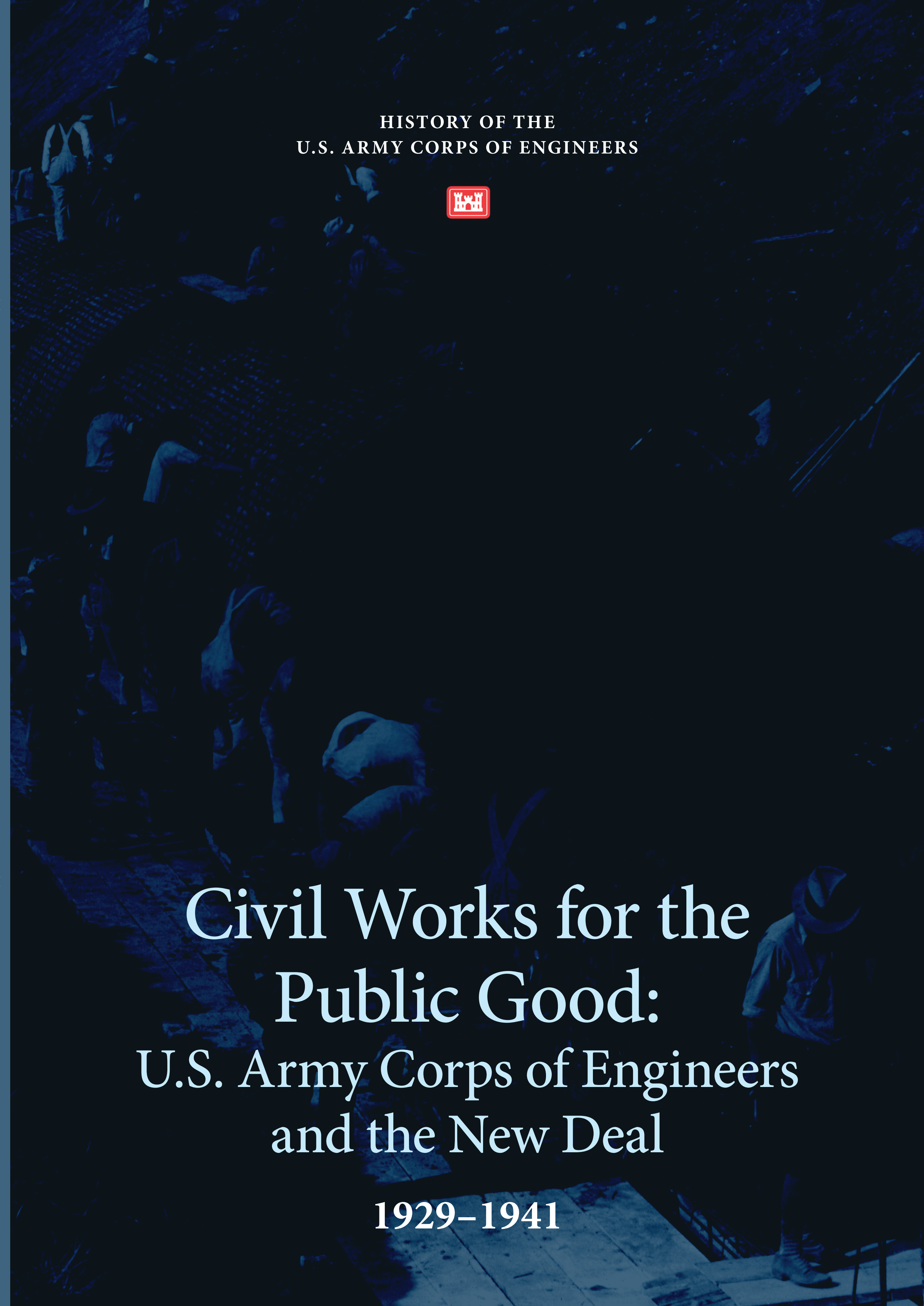

HISTORY OF THE
U.S. ARMY CORPS OF ENGINEERS

Civil Works for the Public Good:
U.S. Army Corps of Engineers and the New Deal

1929–1941

CIVIL WORKS FOR THE PUBLIC GOOD: U.S. ARMY CORPS OF ENGINEERS AND THE NEW DEAL

US Army Corps of Engineers®

EH 870-1-78

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Civil Works for the Public Good:

U.S. Army Corps of Engineers and the New Deal

1929–1941

OFFICE OF HISTORY, HEADQUARTERS, U.S. ARMY CORPS OF ENGINEERS
ALEXANDRIA, VA.
2024

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On the cover:

Hired laborers construct the semi-elliptical brick and concrete arch of the Kenter Canyon storm drain in Santa Monica, California. 18 March 1936.

Office of History, Civil Works Image Collection

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Foreword

THE DECADE OF THE 1930s was a grim period for the United States and, indeed, the world. Most Americans will associate that era with the Great Depression, the most severe and far-reaching economic crisis in the country's history and a turning point both for the nation and for the U.S. Army Corps of Engineers. Although the U.S. had experienced periodic recessions previously, none of them compared to the economic and social turmoil and ruin that took place in the years prior to World War II.

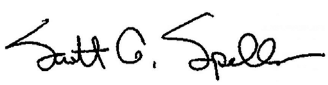
In mid-1929 the U.S. entered a mild recession. The repercussions from the stock market crash in October exacerbated the problem, and the economy spiraled into depression. Waning demand continued to fall; industrial production plummeted; many banks failed; and about 15 million Americans—more than 20 percent of the population—lost their jobs. To address the national crisis, the federal government, through efforts by Congress and the administrations of Herbert Hoover and Franklin D. Roosevelt, intervened as never before, taking steps to provide relief and stimulus in a nearly decade-long effort to restore America's economic health and vitality.

The U.S. Army Corps of Engineers, the nation's premier engineer and water resources agency, was closely involved with many of these efforts while also positioned to play a significant role in public relief activities. For one, its decentralized structure gave it the flexibility and scope to manage projects around the country. In addition, in the 1920s Congress asked the Corps to report on the nation's important waterways to determine which were suitable for potential improvements. These surveys left the Corps with a roster of prospective projects that could be quickly undertaken to provide rapid and robust unemployment relief.

The Corps, like the country, also evolved substantially during the Depression. Although it continued its longstanding and traditional mission to improve navigation on America's waterways (rivers, harbors, and canals included), it also began in earnest to develop multiple-purpose projects, something it had only just begun to consider in the 1920s. These projects served not only navigation and commerce but could also provide hydropower, irrigation, or water supply. Congress also assigned the Corps an official flood control mission in 1936, and the Army Engineers soon shifted to a comprehensive flood-control policy that embraced floodways, reservoirs, and outlets in addition to levees. In fact, the Corps' emergency public works program of 1938 included slightly more flood control projects than navigation improvement projects.

Organizational change occurred in concert with changes to the work performed. Even then the Corps of Engineers boasted an adaptable administrative structure that served it well during the tumultuous decade. The chiefs of engineers opened, closed, and rearranged divisions and districts as the workload demanded, sometimes creating offices specifically to manage large relief projects—such as Bonneville (Oregon), Fort Peck (Montana), Tucumcari (New Mexico), and Eastport (Maine) Districts, among others. The Depression also altered the workforce of the Corps of Engineers, its size steadily increasing as Congress and the president assigned more and more projects, regular and work relief, to the Corps.

This installment of the HISTORY OF THE U.S. ARMY CORPS OF ENGINEERS chronicles the participation of the Corps and its personnel in the federal response to the economic crisis of the 1930s in the form of a nationwide public works relief program. It reveals, again, the remarkable ability of this organization to respond to diverse challenges, to adapt to new circumstances, and to serve this country unfailingly.



Scott A. Spellmon
Lieutenant General, U.S. Army
Chief of Engineers

The Author

WILLIAM F. WILLINGHAM was born in Pendleton, Oregon, in 1944 and received his B.A. in history from Willamette University (1966) and his M.A. and Ph.D. in history from Northwestern University (1972). He has taught at Lafayette College, the University of Kentucky, and Lewis and Clark College (Portland, Oregon); served as District Historian for the Portland District of the U.S. Army Corps of Engineers (1981–1989) and Division Historian for the North Pacific Division of the Corps of Engineers (1989–1996); and worked as a consulting historian (1996–2019) in the fields of water resources development, historic preservation, architectural history, Oregon history, and cultural resources management. He is the author of twelve scholarly books and over twenty articles in his fields of historical specialty.

Preface

THE 1930s BROUGHT TITANIC CHANGES to the civil works program of the Army Corps of Engineers. During a long historical arc of infrastructure engineering—from the early nineteenth century to the early twentieth century—the Corps mostly undertook single-purpose navigation projects on the nation's rivers and harbors. Starting in the late 1920s, however, and increasingly so in the 1930s, it managed the construction of multiple-purpose water resources projects to develop the nation's critical infrastructure for navigation, flood control, hydropower, and water supply serving industrial and domestic purposes. This program shift came at the direction of both Congress and the president.

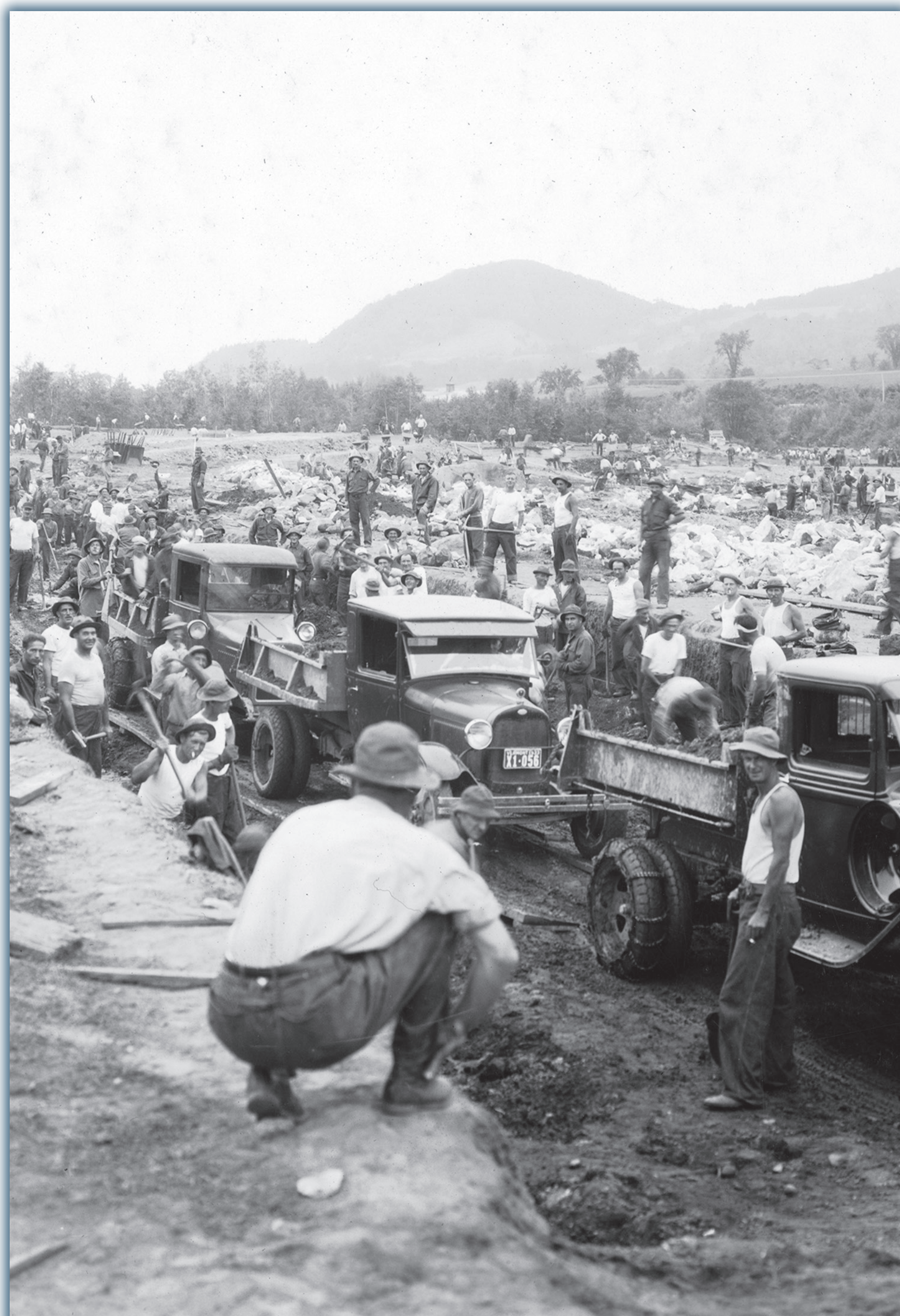
The dire economic conditions and high unemployment created by the Great Depression hastened the New Deal-era embrace of multiple-purpose water resources engineering. President Franklin Roosevelt saw the civil works program of multiple-purpose projects across the nation as a potential jobs program and moved aggressively to grow it. Fortunately, the Corps was well positioned to take on the additional work. In the previous decade, it had carried out a series of preliminary surveys of the nation's rivers to determine which ones might benefit from multiple-purpose development. The subsequent studies, dubbed the 308 reports for the congressional document number authorizing them, provided the Corps with the knowledge and data necessary to plan and carry out the projects that would form the water resources portion of the New Deal relief program. Construction of the Bonneville Dam on the Columbia River and the Fort Peck Dam on the Missouri River—both projects employed thousands—were but two examples of the work originating from the 308 program. The Bonneville Dam constituted a massive, multi-component reinforced concrete structure that tested the limits of dam technology of the period, while Fort Peck Dam posed severe challenges in the construction of huge roller-compacted, earth-filled dams.

Flood control projects were similarly embraced as jobs programs. The destructive consequences of major flooding in the 1920s and 1930s moved Congress towards accepting federal responsibility for flood control and to declare it a national priority. The landmark Flood Control Act of 1936 gave the Corps a national flood control mission, and a major portion of that mission focused on the lower Mississippi River. This complex work saw the Corps move beyond relying on "levees only" and embrace a truly comprehensive approach that combined new levee construction with a mix of floodways and spillways to divert flood waters into the Gulf of Mexico.

In addition to its new multiple-purpose and flood control missions, the Corps maintained its traditional navigation-focused workload, such as the nine-foot channel improvement on the upper Mississippi River. With New Deal relief funding, the Corps expanded its officer corps and civilian workforce and reorganized its headquarters and field organization (see appendices for data on the emergency relief acts, funding, and workplace transformation in the Corps). One operational element that did not change during this tumultuous period was the Corps' traditional reliance on decentralized project decision-making through its division and district administrative structure. Given the remarkable competency and efficiency of the Army Engineers, the Roosevelt administration also called upon select officers to oversee major elements of other New Deal public works programs. Meeting all the multifarious demands of its civil works mission during the 1930s enhanced the Corps' administrative and contracting skills and expanded its knowledge of the latest construction methods. All these enhanced capabilities gave the Corps a solid foundation for managing the massive military construction program that it carried out during World War II.

The above subjects and other issues, such as the Corps' role in New Deal planning and policies and the agency's developing expertise with environmental issues related to its projects, receive summary treatment in this edition of the Office of History's series of books on the Corps' history. Through the lengthy process of producing this book, several historians in the Office of History gave patient encouragement and invaluable assistance. Dr. John C. Lonnquest, chief of the office, pushed for a larger vision of what this and other volumes in the series should cover; Dr. Matthew Pearcy provided valuable insights and thoughtful suggestions for revising the text; Mr. Douglas Wilson made available his own significant research on the Corps' 1930s work and then skillfully edited the entire manuscript, shepherding it through many revisions. These individuals enabled me to craft a book of greater depth and breadth than would otherwise have been the case. Of course, they are blameless for any shortcomings the book may still possess.

William F. Willingham, Ph. D.
Portland, Oregon



Office of History, Civil Works Image Collection

Laborers and vehicles at the East Barre dam site in Vermont. August 1933.

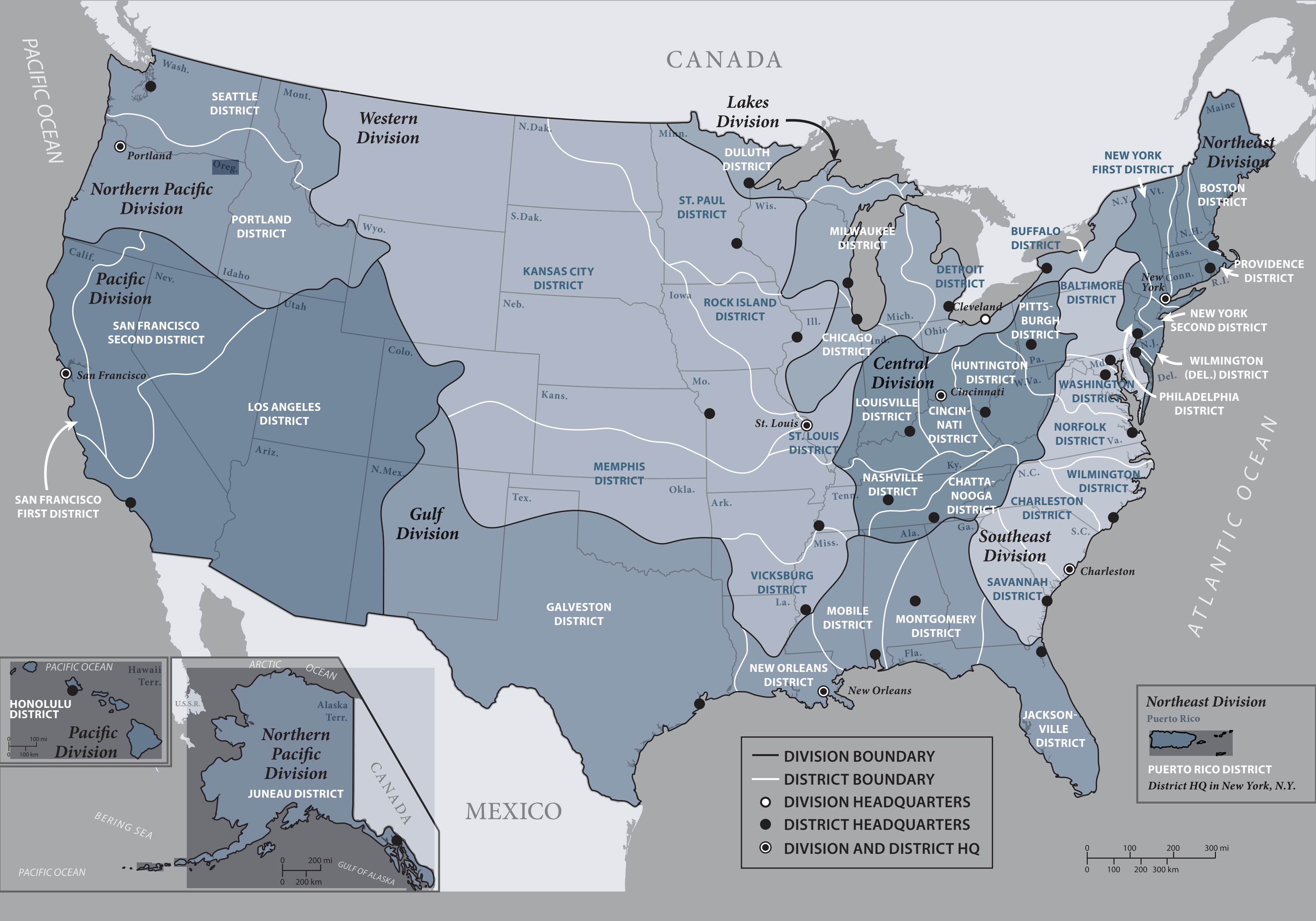
Office of History, Civil Works Image Collection

Workmen in the tunnels of the Fort Peck Dam project in Montana. 26 October 1934.

The Corps and New Deal Relief Measures

LIKE ALMOST EVERY OTHER FEDERAL AGENCY during the 1930s, the U.S. Army Corps of Engineers found its mission and workload greatly affected by the economic fallout of the Great Depression. The severe downturn and consequent massive unemployment called for heroic measures. While the administration of President Herbert C. Hoover tentatively expanded federal relief programs and construction projects between 1930 and 1932, the succeeding administration of President Franklin D. Roosevelt would come to vigorously embrace the notion of federal public works projects to relieve unemployment and jumpstart the economy. The Corps, as the federal agency with a long history in engineering and civil works construction, proved a logical choice to undertake much of the new federal work designed to restore the economic well-being of the United States in the 1930s.

This engineering and construction work was facilitated by an early reorganization of the Corps, initiated by President Hoover in 1929, which aligned the Corps' civil works field agencies (divisions) along river basins, leaving it better prepared to respond to water resource development projects devised by the Roosevelt administration as work relief measures. In addition, by 1933 the Corps had completed many congressionally authorized surveys of streams and rivers. These investigations, and the resultant 308 reports, as they became known, gave the organization extensive information on the development potential of the nation's major rivers and their watersheds.



CANADA
PACIFIC OCEAN
ATLANTIC OCEAN
MEXICO
Western Division
Lakes Division
Northeast Division
Northern Pacific Division
Pacific Division
Central Division
Gulf Division
Southeast Division
SEATTLE DISTRICT
PORTLAND DISTRICT
SAN FRANCISCO SECOND DISTRICT
SAN FRANCISCO FIRST DISTRICT
LOS ANGELES DISTRICT
KANSAS CITY DISTRICT
MEMPHIS DISTRICT
GALVESTON DISTRICT
DULUTH DISTRICT
ST. PAUL DISTRICT
ROCK ISLAND DISTRICT
MILWAUKEE DISTRICT
CHICAGO DISTRICT
DETROIT DISTRICT
BUFFALO DISTRICT
ST. LOUIS DISTRICT
LOUISVILLE DISTRICT
HUNTINGTON DISTRICT
CINCIN-NATI DISTRICT
PITTS-BURGH DISTRICT
NASHVILLE DISTRICT
CHATTA-NOOGA DISTRICT
VICKSBURG DISTRICT
NEW ORLEANS DISTRICT
MOBILE DISTRICT
MONTGOMERY DISTRICT
SAVANNAH DISTRICT
JACKSON-VILLE DISTRICT
CHARLESTON DISTRICT
WILMINGTON DISTRICT
NORFOLK DISTRICT
WASHINGTON DISTRICT
BALTIMORE DISTRICT
PHILADELPHIA DISTRICT
WILMINGTON (DEL.) DISTRICT
NEW YORK SECOND DISTRICT
NEW YORK FIRST DISTRICT
PROVIDENCE DISTRICT
BOSTON DISTRICT
Wash.
Mont.
Oreg.
Idaho
Calif.
Nev.
Utah
Wyo.
Colo.
Ariz.
N.Mex.
N.Dak.
S.Dak.
Neb.
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Ohio
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Ala.
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Fla.
S.C.
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W.Va.
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Md.
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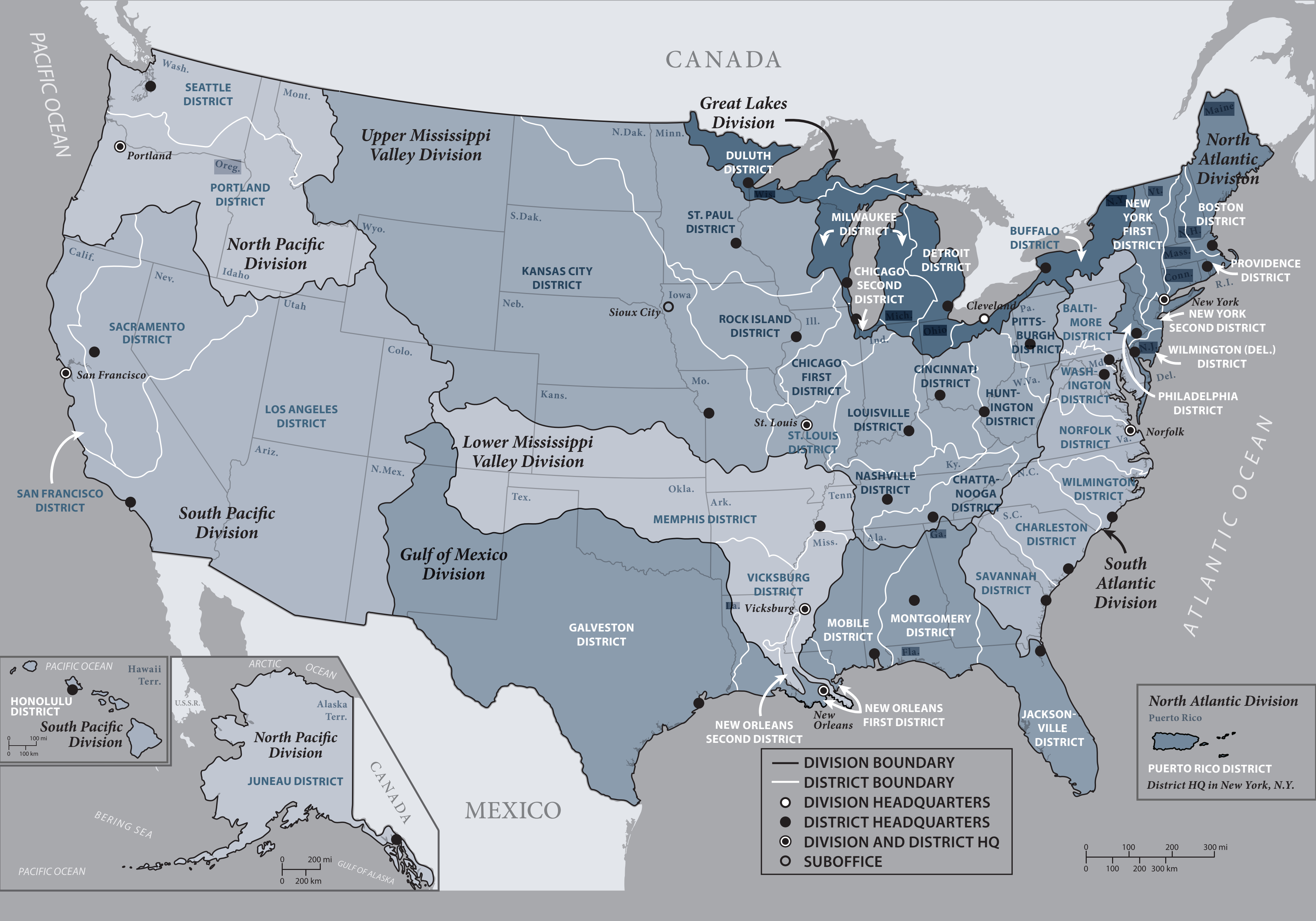
N.J.
N.Y.
Vt.
N.H.
Maine
Mass.
Conn.
R.I.
Portland
San Francisco
St. Louis
Cincinnati
Cleveland
New York
Charleston
New Orleans
PACIFIC OCEAN
Hawaii Terr.
HONOLULU DISTRICT
Pacific Division
100 mi
100 km
ARCTIC OCEAN
U.S.S.R.
Alaska Terr.
Northern Pacific Division
JUNEAU DISTRICT
CANADA
BERING SEA
GULF OF ALASKA
200 mi
200 km
DIVISION BOUNDARY
DISTRICT BOUNDARY
DIVISION HEADQUARTERS
DISTRICT HEADQUARTERS
DIVISION AND DISTRICT HQ
Northeast Division
Puerto Rico
PUERTO RICO DISTRICT
District HQ in New York, N.Y.
0 100 200 300 mi
0 100 200 300 km

THE 308 REPORTS

Until the 1920s, the Corps had focused its civil works program primarily on single-purpose navigation or flood control projects. By then, many engineers, natural resources planners, and politicians were promoting multipurpose projects as the most efficient way to develop the water resources of the nation's major river basins. Congress had, in particular, developed an interest in the hydropower potential of the nation and wanted to better understand how it might be coordinated with other water projects. Accordingly, Congress directed the Corps in 1925 to prepare cost estimates for conducting examinations of approximately two hundred streams and rivers. The examinations were to serve as a basis for devising plans for the most efficient development of the waterways in the interests of navigation, irrigation, flood control, and power development. The Corps responded with a recommendation for twenty-four intensive surveys at a cost of $7.3 million, and in 1927 Congress appropriated the funds to carry these out. The consequent 308 reports assembled baseline economic, social, scientific, and engineering data, which the Corps then analyzed to develop plans and recommend projects that proved capable of guiding the nation's water resources development over the next fifty years.

In all, the Corps produced and sent to Congress over 176 river surveys under the 308 program. Only about 16 of the reports recommended direct federal involvement, and most left the implementation of plans to state or private interests. Additionally, though, the reports provided data and planning approaches for officials undertaking water resources development on a local, regional, or national scale. The Corps published its first 308 report in 1929 (on the Tickfaw River in Louisiana); the last one was published in 1948 (on the St. Marys and North rivers in Florida). By 1938, when all but four of the published reports had been completed, the total funds expended came to $11.6 million. The 308 program, moreover, played a key role in the evolution of multipurpose planning and cost-benefit analysis, constituting a strategic vision for national water resources planning. Congress, in 1935, directed the Corps to update periodically the original 308 reports to reflect changes in economic circumstances, better technical data, and other factors such as environmental conditions. After World War II, the Corps continued to use and update the 308 reports compiled in the 1930s as it developed the water resources potential of the nation's rivers.[2]

Opposite: The field organization of the Corps of Engineers in 1929. With rare exceptions, civil works districts take their name from the city in which their headquarters are located.



