Figure 22. Topock Bridge, 2003.

5 Federal Aid and the Arizona Highway Department in the 1910s and 1920s

The pace of road and bridge construction had quickened in Arizona after statehood in 1912, but the state's efforts still fell far short of its needs. It would take a massive infusion of funds from the federal government—something well beyond the appropriations for specific bridges—for Arizona's road network to begin showing marked improvement. During the 1910s the federal government was beginning to take a more active role in road and bridge construction. Just months after Arizona became a state in 1912, Congress passed the Post Office Appropriation Act, dedicating $500,000 toward construction of rural roads to facilitate mail delivery. This legislation allocated $500,000 through the Secretary of Agriculture toward construction of rural roads to facilitate mail delivery. Seventeen states—not Arizona—took advantage of this opportunity, resulting in construction of 425 miles of improved roads. This mileage, however, represented only a small step in the right direction.

Four years later the government took a much larger step, when President Woodrow Wilson signed the Federal Aid Highway Act on July 11, 1916. This legislation ushered in a massive new level of federal commit-

see continuation sheet

ment to road building. Part of the impetus came from the postal service, which had difficulty delivering mail in many rural areas because of the poor roads. Business leaders also promoted the legislation, citing the need for reliable roads to get farm commodities to market. The act was intended to develop an interconnected network of well-built and well-maintained roads throughout the country.

Seventy-five million dollars were initially available to states over the first five years, apportioned by a ratio based on area, population and miles of rural post roads. The states' allotments could be used only on projects approved by the U.S. Bureau of Public Roads [BPR], predecessor to today's Federal Highway Administration. Expenditures could not exceed $10,000 per mile, exclusive of bridge costs. The latter were to be paid by counties, sometimes with state assistance. Federal funds were to be used on rural roads, or on roads in communities with under 2,500 residents, but they could not be used in urban areas or on projects involving convict labor. Federal aid could be used on new road construction, bridge construction, reconstruction work or extraordinary repairs.[36]

The act stipulated certain organizational requirements for state highway departments. This favored states with established infrastructures and tended to place Western states at a competitive disadvantage. As one of 15 states that did not initially comply with these requirements, Arizona was compelled to restructure its highway administration. In March 1917 the Arizona State Legislature did just this. The State Engineer, with approval of the State Board of Control, was empowered to enter into contracts and agreements with the federal government and administer the program on the state level. Arizona's share of the federal aid fund amounted to $3.7 million, distributed over a five-year period—about two percent of the Congressional appropriation.

With the funding mechanism now in place, the state could receive federal aid grants from the Bureau of Public Roads. But World War I interceded, and shortages of funds, materials and even engineers forced the program into hiatus almost immediately. By 1919 only $500,000 of the $75 million appropriation had been spent, and only 12½ miles of road had been built. In the entire country. After the war, rising inflation, labor strikes, materials shortages and shipping problems further stymied roadwork, so that little construction was accomplished between 1916 and 1921. Meanwhile, Arizona was having its own problems. Despite the promise by the Arizona State Legislature to match all federal funds and State Engineer Thomas Maddock's vow in 1920 that "no Federal Aid has been lost or will be lost to Arizona," the highway department soon had trouble matching the increasing federal allotments.[37]

[36]In its first two years, federal aid was granted exclusively toward construction of post roads. These tended to be lightly traveled secondary roads, with wooden bridges and machine-graded roadways. The 1919 iteration of the Highways Act allowed work on more heavily trafficked through routes or roads connecting urban centers. It also increased the per-mile expenditure on road construction to $20,000.

[37]State of Arizona, State Engineer, *Fourth Biennial Report of the State Engineer to the Governor of the State of Arizona: 1918-1920* (Phoenix: Republican Print Shop, 1921), 21.

The infusion of such large amounts of money was welcome, but federal aid created a number of logistical problems for the highway department. Before the act, the agency had been organized to handle about $1 million of construction and maintenance work annually. Federal aid more than quadrupled this capacity and added new layers of bureaucracy to the construction process. The attendant paperwork increased correspondingly. Additionally, the BPR established more stringent bridge and highway guidelines and required more detailed planning, surveying and engineering for federal aid projects.

Projects were now planned and approved on both state and federal levels. Maddock found himself unable to guide the requisite surveys, plans, specifications, estimates, reviews and bid lettings through the process under the exacting deadlines established by BPR. "The requirements of the Bureau of Public Roads more than doubled the amount of work necessary in the preparation of plans and specifications," he reported to the governor in 1920, "and required so much time that it was not possible to proceed with construction as promptly and rapidly as would otherwise have been the case."

To further complicate the process, the state engineer's office now had to coordinate with fourteen county boards of supervisors, thirteen county highway commissions and several city and town councils—each vying for a share of the federal allocation. "The difficulties, disadvantages and delays of this system are so obvious as to need no comment," Maddock concluded ruefully. "However, we were confronted by facts and not by theories, so we proceeded promptly to make the best of a difficult situation."[38]

Maddock was further frustrated by the $10,000 per mile limitation on highway funding maintained by BPR. Arizona's rugged terrain, especially in the mountains east of Superior where a major highway had been planned, would require far more expensive construction for road building. To help alleviate the problem, he sought cooperation from the counties in planning and funding projects. He urged them to issue bonds of indebtedness to commit money for future projects. Subsequently, twelve of Arizona's fourteen counties voted bond issues totaling $15 million (Maricopa issued $8.5 million; Graham and Gila were the holdouts).

The changes brought about by federal aid transformed the state's road and bridge construction mechanism, as the state engineer's office grew into the Arizona Highway Department [AHD]. By the end of 1920, AHD employed more personnel than all other state agencies combined. The department's total allocation of funds that year exceeded the total expenditures of every state, county, city, school and road district in the state combined for 1914. AHD was the largest employer of engineers in the state. The department's maintenance and construction vehicles constituted Arizona's largest truck fleet. It purchased more supplies for its various construction camps than all other state institutions combined. The department was Arizona's largest consumer of explosives. And following a change in state law in January 1919 that allowed the highway department to contract for road construction, AHD was the state's largest contracting entity.

[38] *Fourth Biennial Report of the State Engineer*, 27.

VEHICULAR BRIDGES IN ARIZONA

Arizona Federal Aid Project No. 1, appropriately enough, involved construction on the Florence Bridge. Originally built in 1885 by the territory, repaired in 1905 and rebuilt in 1909, it was one of the state's most important spans and one of its most problematic. The Florence Bridge was in need of extensive repairs when the state began assigning federal aid dollars in 1917. The project entailed almost $132,000 of work, half of which was funded by the federal government. Federal Aid Project [FAP] No. 2 involved 3.86 miles of concrete paving on the Phoenix-Tempe Highway, FAP 3 involved work on the Holbrook-St. Johns Highway through the Petrified Forest. FAP 4 contemplated reconstruction of about 50 miles of road in the vicinity of the Antelope Hill Bridge but was not undertaken. FAP 5 entailed construction of roadway and drainage structures on 2.2 miles of the Kingman-Oatman Highway (a segment of the Old Trails Highway). This included construction of a two-span concrete slab bridge over Old Trails Wash in Kingman. Completed in 1917, the bridge and adjacent roadway carried mainline traffic. The Old Trails Wash Bridge [**8594**] is today distinguished as the oldest existing bridge built using federal aid funds in Arizona [*see Figure 23*].

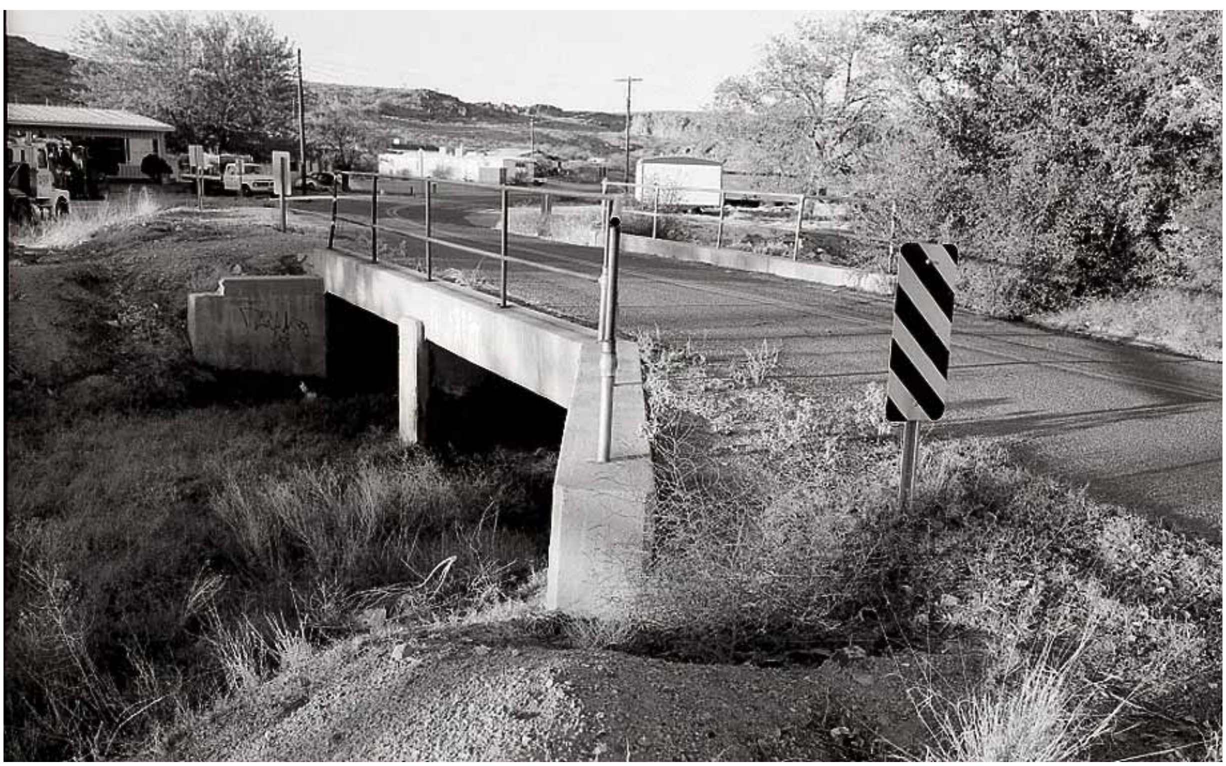


Figure 23. Old Trails Wash Bridge, 2003.

see continuation sheet

Many of Arizona's earliest federal aid projects involved bridge construction of one form or another, often to repair or replace faulty existing spans. FAP 10 funded the Marinette Bridge, a five-span concrete arch structure over the Agua Fria River in Maricopa County. FAP 15-C went toward repairs on the San Carlos Bridge, and FAP 25 was earmarked for bridges on the Tucson-Nogales Highway. FAP 31 funded the Wickenburg Bridge over the Hassayampa River. Built in 1914 by Maricopa County, the original Wickenburg Bridge consisted of four concrete spans. Two spans washed out in autumn 1916 and had been replaced with a steel truss. When the bridge suffered extensive further damage from floods in 1919, the highway department moved to replace it entirely with a three-span through truss, using federal highway money. Merrill Butler, faced with the prospect of another in a growing list of major bridge failures, stated, "Previous efforts to construct and maintain this bridge have cost the taxpayers of Maricopa County something over $20,000, together with a part-time loss of use. This department contemplates an additional expenditure of about $70,000, making a total of over $90,000. A properly designed bridge in the first place would have saved $60,000 and much inconvenience."[39]

Even projects not specifically earmarked for bridgework often entailed construction of small-scale drainage structures—primarily concrete culverts and slabs—as part of the adjacent roadwork. For instance, FAP 13 on the Clifton-Franklin Highway in Greenlee County included construction of a concrete bridge over Railroad Wash near Franklin and smaller bridges and fords in Ward Canyon. And FAP 26 involved construction of 18.63 miles of roadway and several drainage structures on the Yuma-Welton Highway (part of the Ocean-to-Ocean Highway) in Yuma County.

All of this construction work placed a considerable burden on the state engineer's office for bridges. To help shoulder the increased workload, the department hired R.V. Leeson as its bridge engineer on a consulting basis in July 1918. Leeson, who also functioned as assistant chief engineer for the Topeka Bridge and Iron Company, served in this role for a little more than a year. His most noteworthy commission during his tenure with the state was the Gila River Bridge [**8152**] in Greenlee County. In September 1919 Leeson was replaced by Merrill Butler, Arizona's first full-time bridge engineer. One of Leeson's principal responsibilities during the summer of 1919 was to produce a set of standard plans for small-scale concrete bridges. The state engineer's office had been using standards for small-scale concrete bridges beginning with Cobb's administration. With federal involvement, however, these needed to be redrafted and approved by BPR.

Leeson delineated plans for concrete slabs (6- to 24-foot span), concrete culverts (both box and arch) and three-beam deck girders (up to 50-foot span). These designs were to be used by the state engineer's office and promulgated to the individual counties for use on county-funded construction. During the 1918-1920 biennium, the state engineer's office planned or built some 77 slab bridges, 92 box culverts, ten girders and

[39]*Fourth Biennial Report of the State Engineer*, 68-69. Three spans from this structure were later moved to another site to form the Boulder Creek Bridge [**0193**] in Maricopa County.

see continuation sheet

five arch culverts using the standard plans. In all, some 747 such standard-plan structures were planned or built during the biennium, for an aggregate cost of almost $500,000.

Additionally, Leeson and Butler designed about two dozen bridges from site-specific designs. These included concrete girder structures at Mescal Wash, Railroad Wash, Queen Creek, Continental, Sonoita River and Granite Creek [**0042**; *see Figure 24*]; four slab bridges over canals in Maricopa County; and concrete arches at Emerald Gulch, Cottonwood, Marinette, and two over Queen Creek. The state engineer's office also engineered a multiple-span steel truss bridge over the Hassayampa River at Wickenburg [**0193**]. The largest concrete bridges of the biennium were the Marinette Bridge over the Agua Fria River [since demolished] and the two-span filled spandrel arch structure over the Gila River near Clifton [**8152**]. Another notable structure still extant is the Queen Creek Bridge [**8440**], a long single-span arch in Pinal County, built in 1920.

Figure 24. Granite Creek Bridge, 2003.

