Along with substantial changes in the relationship between the Department of the Army, the Department of Defense, and military forces in the field, there were also major modifications in the internal administration of the Department of the Army. The increased importance of research and development, financial management, and common supply and services led to development of Department of Defense programs requiring conformity by the Department of the Army. The trend further accelerated with the changes directed by Secretary of Defense Robert S. McNamara. As a result, in 1962 two new field commands were created to supervise Army supply activities and to determine the organization and doctrine associated with new weapons and equipment. Recently this trend has continued with the Department of the Army constantly refining its organization to better support its forces in the field and the mission of the Department of Defense.

[*See also* Defense, Department of; Joint Chiefs of Staff; *and* Appendix: An Act to Establish . . . the Department of War.]

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—WILLIAM T. BOWERS

## Army Corps of Engineers

The U.S. Army Corps of Engineers Civil Works Directorate (hereafter, the Corps) is a unique and somewhat odd entity among federal government agencies. Although located in the military complex, it has played a significant role in the design, construction, and maintenance of civilian public infrastructure. In a governmental system that rewards incrementalism and short-term responsiveness, the Corps's primary mission and professional norms demand rationality and long-term commitments. And in an agency populated by professionals who regard politics as unprofessional, success has historically depended on the cultivation of political connections and the honing of political skills.

The uniqueness and methods of the Corps make greater sense in historical perspective. To better understand the agency, two closely related factors must be highlighted: the military roots of the engineering profession and the importance of the role of French military advisers in establishing the Army Corps of Engineers.

The modern professional of civil engineering was born and nurtured in the military. The very term *engineers* comes from the French term applied to combat technicians who designed and maintained the "engines" of siege—whether defensive fortifications to withstand attack or the roads and various implements of war that sustained an offensive campaign. It is not surprising that the "science" of engineering would be nurtured in a country like France, where fortifications and sieges formed the stage upon which wars were fought. As the historian Todd Shallat notes, this stands in sharp contrast to modern British military history, where sieges were relatively rare after the consolidation of royal control and the high seas formed the principal stage for action. It was in France that the science and profession of engineering would be cultivated.

French soil also proved to be fertile ground for the adaptation of military engineering to civil works. From at least the seventeenth century onward, France was focused on the challenges to both political centralization and economic expansion posed by its interior landscape. Britain, in contrast, faced the challenge of the open seas. Thus, while England became the center for technical advances in marine instrumentation, mapping, and naval architecture, France nurtured the civilian capacities of its military engineer corps and its capacity to plan and build roads, canals, and other projects that became part of its vast public infrastructure. Among the British, those who would perform the tasks of "engineers" emerged from the ranks of crafts-

men—carpenters, masons, millwrights—who developed and honed their skills on the job, learning from trial and error as they went from project to project. Their approach would be neither scientific nor professional, but pragmatic and infused with the craftsman's pride of problem solving.

The story of the birth of the Corps is rooted in the distinction between those contrasting traditions represented by France and Britain. The military knowledge and skills of the rebelling colonists were steeped in the British tradition for obvious reasons. This posed a problem for General George Washington almost from the outset. Facing the challenge of defending Boston against a superior British force in 1776, Washington had to rely on a congressionally appointed artillery officer, sixty-five-year-old Colonel Richard Gridley, to help establish fortifications to meet the challenge. While Gridley served as the army's first engineer, it was Lieutenant Colonel Rufus Putnam, a millwright by trade, who eventually assumed the role of chief military engineer for the U.S. forces as the war moved to New York. Putnam had established his credentials with Washington by constructing a defensive position at Boston's Dorchester Heights that led the British to change their minds about launching an attack on that position. Putnam later acknowledged that he owed his success at that site to a passage in an English translation of a French military field manual that he had found among Washington's possessions.

That episode, along with the international reputation already established by the French engineers, led the Continental Congress to request that its key ally, Louis XVI, consider sending engineers among the group of officers France had promised to provide in support of the revolutionary effort. Sixteen French engineer officers would serve between 1777 and 1781, most of them trained at Mézières, the school for military engineers. The influence of these officers on both the American war effort and the military's view of the engineering corps would prove significant. Especially important was the role played by Louis Lebébue Duportail, who became the engineering commander of Washington's forces in 1777. Much credit is given to Duportail for the eventual success of the revolutionary forces, especially in designing the siege of Cornwallis at Yorktown that ended the war. Duportail left the United States in 1783, and would play an equally impressive role in the French military during its period of revolutionary turmoil. The American revolutionary army's engineer corps disbanded in 1784, when most of the French officers returned to Europe. Nevertheless, Duportail's influence (and that of other French officers) continued, and their reports on the needs of the new U.S. military proved critical in eventually convincing Washington and the U.S. Congress to establish a military component that included engineers—the Corps of Artillerists and Engineers, which was formally commissioned in 1794.

