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A Great Job Looms in the Colorado River Aqueduct

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WITH THE DECISION on June 2 of the supreme court of California that bonds to the amount of $220,000,000, voted for the construction of the Colorado River aqueduct, are valid, work on that great water-supply project can begin, following the sale of the first block of bonds. The court's decision becomes final thirty days after its publication. The aqueduct will bring Colorado River water over the highlands lying between the Colorado River valley and the Los Angeles basin, a distance of 240 miles, to supply the thirteen cities making up the Metropolitan Water District of Southern California. Power for pumping the water will come, in large part, from Hoover Dam. —Editor.

THE THIRTEEN cities composing the Metropolitan Water District of southern California, on Sept. 29, 1931, by a vote of practically 5 to 1, authorized a bond issue of $220,000,000 to finance the building of an aqueduct to supply the Los Angeles metropolitan area with water from the Colorado River. In November a taxpayers' suit was begun in the superior court of Los Angeles County to invalidate the proposed bond issue. The court upheld the validity of the bonds and of the election at which they were approved. Subsequently appeal was taken to the state supreme court. The decision of that court, which was rendered on June 2 last, upholding the result of this election, removes definitely the menace of water shortage in southern California and strengthens and extends the financial foundation of the remarkable development that has taken place in this semi-arid region during the past three or four decades.

As constituted at present, the district comprises the thirteen cities of Anaheim, Beverly Hills, Burbank, Compton, Fullerton, Glendale, Long Beach, Los Angeles, Pasadena, San Marino, Santa Ana, Santa Monica and Torrance, with a combined population of 1,666,000 and an assessed valuation of $2,400,000,000. Applications for admission are now pending from a number of other cities of the southern California coastal plain.

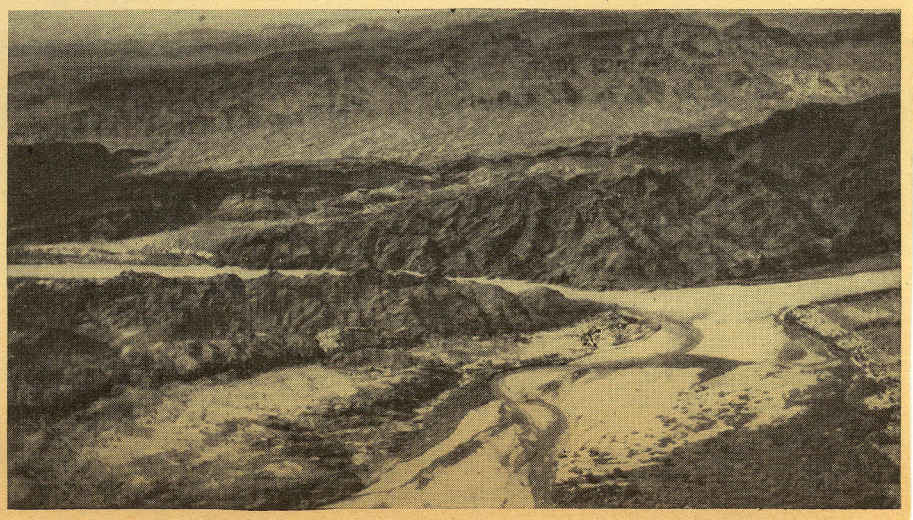
The project will include a main aqueduct 240.5 miles long to bring the water over the high areas between the Colorado River and the basin surrounding the city of Los Angeles, storage facilities for regulating the flow to meet fluctuations in demand, and distribution lines for delivering the water at wholesale into the existing water-supply systems of the cities composing the district. The total static pumping lift will be 1,583 ft. Power for pumping will be secured principally from the government plant at Hoover Dam, but some power will be generated at the intake and at drops within the distribution system. The general location of the project is shown on Fig. 3.

Plans call for the ultimate diversion from the river of an average flow of 1,500 sec.-ft. The main aqueduct is to be built to full capacity at the start, except in the case of multiple-unit features, such as steel pipes, pumping machinery, etc., portions of which may be deferred without greatly increasing the ultimate cost. Local facilities, such as storage reservoirs and wholesale delivery lines, are to be built to about one-half capacity at present and later enlarged as the demand for water increases.

