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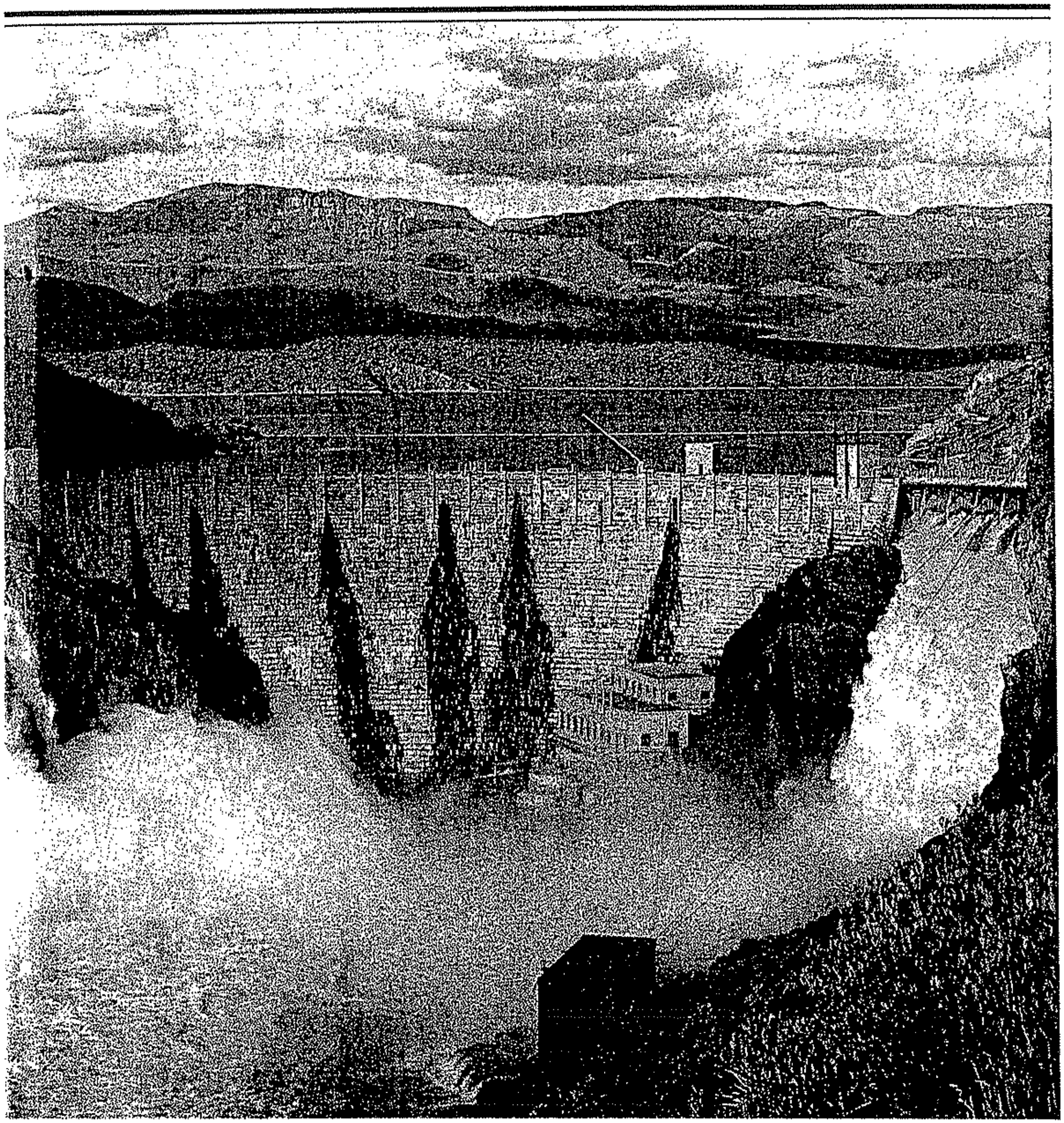
THE MAGNIFICENT EXPERIMENT

Building the Salt River Reclamation Project, 1890–1917

KAREN L. SMITH



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The Magnificent Experiment

Building the Salt River Reclamation Project 1890-1917

KAREN L. SMITH

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About the Author

KAREN L. SMITH, senior planning analyst in the Department of Strategic Planning of the Salt River Project, earned a Ph.D. in history from the University of California at Santa Barbara in 1982. She has served on the boards of directors for the National Council of Public History and the Coordinating Council for History in Arizona. In the early 1980s, as director of a research consulting firm, she was a consultant on water rights and related issues.

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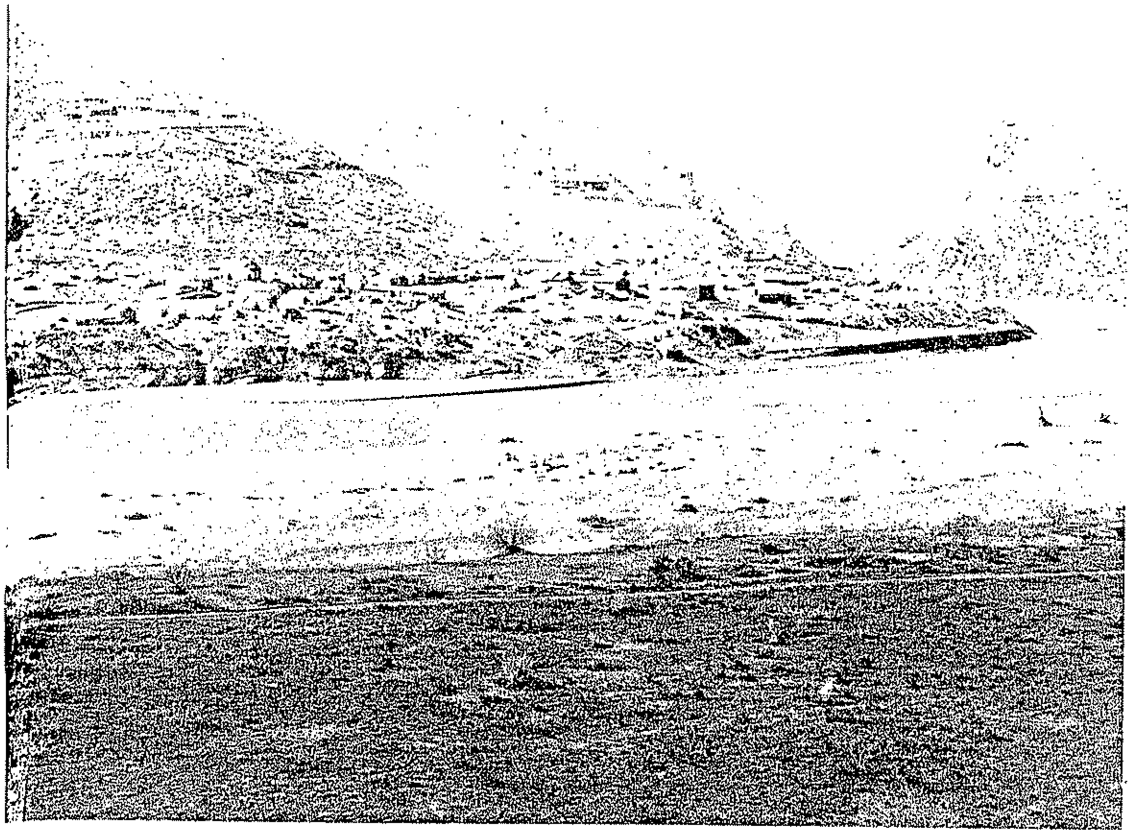
Building the Roosevelt Dam

Just as no precedent existed for the farmers' organizing the Salt River Valley Water Users' Association under the Reclamation Act of 1902, no large-scale irrigation works precedent existed for the engineers of the United States Reclamation Service. Instead, they had to develop original plans for each large system. Frederick Newell placed dam stability and economy at the top of the Service's list of engineering criteria, and the consulting board of engineers planning the Salt River Project under Newell's general supervision attempted to follow his standards carefully.[1]

Plans for the project included several components in addition to the dam. Preliminary construction work consisted of building roads and a base camp for the engineers and workers. A cement mill and sawmill were added to exploit natural resources. A power canal and permanent power-producing facility were designed to take advantage of the abundant possibilities for inexpensive hydroelectricity. The dam itself required a sluicing tunnel, an outlet tunnel, and a coffer dam before the foundation could be excavated. Stone had to be quarried in large pieces before the masonry could be laid.

