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GROUND WATERS AND IRRIGATION ENTERPRISES

IN THE

FOOTHILL BELT, SOUTHERN CALIFORNIA

BY

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CONTENTS.

ILLUSTRATIONS.

GROUND WATERS AND IRRIGATION ENTERPRISES IN THE FOOTHILL BELT OF SOUTHERN CALIFORNIA.

By WALTER C. MENDENHALL.

INTRODUCTION.

In midsummer, 1903, field work was begun on a series of studies of the conditions under which the ground waters of southern California occur. During the preceding decade the inadequacy of surface waters, the perfection of pumping machinery, the development of cheap fuel and electrical power, and the discovery of the wide distribution and accessibility of ground waters combined to make these of increasing importance in the irrigation of the intensively cultivated horticultural districts which have made this portion of the State famous. Even the largest of the systems of irrigation, which a few years ago secured their waters wholly from the mountain canyons, now usually have subsidiary pumping plants, which are depended on to keep up the supply during the summer and fall, when the streams are lowest; and in addition to plants of this character, many companies have been organized that depend entirely on pumped or artesian waters. So extensive has been this development that a conservative estimate indicates that the proportion of underground water to surface water now used during the late summer period after dry winters, when the surface supply is lowest and the pumps are busiest, is as 3 or 4 to 1.

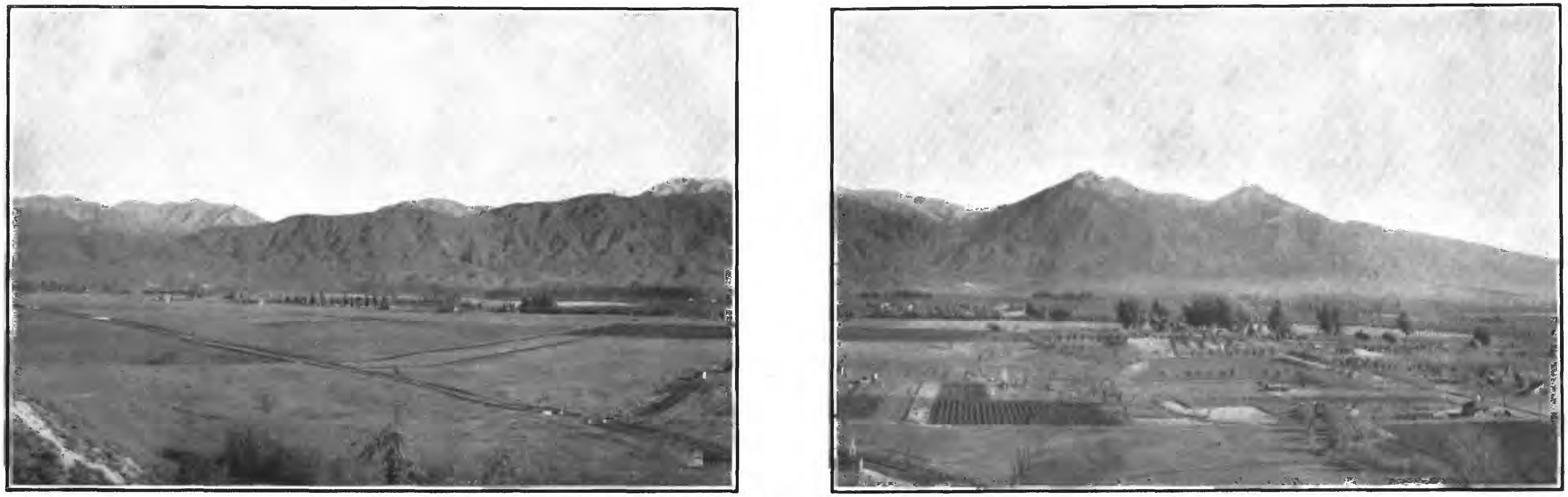
Obviously a resource which has become so important to the continued welfare of so rich a district is worthy of careful study. Such a study is now under way, and its results are being made known through a number of water-supply papers that are being issued by the United States Geological Survey. The earliest of these to be prepared for distribution were a series of three (Nos. 137, 138, and 139) relating to the coastal plain which lies between the Coast Range and the Pacific Ocean. These papers did not embody close geologic determinations, but were rather records of the developments of underground waters which had taken place at the time of their issue, with some discussion of the effects of those developments in the region treated in them.

The more important data were graphically presented in maps and tables. A fourth paper (No. 142), on the San Bernardino basin, was more complete and critical, and contained, in addition to the essential hydrographic data, such significant geologic and economic information as had been brought out in the course of a rather careful general study of the valley.

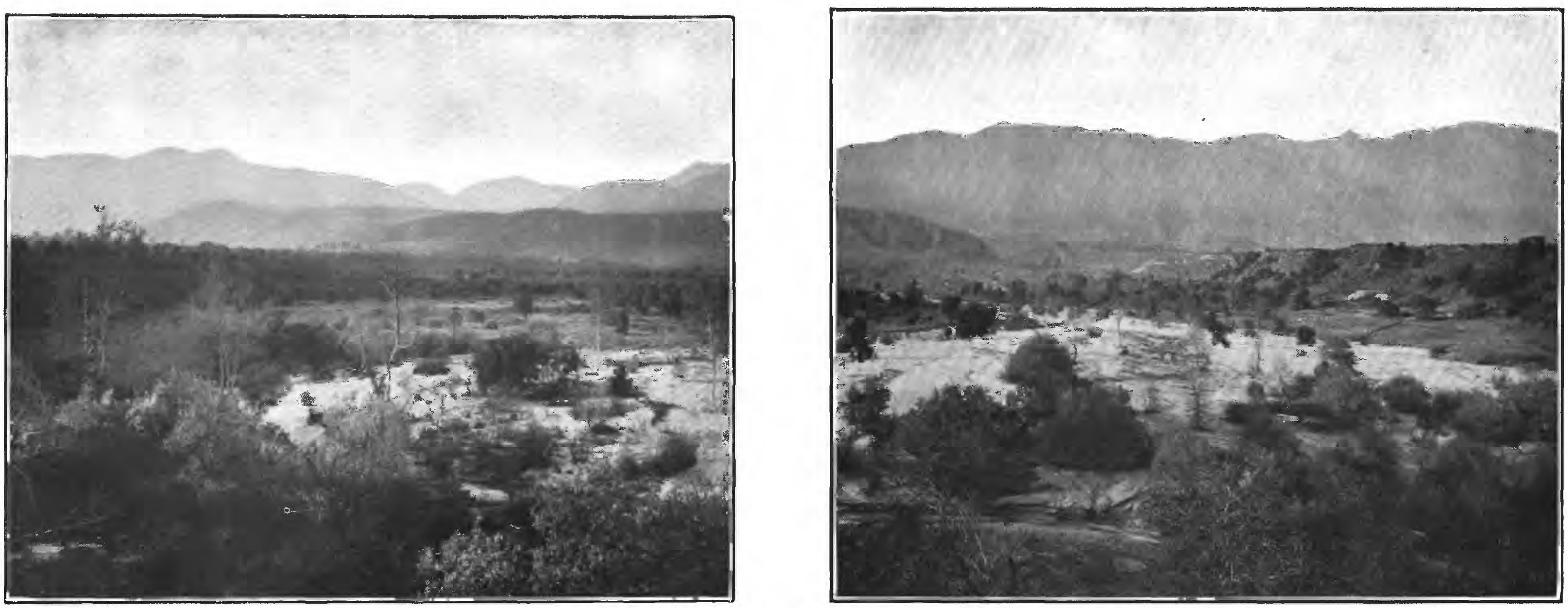
The present paper is intended to continue the presentation of evidence and conclusions which are of value to water users for the important region that lies along the south base of the San Gabriel Mountains from Cucamonga westward to Los Angeles. This belt embraces a small area in the extreme western part of San Bernardino County, but lies for the most part within Los Angeles County. It includes the important communities about Ontario, Pomona, Lordsburg, San Dimas, Covina, Glendora, Monrovia, and Pasadena, and is conveniently and appropriately designated the "foothill belt." Within this area, which comprises only about 450 square miles of lowlands, there are between 55,000 and 60,000 acres of irrigated lands (exclusive of municipalities), a large proportion being in citrus fruits. This acreage ranges in value from $200 to $2,000 an acre, and may be conservatively estimated to be worth $20,000,000 or $25,000,000. In the same area there are about 40 flowing wells and nearly 400 pumping plants, representing an investment of at least $1,000,000 in wells and plants alone. There is, of course, an additional heavy investment in the connecting distributing systems. It is estimated that the pumping plants supply the equivalent of 80 to 100 second-feet of water, continuous flow, used largely for irrigation. This output is not regularly distributed throughout the year, but is largely concentrated in the dry months of July, August, and September, during which, after winters of light rainfall, the production of underground waters amounts to 300 second-feet or more.

GEOGRAPHY.

The valley of southern California is a complex lowland which lies at the south base of the San Gabriel and San Bernardino ranges, opens directly westward to the Pacific, and communicates with the Mohave and Colorado deserts through Cajon and San Gorgonio passes. Its southern boundary is irregular, since in this direction finger-like extensions interdigitate with spurs of the Peninsula Range, whose main mass lies to the south; but its eastern, western, and northern boundaries are perfectly definite. The entire area of this horticultural and productive center of southern California is not more than about 3,000 square miles, yet in wealth, population, and teeming industry it is of more importance than all the rest of the State south of the Tehachapi Mountains.



A, B. PANORAMIC VIEW OF ARROYO SECO ABOVE DEVILS GATE.



C, D. PANORAMIC VIEW OF PALOMARES CIÉNAGA LANDS AND THE SAN GABRIEL RANGE NORTH OF THE CUCAMONGA PLAINS.

The foothill belt is that part of the valley of southern California which lies along the base of the San Gabriels from Pasadena to the western edge of the San Bernardino Valley. It includes the greater part of two lowland areas, the Cucamonga Plains and the San Gabriel Valley, and the divide between them. The divide is a broad, low, interrupted pass that separates a northern outlier of the Coast Range in the vicinity of Lordsburg from the San Gabriel Range. This pass and the valley of San Jose Creek, just south of it, give the most direct lines of communication between Los Angeles and the easterly portions of the valley of southern California, about Riverside, San Bernardino, and Redlands. The Cucamonga Plains, forming the eastern section of the foothill belt, constitute a wide area of valley land, which slopes from an elevation of 2,000 feet on the upper portions of the great alluvial cones at the base of the San Gabriel Range to 500 feet at Rincon, where Santa Ana River enters its lower canyon through the Santa Ana Mountains. Eastward the plains merge without intervening physical barriers into the San Bernardino Valley.

Westward from the pass at Lordsburg the San Gabriel Valley opens. It is a rudely semicircular depression, whose base is the San Gabriel Range and whose encircling hills are the low and scattered representatives of the Coast Range. San Gabriel River crosses this semicircle as a radius from the mouth of its mountain canyon above Azusa to the Paso de Bartolo, through which it flows out upon the coastal plain. One other stream enters the San Gabriel Valley from the mountains and escapes from it by an independent canyon. This is Arroyo Seco (Pl. I, *A*, *B*), which hugs the extreme western edge of the valley, finally breaking through the hills there to join Los Angeles River at the inner edge of the coastal plain. All other streams that drain into the San Gabriel Valley from the mountains are tributary to San Gabriel River when all of their flow does not sink before reaching it.

The general surface aspect of this valley is like that of the Cucamonga Plains. The surface slopes gently, being steepest at the mountain base and flatter at a distance from it. San Gabriel Wash is the valley axis, and slopes are toward it from all directions. But in general the San Gabriel Valley slopes are less steep than those of the Cucamonga Plains, and there are within it, at the foot of the higher mountains, less extensive areas of lands too coarse and rough for cultivation.

All of this foothill belt, and many square miles of mountains north of it, are shown on three of the United States Geological Survey topographic sheets—the Cucamonga, the Pomona, and the Pasadena—drawn on a scale of about 1 mile to the inch.

GENERAL GEOLOGIC CONDITIONS.

The problems of the occurrence, the volume, the direction and rate of percolation, and the accessibility of the ground waters in any region are intimately related to the rock masses, their position, character, and attitude, and these are problems of geology. The study of ground waters, then, is in many of its phases an application of geologic principles and can not be carried out with thoroughness or success unless those elements of the geology which have a bearing on the problems are studied at the same time.

In order to make clear, therefore, the conditions which control the occurrence and circulation of the ground waters in the foothill belt, a résumé of the important geologic factors is given.

From the point of view of the water user the rock masses of the foothill belt fall into two very general classes, those which are water bearing and those which are not.

In the class of the rocks that are not water bearing are the diorites, schists, and gneisses of the San Gabriel Range and of some of the foothills. Among the latter are the Verdugo Mountains and the San Rafael Hills, and there are areas in the Santa Monica Mountains and the Puente Hills which are made up of the same dense, practically impervious rock. Such rocks are not absolutely dry. They are in places fractured and shattered, or are affected by cleavage and joint cracks in which water in small quantities may occur, but it is practically never sufficiently abundant to justify expenditures of capital in development work. Local water companies have at various times and places driven tunnels or bored wells in these rocks, but the result is invariably disappointing. The amount of water obtained does not compensate for the capital expended, and such developments are usually abandoned.

Another series of rocks, very different in origin and appearance, is also placed in this class. These rocks are the shales, sandstones, and conglomerates, usually of Tertiary age, which make up the greater part of the low hills that rise at some distance from the base of the San Gabriel Mountains. The greater part of the Puente Hills, all of the hills about Los Angeles and east of that city toward San Gabriel River, and the main mass of the Santa Monica Mountains are made up of rocks of this type.

These beds are sediments, finely stratified and folded, and they occasionally yield water in sufficient volume to be valuable. A group of deep wells west of Los Angeles, bored originally for oil, obtained water from these Tertiary sandstones. In a few wells it was under sufficient pressure to flow, but, like most waters from the oil-bearing beds, it is of rather poor quality, in that it generally carries a large proportion of alkaline salts in solution and is frequently charged also with sulphuretted hydrogen gas.

As compared with the supply in the gravel beds to be described shortly, these rock waters are negligible in quantity and wholly inferior in quality. From the practical point of view, therefore, the rocks in which they are found are to be considered as dry in this part of southern California, although here and there a successful well has been drilled in them. All these "dry" rocks have an important indirect function to perform in the storage of the ground waters, as they form the bottom and sides of the subterranean reservoirs and so confine the waters which saturate the loose gravels that fill them.

But in any study of conditions controlling underground-water supplies the important formation is the most recent one—the alluvial wash which fills the rock basins, absorbs the flood waters and the return irrigation waters, and yields these up again at lower points through springs of even flow or through artesian and pumped wells. This material is the very latest deposit in the foothill belt. It is composed exclusively of the wash from the heights which surround the lowlands. Of these heights the San Gabriel Mountains, because of their greater relief, are the most efficient and yield much the greatest amount of débris, in the coarsest condition. The lower hills south and east of the foothill belt yield comparatively insignificant amounts of relatively fine material; consequently the greatest accumulations of this alluvium are found along the bases of the higher mountains, where it is also the coarsest. But the alluvium itself is not a simple formation, which has all been deposited in one period. There are unmistakable evidences that it has originated at two different times, and that between these periods the mountain-making and valley-deepening forces were active, so that it is probable that the San Gabriel Range is higher now than when the first of this alluvium was laid down. This is a matter of importance to the water user, because the greater number of those mysterious "dikes" which are cited to account for the apparently erratic behavior of the underground circulation are due to the relations which exist between the earlier and later alluvial deposits. As a matter of convenience the alluvium first laid down will be spoken of as the earlier alluvium and that of the second period as the later alluvium.

Along the base of the San Gabriel Mountains, from Arroyo Seco eastward to the San Dimas, there are a number of benches, capped by and in many places formed entirely of the earlier gravel and clay deposits. These deposits are usually characterized by a dull-red color, due to the more complete oxidation of their constituents, this oxidation being due in turn to the fact that the red clays are older and have been exposed longer to weathering than the gray gravels and sands of the modern stream washes. These older benches usually slope steeply toward the south, and their lower margins are as a rule buried under the modern wash and are indistinguishable from it; but in some localities, as east of Eaton Wash, north of Duarte, and on either side of upper San Dimas Wash, the limit of the older alluvium is marked by an abrupt escarpment. In addition to these exposures of the red wash along the terraces at the foot of the mountains, a few low knobs of this older material lie out in the plains, projecting distinctly above the modern gray stream wash. The most conspicuous and best known of these occurrences are Indian Hill, north of Claremont, and the Red Hills, northeast of North Ontario.

The fact that this older formation occurs at so many points at a greater elevation than the later wash is evidence, although not proof, that mountain-making forces have been in operation since it was deposited, and that the San Gabriel Mountains are now higher than when it was laid down, and they hint that the correlative process—valley deepening—which so often accompanies mountain growth, has likewise been under way and has resulted in a deeper San Gabriel Valley than before.

Although this greater elevation is imperfect evidence of the continued activity of mountain-making forces, actual proof of such activity is found in one or two places, where the old alluvium has been very distinctly folded, and the attitude of its beds, originally horizontal, has been changed to vertical or nearly vertical. East of the mouth of Sawpit Canyon, in an exposure along the edge of the mesa, the red clays and gravels of the old alluvium are found nearly on edge, that is, they dip 60° or 70° S. away from the mountains; and at a number of points farther east lesser dips of 20° or 30° may be noted. These facts indicate that marked crustal movements have taken place since the deposition of the earliest alluvium. These are the movements which presumably have resulted in an increase in the height of the San Gabriel Range.

Although the modern alluvium, the gray wash which underlies the greater part of the San Gabriel Valley and the Cucamonga Plains, is the important water-bearing formation, the older wash is also of direct importance in many localities. Producing wells of value have been drilled in it in the vicinity of Laverne and San Dimas and along the northeastern slope of the Red Hills. It also has a most important indirect effect, in that an older topography—hills and valleys and plains of the older material—has been buried by the later gray wash or has been deeply cut into by the streams which have deposited it; and now these buried or partly buried old hills and valleys deflect or retard or otherwise modify the underground circulation through the later wash, which has been deposited in the older valleys and around the older hills.

These effects of the relations of the alluvium of the two periods are treated more in detail in the discussion of the ground-water conditions in each of the communities. But before this discussion is taken up it is desired to outline, in a general account of the physical geography, the origin of the mountains and valleys and their relative ages. This is a matter of scientific rather than of practical interest, although in the operation of the forces which have given southern California her marvelous diversity of abrupt and rugged mountains and fertile plains, the deep, alluvium-filled basins which are now so important as underground reservoirs have come into being.

PHYSIOGRAPHY.

GENERAL FEATURES.

The corner of Kern, Los Angeles, and Ventura counties, Cal., lies just south of Tejon Pass and near the northern edge of that great mountain area in which the Sierra proper, the northern and the southern Coast ranges, and what may be regarded as the southern representatives of the Sierra, i. e., the San Gabriel and the San Bernardino mountain masses, merge. Southwest of this mountain nodal point lies the Pacific Ocean. Northeast of it is the Mohave Desert. Toward the north the great San Joaquin Valley opens and separates the Sierra from the Coast ranges. Toward the southeast lies the valley of southern California, in a general way comparable in its geographic relations to the San Joaquin Valley, but much smaller in area and very much more complex in character and origin.

This valley consists of a number of distinct basins which are separated by physical barriers so low or so interrupted by passes that they present no serious obstacle to intercommunication between the various cultivable lowlands; but the ranges north and east of these connected basins separate them completely from the northern valleys and from the deserts and give a logical basis for grouping them together as they are grouped in commercial, agricultural, and historical nomenclature, under the collective term "valley of southern California."

As with increasing settlement the necessity has arisen for local names by which the various subdivisions of the valley could be distinguished, these have been supplied, and, as is usually the case in human occupation, they are not merely commercially convenient designations, but have an apt geographic significance which renders them quite as available for the use of the scientific geographer as for the merchant, the tourist, or the traffic manager.

The more important of these subdivisions of the greater valley are the coastal plain, between the Puente Hills and the sea; the San Fernando Valley, an inclosed basin forming the extreme northwestern lobe of the greater lowland; the San Gabriel Valley, another basin inclosed on the east, west, and south by diverging arms of the Coast Range, and abruptly limited on the north by the southern face of the San Gabriel Mountains; the Cucamonga Plains, east of the San Gabriel Basin and passing without intervening physical barriers into the San Bernardino Valley, itself the northeasternmost of the local basins; and finally the San Jacinto Valley, an irregular area drained by San Jacinto River and made up of a multitude of local valleys and intervening irregular heights.

ORIGIN OF PHYSICAL FEATURES.

In the geographic and physiographic sense this valley and its surrounding heights constitute one of the most complex areas of the State. California mountains generally seem to be the immediate products of crustal movement. Many individual ranges are to be explained as results of local uplift. In the interior of the continent and along its eastern margin heights of this character are more uncommon. There it is usual to find that individual mountain groups result from differential erosion acting on broad heights like the Appalachian plateau. In the Pacific coast region, on the contrary, mountain masses of erosional origin are unusual; the individual uplift is the rule.

As this type of mountain range is well marked and to be recognized at many places along the Pacific coast, so there is a corresponding type of valley very common here and in the adjacent deserts, less usual elsewhere, and well illustrated by the individual basins which together constitute the valley of southern California. This is the constructional basin, due, like the mountain ranges, to crustal movement instead of to erosive action. Normally the world over, valleys are due to running water—the greater valleys to long-continued erosion or to erosion of soft rocks, the minor valleys to erosive action of short duration or acting on resistant rocks. It is perhaps even less usual to find lowlands that are directly due to crustal movement than to find mountain ranges of this character, but in southern California all the important lowlands, as well as the uplands, are direct results of crustal deformation. Only the details of sculpturing—the form of the individual peaks and ridges, the canyons, the grade of the mountain streams, and the slopes of the mountain sides—are due to the subaerial erosive agents, water, ice, and wind; the mountain mass as a whole is an upthrust block of the earth's crust. Similarly, the details of the surface of the broader lowlands are due to erosive agents. Their action here, however, has been just the reverse of that in the mountain areas. There the effect of these agents has been to reduce the heights, to undo the work of the mountain-making forces. In the valleys they have deposited the materials which have been removed from the uplands, filled the original depressions, and covered the irregularities in their surfaces; in a word, they are leveling agents, and if their action were not counteracted by that of the mountain-building forces, the whole surface would eventually be reduced to a plain.

The details of the movements in which southern California's attractive alternation of valley and plain originated will perhaps never be known. Many more of them than are now available will, however, be worked out in the detailed geologic and physiographic investigations of the future. But it is possible even with our present imperfect knowledge to outline in a broad way what has happened.

In the middle and northern Sierra, where close geologic studies have been completed, it has been determined that late in Tertiary time the area occupied by the present Sierra Nevada was one of comparatively low relief, with gentle slopes and streams of moderate grade, and that the major part of the movement which has resulted in the present great range has taken place since. It is probable that the history of southern California corresponds in its broad outlines with that of the northern part of the State, and that here, until late in the Tertiary, the mountain ranges were much lower than they are now and the valleys much less deep. It is clear that the forces which have produced these mountains and valleys began to act before the close of the Tertiary period, because the latest Pliocene deposits contain gravels, widely distributed and in many places coarse. Their coarseness indicates that mountains existed near by at the time they were laid down, and their relation to the Tertiary beds whose deposition just preceded theirs indicates that the earlier beds were disturbed between the two epochs. The present mountains and valleys began to form toward the end of the Tertiary, and it is likely that they have been in process of formation ever since. In fact, it seems probable that mountain-making forces are as active on this part of the Pacific coast at present as they have been at any time since early earth history. Incidents like the Owens Valley earthquake of 1872, the San Jacinto earthquake of 1900, the great San Francisco disaster of 1906, and the innumerable minor temblors which occur from time to time are evidences of the activity of these forces. Science no longer regards it as probable that mountains originate in a night, in one tremendous cataclysm, except in volcanic regions. Ordinarily their growth is a gradual process. There are movements of a few inches, or at most of a few feet, from time to time, and the cumulative results give us mountains thousands of feet high and basins thousands of feet deep, where originally were only broad plains.

FAULT LINES.

Movements such as those just discussed, by which the highlands and lowlands are differentiated, are concentrated along lines of weakness where the crust yielded to the earliest strains. When such lines of weakness are once established, they tend to perpetuate themselves as the crust adjusts itself to later strains by yielding along the same lines. These lines of yielding are either faults—actual fractures of the crust—or flexures.

About the borders of the valley of southern California are a number of clearly defined fault lines of this character, movement along which has evidently played a commanding part in the development of the present physical features. The dominant fault of the entire region is the great fracture which extends northwest and southeast along the south base of the San Bernardino Mountains and the north base of the San Gabriel Mountains, and is a continuation of the fault readjustment along which proved so destructive to the country about San Francisco Bay on April 18, 1906. Another disturbance which for at least a part of its length is a fault line is of importance to the oil men of California, because many of the producing wells of this part of the State are found along it. It limits the Santa Ana Mountains on the northeast as far as the lower canyon of Santa Ana River, where it crosses the range and extends along the Puente Hills, near their southern edge, to the vicinity of Whittier, and perhaps farther. A third fracture of this character lies north of San Jacinto and skirts the south base of the badlands which separate the Alessandro Valley from San Timoteo Canyon. Another, somewhat less regular than those described and believed to be older in the sense that no movements have taken place along it as recently as along some at least of the others, bounds the San Gabriel Mountain mass on the south and separates it from the cultivated lowlands of the foothill belt.

It is to be understood clearly that crustal movements along these axial lines—those in an upward direction producing mountain masses, those in a downward direction resulting in basins and valleys—were probably in all cases accompanied by twisting and distortion of the surfaces thus uplifted or depressed, so that after the movement had been accomplished these surfaces were no longer approximately plane, as they probably were when the movements began. Hence the mountain tops, even before the erosion inaugurated by the uplift had destroyed the original surfaces, were probably not level, although they must have included many nearly level areas, and the basin bottoms were likewise depressed much more at one place than another, and so were very irregular.

RELATIVE AGES OF THE PHYSICAL FEATURES.

All the mountains and valleys of southern California have come into being very recently, in a geologic sense, but not all are of the same age. In a great many cases evidence either does not exist or has not been brought out to determine which of two features is the older; but in the case of the two mountain groups, the San Gabriel and the San Bernardino, the dominating mountain masses of this region, evidence apparently does exist for deciding this highly interesting question. This evidence is largely physiographic—that is, it lies in the character of the land forms and so is of a very delicate nature.

If from some commanding point like the summit of Santiago Peak, in the Santa Ana Mountains, the two neighboring ranges, the San Gabriel and the San Bernardino groups, are carefully examined, striking differences in their physical aspect at once become apparent. One seeks in vain for horizontal lines along the San Gabriel tops; a confusion of peaks and ridges of discordant and seemingly unrelated heights makes up the mountain mass. The San Bernardino range is in striking contrast with this. Its west end especially displays a long even sky line at elevations between 5,000 and 6,000 feet above the sea. On the east the broad masses of San Gorgonio Peak rise much higher.

If one enters these ranges to explore them in detail, corresponding differences are found. The San Gabriel Mountains present a labyrinth of canyons and ridges and peaks, with no level areas of any size. The ridges have narrow summits; the peaks are sharp; the streams are all evenly graded from source to mouth. In the San Bernardino Mountains, on the contrary, there are many wide upland valleys, forested and grassy glades, and lakes or playas like Bear Lake and Baldwin Lake. Where these upland levels are attained it is difficult to realize that one is actually in the high mountains. The surrounding topographic forms are rounded and gentle, the level areas are extensive, the streams meander placidly through broad meadows, and the topographic type is that of a rolling country of moderate elevation. But as the edge of these interior uplands is approached the streams plunge into precipitous canyons, the slopes are as steep as earth and rock can stand, the roads and trails twist and turn and double to find a devious and precarious way to the valleys below.

These topographic differences—the presence of broad uplands in one range and their complete absence in the other—have a definite meaning in the history of the mountain masses. The smooth forms are conceived to have been produced by long-continued erosion at relatively low levels in accordance with well-established principles, and their preservation since the mountain mass has been elevated is due to the short time that has elapsed since that event. With the further passage of time, the canyons that are now so pronounced a feature of the border of the San Bernardino mass will have extended to its very heart, and the smooth uplands that now occupy the center of the range will have disappeared. The San Bernardino Mountains will then be as the San Gabriel Mountains are now, a thoroughly dissected range. The important fact that they are not at present in this condition is regarded as satisfactory evidence that they are much younger—that is, that a much shorter time has elapsed since the elevation of the San Bernardino block into a mountain range than since the similar elevation of the San Gabriel block.

SUMMARY.

The topography of southern California in its broad features, and of the foothill belt in particular, is due to the latest crustal movements. These movements may have produced folding in rock masses, but their distinctive effect has been to originate the present relief of the country, to raise the mountains here and to depress the valleys there, the uplands and the lowlands being separated by zones of sharp flexure or of faulting.

Finally, the details of the present topography have been carved by erosion since the differential movement began. Crustal readjustments in response to internal strain, then, have produced the mountain masses and deep valleys, while contemporary and later erosion has produced the canyons and the details of mountain slopes, and has leveled the original basins into broad plains by spreading over them the material removed in sculpturing the mountain areas.

The different mountain masses, although all are comparatively recent, have not been uplifted at the same time. The San Gabriel Range is in this sense much older than the San Bernardino Range, which has come into existence as a mountain mass at a distinctly later date than its neighbor.

RAINFALL.

DISTRIBUTION AND AMOUNT.

The annual distribution of rainfall within the foothill belt is like that throughout the Pacific slope of southern California, since the entire region is one meteorological province with characteristics common to all parts. The chief of these characteristics is the division of the year into wet and dry seasons, the former including the months from November to April, and the latter the remainder of the year. The driest months are June, July, August, and September, during which practically no rain falls, and the wettest are December, January, February, and March, while April and May in the spring and October and November in the autumn serve to bridge the interval between the more pronounced seasons, a variable but generally slight rainfall being recorded for these months.

The geographic distribution of the rainfall within the province is quite as definite as its distribution in time. During the winter season, when the winds from the Pacific pass from the relatively warm ocean over the cooler land, they acquire its temperature, lose capacity to retain moisture, and drop a part of their burden as rainfall. Other things being equal, the greater the reduction in temperature they suffer the greater the rainfall; hence the mountain areas surrounding the southern California lowlands, being higher and cooler, receive heavier rains, and the communities nearer the mountains receive more than those at a greater distance from them. Thus the average at Anaheim is about 12 inches, and at Riverside about 11, while at Los Angeles and San Bernardino, nearer the mountains, the precipitation is between 15 and 16 inches.

This increase from the outlying plains toward the base of the mountains is known to be maintained as the higher parts of the mountains are approached, but exact data to illustrate this generally known fact are not available for the foothill belt, no stations being regularly maintained in the adjacent mountains.

The general character of the rainfall for the valley is illustrated by the following precipitation tables:

Rainfall, in inches, at Los Angeles, Cal.

Year.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total.
1877-78	0.00	0.00	0.00	0.86	0.45	3.93	3.33	7.68	2.57	1.71	0.66	0.07	21.26
1878-79	.00	Tr.	.00	.14	Tr.	4.70	3.59	.97	.49	1.19	.24	.03	11.35
1879-80	.00	.00	.00	.93	3.44	6.53	1.33	1.56	1.45	5.06	.04	.00	20.34
1880-81	Tr.	Tr.	.00	.14	.67	8.40	1.43	.36	1.66	.46	.01	.00	13.13
1881-82	.00	Tr.	Tr.	.82	.27	.52	1.01	2.66	2.66	1.83	.63	Tr.	10.40
1882-83	.00	.00	Tr.	.05	1.82	.08	1.62	3.47	2.87	.15	2.02	.03	12.11
1883-84	Tr.	.00	.00	1.42	.00	2.56	3.15	13.37	12.36	3.54	.34	1.39	38.13
1884-85	Tr.	Tr.	Tr.	.30	1.06	4.64	1.05	Tr.	.01	2.00	.06	Tr.	9.12
1885-86	Tr.	Tr.	Tr.	.26	5.52	1.63	7.72	1.38	2.50	3.29	.00	.01	22.31
1886-87	.24	.21	.00	.01	1.18	.18	.20	9.25	.24	2.30	.20	.04	14.05
1887-88	.07	.00	.15	.12	.78	2.67	6.03	.77	3.15	.11	.02	Tr.	13.87
1888-89	.03	.08	Tr.	.36	4.01	6.26	.25	.92	6.48	.27	.62	.00	19.28
1889-90	.00	.61	.00	6.95	1.35	15.80	7.83	1.36	.66	.22	.03	.02	34.83
1890-91	.00	.03	.06	.03	.13	2.32	.25	8.56	.41	.26	.31	.00	12.36
1891-92	Tr.	.00	.06	.00	.00	1.99	.88	3.19	3.39	.22	2.06	.06	11.85
1892-93	.00	.01	.00	.33	4.40	4.18	6.29	2.27	8.52	.19	.06	.03	26.28
1893-94	.00	.00	Tr.	.75	.20	3.65	.94	.49	.37	.13	.20	Tr.	6.73
1894-95	Tr.	.01	.73	.02	.00	4.62	5.84	.46	3.77	.46	.19	.01	16.11
1895-96	Tr.	Tr.	Tr.	.24	.80	.78	3.23	Tr.	2.97	.19	.30	Tr.	8.51
1896-97	.02	.01	Tr.	1.30	1.66	2.12	3.70	5.62	2.31	.02	.10	Tr.	16.86
1897-98	Tr.	.00	.00	2.47	.01	.05	1.26	.51	.98	.03	1.75	Tr.	7.06
1898-99	.07	Tr.	.02	.09	Tr.	.12	2.64	.04	1.81	.18	.04	.58	5.59
1899-1900	.00	.01	Tr.	1.59	.90	.90	1.17	Tr.	.99	.54	1.81	Tr.	7.91
1900-1901	Tr.	Tr.	Tr.	.26	6.53	Tr.	2.49	4.38	.45	.68	1.50	Tr.	16.29
1901-2	Tr.	.09	.03	1.88	.46	Tr.	1.62	3.35	2.98	.16	.03	Tr.	10.60
1902-3	Tr.	Tr.	Tr.	.40	2.08	2.50	2.10	1.52	6.93	3.77	Tr.	.02	19.32
1903-4	.00	Tr.	.43	Tr.	.00	Tr.	.14	2.68	4.50	.97	Tr.	Tr.	8.72
1904-5	Tr.	.17	.28	.69	.00	2.45	2.57	6.06	6.00	.35	.95	.00	19.52
1905-6	.00	.00	Tr.	.08	2.98	.20	3.85	2.47	7.35	.69	1.02	.01	18.65

Average, twenty-nine seasons, 15.60 inches.

Rainfall, in inches, at Pasadena, Cal.

Year.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total.
1883-84	0.00	0.00	0.00	1.30	0.00	2.73	6.10	13.21	12.99	5.93	0.77	1.90	44.93
1884-85	.00	.20	.00	.25	.89	3.95	1.22	.00	.05	3.00	.33	.11	10.00
1885-86	.00	.14	.00	.00	7.49	2.05	7.40	2.32	2.45	4.11	.15	.00	26.11
1886-87	.05	.26	.04	.10	1.15	.17	.19	10.66	.27	2.33	.28	.00	15.50
1887-88	.17	.00	.33	.12	1.12	4.98	7.40	1.57	5.62	.46	.00	.00	21.77
1888-89	.00	.00	.00	.45	5.68	6.71	.09	1.08	8.83	.41	.95	.00	24.20
1889-90	.00	.62	.00	9.31	1.45	17.17	7.92	2.66	.90	.60	.20	.06	40.89
1890-91	.00	.00	.26	.07	.35	3.52	.14	10.75	.68	1.84	.73	.00	18.34
1891-92	.00	.00	.09	.00	.05	2.25	1.54	3.40	4.23	.25	3.94	.00	15.75
1892-93	.00	.00	.00	.62	3.72	4.30	7.65	2.07	9.84	.47	.00	.00	28.67
1893-94	.70	.09	.00	.80	.20	4.77	1.51	.82	.96	.13	.61	.00	10.59
1894-95	.00	.09	.85	.04	.00	7.24	8.10	1.44	4.53	.53	.25	.00	23.07
1895-96	.00	.00	.00	.32	1.30	.91	2.96	.00	3.73	.50	.17	.00	9.89
1896-97	.05	.15	.00	2.04	1.88	2.33	5.94	5.34	3.57	.00	.23	.00	21.53
1897-98	.05	.15	.23	2.40	.10	.26	1.50	.69	1.14	.39	1.98	.03	8.92
1898-99	.01	.00	.27	.49	.52	.64	3.18	.00	2.08	.12	1.88	.00	9.19
1899-1900	.00	.00	.00	2.02	1.43	1.62	1.11	.00	1.55	.82	2.42	.00	10.97
1900-1901	.00	.00	.05	.34	9.80	.00	3.78	6.80	.17	1.16	1.62	.00	24.22
1901-2	.00	.00	.00	2.76	.73	.00	1.63	3.01	3.29	.38	.09	.00	11.89
1902-3	.00	.00	.00	.53	3.24	3.07	4.03	.90	9.70	3.09	.00	.00	24.56
1903-4	.00	.00	.34	.00	.00	.00	.21	3.89	4.81	.93	.01	.00	10.19
1904-5	.00	.53	.34	.96	.00	1.90	2.63	10.44	8.65	.18	1.44	.00	27.07
1905-6	.00	.00	.05	.17	2.55	.17	4.44	2.54	10.83	2.64	1.67	.00	25.06

Average, twenty-three seasons, 20.14 inches.

Rainfall, in inches, at Pomona, Cal.

Year.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total.
1886-87	0.00	0.00	0.00	0.00	1.05	1.25	0.20	8.28	0.00	2.27	0.28	0.00	13.33
1887-88	.00	.00	.00	.37	1.25	3.56	8.33	1.70	6.63	.00	.00	.00	21.84
1888-89	.00	.00	.00	.00	4.70	6.04	.17	1.48	9.32	.87	.77	.00	23.35
1889-90	.00	.00	.00	3.85	1.82	12.59	7.10	2.56	.52	.31	.00	.00	28.75
1890-91	.00	.14	1.11	.05	.45	3.35	.13	12.78	1.16	1.67	1.02	.00	21.86
1891-92	.00	.12	.11	.00	.00	2.69	1.02	3.41	2.84	.23	3.86	.42	14.70
1892-93	.00	.00	.00	.02	3.45	2.92	7.06	3.87	10.85	.64	.22	.05	29.08
1893-94	.07	.00	.17	1.84	1.44	4.59	1.81	1.13	.95	.26	.44	.00	12.70
1894-95	.00	.00	.63	.02	.00	8.66	9.12	2.43	4.44	1.00	.38	.00	26.68
1895-96	.00	.00	.00	.05	1.36	.91	2.90	.00	4.69	.21	.03	.00	10.15
1896-97	.05	.24	.00	2.44	1.49	1.69	5.20	6.92	4.41	.00	.43	.00	22.87
1897-98	.00	.00	.25	2.84	.53	1.04	2.16	.74	1.46	.13	2.03	.00	11.18
1898-99	.00	.00	.06	.07	.06	.44	2.83	.31	2.97	.07	.07	.89	7.77
1899-1900	.00	.00	.30	1.90	1.94	1.04	1.74	.13	1.35	.80	2.60	.00	11.80
1900-1901	.00	.00	.00	.44	10.12	.00	4.22	4.81	.51	.41	1.47	.01	21.99
1901-2	.00	.00	.17	1.95	.72	.03	2.41	3.21	4.21	.46	.19	.10	13.45
1902-3	.00	.00	.00	.47	1.62	2.91	1.57	1.77	7.23	4.19	.15	.01	19.92
1903-4	.00	.02	.38	.01	.00	.01	.33	2.68	5.57	1.24	.07	.00	10.31
1904-5	.00	.23	.00	1.19	.00	1.42	3.36	8.05	8.50	1.35	2.34	.01	26.45
1905-6	.00	.00	.02	.12	2.71	.64	4.81	2.50	9.65	1.58	1.31	.41	23.75

Average, twenty seasons, 18.60 inches.

Rainfall, in inches, at San Bernardino, Cal.

Year.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total.
1870-71	0.00	0.00	0.02	0.09	3.11	0.89	6.91	2.21	0.19	0.34	0.11	0.07	13.94
1871-72	.00	.04	.13	.60	.88	3.91	.00	2.20	.37	.79	.06	.00	8.98
1872-73	.00	.18	.04	.00	1.17	4.40	6.50	1.25	.51	.84	.21	.00	15.10
1873-74	.00	1.06	.02	.01	.74	5.73	5.51	8.76	1.08	.48	.42	.00	23.81
1874-75	.00	.00	.06	1.82	1.88	2.20	7.20	.15	.22	.07	.05	.00	13.65
1875-76	.00	.00	.00	.00	7.50	.02	6.55	1.92	3.41	.44	.03	.03	19.90
1876-77	.00	.00	.00	.20	.40	.00	3.50	4.03	.83	.26	.30	.00	9.52
1877-78	.00	.00	.00	.86	.50	3.95	3.33	6.68	2.57	1.71	.66	.07	20.33
1878-79	.07	.00	.02	.14	.05	4.70	3.59	1.00	.50	1.20	.24	.03	11.54
1879-80	.11	.02	.01	.94	3.40	6.50	1.56	1.33	1.45	5.00	.04	.00	20.36
1880-81	.00	.00	.00	.14	.67	8.80	1.40	.36	1.66	.46	.01	.00	13.50
1881-82	.00	.00	.00	.80	.27	.50	1.11	2.65	3.30	2.91	.00	.00	11.54
1882-83	.00	.00	.00	.10	.15	.45	1.60	1.10	2.82	2.95	.00	.00	9.17
1883-84	.19	.00	.53	.85	.09	2.63	1.63	12.20	9.95	5.68	3.17	.59	37.51
1884-85	.00	.00	.00	.00	.11	3.75	2.79	.11	.28	1.89	1.69	.19	10.81
1885-86	.00	.00	.00	.39	4.36	1.20	6.34	2.52	4.18	2.36	.32	.16	21.83
1886-87	.00	.00	.00	.00	.11	.61	.39	6.44	4.41	1.90	.42	.22	14.50
1887-88	.11	.04	.09	1.17	2.29	1.91	4.01	3.60	3.41	.58	.52	.03	17.76
1888-89	.00	.00	.00	.05	4.12	4.64	.93	1.50	6.55	2.05	1.13	.00	20.97
1889-90	.17	.63	.11	2.30	2.23	10.85	5.44	2.52	.89	.00	.31	.00	25.45
1890-91	.13	2.16	.88	.58	1.27	3.02	.00	7.78	.06	.53	1.67	.00	18.08
1891-92	.00	.91	.93	Tr.	Tr.	1.67	3.24	3.30	1.75	.37	2.10	.08	14.35
1892-93	.00	.00	.00	.16	1.02	2.23	4.53	3.37	8.00	.48	.03	.00	19.82
1893-94	.20	.00	.05	1.05	.30	2.28	1.26	.88	1.15	.40	.56	.00	8.13
1894-95	.00	.16	.37	.15	.00	7.25	7.39	1.14	3.44	.64	.44	.00	20.98
1895-96	.00	.00	.00	.00	1.14	.66	2.02	.00	2.92	.37	1.00	.00	8.11
1896-97	Tr.	.17	.00	2.10	.98	1.09	3.40	5.40	3.41	.08	.11	.00	16.74
1897-98	Tr.	.00	.13	2.10	.21	.57	2.10	.60	.97	.48	1.08	.00	8.24
1898-99	.00	.00	.00	.03	.05	.44	2.03	.51	3.22	.07	.19	.95	7.49
1899-1900	.00	Tr.	.01	.81	1.47	.84	.92	.00	.92	1.96	1.71	.00	8.64
1900-1901	.34	.00	.23	.36	6.10	.00	3.48	4.58	.43	.56	1.23	.05	17.36
1901-2	.00	.27	.07	1.09	.28	.04	1.65	3.02	3.89	.57	.12	.15	11.15
1902-3	.01	.00	.00	.09	1.94	1.94	1.96	1.67	6.47	3.10	.24	.00	17.42
1903-4	.00	.15	.46	.07	.00	.00	.18	2.21	5.34	.80	.16	.00	9.37
1904-5	.00	.14	.06	.32	.00	1.03	3.92	6.58	6.00	1.18	1.55	.00	20.78
1905-6	.00	.00	.13	.00	2.81	.74	2.97	2.89	8.00	1.16	.96	.22	19.88

Average, thirty-six seasons, 15.74 inches.

The San Bernardino and Los Angeles records are the longest in this part of the State, and therefore give the most reliable general averages; but since Los Angeles is near the southern edge of the foot-hill area, and San Bernardino about an equal distance from the mountains, these records probably express about the lowest rainfall within the district under consideration. The record at Pasadena, kept by Mr. Nelmes, covers a period of twenty-three seasons, during which the average precipitation was 20.14 inches. This average is probably somewhat higher than the final average will prove to be when that shall have been determined by longer records. This conclusion is reached from an inspection of the records at Los Angeles and San Bernardino, where the average for the last twenty-three seasons is in each case slightly greater than the average for the full period of observations. Similar reasoning indicates that the twenty-year average of 18.60 inches, now available for Pomona, is slightly below the final average which will be found for this point. Both Pasadena and Pomona, however, have heavier rainfall than Los Angeles and San Bernardino, since they lie nearer the base of the mountains; and were records available from points on the slopes and at or near the summits they would show still heavier rainfall, in accordance with the well-established fact of a progressive increase of precipitation from the mountain bases to a point near their summits.

DEPENDENCE OF WATER SUPPLIES ON RAINFALL.

The significance of the annual rainfall to the irrigating communities lies in the direct and immediate dependence on it of the surface run-off from each of the mountain drainage basins and in the less immediate but not less important or final dependence of the underground reservoirs on it for recharge.

The marked contrast between the summer and winter run-off from the mountain canyons, with its unfavorable effect on irrigation possibilities and on the recharge of subterranean reservoirs, is of course due primarily to the division of the year into two seasons, a wet and a dry, with strongly contrasted precipitation; but other factors also exert a pronounced influence, and it so happens that nearly all of them in southern California are unfavorable to uniformity of flow. Among these factors are the length and character of drainage lines, the steepness of slopes and of stream channels, the character of the rocks in a drainage basin, and the condition of the forest and brush cover over the slopes.

Where drainage lines are short and direct and channels are straight instead of tortuous, a minimum of time is required for the passage of a given flood wave from the headwaters of the stream to its mouth, and so there is but a limited opportunity for the absorption of water by porous rocks and débris to be released later as summer flow.

A closely related factor is that of steep slopes and stream channels. The process of absorption of water by soil and rocks is a slow one and is controlled by the rate of percolation through the soil, away from the saturated surface, and by the length of the period of saturation. From steep slopes and stream channels of high gradient the water escapes quickly, so there is but little opportunity for its absorption. The streams of the San Gabriel Mountains that drain into the foothill belt have relatively short and direct courses, and the slopes in this mountain range and the grades of the streams are especially steep. These conditions result in extremely rapid run-off in heavy floods of very short duration.

The influence exerted by the type of rock in a drainage basin is also most marked in its effect on the character of the run-off. Loose sandstones absorb water like sponges, to yield it slowly at some lower point, perhaps in a distant drainage basin. Cavernous limestones may offer tortuous underground passages through which water escapes slowly. But dense granitic and metamorphic rocks have little absorptive or storage capacity unless they are extensively shattered, and such water as falls upon them is usually shed promptly. By far the greater part of the San Gabriel Range is made up of rocks of these nonabsorptive types.

Finally, the various cover growths are of great importance in modifying run-off. Trees and brush act in many ways to this end.

They hold loose fragments of rock by their binding root systems, so that they are not carried down to the stream channels so soon. The crevices about the rock fragments which are thus held become little storage reservoirs. The trees also aid in making these crevices by the prying action of their roots and by the disintegrating action of the vegetable acids which are yielded by their decay. The various growths build up a porous absorptive soil by the litter which they shed and the rock sand which becomes enmeshed in their roots, and they protect the soil which thus accumulates and prevent it from being swept away. Finally, they interfere directly with run-off by the obstacles which their roots, stems, and fallen leaves and branches offer to the flow of water over the surface. In all of these functions the immediate escape of rains as sudden floods is checked, and their absorption to be slowly released later is encouraged. The effect of forest and brush cover, then, is to decrease the violence of winter floods and to maintain the stream flow during the crucial summer irrigating season. Forest cover throughout the San Gabriel Mountains is in bad condition through the recurrence of destructive fires during past centuries. Systematic efforts are now being made by the United States Forest Service and by the State forester to improve these conditions by preserving from further destruction such covered areas as remain and by extending timber growth through tree planting. These efforts are for the benefit of the southern California communities which depend on the water supply from the mountains, and are deserving of their heartiest support and most earnest cooperation.

The statement has frequently been made that the underground waters are just as dependent as the surface run-off on precipitation within the local contributing drainage basins, but the tenacity of the oft-asserted belief that these subterranean reservoirs have some other source than local rainfall makes it desirable to repeat this statement with emphasis. Each of the important subterranean basins in southern California is supplied exclusively by the water which falls upon its surface or flows into it through some tributary stream. Any other hypothesis, as, for example, that waters from the distant Sierra or Colorado River or Pacific Ocean may, by underground channels or by seepage, reach the San Gabriel Valley or the Pomona neighborhood, is erroneous, and conclusions based on it are wrong and lead to a false policy in the utilization of the ground waters.

The permanence of the underground reservoirs as sources of water supply is dependent on all the conditions which have been outlined as affecting surface run-off, because, as just stated, it is the surface run-off from the mountain areas which must be relied on to recharge these reservoirs; and, in addition, whatever makes this surface run-off erratic—extremely high in winter and extremely low in summer—not only makes it less effective in the recharge of the underground basins, but increases the summer drafts on them. A discouragingly large proportion of the greater floods escapes entirely to the sea. These floods can not be used by the surface systems, and they pass over the gravels of the valleys too rapidly and in too great volume to be fully absorbed, and so are largely wasted. It is obvious that whatever will reduce the violence of floods will lessen the total loss of waters by surface flow to the sea and will make more effective the restoration of ground-water levels.

These levels suffer in still another way at the present stage of development of the country, by the concentration of the run-off in the winter months and its reduction to a low point during the irrigating season. Since the discovery in the nineties that large bodies of ground water were available for irrigation, there has been a constant tendency to extend acreage beyond the amount which can be covered by the summer surface run-off and to make up the deficiency during that period by pumping. When the summer flow is especially low and continues low for a long period, the pumping season is greatly extended and the drafts on the underground basins are proportionately increased.

To sum up: The available quantity of ground waters is adversely affected by whatever tends to make surface flow more erratic. This effect is brought about in two ways—first, by the large proportion of waters which escape wholly when winter floods are violent; and second, by the greater drafts on underground sources made necessary when summer run-off is low.

STORAGE FACILITIES.

The canyons in the San Gabriel mountain range are too narrow and too steep for storage sites, except of very inferior capacity and excessively high unit cost, and the run-off is so erratic that to be effective reservoirs must be of exceptional capacity. The recorded flows of San Gabriel River vary between a minimum of 3 second-feet and a maximum of 11,130 second-feet; and the total estimated annual discharge since systematic records have been kept varies from a minimum of 10,489 acre-feet to a maximum of 164,700 acre-feet. These minima are probably nearly absolute, since they were obtained during the seasons of lowest rainfall known in southern California; but greater maxima than those given were undoubtedly reached during the season of 1883–84, when the precipitation was nearly twice that of any winter since the stream flow has been accurately measured.

With such widely varying annual run-off, reservoirs capable of storing enough water to supply the tributary lands during two seasons, at least, would be required for safety. Such reservoir sites do not exist in the San Gabriel Mountains.

MEASURES FOR CONSERVATION OF WATERS.

In the lack of surface reservoirs, such minor helpful measures as are possible must be taken to prevent the present distressing waste of flood waters. Restoration of forest and brush cover is one of the most effective of these, although it accomplishes results but slowly. Gradually through reforestation summer flow should be increased 'and the volume and suddenness of winter floods somewhat lessened. Another measure which is practiced in a small way is the spreading of flood waters over the sand and gravel areas about the canyon mouths, so that they may be more fully absorbed and thus may increase the ground-water supply.

With certain important modifications, the simple principle that the quantity of water absorbed varies with the area of the flooded surface and with the time that it is covered is the basis of this work. If the character of a given flood channel can be so altered that the water in its escape covers twice the normal area, the amount absorbed will be increased twofold; and if the flow can be checked so that twice the normal time is required for the passage of the water between two points, absorption is again increased twofold. These are general terms, of course, and would be strictly true only if the flood waters were clear and if drainage from the flood channel were so free that the water could always escape as fast as it is absorbed. Neither of these conditions holds. Early flood waters are filled with fine suspended matter which is deposited as the water seeps into the river bed, and which soon forms a coating of but slightly permeable slime that tends to prevent absorption. Toward the end of a flood stage, when the water is clear, this slime is washed away and absorption becomes more effective.

In those parts of the flood-water channel which lie at some distance from the base of the mountains, where the ground-water plane is near the surface, rapid absorption in the stream channel quickly raises the ground-water plane locally, so that the stream is then flowing, as it were, upon a saturation ridge, and further absorption can take place only as rapidly as the waters can percolate away from this ridge. The practical result of this principle is that the first part of a flood is more effectively absorbed than the latter part, and the first floods at the beginning of a rainy season are more effectively absorbed than those which come later in the winter.

These are important practical modifications of the rule that absorption varies with absorptive area and time. In the application of this rule, flood waters are distributed over as large areas as possible near the heads of the alluvial fans, and the rate of their flow is checked as much as possible. The most effective work of this character that has been done thus far in southern California is that by the Riverside companies in Santa Ana Wash above San Bernardino. Here for some years minor floods have been checked by temporary dams, and the water has been distributed in a small way over the sands of the river wash, with what the engineers in charge regard as excellent results. Similar work on a less extensive scale has been done by the Ontario companies on the Cucamonga fan and in the lower canyon of San Antonio Creek. The great difficulty in work of this kind is to unite the interests to be benefited, so that they will support a work whose results are not easy to demonstrate. But as water becomes more valuable in southern California, and as the direct dependence of the underground reservoirs on recharge during the rainy season becomes more clearly understood, it will be less difficult to unite these interests in a concerted movement to aid in the necessary engineering work.

ABSORPTIVE CAPACITY OF SANDS.

The absorptive capacity of the sands and gravels of varying coarseness in the different portions of an alluvial fan is a subject of debate, and the general opinion among engineers seems to be that absorption takes place most effectively and readily in the sands which occur in the lower part of the stream channel. When the size of the soil particles remains uniform, the transmission capacity of a mass increases with the square of the diameter of the individual particles. The size of the pores, although not the percentage of the open space, increases, and the effect of friction is greatly reduced with this increase. Percolation thus approaches flow as the sand or soil particles become larger and larger. In nature, however, sands rarely consist of particles of uniform size. They are usually heterogeneous mixtures, and their transmission capacity can be determined only by measurement. The effect of mixing particles of a larger size with a uniform sand is thus summarized by Slichter:[a]

> If to a mass of nearly uniform sand particles larger particles be added, the effect on the resistance to the flow of water will be one of two kinds, depending principally upon the ratio which the size of the particles added bears to the average size of the grains in the original sand. If the particles added are only slightly larger than the original sand grains, the effect is to increase the capacity of the sand to transmit water, and the more particles of this kind that are added the greater will be the increase in this capacity. . . . If, however, large particles are added, the effect is the reverse. If particles seven to ten times the diameter of the original sand grains be added, each of the new particles tends to block the course of the water. Thus, for example, a large bowlder placed in a mass of fine sand will tend to block the passage of the water. As more and more of the large particles are added to a mass of uniform sand, the rate of flow of water through it will be decreased until the amount of the large particles equals about 30 per cent of the total mass. From this time on the adding of the large particles will increase the capacity of the whole to transmit water, until, if a very large quantity of the large particles be added, so that the original mass of fine particles becomes relatively negligible, the capacity to transmit will

[a] Slichter, C. S., Water-Sup. and Irr. Paper No. 140, U. S. Geol. Survey, 1905, pp. 10–11.

approach that of the mass of the large particles alone. These facts have an important bearing upon the capacity of gravels to furnish water to wells or to transmit water in the underflow of a river. The presence of large particles is not necessarily to be interpreted as indicating a high transmission capacity of the material, for this is indicated only when the large particles constitute a large fractional per cent of the total mass, as would be the case where the large particles equal 40 or 50 per cent of the whole.

