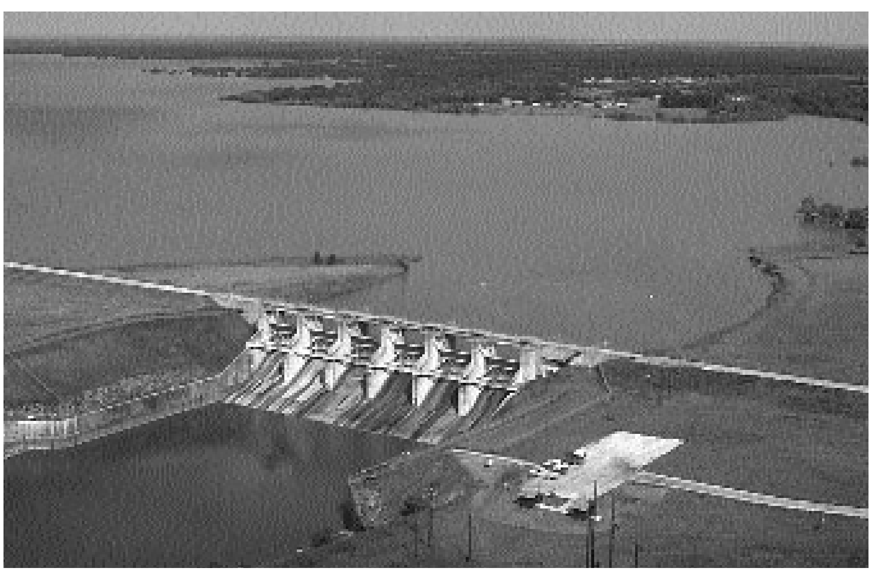


Construction of the Conchas Dam in northeast N.M., 1939

Corps personnel laying down sandbags

The 1936 Flood Control Act recognized that flood control was "a proper activity of the Federal Government in cooperation with States, their political subdivisions, and localities thereof." Congress gave responsibility for federal flood control projects to the U.S. Army Corps of Engineers, while projects dealing with watershed run-off and soil erosion were assigned to the Department of Agriculture. This law made the Corps responsible for flood control throughout the Nation, working in cooperation with the Bureau of Reclamation. In the years following passage of this law, the Corps built, pursuant to congressional authorization and appropriation, close to four hundred reservoirs whose primary benefit was flood control; however, flood control alone could never have justified the construction of these reservoirs. In the age of multipurpose projects, possible navigation, water storage, irrigation, power, and recreation benefits were considered before a final economic benefit figure was determined.

Since the 1970s, in an era increasingly sensitive to environmental protection and to the limitations of traditional structural answers to flood-damage reduction, the Corps has designed and implemented hundreds of nonstructural projects to provide some level of flood protection. Nonstructural measures reduce or avoid flood damages without significantly altering the nature or extent of flooding. They may be considered separately or in combination with structural measures. Nonstructural methods include moving communities away from a flood's destructive path, raising and flood proofing buildings, acquiring vulnerable structures, preserving wetlands, buying out floodplains, and establishing a flood warning system.



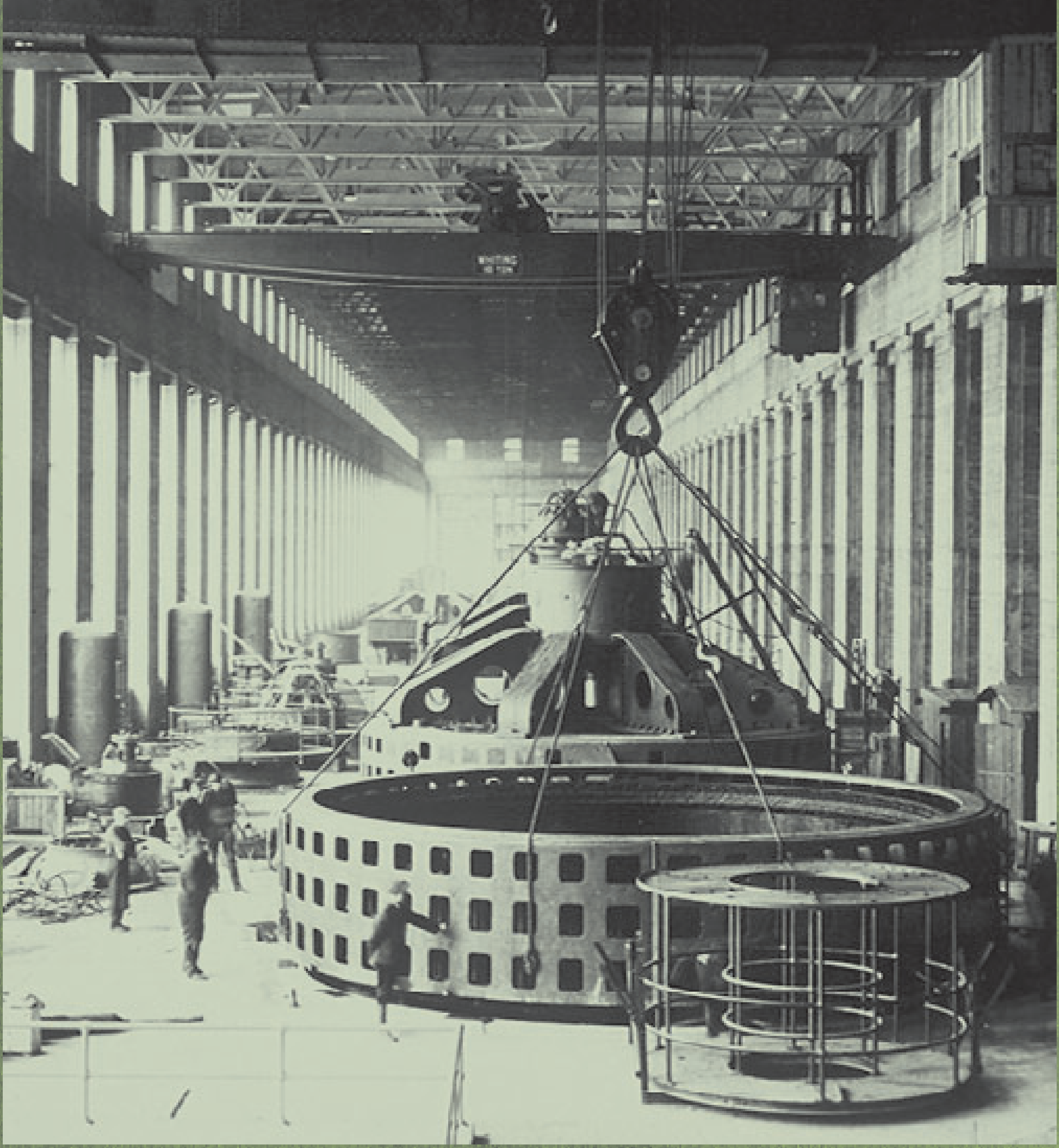
Navarro Mills Lake and Dam in Texas. Completed in 1963, the dam provided flood control and water conservation and later served an important recreational function.

The Bicycle Flood Fight, 1897

The Fourth Engineer District at New Orleans received word in early 1897 that a major flood was southbound on the Mississippi. Major George M. Derby, District Engineer, and civilian assistant W. J. Hardee prepared to defend the levees along more than 450 miles of river in the Fourth District. As had become customary by 1897, they stationed barges and quarterboats loaded with tools, sandbags, and lumber at roughly 15-mile intervals along the river with towboats assigned to each 60-mile section.

During previous flood emergencies, Fourth District personnel had encountered great difficulty maintaining regular patrols of the levee system and coordinating the work of five other involved parties: individual planters, railroads, parish governments, levee districts, and state government. Backwater and washouts had closed roads and railroads; there were no motorized vehicles available then, and the towboats moved too slowly and usually too far from the levees for proper inspection.

To improve coordination and inspection, Hardee equipped field personnel with bicycles. During the subsequent flood fight, the inspectors kept constantly on the move atop the levee crowns on their new transportation equipment. Hardee personally covered as much as thirty miles of levee a day on his bike, including stops for observation (and presumably to catch his breath).



Installation of large turbine at Wilson Dam on the Tennessee River near Florence, Ala. The dam was the largest in the world upon completion in 1925.