The state engineer's office continued at the same accelerated pace during the 1920-1922 biennium, steadily improving and expanding the network of state highways [*shown in solid lines on Figure 25*]. "The office of State Engineer has become in reality the Arizona Highway Department," Thomas Maddock stated in his report to the governor. "While certain duties still exist in regard to the irrigation of land, the highway work has

see continuation sheet

VEHICULAR BRIDGES IN ARIZONA

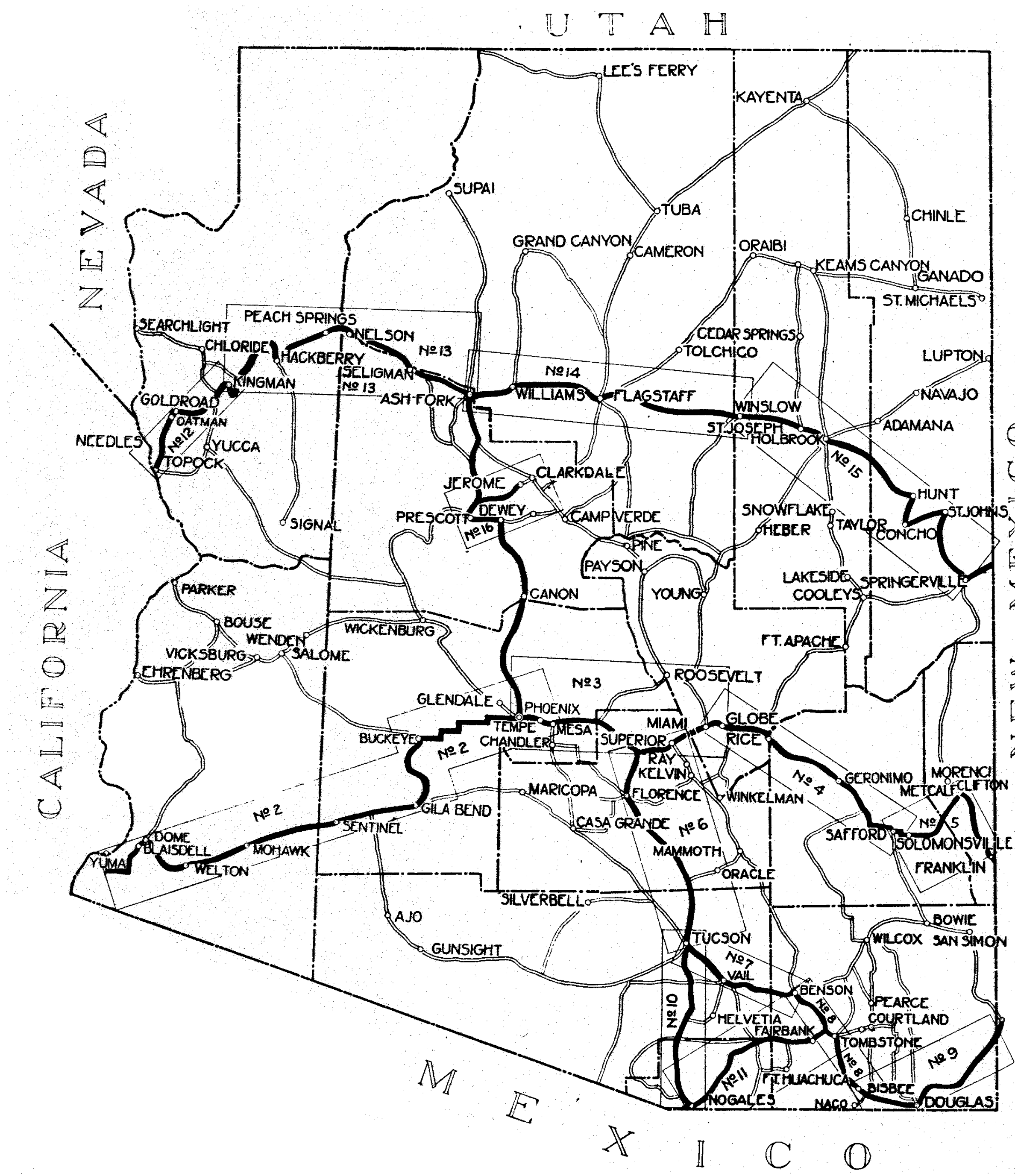


Figure 25. Map of state highway system of Arizona, 1920.

see continuation sheet

so greatly increased that the Highway Department has become the largest single business in the State of Arizona."[40] With Butler as the department's bridge engineer, AHD developed more bridge standards, which it used for its own projects and distributed to the county engineers for use on county roads. Additionally, the department produced or reviewed designs for seven county-built structures. "Various counties in the State have availed themselves of the services of the Department for the preparation of bridge plans and examination of sites and manufacturers' proposals," stated Butler.[41]

Figure 26. Concho Bridge, 2002.

[40]State of Arizona, State Engineer, *Fifth Biennial Report of the State Engineer to the Governor of the State of Arizona: 1920-1922* (Phoenix: Republican Print Shop, 1922), 7. Maddock continued:

> The Arizona Highway Department has endeavored to keep up with the changing conditions of our time and construct the thru roads in the State in such a manner that they will not only carry the present traffic, but that their location will anticipate future increased traffic. And, when this traffic is realized, hard-surfaced pavements can be laid over the present grades and drainage structures and the original investment will not be lost, as has so frequently been the case in the past.

[41]*Fifth Biennial Report of the State Engineer*, 57.

Most of the drainage structures built with federal aid were generated from standard designs and contracted for under the umbrella contracts of the adjacent roadwork. A few bridges, however, were of sufficient scale to warrant individual contracts, let separately from the contracts for the adjacent road grading. For these Butler engineered site-specific concrete and steel spans. Some of Arizona's more noteworthy early concrete bridges date from this formative period. These include the Devils Canyon Bridge [**abd.**], a single-span concrete filled spandrel arch; the Queen Creek Bridge [**abd.**] near Superior, a long-span concrete open spandrel arch; the Granite Bridge [**0042**] and the Cordes Bridge [**8249**], two concrete three-beam girders; the New River Bridge and the Concho Bridge [**8480**; *see Figure 26*], the only concrete through girders built by the state; the Pinal Creek Bridge [**9711**], a five-span concrete slab structure in Globe; and the Cienega Bridge [**8293**; *see Figure 27*], a concrete open spandrel arch with a concrete girder viaduct at one end. None of these bridges were particularly innovative, technologically. The Concho and New River Bridges were clearly design experiments and the three-beam girders were unusual in their configuration, but these were noteworthy only by degree. Rather, these concrete structures—filled and open spandrel arches, deck and through girders and simple slabs— followed industry standards in their profile, reinforcing and span length.

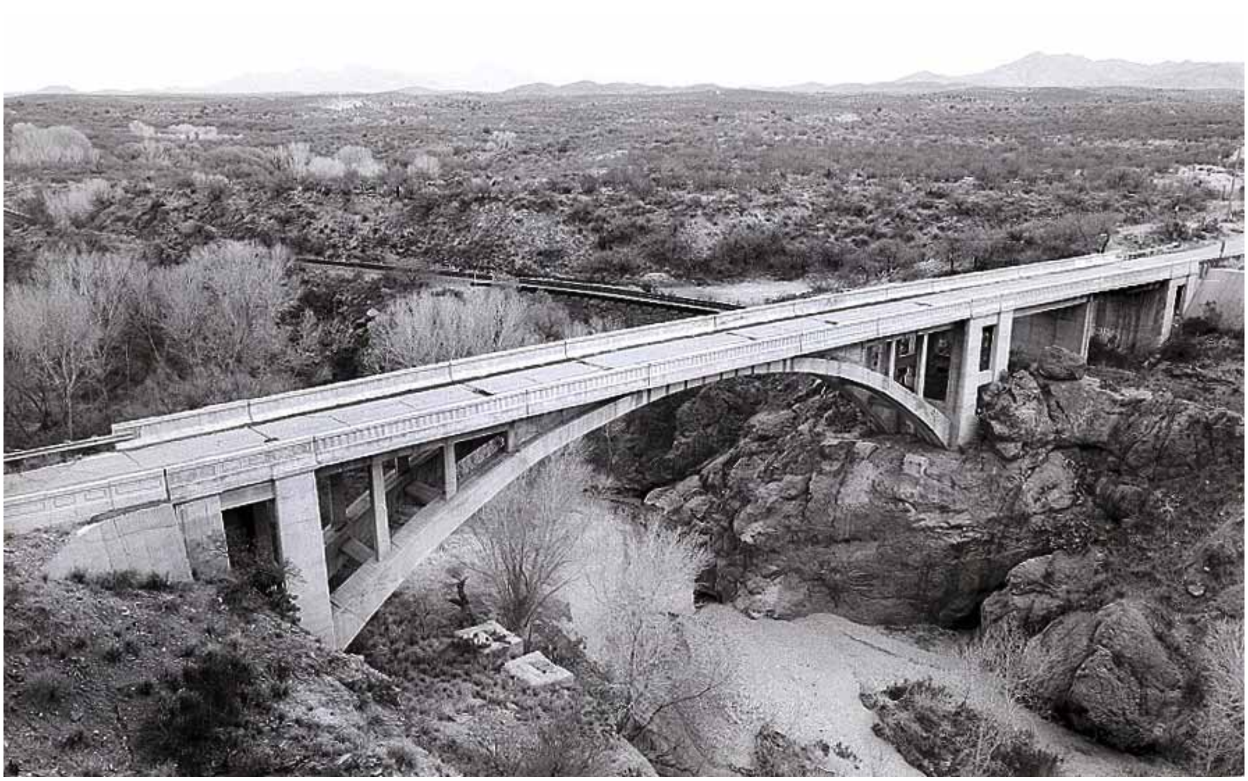


Figure 27. Cienega Bridge, 2003.

see continuation sheet

VEHICULAR BRIDGES IN ARIZONA

As America entered the 1920s, many states were experiencing an economic expansion. This industrial growth was fueled by the automobile industry, which simultaneously helped expand other related industries and expedite the entire country's growth. "The automobile industry, as a result of the assembly line and other technological advances, grew from a relatively modest size in the years before [World War I] to become one of the most important forces in the nation's economy."[1] Americans bought 1.5 million cars in 1921, 5 million in 1929. The same automobile that propelled Arizona's good roads movement had catapulted all transportation networks into the spotlight. The ascendence of the motorcar coincided with the development of a burgeoning new industry: commercial trucking. By the end of the 1920s, the number of commercial vehicles was actually growing faster than the number of passenger cars. The decline of goods transported by railroads and the corresponding expansion of commercial trucking amplified the need for well-constructed, interconnecting roads.

In November 1921 Congress passed the Federal Highway Act, which vastly expanded the 1916 legislation. The new law authorized $50 million for roadwork in 1921, $65 million in 1922 and $75 million in 1923. By the end of the decade, BPR would spend some $750 million on federal aid highways. More importantly for Arizona, the new law acknowledged the greater lengths of highways needed in the western states, the large tracts of federally owned land and the difficulties experienced in raising their 50/50 match of funds. While it did not increase the federal appropriation for highway construction appreciably, it did decrease the states' match proportionately to the amount of federal lands in the states. Using this sliding scale, Arizona's share of road and bridge funding thus fell from 50 percent to less than 30 percent.

Under the new law, federal funds would be apportioned to making improvements on 7 percent of the highways in each state. These so-called 7-percent highways, designated explicitly by the state highway department in each state, thus became essentially the highway systems for the western states. The following year Arizona delineated almost 1,500 miles of roads to be included in its 7-percent network [*see Figure 28*]. Unsurprisingly, these essentially followed the existing state highways. Before the 1921 Act, Arizona had been experiencing difficulties in matching the federal allotment for the state. "Only one-sixth of the Federal Aid appropriated to Arizona had been matched with State funds on projects which could early be completed," Maddock reported. The net result of the law was that the state would receive more federal funds for road and bridge work. Maddock was optimistic about its effect on Arizona's roads, stating:

> At the present rate of progress, it is conservatively estimated by the Arizona Highway Department that Arizona's Seven Per Cent system will be so improved within the next fifteen months that it will be possible to average thirty miles per hour in traversing any road across the State.[2]

[1] Allan Brinkley, et al., *American History: A Survey* (New York: McGraw- Hill, Inc., 1991), 700.

[2] *Fifth Biennial Report of the State Engineer*, 20.

see continuation sheet

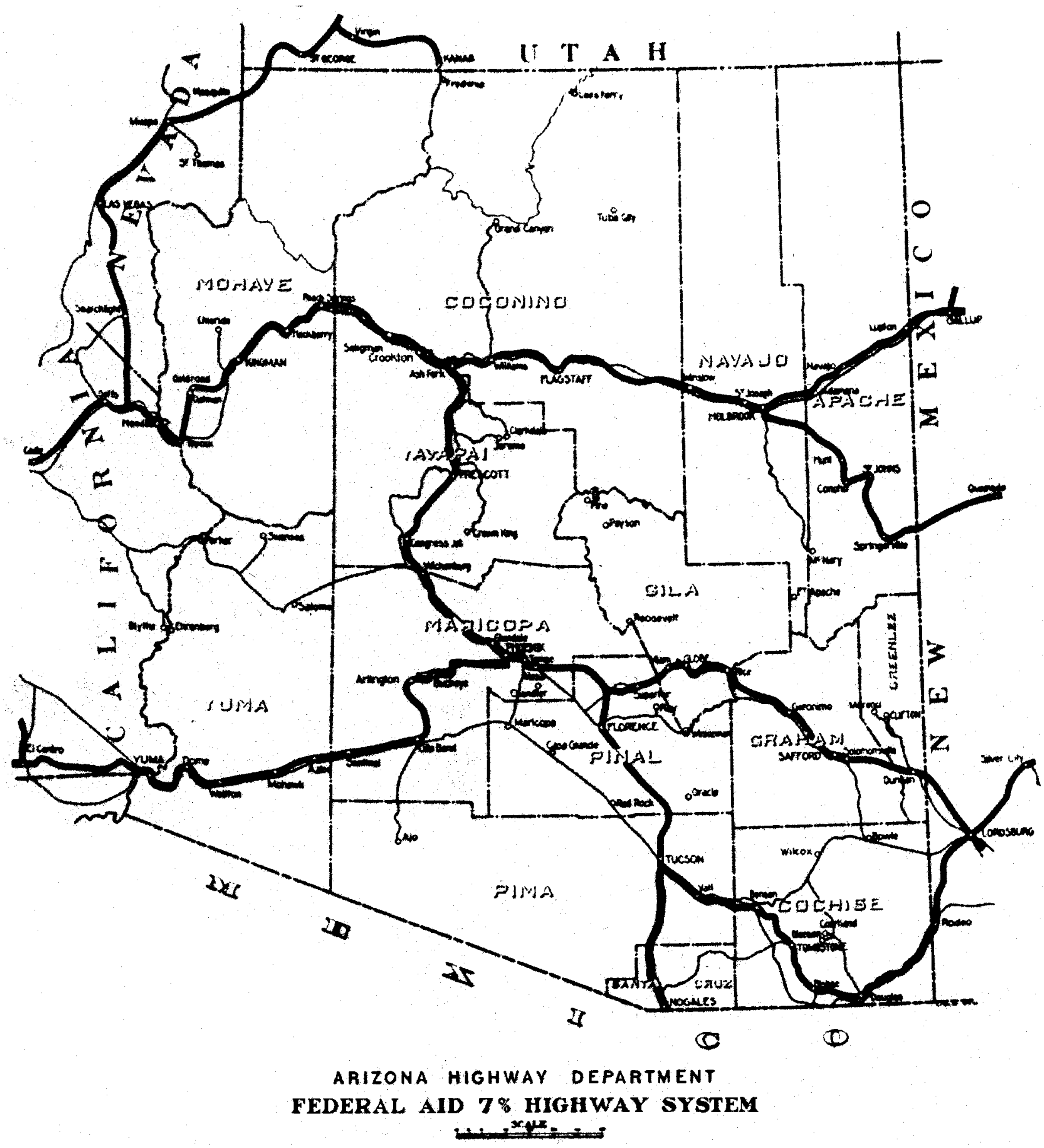


Figure 28. Map `of Arizona's 7-percent system, 1922

see continuation sheet

The establishment of the 7-percent network marked the first definitive designation of Arizona's highway system. An administrative history produced by the state highway department in 1939 described the state of affairs before this designation:

> Throughout the period from 1909 to 1922 the State system was susceptible to many changes. Maps of this era indicated the highway system to be tentative or proposed. If a State engineer decided to expend funds upon a road it was considered as a part of the State highway system; likewise, if he or a successor elected to abandon any section as a State highway, the only apparent action necessary was to discontinue to expend additional State funds for betterment or maintenance, and in the course of time it lost its identity as a part of the system.[3]

By the mid-1920s, the public was becoming disaffected with the highway associations and their transcontinental roads. No fewer than 250 registered highways then vied for travelers' attention. The highway markings were often inconsistent, the guidebooks misleading and confusing, and the highways themselves often little more than dirt tracks. Moreover, they were often routed, not in the straightest line over the best roads possible, but in lengthy meanders to connect dues-paying municipalities. "The harmless tourist in his flivver doesn't know whether he is going or coming," travel writer William Ullman stated, "whether he is a hundred miles from nowhere or on the right road to a good chicken dinner and a night's lodging." When the Pikes Peak Ocean-to-Ocean Highway Association rerouted its road from San Francisco to Los Angeles, the editor of the *Reno Evening Gazette* (one of the towns abandoned by the association) complained bitterly:

> The public is learning this fact—that transcontinental highway associations, with all their clamor, controversy, recriminations and meddlesome interference, build mighty few highways . . . In nine cases out of ten these transcontinental highway associations are common nuisances and nothing else. They are more mischievous than constructive. And in many instances they are organized by clever boomers who are not interested in building roads but in obtaining salaries at the expense of an easily beguiled public.[4]

As early as 1914 the National Highway Association had formulated plans for a 51,000-mile network of highways that included three east-west and three north-south primary routes. The 1916 federal aid legislation had neglected to coordinate the road-building efforts among the states, however. The result was a crazy quilt of mismatched roads that often ended at the states' borders. This problem was national in scope, begging for a national designation of highways. In 1924 the American Association of State Highway Officials [AASHO] began working on just such a plan. The following year AASHO and the Agriculture Department formed a Joint Board on Interstate Highways to adjudicate the highway designations. Late in 1925 the Secretary of Agriculture approved the new system.