In 1802 President Jefferson created a distinct Army Corps of Engineers and offered the chief engineer's position (as well as the rank of colonel) to a civilian and fellow savant of the period, Jonathan Williams. Included in William's charge was the task of establishing a military school of engineering (after the French model) at West Point. For Jefferson and others this was the first step in the creation of a national university that would serve the civilian as well as military interests of the new nation.

Such desires notwithstanding, there followed an era reflecting a return to the less professionalized British view of civil engineering. Carpenters, masons, and other practical craftsmen became the builders of canals and other engineering projects as local and private endeavors filled the void left by the lack of a national civil works agenda. Some French engineers (including Duportail) returned to the United States in the face of revolutionary terror in France, but many joined the thriving private sector endeavors focused on the relatively simple job of building more canals. The only major public project of note, the design and construction of the new federal city on the Potomac River, was placed in the hands of a French engineer, Pierre Charles L'Enfant, who had served under Duportail during the American Revolution.

With one major exception, however, most of this was accomplished without the involvement of the few military engineering officers in the Corps of Artillerists and Engineers. The immedi-

ate reason for the establishment of that Corps in 1794 was the need for the newly established national government to deal with reinforcing coastal fortifications in light of perceived threats from Britain. With such military activities to occupy them, the small cadre of engineers in the Corps did not get involved in civilian undertakings, even after the enhancement of their status in 1802. If anything, the military's view of the major civilian projects of the day was critical, reflecting the attitudes of the French-trained engineers who dominated the Corps and the curriculum at West Point. They regarded the unscientific and unplanned nature of most canal and road building as a tragedy in the making. Such attitudes did not facilitate cooperation between the Corps and other entities when the opportunities arose, nor was it helpful that Americans were becoming increasingly tired of what they regarded as French cultural snobbishness. The first decades of the nineteenth century, in short, were not conducive to an extension of the Corps's functions into the civilian arena.

The major exception was in the federal city itself. While the city had been designed and its public buildings constructed without significant assistance from military engineers, the vulnerability of the capital in the War of 1812 and the lack of any decent public infrastructure (e.g., roadways and drainage) led President Madison to ask for their involvement. With headquarters in Brooklyn, New York, the Corps at first limited its work in the District of Columbia to enhancing the fortifications in and around the city. Ordered by President Monroe to move its offices to Washington in 1817, the chief engineer, Colonel Joseph G. Swift, soon had the Corps involved in a number of civic improvement projects to make the federal city more livable and commercially viable. Civilian endeavors among the Corps's builders, however, were limited primarily to the District of Columbia.

The other major point of involvement for the Corps of Engineers during this period resulted from the role that several of its officers played on the U.S. Board of Engineers for Internal Improvement. Established in 1824 at the urging of President John Quincy Adams (a strong advocate of the national government's positive role in economic and scientific matters), the board provided a base for influencing some of the major projects being developed at the time. While anti-Corps sentiment prevented the Corps from directly undertaking many civil works projects on its own, many Corps personnel were sent to "study" or assist those who were in charge.

During this period, historically relevant events were unfolding for another group of military engineers, that is, the topographical engineers, or "topogs." Topographers and surveyors had occupied a distinct section of Washington's revolutionary army, although they often worked closely with Duportail's construction engineers. Disbanded after the war, the topogs sometimes found positions with boundary commissions, lighthouse districts, and other government entities. A "Topographical Section" reemerged in the War Department in 1813, with the role of assisting the military in its growing role of exploring and opening the West. Section members were soon assigned to Army units, and the Washington office of the section received separate bureau status in 1816 and was given the task of collecting and storing maps and reports generated by topogs and others in the field. In 1818, the six-member bureau was placed in the War Department's Engineer Department.