The water-storage dam, named the Roosevelt Dam in honor of President Theodore Roosevelt, was planned as a simple gravity structure composed of uncoursed rubble masonry. The total height of the dam above the lowest foundation was to be 245 feet; since the damsite favored a curved form, the proposed structure was to be built on a circular curve, convex upstream, with a backside radius of 400 feet. This simple gravity structure, with its curved form, would greatly



The west end of the town of Roosevelt, Arizona, as it was in March 1906, during construction of the dam. Located on the south side of Salt River approximately one-half mile upstream from the damsite, the town had a population of about 500 during the peak of construction. After the dam was completed and the reservoir began to fill, the town was abandoned and eventually inundated.

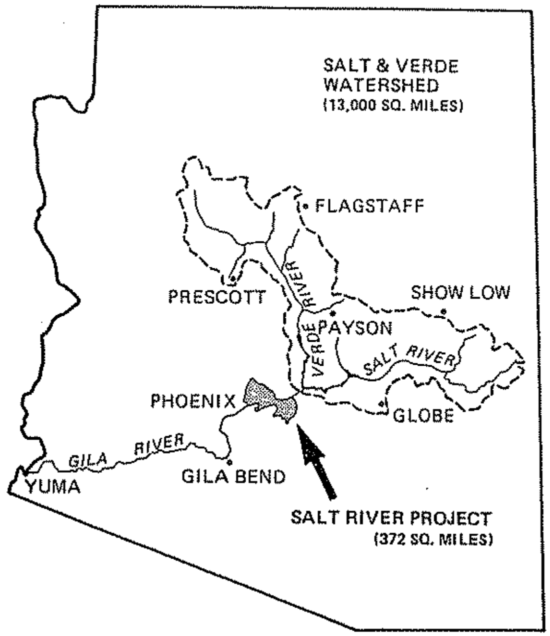
increase the stability of the dam; the masonry dam was the most conservative and permanent design yet devised.[2]

Louis C. Hill, supervising engineer on the Salt River Project, Arthur Powell Davis, chief engineer of the Reclamation Service, and Fred Teichman, design engineer on the Salt River Project consulting board, calculated this engineering design with an eye toward economy. The solid, fine-grained, sandstone cliffs, which the dam would abut, provided the stone necessary for constructing the dam and, thus, eliminated freight and other quarrying charges. Initially, the estimated cost of cement purchased in the open market, shipped by rail to the point nearest the dam, and then hauled to the damsite by wagon was a prohibitive $9 per barrel. Before deciding on a less expensive dam, the Service investigated the possibility of manufacturing its own cement at the damsite. Good limestone and clay deposits at the site produced a quality Portland cement at an estimated $3.14 per barrel, and despite protests from the "cement trust" about government interference in the marketplace, the Service proceeded to build a cement mill at the damsite. Similarly, freight charges for hauling oil to the town of Roosevelt to produce electricity to power construction machinery were too high (usually more than 30 percent of the cost), so the consulting board of engineers designed a power canal to produce cheap hydroelectricity at the construction site. Plans for a government sawmill to cut construction timber in the Sierra Ancha Mountains (about thirty miles northeast of Roosevelt), for a permanent construction headquarters with modern conveniences to attract long-term labor, and for its own shorter and better freight road to minimize the most expensive hauling were other signs of government concern for economy.[3]

PREPARING FOR DAM CONSTRUCTION

Between 1902 and 1904, the Service completed a series of cadastral maps of the Salt River Valley, which showed not only land contours, but canal and road systems in great detail. Working through the hot summer months in the most rugged and desolate of canyons, the engineers and workers on the project glimpsed the problems that climate and terrain would make for construction: temperatures ranged from 20 degrees to 120 degrees Fahrenheit, and the reservoir site was virtually inaccessible by wagon. Sixty miles separated the reservoir site from the town of Mesa, and it was forty miles from Globe, a mining town southeast of Roosevelt. Both towns had railroad connections, but no freight road existed from the construction site to Mesa (which had the advantage over Globe of two railroad connections), and the road to Globe was treacherous, winding through several mountain ranges. Frederick Newell wrote in his Third Annual Report that few reservoirs had been constructed in locations where the natural conditions were so favorable and the transportation facilities so meager. The Reclamation Service needed to build good connective roads to these transportation centers. In addition, roads were needed to link those natural resources available near the damsite: a lumber road to the Sierra Ancha Mountains and a road to the clay flats that were three miles away from the proposed cement mill. The first construction on Salt River was, thus, rather mundane: road-building and permanent camp construction.[4]

The 372-square-mile area of the Salt River Project (shaded) receives its water from the 13,000-square-mile watershed of the Salt and Verde rivers. Located in the central part of Arizona, the Salt River Project was designed to provide irrigation to its member lands within the greater Phoenix metropolitan area. Map drawn by Cartographics Department, Salt River Project.



The road to the sawmill was quickly carved out in early 1903 and was completed by December of that year. With the sawmill plant in place, upon completion of the road, contracts for cutting and sawing lumber were let in early 1904. The Reclamation Service, unhappy with the performance of the two private contractors at work in the sawmill during the first half of 1904, took over management of the mill itself in July; average monthly output increased from 119,500 to 214,000 board feet. By mid-September 1905 all the timber which could be conveniently reached had been cut, and the excess lumber was hauled in to the damsite in November. The lumber road was, by necessity, the first piece of construction on the project; wood was needed for construction of the permanent camp, culverts and bridges for the roads, tunnel timbering, and building forms for concrete structures.[5]

On the north side of Salt River were the clay hills necessary for the production of cement. The cement mill was located on the south side of the river, and a three-mile-long road was built across the river connecting the two in 1903. Usually the ford across the river was inconsequential, but, when the river was high due to rain or snow on the 13,000-square-mile watershed, getting the clay to the cement mill was more difficult. After an excellent-quality clay was discovered on the south side of the river, during excavation for the power canal, little use was made of the clay hills across the river or of the road to these deposits, although the lower one and one-half miles of it formed the lower part of the regular freight road to Globe. This road was simple to construct, probably requiring only dredges to even out the land.[6]

The high-line freight road to Globe, located on the upper side of the power canal, ran twenty miles from the cement mill to the old road from Globe to Livingstone. Construction was difficult, since much of the road was cut out of the hill; it required heavy sidehill work and strongly cemented gravel. Initially the road crossed the power canal about a mile from Roosevelt, but rising water and convenience of delivery caused the engineers to reroute the road higher on the side of the hill. The direction of the heaviest loads was toward the damsite, and the greatest adverse grade built into the road in this direction was about 6 percent; grades as great as 10 percent were permitted in the opposite direction. Since the road to Globe was the only freight road in existence when preliminary work began, all machinery (for the cement mill, the temporary power plant, and the sawmill), oil (for early operation of the cement mill), lumber, feed, and supplies came over this forty-mile road by wagon to the reservoir site. The high-line road to Globe, begun in December 1903 and completed in May 1904, allowed for easier delivery of these supplies from the Globe and Northern Railroad terminus.[7]

Mesa had the advantage of two competing railroad lines—the Santa Fe, Prescott and Phoenix, and the Maricopa and Phoenix; freight rates were also competitive. Since freight charges accounted for so much of the final cost of supplies, and since twenty-two miles of the sixty miles from Mesa to Roosevelt were desert and comparatively level, the Reclamation Service wondered whether a new road from Mesa might not be worth the expense. Calculation of the difference in freight rates was $15 a ton in favor of Mesa, and so work began in October 1903, near Goldfield, Arizona, located on that part of the proposed mountain road nearest the valley; in December road construction began at Roosevelt, on the upper end of the road in the canyon below the dam.[8]

To avoid the spillway on the south side of the river, the new freight road was located in the mountain, high above the dam itself. It descended to the river around the walls of a rocky side canyon with nearly vertical cliffs. Following the river for about seven miles, the road was deep inside the canyon; because some parts of it in this section were built along steep cliffs, solid-rock cuts twenty to sixty feet deep were necessary. A classic understatement described this area as one of the most difficult parts of the road; lifelines were essential to protect the workmen and, even with them, there were fatalities. Another problem-filled part of the road was that at Fish Creek Hill, where the road climbed the hill toward Mesa at a 10 percent grade, primarily along the foot of a vertical cliff several hundred feet high. The sheer cliff in this section required rock fills seventy-five feet high to achieve the recommended width of the road and rock cuts sixty to seventy feet deep.[9]

