REPORT
UPON
The Distribution of the Surplus Waters of The Los Angeles Aqueduct
BY
J. H. QUINTON
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HOMER HAMLIN
ADVISORY ENGINEERS
LOS ANGELES, CALIFORNIA
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LOS ANGELES, CALIFORNIA
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To the Honorable
Board of Water Commissioners
Of the City of Los Angeles,

Gentlemen:—

In accordance with the instructions accompanying the letter of your President, Mr. H. T. Lee, of March 15, 1911, we submit herewith our report upon the disposition of the surplus waters of the Los Angeles Aqueduct. In your letter of instructions, you state that it becomes necessary for you "to formulate a scheme for the distribution and disposal of the waters of the Owens River Valley not immediately needed for the supply of the City of Los Angeles as it exists at present, and among other things to determine upon and suggest the boundaries of the districts outside the present city limits wherein said waters may be distributed."

You also state that "the determination of said questions involve:

(A) A careful estimate of the amount of water that can be safely devoted to such a distribution.

(B) The area of the districts which can be so supplied.

(C) The topical relation of the different possible areas to the City of Los Angeles.

(D) The geological and topographical character of these areas.

(E) The character of their soils, and their comparative abilities for the support of large populations, either agricultural or urban.

(F) Their comparative advantages from the standpoint of their ultimate absorption into the City of Los Angeles, either by annexation, or by consolidation of city and county.

(G) The comparative cost of the systems of distribution to the respective districts, as well as

(H) Many other branches of investigation of a peculiarly technical nature."

We are directed "to prosecute such examinations and investigations concerning the subject as we may deem necessary," and make full report to your honorable body on the results and conclusions arrived at by us.

We have made all the examinations and investigations concerning this subject which we deem necessary, having visited within the last sixty days, all of the districts on which it is proposed to distribute the surplus water of the Los Angeles Aqueduct, and submit the following report to your honorable body upon the conclusions arrived at by us.
(A) The Amount of Water Which Can Be Safely Devoted to Such Distribution.

Upon the completion of the Aqueduct the water resources of the City of Los Angeles will be as follows:—

Diversions from the surface stream, and water pumped from the underflow of the Los Angeles River......................... 80 sec. ft.
Estimated capacity of Aqueduct.................................... 400 sec. ft.

Total.......................................................... 480 sec. ft.

These estimates are conservative, and this amount of water will be available for use at all times, during years of minimum rainfall as well as during succession of dry years, such as has occurred in the past history of the City. The above estimate of water resources takes no note of return water which will be available, in addition to the amount noted above, after the irrigation of large areas for a few years. This return water, principally from the underflow in the San Fernando Valley, may be used again, and thus becomes in fact an addition to the water resources of the City.

It is estimated that the return water, in case the San Fernando Valley is irrigated, will eventually amount to at least 80 second feet, possibly more. The ultimate total water resources of the City will, therefore, on this basis, be approximately 560 second feet or 28,000 miner’s inches.

Needs of the City Within Its Present Limits.

The needs of the City should be considered from two viewpoints: (1) Its immediate needs upon the completion of the Aqueduct. (2) Its ultimate needs.

(1) Immediate Needs:—It is apparent that the land owners and residents within the City, as it exists at present, should enjoy all of the privileges and benefits from the use of water which will be enjoyed by residents and land owners in the areas now outside of the City, and to which it is proposed to furnish surplus water. This is true, whether the water to be supplied to the City be used solely for domestic purposes, or for the irrigation of vacant land.

The area of that portion of the City north of Manchester avenue is 49,670 acres. If Griffith Park, Elysian Park, the official bed of the Los Angeles River, as well as rough hills and wet bottom lands be deducted, there will remain in round numbers 45,000 acres of land within the present city limits, which may be used for cultivation or residence. Much of this 45,000 acres is as yet but partially occupied by homes.

Wilmington, San Pedro, and the Shoestring strip south of Manchester avenue, can be furnished an abundant supply of good water by pumping from underground sources in the vicinity, for less cost than with water from the Aqueduct, and for this reason it is assumed that they will be so supplied. It
is also assumed that Griffith Park and Elysian Park will be supplied directly by water pumped from the Los Angeles River.

The present water system owned and operated by the City covers an area of about 24,000 acres. The present average daily consumption of water in this area is about 40,000,000 gallons. This is at the rate of 1 inch to 7.77 acres. The 24,000 acres is estimated to be but two-thirds built up at present. If it were fully occupied, and the same quantity of water per capita were used, it would require 60,000,000 gallons average per day. This is at the rate of about 1 inch to 5.2 acres.

Rapid transit by street railways, suburban railways, and automobiles, has so changed urban conditions as to make it improbable that Los Angeles will ever become very densely populated. Many cities become congested because they are so situated that suitable areas for expansion cannot be reached even by modern means of rapid transit. Los Angeles is practically unhindered by natural restrictions and can, if necessary, expand as far as desirable.

It is, therefore, believed that as the City expands the density of population taken as a whole will remain about as it is at present, and hence that the water consumption per acre will also be unchanged.

We have, therefore, decided that if water be supplied to the City area at the rate of 1 inch to 7.5 acres the present needs of the citizens will be fully supplied. The habitable area, 45,000 acres, north of Manchester avenue will therefore require 6,000 inches or 120 second feet constant flow.

(2) Ultimate Needs:—What the ultimate needs of the City will be is impossible to foresee. It is not anticipated, however, that the demand for water within the habitable area of 45,000 acres can ever exceed 1 inch to 5 acres, that is 9,000 inches or 180 second feet. This is 116,640,000 gallons per day, which with a daily consumption per capita of 110 gallons would supply a population of over 1,000,000.

If it ever becomes necessary to supply the 45,000 acre area with 180 second feet of water, it will be available from the Aqueduct. Before this quantity is needed a large amount of return water will be available for irrigation, and may be used for this purpose in place of water from the Aqueduct. It should be noted here that no definite area is assigned to which the return water may be supplied, but that phase of the subject is practically left open to be disposed of later, as the needs of the community develop.