CANADA
PACIFIC OCEAN
ATLANTIC OCEAN
MEXICO
Great Lakes Division
Upper Mississippi Valley Division
North Pacific Division
South Pacific Division
Lower Mississippi Valley Division
Gulf of Mexico Division
North Atlantic Division
South Atlantic Division
SEATTLE DISTRICT
PORTLAND DISTRICT
Portland
SACRAMENTO DISTRICT
San Francisco
SAN FRANCISCO DISTRICT
LOS ANGELES DISTRICT
KANSAS CITY DISTRICT
Sioux City
DULUTH DISTRICT
ST. PAUL DISTRICT
ROCK ISLAND DISTRICT
MILWAUKEE DISTRICT
CHICAGO SECOND DISTRICT
CHICAGO FIRST DISTRICT
DETROIT DISTRICT
BUFFALO DISTRICT
Cleveland
PITTSBURGH DISTRICT
CINCINNATI DISTRICT
HUNTINGTON DISTRICT
LOUISVILLE DISTRICT
St. Louis
ST. LOUIS DISTRICT
NASHVILLE DISTRICT
CHATTANOOGA DISTRICT
MEMPHIS DISTRICT
VICKSBURG DISTRICT
Vicksburg
GALVESTON DISTRICT
MOBILE DISTRICT
MONTGOMERY DISTRICT
NEW ORLEANS SECOND DISTRICT
New Orleans
NEW ORLEANS FIRST DISTRICT
JACKSONVILLE DISTRICT
SAVANNAH DISTRICT
CHARLESTON DISTRICT
WILMINGTON DISTRICT
NORFOLK DISTRICT
Norfolk
WASHINGTON DISTRICT
BALTIMORE DISTRICT
PHILADELPHIA DISTRICT
WILMINGTON (DEL.) DISTRICT
NEW YORK SECOND DISTRICT
New York
NEW YORK FIRST DISTRICT
BOSTON DISTRICT
PROVIDENCE DISTRICT
Wash.
Oreg.
Calif.
Idaho
Nev.
Mont.
Utah
Wyo.
Ariz.
Colo.
N.Mex.
N.Dak.
S.Dak.
Neb.
Kans.
Okla.
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Maine
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R.I.
PACIFIC OCEAN
Hawaii Terr.
HONOLULU DISTRICT
South Pacific Division
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ARCTIC OCEAN
U.S.S.R.
Alaska Terr.
North Pacific Division
JUNEAU DISTRICT
CANADA
BERING SEA
PACIFIC OCEAN
GULF OF ALASKA
0 200 mi
0 200 km
DIVISION BOUNDARY
DISTRICT BOUNDARY
DIVISION HEADQUARTERS
DISTRICT HEADQUARTERS
DIVISION AND DISTRICT HQ
SUBOFFICE
North Atlantic Division
Puerto Rico
PUERTO RICO DISTRICT
District HQ in New York, N.Y.
0 100 200 300 mi
0 100 200 300 km

The process of producing the 308 reports transformed the Corps. Through work on the river basin surveys, its officers and civilian employees acquired the knowledge, skills, and commitment necessary to accomplish a national program of multipurpose water resource development. The reports that recommended federal action helped reshape the Corps' civil works mission, broadening its scope of action and involvement with local communities. As a result, the Corps was well placed to assist the Roosevelt administration as it prepared to use federal public works projects to fight unemployment. The Army Corps of Engineers had the experience in planning and conducting a large-scale construction program and, under President Hoover, had already made significant strides in using its expertise to alleviate unemployment. Still, Hoover faced a daunting economic situation, and the federal government lacked the necessary tools for aggressively attacking the growing unemployment problem gripping the country. In 1930 unemployment stood at 4.3 million (8.9 percent of the civilian labor force); by 1931 it had reached 8 million (15.9 percent). The federal construction expenditures for 1929, however, barely reached $200 million, while the states spent ten times as much and private industry invested $9 billion on construction projects. Under these circumstances, it makes sense that President Hoover initially placed his faith in private initiative to combat unemployment. The federal government lacked a base for quickly launching a massive, multi-billion-dollar federal construction program. The limited size and structure of the federal government simply reinforced Hoover's philosophical preference for voluntarism and free market solutions to the economic crisis. Even Roosevelt's New Deal initiatives could not succeed in raising annual federal construction expenditures by as much as $1.5 billion over the 1930 rate until 1939.[3]

Despite their commitment to a balanced federal budget, President Hoover and Congress, through the Corps, did what they could to combat growing unemployment with federal public works. In 1930 Congress allotted the Corps $25.5 million under the Emergency Construction Act "for the purpose of providing for emergency construction on certain public works during the remainder of the fiscal year 1931 with a view to increasing employment." The Corps applied this appropriation to 151 projects throughout the United States, thereby putting an additional 10,766 men to work. This effort was over and above the Corps' $105 million civil works appropriation for 1931. In the following year, the Corps received an emergency work relief

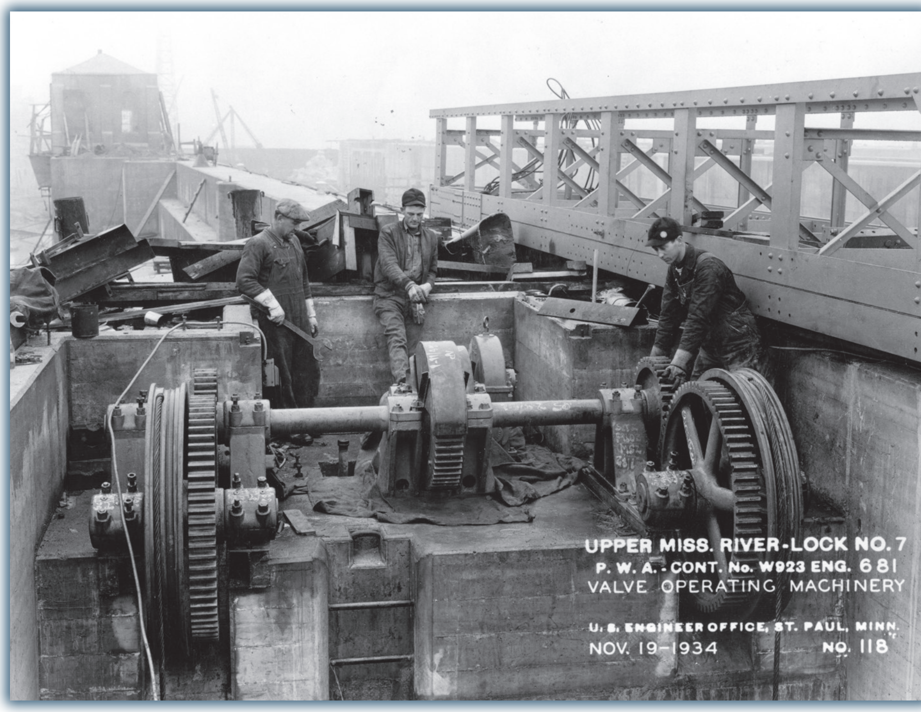
Opposite: The USACE field organization in 1930 after Hoover reorganized the divisions based on river basins.

appropriation of $45.5 million in addition to its regular civil works allotment of $102 million. In all, from 1931 to 1933 the Corps received over $71 million in work relief funds. David Kennedy has fairly summed up President Hoover's effort to fight the onset of the Depression:

> Given the constraints under which he labored … Hoover made impressively aggressive countercyclical use of fiscal policy. Measured against either past or future performance, his accomplishment was remarkable. He nearly doubled federal public works expenditures in three years. Thanks to his prodding, the net stimulating effect of federal, state, and local fiscal policy was larger in 1931 than in any subsequent year of the decade.[4]

The Corps' civil works program certainly reflected the rapid infusion of relief funds. Average annual appropriations for all Corps activities (rivers and harbors, flood control, and operations) in the mid-1920s came to about $65 million, while between 1928 and 1932 the appropriations for regular and relief work reached an average of $120 million. One Army engineer officer calculated in June 1933 that the Corps' regular and emergency work program "provided employment, directly and indirectly to from 75,000 to 100,000 men per year, during the present emergency."[5] (*See* Appendix B.)

The Corps of Engineers was able to respond to President Roosevelt's call for emergency relief through construction of public works for yet another reason. In response to the Employment Stabilization Act of 1933, the Corps developed and maintained a six-year list of rivers and harbors construction projects ready for implementation if and when requested by the cabinet-level Federal Employment Stabilization Board, which monitored economic conditions that might indicate an economic downturn. The goal of this legislation was to have public works projects ready so that Congress could react quickly to an economic emergency by appropriating funds for previously authorized projects. Such advanced planning paid off when Roosevelt's public works and relief agencies, such as the Public Works Administration (PWA) and Civilian Conservation Corps (CCC), requested projects to put people to work quickly. In the first year of the PWA, President Roosevelt gave the Corps $249 million for its civil works projects. In 1933 and 1934 the PWA had $3.4 billion to spend on public works to provide employment and stimulate the economy. It became the initial primary weapon against the Depression, focusing on heavy construction of large-scale structures and spending its funds on projects in almost every county in the nation. When created in 1935 to confront the continuing



Office of History, Civil Works Image Collection

The valve-operating machinery of Lock No. 7 near La Crescent, Minnesota. Construction of the lock and dam was a relief project funded by the PWA and managed by the Corps. 19 November 1934.

problem of large-scale unemployment, the Works Progress Administration (WPA)—the other major federal public works agency—had an initial appropriation of $4.8 billion. The PWA relied heavily on private contractors, while the WPA accomplished its relief construction work through direct hiring of the unemployed. Overall, the funding for public works programs between 1933 and 1939 accounted for over two-thirds of federal emergency expenditures.[6]

THE PEOPLE OF THE CORPS

The Roosevelt administration also selected a number of officers from the Army Corps of Engineers to supervise the agencies of relief and reconstruction used to fight the economic crisis. In 1933 Secretary of the Interior Harold L. Ickes, who was also President Roosevelt's administrator of the new PWA, turned to a Corps of Engineers officer, Col. George Spalding, to assist in setting up the PWA and then

U.S. Army Photo courtesy of Office of History, Personality Image Collection

Maj. Gen. Edward M. Markham, who served as Chief of Engineers from 1933 to 1937.

sought to keep him. The chief of engineers, Maj. Gen. Lytle Brown, however, resisted Ickes' efforts. General Brown needed Spalding for important work on the upper Mississippi River as division engineer. He also did not want his officers placed in situations where they might face accusations of conflicts of interest or of violating the Department of War chain of command. Brown won the argument and kept his officer at his post in the Upper Mississippi Valley Division.[7]

General Brown's successor as chief of engineers, Maj. Gen. Edward M. Markham, took a different, more flexible approach to working with the new administration. Capt. Lucius D. Clay, then a young engineer officer in the Corps' headquarters, later recalled that "General Brown was a very fine, a very able, but not very flexible man. He did not hit it off with President Roosevelt, and … under General Brown we could never have done the work for PWA and WPA that we did later." General Markham, on the other hand, apparently had a style and personality more suited to that of the new president. According to Captain Clay, both men were very intuitive in their political and personal judgments. For whatever reasons, Roosevelt, in selecting General Markham as his chief of engineers, passed over six senior Corps officers.[8]

General Markham quickly saw an opportunity to expand the Corps' public works role in the early days of the New Deal's work relief efforts. At Clay's urging, he and Markham met with Harry Hopkins, supervisor of the WPA, and offered to lend experienced engineer officers to help set up the work relief program. Although initially suspicious of the Corps' motives, Hopkins accepted the offer. As Clay later explained, the Corps was trying to protect its bureaucratic turf during the early days of the New Deal: "You've got to remember that you're always fighting for position. Somebody wants to take over the rivers and harbors work from the Engineers, although they've had it for years. And so you try to establish yourself. It seemed to me that the best way we could establish ourselves was to make ourselves helpful." Clay added, "Frankly, I would have to admit that if we hadn't felt that Mr. Ickes was trying to give us trouble, we might not have thought of going to Mr. Hopkins. It was our theory that Mr. Ickes wanted to turn the Department of Interior into the Department of Public Works, and obviously we didn't want him to. This is one of the reasons why we offered our assistance to Mr. Hopkins."[9]

Other New Deal agencies, such as the National Recovery Administration (NRA), also sought out Army Corps of Engineers officers to help set up their programs. In June 1933 Hugh Johnson, administrator of the NRA, requested the services of a Corps officer, Lt. David Tulley, who briefly served as the deputy administrator of the agency before returning to his Corps duties. Hopkins, who administered the Federal Emergency Relief Administration (1933–1935) and the Civil Works Administration (CWA) (1933–1934) in addition to the WPA (1935–1938), continued to draw on Corps officers to assist him in putting the unemployed to work in construction jobs. Hopkins discovered that Army engineers were capable, honest administrators, and he used them to replace corrupt bureaucrats in both Los Angeles and Chicago.

By the end of 1934 the Corps of Engineers had detailed twenty-nine officers to either full- or part-time duty with various New Deal agencies—more than any other Army branch. Most of them (seventeen officers) worked for Hopkins' CWA. The Corps' role in the CWA then led to major responsibilities in the WPA. The Army engineers demonstrated that they could quickly supply quality engineering plans and capable management skills. For example, Corps personnel provided the WPA's Engineering Division in Washington, D.C., with the technical capability for evaluating all types of construction projects. The chief of engineers offered to lend Hopkins some of his best officers to support the WPA, and Hopkins, who had had trouble finding competent civilian engineers to staff his agency, readily accepted. While engineer Col. Francis C. Harrington oversaw engineering at the WPA headquarters, five Army engineer officers joined the New York City WPA in 1935. Shortly thereafter the Corps detailed other officers to various WPA offices. The Corps eventually assigned forty-seven officers to the WPA in 1936. An Army report of that year listed the chief of engineers as a consulting engineer to the administrator of the WPA.

The increase in the Corps' workload plus the detail of engineers to the PWA, the WPA, and other agencies soon had the Corps' officer ranks stretched thin. The Corps' own workload had increased from 541 river and harbor projects in 1928 to 973 projects by 1935. In addition, the Corps of Engineers had begun work on such very large undertakings as the Bonneville Dam on the Columbia River, Fort Peck Dam on the Missouri, and the nine-foot channel project on the upper Mississippi River. Despite the Corps' resistance, President Roosevelt ordered the agency to serve as a consultant to Hopkins at the WPA for engineering problems and for district and division officers to provide engineering consulting services to field components of the WPA. Not satisfied with this help, Hopkins soon asked for the loan of twenty-two more Army engineer officers.

In three locations—New York, Los Angeles, and Hawaii—engineer officers took over entire WPA programs. Col. Brehon B. Somervell, in charge of the New York City office of the WPA, supervised more than two hundred thousand men on various construction projects, including La Guardia Airport. At one point Somervell was overseeing one out of every seven dollars spent nationally by the WPA. He gained a national reputation as a top manager and adroit administrator, which ultimately led to his being tasked with reorganizing the floundering Quartermaster Corps' Construction Division in 1940. In Hawaii the Corps administrator of WPA programs, Maj. Robert Fleming Jr., emphasized defense-related rather than civilian projects. He had previously been responsible for all WPA programs in southern California.

In the last years of the WPA, a Corps of Engineers officer, Col. Francis C. Harrington, served as the head of the agency. Roosevelt apparently chose Harrington not only for his ability but also because he was serving for his Army pay and therefore would not have to go through the Senate's confirmation process. Harrington's military training and engineering expertise, Roosevelt hoped, would help insulate the WPA from continuing conservative criticism. In 1941 President Roosevelt appointed another Corps officer, Brig. Gen. Philip B. Fleming, to head the new Federal Works Administration, which oversaw both the WPA and the PWA. General Fleming had previously worked for Ickes' PWA and in 1939 as administrator of the Labor Department's Wage and Hour Division that arose from the Fair Labor Standards Act of 1938.

Army engineer officers' service in various federal public works agencies provided valuable training for future administrative duties, especially during World War II. During the life of the New Deal construction agencies, Corps officers served at all levels, using their construction expertise, administrative skill, and integrity to successfully complete water resources projects and achieve program goals focused on national infrastructure needs and higher employment levels. In turn, Corps engineer officers gained more experience and responsibility than the small peacetime Army of the 1930s would have offered. As the Corps lent its seasoned officers to the New Deal agencies, junior officers had the opportunity to move up in command responsibility within the Corps.

The assistance the Corps gave Hopkins and Ickes earned the agency a great deal of respect. When the chief of engineers requested an increase in the number of officers for civil works and later for defense construction, President Roosevelt and Hopkins did not object. Indeed, by the end of 1941 the Corps had even taken over the Army construction program previously administered by the Quartermaster Corps. The Corps of Engineers' experience with the New Deal relief program sharpened its administrative and contracting skills and expanded its knowledge of the latest construction methods. It also provided a solid foundation for successfully managing the larger, even more rushed construction program of World War II.[10]

Based on the growth of the Corps' workload, Congress in 1930 authorized a slight increase in the civil works staff. In 1936 Congress again responded favorably to the Corps' request for an increase in officer strength by adding another 186 officers (from 415 to 601). It was probably no coincidence that the measure passed Congress and was signed by the president during the same week that he gave approval to the Flood Control Act of 1936. In making his request for a large permanent addition in commissioned personnel, Chief of Engineers Markham noted that the dollar amount of the Corps' average annual rivers and harbors and flood control work had increased from $60 million in 1920 to more than $200 million in 1935. The following year the Corps' appropriation for all work grew to $355 million. Also, until 1940 and the buildup of national defense construction projects, Corps officers continued to supply administrators for the New Deal work relief agencies. Commissioned officer strength in the Corps at the end of the 1940 fiscal year stood at 810.[11]

ADMINISTERING THE WORK

When Congress added to the engineer officer strength in 1936, the chief of engineers decided to reorganize his headquarters staff by combining the Rivers and Harbors Section, the Miscellaneous Civil Section, and the Flood Control Section into a Civil Works Division coequal with the Military Division. The chief of engineers further ordered that an assistant chief with the rank of brigadier general should head each division. During the 1930s the Corps, under General Markham, made some alterations to its field structure by establishing two new divisions (the Missouri River and the Ohio River in 1933), reestablishing separate North and South Pacific Divisions (1934), and creating temporary single-project districts. For example, the second Portland (Oregon) District (later Bonneville District) oversaw the Bonneville Dam construction on the Columbia River, the Eastport District (Maine) had responsibility for the Passamaquoddy Tidal Power Project, the Fort Peck District (Montana) built the Fort Peck Dam, the Conchas District (New Mexico) managed the Conchas Dam, the Zanesville District (Ohio) supervised the Muskingum River basin dams project, and the Denison District (Oklahoma) undertook the Denison Dam. The Conchas District later became the Albuquerque District, while the Denison District was renamed the Tulsa District.

The Corps' emergency relief work also meant that it had to enforce the labor regulations of the New Deal. Under the National Recovery Administration (NRA), the Corps' procurement and contracting activities had to follow the uniform bidding and cost measurement procedures, minimum wages, and maximum hours of work established by that program. These requirements added to costs and increased paperwork. The Corps also had to cope with the often-contradictory wage and hour requirements of the various relief agencies. In dealing with wage and hour issues and the requirement for maximum use of unemployed workers, the Corps often found itself caught between the needs of its contractors and the bureaucratic rules of the New Deal agencies. The Corps, however, defended its independent authority over projects to NRA compliance officers who, in the Corps' opinion, attempted to meddle in management matters. Hugh Johnson, the NRA administrator, eventually concluded that the Corps' decentralized organizational structure worked better than one centralized in Washington. Wherever possible, the Corps cooperated with the New Deal relief agencies and local interests, but it carefully defended its independence when necessary.[12]

The Corps of Engineers also had some involvement with the Civilian Conservation Corps (CCC). In 1933 the Corps' Fort Humphreys in northern Virginia became one of the conditioning camps for the CCC. Prior to departure for their work camps, the young men received rigorous physical conditioning and instruction in organizational and disciplinary matters. Thousands of CCC workers took initial training from the Army engineers and then received assignments on Corps-directed work relief projects. In 1933 the Corps of Engineers employed over five thousand CCC workers on the Winooski River flood control project in Vermont. It was one of the largest CCC projects, and initially the Corps was reluctant to accept responsibility for it. The chief of engineers had expressed the fear that the young, inexperienced workers would not be up to the job and would greatly increase costs for the project, but in the end the Corps took on the work. In addition to the specific CCC projects that they directed, Corps officers also oversaw the job of administering some of the CCC camps for conservation work carried on throughout the nation. The Army, however, assigned most procurement and logistics responsibilities for the CCC to the Quartermaster Corps, and over time most camps fell under the command of Army Reserve officers.[13]

CONGRESS, THE PRESIDENT, AND THE PRIVATE SECTOR

The Corps' involvement in the New Deal emergency relief and construction program complicated its traditional relationships with both the Congress and the president. When President Roosevelt temporarily gained control of the authorizing and allocating of funding for federal construction agencies from Congress in 1933, the Corps' longstanding working relationship with Congress changed. For three years the president rather than Congress decided which new projects the Corps would build. President Roosevelt divided the federal budget into two categories. The general category reflected the routine charges of the government, while the new emergency listing consisted of New Deal public works measures aimed at maximizing employment. For the Corps, regular appropriations covered completion of previously signed contracts and maintenance expenditures for existing operations. New work fell under the emergency public works program.

Beginning with the National Industrial Recovery Act of 1933, Congress appropriated $3.3 billion and gave President Roosevelt power to allocate it to projects as he saw fit. This approach also later applied to the PWA and WPA. In establishing the PWA, Congress did specify that the president could approve rivers and harbors improvements only if Congress had authorized them or the chief of engineers had recommended them. This restriction did not apply to flood control or other water-related construction work. The impact of the change in funding had immediate consequences for the Corps. Regular funding for rivers and harbors improvements fell from $102 million in fiscal year 1932 to $59 million in fiscal year 1933, while allotments for work relief projects jumped from $45.5 million to $192.3

million in the same time frame. The two highest years for emergency relief funding occurred in 1934 and 1935, when Congress appropriated $249 million and $206 million respectively for the Corps' program. In all, Congress appropriated approximately $544 million in emergency relief funds for the Corps between 1931 and 1942, which represented 20 percent of the agencies' total civil works expenditures for the period. Another way to gauge the impact of the Corps' emergency relief funding is to measure the cumulative amounts of such funding in its civil works program. At the peak, between 1937 and 1940, the cumulative amount of emergency relief money allotted to the civil works program—mostly rivers and harbors and flood control projects—averaged $518 million. The number of projects receiving this emergency relief funding rose from 97 in 1933 to 291 by 1938. (*See* Appendix C and Appendix D.)

To support its expanded workload during the 1930s, the Corps also had to increase its number of civilian employees. Budget documents show that permanent workers assigned to the civil works program grew from 12,765 in 1928 to a peak of 26,737 in 1940. During the decade, the number of civilian personnel in the civil works program at the headquarters and in the field averaged 14,448. In addition, the workforce employed on Corps projects, either as hired labor under its direct supervision or by contractors, demonstrated the scale of relief employment: between 1933 and 1938, the estimated number of such workers yearly averaged 64,500. The peak year came in 1936, when the Corps' employed 75,000 on its projects. (*See* Appendix E and Appendix F.)

The chief of engineers submitted rivers and harbors projects to the president, some previously approved by Congress and others not. Later, when Congress became concerned about the completion and future maintenance of the new civil works projects under President Roosevelt, it retroactively authorized all previously unauthorized PWA projects. The Rivers and Harbors Act of 1935 approved 127 new projects and retroactively authorized 77 Corps PWA projects then under way. Still, President Roosevelt retained almost total control over the public works program, since he could build projects that had no congressional or Corps sanction as long as the funds came from the 1935 public works appropriation.

Even as Congress worried about the broad discretionary authority over work relief projects that it had ceded to the president, it continued to extend to him large appropriations for such undertakings. In the Emergency Relief Appropriation Act of 1935, Congress earmarked $350 million for rivers and harbors and flood control projects, but the president had the discretion to choose the specific projects. In

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President Roosevelt with Capt. Donald J. Leehy (L) and Lt. Col. Philip B. Fleming (R) of the Corps' Eastport District view a model of the Passamaquoddy Tidal Power Project. 30 July 1936.

setting up the WPA in 1935, President Roosevelt ultimately assigned the Corps large reservoir projects first identified in the 308 reports. This approach continued under the Flood Control Act of 1936 when Congress authorized 270 new projects and appropriated $128.5 million but gave the president discretion about which ones to fund. The 1937 War Department Civil Appropriations Act returned to traditional direct congressional funding of the Corps' civil works program, and thus ended three years during which the president had wielded significant independent control over the Corps' civil works program.

During the 1933–1936 period of presidential dominance, the Corps had been careful to avoid offending Congress. The chief of engineers rarely recommended projects that had not gone through the traditional survey and review process necessary for eventual congressional authorization. Only eighteen of the approved six hundred under way in 1938 had not been traditionally developed, and two of these were not completed by the Corps: the Passamaquoddy Tidal Power Project and the Florida Ship Canal. Congress, aghast at their high costs, ultimately refused to authorize and fund these two projects.

The Corps worked hard at maintaining its close relationship with Congress because that body had such tight control over the Corps' civil works agenda through its committees. Normally, congressional committees not only decided which projects should be funded but also the extent and timing of the appropriations. The committee review process was also a means for congressmen to get the Corps to reconsider reports it had earlier dismissed. This approach proved particularly popular when certain projects were needed for work relief as well as for navigation or flood control. For example, two-thirds of the projects authorized in the 1935 Rivers and Harbors Act had originally received unfavorable reports from the Corps. The Corps, in response to a committee review resolution, subsequently modified these unfavorable reports. This procedure, of course, circumvented both the rest of Congress and the executive branch. The Corps' close cooperation with the Congress, however, served it well when President Roosevelt tried to centralize water resources planning, as Congress blocked all such efforts.

THE RISE OF PRIVATE SECTOR CONSTRUCTION FIRMS

The Corps also took advantage of its expanded public works construction program during the 1930s to improve its relationship with the private construction industry. The private sector construction firms, led by the Associated General Contractors (AGC) organization, had been critical of the Corps during the 1920s because it relied heavily on the use of hired labor (workers employed and paid directly by the Corps) and government equipment in the execution of its rivers and harbors and flood control work. Private construction companies wanted public works accomplished by contract. In the 1920s the Corps was doing as much as 75 percent of its work by government hired labor, and its capital investment in government-owned equipment had reached $50 million. Twenty years earlier, the Corps had only $2.5 million invested in plant. In response to the Corps' construction policy, the AGC actively pushed for a federal public works department to take government construction activities away from the Corps.[14]

The Constructor (the official journal of the AGC) bluntly editorialized: "Is the Corps of Engineers to continue its day labor operations, and adding to the vast amount of equipment at the expense of public monies? Is it to further develop as a

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A specialist contractor taking geophysical soundings for the Fort Peck Dam PWA project. 22 May 1934.

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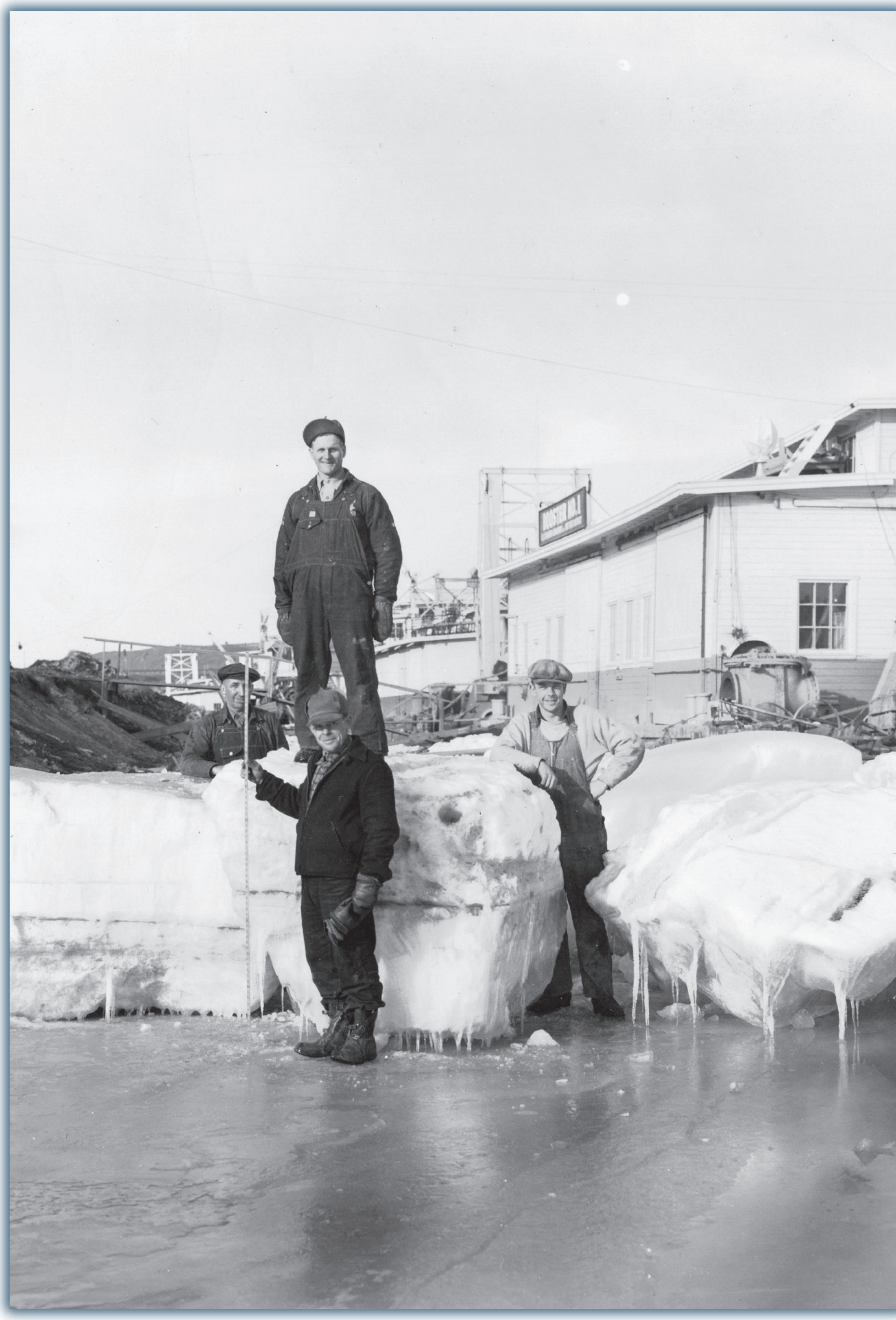
Maj. Gen. Lytle Brown, who served as Chief of Engineers from 1929 to 1933.

bureaucratic construction organization operating in direct competition with citizens of this country?" General Brown, who became chief of engineers in the fall of 1929, immediately responded in a letter to the editor of *The Constructor* that in the future all rivers and harbors work would be done by contract, except where it was "manifestly impracticable or a waste of government funds." General Brown's successors actively followed his policy. General Markham reported in March 1935 that "the percentage of work contracted has increased from 33 percent in 1926 to 62.8 percent in 1934." He assured the construction industry that the Corps would continue contracting its work "as long as reasonable bids are received."[15]

Two years later, in remarks prepared for the AGC annual meeting, General Markham repeated his promise to rely on contracting the Corps' public works construction. He also congratulated the contractors for their "praiseworthy cooperation in carrying out their contracts with the federal government in a sincere effort to meet the requirements of the relief program," even though meeting the technical obligations of relief employment greatly complicated the contracting process. In 1938 the next chief of engineers, Maj. Gen. Julian L. Schley, continued to emphasize amicable relations with the construction industry. He boasted to an AGC convention in February 1938 that "since the establishment of the public works program, the Corps of Engineers has entered into 3,222 construction contracts with 1,149 different contractors. During that period 72 per cent of the *new* work of the department was undertaken by contract and 28 per cent with government plant and hired labor. In 1926 … the percentages were practically reversed." Improved relations with the private sector construction industry helped the Corps in its battle to prevent the establishment of a federal public works department.[16]



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Workmen show off the icy conditions encountered while building the Fort Peck Dam in Montana. 1937.

The Corps and Multipurpose Projects

IN 1933 THE NEW PRESIDENTIAL ADMINISTRATION and Congress drew on the Corps of Engineers' knowledge of and expertise in river improvements as they planned for development projects on such rivers as the Columbia and Missouri. While the Corps' previous efforts in water resources development had focused primarily on navigation improvements in the nation's rivers and harbors, Congress now asked the Corps to expand into multipurpose development—to harness the hydropower, flood control, and water supply capabilities of river drainages.

The concept of multipurpose river basin development by the government was not a new one in the 1930s. It had originated in two aspects of the Progressive Era conservation movement, especially strong between 1900 and 1940. One source of the idea was the progressive belief in the ability to apply technical and scientific solutions to human problems, in this case the wise use of natural resources such as water for irrigation and municipal consumption. The other source was the progressive faith in the government's ability to manage resources for the benefit of all and not to allow their exploitation by private enterprise for the few. Careful planning and development by government experts could ensure the preservation and wise use of the nation's water resources. The Army Corps of Engineers would fill the role of engineering and scientific experts in the multipurpose development of water resources. Also, by the late 1920s Army engineers had begun to overcome many of the technical and cost concerns they had expressed earlier about the feasibility of constructing large dams that would be operated for multiple purposes such as flood control, hydropower, and navigation.[17]

Three projects in particular helped position the Corps to meet the call for New Deal multipurpose water resource projects. These were the Wilson Dam, the comprehensive surveys of the Tennessee River, and, especially, the 308 reports. The reports contained the Corps' recommendations for projects best able to harness the nation's water resources in the combined interests of navigation, hydropower, flood control, and irrigation. Two major projects growing out of the 308 reports—the Bonneville

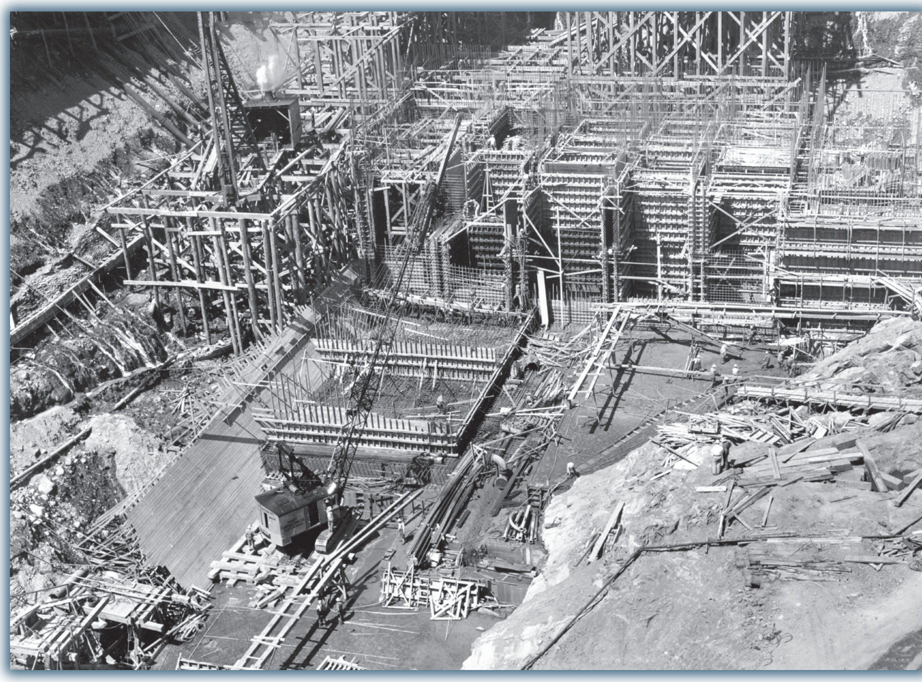
Dam and the Fort Peck Dam—exemplify how the Corps helped launch the New Deal multipurpose program and provided much needed work relief for the unemployed.