Only three miles of the road near Goldfield had been completed when work was temporarily discontinued, pending the outcome of a bonding plan by the valley to contribute toward the cost of the road. Because the cities and towns would benefit more from the new freight road than the landowners of the association, many town boosters, who wanted the road built as soon as possible, believed they should help shoulder the cost. Congress passed enabling legislation in early 1904 so that Phoenix, Mesa, and Tempe could bond themselves, at $65,000, $3,500, and $4,000 respectively; Mesa passed the bonds unanimously, Phoenix by 94 percent, and—to no one's surprise—the bonds barely carried in Tempe. Local banks agreed to secure the money and Phoenix and Mesa sold most of their bonds; as a result, the work force on the Mesa-Roosevelt Road increased to four hundred by the middle of June 1904. Tempe had not yet "taken the trouble to sell her bonds," and most believed the project would realize nothing from that subscription.[10]

The Mesa-Roosevelt Road was first used in early 1905, but it was heavily damaged by flooding that spring and fall. It seemed that "flood followed flood, each succeeding one greater than that before it, with hardly enough time intervening to permit repairs to be made before work was again swept away;"[11] these conditions delayed the road's completion until 1909.

Thirty to fifty Apache Indians built the last major road; the 1907 Tonto Road replaced the old Tonto Road, which had been submerged by the rising reservoir. It, too, was expensive and difficult to build, requiring a 3,700-foot-long crossing over Tonto Creek and the removal of rock and other material eighteen to twenty miles, primarily by hand; over 500 feet of 30-inch concrete pipe culverts were laid, and 4,000 cubic yards of dry wall were put in. The Indians were separated from the rest of the large labor force at work on the Salt River Project, and available evidence does not indicate whether they were also accorded the eight-hour-day and pay equal to the others. They were, however, a consistently productive labor group, responsible for many aspects of the construction and greatly depended upon by the Reclamation Service for much of the heavy work.[12]

Of all the roads built by the Reclamation Service on the Salt River

Project, the Mesa-Roosevelt Road was by far the most difficult and expensive. The Service told the Congress in its Third Annual Report that:

> The construction is as expensive as heavy railroad work, the cost of some short portions reaching $25,000 per mile; in others it fell as low as $500 per mile . . . . [However,] the reduction of rates on oil for burning cement, on food, on machinery, supplies, hay, grain, etc., will nearly pay the full cost of the road.[13]

The U. S. Reclamation Service constructed a total of 112 miles of permanent roads at a cost of over half a million dollars, or about $5,000 per mile on the average. Temporary construction roads, such as those to the cement mill and the clay beds, cost another $44,000, charged entirely to the cost of the project.[14]

Since most of the preliminary work on the project consisted of road-building and surveying, there was little need for a permanent headquarters camp at the damsite throughout 1903. The town of Livingstone, a short distance away, provided temporary quarters for Reclamation Service personnel and the labor force until 1904, when construction on the reservoir site itself necessitated a permanent camp. Preparations, which had been made during the previous year, included a small water system, built for the Roosevelt community, and, in anticipation of the summer heat, a refrigerator plant of two-ton capacity to produce ice. Situated on a high bluff overlooking the reservoir were the office building and reading room, cottages for the engineers, tents for the workers, and a corral.[15]

Because the camp was located so far from any other settled community, the Reclamation Service built a small hospital and hired a Phoenix doctor as camp physician. Sanitation was provided by a septic-tank sewage system, and electric and telephone lines were strung throughout the burgeoning village. A small vegetable garden provided fresh food for the laborers and engineers on the project, and bathhouses were built for their comfort. Completing the picture of civilization at Roosevelt was the jail, used mostly to confine those who had violated the strict anti-liquor rules imposed by the Reclamation Service.[16]

Supervising the work on the Roosevelt Dam was Louis C. Hill, a former railroad engineer and professor of hydraulic and electrical engineering at the Colorado School of Mines. Hill was thirty-eight years old when he took charge of the Salt River Project in 1903, and, although he had been a divisional manager of the Great Northern Railroad, he had never before directed an irrigation project. Perhaps because few engineers had extensive irrigation experience on large-scale projects, Frederick Newell assigned the design for the Roosevelt Dam and the Salt River Project to Hill, Davis, and Teichman, retaining final approval, however, as director of the Reclamation Service. Hill's education in civil and electrical engineering at the University of Michigan made him a good choice for engineer-in-chief. He assembled a team of engineers to direct, under his supervision, the various construction aspects of the project. J. D. Stannard was administrator of the Phoenix office, Howard S. Reed of the canal system, W. A. Farish of the roads, and A. M. Demrich of the electric plant. When Hill was appointed supervising engineer of all Reclamation Service work in Arizona, southern California, New Mexico, Texas, and Utah in late 1904, Chester W. Smith was chosen as the new engineer-in-charge for project construction. Smith was the engineer responsible for implementation of the project design, and for improvisation when things did not work out as they should.[17]

Chester Smith arrived at Roosevelt late in the afternoon of December 22, 1904, and over the few days remaining in the year learned generally the direction of the work and plans. The pace of work on the project increased under Smith, as he took little time from his duties for anything else; unlike Hill, who lived in Phoenix with his wife and children, Smith was alone at Roosevelt. He was an engineer totally involved in his work, who believed in conservation and viewed engineers as key elements in it. Publishing extensively in technical journals, Smith enjoyed solving engineering problems and sharing solutions with his fraternity of fellow engineers. His workday began at sunrise and lasted well into the evening, and this routine stopped only when illness forced him to his bed. While some men might have hesitated to take the challenge of supervising construction of the Salt River Project, given the difficulties of location, economy, and the completion goals, Smith never seemed to waver. He was completely devoted to making the Salt River Project a success, and he expected the same from every other worker there; he seemed to have little regard for those less committed.[18]

During January 1905 Smith reviewed the proposed power-canal lines and the sawmill site and road; he also showed various representatives of national construction companies the reservoir site. Through February and March, he started construction of the temporary bridges and auxiliary cables necessary for hauling material across Salt River (the rock quarry was located on the north side of the river, and almost everything else was on the south side), had two Italian stonemasons at work on stone samples to determine the specific gravity of the rock, and designed and worked out the lumber fill for the temporary dams necessary to divert the normal flow of the river from the various construction sites.[19]

Bids for construction of the dam opened on February 23, 1905. Twenty firms from all sections of the country submitted detailed estimates. Included within these estimates were prices for three classes of excavation, for construction of the masonry dam, coping, wing walls, bridges, bridge piers, and overhaul, and for the time necessary for completing the work. John M. O'Rourke's firm from Denver, Colorado, builders of the Galveston seawall, submitted the winning bid of $1,147,600 for construction of the Roosevelt Dam in two years. Smith, however, preferred the bid of a St. Louis Company, Broderick and Ward ($1,187,200 for a completed dam in seventeen months), and he listed them first in his notes and O'Rourke second; whether economy was the only deciding factor is unknown.[20]

O'Rourke needed cement before he could begin foundation work or the necessary construction of the coffer dam, which would divert the river from the foundation site, and Smith prodded the crews that were completing the problem-riddled cement mill. Although excavation for the foundation of the cement mill began in November 1903, delays—due to slow delivery of equipment and to the floods of early 1905—left the cement mill unfinished until the water receded in February 1905. The rain-soaked road from Globe caused one shipment of cement to take eleven days in January 1905, before reaching the damsite; workers were able to deliver only two loads of oil in February. Smith discovered that no oil-storage tanks had been constructed near the mill; this oversight further decreased productivity, and design of a 2,000-barrel tank began late in 1904. Output increased by 50 percent when he built a second tube mill for grinding cement in November 1905. With an adequate amount of oil stored to fuel the temporary steam plant (prior to completion of the power canal), the cement mill began to run with only minor interruptions. Although the government price of $3.14 per barrel of cement was less than all the others, the use of oil for fuel in the mill accounted for more than 50 percent of that cost.[21]