At the present time the City of Los Angeles is using on an average of about 62 second feet of water, which is furnished from the Los Angeles River, or indirectly by the underground reservoir in the San Fernando Valley which feeds the Los Angeles River. It is believed that 120 second feet will be required within a few years after the completion of the Aque-
duct for the growth of the City, within its present limits, north of Manchester avenue, and it is therefore proposed to furnish the City with 120 second feet of water, which is 40 second feet more than the 80 second feet estimated as the available resources from the Los Angeles River.

We have based our calculations upon the assumption that the remaining 360 second feet of water or 18,000 miner’s inches, the balance of the City’s water resources (excepting return water), will be available for the districts which we have marked on the accompanying map (Exhibit A). All of these districts are contiguous to this City as it is now bounded.

We have assumed that the City has the paramount right to all of the water in the Los Angeles River, and in the San Fernando Valley tributary to said river, so far as it is from time to time needed for the use of its inhabitants.

This is a most valuable right of the City, as it enables it to have at hand, at all times, a ready supply which can be immediately substituted for the Owens River water, if in the future any serious accident which cannot now be foreseen should happen to the Los Angeles Aqueduct. We have therefore made our calculations on the assumption that the water which is now used, in large part, by the City, can, when Owens River water is available for use in the City, be used on the Providencia district to irrigate large tracts of land, by pumping from the underground gravels therein. At the same time it will be possible, when needed, to turn the water thus pumped, into the present conduits of the City of Los Angeles.

The plan of obtaining additional water by pumping from underground sources, as proposed for Wilmington, San Pedro, and the Shoestring strip, can also be adopted for supplying large tracts of land lying south of the present city limits, in the event of the subsequent annexation of these lands.

(B) The Area Which Can Be Supplied With Water for Irrigation.

In calculating the area which can be irrigated with the amount of water which will be available, we have accepted the figures given by Mr. Mulholland and the "duty of water" as one inch constant flow to 7.5 acres. This is equivalent to about one inch to 5 acres for the irrigating season, and these figures we have adopted after long and mature deliberation.

In considering this question, it may be of interest to note, that the allowance of one inch constant flow to 7.5 acres, or 1 inch to 5 acres for the irrigating season of 250 days, is the amount of water which is now used in Riverside on the irrigation of 20,000 acres of land, mostly devoted to raising citrus fruits.

The Government Report Irrigation Investigation Bulletin 119, 1911, gives the results of three years’ observations on the duty of water in this district, and a table giving the data in concise form is included herewith.
<table>
<thead>
<tr>
<th>District and year</th>
<th>Area</th>
<th>Water Used</th>
<th>Depth of Irrigation</th>
<th>Depth of Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td>District No. 1</td>
<td>Acres</td>
<td>Acre-feet</td>
<td>Feet</td>
<td>Feet</td>
</tr>
<tr>
<td>1898-1899</td>
<td>3,595</td>
<td>8,330.46</td>
<td>2.32</td>
<td>2.79</td>
</tr>
<tr>
<td>1899-1900</td>
<td>3,614</td>
<td>8,779.64</td>
<td>2.43</td>
<td>2.87</td>
</tr>
<tr>
<td>1900-1901</td>
<td>3,614</td>
<td>7,478.78</td>
<td>2.07</td>
<td>2.74</td>
</tr>
<tr>
<td>District No. 2</td>
<td>2,871</td>
<td>6,407.80</td>
<td>2.23</td>
<td>2.71</td>
</tr>
<tr>
<td>1898-1899</td>
<td>3,237.34</td>
<td>6,855.71</td>
<td>2.12</td>
<td>2.56</td>
</tr>
<tr>
<td>1900-1901</td>
<td>3,237.34</td>
<td>6,581.44</td>
<td>2.03</td>
<td>2.70</td>
</tr>
<tr>
<td>District No. 3</td>
<td>530</td>
<td>943.55</td>
<td>1.78</td>
<td>2.26</td>
</tr>
<tr>
<td>1898-1899</td>
<td>650</td>
<td>1,059.89</td>
<td>1.63</td>
<td>2.07</td>
</tr>
<tr>
<td>1900-1901</td>
<td>650</td>
<td>904.31</td>
<td>1.39</td>
<td>2.06</td>
</tr>
<tr>
<td>Canal as a Whole</td>
<td>6,996</td>
<td>15,681.84</td>
<td>2.24</td>
<td>2.72</td>
</tr>
<tr>
<td>1898-1899</td>
<td>7,501.84</td>
<td>16,695.24</td>
<td>2.23</td>
<td>2.67</td>
</tr>
<tr>
<td>1900-1901</td>
<td>7,501.84</td>
<td>14,967.58</td>
<td>2.00</td>
<td>2.67</td>
</tr>
</tbody>
</table>

In the Riverside region the rainfall is, on an average, only 10 inches per annum, and, since an inch to 7.5 acres constant flow means a depth of practically 2 feet on each acre during the irrigation season, the total supply amounts to 2 feet 10 inches in depth on the land.

In San Diego county an inch of water is considered sufficient for the irrigation of from 10 to 12 acres of diversified farming lands, and for the irrigation of citrus fruits alone an allowance of but one foot in depth in addition to the rainfall has been proven in the past to be sufficient for the care of the trees. Manifestly this duty of water implies a very intelligent and careful cultivation of the soil.

In the districts recommended by us for a share of the surplus waters, the rainfall averages 15 inches. This amount with the 2 feet in depth to be supplied by irrigation will give a total depth on the land during the year of three feet and three inches. Furthermore, the atmosphere around Los Angeles is not so dry as that around Riverside. Much of the land on which alfalfa will be raised in this region, is naturally moist, and, with continued irrigation, will become more so. For this reason alfalfa land in this vicinity does not require as much water as similar land in arid regions. In fact the land around Los Angeles is not arid, but rather semi-arid, and does not require a large allowance of water. It is a matter of common knowledge that many crops are raised on these lands every year without any water, except that which Nature provides in the shape of rainfall.
It should also be noted that some of the lands already have a supply of irrigating water, although an inadequate one.

We have assumed that only a small proportion of the land around Los Angeles will be devoted to raising alfalfa, which requires the maximum amount of water and which ordinarily must be raised on large areas in order to be profitable.