The diversion

Water is to be taken from the river at a point about 18 miles upstream from Parker, Ariz., where the flow is confined in a narrow rock canyon. The diversion can be made by pumping directly from the river without a dam, but present plans contemplate the construction of a diversion dam as a part of the first development. As released

Fig. 1—The site chosen for the Parker Dam is in the narrow rock canyon, about the center of the picture, below the mouth of the Bill Williams River, which comes in from the foreground. Beyond are the mountains over which the aqueduct goes.



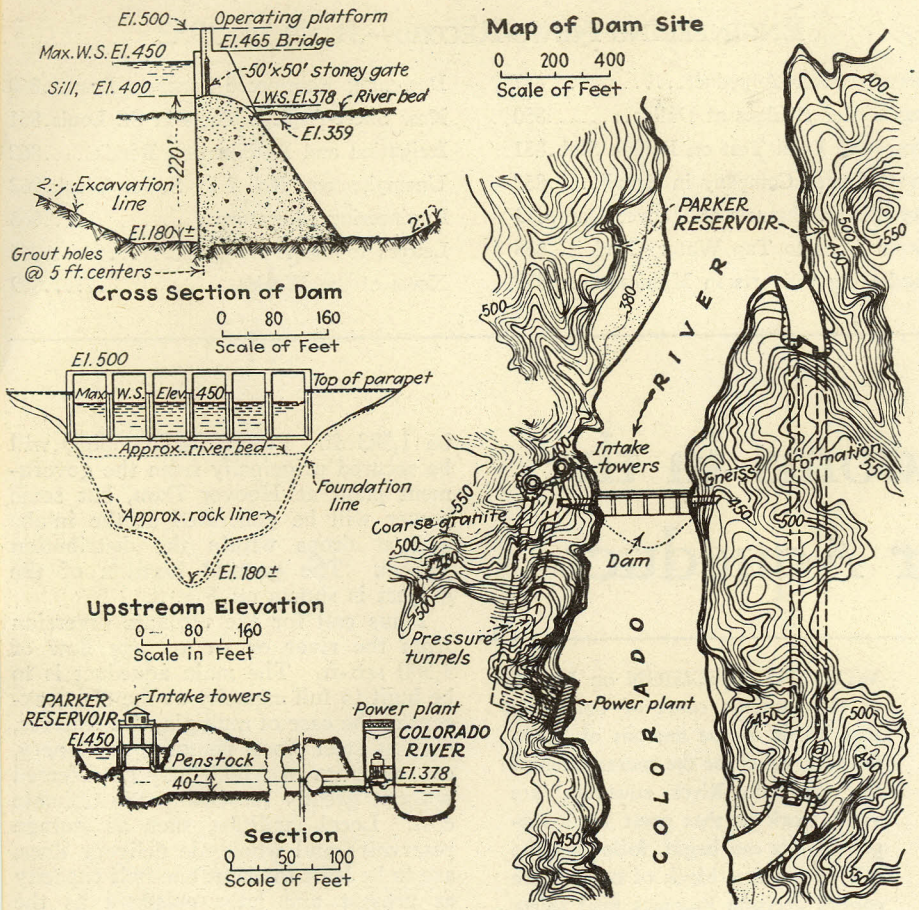


Fig. 2—Parker Reservoir will be formed by a dam raising the water level a maximum of only 72 ft. but extending nearly 200 ft. below the river to a firm foundation.

from the reservoir back of Hoover Dam, the water will be clear; but until a new regimen is established in the river a fresh load of silt will be accumulated before the diversion site is reached.

The diversion dam will raise the water surface 72 ft., creating a reservoir of 716,000 acre-ft. capacity. This will again clarify the flow of the river, stabilize diversion conditions and reduce the required pump lift. It also affords opportunity for the development of 80,000 kw. (maximum) of electrical energy. The general appearance of the dam site is shown in Fig. 1. A cross-section of the river, as established by borings, and a preliminary section of the dam are shown in Fig. 2.

Geological conditions at the dam site are simple. The rock on both sides of the river and beneath the riverbed is coarse granitic gneiss, which is only slightly weathered and is generally of massive character, with only moderate jointing. The rock throughout is of excellent character for a dam foundation. The overburden, consisting of silt, sand and gravel, has a maximum depth of 190 ft. Excavation at the site will not be undertaken until after the river is under control at Hoover Dam, and no particular difficulties are anticipated.