PLANNING FOR HYDROELECTRIC POWER

The high cost of using oil as a fuel source during construction was but one of the reasons that the Reclamation Service designed Salt River as the first multi-purpose reclamation project in the nation. Other arguments supporting the added hydroelectric capacity were chiefly of local interest. Farmers in the valley who were not located under one of the project canals depended upon the pumping of groundwater to irrigate their crops; the power canal and power plant located at Roosevelt would provide inexpensive hydroelectricity for pumping. Several copper mines, located within the Globe-Superior-Miami triangle, about fifty miles from the damsite, also needed cheap power for rock-digging equipment. Still another potential customer of the hydroelectricity produced at the Roosevelt Dam was the City of Phoenix. George Maxwell wanted to develop "every atom of electric power" for the irrigation of the Salt River Valley; Frederick Newell agreed with him. For these reasons, the original plans for the project included a 19-mile-long power canal, which would produce 4,400 horsepower (3,282 kilowatts) in a temporary unit to be used in constructing the dam and in pumping water for irrigation, and a permanent power plant of 4,400 kilowatt capacity.[22]

The power canal, with its head at the upper end of the reservoir, skirted the reservoir basin along the water level when the basin was full, passed around one end of the dam in a channel cut in the rock wasteway, dropped several feet through a hole in the rock, and then went out and over the precipice to the temporary powerhouse. Contracts for excavation were let in March 1904, but the difficulties of digging out 600,000 cubic yards of rock and dirt and of driving 9,000 feet of tunnel were sufficient for Smith to bet a new suit of clothes that excavation would not be finished within the estimated time. He won; excavation was completed in November, three months late.[23] The work was heavy, but the complications of the canal project centered mostly on the construction of the reinforced concrete pressure pipes that carried a capacity water flow of 250 cubic feet per second underneath Pinto Creek, a tributary of Salt River located upstream from the damsite.[24]

The use of pressure pipes to carry water underneath water was not new; municipal waterworks in Europe and in the eastern United States had included them for several years. What was new about the work at Roosevelt, and considered quite timely by other engineers at work in developing water systems, was the use of reinforced concrete pipe, (which could carry water at high pressure) instead of the wood and cast-iron pipes which dominated water-system technology at that time.[25]

Work on the Pinto pressure pipes for the power canal involved a labor gang of about thirty men continuously laying concrete around steel reinforcement rings. The primary reason for continuously laying the concrete was to avoid irregular transverse joints; if the joints were not smooth, the pipe would leak, pressure would devolve upon the concrete rather than the steel, and the pipe would crack. A specially designed movable form facilitated continuous work. Problems arose, however, with cement peeling off its steel plates. Soft soap and oil were used as remedies, but even so the government-produced Portland cement was slow to set, requiring more time and labor than originally anticipated. For this reason, labor was the highest cost in construction of the pipes.[26]

Temperature also adversely affected the pipe's construction. On the first of the two Pinto lines there were few interruptions to continuous work, and most of the pipe was built in comparatively cool weather, so transverse joint problems were minimal. But the second Pinto line was built entirely during the hot, summer months with several interruptions to continuous work, and, when it was first filled during cold weather, at least forty perceptible cracks developed in the transverse joints; the result was severe leakage.[27]

Smith seemed to enjoy diagnosing the problem on the Pinto lines. In his words, he believed the pipes cracked because "the concrete shrank in the process of setting; this was resisted by the steel rings, thus producing a condition in which the steel was in compression and the concrete in tension, therefore on filling the pipe, the concrete took the entire load."[28] He worked on this problem after dinners, until one evening, after dining with Hill and some other engineers, he realized the problem and the solution. Repairs were made by cutting the cracks out, inserting oakum caulking, and then putting stiff mortar over the joints; grout was run into the crack from the outside.[29]

The Reclamation Service constructed the 2,600-foot-long Pinto pipes at a cost of nearly $106,000; similar pipes at Cottonwood Creek cost less than half that amount. Smith acknowledged labor as the principal cost of the Pinto pipes, calling the labor employed in Arizona, "inefficient and high-priced."[30] Yet even with the construction problems and the labor costs, the reinforced concrete conduit pipes for the Salt River Project's power canal received accolades from Thomas Wiggins, an engineer on the New York Board of Water Supply: "The engineers of the Reclamation Service deserve great credit for the way the pipe was built and its cheapness under rather adverse conditions . . . it illustrates what can be done by ingenious engineers who are also practical."[31]

Water was diverted into the power canal intake by a boulder and concrete overflow dam, and the entrance to the intake was governed by gates designed to exclude sand and other material from the canal. Although the intake gates kept much of the heavier debris from flowing down the canal, Teichman designed a novel rotating screen, located at the penstock (where the water flowed into the guide buckets of the powerhouse turbine), to keep grass and sticks from lodging in the buckets and breaking the turbine runner. Settling basins above the entrance to the Pinto pipes and in front of the penstock also removed silt from the water in the canal. The power canal was first put into operation April 1, 1906, but it was plagued with breaks in the banks in September, so that water was kept out of the canal and no power was available. These breaks were quickly repaired, however, and the operation of the canal proved quite satisfactory to the Service. Final cost of the power canal, including all excavation, tunnels, pipes, gates, settling basins, and repairs, was approximately $1.5 million. The Reclamation Service had initially estimated its construction costs at $91,000, but even the engineers did not attempt to justify the expensive overruns; the high labor costs and quirks of nature, as well as the untried character of the work itself, contributed to the inflation.[32]

The permanent power plant was, in a sense, an extension of the temporary plant designed by the project's engineering consulting board. Although the temporary unit was needed immediately, the engineers (George Y. Wisner, W. H. Sanders, O. H. Ensign, and Louis C. Hill) decided to install it in a recess cut out of the canyon wall about thirty-five feet above the low-water mark, which would also house the permanent plant. The temporary unit was enlarged in 1907 to include a second penstock which would connect to the dam (the first connected with the power canal), and the installation of additional turbines (there would eventually be three units producing power). Upon construction of the permanent stone powerhouse, Smith discovered that the waterwheel had been badly cut due to cavitation (the hydraulic erosion of steel due to high velocity flows); he immediately ordered a new one, since that was about the only solution to the problem at the time.[33]

High velocity flows posed other problems in construction as well. At the same time that excavation on the power canal began, the government was at work blasting out the approaches to the sluicing tunnel on the south side of the river, which would carry the water around the damsite during construction. The tunnel, driven by a private contractor beginning in May 1904, was 13 feet wide, 11 feet high, and 480 feet long, and passed through a solid mountain wall of quartzite and sandstone before exiting above the dam spillway. Construction was difficult and uncomfortable; a small rise in the river flooded both portals with mud and debris, and several hot springs were struck, forcing temperatures inside the tunnel to 130 degrees Fahrenheit. Apache Indian and Mexican laborers poured concrete on portions of the tunnel floor, from the entrance to the hydraulic gates, and on the sides and top of the section below the gates, as the engineers had instructed, although the design called for a steel and concrete floor. After completion in September 1906, when water was turned through the tunnel under high pressure, the deep cuts produced required complete reconcreting of the tunnel floor; this was finally finished in 1909.[34]

The hydraulic gates in the sluicing tunnel were unique in that "no other instance [was] known where gates of this size [were] operated under so high a head."[35] A combination of steel and bronze, of the stony type, the six gates moved on rollers and were operated by hydraulic cylinders electrically controlled. Set in two groups of three, the gates were used for both service and emergency purposes. The service gates were designed to regulate the amount of outflow from the reservoir, and the emergency gates were to control water in case of accident or repair to the service gates. Although designed to handle a head of water of one hundred feet, an increase in the head imposed operation limitations on the hydraulic cylinders. When the high flow in September 1906 caused a large amount of damage to the tunnel, it also attacked and damaged the upper battery of gates and carried away a portion of the bronze roller trains. Although repaired with the tunnel, the gates never functioned as they should have.[36]

CONSTRUCTING THE DAM

All of this construction—the roads, permanent headquarters, cement mill, power canal and powerhouse, and sluicing tunnel—was simply a prelude to the main act at Roosevelt—building the dam itself. John O'Rourke's construction company signed a contract with Secretary of Interior Ethan A. Hitchcock in April 1905, agreeing to finish the dam in two years; the company immediately began preliminary work. During the remainder of 1905 O'Rourke's crew established camp on the north side of the river, secured equipment, installed the machine plant, and began stripping the quarries for stone and driving piles for a coffer dam and flume. They were the builders, putting together the pieces designed by the engineers.