Although in the early days of the New Deal fierce competition arose over the initial funds available for emergency work relief through water resources projects, both dam projects moved forward. Giving in to politically astute lobbying by Oregon politicians, President Roosevelt agreed to allocate the necessary funds in September 1933 to begin construction of Bonneville Dam. By November of that year the Corps had work under way at the dam site on the Columbia River. In a like manner, the PWA assigned funds for the Fort Peck Dam on the Missouri River in October 1933. Within two weeks the Corps had five hundred men at work on that project.

TECHNOLOGICAL ADVANCES

One technological advance essential to the construction of these multipurpose water control structures such as dams, locks and canals, and jetties involved the successful use of concrete as a building material. Although invented by the Romans and long used for a variety of structural purposes, the modern development and application of concrete evolved in the late nineteenth century. Following European experiments in the early 1800s with the various ingredients necessary to making concrete, American builders carried out further investigations and began the systematic application of concrete to all sorts of structures in the last half of the century. The most important innovation came from adding iron or steel reinforcement to concrete. Reinforced concrete, unlike regular concrete, could resist tension and thus became a product useful for columns, beams, and floor slabs, as well as for walls and footings such as might be used in dams. The reinforcement of concrete was a key advance in construction technology because concrete by itself can only work in compression and will fail if used in applications subject to high bending forces, such as beams and floor slabs. Engineers found that by adding iron or steel bars to the concrete, the elastic metal will take the tensile and shearing stresses, while the rigid concrete will resist the compressive forces. In its reinforced form, concrete becomes one of the most adaptable of all building materials. Improvements in reinforced concrete design continued in the twentieth century and provided dam builders with an alternative to earth-fill embankment or masonry structures.[18]

Several other technological factors also enabled the Corps—and the other federal dam builder, the Bureau of Reclamation—to undertake multipurpose projects in the 1930s. In the early twentieth century, advances in the technology of concrete



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Use of concrete in the foundation of the extension to the powerhouse at Bonneville Dam. 11 July 1941.

dam design made it possible to construct large-scale concrete dams necessary for the manipulation of large rivers. Initially two engineering approaches to concrete dam design competed for acceptance: one, the massive (or gravity) tradition, relied on a dam's weight to hold it in place; while the other, the structural tradition, depended on a dam's shape for safety. Massive dams simply used the force of gravity acting on the mass of material used to construct the structure to resist the horizontal pressure of the stored water. A structural dam, on the other hand, employed its shape, such as an arch or buttress element, coupled with the strength of concrete to resist hydrostatic pressure. Proponents of structural dams argued that they were less costly than massive ones because they could be built with less bulk. If designed and built properly, either design would work. During the first third of the twentieth century, American engineers refined the theory and practice behind both types of dams and constructed examples of each. American dam builders based their design decisions on site conditions, available construction materials and labor, financial constraints, and the professional preference of the designer.[19]

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Construction of the Winfield Dam on the Kanawha River, showing the completed portion, a cofferdam, and the lock. 17 November 1936.

Innovations in the design of cofferdams in the early twentieth century also played a key role in constructing large-scale dams and other in-water structures. Engineers began replacing the traditional timber crib or sheet-pile-founded cofferdams used in building navigation projects in the nineteenth century with interlocking steel sheet pile cofferdams. Steel structures had a great advantage in that they could be built taller than wooden ones and thus allow work in greater water depths. Economical steel sheet piles became available by 1910 when steel companies developed the means to fabricate sheet piling with interlocks rolled into the beam during manufacturing, rather than having the attachment occur afterwards by riveting. By the 1930s the Corps' use of steel sheet pile cofferdams in river improvements on the Ohio, Kanawha, and Allegheny rivers led to further innovations. Instead of merely substituting steel sheet piling for wooden piling in conventional box cofferdams, the engineers also started using circular cell and diaphragm cell steel sheet pile cofferdams.[20]

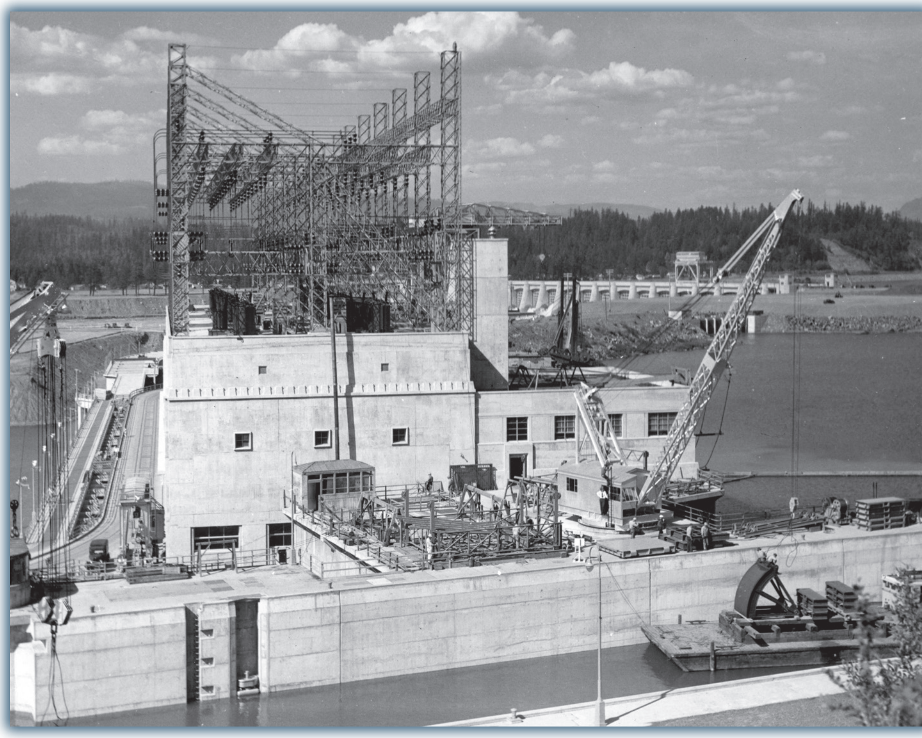
The development and application of electricity, the internal combustion engine, and giant steam shovels in the late nineteenth and early twentieth centuries also enhanced the engineer's ability to economically accomplish large-scale multipurpose water projects. Moreover, being able to generate electrical power from water stored behind dams provided a means to finance other water projects and another way to power equipment needed in constructing the dams themselves. Federal agencies even shared heavy equipment. After the Panama Canal Commission completed the canal, it transferred some of the heavy machinery, such as steam shovels, to the Bureau of Reclamation for use in its dam and irrigation projects.

The massive multipurpose dams on major rivers such as the Columbia and Missouri challenged the Corps' traditional approach to controlling river flow. The need here was not so much for additional new technologies as it was for refinement of existing methods. As water resources historian Martin Reuss has written, "The emphasis is on the effective application of existing technologies; the innovation usually is in the details. In the last two and a half centuries engineers have applied mathematical rationalization to structural design, allowing each unique design to respond to the particular combination of variables affecting flow in a given stretch of river over time." In the case of both the Columbia and Missouri rivers, complex geology, climatic extremes, and wide seasonal variations in stream flow complicated site selection, structural design, and construction of the dams.[21]

BONNEVILLE DAM

The Corps' extensive 308 report (1,845 pages) on the Columbia River laid out a plan to use ten dams to capture the potential energy from the river's hydraulic drop of 309 feet over the course of its 1,210-mile journey from its Canadian origins to its American outlet on the Pacific Ocean.[22] The Corps' Portland and Seattle districts had spent over two years conducting extensive fieldwork that involved foundation investigations, stream flow studies, topographic and hydrographic surveys, and reconnaissance of irrigable and flood-prone areas. The Corps also sought technical information from other federal resource agencies and held specialized private consultations while creating its comprehensive plan for development of the Columbia River basin. In March 1932 the Corps' Board of Engineers for Rivers and Harbors and the chief of engineers approved the report but took a conservative stance on funding the proposed plan. They recommended that the federal government pay for the navigation improvements but that the hydropower aspects be provided by private interests. However, the election of Franklin Roosevelt as president resulted in the government taking a more accommodating stance on federal funding for all elements contained in the Columbia River 308 report.[23]

Building the Bonneville Dam in the Columbia River gorge presented the Corps with many novel design and construction challenges. Because of the need to move quickly, the engineers followed conservative precedent and adhered to the massive tradition, embracing a gravity overflow design for Bonneville. One specific



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The Bonneville Dam, a PWA project on the Columbia River, includes a powerhouse and lock (foreground) and a spillway dam (background). 24 May 1938.

consideration was that the spillway dam had to be located in a narrow channel that experienced wide fluctuations in stream flow. Another was that the structure had to rest on comparatively weak foundation rock and be able to pass a large flood without causing a major rise in headwater elevations. To help solve these and other design problems, the Corps built a hydraulics laboratory in Portland to model the river and to test different spillway solutions. When completed the concrete spillway dam spanned 1,450 feet in length and held eighteen, 50-foot-wide steel gates. Twelve of the gates reached 50 feet in height and six were 60 feet tall. At its base the dam measured 132 feet in width, and it reached a height of 197 feet above its lowest point in bedrock. The wide base kept stresses low on the foundation; for extra security against sliding, the engineers had deep notches excavated into the foundation rock. To help the spillway pass large stream flows without raising flood elevations, the Corps widened the river by excavating almost one million cubic yards of material from the riverbanks. As designed, Bonneville Dam's spillway had a capacity of 1.6 million cubic feet per second, significantly larger than any existing dam in the United States.

Finally, the dam designers had to protect the downstream base of the structure from scour and erosion caused by the high energy of the water passing through the spillways. They overcame this problem by placing a 100-foot concrete apron with baffles at the downstream face of the dam, which decreased the velocity and dissipated the energy of the flowing water.

The design of the reinforced concrete powerhouse and its associated equipment presented its own unique problems. Separated from the spillway by Bradford Island, the powerhouse had to handle large quantities of water at comparatively low head (the difference between the water elevation upstream of the dam and downstream of the dam). The Corps, once again, carried out extensive model studies at its hydraulics laboratory to guide the design effort. Ultimately the engineers came up with a powerhouse design that required large intakes, concrete scroll cases, and deep-draft tubes. The structure itself extended 1,027 in length and 190 feet in both width and height above bedrock. The plans called for the installation of two generators with room for four additional units (which were, in fact, later installed). During World War II the powerhouse was expanded to accommodate four more generators, for a total of ten.

The electrical engineers equipped each generator with the Kaplan adjustable-blade propeller type of turbine, one of the earliest uses of this type of turbine in the United States. Engineers selected the Kaplan turbine because of space constraints at Bonneville and the wide seasonal variation of head at the powerhouse. The Kaplan turbine required less space per horsepower than other types of turbines and achieved maximum efficiency under a wide range of load and head. Each turbine unit weighed nine hundred tons, had a main shaft diameter of forty inches, and possessed a discharge capacity of thirteen thousand cubic feet of water per second. At the time of the dam's completion in 1937, its Kaplan turbines were the largest in the world and represented a major advance for hydroelectric power plants, as they had never been tried on such a scale before installation at Bonneville.[24]

Electrical engineers worked under difficult circumstances, with the design and construction of the powerhouse structure occurring before the actual electrical load and means of achieving it had been established. To have complete confidence that its power plant design and choice of turbines reflected the best available solutions, the Corps sought the advice of top consultants in the field of waterpower work. Construction pushed along at a frantic pace, with one frustrated electrical engineer exclaiming that "the only objective apparently [was] the dumping of yards

Office of History, Civil Works Image Collection

Construction of the enormous navigation lock and hydroelectric powerhouse at Bonneville Dam. 15 October 1936.

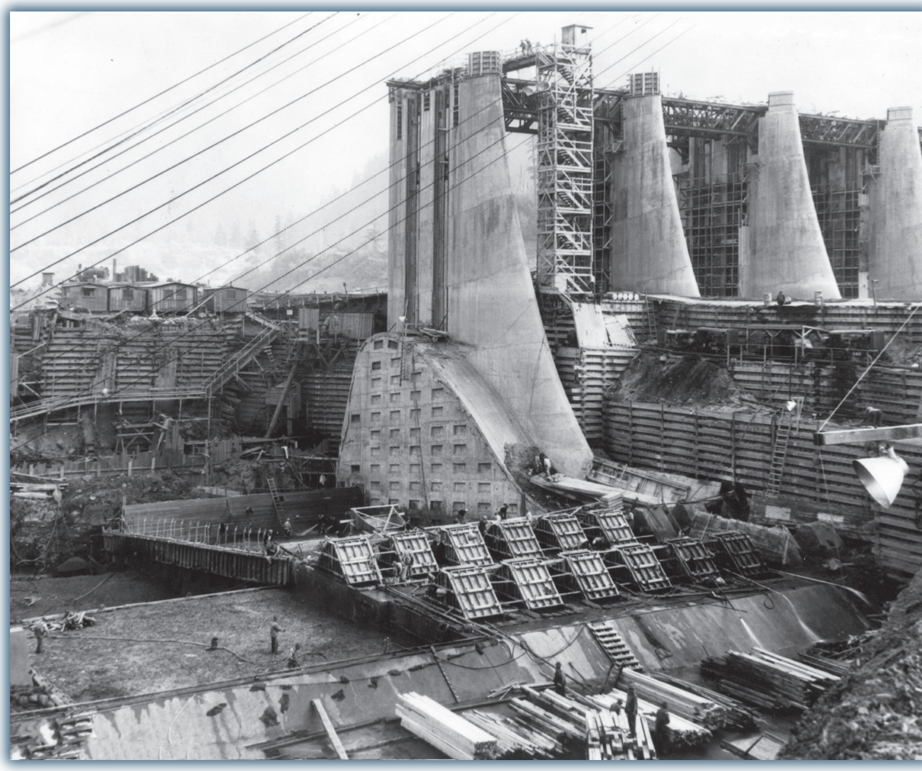
of concrete and placing of tons of steel. Structural design in the office was but a jump ahead of actual construction in the field."[25]

Political considerations led to several changes in the navigation lock plans as work got under way on the structure. A key component of the original justification for the Bonneville Dam was the Corps' proposal of a tandem lock sufficient for existing barge traffic. Under considerable pressure from Oregon politicians, however, the Corps ultimately opted for a single-lift lock that was seventy-six feet wide, five hundred feet long, and twenty-four feet over the sill at low water and capable of handling ocean-going ships. With a vertical lift of sixty feet, the Bonneville lock was the highest single-lift lock built up to that time. An unusual feature of the navigation lock was the use of six floating mooring bits in the lock walls. At the request of Assistant Chief of Engineers Brig. Gen. John Kingman, Lt. Hugh Casey designed the floating fixtures that enabled small craft to overcome difficult and dangerous moorings at low stages of the river. The navigation locks sat between the powerhouse and the Oregon shore.[26]

The actual construction of the spillway dam experienced severe problems. The depth of the water, current velocity, and harsh weather conditions, together with the annual summer flood, presented challenging conditions. The working season was limited to an eight-month period from August to March. After conducting extensive hydraulic studies, the engineers adopted a plan that called for massive timber cofferdams as the best means to divert the river from the work site. The engineers determined that reinforced concrete caissons and steel sheet pile cells would be too expensive, would be difficult to place in the fast-flowing river, and would offer no advantage in strength over timber cribs. According to the plan, the contractors would divide the river in half, dewatering each half successively. After partially constructing the south spillway during the 1935–1936 low-water work season, the workers removed the cofferdam. The river then flowed between the piers over the uncompleted crest sections while another cofferdam was put in place for work on the north section. Workers placed a prefabricated structural steel cofferdam over the crest section between the piers of the uncompleted south portion so that those units could be brought to final elevation.

The crib cofferdam method of construction required "tailoring" the crib bottoms to fit the irregularities of the riverbed. This effort required dredging the thin overburden and careful sounding and mapping of the river bottom. The job of designing, building, and placing these huge structures—each as large as a six-story apartment building—in the nine-hundred-foot-wide river channel with a depth of twenty to fifty feet of water flowing from six to nine feet per second severely tested the capabilities of the engineers and contractors. At the time, it was the largest cofferdam job attempted on a United States river, and it attracted keen interest from the engineering community.

The Bonneville Dam project required placing about one million cubic yards of special-quality concrete. The engineers had to find the best way to lessen the excessive heat caused by the chemical reaction between cement and water, which could cause serious cracking as the concrete set. Such cracking could weaken the structural stability of the dam. After extensive testing of various products, the Corps chose to use Portland-pozzolan cement. In addition to its greater tensile and compressive strength and desired heat of hydration characteristics, it continued to gain strength over time and possessed greater resistance to weathering and rough water action than other cements. At the time of its selection for Bonneville Dam, Portland-pozzolan cement had been little used in mass-concrete construction in the United States. Many hydraulic structures in Europe, however, had used it with



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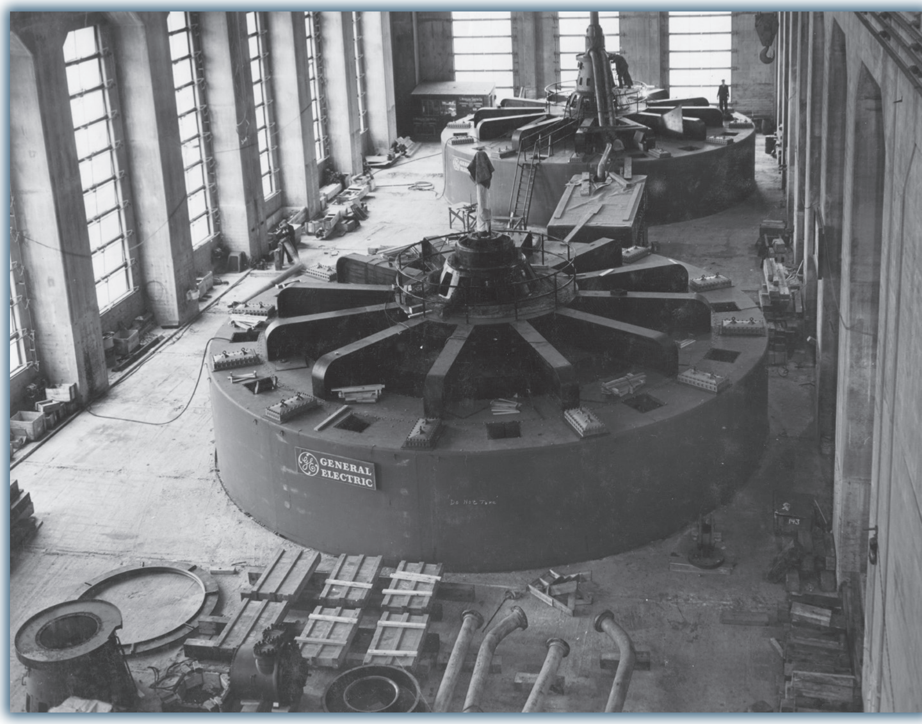
Spillway piers of Bonneville Dam under construction within wooden cofferdams. 24 October 1936.

satisfactory results. Because of limited experience with Portland-pozzolan cement, the Corps developed rigid specifications and implemented a stringent testing program to assure consistently high-quality cement.

As work progressed on Bonneville Dam, the Corps became embroiled in the question of who would administer the facility and market the power it produced once completed. A related controversy swirled around the price to charge for the power. Col. Thomas Robins, North Pacific Division Engineer, opposed a uniform rate for the sale of Bonneville power, arguing that it would drive up the average cost of power and thus discourage industry from locating in the region. This view appealed to the business interests in the Portland area, but people elsewhere in the region argued instead for a blanket or uniform rate, regardless of the distance from the dam. The latter group wanted the power distributed for maximum regional benefits.



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The main room of Bonneville's hydroelectric powerhouse with two large generators installed. 27 November 1937.

After much political debate within both the Roosevelt administration and the Congress, President Roosevelt signed the Bonneville Power Act in August 1937. This measure settled the question of marketing federal power in the Pacific Northwest by assigning the Corps the responsibility for generating the power but rejecting the proposals simply to sell the power at the dam site to those able to come and get it. Instead, the legislation created a federal marketing agency, the Bonneville Power Administration, to sell power in accordance with the policy of "widest possible use of available electric energy that can be generated and marketed." The law gave preference to publicly and cooperatively owned distribution systems, and the new agency adopted a policy of a blanket rate along the entire transmission system. The rates, moreover, were set to enable the government to recover the cost of producing and transmitting the power. In later years, the Bonneville Power Administration's authority to market power expanded to include thirty-two additional federal projects constructed in the northwest.[27]

The labor employed on the Bonneville Dam project came chiefly from the relief rolls in Oregon and Washington. The Corps apportioned the work force between the two states based on the estimated percentage of project funding spent in each state. This formula allowed one Washington worker for every five Oregon laborers hired. The Corps also built some temporary and permanent housing and administration buildings for the project. At its peak of activity, the project employed over three thousand workers, some hired by private contractors. President Roosevelt dedicated Bonneville Dam in September 1938. Construction by then had cost over $40 million.

Two historians of civil engineering, Abbie Liel and David Billington, have succinctly captured what the Corps accomplished on the Columbia River:

> With Bonneville Dam, the U.S. Army Corps of Engineers for the first time brought together several engineering branches, each with its own technological characteristics, to create a concrete multipurpose dam that successfully challenged standard practice in its leading engineering features. As a full-scale laboratory for new technologies, it served as an exemplar for future works.[28]

The Corps' planning, design, and construction of Bonneville Dam demonstrated the agency's ability to solve the many complex engineering problems involved in building a huge multipurpose concrete dam. The Corps, while relying on its in-house engineering staff to lead the entire process, also drew on nationally prominent outside consultants and fresh engineering studies to inform its decisions regarding spillway design, turbine selection, and use of appropriate cement. The Corps' civil engineers and administrators then had to integrate these technological innovations into a coherent construction schedule and complete the building process on a tight timeline and budget.

FORT PECK DAM

The massive, earth-fill Fort Peck Dam, built 1,870 miles upstream of the mouth of the Missouri River, also owed its existence to the Corps' 308 studies and was begun under presidential order with funding by the PWA as a relief measure. With an estimated cost of over $84 million, it was the largest single project authorized under the provisions of the National Industrial Recovery Act. Congress formally adopted the Fort Peck Dam project in the 1935 Rivers and Harbors Act. The dam's primary purpose was to provide flows to maintain a navigation channel of six feet in the

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To transport the material needed to form the core of Fort Peck Dam, builders pump a watery sand-and-clay mixture through pipes to the dam site. ca. 1935-1937.

Missouri River for 795 miles below Sioux City, Iowa. The Corps did note at the time of construction that the dam would also provide incidental flood control benefits and could be adapted in the future for hydropower and irrigation benefits. When completed, the dam would provide storage for 19.4 million acre-feet of water.[29]

The Corps initially expressed great ambivalence about the need for the Fort Peck Dam. While Chief of Engineers Maj. Gen. Lytle Brown strongly endorsed the project, the Missouri River Division commander and the Board of Engineers opposed it, arguing that Fort Peck Dam would not provide sufficient economic benefits to justify its construction, either for navigation or any other purpose. During the dark days of 1933, however, the Roosevelt administration saw the project as a quick way to put thousands of unemployed laborers to work in one of the most depressed regions of the country. In addition, Montana Democratic Senator Burton K. Wheeler, a close friend of President Roosevelt, was up for reelection in 1934, and the president wanted to help him.

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Men working on one of the four pump barges built on site at Fort Peck for use in hydraulicking. 1937.

When the Corps began designing Fort Peck Dam, the study of soil mechanics was underdeveloped, and the elements of earthen dam safety as they related to the dangers of seepage and sliding were not well understood. Initially, though, the factors of time and cost weighed most heavily on the Corps as they undertook the project. Facing the high expense involved in transporting the copious quantities of fill material necessary to build an earthen dam, the Corps chose the least expensive method of transport available: hydraulicking. Workers used pressurized water to create a muddy slurry of water and earth, which they then pumped through pipes to the construction site.

The adopted design for Fort Peck Dam provided for an earth-fill structure constructed by the hydraulic fill method and using materials from the riverbed and surrounding valley. Essentially the dam consisted of two porous sand and gravel shells that held a dense, relatively impervious core of silt, fine sand, and clay. When completed, the main structure would have a height of 242 feet above the river bed, a width at the base of nearly 3,000 feet, and a length of 9,000 feet. The spur forming the left abutment added an additional 11,000 feet to the dam. The crest of the dam stretched 100 feet across. In all, the structure would require nearly 126 million cubic yards of earth to complete. The plan also called for covering the upstream

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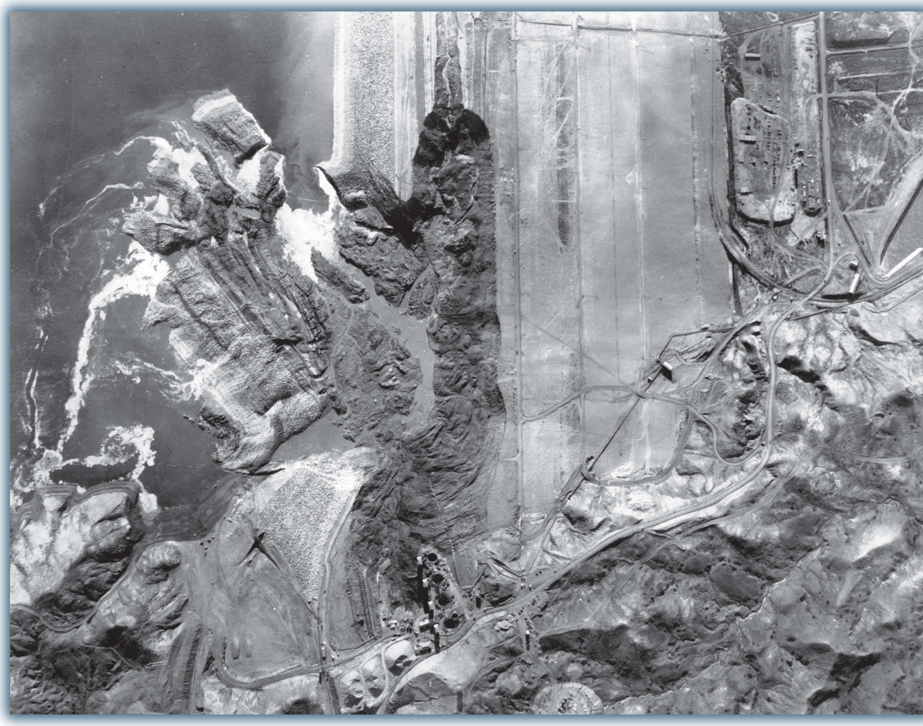
A temporary Corps-built town with modern facilities and amenities serves the needs of eight thousand workers at the remote Fort Peck site. 1936.

and downstream faces of the dam with heavy riprap (consisting of 5.6 million cubic yards of rock and gravel) and placing a steel sheet pile cut-off diaphragm, extending from twenty feet above the base down to bedrock, to reduce percolation through the alluvium under the base of the dam. Because of the extreme length of the piling, engineers had to develop special jetting equipment to penetrate the bedrock.

Actual construction occurred in many steps. To move the materials used in building the dam from the barrow pits above and below the dam site, the Corps used four floating dredging units, which the Corps built at the site. The sides of the dam were constructed first, allowing the natural river channel to operate. After the sides of the dam reached an elevation above maximum flood heights, the workers diverted the river through tunnels by means of a cofferdam and closed the central gap in the dam. They then brought the entire dam to its maximum height.

The project featured several other elements in addition to the earth-fill dam. For the release of stored water from the dam, the design incorporated four concrete tunnels of roughly 26-foot diameter and an average length of 6,160 feet. To pass extreme flood flows, the plan called for a spillway located in the shale bluffs some three miles from the right abutment of the dam. The spillway contained sixteen 25-by-40-foot Stoney gates, and the spillway channel extended for approximately two miles, one mile of which was lined with concrete. Construction of the spillway required the contractors to excavate thirteen million cubic yards of material.

In building Fort Peck Dam, the Corps, as it also did in the case of Bonneville Dam, largely relied on competitively bid contracts. In both projects, however, the



Office of History, Civil Works Image Collection

An aerial view of Fort Peck Dam shows the slide that occurred on 22 September 1938.

Corps used its own employees, or employed hired labor using government equipment, to do some of the specialized work, to carry out the testing of materials, and to inspect all of the completed work. In the case of the Fort Peck project, moreover, the isolated location required major work to extend railroad, highway, and utility lines to the work site. The construction of a 12.2-mile-long railroad line to the dam site from the mainline connection at Wiota, Montana, was a critical first step because it was the chief means of moving equipment and material to the dam site. The Corps later extended the rail line six miles to serve the spillway construction site. The rail line carried over ten million tons of material during the construction period. The Corps also had to construct a temporary town with modern facilities and amenities for up to eight thousand workers. In contrast, the Bonneville Dam location sat next to major rail lines and highways and was within reasonable commuting distance from adequate housing in nearby towns and cities, thereby lessening the Corps' need to provide extensive living facilities for the dam's workforce.

Because of the unique geology and severe climatic conditions of each work site, the Bonneville and Fort Peck dams each had their unusual and challenging

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Construction of Fort Peck's concrete spillway about three miles from the main dam. 11 September 1936.

construction problems. For example, building the four outlet tunnels at Fort Peck Dam required special construction methods. To cope with the weak and unstable bedrock in that section of the Missouri River, all newly exposed surfaces had to be sealed immediately upon exposure and constant high humidity maintained underground. In addition, the severe winter weather necessitated protecting the freshly poured concrete with steam-heated shelters of wood and canvas. Then the Corps decided to speed up tunnel construction because the hydraulic-fill embankment operation was ahead of schedule and the diversion tunnels had to be ready to take the entire river flow. The contractor building the Fort Peck tunnels proved unable to meet the new schedules or carry out complex design changes in the tunnel lining in a timely manner, so the government took over the work and completed the job with hired labor. During July 1936 over thirty-five hundred men worked above and below ground on the tunnels.