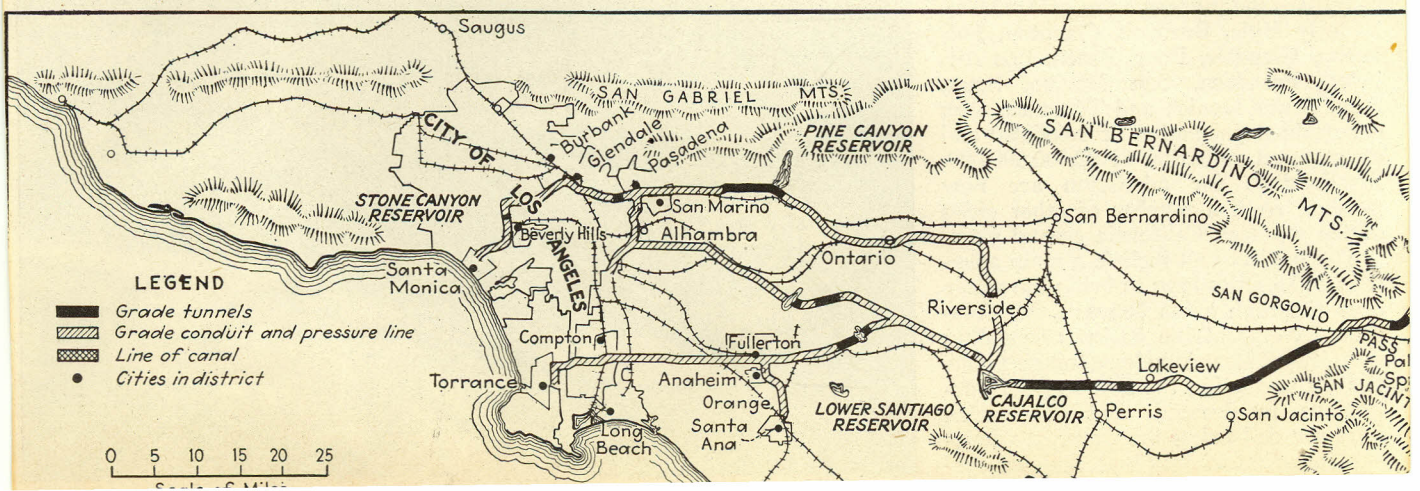
The dam is to be designed to pass a flood of 480,000 sec.-ft. without overtopping the crest. This is a somewhat more liberal provision than that contemplated at Hoover Dam, but it is desirable in order to care for the remote contingency of a flood from the Bill Williams River superimposed upon an upper-river flood. Floods will be passed directly over the spillway section of the dam and controlled by some type of movable crest.

The main aqueduct

The main aqueduct is being designed for an average flow of 1,500 sec.-ft., with an allowance of 7 per cent for loss of time due to interruptions, resulting in a peak capacity of 1,605 sec.-ft. The intake is to be located some distance upstream from the dam site, from which point the water will be raised 591 ft. in two approximately equal stages, first into Gene Wash Reservoir and then into Copper Basin. The first 12 miles from the intake is in rough country and consists of a series of short tunnels, siphons and surface conduit sections, broken by the two reservoirs just mentioned. This is followed by 100 miles of unusually favorable location across a desolate uninhabited region, where the line is largely in open canal, with occasional siphons and tunnels.

Reaching the head of the Chuckwalla Valley at Mile 112, the line climbs by three pump lifts across the hills, skirting the northeast rim of Imperial Valley and passing into the drainage basin of the Salton Sea. The first two of these lifts, which may be combined into one as a result of studies not yet completed,

Fig. 3—The main aqueduct to bring Colorado River water to the towns making up the Metropolitan Water District of Southern California extends from near Parker on the eastern side of the state to a terminal reservoir on the Pacific slope, a distance of 240 miles. From the Cajalco reservoir, distributing lines will serve the cities of the district. Final location of the aqueduct and distributing lines may vary somewhat from those here shown.



deliver the water into Hayfield Dry Lake, where, at nominal cost, an equalizing and reserve storage reservoir of 86,000 acre-ft. capacity can be developed. The third lift of this group raises the water 460 ft. from Hayfield Reservoir to an elevation, whence by tunnel and conduit it is carried across Shavers Summit and along the rim of Coachella Valley. Rounding the eastern end of the Little San Bernardino Mountains, the aqueduct traverses in tunnel, siphon and cut-and-cover conduit the rough and broken country along their lower slopes, reaching the head of the valley at about Mile 190.