Passage of the General Survey Act of 1824 generated increased demand for the services of topogs and an opportunity for the bureau to expand. The head of the bureau at the time, Major Isaac Roberdeau, adapted the agency to the changes, but it was his successor (in 1829), Colonel John J. Abert, who took the bureau on a more active course. By 1831 he had obtained departmental status for the topogs under the secretary of war's office, and in 1838 the unit became the Corps of Topographical Engineers. With thirty-six officers, most of them graduates of West Point and thus steeped in the scientific view of engineering, the new Topographical Corps now had independence from the priorities of the fortification-minded Corps of Engineers to pursue its role of meeting growing civilian demands for more explorations and surveys of the trans-Mississippi West.

For the next twenty-three years, the Topographical Corps would launch numerous expedi-

tions that not only fed the growing American thirst for knowledge of the West but also served the political agendas of individual members of a Congress who sponsored and supported these efforts on an *ad hoc* basis. Until the 1850s there was no national policy on western exploration, and thus Abert and his topogs honed the political skills needed to sustain the agency. When a national policy did develop in the 1850s, however, Abert's political nemesis, then–Secretary of War Jefferson Davis, created a separate office to oversee the new policy.

The Civil War radically altered War Department priorities and led to the merger of the Topographical Corps into the Corps of Engineers. During the postwar period, demand for topog services had been significantly changed. The settlement of the West was now progressing, and from the perspective of the War Department the civilian needs were more for military protection than for exploration and surveying. In addition, many West Point graduates and Corps veterans returned to civilian life and helped establish a nonmilitary cadre of professional engineers through curricula at Yale, Harvard, Rensselaer, and Dartmouth. The Corps of Engineers itself took advantage of these developments, for when it mounted major surveying expeditions after the Civil War it did so by funding civilian-led parties. Civilian agencies emerged as major competitors for the Corps's topogs, particularly in the Department of the Interior. Political battles among the agencies and various scandals ultimately led Congress to establish the U.S. Geological Survey in 1879. [*See* Geological Survey.] Thus the Corps had once again had its civilian role reduced. Nevertheless, the legacy of the topogs would be an established tradition of Corps involvement in civilian projects on a national scale.

For the Army Corps of Engineers in general, the post–Civil War period proved to be both the best and worst of times. The devastation resulting from the war brought demands for civil works to repair all forms of public infrastructure. In 1866 the Corps had a budget of $3.4 million and an agenda of fourty-nine projects and twenty-six surveys; by 1882 there were 371 projects and 135 surveys to conduct, and a budget of $19.5 million. New levees, dredging, rebuilding bridges and rail lines, removing sunken vessels, and many other jobs were the obvious tasks at hand, but there was also considerable pressure for new projects to take advantage of the economic boom times. The Corps thus found its services in demand. The problem was that it was not authorized to increase its officer corps to a number sufficient to deal with the expanded demand. In fact, in 1872 the Corps actually had only ninety-seven officer engineers (not many of senior rank or with sufficient experience), a dozen fewer than it was authorized to have. The agency found itself relying on a growing cadre of civilian "assistants" (110 in 1872), many of them young and inexperienced. Stretched thin in the higher ranks, senior Corps officers were overseeing as many as twenty or more projects at any point in time. The inevitable result was that the Corps suffered from both poor management and a poor reputation.

The problems of the Corps during these boom years were compounding quickly. In 1866 it lost its control over West Point amid charges that the academy's graduates were of low quality and in light of growing intraservice rivalry. The wastefulness and mismanagement of Corps operations were the subject of many articles in the professional and popular political press of the time, and a growing list of fiascoes was being used by the agency's enemies to challenge its effort to develop a more comprehensive civil works program.

General Andrew A. Humphreys, a major theoretician in the field of hydraulics and the chief engineer of the Corps from 1866 to 1879, proved himself politically ineffective in dealing with key issues. Just as he lost the battle to maintain the primacy of the topogs in performing surveying functions for the nation, he and the Corps were made to look inept and foolish by entrepreneurial civilian engineers who opened up the lower Mississippi to navigation by implementing approaches that the agency (relying on Humphreys's theoretical writings) vehemently opposed. By the time Humphreys left, the Corps had reached a low point politically and a critical juncture in its historical development. The final blow to Humphreys and the Corps came a few

days before the chief engineer's decision to retire in the form of congressional action to establish the Mississippi River Commission. The Corps would have three of the seven positions on the commission, including that of president. The leaders of the Corps argued that it alone was capable of making decisions about the river basin's flow, but to no avail. In fact, similar constraints were placed on its jurisdiction over other river basins where it had enjoyed growing discretion.