While construction of Bonneville Dam proceeded without any major mishaps, work at the Fort Peck Dam came to an abrupt halt on September 22, 1938, when a section of the upstream face of the dam, containing 5.2 million cubic yards of fill, slid into the reservoir. Eight men died and a large amount of equipment was temporarily lost. The earth movement did not block the tunnel inlets, so normal discharge continued without endangering the dam. After recovering the disabled equipment and the accessible bodies of two dead workers, the Corps immediately began testing to determine the cause of the failure. The Corps also salvaged the quarry and fieldstone used to face the dam and placed a protective ring dike on the upstream side of the slide. The tests revealed that the foundation rock in the vicinity of the slide was "insufficient to withstand the shearing force to which the foundation was subjected." The investigators theorized that the slide "may have been due … to a partial liquefaction of the material in the slide." In short, the hydraulic fill method of construction created an embankment composed of very loosely compacted wet sand which "liquefied." This saturated sand layer gave way because of a weak foundation, relatively steep upstream slope, the high speed of construction, and the redirection of the river (which undermined the area beyond the toe of the embankment).[30]

Reconstruction of the damaged section of the dam required using a different type of core material (glacial-till) and placing it by rolled-fill rather than hydraulic methods. To secure a bond between the original core and the reconstructed core, the workers drove a steel sheet pile cutoff wall through the overlaying material into the undisturbed core material for a distance of at least twenty feet. Concurrent with the rebuilding effort, the Corps continued using the hydraulic-fill method to complete the rest of the structure. In completing the final twenty-five feet of the dam crest, however, the Corps used the rolled-fill method. The revised plans also increased the dam section by flattening the slope. The slide had also deposited a large amount of material in front of the tunnel intakes, which necessitated changes to the intake structure to avoid restricting water inflows. The Corps completed the remainder of the work on the dam without incident in 1940. The experience gained in constructing Fort Peck Dam led the Corps to build all of its subsequent earth-fill dams with the roller-compacted method and a flatter upstream slope.

EXPERIMENTATION AND COOPERATION

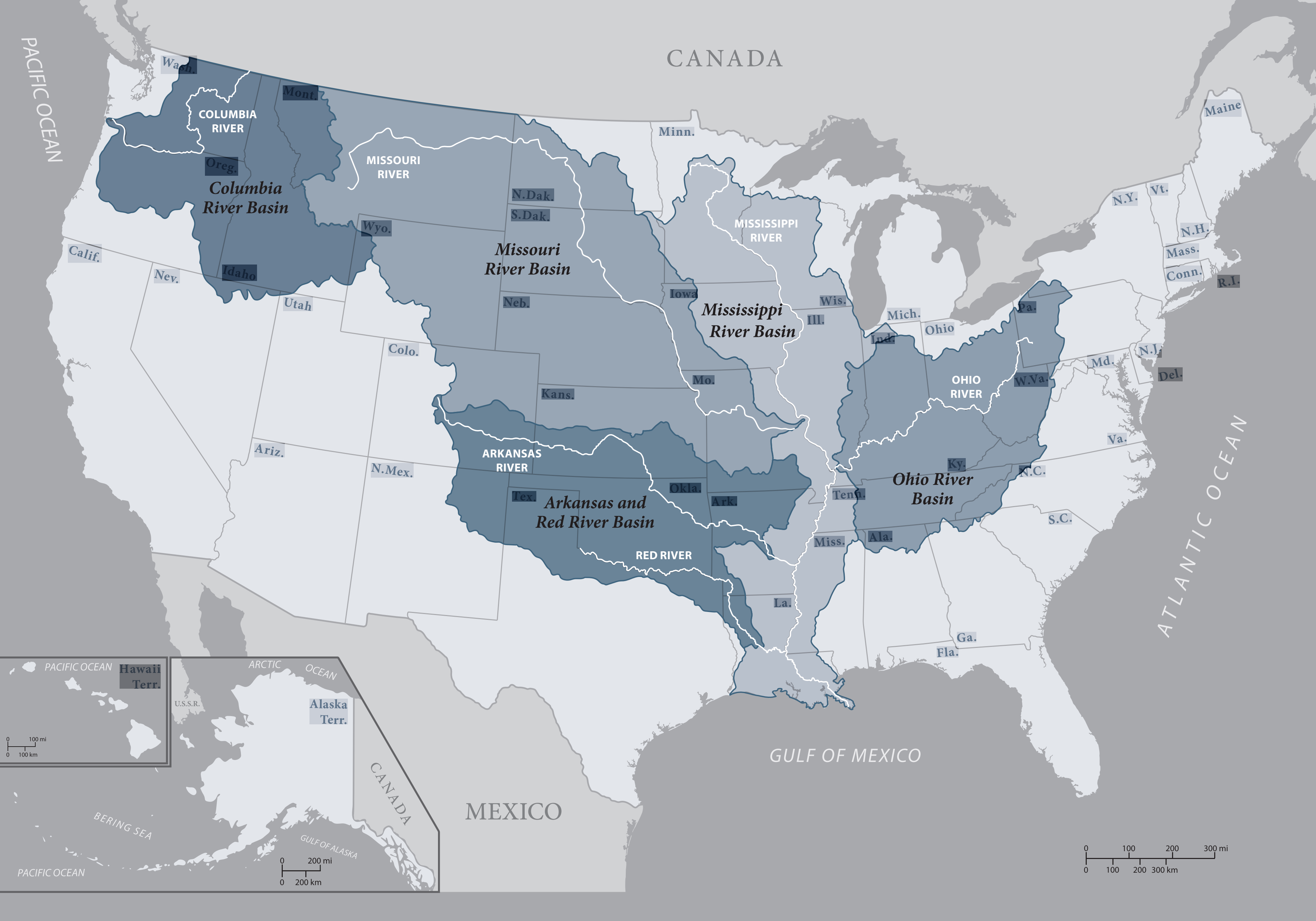
Because of its long tradition of empirical hydraulic research, the Corps was slow to employ laboratory research using river models to investigate river and harbor problems. Although nineteenth-century army engineers often applied scientific knowledge to the practical problems of improving rivers and harbors for navigation, they generally preferred to verify their methods by precise and repetitive empirical measurements. Engineers found in practice that theoretical fluid mechanics did

Waterways Experiment Station

Some of the river models at the Waterways Experiment Station. 1940.

not always adequately explain the many complex forces influencing river dynamics. Whether building wing dams or levees, removing rocky obstructions in a riverbed, or developing gauges to read current velocities, army engineers generally relied on empirical techniques of observation, data collection, and trial-and-error practice for their projects. Still, the Corps paid attention to early twentieth-century European advances in theoretical mechanics and the development of laboratories for studying river hydraulics. It also hired outside experts when appropriate and built models to resolve design issues related to structures such as locks and dams.[31]

Because so many of the projects called for in the 308 reports and flood control examinations included earth-fill dams and earthen levees, the Corps established laboratories to determine the best types of soils to build such structures. The Zanesville District set up a soils laboratory in 1934, and its success led to the creation of such laboratories in other Corps divisions. As noted above, in the initial planning and design for the Bonneville Dam spillway, the Portland District established a hydraulics laboratory and constructed a scale model of the three spillway gates and of the



CANADA
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
MEXICO
COLUMBIA RIVER
Columbia River Basin
MISSOURI RIVER
Missouri River Basin
MISSISSIPPI RIVER
Mississippi River Basin
OHIO RIVER
Ohio River Basin
ARKANSAS RIVER
RED RIVER
Arkansas and Red River Basin
Wash.
Mont.
Oreg.
Idaho
Wyo.
Calif.
Nev.
Utah
Colo.
Ariz.
N.Mex.
N.Dak.
S.Dak.
Neb.
Kans.
Okla.
Tex.
Minn.
Iowa
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La.
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Ohio
Ky.
Tenn.
Miss.
Ala.
Ga.
Fla.
S.C.
N.C.
Va.
W.Va.
Md.
Del.
N.J.
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PACIFIC OCEAN
Hawaii Terr.
0 100 mi
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ARCTIC OCEAN
U.S.S.R.
Alaska Terr.
CANADA
BERING SEA
GULF OF ALASKA
PACIFIC OCEAN
0 200 mi
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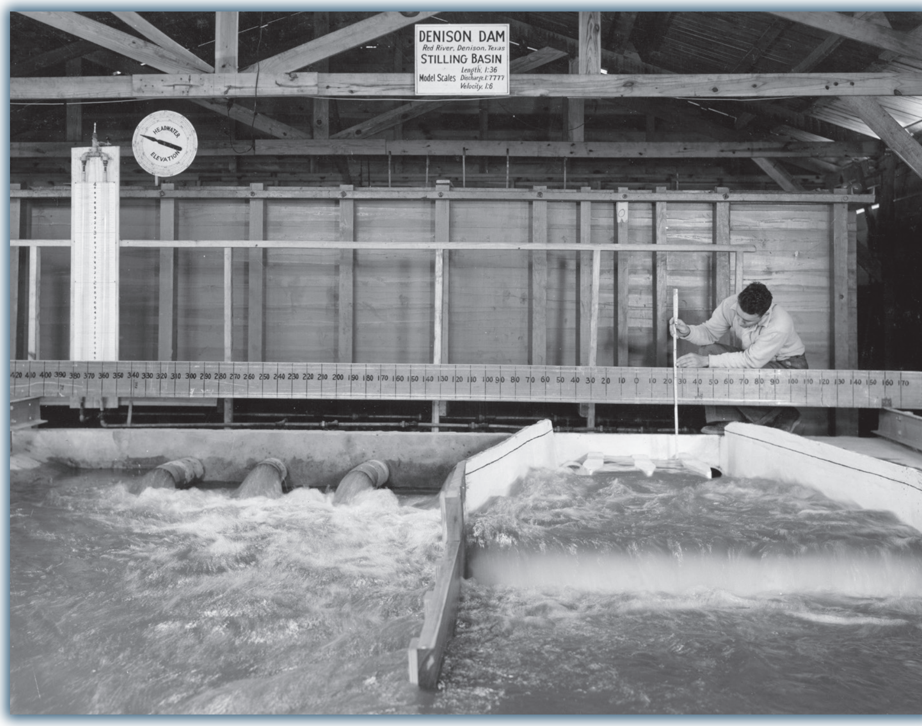
0 100 200 300 km

Columbia River for several miles upstream from the dam site. The studies sought to find a way to prevent erosion below the dam and to limit flowage damage above. The North Pacific Division eventually moved the Portland hydraulics laboratory to the grounds of the Bonneville Dam project. At this location, they built an extensive scale model of the Columbia River, which they used in designing elements of all the 308 report dams later constructed on the Columbia and Snake river system.[32]

Under pressure from outside critics, the Corps established the Waterways Experiment Station (WES) at Vicksburg, Mississippi, in 1929 as part of its response to renewed flood control efforts following the disastrous flood that devastated the lower Mississippi valley in 1927. What distinguished WES from other hydraulics laboratories was its emphasis on river mechanics rather than simply tests on hydraulic structures such as dams, spillways, and locks. During the 1930s, research at WES advanced both theory and practical application in river control. By 1936 WES had 164 tests completed or in progress; and these tests had greatly clarified how water moved through river bends on large rivers and better explained the nature of bed-load material movements. WES also developed some models to test spillways, power tunnels, and other physical structures related to dams then under construction. Much of the early hydraulic research at WES focused on the need for studies supporting New Deal public works.[33]

The Corps' multipurpose undertakings during the 1930s increasingly brought it into fields nominally the responsibility of other federal agencies. This situation could have led to misunderstandings or turf wars with the other agencies. While relations between the Corps and the Bureau of Reclamation or the Federal Power Commission sometimes became testy, for the most part the Corps and the other federal agencies got along well enough. For example, in producing the 308 reports, the Corps relied on assistance and data from a number of federal agencies, including the Bureau of Reclamation, the U.S. Geologic Survey, the Department of Agriculture, and the Federal Power Commission. In the Pacific Northwest, the Corps districts involved in drafting the 308 report on the Columbia River and its tributaries made every effort to assure the Bureau of Reclamation that the Corps was not out to take over irrigation responsibilities in the region and developed a good working relationship at the field level between the two agencies. Still, as the Corps built navigation and flood control projects that included an irrigation component (e.g., Fort Peck, Conchas, and Caddoa dams), the potential for conflict existed and occasionally flared up. In the

Opposite: The river basins of only six rivers cover about half of the contiguous United States.



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A study of the stilling basin and control structures for Denison Dam using small-scale models at the Waterways Experiment Station. October 1939.

late 1930s, for example, the Corps and the Bureau of Reclamation presented differing approaches to water resources development in the Missouri River basin.[34]

When potential conflicts arose, the Roosevelt administration tried to ensure coordination among the Corps, the Department of Agriculture, and the Bureau of Reclamation. This effort ultimately led to a 1939 tripartite agreement that obligated the three agencies to exchange information and consult with one another in preparing reports. While it did not eliminate the major disagreements among the agencies, it did lead to increased cooperation. In 1938 Congress attempted to foster greater coordination in hydropower development by ordering the Corps to consult with the Federal Power Commission on waterpower facilities in flood control dams.[35]

In August 1939 the press asked President Roosevelt at a news conference about conflicts between the Corps and the Bureau of Reclamation in the West. The president responded that he thought it was a good idea to have two construction agencies balanced against each other so “that there would be what might be called a healthy rivalry between the two big government construction agencies instead of having the whole thing done by one." Roosevelt went on to say that his "rule of thumb" was that the Corps would do all the harbor, navigation, Mississippi, and flood control work. The Bureau of Reclamation, on the other hand, would have responsibility for dams "on the upper reaches of a river, especially where navigation did not enter into it … and [where it] has irrigation possibilities…. The system as worked out now will mean no crossing of wires." In 1940 Brig. Gen. Thomas Robins, Assistant Chief of Engineers, while describing the Corps' functions noted: "At present full consideration of this feature of water utilization [i.e., irrigation] is effected through a close liaison and co-operation with the Bureau of Reclamation both in the field and in Washington."[36]

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Dredging in the Cape Cod Canal near Sagamore, Massachusetts. 22 July 1937.

Traditional Corps Projects During the New Deal

DURING THE 1930s the Corps also continued work on its traditional single-purpose civil works projects, which chiefly involved navigation improvements for rivers and harbors and limited flood control work on the Mississippi and Sacramento rivers. For example, the 1930 rivers and harbors bill provided for several enhancements to existing navigation projects on the Great Lakes and upper Mississippi River. The act authorized the Corps to deepen sections of the Great Lakes connecting channels for twenty-four-foot navigation and approved the nine-foot channel project on the upper Mississippi River. The act also extended federal control over the entire length of the Illinois Waterway from Lake Michigan to the Mississippi River.

Under President Roosevelt, the Corps used PWA funds to complete the deepening of the Great Lakes connecting channels and to maintain Great Lakes harbors. Depression-era emergency funds also enabled the Corps to deepen the major harbors to the same depths as the connecting channels where necessary. The Corps achieved the depth of twenty-four feet by 1936. In all, the Corps was responsible for maintaining 102 harbors and connecting channels as well as several major canals and locks in the Great Lakes waterway system. The Corps completed much of the work for the nine-foot channel of the Illinois Waterway and the companion Calumet-Sag Channel by 1941, which connected the Great Lakes with the Mississippi River. In total, the Great Lakes water transportation system handled 10 percent of the commercial traffic of the United States. Of the goods shipped, approximately 90 percent were composed of bulk commodities such as iron ore, coal, and grain.[37]

Also during the 1930s the Corps continued its work to complete and upgrade the canalization of the Ohio River and its major tributaries. Congress had authorized a nine-foot navigation channel for the Ohio River in 1910; by 1929 the Corps had completed the subsequently modified plan for forty-nine locks and movable dams. Advances in barge design and the increasing size of tows required larger locks and upgraded dams. Gradually the Corps replaced the original movable dams with fixed

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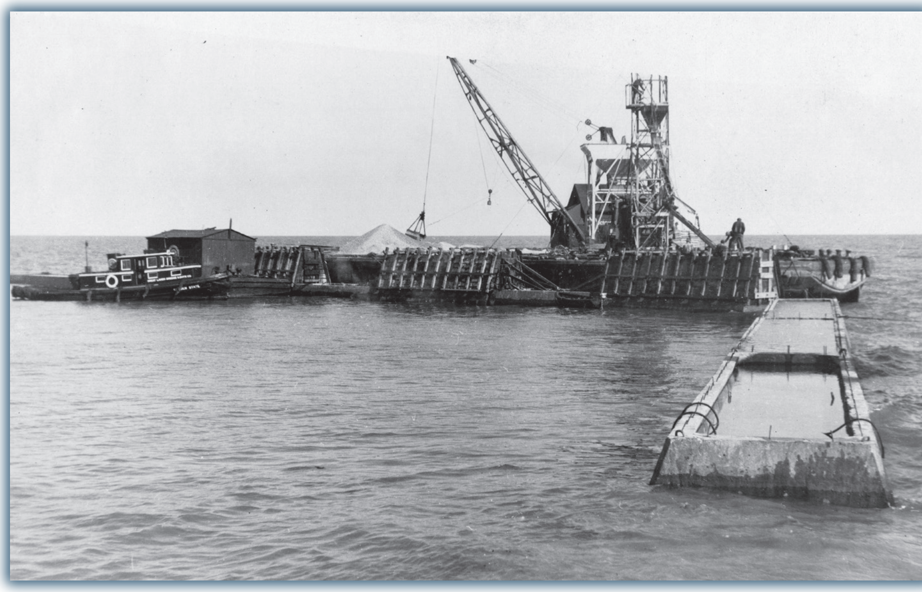

A Corps of Engineers contractor places concrete on a breakwater at Port Washington, Wisconsin, a harbor on the Great Lakes. 28 September 1936.

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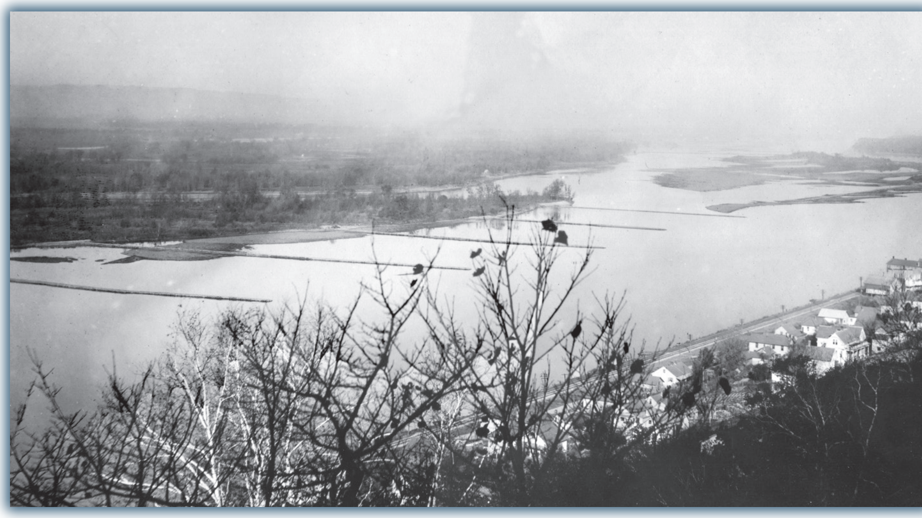
Finishing construction of the center portion of the Gallipolis Lock and Dam as seen from the Ohio side of the Ohio River. 17 November 1936.

dams. These dams provided a more stable depth of water at less cost and were easier to operate and maintain than the older, movable type of dam. Notable projects in the 1930s included the Montgomery Island Locks and Dam (1932–1934) and the Gallipolis Locks and Dam (1935–1937). The Corps of Engineers also reconstructed and replaced locks and dams on the Monongahela, Allegheny, and Kanawha rivers during the 1930s and later.[38]

UPPER MISSISSIPPI RIVER NINE-FOOT CHANNEL PROJECT

Of the traditional, single-purpose river improvement projects undertaken by the Corps, the Upper Mississippi River Nine-foot Channel Project was one of the most ambitious.[39] The project represented the culmination of years of lobbying by agricultural and commercial interests to secure improved navigation on the upper Mississippi. As a result of these early efforts, Congress had authorized three major programs to improve the upper Mississippi River during the late nineteenth and early twentieth centuries. In 1878 Congress approved a 4.5-foot channel and in 1907 increased the project depth to six feet. To achieve these depths, the Corps built wing dams and closing dams, protected shorelines, and dredged river bars. Still, over time transportation on the river decreased. Hoping to revive river commerce and help alleviate the nation's farm crisis of the 1920s, Congress authorized a nine-foot channel in 1930 between Red Wing, Minnesota, and Alton, Illinois. In 1937 it authorized a 4.6-mile extension to the project at its upstream end, adding two additional locks and dams above and below St. Anthony Falls. When completed in 1940, the nine-foot channel project consisted of twenty-six locks and dams and their associated pools extending from St. Paul, Minnesota, to Alton, Illinois. The project turned the once free-flowing river into a slack-water navigation system.

During the 1920s many in the Corps, including two chiefs of engineers (Major Generals Harry Taylor and Edgar Jadwin), had been ambivalent toward the nine-foot channel project. While acknowledging its engineering feasibility, opponents within the Corps doubted the project's economic advisability and feared its environmental consequences. Midwestern political pressure and enthusiastic support from Secretary of Commerce Herbert Hoover, however, forced the Corps to get on board. In the fall of 1929, to ensure that the Corps remained committed to the project, then President Hoover replaced the retiring Jadwin as chief of engineers with Maj. Gen. Lytle Brown. It was a calculated move. Hoover elevated Brown, a



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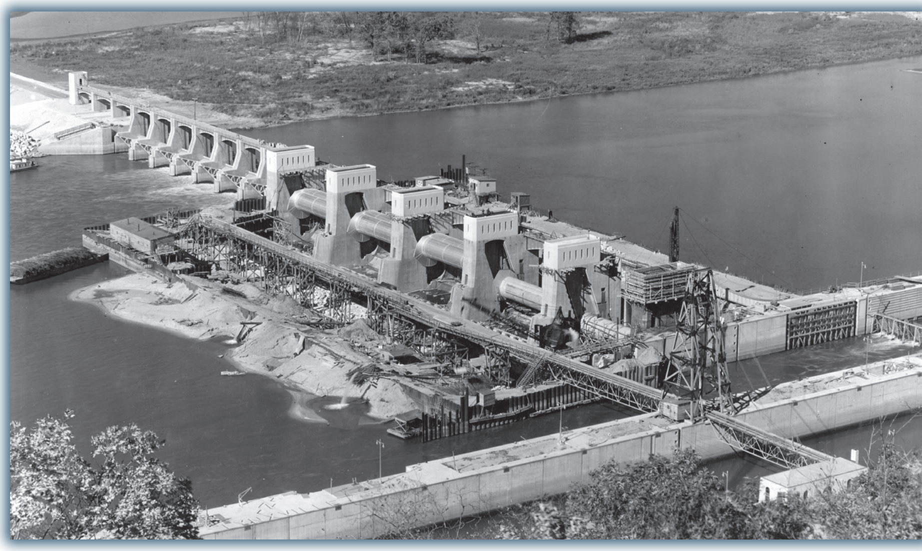
In years prior to the Depression, the Corps built wing dams in the upper Mississippi River (here at Alma, Wisc.) to create a deeper navigation channel. 1910.

supporter of the nine-foot channel project, over several officers who outranked him in point of service.[40]

The advent of the Great Depression in late 1929 changed the situation. Project boosters were alarmed to learn in 1930 that the Corps and President Hoover, while still supporting the project, wanted to delay full authorization pending a more detailed study. For his part, President Hoover, who opposed excessive deficit spending, now found it difficult to justify such an expensive project while the nation was in an economic depression with falling tax revenues. Congressional supporters, however, got the project included in the River and Harbor Act of April 25, 1930, and President Hoover signed it into law three months later.

Congressional authorization actually preceded completion of the Corps' final project survey report and design plan by a year and a half. While railroad interests and environmental conservationists continued to fight the nine-foot channel project, the Corps and supporters gained new adherents by pointing out that its construction would employ large numbers of workers at a time of great unemployment. In fact, the Corps skillfully promoted its upper Mississippi River civil works projects as federal relief work measures. In 1935, for example, the Rock Island District had eleven emergency-relief-funded public works projects under way employing over ten thousand men.



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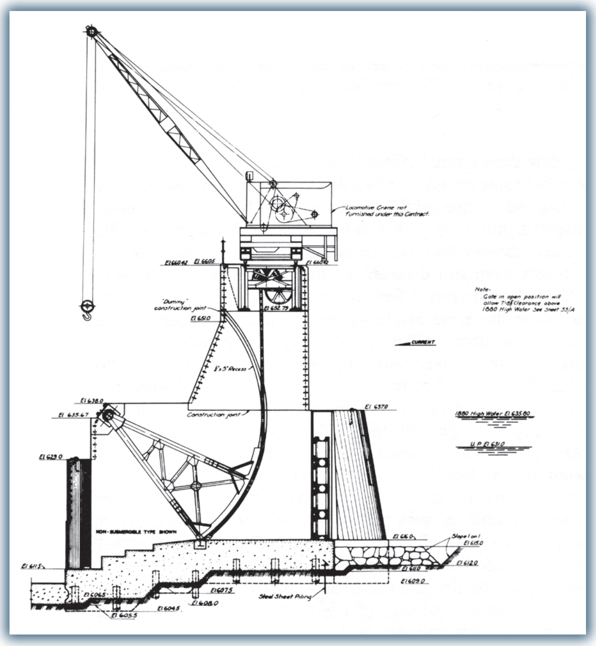
The roller gate section of Lock and Dam No. 9, part of the nine-foot channel project, under construction, with the completed Tainter gate section on the left. 14 October 1937.

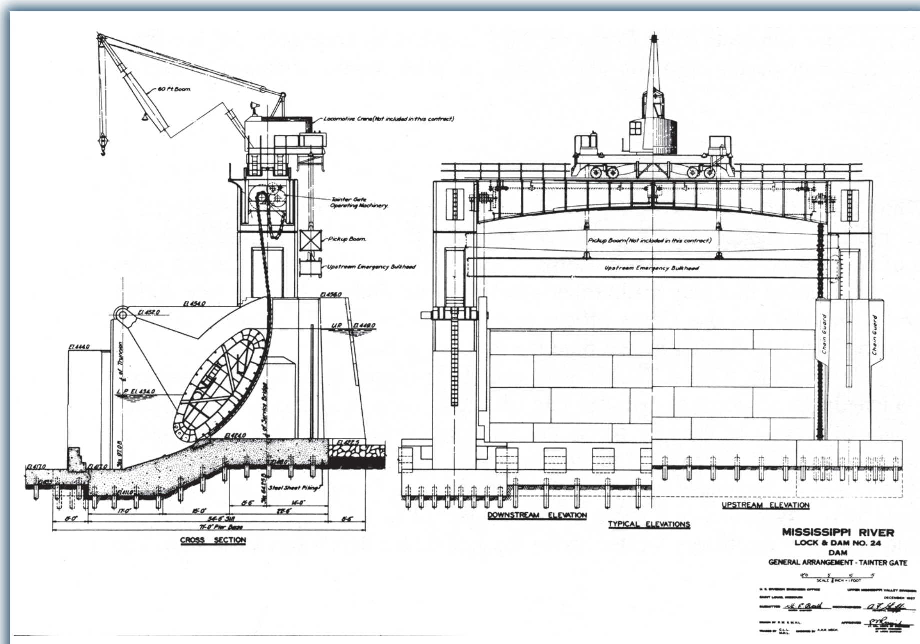
The Corps found that working under the federal relief mantle had its own special burdens. With the relief funds came complicated employment, recruitment, and labor requirements. Often the relief projects were structured to maximize employment rather than efficiency, and the heavy use of unskilled workers increased the potential for accidents and work delays. The Corps took extra precautions to implement safety regulations, conducting classes in job safety, publishing monthly periodicals promoting safety, and using new, on-the-job safety equipment. In fact, in July 1933 the chief of engineers ordered each district and division to establish safety organizations and institute programs designed to reduce the number of deaths and lost-time injuries due to accidents. The program soon bore fruit. Between 1933 and 1938, while civil works employment soared, the rate of injuries and deaths per million man-hours decreased 73 percent. The Corps applied its accident prevention program not only to its own workers, but also to those of its contractors. Contract specifications required that contractors provide a safe and sanitary work place.[41]

In building the nine-foot channel dams, the Corps developed several technological innovations, especially in the design of dam gates. At the beginning, the Corps used non-submersible roller gates. It then tried submersible roller gates that, when lowered below the water surface, allowed for easier passage of ice and debris. Engineers next experimented with combination roller gate/Tainter gate dams, but



St. Paul District

A cross-section of Dam No. 8 showing its wedge-shaped, non-submersible Tainter gate and armature. June 1935.



St. Louis District

A refined design showing submersible, elliptical, streamlined Tainter gates on Dam No. 24. December 1937.

they eventually designed new submersible and elliptical Tainter gate systems that replaced the combination gates. The Corps also innovated in the areas of construction techniques, foundation pilings, lock design, operating machinery, and other technical details. For example, at some sites the Corps had to locate locks and dams on silty riverbed, which required driving pilings deep into the subsurface to support the structures' concrete foundations. In addition, lock design involved detailed, original work modeling the ports, valves, and machinery used to fill and empty the lock chamber. The Corps carried out extensive research and testing at its Vicksburg hydraulics laboratory and at various university testing centers to find solutions to the engineering challenges it faced on the Upper Mississippi River Nine-foot Channel Project.[42]

Before 1925 navigation interests dominated use of the upper Mississippi River. When the nine-foot channel project threatened to reshape the river, many conservationists opposed the project, fearing its effects on the river's fish and wildlife and its scenic qualities. Ever since the 1870s, when the Corps began narrowing the river channel to increase depths for navigation, fish conservationists had sought to increase the quantity of fish in the river. One method they tried was to rescue fingerlings trapped in shallow backwaters. The U.S. Fish Commission, Bureau of Fisheries, and the various state fish commissions successfully pursued this approach; but by the 1920s, pollution and siltation threatened to undo the progress. Conservationists then focused on protecting habitat by trying to establish a national park or create a national refuge on the upper Mississippi. Conservationists urged Congress to create a 260-mile-long national fish and wildlife refuge between Wabasha, Minnesota, and Rock Island, Illinois. They argued that the upper Mississippi River valley faced an environmental crisis that had national implications. Congress responded favorably, passing a refuge bill in June 1924.[43]

Just as the conservationists won this signal victory, navigation interests renewed their push for the nine-foot channel project. Any deepening project threatened to undo the conservation gains because the increased river depth would flood many of the backwater pools used for fish rescue. To reduce opposition to the nine-foot channel project, the Corps began to work with the Bureau of Fisheries to minimize the impact of the project dams on fish in the upper Mississippi River. The two agencies, using Works Progress Administration funds, developed hatcheries and fish-rearing ponds in areas adjacent to the pools created by the new dams. An example of the local, state, and federal partnership that led to such conservation successes occurred at Lock and Dam No. 10 at Guttenberg, Iowa, between 1938 and 1941. On land donated by the city and the Corps and with funding from the Works Progress Administration and Public Works Administration, workers built a hatchery, an aquarium, and five rearing ponds on Twelve Mile Island in the Mississippi River.

Although questions remained about the long-range environmental impacts of the nine-foot channel project, especially about water quality and sedimentation, many conservationists declared their satisfaction with the efforts the Corps had taken to respond to environmental concerns. In 1941 Ray Steele, superintendent of the Upper Mississippi River National Wildlife and Fish Refuge, remarked: “Many conservationists were alarmed and fearful of results when construction of the dams was proposed; however, studies disclose material improvement of the water, and wildlife has responded to the new conditions quite satisfactorily. We are impressed with the fact that in this instance a navigation construction project has, in fact, been of tremendous benefit to wildlife.”[44] Other conservationists remained less sanguine about the physical and ecological changes imposed upon the upper Mississippi River by the nine-foot channel project. All would have to wait and see how the river’s ecosystem would respond and adjust over time.

CAPE COD CANAL

Another single-purpose project undertaken by the Corps in the 1930s was the enlargement of the Cape Cod Canal in Massachusetts. Originally completed in 1916 by private interests at a cost of $13 million, the twenty-five-foot-deep waterway never lived up to its investors’ hopes for large profits from its tolls. Because of hazardous navigation conditions caused by strong currents and a narrow channel (one hundred feet wide at its bottom) that restricted transit to one-way traffic, the canal failed to attract much use. After protracted negotiations, the federal government agreed to purchase the canal in 1927 and dropped all tolls.[45]

Between 1928 and 1935 the Corps operated the Cape Cod Canal, expending $1 million on maintenance alone. It also built two highway bridges and a railroad bridge across the waterway. Congress, in the Rivers and Harbors Act of 1935, authorized a major expansion of the canal. Over the next five years the Corps dredged at least 54 million cubic yards of material to enlarge the canal to a width of 480 feet and a depth of 32 feet and a length of 17.5 miles. It built a harbor of refuge and mooring basins and added a new lighting system and other features. The total cost of canal reconstruction came to just under $20 million, with about half of that coming from relief funds.