Hydropower Development

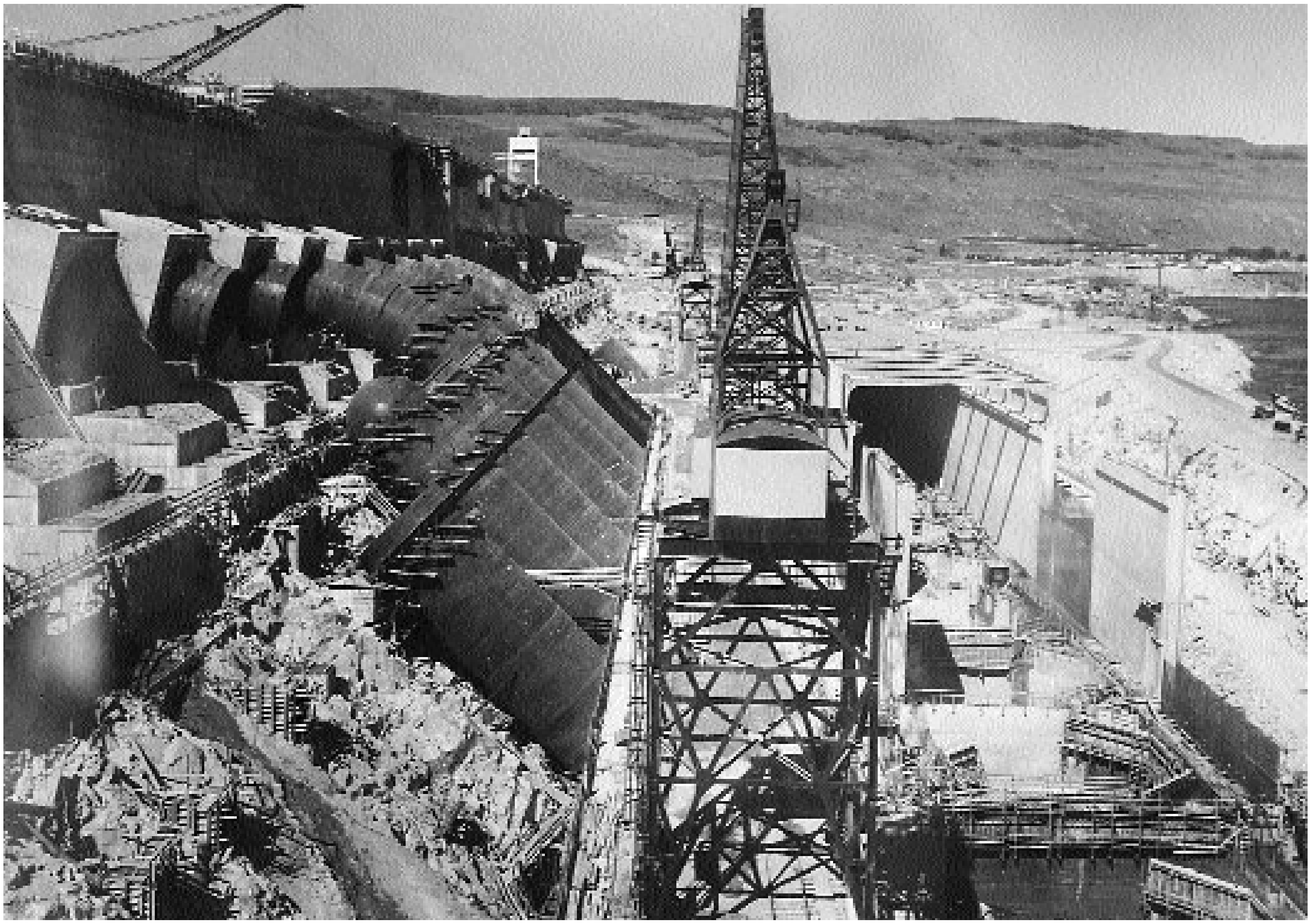
Since the turn of the twentieth century, the U.S. Army Corps of Engineers has moved from a position opposing involvement in hydroelectric power to one of total endorsement. By 1900, Congress had already initiated partial federal control over dam building. The Corps participated in the regulatory process but conceived its role narrowly.

In January 1905, Brigadier General Alexander Mackenzie, the Chief of Engineers, summed up the Corps' traditional views on the federal government's limited role in improving American waterways. Congress, he said, could legally "exercise control over the navigable waters of the United States … only to the extent necessary to protect, preserve, and improve free navigation." Mackenzie further maintained that nothing should be permitted to interfere with the central purpose of locks and dams—to facilitate navigation and commerce. All other interests were clearly secondary. These views fit the prevailing judicial interpretation of federal powers under the Constitution's Commerce Clause.

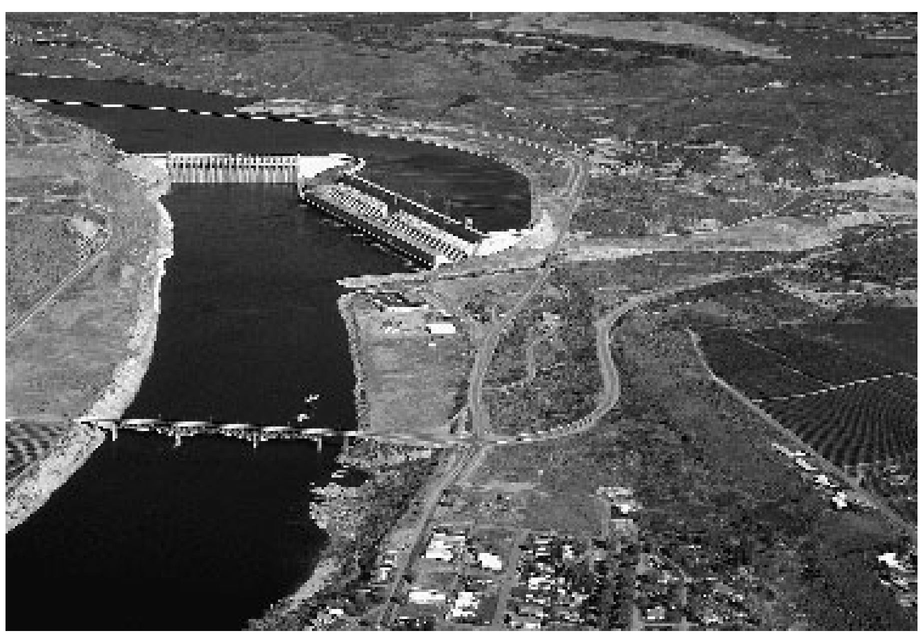
During the years following Brigadier General Mackenzie's pronouncements, attitudes gradually changed. The engineers became convinced that the escalation in private dam building, largely for hydropower purposes, threatened to jeopardize their prerogatives in navigation work, and they guarded those prerogatives jealously. While the federal government redefined its part in water resources development, the Corps staked out its own territory. As an auxiliary to navigation and later to flood control, hydropower benefited from more liberal interpretations of federal authority. Cautiously, with frequent hesitation and some inconsistency, the engineers embraced the new philosophy. What began as a regulatory role in hydropower expanded to include much more. By mid-century, the U.S. Army Corps of Engineers emerged as the largest constructor and operator of federal power facilities.