We make a clear distinction between the "needs" and the "wants" of the water users in general, for long experience has taught us that much land is ruined every year by the application of too much water. In many cases subsequent drainage becomes necessary to reclaim land ruined by supersaturation. The surplus water which the City will have for disposal is too valuable to allow of its being wasted in any way, either in domestic or irrigation uses.

Assuming that an allowance of one inch constant flow to 7.5 acres is sufficient for irrigation purposes, the total net area of the districts, which can be irrigated from the available water supply, exclusive of the City's needs, within its present limits, would be 18,000 multiplied by 7.5 or 135,000 acres. We have not attempted to segregate the irrigable area of land in each district shown on the map (Exhibit A), except in a rough way, and the gross area of all of the districts would amount to much more than the acreage here mentioned. It must be understood, however, that the map only shows the gross acreage in each district, and that we have apportioned to each district certain amounts of water, which we believe will provide for all of its irrigable area at the rate of one inch constant flow to 7.5 acres.

Your attention is directed to the imperative need of storage reservoirs. We cannot too strongly emphasize this point. A complete system of reservoirs, at or near the southern end of the Aqueduct, must be available for storing the surplus Owens River water during four or five months of winter, when not needed for irrigation. We therefore recommend to your honorable body that the lands for the large reservoir near Chatsworth Park be acquired as soon as possible by the City Water Department. We believe that, with the two large reservoirs at San Fernando, already determined upon, and the Chatsworth Park reservoir (the location of all being shown on the map, Exhibit A), together with some small reservoirs, which can be easily acquired, either now or hereafter, there will be ample reservoir capacity to enable the suggested plans of distribution to be carried out. On the supposition that such lands will be acquired by the City, for reservoir purposes, it is proposed to distribute the 18,000 inches which would then be at the disposal of the City, in the following manner and within the districts shown on the accompanying map, Exhibit A.
<table>
<thead>
<tr>
<th>District</th>
<th>Net Irrigable Area in Acres</th>
<th>Amount of Water Allotted in Miner's Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. McClay</td>
<td>4,000</td>
<td>535</td>
</tr>
<tr>
<td>2. Pacoima</td>
<td>5,000</td>
<td>666</td>
</tr>
<tr>
<td>3. Fernando</td>
<td>16,500</td>
<td>2,200</td>
</tr>
<tr>
<td>4. Mission</td>
<td>5,000</td>
<td>666</td>
</tr>
<tr>
<td>5. Chatsworth</td>
<td>30,580</td>
<td>4,077</td>
</tr>
<tr>
<td>6. Glendale</td>
<td>12,000</td>
<td>1,600</td>
</tr>
<tr>
<td>7. Providencia</td>
<td>18,000</td>
<td>2,400</td>
</tr>
<tr>
<td>8. Cahuenga</td>
<td>30,000</td>
<td>4,000</td>
</tr>
<tr>
<td>9. Pasadena, S. Pasadena &amp; Alhambra</td>
<td>11,250</td>
<td>1,500</td>
</tr>
<tr>
<td>10. Bairdstown</td>
<td>2,670</td>
<td>358</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>135,000</strong></td>
<td><strong>18,000</strong></td>
</tr>
</tbody>
</table>

**Note.**—If the Pasadena district, or districts in the San Fernando Valley, do not want all, or any of the surplus water allotted to them, there will be no difficulty in disposing of it on lands east of the Los Angeles River, and in other localities.

When the return waters are available from the irrigated districts on the higher lands, the City will have an additional supply of at least 4,000 inches, which, if not required for other purposes, can be used for the irrigation of additional lands in the Redondo and Inglewood districts, but as noted above, this return water is not definitely allotted to any district.

(C) **Topical Relation of the Different Areas to the City of Los Angeles.**

The topical relations of the various districts to the City of Los Angeles can be expressed in a few words. The accompanying map (Exhibit A) shows the location of the City and the districts to which it is proposed to furnish the surplus water. It seems sufficient to state that these areas are all contiguous to the present City and may be annexed or consolidated with city and county if desirable in the future.

(D) **The Geological and Topographical Character of the Areas To Be Irrigated.**

**SAN FERNANDO VALLEY.**

The San Fernando Valley is a plain almost surrounded by mountains. The length of this plain along its southern border is about 24 miles, and its greatest width on a north and south line through the town of Fernando is about 12 miles.

The surface of the plain is smooth and unbroken by elevations, except for the low hills near Fernando, and a low terrace or bench which extends
easterly from a point near Chatsworth Park almost to the Pacoima Wash. There are also a few low hills along the southern border west of Encino. Its surface is not intersected by canyons, or water courses, except for a few gullies around the borders at the base of the surrounding mountains, the slightly incised channel of the Los Angeles River, and the broad, shallow, sandy washes of the Pacoima, and the Tejunga creeks.

The elevation of the north end of the plain is about 1,500 feet, of the west end about 1,000 feet, and the southeast end near Griffith Park about 450 feet. The drainage of the plain is to the southeast corner.

Geology.

If all of the alluvial formations (that is, gravel, sand, clay, etc., which have been brought down by streams from the surrounding mountains) which lie below the surface of the plain, were removed, there would be exposed to view a great basin or depression. This basin, almost encircled by mountain ranges which rise far above the existing plain, is simply a valley which was formed when the adjacent mountains were elevated, and which has since been filled up to the present level with alluvium. That such an alluvial filled basin does actually lie beneath the plain is amply proven by records of wells, drilled at many points in the valley, and also by the general geology of the region.

 Practically all of the mountain slopes which drain to the San Fernando plain, except those along the northeasterly side, are underlaid by soft rocks such as sandstones, shales, clays, etc. The alluvium derived from such rocks, in general, consists of fine material. For this reason, principally, the alluvium found in the central and western portions of the San Fernando Plain is close textured and dense; the only exception being a small area near Chatsworth Park, where the alluvium and soil is rather sandy, having been derived from the harder sandstones in the Simi Hills.

Another reason for the dense alluvium found in the area noted above is, because all of the streams from the adjacent mountains are short, of small volume, and of intermittent flow. For these reasons they are unable to erode or carry coarse material out on the plain, but are able to transport fine sand, clay, etc.