[3]Arizona Highway Department. "History of the Arizona Highway Department." Unpublished manuscript, 1939, 15.

[4]Quoted by Richard F. Weingroff, "From Names to Numbers: The Origins of the U.S. Numbered Highway System," *AASHTO Quarterly*, Spring 1997.

As a replacement for the often confusing naming system for highways, a uniform system of numbers would be instituted. Under this scheme east-west highways would be given even-numbered designations; north-south highways, odd-numbered. Diagonal highways would receive special designations. Three-digit numbers were assigned to relatively short-distance connector routes.[5] The highways would be marked uniformly with a shield bearing the route's number, the letters "US" and the state's name in black on a white background. Despite the obvious logic behind the numerical national system, the named highways still had their advocates. "I feel that such a move will never waken a popular response," Phil Townsend Hanna wrote in *Western Highway Builder*. "The Lincoln Highway and reputable routes of like character will never lose their identity. Romance is the manna on which the Americano thrives." He concluded: "Of all the idealistic proposals yet advanced for the administration of highways, none can equal this for pure imbecility."[6]

The U.S. highways in Arizona followed predictable patterns [*see Figure 29*]. The Ocean-to-Ocean Highway across the southern part of the state was incorporated into US 80, the transcontinental route between Savannah and San Diego. The National Old Trails Highway that cut across the state's northern tier became part of US 66 between Chicago and Los Angeles. The original territorial North-South Highway became part of US 89 between Provo and Phoenix. And the route that meandered across the center of the state from Springerville to Ehrenberg by way of Globe and Phoenix later became part of US 60, a transcontinental road that began at Norfolk, Virginia, and extended through Arizona to Los Angeles.[7]

This designation and consolidation of routes had little effect on bridge construction in Arizona other than to prioritize the work on the more heavily trafficked routes. The majority of road and bridge work under the new legislation remained under the aegis of the state engineer's office, with oversight provided by the Bureau of Public Roads. For routes in the national forests and national parks, however, this responsibility lay directly with BPR. This agency functioned much like the state in bridge administration. The minor drainage structures were developed from BPR standard designs and let for contract as parts of overall road grading and drainage contracts. Larger and more technologically ambitious bridges were designed individually by engineers in the BPR's San Francisco, Denver or Phoenix offices and contracted for on an individual basis.

---

[5] The American Association of State Highway and Transportation Officials [AASHTO] maintained the connector-route designation until 1934, when it began assigning the three-digit numbers to mainline routes. At the same time AASHTO began eliminating split route designations.

[6] Quoted in Weingroff, "From Names to Numbers."

[7] W.A. Sullivan, "U.S. Highway 60" Arizona Highways IX:1 (January 1933), 3-4. Of this route Sullivan stated:

> Destined to become one of the major arterial routes of Arizona when completed, U.S. Highway 60, running through the central part of the state, virtually bisects the state from east to west, It is one of the few roads in the nation which has been given federal designation before being finished. Its importance in the transcontinental system required recognition before it was completed. Designation has been given to the entire route ([through Arizona), approximately four hundred and ten miles long, except a thirty-five mile link from Show Low to Springerville in Northeastern Arizona.

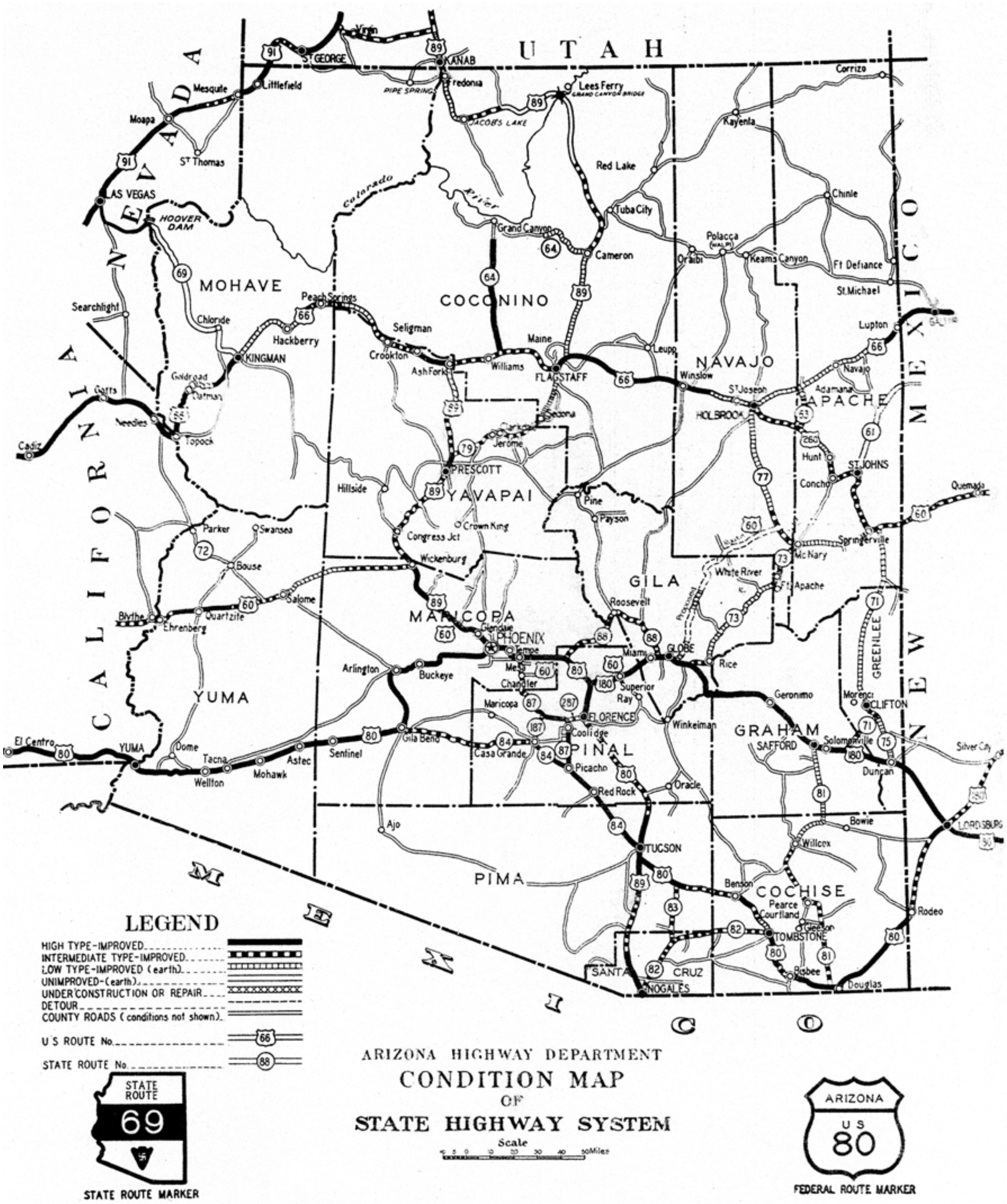


Figure 29. Map of Arizona highway system, 1932..

Several important BPR bridges have been built in Arizona: the Salt River Bridge [**0037**], a long-span steel truss built in 1919 in the Tonto and Crook National Forest; the Dead Indian Canyon Bridge [**0032**; *see Figure 30*], a deck truss built in 1933-1934 on the highway to Grand Canyon National Park; the Parker Bridge [**0191**] over the Colorado River, the Midgley Bridge [**0232**; *see Figure 31*] and Pumphouse Wash Bridge [**0079**] on the Oak Creek Canyon Road through Coconino National Forest; and the Walnut Canyon Bridge [**9225**] in the Prescott National Forest.

Figure 30. Dead Indian Canyon Bridge, 2002.

During the 1920s the Arizona Highway Department expanded its role in road and bridge construction incrementally. In August 1927 the state legislature discontinued the office of state engineer, in its place establishing the Arizona State Highway Department. The legislature at that time also established the Arizona State Highway Commission, a five-member board charged with oversight of the highway department. The highway department called this legislation "the first systematic highway code for the administration of all matters and affairs directly affecting the highways of the State," but in truth the state

see continuation sheet

engineer's office had been calling itself the state highway department unofficially for years.[8] As a practical matter, the newly formed agency functioned much like its predecessor.

The AHD bridge department underwent a steady expansion as well. During the 1922-1924 biennium, Merrill Butler was succeeded by Ralph Hoffman as State Bridge Engineer. The bridge department had grown by then to include three engineers. Arizona's bridges had, to this point, been a sometimes quirky collection of structures—long-span concrete Luten and open spandrel arches, concrete rail top slabs, two-beam and three-beam girders, pin- and rigid-connected steel trusses, timber trestles, three-hinge steel arches, long suspension bridges. Hoffman's arrival marked a philosophical change in the way AHD designed bridges. "The aim of those connected with this department, in the past two years, has been economy in design," he stated. "A former policy of the use of mass sections and excess materials has been discarded in favor of lighter sections with more reinforcement and less concrete, resulting in an appreciable saving."[9]

Figure 31. Midgley Bridge, 2002.

[8]"History of the Arizona Highway Department," 4.

[9]State of Arizona, State Engineer. *Sixth Biennial Report of the State Engineer to the Governor of the State of Arizona: 1922-1924* (Phoenix: Manufacturing Stationers, Inc., 1924), 137-138.

see continuation sheet

Using specs developed by AASHO, Hoffman was able to standardize bridge design in the state to an unprecedented extent. "Structural design is governed largely by the class of road on which the bridge is located," he stated. "There are three such classes of State roads in Arizona, namely the primary and secondary Highways of the Seven Per Cent Federal Aid System and the non-Federal Aid State roads. Up to the present time, however, only two types of design have been used, as no distinction has been made between the two classes of Federal Aid Highways." Hoffman proved more innovative than his predecessor, employing steel superstructures to a greater degree than had Butler and using cantilevering for the first time in Arizona.[10]

During the biennium the AHD bridge department delineated some 40 special bridge designs, including ten steel trusses, four reinforced concrete arches and 26 concrete girders, for an aggregate cost of over $500,000. Among these were the Fish Creek Bridge [**0027**], Lewis and Pranty Creek Bridge [**0028**], and Sanders Bridge [**3074**] three steel pony trusses; the Mormon Flat Bridge [**0026**; *see Figure 32*], a steel through truss; the Dry

Figure 32. Mormon Flat Bridge, 2003.

[10]Hoffman's first cantilevered structure, the Allentown Bridge [3073] in Navajo County, employed a steel deck truss, which cantilevered by two panels over the supporting piers.

see continuation sheet

Wash Bridge [**0015**], Arizona's oldest datable steel stringer bridge; the Verde River Bridge [**8236**; *see Figure 33*], a long-span concrete arch; the Little Hell Canyon Bridge [**3381**], a two-span steel deck truss; and the Hell Canyon Bridge [**abd.**], a five-span concrete girder structure. About this bridge, which started out to be a concrete arch structure before the design was changed, Hoffman stated: "This high trestle has a very pleasing effect, with the arched girders on the high, slightly tapered piers."[11]

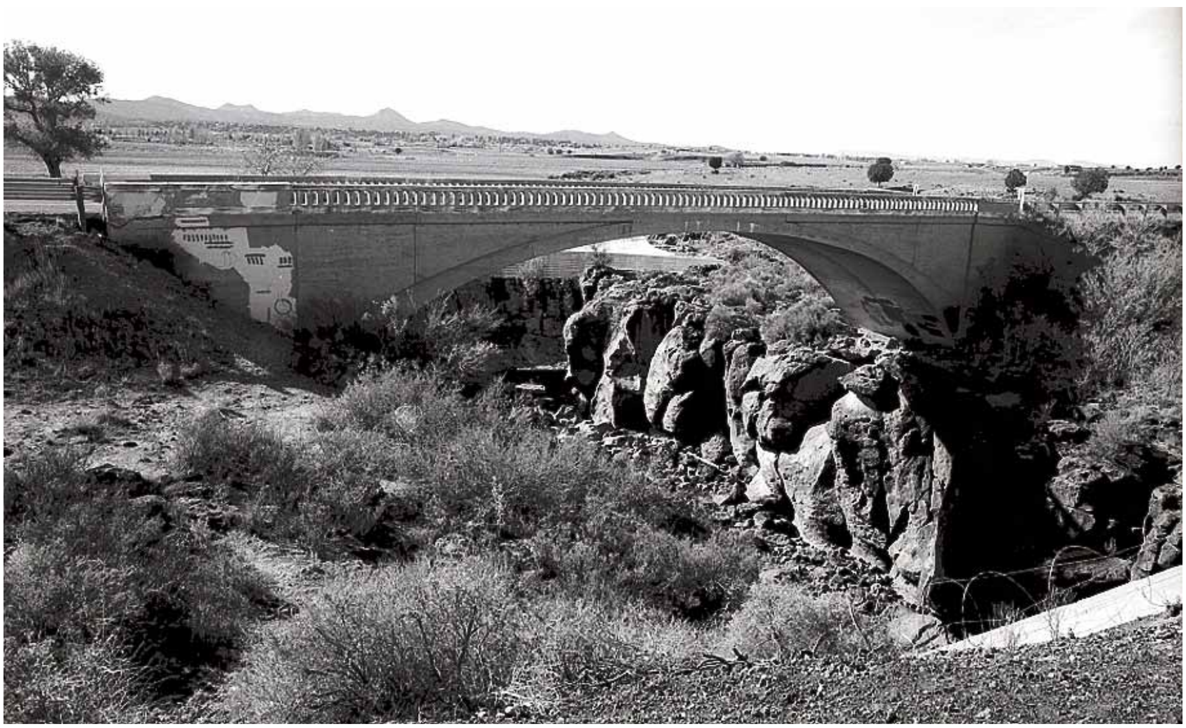


Figure 33. Verde River Bridge, 2003.

The next two years marked a continuation of AHD's standardization of bridge design. With two more engineers in the bridge department, the agency sought to incorporate the new AASHO standards for steel and concrete bridges into the state's repertoire. "At present we are in more of a quandary than before the advent of these new specifications as regards to certain points of design, Hoffman stated, "such as distribution of loads, moment factors, etc. We are using parts of the two new sets of specifications for design as well as part of the old bureau requirements. This Department is now preparing a comprehensive set of formulas for use in the design of structures which will give the men working on design a ready reference on points now covered in three sets of specifications." Hoffman explained the increased work undertaken by his department:

[11] *Sixth Biennial Report* , 143.

> The old practice of using excessive curvature in the road in order to make a right angle crossing on a stream, or to fit a particular bridge site, has, for the sake of safety and future economy, been abandoned, and, whereas, it was a former practice to fit the road to the bridge, we now build the bridge to fit the road and stream regardless of the angle. (This) increases the volume of work in the office and even with the increased force the Department is barely able to keep up with the schedule.[12]

Hoffman and his department engineered some 205 bridges during the biennium, aggregating over $750,000 in construction costs. These included the Pine Creek Bridge [**0031;** *see Figure 34*], a two-span concrete arch on the Apache Trail; the Fossil Creek Bridge [**3215**], a single-span concrete arch; the Tanner Wash Bridge [**8160**], a two-span, four-beam concrete girder; the San Simon Bridge [**demolished**], a long-span pony truss; and the Holbrook Bridge [**demolished**], a four-span pony truss over the Little Colorado River.