The change in the engineers' role was dramatic by the end of the 1920s. By that time, they were heavily involved in surveying rivers for flood control, power, and irrigation,

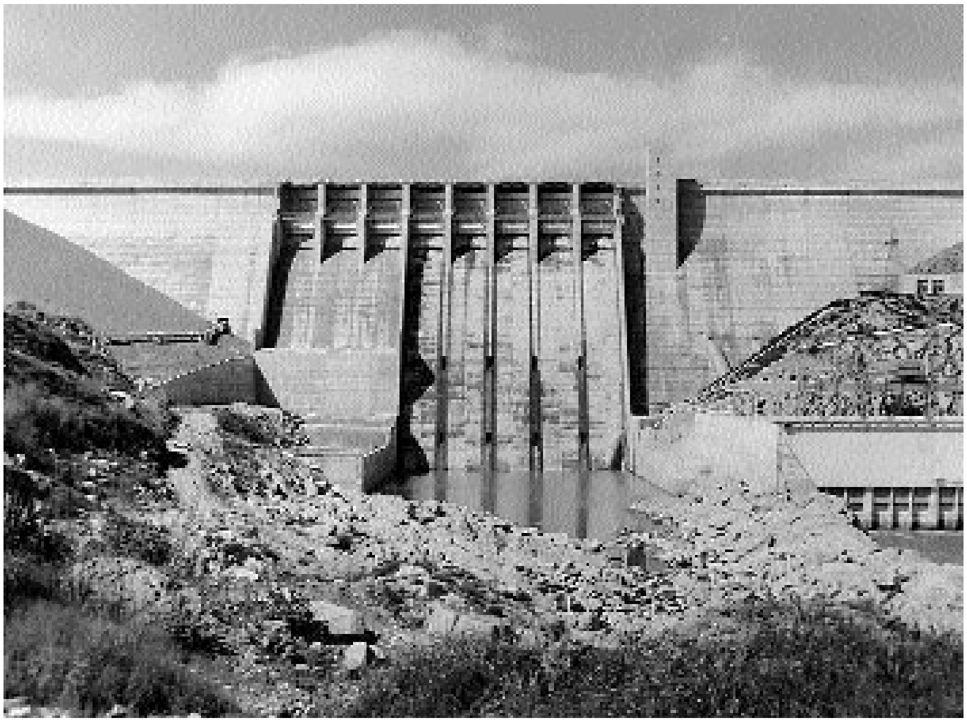
Brig. Gen. Alexander Mackenzie



Chief Joseph Dam under construction, Wash., 1955



Contemporary view of Chief Joseph Dam along the Upper Columbia Basin

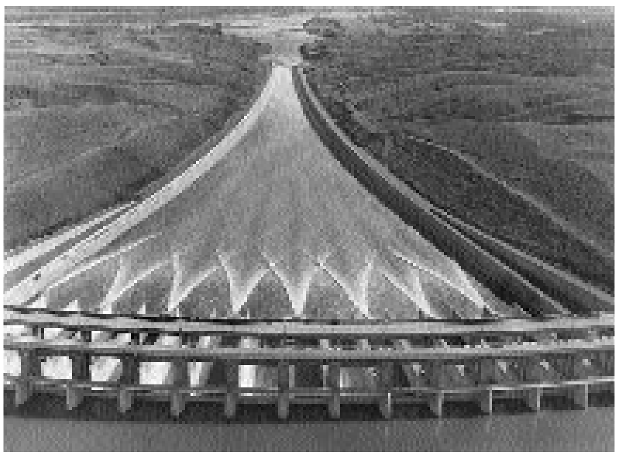


California's Folsom Dam in 1956, the year its construction was completed

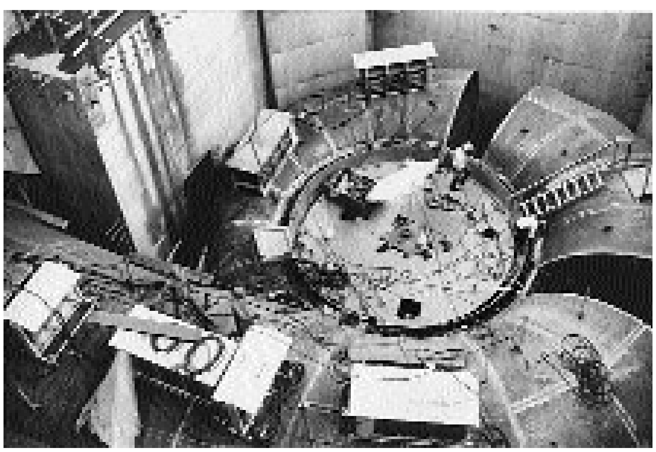
as well as for navigation. Public power at multipurpose projects took hold during the New Deal and proliferated after World War II. In the mid-1950s, the Corps had more than twenty multipurpose projects under construction. By 1975, the energy produced by Corps hydroelectric facilities was 27 percent of the total hydroelectric power production in the United States and 4.4 percent of the electrical energy output from all sources. By the late 1980s, the Corps was operating and maintaining approximately seventy-five projects with hydropower facilities, and the total capacity at Corps dams was more than 20,000 megawatts.

Powerhouses, surge tanks, and switchyard at the Fort Peck Dam along the Missouri River, Mont.

The largest hydropower dams built by the Corps are on the Columbia and Snake Rivers in the Pacific Northwest. The biggest of these is the John Day on the Columbia River, which has a generating capacity of nearly 2,200 megawatts. Although by 2005 the Corps' overall percentage of hydropower capacity had slipped to 24 percent of national hydropower capacity and 3 percent of the total electrical supply, the contribution to the Nation has remained substantial.



Fort Peck Spillway, Mont.



Powerhouse construction, Richard B. Russell Dam on the Savannah River, Ga., 1982

In 1951, the Chief of Engineers referred to the development of hydropower as "one of the most important aspects of water resource development." Further, he argued, "proper provisions for hydroelectric power development are an essential part of comprehensive planning for conservation and use of our river basins for the greatest public good." Two decades later, the Office of the Chief of Engineers reaffirmed and strengthened its commitment, stating that "generation of hydroelectric power to serve the growing needs of the American people is a task the Corps welcomes." The Corps' turn-about and its expanding mission in hydroelectric power development were a significant part of the organization's history during the latter twentieth century. Today, the U.S. Army Corps of Engineers continues to operate, maintain, and occasionally add capacity at existing hydroelectric plants.

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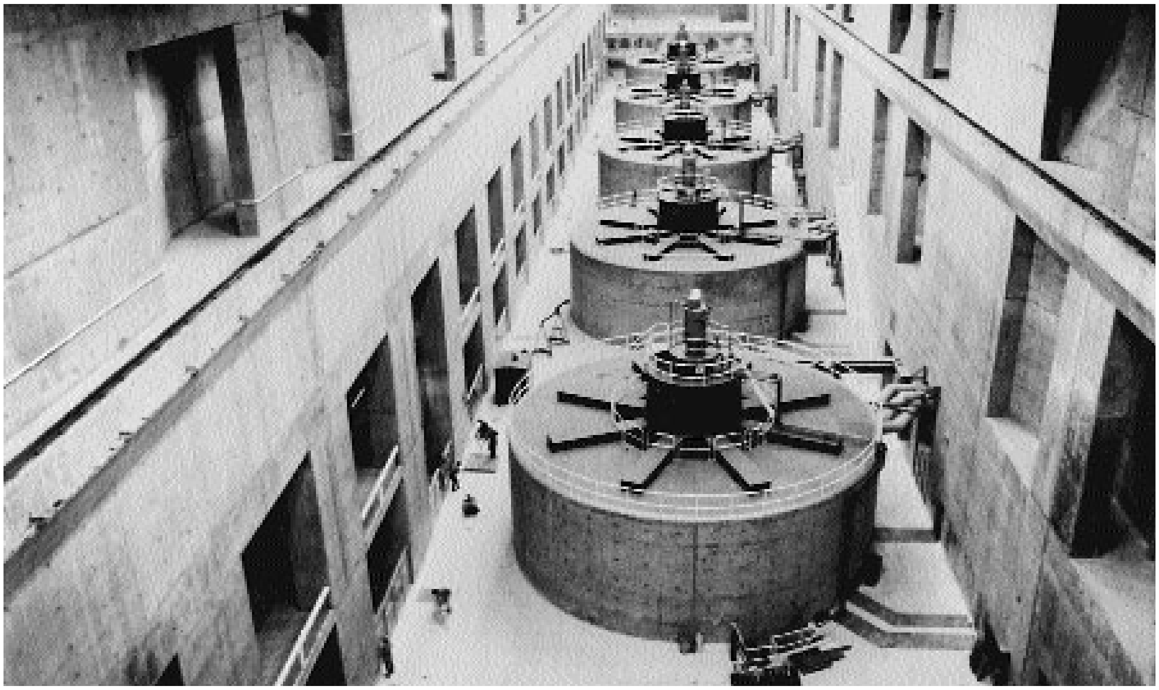
Generators at Bonneville Dam, Ore.

Bonneville Lock and Dam on the Columbia River



The U.S. Army Corps of Engineers: Dam Destroyers?

