The $220,000,000 Construction Project for Southern California

Bond Issues for Colorado River Aqueduct Authorized on Sept. 29 and Work Likely to Start in Next Few Months on Long Tunnels, the Controlling Features of the Length of Construction Period

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THE authorization of the $220,000,000 bond issue on Sept. 29 by the Metropolitan Water District of Southern California makes possible the beginning of actual construction on the Colorado River Aqueduct within a few months. Before funds are available from the bond issue the proposition must be validated by the California Supreme Court. It is expected this process will be completed within 4 or 5 months. In the meanwhile road construction and other preliminary work is being carried out from tax money. Diamond drill borings are being made for the long tunnels through the San Jacinto and Granite Mountains, the controlling features of the construction period, and it is expected that these will be ready for letting by the time the financing arrangements are completed.

The Metropolitan Water District was formed to secure for a domestic supply a portion of the increased flow from the Colorado River resulting from the construction of the Hoover Dam. The plans contemplate the diversion of a continuous flow of 1,500 second feet, which after deducting for losses in transit, will almost double the present water supply of the cities in the district. The water will be brought into the district across a major divide through an aqueduct some 250 miles long.

Nature of the Area to Be Traversed by the Aqueduct.—The entire region between the river and the metropolitan basin is very rugged and the geology is complex. The region is composed generally of barren mountains, separated by deep valleys filled with porous debris. Some of these gravel-filled pockets, of unknown depth, have no outlets and have accumulated the scanty rainfall of past ages until they are now full of water. They are serious barriers against deep tunnels, as are the numerous faults and fissures which traverse the area.

Surface conditions in the detrital materials vary widely but generally are favorable for the construction of lined surface conduits. The mountain areas above the detrital cones are usually rugged and unsuited to surface conduit construction.

The Necessity for a Pumping Project.—The air line distance from Los Angeles to the river is more or less constant all the way from Yuma to the Hoover Dam site. The river bed elevation in this distance varies from about 600 ft. to 120 ft. above sea level. The area to be supplied from the aqueduct varies from sea level to an elevation of 1,500 ft. with limited areas even higher. Assuming that the major portions of the highest areas can be supplied from present high level sources, a fairly large percentage of the Colorado River water may be allocated to areas below elevation 500 ft. But even this level is higher than the bed of the river at most of the possible diversion points. Furthermore, a fall of approximately 1,000 ft. is required to overcome friction in the aqueduct and distributing lines. It is therefore necessary that the water be pumped or elevated by some means at least sufficiently to overcome friction losses.