The Pacoima, Little Tejunga, and Tejunga creeks rise many miles east of the San Fernando Valley among the granite ranges of the San Gabriel Mountains. They are by far the largest streams which debouch into the valley, being in fact the principal tributaries of the Los Angeles River. They are mountain torrents during storms. Because of their size, the steep grade of their channels in the mountains, and their confinement to canyons, they are enabled to carry vast quantities of boulders, gravel, sand, etc., out on the plain. Most of this material is granitic in character, and has been deposited in the eastern end of the valley forming the sandy belt,
traversed by several shallow sandy washes. These washes are simply the present surface flood channels of the creeks above noted.

The rocks in the Verdugo Mountains are also granite, and the alluvium found on the slopes from the base of this range, is of the same general character as that deposited by the streams from the San Gabriel Mountains, but is not as coarse.

For the reasons outlined above, there are, in the San Fernando Valley, two distinct types of alluvium, that is, fine textured and rather impervious in the central and western portions of the valley, and coarse textured and highly pervious in the eastern portion. It seems almost needless to add that there is no absolutely sharp line of demarcation between these two types, but that they blend along the westerly side of the Pacoima and Tejunga washes.

In this connection we wish to call attention to the importance of ground water storage possibilities in the San Fernando Valley.

The basin or depression between the alluvial plain, described above, may be likened to a huge bowl, slightly tipped on a horizontal table, so that its rim is in a sloping instead of a horizontal plane. If all of the alluvium were removed from this bowl, it would appear as a great natural reservoir, created by Nature for the express purpose of holding the water of Owens River, until needed by the City of Los Angeles. The fact that it is now partially filled up with a sponge of porous material, gravel, sand, etc., does not by any means destroy its usefulness as a reservoir, but the porous sponge does reduce its capacity. The alluvium of this bowl is now partially filled with ground water, that is, water which sinks into the gravel, sand, etc., from the surface streams entering the valley, but it will hold or store much more water. If, for example, all of the water from the Aqueduct were poured on the sands and gravels of the Tejunga wash, near the north end of the San Fernando Valley, it would probably all sink into the sponge of porous material, for some months at least.

It would, however, flow underground and eventually, after some time, reach the Los Angeles River, where it would flow on the surface again. When water is spread over the entire surface of the valley, by irrigation, the whole mass of porous material, alluvium, will become a reservoir for the water which is not used up by evaporation, or by the growth and transpiration of plants. Some of the water used for irrigation is sure to sink deep into the ground, and we estimate that at least one-fourth of all the water used in the San Fernando Valley will eventually return to the Los Angeles River as underflow, and can be utilized a second time. This water is just as valuable as water direct from the Aqueduct. On account of the return water, and for other reasons, it is highly desirable that the San Fernando Valley should have an adequate allowance of water for irrigation. The San Fernando Valley is the only place where water can be used in territory contiguous to Los Angeles, which admits of the econom-
ical handling of return water. In all other areas the return water must be pumped to higher land.

In general, the surface soils partake of the character of the alluvium below. In the central and western portion of the valley are found rather fine textured soils, adobe over some considerable area, while the predominant soil in the eastern portion is sandy loam, with some large areas of sand. By far the greater portion of the soils in the entire valley are very fertile and of such a nature that they can be profitably irrigated and cultivated.

CAHUENGA AREA—Topography.

Within the Cahuenga Area are two distinct types of topography: (1) A slope or terrace which extends from the southern base of the Santa Monica Mountains south to Venice and Palms, and from the Palisades in Santa Monica to near Sherman. This slope also continues as a narrow belt just south of the mountains eastery into Hollywood.

(2) An area of flat, or slightly undulating country south of Sherman and west of Colegrove, which area merges into the low level land and marshes between Venice and Playa del Rey.

The elevation above sea level of the upper edge of the terrace is about 500 feet, and that of the lower edge about 100 feet where it drops off suddenly to the low lands to the south. Its surface is rather rough and cut up by stream channels, in part. The elevation above sea level of the flat area noted above is about 250 feet at the eastern end, declining to sea level at the western end.

Geology.

The terrace noted above has been formed by alluvium brought down by streams from the south side of the Santa Monica Mountains. As there are many kinds of rocks in this portion of the range such as granite, slate, sandstone, shale, etc., the composition of the alluvium is not the same throughout the whole terrace, but varies from fine granite detritus to heavy clays.

Shales and clays are found very near the surface over much of the flat area south of Sherman and west of Colegrove. Still further west, the shales are covered with dense clayey alluvium.

Soils.

The soils on the terrace are extremely variable, ranging from fine decomposed granite detritus to heavy clays and adobe. The soils on the flat area are predominantly adobe and heavy, and, moreover, are not very thick in some localities. All the soil, however, in the Cahuenga Area are susceptible of irrigation and the lands are well suited for cultivation or for suburban residences.
REDONDO AND INGLEWOOD AREAS—Topography.

The Redondo and Inglewood areas, being alike topographically and geologically, will be described as one. This area is that portion of the coastal plan of Southern California which lies between the Gardena district and Playa del Rey, and between the west boundary of the City of Los Angeles and the Pacific Ocean. It may be divided into three topographic districts.

(1) A low ridge of rolling hills with an average width of about three miles. This ridge traverses the area in a northwest-southeast direction, leaving a small area of low land between it and the City boundary at the north end. The highest point on the ridge is near the northwest end not far from the Palms, where it has an elevation of slightly more than 400 feet. The hills decline in altitude to the southeast, having an elevation of somewhat less than 200 feet at the southeast end of the area. There is, however, a low gap near Inglewood where the elevation is about 150 feet.

(2) A smooth plain southwest of the ridge noted above. This plain is about three miles wide at the northwest end, and four miles wide at the southeast end, where it merges into the low country around Nigger Slough. It has an elevation of about 150 feet at the northwest end and about 50 feet at the southeast end.

(3) A belt from 2 to 3 miles wide of very irregular hills along the coast and west of the plain. These hills are wind formed, being partly ancient, and partly recent dunes bordering the coast. At the northwest end the old dunes encroach on the plain, reaching nearly to the eastern ridge. The elevation of these hills ranges from 100 feet to somewhat more than 200 feet.

Geology.