On January 15, 1907, Major William Sibert, Pittsburgh District Engineer, learned the depressing news that heavy flooding was undermining the abutment of Allegheny River Dam 3. If the dam continued to hold, which seemed likely, the flooding would gradually undermine the bank, thereby threatening a railroad track and a million-dollar glass factory. Already nine homes, various outbuildings, and 5.3 acres of land had caved into the river.

After a long and undoubtedly agonizing discussion with his staff, Major Sibert made his decision: the dam would have to go. To allow the water to continue around the dam was to invite further catastrophe.

The next morning blasting began. Five-hundred-pound dynamite charges were placed along the dam crest. Dynamiting continued until a 560-foot section at midstream had been removed. Then stones were placed along the bank to protect the glass factory and the railroad.

On January 30, the *New York Sun* printed an editorial that attacked the lack of progress on waterway projects; however, the editors noted, no charge of dilatoriness can be brought against the officer who a few weeks ago saved a million dollars worth of property by assuming the responsibility of blowing up $80,000 worth of dam. Major Sibert became perhaps the only Corps officer ever commended by the Chief of Engineers for blowing up a government dam. His courage, imagination, and ability to bend to circumstances set high standards for his successors at the Pittsburgh District Office.

Maj. William L. Sibert

(above) View of eroded bank below abutment, Allegheny River, Dam 3, Jan. 1907

(below) View of broken dam, Allegheny River, Dam 3, Jan. 1907

(both images) Library and Archives Division, Historical Society of Western Pennsylvania, Pittsburgh, Penn.

The Environmental Challenge

As explorers and mapmakers for the pioneers, the engineers were among the first to recognize the need for protection of natural resources. As early as the 1840s, when the vast herds of buffalo seemed limitless to most travelers, engineer officers warned of their impending destruction. In one observation, Captain Howard Stansbury noted their shrinking ranges and warned that the buffalo "seem destined to final extirpation at the hands of men." While it is unfortunate that such admonitions very nearly came to pass, it is illustrative that at one point in time, one of the few surviving buffalo herds was protected at a U.S. Army Corps of Engineers project.

The U.S. Army Corps of Engineers was also influential in the creation and development of the first national park at Yellowstone in 1874, and the Corps operated and protected that park for many years. In the 1870s, Captain William Ludlow and an engineer survey party at Yellowstone confronted tourists, harbingers of the future, carving their initials, scattering their rubbish, and breaking off pieces of rock formations. Alarmed, Captain Ludlow pleaded with the visitors to respect nature's work. He stopped one woman, poised with a shovel over a mound formed over thousands of years by a bubbling spring's mineral deposits, in time to prevent her smashing the formation. In his report, Captain Ludlow proposed several ways to protect the new park. Congress authorized his recommendations, including military patrols and assignment of road construction to Army engineers, in 1883.

For thirty-five years, from 1883 to 1918, when the newly created National Park Service took over Yellowstone, the U.S. Army Corps of Engineers built and maintained the park's roads and bridges, including 279 miles of main roads, 25 miles of secondary roads, and 106 miles of approach roads in the forest reserves. Partly thanks to Captain Ludlow, who had provided the blueprint for saving the park, and Lieutenant Dan C. Kingman and Captain Hiram M. Chittenden, who designed and oversaw construction of a road system that has left a

Brig. Gen. William Ludlow

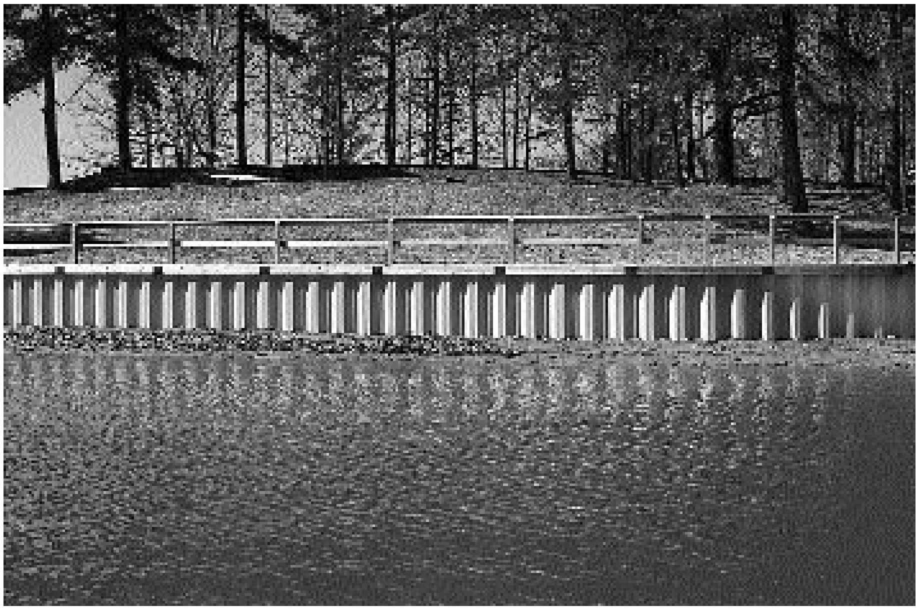
Thomas Moran (1837–1926), Golden Gate, Yellowstone National Park, 1893, *oil on canvas. The artist participated in the Hayden geological survey of Yellowstone in 1871 and returned to the region in 1892 to paint a view of the pass named "Golden Gate." In addition to capturing the inspired beauty of the region, Moran also depicted a precipitous section of the "Grand Loops," a system of scenic roads built under the supervision of Lt. Dan C. Kingman, an officer in the Army Corps of Engineers.*

Buffalo Bill Historical Center, Cody, Wy.

lasting imprint, Yellowstone became one of the crown jewels of America's scenic wonders.

To prevent the obstruction of navigable waterways, Congress in the 1870s directed the Corps to regulate the construction of specific bridges. The job was expanded during the 1880s and 1890s to prevent dumping and filling in the Nation's harbors, a program that was vigorously enforced by the engineers. At the Port of Pittsburgh in 1892, for instance, the Corps took a grand jury on a boat tour of the harbor and later obtained some fifty indictments against firms dumping debris into the harbor. When the engineers learned that firms were piling debris on the stream banks during the day and pushing it into the harbor at night, they began night patrols in fast boats with searchlights.

In 1893, a citizen of an Ohio River city complained to the Corps that the city was dumping into the river "household garbage, refuse of wholesale commission and slaughter houses, wagon loads of decaying melons, fruit and vegetables and car-



Lake Lanier metal basket erosion control, Buford, Ga.

casses of animals." The city officials replied that the complaint was exaggerated—very few dead animals were dumped into the river—and refused to stop the practice because the city then would have to build incinerators to dispose of the refuse. The Corps managed to stop the dumping anyway, forced the city to build an incinerator, and prosecuted the offenders, arguing that the garbage formed piles sufficient to obstruct navigation.

In the Rivers and Harbors Act of 1899, Congress gave the Corps authority to regulate almost all types of obstructions to navigation. The engineers were disappointed that they were not also given authority to deal with polluters, for many of the Corps personnel lived on the waterways and water quality was an immediate personal concern.

Great Salt Plains Lake, Okla., 1964. Located east of the Salt Fork of the Arkansas River, the lake is the oldest in the Tulsa District.

The Corps used the Rivers and Harbors Act of 1899 to the fullest extent legally possible to protect the environment of navigable waterways. In one extreme instance, the Corps managed to stop a firm from discharging a liquid effluent into a waterway by contending in court that the discharge obstructed navigation because it entered steamboat boilers and corroded them. The Oil Pollution Act of 1924 gave the Corps responsibility for protecting the Nation's harbors from offensive and dangerous oil discharges; however, the Corps could not adequately control the problem because of lack of regulatory power and insufficient manpower, and Corps officers periodically urged Congress to grant the agency adequate authority and resources.

The Corps' regulatory authority was expanded by the Clean Water Act (Federal Water Pollution Control Act) of 1972 to include all waters of the United States. The Corps began to regulate discharges of dredged or fill materials into any waters of the United States, and the permit program that resulted gave environmental protection the fullest consideration. This new work was well received even among strong environmentalists. One member of the National Resources Defense Council commended the Corps for the "will with which it is turning to carrying out the responsibilities Congress gave it in Section 404 for protecting the water quality on which the health and economic well-being of every American depends."