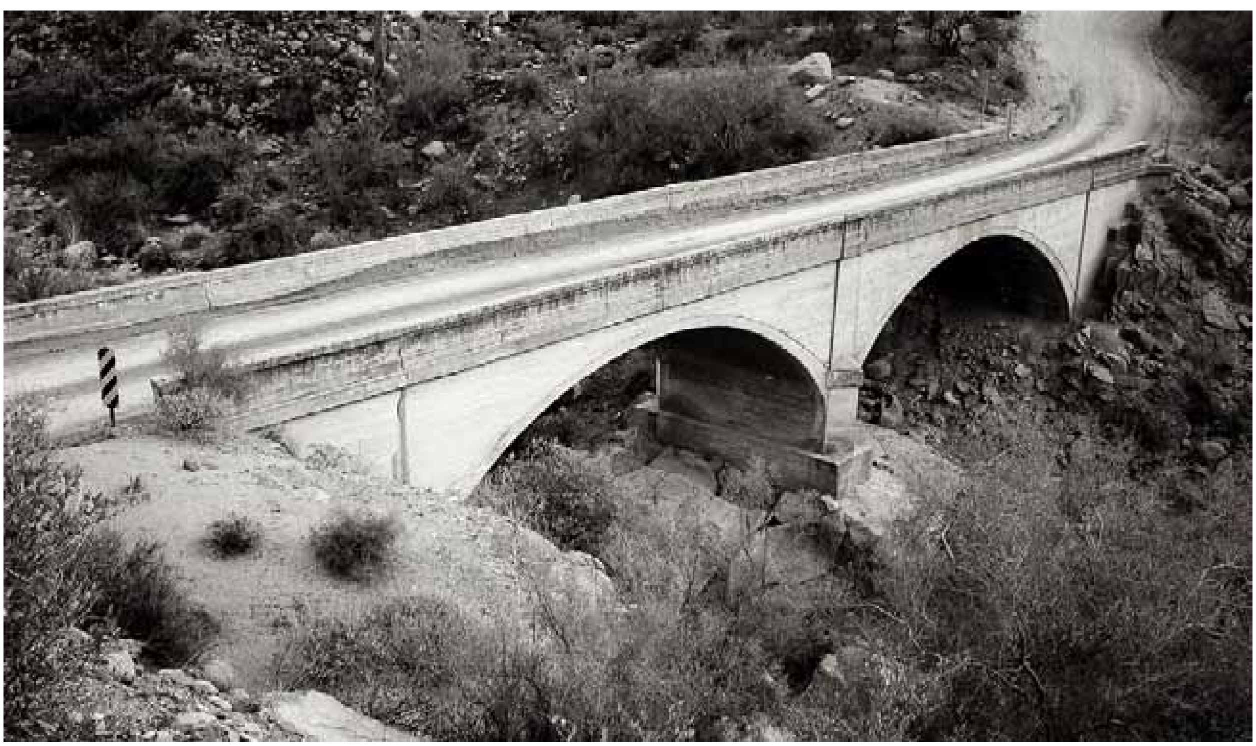


Figure 34. Pine Creek Bridge, 2003.

[12] State of Arizona, State Engineer. *Seventh Biennial Report of the State Engineer to the Governor of the State of Arizona: 1924-1926* (Phoenix: Kelly Print, 1926), 65-66.

The longest bridge undertaken in the mid-1920s spanned the Gila River in Maricopa County. The Arizona Highway Department had intended from the start that the Gillespie Dam apron act as a temporary crossing, with a permanent bridge to follow. AHD engineers had begun planning for a concrete bridge here even before the dam was completed. For this crossing, Thomas Maddock had originally envisioned a reinforced concrete girder structure, similar to other bridges the state had built at Antelope Hill, Florence and Coldwater, despite their structural shortcomings. Later department engineers seemed poised to repeat their mistakes with the Gillespie Dam Bridge, planning a series of long-span concrete girders for this crossing. For additional advice, they contacted R.V. Leeson. Leeson recommended that the highway department drop the girder design in favor of a series of long-span steel trusses. With spans of up to 200 feet in length, the truss design would reduce the number of piers by almost two-thirds from the girder configuration. Given that most of the Gila River bridge failures in Arizona had historically involved catastrophic pier scour and settlement, this reduction was significant.

With Leeson's assistance, AHD bridge engineer Ralph A. Hoffman designed the multiple-span structure. "The plans are designed under modern specifications for live load and heavy trucks for bridges on the Federal Aid Highway system," the highway department stated. "The concrete floor and its supports being designed for two 15 ton trucks abreast on the bridge with an additional allowance of 30 per cent for impact. In this floor alone there is a total of 930 cubic yards of concrete and 75 tons of reinforcing steel, enough to build complete a fair size bridge."[13] As delineated by Hoffman in September 1925, the bridge was comprised of nine truss spans— five 200-foot trusses over the river's channel at the bridge's center, flanked by two 160-foot trusses at each end. The trusses supported a 19-foot-wide concrete roadway, with the deck carried at the trusses' lower chord level and the steel truss webs extending over the roadway on both sides.

The most critical aspect of the bridge's design was the substructure. AHD described the piers and abutments of the Gillespie Dam Bridge:

> The deepest pier foundation is approximately 45 feet below the stream bed and rests on a compact caliche hard pan. The conditions found by drill tests are favorable to the use of steel sheet piling and open dredging. These two piers of about this same depth and contain approximately 500 cubic yards of concrete each. The other piers vary in depth below stream bed from 20 to 30 feet. All piers are of gravity type with but little reinforcing steel for dowels at the construction joints. The abutments are of the U-type with a pier for the support of the span and reinforcing wings tied by reinforced concrete ties in the earth fill, making an economical type for the height which on the east end of the bridge is approximately 35 feet from grade to the bottom of foundations.[14]

Three months after Hoffman completed the construction drawings for the Gillespie Dam Bridge, AHD moved to build the immense structure. With funding for the construction earmarked under Federal Aid Project 64-B,

---

[13] *Ibid.*

[14] *Ibid.*

see continuation sheet

the highway advertised for competitive bids late in 1925. Eleven contractors submitted proposals for the project. On January 11, 1926, The highway department let the contract to the lowest bidder, the Lee Moor Construction Company of El Paso, Texas. On February 12, a Lee Moor crew began excavating for the piers. Pier Nos. 1 through 5 and and 10 were founded on solid bedrock. Pier Nos. 6 through 8 were founded on hard caliche—an unconsolidated gravel bed that floored the river's main channel. To found the shallower piers, the men used Wakefield sheet piling with steel shoes. The deeper piers required either steel sheet piling or open timber crib cofferdams to protect the excavations from the river. Even with that, water was a problem at Pier Nos. 6 and 7, the deepest piers on the structure. The Lee Moor crew was forced to install 12-inch Byron Jackson deep well pumps and 16-inch centrifugal pumps to dewater these two holes. With capacities of 3,600 and 4,500 gallons per minute, respectively, these pumps operated continuously for five weeks while the excavation and pier construction were underway.

The concrete piers had been completed, and the men were erecting the steel trusses when the Gila River flooded in February 1927. With water washing as much as six feet over the crest of the dam, the downstream apron was rendered impassable for days, stranding cars on both sides of the river. After suffering extensive losses, Lee Moor regrouped and completed the bridge superstructure later that spring. With the trusses in place, the men poured the concrete for the monolithic deck that summer. On August 1, 1927, the Gillespie Dam Bridge was opened to vehicular traffic. The Arizona Highway Department opened the bridge unceremoniously, simply pulling aside the barricades shortly after sunrise and letting cars drive across the span without fanfare. "The new state bridge over the Gila river on the Phoenix-Yuma road, the longest bridge of its type in the state, was opened to traffic yesterday morning," the *Arizona Republican* reported. "The opening of the new bridge, which required 18 months to build, will make the Phoenix-Yuma road an all-year road and will eliminate the lining up of traffic on both sides of the Gila river during flood periods in the stream as in the past."[15]

Costing $320,000 to build, the Gillespie Dam Bridge was immense [*see Figure 35*]. The structure consumed approximately 1,200 tons of superstructural and reinforcing steel and 3,200 cubic yards of concrete. Excavation for the substructure involved moving some 5,600 cubic yards of earth. When completed, it was distinguished as Arizona's longest highway bridge and the bridge with the state's deepest foundations. A list of the five longest vehicular structures in the state at that time indicates the tremendous impact that the Gila River had on bridge construction. Four of the five spanned the Gila and the fifth—the Tempe Bridge over the Salt River—spanned a tributary of the Gila near the two rivers' confluence.

---

[15] "New Bridge at Gillespie Dam Open to Travel," *Arizona Republican*, 2 August 1927. **At this time the *Arizona Gazette* reported:**

> In the building of the new structure every possible care was taken to make it capable of withstanding the heaviest of floods. Each pier and the abutments for the bridge extend down through the loose sand to bed rock, some of the piers thereby being over 40 feet in length, according to the highway department. The precautions which have been taken will assure travel over the highway in every season of the year, and trips will no longer be delayed during flood periods owing to high water.

Figure 35. Gillespie Dam Bridge, 2002.

Even into the 1920s, bridges still proved to be the Achilles heel of the highway department. Despite their continued efforts, department engineers were unable to keep the major spans on the Ocean-to-Ocean Highway—or elsewhere in the state—serviceable. "At present there is not a single main route through our State which is not subject to traffic tie-ups at one or more stream crossings," Hoffman despaired in 1927. "Such conditions are distasteful to through tourists and they will seek other routes on which they are not liable to be delayed by washouts. Our State is widely known for its good roads and millions of dollars are spent within our boundaries annually by tourists who travel these roads. Why not make them all-weather roads by building good substantial bridges?" It was not until completion of a concrete bridge over the Hassayampa River and replacement of the Coldwater Bridge [**both demolished**] in the late 1920s that the Ocean-to-Ocean Highway could rightly be considered an all-weather route.

In the 1920s the engineering existed to build substantial bridges that could withstand rivers such as the Gila; the problem was money. Chronically short of funds, AHD was often forced to defer long-term planning for immediate construction and repair. Nowhere was this more apparent than at the state's major bridges. The early road builders had avoided building bridges when they could, and when they could not, they often eschewed permanence for low initial construction costs. AHD engineers could not follow this strategy, however. In a 1927 *Arizona Highways* article notable for its apologetic tone, Hoffman explained the recent failures of several Arizona spans:

see continuation sheet

> The fault for (the bridge failures) cannot be laid at the door of the engineer, although he is not infallible, he can only go as far as the funds provided will permit. The State spends millions to build surfaced roads making them passable in all kinds of weather and leaves an unprotected gap here and there for the reason that the engineer is trying to make his money cover as much mileage as possible.[16]

The Gila prompted long and problematic bridges, but it was the Colorado River that historically has formed the most formidable barrier to bridge construction in the West. The Yuma and Topock Bridges proved expensive and difficult to erect, even on relatively flat sites. This was due to the scale of the Colorado River as well as its unpredictable nature and its propensity to flood at odd times. When the highway department sought to bridge the river a third time in the 1920s, the problem of flooding on the river was eclipsed by the bridge's great height and remoteness. In 1923 AHD began planning for a bridge over the Grand Canyon near Lee's Ferry—Arizona's most challenging bridge construction to date. By October 1924 a connecting route (US 89 Alt.) had been surveyed and preliminary surveys made for the bridge. Government engineers originally considered a suspension bridge like the Cameron Bridge, then a through arch like the Topock Bridge.

When the final design of the Grand Canyon bridge was turned over to AHD in March 1927, it fell into Hoffman's lap. He wasted little time in discarding the earlier designs in favor of his own. "The Bridge Department, after a thorough study of all data available and the local conditions to be met," Hoffman stated, "arrived at the conclusion that the unit prices used in previous estimates were too low on account of the remoteness of the site, and the 130 mile haul of structural materials, and this department prepared estimates based on an entirely different type of design. This had previously been suggested by the Department as the most fitted to the location from all standpoints, using at the same time higher unit prices on structural materials."[17]

Hoffman dismissed the suspension design as too costly and, with a ten-ton load limit, too flimsy. Construction of a through arch, he maintained, would have necessitated the use of heavy overhead cableways to hoist the span halves into place. With the expense of returning the cables and tower materials prohibitively high, these would be abandoned at the site, adding considerably to the cost. "The site appeared to be ideal for the use of a deck arch and a few computations showed that this type had many advantages in erection," Hoffman concluded. "Practically all the erection material could be used in the approach spans. These spans were needed on account of maintaining a high grade line on the structure in order to get a satisfactory grade line out of the canyon on either side."[18]

---

[16]R.A. Hoffman, "Lack of Finances Held Responsible for Washing Away of Bridges in Flood Times." *Arizona Highways* III:1 (January 1927).

[17]R.A. Hoffman, "Bridging the Grand Canyon of Arizona: The Highest Highway Bridge in the World," *Arizona Highways*, May 1929, 5-7.

[18]Hoffman, "Bridging the Grand Canyon of Arizona," 7.

see continuation sheet

The Grand Canyon Bridge was designed by Hoffman and AHD Designing Engineer L.C. Lashmet. Their plan featured a three-hinged deck arch that cantilevered from the canyon walls [*see Figure 36*]. The spandrel-braced arch featured a span length of 600 feet, a roadway width of 18 feet, an arch rise of 90 feet and an overall height of 115 feet from bearing shoe to guardrail. Including two 84-foot deck trusses on the north approach and a 49-foot approach on the south, the bridge extended a total of 833 feet. The most impressive dimension of the immense structure, however, was its distance above the river level: some 467 feet from deck to water, making it the highest bridge in the world at the time of completion.[19]

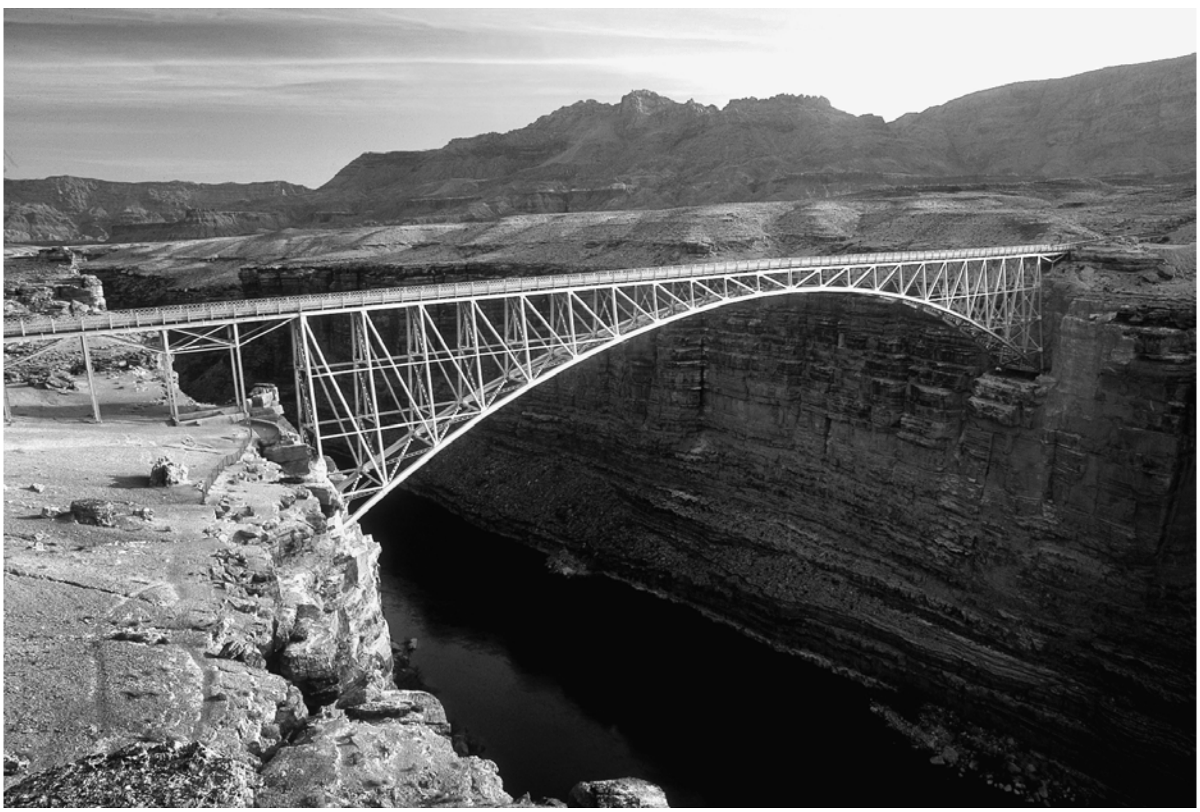


Figure 36. Navajo Bridge, 2002.