The geology of this area is very simple. The district is, in general, underlaid by alluvium which is rather clayey near the surface. In depth it passes into sands and sometimes gravels.

The sand dunes noted above have been blown in from the coast, and cover the western edge of the alluvial plain. As would be expected, the eastern border of these dunes is irregular, and there are many sandy stretches out into the plain.

Soils.

The soils of this area range from heavy adobe to sand. All of these lands are suitable for irrigation and cultivation. The ancient sand dunes, popularly supposed to be poor land, will, under irrigation, prove to be fertile and productive, in fact the best of land for many crops.
(E) The Character of the Soils, and Comparative Abilities of the Districts for the Support of Large Populations, Either Agricultural or Urban.

The character of the soils has been described in the previous section (D) and it is not considered necessary in this report to enter closely into the comparative abilities of the minor districts for the support of large populations.

Taking up first the San Fernando Valley as a whole, it may be stated that all of the districts in that valley can be profitably used for either agriculture or horticulture. The higher parts of the valley are more suitable for raising citrus fruits and other valuable products, and the lower portions of the valley for deciduous fruits. It may be safely asserted that all of the fruits of a semi-tropical climate can be raised in the San Fernando Valley, as well as many products and deciduous fruits of colder regions. Much of this valley is now in close communication with the center of the City of Los Angeles, by steam and electric railroads, and with the system of good roads, which is now being carried out by the county, and private companies, all of it will soon be easily accessible by automobile. These remarks apply in a general way to all of the districts in the San Fernando Valley. All are capable of supporting large populations, either agricultural or urban.

The Cahuenga district is fast becoming a portion of the City of Los Angeles. Because of its freedom from frosts, the building sites in the higher parts of this district are eagerly sought for by men of means, who want homes with large grounds, gardens and orchards.

There seems to be little doubt that all of the upper portion of this district will eventually be thickly settled with beautiful homes, from the present City limits to the sea at Santa Monica, and it is only a matter of time until it will become a part of the City proper. This district now contains the municipalities of Santa Monica, Ocean Park, Venice and Sawtelle, besides many suburban subdivisions, all of which have regular street car communication with the center of the City. It may be safely concluded that all of this district will eventually support a large population. This district, however, has not as great advantages in the matter of return water as the San Fernando Valley, because the water which returns in the form of seepage will have to be raised by pumping to higher land in the Inglewood and Redondo districts.

The districts of Inglewood and Redondo are capable of supporting a large population. Some of the lands in these districts are well adapted to fruit raising, other to general farming, and there are some very choice and attractive building sites in each of them, but on account of their lower altitudes these districts probably will always have more of an agricultural than a horticultural population.

The amount of water which we have allotted to Pasadena, South Pasadena, Alhambra, and Bairdstown, will serve a large area of land of great
productive capacity. We have made provision in the distribution of this water for supplying these districts with 1,856 inches of water, delivered on the right bank of the Arroyo Seco at an elevation of about 900 feet above sea level. We have assumed that the municipalities named will want water. If they do not want it, there is abundant opportunity to dispose of it elsewhere. This area is purely a horticultural section and the cities mentioned are already well established, and have large urban populations.

(F) The Comparative Advantages of the Districts from the Standpoint of Their Ultimate Absorption into the City of Los Angeles, Either by Annexation or by Consolidation of City and County.

All of the districts to which water has been allotted, should logically be annexed to the City in the near future, because of their proximity and adequate transportation facilities. We do not understand just how the consolidation of City and County may be effected, but it is quite evident that the City cannot be made as large as the present County. A county may certainly be made as small as the City, and it is quite possible that the City of Los Angeles may eventually grow to such an extent as to include all of the districts which we have considered as being favorably situated for a share of the surplus waters from the Los Angeles Aqueduct.

(G) The Comparative Costs of the Systems of Distribution to the Respective Districts.

It is not considered necessary to burden this report with the detailed figures on the estimates of cost of the systems of distribution for the various districts. The following table shows the total estimated cost of the main conduits and main distribution systems for seven of the principal districts:

<table>
<thead>
<tr>
<th>District</th>
<th>Net Irrigable Area</th>
<th>Total Cost Per Acre</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>McClay</td>
<td>4,000</td>
<td>$20.02</td>
<td>$80,080</td>
</tr>
<tr>
<td>Pacoima</td>
<td>5,000</td>
<td>40.75</td>
<td>203,750</td>
</tr>
<tr>
<td>Mission</td>
<td>5,000</td>
<td>39.17</td>
<td>195,850</td>
</tr>
<tr>
<td>Fernando</td>
<td>16,500</td>
<td>33.74</td>
<td>556,710</td>
</tr>
<tr>
<td>Glendale</td>
<td>12,000</td>
<td>25.22</td>
<td>302,640</td>
</tr>
<tr>
<td>Chatsworth</td>
<td>30,850</td>
<td>35.76</td>
<td>1,103,196</td>
</tr>
<tr>
<td>Cahuenga</td>
<td>30,000</td>
<td>40.00</td>
<td>1,200,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>103,350</strong></td>
<td></td>
<td><strong>3,642,226</strong></td>
</tr>
</tbody>
</table>

103,350 \(\times\) 3,642,226

\[\text{\$335.24 Average Cost per acre.}\]

Making allowance for engineering, contingencies, cost of right of way, etc., we believe that $40.00 per acre will be a fair average for all of the
districts, including the Inglewood and Redondo areas, if irrigated from return waters or from pumping plants, or for the Providencia, in which pumping plants are now contemplated. As it is not known whether the distribution systems for the several districts will be built separately or in combinations, or as a whole, the above suggestion for an average charge should be considered as merely tentative.

Water for the McClay district must be diverted from the Aqueduct, above one of the proposed power plants, and, hence can not be used to develop power. The value of the power which would be developed in case no water were diverted, when capitalized, amounts to $50.00 per acre.

In the Pacoima and Mission districts there is a loss of power which amounts, when capitalized, to $15.00 per acre.

We mention these items in order that your honorable body may be guided in establishing the annual charge for water for these districts.

This estimate does not include the cost of the reservoirs which should be added to the cost of the Aqueduct in fixing the value of the water.