In 1990, under Public Law 101–640, Congress officially directed the Secretary of the Army to include environmental protection as one of the Corps' primary missions. Four years earlier, in the Water Resources Development Act of 1986, Congress had authorized the Corps to review the operation of completed water resources projects to determine the need for modifications to improve environmental quality. Subsequently, in 1992 and 1996, the Corps received additional authorization to protect, restore, and create aquatic and ecologically related habitats, including wetlands. In the twenty-first century, the Corps actively promotes and is directly involved in ecosystem restoration throughout

Davis Pond Freshwater Diversion Project: lower guide levee at Lake Salvadore at Mile 150 on the Mississippi River, La., 1998

Kotzebue, a hub village in northwestern Alaska, was included in an environmental infrastructure assistance initiative that recommended an upgrade to its freshwater system.

the country, focusing on water and related land resource problems.

Along with protective measures for the environment, the Corps pursues an active program for the preservation of cultural resources on its own land and at authorized project sites. The authorizing legislation, Section 106 of the National Historic Preservation Act of 1966, stipulates that up to 1 percent of the funds for a project can be expended for cultural resource surveys, for artifact and data recovery, and for mitigation efforts. The Corps' cultural resource preservation efforts have generated substantial results. For example, the Corps relocated a navigation lock on the Tennessee-Tombigbee Waterway to avoid destroying an Indian burial ground; and in Pennsylvania, the Corps successfully preserved a unique nineteenth-century wagon works by moving it from the project area. To avoid accidental destruction of archeological sites, the Corps is searching for the homes of ancient tribes, especially along proposed dredge disposal sites.

The Corps' responsibility for improving and maintaining navigation on the Nation's waterways requires dredging if channels are to remain open. In 1969, the dredging

Restored Gruber Wagon Works, Berks County, Pa.

Point Mouillee confined disposal facility, Mich.

Gaillard Island in Mobile Bay, Ala., where a man-made dredge disposal site is home to 16,000 shore and seabirds, including the Brown Pelican.

program was attacked as environmentally unsound. "All of a sudden, dredging became a four-letter word," reminisced Lieutenant General John Morris of the Corps. "Now this came as rather a surprise to us," he continued, "since dredging has been a daily activity within the Corps for 150 years and nobody paid much attention to it."

In 1970, the Corps began the Dredged Material Research Program to identify dredging and dredged material disposal systems that would be compatible with the new environmental protection mission. Completed in 1978, the Dredged Material Research Program reversed some traditional thinking about the effects of dredging. It indicated that dredging need not have adverse impacts on aquatic life and that dredged materials can create new wetlands and wildlife management areas. The research identified improved methods for constructing diked disposal areas and for using physical, chemical, and biological agents in the dredging process. It demonstrated that dredged fill can be used to reclaim strip-mined lands and other environmentally damaged areas.

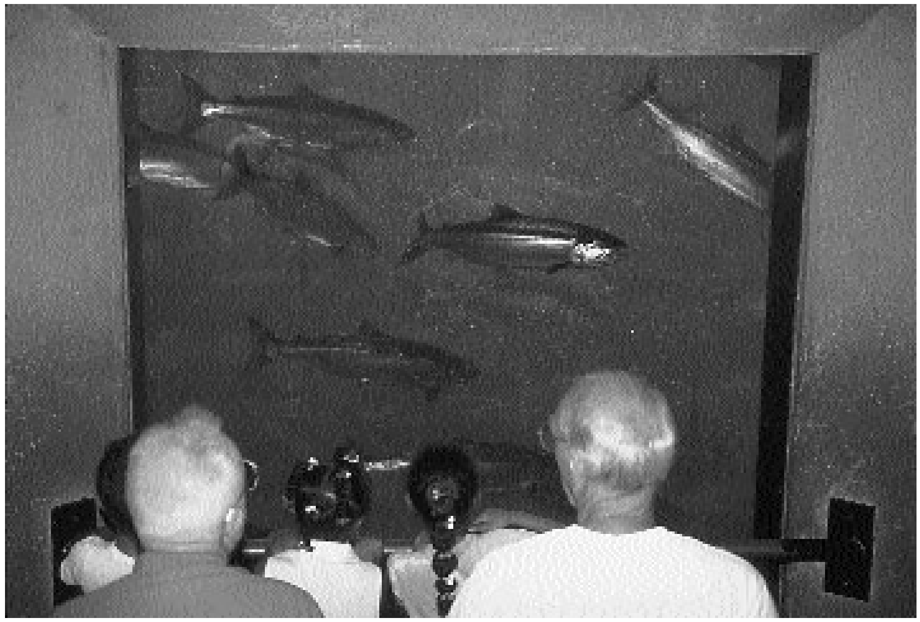
Streambank erosion can cause major detrimental impacts on the environment and human welfare. It results in sediment deposits in reservoirs and waterways; it impairs navigation, flood control, and water supply project effectiveness; and it blights valuable recreation areas and streambank lands. Since 1969, the Corps has conducted intensive studies of streambank erosion, with demonstration control projects along the Missouri, Ohio, and Yazoo rivers, and has identified its causes and some potential new techniques for its control.

Since 1969, the Corps' Coastal Engineering Research Program has devised some innovative approaches to the problems of beach erosion, coastal storm damage, and navigation along the coastline. Analysis of wave patterns has led to rational design of rubble mound structures for the protection of threatened beaches and coastline. Research has identified possible uses for beach and marsh grasses in controlling coastal erosion and has established some basic relationships governing the size and shape of coastal inlets and harbor entrances.

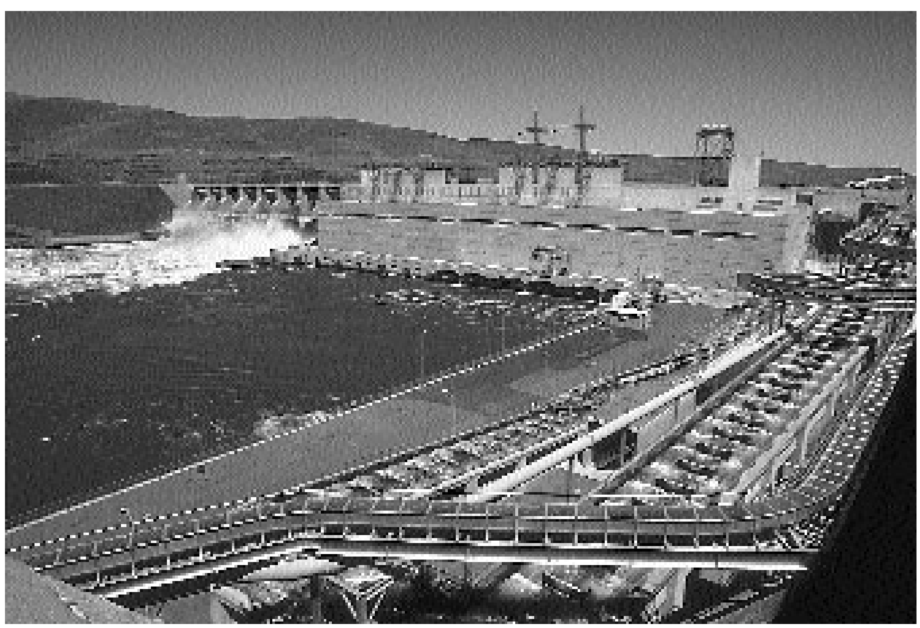
Fish and wildlife conservation has been a concern of the Corps since Captain Stansbury warned that the buffalo were disappearing. The engineers built the first federal fish hatchery in 1879–1880 and have included such features as fish ladders in project planning for many years. Corps projects are designed to minimize damage to fish and wildlife resources, and even enhance wildlife resources through effective wildlife management. Approximately 2.5 million acres of land are primarily used for fish and wildlife purposes; one-fifth of this land is managed by other federal and state agencies in cooperation with the Corps.

"Tanks to Reef" Project in Mobile District: The Corps used surplus tanks to help create a 1,000-square-mile artificial reef zone near Mobile, Ala., 1994.

The intense interest of the Corps in fish and wildlife management derives in part from the program's value to the recreational functions at 456 Corps water resource projects covering an aggregate of more than 11.5 million acres. Nearly 400 million visitors annually enjoy fishing,



Fish viewing window at Lake Washington Ship Canal, Wash., 1990



Fish ladder on Little Goose Dam, Wash.

hunting, swimming, and other water-related sports at Corps recreation areas.