Office of History, Civil Works Image Collection

The Corps works on the Cape Cod Canal—protecting the banks with stone, building steel bulkheads on the right bank, and widening the canal by dredging. 4 September 1936.

The redesign of the Cape Cod Canal presented an engineering challenge to the Corps in that the tides varied at each end of the canal and were out of phase with each other. In the east end of the canal at Cape Cod Bay, the mean range of tide was 9.4 feet, while at the west end at Buzzards Bay, the equivalent range was only 4 feet. The difference created a hazardous alternating current in which the direction of flow reversed every six hours and maximum velocity reached 6 feet per second. Moreover, extreme weather conditions, such as hurricanes, greatly increased these velocities.

Using model studies carried out at the Massachusetts Institute of Technology, the Corps found that greatly increasing the width of the canal would improve maneuverability and eliminate the main hazard of the original canal: the risk of having a vessel caught with its bow on one side of the canal and its stern on the other during a falling tide. In addition, the improved canal would cut the distance between New York and Boston by sixty-five miles, saving shippers both time and money. The newly enlarged Cape Cod Canal proved especially beneficial during World War II;

both merchant ships and naval vessels could use the route to avoid enemy submarines in the Atlantic.

By providing a safe, efficient, and free route, the Corps' efforts attracted much new traffic through the canal. In 1927, under private operators, the canal handled 924,164 tons. By 1939 the Corps' improved canal saw passage of 4.9 million tons. Over the same period, the number of vessels using the canal increased from 5,745 to 14,032.

In other related work, the Corps also enlarged the Chesapeake and Delaware Canal and assisted in the modernization of the New York State Barge Canal. Both efforts were funded under the Emergency Relief Appropriation Act of 1935. In addition to managing the Cape Cod and other canals, the Corps also maintained seventy-one New England harbors and other tidal waterways, supporting commercial traffic of 36.9 million tons with a value of $1.4 billion in 1938. The Corps' system of harbors and channels, including the Cape Cod Canal, played a vital part in the economy of New England.

Office of History, Civil Works Image Collection

Excavation finished and dredging in progress near Summit Bridge, Delaware, to enlarge the Chesapeake and Delaware Canal. 14 September 1936.

OTHER TRADITIONAL WORK

While, as one engineer commented in discussing the Corps' navigation projects in New England, "the typical harbor improvement project, being little more than a ditch dug under water, ranks low among public works in terms of spectacular appeal," the federal investment in such work had been extensive. By 1932 the federal government had spent almost $166 million for constructing water terminals. During the New Deal, such federal expenditure would grow considerably, especially to provide work relief in different sections of the country. For example, Congress had established the Inland Waterways Corporation in 1924 specifically to revitalize commercial transportation on the Mississippi River system by developing a federal barge fleet and building terminal facilities. The Inland Waterways Corporation's extensive operations during the 1930s complemented the Corps' river improvement projects on the upper Mississippi and other rivers. Between 1932 and 1937, various federal relief organizations provided a total of $70.5 million for terminal facilities throughout the nation, with much of the maintenance and new construction work accomplished by the Corps.[46]

Other Corps responsibilities during the 1930s that related to its traditional rivers and harbors mission included work on the Lake Survey and with the Beach Erosion Board. The former undertaking had begun as early as 1816 when engineer officers assigned to the Great Lakes region periodically conducted local harbor surveys for ports. The effort, carried on systematically after 1841, surveyed and charted the rivers and harbors improvements of the Great Lakes, including the observation, investigation, and possible regulation of changing lake levels and their connecting waters in relation to waterborne commerce. During the 1930s those performing the Lake Survey took advantage of new technology, primarily aerial photography as well as significant advances in electronic survey equipment.[47]

Congress responded to rising concerns about shoreline erosion around the nation by authorizing the Corps to study the problem. The Corps thus established the Beach Erosion Board in 1930 and the Shore Protection Board in 1936 to examine problems along the Great Lakes and on seacoasts where federal interests were affected. The boards were charged with conducting investigations to determine the most suitable methods of beach protection and restoration and publishing the results for the use of local authorities concerned with protecting beaches. Among the early shoreline protection studies were those carried out by the Los Angeles District, which pointed out the destructive consequences of manmade intrusions in coastal zones. Because the Corps was precluded from initiating original scientific investigations of shore erosion problems, it usually recommended traditional structural solutions. While other federal agencies, such as the Federal Emergency Relief Administration, interpreted the erosion control law broadly and thus carried out erosion control projects as public works relief measures, the Corps generally resisted such an approach.[48]

Office of History, Civil Works Image Collection

CCC personnel excavating glacial fill by hand at one of the flood control dams on the Winooski River in Vermont. July 1933.

A National Flood Control Policy

DURING THE EARLY TWENTIETH CENTURY, the federal government gradually became involved with flood control efforts on the nation's rivers. The impetus came from states along the Mississippi River seeking assistance from the Corps of Engineers to build or repair levees that provided flood protection. Congress had first assumed administrative responsibility for flood control along the Lower Mississippi River with the creation of the Mississippi River Commission (MRC) in 1879. Proposed by a Louisiana Democrat, Congressman Randall L. Gibson, the new seven-member commission was an executive agency consisting of both military and civilian engineers and charged with creating a comprehensive plan to facilitate navigation and prevent destructive floods. In the wake of damaging Mississippi floods in 1912, 1913, and 1916, Congress enacted the nation's first flood control act in 1917, which authorized flood control activities by the Corps along the Mississippi and Sacramento rivers. That legislation, known as the Ransdell-Humphreys Act and spearheaded by Louisiana Senator Joseph E. Ransdell, authorized the federal government to assume, for the first time, primary responsibility for financing flood control improvements along the Lower Mississippi River and allocated $45 million to fund the completion of the existing levee system. The 1917 act had also allocated $5.6 million for work on the Sacramento River in California, which had been devastated by hydraulic mining. By 1926 much progress had been made on the Mississippi, and the MRC reported, prematurely as it turned out, that its line of levees could prevent the destructive effects of floods. One year later Congress again had to extend the Corps' flood control responsibilities.[49]

In response to the catastrophic Mississippi River flood of 1927, Congress committed the federal government to a dramatically expanded flood control role on the Mississippi. The 1927 flood had inundated more than 16 million acres, caused the loss of at least 250 lives, and cost over $236 million in direct property losses. As it had in the previous floods on the Mississippi, the Corps played a role in first fighting the flood and then in providing disaster relief in its aftermath. In the Flood

Control Act of 1928, Congress assigned the enhanced flood control mission to the Corps. In doing so the federal government assumed the major financial burden of Mississippi River flood control, but the principle of local contribution was embedded in the law. The federal government would pay for the construction of flood control works on the Mississippi, but local interests would have to pay for the maintenance of levees once completed.[50]

Herbert Hoover, both as secretary of commerce and then as president, strongly supported national planning of public works and multipurpose water projects. His support for federally funded flood control during the early 1930s, for example, helped lay the foundation for the New Deal–era Flood Control Act of 1936. However, while recognizing that federal expenditures for flood control projects would help alleviate unemployment, President Hoover was hobbled by his stronger commitment to the principle of balanced budgets. Thus, Hoover supported federal flood control work authorized under the Flood Control Act of 1928 but did not initiate major new flood control projects. It was left to President Roosevelt to undertake a major expansion in federal commitments to flood control efforts.

Initially, Roosevelt appeared hesitant to undertake a massive federal flood control program out of a desire to cut federal expenditures in order to balance the national budget. The depth of the national economic crisis when he assumed office, however, soon caused Roosevelt to put aside his fiscal conservatism and accept federal relief programs, including, half-heartedly, flood control projects. He recognized those labor-intensive programs as powerful tools for putting the nation's unemployed to work. The Corps was soon assigned flood control projects across the country by the new federal relief agencies, such as the WPA and PWA, and even directly by Congress.

As one facet of the drive by the Roosevelt administration to develop a national water resources program, a possible federal flood control program attracted the New Deal planners' attention and disrupted the politicians' traditional approach to the flooding problem. Congress, in part, was concerned that the administration's attempt to centralize water resources planning in the executive branch amounted to a usurpation of congressional authority. Certainly Congress, as the initiator and supervisor of the work done by the Corps of Engineers, exercised broad authority over water resources planning. Through the legislative process, House and Senate committees exercised direct control over the Corps' civil works program. The close working relationship between Congress and the Corps was one most members of Congress were loath to give up.[51]

Library of Congress, LC-USF33-010018-M4

Maine was one of the states hit hard by winter flooding in 1935-36.

The push for centralized planning of water resources development under the control of the executive branch at the expense of Congress complicated the effort to develop a more comprehensive federal flood control program. Severe winter flooding in 1935–1936 and the resulting high property losses in New England and the Ohio River valley highlighted the need for a national policy on flood control. Despite objections from the executive branch that the Corps and its supporters in Congress were proposing a pork barrel approach to flood control, one that prevented a comprehensive assessment of flood control within broad water conservation and development consideration, Congress passed and the president signed the Flood Control Act of 1936. Capt. Lucius Clay, the Corps' liaison with Congress in the mid-1930s, lobbied assiduously during the drafting of the flood control bill to keep the mission in the Corps' hands and out of the jurisdiction of Secretary Harold Ickes' Department of the Interior. Clay later claimed that he played a key role in determining what projects went into the bill.[52]

The new law declared flood control a proper federal concern and established a national policy for carrying out that mission. The act authorized about 270 projects at an estimated cost of $310 million, specifying the use of work relief money to carry out the program. The measure also included $10 million for additional surveys. Although Congress did not appropriate funds to carry out the provisions of the act until July 1937, money authorized under the Emergency Relief Appropriations Act of June 1936 permitted the Corps to initiate planning and design efforts for the flood control projects. The flood control law also set in place requirements for local contribution to the flood control projects. Section 3 of the act stipulated that non-federal interests were to provide land, easements, and rights of way before construction could begin; protect the federal government from damage claims; and operate and maintain the completed flood control works according to regulations prescribed by the Corps. Another key provision of the act mandated that each federal project had to have benefits that exceeded costs before it could go forward. In one important particular, the new flood control program marked a major departure for the Corps. While a majority of the projects in the bill provided for levee construction and stream improvements, almost two-thirds of the total expenditures went for reservoir construction in New England, upstate New York, western Pennsylvania, and a few other localities. Subsequent flood control acts would approve additional flood control reservoirs in the headwaters of all the major Mississippi River tributaries.

In response to severe flooding in the Ohio River valley during 1937, Congress, in the Flood Control Act of 1938, authorized a large number of previously recommended basin-wide flood control projects and amended the cost-sharing policy of the 1936 act. It relieved states and local governments from financial requirements by providing for federal funding of reservoir and channel improvements, and it excluded levee projects. These changes had the effect of breaking the logjam on reservoir construction. The Flood Control Act of 1941 partially reinstated cost sharing by local interests for channel improvements, but it kept the requirement that the federal government pay the costs of land acquisition and easements for reservoir projects.

Some historians have argued that the new federal flood control policy, pushed by the Corps and its congressional supporters, sponsored narrow, single-purpose flood control projects at the expense of broader, multipurpose river development. Moreover, the prevailing federal flood control approach promoted only structural solutions to flood-damage reduction. The basic engineering assumption held that levees, channel improvements, and reservoirs were the proper ways to prevent damages. Non-structural approaches to flood damage reduction were rarely considered in the 1930s. These issues would continue to be debated over succeeding decades as population densities in these flood zones increased. Nevertheless, Congress had finally established a national flood control policy and had given the primary responsibility for implementing it to the Corps of Engineers.[53]

THE CORPS' SHIFTING APPROACH TO FLOOD CONTROL

The Great Mississippi River Flood of 1927 that helped hasten the development of a national flood control policy also had profound consequences for the Corps' Mississippi River navigation and flood control work. Since the mid-nineteenth century, the Corps had relied chiefly on a levees-only approach to flood control. Based on aspects of cost, hydrology, and technology, the Corps did not believe that reservoirs constituted a viable approach to controlling rivers for the benefit of flood control or navigation. The massive devastation caused by flooding on the Mississippi in 1927 demonstrated the bankruptcy of such a policy.[54]

In response, the Corps began to shift its approach to flood control. Based on a report authored by Chief of Engineers Maj. Gen. Edgar Jadwin, Congress passed the Flood Control Act of 1928, firmly committing the federal government to flood control on the Mississippi River. General Jadwin's recommendations, while still relying to a large extent on levees, also proposed a mix of floodways and spillways, including the controversial plan to send half of the Mississippi's floodwaters down the Atchafalaya River into the Gulf of Mexico. The Mississippi River Commission also presented a competing flood control plan to Congress, but its greater expense caused

Maj. Gen. Edgar Jadwin, who served as Chief of Engineers from 1926 to 1929.

Office of History, Personality Image Collection

James W. Sewall Company

The Corps dredging a cut-off at Jackson Point, Mississippi, to shorten the course of the Mississippi River. 17 November 1940.

Congress to reject it in favor of the Corps' approach. Neither proposal recommended a large-scale use of reservoirs to control the Mississippi River floodwaters.[55]

A costly element of both plans was the expense to acquire land and rights-of-way for enlarged levees and flowage easements as well as damages to lands within the proposed floodways. General Jadwin's plan, costing $296.4 million, emphasized that the states and localities should be responsible for real estate costs and property damages. The MRC's plan, on the other hand, recommended federal assumption of the bulk of the real estate costs of the project. After fierce debate, Congress adopted a flood control measure limiting the federal government's responsibility for real estate costs to only those lands affected by "additional" floodwaters diverted from the Mississippi River by new flood control works.

The actual condemnation process for flowage easements or fee-simple rights-of-way and for levee construction proved complex and expensive. Questions over property rights and compensation for land damages in 1929 ultimately led to new concerns about the Corps' floodway plans. It took nearly six years to resolve these issues in the courts and Congress. For its part, the Corps, under a new chief of engineers, Maj. Gen. Lytle Brown, sought to refine its engineering plan for flood control on the Mississippi. After much study, General Brown's approach differed little from General Jadwin's plan. It retained most of the engineering aspects and required non-federal interests to provide all rights-of-way and flowage rights except when the federal government specifically agreed to pay such costs.

During the 1930s the Corps also conducted some experimental dredging in the Mississippi and Atchafalaya rivers. The Corps had relied on dredging since the late nineteenth century, but not on a sustained basis. The chief proponent of the new dredging program was Brig. Gen. Harley Ferguson, who became commander of the Lower Mississippi Valley Division and president of the Mississippi River Commission in 1932. The Corps dredged to create new channels and cut-offs (short-cuts, essentially) that would enable the river flow to transport the maximum amount of material without either scouring the banks or depositing sediment where it was not wanted. These measures met with great initial success, but the main drawback was that the Corps had to do more expensive maintenance dredging than had been anticipated. It continued the dredging, however, as congressional appropriations permitted in the late 1930s. At the time, the Corps expressed no concerns about the negative effects of its dredging or dredged material placement on the region's fish and wildlife. The Corps' focus remained on the engineering and legal issues.

Finally, in 1935 Maj. Gen. Edward Markham, the chief of engineers since 1933, submitted a new plan for flood control in the lower Mississippi valley that contained significant engineering changes from previous approaches. General Markham's plan responded to both engineering advances and political reality. To appease local landowners, he proposed replacing the previously authorized Boeuf Floodway south of Arkansas City with a new, smaller Eudora Floodway and control structure and a setback levee to prevent water from flowing into the Boeuf valley. In addition, the Markham plan called for a control structure and floodway at Morganza instead of the east Atchafalaya Floodway and its fuse plug levee. Another change would have the Corps construct a new Wax Lake outlet to speed floodwaters from the southern part of the Atchafalaya Floodway west of Berwick, Louisiana. General Markham also recommended flood plans for tributaries of the Mississippi River in Missouri and Arkansas that the Corps had previously opposed. In all, the amount of land subject to flooding would be considerably reduced. For example, the proposed Eudora

Floodway would cover only 850,000 acres, while the Boeuf Floodway needed 1.3 million acres for flood control operations.[56]

General Markham's 1935 plan also proposed modifications to the Corps' real estate policies. He wanted the state or local governments to furnish flowage rights over the lands in floodways or in front of the setback levees, with the federal government reimbursing the states or their local agencies for their expenses up to one and a half times the land's assessed value. In 1935 neither the states affected nor Congress could agree on all elements of Markham's plan. During the next year, however, after much debate and compromise over the land acquisition requirements, Congress adopted the basic elements of Markham's plan. Further adjustments in federal land acquisition requirements for the Mississippi River floodways passed Congress in 1938. After ten years of acrimony, delays caused by landowners' objections to federal easement policies, and reconsideration of the engineering aspects of the Mississippi River floodway by the Corps, the project finally proceeded in the late 1930s.

While the real estate acquisition process proved difficult and time consuming and ultimately led to the elimination of the proposed Eudora Floodway, work on raising the various levees and relocating highways and railroad lines commenced. World War II, however, stopped or delayed most work on the floodways. Overall, the Jadwin and Markham plans represented a significant departure from the Corps' levees-only policy and substituted one that utilized both the confinement and release of floodwater and allowed significant engineering modifications over time.

Despite its long-held resistance to the concept of reservoirs on the Lower Mississippi drainage, during the 1930s the army engineers examined building dams on certain tributaries of the Mississippi. Based on its studies, the Corps did not find construction of dams on such rivers as the Yazoo and St. Francis cost effective. Politically, though, this position proved unpopular in a time of large-scale unemployment. Supporters of the reservoirs argued that such projects would alleviate unemployment and provide life-saving flood control benefits. Although never economically justified on the basis of flood control benefits alone, Congress authorized the seven reservoirs in the proposed Yazoo Headwaters Project in 1936. Largely at the insistence of Congressman William Whittington of Mississippi, influential chairman of the House Flood Control Committee, Congress ordered the Corps to incorporate the Yazoo basin reservoirs into the Mississippi River and Tributaries Project. Eventually the Corps built four of the authorized dams to provide public works jobs for the unemployed.[57]

Office of History, Civil Works Image Collection

Tygart Dam, one of the Corps' first major flood control works, under construction. 13 July 1937.

OHIO RIVER AND NEW ENGLAND PROJECTS

A number of New Deal–era flood control projects built by the Corps of Engineers addressed the periodic, severe flooding in the upper Ohio River basin and throughout New England. Tygart Dam, in West Virginia, was one such project. In response to persistent flooding in the Pittsburgh area, the Corps developed a comprehensive Pittsburgh Flood Control Plan. The Tygart Dam, the first high dam built by the Corps for flood control, comprised the largest component of the proposed plan. It was located near the mouth of the Tygart River, which together with the West Fork River forms the Monongahela River about ninety miles south of Pittsburgh. In addition to providing some measure of flood control, the total system created by the fourteen reservoirs would also improve flows for navigation. After the Corps submitted several studies and reports on the project, Congress appropriated funds for the dam late in 1933.[58]

Once the reservoir area was cleared, construction began in December 1934 as Federal Project No. 44, paid for with relief funding. Contractors completed the dam in February 1938 at a cost of $18.3 million. The massive concrete gravity dam—one of the Corps' first major flood control works—stretched 1,921 feet in length, reached 243 feet in height, and extended a width of 207 feet at its base. At the time of

Office of History, Civil Works Image Collection

Workmen prepare to drill boulders at the site of the East Barre dam in Vermont. July 1933.

Office of History, Civil Works Image Collection

Excavation work for the spillway at Wrightsville, Vermont, continues even when temperatures reach 12º below zero. 30 January 1934.

completion under the management of the Ohio River Division of the Corps, it was the largest concrete gravity dam east of the Mississippi River. The design called for a central spillway with deflector piers and a stilling basin, which kept the discharged water velocities low to reduce downstream erosion. Ordinarily water was released through eight steel-lined culverts and two needle valves near the heel of the dam. Only during exceptional floods would water flow over the spillway. To ensure high quality concrete work, the government supplied the cement and carefully monitored the mixing and placing of all materials. The dam ultimately contained 1.2 million cubic yards of concrete.

When the Tygart Dam was only 42 percent complete, the worst flood ever to hit Pittsburgh occurred in March 1936. Coupled with devastating floods throughout the northeast, the western Pennsylvania flooding helped set the stage for congressional action on the Flood Control Act of 1936. That measure included authorization for nine additional reservoirs in the Allegheny-Monongahela basin. By 1939 the Corps had four of those dams under construction. Two were earth-fill structures and two were concrete gravity dams. As part of the congressionally amended Pittsburgh Flood Control Plan, the Corps' Pittsburgh District also built two local protection measures against flooding in the late 1930s—a floodwall at Pittsburgh and channel improvements at Johnstown, Pennsylvania. Tygart and its sister dams and reservoirs, as the first major flood control projects in the Ohio Basin, served as models for similar Corps dams subsequently built in the Ohio River Division.

While construction of the Tygart Dam was under way, the Ohio River Division received authority to design and construct fourteen flood control dams in Ohio's Muskingum River basin. The Muskingum project, like Tygart Dam, began as a public works effort to relieve unemployment. Local interests in southern Ohio had sought increased flood protection since experiencing devastating flooding in 1913. In the early 1930s they redoubled their efforts to gain federal flood control support; and in March 1934 the PWA committed funds to the Muskingum project and requested that the Corps administer it. To manage the undertaking, the Corps established the Zanesville District. Working at top speed, the new district produced plans for fourteen dams less than six months after initiating studies.

The Muskingum project plans called for thirteen earth-fill dams and one combination earthen and concrete dam. To ensure the selection of proper soil types and methods of compaction, the Corps established a soils laboratory at the Zanesville District. The testing program removed earthen dam construction from the realm of trial and error and, in time, led the Corps to establish soils laboratories at several of its other divisions. The Zanesville District also developed several other innovations in dam and reservoir design, including the application of flood routing calculations and the use of piezometer tubes, which measured water pressure inside dams. The Corps completed the Muskingum dams by June 1938 and closed the Zanesville District at that time. The pioneering soils laboratory transferred to the Pittsburgh District, and the Huntington District became responsible for operating and maintaining the Muskingum dams.[59]

The Corps' flood control work in New England drew on its 308 reports and subsequent studies authorized by Congress in the Flood Control Act of 1936.[60] The plans adopted in response to flooding on the Winooski, Merrimack, and Connecticut rivers were typical flood control developments. The first projects to get under way were on the Winooski River in Vermont. The Corps received authority in June 1933 to build three earth-fill dams and to construct channel improvements using relief funds and Civilian Conservation Corps (CCC) personnel. The plans were based on the flood control elements of studies carried out under the 308 examinations. The Corps completed two of the dams by 1935 and the final one in 1938. The Corps employed as many as five thousand CCC workers in building the dams; this comprised the largest construction project during the Depression that used CCC labor.[61]

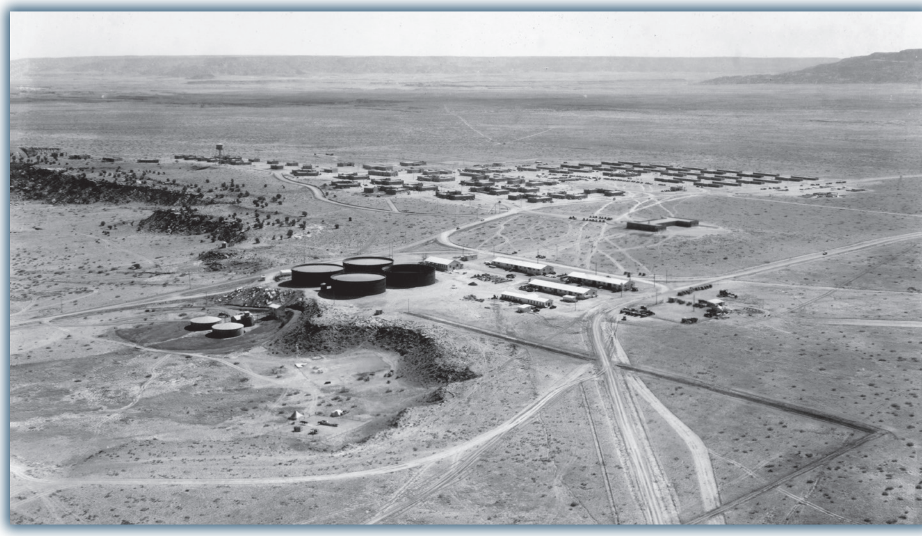
To deal with flooding on the Merrimack River, which lies partly in New Hampshire and partly in Massachusetts, Congress, under the Flood Control Act of 1936, directed the Corps to develop a comprehensive flood control plan. The Corps submitted its recommendations after two years of study, and Congress authorized the plan in the Flood Control Act of 1938. The Corps' plan called for five rolled earth-fill dams, corresponding reservoirs, and local protection works and channel improvements. The Corps initiated work on the dams in 1939, and the total estimated cost to complete the project was $21 million. As built, the dams included provisions for the possible addition of power generation facilities in the future.

To control the flooding problems on the Connecticut River, which flows through New Hampshire and Massachusetts as well as Connecticut, the Corps developed a plan utilizing both reservoirs and local protection measures, the same approach it employed in the Merrimack watershed. The Corps carefully weighed the costs of various reservoirs individually and as a system against benefits to be gained to find the optimum plan. In all, the Corps proposed twenty reservoirs, costing an estimated $57.4 million. With one exception, the Corps recommended the dams be built by the compacted earth-fill method. The exception—the Knightville

Laborers grade the outer face of a dike along the Connecticut River in Hartford in preparation for its seeding. 26 April 1937.

Dam— was based on the hydraulic-fill type of construction. To ensure the optimum operation of the entire system of dams, the Corps installed gate-controlled outlets.

Controversies over the elements of local cooperation required by the Flood Control Act of 1936 delayed some of the major work on New England flood control projects. However, under the Emergency Relief Administration Acts between the years 1935 and 1938 the Corps was free to construct local flood protection works. The local protection measures consisted of levees, concrete floodwalls, and enlarged channels paid for by the federal government but maintained and operated by local entities. While the Corps worked on the local flood protection measures, Congress finally resolved the arguments between the New England states and the federal government over cost sharing, operation and maintenance of the proposed flood control projects, and provisions for future hydropower development. In the Flood Control Act of 1938, Congress stipulated that dams and reservoirs would be constructed at full federal expense and operation and maintenance would remain a federal responsibility. Work on the New England reservoirs finally got under way in the late 1930s but came to a temporary halt in 1943, when World War II military construction took precedence over civil projects.



Office of History, Civil Works Image Collection

The substantial Corps-built housing camp in the New Mexico desert for the hundreds working on the Conchas Dam. 16 October 1936.

PROJECTS IN THE WEST

Elsewhere in the United States, as part of a long-term comprehensive program for the development of the Canadian River in northern New Mexico, the Corps built the Conchas Dam. Even though a 1930 study by the Corps of flood control and irrigation needs on the Canadian River near Tucumcari, New Mexico, could find little economic justification for any project, local interests continued to push for a water resources project. The changed attitude toward the use of public works for unemployment relief brought the Canadian River project back to life. The Corps requested funds for the Conchas Dam as a flood control and work relief measure in May 1935, and Congress responded by including the project in the Employment Relief Act of August 1935. Complex legal and financial battles among the state, federal government, and local landowners, however, threatened to derail the marginally justified flood control project before the Corps could start construction. After serious negotiations among all the parties resolved the outstanding issues, the Corps finally initiated construction of Conchas Dam in November 1935. Once funding had been secured, the Corps still faced the daunting tasks of harnessing the energies of several thousand skilled and unskilled workers and solving the logistics problems of constructing such a large project in isolated high desert country.[62]

Office of History, Civil Works Image Collection

Workmen excavate for the foundation of Conchas Dam by hand and with machine. 13 October 1936.

National Archives, 18-AA-83-22

Conchas Dam on the South Canadian River about thirty miles northwest of Tucumcari, New Mexico. 25 September 1941.

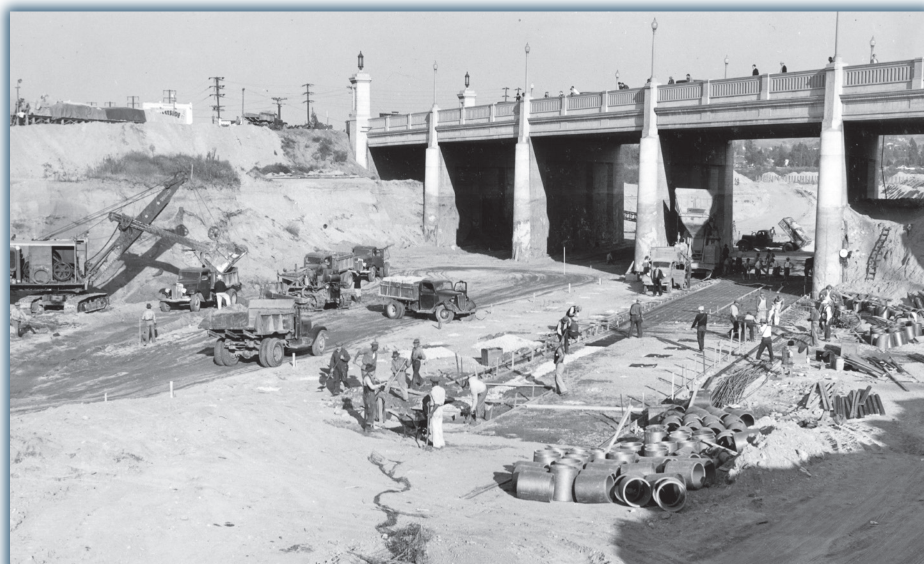
In New Mexico the Corps hired laborers directly rather than by contract in order to maximize the number of relief jobs. At the peak of the dam construction, the project employed over three thousand men. More than 60 percent of the WPA workers on the project were Spanish speakers, which led to some communications problems for the largely English-speaking supervisory personnel. The isolated work location also required the Corps to build and operate an extensive on-site construction town for the workers. When completed in 1939, the concrete gravity dam had a height of 235 feet, a length of 1,250 feet, and storage capacity of 800,000 acre-feet of water. The $15.5 million dam also provided limited irrigation potential.[63]

Like the Conchas Dam, the Denison Dam on the Red River between Oklahoma and Texas was another Depression-era flood control project that owed its existence to heavy lobbying by local interests. The original Corps study, released in 1936, found no economic justification for the proposed dam. The Flood Control Act of 1936, however, authorized a restudy of the Denison Dam for both flood control and hydropower. Completed in 1938, the new study found the dam marginally justified. Supporters in Congress, including House Majority Leader Sam Rayburn, pushed the project through as part of the comprehensive plan for control of floods on the Mississippi River and its tributaries as passed in the Flood Control Act of 1938. The Corps established the Denison District (which later became the Tulsa District) in January 1939 to oversee construction of the dam.[64]

The Denison Dam was not uniformly welcomed in Oklahoma. The state's conservative governor, Leon Phillips, vehemently opposed it on the grounds that it would inundate too much land, would cost the state important tax and oil revenue, and would violate states' rights. Congress attempted to strengthen the dam's justification by reauthorizing it in 1940 as a multipurpose project, providing navigation and "other beneficial uses" in addition to flood control. Governor Phillips fought the Denison Dam project in federal court and ultimately lost in the Supreme Court in 1941. In its decision, the Supreme Court upheld Congress's broad powers under the commerce clause to enact multipurpose water resources projects on navigable waters and their tributaries, whether navigable or not. Construction of Denison Dam continued while opponents had their day in court. When completed, the rolled earth-fill Denison Dam stretched 15,200 feet in length, stood 165 feet above the riverbed, and provided 2.7 million acre-feet of flood control storage. The flood control portion of the project went into operation in July 1942 and power production began in March 1945.