Here the line approaches the San Andreas fault, which intersects every feasible route from the Colorado River to the Los Angeles area. On this route the fault is crossed squarely and on the surface, affording minimum opportunity for damage and interruption of service in case of earth movement. Avoiding the broken material underlying San Gorgonio Pass, a shorter and more direct line pierces the solid granite of the San Jacinto Mountains with a 12.7-mile tunnel, emerging on their western slopes to cross the active San Jacinto fault at the ground surface and proceed in siphon, surface line and tunnel to the terminal reservoirs. The composition of the main aqueduct is as follows:

Tunnel 84.88 miles; cut-and-cover conduit, 54.58 miles; lined canal, 75.04 miles; concrete pipe lines, 24.52 miles; through reservoirs, 1.5 miles; total length, 240.52 miles. Total pump lift is 1,583 ft.; mean diversion capacity, 1,500 sec.-ft.; peak diversion capacity, 1,605 sec.-ft.

Times Wide World Photo

Fig. 5—Major questions as to the aqueduct are put up to members of the engineering board of review. The board is here shown in consultation with the district's engineers. Left to right: Frank E. Weymouth, general manager and chief engineer of the water district; R. W. Sorenson, electrical engineer; Thaddeus Merriman, chief engineer, board of water supply, New York; Richard R. Lyman (above) consulting engineer, Salt Lake City; Harvey S. Mudd, mining engineer; and Arthur P. Davis, consulting engineer, Oakland.

Terminal storage

The main aqueduct will end in either Cajalco, Valverde or Mocking Bird Canyon, in each of which suitable terminal reservoir basins, with excellent foundations for any type of dam, are available. Besides these, several smaller reservoirs are contemplated along the distribution lines, nearer the points of consumption. Storage in these smaller

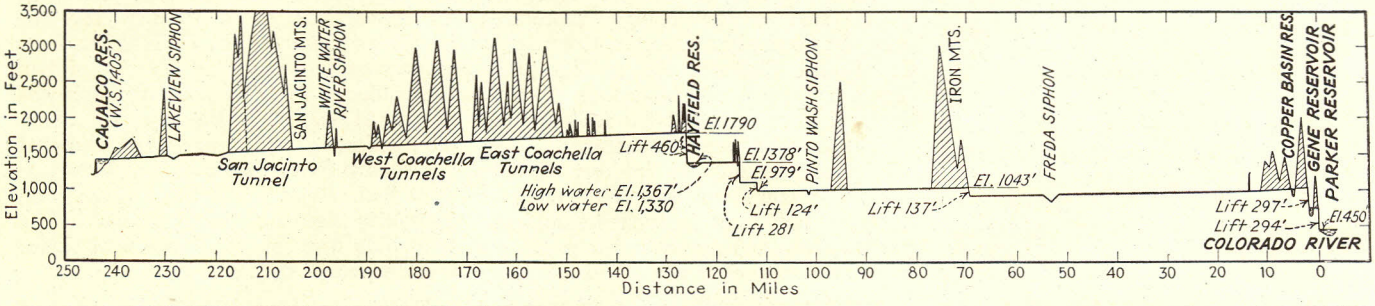
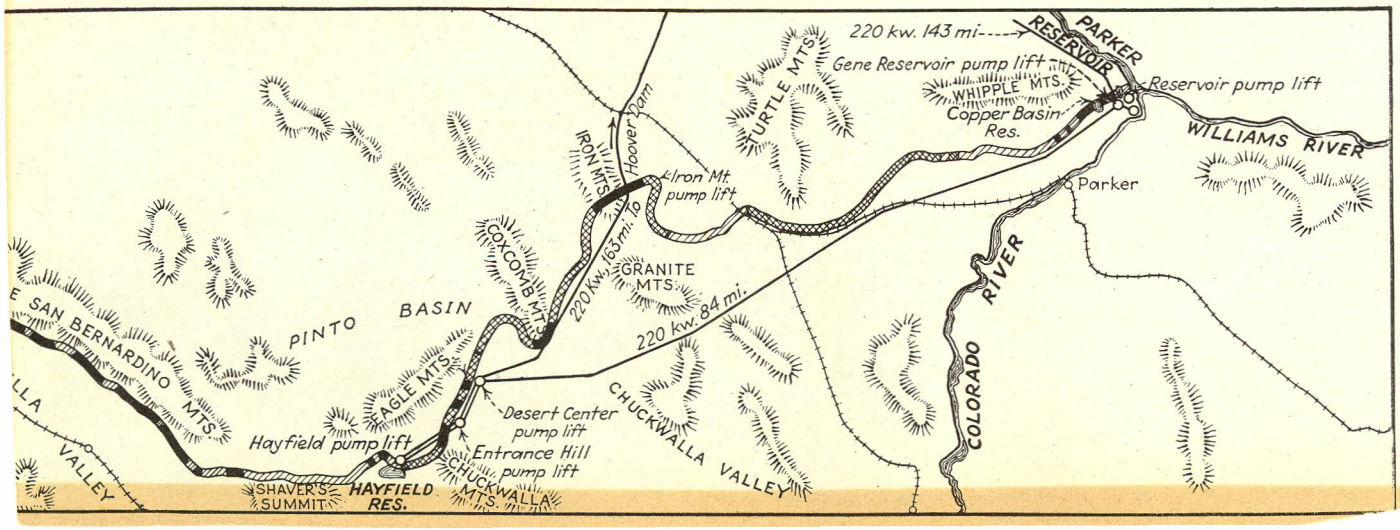