Through its floodplain management program begun in 1960, the Corps provides technical services and planning guidance for many local agencies and groups to encourage prudent use of floodplains. At the request of state or local agencies, the Corps identifies flood hazard potentials, establishes standard project floods (the flow that can be expected under conditions of maximal severity), devises flood frequency curves, and maps the floodplains. The resulting information is used by the local agencies to regulate floodplain development—even to the extent of evacuating flood-prone areas and converting them to recreation parks or fish and wildlife habitats.

Aerial view of Mallard Island, Minn., in the Mississippi River, part of the Weaver Bottoms Habitat Restoration Project

Saving the Salmon

Long before the construction of the famous fish ladders at Bonneville Dam, a U.S. Army engineer warned that the Columbia River salmon required protection. Major William A. Jones, an experienced engineer and explorer who discovered Togwotee Pass through the Wind River Mountains, observed over time the impediments faced by salmon in their efforts to spawn.

While serving as Portland District Engineer, Major Jones wrote his *Report on the Salmon Fisheries of the Columbia River,* published in 1888. Stunned at the maze of nets, traps, and fish wheels that clogged the Columbia near places like Astoria, he concluded that it was a sort of miracle that any fish escape to go up the river.

Jones proposed means for mitigating the threat to the fisheries. Along with continuing the practice of closing the river to fishing at regular intervals, he recommended an increase in the number of hatcheries and uniformity between the fish laws of Oregon and Washington.

Major Jones had recognized the threat to the survival of the salmon fisheries many years before the general public would become aware of the problem. His suggestions were later adopted, but long after he first proposed them.

Fish ladder and the Visitors Center at Bonneville Dam, Ore.

Coho fingerlings at Bonneville Dam

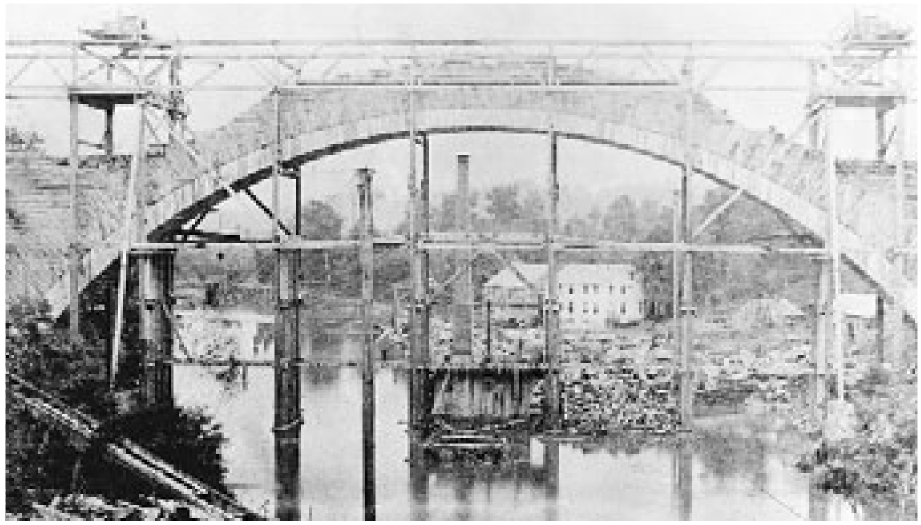
Work in the District of Columbia

U.S. Army engineers contributed to both the planning and construction of the nation's capital. From early bridges to the modern subway system, Corps officers and civilians helped plan and construct Washington's transportation system, city monuments, and public buildings. Parks, water supply and sewage systems, flood control structures, and public health measures in the city were or still are the engineers' responsibility. U.S. Army engineers served as administrators as well as construction experts. Their influence and responsibilities declined only as civilian agencies assumed control of certain activities and home-rule movements lessened

Andrew Ellicott's drawing of L'Enfant's plan of Washington, D.C., 1792

National Archives

Arch of the Cabin John Bridge under construction, August 12, 1861



federal responsibility for public works in Washington.

In 1791, former Continental Army engineer Pierre Charles L'Enfant designed the master plan for the new capital. Other Army engineers designed and built fortifications for the city. During the War of 1812, the British army destroyed some of those defenses as well as the partially built Capitol Building; Chief Engineer Joseph G. Swift helped rebuild the Capitol. In 1822, Major Isaac Roberdeau, a topographical engineer, supervised the installation of cast-iron pipes to bring spring water to the White House and the executive offices around it. In the 1850s, Congress funded the construction of a permanent water supply for the cities of Washington and Georgetown. Eventually placed

U.S. Capitol dome under construction, December 31, 1857 under the supervision of engineer Lieutenant Montgomery C. Meigs, the project evolved into what is today the Washington Aqueduct Division of the U.S. Army Engineer District, Baltimore. Lieutenant Meigs's plans included construction of two bridges to carry traffic as well as water pipes—one over Cabin John Creek and one over Rock Creek. Both bridges were engineering feats of their time, and the Cabin John Bridge remains in use. For forty years, the Cabin John Bridge (begun in 1857 and completed in 1864) held the record for having the longest masonry arch in the world.

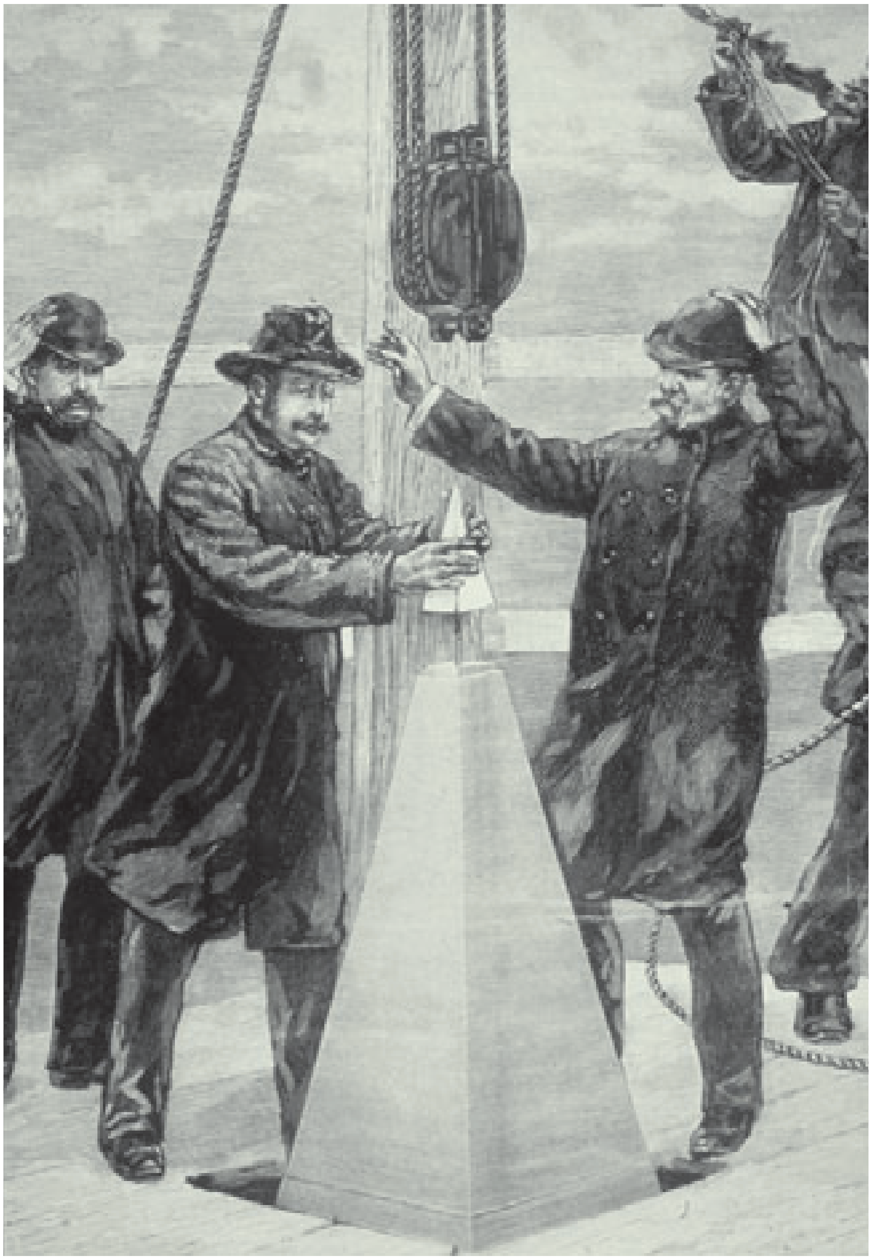
Lieutenant Meigs and other engineer officers also reconstructed the U.S. Capitol, fireproofed the Smithsonian Institution, and rebuilt or repaired bridges and streets throughout the city. Using new techniques, Meigs provided the first adequate heating and ventilation system for the home of Congress. As construction of the two new wings of the Capitol progressed, the old dome began to look disproportionately small; a new Capitol dome was designed, consisting of cast and wrought iron and weighing almost 4,500 tons. Work on the dome continued during the Civil War.