Manifestly, it would not be advisable at the present time to attempt to make a very close estimate on the cost of the different systems of distribution, as such estimates would require much field and office work, which is not considered necessary for the purpose of this report.

(H) Other Branches of Investigation of a Peculiarly Technical Nature.

In our investigations we have had to take into consideration some problems on which you have not asked us to give an opinion, but, since you have instructed us to make a full report, including "other branches of investigation of a peculiarly technical nature," we consider it proper to give you our opinion on such problems. One of these is to determine how the City can be paid by the different districts for the water which is distributed to them for the purposes of irrigation, and for domestic use. At first sight, this appears more of a business proposition than a technical one, but it is so closely interwoven with technical matters that we feel we must consider it. We are unanimous in believing that the City should own all of the reservoirs, trunk line conduits, and main distribution pipes in all of the districts, excepting the distributing systems within the limits of incorporated cities.

The Los Angeles Aqueduct has its terminus in the low hills at the upper end of the San Fernando Valley, at an elevation of 1,461 feet above the sea.

It is proposed to drop practically all of the water from this level to the level of the upper San Fernando Reservoir, a fall of about 300 feet, thus generating a large amount of power. The water may now be said to come to rest after its long journey from Owens Valley in the Sierra Nevada Mountains. From this reservoir, and the other large reservoir at Chatsworth Park, the main trunk lines for the distribution of the water to the
different districts will issue, and from these again, the main distributing pipes for each district will complete the system of distribution, as far as the City is concerned. These distribution pipes should be established about one mile apart, and the sub-distribution, for farms and orchards, should be effected by the owners of the land. The entire system, thus proposed, may well be likened to a man's arm and hand; the arm representing the Los Angeles Aqueduct, the palm of the hand the reservoir system, and the fingers the trunk lines and distributing pipes. Since the water and the main distribution systems will be owned and controlled by the City, there will be no difficulty, as far as water supply is concerned, in annexing any portion of the irrigated districts. Moreover, the amount of water which is required for City purposes has been shown, by Mr. Mulholland, to agree almost exactly with that which is required for irrigation purposes on equal areas.

The question now arises, how can the surplus water be paid for by the users, so as to return to the City the proper proportionate cost of the Aqueduct, reservoirs, trunk lines, and main distribution systems?

One method for solving this problem is one which has been tried, and quite successfully, in all of the government reclamation projects, that of organizing in each district a water users' association. In this case, the water users' association should be empowered to collect from the owners of the land, and pay to the City, a sum sufficient to cover the cost of irrigating the lands within the district. Thus, if a district contains 10,000 acres gross area, and 7,000 acres net irrigable area, as soon as 7,000 acres of irrigable land have been subscribed for, the association, if incorporated, would be in a position to make a contract with the City for the delivery of the water necessary for the irrigation of that amount of land, or these districts might be formed under the Wright Act as recently amended.

In this connection, we have thought it wise to consider what would be a fair price to charge for the water delivered to these districts, but, since you have not asked us to give our opinion on this subject, we feel a little diffident about expressing it, as this seems to be a matter entirely for you to decide. We feel, however, that it is necessary to bear in mind that if too high a price is fixed for the water, the water users may not take it, and if too low a price is set upon it, the City will not get a proper return for its expenditures on the Los Angeles Aqueduct. We believe no distinction should be made between districts, as to the cost of distribution of the water, and that one price for distribution, which will fully protect the City in its expenditures, should be made for all of the districts.

In considering the problem of the charges to be made by the City for the water, the question will arise, as to the method of distribution to municipalities, as distinguished from districts.

Where a municipality, situated in a given district, does not own its water works, but is supplied by a private company, it is not legal for the
City to sell any water to such companies, for the purpose of supplying this municipality. It seems that the only solution of this problem is to insist that every municipality which asks for water, shall own its own water works.

In our calculations we have made no distinction between municipalities and districts in estimating the cost of main conduits and main distributing systems. In tentatively apportioning 1,500 inches to Pasadena, South Pasadena, and Alhambra, we estimate that this quantity would serve an area of 11,350 acres, and calculate that the cost of the main conduit to deliver this water to the right bank of the Arroyo Seco, as contemplated, should be fixed at the uniform figure suggested, i. e., $40.00 per acre.

In subsequently fixing the annual charge for water supplied to a municipality, as distinguished from a district, it will be a simple matter to make the proper equitable charge on the basis of quantity delivered. If it is desired to measure such quantity in inches of constant flow, the sum to be paid annually for each inch would be 7.5 times the amount fixed for the annual charge on irrigated lands.

It may assist you in your deliberations on the subject of the charges for water, to mention that at Riverside, where the amount of water used on 20,000 acres of citrus lands is practically the same as that allowed for by us, or 1 inch constant flow to 7.5 acres, water is sold at from $1,000.00 to $1,500.00 per inch. In addition to this there is an annual charge of from $6.00 to $9.00 per acre. Allowing interest at 5 per cent. on the minimum value of the water, and adding the minimum annual charge, makes a total annual cost to the water users of $12.66 per acre.

It is well to remember in considering the subject of cost, that the City has to maintain the reservoirs, trunk lines, and main distribution systems, as well as to manage and administer the entire distribution of the surplus water of the Los Angeles Aqueduct.

The water users outside of the City should obviously be called upon to pay at least their proportionate part of the entire cost of the Aqueduct and its accessories, and their share of all maintenance charges.

Another subject to which we have given much thought, is the advisability of having an auxiliary supply of water for the City of Los Angeles, in case of an unforeseen accident to the Aqueduct or any of its accessories, or in case of interference with it by a public enemy. We believe that the correct solution of this problem is the proposal to furnish the Providencia district with its supply, by pumping from the sands and gravels of the Tujunga Wash, which is, indeed, the main branch of the Los Angeles River, instead of allowing it to percolate into the galleries which now supply the City conduits.