The contractor's work was closely monitored by Chester Smith. Although the two men seemed amiable toward each other in the early days of construction, by the end of the first year their relationship was strained; O'Rourke must have wondered what he had involved himself in, and Smith quite candidly believed the government could do all the work better and faster than O'Rourke's group. The central problem between the two was quality of construction. Smith was quite concerned with dam stability, as were the other engineers, and insisted on performing the work methodically to insure its safety; no step was to be eliminated and no unauthorized shortcuts would be allowed. O'Rourke, on the other hand, saw before him a contract with a two-year deadline; his goal was to push the work as rapidly as possible. In attempting to meet their respective goals, a certain amount of tension developed between the engineer and the builder.

That the strain between Smith and O'Rourke did not automatically transfer to the men working under their authority was due primarily to the very clear delineation of the work to be performed on the dam by the Reclamation Service and by the contractor. O'Rourke and his men were responsible for building the coffer dam, the flume, and the cableways (from the quarry to the damsite and from the damsite to a spot upstream where waste was hauled), for cutting the stone and spalls (small fragments of stone) from the cliffs for the dam, for excavating the foundation, and for laying the masonry. The Service was to provide power, cement, and sand and to build the toolhouse, gatehouse, reinforced bridge on top of the dam, outlet tunnel, and sluice gates. Accountability for the tasks of building was clear.[37]

In addition to working on separate jobs, the men on O'Rourke's crew worked out of a different construction area from those in the Service, although they all ate together in the mess hall and presumably were housed in the same bunkhouses. There is little evidence to suggest that workers were concerned with the differing philosophies of the contractor or the Service.

It was the vagueness of Smith's instructions—to supervise O'Rourke's construction—which left the contractor somewhat unsettled about his own function. Their relationship was not one that each had embraced, but rather one mandated by the Department of Interior. Latent difficulties between the two men were perhaps unfairly accentuated during the 1905 floods. Rain began to fall at noon on November 26, 1905, and between 6:00 P.M. of that day and 11:00 A.M. of the 27th, the river rose thirty feet at the damsite; the discharge increased from 2,000 second-feet to nearly 130,000 second-feet. All the work done on the coffer dam and flume was washed away, as well as some of the necessary machinery for continuing construction.[38]

Minor flooding occurred throughout the remainder of 1905 and into 1906, preventing renewal of construction until March. When the river receded to a point at which O'Rourke's crew could begin anew on the coffer dam, the contractor requested that the flume be dispensed with and the sluicing tunnel alone carry the river. While Smith and Louis Hill agreed to this change in construction plans—probably in an attempt to hurry the work along—Smith was not entirely pleased with the prospect of the tunnel's carrying the entire flow of the Salt River; the river had already shown its erratic nature, and the tunnel carried a maximum of only 1,300 second-feet. Concern over the sluicing tunnel as the only source of water carriage around the damsite proved well founded, as very minor floods washed over the coffer dam delaying construction several times throughout 1906 and 1907.[39]

While O'Rourke's initial construction delays resulted mainly from flooding during 1905, he was slow to respond to the flood emergency. His company left machinery on the riverbanks and did not quickly rebuild the coffer dam with flume, nor did it employ an adequate number of workers to pump the water from the foundation site. This lack of preventive activity led Smith to believe the contractor from Denver was inexperienced in large construction, despite O'Rourke's Galveston seawall. Construction problems on the dam throughout 1906 gave further credence to his earlier impression. For example, in February 1906, the man scheduled to do the pile driving was ready to start, but the hammer was not available. In addition, O'Rourke had not hired a sufficient number of skilled quarrymen, probably because he underestimated the inaccessibility of skilled labor in Arizona and because he did not pay very well. Although O'Rourke insisted that recently recruited quarrymen from California would arrive by June 14, 1906, Smith was forced, by the end of September, to ask two stonemasons he knew in Pennsylvania to come to work on the dam and to bring masons and laborers with them; Smith even offered to pay railroad fare for the two men.[40] The coffer dam O'Rourke was rebuilding throughout the spring of 1906 remained incomplete by June, and Smith thought the construction crew was "not making any energetic attempt to back up the gap or to make the dam tight by depositing fine material on the upper side."[41]

The gap in the coffer dam allowed as much as 20 percent of the river to flow through, flooding the excavation pit for the foundation of the permanent dam and preventing the use of the hydraulic excavator. The "entire progress [of the dam] is depending on the closing of the upper [coffer] dam," Smith wrote on June 18, 1906, disturbed by the slowness of O'Rourke and his crew. He outlined a plan for the contractor in which the construction workers would work nights, use fine material and rock to fill the gaps in the upper dam, and then concrete the lower one. Even with these instructions, O'Rourke continued to place scarce labor on work projects that could wait; this practice delayed the cutting of stone and the completion of the coffer dam, and generally set back the date at which laying masonry could begin.[42]

In all fairness to O'Rourke, no contractor had experience in building large irrigation works such as those envisioned at Roosevelt; just as the landowners and engineers experimented with new ideas and forms, so the contractor relied on his ingenuity to solve unanticipated problems. Because the coffer dam did not hold all the water expected, more of the river flowed into the damsite than the hydraulic excavator could handle, so the construction crew built a sump just below the upper coffer dam to cut off the water which would normally fill the pit. Although Smith did not believe that the work of lowering the hydraulic excavators was pursued as energetically as it should be, O'Rourke did manage to begin laying the foundation masonry for the permanent dam on September 20, 1906—more than ten days ahead of the schedule Smith pessimistically thought possible.[43]

By the fall of 1906 the coffer dam held a sufficient amount of the river (there were fortunately few rains) so that work of building the dam progressed nicely. Excavation along the dam line to the solid bedrock was completed with little use of explosives, so that the rock would not be weakened. The foundation was thoroughly cleaned of all gravel, sand, and earth, and all fissured or disintegrated rock was removed; the dam would rest on solid rock throughout. Once the foundation was cleaned, the stone could be laid. The aim of the Reclamation Service was to use the largest proportion of stone and the smallest proportion of mortar and concrete in the dam that could be practically secured. For this goal to be accomplished, the Service provided facilities for handling stone weighing as much as ten tons, and large stones were used almost exclusively. To facilitate the drying of concrete during the hot season without cracking, all masonry was kept wet during the time of construction and until the work was at least six days old by piping water by gravity from the power canal to cover the face of the dam with a thin wet film. The temperature of the masonry was, thus, kept as much as 75 degrees below that which it would otherwise have reached.[44]

Chester Smith, other engineers of the Service, and John O'Rourke's crew also developed a faster and better method of laying masonry. In the classic method used on other masonry dams, a dam's vertical joints were filled with comparatively stiff mortar and then spalls were "laboriously laid up by a mason with a trowel." The new method involved filling the vertical joints with quite wet concrete (largely placed by dumping it), churning and spading when necessary, and throwing spalls in the joints. Not only did the new method increase the amount of masonry which could be laid (from an average

Excavation for the foundation of Roosevelt Dam went down to solid bedrock and was accomplished with little use of explosives, so that the rock would not be weakened. This photo, taken in September 1906, shows excavation at the base of the abutment wall. Excavated materials were removed from the pit by large metal buckets, which were transported by cableways; a bucket hook is visible at upper left. Materials were excavated by manual labor, using pick axes, sledge hammers, and shovels.