That particular juncture in 1879 was key to the future of the Corps, for in hindsight it is conceivable that agency leaders could have abandoned the Corps's role in civil works and focused its attention exclusively on its still-substantial military functions. But there were at least two major factors at work countering such a choice. First, despite well-publicized problems in the field and significant political defeats, the Corps remained engaged in many public works projects throughout the country. Second, and perhaps of greatest importance, the devoted professionals who comprised the agency's leadership were incapable of making such a choice. The legacy of both their professional roots and long-standing institutional commitments would have made a retreat from civil works extremely difficult. And yet the Corps of Engineers had to face the reality of an American political scene that was filled with powerful competitors and was inherently suspicious of the kinds of massive government planning efforts so central to the Corp's self-assumed mission.

During the 1880s, the Corps survived several congressional attempts to create a federal civilian public works agency that would take over its civil projects entirely. To placate some of the agency's critics, the civil works directorate was organized and five regional divisions were established in 1888 to make the Corps more responsive to local demands. The regions, in turn, would contain district offices at key localities. This organizational move would prove both permanent and critical for the future operations of the Corps. Officers and civilian staff would find that service to—and support from—local interests in their regions was a key ingredient to long-term success and stability for the agency. The decentralization of the Corps may have saved it politically, but it also changed its culture fundamentally. The professionalism of its past now mixed with a commitment to being responsive to powerful interests within regional and district boundaries.

For the most part, the history of the Corps since the 1880s is a history of the individual regional and district divisions of the agency. A series of rivers and harbors acts in the 1890s and afterwards authorized specific projects that focused on navigation improvements and other tasks that favored commercial development in each locale. In the larger river basins where the Corps operated under the authority of commissions such as those set up in 1879, the agency's representatives were able to establish the Corps's primacy by working more closely with local interests.

In all these locales, the Corps's civil works management structure created a unique situation where political responsiveness was nurtured and constantly reinforced. Regional and district offices were formally headed by military officers who rotated through their assignments on a regular basis, at first serving in a district (initially as a deputy engineer, and eventually as a district engineer), then in a region, then at headquarters, and in other components of the Army as well. Trained in engineering (typically at West Point), they carried with them the professionalism and national perspective of the Corps. At the same time, their stints in district offices as young officers gave them greater appreciation of the need to be responsive to local interests.

At the same time, each office was staffed by a cadre of permanently assigned civilian engineers whose focus was primarily on local projects and needs. The military officers relied on these civilians to do the actual work assigned to the Civil Works Directorate in each locale, and their relationship with the top civilian manager (usually called the chief of the engineering division) was critical to the agency's success. The resulting dynamic has become the norm in the management of the Corps.

The general mission of the Corps has been dynamic as well, responding to changing conditions in the agency's environment. As a conse-

quence of its work on navigation, the Corps naturally found itself involved in flood control as a secondary task. In 1917, after several disasters, the Corps was formally authorized by Congress to undertake flood control as a major component of its mission in the Mississippi and Sacramento river basins. Outside those areas, however, the Corps's work on flood control was strictly on an *ad hoc* basis, and generally the directorate did not seek that as a primary mission among its civil works. During the Great Depression, however, the pressure for creating more jobs through public works led the Corps to undertake flood control projects that it might have passed up earlier. Finally, in 1936, Congress passed a Flood Control Act that made such projects a "proper activity" of the federal government and gave the Corps authority for implementing that national responsibility.

Just as flood control emerged from the Corps's work on navigation, so two additional Corps missions emerged from its flood control efforts. The 1936 act contained provisions that made the damming of rivers the method of choice for flood control projects, and with dams came the opportunity to generate hydroelectric power. Thus, it was not surprising that amendments were made to the Flood Control Act in 1938 that extended the authority of the Corps by permitting it also to engage in the generation and sale of power at those dam sites. A related development was the growing role of the Corps in providing water for irrigation to farmers near the dam sites, thus enhancing the Corps' mission even further.

The regional offices reacted to these developments with lists of potential projects, and soon the construction and maintenance of three-hundred reservoirs were among the Corps's responsibilities. As the reservoirs came on line, still another function was added: the management of recreation and other public facilities created as a result of the construction of dams and reservoir lakes.