It is proposed to furnish the City with the Owens River water in such quantities as may be needed, through the present City conduits, and this water can, on its way to the City, be dropped about 450 feet, and thereby furnish ample power for the pumping necessary for supplying some of the
lands in the Providencia, and possibly in some of the adjacent districts. This arrangement, with auxiliary power, would admit of an easy connection of the pumping plants with the City conduits, so that the supply to the irrigated lands could, on short notice, be transferred to these conduits, in case of accident, until repairs could be made on the Aqueduct. The underground reservoir in the Providencia district happily, has an enormous capacity for water. With pumping plants of sufficient capacity, there would be no difficulty in keeping up both the City supply and that for irrigation in this district for several months, if necessary. It will be seen, therefore, that there is a double advantage in this reservoir. It affords ample space for storing water for which there is no immediate use, and it would furnish a large quantity of water for a short time, in case of necessity, for the auxiliary supply. It may be said that the large reservoirs at the head of the San Fernando Valley would protect the City against a shortage in case of accident, but it must be remembered that the water in these reservoirs is principally for use in irrigation, and could only be used by the City for a short time in case of emergency without damage to the irrigated lands, especially if it became necessary to use the water for the City in the irrigating season. The underground reservoir in the Providencia district, however, is a perfect safeguard to the City supply in case of accidents to the Aqueduct, and we consider it one of the most valuable assets which the City possesses. It should be guarded forever with the most jealous care.

In connection with the subject of "return waters," we wish to emphasize that any water taken from the Los Angeles Aqueduct, and given to Pasadena, South Pasadena, Alhambra, or Baidstown districts, for which we have made a provision, will not yield any return waters by seepage for use elsewhere by the City of Los Angeles. At the same time, it should be clearly understood that if for any reason the districts in the San Fernando Valley should refuse or fail to make proper arrangements with the City for the use of the surplus water, there is, east of these districts, a large area of valuable foothill land, extending to the San Gabriel River, to which this surplus water could easily be furnished.

We have considered that the evaporation from the large reservoirs contemplated in the San Fernando Valley would be practically compensated by the rainfall and run-off on their respective water sheds.

CONCLUSIONS.

First.

The City can never experience a shortage of water when the Los Angeles Aqueduct is completed, because whatever may be its limits from time to time, it has a paramount right in all the waters of the municipality, also a large amount of return waters estimated at 4,000 inches, which could be made available for City use, if needed, and a large reserve in the San Fernando underground reservoir.
Second.

We believe that all of the districts to which we have allotted surplus waters, should be annexed to the present City. This would not only eliminate many important legal questions involved, but would simplify the distribution of the water, and insure maximum economy in the administration, operation, and maintenance of the water system. It would also enable the City to take such steps as are necessary to insure proper sanitary control of the entire water supply.

Third.

In case annexation cannot be immediately effected, we believe that water should not be furnished to any district, unless there is a reasonable assurance that it will ultimately become a portion of the City.

Fourth.

We recommend that all districts should be required to pay in advance the cost of the main distribution conduits, which should be constructed by the City. These districts should also pay an annual charge for water to be continued until annexation or consolidation is effected. It is presumed that upon consolidation, any district will assume its proportionate share of taxation to cover the cost of the Aqueduct, in which event there would no longer be any equitable reason for discrimination in water charges between the annexed territory and the rest of the City.

Fifth.

We wish to emphasize again the fact that the storage of waters below the terminus of the Aqueduct is vitally essential. For this reason, the Chatsworth reservoir, in addition to those already planned at San Fernando, must be constructed, if the plans herein outlined for the distribution of surplus waters are to be successfully consummated. Consequently, if the proposed Chatsworth reservoir cannot be established, it would be impossible to properly supply the Chatsworth district of 23,693 acres, and the water supply allotted to it in this report would have to be diverted to some other district adjacent to the City.

We desire, in closing, to express our thanks to your Honorable Board for the assistance rendered us during our investigations, and we are especially indebted to William Mulholland, your Chief Engineer, whose wide knowledge of local conditions and the water resources of the City has been of great service to us in arriving at the conclusions contained in this report.

During our investigations we have inspected the main features of your present water system, and have a full appreciation of the wise development of limited water resources which has obtained, and the efficient administration that has made it possible for Los Angeles to continue in its remarkable growth without being hampered by an inadequate water supply. The knowl-
edge of what the City of Los Angeles has done in the past in conserving and properly administering its water resources, has been a very important factor in aiding us to arrive at a determination of the problems presented by your Honorable Body for our consideration. We are firm in the belief, heretofore stated, that under an efficient single administration, such as would ensue in the event of consolidation with the City of the various contiguous districts to which we have apportioned surplus water, there would result an economy in the management and operation of the water supply, such as it would otherwise be impossible to obtain.

Yours respectfully,

(Signed)  J. H. Quinton,
(Signed)  W. H. Code,
(Signed)  Homer Hamlin.
Supplemental Report on the Disposal of the Surplus Waters of the Los Angeles Aqueduct

For the benefit of those who have not read the original report, or of those who, having read it, did not understand it, we quote therefrom the following statements. Under heading "B," page 9:

"If the Pasadena district, or districts in the San Fernando Valley do not want all, or any of the surplus water allotted to them, there will be no difficulty in disposing of it on lands east of the Los Angeles River, and in other localities."

Again under heading "D," page 11:

"Some of the water used for irrigation, is sure to sink deep into the ground, and we estimate that at least one-fourth of all the water used in the San Fernando Valley will eventually return to the Los Angeles River as underflow, and can be utilized a second time. This return water is just as valuable as water direct from the Aqueduct. On account of the return water, and for other reasons, it is highly desirable, that the San Fernando Valley should have an adequate allowance of water for irrigation. The San Fernando Valley is the only place where water can be used in territory contiguous to Los Angeles, which admits of the economical handling of return water. In all other areas the return water must be pumped to higher land."

Also under heading "H," page 19:

"In connection with the subject of 'return waters,' we wish to emphasize that any water taken from the Los Angeles Aqueduct, and given to Pasadena, South Pasadena, Alhambra, or Bairdstown districts, for which we have made a provision, will not yield any return waters by seepage for use elsewhere by the City of Los Angeles. At the same time, it should be clearly understood that if for any reason the districts in the San Fernando Valley should refuse, or fail to make proper arrangements with the City for the use of the surplus water, there is, east of these districts, a large area of valuable foothill land, extending to the San Gabriel River, to which this surplus water could easily be furnished."