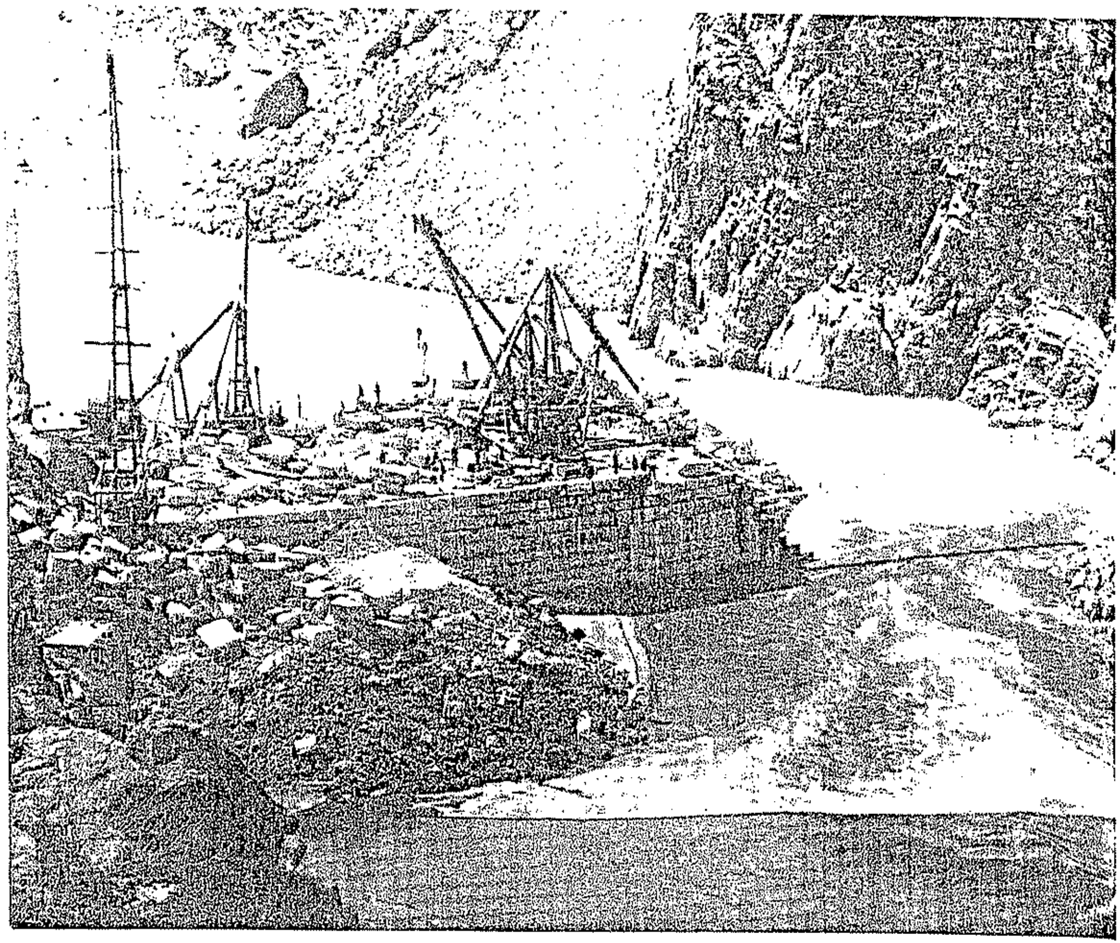
of six cubic yards per derrick-hour to an average of sixteen cubic yards), but it also resulted in masonry that was more watertight than that produced by the classic method.[45]

Despite these new, faster methods of laying masonry and O'Rourke's readiness to begin setting the stone for the dam, Smith remained dissatisfied with the work's progress. He considered the contractor's crew to be unorganized and, as he had done for the construction of the coffer dam, Smith outlined a plan for the builder to follow. All the power drills were to be placed in the excavation pit and work was to begin immediately on the cut-off trench; all the trimming and cleaning of the stone must be performed in the quarry, not at the damsite; no more stone was to be stored in the excavation pit, where it would be in the way of excavation; night work would begin October 1, 1906; the stone would be crushed finer; and more men must be trained to perform the skilled masonry work. Smith's evident displeasure with the contractor's work generated rumors around Roosevelt that the government wanted to finish the job, rather than extend another contract deadline to O'Rourke.[46]

Although Smith denied that the government would finish the dam itself, it is probable that he would have muttered something concerning the wisdom of replacing O'Rourke with a more competent Reclamation Service crew. O'Rourke tried to hurry the work along not by hiring more workers or by paying a wage that would entice skilled labor to remain at the isolated construction site but by trying to evade the eight-hour work day mandated by law. When Smith refused to allow the contractor to ignore this legal provision, O'Rourke, in October 1906, appealed to Louis Hill. The contractor insisted that Hill should declare a state of emergency, a situation that would suspend enforcement of the labor provision. Hill refused; the eight-hour law was to remain in effect.[47]

In November seven skilled workers left the contractor's camp right in the middle of important excavation work because, as Smith noted, "O'Rourke would only pay $3.50 per day instead of $4." On another occasion (November 18, 1906), water was low in the power canal, and the power and lights were shut off from 9:00 P.M. until 12:30 A.M., so O'Rourke's watchman shut down the hydraulic lifts and went home. When water then came in, there was no one there to start the pumps, the bottom of the pit filled with water, and no masonry could be completed for several days until it was pumped out. As Smith remarked, "this need not have been the case."[48]

The problem of diverting the river had not been solved by the coffer dam and sluicing tunnel. High water throughout the winter of 1906 and spring of 1907 continued to flood the excavation of the foundation, so, in 1907, O'Rourke's crew began building a rock-fill dam to supplement the concrete coffer dam in driving the river into the tunnels. By May 6, 1907, more than two years after the signing of the government contract, the rock-fill dam extended completely across the river, and O'Rourke's men were at work making both the rock-fill and concrete coffer dams tighter, so that laying the main body of masonry for the permanent dam could proceed uninterrupted. Even with this bit of progress in taming the river, Smith



When high water came in the spring of 1908, the southern part of the dam (left) was high enough to cause the river to flow over the north end only. About two months after this photograph was taken in April 1908, construction crews began laying masonry at the north end. The wooden, stiff-arm derricks on top of the dam were used to move the quarried stone into position. A temporary walkway stretches across the floodwaters to the north end of the damsite.

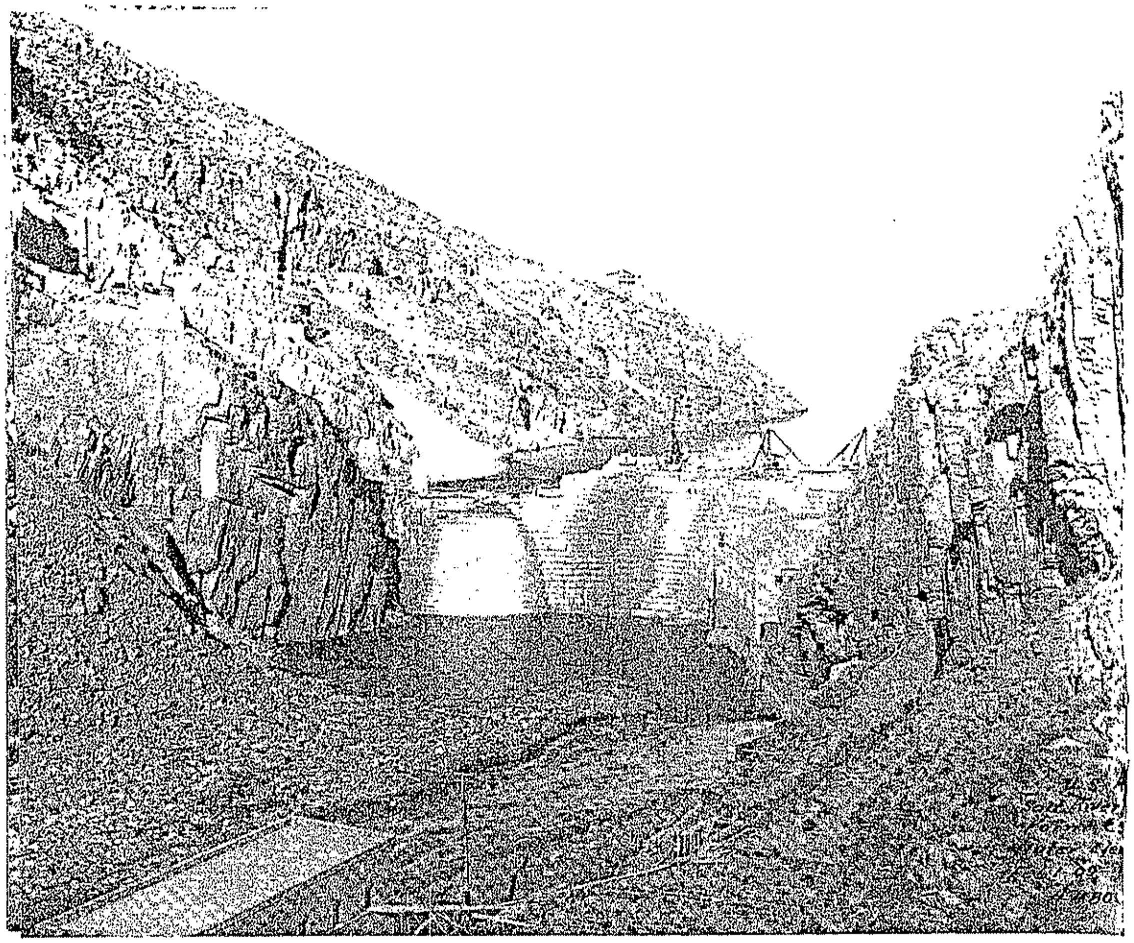
continued to find the contractor and his men inept. On May 8, 1907, Smith went down to the coffer dam and found O'Rourke's crew "fiddling around, doing nothing but [getting] their mixing plant in shape to run."[49] Continual mistakes by O'Rourke's crew in dumping concrete into water that was not still led Smith to report the next day that "the job is not being conducted with energy or brains."[50] Breakdowns in the hydraulic pipes, inadequate provision for steam pumps to power the contractor's centrifugal pumps, and the persistent problem of maintaining an adequate labor force produced postponement after postponement for setting the stone for the main dam.[51]