Thus, as the Corps entered into the business of damming rivers, it soon found itself in competition with a number of other federal agencies, from agencies dealing with soil conservation to those charged with managing national parks. But its greatest nemesis was the Department of the Interior's Bureau of Reclamation, which had been providing water and power to the arid western United States for decades. The two agencies worked around each other for years, but in the 1940s both found themselves making plans for similar projects in the high Sierra and in the Midwest. Representatives of the two agencies finally met and drew up an agreement that effectively divvied up responsibilities for water projects and allowed each to work without threat of constant political competition from the other. Although disagreement arose from time to time, both the Corps and the Bureau of Reclamation continued to flourish through the 1950s and 1960s. [*See* Reclamation, Bureau of.]

The organization of the Corps became even more decentralized as its fortunes improved after World War II. The original five regional divisions of the Civil Works Directorate expanded to eleven. In addition, thirty-seven district offices were opened in locales from New York to Honolulu and from Walla Walla to Jacksonville. By the mid-1970s the agency employed nearly thirty-five thousand workers in the civil works area alone, and an additional three hundred military officers were assigned to key positions at headquarters and top positions in the division and district locations. Its $2.5 billion budget at the time was to pay for nearly three hundred projects actively under way, with an equal number in "active backlog" status and six hundred more projects on the drawing boards. Large as those numbers were, they reflected a relative decrease in Corps expansion.

Twenty years later (fiscal year 1996), the budget had increased to $3.2 billion and the civilian work force had declined slightly (to just under thirty thousand—a figure reached in the middle 1980s), while the number of military officers assigned was reduced to 213. Although the backlog of projects had decreased, the number of active projects had gone up to 352. There were now many more completed projects to manage (e.g., 383 major lakes and reservoirs, 75 hydroelectric generation facilities, 463 recreation areas containing over 4,300 sites, etc.), but fewer "start-

up" projects each year to deal with. Regulatory activities, environmental protection, and emergency response operations have been playing a greater role for the Corps.

Despite the relative stability achieved by the Corps in recent years, it remains one of the more controversial agencies in the federal government. Environmentalists have raised questions about the wisdom of the Corps's projects and methods, and critics inside and outside government protest the continuation of pork barrel politics and inefficient operations. While flooding and similar emergencies keep the engineers busy, current trends portend a shift toward a service agency that devotes more work hours to operating facilities instead of constructing them.

The history of the Army Corps of Engineers Civil Works Directorate is a case study in the complexities that characterized the emergence of an administrative state within a democratic context. In its current form, the Corps bears the formal and organizational scars that emerged from attempts to bring a rational, highly professional commitment to public good (at least as defined by the pre-1879 Corps leadership) into sync with the highly individualistic American political culture. Ironically, another Frenchman, Alexis de Tocqueville, foresaw the troubles facing any grand agenda for a national public works program in a democracy when he observed that "useful undertakings requiring continuous care and rigorous exactitude for success are often abandoned in the end, for . . . the people proceed by sudden impulse and momentary exertions." What the Corps has achieved through organizational decentralization and the honing of political skills can be regarded as a necessary adaptation to the realities of applying rationality in a democratic arena.

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## Atmospheric Research, National Center for

Located in Boulder, Colorado, the U.S. National Center for Atmospheric Research (NCAR, pronounced "en-car") is a federal government–sponsored laboratory that conducts scientific and technological research. The center was established under the guidance of Walter Orr Roberts in 1960 under the auspices of the National Science Foundation to complement and enhance university-based research in the atmospheric sciences and was originally named the National Institute for Atmospheric Research (NIAR, or *rain* spelled backwards). Since that time, NCAR has focused its efforts on addressing fundamental research in the atmospheric sciences and providing major computing, observational, and instrument facilities to the university community. In meeting these objectives NCAR seeks to contribute to a better understanding of climate and weather at local, regional, and global scales.

NCAR conducts and oversees research in the atmospheric sciences in a wide range of areas including large-scale atmospheric and ocean dynamics, atmospheric chemistry, solar physics, local- and regional-scale weather, and relationships between society and the atmosphere. The wide range of research seeks to address (in the words of the center's 1980 annual report) "questions that are important for science, for the nation, and for humanity; and on the production of knowledge that can lead to more informed pol-