In an earlier paper[a] Slichter gives an interesting table showing the rate of percolation through transmitting media of different sizes under fixed conditions. From this table the following is adapted. A uniform size of grain, a standard porosity of 32 per cent, and a temperature of 50° F. are assumed in each case.

Rate of percolation of water through different kinds of soil.

Kind of soil.	Diameter of soil grains.	Velocity with a gradient of 100 feet per mile.
	Inch.	*Feet per year.*
Silt	0.0012	12
Very fine sand	.0028	66
Fine sand	.006	304
Medium sand	.014	1,650
Coarse sand	.03	7,577
Fine gravel	.12	121,229

When the soils are of uniform grain, therefore, the rate of percolation increases as the square of the diameter of the soil particles and the amount of water transmitted increases in the same ratio. Coarse material is therefore very much more effective than fine as a transmitting medium, when the sizes are not mixed. In alluvial fans, however, there is always mingling of coarse and fine material, but the average and probably the effective size of grain is usually much greater at the head of a fan than near its margins, and the transmission capacity is therefore believed to be greater near the head. To take advantage of this condition, distribution of flood waters should be effected at as high a point on an alluvial fan as is practicable, because absorption will be much more rapid at such a point. In some places it may be that the rough, bowldery condition of the head of the fan and the steep grades which exist there will counteract the advantages, and as a practical measure it will be advisable to effect the distribution at a lower point; or bed rock may lie near the surface, as in the Mill Creek fan and perhaps that of the Santa Ana in San Bernardino Valley, practically preventing rapid absorption. Where such conditions exist it is of course necessary to build the distributing works at lower points. So far as is known, however, bed rock does not lie near enough to the surface under the fans of the foothill belt to have an unfavorable effect. Steep grades

[a] Slichter, C. S., Water-Sup. and Irr. Paper No. 67, U. S. Geol. Survey, 1902, p. 27.

and rough ground for constructing distributing canals are the only adverse elements to be considered here.

ABSORPTION ESTIMATES.

The rate and the total amount of the recharge of the subterranean basins through the absorption of flood waters are exceptionally difficult to determine, because accurate measurements of floods are almost impossible to make on account of the steep grades and the indefinite channels that exist across the alluvial fans. But few data are available on the subject, and while theoretical considerations give indications as to what is happening, they can not generally be supported by figures.

In southern California one set of absorption measurements was made on two minor floods in the spring of 1903 by W. B. Clapp,[a] hydrographer, of the United States Geological Survey, and while Mr. Clapp does not regard his measurements as satisfactory, because of the small force and the limited time at his disposal and the inherent difficulties of the work, they yet give certain concrete conceptions of what takes place during the flood periods.

During the twenty-four hours of April 26, 1903, San Gabriel, San Dimas, Dalton, Santa Anita, and Eaton canyons discharged 757 acre-feet of undiverted waters into the San Gabriel basin, 454 acre-feet of which passed the bridge at Elmonte and was lost, while the remainder, 303 acre-feet, was absorbed by the gravels and joined the body of underground waters in the basin. On May 23 of that year the same streams discharged 225 acre-feet of undiverted waters, and all of this except the small amount lost through evaporation was absorbed, none passing the Elmonte bridge. During the two periods of measurement water was being returned to the San Gabriel Valley underground reservoir at the rate of 153 and 113 cubic feet per second.

These measurements were not made during the period of highest water. A flood with a discharge of about 1,220 second-feet occurred on April 17, nine days before the first measurement, and the flow in the San Gabriel slowly diminished from that time until long after the date of the second measurement.

Inasmuch as no calculation has been made of the diverted water used in irrigation, which in the San Gabriel systems was from 20 to 70 second-feet throughout the year, and a part of which was absorbed and returned to the ground waters, nor of the greater absorption during the heavier floods, nor of the rainfall over the San Gabriel Valley, which sinks directly as it falls and does not appear as run-off, nor of the hundreds of minor unmeasured rills which enter the basin during storms, perhaps one or the other of the figures given above may be not far from the average annual rate of recharge. Some slight additional

[a] Hoyt, John C., Water-Sup. and Irr. Paper No. 100, U. S. Geol. Survey, 1904, pp. 339 et seq.

weight is given to this assumption from the fact that the San Gabriel flow at the time of the last measurement was 167 second-feet, which is not far from the annual mean of 148 second-feet for 1903.

In the Paso de Bartolo, San Gabriel Valley ground waters rise in springs at the rate of 65 to 85 second-feet during the irrigating season. In addition, a considerable amount of water must pass into the air from the moist lands above the pass, by evaporation. This is ground water which is brought to the surface by capillarity and there evaporated, wherever the ground-water plane lies within a few feet of the earth surface. In addition, a certain amount of ground water escapes through the Paso de Bartolo as underflow without reaching the surface at all. Slichter,[a] using rather meager data, has estimated the amount of this underflow at 92 second-feet. This, added to 75 second-feet assumed as a mean of the spring waters, gives 167 second-feet of escaping ground waters, without reckoning evaporation or waters pumped for irrigation. These escaping waters must be about equal to the average annual recharge. It seems likely, then, from this consideration of the broad probabilities in the case, that a recharge of the San Gabriel Valley underground reservoirs takes place at a rate equal to a continuous flow ranging between 100 and 200 second-feet, and that, of course, drainage is affected at an equal average rate.

CHARACTER AND CONDITION OF SUBTERRANEAN RESERVOIRS.

The origin of the great reservoirs which are now so extensively drawn on in irrigation has been discussed in general terms in the section on physiography (pp. 13–18), but a résumé is introduced here preliminary to a more minute treatment of water levels. These reservoirs are irregular rock basins, due to the warping of the earth's crust as a result of those stresses to which it is continually subject. The Pacific coast region of the United States has of late been especially affected by such stresses, and its mountains and valleys are to a great extent due to them. The great interior valley of San Joaquin and Sacramento rivers is the most impressive example of a deep and extensive basin formed in this way, and the Sierra Nevada east of it is equally impressive as an example of a mountain range whose origin is to be sought in crustal movement. Earth stresses in the vicinity of the valley of southern California clearly have been most complex, resulting structures are irregular, and the final product has been a number of distinct rock basins irregular in trend and outline, each of which is an underground reservoir more or less extensively drawn on for irrigating waters. Among the more important and best known of these basins are the San Bernardino Valley, the San Jacinto Valley, the Cucamonga Plains, the San

[a] Slichter, C. S., Water-Sup. and Irr. Paper No. 140, U. S. Geol. Survey, 1905, p. 54.

Gabriel Valley, the coastal plain, and the San Fernando Valley. All of these are distinct, each has its own water supply, and the ground waters of each are used for irrigation, either within the basin or on accessible lands outside it.

Each of these rock-floored and rock-rimmed reservoirs is filled with loose material, sand, gravel, or clay, which has been eroded from the mountains as they rose and carried by the streams to the basins as they sank. This filling has been distributed over the basins in a rather even way, so that the present surface of each of them is a plain, usually with a gentle slope away from the mountains, the source of the material.

THE GLACIAL HYPOTHESIS.

Inasmuch as there is a rather widely prevalent idea in southern California—an idea which has been frequently presented in suits at law—to the effect that these sands, clays, and gravels are glacial in origin, it is perhaps worth while to present here the facts which make such a hypothesis untenable.

Students of glaciated regions have come to recognize certain phenomena as characteristic of ice-molded areas. Some or all of these evidences are invariably present where ice in glacial form has covered a region. Their complete absence in southern California leads at once to the setting aside of this theory.

Extensive glaciation in mountain valleys molds them into U form, cuts cirques at their heads, scars their walls and bottoms with striæ, and leaves moraines along their slopes and out on the plains beyond the mountains where the ice streams ended. None of these evidences are found in the valleys of the San Gabriel Mountains.

Ice flowing over mountain uplands or relatively smooth rock-floored plains shears off all rock protuberances, polishes the projecting surfaces into roches moutonnées, sweeps away rock-disintegration products, gouges out basins, which may later become lakes, and leaves in its retreat erratic bowlders that may have been carried across divides from distant sources. The San Gabriel Mountains, instead of exhibiting these phenomena, have many projecting rock pinnacles, are covered with the detritus of rock decay, are free from rock basins and lakes, and have only bowlders of disintegration scattered over them.

If glaciers ride out upon the plains in front of the mountains in which they originate, they leave irregular heaps of unsorted rubble, angular bowlders, a hummocky topography, and deposits of till, a compact clay containing scattering glaciated rock fragments. The plains at the base of the San Gabriel Range are clearly unlike this. They are a series of typically developed alluvial fans; graded as stream-laid deposits always are, with waterworn but unstriated bowlders, progressively finer as the distance from the mountains increases, and free from lakes or undrained depressions. There is no evidence whatever of glacial action in the material of which they are built up nor in its arrangement. Water has been the agent by which this material has been transported from its original position in the mountains to its present resting place in the basins, and in consequence the sands and gravels have always been saturated below a point where they could drain freely. This saturating water is in constant slow motion from the point where it enters the gravels, along some stream channel or at the mouth of a mountain canyon, to the point where it escapes from the basin over the lowest part of its rim. Its movements are impeded by the friction which it encounters in its passage through the fine pores, so that its surface is not level like that of a free body of water, a lake, or a sea, but slopes from the point of supply to the point of drainage. When supply is increased the slope is steepened by raising the surface of saturation at the point of intake. When supply is decreased by a lessened rainfall, the slope of the surface of saturation becomes flatter and the ground-water level falls, the lowering being more marked at a distance from the point at which the basin drains; for since this latter point controls the escape of water in the basin, its level remains practically constant.

CHARACTER OF THE ROCK FLOOR OF THE FILLED AREAS.

The surface of basins like the San Gabriel Valley or that east of the San Jose Hills is invariably a sloping plain, steeper near the mountains, more nearly level at greater distances from them, and varied only by minor knobs or local changes of slope. Red and Indian hills rise above the Cucamonga Plains; a number of bed-rock knobs in the neighborhood of San Dimas and Glendora project above the plain of waterworn material which lies between the San Jose Hills and the San Gabriel Mountains; San Dimas Wash, itself a late sand and gravel filling, lies between bluffs of older alluvium; the Raymond Hill "dike," which extends from Pasadena to a point beyond Santa Anita, is marked for much of the distance by an abrupt change of slope and in places by distinct knobs; and here and there at other points near the edges of the plain bed-rock knobs of shale or of gneiss rise above the general valley level. These projections are sufficient only to indicate the irregularity of the valley bottom; they do not enable us to restore the details of the irregularities. Well records generally do not indicate that bed rock has been reached in the borings, the wells usually being too shallow to accomplish this result. The deepest within the San Gabriel Valley—one drilled by

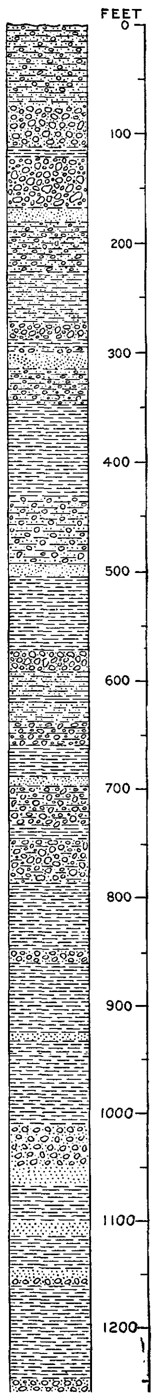


FIG. 1.—Section of well north of Woyden (No. 204, Pasadena quadrangle).

the East Whittier Company (fig. 1), north of Woyden station on the Southern Pacific Railroad—is 1,260 feet deep, and no bed rock was encountered, although the bottom of the well is almost 1,000 feet below sea level. Among the wells in the vicinity of Pomona of which records have been obtained are a number between 500 and 1,000 feet deep. One of the deep wells of the Irrigation Company of Pomona, situated in the old Palomares ciénaga, about three-fourths of a mile northeast of the point of the San Jose Hills, reached bed rock at a depth of about 800 feet. It was drilled 150 feet lower, but of course no water was developed in the deeper formation. Bed rock in this well is about 150 feet above sea level, as the surface of the plain here is about 950 feet above.

The Lorbeer well, 1 mile northwest of Chino, is 973 feet deep and extends nearly 200 feet below sea level without striking bed rock. The lower 500 feet of clays, many of them red and of cemented gravel, were dry and yielded no water. These strata appear to belong to the earlier alluvium rather than to the later, more effective water-bearing gravel series.

Half a mile southwest of this, a well belonging to Black Brothers & Woodhead is 718 feet deep and extends to within 25 feet of sea level. An incomplete record of this well fails to show the presence of strata older than the modern alluvium.

Some other wells near bed-rock hills strike the buried slopes of these hills, but generally those out in the plains and valleys penetrate only loose sands, gravels, and clays.

It may be accepted as true that the bed-rock bottoms of the valleys whose topographic details are concealed by the mantle of wash which forms the Cucamonga Plains and the San Gabriel Valley are irregular, just as the topography of those bed-rock areas which extend above the wash as hills is irregular. The rock basement beneath the San Gabriel Valley is presumably not unlike the hill region between Los Angeles and Pasadena in character.

An attempt to estimate the elevation of bed rock in the deepest part of the San Gabriel Valley is interesting but speculative. Since it is a valley of deformation, not one of erosion, a consideration of stream grades throws no light on the problem. A projection of the mountain slopes on the north and south of the valley to some assumed point of greatest depth probably gives a maximum measure, since it is quite unlikely that the steep slopes of the unburied portion of the surrounding mountains are maintained for greater distances beneath the cover of wash than above it. Such a rude estimate gives 4,000 feet below sea level as a possible depth of the bottom of the San Gabriel basin 2 or 3 miles south of Monrovia. It is likely to be less than this. The deepest well in the basin is that owned by the East Whittier Land and Water Company. This well is just west of San Gabriel Wash and about one-fourth mile north of the main line of the Southern Pacific. No bed rock was encountered in it at a depth of 1,260 feet, or nearly 1,000 feet below sea level.

The Cucamonga Plains east of the San Jose Hills represent a more extended area than the San Gabriel Valley, and bed rock may be buried to a considerably greater depth beneath them. Wells in this area whose records have already been quoted extend to points well below sea level without encountering rock, but the outcropping Red Hills and Indian Hills, the barriers to which are due the old Martin and Del Monte ciénagas, the dry red clays and cements encountered in some of the deep wells between Pomona and Chino, and the traces of earlier alluvium which flank the west end of the Jurupa Mountains on the north, indicate that this formation may be of considerable importance under at least the western portion of the Cucamonga Plains. Beneath the northeastern part of these plains, where the alluvial fans are so steep and high, water is at too great a depth to be accessible, the underground conditions are little known and of little interest, and the depth to the bottom of the basin is purely a matter of conjecture. It has been estimated[a] that the San Bernardino basin may be 3,000 feet deep, or thereabouts. It seems unlikely, from the general evidence which has just been given, that the San Gabriel basin is more than 4,000 feet deep, and it may be less than this. The Cucamonga Plains area may overlie a bed-rock basin that is somewhat more deeply buried than either.

GROUND-WATER DISTRICTS.

Within the foothill belt the development of ground waters has been most intense in certain districts where experience has proved it to be most accessible and present in greatest amount, or where, despite the rather high cost of production, the crops raised by its use are valuable enough to bear easily the expense of pumping against high lifts. It is intended to present in the following paragraphs the essential facts, so far as they are known, as to the occurrence of the waters in each of these areas.

[a] Water-Sup. and Irr. Paper No. 142, U. S. Geol. Survey, 1905, p. 31.

RED HILLS WATERS.

The "Red Hills," so called, lie about 2 miles northeast of North Ontario and nearly 4 miles south of the base of the San Gabriel Range. As a physical feature they form a nearly flat-topped mesa, which interrupts the general slope of this part of the Cucamonga Plains.

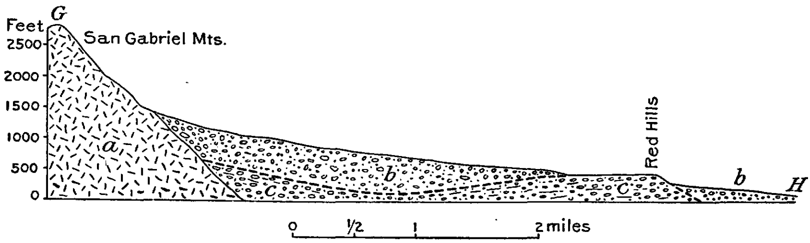


FIG. 2.—Diagrammatic section through the Red Hills; *a* granitic rocks; *b*, *c*, earlier and later alluvium and hypothetical boundary between them.

Approached from the north the mesa appears only as a lessening of the slope, but its southern edge is a scarp 50 to 150 feet high. The hills are made up of a deposit of the earlier red alluvium which has here escaped the destruction of the older topography by erosion during

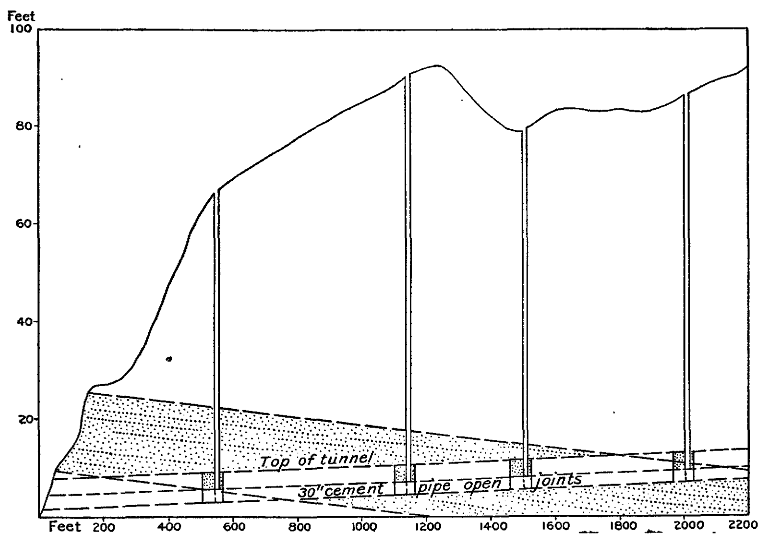


FIG. 3.—Section along line of the Eddy or Cucamonga tunnel.

the deposition of the later alluvium. The low mound therefore represents the top of a hill of red clay, sand, and gravel, whose slopes are deeply buried under modern wash (fig. 2). Indian Hill represents a similar outcrop, and the same red-clay formation is reported to show between these two points. The Martin and Del Monte ciénagas are likewise probably due to buried hills of this older deposit which approach near to the surface. Its distribution beneath the modern gray alluvium therefore appears to be extensive.

This buried earlier alluvium affects the occurrence of underground waters in two ways. In the first place, where the hills of the older, concealed topography lie athwart a line of underground circulation through the later alluvium, they serve as a dike or underground dam, forcing the waters which are percolating through the overlying gravels to or near to the surface, where they flow out in springs or are easily developed by wells. Or again, where the older alluvium lies near the surface the waters which circulate through it may be brought within reach of development. As the older alluvium has been folded in some localities by crustal disturbances which have taken place since its deposition, it may be that where it projects above the general plains surface it has been brought to this position by folding. The section of the Eddy tunnel through the base of the Red Hills near their western margin (fig. 3) seems to show a dip of the beds toward the north. It is probable, therefore, that this body of older alluvium stands above the general plain because it has been brought up along or near the axis of such an arch. Some of the waters which are percolating through it southward from the base of the San Gabriel Mountains will be brought to the surface at this point and will issue as springs, or where their volume is not great enough to force them out as springs, they will at least be brought near enough to the surface to be accessible and may be developed by pumps.

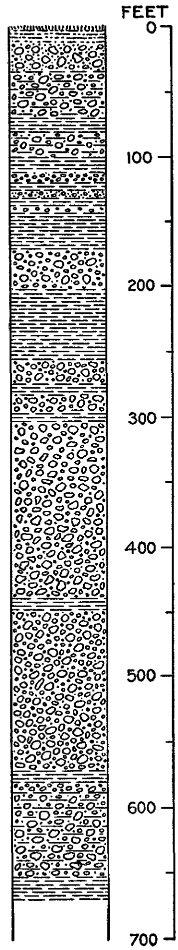


FIG. 4.—Section of Cucamonga Water Company's well (No. 69, Cucamonga quadrangle).

As a matter of fact, the vicinity of the Red Hills has been a source of irrigation water since the settlement of this part of southern California. Originally the waters utilized rose to the surface, principally in the "East" and "West" ciénagas. The West ciénaga lay along the west base of the Red Hills and the East ciénaga in a ravine which drains southward from a point east of the highest part of the mesa, but near the center of the outcrop of the red alluvium.

As the colonies dependent on these waters expanded, several devices were adopted for increasing the output of the water-bearing land.

The Y tunnel was driven into the hill east of the East ciénaga in 1886 and 1887. Another tunnel, three-fourths of a mile farther east, was driven into water-bearing ground in 1887 and 1888, and the Eddy tunnel was extended under the West ciénaga at about the same time. More recently, especially in the late nineties and since, many wells have been drilled and pumping plants installed to increase or to maintain the original supply.

The original ciénaga waters and the pumped waters which now take their place seem certainly to be derived both from the earlier and later alluvium. The ultimate origin of the water in each of these formations is the same—namely, the rainfall upon the San Gabriel Range, north of the Red Hills—but the courses which they follow to the point of development, or at which they originally issued, are probably essentially different. Nevertheless, waters from both sources were no doubt mingled in the old springs and are probably now mingled in some of the wells.

It is to be remembered that the Red Hills as a partially buried topographic feature act as a barrier against which the modern stream wash has been piled. (See fig. 2.) The waters which are percolating southward through this wash reach the barrier, rise behind it, and flow over it as springs, except where they are taken out by development before they reach the surface. Waters within the older formation, the red alluvium of the hills, enter the porous beds of this terrane at points near the base of the mountains, follow a deeper and presumably longer course entirely below the modern wash, and rise along the fold which is expressed by the Red Hills, to escape as springs or to be taken out before their escape by development. Important evidence of this difference in the courses followed by the two groups of waters is furnished by their temperatures. The waters of the east-side wells issue at temperatures of 70° to 72°; those of the west-side wells have temperatures of about 64°. This difference of 6° or 8° indicates that the former waters rise from regions 350 to 400 feet deeper than the latter, if the usual increment of 1° increase in earth heat with each 60 feet in depth is accepted as applying in this region. Inasmuch as the increase is probably less rapid than this in these unconsolidated gravels, it is likely that the difference in the

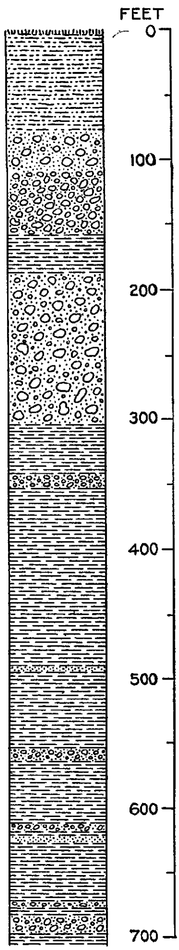


FIG. 5.—Section of Sunset Water Company's well (No. 54, Cucamonga quadrangle).

depth from which the two waters rise is greater than that given above. If this evidence of the temperature is accepted as a safe basis for a division of the waters, the Haskell wells (No. 79, Cucamonga quadrangle) and those farther east fall into the group which derives its waters from the Red Hills formation, the older alluvium; while those to the west derive their waters from the overlying modern wash. The location of the wells in areas which are recognized as respectively in older and in modern alluvium supports this evidence of the temperatures.

It is unlikely that the waters of the two groups are wholly distinct. Interchange probably takes place through leakage from one formation into the other. However, even though the separation is not entirely perfect, it is probably sufficiently definite to bring about certain differences in the behavior of the two groups of waters under the influence of development. The supply in the west-side wells may be expected to respond somewhat more promptly to wet and dry years than that of the east-side wells, whose waters follow a longer course through somewhat less pervious material to the point where they are pumped to the surface. In many places, also, the older gravel is less open and yields its waters less freely than the newer, so that individual wells are expected on the average to have a smaller capacity. The water developed from both formations in the vicinity of the Red Hills is probably supplied largely by the run-off from Cucamonga Canyon and the canyons farther east.

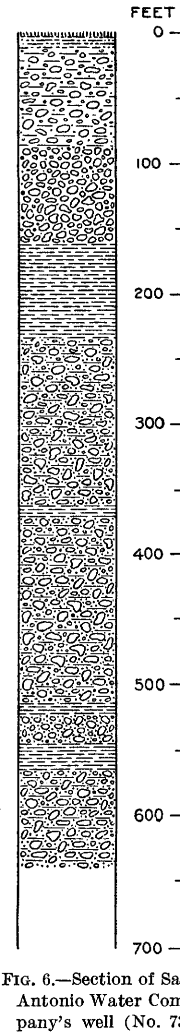


FIG. 6.—Section of San Antonio Water Company's well (No. 73, Cucamonga quadrangle).

SAN ANTONIO UNDERGROUND WATERS.

The area whose ground waters are supplied by run-off from San Antonio Canyon is so distinct and so important that it is best to accord it separate treatment. The Palomares, Del Monte, and Martin ciénagas, at one time prolific sources of artesian water and still yielding valuable pumped waters in large quantity, the Indian Hill group of wells, and another series of scattered wells near the San Gabriel foothills northwest of Claremont all draw the major part of their waters from the run-off of the San Antonio basin and the much smaller and less important basins of Thompson and Liveoak creeks. Their situation, which has been determined as most favorable by years of work in development, is in the belt through which practically all San Antonio waters must percolate. The peculiar position of the old Palomares ciénaga, on the high ground at the eastern point of the San Jose Hills and apparently not in the direct line of run-off from any of the important canyons, together with the abundant water supply which it has always yielded, makes it of especial interest. Practically all of the surface discharge of San Antonio Canyon now passes east of Claremont, and the run-off from the next large canyon to the west—San Dimas—is entirely westward toward the San Gabriel. The Palomares ciénaga is nearly on the divide between them. Apparently the only element in its situation favorable to the formation of an artesian basin is the barrier of the San Jose Hills back of it. Surface conditions alone would lead the student of the ground-water supply to expect the greater part of the San Antonio percolation to be well east of Claremont, but development proves that it is practically all west of a line which crosses the Santa Fe Railway about 1 mile east of the town.

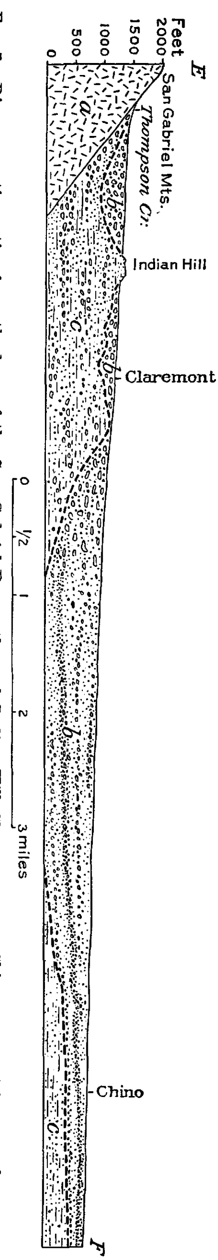


FIG. 7.—Diagrammatic section from the base of the San Gabriel Range through Indian Hill, Claremont, and Chino; *a*=granitic rocks; *b*, *c*=earlier and later alluvium and hypothetical boundary between them.

The true explanation of this diversion of the San Antonio percolating waters westward against the foot of the San Jose Hills, when their normal course apparently should be directly southward from the mouth of the canyon, is to be sought in the buried older topography (fig. 7), which has been discussed in part in the consideration of the Red Hills waters. The evidence furnished by well records, which is rather scant, and by water levels, also scant but yet more complete than the other, indicates that a barrier (a so-called "dike"), which is probably only a buried hill of the older alluvium, extends from the base of the spur east of the mouth of San Antonio Canyon southward and slightly westward in a gentle curve toward the south line of the Palomares ciénaga and the east point of the San Jose Hills. West of this curved line lie the producing wells of the district, with a water plane high enough, except at some points near the base of the mountains, so that the waters may be pumped readily; east of it are many dry shafts, or if water is encountered it is at a much greater depth than across this line. Underground waters from the Cucamonga Canyon are checked and held up so that they are accessible by the Red Hills and by buried northwest and northeast extensions of them, while the same effect is produced on the San Antonio Canyon waters by the buried ridge indicated above.

Between these two valuable water-bearing districts is an irregularly triangular area, with its axis perhaps a quarter or a half mile west of San Antonio avenue and its base extending along the Santa Fe tracks, in which ground waters are found only at depths too great for profitable development at present. This is presumably a valley in the earlier buried "Red Hills" topography, and the underground waters entering it across the buried ridges or "dikes" to the northeast and northwest sink at once to lower levels, much as surface waters are found at lower levels below a dam than above it.

The first waters taken from the old Palomares ciénaga (Pl. I, *C-D* and fig. 8) were waters which rose naturally under artesian pressure and supplied San Jose Creek. These waters were diverted into a ditch and used for irrigation as early as 1840. The use was not extensive, however, until the seventies, when the available amount was increased by developments consisting of drainage ditches cut into the ciénaga and of artesian wells. These wells continued to yield a supply until near the end of the decade between 1890 and 1900, when they gradually failed as a result of increased development and drought. Now all waters drawn from this original artesian basin are pumped. The smaller Del Monte and Martin marshes have had similar histories. They first yielded spring waters; then with the "development" of the water-bearing lands, short-lived artesian wells were procured and the springs dried out. Now all water used is pumped.

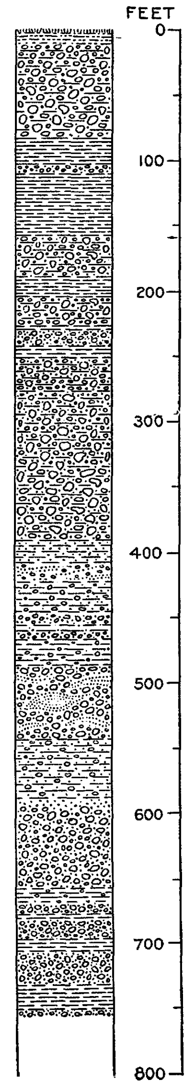


FIG. 8.—Section of Gird well No. 6, Palomares ciénaga (near No. 284, Cucamonga quadrangle).

CHINO ARTESIAN BELT.

All the waters which escape underground from the higher water-bearing lands to the north, all the return irrigation waters from the extensive irrigated areas about Pomona, Claremont, Ontario, and

Cucamonga, and the winter flood waters from the mountain canyons between Lordsburg and Etiwanda which are absorbed south of a line connecting the eastern part of the San Jose Hills and the Red Hills, percolate slowly southward toward Santa Ana River, the main drainage line of this part of the State.

In the vicinity of Chino and for 5 or 6 miles southeast of that town these ground waters are under sufficient pressure to rise to the surface when wells are drilled in the water-bearing sands. The area within which these rising waters are known to occur covered about 21.4 square miles in 1904. This represents a slight shrinkage from the maximum original area of approximately 23 square miles, when the basin was entirely undeveloped and rainfall in this part of the State was heavy. The southwestern rim of the basin is formed by the bed rock of the Puente Hills. Toward the northeast it is indefinitely limited by the rising ground of the Cucamonga Plains. Its southern edge, so far as it is revealed by development, is a rather difinite line that is probably determined by the shoaling of the basin in this direction, through the rise of its relatively impervious base toward the surface. This base seems to consist of an older gravelly alluvium, like the coarser phase of the Red Hills beds, but beneath this Tertiary sandstones and shales or granitic rocks such as outcrop near Corona would doubtless be encountered in sufficiently deep drilling.

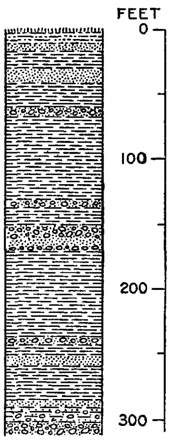


FIG. 9.—Section of W. P. Brown's well (No. 221, Cucamonga quadrangle).

Throughout this belt, as in most of the artesian districts, there are moist lands and springs that mark the points at which the waters under pressure below leak to the surface. Chino Creek and other small streams which drain the area do not show the usual shrinkage of southern California streams during the last decade, but on the contrary have maintained their flow or have increased it slightly. Santa Ana River at the narrows below Rincon has increased in flow from a minimum of 14 or 15 second-feet in 1888 to a minimum of 60 or 70 second-feet in 1904. This increase is accepted as one of the striking examples of the effect of return irrigation waters in adding to the volume of flowing waters below the irrigated lands during a dry period. Much of this increase is no doubt due to irrigation in the vicinity of Riverside, but an important proportion is also to be attributed to the steady application of water to the land in the colonies along the western margin of the Cucamonga Plains. A large part of this latter return water passes through the Chino artesian belt in its slow percolation seaward, and helps to account for the fact that this basin has exhibited less shrinkage during the trying years of drought which have just passed than other important artesian basins of this end of the State. It is also true that this basin has been less vigorously developed than others, chiefly because there has been difficulty in securing good titles to land on the old Chino rancho until recently. These two conditions, then, moderate development and favorable situation in relation to return irrigation waters, account for the fact that this basin is now in excellent condition so far as its water supply is concerned.

The Chino basin proper has not been explored to great depths by the driller, the deepest well being that belonging to Edward Lester (No. 36, Cucamonga quadrangle). It is 467 feet deep, and all the coarser strata are found above 390 feet. Most other wells within the basin are 300 feet or less in depth. (See fig. 9.)

The deepest well in the Cucamonga Plains, the Lorbeer well (fig. 10), just northwest of Chino, was drilled to a depth of 973 feet, but the record indicates that below 500 feet the drill pierced the older alluvium, consisting of red clays and cemented beds which yielded no water. Southwest of Chino, toward Santa Ana River, there are outcrops of slightly hardened gravel which seem to belong to the earlier alluvium. These scattered facts suggest that the filling of modern wash within the Chino district is a comparatively thin veneer, 500 feet or less in thickness, beneath which lie relatively compact older clays and cemented gravels which are dry or but meagerly water bearing. If this inference is correct, the value of wells drilled in this region in the future will not be increased by extending them in depth beyond 300 to 500 feet. The data are too incomplete as yet to state this as more than a probable condition. A few deep test wells drilled in the area extending 4 or 5 miles southeastward from Chino will give much needed light on the underground conditions.

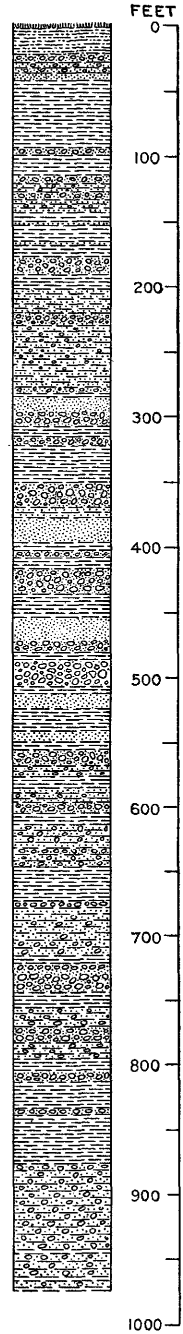


FIG. 10.—Section of Lorbeer well (No. 154, Cucamonga quadrangle).

The apparent shallowness of this basin, taken in connection with the rather irregular topography along its southern border in the vicinity of Saant Ana River, leads to the belief that its limits in this direction are due to the rise toward the surface of the dry older alluvium which forms the floor of the basin farther north.

SAN JOSE VALLEY.

The Puente and San Jose hills, which together constitute the northwestern extension of the Santa Ana Mountains, are separated by the valley of San Jose Creek. This stream is peculiar in that it rises not in the hills themselves but in the western edge of the Cucamonga Plains, whence it flows directly across the hill area through a restricted valley into the San Gabriel basin. It is believed to be a compound stream, resulting from a reversal of drainage caused by the growth of the San Antonio alluvial fan. The original divide between the eastward-flowing and westward-flowing elements of this compound stream seems to have been about 2 miles below Spadra. At that time the east end of San Jose Valley drained into the Santa Ana, and the west end drained as now toward the San Gabriel. With the growth of the San Antonio fan southward the original eastern outlet was blocked, slowly filled, and finally given a westward slope. The Palomares ciénaga probably originated with this growth of alluvial deposits and its excess waters became the source and principal feeder of San Jose Creek. Now, when there is a surface flow in this creek, its waters rise on the north slope of the eastern point of the San Jose Hills, flow westward around the point of the hills, and double back into the San Jose Valley, giving a very tortuous alignment to the upper portion of the stream.

The sand and gravel filling in the eastern portion of the San Jose Valley in the vicinity of Pomona is rather deep; wells have been drilled here to depths between 300 and 400 feet without reaching bed rock. Near Spadra are wells between 150 and 300 feet deep which do not reach the rock bottom of the valley, but others much shallower near the borders of the area encounter rim rock, the "hill formation," as it is locally called. In the vicinity of Lemon bed rock seems to be near the surface of the valley. In the Howell well and tunnel the hill shales are found at a depth of 35 feet, but the McClintock, Lee & St. Clair well, 1 mile farther south, failed to reach rock at 100 feet. From this neighborhood westward the valley presumably deepens gradually until it unites with the main San Gabriel basin below Puente. Its underground water supply, while replenished in part, of course, by local run-off from the surrounding hills, has been fed in the past to an important extent by the excess from the Palomares ciénaga, which San Jose Creek drains, and that supply has, with but little question, been adversely affected by the extensive drafts on this ciénaga for irrigation about Pomona.

SAN DIMAS DISTRICT.

DEVELOPMENT.

West of the Cucamonga Plains and between the San Jose Hills and the base of the San Gabriel Range is an area, extending westward to San Gabriel Wash, which has been growing steadily in importance in recent years as a productive citrus district. It includes the towns of San Dimas, Covina, Glendora, and Azusa, with their surrounding tributary horticultural belts.

The preservation of the citrus acreage planted previous to 1897 and its extension since have been accomplished here, as in most of the orange-growing sections of the south end of the State, by the development of underground waters. To bring about this result many important wells have been put down during the last decade. This development has been particularly extensive in San Dimas Wash because valuable lands about Glendora and Covina could be conveniently served by these waters, and on the mesa lands about Laverne because this region is especially adapted to citrus culture and is not served by gravity waters from either the San Gabriel or the San Antonio system. The flowing waters from the smaller canyons between these two streams are of course utilized, but the flow from them ceases or seriously diminishes during the heated term, and must be augmented by ground waters to provide for the continuous irrigation which citrus fruits require. This development has resulted in the accumulation of a considerable mass of evidence on underground conditions, and inasmuch as a large acreage is dependent on waters obtained by pumping, great interest is felt by the dependent communities in the conditions which the developments reveal.

SURFACE CONDITIONS.

The red mesa lands, which represent the older topography of the Indian Hill and Red Hills type, are widely distributed in this narrowest part of the valley between the San Jose Hills and the San Gabriel Mountains. They form the mesas on either side of San Dimas Wash, which is, indeed, a canyon cut in this older alluvium and then partially refilled by the modern stream dêbris; they extend from San Dimas eastward beyond the mouth of Liveoak Canyon and southward toward Laverne and Lordsburg. In the latter direction their surface extent can not be determined with accuracy because they are mantled by the later alluvium, and the soils derived from the two formations are very commonly so much alike that they can not be distinguished. The obscurity is increased where the older mesa formation is coarse and gravelly, as it is in numerous places near the mountains. In many such places its red color is wanting and it is to be distinguished from the latest wash only by its distribution and by a slight induration, which although very imperfect is usually somewhat greater than that of the later gravels. North of San Dimas Wash a bench of the red clays, in many of the exposures very typically developed, extends eastward from the point of the hill south of Glendora to the base of the main range. Between Azusa and Glendora a fringe of this formation flanks the mountain base. In these described areas it forms the actual surface; over other sections it is probably not deeply buried. For example, it presumably underlies the entire area about the head of Walnut Creek, extending from Laverne, San Dimas, and the country to the west, southward to the San Jose Hills, and it may underlie much of the Glendora district at slight depths. It should be understood clearly that these red clays and gravels were distributed just as the clays, gravels, and sands are being distributed to-day over their channels by the San Gabriel and other streams. In both cases the material laid down is simply the ground-up rock brought by the streams from their mountain canyons, and the total quantity of earlier and later wash is equal to the amount removed by the streams in cutting the canyons.

The important facts about the older alluvium are that in certain areas it has been uplifted since its deposition and that time enough has elapsed to permit it to be eroded by the streams since its uplift, so that an irregular topography has been produced in it. There are hills here and valleys there, canyons in one area, mesas in another, and these have all been smoothed over and partially buried by the modern stream wash. We do not know this older topography, therefore, in detail. We see only here and there a hilltop or a broad mesa standing above the modern wash. The rest of the red alluvial hills and valleys are buried beneath it. In many areas, however, they manifest themselves distinctly in the influence that they exert on the circulation of the ground waters. While this influence is marked, it is not everywhere complete, because the old alluvium is not impervious. A ridge of it buried in the later alluvium may therefore not entirely deflect the waters percolating through the latter, although the difference in porosity is in many places great enough to make the deflection nearly complete.

Both the older and the younger alluvial deposits exhibit the irregularity which is characteristic of the alluvium everywhere. Both have their coarse and their fine phases, their pervious and their impervious lenses and strata. This fact increases the difficulty of distinguishing between them, because though, taken all in all, the modern wash is more open and permits of freer circulation of ground waters than the older wash, yet many of the better beds in the older wash may be superior to the poorer beds in the modern wash in this important respect. Both are water bearing, and under favorable conditions good wells are procured in each, but the greater number of better wells are drilled in the modern gray wash, and in many places the older alluvium is dry.

UNDERGROUND CONDITIONS.

The extensive developments about Lordsburg and Laverne and in San Dimas Wash have brought to light certain important phases of the underground conditions. Bed rock has been found in enough of these wells to give a hint as to the depth of the alluvial filling and the downward limits of water-bearing gravel. A well which has been mentioned before, belonging to the Irrigation Company of Pomona (No. 182, Pomona quadrangle), enters bed rock at a depth of about 800 feet; that is, at 160 feet above sea level.

In one of the Covina Irrigating Company's wells south of Lordsburg the drill entered lava, similar to that which outcrops in the hills farther to the south, at 244 feet from the surface, although other wells of this group which were drilled 150 feet deeper are in alluvium to the bottom.

In the recently drilled Peyton well (No. 247, Pomona quadrangle; see fig. 11) a granite bed rock, first encountered at 538 feet from the surface, was penetrated for nearly 100 feet. Bed rock here stands at something more than 600 feet above sea level and in the Covina well at about 750 feet.

The San Dimas Irrigating Company's wells on the site of the old "Mud Springs" ciénaga reached a shale bed rock at about 200 feet below the surface; that is, at about 800 feet above sea level. These and the Covina wells are near the south rim of the valley.

At the bottom of wells Nos. 208 and 210, owned by Baker & Son and by N. L. Sparks, a lava bed rock was found at 330 and 300 feet, respectively, below the surface; that is, at a little less than 900 feet above sea level. North and south of San Dimas Wash are bed-rock hills of shale, sandstone, and lava, and wells drilled near these knobs strike the same rock formation at slight depth. The Deacon wells, belonging to the Covina Irrigating Company, are of this type. Of the wells mentioned none are in the center of the valley, where bed rock is probably deepest, although the Peyton well, north of Lordsburg, is not far from the center. A number of the San Dimas Wash wells are more than 500 feet in depth (fig. 12), and so far as reported, in no well except those of the Deacon

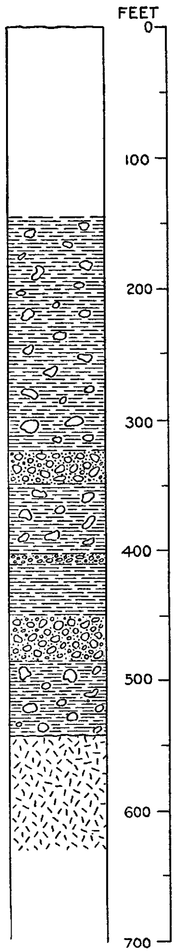


FIG. 11.—Section of Peyton well (No. 247, Pomona quadrangle).

group, drilled near the base of a bed-rock mound, was rock found in place. It seems unlikely, however, that bed rock is more than 1,000 feet below the surface in this vicinity. The buried bed-rock surface, it is to be remembered, is probably quite as irregular as that part of it which lies above the alluvial filling. It consists of ridges, knobs, and valleys, so that the depth to it will not be uniform and can not be predicted with exactness at any point. The records of the wells which have been mentioned support the opinion that would be formed by a mere inspection of the topography, namely, that bed rock lies closer to the surface in this narrow belt, where the Coast Range approaches nearest to the base of the San Gabriel Mountains, than in the broader San Gabriel Valley to the west or in the wide Cucamonga Plains to the east.

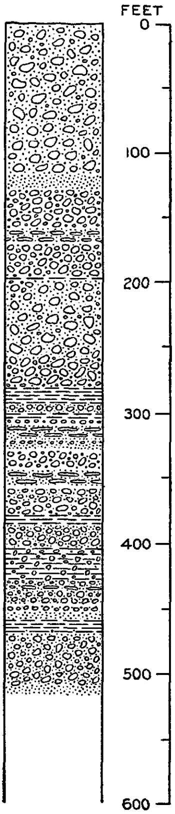


FIG. 12.—Section of Western Water and Power Company's well (No. 233, Pomona quadrangle).

The greater part of the sands, gravels, and clays in the San Dimas area belongs, as has already been indicated, to the older alluvium, the "Red Hills formation," as it is locally called; but in San Dimas Wash itself a fairly deep canyon has been cut into this older wash and then partially filled again by the loose sands and gravels brought out by the stream (fig. 13). The walls of the unfilled portion of this older canyon limit the mesa north of San Dimas and Laverne.

The depth of the loose modern filling in the wash seems to be only about 100 or 200 feet. Below that depth some of the wells encounter red clays which presumably belong to the older alluvium that forms the walls of San Dimas Wash.

The depth to bed rock in the wash is of interest to irrigators because it determines the final lower limit from which irrigating waters can be drawn. None of the owners who have put down wells near the middle of the wash, where the freest water-bearing gravels are found, have reported bed rock, although it has been reached in a number of the wells near the southern edge. In view of the restricted character of the middle valley of the San Dimas and the fact that it is only about 1 mile from rim rock on the south of the wash to rim rock on the north, near the town of San Dimas, it is manifest that bed rock can not lie at great depth below this part of the stream bed.

North of Laverne the valley is broader and may be deeper, since its bottom is probably irregular, but the greatest depth to bed rock here is probably beneath the mesa in the old alluvium, while the principal producing wells lie in the wash within less than three-fourths of a mile from the northern rocky border of the valley. If the general average slope of this mountain rim, a slope of 1,000 to 1,500 feet per mile, is maintained beneath the wash, as it probably is, then bed rock is to be expected at less, probably at considerably less, than 1,000 feet from the surface in that part of the wash where development is most intense.

The great value of the gravels which have been pierced here is due to their coarseness, openness, and looseness, and the consequent freedom with which they yield the water that they contain, and the readiness with which they are recharged after having been heavily pumped.

The San Dimas area forms the extreme eastern extension of the San Gabriel Valley, but has been discussed as a separate district because of the intensity and importance of its development, and because, as it stands near the divide between the San Gabriel Valley

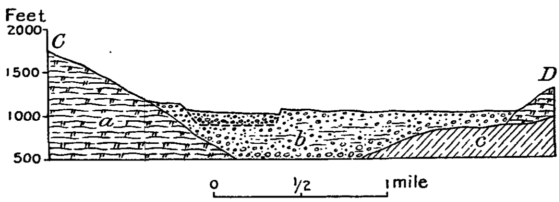


FIG. 13.—Diagrammatic section across San Dimas Wash; *a*, lava; *b*, alluvium; *c*, shale.

and the Cucamonga Plains, underground conditions are unlike those in either of the latter areas.

SAN GABRIEL VALLEY.

Westward from San Dimas the valley of San Dimas Creek gradually opens out into the San Gabriel Valley proper, which extends as a wide plain with a gentle slope toward the south to the San Rafael Hills beyond Pasadena. San Gabriel River at the mouth of its canyon discharges upon this plain and leaves it through the Paso de Bartolo, a dozen miles to the southwest. Throughout much of the year its channel across the plain is a dry wash, but during the period of the winter rains a surface stream often extends entirely across the valley. At other seasons the water which reaches the inner edge of the plain from the canyon sinks and crosses the valley by percolation underground. Water always rises in and near the Paso de Bartolo in springs, which feed Rio Hondo and the San Gabriel and thus supply the canals which head here with irrigating water. So far as known, this central portion of the basin is a simple broad valley of deformation, whose bed-rock bottom may be several thousand feet below the surface.

That part of the San Gabriel Valley, however, which lies north and west of a line connecting South Pasadena with the spur of the San Gabriel Mountains between Santa Anita Canyon and Monrovia, is a distinct province so far as its underground waters are concerned. A fold in the late strata which form the valley filling, a fold which in places expresses itself topographically as a ridge or a series of knobs, here forms an effective underground barrier to the waters that are percolating toward the axis of the valley from the northwest, and so makes of this northwestern tract a distinct area, which will be spoken of as the Pasadena Basin.

In the central part of the San Gabriel Valley development has not as yet been very intense. The cultivable lands along the northern edge, particularly those east of San Gabriel Canyon, are irrigated largely by canals which take gravity water from the canyon. There are a number of successful wells west of the wash close to the foothills, where soils are good, but farther south is a wide area of rough land which has little agricultural value and beneath which the water plane lies at considerable depths. Still farther south, toward Bassett and Elmonte, the soils are finer and more productive, and the water plane lies nearer the surface, so that the development of underground waters is less expensive. In this area they are more generally used. The Paso de Bartolo is the water gap through which the San Gabriel Valley waters are discharged upon the coastal plain. It is less than 2 miles wide, and its depth is not known, although the topography and the records of wells drilled in the pass indicate clearly that the depth must be considerable, perhaps 600 or 800 feet. The valley to the north is doubtless much deeper than this, and the rise of the ground waters in the pass is due to a combined lateral contraction and shoaling of the basin, so that the cross-section of the field through which the waters are percolating is very much lessened, and they are forced out as surface flows. The waters which accumulate here above the pass and escape through it, either over the surface or beneath it, include all the waters that drain into the San Gabriel Valley from San Dimas westward to Pasadena, except those that evaporate from the water or soil surfaces. The greater portion of the subsurface circulation of even Arroyo Seco probably escapes to the coastal plain by this route, although its surface waters join the Los Angeles River system at Los Angeles.

The greater San Gabriel basin, in which the absorptive gravels occur, is a constructional valley of the type almost universal in southern California. It is one of the more extensive of the basins of this type, and its dimensions are difficult to estimate. Wells are not numerous except near the southern margin, and these are generally of depths so moderate that they give no clue to the position of the bottom of the basin. One exception is to be noted. The test well of the East Whittier Land and Water Company, just west of San Gabriel Wash and north of the Southern Pacific tracks, has been extended to a depth of 1,260 feet. Throughout this distance the drill penetrated only alternating sand, gravel, and clay strata. The coarsest beds were found between 70 and 350 and between 570 and 780 feet from the surface. Below 780 feet coarse strata are unusual and clay predominates, but the bottom of the well is in unconsolidated material, bed rock not having been reached.

Wells 300 feet deep in the narrowest part of the Paso de Bartolo likewise failed to reach bottom, so that this outlet of the San Gabriel Basin has been depressed since it was cut by the stream until it stands below sea level. Just below and west of the pass, on the inner slope of the coastal plain, is a 500-foot well which penetrates alluvium throughout.

At Elmonte a well belonging to the Southern Pacific Company is 480 feet deep, and of course is in alluvium to the bottom. Other wells from 300 to 500 feet deep in the vicinity of San Gabriel and Savannah record the same conditions.

East of the San Gabriel and 3 miles north of Puente is a well belonging to Edward Fickewirth which is 850 feet deep (fig. 14). The record shows only an alternation of sand, clay, and gravel strata, but some of the gravel is reported to be cemented and may belong to the Pliocene rocks, which outcrop in the Puente Hills only a mile away. Shallower wells near this one are reported to yield more freely. In general the developments have furnished no evidence which will permit a direct estimate of the position and character of the rock floor of the San Gabriel Valley. It certainly lies well below sea level, not less than 1,000 feet below at the East Whittier pumping station, where the land surface has an elevation of about 300 feet. Without exploration to it, statements as to its position can have little value. The basin is too broad and irregular in outline to make projection of the slopes of the bordering hills a safe guide to the position of bed rock beneath the surface, and the existence of a fault or fault zone of great magnitude along the northern border adds to the uncertainty of the bed-rock position in this direction. It is highly probable that the depression of valleys of this type has been gradual, and that the filling by unconsolidated materials has also been gradual, since it has, no doubt, accompanied the depression and has probably kept pace with it. The more deeply buried sands and gravels are therefore the older, and their consolidation is likely to be more thorough. It is quite possible that alluvial sedimentation of this type began toward the end of the Tertiary period, which is represented in the folded conglomerates, shales, sands, and clays in the Puente Hills, and that it has continued with more or less regularity since. If this is true, bed rock beneath parts of the valley, at least, will not be a distinct and easily recognizable feature.

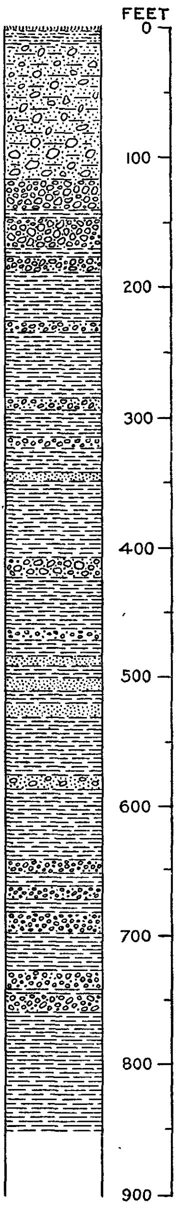


FIG. 14.—Section of Fickewirth well (No. 99, Pomona quadrangle).

Instead, in deep drilling, the late alluvium would gradually become more compact with depth until it passed by imperceptible gradations into bed rock of the type which outcrops in the Puente Hills.

Wherever granitic islands stood up from the deeper-lying granitic basement, however, and were finally engulfed only in the latest accumulations of alluvium, they may be encountered by the drill in its explorations, and then a perfectly distinct and definite bed rock will be recognized. Such a granitic island which projects above the present surface is to be found in Monk Hill, Pasadena, and others which lie beneath this surface are more likely to be encountered in drilling near the northern and western than near the southern and eastern edges of the basin.

PASADENA BASIN.

The Raymond Hotel stands on the crest of a hill near the southern edge of Pasadena. The axis of this hill is an overturned anticline of Miocene sandstones and shales. (See fig. 16.) North of east from the hotel are a series of low knobs and abrupt changes in the valley slope, which extend toward the spur of the San Gabriel Range that lies just east of the mouth of Santa Anita Canyon. At some points along this line the knobs and the steepening slope which are the surface evidences of certain significant underground conditions are conspicuous. At other points they are insignificant, but even here the topography is usually uneven and the zone along the upper edge of the "dike" is marked by dark peaty soil.