Office of History, Civil Works Image Collection

Construction of the Alhambra Wash Storm Drain in southern California, a project on which 700 men were employed. 8 November 1937.



Office of History, Civil Works Image Collection

Deepening the Los Angeles River Channel under the Fletcher Drive Bridge. 8 November 1937.

Office of History, Civil Works Image Collection

The Cottage Grove flood control dam under construction in the Willamette River Basin in Oregon. 11 July 1941.

The Corps also undertook a sizeable flood control effort in southern California during the 1930s. The Corps began flood control improvements in 1935 for the Los Angeles County Flood Control District, using WPA funds and large numbers of unemployed workers. In fact, the Los Angeles District of the Corps increased its personnel from fifteen thousand to seventeen thousand between 1935 and 1936; more than 95 percent of these district employees came from the relief rolls to work on flood control projects. What made the flood situation in southern California different from other parts of the country was that flood prone areas sat in close proximity to densely populated urban centers.

Metropolitan Los Angeles then occupied a twenty-five-mile-wide coastal plain that was and is subject to major storms during the rainy season. Because of the area's unusual physiographical and meteorological conditions, these storms could cause highly destructive floods. To deal with the flooding problems, the Los Angeles District considerably reworked the Los Angeles County Flood Control District's comprehensive flood control plan. In particular, it devoted special attention to controlling the highly destructive heavy debris loads carried by the region's floods.

Renewed flooding in 1938 prodded the Corps to develop an even more elaborate long-term plan for flood control in Los Angeles County. In the late 1930s on the eve of World War II, the Los Angeles District worked feverishly to carry out its flood control plan because of the heavy concentration of national defense industries in southern California. When completed in 1966, the Los Angeles County flood control program represented the largest public works project undertaken by the Corps west of the Mississippi River. The Corps' projects included constructing three major flood control reservoirs; building miles of reinforced, concrete-lined channels; enlarging channel capacities; and establishing debris basins at the mouth of mountain canyons. This work allowed upstream flood control reservoirs to release an increased volume of water when necessary during storm surges.[65]

The Corps also initiated major flood control work in the Pacific Northwest during the 1930s. Congress authorized the Corps' Willamette Basin Project in Oregon in 1938. The project had its genesis in the Corps' studies begun under the 308 reports and in a 1935 congressional directive to carry out additional examinations in order to develop a comprehensive multipurpose plan for using the water resources of the Willamette River basin. At first the Corps had been reluctant to propose major flood control work for the Willamette valley basin. The 308 report for the Willamette River released in 1931 focused on improvements for navigation and downplayed the value of flood control. At that time the district engineer at Portland flatly stated, "there is no flood problem on the Willamette of sufficient magnitude to necessitate formulation of a general plan for flood control."[66]

When the district took another look at the flooding problem in the context of a more comprehensive examination of the water resources in the Willamette basin six years later, it came to a different conclusion. The division engineer then believed that, "with the present development of the valley," a recurrence of a great flood of the magnitude of those that occurred in 1861, 1890, or 1927 "would be somewhat of a catastrophe." The Corps had refined its stream-flow data since the earlier studies, and the primary emphasis had shifted from navigation to flood control as the centerpiece of comprehensive development.[67]

The Willamette basin project adopted in 1938 called for seven reservoirs capable of storing 1.3 million acre-feet of water. In addition to flood control, the stored water could be used for navigation, irrigation, hydropower, and municipal and industrial purposes. The reservoirs and other project improvements were estimated to cost $62 million. Commercial, industrial, and agricultural interests in the Willamette valley actively lobbied in support of the project, and Congress responded

Office of History, Civil Works Image Collection

Members of the Junior CCC placing riprap as part of a drainage project somewhere along the Wallkill River. 8 July 1936.

by authorizing it. Four of the proposed dams were earth-fill structures, two were concrete gravity, and one was concrete arch. The Corps started work on three of the dams in 1940 and 1941 and completed them in 1942. Two more were begun after World War II. Based on later studies, the Corps dropped two of the proposed dams and substituted other reservoirs at different locations for them. Writing in 1939, Maj. Cecil Moore, district engineer at Portland, stated that the Corps considered its Willamette Basin Project "as a model multipurpose plan for water control and use in a large river basin."[68]

FLOOD CONTROL RESERVOIRS

The Flood Control Act of 1936 marked the real beginning of comprehensive federal flood control efforts and gave the Corps a major new mission. The Corps' role in flood control also reinforced its move in the direction of multipurpose work because so much of the new work involved building reservoirs that had other benefits, such as hydropower or irrigation. The new mission requiring the Corps to construct flood control reservoirs caused some Army engineers great discomfort because the organization had for so long expressed skepticism about the role of reservoirs in flood control. Anti-reservoir engineers doubted that it was possible to efficiently operate a flood control reservoir as a multipurpose project or that reservoirs would function effectively and at a reasonable cost in a large river drainage basin containing a complex tributary system. As late as August 1936, two months after passage of the flood control act, the Corps published a pamphlet that argued:

> Of the four methods of controlling floods mentioned above, construction of levees is the most direct and surest method…. Works, such as reservoirs, constructed at localities distant from areas damaged by floods are not so determinate as to effects, and the benefits of reservoirs become smaller and smaller as distances from the reservoir sites increase. As a consequence, a dollar spent for levee construction is more likely to be a dollar well spent than a dollar spent for other methods of flood control.

Within a few years, however, the negative views about reservoirs expressed in the 1936 pamphlet had no place in the Corps of Engineers. Over the next forty years, the Corps constructed more than three hundred reservoirs whose primary benefit would be flood control.[69]

Office of History, Civil Works Image Collection

Channel improvement of the Los Angeles River as a flood control measure in southern California. 20 September 1938.

The Corps and the Environment

THE EXPANSION OF THE CORPS' MISSION from single to multiple purpose projects also brought it into conflict with conservationists. Creating huge reservoirs for navigation, hydropower, flood control, and other purposes brought objections from conservationists and outdoor enthusiasts who feared the loss of unspoiled river valleys. Conservationists accused the Corps of giving too little credence to their views and refusing to consider values that went beyond engineering or economic considerations. The 1934 Fish and Wildlife Coordination Act was the first major statute that promised to broaden the focus of public works planning. The law required consultation with the U.S. Bureau of Fisheries prior to building federal dams and recommended, where not inconsistent with the primary water purposes, the use of reservoirs for fish hatcheries and migratory bird refuges. The accommodations that the Corps had to make for anadromous fish in the design and operation of the multipurpose Bonneville Dam illustrate the new environmental considerations the Corps faced.[70]

The Columbia River watershed supported annual runs of millions of salmon and steelhead trout that spawned in fresh water and grew to maturity in salt water. At the time the Corps undertook the 308 studies for multipurpose dams on the Columbia River, it recognized that those dams posed a threat to the fish runs. The North Pacific Division commander, Col. Gustave Lukesh, pointed out the problem to the chief of engineers in 1929: "In connection with tentative design of dams … it appears that provision should be made for the passage upstream of fish, especially salmon migrating to breeding places." He accurately foresaw that "such provision may have an important effect upon the cost of the dam and possibly upon the water available for power generation during periods of low flow."[71]

Contrary to the claims of some critics (then and since) that the Corps only belatedly recognized the danger Columbia River dams posed for the fish runs and only grudgingly responded to the problem, the Corps forthrightly dealt with the matter. The Columbia River 308 report issued in 1931 included fishways in the design and cost estimates for each proposed dam. Fish passage facilities on the scale called for in dams of the size proposed, however, had never before been attempted. Local fishing interests, both commercial and recreational, raised fears that a dam at Bonneville would prove devastating, and the U.S. Fish Commission promised to assist the Corps in devising adequate passage facilities if the dam were built.

Immediately upon adoption of the Bonneville Dam project in September 1933, the Corps began work on fish passage facilities. After consulting with the U.S. Bureau of Fisheries, state fish and game commissions, and various regional fishing associations, the Corps assembled a team of fisheries experts to devise a plan for passing migratory fish upstream and fingerlings downstream. Working within a tight timeframe, fisheries biologist Harlan Holmes, hydraulic engineer Milo Bell, and others assembled existing data, conducted further studies, and debated the merits of various proposals with interested governmental agencies and private fisheries groups. Consensus on the best type of fishway proved elusive. Most federal and some state fisheries experts favored fish lifts (or locks), but others—especially Oregon experts and commercial fishing interests—thought that the lifts were too experimental and considered conventional ladders preferable. The initial design submitted in September 1934—less than a year after the project started—called for both lifts and ladders and a novel collection and bypass system. The Corps continued revising its plans to accommodate its critics' concerns, but in doing so increased the cost of the fishways from an estimated $2.8 million to $3.6 million.

Harold Ickes, who was both the Secretary of the Interior and the PWA Administrator, balked at the higher cost. Oregon Senator Charles McNary weighed in, and eventually he extracted a commitment from the PWA to release $3.2 million to fund the key elements of the compromise plan. As the Corps incorporated the elements of the fish passage plan into the construction of the dam, these features underwent further modification. The installed system—fish ladders, hydraulic fish lifts, a unique collection system, and bypasses—ultimately cost almost $7 million. President Roosevelt wrote with some exaggeration to Ickes in June 1935, "All I can hope is that the salmon will approve the spillways [i.e., fishways] and find them really useful, even though they cost almost as much as the dam and electric power development."[72]

The main element of the Bonneville fishways system consisted of three reinforced concrete fish ladders. They resembled a long stairway comprised of pools sixteen feet long, forty feet wide, and six feet deep, each one a foot higher than the last and leading to the seventy-two-foot-high pool behind the dam. The plan placed

Office of History, Civil Works Image Collection

The Bradford Island fish ladder on the south end of the main Bonneville Dam. 26 October 1936.

one ladder at each end of the spillway structure and one at the north end of the powerhouse. The effectiveness of the fishway system at Bonneville depended in large measure on its ability to attract fish. Fishways at other North American dams had never satisfactorily solved this problem.

After extensive model studies of the hydraulic features of the devices proposed and thorough analysis of existing data, the Corps fisheries team recommended a collection system that provided an expanded flume-like passageway with openings across the face of the powerhouse and that contained a high volume of water with nearly constant velocity to draw the fish in and lead them to the ladders and locks. For the spillway dam, the fisheries experts recommended an attraction and collection system that extended along the abutment walls from the ladders to the tailrace. At the downstream entrance to the fish ladders, V-shaped collecting traps prevented the fish from returning to the tailrace. The spillway collecting system received auxiliary water by the same method as the powerhouse system. The Corps' fisheries experts also provided several methods to pass the downstream-migrating fingerlings, although at the time researchers believed that most fingerlings could safely make it through the turbines or the spillway gates during the regular releases of excess water.

When the dam went into operation in January 1938, the Corps and the public anxiously awaited the spring salmon runs to test the fish collection and passage system. Prior to the closure of the dam, the Bureau of Fisheries conceded, "there is no way of determining in advance whether or not the fish-protective works will be successful or how much, if any, adverse effects the dam will have upon the fish supply." The Bonneville fish passage system did not disappoint its designers. The fish easily found their way through the collecting channels and up the ladders to the reservoir behind the dam. The fish passage facilities at Bonneville Dam, supplemented with additional studies, served as the model for the passage systems installed at dams built subsequently on the Columbia and Snake rivers as the Corps completed the recommended 308 program. In time, however, the Corps found that the construction of additional dams on the Columbia River and its tributaries created additional problems for the migrating salmon that imperiled their survival as a species. The difficulties included cumulative mortality from downstream passage of juveniles through multiple reservoirs and dam turbines, nitrogen supersaturation during periods of heavy spill, predation by other fish, and the effects of migration delays through the slow-moving current in the reservoirs.[73]

Although today, as the nation's environmental engineer, the Army Corps of Engineers manages one of the largest federal environmental missions, during the 1930s conservationists found it difficult to influence the Corps' planning and building of water resources projects. While the process for planning and authorizing the Corps' civil works projects allowed for interested parties to provide input, conservationists and other concerned groups believed the process had defects. In practice, the critics argued, actual participation in the various phases of the planning process was limited because the Corps gave little credence to views or values outside of traditional hydrologic, engineering, and economic considerations. Interests promoting water resources development projects had the inside track to influence the Corps' plans, they lamented.

In addition, the Corps interpreted its authority under the Refuse Act of 1899 and the Oil Pollution Act of 1924 conservatively, generally rejecting the environmental implications of its regulatory powers. The Corps issued permits for dredging, filling, or dumping waste in the nation's waters based on its assessment of whether or not the activity would obstruct navigation. Rather than control pollution at its source, the Corps supported other strategies for assisting fish and wildlife, such as establishing refuges and hatcheries. The Corps also interpreted its responsibilities under the Fish and Wildlife Coordination Act of 1934 narrowly. Although the act required the Corps—and other federal agencies building dams—to consult with the Bureau of Fisheries on the potential impacts of projects on fisheries, the Corps was not obligated to follow the bureau's advice.[74]

The early conservation laws, such as the 1934 act, did not alter the prevailing situation because they did not place wildlife conservation on an even footing with flood control, hydropower, or navigation in project planning. It was hard to quantify the economic value of wildlife, fish, recreation, or natural scenery. Also, the state and federal conservation agencies had no sanctions or veto power over the Corps, and the Corps had wide discretion to accept or reject recommendations from the conservation agencies. Consequently, conservationists won victories only in collaboration with other interest groups or where the biological or scenic values of a specific area aroused strong local opposition to Corps development plans. During the 1930s conservationists had access to the Corps' planning process but little real influence.

The remarks of the associate chief of the U.S. Biological Survey, Walter Henderson, at a 1936 congressional hearing aptly conveyed conservationists' frustrations with the Corps in the Depression era. He stated that Corps personnel in the Upper Mississippi Division "have shown a desire to cooperate in the interest of wildlife insofar as that is possible without interfering with projects that they have under way. They have adopted our suggestions about wildlife conditions. On the other hand, as a rule, wildlife has been entirely left out of consideration by the Corps. They seldom think about [it] unless it is brought to their attention."[75]

Environmental historian Michael Robinson, after careful study, concluded:

> From the 1920s to the 1950s, an adversarial relationship between the Corps and the conservation community developed. This growing antagonism was exacerbated by the expansion of the Corps' mission to include flood control and power and the attendant environmental changes wrought in river valleys. Frustrated by the planning and authorization process, conservationists eschewed informal cooperation with the Corps and became inclined to seek their objectives through lobbying or by voicing their views at public hearings, to congressmen, and in the press. The size and character of federal water programs offered limited opportunities for cooperation and compromise…. Preserving the specific natural features embraced by conservationists, often would have required the Corps to either abandon projects or seek alternatives that were less economically and hydrologically advantageous.[76]

Since then the Corps of Engineers has come to approach its environmental responsibilities as an integral part of its water resources mission and recognizes that its responsibility to deliver environmentally sound projects and services to the nation touches each of its program areas: military programs, civil works, and research and development.

Jones Photo Historical Collection, No. 15048

Reconstruction of the south jetty at the entrance to Grays Harbor on the Chehalis River in Washington. 21 September 1937.

The Corps and New Deal Planning and Politics

PRESIDENT HERBERT HOOVER carried out a significant internal reorganization of the Corps at the beginning of his term in office in 1929. By his order, the Corps became organized by divisions conforming to river basin boundaries. At the end of his term, President Hoover recommended to Congress a reorganization of the government to bring greater efficiencies to its operations. Among other suggestions, Hoover urged the transfer of river and harbor work from the Corps to a separate public works agency. With unintended irony, an editorial writer in the *Military Engineer* wrote at the time that the "proposed plan has met with great opposition among members of the Congress, most of whom recognize the efficiency and freedom from political influence which has characterized the administration of this work by the Corps of Engineers." In any event, the Democratic-controlled Congress was in no mood to approve such a sweeping proposal from a lame duck Republican president, and it rejected the entire plan. Any future reorganization would be the prerogative of the incoming Democratic president.[77]

The idea of a federal department of public works surfaced periodically during the Roosevelt presidency, and the Corps had to rely on its friends in Congress to defeat the notion. In part, those favoring greater planning in the use and development of the nation's resources kept the proposal alive. The efforts of the New Deal planners on the National Planning Board (1933–1934) and its successors—the National Resources Board (1934–1935), the National Resources Committee (1935–1939), and the National Resource Planning Board (1939–1943)—created considerable anxiety within the Corps. National planning as represented by the National Planning Board was the culmination of intellectual and institutional developments beginning in the 1890s and extending through the 1920s. National planning stemmed from the experiences of academics, social scientists, and businessmen involved in Progressive Era reform, the World War I–era wartime mobilization, and economic stability efforts during the 1920s. By the time of the New Deal, much of the national planning debate centered on public works policy, especially its role in providing work relief. The Corps, as the major provider of public works construction and water resources development, could not escape from the national planning debate.[78]

While the National Planning Board tended to focus on developing a rational long-term policy for resource use, its efforts often collided with the short-term public works projects undertaken by the Corps. New Deal planners were especially interested in multipurpose water planning, and as the Corps engaged in such work it had to rely on its friends in the river and harbor bloc in Congress to protect its independence and control over its program. Many politicians in Congress proved sympathetic to the Corps' continued control of most public works construction and resisted the efforts of the planning agency to reconfigure the federal government's public works program. Conservatives in Congress condemned the resources planning of the National Planning Board and its successors as an unnecessary duplication of the Corps' work in water resources planning and a dangerous promotion of European-style collectivism and centralized command economic planning.

In April 1934 Secretary of War George Dern asserted to President Roosevelt that the Corps, rather than the National Planning Board, was in the best position to carry out planning for comprehensive water resources development on the nation's rivers. After seven years and $10 million worth of studies to produce the 308 reports, Dern felt that the Corps had delivered a credible and comprehensive foundation on which to base future development and specific projects for accomplishing a recommended program. Such an approach, Dern urged, "would keep the work [of water resources development] in the hands of a closely-knit, efficient and continuing agency of the Government, namely, the Corps of Engineers of the Army." In 1940 Maj. Gen. Julian Schley, the chief of engineers, used similar arguments to defeat the efforts of the Water Resources Committee of the National Resources Planning Board to draft a national water policy.[79]

Along with the political struggle over the control of water resources planning, the issue of establishing a federal department of public works also continued to bedevil the Corps. Since the 1880s civil engineers both in and out of government had actively pushed for a federal department of public works. Several bills to accomplish such a goal had been introduced in Congress prior to President Hoover's proposal for a public works department put forward in December 1932, near the end of his presidency. The Corps and its congressional allies had successfully fought to defeat such measures or at least ensure that the Corps' civil works program was specifically excluded from such a consolidated federal public works department.


Office of History, Julian Schley Collection

Col. Julian L. Schley, Commandant of the Engineer School at Fort Belvoir, who later served as Chief of Engineers from 1937 to 1941.

Office of History, Alden K. Sibley Collection

In the 1930s the Corps established laboratories at several of its construction sites, like this concrete lab at the Conchas Dam, to determine the best construction methods and materials to use.

In March 1936 President Roosevelt appointed a committee to investigate executive reorganization; and in January 1937 it recommended creation of a Department of Public Works that would control all federal construction, except the Corps' civil works program. Once again, this proposal, and even a later watered-down version, went nowhere. Secretary of the Interior Harold Ickes believed that the Corps was chiefly responsible for the failure to establish a federal public works department. He wrote in his diary in June 1937, "The two most powerful intragovernment lobbies in Washington are the Forest Service and the Army engineers. I haven't any doubt in the world that they have been busy as hell in spite of the President's orders that no one in the Government service was to lobby against his reorganization bill."[80]

The Corps emerged from its New Deal work and planning battles with its core rivers and harbors mission intact and actually found its total program enhanced through newly added responsibilities for flood control and multipurpose work. Until abolished in 1943, the National Resources Planning Board (and its predecessors) had to defend itself against attacks from the Corps' supporters in Congress, who resisted any efforts by New Deal planners to encroach on the Corps' civil works program and water resources development prerogatives.

As late as 1940, misunderstandings existed between the Corps and the executive branch New Deal planners. The chairman of the National Resources Planning Board, Frederic A. Delano, asked President Roosevelt to intercede on its behalf with certain congressional opponents, including Joseph J. Mansfield, chairman of the House Committee on Rivers and Harbors, who were holding up its budget: "I am

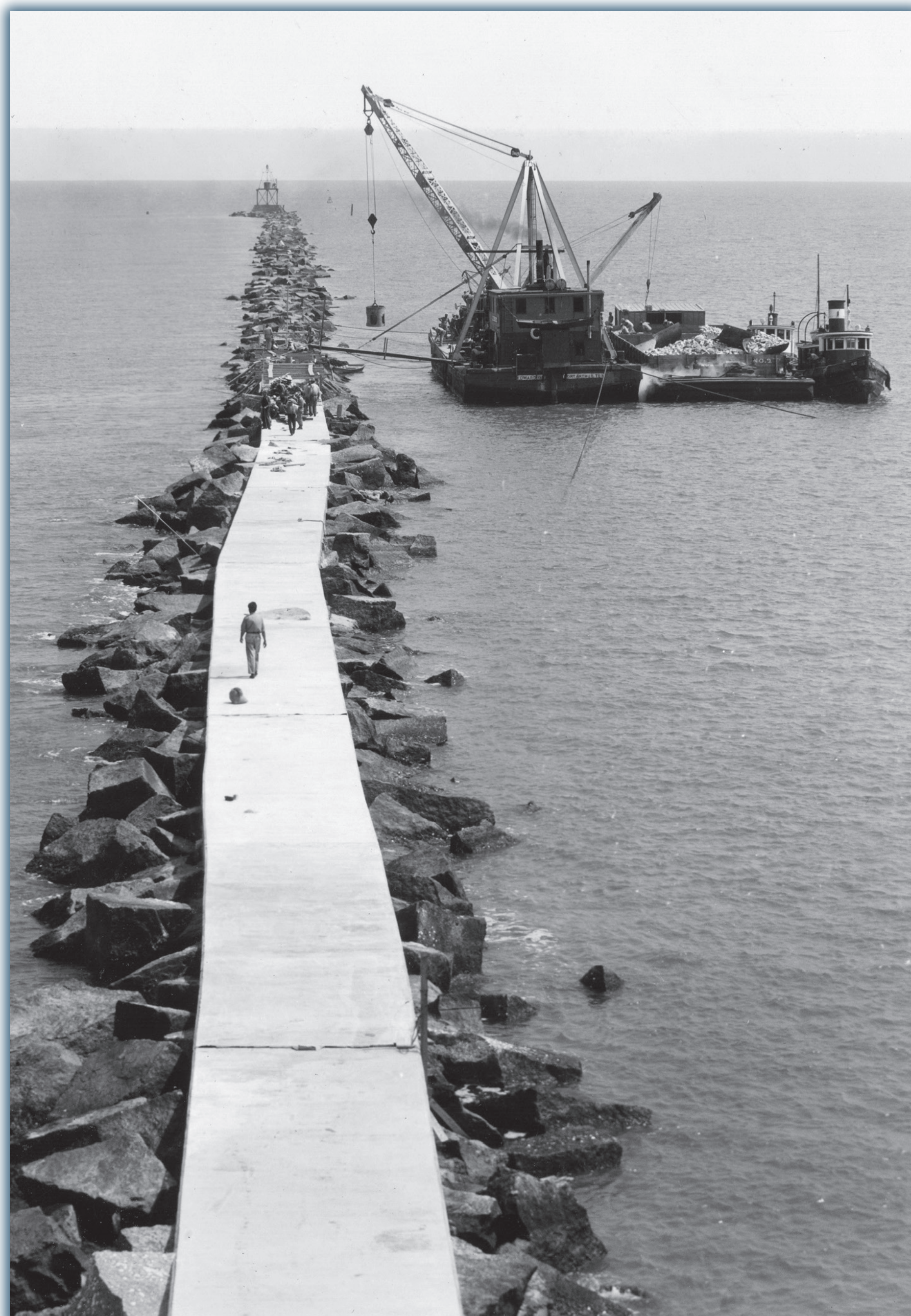
Office of History, Civil Works Image Collection

A contractor pile driving to build the outlet structures of the Sardis Dam in Mississippi. 30 August 1938.

informed that the Rivers and Harbors and Flood Control groups in the House are active in opposition to any appropriation for our work. It has been suggested that if you could talk with Judge Mansfield and Judge Whittington it might be possible to dissipate the fog of misunderstanding as to the relations between the Corps of Engineers and your Resources Planning Board." In response, President Roosevelt then wrote to Congressman William Whittington of Mississippi, influential chairman of the House Flood Control Committee:

> Lest there be any misunderstanding, I can assure you that the work of this National Resources Planning Board interferes in no way with the work of the Army Engineers. Furthermore, this has been stated in writing to the Secretary of the War by the Acting Chief of Engineers, and there is no opposition on the part of the Army Engineers to the coordination of various kinds of public works with the assistance of the National Resources Planning Board. In other words, there is understanding and harmony in the Executive Branch of the Government.[81]

Despite Roosevelt's substantial clout as a two-term and soon-to-be wartime president, Congress never really warmed to the idea of a planning board.



Office of History, Civil Works Image Collection

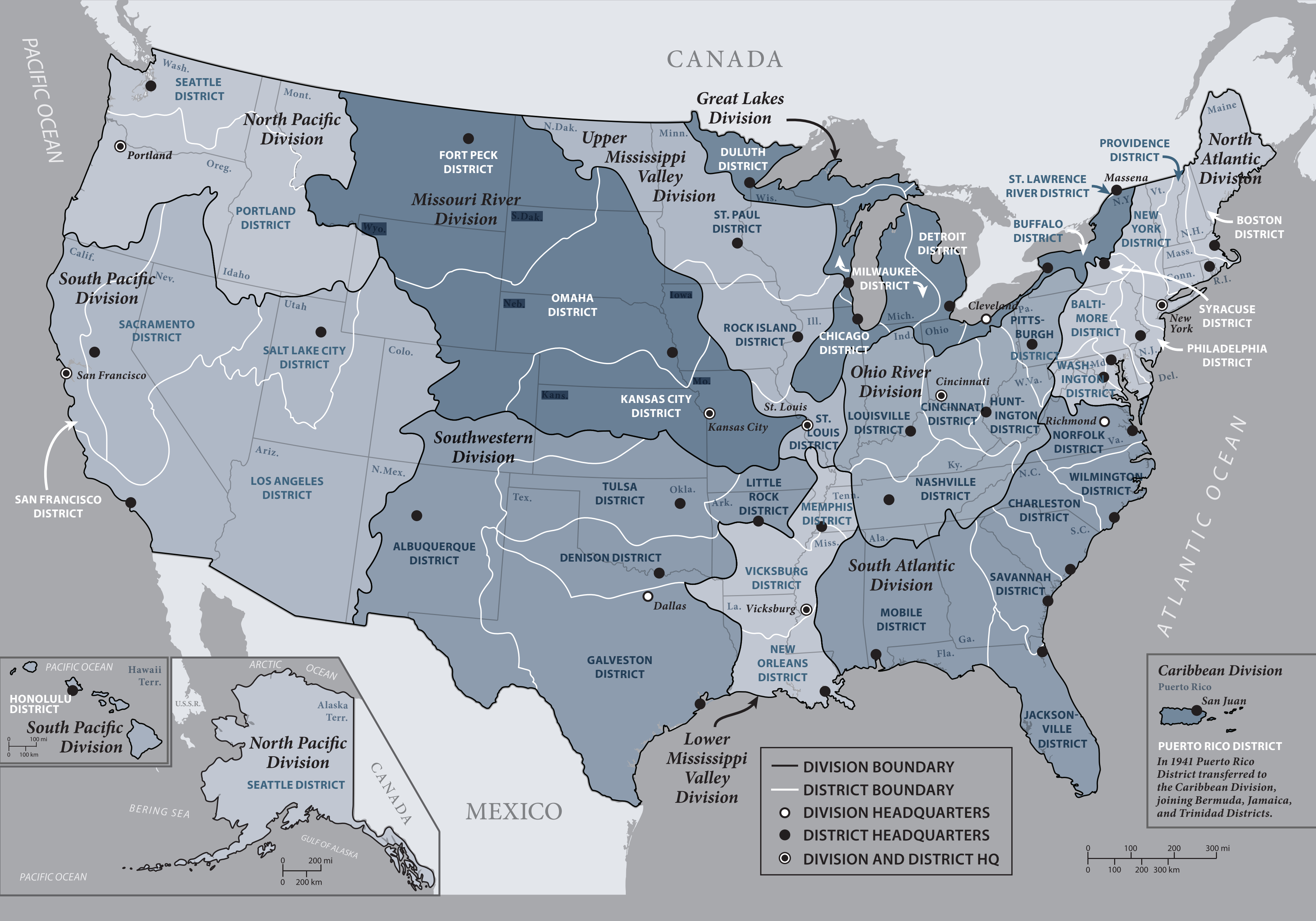
Repairs to a jetty at Sabine Pass near Port Arthur, Texas, by placing a concrete cap. 7 August 1936.

Conclusions

IN RESPONSE TO THE ECONOMIC CRISIS of the 1930s, the federal government engaged in a far-reaching effort to fight high unemployment and restore the economic engine of the nation. The New Deal reformers under President Roosevelt sought to achieve this transformation, in part, through a massive public works program. In the process, the federal government vastly expanded the nation's infrastructure of highways, bridges, dams, airports, and public buildings. In turn, these projects laid the structural foundation for fighting World War II and promoting postwar economic development. The scale of the public works undertakings—especially in the area of water resources projects—was truly exceptional, and the projects required great technical and administrative skill to realize.

The 1930s public works programs proved, in many ways, a watershed for the Corps of Engineers. Based on its extensive experience in civil works construction and its proven management skills, the Corps quickly responded to presidential and congressional orders to fight unemployment with an emergency public works relief program largely under the direction of the Army engineers. The Corps' technical and managerial contribution to the relief effort under the PWA and WPA won it wide praise from Congress and the administration alike. While continuing to plan, build, and operate traditional rivers and harbors projects for navigation, the Corps moved into the planning, design, and construction of multipurpose projects for water resources development. The Corps also received an expanded flood control mission and entered into a large-scale program to construct flood control reservoirs. All of these activities led to ever-larger appropriations and an expansion of agency manpower.