We have been asked to state, in addition to the information furnished in the original report, what it will cost to supply surplus water from the Aqueduct to lands lying east of the Arroyo Seco and the present east boundary of the City of Los Angeles. It should be clearly understood that the extension of any district or districts mentioned in the original report will change the estimates of costs therein given, and in a degree vitiate the con-
clusions reached. In other words, an entirely new report should be written in case any extensive changes are made in the districts, or new districts are added to the territory described in the original report. Obviously, it is possible, for any one, to suggest many combinations of irrigation districts in the San Fernando Valley with other districts south or east of that valley, and it is apparent that, at this stage of the development of the problem, no board of engineers should be expected to report upon the details of all these possible combinations. For these reasons, no estimates of the cost of distribution systems for additional territory are submitted herewith.

Between the San Gabriel River on the east, the Arroyo Seco and the City of Los Angeles on the west, the foothills, up to an elevation of 1,800 feet, on the north, and the original southern boundary of the City of Los Angeles produced eastward as far as shown on the map (Exhibit A), on the south, there are about 63,000 acres of valuable foothill and valley land.

We will call this tract the "West San Gabriel Valley District." It will be seen from the map that it includes the districts of Pasadena, South Pasadena, Alhambra, and Bairdstown (an area of 13,920 acres of irrigable land), all of which were mentioned in the original report, also the San Antonio district, as well as the cities of Sierra Madre, Monrovia, and Duarte, and the intervening territory, which were not mentioned in the former report.

Part of this district is irrigated by water obtained from various sources within, or adjacent to, the district, but we estimate that about 70 per cent. of the entire district should have a full supply of water at the rate of 1 miners inch to 7.5 acres, or in round numbers 45,000 acres should be irrigated.

The quantity of water required for this area, on the above basis, is 6,000 miners inches.

It should be here noted that in the original report, the amount of 1,858 miners inches of water was assigned to the Pasadena, South Pasadena, Alhambra, and Bairdstown districts, so that the additional territory in the West San Gabriel Valley district provides for but 4,142 miners inches.

In order to reach the most valuable portions of the West San Gabriel Valley district water must be diverted from the Aqueduct above the San Fernando and Chatsworth reservoirs, and above one of the proposed power plants. A conduit which will carry an adequate supply, from the Aqueduct to this district, will necessitate very heavy construction work, including a tunnel about five miles long through La Canada, and the cost of distribution will be more than in any of the districts to which water is allotted in our original report.

As noted above, water for this district cannot be used to develop power. The value of the power which would be developed in case no water was diverted, when capitalized at 5 per cent. per annum, amounts to $50.00 per acre.

There is an area of about 40,000 acres of irrigable land lying east of the San Gabriel River, west of the San Jose Hills, south of the San Gabriel
Mountains, and north of the Puente Hills, roughly shown on the map, (Exhibit A). We will call this area the 'East San Gabriel Valley District.' It contains the cities of Azusa, Glendora, and Covina.

Probably 50 per cent. of this area is already irrigated by water obtained from various sources, principally from the San Gabriel River. We estimate, therefore, that 20,000 acres in this district can be profitably irrigated, and will require a supply of 1 miners inch to 7.5 acres, or a total of 2,667 miners inches. This district is, in fact, an extension of the West San Gabriel Valley district, and it is not probable that it will be supplied with water unless the latter is also supplied. The two districts, considered as one large area, will require 8,667 miners inches, constant flow, for the irrigation of 65,000 acres.

Water for these districts must be diverted from the Aqueduct at the same point, and the main conduit must follow the same general location easterly to the San Gabriel River, as that which would supply the West San Gabriel Valley district alone. East of the San Gabriel River, the main conduit should follow the foot of the mountains as far east as Glendora.

As noted above, in the case of the West San Gabriel Valley district, water for both these districts must be diverted from the Aqueduct above one of the proposed power plants, and hence cannot be used to develop power. The value of the lost power, when capitalized, amounts to $50.00 per acre.

It has been asked 'Are there not other lands, exclusive of the districts east of the Arroyo Seco, to which water may be supplied in case landowners in the San Fernando Valley refuse to take the surplus water at the price to be determined by the City?' We have shown on the map (Exhibit A), and described in the original report, the districts of Inglewood, and Redondo, containing together about 50,000 acres of land. It should be noted here that probably not more than 75 per cent. of these areas, or in round numbers, 37,500 acres, will ever take water for irrigation. This area will require, on the basis of 1 miners inch to 7.5 acres, about 5,000 miners inches.

We did not in our original report assign any water to these districts directly from the Aqueduct, but stated:

"When the return waters are available from the irrigated districts on the higher lands, the City will have an additional supply of at least 4,000 inches, which if not required for other purposes, can be used for the irrigation of additional land in the Redondo and Inglewood districts."

In our opinion, the return water from the San Fernando Valley, alone, will eventually be sufficient to irrigate about three-fifths of the area of these districts, if the water is distributed as outlined in our original report. The additional supply needed can be furnished by pumping from underground sources adjacent to the districts. These underground supplies are abundant and will not become depleted in the future when water from the Aqueduct is freely used south of the Santa Monica Mountains.
It is, however, entirely practicable to use water direct from the Aqueduct in these districts if desirable, but at an added cost for distribution.

In this connection, we wish to emphasize the fact that any water taken directly from the Aqueduct, and used on the West San Gabriel Valley, East San Gabriel Valley, Redondo, or Inglewood districts, instead of on the San Fernando Valley, will yield but little return water by seepage, for use elsewhere by the City of Los Angeles.

The loss of power and loss of return water must be taken into consideration when arriving at a final conclusion, or determination as to which districts shall be supplied with surplus water.

We have shown in our original report where the surplus water can, in our opinion, be distributed to the greatest advantage to the City. If, however, the landowners refuse to take it, there is no reason why the City should not distribute it to other lands east of the Arroyo Seco, or on the Inglewood and Redondo districts, if the landowners in these districts desire the water.

We will add that the lands south and east of the City, not included in any of the districts mentioned in these reports, already have, in our opinion, an adequate supply of underground water, and do not require water from the Aqueduct.

Respectfully submitted,

(Signed) J. H. QUINTON,
(Signed) W. H. CODE,
(Signed) HOMER HAMLIN.