A contract to build the Grand Canyon Bridge was awarded to the Kansas City Structural Steel Company [KCSS]. The cost, including engineering, would total $314,000. The contractors faced severe logistical problems in building the immense bridge, hauling equipment and materials 130 miles north from Flagstaff

[19]R.A. Hoffman, "Closing the Arch of the Grand Canyon Bridge," *Arizona Highways*, October 1928, pages 7-8,15; "A.S. Taylor, "Bridging the Colorado Across the Marble Gorge," *Compressed Air Magazine*, Oct. 1928, pages 2547-48.

over a route with, in many places, no real road. By April 1928 the men had set the concrete foundations into the canyon walls. The steelworkers who balanced high above the river refused safety netting, insisting that with it they might become careless. Despite the obvious hazards, only one workman was killed during construction of the bridge. The first steel for the Navajo Bridge was swung into place that April, the last pin coupled on the main span in June 1929. Spanning gracefully between the sheer walls of the Grand Canyon, it is today Arizona's most significant vehicular structure.[20]

Completion of the Navajo Bridge [**0051**] represented a culmination of sorts for highway bridge engineering in Arizona. The Arizona Highway Department would design a few other exotic bridges—most notable of which was the McPhaul Bridge [**abd.**], a 798-foot suspension structure over the Gila River in Yuma County [*see Figure 37*], also completed in 1929—but by and large the experimentation with different structural types that had marked the 1910s and 1920s had given way to design standardization.

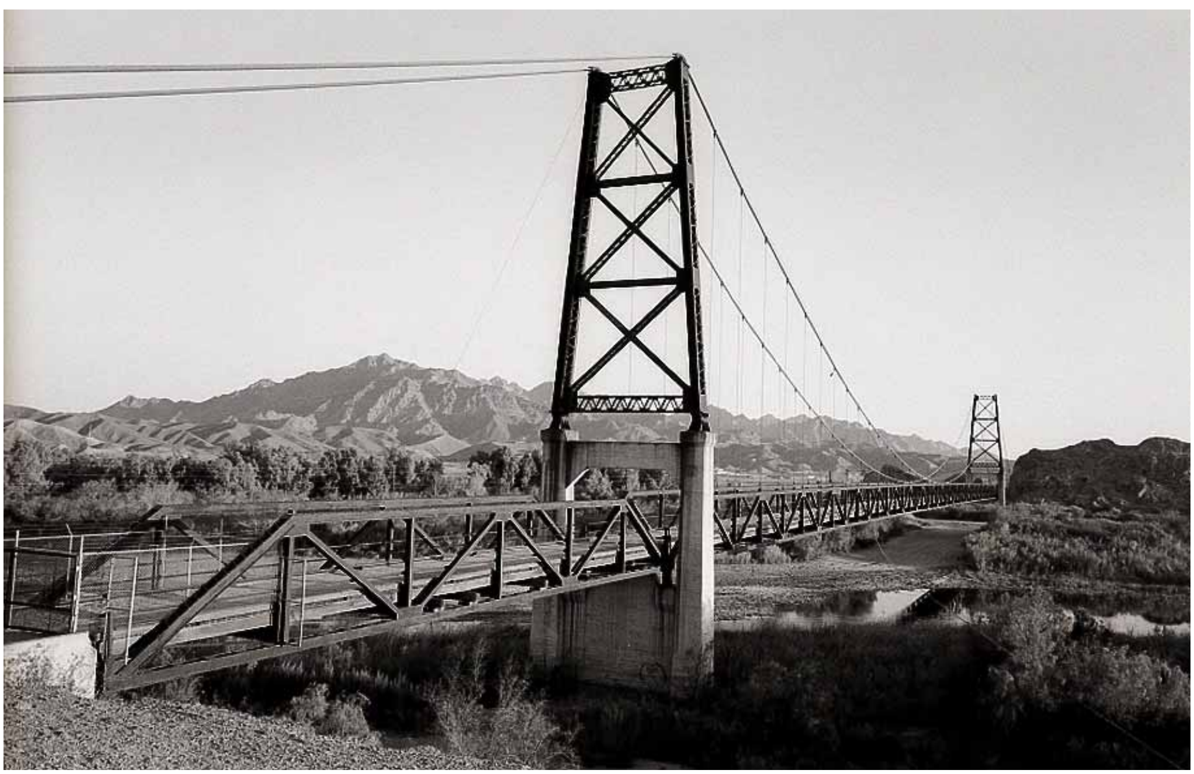


Figure 37. McPhaul (Dome) Bridge, 2003.

[20] In 1993 a second steel arch bridge was built next to the original structure. It now carries the vehicular traffic at this crossing, and the 1929 bridge functions as a pedestrian overlook.

see continuation sheet

The last major vehicular bridge of the decade was built as a replacement for the state's most important vehicular bridge. The original Tempe Bridge over the Salt River had functioned in place with occasional repairs since its completion in 1913, but its 18-foot roadway eventually proved to be a serious impediment to traffic at this congested crossing. In 1928 Ralph Hoffman designed its replacement—a multi-span open spandrel concrete arch along the same lines of the earlier structure. The bridge was later realigned slightly to place the footings on a granite dike that extended beneath the river. With 16 spans of 150 feet, it extended almost 1,600 feet, and its deck was double the width of the earlier structure. Its superstructure was comprised of open-spandrel concrete arches supported by solid concrete piers with bullnosed cutwaters.

The highway department designated the bridge's construction as Federal Aid Project 2B. On January 20, 1930, AHD let a contract for almost $400,000 to the Lynch-Canon Engineering Company to build the immense structure. The Los Angeles contractors began work on the abutments and piers immediately and progressed steadily through the rest of the year. Completed and dedicated formally in July 1931, the Mill Avenue Bridge [**9954;** *see Figure 38*] immediately carried heavy traffic at this pivotal crossing. The longest highway bridge in the state, and one of the most important transportation-related resources at the time of its completion, the Mill Avenue Bridge marked the climactic end of the decade.

Figure 38. Mill Avenue Bridge, 2002.

6 Depression and World War II Bridge Construction: 1933-1945

During the 1930s the Great Depression devastated the nation's economy, leaving millions jobless and homeless. By 1933 more than 13 million workers were unemployed and more than a thousand homes were being foreclosed upon each day. Government officials were quick to recognize the direct correlation between federal highway funding and employment. As early as 1930 Herbert Hoover increased federal funding for highway construction from $75 to $125 million and added an additional $80 million in future federal funds. When Franklin Roosevelt took office in 1933, nearly a third of the nation's work force was on relief, and local governments could not begin to meet the needs of the destitute. Roosevelt was immediately besieged with requests from state governors for aid. "There is no form of improvement," stated one governor, "more necessary and will better serve to relieve the acute unemployment situation than sorely needed highway construction projects on trunk roads in this state."[21]

In an effort to alleviate this financial distress, at least in part, Roosevelt established several agencies under his New Deal umbrella, whose primary purpose was to funnel billions of dollars of relief money to the destitute citizenry. Through the Works Progress Administration (WPA, later renamed the Work Projects Administration), the Public Works Administration and the Reconstruction Finance Corporation, the federal government poured hundreds of millions of dollars per year through the Bureau of Public Roads into road and bridge construction. A favored way of distributing funds to the unemployed was by means of so-called make-work projects—maintaining national forests and parks, producing artwork for public places, writing tourist guides, documenting historic properties, constructing buildings, dams, roads and bridges, etc. One of the first relief agencies established by the Roosevelt Administration was the Public Works Administration. Started in 1933 under the National Industrial Recovery Act, the PWA allocated some $400 million in funds for specific projects that were designed solely to put men to work at predetermined wage rates.

In 1933 Congress also passed the Federal Emergency Relief and Construction Act. Designated for road and bridge construction, the legislation stipulated that not more than half of the millions of dollars allotted under this program was to be used on the federal aid highway system and not less than 25 percent could be directed to extensions of the federal aid system into and through municipalities. While the act initially required states to match funds, that provision was later rescinded, setting a precedent for full federal subsidies. Cities were eligible for federal funding for the first time following passage of the Hayden-Cartwright Road Act in June 1934.[22] The act also reversed previous restrictions on the use of appropriations for urban highway construction. Not only did the cities need the improvements, but most of the unemployed were concentrated

[21]Quoted in Tom Lewis, *Divided Highways: Building the Interstate Highways, Transforming American Life* (New York: Penguin Books, 1997), 22.

[22]A better-known provision of the Hayden-Cartwright Act was the penalty imposed upon the states for any diversions of highway revenues to non-road purposes. The reason given for this was that it was "unfair and unjust to tax motor vehicle transportation unless the proceeds of such taxation are applied to the construction, improvement, or maintenance of highways."

in urban areas. Subsequent legislation encouraged construction of urban grade separations, bridge widenings, and the development of a feeder road network.

Because employment was as important a goal as construction, engineers often eschewed machines for hand labor. Federal funds came with some unusual requirements, in effect turning the clock back to the days before many labor-saving machines were available. "Cement and reinforcing steel shall be unloaded by hand labor methods," one specification read. "Finishing of structural concrete surfaces shall be done by hand rubbing or other labor methods. . . Carpenter work and form work shall be done by hand labor methods and the use of mechanical saws will not be permitted at the bridge site. . . All painting shall be done without the use of mechanical equipment." Civil Works Administration projects permitted not more than 10 percent of funds be used for equipment or materials, so the state was forced to supply these on most projects. By the mid-1930s the Federal Emergency Relief Administration had corrected this overzealous rule and allowed greater expenditure for materials.

During this time the annual federal aid grants continued to come to the states from the BPR. In 1936 alone the federal government awarded $225 million to the states for highway construction. Arizona received $2.6 million of this. In addition to the conventional federal aid for road and bridge work, which had been apportioned to the state annually since 1916, another federal program was established to help alleviate unemployment through road construction. Work under this fell under one of three categories: National Recovery Highway projects (for highways on the 7 percent system), National Recovery Secondary projects (non-federal aid roads on the state highway system), and National Recovery Municipal Highway projects (highways within incorporated cities and towns). A 1933 map of the Arizona highway system indicates the extent of construction contemplated under the new program [*see Figure 39*]. Of the $5.2 million apportioned to Arizona in 1934 under this program, $4.8 million went toward highway projects, $600,000 toward secondary projects and $800,000 toward municipal projects. The highway projects that year included construction of 15 bridges and two railroad grade separations.

The funds were apportioned in the traditional way to federal aid projects devoted to road and bridge construction. AHD engineers designed the projects, then let them out for competitive bids among private contractors. To help ensure that the construction projects would benefit the local labor pool, the contractors were required to hire locally, at stipulated hourly rates, to the extent that they could obtain local labor. Bridges were designed, as they had been in the 1920s, by the highway department, typically using standard plans. These were now being built to AASHO standards, with 24-foot roadways except on the more heavily trafficked highways and in population centers. Like the bridges built by AHD in the 1920s, the structures from the 1930s typically featured standard designs. Concrete was still the preferred material for construction. When culverts were called for, preference was for concrete, multiple-box configurations. Noted for utility and economy, if not elegance, concrete slabs and culverts were excellent choices for rural settings where those traits were of primary importance. Because they were labor-intensive in their construction, timber bridges experienced something of a resurgence for bridges in the state during the period. Steel was still used for bridge superstructures, though sparingly so.

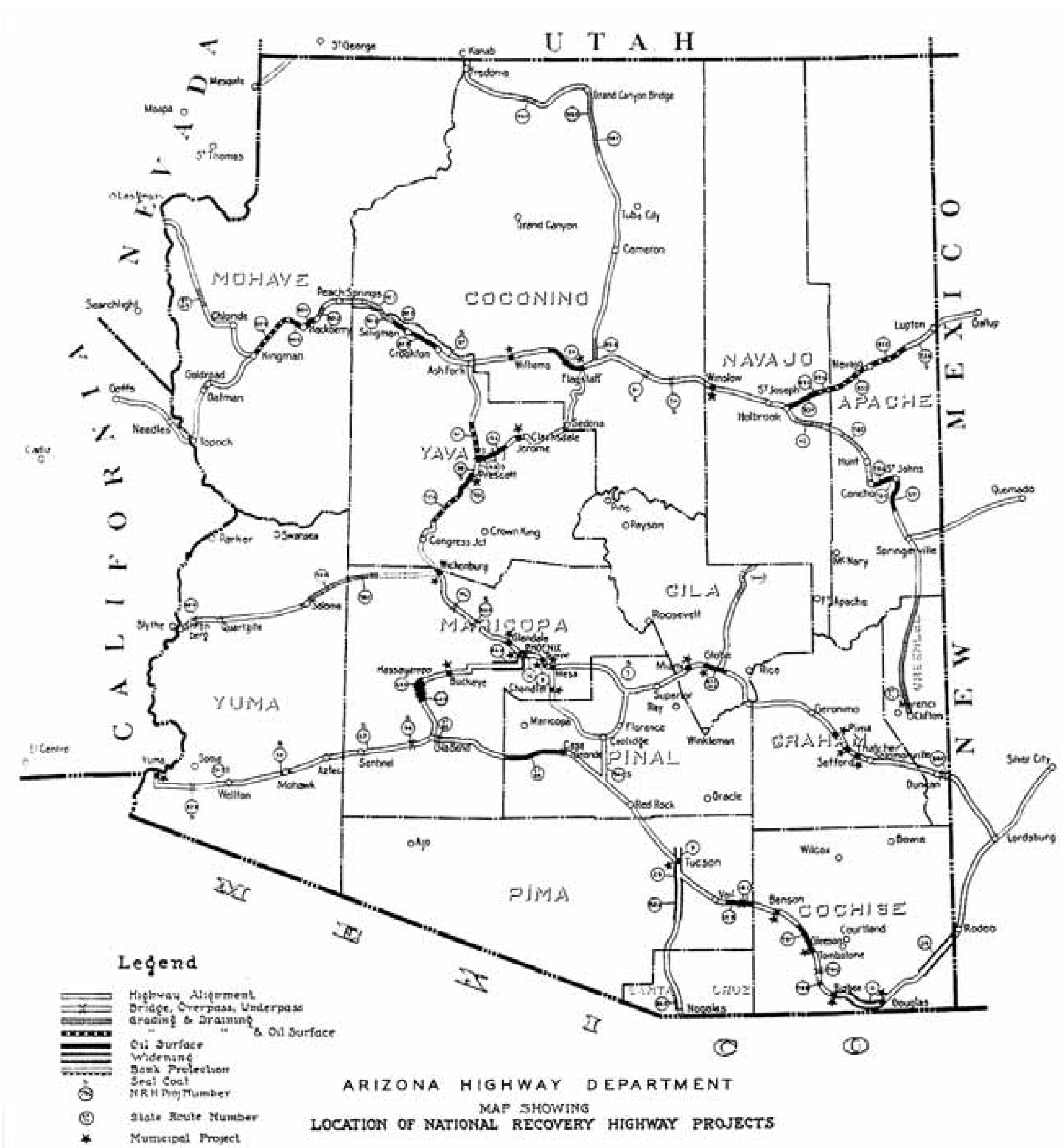


Figure 39. Map `of state highway system of Arizona, 1933.