In 1929, at the beginning of the Depression, the Corps of Engineers had approximately twelve thousand civil and military employees organized into eight divisions and forty-two districts. By 1941, after a decade of explosive growth in its relief and civil works activities, the agency numbered approximately twenty-seven thousand civil and military employees in all fields of engineering, law, administration, and



CANADA
PACIFIC OCEAN
ATLANTIC OCEAN
MEXICO
North Pacific Division
SEATTLE DISTRICT
PORTLAND DISTRICT
Portland
South Pacific Division
SACRAMENTO DISTRICT
SAN FRANCISCO DISTRICT
San Francisco
LOS ANGELES DISTRICT
SALT LAKE CITY DISTRICT
Missouri River Division
FORT PECK DISTRICT
OMAHA DISTRICT
KANSAS CITY DISTRICT
Kansas City
Upper Mississippi Valley Division
ST. PAUL DISTRICT
ROCK ISLAND DISTRICT
ST. LOUIS DISTRICT
St. Louis
Great Lakes Division
DULUTH DISTRICT
MILWAUKEE DISTRICT
CHICAGO DISTRICT
DETROIT DISTRICT
BUFFALO DISTRICT
Cleveland
Southwestern Division
ALBUQUERQUE DISTRICT
TULSA DISTRICT
DENISON DISTRICT
Dallas
GALVESTON DISTRICT
LITTLE ROCK DISTRICT
Lower Mississippi Valley Division
MEMPHIS DISTRICT
VICKSBURG DISTRICT
Vicksburg
NEW ORLEANS DISTRICT
Ohio River Division
Cincinnati
CINCINNATI DISTRICT
LOUISVILLE DISTRICT
HUNTINGTON DISTRICT
PITTSBURGH DISTRICT
NASHVILLE DISTRICT
North Atlantic Division
PROVIDENCE DISTRICT
ST. LAWRENCE RIVER DISTRICT
Massena
NEW YORK DISTRICT
BOSTON DISTRICT
SYRACUSE DISTRICT
New York
BALTIMORE DISTRICT
PHILADELPHIA DISTRICT
WASHINGTON DISTRICT
Richmond
NORFOLK DISTRICT
South Atlantic Division
WILMINGTON DISTRICT
CHARLESTON DISTRICT
SAVANNAH DISTRICT
MOBILE DISTRICT
JACKSONVILLE DISTRICT
Wash. Mont. Oreg. Idaho Calif. Nev. Utah Wyo. Colo. Ariz. N.Mex. N.Dak. S.Dak. Neb. Kans. Minn. Iowa Mo. Wis. Ill. Mich. Ind. Ohio Pa. W.Va. Ky. Tenn. Okla. Tex. Ark. Miss. La. Ala. Ga. Fla. S.C. N.C. Va. Md. Del. N.J. N.Y. Vt. N.H. Mass. Conn. R.I. Maine
PACIFIC OCEAN
Hawaii Terr.
HONOLULU DISTRICT
South Pacific Division
ARCTIC OCEAN
U.S.S.R.
Alaska Terr.
North Pacific Division
SEATTLE DISTRICT
BERING SEA
GULF OF ALASKA
CANADA
Caribbean Division
Puerto Rico
San Juan
PUERTO RICO DISTRICT
In 1941 Puerto Rico District transferred to the Caribbean Division, joining Bermuda, Jamaica, and Trinidad Districts.
DIVISION BOUNDARY
DISTRICT BOUNDARY
DIVISION HEADQUARTERS
DISTRICT HEADQUARTERS
DIVISION AND DISTRICT HQ
0 100 200 300 mi
0 100 200 300 km

finance organized geographically into seven divisions and forty-seven districts across the nation. It had responsibility for 1,000 navigation and 380 flood control projects, in addition to the work of the Mississippi River Commission and the California Debris Commission. Its other miscellaneous activities included conducting investigations in support of beach protection and restoration projects, developing and implementing regulations for use of the boundary waters between Canada and the United States, and performing the Lake Survey on the Great Lakes. The Corps also planned projects on its own or in cooperation with other agencies to further hydropower and irrigation development. The Corps' civil works mission in 1940 embraced a truly impressive array of water resources responsibilities.[82]

As it accomplished its water resources mission, the Corps deftly navigated the perennially thorny political relationship between the executive branch and Congress over the direction of the nation's public works program. In doing so, the Army engineers maintained their premier position within the federal government in carrying out such work. In the process, the Corps discouraged the creation of a federal public works agency, which, if established, surely would have diminished the future role of the Corps in the civil works area. Also, during the 1930s the Corps' leadership successfully placated the private construction industry by moving sharply away from hired labor toward a model more heavily reliant on private contractors.

Because of its New Deal role, the Corps certainly developed a much less parochial outlook than it had when the decade of the 1930s began. Its embrace of multipurpose water projects, as exemplified in its planning and execution of the 308 reports, and the assumption of the new nationwide flood control mission forever changed the reach and conduct of the Corps' civil works program. New kinds of construction responsibilities required the Corps to seek advanced technologies and outside scientific expertise in such fields as mechanical and electrical engineering, river hydraulics and hydrology, and soils mechanics. In the search for the most appropriate technical knowledge for planning and constructing water resources

Opposite: The USACE field organization in early 1942. In 1942 there were several short-lived districts that lacked defined borders. Among these were three—at Columbus, Ohio; Atlanta, Georgia; and San Antonio, Texas—that USACE took over from existing Quartermaster construction offices; one at Wright Field in Ohio to manage airfield construction; and one at Arlington, Virginia, to oversee construction of the Pentagon. Excepting only San Antonio District that survived into 1946, USACE disestablished all of these between 1942 and 1944. Change to its field structure was a near constant for USACE during the 1930s and 1940s.

Office of History, Civil Works Image Collection

Workers placing the first riprap on the upstream slope of the East Barre Dam, a flood control project on the Jail Branch River in Vermont. 7 August 1934.

projects during the 1930s, the Corps established and expanded the Waterways Experiment Station and set up district and division soils and hydraulics laboratories in the field. These laboratories played a key role in the continuing work on multipurpose and flood control dams after World War II. In short, the Corps' multifaceted engineering, planning, and administrative roles during the 1930s resulted in the birth of the modern Army Corps of Engineers.

Between 1920 and 1939, the Corps had carried out a $2.5 billion program of navigation, flood control, and fortifications projects, developing the planning and engineering capability necessary to perform in times of emergencies. In particular, the Corps' New Deal–era construction and work relief activity helped to hone the organizational and management skills necessary to swiftly undertake a crucial role in the war mobilization effort after 1940. In addition, the 1930s work had created a well-trained cadre of junior officers primed to assume larger responsibilities in the expanded military construction program assigned to the Army engineers. Clearly, the Corps' nationwide decentralized civil works organization with a proven construction expertise factored in the decision to reassign the military construction mission from the Quartermaster Department to the Corps of Engineers. Beginning in November 1940, the War Department ordered the Corps to build facilities for the Army Air Corps. Thirteen months later, the Corps received responsibility for all construction for the Army's war effort.

The scope of the Corps' mobilization was remarkable. Between 1936 and 1940 the agency's annual construction budget for military and public works averaged $214 million. In 1941 the Corps' workload expanded fivefold to $1.2 billion. The additional work included surveying and construction on Atlantic island military bases, Civil Aeronautics Administration airfields, as well as Army Air Corps bases in Alaska and elsewhere. By June 1942 the war construction program under the Corps' jurisdiction covered more than 1,678 individual construction jobs at an estimated cost of $7.6 billion and employed almost 900,000 contractor personnel.[83] The massive needs of the war effort temporarily displaced much of the Corps' civil works program. After 1945, however, the Corps of Engineers picked up where it had left off and, over the next twenty-five years, completed much of the multipurpose and flood control work initiated during the 1930s but interrupted by the war. This amounted to almost four hundred multipurpose reservoirs by 1970, when fiscal and environmental challenges brought an end to the Big Dam Era and set the Corps of Engineers on a new path that, by and large, represented a clean break with its New Deal legacy.

Office of History, Civil Works Image Collection

Workers move a 60-inch pipe into position in a relocated sewer tunnel under the Los Angeles River as part of a channel improvement project. 30 June 1939.

Appendices

EMERGENCY RELIEF APPROPRIATIONS AND THE CORPS' CIVIL WORKS PROJECTS THEY FUNDED

WHILE PREPARING THIS MANUSCRIPT, the Office of History sought to include information on USACE funding and workforce levels to show how they were impacted by the emergency relief measures taken to combat the Great Depression. The focus was on the years of the Depression, but some tables present data from years prior and from years later after the U.S. entry into World War II. In addition, although relief measures undertaken by the Corps of Engineers were mainly conducted through civil works programs, some information on military activities is included for comparison.

No single source of these statistics presented itself. The bulk of this material derives from four types of government document: the Annual Reports of the Chief of Engineers on the Corps of Engineers' civil works activities, similar reports on its military activities, congressional appropriation acts, and congressional budget documents. Sources are noted throughout. The subject matter is complex, and the sources are sometimes vague and incomplete. Reporting formats were inconsistent and changed over time. Every attempt has been made to present the data accurately. Nevertheless, anomalies and discrepancies did arise and are addressed in the notes.

Between 1930 and 1938, in the depths of the Great Depression, Congress passed a variety of emergency relief acts to address high levels of unemployment. Eight of these acts (or nine, depending on how you count) appropriated funds that Congress or the president allotted to the Corps of Engineers for Rivers & Harbors or Flood Control projects intended to increase employment and stimulate the economy. These appendices present statistics related to the emergency relief work the Corps undertook during these years.

Once the public works program began in earnest in 1933, these emergency appropriations became the primary funds that the Corps expended each year for civil works. Up until about 1937, fiscal policy dictated that operations under the regular appropriations were limited to "the completion of contracts previously entered into and those necessary for maintenance and similar current operations, new undertakings being provided under the public-works program."[A] As a result, the Annual Reports of the Chief of Engineers sometimes lamented, "many items of work urgently needed for navigation, but so located that they did not meet employment relief requirements, have had to be deferred."[B]

A random check of some of the Rivers & Harbors projects that received emergency relief funds reveals that most were pre-existing projects, previously authorized by congressional acts and in various states of completion. There were exceptions. Some of the larger projects were entirely new, authorized as part of the public works relief effort. These include Bonneville, Fort Peck, and Tygart dams. In contrast, because Congress had authorized very few Flood Control projects prior to the Depression (e.g., the Mississippi River and its tributaries and Sacramento River), most Flood Control projects receiving relief funds were new projects. Funds used for the Office of the Chief of Engineers and administrative expenses are counted here as one "project."

It is worth noting in the annual reports that the Emergency Fund for Flood Control on Tributaries of the Mississippi River was not a public works unemployment relief appropriation or program. The term "emergency" here referred to natural disaster emergencies rather than the economic emergency of the period. This program arose following the devastation of the 1927 flood and was described as an emergency fund provided for the repair and maintenance of flood-control works on any tributaries of the Mississippi threatened or destroyed by floods.

[A] Annual Report of the Chief of Engineers [ARCE] 1933, 4-5.
[B] ARCE 1935, 4.

APPENDIX A: THE EMERGENCY APPROPRIATION ACTS THAT FUNDED CORPS ACTIVITIES

Emergency Construction Act (ECA) 12/20/1930

An act making supplemental appropriations to provide for emergency construction on certain public works during the remainder of the fiscal year ending June 30, 1931, with a view to increasing employment. [Statutes 71st Cong., 3d Sess.]

Emergency Relief & Construction Act (ERCA) 7/21/1932

An act to relieve destitution . . . and to create employment by providing for and expediting a public-works program. [Statutes 72d Cong., 1st Sess.]

National Industrial Recovery Act (NIRA) 6/16/1933

An act to encourage national industrial recovery, to foster fair competition, and to provide for the construction of certain useful public works and for other purposes. . . . Provided, that no river or harbor improvements shall be carried out unless they shall have heretofore or hereafter been adopted by the Congress or are recommended by the Chief of Engineers of the United States Army. [Statutes 73d Cong., 1st Sess.]

Emergency Appropriation Act (EAA or PWA) 6/19/1934

For an additional amount ($900m) for carrying out previous acts: "An Act for the relief of unemployment through the performance of useful public work" of 31 March 1933; the Federal Emergency Relief Act of 12 May 1933; the TVA Act of 18 May 1933; and the NIRA of 16 June 1933. [Statutes 73d Cong., 2d Sess.]

Emergency Relief Appropriation Act of 1935 (ERA35) 4/8/1935

Joint Resolution making appropriations for relief purposes.
[Statutes 74th Cong., 1st Sess.]

Emergency Relief Appropriation Act of 1936 (ERA36) 6/22/1936

To continue to provide relief and work relief on useful projects. Corps work limited to flood control. [Statutes 74th Cong., 2d Sess.]

Emergency Relief Appropriation Act of 1937 (ERA37) 6/29/1937

Making appropriations for relief purposes. Work relief on useful public projects. Corps work limited to flood control. [Statutes 75th Cong., 1st Sess.]

Work Relief and Public Works Appropriation Act of 1938 6/21/1938

Making appropriations for work relief, relief, and otherwise to increase employment by providing loans and grants for public works projects.
[Statutes 75th Cong., 3d Sess.]

Title I: Emergency Relief Appropriation Act of 1938 (ERA38)

Title II: Public Works Administration Appropriation Act of 1938 (PWA38)

APPENDIX B: FUNDING BY FISCAL YEAR ON CIVIL WORKS

This table presents the dollar amounts appropriated each fiscal year (ending 30 June) for the Corps of Engineers' civil works program from regular appropriations and from emergency relief acts, as enumerated in the Annual Reports of the Chief of Engineers. The sum of these yearly figures, however, does not equal the figure that is reported in the late 1940s as the final total amount of emergency relief funds received. It's possible that adjustments for rescissions and reimbursements were made only to the cumulative total and were not reflected retroactively in the annual figures previously reported. It is the final, cumulative figure ($517,670,122.17) that seems the more reliable.

Fiscal Year	Regular Funds Made Available [A]	Funds from Emergency Relief Acts	Total Funds
1929	$93,578,876.62	0	$93,578,876.62
1930	$112,078,906.47	0	$112,078,906.47
1931	$105,086,117.26	[B] $25,500,000.00	$130,586,117.26
1932	$102,294,370.72	$45,500,000.00	$147,794,370.72
1933	$59,085,656.66	0	$59,085,656.66
1934	$59,719,208.96	$249,110,752.84	$308,829,961.80
1935	$57,943,197.98	$205,921,533.84	$263,864,731.82
1936	$186,202,238.16	$23,420,599.92	$209,622,838.08
1937	$234,614,262.42	$17,635,781.87	$252,250,044.29
1938	$219,136,222.28	(-$26,506,619.89)	$192,629,602.39
1939	$282,570,396.68	$6,605,445.13	$289,175,841.81
1940	$180,644,545.35	(-$503,077.91)	$180,141,467.44
1941	$242,554,625.73	(-$2,695,975.30)	$239,858,650.43
1942	[C] $381,130,196.99	$647,724.34	$381,777,921.33
1943	[D] $161,643,432.97	(-$108,716.10)	$161,534,716.87
1944	[E] $197,400,152.20	*no activity*	$197,400,152.20
1945	$135,340,881.10	(-$27,311.82)	$135,313,569.28
1946	$455,663,875.58	(-$10.74)	$455,663,864.84
	Sum of yearly figures	$544,500,126.18	
	Sum reported as final total as of 30 Jun 1946 in annual reports	$517,670,122.17	

[A] Regular and special appropriations, deficiency acts, special funds, trust funds, transfer/working funds, exclusive of emergency appropriation acts for unemployment relief and generally meant to be expended the following fiscal year
[B] The projects on which these emergency funds were spent are listed in the 1933 Budget document beginning on p. 172. Later projects are also listed by emergency appropriation in later Budget documents (e.g., see 1936 Budget, p. 647).
[C] Includes $108,327,093.34 for landing areas for national defense (under the Administrator of Civil Aeronautics)
[D] Includes $54,975,279.64 for landing areas for national defense
[E] Includes $15,000,000.00 for landing areas for national defense

APPENDIX C: CUMULATIVE FUNDING OF THE CORPS' EMERGENCY RELIEF / PUBLIC WORKS PROGRAM

This table presents the cumulative amounts of funding from the various emergency relief acts applied to three broad categories of civil works projects as reported in the Annual Reports of the Chief of Engineers (ARCE). These amounts could increase from year to year if additional funds were appropriated or allotted under a particular act. These figures could decrease when unobligated funds were rescinded or when reimbursements were applied to various projects. Occasionally the Corps would reclassify a project from one category to another. In the 1930s, the Corps reported these cumulative totals as of October each year even though appropriations were linked to the fiscal year, which at that time ended on 30 June. Therefore, the annual increases in the cumulative total do not match that year's allotments because the 12-month reporting periods do not coincide.

The Emergency Appropriation Act (EAA) and Public Works Administration Act (PWA) refer to the same act of 19 June 1934. The Emergency Relief Acts (ERA) were distinct appropriations in 1935, 1936, 1937, and 1938. See abbreviations in Appendix A.

The specific projects that received these allotted funds in years 1931-1938 and the new projects that received funds in 1939 are listed by name in the annual reports for these years.

There was no activity on these accounts during fiscal year 1944. Rescissions in 1945 were applied to the Fort Peck Dam project and reimbursements were applied to "miscellaneous" rivers and harbors projects under the National Industrial Recovery Act (NIRA) and PWA. A mere $10.74 was reimbursed on the PWA account in fiscal year 1946, the last reported transaction involving emergency relief funds. The reports show no changes in fiscal years 1947 through 1950. The accounts are no longer reported as of the fiscal year 1951 annual report.

As of Date	Rivers & Harbors	Flood Control	Other / Misc.	Total
15 Oct 1933	[A] $145,202,808.00	[B] $47,175,000.00	0	$192,377,808.00
15 Oct 1934				
NIRA	$181,471,208.00	$67,932,000.00	$7544.84	$249,410,752.84
EAA/PWA	$93,818,000.00	$46,000.00	0	$93,864,000.00
Total	$275,289,208.00	$67,978,000.00	$7544.84	[C] $343,274,752.84

As of Date	Rivers & Harbors	Flood Control	Other / Misc.	Total
15 Oct 1935				
NIRA	$183,556,263.83	$67,631,833.84	$1,614,489.01	$252,802,586.68
EAA/PWA	[D] $94,653,000.00	$46,000.00	$109,200.00	$94,808,200.00
ERA35	$122,798,500.00	$22,353,669.00	$564,000.00	$145,716,169.00
Total	$401,007,763.83	$90,031,502.84	$2,287,689.01	$493,326,955.68
15 Oct 1936				
[E] NIRA	$183,543,975.46	$71,115,744.27	$1,705,989.01	$256,365,708.74
[F] EAA/PWA	$93,766,959.22	$34,231.20	$129,200.00	$93,930,390.42
[G] ERA35	$111,688,856.11	$19,246,321.89	$349,000.00	$131,284,178.00
[H] ERA36	0	$16,193,686.00	0	$16,193,686.00
Total	$388,999,790.79	$106,589,983.36	$2,184,189.01	$497,773,963.16
15 Oct 1937				
[E] NIRA	$183,508,792.71	$72,767,244.27	$1,654,489.01	$257,930,525.99
[F] EAA/PWA	$93,653,854.08	$54,231.20	$109,200.00	$93,817,285.28
[G] ERA35	$103,807,657.29	$20,272,844.32	$6,440,208.96	$130,520,710.57
[H] ERA36	0	$10,188,358.87	$11,395.47	$10,199,754.34
ERA37	0	$19,942,119.49	0	$19,942,119.49
Total	$380,970,304.08	$123,224,798.15	$8,215,293.44	$512,410,395.67
01 Oct 1938				
NIRA	$183,505,092.71	$72,763,887.60	$1,654,489.01	$257,923,469.32
EAA/PWA	[J] $94,253,854.08	$54,196.70	$109,200.00	$94,417,250.78
ERA35	$103,783,388.95	$20,264,642.19	$6,440,208.96	$130,488,240.10
ERA36	0	$10,174,912.63	$11,395.47	$10,186,308.10
ERA37	0	$22,854,105.89	$7,592.70	$22,861,698.59
Total	$381,542,335.74	$126,111,745.01	$8,222,886.14	[K] $515,876,966.89
01 Oct 1939				
NIRA	$183,504,464.73	$72,763,887.60	$1,654,489.01	$257,922,841.34
EAA/PWA	$94,253,821.31	$3,054,196.70	$109,200.00	$97,417,218.01
ERA35	$103,616,999.57	$20,233,074.57	$6,381,829.09	$130,231,903.23
ERA36	0	$10,174,378.29	$11,395.47	$10,185,773.76
ERA37	0	$21,792,899.10	$7,592.70	$21,800,491.80
ERA38	0	$3,308,208.64	0	$3,308,208.64
Total	$381,375,285.61	$131,326,644.90	$8,164,506.27	$520,866.436.78

As of Date	Rivers & Harbors	Flood Control	Other / Misc.	Total
30 Jun 1940				
NIRA	$183,504,464.73	$72,763,887.60	$1,654,489.01	$257,922,841.34
EAA/PWA	$94,205,142.23	$3,054,196.70	$109,200.00	$97,368,538.93
ERA35	$103,617,279.39	$20,233,085.63	$6,381,889.19	$130,232,254.21
ERA36	0	$10,174,481.54	$11,395.47	$10,185,877.01
ERA37	0	$21,792,899.10	$7,592.70	$21,800,491.80
ERA38	0	$2,999,707.14	0	$2,999,707.14
Total	$381,326,886.35	$131,018,257.71	$8,164,566.37	$520,509,710.43
30 Jun 1941				
NIRA	$183,504,464.73	$72,763,887.60	$1,654,489.01	$257,922,841.34
EAA/PWA	$94,200,442.23	$3,054,196.70	$109,200.00	$97,363,838.93
ERA35	$103,611,847.93	$20,126,260.66	$6,384,626.59	$130,122,735.18
ERA36	0	$10,174,168.50	$11,395.47	$10,185,563.97
ERA37	0	$19,211,455.87	$7,592.70	$19,219,048.57
ERA38	0	$2,999,707.14	0	$2,999,707.14
Total	$381,316,754.89	$128,329,676.47	$8,167,303.77	$517,813,735.13
30 Jun 1942				
NIRA	$183,504,464.73	$72,763,887.60	$1,654,489.01	$257,922,841.34
EAA/PWA	$94,200,442.23	$3,054,196.70	$109,200.00	$97,363,838.93
ERA35	$103,611,607.21	$20,074,637.79	$6,384,393.74	$130,070,638.74
ERA36	0	$10,174,116.53	$11,395.47	$10,185,512.00
ERA37	0	$19,211,349.12	$7,592.70	$19,218,941.82
ERA38	0	$2,999,686.64	0	$2,999,686.64
Total	$381,316,514.17	$128,277,874.38	$8,167,070.92	$517,761,459.47
[L] 30 Jun 1943				
NIRA	$183,503,960.55	$72,763,886.60	$1,654,489.01	$257,922,336.16
EAA/PWA	$94,197,796.57	$3,054,196.70	$109,200.00	$97,361,193.27
ERA35	$103,611,607.21	$20,074,637.79	$6,384,393.74	$130,070,638.74
ERA36	0	$10,174,116.53	$11,395.47	$10,185,512.00
ERA37	0	$19,911,349.12	$7,592.70	$19,918,941.82
ERA38	0	$2,238,822.74	0	$2,238,822.74
Total	$381,313,364.33	$128,217,009.48	$8,167,070.92	$517,697,444.73
30 Jun 1944	-	-	-	$517,697,444.73
30 Jun 1945	(-$27,311.82)	0	0	$517,670,132.91
30 Jun 1946	(-$10.74)	0	0	$517,670,122.17
30 Jun 1947	-	-	-	$517,670,122.17

As of Date	Rivers & Harbors	Flood Control	Other / Misc.	Total
Final Totals 1947				
NIRA	$183,494,754.83	$72,763,886.60	$1,654,489.01	$257,913,130.44
EAA/PWA	$94,179,679.73	$3,054,196.70	$109,200.00	$97,343,076.43
ERA35	$103,611,607.21	$20,074,637.79	$6,384,393.74	$130,070,638.74
ERA36	0	$10,174,116.53	$11,395.47	$10,185,512.00
ERA37	0	$19,911,349.12	$7,592.70	$19,918,941.82
ERA38	0	$2,238,822.74	0	$2,238,822.74
Grand Total	$381,286,041.77	$128,217,009.48	$8,167,070.92	$517,670,122.17

Sources: Annual Reports of the Chief of Engineers: 1933, 4-6, 13; 1934, 5-7, 14; 1935, 4, 6-8; 1936, 6-9; 1937, 4, 7-12; 1938, 3, 9-15; 1939, 12-13; 1940, 10-11; 1941, 12-13; 1942, 10; 1943, 13; 1944, 14; 1945, 13-14; 1946, 12-13; 1947, 15-16.

[A] Includes $20,250,000 for Bonneville Dam & Power Plant
[B] Includes $1,550,000 for Winooski River, Vermont, completion of flood control project after termination of work by Civilian Conservation Corps
[C] Total does not include $1.5m NIRA for Puerto Rico roads & drainage and $20k EAA for Dalecarlia Reservoir in Washington, D.C. There is an unexplained discrepancy of $300,000 in the totals reported on p. 4 and p. 9 and those reported on pp. 6-7 of the 1934 ARCE.
[D] There is an unexplained discrepancy of $20,000 in the EAA/PWA figures reported for FY 1935 on p. 8 and p. 10 of the 1935 ARCE. This table uses the higher number, $94,653,000.00.
[E] Between 1936 and 1937, the $39,500 for surveys at Kansas City and the $12,000 for a model of Kansas City rivers (both NIRA) were reclassified from Misc. to Flood Control projects.
[F] Between 1936 and 1937, the $20,000 for James and Sheyenne Rivers, S. Dak. (EAA), was reclassified from a Misc. to a Flood Control project.
[G] Between 1936 and 1937, the nearly $7 million for the Passamaquoddy power project was reclassified from a Rivers & Harbors to a Misc. project.
[H] Between 1936 and 1937, the approximately $11,400 for repair of Conduit Road, Md. (ERA36), was reclassified from a Flood Control to a Misc. project.
[J] Includes $600,000 allocated from the PWA act of 1938
[K] In addition, $643,000 from the Emergency Relief Act of 1938 was added to two Connecticut River projects, bringing the total to $516,519,966.89.
[L] In the FY 1941 report, Flood Control funds in the amount of $700,000 were incorrectly rescinded from the 1937 act instead of the 1938 act. The correction is made in the FY 1943 report and is reflected in this table. A typographical error in the FY 1940 report in the figures reported for Rivers & Harbors under the PWA act (a difference of $90) is also corrected in the FY 1943 report.
There is an unexplained discrepancy of $44,701.36 between the rescissions listed on p. 13 and those on p. 14 of the 1943 ARCE.

APPENDIX D: NUMBER OF USACE PROJECTS

The table below presents the number of civil works projects funded by the several emergency relief appropriations as of a particular date each year and as listed in the Annual Reports of the Chief of Engineers (ARCE).

Because most of this table shows the number of projects in the program as of October of each year, the figures do not necessarily correspond to the annual reporting on the number of projects seeing financial activity each fiscal year, as at that time the fiscal year ended on 30 June.

The funding levels for the projects listed here ranged from a few thousand dollars each to tens of millions. Projects, initially classified as one of three categories—Rivers & Harbors (RH), Flood Control (FC), and Miscellaneous—were occasionally reclassified from one year to the next and some were defunded and then later funded again from a different appropriation. Beginning in 1939, the annual report dispensed with a cumulative list of emergency relief projects and only listed those projects that had financial activity during that year, resulting in an incomplete roster of projects under way, completed, or new. Instead, emergency relief projects were discussed individually in the sections of the reports devoted to the various engineer districts. Only the ten projects receiving funds from the 1938 appropriation in FY 1939 were reported and are listed here.

Appropriation	Project Type	1931	1932	1933	1934	1935	1936	1937	1938	1939
		30 Jun	21 Jul	15 Oct	15 Oct	15 Oct	15 Oct	15 Oct	01 Oct	01 Oct
ECA	RH [A]	151	-	-	-	-	-	-	-	
ECA	FC [A]	1	-	-	-	-	-	-	-	
ERCA	RH [A]	-	51	-	-	-	-	-	-	
ERCA	FC [A]	-	3	-	-	-	-	-	-	
NIRA	RH	-	-	92	90	70	71	71	71	
NIRA	FC	-	-	4	5	4	4	6	5	
NIRA	Misc.	-	-	1	2	5	5	3	3	
PWA (aka EAA)	RH	-	-	-	1	2	1	1	1	
PWA (aka EAA)	FC	-	-	-	1	1	1	2	2	
PWA (aka EAA)	Misc.	-	-	-	1	0	1	0	0	

Appropriation	Project Type	1931	1932	1933	1934	1935	1936	1937	1938	1939
		30 Jun	21 Jul	15 Oct	15 Oct	15 Oct	15 Oct	15 Oct	01 Oct	01 Oct
NIRA + PWA	RH	-	-	-	26	19	18	19	20	
NIRA + PWA	Misc.	-	-	-	-	1	1	1	1	
ERA35	RH	-	-	-	-	27	25	24	25	
ERA35	FC	-	-	-	-	27	29	27	28	
ERA35	Misc.	-	-	-	-	3	2	1	1	
NIRA + PWA + ERA35	RH	-	-	-	-	17	18	19	18	
NIRA + ERA35	RH	-	-	-	-	8	9	9	6	
ERA36	FC	-	-	-	-	-	32	12	11	
ERA36	Misc.	-	-	-	-	-	0	0	1	
ERA35 + ERA36	FC	-	-	-	-	-	1	0	0	
ERA37	FC	-	-	-	-	-	-	35	73	
ERA37	Misc.	-	-	-	-	-	-	-	1	
NIRA + ERA37	FC	-	-	-	-	-	-	-	1	
ERA35 + ERA37	FC	-	-	-	-	-	-	6	5	
ERA36 + ERA37	FC	-	-	-	-	-	-	15	17	
ERA35 + 36 + 37	FC	-	-	-	-	-	-	1	1	
ERA38	FC	-	-	-	-	-	-	-	-	3
PWA38	FC	-	-	-	-	-	-	-	-	4
PWA38 + previous	FC	-	-	-	-	-	-	-	-	3
Total		152	54	97	126	184	218	252	291	10
Rivers & Harbors		151	51	92	117	143	142	143	141	
Flood Control		1	3	4	6	32	67	104	143	
Miscellaneous		0	0	1	3	9	9	5	7	

Sources: Annual Reports of the Chief of Engineers: 1931, 16-18; 1932, 22-23; 1933, 4-6; 1934, 5-7; 1935, 6-8; 1936, 6-9; 1937, 7-12; 1938, 9-15; 1939, 11-13.

[A] These were existing projects only and not yet considered part of the "public works program."

APPENDIX E: WORKFORCE TYPE AND DIRECT RELIEF EMPLOYMENT

This table presents the percentage of Corps work done by contract and that performed by hired labor using government equipment under supervision of Corps of Engineers employees. It also presents the number of people employed each year as a result of the spending by the Corps. The employment figures represent direct employment; indirect employment being excluded. Direct employment presumably meant persons employed by the Corps or by contractors on specific projects. Indirect employment probably referred to jobs that arose as a result of the increased economic activity and spending, such as with suppliers of goods used on the projects or merchants benefiting from the purchasing power of the direct hires. The report of 1936 specifically mentioned the "improvement of conditions in the heavy construction industry," for example (p. 4). The report authors sometimes claimed that indirect employment was "at least as great" as the direct employment the Corps' projects engendered, but they did not provide estimates. These figures derive from the Annual Reports of the Chief of Engineers.

Fiscal Year (Jul-Jun)	% by contract	% by hired labor	Estimated average yearly workforce (including contractors' employees)
1930	n/a	n/a	n/a ("thousands")
1931	55.4	44.6	40,000+ men [A]
1932	56.6	43.4	40,000+ men
1933	56.9	43.1	48,000+ men
1934	62.6	37.4	70,000 men
1935	67.4	32.6	62,000 men
1936	60.9	39.1	75,000 men
1937	57.8	42.2	68,000 men
1938	57.7	42.3	64,000 men
1939	n/a	n/a	204,000,000 man-hours [B]
1940	54.4	45.6	256,000,000 man-hours
1941	69.7	30.3	341,461,000 man-hours
1942	62.4	37.6	n/a

[A] Increased direct employment on the work provided by the 20 Dec. 1930 special appropriation of $25.5 million for unemployment relief reached a maximum of 10,766 in April. The allocation of these funds by project is listed in the 1933 Budget document, p. 172.
[B] In 1939 the annual reports switched from reporting the number of "men" employed to reporting the number of "man-hours" of work created without supplying the formula used to convert one into the other.

APPENDIX F: CIVILIAN WORKFORCE OF THE U.S. ARMY CORPS OF ENGINEERS

The following table presents figures on the size of the civilian workforce of the Corps of Engineers as reported in federal budget documents.

Personnel are categorized, where possible, as those assigned to military works (MW) or those assigned to civil works (CW) and those working at the Office of the Chief of Engineers (OCE) in Washington (equivalent to Headquarters) and those working at locations in the field. The budget documents detail the various job titles of the personnel and the numbers of positions for each.

For years 1928 through 1936, employees in this table are those funded by regular appropriations and contributions each fiscal year. Figures do not include any additional personnel or salaries deriving from emergency appropriations intended to alleviate unemployment, except for the 20 December 1930 and 21 July 1932 Emergency Relief & Construction Acts, funds from which were applied to existing, ongoing projects. The amounts of funds paid for "personal services" (i.e., personnel) out of each emergency appropriation (e.g., NIRA) are listed in the Budget documents but not the number of individuals receiving those amounts. In the 1939 and 1942 budget documents, covering years 1937–1942, numbers of employees paid with emergency relief funds are listed and included here.