After the Civil War, Corps officers and civilians designed and built many of the monuments and public buildings that decorate Washington today. At the request of the Senate, Major Nathaniel Michler surveyed sites for a new park and a new location for the White House. His praise drew attention to Rock Creek Valley. Later, the Chief of Engineers, Brigadier General Thomas L. Casey, and other officers worked for and supervised the development of that large, urban park.

Congress continued to institutionalize the Corps' role in the District of Columbia. In 1867, the legislators removed control of many public buildings from civilian hands and gave it to what became the Office of Public Buildings and Grounds under the Chief of Engineers. In 1878, Congress replaced Washington's elected government with a three-man commission. A U.S. Army engineer, holding the title of Engineer Commissioner of the District of Columbia, served on that governing board with responsibility for the city's urban infrastructure.

Meanwhile, other engineer work in Washington grew to such an extent that in 1874, the Chief of Engineers, Brigadier General Andrew A. Humphreys, established the United States Engineer Officer, Washington, under the civilian engineer, Sylvanus T. Abert, to carry out navigation improvements on the Potomac River and its tributaries.

Two years later, Congress asked the Corps to complete the Wash-



"572 feet high—Setting the Cap-Stone on the Washington Monument—From a sketch on the spot by S. H. Nealy." Harper's Weekly, *December 20, 1884. Col. Thomas Lincoln Casey is to the right of the capstone and Bernard R. Green, his chief civilian assistant, far left.*

ington Monument, left partially built by its bankrupt sponsors. Then Lieutenant Colonel Thomas Casey and his assistant, Bernard Green, corrected major problems with its foundation, redesigned it, and supervised its completion. The construction culminated in December 1884 with placing on its tip a pyramid of 100 ounces of aluminum, the largest piece of the new metal yet cast in the Western Hemisphere. Casey and Green went on to help design and supervise the construction of the State, War and Navy Building next to the White House. It is now the Eisenhower Executive Office Building. The two men also helped design and construct the Library of Congress.

In 1883, Brigadier General Meigs came out of retirement to build the Pension Building. Designed to house the offices providing pensions to war veterans, the building is so attractive that it is sometimes used for inaugural activities and is the new home of the National Building Museum.

Between the 1880s and the 1920s, Corps dredge-and-fill operations not only protected Washington from Potomac and Anacostia river floods, but also created waterfront park land. Potomac Park, the Washington Channel with its adjacent recreation areas, and the land for the Lincoln and Jefferson Memorials are all products of this river improvement and reclamation work. The attractive tidal basin in front of the Jefferson Memorial that automatically changes the water in the Washington Channel with the tidal flow is another product of this work.

Meanwhile, Lieutenant Colonel William W. Harts of the Office of

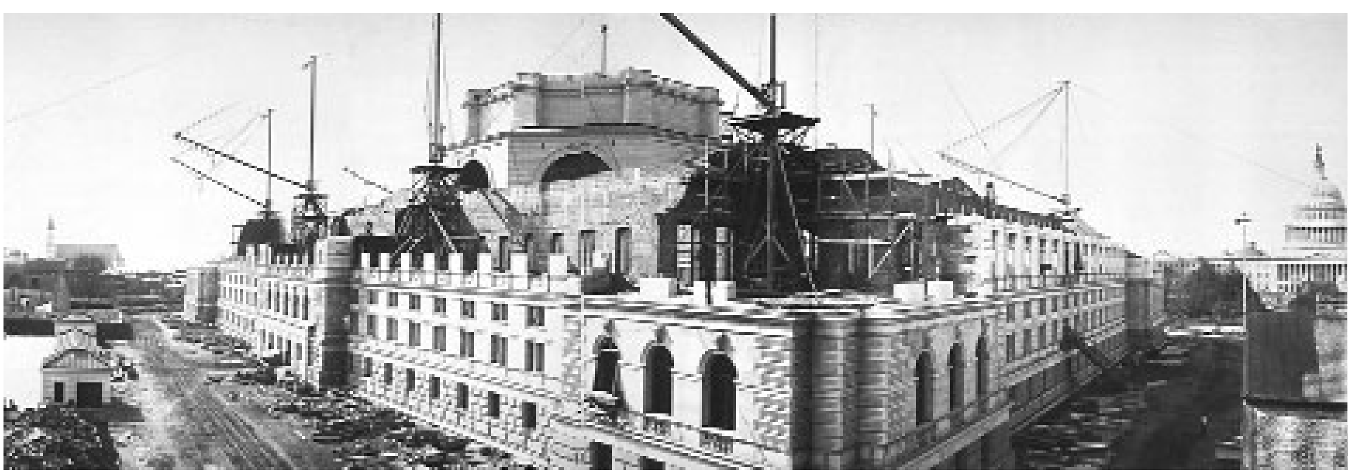
State, War and Navy Building under construction, 1886. Army engineers completed most of the building that is now known as the Eisenhower Executive Office Building.

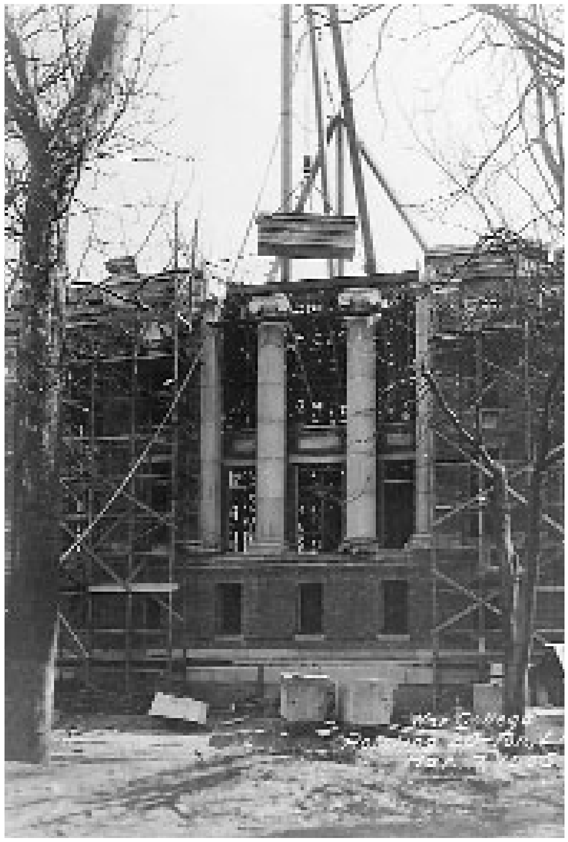
National Archives

Buildings and Grounds accelerated the development of Rock Creek Park into a major resource for urban recreation and beauty. Lieutenant Colonel Harts also oversaw the construction of three other important memorials. In 1913, he directed the start of work on the new headquarters of the American Red Cross. The following year, he initiated construc-

Library of Congress under construction, November 8, 1892

Library of Congress





Hoisting a twenty-ton lintel at the Army War College building at Washington Barracks (later Fort McNair) March 7, 1906
National Defense University

tion on both the Lincoln Memorial and the Arlington Memorial Amphitheater and Chapel.

The Corps also built or supervised the construction of practical and attractive buildings to house the Government Printing Office and the Army War College at Fort McNair. In addition, Army engineers managed the construction of numerous bridges including the Arlington Memorial Bridge and the Francis Scott Key Bridge.