Although George M. Steinmetz, manager of O'Rourke's crew, promised Smith that setting the stone for the main dam would begin June 1, 1907, water in the pit prevented this. When the contractor wanted to lay new masonry on top of the masonry laid in the fall of 1906, rather than at the low point, as Smith required, O'Rourke angrily declared that he would appeal to Washington. Because he was many months behind schedule in building the dam, O'Rourke was in a hurry to get several layers of stone laid as an indication of his progress. Smith knew, however, that stone laid at the low point of the excavated foundation would prevent movement, particularly in the event of flooding, which had plagued the construction of the dam since 1905. Louis Hill supported Smith, of course, and O'Rourke fussed and fumed throughout the summer at what he considered persecution by the two engineers.[52]

In August 1907 Smith and O'Rourke had a long talk about "things generally." The contractor did not feel that he was getting "a square deal"; Smith tried to explain government regulations concerning waste, dumping, and payment for goods produced. The results of this talk were not entirely satisfactory, and O'Rourke continued to go over Smith's head to Louis Hill for permission to do things differently; Hill continued to side with his engineer in charge of construction. This problem continued until the final stone was laid February 5, 1911.[53]

Once the foundation had been cleared, water pumped out, and the masonry set down, dam construction went quickly. There were no floods throughout the winter of 1907 and early 1908 to impede the construction progress. When high water did come in the spring of 1908, the southern two-thirds of the dam were at a sufficient elevation that the excess water passed over the north end of the dam only, without delays to the contractor. In June, O'Rourke's men began laying masonry at the north end of the dam, and from this month forward, the south end of the dam was kept from eighteen to fifty feet higher than the other. On November 29, 1909, the contractor brought the elevation of the lowest part of the dam to 150 feet, the elevation which was supposed to have been reached by April 1907.[54]

Construction of the Roosevelt Dam and its ancillary structures, completed in February 1911, was marked both by new technological features and by inefficient and inexperienced contractors. While the introduction of reinforced concrete pressure pipes, advanced methods of laying masonry, and innovative hydraulic sluice gates helped to spur the pace of building the dam, as well as to characterize it as a modern piece of construction, the problems between John O'Rourke and the U.S. Reclamation Service hindered its progress. The more



The downstream face of Roosevelt Dam, February 1909. Water elevation behind the dam is 73 feet. The completed power house is located just below the dam (center right), and part of the transformer house is visible at the lower left of the photo. The building on the hill in the background is Apache Lodge; built by contractor John M. O'Rourke, it served as the residence for his engineers, foremen, and inspectors. White water at the lower center of photo is discharge from the sluice tunnel. Cableways, which were used to transport material from one side of the river to the other, are visible at top right.

time and men it took O'Rourke's company to build the dam, the more costly it was to become to the landowners of the Salt River Valley Water Users' Association, both in irrigation water lost and in project dollars to repay; the same was true, of course, for the Reclamation Service's expensive overruns on the power canal.

Yet throughout the period 1904 – 1908, when construction problems peaked, visitors to Roosevelt did nothing but praise the work and its creators. Benjamin Fowler, Dwight Heard, A. J. Chandler, and

W. J. Murphy were just a few of the prominent members of the Association who ventured up the winding road from the valley to check on the dam's progress. More often than not, Chester Smith would personally lead them through the labyrinth of tunnels, canals, and proposed dams, so that these men felt they were informed about the project they would eventually call their own. From across the nation came important politicians, such as William G. McAdoo (a power in the Democratic party who would become Secretary of the Treasury in 1913) and Secretary of Interior James Garfield, to check on the nation's reclamation program at Salt River. Often led by Frederick Newell, Louis Hill, Joseph Kibbey, or Benjamin Fowler, these men also followed Smith over the Roosevelt project, seeing for themselves the conditions which they had previously known only through Reclamation Service reports.

Few, if any, of the visitors to Roosevelt were aware of problems, other than the 1905 floods, which were pushing back the date of completion of the dam. Newell, Hill, and Smith considered these problems to be engineering concerns which could be solved by the practical, rational men of the Service. They knew that compared to other reclamation projects, the problems at Salt River were minor ones with predictable solutions. If the private contractors on the sawmill could not produce, the government would take over; if the concreted portion of the sluicing tunnel broke away during high flows, it could be replaced; if the hydraulic gates malfunctioned, they could be fixed. O'Rourke's construction company made mistakes which delayed the final date of the dam's completion but did not mar its ultimate success.

Officials of the Reclamation Service considered the Roosevelt Dam a magnificent achievement, and a "monumental triumph of the skill and genius of [its] scientist creators."[55] Residents of the Salt River Valley and the nation joined them in their praise. The magnitude of engineering and construction accomplishments—and this still cannot be lost on the visitor rounding the final turn up Roosevelt Road to see a dam of solid rock looming between the Mazatzal and Sierra Ancha Mountains—dominated other issues.

36. Ibid.
37. B. A. Fowler to Joseph Kibbey, October 23, 1905, Copies of Letters between Salt River Valley Water Users' Association and U.S. Reclamation Service, 1902 – 1909, Corporate Secretary's Office, Salt River Project; Fowler circular to the Association, March 31, 1906.
38. Joseph Kibbey to B. A. Fowler, October 28, 1905, Copies of Letters between Salt River Valley Water Users' Association and U.S. Reclamation Service, 1902 – 1909, Corporate Secretary's Office, Salt River Project.
39. C. J. Hall to the Board of Governors, November 6, 1905; B. A. Fowler to Frank Parker, November 10, 1905, Copies of Letters between Salt River Valley Water Users' Association and U.S. Reclamation Service, 1902 – 1909, Corporate Secretary's Office, Salt River Project.
40. Commission of Engineers to Charles Walcott, December 8, 1905, Copies of Letters between Salt River Valley Water Users' Association and U.S. Reclamation Service, 1902 – 1909, Corporate Secretary's Office, Salt River Project.
41. B. A. Fowler to the Board of Governors, December 16, 1905, Copies of Letters between Salt River Valley Water Users' Association and U.S. Reclamation Service, 1902 – 1909, Corporate Secretary's Office, Salt River Project.
42. Ibid.
43. B. A. Fowler to the Board of Governors, January 6, 1906, and January 20, 1906, Copies of Letters between Salt River Valley Water Users' Association and U.S. Reclamation Service, 1902 – 1909, Corporate Secretary's Office, Salt River Project; Fowler circular to the Association, March 31, 1906.
44. B. A. Fowler to the Board of Governors, February 19, 1906, Copies of Letters between Salt River Valley Water Users' Association and U.S. Reclamation Service, 1902 – 1909, Corporate Secretary's Office, Salt River Project; *Minutes* of the Board, March 20, 1906.
45. Ibid.
46. B. A. Fowler to the Board of Governors, January 9, 1906, March 8, 1906, Copies of Letters between Salt River Valley Water Users' Association and U.S. Reclamation Service, 1902 – 1909, Corporate Secretary's Office, Salt River Project; *Minutes* of the Board, March 20, 1906.
47. Dwight B. Heard to the members of the Salt River Valley Water Users' Association, April 2, 1906, pamphlet in S.R.P. 1906 Newsclip file, Corporate Secretary's Office, Salt River Project.
48. Dwight B. Heard to Charles Walcott, March 28, 1906, Records of the Bureau of Reclamation, Record Group 115, Salt River 1902 – 1919, series 261, National Archives, Washington, D.C.
49. B. A. Fowler to Morris Bien, March 27, 1906, Records of the Bureau of Reclamation, Record Group 115, Salt River 1902 – 1919, series 261, National Archives, Washington D.C.
50. Ibid.
51. "An Earlier Water Users' Election," *Republican*, 3 April 1926, clipping in the Arizona Collection, Arizona State University.
52. F. H. Newell to Dr. E. W. Wilbur, March 29, 1906, Records of the Bureau of Reclamation, Record Group 115, Salt River 1902 – 1919, series 261, National Archives, Washington, D.C.