The behavior of the underground waters which are seeking an outlet by percolation southeastward from the Pasadena Basin toward the main San Gabriel Valley is even more significant of underground conditions along this line. Above it ground waters lie near to the surface or flow out over the surface in certain places. Below it they lie more than 100 feet lower. The condition is similar to that above and below a surface dam, the water level being much higher above than below because of the impermeable barrier between. Over the face of this subterranean dam, the Raymond Hill dike, the ground-water level has a steep grade, as surface waters have a steep fall over the crest of a surface dam. Above the dike percolating waters are checked in their southward movement and accumulate under pressure where proper physical conditions exist, so that they are artesian.

The greater number of the wells of the Pasadena Basin are located along a zone just above this dike, for the waters here are much more accessible than elsewhere in the basin. A few important wells, all of which, however, involve high lifts, have been installed in a subdivision of the main Pasadena Basin, near its northern edge, which may be spoken of as the North Pasadena Basin. Among these are wells belonging to some of the Pasadena water companies in the neighborhood of Las Casetas and Marengo.

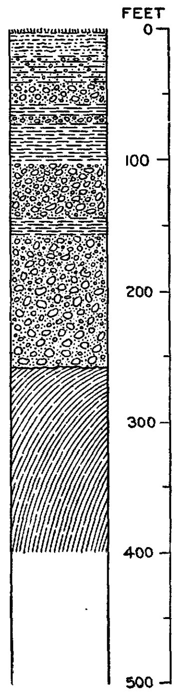


FIG. 15.—Section of Graves & Bean well (No. 449, Pasadena quadrangle).

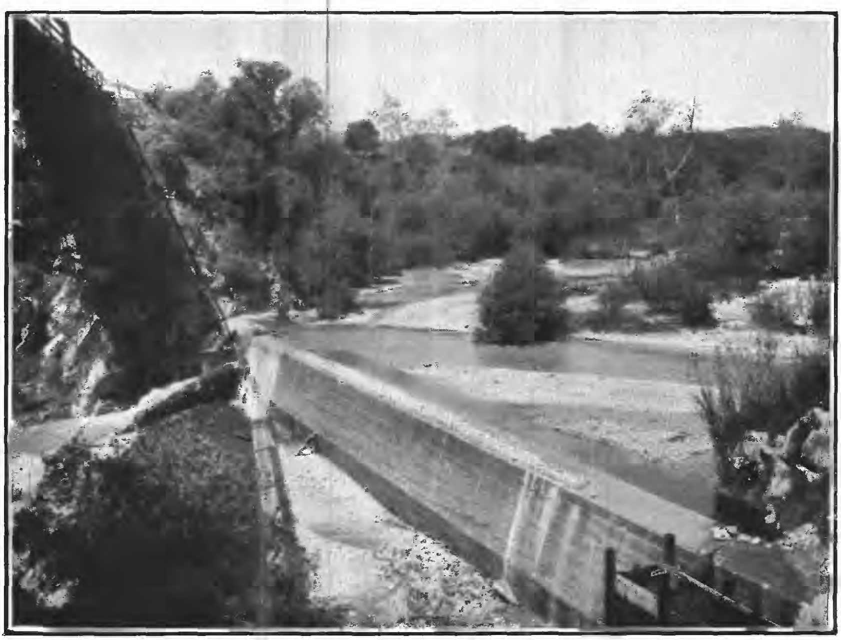
On the mesa just northwest of Devils Gate one of the Pasadena Lake Vineyard Land and Water Company's wells (No. 434, Pasadena quadrangle) is 614 feet deep and does not reach bed rock, although rock outcrops in Arroyo Seco, only a mile away. This illustrates the steepness of the buried bed-rock slopes in this part of the Pasadena Basin. They are probably comparable in steepness with the mountain slopes to the north of the valley. The record of this well indicates a very common succession of sand, gravel, clay, and bowlders to 560 feet. Below that point the proportion of what the driller calls "rock," a term which he generally applies to very coarse material, increases and continues to the bottom of the boring. It seems unlikely that bed rock lies at a great distance below the bottom of this well.

Monk Hill (fig. 16), in North Pasadena, is a bed-rock outcrop which is clearly a southeastward continuation of the spur of the San Rafael Hills through which Arroyo Seco has cut at Devils Gate. This partially buried ridge is thus an eastward extension of the south wall of La Cañada Valley. Its presence is clearly indicated not only by the accumulated underground waters north of it which have been utilized with such success in the Devils Gate developments of the Pasadena companies and the wells about Las Casetas station, and by the much greater depth (200 feet or more) at which waters are found below it, but also by the records of wells Nos. 74 and 74a, which are reported to have reached bed rock at 135 and 146 feet, respectively, from the surface. These wells lie between Monk Hill and the granitic outcrops in Arroyo Seco below Devils Gate (Pl. II, *A*) and furnish practically conclusive evidence that a continuous bed-rock ridge lies buried under the alluvium between these two points. The effect of this barrier is to check the southward movement of the underground waters which accumulate above Devils Gate, and to force them to make a long detour to the eastward around Monk Hill before continuing southward. They are thus thrown into the San Gabriel drainage basin instead of being tributary to that of Los Angeles River as are the flood waters of Arroyo Seco. An underground barrier thus changes entirely the route followed by the underground circulation of the upper course of the stream, and we have the interesting spectacle of the surface flood waters of a drainage basin flowing seaward by way of one river system, and the underground waters seeking the same destination by another route.

Before the Devils Gate developments were undertaken, some of the surplus underground waters which were held behind this Monk Hill barrier rose to the surface at Devils Gate in the series of springs which formed one of the important original sources of Pasadena water. This surplus is now taken out by the tunnels and wells and the springs have ceased to flow. It is safe to say also that more water may be continuously developed by this system than the springs originally yielded, because much was lost by evaporation in the moist lands about the springs under the original conditions, and also because a part of the surplus which originally no doubt found its way eastward around Monk Hill is probably now brought out by way of the tunnels and wells. At the Sheep Corral springs, as at Devils Gate, Arroyo Seco cuts through a spur of the San Rafael Hills so that its canyon becomes narrow, with rock walls and bottom impermeable to percolating waters. These waters are thus forced to the surface—or were before they were intercepted by development work—and appeared as springs. The situation is less favorable here than at Devils Gate because the Monk Hill bed-rock ridge deflects much of the ground waters eastward away from Sheep Corral, and it is probable that the developments there are supplied in an important measure, perhaps almost entirely, by those Arroyo Seco flood waters which are absorbed in the wide part of the arroyo which lies between Devils Gate and Sheep Corral. At both points submerged dams have been built to bed rock across the narrow part of the arroyo to hold back the underground waters or to force them to the surface. (Pl. II, *B*.)

One of the group of four wells belonging to the East Pasadena Land and Water Company on Franklin avenue and California street is 736 feet deep, its bottom being almost at sea level. It is nearly a mile north of the dike and in its record there is no trace either of the sandstone which underlies Raymond Hill or of the crystalline

A. DEVILS GATE.



B. SUBMERGED DAM ABOVE DEVILS GATE.

rocks which appear in the vicinity of the Sheep Corral springs. Sand, clay, and gravel, such as constitute the general basin filling, are reported clear to the bottom of the boring.

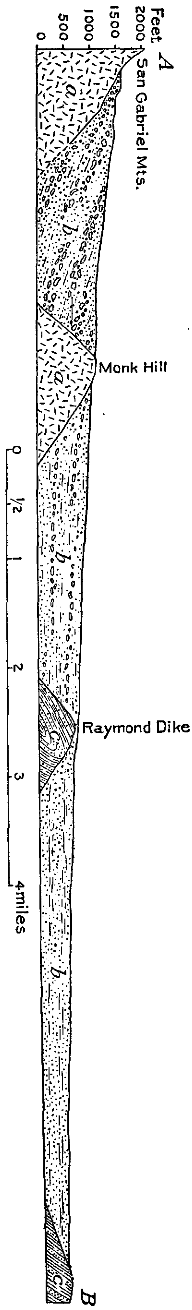


FIG. 16.—Diagrammatic section across San Gabriel Valley from Millard Canyon through Monk Hill and Oak Knoll: *a*, granitic rocks; *b*, alluvium; *c*, sandstone and shale.

The deepest well reported in the Pasadena neighborhood is one drilled on the Hurlburt place near the south end of the city, just east of Orange Grove avenue. The depth given is 1,300 feet, and it is stated that much of this distance was bored through "granite." Details are not available, however, and as the well is near the western border of the basin, where bed rock is to be expected at comparatively shallow depths, it has no especial significance. A few of the wells drilled near Raymond Hill, as for instance No. 53, belonging to the Euclid Avenue Water Company; No. 448, belonging to the Pasadena Land and Water Company, and No. 449, of the Graves & Bean system, reach the shale or sandstone which appears at the surface about Raymond Hill, but is buried farther east. Other wells drilled farther east along the dike, while numerous, are usually shallow, do not reveal the existence of bed rock, and throw comparatively little light on underground conditions. If the consolidated sandstone and shale beds continue to form the core of the dike in this direction, they lie deeper than the drill has yet reached. But the dike is none the less efficient as a dam, and even in those areas where the only surface outcrops are unconsolidated gravels a comparison of the water levels above and below its line indicates that clays or other impervious materials must form its axis. Folds of this character in beds which are very recent are not at all unusual in this part of the State, and they have an important and significant relation to several of the most prominent artesian areas. The San Bernardino artesian belt, for example, is limited on the downstream side by the Bunker Hill "dike," an anticline in late clays very similar to that which extends eastward from Raymond Hill. The great coastal-plain basin also is limited on its seaward side by a broad broken ridge, which is the surface expression of a gentle arch in the coastal-plain sediments.

All these gentle anticlines are very late features, geologically, and are most important factors in the storage and development of California ground waters.

FLUCTUATIONS IN GROUND-WATER LEVELS.

EVIDENT EFFECTS.

It is probable that ground-water levels in the basins of southern California were highest in the early nineties, at the end of the decade of heavy rainfall which included the exceptional seasons of 1883–84, 1885–86, 1889–90, and 1892–93. The recurring wet winters of this period and the fact that at that time comparatively little development of underground waters had been undertaken, so that there was practically no artificial drainage, were favorable conditions for raising the saturation level of the sands and gravels.

The southern California artesian areas occur in the subterranean basins wherever a favorable alternation of coarse and fine material, a sufficient water supply, and a barrier against which the waters can accumulate are found together. These favoring circumstances are to be sought along the lower edge of the various basins, nearly all of which contain areas that yield such flowing waters. The greatest combined area of the artesian water-bearing lands in southern California was 375 square miles, and while a very definite date can not be fixed for this maximum, it probably occurred in the early nineties. By 1904 there had been a contraction of one-third—to 250 square miles. Much of this contraction was due to the lessened rainfall of the last six or seven years of the nineties, but inasmuch as, in some of the basins at least, shrinkage continued during the four years following 1900, when the rainfall throughout southern California was about equal to the average, this shrinkage must be attributed in part to drainage of the reservoirs by pumping plants and artesian wells.

Ground-water levels in the various basins offer better evidence than changes in artesian areas as to the effect of drought and development on the level of the plane of saturation. For certain areas outside of the foothill belt such evidence of this character as is available has been discussed in preceding reports.[a] It may be stated here, however, that records kept by Mr. Neff, near Anaheim, indicate that in that particular region the underground waters are being drawn out by the numerous pumping plants more rapidly than they are restored by natural processes during years of more than average rainfall. A similar conclusion is forced on the student

[a] Water-Sup. and Irr. Papers Nos. 137, 138, 139, and 142, U. S. Geol. Survey, 1905.

of conditions in the San Bernardino Valley, where the artesian basin is smaller and somewhat more complete records are available.[a]

In the foothill belt no long-continued observations of ground-water levels have been made. A series of such observations has been begun by the United States Geological Survey, and in time they will furnish accurate criteria from which to judge the effects of the intensive development which the favorable character of the citrus lands there has induced. As yet no far-reaching conclusions can be drawn from them, but such evidence as they present will be discussed.

Although in this area continuous measurements on ground-water levels are not to be had, certain important facts in the history of the artesian belts are available. In the first place it needs to be reiterated that various parts of the foothill belt constitute separate and independent water basins, and that the fluctuation of the ground-water levels in each of these basins depends on local rainfall or contributing local run-off and local developments, and is not necessarily similar to the fluctuation in an adjacent area. Thus the Cucamonga Plains east of the San Jose Hills are to be regarded as one province, San Dimas Wash as another, the lower San Gabriel basin about Elmonte and Bassett as another, the North Pasadena Basin above Devils Gate as another, and the lower Pasadena Basin above the Raymond Hill "dike" as still another. The developments in some of these basins may affect the supply somewhat in others, but this effect is on the whole slight. For instance, excess waters from both the Pasadena basins and from San Dimas Wash have always drained toward the Elmonte basin, and have made small contributions to the supply there, but inasmuch as far the greater part of this supply comes directly from San Gabriel Canyon, the effect on the Elmonte water levels of developments at Devils Gate or San Dimas is negligible. A more pronounced effect of this sort is to be observed in the result in the San Jose Valley of developments in the old Palomares ciénaga above Pomona. At a time preceding the settlement of the valley San Jose Creek was a summer stream, fed by the waters which rose as springs in this ciénaga. After the settlement these waters were diverted for irrigation, and San Jose Valley was thus deprived of a part of its normal supply. Similarly all developments in the San Dimas pass about Lordsburg probably affect in a small but indeterminable measure the ground-water supply east and west of that locality, in areas toward which these waters would drain if not disturbed. All of these effects are in part, and some, perhaps, are wholly, neutralized by the return waters which seep down from the irrigated lands.

[a] Water-Sup. and Irr. Paper No. 142, U. S. Geol. Survey, 1905, pp. 56-67.

The principal original artesian areas of the foothill belt were the Pasadena Basin, a long, narrow area just above the Raymond "dike;" the area 3 miles south of San Gabriel, in which were three or four weak flowing wells; the Palomares ciénaga, above the eastern point of the San Jose Hills; the Del Monte and Martin ciénagas, near Claremont, and the "east" and "west" ciénagas, in the Red Hills. Water rises to the surface naturally in but two of these areas at present; in the others a heavy lift is required to bring it out to the level of the heads of the ditches. The effect of development and drought here is even more pronounced than that observed in the coastal plain or the San Bernardino Valley, where continuous measurements of the decline in ground-water levels indicate that drafts at present are excessive. In the Palomares ciénaga water rose to the surface as late as 1900 in some of the stronger wells, and much artesian water was available there two or three years before this date. In 1905 the ground-water level in the heart of the old area of flow was 35 feet or 40 feet below the surface, and in some of the wells which were once artesian the water stood 60 or 70 feet below the surface. Tunnels at 50 to 100 feet below the surface now tap the waters of the East and West ciénagas in the Red Hills district, and the gravity flow, even at these levels, is small.

MEASUREMENTS.

In order to obtain definite data on these phenomena of changing water levels the United States Geological Survey has selected a number of wells in various localities for regular measurement.

WELLS NEAR POMONA.

In the vicinity of Pomona two wells thus selected belong to the Gird group near the east end of the old Palomares ciénaga. The measurements thus far made are given below.

Measurements of fluctuation of water level in wells near east end of old Palomares ciénaga.

Date.	Depth to water. Well No. 284. Ft.	in.	Depth to water. Well No. 299. Ft.	in.
1904.				
September 7	75	2	76	2
October 6	75	4½	77	2
November 16	74	6	76	5½
December 13	74	3	76	2½
1905.				
January 11	68	10½	70	5½
February 20	66	1	67	8½
March 10	65	11	67	5½
April 14	63	11	65	7½
May 17	62	11	64	5
June 22	66	8	68	2
July 20	70	10	72	8
1905—Continued.				
August 16	71	11	73	9
September 21	73	5	75	3
November 11	70	4½	71	5
December 20	67		68	8
1906.				
January 26	64	9	68	6
March 14	62	10	67	4
May 8	62	5	62	½
June 26	64	5	65	10
August 1	67		68	1
September 24	67	½	68	3
December 10	64	3½	65	8

These two wells are near together and their measurements are very similar throughout. Each shows a gain between the September measurements of 1904 and 1905, and a more pronounced gain when the water level in September, 1906, is compared with that of September, 1905. The period spanned by the measurements includes only two high-water dates—May, 1905, and May, 1906—and a slight gain is indicated at the later period, the gain being more pronounced in well No. 299 than in its neighbor. Well No. 284 is within 100 feet of one of the Gird wells which flowed until 1896. The sharp rise in the water plane in these wells between the measurements of December, 1904, and January, 1905, is probably to be attributed to the cessation of pumping in the vicinity at this time; and the almost equally sharp fall between the May and June measurements of the following spring marks the vigorous opening of the summer pumping season. If any two dates a year apart are selected in the table, it is seen that the water level has risen by amounts ranging from a few inches to as much as 7 feet in the interval, so that in this part of the basin the heavy rainfall of 1904–5 and 1905–6 has resulted in a marked improvement in conditions. As the water level fell at an average rate of 7 to 8 feet per year during the decade from 1896 to 1906, improvement is welcomed.

A well near the western edge of Pomona, owned by B. Linnastruth (No. 12, Pomona quadrangle), has been measured since December 19, 1904. The results are as follows:

Measurements of fluctuation of water level in Linnastruth well, near Pomona.

Date.	Depth to water.		Date.	Depth to water.	
	Ft.	*in.*		*Ft.*	*in.*
1904.			1905—Continued.		
December 14	90	6½	November 12	93	4
1905.			December 21	93	6
January 12	90	9	1906.		
February 21	91	1	March 15	92	6
April 15	91	5	May 9	94	6
May 17	91	6½	June 27	93	6
June 22	92		August 2	95	6
July 21	92	10½	September 25	96	
September 23	93	6	December 11	95	2

This well is unfavorably situated, in that it lies below the majority of the strong pumping plants of the Pomona neighborhood and away from the storm-water channels, so that it gets the full adverse effect of heavy pumping and but little of the beneficial effect of the flow in the flood channels. The result is that there has been an almost uniform slow decline since the beginning of measurements; the water plane in December, 1906, being 4 feet 7½ inches lower than in December, 1904. During only four of the thirteen intervals between measurements was there any recovery whatever, and the greatest of these, which took place between the May and June measurements, 1906, registers an improvement of only 1 foot.

WELLS NEAR SAN DIMAS.

In the years following 1896 San Dimas Wash attracted attention because of the ease with which water could be developed in it, and because of its elevation, which made it possible to conduct the water by gravity to the citrus lands in the Glendora and Covina neighborhoods. In 1896, when the first plant was installed by J. O. Enell, the ground-water level was within 44 feet of the surface; but with the continued installation of plants and continuous pumping during the dry years the water plane was drawn down to about 135 feet in 1905, and when all the pumping plants are operating, it may be temporarily lowered below 200 feet in this immediate vicinity. Details of this decline are not available. United States Geological Survey measurements have been maintained about two years, and they indicate that during that time there has been a gratifying improvement in conditions in the wash, due directly to the increased rainfall within the San Dimas watershed and the consequent added quantity of water which has been absorbed by the gravels there, and to the increase in gravity waters in other near-by canyons. Since many of the irrigating systems use pumped water only to augment their gravity supply, this increase has greatly reduced the drafts on the San Dimas basin by the pumping plants established there.

One of the wells selected for measurement (No. 246, Pomona quadrangle), belongs to E. Firth, and is situated half a mile west of the principal group of pumping stations and about 50 feet below them. It is far enough away from them not to be greatly affected by the fluctuations due to the starting and stopping of pumps, and so records the general rise and fall of the ground-water level. The record is as follows:

Measurements of fluctuation of water level in Firth well.

Date.	Depth to water. Ft.	in.	Date.	Depth to water. Ft.	in.
1904.			1905—Continued.		
September 7	110	6½	August 16	105	10
October 7	111	7	September 21	106	7½
November 16	113	2	November 11	108	1½
December 13	113	11	December 20	109	1
1905.			1906.		
January 11	114	8½	January 27	107	6½
February 20	113	11	March 15	108	2
March 11	113	7	May 8	87	10
April 14	106	10	June 26	92	11
May 17	104	9	August 1	[a] 114	5
June 22	104	4	September 24	97	4½
July 20	105	6	December 10	96	11

[a] Pumping.

A comparison of September measurements in this well indicates a gain of 4 feet between 1904 and 1905, and a gain of over 9 feet between 1905 and 1906, or a total of 13 feet for the two years. The lowest period following the summer of 1904, however, was not reached until January, 1905, and that of the succeeding season came in December. A comparison of these two dates indicates a gain of somewhat more than 5½ feet in the interval.

If we accept the September measurements of 1904 and 1906, with their recorded recovery of 13 feet, as indicating fairly the improvement in conditions during these two years of heavy rainfall, and regard the decline between 1896 and 1904 as aggregating about 65 feet, the greater part of which took place in the latter part of the interval, we reach the conclusion that ten years of rainfall as heavy as that of the last two seasons will restore the underground waters to their original level. Even during these two years of heavy rainfall, however, not all wells in the vicinity exhibit so marked a recovery, as is evident from the following record of the Azusa Irrigating Company's well (No. 251, Pomona quadrangle):

Measurements of fluctuations of water level in Azusa Irrigating Company's well.

Date.	Depth to water.		Date.	Depth to water.	
1904.	*Ft.*	*in.*	1905—Continued.	*Ft.*	*in.*
October 7	97	2	September 21	97	4
November 16	97	8	November 11	98	6
December 13	98	11	December 20	99	
1905.			1906.		
January 11	99	1	January 27	97	10
February 20	98	4	March 15	97	2
March 11	97	4	May 8	93	2
April 14	95	6	June 26	91	1½
May 17	94	3	August 1	92	4
June 22	94	1	September 24	98	7½
July 20	95	4	December 10	100	11
August 16	96	4			

This well is about one-half mile southwest of the Firth well, is farther from the storm-water channel and from the big pumping plants, and is consequently expected to exhibit less marked fluctuations. There was but 1 inch difference between the low-water periods following the summers of 1904 and 1905; but the low-water period of 1906 is 1 foot 11 inches below that of the preceding fall. The September measurement in 1906 shows a loss over that of 1905, and the latter a slight loss over the October measurement of 1904. The high-water period of June, 1906, however, shows a recovery of 3 feet as compared with that of June, 1905. There is a slight net loss in the two years of observations, but as measurements are made at considerable intervals, with a resulting improbability that either the highest or the lowest water periods are detected, it may be said in a general way that this well is just about holding its own.

Two other observation wells (Nos. 144 and 149, Pomona quadrangle), belonging respectively to William Ferry and Sidney Deacon and located 1½ to 2 miles southwest of San Dimas, show somewhat different results. Their record is given below.

Measurements of fluctuations of water level in wells near San Dimas.

Date.	Depth to water. Well No. 144.		Depth to water. Well No. 149.	
	Ft.	*in.*	*Ft.*	*in.*
1904.				
October 7	199	8	124	3
November 16	199	10	124	
December 13	199	10½	124	
1905.				
January 11	199	9½	123	6
February 21	199	8	123	5
March 10	199	8½	127	
April 14	200	4	125	8
May 17	....		124	8
June 22	200	4½	125	1½
July 23	200	6	125	5
August 16	200	7	125	5
1905—Continued.				
September 21	200	7	125	7
November 11	201		126	
December 20	201		....	
1906.				
January 27	201	3	124	6
March 15	201	3	124	3
May 8	201	2	....	
June 26	201	5½	124	6
August 2	201	9	....	
September 24	201	7½	....	
December 10	202	4	....	

The water levels in these wells exhibit but little variation, but such changes as have taken place have been in the direction of loss, the fall measurements of 1905 and 1906 being in each case about 1 foot lower than those of the preceding year. In the Deacon well (No. 149) the fall measurements for 1906 were interfered with by an abnormal rise, probably due to the inflow of surface water; but the 1905 measurements indicate a loss as compared with those of 1904, and the high-water measurements one year apart indicate the same condition. Both of these wells are some distance from any of the washes through which the ground waters are replenished; therefore they exhibit but slight monthly and annual fluctuations. The slow wave of percolating waters, which starts from the washes in all directions through the gravels, with each winter's floods, is very flat indeed before it reaches these more distant wells. Its maximum height in the Ferry well was 2½ inches, reached in February, 1905. In the Deacon well this crest was 10 inches above the low level reached during the previous October.

WELLS NEAR VINELAND.

Two wells at Vineland, near San Gabriel Wash, show this wave of percolating water much more strongly developed. In a case of this kind, where the annual fluctuations are violent, long records are necessary before accurate conclusions can be drawn. In such short records as we now have, general movements of the water plane up or down are obscured by the great range of the seasonal fluctuations. On the face of these records, however, a distinct net gain is observed.

Measurements of fluctuations of water level in wells at Vineland.

Date.	Depth to water. Well No. 87.		Well No. 88.	
	Ft.	*in.*	*Ft.*	*in.*
1904.				
December 14	104	1	93	10
1905.				
January 12	104	6	93	6
February 21	102	10	91	5
March 10	98	9	87	6
April 15	93	11	82	7
May 17	90	8	78	10
June 22	90	11	79	4
July 21	91	4	79	10
August 16	92	2	81	4
September 20	93	9	82	10
1905—Continued.				
November 12	95	9	84	9
December 21	96	7	85	7
1906.				
January 27	97		86	
March 15	95	3	86	5
May 8	83	4	71	10
June 27	81	1½	70	3
August 1	82	11	69	
September 25	85	11	75	1½
December 11	88	10	78	7

The recovery in each of these wells for the two years of observation was 7 or 8 feet annually, with a net gain for the period of 15 feet 3 inches. Not only are the recoveries rapid and of great magnitude, but the annual fluctuations exhibit the wide range of 7 to 15 feet.

WELLS NEAR LORDSBURG.

Two record wells on the mesa northeast and northwest of Lordsburg, belonging to F. H. Massey and Charles Alley (Nos. 67 and 250, Pomona quadrangle), are measured regularly. They serve to record conditions on these valuable bench lands, where water developments have been extensive of late years.

Measurements of fluctuations of water level in wells on bench lands near Lordsburg.

Date.	Depth to water. Well No. 67.		Well No. 250.	
	Ft.	*in.*	*Ft.*	*in.*
1904.				
October 7	....		145	4
November 16	199	1	146	10
December 13	199	3	146	10
1905.				
January 11	19	11	146	9
February 20	199	10½	147	5½
March 11	199	9	147	6½
April 14	200		147	7
May 17	199	11	*a* 152	
June 22	199	4	146	8
July 20	200	2	150	8
August 16	199	9	150	½
1905—Continued.				
September 21	200		150	11
November 11	202	10	152	7
December 20	200	11	152	
1906.				
January 27	201	1	151	5½
March 15	200	2	149	2½
May 8	198	4½	149	6
June 26	197	6	149	½
August 1	196	5½	153	1½
September 24	197	7½	154	4½
December 10	197	3½	154	7

a Pumping.

The record of well No. 67 is rather erratic within narrow limits, probably because of variations in the pumping in its vicinity, yet general tendencies are discernible. A comparison of the water levels during the autumn months of 1904 with a corresponding period in 1905 indicates a slight loss of 1 to 3 feet, but when the 1905 and 1906 measurements are compared in the same way a distinct gain of 2½ to 5 feet is indicated, the net result for the two years being a recovery of 1 to 3 feet.

Well No. 250, over a mile farther northwest and near more large pumping plants, shows a decline in both the yearly periods. This decline amounted to 5 or 6 feet for the interval between November, 1904, and November, 1905, but was reduced to 2 or 3 feet for the interval from December, 1905, to December, 1906. The net loss in this well for the two years is 8 or 9 feet.

WELLS SOUTHEAST OF POMONA.

The group of four wells here discussed lies southeast of Pomona, toward the Chino artesian belt. In this direction the water plane and the land surface gradually approach, until in the artesian belt they practically coincide. This fact, as well as the fluctuations of the water table, is illustrated by the following measurements:

Measurements of fluctuations of water level in wells southeast of Pomona.

Date.	Depth to water.							
	Well No. 177.		Well No. 201.		Well No. 181.		Well No. 214.	
1904.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
September 8	89				34	6	8	9
October 6	88	10	58	9½	36	6½	6	6½
November 16	88	10½	60	3	34	10	3	10
December 13	88	10	60	6½	34	10	3	3
1905.								
January 11	88	10	60	10	34	9½	2	5
February 20	89		61	1½	34	7½	2	
March 10	89		61	4½	*a* 35	2	2	1½
April 14	88		60	8	32	10	1	5
May 17			60	11	32	7	2	
June 22	88	11	61	1	33	6	7	5
July 20	90	1½	*a* 62	11	35	4	12	10
August 16	90	5	61	6	35		12	2
September 20	90	8½	61	10	35	6	11	10½
November 11	90	5	62	4	35	8	4	7½
December 20	90	6	62	5	35	7½	4	1
1906.								
January 26	89	6	62	3½	36	8½	4	3½
March 14	90	6	63	1	35	8	3	10
May 8	89	7	63	1½	33	2½	4	4½
June 26			65	4	34	4½	13	10
August 1	92	2	63	5	35	5	15	8
September 24	92	2	64	4½	36	2½	13	6
December 10			64	11	36	2½	4	10

a Pumping.

Each of the wells of this group shows a distinct though usually slight decline when corresponding dates one year apart are compared. One exception to this general condition appears in the October, 1904, measurement of well No. 181. No measurements were made in October, 1905, but the September and November measurements of that year indicate a higher water plane than on October 6, 1904. With this exception, however, the decline is general. The explanation is probably to be sought in the fact that all these wells lie below the Pomona dike, above which waters are so extensively pumped that but little of the surplus supplied by the heavy rains of 1904–5 and 1905–6 has escaped to this area farther south.

In addition to this general tendency toward shrinkage, exhibited by all of the wells, No. 214, very close to the edge of the artesian basin, shows interesting annual fluctuations, which are probably due in part to the intense evaporation during the heated term, as well as to pumping in neighboring wells. From January to May, 1905, the water level in this well was but 1½ to 2½ feet below the land surface. From June to September of the same year it stood at 7 to 12 feet below the surface. During the heated term, in the dry atmosphere of this district, evaporation and capillarity act with great force, and draw the ground water from depths of several feet to discharge it as vapor into the air. This action is probably more effective in depressing the water table where it stood initially close to the surface than the drafts made in irrigation during the summer season.

WELLS NORTHEAST OF POMONA.

The four wells of which measurements are given in the subjoined table are located northeast of Pomona, two of them, Nos. 242 and 300, just south of the Santa Fe Railway tracks and three-fourths of a mile east of Claremont, and the other two, Nos. 265 and 265a, in the vicinity of Indian Hill. The buried ridge of red clays and gravels which extends eastward and northeastward from the point of the San Jose Hills, and whose extent beneath the gray gravels of the surface wash is, in a measure, problematical, introduces in the wells of this neighborhood an element of considerable uncertainty. One well may yield a good supply of water, while another near by, which happens to penetrate this older alluvium, will be dry; or the water level may stand at a certain elevation in one well and at a much lower or higher point in an adjacent well just across a buried ridge or "dike" of these dry gravels. There are many illustrations in the area northeast of Pomona of erratic conditions of this kind.

Measurements of fluctuations of water level in wells northeast of Pomona.

Date.	Depth to water.							
	Well No. 242.		Well No. 300.		Well No. 265.		Well No. 265a	
	Ft.	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
1904.								
October 6	158	5	157	10	....		....	
November 16	156	2	154	3½	62	1	40	4½
December 13	155		153	2½	61	10	39	7
1905.								
January 11	153	1½	151	5	62	2	40	3½
February 20	151	1	149		62	1	40	1
March 10	150	2	147	10	61	10½	39	
April 14	148	7	146	7	59	4	37	6
May 17	147	1	145	1	59	1½	37	1
June 22	148	7	146	5	57	5	35	5
July 20	150	10	149	8	57		35	3
August 16	150	8	150	8	59	7	37	4
September 21	152	6½	151	4	58	6	38	3
November 11	152	1	156	8	58	4½	36	3
December 20	149	1	....		57	3	35	7
1906.								
January 26	149	6	....		56	9½	....	
March 14	144	3	....		53	2½	34	3
May 8	141	2	....		54	4	32	6
June 26	132	4	....		53	3½	31	6½
August 1	146	8	147		54	1	31	11½
September 24	149	8½	....		53	3½	30	6½
December 10	149	8	....		56	10	33	10½

This group, lying for the most part above the Pomona dike, contrasts in a marked way with the group last discussed, which lies entirely below it. The three wells in which continuous measurements have been maintained for two years all show substantial recoveries; but, curiously enough, the recoveries were more marked during the first than during the second of the two years. There seems to have been no cumulative effect, such as some other wells exhibit, in consequence of the two successive years of heavy rainfall. The net recoveries for the period from December, 1904, to December, 1906, amount to 5 or 6 feet in each well.

WELLS IN SAN GABRIEL RIVER BASIN.

The group of five wells here discussed lies west of the San Gabriel River in the lower part of the San Gabriel basin. The wells are arranged in the table in the order of their distance from the river, which is the principal source of the water by which the recharge of the basin is effected. In considering these measurements it is well to remember that the lower San Gabriel basin has one of the best supplies of underground water in this part of the State, and that it has not been too heavily drawn upon, as is true of many other moist-land areas. The water plane, therefore, was not depressed excessively during the dry period. Seasonal fluctuations normally are not as great in the Elmonte region as at points like Vineland, higher up on an alluvial fan, but are greater than at places lower down, as in the Paso de Bartolo, for example. The recovery which these wells exhibit is regarded rather as a return of the waters to their normal levels, and an elimination of the effects of drought, than as a replacement of waters withdrawn by development.

The magnitude of the seasonal variations and the amount of the net gain shown in these wells decrease with the distance from San Gabriel River. The net improvement, only the December measurements two years apart being considered, varies from 10 inches in well No. 476 to 7 feet 9 inches in well No. 164, and the range of annual fluctuations from about 3 feet to 6 or 8 feet.

In only one of the numerous canals heading in or just above the Paso de Bartolo and depending on the waters that rise there has it been necessary to install pumping machinery to keep up the supply during the dry years through which the country has passed, and unless there are further extensive developments above the pass the supply to these canals, which now receive gravity water, should remain sufficient. It is indeed possible that considerable amounts of water could be withdrawn from the Elmonte field by pumping without interfering with the supply below, because a slight lowering of the water plane, where it stands very near the surface, would lessen the loss by evaporation from these moist lands during the summer months, and the water thus saved would become available for irrigation. It can be saved only by pumping and so depressing the surface of saturation.

Measurements of fluctuations of water level in wells in lower part of San Gabriel basin.

Date.	Depth to water.									
	Well No. 164.		Well No. 478.		Well No. 141.		Well No. 476.		Well No. 107.	
1904.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
November 8	.....	.....	22	5	.....	.....	21	3	.....	.....
December 9	21	5½	22	6½	16	2	19	6	72	11
1905.										
January 4	21	5	22	6	16	1½	20	1½	72	10
February 9	20	8	21	9	16	3	20	0	73	0
March 17	17	10	20	1	13	8	19	3	72	10
April 12	15	10	18	1	13	2	18	4	72	7
May 10	14	8	16	8	14	8	17	8	a 74	6
June 13	13	8	16	11	14	6	18	7	73	4
July 12	13	9	17	5	13	1	18	11	73	3
August 10	15	9	16	8	13	5½	19	2	74	1
September 13	16	10	17	5	14	4	20	0	a 75	8
November 7	17	3	18	2	14	1	20	3	.....	.....
December 18	17	0	18	0	13	9	21	3	73	0
1906.										
January 24	17	4	18	9½	13	8½	19	10	76	2½
March 22	15	4	17	3	12	6	18	11	72	8½
May 5	12	8	14	4	11	8	18	1	72	7½
June 25	11	9	12	9½	11	5	18	4	72	8
July 31	12	2	12	11½	11	10½	18	8	72	3½
September 20	13	5½	14	1	12	2½	19	6	72	1
December 17	13	8	14	7½	11	9	18	8	71	4

a Pumping.

WELLS IN PASADENA BASIN.

The wells of the next group are in the Pasadena basin above the Raymond Hill dike. They are in a region in which there is relatively little annual fluctuation, because it is far from the regular flood channels and receives its general supply only after it has percolated long distances through the gravels. The well of the group which exhibits the annual pulsations most clearly is No. 40a, on the Titus ranch at Sunny Slope. This well is in the old artesian basin, and the annual variations of its water level are probably due, in part at least, to summer evaporation, as in the well above Chino. While the record of this well is short and somewhat broken, it seems to indicate a slight gain. The record of No. 474 is also imperfect, but indicates an improvement in conditions. On the other hand, Nos. 56 and 17 indicate slight net losses for the period spanned by the measurements, although a gain of 2 inches appears for the last year of the period in No. 17.

Measurements of fluctuations of water level in wells in Pasadena basin.

Date.	Depth to water.							
	Well No. 474.		Well No. 40a.		Well No. 56.		Well No. 17.	
1904.	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*	*Ft.*	*in.*
September 2	44	3			73	3	122	4
October 5	44	10			73	10	122	2½
November 8	44	0			73	11	122	7
December 10	45	1½	13	6	74	6	122	6½
1905.								
January 4	43	6	10	4½	74	6	121	1
February 9	43	1	8	7	74	4	122	2
March 17	43	0	8	6			122	2
April 12	39	11	7	8	73	8	122	2
May 10	39	4	8	1	73	5	122	1
June 13			11	6	73	5	122	4
July 12	41	9	16	1	74	0	123	3
August 10			19	2	74	5	123	5
September 13			16	2	75	0	124	0
November 7			12	10	75	0	124	1
December 18			10	7	75	9	123	7
1906.								
January 24	41	5	10	3			123	3½
March 22	41	0	10	0	74	6	123	2½
May 5			8	4	74	9	122	11
June 25					74	6	122	8
July 10	41	2						
July 31			18	3	75	3½	123	6½
September 20			16	9½	76	1½	123	10
December 17			14	4½	77	1	123	1½

SUMMARY OF RESULTS OF WATER-PLANE MEASUREMENTS.

The wells which have been selected for measurement within the foothill belt are distributed widely over it. They include those favorably situated in relation to pumped areas and flood channels and those less favorably situated. They represent the greater number of the important local basins, and are probably to be depended on to indicate general conditions fairly. Measurements of 28 of these wells have been given in the tables. Fifteen of these show a net gain for the two-year period and 10 show a net loss, while 3 are indeterminate because of incomplete measurements. The year from September, 1905, to September, 1906, was more effective than the preceding year in restoring water levels, as is illustrated by the fact that 16 wells showed net gains for 1906, while net losses are registered in 10, 2 being indeterminate; whereas only 14 register a gain in water levels in 1905, and an equal number show losses. The gains, as has been indicated, are in wells situated close to drainage lines, and the losses in wells farther away from them. Fortunately the pumping plants of the more important systems are thus favorably situated, and a majority of them are gainers by the partial restoration of water levels which has taken place within the past two years. A smaller number are not within the belts that are thus favorably situated.

On the whole, while there has been a definite improvement in conditions in some of the basins during the period of observations—a period of marked excess in rainfall—the fact that water levels have continued to decline steadily in others, when conditions are so favorable for recovery, indicates excessive drafts in these latter localities at least. The general conclusion reached two years ago, that there are serious overdrafts on the ground water-basins, seems to be supported fully by the more abundant evidence now available.

IRRIGATION ENTERPRISES.

INTRODUCTION.

In 1888 Wm. Ham. Hall, State engineer of California, published his volume on "Irrigation in Southern California." This work included an account of the organization and engineering features of practically all the irrigation enterprises in existence in the southern part of the State at that time. The work has been extremely useful to all who have desired to gain a general idea of irrigation development in this part of the State. In the foothill belt many enterprises have been organized since the publication of Hall's work, and the conditions under which some of the older ones operate have been altered by reorganization and otherwise. Especially important have been the development of ground waters and the organization of companies for this purpose, or the extension of the functions of older gravity companies to enable them to utilize ground waters.

It has seemed worth while to present with this volume an account of the more important irrigating companies now operating in the foothill belt. For the earlier history of those enterprises which had been organized before 1888, Hall's volume has been consulted. For developments since, including the organization of new companies as well as changes in the older ones, various sources of information have been utilized, but in the majority of cases officers of the companies themselves have been consulted.

In the collection of this material the writer desires to acknowledge his indebtedness to Mr. W. N. White, field assistant, who gathered much the greater part of the information. Acknowledgments are due also to many engineers, not all of whom it is possible to mention. Mr. T. D. Allin and Mr. E. T. Wright have been consulted especially.

In presenting this material the plan followed has been to discuss the companies in the order of their distribution from east to west along the foothill belt. Those first described, therefore, are the Cucamonga enterprises, and those last described are the companies operating in Verdugo Canyon.

ETIWANDA WATER COMPANY.

The Etiwanda Water Company controls the waters of Day and Etiwanda canyons and utilizes these waters in the irrigation of about 1,200 acres of the Etiwanda colony lands, lying from 1½ to 4 miles north of the Santa Fe Railway at West Etiwanda station. The rights of the company date back to a number of filings by George Day and others from 1867 to 1873. These rights were afterwards consolidated, passed through several transfers, and have been confirmed in a number of suits.

The present company was organized by George and W. B. Chaffey in 1882. It is capitalized at $500,000, divided into 5,000 shares at a par value of $100 each; 2,300 shares have been issued, and the present market value is reported to be about $35 per share. The shares are not appurtenant to the land, but 90 per cent of them are held by irrigators, of whom there are about 75 in the colony.

As the colony lands were originally sold, one share of stock in the water company was transferred with each acre of land, and each 8 shares of stock entitled the owner to 1 miner's inch of water. It is customary to deliver the water monthly in 36-inch heads to each 10-acre tract, this giving approximately the usual duty of 1 inch to 8 acres, at a cost to the irrigators of $1.45 per acre annually.

The water is brought from the canyons through 1½ miles of V-shaped wooden flume and 2 miles of 10 and 12 inch pipe to a distributing box at the head of the colony lands. Below the distributing box are about 20 miles of 7 to 10 inch pipe, through which the water is conducted to the individual holdings. The reported cost of the pipe system is $23,000. There are no auxiliary wells, as in the case of many modern irrigation systems in southern California, ground waters beneath the Etiwanda district being too deep for profitable development.

Citrus fruits and grapes are the principal crops grown.

Only a few measurements of the flow from Day and Etiwanda canyons are available. These are quoted from "Irrigation in Southern California," by Wm. Ham. Hall.

Flow measurements in Day and Etiwanda canyons.

	Miner's inches.
September 1, 1882	224.5
July 15, 1884 (noon)	211
July 15, 1885 (7 a. m.)	170
August, 1885	50
July 15, 1887	189
July 15, 1888	[a] 356
July 16, 1888	[b] 421.31
August, 1888	150

HERMOSA WATER COMPANY.

The next important irrigating enterprise along the foothills west of Etiwanda is that of the Hermosa Water Company. Lying along the slope, 3 miles from Etiwanda and about 1 mile north of Cucamonga,

[a] 28 miner's inches considered as developed water.

[b] Calculated from slope and section of flume.

the Hermosa tract originally embraced 480 acres of land, upon which the waters of Deer Canyon and its tributaries are used.

The Hermosa Water Company was organized by owners of realty who had purchased lands and undivided interests in the waters of Deer Canyon from Adolph Petch or from the Hermosa Land and Water Company, organized by Petch in 1882. The water company was incorporated in October, 1887, with a capital stock of $192,000, divided into 1,920 shares with a par value of $100 per share. Four shares of stock were issued to each acre of the original tract, and each owner received a share of the available water proportional to his holdings of stock and acreage.

For many years the canyon flow was sufficient for the needs of the colony, but after the dry years of the late nineties the supply from the mountains so diminished in volume that it became necessary to augment it from some other source. In 1901 the company purchased 80 acres of land from the Cucamonga homestead, one-half mile north and west of the Hermosa tract, sunk a well on this property, and installed a pumping plant (No. 56, Cucamonga quadrangle).

The water from Deer Canyon and its branches, Calamity and Hermosa canyons, is collected by means of about 4 miles of 2-, 3-, and 4-inch pipe, and carried out of the canyon and down the slope, a distance of nearly 4 miles, through an 8-inch cement main, to a reservoir at the head of the colony lands. Just below the mouth of the canyon a branch pipe from Alder Canyon joins the main line. The company is entitled to the water of Alder Canyon up to 20 miner's inches. The upper part of the main-canyon conduit, which was originally an open flume, has been replaced by an 18-inch cement pipe. Delivery from the reservoir to the lands of the irrigators is made through 4- and 8-inch pipe.

The summer flow from Deer Canyon and its branches varies with the rainfall of the previous winter. The company reports that in July, 1903, it received 70 inches of mountain water, an average of 45 inches through the irrigating season of 1904, and 80 inches in August, 1905. Pumped water is used as an auxiliary to the canyon flow. During the season of 1902 the plant, consisting of a 20-horsepower gas engine and Ames Fulton pump with a capacity of 30 miner's inches, was in operation one hundred and forty days consecutively. During the season of 1903, following a wet winter, the flow from the canyon supplied the needs of the company and the pumping plant was not used. Again during the summer of 1904 mountain water was short in quantity, and pumped water was used freely in making up the deficiency.

The water supply is divided into heads and distributed to the irrigators in rotation every twenty-four days. The time given to each irrigator varies with his holdings of stock. A man owning 40 shares is given twenty-four hours' run of a half head every twenty-four days.

The cost of operating and maintaining the system is prorated among the stockholders according to the proportion of stock held by each, the annual cost of water varying with the volume of pumped water used. The actual cost of pumping a 30-inch head for twenty-four hours is $5.25 under present conditions. The only expense attached to the delivery of canyon water is the cost of keeping the pipe lines in repair, the secretary's annual salary of $50, and the zanjero's fees. The average cost of all water used, gravity and pumped, during the past four seasons, is reported to have been $5.75 per acre per annum. There are 40 irrigators in the colony, and at the present time about 500 acres are supplied with water. The company owns 1,200 acres of land in Deer and Calamity canyons, which were homesteaded by stockholders and deeded to the company in order to protect its water rights there.

The company's investment is as follows: Pumping-plant site, 80 acres, $4,900; reservoir site, 2½ acres, $125; pipe system and reservoir $4,000; well and pumping plant, $3,300; total, $12,325.

The right to use the water for power purposes, reserved by the promoters at the time the land and water rights were sold, is now held by the company.

IOAMOSA WATER COMPANY.

The Ioamosa tract, in which there are 500 acres of irrigated land, lies about 1 mile north and west of the Hermosa colony. The lands are a part of the old Cucamonga Homestead Association's property, and the water with which they are supplied comes entirely from Cucamonga Canyon and belongs in part to the Cucamonga Development Company.

The Ioamosa Water Company was incorporated in 1883, with a capitalization of $50,000, divided into 500 shares, with a par value of $100 per share. The company holds title to $\frac{86}{300}$ of the surface and developed flow of Cucamonga Canyon and leases the balance of all water derived from that source from the Cucamonga Development Company at a yearly rental of $500. The water procured by diversion of the surface flow and by 700 feet of tunnel intended to intercept the underflow is brought to the mouth of the canyon through a 30-inch conduit 3,400 feet long. Thence it is taken diagonally across the slope in a southeasterly dircetion in a 12- and 8-inch cement line to a small reservoir at the upper end of the colony lands. Below the reservoir about 2 miles of 8-inch vitrified and 6-inch iron pipe have been laid for delivering the water to the irrigators.

It is reported that from 10 to 40 inches are developed in the tunnel, while the total flow, natural and developed, is said to vary from 30 to 100 inches. The duty of water in the colony is reputed to be 1 miner's inch for each $7\frac{1}{2}$ acres, distributed in two 40-inch heads, twice each month to each 20-acre lot. Twenty-three irrigators are supplied, and the cost of water is about $2 per acre per year.

CUCAMONGA LANDS AND CUCAMONGA WATER COMPANY.

What are known as the Cucamonga lands are situated in the western portion of San Bernardino County, between the San Bernardino base line and the Southern Pacific Railroad, which is about 4 miles distant on the south. They extend eastward about 4 miles from the Ontario colony lands and Cucamonga Wash, and include in the aggregate between 8,000 and 9,000 acres, about one-third of which is irrigated, while another one-third is cultivated as vineyard but is not under irrigation.

The well-known Red Hills, famous as water-bearing lands, lie in the northwest corner of the Cucamonga tract, and the developments in and adjacent to these hills supply the water used for irrigation in the Cucamonga district and a portion of that used farther west by the San Antonio system.

The Cucamonga Water Company, which at present supplies nearly all of the water used in the district, was incorporated in December 1887, by certain members of an older organization called the Cucamonga Fruit Land Company. This company owned all the waters flowing from the "West ciénaga," the moist lands west and north of the Red Hills, and one-half of the waters flowing from the "East ciénaga," a similar area lying in and northeast of the Red Hills. At that time the total amount of water thus owned was between 250 and 300 miner's inches. The other half of the east-side waters belonged to the Cucamonga Vineyard Association, and a total of about 400 acres was under irrigation by both organizations, the Vineyard Association being the heaviest water user.

In addition to these rights there were certain obligations outstanding against the Fruit Land Company. The "Class A" rights comprised 33.84 miner's inches due a certain group of "old settlers:" The "Class B" rights comprised 67.75 miner's inches due another group of "old settlers," who had signed agreements to accept 1 miner's inch of water for each 10 acres of land owned by them. Other obligations constituting classes "C" and "D" were agreements to furnish water, by a company to be formed later, to lands which had been sold earlier by the Fruit Land Company. Something more than 300 inches was conveyed under these two classes.

All of the Fruit Land Company's rights to waters that were then flowing, all of its lands which were then recognized as water-bearing lands, and all of its obligations were conveyed to the Cucamonga Water Company at the time of its organization in 1887, and in addition the older company contracted to develop and deliver to the purchasing company enough water to fulfill all of the obligations which had been conveyed with the rights in the deed.

In fulfillment of the terms of this contract, the Fruit Land Company, during the years 1888, 1889, and 1890, expended from $75,000 to $100,000 in developing water by sinking wells and driving tunnels, so that when measurements were made in July, 1890, it was found that about 500 inches of gravity water, in part natural flow and in part the result of the development work, belonged to the Cucamonga Water Company. This amount was more than enough to satisfy the rights outstanding at that time.

During the dry period which followed, the flow from these various sources decreased, until in 1899 only 190 inches of gravity water were available, and the water company was forced to augment its supply by pumping from the Lone Star Springs above the base line. During this year the Fruit Land Company bored a deep well on the lands which it still held on the west side but which, at the time of the transfer of its rights to the Cucamonga Water Company, had not been recognized nor classified as water-bearing lands and were therefore not included in the transfer. This well at first yielded 100 inches of water, and at about the time of its development the Fruit Land Company contracted to deliver to the San Antonio Water Company 100 inches of water for $100,000. Suit was brought by certain stockholders of the Cucamonga Water Company against both the Cucamonga Fruit Land Company and the San Antonio Water Company to prevent the consummation of the sale, but judgment was rendered in 1900 against them and the sale was confirmed. During the summer of 1900 the control of the Cucamonga Water Company passed into the hands of the stockholders who had brought this suit, through the purchase of outstanding stock, and they also bought of the Cucamonga Fruit Land Company an interest in all the lands still owned by that company that could be regarded as water bearing on the east and west sides of the Red Hills.

Since 1900 three or four wells have been put down, the tunnel has been extended, and a pumping plant known as the Lone Star system has been installed, so that stockholders have received their full quota of water, although gravity water has constantly decreased. This decrease has been particularly marked in the Y tunnel and in the creek near the old Cucamonga Hotel that drains the original East ciénaga. It is stated that the original supply from these sources was from 150 to 500 inches of water, and that now (1906) it is less than 5 inches. The Cucamonga Water Company regards this decrease as due to the battery of wells and pumps installed by the San Antonio Water Company north and west of the Red Hills and used extensively as an adjunct to the San Antonio system. Suit has therefore been brought against the San Antonio Company to prevent pumping from these wells and to recover damages for property claimed to have been destroyed through this pumping. This suit was still in the courts in 1906.

When the Cucamonga Water Company was organized, in 1887, its capital was fixed at $100,000, divided into 10,000 shares at $10 per share. One share, representing one-tenth of a miner's inch of water continuous flow, was to be distributed with each acre of land sold. In 1901 or 1902, when a consolidation of interests was effected by the purchase of stock and rights owned by the Cucamonga Fruit Land Company and others, the capital stock was increased to $100 per share and bonds to the value of $250,000 were issued. Although the capitalization of the company was effected on the basis of 10,000 shares, the issue of stock has been controlled by the quantity of water available, not more than 10 shares being distributed for each inch of water owned, the amount of the water being determined by measurements made on July 15 of each year. The greatest amount of stock outstanding at any time was 4,500 shares, and this has been reduced by purchase to less than 3,000 shares.

In addition to the rights and lands which have been referred to, the company owns a number of tunnels, wells, and reservoirs, constructed generally by the Cucamonga Fruit Land Company in fulfillment of the contract entered into by it at the time of the organization of the Cucamonga Water Company. The west side or Eddy tunnel is one of these structures. It was originally a timbered tunnel, 3,600 feet long, but the timbering has been replaced by a 30-inch concrete pipe line. The charges for the maintenance of this line are shared with the San Antonio Water Company, which also uses it, the proportion of water in the tunnel belonging to each company determining the proportion of the running expenses borne by each. The east side or Y tunnel, just east of the old Cucamonga Hotel, also belongs to the Cucamonga Water Company, and, like the Eddy tunnel, has been replaced by a concrete pipe line. At the head of each arm of the Y is a well, but since 1903 this work has yielded no water. A third tunnel, 3,000 feet in length and running northwest from the center of sec. 3, on Hellman avenue, extends through a 35-acre tract belonging to the Cucamonga Water Company and into the Lone Star tract. Eight or ten artesian wells discharge into this tunnel, but the greater part of the water which it yields is supplied by the upper well of the Lone Star group. In addition to these development works the company owns an adequate distributing system, which includes three reservoirs and 20 or 25 miles of iron pipe that serves all of the lands under irrigation.

All of the water distributed is delivered under pressure in 30-inch heads, each 10 shares of stock entitling the holder to a flow of 30 inches for one day in each month.

The fixed charges of the company, comprising the interest charges on the bond issue, amount to $15,000 annually. The maintenance charges amount to about $6,000 per year, and these expenses are met by annual assessments on the stock of $10 or less per share.

OLD SETTLERS WATER COMPANY.

The Old Settlers Water Company was organized by stockholders of the old Cucamonga Fruit Land Company, who held rights to 33.84 inches of the surface flow of the Red Hills East ciénaga. When this ciénaga ceased to flow, because of the dry years and the draft on the underflow caused by the tunnels and pumping plants in the vicinity, these irrigators found it necessary also to resort to pumping. With this purpose in view the present company was incorporated June 21, 1902, and capitalized at $33,840, divided into 33,840 shares of $1 par value each. Land was purchased three-fourths of a mile north of Cucamonga, a well was sunk, and a pumping plant, consisting of an 18-horsepower gas engine and an Addison deep-well pump, was installed (No. 53). This plant pumps about 33 inches of water. The distributing system consists of 1½ miles of 6-inch and 1 mile of 8-inch concrete and vitrified pipe. Two hundred and seventy acres are irrigated and the water is delivered in 33-inch heads in rotation, every thirty days, on the basis of 1 inch constant flow to 8 acres. The cost is $10 per acre per annum. The water is not appurtenant to the land, but stock is held exclusively by irrigators. Oranges and deciduous fruits are raised.

SUNSET WATER COMPANY.