Except for years 1928, 1929, and 1930, the actual numbers of temporary employees are not given in the budget documents, only the total dollar amount expended on such employees. The sum of the salaries paid each year to permanent employees is divided by the number of permanent employees to give an average salary per employee. This average is then divided into the total sum paid to temporary employees to determine a rough estimate of the number of full-time equivalent personnel employed on a temporary basis that year. The actual numbers of temporary employees for 1928–1930 are recorded here. It appears that temporary employees worked only in the field.

After January 1941, airport construction (civil) was assigned to the Corps of Engineers, requiring an increase in the workforce. The workforce would again expand after the 16 December 1941 transfer of Quartermaster Corps construction work to the Engineers and with wartime mobilization.

Date	Permanent Employees					Temporary Employees	
	HQ-OCE		Field		Total	Field	
	MW	CW	MW	CW		MW	CW
FY 1928	64.6	78.7	182.6	12,686.2	13,012.1	6.9	8906.4
FY 1929	64	93	184	11,568	11,909.0	5.3	10,073
FY 1930	61	93	178	11,934	12,266.0	5.7	11,363
FY 1931	58.9	103.8	178.2	11,687.1	12,028.0	2.7	8369.8
FY 1932	58	105	192.8	11,347	11,702.8	1.3	7290.4
FY 1933	58	108	191	10,999	11,356.0	2.7	5432.4
FY 1934	57	102.1	112.5	10,412.9	10,684.5	0.2	5328.9
FY 1935	57	107	113.9	10,492	10,769.9	0.72	5171.3
FY 1936	57	107	113.9	10,665	10,942.9	2.7	4672.7
FY 1937	57	158	113.2	20,509.4	20,837.6	1.8	3356.8
FY 1938	61	325	115.4	23,413	23,914.4	2.4	19,741.8
FY 1939	61	325	115.4	21,483	21,984.4	2.4	21,482.7
FY 1940	77.4	249.9	168.9	26,486.7	26,982.9	0	10,555.6
FY 1941	439	299	539	26,697	27,974.0	14.6	7507.4

Sources:

- 1928-1930: Annual Budget 1930 (wherein figures for 1928 are actual and those for 1929 and 1930 are estimates: p. 1060 (OCE MW); p. 1126–1131 (Field MW); p. 1198–1200 (OCE CW); p. 1195–1222 (Field CW). In the list of job titles, some positions are reported as fractions, such as 3.2 draftsmen or 13.8 assistant clerks.
- 1931-1933: Annual Budget 1933 (wherein figures for 1931 are actual and those for 1932 and 1933 are estimates): p. 542 (OCE MW); p. 567–569 (Field MW); p. 596–598 (OCE CW); p. 594–617 (Field CW).
- 1934-1936: Annual Budget 1936 (wherein figures for 1934 are actual and those for 1935 and 1936 are estimates): p. 596–597 (OCE MW); p. 624 (Field MW); p. 645–646 (OCE CW); p. 653–655 (Field CW).
- 1937-1939: Annual Budget 1939 (wherein figures for 1937 are actual and those for 1938 and 1939 are estimates): p. 650 (OCE MW); p. 676–677 (Field MW); p. 142–143, 704 (OCE CW); p. 698–707 (Field CW).
- 1940-1941: Annual Budget 1942 (wherein figures for 1940 are actual and those for 1941 are estimates): p. 842 (OCE MW); p. 824–825 (Field MW); p. 856 (OCE CW); p. 851–857 (Field CW).

Notes

1. President Hoover, a professional engineer, ordered the reorganization of the Corps into eight divisions, in part, to better support canalization of the Upper Mississippi River with locks and dams from St. Paul to St. Louis—a favorite project of his. He appointed Maj. Gen. Lytle Brown to carry out this reorganization. Hoover later urged the transfer of river and harbor work from the Corps to a new public works agency. Leland R. Johnson, *The Ohio River Division, U.S. Army Corps of Engineers: The History of a Central Command* (Cincinnati: Ohio River Division, U.S. Army Corps of Engineers, 1992), 115. *See also* Hoover, State of the Union Address, 8 December 1931, 594; Hoover, The President's News Conference of 29 December 1931, 652; Hoover, Special Message to Congress on Reorganization of the Executive Branch, 9 December 1932, 882-91; all in *Public Papers of the Presidents of the United States* (Washington, D.C.: Office of the Federal Register, National Archives and Records Service, 1977). Copies of some of these Hoover materials and additional ones are in the U.S. Army Corps of Engineers, Headquarters, Office of History (CEHO), Research Collection, Alexandria, Va. [hereafter CEHO]; *see* Civil Works, Reorganization, Series III, Boxes 1–2.
2. David P. Billington and Donald C. Jackson, *Big Dams of the New Deal Era: A Confluence of Engineering and Politics* (Norman: University of Oklahoma Press, 2006), 71–101. The finished studies became known as the "308 reports," named after the number of the House of Representatives document containing the Corps' original survey estimates. Seven reports were never published. *See also* www.iwr.usace.mil/library/IWR-library/308-reports-series (accessed Oct. 27, 2016).
3. For background on the Depression and the New Deal response, see David M. Kennedy, *Freedom from Fear: The American People in Depression and War, 1929–1945* (New York: Oxford University Press, 1999), especially pp. 54–59 for Hoover's role in combating the early stages of the Depression; Robert S. McElvaine, *The Great Depression: America, 1929–1941* (New York: Three Rivers Press, 2009); Elliot A. Rosen, *Roosevelt, the Great Depression, and the Economics of Recovery* (Charlottesville: University of Virginia Press, 2005); William E. Leuchtenburg, *Franklin D. Roosevelt and the New Deal* (New York: Harper & Row, 1963); Richard Lowitt, *The New Deal and the West* (Norman: University of Oklahoma Press, 1993); Phillip Payne, *Crash! How the Economic Boom and Bust of the 1920s Worked* (Baltimore, Md.: Johns Hopkins University Press, 2015); and Jason Scott Smith, *A Concise History of the New Deal* (New York, Cambridge University Press, 2014). Each book contains excellent bibliographies for further study.
4. Quote in Kennedy, *Freedom from Fear*, 57–58; much of the background material in this and succeeding paragraphs of this section is based on Martin K. Gordon, "The U.S. Army Corps of Engineers and the Great Depression of 1929," Draft History, CEHO; *Annual Report of the Chief of Engineers, 1928–1940* [hereafter *ARCE*]; and Martin Reuss and Paul K. Walker, *Financing Water Resources Development: A Brief*

History (Washington, D.C.: Historical Division, Office of the Chief of Engineers, 1983); Nick Taylor, *American Made: The Enduring Legacy of the WPA* (New York: Bantam Books, 2008); Jason Scott Smith, *Building New Deal Liberalism: The Political Economy of Public Works, 1933–1956* (New York: Cambridge University Press, 2006).

5. Hugh J. Casey, "Waterway and Flood-Control Activity," *The Military Engineer* 25 (Jan.–Feb. 1933): 55–59, quote on p. 56. Between 1933 and 1938, the Corps provided direct employment for an average of 65,000 men a year; see *ARCE 1933–1938*, pt. 1.

6. In total, between 1933 and 1939 the PWA spent over $6 billion on 34,448 projects, with federal agencies building 17,831 projects at a cost of $1.9 billion, while nonfederal bodies completed 16,677 projects at a cost of $4.2 billion. The largest percentages of PWA undertakings included streets and highways (33%), schools (22%), and public buildings (12.4%). The WPA, while placing a greater emphasis on work relief, still built an impressive array of public works as well. Typically, WPA infrastructure projects included highways and roads, public buildings, airports, conservation projects, and municipal engineering projects, such as water and sewer facilities. From 1935 to 1943, the WPA employed a total of 8.5 million people, peaking at 3.5 million in 1938. *See* Smith, *Building New Deal Liberalism*, 85–122.

7. Material in this section is based on the following sources: Gordon, "The U.S. Army Corps of Engineers and the Great Depression"; Smith, *Building New Deal Liberalism*; Taylor, *American Made*; various issues of *The Military Engineer* for the 1930s; Roger J. Spiller, Joseph G. Dawson, III, and T. Harry Williams, eds., *Dictionary of American Military Biography*, Vols. I-III (Westport, Conn.: Greenwood Press, 1984); and Harold Kanarek, "Preserving Human Resources: The U.S. Army Corps of Engineers and the New Deal," draft history, CEHO, Research Collection.

8. Jean Edward Smith, *Lucius D. Clay: An American Life* (New York: Henry Holt, 1990), 61; Biographical Files, Maj. Gen. Edward Markham, CEHO.

9. Smith, *Lucius D. Clay*, 62–63.

10. Lenore Fine and Jesse A. Remington, *The Corps of Engineers: Construction in the United States*, U.S. Army in World War II (Washington, D.C.: U.S. Army Center of Military History, 1972), 56–57.

11. "Increase in the Corps of Engineers," *The Military Engineer* 28 (Sept.–Oct. 1936): 391; U.S. Congress, Senate, Committee on Military Affairs, *To provide a commissioned strength for the Corps of Engineers…*, 74th Cong., 2d sess., 12 May 1936, S. Rept. 2118.

12. Julian Schley, "Construction Activities of Army Engineers," *The Constructor* 20 (Mar. 1938): 43–44.

13. John D. Guthrie, "The Civilian Conservation Corps," *The Military Engineer* 26 (Jan.–Feb. 1934): 15–19; H. J. Woodbury, "Flood Control in New England," *The Military Engineer* 32 (Nov.–Dec. 1940): 397–98; Marion J. Klawonn, *Cradle of the Corps: A History of the New York District, U.S. Army Corps of Engineers, 1775–1975* (New York: New York District, U.S. Army Corps of Engineers, 1977), 223–27; Michael F. Huebner, "Army Khaki and Forest Green: The U.S. Army and the CCC," *Army* (Sep. 1997): 28–36.

14. Fine and Remington, *Construction in the United States,* 57–63.

15. "The Opportunities of General Brown," *The Constructor* 11 (Oct. 1929): 28; letter to the editor quoted in Fine and Remington, *Construction in the United States*, 63;

"The General Contractor's Part in the Engineer Corps' Program," *The Constructor,* 17 (Mar. 1935): 5.

16. "The Federal Flood Control Program," *The Constructor* 19 (Apr. 1937): 25; "Construction Activities of Army Engineers," *The Constructor* 20 (Mar. 1938): 44.

17. Beatrice Hort Holmes, *A History of Federal Water Resources Programs and Polices, 1961–1970*, Miscellaneous Publication No. 1379, Department of Agriculture, Economics, Statistics, and Cooperatives Service (Washington, D.C., 1979), 75–83; Jamie W. Moore and Dorothy P. Moore, *The Army Corps of Engineers and the Evolution of Federal Flood Plain Management Policy* (Boulder: Institute of Behavioral Science, University of Colorado, 1989), 5, 8; Joseph L. Arnold, *The Evolution of the 1936 Flood Control Act* (Fort Belvoir, Va.: Office of History, U.S. Army Corps of Engineers , 1988), 16–17; Billington and Jackson, *Big Dams*, 71–101.

18. Carl Condit, *American Building* (Chicago: University of Chicago Press, 1982), 155–76, 240–61; Amy E. Slaton, *Reinforced Concrete and the Modernization of American Building, 1900–1930* (Baltimore: The Johns Hopkins University Press, 2001), 1–126; Betsy H. Bradley, *The Works: The Industrial Architecture of the United States* (New York: Oxford University Press, 1999), 23, 155–60.

19. Billington and Jackson, *Big Dams*, 13–14, 28–70.

20. Patrick O'Bannon, *Working in the Dry: Cofferdams, In-River Construction, and the United States Army Corps of Engineers* (Pittsburgh: Pittsburgh District, U.S. Army Corps of Engineers, 2009).

21. Martin Reuss, "The Art of Scientific Precision: River Research in the United States Army Corps of Engineers to 1945," *Technology and Culture* 40 (Apr. 1999): 293.

22. The following discussion of the Bonneville Dam project is based on William F. Willingham, *Water Power in the "Wilderness": The History of Bonneville Lock and Dam* (Portland, Ore.: Portland District, U.S. Army Corps of Engineers, 1987, rev. 1997); *see also* Billington and Jackson, *Big Dams*, 152–68; O'Bannon, *Working in the Dry*, 117–21; Abbie B. Liel and David P. Billington, "Engineering Innovation at Bonneville Dam," *Technology and Culture* (Jul. 2008): 727–51.

23. William F. Willingham, *Army Engineers and the Development of Oregon: A History of the Portland District, U.S. Army Corps of Engineers* (Washington, D.C.: Government Printing Office, 1983), 93–95; William F. Willingham, *Northwest Passages: History of the Seattle District, U.S. Army Corps of Engineers, 1920–1970*, Vol. 2 (Seattle: Seattle District, U.S. Army Corps of Engineers, 2006), 2–16.

24. Charlie Allen, senior turbine specialist at the Corps' Hydroelectric Design Center in Portland, explains that "head" is the difference in water elevation across the dam. In equation form, it is "Reservoir elevation - tailrace elevation = head." When Bonneville Dam was built, there were few storage reservoirs upstream, either on the Columbia River or on the Snake River. Bonneville had to pass whatever flows came down the river—massive floods in the spring and minuscule trickles in late summer and early fall. Regardless of the season, dam operations maintained the upstream reservoir at a relatively constant elevation. The tailrace elevation, however, fluctuated dramatically due to seasonal flows. The tailrace was very high during floods and very low during the "low flow" periods of late summer. The variation in head was therefore caused by variation in tailrace elevation, not by variation in reservoir elevation. Load refers to the demand for electrical current, which can fluctuate widely.

25. Quote in Willingham, *Water Power in the "Wilderness,"* 13.

26. Both Kingman's and Casey's names appear on the patent for the floating mooring device. John T. Greenwood, *Engineer Memoirs: Major General Hugh J. Casey, U.S. Army* (Washington, D.C.: Office of History, U.S. Army Corps of Engineers, 1993), 58–60, 87–88.

27. The debate over marketing power from Bonneville and other federal dams in the Northwest is covered in Willingham, *Water Power in the "Wilderness,"* 42–43; Lowitt, *The New Deal and the West*, 160–63. *See also* Paul W. Hurt, *The Wired Northwest: The History of Electric Power, 1870s-1970s* (Lawrence: University of Kansas Press, 2012), 230–326.

28. Liel and Billington, "Engineering Innovations at Bonneville Dam," 750–51.

29. The following discussion of the Fort Peck Dam project is based on John R. Ferrell, *Big Dam Era* (Omaha, Nebr.: Missouri River Division, U.S. Army Corps of Engineers, 1993), 4–8; Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Pantheon Books, 1985), 267–68; Billington and Jackson, *Big Dams*, 200–30; Henry C. Wolpe, "The Fort Peck Dam—The Project," *The Military Engineer* 27 (Jan.–Feb. 1935): 31–35; C. H. Chorpening, "Fort Peck Dam—Progress of Construction," *The Military Engineer* 27 (Jan.–Feb. 1935): 36–41; D. A. Ogden, "Building the Fort Peck Dam," *The Military Engineer* 28 (Nov.–Dec. 1936): 24–28; A. W. Pence, "The Fort Peck Dam Tunnels," *The Military Engineer* 29 (Jan.–Feb. 1937): 18–23; John R. Hardin, "Fort Peck Dam Spillway," *The Military Engineer* 29 (Jan.–Feb. 1937): 24–28; James Halloran, "Earth Movement at Fort Peck Dam," *The Military Engineer* 31 (Jan.–Feb. 1939): 5–8; Jay S. Leland, "Investigation and Reconstruction of the Fort Peck Dam Slide," *The Military Engineer* 33 (Jan.–Feb. 1941): 26–31.

30. Leland, "Investigation and Reconstruction," 30.

31. Reuss, "Art of Scientific Precision," 292–323.

32. Johnson, *The Ohio River Division,* 142-43; Willingham, *Water Power in the "Wilderness,"* 10.

33. Reuss, "Art of Scientific Precision," 305–23.

34. Willingham, *Army Engineers and the Development of Oregon*, 93–95; Willingham, *Northwest Passages*, Vol. 2, 2–16; Lowitt, *The New Deal and the West*, 87; Mary E. Reed, *A History of the North Pacific Division* (Portland, Ore.: North Pacific Division, U.S. Army Corps of Engineers, 1991), 34–43; Beatrice Hort Holmes, *A History of Federal Water Resources Programs and Policies, 1800–1960,* Miscellaneous Publication No. 1233, U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service, (Washington, D.C., 1972), 18–19. *See also* Paul C. Pitzer, *Grand Coulee: Harnessing a Dream* (Pullman: Washington State University Press, 1994), 48, 54, 56, 62, 68, 76–77.

35. Martin Reuss, "Civil Works Developments," in Barry Fowle, ed., *Builders and Fighters: U.S. Army Engineers in World War II* (Fort Belvoir, Va.: Office of History, U.S. Army Corps of Engineers, 1992), 224–25; Holmes, *History of Federal Water Resources Programs, 1800–1960,* 16.

36. *The Public Papers and Addresses of Franklin D. Roosevelt,* 1939 Volume "War—And Neutrality" (New York: MacMillan, 1941), 418–20; Thomas M. Robins, "The River and Harbor Functions of the Corps of Engineers," *The Military Engineer* 32 (Sep.–Oct. 1940): 331.

37. N. Y. DuHamel, "Great Lakes Ports and Waterways," *The Military Engineer* 33 (Mar.–Apr. 1941): 123–32; Malcolm Elliott, "Chicago to Cairo by Water,"

The Military Engineer 33 (Sept.–Oct. 1941): 459–64; John Larson, *Those Army Engineers: A History of the Chicago District, U.S. Army Corps of Engineers* (Chicago: Chicago District, U.S. Army Corps of Engineers, 1979), 211–22; John Larson, *Essayons: A History of the Detroit District, U.S. Army Corps of Engineers* (Detroit: Detroit District, U.S. Army Corps of Engineers, 1995), 187–200.

38. Johnson, *The Ohio River Division,* 103–36; O'Bannon, *Working in the Dry*, 78–94.

39. The material on the Nine-foot Channel Project is based on William P. O'Brien, et al., *Gateways to Commerce: The U.S. Army Corps of Engineers' 9-Foot Channel Project on the Upper Mississippi River* (Denver: National Park Service, Rocky Mountain Region, 1992); John O. Anfinson, *The River We Have Wrought: A History of the Upper Mississippi* (Minneapolis: The University of Minnesota Press, 2003); John O. Anfinson, "Historical Evaluation: The Upper and Middle Mississippi River History (1866–1993)," in U.S. Army Corps of Engineers, *Floodplain Management Assessment of the Upper Mississippi River and Lower Missouri Rivers and Tributaries* (St. Louis: U.S. Army Corps of Engineers, 1995), 2-1 to 2-24; Raymond H. Merritt, *Creativity, Conflict and Controversy: A History of the St. Paul District, U.S. Army Corps of Engineers* (Washington, D.C.: Government Printing Office, 1979), 147–49, 198–208; Roald Tweet, *A History of the Rock Island District, U.S. Army Corps of Engineers, 1866–1983* (Rock Island, Ill.: Rock Island District, U.S. Army Corps of Engineers, 1984), 255–82.

40. On General Brown's elevation to chief of engineers, see Johnson, *Ohio River Division*, 115; "Lytle Brown is New Chief of U.S. Corps of Army Engineers," *The Constructor* 11 (Oct. 1929): 55; *Public Papers of the Presidents of the United States: Herbert Hoover, March 4 to December 31, 1929* (Washington, D.C.: Office of the Federal Register, National Archives and Records Service, General Services Administration, 1974), 292–93.

41. H. B. Vaughan Jr., "Safety Pays! The Corps of Engineers Proves It," *The Military Engineer* 31 (Sept.–Oct. 1939): 363–65; A. G. Matthews, "A District Looks at Safety," *The Military Engineer* 31 (Nov.–Dec. 1939): 416–21; Schley, "Construction Activities of Army Engineers," 44; *ARCE 1935,* 5; *ARCE 1938*, 7. Although the combined frequency rate of injuries and deaths per million man-hours of exposure decreased substantially from 42.91 for the second half of 1933 to 11.55 for 1938, the rate of deaths alone improved less dramatically. The number of deaths per million man-hours dropped from .67 in 1933 to .38 in 1937 but rose again in 1938 to .49. However, 13 of the 50 deaths that year were attributed to "conditions or causes beyond the control of a safety organization." *See* Vaughan, "Safety Pays," 363.

42. The Tainter gate had been refined throughout the nineteenth century, and it was first used by the Corps in 1889 on a movable dam across the Rock River in Illinois. The Tainter gate consists of an arced metal panel supported by triangular arms connected to pivots set in supporting piers at the side. The cylindrical gates close down on a concrete sill to hold back a pool of water. When debris or ice arrive at the dam, the gates are rotated to clear a passage.

43. This and the following two paragraphs are based on Anfinson, *The River We Have Wrought*, 239–69; John O. Anfinson, "Commerce and Conservation on the Upper Mississippi River," *The Annals of Iowa* 52 (Fall 1993): 385–417; Raymond H. Merritt, *The Corps, the Environment, and the Upper Mississippi River Basin* (Washington, D.C.: Historical Division, Office of the Chief of Engineers, 1984), 53–63.

44. Quoted in Merritt, *The Corps, the Environment, and the Upper Mississippi River Basin,* 62.

45. The discussion of the Cape Cod Canal is based on Aubrey Parkman, *Army Engineers in New England: The Military and Civil Work of the Corps of Engineers in New England, 1775–1975* (Waltham, Mass.: New England Division, U.S. Army Corps of Engineers, 1978), 87–104; and John B. Luby, "New England Harbors and Channels," *The Military Engineer* 33 (Jan.–Feb. 1941): 49–50. For other canal work during the 1930s, see John W. Chambers II, *The North Atlantic Engineers: A History of the North Atlantic Division and its Predecessors in the U.S. Army Corps of Engineers, 1775–1975* (New York: North Atlantic Division, U.S. Army Corps of Engineers, 1980), 55–60.

46. Quote from Luby, "New England Harbors and Channels," 51; Michael C. Robinson, "The Federal Barge Fleet: An Analysis of the Inland Waterways Corporation, 1924–1939," in *National Waterways Roundtable Papers: Proceedings on the History and Evolution of U.S. Waterways and Ports* (Fort Belvoir, Va.: U.S. Army Engineer Water Resources Support Center, Institute for Water Resources, 1980), 107–21.

47. Arthur M. Woodford, *Charting the Inland Seas: A History of the U.S. Lake Survey* (Detroit: Detroit District, U.S. Army Corps of Engineers, 1991), 122–36.

48. Robins, "River and Harbor Functions of the Corps of Engineers," 331; Anthony F. Turhollow, *A History of the Los Angeles District, U.S. Army Corps of Engineers, 1898–1965* (Los Angeles: Los Angeles District, U.S. Army Corps of Engineers, 1975), 117–18; Moore and Moore, *Evolution of Federal Flood Plain Management Policy,* 121.

49. Matthew T. Pearcy, "A History of the Ransdell-Humphreys Flood Control Act of 1917," *Louisiana History* 41 (Spring 2000): 133–59.

50. The discussion of flood control is based largely on Arnold, *Evolution of the 1936 Flood Control Act*; Moore and Moore, *Evolution of Federal Flood Plain Management Policy*, 1–23; Martin Reuss, *Designing the Bayous: The Control of Water in the Atchafalaya Basin, 1800–1995* (Alexandria, Va.: Office of History, U.S. Army Corps of Engineers, 1998); Holmes, *History of Federal Water Resource Programs, 1800–1960*, 18; William E. Leuchtenburg, *Flood Control Politics: The Connecticut River Valley Problem, 1927–1950* (Cambridge: Harvard University Press, 1953); Leland R. Johnson, *Situation Desperate: U.S. Army Engineer Disaster Relief Operations, Origins to 1950* (Alexandria, Va.: Office of History, Headquarters, U.S. Army Corps of Engineers, 2011).

51. Holmes, *History of Federal Water Resources Programs 1800–1960*, 21.

52. Smith, *Lucius D. Clay*, 67–70.

53. See especially Moore and Moore, *Evolution of Federal Flood Plain Management Policy*, 11–15; Leuchtenburg, *Flood Control Politics*, 96–98.

54. Matthew T. Pearcy, "After the Flood: A History of the 1928 Flood Control Act," *Journal of the Illinois State Historical Society* 95:2 (Summer 2002): 172–201; John M. Barry, *Rising Tide: The Great Mississippi Flood of 1927 and How It Changed America* (New York: Simon & Schuster, 1997).

55. Much of the following discussion is based on Reuss, *Designing the Bayous*, 103–204; Charles Hendricks, "History of the Corps of Engineers Real Estate Policy," Draft History, Ch. 4, CEHO. An Army engineer headed the Mississippi River Commission.

56. Charles A. Camillo and Matthew T. Pearcy, *Upon Their Shoulders: A History of the Mississippi River Commission from its Inception through the Advent of the Modern*

Mississippi River and Tributaries Project (Vicksburg, Miss.: Mississippi River Commission, 2004), 216–21.

57. The four dams were the Sardis, Arkabutla, Enid, and Grenada. Martin Reuss, "The Army Corps of Engineers and Flood Control Politics on the Lower Mississippi," *Louisiana History* 23 (Spring 1982): 131–48.

58. The discussion of Tygart Dam is based on W. E. Potter, "Tygart River Reservoir Dam," *The Military Engineer* 28 (Sep.–Oct. 1936): 331–35; W. E. Covell, "Flood Control in the Pittsburgh District," *The Military Engineer* 31 (May–Jun. 1939): 177–81; Johnson, *Ohio River Division*, 138–40.

59. Johnson, *Ohio River Division*, 141–44.

60. Arnold, *Evolution of the 1936 Flood Control Act*.

61. The discussion of New England dams is based on Woodbury, "Flood Control in New England," 397–405, and Parkman, *Army Engineers in New England*, 172–83. The three earth-fill dams were the East Barre Dam on the Jail Branch, the South Barre Dam on the Stevens, and the Wrightsville Dam on the North Branch of the Winooski River.

62. Michael Welsh, *A Mission in the Desert: Albuquerque District, 1935–1985* (Albuquerque: Albuquerque District, U.S. Army Corps of Engineers, 1985), 19–52.

63. Brig. Gen. Pillsbury to Sen. Dennis Chavas, 28 Feb. 1936, National Archives and Records Administration, Record Group 77, Box 313, Entry 111.

64. William A. Settle Jr., *The Dawning: A New Day for the Southwest. A History of the Tulsa District Corps of Engineers, 1939–1971* (Tulsa, Okla.: Tulsa District, U.S. Army Corps of Engineers, 1975), 59–66.

65. Turhollow, *History of the Los Angeles District*, 144–70; Blake Gumprecht, *The Los Angeles River: Its Life, Death, and Possible Rebirth* (Baltimore: Johns Hopkins University Press, 1999), 221–33.

66. Willingham, *Army Engineers and the Development of Oregon*, 106–16, quote on 109; William G. Robbins, *Landscapes of Promise: The Oregon Story, 1800–1940* (Seattle: University of Washington Press, 1997), 283–293.

67. Willingham, *Army Engineers and the Development of Oregon*, 110.

68. Cecil R. Moore, "The Willamette Basin Project," *The Military Engineer* 31 (May–Jun. 1939): 208–11, quote on 211.

69. Quote in Reuss and Walker, *Financing Water Resources Development*, 31; George Clemens, "The Reservoir as a Flood-Control Structure," *Transactions of the American Society of Civil Engineers* 100 (1935): 879–927.

70. For background on the Corps and environmental concerns, see Michael C. Robinson, "The Relationship Between the U.S. Army Corps of Engineers and the Environmental Community," *Environmental Review* 13 (Spring 1989): 1–41, and sources cited in note 30 above.

71. The discussion of fish issues at Bonneville Dam is based on Willingham, *Water Power in the "Wilderness,"* 47–54, quote on 47; *see also* Lisa Mighetto and Wesley J. Ebel, *Saving the Salmon: A History of the U.S. Army Corps of Engineers' Efforts to Protect Anadromous Fish on the Columbia and Snake Rivers* (Portland, Ore.: North Pacific Division, U.S. Army Corps of Engineers, 1994), 49–64.

72. Quote in Lowitt, *The New Deal and the West*, 159.

73. Quote in Willingham, *Water Power in the "Wilderness,"* 51.

74. Merritt, *The Corps, the Environment, and the Upper Mississippi River Basin, passim*; Robins, "River and Harbor Functions of the Corps of Engineers," 328, 331.

75. Quote in Keir Sterling, Draft Manuscript on Fisheries Issues, CEHO, 28.

76. Michael Robinson, "The Relationship Between the U.S. Army Corps of Engineers and the Environmental Community, *Environmental Review* 13 (Spring, 1989): 1–41, quote, 21.

77. Quote in "The Reorganization Plan," *The Military Engineer* 25 (Jan.–Feb. 1933): 104; Maj. Gen. Lytle Brown to Rep. Whittington, 31 Mar. 1932, Civil Works, Reorganization File, III-2, CEHO; "Federal Consolidation," *The Constructor* 14 (Aug. 1932): 4; U.S. Congress, House of Reps., Committee on Expenditures in the Executive Departments, *Establish a Public Works Administration*, 72d Cong., 1st sess., 4 Apr. 1932, H. Rept. 989; Fine and Remington, *Construction in the United States,* 63–64.

78. The discussion of the Corps' relationship with Congress and executive branch planners is based on Patrick D. Reagan, *Designing a New America: The Origins of New Deal Planning, 1890–1943* (Amherst: University of Massachusetts Press, 1999); Smith, *Building New Deal Liberalism*; Martin Reuss, "Coping with Uncertainty: Social Scientists, Engineers, and Federal Water Planning," *Natural Resources Journal* 32 (Winter 1992): 101–35; "Federal Department of Public Works?" *Civil Engineering* 8 (Mar. 1938): 155–65; Fine and Remington, *Construction in the United States,* 64–65; *see also* Moore and Moore, *Evolution of Federal Flood Plain Management Policy*, 11–15.

79. Secretary of War George Dern to President Franklin Roosevelt, 20 Apr. 1934, Civil Works, Reorganization File, CEHO; *see also* Dern to Rep. Allard H. Gasque, 5 Jun. 1935, Civil Works, Reorganization File, CEHO; Martin Reuss, "Civil Works Developments," 222–23.

80. Quote in Harold L. Ickes, *The Secret Diary of Harold Ickes,* Vol. 2, *The Inside Struggle, 1936–1939* (New York: Simon & Schuster, 1954), 151–52; *see also* 318, 337–38, 356–57. U.S. Congress, Senate, Select Committee on Government Organization, *Government Organization,* 75th Cong., 1st sess., 16 Aug. 1937, S. Rept. 1236; U.S. Congress, Senate, Committee on Commerce, *Comprehensive National Plan for Prevention and Control of Floods—Veto Message*, 75th Cong., 1st sess., 13 Aug. 1937, S. Doc. 95.

81. Frederic A. Delano to President Roosevelt, 8 Feb. 1940, and President Roosevelt to Judge Whittington, 14 Feb. 1940, Civil Works, Reorganization File, CEHO; *see also* Charles Eliot to Mr. Delano, 5 Apr. 1939, Civil Works, Reorganization File, CEHO. Eliot wrote that opposition to legislation permanently establishing the National Resources Committee came from the "so-called River and Harbor bloc" in the House of Representatives.

82. Robins, "River and Harbor Functions of the Corps of Engineers," 325–31.

83. *Annual Report Covering Military Activities of the Corps of Engineers for the Fiscal Year Ending June 30, 1941*, 4, and *Annual Report to the Army Service Forces, Fiscal Year 1942*, Construction Division section, 1, and Military Personnel Branch submission, 9, both in Military Files, CEHO.

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Workers drilling rock by hand for a channel improvement project at Middlesex, Vermont. July 1933.

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