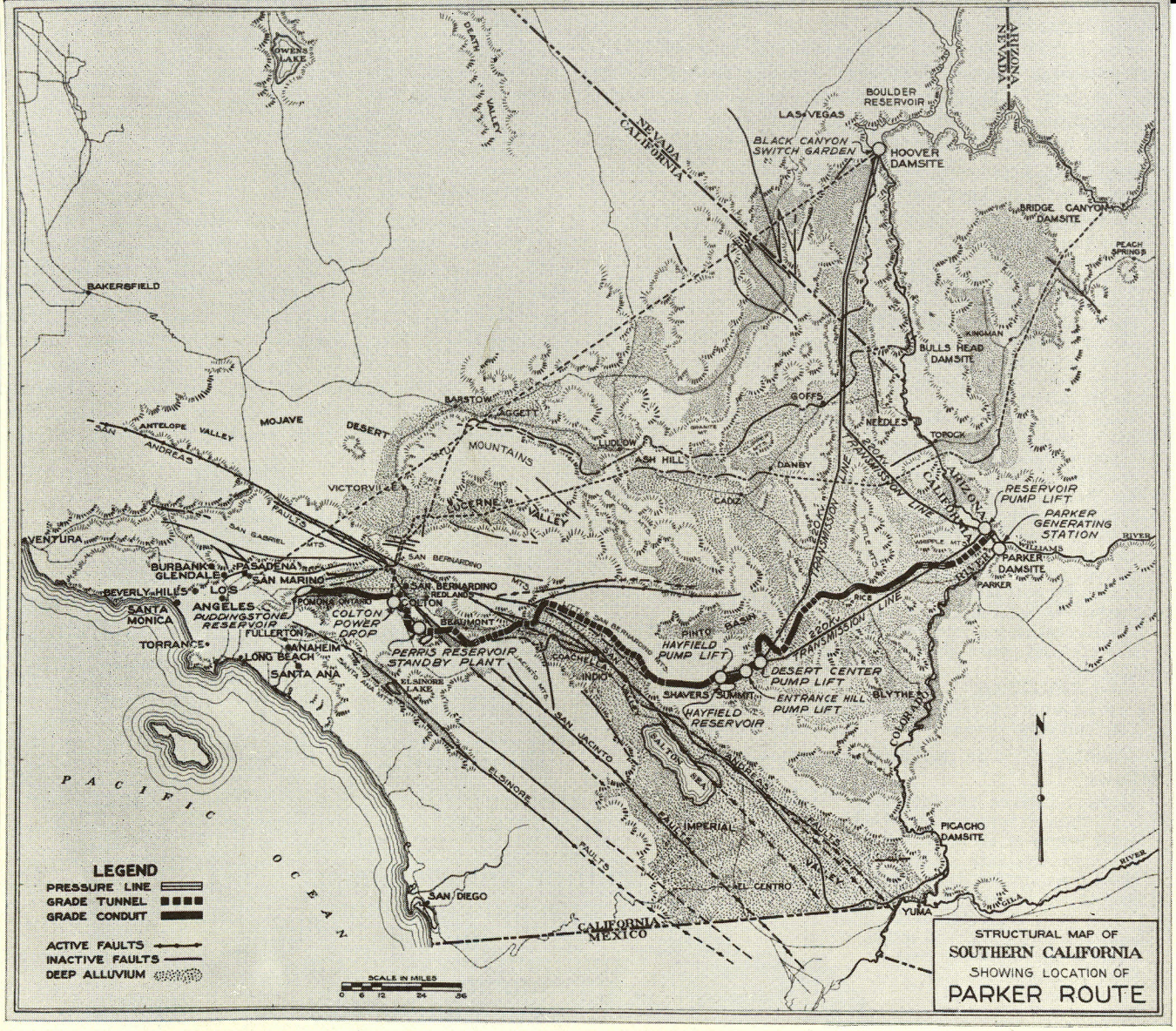
Also, the district area is separated from the Colorado River watershed by high plateaus and mountain ranges. To tunnel entirely through these high areas, at the minimum level required for the delivery of water, would be enormously expensive even if feasible. Actually, such a tunnel would be impossible of construction because of geological difficulties. The water must therefore be lifted an additional amount over the minimum requirement for delivery, to avoid expensive construction, the proper height of lift being found from economic considerations. Part of the energy required for pumping over the mountains can be recovered in fall after the summit is passed.

Description of Parker Route.—The aqueduct leaves the river in a steep pressure line and then goes into a series of tunnels aggregating about 12 miles in length. Then it follows a long reach of canal, interrupted occasionally by short pipe lines and tunnels, to Shavers Summit, a controlling pass. West of this summit the topography is rough and for a distance of some 40 miles the line is in a succession of short tunnels along the base of the Little San Bernardino Mountains. It then turns south across the western end of the Coachella Valley, crosses the active San Andreas fault on the surface and then goes into the longest and deepest tunnel of the line, under the San Jacinto Mountains, south of the San Gorgonio Pass. This pass marks the final divide between the Colorado River watershed and the Pacific slope. The tunnel through it will be about 14 miles long and two intermediate construction shafts will be required to permit its construction within a reasonable time. West of this tunnel the line may proceed to the distribution center by either of several satisfactory routes.

The total length of the route, is 267 miles. Of this length, 74 miles will be lined canal, 80 miles cut and cover conduit, 94 miles tunnel, and 19 miles will be pressure lines, inverted siphons, etc.

The low water level in the Colorado River at Parker is 378 ft. It is proposed to raise this level by a concrete storage diversion dam to elevation 450 ft. from which level it will be lifted 539 ft. by two pumping plants into the aqueduct at 989 ft. elevation. Two additional plants at mileposts 100 and 104 again lift the flow 497 ft. and deliver it into the Hayfield reservoir at elevation 1,367 ft. The fifth and final lift of 450 ft. takes the water from this reservoir and delivers it through the pass at Shavers Summit. The total pump lift is 1,486 ft., unless the dam at Parker is omitted, in which case the total lift is 1,558 ft. The line as described and the figures given are from preliminary locations and subject to change.