The Sunset Water Company was incorporated January 10, 1901, with a capital stock of $60,000, divided into 2,400 shares, all of which have been issued. The company was organized by stockholders of the Cucamonga Water Company for the purpose of increasing their water supply. Thirty acres were purchased in the water-bearing lands northeast of the Red Hills, where a well was sunk and equipped with machinery for pumping. The pumping plant (No. 54, Cucamonga quadrangle) consists of a 14-horsepower motor and a Garrett pump, and has a capacity of 30 inches. The water is raised to the level of a discharge tunnel 30 feet below the ground level at the well, and brought to the surface through the tunnel, 1,000 feet below the plant. From this point the water is distributed to the lands of the irrigators through 3¼ miles of steel pipe 4 to 12 inches in diameter. In practice about 1 inch to 10 acres is used, though there is no restriction on the amount that may be used. Six hundred acres are partially irrigated. The water is distributed in 30-inch heads monthly. The cost to the irrigators is $10 for a twenty-four-hour run of 30 inches. During the three seasons preceding the spring of 1904 the water level in the company's wells declined 4 to 6 feet annually, and with the lowering of the water plane the capacity of the plant has dropped from 42 to 30 inches. The plant is in operation about six months of each year.

ONTARIO COLONY AND SAN ANTONIO WATER COMPANY.

HISTORY OF RIGHTS.

The Ontario colony occupies lands lying immediately west of Cucamonga Wash and extending in a strip 1 to 3 miles wide from the mesa at the foot of the San Antonio Mountains down the slope for a distance of about 6 miles. On the west the upper part of the colony tract is separated from the Claremont and Pomona irrigating districts by San Antonio Wash, and the lower part of the tract adjoins lands that are covered by the Del Monte Irrigating Company of Pomona. On the east Cucamonga Wash lies between the colony lands and those of the Cucamonga irrigators.

About 5,000 acres are under irrigation in the Ontario district. Gravity water is supplied to the tract from San Antonio Canyon and from the Cucamonga tunnel in the water-bearing lands of the Red Hills, which lie to the east of the colony, midway between North Ontario and Cucamonga. The canyon and tunnel flow is supplemented by pumped water derived from wells north of the Red Hills on the east and from the neighborhood of Claremont and Indian Hill on the west.

By far the greater part of the water supplied to the colony is owned and distributed by the San Antonio Water Company. The Ontario Water Company is an adjunct organization, whose stockholders belong to the San Antonio Water Company but pump independently in case of a shortage. Several hundred acres lying west of North Ontario are supplied with pumped water by the plants of the Upland, Mountain View, and Canyon Ridge water companies.

The San Antonio Water Company is a mutual company, one of the early organizations of its kind in the State. Stockholders are owners of realty, and water can not be delivered by the company to others than stockholders. The company was incorporated in October, 1882, by the Messrs. Chaffee, who owned the water rights on the east side of San Antonio Canyon, and these rights, together with diversion works, conduits, and pipe system, were later transferred to the San Antonio Water Company. This company was organized with a capital stock of $1,500,000, divided into 15,000 shares of a par value of $100 each; 6,064 shares have been issued. In 1882, by agreement between the Chaffees and the Pomona Land and Water Company, which owned water rights on the west side of the canyon, the surface flow at a point about 1 mile above the mouth of the canyon was divided equally, and a joint diversion dam was constructed. About 1896 the San Antonio Water Company acquired what was known as the Gird or Dexter interest in the canyon, consisting of several hundred acres of land, together with a prior right to 20 miner's inches of water. In 1897 the San Antonio Water Company and the Pomona Land and Water Company entered into an agreement by which the latter conveyed to the San Antonio Water Company all of its interests in the canyon, in return for which the San Antonio company agreed that whenever the total flow in the canyon was 624 inches or less the Pomona company was to receive one-half, and that all water in excess of 624 inches should belong to the San Antonio company. After entering into the above agreement the San Antonio company began to divert the 20 inches of Gird or Dexter water, piped it past the division dam, and continued this diversion for five years, when suit was brought by the Pomona Land and Water Company; but January 6, 1905, Judge Allen rendered a decision in which he held that the San Antonio company had acquired a good title to this water.

In 1902–3 the Ontario Power Company laid a conduit from the south line of sec. 36, T. 2 N., R. 8 W., diverted the canyon flow at that point, and piped the water along the west side of the canyon to a point on the hills above the division dam and constructed a power plant. This conduit is a 30-inch cement line, except where iron pipe is used in inverted siphons in crossing side canyons. It is laid partly in trenches and partly through tunnels. For a year previous to the laying of the conduit careful measurements were taken by expert hydraulic engineers at the south line of sec. 36 and at the division dam 3 miles below, and it was determined that 19 per cent of the water was lost from the natural flow of the canyon stream between the two points. After the completion of the conduit by which this loss was prevented, the Ontario Power Company laid claim to and appropriated 20 per cent of the flow of the canyon as salvage. This claim was subsequently disallowed by the courts, which ruled that the Pomona irrigators were entitled to one-half of the saving effected through the higher diversion of the Ontario Power Company.

It became apparent in the early days of the colony that there would not be sufficient surface water from San Antonio Canyon to supply all of its requirements, and steps were taken to procure additional water from other sources. In January, 1883, a tunnel was begun in the gravel bed of the canyon about 1 mile above its mouth; it was gradually extended during the succeeding years, and completed about 1889. This tunnel has a sectional area of 3½ by 6½ feet. It is 3,000 feet in length and is reported to have cost about $50,000. The upper 600 feet penetrates bed rock below the wash material of the creek, the bottom at the upper extremity being 110 feet below the bed of the creek. F. E. Trask reported the average July output from this tunnel for 15 years previous to 1903 as 116 miner's inches. B. C. Shepherd, secretary of the company, states that the flow varies from 50 to 150 inches and averages about 75 inches during the irrigating season. The creek waters and the San Antonio tunnel waters are brought together in the main ditch about 500 feet below the mouth of the tunnel.

West of the Red Hills, in what is known as the West ciénaga, a tunnel 3,600 feet in length was constructed by the Cucamonga Fruit Land Company for the Cucamonga Water Company in the late eighties. This tunnel, which has since been extended to 4,000 feet or more in length, is known as the Eddy or Cucamonga tunnel. Some time after its construction the San Antonio Water Company acquired water-bearing lands in the West ciénaga, a 20-foot right of way, and one-half interest in the carrying capacity of the tunnel. In 1889 a 22-, 24-, and 30-inch cement pipe was laid from the division box at the mouth of the tunnel to North Ontario, and connected with the system there. Several wells were sunk along the upper course of the tunnel, and cut to flow into it at depths of 90 to 110 feet from the surface. It is known that one of these wells (No. 80, Cucamonga quadrangle) was flowing in 1905, and it is supposed that others were flowing then, but this could not be ascertained. The water from this tunnel, which belongs in part to the Cucamonga Water Company, is apportioned in a division box at the mouth of the tunnel, and is conducted thence to the distributing systems of the owning companies. Of the Ontario companes' share of the Cucamonga tunnel gravity water, the San Antonio Water Company receives the first 130 inches and the Ontario Power Company the balance. The average flow received by these two companies during the irrigating season has been reported as 150 miner's inches.

Previous to 1893 the canyon and tunnel water had been nearly sufficient for the needs of the colony. Beginning at about that time, several dry years followed in succession, causing a decline in the canyon flow and an extreme shortage of water. As the necessity for more water became pressing, the company sought relief through the further development of underground waters, which had been begun in a small way in the Del Monte ciénaga in 1889. Nine hundred and fifty acres of land were purchased east of the colony, north of Sixteenth street above the Cucamonga Red Hills, and in 1898 a well was sunk (No. 75, Cucamonga quadrangle), a pumping plant installed, and 16- and 20-inch vitrified pipe laid to connect with the canyon distributing system. At various times since then four additional plants have been installed on this property, the last in 1904. Water rights have also been acquired on the adjoining Rubio property, where a plant has been installed, and still farther east two other wells, known as the Haskell wells, have been purchased and equipped with pumping plants.

In all, the San Antonio Water Company owns and operates eight plants (Nos. 73–79, Cucamonga quadrangle) in the Red Hills district, with a combined pumping capacity of 450 inches. The wells are seldom pumped to their full capacity, and the output varies with the needs of the colony and the fluctuations in the gravity flow from San Antonio Canyon and tunnel and the Cucamonga tunnel.

In addition to these more important Sixteenth street and Red Hills wells, the company has four wells, two of which are equipped with pumping plants, in the old Del Monte ciénaga, near Claremont. The output of the two wells pumped in this field is given as 75 miner's inches. In the operation of these wells, electric power supplied by the adjunct corporation, the Ontario Power Company, is used. This power succeeds the gas and steam engines which were used in the early pumping operations.

In 1898 the company acquired the Bodenhammer well (No. 88, Cucamonga quadrangle) and a tunnel located along the west line of the colony lands, about 1½ miles below the mouth of San Antonio Canyon. Since the well was sunk and the tunnel driven the water plane in this vicinity has dropped many feet below the tunnel level.

The San Antonio company also owns 1 mile of tunnel, which was driven into the mesa at the foot of the mountains just west of Cucamonga Wash. This work is reported to have cost $80,000. There is no summer yield during dry years, but in winter a moderate amount flows from the tunnel.

PIPE LINES AND CONDUITS.

The Ontario colony is piped throughout with carrying lines, constructed principally of cement and vitrified clay, and ranging from 8 to 40 inches in diameter. Distributing mains and diagonals have been laid in such a manner that the supply from the various sources can be readily shifted to different parts of the tract. Water in the pipes is not under pressure, but the onward flow is partially cut off by gates which hold the water and cause it to rise to the top of a short standpipe or turn-out, placed at the highest point of each 10-acre lot. Domestic water is carried from these turn-outs through iron pipes to the homes of the irrigators.

OPERATION AND MAINTENANCE.

Theoretically the San Antonio Water Company delivers 1 miner's inch of water to each 10 acres on each 10 shares of stock. In practice the available supply is prorated to the stock and a twenty-four-hour run is given each 10 acres monthly, but the size of the irrigating head varies with the water supply, though the average is about 30 inches. During the irrigating season of 1905, succeeding a winter of excessive rainfall with a large canyon flow, the company expected to deliver 40-inch heads throughout the season.

ANNUAL COST.

The average cost of operating and maintaining the system of the San Antonio Water Company is $60,000 per annum, and the average cost per acre varies from $10 to $12. Funds for meeting obligations in the shape of interest, sinking fund, maintenance, and expenses are derived from assessments on the stock. A part of the floating indebtedness was paid off during 1904, and total assessments of $25 per acre were levied that year. Other payments were made in 1905, and an assessment of $20 per acre was collected.

ONTARIO WATER COMPANY.

The Ontario Water Company was organized in 1900 by stockholders of the San Antonio Water Company who did not hold enough stock in that company to insure them a sufficient water supply in years of light rainfall. The organization was effected on the basis of a capitalization of $100,000, divided into 1,000 shares with a par value of $100 each. In 1905 six hundred and twenty shares had been issued, 495 to irrigators and 125 to nonresidents, and the market value was reported by the company's officers to be $50 per share.

In 1900 a tract of 134 acres lying east and south of Indian Hill was purchased at a cost of $34,000. Six wells were at on cesunk on the tract and a pumping plant was installed, the expenditures for these purposes being $10,000. The plant consists of a 70-horsepower steam engine and a Smith-Vaile air compressor, by which all the wells which lie within a radius of 600 feet of the plant may be pumped. The water, about 70 miner's inches, is conducted through a 14-inch line about 3 miles in length to the tract owned by the stockholders. This tract lies about 1 mile southwest of Upland. As the water is used as an auxiliary to the canyon supply, it is necessary to pump only during the summer months, and not then if the flow from the canyon is large. The plant was in operation during four months in 1900, 1901, and 1902, but was not used in 1903.

The water is distributed in 30-inch heads and is prorated to stockholders according to their interest. The cost of the water is given at 67½ cents per hour for a 30-inch head; that is, 2¼ cents per hour-inch.

In order to carry out the necessary improvements for developing and distributing the waters, bonds amounting to $25,000 were issued in July, 1900. Two thousand dollars of these bonds fall due annually for ten years, beginning with 1906, and $1,000 each year thereafter until they are paid.

POMONA IRRIGATION.

RIGHTS.

The flourishing district about Pomona and Claremont derives its irrigating water from San Antonio Canyon and from numerous wells and pumping plants that have been installed, mainly in the old ciénaga lands in the vicinity of Claremont and about the eastern point of the San Jose Hills. (See Pl. I, *C*, *D*, p. 8.)

The rights to the flowing waters of the canyon date back to Ignacio Palomares, one of the early owners of the San Jose rancho, and to N. Alvarado, a squatter on this tract. Both of these men built ditches from San Antonio Creek and acquired rights to its waters. These rights were subsequently transferred to American purchasers and have been subject to adjustment as between the Pomona and Ontario users, the former holding the old rights to the west-side waters from San Antonio Canyon, and the latter to the east-side waters. As the matter stands at present, the San Antonio Water Company, supplying Ontario and vicinity, and owners of the earliest right on the stream, the Gird or Dexter right, are entitled to the first 20 miner's inches flowing from the canyon. After this amount is taken out, the remainder is divided equally between the east-side and west-side users, until it exceeds 624 inches. All of the flow in excess of this amount belongs to the San Antonio Company, representing the east-side ownership. The Pomona users may therefore receive not to exceed 312 miner's inches of this water, and will receive less than that if the canyon flow falls below 644 inches.

CANYON WATER COMPANY OF POMONA.

About 83 of these 312 inches (or a proportional amount of a smaller flow of canyon water) belong to lands lying in the north Palomares and Martin tracts; the remainder of the flow belongs to the Loup & Meserve tract, and the owners of a larger part of this share organized in 1897 as the Canyon Water Company of Pomona. This company controls 45½ per cent of the west-side San Antonio waters. The remainder of the Loup & Meserve owners maintain their original status of tenants in common.

The Canyon Water Company is capitalized at $312,000, divided into 31,200 shares with a par value of $10 each; 14,169.3 of these shares have been issued. The organization was effected by a number of the holders of canyon water rights, who deeded those rights to the company and received stock in exchange. In 1905 there were 87 stockholders. The majority of the stockholders held 125 shares per 10 acres, some held in excess of this number, and a few had but 100 shares. Each share represents one one-hundredth of a miner's inch when there is enough water flowing in the canyon to give the west-side irrigators their full quota of 312 inches. At other times it represents a smaller amount, whose value is proportional to the water available. The officers of the company state that the cost of the water to users is about 80 cents per acre per year, for maintenance and distribution.

During periods of diminished flow in the canyon the water derived from this source is supplemented by pumped water supplied by several private plants and by the Kingsley Tract Water Company, the Claremont Cooperative Water Company, and the C. W. Brundage Company. This accessory water is arranged for by individual irrigators and not through the company.

Official measurements of the waters of San Antonio Canyon are made three times yearly, on the first Mondays in July, August, and September, as a basis for the division of the waters. The share received by the Pomona irrigators as a result of these measurements from 1900 to 1905 is given in the following table:

Quantity of water, in miner's inches, delivered to Pomona irrigators from San Antonio Canyon, 1900–1905.

Year.	July.	August.	September.
1900	115	(?)	(?)
1901	312	257.07	213.55
1902	170.5	128.06	101.6
1903	312	271.05	214.77
1904	186.935	147.54	132.25
1905	312	312	312

DEL MONTE IRRIGATION COMPANY.

The Del Monte Irrigation Company is one of the four companies distributing water in the Pomona region, organized originally by the Pomona Land and Water Company. The organization of this branch was effected in February, 1887, with a capital stock of $400,000, divided into 40,000 shares with a par value of $10 each; 21,000 shares have been issued at the rate of 10 shares per acre, and the market value was reported in 1906 as $8 per share. There were at that time between 175 and 200 shareholders, all of whom were landowners under the system. Absentee ownership is not permitted.

From the Pomona Land and Water Company the Del Monte Company received the right to the natural flow from Del Monte ciénaga, one-fourth mile southeast of Claremont, and a right to develop water in a tract of 150 to 200 acres there. They also obtained from the same source the right to develop water in a 12-acre tract in

Martin ciénaga, one-fourth mile west of Claremont. In 1899 the company purchased an additional water right covering 68 acres in the Martin ciénaga. The price paid for this right was $25,000.

As early as 1886 artesian wells were bored in the ciénagas, and the number was gradually increased until about 28 in all had been sunk. The artesian flow, however, slowly decreased as a result of the increasing development and the succeeding dry years, and finally ceased in 1897. Thereafter the company depended entirely on pumping. The lift in 1905 was about 80 feet, but decreased markedly as a result of the three succeeding wet years.

In the Del Monte ciénaga the company operates a compressed-air plant, installed in 1899, from which seven wells within a few hundred feet of the plant were pumped in 1905. A Corliss air compressor operated by a 140-horsepower steam engine is used. Three wells in the Martin ciénaga have been pumped from this plant, but they were not in use in 1905. The air compressor, engine, and pipes are reported to have cost $15,000, and the output is given at 155 miner's inches. In addition to this central plant, one well in the Del Monte ciénaga is in use. A 40-horsepower motor and a Pomona deep-well pump are also used in the Martin ciénaga.

The water developed by the pumping plants is divided into four heads, prorated to stock and distributed at intervals of twenty-seven and one-half days by schedule through about 15 miles of 8 to 20 inch cement pipe owned by the company.

Annual assessments of 60 cents per share, or $6 per acre, cover the cost of operating and maintaining the system and interest on indebtedness.

IRRIGATION COMPANY OF POMONA.

The Irrigation Company of Pomona was organized by the Pomona Land and Water Company in July, 1886. It was capitalized at $245,000, divided into 24,500 shares with a par value of $10 each; 2,450 acres were included in the district, and lands in the tract were sold with 10 shares of water stock per acre. All of the stock has been issued. When the majority of the stock had been transferred to the purchasers of land in the district, the management of the company was turned over to them and the organization has since been operated as a mutual water company.

The original sources of water were San Jose Creek and the moist lands in which it rose and a number of artesian wells bored in these lands, which constituted the old artesian belt north of Pomona. About 45 wells have been bored at various times. With continued development and recurring dry seasons these sources of cheaper water failed, the artesian wells ceasing to flow from 1896 to 1899, and now the company depends entirely on pumped water. One large central pumping plant (No. 182, Pomona quadrangle) has been installed, and from this station, equipped with a 150-horsepower Corliss-Cross compound air compressor, 16 wells, the farthest half a mile away, are pumped. Smaller auxiliary plants have been used in the past, but were abandoned for the more economical concentrated system. It is estimated that the company has, in addition to the pumping plant, about 25 miles of iron and cement distributing pipe, varying from 6 to 20 inches in diameter. It owns one reservoir on Holt avenue, east of Pomona, whose capacity is 1,900,000 gallons. It also has the right to develop water on 200 acres of ground in the vicinity of the plant.

The company pumps for about seven months in the year, and produces from 200 to 250 inches continuous-flow during this period. The water is divided into four heads, and each block of 100 shares of stock is given a twelve-hour run of one head monthly.

The expenses of maintenance, operation, and distribution are met by assessments on the stock, which amount to about 40 cents per share, or $4 per acre annually.

Of the 2,000 acres irrigated by this company, one-third is planted to citrus fruits and the remainder to diversified crops.

PALOMARES IRRIGATION COMPANY.

The Palomares Irrigation Company is one of the four companies organized by the Pomona Land and Water Company and succeeding to its rights. The organization was effected on February 23, 1887, with a capital stock of $60,000, divided into 6,000 shares at $10 per share. The water rights which the company owned were made appurtenant to 600 acres of land, and 10 shares of stock were sold with each acre.

The original source of the water used was a group of five artesian wells near the northern edge of the Pomona artesian area. These wells ceased to flow, with others in the same belt, in the late nineties. A pumping plant was then installed, and by its use from 40 to 80 inches of water are now procured from two wells (No. 291, Cucamonga quadrangle) and carried through a 22-inch main in a southeasterly direction to the Palomares tract, which lies between the territory covered by the Irrigation Company of Pomona and that served by the Del Monte Irrigation Company.

Pumping is usually begun in April and is continued thirty days per month and twenty-four hours per day until November. The water is distributed in full heads of 40 to 80 inches, each 100 shares receiving a twelve-hour run monthly.

The expenses involved in the maintenance of the plant and the distribution of the water are met by an annual assessment on the shareholders. For a number of years this assessment varied between a minimum of $3 and a maximum of $6 per acre annually.

CONSOLIDATED WATER COMPANY OF POMONA.

The Consolidated Water Company of Pomona was organized by Messrs. Becket, Brady, and Lathrop, and incorporated May 23, 1889, with a capital stock of $500,000, divided into 5,000 shares of $100 par value each.

The company serves the city of Pomona with water for domestic purposes. The supply is obtained from five pumping plants located in the old artesian basin about three-fourths of a mile south of North Pomona and from wells and tunnels in San Antonio Wash, one-fourth of a mile east of Indian Hill. Four of the five plants were installed in 1897 and 1898, and the fifth in the spring of 1904. Three of them are equipped with Addison-Lindsey deep-well lift pumps and two with centrifugal pumps. Electric power is used, and the combined capacity of the five plants is given at 200 inches. The cost is stated to be about $15,000.

In the years 1892–1896 land east of Indian Hill was purchased from Peter Fleming and James Becket, and a tunnel was driven into the wash in order to develop a gravity flow. This tunnel, starting at the surface near Claremont, is about 1 mile in length and reaches a depth of 120 feet at the upper end. Two wells have been sunk along it and now flow into it. A pipe line has also been laid along the lower part of the tunnel, and this section filled. The combined cost of the land, tunnel, and wells is given as $150,000.

The flow from this system varies with the season and the rainfall. During the winter months it reaches 160 inches, and is then ample for the city's needs. During the summer season, when the demands are heavy, the flow decreases, and an auxiliary supply is furnished by the pumping plants. Early in June, 1904, the flow from the wells and tunnel was reported at 70 inches, and during July of the same year, 54 inches. The city requires about 130 inches during the heated term, a large amount being applied to lawns, shrubbery, gardens, etc.

In 1905 the company reported 1,500 taps in active use. A part of the service is equipped with meters, of which there were then about 300, more than half of them owned by the consumers. Citizens may install meters at any time at a cost of $12, and pay thereafter for the actual amount of water used. Where meters are not used, the charges are regulated in great detail by city ordinance. An idea of the rates may be obtained from the following items: A charge of $1 per month is made for houses of five and six rooms, and 10 cents per month for each additional room. For irrigating lawns, 25 cents per month is charged throughout the year for 50 square yards or less, and one-fourth of a cent for each additional yard. Where meters are installed the following rates were established for the year beginning July 1, 1904: Minimum rate, 600 cubic feet or less, per month, $1; each additional 100 cubic feet to 2,500 cubic feet, 10 cents; each 100 cubic feet over 2,500 cubic feet, 8 cents. In its collecting and distributing system the company owns 6.6 miles of cement pipe, 8 to 20 inches in diameter; 9.4 miles of iron pressure pipe, 6 to 16 inches in diameter; 43.5 miles of iron pressure pipe, 2 to 5 inches in diameter; and 1 reservoir, capacity 1,000,000 gallons.

The cost of this system is about $90,000, while the total investment in lands, water rights, tunnels, wells, pumping plants, and distributing systems is given as $362,000.

KINGSLEY TRACT WATER COMPANY (LIMITED).

The irrigating enterprise known as the Kingsley Tract Water Company (Limited) was incorporated September 10, 1900, and capitalized at $53,625, divided into 5,362½ shares of a par value of $10 per share. About 2,900 shares have been issued to the 55 stockholders, and the water is distributed to these and to five tenants in common on the tract who have not come into the corporation.

The Kingsley tract is located northeast of Pomona, and is a part of the original Loup & Meserve tract, to which a portion of the San Antonio Canyon water is appurtenant. The Kingsley Tract Water Company is a mutual water-supply company, organized to distribute the stockholders' share of the canyon water and to develop and control a supply of domestic water. It has no control over the canyon water, but, with the the consent of the holders of canyon rights, distributes their water and collects assessments for maintaining the canyon system. When the flow from San Antonio Canyon apportioned to Pomona irrigators equals 312 inches, the Kingsley tract receives 52.65 inches, and the same proportion of a lesser flow. The company pumps domestic water and an auxiliary supply for irrigation from well No. 280 (Cucamonga quadrangle). Pumped water is used for irrigation only when necessary to keep the canyon head up to the regular amount. The well was sunk in 1884 by S. B. Kingsley, under contract with R. Cathcart, the owner of the property on which it is located. It was once artesian but it ceased flowing about 1892. By the terms of the contract Mr. Cathcart retained a two-fifths interest in the well and guaranteed a protection strip of 600 feet surrounding it.

The pumping plant, consisting of a 30-horsepower gas engine and centrifugal pump, was installed in 1898 or 1899. It has a capacity of 30 inches. The water is piped a distance of half a mile southeastward to a reservoir in the upper part of the tract, and thence is distributed to two smaller reservoirs. The large reservoir is 300 feet in diameter and 12 feet deep. Because of the large storage capacity of the reservoirs, night and Sunday irrigation is unnecessary. The distributing system consists of 6½ miles of irrigating pipe from 6 to 10 inches in diameter, and of about the same amount of iron pipe for domestic supply, from 1 to 4 inches in diameter.

Canyon water costs the irrigators about $2 per miner's inch per year, and pumped water is supplied at cost to the stockholders. About 350 acres are partially supplied with irrigating water, and domestic water is furnished to 55 families. The water is distributed in 25-inch heads, each acre being given a 102-minute run every two weeks. This is about equivalent to 1 miner's inch constant flow to 8 acres. For any excess over the regular head irrigators pay 2 cents per hour-inch.

Including the Loup & Meserve tract assessment of $104, the cost of operating and maintaining the system from January 1, 1904, to January 1, 1905, was $1,768. During the same period $2,546 was spent in development and new machinery. These charges are met by assessments on the stock.

MOUNTAIN VIEW WATER COMPANY.

The Mountain View Water Company is the successor of the old Fleming & Rohrer works, which consisted of several miles of pipe line and several hundred feet of tunnel driven into an outcrop of the old red alluvium that is exposed in San Antonio Wash about 1½ miles east of Indian Hill. With these earlier works the company acquired 480 acres of land, paying for the land and the developments $13,875. After acquiring the property the company sunk several wells and extended the tunnels to tap them. In July, 1896, a corporation was formed, the capital stock being fixed at $45,000, divided into 13,875 shares. This stock is not appurtenant to the land, but is held only by landowners.

In 1895 the gravity flow from the tunnel and wells reached 138 inches, but during the succeeding years the output diminished, and in 1899 two pumping plants were installed. These plants consist of 18- and 12-horsepower gas engines and centrifugal pumps. Their combined capacity is 45 miner's inches. During the winter season one well (No. 111, Cucamonga quadrangle) still flows a small amount into the tunnel. In the distributing system there are about 5 miles of 6- to 16-inch pipe.

The water developed is piped to the east a distance of 1½ miles and used on the Mountain View tract, about 1½ miles northwest of Upland, except for three days of each month, when it is conducted to the village of Claremont and used there for domestic supply. There are about 400 acres under irrigation in this system, and the water is distributed monthly in 30-inch heads on the basis of 1 inch to 10 acres. The cost of the water to the users is approximately $50 per inch, or $5 per acre annually.

CANYON RIDGE WATER COMPANY.

The Canyon Ridge Water Company is a small company which irrigates about 160 acres of land northwest of Upland, near the Mountain View Water Company's tract. It was incorporated March 12, 1900, and capitalized at $20,000, divided into 400 shares with a par value of $50 each. The stock is distributed among irrigators only. The company owns 10 acres of land in the upper part of the Ontario colony tract, on which a well has been sunk (No. 86, Cucamonga quadrangle) and a pumping plant installed. The plant consists of a 20-horsepower gas engine and a deep-well pump with a capacity of 25 miner's inches. About 2½ miles of 6-inch pipe are laid down the slope to the stockholders' lands, where the water is used. Distribution is effected in full heads in rotation at intervals of thirty days. The cost of the water to the users is given at about $60 per inch annually.

UPLAND WATER COMPANY.

The Upland Water Company is a corporation organized principally by stockholders of the Mountain View Water Company for the purpose of developing an auxiliary supply. The organization was effected in 1900, on the basis of a $30,000 capitalization divided into 300 shares. During the same year the company bought 30 acres of land, east of Upland and north of the Red Hills, sunk a well (No. 58, Cucamonga quadrangle), and installed a pumping plant. The original plant, consisting of a steam engine and Worthington pump, was replaced in 1905 by an electric motor and Pomona deep-well pump. The total investment in well and plant up to 1905 was about $1,200.

The capacity of the plant is reported as 40 inches. The water produced flows through about 26,000 feet of 10- and 8-inch cement pipe to the Mountain View tract, west of Upland, where it is distributed monthly in full heads to the stockholders, who are all irrigators. The cost of the water per annum is given as $10 per acre.

ORANGE GROVE TRACT WATER COMPANY.

The Orange Grove Tract Water Company was organized in 1889 by John E. Packard, who owned artesian water-bearing lands north of Pomona and about three-fourths of a mile from the easternmost point of the San Jose Hills. Mr. Packard sunk wells on this property, laid pipe lines and constructed reservoirs, and sold the rights to 14½ inches of water to the owners of the Vineyard tract of 80 acres, located in the present city of Pomona. A large part of the Vineyard tract has since been cut up into city lots. The water right of the

23 acres north of Pomona, on which the pumping plant is situated, was transferred by Mr. Packard to the Orange Grove Water Company, subject to the prior right of 14½ inches, made appurtenant to the Vineyard tract, as mentioned above.

Lands of the present Orange Grove tract, which lies south of the San Jose Hills and west of Pomona on Holt avenue, were sold with 10 shares of water stock per acre. Four thousand seven hundred and twenty shares were issued, covering 472 acres. There are 26 stockholders in the company, and all water developed except that belonging to the Vineyard tract is used by them. None is sold outside.

In the late nineties the artesian flow of the wells ceased, and about 1899 the company put in a pumping plant. This plant was installed for the purpose of supplying the Orange Grove company with domestic water and the Vineyard tract with the 14½ inches to which it was entitled. The plant consists of a 25-horsepower gas engine and a centrifugal pump. It is in operation throughout the year.

For irrigating purposes the company utilizes the water developed from the Alkire tunnel, which it has leased for a term of years. This tunnel; constructed by Josiah Alkire, is located close to the eastern point of the San Jose Hills and intercepts a part of the underflow around that point. The flow from this tunnel during August, 1905, was stated by Mr. French, the secretary of the company, to be 28 inches. The water developed is delivered to the Orange Grove tract and distributed in open ditches in 20-inch heads, each acre being given a run of three and three-fourths hours per month.

The combined cost of irrigating and domestic water during the four years from 1902–1905 is reported to have been about $5 per acre. This was covered by assessments on the stock.

CLAREMONT COOPERATIVE POWER COMPANY.

The Claremont Cooperative Water Company was organized in 1902, and 90 acres of land close to the foothills 2 miles northwest of Claremont were purchased. A well and pumping plant which had already been installed on the property were included in the purchase.

The lands on which the water is used lie just north of Claremont, and the water is delivered to them through about 2¾ miles of 12- and 8-inch cement pipe. The plant has a capacity of 30 miner's inches, but only about 60 acres are irrigated. No water is sold, the stockholders of the company using all that is pumped. The cost to them is reported to be about 1¼ cents per hour-inch.

CITIZENS' LIGHT AND POWER COMPANY.

The Citizens' Light and Power Company was organized principally for the purpose of supplying the village of Claremont with domestic water. It was incorporated December 6, 1902, on a basis of 1,045 shares of stock of a par value of $10 per share, making a total capital of $10,450.

In April, 1903, 40 acres of land were purchased, high up on the slope above Claremont, about 1 mile from the foothills. Development was begun on this property the same season. A well was sunk and equipped with a 25-horsepower gas engine and Pomona plunger pump, an 8- or 10-inch main was laid to the village 2 miles below, and a reservoir with a capacity of 1,250,000 gallons was constructed. The plant will produce about 25 inches of water.

CHINO LAND AND WATER COMPANY.

The Chino Land and Water Company was organized in 1900, with a capital stock of $1,500,000, divided into 15,000 shares, the par value of each being $100. It succeeded to the holdings of Richard Gird, of Chino, these holdings including the greater part of the Chino ranch of 37,500 acres, with certain water rights and obligations. The company owns 14 or 15 flowing wells in the Chino artesian belt and two pumping plants.

The greater part of the water supply is furnished by a group of ten artesian wells, situated about 1¼ miles southwest of Chino. The water from this group is conducted for several miles in a southeasterly direction through an earthen ditch, to 600 or 700 acres of alfalfa land to which it is applied. The artesian flow is supplemented during the heated term by the water yielded by a pumping plant installed in 1903, about half a mile from the artesian group.

A second pumping plant, which supplies the village of Chino with domestic water, is situated about 1½ miles north of Pomona. This plant was installed in 1901, and a portion of its product is sometimes sold to outsiders. The well is one of the original Gird group, bored in the early eighties, and is reported to have yielded 80 inches of artesian water when first put down. There were 23 of these wells, drilled in the old Palomares ciénaga, and their reported total yield in the latter part of the decade between 1880 and 1890, is 300 or 350 inches. A pipe line with a capacity of 300 inches was laid by Mr. Gird from the wells to the vicinity of Chino, and his total investment in wells, pipe lines, and water rights is given as $200,000. The wells failed rapidly, however, and all ceased flowing in the years 1888 to 1891, and since Mr. Gird had agreed not to pump them, they have all been abandoned, except Nos. 280 and 287, Cucamonga quadrangle, over which pumping plants have been installed, and five or six others which are used by ranchers for domestic supply.

Some supplementary irrigation is accomplished on the Chino rancho by the use of waste waters from the beet-sugar factory at Chino. A group of 15 wells is pumped by compressed air for the use of the factory when it is in operation, and the waste is conducted south of Chino to lands on the north and south banks of Chino Creek.

SAN JOSE VALLEY SYSTEMS.

CURRIER TRACT WATER COMPANY.

The Currier Tract Water Company was incorporated in September, 1900, with a capital stock of $10,000, divided into 300 shares, whose par value is $33.33 each. There are at present 35 stockholders in the company. The company owns a well and pumping plant (No. 1, Pomona quadrangle), located a short distance west of Pomona. The plant consists of a 30-horsepower electric motor and centrifugal pump, which with the well cost $3,300. In addition to this plant, 1¼ miles of 10-inch cement pipe have been laid at an expense of $2,300, bringing the total investment up to $5,600. From this plant about 100 acres, principally in citrus fruits, are irrigated. It is reported by officers of the company that in July, 1905, an official measurement was made which indicated an output of 56 miner's inches from the plant. Costs are given as 85 cents per hour for pumping, while the total cost for operation and maintenance is from $550 to $560 annually.

A. T. CURRIER DEVELOPMENT.

The plant of A. T. Currier is a private enterprise, but its magnitude justifies a brief description. It consists of two wells located on the south bank of San Jose Creek about 1½ miles below Spadra, 560 feet of wooden flume, and 3¼ miles of 18- and 20-inch vitrified pipe, through which the water is carried along the foot of the hills south of San Jose Creek valley, the line terminating south of Lemon. The wells were sunk in 1902 to bed rock, which was reached at 80 and 115 feet, and the pipe line was laid during the same year, at a total expense of $15,400.

NORTH DITCH.

The old irrigation work formerly known as the Rowland & Foster ditch diverts water from the bed of San Jose Creek about 1½ miles northeast of Lemon. It follows the creek for one-fourth mile until it attains the elevation of the bottom lands, thence it passes due west across the valley for about 1 mile. The original ditch was built fifty or sixty years ago by the Spanish, but the present work, a dirt ditch throughout, was dug in 1885.

The water supply from the creek varies with the season, but is usually less than 40 miner's inches. The supply being lowest during the summer season, when irrigating water is most needed, it has been found necessary to supplement it by installing pumping plants, four of which are in operation. The water is used by the ranchers in the Lemon district on the north side of the creek, who irrigate from 100 to 125 acres. The entire head is distributed on the basis of one hour per acre each twenty-one days.

SOUTH DITCH.

About one-half mile below the diversion dam on San Jose Creek at the head of the combined north and south ditches the water is divided and half the flow is carried across the creek by flume and through the south ditch for about 2 miles in a southwesterly direction to the ranches which are served by it on the south side of the valley. Eleven individual ranchers are entitled to the water from this ditch, but as the flow is much too small for the acreage under cultivation, five or six pumping plants have been established to furnish an additional supply. The north and south ditches share the water of San Jose Creek at their common diversion point equally, each receiving, it is said, from 15 to 40 miner's inches. On the south ditch the full head is distributed on the basis of one hour per acre each twenty-five days.

LORDSBURG WATER COMPANY.

The Lordsburg Water Company was incorporated December 5, 1900, with a capital stock of $36,000, divided into 3,600 shares, with a par value of $10 each. Before the incorporation of the company its organizers had sunk wells, installed pumping plants, and laid a pipe line, at an expense of nearly $12,500. This property was exchanged for the stock, which is distributed among 35 shareholders. Three thousand five hundred shares were issued to the original owners, while 100 shares were retained as treasury stock. Later the company purchased some stock, so that in 1905 there were but 3,146 shares out.

The company owns three wells, two of which (Nos. 50 and 63, Pomona quadrangle) are in use. One of these wells is pumped by a 20-horsepower electric motor and the other by a 24-horsepower gas engine. The officers of the company report that from 50 to 60 miner's inches are developed by the two plants.

The distributing system includes about 5 miles of pipe line, nearly 3½ miles of which are in the main conduit, which extends northwestward from the pumping plants to San Dimas Wash and connects with the San Dimas, Covina, and Azusa irrigating systems. This conduit is 16, 12, and 10 inches in diameter, according to grade, and has a capacity of 120 to 140 miner's inches.

The cost of the water is given by the company's officers as about $1\frac{1}{2}$ cents per hour-inch. Some stockholders have more water than they need, and sales are sometimes made to outsiders at a rate of $2\frac{1}{2}$ cents per hour-inch.

There are 300 acres irrigated by the company, 40 acres south of the plant at Lordsburg and the balance below the pipe line between Lordsburg and San Dimas. Citrus fruits, alfalfa, and potatoes are grown.

LAVERNE LAND AND WATER COMPANY.

The Laverne Land and Water Company is a cooperative concern, organized and incorporated October 30, 1899. The capitalization is $25,000, divided into 500 shares whose par value is $50 each. The paid-up capital represents about one-half of the capital stock, $241\frac{1}{2}$ shares having been issued.

At the time of the organization of the company 15 acres of land were purchased, and in 1900 two wells (No. 249, Pomona quadrangle) were sunk on this property, which lies $1\frac{1}{2}$ miles northeast of Lordsburg. A 38-horsepower gas engine and two deep-well pumps, with a combined capacity of 55 inches, were installed, and 3 miles of cement, steel, and vitrified pipe were laid west and northwest from the plant for the delivery of water to the lands under irrigation. Both pumps are in operation only when the demand for water is large. The company reports that in 1903 one pump was used 1,087 hours and two pumps were used 1,402 hours, and that in 1904 one pump was used 650 hours and two pumps were used 3,170 hours.

A charge of 75 cents per hour is made for the output of both pumps, a rate of $1\frac{4}{11}$ cents per hour-inch when the full head of 55 inches is delivered; and 40 cents per hour is charged for the output of one pump.

The water is used to irrigate 241 acres of citrus fruits. Each acre is given a two and one-half hours' run of a full head every thirty days, which is equivalent to a duty of 1 inch continuous flow to 5.3 acres when the full head of 55 inches is delivered. Water in excess of the regular supply is sometimes furnished to stockholders and to outsiders. In these cases a charge of 3 cents per hour-inch is made.

LEVERNE IRRIGATING COMPANY.

The Laverne Irrigating Company was incorporated March 17, 1902, with a capital stock of $25,000, divided into 500 shares. One acre of land with a water right to 5 acres and one-third interest in a well and pumping plant were acquired at Laverne, 1 mile east of San Dimas, from L. T. Gillett. The well had been sunk, the plant installed, and the pipe line laid in 1900. The pumping machinery consists of a 35-horsepower gas engine and centrifugal pump No. 4 and the distributing system of 2 miles of 10-inch cement pipe. One hundred acres of citrus fruits are irrigated, the water costing, it is reported, 1 cent per hour-inch. Water is distributed in full heads at thirty-day intervals.

SAN DIMAS IRRIGATION COMPANY.

In 1885 Messrs. Lyman, Allen, and Bixby, owners of riparian water rights in San Dimas Canyon, which they had purchased from Messrs. Brooks and Rogers, who made the original filings, laid an 8-inch pipe from the bed of San Dimas Creek out to the mesa lands east of the wash. During the same year they organized the San Dimas Land and Water Company, capitalizing it at $60,000, with 1,200 shares of of stock, 1,025 of which have been issued. The San Jose Ranch Company was organized in April, 1887, with a capital stock of $300,000, and controlled several thousand acres of land lying south of San Dimas Wash and extending westward to the Covina district. Its water rights covered the "Mud Springs" ciénaga, 1 mile southeast of San Dimas; the developments in Sycamore Flat Canyon, which then yielded 10 to 15 inches, but have since been abandoned; and certain claims on the flow of San Dimas Canyon based on the company's holdings of lands in the upper part of the canyon. In addition, it took possession of the water rights and development work of the San Dimas Land and Water Company, agreeing in return to furnish the latter company with 35 miner's inches constant flow.

Extended and expensive developments were at once undertaken. A 12- and 14-inch cement conduit was laid from the masonry forebay at the opening of San Dimas Canyon to the plain on the south, which formed a part of the large tract controlled by the Ranch Company. Sixteen 7-inch wells were sunk in the Mud Springs ciénaga, and a tunnel was driven to cut the wells at points varying from 20 to 30 feet below the surface. During the year of organization (1887) and the five years following, 3,300 feet of 3- by 6-foot tunnel were constructed in the ciénaga and a gravity flow was developed which is reported to have at one time reached a maximum of 77 miner's inches. From the canyon line and the Mud Springs ciénaga, 12 to 14 miles of 8- by 10-inch cement distributing pipe were laid to the ranch lands lying west of these sources. While these expenditures were being made, lands with water rights were sold, and by 1891 these rights, aggregating 160 inches, had been disposed of on the basis of $1,000 per inch. The company, unwisely managed from the start, had expended in various ways the money derived from the sale of the lands, but had made no adequate provision for obtaining the water which it had agreed to supply.

During the years 1891 to 1894 the flow from the only sources, San Dimas Canyon and Mud Springs ciénaga, gradually declined, and the company, unable to meet the demands of those who had bought water from it, offered to turn over to them its remaining assets, consisting of pipe and tunnel systems, various water rights, and $3,000 in cash. This offer was declined, and suit was instituted against the company to compel the delivery of the full quota of water according to contract; but a minority of the ranchers, believing that the company was exempt from penalty through the operation of the statute of limitations, withdrew from the suit, and after negotiations with the San Jose Ranch Company organized the San Dimas Irrigation Company on October 15, 1894. This company was capitalized at $160,000, divided into 1,600 shares, and to it the system of pipe lines and tunnels belonging to the Ranch Company was deeded. It was provided also that other purchasers of water rights from the San Jose Ranch Company should be allowed to join the new company within a year, the applicant to receive 10 shares of stock in the new organization for each inch of water purchased from the old.

Immediately after the formation of the San Dimas Irrigation Company, suit was brought to determine the ownership of the water from the Mud Springs ciénaga. In 1896 a decision was rendered, awarding this water, which had now fallen to 33 inches, according to precedence in use, thus leaving all except the first users without water. These first users shortly afterward organized the Ciénaga Land and Water Company.

The flow from the Mud Springs continued to decline, but the Ciénaga Company was unable to pump because the wells and tunnels belonged to the San Dimas Irrigation Company, and the latter company was unable to pump because the water belonged to the Ciénaga Company. This deadlock was broken by an agreement reached in 1898, whereby the San Dimas Irrigation Company agreed to install a pumping plant and deliver to the Ciénaga Land and Water Company, free of charge, 33 miner's inches, but reserved the privilege of turning the plant over to the Ciénaga Company at any time, allowing the latter company to pump the 33 inches at its own expense. In case this was done the San Dimas Irrigation Company was to be permitted to enter on the ciénaga lands and install an independent plant there.

In accordance with the terms of this agreement, the San Dimas Company installed a plant in 1898, and for three years delivered 33 miner's inches to the Ciénaga Company free of charge. At the end of this period, becoming dissatisfied, the San Dimas Company took advantage of the option in the agreement of 1898, and for one year the plant was operated at the expense of the Ciénaga Company, and but 33 inches developed. Finally, the latter company claiming that the cost of pumping under this arrangement was excessive, a contract was entered into, by the terms of which the San Dimas Company agreed to furnish the Ciénaga Company with 33 inches at a charge of three-fourths of a cent per hour-inch. This contract expired in December, 1907.

In 1895 it was discovered that a large body of water underlay San Dimas Wash, and from that time on many wells were sunk there and plants were established to supplement the supply in the surrounding districts. The San Dimas Irrigation Company, among others, entered this district in 1900, purchased land, put in a well, and erected a pumping plant. In 1904, because of the increased demand and the lowering of the water plane, a second, deeper well, 14 inches in diameter, was bored in the wash, and a 75-horsepower electric motor installed over it. The two wells there yielded 60 miner's inches after these improvements were completed.

In 1902 a well was sunk and equipped with pumping machinery on Bonita avenue, about one-fourth mile north of the Mud Springs ciénaga, and a considerable addition to the supply was thus obtained. At times, also, water has been purchased from outside systems when available at a reasonable price, and by these various means the supply has been kept equal to the demand. The only gravity water owned by the company is the tenth part of the flow of San Dimas Canyon, when the total is 37½ inches or less, and one-half of all in excess of this amount. Title to this share is a result of the compromise of January, 1905, which ended the long suit between the San Dimas Land and Water Company and other claimants to San Dimas Canyon water.

Stock of the San Dimas Irrigation Company is held exclusively by landowners, and the basis of distribution is 1 inch to 10 acres. Water rates are established yearly and are controlled by the cost of pumping. All improvement and maintenance charges are met by separate assessments.

In addition to the water owned by the company, about 150 inches of alien water produced by independent pumping plants is distributed through the San Dimas system, one-fourth cent per hour-inch being charged for this service.

Of the 3,000 acres irrigated in the San Dimas district, about 1,050 are supplied by the San Dimas Irrigation Company. Its assets are distributed about as follows: Pipe lines, 20 miles of 8- to 18-inch pipe, \$30,000; wells and three pumping plants, \$26,000; three pumping-plant sites, \$2,300; land in San Dimas Canyon, \$1,000; total, \$59,300.

ARTESIAN BELT WATER COMPANY.

The Artesian Belt Water Company was incorporated August 14, 1897, and capitalized at \$30,000, divided into 300 shares, which are distributed among 64 stockholders. This was one of the first companies organized in the San Dimas district for the purpose of developing and distributing pumped water, and it now owns and pumps the first well sunk there (No. 234, Pomona quadrangle). This well was bored in 1895 and the first plant was installed in 1896 by J. O. Enell. The original plant was a 30-horsepower boiler and duplex steam pump. Now a 54-horsepower engine is used. When the well was first bored water was encountered at 44 feet from the surface, but the water plane has since declined so that the lift is now much more than this.

In addition to the well and plant, the company owns 10 acres of land in San Dimas Wash and about 2½ miles of 12-inch cement pipe, the total estimated investment being $20,000. The distribution of the waters and the administration of the company are managed much as in the larger San Dimas Irrigation Company, several landowners being stockholders in both organizations.

NEW DEAL LAND AND WATER COMPANY.

The New Deal Land and Water Company was organized September 25, 1890, with a capital stock of $100,000, divided into 2,000 shares. It owns and operates a well and pumping plant (No. 236, Pomona quadrangle), 1 mile southeast of San Dimas, near the old Mud Springs ciénaga. The property on which the plant is located was purchased on the supposition that in the original deed from the San Jose Ranch Company no reservation had been made of the rights to the underground water in this vicinity, but after the transfer of the Ranch Company's rights to the San Dimas Irrigation Company, the latter organization claimed all underground waters in the vicinity of the springs, and the matter was carried to the courts. An agreement was finally reached, however, by the terms of which the New Deal Land and Water Company was given the right to sink and maintain its present well and was guaranteed a protection strip within a radius of 75 feet of the plant. The plant consists of a 12-horsepower gas engine and a No. 2 Fulton pump, and produces from 10 to 20 inches of water, with which about 100 acres of citrus fruits are irrigated.

FROSTLESS BELT WATER COMPANY.

The Frostless Belt Water Company was incorporated in April, 1901, with a capital stock of $10,000, divided into 1,000 shares, all of which have been issued. There are 13 stockholders, 10 of whom also own stock in the San Dimas Irrigation Company.

Soon after its organization the company purchased 20 acres of land at Laverne at a cost of $1,500, and not long thereafter a well was bored (No. 224, Pomona quadrangle) and equipped with a 30-horsepower gas engine and centrifugal pump. The plant is reported to yield 30 miner's inches. About 12,000 feet of 10-inch cement pipe have been laid for delivering the water to the lands of the stockholders southwest of San Dimas. The water is delivered in full heads of 25 to 30 inches at thirty-day intervals, at the rate of 1½ inches to 10 acres. Citrus fruits are raised. The company reports its investments as follows: Well and plant, $2,800; pipe line, $3,300; real estate, $1,500; total, $7,600.

SAN GABRIEL SYSTEMS.

HISTORY OF RIGHTS.

Wm. Ham. Hall states that the church fathers are reported to have taken water from San Gabriel River as early as 1821 for irrigation in the neighborhood of the San Gabriel mission. None of the present rights, however, date back to this earliest diversion, if it was actually made. The oldest of the present ditches is the Azusa, built in 1843 by Luis Arenas, owner at that time of the Azusa rancho. Eleven years later Andrés Duarte, who owned the Duarte rancho, built a second west-side ditch, to which some of the west-side irrigators claim their rights are traceable.

In 1852 or 1853 Mr. Dalton, who had meanwhile acquired the Azusa rancho, enlarged the east-side ditch, and disputes quickly arose, both as to the boundaries of the rancho and as to the ownership of the water carried in the enlarged ditch, settlers on the lower part of the ranch claiming a proportion of the waters carried in it. The period which intervened up to 1889 was one of much confusion. Disputes, litigation, and compromises were of repeated occurrence, the settlements which resulted from the latter often being of short duration. At the same time other settlers were taking up lands, and the interests involved became constantly greater and more complex. Slauson & Martz, from whose interests the Azusa Agricultural Water Company was later developed, secured possession of the Azusa ranch between 1880 and 1883, and in 1882 the Azusa Water Development and Irrigating Company, later the Covina Irrigating Company, began a tunnel for developing the underflow of the San Gabriel. This tunnel was completed in 1889, although the canal by which its waters were carried to a district east and south of that served by the older Azusa canal had been finished about 1885. The builders of this tunnel claimed to have developed by its construction 137 miner's inches of water, but the claim was disputed by the other companies interested in the San Gabriel flow. January 26, 1889, all of the claimants to San Gabriel River waters entered into an agreement, by the terms of which the water was divided among them, and perfected a scheme for controlling its distribution. For purposes of division the water was considered as consisting of 720 parts. When the total quantity is equal to or less than 1,700 miner's inches, each of the claimants gets a certain number of these parts, while the excess above 1,700 inches is divided somewhat differently. The number of 720ths that each claimant to the first

1,700 inches and to the excess receives, as agreed on in this compromise, is given in the following table:

Division of San Gabriel River waters.

[In seven hundred and twentieths.]

	First 1,700 inches.	Excess.
Azusa Water Development and Irrigating Co	72	241
Duarte Mutual Irrigation and Canal Co. and Beardslee Water Ditch Co	216	160
Azusa Land and Water Co	45	33
Azusa Agricultural Water Co	54	40
Kate S. Vosburg and Louise McNiel	27	20
"Old users," represented in part by the Azusa Irrigating Co. and Azusa Water Development and Irrigating Co	306	226

At the time of the compromise a committee of nine members, appointed by the several companies and associated irrigators, was given control of the water from its source to the point of division between the east-side and west-side users. Subcommittees, representing the respective interests, take charge of the water below this point.

This compromise served as a basis for the division of the water until the completion of the San Gabriel Power Company's conduit in 1898. After this conduit was built the power company claimed as salvage and was allowed one-tenth of all the canyon flow except 200 inches, which it was agreed to consider as developed by the Covina tunnel. This tenth was deducted proportionately from the share of each of the users under the compromise agreement of 1889, and on August 1, 1898, the salvage water was purchased from the power company by the Covina Irrigating Company for $66,500, and is now owned and used by the latter organization. The old apportionment, except as it is modified by this salvage agreement, is still in force. An account of the later developments is given in connection with the sketch of each of the companies that follows. The quantity of water available in the San Gabriel for all users and the fluctuations in the flow of the stream are shown in the accompanying tables, taken from the records of the United States Geological Survey. The minimum discharge of which there is record is 3 second-feet, reached in July and September, 1899, and in September, 1900; the maximum is the flood of March, 1905, with a discharge of 11,130 second-feet.

Estimated monthly discharge of San Gabriel River and canals at Azusa, Los Angeles County, 1896–1906.

[Drainage area, 222 square miles.]

	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1896.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	51	26	37	2,275	0.17	0.20
February	61	36	41	2,358	.18	.19
March	169	37	111	6,825	.50	.58
April	91	40	54	3,213	.24	.27
May	40	29	36	2,214	.16	.18
June	27	13	19	1,131	.09	.10
July	15	9	12	738	.05	.06
August	36	9	14	861	.06	.07
September	19	11	13	774	.06	.07
October	188	10	24	1,476	.11	.13
November	40	15	19	1,131	.09	.10
December	37	17	22	1,353	.10	.12
The year	188	9	34	24,349	.15	2.07
1897.						
January	147	25	57.9	3,617	.260	.292
February	1,713	64	344.8	19,146	1.553	1.579
March	1,765	294	465.6	28,623	2.097	2.418
April	370	201	294.4	17,519	1.325	1.478
May	196	94	145.0	8,851	.653	.748
June	91	54	67.8	4,033	.306	.341
July	52	27	38.1	2,343	.171	.197
August	34	22	26.4	1,613	.118	.136
September	23	18	20.7	1,226	.088	.098
October	1,640	22	90.5	5,564	.403	.465
November	34	31	33.3	1,860	.141	.149
December	34	28	30.5	1,875	.137	.158
The year	1,765	18	134.6	96,270	.604	8.059
1898.						
January	63	28	40	2,453	.18	.20
February	70	32	40	2,241	.18	.19
March	48	28	35	2,131	.16	.18
April	37	25.3	33	1,950	.15	.17
May	83	25.0	36	2,223	.16	.19
June	30	14.5	19	1,159	.09	.10
July	14	9.0	11	672	.05	.06
August	9	5.0	7	456	.03	.04
September	10	6.1	8	467	.04	.04
October	10	7.5	9	533	.04	.05
November	11	8.0	10	580	.04	.05
December	18	11.7	14	832	.06	.07
The year	83	5.0	22	15,697	.10	1.34
1899.						
January	33	15	23	1,414	.104	.120
February	28	20	22	1,244	.102	.106
March	40	18	26	1,623	.119	.137
April	28	16	21	1,262	.096	.107
May	17	12	14	842	.062	.071
June	22	5	10	565	.043	.048
July	4	3	4	221	.016	.018
August	6	4	5	295	.022	.025
September	6	3	4	220	.019	.021
October	26	4	11	709	.050	.058
November	24	10	14	847	.064	.071
December	39	16	20	1,247	.091	.105
The year	40	3	14.5	10,489	.065	.887
1900.						
January	89	22	32	1,968	.14	.16
February	23	18	20	1,111	.09	.09
March	30	16	20	1,230	.09	.10
April	26	13	17	1,012	.08	.09
May	86	16	37	2,275	.17	.20
June	22	8	15	893	.07	.08
July	10	4	6	369	.03	.03
August	5	4	4	246	02	.02
September	6	3	4	238	.02	.02
October	6	4	5	307	.02	.02
November	5,200	5	186	11,068	84	.93
December 1–16	53	31	40	1,269	.18	.11
The year	5,200	3	32	21,986	.15	1.85

Estimated monthly discharge of San Gabriel River and canals at Azusa, Los Angeles County, 1896-1906—Continued.