AHD adopted two new structural types during this period. The first was the girder-ribbed steel deck arch. The highway department preferred this type of arch for medium-span applications, because the girders could be prefabricated using riveted steel plates in lieu of the complicated trussing of the spandrel braced arches, and then assembled on-site. This allowed for more rapid construction than possible with a spandrel braced configuration like the Navajo Bridge. The girder-ribbed arch design weighed more than its spandrel-braced counterpart, but it simplified fabrication and erection considerably, saving both time and money. In locations that did not require extensive cantilevering, the girder-ribbed arch proved more economical to build. Its adoption by AHD represented an evolutionary step in bridge engineering. Completed in 1934, the Salt River Canyon Bridge [**0129**; *see Figure 40*] in Gila County was AHD's first girder-ribbed arch. It was soon followed by other similar arches: the Cedar Canyon Bridge and the Corduroy Creek Bridge [**0215**], the Clear Creek Bridge [**1038**] and the Canyon Padre Bridge [**0671**].

Figure 40. Salt River Canyon Bridge, 2002.

The second structural type was the concrete rigid frame. Like the girder-ribbed arch, it represented an evolutionary step toward simplification, in this case of small-scale concrete spans. AHD experimented with rigid frame bridges at rural crossings to a limited extent during the 1930s. The agency used rigid frames much

see continuation sheet

more for urban grade separations, where they lent themselves to relatively short spans and could be readily overlaid with architectural ornamentation. AHD's grade separations of the 1930s typically employed conventional concrete slab or rigid frame superstructures for the overpasses and steel girders for the underpasses. These were treated with either traditional (Spanish Revival or Mission Style) or contemporary (Art Deco or Art Moderne) styles. Examples of the former include the Winslow Underpass [**0194**; *see Figure 41*] and the Stone Avenue Underpass [**7987**]. Examples of the latter include the Wickenburg Underpass [**0195**], the Benson Underpasses [**0262** and **0264**], the Central Avenue Underpass [**9168**] and the Casa Grande Underpass [**0143**]. AHD even began applying architectural treatments to its grade separations located in rural areas, as illustrated by the Ligurta Underpass [**8406**] and the Peoria Underpass [**0160**; *see Figure 42*].

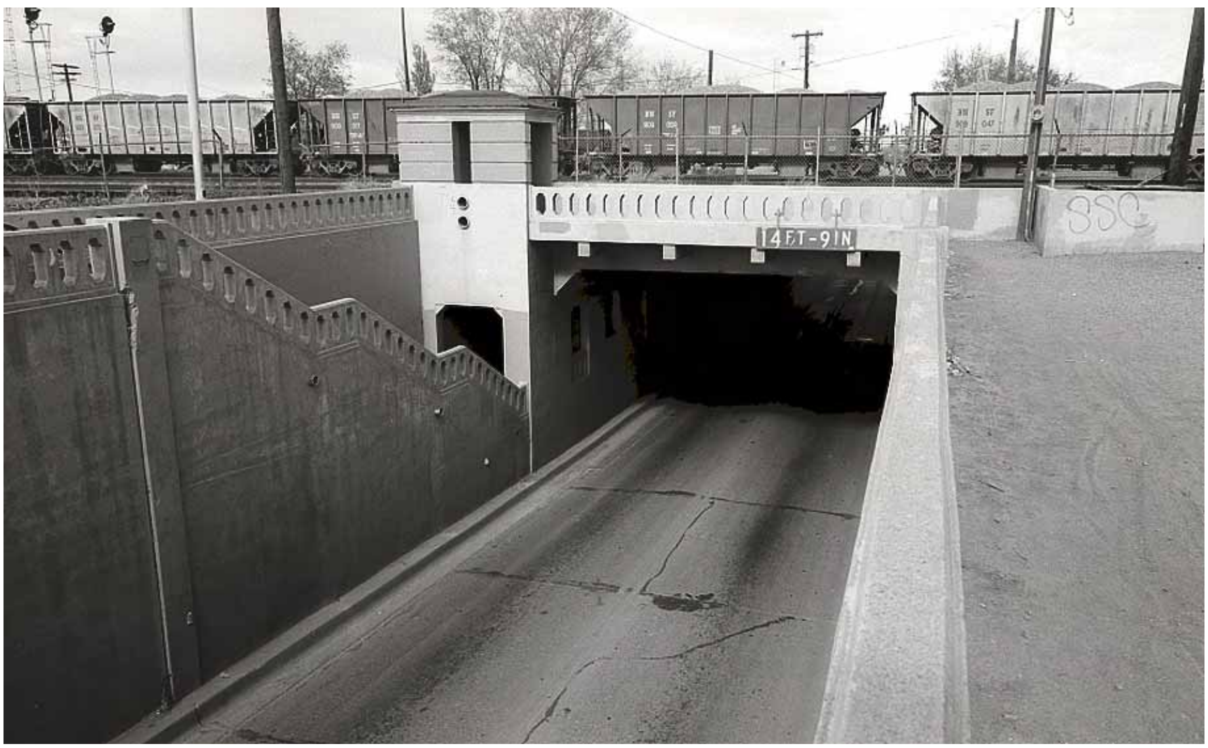


Figure 41. Winslow Underpass, 2002.

Early in its existence the state highway department had paid little attention to bridge aesthetics, instead concentrating on economy and functionality. Some of the more graceful structures designed by Ralph Hoffman (e.g., the Navajo Bridge [**0051**]) appear to have been motivated, at least in part, by aesthetic considerations, though he was loathe to admit it when discussing their design. "The speed with which it has been necessary to create wider and faster highways to meet the demands of

see continuation sheet

Figure 42. Peoria Underpass, 2002.

traffic have left little room for thought of such fine points," he sniffed in a 1934 article.[23] But the federal law specified that a portion of the NRH funds be earmarked for highway beautification. In response AHD began to consider the way its bridges looked in addition to the way they functioned. The answer to bridge aesthetics, according to Hoffman, lay in making the bridges as unobtrusive as possible and blending them with their natural surroundings. He believed that the superstructures should be hidden as much as possible beneath the roadway and that guardrails should be low—"as low as safety will permit"— and unnoticeable to keep from impeding the view from vehicles passing over the bridge. Hoffman reflected conventional wisdom about bridge design when he stated:

> Plain surfaces with softening curves are usually more fitting, such as are to be found in arch construction and in the development of the more recent rigid frame designs. Even with the advantages offered by these types, the straight line necessary for strength and economy do not successfully blend with nature. . . A more difficult problem presents itself in attempting to blend the bridge with the surroundings. A structure with steel trusses or other work above the deck, is usually the worst offender in this respect, an unfortunate occurrence.[24]

[23]R.A. Hoffman, "Bridges and Beautification." *Arizona Highways* X:11 (November 1934), 3-4.

[24]Ibid. 4.

see continuation sheet

AHD began rendering perspective views on some of its more complex rural structures to be able to judge their appearance. For its structures located in urban areas, AHD could not rely on invisibility as an aesthetic strategy, however. When the highway department began designing urban grade separations in the mid-1930s, it used architectural treatments to integrate the highway structures with their surroundings. The first three such structures, erected simultaneously in 1933-1934, featured an Art Deco architectural treatment, "the first of its type in architectural treatment to be constructed in Arizona," according to AHD.

The most noteworthy of the bridges constructed in the 1930s are today distinguished either by their high degree of physical integrity or by their deviance from standard-plan design. These include the Salt River Canyon Bridge [**0129**], a long-span steel arch on US 60; the Side Hill Viaduct [**0145**], a unique concrete slab structure on US 60; the Dead Indian Canyon Bridge [**0032**], a riveted deck truss on the Grand Canyon Highway; the Midgley Bridge [**0232**] a spandrel-braced steel arch in Coconino County; the Safford Bridge [**9333**], a multiple-span steel stringer structure over the Gila River; the Winslow Bridge [**0229**] and Wickenburg Bridge [**0161**], two long-span steel girder structures; and the Black Jack Canyon Bridge [**0258**], Negro Canyon Bridge [**0267**] and Rattlesnake Canyon Bridge [**0270**; *see Figure 43*], three well-preserved structures in Greenlee County.

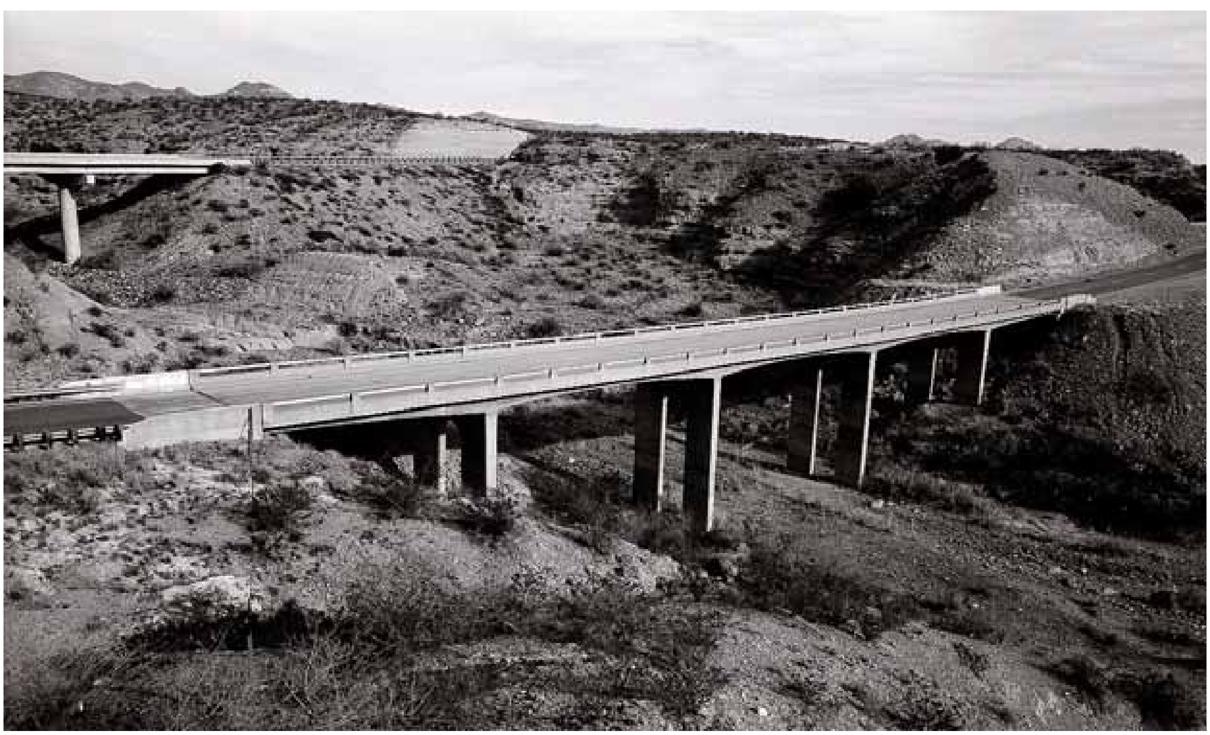


Figure 43. Rattlesnake Canyon Bridge, 2003.

see continuation sheet

In addition to programs administered through the state highway departments, the federal government undertook roadwork through one of its own agencies, the Works Progress Administration. Created under the Emergency Relief Appropriations Act in 1935, this agency was responsible for thousands of small-scale projects around the country. About 75 percent of these projects involved construction of some sort. The majority were planned and sponsored by cities, counties or other public agencies, with local match of funds that ranged from 10 to 30 percent. Despite criticism of its freewheeling spending, the WPA had a considerable impact on unemployment during the 1930s. At its peak the WPA provided relief to nearly a third of the nation's unemployed.

One of the favored venues of WPA work was road and bridge construction. "WPA is doing its share to cut down the tragic toll of sudden death on America's highway," *The WPA Worker* reported in July 1936. "Under the Emergency Program, workers from relief rolls have replaced thousands of narrow and dangerous bridges. They have built 11,000 new bridges in addition to repairing 17,000 others."[25] In Arizona approximately 20 percent of the WPA projects undertaken involved construction on the state's secondary roads, highways and city streets, "proposing paving, surfacing, widening, drainage and beautification over an area from Short Creek, in the northwest corner of the state, to Douglas in the southeast," according to Arizona WPA administrator W.J. Jamieson. Jamieson continued:

> With secondary roads receiving the largest percentage of funds allotted, road and highway improvement projects contemplate the expenditure of nearly $1,600,000 of federal funds. City street paving, improvement, and drainage projects propose the expenditure of more than $250,000. In Maricopa County alone, almost three-quarters of a million dollars has been allotted for projects which include the improvement of approximately 1,000 of the 3,000 miles of county roads, as well as other projects.[26]

In 1936 the WPA undertook highway projects in Arizona as diverse as improvement and beautification of US 89 between Nogales and Tucson, paving south of Bisbee and at Clifton, improvement of county roads near Douglas, construction of a highway through Papago Park in Scottsdale, construction of a bridge over Bumble Bee Creek in Yavapai County, over Short Creek in Apache County, and in Yuma County, and other work in Nogales, Superior, Phoenix, Jerome, Willcox and Globe.

The goal of the WPA was employment, with improvement of public facilities as a secondary consideration. "What is more important," WPA head Harry Hopkins asked in 1935, "that the fellow who has been kicked around now for years and given a lot of relief some of it pretty miserable and uncertain, be given a job, or that some great bridge be built and he not get a job? Never forget that the objective of this whole program as laid down by the President. . . is the objective of taking 3.5 million people off relief and putting them to work, and the secondary objective is to put them to work on the best possible projects we can, but don't ever

[25]"Bridges." *The WPA Worker* 1:2 (July 1936).

[26]Lewis Allison, "WPA Building Highways." *Arizona Highways* XII:2 (February 1936).

see continuation sheet

forget that first objective, and don't let me hear any of you apologizing for it because it is nothing to be ashamed of."[27] WPA administrator Ralph J. O'Rourke explained the purpose and operation of the WPA:

> It should be understood that the primary responsibility of W.P.A. projects is the employment of able bodied but destitute workers. With this responsibility in mind W.P.A. is exerting every effort to conduct projects along economical and efficient lines. Wherever possible W.P.A. has developed the type of work which will react to the benefit of the community in which the work is being performed, and it is believed that a large part of the funds expended on these projects will be returned to the community through improved conditions, elimination of dangerous roads, and the stabilization of existing highways by improved drainage facilities. Experienced personnel has been assigned to inspect the conduct and progress of the work. It is the responsibility of the sponsor of a project to provide plans and specifications for work that is to be conducted under the W.P.A.; however, W.P.A. field engineers are instructed to confer with the sponsors about changes when sound engineering principals have not been followed in the preparation of plans.[28]

The WPA program wound down as the United States entered World War II. Between 1935 and 1943, the agency had employed some 8½ million people (with over 30 million dependents), who performed nearly 19 billion hours of work for $9 billion in subsistence wages. The resulting public works projects completed by the WPA changed the physical fabric of America, if for no other reason than by their sheer numbers. In its eight years of service, the WPA was responsible for construction or repair of 650,000 million miles of roads and some 124,000 bridges; construction of 40,000 new public buildings and improvement to 85,000 others; construction of thousands of public parks, playgrounds, swimming pools and tennis courts; construction or improvement of thousands of municipal airports; construction of sanitation and water works, flood control systems and irrigation systems; and preservation of numerous historic buildings, including Independence Hall in Philadelphia and Faneuil Hall in Boston.

By all accounts the program was successful. "It was the most massive and comprehensive effort ever undertaken in the nation's history to ensure that every able-bodied American male—and even some able-bodied American females—would be able to earn at least the basic needs of life for themselves and their families," stated historian T.H. Watkins. "Even more than the New Deal's earlier relief programs, it was responsible for the creation of a new and immutable intimacy between the people and their government— an intimacy so thoroughly in place today that it is difficult to remember that it was once a revolutionary concept."[29]

WPA-built bridges in Arizona tended to be small-scale structures that employed standard highway department designs. They were generally indistinguishable from the concrete and steel structures being erected under traditional federal aid projects of the time. Although they were overshadowed in number and scale

---

[27] Quoted in Lois Craig, *The Federal Presence: Architecture, Politics, and Symbols in United States Government Building* (Cambridge, Massachusetts: MIT Press, 1978), 355.