The George Washington Memorial Parkway, the Pentagon, and Ronald Reagan Washington National Airport began as pre-World War II construction projects of the Corps of Engineers. After World War II, the Corps was involved in the

Lincoln Memorial under construction, July 1916
National Archives

Red Cross Building built as a memorial to women in the Civil War, under construction, 1916

complete gutting and rebuilding of the inside of the White House, expanding the water supply for the District of Columbia, and planning for housing and transportation.

U. S. Grant III, grandson of the president, and other officers served on the planning boards that oversaw growth in the Washington metropolitan area. Gradually, civilian agencies, such as the National Park Service and the home rule municipal government of D.C., began to assume responsibility for developing the memorial buildings, streets, sewage systems, and parks that the Corps had once handled.

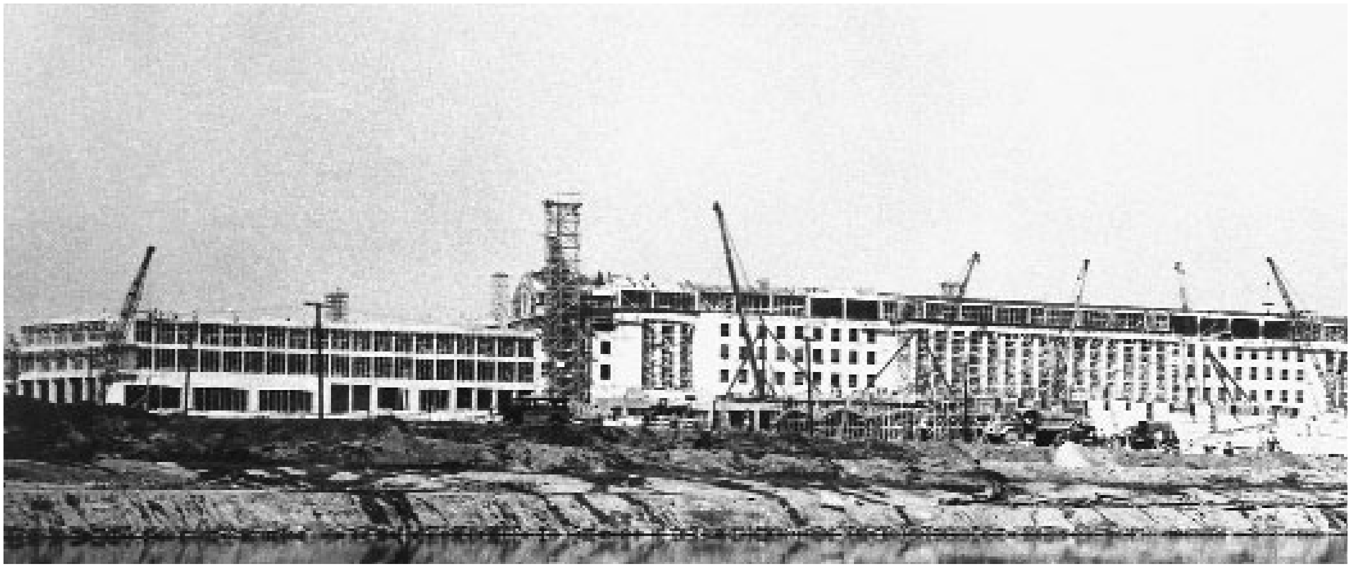
However, the Washington Aqueduct remains a special responsibility of the U.S. Army Engineer District, Baltimore, and the district continues to carry out civil works and military projects in the National Capital area.

The Washington Engineer District built the reinforced concrete Francis Scott Key Bridge over the Potomac River from 1917 to 1923. Just above the arches of the Key Bridge still under construction, the old Aqueduct Bridge, completed in 1843 and rebuilt in the 1880s by Army engineers, was dismantled after the new bridge opened. Georgetown and Georgetown University are shown on the right.

National Archives

The Office of Public Buildings and Grounds built Arlington Memorial Bridge linking the Lincoln Memorial to Arlington National Cemetery and Custis-Lee Mansion between 1925 and 1932.

Library of Congress



The Corps of Engineers managed construction of the Pentagon, designed to consolidate most of the War and Navy departments' offices in Washington, and completed it in a remarkable sixteen months between September 1941 and January 1943.

A retired engineer officer managed the reconstruction of the White House from 1948 to1952 during which time the building was stripped to its bare walls. In May 1950 this bulldozer was digging more basement space for the many offices and other facilities added to the building.

National Park Service

National Airport under construction, July 1, 1940

The Baltimore Engineer District carried on the tradition of Corps of Engineers' work in the national capital area with a wide variety of military construction and civil works projects. One example is construction of the Korean War Veterans Memorial near the Lincoln Memorial (barely visible in the background). The Korean War Veterans Memorial is shown here nearing completion in April 1995.

Army Engineers and the District of Columbia Parks

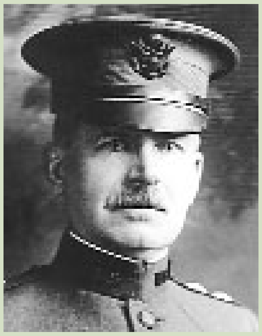
One of the most beautiful areas in the Nation's Capital is Rock Creek Valley, which runs from north to south through the entire District of Columbia. In 1867, Major Nathaniel Michler, the first U.S. Army engineer to head the federal government's Office of Public Buildings and Grounds, proposed the valley as a new site for the White House.

The suggestion touched off great interest in the valley. Praising the region's "primeval forest and cultivated fields, its rocks clothed with rich ferns and mosses, its repose and tranquility, its light and shade," he saw it as a potential refuge for the president from the malarial river front and an unsightly marsh known as the Potomac Flats.

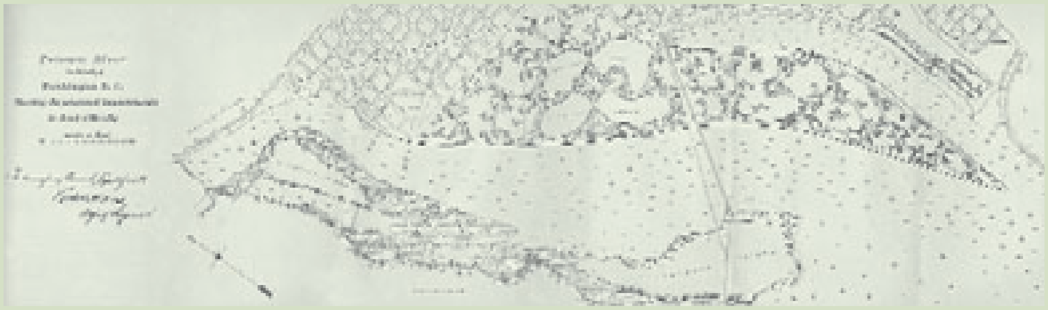
Although the White House was not relocated to Rock Creek Valley, development of the area into what became Rock Creek Park began under one of Major Michler's successors, Colonel Theodore A. Bingham. Bingham believed that the park would provide fresh air and places of recreation for crowded city dwellers and serve as an "emerald setting for the beautiful city." Other engineers shared his vision, and Frederick Law Olmsted, Jr., was hired to create the basic plan of the park and construct the parkways that would link the green areas together. Captain Lansing H. Beach would lend his name to the road he constructed that traverses the length of the park.

U.S. Army engineers also transformed the unsightly Potomac Flats. Beginning in the 1880s, the Corps dredged the river channel and dumped the material onto the flats to create new land to the south and west of the National Mall. In 1897, Congress dedicated some 638 acres of this reclaimed land and directed that it be "forever held and used as a park for the recreation and pleasure of the people." Col. Bingham personally provided Potomac Park with gardens and athletic fields. The southernmost tip of the park became known as Hains Point after engineer Brigadier General Peter C. Hains.

The Corps constructed the Tidal Basin to flush the Potomac River and help prevent pollution. This area became the center of a still-famous location of natural beauty when the U.S. Army Corps of Engineers directed the planting of donated Japanese cherry blossom trees around the basin.



Maj. Gen. Lansing H. Beach as Chief of Engineers, 1920–1924



Plan for Improvement of Potomac Flats by Major Peter C. Hains, 1882