[Drainage area, 222 square miles.]

	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1901.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches.*
January	1,450	28	169	10,391	.76	.87
February	2,605	137	680	37,765	3.06	3.19
March	440	135	221	13,589	1.00	1.15
April	130	95	110	6,545	.50	.56
May	272	83	121	7,440	.55	.63
June	93	41	63	3,749	.28	.31
July	41	24	30	1,845	.14	.16
August	27	15	20	1,230	.09	.10
September	20	15	17	1,012	.08	.09
October	122	15	24	1,476	.11	.13
November	50	29	32	1,904	.14	.16
December	30	26	27	1,660	.12	.14
The year	2,605	15	126	88,606	.57	7.49
1902.						
January	51	24	28	1,722	.13	.15
February	120	38	37	2,055	.17	.17
March	378	63	99	6,087	.45	.52
April	99	48	66	3,927	.30	.33
May	48	30	39	2,398	.17	.20
June	29.5	13.5	20	1,190	.09	.10
July	17	7.5	11	676	.05	.06
August	8.5	6	7	430	.03	.03
September	6	4.5	5	298	.02	.02
October	10.5	5.5	7	430	.03	.03
November	80	7.5	19	1,131	.09	.10
December	68	16	32	1,968	.14	.16
The year	378	4.5	31	22,312	.14	1.87
1903.						
January	2,999	22	148	9,100	.67	.77
February	203	61	102	5,665	.46	.48
March	1,417	57	257	15,802	1.16	1.34
April	5,892	267	792	47,127	3.57	3.98
May	355	125	217	13,343	.98	1.13
June	125	62	95	5,653	.43	.48
July	58	35	43	2,644	.19	.22
August	35	24	29	1,783	.13	.15
September	34	21	25	1,488	.11	.12
October	32	20	24	1,476	.11	.13
November	26	22	24	1,428	.11	.12
December	26	22	24	1,476	.11	.13
The year	5,892	20	148	106,985	.67	9.05
1904.						
January	28.2	23	24.4	1,500	.11	.13
February	438	23	47.7	2,744	.21	.23
March	1,130	35	110.8	6,813	.50	.58
April	120	57	89.7	5,337	.40	.45
May	104	37	66.5	4,089	.30	.35
June	38	17.5	25.5	1,517	.11	.12
July	18	11	14.0	861	.06	.07
August	29	9.5	12.9	793	.06	.07
September	13.5	7.5	10.8	643	.05	.06
October	15.5	9.0	12.0	738	.05	.06
November	14.5	11.0	12.8	762	.06	.07
December	48	14.7	16.9	1,039	.08	.09
The year	1,130	7.5	37	26,836	.17	2.28
1905.						
January	108	18.5	36.6	2,251	.16	.18
February	3,010	34	466	25,880	2.10	2.19
March	11,130	142	1,222	75,140	5.50	6.34
April	474	206	329	19,580	1.48	1.65
May	540	193	278	17,090	1.25	1.44
June	182	63	139	8,271	.63	.70
July	109	56	83	5,103	.37	.43
August	55	33	42.8	2,631	.19	.22
September	35	28	31.4	1,869	.14	.16
October	32	27	28.8	1,771	.13	.15
November	97	29	44.7	2,660	.20	.22
December	50	37	40.1	2,466	.18	.21
The year	11,130	18.5	2,284	164,700	1.03	13.89

Estimated monthly discharge of San Gabriel River and canals at Azusa, Los Angeles County, 1896-1906—Continued.

[Drainage area, 222 square miles.]

	Discharge.			Total discharge.	Run-off.	
	Maximum.	Minimum.	Mean.		Per square mile.	Depth.
1906.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Sec.-feet.*	*Inches*
January	441	36	68.1	4,190	.307	.35
February	92	47	68.1	3,780	.307	.32
March	9,430	56	2,160	133,000	9.73	11.22
April	1,110	321	578	34,400	2.60	2.90
May	1,110	251	342	21,000	1.54	1.78
June	364	204	262	15,600	1.18	1.32
July	295	97	155	9,530	.698	.80
August	93	57	72.8	4,480	.328	.38
September	55	42	47.7	2,840	.215	.24
October	42	38	39.8	2,450	.179	.21
November	47	37	40.4	2,400	.182	.20
December	1,600	45	188	11,600	.847	.98
The year	9,430	36	335	245,000	1.51	20.70

AZUSA IRRIGATING COMPANY.

The Azusa Irrigating Company was organized and incorporated August 23, 1886, by a part of the Azusa "old settlement" irrigators. The company was capitalized at $60,000, divided into 4,000 shares with a par value of $15 each, but the capital has since been increased to $180,000. Of the 12,000 shares, 10,865 have been issued and are distributed among 199 shareholders. They are reported to have a market value of about $35 each. The basis of the distribution is three shares to the acre. Delinquent stock reverts to the company and may be reissued, but only to lands within the Azusa water district established by the compromise of 1889. This district includes 5,508 acres, of which 4,043 are covered by the Azusa Irrigating Company and 1,465 acres are under contract by the Covina Irrigating Compay.

Water is prorated to stock and is distributed in 100-inch heads, which during times of abundant supply are given twelve-hour runs to each 10-acre tract in turn. When the supply becomes short, the time in each run is reduced.

The company owns the Azusa ditch, the oldest of the east-side canals, and other canals and pipe lines aggregating about 40 miles. The main canal is about 3 miles in length from the Azusa ice house, where the Covina and Azusa waters are divided, and this main line is extended 1½ miles beyond the terminus of the canal by a 30-inch vitrified pipe. The main distributing lines consist of 10-, 12-, and 14-inch cement pipe, according to grade, and are designed to carry 120 miner's inches. A reservoir with a capacity of 6,500,000 gallons and capable, therefore, of impounding a continuous flow of 800 miner's inches for fifteen hours, forms a part of the system. It was built in 1893 at a cost of $13,000.

In addition to the rights of the San Gabriel waters and the distributing system mentioned above, the company owns 40 acres of land in San Dimas Wash. Wells were sunk on this property, a pumping plant was installed, and a pipe line 4½ miles in length was laid due west to the main ditch, but the plant was sold later. Nevertheless, much pumped water is used in the district during seasons when the supply of gravity water is low. The Glendora and Azusa Water Company supplies the upper part of the district, and the lower part receives water from the Irwindale wells, operated by the Irwindale Land and Water Company, the Orange Avenue Water Company, and the Cypress Avenue Water Company. The majority of the stockholders in these subsidiary companies are also stockholders in the Azusa Irrigating Company.

Water rates are collected on the basis of a sliding scale, charges varying from $1.20 in February to $5.40 in July, August, and September for a twelve-hour run of a 100-inch head. The winter and spring charges, when water is abundant, are intended to be only nominal and merely to cover the zanjero's fees.

COVINA IRRIGATING COMPANY.

The Azusa Water Development and Irrigating Company, whose name was changed later to the Covina Irrigating Company, was incorporated May 20, 1882, capitalized at $5,000, and 6,667 shares of stock were issued at a par value of 75 cents per share. As its works were extended the capital stock of the company was increased at various times, and finally, in October, 1886, it was organized on its present basis of 10,000 shares at $50 per share.

The original company was organized to develop the underflow of San Gabriel Canyon and furnish a water supply for summer irrigation when the surface flow is low. In fulfillment of this purpose the tunnel, which cuts through two rock points in a crooked part of the canyon, about a mile above its mouth, was undertaken in 1882 and completed in 1889. This work, about 2,200 feet in length, in connection with a bed-rock dam below its upper section, delivers about 137 miner's inches, which amount, it was claimed by the promoters of the enterprise, had been developed by their work. This position was contested by other companies holding rights to San Gabriel waters, and the matter was not settled until in the compromise of 1889 one-tenth of the combined natural and developed flow of the canyon, so long as this was 1,700 inches or less, was awarded to the Covina Company.

On August 1, 1898, the salvage, which had been construed as belonging to the San Gabriel Power Company, whose canal above the power house had effected the saving, amounting to one-tenth of the total flow at the point of diversion 7 miles above the power house, after 200 inches had been deducted, was purchased by the Covina Company for $66,500. In addition to water from these two sources the company receives the share of certain old users, whose interests aggregate about one-tenth of the flow of the canyon, and delivers this water to its owners at the rate of about 1 inch to 8 acres. About 1,465 acres are irrigated under this contract. When the total flow of the San Gabriel is 2,000 inches, the Covina Irrigating Company receives a total of 593.72 inches, consisting of company water, 210.7 inches; San Gabriel power water, 180 inches; and "old users" or contract water, 203.02 inches.

Like many other irrigating enterprises previously dependent on mountain water for a supply, the Covina Irrigating Company found during the dry years of the late nineties that its gravity water was insufficient for its needs and it was forced to resort to pumping. With this contingency in view, 104 acres of land one-half mile south of Lordsburg had been purchased for $20,000 on November 25, 1896. During 1898 and 1899 ten wells were bored on this property, a 100-horsepower steam engine and compressor were installed (Nos. 200–201) at a cost of $14,000, and a 12- and 16-inch pipe line was laid westward 6 miles from the pumping plant to the main canal. March 21, 1899, 40 acres of water-bearing land were bought in San Dimas Wash for $10,000. A well (No. 242, Pomona quadrangle) was sunk shortly afterward on this property, equipped with a steam and air plant at a total cost of $5,000, and a 16-inch pipe line was laid to connect this plant with the system. Later in 1899 several hundred acres additional were purchased in San Dimas Wash at an outlay of about $15,000. In 1900 a plant (No. 230, Pomona quadrangle) was installed on this property, and connections with the system were effected. A further extension of the pumping system was made in 1904 by the addition of a small gasoline engine as an auxiliary to the Lordsburg plant.

The volume of this pumped water varies with the seasons, since it is used only to augment the canyon flow. During the summer of 1904, following an unfavorable winter, San Gabriel River was very low, and the pumping plants were in operation for a longer period than during any previous season. The following statement summarizes these operations:

Operations of Covina Irrigating Company's pumping plants, 1904.

No. of plant.	Time operated.	Average yield.	Cost per hour-inch.
	Days.	*Inches.*	*Cents.*
200–201	224	90	1.4
200–201, gasoline adjunct	12	30	
230	139	25	2.13
242	115	37	2.65

During this season the volume of pumped and canyon water delivered by the Covina Irrigating Company was as follows: Company water, 66,483 hour heads (25 miner's inches), equivalent to 189.75 inches continuous flow; contract water, 24,375 hour heads, equivalent to 69.6 inches continuous flow; alien water, 4,432 hour heads, equivalent to 12.6 inches continuous flow.

The company owns 5½ miles of the original Azusa Water Development and Irrigating Company's canal, built in 1885 at a cost of $40,000. This canal is cement lined, averages 4 feet in depth, and is from 4 to 8 feet wide. It ends in a 15,000,000-gallon cement-lined reservoir, located about 1 mile northeast of Covina. This reservoir was built in 1887 at a cost of $13,000. In addition to the canal and reservoir, which form the main artery and regulator of the system, there are nearly 1,200 feet of 16-inch, over 60,000 feet of 12-inch, 44,200 feet of 10-inch, and 1,500 feet of 8-inch cement mains and distributing pipe.

The stock of the Covina Irrigating Company is practically all held by landowners, although it is not appurtenant to the land and there is no provision in the charter prohibiting outside ownership. Nor is there any restriction as to the number of shares that may be acquired per acre, the irrigator being free to purchase as much stock as he thinks he needs. It is said that this condition occasionally results in abuse, and that a certain amount of trickery sometimes appears in the practical operation of the system. For instance, a part of the water stock pertaining to a given tract may be sold, leaving the property without a sufficient water supply. The land with the remaining stock may then be sold to some outsider who is not familiar with local conditions and who believes that he is buying enough water to irrigate his acreage.

All of the company water, gravity and pumped, is apportioned to stock, independent of acreage, and is distributed in rotation by schedule. Usually in midsummer a 25-inch head is given a six-hour run to each 10 acres, but a 50- or 100-inch head may be used at the option of the irrigator. The regular charge for delivery is at the rate of $2.50 per 100 inches for a twelve-hour run, and the annual water charge therefor is from $1.25 to $1.50 per acre. In addition to this, stock is assessed for whatever expense there may be in operating and maintaining the system in excess of the water receipts. This annual assessment varies from $2 to $3.50 per share. In 1904 water collections amounted to $5,126 and stock assessments to $30,000. There are 243 stockholders in the company, and water is delivered to about 350 irrigators, including the contractors. Many of the latter are stockholders also.

There are about 3,000 acres under the Covina system, but as an indefinite part of this acreage is supplied with water from outside sources, it is not possible to state just the area irrigated by the Covina Company. The Citrus Belt Water Company supplies accessory water to the upper part of the district, between Glendora and Azusa, and the Columbia Water Company to the lower lands in the neighborhood of Covina. Most of the stockholders in these companies hold stock in the Covina Irrigating Company also.

AZUSA AGRICULTURAL WATER COMPANY.

In 1887 J. S. Slauson, J. D. Bicknell, and others, owners of 4,500 of the 5,000 acres in the Azusa ranch, combined these lands and the waters belonging thereto, forming an organization under the name of the Azusa Land and Water Company. The next year the Azusa Agricultural Water Company was organized with 6,000 shares, of a par value of $100 each, and the water rights of the Azusa Land and Water Company were transferred to it. Two shares of stock in the water company were conveyed with each acre of land sold by the Land and Water Company.

The rights of these companies, which depended on those of Mr. Dalton, former owner of the Azusa ranch, were not definitely settled until by the compromise of 1889 they were awarded $\frac{99}{720}$ of the total San Gabriel flow up to 1,700 inches, and $\frac{73}{720}$ of the excess over this amount. This apportionment, like that of all the other claimants to San Gabriel waters, has since been altered by the award of one-tenth of these waters to the San Gabriel Power Company as salvage.

The San Gabriel Canyon waters of the Azusa Agricultural Water Company reach the Azusa district through the Azusa canal, which carries the water of the Azusa Irrigating Company also. The division is effected at a point about one-quarter of a mile southeast of the Azusa ice house, where the water of the Azusa Agricultural Water Company enters its own system. This system, by means of which 900 acres, chiefly in oranges and lemons, are irrigated, includes about 4 miles of open cement flume 12 by 14 inches, and 4 miles of 8-, 10-, and 14-inch cement pipe. A reservoir with a capacity of 1,000,000 gallons has been built at a cost of $2,000.

The canyon water of this system has been supplemented by pumped water, a well (No. 255, Pomona quadrangle) just within the mouth of San Gabriel Canyon having been sunk in 1901 and equipped with a 30-horsepower electric motor at a total cost of $5,000. The water is pumped into the main canal and is taken out with the rest of the Azusa Agricultural Water Company's water, one-quarter of a mile southeast of the Azusa ice house. About 50 miner's inches are reported to be developed by this well. During the spring of 1905 another well was sunk in the wash, about one-half mile below the mouth of the canyon, and 8,440 feet of 16- and 20-inch cement pipe were laid to connect with the Azusa irrigating ditch above Azusa.

The water supply of this company is prorated to stock and distributed at intervals of four to six weeks. The domestic supply for the city of Azusa is taken from the Azusa Agricultural Water Company's share of the San Gabriel water, and in addition 39 families outside the town are supplied with domestic water.

CITRUS BELT WATER COMPANY.

The Citrus Belt Water Company was organized in 1900 by a number of irrigators in the district south and southwest of Glendora. They were owners of stock in the Covina Irrigating Company, who desired to supplement their portion of canyon water with pumped water. The capital stock of the new company was fixed at $35,000, divided into 500 shares with a par value of $70. Two hundred and thirty-five shares have been issued.

In the fall of 1900 the company purchased 42½ acres in San Dimas Wash, 5 or 6 miles from the lands of the stockholders, sunk a well, and installed a pumping plant. This plant consists of a 105-horsepower steam engine and centrifugal pump, and its capacity is given as 75 miner's inches. The cost of installation was $4,000. About 8 miles of 10- and 12-inch cement pipe, costing $9,000, and a reservoir costing $1,050 constitute the main distributing system. The water is delivered to each irrigator in turn in 25- or 50-inch heads, at intervals of two weeks. It costs the stockholders, of whom there are 43, about 2½ cents per hour-inch. The investments of the company is summarized by its officers as follows:

Property of Citrus Belt Water Company.

Land, 43½ acres	$10,000
Cement pipe, 3 miles 12-inch, 5 miles 10-inch	9,000
Pumping plant, 105 horsepower	4,000
Reservoir	1,050
	24,050

COLUMBIA LAND AND WATER COMPANY.

The Columbia Land and Water Company, like the Citrus Belt Company, was organized by stockholders of the Covina Irrigating Company to supply pumped water to their lands at times when the canyon flow is low. The company was organized in April, 1899, and capitalized at $60,000, divided into 600 shares. Twenty acres of land were acquired in San Dimas Wash, with two wells and pumping plants (No. 241, Pomona quadrangle) and several miles of pipe line. Each pumping plant is equipped with a 30-horsepower gas engine and centrifugal pump. The initial combined capacity of the two is given as 50 inches, which falls to 30 inches as the water level declines with continuous pumping. The pumps are operated twelve hours per day and about five months of each year, from June until the beginning of the rains. A full head is used in irrigating and is charged for at the rate of $1 per hour, which, inasmuch as the amount of water in a head varies, equals 2 to 3 cents per hour-inch. The distributing system includes a reservoir built in 1904, and about 5 miles of 8- to 12-inch main, extending from the wells to the reservoir, 1 mile northeast of Covina.

The company's investment is as follows:

Property of Columbia Land and Water Company.

Wells and pumping plants	$3,700
Pipe lines, 5 miles	5,000
Reservoir	2,500
Real estate	1,000
	12,200

WESTERN WATER AND POWER COMPANY.

The predecessor of the Western Water and Power Company, the Glendora Water Company, was organized in 1887, with a capital stock of $62,500, divided into 1,250 shares, the par value being $50 each. Lands were acquired at once in Big Dalton Canyon, which gave to the company the control of all of this canyon and its water rights except 120 acres with the water pertaining thereto. This amount belonged to the Mountain Base Water Company until 1888, when it was purchased by the Glendora Water Company for $5,000, thus placing in the latter company complete control of Big Dalton Canyon and all its water rights. From 1887 to 1898, inclusive, the capital stock of the company was paid up in full and the money expended in improvements and betterments, approximately as follows:

Expenditures of Glendora Water Company.

Lands and riparian rights	$10,000
Reservoirs, 3; combined capacity, 2,500,000 gallons	8,000
Puddle dam in Big Dalton Canyon	8,000
Tunnel (1,200 feet) in Big Dalton Canyon for developing water	14,000
Supply pipe (8-, 10-, and 12-inch) for conducting waters from Big Dalton Canyon to Glendora and vicinity	10,000
Distributing pipe (12 miles, 1½- to 4-inch) for distributing water in Glendora	13,000
	63,000

During the trying years from 1897 to 1900 the Glendora Company, like the majority of southern California water companies, found its gravity supply insufficient to maintain the acreage already under irrigation, and it became necessary to resort to pumping. In 1901 160 acres were purchased in San Dimas Wash, in which several successful wells had already been located; two 12-inch wells (Nos. 232 and 233, Pomona quadrangle), each about 500 feet deep, were bored, and a 250-horsepower pumping plant was installed and connected with a No. 6 centrifugal pump in each well. A 14-inch pipe line was then laid from the wells to connect with the Dalton Canyon line, 5 miles away. The wells produce about 125 miner's inches. These additions to the system were effected by means of a loan of $41,500 negotiated in 1901, the company's property serving as security. The details of the expenditures are about as follows: Land, $20,000; wells, $5,000; pumping plant, $10,000; supply pipe, $7,000. From 1901 to 1904 about $20,000 additional was expended on the pumping plant and branch pipe lines, and a considerable reduction was made in the company's indebtedness. As the expenditures and the value of the property owned exceeded the capital stock of the Glendora Water Company by a large amount, a reorganization seemed desirable. This was effected in April, 1904, by a sale of the company's property to the Western Water and Power Company, of Chicago, Ill. The capital stock of the newer organization is fixed at $100,000, divided into 1,000 shares whose par value is $100 each.

Since this sale the Western Water and Power Company has bought out the Alosta Water and Development Company, consisting of lands that control the water rights of Little Dalton Canyon and a system of pipe lines from this canyon to Alosta, just south of Glendora. Thus the present organization owns all the gravity water from Big and Little Dalton canyons and the pumping plant in San Dimas Wash. The gravity water is used when it is available; during favorable years it is sufficient to supply the system until after June 1, and yields a portion of the water required until a later date. The pumps are operated during the summer and fall.

Water rights have been sold to purchasers at 2½ and 4 cents per hour-inch. The rights have no relation to the lands, except that many of the large stockholders in the company are also large landowners under the Glendora system, so that their interests are identical.

GLENDORA-AZUSA WATER COMPANY.

The Glendora-Azusa Water Company was incorporated August 29, 1898, and capitalized at $48,450, divided into 484½ shares with a par value of $100 each. In 1898 170 acres of land were purchased in San Dimas Wash, at a cost of about $6,000. In 1900 a pumping plant was installed, and in 1902 a second well was sunk and equipped with pumping machinery. Centrifugal pumps are used in both wells (No. 231, Pomona quadrangle), a 75-horsepower motor running one and a 100-horsepower motor the other. The water is conducted from the wells through 10 or 11 miles of concrete pipe line to the lands served, lying west of Glendora, and distributed there. The system also includes one small reservoir with a capacity of about 200,000 gallons.

This is one of the systems developed partly to supplement the flow from San Gabriel Canyon, a part of the lands served lying below the Azusa and Covina canals and receiving gravity water from them. The pumping season of the Glendora-Azusa Company, therefore, varies with the supply of gravity water, being shortest during seasons of greatest rainfall. From 500 to 1,000 acres are wholly or partially supplied with water, which is distributed at a cost of 2½ cents per hour-inch. The average output during the season of 1905 is given at something less than 100 inches.

IRWINDALE WATER COMPANIES.

In the lower part of the Azusa water district, near Irwindale, three companies have been organized and pumping plants have been installed to develop underground water to serve as a supplement to the San Gabriel Canyon water. These are the Orange Avenue Land and Water Company, the Irwindale Land and Water Company, and the Cypress Avenue Land and Water Company.

ORANGE AVENUE LAND AND WATER COMPANY.

The Orange Avenue Company was organized in September, 1902, with a capital of $4,500, divided into 300 shares, distributed among 18 stockholders, all landowners. The plant consists of a well (No. 82, Pomona quadrangle) equipped with a 75-horsepower steam pumping plant. There is no pipe line, water being distributed to the stockholders directly or through the system of the Azusa Irrigating Company. The water costs the stockholders 1.55 cents per hour-inch, and is sold to outsiders for 3 cents per hour-inch. Distribution is effected in 25-, 50-, or 100-inch heads, as desired. About 380 acres are reported to be under irrigation.

IRWINDALE LAND AND WATER COMPANY.

The Irwindale Land and Water Company was incorporated September 19, 1899, and capitalized at $5,000, divided into 500 shares, which are distributed among 21 stockholders. Soon after organization one-tenth of an acre of land was purchased close to Irwindale, a well was sunk (No. 83, Pomona quadrangle), and a pumping plant was installed upon it. The plant consists of a 30-horsepower steam engine and Worthington pump, and its capacity is given as 60 inches. The output is pumped into the Azusa Irrigating Company's system and distributed through it. Distribution is effected in full heads, each share of stock being entitled to one hour's run monthly. The charge to stockholders is 2 cents per hour-inch, and to outsiders 3 cents per hour-inch. The water is used only to supplement the cheaper canyon water.

CYPRESS AVENUE WATER COMPANY.

The Cypress Avenue Water Company was organized in 1900 with a capital stock of $10,000, divided into 400 shares having a par value of $25 each; 202 shares have been subscribed for. The company operates a plant (No. 92, Pomona qadrangle) equipped with a 125-horsepower steam engine and centrifugal pump, reported to produce 113 inches of water. An independent steel pipe line, 1,300 feet in length, is also owned by the company. About one-half of the water is pumped into the Azusa Irrigating Company's system and the other half is distributed directly to stockholders. The water costs stockholders 1 cent per hour-inch; a charge of 3 cents per hour-inch is made to outsiders. All the members are stockholders in the Azusa Irrigating Company.

VINELAND IRRIGATION DISTRICT.

The Vineland irrigation district was organized in 1891, to include 4,000 acres in the vicinity of Vineland, just east of San Gabriel Wash. It claimed certain rights to San Gabriel Canyon waters, and these rights were sold with the land in the district. In the disputes which followed, however, the rights claimed by the district were given up in return for the installation of a pumping plant by the San Gabriel Power Company on a well which had been sunk by the Vineland irrigators on their tract. Such irrigation as is carried on in the district now depends on developed water from this plant, and inasmuch as the soil is sandy and porous and requires a large amount of water, and pumped water costs from 2 to 2½ cents per hour-inch, it has not been found practicable to irrigate vineyards or deciduous fruits. About 120 acres of citrus fruits, walnuts, and vegetables are irrigated, and perhaps 80 acres more are under cultivation.

An open stone ditch about 12 by 18 inches in size extends from the mouth of San Gabriel Canyon to a point 1 mile north of this district. This ditch catches some water from the Azusa ice-house waste ditch in winter, and this water is sometimes used by the Vineland irrigators.

DUARTE WATER COMPANIES.

RIGHTS.

The Duarte district is supplied with water by the Duarte Mutual Irrigation and Canal Company and the Beardslee Water Ditch Company. The upper part of the tract, consisting of about 1,000 acres, principally in citrus orchards, receives water from the former company. This area lies close to the base of the San Gabriel Mountains, on the sloping bench lands northwest of San Gabriel Wash. It extends from northeast to southwest a distance of 3 miles, and ranges in width from three-eighths of a mile at the eastern extremity to 1¼ miles on the west. The Beardslee Water Ditch Company serves about 400 acres of alluvial lands lying above San Gabriel Wash and adjoining the Duarte district on the west and south.

It is claimed that the rights of the Duarte irrigators to San Gabriel River water date back to 1854, when Andrés Duarte, the owner of the rancho, constructed a ditch and diverted a part of the San Gabriel flow to the west side. In 1859 or 1860, N. Beardslee acquired a part of the Duarte ranch by purchase, with the right to take water from the river for irrigation, and in the later year constructed a branch ditch to the lower Duarte neighborhood.

In 1872 Alexander Weil succeeded to the ownership of the Duarte interests, subdivided a part of the ranch, and sold off numerous small parcels along the upper part of the ranch, close to the base of the mountains, with rights to the Duarte ditch waters. In 1875 Mr. Beardslee sold several small tracts with rights to his share of river water, and in 1881 the purchasers of his lands and water rights organized and incorporated the Beardslee Water Ditch Company. In February, 1882, the property owners who had succeeded to the water rights of the Duarte ditch incorporated the Duarte Mutual Irrigation and Canal Company. For several years the flow through the joint ditch was divided equally between the two companies, but when the present works were built (1882–1887) and paid for by arrangement between the two companies in the proportion of 1,260 parts by the Duarte to 225 parts by the Beardslee company, the latter released to the former one-third of its one-half interest, so that two-thirds of the water right and works are now owned by the Duarte Mutual and one-third by the Beardslee company. Originally the two companies claimed one-third of the total flow of San Gabriel River. In the compromise agreement of 1889, by which all claims to the river water were adjusted, the Duarte companies were given title to three-tenths of the flow, surface and developed, when the total is equal to or less than 1,700 inches and $\frac{160}{720}$ of all excess over 1,700 inches.

In 1898 the San Gabriel Power Company acquired by right of salvage one-tenth of the total canyon flow, less 200 miner's inches, and disposed of this interest to the Covina Irrigating Company. Since this right was acquired, the total flow minus the above-mentioned proportion of salvage water has been divided as stipulated in the compromise agreement. As the flow of the San Gabriel fluctuates with the seasons and the rainfall, the supply of gravity water available for the use of the Duarte and Beardslee irrigators varies greatly in volume. During the irrigating seasons following dry winters, their combined share of San Gabriel River water sometimes falls as low as 75 inches. The maximum received is about 600 inches.

The Duarte and Beardslee irrigators claim and utilize the water of Fish Creek when the flow from that source is of sufficient volume to reach their system. This occurs only during the rainy season. The waters of Fish Creek after the winter storms are clearer than those of the San Gabriel and are preferred and taken, for at that season the use is confined for the most part to domestic service.

JOINT WORKS.

The Duarte and Beardslee share of the San Gabriel water is taken out from the main associated water companies' canal at the San Gabriel Power Company's station a short distance below the mouth of the canyon. The water is conducted westward across the old east-side gravel wash to the main river channel through a 30-inch wood pipe, 1,000 feet in length, and a bowlder and cement lined ditch 1,500 feet long. The river crossing is effected by means of a steel siphon 24 inches in diameter, sunk deep below the bed of the river and cased heavily in cement and rock. From the river channel westward to the point of division between the two companies, the work consists of 2,700 feet of rock-paved and cemented ditch, 1,200 feet of brick-lined culvert, and 1,300 feet of 26-inch cement pipe. The entire conduit from the point of diversion at the San Gabriel power house to the division box, near the east end of the Duarte tract, is about 1¾ miles in length and cost $15,000.

DUARTE MUTUAL IRRIGATION AND CANAL COMPANY.

The Duarte Mutual Irrigation and Canal Company was incorporated in February, 1882, and capitalized at $12,590, divided into 1,259 shares, the par value being $10 per share. The capital stock has not been increased, but the market value of each share is now about $100. The stock is transferable and not appurtenant to the land, but practically all of it is held by landowners.

Water is delivered to stockholders only, and is divided on the principle of measurement of time in proportion to holdings of stock—that is, if the owner of 20 shares is entitled to a run of one head for twenty-four hours, the owner of 30 shares is entitled to a run of one head for thirty-six hours. The regular irrigating head used is 35 inches, but the period of rotation varies with the amount of water available. When the supply is low the division is made on half time, and an irrigator who would ordinarily be entitled to a run of twenty-four hours receives water for only twelve hours. There is no charge for the water as such, but the running expenses of the company, which include zanjero's and secretary's fees and maintenance charges, amount to about $1 per acre per year. Betterments and interest on indebtedness and payments on principal are met by separate assessments, which have been as high as $9 per acre annually.

In 1900–1901 this company bought an acre of ground in the eastern part of the district, sunk a well (No. 73, Pomona quadrangle), and installed a 60-horsepower steam engine and Wigmore pump, at a cost of $17,000. The capacity of this plant is stated to be about 60 inches, and the water delivered costs the irrigators 1⅓ cents per hour-inch. In 1904 another well was sunk above the first plant and adjoining the company's main pipe line. This well is 133 feet in depth, and a 4 by 6 foot tunnel has been driven horizontally from the bottom of the shaft for a distance of 125 feet into the gravels. The well is equipped with a 60-horsepower gas engine and a No. 6 centrifugal pump. The cost of the plant was $10,000. These two wells are used to supply accessory water during periods when the canyon flow is low.

The main distributing system of the Duarte Company, below the point of division between it and the Beardslee Company, consists of a 3,000,000-gallon reservoir which cost $5,000, and two main cement conduits, each about 2½ miles long. The upper conduit is 22 inches in diameter and the lower 16 inches. These lines, together with the distributing laterals, cost $15,000. About 1,000 acres are under irrigation.

BEARDSLEE WATER DITCH COMPANY.

The Beardslee Water Ditch Company was incorporated in September, 1881, with a capital stock of $2,250, divided into 225 shares. In 1884 this was increased to $20,000, divided into 630 shares. The market value is reported to be about $100 per share. This company, as has been stated, receives one-third of the west-side San Gabriel waters and one-third of the flow of Fish Creek, and in addition to maintaining its own canals and reservoirs, assumes one-third of the expense of maintaining and repairing that part of the west-side system, which it owns jointly with the Duarte Mutual Irrigation and Canal Company.

Below the point of division between the two west-side companies the water of the Beardslee Company is conducted through 3 miles of 12- and 14-inch cement pipe to a reservoir above the company's lands. This reservoir has a capacity of 2,000,000 gallons, and was constructed in 1898 at a cost of $7,500. Below the reservoir the company owns about 1¾ miles of distributing pipe. Other laterals have been laid by stockholders at their own expense, and the company water is distributed largely through these private lines.

The available water is divided into two heads, and each share is given a run of one head for fifteen minutes each week. The company has no zanjero, but each irrigator has a schedule giving the exact time when he may use the water, and when the proper time comes he himself turns it on.

The company has no accessory pumping plants, and its expenses are light, so that the annual cost of the water to the users is only about $1 per acre. The crops raised are diversified, and include citrus and deciduous fruits, alfalfa, and garden products.

MONROVIA WATER COMPANY.

The surface flow from Sawpit Canyon, which discharges into the San Gabriel Valley just north of Monrovia, was divided originally between the Bradbury and Santa Anita ranches. In 1886 the Monrovia Water Company was organized, and in 1887 it acquired the Santa Anita rights. Improvements were at once instituted in the canyon system, and on the basis of these improvements the company claimed and later obtained possession of four-fifths of all water flowing there.

The original conduit was a 20-inch cement line running into the canyon about half a mile from the reservoir at its mouth. Below the reservoir the water was distributed through 2 miles of 12-inch cement pipe laid along the Santa Anita-Azusa grant line. After its purchase of the Santa Anita rights the Monrovia Water Company expended $60,000 in constructing pipe lines in Sawpit and one of its tributary canyons. About 17,000 feet of 6-inch, 10-inch, and 12-inch iron and steel pipe were laid in the two canyons and connected with the original cement line.

Finding that the canyon water was not sufficient to supply the needs of the city, the company bought 5 acres of land in 1898 for $1,700 on the Chapman ranch, 3½ miles to the west. Three wells were sunk on this property, an 80-horsepower steam and air plant was installed, a reservoir built, and a 12-inch pressure main laid eastward 5 miles to connect with the city system. The total cost of these improvements was about $40,000.

Originally the city of Monrovia sold water rights with the city property, but water is now disposed of independently of property interests, though none is distributed outside the city limits.

An average of 120 miner's inches is now distributed during the irrigating season, about two-thirds of it being used to irrigate 900 acres of land. The remainder is utilized as a domestic supply for 550 to 600 families. The irrigating water is distributed in 25-inch heads, each acre receiving this amount for not more than four hours during each interval of four or five weeks. Two cents per hour-inch is charged for this water.

SANTA ANITA COMPANY.

The Santa Anita Water Company was incorporated July 9, 1886, with a capital stock of $300,000, divided into 3,000 shares. The company was organized for the purpose of supplying water to the

Santa Anita tract of 3,000 acres, and stock was issued on the basis of one share per acre.

Originally controlling and utilizing one-half of the flow of both Sawpit and Santa Anita canyons, about the year 1890 the company entered into a contract with the city of Monrovia, by the terms of which it turned over to the city the control and use of the waters of Sawpit Canyon. It was stipulated in return that the city should supply those lands of the Santa Anita rancho that lie north of the south boundary of the city and east of an irregular line which conforms closely with its western boundary. The Santa Anita Water Company retained the half interest in the water and works of Santa Anita Canyon and undertook the delivery of water to stockholders west of Monrovia.

The works in Santa Anita Canyon were built jointly by the company and E. J. Baldwin, who owns one-half interest in the canyon waters. They consist of a low dam about half a mile above the canyon mouth, a short tunnel, the necessary gates and wasteways, and 1,800 feet of 20-inch cement pipe, leading to a partitioner, where the waters are divided between the joint owners. Below the partitioner are something more than 6 miles of 4-inch to 12-inch pipe, which serve as main conduit and distribution system.

The Santa Anita Company's share of this canyon water, stated by officers of the company to average about 25 inches during the irrigating season, is not sufficient to supply the needs of the irrigators, and a supplementary supply is procured from a well and pumping plant (No. 254, Pasadena quadrangle) belonging to E. J. Baldwin.

Canyon water is appurtenant to the Santa Anita tract, and is distributed only to shareholders, of whom there were nineteen in 1906.

BALDWIN SYSTEMS.

E. J. Baldwin holds in private ownership one-half the waters of Santa Anita and Little Santa Anita canyons, all of the flow from the ciénagas and artesian wells in the vicinity of Santa Anita, a part of the waters which rise in the moist lands above the Paso de Bartolo, and a number of pumping plants on the Santa Anita rancho, which are utilized as needed. The diversion works in Santa Anita Cañyon have been briefly described in connection with the account of the Santa Anita Water Company, joint owner of the water, diversion dam, and main pipe line. The ownership in the Little Santa Anita water is shared with the Sierra Madre Water Company, and the works at the point of diversion are also jointly owned. These joint works consist of a tunnel 230 feet long at the head of the system, about one-third mile above the canyon opening, and a 10-inch cement pipe about 4,000 feet long which leads to a division box where the waters are partitioned between the two interests. Below this partitioner a 6-inch concrete pipe about 2 miles in length conducts the Baldwin share of the water to the lands on which it is used. This share is reported to amount to 10 or 15 inches during irrigating seasons, which follow winters of good rainfall.

The springs and artesian wells are distributed along the upper side of the irregular ridge which extends from above Monrovia to Raymond Hill. This district has always been an area of moist lands, and has furnished irrigation water since the settlement of the country. On the Santa Anita rancho are about 12 artesian wells, and the moist-land waters are collected by means of open ditches and tile drains; the combined yield from these sources is given as about 80 inches during the irrigating season.

Pumping plants have been installed at wells Nos. 273, 480, and 481 (Pasadena quadrangle), and when these are in operation a very much larger amount of water is obtained, their combined capacity being reported by the owner at 250 miner's inches.

Just above the Paso de Bartolo and between Lexington Wash and San Gabriel River the rising waters which are characteristic of this section are collected in earthen ditches and conducted through these and some small wooden flumes to lands within the pass and on either side of Rio Hondo, where they are used for irrigation. The flow in these ditches sometimes exceeds 150 inches.

In the vicinity of Santa Anita about 1,200 or 1,400 acres are under irrigation by the Baldwin and Santa Anita systems. Citrus and deciduous fruits, grapes, and alfalfa are grown.

SIERRA MADRE WATER COMPANY.

The Sierra Madre Water Company was organized by N. C. Carter, owner of the Sierra Madre tract, in 1882. At first there were 1,100 shares, one share to each acre of land in the tract, and as the par value of each share was \$10, the capitalization was \$11,000. August 24, 1894, the capital stock was increased to 8,800 shares, with a par value of \$10 each. The original water supply came solely from Little Santa Anita Canyon, one-half of the surface flow of which belonged to the Sierra Madre Company and one-half to the owner of the Santa Anita rancho. This supply proving unreliable during the summer season, a well (No. 258, Pasadena quadrangle) was installed in the eastern part of the tract in 1900 and connected with the company's distributing system. Two engines are installed at the well, a 25-horsepower Columbus to operate the lift pump, and a 30-horsepower to operate the force pump, which drives the water up the slope to the higher parts of the system. The cost of the well, pumping plant, and distributing pipes is estimated at \$13,000. Meters are installed in the system, and the pumped water is charged for at the rate of 10 cents per 1,000 gallons.

PRECIPICE CANYON WATER COMPANY.

The Precipice Canyon Water Company was incorporated in 1887 by four individual owners of all of the water rights in Precipice or Eaton Canyon. The organization was effected on the basis of 12,500 shares, the par value of each share being $50. Each of the incorporators received a number of shares directly proportionate to his original rights in the canyon waters. Since the organization 2,500 shares have been sold in small lots to fifteen or twenty individuals, while the remaining 10,000 shares are held by four stockholders.

The company owns 3 or 4 miles of pipe line. Some of the stockholders own small reservoirs, but the company itself owns none.

The water is divided among the shareholders, each owner receiving an amount proportionate to his ownership of stock. This water, however, is not appurtenant to the land, and shareholders need not be owners of realty. An owner of stock may, therefore, grant his proportion of water to whomever he may choose. About 120 acres of citrus fruits are irrigated by the system, and perhaps 200 acres of grapes receive water during the winter and spring. The expense of maintaining the system is borne by assessments on stock. The average cost is said to be about 25 cents per share.

W. I. Allen, manager of the company, furnishes the following table of flow from the canyon for a part of 1904 and 1905:

Flow from Eaton Canyon, in miner's inches.

	1904.	1905.		1904.	1905.
April	98.36	150.00	September	5.05	....
May	68.44	155.00	October	7.00	....
June	27.58	150.00	November	10.05	....
July	13.13	112.00	December	14.07	....
August	6.35	[a] 60.00			

[a] Approximate.

LINCOLN AVENUE WATER COMPANY.

The Lincoln Avenue Water Company was incorporated March 26, 1896, and capitalized at $72,000, divided into 7,200 shares, whose par value is $10 each. The individual interests that had held the rights to which the company succeeded transferred these rights to the company and received stock in payment; 3,670 shares have been issued; and the market value in 1906 was given as $8 per share.

The company holds all the water rights of Millard Canyon above the falls except those of Saucer Canyon, a small tributary which joins the main canyon from the north. This right and that of Millard Canyon below the falls are owned by the Giddings family, the water being used on Mountain View Cemetery, about 1 mile south of the base of the mountains.

The 700 acres of the Lincoln avenue tract, the water rights in Millard Canyon, and other lands and water rights were acquired by the Pasadena Improvement Company in the middle eighties. An 8-inch steel main was laid from the point of diversion in the canyon out to the head of the tract, reservoirs were built, and distributing lines were laid. This company, however, was disincorporated in 1893, and the water rights and such lands as had not been sold were divided among the stockholders. In 1896, as already stated, the present company was formed, largely of interests formerly included in the Pasadena Improvement Company. There are 30 to 40 stockholders in the company, all of whom are owners of property in the Lincoln avenue tract of 700 acres. Water, however, is not appurtenant to the land, and provision is made in the by-laws for distributing water outside the tract if desired. It is estimated that there are about 150 acres under irrigation.

In 1902 the company sunk a well (No. 436, Pasadena quadrangle) and installed a steam pumping plant. This plant is in operation twelve hours daily during the irrigating season, and is reported to yield 25 miner's inches. The canyon flow is said to vary from 3 to 20 inches, and since it is lowest during the summer and fall, pumped water is the principal reliance for irrigation. Canyon water, which is used for domestic purposes and during the spring and early summer for irrigation, is distributed for 1 cent per 1,000 gallons or less, which is something less than half a cent per hour-inch. Pumped water costs 6 cents per 1,000 gallons, or about 3 cents per hour-inch.

The well and pumping plant cost about $10,000. In addition, the company owns about 1½ miles of 8-inch steel main and 5 or 6 miles of 2- to 6-inch iron distributing pipe.

SUNNY SLOPE WATER COMPANY.

The Sunny Slope Water Company was organized by the Sunny Slope Land and Water Company and incorporated January 7, 1895, with a capital stock of $140,000, divided into 1,400 shares. The entire capital stock was issued to the land company and land was sold thereafter with one share of water stock to each acre. The water is made appurtenant to the 1,400 acres of land within the Sunny Slope tract and can not be delivered by the company outside of this area. The company has the right to develop water on 100 acres of ciénaga land surrounding its pumping plant (No. 465, Pasadena quadrangle). This tract is a part of the long, narrow belt of moist lands which lie on the north side of the "dike" extending from Raymond Hill, northeastward toward Santa Anita Wash. In the Sunny Slope area about 40 wells have been bored at various times, but the majority of them were long ago abandoned. The first of these wells was put in during the decade between 1860 and 1870, but the maximum flow is reported to have been obtained about 1890, at the end of the wet decade which included the winters of 1884 and 1887, with their exceptional rainfall. The artesian flow at that time is given as 140 inches, but has steadily declined since. During the irrigating season, while pumping is under way, the flow is now an inconsiderable amount.

In 1903 the Sunny Slope Water Company installed a centrifugal pump operated by a 20-horsepower motor. The plant, whose cost is given at $3,000, has a capacity of 70 miner's inches. The distribution system, built before the organization of the present company, includes an earthen reservoir, about 60 by 150 by 10 feet, and 4 miles of 4-, 6-, and 8-inch steel mains.

About 250 acres of orange and lemon orchard are irrigated by the company, and water is applied once annually to about 500 acres of vineyard. Water is distributed in 25-inch heads by schedule in rotation periods of six weeks, and is charged for at the rate of 7½ cents per miner's inch for a twelve-hour run.

CHAPEA WATER COMPANY.

The Chapea Water Company was incorporated July 22, 1896, and capitalized at $28,000, divided into 400 shares whose par value is $70 each.

During the year of organization the company purchased from Mr. Chapman, owner of the Chapman ranch, 40 miner's inches of water, paying therefor $500 per inch. At that time the water was artesian, but with increased drafts on the basin and the installation of pumping plants on adjacent wells, those from which the Chapea Company is supplied ceased to flow and a pumping plant was installed over them. The 40 inches furnished in 1905 werepumped. The company has no reservoir, but owns 4 miles of 10-, 6-, and 4-inch riveted steel pipe, laid in 1896 at a cost of about $8,000.

Each irrigator receives in a continuous flow during the irrigating season a share of the water proportionate to his holdings of stock. The irrigation is accomplished on the basis of 1 miner's inch to 5 acres. Two hundred acres planted to oranges are under irrigation. The total cost to the irrigators, including the salary of $60 per year which the secretary, the only paid officer of the company, receives, is $1,200.

GARVEY WATER COMPANY.

The Garvey Water Company was organized in 1892, and capitalized at $50,000, divided into 1,000 shares, with a par value of $50 each. The company owns a well and pumping plant (No. 58, Pasadena quadrangle) in the old artesian belt 1 mile northwest of North San Gabriel, and the water developed there is carried through about 6 miles of 8-inch steel main to a reservoir in the hills south of San Gabriel Valley, overlooking the Garvey tract, upon which the water is used.

This reservoir and main were constructed in 1892 at a cost, as given by the company's officers, of $31,000. The well is reported to have yielded 70 inches of gravity water at the time of purchase, but during the three years from 1903 to 1905 it was necessary to pump during the irrigating season, although the gravity flow at the point where the well is tapped, 20 feet below the surface, was sufficient for a domestic supply for the tract. A centrifugal pump and a 16-horsepower electric motor, supplied with power from Pasadena, are used when pumping is necessary.

About 200 acres are irrigated, the water costing the users at the rate of $2.50 for a ten-hour run of 30 miner's inches, or five-sixths of a cent per hour-inch. Each acre is given a two and one-half hour run of 30 inches monthly.

ALHAMBRA ADDITION WATER COMPANY.

The Alhambra Addition Water Company was incorporated in December, 1883, with a capital stock of $250,000, divided into 2,500 shares, of a par value of $100 each. The rights to the surface flow of El Molino Canyon, which cuts through the Raymond "dike" about 1 mile east of Raymond Hill, were purchased from the owner, and 50 inches of water were diverted. Up to 1905 ten wells had been sunk in the canyon, several of which are pumped by the 30-horsepower steam plant and air compressor that have been installed. The capacity of the plant is given by the company as 150 inches. A number of the wells are not connected with the pumping plant, but have been tapped several feet below the surface. The flow from these and from the canyon aggregated about 20 inches in the spring of 1905.

The company owns about 20 miles of distributing pipe from 4 to 16 inches in diameter, laid between 1876 and 1905, from the canyon to Alhambra. It also has constructed one 4,000,000-gallon reservoir, and three with a combined capacity of 2,000,000 gallons. It owns 27 acres of land—17 acres in El Molino Canyon and the balance in reservoir sites.

One thousand acres of land in Alhambra and vicinity are irrigated at an annual cost to the irrigators of $1 per acre. The water is delivered in 25-inch heads, at the request of irrigators.

EUCLID AVENUE WATER COMPANY.

The Euclid Avenue Water Company was incorporated December 24, 1900, with a capital stock of $25,000, divided into 2,500 shares, whose par value is $10 each. Its organizers are the owners of 165 acres constituting the Los Robles tract, and of a right to 17½ inches of water in Los Robles Canyon, a short distance east of the Raymond

Hotel. So far 1,325 shares have been issued; these are held exclusively by owners of realty in the Los Robles tract.

The first development work in the canyon was a tunnel which furnished a gravity flow. This flow ceased in 1898. In 1901, after the organization of the present company, a small tract of land was bought in Los Robles Canyon for $250, a well (No. 53, Pasadena quadrangle) was sunk, and a small pumping plant was installed. At the same time another small tract half a mile farther up the canyon was purchased. This tract is held in reserve. The well in use is equipped with a centrifugal pump, run by a 15-horsepower motor. It is reported that 26 inches of water are developed.

The company owns 1½ miles of steel distributing pipe and a reservoir of 1,000,000 gallons capacity. The pipe lines were laid and the reservoir constructed in 1891.

The 165 acres of the original tract are irrigated at a cost of $15 per acre per year, but no water is sold outside this tract. The water is distributed in heads of 40 weir inches, "Pasadena module" (equivalent to about 18 miner's inches), at intervals of approximately six weeks.

MARENGO WATER COMPANY.

The Marengo Water Company was organized December 27, 1884, on the basis of a capitalization of $250,000, divided into 5,000 shares, with a par value of $50 each. An area of 1,250 acres, comprising what was originally known as the Bacon ranch, but later was divided into the Raymond Improvement Company tract and the Marengo tract, is entitled to water, four shares of stock having been allotted to each of the original 1,250 acres.

The first source of water for this acreage was a series of springs which represented overflow from the Pasadena Basin across the Raymond Hill dike, but as these springs dried away the water supply was maintained by developments consisting of wells and tunnels along San Pasqual Wash to the north and west of Raymond Hill. The first tunnel was driven under the hills west of the Raymond Hotel in 1883, and for a time furnished a supply of about 20 miner's inches, but this flow dwindled and the tunnel is not now used. A later tunnel driven east of Raymond Hill into San Pasqual Wash furnishes a constant flow, which is given as 45 inches during the winter months and 30 inches during the summer months. In addition to this tunnel development the company has in use two 12-inch wells, located at the upper end of San Pasqual Wash, in the south end of the Pasadena Basin. An Ames pump driven by a gasoline engine and a Wood pump driven by electrical power constitute the equipment of these wells, which are reported to yield about 40 inches each.

The distribution system includes a covered and cement-lined reservoir 450 by 100 by 7½ feet, with a capacity of 2,500,000 gallons. There are a number of miles of pipe line from 2 to 10 inches in diameter and 220 meters representing domestic users. Only about 160 acres of the original tract are now under cultivation as agricultural lands, and these are planted to orange groves almost exclusively. The rate charged for water used in irrigation is $2 per day of ten hours for a head of 25 weir inches. For water used for domestic purposes $1.25 is charged for the first 1,300 cubic feet and 6 cents per 100 cubic feet for all in excess of this amount.

MONTEBELLO LAND AND WATER COMPANY.

The Montebello Land and Water Company was incorporated February 10, 1900, and capitalized at $125,000, divided into 1,250 shares, with a par value of $100 each. The company was organized for the purpose of supplying the Montebello tract of 1,250 acres, lying 3 or 4 miles southwest of the Paso de Bartolo, with water. One share of stock is issued with each acre of land sold. This share entitles the holder to a twelve-hour run of 7½ inches monthly, a rate of about 1 miner's inch to 8 acres. Extra water, which will be furnished if available after all regular orders are filled, is charged for at the rate of $8 for a twelve-hour run of 100 inches, or two-thirds of a cent per hour-inch.

The pumping station (No. 279, Pasadena quadrangle) which furnishes the water is situated on the mesa about one-fourth mile east of Rio Hondo and one-half mile north of the Los Angeles–Whittier road. It consists of six wells operated by two plants, a cross compound Corliss engine and centrifugal pump, and a Worthington engine and pump. These plants develop 110 horsepower and the company gives their capacity as 300 inches, with an output of 225 inches during the irrigating season. The tract of 1,250 acres lying west of the station has been piped with 4-inch and 6-inch steel distributing lines, of which 12 miles have been laid. Two reservoirs have been built whose combined storage capacity is stated to be 6,500,000 gallons. The total investment is summarized by the company's officers as follows: Wells and pumping plants, $35,000; pipe lines, $20,000; reservoirs, $3,000; total, $58,000.

Six hundred acres were under irrigation during the season of 1905. Berries, vegetables, citrus fruits, and walnuts are grown.

NORTH PASADENA LAND AND WATER COMPANY.

The North Pasadena Land and Water Company was incorporated in 1885 with a capital stock of $90,000, divided into 1,800 shares, whose par value is $50 per share. In 1880 J. H. Painter and B. F. Ball had acquired 1,800 acres of land on the east bank of Arroyo

Seco, beginning perhaps 1 mile below the mouth of the canyon and extending thence eastward and southward. At the same time rights to all water flowing in the main canyon above its lower tributary, Millard Canyon, were secured. In 1887 a 10-inch by 12-inch cement pipe something more than 2 miles in length was laid to the tract. This property was all turned over to the North Pasadena Land and Water Company after its incorporation, the former owners of the property receiving stock in payment. Land was then sold, with one share of water stock to each acre, and the control of the company passed into the hands of the landowners.

The old pipe line from the canyon to the company lands was replaced in 1893 by a vitrified-clay and steel main, ranging from 13 to 18 inches in diameter. The water from springs and small tunnels in the upper part of the canyon and its tributaries is collected and carried to the head of the main-canyon conduit through several miles of small iron pipe.

The total gravity flow from the canyon attains considerable volume during the winter and is usually sufficient for the needs of the tract during the spring and early summer, but has to be augmented by pumped water during the summer and fall. The average gravity flow during the summer months, July to November, 1904, following a dry winter, was 4.3 miner's inches. The following series of measurements, taken during the wet winter and spring of 1905, represent contrasting conditions:

Gravity flow from Arroyo Seco canyon, 1905.

	Miner's inches.		Miner's inches.
January 12	55	March 25	2,620
January 19	58	March 31	1,356
January 25	99	April 7	725.5
February 18	2,700	April 15	877.5

About 1895 this company, pursuing a policy forced on the majority of the water companies owning gravity systems in the southern part of the State at that time, prepared to develop underground waters, with which to augment the surface supply. Water-bearing lands were bought, and two wells were sunk (Nos. 435 and 437, Pasadena quadrangle) and equipped with pumping machinery. One of these (No. 435) is about half a mile north and half a mile east of Devils Gate, and is 160 feet deep. A 35-horsepower engine and deep-well plunger pump are installed. The other well (No. 437) is about three-fourths of a mile south of Devils Gate and but a few hundred feet east of the Arroyo Seco canyon. Originally 96 feet deep, it was sunk to 135 feet in 1904 in consequence of the lowering of the water plane. The well is evidently north of the bed-rock spur which extends from the banks of the arroyo toward Monk Hill and dams back the ground waters above it. The bottom of the shaft did not reach bed rock, but probably closely approached it. The output of these two wells from July to November, 1904, is reported to have averaged 87 inches. The greater proportion of the water is furnished by the lower well, because as its lift is less it is operated more constantly.

The company reports that the cost of its pumped water during 1904 amounted to $2.78 per 1,000 gallons, or $48 per miner's inch per year. Irrigation water is supplied at 3 to 5 cents per hour-inch (miner's, not "surface" inch), the charge varying with the proportion of pumped and gravity water. The water is distributed in rotation in heads of 20 "surface" inches (about 9 miner's inches) at intervals of thirty days. The output is apportioned in proportion to holdings of stock. An area of 173 acres, belonging to 25 irrigators, is supplied by the company.