Fig. 4—Pumping will be required at several points along the aqueduct. Most of the power will come from Hoover Dam.



reservoirs will reduce the required peak capacity in the delivery lines, aid in the manipulation of water for power generation and increase the safety by division of storage.

Present plans contemplate an ultimate terminal storage capacity of 250,000 to 300,000 acre-ft. This will regulate the flow and provide a 60-day emergency supply. Of this amount 100,000 acre-ft. will be built now, leaving the remainder to be added as required. Unlimited seasonal storage is available in the Hoover Dam reservoir, local emergency storage being required only as a protection against an interruption of aqueduct flow.

Wholesale delivery lines

The general location of the feeder lines is shown in Fig. 3. The northern line will have an initial capacity of 510 sec.-ft., which will be sufficient to meet

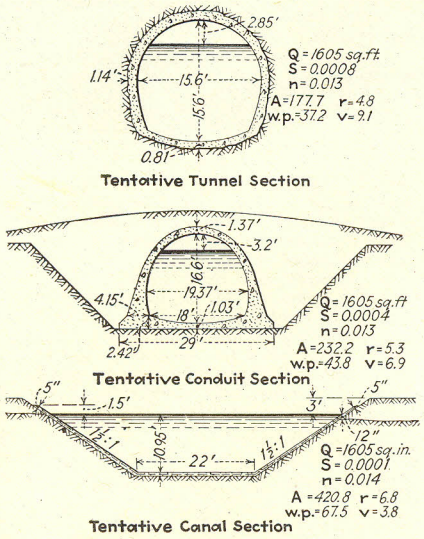


Fig. 6—The aqueduct will be made up chiefly of open canal, closed conduit or tunnel of sections shown here.

the ultimate needs of the higher areas to be served with Colorado River water. It will therefore have excess capacity at first. This excess capacity will be utilized temporarily to supply certain areas at intermediate levels, thus avoiding a separate line for these areas for the present. This line may utilize the Pine Canyon Reservoir in San Gabriel Canyon, contract for which has been let.

The initial construction will also include a low line of some 320 sec.-ft. capacity direct to Long Beach and the harbor district, supplying also the Orange County area. This line is to be controlled by a reservoir in San Juan Canyon. The area served by this line is at a relatively low elevation, and a power drop of 330 ft. is possible near the head of the line. For ultimate development, an intermediate line will be required, to relieve the draft on the high line and to supplement to some degree the low line deliveries. The prospective locations of these future lines are shown on Fig. 3.