[28] Ralph J. O'Rourke, "Works Progress Administration Highway Projects." *University of Colorado Highway Conference*, March 1936, n.p.

[29] T.H. Watkins, *The Great Depression: America in the 1930s* (Boston: Little, Brown Company, 1993), 248.

see continuation sheet

by federal-aid bridges, numerous structures were constructed by the WPA in Arizona during the Depression. Several of these remain in place today, including the Bumble Bee Creek Bridge [**8221**], a two-span steel stringer with stone substructure and parapets; the Main Street Bridge [**9630**] in Bisbee, a steel stringer structure; the Davis Wash Bridge [**0221**], a three-span concrete slab structure on the Apache Trail; and the Olsen Wash Bridge [**0224**], a four-span concrete slab structure in Pinal County. The most noteworthy of these small-scale bridges is the Willis Street Bridge [**8550**; *see Figure 44*] in Prescott, a two-span concrete deck girder structure with stone masonry substructre and steel pipe guardrails with stone masonry columns.

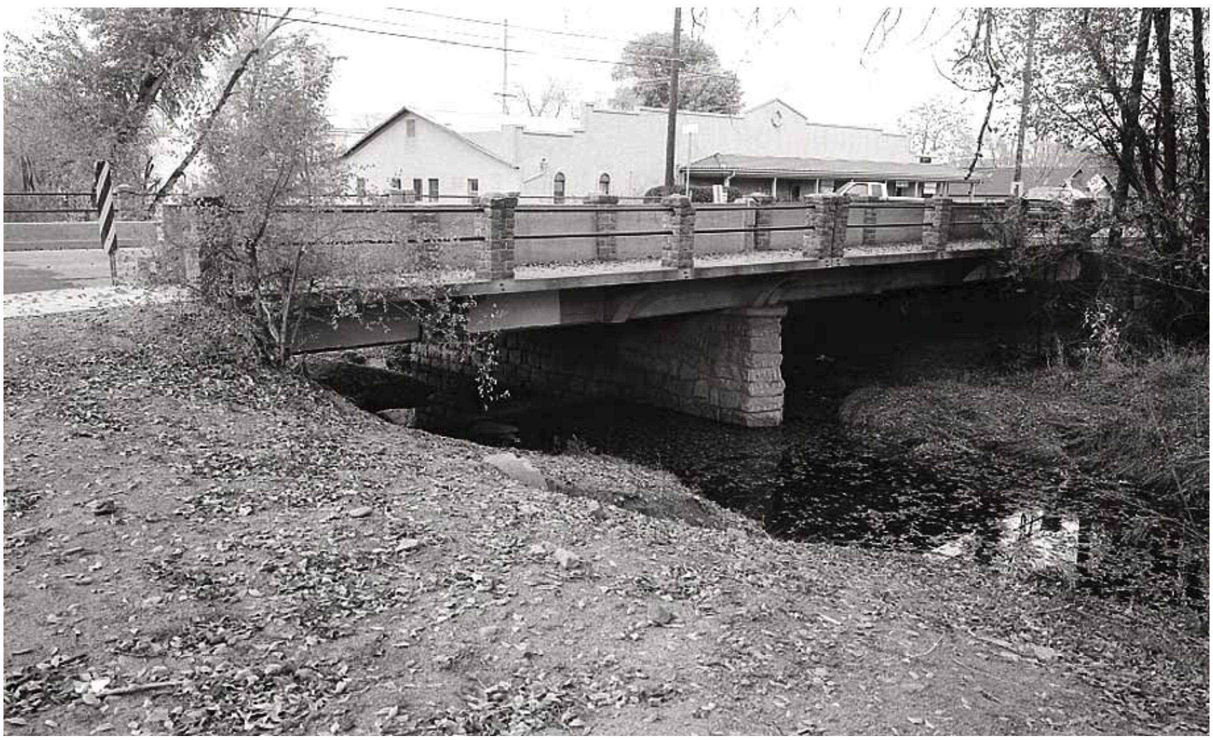


Figure 44. Willis Street Bridge, 2003.

While devastating much of the United States, the Great Depression—and Roosevelt's response to it—proved to be a boon to the nation's road system. Between 1933 and 1940 the New Deal was responsible for funneling some $1.8 billion into road and bridge construction throughout the country, funding millions of man-years of employment. During this time Arizona's state highway system grew from approximately 2,000 miles of aggregate length in 1930 to 3,624 miles eight years later [*see Figure 45*]. Most of the construction undertaken during this period involved improvement of existing roads. A notable exception to this was construction of US 60 between Globe and Show Low through the Salt River

Canyon. Intended to complete the last leg of the transcontinental route, the road would link Springerville, Show Low and other towns on the Mogollin Rim with the town of Globe—and, by extension, with Phoenix. Construction on US 60 illustrated road and bridge work of the period.

AHD had begun planning for this route in the late 1920s. Department engineers initially considered upgrading the existing regional route, a road built in part by soldiers from Fort Apache that crossed over both the Black River Bridge [**3128**] and the White River Bridge [**3129**]. But the Rice-McNary Road, as this territorial route was called, was still little more than a wagon trail, despite construction over the previous four years to improve it. Rather than upgrade the existing road further, the highway department instead surveyed an all-new route in 1930-1931. With the route design completed early in 1931, the highway department divided the 130-mile road into a series of shorter sections and began letting contracts for its construction under the umbrella of Federal Aid Project 99.

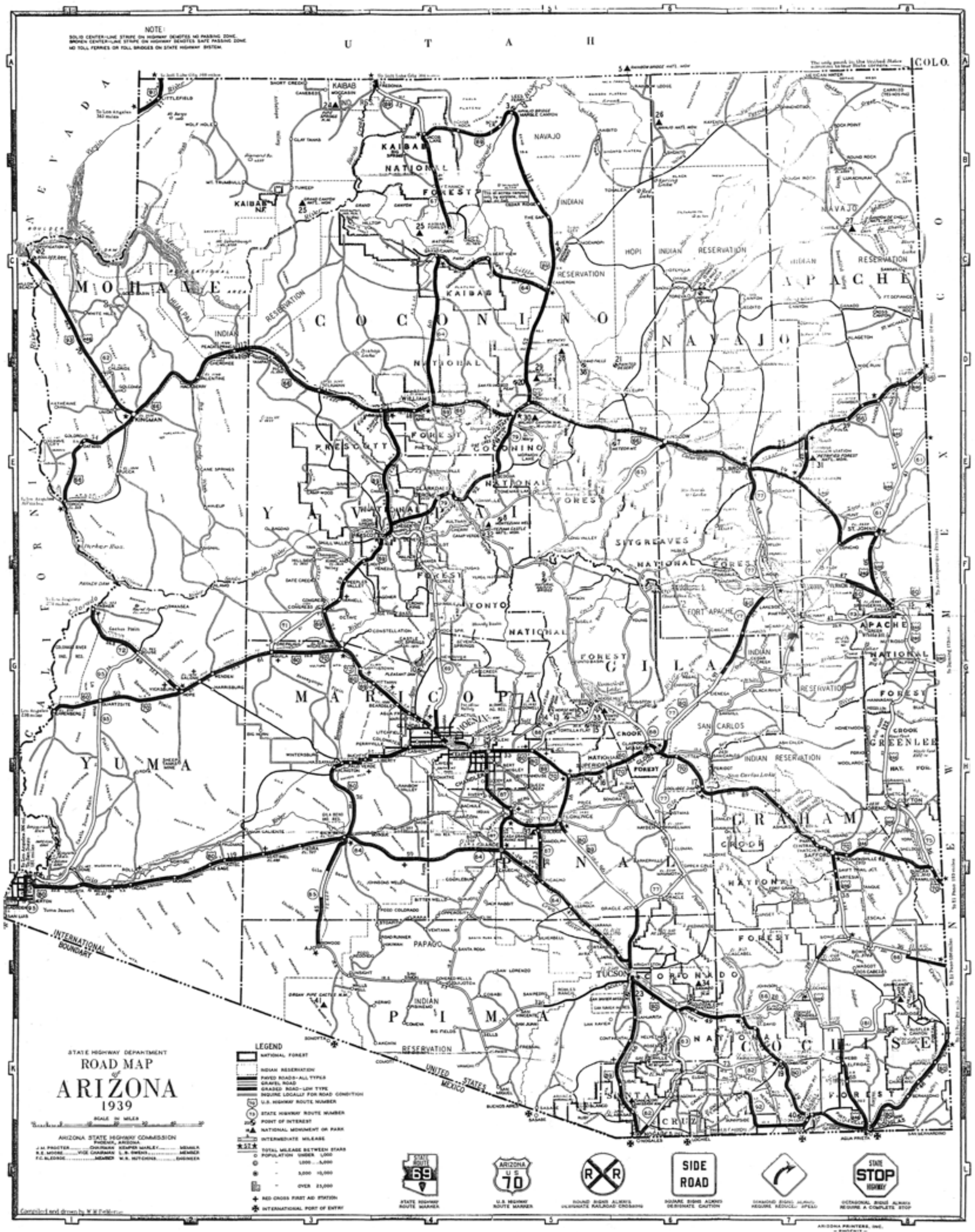
Section A, the first one undertaken, included some of the route's most rugged terrain. Work on it began in mid-June of that year. Using everything from mule teams to trucks, tractors and power shovels, the contractors proceeded through summer rainstorms and sub-zero temperatures in the winter, blasting, filling and grading the road through mountainous terrain on the San Carlos Indian Reservation. After eighteen months of brutal construction, Section A was completed near the end of the year. Comprising the southernmost 10.8 miles of the route, Section B began just outside of Globe and extended through the Crook National Forest to Apache Peak. This part of the highway also ran through rugged terrain but was more accessible than Section A. Construction on it advanced more rapidly through completion in July 1932. Sections C and D, built in 1932-1933, passed through rolling woodlands before making the steep descent into the Salt River Canyon.

As construction progressed on the highway, the Depression deepened across the country; soon a premium was placed on employment for the local work force. Labor-intense hand work was used extensively in lieu of mechanized construction, and the work schedule was changed from the standard eight-hour, five-day shift to two five-hour, six-day shifts with extended furloughs to employ more workers and push construction. "Except for a few, all skilled and unskilled employees were Gila county men," reported AHD resident engineer A.F. Rath, "Labor reports compiled from records show that for a period of 50 weeks the two jobs [Sections C and D] averaged 180 men per day... The benefits derived from roadwork spread over a large area, if one should care to follow it through from start to finish."[30] Using these methods, some 42 miles of highway had been graded between Globe and the Salt River Canyon by October 1933.

The steep rock walls and constricted contour of the Salt River Canyon called for a single-span bridge to carry the roadway high above the river. For this natural crossing, the AHD bridge department engineered a single-span steel arch that flexed against the canyon walls on concrete pedestals. The Salt River Canyon Bridge was an innovative structure—only the third steel arch built for Arizona's highway system. The highway department designated the bridge's construction Section E and in September 1933 contracted with the Lee Moor Construction Company of El Paso, Texas, for its fabrication and erection. The contractor began immediately on the concrete arch pedestals. The Salt River Canyon Bridge and its approaches presented

[30] A.F. Rath, AHD Resident Engineer, "Highway 60 Moves Northward," *Arizona Highways*, July 1933, 4.

see continuation sheet



■ Figure 45. Map of state highway system of Arizona, 1939.

multiple curvature problems -"more, in fact, than any bridge so far constructed in the state," according to Rath. As a result, its construction went slowly. In January 1934 work on the first pylon began. Each 18-ton arch girder was erected in five sections that spring, and in June the immense structure was completed. "From a distance and with its aluminum paint shining in the sunlight, the structure looks more like a delicate piece of filigree than a well designed and constructed highway bridge," rhapsodized Rath.[31]

Completion of the Salt River Canyon Bridge [**0129**] marked the symbolic halfway point on the Globe-Springerville Highway. Although almost 90 miles remained between the bridge and Springerville, once out of the Salt River Canyon most of the path ahead was relatively mild compared to the rugged construction in Sections A through D. The highway department dubbed the three-mile climb up the other side of the canyon Section F and subsequent segments Sections G through J, as construction progressed steadily northward between 1934 and 1936. Meanwhile, work had begun on the highway from the Springerville side under Federal Aid Project 105. Again, AHD divided the construction into smaller segments, the first of which extended from the outskirts of Springerville. Two of the last segments designated—F.A.P. 105-D and 105-E—involved erection of a unique multiple-span, concrete slab structure, the Side Hill Viaduct [**0145**], which skirted the side of a steep slope and two girder-ribbed arch bridges over Cedar Canyon and Corduroy Creek [**0214** and **0215**].[32] Completion of these last two bridges marked the last link in U.S. 60 between Globe and Springerville, and one of the last links in the national highway.

The onset of World War II brought highway plans in Arizona to an abrupt halt. With fuel under tight rationing, automobile production suspended and tires and car parts in short supply, overland travel diminished accordingly. Funds and most construction materials— especially concrete, oil and steel—were diverted to the war effort. The WPA was dismantled, as the federal government shifted its focus from helping the unemployed to mobilizing for war. And many of the highway department engineers and laborers left to fight in the war, reducing the agency's force considerably. AHD was compelled to suspend its construction program almost entirely to concentrate its reduced resources on maintenance work. "Rationing slowed traffic almost to nothing [on Route 66]," stated merchant Bud Gunderson. "In 1943 the traffic on 66 was practically at a standstill other than military convoys."[33] No bridge construction was undertaken that was not absolutely necessary. The bridges that were built during the war used non-critical materials when possible, and some were constructed using materials salvaged from other structures.

---

[31] A.F. Rath, "New Bridge Across Salt River and the Country Which It Will Open," Arizona Highways, September 1933, 14.

[32] The Side Hill Viaduct still carries traffic with the installation of Thrie beam guardrails as its only alteration. The Cedar Canyon and Corduroy Creek bridges also functioned in place with no alterations, until 1993, when the superstructure of the Corduroy Creek Bridge was lifted, moved to the Cedar Canyon site, and installed next to the other arch as a means to widen the roadway.

[33] Quoted in Susan Kelly, *Route 66: The Highway and Its People* (Norman: University of Oklahoma Press, 1988), 79.

A new form of federal grant program—Defense Access Projects—was instituted in 1941 under the Defense Highway Act. These projects were intended to build or improve roads associated with defense facilities, critical industries and sources of raw materials. Defense Access Project No. 1 in Arizona entailed construction of three timber stringer bridges, 17 concrete culverts and about five miles of road within the Fort Huachuca Military Reservation. Another such military highway improved by the WPA under this program was the 6.2-mile segment of SR 92 that connected Fort Huachuca with SR 82. Four Defense Access structures—three concrete box culverts and a concrete slab—have been identified by the bridge inventory. Located on State Route 87 south of Winslow, these four structures [**4671**, **4672**, **4677** and **0275**] were built in 1944.

In actuality, Arizona's participation in the Defense Access program was limited. The state in 1944 had only 133 miles of roads on military facilities (versus 3,800 miles of state highways and 15,440 miles of county roads). The impact of the war on Arizona's roads was not so much the extent of construction on defense-related facilities as the absence of other conventional road and bridge construction. The bridge inventory includes only two dozen bridges and culverts built during the three years between 1943 and 1945 (versus 34 bridges in 1942 and 40 bridges in 1946). Most were minor concrete structures, built using standard AHD designs.