In addition to this irrigating water, domestic water was supplied in 1905 to 972 taps, at the following rates: One thousand cubic feet or less, $1.50; first additional 1,000 cubic feet, $1; each additional 100 cubic feet, 6 cents. The daily consumption of domestic water in 1905 was 1,065,000 gallons, and on the basis of four users to each tap, 3,888 people were served and the rate of consumption was 275 gallons per capita daily.

The company's pipe system includes the main-canyon conduit, 5,000 feet of 16- and 18-inch vitrified-clay pipe, 6,450 feet of 13-inch iron pipe, and about 26.2 miles of steel pipe from 1 to 14 inches in diameter in the distributing system. Two reservoirs, concrete and asphalt lined and roofed, also form a part of the system.

PASADENA LAKE VINEYARD LAND AND WATER COMPANY.

ORGANIZATION AND TERRITORY.

The Pasadena Lake Vineyard Land and Water Company was incorporated in January, 1884, with a capital stock of $250,000, divided into 5,000 shares, the par value being $50 per share. This company, spoken of generally as the "east side company," delivers irrigating and domestic water to Pasadena east of Fair Oaks avenue, and to lands outside of the city limits, eastward from Pasadena toward Lamanda. The greater part of the territory supplied lies within the boundaries of the original 2,500-acre Lake Vineyard tract, of the San Pasqual rancho. Consumers located within the limits of this tract can purchase water from the company without owning stock, but outside residents, in order to obtain water, either for domestic use or irrigation, must become shareholders. The area under irrigation in the Lake Vineyard tract is said by Wm. Ham. Hall to have reached 2,000 acres in 1884, but with the expansion of the city of Pasadena a large part of the orchards and vineyards which formerly covered this area have been divided into town lots, and streets have been cut through to afford them frontage. As a result the area of irrigated lands has steadily diminished until at the present time it is estimated that the company supplies, within and without the original tract, a total of not more than 200 acres with irrigating water. By far the greater part of the revenues of the company is derived from the sale of domestic water within the city limits of Pasadena.

WATER SUPPLY.

The water supply of the Pasadena Lake Vineyard Land and Water Company is derived from wells and tunnels near Devils Gate, on the east side of Arroyo Seco, and from wells on the mesa near the reservoir at the head of the Lake Vineyard tract. The works and water rights at Devils Gate are owned jointly by the Pasadena Lake Vineyard Company and the Pasadena Land and Water Company in the proportion of seven-tenths to the former and three-tenths to the latter company. The Copelin and Banbury wells and pumping plants (No. 432, Pasadena quadrangle) are independent properties of the Pasadena Lake Vineyard Company.

HISTORY OF WATER RIGHTS.

In 1874 the Lake Vineyard Land and Water Association was incorporated and acquired 2,500 acres of the San Pasqual rancho, adjoining the San Gabriel Orange Grove Association's tract on the east, with a part interest in the springs immediately above and below Devils Gate. It was the object of the company to divide the tract into small lots, sell these, and grant to each purchaser an interest in the water, proportional to the amount of land purchased. The company's share of water was made appurtenant to the 2,500-acre tract, and a concrete-lined ditch 13,000 feet long was constructed to deliver water from the springs to a reservoir on the mesa at the head of the company's lands. Distributing pipe was laid from the reservoir, and lands under the system were sold, one share or a five-hundredth interest in the water being conveyed with each 5 acres of land, with the right to the use of the company's canal and pipe lines for delivery. In 1883, after having disposed of 1,500 acres of the 2,500-acre tract, the company sold an undivided tenth interest in its waters, and an undivided three-tenths interest in its water-bearing lands to the San Gabriel Orange Grove Association, and the remaining interests not disposed of to a syndicate of twelve residents of Pasadena. The original interests having thus become scattered with no strong central organization in control, no effective administration was possible, the canals and pipe lines were neglected, and the entire system deteriorated. Accordingly, the Pasadena Lake Vineyard Land and Water Company was organized in 1884 by a large majority of the purchasers of land and water rights from the old association for the purpose of repairing the system and acquiring and developing a greater quantity of water. These granted to the new corporation their interests, and received therefor shares of the corporation stock, 10 shares being issued for each of the old 5-acre water rights. A few of the holders of the water rights purchased from the old association declined to join the new organization and did not convey their interests. The new company repaired the system and developed the springs, greatly increasing their flow. To enable this work to be carried out, assessments on stock amounting to $8.37 per share were levied. A definite water rate to stockholders was also fixed, the figure being made high enough to cover the cost of operation and of repairs. In 1885 suit was brought by the Lake Vineyard Land and Water Company to determine the ownership of water rights as between the old Lake Vineyard Association and the Orange Grove Association. This suit was subsequently compromised and the Pasadena Land and Water Company, which had succeeded to the rights of the Orange Grove Association, was given title to three-tenths of all the water of the Devils Gate springs, the Lake Vineyard Company retaining title to seven-tenths.

After the organization of the Lake Vineyard Land and Water Company, some of the holders of the original water rights who had remained outside of the corporation attempted to establish a pro rata interest in the water developed by the company by paying their share of the expense of operation. George W. Beck, one of those who had succeeded to $\frac{1}{1250}$ of the original water rights, as appertaining to 2 acres, refused to pay the rate charged him for water by the company and applied for a permanent injunction to restrain the directors from discontinuing service in supplying him with his share of water. A decision was rendered by the State supreme court in December, 1889, defeating the plaintiff. In 1894 the parent organization, the Lake Vineyard Land and Water Association, was disincorporated.

DEVILS GATE JOINT WORK.

In 1887 the Pasadena Land and Water Company and the Pasadena Lake Vineyard Company joined in laying a 22-inch lapped and riveted steel conduit, to replace the old open ditch, from the Devils Gate springs to a point of division on the mesa at the main reservoir. About 1891 the two companies, finding the flow from the springs inadequate for their needs, began the construction of works to develop and bring to the surface the waters of the underflow of Arroyo Seco and the east-side mesa. About 1891, 2,008 feet of tunnel were constructed through the rocky point on the east side of Devils Gate into the east-side mesa and under the gravel beds of the arroyo. Beginning at the lower end of the gorge and passing northward into the point of rocks for about 100 feet, the tunnel was divided into two branches, the right-hand branch taking a northeast course into the mesa a distance of 600 feet, and the left-hand branch a northwest course for a few hundred feet to a second fork. From this second dividing point another branch was continued westward and under the stream bed at the upper end of Devils Gate, while the main work was extended nearly due north about 1,000 feet under the bed of the arroyo close to the east-side mesa. In 1895 the main tunnel was extended from its northern extremity eastward into the mesa a distance of 2,529 feet. In 1902 two wells were sunk (Nos. 434 and 434a, Pasadena quadrangle) and a further extension of the tunnel of 337 feet was made to these wells. The tunnel tapped the wells at a depth of 175 feet from the surface. These wells flow and are pumped by compressed air into the tunnel. They have a depth of 375 and 575 feet, respectively. A third well has been sunk recently and is being connected with the tunnel.

In 1897 a submerged dam was built across the narrows at the upper end of Devils Gate, immediately below the west branch of the tunnel (Pl. II, *B*, p. 52). The underflow of the arroyo is held by this dam, while the tunnel taps the gravels and leads the water into the pipe system below. At the extremity of this branch on the west side of the stream channel an opening is provided for the admission of the storm waters. In 1897 a solid masonry dam was laid in the bed rock a short distance within the mouth of the tunnel, and a valve was constructed by which the tunnel can be sealed entirely or the flow partially cut off at will. As a result of closing the tunnel in winter the water plane in the wells above rises about 20 feet. That the general water plane in the area surrounding the wells is raised is evident also from the fact that an increased flow comes from the wells for weeks after the opening of the tunnel.

In 1903 a 100-horsepower compressed-air plant was installed at the mouth of the tunnel below Devils Gate. Compressed air is piped from this plant to the wells described above, and by its use water is raised to the tunnel level, whence it flows by gravity past the plant into the main conduit below. The gravity flow from the tunnels and wells varies with the seasons. The tunnels are partially sealed during the winter months, so that no measurements of the total flow are available. During the summer the pumping plant is in operation for a variable period, whose length depends on the previous winter's rainfall and the amount of gravity water available. During the summer of 1906 it was not found necessary to start the pumps at all, because of the copious rainfall of the two preceding seasons. Engineers who have studied the local situation thoroughly express the belief that if pumping operations were suspended for a considerable period of time the gravity flow would reach 100 miner's inches.

Records of measurements taken in 1904 of gravity and pumped water discharged from the tunnel and tunnel wells show on August 1, after the pumping plant had been shut down three hours, a gravity flow of 55.05 miner's inches; on the same day, after the plant had been shut down seven hours, a flow of 53.25 miner's inches; and on August 4, after a nine-hour shut down, a flow of 53.25 miner's inches. The officers of the company call attention to the facts that during the seven years preceding 1904 the rainfall had been low, and that periods of three to nine hours after closing the pumps may not be sufficient to allow the maximum flow to be reached.

OTHER WORKS IN ARROYO SECO.

In addition to the main work, three minor tunnels have been constructed and a pumping plant installed in the arroyo along the pipe line within half a mile of the mouth of the main tunnel. About 1889 a shaft (well No. 433, Pasadena quadrangle) was sunk close to the east bank of the arroyo, a few hundred feet below the mouth of the main tunnel, and a short tunnel was driven westward under the bed of the arroyo a distance of 288 feet. A pumping plant was placed over the shaft and equipped with a 12-horsepower gas engine and No. 4 centrifugal pump. This plant has a capacity of 25 inches for twelve hours. In 1894 a tunnel 575 feet long was driven eastward into the mesa at Wilson's Spring and another 665 feet in length at Richardson Springs. These works are located along the bank of the arroyo about half a mile below the main plant. August 1, 1904, the Wilson tunnel was flowing 3.79 miner's inches, and August 4, 1904, the Richardson tunnel was flowing 8.35 miner's inches.

INDEPENDENT PROPERTY.

Besides the Arroyo Seco properties, which are held in joint ownership with the Pasadena Land and Water Company, the Lake Vineyard Company has two independent wells and pumping plants (No. 432, Pasadena quadrangle). These are known as the Copelin and Banbury wells and are located on the mesa a short distance above the main reservoir. The Banbury well is not in active use at the present time, but in April, 1905, a 200-horsepower Corliss engine and a centrifugal pump were installed on the Copelin well, raising the normal output of the plant to nearly 200 inches.

DISTRIBUTION.

Water for irrigating purposes is delivered on orders filed at the office of the company and filled in succession. Water is distributed in heads varying in volume from 5 to 25 weir inches ("Pasadena module") and charged for at the rate of 1 cent per hour-inch. It is estimated that the company supplies about 200 acres with irrigating water.

Domestic water is metered and a charge of $1 is made for 600 cubic feet and 5 cents per hundred for each additional 100 feet. The company has 1,958 meters in use.

VALUE OF PROPERTIES.

October 15, 1904, T. D. Allin, city engineer, and Lippincott & Parker, consulting engineers, submitted a report to the city of Pasadena on the properties of the Pasadena Land and Water Company and the Pasadena Lake Vineyard Land and Water Company. In this report the works of each company are described in detail and a careful estimate is made of their present value. The following valuation is summarized from this report:

Summary of values of the property of the Pasadena Lake Vineyard Land and Water Company (east-side system) exclusive of real estate, water, and water rights.

	Cost, new.	Depreciation.	Present value.
Pipe system purchased prior to January 1, 1889	$22,897.24	$9,625.63	$13,271.61
Pipe system purchased since January 1, 1889	103,220.63	29,502.20	73,718.43
Meters purchased prior to June, 1900	15,384.30	3,846.08	11,538.22
Meters purchased since June, 1900	8,007.00	556.84	7,450.16
Air valves	78.00	24.36	53.64
Gate valves	3,536.48	636.57	2,899.91
Specials	1,527.04	546.71	980.33
Clamps	431.75	154.58	277.17
Bands	124.97	44.71	80.26
Banbury well	3,175.70	1,561.26	1,614.44
Copelin well	13,632.54	3,553.60	10,078.94
Reservoir No. 1, less three-tenths of division box	19,245.36	806.99	18,438.37
Reservoir No. 2	49,083.60	1,874.97	47,208.63
Dry tunnel, seven-tenths	2,377.44		2,377.44
Wagon road and fence, seven-tenths	453.68	23.10	430.58
Office furniture	500.00		500.00
Total value of construction work, including Banbury and Copelin wells and not including other water-development work	243,675.73	52,757.60	190,918.13
Add 20 per cent for engineering, administration, contractor's profits, etc			38,183.63
Value of the going business			13,500.00
			242,601.76

This is the estimated value of the property exclusive of the Devils Gate developments, property outside of the city of Pasadena, and real estate.

The engineers, in endeavoring to arrive at the value of the Devils Gate waters, concluded that the works there would deliver to the systems 100 inches of gravity water or 200 inches of pumped water, and under the conditions which existed in Pasadena at that time the gravity waters were valued at $2,000 and the pumped waters at $1,000 per miner's inch; so that whether the waters procured by the Devils Gate developments are regarded as the lesser amount at the higher valuation or the greater amount at the lower valuation is immaterial. The total value by either method of reckoning is $200,000. In this calculation the value of the works by which the water is developed is included in the estimate. Since seven-tenths of the Devils Gate developments belong to the Pasadena Lake Vineyard Land and Water Company, its interest in the total amounts to $140,000. The city engineer, T. D. Allin, has estimated the value of that portion of the company's plant outside of the city of Pasadena at $18,531.95, and a special commission appraised the real estate at $34,816.97. The total valuation of the east-side company's property, therefore, may be summarized as follows:

Value of property of Pasadena Lake Vineyard Land and Water Company.

Plant in Pasadena (exclusive of Devils Gate interests) pipe system, reservoirs, going business, etc	$242,601.76
Seven-tenths interest in Devils Gate developments	140,000.00
Real estate	34,816.97
Portion of plant outside of Pasadena	18,531.95
	435,950.68

PASADENA LAND AND WATER COMPANY.

ORGANIZATION AND TERRITORY.

The Pasadena Land and Water Company was incorporated in March, 1882, with a capital stock of $50,000, divided into 200 shares with a par value of $250 each. In December, 1885, the capital stock was increased to $75,000 and the number of shares to 3,000, the par value of each share being reduced to $25.

This company, usually spoken of as the "west-side company," to distinguish it from the Pasadena Lake Vineyard Land and Water Company, known as the "east-side company," serves an area of about 1,500 acres, lying in a strip less than a mile wide and about 4 miles long on the east bank of Arroyo Seco. Two-thirds of this area is at present in the city of Pasadena, and one-third in the separate municipality of South Pasadena. Only about 100 of the original 1,500 acres are now under irrigation, the remainder being occupied by homes and users of domestic water.

WATER SUPPLY.

The water supply of the west-side company is derived from the Devils Gate developments, owned and controlled jointly by the east-side and west-side companies, title to three-tenths of the works and of the water developed being in the latter, from the Sheep Corral Springs developments, which belong exclusively to the west-side company, and from the Bradford street well, the Culver well, and the Glenarm street well.

The capacity of the Devils Gate developments is estimated at 200 inches of pumped water, and the west-side interest of three-tenths of this amounts to 60 inches. The Sheep Corral developments have yielded 90 inches or more in the past, but, as this is regarded in excess of the permanent supply, the capacity of the works is placed at 50 inches. The Bradford street well yields 8 inches during the summer months, the Culver well yields about the equivalent of 10 inches constant flow, and the capacity of the Glenarm street battery of wells with present water levels is given as 90 inches. The total available permanent supply for the west-side company with its present installation, therefore, amounts to about 218 miner's inches.

HISTORY OF WATER RIGHTS.

In 1873 an association was formed at Indianapolis, Ind., under the title of the Indiana Colony, for the purpose of settlement in southern California. The association's representatives acquired 4,000 acres of land in two tracts, one of 1,500 acres along Arroyo Seco, and the other of 2,500 acres in the Altadena and Mesa de Las Flores neighborhoods. Title to all the waters at Sheep Corral Springs and to an interest in the waters about the Devils Gate was purchased with these lands. Only about twelve of the original Indiana colonists emigrated to California, but the uncalled-for shares were taken in Los Angeles and the general plan was carried through. The subscribers, of whom there were about thirty, then organized and incorporated the San Gabriel Orange Grove Association, with 100 shares, each share entitling the holder to a 15-acre subdivision of the lower 1,500-acre tract. The water rights and the 2,500-acre tract were not subdivided, but were held for the benefit of the association as a whole, and afterwards the latter tract was sold and the proceeds invested in improvements in the water system, etc.

A series of disputes between the east-side and west-side parties at interest as to the ownership of the waters in the springs about Devils Gate began in the seventies and was not finally settled until a compromise was effected in 1885. The first of these suits was decided in 1879 adversely to the interests of the Orange Grove Association. In July, 1883, the association bought from the east-side organization for $10,000 an undivided one-tenth interest in its waters and an undivided three-tenths interest in its unsold water-bearing lands and main conduit. By the terms of the compromise of 1885, these purchased interests were accepted as equivalent to a three-tenths interest in all the waters of all the upper springs, title to the remaining seven-tenths remaining in the east-side company. This adjustment has served as the basis for the distribution of all costs of improvements and maintenance, and for the division of all Devils Gate waters since it was effected. The Sheep Corral waters and water rights have never been in dispute, but have been acknowledged as the property of the west-side company since the predecessors in interest of the Indiana Colony first purchased the San Pasqual rancho in 1858.

The Bradford street well, situated on a lower bench just west of Arroyo Seco, was dug and a pumping plant installed over it in 1903; the Culver well, on the east side of the arroyo, was purchased from F. J. Culver in 1904 for $8,000, and the Glenarm street wells, one-fourth mile northeast of the Raymond Hotel, were bored and equipped in the summer of 1904.

DEVILS GATE JOINT WORKS.

A brief account of these works, constructed and owned jointly by the Pasadena Land and Water Company and the Pasadena Lake Vineyard Land and Water Company, is given on pages 126–128.

INDEPENDENT PROPERTY.

The oldest of the water sources owned exclusively by the Pasadena Land and Water Company is the Sheep Corral Springs and development works. Before the sinking of wells and driving of tunnels in their immediate vicinity and the completion of more distant developments which have nevertheless affected their supply, these springs yielded from 50 to 130 miner's inches during the dry months of summer, and their average flow was given by Wm. Ham. Hall[a] as 90 miner's inches.

As the demand for water on the Pasadena mesa increased, work was undertaken at the springs, with the purpose of increasing the supply available from them. In 1890 a tunnel was begun just above the gorge at Sheep Corral Springs, at a depth of 29 feet, and during the three succeeding years it was extended northward until it reached a length of 1,345 feet, its construction having cost $14,500. At the same time (1890) a small gasoline engine was installed for the purpose of lifting the water developed in the tunnel into a receiving tank, whence it was pumped with other waters from the springs to a reservoir on the edge of the mesa 100 feet above the arroyo level. The plants for this greater lift were installed in 1882 and in 1892, and consist of two Wellington compound duplex pumps, each with a capacity of 100 miner's inches. In 1895, in order to recover whatever underflow might be escaping through the gravels of the gorge below the springs, a submerged dam was constructed across this gorge and extended from bed rock to 4 feet above the original surface of the gravels in the arroyo. The dam, which is of concrete-masonry construction, has a maximum depth of 28 feet, and a width of 4 feet and contains 336 cubic yards of material. Its cost was $5,200. Finally, in 1904 a well was sunk in the tunnel and water is now pumped from 40 feet below its floor.

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[a] Irrigation in Southern California, 1888, p. 498.

The Bradford street well was dug in 1903. It is located in Pasadena, just west of Arroyo Seco and something more than 1 mile south of Sheep Corral Springs. From the bottom of the well, which is 70 feet deep, a drift extends eastward for 170 feet. The well is operated by electric power, and the water, about 8 miner's inches, is pumped directly into the South Pasadena main, which runs near by.

The Culver well, on the east side of the arroyo, about 600 feet north of the Bradford street well, was sunk in 1899 and 1900 by F. J. Culver, and was purchased by the Pasadena Land and Water Company in 1904 for $8,000. The well is 54 feet deep, and a tunnel extends northeastward 122 feet from its bottom. Water from this well is pumped into the South Pasadena main directly by electric power. The yield is approximately 40 inches for the six hours per day during which it is pumped. Neither the Bradford street nor the Culver well is used except during the dry periods of mid and late summer.

The latest addition to the Pasadena Land and Water Company plants is the Glenarm street group of three 12-inch wells, bored and equipped with a pumping plant in 1904. These wells are located about one-fourth mile northeast of the Raymond Hotel. They vary in depth from 215 to 256 feet, and their total cost was $1,840. An air lift has been installed to pump the water from the wells, and a centrifugal pump then raises it over the Orange Grove avenue ridge into the South Pasadena main. From this main the water will flow by gravity to the Sheep Corral plant, and may then be pumped into the Pasadena system. The cost of this pumping plant is given as $7,023, and its capacity as 90 inches. The wells easily yield this amount, and inasmuch as their situation is most favorable, both as to permanence of supply and accessibility of water, it is probable that they will continue to furnish the full amount for a long period.

DISTRIBUTION.

Although the San Gabriel Orange Grove Association, to whose rights and property the Pasadena Land and Water Company has succeeded, was essentially an irrigation company, the present corporation, through the growth of the cities of Pasadena and South Pasadena, has become in reality a municipal water company. Only about 100 of the 1,500 acres in the original tract are now under irrigation.

Within the city limits of Pasadena practically all services are under meter, the company having about 1,200 instruments in use. The minimum charge for water where meters are installed is $1.25 per month. This sum entitles the user to 800 cubic feet. For all water in excess of that amount a charge of 6 cents per 100 cubic feet is made. In South Pasadena and at those few points in Pasadena where meters are not installed, flat rates of 50 cents to $2 per month are charged. The irrigating rate is 1¼ cents per hour per "surface inch," probably equivalent to a little more than 2¾ cents per hour per California miner's inch.

VALUE OF PROPERTIES.

The board of engineers, Messrs. Allin, Lippincott, and Parker, engaged in 1904 to determine the value of the property of the companies supplying Pasadena with water, summarized the value of the system, exclusive of the interest in the Devils Gate works, the Sheep Corral developments and rights, the South Pasadena portion of the system, and the real-estate holdings, as follows:

Summary of values of the property of the Pasadena Land and Water Company (west-side system) exclusive of real estate, water, and water rights.

	Cost new.	Depreciation.	Present value.
Pipe system	$78,234.52	$25,500.46	$52,734.06
Gate valves	1,655.18	297.93	1,357.25
Specials	848.12	276.49	571.63
Meters laid prior to June, 1900	8,795.10	2,506.59	6,288.51
Meters laid since June, 1900	6,557.50	565.11	5,992.39
Orange Grove avenue reservoir	26,929.67	5,088.65	21,841.02
Bradford street pumping plant	4,553.24	339.54	4,213.70
Glenarm street wells	1,840.20		1,840.20
Glenarm street pumping plant	7,023.42		7,023.42
Sheep Corral main pumping plant	8,480.81	3,869.33	4,611.48
Division box, three-tenths	40.50		40.50
Dry tunnel, three-tenths	1,018.91		1,018.91
Wagon road and fence, Devils Gate, three-tenths	194.43	9.89	184.54
Tool house and office furniture	500.00		500.00
Total value of construction work, including Glenarm and Bradford street wells, and not including other development work	146,671.60	38,453.99	108,217.61
Add 20 per cent for engineering, administration, contractor's profits, etc			21,643.52
Value of the going business			10,000.00
			139,861.13

The Devils Gate developments (see pp. 126–128 for details) are valued at $200,000, three-tenths of which, or $60,000, belong to the west-side system. The water supply from Sheep Corral Springs was valued at $500 per miner's inch, and the permanent supply there estimated at 50 miner's inches, or a total valuation of $25,000. T. D. Allin, city engineer of Pasadena, estimated that portion of the company's plant outside of the city to be worth $15,295.73, and the real estate commission estimated the value of the real estate holdings of the corporation to be $49,603.28.

The final valuation of the west-side company's property may therefore be summarized thus:

Value of property of Pasadena Land and Water Company.

Plant in Pasadena (exclusive of Devils Gate and Sheep Corral developments)	$139,861.13
Three-tenths interest in Devils Gate developments	60,000.00
Sheep Corral developments and supply	25,000.00
Real estate	49,603.28
Portion of plant outside of Pasadena	15,295.73
	289,760.14

VERDUGO CANYON WATER COMPANY.

The waters of Verdugo Canyon are percolating waters of rather uniform flow, which escape from gravels that fill the valley of La Cañada, between the San Rafael and Verdugo hills to the south and the San Gabriel Range to the north. They drain into the lower San Fernando Valley through Verdugo Canyon, rising to the surface in a number of springs along the southern $1\frac{3}{4}$ miles of its course. The flow from these springs forms two small surface streams, one on either side of the canyon. By a court decree, handed down in November, 1871, the waters on the east side of the canyon were awarded to Theodore Verdugo and his assigns, and made appurtenant to 2,629.01 acres lying within the limits of the canyon. Since the award, portions of the tract have been sold, and there are now several owners of the east-side water. By the same decree all surplus east-side water, above that reasonably required by Verdugo and his successors in interest, was to be turned into the channel of the west-side springs and to become a part of those waters which were allotted to lands lying in the east end of the San Fernando Valley below the canyon. This west-side water was divided into 10,000 parts, and apportioned among the various interests claiming it. The division was made by time, an owner of one part being entitled to the total west-side flow for one minute of each week.

June 18, 1884, the Verdugo Canyon Water Company was organized to better effect the distribution of this west-side water by constructing and maintaining a system of pipe lines, hiring a zanjero, etc., and to develop the underflow of the canyon. The capital stock was fixed at $10,000, divided into 10,000 shares, each representing one of the original 10,000 parts of the west-side water. Three-fourths of the owners of the west-side interests joined the organization, and 7,500 shares were issued, C. E. Thom and E. M. Ross, owners of one-fourth interest, remaining outside the company. No subscriber to the capital stock of the company may hold more shares than he owns ten-thousandths of west-side water. There are 300 stockholders, each of whom receives a proportion of the total flow equal to the ratio of his stock to the total issue of 10,000 shares. Only six of these stockholders, however, receive their water directly from the company's pipe lines. The remainder have organized a number of subordinate companies. These companies and the number of ten-thousandths of west-side water which they receive are listed in the following table:

Subordinate companies receiving west-side water of Verdugo Canyon.

Verdugo Springs Water Company	666
Verdugo Pipe and Reservoir Company	1,307.5
Tropico Water Company	1,191
Independent Water Company	924.5
North Glendale Pipe and Reservoir Company	2,128
East Glendale Reservoir and Pipe Company	670
Glassell Pipe Company	613

Five of these subsidiary companies own reservoirs, and the share of each is delivered to it in a constant flow. The West Glendale Reservoir and Pipe Company and the Glassell interests do not own reservoirs, and their share of water is delivered once or twice weekly in accumulated heads. The Verdugo Canyon Water Company also delivers to C. E. Thom and E. M. Ross their proportion of canyon water, collecting from them a proportionate share of operating expenses.

The responsibility of the Verdugo Canyon Water Company ceases with the delivery of its share of water to each of the subordinate companies. The further subdivision of the water and its delivery to the individual stockholders, through the pipe lines and reservoirs of the subordinate companies, is charged for by the companies.

During the five seasons covering the years 1900 to 1904 the average annual expenses of the Verdugo Canyon Water Company were 27 cents per share. This charge covered operation, maintenance, legal fees, and other expenses, and a payment of $2,500 on the indebtedness. The total flow, surface and developed, controlled by the company varies from 65 to more than 100 inches. The maximum surface flow recorded, 171 miner's inches, was measured in August, 1890. The minimum combined surface and developed underflow, 64.2 miner's inches, was measured October 1, 1904. Other records of measurements are given below:

Measurements of Verdugo Canyon waters.

Date.	Surface flow.	Underflow diverted by dam.	Total.
	Miner's in.	*Miner's in.*	*Miner's in.*
May 14, 1904	51	26.7	77.7
August 14, 1904	45.6	19.7	65.3
May 27, 1905	77.7	23.9	101.6

Soon after the incorporation of the Verdugo Canyon Water Company, steps were taken to divert the canyon water. A masonry dam 50 feet long was built across the bed of the creek, a short distance below the tract now known as Verdugo Park. No attempt was made to reach bed rock, the base of the dam being sunk only 6 feet below the surface. From the dam about 26,000 feet of 16-, 10-, and 8-inch cement pipe were laid to the reservoirs below. Practically this same system remains in existence to-day, the only change being an extension of 500 feet of 25-inch cement main upstream to the submerged dam begun in 1895. Preparations for this latter construction had been made in 1894 by the purchase of $7\frac{4}{5}$ acres of land, above the old diversion dam, for $2,500, all of the west-side interests joining in the purchase. Explorations for bed rock were carried out, and as they resulted favorably, construction was about to be undertaken when it was found impossible to procure a direct right of way across the canyon from the owner of the adjoining property on the east. An alternative indirect right of way was offered, however, and accepted, and construction was begun. Two hundred and forty feet of dam had been built when the channel deepened and bed rock was lost. Exploration for it resulted in an estimate that the dam could not be completed for less than $50,000. As $20,000 had already been expended, the estimate was considered prohibitive and work was stopped. This incomplete dam results in the recovery of some of the underflow, as is indicated by the table on page 136.

YIELD OF FLOWING WELLS.

In the endeavor to use tables heretofore published, for the easy determination of the yield of flowing wells when the diameter of the casing and the height of the dome are known, difficulties have been encountered, the majority of the tables extant proving inaccurate. The most satisfactory formulas known to the writer for the yield of wells discharging vertically are those of C. E. Grunsky. From these formulas, which are given below, a set of simple tables of the yield of wells flowing 250 California miner's inches or less has been compiled. These tables have proved convenient in the field work of the author of this report, and it is hoped that they may prove equally useful to others.

Grunsky's formulas for yield of flowing wells.

[Q=Gallons per minute; d=diameter; h=dome.]

When $h>d$ (spouting wells), $Q=5.35d^2\sqrt{h}$

When $h<\frac{1}{10}d$, $Q=10d\sqrt{h^3}$

When $h<d$ and $>\frac{1}{10}d$, $Q=\dfrac{10dh\sqrt{h}}{\sqrt{1+2.525\left(\frac{h}{d}\right)^2}}$

Yield of flowing wells.

[California miner's inch of 9 gallons per minute or 0 .02 second foot.]

Height of dome, in inches. \ Diameter of well, in inches.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0.2	½	½	½	½	½	¾	1	1	1	1	1	1	1	1	1
.4	½	1	1	1	1	2	2	2	3	3	3	3	4	4	4
.6	½	1	2	2	2	3	3	4	4	5	5	6	6	7	7
.8	1	1	2	3	4	4	5	6	7	8	8	9	10	10	11
1.0	1	2	3	4	5	6	7	8	9	11	12	13	14	15	16
1.2	1	2	4	5	7	8	9	11	13	14	16	17	19	20	21
1.4	1	2	4	6	8	10	12	14	16	18	20	22	24	25	27
1.6	1	3	5	7	10	12	15	17	19	21	24	26	29	31	34
1.8	1	3	5	8	12	14	17	20	23	25	28	31	34	36	40
2.0	1	3	6	9	13	16	19	23	26	29	32	36	40	42	46
2.2	1	3	6	11	15	18	22	26	30	34	37	41	45	49	52
2.4	1	4	7	12	16	20	25	30	34	38	42	46	50	55	59
2.6	1	4	7	13	18	22	28	32	38	42	47	51	37	61	67
2.8	1	4	8	14	19	24	31	36	42	47	52	57	63	69	75
3.0	1	4	9	15	21	26	33	40	46	51	57	63	70	76	83
3.2	1	4	10	16	22	28	35	43	50	56	62	70	77	83	90
3.4	1	4	10	17	23	30	38	46	53	60	68	77	84	91	99
3.6	1	4	11	17	24	32	41	49	57	65	73	82	91	99	107
3.8	1	4	11	18	26	34	43	52	61	70	80	89	97	106	115
4.0	1	5	11	18	27	36	46	56	65	75	85	94	103	113	123
4.2	1	5	11	19	28	38	48	58	69	80	90	100	110	121	132
4.4	1	5	12	19	29	39	50	61	73	85	96	106	117	129	141
4.6	1	5	12	20	30	41	52	64	77	90	101	112	124	138	149
4.8	1	5	12	20	31	42	54	67	81	94	106	118	131	145	156
5.0	1	5	12	21	32	44	57	70	84	97	111	124	139	153	164
5.2	1	5	12	21	33	45	59	73	87	101	116	130	146	160	172
5.4	2	5	12	22	34	46	61	76	91	106	121	136	152	168	178
5.6	2	5	13	22	34	48	62	79	94	110	126	142	157	175	188
5.8	2	5	13	23	35	49	65	81	97	114	131	148	164	181	198
6.0	2	5	13	23	36	50	67	84	100	118	136	154	172	187	206
6.2	2	5	13	24	36	51	68	86	104	121	141	159	177	196	213
6.4	2	6	14	24	37	52	70	89	107	126	146	164	185	204	222
6.6	2	6	14	24	38	53	72	91	111	130	151	170	190	210	230
6.8	2	6	14	25	39	54	73	93	114	134	155	175	197	218	237
7.0	2	6	14	25	39	56	75	96	116	138	160	181	204	225	246
7.2	2	6	14	25	40	57	76	98	119	142	164	187	210	232	....
7.4	2	6	14	26	40	58	78	100	122	146	168	193	215	240	....
7.6	2	6	15	26	41	58	79	102	124	149	173	199	221	247	....
7.8	2	6	15	26	41	59	80	104	128	152	177	204	227	.....	....
8.0	2	6	15	27	42	60	81	106	130	154	182	208	233	.....	....
8.2	2	6	15	27	42	60	82	108	133	157	187	212	240	.....	....
8.4	2	7	15	27	43	61	83	110	136	160	191	217	247	.....	....
8.6	2	7	15	28	43	62	85	111	138	163	196	221	.....	.....	....
8.8	2	7	15	28	44	63	86	113	140	167	200	225	.....	.....	....
9.0	2	7	16	28	44	63	87	114	142	170	204	229	.....	.....	....
9.2	2	7	16	29	45	64	88	116	144	175	207	235	.....	.....	....
9.4	2	7	16	29	45	65	89	117	146	178	210	241	.....	.....	....
9.6	2	7	16	29	46	66	90	118	148	180	213	246	.....	.....	....
9.8	2	7	16	30	47	67	91	119	150	184	217	251	.....	.....	....
10.0	2	7	17	30	47	68	92	121	153	187	220	.....	.....	.....	....

MAPS AND TABLES.

Such information on the foothill belt as is capable of graphic presentation has been assembled in maps and tables.

The maps (Pls. III–IX, in pocket) show the lands irrigated in the foothill belt, the chief pipe and canal lines of the various irrigating companies, the pumping plants, the artesian wells, a few of the domestic wells, ground-water levels, indicated by hydrographic contours, and artesian areas past and present.

In the tables the information collected during a careful canvass of the wells of the foothill belt has been assembled. This information includes the name of the owner, the location of the well, the date of its completion, its diameter, depth, and cost, the cost of the installation where pumping machinery is in use, the use made of the water, and the amount produced. For some wells temperature data and rough determinations of the amount of solid matter in the water in parts per 100,000, as a result of measurements of the electric resistance by the Wheatstone bridge, are included.

It has not been possible to obtain all of this information for each well examined, and in many cases that collected is only approximately correct, but such facts as are known are presented.

The greater part of the data thus assembled, both in the tables and maps, has been collected by W. N. White, field assistant, to whom cordial acknowledgments are due. In assembling the material in the office for publication, both Mr. White and A. J. Fisk, jr., have assisted.

The following list of useful equivalents has been compiled by J. B. Lippincott:

USEFUL EQUIVALENTS.

1 United States gallon of water weighs 8.345 pounds.
1,000,000 gallons per day=1.54723 second-feet.
1 cent per 1,000 gallons=$3.367 per acre-foot.
1 old California miner's inch=1,728 cubic feet per day, or
$\frac{1}{50}$ second-foot, or
12,925 gallons per day, or
538.5 gallons per hour, or
630,720 cubic feet per year, or
14,478 acre-feet per year.
1 new California miner's inch=1½ cubic feet per minute, or
$\frac{1}{40}$ second-foot.
1 Colorado miner's inch=2,250 cubic feet per day, or
17,000 gallons per day (approximately).
1 second-foot=50 California miner's inches, or
38.4 Colorado miner's inches, or
450 gallons per minute, or
723.92 acre-feet per year, or
1.983471 acre-feet in 24 hours, or
59½ acre-feet in 30 days, or
646,315 gallons per day.
1 second-foot per year=13.57 inches in depth per square mile.
1 acre-foot=25.2 California miner's inches for 24 hours, or
43,560 cubic feet, or
325,851 United States gallons.
2 acre-feet in 30 days=continuous flow of 0.03⅓ second-foot.
1 cubic foot=7.4805 gallons.
1 cubic foot of water at 62° F. weighs 62.355 pounds.
1,000,000 cubic feet=23 acre-feet (approximately).
1 barrel crude oil=42 gallons.
1 barrel crude oil of 14° gravity weighs 340.6 pounds (usually taken at 341 pounds).
1 gallon crude oil weighs 8.12 pounds.
Pressure per square inch for each foot of head=0.433 pound.
Pressure in pounds per square inch × 2.31=head in feet.
Grains per gallon × 1.71=parts per 100,000 of solids.
Velocity of 1 mile per year=0.000167 foot per second.

GENERAL STATISTICS.

Flowing wells, pumping plants, irrigated area, etc., in foothill belt of southern California in 1905.

	Cucamonga quadrangle.	Pomona quadrangle.	Pasadena quadrangle.	Total.
Number of flowing wells	25	0	13	38
Number of pumping plants	107	93	168	368
Estimated investment in wells and pumping equipment	$388,839	$355,643	$448,642	$1,193,124
Estimated average output, continuous flow, second-feet	25	20	40	85
Area irrigated ... acres	21,643	17,288	16,750	55,681
Artesian area, 1905 ... square miles	3.5	0	1.3	4.8
Original artesian area ... do	4.75	1.1	2	7.6
Estimated area tillable land ... do	150	147	148	445

WELL DATA.

Wells in the foothill belt of southern California.

CUCAMONGA QUADRANGLE.

[* Cost of well and equipment combined; † yield estimated or statement of owner taken; ? doubtful. The miner's inch used in these tables is the old California miner's inch, i. e., the amount of water which flows from a 1-inch orifice under a 4-inch head; it is equal to 9 gallons per minute, 14,478 acre-feet per year, or one-fiftieth second-foot.]

No. of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet)—approximate only.	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Temperature of water (°F.).	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
1	D. G. Henderson	Sec. 16, T. 1 N., R. 6 W	N-6	1883		2,300					Tunnel			Irrigation	†5
2	Sexton Bros	Sec. 5, T. 1 S., R. 6 W.	M-10	1901	Bored, 10-inch	1,280	980	1,000?				$4,000.00?		Not used	
3	Joseph Gecman	Sec. 20, T. 1 S., R. 6 W.	M-12, 13	1886	Bored, 2-inch	1,040	810	300			Wind	300.00	$80.00	Domestic	
4	H. Schoenfelder	Sec. 33, T. 1 S., R. 6 W.	N-14	1896	Dug, 3½ by 2½ foot.	910	768	160			do	250.00	90.00	do	
5	Riverside Vineyard Co.	Sec. 4, T. 2 S., R. 6 W.	M-15	1900	Bored, 12-inch	840	740	400			Steam	500.00	7,500.00	Irrigation	†175
6	H. Maittral	Sec. 32, T. 1 S., R. 6 W.	M-15	1896	Bored, 7-inch	850	698	230			Wind			Domestic; stock	
7	Riverside Vineyard Co.	Sec. 4, T. 2 S., R. 6 W.	M-16	1889	Bored, 10-inch	805	685	176			do	250.00	100.00	do	
8	do	do	M-16	1895	Bored, 8-inch	798	684	150			do	200.00	75.00	Stock	
9	Union school district.	do	M-16	1894	Bored, 7-inch	785	700	145			do	250.00	75.00	Domestic	
10	I. N. Van Nuys	Sec. 10, T. 2 S., R. 6 W.	M-17	1884	do	740	650	150			do	300.00	75.00	Domestic; stock	
11	do	do	N-16, 17	1884	do	775	687	143			Not raised	275.00	75.00	Not used	
12	G. M. Laren	Sec. 8, T. 2 S., R. 6 W.	M-17	1894	do	770	686	148			Wind			Domestic	
13	R. L. Summerwell	do	L-16	1895	do	780	687	140			do	200.00	100.00	Not used	
14	F. A. Gallwas	Sec. 6, T. 2 S., R. 6 W.	K-16	1892	do	790	671	154			do	200.00	100.00	Domestic; stock	
15	C. Carroll	Sec. 7, T. 2 S., R. 6 W.	L-16	1890	do	770	686	100			Not raised			Not used	
16	A. T. Galloway	Sec. 6, T. 2 S., R. 6 W.	L-16	1896	do	790	689	139			Wind	225.00	75.00	Domestic	
17	R. T. Garner	do	L-15	1885	do	840	703	164			Hand	300.00		do	
18	A. T. Galloway	do	L-16	1895	do	825	687	140						Not used	

19	Mrs. M. L. Johnson	do	K-15	1892	do	840	703	164			Wind	225.00	100.00	Domestic; stock	
20	A. La Fourcade	Sec. 29, T. 1 S., R. 6 W.	L-14	1889	Bored, 8-inch	965	645	400			do	700.00	100.00	do	
21	Smith Bros	Sec. 7, T. 1 S., R. 6 W.	L-11	1903	Dug, 4½ by 4½ foot, 158 feet; bored, 12-inch, 492 feet.	1,125	895	650	23		Steam	3,000.00		Irrigation	†15
22	Cucamonga winery	Sec. 11, T. 1 S., R. 7 W.	J-11	1903	Bored, 5-inch	1,122	822	497	21		Gas	2,500.00	3,000.00	Winery	†3
22a	do	do	J-11	1903	Bored, 12-inch	1,122	805	540	21		do	3,000.00		do	†5
23	Colonel Post	Sec. 18, T. 1 S., R. 7 W.	K-11		Bored, 7-inch	1,110	820	420						Not used	
24	Benton Ballou	Sec. 26, T. 1 S., R. 7 W.	J-14	1892	do	885	756	158	23		Wind	250.00	100.00	Domestic; stock	
25	Mrs. Martha Collins	Sec. 35, T. 1 S., R. 7 W.	J-14	1884	do	865	705	180	23		do	300.00	100.00	do	
26	A. T. Hamilton	do	J-14	1888	do	880	702	252			do	640.00	150.00	do	
27	Thos. Monks	do	J-15	1900	do	845	717	164	22		do	250.00	100.00	do	
28	J. R. Merrill	Sec. 2, T. 2 S., R. 7 W.	J-16	1901	do	830	711	151	21		do	250.00	75.00	do	
29	F. H. Hollister	Sec. 11, T. 2 S., R. 7 W.	J-16	1892	do	785	673	148	22		Hand	180.00	38.00	Not used	
30	L. H. Farron	do	J-16		do	785	676	125	22					do	
31	R. W. Henderson	Sec. 12, T. 2 S., R. 7 W.	J-16	1892	do	790	695	117	23		Wind	225.00	125.00	Domestic; stock	
32	Wm. B. Jackson	Sec. 11, T. 2 S., R. 7 W.	J-17	1901	do	740	663	113	23		do	152.00	125.00	do	
33	D. McDougall estate.	Sec. 14, T. 2 S., R. 7 W.	I-17	1896	do	730	678	81				75.00	75.00	Not used	
34	L. Bergstrom	Sec. 10, T. 2 S., R. 7 W.	I-17	1896	do	735	680	79			Wind	100.00	90.00	do	
35	J. Martinas	do	I-17	1896		740	688	100							
36	A. H. Blakeley	do	I-17	1892	Bored, 7-inch	755	695	75	22		Wind	100.00	85.00	Domestic; stock	
37	George W. Ingram	do	I-17	1892	do	750	689	100	22		do	175.00	150.00	Domestic	
38	Charles Lambe	do	I-17	1896	do	735	677	112	22		do	95.00	125.00	Domestic; stock	
39	Torence Pratt	do	I-17	1896	do	745	684	86			do			Not used	
40	William Riggs	Sec. 11, T. 2 S., R. 7 W.	I-17	1889	do	760	681	99			Not raised			do	
41	Arthur Pooley	Sec. 10, T. 2 S., R. 7 W.	I-17	1897	do	765	690	88	20		Wind	100.00	100.00	Domestic	
42	Mr. Searls	do	I-16	1893	do	775	Dry.	61							
43	Mountain View district school.	Sec. 2, T. 2 S., R. 7 W.	I-16	1887	do	810	700	140	21		Wind	250.00	175.00	Domestic	
44	D. F. Stoner	Sec. 3, T. 2 S., R. 7 W.	I-16	1894	do	825	710	165	21		do			do	
45	George Andrews	Sec. 33, T. 1 S., R. 7 W.	H-14		do	890	760	138			do			Not used	
46	Mr. Eason	do	H-14		do	880	756	130						do	
47	do	Sec. 28, T. 1 S., R. 7 W.	H-14	1901	Bored, 10-inch	930	Dry.	173						do	
48	James Quibell	Sec. 27, T. 1 S., R. 7 W.	I-14	1902	do	915	770	211			Gas	371.00	1,350.00	Irrigation	†15

Wells in the foothill belt of southern California—Continued.

CUCAMONGA QUADRANGLE—Continued.

No. of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet)—approximate only.	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Temperature of water (°F.).	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
49	Mr. Southworth	Sec. 32, T. 1 N., R. 6 W.	L-9			1,325	Dry.	320							
50	J. Bennett	Sec. 1, T. 1 S., R. 7 W.	K-10			1,210	Dry.	200							
51	O. Bartell	Sec. 8, T. 1 S., R. 6 W.	M-10		Dug, 4 by 4 foot.	1,210	Dry.	200							
52	Mrs. Louis Smith	Cucamonga	I-11	1899	Dug, 3 by 3 foot.	1,175	Dry.	149				$200.00			
53	Old Settlers Water Co.	do	I-10	1902	Bored, 15-inch, 180 feet; 12-inch, 120 feet; 10-inch, 48 feet.	1,315	1,271	348	23		Gas	1,047.00	$1,900.00	Irrigation	†32
54	Sunset Water Co.	do	I-9	1901	Dug, 5 by 7 foot, 110 feet; bored, 15-inch, 200 feet; 12-inch, 555 feet.	1,395	1,305	865			Electric motor	4,000.00	2,500.00	do	†30
55	do	do	I-9	1900	Dug, 4 by 6 foot; bored, 12-inch.	1,410	1,324	190						Not used	
56	Hermosa Water Co.	do	I-8	1901	Bored, 10-inch.	1,520	1,360	275			Gas	800.00	2,500.00	Irrigation	†30
58	Upland Water Co.	do	H-9	1901	Dug, 5 by 7 foot, 110 feet; 7 by 14 foot, 63 feet; bored, 12-inch, 261 feet.	1,560	1,387	434			Steam		3,400.00	do	†40
59	Cucamonga Water Co.	do	H-9	1897	Bored, 12-inch, 381 feet; 8-inch, 160 feet.	1,429	1,343	541	20	71		1,500.00		Not used	
60	do	do	H-9	1897	Dug, 4 by 6 foot, 114 feet; bored, 12-inch, 195 feet; 8-inch, 195 feet.	1,457	1,355	479	21	72	Electric motor			Irrigation	†25

61	do	do	I-9	1899	Bored, 9½-inch	1,358	1,271	456	17	72	Flows into tunnel.			do	5
62	do	do	I-10	1899	Dug, 40 feet; bored, 9½-inch, 464 feet.	1,346	1,265	504			Electric motor			do	†50
63	do	do	I-9	1899	Dug, 47 feet; bored, 9½-inch, 386 feet.	1,389	1,292	433	17	72	Flows into tunnel.			do	†3
64	do	do	I-10	1899	Dug, 90 feet; bored, 9½-inch, 338 feet.	1,395	1,298	428		73	do			do	†4
65	do	do	I-9	1899	Bored, 9½-inch	1,376	1,276	547			do			do	†2
66	do	do	I-9	1899	do	1,379	1,283	287			do			do	†4
68	do	do	G-10	1897	do	1,388	1,303	371						Not used	
69	do	do	G-10	1899	Bored, 12-inch, 366 feet; 10-inch, 300 feet.	1,374	1,294	666		64	Flows into tunnel.			Irrigation	
70	do	do	G-10	1904	Bored, 10-inch	1,395	1,299	540			do			do	†35
71	do	do	G-10	1901	Bored, 15-inch, 224 feet; 12-inch, 296 feet.	1,398	1,300	520			do			do	†40
72	do	do	G-10											Not used	
73	San Antonio Water Co.	do	G-9	1901	Dug, 5 by 8 foot, 110 feet; bored, 12-inch, 528 feet.	1,488	1,365	638		62	Electric motor			Domestic; irrigation.	†75
74	do	do	G-9	1901	Dug, 125 feet; bored, 12-inch, 499 feet.	1,483	1,351	624	20	62	do			Irrigation	†75
75	do	do	G-9	1898	Dug, 124 feet; bored, 12-inch, 516 feet.	1,482	1,352	640	19	62	do			do	†75
76	do	do	G, H-9	1901	Dug, 126 feet; bored, 10-inch, 414 feet.	1,493	1,361	540	20	62	do			Domestic; irrigation.	†75
77	do	do	H-9	1901	Dug, 130 feet; bored, 7-inch, 270 feet.	1,495	1,365	400			do			Irrigation	†75
78	do	do	H-9		Dug, 103 feet; bored, 9½-inch.	1,480	1,364		21	60	do			do	† 30
79	do	do	H-9	1900	Dug, 142 feet; bored, 12-inch, 507 feet (2 wells).	1,495	1,356	649		70	do			do	† 150
80	do	do	G-10	1902	Bored, 15-inch	1,410	1,310			64	do			do	† 175
85	Stewart & Co	do	E-8	1898	Dug, 3 by 5 foot.	1,805	Dry.	250							
86	Canyon Ridge Water Co.	do	E-8	1898	Dug, 4 by 5 foot.	1,815	1,700	165			Gas			Irrigation	† 25
87	S. A. Bard	do	E-8	1896	Dug, 3 by 6 foot.	1,820	1,710	160	23		do		1,200.00	do	† 20
88	San Antonio Water Co.	do	E-8	1903	Dug, 5 by 12 foot, 182 feet; bored, 14-inch, 228 feet.	1,820	1,710	410				2,000.00		do	

Wells in the foothill belt of southern California—Continued.

CUCAMONGA QUADRANGLE—Continued.

No. of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet)—approximate only.	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Temperature of water (°F.).	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
89	San Antonio Water Co.	Cucamonga	E-9		Dug	1,875	1,705	212						Not used	
90	Colonel Paul and C. D. Adams.	do	E-8	1897	Dug, 4 by 5 foot.	1,885	1,700	220			Electric motor.			Irrigation	† 16
92	James Illingworth	do	E-7	1901	Dug, 3 by 5 foot.	2,160	2,026	143		61	Wind	$400.00	$125.00	Domestic; irrigation.	
94	San Antonio Water Co.	Sec. 25, T. 1 N., R. 8 W.	E-9	1895	Dug, 4 by 4 foot.	1,718	Dry.	100				500.00		No water	
97	do	do	E-8, 9	1895	do	1,745	Dry.	122				600.00		do	
98	do	do	E-9	1895		1,695	Dry.	102						do	
99	Citizens' Bank of Ontario.	Cucamonga	F-9	1898	Dug, 5 by 5 foot.	1,535	Dry.	275							
101	William Littlewood.	do	E-9	1899	Dug, 4 by 5 foot.	1,590	Dry.	300				700.00			
102	J. W. Mabb	do	F-9		Dug, 3 by 4½ foot.	1,525	Dry.	128							
103	Kirk Farlow Water Co.	do	F-8, 9		Dug, 3 by 5 foot.	1,645	Dry.	204							
104	Doctor Fargo	do	F-7		Dug, 4 by 6 foot.	1,925	Dry.	400							
105	San Antonio Water Co.	do	G-7	1896	Dug						Tunnel	80,000.00?		Irrigation	† 10
108	Mr. Hemen	Sec. 27, T. 1 N., R. 8 W.	C-8	1896	do	1,735	1,697	40			Wind			Stock	
109	Mountain View Water Co.	Sec. 2, T. 1 N., R. 8 W.	D-10	1899	Dug, 5 by 6 foot, 63 feet; bored, 10-inch, 62 feet.	1,412	1,354	125			Gas	750.00	475.00	Irrigation	† 15
110	do	do	D-10	1899	Dug, 5 by 6 foot, 93 feet; bored, 10-inch, 47 feet.	1,410	1,354	140			do	1,000.00	750.00	do	† 30
111	do	do	C-10	1892	Dug, 4 by 5 foot, 71 feet; bored, 8-inch, 42 feet.	1,390	1,352	113		62	Flows into tunnel.			do	
112	B. K. Brant	Sec. 12, T. 1 N., R. 8 W.	D-10	1900	Dug, 4 by 6 foot.	1,350	Dry.	507				2,000.00		do	
113	J. L. Means	Sec. 15, T. 1 S., R. 8 W.	C-12	1900	Bored, 10-inch.	1,050	783?	331			Gas	900.00	2,000.00	do	† 30
113a	do	do	C-12	1901	Bored, 14-inch.	1,050	782?	350			do	1,000.00			

114	M. W. Cobban	Sec. 22, T. 1 S., R. 8 W.	C-13	1899	Bored, 7-inch	1,005	800	260	20		Wind	700.00	175.00	Domestic	
115	W. L. Holmes	do	C-13	1903	Bored, 10-inch	965	777	280	19	64		640.00		Not installed	
116	F. E. Jones	Sec. 26, T. 1 S., R. 8 W.	C-14	1902	Bored, 7-inch	945	773	408			Wind	700.00	350.00	Domestic; irrigation.	
117	Mr. McLaughlin	Sec. 23, T. 1 S., R. 8 W.	D-13		do	980	775	208			do			Not used	
118	Mrs. M. H. Fitch	do	D-13		do	995	785	250	22	58	do				
119	Fortier, Green & Hill Water Co.	do	D-13	1899	Bored, 10-inch	1,015	783	334	21	59	Gas	800.00	1,700.00	Irrigation	† 20
120	J. Sternberg	do	D-13	1898	do	990	780	308	21	62	do	800.00	1,500.00	Domestic; irrigation	† 10
121	Crawford Bros.	Sec. 26, T. 1 S., R. 8 W.	D-13	1899	Bored, 10½-inch (2 wells).	980	775	325	20		do	800.00	5,000.00	Irrigation	† 35
122	J. Sullivan	Sec. 25, T. 1 S., R. 8 W.	E-13	1903	Bored, 9½-inch	990	770	335	19		Electric motor	815.00		do	† 20
123	A. L. King	do	E-13	1899	Bored, 12-inch	995	771	476	21		Gas	1,000.00	1,700.00	do	† 17
124	Lyman Stewart	Sec. 24, T. 1 S., R. 8 W.	E-12	1901	Dug, 6 by 8 foot, 320 feet; bored, 12-inch, 180 feet.	1,085	780	500			Steam	5,000.00	5,000.00	do	† 20
125	George Hocknell	do	E-13	1900	Bored, 10-inch	1,043	767	320			Not raised	850.00		Not used	
126	George C. Hagar	Sec. 21, T. 1 S., R. 7 W.	H-13	1895	Dug, 4 by 4 foot, 176 feet; bored, 7-inch, 44 feet.	980	782	220			do			do	
127	R. H. Hannah	Santa Ana del Chino.	F-14	1900	Bored, 10-inch	931	758	211			Wind	350.00	125.00	Domestic; irrigation.	
128	James H. Sauerwein	Sec. 1, T. 1 S., R. 8 W.	E-9	1894	Dug, 3 by 5 foot	1,540	Dry.	300				2,000.00		No water	
129	Doctor Turner	Santa Ana del Chino.	D-15		Bored, 10-inch (2 wells).	865	750	125	27		Wind			Irrigation	
130	Edward Chapman	do	D-16		Bored, 7-inch	810	746	150	27		do			Domestic; stock	
131	F. E. Schaad	do	D-16	1894	do	785	739	375	30	64	Gas			Irrigation	
132	H. C. Roberts	do	D-16	1899	do	775	739	126	19	67	do	500.00	300.00	Domestic	
133	Stephen Bush	do	D-16	1894	do	770	728	53			Wind		75.00	do	
134	J. B. Mart	do	D-16	1900	do	765	729	160	20	64	do			do	
135	C. W. Brenell	do	D-17	1903	do	740	717	112			do	100.00	75.00	do	
136	H. E. Benjaman	do	D-17	1901	do	725	700	160		68	do	200.00	100.00	do	
137	Mrs. E. G. Tateng	do	D-17	1897	Dug, 4 by 4 foot.	705	682	25	21		do			do	
138	C. Nabakowski	do	E-17	1900	Bored, 7-inch	705	701	255						Not used	
139	American Beet and Sugar Co.	do	E-17			695	695	300		69	Artesian			do	
140	J. T. Curlee	do	E-17	1900	Driven, 2-inch	715	704	13	19	68	Hand			Domestic	
141	W. C. Rightmier	do	E-17	1894	Bored, 7-inch	690	690	148	19	67	Gas, artesian	240.00	415.75	Irrigation	a† 22
142	W. J. Schaefer	do	E-17	1897	do	695	695	323			do	700.00	700.75	Domestic; irrigation.	b† 4
143	L. Anderson	do	D-17	1900	do	690	690	243			Artesian			Irrigation	4
144	W. C. Rightmier	do	D-17	1901	do	680	680	126			do			do	5
145	Mr. Dunn	do	D-17		do	675			19	67	do			Domestic; stock.	
146	Z. Wilkison	do	D-16		Dug, 3½ by 3½ foot.	760	721	41	22		Hand			Domestic	

a Pumped. b Flow.