Terminal Facilities.—The locations for the aqueduct west of the San Jacinto Mountains are tentative and the locations of the return power drops have not been definitely decided upon. It is probable that a large amount of the flow can be dropped through a height of 400 ft. or perhaps more. The flow to the coastal



The Route of the Colorado River Aqueduct Showing Location of Various Types of Sections

areas, which will no doubt be of considerable importance, may be dropped through 800 or 900 ft. The exact location of terminal storage reservoirs is likewise yet to be determined. Ample reservoir space can be developed at satisfactory locations. A storage capacity of 300,000 acre feet has been tentatively selected as sufficient for ultimate regulation and protection. Seasonal storage is available in the Boulder Canyon reservoir above the Hoover Dam, local storage being required only to care for variations in demand and for protection against accidental interruption in service. The volume and distribution of storage will also have an important bearing on the value of the power producible at the drops on the aqueduct.

Sources of Power for Pumping.—Power for pumping will be secured from the plant to be constructed at Hoover Dam. Contracts have been signed with the United States Government for 36 per cent of the firm power output of its proposed plant at 1.63 mills per kw-hr. in the falling water. An additional charge will be made for generation, making the total cost something less than 2.0 mills. There will be available at times a considerable output of secondary power and the district has contracted for as much of such power as it may need, when available, at 0.5 mill per kw-hr. in the falling water, plus the cost of generation. The power plant will be constructed by the Government but will be leased for operation to the principal contractors for power. The district has no operating lease but will secure its power from the part of the plant leased to the city of Los Angeles. Under full development the five pumping plants on the Parker route will require 291,000 kw.

It is expected that the district will construct and operate a power plant at the Parker dam. It is possible to generate 80,000 kw. at this point, all of which may go to the district, unless the dam and generating plants are constructed as a joint enterprise, in which event the power output will probably be shared with other users. In the early years of operation the power contracted for at Hoover Dam may be found sufficient to fully meet the district's demands, in which case it is possible that the construction of the Parker dam may be deferred for a time. Under such circumstance, deferment of the dam construction might have certain financial advantages, although these are largely offset by

the cost of temporary pumping plants and clarification works required at the intake.

The power generated at Parker will be used there for pumping. Power produced at drops along the line may be used by the district for pumping in the aqueduct or distribution system, or it may be sold at wholesale, as may be found most advantageous. Provision will be made for producing such power at hours of peak demand, which is expected to add to its sale value.

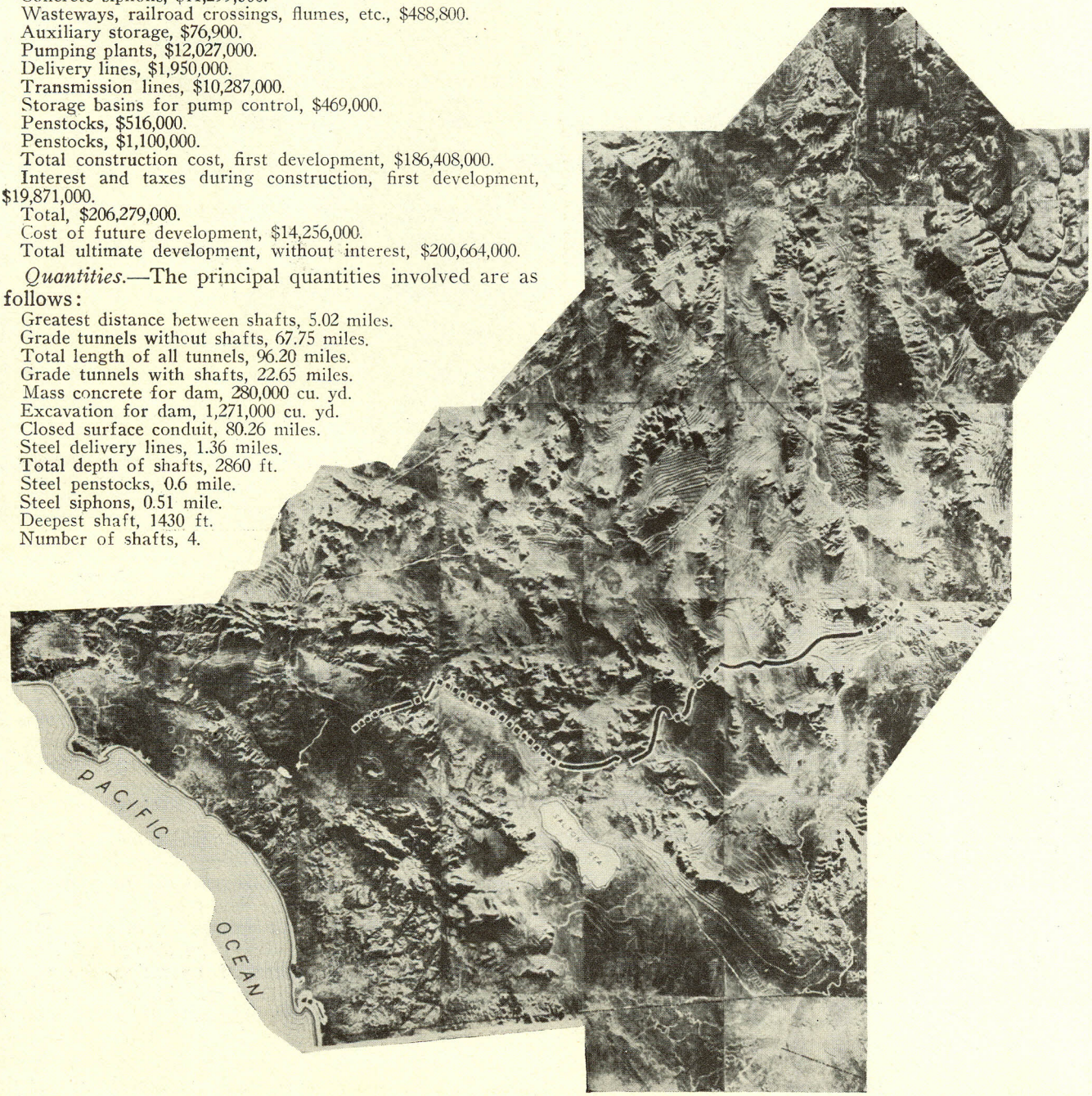
Estimated Costs.—The estimated cost of project includes the following:

Preliminary investigations, $2,500,000.
Diversion dam, $12,958,400.
Headworks, $100,000.
Open canal (lined or unlined), $15,159,300.
Closed surface conduit, $36,317,700.
Pressure tunnel, $2,220,600.
Grade tunnel with shafts, $20,791,400.
Shafts, $894,000.
Grade tunnel without shafts, $56,560,400.
Steel siphons, $690,000.
Concrete siphons, $11,299,500.
Wasteways, railroad crossings, flumes, etc., $488,800.
Auxiliary storage, $76,900.
Pumping plants, $12,027,000.
Delivery lines, $1,950,000.
Transmission lines, $10,287,000.
Storage basins for pump control, $469,000.
Penstocks, $516,000.
Penstocks, $1,100,000.
Total construction cost, first development, $186,408,000.
Interest and taxes during construction, first development, $19,871,000.
Total, $206,279,000.
Cost of future development, $14,256,000.
Total ultimate development, without interest, $200,664,000.

Quantities.—The principal quantities involved are as follows:

Greatest distance between shafts, 5.02 miles.
Grade tunnels without shafts, 67.75 miles.
Total length of all tunnels, 96.20 miles.
Grade tunnels with shafts, 22.65 miles.
Mass concrete for dam, 280,000 cu. yd.
Excavation for dam, 1,271,000 cu. yd.
Closed surface conduit, 80.26 miles.
Steel delivery lines, 1.36 miles.
Total depth of shafts, 2860 ft.
Steel penstocks, 0.6 mile.
Steel siphons, 0.51 mile.
Deepest shaft, 1430 ft.
Number of shafts, 4.
Excavation for canal and conduit, 30,380,259 cu. yd.
Concrete for canal and conduit, 2,894,789 cu. yd.
Total length of all pipe lines, 18.38 miles.
Pressure tunnel 2.2 miles.
Longest tunnel, 12.95 miles.
Second deepest shaft, 615 ft.
Open canal, lined or unlined, 74.12 miles.
Tunnel excavation, 5,506,487 cu. yd.
Tunnel concrete, 1,312,633 cu. yd.
Second longest tunnel, 9.7 miles.
Concrete pipe lines, 15.91 miles.

Investigation of the Colorado River project was begun by the Bureau of Water Works and Supply of the City of Los Angeles in 1923 and was carried on under the direction of Chief Engineer William Mulholland and his successor, H. A. Van Norman, until the spring of 1930 when it was taken over by the present district organization. F. E. Weymouth is chief engineer of the district. W. P. Whitsett is chairman of the board of directors. The main office of the Metropolitan Water District is 306 West 3rd St., Los Angeles, Calif.



Relief Map of Area from Colorado River to Coast, Giving an Idea of the Roughness of the Country