7 Post-War Construction and the Interstate Highway System: 1945-1964

As the war was winding down, Congress resumed funding the federal aid highway program, and the Arizona Highway Department continued its construction and maintenance work. After the war the state returned to its pre-war routine, with AHD planning and undertaking projects, using oversight and funding from BPR. Many of the AHD engineers and construction managers returned to the agency after the war. Others, most notably Ralph Hoffman, AHD chief bridge engineer since the early 1920s, continued with the agency through the war. Despite four years of deferred maintenance during the war, Arizona's road and bridge network remained largely intact. In 1946 an engineer from the Bureau of Public Roads gave his appraisal of the state of affairs on Arizona's highways:

> On the whole, a critical examination of the Arizona State highway system discloses a healthy condition. The Federal-aid highway system of about 2,500 miles has had almost complete first- or second-stage improvement. It shows, as it should for the average traffic, a large percentage of construction with intermediate types of bituminous surfacing... The first obligation of the State is to maintain the system (and) most of the past construction will require revamping or reconstruction in 25 or 30 years. The future healthy highway development in Arizona seems assured.[34]

In 1944 Congress passed the Federal Aid Highway Act. Over a three-year period, the law allocated $500 million annually for construction and improvement of local and interstate roads. The total amount was divided into 45 percent ($225 million) for use on primary roads, 30 percent ($150 million) for secondary systems, and the remaining 25 percent ($125 million) for municipal roads. Beyond this, the act formally established the National System of Interstate Highways, which required states to build roads to connect major metropolises.

[34] L.I. Hewes, "Some Observations on a Modern State Highway System," *Papers Presented at the Sixth Arizona Roads and Streets Conference, April 26, 1946*, University of Arizona, 1946.

see continuation sheet

The roads proposed by this legislation were minimally configured as four-lane, divided highways, expanding to six or eight lanes in urban areas. Arizona's allotted mileage under the Act included what is now Interstate 17 between Phoenix and Flagstaff; Interstate 40, which generally followed the Old Trails Highway across the northern part of the state; and Interstate 10, which generally followed the Ocean-to-Ocean Highway across the southern part of the state. The Federal Aid Act was the first step toward the establishment of a coherent federal interstate system.

In the post-war years both the American economy and its population boomed. By 1953 the population exceeded 157 million, a 20 percent increase since the beginning of the war. These people enjoyed substantial increases in their economic status and standard of living. That year visits to national parks exceeded 17 million, and Chevrolet, Ford, and Plymouth sold over 3.3 million cars. As more Americans became mobile, they logged nearly 550 billion miles on inferior roads. Despite the obvious need for improved highways, little headway was made over the next ten years. President Harry Truman authorized a National System of Interstate and Defense Highways in August 1947, but nothing was done to actually build these interstates. Further action—and a change of administrations—was required a decade later to complete the work of the 1944 and 1947 authorizations. It would not be until the Eisenhower administration that work on the interstate system would begin.

With a background of logistical planning from his military experience, President Dwight D. Eisenhower was an outspoken advocate for an integrated system of interstate highways. As early as April 1954, Eisenhower had begun staging high-level meetings on the subject of improving federal highway programming. After lengthy debate, Congress finally passed a highway bill, the Federal Highway Act, on June 29, 1956. Acting on the President's recommendation, the legislators authorized $33.5 billion for construction of over 41,000 miles of limited-access superhighways during the next sixteen years. The federal government would pay 90 percent of the construction cost, establishing a Highway Trust Fund as a crediting mechanism within the general treasury.

The proposed network would link almost all of the cities with populations over 50,000. Built to standards heretofore unused for the nation's highways, the interstates would be engineered to accommodate speeds of 70 miles per hour. They would be sized to accommodate traffic volume projected to 1972, the year of the system's proposed completion. This represented by far the most ambitious road construction program in America. From 1956 through the 1970s, interstate highway construction continued at an unprecedented pace, establishing the basis for the U.S.'s current extensive highway system and transforming the urban and rural landscape through which they ran.

The new highway numbering system resembled the 1925 system in some ways. In the new interstate nomenclature, east-west highways descended numerically in even numbers from north to south and north-south highways descended numerically in odd numbers from east to west. Thus America's northernmost east-west interstate was Interstate 94 across North Dakota, Minnesota and Wisconsin and its southernmost east-west

see continuation sheet

route was Interstate 4 in Florida. The easternmost north-south route was Interstate 95 from Florida to Maine and its westernmost north-south route was Interstate 5 along the west coast. Belt routes in and around large metropolises were assigned three-digit numbers. The distinctive Interstate shield sign was adopted by AASHO in August 1957 and has been in use since.

Design standards for the interstate system were detailed by AASHO in its annual publication, *A Policy on Geometric Design of Highways and Streets*, commonly called the Green Book.[35] Although the AASHO standards were ostensibly voluntary, they were adopted in whole by the Bureau of Public Roads. With the BPR funding 90 percent of the interstates' construction, the standards were in turn adopted by virtually all of the state highway departments, including Arizona's. Under the guidelines, directional travel on the highways would be separated, with entrances and exits limited. Traffic lanes were required to be 12 feet wide and shoulders 10 feet wide. Median strips dividing oncoming traffic in rural areas would be at least 36 feet wide; medians in urban areas 16 feet wide. The highways would have no on-grade crossings with railroads and other vehicular roads, vertical clearance at underpasses would be 14 feet, and grades would not exceed 3 percent. According to historian Tom Lewis:

> The Bureau of Public Roads and the American Association of State Highway Officials issued specifications for construction that left little leeway for interpretation. Engineers simply applied the rules to the task at hand, be it Interstate 10 through Santa Monica, California, or Interstate 94 through Dickinson, North Dakota. They simply repeated the tasks in small increments of usually five, ten, twenty, or thirty miles many times over; surveying, walking the line, grading the land, laying the substrate, laying the asphalt or concrete, painting the lines, erecting the signs, holding the ribbon-cutting ceremony, and moving on.[36]

Planning for a freeway system in and around the Phoenix metropolitan area had already begun well before passage of the Federal Highway Act of 1956. As early as 1948 the Arizona Highway Department [AHD], the U.S. Bureau of Public Roads, Maricopa County and the City of Phoenix had jointly sponsored a study of arterial traffic through the city. The plan that these agencies formulated involved multi-lane arterial streets—Roosevelt, Jefferson and Madison, primarily—that would carry traffic east-west through the city. Roosevelt would be reconstructed as a six-lane parkway to carry U.S. 60/70/80/89. At the west edge of Phoenix, along the alignment of 23rd Avenue, would be State Highway 69. This would collect traffic from the east-west streets and carry it northward.

The most noteworthy aspect of the plan was the configuration of SR 69. As delineated, it would be constructed as a limited-access freeway—Arizona's first. The freeway design remained on the drafting board through

---

[35] By the early 1970s AASHO had renamed itself American Association of State Highway and Transportation Officials [AASHTO], but the organization's function remained unchanged.

[36] Tom Lewis, *Divided Highways: Building the Interstate Highways, Transforming American Life* (New York: Penguin Books, 1997), 253.

see continuation sheet

the 1950s. Within months after enactment of the Federal Highway Act, however, the system reappeared in a more detailed plan developed by the state highway department. In February 1957 AHD released the plan of an interstate system that would carry traffic from the north, south and west into Phoenix. State Highway 69 was then programmed for construction along the earlier alignment. As proposed, Interstate 10 would enter the city from the south immediately west of 56th Street, turn westward at Broadway and curve through town before exiting west between Southern and Broadway.

Facing complex, politically charged issues of routing, engineering, land acquisition, project funding and construction logistics, the highway planners worked slowly through the late 1950s laying out the proposed system. Finally, by May 1961 a master plan had been signed by the Arizona State Highway Commission, Maricopa County and the cities of Phoenix, Glendale, Avondale, Mesa, Buckeye and Tempe. This plan incorporated elements of the earlier schemes and combined both federal interstate highways with state primary routes. It integrated limited access freeways and traditional roads into a coherent network of arterial routes.

In this scheme, Interstate 10—tagged the Pima Freeway—would enter Phoenix from the south as it had in the 1957 design. The route became the Maricopa Freeway when it turned westward toward Yuma. The original SR 69 route—renamed the Black Canyon Freeway—kept its old alignment as Interstate 17. The new master plan delineated other non-interstate freeways as well: the Squaw Peak and New River freeways, which extended north-south on either side of the Black Canyon; and the Papago and Paradise freeways, which ran east-west through town.

Elsewhere in the state, AHD engineers began planning a statewide network of freeways. The proposed new routes would follow familiar corridors. Interstate 40 in the northern tier of the state generally followed US 66—which itself followed the National Old Trails Highway, which followed the northern territorial road, which followed Beale's Road. Interstate 8/10 generally followed US 80—which followed the Ocean-to-Ocean Highway, which followed the southern territorial road, which followed the Gila Trail. The original territorial north-south road would eventually be incorporated into Interstates 19, 10 and 17 between Nogales and Flagstaff. Construction on Interstate 10 began in the late 1950s and continued into the 1980s. Interstate 40 was built in the 1960s and 1970s. Other limited access highways were built in and around the Phoenix and Tucson metropolises and some are still under construction today.

Bridge design and construction in Arizona after World War II followed national trends, with an emphasis on small-scale concrete drainage structures. The Arizona Highway Department used AASHO standard designs for its box culverts, concrete slabs, concrete girders and rigid frame bridges. Their design changed incrementally from the 1930s, with the modifications occurring in the form of steel reinforcing, substructural design (e.g., driven concrete piles under bridge piers and abutments), roadway widths and guardrail configurations. With four years' catching up to do and an entire state to cover, the focus was on rapid construction of highways with economical drainage structures. It was not a memorable period for bridgework. Of the forty structures identified in the inventory from 1946, the first full year after war's

see continuation sheet

end, 34 were concrete box culverts, five were concrete slabs and a single bridge, the Pine Creek Bridge [**0283**] in Gila County, was a modestly scaled rigid frame. With a span length of only 50 feet, it was the longest bridge of the year.

Over the rest of the decade, the overwhelming majority of structures—over 90 percent—were concrete box culverts or simple concrete slabs. A few simply supported steel stringer bridges were built, none of which exceeded 70 feet in span length. The inventory contains a single concrete arch bridge, a 30-foot filled spandrel structure, built at the Clifton Overpass [**0300**] in Greenlee County in 1947. AHD did manage to erect at least two structurally adventurous structures during the period. Without question the most noteworthy structures in the inventory from the late 1940s were the Pinto Creek Bridge [**0351**; *see Figure 46*] and the Queen Creek Viaduct [**0406**] , both built on US 60 between Superior and Miami. Designed in 1947 by Ralph Hoffman and completed in 1949 these nearly identical, long-span structures featured two-hinge, girder-ribbed deck arch superstructures. They had been modeled after the Salt River Bridge, the state's first such structure. Both were handsomely detailed and configured and dramatically set in picturesque canyons; the Pinto Creek Bridge won an award from the American Institute of Steel Construction as the most beautiful bridge in America in its class.

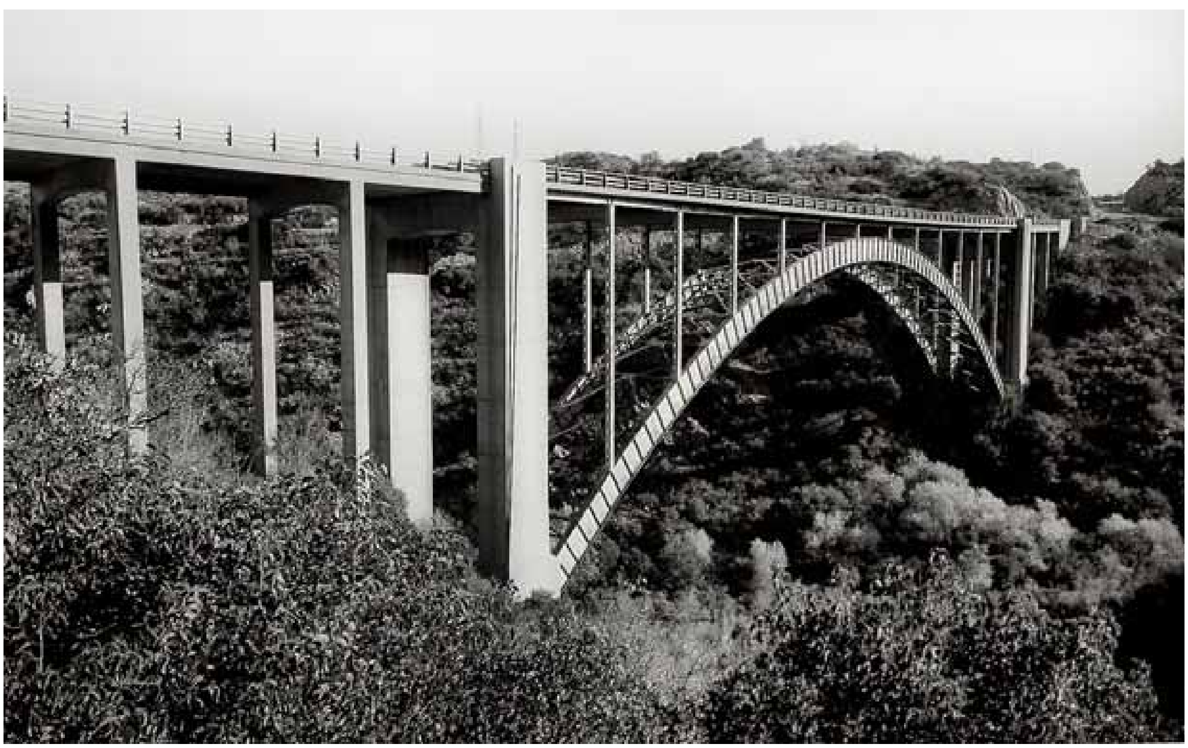


Figure 46. Pinto Creek Bridge, 2003.

see continuation sheet

The early 1950s marked a continuation of the 1940s, with little that was innovative or even memorable in bridge construction in Arizona. The noteworthy exceptions to this were the Guthrie Bridge [**0352**; *see Figure 47*], a long-span cantilevered deck truss erected over the Gila River in 1950 in Greenlee County; the Benson Bridge [**0350**], a cantilevered plate deck girder bridge built in 1950 over the San Pedro River in Cochise County; the Clear Creek Bridge [**1038**; *see Figure 48*], a girder-ribbed steel arch built in 1951 in Navajo County; and the Hell Canyon Bridge [**0483**], a cantilevered steel deck arch built in 1954 in Yavapai County. Trusses, arches, girders—all of Arizona's significant steel structures from the post-war years involved cantilevering, which had been Ralph Hoffman's trademark engineering style since the Allentown Bridge [**3073**] in 1923.

Figure 47. Guthrie Bridge, 2003.

Construction of the interstate highway network in the state, beginning in the late 1950s, marked a watershed in bridge design, both in the number of structures built and their configuration. The interstates required construction of numerous over- and underpasses at their interchanges. For these and at other crossings in the 1940s, 1950s and 1960s the highway department employed AASHO standard designs for a new array of concrete/steel structural types: precast box beams, prestressed concrete girders and twin tees, which largely

see continuation sheet

superseded its previous structural types. Though more structurally sophisticated than their predecessors, these recent bridges are far less graphic and have little to distinguish them technologically. The significant bridges from the late 1950s and early 1960s are all singular structures that depart from standard design trends. These include the Glen Canyon Bridge [**0537**], a large-span steel arch built over the Colorado River in 1958 by the U.S. Bureau of Reclamation; the Burro Creek Bridge [**0846**], a long-span steel arch completed in 1965 on US 93 in Mohave County; the Cameron Truss Bridge [**0532**], a cantilevered deck arch built next to the Cameron Suspension Bridge in 1959; and long-span welded steel girder bridges over Black Canyon [**0758**] and Wilbur Canyon [**0781**] in Yavapai County and the Mountain View Interchange [**1053**] in Pima County.

Figure 48 Clear Creek Bridge, 2002.

Most of the earliest bridges in the state are now anachronisms, types of which are seldom still built. The last Luten arch in Arizona, the Mineral Creek Bridge, was built around 1923, the last pin-connected truss, the Palominas Bridge, in 1917. Many now standing abandoned, the early roadway arches, girders and trusses function as reminders of past technologies, whose numbers are slowly dwindling through attrition.

see continuation sheet