Although plans for the distribution

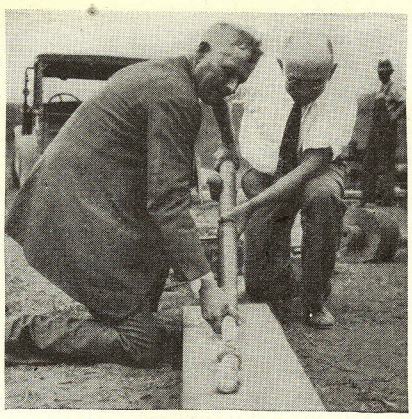


Fig. 7—Thaddeus Merriman, consultant, and J. B. Bond, construction engineer of the district, getting first-hand information as to rock formations along the line of the aqueduct.

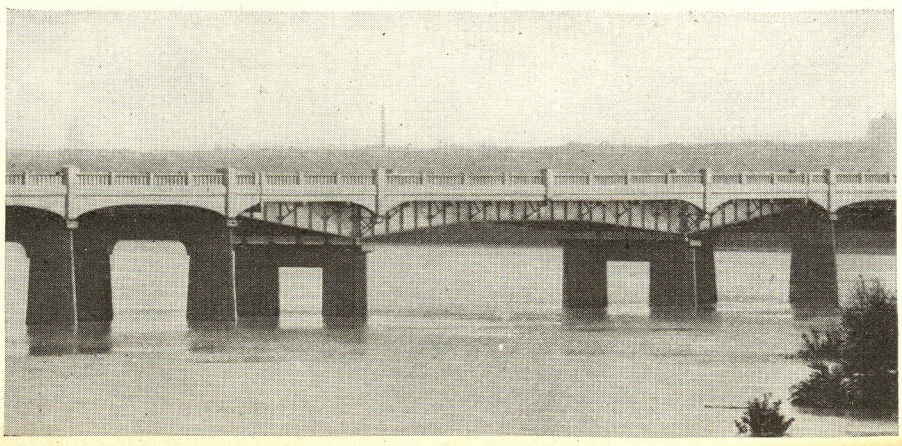
system have been worked out with great care, they are nevertheless to a certain extent tentative, as the ultimate composition of the district is not yet known. Also, before the plans become final they will be discussed in further detail with the waterworks officials of the various cities and adjusted, as far as possible, to meet all local needs.

Present status of work

Active prosecution of construction work has not been possible pending validation by the state supreme court of the district bond issue. This has now been accomplished by a unanimous decision of the court announced June 2, 1932, which decision, however, does not become final until 30 days after that date. As soon thereafter as funds are assured, calls will be issued for bids on several of the longer tunnels and other construction features. Until money thus becomes available no enlargement of the existing engineering organization or construction forces is planned.

On account of the present unemployment situation, men are now available in southern California in excess of all requirements for every opening that the aqueduct work can possibly afford for months to come, and in the hope of avoiding the otherwise inevitable disappointment and possible suffering awaiting newcomers and their families the board of directors last fall announced the policy, effective until conditions have materially improved, of permitting the employment in the district organization or by contractors on district work of none but those who have resided within the district for at least one year. W. P. Whitsett is chairman of the board of directors of the district, and the author is general manager and chief engineer. Julian Hinds is chief designing engineer.

Long Cantilevers in Trinity River Crossings at Dallas

CONSTRUCTION of the Trinity River levees at Dallas, Tex., required four major bridge structures over the floodway at Lamar, Commerce, Cadiz and Clarence Sts. The view shows a portion of the Lamar St. viaduct, which is about 2,000 ft. long and typical of the other structures. The particular element of interest in the bridges centers on the steel channel spans, which are haunched-cantilever girders 200 ft. long over all, made up of two 40-ft. anchor arms and a 120-ft. main span. In addition to their unusual length, these channel spans are given the same concrete fascia finish as the flanking concrete spans, thus providing an appearance of continuity for the bridge as a whole. F. D. Hughes, consulting engineer, Dallas, Tex., designed the viaducts, the total cost of which was about $1,865,000. Because of many duplications of spans and piers the cost per square foot of all the structures was very low, about $3.60 per square foot, including lighting and paving. The total bids were about 27 per cent under the estimated cost.

Typical new viaduct in Dallas, Tex., which crosses newly created floodway for Trinity River.