Wells in the foothill belt of southern California—Continued.

CUCAMONGA QUADRANGLE—Continued.

No. of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet)—approximate only.	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Temperature of water (°F.).	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
147	F. M. Hildebrand	Santa Ana del Chino.	D-16	1903	Bored, 7-inch	745	721	138	23		Gas, wind	$160.00	$230.00	Domestic; irrigation.	
148	State Experiment Station.	do	C-15, 14.	1899	do	855	761	142	23		Wind			Domestic; stock.	
149	W. McCain	do	C-15	1895	do	825	733	162+			do			Domestic; irrigation.	
150	A. Armstrong	do	C-15	1900	Bored, 10-inch	830	740	412			Gas		2,000.00	do	† 70
151	J. M. Mitchell	do	C, D-15.	1900	Bored, 12-inch	860	750	336			do	800.00	1,975.00	Irrigation	† 30
152	Mrs. L. D. Greene	do	C-17	1896	Bored, 7-inch	720	709	135			Wind			Domestic	
153	Victor Gustafson	do	C-16	1902	Bored, 10-inch	735	719	640			Gas	1,500.00	1,000.00	Irrigation	† 60
154	O. W. Lorbeer	do	C-16	1888	do	755	727	973						Not used	
155	George E. Hollister	do	C-16	1903	Bored, 7½-inch	756	723	180	19		Wind	250.00	85.00	Domestic; irrigation.	
156	Black Bros. & Woodhead.	do	C-16	1903	Bored, 10-inch	743	725	718			Gas	1,900.00	1,000.00	Irrigation	† 80
157	Mrs. E. M. Day	do	C-16	1899	Bored, 7-inch	725	716	314				500.00		Not installed	
158	I. Bristol	do	B-16	1891	Bored, 4-inch	720	717	150			Wind	225.00	75.00	Domestic	
159	Mrs. M. A. Murdock	do	B-16	1899	Bored, 7-inch	715	715	247			Gas	500.00	800.00	Irrigation	
160	F. E. Reimers	do	B-16	1902	do	780	734	65			Wind	85.00	75.00	Domestic	
161	M. Payne	do	B-15	1892	do	780	734	50			do	62.50	90.00	do	
162	W. E. Jones	do	B-15	1892	Bored	785	742	900			Gas			Irrigation	† 35
163	John O'Donnell	do	B-15	1899	Bored, 10-inch	810	755	374	20	66	do		2,000.00	do	† 80
164	do	do	B-15	1889	do	795	742	160			Wind			Domestic; stock.	
165	American Beet and Sugar Co.	do	D-17		Bored, 9-inch	700	694	319			Compressed air			Factory	
165a	do	do	D-17		do	700	694	138			do			do	
166	do	do	D-17		Bored	695	695?	309			do			do	
166a	do	do	D-17		do	695	695?	297			do			do	
167	do	do	D-17		do	690	690	481			Compressed air, artesian.			do	
168	do	do	D-17		Bored, 8-inch	700	696?	250			Compressed air			do	
168a	do	do	D-17		Bored, 7-inch	700	696?	223			do			do	
169	do	do	D-17	1897	Bored, 8-inch	690	690?	315			do			do	
169a	do	do	D-17	1897	Bored	690	690	250			do			do	
170	do	do	B-16		Bored (5 wells)	735	729?	250-383			Not raised			Not used	

171	....do....	....do....	B-17....	....	Bored....	705	701	260	....	....	Compressed air.	....	....	Factory....	....
172	Chino Land and Water Co.	....do....	B-17....	1899	Bored, 9½-inch (6 wells).	665	665	100-140	....	....	Artesian....	....	....		
172a	....do....	....do....	B-17....	1903	Bored, 9½ to 13 inch (2 wells).	665	665	100-140	....	....	....do....	....	....	Irrigation....	103
172b	....do....	....do....	B-17....	1903	Bored, 14-inch..	665	665	140	....	....	....do....	....	....		
172c	....do....	....do....	B-17....	1903	....do....	665	665	300	....	....	....do....	....	....		
173	....do....	....do....	B-16....	....	Bored, 10-inch..	715	715	345	....	....	....do....	....	....	Domestic; stock.	5
173a	....do....	....do....	B-16....	....	....do....	715	715	150	....	....	....do....	....	....		
174	H. W. Trayermuth.	Sec. 28, T. 1 S., R. 8 W.	B-14....	1897	Bored, 6-inch...	885	776	175	22	....	Wind....	....	....	Domestic....	....
175	S. L. Crane....	Sec. 29, T. 1 S., R. 8 W.	A-14....	1884	Bored, 7-inch...	865	777	90	....	....	....do....	....	....	....do....	....
176	Mrs. M. E. Porter...	Sec. 28, T. 1 S., R. 8 W.	B-14....	1886	....do....	865	735	160	21	....	....do....	....	....	....do....	....
177	Mrs. Tiegs....	....do....	B-14....	....	Bored, 10-inch..	835	749	341	....	....	Not raised....	....	....	Not used....	....
178	J. O'Donnell....	Santa Ana del Chino.	B-15....	....	Bored, 7-inch...	840	752	174	....	....	Wind....	....	....	Irrigation....	....
179	J. F. Mast....	Sec. 28, T. 1 S., R. 8 W.	B-14....	....	Bored, 10-inch..	870	764	150	21	....	....do....	....	....	Domestic; irrigation.	....
180	M. E. Foster....	....do....	C-14....	1895	Bored, 7-inch...	860	769	106	....	....	....do....	....	....	Domestic....	....
181	R. Reimers....	....do....	B-16....	1894	....do....	770	737	65	....	....	....do....	75.00	60.00	....do....	....
182	W. D. McCrosky....	....do....	B-16....	1891	Bored, 4-inch...	760	734	60	....	66	....do....	....	....	....do....	....
183	McCrosky & Bowler	....do....	B-16....	....	Bored, 10-inch..	745	727	400	....	....	....	....	....	Not installed....	....
184	G. Y. Robertson....	....do....	B-16....	1898	....do....	720	715	160	19	67	Gas....	250.00	1,000.00	Irrigation....	† 40
185	George J. Weigle....	San Jose....	A-16....	1899	Dug, 25 feet; bored, 9-inch, 280 feet.	765	743	305	....	....	....do....	500.00	1,000.00	....do....	† 50
186	R. M. Thurman....	....do....	B-16....	1900	Bored, 9½-inch..	770	741	380	....	....	....do....	....	....	....do....	† 75
187	J. J. Allan....	....do....	A-15....	1899	Bored, 10-inch..	780	744	346	....	....	....do....	600.00	1,500.00	....do....	† 75
188	B. F. Whipp....	....do....	A-15....	1897	....do....	785	745	180	18	....	....do....	....	....	....do....	† 60
189	Humes & Gallup....	....do....	A-15....	1901	Bored, 9-inch...	785	745	379	....	....	....do....	....	....	....do....	† 60
190	N. W. Miller....	....do....	A-15....	1898	Bored, 9½-inch..	790	753	245	....	....	....do....	440.00	1,230.00	....do....	† 50
191	C. G. Taylor....	....do....	B-15....	1888	Bored, 7-inch...	790	752	275	....	....	Wind....	....	....	Domestic....	....
192	Van Syke & Wickersham.	....do....	B-15....	1900	Bored, 13-inch..	805	755	434	19	....	Gas....	1,300.00	1,700.00	Irrigation....	† 76
193	Cobb, Walls, Landon & Co.	....do....	A-15....	1898	Bored, 10-inch..	800	760	400	....	....	....do....	1,000.00	2,100.00	....do....	† 60
194	Mrs. Edgar....	....do....	A-14....	1903	....do....	845	773	....	....	....	Wind....	....	....	Domestic....	....
195	Sanford Ballou....	....do....	A-14....	1884	Bored, 7-inch...	855	777	174	....	....	....do....	300.00	....	....do....	....
196	R. A. Krause....	....do....	A-14....	....	....do....	845	772	178	16	....	....do....	....	....	....do....	....
197	T. E. Seagoe....	....do....	A-14....	1890	....do....	830	Dry.	70	....	....	....	....	....	No water....	....
198	J. J. Gorman....	....do....	A-14....	1886	....do....	825	763	116	19	....	Wind....	....	....	Domestic....	....
199	G. W. Harp....	....do....	D-14....	....	....do....	843	768	120	....	....	....do....	....	....	....do....	....
200	E. Goytte....	....do....	B-14....	1892	....do....	860	Dry?	78	....	....	....	....	....	No water....	....
201	J. J. White....	....do....	A-14....	1884	....do....	830	773	67	....	....	Wind....	....	....	Domestic....	....
202	H. B. Hansen....	....do....	A-14....	1884	....do....	825	771	57	....	....	....do....	....	....	Not used....	....
203	J. W. Snedaker....	....do....	A-15....	....	....do....	810	764	67	....	....	....do....	....	....	Domestic....	....
204	Charles Peterson...	....do....	A-15....	1896	....do....	820	763	73	....	....	....do....	....	....	....do....	....
205	J. A. Walz....	....do....	A-15....	1884	....do....	815	761	64	25	....	....do....	99.00	70.00	....do....	....
206	W. M. Niebel....	Santa Ana del Chino.	B-16....	....	....do....	765	736	....	22	....	....do....	....	....	....do....	....

Wells in the foothill belt of southern California—Continued.

CUCAMONGA QUADRANGLE—Continued.

No. of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet)—approximate only.	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Temperature of water (°F.).	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches.)
207	V. DesNoyers	Santa Ana del Chino.	B-16	1899	Bored, 10-inch	730	723	224	17		Gas	$500.00	$800.00	Irrigation	†35
208	F. B. Troxell	do	B-16	1893	Bored, 4-inch	720	720	160	18	66	Artesian	300.00		Domestic; irrigation.	4
209	Louis Lockenour	do	B-17	1897	Bored, 7-inch	685	685	160	19	67	do			Irrigation	†3
210	J. Wire	do	B-17	1901	do	685	685	156			do	300.00		do	†40
211	George Beck	do	B-16	1901	Bored, 10-inch	710	710	220	18	69	do	425.00		do	†50
212	Mr. McKinley	do	B-16		do	710	710	140	20	69	do			do	†30
213	Mr. Marion	do	B-16	1899	Bored, 8-inch	720	720	198	19	69	do	400.00		do	†20
214	C. P. Brown	do	B-16		Bored, 9½-inch	730	722	160						Not used	
215	A. L. Tufs	do	B-16	1891	Bored, 10-inch	730	722	357				727.00		do	
216	Bowler Bros	do	B-17	1896	Bored, 7-inch	680	680	139	18	68	Artesian	200.00		Irrigation	†35
217	R. J. Stewart	do	B-17	1902	do	675	675	124			do			do	
218	Chino Land and Water Co.	do	B-17			665	665	180	17	68	do			Stock	
219	Mrs. F. Fabian	do	C-17	1897	Bored, 7-inch	670	670	255	19	68	do			Irrigation	†8
220	American Beet and Sugar Co.	do	C-17			675	675	140	20		do			Stock	
221	W. P. Brown	do	C-17	1897	Bored, 7-inch	685	685	311			do			Irrigation	
222	B. Ross	do	C-17		Bored, 10-inch	690	690	300	17	67	do			do	†20
223	S. H. Adams	do	B-16	1902	Bored, 7-inch	715	715	256	19	65	do	325.00		do	4
224	A. J. Morrison	do	B-17	1899	do	675	675	250	18	68	do	600.00		do	†20
225	Charles Mason	do	C-17		do	675	675	160			do			Stock; irrigation	
226	H. F. Haman	do	C-16	1900	do	758	728	347	17	65	Gas	500.00	750.00	Irrigation	†20
227	John Boesch, jr	do	C-16	1901	do	765	729	95			Wind	150.00	85.00	Domestic	
228	John Fintel	do	C-16	1901	do	775	731	68	22	63	Hand	75.00	20.00	do	
229	C. A. Mosher	do	C-15		do	790	739	80			Wind			do	
230		do	C-15		Dug, 4 by 5 foot.	820	761	62	20	64	do			do	
231	F. W. Olmstead	Sec. 22, T. 1 S., R. 8 W.	C-13	1901	Bored, 10-inch	945	785	320			Gas	700.00	2,800.00	Irrigation	†20
232	Mrs. J. Cooley	San Jose	B-13	1896	Bored, 4-inch	930	782	170			Not raised			Not used	
233	Edward Gilson	do	B-13	1898?	Bored, 8-inch	940	809	200	17	62	Gas	300.00	600.00	Domestic	†7
234	M. Baldridge	do	B-13	1898	do	930	783	250			do	400.00	1,300.00	Irrigation	†10
235	W. N. Hendricks	do	B-12	1900	Bored, 10-inch	1,085	971	129			Not raised	250.00		Not used	
236	Stoddard, Hill & Tuttle.	do	B-12	1901	Bored, 14-inch	1,075	964	280			Compressed air.	600.00	1,600.00	Irrigation	40
236a	do	do	B-12	1901	do	1,075	964	265							

237	....do	....do	B-12	1901	....do	1,070	954	268	....	....	....do	600.00		....do	†40
237a	....do	....do	B-12	1901	....do	1,070	954	270	....	....	....do			Not used	
238	W. J. Warden	....do	B-12	1897	Bored, 10-inch	1,065	952	187	10	....	Not raised	1,900.00		....do	
238a	....do	....do	B-12	1897	....do	1,065	952	115	10	....	....do			Irrigation	†20
238b	....do	....do	B-12	1897	....do	1,065	952	178	10	....	Gas		800.00	....do	†15
239	John Miller	....do	B-12	1898	....do	1,045	942	172	20	63	....do	500.00	1,500.00	....do	†15
240	George H. Miller	....do	B-12	1899	....do	1,085	972	200	21	64	....do	500.00	1,000.00	Not used	
241	G. F. Ferris	....do	B-11	1892	Bored, 7-inch	1,100	872	190	....	....	Wind			....do	
242	San Antonio Water Co.	....do	B-11		Bored, 12-inch	1,121	966	558	....	....					
242a	....do	....do	B-11		....do	1,121	966	535	....	....	Electric motor			Irrigation	†27
243	....do	....do	B-11		Bored	1,105	1,033				....do			....do	†55
244	....do	....do	B-11, 12		Dug, 7 by 10 foot.	1,100	1,031		20	58	Not raised			Not used	
245	Bartlett Bros	....do	B-11	1899	Bored, 10-inch	1,115	965	200	....	....	Gas	472.00	1,200.00	Irrigation	
246	H. R. Hawley	....do	B-12		Bored	1,100	1,028				Not raised			Not used	
247	Del Monte Irrigation Co.	....do	B, C-11	1886	Bored, 7-inch	1,135	1,065	275	....	62	Compressed air	750.00	15,000.00	Irrigation	†60
247a	....do	....do	B, C-11	1902	Bored, 12-inch	1,135	1,065	300	....	....	....do	750.00			
248	....do	....do	C-11	1902	....do	1,130?	1,060?	300	....	62	....do	750.00			†75
248a	....do	....do	C-11	1903	Bored, 14-inch	1,135?	1,065?	400	....	62	....do	1,200.00			
249	....do	....do	B, C-11	1888	Bored, 7-inch	1,130	1,060	225	....	....	....do	700.00			35
249a	....do	....do	B, C-11	1888	....do	1,135	1,065	160	....	....	....do	550.00			
250	R. Bieley	....do	C-11	1900	Bored, 10-inch	1,155	1,071	117	....	....	Wind			Domestic; stock	
251	George Jencks	Sec. 10, T. 1 S., R. 8 W	C-11	1901	....do	1,230	1,089	175	....	....	Gas	400.00	600.00	Stock; irrigation	†5 †25
252	C. N. Brundage	....do	B-12	1897	Bored, 14-inch	1,060	954	310	21	....	Electric motor	250.00	1,200.00	Irrigation	
253	Garlock, Phillips & Loop.	San Jose	B-11	1882	Dug, 8 by 10 foot, 50 feet; bored, 12-inch, 90 feet.	1,165	1,080	140	....	....	Steam	350.00		....do	†20
254	Del Monte Irrigation Co.	Sec. 9, T. 1 S., R. 8 W.	B-11	1899	Dug, 5 by 8 foot, 106 feet; bored, 10-inch, 119 feet.	1,180	1,100	225	....	....	Electric motor	600.00	1,700.00	....do	†60
255	A. T. Currier	San Jose	A-11	1895	Bored, 10-inch	1,175	1,040	310	....	....	Gas			....do	†15
256	L. Brosseau	....do	A-12	1894	Bored, 7-inch	1,070	Dry.	98	....	....					
257	Del Monte Irrigation Co.	Sec. 9, T. 1 S., R. 8 W.	B-11	1899	Bored, 10-inch (3 wells).	1,190	1,110	225	....	....	Compressed air	1,800.00	(a)	....do	†50
258	Dr. M. B. Cambell	San Jose	B-11		Bored	1,170	1,018	300	....	....	Gas			....do	†20
259	John Beck	Sec. 9, T. 1 S., R. 8 W.	B-11		Bored, 7-inch	1,215	1,100		17	....	Wind			Domestic	
260	G. G. Charlton	....do	B-10	1899	Dug, 138 feet; bored, 9½-inch, 222 feet.	1,245	1,101	360	....	....	Steam	900.00	7,000.00	Irrigation	†30
261	A. W. Town	Sec. 4, T. 1 S., R. 8 W.	B-10	1886	Bored, 6-inch	1,240	1,090	320	....	....	Wind		40.00	Domestic	
262	....do	....do	B-10	1902	Bored, 12-inch	1,280	1,105	320	....	....	Gas	1,000.00	2,000.00	Irrigation	15
263	C. Siever	....do	B-10	1895	Dug, 70 feet; bored, 9½-inch, 224 feet.	1,350	1,275	294	....	....	Tunnel			Not used	

a Connected with plants Nos. 247–249.

Wells in the foothill belt of southern California—Continued.

CUCAMONGA QUADRANGLE—Continued.

No. of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet)—approximate only.	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Temperature of water (°F.).	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
264	Consolidated Water Co.	Sec. 3, T. 1 S., R. 8 W.	C–10		Bored, 10-inch	1,300	1,204	200?			Flow into tunnel.			Domestic	† 70
265	Ontario Water Co.	do	C–10	1900	Bored, 10-inch (2 wells).	1,265?	1,224?	160			Compressed air.				
265a	do	do	C–10	1900	Bored, 10-inch	1,265?	1,224?	225			do	$2,400.00			35
265b	do	do	C–10	1900	do	1,285?	1,225?	225			do		$5,200.00	Irrigation	
265c	do	do	C–10	1900	do	1,270?	1,223?	225			do				
265e	do	do	C–10	1900	do	1,300?		225			do	2,400.00			35
265	do	do	C–10	1901	do	1,305?	1,233?	200			do				
266	Citizens' Light and Power Co.	Sec. 33, T. 1 N., R. 8 W.	B–9	1903	Bored, 12-inch	1,370	1,217	385	21	64	Gas	1,400.00	3,000.00	Domestic; irrigation.	† 30
267	Martin Bros	do	B–9	1899	Dug, 4 by 4 foot.	1,390	1,344	70	23		Wind	200.00	125.00	Irrigation	† 1
268	do	do	B–9	1902	Dug, 3½ by 3½ foot, 106 feet; bored, 12-inch, 261 feet.	1,380	1,205.	367	19	70	Gas	1,200.00	2,200.00	do	† 25
269	C. C. Johnson	do	B–9	1903	Dug, 3 by 3 foot.	1,345	1,217	130	21		Wind			Domestic; irrigation.	
270	B. E. Street	do	B–9	1899	Dug, 100 feet; bored, 9-inch, 167 feet.	1,325	1,225?	267			Gas	800.00	200.00	Irrigation	2½
271	Claremont Cooperative Water Co.	Sec. 32, T. 1 N., R. 8 W.	A–9	1900	Bored, 12-inch	1,265	1,200	277			do	1,000.00	2,000.00	do	35
272	L. C. Pitzer	Sec. 5, T. 1 N., R. 8 W.	A–9	1903	Dug, 3 by 5 foot, 50 feet; bored, 14-inch, 370 feet.	1,270	1,200	420			do	1,500.00	3,500.00	do	† 35
273	Seth Richards Orange Grove Co.	do	A–9	1899	Bored, 10-inch	1,255	1,197	305			Compressed air.	(*a*)		do	† 40
274	Prof. Sumner	do	A–10	1897	Bored, 12-inch	1,250	1,215	275			Gas	750.00	1,600.00	do	† 25
275	Schesler & Soaper	do	A–10	1902	Dug, 160 feet; bored, 10-inch, 148 feet.	1,275	1,107	308			do	900.00	2,000.00	do	† 15
276	John Joss	do	A–10	1898	Bored, 8-inch	1,185	1,044	205	21		do			Domestic; irrigation.	† 15

277	Seth Richards Orange Grove Co.	Sec. 5, T. 1 S., R. 8 W.	A-10	1899	Bored, 10-inch	1,200	1,072?	293	....	....	Compressed air			Irrigation	
278	....do	....do	A-10	1899	....do	1,190	1,068?	301	....	....	....do	(*b) 12,400.00	....		......
279	....do	....do	A-10	1900	....do	1,180	1,064?	322	....	....	....do				
280	Kingsley Tract Water Co.	San Jose	A-12	1889	Bored, 6-inch	1,185	1,122	265	16	....	Gas	1,000.00	1,500.00	....do	†30
282	O. W. Lorbeer	....do	A-14	1902	Bored, 10-inch	860	775?	393	....	....	Steam	700.00	....	Laundry	......
283	C. Seaver	....do	A-13	1902	Bored, 7-inch	873	777	151	....	....	Wind	250.00	90.00	Domestic	1
284	Dr. A. R. Reed	....do	A-12	1900	Bored, 9½-inch	1,010	952	200	....	....	....do	....	....	....do	......
288	M. A. Williams	....do	A-12	1896	Dug, 40 feet; bored, 7-inch, 120 feet.	955	923	160	....	....	Wind	....	....	....do	......
289	Irrigation Co. of Pomona.	....do	A-12	1887	Dug, 4 by 6 foot, 50 feet; bored, 7-inch, 297 feet.	950	915	347	....	....	Electric motor	900.00	1,200.00	Irrigation	†60
290	Palomares Irrigation Co.	....do	A-12	1886?	Bored, 7-inch	975	938	500	....	....	Wind	700.00	....	Domestic	......
291	....do	....do	A-12	1886?	Dug, 50 feet; bored, 7-inch, 155 feet (2 wells).	995	948	205	....	....	Electric motor	400.00	2,450.00	Irrigation	†55
291a	....do	....do	A-12	1899	Bored, 10-inch	995	948	200	....	....	....do				
292	Consolidated Water Co.	....do	A-12	1904	Bored, 14-inch	985	935	223	....	....	....do	*3,000.00	....	....do	†60
293	....do	....do	A-12	1898	Bored, 10-inch	1,010	945	225	....	....	....do	*3,000.00	....	Domestic	†30
294	Major Thomas	....do	A-12	1892	Bored, 7-inch	1,020	960	200	21	....	Compressed air	....	3,000.00	Irrigation	†25
295	Consolidated Water Co.	....do	A-12	1898	Bored, 10-inch	1,005	948	57	....	....	Electric motor	*3,000.00	....	Domestic	†27
295a	....do	....do	A-12	1897	Bored, 9-inch	1,005	952	223	....	....	....do				
297	Chino Land and Water Co.	....do	....	1889	Bored, 12-inch	990	950?	535	....	....	....do	2,000.00?	....	Domestic; irrigation.	†60
298	Mr. Smith	....do	....	......	Bored, 9-inch (3 wells).	975	925	229-321	....	....	Wind	....	....	Domestic	......
299	Cathcart estate	....do	A-12	1886?	Bored, 12-inch (5 wells).	980	912	300-600	....	....	Not raised	....	....	Not used	......
300	J. W. Romick	....do	B-11	......	....	1,125	969	200?	....	....	Wind	....	....	Irrigation	......
301	Del Monte Irrigation Co.	Sec. 9, T. 1 S., R. 8 W.	B-11	......	Bored, 14-inch	1,180	1,090	200†	....	....	Not raised	....	....	Not used	......

a Included in Nos. 277-279.

b Including No. 273.

Wells in the foothill belt of southern California—Continued.

POMONA QUADRANGLE.

No. of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet)—approximate only.	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Temperature of water (°F.).	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
1	Currier Tract Water Co.	San Jose	M-13	1900	Bored, 10-inch	855	759	356			Electric motor	$1,200.00	$2,300.00	Irrigation	†70
2	M. L. García	do	M-13	1902	Bored, 7-inch	850	780	100	22		Wind			Domestic	
3	L. R. Phillips	do	L-13	1899	do	800	754	56	22		do			do	
4	L. Monro	do	L-13		do	775	741	103			Not raised			Not used	
5	Mrs. S. L. Fryer	do	K-14		do	735	712	50			Wind			Domestic	
6	Fryer ranch	do	L-14	1900	Bored, 10-inch	738	710	190			Gas			do	
7	Earnest Whipp	do	K-14	1886	Bored, 7-inch	730	704	40	28		do			do	
8	J. M. Fryer	do	K-14	1895	do	720	695	44	25		Wind			do	
9	S. E. Hicks	do	J, K-14	1900	do	745	716	48	35		do			do	
10	J. M. Fryer	do	K-14		Dug, 3 by 3 foot	745	715	34			Hand			Domestic; stock	
11	Los Angeles County	do	K-14		Bored, 7-inch	780	748	55			Wind			Roads	
12	B. Linnastruth	do	N-13	1900	do	850	772	83	23		do			Domestic	
13	do	do	N-13	1897	do	862	792	75	16		do			do	
14	F. G. Herman	Sec. 30, T. 1 S., R. 8 W.	M, N-13		Bored, 8-inch	850	769	90	21		do			do	
15	Mrs. M. C. Blevett	San Jose	M-13		Bored, 7-inch	840	756	95			do			do	
16	A. M. Way	Sec. 34, T. 1 S., R. 9 W.	K-14	1900	do	695	673	61	24		do	70.00		do	
17	Stanley Bates	do	K-15		Dug, 4 by 6 foot, 11 feet; bored, 7-inch, 69 feet.	678	669	80	25		do			do	
18	Lynch ranch	do	K-15	1898	Bored	670	661	150	24		do			do	
20	D. H. Collins	do	K-15		Dug, 8-foot diameter.	657	656	3	25		do			do	
21	M. T. Scanlon	do	K-15	1901	Dug, 2 foot diameter.	662	659	12	170		Hand			Stock	
22	Antone Rayes	Sec. 4, T. 2 S., R. 9 W.	J-14		Bored, 7-inch	650	639	70	23		Wind			Domestic	
23	R. T. Currier	Sec. 9, T. 2 S., R. 9 W.	J-16, 17		Bored, 8-inch	600	583	86	32		do			do	
24	K. H. Dorsey	San Jose	K-14	1898	Bored, 7-inch	705	682	81			Steam	*1,250.00		Irrigation	50
25	do	do	K-14	1898	Bored, 10-inch	705	682	65			do				
28	Sam Lee Co.	do	L-14		do	755	732	149			Gas			do	†40
29	do	do	L-14		do	755	732	149			Flows 23 feet below surface.				

30	D. D. Ross	do	M-14	1880	Bored, 6-inch	840	771	75	25		Wind			Domestic	
31	Robert Allen	do	M-14	1900	Bored, 7-inch	830	780	90	23		do			do	
32	Pomona Brick Co	do	M-14		do	815	771	80			do			do	
33	Mr. Barnhardt	do	N-14		do	810	769	57	24		do			do	
34	Miss Sarah Dundas	do	N-15		Dug, 6 by 6 foot	800	774	40	29		do			do	
35	D. Hawkins	do	N-14	1885	Bored, 7-inch	840	775	96			do			Irrigation	
36	James Gallaway	do	N-15	1902	do	802	770	70	28		do	115.00	210.00	Domestic; irrigation.	
37	F. C. Westphal	do	N-15	1900	Dug, 4 by 4 foot	790	769	26	22		do			Domestic	
38	Mrs. L. R. Matthews	do	N-15	1899	Bored, 10-inch	800	762	250			Gas	450.00	1,800.00	Irrigation	†80
39	Hill & Wickson	do	N-14	1899	do	815	757	245			do	425.00		do	†75
40	P. R. Perris	do	N-15	1902	Dug, 3 by 3 foot	790	766	25	30		Hand			Domestic	
41	W. C. McGuire	do	N-14	1897	Bored, 8-inch	825	772	110	23		Wind			do	
42	Kerckhoff - Cuzner M. & L. Co.	do	N-13	1885	do	860	783	166			Not raised			Not used	
43	D. R. Kelsey	do	N-13	1902	Bored, 10-inch	880	800	161			Gas	325.00	1,650.00	Irrigation	†25
44	S. J. Bromley	do	N-12	1895	do	935	909	100	18		Wind			Domestic	
45	R. Vejar	do	N-11, 12	1886	Bored, 7-inch	1,046	972	260	16		do	800.00		do	
46	Frank Vejar	do	N-11	1897	do	1,045	968	115	16		do			do	
47	P. T. Yorba	do	M, N-11	1900	do	1,045	964	120	24		do			do	
48	James Fulton	do	N-11	1898	Dug, 4 by 4 foot, 95 feet; bored, 12-inch, 205 feet.	1,070	977	300			Gas			Domestic; irrigation.	†30
49	J. Steves	do	N-11	1895	Bored 7-inch	1,085	985	128	70		do	250.00	450.00	do	†10
50	Lordsburg Water Co.	do	N-11	1899	Dug, 5 by 5 foot, 120 feet; bored, 10-inch, 180 feet.	1,100	981	300			do	800.00	2,200.00	Irrigation	†33
51	William Bosbyshell	do	N-11	1900	Bored, 10-inch	1,050	965	340			do		1,475.00	Domestic; irrigation.	†50
54	B. F. Whipp	do	N-13	1897	Bored, 7-inch	900	840	61	20		Wind			Domestic	
55	Orange Grove Avenue Water Association.	do	N-13	1900	Dug, 5 by 7 foot, 62 feet; bored, 10-inch, 278 feet.	920	904	340	14		Electric motor	1,700.00	1,600.00	Irrigation	†65
56	Mel Campbell	do	N-13	1897	Bored, 7-inch	920	908	250	16		Gas	900.00	1,350.00	Domestic; irrigation.	†40
57	do	do	N-13	1896	do	920	908	180			do			Irrigation	
59	Mrs. L. T. Alkire	do	N-13		do	900	862	60			Wind			Domestic	
60	Frank Vejar	do	M-12	1880	do	990	972	48	24		do			Stock	
61	Palomares ranch	do	M-12		Dug, 4 by 4 foot	995	978	20	32		Hand			Domestic	
62	Keiser Bros	do	M-11	1899	Bored, 10-inch	1,030	960	360			Gas			Irrigation	†50
63	Lordsburg Water Co.	do	M-11	1900	Dug, 4 by 5 foot; bored, 10-inch.	1,065	982	202			do	400.00	1,800.00	Domestic; irrigation.	†25
64	S. L. Gross	do	N-11	1902	Bored, 12-inch	1,090	990?	100?			Electric motor		*4,000.00	do	
65	do	do	N-11	1902	Bored, 14-inch	1,090	990?	100?			do				†50
66	H. J. Nichols	do	N-11		Bored, 7-inch	1,115	976	162	18		Wind			Domestic	
67	F. H. Massey	do	N-11	1898	Bored, 10-inch	1,165	977	200+			Not raised			Not used	
69	Mesa Water Co	Sec. 5, T. 1 S., R. 8 W.	N-10	1903	Dug, 4 by 6 foot, 140 feet; bored, 12-inch, 180 feet.	1,230	1,129	320			Electric motor				†30

Wells in the foothill belt of southern California—Continued.

POMONA QUADRANGLE—Continued.

No. of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet)—approximate only.	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Temperature of water (°F.).	Method of lift.	Cost of well.	Cost of machinery	Use of water.	Quantity of water (miner's inches).
71	R. E. Winter	Sec. 5, T. 1 S., R. 8 W.	N-9	1901	Bored, 12-inch	1,240	1,110	300			Gas			Domestic; irrigation.	†15
72	R. A. Wallace	Sec. 6, T. 1 S., R. 8 W.	N-10		Bored, 7-inch	1,152	997	165			do			Domestic	5
73	Duarte Mutual Irrigation and Canal Co.	Azuza Duarte	C-8	1901	Dug, 9 by 6 foot.	598	553	218			Steam	*$20,000.00		Domestic; irrigation.	64
74	J. H. Maddock	do	C, D-7	1899	Dug, 2$\frac{2}{3}$ by 3$\frac{2}{3}$ foot.	695	582	120	28		Gas	*2,000.00		do	†15
75	Duarte Mutual Irrigation and Canal Co.	do	D-7	1902	Dug, 6 by 6 foot.	690	612	130			Not raised			Not used	
76	A. C. Thompson	do	D-8	1900	Dug, 6 by 8 foot.	650	614	80			Steam	*7,000.00		Irrigation	†100
77	D. H. Thrasher	do	C-8	1898	Dug, 4 by 6 foot, 235 feet; bored 12-inch, 26 feet.	550	315	261			Not raised	1,200.00		Not used	
78	West Duarte Development Co.	do	B-7	1903	Dug, 4 by 6 foot, 118 feet; bored, 8-inch, 92 feet.	620	566	210			Gas			Domestic; irrigation.	†15
79	Duarte Mutual Irrigation and Canal Co.	do	B-8		Bored, 10-inch	610	Dry.	200						No water	
80	E. D. Northup	do	B-8, 9	1895	do	475	306	222	26		Wind	1,400.00		Domestic	
81	W. S. Newhall	do	D-7	1900	Dug, 4 by 5 foot.	680	610	100			Steam			Irrigation	†25
82	Orange Avenue Land and Water Co.	La Puente	D-12	1903	Bored, 12-inch	420	293	262			do	1,075.00	$3,400.00	do	
83	Irwindale Land and Water Co.	do	D-12	1899	Dug, 4 by 6 foot, 130 feet; bored 12-inch, 72 feet.	428	294	202	25		do	*5,000.00		do	†65
84	J. F. Irwin	Sec. 16, T. 1 S., R. 10 W.	D-11		Dug, 120 feet; bored, 10-inch, 60 feet.	424	294	180			Gas			do	†35
85	D. L. Allen	Sec. 17, T. 1 S., R. 10 W.	C-11		Bored, 7-inch	390	287	115	28		Wind				

86	Vineland irrigation district plant.	Sec. 9, T. 1 S., R. 10 W.	C-11	1898	Dug, 104 feet; bored, 12-inch, reduced to 10-inch, 370 feet.	400	294	474			Steam	3,000.00		Domestic; irrigation.	†100
87	Vineland school district.	Sec. 18, T. 1 S., R. 10 W.	C-11		Bored, 7-inch	382	288	140	27		Wind			Domestic	
88	C. N. Buck	do	B-11		do	372	285	100	28		do			do	
89	Washington Bunch	Sec. 7, T. 1 S., R. 10 W.	B-11	1895	Dug, 3 by 3 foot	380	289	100			Not raised			Not used	
90	Baker ranch	Sec. 18, T. 1 S., R. 10 W.	B-11		Bored, 7-inch	370	284	80			Wind			Domestic	
91	G. Nebbir	Sec. 12, T. 1 S., R. 11 W.	B-11		do	352	282	75	28		do			do	
92	Cypress Avenue Water Co.	La Puente	E-11	1903	Dug, 4 by 6 foot, 170 feet; bored, 12-inch, 130 feet.	466	296	300			Steam	935.00?		Irrigation	
93	P. C. Basher	do	F-12	1900	Dug and bored, 10-inch.	485	315	304	29		Gas	400.00	900.00	do	†15
94	William Overholtzer	do	E-12	1900	Bored, 10-inch	465	300	300	30		do	800.00	2,175.00	Domestic; irrigation.	23
95	E. C. Mullendor	do	E-12	1903	Dug, 4 by 6 foot	430	304	128			Installing plant				
96	G. F. Chamberlain	do	E-12, 13	1900	Dug, 3 by 3 foot	422	306	118	22		Wind			Domestic	
97	Griffith Bros.	do	E-14	1892	Bored, 7-inch	422	294	130	40		do			do	
98	Edward Fickewirth	do	C-12		Bored, 10-inch	352	307	300?	26		do			do	
99	do	do	D-15	1900	Bored, 12-inch	362	312	850							
100	do	do	D-15	1900	do	362	302	287			Not raised			Not used	
101	do	do	D-15	1900	do	362	302	307			do			do	
102	E. J. Baldwin	do	A-15		Driven, 2-inch	278	263	24	31		Hand			Domestic	
103	Los Angeles County	do	A-14		Bored, 7-inch	275	263	60	26		Wind			Roads	
104	C. N. Bassett	do	A-14	1899	Bored, 12-inch	315	289	125			Steam	2,500.00	2,400.00	Irrigation	135
105	E. M. Haddock	do	A-14	1900	Bored, 9½-inch	305	275	125	27		do			do	†90
106	E. J. Baldwin	do	B-14		Bored, 7-inch	335	292	58	26		Wind			Domestic	
107	Los Angeles County	do	C-16		do	320	302	58	53		do			Roads	
108	do	do	B-15		do	295	280	65	38		do			do	
109	E. J. Baldwin	do	B-16		Bored, 9-inch	295	286	22			Not raised			Not used	
110	L. F. Lewis	do	B, C-16		Bored, 10-inch	312	288	300			do			do	
111	J. W. Hudson	do	C-17	1880	Bored, 7-inch	330	305	39	41		Wind			Domestic	
112	Joseph Ferara	do	C-17		Dug, 5 feet diameter.	342	320	25	75		do			do	
113	Rowland ranch	do	D-17		Bored, 7-inch	360	326	60	47		do			do	
114	San Pedro, Los Angeles and Salt Lake R. R.	do	D-17	1903	Bored, 14-inch	380	347	300	74		Gas			Engines	
115	Rowland school district.	do	D-17		Dug, 4 by 4 foot	350	332	22	71		Hand			Domestic	
116	L. Didier	do	E-17	1893	Dug, 30 feet; bored, 7-inch, 70 feet.	370	347	100	107						
117	H. Heinze	do	C-16	1896	Bored, 7-inch	323	297	127	59		Wind			Domestic	
118	E. Rambaud	do	C-16	1900	Dug, 4 by 4 foot	340	310	42	78		do			do	
119	George Cross	do	C-16		Bored, 7-inch	342	311	93	57		do			do	

Wells in the foothill belt of southern California—Continued.

POMONA QUADRANGLE—Continued.

No. of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet)—approximate only.	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Temperature of water (°F.).	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
120	George Cross	La Puente	D-17	1902	Bored, 9½-inch	340	328	148	70		Not raised	$350.00		Not used	
121	William Rowland	do	D-17	1901	Bored, 9⅝-inch	355	331	165			Electric motor	272.50?	$3,500.00	Irrigation	
122	do	do	D-17	1901	do	355	331	165			do	272.50		do	
123	do	do	D-17	1901	do	355	331	165			do	272.50		do	†104
124	do	do	D-17	1901	do	355	331	165			do	272.50		do	
125	do	do	D-17	1901	do	356	326	500			do			Domestic; irrigation.	†15
126	H. L. Armstrong	do	C-17	1902	Bored, 8-inch	320	315	120	58		Gas				
127	do	do	C-17	1902	do	320	315	290			do		1,200.00	Irrigation	†80
128	do	do	C-17	1902	do	320	315	160			do				
129	B. F. Rowland	do	E-17		Bored, 7-inch	370	348	26			Wind			Domestic	
131	Rowland estate	do	D-15		do	345	307	73	31		Hand			do	
132	E. J. Baldwin	do	C-14		do	340	295	80			Wind			do	
133	Robert Rowland	do	F-17		Dug, 5-foot diameter.	390	365	26			do			do	
134	A. H. Yorba	do	F-17	1893	Bored, 7-inch	430	383	84	46		do			do	
135	B. Yorba	do	F-17		do	395	367	50	60		do			do	
136	J. P. Edwards	do	D-17	1901	do	365	330	42	49		do			do	
137	M. Vasquez	do	D-16	1902	Dug, 4 by 4 foot	346	324	30	56		Hand			do	
138	Jose Cota	do	D-16	1903	do	338	324	17	61		do			Domestic; irrigation.	
139	William Aschenbrenner.	do	F-12, 13	1900	Bored, 10-inch	475	325	300			Not raised			Not used	
140	W. G. Kerchkoff	do	G-13	1900	do	545	385	400			Electric motor	*3,000.00		Irrigation	†15
141	G. O. Shouse	do	H-12	1903	Bored, 12-inch	660	553	400	86		Wind			Domestic	
142	do	do	H-12	1900	do	550	550	90			Not raised			Not used	
143	C. H. Cannon	San Jose	J, K-11		Bored, 10-inch	850	Dry.	180						No water	
144	William Ferry	do	J-11	1900	do	855	657	222			Not raised	723.00		Not used	
145	Macneil ranch	Azusa Dalton	G-9		Bored, 12-inch	602	326	600?			do			do	
146	L. G. Parker	Sec. 1, T. 1 S., R. 10 W.	G-10		do	615	344	294			do			do	
147	A. Jackson	San Jose Addition.	H-10	1900	Dug, 3 by 6 foot	745	646	110	65		Gas			Irrigation	†10
148	Hauser Bros. Co	do	H-10	1900	do	700	Dry.	224						No water	
149	Sidney Deacon	do	J-11		Bored, 12-inch	825	694	160			Steam			Not used	
150	do	do	J-11		do	825	695	155			Not raised			do	

151	H. Rees	San Jose	J-11	1895	Bored, 7-inch	830	Dry.	162						No water	
152	A. R. Evans	La Puente	F-13	1899	Bored, 10-inch	485	330	400			Compressed air	1,300.00	2,700.00	Irrigation	†20
153	Mr. Davison	Sec. 31, T. 1 N., R. 9 W.	H-9	1900	Dug, 4 by 6 foot	698	652	70	27		Not raised			Not used	
154	B. F. Taylor	San Jose Addition.	H-10	1899	Dug, 5-foot diameter.	720	653	86	23		do			do	
155	West Middleton	do	I-10		Dug, 3 by 6 foot	810	Dry.	116						No water	
156	William Bowring	do	I-10	1900	Dug, 4 by 4 foot	810	682	158	35		Not raised	1,000.00		Not used	
158	J. W. Cook	Sec. 20, T. 1 N., R. 9 W.	I-7	1897	Dug, 4 by 6 foot	1,050	1,036	70	49		do			do	
159	John Engelehardt	do	I-7	1899	do	1,080	Dry.	200				2,000.00		No water	
160	I. R. Miller	do	I-7	1897	do	1,070	1,058	64	76		Not raised			Not used	
161	J. F. Shank	Sec. 31, T. 1 N., R. 9 W.	H-9	1899	Bored, 10-inch	700	Dry.	190						No water	
162	G. S. Thomas	do	H-9	1898	do	738	628	185	34		Gas			Domestic	7
163	W. H. Hall	do	H-9	1899	Dug, 3 by 6 foot	730	624	112	32		do			Irrigation	
164	A. B. Rodgers	do	H-9	1899	Dug, 4 by 6 foot	725	620	151			Not raised	1,000.00		Not used	
165	J. H. Hommell	do	H-9	1900	Bored, 10-inch	700	580	190			Gas	300.00	950.00	do	7
166	Jacob Boerlin	do	H-9	1903	Dug, 4 by 4 foot	740	713	33	48		Hand				
181	Pomona Land and Water Co.	San Jose	N-12	1894	Bored, 7-inch	1,000	945	325			Electric motor	1,200.00	2,200.00	Irrigation	†60
182	Irrigation Co. of Pomona.	do	N-12	1888	Bored, 9½-inch and 8-inch.	960		950			Compressed air	6,000.00	1,500.00	do	†60
183	do	do	N-12	1887	Bored, 7-inch	955		440			do	900.00		do	†15
185	Mr. Strause	Sec. 8, T. 2 S., R. 9 W.	I-17	1896	Dug, 3 by 3 foot	555	537	20	55		Hand			Domestic	
186	Paton & Co	Sec. 17, T. 2 S., R. 9 W.	I-17	1903	Bored, 10-inch	570	532	60	31		Gas	300.00	1,500.00	Irrigation	†77
187	McClintock, Lee & St. Clair.	La Puente	I-17	1902	do	550	518	100			do	250.00	1,360.00	do	†62
188	Mrs. E. M. Dailey	do	I-17	1897	Bored, 8-inch	540	517	55			do			do	†60
189	Mr. Swan	do	I-17	1902	Bored, 7-inch	550	517	55			Wind			Domestic	
190	G. W. Bowman	do	H-17	1903	Dug, 4 by 6 foot	535	514	38	46		Gas	350.00	1,100.00	Irrigation	†80
191	L. Snodgrass	do	H-17	1894	Bored, 7-inch	510	487	40	56		Wind			Domestic	
192	S. M. Bowers	do	H-16	1903	Dug, 6 by 8 foot	555	527	40			Gas		600.00	Irrigation	†12
193	B. F. Bowers	do	H-16	1903	do	560	530	36	55		do			do	5
194	William Rowland	do	H-17	1890	Dug, 3 by 3 foot	540	502	45	52		Wind			Domestic	
195	W. H. Swan	do	H-17	1896	Dug, 3½ by 3½ foot.	530	505	30			do			do	
196	G. W. Bowman	do	H-17	1891	Bored, 4-inch	530	502	120	52		do			do	
197	F. M. Howell	do	H-17	1902	Dug, 8 by 8 foot	515	495	40			Gas			Irrigation	†25
198	Joseph Monroy	do	I-16	1896	Dug, 3 by 3 foot	540	528	14	55		Wind			Domestic	
199	James Huff	San Jose	M-11	1899	Bored, 10-inch	1,010	966	280	21		do	600.00	75.00	do	
200	Covina Irrigating Co	do	M-11	1898	Bored, 10-inch (5 wells).	995?	950?	240-400			Compressed air	7,000.00	7,000.00	Irrigation	†125
201	do	do	M-11	1899	do	995?	950?	240-300			do				
202	J. S. Soto	do	M-11	1884	Bored, 7-inch	1,020	972	50	17		Wind			Domestic	
203	A. A. Macias	do	M-11	1899	Dug, 3½ by 3½ foot.	1,015	973	43			do			do	
204	Mrs. Dolores de Carrión.	do	L-11	1898	Dug, 5 by 5 foot, 40 feet; bored, 10-inch, 40 feet	975	951	80			Gas	400.00	700.00	Domestic; stock.	†10

Wells in the foothill belt of southern California—Continued.

POMONA QUADRANGLE—Continued.

No. of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet)—approximate only.	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Temperature of water (°F.).	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
205	Margaret Flemming	San Jose	M-11	1897	Bored, 7-inch	1,042	1,002	275			Compressed air	$600.00	$3,500.00	Irrigation	†25
206	H. C. Fisher	do	M-11	1894	do	1,049	1,004	375			Gas	700.00	450.00	do	†7
207	Stratton & Hayes	Sec. 1, T. 1 S., R. 9 W.	M-10	1891	do	1,135	1,037	170			do	275.00	500.00	do	†10
208	A. Baker & Son	Sec. 36, T. 1 N., R. 9 W.	M-9	1902	Bored, 12-inch	1,215	1,031	347			do	1,259.00	1,250.00	Domestic	8
209	do	Sec. 1 T. 1 S., R. 9 W.	M-9	1902	do	1,175	995	450			do	1,500.00	5,200.00	Irrigation	†40
210	N. L. Sparks	Sec. 36, T. 1 N., R. 9 W.	M-9	1901	Dug, 157 feet; bored, 12-inch, 167 feet.	1,185	1,001	324			do	1,100.00	4,000.00	do	†40
211	Williams Bros	San Jose	L-9	1900	Dug, 136 feet; bored, 10-inch, 139 feet.	1,090	920	275			do			do	†30
212	A. Swerdfeger	do	L-10	1902	Bored, 12-inch	1,080	915	300			do			do	†35
213	W. T. Michael	do	L-9	1897	do	1,120	1,035	200	31		do	750.00	3,000.00	do	†25
214	Partin & Allman	do	M-9, 10	1900	do	1,130	980	350			do	225.00	2,250.00	do	†30
215	Michel, Bixby, Kroeger & Co.	Sec. 1, T. 1 S., R. 9 W.	M-9	1902	do	1,140	980	339			do		1,750.00	do	†35
216	James A. Johnstone	San Jose	M-10	1902	Bored, 14-inch	1,095	970	333			do		4,000.00	do	†35
217	L. S. Thacker	do	M-10	1893	Bored, 7-inch	1,085	970	152			Wind	225.00	125.00	Domestic	
218	F. H. Paine	Sec. 36, T. 1 N., R. 9 W.	M-8	1902	Bored, 12-inch	1,305	1,238	148			Gas	600.00	800.00	Irrigation	†8
219	E. W. Hart	San Jose	L, M-10	1901	do	1,095	972	300	17		do	1,000.00	1,200.00	do	†20
220	W. S. Carson	do	L-10	1896	Bored, 7-inch	1,070	972	124	20		Wind	175.00	60.00	Domestic	
221	Laverne Irrigating Co.	do	M-10	1903	Bored, 12-inch	1,095	971	230			Gas	840.00		Irrigation	†35
222	L. C. Meredith	do	L-10	1895	do	1,060	967	265			do	600.00	1,700.00	do	†30
223	R. C. Callander	do	L-10	1900	Bored, 10-inch	1,065	920	233	25		do	260.00	950.00	do	†20
224	Frostless Belt Water Co.	do	L-10	1902	do	1,042	948	254	23		do	1,000.00	1,800.00	do	†30
225	George E. Coleman and Laverne Irrigating Co.	do	L-10	1900	do	1,050	985	270			do		1,200.00	do	†52

226	W. G. Doughty	San Jose Addition.	L-9	1900	....do	1,055	920	246			Steam	1,000.00	2,500.00	....do	†52
227	L. S. Thacker	....do	L-9	1899	Bored, 12-inch	1,050	920	245			Gas	700.00	2,200.00	....do	†20
228	San Dimas Irrigation Co.	....do	L-9	1900	....do	1,055	913	264	24		....do		3,500.00	....do	†40
229	Johnston & Rutherford.	San Jose	L-10	1901	....do	1,065	921	216			....do	1,000.00	3,500.00	....do	†30
230	Covina Irrigating Co.	San Jose Addition.	L-9	1904	....do	1,045	915	270			....do	500.00	1,500.00	....do	
231	Glendora and Azusa Water Co.	Sec. 35, T. 1 N., R. 9 W.	L-9	1900	....do	1,065	912	376			Electric motor			....do	†45
231a	....do	....do	L-9	1901	....do	1,065	912	530			....do			....do	†110
232	Western Water and Power Co.	....do	L-9	1900	....do	1,070	915	514	24		Steam	9,387.44	13,995.32	....do	†125
233	....do	....do	L-9	1901	....do	1,075	915	546	24		....do			Domestic; irrigation.	
234	Citrus Belt Water Co.	....do	L-9		Bored	1,070	913					*4,000.00			
235	San Dimas Irrigation Co.	San Jose	L-10	1898	....do	1,005	954	220			Steam			Irrigation	†45
236	New Deal Land and Water Co.	....do	L-10	1898	Bored, 10-inch	1,020	953	170			Gas	305.00	564.00	....do	†18
237	San Dimas Irrigation Co.	....do	L-10	1902	Bored	1,025	955	300			....do	700.00	2,500.00	....do	†30
238	David Teague	....do	L-11	1898	Bored, 10-inch	980	850	260			....do			....do	†20
239	J. C. Marquart	Sec. 32, T. 1 N., R. 9 W.	I-9		Dug, 4 by 4 foot	830	740				Not raised			Not used	
240	S. R. Deacon	Sec. 33, T. 1 N., R. 9 W.	J-9	1903	Bored, 7-inch	840	770	102	30		....do			....do	
241	Columbia Land and Water Co.	San Jose Addition.	K-9, 10	1897	Bored, 12-inch (2 wells).	940	880	180	21		Gas	1,200.00	2,500.00	Irrigation	†50
242	Covina Irrigating Co.	....do	K-10	1889	Bored, 12-inch	930	880	150			....do	2,000.00	3,000.00	....do	†42
244	James Walker	....do	K-10	1902	....do	1,005	905	200			Steam			....do	†50
245	Artesian Belt Water Co.	....do	L-10	1898	....do	1,010	909	386			....do			....do	†35
245a	....do	....do	L-10	1899	....do	1,010	909	210			....do			....do	†35
246	E. Firth	....do	K-9								Gas			....do	†20
247	Valentine Peyton	San Jose	N-10	1905	Dug, 166 feet; bored, 12-inch, 436 feet.	1,145	997?	636			Steam	*14,000.00		....do	
248	Live Oak Water Co.	Sec. 6, T. 1 S., R. 8 W.	N-9		Bored, 12-inch	1,275	1,123	383			Electric motor	*4,000.00		....do	†30
249	Laverne Land and Water Co.	Sec. 5, T. 1 S., R. 8 W.	N-10	1900	Bored, 12-inch (2 wells).	1,235	1,075	300?			Gas	1,800.00	5,000.00	....do	†55
250	Charles Alley	San Jose	M-10		Bored, 10-inch	1,120	975	175			Wind			Stock	
251	Azusa Irrigating Co.	San Jose Addition.	K-10	1899	Dug, 4 by 10 foot, 104 feet; bored, 12-inch, 200 feet.	1,000	903	304?			Not raised			Not used	
252	George Smith	La Puente	G-12		Bored, 7-inch	550	333	220			....do			....do	
253	W. A. Sproul	Azusa Dalton	F-8		Dug, 3 by 3 foot	645	557	88			Gas	*2,000.00		Irrigation	†15

Wells in the foothill belt of southern California—Continued.