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1. U.S., Department of Interior, Reclamation Service, *Third Annual Report of the United States Reclamation Service, 1903 – 1904* (Washington, D.C.: Government Printing Office, 1905), p. 44.
2. U.S., Department of Interior, Reclamation Service, *First Annual Report of the United States Reclamation Service, June 17 to December 1, 1902* (Washington, D.C.: Government Printing Office, 1903), pp. 95 – 99. In 1986 the dam stood at 280 feet.

3. Chester Smith, "The Construction of the Roosevelt Dam," *Engineering Record* 62 (December 31, 1910): 756–762; "History of the Salt River Project," author unknown, no date (probably the U.S. Reclamation Service, c. 1911), pp. 65–66, 80–82, unpublished typescript, Salt River Project Archives; Chester Smith, "Progress on the Roosevelt Dam, Salt River Project," *Engineering News* 60 (September 10, 1908): 265–268; *Third Annual Report of the U.S. Reclamation Service*, p. 140. The "History of the Salt River Project" is primarily a technical report which describes the construction plans and specifications.
4. "History of the Salt River Project," pp. 59–74; *Third Annual Report of the U.S. Reclamation Service*, p. 140.
5. "History of the Salt River Project," pp. 65–67.
6. Ibid., p. 68.
7. Ibid., pp. 68–69.
8. Ibid., pp. 69–70.
9. Ibid., pp. 70–71.
10. Ibid., p. 71.
11. Ibid., p. 72; Salt River Valley Water Users' Association, "Data for the Committee of Special Advisers on Reclamation of the Department of Interior," December 24, 1923, pp. 3–4, Central Records Box S-7-21, Salt River Project.
12. "History of the Salt River Project," p. 73. Chester W. Smith, Diary No. 1, December 22, 1904, Salt River Project History Center, illustrates the use of Apache Indians on the Salt River Project. See also Clarence J. Blanchard, "A Great Work of Irrigation in the West," *Travel* 12 (August, 1907): 483.
13. *Third Annual Report of the U.S. Reclamation Service*, p. 141.
14. "History of the Salt River Project," p. 74.
15. Ibid., pp. 60–61. Chester W. Smith continually refers to engineers moving into new cottages throughout his diaries, and occasionally notes the workers in the tents.
16. Ibid.
17. *Who's Who in America, 1897–1942* (Chicago: The Marquis Company, 1943), p. 564; William E. Curtis, "Roosevelt Dam Gigantic Piece of Engineering," clipping April 19, 1911, McClintock Scraps: Arizona–Reclamation–Salt River Valley, Arizona Room, Phoenix Public Library, Phoenix, Arizona.
18. Chester W. Smith left four diaries of his work on the Salt River Project with the project upon its completion, and my general impressions of Smith are formed from these as well as his published pieces.
19. Chester Smith Diary No. 1, January–March, 1905.
20. Ibid.
21. "History of the Salt River Project," pp. 76–82.
22. Oscar C. S. Carter, "The Government Irrigation Project at Roosevelt Dam, Salt River, Arizona," *Journal of the Franklin Institute* 163 (April, 1907): 297–298; George H. Maxwell to Frederick H. Newell, April 23, 1903, and F. H. Newell to George Maxwell, May 1, 1903, Records of the Bureau of Reclamation, Record Group 115, Salt River, 1902–1919, series 305, National Archives, Washington, D.C.; Arthur P. Davis, *Irrigation Works Constructed by the United States Government*, (New York: John Wiley & Sons, Inc., 1917), pp. 17–18. A horsepower unit equals 746 watts.
23. Chester Smith Diary No. 1, June 7, 1905.
24. *Third Annual Report of the U.S. Reclamation Service*, p. 137; F. Teichman, "Rotating Screen of Power Canal, Salt River Project," *Transactions of the A.S.C.E.* 60 (1908): 337–338; "History of the Salt River Project," p. 118.
25. Chester Smith, "Reinforced Concrete Pipe for Carrying Water Under Pressure," *Transactions of the A.S.C.E.* 60 (1908), pp. 142–159.
26. Chester Smith, "Reinforced Concrete Pipe," pp. 124–141; "History of the Salt River Project," pp. 126–127.
27. Smith, "Reinforced Concrete Pipe," pp. 132–133.
28. Ibid., p. 133.

29. Ibid.
30. Ibid., p. 159.
31. Ibid., p. 156.
32. "History of the Salt River Project," pp. 88 – 89, 107 – 112; Chester W. Smith, "Progress on the Roosevelt Dam," pp. 265 – 268; Chester Smith Diary No. 2, March 15, 1906, and Diary No. 3, September 25, 26, and 28, 1906, Corporate Secretary's Office, Salt River Project; Teichman, "Rotating Screen," p. 337; Salt River Valley Water Users' Association to Secretary of Interior Franklin K. Lane, no date, (c. 1916), Central Records Box S-7-20, *Board of Review*, Salt River Project.
33. Davis, *Irrigation Works*, pp. 17 – 18; Chester Smith Diary No. 4, May 16, 20, and 25 – 27, and June 1, 1907, Corporate Secretary's Office, Salt River Project; Interview with A. E. McQueen, Manager of Civil Engineering, Salt River Project, November 17, 1981; "History of the Salt River Project," pp. 132 – 142.
34. "History of the Salt River Project," pp. 85 – 86.
35. Arthur P. Davis, "The Salt River Project," *Engineering Record* 57 (June 20, 1908): 769.
36. Ibid.
37. "History of the Salt River Project," pp. 132 – 165.
38. Ibid., pp. 167 – 168; Smith, "Progress on the Roosevelt Dam," p. 266; Davis, *Irrigation Works*, pp. 9 – 10.
39. Ibid.; Chester Smith Diary No. 2, February 27, 1906.
40. Chester Smith Diary No. 2, February 27 and June 4, 1906, and Diary No. 3, September 22 and November 11, 1906.
41. Chester Smith Diary No. 2, June 14 – 15, 1906.
42. Ibid., June 14 and 18, August 21, 1906.
43. Ibid., July 26 and August 3, 1906; Chester Smith Diary No. 3, September 20, 1906.
44. "The Salt River Project, U.S.R.S.," *Engineering Record* 52 (October 14, 1905): 422 – 423; Smith, "The Construction of Roosevelt Dam," pp. 756 – 762.
45. Smith, "The Construction of Roosevelt Dam," p. 761.
46. Chester Smith Diary No. 3, September 21 and October 10, 1906.
47. Ibid., October 13 and 15, November 11 and 18, 1906.
48. Ibid.
49. Chester Smith Diary No. 4, May 8, 1907, Corporate Secretary's Office, Salt River Project (see also entries for April 21 and 25, May 1, 4, and 6, 1907; interview with A. E. McQueen, November 17, 1981.
50. Chester Smith Diary No. 4, May 9, 1907.
51. Ibid., May 20 and 30 – 31, June 1, 3, and 13, 1907.
52. Ibid., May 12, June 17 and 19 – 20, 1907; interview with A. E. McQueen, November 17, 1981.
53. Chester Smith Diary No. 4, August 9 and 12, 1907; C. R. Weitze, U.S. Reclamation Service, Diary No. 2, February 5, 1911, Salt River Project History Center.
54. "History of the Salt River Project," pp. 168 – 171.
55. Dorothy Lampen, "Economic and Social Aspects of Federal Reclamation," *Johns Hopkins University Studies in Historical and Political Science*, 48 (1930): 54 – 55.

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