POMONA QUADRANGLE—Continued.

No. of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet)—approximate only.	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Temperature of water (°F.).	Method of lift.	Cost of well.	Cost of machinery	Use of water.	Quantity of water (miner's inches).
254	Azusa Agricultural Water Co.	Azusa Dalton	E-8		Dug, 90 feet; bored, 15-inch, 120 feet.	690	600	210			Not installed				
255	do	Sec. 23, T. 1 N. R. 10 W.	F-7		Dug, 6 by 8 foot.	700	630	100			Electric motor		*$5,000.00	Irrigation	†50
256	William Rowland	La Puente	D-17	1902	Bored, 10-inch	350	260	90			Wind			Domestic; stock.	
257	F. Bowers	do	H, I-17	1900	Bored, 7-inch	525	502	40			do			Domestic	
258	S. E. Hicks	San Jose	K-14		do	700	664	78			do			do	
259	Los Angeles County	do	K-14		do	705	667	55			do			Roads	
260	Irrigation Co. of Pomona.	do	N-12		Bored, 9½-inch	950	912	51			Not raised			Not used	
261	Mrs. M. Myers	do	N-12		do	950	913	97			Wind			Domestic	
262	A. T. Currier	Los Nogales	J-15	1898-1902	Bored, 9½-inch (6 wells).	625	625	80-115			Artesian			Irrigation	86
263	San Pedro, Los Angeles and Salt Lake R. R.	do	K-15		Bored, 7-inch	655	655	32			do			Not used	1

PASADENA QUADRANGLE.

No. of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet)—approximate only.	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Temperature of water (°F.).	Method of lift.	Cost of well.	Cost of machinery	Use of water.	Quantity of water (miner's inches).
1	Mrs. Titus	Santa Anita	I-8	1892	Bored	690	674?	558			Wind	$4,000.00		Domestic; irrigation.	
2	G. Hutchinson	do	I-8	1890	Bored, 8-inch	713	651	230			do			Domestic	
3	J. P. Butler	do	I-8	1894	Bored, 7-inch	720	630	127			Gas	175.00	$480.00	Domestic; irrigation.	3
4	J. T. Butler	do	I-8	1902	do	718	658	150			do	375.00	500.00	do	5
5	F. E. Chapman	do	H, I-8	1888	do	725	655	104			do	200.00	50.00	do	3
6	Mrs. Black	do	H-8			712	654	100?							
7	R. H. Schoemaker	do	H-8	1900	Bored, 10-inch	722	652	130?			Gas	200.00	100.00	Domestic; irrigation.	
8	J. B. Bonnalie	do	H-8	1897	Bored, 7-inch	723	649	102			do	110.00	350.00	do	
9	James MacAdam	do	H-8	1893	do	740	651	150			do	400.00	1,000.00	do	3
10	Mr. Merwin	do	H-8			735	657	95							

11	Mrs. L. C. Scoville	do	H-8	1896	Bored, 7-inch	741	669	175						Domestic; irrigation.	
12	I. McCollum	San Pasqual	H-8			785	663	151			Wind			do	
14	G. W. Clark	Santa Anita	H-8	1897	Bored, 7-inch	776	651	151			Wind; gas			do	2
15	H. L. Moses	San Pasqual	H-8	1895	do	790	664	200			Gas	350.00	220.00	do	†2
16	H. C. Rice	do	H-8	1902	do	798	658	196			do	260.00	435.00	do	4
17	S. V. Harkness	do	H-8	1902	Bored, 12-inch	787	670	272			Not raised	265.00		Not used	
21	Mr. Miles	Santa Anita	I-7			817	652	225			Gas		400.00		
22	Andrew Ruedy	do	I-7	1884		813	646	168			Wind		255.00	Domestic	
23	C. A. Hobart	do	J-7	1899	Bored, 7-inch	705	610	129				165.00		Stock	
24	Pasadena Brick Yard.	do	G-9	1901	do	750	694	750			Not raised			Not used	
25	City of Monrovia	do	K-8		Bored, 10-inch	645	628	540			Compressed air		5,000.00	Domestic; irrigation.	†25
26	do	do	K-8	1902		645	633	386			do			do	
27	do	do	K-8			645	633	386			do			do	†115
28	C. F. Lee	San Pasqual	H-7	1902	Bored, 7-inch inside of 10 inches.	796	656				Gas	470.00	1,450.00	do	11
29	Mr. Garvin	do	H-8		Bored, 10-inch	784	657	290			Not raised			Not used	
30	E. A. Bonine	Santa Anita	I-8	1881	Bored, 7-inch	749	664	113			Gas	115.00	750.00	Domestic; irrigation.	2
31	P. S. MacKay	do	I-8	1902	Bored, 8-inch	722	635	250			Compressed air	525.00	1,065.00	Irrigation	†15
32	Mrs. Baker	do	I, J-8	1896	Bored, 7-inch	700	619	86			Wind	100.00	70.00	Domestic; irrigation.	
33	Mrs. Humphrey	do	I, J-8			690	622	90+							
34	Mr. Ackerman	do	I-8		Bored	710	630	149							
35	F. C. Ballinger	do	I-8	1882?		686	645	55			Wind				
37	Titus ranch	do	I-9			635	633	153			Electric motor			Irrigation	
41	I. N. Van Nuys	do	I-9		Bored, 10-inch	633	623	482			Flows into tunnel.			do	15
42	do	do	I-9		Bored, 7-inch	633	623	280			Siphon			do	16
43	do	do	I-9		do	633	623	71			do			do	10
44	do	do	I-9		do	633	623	25			Not raised			Not used	
45	do	do	I-9		do	633	623	25			do			do	
46	do	do	I-9		do	633	623	25			do			do	
47	do	Sec. 35, T. 1 S., R. 12 W.	I-9								Tunnel				6
48	William Blake	San Pasqual	F-8	1900	Dug, 3½ feet diameter.	812	748	65			Wind		55.00		
49	F. W. Richmond	do	F-8	1896	Dug, 30 feet; bored, 30 feet.	790	743	60?			do			Domestic	
50	Charles Wilson	do	F-9	1900	Dug, 3½ feet diameter.	775	745	33			Hand	100.00		do	
51	Pasadena and Pacific power house.	do	F-9		Bored, 10-inch	750	719								
52	Raymond station	do	F-9		Dug, 12 feet diameter.	750	728	24							
53	Euclid Avenue Water Co.	do	F-9	1901	Bored, 12-inch	750	727	126			Electricity			Irrigation	26

Wells in the foothill belt of southern California—Continued.

PASADENA QUADRANGLE—Continued.

No. of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet)—approximate only.	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Temperature of water (°F.).	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
54	Oak Knoll ranch	San Pasqual	G-9	1899	Dug, 41 feet; bored, 12-inch, 148 feet.	752	709	189			Electric motor	*$1,500.00		Irrigation	†48
55	do	do	G-9		Dug, 50 feet; bored, 7-inch, 100 feet.	752	709	150			Gas			do	15
56	Hurlbut place	do	F-9		Bored, 7-inch	816	745	1,300						Not used	
57	I. A. & T. T. Cooper	Sec. 34, T. 1 N., R. 12 W.	H-9	1901	Bored, 12-inch, 600 feet; 10-inch, 200 feet.	600	338	800				3,700.00		do	
58	Garvey Water Co	Sec. 35, T. 1 N., R. 12 W.	H-9		Bored, 10-inch	634	614	360			Gas			Irrigation	†30
59	do	Santa Anita	H-9		Bored, 12-inch	700	620	360			Electric motor			do	
60	do	do	H-9			700	620	350			do			do	
64	do	do	H-9		Bored, 7-inch	660	650	60						Not used	
65	Mr. Baker	San Pasqual	E-9			740	717	32						Domestic	
66	F. J. Culver	do	E-9	1899	Dug, 5-foot diameter.	748	720	59			Electric motor				8
67	do	do	E-9			752	719	50							
68	Mr. Reed	do	F-8		Bored, 12-inch	860	734	200+			Gas			Domestic; irrigation.	†9
70	Mr. Cooper	do	E-7			845	759	90			Wind				
71	Weymouth & MacAdams.	do	E-7	1902	Bored, 12-inch	850	746	457						Not used	
72	Mr. Stone	do	E-5, 6		Dug, 6 by 4 foot	1,040	954	106							
73	Mr. Lloyd	do	E-6		Dug, 3 by 4 foot	1,035	952	85			Wind				
74	MacDonald & Staats	do	E-6		do	995	865	134							
75	K. G. Hommel & Co.	do	F-5	1900	Dug, 5 by 4 foot	1,185	984	210			Gas	500.00	$1,200.00	Not used	
76	Mountain View Cemetery.	do	F-5	1902	Dug, 4-foot diameter.	1,185	940	265			do	1,000.00	1,200.00	Irrigation	†8
78	Rubio Canyon Land and Water Association.	do	G-5	1902	Bored, 12-inch	1,150	965	280			do	850.00	4,300.00	Domestic; irrigation.	23
80	Mr. Meer	do	G-6			1,060	884	300							
81	Fair Oaks ranch	do	H-6			1,090	800	300?							
82	do	Santa Anita	I-6	1902	Bored, 12-inch	1,010	770	330			Gas	825.00	3,000.00	Irrigation	†22

83	Mr. Craig	do	H-7	1899	Bored, 11-inch	855	635	632			Electric motor		950.00	Domestic; irrigation.	20
84	Thomas B. Bishop	Sec. 15, T. 1 S., R. 12 W.	G-12	1901	Bored, 12-inch	465	279	190						Not used	
85	W. N. Murray	do	H-12	1899	Bored, 10-inch	425	290	265			Gas	499.50	1,327.50	Irrigation	†10
86	John Cazauraug	Sec. 21, T. 1 S., R. 12 W.	F-13			440	416				Wind			do	
88	H. E. Farmen	Sec. 22, T. 1 S., R. 12 W.	G-13	1902	Bored, 12-inch	410	298	266			Gas				
89	do	do	G-13		do	408	299	455							
90	do	do	G-13		do	402	296	450							
91	Mr. Howe	Sec. 27, T. 1 S., R. 12 W.	H-13		Bored, 10-inch	383	331	100							
92	P. G. Mason	Sec. 23, T. 1 S., R. 12 W.	I-13	1902	Bored, 5½-inch	350	286	74			Not installed	56.00			
93	Martin Haig and J. & E. Parker.	Potrero Grande	J-13		Bored, 7-inch	267	267	424			Compressed air, artesian.			Irrigation	
94	do	Sec. 24, T. 1 S., R. 12 W.	I-13		do	285	260	686			Compressed air			do	†60
95	do	Potrero Grande	J-13		do	267	262	263						Not used	
96	do	Sec. 26, T. 1 S., R. 12 W.	J-13			400	300	160						Domestic	
97	Garvey ranch	Potrero Grande	J-13	1898	Bored, 12-inch	267	267	775			Compressed air, artesian.	3,000.00		Irrigation	150
98	do	do	J-13	1899	Bored, 10-inch	267	267	425			Artesian	1,050.00		do	
99	do	do	J-13	1895	Bored, 7-inch	267	267	214			do	550.00		do	
100	do	do	J-14	1888	do	265	257	75			Wind				
101	E. J. Baldwin	do	J-14			260	260	100			Artesian, wind			Stock; irrigation.	
102	F. E. Wilson	Sec. 24, T. 1 S., R. 12 W.	I-13	1901	Bored, 6-inch	287	267	36			Wind			Domestic	
103	A. J. B. Immel	do	I-13	1902	Bored, 10-inch	297	270	203			Gas	400.00	400.00	Irrigation	12
104	F. Wyman	do	I-13		Bored, 7-inch	300	269	60			Hand			Domestic	
105	H. McCoy	do	I-13		do	311	274	51			Wind			do	
106	Mrs. C. E. Mitchell	do	I-13		do	312	274				do	225.00		do	
107	John McClain estate	Sec. 14, T. 1 S., R. 12 W.	I-12	1896	do	342	273	130			do			do	
108	John McKay	do	I-12	1896	do	337	273	110			do	130.00	75.00	do	
109	Judge Northrup	Sec. 23, T. 1 S., R. 12 W.	I-12, 13		do	330	273				do				
110	W. W. Gaines	Sec. 24, T. 1 S., R. 12 W.	I-13	1900	do	317	274	100			do			Domestic	
111	John McClure	do	J-13	1890	Dug, 3-foot diameter.	320	282	44							
112	do	do	J-13		do	320	280	51							
113	Isabell McLeod	Sec. 13, T. 1 S., R. 12 W.	I-12	1867	Dug, 4 by 6 foot, 50 feet; bored, 10-inch, 30 feet.	330	285	80						Not used	
114	Pasadena city farm	Sec. 14, T. 1 S., R. 12 W.	H-12		Bored, 7-inch	387	287	150			Wind, horse-power.			Domestic	
115	G. Purcell	Sec. 11, T. 1 S., R. 12 W.	I-11		Dug, 3-foot diameter.	416	378	45			Wind			do	

Wells in the foothill belt of southern California—Continued.

PASADENA QUADRANGLE—Continued.

No. of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet)—approximate only.	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Temperature of water (°F.).	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
117	Warde Bros	Sec. 13, T. 1 S., R. 12 W.	I-12		Bored, 7-inch	328	278	80			Wind				
118	A. E. McClintock	Sec. 19, T. 1 S., R. 11 W.	I-12	1876	do	310	269	52			do		$130.00	Domestic	
119	Harry E. Rose	Sec. 7, T. 1 S., R. 11 W.	J-11	1900	Bored, 12-inch	380	289	350			Steam	$*7,000.00		Irrigation	75
120	do	do	J-11	1900	do	380	289	650							
121	Reed ranch	Sec. 18, T. 1 S., R. 11 W.	I-12		Bored, 7-inch	330	262				Wind			Domestic	
122	J. Rudel winery	Sec. 7, T. 1 S., R. 11 W.	J-11	1890	do	398	300	300			Compressed air	500.00	1,500.00	Domestic; irrigation.	40
123	Margaret Tecklenborg.	Sec. 9, T. 1 S., R. 12 W.	H-11	1901	Bored, 12-inch	468	293	311			Gas	650.00	1,500.00	do	†10
124	A. C. Weeks	Sec. 10, T. 1 S., R. 12 W.	G, H-11		do	480	295	294			do	700.00	1,700.00	do	
125	E. E. McCollough	Sec. 11, T. 1 S., R. 12 W.	H-11	1899	Bored, 10-inch	430	330	451			do	*4,000.00		Irrigation	
126	S. F. Wuest	Sec. 9, T. 1 S., R. 12 W.	G-11	1899	Bored, 9½-inch	565	325	470			do	1,000.00	2,000.00	do	12
127	H. Hellman	Sec. 7, T. 1 S., R. 11 W.	J-11		Bored, 7-inch	402	301	166			Wind			Domestic	
128	J. W. Barton	San Francisquito	K-11		Bored, 10-inch	375	285	105			do			do	
129	Mr. Lukens	do	L-11		Bored, 7-inch	370	283	95							
130	Mr. Olmstead	do	L-11		do	350	284				Wind, gas			Domestic; irrigation.	
131	Mrs. Olmstead	do	L-11			351	283				Wind			do	
132	Mr. Meek	do	L-11		Bored, 7-inch	342	281				Gas				
133	T. S. Stucker	do	L-11	1895	do	326	280	50			Wind	45.00	60.00	Domestic	
134	J. A. Lucas	do	L-11	1893	do	320	281	180			do			Domestic; irrigation.	
135	J. C. Hannan	do	L-11		do	322	282	70			do				
136	E. J. Baldwin	do	L-11		do	306	280	27			Hand			Domestic	
137	C. E. Gidley	do	L-11, 12	1891	do	314	277	48			Wind			do	
138	J. W. Cushing	do	K-11		do	328	284	60			do			do	
139	J. Murray Craig	do	K-12		do	306	276	80			do			do	
140	John Abell	do	K-12		do	298	278	30			do			do	
141	J. A. Saw	do	L-12		do	282	269	50			do	50.00	170.00	do	

142	J. H. Jones	do	K-12	1890	do	286	273	26						do	
143	F. A. Forst	do	K-12		do	292	274				Wind				
144	Savannah cemetery	Sec. 18, T. 1 S., R. 11 W.	K-12		do	305	267	45			do			Irrigation	
145	Annie P. Adams	~~San Francisquito~~	K-12	1897	do	326	284	78			do	130.00		Domestic	
146	C. W. Cook	Sec. 18, T. 1 S, R. 11 W.	K-12		do	340	284	90			do				
147	do	do	K-12		Dug, 60 feet; bored, 10-inch, 26 feet.	345	285	86			Horsepower			Irrigation	
148	Andrew Lassmull	Sec. 19, T. 1 S., R. 11 W.	J-13	1888	Bored, 7-inch	284	260	64			do		40.00		
149	C. E. Negus	Potrero Grande	J-13	1899	Dug, 4 foot diameter.	250	247	6			Hand			Domestic	
150	Mr. Olmstead	do	J-14		Dug, 2 foot diameter.	249	246	6							
151	E. J. Baldwin	do	K-13		Dug, 2½ by 2½ foot.	248	242	10			Hand			Domestic	
152	T. P. Herbert	do	L-13	1901	Driven, 2-inch	255	247	18			do			do	
153	E. J. Baldwin	do	L-13		Bored, 7-inch	260	248	23			Gas			Domestic; irrigation.	
154	L. A. Crawford	Sec. 21, T. 1 S., R. 11 W.	L-13		do	270	256	18			Wind			Domestic	
155	F. Crab	do	L-13		Bored, 10-inch	273	256	130			Gas			Irrigation	
156	W. R. Dodson	do	L-13	1897	Bored, 12-inch	280	263	153			do	200.00	1,000.00	do	
157	Southern Pacific R. R.	San Francisquito	L-12	1870	Bored, 7-inch	285	261	480			Steam			Engines	6
158	G. H. Kallmayer	Sec. 21, T. 1 S., R. 11 W.	L-13	1895	do	280	261	30			Wind			Domestic	
159	Los Angeles County	San Francisquito	L, M-13		do	280	259				do			Stock	
160	Nicholas Smith	do	M-13	1879	do	280	261	40			do				
161	Newman ranch	Sec. 28, T. 1 S., R. 11 W.	M-13		do	270	257	80			do			Domestic	
162	Mountain View school.	Potrero de Felipe Lugo.	M-13		do	280	260	24			do			do	
163	Los Angeles County	San Francisquito	M-13		do	284	261	30			do			Stock	
164	T. D. Andrews	Potrero de Felipe Lugo.	M-13, 14		do	275	257	25			Hand			Domestic	
165	Newman ranch	Sec. 22, T. 1 S., R. 11 W.	L-13		Bored, 10-inch	280	261	140			Gas			Irrigation	
166	Hop Yuck Co	Sec. 28, T. 1 S., R. 11 W.	L-14		Dug, 3 by 3 foot	258	250	9			Hand			Domestic	
167	Com Song Co	Potrero Grande	L-14		do	254	247	8						do	
168	W. L. Hinman	do	L-14	1900	Bored, 7-inch	248	241	35			Wind	40.00		do	
169	Sam Gee Co	do	L-14			245	240	7			Hand			do	
170	J. R. Allen	Potrero de Felipe Lugo.	L-15	1899	Bored, 7-inch	245	238	42			Wind	42.00		do	
171	J. D. Durfee	do	L-15		do	242	236	40			do			do	
172	Charles Flickett	do	M-15		do	249	238	29			do			Domestic; irrigation.	
173	Jackson Frees	do	N-14		do	290	267				do			Domestic	
174	do	do	N-14		Bored, 12-inch	292	266	95			Gas	450.00	2,000.00	Irrigation	
175	A. E. Shugg	do	M-14	1887	Bored 7-inch	280	260	48			Wind			Domestic	

Wells in the foothill belt of southern California—Continued.

PASADENA QUADRANGLE—Continued.

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176	William Elliot	Potrero de Felipe Lugo.	N-14		Bored, 7-inch	271	255	25			Wind				
177	W. S. Parker	do	M-15		do	252	242	38			Hand				
178	G. Castino	do	M-15	1900	Bored, 1½-inch	250	238	18			do			Domestic	
179	Lou Gan	Potrero Grande	L-15		Dug, 2 by 2 foot	223	218	70			do			do	
180	H. C. Yerby	do	K-15	1898	Bored, 7-inch	220	213	100			Wind			do	
181	Puente school	Paso de Bartolo	K, L-15		do	215	207				Hand			do	
182	S. A. McClean	do	K-16		do	215	204	50			Wind, horse-power.			Domestic; irrigation.	
183	E. J. Baldwin	do	K-16		Dug, 2 by 2 foot	210	204	7			Hand			Domestic	
184	G. Puima	do	K-16		do	200	194	7			Wind			do	
185	M M. Zunica	do	J-16		Dug, 4 by 4 foot	210	197	14			Hand			do	
186	Mr. Botha	do	K-16		Dug, 3 by 3 foot	195	187	10						do	
187	Joe Contraro	do	J-16		do	195	187	9			Hand			do	
188	O. Fizzette	do	J-16		Bored, 4-inch	190	182	45			do			do	
189	W. Hyler	do	J-16		Driven, 2½-inch	190	180	12			do				
191	Rincon Irrigation Co.	do	L-17	1901	Bored, 10-inch	220	208	165			Gas	$*2,200.00		Irrigation	
192	R. Garvey	Sec. 27, T. 1 S., R. 11 W.	N-14	1902	Bored, 7-inch	290	265	60			Wind	70.00		Domestic	
193	T. J. Wiggins	Sec. 26, T. 1 S., R. 11 W.	N-14		do	280	262	57			Hand			do	
194	do	do	N-14	1898	Bored, 12-inch	270	266	104			Steam	225.00	$1,000.00	Irrigation	100
195	E. J. Baldwin	Sec. 35, T. 1 S., R. 11 W.	N-15			290	258	50			Wind			Domestic	
196	Mr. Harvey	Sec. 3, T. 2 S., R. 11 W.	M-15		Dug, 3 by 3 foot	300	251	50			Hand			do	
198	John Petriti	Paso de Bartolo	L-17		Dug, 4 by 4 foot	220	193				Wind				
199	Joseph Eady	do	K-17		Bored, 4-inch	205	192	36			do			Domestic	
200	Paso de Bartolo Water Co.	do	K-16		Bored, 10-inch (3 wells).	200	200	300			Artesian			Irrigation	
201	do	do	K-16		Bored, 10-inch	200	188	350			Steam		2,500.00	do	
202	Mr. Pellett	do	K-16			200	187	20			Hand			Domestic	
203	Mrs. Phoebe Barnett.	do	K-16		Bored, 7-inch	195	181	33			Wind			do	
204	California Domestic Water Co.	San Francisquito	N-13	1902	Bored, 15-inch, 580 feet; 12-inch, 420 feet.	295	274	1,000			Compressed air			Irrigation	

205	Thomas McMichael	do	N-13		Bored, 7-inch	292	266	50			Wind			Domestic	
206	E. T. Hargrave	do	N-13		do	296	267	72			do				
207	W. Richards	do	M-13		Bored, 10-inch	286	264	114			Steam			Domestic	
208	A. C. Drake	do	N-13		Bored, 7-inch	290	262	45						Irrigation	
209	do	do	N-13		Bored, 12-inch	308	270	140			Gas			Domestic	
210	A. E. Nelson	do	N-12	1902	do	318	274	127			Hand	200.00		do	
211	B. A. Benjamin	do	N-12		do	318	274	93			Wind, gas			Domestic; irrigation.	
212	John Hayes	Sec. 14, T. 1 S., R. 11 W.	N-12	1901	do	316	273	112			Gas	700.00	2,500.00	Irrigation	
213	do	San Francisquito	N-12	1901	do	315	272	130			do				
214	James Freer	do	M-13	1897	Bored, 7-inch	292	267	46			Wind, horse-power.			Domestic	
215	M. Metcalf	do	M-13	1900	do	290	267	45			Wind			do	
216	J. S. Killian	do	N-12		Bored, 12-inch	325	272	130			Steam			Irrigation	
217	do	do	N-12		do	325	272	100			do			do	
218	do	do	N-12		do	325	272	100			do			do	
219	do	do	N-12		do	325	272	100			do			do	
220	John Hayes	do	N-12		Bored, 8-inch	302	273	46			Gas		300.00	Domestic	
221	D. C. Nidever	do	M-12	1897	Bored, 10-inch	296	267	101			Steam	*1,200.00		Irrigation	100
222	R. E. Damer	do	M-12		Bored, 7-inch	300	269	60			Wind			Domestic	
223	B. W. Daucer	do	M-12		do	302	269				Hand			do	
224	Daucer Bros	do	M-12	1898	Bored, 10-inch	305	269	103			Steam	*1,300.00		Irrigation	
225	P. F. Cogswell	do	N-13	1892	Bored, 12-inch	305	272	137			Gas			do	
226	Yock ranch	do	N-12		Bored, 7-inch	320	274	50			Hand			Domestic	
227	Piercy ranch	do	N-11	1898	Bored, 12-inch	335	277	129			Steam		2,500.00	Irrigation	
228	do	do	N-11	1894	Bored, 10-inch	335	277	107			do				
229	D. F. Pearson ranch	do	N-11	1896	Bored, 12-inch	325	273	150			Gas	300.00	1,400.00	do	150
230	do	do	N-11	1895	do	325	273	114			do	250.00			
231	Sumar ranch	do	N-10	1899	Dug, 4 by 4 foot.	344	277	72			Hand			Domestic	
232	Stucker estate	do	L, M-11		Bored, 4-inch	312	274	40			Wind			do	
233	M. A. Papon	do	M-11		Bored, 7-inch	320	276	46			do			do	
234	W. Snoddy	do	M-10		do	340	289	52			do			do	
235	do	do	M-10	1899	Bored, 12-inch	345	291	247			Steam	525.00	1,700.00	Irrigation	
236	Alvarida Water Co.	Santa Anita	M-10	1899	do	385	325	209			Gas		4,000.00	do	25
237	A. J. Averell	do	M-7	1899	Dug, 4 by 7 foot, 218 feet; bored, 10-inch, 178 feet.	511	305	396			Steam?		16,000.00	do	25
238	Mr. Boyd	do	M-7		Bored, 12-inch	530	310	350						Not used	
239	Harry R. Stocker	do	M-7	1902	Dug, 4 by 6 foot.	550	514	49			Gas?		1,150.00	Irrigation	†18
240	E. J. Baldwin	do	K-8		Bored, 7-inch	630	625	270			Compressed air, artesian.				
241	do	do	K-8		Bored, 10-inch	630	627	450			do			Irrigation	
242	do	do	K-8		Bored, 7-inch	610	611	300			Artesian			do	
243	do	do	K-8		do	618	608	130			Hand			Domestic	
244	do	do	K-8		do	618	612							Not used	
245	do	do	K-8		do	585	585	225			Artesian				
246	do	do	K-8	1902	Dug, 4 by 6 foot, 71 feet; bored, 7-inch, 289 feet.	614	594?	480			Steam, air			Irrigation	†40

Wells in the foothill belt of southern California—Continued.

PASADENA QUADRANGLE—Co ntinued.

No. of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet)—approximate only.	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Temperature of water (°F.).	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
247	E. J. Baldwin	Santa Anita	K-8		Bored, 7-inch	600	601	300			Artesian			Domestic	
248	do	do	K-8		do	614	614	300			do				
249	do	do	K-8		do	605	606	300			do			Domestic	
250	do	do	K-8		do	600	601	300							
251	do	do	K-8		do	596	599	300			Artesian			Stock	
252	do	do	K-8		do	593	595	300			do			do	
253	do	do	K-8		do	590	594	300			do			Not used	
254	do	do	M-7		Dug, 6 by 6 foot.	570	528	57			Gas			Irrigation	†60
255	do	do	M-6		Dug, 3 by 5 foot.	750	709	62							
256	T. E. Yerxa	do	M-7		Dug, 4 by 6 foot.	745	577	178			Gas	$1,300.00	$1,400.00	Irrigation	10
257	J. C. Pegler	do	M-6	1897	do	777	569	236			do		3,000.00	do	10
258	Sierra Madre Water Co.	do	M-7	1900	Dug, 5 by 6 foot, 136 feet; bored, 12-inch, 223 feet.	675	552	359			Gas (2 plants)	2,500.00	6,000.00	do	20
259	Graves & Bean	San Pasqual	G-9		Bored	750	701	204			Flows into tunnel.				
260	do	do	G-9		do	752	703	256			do			Irrigation	†20
261	do	do	G-9		do	755	703	212							
262	Sunny slope ranch	San Anita	J-9		Bored, 7-inch	618	615	117			Wind				
263	do	do	J-9		do	620	616	160						Not used	
264	do	do	J-9		do	618	604	210						do	
265	do	do	I-9		do	618	604	200+			Tapped below surface.				
267	J. S. Maderis	do	J-8	1901	do	645	621	200			Gas	350.00	550.00	Domestic; irrigation.	
268	Fred W. Elleby	do	J-8		Bored, 8-inch	648	614	112			do			do	11
269	E. Messenger	Sec. 9, T. 1 S., R. 12 W.	G-11	1900	Bored, 9½-inch	525	305	340			Gas?	600.00	1,495.00	do	12
270	F. J. Culver	San Pasqual	E-9		Bored, 7-inch	768	725	105							
272	M. M. Langford	do	F-8		do	800	734	73			Wind			Domestic	
273	E. J. Baldwin	do	K-8		do	650					Compressed air			Irrigation	
274	Joe Agure	Paso de Bartolo	J-17		Dug, 3½ by 3½ foot.	175	164	11			Hand			Domestic	
275	A. Genen	do	J-11		Bored, 4-inch	175	185	34			do			do	
276	T. P. Passons	do	J-17		do	185	173	43						do	
277	A. Dixon	do	J-17		do	180	160	64			Hand			do	

278	D. A. Sugg	do	I-17		Dug, 3½ by 3½ foot.	180	161	20			do				
279	K. Cohn	San Antonio	I-17	1899	Bored, 12-inch	220	180	245			Steam			Irrigation	200
280	do	do	H-17		Bored, 7-inch	198	154	146			Wind			Domestic	
281	W. C. Rushing	do	H-17	1902	Bored, 5½-inch	200	148	57			Hand	45.00		do	
282	Vail, Gates & Co	do	H-17		Bored, 12-inch	195	150	500			Electric motor			Irrigation	100
283	Bicknow & White	do	G-16		Bored, 7-inch	205	133	100			Wind			Domestic	
284	Mr. Pendina	do	F-16		do	200	154	65			do			do	
285	George Peterson	do	E-16		do	200	158	100			do			do	
286	E. G. Green	do	D-16		Bored, 8-inch	200	150	65			do			do	
287	Mr. Shaffinger	Sec. 31, T. 1 S., R. 12 W.	E-15			310	175	165			do			do	
288	I. W. Hellman	Sec. 32, T. 1 S., R. 12 W.	F-15	1903	Bored, 10-inch	285	157	250			Gas	512.00	300.00	do	
289	J. M. Clyman	Sec. 31, T. 1 S., R. 12 W.	E-15		Bored, 2-inch	320	220	115			Wind			do	
290	P. H. Matthews	Sec. 32, T. 1 S., R. 12 W.	E-15		Bored, 7-inch	295	170	335			do			Domestic; irrigation.	
291	Calvary Cemetery	San Antonio	E-16		Bored, 10-inch	220	160	213			Gas			Irrigation	
292	F. Escallier	do	D-16	1903	Bored, 12-inch	225	152	171			Not installed				
293	L. Pilaria	do	D-16		Bored, 7-inch	280	160	140						Not used	
294	G. W. Shields	Sec. 1, T. 2 S., R. 13 W.	D-16		do	315	165	180			Wind			Domestic	
295	F. C. Randolph	Sec. 31, T. 1 S., R. 12 W.	D-15		do	330	224	110			do			do	
296	B. J. Nettleton	San Antonio	D-16		do	215	157	120			do			do	
297	I. O. O. F. cemetery	Sec. 1, T. 2 S., R. 13 W.	C, D-16	1899	Bored, 9-inch	250	144	248			Gas	500.00		Irrigation	†3
301	C. Spect	Los Angeles city	B-12		Bored, 7-inch	333	303	38			Wind			Domestic	
302	Eli Taylor	do	B-12	1894	do	395	335	54			do	100.00		do	
303	Armour Packing Co.	do	B-12	1902	Bored, 8-inch	340	310	55			Electric motor			do	†3
304	Mrs. Norman	do	A-11		Bored, 7-inch	340	328	40			Wind			do	
305	Mary Everett	do	A-11		Dug, 5 by 5 foot.	450	420	29						Not used	
306	Mrs. E. Dupuis	do	B-11	1885	Bored, 8-inch	350	327	9			Wind			Domestic; irrigation.	
307	Mr. Mackay	do	B-11	1880	Bored, 7-inch	360	310	20			do			Not used	
308	Chinese vegetable garden.	San Rafael	A-11		Dug, 4 foot diameter.	340	331	11			Hand			Domestic	
309	L. Sbilker	do	A-11	1890	Bored, 8-inch	360	344	40			Wind			do	
310	Fraternal Club	do	A-11		Dug, 2 by 2 foot.	375	344	34			do			do	
311	F. Douillard	do	A-11		Dug, 6 by 6 foot.	450	446	10			do			do	
312	Joe Hunter	do	A-10		Dug, 4 by 4 foot.	375	366	21			Hand			do	
313	V. & E. Sentona	do	A-10		Bored, 7-inch	370	353	30			Wind			do	
314	Samuel Hunter	do	A-10		do	375	357	43			do			do	
315	L. Salzgeber	do	A-11	1902	Bored, 12-inch	350	336	97			Gas	150.00	1,400.00	Irrigation	†90
316	J. W. Cook	do	A-10		Bored, 7-inch	400	361	60			Wind			Domestic	
317	Mr. Glassale	do	A-10			410	359	90			do			do	
318	Jack Greggians	do	A-10		Bored, 7-inch	390	372	60			do				
319	Conrad Winter	do	A-10		do	390	381	45			do			Domestic	
320	Silas Hollenbeck	do	A-8		Dug, 4-foot diameter.	540	512	46			do			do	
321	A. Workman	do	A, B-8, 9.	1901	Bored, 12-inch	600	535	171			Gas	427.00	1,000.00		8

Wells in the foothill belt of southern California—Continued.

PASADENA QUADRANGLE—Continued.

No. of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet)—approximate only.	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Temperature of water (°F.).	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
322	A. Workman	San Rafael	A-9		Dug, 8 by 8 foot.	530	499	40							
323	T. Brooks	do	B-9	1903	Bored, 8-inch	510	492	140						Not used	
324	Cromwell Galpin	do	B-9	1899	Bored, 7-inch	540	510	66			Gas	$120.00	$600.00	Irrigation	6
325	S. G. Spear	do	A-10	1887	Dug, 6 by 6 foot.	450	395	70			Wind			Domestic	
326	A. Glassell	do	B-9	1880	Bored, 7-inch	495	495	80			Artesian	80.00		Domestic; irrigation.	
327	do	do	B-9		Bored, 7-inch (2 wells).	490	490	210, 140			do			do	
329	O. D. Nagle	do	A-10	1901	Dug, 4 by 4 foot.	395	380	75			Wind, gas			do	
330	W. R. White	do	C-8, 9	1899	Bored, 7-inch	550	510	142			Gas			do	20
330a	do	do	C-8, 9	1902	Bored, 12-inch	550	510	113			do			do	
331	J. A. Gates	do	C-8		Bored, 12-inch (2 wells).	550	510	144			do			Irrigation	20
332	G. W. Benson	do	B-8		Dug, 3-foot diameter.	590	530	100			Wind			Domestic	
333	P. Young	do	B-8	1901	Bored, 12-inch	570	511	140			Gas			Irrigation	6
334	J. L. Hickson	do	C-8		Bored, 7-inch	640	610	86			do			do	
335	L. F. Meyers	do	C-8		Bored, 9-inch	590	540	78			Wind			Domestic	
336	A. M. Torrey	do	C-8, 9		Bored, 8-inch	650	596	86			do			do	
337	C. E. Thom	do	A-7		Bored, 12-inch	635	555	170			Gas			Domestic; irrigation.	16
338	McWhorter Bros.	do	A-10		Bored, 7-inch	375	351	50			Wind			Domestic	
339	E. Leavitt	do	A-7	1902	Dug, 4 by 4 foot, 100 feet; bored, 9½-inch, 147 feet.	625	438	247			Gas	500.00	1,500.00	Domestic; irrigation.	14
340	F. M. Beers	do	A-8		Dug, 3 by 4 foot.	585	435	180			do			do	1½
341	Dr. Horace Wing	do	A-8	1900	Dug, 4 by 4 foot, 105 feet; bored, 14-inch, 82 feet.	565	459	187			do			Irrigation	9
342	Mr. Lukens	do	A-8		Dug, 4 by 5 foot, 153 feet; bored, 12-inch, 115 feet.	605	448	268			do			do	16
343	Hall & Russell	do	A-7	1903	Bored, 12-inch	640	550	195			do			do	15
344	Dodge, Sinclair & Co	do	A-7	1899	Dug, 4 by 5 foot.	655	595	78			do			do	10

345	W. A. Norton	do	B-7		Bored, 7-inch	740	655	145			Wind			Domestic	
346	W. Llewellyn	do	A-7		Dug, 4 by 5 foot	655	557	102			Gas			Irrigation	10
347	Independent Water Co.	do	A-7	1902	Dug, 4 by 5 foot, 60 feet; bored, 12-inch, 287 feet.	665	565	347			do	1,000.00	1,200.00	Domestic; irrigation.	22
349	Charles Moser	do	A-8		Dug, 75 feet; bored, 10-inch.	520	445				do			Irrigation	
350	John Ungerland	do	A-9	1901	Dug, 4 by 4 foot	540	500	60			do			Domestic; irrigation.	
351	Tropico Water Co.	do	A-8	1897	Bored, 12-inch	535	439	150			do	400.00	2,500.00	do	70
352	George M. Payne	Los Angeles city	A-11	1902	do	340	331	50			do	89.00	1,000.00	Irrigation	20
353	C. E. Thom	San Rafael	B-5	1903	Dug, 6 by 6 foot	950	913	49			do	490.00		Not completed	
354	do	do	A-7		Dug, 6 by 7 foot	700	660	60			do			Domestic; irrigation.	15
355	do	do	A-7		Dug, 5 by 6 foot	700	660	100			do			do	10
356	Brooks Bros.	Los Angeles city	A-12	1904	Bored, 12-inch	335	327	109			Not installed				
357	L. M. Sifford	do	B-12	1898	Dug, 3 by 3 foot	340	322	18	47		Wind			Not used	
358	Sarah Brown	do	B-12	1892	Dug, 3½ by 4 foot	340	307	35	48	68	do			do	
359	Los Angeles Stone and Sewer Pipe Co.	do	B-12	1903	Dug, 5 by 8 foot	345	312	45			Steam			Manufacturing	
360	L. D. Drake	do	B-13		Bored, 6-inch	345	312	60?			Wind			Domestic	
361	Joe Cuceia	do	B-13	1895	Bored, 2-inch	300	287	22			do			do	
362	Mrs. M. S. Helm	do	B-13	1890?	Dug, 3 by 3 foot	300	283	18	80	66	do			Not used	
363	Peter Capro	do	B-13	1897	Dug, 3 foot diameter.	285	276	9	64	66	do			Domestic	
364	Los Angeles Brewing Co.	do	B-13		Bored, 7-inch (2 wells).	290	280	57?	38	68	Steam			Brewery	45
364a	do	do	B-13		Bored, 12-inch (2 wells).	290	280	60?	38	68	do			do	
365	Mrs. J E. Kennedy	do	C-13	1894?	Bored, 7-inch	315	273	98	96		Wind			Domestic	
366	L. M. Gilman	do	C-13		do	350	294	100+			do			Not used	
367	A. T. Leonard	do	C-13	1890?	do	340	295	153	74		do			Domestic	
368	Jessie P. Monte	do	C-14	1890?	Dug, 2½-foot diameter.	300	289	22	140		do			do	
369	J. G. Bell	do	C-15		Dug, 3-foot diameter.	340	276	71	91	68	do			Not used	
370	Diamond Hill Floral Co.	do	B-15	1892?	Dug, 5-foot diameter.	325	275	91	47		do			do	
371	J. C. Putnam	do	B-16	1895?	Bored, 7-inch	310	Dry.	98			do			No water	
372	Charles Karstadt	do	A-16	1894?	Bored, 6-inch	225	115?	125	45		do			Domestic	
373	J. Eustace	do	A-16	1896	Bored, 7-inch	240	188?	93	51		do			do	
374	Pacific Electric Rwy. Co.	do	A-15		Bored, 12-inch (3 wells).	245	159	100+			Not installed				
375	Inman Poulson Lumber Co.	do	A-17		Bored, 12-inch	225	150	165			do				
376	J. J. Maxey	Sec. 9, T. 2 S., R. 13 W.	A-17	1885	Bored	215	141		50		Wind			Domestic; stock.	
377	L. Hooper	do	A-17	1874	Bored, 7-inch	215	167	50	44		do			Domestic	
378	Miss J. R. Dorsey	do	A-17	1901	Bored, 12-inch	210	140	211	53	65	Gas			Irrigation	†65
379	Miss M. J. Cameron	do	A-17	1899?	Bored, 7-inch	200	126	90?	49		Wind			Domestic	
381	Mrs. R. J. Withers	Sec. 10, T. 2 S., R. 13 W.	A-17	1902	Bored, 9-inch	195	135	206	43		do			Domestic; irrigation.	

Wells in the foothill belt of southern California—Continued.

PASADENA QUADRANGLE—Continued.

No. of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet)—approximate only.	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Temperature of water (°F.).	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (miner's inches).
382	W. S. Holland	San Antonio	B-17	1902	Bored, 10-inch	195	125	155	50		Wind			Domestic	
383	Moore Bros	do	B-17	1902	Bored, 12-inch	190	119?	226		60	Compressed air			Irrigation	†100
383a	do	do	B-17	1904	do	190	119?	287			do			do	
384	Peter Scott	Sec. 10, T. 2 S., R. 13 W.	B-17	1900?	Bored, 7-inch	195	130	75?	48		Wind			Domestic	
385	J. W. Kniffin	do	B-17	1902	Bored, 10-inch	205	137	215	64		Gas, wind			Domestic; stock	
386	Hercules Oil Refining Co.	San Antonio	B-17	1902	Bored, 9-inch	205	145	280	40	60	Compressed air			Manufacturing	
387	W. M. Stephens	do	B-17	1903	Bored, 7-inch	210	142	175	43		Wind			Stock	
388	David Vaccero	Sec. 9, T. 2 S., R. 13 W.	A-17	1902	do	210	141	100	53		do	$100.00	$35.00	Domestic	
389	James Sweet	Sec. 10, T. 2 S., R. 13 W.	A-17	1901	do	200	133	104	53		do			Domestic; irrigation.	
390	C. Smith	San Antonio	B-17	1902	do	190	129	100			do			Domestic	
391	J. H. Van Nest	do	B-17	1900	Dug, 62 feet; bored, 10-inch, 127 feet.	190	125	189	42	62	Steam	450.00	1,500.00	Irrigation	40
392	J. L. Graham	do	B-17	1899	Dug, 5 by 5 foot, 49 feet; bored, 12-inch, 151 feet.	185	125	200	43	61	Gas			do	†30
393	A. Koppe	do	B-17	1903	Dug, 5 by 5 foot, 65 feet; bored, 12-inch, 30 feet.	195	144	95	49		do		1,850.00	do	40
394	Lada Terry	do	B-17		Bored, 12-inch	195	136	110	46		Wind			Stock	
395	Mrs. Anderson	do	C-17	1879?	Bored, 7-inch	190	135	85	53	62	do			Domestic; stock	
396	A. A. Gast	do	C-17		do	185	125	100	47		do			Domestic	
397	J. G. Evans	do	B-17	1900	Dug, 6 by 6 foot, 40 feet; bored, 12-inch, 116 feet.	185	127	156	41	62	Gas			Irrigation	†15
398	do	do	B-17	1901	Bored, 12-inch	185	127	202	40	61	do			do	†15
399	L. A. Turner	do	C-17		Bored, 7-inch	175	130				Electric motor			do	
400	B. Beone	do	C-17	1900	do	185	138	98	47		Wind				
401	Chong Wong & Co.	do	C-17		do	185	145	63	51	62	do			Domestic; irrigation.	
402	E. G. Greening	do	D-17		Bored	175			27	68	Electric motor			Irrigation	†75
403	J. D. Hart	Los Angeles city	C-16	1901	Bored, 7-inch	210		100	53		Wind			Domestic	
404	Mr. MacHaley	do	B-16	1900	do	220	160	88	44		Gas			Domestic; stock	†1

405	Mr. Appel	do	B-17		do	220	160	93	46		Wind			do	
406	P. T. Sullivan	do	C-16	1882	Bored, 9-inch	240	148	140			do			Domestic	
407	J. O. Sullivan	do	G-16	1904	Bored, 10-inch	215		229			Not installed				
408	J. J. Adams	do	C-16	1899	Bored, 7-inch	215	157	150	38		Wind			Domestic; stock	
409	George E. Platt	San Antonio	D-16	1899	Bored, 12-inch	220	151	214	37		Gas			Irrigation	†70
409a	do	do	B-16	1902	Bored, 16-inch	220	151	218	37		do			do	
410	B'nai B'rith cemetery.	do	E-16	1902	Bored, 14-inch	200	150	200			Electric motor			do	†8
411	Laguna Land and Water Co.	do	H-17	1902	Bored, 12-inch	190	148	450	34		do			do	†200
412	J. H. Barbour	do	H-17	1903	Bored, 7-inch	200	151	130	31		Gas	100.00	300.00	Domestic; stock	
413	G. W. Scott	Paso de Bartolo	I-17	1904	Bored, 12-inch (2 wells).	160	150	107	23	64	do	500.00	1,500.00	Irrigation	†200
414	Louis Farmer	Potrero de Felipe Lugo.	L-15		Bored, 7-inch	225	216	20	20	62	Wind			Domestic	
415	F. F. Pellissier	La Puente	M-15		Bored, 12-inch	260	248		29		Gas			Irrigation	
416	John Waggoner	Paso de Bartolo	L-17	1900	Bored, 4-inch	235	218	48			Wind			Domestic; stock; irrigation.	†200
417	Rincon Irrigation Co.	do	L-16	1900	Bored, 10-inch	235	219	160	24	70	Gas			Irrigation	†110
418	J. D. Durfee	Potrero de Felipe Lugo.	L-15	1892	Bored, 7-inch	240	232	50	20	60	Wind			Domestic	
420	P. Cartota	San Rafael	A-11	1904	Bored, 12-inch	345	327	120			Gas			Irrigation	
421	J. N. Witham	do	A-8	1902	Bored, 9½-inch	545	435	170			do	350.00	650.00	do	
422	E. M. Ross	do	B-6	1897	Bored, 12-inch	805	797	119			do			do	†12
423	L. G. Allen	La Canada	A-3	1894	Dug, 5 by 5 foot.	1,200	1,164	43			do			do	†8
424	A. C. Palfrey	San Rafael	B-4		Dug	1,225	1,033	214			do			do	†12
425	N. B. Huff	do	A-8	1904	Dug, 4 by 5 foot, 80 feet; bored, 9-inch, 110 feet.	515	435?	191			do			do	
426	Mr. Laux	do	C-8	1901	Bored, 12-inch	650	605?	200			do			do	†5
427	Mrs. Mary Hunter	Los Angeles city	C-12		Dug, 4 by 4 foot.	390	358	34	35		Wind			Domestic; irrigation.	
428	Mrs. E. M. Winston	San Rafael	C-11	1903	Bored, 7-inch	505	461	85	25		do			Domestic	
429	Charles Wenrich	do	D-10	1899	Dug, 5 by 5 foot.	575	563	40	40		do			do	
430	M. H. Dunn	do	C-9	1902?	Dug, 4 by 4 foot; bored, 7-inch.	580	564	150	21		do			Domestic; irrigation.	
431	J. W. Means	do	C-10	1896?	Dug, 4-foot diameter.	572	521	55	52		do			Domestic	
432	Pasadena Lake Vineyard Land and Water Co.	San Pasqual	F-6	1896	Dug, 6 by 10 foot; bored, 12-inch.	930	744	700	18		Steam	13,632.00		Domestic; irrigation.	
433	Pasadena Lake Vineyard Land and Water Co. and Pasadena Land and Water Co.	do	E-5	1899	Dug, 6 by 8 foot.	1,000	975	55	23	64	Gas			do	25
434	do	do	E-5	1903?	Dug, 175 feet; bored, 200 feet.	1,140	965?	375	20	63	Compressed air		152.80	do	154
434a	do	do	E-5	1903?	Dug, 175 feet; bored, 400 feet.	1,140	965?	575	20	63	do				

Wells in the foothill belt of southern California—Continued.

PASADENA QUADRANGLE—Continued.

No. of well.	Owner.	Location.	Map location.	Year completed.	Class of well.	Elevation of surface (feet)—approximate only.	Elevation of water (feet).	Depth of well (feet).	Solids per 100,000.	Temperature of water (°F.).	Method of lift.	Cost of well.	Cost of machinery.	Use of water.	Quantity of water (Miner's inches).
435	North Pasadena Land and Water Co.	San Pasqual	E-5	1893?	Dug, 4 by 8 foot.	1,125	980	160	21	65	Steam	a$20,145.00		Domestic; irrigation.	†30
436	Lincoln Avenue Water Co.	do	E, F-4		Dug, 5 by 7 foot, 236 feet; bored, 10-inch, 256 feet.	1,200	955	492	25	65	do			do	†25
437	North Pasadena Land and Water Co.	do	E-6		Dug, 6 by 9 foot, 110 feet; bored, 14-inch, 30 feet.	1,040	960	140	22	67	do	(b)		do	†50
438	H. E. Huntington	Santa Anita	I-8	1903	Bored, 10-inch	730	615	300			Electric motor			do	†18
439	Lloyd & Wood	do	L, M-7	1900	Dug, 4 by 6 foot	650	543	122	23		Gas			Irrigation	†12
440	E. J. Baldwin	do	K-9		Bored	505		300			do			do	
441	A. Scott Chapman	do	J-8	1892	Bored, 7-inch	660	620	450	24		Steam			do	†30
442	A. B. Chapman	do	J-8			630	617		19		Gas			do	
443	do	do	J-8	1898	Bored, 10-inch	610	606	560	18		do			do	150
444	do	do	J-9		Bored, 7-inch	606	606	156	19	71	Artesian			do	†4
445	do	do	J-8		Bored, 10-inch	615		400			Electric motor			do	†70
446	A. S. Chapman	do	J, K-8			600					Gas				†25
447	G. P. Wegener	Sec. 16, T. 1 S., R. 12 W.	G-12	1903	Bored, 10-inch	475	250	330	21		do			Domestic; irrigation.	†15
448	Pasadena Land and Water Co.	San Pasqual	G-9	1904	Bored, 12-inch	760	721?	215	23		Steam			Domestic	†90
448a	do	do	G-9	1904	do	760	721?	254	23		do			do	
448b	do	do	G-9	1904	do	760	721	256	23		do			do	
449	Graves & Brean	do	G-9	1904	Bored, 10-inch (3 wells).	765	725?	250-700			Flow into tunnel.			Irrigation	†60
449a	do	do	G-9		Bored, 10-inch (6 wells).	765	725?	250-700			do			do	
450	H. C. Allen	do	G-9	1891	Bored, 10-inch	755		130	27	71	Gas			do	2
451	Alhambra Addition Land and Water Co.	do	G-9	1896?	Bored, 6-inch (6 wells).	700	675	120	23		Compressed air			do	†100
452	Huntington Land and Improvement Co.	Sec. 3, T. 1 S., R. 12 W.	G-9	1901	Bored, 10-inch	600	588	417	22		Electric motor			Domestic; irrigation.	†68

453	....do	Sec. 35, T. 1 N., R. 12 W.	I-9	......	Dug, 4 by 6 foot.	610	590	......	17	69	....do			Irrigation	
454	....do	....do	I-9	1904	Dug, 7-foot diameter; bored, 14-inch.	635	602	400	....	....	....do			....do	†10
455	A. E. Johnson	Potrero Grande	J-13	1899	Bored, 8-inch	260	258	430	20	....	Gas			....do	66
456	Mr. McCloud	Sec. 13, T. 1 S., R. 12 W.	I-12	1904	Bored, 10-inch	335	274?	300	27	....	....do			....do	†30
457	Warde Bros	....do	J-12	1904	....do	340	280	375	....	....	....do			....do	†125
458	T. P. Herbert	Sec. 20, T. 1 S., R. 11 W.	L-13	1904	Bored, 12-inch	260	249	302	17	68	....do			....do	†60
459	G. Kallmeyer	San Francisquito	M-12	1904	....do	300	267	127	22	....	....do			....do	†40
460	G. R. Green	....do	M-11	1902	....do	310	270	130	21	64	....do			....do	†155
461	Frank Proctor	....do	M-12	1901	Bored	315	265	140	....	....	....do			....do	†100
462	C. H. Rhodes	San Rafael	G-9	1904	Dug, 5 by 5 foot, 50 feet; bored, 10-inch, 85 feet.	740	......	135	....	....	Steam			....do	......
463	Frank Jones	Santa Anita	J-8	1903	Bored, 12-inch	650	618	236	....	....	Compressed air			....do	18
464	Jack Butler	....do	J-8	1904	Bored, 10-inch	645	619	198	....	....	Gas			....do	†30
465	Sunny Slope Water Co.	....do	J-9	1903	....do	610	605?	380	....	....	Electric motor			....do	......
466	Pasadena Land and Water Co.	San Pasqual	E-7	1901	Dug, 6 by 8 foot.	775	......	75	....	....	Gas, steam			Domestic	†85
467	S. Richardson	....do	G-10	1898	Bored, 8-inch (2 wells); 12-inch (2 wells).	650	580	150-180	....	....	Steam			Irrigation	†75
468	East Pasadena Land and Water Co.	....do	G-8	1902?	Dug, 6 by 8 foot, 90 feet; bored, 12-inch (4 wells)	785	715	630-734	....	....	....do			Not used	†100
469	Marengo Water Co.	....do	F-9	1901	Bored, 12-inch (3 wells).	......	......	......	....	....	Gas, electric motor (2 plants).			Irrigation	†120
470	George S. Patton	....do	G-9	......	......	725	......	......	....	....	Gas			....do	
471	....do	Santa Anita	H-9	......	Dug, 40 feet	675	660	300-400	....	....	Electric motor			....do	†100
472	Huntington Land and Improvement Co.	....do	H, I-9	......	......	650	612	200	....	....	....do			Domestic; irrigation.	†7
473	Pasadena Land and Water Co.	San Pasqual	E-9	......	Dug, 6 by 8 foot	750	710	70	....	....	....do			....do	......
474	J. T. Eldridge	....do	I-8	......	Bored, 7-inch	650	607	140	....	....	Gas			....do	......
475	Titus ranch	....do	J-9	......	....do	620	608	132	....	....	Not raised			Not used	......
476	G. B. Renfro	Sec. 18, T. 1 S., R. 11 W.	K-12	......	....do	300	279	46	....	....	Wind			Domestic	......
477	Mr. Beck	San Francisquito	L-12	......	....do	275	260	......	....	....	....do			....do	......
478	M. Ritter	....do	L-13	......	....do	275	257	60	....	....	Hand			....do	......
479	Mrs. McClure	Sec. 21, T. 1 S., R. 11 W.	L-13	......	....do	265	251	61	....	....	Wind			....do	......
480	E. J. Baldwin	Santa Anita	K-8	......	Bored, 12-inch	535	535	500	....	....	Artesian, gas			Irrigation	†75

[a] Including No. 437.

[b] Including No. 435.

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